PROPOSED

Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Blue Whale (*Balaenoptera musculus*), Northwest Atlantic Population, in Canada (PROPOSED)

Blue Whale, Northwest Atlantic Population

August 2009

Fisheries and Oceans Canada
Pêches et Océans Canada

Canada

About the *Species at Risk Act* 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 (http://www.sararegistry.gc.ca/approach/act/default_e.cfm) outline both the required content and the process for developing recovery strategies published in this series.

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/).

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August 2009

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Additional copies:

Additional copies can be downloaded from the Species at Risk Act Public Registry (http://www.sararegistry.gc.ca/).

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PREFACE

The blue whale, northwest Atlantic population, is a marine mammal and is under the responsibility of the federal government. The Minister of Fisheries and Oceans is a “competent minister” for aquatic species under the *Species at Risk Act* (SARA). Since blue whales are regularly found in the Saguenay–St. Lawrence Marine Park and rarely in Forillon National Park administered by the Parks Canada Agency (Parks Canada), the Minister of the Environment is also a “competent minister” under SARA. SARA (s. 37) requires the competent ministers to prepare recovery strategies for listed extirpated, endangered and threatened species. The northwest Atlantic population of blue whale was listed as endangered under SARA in January 2005. The development of this recovery strategy was led by Fisheries and Oceans Canada – Quebec Region, in cooperation and consultation with many individuals, aboriginal communities, organizations and government agencies, as indicated below. The strategy meets SARA requirements in terms of content and process (ss. 39–41).

Success in the recovery of this population 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 and Parks 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 and the Minister of the Environment invite all responsible jurisdictions and Canadians to join Fisheries and Oceans Canada and Parks Canada in supporting and implementing this strategy for the benefit of the Northwest Atlantic blue whale and Canadian society as a whole. Fisheries and Oceans Canada and Parks Canada will support implementation of this strategy to the extent possible, given available resources and their 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 competent ministers 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 competent ministers will take steps to ensure that, to the extent possible, Canadians interested in or affected by these measures will be consulted.

In November 2002, a workshop on blue whale research priorities was held in order to:
1) summarize the existing research programs in Canada, the United States and Iceland;
2) identify knowledge gaps; 3) establish priorities for future research activities. This summary of species information, knowledge gaps and research activities was a significant step to be taken prior to developing and implementing a recovery strategy for the blue whale (Lesage and Hammill, 2003).

Next, a blue whale (Northwest Atlantic population) recovery team was established. This team is composed of a dozen members from various departments and organizations (see Section 4, Recovery Team Members): Fisheries and Oceans Canada (Quebec, Newfoundland and Labrador, and Maritimes Regions), St. Lawrence Economic Development Council (SODES), Parks Canada (i.e., the Saguenay–St. Lawrence Marine Park, SSLMP), the Innu Community of Essipit, the Group for research and education on marine mammals (GREMM) and the Mingan Island Cetacean Study (MICS). At the first meeting, held in February 2004, the recovery team drew on the latest knowledge to develop a priority list of current threats to the blue whale population and its habitat. Current knowledge is rather limited and based mainly on summer observations of blue whales in the Estuary and Gulf of St. Lawrence area, a small part of the distribution area of this species. During this first meeting, the recovery team also finished its identification of research needs, which began at the 2002 workshop. The second meeting, in December 2004, established the recovery goals and objectives. The recovery team also began to prepare a list of overall approaches and specific measures to address the threats. This list was completed during a third meeting held in March 2005. Together, these three meetings facilitated the collection and assessment of the information necessary to develop the current recovery strategy, which will be in effect from 2009 to 2014.

COMPETENT MINISTERS

Under the *Species at Risk Act*, the Minister of Fisheries and Oceans Canada (DFO) is the competent Minister for the blue whale, northwest Atlantic population. The Minister of the Environment as the responsible Minister for the Parks Canada Agency is the competent Minister for the individuals located within the Saguenay–St. Lawrence Marine Park and Forillon National Park.

AUTHORS

This document was written by Jacinthe Beauchamp, Hugues Bouchard, Paule de Margerie, Nancy Otis and Jean-Yves Savaria on behalf of the Blue Whale Recovery Team, Northwest Atlantic population.

ACKNOWLEDGEMENTS

Fisheries and Oceans Canada would like to thank the recovery team members for their contributions to the recovery of the Northwest Atlantic population of blue whales. Thanks to Andréanne Demers of DFO for her comments and editing of this recovery strategy. We would also like to thank the governments of Quebec and Newfoundland and Labrador for their comments on the preliminary version of this recovery strategy.

STRATEGIC ENVIRONMENTAL ASSESSMENT

In accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*, the purpose of a Strategic Environmental Assessment (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 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 habitat.

This recovery strategy will clearly benefit the environment by promoting the recovery of the blue whale. The potential for the strategy to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this strategy will clearly benefit the environment and will not entail any significant adverse effects. Refer to the following sections of the document in particular: Habitat and biological needs in Canadian Atlantic, Ecological role and Anthropogenic value, Intrinsic limiting factors, and Effects on other species.

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

EXECUTIVE SUMMARY

The blue whale population (*Balaenoptera musculus*) in the Northwest Atlantic[1] was designated as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in May 2002. This species was added to the *Species at Risk Act* (SARA) list as an endangered species in January 2005. Commercial whale hunting historically carried out in the Atlantic reduced the population by about 70%; at least 11,000 blue whales were killed before the 1960s including at least 1,500 animals in eastern Canada waters (Sergeant, 1966). Currently, the size of the Northwest Atlantic population is unknown, but it is unlikely that the number of mature animals exceeds 250 individuals according to experts' estimates (Sears and Calambokidis, 2002). According to available information, blue whales use Atlantic coastal and pelagic Canadian waters mainly in the summer, to feed primarily on euphausiids (commonly known as krill).

In addition to historic hunting and natural sources of mortality (i.e., ice entrapments and predation), a total of nine threats to the recovery of the Northwest Atlantic blue whale population are listed in this recovery strategy. Because of this population's small size, activities affecting even a small number of individuals can have a significant impact on the species' survival in the Atlantic. Among the threats described, two could represent a high risk for the blue whale population due to their probability of occurrence and/or the severity of their theoretical effect: anthropogenic noise which causes a degraded underwater acoustic environment and alters behaviour, and food availability for the blue whale. Medium risk threats include persistent marine contaminants, collisions with ships and disturbance caused by whale-watching activities of tourists or scientists. Lower risk threats include physical damage caused by noise, accidental entanglements in fishing gear, epizootics[2] and toxic algal blooms as well as toxic product spills.

The long-term goal of this recovery strategy is to reach a total of 1,000 mature individuals for the Northwest Atlantic blue whale population. In aiming to reach this recovery goal, three five-year objectives were set for the Canadian blue whale range: 1) Define and undertake a long term assessment of the number of Northwest Atlantic blue whales, the structure and trends of the population, and determine their range as well as their critical habitat within Canadian waters; 2) implement control and monitoring measures for activities which could disrupt the recovery of the blue whale in its Canadian range; 3) increase knowledge concerning the principal threats to the recovery of the blue whale in Canadian waters, in order to determine their true impact and identify effective measures to mitigate the negative consequences for this population's recovery. To achieve these objectives, several recovery measures are proposed under three broad strategies: research and monitoring, conservation, and public awareness and education.

As the distribution range of the Northwest Atlantic blue whale population extends outside Canadian territorial waters, reaching the goal of 1,000 mature animals is related to the involvement and contribution to blue whale recovery of governments from bordering countries and international ocean management organizations.

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[1] Blue whales in the North Atlantic make up two distinct groups, one in the east and one in the west of the Atlantic (Gambell, 1979; Clapham *et al.*, 1999; Sears and Calambokidis, 2002; Sears, 2002, 2003). The Canadian population that is part of the current recovery strategy is the Northwest Atlantic population.
[2] A disease affecting an animal species or a group of species as a whole in a more or less extensive area. Epizootics are epidemics that affect animals.

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1. BACKGROUND

1.1 Species Assessment Information from COSEWIC

The following summary of the COSEWIC assessment appears in the status report from Sears and Calambokidis (2002):

Common Name (population): Blue whale (Atlantic population)

Scientific Name: *Balaenoptera musculus*

Legal listing (SARA): January 2005 (Endangered)

COSEWIC Status: Endangered

Date of Assessment: May 2002

Reason for designation: Whaling reduced the original population. There are fewer than 250 mature individuals and strong indications of a low calving rate and a low rate of recruitment to the studied population. Today, the biggest threats for this species come from ship strikes, disturbance from increasing whale watch activity, entanglement in fishing gear, and pollution. They may also be vulnerable to long-term changes in climate, which could affect the abundance of their prey (zooplankton).

Canadian Occurrence: Pacific and Atlantic Oceans

COSEWIC Status History: Entire Canadian range was designated as Special Concern in April 1983. Split into two populations in May 2002. The Atlantic population was up-listed to Endangered in May 2002. Last assessment based on an updated status report.

1.2 Description

Blue whales (*Balaenoptera musculus*) have a tapered elongated shape and a varying blend of light and slated shades of gray with mottled pigmentation (Sears, 2002; Sears and Calambokidis, 2002). Some blue whales have very sparse mottling and appear uniformly pale or dark, while others have obvious mottling patterns, which are unique to them and stable throughout their lives. These differences in pigmentation and mottling patterns have allowed individuals to be identified and tracked through photo-identification (Sears *et al.*, 1987, 1990; Calambokidis *et al.*, 1990).

This cetacean has a large U-shaped head, which represents around 25% of its total body length and whalebones that can reach 1 m in length. The flippers measure around 4 m long. Their flukes are grey, broad and triangular with a straight or slightly curved trailing edge. Individual whales may have white patches (Sears, 2002; Sears and Calambokidis, 2002).

The blue whale is the largest animal known to have lived on Earth. Their weight varies between 73,000 and 136,000 kg (Sears 2002; Sears and Calambokidis, 2002). Females are generally larger and longer than males and animals are larger on average in the southern hemisphere than in the northern hemisphere (Lockyer, 1984; Yochem and Leatherwood, 1985).

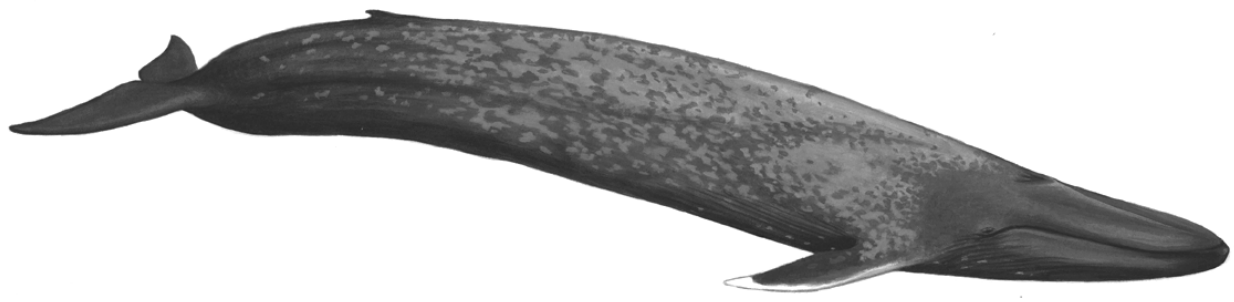

Figure 1. **Blue Whale — Illustration by Daniel Grenier, courtesy of Mingan Islands Cetacean Study (MICS).**

1.3 Populations and Distribution

Blue whales are part of the Mysticeti group of baleen whales and more specifically the Balaenopteridae family. There are three blue whale subspecies spread out across most of the world's oceans: 1) the northern blue whale, *B. m. musculus* (Linnaeus, 1758), occupies the northern hemisphere; 2) the southern blue whale, *B. m. intermedia* (Burmeister, 1871), lives in the waters around Antarctica; 3) the pygmy blue whale, *B. m. brevicauda* (Ichihara, 1966), is found from the sub-Antarctic zone of the southern Indian Ocean and southwestern Pacific Ocean (Yochem and Leatherwood, 1985; Sears, 2002). Using characteristics of the vocalizations produced by blue whales, McDonald *et al.*, (2006a) divided the blue whale population into nine regions or populations (i.e., 4 in the Pacific, 3 in the Indian Ocean, 1 in the Atlantic and 1 in the South).

Two geographically separated populations exist in Canadian waters, one in the North Atlantic and one in the North Pacific (Figure 2) (Sears and Calambokidis, 2002). The North Pacific population was part of a recovery strategy in 2005 (Gregr *et al.*, 2005). In the North Atlantic, blue whales have been split in two populations, one in the east and one in the west of Atlantic, but this split has not been accepted by all authors (Gambell, 1979; Wenzel *et al.*, 1988; Sears *et al.*, 1990; Clark, 1994; Reeves *et al.*, 1998; Clapham *et al.*, 1999; Sears and Larsen, 2002; Sears and Calambokidis, 2002; Sears, 2002, 2003; Reeves *et al.*, 2004; McDonald *et al.*, 2006a). Photo-identification indicates that blue whales from the St. Lawrence, Newfoundland, Nova Scotia and New England would belong to the Northwest population, while blue whales photographed off Iceland and the Azores would belong to the Northeast population (CETAP 1982; Wenzel *et al.*, 1988; Sears and Larsen, 2002; Sears, 2002, 2003). Consequently, the Canadian blue whale population in the Atlantic, which is part of the current recovery strategy, belongs to the Northwest Atlantic population.

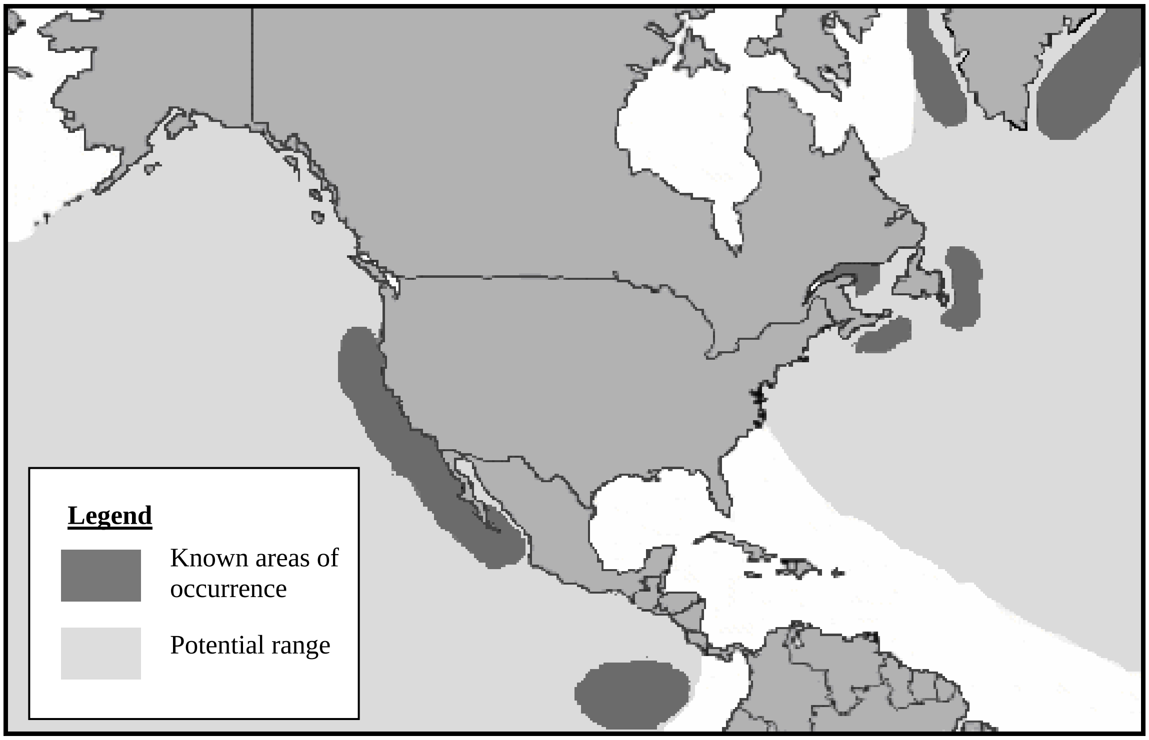

Figure 2. Geographical range of the blue whale, along the coast of North and Central America. Adapted from Sears and Calambokidis (2002).

Every year, blue whales undertake long seasonal migrations, south to north, from their wintering areas in equatorial latitudes to summer feeding areas located in the productive waters of temperate to subarctic latitudes (Lockyer, 1984; Reeves *et al.*, 1998; Perry *et al.*, 1999; Sears and Calambokidis, 2002; Reeves *et al.*, 2004). This migration allows blue whales to feed during four to six months in very productive areas, to increase their body fat and store reserves for the months of the year when food isn't as abundant in their wintering areas (Lockyer, 1984).

Little is known about the wintering and reproductive areas of blue whales in the North Atlantic, though some researchers suspect that they may travel south to Bermuda or Florida, while some whales remain in waters south of Iceland, and near Newfoundland and Nova Scotia (Sears, 2002; Sears and Calambokidis, 2002). Indeed, winter reports from various regions of the Estuary, northern Gulf of St. Lawrence and south and southwest of Newfoundland suggest that a proportion of the animals remain at our latitudes all year long (Sears and Williamson, 1982; Sergeant, 1982; Sears and Calambokidis, 2002; Lawson, 2003; Stenson *et al.*, 2003). In summer, blue whales from the Northwest Atlantic population probably range between Davis Strait, off the western coast of Greenland, and New England (Jonsgård, 1955, 1966; Sears *et al.*, 1990; Rice, 1998; Sears, 2002; Sears and Calambokidis, 2002).

Most of the recent sightings for the Northwest Atlantic population have been made in the Gulf of St. Lawrence (Sears, 1983; Sears *et al.*, 1990), more precisely in the area of the Mingan Islands, Anticosti Island, off the Gaspé Peninsula (Sears and Calambokidis, 2002; Sears, 2003), southwest and south coasts of Newfoundland (Mitchell, 1974a, 1974b, 1975a, 1976, 1977, 1978, 1979, 1980, 1981, 1982; Sergeant, 1966; Lien *et al.*, 1987, 1990; J. Lawson, DFO, unpubl. data) and on the Scotian Shelf (Sutcliffe and Brodie, 1977; CETAP, 1982; Whitehead *et al.*, 1998; Reeves, 1999; J.-F. Gosselin, DFO, unpubl. data). In the St. Lawrence Estuary, sightings have been made between Forestville and Tadoussac; in the Gulf, at the eastern tip of the Gaspé Peninsula, and on the North Shore, in the area of Sept-Îles and Port-Cartier. Observations have generally occurred from May to December, with peak sightings between June and August (Sears and Calambokidis, 2002). According to acoustical data, blue whales have been present on the Grand Banks between August and May, with a peak in vocal activities recorded from September to February (Clark, 1995). Furthermore, concentrations of individuals have also been sighted in the Laurentian channel, as well as south and northeast, in the Orphan Basin area, of Newfoundland (LGL, unpubl. data).

Current global blue whale population estimates range between 5,000 and 12,000 individuals, although the accuracy of these estimates is uncertain (Carretta *et al.*, 2003). As for the Northeast Atlantic population, a survey conducted in 2001 indicated that summer abundance of blue whales in Iceland and in adjoining waters could be around 1,159 individuals (Vikingsson, 2003). Furthermore, the number of blue whales in the Northwest Atlantic population is unknown, but it would be unlikely that this population comprises more than 250 individuals that have reached sexual maturity (Sears and Calambokidis, 2002).

From 1979 to the spring of 2007, a total of 405 blue whales were photo-identified mainly in the estuary and northwest of the Gulf of St. Lawrence and biopsies were taken on nearly 40% of them (R. Sears, pers. comm.). Each year, from 20 to 105 blue whales are identified in this region. Approximately 40% of the identified blue whales frequently return to the study area, the others have been observed during fewer than three seasons between 1979 and 2002, which suggests that these individuals range mostly outside the St. Lawrence, possibly in the waters at the edge of the continental shelf, from the Labrador Sea and Davis Strait in the north, east to the Flemish Cap and south to New England (Sears and Calambokidis, 2002). Photo-identification data from outside the Estuary and Gulf of St. Lawrence are limited. A few blue whales have been photographed along the coast of Newfoundland, on the Scotian Shelf and in the Gulf of Maine, and some are not included among the 405 blue whales that have been identified in the Estuary and northwest of the Gulf of St. Lawrence (Sears and Calambokidis, 2002; J. Lawson, pers. comm.). Ramp *et al.* (2006) estimate the survival rate at 0.975 and the gender ratio of the 139 biopsy sampled individuals at 79 males for 67 females (Sears, 2003). Given the small proportion of blue whale distribution range that has been sampled until now and considering the low abundance of blue whales, the current data based on photo-identification do not allow for an estimate with a minimum degree of certainty the abundance of this species in the Northwest Atlantic (Hammond *et al*. 1990; Sears and Calambokidis, 2002).

1.4 Needs of the Blue Whale

1.4.1 Habitat and Biological Needs in the Canadian Atlantic

According to available information, blue whales use coastal and pelagic waters in the Canadian Atlantic mainly in the summer, to feed primarily on euphausiids (commonly known as krill).

These large whales are typically observed alone or in pairs (Sears *et al.*, 1990; Sears and Calambokidis, 2002). Some heavy blue whale concentrations (up to 20 to 40 individuals, Sears *et al.*, 1990; R.Sears, MICS, unpubl. data) have been observed in areas where their food is concentrated at certain times of the year. These areas are typically at the edges of the continental shelf, at topographic breaks, at the head of canyons or in deep channels where the interaction of currents with the landform often generates deep-water upwellings and a krill aggregation process (Sameoto, 1976, 1983; Simard *et al.*, 1986; Schoenherr, 1991; Sameoto *et al*., 1993; Fiedler *et al.*, 1998; Perry *et al.*, 1999; Croll *et al.*, 1998, 2005; Lavoie *et al.*, 2000; Sourisseau *et al.*, 2006; Simard, 2009; I. McQuinn, DFO, unpubl. data).

There is no study simultaneously linking krill concentrations with blue whale concentrations. Nevertheless, several areas of high concentrations of krill, which may be potential feeding areas for the blue whale, were pointed out, the most studied being the area at the head of the Laurentian Channel in the St. Lawrence maritime Estuary. There are also other significant areas in the Estuary, the Gulf and the Northwest Atlantic where concentrations of krill are found, in particular Honguedo Strait, the north shore of the Gaspé Peninsula and the Emerald Basin in Nova Scotia (Sameoto, 1976, 1983; Sameoto *et al*., 1993; Cochran *et al*., 2000; I. McQuinn, DFO, unpubl. data). Other areas with high concentrations of macrozooplankton (mainly krill) were sampled throughout the Gulf of St. Lawrence using an acoustic technique (I. McQuinn, DFO, unpubl. data) indicating other potential feeding areas of blue whale. These included the Gaspé current in the area off Sainte-Anne-des-Monts and Gaspé, in the Estuary, between Pointe aux Outardes and Pointe Mitis, at the western tip of Anticosti Island, around the Banc Parent, and off the west coast of Newfoundland, near the 150-m isobath.

Even though there is no systematic monitoring of these areas, the available data indicates that it is likely that krill aggregations form according to predictable patterns each year in these areas, as is the case in Honguedo Strait (Sameoto, 1983; I. McQuinn, DFO, unpubl. data), in the St. Lawrence Estuary at the head of the Laurentian Channel (Simard et Lavoie, 1999; Cotté et Simard, 2005) and in several other locations. A numerical model supports the aggregation of particles with some similar behaviour patterns as krill in several of these areas (Sourisseau *et al*., 2006). The basin's topography coupled with its hydrodynamic circulation[3] seem to influence where blue whale food aggregations are likely to build up (Sourisseau *et al*., 2006). At this time, it is not known to what extent krill aggregate in all of these areas, nor to what extent they are used by blue whales for feeding.

Blue whales have been sighted in several of these areas over the years and seasons, as well as in the Pointe-des-Monts area and between Sept-Iles and Blanc-Sablon, where deep-water upwellings occur that typically contain high concentrations of krill (see review in Lesage *et al*., 2007). Present data are insufficient to determine the relative importance of krill and macrozooplankton aggregation areas for the blue whale. Even though there exists some connection between certain areas and the recurring occurrence of blue whales, a large yearly variation in summer sightings has been observed.

[3] Displacement of water masses due to the action of currents in the three-dimensional space and in time on various scales such as the semi-diurnal or semi-monthly tide, the season, the year, and multi-year cycles.

1.4.2 Ecological Role and Anthropogenic Value

Blue whales are lower trophic level predators that ingest several tons of prey each day and could be prey for killer whales (*Orcinus orca*). The recovery of the Northwest Atlantic blue whale population will allow these animals—which historically were much more numerous—to fulfill their ecological role as predator and prey.

Blue whales are also an animal species valued by whale watchers, scientists, and environmentalists. Recently, Olar *et al.* (2007) conducted a study with Canadians to evaluate the economic benefits the recovery of marine mammals has in the St. Lawrence Estuary. They showed that Canadians are concerned about protecting marine mammals and that they agreed that Canada should spend more money for protecting the blue whale in the St. Lawrence Estuary.

1.4.3 Limiting Intrinsic Factors

Intrinsic characteristics of the blue whale's life history and ecology can affect its recovery potential, specifically in terms of reproduction and dietary specialization.

Blue whales mate and calve from late fall to mid-winter in the northern hemisphere (Yochem and Leatherwood, 1985). Females usually give birth to a single calf every 2–3 years after a 10–11-month gestation period (Lockyer, 1984; Sears, 2002). At birth, calves measure 6–7 m and weigh over 2 tons (Sears and Calambokidis, 2002; Sears, 2002). Calves are dependant on their mothers during 7–9 months, i.e., until the weaning period (Lockyer, 1984; Tillman and Donovan, 1986). Weaning occurs in summer in feeding areas (Lockyer, 1984; Yochem and Leatherwood, 1985; Tillman and Donovan, 1986) where calves are taught to feed themselves (Lockyer, 1984). Sexual maturity in male and female blue whales is reached at 5-15 years of age (Yochem and Leatherwood, 1985; Perry *et al.*, 1999; Sears, 2002). In the northern hemisphere, females reach a length of 21–23 m, while males are 20–21 m long (Sears and Calambokidis, 2002; Sears, 2002). Blue whales are thought to live for more than 80 years. (Yochem and Leatherwood, 1985; Sears, 2002).

The Northwest Atlantic population's annual growth rate is unknown. In the Antarctic, the annual growth rate has been estimated at 7.3% from 1968 to 2001 (Branch *et al.*, 2004), whereas the Northeast Atlantic population's growth rate has been estimated at 5.2% between 1979 and 1988 (Sigurjónsson and Gunnlaugsson, 1990). In the Gulf of St. Lawrence, between 1979 and 1988, only five calves were seen (Sears *et al.*, 1990). No mother-calf pairs were seen over the seven subsequent years. Then, between 1994 and 2002, six mother-calf pairs were sighted near Gaspé or in the Estuary (only one pair per year). During the 2003 season, for the first time in 25 years of observation, three females with calves were seen. Then, in 2004, 2005 (west of Newfoundland; J.-F. Gosselin, DFO, unpubl. data), 2007 and 2008, one mother-calf pair per year was sighted which brings the total to only 19 pairs for the last 30 seasons (R. Sears, pers. comm.). However, considering that only a small proportion of the range is surveyed in Canada, it is difficult to assess whether the low number of mother-calf pairs sighted is representative of the actual reproduction rate for the whole Northwest Atlantic blue whale population.

Another intrinsic limiting factor is that blue whales feed almost exclusively on krill (Jonsgård, 1955; Kawamura, 1980; Lockyer, 1984; Sergeant, 1966; Schoenherr, 1991) and display an individual consumption between 1,800 and 3,600 kg (2–4 tons) of krill every day (Yochem and Leatherwood, 1985). In the North Atlantic, their main preys are *Thysanoessa inermis, T. longicaudata, T. raschii* and *Meganyctiphanes norvegica* (Yochem and Leatherwood, 1985; Sears and Calambokidis, 2002). To meet their energy requirements, blue whales must feed exclusively in areas of very high concentrations of krill (Croll *et al.*, 2005; Brodie *et al.*, 1978; Kawamura, 1980). The areas where such densities of zooplankton exist are rare in the ocean; consequently, they are of critical importance for blue whale survival. The blue whales' fat reserves accumulated during four or five months of intensive feeding are likely necessary for their winter migration and reproduction. The success of biological processes such as fertility, gestation, lactation, development, growth, sexual maturity and recruitment are all dependent on the blue whale's capacity to store energy reserves (Lockyer, 1984).

Significant limiting factors that can affect the recovery potential of the species include a low birth rate (a female produces only a single calf every three years), combined with a late sexual maturity, resulting in a low population growth rate. Although there has been no whaling of the Northwest Atlantic blue whale population since 1966, its natural population growth is not fully understood. Furthermore, the blue whale population's viability and recovery can been held back by factors that limit the availability of food resources (see section *1.5.3.2, Food Availability*).

1.5 Threats: Classification and Description

The most important factor responsible for the low numbers of blue whales in Canada is historical whaling, which decimated populations from the end of the 19th century until it was prohibited by the International Whaling Commission (IWC) in 1966. In the North Atlantic, 11,000 blue whales were likely captured prior to the 1960s (Sigurjónsson and Gunnlaugsson, 1990); 1,500 of them were captured in eastern Canadian waters from 1898 to 1915 (Sergeant, 1966; Mitchell, 1974a, 1974b). It is estimated that whaling reduced the blue whale population by about 70%, and although the current size of the Northwest Atlantic population is unknown, it is very unlikely that the number of mature animals exceeds 250 individuals (Sears and Calambokidis, 2002). Consequently, the population could face reduced genetic diversity, which could in turn affect individuals (e.g., reduced fertility, reduced disease resistance) or the population (e.g., reduced population growth rate) (Lacy, 1997). The latter could also be subjected to the Allee effect[4] (Allee *et al.*, 1949), which could substantially disrupt this population's recovery.

The authors of the COSEWIC status report (Sears and Calambokidis, 2002) mention several threats that are thought to hinder the recovery of the Northwest Atlantic blue whale population since the end of commercial whaling: shipping traffic, disturbance caused by whale-watching activities, entanglement in fishing gear, pollution, the effects of climate change on prey abundance, ice entrapments and predation. The current recovery strategy lists nine threats along

[4] The Allee effect is a biological phenomenon that is based on a positive relationship existing between the density of a population and its growth rate, i.e., the birth rate decreases when population density decreases. If there is a density threshold under which the growth rate of a population becomes negative, the Allee effect can lead to the disappearance of this population.

with whaling and natural mortality (i.e., caused by ice entrapments and predation). Threats are divided into three risk categories based on their probability of occurrence and/or the severity of their theoretical effect on blue whales: high, medium and lower risk. This threat priority list (Appendix 1) was established based on current knowledge (which is limited and based mainly on blue whale sightings in the Estuary and Gulf of St. Lawrence area) and could change according to the context itself and/or with the increase of knowledge. Because of the blue whale population's small size in the Northwest Atlantic, even activities that affect a small number of individuals could have a serious impact on the population's health.

1.5.1 Whaling

Three types of whaling can threaten cetacean populations: commercial whaling, subsistence whaling and whaling for scientific purposes (Clapham *et al.*, 1999). Despite an international moratorium by the IWC on commercial whaling since 1966, some countries continue to whale, both for scientific (e.g., Japan) and commercial (e.g., Norway) purposes. According to genetic analysis of whale meat found on the Japanese and south Korean markets, meat from blue whales, fin whales (*Balaenoptera physalus*), humpback whales (*Megaptera novaeangliae*) and many other species protected under the IWC are still being sold (Lerto *et al.,* 1998 *in* Rafic 1999; Baker *et al.*, 2000). In addition, the former Soviet Union continued to hunt certain species of whales, including blue whales, after the moratorium was introduced in 1966, killing approximately 8,000 blue whales (Zemsky *et al.*, 1995, 1996 *in* Clapham *et al.*, 1999; Yablokov *et al.*, 1998 *in* Clapham *et al.*, 1999).

In Canada, according to the *Marine Mammal Regulation* of the *Fisheries Act*, hunting blue whales is prohibited within Canada's exclusive economic zone. Moreover, blue whales are protected by the *Species at Risk Act* (SARA), which states that it is prohibited to kill an individual belonging to a species listed under the Act. Subsistence whaling practised by aboriginal people would require permits or exemptions, but this type of hunting does not occur in Canada. Whaling remains a potentially significant human-induced source of mortality for large cetaceans. However, because it is unlikely that commercial whaling will resume in the near future in the Northwest Atlantic, whaling is not considered a current threat for blue whales in Canada.

1.5.2 Natural Mortality

1.5.2.1 Ice

Ice carried by wind and currents in late winter/early spring can injure blue whales; they can even die by anoxia (lack of oxygenation) or be crushed by moving ice blocks. A small percentage of the individuals sighted in the St. Lawrence have dorsal scars caused by ice contact (Sears *et al.*, 1990; Sears, pers. comm.).

From 1868 to 1992, 23 ice entrapment events involving one to four blue whales were reported, affecting a total of 41 individuals southeast of Newfoundland. Based on information available, these events occurred between March and April. Among the blue whales that were trapped, 28 died, five escaped and eight were unaccounted for. Most of the dead individuals that were examined were mature (i.e., 21-25 m in length). Two of the six blue whales that were examined for gender were females, one of which was pregnant (Stenson *et al.*, 2003).

1.5.2.2 Predation

The only known predator of blue whales is the killer whale (Perry *et al.*, 1999; Sears, 2002), but there is limited knowledge of the frequency of these attacks and the extent to which they are fatal (Reeves *et al.*, 1998). This predator attacks several cetacean species, including large whales (Jefferson *et al.*, 1991). Recent cases include mortal attacks on a group of sperm whales (*Physeter macrocephalus*) (Pitman *et al.*, 2001) and on minke whales (*Balaenoptera acutorostrata*) (i.e., four mortal attacks out of nine; Ford *et al.*, 2005). There have been some reported cases for blue whales (Jefferson *et al.*, 1991), such as the instance where almost 30 killer whales attacked and killed a young blue whale off Baja California (Tarpy, 1979).

Killer whales make specific rake-like markings with their teeth on their victims. Very few blue whales in the St. Lawrence carry such markings. In the Pacific, in the Sea of Cortez where killer whales are more abundant, 25% of the blue whales sighted carry marks caused by killer whale attacks (Sears and Calambokidis, 2002).

Knowledge of the Atlantic killer whale population is limited (Baird, 2001); they are not very abundant. Individuals have been sighted off the coasts of Labrador, Newfoundland, Nova Scotia and in the Gulf of St. Lawrence (Baird, 2001). A group of three or four individuals were sighted in the Gulf of St. Lawrence off Mingan, beginning in 1984. Between 1997 and 1999, only the male from this group has been seen between Percé and Mingan (MICS, unpubl. data). More recently, however, killer whales alone or in groups were seen in the Gulf (i.e., several individuals off Blanc Sablon, in 2001, a group of eight individuals and another of two individuals; in 2004, one individual in the Belle-Isle Strait) and even in the Estuary off Bergeronnes and at the mouth of the Saguenay River (i.e., two individuals together in October 2003) (GREMM, unpubl. data; MICS, unpubl. data). The decline in the St. Lawrence beluga population (*Delphinapterus leucas*), a major prey for killer whales, could partly explain the low number of killer whales observed in the last decades (Mitchell and Reeves, 1988).

1.5.3 High-risk Anthropogenic Threats

1.5.3.1 Anthropogenic Noise: Acoustic environmental Degradation and Changes in Blue Whale Behaviour

Blue whales produce very low frequency sounds (< 200 Hz) whose function is little understood (Ketten, 1998; Mellinger and Clark, 2003; Berchok *et al*., 2006; McDonald *et al*., 2006a). The whales could use the sounds to investigate the environment, locate feeding grounds, and/or to communicate with other individuals over short and long distances (Richardson *et al*., 1995; Stafford *et al*., 1998, 2007; McDonald *et al*., 2001). Blue whales could also transmit information on their whereabouts and their reproductive status in order to coordinate reproductive activities (Richardson *et al*., 1995). Some of these low-frequency sounds are difficult to detect when ambient noise levels are loud (Simard *et al.*, 2006; Mouy 2007; Stafford *et al.*, 2007; Simard and Roy, 2008; Simard *et al*., 2008). Depending on the purpose of these sounds, making them difficult to hear may affect certain behaviours.

Anthropogenic noise levels (e.g., seismic noise, shipping traffic, explosions, low frequency sonar, industrial and military activities) in the oceans have been increasing over the last 50 years (Croll *et al*., 2001; Andrew *et al*., 2002; National Research Council, 2003; McDonald *et al.*, 2006b; Tyack, 2008). A 0.2 to 0.3 decrease in pH in the deep water in the St. Lawrence estuary (M. Starr, DFO, pers. comm.), owing to climate change, combined with eutrophication, enable noise to carry over greater distances, possibly further affecting cetacean communication. Hester *et al*. (2008) have demonstrated that a pH decrease of 0.3 would result in a 40% decrease of noise absorption by water at frequencies lower than 10 kHz. Furthermore, the Intergovernmental Panel on Climate Change (IPCC) predicts that by the year 2050, oceanic surface waters will decrease in pH by 0.3 (Brewer, 1997). Noise propagation in the ocean would thus increase. These anthropogenic noises could have a harmful impact on marine mammals by: 1) disrupting their ability to passively observe their environment, to detect the sounds emitted by other marine mammals or any other sounds; 2) causing behavioural changes; 3) altering hearing sensitivity or by causing injury which, in certain cases, are fatal (Richardson *et al*., 1995; Southhall, 2005; Nowacek *et al*., 2007; Weilgart, 2007; Stokin *et al*., 2008). This third point will be discussed in Section 1.5.5.1 Anthropogenic Noise: Physical Harm.

In the ocean before the Industrial Revolution, the call of a blue whale may have been heard over 100–1,000 nautical miles, while in today's noisier oceans it might be heard over only 10–100 nautical miles (Clark, 2003). Although the function of the sounds emitted is not well understood, it has been suggested that a decrease in communication range could affect blue whale reproduction by reducing the effectiveness of male communication with receptive females (Croll *et al.*, 2002). This harmful effect could be significant for a small-sized population (National Research Council, 2003) such as the blue whale population. Based on the assumption that ambient noise has a significant impact on the capacity of the blue whales to communicate for reproduction or any other critical activity, anthropogenic noise could represent a factor that is likely to negatively affect this population's recruitment and recovery (Croll *et al*., 2002).

Moreover, in response to anthropogenic noise, blue whales can adopt a variety of reactions. Reactions can range from a brief interruption of normal activities (e.g., rest, feeding, social interaction, nurturing their calves, vocalizations, breaths, dives) to avoiding noisy areas for a short or long period (Richardson *et al*., 1995; McDonald *et al*., 1995; National Research Council, 2003; DFO, 2004; Bejder *et al*., 2006; Weilgart, 2007). There is a cost in terms of energy associated with these behavioural changes. The energy that would normally be used for vital activities (e.g., acquiring food, reproductive activities) is instead expended on avoidance behaviour. Although the effects of a behavioural change in response to anthropogenic noise on blue whales are unknown, they might not be negligible (Richardson *et al*., 1995; National Research Council, 2003; DFO, 2004).

Among the anthropogenic noise occurring in Canadian waters, two are particularly significant: maritime shipping as well as seismic surveys and petroleum or gas development activities. As important shipping routes, the Estuary and Gulf of St. Lawrence offer a noisy aquatic environment, which could be a problem for marine mammals in certain areas, i.e., mainly in the Estuary and at the head of the Laurentian Channel (Scheifele *et al*., 1997; Berchok *et al*., 2006; Simard *et al*., 2006; Stafford *et al*., 2007; Simard and Roy, 2008; Simard *et al*., 2008). In this area, blue whales emit sounds in a wider range of frequencies than those observed in other areas in the Northwest Atlantic (Mellinger and Clark, 2003; Nieukirk *et al*., 2004; Berchok *et al.*, 2006). These authors have theorized that loud ambient noise in the St. Lawrence River could force blue whales to change the frequency of their signals in order to improve the likelihood that these signals will be heard by other blue whales (Berchok *et al*., 2006). Changes in the vocalization pattern over time in response to ambient noise were also recorded for right whales (Parks et al. 2007).

Seismic surveys and oil and gas development are conducted in several coastal areas around the world, including the east coast of Canada (east of Newfoundland and Labrador and on the Scotian Shelf) (Nieukirk *et al*., 2004; Lawson and McQuinn, 2004). Under conditions of low ambient noise and good propagation, noise produced by air gun arrays used in seismic surveys can be detected up to 3,000 km away, sometimes masking the ability to detect vocalizations produced by blue whales in affected areas (Nieukirk *et al*., 2004). Moreover, it was shown that seismic activities have consequences on cetacean behaviour in general; they can change navigation routes, alter their displacement speed, and modify their dive profiles and feeding (Stone, 2003). Because of the potential effects on the ecosystem and on blue whale behaviour, anthropogenic noise is a threat that is likely to jeopardize blue whale recovery in the Northwest Atlantic.

1.5.3.2 Food Availability

With their restrictive diet (stenophagous) and their requirement for areas with high concentrations of prey, blue whales are particularly vulnerable to changes in prey abundance and/or distribution (Croll *et al.,* 1998; Clapham *et al.,* 1999; Acevedo-Gutiérrez *et al.*, 2002). A drop in food resources could have significant consequences on the population, and more specifically on recruitment. For example, Greene *et al.* (2003) showed that recruitment for the North Atlantic right whale (*Eubalaena glacialis*) was affected by the availability of food resources. In a context where food resources are limited, a post-lactating female blue whale may not accumulate enough energy for its subsequent conception or for the subsequent nursing period, and consequently abort the pregnancy or give birth to a calf that is unable to survive (Lockyer, 1984).

In addition to natural variability in the ocean's climate, three anthropogenic factors could have an effect on krill availability for blue whales. Firstly, an increase in pelagic fish that feed on krill such as capelin (*Mallotus villosus*) and Atlantic herring (*Clupea harengus*) could limit the availability of this resource for blue whales (i.e., interspecific competition). In recent decades, the abundance and distribution of pelagic fish has changed considerably in the Estuary and Gulf of St. Lawrence following the decline of their predators, Atlantic cod (*Gadus morhua*) and redfish (*Sebastes* spp.), caused in part by the commercial fishery (CAFSAC, 1994; Gascon, 2003). Cetaceans and seals have gradually replaced them as principal predators for pelagic fish (Savenkoff *et al.*, 2004, 2006), but they exert weaker predatory pressure than the groundfish did (Savenkoff *et al.*,2007). Although the effect on pelagic fish of having fewer predators is unknown, it could have increased their numbers (Worm and Myers, 2003).

Moreover, Fisheries and Oceans Canada (DFO) research surveys have shown a major expansion in the geographical distribution of capelin throughout the Gulf of St. Lawrence in the 1990s (DFO, 2001). There was a concomitant increase in the observations of cetacean species such as humpback whales (*Megaptera novaeangliae*) in the northern Gulf of St. Lawrence (Sears, unpubl. data). With their larger prey spectrum, these opportunist predators target both macrozooplankton and pelagic fish species (Mitchell, 1975b; Borobia *et al.*, 1995). All these findings point to a deep change in the trophic structure of the St. Lawrence ecosystem, which may have affected and/or could eventually modify the distribution and abundance of blue whales. For example, the Mingan Islands in the Gulf of St. Lawrence, used to be a very active area for blue whales during the 1980s, which is no longer the case (Sears, pers. comm.).

Commercial exploitation of krill in the St. Lawrence Gulf for the nutritional food industry could reduce the availability of this food resource for blue whales. However, in 1998, a moratorium on the issuance of new licences for all the unexploited forage species (including krill) was put in place by the Minister of Fisheries and Oceans and is still in force in Eastern Canada.

Finally, climate change as a result of human activities could lead to variations in the ocean climate that are likely to have an effect on primary production as well as prey distribution and/or abundance for marine mammals (Harwood, 2001). Long term impacts of global warming, which is occurring at a faster rate than previously expected, are difficult to forecast, but could lead to an increase in average temperature between 1.5°C and 5.5°C by 2050, in central and southern Québec (Bourque et Simonet, 2008). From 1960 to 2003, an increase in temperature between 0.4°C and 2.2°C has been observed in several regions of southern Quebec (Yagouti *et al*., 2006). For the Maritimes region, seasonal temperature trends from 1948 to 2005 reveal a general increase of 0.3°C, with a peak in the summer of 0.8°C. By 2050, summer temperatures will increase by 2°C to 4°C in Atlantic Canada (reviewed in Vasseur and Catto, 2008). Similar changes are expected in other ecosystems frequented by blue whales, such as in the Pacific, where the increase in surface water temperatures has led to a drop in zooplankton abundance since the 1970s (Roemmich and McGowan, 1995). Climate change could have an impact on blue whale food resources by affecting 1) the production of the krill included in blue whale diet, including *Thysanoessa raschi* and 2) the krill aggregation processes within feeding areas. For example, climate change could reduce the habitat of *T. raschi*, which is associated with the cold intermediate layer (Simard *et al*., 1986), with unknown impacts on the medium-term production of this species. The estuarine two-layer circulation pattern observed in the Estuary and Gulf of St. Lawrence, which, presumably, is responsible for the aggregations of krill, and which depends on the freshwater inputs from the St. Lawrence River and on the vertical stratification of the water column (Saucier and Chassé, 2000; Saucier *et al*., 2003; Smith *et al*., 2006), will also be likely affected by climate change.

For the Northwest Atlantic, Greene *et al.* (2003) theorized that changes in ocean climate will adversely impact the recruitment and recovery of the North Atlantic right whale by decreasing the abundance of its food resources (i.e., zooplankton, mainly copepods). Considering that the blue whale is a selective species in terms of food choice (like the right whale), similar climate repercussions on food resources for blue whales in the Northwest Atlantic could impact the species' recovery. Consequently, climate change could be affecting existing feeding grounds, but current knowledge is insufficient to predict how.

1.5.4 Medium-risk Anthropogenic Threats

1.5.4.1 Contaminants

Contaminant sources in the aquatic environment are numerous (e.g., agricultural, industrial and municipal waste, shipping, dredging, gas and oil exploitation, aquaculture) and so are their impacts on marine mammals (e.g., depression of the immune system, altering reproductive capacity, lesions and cancer) (Colborn and Smolen, 1996; Aguilar *et al.*, 2002).

Levels of polychlorinated biphenyls (PCBs) and other organochlorinated compounds have been found in St. Lawrence blue whales (Gauthier *et al*., 1997; Koenig *et al*., 1999). The levels of contamination, although lower than those measured in St. Lawrence belugas (possibly due to differences in diet and time spent in the St. Lawrence River; O' Shea and Brownell, 1994; Angell *et al*., 2004; Lebeuf *et al*., 2007), are sufficiently high to trigger abnormal activity in certain cytochromes, which could lead to biological impacts on the whales' health (Angell *et al*., 2004).

The impact of contaminants on blue whales is difficult to track because this threat has many variables and depends on several determining factors such as age, gender, length of exposure, intensity of the exposure, season, and nutritional status (Colborn and Smolen, 1996). Blue whales can draw on their fat reserves in winter, which increases their exposure to the contaminants (Colborn and Smolen, 1996). Concentrations of contaminants generally increase with age in males, while in mature females, they decrease as they age due to the transfer of contaminants to their young (O'Shea and Brownell, 1994; Metcalfe *et al.,* 2004). Indeed, during gestation and nursing, a portion of the contaminants from the mother is transmitted to the calf. This transfer of contaminants is a serious issue that can generate contaminant levels as high in the calves as in their mothers (e.g., Metcalfe *et al.,* 2004). Although there is no reason right now to believe contaminants have a lethal impact on baleen whales (O'Shea and Brownell, 1994), there is enough evidence to suggest that some contaminants can alter the reproductive potential and health of cetaceans (Colborn and Smolen, 1996). Consequently, improving knowledge is necessary in order to better assess the genuine risk with regards to contaminants for the blue whale in the Northwest Atlantic.

1.5.4.2 Collisions with Vessels

In addition to disturbing marine mammals' activities on the water's surface (e.g., breathing, feeding, socializing, nurturing), vessels can collide with them, severely injuring or killing them.

Large vessels traveling at more than 14 knots (26 km/h), such as container ships and other large vessels (i.e., measuring 80 m long and more), have been found to be the principal source of severe or fatal injuries for large whales (Laist *et al.*, 2001). Vanderlaan and Taggart (2007) also showed that the probability of a collision being fatal for a large whale increases quickly when vessel speeds range between 8.6 and 15 knots. Jensen and Silber (2004) estimate that at least 70% of vessel collisions with large whales are fatal.

Individuals that move along inhabited coastal areas or in busy seaways, such as the St. Lawrence Estuary, are more vulnerable to collisions with vessels (Clapham *et al.*, 1999; Laist *et al.*, 2001). According to the Bureau d’audiences publiques sur l’environnement (BAPE), over 12,000 vessel movements were recorded for 2003 in the Estuary between Sept-Îles and Les Escoumins, with a little more than 6,000 west from Les Escoumins and 226 at Cacouna (BAPE, 2006). So it is not surprising that deep wounds and scars, which can be attributed to collisions with the propeller or hull of large vessels, have been observed on at least 5% of the blue whales seen in the St. Lawrence (Sears, pers. comm.).

Blue whale mortalities related to collisions with vessels have been reported in various oceans (Barlow *et al.*, 1997; Reeves *et al.*, 1998; Laist *et al.*, 2001). Even though there have not been many cases reported in the Northwest Atlantic, the number of St. Lawrence blue whales with scars from collisions indicates that this threat is real and likely significant (Sears and Calambokidis, 2002). It is possible that whales struck and killed by fast-moving vessels sink to the bottom without being detected, leading to an underestimate of the real impact of this threat (Sears and Calambokidis, 2002).

The blue whale’s ability to detect and avoid ships is yet to be determined (Laist *et al.*, 2001). Adequately locating large ships acoustically can be difficult since the main sound source, the propeller, is located at the back of the ship with a long hull dampening the sound propagation forward. The least noisy area is the prow (Arveson and Vendittis, 2000), in the direction the ship is moving, where the risk of collision is the highest. Calves and juveniles are probably more vulnerable than adults, as they spend more time near the surface and have less experience avoiding ships (Laist *et al.*, 2001). Because of the low number of blue whales in the Northwest Atlantic, the loss of even a few individuals can represent a significant obstacle to this population’s recovery (Laist *et al.*, 2001). When the critical habitat and distribution of the species in the North Atlantic is better understood, it will be easier to assess the significance of this threat to the blue whale population.

1.5.4.3 Whale Watching

The increase in whale-watching activities by cruise lines, recreational boaters and scientists represents a significant threat to many coastal cetaceans, including blue whales. In the Estuary and Gulf of St. Lawrence, several sites frequented by blue whales have been attracting a significant number of tourists for a number of years (e.g., Parks Canada estimates, for 2005, that nearly 275,000 people participated in whale-watching activities at sea in the Saguenay–St. Lawrence Marine Park). In the St. Lawrence Estuary, up to 50 cruise ships sail the waters in search of cetaceans. For example, 7-13 boats have been observed simultaneously in very close proximity (within 20 m) to blue whales (Sears and Calambokidis, 2002). Whale watchers in the Gaspésie region seek out blue whales specifically. On several occasions, whale-watching vessels were seen within 200 m of this species (Pieddesaux *et al.*, 2007). In addition, teams of scientists conducting research activities aimed at improving knowledge of the species must approach the blue whales within 25 m (e.g., collecting biopsies, deploying data collection equipment), which can cause stress for these animals.

Whale-watching activities can disturb cetaceans during daily activities that are essential to their survival (i.e., resting, feeding, avoiding predators, communicating, socializing, mating and nurturing calves). When these disturbances are repeated and/or sustained, they can affect the survival of individuals and the conservation of the species. Furthermore, the dependence of these animals on certain habitats leads to the concentration of whales and whale watchers in these important areas (Lien, 2001).

There has been no long-term study on the effects of whale-watching activities in the Estuary and Gulf of St. Lawrence (Lien, 2001). Among the short-term behavioural changes observed in various cetacean species, there have been alterations in swimming, diving, breathing, vocalization, feeding, resting, socializing, nursing and aerial acrobatics, as well as the short-term abandonment of habitat (GBRMPA, 2000 *in* Lien, 2001). Cetaceans could be forced to move to sub-optimal areas that are inadequate to meet their needs (IFAW, 1997 *in* Lien, 2001). There is a cost associated with these changes in behaviour and habitat, which can reduce the blue whale's capacity to store energy reserves that are critical for ensuring reproductive success and their survival during periods when food is scarcer (Richardson *et al.*, 1995; National Research Council, 2003).

1.5.5 Low-risk Anthropogenic Threats

1.5.5.1 Anthropogenic Noise: Physical Harm

In addition to the potential for masking the sounds produced by blue whales and affecting their behaviour ("1.5.3.1, Anthropogenic noise: acoustic environmental degradation and changes in blue whales' behaviour"), high amplitude or long-term anthropogenic noise could cause, in cetaceans, temporary or permanent alteration of hearing thresholds, production of stress hormones, and/or physical damage such as internal lesions that could cause death (Ketten *et al.*, 1993; Crum and Mao, 1996; Evans and England, 2001; Finneran, 2003; National Research Council, 2003; DFO, 2004). For several species, knowledge is insufficient to clearly establish the noise levels perceived at the various frequencies and if these sounds can cause physical harm (Richardson *et al*., 1995; National Research Council, 2003; DFO, 2004; Southall *et al*., 2007).

It is during seismic research or the use of low frequency active sonar that the highest levels of underwater noise are usually recorded (Richardson *et al*., 1995). Since the ears of mammals share certain structural similarities with other vertebrates (Fay and Popper, 2000), and some noise exposure studies on different vertebrate species (see reviews in Ketten and Potter, 1999; Caldwell, 2000; McCauley *et al.*, 2003; Lawson and McQuinn, 2004; Popper *et al*., 2004; Cox *et al*., 2006; Lawson, 2006, 2007; Southall *et al*., 2007) indicate that it is possible that exposure to the intense noise produced close to airgun arrays might also damage the hearing of cetaceans if they do not avoid the noise source.

High-amplitude sound energy from underwater explosions (e.g., demolition or construction blasting, wellhead decommissioning) can also cause injury or death to cetaceans nearby. A high-amplitude impulsive noise caused by sea-floor dynamiting might have caused the death of two humpback whales found in fishing gears along the coast of Newfoundland. Both individuals had significant lesions on their temporal bones, and fractures of their auditory systems (Ketten *et al.*, 1993).

Even in the absence of direct physical effects from exposure to loud anthropogenic noise, it is possible that behavioural reactions by cetaceans could produce adverse effects (National Research Council, 2005). Jepson *et al*. (2003) reported the death of approximately ten cetaceans following the occurrence of air bubbles in their vital organs, in an area where military sonar had been used in the previous hours. The noise produced by the sonar might have precipitated a rapid, abnormal resurfacing of these deep-diving species, which might have caused these lesions (Jepson *et al.*, 2003).

1.5.5.2 Accidental Entanglements in Fishing Gear

The presence of certain types of fishing gear could present a threat to blue whales since the gear can kill animals by anoxia if they become entangled. Even when blue whales manage to escape fishing gear, they can be injured and tow parts of the gear (e.g., cables, buoys) over a long time. In 1987, a blue whale was observed north of Cape Cod trailing a fishing cable and buoy that appeared to be from the lobster fishery (Reeves *et al.*, 1998). In some cases, entangled whales could have difficulty moving and feeding, to the point that their reproductive activities and survival are compromised (Reeves *et al.*, 1998; Clapham *et al.*, 1999). Blue whales are powerful animals that rarely become entrapped in fishing nets. Despite this, three blue whales caught in gillnets have died in the St. Lawrence since 1979 (Sears and Calambokidis, 2002). It is estimated that nearly 10% of blue whales occurring in the St. Lawrence have scars caused by contacts with fishing gear (R. Sears, pers. comm.).

Anthropogenic noise may also hamper the efforts of certain cetacean species to detect fishing nets by disrupting their ability to orient themselves. This phenomenon was observed on the east coast of Newfoundland; where the entanglement of several humpback whales in fishing nets was associated with noise produced by construction activities (e.g., explosion, drilling) that modified the underwater acoustic environment (Todd *et al*., 1996). The relatively noisy underwater environment of the Gulf of St. Lawrence could pose similar threats to blue whales, but no study has yet confirmed this assumption. In conclusion, it remains difficult to evaluate the real impact of noise on the capacity of blue whales to detect fishing gear as these animals tend to flee far from the point of contact with such gear (Reeves *et al*., 1998; Perry *et al*., 1999).

1.5.5.3 Epizootics and Toxic Algal Blooms

In the North Atlantic, the number of cases of large-scale marine mammal mortality caused by disease appears to be rising since the second half of the 20th century (Harvell *et al.*, 1999). According to Harwood (2001), this trend is likely to continue through the 21st century. This increase in disease occurrence is likely to be caused by climate variations and human activities (i.e., habitat degradation and pollution) (Harvell *et al.*, 1999). A significant number of pathogenic agents can be transmitted to marine mammals by municipal wastewater, septic tanks, leachates, agricultural runoff, and commercial shipping (Measures and Olson, 1999; Measures, 2002a, 2002b; Measures *et al.*, 2004a). Marine mammals that may be immunocompromised or weakened by exposure to marine pollution may also be exposed to new pathogens recently introduced into the environment or to existing pathogens that attack an increased variety of hosts (Harvell *et al.*, 1999).

In Canada, pathogenic agents that can cause death in marine mammals are still not well documented, but the risk is nevertheless present, and could have significant impacts on a population with a low number of individuals such as the Northwest Atlantic blue whale. According to Nielsen *et al.* (2000), Mikaelian *et al.* (1999) and DFO (2007), viral epizooty risks exist (especially for beluga whales), but have not yet been evaluated in the St. Lawrence. Viruses, including morbilliviruses, are especially dangerous because they can rapidly cause epizootics. The Atlantic white-sided dolphin (*Lagenorhynchus acutus*), a species that visits the St. Lawrence, and the long-finned pilot whale (*Globicephala melas*), another less frequent visitor, are significant reservoirs for these viruses. It should be noted that climate change is likely to lead to increased occurrences of new marine mammal species in the St. Lawrence (e.g., pygmy sperm whale, *Kogia breviceps*) (Measures *et al.*, 2004b), thereby increasing the risk of exposure to new diseases (DFO, 2007). In addition, according to Measures (2004), introduction of novel or exotic pathogens can also represent significant risks to wild populations from wildlife rehabilitation programs.

In addition, there could also be a rise in the number of cases of toxic algae poisoning in cetaceans in all oceans (Harvell *et al.*, 1999). In summer 2008, a red tide occurred over 600 km^2 in the St. Lawrence estuary and resulted in the death of several cetaceans (including a dozen belugas and harbour porpoises, *Phocoena phocoena*), dozens of seals and thousands of birds, invertebrates and fish (L. Measures, DFO, unpub. data; S. Lair, U. of M., unpub. data). This red tide was the work of *Alexandrium tamarense*, a microscopic alga which occurs naturally in the Estuary and Gulf of St. Lawrence. These algae produce a neurotoxine, saxotoxine, which affects the nervous system and induces temporary neurological problems that can cause death. Whales ingest this toxin through their prey (i.e. intoxication through the food web). The size of this event is probably due to the particularly abundant rainfall during summer 2008 (M. Starr, DFO, unpub. data) which resulted in higher temperatures and lower salinity of surface waters. Climate change and the resulting alteration in the rainfall regime could be responsible for an increase in algal blooms, thus rendering this a significant threat for blue whales.

Few blue whale carcasses have been found on accessible shores, and the carcasses that have been found have usually been in an advanced stage of decomposition, making it impossible to identify any diseases (Measures, 2003). However, carcasses can be examined for ship collision evidence (i.e. broken bones, hematoma evidence, etc.) or to detect the presence of certain parasites (Measures, 1992, 1993). More than 40 blue whale carcasses have been reported on the Canadian east coast since 1951. All documented cases were immature whales and in most cases, the cause of death was not determined (Measures, 2003). Parasitic infections can cause health problems and even the death of certain individuals. Infections caused by *Crassicauda boopis*, a 2-m nematode that attacks the kidneys, could be the cause of a certain number of mortalities recorded in large whales, but its prevalence in blue whales remains unknown (Measures, 2003).

Epizootics, algal blooms or any other event resulting in mass mortalities could indeed be problematic for the blue whale because of the small size of this population.

1.5.5.4 Toxic Spills

The consequences of a toxic spill for blue whales are variable and difficult to evaluate. Although most cetaceans avoid oil slicks on the water's surface, they can accidentally come in contact with toxic products (e.g., Harvey and Dahlheim, 1994; Matkin *et al*., 1994; Smultea and Würsig 1995). The contamination risks associated with direct contact are low for marine mammals because their skin is an effective barrier (Geraci, 1990). Oil spills can nonetheless represent a risk for marine mammals because the toxic fumes can harm sensitive tissue (e.g., eye, mouth, and lung membranes) (Geraci and St. Aubin, 1990). In addition, marine mammals can ingest the spilled product either directly or by eating contaminated prey, which can lead to various toxic and physiological effects (Geraci and St. Aubin, 1990). Cases of gastro-intestinal and pulmonary intoxication have been reported (Geraci, 1990). Finally, the whalebones of baleen whales, like those of blue whales, can temporarily be obstructed by spilled products which can lead to feeding problems and lead to ingestion of petroleum products.

The maritime transportation of petroleum and other toxic products (e.g., chlorine, bauxite, sulfite) is significant in the Atlantic and especially in the St. Lawrence Estuary, and is therefore considered a potential source for an environmental disaster likely to impact blue whales (Savaria *et al.*, 2003). The St. Lawrence Estuary, with its distinctive oceanographic conditions (e.g., the occurrence of intense currents and tides) and its heavy shipping traffic, is an area where the risks from major spills are high (Savaria *et al.*, 2003). The exploitation of oil and gas along the Northwest Atlantic coasts and in the Gulf of St. Lawrence also represents an additional risk for pollution. Toxic spills are therefore a potential threat that cannot be ignored.

1.6 Actions Already Completed or Under Way

1.6.1 Blue Whale Protection

1.6.1.1 International Legal Protection

This species has been protected from whaling worldwide by the International Whaling Commission (IWC) since 1966. The blue whale is listed in the "protected" category, since stocks estimates are under 40% of the required numbers to sustain a maximum long-lasting yield. This species is also designated as “endangered” by the World Conservation Union (IUCN). The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has listed the blue whale in its Appendix 1, which contains “species threatened with extinction and for which international trade is prohibited”. In the United-States, blue whale is designated “endangered” under the *Endangered Species Act* and the *Marine Mammal Protection Act*.

1.6.1.2 Canadian Legal Protection

In Canada, the blue whale was legally listed and protected as an “endangered” species under SARA in January 2005. Listing under this Act prohibits the killing, harming, harassing, capturing or taking of individuals of a listed species. The Act also prohibits damaging or destroying the species’ residence or any other component of its critical habitat. It includes provisions to protect critical habitat and requires the creation of a recovery strategy and action plan for each listed species.

Since 1993, the blue whale has been protected under the *Marine Mammal Regulations* of the *Fisheries Act*, according to which it is prohibited to disturb a marine mammal. A public consultation began in 2005 to amend the *Marine Mammal Regulations* in order to elaborate on the concept of marine mammal disturbance to make it more understandable to the public and to provide a reference point as to when a disturbance is deemed to take place. These amendments (ability to licence whale watching industry, obligation to declare any physical contact with cetaceans and to avoid approaching to less than 100 m from any cetacean) are aimed at protecting the normal life processes of marine mammals.

Food resources of the blue whale have been protected from fishing since 1998, when a moratorium on the issuing of new permits for the harvest of any unexploited forage species (including krill) was ordered by the Minister of Fisheries and Oceans Canada. This moratorium is still in effect.

Individuals found within protected heritage areas, managed by Parks Canada (i.e., Saguenay–St. Lawrence Marine Park and the waters of the Forillon National Park), are protected under the *Canada National Parks Act*, the *Saguenay–St. Lawrence Marine Park Act* and their regulations. Note also that the Quebec government has added this species to the list of species likely to be designated as “threatened” or “vulnerable” (i.e., provincial rank S4 and global rank G3G4).

1.6.2 Habitat Protection Measures, Awareness Raising and Other Measures

1.6.2.1 The Saguenay–St. Lawrence Marine Park (SSLMP)

The SSLMP, with a surface area of 1,245 km², was created in 1998 to increase, for the benefit of the present and future generations, the level of protection of the ecosystems of a representative portion of the Saguenay River and the St. Lawrence Estuary for conservation purposes, while encouraging its use for educational, recreational and scientific purposes (*Saguenay–St. Lawrence*

Marine Park Act, s. 4). Several management measures were set up and are under way in this territory to contribute to the recovery of blue whale.

- Whale watching activities within the Park are managed through the application of the *Regulations on marine activities in the Saguenay–St. Lawrence Marine Park* by the park's resource conservation service. Under these regulations, the eligibility of permit applications made by marine tour businesses, research scientists and organizers of special activities are assessed. The Regulations determine mandatory approach distances (i.e., 100 m from cetaceans in the case of commercial boats with marine tour license, 200 m from cetaceans for boats without licence, and 400 m in the case of endangered species), the number and speed of boats, the duration of watching activities, the height of flight for aircrafts, and an obligation to report any accident resulting in wounds to or death of a marine mammal.
- An emergency environmental plan.
- A zoning plan, which is under development.
- Awareness raising activities: communication plan for species at risk, action and education strategy in terms of species at risk, awareness raising tour aimed at boaters.

1.6.2.2 Marine Protected Areas

Marine Protected Areas (MPA) were created or are currently under study, pursuant to the *Canada Oceans Act* (which came into effect in 1997), in order to raise the level of protection of marine species and their habitat.

- The Gully MPA was created on the Scotian Shelf in May 2004. This area, located about 200 km off the coast of Nova-Scotia, includes a deep underwater canyon which shelters several species of marine mammals, including the blue whale.
- Two MPA projects are under development in the St. Lawrence:
    - The St. Lawrence Estuary MPA aimed primarily at the protection of marine mammals, is under development at the edge of the SSLMP, in an area in the Estuary where marine mammals concentrate and are under significant anthropogenic pressure (e.g., whale-watching activities). This project, covering approximately 6000 km², should increase protection and ensure the long-term conservation of the blue whale and part of its habitat and food resources. For this purpose, a data acquisition study on whale-watching at sea and boating activities has been under way since 2005 in the proposed MPA in order to characterize these activities and their use of the territory (Michaud *et al.*, 2007). This study also aims at analyzing the distribution of observations by species, including the blue whale, in order to determine their relative importance. This information will help the management of whale-watching activities in the future St. Lawrence Estuary MPA.
    - The Manicouagan MPA, covering 543 km², aims to protect the overall biodiversity of the coastal zone up to a depth of 300 m in the St. Lawrence River and thus partially covers a territory which is occasionally frequented by the blue whale.

1.6.2.3 Awareness-raising Activities

Projects aimed at informing the public and at decreasing the risk of disturbance and collision with ships have been financed under various programs.

- Increasing kayakers' awareness of proper navigation behaviours around species of marine mammals at risk – Priority Intervention Zone (PIZ) Committee on the North Shore of the Estuary.

- Development of whale watching from the shore to protect marine mammals at risk - PIZ Committee on the North Shore of the Estuary

- Project aimed, over several years, at encouraging employees and industry leaders to rethink their whale-watching activities with, among other things, an information pack to provide a better service to their clients with regards to content – Réseau d'observation des mammifères marins (ROMM).

- A teaching kit for raising awareness on species of marine mammals at risk has been distributed in schools – ROMM and Corporation PARC Bas-Saint-Laurent.

- An excellent reference and information website (http://www.baleinesendirect.net/) dedicated to education on the conservation of St. Lawrence whales and of their natural habitat. Weekly publication between June and October of bulletin called *Portraits of whales* containing updates on projects under way and on actions undertaken to protect the whales – GREMM.

- An awareness raising initiative on the blue whales – Forillon National Park.

- Awareness campaign and training of hunters and fishers on distribution of marine mammals and disentanglement techniques – Quebec-Labrador Foundation.

1.6.2.4 Emergency Response for Marine Mammals in Difficulty

Since 2004, the GREMM in collaboration with various partners, such as DFO and Parks Canada, implemented the Quebec Marine Mammal Emergency Response Network. This network's goal is to increase response capabilities when animals become entangled with fishing gear and to reduce mortalities of cetaceans caused by anthropogenic activities in the Estuary and Gulf of St. Lawrence. With DFO support, a similar program was established in Newfoundland and Labrador a few decades ago to allow fishers, partners and the public to report any case of marine mammal entanglement, injury or death, and for dispatching a team to help marine mammals in difficulty. Other research groups such as the Grand Manan Whale & Seabird Research Station from New Brunswick and the Marine Animal Response Society from Nova Scotia work for the conservation of marine mammals in the Maritime provinces.

1.6.2.5 Guidelines for Best Practices for Watching Marine Mammals in Quebec

Guidelines for best practices for watching marine mammals in Quebec (http://www.qc.dfo-mpo.gc.ca/peches/en/observation_mammiferes/Default.htm), which follow the code of ethics for the observation at sea of marine mammals, were developed by DFO. The objective of these guidelines is to minimize the risks of disturbance when encountering marine mammals. Although these best practices were developed first for the general public, they are also adapted to commercial activities. It should be noted that these *best practices* have no force of law and do not override any laws and regulations in force.

1.6.2.6 Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment

DFO has developed a statement of Canadian practice with respect to the mitigation of seismic noise in the marine environment in collaboration with various partners, in order to formalize and standardize mitigation measures in Canada for conducting seismic surveys in marine environments. This statement represents a set of basic standards that can be applied by existing regulatory agencies to reduce the possible effects of seismic surveys on marine wildlife.

1.6.3 Research

A number of research projects on the Northwest Atlantic blue whale population are carried out in Canada, many in the Estuary and the Gulf of St. Lawrence. Here is a non-comprehensive list of some of these programs.

- The Mingan Island Cetacean Study (MICS) focuses its efforts on the blue whale: photo-identification; collecting biopsies to determine gender and concentrations of contaminants; studying movements and distribution via observations in the field and the use of a mobile acoustic recording system by way of VHF beacons. In 2007 and 2008, MICS will lead a study relating spatial distribution and abundance of blue whales in the maritime Estuary and northern Gulf of St. Lawrence to food availability, with the collaboration of DFO. This project will attempt to verify whether blue whale abundance is affected by competing smaller pelagic fish, which have been growing in numbers with the declining number of predators (e.g., Atlantic cod and redfish). With the help of temporal distribution maps of the different species, of models and of geomatics, this research project will allow for a greater understanding of one of the main threats to the recovery of the blue whale, limited food resources.

- The GREMM has been studying whale-watching activities since 1994 for the SSLMP by placing observers on board cruise ships (Michaud *et al.*, 2007). The objectives of this study are: 1) to characterize the activities; 2) to assess marine mammal distribution; and 3) to measure the impacts of the management measures in place in this area. The study area covered by this project was increased in 2005 in order to cover the future St. Lawrence Estuary MPA. In 2006, for the first time, the whale-watching activities from the Gaspé Peninsula were also part of a similar study carried out by ROMM (Pieddesaux *et al.*, 2007).

- The GREMM is also participating in the blue whale photo-identification project and the systematic numbering of large whales. Moreover, the GREMM conducted a telemetric monitoring project between 2002 and 2006 in cooperation with DFO. Telemetric transmitters and data recorders (i.e., time, depth, water temperature, swimming speed) are attached by suction to the blue whale's back using a pole or crossbow for a 6–8 hour period. The project's objective is to increase knowledge pertaining to the displacements of blue whales and their habitat. In 2006, the project also looked at the impact of whale-watching activities on blue whales.

- The research group Mériscope at Portneuf-sur-mer works on the photo-identification of blue whales and on the bioacoustic programs. It records whale vocalizations and ambient noise produced by shipping traffic using mobile hydrophones. The researchers simultaneously observe the surface behaviour of blue whales in an attempt to link certain behaviours to the type of noise they produce. In addition, a project lead in cooperation with Cornell University deployed several continuous recording buoys between 2003 and 2006 in order to record vocalizations and ambient noise. In collaboration with the Mériscope team, the University of California at Los Angeles has been studying large whale feeding strategies. The whales are observed and filmed underwater in order to collect data on their behaviour, swimming speed, the volume of water ingested, the amount of food consumed and the energy spent to catch their prey.

- Since 2002, the DFO has been conducting a project based on passive acoustic techniques. Autonomous hydrophones continuously record sound ranging from 5 to 1,000 Hz (e.g., whale vocalizations, ambient noise related to shipping traffic). The project goal is to study the distribution of whales in the territory covered and attempt to assess their exposure to the existing noise in their environment. In 2003, a project to determine whether food abundance and whale-watching activities represent factors that could harm the recovery of blue whales was also established (i.e., analysis of fatty acids and the reproductive status in skin samples collected by biopsy). DFO is also coordinating the study of beached blue whales. Baleen, skin, fat and muscle samples are taken from beached cetaceans in order to study their diet and contaminant concentrations in their tissues.

- Using hydroacoustic techniques, DFO, in cooperation with the Institut des sciences de la mer de Rimouski (ISMER) and other collaborators, are investigating the biological and physical processes that are responsible for creating the large concentrations of zooplankton and fish at the head of the Laurentian Channel and other sites in the Estuary and Gulf of St. Lawrence. Furthermore, since 1994, DFO has been studying zooplankton in the Estuary and western part of the Gulf. This project is aimed at better understanding abundance, production and distribution of mesozooplankton (e.g., copepods) and macrozooplankton (e.g., krill) by various plankton net sampling techniques. Another project objective is to study the impacts that changes to the cold intermediate layer have on zooplankton community structure and abundance.

- Since 2004, DFO has worked on the identification of areas of concentration of forage species (pelagic fish, macro and mesozooplancton) in the Gulf of St. Lawrence, which could constitute critical habitat for marine mammals, and in particular for baleen whales like the blue whale. This project is aimed at using hydroacoustic data combined with data from plankton nets to better characterize the vertical and horizontal distribution of prey throughout the Gulf of St. Lawrence and describe potential whale habitat.

- In 2007, a trans-Atlantic cetacean air survey in the North Atlantic was jointly conducted by the government of Canada (DFO), United States and Europe. This project was aimed at evaluating the distribution and abundance of the various cetacean species and more specifically to the blue whales, and to map their summer range. This project provides a good example of collaboration between several countries to enhance recovery of species at risk with a wide geographical range. This type of international initiative is encouraged and should continue to further the recovery of the Northwest Atlantic blue whale.

- Elsewhere in Canada, in the Newfoundland and Labrador region, DFO is currently mapping the geographical distribution of blue whales. Cases of cetacean sightings, beaching and ice entrapment have been reported since 1979 to a whale study group at Memorial University or to DFO. In 2007, two autonomous acoustic recorders were deployed offshore Newfoundland areas with the goal of detecting and recording blue whale vocalizations over the fall and winter.

- The blue whale and its habitat in the St. Lawrence Estuary were recently the subject of scientific publications. This is a non-exhaustive list:

    - Contaminants found in tissues (Metcalfe *et al.*, 2004);
    - Vocalizations (Berchok *et al.*, 2006; Mouy, 2007);
    - Survival of adult blue whales (Ramp *et al.*, 2006);
    - Influence of thermal fronts on habitat selection in the Gulf of St. Lawrence (Doniol-Valcroze *et al.*, 2007).

- Acoustics (vocalisations and noise) (Simard *et al.*, 2004, 2006; Simard and Roy, 2008; Simard *et al*., 2008);
- Krill aggregations (Cotté and Simard, 2005; Sourisseau *et al*., 2006, Sourisseau *et al.*, 2008; Simard, 2009);
- Literature review (Lesage *et al*., 2007).

1.7 Knowledge Gaps

A workshop on research priorities for the Northwest Atlantic blue whale population was held in 2002 (Lesage and Hammill, 2003). The priorities, ranked in order, are:

1) increased knowledge on seasonal distribution, abundance, stock structure and seasonal migrations of blue whales;
2) knowledge acquisition of population parameters such as reproductive rates, sex ratio and age structure;
3) determining and defining feeding and reproductive grounds, as well as the effects that physical and biological processes have on determining distribution, behaviour and blue whale movements;
4) improving knowledge on the current threats to blue whales (e.g., studying the various levels of contaminants and different sources of noise in their habitat and their impact on blue whales).

To fill these knowledge gaps, in particular those concerning reproduction and wintering areas, partnerships with several countries bordering the Atlantic will be essential.

2. RECOVERY

2.1 Recovery Feasibility

The recovery of the Northwest Atlantic blue whale population is feasible. This population's extensive distribution range goes far beyond Canadian jurisdiction and therefore limits the scope of this recovery strategy. Adequate protection throughout this population's entire distribution range requires international efforts, both new and continuing.. The following criteria were considered to determine whether recovery was feasible:

1) **There are individuals able to reproduce**: The number of adult blue whales seems sufficient to increase population growth rate or abundance, despite uncertainties in terms of growth rates and the overall number of blue whales in the Northwest Atlantic (Sears and Calambokidis, 2002). More than 400 blue whales have been photo-identified in the Estuary and Gulf of St. Lawrence since 1979 (R. Sears, pers. comm.). This species' survival rate, whose longevity exceeds 80 years (Yochem and Leatherwood, 1985; Sears, 2002) is estimated at 97.5% in the Gulf of St. Lawrence (Ramp *et al.*, 2006). In addition, since 1994 (except for 2006), at least one mother-calf pair has been sighted every year in the Estuary and Gulf of St. Lawrence, which indicates a certain level of reproductive activity.

2) **There is sufficient suitable habitat available to support the species:** The blue whale is a migratory species that occupies a vast distribution range in which limited habitat availability initially does not appear to be an issue for the population's survival. According to available information, the blue whale uses Canadian coastal and pelagic Atlantic waters in the summer to feed. In order to fulfill its energy requirements, the blue whale must feed in areas with high krill densities (Croll *et al.*, 2005; Brodie *et al.*, 1978; Kawamura, 1980). Many such areas that could constitute feeding areas for blue whales have been identified in the Estuary and Gulf of St. Lawrence. These potential feeding areas could be protected or restore (e.g. noise reduction) to ensure their availability for blue whales.

3) **Significant threats to the population or to its habitat can be avoided or mitigated with recovery measures:** Several significant threats to the species and its habitat can be avoided or mitigated by recovery actions (e.g. a moratorium on forage species and approach distances for whale-watching activities). For blue whale habitat in Canadian waters that shows some deterioration (e.g., head of the Laurentian Channel), most of the disruptive elements are caused by humans (e.g., noise, disturbances). There are ways to mitigate the impacts of these disruptive elements in order to improve habitat quality for the blue whale. These measures can be effective providing sufficient resources are invested in education and raising awareness as well as in control and implementation.

2.2 Recovery Goal

In order to ensure the survival and recovery of the blue whale population in the Northwest Atlantic, this recovery strategy's goal is to reach a level of 1,000 **mature** individuals. This recovery target corresponds to the COSEWIC criteria for marking down the blue whale population from a status of “endangered” to a “no at risk” status. This target based on COSEWIC criteria was chosen over the precautionary approach implemented by the DFO for managing various marine resources (DFO, 2006; Hammill and Stenson 2007), which proposes a threshold target of 70 % from the maximum historic population size.

The best historic blue whale population size estimates were from hunting data analyses, which suggest a population size between 1,100 and 1,500 individuals before intensive hunting began (Sergeant, 1966; Allen, 1969). Sergeant (1966) estimated that between 1898 and 1915, approximately 1,500 blue whales were hunted by the whaling stations located in Newfoundland and in Labrador. Allen (1969) concluded after comparing blue whale and fin whale yield indices that the initial population of blue whales was slightly more than 1,100 individuals. However, experts believe these estimates of historic population size might represent only a fraction of the entire Northwest Atlantic population. By using the precautionary approach, the recovery target would have been around 1,050 **mature and immature** individuals (70% of 1,500 individuals), a slightly lower target than the one proposed (1,000 **mature** individuals). The recovery team preferred using a target of 1,000 **mature** individuals because applying a precautionary approach on a likely underestimate of the maximum historic size seemed less judicious. However, it is difficult to estimate the time necessary to reach this target owing to the knowledge gaps on the present population structure.

2.3 Recovery Objectives

In order to reach the recovery goal previously set, three objectives were established for the next five years:

1. Define and undertake a long term assessment of the number of Northwest Atlantic blue whales, the structure and trends of the population, and determine their range as well as their critical habitat within Canadian waters.

2. Implement control and follow-up measures for activities which could disrupt the recovery of the blue whale in its Canadian range by prioritizing the following actions:

    2.1 first, reducing anthropogenic noise (e.g., seismic exploration) and protecting food resources;

    2.2 second, reducing disturbance from anthropogenic activities (e.g., whale-watching), reducing the risks of accidents associated to collisions as well as other human activities (e.g., fisheries and by-catches) and by reducing toxic contamination in the marine environment, which may have an impact on blue whales.

3. Increase knowledge concerning the principal threats to the recovery of the blue whale in Canadian waters, such as anthropogenic noise, the reduced availability of food resources, anthropogenic activities that can lead to disturbance, injuries or mortality (e.g., whale-watching activities, shipping traffic, coastal and offshore developments) and

contamination, in order to determine their true impact and identify effective measures to mitigate the negative consequences for this population's recovery.

2.4 Approaches Recommended to Meet Recovery Objectives

2.4.1 Recovery Planning

To achieve these objectives, several approaches are recommended, grouped in three broad strategies: "research and monitoring", "conservation" and "awareness and education" (Table 1). Recommended approaches to meet objectives are presented in table format along with related performance measures. Performance measures allow for an assessment of progress in reaching the listed recovery objectives for the Northwest Atlantic blue whale population. These will help determine whether the recovery approaches used have a positive impact on the blue whale population, assess whether or not the objectives are being reached, report on the progress, and finally evaluate the objectives in order to improve them.

Table 1. Recovery Planning Table and performance measures

Objectives	Broad strategies	Threat(s) addressed	Recommended approaches to meet recovery objectives	Performance measures
Objective 1. Assess the number of Northwest Atlantic blue whales, the structure and trends of the population, and determine their Canadian range				
Urgent	Research and monitoring	All	Develop and implement a Northwest Atlantic blue whale population monitoring program.	- Data acquisition on population size, structure and dynamics within Canadian waters. - Development of multiple temporal and spatial frequentation change indicators and implementation of a monitoring based follow-up system. - A monitoring program is joined to international programs in order to acquire a uniform and extended spatial and temporal coverage.
Urgent	Research and monitoring	All	Better understand the biological and physical processes that influence the life cycle of blue whales.	- Number of publications and studies on the biological and physical processes that influence the life cycle. - Number of management measures stemming from these studies.
Urgent	Research and monitoring	All	Analyze existing and newly acquired data in order to identify high concentration areas or areas that are regularly visited by blue whales and periods of intensive habitat use.	- Identification of the boundaries of the seasonal distribution range (in particular feeding, reproduction and wintering areas), periods of intensive habitat use, and critical blue whale habitat and its degree of sustainability
Necessary	Research and monitoring	All	Encourage the implementation and continuation of marine mammal observation networks.	- Functional network of marine mammal observers and database.
Objective 2. Implement control and follow-up measures for activities which could disrupt the recovery of the blue whale in its Canadian range				

Objectives	Broad strategies	Threat(s) addressed	Recommended approaches to meet recovery objectives	Performance measures
Urgent	Conservation	Noise	Implement adequate mitigation measures for all inshore and offshore projects within the range of the blue whale.	- Percentage of noise reduction from anthropogenic sources (e.g., seismic exploration, military operations, explosions, drilling) within the Canadian portion of the range.
Urgent	Conservation	Noise and collisions	Minimize blue whale exposure to vessel noise and risk of collisions.	- Boats use shipping lanes in the Gulf of the St. Lawrence and off the North American coast reducing impact on blue whales.
Urgent	Conservation	Prey availability	Promote the continuation of the moratorium on the exploitation of forage species to prevent further strain on their food resources.	- The moratorium on the exploitation of forage species is maintained.
Urgent	Awareness and education	Noise	Encourage/raise awareness for boaters, ship owners or other industries that generate high noise levels of low frequency to develop or use technologies or alternate behaviours in order to reduce the production and the propagation of these noises.	- Target audiences have been identified and appropriate activities to raise awareness were carried out. - Efficiency of awareness campaigns to change behaviours and maintain new behaviours.
Necessary	Conservation	All	Designate Marine Protection Areas (MPA) in the range of the blue whale	- Designation of the St. Lawrence Estuary MPA and of the Manicouagan MPA.
Necessary	Conservation	Whale-watching	Review, adopt and implement the *Marine Mammals Regulations* and the *Marine Activities in the Saguenay–St. Lawrence Marine Park Regulations* to better protect blue whales against anthropogenic disturbances within their range	- Implementation of the new *Marine Mammals Regulations* to better protect blue whales, in particular by maintaining a distance requirement of 400 m with blue whales, for all boats within Canadian waters. - Improvement of surveillance of marine tours within known areas of occurrence during the tourism high season.
Necessary	Conservation	Whale-watching	Improve the decision-making process for issuing permits for research or activities requiring approaches of less than 400 m.	- Establishment of rules and a centralized decision-making committee, one-stop service for all jurisdictions, to assess the relevance, methods and licensing for activities targeting whales or their critical habitat.

Objectives	Broad strategies	Threat(s) addressed	Recommended approaches to meet recovery objectives	Performance measures
Necessary	Conservation	All, whaling	Enhance Canadian participation in international conservation efforts for marine mammals in general, and for blue whales in particular.	- Number of Canadian initiatives in the international effort for marine mammal conservation. - Maintaining the moratorium set by the International Whaling Commission.
Necessary	Awareness and education	Whale-watching	Raise the awareness of whale-watching activity enthusiasts, recreational boaters and the general public to the issue of blue whale disturbance.	- Target audiences have been identified and appropriate activities to raise awareness were carried out. - Efficiency of awareness campaigns to change behaviours and maintain new behaviours.
Necessary	Awareness and education	Noise and collisions	Raise awareness in the marine shipping industry and on large cruise vessels of their negative impact on the blue whale population.	- Target audiences have been identified and appropriate activities to raise awareness were carried out. - Efficiency of awareness campaigns to change behaviours and maintain new behaviours.
Useful	Conservation	Spills, epizootics and algal blooms	In known areas of occurrence of blue whales, implement contingency plans in order to reduce damages which can be caused by toxic spills, epizootics and algal blooms.	- Contingency plans in the case of toxic spills, epizootics or algal blooms have been written and are updated regularly.
Useful	Conservation	Accidental entanglement in fishing gear or entrapment in ice	Encourage the maintenance of activities conducted by the Quebec Marine Mammal Emergency Response Network and develop a warning system when conditions are likely to trap blue whales in the ice during spring for the southwest part of Newfoundland.	- Number of effective and successful responses to entanglement in fishing gear or entrapment in ice contributing to blue whale survival.
Useful	Conservation	Contaminants	Start an extensive pollution reduction program aimed at the various sources of pollution.	- Percentage reduction of contaminant concentrations in the environment and the tissues of blue whales. - Percentage reduction of emissions by source (waste disposal areas, landfills, sewage treatment plants, industries, etc.) and by pollutant type.

Objectives	Broad strategies	Threat(s) addressed	Recommended approaches to meet recovery objectives	Performance measures
Objective 3. Increase knowledge concerning the principal threats to the recovery of the blue whale in order to determine their true impact and identify effective measures to mitigate the negative consequences for this population's recovery				
Urgent	Research and monitoring	Contaminants	Evaluate contaminant concentrations in blue whale tissues, its food and its environment.	- Number of publications and studies on the main sources of pollution, on contamination levels and on main contaminants. - Number of management measures stemming from these studies.
Urgent	Research and monitoring	Prey availability	Implement a research and monitoring program to fill in the knowledge gaps in terms of zooplankton and other prey (distribution/concentration/variability) of the blue whale.	- Number of publications and studies on the carrying capacity of habitat as well as the distribution of forage species, fluctuations in abundance and the factors responsible for these fluctuations. - Number of management measures stemming from these studies.
Urgent	Research and monitoring	Noise	Identify/characterize noise sources and levels in different areas of the blue whale distribution range and assess the degree of exposure to the noise, particularly in the known areas of occurrence.	- Number of noisy areas and noise sources identified. - Number of publications and studies on the impacts of noise on blue whales. - Number of management measures stemming from these studies.
Urgent	Research and monitoring	All	Implement a blue whale carcass necropsy program in eastern Canada in order to routinely identify the causes of mortality.	- Number of publications and studies on causes of mortality and the overall health status of individuals. - Number of management measures stemming from these studies.
Necessary	Research and monitoring	Noise	Study reactions of blue whales when exposed to various noise sources in various contexts.	- Completion of an assessment report on the circumstances leading to the most significant noise impacts on blue whales.

Objectives	**Broad strategies**	**Threat(s) addressed**	**Recommended approaches to meet recovery objectives**	**Performance measures**
Necessary	Research and monitoring	Prey availability	Study the feeding behaviour and diet of blue whales.	- Number of publications and studies on the feeding behaviour and diet of blue whales. - Number of management measures stemming from these studies.
Necessary	Research and monitoring	All	Study the impact of various anthropogenic activities on the feeding behaviour and distribution of blue whales.	- Number of publications and studies on impacts of various threats (e.g., whale-watching, shipping traffic, coastal or offshore development) on the feeding behaviour, diet and energy requirements of blue whales. - Number of management measures stemming from these studies.
Useful	Research and monitoring	Noise and prey availability	Study the impact of loud noise on the aggregation of prey in blue whale feeding areas.	- Completion of an assessment report on the impact of loud noise on the availability and aggregation of prey in blue whale feeding areas.

2.5 Critical Habitat

Critical habitat is defined by SARA as the habitat that is necessary for the survival or recovery of a listed wildlife species. This critical habitat must be identified in the recovery strategy or in an action plan for the species (s. 2). Identifying the critical habitat is mandatory within the framework of a recovery strategy for an endangered species such as the blue whale (Sections 41 and 49). When the critical habitat has not been clearly identified, a research schedule leading to its identification must be included in the recovery strategy. After the critical habitat has been identified, measures must be applied to protect this habitat (ss. 57–63) as SARA prohibits the destruction of any part of the critical habitat of a wildlife species listed as endangered.

2.5.1 Identification of the Species' Critical Habitat

At the time the current recovery strategy was developed, the critical habitat of blue whales could not be identified. There are knowledge gaps regarding the Northwest Atlantic blue whale population habitat that could be considered "critical". For marine mammals, Harwood (2001) suggests that the critical habitat be established in terms of functional ecological units in order to ensure feeding and reproductive success. This recovery strategy identifies the areas where knowledge acquisition will be necessary in order to complete the identification of blue whale critical habitat.

2.5.2 Schedule of Studies to Identify Critical Habitat

The information available concerning feeding and reproductive areas for the Northwest Atlantic population is currently sparse. Because available data indicates the blue whale uses Canadian coastal and pelagic Atlantic waters in the summer to feed, research to identify critical habitat within Canadian waters will focus on blue whale distribution and feeding areas (Table 2). This species' restricted diet and its feeding method suggest that krill concentration areas, whose formation seems to depend on the interaction between hydrodynamic circulation and submarine landform, are the blue whales' preferred feeding areas. As a result, studies will be required to identify and validate krill aggregation areas in the Gulf of St Lawrence and the Canadian continental shelf, and to determine and characterize blue whale feeding areas within Canadian waters, in order to gain the knowledge needed to identify blue whale critical habitat.

Table 2. Schedule of studies to identify critical habitat

Research objective	Activity Description	Due date
Improved knowledge of blue whale distribution.	• Determine blue whale seasonal distribution in Canadian waters. • Determine distribution in areas where there are few or no data such as off the coast of Newfoundland and Labrador, the Scotian Shelf, the Eastern and Sourthern parts of the Gulf of St. Lawrence.	2014
Improved knowledge of feeding areas	• Determine and characterize blue whale feeding areas within Canadian waters. • Identify and validate krill aggregation areas in the Gulf of St. Lawrence and the Canadian continental shelf. • Study physical and biological processes that influence krill aggregation and abundance.	2014

2.6 Existing and Recommended Approaches to Habitat Protection

As mentioned in Section 1.6.2 Habitat Protection Measures, Awareness Raising and Other Measures, a marine park was created in 1998 in the St. Lawrence Estuary. Some marine protected areas have also been created (e.g., The Gully MPA located on the Scotian Shelf) or are being developed (e.g., St. Lawrence Estuary MPA) under the *Oceans Act*. In addition, the *Fisheries Act* protects marine mammal habitat by prohibiting any operation or undertaking that would cause the harmful alteration, disruption or destruction of fish habitat (a term that includes marine mammals under this Act).

A moratorium on new permits for the harvest of unexploited forage species (including krill) ordered by the Minister of Fisheries and Oceans has been in place since 1998. This moratorium allows in part for the protection of an important part of the habitat of the blue whale, its food.

2.7 Effects on Other Species

Thirteen cetacean species visit the Estuary and the Gulf of St. Lawrence, of which eight are toothed whale species (odontocete) and five are baleen whale species (mysticeti) (Appendix 2). In addition, at least nine other odontocete species visit the Canadian Atlantic coast and one species, the grey whale (*Eschrichtius robustus*) is extirpated from the Canadian Atlantic coast. Therefore, studies within the framework of this recovery strategy (e.g., impact studies on anthropogenic activities) and proposed mitigation measures (e.g., restrictive measures for whale-watchers) can also be beneficial for some of the species visiting the Estuary and the Gulf of St. Lawrence and Canadian Atlantic coast. If the blue whale population increased from 250 to 1,000 individuals, krill could become less abundant, which could affect the entire food chain. However, the targeted population objective, 1,000 mature individuals, is in line with the blue whale stock status before commercial whaling.

2.8 Statement on Action Plan

A blue whale (Northwest Atlantic population) recovery action plan will be developed within 5 years, by 2014 at the latest. Meanwhile, many of the recommended approaches proposed in this recovery strategy, notably those related to research needs, can be initiated and pursued even in the absence of a formal action plan. The action plan will include a schedule and specific details for implementing the recovery strategy and will include measures for implementing and monitoring the recovery, solve issues pertaining to threats and work towards meeting the objectives. The action plan will also include the identification of critical habitat, to the extent possible, and examples of activities that are likely to lead to their destruction or degradation. It will also include recommendations aimed at protecting critical habitat and will report on any portion of critical habitat that is not already subject to protection. However, if knowledge regarding the identification of critical habitat is acquired before the drafting of an action plan, the designation of critical habitat will be made before the five year timeline.

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4. RECOVERY TEAM MEMBERS

Current members of the blue whale (Northwest Atlantic population) recovery team

- David Bolduc, St. Lawrence Economic Development Council (SODES), Quebec
- Hugues Bouchard, Fisheries and Oceans Canada, Quebec Region
- Guy Cantin, Fisheries and Oceans Canada, Quebec Region
- Suzan Dionne, Parks Canada, Quebec
- Raynald Gosselin, Fisheries and Oceans Canada, Quebec Region
- Jack Lawson, Fisheries and Oceans Canada, Newfoundland and Labrador Region
- Pierre Léonard, Innu Community of Essipit
- Véronique Lesage, Fisheries and Oceans Canada, Quebec Region
- Frédéric Lessard, Fisheries and Oceans Canada, Quebec Region
- Ian McQuinn, Fisheries and Oceans Canada, Quebec Region
- Robert Michaud, Group for research and education on marine mammals (GREMM), Quebec
- Richard Sears, Mingan Island Cetacean Study (MICS), Quebec
- Kent Smedbol, Fisheries and Oceans Canada, Maritimes Region

Previous members of the blue whale (Northwest Atlantic population) recovery team

- Anne Lagacé, Fisheries and Oceans Canada, Quebec Region
- Claude Mailloux, St. Lawrence Economic Development Council (SODES), Quebec
- Jean-Yves Savaria, Fisheries and Oceans Canada, Quebec Region

5. LIST OF ACRONYMS

CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Fisheries and Oceans Canada
GREMM	Group for research and education on marine mammals
IUCN	International Union for Conservation of Nature
IWC	International Whaling Commission
MICS	Mingan Island Cetacean Study
MPA	Marine Protected Area
PIZ	Priority Intervention Zone
ROMM	Réseau d’observation des mammifères marins
SARA	*Species at Risk Act*
SODES	St. Lawrence Economic Development Council
SSLMP	Saguenay–St. Lawrence Marine Park

APPENDIX 1. CLASSIFICATION OF THREATS BY ORDER OF PRIORITY

Each threat is defined according to these 12 criteria:

Threat category: Broad category indicating the type of threat.

General threat: 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 the population viability.

Extent: Indicate whether the threat is widespread, localized, or unknown across the species range.

Occurrence: Indicate whether the threat is historic (contributed to decline but no longer affecting the species), current (affecting the species now), imminent (is expected to affect the species very soon), anticipated (may affect the species in the future), or unknown.

Frequency: Indicate whether the threat is a one-time occurrence, seasonal (either because the species is migratory or the threat only occurs at certain times of the year – indicate which season), continuous (on-going), recurrent (reoccurs from time to time but not on an annual or seasonal basis) or unknown.

Causal certainty: Indicate 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: Indicate whether the severity of the threat is high (very large population-level effect), moderate, low, or unknown.

Level of concern: Indicate 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.

Local: Indicates threat information relates to a specific site or narrow portion of the range of the species.

Range-wide: Indicates threat information relates to the whole distribution or large portion of the range of the species.

Anthropogenic threats

1) Anthropogenic noise: Acoustic degradation and changes in blue whale behaviour
Threat category: Loss or degradation of habitat; disturbance
Overall threat: Low frequency anthropogenic noise (e.g., shipping, seismic exploration, oil and gas development, and military sonars)
Specific threat: Change in behaviour and/or habitat characteristics
Stress: Change in behaviour and risk of abandoning the critical habitat
Range: Generalized
Occurrence: Current
Frequency: Continuous
Causal certainty: Medium to high
Severity: Unknown
Level of concern: High

2) Food availability
Threat category: Consumption; climate and natural disasters; natural activities or processes
Overall threat: Krill fishery; climate change; competing with pelagic fish
Specific threat: Influences krill distribution and abundance
Stress: Reducing food resource availability for blue whales which leads to decreased physical condition which could impact reproductive success and the ability to migrate.
Range: Generalized
Occurrence: Current
Frequency: Continuous
Causal certainty: Low to high
Severity: Unknown
Level of concern: High

3) Contaminants
Threat category: Pollution
Overall threat: Agricultural, industrial and municipal waste, shipping, dredging, oil and gas development, aquaculture
Specific threat: Changes to habitat characteristics and water chemistry; direct exposure; consumption of contaminated prey
Stress: Depression of the immune system, cancer and lesions; reduced reproductive capacity
Range: Generalized
Occurrence: Current
Frequency: Continuous
Causal certainty: Low
Severity: Unknown
Level of concern: Medium

4) Collisions with vessels
Threat category: Accidental mortalities
Overall threat: Collisions with vessels
Specific threat: Vessels traveling at high speeds (i.e., 14 knots or more)
Stress: Increased injuries and mortalities
Range: Localized
Occurrence: Current
Frequency: Continuous
Causal certainty: Medium
Severity: Moderate
Level of concern: Medium

5) Whale-watching
Threat category: Disturbance or persecution
Overall threat: Whale-watching activities by cruise operators, recreational boaters and scientists
Specific threat: Disturbing critical activities (e.g., rest, feeding, communication, socializing, mating and nurturing calves)
Stress: Change in behaviour or abandoning habitat
Range: Localized
Occurrence: Current
Frequency: Seasonal
Causal certainty: Medium to high
Severity: Moderate
Level of concern: Medium

6) Anthropogenic noise: physical damage
Threat category: Accidental mortalities
Overall threat: Low frequency or high amplitude anthropogenic noise (e.g., seismic exploration, oil and gas development, and military sonars)
Specific threat: Physical harm leading to hearing loss and death
Stress: Injuries, mortalities, reduced population sustainability
Range: Generalized
Occurrence: Current
Frequency: Continuous
Causal certainty: Medium
Severity: Unknown
Level of concern: Low

7) Accidental entanglement in fishing gear
Threat category: Accidental mortalities
Overall threat: Fishery
Specific threat: Entanglement in fishing gear (e.g., gillnets)
Stress: Injuries, change in behaviour and/or mortality
Range: Generalized
Occurrence: Current
Frequency: Continuous
Causal certainty: Medium
Severity: Unknown
Level of concern: Low

8) Epizootics and toxic algal blooms
Threat category: Changes in the ecological dynamics or natural processes
Overall threat: Epizooty and toxic algal blooms
Specific threat: Health problems and toxic effects for blue whales
Stress: Reduced physical condition and increased mortalities
Range: Generalized
Occurrence: Anticipated
Frequency: Unknown
Causal certainty: Unknown
Severity: Unknown
Level of concern: Low

9) Toxic spills
Threat category: Pollution
Overall threat: Toxic product spills
Specific threats: Direct exposure; consumption of contaminated prey; changes to habitat characteristics
Stress: Toxic and physiological effects, reduced physical condition, mortalities
Range: Generalized
Occurrence: Anticipated
Frequency: Recurrent
Causal certainty: Medium
Severity: Low to moderate
Level of concern: Low

Whaling and natural mortality

10) Whaling
Threat category: Consumption
Overall threat: Whaling
Specific threat: Commercial, scientific or subsistence whaling
Stress: Mortalities which lead to a significant drop in terms of numbers of individuals and reduced population sustainability
Range: Generalized
Occurrence: Historical in Canada, but still ongoing or anticipated in all the distribution range
Frequency: Abandoned in Canada, but possibly still ongoing in certain areas of the distribution range
Causal certainty: High
Severity: High
Level of concern: Low

11) Ice
Threat category: Natural activities or process
Overall threat: The creation of a layer of ice and/or the movement of the ice layer
Specific threat: Entrapment of blue whales under the ice layer
Stress: Reduced physical condition (i.e., injuries) and/or death by anoxia or crushing by ice blocks
Range: Localized
Occurrence: Current locally, but not for the entire range
Frequency: Seasonal
Causal certainty: High
Severity: Moderate
Level of concern: Medium

12) Predation
Threat category: Natural activity or process
Overall threat: Predation of individuals
Specific threat: Killer whales
Stress: Reduced physical condition (i.e., injuries) or increased mortalities
Range: Localized
Occurrence: Current
Frequency: Recurrent
Causal certainty: Low
Severity: Low
Level of concern: Low

APPENDIX 2. CETACEAN SPECIES PRESENT IN THE CANADIAN ATLANTIC

Table 3. Status of marine mammal species assessed by the COSEWIC that visit the St. Lawrence and Atlantic Ocean. * Species or populations present in the Atlantic, but absent from the estuary and Gulf of St. Lawrence.

Common name (population)	Scientific name	COSEWIC assessment	COSEWIC designation	SARA status
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	April 1991	Not at risk	No status
Beluga whale (St. Lawrence estuary) (Ungava Bay)* (Eastern Hudson Bay)*	*Delphinapterus leucas*	 May 2004 May 2004 May 2004	 Threatened Endangered Endangered	 Threatened No status No status
Blainville's beaked whale *	*Mesoplodon densirostris*	April 1989	Not at risk	No status
Blue whale (Atlantic)	*Balaenoptera musculus*	May 2002	Endangered	Endangered
Common dolphin*	*Delphinus delphis*	April 1991	Not at risk	No status
Cuvier's beaked whale*	*Ziphius cavirostris*	April 1990	Not at risk	No status
Dolphin bottlenose *	*Tursiops truncatus*	April 1993	Not at risk	No status
Fin whale (Atlantic)	*Balaenoptera physalus*	May 2005	Special concern	Special concern
Grey whale (Atlantic)*	*Eschrichtius robustus*	May 2000	Extirpated	Extirpated
Harbour porpoise (Northwest Atlantic)	*Phocoena phocoena*	April 2006	Special concern	No status
Humpback whale (North Atlantic)	*Megaptera novaeangliae*	May 2003	Not at risk	No status
Killer whale (Northwest Atlantic)	*Orcinus orca*	November 2001	Data deficient	No status
Long-finned pilot whale	*Globicephala melas*	April 1994	Not at risk	No status
Minke whale (Atlantic)	*Balaenoptera acutorostrata*	April 2006	Not at risk	No status
North Atlantic right whale	*Eubalaena glacialis*	May 2003	Endangered	Endangered
Northern bottlenose whale (Scotian Shelf population) (Davis Strait)*	*Hyperoodon ampullatus*	 November 2002 April 1993	 Endangered Not at risk	 Endangered No status
Pygmy sperm whale*	*Kogia breviceps*	April 1994	Not at risk	No status
Sei whale (Atlantic)*	*Balaenoptera borealis*	May 2003	Data deficient	No status
Sowerby's beaked whale *	*Mesoplodon bidens*	November 2006	Special concern	Special concern
Sperm whale	*Physeter macrocephalus*	April 1996	Not at risk	No status
Striped dolphin*	*Stenella coeruleoalba*	April 1993	Not at risk	No status

Common name (population)	**Scientific name**	**COSEWIC assessment**	**COSEWIC designation**	**SARA status**
True’s beaked whale*	*Mesoplodon mirus*	April 1989	Not at risk	No status
White-beaked dolphin	*Lagenorhynchus albirostris*	April 1998	Not at risk	No status