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ARCTIC
VOL. 56, NO. 3 (SEPTEMBER 2003) P. 283–292

Historical Population Characteristics of Bowhead Whales (*Balaena mysticetus*) in Hudson Bay

RANDALL R. REEVES[1] and SUSAN E. COSENS[2]

(*Received 30 May 2002; accepted in revised form 21 January 2003*)

ABSTRACT. Historical records of commercial whalers operating in northwestern Hudson Bay during the 19th century were examined for information on size, age, sex, and location of bowhead whales that were either sighted or killed. Correlations between body size and either oil yield or baleen length were used to estimate the relative age classes (calf, subadult, adult) of whales for which no explicit age-class information was reported in the whaling logbooks. Cow-calf pairs and subadults, as well as adult whales, were sighted or killed throughout the whaling season in the area extending from Wager Bay south to Marble Island. This finding indicates that whales of many different age classes were present south of Wager Bay, even during the open-water period when whaling activity shifted northward to include Repulse Bay and Lyon Inlet. Recent observations suggest that few bowhead whales occur south of Wager Bay during the open-water season and that the population in this area has not recovered from the effects of commercial whaling. It is not clear whether this group of bowheads was a separate stock or, alternatively, waters south from Wager Bay constituted a second calf-rearing area for a single Hudson Bay-Foxe Basin stock.

Key words: bowhead whale, *Balaena mysticetus*, Hudson Bay, Foxe Basin, stock structure

RÉSUMÉ. On s'est penché sur des documents historiques provenant de baleiniers commerciaux en activité dans le nord-ouest de la baie d'Hudson au XIX^{e} siècle, afin d'extraire de l'information sur la taille, l'âge, le sexe et l'emplacement des baleines boréales qui avaient été aperçues ou tuées. On s'est servi des corrélations entre la taille des cétacés et la production d'huile ou la longueur des fanons pour estimer les groupes d'âge relatifs (baleineau, subadulte, adulte) de baleines pour lesquelles aucune information explicite sur le groupe d'âge n'avait été rapportée dans le livre de bord des baleiniers. Des paires de baleine mère-petit et des subadultes ainsi que des mâles adultes avaient été aperçus ou tués durant toute la saison de chasse à la baleine dans la zone s'étendant de la baie Wager jusqu'à l'île Marble vers le sud. Ces résultats montrent que des baleines appartenant à de nombreux groupes d'âge se trouvaient au sud de la baie Wager, même durant la période d'eau libre quand la pêche à la baleine se déplaçait plus au nord en incluant Repulse Bay et Lyon Inlet. Des observations récentes suggèrent que peu de baleines boréales sont maintenant présentes au sud de la baie Wager durant la saison d'eau libre et que, dans cette zone, la population n'a pas récupéré des effets de la chasse commerciale à la baleine. On ne sait pas exactement si ce groupe de baleines boréales appartenait à un stock distinct, ou si, par contre, les eaux au sud de la baie Wager représentaient une deuxième zone d'élevage des petits pour un stock unique habitant la baie d'Hudson et le bassin de Foxe.

Mots clés: baleine boréale, *Balaena mysticetus*, baie d'Hudson, bassin de Foxe, structure du stock

Traduit pour la revue *Arctic* par Nésida Loyer.

INTRODUCTION

The bowhead whales (*Balaena mysticetus*) in Canadian waters belong to three different stocks: the Bering-Chukchi-Beaufort Seas (BCB) stock in the western Arctic and the Baffin Bay-Davis Strait (BBDS) and Hudson Bay-Foxe Basin (HBFB) stocks in the eastern Arctic (Fig. 1). This stock structure was proposed initially on the basis of discontinuities in the summer distribution and differences in population-level responses to commercial whaling (IWC, 1978, 1992; Mitchell and Reeves, 1981; Reeves and Mitchell, 1990; Ross, 1993). After the number of whales in the BBDS stock had declined because of commercial whaling, a new and unexploited whaling ground was discovered in northwestern Hudson Bay. Recent analyses of DNA from bowhead whales in the Beaufort Sea, Foxe Basin, Repulse Bay, and Cumberland Sound are consistent with the conventional three-stock model of the species' distribution in Canadian waters (Maiers et al., 1999, 2001).

In addition to the large-scale stock structure of the aggregate bowhead population, there appears to be further, finer-scale structuring within stocks, based on age and sex. Seasonal segregation by age and sex has been documented for the BCB stock in its summer feeding areas

[1] Okapi Wildlife Associates, 27 Chandler Lane, Hudson, Quebec J0P 1H0, Canada; rrreeves@total.net
[2] Fisheries and Oceans, Freshwater Institute Science Lab, 501 University Crescent, Winnipeg, Manitoba R3T 2N6, Canada; cosenss@dfo-mpo.gc.ca
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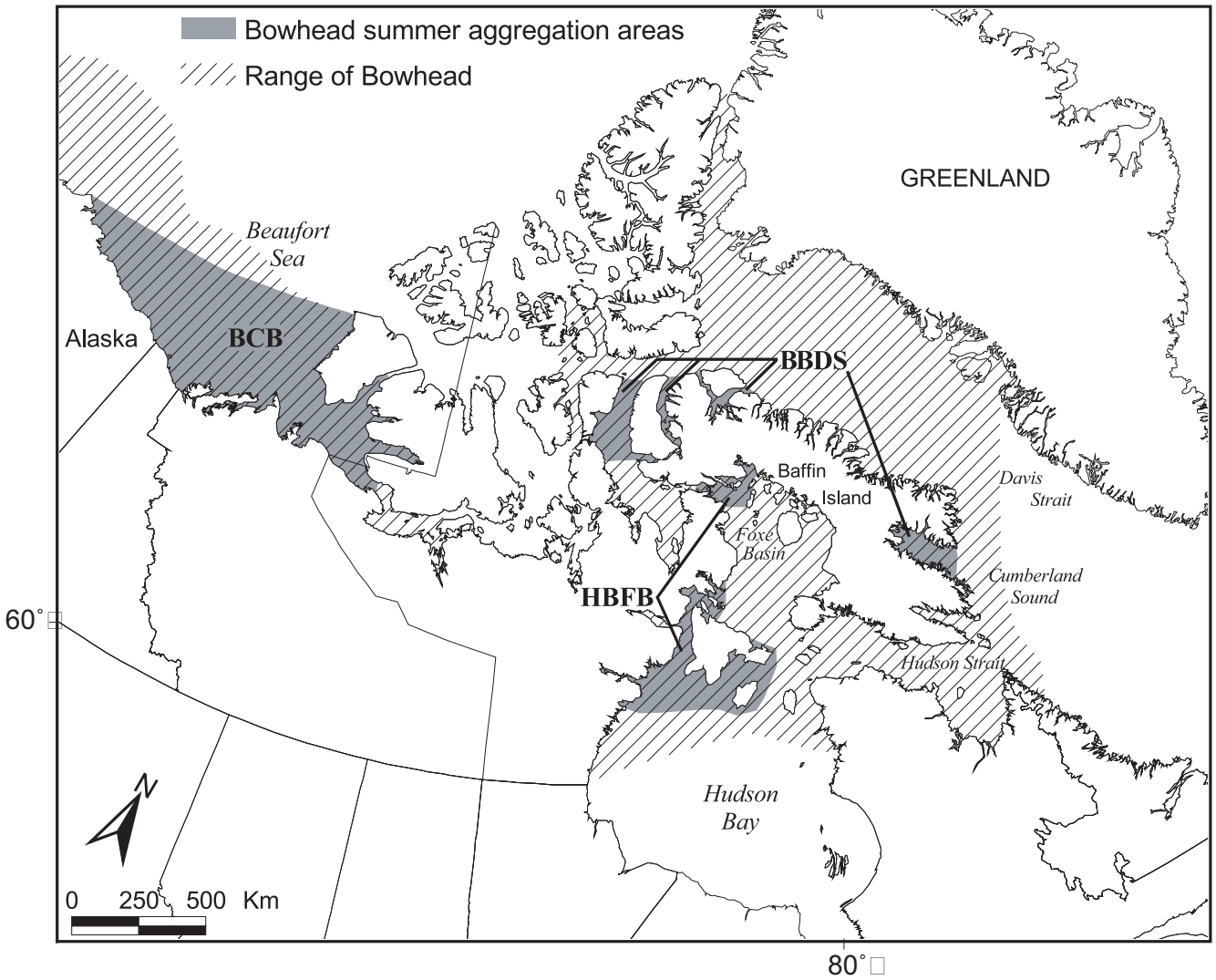

FIG. 1. Ranges and summer aggregation areas of the three putative stocks of bowhead whales in Canadian waters. BCB = Bering-Chukchi-Beaufort Seas stock; BBDS = Baffin Bay-Davis Strait stock; HBFB = Hudson Bay-Foxe Basin stock.

(Cubbage and Calambokidis, 1987), for the BBDS stock in Isabella Bay on the east coast of Baffin Island (Finley, 1990) and, most recently, for the HBFB stock in northern Foxe Basin (Cosens and Blouw, 2003). Mitchell and Reeves (1981) proposed that age and sex segregation in the BBDS stock might account for the observed bimodal peaks in catches of bowheads by the Davis Strait commercial whale fishery. These authors implied that the high catches by the primarily Dutch fishery in Davis Strait during the 1720s and 1730s resulted from exploitation of one portion of the population, while the second peak in catches by the mainly British fleet a century later occurred because changes in vessel design and fishing strategy allowed the whalers to reach northwestern Baffin Bay and the inlets and sounds to the west, areas used by a different segment of the population (i.e., cow-calf pairs and subadults).

Recent aerial surveys indicated that subadults, adult females, and young-of-the-year calves feed in northern Foxe Basin during the open-water season (Cosens and Blouw, 2003). It has been inferred that other components of the population not seen during the surveys, specifically adult males and nonparous adult females, occur in more southern waters around Southampton Island in northwestern Hudson Bay (DFO, 1999; Cosens and Blouw, 2003). If the HBFB stock is indeed segregated in this manner, the division has important implications for survey design and interpretation, as well as for hunt management (i.e., setting catch limits). For example, results of surveys in northern Foxe Basin in August 1994 (Cosens et al., 1997) and in northwestern Hudson Bay in August 1995 (Cosens and Innes, 2000) were combined to produce a single abundance estimate for the HBFB stock (DFO, 1999). This procedure was based on the assumption that the two surveys covered different components of the same whale population, and the combined estimate of abundance was used to calculate a "sustainable harvest rate" of one whale killed every two years (DFO, 1999).

In addition to its potential value in planning surveys and managing the hunt, a better understanding of historical patterns of segregation and whaling mortality may clarify

the impact of commercial whaling on the putative HBFB stock and contribute to the development of recovery models. The degree to which exploitation in Hudson Bay affected mortality of the whole stock, including the animals summering in northern Foxe Basin, may depend upon how much interchange there was between the two main summering areas.

We examined records of sightings and kills of bowhead whales by commercial whalers in the Hudson Bay–Hudson Strait–Foxe Basin region (hereafter referred to as the study area) during the 19th and early 20th centuries. The explicit purpose of the present study was to develop a better understanding of historical patterns of bowhead whale distribution by age and sex, and to provide a basis for comparing the population characteristics of bowhead whales today with those of the past. Previous work by Ross (1974, 1975, 1993) provided a useful overall understanding of the history of the fishery, as well as a guide to data sources.

MATERIALS AND METHODS

The commercial whaling grounds in our study area, as defined by Ross (1974), extended from Rankin Inlet and Whale Cove in the south to Frozen Strait and Repulse Bay in the north (see Cosens and Innes, 2000: Fig. 2). The commercial whalers did not hunt bowheads in northern Foxe Basin; as a consequence, the available historical records pertain almost entirely to areas south of there. According to Ross (1993), there were 146 commercial whaling voyages to Hudson Bay, representing 210 ship-seasons (two ship-seasons sometimes occurred in a single voyage, one before and one after overwintering).

Ross (1974) plotted the positions of 265 kills of bowheads, by month, and also provided decadal averages of the earliest (spring) and latest (autumn) sightings at Marble Island, the Depot Island-Fullerton area, and Repulse Bay. All of his data apparently came from reading the logbooks or journals (hereafter "logs") of approximately 70 whaling voyages—roughly half of the total commercial whaling effort in the region (for bibliographic details, see Ross, 1975). For the present study, we examined logs covering 50 American whaling voyages to Hudson Bay, representing 92 ship-seasons (see References and Appendix). Most of these logs were included in the bibliography of Ross (1975); therefore, many of the kills in our database were also considered by Ross (1974). Our studied sample represented roughly 44% of the total commercial whaling effort (in terms of ship-seasons) in Hudson Bay between 1860 and 1915. Our examination of logs emphasized the period from mid-May to mid-September, which bracketed most of the whaling effort (Ross, 1974, 1975). For all whale observations, data recorded included date, position, number of animals, and whether they were seen, chased, struck, or killed. In addition, we noted any information concerning the absolute or relative size of the whale, its sex, oil or baleen yield (in gallons, barrels, or pounds), and length of longest baleen (normally given by the whalers in feet and inches). Most historical records of whale observations or kills do not include explicit information concerning the animal's sex or relative age. Therefore, indices such as total body length, length of the longest baleen plate, and oil or baleen yield, or notations concerning associations between individuals, often had to be used to infer these parameters (cf. Finley and Darling, 1990).

Bowhead whales are about 4.5 m long at birth, and the baleen of a newborn is about 18 cm long (11 cm in gum, 7 cm exposed) (Haldiman and Tarpley, 1993). On the basis of annual oscillations in radiocarbon content along baleen plates, Schell and Saupe (1993) estimated that the baleen grows more than 50 cm in the first year of life and then the growth rate slows markedly, e.g., to 35–45 cm in year 2 and 27.5–35 cm by year 3. Annual growth increments in older animals are typically 20 cm or less (Schell and Saupe, 1993). It was therefore assumed that whales with baleen less than about 70 cm (2–2.5 ft) long were first-year animals, while those with baleen up to about 110–120 cm (3.5–4 ft) long were between one and two years old.

Baleen length and total body length are significantly correlated in bowheads, at least for animals larger than about 8.5 m in body length, when the baleen is about 48 cm (Lowry, 1993:204). The following equation from Lowry (1993: Fig. 6.1) was used to estimate total body lengths from reported baleen lengths: $y = 27.586x - 123.591$, where y is baleen length in cm and x is total body length in m. This equation gives larger body size estimates than the equation presented by Finley and Darling (1990). Lowry's regression was derived from a scientifically measured sample of 80 bowheads in Alaska and is likely to be more accurate than Finley and Darling's equation, which was based on data from the log of a single British whaling voyage to Baffin Bay in 1823. We recognize, nonetheless, that the relationship could differ between bowhead stocks. Moreover, standard errors or confidence intervals reflecting uncertainty in the derived estimates would be desirable. However, without access to Lowry's original data, it is impossible to produce such measures. Note also that our estimates may be somewhat biased because we have used Lowry's equation to solve x (body length) for a given y (baleen length), which gives an answer slightly different from the one produced if whale length is regressed against baleen length.

In addition to examining unpublished ship's logs, we searched published sources for relevant data on individual whales in the study area. Most prominent among these sources were the journal of Robert Ferguson (1938), harpooner aboard the *Abbie Bradford* during a Hudson Bay cruise in 1878–79; and Ross (1984), an edited volume containing the journal of Captain George Comer during the 1903–05 voyage of the *Era*. Data from these sources were fully integrated with data from the manuscript sources examined.

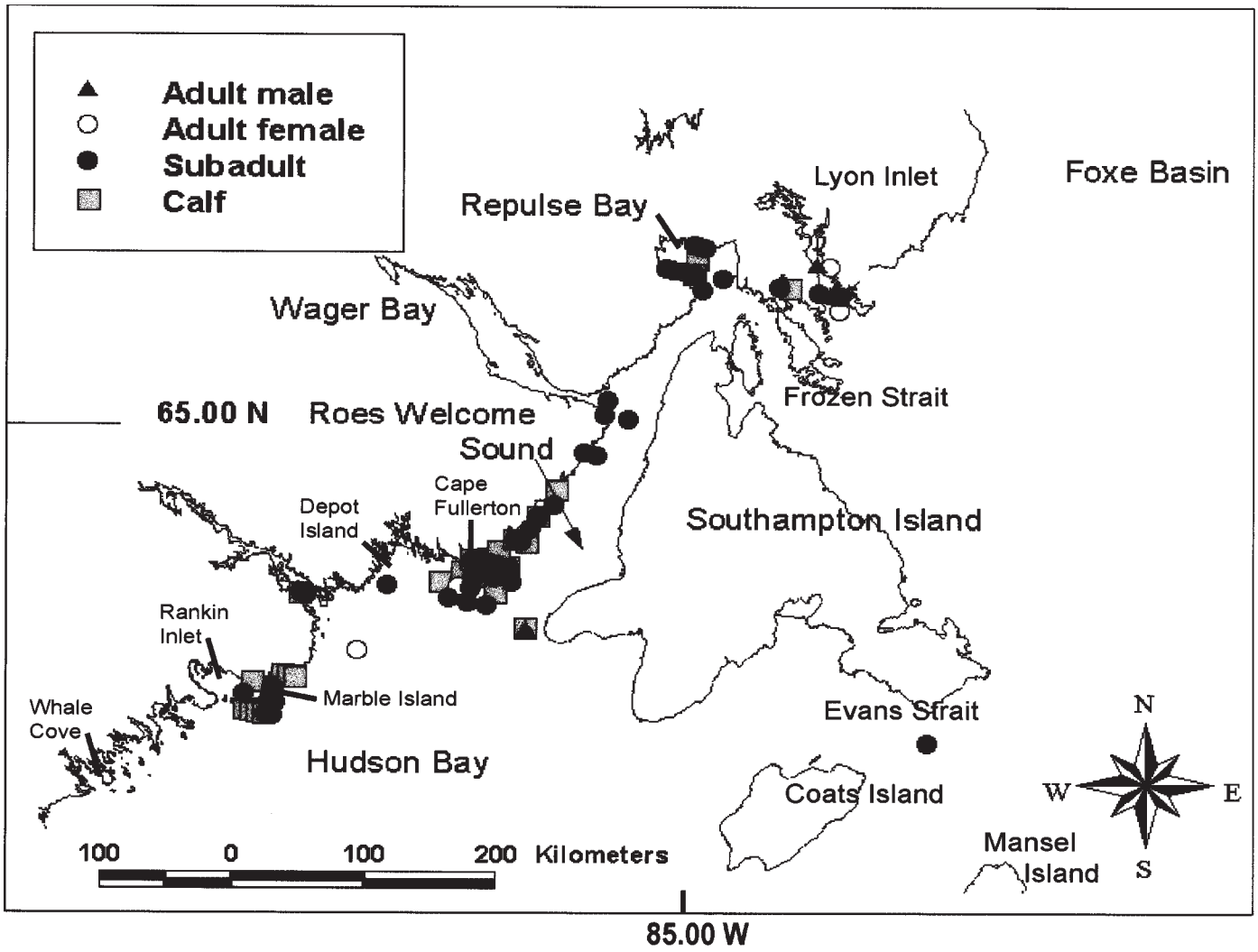

FIG. 2. Locations of sightings, strikes, or kills of 164 bowhead whales in northwestern Hudson Bay and the Repulse Bay area from 1862 to 1905. Data from whaling vessel logs.

From the total sample of individual whale records, those with associated information on size, sex, or age class were selected for analysis. The sample was sorted into five categories: *adult male*, *adult female*, *adult sex not known*, *subadult*, and *calf*. Whales described in the records as "large" or "very large" were classified as adults. Whales described as "medium-sized" or "small" were classified as *subadults*. Those described explicitly as "calves," as well as those described as "little" or "very small," were classified as *calves*. Although the sex of *subadults* and *calves* was mentioned occasionally, these categories were not broken down by sex.

Some records reported only the product yields of individual whales, with no information on approximate size or age class. Records for which information on body size and product yields was available were therefore used to calibrate those records for which no size or age information was given. Within the sample of 174 individual whale records, 27 included information on the whale's sex or relative size in combination with some information on its product yields (Table 1). These records suggested that any whale yielding 5 barrels of oil or less should be classified as a *calf*. The whalers described whales that yielded as much as 35 barrels of oil or baleen up to 6 ft 3 in. long and weighing up to 462 lb as "small." Lowry's (1993) equation (see above) estimates the body length of a bowhead with 6 ft 3 in. (190.5 cm) baleen as 11.4 m, which is well below the estimated length of females at sexual maturity (13.0–13.5 m) but approaches that of males (perhaps 12–13 m) (Koski et al., 1993). Thus, in the present study, whales yielding 10–35 barrels of oil were classified as *subadults*, as were whales whose baleen measured less than 6 ft 6 in. (198.1 cm) and weighed less than 500 lb (227 kg).

In the original sources, positions of sightings and strikes of bowheads were almost never given by latitude and longitude, but rather in relation to landmarks. For example, whales were described as being encountered off Whale Point or Mount Jones, or at the Marble Island or Depot Island floe edge. In some instances, the locality information was even more vague, such as simply in Roes Welcome Sound or Repulse Bay, or somewhere east of Evans Strait. To plot the approximate locations of sightings and

TABLE 1. Whales for which information was available on relative size (e.g., "large" or "small"), sex, or both, *and* on one or more production values (e.g., oil yield or baleen length).

Date	Description	Production	Source
3 September 1864	Small	35 barrels oil	*Cornelia* (1864–65)
11 July 1865	Calf	5 barrels oil	*Glacier* (1864–65)
11 July 1865	Very large	95 barrels oil	*Orray Taft* (1864–65)
14 August 1868	Small	20 barrels oil	*Ansel Gibbs* (1868–69)
6 June 1872	Calf	2.5 barrels oil	*Glacier* (1871–73)
20 June 1872	Small	10 barrels oil	*Glacier* (1871–73)
23 July 1878	Large cow	50 barrels oil (log); 43 barrels oil (Ferguson)	*Abbie Bradford* (1878–79); Ferguson (1938)
30 July 1882	Small	25 barrels oil	*Abbie Bradford* (1882–83)
2 July 1886	Cow with calf	145 barrels oil	*Wave* (1885–86)
31 July 1887	Small	20 barrels oil	*Abbie Bradford* (1886–88)
14 September 1895	Large cow	95 barrels oil	*Canton* (1895–96)
17 September 1895	Large	11' 6" baleen	*Canton* (1895–96)
3 July 1896	Small	5' 6" baleen	*Era* (1895–96)
4 September 1896	Large	3006 (US) gallons oil (= 82 barrels)	*Era* (1895–96)
21 August 1897	Very small	4' baleen	*Platina* (1896–97)
8 September 1901	Cow	8' 8" baleen	*Era* (1900–02)
9 September 1901	Small	5' 10" baleen	*Era* (1900–02)
August 1903	Small	4' 8" baleen	Ross (1984)
Between mid-June and mid-July 1904	Small	230 lbs baleen (cleaned)	Ross (1984)
13 June 1905	Male	9' 6", 1456 lbs baleen	Ross (1984)
16 June 1905	Female	4' 6", 241 lbs baleen	Ross (1984)
30 July 1905	Male	6' 10", 612 lbs baleen	Ross (1984)
1 August 1905	Female	6' 10", 524 lbs baleen	Ross (1984)
4 August 1905	Female	8 ft, 10 in., 1136 lbs baleen	Ross (1984)
4 August 1905	Male	9', 1397 lbs baleen	Ross (1984)
13 August 1905	Male	9' 3", 1381 lbs baleen	Ross (1984)
17 August 1905	Small cow	6' 3", 462 lbs baleen	Ross (1984)

kills in ArcView GIS (Version 3.1, Environmental Systems Research Institute, Inc.), we assigned a latitude and a longitude, expressed as decimal degrees, to each position. In some instances, these assignments were little more than crude interpolations and approximations.

RESULTS

The database generated for this study contained a total of 164 records of bowhead whales (seen, landed, or struck but lost) that included some information on size, age class, or sex. Locations are shown in Figure 2. The age-class distribution estimated from these data indicated that substantial numbers of calves and juveniles were present in the study area (Fig. 3). Of the 164 whales in our sample, about 16% were classified as calves, 33% as subadults, and 51% as adults. In view of the hiatus in catches between Wager Bay and Repulse Bay reported by Ross (1974), we divided our sample at 65˚ N (Fig. 2). The majority of sighting and kill records were from areas near to or south of Wager Bay (≤ 65˚N), and animals of all age classes were recorded there throughout the whaling season (Fig. 4). As the season progressed and the ice retreated, increasing numbers of whales were encountered north of Wager Bay. In August, similar numbers of whales were reported from both sectors (i.e., north and south of 65˚N), and whales of all age classes were taken or sighted in both sectors as late as September.

In addition to the records from whaling logs, we know of two records of small bowheads taken by Hudson's Bay Company personnel in the mouth of the Churchill River, more than 400 km south of the main whaling ground. One was killed in mid-June 1772 (2 ft 6 in. baleen, 10 hogsheads of oil) and the other in early July 1813 (3 ft baleen, 900 gallons of oil) (Reeves and Mitchell, 1990). These whales would have been classified as subadults.

DISCUSSION

Biases in the Data

Before 1870, there was a tendency for logs to give fewer details, perhaps because single capture events were less noteworthy than they were to become in the later years of the fishery, when bowheads were much less abundant and harder to find and catch. During the final decades of the fishery, when catches on a single voyage rarely exceeded a handful of whales, it was not unusual for some information to be provided on the relative size of most or all of the whales taken. Therefore, the profile of the population inferred from the historical data is more likely to apply to the second half of the whaling period (i.e., 1880s to early 1900s) than to the first half (1860s to 1870s).

In the early years of the Hudson Bay whale fishery, oil was still a commercially valuable product. By the 1890s, however, the value of baleen greatly exceeded that of oil, and the whalers often kept only the baleen and ignored the blubber (Ross, 1993). This trend affected the data recorded. In early years, the logs were more likely to contain

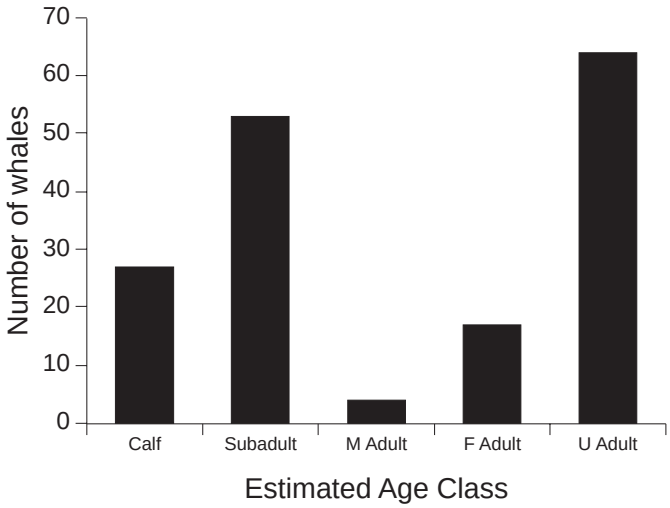

FIG. 3. Approximate age-class and sex distribution of 164 bowhead whales that were sighted, struck, or killed by commercial whalers in the study area between 1862 and 1905. Assignments to class were based on reported body size, baleen length and weight, or oil yield. Each cow-calf pair was scored as one calf and one adult. Data from whaling vessel logs. F = Female, M = Male, and U = Sex unspecified.

information on oil yield, whereas in later years, the weight of the baleen ("bone") and the length of the longest plate of baleen were noted more frequently. In a few instances, it was possible to combine information from a published source or a second vessel's log to establish the oil or baleen yield of a given whale. This procedure, however, was fraught with problems because of inconsistencies between the two or more independent sources. We found, as did Ross (1974), that log keepers had a tendency to round values upward to the nearest 10.

Implications for Stock Structure

Aerial photogrammetry in northern Foxe Basin in early to mid-August of 1996 to1999 found that a much higher than expected proportion of the bowheads summering there were calves and subadults (Cosens and Blouw, 2003). Inuit have also reported seeing "many" mother-calf pairs in northern Foxe Basin, and one hunter reported observing a birth in the Igloolik area (NWMB, 2000). Northern Foxe Basin is clearly a major summer feeding and nursery area for young animals and parturient females. However, the historical occurrence of mother-calf pairs and subadults in northwestern Hudson Bay, not only in June and July but also in August and September, indicates that the summer feeding range of these population components historically extended well south of northern Foxe Basin. Cosens and Innes (2000) observed few bowheads south of Wager Bay, where American whalers found high densities of bowheads from 1860 into the 1870s. Thus, either the pattern of distribution has changed over the past 130–140 years, or the population or subpopulation that summered in the southern part of the range has failed to recover from the effects of commercial whaling. Calf sightings by Inuit have been reported near southeastern Southampton Island and in Repulse Bay (NWMB, 2000), but such sightings are not common today. The timing of the 1995 surveys (mid-August; Cosens and Innes, 2000) was such that, if large numbers of whales had been present south of Wager Bay, more should have been seen.

One interpretation of the difference between historical whaling data and recent survey data would be that the whales summering south of Wager Bay during the commercial whaling period constituted a population distinct from that (or those) in Repulse Bay and Foxe Basin. Consistent with such a hypothesis is the hiatus in commercial catches between Wager Bay and Repulse Bay noted by Ross (1974:91), who surmised that Repulse Bay could have received "a separate influx from Foxe Basin by way of Frozen Strait and Hurd Channel" during the open-water season. Recent satellite-linked telemetry data have confirmed movement of whales from Foxe Basin to Southampton Island in August (L. Dueck, pers. comm. 2002). Reports of bowhead whales in western and southern Hudson Bay (Reeves and Mitchell, 1990), eastern and north-central Hudson Bay (e.g., near Coats and Mansel Islands; see Reeves et al., 1983), and Hudson Strait (Finley et al, 1982; McLaren and Davis, 1982) complicate the picture. It is not clear whether the animals moving through Hudson Strait in the spring and autumn are bound to and from Foxe Basin, or Hudson Bay, or both.

In the scenario of separate Hudson Bay and Foxe Basin-Repulse Bay stocks, one would expect the whales in Repulse Bay to be genetically more similar to those in Foxe Basin than to those summering south of Wager Bay. There is ongoing research to examine the genetic relationships between whales in Repulse Bay and Foxe Basin. However, given the present-day scarcity of whales summering south of Wager Bay, it will be difficult to assess the genetic relationships between animals from Hudson Bay and Roes Welcome Sound and those from Repulse Bay. A promising approach for examining historical population structure involves the extraction of DNA from baleen in museum collections (Rosenbaum et al., 1997). Compilation of an inventory of such materials in North American and European museums is underway (see Rosenbaum et al., 2001), and as additional samples from the range of bowheads in the eastern Arctic become available for analysis, it may be possible to test the hypothesis that the putative Hudson Bay/Foxe Basin population was, at least historically, composed of two separate stocks.

A second possible interpretation is that waters south of Wager Bay were used as a summer "nursery" by a component of the Hudson Bay-Foxe Basin population. The North Atlantic right whale (*Eubalaena glacialis*) is closely related to the bowhead whale. Right whales off the eastern United States and southeastern Canada comprise a single breeding population, but population substructure is reflected in their mitochondrial DNA (Schaeff et al., 1993). Females tend to take their calves to particular summer nursery areas, and female calves (if not also male calves) presumably imprint on the nursery areas visited with their

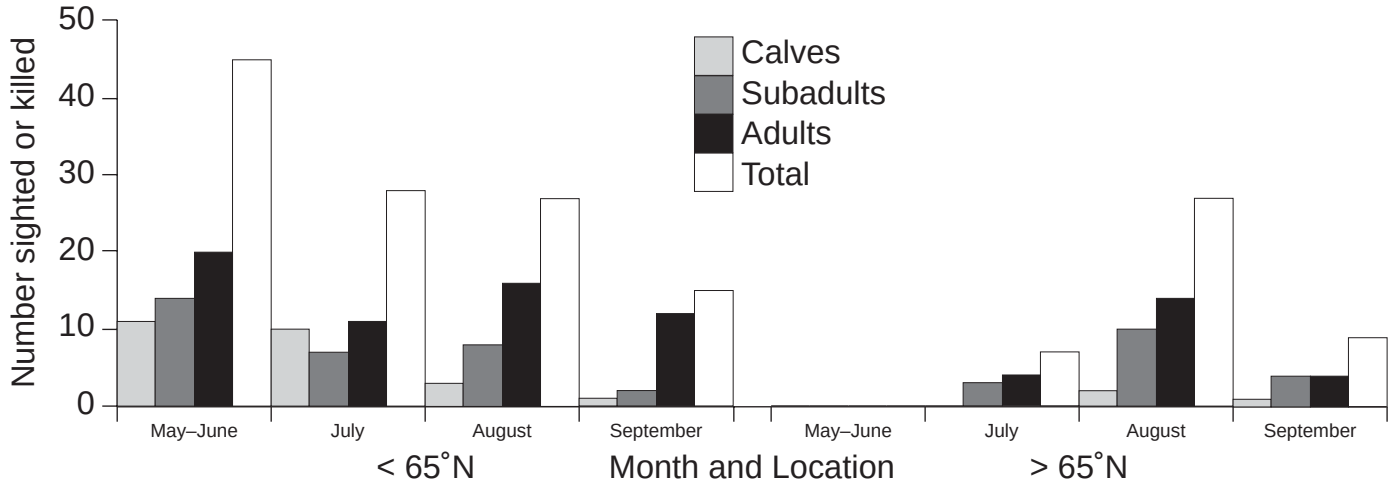

FIG. 4. Approximate age class of bowhead whales that were sighted, struck, or landed, according to location and month. Whales encountered in or south of Wager Bay were designated as < 65˚N while those encountered north of Wager Bay were designated as > 65˚N.

mothers in their first year of life. This apparently results in a high degree of philopatry that limits the overall ability of the population to disperse and expand its range as numbers increase. One might also expect bowhead whales in our study area to constitute a single breeding population, with substructure driven by female philopatry to geographically distinct nursery areas. In this scenario, the matrilines that homed on Roes Welcome Sound and other areas of northern or western Hudson Bay (and probably also to some extent Repulse Bay) would have experienced differentially high mortality during the commercial whaling era, while the Foxe Basin matrilines would have survived relatively well. This could explain the present-day situation, with relatively high whale densities in northern Foxe Basin and comparatively low densities on the old commercial whaling grounds in and south of Roes Welcome Sound.

Trends in Historical Distribution

The data presented here are in broad agreement with Ross's (1974) concept of a northward shift by the whales in Roes Welcome Sound from June through August, which of course would not preclude a southward movement into Repulse Bay by animals from Foxe Basin. As Ross acknowledged, however, the whalers' movements were presumably much more restricted (by ice) than were those of the bowheads and, therefore, our depictions of whale distribution at any point in time are not unbiased. The locations of whale encounters depended more on where the whalers were able to travel than on where the whales actually occurred. Whales occupied a larger area than could be accessed by whaling ships.

Bowheads were present throughout the open-water season in Roes Welcome Sound, as far north as Wager Bay, and as far south as Marble Island during the early years of the commercial fishery. Already by the mid-1860s, however, some of the American whalers were making an effort to move north into Repulse Bay because whales had become harder to find and catch in the southern areas. There is a suggestion in the historical data that the whales were rapidly depleted by the whaling fleet and that, within only a few years, whale availability had changed dramatically in the most accessible parts of the whaling grounds. Ross (1974) did not explicitly analyze the changing distribution of catch localities through time. However, it is clear from our preliminary examination of logbook and other data that the focus of whaling effort shifted northward, from Roes Welcome Sound and its southern approaches to Repulse Bay and the ice-choked waters immediately east and north of there (see Ross, 1984). Further work is needed to determine whether these distinct groups of whales represented different populations or different subgroups of related animals.

In this regard, it is useful to compare the development of the fishery in Hudson Bay to that in the western Arctic. Bockstoce and Botkin (1983) recorded that the southern limit of the bowhead whaling grounds in the Bering and Chukchi Seas "retreated" northward at a rate of about 3˚ of latitude every ten years. Citing those authors' results, Bockstoce and Burns (1993:572) offered two alternative explanations. Firstly, "it is…possible that what we refer to as the Bering Sea population was comprised of several subpopulations, each with its own normal range and feeding area, and each of which was successively exterminated or extirpated as the fleet steadily expanded its hunting range." Secondly and alternatively, there may have been "a single, integrated population that responded rapidly to the activities of whaling ships and fled from areas of intensive whaling, receding farther and farther north and east to temporarily safer areas."

CONCLUSIONS

Commercial whaling records from Hudson Bay and Repulse Bay indicate that subadults and cow-calf pairs occurred in August and September both south and north of

APPENDIX

Logbooks, in addition to those cited in References, examined to produce the database of bowhead whale observations for this paper. Repositories are abbreviated as follows: KI = Kendall Institute, New Bedford Whaling Museum, 18 Johnny Cake Hill, New Bedford, Massachusetts 02740, USA; PPL = Providence Public Library, 225 Washington Street, Providence, Rhode Island 02903, USA; NBFPL = New Bedford Free Public Library, 613 Pleasant Street, New Bedford, Massachusetts 02740-6203, USA; RRR = Privately owned by author.

Vessel	Years Sailed/Returned	Port of Origin	Master	Repository
A. HOUGHTON	1876/1877	New Bedford	James G. Sinclair	KI
A.J. ROSS	1878	New Bedford	James G. Sinclair	RRR
A.R. TUCKER	1891/1892	New Bedford	Elnathan B. Fisher	NBFPL
A.R. TUCKER	1893/1894	New Bedford	A.D. West	NBFPL
A.R. TUCKER	1895/1896	New Bedford	A.D. West	NBFPL
A.R. TUCKER	1897/1898	New Bedford	J.W. Nichols	NBFPL
ABBIE BRADFORD	1874/1875	New Bedford	Elnathan B. Fisher	KI
ABBIE BRADFORD	1880/1881	New Bedford	William H. Murphy	KI
ABBIE BRADFORD	1884/1885	New Bedford	Gilbert B. Borden	KI
ABBOT LAWRENCE	1878/1879	New Bedford	Joseph A. Mosher	RRR
ABBOT LAWRENCE	1880/1881	New Bedford	Joseph A. Mosher	KI
ALEXANDER	1886/1887	New Bedford	Benjamin C. Blossom	KI
ANDREWS	1867	New Bedford	Timothy C. Packard	KI
ANSEL GIBBS	1862/1863	New Bedford	C.B. Kilmer	KI
ANSEL GIBBS	1864/1865	New Bedford	C.B. Kilmer	KI
ANSEL GIBBS	1866/1867	New Bedford	C.B. Kilmer	KI
ANSEL GIBBS	1871/1872	New Bedford	Thomas McPherson	KI
ANTARCTIC	1890	New Bedford	Elnathan B. Fisher	KI
ANTELOPE	1861/1863	New Bedford	George Taber	KI
ANTELOPE	1864/1866	New Bedford	George E. Tyson	KI
BLACK EAGLE	1862/1863	New Bedford	Charles E. Allen	KI
BLACK EAGLE	1864/1865	New Bedford	Edwin W. White	KI
DANIEL WEBSTER	1863/1864	New Bedford	Merrill W. Sanborn	KI
ERA	1897/1899	New Bedford	George Comer	KI
GEORGE AND MARY	1879/1880	New Bedford	Michael A. Baker	KI
GEORGE AND MARY	1881/1882	New Bedford	Albert C. Sherman	NBFPL
GEORGE AND MARY	1883/1884	New Bedford	Elnathan B. Fisher	KI
GEORGE AND MARY	1885/1886	New Bedford	Erastus Church	KI
ISABELLA	1867/1868	New London	— Bailey	KI
ISABELLA	1880/1881	New Bedford	Benjamin C. Blossom	KI
ISABELLA	1882/1883	New Bedford	Benjamin C. Blossom	KI
MILWOOD	1867/1868	New Bedford	Isaac Allen	KI
MORNING STAR	1864/1865	New Bedford	Charles E. Allen	KI
ORRAY TAFT	1866/1867	New Bedford	George J. Parker	KI
ORRAY TAFT	1872	New Bedford	George J. Parker	KI
SIREN QUEEN	1860/1861	Fairhaven	C.B. Chapel	KI

Wager Bay. Two hypotheses were proposed above that could explain the present-day rarity of bowhead sightings south of Wager Bay. Although historical whaling data were useful for framing these hypotheses about stock identity and population structure, studies using photo-identification, tagging, telemetry, and various biochemical markers (e.g., fatty acids, stable isotopes, contaminant levels, and DNA) are needed to test them.

Although we believe that the data from whaling logs and other written historical materials are adequate for answering some specific questions, such as whether certain size classes or sexes of bowheads did or did not occur in particular areas at particular times, these data have serious limitations for addressing more general questions. For example, logbook data are not necessarily representative of the historical whale population, and we would therefore be reluctant to derive a model of contemporary age structure from them. Although it might be possible to devise a means of quantifying search effort and therefore of weighting observations in terms of encounter rates, the irregular nature of logbook reporting on the relative ages (e.g., sizes or yields) and sexes of whales would undermine the credibility of results. Similarly, we would advise caution in using these data as the basis for estimating the age and sex distribution of the historical commercial catch, given that record keeping by the American whalers was so unsystematic.

ACKNOWLEDGEMENTS

This study was funded by the Department of Fisheries and Oceans through the Species at Risk Program. Two of the referees, Jeff Breiwick and Lloyd Lowry, provided useful criticism and advice, for which we are grateful.

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