

## Eastern Beaufort Sea Beluga Whales

### Background

The Eastern Beaufort Sea stock of beluga whales congregates in the Mackenzie estuary in the early summer, and ranges from the Alaska-Canada border north into the polar pack ice and the Canadian Arctic archipelago. The beluga, white whale or qilaluqag, *Delphinapterus leucas*, has long been a primary food resource for the Inuvialuit\* living in the Mackenzie River delta (Friesen and Arnold 1995) and coastal communities of the Beaufort Sea. Their whale harvests have occurred in four transportation-determined phases, beginning with the pre-contact kayak hunting phase some 500 years before present (B.P.) (McGhee 1988), through the whale boat, schooner and present modern hunting era (B. Day personal communication.).

Fisheries and Oceans Canada, under the Oceans Act and with the support of the Fisheries Joint Management Committee (FJMC), Inuvialuit Game Council, and the Inuvialuit Regional Corporation, is undertaking research and consultation leading to a Marine Protected Area in support of the Beaufort Sea Beluga Management Plan (FJMC 1998, Mathias and Fast in press). The work is part of an integrated marine management project in Canada's Western Arctic (Fast et al. 1998, Fast and Mathias in press). This status report was initiated in support of that process.

\* Inuvialuit are the aboriginal peoples, now mainly residing in the communities of: Aklavik, Inuvik, Tuktoyaktuk, Sachs Harbour, Paulatuk, and Holman (Ulukhartok).

### Summary

- The Eastern Beaufort Sea beluga whale stock congregates in the Mackenzie estuary in early summer, disperses eastward towards Amundsen Gulf and Viscount Melville Sound in August and migrates westward along the Alaskan coast and far offshore under the polar pack ice in the autumn.
- Samples obtained during the summer season confirm that the Eastern Beaufort Sea belugas are genetically distinct from four other stocks of beluga found in Alaskan waters.
- The Inuvialuit have long depended on the belugas for their sustenance and survival, and belugas continue to be an important element of diet, tradition and culture.
- The latest aerial surveys (1992) give an index of abundance of 19,629. These surveys did not sample the complete range of this population and a considerable, but yet undetermined number of whales were underwater during the aerial counts. Thus, this index is a low number in comparison to the yet undetermined estimate of the total size of the Eastern Beaufort Sea stock.
- An average of 111 beluga (since 1990) are harvested annually by hunters from the Inuvialuit communities of Aklavik, Inuvik, Tuktoyaktuk, Sachs Harbour, Paulatuk and Holman (Ulukhartok). The total removal from this stock (landed, struck and lost) for Alaska and Canada combined is estimated at 186 annually. This is far below the level which might negatively affect the population.
- Major uncertainties remain relating to population vital rates for this stock, total removals through harvesting in other parts of its range; the extent and annual

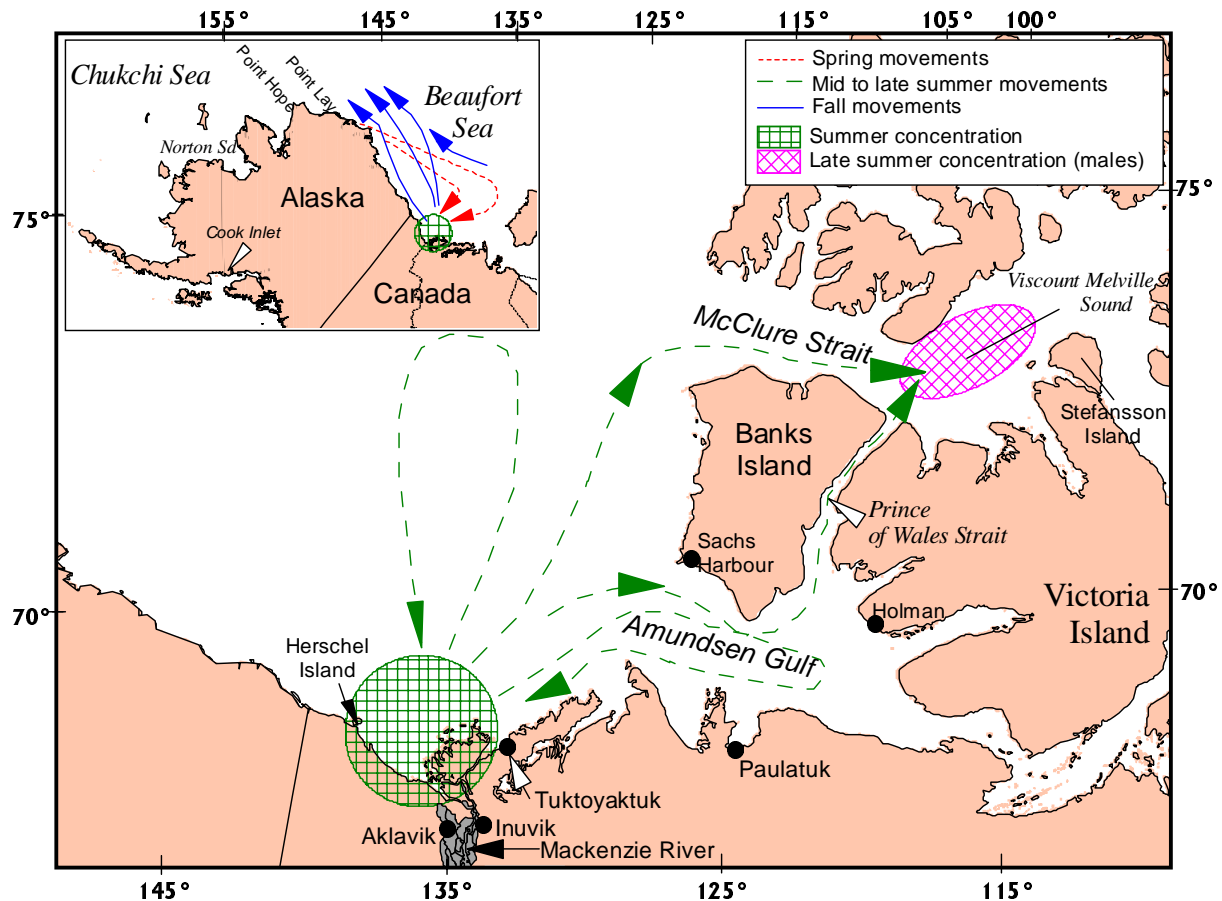


Figure 1. Distribution of eastern Beaufort Sea beluga during spring, summer and fall, showing concentration areas and seasonal movements. Actual distribution of beluga ranges throughout the area depicted, with the hatched regions defining the areas where densities of beluga are typically higher.

variability of the total summer range, and actual stock size.

- The index of abundance, estimated removal rates, and age/sex structure of the harvest indicate that the Eastern Beaufort Sea stock of belugas is not in danger of overexploitation and remains a healthy robust population.
- Temporal trends in the levels of organic pollutants and heavy metals are unclear.
- Infectious agents, such as bacteria or viruses, may be present in these whales as evidenced by the presence of antibodies.

### **Species Biology**

The beluga or *qilaluqag* is a toothed whale, lacks a dorsal fin, and is found throughout

the Arctic. Belugas are also called white whales because they lose all pigmentation in their skin and become almost pure white at between seven and nine years of age. Newborn beluga calves, *nalungiait*, measure 1.5 m in length, weigh 50 to 80 kg at birth, and are light to dark-mottled grey in appearance. Juveniles, *tunguvyuit*, consisting of ages 2-5 years of age, range from 2.4 to 2.8 m in length (Caron and Smith 1990) and gradually become lighter gray in colouration as they age. Adult females, *nalungialit*, of the Eastern Beaufort Sea stock average 3.8 m and adult males, *anguhalluit*, 4.3 m in length (Harwood *et al.* 2000). Belugas can weigh from 1500 to 2000 kg, and males are significantly heavier than females (Stewart and Stewart 1989).

In the spring, belugas of the Eastern Beaufort Sea stock are seen migrating eastward through leads offshore of Point Hope, Alaska. They have been observed to move into the southeast Beaufort Sea from the west, through leads far offshore, and arrive off the west coast of Banks Island and offshore of Cape Bathurst in late spring (Fraker 1979). Inuvialuit have long reported the occurrence of beluga whales in waters offshore of Banks Island during the months of May and June, coinciding with the onset of break-up. The beluga then appear to move to the southwest, following the seaward edge of the land-fast ice along the Tuktoyaktuk Peninsula (Norton and Harwood 1986). Depending on ice conditions, they normally arrive in Kugmallit Bay, Shallow Bay and east Mackenzie Bay in late June or early July (Byers and Roberts 1995). While belugas concentrate in the Mackenzie estuary during July, a proportion are also widely distributed throughout the offshore at low densities during this period (Norton and Harwood 1985, 1986, Harwood *et al.* 1996). Some belugas leave the estuary and begin moving towards the east in late July and move into the Amundsen Gulf.

During two years of satellite-linked telemetry studies, male belugas tagged in the Mackenzie estuary were found to travel northward and eastward to distant Viscount Melville Sound, some as far east as Stefansson Island (Fig 1). In 1993 and 1995 eleven of fourteen male belugas, but none of the nine females, followed this route; of the eleven males, nine went north via M'Clure Strait, but two individuals used Prince of Wales Strait. In 1997, when 7 males and 3 females were tagged later in the season, none traveled into the Viscount Melville Sound area, but moved to the Amundsen Gulf and remained there for 2-3 weeks before beginning the autumn westward migrations.

By mid-August to early September, belugas begin their migrations to the west along the Beaufort Sea-Alaskan coastline. Studies involving satellite tagged belugas have also shown that some animals travel far offshore and sometimes under heavy pack ice. Satellite tagged Eastern Beaufort Sea belugas have been followed as far as Wrangel Island and into the Bering Sea (Richard *et al.*, *In Press*). They are thought to over-winter in the Bering and Chukchi Seas.

Females in other stocks are sexually mature between 4-7 years, while males mature at 6-7 years (Heide-Jørgensen and Teilmann 1994). Belugas live to be 35 to 40 years of age (Smith, 1999), although in the Eastern Beaufort Sea stock, individuals older than this have been found (one 49 year old female and one 57 year old, Harwood *et al.* 2000), but no good estimate of average life span exists because of tooth wear in the older age classes (Burns and Seaman 1985).

No estimates of population vital parameters are available for the Eastern Beaufort Sea stock of belugas. Although age specific data have been collected from the harvest since 1980, the selection of older and predominantly male belugas by the hunters makes the sample unrepresentative of the population. Measurements that might provide some index of change in the productivity of the stock, such as age (or length) at sexual maturity, calving intervals and the calculated crude birth rate (percent of sexually mature females that are pregnant) have not been made for this stock.

Life history parameters are available for the female segment of seven other hunted beluga populations (Smith 1999). Most studies agree that belugas calve once every three years, while age specific fecundity is lacking for most stocks because of low sample sizes. Burns and Seaman (1985)

showed that females greater than 20 years of age appear to calve less frequently.

Estimates of survival rates are not available for Eastern Beaufort Sea beluga or for most other beluga stocks. However annual survival of beluga is high, ranging from an estimate of 90.6% per year for a hunted stock (Burns and Seaman 1985) to 97% per year for a stock which is not hunted (Beland *et al.* 1988). Kingsley *et al.* (unpublished) estimated that with such high survival rates and documented fertility rates, beluga could sustain a catch of between 2.5 to 3.0 % depending on the age structure of the harvest.

Natural mortality can occur from polar bears (Smith 1985, Lowry *et al.* 1987, Smith and Sjare 1990), killer whale predation (Byers and Roberts 1995), ice entrapments (Porsild 1918, Freeman 1968), and diseases (O. Nielsen, personal communication).

Belugas in the nearshore areas of the Mackenzie River estuary have been found with arctic cisco, burbot and whitefish in their stomachs. They probably also feed on other species that are present, including Pacific herring, *qaaktak*, the Least cisco, *piqoaqtitaq*, Rainbow smelt, *qiqotiliqaoaraq*, and Inconnu, *siqaq*. Belugas are recognized to feed on a great variety of prey species, which also includes many invertebrates (Vladikov 1947, Kleinenberg *et al.* 1969).

Recent results from satellite-tagged belugas from this stock suggest that they are also feeding near the ocean floor, at depths to 600 meters in areas they visit after they have left the estuaries (Richard *et al.* 1997). So far we do not know what prey species are being eaten in those deep water areas.

## The Hunt

Inuvialuit from Aklavik, Inuvik and Tuktoyaktuk regularly harvest belugas from the Mackenzie River estuary each summer. Residents of Paulatuk began an annual hunt in 1989, with results varying from year to year depending on hunting conditions (Table 1). Residents of Holman (Ulukhartok) and Sachs Harbour may occasionally harvest beluga as the opportunity arises (FJMC 1998).

Table 1. Number of beluga whales struck, landed and lost by Inuvialuit harvesters, 1990-1999.

Year	No. of beluga landed <sup>1</sup>				Total <sup>2</sup>
	AK	IN	TK	PA	
1990	31	29	27	0	87 (19)
1991	17	34	49	16	116 (28)
1992	17	38	48	18	121 (9)
1993	20	42	45	3	110 (10)
1994	26	50	57	8	141 (8)
1995	26	46	46	11	129 (14)
1996	19	35	41	25	120 (19)
1997	12	44	51	7	114 (9)
1998	13	31	40	2	86 (7)
1999	8	36	41	1	86 (16)

<sup>1</sup> AK = Aklavik; IN = Inuvik; TK = Tuktoyaktuk; PA = Paulatuk.

<sup>2</sup> Numbers in brackets are additional number of whales struck but lost, pooled for all communities.

The present average annual landed catch of belugas in Canada from the Eastern Beaufort Sea stock is 111 per year (1990-1999). The landed catch sex ratio consists of 2.3 adult males to 1 adult female, with an average age of 23 years (Harwood *et al.* 2000). When struck and lost data from the Canadian harvest (Table 1) and the estimated Alaska landed harvest (Hill and DeMaster 1999) are added, there is a combined known removal from this stock of 186 belugas per year. This is an underestimate of total removal since the loss rate is not known for the spring and fall hunts off the Alaskan North Slope, and neither are the landings nor

losses known for hunts in Russian waters (Harwood *et al.* 2000).

Hunts today are commonly carried out from 18' 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. In deeper water hunting situations, belugas are sometimes wounded to slow them down before a harpoon line is attached. Inuvialuit beluga hunters have used nets successfully in the past, and continue to do so occasionally in the present; however, they must be tended continuously to prevent wasting animals should they die and remain too long in the net before retrieval and processing. The Hunters and Trappers Committees in each of the communities of the Inuvialuit Settlement Region have developed beluga hunting by-laws and whale-watching guidelines for tourism (FJMC 1998).

A hunter-based sampling program, currently funded through the Fisheries Joint Management Committee, has been ongoing since 1980. Data on the number, sex and size of the whales landed is recorded, as well as estimates of the numbers of whales that are struck and lost. Standard length and flipper width are measured, and lower mandibles (with teeth, for age determination) are collected from as many of the harvested whales as possible (Harwood *et al.* 2000), as are tissue samples for genetic, contaminant levels and studies of diseases.

### ***Resource User Perspective***

For 500 or more years, the aboriginal people of the Western Arctic have harvested the beluga whale in the Mackenzie Estuary (McGhee 1988). Belugas were the primary

and most reliable of resources for the Inuvialuit, essential to their survival and important for the development of the Inuvialuit culture. Belugas were used as a source of human and dog food. There is limited information on the size of the beluga harvest during the pre-contact (prior to 1888) and bowhead commercial whaling (1888-1907) periods (Bockstoece 1986), and from the end of that commercial whaling era up until the 1950s. Available data suggest that the harvests in earlier times were likely higher than present day takes (Nuligak 1966, Smith and Taylor 1977, McGhee 1988, Strong 1989, Friesen and Arnold 1995; B. Day, personal communication). The harvest of belugas has always been self-regulated and limited to that required for subsistence needs (FJMC 1998).

Each summer, present day hunters and their families from Inuvik, Aklavik, and Tuktoyaktuk, NT (Fig. 1) travel to traditional whaling camps along the Beaufort Sea coast. The hunt has always been conducted largely during the month of July, lasts for four to six weeks, and takes place while the beluga are aggregated near and within the warm waters of the Mackenzie River estuary (Fraker *et al.* 1979, Norton and Harwood 1986).

The Inuvialuit of Holman and Paulatuk, NT (Fig. 1) also have a history of hunting belugas. This takes place when 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).

Because of the importance of belugas as a principle food source, there is community concern regarding contaminants and disease agents that could affect the health of belugas or their human consumers. Other global issues, such as climate change and the resultant changes in sea ice, which might eventually change animal movements,

feeding, and hunter access to the resource, are also a subject of concern to the Inuvialuit.

### ***Resource Status***

#### *Stock delineation*

Two genetic techniques have been used for stock delineation. Maternally inherited mitochondrial DNA (mtDNA) markers clearly differentiate between samples from the Eastern Beaufort Sea and Point Lay, Alaska (Brown Gladden *et al.* 1997, O’Corry-Crowe *et al.* 1997). Mitochondrial DNA markers show that there are at least 5 different stocks in Alaska, and that belugas migrating past Point Hope, Alaska in the spring are from the eastern Beaufort Sea stock (O’Corry-Crowe *et al.* 1997). The five stocks, namely Bristol Bay, Norton Sound, Chukchi (Point Lay, Alaska), eastern Beaufort Sea, and Cook Inlet are known collectively as the Bering Sea population. Recent analyses of nuclear DNA markers also clearly differentiate Beaufort Sea and Chukchi stocks (Brown Gladden *et al.* 1999, de March *et al.* 1999). Using both types of markers, it is possible to correctly identify a beluga from either stock in 95% of all cases.

#### *Stock Size*

The most comprehensive scientific index of abundance for Eastern Beaufort Sea beluga, based on an aerial survey in 1992, is 19,629 belugas within the visible depth-range of the surface (95% CI 15,134 - 24,125). This does not account for whales under water beyond visible depth-range during the counts, nor does it factor in belugas now known from telemetry studies (Richard *et al.* 1997) to occupy areas to the north and east of the survey area during the summer months. The index of abundance is therefore a low number in comparison to the yet

undetermined estimate of the total size of the Eastern Beaufort Sea stock. Traditional knowledge also holds that there are more whales present than can be estimated by aerial surveys.

Multipliers to correct for whales underwater during aerial surveys, ranging from 1.41 (Martin and Smith 1992) to 5.0 (Heide-Jørgensen *et al.* 1998), have been estimated for beluga whales (see Table 3 in Smith 1999). However, these correction factors, derived from satellite tagged belugas, must be used with caution since they are not directly applicable to the 1992 aerial surveys. Factors such as whale behaviour, water depth and water clarity all must be taken into account when deriving a correction factor for aerial survey results from satellite tag data. The actual proportion of belugas beyond visible depth-range would be expected to vary in relation to the depth of the water of their prey species if they are foraging, whether they are travelling in a directed manner, and probably also with the particular time of the year and daylight regimes (Heidi-Jørgensen *et al.* 1998, Martin and Smith 1999). 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.

#### *Stock Trend*

Data on age, size and the sex ratio of belugas reveal no trend indicating changes in the age-size characteristics of the stock in the period since 1980 (Harwood *et al.* 2000). The landed catch continues to be largely of older adult belugas which is typical of a lightly harvested and healthy population.

There are limited biological data, no catch per unit effort statistics, and no series of

comparable indices of abundance available to comment on trends in stock size of the Eastern Beaufort Sea belugas. Given the broad confidence limits associated with abundance indices for a widely dispersed and highly clumped distribution, it would be extremely difficult to ascertain trends. The latest index from aerial surveys is the largest obtained to date simply because of greater coverage and the use of the best methodology available.

### *Sustainable Hunting Rate*

The known removal of 186 belugas per year is less than 1% of the most recent index of abundance (19,629). This is well below the 2.5-3% safe level of exploitation for beluga populations (Kingsley *et al.* unpublished). Since the actual stock size is certainly larger than the index of abundance, the sustainable yield is undoubtedly much greater than present estimates of total removals.

### *Sources of Uncertainty*

Data from the 1993 and 1995 satellite tag studies indicates that some belugas were present outside the areas surveyed in 1992 in far offshore deepwater areas. The proportion of the stock that was outside the survey area and the importance of this habitat are not known. The far ranging mid-summer movements of belugas into Viscount Melville Sound was documented in two of three years of satellite tagging and involved 11 of 14 males and 0 of 6 females. In the third year, 7 male and 3 female belugas were tagged, 10 to 16 days later in the summer than in the first two years (Richard *et al.* in press); none of these belugas traveled into Viscount Melville Sound. There appears to be a repeatable pattern to the seasonal movements, but it is not clear whether it is confined to males

only or what factors influence the timing of these movements.

Age specific mortality and reproductive rates are not available for the Beaufort Sea stock. Because of hunter selections for adult whales, it is not likely that newborn and juvenile mortality rates will ever be available. Overall estimates of mortality or survivorship will not likely be derived for this stock from hunter collected specimens. Calving intervals and adult female reproductive rates, although obtainable, are not yet available. It is uncertain whether reproductive rates from other stocks are similar to those of the Eastern Beaufort Sea beluga.

The annual removal calculated by Harwood *et al.* (2000) is 186, but errs on the low side because mortality of a small number of dependent calves accompanying hunted females could not be accounted for, and because hunting losses in Alaska and landings and losses in Russia are not included. Sources of natural mortality from predation, ice entrapment and/or stranding are impossible or difficult to quantify. The impact of these events or the potential of industrial activities or changes in climate and ice regimes to cause increases in the frequency and magnitude of these, is not known.

### *Outlook*

Although we do not have an estimate of stock size, current data show that the population is large in comparison to catches. The Eastern Beaufort Sea beluga has a wide geographic range, much of which lies outside normal hunting areas. These facts suggest that the population is not at risk from present or projected future harvesting demands. Other anthropogenic factors, such as offshore oil and gas activities or year

round shipping, do not at present pose any serious concerns. Climatic warming does not appear to have resulted in a measurable change in the seasonal distribution or numbers of belugas. The ongoing harvest-based studies and scientific studies are positioned to monitor significant changes which might occur in the future.

### ***Management Considerations***

Beluga management initiatives in the Beaufort Sea have been implemented under a variety of federal acts and regulations and, most importantly, under the Inuvialuit Final Agreement (INAC 1984). With specific management and conservation goals in mind, the Beaufort Sea Beluga Management Plan (FJMC 1998) was prepared by both the Inuvialuit hunters and the Department of Fisheries and Oceans Canada. The Inuvialuit Inupiat Beaufort Sea Beluga Whale Agreement (2000) was formalized between the North Slope Borough, the Inuvialuit Game Council and the Kivalina Whaling Captains Association in March 2000. This aims at sharing information, managing and conserving the Eastern Beaufort Sea stock which is harvested by both the Alaskan Inupiat and the Canadian Inuvialuit.

The human population has increased by 26.4% between 1981 and 1996, but there has been no increase in the average landed catch of belugas (Harwood *et al.* 2000). The hunters of Paulatuk have recently (1989) formalized their beluga hunting, although prior to that elders recount the occasional beluga whale was taken. Their landed catch has been quite variable over the last decade (0-25 per year, average 9.3 per year), thought to be due to annual differences in the distribution of the whales, hunting conditions (availability of good weather and favourable ice conditions), and the number

of hunters available to participate. Because of these factors, the long term average harvests levels for Paulatuk are difficult to predict.

There are no indications to date showing increased harvesting pressures related to trade, barter or sale of edible beluga products among beneficiaries of the Inuvialuit Final Agreement or adjacent land claims.

In other more populated areas, such as the St. Lawrence Estuary, disturbance from maritime traffic, but more importantly specific harassment by tourist whale-watching activities, has become a management concern. The existing tourism (whale watching) guidelines, prepared by the HTC's as part of the Beaufort Sea Beluga Management Plan (FJMC 1998), provide information on how whale hunting and whale-watching can coexist, from a community-based perspective. However, no legal framework exists to enforce these guidelines. The creation of a marine protected area in the Mackenzie estuary in the future (Fast *et al.* 1998) might enable such protection, providing a legal basis to these aspects of the Beaufort Sea beluga management plan.

### ***Other Considerations***

#### *Contaminants*

Arctic marine predators, such as beluga, which are near the top of the Arctic marine food chain, accumulate relatively high levels of persistent organic pollutants. Temporal trends in the levels of organic contaminants (OCs) are not obvious. Beluga oil samples from Churchill, Manitoba taken in 1966/67 had lower OC concentrations than beluga blubber samples from several different communities taken in the 1980s (Muir *et al.*



1990). Concentrations ranged from 1/2 to 1/6 of values in the 1980s, but differences in methods and sample types leave comparisons less than certain. Studies comparing OC concentrations in the 1980s to those in the 1990s generally show no temporal trends (de March *et al.* 1998).

Mercury and other heavy metals have been measured in tissues of Eastern Beaufort Sea belugas (Wageman *et al.* 1990). To date, there is no evidence that marine mammals or human consumers in the Beaufort Sea region have shown any clinical signs or symptoms of mercury or other heavy metal contamination.

### *Diseases*

Recently, signs of infectious diseases, notably the presence of antibodies to viruses and the bacterium *Brucella*, have been identified in marine mammals. The presence of *Brucella* in foods consumed by humans is considered a health hazard. The risks to humans of the presence of *Brucella* antibodies in the tissues of belugas has not been evaluated. Several large-scale die-offs of seals (Geraci *et al.* 1982, Harwood 1990) and toothed whales, (Hinshaw *et al.* 1984, Lipscomb *et al.* 1994) have been directly caused by viruses in other parts of the world. Any indications of mortality of belugas associated with disease organisms in the eastern Beaufort Sea stock would require a rapid response in order to determine the risk to human health and to re-evaluate the harvest level.

### *Industrial development*

Increased interest in building gas pipelines and exploiting the proven offshore petroleum reserves under the Beaufort Sea have the potential for future impacts on belugas. Experimental work on the short term effects of oil spills on seals (Geraci and Smith 1976) and toothed whales (Geraci *et*

*al.* 1983, St. Aubin *et al.* 1985) showed that marine mammals could survive and in some cases avoid short term exposure to oil (Smith *et al.* 1983). Less clear are the impacts of oil spills on the food chain and how whales would react to large scale disasters such as the Valdez super tanker accident. Even more difficult is the task of measuring the effect of disturbance of ship traffic offshore construction and other acoustic interference (Ford 1977, Fraker 1977, Fraker and Fraker 1979, Finley *et al.* 1990). Such disturbance might be expected to increase in the future as whale watching and other traffic increases in the Arctic.

### ***For more Information:***

Contact: Lois Harwood  
Department of Fisheries and  
Oceans  
Box 1871  
Inuvik, NT Canada  
X0E 0T0

Tel: 867-777-7505  
Fax: 867-777-7501  
E-Mail: harwoodl@dfp-mpo.gc.ca

### ***References***

- Adams, M., K. J. Frost, and L. A. Harwood. 1993. Alaska and Inuvialuit Beluga Whale Committee (AIBWC) – An Initiative in “At Home Management”. *Arctic* 46: 134-137.
- Addison, R.F., and P.F. Brodie. 1973. Occurrence of DDT residues in beluga whales (*Delphinapterus leucas*) from the Mackenzie Delta. N.W.T. *Journal of the Fisheries Board of Canada* 30: 1733-1736.

- Addison, R.F., and T.G. Smith. 1998. Trends in organochloride residue concentrations in blubber of ringed seal (*Phoca hispida*) from Holman, N.W.T., 1972-1989. *Arctic* 51: 253-261.
- Beland, P., A. Vezina, and D. Martineau. 1988. Potential for growth of the St-Lawrence (Quebec, Canada) beluga whale (*Delphinapterus leucas*) population based on modelling. *Journal du Conseil International pour l'Exploration de la Mer*. 45: 22-32.
- Bockstoce, J.R. 1986. Whales, ice and men. University of Washington Press, Seattle.
- Brown Gladden, J. G., M. M. Ferguson and J. W. Clayton. 1997. Matriarchal genetic population structure of North American beluga whales *Delphinapterus leucas* (Cetacea: Monodontidae). *Molecular Ecology* 6: 1033-1046.
- Brown Gladden, J. G., M. M. Ferguson, M. K. Friesen, and J. W. Clayton. 1999. Population structure of North American beluga whales (*Delphinapterus leucas*) based on nuclear DNA microsatellite variation and contrasted with the population structure revealed by mitochondrial DNA variation. *Molecular Ecology* 8: 347-363.
- Burns, J.J. and G.A. Seaman. 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, USA 99701. 129 p.
- Byers, T., and L.W. Roberts. 1995. Harpoon and Ulus: Collective wisdom and traditions of Inuvialuit regarding the beluga (*qilalugaq*) in the Mackenzie River estuary. Unpublished Report to the Department of Indian and Northern Affairs (Arctic Environmental Strategy) and the Fisheries Joint Management Committee, Inuvik. 76 p.
- Caron. L.M. and T.G. Smith. 1990. Philopatry and site tenacity of belugas, *Delphinapterus leucas*, hunted by the Inuit at the Nastapoka estuary, Eastern Hudson Bay. In *Advances in Research on the beluga whale*, edited by Smith, T.G., D.J. St-Aubin and J.R. Geraci, Canadian Bulletin of Fisheries and Aquatic Sciences. 224: 69-79.
- de March, B.G.E., L.D. Maiers, and M.K. Freisen. 1999. Genetic differences among Canadian and adjacent beluga whale stocks as determined by mitochondrial DNA and 15 nuclear DNA microsatellite loci. Paper SC/7/BN/4, NAMMCO Scientific Committee, Oslo, Norway.
- de March, B.G.E., C.A. de Wit, and D.C.G. Muir & 34 other authors and contributors. 1998. pp. 183-372 in AMAP Assessment Group: Arctic Pollution Issues. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. xii + 859 p.
- Ewalt, D.R., J.B. Payeur, B.M. Martin, D.R. Cummins, and W.G. Miller. 1994. Characteristics of a *Brucella* species from a bottlenose dolphin (*Tursiops truncatus*). *Journal of Veterinary Diagnostic Investigation* 6: 448-452.
- Fast, H., and J.A. Mathias. *In Press*. Direction toward marine conservation in Canada's western Arctic. *Journal of Ocean and Coastal Management*.
- Fast, H., J.A. Mathias, and F. Storace. 1998.

- Marine conservation and beluga management in the Inuvialuit Settlement Region: can marine protected areas play a role? Unpublished Report to the Fisheries Joint Management Committee, Box 2120, Inuvik, NT, Canada X0E 0T0.
- Finley, K.J, G.W. Miller, R.A. Davis, and C.R. Greene. 1990. Reactions of belugas, *Delphinapterus leucas*, and narwhals, *Monodon monoceros*, to ice-breaking ships in the Canadian High Arctic. Pg. 97 to 117. In *Advances in Research on the beluga whale, Delphinapterus leucas*. edited by Smith, T.G., D.J. St. Aubin, and J.R. Geraci. Canadian Bulletin of Fisheries and Aquatic Sciences. 224: 206 p.
- FJMC (Fisheries Joint Management Committee). 1998. Beaufort Sea Management Plan. Fisheries Joint Management Committee, Box 2120, Inuvik, Northwest Territories, X0E 0T0. 28 p.
- Ford, J.K.B. 1977. White whale offshore exploration acoustic study. Unpublished. FF Slaney and Co. report for Imperial Oil Limited, Calgary, Alberta. Available from the Department of Fisheries and Oceans, Box 1871, Inuvik, NT, Canada, X0E 0T0. 21 p.
- Fraker, M.A. 1977. The 1977 whale monitoring program, Mackenzie Estuary, N.W.T. Report by F.F. Slaney and Company, Limited, Vancouver, BC. Available at: Department of Fisheries and Oceans, Box 1871, Inuvik, NT, Canada, X0E 0T0. 53 p.
- 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 No 859. 36 p.
- Fraker, M.A. and P.N. Fraker. 1979. The 1979 whale monitoring program, Mackenzie Estuary. Report by LGL Limited, Sidney, BC. Available at: Department of Fisheries and Oceans, Box 1871, Inuvik, NT, Canada X0E 0T0. 51 p.
- Fraker, M.A., C.D. Gordon, J.W. McDonald, J.K.B. Ford, and G. Cambees. 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: 56 p.
- Freeman, M.R. 1968. Winter observations on beluga (*Delphinapterus leucas*) in Jones Sound N.W.T. Canadian Field Naturalist 82: 276-286.
- Friesen, T.M. and C.D. Arnold. 1995. Zooarchaeology of a focal resource: dietary importance of beluga whales to pre-contact Mackenzie Inuit. Arctic 48: 22-30.
- Geraci, J. R. and T. G. Smith. 1976. Direct and indirect effects of oil on ringed seals (*Phoca hispida*) of the Beaufort Sea. Journal of the Fisheries Research Board of Canada 33: 1976-1984.
- Geraci, J.R., D.J. St. Aubin, I.K. Baker, R.G. Webster, V.S. Hinshaw, W.J. Bean, H.L. Kuhnke, J.H. Prescott, G. Early, A.S. Baker, S. Madoff, and R.T. Schooley. 1982. Mass mortality of harbour seals: pneumonia with influenza A virus. Science 215: 1129-1131.
- Geraci, J.R., D.J. St. Aubin, and R.J. Reisman. 1983. Bottlenose dolphins, *Tursiops truncatus*, can detect oil.

- Canadian Journal of Fisheries and Aquatic Sciences. 40: 1516-1522.
- Harwood, J. 1990. The 1988 seal epizootic. *Journal of Zoology (London)* 222: 349-351.
- Harwood, L.A., S. Innes, P. Norton and M.C.S. Kingsley. 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., P. Norton, B. Day, and P. Hall. 2000. The harvest of beluga whales in Canada's Western Arctic: hunter-based monitoring of the size and composition of the catch. Canadian Stock Assessment Secretariat Research Document 00/141.
- Heidi-Jørgensen, M.P., P.R. Richard, and A. Rosing-Asvid. 1998. Dive patterns of belugas (*Delphinapterus leucas*) in waters near Eastern Devon Island. *Arctic* 15: 17-26.
- Hill, P.S., and D.P. DeMaster. 1999. Alaska marine mammal stock assessments 1999. U.S. Department of Commerce, National Oceanic & Atmospheric Administration (NOAA), National Telecommunications & Information Administration, NOAA-TM-NMFS-AFSC-110, 166p. Available: National Marine Mammal Laboratory, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, Washington, USA, 98115.
- Hinshaw, V.S., W.J. Bean, J.R. Geraci, P. Fiorelli, G. Early, and R.G. Webster. 1984. Characterization of two influenza A viruses from a pilot whale. *Journal of Virology* 58: 655-656.
- INAC (Indian and Northern Affairs Canada). 1984. The Western Arctic Claim, The Inuvialuit Final Agreement. Published by Indian Affairs and Northern Development, Ottawa, Canada. 115 p.
- Inuvialuit Inupiat Beluga Agreement. 2000. Inuvialuit Inupiat Beaufort Sea Beluga Whale Agreement, signed in Inuvik, 3 March 2000 (3 pp). Copies available from the Joint Secretariat, Box 2120, Inuvik, NT, X0E 0T0
- Kingsley, M.C.S., P. Richard, and S. Innes. Unpublished. The effect of management options on the dynamics of beluga populations: The results of a population modelling workshop. Report prepared for the Northern Quebec and Native Affairs Division. Science Branch, Quebec Region. Department of Fisheries and Oceans Canada, P.O. Box 1000, Mont-Joli, Quebec, G5H 3Z4. 21p.
- Kleinenberg, S.E., A. V. Yablokov, B.M. Bel'Kovich, and M.N. Tarasevich. 1969. Beluga (*Delphinapterus leucas*); investigation of the species. Israeli Program for Science Translations, Jerusalem, No. TT-6751345. 376 p., (Original publication in Russian, Moscow, 1964).
- Lipscomb, T.B., F.Y. Schulman, D. Moffet, and S. Kennedy. 1994. Morbillivirus disease in Atlantic bottlenose dolphins (*Tursiops truncatus*) from the 1987-1988 epizootic. *Journal of Wildlife Diseases* 30: 567-571.
- Lowry L.F., J.J. Burns, R.R. Nelson. 1987. Polar bear, *Ursus maritimus*, predation on belugas, *Delphinapterus leucas*, in the Bering and Chukchi Seas. *Canadian Field-Naturalist* 101: 141-146.

- Martin, A.W., and T.G. Smith. 1992. Deep diving in wild, free-ranging beluga whales. *Canadian Journal of Fisheries and Aquatic Science* 48: 2180-2183.
- Martin, A.W., and T.G. Smith. 1999. Strategy and capability of wild belugas, *Delphinapterus leucas*, during deep benthic diving. *Canadian Journal of Zoology* 77: 1783-1793.
- Mathias, J.A., and H. Fast. *In Press*. Options for marine protected areas in the Inuvialuit Settlement Region. Canadian Manuscript Report of Fisheries and Aquatic Science.
- McGhee, R. 1988. Beluga hunters. An archaeological reconstruction of the history and culture of the Mackenzie Delta Kittingaryumuit. Newfoundland Social and Economic Series No. 13. Institute of Social and Economic Research, Memorial University of Newfoundland. 124 p.
- Muir, D. C. G., C. A. Ford, R. E. A. Stewart, T. G. Smith, R. F. Addison, M. E. Zinck and P. Beland. 1990. Organochlorine contaminants in belugas, *Delphinapterus leucas*, from Canadian waters. Pg. 165-190. *In Advances in Research on beluga whales, Delphinapterus leucas. Edited by Smith, T.G., D.J. St. Aubin, and J.R. Geraci. Canadian Bulletin of Fisheries and Aquatic Sciences* 224: 206 p.
- Norton, P. and L.A. Harwood. 1985. White whale use of the south-eastern Beaufort Sea, July-September 1984. Canadian Technical Report of Fisheries and Aquatic Sciences 1401. 46 p.
- Norton, P. and L.A. Harwood. 1986. Distribution, abundance and behaviour of white whales in the Mackenzie Estuary. Environmental Studies Revolving Funds, Report 036. 73 p.
- Nuligak. 1966. I Nuligak. The autobiography of a Canadian Eskimo. Simon and Schuster of Canada. Toronto, Ontario. 191 p.
- O'Corry-Crowe, G.M., R.S. Suydam, A. Rosenberg, K.J. Frost and A.E. Dizon. 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.
- Porsild, M.P. 1918. On "Savsatts" a crowding of Arctic mammals at holes in the sea ice. *Geographic Review* 6: 215-228.
- Richard, P.R., A.R. Martin and J.R. Orr. 1997. Study of summer and fall movements and dive behaviour of Beaufort Sea belugas, using satellite telemetry: 1992-1995. Environmental Studies Research Funds, Report No. 134, Ottawa. 26 p.
- Richard, P.R., A.R. Martin, and J.R. Orr. *In Press*. Summer and autumn movements of belugas of the Eastern Beaufort Sea. Arctic.
- Smith, T.G. 1985. Polar bears, *Ursus maritimus*, as predators of belugas, *Delphinapterus leucas*. *Canadian Field-Naturalist* 99: 71-75.
- Smith, T.G. 1999. Parameters for a precautionary co-management model of Nunavik beluga whale populations. Unpublished report for Department of Fisheries and Oceans Canada, Maurice Lamontagne Institute, P.O. Box 1000, Mont Joli, Quebec, G5H 3Z4. 52 p + 1 figure.

Smith, T. G., J. R. Geraci and D. J. St. Aubin. 1983. The reaction of bottlenose dolphins, *Tursiops truncatus*, to controlled oil spills. Canadian Journal of Fisheries and Aquatic Sciences 40: 1522-1525.

Smith, T. G. and B. Sjare. 1990. Predation of belugas and narwhals by polar bears in the nearshore areas of the Canadian High Arctic. Arctic 43: 99-102.

Smith, T.G., and D. Taylor. 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.

St. Aubin, D. J., J. R. Geraci, T. G. Smith and T. Friesen. 1985. How do bottlenose dolphins, *Tursiops truncatus*, react to oil films under different light conditions? Canadian Journal of Fisheries and Aquatic Sciences 42: 430-436.

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

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. iv + 14 p.

Vladikov, 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, 160p. + 40 fig. + 28 tables.

Wageman, R., R.E.A. Stewart, P. Beland, and C. Desjardins. 1990. Heavy metals and selenium in tissues of beluga whales, *Delphinapterus leucas*, from the Canadian Arctic and the St-Lawrence

estuary. In: Advances in research on the beluga whale, *Delphinapterus leucas*. edited by: Smith, T.G., D.J. St. Aubin, and J.R. Geraci. Canadian Bulletin of Fisheries and Aquatic Sciences. 224: 191-206.

#### *Personal Communications*

Day, B., Fisheries Joint Management Committee, Inuvik, N.T.

Nielsen, O., Department of Fisheries and Oceans Canada, Winnipeg, Manitoba.

This report is available:

Freshwater Institute  
c/o Larry Dueck  
Central and Arctic Region  
501 University Crescent  
Winnipeg, Manitoba R3T 2N6

Tel: (204) 983-7795  
Fax: (204) 984-2403  
dueckl@dfo-mpo.gc.ca  
[www.dfo-mpo.gc.ca/csas](http://www.dfo-mpo.gc.ca/csas)

ISSN 1480-4913 (for English series)  
ISSN 1480-4921 (for French series)

*La version française est disponible à l'adresse ci-dessus.*



#### *Correct Citation for this Publication*

DFO, 2000. Eastern Beaufort Sea Beluga. DFO Science Stock Status Report E5-38 (2000).