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Bowhead Whale (*Balaena mysticetus*) Feeding near Point Barrow, Alaska, during the 1985 Spring Migration

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ABSTRACT. Examination of stomach contents and behavioral observations showed conclusively that bowhead whales were feeding in the Point Barrow area during the spring of 1985. All three bowheads harvested near the village of Barrow had over five litres of pelagic zooplankton (calanoid copepods and euphausiids) in their stomachs. Over 60 whales were observed during the period 26 May through 6 June diving repeatedly under the landfast ice and feeding in an area 11.2 km southwest of Point Barrow. Observers recorded times for dive, surfacing and respiration intervals for these whales. The recorded times were significantly different from those of bowhead whales migrating past Point Barrow in the spring and from bowheads, whose major activity was feeding, recorded in the Canadian Beaufort Sea during the summer and fall.

Key words: *Balaena mysticetus*, Point Barrow, feeding, bowhead whale, behavior, copepod, euphausiid, respiration, spring

RÉSUMÉ. Un examen du contenu stomacal de baleines franches et des observations de leur comportement ont montré sans aucun doute qu'elles se nourrissaient dans la zone de Point Barrow pendant le printemps de 1985. Les trois baleines franches pêchées près du village de Barrow avaient toutes dans l'estomac plus de cinq litres de zooplancton pélagique (copépodes calanoïdes et euphausiacés). Pendant la période allant du 26 mai au 6 juin, on a observé plus de 60 baleines qui plongeaient de façon répétée sous la banquise côtière pour se nourrir dans une zone située à 11,2 km au sud-ouest de Point Barrow. Les observateurs ont noté le moment de la plongée et celui du retour à la surface, et l'intervalle entre les souffles des baleines. Les durées enregistrées étaient nettement différentes de celles mesurées pour des baleines franches qui passaient à Point Barrow pendant leur migration au printemps, et de celles enregistrées dans la mer de Beaufort canadienne en été et en automne pour des baleines franches dont l'activité principale était de se nourrir.

Mots clés: *Balaena mysticetus*, Point Barrow, se nourrir, baleine franche, comportement, copépode, euphausiacé, respiration, printemps

INTRODUCTION

Researchers have thought that bowhead whales seldom, if ever, feed during the spring and that unless their path is blocked by ice they seldom deviate from active migration. However, during spring 1985 we saw bowhead whales interrupt their migration and feed intensively in an area southwest of Point Barrow.

Bowhead whales have been observed during spring migration each year since 1976 by ice-based census personnel working for the Department of Wildlife Management of the North Slope Borough (DWMNSB) and the National Marine Mammal Lab (NMML), and there have been only occasional reports of "possible feeding behavior" (unpublished whale census data). Stomachs of harvested whales have been examined since 1974 by DWMNSB and NMML researchers and have always been empty or contained less than 2 litres of food (Lowry and Frost, 1984).

Bowhead whale feeding behavior has been observed in the summer and fall in the Canadian Beaufort Sea (Würsig *et al.*, 1983, 1984, 1985) and in the Alaskan Beaufort Sea (Reeves *et al.*, 1983; Ljungblad *et al.*, 1986). Bowheads have been reported feeding near Point Barrow in the fall (Braham *et al.*, 1984; Ljungblad *et al.*, 1985a). Stomachs examined from whales harvested at Kaktovik and Barrow, Alaska, during the fall have all contained food (Lowry *et al.*, 1978; Lowry and Burns, 1980; Lowry and Frost, 1984).

Carroll and Smithhisler (1980) reported a brief description of bowheads apparently feeding during the 1978 spring migration near Point Barrow. Hazard and Lowry (1984) described the stomach contents of a bowhead taken in the Bering Sea in May 1982 at St. Lawrence Island. The report included an account of the whale's feeding behavior given by Ralph Apatiki, the Inupiat hunter who harvested the whale. According to senior Barrow whaling captain Harry Brower, Inupiat hunters have, on occasion, observed feeding behavior during spring migration near Point Barrow in the past.

In this paper we describe a previously unreported feeding behavior of bowhead whales during spring migration and identify the prey species obtained from whales harvested in the Barrow area.

Study Area

We worked from the seaward edge of the landfast ice in the Point Barrow and village of Barrow area (Fig. 1). The village of Barrow will be referred to as Barrow. Landfast ice is an ice sheet that develops along the coast during the fall and winter and remains attached to the shore through the spring. Polar pack ice generally covers the water beyond the landfast ice. The pack ice is moved by wind and ocean currents, creating a dynamic shear zone between the ice masses that bowhead whales follow during their spring migration. Leads of open water open and close within the shear zone. Occasionally, the pack ice is pushed against the landfast ice, causing pressure ridges of fractured ice to form. Pressure ridges extend above and below the surface of the water and may be resting on the bottom (grounded) if the depth of the keel of the pressure ridge is greater than the depth of the water. For safety reasons, most past bowhead observations have been made from grounded pressure ridges near open leads. Behavioral observations reported here, however, were made from an observation perch on ungrounded landfast ice floating on water 45 m deep, located at 71°22.45′N and 156°41.42′E, 11.2 km southwest of Point Barrow. The perch was 6.1 m in height, next to a lead approximately 4 km wide. Stomach con-

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tents were taken from whales harvested near Barrow and pulled up onto the landfast ice.

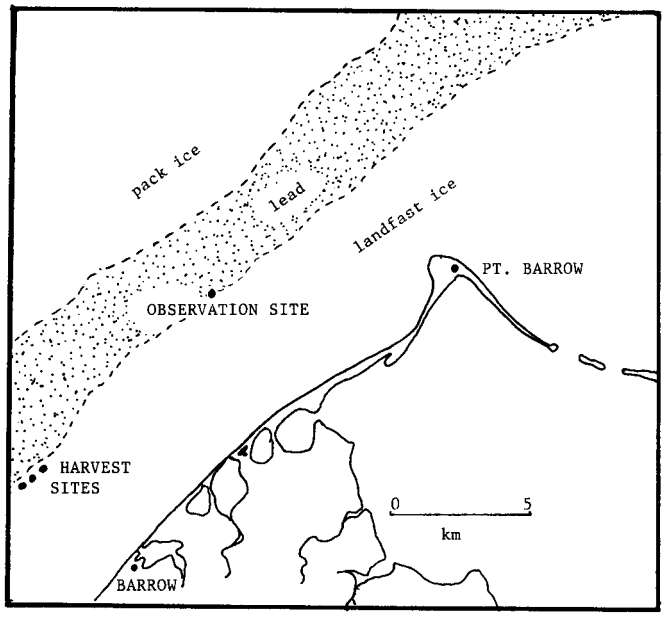

FIG. 1. The location of the observation site in relation to Point Barrow, Alaska. The approximate margin of the landfast ice and the pack ice during the study period is shown with dashed lines. Also shown are the approximate harvest sites for the whales landed at Barrow during May 1985.

Definition of Terms

Bowhead whales generally progress with long, presumably deep dives (sounding dives) interspersed with a series of brief, shallow dives (series dives), during which they exhale and inhale each time they surface. The time between sounding dives (while a whale is making its series dives) will be called a surfacing. The number of blows refers to how many times the whale respires during one surfacing.

A blow is generally thought of as a visible vapor cloud created by the condensation of warm, moisture-laden air expelled from the lungs of a cetacean into the atmosphere. However, there was not a visible cloud each time bowheads exhaled (Carroll and Smithhisler, 1980; Würsig *et al.*, 1983). It was apparent from our vantage point (often within 30 m of the whales) that the vapor cloud was much more visible when water pooled in the grooves of the whales' closed external nares and was vaporized upon exhalation. When there was little or no pooled water, the blow was difficult to see or not visible. For the purposes of this report we have defined a blow as each time the whale surfaced during a dive series or each exhalation if the whale stayed on the surface. The blow interval is the time between exhalations within a single surfacing. The respiration rate is the overall number of respirations per minute during a complete dive cycle (the number of blows divided by the surfacing time and the following sounding dive time). Aerial activity refers to spy hopping, breaching, lob tailing or flipper slapping where part of a whale's body is brought out of the water.

METHODS

A primary observer verbally relayed information when whales surfaced, dove, respired or displayed any other surface behavior to a recorder who entered data, including exact times, onto dive profile forms. A digital watch was used to time the events. We used binoculars (with a compass attachment) to observe the whales and an electronic theodolite to locate whale positions. Some whales could be recognized by scar patterns and varying degrees of pigmentation, allowing accurate timing of dive events for particular inidividuals.

Using the behavioral notes and times, we calculated the number of blows per surfacing; the duration of the time on the surface, blow interval and sounding dive; and the respiration rate for each whale. The mean and standard deviation were calculated for each of these categories for all the whales seen diving under the ice and apparently feeding during the spring of 1985 (spring 1985 bowheads). A Student's t-test was used to compare the means of spring 1985 bowheads to whales observed actively migrating during the springs of 1980-85 (spring migrating bowheads) and to whales observed by Würsig *et al.* (1985) during the summer and fall of 1980-84 (summer and fall bowheads).

The stomachs of whales harvested by Inupiat hunters near Barrow were opened and examined for the presence of food. The volume of stomach contents was estimated in the field. The samples were preserved with 10% buffered formalin and placed in an insulated box to avoid freezing. In the laboratory we sorted the subsamples into taxonomic groups and identified prey items using appropriate keys and reference specimens. Representative intact specimens were measured to the nearest 0.5 mm (cephalothorax length for copepods, total length for all other taxa). The volume of each prey taxon was determined to the nearest 0.1 ml by water displacement in graduated containers.

RESULTS

Behavioral Observations

Prior to 25 May, all observed bowhead whales followed the usual migration corridor toward the northeast, parallel to the edge of the lead. Starting on 25 May we saw many whales turn from the migration route and swim to an area about 300 m long, along the seaward edge of the landfast ice in front of the perch, where they repeatedly dove under the ice. This behavior continued until we ended observations 6 June because ice conditions became unsafe. Individual whales stayed in the area up to 15 h, then proceeded along the lead edge to the northeast. We were able to recognize 17 different whales and estimated that at least 60 used the area during the 13 d period. One was recorded diving in the same area at least 18 times.

As the bowhead whales repeatedly dove under the ice we observed a consistent surfacing sequence (Fig. 2). Whales emerged from under the landfast ice and surfaced with their heads oriented away from the edge of the ice or parallel to it. Occasionally, the tip of the rostrum was thrust above the water's surface and water could be seen streaming from the baleen. The whales exhaled immediately when they surfaced, with the first blow being the loudest of the series. They then respired several times while slowly swimming in a circle (usually counterclockwise) until they faced the ice. Some whales kept their backs and blow holes above the surface the entire time, while others made series dives between respirations. As they approached the ice edge the whales arched their backs sharply and made sounding dives, exposing their flukes 34% of the time. The whales inhaled before each dive, and their nares audibly clapped shut just as the blowhole submerged. The fact

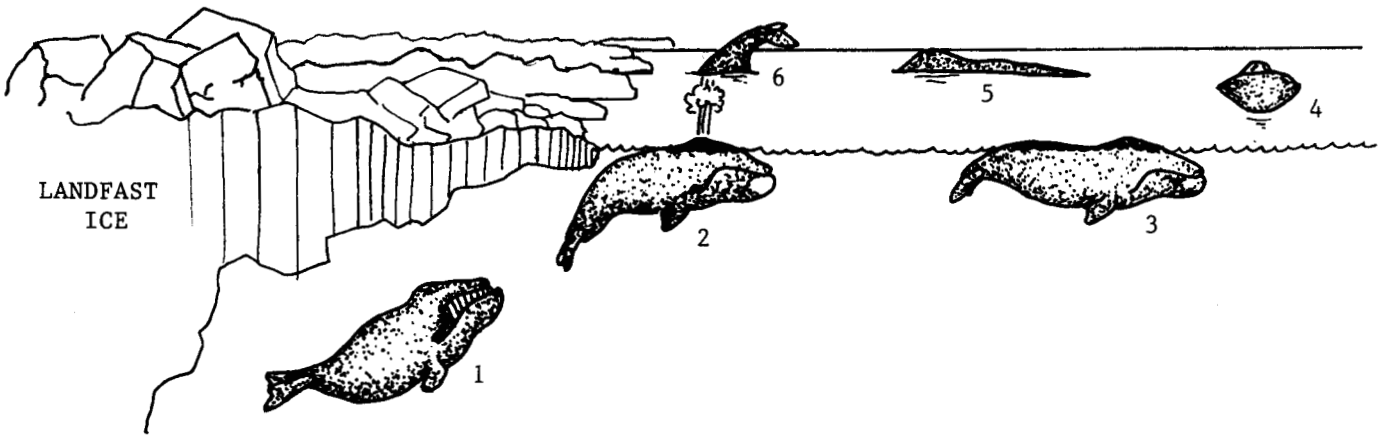

FIG. 2. The observed surfacing pattern of the bowhead whales feeding under the shorefast ice near Barrow, Alaska. Numbers indicate the sequence for a single whale.

that whales inhaled just before their sounding dive and exhaled upon surfacing indicated that air was taken down when they dove.

During this period we generally saw whales in groups of 2-7 (Fig. 3) that surfaced and dove within a few body lengths of one another, sometimes simultaneously. This was in contrast to their normal spring migration behavior, during which bowheads generally travel singly or in loosely associated groups (Carroll and Smithhisler, 1980). Bowhead whales seen in groups during spring migration in the past were generally engaged in mating or other social activities (Carroll and Smithhisler, 1980). However, among the spring 1985 bowheads we saw no mating or aerial activity. Different groups of whales had different tendencies to raise their tails before their sounding dives. For instance, one group that we watched for 15 h on 26 May raised its flukes 8.2% of the time, while another group of whales watched for 4.3 h on 6 June raised its flukes before its sounding dives 57.1% of the time. The whales seemed totally oblivious to observers, although we were standing within 5 m of the whales at times. At this range it was possible to see that the skin on the blowhole region was quite abraded on most of the whales, possibly from pushing up through ice to breathe in other areas.

Diving, surfacing and respiration patterns of spring 1985 bowheads were different from those of spring migrating bowheads and summer and fall bowheads (Table 1; Fig. 4). At $\alpha = 0.05$ there was a significant difference between the measured

TABLE 1. Surfacing, dive and respiration statistics for bowhead whales observed: a) feeding during spring 1985 near Point Barrow, Alaska; b) actively migrating during spring 1980-85 at Point Barrow; and c) during summer and fall 1980-84 in the eastern Beaufort Sea[1]

	Mean	Standard deviation	n	t value[2]	p
Number of blows per surfacing					
a)	12.6	2.20	37		
b)	6.5	2.64	78	11.96	<0.001
c)	4.3	3.19	588	20.90	<0.001
Duration of sounding dive (min)					
a)	14.70	6.513	16		
b)	11.72	5.299	156	2.10	<0.05
c)	4.42	6.319	333	6.35	<0.001
Duration of surfacing (min)					
a)	2.32	0.601	39		
b)	1.59	0.472	19	4.65	<0.001
c)	1.19	1.137	715	10.76	<0.001
Blow interval (s)					
a)	11.9	4.06	361		
b)	13.7	3.69	140	4.72	<0.001
c)	13.5	8.88	5161	6.39	<0.001
Respiration rate (blows·min^{-1})					
a)	0.91	0.422	10		
b)	0.99	0.678	21	0.30	>0.5
c)	1.10	0.873	156	1.27	<0.5

[1]Würsig *et al.*, 1985.
[2]A Student's t-test was used to compare category a) with category b) or c).

FIG. 3. Group of feeding bowhead whales near Point Barrow, Alaska, during May 1985, with landfast ice in the background.

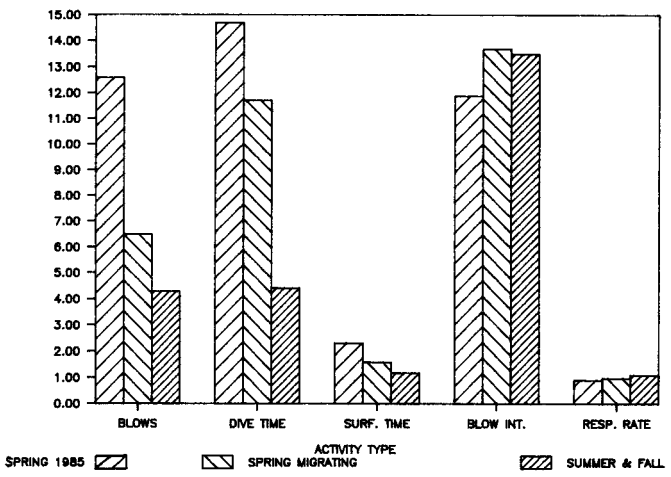

FIG. 4. Mean surface, dive and respiration data for bowhead whales observed: a) feeding during spring 1985 near Pt. Barrow, Alaska (SPRING 1985), b) actively migrating during spring 1980-85 at Pt. Barrow (SPRING MIGRATING) and c) during summer and fall 1980-84 in the Eastern Beaufort Sea (SUMMER & FALL), from Würsig *et al.*, 1985. Parameters shown are: number of blows per surfacing (BLOWS), duration of sounding dive in minutes (DIVE TIME), duration of surfacing in minutes (SURF. TIME), blow interval in seconds (BLOW INT.), respiration rate in blows per minute (RESP. RATE).

respiration patterns of spring 1985 bowheads and both the spring migrating bowheads and summer and fall bowheads in: 1) blows per surfacing, 2) duration of sounding dive, 3) duration of surfacing and 4) blow interval. However, there was no significant difference between the respiration rates of either group.

Stomach Contents of Harvested Whales

The stomachs of all three whales harvested near Barrow in spring 1985 contained substantial quantities of recently eaten food (one stomach contained 16-24 *l*). The stomach contents consisted almost entirely of calanoid copepods and euphausiids (Table 2). Hyperiid amphipods (1-3 individuals per sample) occurred in all three samples. One sample also contained one mysid (*Mysis litoralis*) and three gammarid amphipods (*Rhacotropis* sp. and *Anonyx* sp.).

In two of the samples (85B2 and 85B3) all copepods were *Calanus glacialis*. The other contained approximately 920 *C. glacialis* and 1 *C. hyperboreus*. The *C. glacialis* measured about 3.5 mm in cephalothorax length, had an average unit volume of 0.006 ml and were mostly adult females. Euphausiids in the samples included both *Thysanoessa raschii* and *T. inermis*. Total lengths were 13-22 mm, with unit volumes averaging approximately 0.2 ml. Both adult males and juveniles were present. Adult female euphausiids may also have occurred but were not identifiable due to partial digestion of the specimens.

TABLE 2. Stomach contents from bowhead whales harvested in the spring 1985 subsistence hunt at Barrow, Alaska

	85B1	85B2	85B3
Collection date	9 May 1985	10 May 1985	16 May 1985
Length and sex	9.0 m;male	12.4 m;male	9.5 m;male
Calanoid copepod	47.2%	98.6%	71.7%
Euphausiid	52.8%	1.4%	27.7%
Hyperiid amphipod	trace	trace	0.2%
Gammarid amphipod	—	—	0.4%
Mysid	—	—	trace
Total volumes:			
Sample	12.7 ml	125.7 ml	53.4 ml
Stomach contents	5-10 *l*	16-24 *l*	5-10 *l*

We calculated the overall composition of the bowheads' food based on the proportion of each prey type in each sample, weighted by the estimated total volume of stomach contents (using the midpoints of the range estimates). Based on these calculations, the overall composition of the diet of whales feeding near Barrow in May 1985 was: copepod, 81.1%; euphausiid, 18.7%; and other prey, 0.1%.

DISCUSSION

Examination of stomach contents and behavioral observations shows conclusively that bowheads were feeding in the Point Barrow area during the 1985 spring migration. In addition to our observations, NMML personnel flying aerial surveys observed whales defecating during late May and early June in the vicinity of Point Barrow (Rugh, pers. comm. 1985). This also indicated that whales were feeding in the area.

Feeding occurred over considerable time and distance. We collected stomach contents from a whale on 9 May and observed feeding behavior on 6 June, indicating that feeding activity occurred for over three weeks. Bowhead whales that were harvested presumably fed south of the village of Barrow. NMML personnel observed bowhead whales with sediments streaming from their mouths north of Point Barrow (Rugh, pers. comm. 1985). Würsig *et al.* (1985) state that mud emanating from the mouth is apparently an indication of feeding at or near the bottom. Therefore, feeding activity may have occurred over an area at least 20 km in length.

The behavior we observed indicated intensive use of the area. At least 60 bowheads were seen during a period of 13 d. There were often up to 12 whales feeding at a time. The tendency for the bowheads to use this area so intensively would suggest that there was a large food source attracting the whales.

Point Barrow is periodically an important feeding area for bowhead whales. In addition to what has been reported here, Ljungblad *et al.* (1985a) reported that the largest aggregations of feeding bowhead whales observed during their 1984 fall surveys along the Alaskan and Canadian Beaufort Sea Coast were near Point Barrow. Forty-five to 70 feeding whales were seen on three separate days over a 6 d period (22-28 September). Braham *et al.* (1984) reported bowheads feeding east of the Barrow area during fall aerial surveys in 1974, 1975, 1976 and 1978. Whales taken at Barrow in September 1976 had been feeding mostly on euphausiids (Lowry *et al.*, 1978).

Diving, surfacing and respiration patterns for spring 1985 bowheads were significantly different from spring migrating bowheads and from summer and fall bowheads. Richardson *et al.* (1985) state that in the summer and fall the dominant activity of bowheads was feeding. Not only was the behavior reported here different from normal migration patterns, it was quite different from the feeding usually observed in the Canadian Beaufort Sea. Diving under the ice seemed to require dives of longer duration than either of the other categories, with correspondingly longer times at the surface and more blows. Interestingly, even though the individual elements of the respiration cycles were quite different, there was no significant difference in overall respiration rates between the groups.

Other researchers report dive times more similar to those recorded for spring 1985 bowheads when whales were diving in deep water and when they may have been water column feeding. Ljungblad *et al.* (1985b) reported a mean overall dive time of 9.61 min for undisturbed whales in the Alaskan Beaufort Sea during fall 1984, but a mean dive time of 13.6 min for whales seen diving in deep (30-59 m) water. Würsig *et al.* (1983) report that during 1982 when whales seemed to be water-column feeding the mean dive time was considerably longer (12.08 min) than other years.

Most of the prey species we found in the stomachs of the harvested whales were pelagic, which would indicate the whales were feeding in the water column. The presence of a mysid and gammarid amphipods in 85B3 suggests at least some near-bottom feeding for that whale. The whales we observed diving under the landfast ice raised their flukes above the surface considerably more often (34%) during a sounding dive than during normal migratory behavior (2%), indicating they were making relatively deep dives, which would be required to dive under the ice and feed in the water column. We occasionally saw bowheads coming to the surface with water streaming out of their baleen. This could have been water being expelled as part of a water column feeding process.

Stomach content samples differed in several major aspects from those previously obtained from whales taken at Barrow during spring migration (Lowry and Frost, 1984). First, the stomachs of all three whales examined in 1985 contained food, whereas only four out of eleven examined during 1976-82 contained food. Second, the 1985 whales each contained over 5 *l* (one had 16-24 *l*) of food, whereas 2 *l* of prey was the maximum previously recorded. Third, the composition of the food was different, both in terms of the overall proportion of prey (1985: copepod, 81.1%, euphausiid, 18.7%; 1977 and 1980: copepod, 30.7%, euphausiid, 59.1%) and in their specific identity. The dominant copepod species in 1985 samples, *C. glacialis*, occurred in only two of four previous samples, in which the dominant copepods were *C. hyperboreus*, *Euchaeta glacialis* and *Metridia longa*.

The question arises as to why there were substantial stomach contents and extensive under-ice feeding observed in the Point Barrow area during spring 1985 but not in the past. A possible explanation is that oceanographic conditions could have encouraged high productivity of invertebrates near Point Barrow in 1985. Ice algae blooms occur on the underside of sea ice (Horner and Schrader, 1982) and may attract zooplankton, creating a feeding opportunity for bowhead whales. We happened to be observing near a productive area where whales could swim underneath the ice and feed. Feeding bowheads were again seen on 5 and 6 June *1986* in the Barrow area. We saw at least 9 bowhead whales during aerial surveys 29 km southwest of Point Barrow diving repeatedly underneath landfast ice, and one was seen defecating (George *et al.*, 1987). Similar circumstances may occur at other locations in the spring lead system of the Chukchi Sea, and bowhead whales most likely use these opportunistically during spring migration.

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