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BOWHEAD WHALE *(Balaena mysticetus)* PRELIMINARY RESEARCH RESULTS, JUNE–DECEMBER 1978

March 1979

This report does not constitute a publication and is for information only. All data herein are to be considered provisional.

BOWHEAD WHALE (BALAENA MYSTICETUS) PRELIMINARY RESEARCH RESULTS, JUNE THROUGH DECEMBER 1978*

by

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INTRODUCTION

On June 6, 1978, the Arctic Whales Research Staff, National Marine Mammal Laboratory, NMFS, NOAA, completed a preliminary report covering research conducted on bowhead whales during the spring 1978 (Braham et al. In press). That report formed the basis of a comprehensive summary of the NMFS research and management plans submitted to the International Whaling Commission (IWC) meeting held in London, England, June 1978.

The report that follows is the result of continued bowhead whale research by the NMFS since Braham et al. (In press) and covers the time period June-December 1978. The report includes 1) research which had not been conducted prior to June 1978 (e.g., the chartered vessel Western Viking survey and fall harvest monitoring) and 2) an update of analyses performed on data or material collected prior to June 1978 (e.g., biochemical analysis of tissue parts and evaluation of some biases related to counting whales from ice camps).

The breadth and depth of the bowhead research effort means that some results will take many months to complete, or will have little significance without additional sampling in other years. As such, data analysis is an ongoing process. The following report is a preliminary summary, and will be continuously updated as new data are obtained, or new techniques developed.

This document is primarily for informational input to government and private parties interested in updating themselves as to our activities. Because this report is essentially a continuation of the report we submitted to the IWC in June 1978, much methodology and background material needed to fully interpret this report can only be obtained by reading Braham et

al. (In press) or the report entitled "Bowhead whales - A special report to the International Whaling Commission, U. S. Department of Commerce, NOAA, June 1978, 63 pp.

BOWHEAD POPULATION SURVEYS

FIXED SITE COUNTING STUDY

Factors Affecting Ice Camp Census

A bias has been identified with NMFS ice camp observers estimating distances to sighted whales. This problem is solvable, through rather straightforward mathematical and statistical analyses, and will require completion of appropriate computer programs.

Reports on behavioral observations are progressing at a more rapid rate because this assessment is not iterative in nature as are the above analyses. Further progress of the NMFS ice camp data analysis is planned for the 1979 IWC meeting (June).

Eskimos and NMFS observers at the Alaska Eskimo Whaling Commission (AEWC) sponsored whale counting camp at Barrow began counting on April 24, 1978, one week after the NMFS ice camps were set up. Counts made at the AEWC camp (Table 1) were significantly lower than counts made at the primary NMFS counting station -- South Camp ($P<0.05$). An analysis of the sampling methods employed at the AEWC camp compared with those at the NMFS camp helps explain the discrepancy in counts. The NMFS camp consistently had from 6-12 observers available to conduct 3 hour watches with 2 people per watch, while the maximum number employed at the AEWC camp was 8, though 5 men operated for the major part of the season. As a result, watch

TABLE 1.--Bowhead whale counts and 1978 watch effort for the Alaska Eskimo Whaling Commission ice camp located along the nearshore lead northwest of Barrow, Alaska.

Date		No. hours on watch	No. whales counted, plus conditionals	No. whales/hour		
				Min.	Mean	Max.
April	15	-	-	-	-	-
	16	-	-	-	-	-
	17	-	-	-	-	-
	18	-	-	-	-	-
	19	-	-	-	-	-
	20	-	-	-	-	-
	21	-	-	-	-	-
	22	-	-	-	-	-
	23	-	-	-	-	-
	24	6:05	0/0	0	0	0
	25	20:45	5/1	.24	.27	.29
	26	23:50	3/0	.13	.13	.13
	27	24:00	24/2	1.00	1.04	1.08
	28	11:10	9/1	.81	.85	.90
	29	-	-	-	-	-
	30	-	-	-	-	-
May	1	3:05	16/5	5.19	6.01	6.82
	2	11:37	85/32	7.31	8.69	10.07
	3	24:00	166/32	6.92	7.58	8.25
	4	24:00	13/2	.54	.58	.63
	5	24:00	15/1	.63	.65	.67
	6	24:00	36/4	1.50	1.58	1.67
	7	24:00	2/0	.08	.08	.08
	8	24:00	43/4	1.79	1.88	1.96
	9	24:00	60/0	2.50	2.50	2.50
	10	24:00	60/0	2.50	2.50	2.50
	11	24:00	73/9	3.04	3.23	3.42
	12	24:00	152/10	6.33	6.54	6.75
	13	23:40	34/1	1.44	1.46	1.48
	14	24:00	29/4	1.21	1.29	1.38
	15	23:30	26/1	1.11	1.13	1.15
	16	24:00	13/0	.54	.54	.54
	17	23:05	1/0	.04	.04	.04
	18	21:00	2/0	.10	.10	.10
	19	20:45	8.0	2.59	2.59	2.59
	20	-	-	-	-	-
	21	17:00	1/0	.06	.06	.06
	22	24:00	3/0	.13	.13	.13
	23	24:00	3/0	.13	.13	.13
	24	24:00	3/0	.13	.13	.13
	25	-	-	-	-	-
	26	-	-	-	-	-
Totals		21:00*	885/39			

*Average hours of watch for those days a watch was kept

periods at the AEWC camp were 4-8 hours long, often with one person on watch. Fatigue causes an important negative bias. We believe that observational performance decreases dramatically after 3 hours of watch. The NMFS camps had 2 observers working per watch while the AEWC had only one observer for most of the season. Results from past years indicate that 2 observers are likely to be more effective in seeing whales than one.

Camp placement is apparently an important variable when censusing bowheads. The NMFS South Camp was north of Pt. Barrow, and the AEWC camp approximately 5 km south of the NMFS South Camp. The lead width adjacent to the AEWC camp was consistently wider than at the NMFS camp; thus whales probably funneled past the NMFS camp in greater concentration than by the AEWC camp.

A second test (correlation coefficient, r) was applied to the AEWC and NMFS South Camp data to assess whether the variation in the daily rates of whales passing was consistent for the two camps. The correlation coefficient indicated a very close degree of fluctuation in the number of whales passing the two camps ($r_{0.05(2)24} = 0.330$; $r_{sample} = 0.960$), indicating that, although the AEWC observers counted fewer animals, they were consistent in their underestimates throughout the season. This suggests that the difference in counts between the NMFS and AEWC camps was probably because of a difference in methodology and/or environmental conditions. The factors which may have contributed to the difference, then, were: variations in sampling technique, notably watch periods and the number of observers on watch, and different camp locations.

Because of the watch activity by members of the AEWC camp, we now have a better understanding of the difference in performance as a result of watch

length and ice camp placement. To reduce negative bias when conducting bowhead counts from the ice, 2 observers should be placed on watch for short time periods (4 hours). Variability in counts due to camp location may be explained as we learn more about the movement of whales around Pt. Barrow.

Sightings Recorded in Eskimo Logbooks

Using logbooks supplied by the National Marine Mammal Laboratory, NMFS, NOAA, Alaskan Eskimo whalers recorded sighting data on bowhead and white whales (Delphinapterus leucas) during the 1978 spring hunt. Thirty-seven whaling crews from four villages participated by recording observer effort and numbers of whales seen at Gambell from April 9 to May 7, near Southwest Cape, St. Lawrence I. (Savoonga whalers) April 15 to 16, at Point Hope from April 24 to May 22, and at Barrow from April 17 to May 22. Observer effort among villages generally varied from 25 to 50% of the total number of hours of light available for counting whales (generally 20-24 hours per day).

Numerical analysis of logbook data was difficult because: 1) duplicate animals were not specified either between or within crews; 2) time of sighting was not always recorded; 3) start and finish of watch period were frequently not listed; and 4) the relative location of whaling crews to each other on the ice was not known. Given these limitations, it was felt that a measure of relative abundance over time could be achieved by dividing the total number of whales observed by all crews by the total number of crews per village to yield mean number of whales seen by village per period of observation. This calculation allows comparison on a village by village basis.

Mean number of bowhead whales was highest at Barrow, where 258 animals were recorded, compared to 190 at Gambell, 89 at Point Hope, and 75 by Savoonga whalers. Logbooks were not available from Wainwright. Correspondingly, 446, 147, 77, and 0 white whales were recorded by Point Hope, Barrow, Gambell, and Savoonga whalers, respectively. The bulk of the bowhead and white whales recorded at each village were seen over a narrow time span, suggesting that these species travel in waves of varying densities. "Pulses" in the bowhead migration occurred April 14-21 at Gambell, May 1-3 at Pt. Hope, and April 29-May 2 at Pt. Barrow. The wave of bowheads recorded at Gambell may have been the same wave logged at Pt. Hope and Pt. Barrow. The difference in time (15-20 days) and distance (300-500 km) is within the traveling speed (1-4 kn) estimated by Braham et al. (In press) for whales migrating during spring 1978.

Cape Lisburne Land Camp

Between May 29, the last day covered in the preliminary spring report (Braham et al. In press), and June 7, 1978, the last day of research at Cape Lisburne, 100.7 hours were spent on watch, of which 96.7 hours were in fair to excellent visibility. No bowhead whales were sighted during this period.

Between April 2 and June 7, the duration of the study at Cape Lisburne, 690.7 hours were spent on watch, and 280 bowhead whales were sighted (maximum count). By treating sightings as counts per unit time, estimates were made for each day and extrapolated to a total count of 478 bowheads. This estimate is based on a more conservative approach to interpolating for unwatched periods than was used in Braham et al. (In press), in which interpolations were made for all questionable periods. Counts

from Cape Lisburne were lower than at Pt. Barrow because: 1) frequent periods of fog occluded the view; 2) the immense viewing area could not be adequately covered by only one or two observers at a time; and 3) we believe that in 1978 most bowheads migrated past Cape Lisburne on a northeasterly course farther offshore than we were able to see -- given the frequency of reduced visibility.

A test was made to evaluate the accuracy of designating "duplicate" sightings of what the observers assumed to be the same whales. Whales were often recorded during several series of blows, each blow considered to be from the same whale. By plotting these sightings in the laboratory and examining routes of travel with three or more bearings, we were able to evaluate designations assumed to be duplicates. Where plotted routes showed abrupt turns, backtracking, or unrealistic speeds, the duplicate designations were considered suspect. Out of 26 sightings considered duplicates, 9 (35%) appeared to be inaccurately (i.e. questionably) designated. In 7 (78%) of these questionable duplicates, the observer had indicated confidence that only one whale was being followed. The number of whales present was therefore greater than we observed. It is impractical to now correct for possible erroneous duplicate designations. However, it was evident that new whales were seen but not recorded because of the confusion with counts of nearby whales.

The positions (true north bearings) of bowheads in the leads were calculated as a ratio of the distance between a whale and the pack ice and the distance between the pack ice and the shorefast ice (i.e., the width of the lead). All bearings were made on common azimuths. Analysis of the

ratios (where n = 19) show that most bowheads were sighted beyond the middle of the lead, and over one-half (11) of the sightings were within 20% of the distance from the pack ice. Thus, bowheads tend to follow the far shore of the lead as they pass Cape Lisburne. As the season progressed, the pack ice and whale sightings tended to be further offshore. This tendency is not an artifact of increased observer ability, as some of the greatest distances to sightings were recorded early in the season. Most whales passing Cape Lisburne probably did not follow the coast even when distinct leads were available there; they followed a course that kept them on the west side of visible leads and in polynyas beyond the nearshore lead. Bowheads apparently pass Pt. Hope farther offshore than at Pt. Barrow. Although many are in the nearshore lead at Pt. Hope, too, most do not appear to begin moving into the nearshore lead until they pass Cape Lisburne. This is, of course, also supported by whalers from Point Hope.

St. Lawrence Island Summer-Fall Counts

From May 16 to December 31, 1978, daily observations of whales were made by Mr. Donald Harry, a resident of Gambell, St. Lawrence Island. The purpose of this cooperative research was to document the seasonal timing of whale movement to the west end of the Island and, in particular, to determine 1) if bowheads are present during the summer months, and 2) the timing of bowhead movements near the Island during the fall and winter months, when the pack ice retreats south. Observations were made by Mr. Harry from strategic points along the coast near the village, and sightings of all species of whales were reported to Mr. Harry from resident walrus and seal hunters.

Bowhead whales were routinely seen in the spring to May 20, 1978, then only sporadically to the end of May. Ten bowheads were seen May 16-20, and one bowhead or gray whale (Eschrichtius robustus) was seen on May 26. One tentative sighting of a bowhead or gray whale was made on July 3, but no other bowhead sightings were made throughout the summer. The first fall sighting of a single bowhead occurred on September 26. One bowhead was seen on October 13; 2 and 5+ on November 7 and 13 respectively; and 1, 2, and 1 on December 2, 11, and 21, respectively. The majority of sightings from May 16 to December 31 were of gray whales (89+; most from late May to August); fin (Balaenoptera physalus) and/or minke (Balaenoptera acutorostrata) whales (64; most from July to October); white whales (15 on May 31 and 7 on December 18); and killer whales (Orcinus orca) (8 on June 28; 8 on July 23, and a "group" on October 10).

Many sightings of bowheads were made near Gambell in January 1979, somewhat later than usual (Conrad Oozeva, Gambell, St. Lawrence I., AK 99742. Pers. commun., January 31, 1979), as most fall southbound migrating bowheads are generally seen in December. December 1978 and January 1979 appeared to have been mild as far as the extent of the pack ice is concerned; however, in February the pack ice surrounded the Island, and no bowheads were seen.

SUMMER-FALL VESSEL SURVEYS

No information is available on the number of whales, if any, which migrate into Soviet waters during or after the spring migration. Late summer and fall arrival of bowheads in north Siberian waters is well documented (Townsend 1935; Tomilin 1957). These whales are believed to be

part of the migration across the Arctic Ocean from the Beaufort Sea to the Chukchi Sea. Townsend's (1935) records indicate that bowheads formerly migrated into the Chukchi Sea during the summer months. Commissioners of the Alaska Eskimo Whaling Commission at a meeting in Barrow, Alaska, April 13, 1978, stated that they believe large numbers of bowhead whales migrate into Soviet waters and, thus, would represent a potentially important component of any population estimate. This hypothesis was the basis for our original plan in 1977 to conduct a vessel survey in the open water areas of the northern Bering Sea and southern Chukchi Sea at the conclusion of the spring 1978 whale hunt.

This section reports on a vessel survey into the Bering and Chukchi Seas in June and July 1978 aboard the chartered F/V Western Viking to search for bowhead whales not accounted for in the spring migration. Our objectives were to determine if bowheads still migrate north into the Chukchi Sea during the summer and what, if any, correction factor should be applied to the Pt. Barrow counts for estimating the population size.

Also included in this section are vessel survey data from the NOAA research ship Surveyor, the Soviet sealing vessel Zubarevo, and the U. S. Coast Guard icebreaker Northwind during their respective surveys in the Bering, Chukchi, and Beaufort Seas during 1978. Data from these surveys were supplied by scientists and crew members aboard those ships.

Chartered Fishing Vessel Western Viking

The NMFS summer survey to locate late migrating bowhead whales was conducted aboard the F/V Western Viking, a 31 m long crab boat. The survey began at Seward, Alaska, on June 14 and ended in Nome, Alaska, on July 15, 1978. The vessel survey plan followed the route shown in Figure 1.

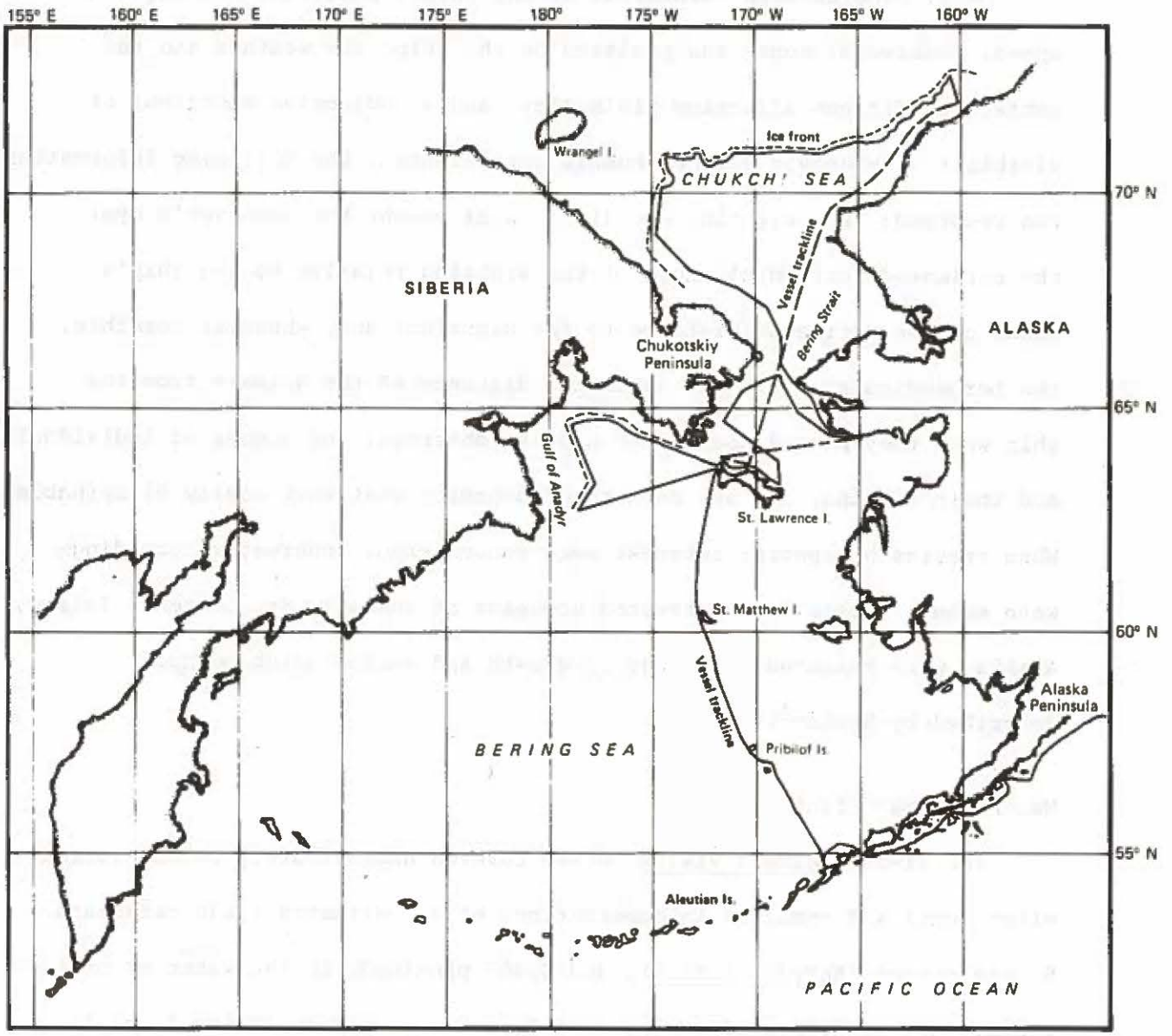

Figure 1.--Bowhead whale study area and vessel survey tracklines north (———) and south (— —) during the F/V Western Viking survey June 14 - July 15, 1978. Smaller dashed lines (---) represent the ice front.

Watches were maintained along the route on a 24-hour basis. Locations of the observers on the ship varied with weather and visibility.

Daily records were maintained of the ship's position, heading and speed, observers' hours and position on the ship, the weather and sea surface conditions affecting visibility, and a subjective appraisal of visibility. Whenever marine mammals were sighted, the following information was recorded: the sighting cue (i.e., what caught the observer's eye); the estimated horizontal angle of the sighting relative to the ship's heading; the estimated distance to the sighting, and, whenever possible, the perpendicular angle and estimated distance of the animals from the ship when they passed abeam; the species observed; the number of individuals and their heading; and any aspects of behavior that were easily discernable. When species of special interest were encountered, underwater recordings were made. Skulls from harvested bowheads at Gambell, St. Lawrence Island, Alaska, were measured for study of growth and ageing using methods described by Braham[1/].

Marine Mammal Sightings

The 31-day Western Viking survey covered approximately 5,500 nautical miles (nmi) and resulted in observations of an estimated 1,238 cetaceans, 51 sea otters (Enhydra lutris), and 4,463 pinnipeds in the water or on ice floes. All sightings of marine mammals are reported in Tables 2 and 3.

1/ H. W. Braham. Skull bone measurements of bowhead (Balaena mysticetus) and gray (Eschrichtius robustus) whales at Kialegak and Gambell, St. Lawrence I., Alaska, 1977-1978. Unpubl. manuscr., Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115.

TABLE 2.--Number of cetaceans sighted, by area and species, during the NMFS bowhead whale survey aboard the Western Viking in the Bering and Chukchi Seas, June 14 - July 15, 1978.

Species	Area				Total
	Seward to Dutch Harbor	Dutch Harbor to St. Lawrence Island*	St. Lawrence Island to Diomede	Chukchi Sea	
Gray whale	2	14	664	364	1,044
Fin whale	4	0	0	0	4
Minke whale	7	2	5	0	14
Killer whale	5	5	0	13	23
Dall porpoise	77	10	0	0	87
Harbor porpoise	26	0	1	5	32
Unidentified whales	10	8	3	7	28
Unidentified porpoises	1	0	2	3	6
Total	132	39	675	392	1,238

*Includes Gulf of Anadyr

TABLE 3.--Number of pinnipeds and sea otters sighted, by area and species, during the NMFS bowhead whale survey aboard the Western Viking in the Bering and Chukchi Seas, June 14 - July 15,1978.

Species	Area				Total
	Seward to Dutch Harbor	Dutch Harbor to St. Lawrence Island	St. Lawrence Island to Diomede	Chukchi Sea	
Walrus	0	0	13	4,469	4,482*
Northern sea lion	33	2	0	0	35
Northern fur seal	25	5	0	0	30
Bearded seal	0	0	1	21	22
Ringed seal	0	0	1	20	21
Ribbon seal	0	13	1	0	14
Spotted seal	0	0	1	6	7
Harbor seal	0	4	2	0	6
Unidentified pinnipeds	2	6	1	19	28
Sea otter	51	0	0	0	51
TOTAL	111	30	20	4,535	4,696

*Does not include counts on King Island

No bowheads were observed despite nearly ideal observation conditions over much of the survey route, particularly in the northern Bering and southern Chukchi Seas, and along the ice edge, where bowhead whales might have been expected. There are several possible explanations why we found no bowheads where Townsend (1935) reported them taken. Bowheads harvested in the Bering Sea prior to 1919 may have represented the southern fringe of a broader distribution of the overall populations, now severly depleted. Secondly, they could have represented whales taken south of the pack ice during extensive ice years when the population was displaced further south. A third possibility is that bowheads taken prior to 1919 may have represented a segment of the population not predisposed to migrating early in the spring, and therefore the first and most heavily hit by Yankee whaling. This segment of the population gene pool may now be eliminated. Whatever the explanation, we encountered no bowheads south of the ice front or in other areas covered during the Western Viking summer survey in the Bering and Chukchi Seas, including Soviet waters.

NMFS summer aerial surveys, along with statements of Eskimos from Little Diomede Island and the villages of Gambell and Savoonga, gave additional evidence that bowheads are not present in these areas during the summer months (see section on aerial surveys, p. 20; Donald Harry and Conrad Oozeva, Gambell, St. Lawrence I., and Patrick Omiak, Little Diomede I. Pers. commun.).

Whale Skull Measurements

From June 27 to 29, 1978, four NMFS personnel remained on St. Lawrence Island to locate and measure bowhead and gray whale skulls as part of an ongoing morphometrics study of development and ageing in these species.

Near Gambell, 113 bowhead whale skulls of varying sizes were located and measured. The results of this study will be reported after a follow-up study, planned for the summer of 1979, is completed.

Passive Sonar Recordings

The results of the acoustic recordings (using passive sonar) made during the Western Viking survey are incomplete as of this writing; however, no bowhead whale vocalizations have been identified at this time.

NOAA Research Ship Surveyor

During the period April 25 - May 14, 1978, the NOAA ship Surveyor surveyed the area from the southern edge of the pack ice in the Bering Sea, including St. Lawrence Island. On May 7, 1978, at 0710, one tentative sighting of a bowhead whale was made at lat. 61°15'N, long. 172°41'W. At 0835 on the same date, one bowhead was sighted along the ice edge at lat. 61°16'N, long. 172°13'W. Other marine mammal sightings were made, but none were of bowhead whales.

Soviet Sealing Vessel Zubarevo

On August 4, 1978, Geoff Carroll, NMFS, National Marine Mammal Laboratory, boarded the Soviet sealing vessel Zubarevo at Barrow, Alaska. The vessel departed Barrow and proceeded southwestward along the ice edge to a point 30 km northwest of Wainwright, Alaska. The vessel remained in this area until August 13, then gradually worked west, arriving off Herald Island on August 14. The cruise proceeded south through the Bering Strait to Arakamchechen Island, and on to Gambell, where Carroll disembarked on August 16. During this cruise no bowheads were observed, even though coverage was very thorough in the area along the ice front (lat. 70°55'N, long. 160°32'W to lat. 71°57'N, long. 160°59'W).

USCG Icebreaker Northwind

The U.S. Coast Guard icebreaker Northwind was working in the Beaufort Sea from August 15 to September 15, 1978. Unfortunately, detailed records on marine mammal sightings were not maintained. No bowhead whales were seen during the first two weeks of the survey (K.J. Frost, Alaska Department of Fish and Game, 1300 College Road, Fairbanks, AK 99701. Pers. commun.) but during the rest of the cruise no records were kept by scientists on board.

Implication of Results

The cumulated 1978 sighting data from aerial surveys and three separate research vessel surveys in the area south of the ice front in the southern Chukchi Sea during the summer months indicate that bowheads do not occupy as great a range as they did prior to commercial exploitation. Although considerable survey effort was expended in the southern portion of this species' historical summer range, bowhead whales were not seen. Bowheads are apparently not present in any substantial numbers south of the ice front in U.S. or Soviet waters.

Results from the spring and summer research effort suggest that the bowhead population spends the summer months in the Beaufort Sea prior to migrating into the Chukchi and Bering Seas in late fall and early winter. Observations of bowhead whales along the northeast coast of the Chukotskiy Peninsula in September 1974 and September 1975 suggest that the migration route into the Chukchi Sea from the Beaufort Sea is, at least in part, by way of Herald Island (A. A. Berzin, Pacific Scientific Research Institute of Fisheries and Oceanography (TINRO), 20 Lenin Street, Vladivostok, U.S.S.R. Pers. commun.). This seems to corroborate Townsend's (1935) data.

Although we feel confident that our survey coverage was as complete as could be achieved under the limitations of time, personnel, funding, and clearance into Soviet waters, some bowheads may have avoided our detection during this year's study and moved into Soviet waters between April and June. However, landfast ice is generally extensive, and pack ice is heavy northwest of the Bering Strait along the north Siberian coast of the Chukotskiy Peninsula, as winds in the spring are generally from the northeast. It seems unlikely that any persistent leads develop along the Soviet north coast, and thus few bowheads, if any, would be present. This is substantiated by the fact that there are no known Siberian Eskimo whaling villages along the north coast of the Chukotskiy Peninsula, and yet Eskimos used to take bowheads at villages along the south and east coasts of the Peninsula (A.A. Berzin. Pers. commun.). Today, bowheads are not taken by these villages because it is prohibited by the Soviet government.

Since no bowheads were sighted after the spring migration period during these vessel surveys, it does not appear as though a correction factor is needed in our spring 1978 population estimate.

AERIAL SURVEYS

Aerial surveys were conducted between June 8 and October 30, 1978, to: 1) determine the duration of the bowhead spring migration following the termination of the census effort at Pt. Barrow, 2) delineate the temporal and spatial distribution of the bowhead fall migration in the Beaufort Sea, and 3) assess whale movement in relation to sea ice conditions.

June: Bering-Chukchi Seas

From June 8 to 11, 19.3 hours were flown over open water and along sea ice leads from Pt. Barrow to St. Lawrence and Nunivak Islands. This was an attempt to delineate the distribution of bowhead whales in the eastern Chukchi and northern Bering Seas following the principal known spring migration into the Beaufort Sea. No bowhead whales were seen during these surveys (Table 4). Unless there were animals in unsurveyed areas of the Chukchi Sea (which was mostly solid pack ice), this survey suggests that most, if not all, bowheads migrated north and east into the Beaufort Sea during the spring. No assessment of whales migrating along the Soviet coast was made beyond the May 22 sighting of 6 whales north of the Bering Strait (see Braham et al. In press), because we did not receive permission to fly any closer to the Soviet mainland than 10.5 nmi to sample nearshore leads. Generally, there is less open water available along the north side of the Chukotskiy Peninsula in the spring than north and east of the Bering Strait, as viewed from NOAA satellite photographs and seen from our surveys conducted since 1976. This part of the Soviet coast remains an important area to survey.

September: Beaufort Sea

From September 7 through 21, 22.8 hours were flown between Kotzebue and Barter Island searching for bowhead whales before the expected fall migration westward in the Beaufort Sea. One tentative sighting of a bowhead whale was made between Pt. Barrow and Lonely. The paucity of sightings indicates that bowheads may have been in the eastern Beaufort Sea

Table 4.--Bowhead whale aerial surveys, June 8 to October 30, 1978.

Date	Survey origin	Survey termination	Survey time (hrs)	Bowhead counts
June 8	Barrow	Cape Lisburne	4:42	0
8	Cape Lisburne	Kotzebue	:44	0
9	Kotzebue - Bering Strait	Nome	6:16	0
10	Nome	St. Lawrence I.	4:22	0
10	St. Lawrence I.	Nome	:33	0
11	Nome	Hooper Bay	2:07	0
11	Hooper Bay	Bethel	:28	0
Sept 7	Kotzebue	Pt. Lay	2:13	0
8	Pt. Lay - 72°N, 167°W	Pt. Lay	4:13	0
9	Pt. Lay	Pt. Barrow	1:37	0
12	Barrow	Barrow	:57	0
14	Barrow	Lonely	3:16	1?
15	Lonely	Deadhorse	3:07	0
15	Deadhorse	Oliktok	:09	0
16	Oliktok	Oliktok	1:33	0
17	Oliktok	Deadhorse	1:31	0
17	Deadhorse	Barter I.	1:30	0
18	Barter I.	Barter I.	:46	0
21	Barter I.	Barrow	1:49	0
Oct 9[1/]	Barrow - Barter I.	- Barrow	3:06	0
13[1/]	Barrow - Deadhorse	- Barrow	4:12	0
14[1/]	Barrow - Oliktok	- Barrow	:31	0
16[1/]	Barrow - 72°N, 158°W	- Barrow	7:22	9
17[1/]	Barrow - Barter I.	- Barrow	9:01	0
18[1/]	Barrow - 72°N, 158°W	- Barrow	4:10	4
20[1/]	Barrow - 72°N, 169°W	- Barrow	5:46	0
22	Barrow - 72°N, 159°W	- Barrow	4:07	11
27	Barrow - 72°N, 159°W	- Barrow	3:48	2
28	Barrow - Wainwright	- Barrow	5:28	0
30	Barrow - Barter I.	- Barrow	4:25	0
Totals			93:49	26-27

1/ Opportunistic flights not directed towards searching for whales

during the summer, as suggested by Braham and Krogman (1977[2/]) and Fraker et al. (1978), and that the 1978 fall migration was not significantly underway until late September. Frequent periods of high winds and fog precluded more extensive surveys.

October: Beaufort Sea

From October 9 through 28, 1978, 7 aerial surveys totaling 33.6 hours were flown between lat. 71°00'N - lat. 72°20'N and long. 143°40'W - long. 171°00'W. At least 26 bowheads were seen, excluding potential duplicate sightings.

Bowheads were seen repeatedly in leads packed with 50-80% drift ice, while white whales were sighted in open water areas. The bowheads did not exhibit migratory behavior but were often seen milling and occasionally feeding. The last report of a whale passing the Pt. Barrow area was on November 4. Survey conditions beyond this point were unfavorable due to short day lengths and inclement weather.

During the same period, 4 flights, totaling 18.4 hours, were made by Naval Arctic Research Laboratory scientists. These flights were part of an ice reconnaissance study and, because they took place over ice, no bowheads were seen.

[2/] Braham, H., and B. Krogman. 1977. Population biology of the bowhead (Balaena mysticetus) and beluga whale (Delphinapterus leucas) in the Bering, Chukchi and Beaufort Seas. Proc. rep., 28 p. Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115.

YANKEE WHALERS' LOGBOOK STUDY

The contract with the Old Dartmouth Historical Society Whaling Museum in New Bedford, Massachusetts, to assess bowhead whale distribution and abundance prior to commercial exploitation, is progressing on schedule. Approximately four-fifths of the logbooks and records have been reviewed. An estimate of the size of the western Arctic stock prior to 1848 is being developed using a 10% sample of existing records. A description of distribution and an estimate of early stock size are expected to be available for the June 1979 IWC meeting.

HARVEST AND STOCK ASSESSMENT

BIOLOGICAL STUDIES

Biochemistry and Genetics

The biological work undertaken since June 1978 has been primarily concerned with the question of stock discreteness. We have begun electrophoretic studies of blood proteins and liver enzymes to detect protein heterozygosity. Although speculative at this time, such heterozygosities may prove to be useful in the identification of stocks. One question we had hoped to explore is whether animals designated as ingutuks (or ingutuqs) might have different proteins, or have biochemical-genetic heterozygous forms.

Liver tissue from 7 whales was analyzed. Of the 30 enzyme systems tested, 6 (20%) exhibited variability in at least one individual. Further extrapolation indicated an average individual is heterozygous at 4% of its gene loci. The whale with the greatest variability differed in 4 of 30 enzymes but did not possess the morphological attributes of an ingutuk. Conversely, the ingutuk tested was not distinguishable from the other

bowheads by electrophoresis.

Blood protein analysis provided similar results. Of 3 whales sampled in 1978, all had identical hemoglobins. One whale differed from the others at one protein peak. Once again the variant animal was not an ingutuk.

These analyses, together with previous karyotype (where 2n=42 for bowheads) examinations, suggest that the population of bowhead whales maintains some enzymatic heterozygosity that does not manifest itself morphologically. The preliminary conclusion reached by Braham et al.[3/] is that the ingutuk is within the normal range of variation in the bowhead population, and that both are the same species.

Ageing

Measurements of harvested animals collected by researchers over the past five years are being analyzed for morphometric correlations useful in ageing studies. Although we have measurements from 101 bowheads, the records from each animal are incomplete. From preliminary analysis it appears that girth is not linearly correlated with total length. There is a disproportionate increase in girth with an increase in length once the whale exceeds 1,400 cm (47 ft). Also, there is no correlation between blubber thickness and total length of the animal. In addition, we have been able to evaluate the accuracy of some of the

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[3/] H. Braham, F. Durham, G. Jarrell, and S. Leatherwood. 1979. Ingutuk: Preliminary evaluation of a bowhead whale (Balaena mysticetus) morphological variant. Unpubl. manuscr., 15 p. Natl. Mar. Mammal Lab., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115.

measurements in light of their usefulness in age analysis.

We have been using X-rays and a thickness measuring device to study baleen plates. A pilot experiment to determine if growth layers are detectable by X-rays was unsuccessful and has ended. It is too early to determine how useful the baleen plate ridge measuring device will be.

Pathology

Intestinal sections sent to pathologists in the spring of 1979 have contained a parasitic trematode that was not known to occur in bowheads (L.M. Shults, University of Alaska, Fairbanks, AK 99701. Pers. commun.).

Projected Research

Other projects underway include histological work-up (baseline histopathology), reproductive assessment of ovaries and testes (maturation and incidence of pregnancy), and age determination using eyes and earplugs as possible source materials. See Appendix II for cooperating scientists.

FALL HARVEST

At the conclusion of the spring 1978 season 10 whales had been landed and 15 struck. The 1978 quota of 12 landed and 18 struck was not filled during the spring hunt; the remainder of the quota was, therefore, available for the autumn hunt and was allocated to the villages of Kaktovik on Barter Island (1 landed or 2 struck) and Nuiqsut (1 landed or 1 struck). Barrow had no additional fall allocation prior to October 19. Effective that date, the IWC increased the 1978 quota by 2 landed and 2 struck resulting from the adoption of an amendment to the Schedule of the International Convention for the Regulation of Whaling 1946. The increase was assigned to Barrow.

The AEWC advised the NMFS on August 22 that it had decided to ignore the IWC quota and establish its own quota for the autumn hunt, consisting of: 1) Kaktovik - 2 whales landed, or 3 whales struck, whichever came first; 2) Nuiqsut - 2 landed or 3 struck; and 3) Barrow - 6 landed or 9 struck. These amendments to the AEWC management plan increased the annual quota to 20 whales landed or 30 struck, in contrast to the IWC quota of 14 whales landed or 20 struck.

Kaktovik

The whaling season at Kaktovik began on September 14. NMFS biologists were stationed in the village from September 13 to October 2 to monitor the harvest. Five crews actively participated in whaling at Kaktovik during the autumn season. One whale was struck but lost on September 15, and a second struck and lost on September 17. The hunters ceased whaling at this time in observance of the IWC quota established for their village, but they continued to search for the two lost whales. On September 22 the whale that had been struck on September 15 was located and recovered as a "stinker". It was a 1,107 cm (36 ft 4 in) long male. On September 20, the village of Nuiqsut reassigned its quota to Kaktovik whalers who returned to the hunt and succeeded in taking a second whale on September 26. This animal was a 1,334 cm (43 ft 9 in) long male. After the carcass had been cut up and placed in storage, the hunters of Kaktovik ceased whaling.

In addition to the two bowhead whales landed at Kaktovik, two white whales from a group of about 100 were taken about September 1. The hunters declared that the harvest this year was better than the average at Kaktovik.

Barrow

NMFS observers were stationed at Barrow from September 6 to November 1 to monitor the harvest. Unfavorable winds and fog severly limited whaling and few animals were sighted. Approximately 10 crews participated sporadically in the hunt from September 16 to October 13, when the formation of new ice prevented the use of boats. On November 3, however, favorable winds moved the ice away from the shore and at least one boat was reported to have resumed the hunt. On this date a single bowhead was sighted by the whalers, but they were unable to approach it closely enough to make a strike. The ice returned to the shore on November 5, ending the whaling season.

No whales were landed by Barrow whalers during the autumn season. An unsuccessful strike was alleged to have occurred on or about October 3.

PASSIVE SONAR RESEARCH

FIXED HYDROPHONE ARRAYS

The National Marine Fisheries Service bowhead research group is seeking to determine whether or not bowhead whales can be identified and counted using passive sonar techniques. In the spring of 1978 we found that at least some bowheads vocalized while passing Pt. Barrow, Alaska (Braham et al. In press). But questions immediately arose concerning the range of sound detection, and what proportion of the whales seen were vocalizing. Answering these questions requires knowing the precise location of the sound source and comparing that position to the position of an observed whale.

Several systems have been developed for locating bioacoustic sources, including whales, in the sea. One system, possibly adaptable to our

needs, makes use of the fact that sound travels through sea water at a known speed. The system measures the differences in time-of-arrival of a given sound at two or more hydrophones, and converts those measurements into a plotted position of the sound source.

Acoustic Array Test

In August 1978 we contracted with the Moclips Cetological Society, Moclips, Washington, to test a multi-hydrophone array and appropriate receiving equipment in an area of Puget Sound frequented by killer whales. Results of the test were expected to show whether this type of system might be useful in censusing bowhead whales, i.e., to help determine if visually undetected bowheads are passing the census camps, and if a sound source can be coupled to an animal under observation. The test site for the acoustic array test was on the west side of San Juan Island, Washington, about 16 km northeast of Victoria, British Columbia. Haro Strait, the separating waterway, is a channel frequented by killer whales (Figure 2).

The hydrophone array was deployed within 200 m of shore, below a house which served as a test control center and observation post for whale watching. The array consisted of 3 sets of 3 hydrophones each, arranged as shown in Figure 2. Hydrophone separation in each triangular set was about 50 m. Sets were located at depths ranging from 6 to 20 m; individual hydrophones were held about 1 m off the bottom by floats. For test calibration, 2 of the 3 sets were equipped with transducers which could be activated from the shore control center.

Hydrophone signals transmitted by cable to the control center were amplified and recorded on a multichannel tape recorder. When desired,

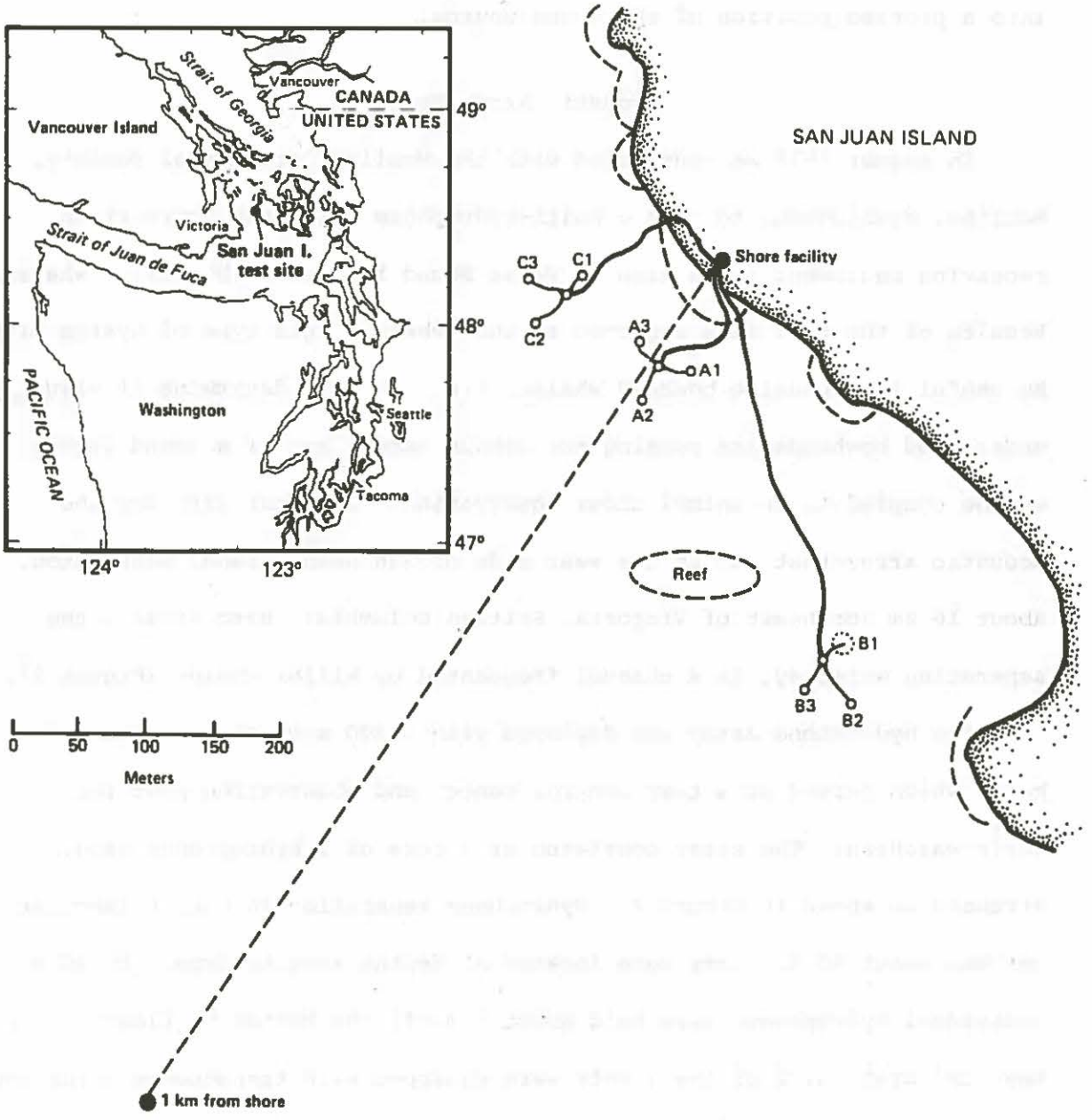

Figure 2.--Passive sonar test array deployed August 1978 in Haro Strait, off San Juan Island, Washington.

incoming signals (or taped signals replayed) could be displayed on a dual trace oscilloscope, or signal amplitude from each hydrophone could be compared on a 14 channel VU meter.

Killer whales were visually or acoustically detected within range of the test facility on 19 of the 30 days the test array was operational during September. Acoustic signals from the whales were received 18 of the 19 days the whales were within range, usually well in advance (up to 17 min) of visual sighting. At night, acoustic detection was the only evidence that whales were passing.

Comparison of signal amplitude from the 3 hydrophone sets indicated the direction the whales were moving. Visual locations of whales using a transit established the range of detection of vocalizing killer whales at over 6 km. Approximately 18 hours of acoustic recordings were made when whales were within 5 km of the test array.

Evaluation of Test

Previous experiments of this type have shown that the precision of locating a sound source decreases with increasing distance of the source from the array. The test described here did nothing to overcome this problem, nor was it expected to. This test did result in vocalizations of wild whales being recorded through a multi-hydrophone array, demonstrating some advantages of acoustic detection of whales over visual techniques alone for vocalizing whales. Most important, it provided us with a partial demonstration of what would be involved were an attempt to be made in the arctic to count bowhead whales acoustically. The tests showed 1) that killer whales could be consistently detected acoustically before they were

visually observed, thus providing an important cue to the observation effort, and 2) that some whales were heard but not seen.

To find the proportion of passing bowheads that are vocalizing (i.e., by being able to determine whether a particular sighted whale is vocalizing or not) would require analysis of incoming hydrophone signals on a real-time basis (within seconds) with the position of the whale electronically displayed on a chart of the study area. Also, to determine precisely the location of a single sound source requires that the whale pass either within or close to the array. We have not solved the problem of deploying a stationary array system such that bowheads are required to pass between the hydrophones. A minicomputer and automatic plotter would also be needed, housed in a heated building with reliable power supply well away from the uncertain ice of the arctic study area, which would in turn require a sophisticated communication system (probably microwave radio) for transmission of hydrophone signals from the ice camp to the processing center, and transmission of processed data back to the ice camp. The cost of assembling and operating such a system for a month in the arctic is conservatively estimated at several hundred thousand dollars.

FALL PASSIVE SONAR RESULTS

During the October Beaufort Sea aerial surveys, when conditions were optimal, SSQ-41A sonobuoys were dropped from a twin-engine Grumman Otter to record any sounds (vocalizations) made by bowhead whales.[4/] The aircraft circled the spot where the sonobuoys were dropped in order for our observer

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[4/] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

to visually monitor whale behavior.

Six sonobuoys were dropped, two each on October 13, 16, and 18. Over two hours of tape recordings of sounds of bowhead and white whales were made. The effective range of the hydrophone was no more than 3 nmi. The transmission range did not exceed 5 nmi at 250 m altitude. Occasionally, white whales could be heard while not in view. Spectrographs of these recordings indicate that the range of frequencies for bowheads is 40 Hz to 1900 Hz, and perhaps beyond.

REVIEW OF OBJECTIVES AND RECOMMENDATIONS

No single research effort can be comprehensive within a restricted time period. The major objective of the NMFS bowhead research plan for 1978 was to evaluate and make the best possible estimate of the size of the bowhead whale population. To accomplish this meant that information on the spatial and temporal distribution of the population (including migration patterns) was essential for correcting the whale counts taken during the "census" effort. To this end, data collected during 1978 suggest that most, if not all, bowheads were available and were counted by our census teams (at the NMFS and AEWC ice camps).

The NMFS bowhead research effort is expected to continue through 1982. The bowhead whale research objectives through 1982 are to:

1. Make the best estimate of the precommercial and present population size.
2. Estimate net recruitment.
3. Evaluate the potential effects of:
   a. the Alaska Eskimo subsistence hunt on the bowhead population, and
   b. oil and gas exploration and developmental activities.

4. Characterize life history and ecological strategies, such as trophic dynamics, reproduction, and seasonal movements.
5. Assess stock identity and discreteness through morphometrics, biochemical and genetics studies, and other means as they develop.

Not all of the above objectives will be addressed simultaneously each year. A timetable of our proposed long range research activities, although preliminary at this time, is summarized in Table 5.

In order to adequately evaluate the present and future status of the western Arctic stock of bowhead whales, an understanding of how many animals are added or lost to the population is needed. This problem is being addressed in the NMFS 1979 research plan. What impact exploration and/or development of oil and gas has on the population remains an important question--as is characterizing life history strategies. Most of the aforementioned objectives planned through 1982 (i.e., numbers 1,2,3a, 4, and 5) are being addressed by the NMFS, but will require several years of sampling. Much more research remains to be conducted on objective number 3b.

Assuming adequate funding continues, more information on the population size, biology, and ecology of the species will be forthcoming within the planned 5 year period. Serious questions remain, however, about the adequacy of short term versus long term studies of the bowhead in the Beaufort Sea relevant to the development of the Outer Continental Shelf (OCS). On a short term basis, many questions about the vulnerability of individuals in the population may not be adequately addressed for decisions which are planned in 1979. The following recommendations address only this problem.

TABLE 5.--Long range NMFS expanded bowhead whale research program planning timetable. S - spring (Feb-June), F - fall (July-Dec), blank - no projection.

Research activities	Fiscal year and (in parenthesis) estimated budget[1/] FY78 (78K)	FY79 (86K)	FY80 (72K)	FY81 (54K)	FY82 (50K)
Ice camp census	S	S	S	S	S
Population modelling	--	--	X	X	X
Land camp census	S	--	SF	--	--
Distribution - Aerial					
Bering Sea	S	--	--	S	--
Chukchi Sea	S	S	SF	S	--
Beaufort Sea	SF	S	SF	SF	--
Canadian Beaufort	--	F?	F	F?	--
Distribution - Vessel					
Icebreaker	--	S	SF?	F?	S?
Charter/Bering-Chukchi Beaufort	SF[2/]	F?	F	F	--
Trophic studies	--	--	F	F	F
Harvest monitoring	SF	SF	SF	SF	SF
Biological general[3/]	SF	SF	SF	SF	SF
Remote sampling[4/]	--	--	SF	SF	SF
Coop. contracts[4/]	X	X	X	X	X
Technological development					
Acoustics	SF	SF	SF	SF	SF
Pinger development	S	S	SF	SF	--
Tagging	--	--	F?	?	?
Logbook study	X	X	--	--	--
Eskimo cooperative program	X	X	X	X	X

1/ $K = 10^3$
2/ S/F overlap
3/ Includes studies of tissue sampling, ageing, reproductive status, morphometrics, etc.
4/ See Appendix II.

The National Marine Mammal Laboratory's OCSEAP bowhead field research effort in the Beaufort Sea ended in 1978[5/]. And, no specific plans are being made by the NMFS bowhead research staff to study the movement of whales near the OCS lease area in 1979. As such, the following list of research activities is recommended, should funds become available, to assess the distribution and movement of bowheads in and adjacent to the state and federal OCS lands in the Beaufort Sea. The objectives of any research in and near the OCS lease should be 1) establish presence or absence of whales; 2) determine the seasonal frequency of occurrence from the shoreline to the pack ice; 3) determine why animals are present (i.e., is the OCS area important for bowhead feeding?); and 4) determine if jeopardy can be established.

Proposed research (only generalized):

1. Baleen plate fouling study.
2. Small craft charter to study feeding behavior and document vocalizations of whales. Follow whales in study area, and perhaps study effects of boat traffic.
3. Passive sonar monitoring between the barrier islands and shore, as well as beyond the islands; and between Barter Island and Prudhoe Bay to assess frequency distribution of vocalizing whales in and out of the lease area.
4. Integrate vessel(s), aircraft, and passive sonar studies to compare the occurrence and frequency distribution of animals between the shore and pack ice.

[5/] Final report for OCS Research Unit No. 69 (Contract No. R7120807) to the Alaska Outer Continental Shelf Environmental Assessment Program Office, Juneau, AK. In preparation at the Natl. Mar. Mammal Lab.

5. Noise effects study. Document kinds and frequencies of noises from fixed and mobile sources and, if possible, behavioral or acoustic interference with whales.
6. Aircraft or vessel "census" study of bowheads in the western Canadian arctic (i.e., Amundsen Gulf) and the U.S. Beaufort Sea to compare the magnitude of the summer-fall "population" to that counted at Pt. Barrow in the spring; and to assess habitat utilization.

Admittedly, this list could be expanded. Assuming the above research is accomplished in 1979, it should provide the means to make some immediate decisions. Naturally, several years of sampling are needed because of the variability of ice movement in the fall, as there is thought to be a 5-year ice cycle in the arctic (Barnett 1976).

SUMMARY

1. Sightings per unit effort among Eskimo whaling villages, as tabulated from AEWC-NMFS logbooks, indicated that bowheads were seen in greatest numbers by Barrow, Gambell, Point Hope, and Savoonga whalers, respectively. The level of interest in reporting, and thus effort (i.e., sightings per time spent observing), was assumed to be equal among villages. No records from Wainwright were available for analysis.
2. More bowheads were counted at the NMFS South Camp counting site per unit of effort than at the AEWC ice camp site ($P<0.05$). At least two factors contributed to this difference. First, the NMFS camp used 2 observers per watch at 3-hour intervals, whereas the AEWC camp used one person for 4-8 hours per watch. Secondly, the lead was consistently

narrower near the NMFS camp than the AEWC camp, apparently causing whales to move closer to the nearshore edge of the lead by the NMFS camp than the AEWC camp.

3. Plots of routes which took individual bowheads past Cape Lisburne indicated that our observers slightly overestimated the number of duplicate sightings. Therefore, more whales passed the observer site than estimated. The difference in estimates is not significant.
4. Evaluation of the Cape Lisburne sightings and efficiency of viewing time using the 1977 and 1978 data indicated that Cape Lisburne is less than an optimal place for viewing bowhead whales. No research will be conducted there in 1979.
5. Bowheads were last seen near Gambell, St. Lawrence Island, in late May 1978, and not again with any regularity until January 1979, although 12 animals were seen between September 26 and December 21. No bowheads were seen in the northern Bering Sea or southern Chukchi Sea June-September during 19 aerial and 3 vessel surveys. It now appears that there is not a significant number of bowhead whales, if any, which migrates from the Bering Sea into the Chukchi or Beaufort Seas after the spring whaling season, and whale watching camps end in early June.
6. Preliminary biochemical-genetic studies (blood protein and liver enzyme electrophoresis and karyotyping) suggest that the morphological variant called ingutuk is not a species separate from Balaena mysticetus. Although biochemical heterogeneity does occur in the bowhead population, it is not associated with any apparent morphological feature.

7. During the 1978 fall bowhead hunt, 2 whales were landed and 1 was reported struck but lost. The total number of whales landed (12) and reported struck and lost (6) for 1978 was within the AEWC and IWC guidelines.
8. Results of a hydrophone array test conducted on killer whales in Puget Sound, Washington, in September showed that such a system can reveal the presence and direction of movement of vocalizing whales and alert watchers of their approach. The feasibility of "counting whales" with passive sonar awaits further testing, however, and even if a usable system could be developed, its cost might be prohibitive.
9. Clear, high quality recordings of a bowhead vocalizing were made of an animal under observation during an aerial survey-hydrophone test in the western Beaufort Sea in October 1978. These and other sounds collected during the spring of 1978 suggest that bowheads apparently vocalize frequently, within the range of approximately 40-1900 Hz.

ACKNOWLEDGEMENTS

Success of the NMFS research effort depends on the cooperation and enthusiasm of the Alaska Eskimo community. Few individuals have shown as much interest or sincerity and have made as significant a contribution to our research as Mr. Donald Harry, Gambell, Alaska. In January 1979 Don passed away in Nome. We have lost a good friend. This report is dedicated to him.

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APPENDIX I:

Arctic Whale Research Program Staff, 1978

Program Leader - Howard Braham

Project Leaders - Bruce Krogman, population dynamics
Stephen Leatherwood, aerial survey *
James Johnson and
Marilyn Dahlheim, bioacoustics and remote sensing
Willman Marquette, harvest and whaling activities
Mary Nerini, biology and physiology
Ronald Sonntag, data management
David Rugh, habitat utilization and behavior

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Karl Haflinger
Katherine Hazard
Pauline Hessing
Scott Home
Edwin Iten
Gordon Jarrell
Eric Knudsen
William Lawton
Patrick McGuire
Rodney McLain
J. R. Patee
Jon Petersen
Carl Peterson
Richard Punsly
Steven Savage
Richard Schuette
John Smithhisler
Ronn Storro-Patterson
Andrew Taber
Richard Tremaine
David Withrow

* Under contract to the Naval Ocean Systems Center, San Diego, California

APPENDIX II

List of cooperating scientists who have received biological specimen material from bowhead whales harvested since 1975.

Investigator	Institution	Samples loaned
U. Arnason	University of Lund, Sweden	Variety of tissues for genetics study
T.F. Albert	Naval Arctic Research Laboratory, Barrow	Variety of tissues for endocrinological study
H.A. Behrisch	University of Alaska	Variety of tissues for diving adaptations study
D.A. Duffield	Portland State University, Oregon	Blood samples for electrophoretic study
F.E. Durham	Los Angeles County Natural History Museum	Baleen and ear plugs for ageing study
R. Elsner	University of Alaska	Heart tissue for comparative study of cetacean vascularization
G. Fleischer	Umweltbundesmat, Berlin West Germany	Cochlea for hearing study
G.E. Folk	University of Iowa	Bowhead eye for comparative anatomy and physiology
D. Hedgecock	University of California, Bodega Bay	Liver tissue for electrophoretic analysis
G.H. Jarrell	University of Alaska	Skin, kidney, and lung tissue for cytogenetic study
L.F. Lowry	Alaska Department of Fish and Game , Fairbanks	Stomach contents for trophics study
A.P. McCartney	University of Arkansas	Mandible for archeological study
L.K. Miller	University of Alaska	Peripheral nerve tissue
L.M. Shults	University of Alaska	Parasites