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Age Classes of Bowhead Whales Summering in Northern Foxe Basin

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Abstract

Bowhead whales, summering in northern Foxe Basin, were aerially photographed in August of 1996, 1997 and 1998. Image lengths on either the negatives or contact prints were measured and total body lengths were estimated. Results indicated that, in all three years, the majority of whales photographed were less than 11.5 meters long. Calves made up 24%, 7% and 34% of the total number of measured whales in 1996, 1997 and 1998 respectively. The number of bowheads longer than 13.5 meters, the approximate size at which females reach sexual maturity, that were photographed was directly proportional to the number of calves photographed. Results indicate that northern Foxe Basin bowheads are part of a larger stock. Adult males and resting adult females appear to summer in another part of the range, probably northwestern Hudson Bay. Northern Foxe Basin appears to be used as a nursery area and any adults present are likely females with young-of-the-year calves.

Résumé

Les baleines boréales qui séjournent en été dans la partie nord du bassin Foxe ont fait l'objet de relevés par photographie aérienne aux mois d'août de 1996, 1997 et 1998. La longueur apparente des individus a été déterminée sur les négatifs ou les épreuves par contact et la longueur totale a ensuite été estimée. Les résultats ont indiqué qu'au cours des trois années, la majorité des baleines photographiées mesuraient moins de 11,5 mètres de longueur. Les jeunes représentaient 24 %, 7 % et 34 % du nombre total de baleines mesurées respectivement en 1996, 1997 et 1998. Le nombre de baleines de plus de 13,5 mètres, longueur où la maturité sexuelle des femelles est généralement atteinte, était directement proportionnel au nombre de jeunes qui ont étés photographiés. Les résultats montrent que les baleines boréales du nord du bassin Foxe font partie d'un stock plus important. Les mâles adultes et les femelles adultes sans petit semblent estiver dans une autre partie de l'aire de répartition, probablement dans le nord-ouest de la baie d'Hudson. Il semble que la partie nord du bassin Foxe serve de zone d'élevage et que tous les adultes que l'on y trouve soient des femelles accompagnées de jeunes de l'année.

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ᐊᕐᕖᕐ, ᐊᐅᔭᖃᑦᑕᖅᑐᑦ ᐅᐊᖕᓇᖅᐸᓯᐊᓂ ᓯᑯᓯᒫᒥᐅᑦ ᑕᕆᐅᖕᒐᓂ, ᖃᖓᑕᓲᒃᑯᑦ ᐊᔭᕆᐅᖅᑕᐅᓚᐅᕐᒪᑕ ᐊᒡᒌᓯᐅᑎᓪᓗᒍ 1996-ᒥ, 1997-ᒥ ᐊᒻᒪ 1998-ᒥ. ᐊᖏᓂᖏᑦ ᐊᕐᕖᑦ ᐊᔭᕆᐅᖅᑕᐅᓚᐅᖅᑐᑦ ᐆᒃᑐᕋᖅᑕᐅᓪᓗᑎᒃ ᑕᑭᓂᖏᑦ (ᐊᔭᒃᓴᓂᒃ ᐊᔭᓐᖑᐊᓪᓚᕆᖕᓂᓪᓗ) ᓇᓚᐅᑦᓵᖅᑕᐅᓚᐅᖅᐳᑦ. ᐅᓄᕐᓂᖃᖅᑎᒋᔪᑦ 25-ᓂᑦ 28-ᓄᑦ ᐊᒻᒪ 29-ᓄᑦ ᐊᕐᕖᑦ ᑕᑭᓂᖏᑦ ᐆᒃᑐᕋᖅᑕᐅᓚᐅᖅᐳᑦ 1996-ᖑᑎᓪᓗᒍ, 1997-ᖑᑎᓪᓗᒍ ᐊᒻᒪ 1998-ᖑᑎᓪᓗᒍ. ᖃᐅᔭᓴᖅᑕᐅᓂᑯᓂᑦ ᖃᐅᔭᔭᐅᔪᕐ, ᐊᕐᖀᒍᓂᑦ ᐱᖕᒐᓱᓂᕐ, ᐅᓄᕐᓂᖅᓴᐅᔪᑦ ᐊᔭᕆᐅᖅᑕᐅᓚᐅᖅᑐᑦ ᐊᕐᕖᑦ ᑕᑭᓂᖃᖃᑦᑕᓚᐅᖅᐳᑦ 11.5 ᒥᑕᓂᒃ, ᓇᓗᓇᐃᕐᓯᔪᑦ ᐅᓄᕐᓂᖅᓴᐅᔪᑦ ᐊᕐᕖᑦ ᐃᓐᓇᐅᑎᐅᖏᓐᓂᖏᓐᓂᒃ ᐊᕐᕕᐊᓛᖑᓪᓗᑎᒃᓗ. ᐊᕐᕕᐊᓛᑦ 24 ᐳᓴᒥᓚᐅᖅᑕᖏᑦ ᐊᕐᕕᓚᒦᕐ, (6-ᖑᓪᓗᑎᒃ ᐊᕐᕕᐊᓛᕐ), 7 ᐳᓴᖏᑦ (ᒪᕐᕉᒃ ᐊᕐᕖᒃ) ᐊᒻᒪ 34 ᐳᓴᖏᑦ (ᖁᓚᐅᔪᑦ ᐊᕐᕖᕐ) ᐆᒃᑐᖅᑕᐅᓚᐅᖅᑐᑦ ᑕᑭᓂᖏᑦ 1996-ᖑᑎᓪᓗᒍ, 1997-ᖑᑎᓪᓗᒍ ᐊᒻᒪ 1998-ᖑᑎᓪᓗᒍ. ᐊᕐᕖᑦ ᑕᑭᓂᖅᑐᑦ ᐅᖓᑖᓄᑦ 13.5 ᒥᑕᓂᒃ, ᕿᑐᓐᖏᐅᕈᓐᓇᕐᓯᓯᒪᔪᕐ, ᐊᔭᕆᐅᖅᑕᐅᓯᒪᔪᑦ ᒪᓕᒃᓗᒋᑦ ᐅᓄᕐᓂᖏᑦ ᐊᕐᕕᐊᓛᕐ. ᖃᐅᔭᔭᐅᔪᑦ ᒪᓕᒃᓗᒋᑦ ᓯᑯᓯᓛᕐᒥᐅᑦ ᑕᕆᐅᖕ ᐃᕐᓂᐅᕐᕕᐅᖕᒪᑦ ᐊᒻᒪ ᐃᓐᓇᐅᑎᐅᓂᖏᑦ ᐊᕐᓇᓪᓗᐃᓐᓇᐅᓪᓗᑎᒃ ᐊᕐᕙᓛᓂᒃ ᐱᖃᑎᖃᖅᓗᑎᒃ.

Introduction

Two stocks of bowhead whales (*Balaena mysticetus*), the Hudson Bay-Foxe Basin and the Baffin Bay-Davis Strait stock (Figure 1), occur in the eastern Canadian Arctic (Maiers *et al.* 1999; Mitchell and Reeves 1981, 1982; Reeves and Mitchell 1990; Reeves *et al.* 1983). The Hudson Bay-Foxe Basin stock uses two main summering areas within its range, including the waters around Southampton Island and those in northern Foxe Basin (Figure 1). The relationship between the whales in these two summering areas has not been well understood (Mitchell and Reeves 1990). Although commercial whaling occurred only in Hudson Strait and Hudson Bay, sightings of bowheads were rare in northern Foxe Basin after the end of commercial whaling (Anonymous 1995; Hay 1997). These observations suggest that bowheads using the two summering areas are part of the same stock. The numbers of whales present in northern Foxe Basin appears depend on mortality levels in Hudson Bay.

Although Cosens *et al.* (1997) indicated that all age classes were present in northern Foxe Basin in 1994, it was not clear whether whales in northern Foxe Basin might interchange from year to year with those in northwestern Hudson Bay. The presence of large bowheads in northern Foxe Basin also did not show whether the age distribution of whales in the summering area was representative of the total stock. Age segregation of summering bowhead whales has been documented in the Bering-Chukchi-Beaufort stock (Cubbage and Calambokidis 1987). It has also been seen in the Baffin Bay-Davis Strait stock where adults aggregate in Isabella Bay during the fall migration to feed (Finley 1990). A project to describe the age structure of the summering aggregation in northern Foxe Basin began in 1996. Aerial photographic surveys were conducted in August of 1996, 1997 and 1998. Results of these surveys are presented in this report.

Methods

Aerial photographic surveys were flown with a de Havilland Twin Otter. Photographs were taken through a cameral hatch, mounted in the belly of the aircraft. Limitations on funding and access to the aircraft limited sampling to 2 survey days each year. Based on the distribution of summering whales documented by Cosens *et al.* (1997), north/south transects were flown in 1996 and 1997 (Figure 2a and 2b). The location of the first transect was selected randomly and remaining transects were positioned on the basis of the location of the first transect.

In 1996, transect spacing was 20 km. This spacing distance was selected to minimize the chances of re-photographing individuals when the aircraft flew off transect to sample. Mapping of sample points after the survey was completed indicated, however, that individuals were not likely to be re-photographed if transect spacing was reduced. In 1997, coverage was doubled by reducing transect spacing to 10 km. Doubling of sampling effort also ensured that

sufficient data could be collected in the event that poor weather limited our flying time to one survey day.

In 1998, the same sampling protocol, as was used in 1996 and 1997, was followed on the first survey day however only two whales were sighted. We were uncertain as to whether wind conditions (10 knots) were limiting our ability to see the whales (see Cosens *et al.* 1997) or whether the distribution of whales was different than it had been in previous years. Reconnaissance surveys were flown through Fury and Hecla Strait and in the southern portion of the Gulf of Boothia. No whales were sighted on this flight. On the second survey day, we flew east/west transects to sample the area east of where the whales were normally seen. After completion of two east-west transects, three north-south transects were also flown (Figure 2c). Most whales were seen in their typical aggregation area, suggesting that wind probably reduced the sightability of whales on the first survey day.

The altitude of the aircraft was maintained at approximately 338 metres (1100 feet) for all surveys. In 1996, we relied on the aircraft altimeter for altitude readings but, in 1997 and 1998, we used a laser rangefinder mounted in the camera hatch to more accurately record altitude and calibrate the aircraft altimeter. When whales were photographed time of day, aircraft position, altitude and number of frames were recorded with a cassette tape recorder that had a time and date stamp feature. Aircraft location was determined from the onboard Global Positioning System (GPS). The tape recorder time was synchronized with that of the camera to facilitate the matching of the photographs with the location and altitude data.

In 1996, two hand held Nikon F90X cameras were used to photograph the whales. Using two camera bodies enable the photographer to rapidly switch from one camera to another when film had to be reloaded. In 1997 and 1998, a large format Rolleimetric 6006 camera was used. All cameras had a time-date stamp feature that allowed for easy and accurate matching of the photographs to the field notes on location and altitude.

In 1996, Nikon 180 and 105 mm lenses were used. Aperture and shutter speed varied depending on lighting conditions. The shutter speed was not less than the reciprocal of the lens focal length (not less than 1/200 sec). Spot meter readings (5 degrees) were used. In 1998, Rollei 150 and 200 mm lenses were used and aperture and shutter speed protocol was the same as in 1996. The spot meter covered 8 degrees.

The survey team consisted of two observers to look for whales; one coordinator to direct the pilot toward whales to be sampled and to record field data and one photographer who remained positioned at the camera hatch throughout the survey. When whales were sighted along a transect, the aircraft circled back to directly over-fly the individual or group. To reduce disturbance effects of the turning aircraft, the approximate position of sighted whales was recorded by the

pilot who then continued to fly along the transect some distance before turning the aircraft. The aircraft was not above the whales when it was turning and was leveled out before the group was over-flown and photographed. The search area was significantly reduced by having the GPS location with which to orient the search. If the whales dove before a photograph could be taken, the next group was sampled. In general, whales were sampled in the order in which they were sighted. We attempted to photograph all whales that were visually sighted. Some whales, however, could not be relocated after the aircraft had been turned (Table 1).

In 1996 and 1997, all total body lengths were measured from the magnified images on the film negatives. Total body length was defined as the distance between the tip of the rostrum and the tips of the flukes (Angliss *et al.* 1995). Images where turbulence of the water or submergence of the animal made accurate measurement difficult were noted. These were later discarded from further analysis. Images where the whales were strongly flexed and the body length would therefore have been significantly underestimated were also discarded from further analysis.

In 1998, most whales were submerged and when negative images were magnified, the edges of most individuals were not clear. Examination of contact prints indicated that the length of most of these animals could be more accurately measured from printed images. If the clarity of the negative image was considered to be less than 75%, the measurement from the photograph was used. Images in which the outline of the body could not be seen in the prints, were discarded from the analysis.

Body lengths of each image were measured three times and the average used as the length estimate. Each image length was then converted to absolute body length by multiplying image length by the conversion factor:

Representative Fraction = focal length of lens/Aircraft altitude.

The lens used for each whale photographed was recorded and later matched with the photograph. The lens size was matched with the altitude of the aircraft recorded while the whales were being photographed and the appropriate conversion factor determined for each image.

The age class category of each animal photographed was based on data collected on Bering-Chukchi-Beaufort bowheads (Koski *et al.* 1993). Koski *et al.* (1993) concluded from photogrammetric measurements that most bowheads seen in close association with calves were 13.5 meters or larger, therefore bowheads seen with calves were assumed to be females. Bowheads smaller than 7.5 meters were assumed to be young-of-the-year calves. Calves are about 4 meters long at birth and grow to about 7.5 meters by the end of the summer (Koski *et al.* 1993).

Several bowheads in this size category were seen in close association with large bowheads and several appeared to be nursing, thus this size category seems appropriate for young-of-the-year whales. Whales between 7.5 and 13.5 meters were placed into three size categories: > 7.5 and $\leq$9.5 meters, >9.5 and $\leq$11.5 meters, >11.5 and $\leq$13.5 meters. All whales in these latter three categories were considered to be juveniles. Animals were classified according to body length and frequency distributions of body length categories were determined for each year.

Results

Of 36 whales photographed in 1996, body lengths of 26 whales were estimated. Similarly, in 1997, 28 out of 36 photographed whales were measured and in 1998, 29 of photographed 47 whales were measured. Usually more than one photograph was taken of each whale, however, many replicates had to be discarded because turbulence caused by movement of the flukes reduced the clarity of the image or because the animal was submerged or flexed.

In each year of the survey, most animals photographed were juveniles or calves (Figure 3). In 1996, 11.5 % of the whales were larger than 13.5 meters and were considered to be adults. Twice as many calves were photographed as adults. During this survey, only one cow-calf pair was observed. All other calves were photographed either alone or in association with juveniles. In 1997, only 2 calves were photographed and the single adult made up only 4% of the sample. A relatively large number of older juveniles (9.5 to 11.5 meters) was recorded that year. In 1998, a relatively large number of both calves and adults was photographed. Adults made up 21% of the total sample. The number of adults photographed in northern Foxe Basin was directly related to the number of calves photographed (Figure 4, Pearson $r = .993$, $p < 0.01$).

Calves and juveniles made up 88%, 96% and 79% of the samples in 1996, 1997 and 1998 respectively. Results further show than whales between 11.5 and 13.5 meters were usually less common than adults, making up only 4%, 7% and 7% of the sample in the three survey years compared to 12%, 3.6% and 21% for adults. Calves made up 24%, 7% and 34% of the sample in 1996, 1997 and 1998 respectively. Data pooled for all years (Figure 5) clearly show that older juveniles and adults make up a small proportion of the bowheads found in northern Foxe Basin in August.

Over the 3 years, 6 large bowheads, closely associated with small calves, were photographed. Of these, body lengths of five could be measured. Body lengths of 4 whales over 13.5 meters ranged from 14.7 to 16.9 meters. The fifth whale was estimated to be 12.4 meters in length.

The range in body lengths estimated for animals, for whom at least 2 body length measurements were acquired, varied from near 0 to as much as 3.4 for one whale in 1998 (Table 2). The range in estimated body lengths was smallest in 1996 and largest in 1998. In each year, the range of body length estimates for an individual whale was positively correlated with sample size (Table 2).

This variability in body length estimates did not significantly affect the resulting frequency distributions. In 1996, the sampled body lengths of 3 calves overlapped the cut-off between the calf ($\leq$7.5 m) and juvenile (>7.5 m) categories. Two of these whales were classed as juveniles and 1 as a calf. Similarly in 1997, there were two whales for which measurements straddled the calf and juvenile categories. One was classed as a juvenile and one as a calf. Of 4 whales straddling the juvenile and calf categories in 1998, two were classed as juveniles and two as calves.

In all years, a number of juveniles straddled categories, however all would remain classed as juveniles even if the largest body measurement was used. Six animals (1 in 1996, 3 in 1997, and 2 in 1998) could have been misclassified as belonging in the $\leq$ 11.5 m class when they should have been in the > 11.5 m class. For the 1996 whale, only 1 of 4 measurements (range = 1.1) exceeded 11.5 m. For the 1997 whales, 3 of 4 samples for the first whale exceeded 11.5 (range = 1.9 m), 3 of 5 samples of the second whale (range = 1.6) exceeded 11.5 m and 2 of 5 samples for the third whale (range = 1.8) exceeded 11.5 m. For the 1998 whales, 1 of 2 samples of the first whale (range = 1.3 m) was larger than 11.5 m and 2 of 4 samples for the second whale (range = 3.4 m) exceeded 11.5 m.

Only two animals could have been misclassified as adults. In 1996, 1 of 3 estimates was less than 13.5 m for an animal classed as an adult at 13.8 meters. The other estimates for this animal were 14.0 and 14.4. In 1998, samples of one animal, estimated at 13.7 meters, ranged from 12.1 to 14.8 m. The third measurement of this animal was 14.2 so 2 of 3 estimates exceeded 13.5 m.

Discussion

Results suggest that bowheads of the Hudson Bay-Foxe Basin stock segregate on the basis of age, sex and reproductive status. The correlation between the numbers of adults in relation to calves in northern Foxe Basin suggests that this area serves as a nursery for summering females and young-of-the-year calves. If adult males and resting adult females were present, a correlation between numbers of adults and numbers of calves would not be expected. Young juveniles made up the majority of the remaining whales. Once the juveniles reach 11.5 meters in length, most appear to leave Foxe Basin to summer in another location. The most likely site is the area around Repulse Bay and

Frozen Strait, the other major summering area of this stock. It was from this area that the large male was landed in 1996, consistent with the hypothesis that these two summering locations support sub-stocks based on age and, as adults, on sex and reproductive state.

Males mature at a smaller size than do females (Koski *et al.* 1993). Koski *et al.* (1993) suggests that most males may become mature by the time they are 12 to 13 m long. The low numbers of bowheads in northern Foxe Basin that are between 11.5 and 13.5 m in length is consistent with male maturation between 12 to 13 m. If the nursery hypothesis is correct, then males would leave northern Foxe Basin once they reach reproductive age. Animals between 11.5 and 13.5 m that are found in northern Foxe Basin in the summer are likely to be immature females.

This sub-stock structure may not be absolute. Sightings of small whales have been reported during skin sampling activities (Dueck, unpublished data) around Repulse Bay and there have been sightings of females and calves in areas, such as Whale Cove, along the western Hudson Bay coast. There have been reports of kills of females and calves in northwestern Hudson Bay (Ross 1974). Reeves and Mitchell (1990) report that female-calf pairs and small whales occur in northwestern Hudson Bay, however their table of data does not distinguish between northwestern Hudson Bay and northern Foxe Basin.

The minimum size of females with calves in northern Foxe Basin appears to be similar to that of females that have been photographed with calves in the Beaufort Sea. In northern Foxe Basin, 4 out of 5 bowheads closely associated with small calves were larger than 13.5 meters but one whale, seen in close association with a calf, measured 12.4 meters. A bowhead as small as 12.2 m has been photographed with a calf in the Beaufort Sea (Koski *et al.* 1993), thus a small proportion of females in the Bering-Chukshi-Beaufort stock mature at a relatively small size. This may also be the case in the eastern arctic.

Angliss *et al.* (1995) discuss some of the biases associated with aerial photographic measurements of body size. In addition, calves are likely over-represented during photographic sampling. They probably spend more time on the surface of the water and are more likely to be seen and photographed than either juveniles or adults. The approximate 2:1 ratio of calves to adults in the northern Foxe Basin sample is consistent with calves being more likely to be sampled than adults. Application of size class frequencies derived from photographic sampling must, therefore, be done with caution.

Substantial variation occurred from one measurement of body length to another. Several sources of error contribute to this lack of precision. Slight changes in aircraft altitude, camera angle or whale position result in small variations in the image size on the film. These small variations are amplified by the conversion factor. Although the measurements are adequate for describing age classes, this method could not be used for studies requiring a high degree of precision.

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Table 1. Sampling success for each year of the study.

Year	Number of whales Sighted	Number of whales Photographed	Number of whales Measured
1996	No data	36	25
1997	No data	36	28
1998	76	47	29

Table 2. Ranges in body length estimates for individual whales. The Pearson r is the correlation between the range in body length measurements for individual whales and the number of photographs used to estimate body length. For this analysis only whales for which 2 or more photographs were used to estimate length were included.

Year	Smallest Range (N)*	Largest Range (N)	Pearson r (N)
1996	0.1 (2)	2.04 (5)	0.59** (22)
1997	0.4 (2)	2.35 (6)	0.77** (23)
1998	0 (3)	3.36 (4)	0.55 *** (16)

*N = number of photographs used to estimate body length.

**$p < 0.01$, ***$p < 0.05$

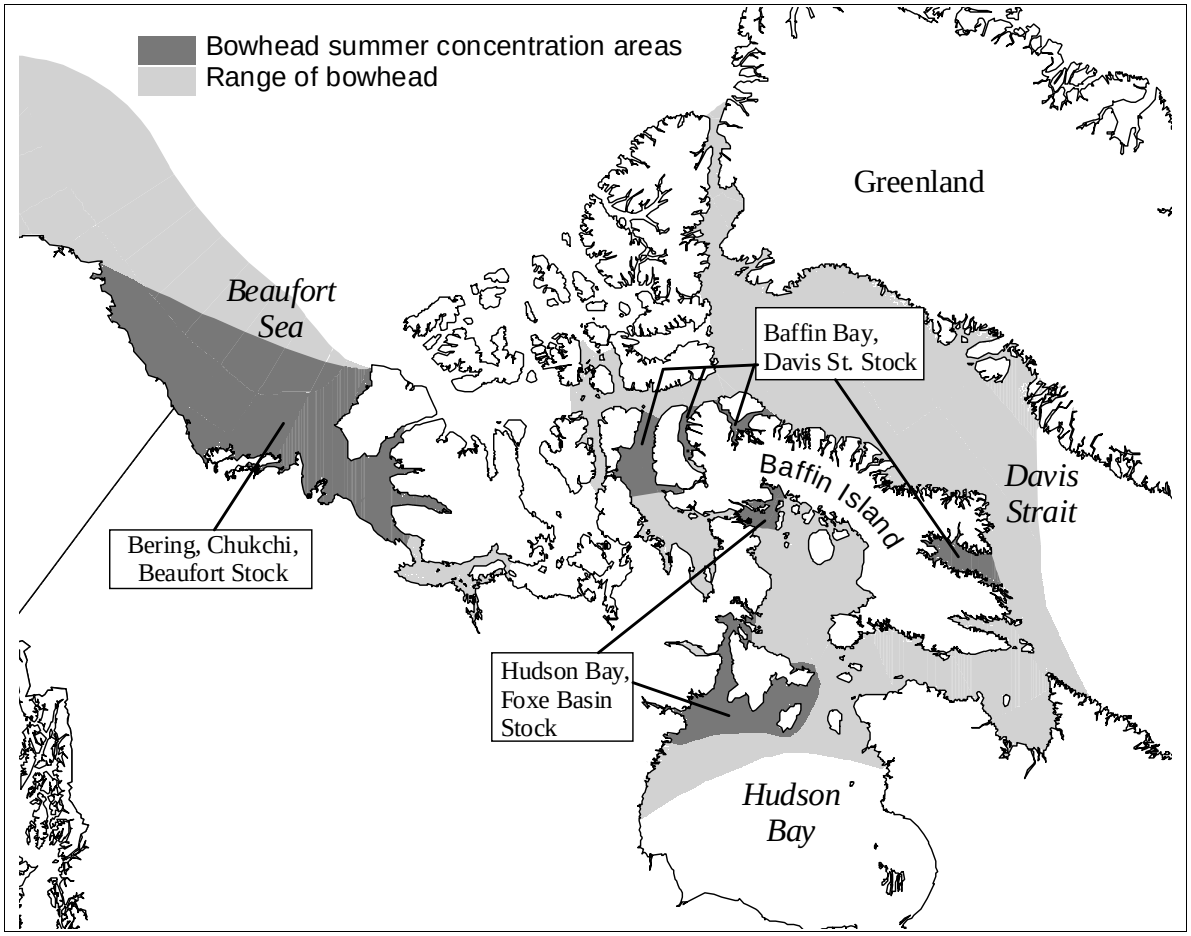

Figure 1. Bowhead stocks summering in Canadian waters. Summer aggregation areas are in black.

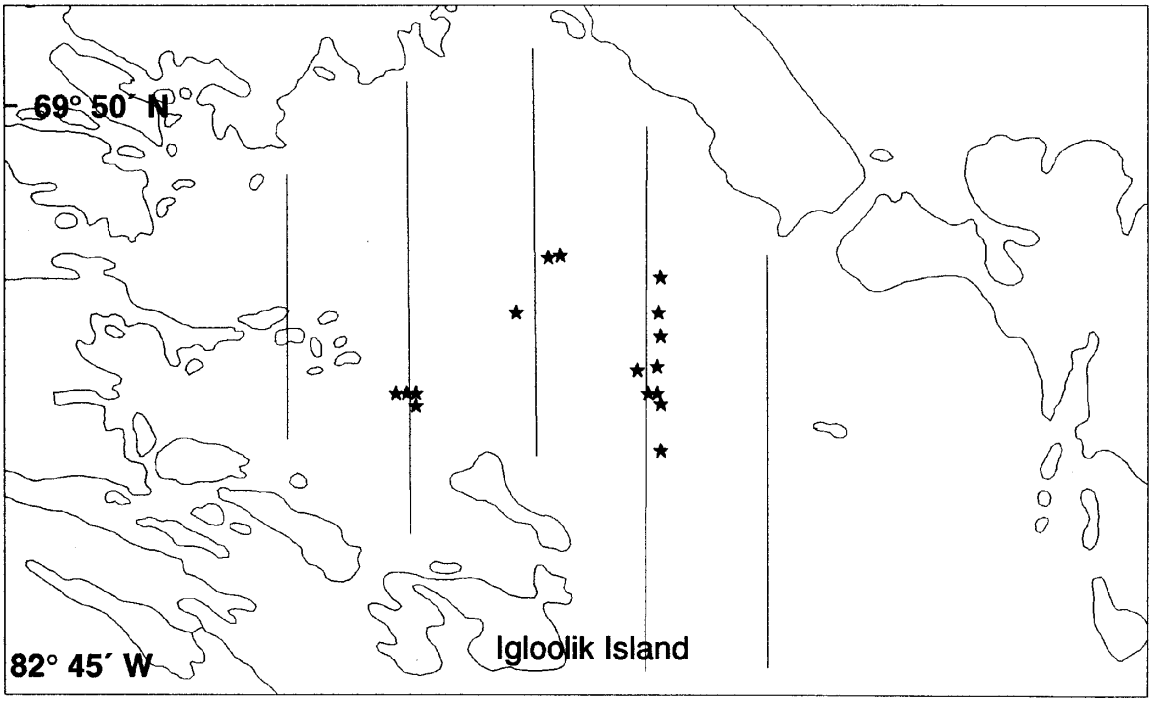

Figure 2a. Survey routes flown in northern Foxe Basin to photograph the summering aggregation for estimation of body lengths in 1996. Points on the map indicate the locations of photographed whales. The locations of several individuals may overlap so one point may represent several sampled whales.

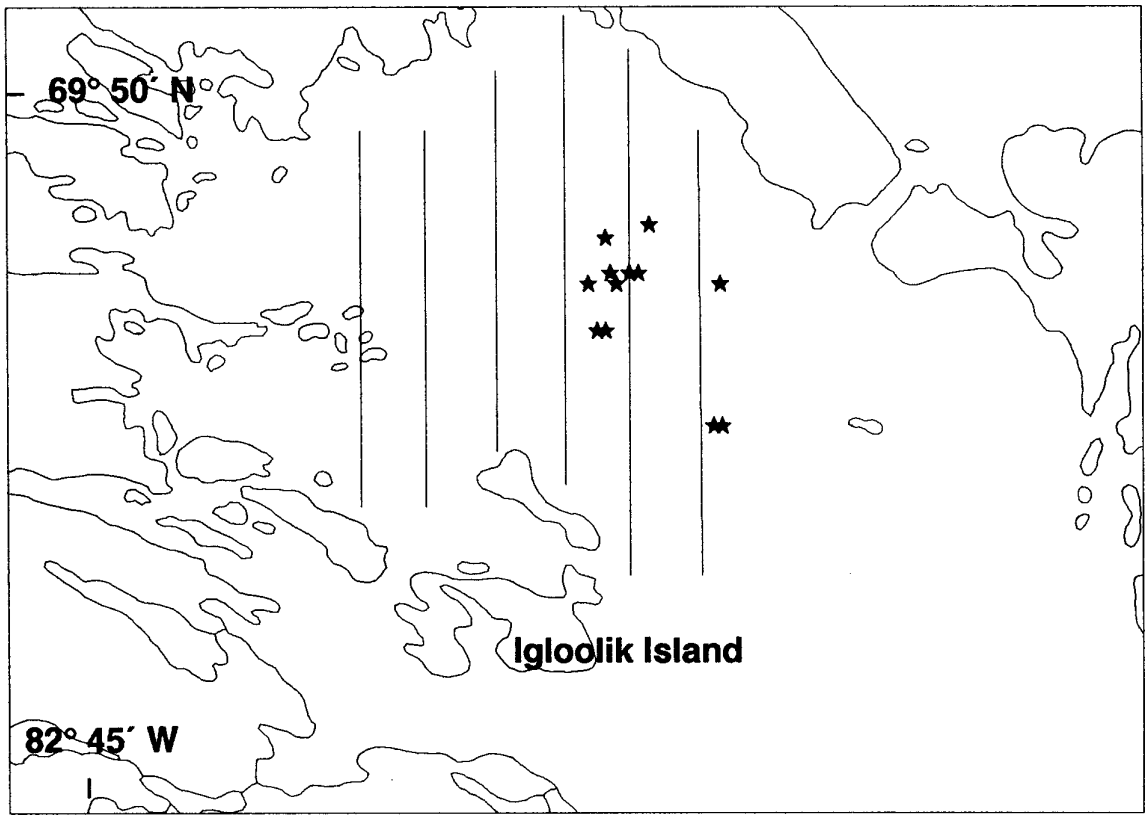

Figure 2b. Survey routes flown in northern Foxe Basin to photograph the summering aggregation for estimation of body lengths in 1997. Points on the map indicate locations of photographed whales. The locations of several individuals may overlap so one point may represent several sampled whales.

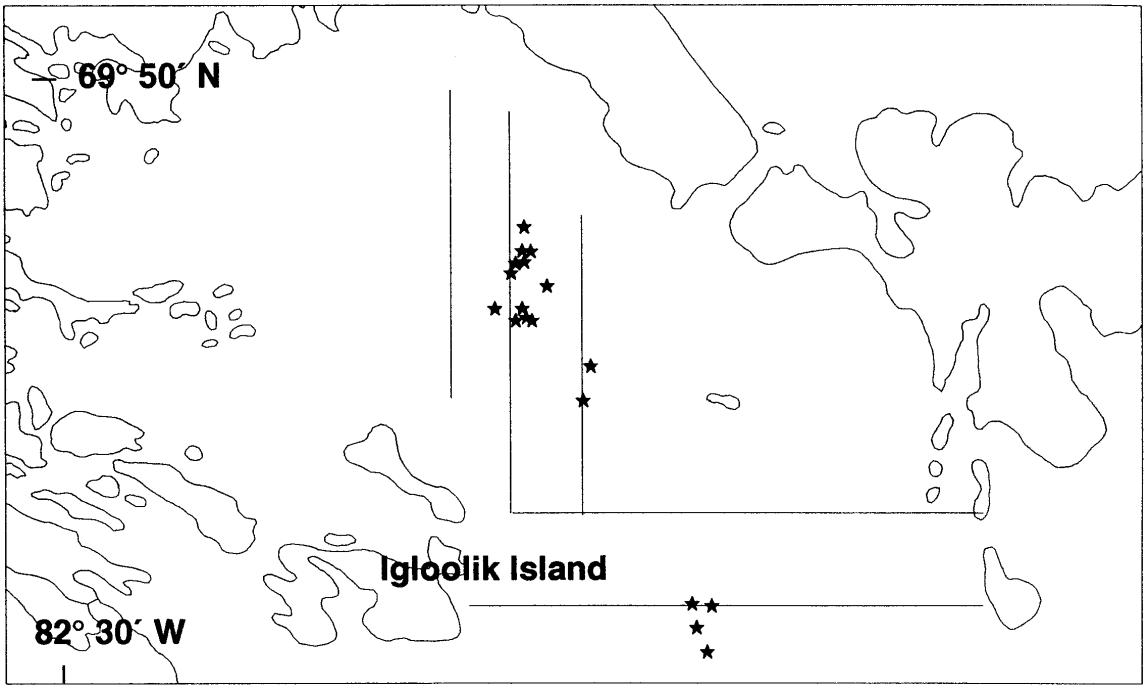

Figure 2c. Survey routes flown in northern Foxe Basin to photograph the summering aggregation for estimation of body lengths in 1998. Points on the map indicate locations of photographed whales. The locations of several individuals may overlap so one point may represent several sampled whales.

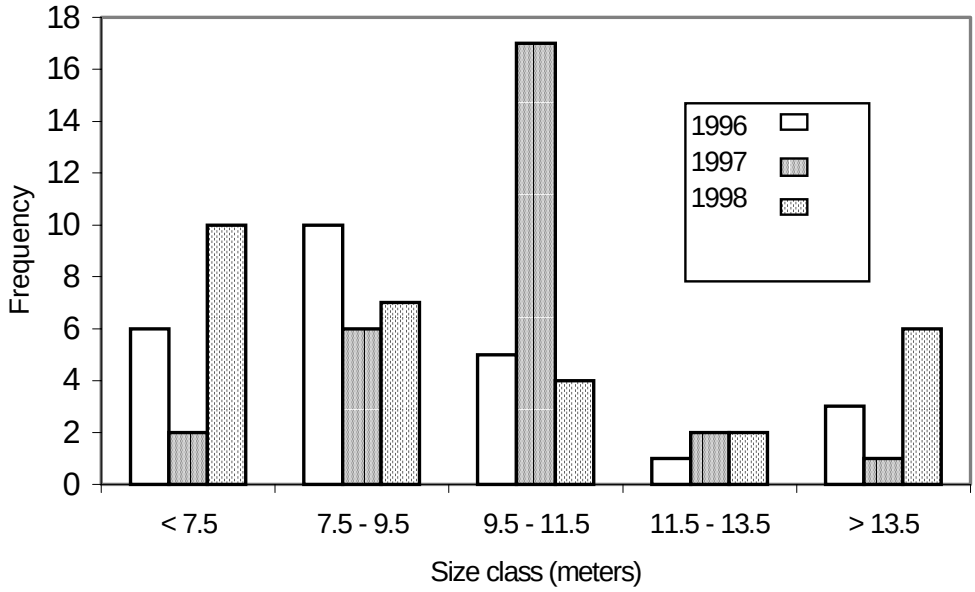

Figure 3. Size classes of whales photographed in northern Foxe Basin in 1996, 1997 and 1998.

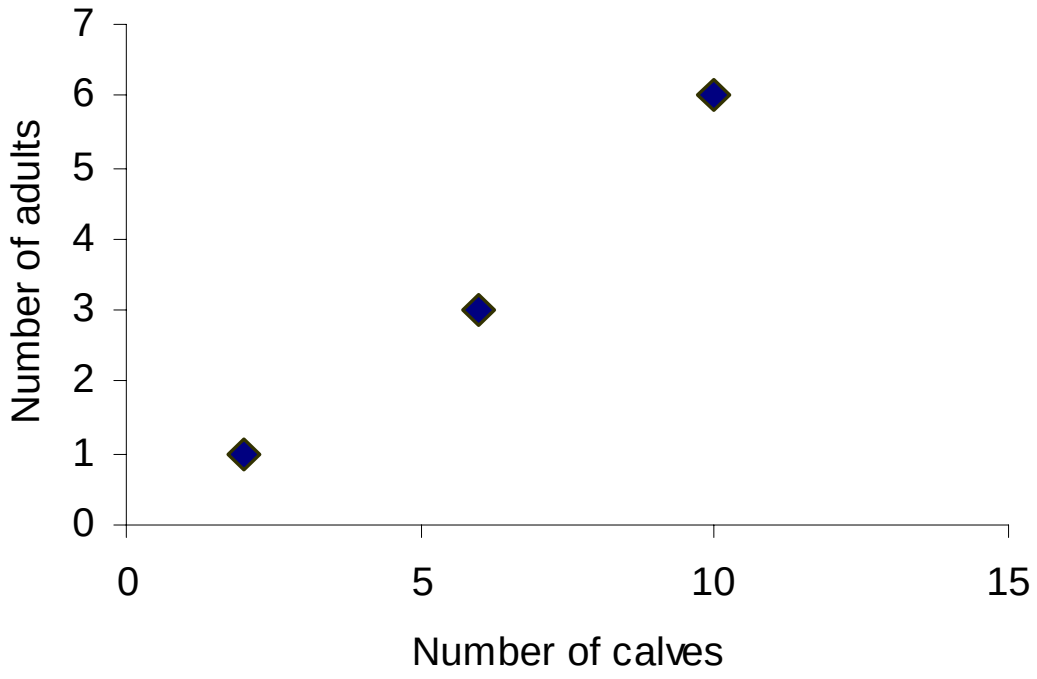

Figure 4. Number of adults photographed in relation to the number of calves photographed.

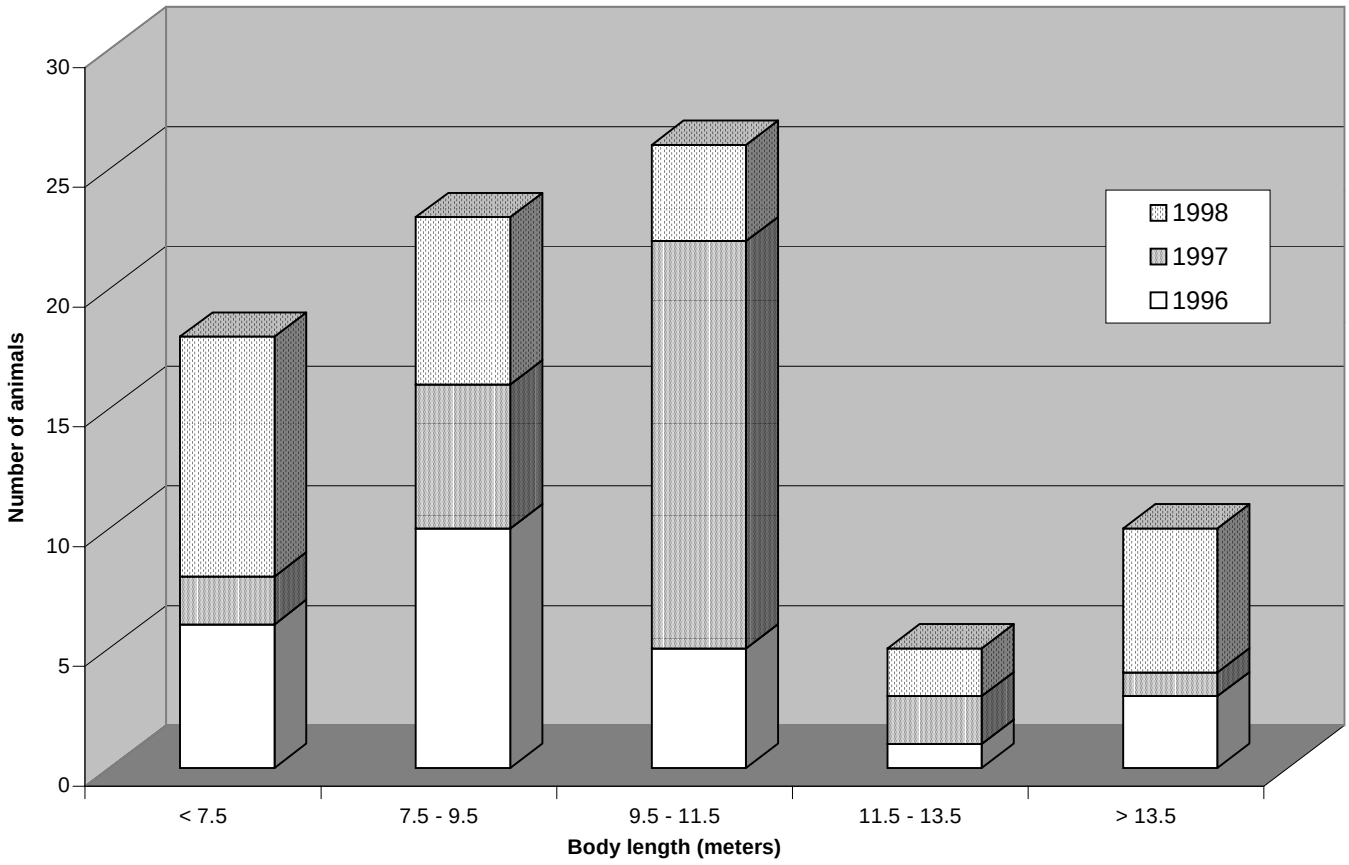

Figure 5. Size distribution of bowheads photographed in northern Foxe Basin pooled across survey years.