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Management implications of closure of estuaries to hunting of beluga in Nunavik

Conséquences pour la gestion de la fermeture des estuaires à la chasse des bélugas au Nunavik

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ABSTRACT

Beluga whales (*Delphinapterus leucas*) aggregate in large numbers in Nunavik estuaries during summer. Inuit hunters harvest beluga from a mix of stocks, designated after their specific summering areas. Processes by which fidelity to a summer area is maintained are uncertain, but since beluga calves spend 2-3 years with their mother, it is possible that adult-offspring transfer of information could be the basis for learning migratory pathways and site fidelity.

In the 1980's, low estimates of beluga abundance for eastern Hudson Bay (EHB) and Ungava Bay (UB) stocks resulted in limits being placed on harvesting through a combination of total allowable takes (TAT) and regional closures. These closures included the permanent sanctuary in southern Ungava Bay at the Whale, Mucalic, Tuctuc and Tunulic rivers (1986), and seasonal closures at the Nastapoka (1990) and Little Whale (1995) rivers in eastern Hudson Bay. Here, we address the scientific rationale for keeping these estuaries closed, and the impact of this closure on beluga stocks and their management in Nunavik.

Satellite telemetry data from the Little Whale and Nastapoka rivers confirmed that beluga exhibit within-season site fidelity to a specific estuary. Most tagged individuals made repeated round-trips, often hundreds of kilometres away from the estuary, over the course of several weeks, but returned repeatedly to the same estuary. This pattern was observed for both males and females, but was variable among individuals, with round-trips outside estuaries lasting from one day to one month, and the number of round-trips ranging from 0 to 12.

An analysis of subsistence harvest data shows that beluga were likely to be captured in greater numbers in estuaries in a single hunting event than outside of estuaries. Recent genetic analyses indicated that beluga killed on the same day at the same summering sites were frequently closely related. Since more individuals are harvested in each hunting event inside estuaries, it is thus more likely that social groups with knowledge of specific migration routes could be eliminated. This could impede the recolonization of extirpated summering areas, and limit the exchange among stocks using different migration routes.

The strong philopatry of discrete stocks makes them vulnerable to overexploitation. At a finer scale in eastern Hudson Bay and Ungava Bay, dependence on a small number of specific estuaries makes beluga particularly vulnerable to the loss of critical habitat and has led to the disappearance of beluga from several estuaries. The closure of estuaries was aimed at limiting overharvesting and protecting a critical habitat where beluga could fulfill important biological needs. The two estuaries in eastern Hudson Bay that were closed to hunting are the only rivers where beluga have been sighted regularly from coastal aerial surveys over the last 25 years. Other estuaries now appear vacant, either following avoidance of disturbed sites or via depletion of a local herd. Recolonization of abandoned areas may have been hindered by the loss of knowledge of these locations among remaining animals.

RÉSUMÉ

Durant l'été au Nunavik, les bélugas (*Delphinapterus leucas*) se rassemblent en grands nombres dans les estuaires. Les Inuits chassent des bélugas provenant d'un mélange de plusieurs stocks définis d'après leurs aires de distribution estivale. Les processus permettant la fidélité à une aire d'estivage sont encore mal connus, mais puisque les jeunes bélugas passent deux à trois ans auprès de leur mère, il est possible que des transferts d'information entre jeunes et adultes constituent la base de l'apprentissage des chemins migratoires et de la fidélité au site.

Dans les années 1980, les basses estimations d'abondance des bélugas de l'est de la baie d'Hudson et de la baie d'Ungava ont entrainé la mise en place de limites sur les nombre de prises ainsi que des fermetures régionales. Ces fermetures incluent la création d'un sanctuaire permanent dans le sud de la baie d'Ungava, aux rivières à la Baleine, Mucalic, Tuctuc and Tunulic (1986), et des fermetures saisonnières pour la rivière Nastapoka (1990) et la petite rivière à la Baleine (1995), dans l'est de la baie d'Hudson. Dans ce document, nous examinons les raisons scientifiques de garder ces estuaires fermés à la chasse, et les impacts de ces fermetures sur les stocks de bélugas et leur gestion au Nunavik.

Les données de télémétrie satellite confirment que les bélugas font preuve de fidélité à certains estuaires au sein de la même saison. La majorité des individus équipés d'émetteurs satellites à la Nastapoka et la petite rivière à la Baleine ont effectué des allers-retours répétés sur le cours de plusieurs semaines, parcourant parfois plusieurs centaines de kilomètres, mais retournant toujours à proximité du site de déploiement. Ce patron a été observé pour les mâles et les femelles, mais le nombre d'allers-retours varie d'un individu à l'autre (de 0 à 12) ainsi que leur durée (d'un jour à un mois).

L'analyse des données de chasse montre que les bélugas sont plus susceptibles d'être capturés en grands nombres lors de chaque évènement de chasse à l'intérieur des estuaires qu'en dehors. Des analyses génétiques récentes ont montré que les bélugas tués le même jour au même site d'estivage partageaient fréquemment un lien de parenté. Puisqu'un plus grand nombre d'individus sont habituellement capturés lors de chaque évènement de chasse à l'intérieur des estuaires, il y est donc plus probable d'éliminer des groupes sociaux possédant la connaissance de différentes routes de migration. Cela pourrait ralentir la recolonisation d'aires d'estivage abandonnées, et limiter les échanges entre des stocks utilisant des routes de migration différentes.

La forte philopatrie qui caractérise les différents stocks estivaux les rend vulnérables à la surexploitation. À plus fine échelle, la dépendance envers un petit nombre d'estuaires spécifiques rend les bélugas particulièrement vulnérables à la perte d'habitat critique et a mené à leur disparition de plusieurs estuaires dans l'est de la baie d'Hudson et de la baie d'Ungava. La fermeture des estuaires visait à limiter les risques de surexploitation et à protéger l'habitat critique où les bélugas satisfont des besoins biologiques importants. Les deux estuaires qui ont été fermés à la chasse dans l'est de la baie d'Hudson sont les seuls dans lesquels des bélugas ont été observés régulièrement lors de relevés aériens côtiers au cours des 25 dernières années. Les autres estuaires paraissent désormais vacants, suite à un évitement des sites dérangés ou bien à l'élimination des groupes d'animaux qui les fréquentaient. La recolonisation des aires abandonnées a pu être limitée par la perte de savoir collectif de ces sites parmi les individus restants.

INTRODUCTION

Across their entire range, beluga whales (*Delphinapterus leucas*) are known to visit estuaries and river mouths during summer (Reeves and Mitchell 1989). In Nunavik, some of these estuaries are places of regular aggregations for large numbers of whales (Smith and Hammill 1986, Caron and Smith 1990). These sites have traditionally provided good harvesting opportunities for subsistence hunters, because frequentation by beluga is predictable and numerous whales are present in a confined environment that facilitates hunting. Indeed, reliable access to these aggregation sites appears to have been important in determining ancient settlement patterns in Ungava Bay (Taylor 1975). For the same reasons, several of these estuaries were later chosen by the Hudson Bay Company (HBC) to establish hunting camps and trading posts (Reeves and Mitchell 1987).

Nunavik hunters harvest beluga from a mix of stocks, designated after their specific summering areas: Cumberland Sound (CS), Western Hudson Bay (WHB), Eastern Hudson Bay (EHB), and Ungava Bay (UB). In the winter, these stocks are found in Hudson Strait, Ungava Bay, the Labrador Sea and southwest Davis Strait where their distributions are largely unknown but are believed to overlap (Brodie 1971, Lewis et al. 2009, Luque and Ferguson 2010). Mating is thought to occur during winter or early spring. In spring and fall, each stock migrates to and from their specific summering grounds (Richard 1991, Lewis et al. 2009). Processes by which fidelity to a summer area and distinct migration routes are maintained are undocumented.

Cultural transmission of information from parent to offspring or among close relatives (i.e. vertical transmission) is likely to occur when social networks consist of interactions amongst close relatives (Rendell and Whitehead 2001). Extended associations between offspring and parents in long distance migratory animals can allow direct learning of migratory routes (Harrison et al. 2010). Beluga calves spend 2-3 years with their mother (Heide-Jørgensen and Teilman 1994), during which they perform 4-6 migrations. Vertical transmission could therefore be the basis for migratory pathways and site fidelity in beluga. If so, this would limit contributions of individuals from a healthy stock to a depleted one (as observed in southern right whales, Valenzuela et al. 2009), and have important implications for the management of these stocks.

Commercial harvests by the HBC probably initiated the depletion of EHB and UB beluga stocks, whereas high subsistence harvests have likely limited opportunities for recovery (Finley et al. 1982, Reeves and Mitchell 1987). Beginning in 1986, the low estimates of beluga abundance for these two stocks resulted in limits being placed on harvesting through a combination of total allowable takes and regional closures, including the creation of a permanent sanctuary in southern Ungava Bay at the Whale, Mucalic, Tuctuc and Tunulic rivers (1986), and seasonal closures at the Nastapoka River (NR) and Little Whale River (LWR) rivers in eastern 1990 and 1995, respectively. Concerns for the UB and EHB stocks eventually led to their designation as 'endangered' by the Committee on the Status of Endangered Wildlife in Canada in 1988 and 2004, respectively (COSEWIC 2004). Harvesting in the eastern Hudson Bay arc was closed from 2001 to 2006, and the NR and LWR estuaries have remained close since harvesting resumed in the area in 2007. The Ungava Bay was entirely closed to hunting during four years (2002−2003, 2005−2006), and the Mucalic has remained a sanctuary since 1986.

Science was requested to address the scientific rationale for keeping the Mucalic, NR and LWR estuaries closed, and the impact of this closure on beluga populations and their management in Nunavik. In addition to reviewing the latest results from genetic studies, we propose two novel elements of information: an analysis of within-season site fidelity from satellite telemetry data and a comparison of the harvest composition inside and outside estuaries.

METHODS

SATELLITE TELEMETRY

We used satellite telemetry to investigate within-season fidelity to estuaries. From 1993 to 2004, 34 beluga were captured in July or August at LWR (n = 30) or NR (n = 4) using shore-anchored nets, and equipped with satellite tags secured to the dorsal ridge (Kingsley et al. 2001). These individuals (11 females, 18 males and 5 undetermined) were tracked throughout the summer and during their fall migration (Bailleul et al. *in press*).

Animal locations were obtained via the ARGOS satellite system. Accuracy varied depending on transmission classes: 150 m, 350 m, 1 km, and >1 km for classes 3 through 0, respectively. Classes A, B, and Z had undetermined accuracies. For this analysis, unrealistic locations were rejected using a forward particle-filtering model (Tremblay et al. 2009). The model assumes that each location corresponds to the geographic average of the many possible positions, the spread of which is a function of location accuracy. The first step of the filtering procedure consisted of generating 50 possible locations ("particles") around each received position within a radius defined by that location's accuracy. Each particle was weighted according to the likelihood of the speed needed to get there from the previous location. A maximum speed of 3 m s^{-1} was assumed (Richard et al. 1998), and particles on land were eliminated. The particles were then sampled randomly, resulting in 50 complete tracks. The final tracks were then computed as the geographic average of the bootstrapped tracks (Bailleul et al. *in press*).

We plotted the tracks of each individual during the July–October period to examine movements to and from the estuaries where deployment had occurred. We calculated the distance from the estuary and considered that beluga had returned to the estuary (i.e., completed a round-trip) when this distance was less than 3 km.

COMPOSITION OF HARVEST

Reports of landed catch have been collected in different ways over the years (summarized in Lesage et al. 2009) and are now compiled on a weekly basis. The information necessary to define each harvest event with precision, including the exact number of whales harvested and whether they were in the same group, was not available for this analysis. Instead, we based our examination of harvest events on the samples collected by hunters, even though samples were not collected for each and every harvested beluga whale. To define harvest events based on the dates and locations of samples reported by hunters, we considered that all whales killed on the same day at the same location were part of the same event.

We examined the size distribution of harvest events for the NR and LWR estuaries previous to their complete closure in 2002, i.e., for the period 1980-2001, which includes the years during which the estuaries were closed only in July. Sample size for the post-closure EHB harvest (2007-2010) was too small (11 events) for any meaningful comparison. Therefore, we compared in-estuary harvests with those having taken place outside of estuaries both in the EHB arc and Hudson Strait (HS) area for the same period (1980-2001). We tested for statistical differences between the group distributions using a two-sample Kolmogorov-Smirnov (KS) test.

To examine the effectiveness of closing the estuaries year-round vs. for part of the summer, we compared the size distribution of hunting events at the NR during the period when it was closed only in July (1990-2001) with the period before closure (1980-1989). Sample size was insufficient to examine harvest characteristics in the Mucalic sanctuary prior to its closure or at any other site in Ungava Bay.

The sex of harvested animals was determined visually in the field or from DNA analysis. We estimated ages from teeth collected by the hunters, assuming the deposition of one dentinal growth layer group per year (Stewart et al. 2006). We used this information to examine differences in proportions of males and females, as well as differences in age distribution of the catch, between whales caught in estuaries and those caught outside of estuaries.

RESULTS

SATELLITE TELEMETRY

Examination of satellite tracks showed that individual beluga left the estuary where they were equipped with the transmitters, sometimes moving as far away as several hundreds of kilometers, but returned repeatedly to the same estuary during summer (Fig. 1). Overall, 71% of the tagged individuals made at least one such loop before their last transmission or before their departure for the fall migration. This proportion increased to 79% when only deployments that lasted at least one month were examined, and to 87% for deployments over two months.

This pattern was observed for animals tagged in NR as well as LWR, and for both sexes, with 73% of equipped females and 78% of equipped males performing at least one round-trip. However, patterns were variable among individuals, with round-trips outside estuaries lasting from one day to one month, and the number of round-trips ranging from 0 to 12.

COMPOSITION OF HARVEST

Event size

The number of beluga sampled in a given harvest event in EHB estuaries for the period 1980-2001 ranged from 1 to 13 individuals with a mean of 3.1 ± SD 2.6 (Fig. 2a). In estuaries, 66% of events involved more than 1 whale and 44% involved more than 2. Event size for harvests taking place outside of estuaries for the same period was smaller (mean = 2.3 ± SD 2.1 individuals), with 51% of events involving more than 1 whale and only 26% involving more than 2 (Fig. 2b).

The cumulative distribution of event sizes for the estuaries was below that of outside estuaries for the entire range of event sizes (Fig. 3). In other words, for any given event size, the proportion of events smaller than or equal to that size was higher outside than inside estuaries. The two distributions differed significantly (KS, $p = 0.02$).

In the NR estuary, slightly more beluga were killed per hunting event for the period 1990-2001, during which it was closed in July (Fig. 4: median = 3, mean = 4.3 ± 3.3), than prior to its closure (1980-1989, median = 2, mean = 3.3 ± 2.7. The difference was not statistically significant (KS, $p > 0.50$).

Sex and age

The female-to-male ratio in the harvest during 1980-2001 was 1.01 in EHB estuaries (n=260), and 0.90 outside the estuaries (n=355). The medians of the age distribution of beluga harvested in estuaries and outside estuaries were 16 and 17 years, respectively (Fig. 5). The mean age was 15.7 inside estuaries and 18.4 outside estuaries. A one-tail KS test showed that the cumulative distribution of the ages in the estuaries was below that of outside-estuaries hunts ($p < 0.01$) (Fig. 6).

DISCUSSION

ESTUARIES AS CRITICAL HABITAT

Site fidelity

Strong evidence of fidelity to summering areas supports the concept of discrete stocks defined by their summer distribution and has been the basis for the current management approach (Smith and Hammill 1986). Little information is available, however, on whether individuals or pods show fidelity to specific sites within these summering areas, e.g., estuaries, and whether this fidelity is exhibited within seasons and between years.

The only indication of between-year site fidelity comes from photo-identification studies conducted at the NR in 1983 and 1984, in which 8 of 18 individually recognized whales from the first year were resighted the next year (Caron and Smith 1990). Previous evidence of within-season fidelity to specific estuaries also comes from land-based studies. Caron and Smith (1990) observed a number of hunts in the NR estuary which resulted in departure of beluga from the hunting site. Whale numbers returned to 70% of pre-disturbance levels within 12−56 h. Photo-identification showed that some of those whales were the same before and after the disturbances, and that average period of absence was 185 h or 7.7 d for the 18 recognizable whales. In 1983, 14 out of 18 photographed whales were seen on 2 or more days, and 46 individuals were seen on a regular basis from early July to late August in 1984.

Satellite telemetry data from both the LWR and NR estuaries confirm these conclusions and offer new insights into site fidelity. Tagged individuals made repeated round-trips, often hundreds of kilometres away from their estuary, over the course of several weeks. Detailed examination of the intrinsic (sex, age) and extrinsic (e.g., tides) factors affecting the frequency of these trips was beyond the scope of this study. However, tracking data for whales from the LWR and NR estuaries revealed marked patterns of within-season site fidelity: most of the whales left and returned repeatedly to the same estuary, regardless of sex or age.

Reasons for this fidelity to specific estuaries within the same season are unknown. Animals may be attracted to the physical features of these sites or by the social assemblage of beluga associated with them. Nevertheless, this confirms that these sites are important to individuals.

Biological functions of estuaries

Aggregations in river estuaries during summer are observed in most beluga stocks in the Arctic (e.g., Watts and Draper 1991, Doidge and Finley 1994, Hobbs et al. 2005), suggesting that estuaries fulfill one or several biological functions. The exact nature of these functions, however, remains unclear.

Estuaries frequented by beluga differ in shape and in the degree of shelter they offer, but share common features of low salinity and relatively warm waters (Smith et al. 1994). Herd structure is usually similar among estuaries, but offers few clues as to their function. Adult males maintain tight pods of 10-15 individuals, stay for shorter periods, make up a small component of the herd and stay closer to river mouth (Caron and Smith 1990, Smith et al. 1994). Females are more numerous and gregarious, and the proportion of females with calves increases as summer progresses. No birthing has been observed in estuaries, however, and the hypothesis of Sergeant (1973) that estuaries offer thermal advantages for calving has been invalidated by Doidge (1990). Segregation by age and sex has been documented, with groups of females and calves being usually farther inside the estuary and males closer to the river mouth, prompting hypotheses that estuaries may offer protection for young against predators (Loseto et al. 2006). Rubbing behaviour has been observed in different estuaries, as well as signs of epidermal moult (Caron and Smith 1990, Smith et al. 1994).

Despite evidence of site tenacity, beluga in estuaries are sensitive to disturbance (Doidge and Lesage 2001). Numerous Inuit hunters believe there are fewer beluga in EHB and UB estuaries partly because of disturbance by human-made noise, which has led to site desertion. Hunters have identified estuaries in other areas (e.g., near Puvirnituq and Inujkuak) where whales were disturbed and stopped visiting. However, large numbers of animals have been removed from these sites, so that we cannot exclude the possibility that there has been a loss of collective knowledge of these sites. Laurin (1982) documented a similar process following an important beluga harvest near Baie-Comeau in the St Lawrence River estuary, where whales were overexploited and never returned.

Regardless of the uncertainty about the exact functions fulfilled by estuaries, strong evidence of site fidelity for all sex and age components of the population suggests that these sites constitute critical habitat. Estuaries in Cook Inlet (Alaska) have been declared critical habitat for the Cook Inlet stock. In the Canadian Arctic, Clearwater Fiord was suggested as critical summer habitat for Cumberland Sound beluga (Richard and Stewart 2008). Most of the summer distribution area of St Lawrence Beluga, which is centered on the St Lawrence Estuary, has been designated critical habitat (DFO 2011).

SIZE AND COMPOSITION OF HARVEST IN ESTUARIES

Historical information

Both Inuit traditional knowledge and reports of the HBC show that the Great Whale River (GWR), LWR and NR were all major areas of beluga aggregation during July-August (Reeves and Mitchell 1987). During commercial whaling, both GWR and LWR beluga were harvested by using barrier nets to trap them in rivers. Over the period 1856–1868, 5600 beluga were removed from GWR in about 10 major netting events (maximum = 1511 beluga in 1860). LWR was exploited in a similar way during 1854–1868 with over 3000 beluga caught in 10 netting events (maximum = 743 beluga in 1859). NR was not amenable to being shut off completely by a barrier net and harpooning was used instead, resulting in lower yields (Reeves and Mitchell 1987).

Analysis of 1980–2001 harvest

Past information indicates that gathering of numerous beluga in relatively confined estuaries likely creates favourable conditions for the capture of large numbers of individuals. Subsistence harvest data in this document shows that beluga were indeed more likely to be captured in greater numbers in estuaries in a single hunting event than outside of estuaries in EHB or HS. Outside estuaries, the frequency of capturing less than a certain number of whales in a single day was always higher than in EHB estuaries.

Hunt event sizes were slightly larger when estuaries were closed in July than when no closure was in place. As noted by Lesage and Doidge (2005), during the mid-1980s, harvesting effort in NR and LWR was spread out over July and August. When estuaries were closed in July, however, most hunting was concentrated in the first few days of August at the opening of the hunting season. During this rush, large numbers of beluga may have been killed at once. This suggests that closure of estuaries for part of the year is not an effective management measure.

Previous studies of herd composition in estuaries have suggested that males stay for shorter periods and make up a smaller component of estuarine herds than females, and that the proportion of females with calves increases as summer progresses (Smith et al. 1994). We could then expect catch in estuaries to be biased towards females and younger animals (if there was no selectivity in hunting). In our data, the proportion of females was slightly higher in estuaries than outside the estuaries. The age distribution differed, however, between the harvest in estuaries and outside. Beluga harvested inside estuaries tended to be younger overall.

There are strong limitations to our analysis. First, it was based on samples collected by hunters rather than on the actual reports of landed animals. Samples were not collected for each and every harvested beluga whale. If there was any bias in sampling (e.g., in sex or age classes, or within estuaries vs. outside), the samples might not be representative of the actual harvest. Second, we could not distinguish among separate hunting events that may have taken place on the same day at the same site. This may have inflated event size in certain circumstances. This also limits our ability to make inference about the exact composition of groups from which whales were caught.

Despite these limitations, our results suggest that harvesting beluga inside estuaries can result in catching more whales per hunting event. Because of this, subsistence hunting in the estuaries has sometimes resulted in significant over-harvesting. In 2001 for instance, a maximum of 15 beluga was prescribed for LWR. More than 18 were actually caught in a single day at LWR, which contributed to a regional harvest of 64−88 whales, far exceeding the total allocation 30 prescribed by the management plan (Lesage and Doidge 2005).

Relatedness

Genetic analyses of the levels of relatedness between belugas caught at the same sites on a given day or month suggest that young beluga remain in close association with their mother, most probably beyond weaning (J. Turgeon, pers. comm.). Some individuals, and especially females, remain faithful to their group of matrilineal relatives, establishing a network of related individuals. Relatedness pattern are most evident while belugas are travelling, as is expected if associating with relatives is useful to learn migratory routes. These networks seem to move along the migratory pathway to and from their summering and wintering areas. Therefore, young individuals have ample opportunity to learn the specific migratory route of their mother and close relatives, suggesting that migratory routes could be vertically transmitted in beluga.

Although genetic analyses did not specifically compare events from within and outside estuaries, they also found that beluga killed on the same day at the same summering sites were more likely to be close kin or even have parent-offspring associations. If hunting events are of a larger size in estuaries, as observed in the harvest data, it is thus more likely that several whales from the same social group may be captured. This could impact the presumed vertical transmission of migration routes and thus patterns of site fidelity to summer sites. In turn, this could impede the recolonization of extirpated summering areas, and limit the exchange among stocks using different migration routes.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

The strong philopatry of discrete stocks makes them vulnerable to overexploitation. At a finer scale in eastern Hudson Bay and Ungava Bay, dependence on a small number of specific estuaries makes beluga particularly vulnerable to the loss of critical habitat and has led to the disappearance of beluga from several estuaries (Finley et al. 1982, Reeves and Mitchell 1989).

The closure of estuaries in the 1990's was part of a management action that included severe TAT reductions and complete closure of hunting in eastern Hudson Bay and Ungava Bay to protect the long-term sustainability of these summer stocks. Harvesting later resumed in these areas, but estuaries remained closed. This decision was based on a combination of Inuit Traditional Knowledge, operational difficulties and conservation challenges. The objective was to identify a place where whales could come and go without being disturbed and fulfill important biological needs.

LWR and NR, the two estuaries in eastern Hudson Bay that were closed to hunting, are the only rivers where beluga have been sighted regularly from coastal aerial surveys over the last 25 years (Gosselin et al. 2009). Other estuaries now appear vacant, either following avoidance of disturbed sites or depletion of local groups. Continued use of the Churchill (MB) area, where hunting is limited but where there is commercial and leisure shipping activity, and repeated re-occupation of estuaries after hunting events, suggest that beluga are less prone to abandon a site due to disturbance. Instead, the lack of recolonization of GWR concur with the hypothesis that recolonization of abandoned areas is hindered by the loss of knowledge of these locations among remaining animals. The same explanation has been proposed for the lack of recolonization of the Manicouagan banks in the St Lawrence River estuary (Laurin 1982). In contrast, the continued presence of whales in the LWR and NR estuaries has shown the value of both the traditional knowledge information and the management decision.

In recent years, this decision has been supported by additional scientific evidence. Results from satellite telemetry show that beluga exhibit strong within-season fidelity to a particular estuary. This observation, combined with previous studies of the behaviour of beluga within estuaries reinforces the conclusion that estuaries are areas of particular biological significance. Such site fidelity is probably developed through a learning process within family groups over a prolonged period (Smith et al. 1994). Observations that hunting events in estuaries tend to be larger, combined with the high relatedness measured among individuals sharing the same summer sites, raises concerns that hunting in estuaries could wipe out entire family units. This could impact genetic diversity as well as the vertical transmission of migration route information that is presumably the mechanism for site fidelity. We note that this is in strong contrast to the belief expressed by many hunters that hunting whales at a given site will result in more animals coming back, and thus this is a difficult management point to convey.

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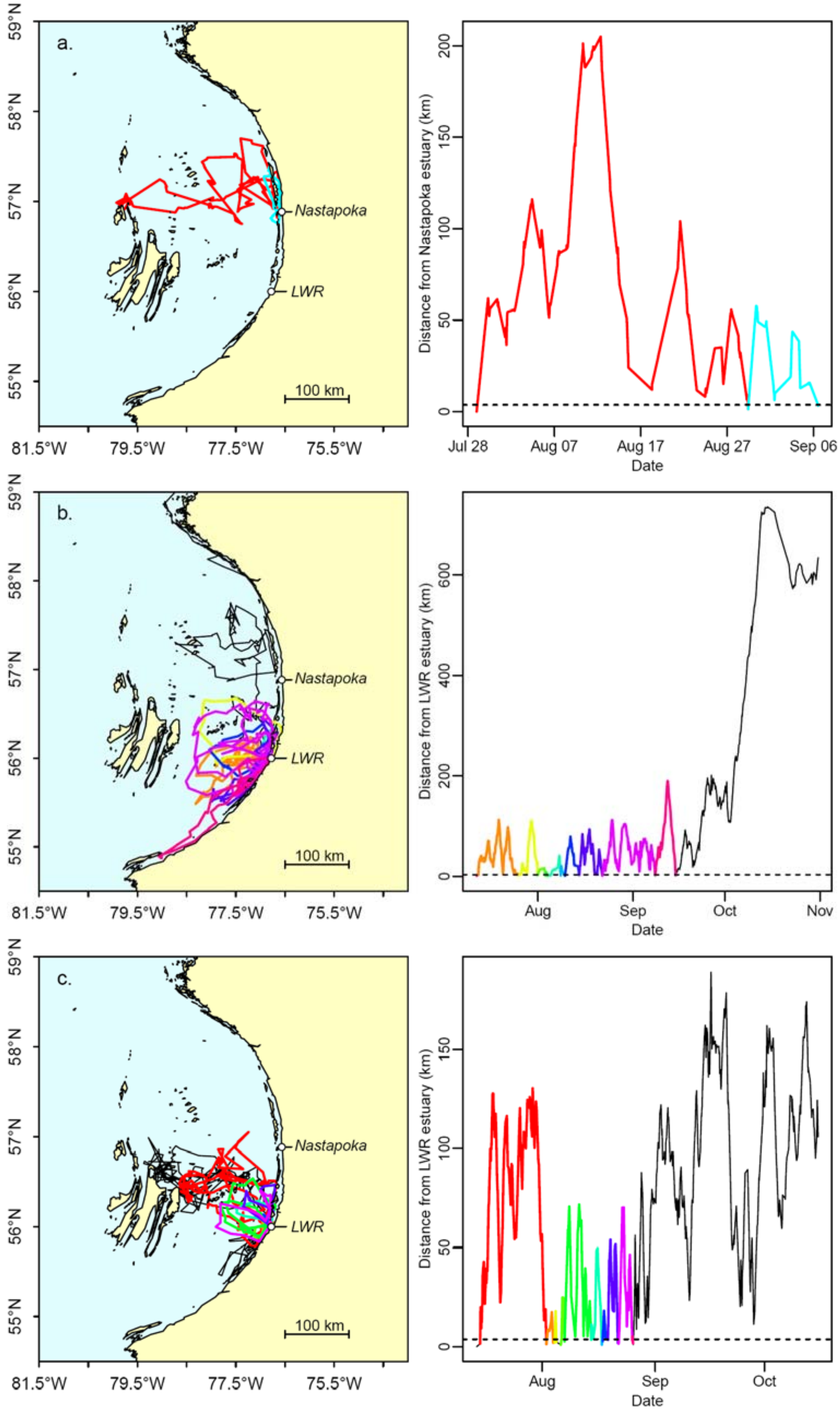
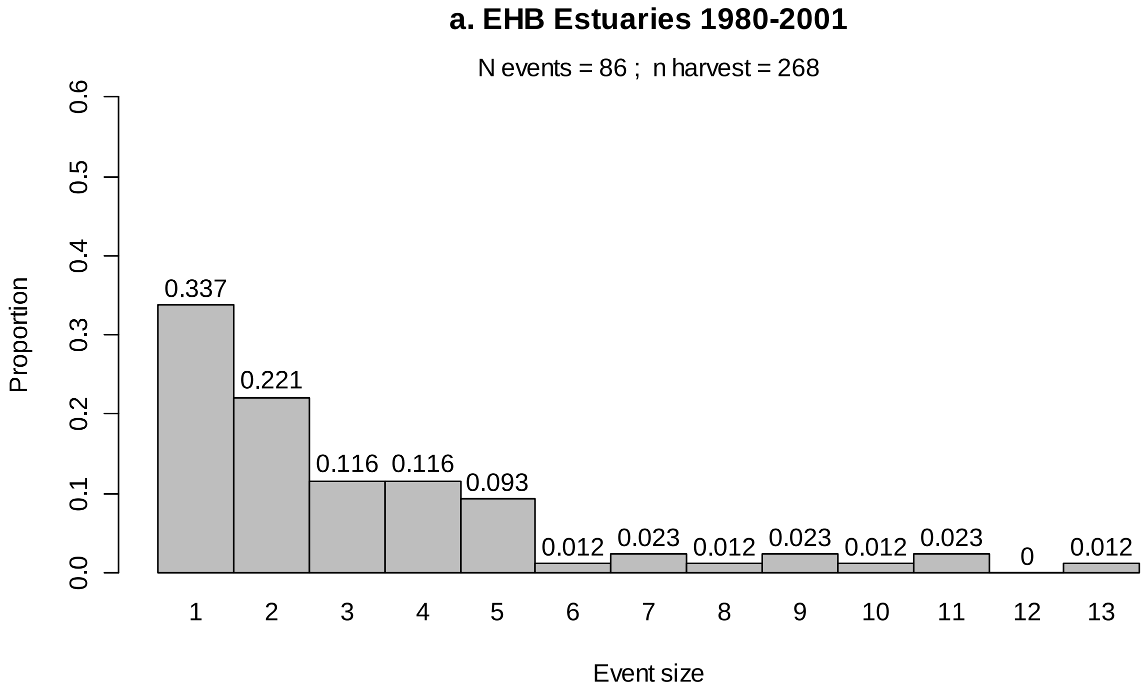


Figure 1. Left: Tracks of beluga whale equipped with satellite transmitters. Colour represent round-trips from the deployment site. Right: Distance from the deployment estuary over the same time period. a.) Beluga of unknown sex equipped at the Nastapoka estuary (July 29, 1999). b.) Female beluga equipped at the LWR estuary (July 12, 2004). c.) Male beluga equipped at the LWR estuary (July 14, 2004).



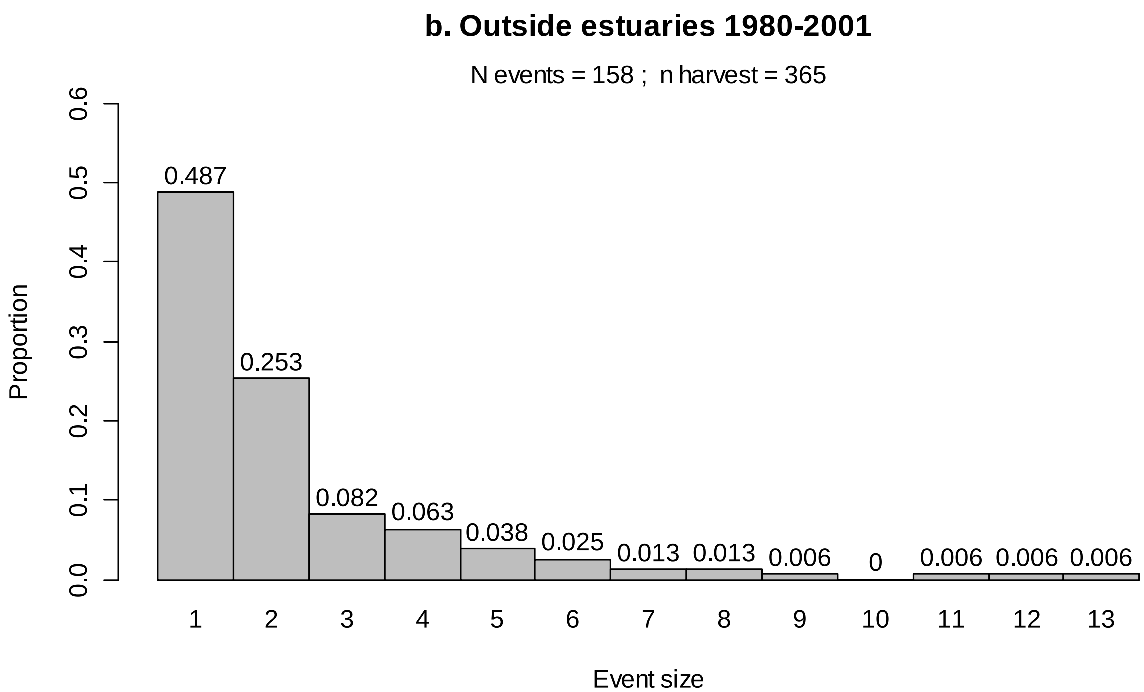


Figure 2. Size of hunting events a.) in EHB estuaries and b.) outside of estuaries in the eastern Hudson Bay arc and Hudson Strait for the period 1980-2001.

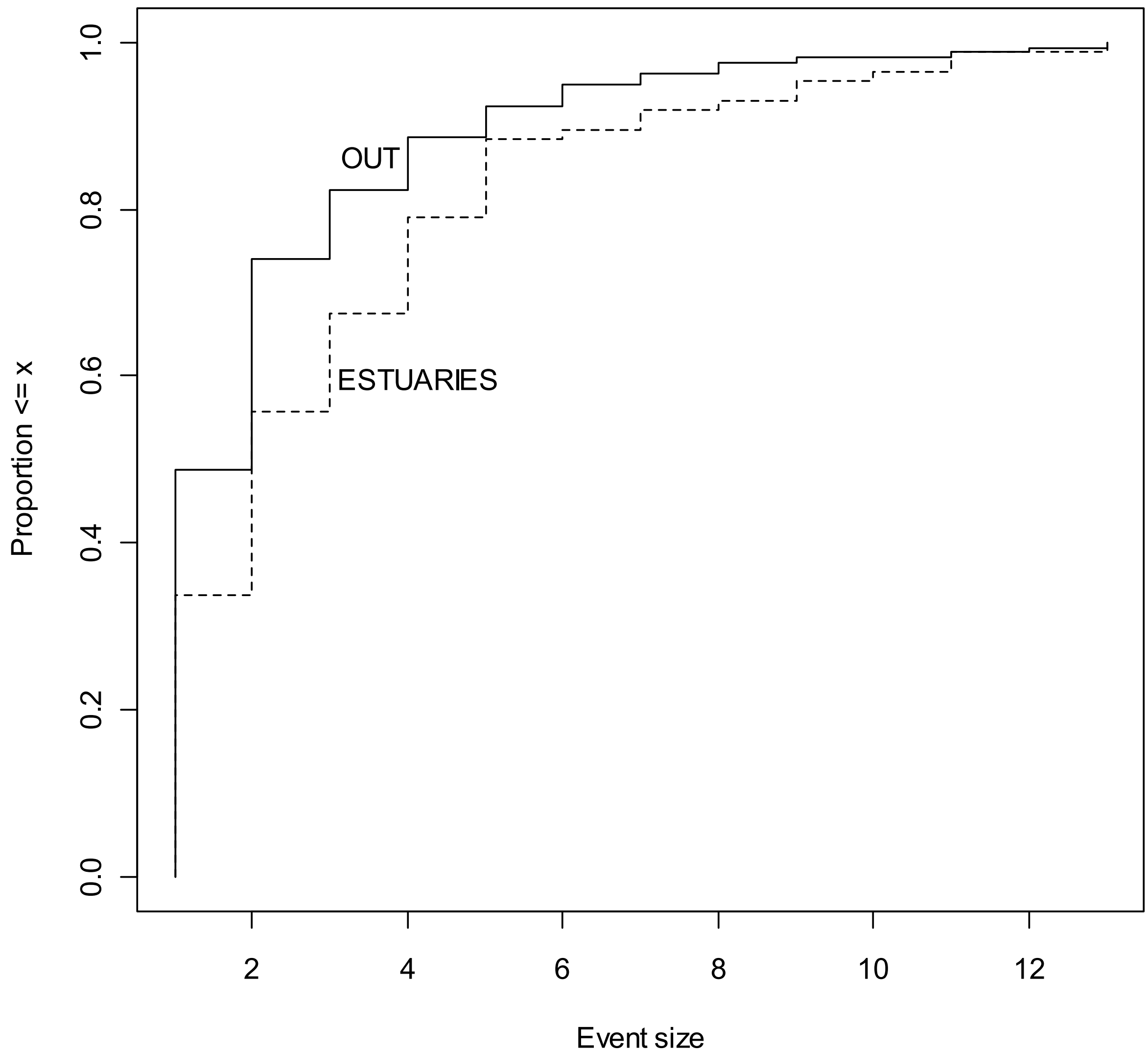


Figure 3. Cumulative distribution of the size of hunting events in EHB estuaries (dashed line), and outside of estuaries in the EHB arc and Hudson Strait (solid line) for the period 1980-2001.

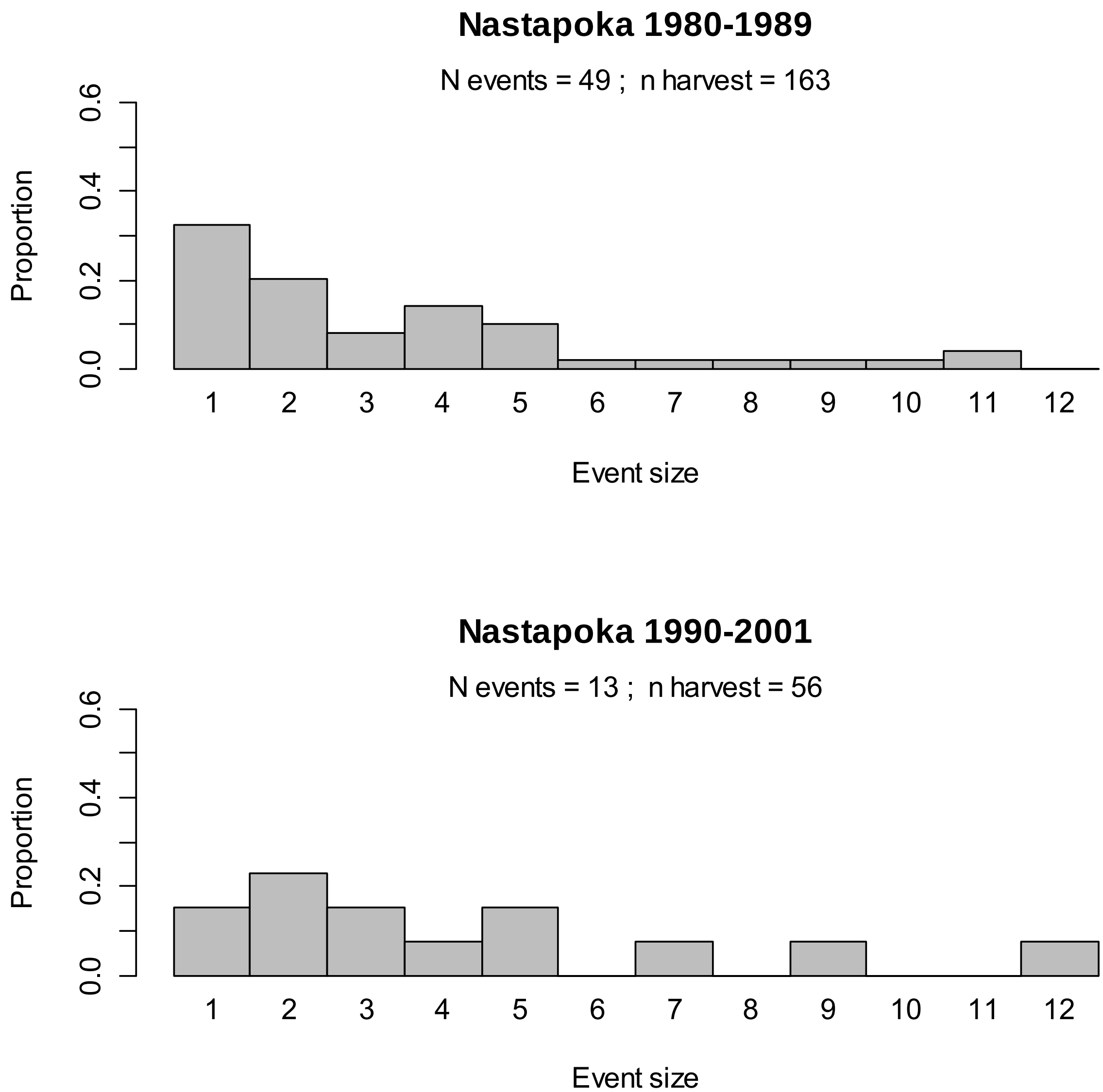


Figure 4. Size of hunting events in the Nastapola River estuary for the period 1980-1989 before closure (top) and the period 1990-2001 during which hunting was closed in July (bottom).

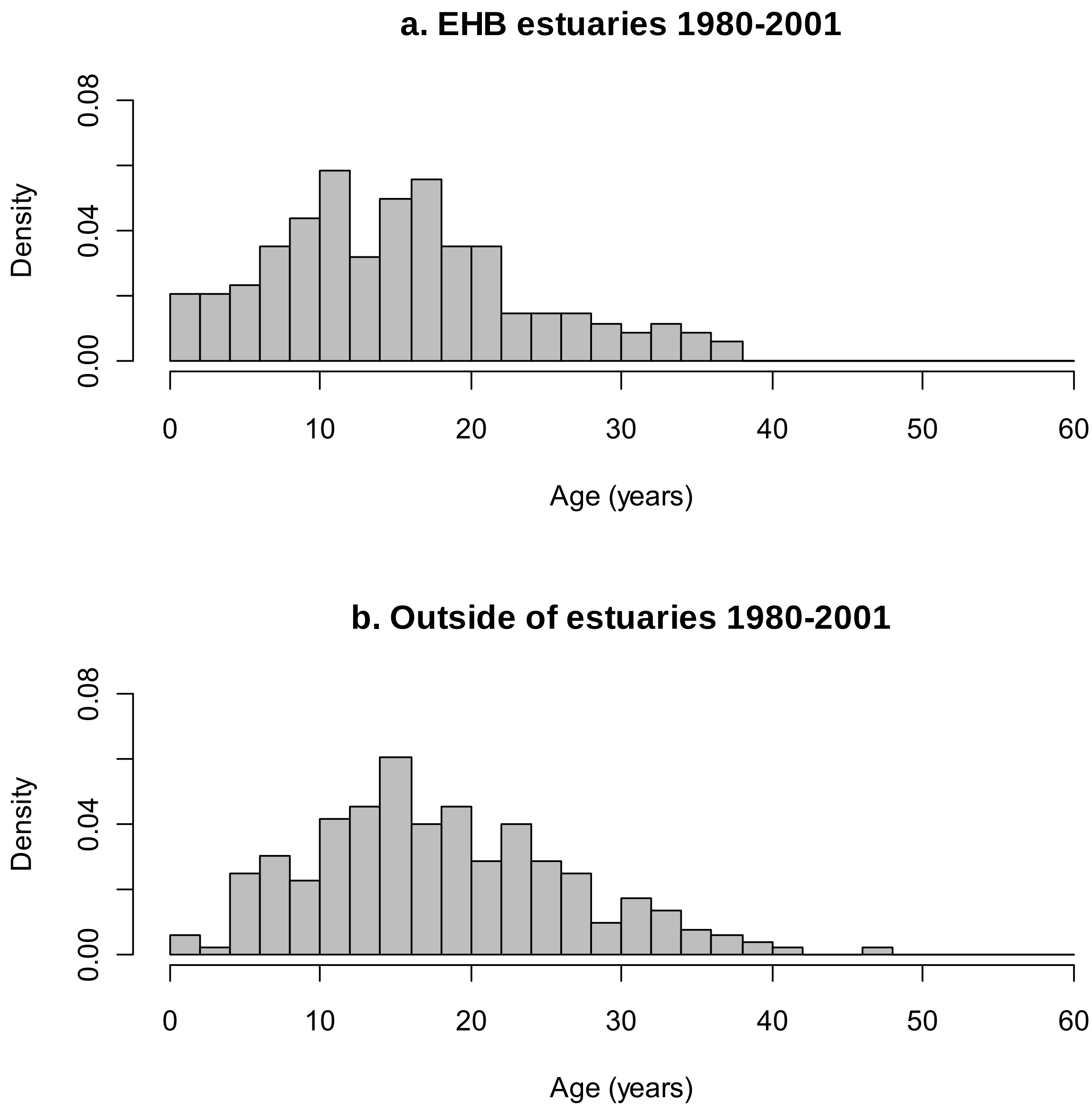


Figure 5. Age distribution in the harvest a.) from EHB estuaries, and b.) outside of estuaries in the EHB arc and Hudson Strait for the period 1980-2001.

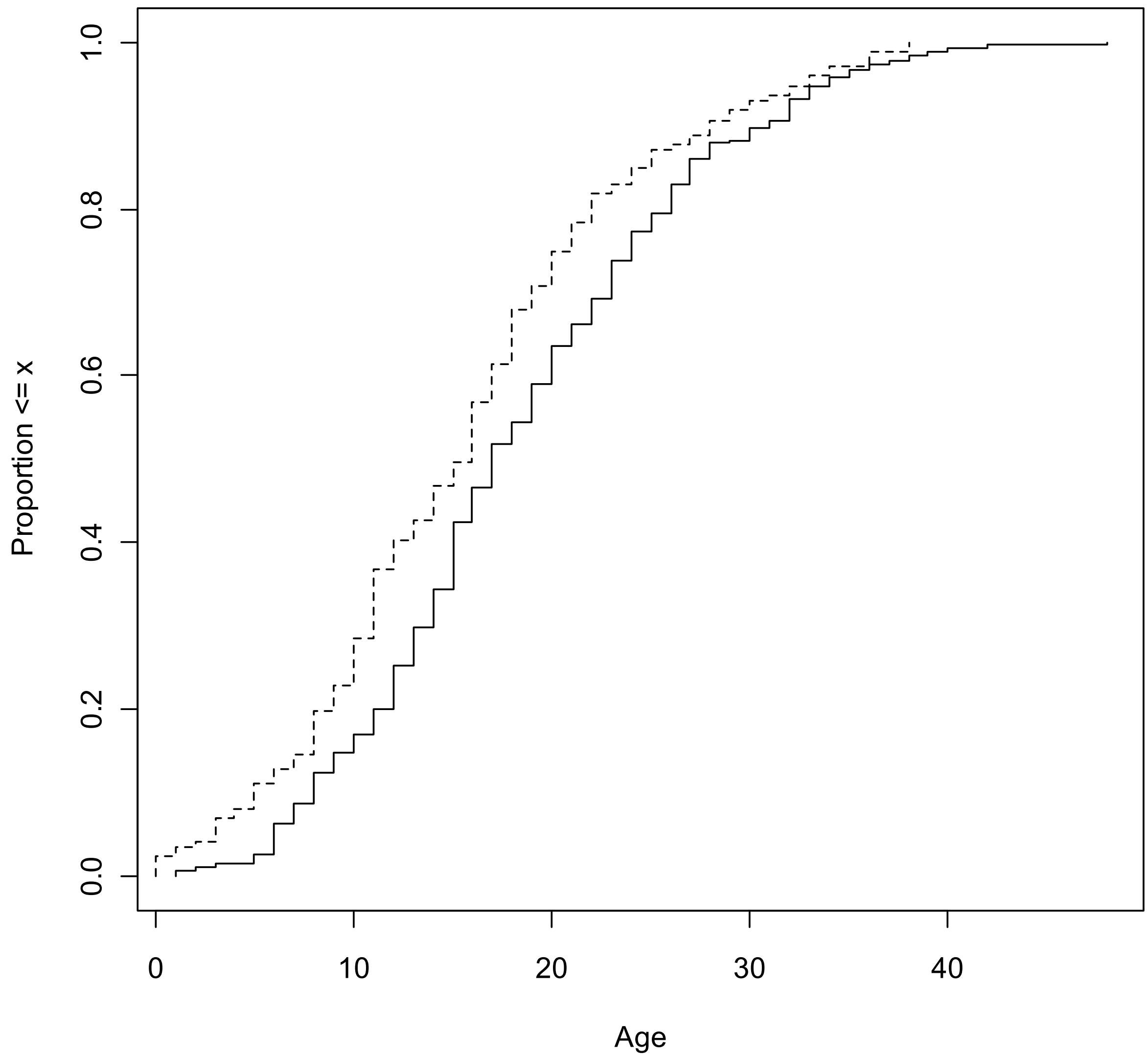


Figure 6. Cumulative distribution of ages in the harvest for the period 1980-2001. Dashed line: hunting events in EHB estuaries. Solid line: outside estuaries in the EHB arc and Hudson Strait for the period 1980-2001.