Fisheries and Oceans Science | Pêches et Océans Sciences

C S A S | ***S C É S***

Canadian Stock Assessment Secretariat | **Secrétariat canadien pour l'évaluation des stocks**

Research Document 2000/141 | **Document de recherche 2000/141**

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The harvest of beluga whales in Canada's Western Arctic: Hunter-based monitoring of the size and composition of the catch

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This document is available on the Internet at: Ce document est disponible sur l'Internet à:
http://www.dfo-mpo.gc.ca/csas/

ISSN 1480-4883
Ottawa, 2000

ABSTRACT

Hunter-based beluga monitoring programs, in place in the Mackenzie Delta since 1973, and in the Paulatuk, NT area since 1989, have collected data on the number of whales harvested and on the efficiency of the hunt. Since 1980, data on the standard length, fluke width, sex and age of the landed whales have also been collected. The number of whales landed each year averaged 131.8 beluga (SD 26.5, n=1337) between 1970-1979, 124.0 beluga (SD 23.3, n=1240) between 1980-1989, and 111.0 beluga (SD 19.0, n=1110) between 1990-1999. The human population increased during this same period. Estimated removal of beluga from the Beaufort Sea stock, including appropriate Alaskan harvests but not losses, is estimated at 186 beluga per year. The harvest consisted of 2.3 males to each female, with a median age of 23.5 yr for females (n=80) and 24 yr for males (n=286). More than 92% of an aged sample from the harvest (n=368) consisted of whales aged 10 yr (20 GLG) and older. The rate of removal is small in relation to the expected maximum net productivity rate. Also, the continued availability of large and old individuals after centuries of harvesting, and the apparent lack of change in the size and age structure of the catch in recent years, all support the conclusion that the present level of harvest is sustainable and robust to most perturbations.

RÉSUMÉ

Des données sur le nombre de bélugas capturés et l'efficacité de la chasse ont été recueillies dans le cadre de programmes de surveillance des bélugas par les chasseurs mis en œuvre dans le delta du Mackenzie depuis 1973 et dans la région de Paulatuk (T. N.-O.) depuis 1989. Depuis 1980, des données sur la longueur standard, la largeur du lobe de la queue, le sexe et l'âge des baleines débarquées sont également recueillies. La moyenne du nombre de bélugas débarqués annuellement était de 131,8 (écart type=26,5; n=1337) entre 1970 et 1979, de 124,0 (écart type=23,3; n=1240) entre 1980 et 1989, et de 111,0 (écart type=19,0; n=1110) entre 1990 et 1999. La population humaine a augmenté au cours de cette période. On estime à 186 le nombre de bélugas prélevés sur le stock de la mer de Beaufort, ce qui comprend les prises alaskiennes pertinentes, mais pas les baleines perdues. Pour chaque femelle capturée, 2,3 mâles sont pris; l'âge médian de ces femelles est de 23,5 ans (n=80) et celui des mâles, de 24 ans (n=286). Plus de 92 % des bélugas capturés qui ont été échantillonnés pour en déterminer l'âge (n=368) avaient au moins 10 ans (20 groupes de couches de croissance). Le taux de capture est faible par rapport au taux maximum de production nette attendu. En outre, le fait qu'il reste de vieux individus de grande taille après des siècles d'exploitation et le fait que les structures de taille et d'âge des prises semblent inchangées depuis quelques années appuient la conclusion voulant que le niveau actuel des captures est durable et pourra être maintenu face à la plupart des perturbations possibles.

INTRODUCTION

Beaufort Sea beluga (*Delphinapterus leucas*) winter in the Bering Sea, and each spring migrate along the north coast of Alaska to summer range in the Mackenzie Estuary, Beaufort Sea and Amundsen Gulf (Fraker 1979; Richard *et al.* 1997). They share the Bering Sea wintering areas with at least three other stocks of beluga, the Bristol Bay, Norton Sound and eastern Chukchi Sea stocks (Brennin *et al.* 1997; O'Corry-Crowe *et al.* 1997a; 1997b). Together these four stocks make up the Bering Sea beluga population (Burns and Seaman 1985).

There is a long history of utilization of beluga by Inuit for food and dog food. For 500 or more years, the aboriginal people of the Western Arctic have harvested the beluga whale in the Mackenzie Estuary (McGhee 1988). There is limited information on the size of the beluga harvest during the pre-contact (prior to 1888) and commercial whaling (1888-1907) periods (Bockstoce 1986), and from the end of the commercial whaling era up until the 1950's. Available data suggest that the harvests in those times were likely higher than present day takes (Nuligak 1966; Smith and Taylor 1977; McGhee 1988; Strong 1989; Friesen and Arnold 1995; Billy Day, unpublished data).

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 (Fig. 2). The hunt has always been conducted largely during the month of July, lasts for four – six weeks, and takes place while the beluga are congregated in the 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 the beluga. Hunting takes place when the beluga 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).

Beaufort Sea belugas are also hunted by Inuit of Alaskan villages during their spring and fall migrations (i.e., Diomede, Kivalina, Point Hope, Barrow, Wainwright and Kaktovik; Lowry *et al.* 1988). Chuktoka residents probably also take beluga from this stock, but the size of this take has not been documented (Klumov, 1939). Harvest in Russian waters since 1990 have been very low probably not exceeding 20-30 animals per year (Belikov, 1999).

The first written records on this beluga harvest are from RCMP and Game Officer reports in 1954, where it was reported that 210 beluga were landed (Smith and Taylor 1977). Between 1960-1963, Smith and Taylor (1977) report the harvest averaged 120 beluga per year, while Strong (1989) reports the harvest averaged 146 beluga per year between 1960-1966.

A formal harvest monitoring program was conducted from 1973-1975 (Hunt 1979) by the Fisheries and Marine Service of the Government of Canada. An oil and gas

industry-sponsored program followed from 1977 through 1982 (Fraker 1977, 1978; Fraker and Fraker 1979; Fraker and Fraker 1981; Norton Fraker 1983). The Department of Fisheries and Oceans (DFO) program followed from 1981 through 1986 (Strong 1990; Weaver 1991), and finally, the Fisheries Joint Management Committee (FJMC) program from 1987 through to the present (FJMC, unpublished data, Box 2120, Inuvik, NT, Canada, X0E 0T0).

In all years, the basic program was conducted at the seasonal whaling camps. Data was collected from the hunters on number of whales struck, landed and lost in the harvest; the size and timing of the harvest; and, from 1980 onward, the whales were measured, sexed and biological samples were taken from the landed whales. This information was collected to document the size and trend of the harvest, and to obtain data necessary to assess the health of the beluga stock and the impact of the harvest on that stock. The program has been conducted annually since that time, and now comprises the longest and largest database on harvested beluga whales in Canada.

Here we collate and summarize the available data on the number of whales struck, landed and lost from the Beaufort Sea stock during the last four decades. We also provide a summary of the biological data collected from the monitoring programs for the 17-year period between 1980-1996.

METHODS

The main objective of the beluga harvest-monitoring program was to measure parameters to detect changes in the harvest and the beluga stock over time. Prior to 1980, appropriate biological data were collected on an opportunistic basis, when an independent contractor and a local hunter were present in a given whaling camp. During these visits, which usually took place every 5-7 days, the hunters were interviewed as to how many whales had been struck since the previous visit. The contractors would also sample any whales that happened to be landed during the course of the camp visit (Fraker 1977; 1978; Fraker and Fraker 1979; Fraker *et al.* 1979; Fraker and Fraker 1981, Norton Fraker 1983).

In 1980, sampling was enhanced, when as many as six local hunters were hired per year, at six different locations within the Delta, to be “Beluga Monitors”. They were tasked with collecting hunt-related and biological data at their own and neighbouring (usually extended family) whaling camps, throughout the whaling season. The monitors received pre-season training individually or as a group, from a biologist. Often the same hunter held the Beluga Monitor position year after year, in one instance the same monitor worked at the same site for all but one year between 1977 and 1999.

After each hunt, the monitor interviewed each hunt captain for information on the number of struck, landed and lost whales. The monitor also collected samples, determined the sex,

and measured the standard length of as many of the landed whales as possible (American Society of Mammalogists 1961).

Lower mandibles were collected, labelled and air dried in the field, and later separated into left and right dentaries. These were trimmed by cutting transversely through the bone, posterior to the tooth row. Teeth were prepared following methods described by Wainwright and Walker (1988). Dentaries were boiled gently to facilitate extraction of two mandibular teeth, usually the second and fifth, for age estimation. These were embedded in clear casting resin and longitudinally thin sectioned at ~.3 mm intervals using a diamond wafering blade. Finished thin sections were stored in 70% ethanol.

Thin sections were examined wet, using a dissecting microscope and reflected light. A single reader produced the age estimates, using counts of dentinal growth layer groups (GLGs) to estimate minimum age. A growth layer group consists of two adjacent growth layers, one light and one dark (Perrin and Myrick 1980). For each tooth, the mean of individual counts was used as the final GLG estimate. Chronological age, based on the assumption that beluga deposit two GLGs annually (Goren *et al* 1987), was rounded upward to the next integer.

A database of all whales sampled from 1974-1996 was prepared from the original data sheets and published reports. These data are now archived as Lotus 123 files at the FJMC office in Inuvik, NT, Canada.

The number of whales struck and the number landed was tabulated from the literature for the 1960's and 1970's (Smith and Taylor 1977; Strong 1989) and from the database for subsequent years. To determine if the number of whales landed per year was related to the size of the human population in a given community, Spearman's ranked correlations were done (Sokol and Rohlf 1995). Human population data were provided by Statistics Canada for all ages and by ethnic group for 1981, 1986, 1991 and 1996 national censuses (Available from Statistics Canada, Advisory Services, Calgary, Alberta, Canada T2L 2K7) and by the Inuvialuit Regional Corporation (IRC) for beneficiaries aged 18 years and older for the years 1988 through 1996 (proprietary data, IRC, Box 2120, Inuvik, NT, Canada, X0E 0T0).

The annual harvest-related removal of beluga whales from the Beaufort Sea stock was set as the number of whales struck in a given year. There are no available independent data with which to assess the completeness of the reporting of struck and lost whales, however like the landed whale data, the struck data were collected immediately after the hunt, in person, and by the monitor, himself a peer and a beluga hunter.

Recorded annual removal of beluga from the stock was calculated by summing Inuvialuit strikes and an estimate of Alaskan takes from this same stock. The data from Alaska consist of landed whales only, which thus provides a negative bias to the harvest estimates from Alaska.

The proportions of the catch from the Mackenzie Estuary that was measured each year for standard length, sex, age and colour were tabulated from the database. In 1977-1979, the proportion of the landed whales that was sampled was low (e.g. on average, only 24% of the landed whales were measured for standard length, and sex was determined for only 36%). From 1980 onward, monitors were tasked with sampling as many of the landed whales in their monitoring area as possible. We have limited our analysis of the basic biological parameters to the years 1980-1996 when sample size was large (516 females, 1240 males) and coverage higher (81.8% for standard length, 91.6% for sex, 85.5% for colour).

A Kolmogorov-Smirnov 2-sample test was used to compare the length frequency distribution of males and females (Keifer 1959). A one-way analysis of variance, available in SAS (1996), was used to examine for differences in the mean length of harvested beluga between years, separately for males and females. Duncan Multiple Range test, an option in SAS (1996), was then used to rank and compare the mean annual standard lengths of belugas, separately for each sex (Keifer 1959).

The estimated ages for 368 beluga were available for the years 1988-1994. The median ages for beluga were determined, separately for each sex. Age-frequency histograms were prepared for each sex, and compared using a Kolmogorov-Smirnov 2-sample test (Keifer 1959).

Gompertz growth curves for standard length (cm) were fitted to the data using a non-linear regression available in SAS (1996), according to the equation [1]:

$$L_s = A(e^{(-e-k*age+k*to)}) \qquad [1]$$

where A is the asymptote (cm), k and t_o are fitted constants, *e* is the base of natural logarithms (approximately 2.7183), age is the estimated age of the whale (yr) and L_s is the standard length (in cm) that is predicted from the equation. Annual differences in the asymptotic length of male beluga were examined by comparing predicted values and the associated 95% confidence intervals.

For the other years in the database, aging material was not collected or estimated ages are not yet available. For this reason, the monitors' colour category assignments (white, white with gray, gray and dark gray) were used to provide an assessment of the relative age of the whales taken in the harvest. We calculated the mean age of whales in each of the four colour categories, for 335 whales in our database for which there was both age estimates and monitors assessment of colour.

RESULTS

The Landed Harvest

Inuvialuit beluga hunters and their families travel from the communities of Inuvik, Aklavik and Tuktoyaktuk to whaling camps along the Beaufort Sea coast. The seasonal camps are located on the shores of Kugmallit Bay, Kendall Island, Shallow Bay, and along the northern Yukon coast as far west as King Point (Fig. 2). Since 1989, beluga hunting has also taken place regularly by the residents of Paulatuk, NT, approximately 350 km east of the Mackenzie Delta.

The annual landed harvest of beluga whales from the shores of the Beaufort Sea averaged 131.8 beluga (SD 26.5, n=1337) from 1970-1979, 124.0 beluga (SD 23.3, n=1240) from 1980-1989, and 111.0 beluga (SD 19.0, n=1110) from 1990-1999 (Table 1). Most of these were taken in the Mackenzie Delta (91.8%), by hunters from Aklavik (17.0%), Inuvik (34.7%), and Tuktoyaktuk (40.1%). Residents of Holman were reported to have landed one beluga in 1973, seven in 1975 and two in 1978 (Strong 1989). Paulatuk reports the harvest of four beluga in 1966, three in 1985 and one in 1987 (Strong 1989), and a 'regular' annual harvest since 1989 which totaled 91 whales between 1990-1999 (mean = 9.1 whales/yr).

The average number of beluga harvested has decreased over the last three decades, while the number of Inuvialuit beneficiaries has increased. Between 1988 and 1996, the number of beneficiaries aged 18 years and older has increased by 14% (Inuvialuit Regional Corporation, Box 2120, Inuvik, NT, Canada, X0E 0T0, unpublished data). Statistics Canada reports an overall increase in the aboriginal population of 26.4% for Inuvik, Tuktoyaktuk, Aklavik and Paulatuk between 1981 and 1996. There were no positive correlations between the size of the human population and the size of the beluga harvest for the 1981, 1986, 1991 and 1996 census data (Inuvik: $|r|=0.63$, $p=0.37$; Tuktoyaktuk: $|r|=0.45$, $p=0.54$; Aklavik: $|r|=0.73$, $p=0.26$). The same was true for comparisons with the Inuvialuit beneficiary data and the size of the beluga harvest (Inuvik: $|r|=0.12$, $p=0.75$; Tuktoyaktuk: $|r|=0.07$, $p=0.84$; Aklavik: $|r|=0.23$, $p=0.55$).

Total removal

The average number of beluga struck but lost, expressed as a percentage of the number struck, was lower in the 1990's (averaged 11.2%), than in the 1970's (estimated 15.9%) or the 1980's (averaged 17.7%; Table 1). The past and present efficiency of this hunt, and the factors that affect it, are relevant here for the calculation of the total number of beluga removed from the stock due to the harvest. Including strikes by all Inuvialuit hunters, the mean annual number of beluga struck averaged 124.9 beluga (SD 19.5, n=1249) during the period from 1990-1999 (Table 1).

The Inupiat of the north coast of Alaska took an estimated 61 beluga per yr (range 26-85) during the period from 1993 through 1997, from this same stock (Hill and DeMaster

1999). Struck and loss rates are not available for this estimated harvest, although programs are in place to address this data gap (Adams *et al.* 1993).

Combining what is known about Alaskan harvests from this stock, with the removal of beluga by the Inuvialuit, indicates a total removal from this stock of approximately 186 beluga per year. If, for example, the loss rate in Alaska was 20%, this would increase our estimate of total removal by a further 12 whales.

The latest aerial surveys conducted in 1992 give an index of abundance of 19,629 (95% confidence interval 15,134 – 24,125; Harwood *et al.* 1996). It is now known that the total area occupied by Beaufort Sea belugas was not covered and that a considerable but yet undetermined number of whales are underwater during the aerial counts. The index is thus undoubtedly lower than the actual population size. The present removal of 186 beluga per year represents less than 1% of that index of stock size, or 1.1%, if the hypothetical loss rate of 20% for Alaska is included in the calculation.

Composition of the Mackenzie Estuary Harvest

Sex was determined for 91.6% (1756/1916) beluga that were landed between 1980-1996 (Table 2), with males outnumbering females in the harvest 2.3:1 (average was 29.3% females per year, ranging from 15.3% - 48.3%). The proportion of males and females in the harvest for each year was calculated and plotted on a frequency histogram. The sex ratio remained consistent in the 17 consecutive years examined here (Fig. 3). In the 1980's, the average number of females landed per year was 34.7, while the in 1990's, the average number of females landed was 24.1.

The ages of 368 beluga harvested between 1988 and 1994 were available for 80 females and 286 males, representing 48.5% of the total landings (n=758) in those years. The age-frequency histogram (Fig. 4) shows a wide range of ages of whales in the sampled harvest, with 92.9% (351/368) being 10 yr (20 GLG) and older. Females sampled from 1988-1994 for which age estimates are available ranged from 0 to 49 yr, with a median of 23.5 yr. Males ranged from 3 to 57 yr, with a median of 24 yr. The age-frequency distributions of males and females were not statistically different between the sexes (Kolmogorov test, Kiefer 1959; KS_a=1.233, n=366, p>KS_a= 0.1003).

Colour was recorded for 1638/1916 or 85.5% of the landed catch in the Estuary between 1980-1996 (Table 2). The proportion of the catch in each colour class category was tallied. The mean age of our sample of white beluga was 27.1 yr (SD 10.8, n=274), while the mean age of white with gray beluga was 20.4 yr (SD 8.0, n=25), the mean age of "gray" beluga was 17.3 yr (SD=9.8, n=35), and the age of our one "dark gray" beluga was estimated at 3 yr.

Our colour category assignments, spanning 17 consecutive years, showed similar results as the aging data available for seven of those years. Most of the hunting was

directed toward adult animals, with 89.1% of the harvested whales (1460/1638) being white or white with gray.

A length-frequency histogram was prepared for beluga landed in the Mackenzie Delta, for male and female beluga, for the years 1980 through 1996. Standard length was determined for 83.4% (1567/1916) of the whales landed in the Mackenzie Estuary in those years.

The length-frequency distribution (Fig. 5) shows the modal 10-cm size class for females (370-380 cm) to be 60 cm less than the modal size class for males (430-440 cm). The length-frequency distributions for males and females were significantly different from each other (KS_a =11.22, p>KS_a <0.0001, n=1567).

Asymptotic lengths, predicted by the Gompertz curves for our 1988-1994 sample of aged beluga, were 432.0 cm (SD 2.47, n=3,282; 95% CI 427.1-436.8 cm) for males and 386.2 cm (SD 4.39, df=3,79; 95% CI 377.4 - 394.9 cm) for females. Between year differences in the asymptotic lengths were not apparent for males, and within each others confidence regions (Table 3). Sample size was not sufficient to make this comparison for females.

The mean standard length of all males taken in the Delta varied among years (F=2.23 df=16,1122; p>F=0.0036), although there were no obvious temporal trends toward increasing or decreasing size over time (Table 4). The mean standard length of all females taken in the Mackenzie Estuary also varied among years (F=1.67, df=16,443, p>F=0.0503), but no obvious temporal trends toward increasing or decreasing size were found over the 17 years examined (Table 4).

DISCUSSION

The Inuvialuit of the Western Arctic and their ancestors have a long history of hunting belugas for food. The size of the present day harvests, averaging 111.0 beluga over the last decade, appear to be at a lower level than they have been in the past. Present day harvests are lower than the estimated takes prior to commercial whaling (Nuligak 1966), and for the decades since then for which harvest data exist (1960's, 1970's, and 1980's). In the late 1800's, the annual take of whales may have been upwards of 300 whales per season. As a small boy, Nuligak (1966) recall a communal drive hunt on which 150 beluga were landed on a single day in Kugmallit Bay.

Between 1981-1996, the human population increased by more than 26%, yet there was not a corresponding increase in the average landed catch of beluga by the Inuvialuit. This is thought to be the result of recent trends toward a reduction in the per capita consumption of traditional food items, in particular for items requiring special equipment and knowledge to hunt and process, such as the beluga (Billy Day, personal observation).

Although there has been an overall downward trend in the mean harvest level, annual harvests were variable among years, fluctuating by as much as a factor of two between the extreme low and high harvest years in a given decade. The reasons for these variations have not been quantified, but likely include a variety of factors. For example, changes in the local subsistence need (i.e., during periods of increased wage employment in the oil and gas industry in the late 1970's and early 1980's) or in the requirement for beluga products for trade, barter and sale to other Inuvialuit communities (i.e., increased opportunities for this after the signing of the Inuvialuit Final Agreement in 1984) would have influenced the level of the harvest in any given year. As well, environmental factors such as wind, weather and ice conditions are known to affect the local distribution and availability of whales in a given whaling season (i.e., during 1985 whales did not come in to Kugmallit Bay until late in the season due to the late break up of the ice (Norton and Harwood 1986).

Data from the monitoring programs have documented that the harvest is directed toward males. This practice has the benefit of conserving reproductive females. The majority of whales (>94%) taken in this harvest are older than 10 yr, and have thus contributed offspring to the stock before they were removed through the harvest. In other areas of the Canadian Arctic, beluga tend to be harvested at a younger age. For example, the mean age of belugas sampled from the hunt at Arviat, Pangnirtung and Grise Fiord, Nunavut Territory, were 8.3 yr (n=52) for females and 11.5 yr (n=70) for males; 8.5 yr (n=7) for females and 7.0 yr (n=25) for males, and 5.6 yr (n=12) for females and 5.2 yr (n=18) for males, respectively (Stewart 1994). Many of the whales taken in these hunts would have been removed before they had contributed offspring to the stock.

The Eastern Beaufort Sea Beluga stock is harvested at a rate well below the 2.0 - 3.85% rate of population increase expected for beluga stocks (Kingsley 1996, 1998; Cosens *et al.* 1998). This is because the harvest rate is less than 1% of the available index of stock size of 19,629 (Harwood *et al.* 1996). The rate of removal is not known in relation to the actual size of the stock, larger than the index but undetermined at the present time. It is expected that, at this rate, the population is above it's maximum net productivity level and that the present level of harvest is therefore sustainable (Innes 1996; Cosens *et al.* 1998; Hill and DeMaster 1999).

The results from the hunter-based sampling programs reported here support this conclusion. The low rate of removal, the continued availability of large and old individuals after centuries of harvest, and the apparent lack of change in the size and age structure of the catch in recent years, all suggest that the present harvest has been sustained.

Struck and lost whales in Alaska, and losses of calves due to the removal of adult females, are still to be determined. To illustrate how these aspects could contribute to the total removal, a hypothetical example is instructive. If the loss rate in Alaska was

equivalent to that of the Inuvialuit, then the estimate would be increased by a further six whales. If calves lost due to harvest of adult females are included at a rate of one calf lost per every three females landed (L. Harwood, unpubl. data), then the estimate of total removal would increase by a further 9 whales in the Inuvialuit Settlement Region and a further 14 in Alaska. This assumes a sex ratio of 50% in the Alaskan harvest. Adding these whales to the removal estimate of 186 described above, yields a revised estimate of 209 beluga, still only 1.1% of the *index* of stock abundance (Harwood *et al*. 1996).

Hunter-based sampling through the FJMC beluga monitoring program is ongoing. It would be fruitful in the future if the monitors were trained to examine female reproductive tracts on-site. This information would be used to determine the reproductive status, and history of the individual females, and important reproductive parameters including age of maturation, age at first birth, and age-specific calving interval which at the present time are not documented for this stock (Harwood and Smith 1999).

The hunter-based nature of this program has provided a mechanism for the Inuvialuit to be active partners in the collection of biological data used to assess the well-being of the stock on which they depend. The Inuvialuit have been partners in other beluga research projects, including the capture and handling of beluga for satellite telemetry studies (Richard *et al.* 1997) and the conduct of aerial surveys to enumerate the stock (Harwood *et al.* 1996). These projects have elevated awareness and ownership about Beaufort Sea beluga management issues and initiatives, at the level of the hunter, the user and the community.

ACKNOWLEDGEMENTS

This manuscript reports on the work of many people; in particular we acknowledge the Beluga Whale Monitors and hunters that participated in the various studies from 1974-1999. Without their efforts and co-operation, these data would not have been collected. We acknowledge others who have facilitated the collection of the monitoring data in the past, including contractors from F.F. Slaney and Co., Esso Petroleum Ltd., LGL Ltd., Fisheries and Marine Service, DFO, and the FJMC members and staff. We also thank the HTC's (HTA's prior to 1984) from Inuvik, Tuktoyaktuk, Aklavik, and Paulatuk, NT, for guidance and support of the monitoring program throughout the years. Finally, thanks to Michael Fabijan, and to Program Co-ordinators Billy Archie (1991), Matt Stabler (1993-1996), Mae Cockney (1997) and Joey Amos (1998-1999) for assistance in obtaining and collating published and unpublished data. Drs. Mike Hammill and Rob Stewart assisted with programming for the growth curve analyses. We also wish to acknowledge the Joint Secretariat, Inuvik; Statistics Canada, Edmonton; Inuvialuit Regional Corporation, Inuvik; Canadian Ice Service, Environment Canada, Ottawa, and DFO, Winnipeg; for providing access to unpublished information. We thank Drs. Susan Cosens, Jack Mathias, the late Stu Innes and Brigette de March, all of the Dept. of Fisheries and Oceans, Winnipeg, MB, for thoughtful reviews of the manuscript.

LITERATURE CITED

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(2): 134-137.

American Society of Mammalogists. 1961. Standardized methods for measuring and recording data on the smaller cetaceans. Journal of Mammalogy 42 (4): 471-476.

Belikov, S. 1999. The status of the white whale population (*Delphinapterus leucas*) inhabiting the Russian Arctic. Int. Whaling Comm. SC/51/SM21, 19p.

Bockstoce, J. R. 1986. Whales, ice and men. The history of whaling in the Western Arctic. University of Washington Press, Seattle and London. 400 p.

Brennin, R., B.W. Murray, M.K. Friesen, D. Maiers, J.W. Clayton, and B.N. White. 1997. Population genetic structure of beluga whales (*Delphinapterus leucas*): mitochondrial DNA sequence variation within and among North American populations. Canadian Journal of Zoology 75: 795-802.

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 Dept. of Fish and Game, 1300 College Road, Fairbanks, Alaska, USA 99701. 129 p.

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.

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: Dept. of Fisheries and Oceans, Box 1871, Inuvik, NT, Canada X0E 0T0. 53 p.

Fraker, M.A. 1978. The 1978 whale monitoring program, Mackenzie Estuary, N.W.T. Report by F.F. Slaney and Company, Limited, Vancouver, BC. Available at: Dept. of Fisheries and Oceans, Box 1871, Inuvik, NT, Canada X0E 0T0. 28 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. 36p.

Fraker, M.A. and P.N. Fraker. 1979. The 1979 whale monitoring program, Mackenzie Estuary. Report by LGL Limited, Sidney, BC. Available at: Dept. 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. Cambers. 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.

Fraker, P.N. and M.A. Fraker. 1981. The 1980 whale monitoring program, Mackenzie Estuary. Report by LGL Limited, Sidney, BC. Available at: Dept. of Fisheries and Oceans, Box 1871, Inuvik, NT, Canada X0E 0T0. 98 p.

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(1): 22-30.

Goren, A.D., Brodie, P.F., Spotte, S., Ray, G.C., Kaufman, H.W., Gwinnett, A.J., Sciubba, J.J. and Buck, J.D. 1987. Growth layer groups (GLGs) in the teeth of an adult belukha whale (*Delphinapterus leucas*) of known age: evidence for two annual layers. Marine Mammal Science 3: 14-21.

Harwood, L. A. and T.G.Smith. 1999. Whales of the Beaufort Sea: an overview and outlook. Paper presented at the Beaufort Sea 2000 Conference, Inuvik, NT Canada, September 15-18, 1999.

Harwood, L.A., S. Innes, P. Norton and M.C.S. Kingsley. 1996. Distribution and abundance of beluga whales in the Mackenzie Estuary, south-east Beaufort Sea, and west Amundsen Gulf during late July 1992. Canadian Journal of Fisheries and Aquatic Sciences 53: 2262-2273.

Hill, P.S., and D.P. DeMaster. 1999. Alaska marine mammal stock assessments 1999. US Dep. of Comm., NOAA-TM-NMFS-AFSC-110, 166pp. Available: National Marine Mammal Laboratory, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, Washington, USA 98115.

Hunt, W.J. 1979. Domestic whaling in the Mackenzie Estuary, Northwest Territories. Canadian Fisheries and Marine Service Technical Report 769: iv + 14 p.

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

Kiefer, J. 1959. K-sample analogues of the Kolmogorov-Smirnov and Cramer-von Mises tests. Annals Math. Stat. 30: 420-447.

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. XII, 77p.

Lowry, L.F., J.J. Burns, and K.J. Frost. 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.

McGhee, R. 1988. Beluga hunters. An archaeological reconstruction of the history and culture of the Mackenzie Delta Kittygaryumuit. Newfoundland Social and Economic Series No. 13. Institute of Social and Economic Research, Memorial University of Newfoundland. 124 p.

Norton Fraker, P. 1983. The 1982 white whale monitoring program, Mackenzie Estuary. Prep. by LGL Ltd., Sidney, B.C., for Esso Resources, Dome Petroleum, and Gulf Canada, Calgary, Alberta. Available at: Dept. of Fisheries and Oceans, Box 1871, Inuvik, NT, Canada X0E 0T0. 53p.

Norton, P. and L.A. Harwood. 1985. White whale use of the south-eastern Beaufort Sea, July-September 1984. Can. Tech. Rep. Fish. Aquat. Sci. 1401. 46p.

Norton, P. and L.A. Harwood. 1986. Distribution, abundance and behaviour of white whales in the Mackenzie Estuary. Environmental Studies Revolving Funds Report 036. 73p.

Nuligak. 1966. I Nuligak. The autobiography of a Canadian Eskimo. Simon and Schuster of Canada, Toronto, ON. 191 p.

Perrin, W.F. and A.C. Myrick Jr (eds.). 1980. Report of the Workshop. Age Determination of Toothed Whales and Sirenians. Report of the International Whaling Commission, Special Issue 3: p 2.

O'Corry-Crowe, G.M. and L.L. Lowry. 1997a. Genetic ecology and management concerns for the beluga whale (*Delphinapterus leucas*), Molecular Genetics of Marine Mammals. A.E. Dizon, S.J. Chivers and W.F. Perrin (eds.). Society for Marine Mammalogy, Special Publication No. 3:249-274.

O'Corry-Crowe, G.M., R.S. Suydam, A. Rosenberg, K.J. Frost and A.E. Dizon. 1997b. 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.

Richard, P.R., A.R. Martin and J.R. Orr. 1997. Study of summer and fall movements and dive behaviour of Beaufort Sea beluga, using satellite telemetry: 1992-1995. Environmental Studies Research Funds, Report No. 134, Ottawa. 26 p.

SAS (Statistical Analysis System). 1996. SAS Users guide: Statistics Version 6. SAS Institute Inc., Cary, NC.

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.

Sokol, R.R. and Rohlf, F.J. 1995. Biometry. Third Edition, W.H. Freeman and Company, California.

Stewart, R.E.A. 1994. Size-at-age relationships as discriminators of white whale (*Delphinapterus leucas*) stocks in the eastern Canadian Arctic. Bioscience 39: 217-225.

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. 14 p.

Strong, T. 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. 52 p.

Wainwright, K.L. and R.S. Walker. 1988. A method of preparing beluga (white whale), *Delphinapterus leucas*, teeth for aging. Can. Man. Rep. Fish. Aquat. Sci. 1967. 15 p.

Weaver, P.A. 1991. The 1987 beluga (*Delphinapterus leucas*) harvest in the Mackenzie River Estuary, NWT. Canadian Man. Rep. Fish. Aquatic Sci. 2097. 18 p.

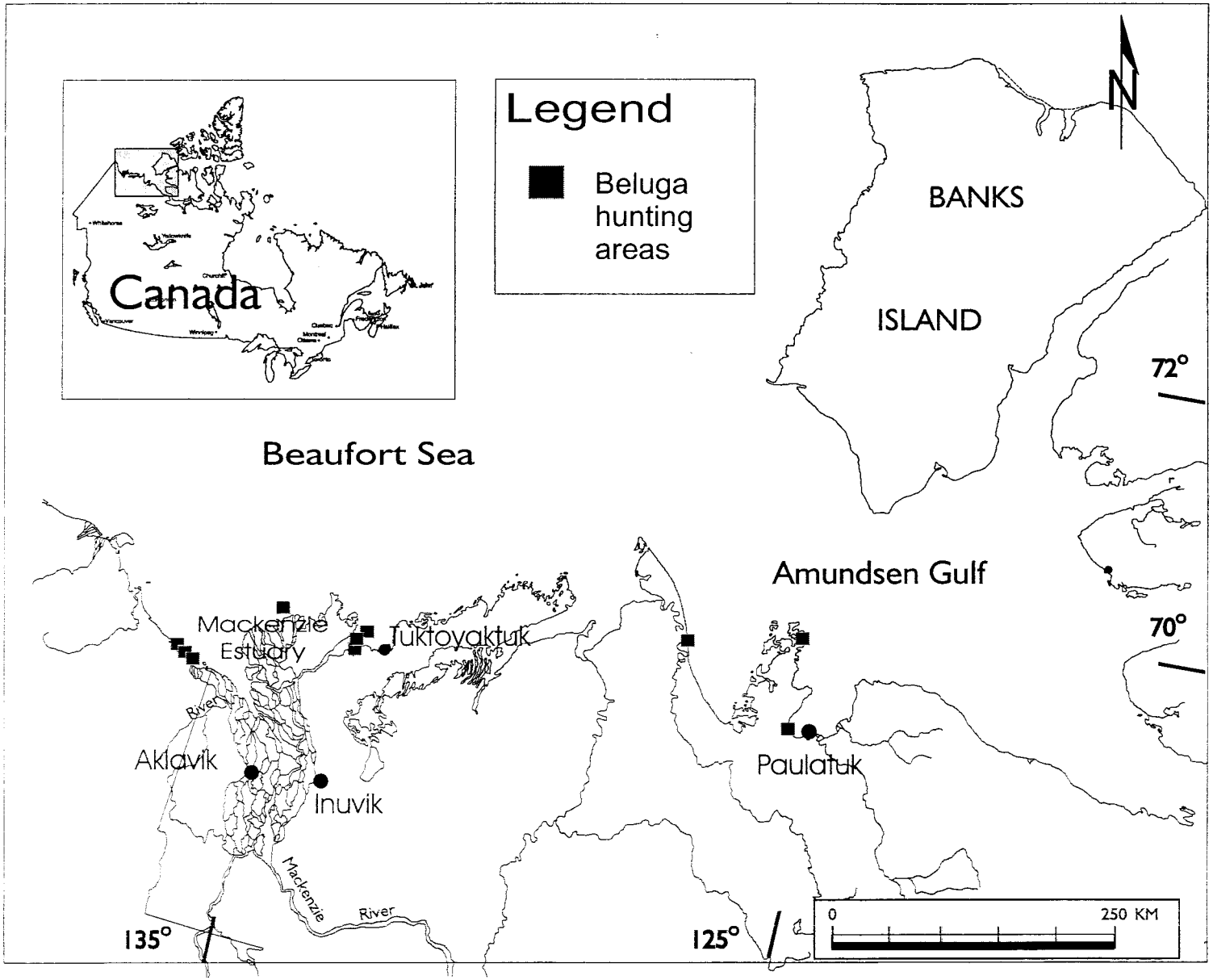

Fig. 1. Inuvialuit communities in the Western Arctic that regularly hunt the beluga whale

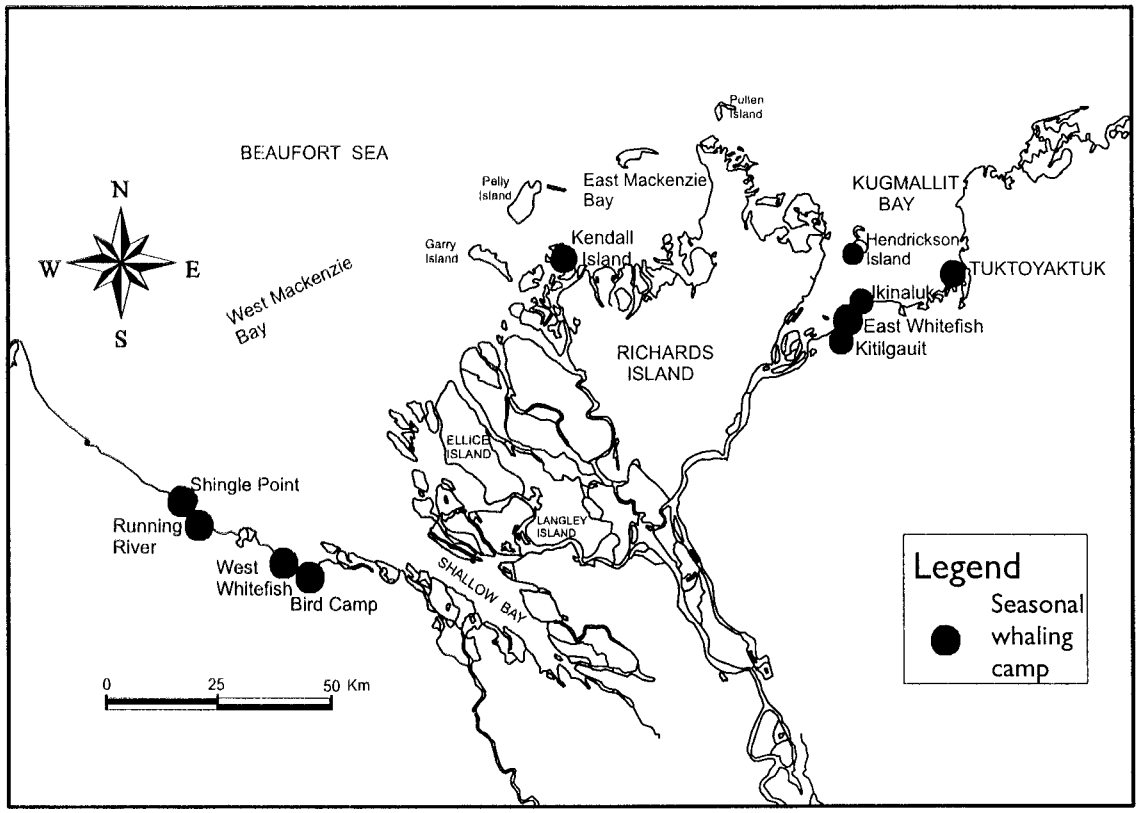

Fig. 2. Seasonal whaling camp locations used by the Inuvialuit of the Mackenzie Delta region

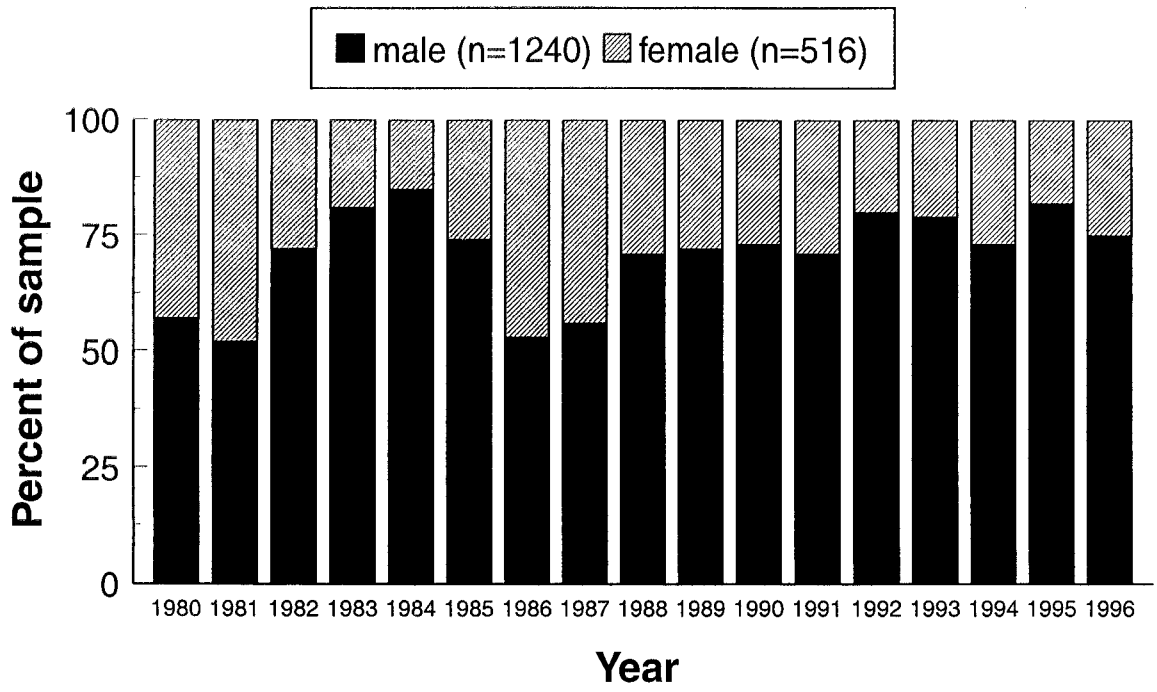

Fig. 3. Sex composition of the landed catch of beluga whales from the Mackenzie River Estuary, 1980-1996 (n=1756)

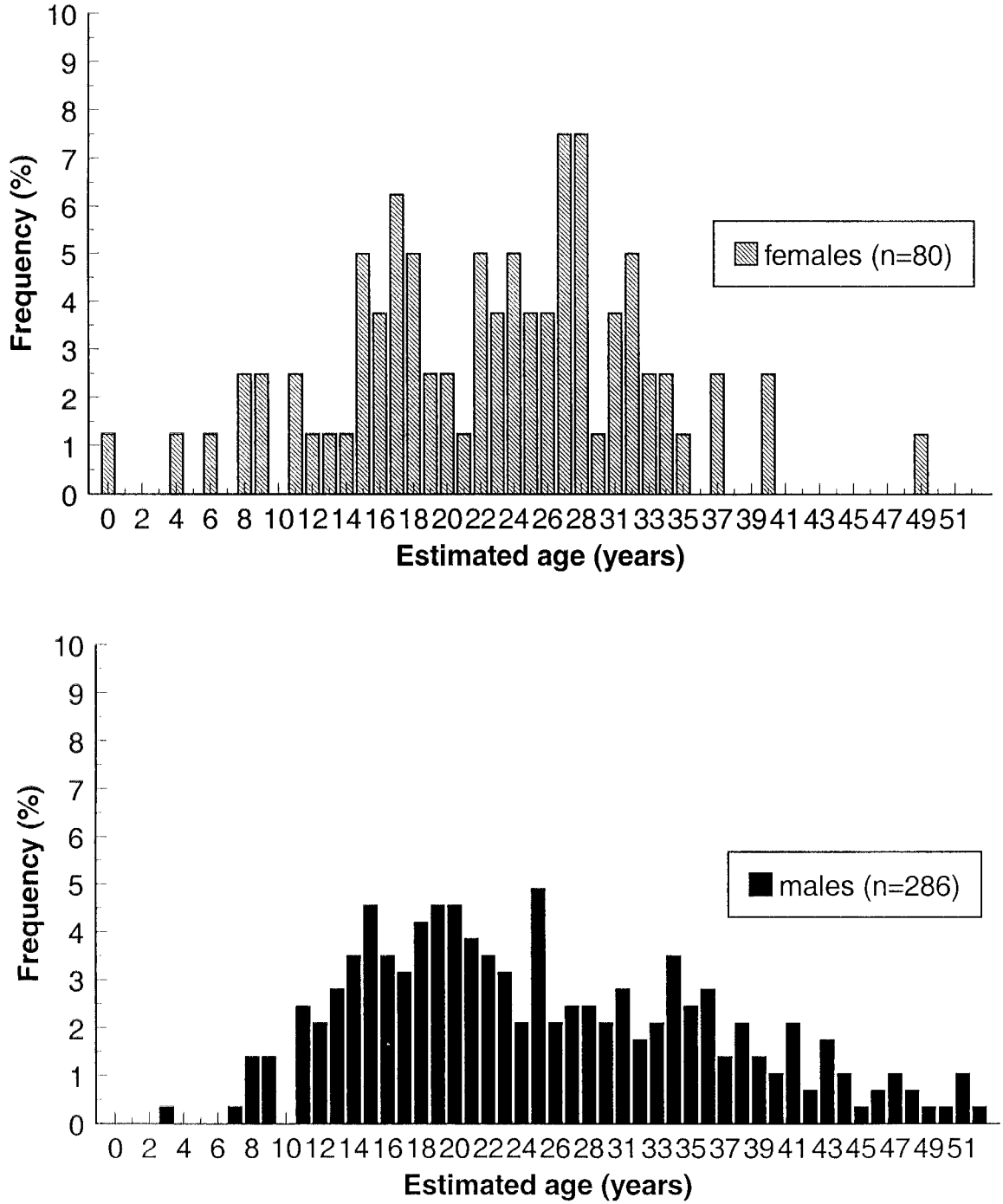

Fig. 4. Age-frequency distribution of a sample of female and male belugas landed in the Mackenzie River Estuary, 1988-1994 (n=368)

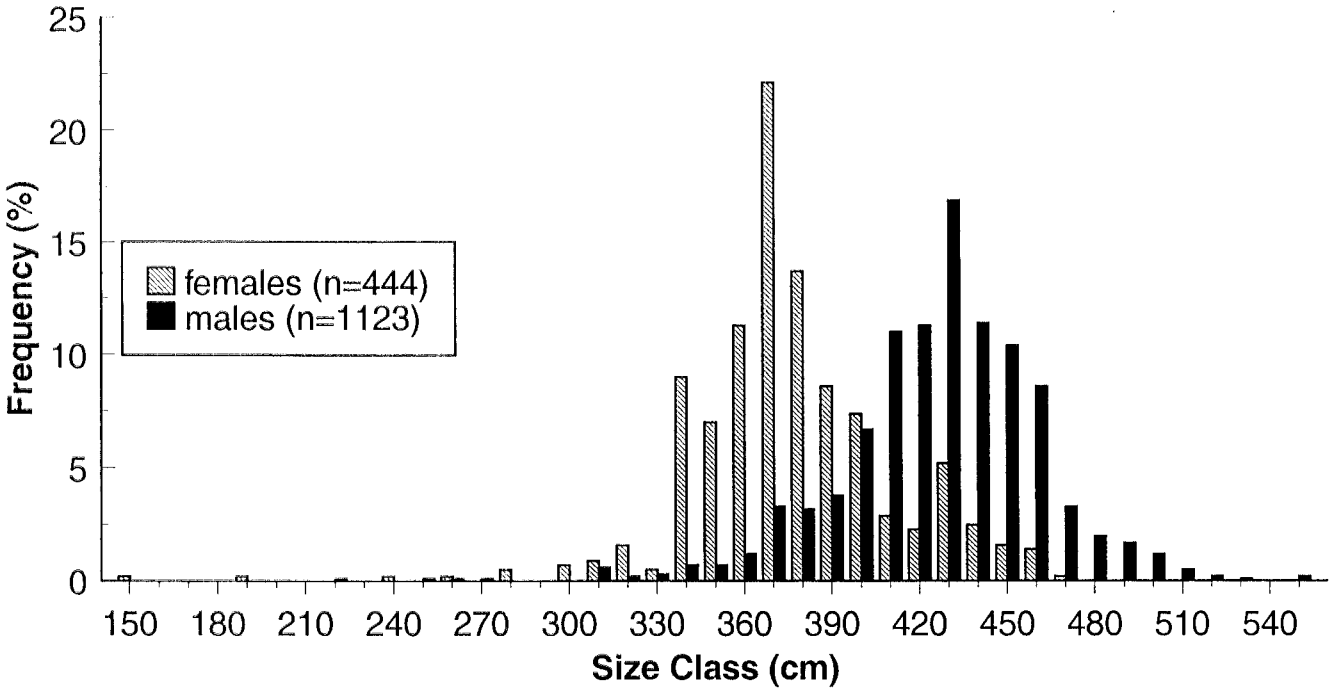

Fig. 5. Size-frequency distribution of a sample of female and male belugas landed in the Mackenzie River Estuary, 1980-1996 (n=1567)

Table 1. Number of beluga whales struck, landed and lost in the Mackenzie Delta and Paulatuk areas, 1970-1999 (data from Strong 1989; Weaver 1991; FJMC unpubl. data)

Year	No. Of Beluga			Percent
	Struck	Landed	Lost	Lost
1970	nr	115	nr	nr
1971	nr	79	nr	nr
1972	nr	113	nr	nr
1973	nr	178	nr	nr
1974	nr	128	nr	nr
1975	nr	149	nr	nr
1976	nr	154	nr	nr
1977	172	148	24	14.0
1978	157	129	28	17.8
1979	nr	144	nr	nr
Mean	*164.5*	*133.7*	*26.0*	*15.9*
SD		*26.0*		
1980	85	85	nr	nr
1981	155	155	nr	nr
1982	146	126	20	13.7
1983	102	86	16	15.7
1984	156	141	15	9.6
1985	148	120	28	18.9
1986	199	150	49	24.6
1987	174	144	30	17.2
1988	139	116	23	16.5
1989	156	117	39	25.0
Mean	*146.0*	*124.0*	*27.5*	17.7
SD		*23.3*		
1990	106	87	19	17.9
1991	144	116	28	19.4
1992	130	121	9	6.9
1993	120	110	10	8.3
1994	149	141	8	5.4
1995	143	129	14	9.8
1996	139	120	19	13.7
1997	123	114	9	7.3
1998	93	86	7	7.5
1999	102	86	16	15.7
Mean	*124.9*	*111.0*	*13.9*	*11.2*
SD	*19.5*	*19.0*		

nr= no record

Table 2. Proportion of beluga whales landed that were measured, aged, sexed and assessed for colour, 1977-1996 in the Mackenzie River Estuary beluga monitoring programs*

Year of harvest	Total landed	Number measured	% measured	Number aged	% aged	Number sexed	% sexed	No. With Colour recorded	% Colour recorded
1977	98	15	15.3	.	.	21	21.4	2	2.0
1978	114	24	21.1	.	.	44	38.6	3	2.6
1979	121	42	34.7	.	.	59	48.8	0	0.0
1980	82	77	93.9	.	.	77	93.9	75	91.5
1981	146	107	73.3	.	.	116	79.5	62	42.5
1982	107	96	89.7	.	.	98	91.6	99	92.5
1983	86	74	86.0	.	.	83	96.5	81	94.2
1984	141	99	70.2	.	.	111	78.7	112	79.4
1985	118	101	85.6	.	.	102	86.4	106	89.8
1986	131	109	83.2	.	.	121	92.4	118	90.1
1987	134	94	70.1	.	.	122	91.0	119	88.8
1988	114	94	82.5	62	54.4	111	97.4	95	83.3
1989	114	78	68.4	51	44.7	101	88.6	107	93.9
1990	87	63	72.4	53	60.9	78	89.7	75	86.2
1991	100	75	75.0	60	60.0	99	99.0	90	90.0
1992	103	89	86.4	73	70.9	103	100.0	94	91.3
1993	107	96	89.7	26	24.3	99	92.5	83	77.6
1994	133	117	88.0	43	32.3	128	96.2	127	95.5
1995	118	108	91.5	.	.	114	96.6	109	92.4
1996	95	90	94.7	.	.	93	97.9	86	90.5

Table 3. Asymptotic lengths of male beluga taken in the Mackenzie Estuary harvests, 1988-1994

Year	Asymptotic length (cm)	SD	df	95% confidence interval	
				lower	upper
1988	450.6	12.5	42	425.2	475.9
1989	446.9	13.8	37	418.9	474.8
1990	437.2	5.6	39	425.9	448.5
1991	433.1	3.4	47	426.2	440.0
1992	429.0	6.8	63	415.4	442.6
1993	443.2	14.7	20	412.3	474.1
1994	422.2	17.2	35	387.3	457.2
Years Pooled	432.6	2.6	289	427.5	437.6

Table 4. Mean annual standard length of male and female beluga landed in the Mackenzie Estuary harvest, 1980-1996

Females						Males					
SL (cm)	n	year	Means with same letter not statistically different*			SL (cm)	n	year	Means with same letter not statistically different*		
390.6	27	1988	A			438.0	44	1980	A		
387.1	33	1980	A	B		435.6	67	1988	A	B	
385.5	31	1994	A	B		431.5	75	1985	A	B	
379.6	15	1990	A	B	C	430.8	69	1982	A	B	
379.3	16	1992	A	B	C	429.6	84	1984	A	B	
378.5	15	1983	A	B	C	429.3	54	1991	A	B	
378.5	50	1986	A	B	C	428.8	57	1987	A	B	
376.6	20	1993	A	B	C	427.9	59	1983	A	B	
376.3	19	1995	A	B	C	427.8	48	1990	A	B	
376.1	37	1987	A	B	C	424.6	61	1989	A	B	C
372.6	21	1991	A	B	C	423.8	89	1995	A	B	C
371.0	15	1984	A	B	C	422.9	55	1981		B	C
370.6	23	1996	A	B	C	422.2	86	1994		B	C
370.2	17	1989	A	B	C	421.6	59	1986		B	C
366.7	26	1985	A	B	C	421.6	67	1996		B	C
365.4	52	1981		B	C	421.4	76	1993		B	C
357.6	27	1982			C	410.7	73	1992			C

* using Duncan's Multiple Range test