

Isabella Bay, Baffin Island: An Important Historical and Present-day Concentration Area for the Endangered Bowhead Whale (*Balaena mysticetus*) of the Eastern Canadian Arctic

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ABSTRACT. A late summer concentration of bowheads (*Balaena mysticetus*) at Isabella Bay, Baffin Island, was studied during 1983-88. The general results of the field study are presented and integrated with historical research and artifactual evidence of British whaling.

Bowheads were observed from shore on virtually every day of adequate visibility in late summer, early fall of 1984-88, but in 1983 only two whales appeared. Peak numbers occurred in September, when as many as 68 whales were counted on one day. The whales congregated in specific areas corresponding to significant underwater topographic features. Most feeding took place in one of two deep (>200 m) troughs and most social activity occurred on a shallow bank (<30 m). Earliest arrivals were large subadults that engaged in social-sexual activities on the bank; adults arrived later and fed in deep troughs. Migrants from the north arrived in October.

The mean length of 83 whales, measured photogrammetrically, was 14.4 m; 89% were >13 m long, which is about the minimum size of sexual maturity. The smallest whales, presumed to be large subadults, had less white on the tail stock. Females with calves were rarely seen. One distinctively marked individual was observed in 4 of 6 years. Another was observed in 1984 as a late summer "resident" and in 1986 as an autumn "migrant." Seven of 47 whales identified individually from aerial photographs in 1987 were identified among 107 photo-identified individuals in 1986.

Interactions of killer whales with bowheads were observed twice. About one-third of the bowheads bear killer whale scars.

Whaling literature indicates that bowheads on the east coast of Baffin Island, called rocknosers, were segregated in late summer from those in the High Arctic archipelago. This population was exploited mostly after 1859 with the advent of steam power, in an operation called rocknosing. Isabella Bay was a significant port of operation during this last phase of the industry; the whalers were strategically positioned to hunt large whales in offshore troughs late in the season. Other locations with similar characteristics on the east coast of Baffin are identified from Inuit lore and historical literature.

Key words: bowhead whale, *Balaena mysticetus*, Isabella Bay, Baffin Island, numbers, distribution, habitat, segregation, site fidelity, whaling history, predation

RÉSUMÉ. De 1983 à 1988, à la fin de l'été, on a étudié un groupe de baleines franches à Isabella Bay, dans la terre de Baffin. Les résultats généraux de l'étude sur le terrain sont présentés et intégrés à la recherche historique et à l'existence de la pêche à la baleine pratiquée par les Britanniques, telle qu'attestée par les artefacts.

On a observé les baleines franches depuis le rivage, pratiquement chaque jour où la visibilité le permettait, à la fin de l'été et au début de l'automne, de 1984 à 1988. En 1983 cependant, on n'a aperçu que deux baleines. C'est en septembre qu'on a relevé les nombres les plus grands, avec au moins 68 animaux dans une seule journée. Les baleines se regroupaient dans des endroits précis dont la topographie sous-marine avait des caractéristiques marquées. Les animaux se nourrissaient la plupart du temps dans l'une de deux tranchées profondes (>200 m) et leur activité sociale se déroulait presque toute sur un banc peu profond (<30 m). Les premiers arrivés étaient de jeunes adultes de grande taille qui s'engageaient dans des activités sociales et sexuelles sur le banc; les adultes arrivaient plus tard et se nourrissaient dans les tranchées profondes. Les baleines migrant du nord arrivaient en octobre.

La longueur moyenne de 83 baleines, obtenue par photogrammétrie, était de 14,4 m; 89 % des baleines mesuraient plus de 13 m de longueur, ce qui représente à peu près la taille minimale de la maturité sexuelle. Les plus petites baleines, que l'on a considérées comme de jeunes adultes de grande taille, avaient moins de blanc sur le pédoncule. On a aperçu peu de femelles avec des baleineaux. Un individu qui portait des marques caractéristiques a été observé quatre années sur les six et un autre a été observé en tant que «résident» de fin d'été en 1984 et en tant que «migrateur» d'automne en 1986. Sept baleines sur les 47 identifiées individuellement en 1987 à partir de photos aériennes ont été reconnues parmi les 107 individus identifiés par photos en 1986.

On a observé à deux reprises des interactions d'épaulards et de baleines franches. Environ un tiers des baleines franches portaient des cicatrices qui résultaient d'attaques par des épaulards.

Les documents concernant la pêche à la baleine indiquent que, sur la côte est de la terre de Baffin, les baleines franches que l'on appelait les «rocknosers», étaient séparées des baleines de l'archipel de l'Extrême-Arctique à la fin de l'été. C'est surtout après 1859, date de l'apparition des navires à vapeur, que leur population fut exploitée et cette pêche était connue sous le nom de «rocknosing». Au cours de la dernière phase de l'industrie, Isabella Bay fut un port important relié à cette exploitation; tard dans la saison, les baleiniers occupaient une position stratégique pour la pêche des grosses baleines dans les tranchées de haute mer. On a identifié d'autres lieux possédant des caractéristiques semblables sur la côte est de la terre de Baffin à partir du folklore inuit et de documents historiques.

Mots clés: baleine franche, *Balaena mysticetus*, Isabella Bay, terre de Baffin, nombres, distribution, habitat, ségrégation, fidélité à un site, histoire de la pêche à la baleine, prédation

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INTRODUCTION

The bowhead whale, or Greenland right whale (*Balaena mysticetus*), is an ice-adapted baleen whale with a disjunct circumpolar distribution in arctic waters. These large, slow-moving whales were severely reduced through three centuries of intensive commercial hunting. Although substantial numbers still exist in the Bering-Beaufort Sea stock, there are

only remnants of the other three or four recognized stocks. This paper deals with one of the latter groups, the bowheads of Baffin Bay-Davis Strait in the eastern North American Arctic.

The problem of stock identity of the eastern arctic bowheads is not resolved, but historically there appear to have been two stocks — one that summered in northern Hudson Bay and Foxe Basin, and the Baffin Bay-Davis Strait stock that

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summered among the High Arctic islands (Fig. 1; Reeves *et al.*, 1983). The Baffin Bay stock presently winters among the pack ice in Davis Strait (McLaren and Davis, 1981, 1983; Born and Heide-Jorgenson, 1983). Some Hudson Bay whales appear to winter as far east as eastern Hudson Strait (Finley *et al.*, 1982), so the degree of segregation of these two groups is uncertain.

The Baffin Bay bowheads were hunted by Dutch whalers in the 18th century and by the British in the 19th century (Lubbock, 1937; Ross, 1979, 1985; Mitchell and Reeves, 1981; Ross and MacIver, 1982). Based on available records for 1719-1911, Ross (1979) concluded that a minimum of 28 000 bowheads was taken from the Baffin Bay stock. Mitchell and Reeves (1981) conservatively estimated that the population was 11 000 animals prior to the peak period of British whaling, 1825-34. By the turn of this century, eastern arctic bowheads were near extinction (Low, 1906).

Although the Baffin Bay bowheads continue to occupy much of their historic range and to follow traditional migration routes, they have not recovered appreciably since commercial whaling ceased over 75 years ago. Mansfield (1971) suggested that the population was recovering well by 1970; however, despite extensive aerial surveys in northwest Baffin Bay and Lancaster Sound, Davis and Koski (1980) found few bowheads in their former range. They stated that the population was in the low hundreds at most, and possibly less than a hundred. They noted that the increase in numbers of sightings reported by Mansfield was due largely, if not entirely, to increased opportunities for observation. Mitchell and Reeves (1982) suggested that the failure of the stock to recover is due to a combination of occasional hunting by Inuit, predation by killer whales and habitat instability. Because of its rarity, the eastern arctic bowhead has been considered too sparsely distributed to warrant dedicated field studies. The stock is designated as endangered by the Committee on the Status of Endangered Wildlife in Canada.

Much of what is known about the natural history of the eastern arctic bowheads is derived from the accounts of British naturalists, many of whom travelled as surgeon-naturalists aboard whaling vessels (Scoresby, 1820; Brown, 1868; Markham, 1874; Gray, 1888; Ross, 1985). Until recently, the bowhead whale had not been studied and knowledge was little advanced from the 1800s. However, in the past decade, the western arctic bowhead whale has been studied intensively in the field and some archival research has been conducted on eastern arctic bowheads. In particular, Reeves *et al.* (1983) produced a detailed overview of the historical distribution and migration of the bowhead whale, based on published and unpublished historical literature. Ross and MacIver (1982) reconstructed the historical distribution of the Baffin Bay bowheads by plotting kills recorded in unpublished logbooks of the British whalers, and Ross (1985) described the Baffin Bay whale fishery from unpublished logbooks, journals and other archival sources. Until the present study, there had been no dedicated field study of eastern arctic bowheads, although their distribution and migration in Lancaster Sound and northwest Baffin Bay were documented during extensive aerial surveys and shore-based observations (Davis and Koski, 1980; Koski and Davis, 1980).

The importance of Isabella Bay, on the east coast of Baffin Island, as a significant summering area for bowheads was

first brought to our attention by local Inuit. The present study, conducted in 1983-88, was designed to evaluate the importance of Isabella Bay to the remnant eastern arctic population of bowheads. The objectives were 1) to chronicle the seasonal patterns of habitat use, local movements, and numbers of bowheads that use Isabella Bay; 2) to assess the potential significance of the area for calving, calf-rearing or breeding; 3) to determine the physical and biological characteristics of Isabella Bay that are important to specific bowhead activities, such as feeding and socializing; and 4) to evaluate the status of the whales and the need to protect the area.

This paper presents general results from the six-year program and attempts to integrate these results with historical information and local natural history.

METHODS

Shore-based Observations

Observations of bowheads in Isabella Bay were obtained from near Cape Raper, the coastal headland at the northeast corner of the bay (Fig. 2). Most data were collected from the top of a 136 m hill, now officially known as Balaena Lookout (69°44'N, 67°09'W), about 2 km west of the tip of Cape Raper. Observation periods were 3-5 weeks in duration, usually beginning in mid- to late August and ending as late as 9 October (Fig. 3).

Because of limited logistic support and deteriorating weather and high sea states just prior to freeze-up, observations were not conducted beyond early October. In 1986, we attempted to continue observations long enough to document the arrival of migrant whales from summering areas farther north. In 1978 and 1979, most southward migrating bowheads were seen during the first week of October at Cape Adair, 240 km north of Cape Raper (Koski and Davis, 1980).

There were usually two or three observers, except in 1988, when only one observer was present. Observations were made with binoculars and a theodolite, which starting in 1985 was mounted on a permanent concrete pillar at 136.2 m asl. The site provided a wide field of view (280°) over Isabella Bay and northward along the Baffin coast. The theodolite was used to determine positions of whales, oceanographic features, zooplankton and bathymetric stations, and kayak-based observers during underwater recording sessions. Malfunction of the theodolite in 1987 precluded precise positional data on whales (or other features), so positions were categorized by specific physiographic areas with which bowheads often associate (e.g., Isabella Bank, Aqvik Trough, etc.).

Two behavioural sampling techniques were employed: focal-animal and scan-sampling (Altmann, 1974). During focal-animal sampling, activities and positions of a recognizable individual, pair or group of whales were described for as long as possible (usually 2-8 h). Scan-sampling was conducted on an opportunistic basis depending on other sampling priorities, but usually once a day. During scans, positions of all visible whales were determined and they were observed for a sufficient period (1/2-1 min) to assign them to one of the following general behavioural categories: 1) directed swimming (including direction and speed determined from two positions), 2) resting, 3) socializing (including group size and type of display), and 4) feeding (including orientation to surface features and avian associations).

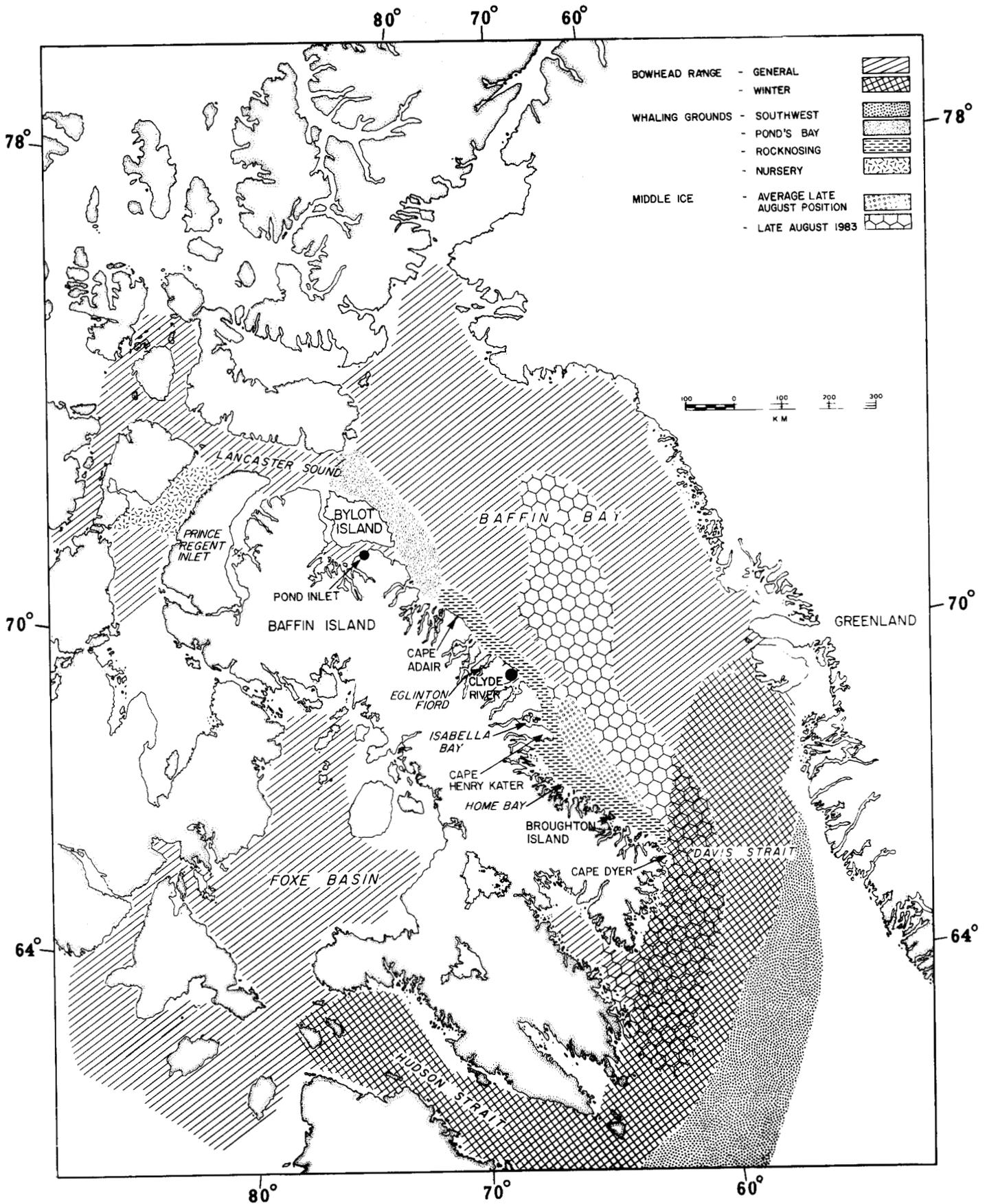


FIG. 1. Distribution of bowhead whales, British whaling grounds and the Middle Ice in the eastern North American Arctic.

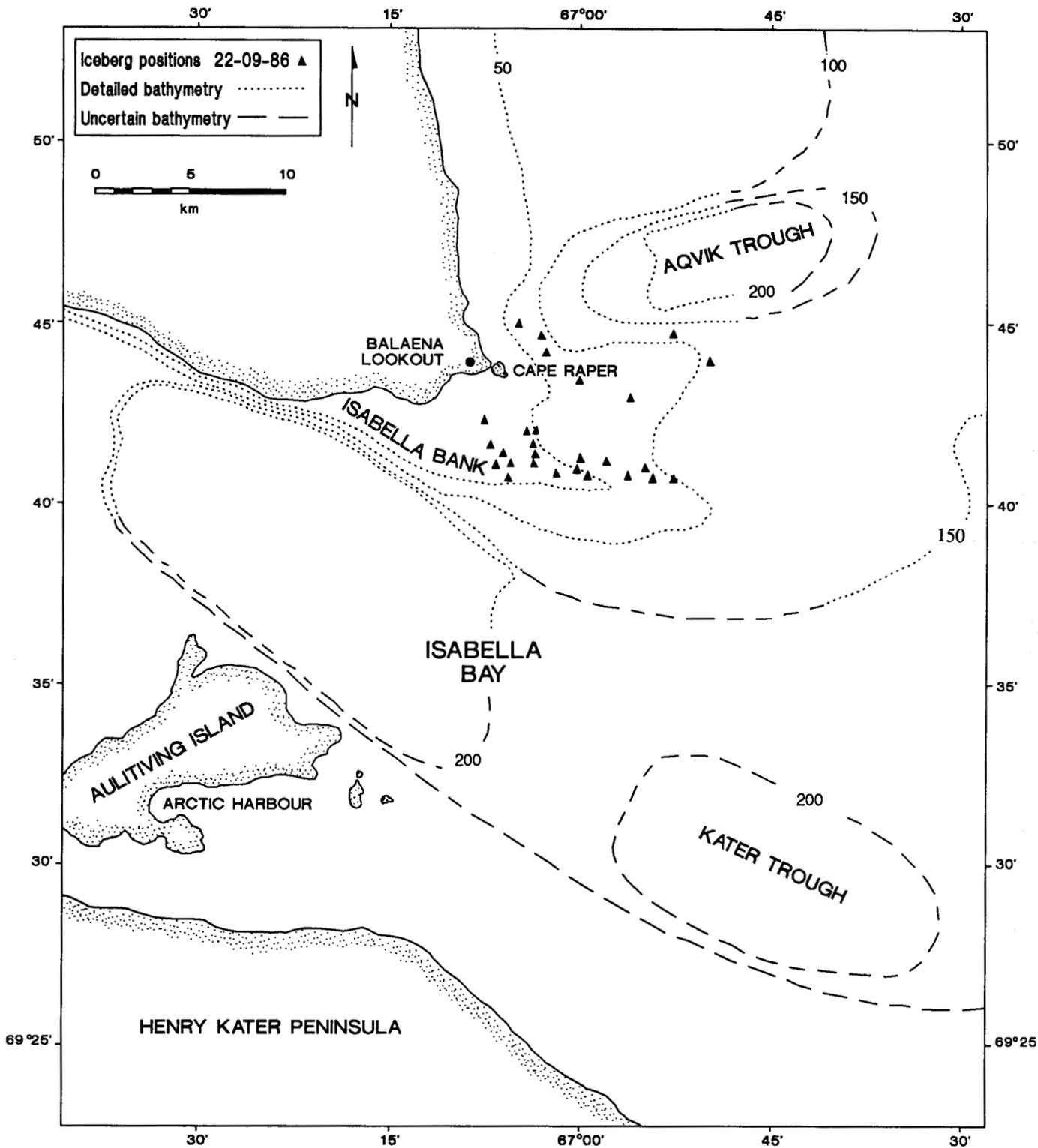


FIG. 2. Isabella Bay study area showing bathymetric contours (50 m intervals) and significant topographic features. The extent of Kater Trough is poorly known.

Bathymetry

Bathymetric charts of the study area are incomplete and inconsistent. We therefore attempted to profile significant bottom features that were relevant to whale distribution patterns. Depth profiles were recorded with a 200 kHz echo-

sounder (Furuno model FE-300A), while positions of the boat were determined by theodolite. Because of limited logistic capabilities (i.e., only a 7.5 m boat), we were unable to work beyond 15 km from the theodolite station.

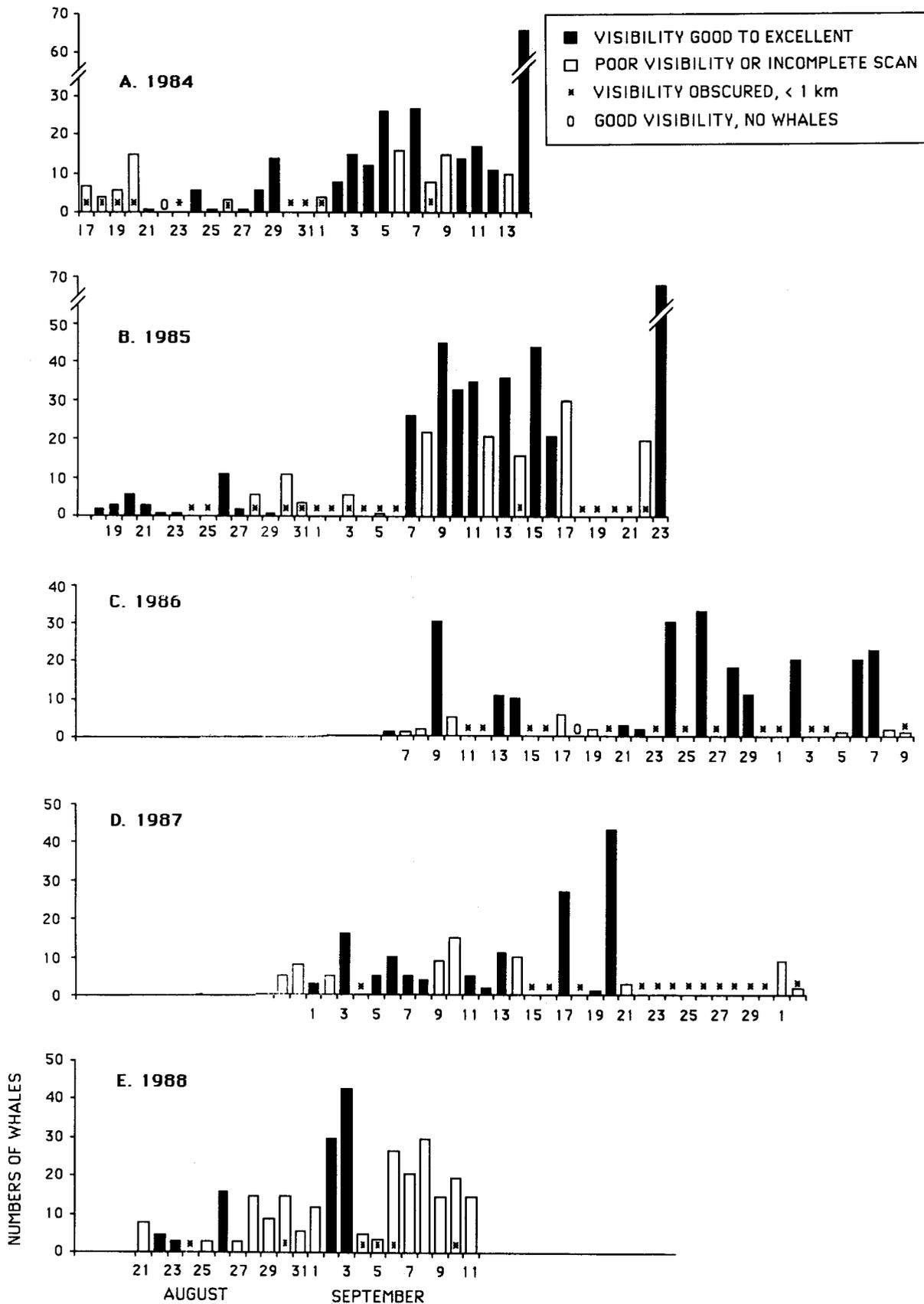


FIG. 3. Daily maximum numbers of bowheads observed at Isabella Bay, 1984-88. In 1986 and 1987 numbers observed after mid-September were based mostly on sightings of distant blows and probably underestimate total numbers.

Aerial Photogrammetry

Bowhead whales were photographed at Isabella Bay in late September 1986 and 1987 using the calibrated vertical photographic technique of Davis *et al.* (1983). Aerial photographs were taken through a camera port in the floor of a DHC-6 Twin Otter aircraft. The camera was a hand-held, medium-format (6x7 cm) camera equipped with a 105 mm, f2.4 lens and Kodak Ektachrome 200 colour reversal film. An altitude as close as possible to 145 m was maintained by radar altimeter during photographic sessions, and actual altitude for each photograph was read from the radar altimeter. Due to poor weather during the 1987 photographic sessions, we were unable to maintain a constant altitude; the resultant photographs were not suitable for estimating whale lengths. For calibration purposes, a series of photographs of a known-size target were taken prior to the photographic sessions.

Measurements of whale length in 1986 were obtained directly from original colour transparencies with a Zeiss binocular dissecting microscope (at 16 or 32x magnification) and a Wild stage micrometer (read to 0.01 mm). The average of three blind replicate measurements was calculated. The dimensions of the whale or target were calculated by using the following equation from Jacobsen (1978): length = altitude x image size ÷ focal length of lens.

Individual Identification

Individual bowheads were identified from aerial photographs, and to a lesser extent from shore- and kayak-based observations and photographs.

Aerial photography in 1986 and 1987 provided 164 and 74 bowhead images respectively suitable for printing as 18 x 12.5 cm colour enlargements. As in Davis *et al.* (1983), grade A photographs were of whales that were sufficiently well marked by scars or other permanent markings that they would be recognizable in a photograph of similar or better quality taken in another year. Grade B photographs were of whales that had temporary markings (such as mottled patterns of sloughed skin) that would be recognizable in a photograph of similar or better quality taken the same day or within a few days. Poorer quality photographs, graded C, were not considered for further analyses.

Grades were affected by focus, resolution, lighting, glare, sea state and posture of the whale, as well as distinctiveness of markings. A poor quality print of a distinctively marked whale might be an A, while an excellent photograph of a poorly marked whale might be a C. In the search for repeat photographs of individual whales, we compared each image with all other grade A and B images from the study.

When possible we obtained close-up photos of individual whales from kayaks or from shore. We used 35 mm cameras equipped with various lenses (28-210 mm). In addition, sketches and detailed descriptions of distinctively marked whales were made.

RESULTS

Oceanography and Climate of the Study Area

Bathymetry and Currents: Isabella Bay is the outer extension of McBeth Fiord, a typical deeply incised Baffin Island fiord. Maximum depths reach 560 m near the head of the fiord and

gradually diminish toward the mouth, where there is a sill. Depths at the mouth of Isabella Bay do not exceed 260 m (Fig. 2). The 200 m isobath of the continental shelf is situated about 55 km east of Cape Raper.

Three local bathymetric features influence the bowhead's distribution patterns. The first, Isabella Bank, is an extensive, shallow area less than 30 m deep, immediately adjacent to the observation site. The other two features, Aqvik Trough and Kater Trough, are submerged glacial troughs up to 250 m deep that cut across the continental shelf (Fig. 2). The extent of Kater Trough is poorly known.

The marine system at Isabella Bay is dominated by the cold (< 0°C), southward-flowing Baffin current. Strongest flows (generally 24-40 cm/s) occur over the steepest portion of the shelf, whereas nearshore currents tend to be slower (generally 12-24 cm/s; Fissel *et al.*, 1982). Interaction of the Baffin current with the bathymetry and tidal currents of the fiords establishes the ephemeral small-scale circulation features, such as eddies observed at the mouth of Isabella Bay. Isabella Bank is sheltered from the prevailing current by Cape Raper.

Weather Patterns and Ice Conditions: The east coast of Baffin Island is notorious for dramatic climatic fluctuations — a phenomenon attributable to its situation beneath a major upper-atmospheric trough (Jacobsen *et al.*, 1974; Maxwell, 1982). Small shifts in atmospheric circulation can have profound effects on the physical and biological environment of the east coast of Baffin Island. This has been manifested in conditions ranging from the extremely heavy ice year of 1983 to the extremely light ice year of 1985.

Annual variability in weather conditions greatly influenced the study. Fog in 1986 prevented observations on over half the days. In 1987, persistent strong winds and blizzard-like conditions late in the season obliterated our view for up to a week at a time. Lack of pack ice in 1985 promoted high sea states, thereby interfering with boat-based studies. The persistence of pack ice in 1983 dampened the oceanic influence, resulting in unusually stable weather and excellent visibility.

Generally, the last of the Baffin Bay fields of pack ice (called the Middle Ice by the British whalers) disintegrate in late summer in the coastal region between 68° and 70°N. In extreme years, such as 1983, the pack ice can remain throughout the year. Ice conditions in Davis Strait in 1983 were the most severe of this century and were attributed to "regional meteorological anomalies" and variations in the West Greenland current (Stein and Buch, 1985). In some years, such as 1985, the pack ice leaves by early August, and in most years it is gone by early September. New ice usually begins forming in mid-October and fast ice covers the fiords by mid-November. Icebergs are always present, either drifting southward or grounded in shallow waters.

Numbers, Timing of Occupation and Migration

Bowheads were seen in Isabella Bay on virtually every day of adequate visibility in 1984-88 (Fig. 3). However, in 1983 only two bowheads were seen (on 25 August). In those years when observations began in mid-August (1984, 1985, 1988), a few whales were already present by mid-August. Bowheads were present on most days, if not all, in the latter half of August of these three years (usually < 10 on any day, never > 15).

More bowheads arrived in September, when 20-45 whales typically could be seen on days of good visibility. Larger numbers were counted during systematic scans of the bay on two occasions: 66 whales on 14 September 1984 and 68 whales on 23 September 1985. Maximum numbers counted in 1986 and 1987 were 34 whales on 26 September 1986 and at least 43 on 20 September 1987; although peak numbers were similar in 1986-87 to average peak numbers in other years, the whales were often located in Kater Trough, too far from the observation site to be counted accurately. Results from aerial photographic surveys in 1986 indicated that as many as 107 different whales were present in the area over a two-day period at the end of September (see below). In 1986 and 1987, whales were still present when observations ended in early October. At least 23 were present as late as 7 October 1986, the last observation date with good visibility.

Migrant whales, appearing from the north along the coast, were identifiable by their consistent, strong (6.5-7.5 km/h), linearly directed movements. Bowheads exhibiting "migrant" behaviour were observed only in October 1986 and 1987, the only years that observations extended into October. Only five whales passed by during 42 h of observation in the first week of October 1986 (0.12 whales/h). In 1987, two whales were observed moving south past Cape Raper on 2 October. At Cape Adair, 240 km to the northwest, the bulk of migration in 1978-79 occurred during the first week of October (Koski and Davis, 1980). Observers there recorded 33 whales during 90 h of adequate visibility in 1978 (0.36 whales/h) and 30 bowheads during 73 h in 1979 (0.41/h). Thus, it appears that the bulk of the southward migration past Cape Raper in 1986 and 1987 occurred later in October. Presumably the "migrant" whales join the "resident" whales and most whales must vacate the area by late October, when ice is rapidly forming.

Regional Distribution

During the same seasons as the Isabella Bay studies, bowheads were reported by Inuit hunters in other areas along the Baffin coast. Most sightings were in August and consisted of single animals or groups of up to 10 whales. The majority occurred at the mouths of Clyde Inlet and Eglinton Fiord. The earliest sighting, on 10 May 1986, was of a single animal along the edge of the fast ice about 35 km offshore from Cape Raper. The latest sighting, on 13 November 1984, was of a single animal at the mouth of Clyde Inlet during freeze-up. In part, the distribution of hunter sightings was determined by boating patterns to autumn hunting areas north of Clyde River and by annual variability in sea and ice conditions. The decrease in sightings late in September and October may be explained in part by deteriorating weather conditions and also by bowhead movements.

Aerial surveys during this and other studies indicate that most of the bowheads that summer along the east Baffin coast congregate at Isabella Bay in mid- to late September. Isabella Bay was the only location along the Baffin coast between Clyde and Broughton Island where bowheads were found during aerial reconnaissance surveys in late September 1986 and 1987. Similarly, the only bowheads observed in September by Webb (1976) and Koski and Davis (1980) during aerial reconnaissance flights along the coast between Pond Inlet and Home Bay were at Isabella Bay.

Local Distribution Patterns and Associated Activities

The distribution of bowheads at Isabella Bay was not uniform. In all years when whales were present in substantial numbers, they congregated in a few areas that corresponded to major underwater topographic features (Fig. 4), and their general behavioural activities varied with location. Most feeding activity took place in the two deep glacial troughs, Aqvik and Kater, and most social-sexual activity took place on Isabella Bank. Bowheads also used Isabella Bank for other activities, including "grooming" (rubbing on the bottom) and resting. Otherwise, bowheads were usually involved in casual (<4 km/h) directed movements between areas, particularly between Aqvik Trough and Isabella Bank, or across Isabella Bay to the south side.

The distribution of the whales changed as the season progressed. Early in the season most of the whales present engaged in social-sexual activities on Isabella Bank. After early September, most whales fed in offshore troughs. It is suspected that whales arriving at Isabella Bay in mid- to late September were ones that spent the late summer elsewhere along the east coast of Baffin Island.

The distribution of bowheads also varied among years (Fig. 4). In 1984, 1985 and 1988, bowheads were observed primarily in the northern half of Isabella Bay. In 1986 and 1987, bowheads were usually in the southern half of the bay, far from the observation site, where they were usually detected only by their blows. Surprisingly, blows could be seen at ranges >35 km under good conditions; however, due to the effects of refraction near the horizon on the depression angles measured by theodolite, the distant sightings shown on the distribution maps are likely scattered over too broad a range. Nonetheless, the distribution of bowheads in the southern part of Isabella Bay corresponds approximately to Kater Trough. If anything, the plotted positions of the whales probably more accurately represent the actual position of the trough than is indicated in Figure 4. Unfortunately, due to malfunction of the theodolite in 1987, exact positions of whales are unavailable. However, the distribution would appear quite similar to 1986, when only 5.4% of 203 sightings occurred in Aqvik Trough, whereas 38% occurred in Kater Trough; the remainder occurred on Isabella Bank (46.3%) and in the adjacent waters of Isabella Bay (10.3%).

Population Segregation

Aerial photogrammetry on 28-29 September 1986 in Kater Trough showed that at that time Isabella Bay was used primarily by adult bowheads not attended by calves (Fig. 5). The mean length of 83 measurable whales was 14.4 m; 89% were >13 m long, which is about the minimum size of mature females in the Western Arctic (Davis *et al.*, 1983). Only one small subadult (<10 m) was photographed. One cow (15 m) attended by a 6 m calf was photographed. Although aerial photographs of bowheads taken in 1987 were not suitable for accurate measurements, the size distribution was apparently similar to the previous year. No cow-calf pairs were photographed in 1987.

Results from the aerial photogrammetry support the impression that most whales observed from shore or from kayaks were adults or large subadults. Small subadults (estimated to be <10 m) were observed on only seven occasions,

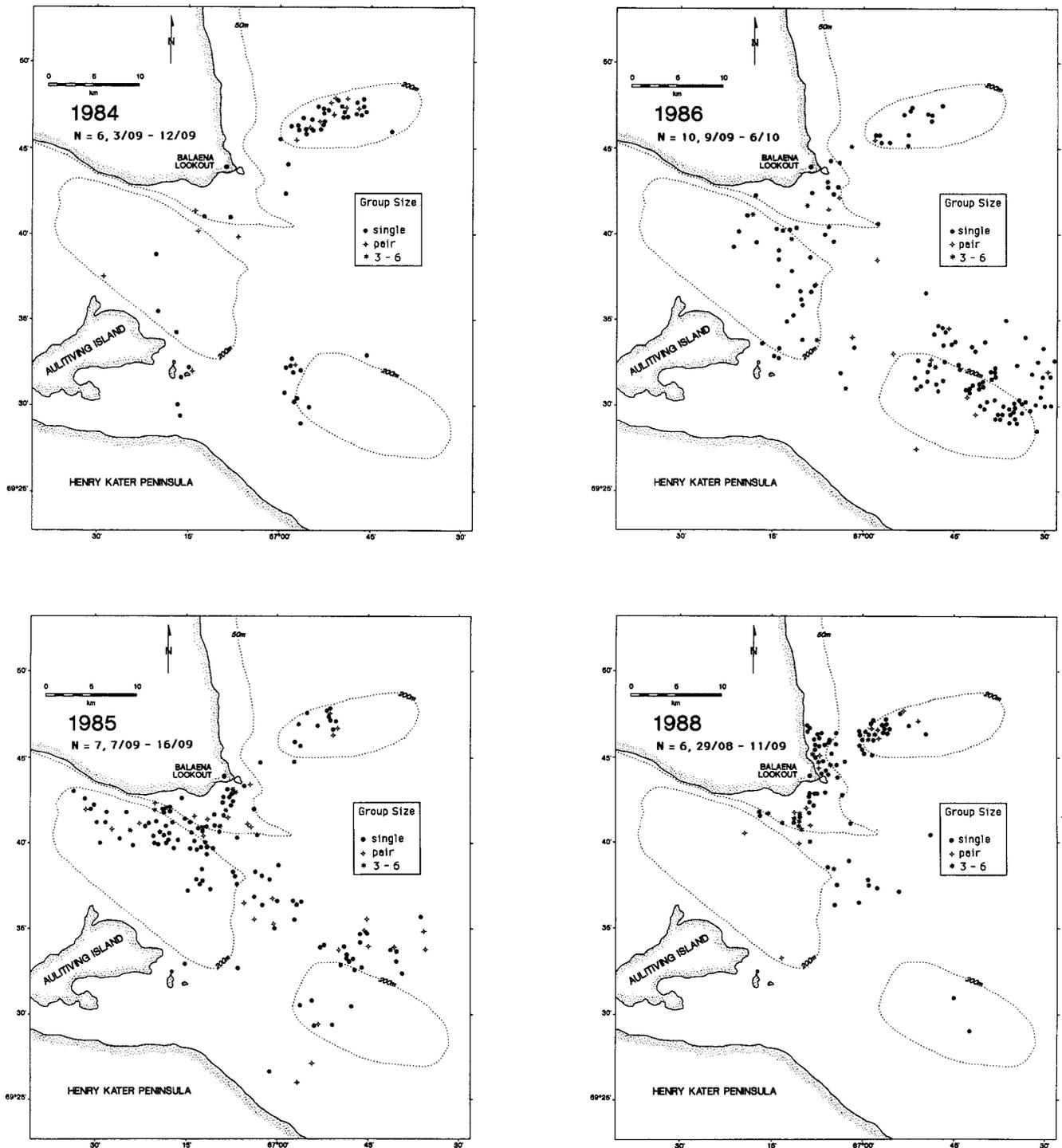


FIG. 4. Annual variation in the distribution of bowheads at Isabella Bay, 1984-88. Transitted data were not available for 1987 but the pattern was similar to 1986.

always close to shore. Until 1988, no calves had been seen from shore at Isabella Bay, but in that year, two different cow-calf pairs were observed on several occasions in late August-early September. Two small independent whales, estimated to be about 8 m in length, were also observed from a kayak in 1988.

Photogrammetric studies of bowheads in the Beaufort Sea have shown that the amount of white on the peduncle (tail

stock) is correlated with whale length: larger whales have more white (Davis *et al.*, 1983). This also holds true for bowheads at Isabella Bay (Fig. 5). In 1986, 28% of the whales whose caudal area was visible had black peduncles. Whales with black peduncles were significantly smaller ($13.7 \text{ m} \pm \text{s.d. } 1.5$, $n = 15$) than those with white peduncles ($14.9 \text{ m} \pm \text{s.d. } 1.1$, $n = 38$; $t = -3.30$, $p < 0.01$). Large whales with black peduncles are probably near or at the age of sexual maturity; in the

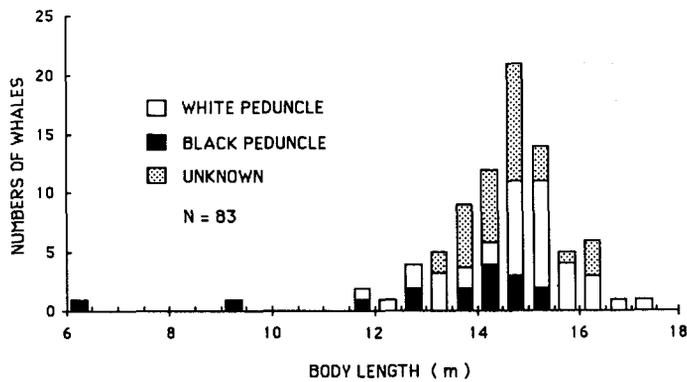


FIG. 5. Length-frequency distribution of bowheads photographed at Isabella Bay, 28-29 September 1986, classified according to the presence of white on the peduncle.

Western Arctic this occurs when females reach a length of about 13 m (Davis *et al.*, 1983). The 15 m mother photographed in 1987 had a moderate amount of white on its peduncle. However, one of the mothers observed in 1988 had a black peduncle, indicating that a black peduncle is not a certain mark of sexual immaturity.

Bowheads lacking white on their peduncles were the first whales to appear at Isabella Bay. They were more likely to be seen in nearshore areas, particularly the shallow Isabella Bank, than white-tailed animals, which arrived later and were seen more often in offshore troughs. For example, during late August 1988, 23 of 25 whales observed on Isabella Bank had little or no white on their peduncles. On 8 September, there were 15 whales on the bank, only 2 of which had white peduncles. However at the same time, the majority (9 of 11) of whales observed feeding in Aqvik Trough had notably white peduncles. Aerial photographic surveys in offshore troughs in late September 1986 and 1987 showed that 28-34% of the individuals had black peduncles, indicating that these smaller whales integrate with the larger, white-peduncled whales later in the season.

Site Fidelity

Shore- and Boat-Based Records: Distinctive whales at Isabella Bay were sometimes recognized from day to day and occasionally from year to year. Only those whales with particularly distinctive markings were likely to be reidentified from shore or boat. Shore- and boat-based records were limited to whales close to Cape Raper, principally on Isabella Bank. In 1986 and 1987, relatively few whales were there and opportunities for close observation were limited. Furthermore, whales close to shore tended to be smaller and less distinctively marked than those offshore, and because of behavioural differences, they usually revealed less of themselves above the surface.

Although we saw several whales that appeared similar to whales observed in previous years, we are confident of our between-year reidentifications of only two individuals. One, a very distinctive whale with a pure white tail and peduncle, was seen each year from 1984 to 1986 and again in 1988 (Table 1) and was photographed during the aerial survey on 28 September 1986. This whale has appeared near Cape Raper about the same date each year (9-14 September), always

alone. The other identifiable individual was also very distinctive by virtue of its low nasal prominence and supplementary features. This whale was observed several times in early September 1984, usually as a member of a pair, but it was observed alone on 5 October 1986 moving south past Cape Raper, apparently a migrant.

Aerial Photographic Records: The aerial photographic surveys were hampered by poor weather and high sea states late in September 1986 and 1987. In both years the whales were found in Kater Trough, too far from the observation site to be counted from shore simultaneously with the aerial photogrammetry.

A total of 138 grade A and B images of bowheads were acquired during three photo sessions on 28-29 September 1986, and 74 grade A and B images were acquired on 29-30 September 1987 (Table 2). Of the 1986 images, 83 (60%) represented whales photographed only once insofar as we could determine; in 1987, 35 (47%) were photographed only once. The remaining photos were of whales that were photographed 2-4 times within one session.

Three of 61 individuals photographed during the first day in 1986 were recognized among 49 individuals photographed the following day. In 1987, 5 of 32 individuals from the first day were recognized among 20 individuals the next day. The

TABLE 1. Resightings of bowheads from shore-based observations at Isabella Bay, 1984-88

Whale #	Date identified				
	1984	1985	1986	1987	1988
1	6/09 10/09 11/09 12/09		5/10		
2	14/09	10/09	10/09 ^a		9/09
3 ^b					27/08 28/08 29/08 3/09

^a Also photographed from air on 28 September.

^b Female with calf.

TABLE 2. Number of photographs of recognizable bowheads acquired at Isabella Bay in late September 1986 and 1987 and number of inter-day and inter-annual resightings

	# whales photographed		# different whales ^a	# inter-day resightings	# inter-year resightings
	# of grade A & B images	Once >Once			
28-09-86 (a.m.)	46	34	6	40	2
28-09-86 (p.m.)	29	13	8	21	1
29-09-8	63	36	13	49	3
Total 86	138	83	27	110	3
29-09-87	44	23	9	32	5
30-09-87	20	14	6	20	5
Total 87	74	37	15	52	7 ^b

^a These figures are maxima because some repeat photographs may not have been identified.

^b Two of the seven inter-year matches were also matched between days.

proportion of inter-day resightings in 1987 (10.6%) was higher than in 1986 (2.8%), although only 45% of the photographs in 1987 were grade A quality, compared to 72% grade A images in 1986. The low proportion of recognized resightings between days in both years was probably a result of high sea states on one or both days, which obscured large portions of the whales. Distinctive markings in one photograph may have been obscured by wave wash in another photograph of the same whale, thereby reducing the likelihood of a match. However, given the restricted area in which the whales were photographed, and given that many whales were well marked with scars or natural pigmentation patterns, the low proportion of day-to-day resightings is surprising. Based partly on this evidence, it is unlikely that all whales in the area were photographed during any one session.

Only 21 grade A photographs taken in 1987 were of different whales, but of these, 7 (33%) were recognized from among 77 grade A photographs of different whales from 1986. Two inter-year matches included whales recognized both days in 1987. One reidentified whale was an individual that had been severely scarred by killer whales. The distinctive white-tailed whale that was observed every year from 1984 to 1986 and also photographed in 1986 was not found in 1987 photos, nor was it seen during 1987.

Predation by Killer Whales

Elder Inuit believe that killer whales (*Orcinus orca*) are significant predators of bowheads, particularly young ones, and especially during the open water season. We twice observed killer whale interactions with bowheads at Isabella Bay.

On 11 September 1984 at 15:34 four killer whales, two large and two small, were observed moving through Aqvik Trough. The two smaller individuals separated from the larger pair and approached (at 15:58) a single bowhead. For 12 min there was much splashing and strong upwellings. Large numbers of fulmars (*Fulmarus glacialis*) gathered at the site of disturbance and appeared to be feeding. During the presumed attack, the two larger killer whales continued to move strongly to the north and disappeared. Following the encounter, a single bowhead was seen moving slowly toward shore. It was attended by many fulmars, possibly attracted by oil from unverified wounds. During the encounter, 12 large bowheads were socializing close to shore, apparently oblivious to the attack occurring about 6 km away.

On 17 September 1985 at 12:56, about 22 killer whales, in subgroups of 2-6 animals, were noticed moving rapidly into the fiord south of Isabella Bank just as we were completing a scan of the entire area. During the scan about 23 bowheads were observed over the bank and in deep water along its southern margin. Apparently the bowheads were already reacting to the killer whales, as many of them were tightly grouped and were moving rapidly along the bank. One bowhead was tail slapping vigorously. Just prior to the arrival of the killer whales, a single bowhead had been observed (at 12:41) farther offshore in the fiord than most of the others. The killer whales were moving in its direction, bypassing most of the bowheads on the bank. At 13:54 flurries of violent activity involving a bowhead and killer whales were seen in the same area where the above-mentioned bowhead was last seen. Unfortunately, it was not possible to

observe the outcome because the weather and visibility were rapidly deteriorating in that area. Following the arrival of the killer whales, the bowheads remained tightly grouped in shallow (<20 m) water on the bank.

We observed considerable evidence of what we judged to be previous encounters between killer whales and bowheads. The tails of many whales that were observed closely from kayaks had scars consistent with the dentition of killer whales; flukes of some bowheads had notched trailing edges.

Aerial photographs provided additional evidence of previous attempted killer whale predation on bowheads. Five of 16 bowhead images (31%), in which the trailing edge of the flukes could be seen clearly, showed scarring and fraying that were probably due to killer whales. The most conspicuous case was a severely scarred bowhead photographed on 28 September 1986 and 29 September 1987. Its flukes had been reduced to 65% of expected size, and the whale had numerous irregular scars over much of its body, especially on its rostrum. Although the flippers of this whale could not be seen clearly, they were obviously white, presumably from scar tissue.

DISCUSSION

Evolution of Commercial Whaling in Baffin Bay

Many of the insights gained in this study would not have been possible without background information available through the dedication of several naturalists who served in the British whaling trade. Fortunately, the historical research of Ross and MacIver (1982), Ross (1985), Mitchell and Reeves (1981, 1982) and Reeves *et al.* (1983) appeared nearly contemporaneously with this field study. Community elders in Clyde River also contributed to the understanding of the natural history of the bowhead. The following discussion integrates information from these sources with the results of the field research.

When Reeves *et al.* (1983) synthesized data on historical patterns of bowhead distribution and migration in Baffin Bay, they acknowledged (p. 48) that it "reflected not only the state of knowledge as to the bowhead's distribution and movements, but also the severe limitations on [the whalers'] navigation imposed by ice conditions." Knowledge of the evolution of the fishery and the development of ice navigation skills is essential in comparing the present and past distribution patterns of the bowhead in Baffin Bay. This history, particularly concerning the "rocknosing fishery," is reviewed below. It is organized chronologically according to three distinct pulses in the number of ships entering the Davis Strait fishery (Ross, 1979: Fig. 2); these pulses correspond to significant developments in technology and ice navigation and the changing emphasis of the fishery.

First Pulse — Dutch Whaling in Davis Strait: The beginnings of the Davis Strait whale fishery are obscure, but it was seriously initiated by the Dutch in 1719 and was dominated by them through most of the 18th century. Peak activity occurred in 1720-40, when more than 100 vessels departed from Dutch ports in some years (Ross, 1979). This fishery concentrated along the west coast of Greenland and along the edge of the pack ice in Davis Strait in spring. By the late 1700s the British had taken over this fishery, which became known as the "south-west fishery" (Fig. 1; Reeves *et al.*, 1983).

Second Pulse — Breaching the Middle Ice, the Northwater: With the circumnavigation of Baffin Bay and the Middle Ice in 1818, Sir John Ross officially opened a new frontier to the British whaling industry. In that year, about forty whaling vessels accompanied Ross into the "Northwater" and the "success which they met with on this occasion was such as has seldom occurred in the Davis' Straits fishery in any former season; and thus has a new and extensive field been opened for one of the most lucrative branches of our commerce" (Parry, 1821:301). During the next two decades the fishery enjoyed unprecedented success, particularly on the "Pond's Bay grounds" at the mouth of Lancaster Sound.

The Middle Ice often persisted late in the year in southwest Baffin Bay and constituted a formidable hazard during the homeward journey along the east coast of Baffin Island. In 1835, eleven ships were entrapped in this field, resulting in many deaths; again in 1836, six vessels were entrapped (Lubbock, 1937; Ross, 1985). These events marked an important turning point in British arctic whaling. "Thereafter, whaling activity was markedly reduced; no subsequent year ever saw more than thirty ships depart for Davis Strait, and the general trend during the next three-quarters of a century was one of decline in number of voyages and in whales secured. The nature of the operation changed too" (Ross, 1985:107).

Third Pulse — Steam Power and the Westwater: The final pulse of the Baffin Bay fishery began in 1859 with the advent of steam power. Steam power allowed the whalers to penetrate deep into the last strongholds of the whale, the ice-choked channels of the High Arctic archipelago and along the western margins of the Middle Ice, i.e., east Baffin Island. Eschricht and Reinhardt commented (1866:14), "the English have tried to employ screwsteamers for whaling. . . . This year several such steamers have been fitted out; it must therefore be supposed that the earlier attempts have been remunerative. But the whale fishing trade can hardly rise to any considerable height in Baffin's Bay." The last pulse lasted about two decades and was dominated almost exclusively by the Scottish fleet from the ports of Dundee and Peterhead. Much of the renewed effort of the dying whale fishery was exerted on the "nursery grounds" of Prince Regent Inlet and on the "rocknosing grounds" of the east Baffin coast.

The Rocknosing Grounds

Brown (1868:544) provides a good description of the enterprise called "rocknosing" along the east coast of Baffin Island:

As the season gets more tempestuous and the nights dark, most of [the whaleships] toward the end of September, to avoid the icebergs dashing about in this region at that time of the year, anchor in a snug cove, . . . localities intimately known to these hardy seamen, but by name only to geographers. Whilst the good ship lies secure in these unsurveyed and unauthorized harbours (each master mariner according to his predilection) the boats go outside to watch for whales. If they succeed in capturing one, frequently, if possible, the vessel goes and assists in securing it. Though they are supposed to return to the ship every night, yet at this time the men are often subjected to great hardships and danger. This is known as the "autumn" or "fall fishing" and this method of pursuing it as "rocknosing."

Reeves *et al.* (1983) concluded that virtually the entire Baffin coast between Pond Inlet and Cape Dyer was used for rocknosing. They identified some of the harbours and headlands considered to be important refuges or landmarks of the whalers, such as Agnes Monument at the mouth of Clyde Inlet and "Cape Kater." However, because rocknosing was carried out in a clandestine manner, it is difficult to pinpoint centres of operation and kill locations with certainty (W.G. Ross, pers. comm. 1988). To confound matters, whalers had their own place names: Cape Raper was their Cape Kater, and their Kater Harbour is now Arctic Harbour. Thus, when Reeves *et al.* (1983) concluded that many whales were taken between Cape Kater (i.e., Cape Raper) and Home Bay, this meant Isabella Bay — not Home Bay, as implied.

Despite the uncertainties, plots of kill distribution by Ross and MacIver (1982) best reveal the distribution of the various whaling grounds and their development. Their plots show the major whaling ground during July, the "Pond's Bay" fishery, at the entrance to Lancaster Sound (Fig. 1). More kills were recorded in August along the east coast of Baffin Island. In September and October, most kills occurred along the Baffin coast between Pond Inlet and Cape Dyer, especially around Isabella Bay. The majority of bowhead kills around Isabella Bay occurred after 1860, concomitant with the initiation of steam-powered whaling.

Mutch (1906) gives a good impression of the location of the rocknosing grounds as he sailed north in the *Albert* along the Baffin coast in August and early September 1903. Leaving Cumberland Sound on 2 August, he sailed north through Home Bay, mentioning "Qivitung or Cape Hooper." "Cape Kater (Ross's Cape Raper) hove in sight with its icebergs, then the Isabella Bank icebergs. No whales were seen. . . . When close to Eglinton Fiord (Aqbitijung), the 'Diana' (Captain Adams, master) came and took us into the harbor. At one time this was a great whaling place" (Mutch, 1906:486). He also mentioned where ships were wrecked near Cape Adair (Tugdliunirn).

Mutch referred often to the situation of Eskimo camps in relation to the rocknosing grounds. Because of the shore-based nature of rocknosing, the local Eskimos had become involved in the whaling economy, and their late summer camps were established at strategic points of contact. These sites are well known to the elders in the community of Clyde. Tallugujaq (Arctic Harbour in Isabella Bay) was probably the most important place of contact. Aqviqtiuk (Eglinton Fiord) and Qivituq (Kivitoo) were also important places, and it is well known that Tullarutit (Cape Adair) is where some whaling ships were wrecked. The bowheads are known to traditionally migrate south past Cape Adair in early October. Despite phonetic interpretations, these historic place names remain unchanged in the elders' vocabulary.

Contrary to a statement by Reeves *et al.* (1983:52), Markham's (1874) account contains important evidence of the location and discreteness of the rocknosing grounds. After they secured their last whale on the Prince Regent nursery grounds, the *Arctic* sailed back through Lancaster Sound and the "old fishing ground" off Cape Graham Moore, Bylot Island. They continued south, without encountering whales, until they arrived on 20 August "in the latitude of Cape Kater of the whalers (Cape Raper of the chart)" and found themselves "amidst the whaling fleet with several of them chasing

whales." The *Arctic* then cruised in the area for a week; on 27 August they were "in the latitude of Cape Hewitt [near Clyde Inlet] where we have seen fish" but were unsuccessful in taking any more.

Parry (1821) provided the first evidence of the future discreteness of the rocknosing grounds. During his homeward voyage, after overwintering on Melville Island, he sailed through Lancaster Sound in late August, commenting on the absence of whales (p. 268): "Considering the extraordinary number of whales we had met with in our [late July] passage up Sir James Lancaster's Sound in 1819, it could not but be a matter of surprise to us that we had now seen so few." On 5 September he arrived at Clyde Inlet and saw more than a dozen bowheads and the first whaling vessel. On 9 September he saw "several young black whales" in Isabella Bay. This late summer hiatus in bowhead distribution in Lancaster Sound is evident in other accounts of the period (e.g., M'Clintock, 1859) and is consistent with the results of extensive aerial surveys in recent years (Davis and Koski, 1980). In fact, August was "generally regarded as a blank month . . . very few whales being seen" (Markham, 1874:121) because the whales had retreated into inaccessible recesses of Lancaster Sound or southward with the Middle Ice. Thus, with more certainty than Reeves *et al.* (1983), we can conclude that whales on the rocknosing grounds were segregated in late summer from those in the High Arctic archipelago.

The Strategic Situation of Arctic Harbour: Arctic Harbour in Isabella Bay (see Fig. 2) was a significant port of operation during the rocknosing fishery. The harbour was strategically situated at the mouth of the bay, close to the present bowhead feeding area in Kater Trough. Gravesites of David Vallance, William Yule and Peter Tait in Arctic Harbour show that the port was visited by the *Intrepid* on 26 September 1871, the *Esquimaux* on 31 July 1875 and the *Mazinthien* on 11 September 1882, all steam-powered vessels from the Scottish port of Dundee. The following details on these voyages were provided by W.G. Ross from the "Kinnes Lists": "*Intrepid* — 326 tons; Captain Soutar; Catch — 24 whales making 158 tons oil, and 160 Cwt of 'bone' (baleen). *Esquimaux* — 436 tons; Captain C. Yule; Catch — 5 whales making 40 tons oil and 53 Cwt of bone, and 13,768 seals making 130 tons seal oil. *Mazinthien* — 308 tons; Captain Soutar; Catch — 11 whales making 85 tons oil and 60 Cwt of bone."

During this same period Isabella Bay was also visited by the *Narwhal* of Dundee. From the logbook of surgeon Macklin, we learn that the *Narwhal* arrived on the fall fishing grounds on 29 August 1874 and that she would "lie in harbour till the fall fishing commences, which is generally about the middle of September" (Ross, 1985:206). From a detailed description of the harbour and reference to the 1871 gravesite of D. Vallance, it is clear that the *Narwhal* was in Arctic Harbour (Kater Harbour) on Aulitiving Island. Macklin's account provides significant details on the manner in which the fall fishing or rocknosing was conducted. On 2 September he wrote (Ross, 1985:206), "Yesterday our boats got fast to a fish, while rocknosing, that is, boats which are sent away to the rock [illegible word] outside the harbour. Every ship has away four or six boats while in harbour, with the merest chance of getting a fish. We got up steam as soon as we got word, and went out and towed her into harbour, when we proceeded to flinch her."

I visited Aulitiving Island in September 1987 (113 years after Macklin). It is clear from Macklin's account that the whalers were able to signal back to the ship in the harbour that they had taken a whale. Therefore, the whalers' position had to be within visible range, or within visible signal relay range, of the harbour. This vantage is offered only by three rocky islets 9 km east of Arctic Harbour. Indeed, two of the islets contain evidence that they were lookout stations. The most notable structures are two rock-walled shelters from which the whalers presumably kept watch. The shelter on the smallest islet is rectangular and has a porthole that looks east (80°T) toward Kater Trough. It was no coincidence that, as I stood there, a bowhead appeared, framed in the whalers' window.

Reports of whale strikes must have been relayed by signal to another lookout station on southeast Aulitiving Island, then to the ships in harbour. Knowing these locations, it was possible to deduce where the ships lay at anchor. The assumed anchorage was briefly surveyed by scuba diver William Hansen in 1988, who found several whale bones and a ship's davit. Adjacent to the assumed anchorage, along the beach, there are several large rock cache sites where the Inuit apparently stored whale meat. Many artefacts of the era were found above the caching site among Inuit structures, some of which were constructed of whale ribs. Perhaps the bones could reveal something about the physical characteristics of the rocknose whale.

What Was a Rocknose Whale?

The old whaling literature contains many suggestions that different components of the eastern arctic bowhead population concentrated in different summering areas. Subadults, cows and calves were said to concentrate in the "nursery grounds" in the High Arctic archipelago, particularly in Prince Regent Inlet. In contrast, whales found in late summer along the east coast of Baffin Island were said to be primarily large whales without calves. In fact, these latter whales were given the special designation "Rock-nose whales" because of their size and peculiar habits" (Guerin, 1845). Guerin (p. 269) proclaimed that the Rocknose whale of the east coast of Baffin Island was "a distinct variety, if not a distinct species." This claim was dismissed by Brown (1868:545), who stated that "Whales of different ages keep a good deal together, hence young whales frequent bays; the old ones roam in the vicinity of the 'middle ice' of Davis Strait, and afterwards come into bays; and those killed early in the year at Pond's Bay are chiefly young animals. Hence, the whaler uses the terms 'middle-icers', 'rock-nosers', and 'Pond's Bay fish' to designate not a separate species or even variety, but to express a geographical fact and a zoological habit."

Guerin was surgeon-naturalist of the French whaling ship *Superieur*. His account of the peculiar habits of the Rocknose whale was based largely on the stories of the British whalers who were hired by the French. Undoubtedly much was added or lost in the translation, but since it remains the only detailed description, it deserves examination.

First, in regard to its name, Guerin (1845:267) states: "There is a strange peculiarity in the habits of the Rock-nose, from which it has received its rather curious, though very expressive and appropriate name. It frequently places the

extremity of its head, or nose as the whalers call it, close to the shore, upon a rock, or on the steep and stony bottom, with its spiracles, and part of its head and body above the surface, and there remains perfectly motionless for several minutes." Allowing for the expressive licence of the whalers, this description could resemble some of the head-down, tail-up postures that the whales exhibit on the shallow Isabella Bank. However, Guerin states that he personally saw "several of them in that position; and on one occasion a pair of them, within a few feet of each other, as just described, for more than ten minutes" (p. 267) near Cape Dyer, latitude 67°12'N. Guerin's account is probably somewhat fanciful and based on whalers' stories from farther north along the coast; indeed, he mentions that the rocknose whales "remain in large shoals in the bays and inlets of lat. 71 to 74 . . ." (p. 268) until late September or early October.

Of the morphometric peculiarities that the whalers attributed to Rocknose whales, Guerin stated that the most important was the relative proportions of the head and body: rocknosers were said to seldom reach above 40-42 feet (12-13 m) and their heads were proportionately larger than in the "true *Mysticetus*." Brown (1868) dismissed this physical description, stating that the relative proportion of the head was a variable characteristic related to age. Eschricht and Reinhardt (1866:57-59) also remarked on the highly variable size of the bowhead's head, ranging from three- to four-tenths of the total length; they wondered "whether the difference is rather a character of age or of sex" and, based on a small sample size, concluded "the male, though somewhat smaller than the female will, nevertheless, be found to have a much larger head even absolutely speaking." Whether this is true or not has yet to be evaluated.

Conspicuous social-sexual displays of bowheads, such as tail lofting and tail slapping, probably attracted the whalers to places like Isabella Bank, where they found easy prey. If the whalers were strictly hunting rocknosers, that is, those displaying any of the head-down, tail-up postures that we have observed on Isabella Bank, it is likely that they would have taken a disproportionate number of smaller (and possibly mostly male) whales, judging from the propensity of this group to occupy the shallow banks today (Finley, unpubl. data). Perhaps this was the case during the early years of the rocknosing fishery (thus Guerin's emphasis on small size), but later accounts (e.g., Southwell, 1898; Lindsay, 1911) indicate that the whalers pursued the rocknosers for their large size. The position and viewing angle of the whalers' lookout sites near Arctic Harbour, together with the account of Macklin, indicate that the whalers were strategically poised to hunt whales in Kater Trough, where, presumably then as now, large whales predominated. Macklin's records show that the *Narwhal* took large whales (i.e., 8 ft 3 in and 10 ft baleen; >12 m body length; Finley and Darling, 1990 [this issue]) on 13 and 15 September 1874 while rocknosing in Isabella Bay.

In summary, rocknosing probably referred generically to the entire whaling endeavour along the east coast of Baffin Island. The name may have been derived from the peculiar shallow-water behaviour of smaller whales but the enterprise likely depended on large adults that were attracted to coastal troughs at the mouths of certain fiords (e.g., Isabella Bay, Clyde Inlet, Eglinton Fiord) late in the season.

Role of the Middle Ice in the Rocknosing Fishery and the Movements of the Bowhead

The role of the Middle Ice in the seasonal movements of the bowhead was strongly emphasized by Eschricht and Reinhardt (1866:11): "It is not difficult to point out a connection between the wanderings of the whale and the state of the climate or more particularly, the motion and drift of the ice in Baffin Bay; for all observations prove the Greenland whale to be closely and inseparably associated with the (Middle) ice; . . . its arrival at the coast is in the most remarkable manner contemporaneous with the arrival of these huge masses of drifting ice." The whalers were forced to circumnavigate the Middle Ice, engaging the whale in dangerous proximity to the ice. Annual variations in the extent of the Middle Ice greatly influenced the whalers safety, mobility and success.

In heavy ice years (e.g., 1825, 1835-37, 1839-41, 1852), when the Middle Ice persisted throughout the season, the whalers were unable to reach the Northwater. The extent of the Middle Ice in 1983 (Fig. 1) was probably similar to that in the severe ice years of the 1830s. Even when the whalers were able to reach the Northwater, on their homeward journey they often had to detour to the Greenland coast around the Middle Ice, which remained along the central Baffin coast until late in the season. Whalers who failed to clear the Middle Ice early in the season sometimes tried to sail north along the southeastern Baffin coast, but this strategy was not very productive, especially before the introduction of steam power in the 1860s. This route was not desirable because the sailing vessels had to beat upwind into a strong, south-flowing current that carried the icefields.

In light ice seasons, the whaleships were able to move south along the east coast of Baffin Island in mid- to late July, but normally this coast was beset with the western margin of the Middle Ice, and the southward passage was made in late August and September. After the calamitous events of the 1830s, whalers were especially wary of becoming beset in the western margin of the Middle Ice. The persistence of the Middle Ice, along with fog and icebergs, made rocknosing an especially dangerous business, disliked by the whalers and avoided if possible.

The persistence of the Middle Ice in many years often prevented incursions of the whalers along the east Baffin coast, at least until the advent of steam power in the 1860s. The increased proportion of kills recorded in this area after 1860 (Ross and MacIver, 1982), when the bowhead population was already severely depleted, suggests that the whalers were pursuing a component of the population that until then had been protected by the Middle Ice. The survival of the Isabella Bay bowheads may be a legacy of differential hunting pressure and their discovery only late in the whaling era, in combination with the conservative habits of animals.

Although the role of the Middle Ice was often emphasized in explaining the distribution of the bowhead, Parry remarked (1821:23), "It is, I believe, a common idea among the Greenland fishermen, that the presence of ice is necessary to ensure the finding of whales; but we had no ice in sight today, when they were most numerous." Our observations initially supported the view that bowheads remained with the pack ice as long as possible. Bowheads failed to appear at Isabella Bay in 1983 when the pack ice prevailed throughout

the season. And in 1984, peak numbers appeared soon after the disappearance of the pack ice. However in 1985, a light ice year, peak numbers appeared well over a month after the ice was gone, and in subsequent years the timing of peak occupation of Isabella Bay was not strictly tied to the disappearance of the pack ice. We suspect that the timing of their arrival in coastal areas is at least partly determined by special feeding opportunities, which are a complex function of zooplankton behaviour and hydrometeorological conditions.

Population Segregation and Site Fidelity

Shore-based observations at Cape Adair show that the peak southward migration of the northern-summering group of whales does not occur until early October (Koski and Davis, 1980). The scarcity of migrating whales at Isabella Bay as late as early October suggests that the bulk of the migrant whales do not reach there until at least mid-October. Thus, the whales at Isabella Bay in late summer are segregated from those summering farther north between August and October.

Both Reeves *et al.* (1983) and Ross and MacIver (1982) deduced from historical whaling records that fall migration began as early as August and continued through October. Although they acknowledged that the whalers' records were biased because of the limited mobility of ships in ice, their discussions of fall migration, particularly as it relates to the question of population segregation, may be misleading. For example, Ross and MacIver's (1982) maps of historical kill locations show patterns of seasonal and spatial continuity suggestive of migration routes, especially when plots from several years are overlain. In fact, the patterns may merely reflect the characteristic movements of whaling ships.

Historians also may have failed to appreciate that the advent of steam-powered ships influenced the length of the whaling season, and hence their conclusions about fall migration. At the height of the fishery in the 1830s many sailing ships had returned home by late September, but in the 1860s many steam ships did not depart from the whaling grounds until October. "According to the state of their cargo, the industry of the captain, on the state of the weather, the whalers leave for home from the 1st to the 20th of October, but rarely delay their departures beyond the latter date" (Brown, 1868:545). Macklin's account, written in 1874 (Ross, 1985), states that fall fishing generally commenced in mid-September, and Brown (1868) stated that it occurred toward the end of September. The timing of this peak of whaling activity coincides with the timing of peak numbers of bowheads at Isabella Bay today, but it occurred prior to the arrival of migrants from the northern summer grounds. Thus, it seems likely that the rocknosing fishery of the late 1800s concentrated on the resident whales.

The preponderance of adults and the rarity of calves and small subadults at Isabella Bay indicate that the Baffin Bay population is age segregated and possibly to some degree sex segregated during late summer. Age and sex segregation occur on the winter breeding grounds of the southern right whale (*Eubalaena australis*) in Argentine coastal waters (Payne, 1986); there, the females return about every third year, whereas the males return annually. If the population segregation model for southern right whales can be applied to the bowhead, then anestrus females may return to Isabella Bay be-

tween calving periods and forays into the northern "nursery grounds." However, the seasonal timing of bowhead segregation in summer may not be comparable to the winter segregation of the southern right whale. Furthermore, it is uncertain when the breeding season of the bowheads occurs.

The smaller, black-peduncled whales that arrive earliest at Isabella Bay engage in much social-sexual activity, and many of them are males (Finley, unpubl. data). They may represent the cohort of the Baffin Bay population that is being recruited into the breeding population. Their proportional representation may be indicative of the potential for growth in the population, although it is not known whether other animals of this cohort summer elsewhere. Females are also present at Isabella Bay, but the proportion is unknown.

Although the evidence for age segregation of the Isabella Bay whales is incontrovertible, the exact nature of this segregation remains unknown. In the Beaufort Sea, different size classes of bowheads often occur in different areas and habitats in late summer; in general, smaller whales tend to occur in shallower coastal waters (Davis *et al.*, 1983, 1986; Cabbage and Calambokidis, 1984).

Results from aerial photographic surveys indicate that a significant portion of the Isabella Bay whales return annually. The rate of reidentification in this study (33%) is considerably higher than reidentification rates in the Beaufort Sea (e.g., 1.6% of 186 images, Davis *et al.*, 1986). This suggests a higher degree of site tenacity at Isabella Bay, although the restricted area and time in which the whales were photographed were probably also contributing factors. Because the Isabella whales are large and well marked, they are more likely to be recognized from year to year compared to those photographed in the Beaufort Sea, which include a large proportion of small, poorly marked whales. Under ideal survey conditions (which rarely exist on the Baffin coast in late summer) the resighting rate at Isabella Bay would probably be even higher.

The only indication of interchange with the High Arctic summering grounds is that a whale regarded as "resident" in 1984 was resighted as a "migrant" in 1986. Questions of segregation and site fidelity of the rocknoser whales of Isabella Bay obviously deserve more study using aerial photogrammetry.

Status and Potential Threats to Species and Habitat

The Isabella Bay group of bowheads is by far the largest known concentration remaining in the entire North Atlantic range. Consistent peak numbers in 5 of 6 years of the study suggest that a relatively constant proportion of the Baffin Bay population returns to Isabella Bay in most years. Maximum counts (66 in 1984, 68 in 1985) probably represent a significant proportion of the population that summers along the east coast of Baffin Island. Aerial photographic identification suggests that there were as many as 107 different whales in the area in late September 1986. The summer resident population is probably joined by the High Arctic component in mid- to late October. About 140 bowheads were estimated to have migrated south past Cape Adair in 1979, a year when bowheads were also present farther south in Isabella Bay (Koski and Davis, 1980). Thus, a conservative estimate of the Baffin Bay population is about 250 individuals, consistent with Davis and Koski's (1980) estimate of "low hundreds at

most." This represents <3% of the initial population size estimated by Mitchell and Reeves (1982).

The potential for recovery of the eastern arctic bowhead is inherently limited by their slow rate of reproduction. Although a few calves have been seen in the northern range of the bowhead in recent years, extensive aerial surveys of these areas in the late 1970s failed to find a high proportion of calves in any part of the High Arctic range (Davis and Koski, 1980). Estimates of the proportion of calves in the High Arctic population were between 2.2 and 3.6%, but this did not take into account the possibility that the population was segregated. Given the rarity of calves among bowheads summering in Isabella Bay, the reproductive rate for the entire population may be substantially less than the already low estimate of Davis and Koski. The viability of the eastern arctic population of bowheads appears precarious.

Mitchell and Reeves (1982) stated that although eyewitness accounts of killer whale predation on bowheads were rare, there was sufficient anecdotal evidence to suggest its importance as a mortality factor. Our observations and those of local Inuit support this view. Predation may be especially important at low population levels, particularly when killer whales have an abundant alternate food source, as they do in the Eastern Arctic (i.e., the killer whale population was not food limited when the bowhead population declined). The theory suggests that K-selected species (long-lived, slow-growing, late-maturing) such as the bowhead are more severely limited (than r-selected species) by density dependent factors such as resources or predators (MacArthur and Wilson, 1967). According to elder Inuit, young bowheads are especially susceptible to predation by killer whales. The behaviour of bowheads during the open water season may be strongly influenced by the predatory threat of killer whales. *Ardlingayuq*, fear of killer whales, describes a suite of behaviours that bowheads and other marine mammals show in response to killer whales. Finding shelter in ice is the first response of bowheads, but in the absence of ice, they are believed to take shelter in shallow coastal waters. Inuit who once lived at Isabella Bay said that bowheads congregated in the shallow waters around Cape Raper because of killer whale predation. The "coast-hugging" tendency of migrant whales in autumn may reflect a behavioural response to potential killer whale predation in the absence of protective ice cover. Southern right whales are also thought to use certain shallow coastal habitat in South America because of the threat of killer whale predation (Thomas and Taber, 1984).

Isabella Bay is presently remote from most human and industrial activities (Richardson and Finley, 1989). However, it is a traditional Inuit hunting area and was inhabited continually up to the 1960s. The difficulty of boat travel along the exposed outer coast has discouraged use of the area by hunters during the open water season. This may change with the acquisition of larger, faster boats. Aside from the long-term prospect of Inuit resettlement of traditional hunting areas such as Isabella Bay, there is growing concern about the potential development of tourism in the area. Growing public awareness of the Isabella Bay bowheads has attracted attention from the tourism industry, which is being strongly promoted in the Eastern Arctic.

Isabella Bay offers a unique combination of habitats that

serve the bowhead in various ways, including feeding, socializing, shelter from predation and energetic advantages. Deep glacial troughs constitute important feeding habitat, whereas the shallow water of Isabella Bank is preferred for social-sexual activities (Finley, unpubl. data). Isabella Bank also offers protection from killer whales, and because it is in the lee of Cape Raper, it offers shelter from high sea states and strong currents. Outside the fiord, the whales would have to expend considerable energy to remain in one place because the Baffin current flows at rates approaching a bowhead's casual rate of movement; thus, the preference for Isabella Bank may be advantageous in energetic terms. Disturbance and displacement from preferred habitat could subject the population to more predation and energetic demands. The survival and eventual recovery of the eastern arctic bowhead may depend on the implementation of protective measures for the species and its essential habitats. Obviously, Isabella Bay is an important habitat for part of the year.

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