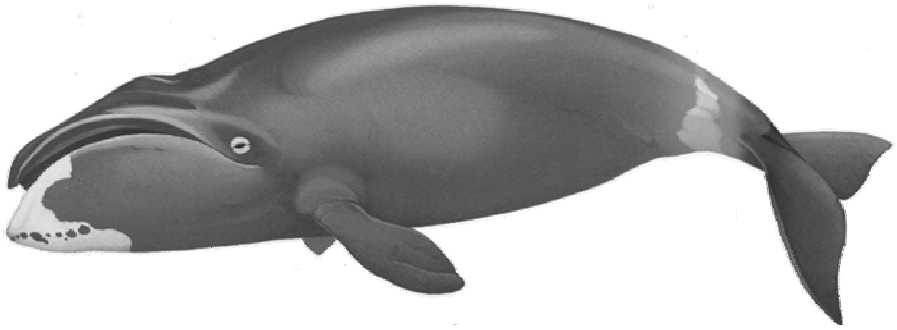
COSEWIC
Assessment and Update Status Report

on the

Bowhead Whale
Balaena mysticetus

Hudson Bay-Foxe Basin population
Davis Strait-Baffin Bay population
Bering-Chukchi-Beaufort population

in Canada



HUDSON BAY-FOXE BASIN POPULATION - THREATENED
DAVIS STRAIT-BAFFIN BAY POPULATION - THREATENED
BERING-CHUKCHI-BEAUFORT POPULATION - SPECIAL CONCERN
2005

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION
DES ESPÈCES EN PÉRIL
AU CANADA

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Previous report(s):

Mitchell, E. and R.R. Reeves. 1986. Update COSEWIC status report on the bowhead whale *Balaena mysticetus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 71 pp. [note: update prepared only on the Beaufort Sea/Arctic Ocean population].

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur la baleine boréale (population du détroit de Davis et de la baie de Baffin, population de la baie d'Hudson et du basin de Foxe, population des mers de Béring, des Tchouktches et de Beaufort) (*Balaena mysticetus*) au Canada – Mise à jour.

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Bowhead whale — ©Illustration by Martin Camm.

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COSEWIC
Assessment Summary

Assessment Summary – May 2005

Common name
Bowhead whale (Hudson Bay-Foxe Basin population)

Scientific name
Balaena mysticetus

Status
Threatened

Reason for designation
The population was severely reduced by commercial whaling between 1860 and 1915. Recent population estimates are uncertain, but indicate that there could be as few as 300 mature individuals, of which only half might be females. Threats to this small population include illegal hunting and increased vulnerability to killer whale predation as a result of reduced ice coverage.

Occurrence
Arctic Ocean

Status history
The "Eastern and Western Arctic populations" were given a single designation of Endangered in April 1980. Split into two populations (Eastern Arctic and Western Arctic) to allow separate designations in April 1986. The Eastern Arctic population was not re-evaluated in April 1986, but retained the Endangered status of the original "Eastern and Western Arctic populations." The Eastern Arctic population was further split into two populations (Hudson Bay-Foxe Basin population and Davis Strait-Baffin Bay population) in May 2005, and the Hudson Bay-Foxe Basin population was designated Threatened. Last assessment based on an update status report.

Assessment Summary – May 2005

Common name
Bowhead whale (Davis Strait-Baffin Bay population)

Scientific name
Balaena mysticetus

Status
Threatened

Reason for designation
The population numbered at least 11,000 animals when commercial whaling began. Whaling reduced the population to less than 30% of its former abundance. Recent estimates indicate that the population is growing and is larger than previously thought, but is likely to still number fewer than 3,000 individuals of all ages. The population qualifies for endangered, but is not judged to be in imminent danger of extinction. Threats include illegal hunting and increased vulnerability to killer whale predation as a result of reduced ice coverage.

Occurrence
Arctic Ocean

Status history
The "Eastern and Western Arctic populations" were given a single designation of Endangered in April 1980. Split into two populations (Eastern Arctic and Western Arctic) to allow separate designations in April 1986. The Eastern Arctic population was not re-evaluated in April 1986, but retained the Endangered status of the original "Eastern and Western Arctic populations." The Eastern Arctic population was further split into two populations (Hudson Bay-Foxe Basin population and Davis Strait-Baffin Bay population) in May 2005, and the Davis Strait-Baffin Bay population was designated Threatened. Last assessment based on an update status report.

Assessment Summary – May 2005

Common name
Bowhead whale (Bering-Chukchi-Beaufort population)

Scientific name
Balaena mysticetus

Status
Special Concern

Reason for designation
This population was hunted to low levels during commercial whaling. Although supporting a regulated hunt, it is recovering and is currently at about 50% of its historical population size. The population is not yet secure and is potentially negatively affected by climate change, and by oil and gas development.

Occurrence
Arctic Ocean

Status history
The "Eastern and Western Arctic populations" were given a single designation of Endangered in April 1980. Split into two populations (Eastern Arctic and Western Arctic) to allow separate designations in April 1986. The Western Arctic population was designated Endangered in April 1986. The population was renamed to "Bering-Chukchi-Beaufort population" and designated Special Concern in May 2005. Last assessment based on an update status report.

COSEWIC
Executive Summary

Bowhead Whale
Balaena mysticetus

Species information

Bowhead whales (*Balaena mysticetus*) (Linnaeus 1758) are large baleen whales of the family Balaenidae. The body is predominantly black with white (nonpigmented) regions on the chin, eyelids, flipper insertions, ano-genital area, tail stock, and flukes.

Distribution

Bowheads have a nearly circumpolar distribution in the northern hemisphere. There are 3 recognized populations in Canada. The Bering-Chukchi-Beaufort population summers in the eastern Beaufort Sea and Amundsen Gulf, and winters in the Bering Sea. The Hudson Bay-Foxe Basin population summers mainly in northwestern Hudson Bay and northern Foxe Basin, and may winter in northern Hudson Bay and Hudson Strait. The Davis Strait-Baffin Bay population summers in the Lancaster Sound region and western Baffin Bay and winters in Davis Strait.

Habitat

Bowheads occur in marine waters and in conditions ranging from open water to thick, extensive (but unconsolidated) pack ice.

Biology

Bowhead whales become sexually mature at around 25 years of age, and give birth to a single calf about every 3 years. Longevity may exceed 100 years. Growth is rapid during the first year (1.5 cm/day) and appears to slow after weaning to less than 1 m/yr. The Bering-Chukchi-Beaufort population consists of about 5% calves (<6 m), 54% juveniles (6-13 m) and 41% adults (>13 m), with an even sex ratio. Age-class segregation has been documented in all three populations. The spring and autumn migrations along northern Alaska are age-structured. In the eastern Canadian Arctic, juveniles and mothers with calves tend to remain apart from the rest of the adults during summer. Bowheads eat zooplankton, particularly euphausiids and copepods. Adaptations include great longevity, massive energy storage capability, a fairly sophisticated acoustic sense for ice navigation and long-range communication, and a peaked head profile with a “crown” for pushing up through ice to breathe.

Population sizes and trends

All populations were severely depleted during intense commercial whaling prior to the 20th century. In 2001, the Bering-Chukchi-Beaufort population consisted of approximately 10,470 whales (95% CI 8,100-13,500), with an estimated annual rate of increase of 3.4% (95% CI 1.7-5.0%).

The Hudson Bay- Foxe Basin population numbered at least 345 individuals in the mid-1990s. This estimate was not adjusted for submerged animals that would have been missed during the aerial surveys, and is the sum of 270 whales estimated in northern Foxe Basin (95% CI 210-331) and 75 in northwestern Hudson Bay (95% CI 17-133). In 2003, the best partial estimate for the Hudson Bay-Foxe Basin population (corrected for animals underwater) was 1,026 individuals (95% CI = 338-3,124, using a correction factor of 3.8).

The Davis Strait-Baffin Bay population numbered at least 11,000 whales prior to commercial whaling. At least 375 whales were present in the early 1990s (95% CI 315 to 435; uncorrected estimates), but more extensive surveys in 2003 resulted in a partial estimate (corrected for submerged animals) of between 1,539 (95% CI = 63-3,770) and 1,944 individuals (95% CI = 797- 4762).

The best partial estimate for the combined 2002 eastern Canadian arctic bowhead populations was 5,016 (95% CI = 2,611-9,633) (i.e., Davis Strait-Baffin Bay and Hudson Bay-Foxe Basin populations combined).

No quantitative data are available for trend analyses of either of the two eastern arctic populations.

Limiting factors and threats

The bowhead is a large, long-lived species with low fecundity and small population sizes. It has a fairly narrow niche in high northern latitudes and can be affected by a range of human activities (underwater noise and illegal hunting) and by climate change that reduces ice coverage and refuge from predation by killer whales.

Special significance of the species

Bowheads are hunted by Alaska Natives for subsistence and cultural purposes. A much smaller hunt by Inuit takes place in the Canadian Arctic.

Existing protection or other status designations

All bowhead populations in Canadian waters were designated as Endangered in 1980. The population in the Beaufort Sea was last reviewed in 1986. The species is legally protected in Canada under the Cetacean Protection Regulations of 1982, with hunting allowed only by permit. Bowhead whales are currently listed as Endangered under the US Endangered Species Act of 1973 and as Depleted under the US Marine Mammal Protection Act of 1972.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal agencies (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government members and the co-chairs of the species specialist and the Aboriginal Traditional Knowledge subcommittees. The Committee meets to consider status reports on candidate species.

DEFINITIONS (NOVEMBER 2004)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and it is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A wildlife species for which there is inadequate information to make a direct, or indirect, assessment of its risk of extinction.

* Formerly described as “Vulnerable” from 1990 to 1999, or “Rare” prior to 1990.
** Formerly described as “Not In Any Category”, or “No Designation Required.”
*** Formerly described as “Indeterminate” from 1994 to 1999 or “ISIBD” (insufficient scientific information on which to base a designation) prior to 1994.

Environment Canada
Canadian Wildlife Service

Environnement Canada
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Canada

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

Update
COSEWIC Status Report

on the

Bowhead Whale
Balaena mysticetus

Hudson Bay-Foxe Basin population
Davis Strait-Baffin Bay population
Bering-Chukchi-Beaufort population

in Canada

2005

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SPECIES INFORMATION

Name and classification

The bowhead whale (*Balaena mysticetus*) (Linnaeus 1758) is a baleen whale in the family Balaenidae. It is also known as the Greenland whale, Greenland right whale, or polar whale in the English language. In the French language it is known as baleine boréale. In Aboriginal languages of northern Canada, Alaska and Russia, the bowhead whale is known as Arviq or Arvik (Inuktitut and Inuvialuktun), Agkhovik (Inupiat), Akhgvopik (Yupik), or Ittiv (Chukchi).

Description

The bowhead is one of the stockiest of the baleen whales, with a barrel-shaped body and a very large head (about 30% of the total body length) (Figure 1). The upper jaw is bowed sharply upward and there is an average of 330 baleen plates up to 427 cm long in each side of the upper jaw (Haldiman and Tarpley 1993). The flippers are small and paddle-shaped, and there is no dorsal fin or dorsal hump. Flukes are pointed at the tips and deeply notched on the rear margin (Haldiman and Tarpley 1993).

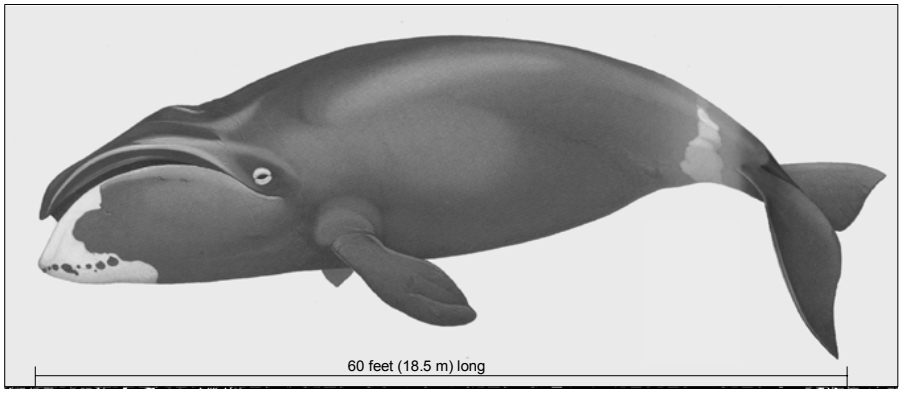

Figure 1. Bowhead whale (*Balaena mysticetus*).

The body is basically black with regional white (nonpigmented) areas on or around the chin, eyelids, flipper insertions, ano-genital area, tail stock, and flukes (Haldiman and Tarpley 1993). Areas of intermingled light-gray and white epidermis (speckled appearance) occur on some individuals in various body regions (Haldiman and Tarpley 1993).

DISTRIBUTION

Global range

Bowheads have a nearly circumpolar distribution in the northern hemisphere, spanning latitudes 54°N – 75°N in the North Pacific basin and 60°N – 85°N in the North Atlantic basin (Moore and Reeves 1993). Several physical barriers (land or impassable sea ice) have been thought to divide the world bowhead population into five populations (Moore and Reeves; Figure 2): (1) Okhotsk Sea population, largely or entirely confined to this sea year-round; (2) Bering-Chukchi-Beaufort Seas population, which summers in the eastern Beaufort Sea and Amundsen Gulf, and winters in the central and eastern Bering Sea; (3) Hudson Bay-Foxe Basin population, assumed to winter mainly in northern Hudson Bay and Hudson Strait, and to summer mainly in Foxe Basin and northwestern Hudson Bay; (4) Davis Strait-Baffin Bay population, which summers in Baffin Bay and the Canadian High Arctic, and winters along the ice edge in Davis Strait and off West Greenland; and (5) Svalbard (Spitsbergen) population, centred in the Barents and Greenland Seas.

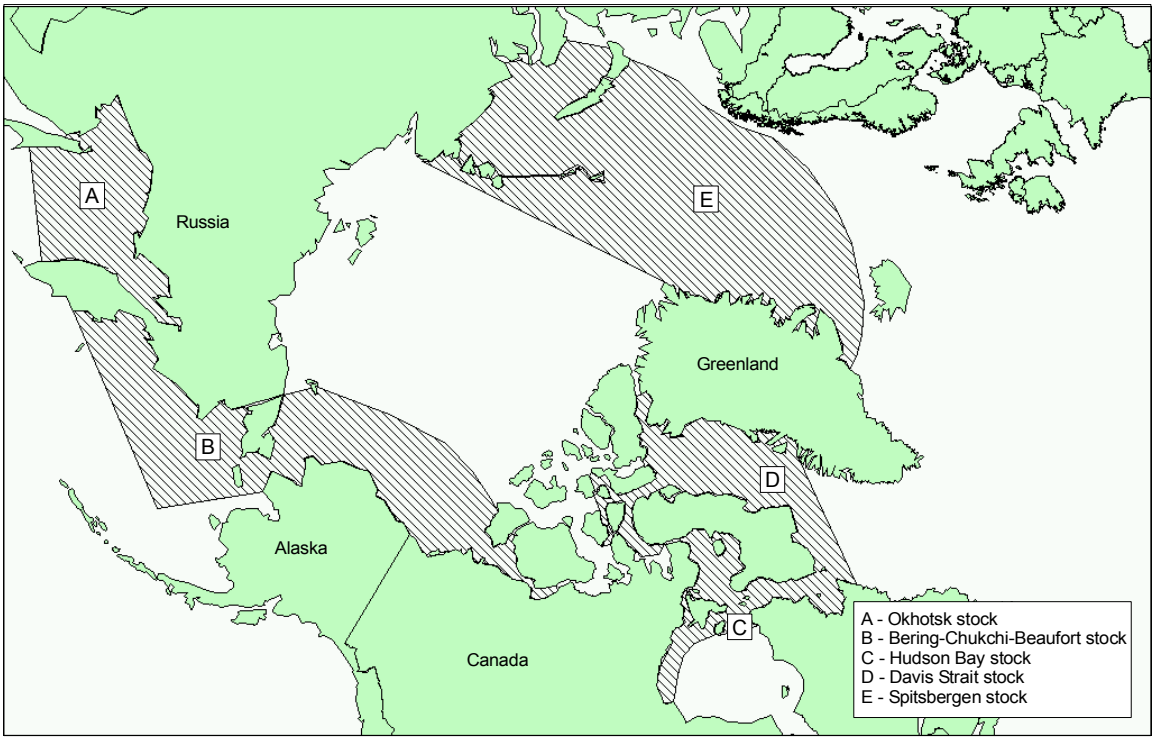

Figure 2. Approximate global distribution of the five bowhead whale populations (after Braham *et al*. 1984).

Bowheads were hunted by Inuit in the 1700s along the Labrador coast to as far south as Hopedale (Taylor 1988). They were also a major target, and possibly the principal target, of the very large-scale Basque commercial whale hunt centred in the Strait of Belle Isle during the 1500s and 1600s (Rastogi *et al.* 2004). No live bowheads have been observed in the southern Labrador Sea for more than a century, but a dead juvenile was found floating off northeastern Newfoundland in October 1998 (Daoust *et al.* 1998). It is not clear whether the bowhead whales killed in the Strait of Belle Isle and St. Lawrence estuary in the 1500s and 1600s formed a distinct population, or whether they were part of the Davis Strait-Baffin Bay population that ranged further south during the Little Ice Age (Rastogi *et al.* 2004). Genetic analysis of bones recovered from historic whaling sites is required to resolve this question.

The bowhead's range is affected over long time scales by sea ice fluctuations (Schledermann 1976; McCartney and Savelle 1985; Dyke and Morris 1990; Dyke *et al.* 1996). During the climatic optimum (7,500 - 10,000 years ago) bowheads roamed more widely in the Canadian Arctic, with possible mixing between the eastern and western Arctic populations (Bednarski 1990). Some exchange may have occurred in more recent times as well (Bockstoce and Burns 1993).

Of particular relevance to the description of population ranges is the distinction between the Hudson Bay-Foxe Basin and Davis Strait-Baffin Bay populations. Until recently, the evidence supporting the distinction was circumstantial and indirect (Reeves *et al.* 1983; Reeves and Mitchell 1990). Preliminary genetic evidence of mtDNA haplotype frequencies, presented by Maiers *et al.* (1999), appear to be corroborative. The most common of 22 haplotypes studied made up the highest proportion in both the Bering-Chukchi-Beaufort (3/9 animals) and Hudson Bay-Foxe Basin (13/34 animals) samples, but this haplotype was not found at all in the Davis Strait (0/19 animals) samples. Maiers *et al.* (1999) also concluded provisionally that the Hudson Bay-Foxe Basin population was more similar to the Bering-Chukchi-Beaufort than to the Davis Strait-Baffin Bay population.

More recently, molecular genetic analyses (DNA sequencing of the mitochondrial d-loop region and analysis of 15 nuclear DNA microsatellite loci) were completed for 286 individual bowheads sampled at various locations across the eastern Canadian Arctic and west Greenland (Postma *et al.* 2005, DFO 2005). Nuclear DNA microsatellite results showed genetic differentiation among some of the sample groups, specifically the samples from Igloolik in northern Foxe Basin as compared to those from West Greenland and from Pangnirtung in southeastern Baffin Island. Furthermore, the Repulse Bay (Hudson Bay) samples were differentiated from the West Greenland samples, but not from the Pangnirtung samples.

DFO (2005) noted that the recent genetics data could be explained as indicating a complex structure of a single population that is segregated by age and/or sex or selective mating strategies. However, the available genetic analyses indicate that the tissue samples obtained from bowhead whales from the eastern Canadian Arctic came from more than one population (DFO 2005). This is consistent with the earlier genetic

evidence and the assumption that there are two populations of bowhead whales in the eastern Canadian arctic-the Hudson Bay-Foxe Basin population and the Davis Strait-Baffin Bay population.

Canadian range

Bering-Chukchi-Beaufort population

Bering-Chukchi-Beaufort bowheads winter (November to April) in the western and central Bering Sea where there is adequate open water and broken pack ice. Recent winter sightings have been mainly along the ice edges and in polynyas in the pack ice near St. Matthew and St. Lawrence Islands and in the northern Gulf of Anadyr (Moore and Reeves 1993) (Figures 3 and 4). In spring (April through June) the whales migrate north and east to the eastern Beaufort Sea (Figure 3). The spring distribution is restricted to open-water areas that develop as the ice breaks up. The summer (June to September) distribution is primarily in the eastern Beaufort Sea, along the south and

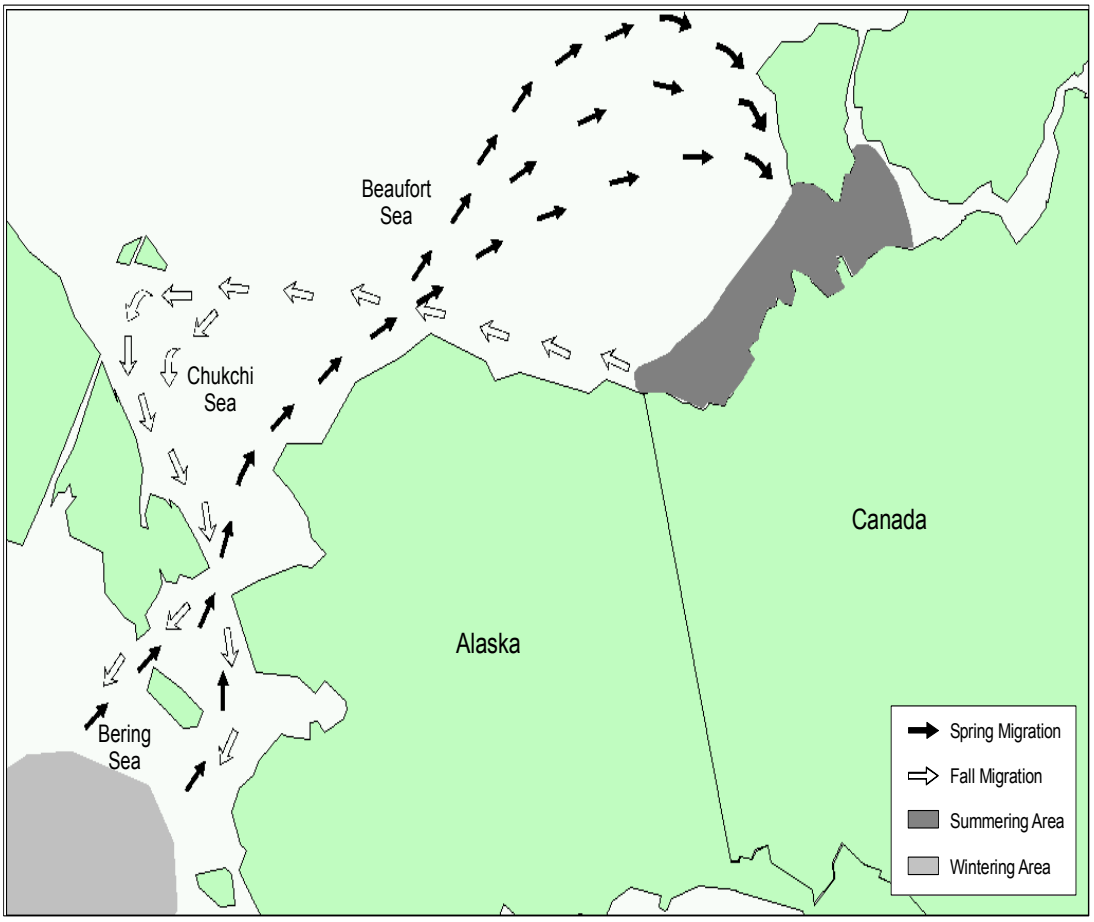

Figure 3. Generalized seasonal occurrence and migration corridor for the Bering-Chukchi-Beaufort Sea bowhead population.

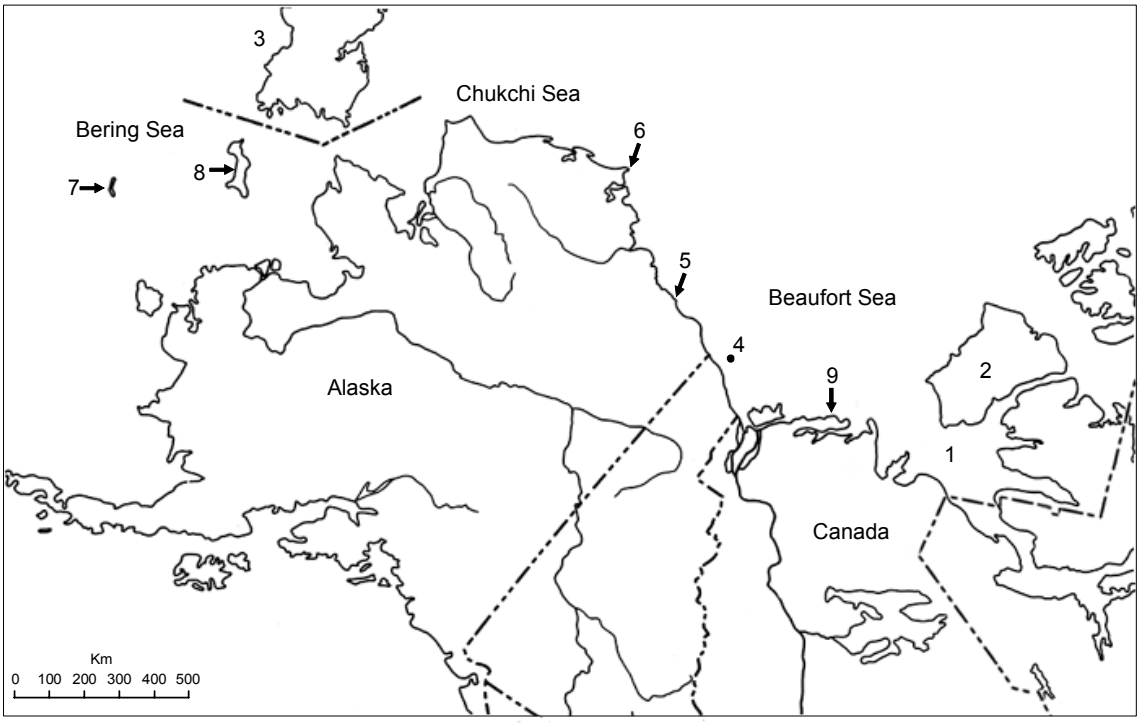

Figure 4. Map of the Canadian western arctic showing places mentioned in text showing 1. Amundsen Gulf; 2. Banks Island; 3. Gulf of Anadyr; 4. Hershel Island; 5. Kaktovik; 6. Point Barrow; 7. St. Lawrence Island; 8. St. Matthew Island; 9. Tuktoyaktuk Peninsula.

west coasts of Banks Island, in Amundsen Gulf, and along western Tuktoyaktuk Peninsula. Sightings in the eastern Chukchi and western Beaufort Seas in June (Braham *et al.* 1980; Carroll *et al.* 1987), along the Chukotka Peninsula throughout the summer (Bogoslovskaya *et al.* 1982), and in the Alaskan Beaufort Sea in August (Moore *et al.* 1989) indicate that not all animals in this population summer in the eastern Beaufort Sea. In the fall (September and October), bowheads migrate west from the Canadian Beaufort Sea into the Alaskan Beaufort and the Chukchi Sea, and then into the Bering Sea.

Nineteenth-century commercial whalers took bowheads from spring to autumn in the northern and southwestern Bering Sea (Bockstoce and Burns 1993). Bockstoce and Burns (1993) assumed that these bowheads were on their normal feeding grounds and not migrating through those areas, leading to the speculation that the Bering-Chukchi-Beaufort population consisted of several subpopulations. Bockstoce and Burns (1993) suggested as an alternative hypothesis that the bowheads comprised a single population that responded rapidly to the whaling activities and fled from areas of intense hunting, causing them to recede farther north and east to temporarily safer areas. The issue of whether there was (or is) more than one population in the western Arctic has been the subject of intense debate within the IWC Scientific Committee over the last few years.

The extent of occurrence of the bowheads in western Canadian Arctic waters extends from the Alaskan/Yukon border east into Amundsen Gulf (~900 km) and from the shore out to at least 230 km, with most animals occurring within 100 km of shore (Richardson *et al*. 1987a). The extent of occurrence of the Bering-Chukchi-Beaufort population in Canadian waters is therefore approximately 200,000 km^2 (900 km x 230 km). This extent of occurrence is stable. The area of occupancy of this population in Canadian waters is approximately 90,000 km^2 (900 km x 100 km). The area of occupancy obviously fluctuates seasonally, depending on prey distribution and other factors. Annual differences are also linked to variability in prey distribution (Richardson *et al*. 1987a).

Hudson Bay-Foxe Basin population

Relatively dense aggregations of bowhead whales occur in summer in northwestern Hudson Bay around Repulse Bay and Frozen Strait, and in northern Foxe Basin, north of Igloolik (Figures 5 and 6). Scattered individuals and small groups also occur along the west coast of Hudson Bay and near Mansel and the Ottawa Islands in eastern Hudson Bay (Reeves and Mitchell 1990). Some animals winter in Hudson Strait (ca. 800 km long) and northeastern Hudson Bay (McLaren and Davis 1982).

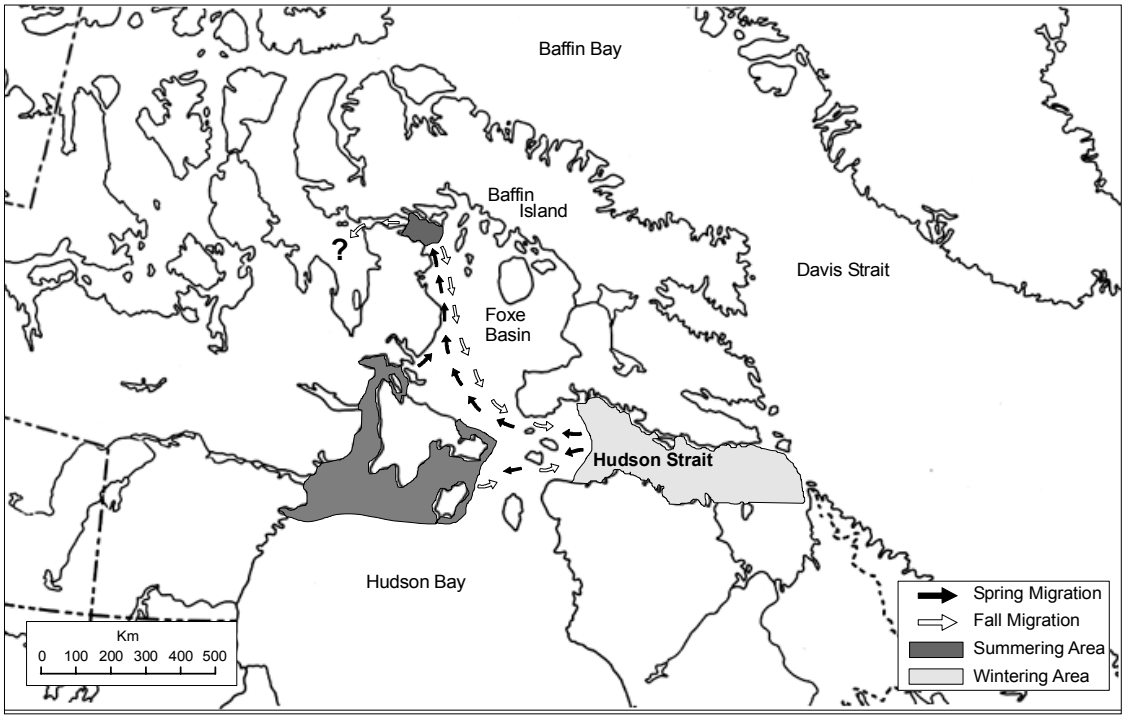

Figure 5. Generalized seasonal occurrence and migration corridor for the Hudson Bay-Foxe Basin population of bowhead whales.

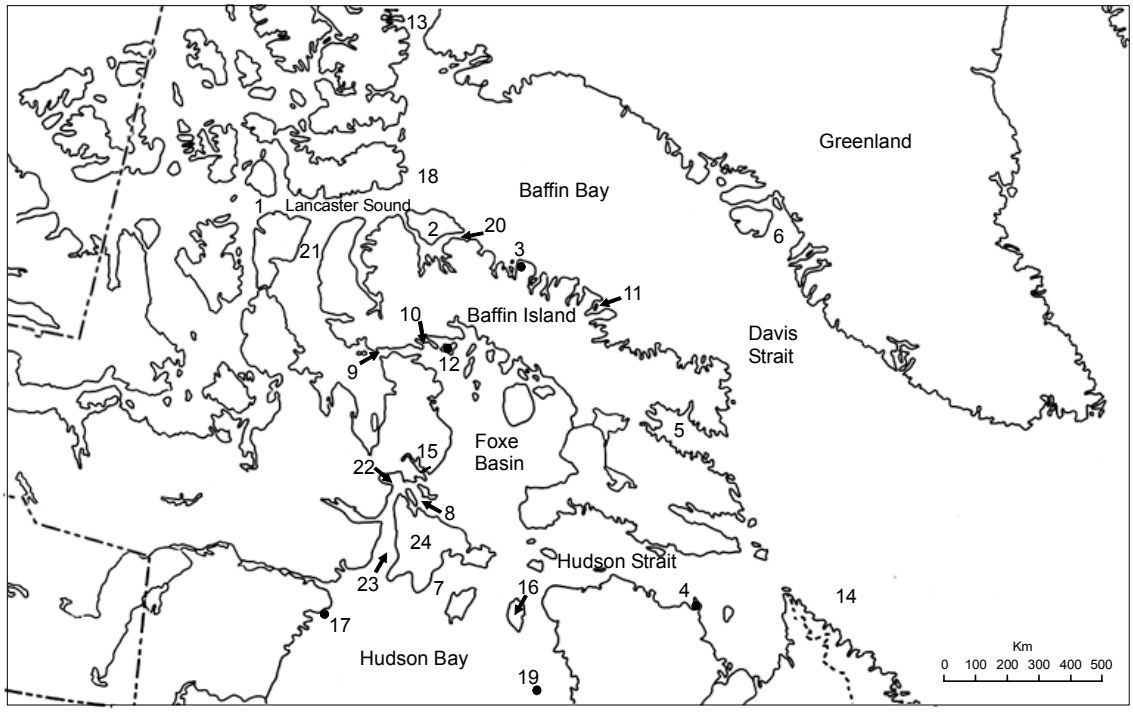

Figure 6. Map of the Canadian eastern arctic showing places mentioned in text showing: 1. Barrow Strait; 2. Bylot Island; 3. Cape Adair; 4. Cape Hopes Advance; 5. Cumberland Sound; 6. Disco Bay; 7. Fisher Strait; 8. Frozen Strait; 9. Fury and Hecla Strait; 10. Gifford Fiord; 11. Isabella Bay; 12. Jens Munk Island; 13. Kane Basin; 14. Labrador Sea; 15. Lyon Inlet; 16. Mansel Island; 17. Marble Island; 18. North Water; 19. Ottawa Islands; 20. Pond Inlet; 21. Prince Regent Inlet; 22. Repulse Bay; 23. Roes Welcome Sound; 24. Southampton Island.

Ross (1974) estimated that the 19th century commercial whaling grounds for bowheads in northwestern Hudson Bay covered an area of 60,000 km^2 (23,000 square miles), extending from Marble Island northeastward through Roes Welcome Sound to Lyon Inlet and into Fisher Strait (also see Reeves and Cosens 2003). Much of this area is still used by bowheads (NWMB 2000). Aerial surveys in August 1995 found bowheads in Roes Welcome Sound, Repulse Bay and Frozen Strait (Cosens and Innes (2000). In Foxe Basin, animals congregate in a well-defined area of approximately 3,700 km^2 north of Igloolik Island. This region extends from Fury and Hecla Strait eastward 71 km to Jens Munk Island, and from Igloolik Island northward 52 km to Gifford Fiord. Recent satellite tracking has shown that bowheads also move through Fury and Hecla Strait and into the Gulf of Boothia and northward into at least the southern reaches of Prince Regent Inlet (Dueck pers. comm. 2002). Bowheads are observed migrating north along the western side of Foxe Basin, and they have also been seen along the eastern side of Foxe Basin during the spring (NWMB 2000).

The extent of occurrence of the Hudson Bay-Foxe Basin population is approximately 350,000 km^2 (Appendix 1, Table 1). This extent of occurrence is considered stable. The area of occupancy of the Hudson Bay-Foxe Basin population is approximately 250,000 km^2 (Appendix 1, Table1).

The fine-scale distribution of bowheads is probably influenced by the movements of killer whales and the availability of invertebrate prey species. In August 1999 bowheads were nearly absent in their usual northern Foxe Basin feeding area (Cosens and Blouw 2003). They had arrived there in June 1999, but by August they had moved away. Local people reported unusual behaviour by many marine mammals that summer (Wheatley pers. comm. 2004). Ice breakup patterns differed from "normal," in part owing to the early passage of an ice-breaker through Frozen Strait; also, killer whales were present in higher numbers than usual (Wheatley pers. comm. 2004).

Davis Strait-Baffin Bay population

Some of the animals in this population move westward through Lancaster Sound in late June and early July, remaining in the inlets and sounds of the High Arctic until September (Figures 6 and 7). Others, mainly adults and adolescents, remain off the east coast of Baffin Island for the summer and autumn (Davis and Koski 1980; Finley 1990), migrating northwards from eastern Baffin Island (NWMB 2000) or across from Greenland (Heide-Jørgensen *et al*. 2003). Some bowheads winter in and near Disko Bay, West Greenland (Heide-Jørgensen and Finley 1991; Reeves and Heide-Jørgensen 1996), arriving there in late November and December and remaining until April or May (Born and Heide-Jørgensen 1983). Other bowhead whales are believed to winter in central Davis Strait and southern Baffin Bay in the unconsolidated pack ice and in polynyas (Finley 1990, 2001).

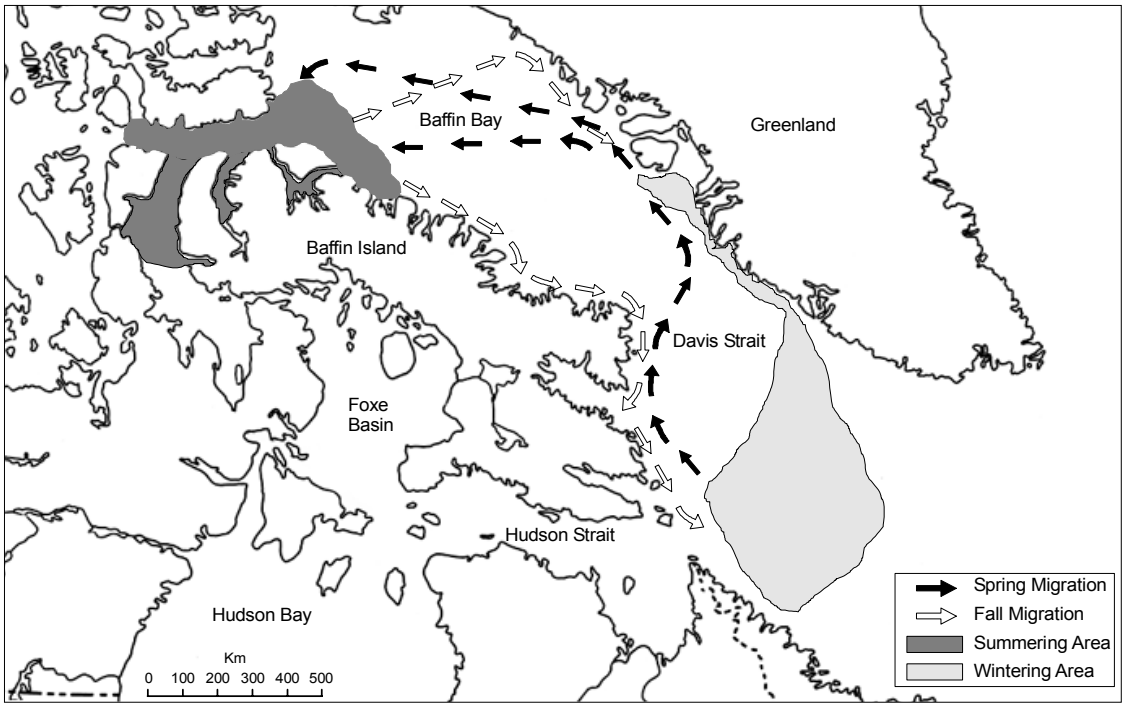

Figure 7. Generalized seasonal occurrence and migration corridor for the Davis Strait-Baffin Bay population of bowhead whales.

Bowheads attributed to this population occur in Canadian waters from the southern ice edge in Davis Strait north to the North Water in the High Arctic (~2,100 km), and from Baffin Island east to the Greenland coast. During the summer months they are also found in Lancaster Sound and Barrow Strait, and in the inlets adjoining them. The extent of occurrence of the Davis Strait-Baffin Bay population in Canadian waters is therefore approximately 800,000 km^2 (Appendix 1, Table 2).

The extent of occurrence in the Arctic is considered stable as bowheads occur in many of the same areas where they were found during the period of commercial whaling. However, they are no longer found in the Gulf of St. Lawrence and Strait of Belle Isle where they were hunted by Basque whalers in the 1500s (Rastogi *et al*. 2004). Whether or not the whales that were killed in this region belonged to a separate population or were part of the Davis Strait-Baffin Bay population is unknown (Rastogi *et al.* 2004). The current area of occupancy for the Davis Strait-Baffin Bay population is approximately 300,000 km^2 (Appendix 1, Table 2).

HABITAT

Habitat requirements

Bowheads occur in marine waters and in conditions ranging from open water to thick, extensive (but unconsolidated) pack ice. They are able to break thick ice (over 20 cm) to breathe and can navigate under extensive ice fields (George et al. 1989). Once bowheads arrive on their summering grounds, their primary activity is feeding (Thomas 1999; Würsig et al. 2001). Thus habitat requirements during this time would depend on the distribution of their primary food source (zooplankton), which can be affected by temperature and salinity, nutrient availability, and light intensity (Mackas *et al.* 1985). This along with water masses of different properties can influence the distribution and abundance of zooplankton (Simard *et al.* 1986; Castel and Veiga 1990). Physical processes in the Beaufort Sea vary considerably from year to year, causing the distribution and abundance of zooplankton to also vary (Griffiths and Thomson 2001).

On the summering grounds in July, bowheads from the Bering-Chukchi-Beaufort population seem to aggregate in the western half of Amundsen Gulf in deep areas (>200 m), where breakup occurs early. By late August, they have moved farther west into shallower waters (<100 m) east and west of the Mackenzie Delta (Richardson *et al.* 1987a). Subadults (<10 m long) are the dominant group in shallow (<20 m) nearshore areas during the fall migration in the Alaskan Beaufort Sea, with progressively fewer small subadult whales and more large subadults and adults as water depth increases (Koski and Miller 2001). Using sighting data from aerial surveys, Moore et al. (2000) found that bowheads selected inner shelf waters (≤50 m) and light ice conditions in the autumn. Moore (2000) also found that bowheads selected shallow inner-shelf waters (≤50 m) during moderate and light ice conditions, and deeper slope habitat (201-2000 m) during heavy ice conditions. Some adults may summer far offshore in pack ice or at the ice edge (Richardson et al. 1987a; Koski pers. comm. 1999).

Bowheads in Foxe Basin aggregate along the land-fast ice edge in June and July before the ice breaks up. The whales use the ice edge for socializing and feeding, possibly because the ice edge offers both food and shelter (Thomas 1999).

In Isabella Bay (east coast of Baffin Island), whales congregate in areas that correspond to major underwater bathymetric features (Finley 1990; Finley et al. 1994). Most feeding activity takes place in two deep troughs where food is most concentrated, and most social-sexual activity takes place on Isabella Bank, possibly because it offers both protection from killer whales and shelter from heavy seas and strong currents (Finley 1990; Finley et al. 1994).

Trends

There is considerable variation among years in the geographic locations where bowheads are sighted during their fall migration (Koski and Miller 2001), and in the summering areas in the Canadian Beaufort Sea (Richardson et al. 1987a; Moore and Reeves 1993). The near absence of bowheads in northern Foxe Basin in August 1999, when they are normally abundant there, raised a number of questions about the distribution patterns of the Hudson Bay-Foxe Basin population (Cosens and Blouw 2003). Koski and Miller (2001) suggested that between-year variation is related to the local abundance of bowhead prey and the differing locations of water mass boundaries that affect zooplankton (Griffiths and Thomson 2001; Griffiths et al. 2001).

Oil development in the Alaskan Beaufort Sea may be causing bowheads to migrate farther offshore. Richardson et al. (1995) observed an avoidance response to active seismic vessels as far as 20 km away. However, the disturbance from oil and gas development is not known to have affected the population growth rate.

Protection/ownership

Bowhead habitat is potentially protected in Canada by the Fisheries Act, which prohibits the destruction of any fish habitat (Section 32, 27(2) of the Fisheries Act). A marine protected area is being developed for Igaliqtuuq, near Clyde River, through the proposed Igaliqtuuq Bowhead Conservation Plan (Moshenko *et al*. 2003). The Hudson Bay Oceans Working Group is developing an Integrated Management Plan for Hudson Bay, with the goal of protecting, maintaining and enhancing the health of the Hudson Bay ecosystem (Oceans Canada 2002). Although there is no marine protected area in the Beaufort Sea yet, a harvest-based monitoring program called the Tariuq (Ocean) Monitoring Program is undertaken by local fishermen, and deals with the ecology, management and contaminants of the southern Beaufort Sea (Oceans Canada 2002). Also, the Beaufort Sea and Amundsen Gulf are in the Inuvialuit Settlement Region, and any project that could disturb the habitat there would have to be subjected to screening and possibly public review under the screening and review process of the Inuvialuit Final Agreement. In the Nunavut Settlement Area, projects that could potentially disturb bowhead habitat are initially reviewed by the Nunavut Impact Review Board, which forwards its findings to other organizations such as DFO and NWMB.

BIOLOGY

General

Bowheads are slow swimmers, averaging speeds of 4.50 ± 1.22 km/h during their fall migration (Koski *et al.* 2001) and 4.0 km/h (Rugh 1990) to 3.89 ± 1.48 km/h (Richardson *et al.* 1995b) during their spring migration. Bowheads are among the more vocal of baleen whales (Clark and Johnson 1984). Würsig and Clark (1993) suggested that calls may function to maintain social cohesion of groups and monitor changes in ice conditions. Bowheads may use the reverberations of their calls off the undersides of ice floes to help them orient and navigate (Ellison *et al.* 1987; George *et al.* 1989).

Reproduction

Sexual activity occurs during much of the year, although studies of fetuses indicate that most conceptions occur in late winter or early spring (Koski *et al.* 1993). Gestation lasts 13-14 months (Nerini *et al.* 1984) or 12-16 months (Tarpley *et al.* 1988), with one offspring per pregnancy. Calves are usually born during the spring migration between April and early June (Koski *et al.* 1993), with a peak in May (Nerini *et al.* 1984). Calves are 4.0-4.5 m long when born and grow at a rate of 1.5 cm/day for the first year (Koski *et al.* 1993). Weaning occurs between the ages of 9-15 months (Nerini *et al.* 1984) with about 95% of the yearlings weaned by the next spring migration (Rugh *et al.* 1992). Yearlings are 6.6-9.4 m long in spring (Nerini *et al.* 1984) and 7.0-8.7 m in summer (Koski *et al.* 1993). The growth rate appears to slow after weaning, with rates of less than 1 m/yr estimated for small bowheads re-identified in successive years (Davis *et al.* 1986; Schell *et al.* 1989; Koski *et al.* 1992).

Carbon isotope analysis suggests bowhead whales grow and develop slowly, taking about two decades (Schell *et al.* 1989; Schell and Saupe 1993) or longer (Zeh *et al.* 1993; George *et al.* 1999) to reach sexual maturity. Ovarian evidence suggests that females attain sexual maturity at lengths of 14.2 m or more, and perhaps at least occasionally when they are as small as 12.3 m (Nerini *et al.* 1984; Tarpley *et al.* 1988). Aerial photogrammetry indicates that whales as small as 12.2 m can be accompanied by calves (Davis *et al.* 1983; Cosens and Blouw 2003). George *et al.* (1999) estimated sexual maturity to occur at around 25 years of age (age at length 12-13 m for males and 13-13.5 m for females) using an aspartic acid racemization technique to age individuals. They also found that females grow faster than males. Smaller females tend to calve later in the spring migration than larger females: 1.5% (1/68) of the adults with calves photographed in the spring were <13.5 m long compared to 12% (7/59) in the summer (Koski *et al.* 1993). Evidence such as ivory or stone harpoon heads found in killed whales suggests that bowhead whales can live >50 years (Philo *et al.* 1993) or >75 years (George *et al.* 1995). Using an aspartic acid racemization technique, George *et al.* (1999) estimated four individuals (all males) to be more than 100 years of age.

Aerial photogrammetric surveys from 1985-92 found that 5.2% of the sampled population in the Barrow area (Bering-Chukchi-Beaufort population) in spring were

calves (<6 m), 53.7% were juveniles (6-13 m) and 41.1% were adults (>13 m) (Angliss *et al.* 1995). The sex ratio of bowheads landed by Alaskan Eskimo hunters from 1973 to 1992 was equal (Braham 1995). Cosens and Blouw (2003) estimated the ratio of bowheads by size classes in northern Foxe Basin from surveys in 1996, 1997 and 1998. Combining their data over the three years showed that 17% of the photographed population were calves, 71% were juveniles, and 12% were adults. Cosens and Blouw (2003) thus considered northern Foxe Basin to be a "nursery" area.

Annual pregnancy rates have been estimated as 0.21 (Tarpley *et al.* 1988) or 0.20-0.35 (George *et al.* 1995) calves/mature female, with a possible increase since 1985 (George *et al.* 1992). These pregnancy rates imply calving intervals of three to five years (Miller *et al.* 1992; Rugh *et al.* 1992). The mean calving interval appears to be 3-4 yr based on aerial photogrammetric data along with rates of sightings of calves by ice-based observers (Rugh *et al.* 1992; Withrow and Angliss, 1992; Koski *et al.* 1993). The gross annual reproduction rate (calves/non-calf/year) from all available information from 1982-89 (summarized in Koski *et al.* 1993) was 0.052, but year-to-year variation was substantial. Even with this low rate, the Bering-Chukchi-Beaufort population is increasing, suggesting a very low rate of natural mortality (Koski *et al.* 1993).

Survival

Zeh *et al.* (2001) used a Bayesian statistical approach to calculate an annual survival rate of 0.980, with a lower confidence limit of 0.898. This estimate is for adults since whales were identified using patterns of scars on their rostrums, backs or flukes, which are more abundant on older whales.

Growth of calves during the first three to four years after weaning is thought to be limited because baleen plates are short and feeding efficiency is poor (Schell and Saupe 1993). Calves are the age class that likely suffers the highest mortality (Moshenko *et al.* 2003). Most beached carcasses found in the eastern Arctic are of young bowheads and young bowheads are considered more vulnerable to lethal attacks by killer whales (Finley 1990; Moshenko *et al.* 2003).

The managed subsistence hunt of bowheads by Alaskan Inuit is the only measurable bowhead mortality. A quota of 280 bowhead whales was set for 1999-2002, of which a total of 67 (plus up to 15 unharvested in the previous year) could be taken each year (NMFS 2000). Although bowhead whale mortality caused by the subsistence hunt is fairly well documented (summarized in Stoker and Krupnik 1993), little is known about natural mortality of bowhead whales (Philo *et al.*, 1993). Since 1964 (through the early 1990s), at least 36 cases exist in which the cause of death could not be established (Philo *et al.* 1993). Nine stranded bowheads were found in the western arctic from 2000-2004 (Carpenter pers. comm. 2005). Some of these deaths may have been the result of hunter-inflicted wounds. Types of human-induced injuries include embedded shrapnel and harpoon heads from hunting attempts, rope and net entanglements from harpoon lines and crab pots, and collisions with vessels (summarized in Philo *et al.* 1993). Exposure to man-made noise and contaminants may

produce short- and long-term effects (Richardson and Malme 1993; Bratton *et al.* 1993) that compromise the health and reproductive performance of some whales.

The killer whale (*Orcinus orca*) is the only known predator of bowheads, besides man. Of 195 bowheads examined during the Alaskan subsistence harvest (1976-92), 8 bore evidence of encounters with killer whales (George *et al.* 1994). The frequency of attacks on bowhead whales in the Bering-Chukchi-Beaufort population is thought to be low (George *et al.* 1994), although it is not possible from the available data to assess this in a quantitative way (Shelden and Rugh 1995). Predation by killer whales may be a greater source of mortality for the Baffin Bay-Davis Strait population, where about one-third of the bowheads observed in a study of living animals bore killer whale scars (Finley 1990). Killer whales regularly appear in Cumberland Sound and Pond Inlet (eastern Baffin Island) where they have at least occasional access to bowhead whales (Mitchell and Reeves 1982). A high proportion of stranded bowheads have exhibited evidence suggesting that killer whales were responsible for their deaths (NWMB 2000). Some Inuit have observed killer whales killing bowheads (NWMB 2000).

Physiology

Enlargement of the head region to accommodate baleen is carried to an extreme in the bowhead whale (Lowry 1993). In adults, the head may be as much as two-fifths of the total body length. The head profile is distinctive, with the blowholes elevated by a kind of crown that allows the whale to push up through ice to breathe (Finley 2001).

The blubber layer is particularly thick — from 5.5 cm on the chin to about 28 cm thick over the majority of the trunk (Fetter and Everitt 1981 in Haldiman and Tarpley 1993; Haldiman *et al.* 1981 in Haldiman and Tarpley 1993). Maximal thickness is about 50 cm (Tomilin 1957 in Lowry 1993). The thick blubber layer is probably, at least in part, an adaptation for maintaining normal body temperature in the Arctic and sub-Arctic (Lowry 1993).

Movements/dispersal

Bering-Chukchi-Beaufort population

The Bering-Chukchi-Beaufort population is widely distributed in the central and western Bering Sea in winter (November to April), generally associated with the marginal ice front (Bogoslovskaya *et al.* 1982; Brueggeman 1982; Braham *et al.* 1984). From April through June, these whales migrate north and east into the eastern Chukchi Sea until they pass Point Barrow where they travel east toward the southeastern Beaufort Sea (Braham *et al.* 1980; Braham *et al.* 1984). Most of the summer (June through September), bowhead whales range through the Beaufort Sea (Hazard and Cubbage 1982; Richardson *et al.* 1987a; Richardson *et al.* 1987b), spending a large portion of time feeding in Canadian waters. Eskimo hunters from the eastern Alaskan Beaufort Sea have observed large concentrations of bowheads east of Hershel Island in July (Galginaitis and Koski 2001). In September and October, bowheads migrate west from the Canadian Beaufort Sea into the

Alaskan Beaufort, and then into the Chukchi Sea. Eskimo hunters from the eastern Alaskan Beaufort Sea, describe the migration as noticeably starting in August and lasts through October (Galginaitis and Koski 2001). During fall, unlike spring, there is open water along the north coast of Alaska, where many bowheads are seen within 25 km of the shore (Richardson et al. 1987b; Moore and Reeves 1993; Moore 2000; Moore *et al.* 2000; Griffiths *et al.* 2001; Koski and Miller 2001).

Age class segregation has been documented during the spring migration past Barrow, Alaska (Zeh *et al.* 1993; Angliss *et al.* 1995; Richardson *et al.* 1995b; Koski *et al.* 2004); on the summering areas in the Canadian Beaufort Sea and Amundsen Gulf (Cubbage and Calambokidis 1987; Koski *et al.* 1988); and in the eastern Alaskan Beaufort Sea during late summer and autumn (Koski and Miller 2001). During spring at Barrow, subadults tend to occur in deeper water with more ice. During summer in the Canadian Beaufort Sea, Cubbage and Calambokidis (1987) found a significant inverse correlation between longitude and size class, with larger animals occurring further east. During fall migration in the eastern Alaskan Beaufort Sea, subadult whales tend to occupy shallow nearshore areas and adults tend to be found further offshore (Koski and Miller 2001). Eskimo hunters from the eastern Alaskan Beaufort Sea described the whales in the fall as segregated temporally by size, with larger whales seen later in the season, and they also described smaller whales tending to be closer to shore (Galginaitis and Koski 2001). During both spring migration past Barrow (Rugh 1990; Withrow and Angliss 1992, 1994; George *et al.* 1995; Koski et al. 2004) and fall migration past Kaktovik (Galginaitis and Koski 2001; Koski and Miller 2001), the initial segment of the bowhead whale migration is made up primarily of subadults, followed by adult whales with much overlap in dates. The mothers and calves tend to migrate late in the season, especially in spring.

Hudson Bay-Foxe Basin population

The Hudson Bay-Foxe Basin population is believed to winter in Hudson Strait. Some of the bowheads winter in the waters off Mansel Island and some of the more southern islands of the east side of Hudson Bay (Low 1906). Inuit from Igloolik, Repulse Bay, and southwestern Southampton Island have reported a few bowheads at the floe edges in some winters, although they are a rare occurrence (NWMB 2000). McLaren and Davis (1981, 1983) observed bowheads wintering in western Hudson Strait. From April through May, these whales migrate west into Hudson Bay until they reach the northwest region of the bay (Reeves and Mitchell 1990), while others may move directly from Hudson Strait north into Foxe Basin appearing in northern Foxe Basin (Igloolik floe edge) by late June (Cosens *et al.* 1997b; NWMB 2000). Historically, Hudson Bay whales arrived at the floe edge off southwestern Southampton Island in May and June, then moved north, following ice breakup, through Roes Welcome Sound, where they remained abundant until September, but eventually moved into Foxe Basin (Reeves *et al.* 1983; Reeves and Mitchell 1990; Ross 1993). Recent tagging data show that some of the Foxe Basin bowheads move west through Fury and Hecla Strait (Dueck pers. comm. 2002). In September and October, bowheads apparently migrate east from Roes Welcome Sound and south from Foxe Basin into Hudson Strait.

Ross (1974) found little evidence of bowheads in Hudson Strait during the commercial whaling era. The few sightings in Hudson Strait occurred as early as May and as late as early August (Reeves *et al*. 1983). Most ship navigation occurred between mid-July and mid-September. It is possible that the whales usually cleared the strait in advance of the whalers in summer and after them in fall (Reeves et al. 1983). There is some evidence that whalers left Hudson Strait before the bowheads did. From October to November, Finley *et al*. (1982) observed bowheads swimming east in Hudson Strait. Low's (1906:257) assessment of the migration of bowheads into and out of Hudson Bay was based on the information received from whalers: "The whales are known to enter Hudson Strait early in the spring; they have been captured around Big Island in April and May, and at the western end of the Strait in the latter part of May. They then cross to the west side of the bay along the edge of the open water, being found in June and early July along the land-floe on both sides of the southern part of Roes Welcome. As the Welcome clears of ice they proceed north to Repulse Bay, and, still later, pass through Frozen Strait into Fox Channel. Late in the autumn they again pass through Hudson Strait going eastward."

Age class segregation has been documented in the Hudson Bay-Foxe Basin population (Cosens and Blouw 2003). Whales summering in northern Foxe Basin (aerially photographed in August of 1996, 1997 and 1998) were largely juveniles ranging up to 13.5 metres in size (Cosens and Blouw 2003). Calves and juveniles made up 89%, 97% and 79% of photographed bowheads in each of the three years. The numbers of adults and calves photographed suggest that adults summering in northern Foxe Basin are nursing females. Cosens and Blouw (2003) suggested that adult males and non-calving females aggregate in northwestern Hudson Bay. Similar data are not available for northwestern Hudson Bay.

Davis Strait-Baffin Bay population

From their wintering grounds in central Davis Strait, southern Baffin Island, and west Greenland, bowheads migrate north into northwestern Baffin Bay in spring. Heide-Jørgensen *et al.* (2003) tracked two bowheads from Disko Bay (West Greenland) to North Water-Southeast Bylot Island (Canada) in May-June 2001. A single whale photographed in Canada (NE Baffin Island) in late September (1986) was re-identified in Greenland in early April (1990) (Heide-Jørgensen and Finley 1991). Bowheads that appear at the Cumberland Sound floe edge in April and May are believed to migrate north along the Greenland coast to northern Baffin Bay and westward in May and June (Davis and Koski 1980; Holst and Stirling 1999). Between Cumberland Sound and Pond Inlet, Inuit have observed bowheads migrating northward along the Baffin coast from May to July (NWMB 2000). Bowheads summer in the inshore waters and fiords of northern Baffin Island and along the northeast coast of Baffin Island from May through August (NWMB 2000). Fall migration begins in late August and September and occurs casually over the next two to three months, with periods of directed swimming, resting, or feeding. Migration past Cape Adair (71°30' N), northeast Baffin Island, peaks in late September to early October (Davis and Koski, 1980). Movements slow as the whales feed on the autumn grounds (western Baffin Bay) (Finley 1990). Bowheads eventually

reach Cumberland Sound, southeast Baffin Island, in late October and November. The peak movement of bowheads past Cape Hopes Advance (Hudson Strait) occurs in late November (Finley *et al.* 1982).

Age class segregation has been observed in the Baffin Bay-Davis Strait population (Finley 1990). Aerial photogrammetry on 28-29 September 1986 in Isabella Bay (east coast of Baffin Island) showed that adult bowheads primarily used the area at that time (89% were >13 m long) (Finley 1990). Results from the aerial photogrammetry support the impression that most whales observed from shore or from kayaks were adults or large subadults (Finley 1990). Most of the whales taken during the years of commercial whaling on the autumn grounds (east coast of Baffin Island) were large males (Reeves *et al.* 1983). During commercial whaling, the predominance of young whales and females with calves in early season catches at the Pond Inlet floe edge and in the summer catches well inside Lancaster Sound and Prince Regent Inlet suggests that this may be the nursery grounds for the Davis Strait-Baffin Bay population (Reeves *et al.* 1983).

Nutrition and interspecific interactions

Most of the prey species identified in the stomachs of 35 bowhead whales (21 males and 14 females) taken by Alaskan Inuit between 1975 and 1989 were crustacean zooplankton, particularly euphausiids and copepods ranging in length from 3 to 30 mm (Lowry 1993). Epibenthic organisms, mostly mysids and gammariid amphipods, were also common in the stomachs, with only a small representation of benthic species (Lowry 1993). Slightly higher proportions of epibenthic organisms were found in the stomachs of small whales (<10.5 m in length) (Lowry 1993). It appears that copepods are more important in the diet of larger whales (Schell *et al.* 1987). Some may feed on benthic invertebrates as they migrate east along the Yukon North Slope based on observations of bowhead whales coming to the surface in summer with mud streaming out of their mouths (Carpenter pers. comm. 2005).

Based on patterns of isotope variation in the visceral fat and muscle sampled from three adults and six subadults, Schell and Saupe (1993) and Schell *et al.* (1987) proposed that significant feeding occurs outside the eastern Beaufort Sea, particularly by older whales in the fall and early winter when they are in the Chukchi and Bering Seas. Older animals may feed in different areas or on different prey types than younger animals (Schell and Saupe 1993). In contrast to the Schell and Saupe (1993) data, Hoekstra *et al.* (2002) found that seasonal fluctuations in stable carbon isotope values were consistent for all age classes, suggesting that the Bering and Beaufort seas are both important feeding grounds.

Inuit believe that bowheads and other marine mammals are strongly influenced by the tidal cycle and tide-induced sea currents (NWMB 2000). Bowheads are said to be very active and to feed heavily in areas where the currents are strongest around the full moon when tidal variation is greatest. Feeding behavior has been observed during spring and summer in the Beaufort Sea and fall in the Chukchi Sea, but not in winter in

the Bering Sea (Lowry 1993). Lowry (1993) suggested that bowheads rely on the abundant food supply in late summer and fall to acquire lipid reserves to sustain them during the winter.

Behaviour/adaptability

Bowheads are exquisitely adapted to living in an arctic environment (McLeod *et al.* 1993). Among their obviously adaptive features are great longevity, massive energy storage capability, a sophisticated acoustic sense for ice navigation and long-range communication, and a crown on the head for pushing up through ice to breathe (Finley 2001).

Bowheads often exhibit a fright reaction to the presence of killer whales. They move into areas of broken sea ice or shallow near-shore waters, apparently seeking protection from the killer whales (NWMB 2000). Inuit believe that killer whales have influenced bowhead distributions and migrations (NWMB 2000). For example, bowheads may avoid or abandon the Isabella Bay area in summer/early fall if killer whales are present (NWMB 2000).

Bowhead whales are known to react to man-made sources of underwater noise, with reactions varying by season, habitat and behavioural state (Richardson et al. 1985; Richardson and Malme 1993). Fall migrants appear to react more strongly than summering whales. Startle reactions such as hasty dives and avoidance behaviour may occur in response to aircraft flying at altitudes below 460 m (Richardson *et al.* 1985; Richardson and Malme 1993). Summering bowheads react to some vessel traffic at distances of 1 to 4 km by moving away from the ship track, whereas drillships appear to induce avoidance reactions at distances of up to 10 km. Bowheads avoid seismic vessels at distances of 6-8 km (Richardson and Malme 1993), or even at distances of 20 km (Richardson *et al.* 1995).

POPULATION SIZES AND TRENDS

Commercial whaling had severely depleted all populations of bowhead whales by the 1900s. Whaling started near Labrador in the 1500s and had spread to the Bering Sea by the mid-1800s (Braham 1984). Woodby and Botkin (1993) estimated that there were 10,400-23,000 bowheads in the Bering-Chukchi-Beaufort population prior to whaling and that this number had fallen to less than 3,000 by the time commercial whaling stopped. The commercial whaling period for the Bering-Chukchi-Beaufort Seas population lasted from 1848-1914, with about 20,070 bowheads landed (Ross 1993). Woodby and Botkin (1993) estimated that the Hudson Bay-Foxe Basin population numbered 440 to 470 in 1859 based on catch data from northwestern Hudson Bay between 1860-1915, during which time about 565 bowheads are estimated to have been landed (Ross 1993). Woodby and Botkin (1993) estimated that the Davis Strait-Baffin Bay population numbered 11,000 in 1825, with about 28,695 bowheads landed from 1719-1915 (Ross 1993).

Bering-Chukchi-Beaufort population

Several methods have been used to estimate the population size of the Bering-Chukchi-Beaufort population (summarized in Zeh *et al.* 1993). The most recent published estimate, based on the 2001 ice-based census, is 10,470 (95% CI 8,100-13,500 (George *et al.* 2004). The estimated annual rate of increase from 1978-2001 was 3.4% (95% CI 1.7-5.0%) (George *et al.* 2004).

Hudson Bay-Foxe Basin population

Aerial surveys flown on two days in August of 1994 in northern Foxe Basin estimated 256±31.3 and 284 ±48.6 whales (Cosens *et al.* 1997b). The average of these estimates was 270 bowheads (95% CI 210 - 331) (Cosens *et al.* 1998; DFO 1999). An estimate of 75 (95% CI 17-133) whales was calculated from an aerial survey of bowheads in northwestern Hudson Bay in August 1995 (Cosens and Innes 2000). These estimates were not adjusted to account for animals that were submerged or otherwise missed by the observers aboard the aircraft. Therefore they are negatively biased. DFO (1999) have used the combined central estimates from the two surveys—345 bowheads—as a minimum estimate of population size (DFO 1999).

The most recent summer surveys (2002-2004) provide the most comprehensive coverage to date of the bowhead whale distribution in the eastern arctic (Cosens *et al.* 2005). However, the large size of the summer range precluded surveying all areas in one season. In 2002, bowheads were surveyed in Eclipse Sound, Prince Regent Inlet and Gulf of Boothia. In 2003, two concurrent surveys were conducted: southern Gulf of Boothia-Foxe Basin-Hudson Bay and Admiralty Inlet-east coast of Baffin Island. In 2004, surveys were repeated in Admiralty Inlet and Eclipse Sound, and in Barrow Strait.

The total size of the Hudson Bay- Foxe Basin bowhead whale population cannot be estimated because an unknown number of individuals from this population were in Prince Regent Inlet (and thus outside the study area) during the 2003 survey. The best partial estimate for the Hudson Bay-Foxe Basin population in 2003 was 1026 individuals (95% CI = 338-3124) (DFO 2005, Cosens *et al.* 2005). The confidence limit is extremely wide, indicating considerable uncertainty in the estimate. A total estimate would need to include the unknown proportion of the whales from this population that were summering in Prince Regent Inlet.

The 2003 population estimate was corrected for numbers of whales that were underwater when counts were made. A mean adjustment factor of 3.8 (95% CI = 3.6-4.0) was applied to the survey counts (i.e., number of whales present was 3.8 times more than the number seen) based on the diving behaviour of 4 whales (DFO 2005, Dueck *et al.* 2005). An important shortcoming, apart from the small numbers of tracked whales, is that the correction factor incorrectly only considers the fraction of time animals are at the surface, and does not consider the window of time that an aircraft would be able to see a whale at the surface (Barlow pers. comm. 2005). The 2003 estimates of abundance are thus biased, and may overestimate population size by 20% (Cooper pers. comm. 2005).

Assuming a total population of 800 (i.e.,1000 reduced by 20% to account for the potential bias) of which 59% are immature, there may be as few as 300 mature individuals and only about 150 mature females. However, a more precautionary approach in view of the uncertainties summarized above is to apply the lower confidence limit of the estimate (i.e., 338), which suggests the current population is significantly lower than pre-exploitation levels (i.e., there may in fact be no more than 50 mature females).

Insufficient quantitative data are available to assess trends for this population. The Inuit Bowhead Knowledge Study (NWMB 2000) reports that elders and hunters from Hall Beach and Igloolik have seen more whales in the 1990s than they did during the 1960s. Similarly, Repulse Bay and Coral Harbour residents report that they saw more bowheads in the 1990s than they did in the 1970s.

Davis Strait-Baffin Bay population

On the basis of extensive aerial surveys of NW Baffin Bay and Lancaster Sound (conducted between 1974 and 1979), Davis and Koski (1980) estimated that the number of bowheads migrating southward past Cape Adair was 140 $\pm$ 33. With the rediscovery of the Isabella Bay whales, and a better understanding of population segregation and migrations, Finley (1990) estimated the Baffin Bay population at about 250. Using Finley's photo-identification data, it was estimated that about 214 whales were present over a two-year period at Isabella Bay (1986-87) and that the total population could number at least 350 (Zeh *et al.* 1993), or 375 (95% CI 315 - 435) with the inclusion of the northern component of 140 $\pm$ 33 (Cosens *et al.* 1998). The estimate of 375 was considered negatively biased because no adjustment was made to account for submerged whales or whales missed by the observers for the northern component and not all of the whales photographed were included in the mark-recapture estimate for Isabella Bay. In the winter of 1998 Heide-Jørgensen and Acquarone (2002) estimated that 246 bowheads (95% CI 62 - 978) were present off West Greenland between Qeqertarsuaq (lat 69° N 00') and Paamiut (lat 62° N 00') and to as far west as 80 km from the coast. This number included an adjustment to account for submerged whales but the survey area did not cover the entire winter range of the population.

A comprehensive estimate of the Davis Strait- Baffin Bay population is not available for 2003 because an unknown number of individuals from this population were already in Prince Regent Inlet, where both Foxe Basin and Baffin Bay whales summered during the 2003 Admiralty Inlet-Baffin Bay survey. The best partial estimate for the Davis Strait-Baffin Bay population is 1539 individuals (95% CI = 631-3770) if the correction factor including cows with calves is used (3.8; time-at-surface=26% of time) and 1944 individuals (95% CI = 797-4762) if the correction factor does not include the data from cows with calves (4.8; time-at-surface=21% of time) (DFO 2005, Cosens *et al.* 2005). However, the probability of detecting a whale on the aerial survey trackline was incorrectly calculated, and over-inflates the estimate of abundance (Barlow *et al.* 1988, Laake *et al.* 1997, Barlow pers. comm. 2005) by perhaps 20% (Cooper pers. com. 2005). The total size of the Davis Strait-Baffin Bay population is unknown, and could

only be obtained if the proportion of the population that summers in Prince Regent Inlet were known.

Bowhead whale surveys were conducted in 2004 in Barrow Strait, Admiralty Inlet and Eclipse Sound. However, bowhead whales were seen only in Eclipse Sound (Cleator pers. comm. 2005). Further work is needed to determine if the animals seen were juveniles or adults. Several factors could explain the absence of whales in other areas including weather conditions, presence of killer whale, or ice (DFO 2005, Cosens *et al.* 2005).

Insufficient quantitative data are available to assess trends for the Davis Strait-Baffin Bay population. Greenlanders reported that the population had not noticeably increased in the last few decades (Reeves and Heide-Jørgensen 1996), but Inuit hunters from Baffin Island reported that numbers there had increased (NWMB 2000). Reeves and Heide-Jørgensen (1996) stated that if this population was increasing in size, it appeared to be doing so mainly in the western part of its range. Aerial surveys continue to be undertaken by DFO to estimate numbers of bowheads in Baffin Bay/Davis Strait, so better estimates of bowhead numbers may be available in future years.

The best partial estimate for the combined eastern Canadian arctic bowhead populations is 5016 (95% CI = 2611-9633) (i.e., Davis Strait-Baffin Bay population and Hudson Bay- Foxe Basin population combined) (DFO 2005, Cosens *et al.* 2005). This estimate is derived from the pooled 2002 surveys in Eclipse Sound, Prince Regent Inlet and Gulf of Boothia—and is likely overestimated due to the error in calculating the applied correction factor (Barlow pers. com. 2005). A single estimate of all bowheads in the eastern Canadian arctic is unavailable because no single survey covered the entire summer range in one year. The combined estimate is much larger than the totalled partial estimates of the Davis Strait-Baffin Bay and Hudson Bay–Foxe Basin populations. This difference is largely due to the numbers of whales seen during summer in Prince Regent Inlet, which cannot be partitioned between the two populations.

The best available census data suggest that the current population size numbers less than 50% of historic numbers (i.e., pre-commercial whaling). The 2003 partial population estimates indicate that there may be between 1539 (95% CI = 631- 3770) and 1944 individuals (95% CI = 797 - 4762). Even the most optimistic population estimate for all of the eastern Canadian Arctic is less than 50% of pre-exploitation numbers (i.e., 5016: 95% CI = 2611-9633 for Davis Strait-Baffin Bay population *and* Hudson Bay population). This suggests a population that could number fewer than 3,000 individuals of all ages (i.e., 3,000 ≈ [5,000 – 1,000 HBFB pop. est.] X 0.80 bias correction).

LIMITING FACTORS AND THREATS

The severe depletion of the bowhead population by commercial whalers is the main reason that the species is listed as endangered in several parts of its range. A recent report suggests that killer whales may be the number one threat to the bowheads

in the eastern Canadian Arctic (Moshenko *et al.* 2003). An additional concern comes with increased interest in offshore developments in the Beaufort Sea and the eastern Canadian Arctic, which could possibly affect whale populations with the traffic, noise, and possible oil spills associated with such developments. Illegal hunting could directly affect population numbers. It has been suggested that climatic factors, which are influencing ice conditions, may also affect both the survival and the distribution of bowhead whales in the future (Tynan and DeMaster 1997). None of the other threats discussed below is expected to pose a serious threat to the population.

Killer Whales

The distributions of killer whales and bowhead whales in the Bering Sea overlap, at least during fall (George *et al.* 1994). Killer whales have never been seen during the 15 years of ice-based censusing in spring at Barrow (George *et al.*, 1994), and only two sightings have been reported from the Beaufort Sea (Lowry *et al.*, 1987) where bowheads spend the summer months. George *et al.* (1994) examined bowhead whales of the Bering-Chukchi-Beaufort population harvested by Alaskan Inuit for scars from killer whale injuries. They estimated that the frequency of scars from killer whale attacks ranged from 4.1% to 7.9%. The relatively low frequency of bite marks on the Bering-Chukchi-Beaufort population likely reflects a relatively low frequency of killer whale attacks and predation pressure, although most bowheads that are successfully killed probably go unrecorded (George *et al.* 1994).

Predation by killer whales has been suggested to be a higher source of mortality for the Baffin Bay-Davis Strait population (than the Bering-Chukchi-Beaufort population), where about one-third of the bowheads have killer whale scars (Finley 1990). Killer whales regularly appear in Cumberland Sound and Pond Inlet (eastern Baffin Island) where they would have frequent access to bowhead whales (Mitchell and Reeves 1982). Inuit report the presence of killer whales in all regions of Nunavut (NWMB 2000). Many stranded bowheads have been found with evidence suggesting that killer whales were responsible for the deaths (NWMB 2000). Some Inuit have observed interactions between bowheads and killer whales with the end result of the killer whale killing the bowhead (NWMB 2000). According to elder Inuit, young bowheads are especially susceptible to predation by killer whales (Finley 1990). Moshenko *et al.* (2003) rated the killer whale as possibly the greatest threat to the recovery of eastern arctic bowhead whales.

Predation by killer whales on bowhead whales may increase in the future if the refuge provided by ice coverage is reduced by global warming.

Illegal hunting

Due to the relatively old age of first birth (age 25 yr) and low birth rate (1 calf every 3-4 yr), the sustainable removal rates from bowhead whale populations are extremely low. For example, the sustainable removal rate from the Hudson Bay-Foxe Basin population has been estimated as one whale per two or three years based on historical hunting and the associated assumption that the population has been increasing or

stable despite the removals. For the Davis Strait-Baffin Bay population, the sustainable removal rate has been estimated as one whale every thirteen years.

From 1993-2004, one bowhead whale was reported landed from the Davis Strait Baffin Bay population, and five were reported landed from the Hudson Bay-Foxe Basin population. Regulated hunting does not appear to be a threat under current management. However, there have been unsubstantiated reports from the eastern Canadian Arctic of bowhead whales being shot at illegally and, on at least a few occasions, killed over the past few decades (Reeves pers. comm. 2005). Illegal hunting could pose a threat to bowheads given their low abundance.

Strandings

Reports of stranded bowhead whales are exceedingly rare due perhaps to the remoteness of such events from human habitation. Nonetheless, nine stranded bowheads were found in the western Canadian Arctic from 2000-2004 (Carpenter pers. comm. 2005). The reason(s) for these strandings are uncertain but may range from natural mortality to illegal shootings. No similar strandings have been reported in Alaska (Nelson pers. comm. 2005).

Toxins (pollution contaminants)

Jayko *et al.* (1990) developed a model to quantify the probability of bowhead whales encountering spilled oil in Alaskan waters. Their spill scenarios resulted in the oiling of an average of 0.1-2.0% of the Bering-Chukchi-Beaufort bowhead population. The model simulations discussed by Jayko *et al.* (1990) indicate that oil spills in the Beaufort Sea are unlikely to affect a significant portion of the bowhead whale population. There is no evidence that any of the large oil spills to date have had a significant impact on a baleen whale population (Geraci and St. Aubin 1990). St. Aubin *et al.* (1984) showed that oil fouling of the fringes of the baleen reduces feeding efficiency but that the impact would be short-term if the animal does not remain in the affected area. Offshore oil/gas exploration is rapidly increasing in Davis Strait (off West Greenland), and Lancaster Sound is known to have some significant deposits of oil and natural gas (though not yet commercially viable to extract) (Moshenko *et al.* 2003). Many Inuit fear that oil spills may pose a hazard for bowheads and other sea mammals in Nunavut (NWMB 2000). Moshenko *et al.* (2003) ranked pollution and contaminants as a high threat to bowheads in the eastern arctic populations.

Baleen whales generally have lower tissue contaminant levels than the toothed whales (O'Shea and Brownell 1994). Chemical pollutants are believed to accumulate at low concentration levels due to the low trophic level of bowhead (O'Hara *et al.* 1998). Bratton *et al.* (1993) describe various aspects of contaminants but data and understanding of physiological mechanisms are limited. The limited available information suggests that contaminant exposure poses no present threat to bowheads; however, productivity damage by chemical contaminants on planktonic food resources could potentially affect them.

Man-made noise

The main sources of man-made noise pollution are ships, aircraft, seismic exploration, marine construction, drilling, and motor boats (Richardson and Malme 1993). Most of the research on bowhead reactions to industrial activities has been done on the Bering-Chukchi-Beaufort population that summers in the Beaufort Sea (Richardson *et al.* 1985; Richardson and Malme 1993). Bowhead whales are known to react to man-made sources of underwater noise by avoiding the area where the noise comes from. Reactions appear to vary by season, habitat and behavioural state (Richardson *et al.* 1985; Richardson and Malme 1993). Inuit hunters from the eastern Alaskan Beaufort Sea reported that noise affected whale behaviour when there was seismic activity in the area (Galginaitis and Koski 2001). They observed that the whales moved further offshore, and that they were easily spooked when they did see them. Some Inuit report that bowheads react negatively to noise from snowmobiles and small motorized boats, although many Inuit have also reported that bowheads do not seem to be adversely affected by the same noises (NWMB 2000). Inuit in Clyde River are concerned with the increasing numbers of large tour ships, and their unregulated operations (Moshenko *et al.* 2003). With an increasing number of motorized boats, both from tourism and local recreational activities, the potential for interference with bowhead activities increases (Moshenko *et al.* 2003). Moshenko *et al.* (2003) ranked man-made noise and tourism and recreation as a high threat to bowheads in the eastern arctic.

Climate change

Direct effects of climate change on arctic marine mammals include the loss of ice-associated habitat (Tynan and DeMaster 1997). Indirect effects include regional or seasonal shifts in prey availability, which can affect nutritional status, reproductive success, and geographic range. It may also alter the timing or patterns of migrations, which may produce changes in species distributions and population structure of bowheads (Tynan and DeMaster 1997). Schell (2000) found isotopic evidence that the Bering Sea ecosystem underwent a reduction of between 30-40% in average seasonal primary productivity from 1966 to 1997. Gough and Wolfe (2001) compared two generations of a climate model using the impact of a CO_2 doubling on the Hudson Bay region. One model suggests that sea ice might virtually disappear in Hudson Bay, leading to a substantially higher regional temperature. This degree of climate change would likely affect the bowhead population by altering the food web, although it is not known whether this would be a positive or negative effect.

In the high Arctic, the base of the food chain consists of ice algae (Alexander 1995) formed on the underside of the ice at the ice-seawater interface. With spring warming and ice melt, algal cells are sloughed off into the surrounding water column, where a seasonal bloom of phytoplankton is initiated. Ice edge habitat generates a restricted zone of high productivity (Sakshaug *et al.*, 1994). Many species of copepods (the primary prey of bowheads) reproduce under the ice before the phytoplankton bloom and feed on sedimenting ice algae (Drolet *et al.*, 1991). With a loss in ice habitat, there would be less ice algae produced and possibly less food for copepods (bowhead prey).

Given the coupling between the ice-edge habitat and the prey of many species of arctic marine mammals, Tynan and DeMaster (1997) speculated that a sufficient reduction in the extent of the ice edge, and its associated community, may have deleterious consequences for marine mammals that have evolved with these unique systems. There is the additional concern that species which rely on the ice-edge community for foraging could be adversely affected by a reduction in the areal extent and latitudinal shift of ice-edge habitat (Tynan and DeMaster 1997).

In the Bering-Chukchi-Beaufort population, bowhead whales stay with the ice edge as it advances and retreats each year (Goering and McRoy 1974). Reductions in the southern extent of seasonal sea ice could displace southern ranges of bowheads northward. Interannual changes in the onset and severity of seasonal sea ice may also affect the length of feeding seasons, timing of migration, fecundity, and survivorship of marine mammal species (Tynan and DeMaster 1997). Inuit hunters from the eastern Alaskan Beaufort Sea report more whales migrate later in the season than they used to (Galginaitis and Koski 2001). It is not possible at this time to determine the impact (whether positive or negative) of climate change on the bowhead population. Moshenko *et al.* (2003) ranked climate change as a high threat to bowhead whales.

Ship collisions

George *et al.* (1994) examined bowhead whales of the Bering-Chukchi-Beaufort Seas population harvested by Alaskan Eskimos for scars from ship-collision injuries. They estimated that the frequency of scars from ship-collisions was about 1%. These low numbers suggests that the incidence of ship collisions with bowheads is quite low, because few vessels pass through most of the bowhead's range, but it may also be that bowheads do not survive the collision (Kraus 1990). It is unlikely that many bowheads come in contact with ships in any of the bowhead ranges, due to the low number of ships that enter the arctic waters, and bowhead are generally associated with ice, where ships would generally travel in the ice-free areas. Moshenko *et al.* (2003) ranked ship collisions as a low threat to bowheads in the eastern arctic.

Richardson *et al.* (1987a) reported that most bowheads show avoidance reactions to approaching ships more than 1 km distant in the Eastern Canadian Beaufort, which would reduce the likelihood of a ship collision. However, they found these reactions were short-term and suggest that summering bowheads could habituate to an ongoing stimulus from offshore drilling or vessel operations, especially when they are feeding.

Ice-entrapment

The close association of bowheads with ice places them at risk. Mitchell and Reeves (1982) describe accounts of fatal ice entrapment, but whether the whale was frozen in the ice after it died could not be determined. Inuit have observed ice-entrapped bowheads on a few occasions (NWMB 2000). One bowhead was discovered entrapped on March 20, 1997 in a polyna in Admiralty Inlet (NWMB 2000). The whale was still alive when last seen just before ice breakup, and was believed to have survived since

no carcass was ever found (NWMB 2000). Short of direct mortality due to ice entrapment, there is little doubt that bowheads can be prevented from reaching preferred feeding grounds during heavy ice years (Mitchell and Reeves 1982), which may affect their survival. Inuit report bowheads avoid areas where the ice cover is very extensive or apparently continuous (NWMB 2000). Ice-entrapment is likely the lowest threat to bowheads due to their ability to navigate through extensive ice fields and punch holes up through the ice in order to breathe.

Diseases and parasites

There is limited information on causes of natural mortality in bowhead whales. What is known has come from the study of what were otherwise apparently healthy whales taken in the subsistence hunt (Philo et al. 1993). Bowheads carry parasites, such as whale lice, internal roundworms, tapeworms, and potentially pathogenic microbes (yeasts, bacteria and viruses), but none of these are thought to contribute to bowhead mortality (Philo *et al.* 1993). They also are known to occasionally suffer from developmental and degenerative conditions. Smith *et al.* (1986, 1987) suggests there is evidence that bowheads may be hosts for viruses such as caliciviruses, of which symptoms may include formation of cysts, open sores, inflammation of the lungs, brain, heart, stomach and intestine lining, and abortion. How these viruses affect mortality and reproductive rates is unknown (Philo *et al.* 1993). Moshenko *et al.* (2003) ranked disease and parasites as a low threat to bowhead whales.

Entanglement

There are no data to estimate the number of entanglement fatalities that occur in bowhead whales, although smaller bowheads are more likely to die from entanglement than larger whales because they may not be powerful enough to break the ropes or have the stamina to drag the gear (Philo *et al.* 1992). Reports of bowhead whales entangled in harpoon lines or ropes from fishing gear have occurred (summarized in Philo *et al.* 1992), but are rare. Inuit have reported bowheads swimming into nets set for belugas, narwhals and fish in Cumberland Sound and near Pangnirtung, resulting in destroyed nets and entanglement (NWMB 2000). The effect of entanglement mortality on the bowhead whale population is unknown, but is likely small at present. Moshenko *et al.* (2003) ranked entanglement as a low threat to bowhead whales at this time.

SPECIAL SIGNIFICANCE OF THE SPECIES

The Hudson Bay-Foxe Basin population is probably endemic to Canada, but the Bering-Chukchi-Beaufort population and the Davis Strait-Baffin Bay population are not. McLeod *et al.* (1993) state that the bowhead is a relict species (both geographically and evolutionarily) that probably arose during Pliocene time in the northern hemisphere. Tynan and DeMaster (1997) list the bowhead as a possible indicator species for climatic change in the northern hemisphere, and is therefore of special interest for scientific reasons. The bowhead is a monotypic species, with its closest relative being the right

whale (*Eubalaena australis*). The bowhead is listed as endangered worldwide, although the Bering-Chukchi-Beaufort population constitutes more than 90% of the world's remaining individuals (Marine Mammal Commission 1999).

Bowhead whales are killed by subsistence hunters in Alaska and Russia, and a smaller hunt by Inuit takes place in the Canadian Arctic. The International Whaling Commission regulates Alaskan and Russian hunts. In Canada, bowhead hunting is co-managed by Fisheries and Oceans Canada and Wildlife Management Boards created under land claims agreements. These include the Fisheries Joint Management Committee in the Inuvialuit Settlement Region and the Nunavut Wildlife Management Board in Nunavut.

The bowhead had great significance to the early human communities along the shores of the Arctic. The hunting of bowheads for subsistence was well established in Hudson Bay and Foxe Basin long before the British and American commercial whale fishery became established (Reeves and Mitchell 1990). The archaeological record indicates that various species of whale have been hunted in northern regions of Canada for at least 2,000 years (Freeman *et al.* 1998). From about A.D. 1100 to 1440, the ancestors of today's eastern Canadian Arctic Inuit hunted bowhead whales (Freeman *et al.* 1998). The bowhead whale was one of the most important species harvested by Inuit, whereby one whale could provide enough food, oil and building material for an entire camp, for a year (NWMB 2000).

Commercial whaling had a profound impact on the Inuit and the wildlife on which they subsisted. During most of the commercial whaling period, the Beaufort Sea and Nunavut Inuit obtained abundant supplies of bowhead muktuk and meat as a by-product of the commercial whaling operations (Freeman *et al.* 1992; NWMB 2000). This ease with which supplies of muktuk could be obtained from the commercial whalers caused a suspension of traditional bowhead hunting. For Inuit, who had become accustomed to the now-familiar pattern of living near the whaling stations, the eventual closing of the whaling stations brought about real hardship (Freeman *et al.* 1998). Severe depletion of the bowhead population undermined the importance of these animals to Inuit subsistence (Reeves and Mitchell 1990).

The present significance of bowheads to humans can be expressed in terms of their future potential as a renewable subsistence and aesthetic resource (Reeves and Mitchell 1990). Most Inuit are concerned about losing Inuit knowledge of the bowhead whale and techniques for hunting it (NWMB 2000). The Inuit have a strong desire to preserve their culture, so intimately linked with bowheads and whaling, and many believe that resuming the bowhead hunt may help to preserve their culture (NWMB 2000).

Limited numbers of bowhead whales have been hunted since 1990. Inuvialuit of the western arctic landed one bowhead in 1991 and another in 1996 under licence from DFO. One bowhead from the Davis Strait-Baffin Bay population was reported landed in 1993, and five are known to have been removed from the Hudson Bay-Foxe Basin population since 1993.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The bowhead whale has been protected in Canada from commercial whaling under the International Convention for the Regulation of Whaling (1946). However, the convention exempts Aboriginal subsistence (Reeves and Mitchell 1990). In 1979, Canada banned all hunting of bowheads, without a licence, under the Cetacean Protection Regulations of the Fisheries Act (Reeves and Mitchell 1990). The bowhead whale is now protected under the Marine Mammal Regulations of the *Fisheries Act* (Cosens 1997a). It has not been assigned a Canadian national (N) rank by the Nature Conservancy, or a provincial (S) rank by the Conservation Data Centres or Natural Heritage Information Centres. The Global Heritage rank is G4 (Moshenko *et al.* 2003).

The Nunavut Land Claim Agreement, legislated in 1993, contains a provision (5.6.18) that the Nunavut Wildlife Management Board must establish a total allowable harvest of “at least one bowhead subject to conservation requirements”. One estimate of the sustainable removal rate, based on historical bowhead hunts and the assumption that the population was stable or increasing, is one whale per two or three years for the Foxe Basin-Northern Hudson Bay population (DFO 1999) and one whale per 13 years for the Baffin Bay-Davis Strait population (Cosens *et al.* 1993).

Only five bowheads have been landed in Nunavut since 1993 (NWMB 2000). The first one (not licensed) occurred in September 1994 at Igloolik; the second bowhead hunt (approved by the Nunavut Wildlife Management Board and licensed by the federal Department of Fisheries and Oceans) occurred in August 1996 at Repulse Bay; the third licensed hunt occurred in July 1998 in Cumberland Sound; the fourth licensed hunt occurred in 2000 in the Coral Harbour area (NWMB 2000); and the fifth licensed hunt occurred in the Igloolik/Hall Beach area in 2002 (Galipeau pers. comm. 2005).

The Inuvialuit of the Western Arctic have been interested in re-establishing the harvest of bowhead whale from the Beaufort Sea since 1963. Only two bowheads have been landed, both by the Aklavik Hunters and Trappers Committee (HTC) in 1991 and 1996 (Harwood and Smith 2002). No further licences have been requested by (or issued to) the Aklavik HTC since 1996 (Harwood and Smith 2002). There is a subsistence harvest of the Bering-Chukchi-Beaufort population by the Alaskan Inuit. A quota of 280 bowhead whales was set for 1999-2002, of which a total of 67 (plus up to 15 unharvested in the previous year) could be taken each year (NMFS 2000).

Internationally, the bowhead species has been listed since 1994 as Lower Risk/conservation-dependent on the Red List of the World Conservation Union (IUCN). The three populations in Canada are listed separately on the Red List, as follows: Davis Strait-Baffin Bay, Endangered; Hudson Bay-Foxe Basin, Vulnerable; and Bering-Chukchi-Beaufort, Lower Risk/conservation-dependent. The bowhead is in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), meaning that commercial trade in bowhead products is prohibited. The bowhead whale is listed as endangered under the US Endangered Species Act of 1973 (ESA) and depleted under the US Marine Mammal Protection Act of 1972 (MMPA) (Shelden and Rugh 1995).

In the United States, the Commissioner of the Alaska Department of Fish and Game established a new administrative list of Species of Special Concern to complement the Alaska Endangered Species List. A Species of Special Concern is defined as any species or subspecies of fish and wildlife native to the State of Alaska which has entered a long-term decline in abundance or is vulnerable to a significant decline due to low numbers, restricted distribution, dependence on limited habitat resources, or sensitivity to environmental disturbance (The Alaska National Heritage Program 1998). The Bering-Chucki-Beaufort population is on this Species of Special Concern list.

SUMMARY OF STATUS REPORT

Prior to commercial whaling, the Bering-Chukchi-Beaufort population is estimated to have numbered 10,400-23,000 (reduced to fewer than 3,000 at the end of commercial whaling). In 2001, that population was estimated to contain 10,470 (95% CI 8,100-13,500) whales, increasing at an annual rate of 3.4% (95% CI 1.74-5.0%).

The Hudson Bay population (excluding the Foxe Basin segment) was estimated to number 440-470 whales, and the Davis Strait-Baffin Bay population was estimated to number 12,000 whales prior to the onset of commercial whaling. In 1994 the Foxe Basin segment of the northern Foxe Basin summering aggregation was estimated to number 270 bowheads (95% CI 210 to 331), and in 1995 the Hudson Bay segment was estimated to number 75 bowheads (95% CI 17 to 133), with no correction in either case for submerged animals that would have been missed by the observers, e.g., due to submergence. In 2003, the best partial estimate for the Hudson Bay-Foxe Basin population (corrected for animals underwater) was 1026 individuals (95% CI = 338-3124) (DFO 2005, Cosens *et al.* 2005). However, there is considerable uncertainty in the estimates (given the wide confidence limits) and there is an error in calculating the probability of detecting bowheads in 2003 that is believed to have positively biased the estimate by some unknown amount.

The Davis Strait-Baffin Bay population was estimated in the early 1990s to number at least 375 (95% CI 315 to 435; uncorrected estimates), but more extensive surveys in 2002-2004 resulted in a partial estimate (corrected for submerged animals) of between 1539 (95% CI = 631- 3770) and 1944 individuals (95% CI = 797 – 4762) (Cosens *et al.* 2005, DFO 2005). The best partial estimate for the combined 2002 eastern Canadian arctic bowhead populations was 5016 (95% CI = 2611-9633) (i.e., Davis Strait-Baffin Bay population and Hudson Bay-Foxe Basin population combined) (DFO 2005, Cosens *et al.* 2005). However, estimates have extremely wide confidence limits, the correction factor applied to estimate total abundance is overly optimistic, and quantitative data are insufficient to assess trends for either population.

The bowhead has great cultural and, potentially, economic significance to Inuit in parts of the Canadian Arctic. NWMB (2000) documented knowledge of interactions between killer whales and bowheads, including predation and the effect of killer whales

on bowhead behaviour, distribution, and migration. In addition to predation, climatic factors that influence ice conditions may affect the survival and distribution of bowhead whales. An additional concern is the increased interest in offshore oil and gas development in the Beaufort Sea and the eastern Arctic. Bowhead whales respond to man-made sources of underwater noise. They avoid seismic vessels, with avoidance responses observed at distances of up to 20 km from the sound source. Such disturbance would be significant if the seismic vessel was operating in a prime feeding area at a time when bowheads are present.

TECHNICAL SUMMARY

Balaena mysticetus
Bowhead Whale — Baleine boréale
Hudson Bay-Foxe Basin population
Range of Occurrence in Canada: Hudson Bay, Foxe Basin, Hudson Strait

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* For calculation see Table 1	approx. 350,000 km²
• *Specify trend in EO*	stable
• *Are there extreme fluctuations in EO?*	no
• *Area of occupancy (AO) (km²)* For calculation see Table 1	approx. 250,000 km²
• *Specify trend in AO*	stable
• *Are there extreme fluctuations in AO?*	seasonal
• *Number of known or inferred current locations*	not applicable
• *Specify trend in #*	not applicable
• *Are there extreme fluctuations in number of locations?*	not applicable
• *Specify trend in area, extent or quality of habitat*	unknown
Population Information	
• *Generation time (average age of parents in the population)*	60 years[a]
• *Number of mature individuals*	< 1000
• *Total population trend:*	possibly increasing
• *% decline over the last/next 10 years or 3 generations.*	-
• *Are there extreme fluctuations in number of mature individuals?*	unlikely
• *Is the total population severely fragmented?*	no
• *Specify trend in number of populations*	not applicable
• *Are there extreme fluctuations in number of populations?*	not applicable
• *List populations with number of mature individuals in each:*	not applicable
Threats (actual or imminent threats to populations or habitats)	
Potential threats are man-made noise, climate change, and illegal hunting.	
Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* **Alaska/western Canadian Arctic; eastern Canadian Arctic/West Greenland**	Endangered
• *Is immigration known or possible?*	possible
• *Would immigrants be adapted to survive in Canada?*	yes
• *Is there sufficient habitat for immigrants in Canada?*	yes
• *Is rescue from outside populations likely?*	uncertain
Current Status **COSEWIC:** Threatened (May 2005)	

[a]Assuming that the average age of maturity is 25 years, and that the average bowhead lives to 120 years.

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code:** D1

Reasons for Designation:
The population was severely reduced by commercial whaling between 1860 and 1915. Recent population estimates are uncertain, but indicate that there could be as few as 300 mature individuals, of which only half might be females. Threats to this small population include illegal hunting and increased vulnerability to killer whale predation as a result of reduced ice coverage.

Applicability of Criteria

Criterion A (Declining Total Population): Criterion not met. The population is believed to have numbered at least 500 animals in the mid-1800s. Whaling reduced the population in the late 19th C, to the point that it was difficult for the commercial whalers to find a single whale. There is considerable uncertainty in the numbers of whales present in 2003. The 2003 partial estimate has extremely wide confidence limits and is believed to be biased upwards (mean = 1026, 95% CI = 338-3124 individuals). A precautionary approach is to therefore apply the lower confidence limit, which suggests the current population is lower than pre-exploitation levels—but the extent of the decline cannot be ascertained.

Criterion B (Small Distribution, and Decline or Fluctuation): Criterion not met. EO and AO are large, and there is no evidence of fluctuations.

Criterion C (Small Total Population Size and Decline): Criterion not met. Number of mature individuals is <2,500, but there is no evidence of continuing decline.

Criterion D (Very Small Population or Restricted Distribution): Meets Threatened D1. Number of mature individuals <1,000. There is considerable uncertainty about population size due to uncertainties associated with the correction factor applied to the 2003 survey and the portion of the population that was outside the surveyed area. The best partial estimate in 2003 was 1026 individuals (95% CI = 338-3124) and is believed to be overestimated by 20%. Assuming a total population of 800 of which 59% are immature, there may be as few as 300 mature individuals and only 150 mature females. However, there could be even fewer mature females in the population if the lower confidence limit (338) more accurately reflects the total numbers present in 2003.

Criterion E (Quantitative Analysis): Not available.

TECHNICAL SUMMARY

Balaena mysticetus
Bowhead Whale — Baleine boréale
Davis Strait-Baffin Bay population
Range of Occurrence in Canada: Davis Strait, Baffin Bay and Lancaster Sound

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* **For calculation see Table 2**	approx. 800,000 km²
• *Specify trend in EO*	stable
• *Are there extreme fluctuations in EO?*	no
• *Area of occupancy (AO) (km²)* **For calculation see Table 2**	approx. 300,000 km²
• *Specify trend in AO*	stable
• *Are there extreme fluctuations in AO?*	seasonal
• *Number of known or inferred current locations*	not applicable
• *Specify trend in #*	not applicable
• *Are there extreme fluctuations in number of locations?*	not applicable
• *Specify trend in area, extent or quality of habitat*	unknown
Population Information	
• *Generation time (average age of parents in the population)*	60 years[a]
• *Number of mature individuals*	<1000
• *Total population trend:*	possibly increasing
• *% decline over the last/next 10 years or 3 generations.*	-
• *Are there extreme fluctuations in number of mature individuals?*	unlikely
• *Is the total population severely fragmented?*	no
• *Specify trend in number of populations*	not applicable
• *Are there extreme fluctuations in number of populations?*	not applicable
• *List populations with number of mature individuals in each:*	not applicable
Threats (actual or imminent threats to populations or habitats)	
Potential threats are man-made noise, climate change, and illegal hunting.	
Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* **USA:**	Endangered
• *Is immigration known or possible?*	possible
• *Would immigrants be adapted to survive in Canada?*	yes
• *Is there sufficient habitat for immigrants in Canada?*	yes
• *Is rescue from outside populations likely?*	no
Current Status **COSEWIC:** Threatened (May 2005)	

[a]Assuming that the average age of maturity is 25 years, and that the average bowhead lives to 120 years.

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code:** Meets criterion for Endangered, A1b, but assessed as Threatened, A1b, because commercial whaling—the primary cause of population reduction—has ceased.

Reasons for Designation:
The population numbered at least 11,000 animals when commercial whaling began. Whaling reduced the population to less than 30% of its former abundance. Recent estimates indicate that the population is growing and is larger than previously thought, but is likely to still number fewer than 3,000 individuals of all ages. The population qualifies for endangered, but is not judged to be in imminent danger of extinction. Threats include illegal hunting and increased vulnerability to killer whale predation as a result of reduced ice coverage.

Applicability of Criteria

Criterion A (Declining Total Population): Meets Endangered A1b. The population numbered at least 11,000 animals in the early 1700s. Commercial whaling reduced the population to less than 30% of its former abundance. Recent partial population estimates indicate that there may be between 1539 (95% CI = 631-3770) and 1944 individuals (95% CI = 797-4762). This suggests a population that could number less than 3,000 individuals of all ages. Even the most optimistic population estimate for all of the eastern Canadian Arctic is less than 50% of pre-exploitation numbers (i.e., 5016: 95% CI = 2611-9633 for Davis Strait-Baffin Bay population *and* Hudson Bay population).

Criterion B (Small Distribution, and Decline or Fluctuation): Criterion not met. AO and EO are large.

Criterion C (Small Total Population Size and Decline): Criterion not met. Population is small, but there is no evidence of a continuing decline.

Criterion D (Very Small Population or Restricted Distribution): Meets Threatened D1. Number of mature individuals is < 1,000. There is considerable uncertainty about population size due to uncertainties associated with the correction factors applied to the 2003 survey data, and the unknown portion of the population that summered outside the survey area. The best partial estimate in 2003 was between 1539 individuals (95% CI = 631-3770) and 1944 individuals (95% CI = 797-4762), of which 41% could be considered mature individuals.

Criterion E (Quantitative Analysis): Not available.

TECHNICAL SUMMARY

Balaena mysticetus
Bowhead Whale baleine boréale
Bering-Chukchi-Beaufort population
Range of Occurrence in Canada: Canadian Beaufort Sea and Amundsen Gulf

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* Calculation found in Distribution Section, Canadian range, Bering-Chukchi-Beaufort population.	approx. 200,000 km²
• *Specify trend in EO*	stable
• *Are there extreme fluctuations in EO?*	no
• *Area of occupancy (AO) (km²)* Calculation found in Distribution Section, Canadian range, Bering-Chukchi-Beaufort population.	approx. 90,000 km²
• *Specify trend in AO*	stable
• *Are there extreme fluctuations in AO?*	seasonal
• *Number of known or inferred current locations*	not applicable
• *Specify trend in #*	not applicable
• *Are there extreme fluctuations in number of locations?*	not applicable
• *Specify trend in area, extent or quality of habitat*	unknown
Population Information	
• *Generation time (average age of parents in the population)*	60 years[a]
• *Number of mature individuals*	4118 bowheads (41.1% of population)
• *Total population trend:*	increasing
• *% decline over the last/next 10 years or 3 generations.*	-
• *Are there extreme fluctuations in number of mature individuals?*	no
• *Is the total population severely fragmented?*	no
• *Specify trend in number of populations*	not applicable
• *Are there extreme fluctuations in number of populations?*	not applicable
• *List populations with number of mature individuals in each:*	not applicable
Threats (actual or imminent threats to populations or habitats)	
• Potential threats are climate change, man-made noise, and oil spills.	
Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* **USA:**	Endangered
• *Is immigration known or possible?*	possible
• *Would immigrants be adapted to survive in Canada?*	yes
• *Is there sufficient habitat for immigrants in Canada?*	yes
• *Is rescue from outside populations likely?*	no
Current Status **COSEWIC:** Special Concern (May 2005)	

[a]Assuming that the average age of maturity is 25 years, and that the average bowhead lives to 120 years.

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** Not applicable

Reasons for Designation:
This population was hunted to low levels during commercial whaling. Although supporting a regulated hunt, it is recovering and is currently at about 50% of its historical population size. The population is not yet secure and is potentially negatively affected by climate change, and by oil and gas development.

Applicability of Criteria

Criterion A (Declining Total Population): Threatened A1 is almost met. The last census in 2001 suggested that the population was still reduced from historical levels by almost 50%. However, the population has been increasing for at least the last decade, and the hunts in Russia, Alaska, and Canada are regulated to allow for continued recovery.

Criterion B (Small Distribution, and Decline or Fluctuation): The population is widely distributed, and there is no evidence of change in EO or AO.

Criterion C (Small Total Population Size and Decline): Number of mature individuals is <10,000, but there is no evidence of continuing decline.

Criterion D (Very Small Population or Restricted Distribution): Number of mature individuals >1,000 and distribution is not restricted.

Criterion E (Quantitative Analysis): Not available.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Tannis Thomas holds a M.Sc. in Zoology from the University of Manitoba (1999). She completed a master's thesis entitled "Behaviour and Habitat Selection of Bowhead Whales in Northern Foxe Basin, Nunavut," and worked for LGL Limited on a three-year project, which determined if the Eastern Alaskan Beaufort Sea was important to feeding bowhead whales. In this time, she has acquired professional experience on bowhead whales including five years of data collection and analysis on bowheads (boat surveys, aerial surveys, and aerial photography) in the arctic.

Appendix 1. Calculation for Extent and Area of Occurrence of Bowheads

Table 1. The calculation for the extent of occurrence and the area of occupancy for bowheads in the Hudson Bay-Foxe Basin population. Lengths and widths are based on estimated distances from distribution maps.

	Hudson Bay-Foxe Basin Population					
	Extent of Occurrence			Area of Occurrence		
Place	Length (km)	Width (km)	Area (km^2)	Length (km)	Width (km)	Area (km^2)
Hudson Bay			59570[a]			59570[a]
Foxe Basin	300	400	120000	71	52	3692
Hudson Strait	800	150	120000	800	150	120000
Gulf of Boothia	350	150	52500	350	150	52500
Total			352070			235762

[a]Ross's (1974) estimate of the area of the Hudson Bay commercial whaling grounds during the nineteenth century.

Table 2. The calculation for the extent of occurrence and the area of occupancy for bowheads in the Davis Strait-Baffin Bay population. Lengths and widths are based on estimated distances from distribution maps.

	Davis Strait-Baffin Bay Population					
	Extent of Occurrence			Area of Occurrence		
Place	Length (km)	Width (km)	Area (km^2)	Length (km)	Width (km)	Area (km^2)
Davis Strait/Baffin Bay	2100	322[a]	676200	2100	100[b]	210000
Lancaster Sound	500	65	32500	500	65	32500
Prince Regent Inlet	350	100	35000	350	100	35000
Admiralty Inlet	150	20	3000	150	20	3000
Pond Inlet	300	10	3000	300	10	3000
Cumberland Sound	250	75	18750	250	75	18750
Frobisher Bay	200	30	6000	200	30	6000
Total			774450			308250

[a]There is movement between Greenland and Baffin Island, so the 200-mile limit is used as the extent of occurrence.
[b]Most bowheads concentrate within 100 km from shore, so the 100-km width was used as the area of occupancy.