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Harvest statistics for beluga whales in Nunavik, 1974–2004

Statistiques des captures du béluga au Nunavik, 1974-2004

Véronique Lesage[1]
D. William Doidge[2]

[1]Fisheries and Oceans Canada
Maurice Lamontagne Institute, P.O. Box 1000, 850 route de la Mer
Mont-Joli, QC G5H 3Z4

[2]Makivik Corporation Inc.
Nunavik Research Center, Box 179, Kuujjuaq, QC J0M 1C0

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Abstract

The Nunavik communities have traditionally harvested beluga along the eastern Hudson Bay, Hudson Strait and Ungava Bay coasts of northern Quebec. Harvest statistics have been monitored over the last 30 years. A first report in 2001 summarized and qualified the information collected since 1974 (Lesage et al. 2001). The current report provides an update of this information for the period 2001–2004. A general decline in annual harvests was observed between the periods preceding and following quota introduction in 1986 after which, total harvests were less variable between years. Annual harvests were relatively similar over the last three years (2002–2004) at 168 to 216 beluga per year, but peaked at 395 beluga in 2001, a level last attained in 1980. Compliance with management measures improved during the period 2001–2004, and especially during 2002–2004, as indicated by a greater transmission of information through weekly reports, and participation in the sampling program, and by a general reduction in the total harvest in all regions of the Nunavik. In spite of these improvements, regional allocations were exceeded almost each year and in each region. Hudson Strait historically supported the largest harvests, and continued to do so during 2001–2004, with 60–84% of the allocations and 58–84% of the total annual harvest by Nunavik communities. One noticeable change during the period 2001–2004 in comparison with previous years was the increase in the number of communities harvesting in Hudson Strait. Although white beluga dominated the harvest, with 58% of the total catches, grey beluga, including dark grey animals, represented 42% of the catches during 2001–2004. The sex composition of the harvest indicates that females were generally killed as often as, or more often than males, both when considering genders independently of their colour, or when considering either white or grey beluga independently. The harvest during 1993–2004 also comprised a larger proportion of younger individuals than the harvest from the mid-1980s, resulting in a distribution with a median age of 9.5 yrs, compared with 13.0 yrs in the 1980s. This tendency to harvest younger individuals was also observed in the harvests of eastern Hudson Bay (median age = 8.5 yrs) and Hudson Strait (median age = 9.5 yrs.

Résumé

Les communautés du Nunavik ont traditionnellement chassé le béluga dans l'est de la Baie d'Hudson, le Détroit d'Hudson et la Baie d'Ungava dans le nord du Québec. Les statistiques de chasse ont été colligées depuis maintenant 30 ans. Un premier rapport résumant et qualifiant les informations récoltées depuis 1974 a été produit en 2001 (Lesage et al. 2001). Le présent rapport vise à mettre à jour ces informations pour la période 2001–2004. Un déclin général de la chasse a été observé entre les périodes précédant et suivant l'introduction de quotas en 1986 après quoi, les variations interannuelles des totaux de chasse étaient aussi moins importantes. Les prises au cours des trois dernières années (2002–2004) ont été relativement similaires, soit 168 à 216 beluga par an, mais elles ont atteint un maximum de 395 beluga en 2001, leur plus haut niveau depuis 1980. Le respect des mesures de gestion s'est amélioré en 2001–2004, particulièrement en 2002–2004, tel qu'indiqué par une transmission accrûe d'information à travers les rapports hebdomadaires, une meilleure participation au programme d'échantillonnage, et une réduction globale des prises dans toutes les régions du Nunavik. Malgré ces améliorations, les quotas régionaux ont été surpassés presque chaque année et dans chaque région. Le détroit d'Hudson était historiquement et demeure le lieu des plus grandes prises durant 2001–2004, avec 60–84% des quotas et 58–84% des prises par les communautés du Nunavik. Un changement notable pour la période 2001–2004 par rapport aux années précédentes a été l'augmentation du nombre de communautés à chasser dans le détroit d'Hudson. Bien que les individus blancs dominaient la chasse, avec 58% de l'ensemble des prises, les bélugas gris, incluant les individus gris foncés, représentaient 42% des prises en 2001–2004. La composition de la chasse indique aussi que les femelles ont été tuées aussi souvent, sinon plus souvent que les mâles, autant en considérant les genres indépendamment des couleurs qu'en considérant les bélugas blancs et gris séparément. Les prises durant 1993–2004 comprenaient également une plus grande proportion de jeunes bélugas que celles des années 1980s, résultant en un âge médian de 9.5 ans, comparativement à 13.0 ans durant les années 1980s. Cette tendance à chasser des bélugas plus jeunes subsiste également en examinant séparément les prises de l'est de la Baie d'Hudson (âge médian = 8.5 ans) et du détroit d'Hudson (âge médian = 9.5 ans).

Introduction

The beluga, *Delphinapterus leucas*, is a medium-sized odontocete with a circumpolar distribution. In northern Quebec (Nunavik), beluga are observed in large concentrations in Hudson Strait during the winter (Finley et al. 1982; Richard et al. 1990). Beluga disperse during the summer, and are observed along both coasts of Hudson Bay, as well as in James Bay and Ungava Bay. Molecular genetic studies (Brennin et al. 1997; Brown Gladden et al. 1997; de March and Postma 2003) indicate at least two separate stocks: a western Hudson Bay stock of ≈ 24,000 individuals, and an eastern Hudson Bay stock of 1300–2000 individuals (these estimates are uncorrected for animals missed because they were underwater during censuses; Smith and Hammill 1986; Richard et al. 1990; Kingsley 2000; Hammill et al. 2004; Gosselin 2005). Approximately 3,000–8,000 beluga enter James Bay during summer (Hammill et al. 2004; Gosselin 2005), but their relationship to other beluga is unclear. Beluga entering Ungava Bay during this period are now too few to be estimated using standard techniques (Smith and Hammill 1986; Kingsley 2000; Gosselin et al. 2002). In 1993, an estimated minimum of 20 individuals were present in Ungava Bay during summer, with an imprecise upper 90% confidence limit of 150 individuals (Kingsley 2000).

During the eighteenth, nineteenth, and early twentieth centuries, commercial whaling at various sites along the eastern Hudson Bay and Ungava Bay coasts increased hunting pressure on northern Quebec beluga stocks (Doan and Douglas 1953; Finley et al. 1982; Reeves and Mitchell 1987a; 1987b). Commercial harvests by the Hudson's Bay Company probably initiated the depletion of beluga stocks, whereas high subsistence harvests have likely limited the opportunity for stocks to recover (Finley et al. 1982; Reeves and Mitchell 1987a, b). Concerns for beluga in eastern Hudson Bay and Ungava Bay led to their designation as 'threatened' and 'endangered' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Reeves and Mitchell 1989; Richard 1993).

Native people from the Nunavik still harvest beluga along the northern Quebec coasts. However, beginning in 1986, the low estimates of beluga abundance for eastern Hudson Bay and Ungava Bay resulted in limits being placed on harvesting through a combination of quotas and seasonal and regional closures (Appendix 1). A population model incorporating harvest information since 1974, and fitted to the aerial survey data for the period 1985–2001 indicated a decline in the number of beluga in eastern Hudson Bay by almost half since 1985 (Hammill et al. 2004). These findings led to more stringent limits on harvesting, including a complete closure of eastern Hudson Bay since 2002 (Table 1). In 2004, the status of the Nunavik beluga stocks was reviewed by COSEWIC; the committee reaffirmed the 'endangered' status of the Ungava Bay stock, and afforded a status of 'endangered' to eastern Hudson Bay beluga (Smith 2004).

A review and qualification of the harvest statistics available from the different communities of the Nunavik between 1974 and 2000 is available from Lesage et al. (2001). This study presents catch data in relationship with regional allocations for the period 2001–2004, as well as information on the spatial distribution, and age, colour and gender composition of the harvests.

Methods

The number of beluga harvested by communities of the Nunavik has been collected systematically since 1974, although the degree of participation and quality of the information varied between communities and years (reviewed in Lesage et al. 2001). Catch data during 1974 and 1975 were obtained *a posteriori* through questionnaires to hunters, whereas those from 1976 to 1980 were obtained through weekly reports by individual hunters. It is unclear how catch data were obtained during the 1980–1984 period, but in 1985, beluga harvests were monitored on a daily basis using booklets distributed to individual hunters (Brooke and Kemp 1986). Beginning in 1986, community agents, and depending on years, personnel from Anguvigaq, Makivik, or Kativik Regional Government, assisted in the monitoring of beluga harvests through weekly and annual reports (Brooke 1992; 1995; 1996; 1997; 1998; Olpinski 1993; Portnoff 1994; Richard 1993; R. Fibich, Coordinator, Northern Quebec Affairs, Fisheries and Oceans Canada, for years 1998–2000). During the period 2001–2004, harvest statistics were obtained through weekly reports from community Fisheries Guardians (2001–2003) or Renewable

Resources Officers (2004) to the Kativik Regional Government (subsequently transmitted to D. Baillargeon, Coordinator, Northern Quebec Affairs, Fisheries and Oceans Canada).

A sampling program to document the composition, seasonal and spatial distribution of harvests exists since 1993. Hunters were provided data sheets and sampling kits, and were asked to indicate the gender and colour of each individual, location and date of harvesting. Hunters also collected a tooth for age determination and a skin sample for genetic studies (de March and Postma 2003). The proportion of the harvest that was sampled under this program varied between communities and years.

Harvest statistics during the pre-quota (1974–1985) and post-quota period were examined separately. Between 1974 and 1985, an estimate of annual harvests by each community was obtained by correcting catch data provided by participating hunters in a community for those who were unwilling to participate in the program (Native Harvesting Research Committee 1976; 1982a; 1982b). For years 1986 to 2000, this correction does not appear to have been maintained, and reported harvests for 1986–2004 represent total harvests. In years when a community did not participate in the program, harvest levels were estimated using median catch levels for the period characterized by similar management measures. For example, annual harvests for Ivujivik in yrs 1974 to 1980 were estimated as the median catch levels over the 1981–1985 period, *i.e.* 69 beluga. However, the use of a similar estimate was not possible in the case of Puvirnituq during 1974–1985, this community having failed to provide harvest statistics during the entire period when there was no regulation of the beluga harvest.

Harvest statistics were examined separately for five regions of the Nunavik, i.e., James Bay (JB), Long Island area, eastern Hudson Bay (EHB), Hudson Strait (HS), and Ungava Bay (Figure 1). These divisions were the basis for the most recent management plans (2001–2004), and were inspired from recent information on the seasonal movements and distribution of eastern Hudson Bay and western Hudson Bay beluga through satellite telemetry (Hammill et al., unpublished data; P. Richard et al., Fisheries and Oceans Canada, Winnipeg, unpublished data). For the period 2001–2004, weekly reports by each community were scrutinized to determine the location of each hunt. Complementary information was obtained from the sampling program and from consultations with the community majors and members of the Hunters, Fishers and Trappers Association. In spite of the existence of these different sources of information, harvest locations remained unknown for some of the beluga harvested during 2001–2004. In order to account for this uncertainty in the harvest relative to allocations, regional harvest statistics were presented as a range of values, where the minimum represented the number of beluga known to have been killed in a given area, and the maximum indicated the total harvest, assuming beluga killed in unknown locations were all harvested in this area.

Information on the colour and gender of harvested beluga were available through weekly reports and the sampling program. However, only the latter source of data was used in this study, since information on gender and colour of harvested beluga were disseminated in the many weekly reports provided during the period 1993–2004, and thus, were not readily available.

Age was determined, assuming the deposition of two growth layer groups (GLGs) per year (Goren et al. 1987; Brodie et al. 1990). Tooth wear might bias age downward in older animals, and was noted for each tooth, except in 1993, 1995 and 1997. The reader involved in the age determination during the 1980s double-checked some of the ages obtained during 1993–2004 to insure consistency of the results. The age of the beluga harvested during 1993–2004 were compared with those harvested in the same area during 1980–1987, using information provided by hunters (1993–2004) and published information (1980, 1983–1987: Doidge 1990).

Results

Annual total harvests, harvest trends and location

A general decline in annual harvests was observed between the period preceding and following quota introduction in 1986 (Figure 2; Appendix 2). After 1986, total harvests were also less variable between years (Figure 2). Annual harvests in recent years (2001–2004) were relatively similar in 2002, 2003 and 2004 at 168–216 beluga/yr but peaked at 395 beluga in 2001, a level last attained in 1980

(Appendix 2). This high harvest was the combined result of a high allocation in Hudson Strait (N = 310 beluga) and harvests in excess of quotas in eastern Hudson Bay and Ungava Bay (Table 2). Compliance with management measures improved during the period 2001–2004, and particularly during 2002–2004, as indicated by: 1) a greater willingness to report catches through weekly reports in communities once reluctant to do so (e.g., Ivujivik), 2) an increased participation in the sampling program (N = 327 samples during 2001–2004 vs N = 363 during 1993–2000), 3) a global reduction in the total harvests (Table 2). In spite of these improvements, regional allocations were exceeded almost each year and in each region (Table 2; Figure 3).

Annual beluga harvests varied greatly between regions and communities (Table 2; Appendix 2). Historically, the largest harvests were from the Hudson Strait communities, whereas the lowest catches consistently came from communities of Ungava Bay. Inujjuaq and Puvirnituq in eastern Hudson Bay also harvested large numbers of beluga annually, either prior to or after quota introduction in 1986 (Appendix 2; reviewed in Lesage et al. 2001). During the period 2001–2004, the communities with the largest harvests were still the four communities of Hudson Strait and Puvirnituq, with mean annual harvests of 20–36 beluga. Communities whose harvesting was the least intense were Umiujaq, Inujjuaq, Aupaluk and Kangirsualujjuaq, with an average harvest of ≤ 8 beluga/yr.

When examined on a regional basis, Hudson Strait historically supported the largest harvests (Appendix 2), and continued to support most of the harvest during 2001–2004, with 60–84% of the allocations and 58–84% of the total annual harvest by Nunavik communities. However, one noticeable change during the period 2001–2004 in comparison with previous years was the increase in the number of communities harvesting in this area. This tendency was particularly obvious for the Ungava Bay communities, all of which harvested part of their quota in Hudson Strait during 2001–2004, compared with only one or two communities doing so prior to 2001 (Table 2).

In Ungava Bay, prescriptions of time/area closures and allocations varied between 2001–2004 from a closure of the Bay in August with a maximum of 25 beluga per community that were to be harvested as much as possible in Hudson Strait in 2001, to a strict closure of the entire Bay in 2002 and 2003, and an opening of the Bay in July only, but a maximum allocation of 3 whales per community in 2004 (Table 1). A vast majority of the communities from Ungava Bay harvested in locations or at times when the hunt was not permitted, even though few communities exceeded their allocations (Table 2).

The management plan of 2001 prescribed that no more than 30 beluga be harvested in eastern Hudson Bay, including a maximum of 15 beluga at the Nastapoka and 15 beluga at Little whale River (Table 1). These allocations were largely exceeded during that year, with a regional harvest of 64–88 beluga (Table 2), including ≥ 18 and 14 beluga harvested at LWR and Nastapoka River, respectively. In the following (2002) and subsequent years, a complete closure of eastern Hudson Bay was proposed, which led to a reduction in the total regional harvests (Tables 1, 2). A minimum of 4 beluga/yr were harvested in the closed area, with a maximum of 19 individuals in 2003. Puvirnituq and Akulivik shifted most of their harvest in Hudson Strait near Ivujivik, although they continued to harvest some beluga in the vicinity of their community (Table 2). During 2001–2004, eastern Hudson Bay communities were also encouraged to harvest beluga in James Bay and near Long Island, and in Nunavut to reduce hunting pressure on the eastern Hudson Bay stock. As a result, 1–16 beluga/yr were harvested in these areas.

Age and sex composition of harvests

Of the 690 beluga sampled in Nunavik waters between 1993 and 2004, 628 individuals had their colour qualified, including 301 during the period 2001–2004. Dark grey juveniles represented 9% (N = 59) and 11% (N = 32) of the total harvest during the periods 1993–2004, and 2001–2004, respectively. Grey or light grey beluga accounted for about one third of the harvest during both periods, with 36% (N = 223) and 31% (N = 93) occurrences in 1993–2004 and 2001–2004, respectively. White beluga dominated the harvest during both 1993–2004 and 2001–2004, representing 55% (N = 346) and 58% (N = 176) of the harvest, respectively.

A total of 609 beluga sampled during 1993–2004 were of known gender, including 296 (48.6%) individuals for the period 2001–2004. The proportion of males (M) and females (F) harvested in the different regions of the Nunavik varied between years (Figure 4). However, the overall sex ratio between

males and females was not significantly different from unity (0.96:1.0) during 1993–2004 ($\chi^2 =$ 0.20, P = 0.65). Similar results were obtained when treating each region separately (ratios of 1:06:1, 0.91:1, and 0:79:1 for EHB, HS, and Ungava Bay, respectively; all $P > 0.05$), and when examining the overall sex ratio 2001–2004 only (ratio = 0.95:1.0, N = 296, χ^2 = 0.21; P = 0.64). However, regional sex ratios deviated significantly from unity during 2001–2004 in eastern Hudson Bay (ratio 2.4:1, N = 31, (χ^2 = 5.45, P = 0.02), and Hudson Strait (ratio = 0.76:1, N = 210, (χ^2 = 3.73, P = 0.05), but not in Ungava Bay (ratio = 0.77:1, N = 23, (χ^2 = 0.39, P = 0.53), when more males than females were harvested in eastern Hudson Bay, and the reverse was observed in Hudson Strait.

Among white beluga, females were harvested as often as males, both when considering overall sex ratio, and each region separately during 1993–2004 (Table 3). This tendency was maintained in 2001–2004, although of the 24 white beluga of know gender harvested in Eastern Hudson Bay during that period, two females were killed for each male harvested (χ^2 = 2.67, N = 24, P = 0.10, so non-significant). When considering only grey or light grey beluga, significantly more grey females were killed than grey males during both 1993–2001 and 2001–2004 (χ^2 = 7.84 and 6.53, N = 204 and 81, P = 0.005 and 0.01, respectively). This tendency for a larger harvest of grey females than grey males was observed in each region and both periods, except in eastern Hudson Bay in 2001–2004 when only 8 beluga were killed (3 females and 5 males). This trend was statistically significant in Hudson Strait during both periods (χ^2 = 5.52 and 7.67, N = 142 and 69, P = 0.01 and 0.006, respectively), but not in the other regions, although a lack of statistical power may be involved in some cases (N = 4–46 ind.) (Table 3).

The relatively large proportion of grey beluga in the harvest was reflected in its age structure. In the analysis performed in 2001, a statistically significant reduction was documented in the age composition of the beluga harvest during 1993–1999 compared to the 1980s (Lesage et al. 2001). This tendency was also observed when considering eastern Hudson Bay or Hudson Strait, separately. Adding beluga harvested during 2000–2004 to this dataset resulted in a similar trend. Beluga harvested throughout Nunavik during 1993–2004 comprised a larger proportion of younger individuals than the harvest from the mid-1980s, resulting in a distribution with a median age of 9.5 yrs, compared with 13.0 yrs in the 1980s (Kolmogorov-Smirnov two-sample test: $D_{194,511}$ = 0.29; $P < 0.0001$; Figure 5). This tendency to harvest younger individuals was also observed in eastern Hudson Bay (median age = 8.5 yrs) and Hudson Strait (median age = 9.5 yrs) (Kolmogorov-Smirnov two-sample test: $D_{120,119}$ = 0.364 and $D_{194,309}$ = 0.297; both $P < 0.0001$; Figure 6). The overall decrease in the age of harvested beluga was also reflected in the proportion of beluga with worn teeth, which declined from 42% in 1980—1987 to 21% in 1993—1999 and 31% in 1993–2004.

Recent harvests are also characterized by an absence of older individuals. In the 1980–87 harvest, the oldest beluga was 34 yrs-old, whereas during 1993–2004, the maximum age declined to 21 yrs, both in eastern Hudson Bay and Hudson Strait.

Discussion

The methodology of harvest data collection changed on several occasions between 1974 and 2000, and the possible consequences of these changes were reviewed in Lesage et al. (2001). Between 2001 and 2004, harvest statistics were compiled by the Fisheries Guardians or Renewable Resources Officers of each community and thus, were collected in a consistent manner. Nevertheless, trends in beluga harvests must be interpreted with caution due to partial reporting of catches by some communities, and to partial, and sometimes fragmentary information on harvest location. For example, the official harvest statistics indicate a harvest of 13 beluga in 2001 for Ivujivik. This community has a history of heavy harvesting (Appendix 2), and the harvest figures provided to the Regional government probably underestimated their total harvest, but by an unknown amount. During the same year, the community of Puvirnituq harvested 50 beluga. The proportion of their harvest taken from eastern Hudson

Bay vs Hudson Strait is unknown owing to a low participation in the sampling program and transmission of weekly report (during harvesting weeks), and the lack of details within the reports when provided.

The regional distribution of the harvests indicates little compliance with the management measures in 2001 (Table 2). However, a lack of clarity in these measures in Ungava Bay and eastern Hudson Bay were probably partly responsible for these observations. The management plan for 2001 allocated quotas of 25–30 beluga per community. In Ungava Bay, communities agreed to *favour Hudson Strait hunting*, and to close the Bay (excluding the Mucalic sanctuary) to harvesting in August. In other words, although the communities were 'encouraged' to harvest outside of Ungava Bay, there were no sanctions if the entire quota (of 125 beluga) was harvested in the Bay at other times than August. During that year, 21–78 beluga were harvested in Ungava Bay, and only 7 were clearly harvested illegally, i.e., in August (Table 2). A similar confusion probably arose from the management plan for eastern Hudson Bay, where the three communities from the EHB arc (Kuujjuaraapik, Umiujaq and Inujjuaq) were allowed each to harvest 25 beluga. However, only 30 beluga were to be harvested in the EHB arc (i.e., a max. of 15 beluga at Little Whale River and a max. of 15 beluga at the Nastapoka River). The remaining portion of the quota was to be taken in Hudson Strait (Anonymous 2001). This measure required a certain level of consultation among the communities of the EHB arc over the course of the hunting season. The fact that 2001 was the first year when management measures other than maximum allocations per communities were introduced probably contributed to the observed situation (Fisheries and Oceans Canada 2001).

In 2002, 2003 and 2004, regional allocations were consistently exceeded, except in Ungava Bay in 2004 (Table 2). Nevertheless, the total harvests in each area were reduced considerably compared to 2001, which suggests an increasing awareness of the problematic related to over-harvesting of beluga stocks by most of the Nunavik communities.

Overall, the capacity to monitor the harvest improved during 2001 to 2004, compared with previous years. In eastern Hudson Bay, a close collaboration with the authorities of the different communities, particularly those from the EHB arc, reduced the uncertainty related to the location of harvesting and contributed to augment the database related to gender, age, colour and genetic make-up of the beluga harvested in this region through the sampling program. However, the lack of information on the distribution of the harvest in communities such as Puvirnituq, introduces uncertainties in the modeling exercises of population dynamics in eastern Hudson Bay (Hammill et al. 2004; Hammill et al. 2005). Similarly, the variable collaboration from Ungava Bay communities hampered the monitoring of the impacts of the harvest on the Ungava Bay beluga stock, since total harvests varied by a factor of four during 2001–2004, depending on whether beluga harvested in undeclared locations were harvested or not in Ungava Bay.

The colour and sex composition of the harvest indicate that females and grey beluga contributed for a large proportion of the harvest. Females were generally killed as often as, or more often than males, both when considering genders independently of their colour, and when considering either white or grey beluga independently. Management plans since 1996 specifically recommended that individuals with the highest reproductive values, *i.e.* reproductively active females and grey beluga, be protected. The tendency to harvest females and males indiscriminately and to harvest juvenile beluga was also observed prior to 2001 (Lesage et al. 2001). The harvest statistics indicate that the management measure in its current form is largely inefficient in protecting these components of the population. The large proportion of grey and large animals in the harvests might reflect a reduced availability of white animals, whereas the large proportion of white females might reflect the inability of hunters to distinguish between white males and females.

This study provided evidence that beluga currently harvested in Nunavik are considerably younger than those landed during the mid-1980s. The differences observed in the estimated age distributions between the 1980s sample and the 1990–2000s sample were unlikely an artefact of differences in the interpretation of growth layer groups in the teeth between the two periods. The person involved in teeth reading during the mid-1980s (DWD) double-checked some of the teeth from the 1990s to ensure consistency in age reading between the two periods. In addition, the decline in the proportion of worn teeth from 44% in the 1980s to 31% in 1993–2004 is consistent with a recent harvest incorporating a larger number of younger beluga.

The apparent difference in the estimated age distributions between the two periods might have arisen from changes in the availability of older beluga. This could have happened through a change in hunting practices, a change in the inshore/offshore distribution of adults, or a depletion of the population. During the mid-1980s, harvesting effort in estuaries such as the Nastapoka River or Little Whale River was spread out over July and August. By the 1990s, most hunting was concentrated in the first few days of August, when the season opened. The types of vessels and engines that are used to hunt beluga have also changed since the 1980s (Doidge 2001), hunters are now younger, and there are more less-experienced hunters than during the 1980s. During these short-term hunts, a large proportion of the beluga may be killed all at once. Selectivity is then probably low, and these two factors might result in a larger proportion of younger animals being killed. The quicker return to estuaries of females with calves after a disturbance (Caron and Smith 1990) may also increase their vulnerability to hunters. The overall seasonal distribution of harvests has changed little between the 1980s and 1993–2004 and thus, has unlikely affected the composition of catches. However, the extent to which different areas are used for hunting, *e.g.* estuaries *vs* more open water, may have changed compared to the 1980s. The extent of changes in hunting practices over time, and how they might have affected the age structure of the harvests remain uncertain.

Disturbance in estuaries has increased since the 1980s (Doidge 2001; Doidge and Lesage 2001), and might have caused older, less naïve, white beluga to stay offshore. The proportion of white to grey beluga in herds observed in the Nastapoka estuary increased during the 1990s (58% in 1993 and 63% in 2000: Doidge 2001) compared to the 1983—1984 period (54%: Caron and Smith 1990, in Doidge 2001) and thus, does not support the hypothesis of a recent, greater avoidance of estuaries by white beluga. A similar increase in the proportion of white beluga in the harvests from 40% in the 1980s (D.W. Doidge, unpublished data) to 55% in the 1990s also tends to dismiss this hypothesis, if one assumes hunters were not selective towards a colour or sex class. The residency time, movement patterns, and motivations in frequenting estuaries are poorly understood in northern Quebec beluga. A study conducted at the Nastapoka Estuary during the mid-1980s indicates that white females at that time, were four times more abundant than white males in this estuary (Caron and Smith 1990). These observations and the quicker return of females with calves to estuaries after a disturbance (Caron and Smith 1990) suggest that adult females with calves may be more strongly attached to estuaries than white males. No information on the relative abundance of white males and females is available for the 1990s. However, during both the 1980s and the 1990s, the Nunavik hunters killed white males and females in approximately equal numbers (Lesage et al. 2001; this study). If one assumes selectivity – if it existed – remained constant over time, these observations would indicate that the relative availability of sex classes of white beluga were similar during both periods.

The recent change observed in the age distribution of harvests could be an evidence of stock depletion. A study conducted in 2000, and which indicated longer duration-of-absence of beluga from the Nastapoka Estuary following a disturbance than during the 1980s, tend to support this hypothesis (Doidge 2001; Doidge and Lesage 2001). The beluga first entering an estuary following a disturbance were shown not to be the same as those that were disturbed (Caron and Smith 1990). As a population decline, the probability of a herd entering an estuary soon after a disturbance also declines, which might result in longer duration-of-absence of beluga from estuaries (Doidge 2001). On the other hand, if the recent change towards younger beluga resulted solely from the depletion of the eastern Hudson Bay stock, one would expect the age distribution of the beluga harvested in Hudson Strait to resemble that of the 1980s, given the small contribution (approx. 20%) by eastern Hudson Bay beluga to the harvest in this region, according to DNA analyses (reviewed in Hammill et al. 2005). However, a shift in the age distribution of the harvest towards younger individuals was also observed in Hudson Strait, although it was not as pronounced as in eastern Hudson Bay (Median age = 9.5 in Hudson Strait vs 8.5 y in EHB). These results might indicate one of two things: 1) the contribution of EHB beluga to the harvest of Hudson Strait is underestimated in the current information available from genetics studies, or 2) some of the factors discussed above, such as a change in harvesting practices, also contributed to the observed patterns.

In summary, the implementation of quotas to the beluga harvest had the effect of stabilising total harvests, although regional or community quotas continue to be regularly exceeded. This study indicated that females and grey beluga contributed for a large proportion of the harvest, and that beluga harvested

in northern Quebec during 1993–2004 were younger than those landed in the 1980s. Although these results could indicate population depletion, other factors might have resulted in a change in the age distribution of harvest since the 1980s, and require further investigation.

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Table 1. Beluga management plans for the Nunavik region 2001–2004. Additional management measures are presented in the different source reports. Management plans prior to 2001 are presented in Appendix 1.

Region	Community	2001	2002	2003	2004
Eastern	Kuujjuaraapik	25[a]	10 Long Is. + 5 JB	10 Long Is. + 5 JB	10 Long Is./JB + 5 Nunavut
Hudson Bay (EHB)	Umiujaq	25[a]	10 Long Is. + 5 JB	10 Long Is. + 5 JB	10 Long Is./JB + 5 Nunavut
	Inujjuaq	25[a]	10 Long Is. + 5 JB	10 Long Is. + 5 JB	10 Long Is./JB + 5 Nunavut
	Puvirnituq	25 H. Strait	15 H. Strait	15 H. Strait	15 H. Strait
	Akulivik	25 H. Strait	15 H. Strait	15 H. Strait	15 H. Strait
	Other agreements	Little Whale and Nastapoka closed in July	EHB closed	EHB closed	EHB closed
Hudson Strait (H. Strait)	Ivujivik	30	15 H. Strait	15 H. Strait	15 H. Strait
	Salluit	30	15 H. Strait	15 H. Strait	15 H. Strait
	Kangirsujuaq	30	15 H. Strait	15 H. Strait	15 H. Strait
	Quartaq	30	15 H. Strait	15 H. Strait	15 H. Strait
Ungava Bay (UN)	Kangirsuk	25 (all outside UN)	15 H. Strait	15 H. Strait	15 H. Strait
	Aupaluk	25 (all outside UN)	5 H. Strait + 10 JB	5 H. Strait + 10 JB	5 H. Strait + 3 UN + 7 Nunavut
	Tasiujuaq	25 (all outside UN)	5 H. Strait + 10 JB	5 H. Strait + 10 JB	5 H. Strait + 3 UN + 7 Nunavut
	Kuujjuaq	25 (all outside UN)	5 H. Strait + 10 JB	5 H. Strait + 10 JB	5 H. Strait + 3 UN + 7 Nunavut
	Kangirsualujjuaq	25 (all outside UN)	5 H. Strait + 10 JB	5 H. Strait + 10 JB	5 H. Strait + 3 UN + 7 Nunavut
	Killiniq	-	-	-	-
	Other agreements	Ungava Bay closed in August Mucalic R iver[b] closed	Ungava Bay closed	Ungava Bay closed	Ungava Bay opened (max. 12 ind.) in July only Mucalic River[b] closed

[a] To be harvested in consultation with the other two communities from the EHB Arc so that total harvest did not exceed 15 beluga at the Nastapoka river, 15 beluga at Little Whale river, and 30 individuals in James Bay; the remaining beluga were to be taken in Hudson Strait

[b] Comprises the Whale, Mucalic, Tuctuc and Tunulic river

Table 2. Annual and regional harvests of beluga by the different communities of the Nunavik during 2001–2004. The minimum in range values indicate the number of beluga known to have been killed in a given area, whereas the maximum of the range indicates the maximum harvest, assuming beluga killed in unknown locations were harvested in the area.

Region	Harvest	Community	2001	2002	2003	2004
James Bay		Umiujaq/Inujjuaq	1			
		Inujjuaq		5		
		Umiujaq			0–2	
		Kuujjuaraapik			4–5	
	Total		**1**	**5**	**4–7**	**0**
	Quota		**30**	**55**	**30[a]**	**30[a]**
Long Island		Umiujaq			2–4	2
		Kuujjuaraapik			3–4	15
	Total		**0**	**0**	**5–8**	**17**
	Quota		**-**	**30**	**30[a]**	**30[a]**
Eastern Hudson Bay		Inujjuaq	25**		4**	
		Akulivik	2		0–1**	
		Kuujjuaraapik	15**	0–3**	5–6**	
		Umiujaq	17**	4–5**		3**
		Puvirnituq	5–29**		1–10**	
		Kangirsujuaq			1**	
	Total		**64–88****	**4–8****	**11–22****	**3****
	Quota		**30**	**0**	**0**	**0**
Hudson Strait		Ivujivik	13	41**	52**	22**
		Salluit	57**	21**	18**	21**
		Kangirsujuaq	34**	16**	15	14
		Quartaq	60**	34**	34**	15
		Akulivik	31**	16**	0–1	16**
		Puvirnituq	21–45**	16	0–9	19**
		Kangirsuk	0–16	2–10**	3–13	15
		Aupaluk	0–5	1–2	5–10**	7**
		Tasiujaq	0–20	0–4	4–5	2
		Kuujjuaq	0–16	2–9**	23**	6**
		Kangirsualujjuaq	13		0–2	4
Hudson Strait (Killinik)		Kangirsualujjuaq		3[b]	1[b]	
	Total		**229–310**	**149–169****	**155–183****	**141****
	Quota		**310**	**125**	**125**	**125**
Ungava Bay		Kangirsualujjuaq	4 (4)[c]	1	2–4**	
		Kuujjuaq	4–20 (0–16)[c]**	3–9	4**	2 (0)[c]
		Tasiujaq	3–23 (0–19)[c]**	5–9	3–4	
		Aupaluk	2–7 (2–7)[c]	1–2	0–5**	
		Kangirsuk	8–24 (8–24)[c]	1–9	4–14**	2 (0)[c]
	Total		**21–78 (14–70)****	**11–30****	**13–31****	**4 (0)[c]**
	Quota		**0[d]**	**0**	**0**	**12[e]**
Nunavut		Puvirnituq			2	
		Inujjuaq				
	Total				**2**	**0**
	Quota				**43[f]**	**43[f]**

[a] For Long Island and James Bay combined
[b] As part of Hudson Strait quota
[c] The N of beluga legally harvested is indicated in parentheses (i.e., during area opening)
[d] Hunters encouraged to hunt outside of Ungava Bay, with a strict closure in August
[e] Ungava Bay opened to harvesting only in July
[f] Proposed but needed approval by NWMB
** Indicates that the harvest exceeded the allocation

Table 3. Total numbers of beluga of known colour and gender that were harvested during 1993–2004 in different regions of the Nunavik. Figures corresponding to the most recent period only (i.e., 2001–2004) are presented in parentheses.

Sex	Colour	Sector			Total
		Eastern Hudson Bay	Hudson Strait	Ungava Bay	
Female	Dark Grey	5 (1)	19 (13)	6 (2)	30 (16)
	Grey	26 (3)	85 (46)	11 (3)	122 (52)
	White	36 (8)	85 (52)	16 (8)	137 (68)
	Unknown	0 (0)	9 (8)	0 (0)	9 (8)
Total		**67 (12)**	**198 (119)**	**33 (13)**	**298 (144)**
Male	Dark Grey	4 (1)	15 (7)	3 (2)	22 (10)
	Grey	20 (5)	57 (23)	5 (1)	82 (29)
	White	45 (16)	102 (54)	18 (7)	165 (77)
	Unknown	1 (0)	7 (7)	0 (0)	8 (7)
Total		**70 (22)**	**181 (91)**	**26 (10)**	**277 (123)**
Unknown	Dark Grey	2 (1)	1 (1)	2 (0)	5 (2)
	Grey	2 (0)	12 (8)	2 (0)	16 (8)
	White	7 (0)	7 (7)	2 (0)	16 (7)
Total		**11 (1)**	**20 (16)**	**6 (0)**	**37 (17)**

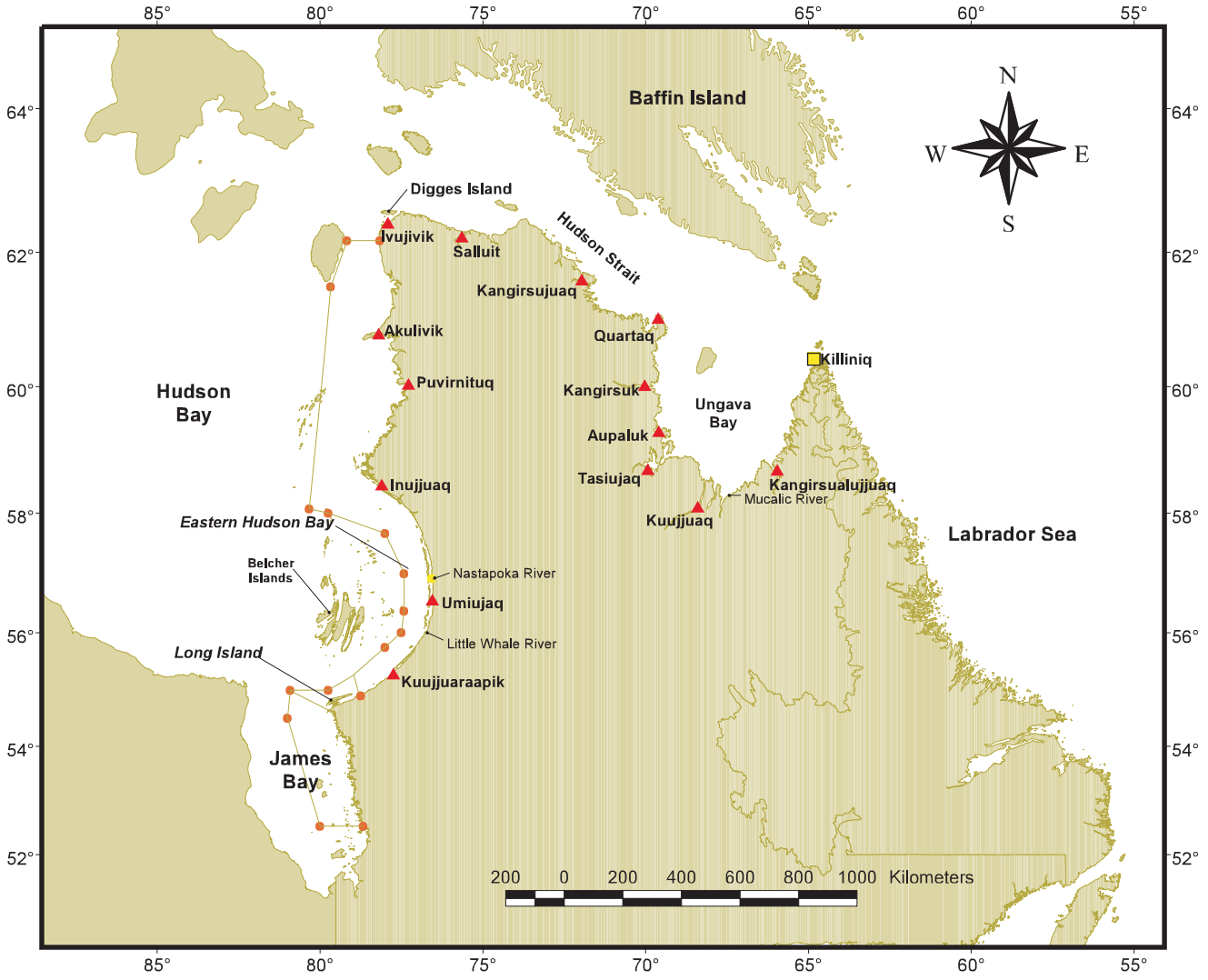

Figure 1. Regions considered in the analysis of the harvest statistics on beluga during 2001–2004. The limits among the three regions of James Bay, Long Island, and eastern Hudson Bay are indicated by the broken line. The other two regions are Hudson Strait and Ungava Bay.

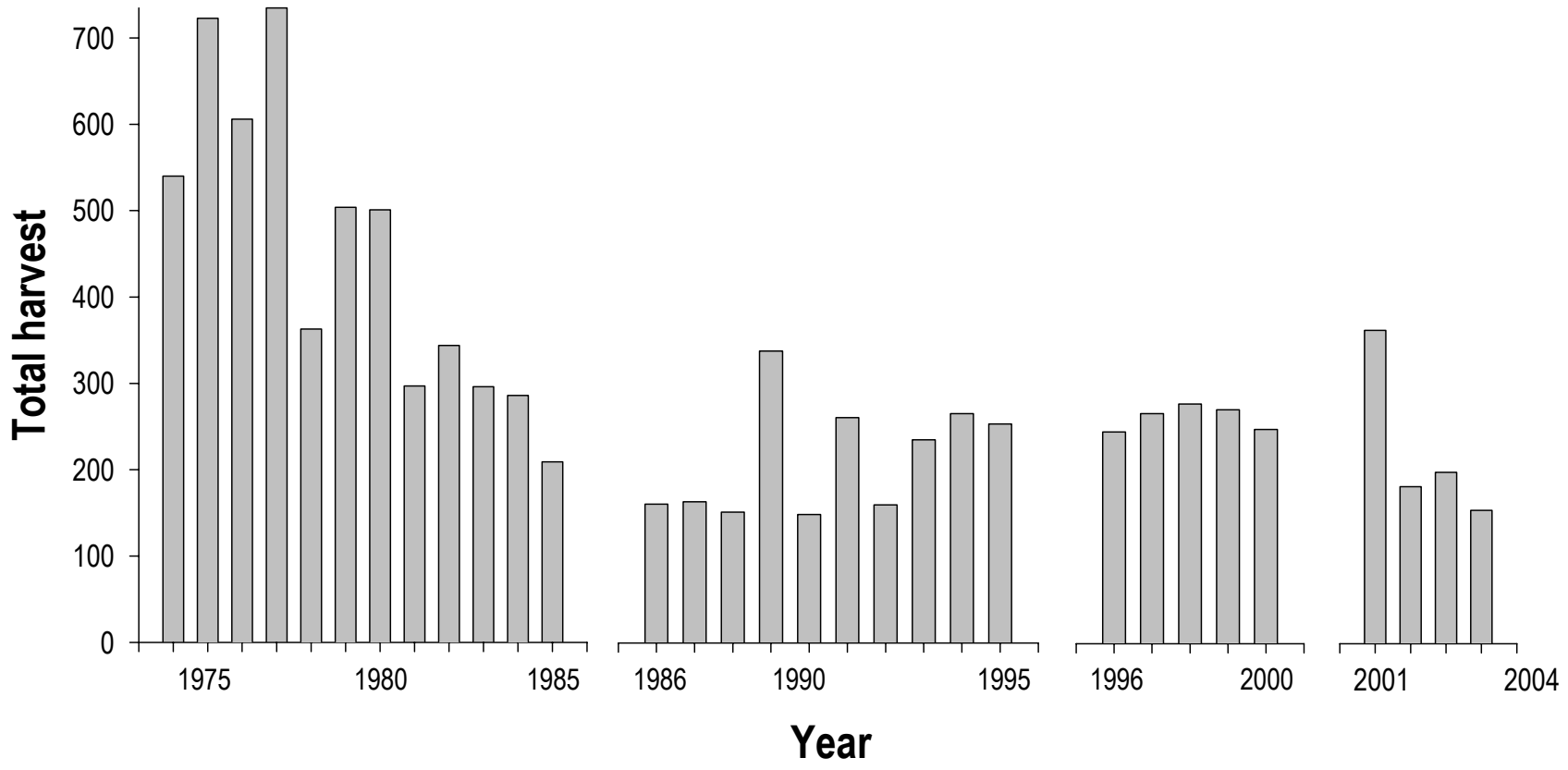

Figure 2. Total number of beluga harvested by the Nunavik communities between 1974 and 2004. Data were compiled by the Native Harvesting Research Committee (1974–1980: used 'Estimate total harvest' from Native Harvesting Research Committee 1976; 1979; 1982a; 1982b), by Anguvigaq Wildlife Management Inc. and the Department of Fisheries and Oceans (1981–1985: Brooke and Kemp 1986), the Department of Fisheries and Oceans, and depending on years, Anguvigaq, Makivik or Kativik Regional Government (1986–1990: Richard 1993), and community agents and the Department of Fisheries and Oceans (1991–2004: Brooke 1992; 1995; 1996; 1997; 1998; Olpinski (1993); Portnoff (1994) for years 1991–1997, and R. Fibich or D. Baillargeon, Coordinators, Northern Quebec Affairs for years 1998–2004).

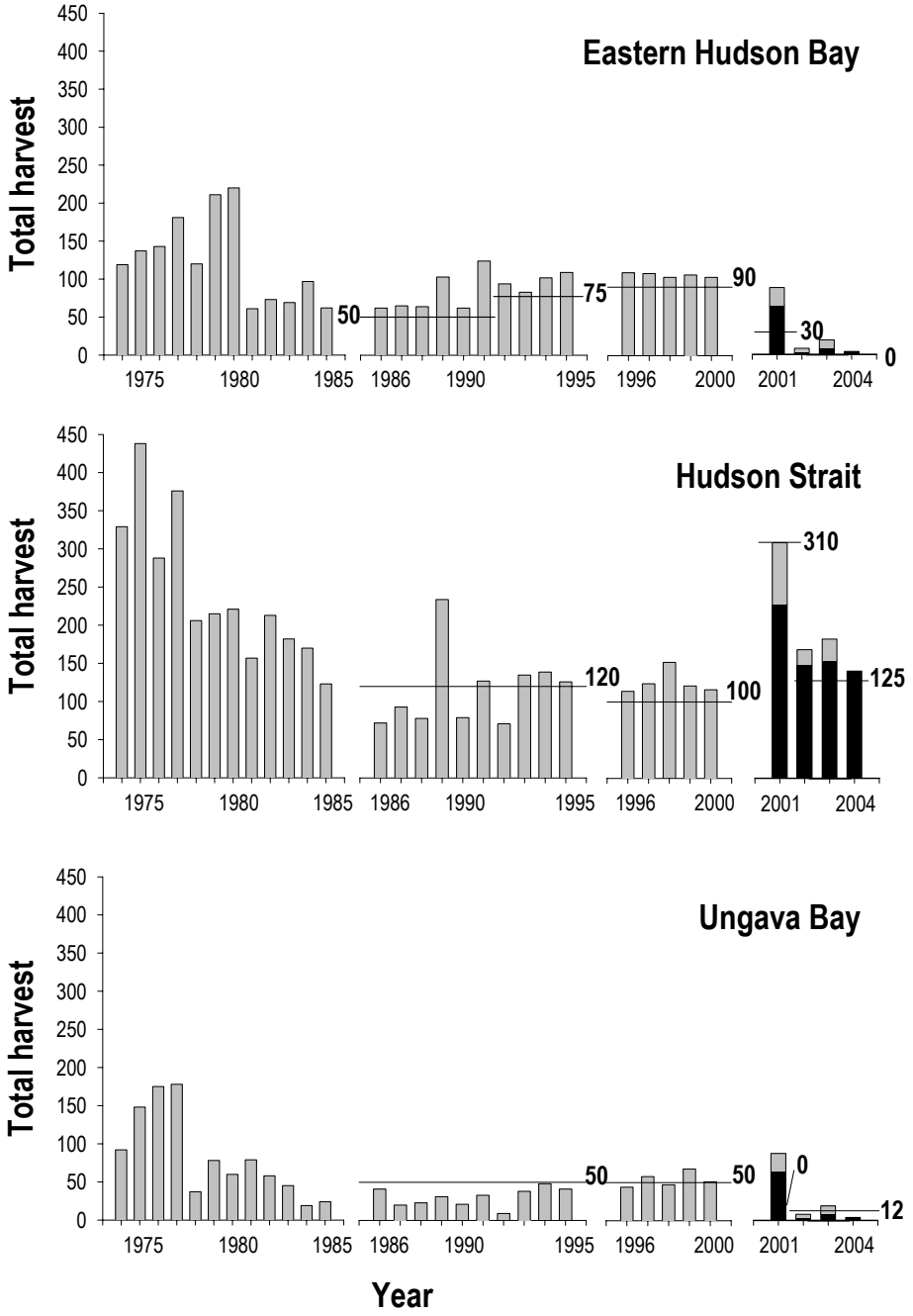

Figure 3. Total harvest of beluga relative to quotas (curves) in different regions of the Nunavik during 1974–2004. Harvest location were based on information on areas traditionally used for harvesting and samples provided from harvested individuals (1974–2000), or exclusively on direct communications of the harvest location or samples (2001–2004). Stacked bars represent the minimum and maximum harvest, i.e., including harvests from unknown locations. Median catch levels over a management period were used for communities and years where catch levels were missing.

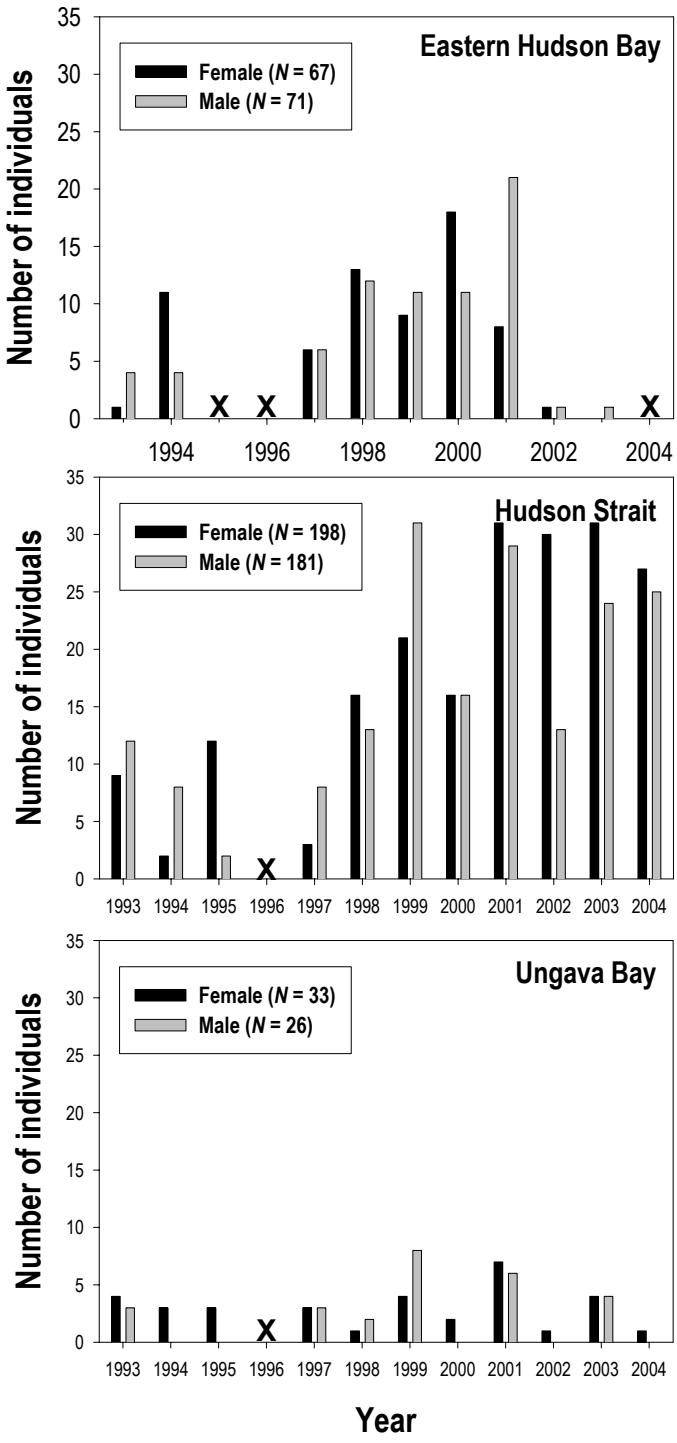

Figure 4. Proportion of male and female beluga harvested in eastern Hudson Bay, Hudson Strait, and Ungava Bay, 1993–2004. Individuals of undetermined gender or harvested from unknown locations were not accounted for in this figure. An 'x' indicates a lack of data.

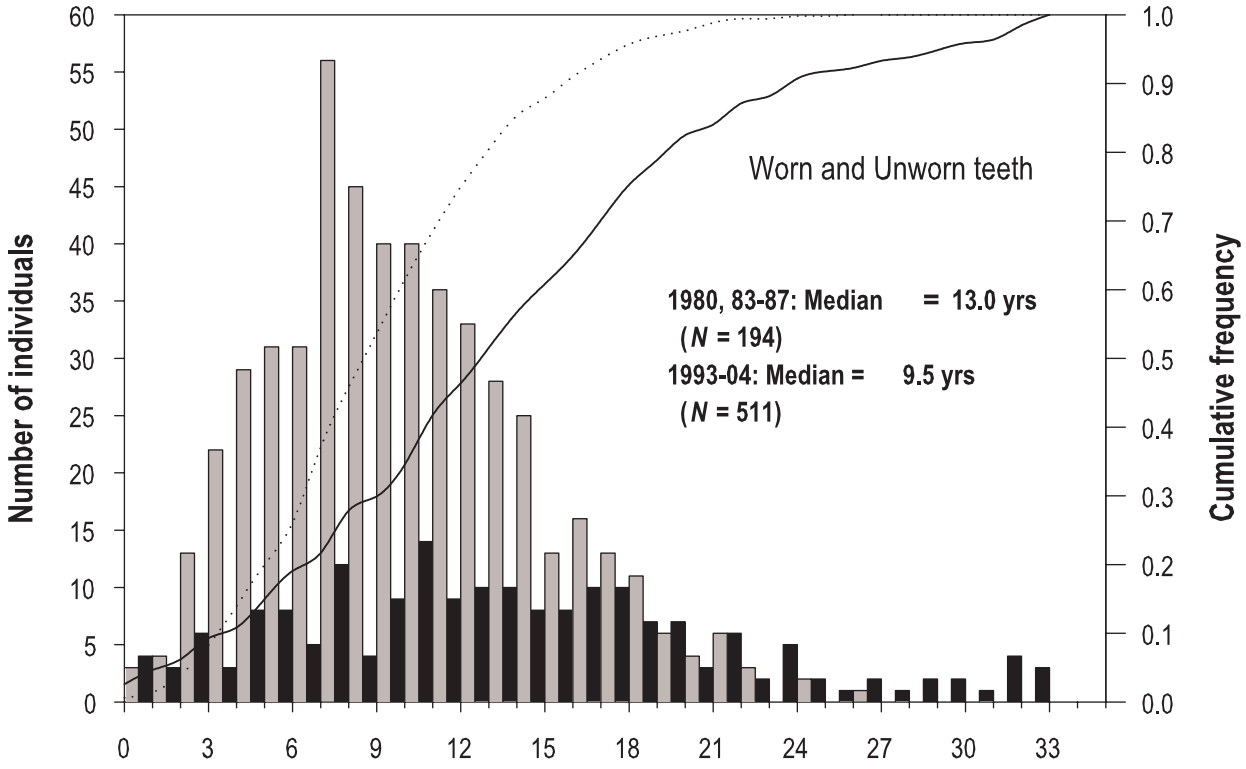

Figure 5. Age of beluga harvested in northern Quebec during 1980, 1983–1987 (black bars and plain curve; Doidge 1990) and 1993–2004 (grey bars and dotted curve), presented as age frequencies (bars) and cumulative frequencies (curves), while using both worn and unworn teeth.

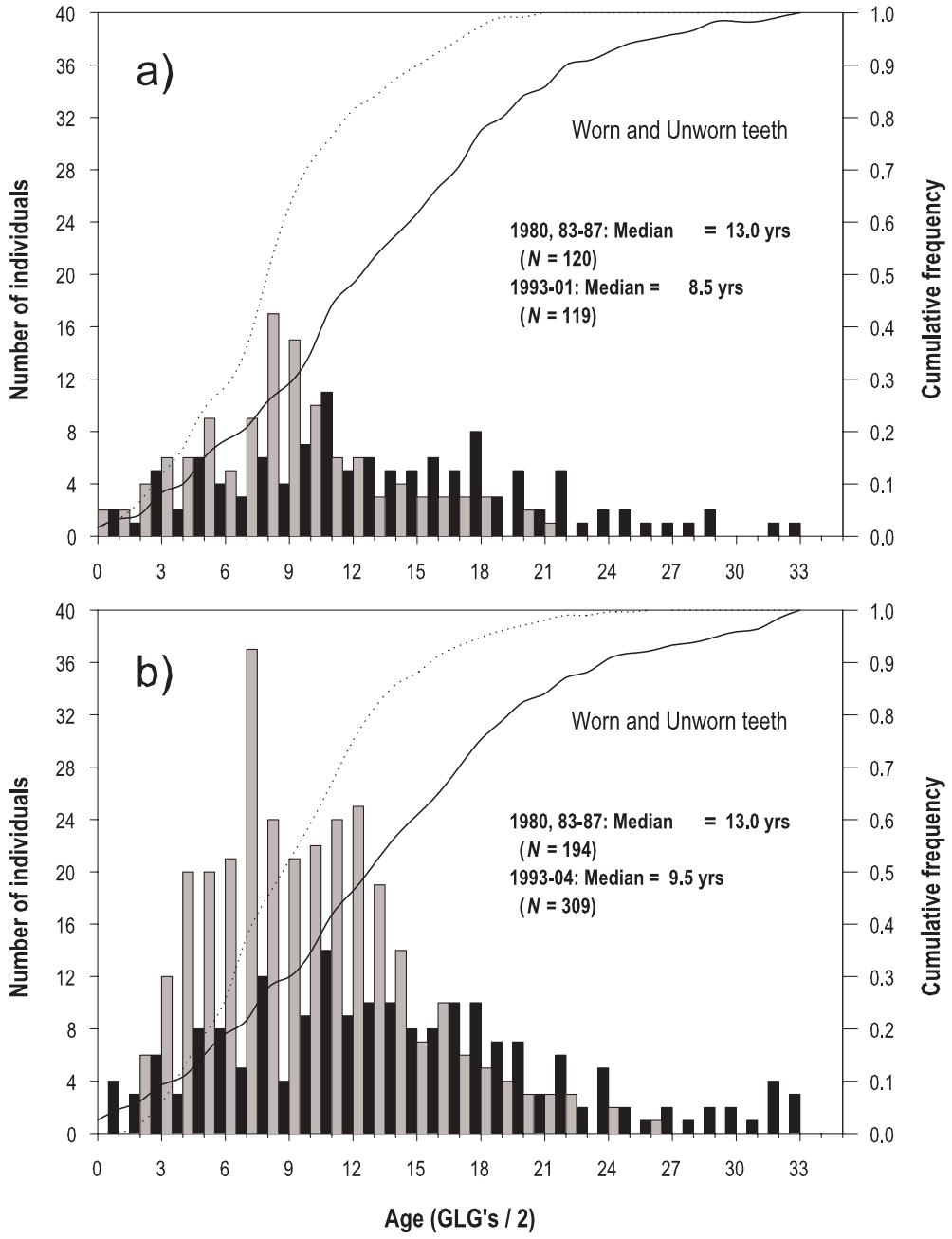

Figure 6. Age of beluga harvested in a) Eastern Hudson Bay (EHB) and b) Hudson Strait during 1980, 1983–1987 (black bars and plain curve; Doidge 1990) and 1993–2004 (grey bars and dotted curve), presented as age frequencies (bars) and cumulative frequencies (curves), and using both worn and unworn teeth. In graph b), the age of beluga harvested in both EHB and Hudson Strait were used for 1980, 1983–1987 due to the small sample size in Hudson Strait (N = 53).

Appendix 1. Beluga management plans for the Nunavik region 1986–2000. Sources: Fisheries and Oceans Canada 1986; 1987; 1990; 1993a; 1993b; 1996; Olpinski 1993; Portnoff 1994. Additional management measures are presented in the different source reports.

Region	Community	1986	1987–1989	1990–1991	1992–1994	1995–2000
Eastern Hudson Bay	Kuujjuaraapik	9	10	10	15	18
	Umiujaq	15	10	10	15	18
	Inujjuaq		10	10	15	18
	Puvirnituq	9	10	10	15 (all in H. Strait)	18
	Akulivik	9	10	10	15 (all in H. Strait)	18
	Other agreements			Nastapoka River closed in July	Nastapoka River closed in July	Nastapoka and Little Whale rivers closed in July
Hudson Strait (H. Strait)	Ivujivik	25	30	30	30	25
	Salluit	25	30	30	30	25
	Kangirsujuaq	25	29	29	29	25
	Quartaq	25	29	29	29	25
Ungava Bay (UN)	Kangirsuk	8 (3 outside UN)	10 (5 outside UN)	10 (all outside UN)	10 (all outside UN in Aug)	10 (all outside UN in Aug)
	Aupaluk	8 (3 outside UN)	10 (5 outside UN)	10 (all outside UN)	10 (all outside UN in Aug)	10 (all outside UN in Aug)
	Tasiujuaq	8 (3 outside UN)	10 (5 outside UN)	10 (all outside UN)	10 (all outside UN in Aug)	10 (all outside UN in Aug)
	Kuujjuaq	8 (3 outside UN)	18 (13 outside UN)	10 (all outside UN)	10 (all outside UN in Aug)	10 (all outside UN in Aug)
	Kangirsualujjuaq	8 (3 outside UN)	10 (5 outside UN)	10 (all outside UN)	10 (all outside UN in Aug)	10 (all outside UN in Aug)
	Killiniq	8 (all outside UN)	10 (all outside UN)	10 (all outside UN)	10 (all outside UN in Aug)	10 (all outside UN in Aug)
	Other agreements	Mucalic River closed*	Mucalic River closed*	Mucalic River closed*	Mucalic River closed*	Mucalic River closed*

* Comprises the Whale, Mucalic, Tuctuc and Tunulic rivers

Appendix 2. Summary of beluga catches by the Nunavik communities, 1974–2000. Data were compiled by the Native Harvesting Research Committee (1974–1980: used 'Estimate total harvest' from Native Harvesting Research Committee 1976; 1979; 1982a; 1982b), by Anguvigaq Wildlife Management Inc. and the Department of Fisheries and Oceans (1981–1985: Brooke and Kemp 1986), community agents and depending on years, personnel from Anguvigaq, Makivik or Kativik Regional Government (1986–1990: Richard 1993), and community agents and the Department of Fisheries and Oceans (1991–2000: Brooke 1992; 1995; 1996; 1997; 1998; Olpinski 1993; Portnoff 1994 for years 1991–1997, and R. Fibich, Coordinator, Northern Quebec Affairs for years 1998–2000). Reports from 1991 to 2000 include animals that were struck but lost, but it is unclear whether these animals were accounted for in reports earlier than 1991.

Region	Community	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Eastern	Kuujjuaraapik	28	24	60	55	51	63	75	32	45	46	35	40[a]	10	11	0	8	8	12	16	12	22	14	15	11	14	14	8
Hudson	Umiujaq	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A[b]	3	15	12	18	12	24	24	19	18	21	19	19	18	24	19[l]
Bay	Inujjuaq	88	106	79	124	62	120	144	26	18	19	58	11	7	11	17	17	11	20	16	13	19	20	22	21	18	19	35
	Puvirnituk	-	-	-	-	-	-	-	-	-	-	-	-	-	16	23	41	22	50	22[g]	23	23	36	38	33	36	27	29
	Akulivik	3	7	4	2	7	28	1	3	10	4	4	11	12	12	12	19	9	18	16	16	20	18	15	24	17	22	12
Hudson	Ivujivik	-	-	-	-	-	-	-	58	126	69	69	35	5	24	19	118	20[h]	31	2[g]	37	-	38	34[j]	22	44	37	36
Strait	Salluit	84	159	66	104	36	42	50	57	41	53	29	22	24	20	16	53	17	28	19	37	46	40	32	46	54	33	28
	Kangirsujuaq	150	174	98	118	62	74	37	14	21	22	26	32	22	28	28	28	24	39	28	29	34	22	25	25	22	27	26
	Quartaq	26	36	55	85	39	30	65	28	25	38	46	34[k]	21	21	15	35	18	29	22	32	35	28	23	31	32	24	26
Ungava	Kangirsuk	37[f]	48[f]	44	79	10	4	4	14	9	12	3	7	9	8	7	11	10	12	3	12	10	10[d]	16	16	13	19	12
Bay	Aupaluk	N/A[f]	N/A[f]	6	31	4	0[e]	0[e]	4	2	3	2	3	3	1	2	3	5	9	0	3	6	6	8	8	4	13	8
	Tasiujaq	4	9	3	23	0[e]	3	11	5	6	13	4	9	14	4	11	9	3	2	2	7	12	11	6	14	17	21	13
	Kuujjuaq	41	64	102	30	13	34	31	30	29	14	5	2	10	5	2	8	3	3	4	12	9	10	5	13	10	8	7
	Kangirsualujjuaq	10	27	20	15	10	37	14	26	12	3	5	3	5	2	1	0	0	7	0	4	11	2	9	7	3	7	11
	Killiniq[c]	0	15	9	16	-	-	-	-	-	-	-	8	1	0	4	-	-	-	-	-	-	-	-	-	-	-	-
	Total Nunavik	540	723	606	735	363	504	501	297	344	296	286	207	175	178	165	368	162	284	174	256	289	276	267	290	302	295	258

[a] Includes Umiujaq
[b] Community established in 1985
[c] killiniq closed in 1978, but some families resided there sporadically
[d] From Tables 3 and 4; erroneous reporting in Table 1 (Brooke 1996) carried over in following reports (Brooke 1997; 1998; R. Fibich, DFO, Laurentian Region, pers. comm. for years 1998–2000)
[e] inferred from non-zero rate of participation by the community (63–95%) since total harvest is absent from the harvest statistics (Native Harvesting Research Committee 1976; 1982a, b); zero value for the community is erroneously reported as missing data in subsequent reports (1981–2000)
[f] Includes Aupaluk ('Aupaluk not distinguished from Kangirsuk in 1974 and 1975', Native Harvesting Research Committee 1979)
[g] Unconfirmed harvest numbers
[h] R. Fibich, Department of Fisheries and Oceans, Northern Quebec Affairs, Laurentian region, pers. comm.
[i] Corrected for hunters unwilling to participate in the program
[j] Harvest is an estimate
[k] Monthly harvests sum up to 34 beluga, and not 32 as reported in total harvests (Brooke and Kemp 1986: p. 18)
[l] Umiujuaq community agent, pers. comm. to M.O. Hammill, Department of Fisheries and Oceans, Laurentian Region

Appendix 2. (Continued)

Region	Community	2001	2002	2003	2004
Eastern	Kuujjuaraapik	15	3	13	15
Hudson	Umiujaq	17	5	5	5
Bay	Inujjuaq	25	5	1[a]	0
	Puvirnituk	50	16	10[b]	19
	Akulivik	33	16	1	16
Hudson	Ivujivik	13	41	52	22
Strait	Salluit	57	21	18	21
	Kangirsujuaq	34	16	15	14
	Quartaq	60	34	34	18
Ungava	Kangirsuk	24	11	17	17
Bay	Aupaluk	7	3	10	7
	Tasiujaq	23	9	8	2
	Kuujjuaq	20	14	27	8
	Kangirsualujjuaq	17	4	5	4
	Killiniq[c]	-	-	-	-
	Total Nunavik	395	198	216	168
	Total Nunavut	-	-	5	-

[a] An additional 3 beluga were harvested in Nunavut
[b] An additional 2 beluga were harvested in Nunavut
[c] killiniq closed in 1978, but some families resided there sporadically