

Delineation of Walrus in Canada

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Abstract

Information that has become available since Born *et al.* (1995) reviewed stock-structure of walrus in Canada does not radically alter their conclusions. Walrus in Foxe Basin appear to be a separate population although there is evidence of limited exchange with other areas. There is new evidence to support the previously speculated separation of the walrus in SEHB from others. The suspected subdivisions in HBDS walrus appears substantiated by isotopic evidence although interbreeding among walrus at various wintering areas needs to be examined. Among Baffin Bay walrus, there now are preliminary data that suggest further subdivision into west Lancaster Sound, west Jones Sound, and east Jones Sound.

General Considerations

The concept of "stock" is common in fisheries management for making intraspecific subdivisions, usually focussing on the question "Which animals are taken where by whom?" to assist managers in making allocation decisions. But, while prevalent in the literature, the concept of "stock" is not rigorously defined. Outside of fisheries, the word "stock" generally refers to the base from which other groups derive, analogous to the stem of a tree rather than its branches; an interpretation constant since at least the 14th

century (Booke 1981). In fisheries, it has been applied "...vaguely in many ways to delimit groups of fish, from systematic (taxonomic) to applied management units." (page 1479, Booke 1981,). Royce (1972) defined a stock as a management unit for operational purposes, as a group of animals "capable of independent exploitation or management and containing as much of an interbreeding unit or as few reproductively isolated units as possible" (pages 198-199). The premise Royce uses is that removal of animals by one group of consumers affects the availability of animals to other consumers, separated by time and/or geography (Waldman 2005). "Stock" is therefore defined by its interaction with humans: "The part of the fish population which is under consideration from the point of view of actual or potential utilization" (page 5, Ricker 1975).

This operational definition based on anthropogenic interaction has at least three influential consequences. First, the delineation of the stock is dependant on the nature of the interaction. The walrus stock vulnerable to increased mortality due to eco-tourism at haulouts, trampled calves for instance, may be a different stock than the one that sustains hunting mortality. Trophy-sized male walrus, the object of sports hunts, may be a different stock than the part of the same population that supports the subsistence hunt in the same area. Trophies are selected on the basis of absolute size and as long as the number of big males removed does not reduce the productivity of the population (surplus male hypothesis) the number of animals available for subsistence hunting will not change. (The edible products of trophy-kills return to the subsistence consumers so the sport hunt is not considered additive.)

Second, with respect to removals by hunting, the interaction basis for defining stocks means that if one has biological information on every landed walrus at a community, one

has the definition of that stock (except for killed and lost animals) at that location.

Statistical differences in one or more parameters between harvests mean they are different stocks, or different "harvest stocks" (Waldman 2005). Off-setting this advantage is the first influential consequence: sampling by biologists is a different interaction than hunting and may not accurately represent the intraspecific group which will enter the harvest stock.

Third, the perception of "stock" is dependent on the character set used to differentiate it (Ihssen *et al.* 1981, Waldman 2005). Genetic data provide insights to population identity but reflect not only current distribution but also ancestral patterns that may not relate to existing conditions (Swain *et al.* 2005, Waldman 2005). The use of population parameters, behaviour, morphology or meristics (to name a few methods) all present different views of the group being studied. Among fish, meristics may reflect the temperatures experienced during early growth. Contaminant profiles and stable isotope signals used to identify significantly different groups of marine mammals indicate that one group of animals lived its lives – sampled its environment - differently than the other group. These are real stock differences; removing animals at one locale characterized by certain chemicals does not affect the number of animals at another locale with different chemical profiles, at least not directly. "A stock is a stock if a marker discriminates among them..." (page 12, Waldman 2005). But until the hypothesis of interbreeding coupled with philopatric dispersal to hunting areas can be rejected, it would be unwise to manage these two groups as two stocks.

It would, therefore, be most convenient if all members of an interbreeding unit (population) were equally exposed to harvesting and other interactions with humans, and

no members of other populations ever were included. This is unlikely for walrus and the methods we use to delineate management units must be viewed in relation to the underlying biology. The population structure is the fundamental aspect of living resources (Secor 2005).

The term "stock" is used infrequently by wildlife managers, who tend get by with "population" (see for example Novaks *et al.* 1987) meaning an intraspecific group more likely to interbreed than to breed with members of another group (Pianka 1988). (Here I adopt the convention used for polar bears that "more likely" means the dynamics are driven more by reproduction and death than by immigration and emigration (P. Wilson pers. com 2004)). This reproductive isolation is often manifest in geographic separation which was an underlying consideration in the separation of walrus stocks described by Born *et al.* (1995). The geographic distribution of animals is something that can be seen in real time, as opposed to genetic or chemical stock-identifying markers. Indeed, aside from trophy walrus, few walrus stocks could be discerned outside of the laboratory. And, as outlined above, if the stock is not the complete, self-sustaining unit but rather a distributional branch of a larger, interbreeding population, managers must return to the population structure and be aware of both the local group (stock) and the population that supports it for a basis of management decisions (Secor 2005).

The "evolutionarily significant unit" (ESU) applied to Pacific salmon stock issues was defined as (1) a population that is reproductively isolated and (2) an important part of the species evolutionary legacy (Waples 1991). Waldman concluded the first criterion, *i.e.* a population, is "essentially the definition of a stock" (page 11, Waldman 2005,). Secor (2005) however cautions against this default option and considers a stock to *be* "... a

specific portion of a population that is influenced by an anthropogenic activity that affects population productivity..." (page 38).

Here I adopt Secor's definition with the minor modification that the human activity may affect productivity. Therefore I refer to walrus populations in Canada and assume they are best represented by over-wintering aggregations when breeding occurs (e.g. Sjare and Stirling 1996). More widely dispersed aggregations or herds in the open-water season are expected to be segregated by age and sex, with, at least female, philopatry (Andersen and Born 2000). Various parts of a population may be selectively removed, sampled, or otherwise impacted at one or more locations and I refer to those aggregations as stocks. This conceptual framework parallels that used for "harvest stocks" of beluga by Innes *et al.* (2002) and of walrus by Outridge *et al.* (2003) except for the inclusion of summering herds that are not known to be exposed to hunting. It is also similar to that proposed by Andersen and Born (2000) except I consider separate breeding groups of walrus to be populations instead of sub-populations.

Walrus in Canada

Walrus have occupied Canadian waters from Nova Scotia to perhaps 85°N and from the boundary with Greenland to roughly 100°W. Their range now is less extensive and more discontinuous. These breaks in distribution, as well as other data when available, were used by Born *et al.* (1995) to identify four walrus stocks in Canada (Fig. 1). These were: Foxe Basin (#1 in Born *et al.* 1995); Southern and Eastern Hudson Bay (#2); Northern Hudson Bay – Hudson Strait – Southeastern Baffin Island – Northern Labrador (#3); and North Water (Baffin Bay-Eastern Canadian Arctic) (#5). Reflecting the arguments in *General Considerations*, in the interest of brevity, and to base the names, as much as

possible, on the relevant water bodies, here I adopt common Canadian terminology for these stocks:

- #1 Foxe Basin (abbreviated to FB) population;
- #2 Southern and Eastern Hudson Bay (SEHB) population;
- #3 is referred to as the Hudson Bay-Davis Strait (HBDS) population; and
- #5 is referred to as the Baffin Bay (BB) population.

I review information available since the previous NAMMCO assessment for each population in Canada. The former walrus range around Canada's maritime provinces (West Atlantic population) is considered briefly and the West Greenland stock of Born *et al.* (1995) is considered as it relates to walrus in Canada.

The distribution of approximately 1200 walrus harvested between 1996 and 2001 (Priest and Usher 2004 CD-ROM inclusion) was used to help define stock areas (Fig. 2). In addition to other studies reviewed below, I also examined incidence of diseases that may have been instructive in postulating population separations. For example, antibodies to canine distemper virus (CDV) and phocine distemper virus (PDV) were found in samples from Loks Land and Foxe Basin, but not from Nottingham Island (Nielsen *et al.* 2000) although one sero-positive animal had been reported previously (Duignan *et al.* 1994). Incidence of *Brucella* sp., PDV, CDV, canine adenovirus and influenza A antibodies (Duignan *et al.* 1994, Nielsen *et al.* 1996, 2000, 2001, Philippa *et al.* 2004) do not reveal striking stock differences. *Brucella* antibodies were not found in small samples of walrus from Grise Fiord (n=5), Resolute Bay (n=4) and Nunavik (n=4) but were found in Foxe Basin at low frequency (3.2%, n=157, Nielsen *et al.* 2001b). Generally, incidence of antibodies was not useful in discerning stock differences.

West Atlantic

Walrus were once common in the Gulf of St. Lawrence and around Nova Scotia but had been extirpated by the mid-1800's (Reeves 1978). Five walrus were reported in the Gulf between 1992 and 1996 in four different sightings and walrus are seen occasionally on the coast of Newfoundland (Kingsley 1998). A walrus was seen at the east tip of Cape Breton, NS, in June 2003 (Richer 2003). Whether these observations mark recolonization of former range or random wanderings of a few individuals remains to be seen. Should they not be itinerant animals, the population size is small.

South and East Hudson Bay

Walrus over-winter at the floe-edges around the Sleeper and Belcher archipelagos (Stewart 2004). The nearest winter concentrations are in the HBDS population area, around Ivujivik-Nottinham-Salisbury islands and Bell Peninsula-Foxe Peninsula (Priest and Usher 2004, Stewart 2004) and are likely separated from the SEHB population by distance and ice.

Dispersal from this area in the open-water season seems limited. Hunters from Sanikiluaq and Inukjuak hunt among the Sleeper and Belcher islands. Between June 1996 and May 2001, Sanikiluaq reported landing 25 walrus; the 11 of those that included location data were taken at the north end of the Belcher Islands and at the Sleeper Islands (Priest and Usher 2004). The harvest at Sanikiluaq occurs mostly in September and October (92% of 25 animals over 5 years, Priest and Usher 2004). Hunters from Inukjuak hunt in the same area (Fig. 2) at about the same time. The locations of harvests reported by Kuujjuarapik, and Umiuijaq are unknown but numbers are small (0 in 1994 and 1995, Brooke 1994, 1995).

Communities (Puvirnituk, Akulivik, Ivujivik, Salluit) north of Inukjuak on the east side of Hudson Bay are thought to hunt the HBDS population. Hunters from Akulivik, the nearest community outside the SEHB area, hunt in September and October so overlap the Belcher-Sleeper hunt in time but they hunt farther north, around Nottingham and Salisbury Islands (Fig. 2). Walrus occupy the shoals near Cape Henrietta Maria in July-October at least, with several peak counts in September and October. It is possible that walrus that summer one year at Cape Henrietta Maria, could summer in other years at the Belcher-Sleeper islands, or even farther north where they could be hunted by Akulivik. However, harvested walrus at Akulivik are different from those landed at Inukjuak.

Concentrations of heavy metals appeared to differ between Inukjuak (Hg: 8.00 µg/g dry wt; Cd: 19.0 µg/g dry wt) and Akulivik (Hg: 4.20 µg/g dry wt; Cd: 30.0 µg/g dry wt) but sample sizes were small (9 and 4 respectively) and these differences were not statistically significant (Wagemann and Stewart 1994). Muir *et al.* (1995) found significant differences of OC concentration and profiles in walrus sampled at Inukjuak and Akulivik. Lead isotope ratios ($^{208}\text{Pb}/\text{Pb}^{207}$) and trace element profiles both showed significant differences between Inukjuak and Akulivik samples (Outridge and Stewart 1999, Outridge *et al.* 2003). Indeed, lead isotope ratios from Inukjuak are distinct from all other sampling locations (Stewart and Outridge 2003), although, based on the underlying geology, one would expect them to be the same as walrus from Sanikiluaq, when those come to be analysed.

Born *et al.* (1995) defined the SEHB population mostly on the basis of distribution and noted that evidence for separating it from other walrus groups in NE Hudson Bay was not strong. Since then, new information shows significant stock-differences between walrus landed at Inukjuak and at Akulivik. Distribution data suggest herds in southern Hudson Bay may face different exploitation regimes than those farther north. There are no new genetics data by which to assess the degree of interbreeding among these various components.

Hudson Bay-Davis Strait

In this region, walrus are found at several widely dispersed areas in winter (Fig. 2). They winter in Roes Welcome Sound, both sides of Foxe Channel, in the SW corner of Hudson Strait, along the north shore of Hudson Strait, in pack ice in Davis Strait and probably (based on harvest dates) at the mouths of Frobisher Bay and Cumberland Sound (Orr and Rebizant 1987, Born *et al.* 1995, Priest and Usher 2004, Stewart 2004). There are no data to determine if significant numbers of walrus change wintering areas over years or if there is within-season movement among nearby areas. Certainly Foxe Channel, SW Hudson Strait and northern Hudson Strait are close enough to allow exchange.

Cape Dorset reports landing at least a few walrus almost every month with peaks in March and November, at the same time that Kimmirut lands about 75% of its catch (Priest and Usher 2004). These communities may therefore be sampling at the population (over-wintering) level.

Walrus in this population are hunted at many other communities in Nunavut and Nunavik as well, usually in the open-water season. Harvests in Nunavut tend to be close to the communities with little overlap of hunting areas among communities but the hunting areas of many communities in Nunavik overlap (Fig. 2). Along western Hudson Bay, three communities land a few walrus every year from coastal areas between Whale Cove and Roes Welcome Sound, usually in May to September. Repulse Bay hunters hunt mostly in Frozen Strait with peak harvests a bit later than communities immediately to the south (Priest and Usher 2004) and it is possible that walrus along this coast are hunted by all these communities.

Outridge *et al.* (2003) examined the lead isotopes of walrus landed at Repulse Bay, Coral Harbour, Akulivik, Loks Land and Sisimiut (Greenland), all communities expected to harvest from this population, as well as samples from Foxe Basin and SEHB. Although sample sizes for Repulse Bay were small, they differed from walrus landed at Coral Harbour by substantial amounts. Movement from west Hudson Bay to the Coral Harbour hunting area therefore seems infrequent. Walrus landed at Coral Harbour were significantly different from those landed at Akulivik which also appeared to differ from the small sample from Loks Land, although again there was some overlap. These authors concluded that most communities were harvesting walrus that inhabited different geological areas, while noting incomplete separation. This is consistent with a clinal population model suggested by the distribution of wintering areas.

The temporal and spatial distribution of walrus harvests is consistent with Outridge *et al.*'s (2003) concept of local stocks, grading into each other. Peak harvests tend to occur from May to September and must reflect wide-spread availability. Four communities on

NE Hudson Bay report peak walrus harvests that overlap in both time (August-September, Priest and Usher 2004) and space (Fig. 2) and share a stock. Similarly, the seven communities on Ungava Bay hunt at Akpatok Island, mostly in July-August. Repulse Bay and Coral Harbour harvests both peak in August, suggesting different stocks. Both Pangnirtung and Iqaluit take 95% of their walrus between May and November over large areas, that may overlap (Fig. 2).

Harvest data contribute little to our understanding of populations. Although some walrus are taken in December-May at Pangnirtung and Iqaluit, there is nothing in the harvesting data to reject the hypothesis that walrus from SE Baffin migrate to West Greenland for the winter breeding season. Those remaining in Canada may be immature animals, mature non-breeders, breeding animals that breed in both countries in the different years, or a separate population.

The distribution of HBDS walrus stretches 1500 km east-west or over 2500 km following the coastline. Born *et al.* (1995) noted the absence of data by which to partition the group and speculated there may be subunits within the range. Two groups of northern Quebec communities each share stocks. Nunavut communities appear to harvest local animals but there is a real possibility that there is a gradation at the population level over the expanse of this range.

Foxe Basin

Walrus in Foxe Basin generally winter at the floe edge around Rowley Island (Stewart 2004). They move to summer areas around islands in northern Foxe Basin and are routinely found on pack ice.

Iglulik and Hall Beach are the main sources of hunters on these walrus although hunters from Pond Inlet, Iqaluit, and Arctic Bay/Nanisivik also report landing walrus in Foxe Basin (Figs. 2 and 3A). Walrus landed by hunters at Hall Beach were not distinguishable from walrus landed at Iglulik on the basis of genetic (mtDNA, 9 microsatellite loci, de March *et al.* 2001), heavy metal (Wagemann and Stewart 1994) or major organochlorine group data (Muir *et al.* 1995). But Outridge and Stewart (1999) reported differences in lead isotope ratios ($^{206}\text{Pb}/^{207}\text{Pb}$ and $^{208}\text{Pb}/^{207}\text{Pb}$) and trace elements. They also noted statistical outliers which, when removed, did not affect the significant differences in $^{206}\text{Pb}/^{207}\text{Pb}$ ratios. The isotope data are not contrary to the OC and metals data because the environmental variation in the latter two is reduced by long-range transport and long residence times.

Walrus landed at Foxe Basin communities are different from those landed at HBDS communities:

- Akulivik, Coral Harbour, Repulse Bay, Loks Land, Sisimiut on the basis of lead isotope ratios (Outridge and Stewart 1999, Outridge *et al.* 2003);
- Akulivik on the basis of organochlorines (Muir *et al.* 1995);
- Hudson Bay on the basis of body size (Garlich-Miller and Stewart 1998);

and from Baffin Bay walrus:

- Grise Fiord, Resolute Bay, Bathurst Island on the basis of genetic data (de March *et al.* 2001)
- Grise Fiord, Resolute Bay, Thule on the basis of lead isotope ratios (Outridge and Stewart 1999, Outridge *et al.* 2003)

Stewart and Outridge (2003) interpreted differences in lead isotope ratios of growth layer groups in teeth of walrus landed at Hall Beach to indicate changes in the way these male walrus sampled their isotopic environments. Although some of these layers resembled walrus teeth landed at three HBDS communities and one SEHB community, similarity does not prove congruence (Waldman 2005); for example Scoresby Sund and Inukjuak walrus have similar lead isotope ratios which reflect common geology, not common distribution (Outridge *et al.* 2003). It is still unclear, therefore, if some males from Foxe Basin move into other walrus populations, or if they contribute to those populations once there. The number of animals involved was low but one successful male may make a significant contribution to those populations.

Peak landings at Iglulik and Hall Beach overlap in time (Priest and Usher 2004) but are somewhat separated in space (Fig. 3A). It is probable that, while landed walrus are different at these two sites, both communities are relying on a single interbreeding population which is characterized by primarily local movement. There may be some low level exchange with other more distant populations but recent data do not refute the conclusion by Born *et al.* (1995) that this population is "...largely isolated from other groups..." (page 9).

Baffin Bay

Over-wintering areas (Fig. 2) occur in the Cardigan Strait-Fram Sound areas at the west end of Jones Sound and the Penny Strait-Queens Channel area around Dundas Island (Born *et al.* 1995, Stewart 2004) as well as the floe edges of Jones and Lancaster sounds and in the north water polynia between Avanersuaq and Qeqertarsuaq, Greenland (Born *et al.* 1995). The degree of separation among wintering areas is not

clearly known. Andersen and Born (2000) found genetic (mtDNA and microsatellite) differences between walrus landed in West Greenland and North Greenland, but no seasonal or sex-related differences in the North Greenland sample.

As the ice recedes in spring, walrus follow it from the eastern reaches of Jones and Lancaster Sounds, and away from north Greenland (Born *et al.* 1995). There are no walrus around Avanersuaq between mid-June and mid-July; they may travel north into Smith Sound or east into Canada (Born *et al.* 1995). An ICP-MS comparison of lead isotope ratios ($^{206}\text{Pb}/^{207}\text{Pb}$ and $^{208}\text{Pb}/^{207}\text{Pb}$) of walrus landed at Grise Fiord and Avanersuaq (Outridge *et al.* 2003) was ambiguous. There were no significant differences in mean ratios (Table 1 of Outridge *et al.* 2003) but only 8 samples from Grise Fiord were available. However, approximately 80% of the animals at Thule and 20% at Grise Fiord were dissimilar and the authors concluded they represent different stocks. More sensitive TIMS analysis showed significant differences, as well as separation of walrus landed at Resolute Bay. (Resolute Bay animals also appeared to be separate based on ICP-MS but were not compared statistically due to small sample sizes.)

Hunters at Grise Fiord tend to take walrus in August at the mouth of Grise Fiord, in September and October east of Lee Point and February to May in Glacier Strait. Hunters at Pond Inlet take walrus in spring at the floe edges in Milne Inlet and Pond Inlet, and in summer farther into these inlets. Hunters from Arctic Bay report most of their harvest from the floe edge of Admiralty Inlet, also in spring. Hunters from Arctic Bay, Pond Inlet and Resolute Bay may all be hunting stocks of the population that over-winters at the mouth of Lancaster Sound.

de March *et al.* (2001) distinguished Foxe Basin samples from Grise Fiord (n=5) and Resolute Bay + Bathurst Island (biopsies) but found no differences among the high Arctic sites. Preliminary data from 2004 found significant differences in microsatellite allele frequencies between samples of the harvest at Grise Fiord and biopsy samples from the west end of Jones Sound, and between west Jones Sound and Bathurst Island/west Devon Island (biopsies), but not west Jones Sound and Resolute Bay (harvest sample) and SW Devon Island (biopsies) (Stewart and Postma, unpublished).

One adult male walrus tagged at Bathurst Island in 1993 was killed in June 1994 near Pond Inlet (Stewart 2002) and another walrus observed at Bathurst Island in 1993 had, some years before, been branded at Dundas Polynia (B. Sjare, pers. comm.). Whether Bathurst Island represents an area of overlap for two populations, one to the north and one to the east, or whether all three areas are occupied by members of a single population is unknown.

Location data from satellite tags (Stewart unpublished) deployed at the west end of Jones Sound show no movement to the east half of the sound, past South Cape, or into the main Grise Fiord hunting area (Fig. 4). None has travelled into through Hell Gate/Cardigan Strait. All the tags that transmitted into November remained in the general area of Fram Strait. One female walrus tagged in August 2002 in Penny Strait moved south to the area of Kearney Cove on SW Devon in early September (Fig. 4). One male of a group of at least 40 males that occupied Kearney Cove at the same time was also tagged and remained in that cove also until early September. All other tags deployed in the areas of SW Devon and Bathurst Island have remained in that general

area (Fig. 4); none has travelled north out of Penny Strait or south into Prince Regent Inlet.

During aerial searches in 2 years in August, no walrus have been seen in Belcher Channel (north of Grinnell Peninsula) where the shoreline is low and gradual. The area was ice-choked in another year. This may be an area of separation between two populations; one that winters around Cardigan Strait/Hell Gate and one that winters around Dundas Island. Similarly, sightings of walrus between Musk Ox Fiord and Grise Fiord were sparse in August which, in conjunction with the tag data, may indicate some separation between the summer aggregations at the west end of Jones Sound and the hunted group at the east end.

Thoughts on future research

- coordinate genetic sampling and analysis between Canada and Greenland (planned);
- obtain genetic samples from SE Baffin to compare to West Greenland (planned);
- obtain more samples in Jones and Lancaster sounds (planned);
- obtain genetic samples from over-wintering walrus, especially from the Baffin Bay and Hudson Bay – Davis Strait populations;
- improve isotope map and examine more growth layer groups to better understand individual movements.

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Fig 1. Reproduction of Figure 3 of Born et al 1995.



Figure 2. Walrus harvest locations, 1996-2001, adapted from Priest and Usher 2004.

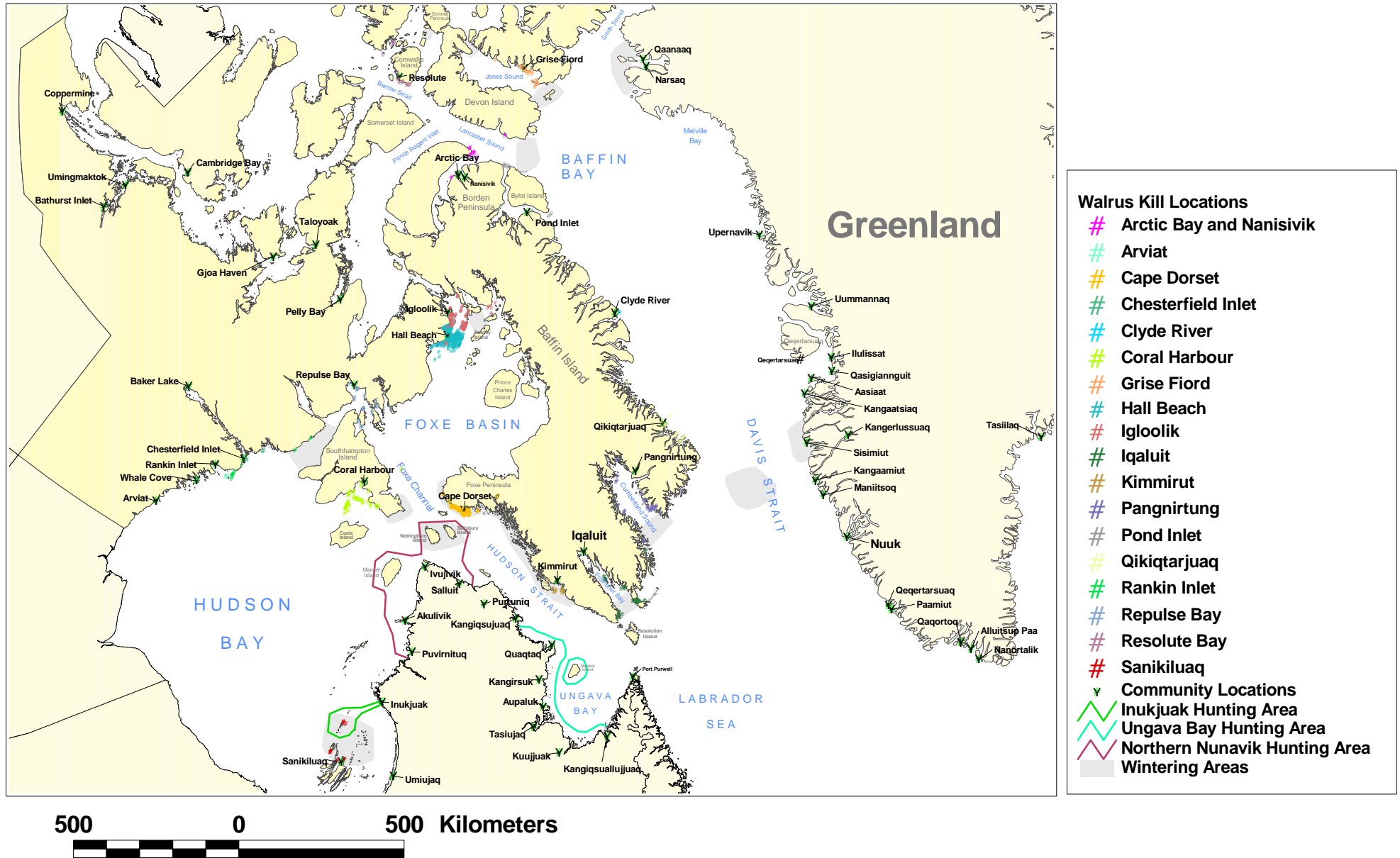


Figure 3. Detail of harvest sites for A) Foxe Basin and B) High Arctic.

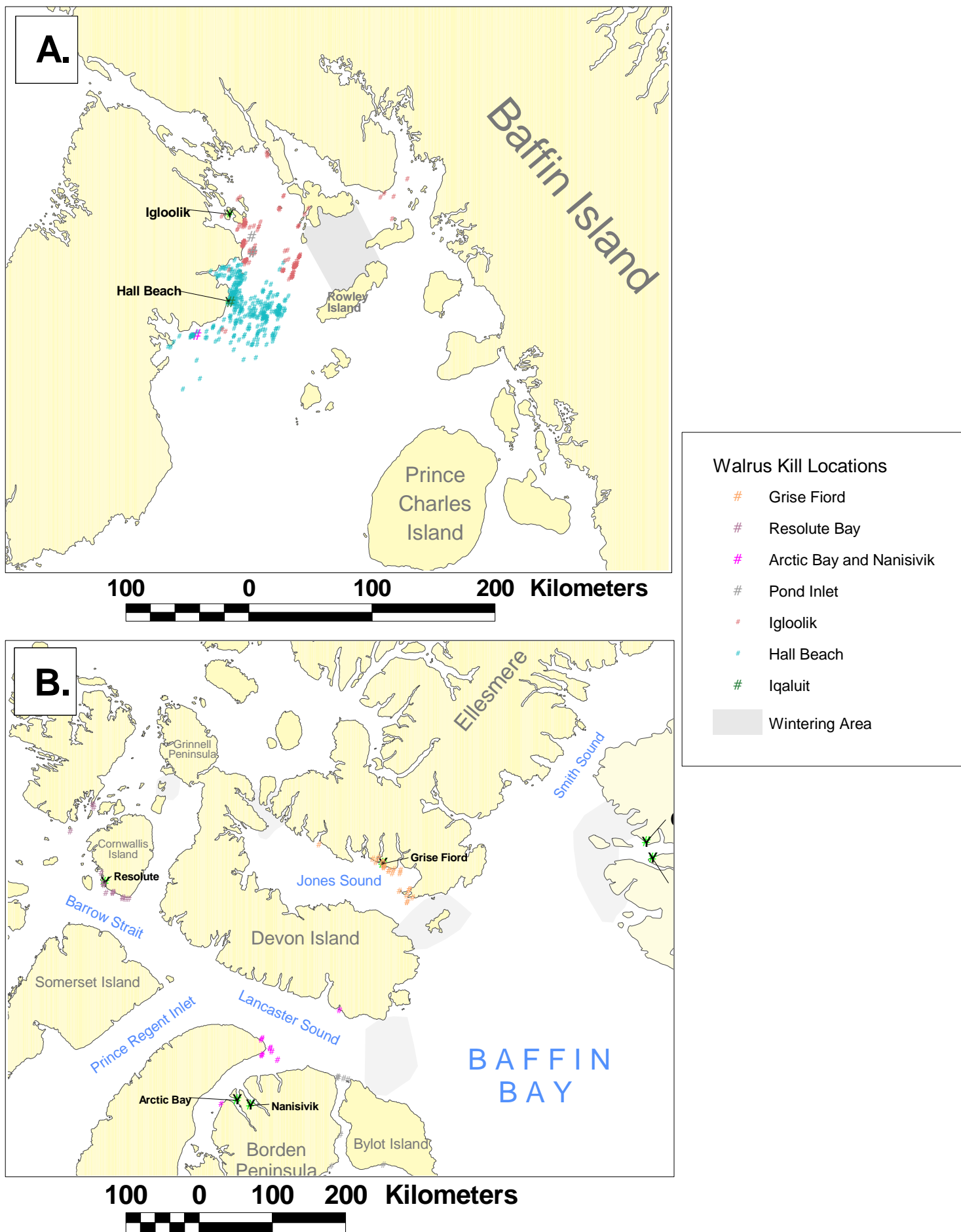


Figure 4. Preliminary tag location data 1993, 1998- 2004.

