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Whales of the Inuvialuit Settlement Region in Canada's Western Arctic: An Overview and Outlook

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ABSTRACT. The beluga whale (*Delphinapterus leucas*) and the bowhead whale (*Balaena mysticetus*) are seasonal migrants to Canada's Western Arctic, occupying summer range in the southeastern Beaufort Sea and Amundsen Gulf within the Inuvialuit Settlement Region (ISR). These whales also travel through United States (Alaskan) and Russian offshore waters, which include migration routes and overwintering areas for both species. The beluga has for centuries been an important food resource of the aboriginal people of the Mackenzie Delta. From 1990 to 1999, the annual subsistence harvest of beluga in the ISR averaged 111, while only two bowheads were landed during this same period. The minimum size of the Eastern Beaufort Sea beluga stock has been estimated at 32 453 whales. The total annual removal of beluga by subsistence hunters from the ISR and Alaska is estimated at 189 whales, which is less than 0.6% of the minimum estimate of stock size. This level of harvest is sustainable. Between 1848 and 1921, commercial whalers decimated the Bering Sea population of bowhead whales. The size of the population, based on 1993 data, is estimated at 8200 (95% estimation interval of 7200–9400), constituting more than 90% of the world's remaining bowheads. This population increased at a rate of 3.2% from 1978 to 1993, while sustaining a harvest of about 0.6% per year. To ensure the continued well-being of these whales and their habitats, it is recommended that existing monitoring programs, commitments, and co-management partnerships be nurtured and maintained.

Key words: beluga, bowhead, stock status, migration, Beaufort Sea, subsistence hunting

RÉSUMÉ. Le béluga (*Delphinapterus leucas*) et la baleine boréale (*Balaena mysticetus*) sont des migrateurs saisonniers qui fréquentent l'ouest de l'Arctique canadien, occupant un territoire estival dans le sud-est de la mer de Beaufort et le golfe Amundsen au sein de la Région désignée des Inuvialuit (RDI). Ces baleines se déplacent également dans les eaux situées au large des États-Unis (alaskiennes) et de la Russie, qui comprennent des voies migratoires et des aires d'hivernage pour les deux espèces. Le béluga représente depuis des siècles une importante ressource alimentaire pour les Autochtones du delta du Mackenzie. De 1990 à 1999, la moyenne annuelle des prélèvements de subsistance du béluga dans la RDI était de 111, alors que seulement deux baleines boréales avaient été débarquées durant la même période. La taille minimum du stock de bélugas dans l'est de la mer de Beaufort est évaluée à 32 453 individus, et les prises annuelles de bélugas effectuées au sein de la RDI et de l'Alaska dans le cadre de la chasse de subsistance sont évaluées à 189 individus, ce qui représente moins de 0,6 p. cent de la taille minimun du stock. Ce niveau de prélèvement est par conséquent durable. Entre 1848 et 1921, les baleiniers commerciaux ont décimé la population des baleines boréales dans la mer de Béring. D'après les données de 1993, on estime la taille de la population à 8200 (comprise entre 7200 et 9400 avec 95 p. cent de probabilité), soit plus de 90 p. cent du nombre de baleines boréales qui existent aujourd'hui dans le monde. Cette population a augmenté à un taux de 3,2 p. cent de 1978 à 1993, tout en faisant l'objet d'un prélèvement annuel d'environ 0,6 p. cent. Afin d'assurer le bien-être permanent de ces baleines et de leurs habitats, on recommande d'appuyer et de conserver les programmes de surveillance, les engagements et les partenariats de cogestion actuellement en place.

Mots clés: béluga, baleine boréale, statut du stock, migration, mer de Beaufort, chasse de subsistance

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INTRODUCTION

Two species of cetacea, the beluga whale (*Delphinapterus leucas*) and the bowhead whale (*Balaena mysticetus*), are seasonal migrants to the southeastern Beaufort Sea and Amundsen Gulf, both within the Inuvialuit Settlement Region (ISR) in Canada's Western Arctic (INAC, 1984). Beluga whales that range through this region are known as the Beaufort Sea stock (Hill and DeMaster, 1999), or, as referred to here, the Eastern Beaufort Sea stock (Hazard, 1988). Bowhead whales that occur in the southeastern Beaufort Sea belong to a stock known as the Bering Sea stock (Burns et al., 1993), the Western Arctic population (Hill and DeMaster, 1999), or the Bering-Chukchi-Beaufort Seas Stock (e.g., Zeh et al., 1991). The term "Bering Sea stock" is used here.

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The Bering Sea bowhead population and the Eastern Beaufort Sea beluga stock spend part of their annual cycle in Alaska and Russia, as well as in Canada, where they summer in open-water habitat in the southeastern Beaufort Sea and Amundsen Gulf (Fig. 1).

There are extralimital records for three other species of cetacea as well: gray whales (*Eschrichtius robustus*), observed in offshore waters by researchers studying the bowhead whale (Rugh and Fraker, 1981; Wartzok, 1990; Richardson, 1999); killer whales (*Orcinus orca*); and narwhals (*Monodon monoceros*). Beluga hunters in the nearshore areas (Billy Day, pers. comm. 1999) have observed these latter two species, but only rarely. The existence of an Inuvialuktun word (*aarlu*) for killer whale (Lowe, 1984a, b) indicates that the people of the Mackenzie Delta and Beaufort Sea knew of this species. Although no sightings of killer whales have been confirmed in recent times, there was one report in 1957 of a killer whale in Kugmallit Bay, and the hunters linked this to the fact that beluga did not enter the Bay in that year (Billy Day, pers. comm. 1999). Killer whales have been recorded for the Alaskan Beaufort Sea (Leatherwood et al., 1986; Lowry et al., 1987a) and from the Point Barrow area (George et al., 1994).

There have been no recent records of narwhal in the region, although one beluga landed off Tuktoyaktuk in October 1991 had the tip of a narwhal tusk embedded in its melon (Orr and Harwood, 1998). Earlier, a narwhal skull, complete with tusk, had been found in Prince Albert Sound on western Victoria Island (Smith, 1977).

Beluga Whale

The beluga whale or white whale, known by the Inuvialuit as *qilalugaq* (Lowe, 1984b), is an odontocete or toothed whale (Stewart and Stewart, 1989). It lacks a dorsal fin, is found throughout the Arctic, and is the most common cetacean species in the Beaufort Sea.

Newborn calves measure 1.5 m in length, weighing 50–80 kg at birth. Belugas are called white whales because they lose all the pigmentation in their skin and become almost pure white between seven and nine years of age. Adult female belugas harvested from the nearshore Beaufort Sea average 3.8 m in length, and adult males average 4.3 m (Harwood et al., 2002). Data from other stocks indicate that female belugas are sexually mature between four and seven years of age, while males mature at six to seven years (Heide-Jørgensen and Teilman, 1994). Belugas live to be 35–40 years of age, although individuals older than this have been found in the Eastern Beaufort Sea stock (DFO, 2000).

Natural mortality can result from predation by polar bears (Freeman, 1968; Heyland and Hay, 1976; Lowry et al., 1987b; Smith and Sjare, 1990; Rugh and Shelden, 1993) or killer whales (Sergeant and Brodie, 1969; Burns and Seaman, 1985; Byers and Roberts, 1995), ice entrapments (Freeman, 1968), and disease (Young, 1994; O. Nielsen, DFO, pers. comm. 2000).

The stock of beluga that ranges to the Beaufort Sea is one of at least seven in Canadian waters (Breton and Smith, 1990) and is one of Canada's largest stocks of beluga. Much progress has been made using both mitochondrial and nuclear DNA markers to identify the many stocks of beluga inhabiting the North American Arctic (Helbig et al., 1989; Brown, 1996; Brennin et al., 1997; Brown-Gladden et al., 1997, 1999; O'Corry-Crowe and Lowry, 1997; O'Corry-Crowe et al., 1997). These studies have shown that genetic differences exist between Eastern Beaufort Sea beluga and other stocks in Canada's eastern Arctic (Brown, 1996), and between the other beluga stocks found in Alaska (Lowry et al., 1988; O'Corry-Crowe and Lowry, 1997; O'Corry-Crowe et al., 1997).

The beluga whale is a highly vocal species, with a well-developed capability for echolocation (Turl, 1990). Belugas are well known for their habit of aggregating in nearshore habitats and estuaries during the summer months (Smith et al., 1990). The reasons why belugas come into estuaries were not well understood until recently. Earlier theories included a thermal advantage for calves and food availability (Fraker et al., 1979). More recently, it has been shown that the occupation of the warm, less saline waters of an estuary is related to the annual moult and is connected with significant hormonal changes correlated with new skin growth (St. Aubin et al., 1990). Although the muddy water of the Mackenzie River precludes direct observation of subsurface behaviour, in other areas of the Arctic belugas have been observed actively rubbing their skin on the seafloor. This removes the old dead skin and accelerates the moulting process (Smith et al., 1992).

Bowhead Whale

The bowhead whale is a mysticete, or baleen whale, mostly black in colour, with white markings on chin and flukes. The white markings are often associated with maturity (Koski et al., 1993) but are not a certain indicator of it. Bowheads are known to the coastal Inuvialuit as *arviq* (Lowe, 1984a).

Female bowhead whales mature when they reach 12.5–14 m in length (Koski et al., 1993), at 17 to 20 years (Schell and Saupe, 1993) or older (Zeh et al., 1993; George et al., 1999). They calve once every three to five years (Miller et al., 1992; Rugh et al., 1992), and have a low reproductive capacity (Nerini et al., 1984). Since 1981, six stone harpoon blades have been found in five bowhead whales taken in Alaska. These were of the variety used in the 19th century, attesting to the advanced age of these individual whales (Weintraub, 1996). These findings, along with aspartic acid racemization analyses on eye lenses of harvested whales, suggest that the longevity of bowheads may exceed 100 years (George et al., 1999).

Bowheads of the Bering Sea population winter in the Bering Sea and range to the Beaufort Sea and Amundsen Gulf in summer. They are one of three bowhead whale

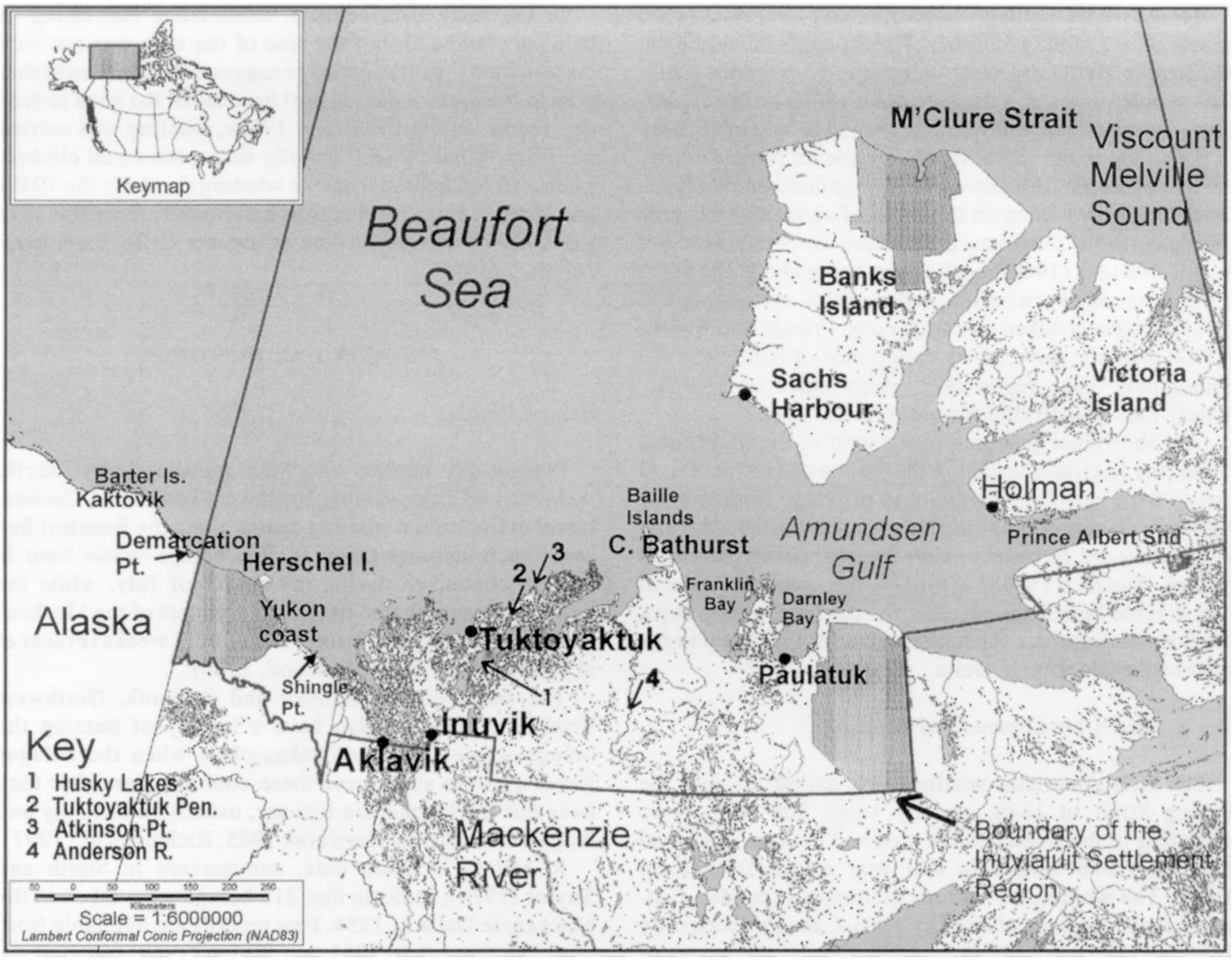

FIG. 1. Location of Inuvialuit communities and geographic locations mentioned in text.

stocks that summer in Canadian waters, the others being the Foxe Basin/Northern Hudson Bay stock and the Baffin Bay stock. The Bering Sea population constitutes more than 90% of the world's remaining bowhead whales (Marine Mammal Commission, 1999). Bowhead whales are preyed upon by killer whales (George et al., 1994) and have long been harvested by the Inuit as a source of food (Stoker and Krupnik, 1993). The present harvest of bowhead whales in Alaska and Russia is regulated according to a block quota set by the International Whaling Commission (IWC) and administered by the Alaska Eskimo Whaling Commission (AEWC) (Marine Mammal Commission, 1999).

Of the three stocks of bowhead whales in Canada, the Bering Sea stock has been the most studied (Burns, 1993). Recent genetic research, based on a small number of samples from biopsy darts, suggests that Davis Strait bowhead whales differ from those found in Foxe Basin and Northern Hudson Bay, which are actually more closely related to the Bering Sea population (Leduc et al., 1998; Maiers et al., 1999). Rooney et al. (1999) found no evidence of genetic differentiation among bowheads of the Bering Sea population.

HISTORY OF USE

Pre-Commercial Whaling

Aboriginal people from Siberia are thought to have hunted marine mammals, including the bowhead, as far back as 2500 years ago (Bockstoce, 1986). One thousand years ago, they crossed the Bering Strait to what is now northern Alaska, northern Canada, and Greenland. In coastal areas between the Baillie Islands and Herschel Island, McGhee (1988) estimates there were 2000–4000 aboriginal people living in five distinct groupings. This human population was thought to be greater than the combined population in all areas of the Eastern Canadian Arctic at that time.

Beluga whale hunting was particularly important to the people of two of the groupings. These people inhabited the Mackenzie Delta and were called the Kupugmiut (300–400 people) and the Kittegaryumiut (800–1200 people). They shared a common whaling ground in Kugmallit Bay in the summer and likely lived as separate groups during the winter months (McGhee, 1988). The number of belugas landed may have been on the order of about 150 per year (Nuligak, 1966). At times, the harvests were considerably higher. Nuligak (1966) recalls there being about 200 hunters and that on one occasion, he heard that as many as 300 belugas had been taken on a single day. Friesen and Arnold (1995) describe the relative importance of belugas to the Kupugmuit. They report that beluga made up approximately half of their diet for half of each year.

One aboriginal grouping to the west of the Mackenzie Delta (the Kigirktarugmiut in the Yukon coastal area) and two to the east (the Avvagmiut in the Cape Bathurst and Anderson River areas and the Nuvorugmiut in the Atkinson Point area) are thought to have hunted mainly bowhead whales. McGhee (1988) estimates the combined take at two to three bowheads per year for the latter two groups, but does not estimate the harvest size for the group to the west of the Mackenzie Delta.

During and After Commercial Whaling

The first American whaling ship sailed through the Bering Strait in 1848, and by 1850, 200 ships were operating in the Beaufort Sea area and took an estimated 1700 bowhead whales in that year alone (Bockstoce, 1986). The whaling operations gradually expanded eastward, reaching Barter Island by 1886, Canadian waters by 1888, and Herschel Island by 1889. During the winter of 1894–95, the crews of 15 whaling ships spent the winter at Herschel Island. The price of whalebone collapsed in 1907, and the last bowhead whale taken by a commercial whaling ship in Canadian waters was taken in 1921. Between 1849 and 1914, the commercial whalers were estimated to have killed 18 684 bowhead whales (Bockstoce, 1986). Assuming the stock numbered 3000 at the cessation of commercial whaling, the size of the Bering Sea bowhead population before commercial whaling began has been estimated at 10 400 to 23 000 (Woodby and Botkin, 1993).

Disease and alcohol decimated the human population during the period of commercial whaling. At its lowest point in 1910, the human population, from Demarcation to the Baillie Islands, likely numbered 260 (Usher, 1971). A wave of immigrants arrived from Alaska between 1913 and 1923, and by the early 1920s, the human population was about 400. There appears to have been little subsistence whaling for the bowhead during or after the commercial whaling era (Reeves and Mitchell, 1985). The last bowhead whale landed by the ancestors of the Inuvialuit in Canada's Western Arctic was taken in 1926 at the Baillie Islands (Fig. 1; Billy Day, pers. comm. 1999).

In the early 20th century, subsistence harvesting of belugas continued, but the size of the take was not well documented. Local knowledge suggests the take was higher than in the present day, in part because of the need to feed dog teams. In the 1920s and 1930s, whaling was carried out from "whale boats" or jolly boats, the small clinker-built craft left behind from the whaling ships. By the 1940s and 1950s, beluga whaling was done mainly from 10–12 m gasoline- or diesel-powered schooners (Billy Day, pers. comm. 1999).

PRESENT-DAY HUNTING

Beluga Whale

Present-day hunters and their families from Inuvik, Aklavik, and Tuktoyaktuk, Northwest Territories, Canada, travel to traditional whaling camps along the Beaufort Sea coast each summer (Fig. 2). The beluga whale hunt is usually conducted during the month of July, while the belugas are aggregated in the warm waters of the Mackenzie River estuary, and lasts for four to six weeks (Fraker et al., 1979; Norton and Harwood, 1986).

The Inuvialuit of Holman and Paulatuk, Northwest Territories (Fig. 1) also have a history of hunting the beluga whale. This hunt takes place when the belugas travel close to shore near these communities, after they have left the Mackenzie Estuary, usually in late July and August (Norton and Harwood, 1985; Richard et al., 1997).

RCMP G Division data, summarized in Smith and Taylor (1977), indicate that 210 beluga were taken in the Mackenzie Delta in 1954. Few records are available from that time through to 1961, but Strong (1989) reported the average takes from 1961 to 1966 to be 160 belugas annually. The combined landed harvest of beluga whales from the shores of the Beaufort Sea and Amundsen Gulf averaged 134 from 1970 to 1979, 124 from 1980 to 1989, and 111 from 1990 to 1999 (Harwood et al., 2002).

Hunts today are commonly carried out from 4.6 m long aluminum boats, using fewer hunters than in the past. Often only one or a few boats work together in a beluga harvest. It is common practice to harpoon a whale before killing it, so that retrieval is easier (DFO, 2000). Inuvialuit beluga hunters have used nets successfully in the past and continue to do so occasionally in the present; however, the nets must be tended continuously. In each community of the ISR, the Hunters and Trappers Committee has developed by-laws for beluga hunting and guidelines for touristic whale watching (FJMC, 1998).

Beluga of the Eastern Beaufort Sea stock are also harvested during their migrations to and from the eastern Beaufort Sea by residents of some coastal villages in Alaska (Diomede, Kotzebue, Kivalina, Point Hope, Wainwright, Point Barrow, and Kaktovik) (Lowry et al., 1988). The average take of beluga (including losses) from these Alaskan villages was 64 per year (range 42–117 whales

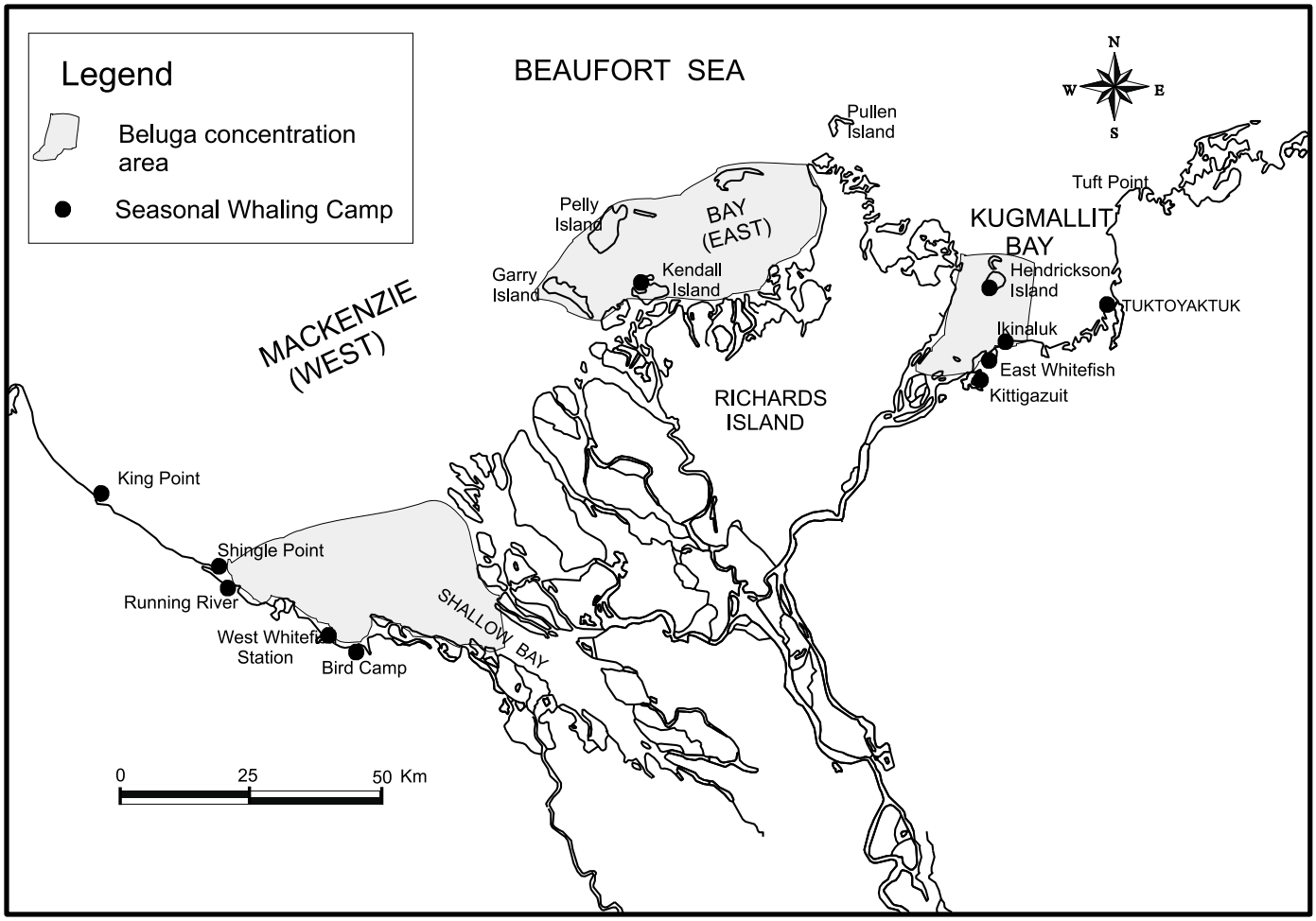

FIG. 2. Beluga whale concentration areas in the Mackenzie Estuary and the location of seasonal whaling camps used by Inuvialuit hunters and their families.

per year) between 1995 and 2000 (Suydam and Frost, 2001). The Alaska Beluga Whale Committee (Adams et al., 1993) has been facilitating the collection of these harvest statistics in recent years.

Chukotka residents may also take beluga from this stock, but the size and origin of this take has not been documented (Klumov, 1939). Harvests in Russian waters since 1990 have been low, probably not exceeding 20–30 animals per year (Belikov, 1999). The stock(s) from which these harvested animals came has not been determined. Future work is proposed to address this aspect (Huntington, 2001).

Hunter-based beluga monitoring programs, in place in the Mackenzie Delta since 1973 and in the Paulatuk, Northwest Territories, area since 1989, have collected data on the number of beluga whales harvested and on the efficiency of the hunt (Hunt, 1979; Norton and Harwood, 1986; Strong, 1990; Weaver, 1991; Harwood et al., 2002). Between 1980 and 1999, data on the size (n = 1953), sex (n = 2163), and age (n = 383) of the landed whales have also been collected from both the Mackenzie and Paulatuk harvests. The harvest consisted of 2.3 males to each female in the Mackenzie, and 3.7 males to each female in the Paulatuk area.

Assuming that a growth layer group (GLG) consists of two dentinal annuli, one dark and one light, deposited in the teeth in one year (Perrin and Myrick, 1980), the median ages of belugas taken in the Mackenzie harvests were 23.5 years (47 GLG) for females (n = 80) and 24 years (48 GLG) for males (n = 286). More than 92% of the aged sample from the harvest consisted of whales estimated to be 10 years and older (≥ 20 GLG).

The Fisheries Joint Management Committee (FJMC) was established in 1986 in accordance with the terms of the Inuvialuit Final Agreement (INAC, 1984), to advise the Minister of Fisheries and Oceans on fish, fish habitats, and fish usage in the ISR. Together with the FJMC, beluga hunters of the ISR have been active participants in the delivery of the annual Beluga Monitoring Program.

As well, the hunters have worked with the FJMC to prepare and implement the Beaufort Sea Beluga Management Plan (FJMC, 1998), which includes guidelines for tourism operators in the region, community-specific bylaws to govern beluga hunting, and guidelines for protection of beluga habitat according to beluga management zones. The Department of Fisheries and Oceans (DFO), under the Oceans Act and with the support of the FJMC and other Inuvialuit organizations, is undertaking research and consultation activities that will possibly lead to the designation of this habitat as a Marine Protected Area

under the *Oceans Act*. This designation would support the Beaufort Sea Beluga Management Plan, and part of the DFO's larger Beaufort Sea Integrated Management Initiative (BSIMPI) for the western Canadian Arctic (Fast et al., 1998, 2001).

Bowhead Whale

The Inuvialuit of the Western Arctic have long been interested in re-establishing their tradition and, with recent land-claim legislation, their right to harvest the bowhead whale from the nearshore Beaufort Sea. An internal government report dated 1963 is the first written record of the people's interest in resuming bowhead whale hunting (Freeman et al., 1992). In 1965, the Department of Northern Affairs and Natural Resources issued licenses to the communities of Aklavik, Tuktoyaktuk, and Sachs Harbour to take one bowhead whale each. No bowheads were harvested under these licenses. Other attempts by residents of Aklavik to resume bowhead hunting took place in 1969, 1975, and 1979, but no hunting took place (chronology and documents are presented in Freeman et al., 1992).

In 1988, the Aklavik Hunters and Trappers Committee (HTC) prepared a formal proposal for a license to land one, or strike two, bowhead whales from the waters off Shingle Point, Yukon (Freeman et al., 1992). After a lengthy consultative and review process, the DFO issued the license to the Aklavik HTC in 1991, and one subadult male bowhead whale (11.1 m long) was landed at Shingle Point on 3 September of that year (Fig. 1).

Licenses were requested and issued annually from 1991 through 1996, and a second whale, also a subadult male (11.2 m), was landed by the Aklavik HTC at Shingle Point on 24 July 1996. With DFO officials on site, the whale was killed within 45 minutes of being struck, using shoulder guns and explosives, equipment that was used in the commercial whaling era. No further licenses have been requested by (or issued to) the Aklavik HTC since 1996.

DISTRIBUTION, MOVEMENTS AND FEEDING

Beluga Whale

Beaufort Sea belugas leave their Bering Sea wintering areas in early spring and migrate eastward past Point Barrow and through the Alaskan Beaufort during April and May (Moore et al., 1993). They are thought to move to the southeastern Beaufort Sea through leads far offshore, arriving off the west coast of Banks Island in late May and early June (Fraker, 1979). When they arrive in the southern Beaufort Sea, usually during early June, they are known to move in a southwestward direction along the landfast ice edge off the Tuktoyaktuk Peninsula (Norton and Harwood, 1986). When the landfast ice barrier that spans the outer Mackenzie Estuary breaks in late June or early July, the belugas then move into the main bays (Kugmallit Bay, East and West Mackenzie Bays, and Shallow Bay), where they aggregate for much of the month of July (Fig. 2; Norton and Harwood, 1986). The number of belugas in the Mackenzie Estuary generally peaks in early July and begins to decline by mid-July. By early August, few belugas remain.

At the same time that the belugas are aggregated in the Mackenzie Estuary, others are widely distributed throughout the offshore Beaufort Sea and in Amundsen Gulf (Norton and Harwood, 1985). In offshore areas, belugas were found to be widely distributed as individuals or in small groups (i.e., two surfaced whales). The whales frequently exhibit directional movement, and whales in groups often dive in a synchronous pattern (Harwood et al., 1996).

Belugas feed on a wide variety of prey species, including squid (Fraker, 1979), fish (Seaman et al., 1982), and invertebrates (Vladikov, 1947; Kleinenberg et al., 1969). Belugas harvested in nearshore areas of the Mackenzie River estuary had Arctic cisco (*Coregonus autumnalis*), burbot (*Lota lota*), and whitefish (*Coregonus* spp.) in their stomachs (B. Day, pers. comm, 1999; L. Harwood, pers. obs. 2000). They probably also feed on other available prey species, including Pacific herring (*Clupea pallasi*), least cisco (*Coregonus sardinella*), rainbow smelt (*Osmerus mordax*), and inconnu (*Stenodus leucichthys nelma*).

In the Mackenzie estuary, belugas landed in the subsistence hunt invariably have empty stomachs, but this is thought to be due to regurgitation during the chase (B. Day, pers. comm. 1989). Residents of the coastal whaling camps have observed belugas feeding at the mouth of the river channel. However, during studies of other stocks in other estuaries, feeding has not been observed, and empty stomachs are common (Smith et al., 1994).

Feeding appears to be an important activity of belugas while they are in the offshore. During aerial surveys, Norton and Harwood (1985) saw belugas making rapid, erratic movements in the lee of artificial islands and near the Baillie Islands, presumably feeding on schools of fish. One beluga landed off Tuft Point along the Tuktoyaktuk Peninsula had a stomach full of Arctic cisco (*Coregonus autumnalis*) (Orr and Harwood, 1998).

A total of 30 satellite tags have been placed on belugas in the Mackenzie River estuary (4 in 1993, 16 in 1995, and 10 in 1997) (Richard et al., 1997, 2001). Twelve adult males fitted with satellite tags, one in 1993 and 11 in 1995, made their way over 1000 km to distant Viscount Melville Sound. There they made repeated dives to the ocean floor, to depths exceeding 540 m. The other tagged whales moved directly into Amundsen Gulf from the Mackenzie, and all those that continued to transmit into September eventually moved westward.

The return migration to the Bering Sea begins in late August. This is indicated by a general decline in the relative abundance of belugas in the offshore aerial surveys in early September compared with late August (Harwood and Borstad, 1985; Norton and Harwood, 1985),

as well as by results from satellite telemetry studies (Richard et al., 2001) and aerial surveys conducted over the Beaufort Sea in Alaska (Clark et al., 1993). Using a variety of migration routes, varying from 100–400 km offshore of northern Alaska, belugas tagged in 1997 moved west to the Wrangel Island area, where they converged and subsequently aggregated during the month of October. The longest-lasting tag (129 days) was attached to a 421 cm male, which went through the Bering Strait in late November 1997 just before signal transmission ceased (Richard et al., 2001).

The exact locations of the wintering grounds in the Bering Sea are not known. Traditional knowledge gathered from Chukotka hunters and data provided by Russian scientists (Huntington, 1998; Melnikov et al., 1998) have revealed information about belugas seen off these shores in winter, although it is not known if they are from the Beaufort stock. Beaufort Sea belugas share the Bering Sea wintering areas with at least three other beluga stocks, from Bristol Bay, Norton Sound, and the eastern Chukchi Sea (Point Lay) (Lowry et al., 1988; O'Corry-Crowe et al., 1997).

In Alaskan waters, satellite telemetry studies of belugas tagged at Kasegaluk Lagoon in 1998 and 1999 have begun to describe the summer and autumn movements of belugas of the Eastern Chukchi Sea stock (Suydam et al., 1999). Future work may include capture and tagging of belugas along the northern shores of the Chukotka Peninsula, or at Wrangel Island in Russia, to enable tracking through the winter period (Huntington, 2001). Such tracking is needed to determine the specific locations in the Bering Sea where overwintering takes place and to study other aspects, including behaviour on the wintering grounds.

Bowhead Whale

Bowhead whales of the Bering Sea population migrate eastward past Point Barrow in April and May (Clark and Johnson, 1984; George et al., 1989). They are thought to move to the southeastern Beaufort Sea through offshore leads (Moore and Reeves, 1993), arriving in the Canadian Beaufort Sea off the west coast of Banks Island by late May and early June (Fraker, 1979).

From their arrival in late spring until the middle of August, bowhead whales are widely distributed throughout the offshore, singly or in small groups of 2–3 surfaced animals (Davis et al., 1982; Harwood and Borstad, 1985). By mid-August, oceanographic conditions tend to concentrate the bowhead whale's planktonic prey items (Thomson et al., 1986). At this point, the bowhead whales aggregate in relatively few (perhaps four or five) specific areas on their summer range (Fig. 3; Harwood, 1989). Extensive aerial surveys conducted throughout the southeastern Beaufort Sea in August and September of 1980–86 (for summary, see Richardson et al., 1987) revealed that the same areas are used in successive years, although not all areas are used in all years.

Bowhead whales feed on crustaceous zooplankton and must seek out areas where prey is adequately concentrated in order to meet their energy requirements (Lowry, 1993). In the southeastern Beaufort Sea, 1985 and 1986 sampling of plankton in close proximity to feeding bowhead whales revealed predominantly (76–92%) copepods (*Limnocalanus macrurus*, *Calanus hyperboreus*, *Calanus glacialis*), along with gammarid and hyperiid amphipods, euphausiids, and isopods (Bradstreet and Fissel, 1986, 1987). Bowhead whales feeding near the interface of the Mackenzie River with the saline waters of the offshore Beaufort Sea were most likely feeding on dense aggregations of mysids (*Mysis oculata*) near the seafloor (Bradstreet and Fissel, 1986, 1987).

Clearly, oceanographic features that lead to upwelling of nutrient-rich waters are important in determining zooplankton distribution (Harwood and Borstad, 1985), which in turn appears to influence the distribution of bowhead whales. The major determinant of zooplankton distribution in the southeastern Beaufort Sea appears to be the Mackenzie River plume (Grainger, 1975; Thomson et al., 1986), the nature and extent of which are determined by surface winds and currents.

The fall migration of bowhead whales starts in September, and they feed as they travel westward back to the Bering Sea. Bowhead whales have been seen feeding in Franklin Bay, off Cape Bathurst, and off the Tuktoyaktuk Peninsula in late September, and in Yukon coastal waters as late as 4 October 1986, while sea ice formed 30 km away in the Mackenzie estuary (Harwood and Borstad, 1985; Harwood, 1989). Aerial surveys were conducted over the Alaskan Chukchi and Beaufort Seas during fall of 1982–91 (Ljungblad et al., 1986; Moore and DeMaster, 1998; Moore, 2000; Moore et al., 2000). Results were used to determine bowhead whale distribution and migration routes and later to examine habitats selected by the whales throughout Alaskan offshore waters (Moore, 2000). This aerial survey program by the U.S. Minerals Management Service, Anchorage, Alaska, has continued annually since 1991, although the results have not yet been published.

Bowhead whale movements have recently been studied using satellite-linked telemetry (Krutzikowsky and Mate, 2000; Mate et al., 2000). This is the first study to measure dive depth, dive duration, and time-at-depth in this species. This telemetry work also elucidated feeding areas and travel routes used by bowhead whales on their summer range and during fall migrations through Canadian, Alaskan, and Russian waters. Moore et al. (1995) found that the Chukotka coast may be an important feeding or staging area for bowheads during the month of October.

Current research suggests that the present-day distribution of the bowhead whale is different from what it was 10000 years ago. Post-glacial remains of bowhead whales indicate several periods of expansion and contraction of the west-to-east range of bowhead whales over the past 10500 years (Dyke et al., 1996). From 10500 to 8500 years ago, bowhead whales extended their range to the

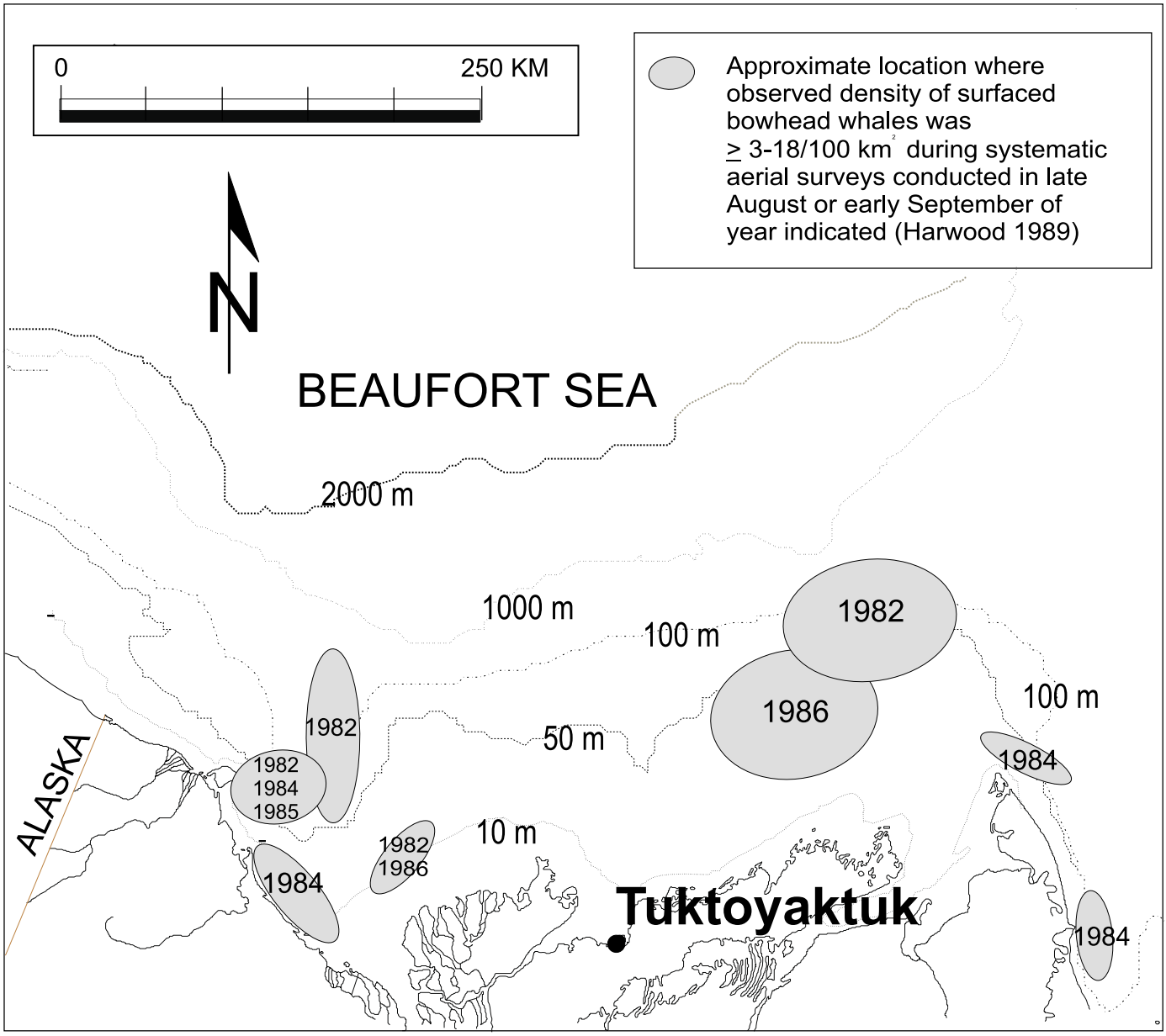

FIG. 3. Areas of the southeastern Beaufort Sea and Amundsen Gulf where bowhead whales aggregated during late summer in 1982, 1984, 1985, and 1986.

glacial ice margins, from the Beaufort Sea all the way into Baffin Bay. From 8500 to 5000 years ago, with cooler dry conditions, bowheads were excluded from most of the Central Arctic archipelago, but entered the area with warming conditions from 5000 to 3000 years ago (Dyke et al., 1996). From 3000 years ago to the present, with cooler conditions, bowhead whales were again separated as western and eastern stocks. Recently initiated work in the Amundsen Gulf–Coronation Gulf areas, confirms that the bowhead population existed as far east as western and southern Victoria Island during the Holocene (10200–8800 years ago). Decreasing numbers of bowhead remains have been found as sampling has proceeded farther east (A. Dyke, Geological Survey of Canada, Ottawa, pers. comm. 1999) towards the Central Arctic channels, where the ice plug existed during the cooler periods.

STOCK STATUS

The latest aerial surveys (1992) give an index of stock abundance of 19 629 belugas (95% confidence interval 15 134–24 125, Harwood et al., 1996). These surveys did not sample the complete range of this stock, and a considerable but yet undetermined number of whales was underwater during the aerial counts. Using the Potential Biological Removal (PBR) guidelines described by Wade and Angliss (1997), Hill and DeMaster (1999) calculated the population size for Beaufort Sea beluga to be 39 258, with a coefficient of variation (CV) of 0.229, and a minimum population size of 32 453.

Total annual removal of belugas from the Beaufort Sea stock, estimated from landed harvests and losses in the ISR (average 125/yr, 1990–99) and in Alaska (average 64/yr,

1995–2000; Suydam and Frost, 2001), is estimated at 189 whales. This level of harvest is less than 0.6% of the minimum estimate of stock size and thus well below the 2.0–3.85% rate of population increase expected for beluga stocks (Kingsley, 1996, 1998; Cosens et al., 1998, 1999). The available biological data provide further evidence that this stock is not being overharvested (Cosens et al., 1998, 1999; Hill and DeMaster, 1999; DFO, 2000; Harwood et al., 2002).

The most recent estimate of the size of the Bering Sea bowhead whale population, 8200 (with 95% estimation interval of 7200–9400), was based on the acoustic and visual census done in spring 1993 (Raftery and Zeh, 1998). The annual rate of increase has been estimated at 3.2%, with a 95% confidence interval of 1.4% to 5.1% (Raftery and Zeh, 1998). The total number of bowheads struck in Alaska averaged 47 per year between 1988 and 1998 (Marine Mammal Commission, 1999), equivalent to 0.6% of the 1993 estimate of stock size. The population is thought to be recovering and sustaining this take (Raftery and Zeh, 1998).

The subsistence take of bowhead whales by Alaskan hunters is managed by the Alaska Eskimo Whaling Commission (AEWC), under a quota system administered by the International Whaling Commission (IWC). A five-year (1998–2002) block quota of 280 bowhead whales has been set for Alaska and Chukotka: no more than 67 whales are to be struck in any given year, except that up to 15 unused strikes can be carried forward to the next year (Marine Mammal Commission, 1999). This quota includes a new allowance of five bowhead whales for Chukotka hunters.

OTHER SOURCES OF MORTALITY

Disease

Emerging infectious diseases have been shown to have considerable negative impacts on populations of marine mammals (Young, 1994). Influenza A virus strains (Hinshaw et al., 1984) and morbilliviruses (Lipscomb et al., 1994) not only cause sporadic mortality among individual cetaceans that become infected, but are also capable of causing widespread die-offs in susceptible populations of animals (Young, 1994).

Bacterial pathogens such as *Brucella*, which rarely kill infected animals, can have significant effects on populations by interfering with and limiting reproductive success (Kennedy and Miller, 1993). Evidence is accumulating that this may also be the case in marine mammals (Ewalt et al., 1994; Miller et al., 1999). Serological evidence of *Brucella* infection has been found in belugas of the Beaufort Sea, where 1.8% (2 of 109) tested positive in 1995 and 1996, and 10% (3 of 30) tested positive in 2000 (O. Nielsen, DFO, unpubl. data). These results indicate that the Beaufort Sea belugas are enzootically infected with a strain of *Brucella* that may be causing illness, as well as having some direct effect on reproductive success in the infected animals.

O'Hara et al. (1998) found that serum from 21 of 36 bowhead whales harvested in Alaska tested positive for antibodies to at least one type of virus in the calicivirus, swine, and San Miguel sea lion virus families. However, the absence of any clear patterns of antibody prevalence led them to conclude that, at least at the present time, these are questions of academic interest, but probably not critical to the health of the bowhead whale population.

Ice Entrapment

In 1989, an estimated 125 belugas became entrapped in the Husky Lakes, Northwest Territories, following freeze-up (Fig. 1). They were trapped in three separate locations in these lakes, unable to retrace their route to the ocean as the winter ice formed around them in October of that year. The situation repeated itself, although on a smaller scale, in 1996, when 21 belugas were found trapped in the ice of Husky Lakes. They maintained a single 4.7 m × 1.8 m breathing hole for approximately two months after freeze-up before they were discovered by a hunter travelling through the area on a snowmachine. The trapped beluga were removed and sampled by the local Hunters and Trappers Committee representatives, with DFO staff on site. The 1989 entrapment consisted of three separate groups which were predominantly (> 80%) adult males, while the 1996 situation involved only one group that contained a mixture of adult males (> 430 cm), females with calves, unaccompanied females, and adolescents. Preliminary stock-specific data on calving interval and familial relationships were obtained through sampling of the trapped whales (L. Harwood, unpubl. data 1989, 1996; G. O'Corry-Crowe, U.S. National Marine Fisheries Service, La Jolla, California, unpubl. data 1997).

FUTURE RESEARCH: NEEDS AND OPPORTUNITIES

Beluga Whales

Of primary importance is the continuation of hunter-based sampling of harvested belugas through the well-established monitoring program in the Inuvialuit Settlement Region. Population parameters, including survivorship and reproductive rates, are stock-specific and essential for the proper management of any harvested stock. Opportunities for obtaining age-specific reproductive material, plus information on feeding, genetics, and body condition, along with other tissues for analysis of contaminant levels or disease, should never be missed.

Monitoring of population parameters and population health indices from cost-effective programs such as the FJMC monitoring program will continue to provide relevant information to managers faced with unpredictable

future impacts on wildlife resources. For example, new research using contaminant profiles seems to be able to provide finer detail on stock identification needed to address some beluga management questions in the Eastern Arctic (Innes and Stern, 1999).

Recent controversy regarding the interpretation of age by tooth analyses (Hohn and Lockyer, 1999) points to the importance of obtaining such samples, along with as much ancillary data as possible, from harvested whales (Suydam and DeMaster, 1999). Seeing and recapturing a previously tagged whale in the Beaufort Sea beluga stock, and thus possibly obtaining a tooth of known age, would help solve some of the problems regarding age determination (Orr et al., 1998).

In other areas, beluga surveys have been flown in conjunction with satellite tagging efforts in order to obtain correction factors for animals missed because they were underwater during the aerial counts. Interpretation of diving data obtained during the Eastern Beaufort Sea beluga satellite-tagging programs (1993, 1995, and 1997), in the context of producing at least a broad correction for the 1992 survey results, is considered possible, but still in the preliminary stages. Such corrected estimates are important even for stocks that are hunted at a low level, such as the Beaufort Sea beluga stock. In other areas of the Canadian Arctic, where it is suspected that some shared stocks are threatened by overharvesting, improved population estimates are urgent.

The identification of specific deepwater feeding areas used by Beaufort Sea belugas in Viscount Melville Sound (Richard et al., 1997, 2001) emphasizes the need for more research on feeding and energetics. Similar deepwater feeding areas have been identified for the Baffin Bay stock (Martin and Smith, 1992, 1999; Martin et al., 1993, 1998; Smith and Martin, 1994).

These findings prompted a pilot study in Canada's High Arctic to evaluate the possibility of recapturing jettisonable tags or individual belugas to recover archival-type tags. These types of instrument packages can accumulate more detailed information on feeding, for example, by recording how many times and when a whale ingests food using a temperature sensor placed in the stomach (Andrews, 1998; T. Smith, unpubl. data 1999). Two of the five whales tagged at Cunningham Inlet, Somerset Island, were recaptured after having spent a few weeks at sea, caught in a small bay on southwestern Prince of Wales Island. We judged that we could improve the recapture rates and that this approach would open the door to new areas of research on the feeding, behaviour, physiology, and bioenergetics of wild Arctic cetaceans. This technique may soon be feasible for use on Beaufort Sea belugas.

Bowhead Whales

Limited satellite-linked telemetry work has been done on bowhead whales (Mate et al., 2000), but much is still to be learned of their summer movements and feeding areas in the southeastern Beaufort Sea. Oceanographic features known to concentrate prey in the Beaufort Sea have started to be described (Bradstreet and Fissel, 1986, 1987), but might be more fully discerned from some of the remote sensing data currently available.

Information on feeding and energy budgets can be obtained from sampling lipids, and by stable isotope analyses (Schell et al., 1989; Schell and Saupe, 1993) obtained from non-lethal biopsy samples. Genetic samples could be obtained at the same time. In the future, acoustic surveying techniques might prove useful in correcting bowhead population estimates for whales invisible from the surface during aerial surveys (Clark and Johnson, 1984).

OUTLOOK

The future in cetacean research lies in investigating the oceanographic features that affect the productivity of the resources on which whales depend. Because of the logistical problems and high costs of doing physical and biological oceanography in an ice-filled ocean environment, traditional ship-based studies have been conducted on a limited scale and confined primarily to the summer open-water season. The extreme heterogeneity of planktonic organisms and the illusive nature of such keystone species as arctic cod, *Boreogadus saida*, have made the study of Arctic marine ecosystems very difficult. Few studies have attempted to evaluate the trophic dynamics of Arctic ecosystems (Welch et al., 1993; Stirling and Øritsland, 1995). The rapidly developing technology being used to relay various parameters from instrumented cetacea via satellite, or from recoverable instrument packages, has created a new approach to studying previously inaccessible oceanic habitats.

Most Arctic marine mammal species have been captured and outfitted with some sort of acoustic or radiotelemetry device. Belugas and narwhals (Martin and Smith, 1992, Martin et al., 1993; Heide-Jørgensen et al., 1998) and bowhead whales (Mate et al., 2000) have been instrumented with satellite, VHF radio, or acoustic telemetry tags. Ringed seals (*Phoca hispida*) (Lydersen, 1991, Tielman et al., 1999; bearded seals (*Erignathus barbatus*) (Kovacs, 1997), hooded seals (*Cystophora cristata*), harp seals (*Pagophilus groenlandicus*) (M. Hammill, Institute Maurice Lamontagne, DFO, pers. comm. 1999); and walrus (*Odobenus rosmarus rosmarus*) (Born and Knutsen, 1992) have all been studied with this new technology. These efforts are producing a large amount of new information on seasonal movements and migration routes.

Another dimension of having tags on Arctic whales and seals is that they can reveal the location, depth, and seasonal changes in the prey on which the animals are feeding. Marine mammals, which have evolved over millions of years to function in ice-covered waters and to find their prey, can now be used as "educated" oceanographic sampling platforms (Smith, 2001).

The continued technological development of telemetry instrumentation, which soon will involve measurement of many oceanographic parameters coupled with video and acoustic recorders carried by whales and seals, will advance our knowledge of ocean ecology and lead to the possibility of accurate monitoring of marine productivity. It will take us far beyond the narrower study of individual marine mammal species ecology and the useful but quantitatively weaker "top-down" ecosystem studies of the present day.

A MODERN NORTHERN PERSPECTIVE

Belugas provide the Inuit with meat and muktuk, both highly regarded dietary items. For the Inuvialuit of the Western Canadian Arctic, belugas have been the primary cetacean dietary species for centuries (McGhee, 1988; Friesen and Arnold, 1995). The Inuvialuit have conducted a self-regulated harvest of beluga whales from a large and healthy stock (Cosens et al., 1998, 1999). They are active stewards of the resource through their Beluga Management Plan (FJMC, 1998). They have been involved in the longest-running harvest monitoring study in the Arctic (Weaver, 1991; Harwood et al., 2002). They are active collectors and preservers of traditional knowledge about the beluga (Byers and Roberts, 1995). It would seem that the "house is in order" as far as the Eastern Beaufort Sea beluga stock and the Inuvialuit are concerned. However, the existing programs, commitments, and partnerships with government and co-management bodies must be nurtured and maintained to ensure the long-term well-being of the belugas and their habitats.

A similar situation exists with regard to the bowhead whale. Through extensive research in the Canadian and United States Beaufort Sea areas in the 1980s, as well as the efforts of the Alaska Eskimo Whaling Commission over the past two decades, the database for the Bering Sea bowhead population is huge in comparison to that for the world's other bowhead stocks (Burns, 1993). One important aspect for the Inuvialuit will be the continued national recognition of their right to harvest the bowhead whale in the southern Beaufort Sea (Freeman et al., 1992), subject only to conservation and human safety. The local skills and knowledge for hunting and processing the bowhead whale must be maintained and passed on to future generations, otherwise it will be lost with the passing of elders over time. Management agencies must plan for funds to ensure any whales that are landed are fully sampled and measured according to standard protocols.

Hunters, managers, and scientists alike must review their respective preparedness for renewal of oil and gas industry activities in the offshore and nearshore Beaufort Sea in the near future. Also of paramount interest is to identify specific areas of the Bering Sea where the beluga and bowhead overwinter, and in turn to protect these distant habitats from degradation. Finally, because the beluga and bowhead stocks are shared, it is important that the partner nations (Canada, the United States, and Russia) continue to exchange biological and harvest information and collaborate on research and management initiatives. The Inuvialuit-Inupiat Beluga Agreement (2000) called for the establishment of the Inuvialuit-Inupiat Beluga Commission. This group facilitates the exchange of harvest statistics, traditional knowledge, and research results; coordinates the planning and conduct of joint research projects; and directs the establishment of technical committees as required. This is an excellent example of how cooperation can occur between hunters in different nations that share the same resource. In the future, it is envisaged that Russian representatives will be participants in the agreement.

A greater effort must be made to promote co-management through the development of collaborative research and educational programs involving scientists and the resident users of Arctic renewable resources. The current emphasis on documentation of Traditional Ecological Knowledge (TEK), which seeks to involve northern indigenous peoples (Byers and Roberts, 1995; Fehr and Hurst, 1996; Huntington, 1998; Mymrin, 1999), is laudable and should proceed as far as it can to define cultural philosophies and to contribute useful factual knowledge.

Aboriginal people and all northern residents must be equipped by relevant experiences gained through education and direct participation in the actual scientific and management programs related to the protection of their resources. To advance this process, small regional laboratories or research centres could be created. Government could encourage such an initiative as a means of developing the local economy and capacity. The day-to-day processing of biological materials, the detailed analyses of stomach contents, and the preservation and archiving of materials and data from harvested animals are tasks that would lend themselves well to such an enterprise in the Arctic. Such centres would also provide opportunities for some northern students in technical and university programs to obtain pertinent on-the-job training in their own or neighbouring communities.

A significant number of Inuvialuit have participated in the actual capture and handling of belugas and other marine mammals in the past 10 years of satellite telemetry studies. This human resource should be maintained and further developed to provide expertise to researchers and other interested parties in the future. Training programs could be implemented, including apprenticeships in aquaria and courses on animal husbandry, tag application procedures, and basic medical techniques such as blood and tissue sampling.

The future of research on Arctic wildlife lies largely in the increasing participation of the full-time residents of these regions. Current demographic and economic factors, combined with traditional cultural values and conservation ethics, are finally beginning to be significant in shaping the management of renewable resources in the Arctic.

DEDICATION

Titus Taktuk Allen,
February 17, 1947 – February 21, 1997

This manuscript is dedicated to the memory of the late Titus Taktuk Allen, formerly of Aklavik, Northwest Territories, Canada. Titus was a well-known and very much respected beluga whale hunter; a dedicated Beluga Harvest Monitor and proficient whale sampler; the harpooner on the Aklavik Hunters and Trappers Committee's (HTC) bowhead whale hunt in 1991; and the Captain of the HTC's successful bowhead hunt in 1996. Titus served as a director on the Inuvialuit Game Council and as a director of the Aklavik HTC, and he was involved in joint management initiatives on beluga whales with Alaskan Inupiat. He was a beloved father, husband, grandfather, colleague, and friend.

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REFERENCES

ADAMS, M., FROST, K.J., and HARWOOD, L.A. 1993. Alaska and Inuvialuit Beluga Whale Committee (AIBWC) – An Initiative in "at home management." Arctic 46(2):134–137.

ANDREWS, R.D. 1998. Remotely releasable instruments for monitoring the foraging behaviour in pinnipeds. Marine Ecology Progress Series 175:289–294.

BELIKOV, S. 1999. The status of the white whale population (*Delphinapterus leucas*) inhabiting the Russian Arctic. International Whaling Commission Scientific Committee Report SC/51/SM21.

BOCKSTOCE, J.R. 1986. Whales, ice and men: The history of whaling in the western Arctic. Seattle: University of Washington Press.

BORN, E.W., and KNUTSEN, L.O. 1992. Satellite-linked radio tracking of Atlantic walruses (*Odobenus rosmarus rosmarus*) in northeastern Greenland, 1989–1991. Saugetierkunde 57:275–287.

BRADSTREET, M.S.W., and FISSEL, D.B. 1986. Zooplankton of a bowhead whale feeding area off the Yukon coast in August 1985. Part 2. In: LGL Ltd. Bowhead whale food availability characteristics in the southern Beaufort Sea: 1985 and 1986. Environmental Studies No. 50. Ottawa: Indian and Northern Affairs Canada.

———. 1987. Zooplankton and bowhead whale feeding in the Canadian Beaufort Sea, 1986. Part 1. In: LGL Ltd. Bowhead whale food availability characteristics in the southern Beaufort Sea: 1985 and 1986. Environmental Studies No. 50. Ottawa: Indian and Northern Affairs Canada.

BRENNIN, R., MURRAY, B.W., FRIESEN, M.K., MAIERS, L.D., LAYTON, J.W., and WHITE, B.N. 1997. Population genetic structure of beluga whales (*Delphinapterus leucas*): Mitochondrial DNA sequence variation within and among North American populations. Canadian Journal of Zoology 75(5):795–802.

BRETON, M., and SMITH, T.G. 1990. The beluga. Underwater World Fact Sheet. Available from Fisheries and Oceans Canada, Communications Directorate, Ottawa, Ontario K1A 0E6.

BROWN, J.G. 1996. Population structure of North American beluga whales, *Delphinapterus leucas*. Ph.D. thesis, University of Guelph, Guelph, Ontario.

BROWN-GLADDEN, J.G., FERGUSEN, M.M., and CLAYTON, J.W. 1997. Matriarchal genetic population structure of North American beluga whales, *Delphinapterus leucas*, (Cetacea: Monodontidae). Molecular Ecology 6: 275–281.

BROWN-GLADDEN, J.G., FERGUSEN, M.M., FRIESEN, M.K., and CLAYTON, J.W. 1999. Matriarchal genetic population structure of North American beluga whales (*Delphinapterus leucas*, Cetacea: Monodontidae). Molecular Ecology 8:347–363.

BURNS, J.J. 1993. Epilogue. In: Burns, J.J., Montague, J.J., and Cowles, C.J., eds. The bowhead whale. Special Publication No. 2. The Society of Marine Mammalogy. Lawrence, Kansas: Allen Press, Inc. 745–762.

BURNS, J.J., and SEAMAN, G.A. 1985. Investigations of belukha whales in coastal waters of western and northern Alaska. II. Biology and ecology. Final Report submitted to NOAA, Outer Continental Shelf Environmental Assessment Program, Alaska Department of Fish and Game, 1300 College Road, Fairbanks, Alaska 99701, U.S.A.

BURNS, J.J., MONTAGUE, J.J., and COWLES, C.J. 1993. The bowhead whale. Special Publication No. 2. The Society for Marine Mammalogy. Lawrence, Kansas: Allen Press, Inc. 787 p.

BYERS, T., and ROBERTS, L.W. 1995. Harpoons and ulus: Collective wisdom and traditions of Inuvialuit regarding the beluga ("qilalugaq") in the Mackenzie River estuary. Byers Environmental Studies and Sociometrix Inc. Available from the Fisheries Joint Management Committee, Box 2120, Inuvik, Northwest Territories X0E 0T0, Canada. 76 p.

CLARK, C.W., and JOHNSON, J.H. 1984. The sounds of the bowhead whale, *Balaena mysticetus*, during the spring migrations of 1979 and 1980. Canadian Journal of Zoology 62(7):1436–1441.

CLARK, J.T., MOORE, S.E., and JOHNSON, M.M. 1993. Observations on beluga fall migration in the Alaskan Beaufort Sea, 1982-87, and northeastern Chukchi Sea, 1982-1991. Report of the International Whaling Commission 43:386–396.

COSENS, S.E., de MARCH, B.G.E., INNES, S., MATHIAS, J., and SHORTT, T.A. 1998. Report of the Arctic Fisheries Scientific Advisory Committee for 1993/94, 1994/95 and 1995/96. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2473.

———. 1999. Report of the National Peer Review Committee, Winnipeg, Manitoba, 7–8 February 1996. Appendix 3. Eastern Beaufort Sea beluga (1996 update) for AFSAC. Available at the Department of Fisheries and Oceans, 501 University Crescent, Winnipeg, Manitoba R3T 2N6, Canada. 15–20.

DAVIS, R.A., KOSKI, W.R., RICHARDSON, W.J., EVANS, C.R., and ALLISTON, G.W. 1982. Distribution, numbers and productivity of the western Arctic stock of bowhead whales in the eastern Beaufort Sea and Amundsen Gulf, 1981. Prepared for Sohio Petroleum Ltd., Dome Petroleum Ltd., and others. Available at LGL Ltd., Box 457, King City, Ontario L0G 1K0, Canada.

DFO. 2000. Fisheries and Oceans Canada. Eastern Beaufort Sea Beluga. DFO Science Stock Status Report E5-38 (2000).

DYKE, A.S., HOOPER, J., and SAVELLE, J.M. 1996. A history of sea ice in the Canadian Arctic Archipelago based on postglacial remains of the bowhead whale (*Balaena mysticetus*). Arctic 49(3):235–255.

EWALT, D.R., PAYEUR, J.B., MARTIN, B.M., CUMMINS, D.R., and MILLER, W.G. 1994. Characteristics of a *Brucella* species from a bottlenose dolphin (*Tursiops truncatus*). Journal of Veterinary Diagnostic Investigation 6:448–452.

FAST, H., MATHIAS, J.A., and STORACE, F. 1998. Marine conservation and beluga management in the Inuvialuit Settlement Region: Can marine protected areas play a role? Unpubl. report prepared for the Fisheries Joint Management Committee, Box 2120, Inuvik, Northwest Territories X0E 0T0, Canada.

FAST, H., MATHIAS, J., and BANIAS, O. 2001. Directions toward marine conservation in Canada's Western Arctic. Journal of Ocean and Coastal Management 44:183–205.

FEHR, A., and HURST, W. 1996. A seminar on two ways of knowing: Indigenous and scientific knowledge. Proceedings, 15–17 November 1996, Inuvik, NT, Canada. Sponsored by: Inuit Circumpolar Conference and Fisheries Joint Management Committee (FJMC). Available at Fisheries Joint Management Committee, Box 2120, Inuvik, Northwest Territories X0E 0T0, Canada.

FJMC (FISHERIES JOINT MANAGEMENT COMMITTEE). 1998. Beaufort Sea Beluga Management Plan. 3rd ed. FJMC, Box 2120, Inuvik, Northwest Territories X0E 0T0, Canada.

FRAKER, M.A. 1979. Spring migration of bowhead (*Balaena mysticetus*) and white whales (*Delphinapterus leucas*) in the Beaufort Sea. Fisheries and Marine Service Technical Report 859.

FRAKER, M.A., GORDON, C.D., McDONALD, J.W., FORD, J.K.B., and CAMBERS, G. 1979. White whale (*Delphinapterus leucas*) distribution and abundance and the relationship to physical and chemical characteristics of the Mackenzie Estuary. Fisheries and Marine Service Technical Report 863.

FREEMAN, M.M.R. 1968. Winter observations on beluga (*Delphinapterus leucas*) in Jones Sound NWT. Canadian Field-Naturalist 82:276–286.

FREEMAN, M.M.R., WEIN, E.E., and KEITH, D.E. 1992. Recovering rights: Bowhead whales and Inuvialuit subsistence in the Western Canadian Arctic. Studies on Whaling No. 2. Edmonton: Canadian Circumpolar Institute, University of Alberta, and Inuvik: Fisheries Joint Management Committee.

FRIESEN, T.M., and ARNOLD, C.D. 1995. Zooarcheology of a focal resource: Dietary importance of beluga whales to the precontact Mackenzie Inuit. Arctic 48(1):22–30.

GEORGE, J.C., CLARK, C., CARROLL, G.M., and ELLISON, W.T. 1989. Observations on the ice breaking and ice navigation behaviour of migrating bowhead whales (*Balaena mysticetus*) near Point Barrow, Alaska, Spring 1985. Arctic 42(1):24–30.

GEORGE, J.C., PHILO, L.M., HAZARD, K., WITHROW, D., CARROLL, G.M., and SUYDAM, R. 1994. Frequency of killer whale (*Orcinus orca*) attacks and ship collisions based on scarring on bowhead whales (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort Seas stock. Arctic 47(3):247–255.

GEORGE, J.C., BADA, J., ZEH, J., SCOTT, L., BROWN, S.E., O'HARA, T., and SUYDAM, R. 1999. Age and growth estimates of bowhead whales (*Balaena mysticetus*) via aspartic acid racemization. Canadian Journal of Zoology 77(4):571–580.

GRAINGER, E.H. 1975. Biological productivity of the southern Beaufort Sea: The physical-chemical environment and the plankton. Beaufort Sea Project Technical Report 12a. Victoria, British Columbia: Environment Canada.

HARWOOD, L.A. 1989. Distribution of ringed seals in the southeast Beaufort Sea during late summer. M.Sc. thesis, Department of Zoology, University of Alberta, Edmonton, Alberta, Canada. 131 p.

HARWOOD, L.A., and BORSTAD, G.A. 1985. Bowhead whale monitoring study in the southeast Beaufort Sea, July-September 1984. Environmental Studies Revolving Funds Report No. 009. Ottawa: Department of Indian and Northern Affairs.

HARWOOD, L.A., INNES, S., NORTON, P., and KINGSLEY, M.C.S. 1996. Distribution and abundance of beluga whales in the Mackenzie Estuary, southeast Beaufort Sea, and west Amundsen Gulf during late July 1992. Canadian Journal of Fisheries and Aquatic Sciences 53:2262–2273.

HARWOOD, L.A., NORTON, P., DAY, B., and HALL, P. 2002. The harvest of beluga whales in Canada's Western Arctic: Hunter-based monitoring of the size and composition of the catch. Arctic 55(1):10–20.

HAZARD, K. 1988. Beluga whale. In: Lentfer, J.W., ed. Selected marine mammals of Alaska: Species accounts with research and management recommendations. Washington, D.C.: Marine Mammal Commission. 195–235.

HEIDE-JØRGENSEN, M.P., and TEILMANN, J. 1994. Growth, reproduction, age structure and feeding habits of white whales (*Delphinapterus leucas*), in West Greenland waters. Meddelelser om Grønland, Bioscience 39:195–212.

HEIDE-JØRGENSEN, M.P., RICHARD, P.R., and ROSING-ASVID, A. 1998. Dive patterns of belugas (*Delphinapterus leucas*) in waters near eastern Devon Island. Arctic 51(1): 17–26.

HELBIG, R.P., BOAG, P.T., and WHITE, B.N. 1989. Stock identification of beluga whales (*Delphinapterus leucas*) using mitochondrial DNA markers: Preliminary results. Musk-ox 37:122–128.

HEYLAND, J.D., and HAY, K. 1976. An attack by a polar bear on a juvenile beluga. Arctic 29(1):56–57.

HILL, P.S., and DeMASTER, D.P. 1999. Alaska marine mammal stock assessments 1999. U.S. Department of Commerce, NOAA-TM-NMFS-AFSC-110. Available from the National Marine Mammal Laboratory, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, Washington 98115, U.S.A. 166 p.

HINSHAW, V.S., BEAN, W.J., WEBSTER, R.G., REHG, J.E., FIORELLI, P., EARLY, G., GERACI, J.R., and St. AUBIN, D.J. 1984. Are seals frequently infected with avian influenza viruses? Journal of Virology 51(3):863–865.

HOHN, A.A., and LOCKYER, C. 1999. Growth layer patterns in teeth from two known-history beluga whales: Reconsideration of deposition rates. Paper SC/51/SM14 presented to the Scientific Committee of the International Whaling Commission.

HUNT, W.J. 1979. Domestic whaling in the Mackenzie Estuary, Northwest Territories. Canadian Fisheries and Marine Service Technical Report 769.

HUNTINGTON, H.P. 1998. Observations on the utility of the semi-directive interview for documenting traditional ecological knowledge. Arctic 51(3):237–242.

———. 2001. Report of the workshop on Bering-Chukchi-Beaufort belugas. 15–17 November 2000. Available from the National Marine Mammal Laboratory, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, Washington 98115, U.S.A.

INAC (INDIAN AND NORTHERN AFFAIRS CANADA). 1984. The Western Arctic Claim, The Inuvialuit Final Agreement. Ottawa: Indian Affairs and Northern Development. 115 p.

INNES, S., and STERN, G. 1999. Stock identity of beluga (*Delphinapterus leucas*) from southeast Baffin Island based on multivariate analysis of the concentration of organochlorine contaminants found in their blubber. NAMMCO Scientific Committee SC/7/BN/16. Tromsø, Norway: North Atlantic Marine Mammal Commission.

INUVIALUIT-INUPIAT BELUGA AGREEMENT. 2000. Inuvialuit-Inupiat Beaufort Sea Beluga Whale Agreement, signed in Inuvik, 3 March 2000. Available from the Joint Secretariat, Box 2120, Inuvik, Northwest Territories X0E 0T0, Canada.

KENNEDY, P.C., and MILLER, R.B. 1993. The female genital system. In: Jubb, K.V.F., Kennedy, P.C., and Palmer, N., eds. Pathology of domestic animals. 4th ed. San Diego: Academic Press. 396–402.

KINGSLEY, M.C.S. 1996. Population index estimate for the belugas of the St. Lawrence in 1995. Canadian Technical Report Fisheries and Aquatic Sciences 2117.

———. 1998. Population index estimates for the St. Lawrence belugas, 1973-1995. Marine Mammal Science 14(3):508–530.

KLEINENBERG, S.E., YABLOKOV, A.V., BEL'KOVICH, B.M., and TARASEVICH, M.N. 1969. Beluga (*Delphinapterus leucas*): Investigation of the species. (Original publication in Russian, Moscow, 1964.) Israeli Program for Science Translations, Jerusalem, No. TT-6751345. 376 p.

KLUMOV, C.K. 1939. Belukha sovetskogo severa (syryevaya baza i promysel) [Belukhas of the Soviet North (Raw material base and hunting)]. Moscow: Trudy VNRIO. v. 12.

KOSKI, W.R., DAVIS, R.A., MILLER, G.W., and WITHROW, D.E. 1993. Reproduction. In: Burns, J.J., Montague, J., and Cowles, C.J. The bowhead whale. The Society for Marine Mammalogy, Special Publication No. 2. Lawrence, Kansas: Allen Press Inc. 239–274.

KOVACS, K. 1997. Bearded seals. Journal of the National Geographic Society 91:123–137.

KRUTZIKOWSKY, G.K., and MATE, B.R. 2000. Dive and surfacing characteristics of bowhead whales (*Balaena mysticetus*) in the Beaufort and Chukchi Seas. Canadian Journal of Zoology 78:1182–1198.

LEATHERWOOD, S., BOWLES, A.E., and REEVES, R. 1986. Aerial surveys of marine mammals in the southeastern Bering Sea. U.S. Department of Commerce, NOAA, OCSEAP Final Report 42:147–490.

LEDUC, R.G., ROSENBERG, A., DIZON, A.E., BURDIN, A.M., BLOKHIN, S.A., and BROWNELL, R.L., Jr. 1998. Preliminary genetic analyses (mt DNA and microsatellites) of two populations of bowhead whales. International Whaling Commission Scientific Committee Report No. SC/50/AS11.

LIPSCOMB, T.P., SCHULMAN, F.Y., MOFFETT, D., and KENNEDY, S. 1994. Morbilliviral disease in Atlantic bottlenose dolphins (*Tursiops truncatus*) from the 1987–1988 epizootic. Journal of Wildlife Diseases 30(4):567–571.

LJUNGBLAD, D.K., MOORE, S.E., CLARK, J.T., and BENNETT, J.C. 1986. Aerial surveys of endangered whales in the northern Bering, eastern Chukchi and Alaskan Beaufort Seas 1985: With a seven year review, 1975-1985. Report of the Naval Oceans Systems Centre. U.S. Minerals Management Service. NTIS No. AD-172753/6.

LOWE, R. 1984a. Siglit Inuvialuit *Uqausitta Kipuktirutait*. Basic Siglit Inuvialuit Eskimo Dictionary. Inuvik: Committee for Original Peoples Entitlement.

———. 1984b. *Uummarmiut Uqalungiha Mumikhitchirutingit*. Basic Uummarmiut Eskimo Dictionary. Inuvik: Committee for Original Peoples Entitlement.

LOWRY, L.F. 1993. Foods and feeding ecology. In: Burns, J.J., Montague, J.J., and Cowles, C.J., eds. The bowhead whale. The Society for Marine Mammalogy, Special Publication No. 2. Lawrence, Kansas: Allen Press Inc. 201–238.

LOWRY, L.F., NELSON, R.R., and FROST, K.J. 1987a. Observations of killer whales (*Orcinus orca*) in western Alaska: Sightings, strandings and predation on other marine mammals. Canadian Field-Naturalist 101:6–12.

LOWRY, L.F., BURNS, J.J., and NELSON, R.R. 1987b. Polar bear, *Ursus maritimus*, predation on belugas, *Delphinapterus leucas*, in the Bering and Chukchi Seas. Canadian Field-Naturalist 101:141–146.

LOWRY, L.F., BURNS, J.J., and FROST, K.J. 1988. Recent harvests of belukha whales in western and northern Alaska and their potential impact on provisional management stocks. Report to International Whaling Commission Scientific Committee Report No. SC\40\SM4.

LYDERSEN, C. 1991. Monitoring ringed seal (*Phoca hispida*) activity by means of acoustic telemetry. Canadian Journal of Zoology 69(5):1178–1182.

MAIERS, L.D., de MARCH, B.G.E., CLAYTON, J.W., DUECK, L.P., and COSENS, S.E. 1999. Genetic variation among populations of bowhead whales summering in Canadian waters. Canadian Stock Assessment Secretariat Research Document 99/134.

MARINE MAMMAL COMMISSION. 1999. Annual Report to the U.S. Congress 1998. Bethesda, Maryland: Marine Mammal Commission.

MARTIN, A.R., and SMITH, T.G. 1992. Deep diving in wild, free-ranging beluga whales, *Delphinapterus leucas*. Canadian Journal of Fisheries and Aquatic Sciences 49(3):462–466.

———. 1999. Strategy and capability of wild belugas, *Delphinapterus leucas*, during deep benthic diving. Canadian Journal of Zoology 77:1783–1793.

MARTIN, A.R., SMITH, T.G., and COX, O.P. 1993. Studying the behaviour and movements of High Arctic belugas with satellite telemetry. Symposia Zoological Society of London 66:195–210.

———. 1998. Dive form and function in belugas of the Canadian High Arctic. Polar Biology 20:218–228.

MATE, B.R., KRUTZIKOWSKY, G.K., and WINSOR, M.H. 2000. Satellite-monitored movements of radio-tagged bowhead whales in the Beaufort and Chukchi Seas during the late summer feeding season and fall migration. Canadian Journal of Zoology 78:1168–1181.

McGHEE, R. 1988. Beluga hunters, an archeological reconstruction of the history and culture of the Mackenzie Delta Kittegaryumuit. 2nd ed. Social and Economic Studies 13. St. John's, Newfoundland: Memorial University.

MELNIKOV, V.V., ZELENSKY, M.A., and AINANA, L.I. 1998. Distribution and migrations of the belukha (*Delphinapterus leucas*) in the Chukchi Sea and northern Bering Sea. International Whaling Commission Scientific Committee Report No. SC/50/SM4.

MILLER, G.W., DAVIS, R.A., KOSKI, W.R., CRONE, M.J., RUGH, D.J., WITHROW, D.E., and FRAKER, M.A. 1992. Calving intervals of bowhead whales – an analysis of photographic data. Report of the International Whaling Commission 42:501–506.

MILLER, W.G., ADAMS, A., FICHT, T.A., CHEVILLE, N.F., PAYEUR, J.P., HARLEY, D.R., HOUSE, C., and RIDGWAY, S.H. 1999. Brucella-induced abortions and infection in bottlenose dolphins (*Tursiops truncatus*). Journal of Zoo and Wildlife Medicine 30:100–110.

MOORE, S.E. 2000. Variability of cetacean distribution and habitat selection in the Alaskan Arctic, autumn 1982–91. Arctic 53(4):448–460.

MOORE, S.E., and DeMASTER, D.P. 1998. Cetacean habitats in the Alaskan Arctic. Journal of Northwest Atlantic Fisheries Science 22:55–69.

MOORE, S.E., and REEVES, R.R. 1993. Distribution and movements. In: Burns, J.J., Montague, J.J., and Cowles, C.J., eds. The bowhead whale. The Society for Marine Mammalogy, Special Publication No. 2. Lawrence, Kansas: Allen Press Inc. 313–386.

MOORE, S.E., CLARKE, J.T., and JOHNSON, M.M. 1993. Beluga distribution and movements offshore northern Alaska in spring and summer, 1980–1984. Report of the International Whaling Commission 43:375–386.

MOORE, S.E., GEORGE, J.C., COYLE, K.O., and WEINGARTNER, T.J. 1995. Bowhead whales along the Chukotka coast in autumn. Arctic 48(2):155–160.

MOORE, S.E., DeMASTER, D.P., and DAYTON, P.K. 2000. Cetacean habitat selection in the Alaskan Arctic during summer and autumn. Arctic 53(4):432–447.

MYMRIN, N.I. 1999. Traditional ecological knowledge of Siberian Eskimo, bowhead whale, north of Bering Sea and Chukchi Peninsula. Unpubl. report for the John D. and Catherine T. MacArthur Foundation. Translation by O.V. Veter, Provideniya, Chukotka, Russia. VNIIOZ, 79 Engels Street, Kirov, Russia.

NERINI, M.K., BRAHAM, H.W., MARQUETTE, W.M., and RUGH, D.J. 1984. Life history of the bowhead whale, *Balaena mysticetus*, (Mammalia: Cetacea). Journal of Zoology (London) 204(4):443–468.

NORTON, P., and HARWOOD, L.A. 1985. White whale use of the southeastern Beaufort Sea, July-September 1984. Canadian Technical Report Fisheries and Aquatic Sciences 1401.

———. 1986. Distribution, abundance and behaviour of white whales in the Mackenzie Estuary. Environmental Studies Research Funds Report 036. Ottawa: Indian and Northern Affairs Canada.

NULIGAK, 1966. I, Nuligak: The autobiography of a Canadian Eskimo. Toronto, Ontario: Simon and Schuster of Canada.

O'CORRY-CROWE, G.M., and LOWRY, L.L. 1997. Genetic ecology and management concerns for the beluga whale (*Delphinapterus leucas*). In: Dizon, A.E., Chivers, S.J., and Perrin, W.F., eds. Molecular genetics of marine mammals. The Society for Marine Mammalogy, Special Publication No. 3. Lawrence, Kansas: Allen Press Inc. 249–274.

O'CORRY-CROWE, G.M., SUYDAM, R.S., ROSENBERG, A., FROST, K.J., and DIZON, A.E. 1997. Physiology, population structure and dispersal patterns of the beluga whale, *Delphinapterus leucas*, in the Western Nearctic revealed by mitochondrial DNA. Molecular Ecology 6:955–970.

O'HARA, T.M., HOUSE, O., HOUSE, J.A., SUYDAM, R.S., and GEORGE, J.C. 1998. Viral serologic survey of bowhead whales in Alaska. Journal of Wildlife Diseases 34(1):41–46.

ORR, J.R., and HARWOOD, L.A. 1998. Possible aggressive behaviour between a narwhal (*Monodon monoceros*) and a beluga (*Delphinapterus leucas*). Marine Mammal Science 14(1):182–185.

ORR, J.R., ST. AUBIN, D.J., RICHARD, P.R., and HEIDE-JØRGENSEN, M.P. 1998. Recapture of belugas, *Delphinapterus leucas*, tagged in the Canadian Arctic. Marine Mammal Science 14(4):829–834.

PERRIN, W.F., and MYRICK, A.C., Jr., eds. 1980. Report of the Workshop: Age Determination of Toothed Whales and Sirenians. Report of the International Whaling Commission, Special Issue 3:2.

RAFTERY, A.E., and ZEH, J.E. 1998. Estimating bowhead whale population size and rate of increase from the 1993 census. Journal of the American Statistical Association 93:451–463.

REEVES, R.R., and MITCHELL, E.D. 1985. Shore-based bowhead whaling in the eastern Beaufort Sea and Amundsen Gulf. Report of the International Whaling Commission 35:387–404.

RICHARD, P.R., MARTIN, A.R., and ORR, J.R. 1997. Study of the summer and fall movements and dive behaviour of Beaufort Sea belugas using satellite telemetry: 1992–1995. Environmental Studies Research Funds Report 134. Available in the Library of the Arctic Institute of North America, University of Calgary, Calgary, Alberta T2N 1N4, Canada.

———. 2001. Summer and autumn movements of belugas of the eastern Beaufort Sea stock. Arctic 54(3):223–236.

RICHARDSON, W.J., ed. 1999. Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998: 90-day report. Available from LGL Ltd., Box 280, King City, Ontario L7B 1A6, Canada

RICHARDSON, W.J., DAVIS, R.A., EVANS, C.R., LJUNGBLAD, D.K., and NORTON, P. 1987. Summer distribution of bowhead whales, *Balaena mysticetus*, relative to oil industry activities in the Canadian Beaufort Sea, 1980-84. Arctic 40(2):93–104.

ROONEY, A.P., HONEYCUTT, R.L., DAVIS, S.K., and DERR, J.N. 1999. Evaluating a putative bottleneck in a population of bowhead whales from patterns of microsatellite diversity and genetic disequilibria. Journal of Molecular Biology 48: 682–690.

RUGH, D.J., and FRAKER, M. 1981. Gray whale (*Eschrichtius robustus*) sightings in the eastern Beaufort Sea. Arctic 34(2): 186–187.

RUGH, D.J., and SHELDEN, K. 1993. Polar bears, *Ursus maritimus*, feeding on beluga whales, *Delphinapterus leucas*. Canadian Field-Naturalist 107(2):235–237.

RUGH, D.J., MILLER, G.W., WITHROW, D.E., and KOSKI, W.R. 1992. Calving intervals of bowhead whales established through photographic identifications. Journal of Mammalogy 73(3):487–490.

SCHELL, D.M., and SAUPE, S.M. 1993. Feeding and growth as indicated by stable isotopes. In: Burns, J.J., Montague, J.J., and Cowles, C.J., eds. The bowhead whale. The Society for Marine Mammalogy, Special Publication No. 2. Lawrence, Kansas: Allen Press Inc. 491–509.

SCHELL, D.M., SAUPE, S.M., and HAUBENSTOCK, N. 1989. Natural isotope abundance in bowhead whale (*Balaena mysticetus*) baleen: Markers of aging and habitat usage. In: Rundetl, P., Ehleringer, J., and Nagy, K., eds. Stable isotopes in ecological research. Ecological Studies 68. 260–269.

SEAMAN, G.A., LOWRY, L.F., and FROST, K.J. 1982. Foods of belukha whales (*Delphinapterus leucas*) in western Alaska. Cetology 44:1–19.

SERGEANT, D.E., and BRODIE, P.F. 1969. Body size in white whales, *Delphinapterus leucas*. Journal of the Fisheries Research Board of Canada 26:2561–2580.

SMITH, T.G. 1977. The occurrence of a narwhal (*Monodon monoceros*) in Prince Albert Sound, western Victoria Island, Northwest Territories. Canadian Field-Naturalist 91:299.

———. 2001. Marine mammals as oceanographic sampling platforms. Arctic 54(3):350–355.

SMITH, T.G., and MARTIN, A.R. 1994. Distribution and movements of belugas, *Delphinapterus leucas*, in the Canadian High Arctic. Canadian Journal of Fisheries and Aquatic Sciences 51:1653–1663.

SMITH, T.G., and SJARE, B. 1990. Predation of belugas and narwhals by polar bears in the nearshore areas of the Canadian High Arctic. Arctic 43(2):99–102.

SMITH, T.G., and TAYLOR, D. 1977. Notes on marine mammal, fox and polar bear harvests in the Northwest Territories 1940 to 1972. Fisheries and Marine Service, Technical Report 694. 37 p.

SMITH, T.G., ST. AUBIN, D.J., and GERACI, J.R. 1990. Research on beluga whales, *Delphinapterus leucas*: Introduction and overview. In: Smith, T.G., St. Aubin, D.J., and Geraci, J.R., eds. Advances in research on the beluga whale, *Delphinapterus leucas*. Canadian Bulletin of Fisheries and Aquatic Sciences 224. 1–6.

SMITH, T.G., ST. AUBIN, D.J., and HAMMILL, M.O. 1992. Rubbing behaviour of belugas, *Delphinapterus leucas*, in a High Arctic estuary. Canadian Journal of Zoology 70:2405–2409.

SMITH, T.G., HAMMILL, M.O., and MARTIN, A.R. 1994. Herd composition and behaviour of white whales (*Delphinapterus leucas*) in two Canadian Arctic estuaries. Meddelelser om Grønland, Bioscience 39:175–184.

ST. AUBIN, D.J., SMITH, T.G., and GERACI, J.R. 1990. Seasonal epidermal molt in beluga whales, *Delphinapterus leucas*. Canadian Journal of Zoology 68(2):359–367.

STEWART, B.E., and STEWART, R.E.A. 1989. *Delphinapterus leucas*. Mammalian Species 336:1–8.

STIRLING, I., and ØRITSLAND, N.A. 1995. Relationships between estimates of ringed seal (*Phoca hispida*) and polar bear (*Ursus maritimus*) populations in the Canadian Arctic. Canadian Journal of Fisheries and Aquatic Sciences 52(12):2594–2612.

STOKER, S.W., and KRUPNIK, I.I. 1993. Subsistence whaling. In: Burns, J.J., Montague, J.J., and Cowles, C.J., eds. The bowhead whale. The Society for Marine Mammalogy, Special Publication No. 2. Lawrence, Kansas: Allen Press Inc. 579–630.

STRONG, T. 1989. Reported harvests of narwhal, beluga and walrus in the Northwest Territories, 1948-1987. Canadian Data Report of Fisheries and Aquatic Sciences 734.

———. 1990. The domestic beluga (*Delphinapterus leucas*) fishery in the Mackenzie River Estuary, Northwest Territories, 1981–1986. Canadian Data Report of Fisheries and Aquatic Science 800.

SUYDAM, R.S., and DeMASTER, D.P. 1999. Growth layer patterns in beluga teeth. International Whaling Commission Scientific Committee Report No. SM/WP/26.

SUYDAM, R.S., and FROST, K. 2001. Programs, activities, and research of the Alaska Beluga Whale Committee, 2000–2001. Annual Report to the National Marine Fisheries Service/NOAA, Alaska Beluga Whale Committee, Barrow, Alaska. 99 p.

SUYDAM, R.S., FROST, K.J., LOWRY, L.L., O'CORRY-CROWE, G.M., and PIKOK, D. 1999. Satellite tracking of Eastern Chukchi Sea beluga whales in the Arctic Ocean. International Whaling Commission Scientific Committee Report No. SC/51/SM39.

TEILMAN, J., BORN, E.W., and ACQUARONE, M. 1999. Behaviour of ringed seals tagged with satellite transmitters in the North Water polynya during fast-ice formation. Canadian Journal of Zoology 77:1934–1946.

THOMSON, D.H., FISSEL, D.B., MARKO, J.R., DAVIS, R.A., and BORSTAD, G.A. 1986. Distribution of bowhead whales in relation to hydro-meteorological events in the Beaufort Sea. Environmental Revolving Funds Report 28. Available in the Library of the Arctic Institute of North America, University of Calgary, Calgary, Alberta T2N 1N4, Canada.

TURL, W. 1990. Echolocation abilities of the beluga, *Delphinapterus leucas*: A review and comparison with the bottlenose dolphin *Tursiops truncatus*. In: Smith, T.G., St. Aubin, D.J., and Geraci, J.R., eds. Recent advances in research on the beluga whale (*Delphinapterus leucas*). Canadian Bulletin of Fisheries and Aquatic Sciences 224. 119–128.

USHER, P.J. 1971. The Canadian Western Arctic, a century of change. In: Lotz, P., and Lotz, J., eds. Pilot not commander: Essays in memory of Diamond Jenness. Anthropologica 13(1&2):169–183.

VLADYKOV, V.D. 1947. Études sur les mammifères aquatiques IV. Nourriture du marsouin blanc ou béluga (*Delphinapterus leucas*) du fleuve Saint-Laurent. Contribution de l'Institut de biologie générale et de zoologie No. 19. 160 p.

WARTZOK, D. 1990. Bowhead whale radio tagging. Final report. Prepared by Purdue University, Fort Wayne, Indiana. Available from the DFO, 501 University Crescent, Winnipeg, Manitoba R3T 2N6, Canada.

WEAVER, P.A. 1991. The 1987 beluga (*Delphinapterus leucas*) harvest in the Mackenzie River Estuary, NWT. Canadian Manuscript Report of Fisheries and Aquatic Science 2097.

WEINTRAUB, B. 1996. Harpoon blades point to long-lived whales (March 1996, Geologica, National Geographic). Washington, D.C.: National Geographic Society.

WELCH, H.E., CRAWFORD, R.E., and HOP, H. 1993. Occurrence of Arctic cod (*Boreogadus saida*) schools and their vulnerability to predation in the Canadian High Arctic. Arctic 46(4):331–339.

WOODBY, D.A., and BOTKIN, D.B. 1993. Stock sizes prior to commercial whaling. In: Burns, J.J., Montague, J.J., and Cowles, C.J., eds. The bowhead whale. The Society for Marine Mammalogy, Special Publication No. 2. Lawrence, Kansas: Allen Press Inc. 387–407.

YOUNG, T.P. 1994. Natural die-offs of large mammals: Implications for conservation. Conservation Biology 8:410–418.

ZEH, J.E., GEORGE, J.C., RAFTERY, A.E., and CARROLL, G.M. 1991. Rate of increase 1978–1988 of bowhead whales, *Balaena mysticetus*, estimated from ice-based census data. Marine Mammal Science 7:105–122.

ZEH, J.E., CLARK, C.W., GEORGE, J.C., WITHROW, D., CARROLL, G.M., and KOSKI, W.R. 1993. Current population size and dynamics. In: Burns, J.J., Montague, J.J., and Cowles, C.J., eds. The bowhead whale. The Society for Marine Mammalogy, Special Publication No. 2. Lawrence, Kansas: Allen Press Inc. 409–490.