CHAPTER 2

Birds and Marine Mammals

by

Stephen R. Johnson
LGL Ecological Research Associates, Inc.
1410 Cavitt Street
Bryan, Texas 778oI

ACKNOWLEDGEMENTS

The U.S. Fish and Wildlife Service, Arctic National Wildlife Refuge, Fairbanks, Alaska, kindly allowed us to use their field station at Beaufort (Nuvagapak) Lagoon. Gerald Garner, Mike Spindler and Bob Bartels of the U.S. Fish and Wildlife Service helped in a number of ways. Lloyd Lowry, Alaska Department of Fish and Game, provided valuable information and advice prior to the initiation of our field program.

The National Oceanic and Atmospheric Administration, Office of Oceanography and Marine Services, Juneau, Alaska, provided logistics support. George Lapine, Mike Meyer and Mike Albertson helped coordinate logistics. Bob Gerard of ERA Helicopters, Deadhorse, Alaska, piloted the Twin otter during surveys of nearshore marine waters. Gary Vandenberg and Bud Christman of NOAA piloted the helicopter during lagoon surveys.

Chip Welling and Dale Herter of LGL provided invaluable assistance in the field, especially during the August sampling period. Steve Zimmerman of NOAA, Juneau, accompanied us during the September sampling period and helped in a variety of ways.

Nell Stallard of LGL sorted, identified and measured the invertebrate samples from bird stomachs and habitat samples. Jeff Green, Josh Baker and Lynn Maritzen of LGL helped with the data analysis. Bonnie Bower-Dennis and Betsy Sturm prepared the illustrations and Jean Erwin typed this report several times.

SUMMARY AND CONCLUSIONS

To compare habitat uses by marine-associated birds and mammals in the coastal regions of the eastern Alaskan Beaufort Sea with those in the central and western portions, biological investigations were conducted in the Beaufort Lagoon region of north coastal Alaska during early August and late September 1982. These investigations included 1) six aerial surveys to document the distribution and abundance of marine mammals and birds in nearshore marine waters from Barter Island to the Alaska-Canada border, 2) four aerial surveys to document the distribution, abundance and habitat relationships of marine birds and mammals in coastal lagoons and adjacent nearshore regions and 3) nine surveys to document the distribution, abundance and habitat relationships of shoreline-associated birds and mammals in the eastern Beaufort Sea region of Alaska. In addition, representative samples of feeding oldsquaws and phalaropes (key bird species in this area) and of their potential prey in feeding habitats also were collected.

Few marine birds or mammals were recorded during aerial surveys of nearshore marine waters in August, except that a significant number of bearded and ringed seals were recorded throughout the study area on 4 August. On all survey dates in August, ice was present in virtually the whole study area from Barter Island to the Alaska-Canada border. Few marine birds and mammals were recorded during the second sampling period (15-23 September) until 22 September, when 128 bowhead whales were observed on- and off-transect in the eastern half of the study area. Most of these whales (91, 71%) were on-transect. Based on conservative density extrapolations, at least 281.5 bowheads were estimated to be present in the eastern half of the study area. Of these, 4.9% were young-of-the-year. Waters where whales occurred were very turbid which allowed only limited observations of behavior (feeding, migration). Nine of 11 bowheads that were moving were oriented towards the west; two were oriented towards the north. Forty-nine bowheads were resting on the surface and 12 were diving; these whales may have been feeding. There was no evidence during this study that bowhead whales, or other marine mammals or birds, were concentrating (to feed) in any particular part of the study area. However, the concentration of bowheads in the eastern half of the study area on 22 September was one of the largest recorded since exploitation of this stock began late in the last century.

Oldsquaws were the most abundant birds recorded in lagoon habitats in the Beaufort (Nuvagapak) Lagoon study area. Densities of this species were highest along mid-lagoon and mainland shoreline transects in the study area, which was a different distribution of oldsquaws than had been found in other recent investigations in this area, end in investigations in other lagoons along the central Alaskan Beaufort Sea coast. There was no evidence that oldsquaws concentrated to feed near the entrances to lagoons in this area.

Red-necked (northern) phalaropes (primarily feeding juveniles) with smaller numbers of red phalaropes and sanderlings were the most abundant birds recorded along barrier island shoreline habitats in August. In September, an apparent influx of red phalaropes from offshore resulted in more of these birds than red-necked phalaropes in shoreline habitats. Only glaucous gulls were recorded in significant densities along mainland shoreline transects in this study; several pairs nested adjacent to this transect.

The diets of feeding oldsquaws and phalaropes collected in this study were similar to those of birds collected in Simpson Lagoon along the central Alaskan Beaufort coast in 1977 and 1978. Both mysid and amphipod crustaceans were important items In the diets of both oldsquaws and phalaropes. A larger proportion of small cottid fish (sculpins) was present in the diets of oldsquaws and phalaropes in the Beaufort Lagoon area than in other coastal lagoons investigated. Some fish were taken in shoreline habitat samples where phalaropes were feeding when they were collected, but no fish were present in drop net samples taken where feeding oldsquaws were collected. Mysids and amphipods (primarily *Gammarus setosus*) and some benthic organisms (polychaete worms) dominated habitat samples where feeding oldsquaws were collected.

INTRODUCTION

The nearshore Beaufort Sea of Alaska supports a number of marine mammals and birds that are important locally and nationally (e.g. whales, seals, waterfowl). In recent years, much research on these species has been conducted in the central and western Beaufort shelf regions of Alaska, where petroleum interests have been most immediate. Currently, petroleum related interests have expanded eastward, signaling the need to conduct research on birds and marine mammals there. This report presents results of research conducted in the portion of the Alaska Beaufort Sea between Barter Island and the Alaska-Canada border during two summer sampling periods in 1982.

STUDY AREA

The "PREFACE" to this volume gives a general description of the overall study area. However, Figures 2-1 and 2-2 in this Chapter on 'Birds and Marine Mammals" give specific locations of aerial survey and ground transects associated with this part of the project.

METHODS

Investigations of marine birds and mammals during this study were conducted during two field sampling periods (1-8 August and 15-22 September 1982) that included at least 1) three aerial surveys or attempts of surveys of 12 marine transects, 2) two aerial surveys of the four lagoon transects and 3) three surveys of the 10 shoreline transects (see Figs. 2-1 and 2-2). In addition, during each of the two sampling periods, collections were made of at least 10 feeding oldsquaw ducks. During the August sampling period, 10 feeding phalaropes also were collected. Samples of prey of oldsquaws and phalaropes were collected from areas where the birds were feeding when they were collected.

Aerial Surveys of Nearshore Marine Waters

It was hypothesized before the field program (see Truett 1982 for a report of workshop proceedings) that marine mammals and birds may concentrate in an area of upwelling between Barter Island and the Alaska-Canada border in water depths of 25-40 m. The aerial surveys of nearshore marine waters were designed to document the distribution and abundance of marine mammals and birds in these nearshore waters, in order to evaluate

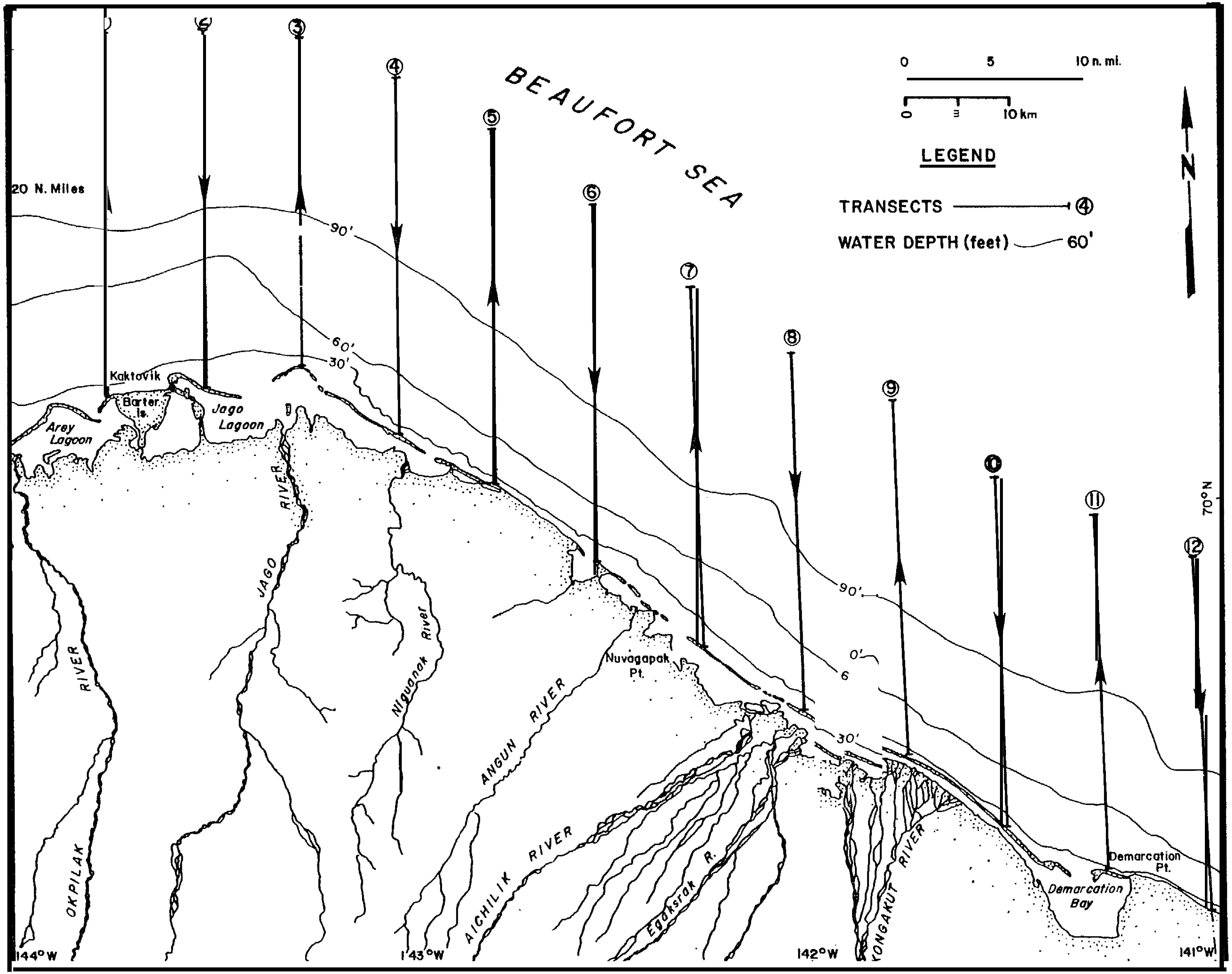

Figure 2-1. Nearshore marine aerial survey transects in the study area.

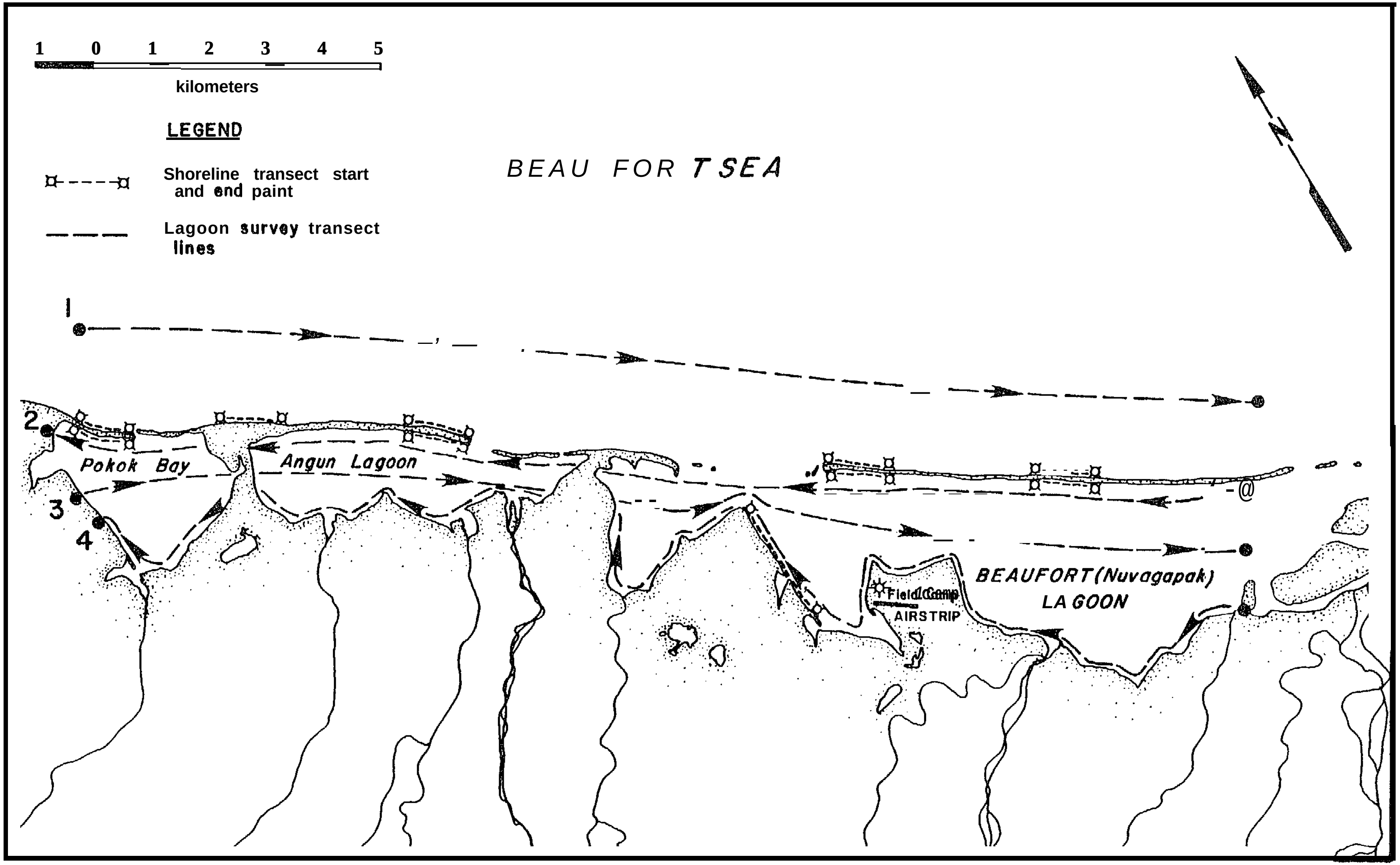

Figure 2-2. Beaufort Lagoon, Alaska, study area showing the aerial survey route through the lagoons and the locations of shoreline transects surveyed in August and September, 1982.

this hypothesis. Aerial. surveys were conducted *during the* first sampling period on 1, 4 and 8 August and during the second sampling period on 15, 18 and 22 September. Table 2-1 gives the number of′ transects and the areal coverage of each survey.

All three surveys of marine waters were conducted in a DeHavilland Twin Otter equipped with an VLF Omega navigation system and a radar altimeter. The surveys were flown at an altitude of 152 m and at *a* speed of 212 km/h. Twelve transects were established along lines of longitude 15 minutes (about 8.8 km or 5'nm) apart, from 143°45'W in the West, to 141°W (Alaska-Canada border) in the East. The southern end of each transect was near the seaward beach of the mainland or barrier island (Appendix 2-I). Each transect was approximately 35.2 km (20 n mi) long and 1.6 km wide (56.3 km^2), extending seaward to water depths of between 40 and 60 m. Two surveyors were seated on opposite sides of the aircraft, two seats behind the pilot and co-pilot. They recorded into portable tape recorders all mammals and birds within 800 m of the aircraft (on-transect) and all those seen that were farther than 800 m (off-transect). It was not possible to see directly beneath the aircraft, and some individuals may not have been detected in this area. Clinometers were used to determine the 800 m distance and binoculars were used to aid in identification of birds and marine mammals. Each transect was divided into l-rein time intervals using a timing device audible to both observers.

The information recorded during each survey was of four types: 1) systematic information about the transect (time, visibility, weather, extent of ice, direction of travel, etc.); 2) systematic information about habitats below the aircraft at l-rain intervals (percent ice, meltwater, etc.); *3)* systematic information about each sighting of a bird or marine mammal (number, behavior, sex, etc.); and 4) general remarks. All information except general remarks was numerically coded and transcribed later onto data forms.

Lengths of the transects and locations of the sampling intervals and marine mammal sightings along each transect were determined from *the* constant readout of the Omega VLF navigation system, which was visible to both observers.

Table 2-1. Number of transects and the area surveyed during marine mammal surveys of nearshore water between Barter Island and the Alaska-Canada border, 1982.

Date	Number of Transects Surveyed	Area Surveyed (km^2)	Time of Survey (ADT*) start	End
August				
1	7+	273.1	13:26	15:08
4	12	675.6	09:21	12:10
8	12	675.6	09:50	12:38
September				
15	12	675.6	13:02	16:39
18	12	675.6	14:14	17:08
22	8 (12)**	326.6 (573.7)**	13:49	15:57

* Alaska Daylight Time.

\+ Fog obscured visibility and prevented the survey of Transects 2-6 and portions of Transects 1 and 7-9.

**Fog obscured visibility and prevented the survey of Transects 2-4 and 6 and portions of Transects 1, 5 and 7-9. Four opportunistic transects were established in order to more completely survey the area not obscured by fog on this date (see Fig. 2-4).

Aerial Surveys of Lagoons and Adjacent Nearshore Marine Waters

Before the field program, it was hypothesized (Truett 1982) that the species composition? timing of use, distribution and abundance of birds (primarily oldsquaws and phalaropes) in lagoons in the eastern Beaufort Sea of Alaska would be similar to what had been observed for birds along the central Beaufort coast in earlier studies. The aerial surveys of lagoons in the study area were designed, in part, to examine the distribution and abundance of marine birds during early August and mid- to late September in order to evaluate the above hypothesis.

Figure 2-2 shows the locations of the three transects through Beaufort Lagoon, Angun Lagoon and Pokok Bay and the *one* transect in adjacent nearshore waters. The survey procedures and positions of these transects are similar to those described in Johnson and Richardson (1981) for surveys in the Simpson Lagoon area.

All of the lagoon and nearshore surveys were conducted in a Bell 204 helicopter flown at 30 m ASL and at a speed of approximately 160 km/h. The nearshore transect (Transect 1) was located approximately 1.6 km offshore of and parallel to the barrier islands and spits. The barrier island transect (Transect 2), was located 200 m south of the barrier islands and spits, the lagoon transect (Transect 3) was through the approximate center of each lagoon, and the mainland transect (Transect 4) was located approximately 200 m to the lagoon side of the mainland shoreline.

Procedures during lagoon surveys were similar to those described above for surveys of marine *waters.* However, *the aircraft* was a helicopter rather than a fixed-wing aircraft, the transects were narrower (200 mrather than 800 beachside of the aircraft), the survey altitude (30 m) and speed (161 km/h) were lower and slower, and the time intervals along the lagoon and nearshore transects were 30-sec rather than 1-min. All of the data recording procedures were identical to those described earlier for marine surveys. More detailed information about the aerial surveys in the Beaufort Lagoon area is given in Appendix 2-II.

Shoreline Surveys

Prior to the field program, it was hypothesized (Truett 1982) that the species composition, distributions and abundances of shorebirds (mainly phalaropes) along the beaches, spits and barrier islands in the eastern Alaskan Beaufort Sea were similar to those in the central Beaufort. Shoreline transects were designed to measure the distribution, abundance and habitat utilization of birds (and mammals) along the barrier islands in order to evaluate this hypothesis.

Five transects were established along seaward shorelines of the barrier islands and four were established along the lagoonside beaches of the barrier islands. Although research in the Simpson Lagoon area in 1977 and 1978 (Johnson and Richardson 1981) indicated that mainland shorelines were rarely used by shoreline-associated birds or mammals, we nevertheless established and monitored one long mainland shoreline transect throughout this study. Each barrier island transect was 1 km long by 20 m wide (10 m either side of the waterline). The mainland shoreline transect was 2 km long. The start and end points of the transects were marked with wooden poles.

Table 2-2 summarizes information about censuses of each of the shoreline transects. During each survey, all ten of the transects were censused in one 8-h period. The surveys were conducted either from a slowly moving boat, as described in Johnson and Richardson (1981) or, by slowly walking adjacent to the transect. All data were recorded into field notebooks. Binoculars were used to aid in identification of species. The following information was recorded about each transect and birds or mammals sighted:

1. The date, transect number, observers, start and end time of the survey, weather and water conditions and direction of travel.
2. The number of individuals of each species present on the transect (within 10 m of the waterline) *or* adjacent to it (off-transect).
3. The behavior of each bird or groupof birds sighted along or adjacent to the transect.

Table 2-2. *Sampling* schedule of shoreline transect in the Beaufort Lagoon area of the Alaskan Beaufort Sea.

Date of Survey	Number of km of Shoreline Transects Surveyed: Barrier Island Oceanside	Barrier Island LagoonSide	Mainland
August			
2	4	3	
3	3	2	2
4	5	4	2
6	5	4	2
7	4	3	2
8	1	1	
Subtotal	22	17	8
September			
16	5	4	2
18	5	4	2
21	4	3	2
Subtotal	14	11	6
TOTAL	36	28	14

Feeding Studies

Studies of the feeding ecology of marine birds provide a key link in the interpretation of relationships among physical parameters, biological productivity, and distribution and abundance of marine birds in barrier island-lagoon systems. The primary purpose of the avian feeding ecology studies was to determine which food organisms comprised important portions of the diets of those species of birds most widely distributed and most abundant in the study area (oldsquaws and phalaropes).

Collections of Birds and Habitat Samples

On I-8 August, 22 oldsquaws ($\bar{x}$ = 3.8 birds/collection) and 10 phalaropes ($\bar{x}$ = 3.3 birds/collection) were collected in Beaufort Lagoon, Angun Lagoon and Pokok Bay. Later, during 15-23 September, 13 more oldsquaws were collected in Beaufort Lagoon. Most of the oldsquaws and all of the phalaropes were collected while they were feeding. The stomach contents of the birds were retained for prey analysis.

Samples of potential food organisms (hereafter referred to as habitat samples) were obtained immediately after collection of the birds, and from the precise locations at which the birds were feeding when they were collected.

Since earlier studies of feeding oldsquaws in Simpson Lagoon (Johnson and Richardson 1981, Johnson in press) showed that they fed almost solely on epibenthic organisms, our sampling of oldsquaw prey in this study was conducted only in the epibenthos using a drop net,. Phalarope prey were sampled along shorelines using a neuston net. Johnson and Richardson (1981) and Griffiths and Dillinger (1981) give details of the procedures and equipment used to sample oldsquaws and phalaropes and their prey in this study.

Similarly, the laboratory procedures used to sort, identify, weigh and measure the prey taken from oldsquaws and phalarope stomachs and the potential prey taken from the habitat samples were identical to those used in previous studies. Those procedures are thoroughly described in Griffiths and Dillinger (1981), Johnson and Richardson (1981) and Johnson (in press).

RESULTS

Aerial Surveys of Nearshore Marine Waters

Surveys During August

Considerable ice was present throughout the study area during the entire 1-8 August sampling period. In addition, high winds, rough seas and extensive fog over about 60% of the area resulted in very poor survey conditions on 1 August (Table 2-3). On this date no marine mammals and only a few birds (primarily glaucous gulls) were recorded on-transect (Tables 2-4 and 2-5). It should be noted, however, that many birds (small species or those not flying) are difficult to detect from a survey altitude of 152 m.

Although ice covered much of the study area (Present on 128 of 130 time periods; mean area covered by ice was 60.8%), survey conditions on 4 August were considerably improved from 1 August and the entire study area was surveyed. Bearded seals (20 individuals; $0.03/km^2$) and ringed seals (14 individuals; $0.02/km^2$) were uniformly distributed (hauled out on ice pans) on all 12 transects across the study area. On the basis of simple extrapolation across the study area, it was estimated that about 75 and 50 bearded and ringed seals, respectively, were present in the entire 2546.5 km^2 of marine habitat east of Barter Island on 4 August 1982. No whales were recorded in the study area on 4 August and westward migrating eiders were the only birds recorded in densities greater than $0.1/km^2$ (Table 2-5).

Survey conditions on 8 August were nearly perfect and the entire study area was surveyed. Although ice persisted throughout (present on 117 of 124 time periods; the mean area covered by ice was 52.2%), winds and seas were calm, and no fog was encountered (Table 2-3). No whales were recorded and notably lower densities of bearded seals (12 invididuals; $0.02/km^2$) and especially ringed seals (3 individuals; $<0.01/km^2$) were recorded on 8 August compared with densities recorded on the survey four days earlier (see Table 2-4). Of four groups of waterbirds recorded on 8 August, only the density of oldsquaw ducks ($0.03\ /km^2$) exceeded 0.01 $individuals/km^2$ (Table 2-5).

Table 2-3. Conditions during marine mammal surveys in the area between Barter Island and the Alaska-Canada border, 1982.

Survey Date	Time Periods #	Time Periods # With Ice	% Ice $\bar{x} \pm$ s.d.	Location Of' Ice	Transects With >50% Fog	Estimated Wind Speed (km/h)	Estimated Wave Ht (m)
August							
1	50	34	10.8 ± 17.6	<8 km from coast	1-7	35	1
4	130	128	60.8 ± 32.0	Throughout	None	8	0.3
8	124	117	52.2 ± 29.0	Throughout	None	Calm	0
September							
15	126	30	7.3 ± 6.0	<8 km from coast	None	8	0.2
18	129	26	5.5 ± 6.5	<8 km from coast	None	35-50	1-3
22	62	10	25.9 ± 33.9	<8 km and >26 km from coast	1-6	Calm-8	0.5

Table 2-4. Overall numbers and densities of ringed, bearded and unidentified seals, and polar bears in nearshore waters between Barter Island and the Alaska-Canada border, 1982.

Date in 1982	Number of km^2 Surveyed	Ringed Seal		Bearded Seal		Unidentified Seal		Polar Bear	
		#	#/km^2	#	#/km^2	#	#/km^2	#	#/km^2
August									
1	273.1	0	0	0	0	0	0	0	0
4	675.6	14	0.02	20	0.18	3	<0.01	1	<0.01
8	675.6	3	<0.01	12	0.02	0	0	1	<0.01
September									
15	675.6	5	0.01	8	0.01	0	0	0	0
18	675.6	1	<0.01	0	0	0	0	0	0
22	326.6	2	<0.01	0	0	0	0	1	<0.01

Table 2-5. Overall numbers and densities of glaucous gulls, oldsquaws, eiders and other birds in nearshore waters between Barter Island and the Alaska-Canada border, 1982.

Date in 1982	Number of km^2 Surveyed	Glaucous Gull		Oldsquaws		All Eiders		All Other Birds*	
		#	#/km^2	#	#/km^2	#	#/km^2	#	#/km^2
August									
1	273.1	7	0.03	0	0	0	0	2	0.01
4	675.6	62	0.09	50	0.07	89	0.13	15	0.02
8	675.6	5	0.01	21	0.03	1	<0.01	5	0.01
September									
15	675.6	8	0.01	15	0.02	18	0.03	83	0.12
18	675.6	3	<0.01	0	0	2	<0.01	1	<0.01
22	326.6	8	0.01	1	<0.01	0	0	40	0.12

*This category includes all loons, white-fronted geese, phalaropes, ravens, murres, jaegers, black-legged kittiwakes and unidentified ducks.

Surveys During September

Significantly less ice was present throughout the study area during September than during August. During the survey on 15 September, ice was recorded during only 30 of 126 time periods and the mean area covered by ice was only about 7.3% (Table 2-3); most of this ice appeared to be grounded along the coast. No seals were recorded in densities higher than 0.01/km^2 during the 15 September survey, and aside from one flock of 80 white-fronted geese recorded on-transect near the start of Transect 7, few birds were recorded in nearshore marine waters between Barter Island and the Alaska-Canada border (Tables 2-4 and 2-5).

The 15 September survey was significant, however, in that bowhead whales (seven different individuals) were recorded for the first time during the aerial survey program. One was on-transect resting at the surface near the beginning of Transect 5 and the remaining six whales were off-transect near the end of Transect 9 and near the start of Transect 10 (Fig. 2-3). Since the distribution of the few bowheads seen on 15 September was very uneven, no attempt was made to estimate, on the basis of the number seen, the total number in the survey area. Survey conditions were nearly perfect on this survey. It is likely that few whales were undetected because of poor weather or rough water; winds and seas were relatively calm and no fog was encountered.

Conditions during the aerial survey on 18 September were poor because of high winds and very rough seas (Table 2-3). Few marine mammals and birds were recorded. Of the three marine mammals recorded on-transect, two were bowhead whales (single individuals on Transects 7 and 12) and one was a ringed seal (Transect 4) (Table 2-4, Fig. 2-3). Of the six marine birds recorded on-transect, three were glaucous gulls and two were eiders (see Table 2-5).

The aerial survey on 22 September was remarkable because of the large number of bowhead whales seen (128 individuals) (Fig. 2-4), despite relatively poor survey conditions. Although winds and the sea were relatively calm, fog prevailed over most of the western half of the study area (Transects 1-6), obscuring visibility and frustrating attemPts to conduct a thorough survey. Sixty-one bowheads, including three young-of-the-year individuals, were seen on-transect in the eastern half of the

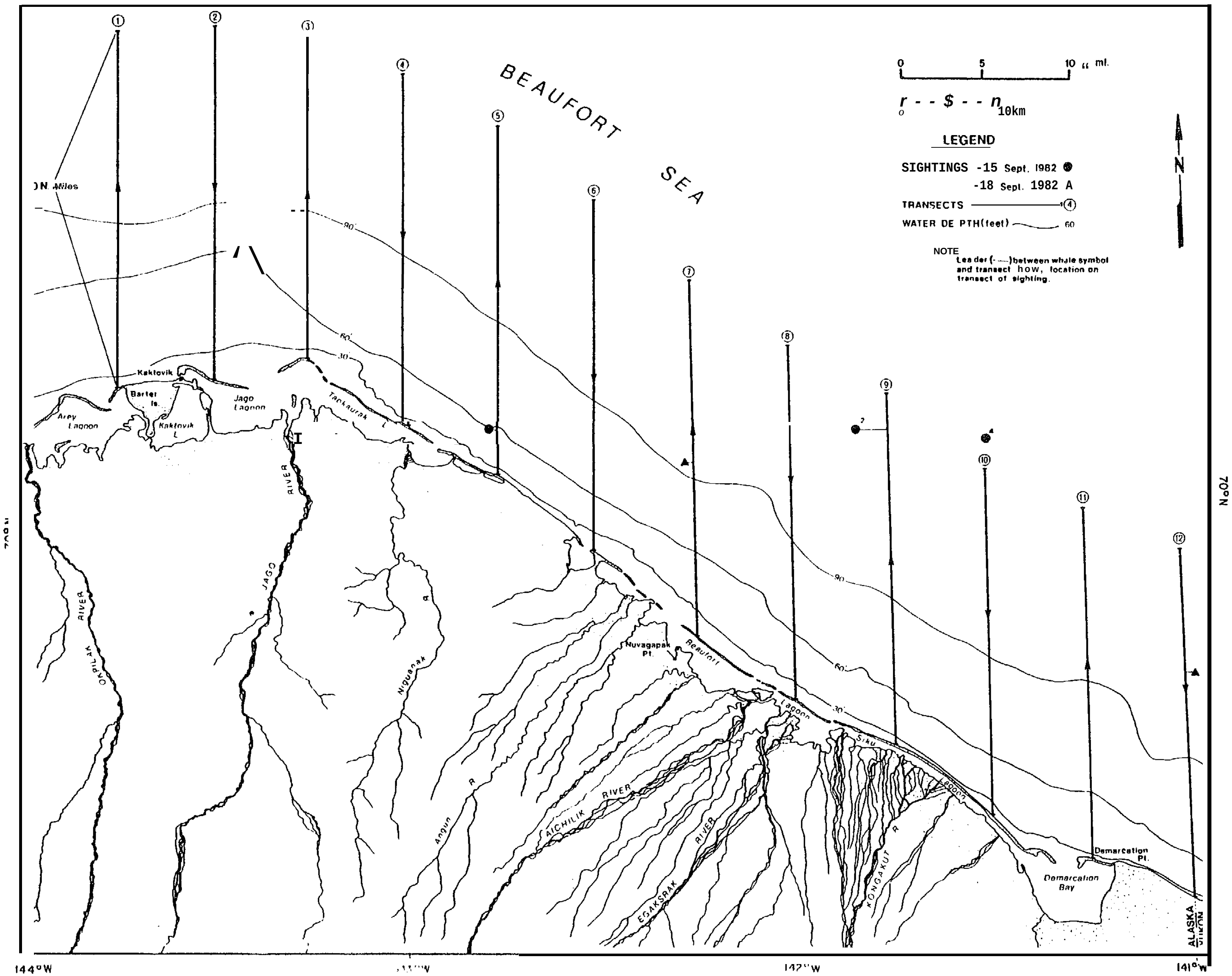

Figure 2-3. Distribution of bowhead whales recorded during aerial surveys on 15 September (●) and 18 September (▲), 1982 in nearshore marine waters between Barter Island and Alaska-Canada border.

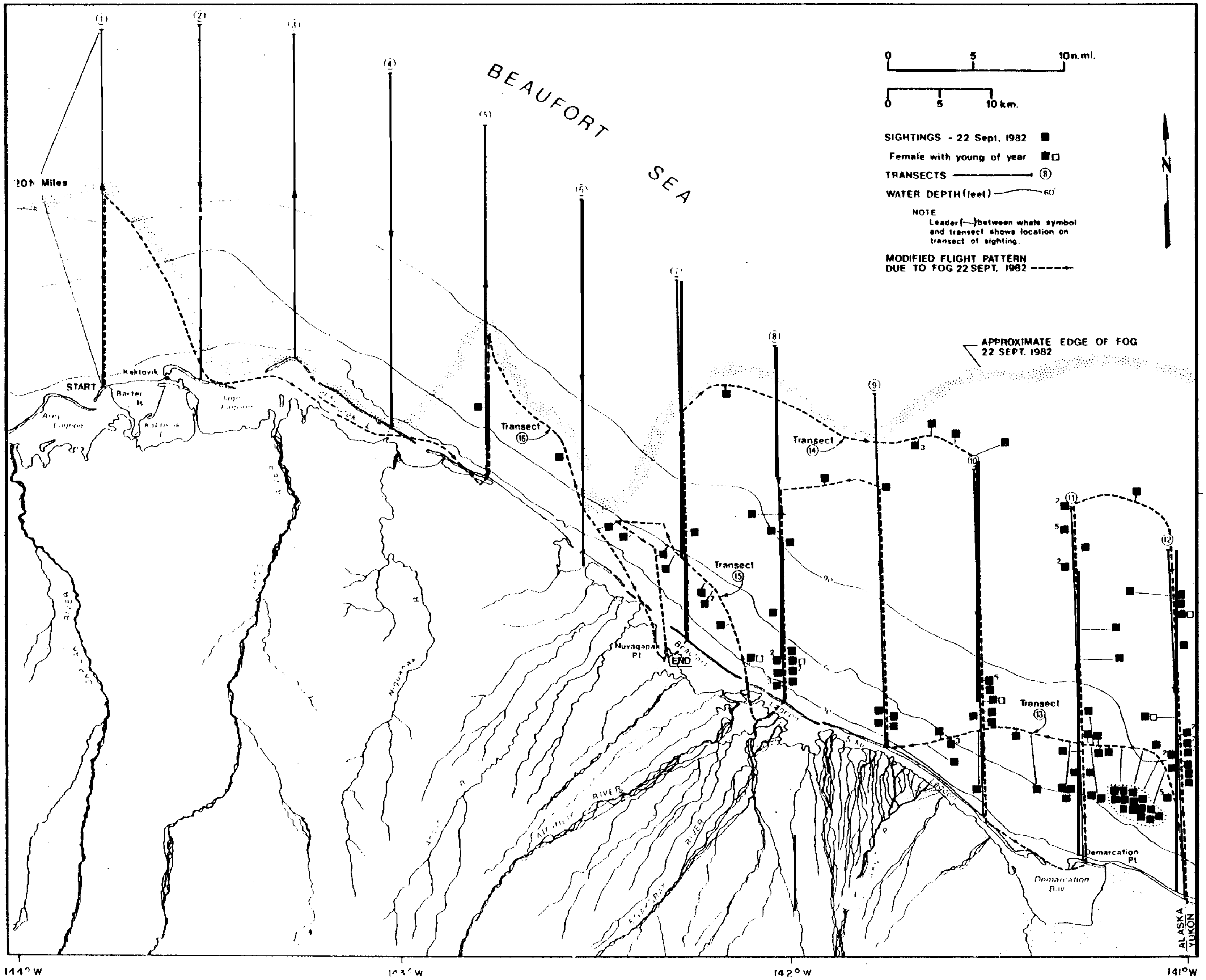

Figure 2-4. Distribution of bowhead whales recorded during aerial surveys on 22 September 1982 in nearshore waters between Barter Island and the Alaska-Canada border (dashed lines include opportunistic transects 13-16).

study area (Transects '7-12]; another adult sized individual was seen along Transect 5. An additional 29 bowheads (including one young-of-the-year individual) were seen on four opportunistic transects established in the study area (Fig. 2-4). However, it is probable that some of the bowheads seen on these opportunistic transects had been recorded earlier on Transects 7-12.

A total of 42 bowheads were recorded off-transect, all in the eastern half of the study area. Seven of these were recorded adjacent to Transects 7-12, and 35 were recorded adjacent to Transects 13-16 (Table 2-6). In general, too small a proportion (8%; 50.7 km^2) of Transects 1-6 was surveyed to enable reliable estimation of the total number of bowheads in the western half of the study area. However, a sufficiently large proportion (82%; 275.9 km^2) of Transects 7-12 was surveyed to enable simple extrapolations* of the on-transect densities over areas not surveyed in the eastern half. Using this procedure, we conservatively estimated that 281.5 bowhead whales were present in the eastern half of the study area on 22 September.

Of the 95 groups of bowheads recorded on- and off-transect, most were single individuals (78%), far fewer were pairs (16%) and even fewer were in groups of three (3%), four (none) or five (3%) (Table 2-7).

Although there appeared to be a disproportionately large concentration of bowheads along Transects 10, 11 and 12 in the 18-27 m (60-90 ft) depth range, a more detailed analysis of the 22 September survey data indicated that the relative number of bowheads recorded in each depth range was not significantly different from the relative survey effort (number of km^2 surveyed) in each depth range (χ^2 = 1.71; d.f. = 3; P>0.20). This analysis was based on the distribution of the 91 bowheads recorded on-transect on all 16 transects surveyed on 22 September (including opportunistic Transects 13-16) (Table 2-8).

$$\bullet \left(\begin{array}{c}\text{Average density of bowheads} \\ \text{on Transects 7-12; 0.221} \\ \text{bowheads/km}^2\end{array}\right)\left(\begin{array}{c}\text{Surface area of eastern} \\ \text{half of the study} \\ \text{area; 1273.3 km}^2\end{array}\right) = 281.5 \text{ bowheads}$$

Table 2-6. Total numbers and densities of bowhead whales observed during aerial surveys of 16 transects in nearshore waters between Barter Island and the Alaska-Canada border, 22 September 1982.

Transect #	Area Surveyed (km^2)	# Bowheads On-transect	# Bowheads Off-transect	Total # on & off Transect	Density of Bowheads (# on/km^2)	Linear Density (Total #/km)
1	28.2	0	0	0	0.00	0.00
2	0					
3	0					
4	0					
5	22.5	1	0	1	0.04	0.07
6	0					
7	33.8	1	0	1	0.03	0.05
8	33.8	15(1)+	1	16	0.44	0.76
9	39.4	5	0	5	0.13	0.20
10	56.3	11(1)	0	11	0.20	0.31
11	56.3	12	3	15	0.21	0.43
12	%.3	17(1)	3(1)	20	0.30	0.57
13	73.8	15	23	38	0.20	0.82
14	57.5	6	1	7	0.03	0.19
15	64.8	6(1)	4	10	0.09	0.25
16	51.0	2	0	2	0.04	0.11
Subtotal/ Overall*	326.6	62(3)	7	69	0.19	0059
Total/ Overall	573.7	91(4)	35	126	0.16	0.62

ʻNumbers in parentheses represent the number of adult + calf pairs.
*Does not include opportunistic Transects 13-16.

Table 2-7. Approximate number* of bowhead whales of different group sizes recorded in four different depth ranges** during aerial surveys of nearshore waters between Barter Island and the Alaska-Canada border, 22 September 1982.

Depth (feet)	Group Size+					Total Groups		Total Individuals	
	1	2	3	4	5	#	%	#	%
0-30	0	1(1)++	1	0	0	2	2.1	5	3.9
30-60	19	5(2)	1	0	0	25	26.3	32	25.0
60-90	39	1	0	0	2	42	44.2	51	39.8
90+	16	8(2)	1	0	1	26	27.4	40	31.3
Total Groups	74	15(5)	3	0	3	95	100.0		
Total Individuals	74	30	9	0	15			128+++	100.0

* It was not possible to record the precise position of each bowhead, therefore the above group size distributions by depth range should be considered approximate.

** The position of the 90 ft depth contour was estimated from National Ocean Survey hydrographic charts 16041, 16042 and 16043.

+ An aggregation of whales was considered to be a group if all individuals were within approximately two adult bowhead lengths (25-30 m) of each other.

++ Numbers in parentheses represent the number of adult + calf pairs.

+++ This total includes two bowheads recorded during ferry flights between transects.

Table 2-8. Relative proportions of bowhead whales recorded and the area surveyed in each depth range in waters out to 40-60 m depths between Barter Island and the Alaska-Canada border, 22 September 1982.

Depth Range (ft)	**Total** # **km²** **Surveyed***	%	Total # Bowheads On-transect	%	Total # Bowheads On + Off Transect	%
0-30	35*3	6.1	5	5.4	5	3.9
30-60	109*J-I	19.1	22	24.2	32	25.0
60-90	202.4	35*3	32	35.2	51	39.8
90+	226.6	39.5	32	35.2	40	31.3
Total	573*7	100.0	91	100.0	128+	100*0

*Each transect was 35.2 km (20 nm) long x 1.6 km wide (56.3 km^2); the total area of the 12 transects is approximately 675.6 km^2. The total area of study was about 2547 km^2.

'This total includes two whales recorded during ferry flights between transects.

Only three other marine mammals were recorded on the 22 September survey (two ringed seals and one polar bear) and, other than one flock of white-fronted geese (0.10/km^2), only nine birds (eight glaucous gulls and one oldsquaw) were recorded on-transect (see Table 2-5).

Aerial Surveys of Lagoons and Adjacent Nearshore Waters

The oldsquaw duck was the most abundant bird recorded on all four of the surveys of lagoon transects and on the adjacent nearshore transect (see Fig. 2-2; Table 2-9). On three of the four lagoon surveys (2 and 8 August and 23 September), the highest densities of oldsquaws were recorded on the mid-lagoon transect. On the one other survey (22 September), the highest density was on the mainland shoreline transect.

Glaucous gulls also were most abundant along mid-lagoon and mainland transects. This species was second in abundance only on 2 August; on all other surveys, red-breasted mergansers were the second most abundant bird recorded (Table 2-9). Mergansers were particularly abundant along the mainland shoreline (Transect 4) on 23 September (79 birds; 6.7/km^2) (Table 2-9).

Shoreline Surveys

Phalaropes and sanderlings were the most abundant shorebirds recorded along shoreline transects in the study area. The highest linear densities of phalaropes consistently were recorded on transects along the lagoon sides of the barrier islands (Table 2-10). Densities of sanderlings also were slightly higher along the lagoon-sides of the barrier islands during August, but in September, were greatest along oceanside barrier island transects (see Table 10). Overall, for both sampling periods, densities of shorebirds (primarily phalaropes) recorded along lagoonside barrier island transects were about twice as high as those along oceanside transects.

Except for the relatively large influx of red phalaropes along the lagoonside barrier island transects in September, the density of red-necked phalaropes exceeded the density of reds on all the barrier island

Table 2-9. Numbers and densities of oldsquaws, glaucous gulls, red-breasted mergansers and other birds recorded along four transects through lagoon and nearshore habitats near Beaufort Lagoon, Alaska, 1982.

Date and Species	Transect 1 #	Transect 1 #/km²*	Transect 2 #	Transect 2 #/km²	Transect 3 #	Transect 3 #/km²	Transect 4 #	Transect 4 #/km²
2 August								
Oldsquaw	4	0.5	1312	76.6	3251	180.6	1025	43.7
Glaucous gull	0	0	12	1.4	4	0.4	12	1.0
R-b merganser	0	0	0	0	0	0	0	0
Other birds	5	0.6	4	0.5	25	2.8	80	6.8
8 August								
Oldsquaw	0	0	146	17.0	229	25.4	274	23.3
Glaucous gull	0	0	0	0	1	0.1	3	0.3
R-b merganser	0	0	0	0	0	0	33	2.8
Other birds	1	0.1	4	0.5	8	0.9	3	0.3
22 September								
Oldsquaw	0	0	203	26.7	557	61.8	1242	105.8
Glaucous gull	1	0.1	3	0.4	27	3.0	16	1.4
R-b merganser	0	0	35	4.1	1	0*1	30	2.6
Other birds	1	0.1	19	2.2	6	0.7	2	0.2
23 September								
Oldsquaw	26	3.1	135	15.8	527	58.4	339	28.9
Glaucous gull	0	0	1	0.1	1	0.1	36	3.1
R-b merganser	17	2.1	11	1.3	0	0	79	6.7
Other birds	0	0	30	3.5	6	0.7	6	0.5

*The areas (km²) of Transects 1-4 are 8.3, 8.6, 9.0 and 11.7, respectively.

Table 2-10. Numbers and linear densities of phalaropes, sanderlings and other shorebirds along shoreline transects in the vicinity of Beaufort Lagoon, Alaska, 1982.

	Beach Type					
	Barrier Island Oceanside		Barrier Island Lagoonside		Mainland	
Species	#	#/lull*	#	#/km*	#	#/km*
<u>2-8 August</u>						
All phalaropes	83	3.8	103	6.1	34	4.3
Sanderlings	30	1.4	38	2.2	0	0
Other shorebirds	26	1.2	31	1.8	0	0
Subtotal	139		172		34	
n (km)	22	6.3	17	10.1	8	4.3
<u>16-?1 September</u>						
All phalaropes	10	0.7	117	10.6	0	0
Sanderlings	37	2.6	0	0	0	0
Other shorebirds*	1	0.1	0	0	0	0
Subtotal	48		117		0	
n (km)	14	3.4	11	10.6	6	0
<u>All Dates</u>						
All phalaropes	93	2.6	220	7*9	34	2.4
Sanderlings	67	1.9	38	1.4	0	0
Other shorebirds*	27	0.8	31	1.1	0	0
Total	187		289		34	
n (km)	36	5.2	28	10.3	14	2.4

*The category "other shorebirds includes (in order of abundance) black-bellied plover, unidentified shorebirds, semi-palmated sandpiper, ruddy turnstone, Baird's sandpiper and lesser golden plover.

transects by a ratio of about 10:1. No red-necked phalaropes were recorded on the 2-km long mainland shoreline transect and no phalaropes were recorded on this transect during September.

Summaries of phalarope densities along all transects during August and September are given in Table 2-11. Summaries of the distribution and relative abundance of other water-associated birds are given in Table 2-12. Densities of glaucous gulls were highest along the mainland shoreline transect during August and densities of oldsquaws were highest along lagoonside barrier island transects during August. On 16 and 18 September, a total of seven different sets of polar bear tracks were recorded along four separate shoreline transects on barrier islands. No polar bears or tracks were seen in the study area during August, even though the Beaufort Sea pack ice was very close to the barrier islands in the study area during this sampling period.

Feeding Studies

Oldsquaws

Thirty-five oldsquaws were collected during August and September 1982 in Pokok Bay and Angun and Beaufort lagoons (Fig. 2-2). Table 2-13 shows the number of males and females, and the means of body weights, wing lengths, subcutaneous fat thicknesses and estimates of stomach fullness (Hynes points) for these 35 oldsquaws.

Twenty-four oldsquaws had stomachs with food present. The contents of these stomachs were compared with the contents of 22 drop net samples taken at the locations where the birds had been feeding when they were collected.

Epifauna, namely small cottid fish (47%), mysids (38%) and amphipods (13%) were the dominant prey consumed by oldsquaws, with infauna representing only a very small portion of the diet (<1%) (Table 2-14). In contrast, epifauna were only about half (52%) the contents of drop net samples, and no small fish were taken in the drop nets. Infauna, especially polychaetes (36%), represented a major proportion (47%) of the drop net samples. Appendix 2-III provides detailed tabulations of prey consumed by oldsquaws as well as the contents of drop net samples.

Table 2-11. Numbers and linear densities of phalaropes along shoreline transects in the vicinity of Beaufort Lagoon, Alaska, 1982.

	Beach Type					
	Barrier Island Oceanside		Barrier Island Lagoonside		Mainland	
Species	#	#/km	#	#/km	#	#/km
2-8 August						
Red	4	0.2	6	0.4	34	4.3
Red-necked	56	2.6	56	3*3	0	0
Unidentified	23	1.1	41	2.4	0	0
Subtotal	83		103		34	
n (km)	22	3.8	17	6.1	8	4.3
16-21 September						
Red	2	0.1	117	10.6	0	0
Red-necked	8	0.6	0	0	0	0
Unidentified	0	0	0	0	0	0
Subtotal	10		117		0	
n (km)	14	0.7	11	10.6	6	0
All Dates						
Red	6	0.2	123	4.4	34	2.4
Red-necked	64	1.8	56	2.0	0	0
Unidentified	23	0.6	41	1.5	0	0
Total	93		220		34	
n (km)	36	2.6	28	7.9	14	2.4

Table 2-12. Numbers and linear densities of oldsquaws, glaucous gulls and other birds* along shoreline transects in the vicinity of Beaufort Lagoon, Alaska, 1982.

Species	Barrier Island Oceanside #	Barrier Island Oceanside #/km²	Barrier Island Lagoonside #	Barrier Island Lagoonside #/km²	Mainland #	Mainland #/km²
2-8 August						
Glaucous gull	5	0.2	11	0.7	44	5.5
Oldsquaw	20	0.9	204	12.0	4	0.5
Others	15	0.7	11	0.7	1	0.1
Subtotal	40		226		49	
n (km)	22	1.8	17	13.3	8	6.1
16-?1 September						
Glaucous gull	7	0*5	2	0.2	4	0.7
Oldsquaw	4	0*3	5	0.5	0	0
Others**	35	2.5	0	0	1	0.2
Subtotal	46		7		5	
n (km)	14	3.3	11	0.6	6	0.8
All Dates						
Glaucous gull	12	0.3	13	0.5	48	3.4
Oldsquaw	24	0.7	209	7*5	4	0.3
Others	50	1.4	11	0.4	2	0.1
Total	86		233		54	
n (km)	36	2.4	28	8.3	14	3*9

* Exclusive of shorebirds mentioned in Tables 10 and 11.
**On 16 and 18 September, a total. of 7 different sets of polar bear tracks were recorded along 4 separate shoreline transects on barrier islands.

Table 2-13. Measurements of oldsquaws collected near Beaufort Lagoon, Alaska, 1982.

	Sample Size (n)	Weight (g) ($\bar{x}$ ± s.d.)	Wing Length (cm) ($\bar{x}$ ± s.d.)	Subcutaneous Fat Thickness (mm) ($\bar{x}$ ± s.d.)	Stomach Fullness (H.P.)* ($\bar{X}$ ± s.d.)
2-8 August					
Males	11	887.3 ± 60.2	14.2 ± 2.5	6.9 ± 1.3	6.3 ± 6.1
Females	11	771.6 ± 65.8	20.0 *3.4	5.1 ± 1.4	6.5 ± 5.8
17-22 September					
Males	4(3)**	836.0 ± 11.0	22.5 ± 0.7	2.2 ± 0.8+	7.3 ± 8.5
Females	9(3)	766.9 ± 61.8	21.1 ± 0.8	2.7 ± 1.8	6.4 ± 4.0

* Hynes Point values are based on visual estimates of fullness, with 20 points as maximum. Griffiths et al. (1975) Johnson and Richardson (1981) and Johnson (in press) describe procedures used to estimate fullness and assign Hynes Point values.

**Numbers of young-of-the-year birds are in parentheses.

+ n = 3 males and n = 8 females, respectively, for these $\bar{x}$ ± s.d. computations.

Table 2-14. Comparisons of organisms consumed by feeding oldsquaws and organisms found in habitat samples collected where birds were feeding, Beaufort Lagoon, Alaska, 1982.

Taxon	Stomachs (n=24)		Habitat Samples (n=22)	
	Estimated Wet Weight (g)	%	Estimated Wet Weight (g)	%
Amphipods	10.'I	13.1	3.0	18.6
Mysids	31.2	37*7	2.7	16.8
Small fish*	38.5	46.6	0.0	0.0
Isopods	1.1	1.3	1.1	6.8
Gastropod	0.7	0.9	1.6	10.0
ALL EPIFAUNA	82.2	99.6	8.4	52.2
Bivalves	0.3	0.3	0.8	5.0
Polychaetes	0.0	0.0	5.8	36.0
Others	0.1	0.1	1.1	6.8
ALL INFAUNA	0.4	0.4	7.7	47.8
TOTAL	82.7	100.0	16.1	100.0

*Primarily sculpins (Cottidae).

Phalaropes

Ten phalaropes were collected in Angun Lagoon and Beaufort Lagoon during August 1982. Table 2-15 shows the species composition and the mean weights and subcutaneous fat thicknesses of these 10 birds--all were young-of-the-year males.

All 10 of the phalaropes had some food present in their stomachs. These stomach contents were compared with the contents of five habitat samples taken along the lagoonside shorelines where these birds were feeding when they were collected (Table 2-16).

Small fish (32%), amphipods (35%) and mysids (33%) each represented about equal proportions of the diet. In the shoreline habitat samples, mysids (54%), small fish (21%) and amphipods (21.4%) were the dominant organisms.

In general, phalaropes consumed slightly more amphipods and small fish and fewer mysids compared to what was available in their feeding habitats. Appendix IV provides detailed tabulations of prey consumed by phalaropes as well as the contents of shoreline habitat samples.

DISCUSSION

Aerial Surveys of Nearshore Marine Waters

Seals

In their study of feeding and trophic relationships of marine mammals in the Alaskan Beaufort Sea, Frost and Lowry *(1981)* collected a large sample of ringed seals seaward of Beaufort Lagoon in September 1980. They found that ringed seals were particularly abundant in these waters and that they were feeding primarily on arctic cod and euphausiid crustaceans (Frost and Lowry 1981:52). They hypothesized that marine mammals may concentrate in this area to feed because of upwelling (Hufford 1974) and associated high productivity between approximately the 25-m and 40-m bathymetric contours (see Truett 1982). During our aerial surveys seaward of the barrier island in this area, we detected too few seals on most dates to enable us to make a proper evaluation of this hypothesis.

Table 2-15. Measurements of ten phalaropes* collected near Beaufort Lagoon, Alaska, 7 August 1982.

Species	Sample Size	Weight	Subcutaneous Fat
Red phalarope	2	52.3 ± 3.2	3.0 ± 0.0
Red-necked phalarope	8	34.5 ± 1.7	2.9 ± 0.6

*All ten of these phalaropes were young-of-the-year males.

Table 2-16. Comparisons of organisms consumed by feeding phalaropes and organisms found in habitat samples collected where birds were feeding, Beaufort Lagoon, Alaska, 1982.

	Stomachs (n=10)		Habitat Samples (n=5)	
Taxon	Estimated Wet Weight (mg)	%	Estimated Wet Weight (mg)	%
Amphipods	413.7	34.9	50.0	21.4
Mysids	385.6	32.6	127.0	54.3
Small fish*	380.3	31.9	48.0	20.5
Copepods	0	0	1.0	0.4
Gastropod	0	0	1.0	0.4
Insects	4.4	0.3	0	0
Others	0	0.3	7.0	3.0
TOTAL	1184.0	100.0	234.0	100.0

*Primarily small sculpins (Cottidae).

However, the small number of seals seen suggests that this area is not an important concentration area for these marine mammals in August and September.

The relatively high densities of both bearded and ringed seals recorded during our surveys in August 1982 (particularly on 4 August; Table 2-4) compared with surveys in September 1982 was probably a result of the large amount of ice (pans) present throughout the study area in August. Virtually all of the bearded seals (31 of 32 individuals) and most of the ringed seals (10 of 17 individuals) seen were hauled out on ice pans. No doubt they were more conspicuous and more easily detected hauled out than if they had been swimming in the water. Several investigators (Burns and Frost 1979, Kingsley et al. 1982, and Stirling et al. 1982) have shown that densities of both ringed and bearded seals in the Beaufort Sea during spring are strongly and positively correlated with the amount of ice present. This relationship has not been thoroughly investigated during the summer and fall periods, when our surveys were conducted.

Water depth and type of ice (fast ice vs. broken ice) are other important variables affecting the distribution and density of both ringed and bearded seals during spring when ice is present in nearshore waters. Bearded seals apparently prefer broken rather than shorefast ice (they haul out on the edges of ice pans) and relatively shallow water (they are primarily bottom-feeders). Ringed seals, on the other hand, apparently avoid extremely deep and extremely shallow water and prefer very large pans or stable shorefast rather than broken ice. They feed in the water column, under the ice and near the bottom and haul out near holes and cracks on shorefast ice or on very large pans (Kinglsey et al. 1982, Stirling et al. 1982). Virtually all of the ice present in the study area during August and September 1982 consisted of variable-sized pans; no shorefast ice was encountered. However, the degree to which these relationships hold true during summer and fall are presently unknown.

Few studiesof seals have been conducted in the eastern part of the Alaskan Beaufort Sea during summer and fall. Most have been conducted during spring and early summer when ringed seals are molting and a large proportion are hauled out on the ice for relatively long periods and are therefore easy to count. During the few spring surveys conducted in the area between Barter Island and the Alaska-Canada border, the densities of ringed seals were similar to those recorded in areas to the east and west (see USFWS 1982:226-228 for a review).

Bowhead Whales

Evidence from current investigations of bowhead whales in the eastern Beaufort Sea (Ljungblad et al. 1980; Ljungblad 1981, 1982; Richardson 1981, 1982; Davis et al. 1982, 1983) suggest that the peakof their fall movement from the western Canadian to the eastern Alaskan Beaufort Sea occurs in late September. Evidence from other studies (Lowry and Burns 1980, Frost and Lowry 1981) suggests that these whales may concentrate to feed for several weeks during the fall in the shelf zone around the 25- to 40-m bathymetric contour, near and east of Barter Island. The aerial surveys of nearshore marine waters conducted in this study were designed to investigate in more detail the distribution and abundance of bowheads in relation to depth and to test the hypothesis that these whales may concentrate in this area (see Truett 1962).

Only a small number of bowheads (nine individuals) were seen in the study area until 22 September, when 128 were seen on- and off-transect; none were seen during August. The distribution of bowheads and the large number seen on 22 September compared with those seen on surveys on 15 and 18 September suggested they had only recently moved into Alaskan waters. Large concentrations of bowheads have been reported near Herschel Island, Y.T. (only 75 km E of the Alaska-Canada border), during late August through early September (Davis et al. 1982, 1983), and into late September (Ljungblad et al. 1982; T.P. Dohl, University California, Santa Cruz, pers. comm. 1983) and in at least one year (i.e. 1982, Ljungblad et al. 1982) a small number of bowheads were recorded offshore of our study area as early as August. However, our results corroborate those referred to earlier (especially those in 1979 of Ljungblad et al. 1980:123, 129; Dohl, pers. comm. 1983) that suggest that the bulk of the fall movement of these whales into Alaskan waters occurs in the last 10-15 days of September.

The great number of bowheads recorded on-transect in the eastern half of our study area on22 September 1982 represents an order of magnitude previously recorded (see Ljungblad 1981; Ljungblad et al. 1980, 1982; Davis et al. 1982; Harwood and Ford 1983). Furthermore, our density estimates have not been corrected for whales not detected because they were 1) submerged or 2) overlooked because of surface glare on the water, because of the position of the whale directly beneath the aircraft or, in the case of young-of-the-year bowheads, because of their close proximity to an adult. Davis et al. (1982) give a thorough discussion of most of the factors that might affect detectability of bowheads during aerial surveys.

The proportion of young-of-the-year bowheads recorded in our eastern Beaufort Sea study area during 1982 (4.9%) is about half that (11.1%) recorded by Harwood and Ford (1983) using survey techniques similar to ours in the Canadian Beaufort Sea during August and September 1982 and about the same as that recorded by Ljungblad (Ljungblad et al. 1982) using similar survey techniques during his 1982 surveys in the Alaskan Beaufort Sea (4.7$).

As mentioned in the "RESULTS" section, we found no evidence that bowheads were concentrating in waters of any particular depth during our surveys on 22 September. Davis et al. (1982:38) comment on depths in which bowheads occur: 'Fraker and Bockstoce (1980) summarized the available information on the summer distribution of bowheads in the eastern Beaufort Sea and western Amundsen Gulf. They concluded that waters of less than 50 m depth off the Tuktoyaktuk Peninsula and Cape Bathurst [in Canada] were particularly important for bowheads from late July to early August. Studies in August 1980 also indicated that bowheads were common in waters <50 m deep in the [Mackenzie] Delta and Tuktoyaktuk Peninsula [survey] blocks (Renaud and Davis 1981, Wursig et al. 1982). However, the data from 1981 surveys [Davis et al. 1982] do not indicate a marked preference for these shallow (less than 50 m) waters." Currently, insufficient data are available from any investigation to allow proper evaluation of this question of preference for a certain water depth for feeding by bowheads.

The extensive aerial survey data of Ljungblad (Ljungblad 1981; Ljungblad et al. 1980, 1982) indicate that the 18 m depth contour generally defines the nearshore limit of the bowhead distribution in the Alaskan Beaufort Sea. In our study, a small number of bowheads were seen in waters as shallow as 10 m, and many were present in waters 10-20 m deep. Thus, in the portion of the eastern Alaskan Beaufort Sea east of Barter Island, bowheads may be found very close to shore.

During our surveys on22 September 1982, shelf waters in the study area were very turbid, and we obtained no direct observations of' feeding by bowheads. Similarly, it was difficult to identify individuals that appeared to be involved in deliberate migratory movements. Many (49 of 72 on-transect individuals recorded by the prime observer] appeared to be resting on the surface of the water. Twelve other bowheads were diving; these whales may have been feeding (refer to Richardson 1982). Of the 11 individuals that were recorded as moving, nine were oriented to the west; the remaining two were oriented to the north.

Although we did not investigate the feeding ecology of bowhead whales in nearshore waters of the eastern Alaskan Beaufort, Frost and Lowry (1981) and Lowry and Burns (1980), have discussed this issue. Indeed there is circumstantial evidence that bowheads do feed in the portion of the Alaskan Beaufort east of Barter Island. R.A. Davis (LGL Ltd., pers. comm. 1983) has hypothesized that the distribution of bowheads in the' Canadian portion of the Beaufort Sea during summer may be related to the distribution of food (primarily zooplankton) there. He has speculated that the influence of the Mackenzie River plume in the Canadian Beaufort Sea may be an important factor directly regulating temperature, salinity, nutrient concentrations and thereby indirectly regulating the production and distribution of phytoplankton and ultimately zooplankton (bowhead food). No doubt other physical oceanographic characteristics (upwellings, convergent fronts, small gyres) also play an Important role in regulating (concentrating) the distribution of zooplankton and thereby of bowheads.

Similar relationships and processes also may be important in determining the distribution of bowheads in the eastern Beaufort of Alaska. In this volume Schell has described very high levels of some nutrients originating from some coastal rivers and streams in the study area. Hufford (1974) has described an apparent upwelling in this same region. Although we have shown no strong link between these physical characteristics and the distribution of bowhead whale food resources, they warrant further consideration and more study.

Birds

Very low densities of' all species of birds were recorded in waters seaward of the barrier islands during our aerial surveys in August and September 1982. The only densities over 0.1 bird/km^2 were recorded when one or two flocks of migrating eiders (4 August) or single flocks of migrating white-fronted geese (15 and 22 September) were observed on-transect (Table 2-5).

Divoky (1983:84-85) found that the shelf waters of eastern Beaufort Sea (E of Flaxman Island) had lower bird densities than five other shelf regions that he surveyed in the western and central Alaskan Beaufort Sea. He found oldsquaws and eiders to be the only birds present in densities higher than 1 bird/km^2 in the nearshore zone (0-20 m deep) and pelagic zone (20-200 m deep); all other species in those zones were present in densities lower than 0.6 birds/km^2.

Divoky's data are not directly comparable to ours because most of his surveys were from ships and ours were from aircraft. Furthermore, few of Divoky's ship-board surveys in the eastern Beaufort Sea were in waters less than 20 m deep; but our surveys ranged from the coast to depths of over 40 m.

Aside from data of Divoky (1983), little information exists on the distribution and abundance of birds in marine waters between Barter Island and the Alaska-Canada border. The data given in USFWS (1982, 1983) is for a narrow strip immediately seaward of the barrier islands, spits, and exposed coast in the Arctic National Wildlife Refuge and are not comparable to our data. The data given by Harrison (1977) are primarily for the area seaward of that where our surveys were conducted and were collected by different survey procedures.

Aerial Surveys of Lagoons and Adjacent Waters

Oldsquaws were the most abundant birds using lagoon habitats in this study, as they were in other studies of bird use of barrier island-lagoon habitats along the Beaufort Sea coast (Johnson and Richardson 1981; USFWS 1982, 1983; Troy et al. 1983).

Table Z-17 compares the densities of oldsquaw ducks in a number of Beaufort Sea lagoons during the peakof molt period (1-10 August). The mean density of oldsquaws in the three lagoons in our Beaufort Lagoon study area was very similar to densities recorded by the USFWS during 1981 and 1982 in the same general portion of the Arctic National Wildlife Range (ANWR) (Nuvagapak Lagoon), and in nine other lagoons along the coast of the ANWR. All of the densities of oldsquaws in the ANWR were much higher than those recorded in Stump Island Lagoon near Prudhoe Bay (Troy et al. 1983) but were only about half those recorded in Simpson Lagoon (see Table 2-17) .

The distribution of oldsquaws within our Beaufort Lagoon study area during August and September 1982 was different from that observed in most surveys of barrier island-lagoon systems in the central Beaufort Sea. In those studies (Johnson and Richardson 1981, Johnson 1982, Troy and Johnson 1982, Troy et al. 1983) the highest densities of oldsquaws *were* consistently along the south sides of the barrier islands. Similarly, the USFWS (1983) found a significantly higher proportion of oldsquaws in ten lagoons in the ANWR to be concentrated along the south sides of barrier islands (USFWS 1983:68). In all four of our aerial surveys of the three lagoons [Pokok Bay, Angun Lagoon and Beaufort (Nuvagapak) Lagoon] in our study area, the density of oldsquaws on the barrier island transect (Transect 2) was lower than that along the mid-lagoon transect (Transect 3) (see Table 2-9). In three of the four aerial surveys, the density of oldsquaws along the mainland *transect* (Transect 4) exceeded the density recorded along the barrier island transect. The reasons for this apparent difference in distribution are unknown; further investigation is necessary to substantiate that this phenomenon is real, rather than an artifact of our sampling procedure during 1982.

An interesting hypothesis presented by the USFWS in 1981 at the Arctic Nearshore Symposium (Truett 1982) was that oldsquaws tended to concentrate (to feed) near the entrances to lagoons in the ANWR. Figure 2-5 shows the average density of oldsquaws recorded on 17 30-sec time periods during four aerial surveys of Transect 2 (within 400 mof the S shore of the barrier islands and spits) in August and September 1982. The mean density (#/km^2) of oldsquaws in those time periods on and adjacent to entrances to lagoons was not significantly higher than the mean density of

Table 2-17. Comparisons of densities* of oldsquaw ducks during the peak of the molt period (1-10 August) at various lagoon locations along the Alaskan Beaufort Sea coast, 1977-82.

Location	Estimated Density of Oldsquaws (#/km^2)						
	1977	1978	1979	1980	1981	1982	MEAN
Simpson Lagoon (Johnson and Richardson 1981 ; Troy et al. 1983)	321	91	173	210	187	291	212
Stump Island Lagoon (Johnson and Richardson 1981; Troy et al. 1983)		5	24	104	15	26	35
Nine lagoons in ANWR (USFWS 1983)					108	86	97
Nuvagapak Lagoon (USFWS 1983)					79	86	83
Beaufort Lagoon Area (This study)						100	100

* These densities are for the estimated total number of oldsquaws present in each lagoon for each survey in each year. They are not means of on-transect densities.

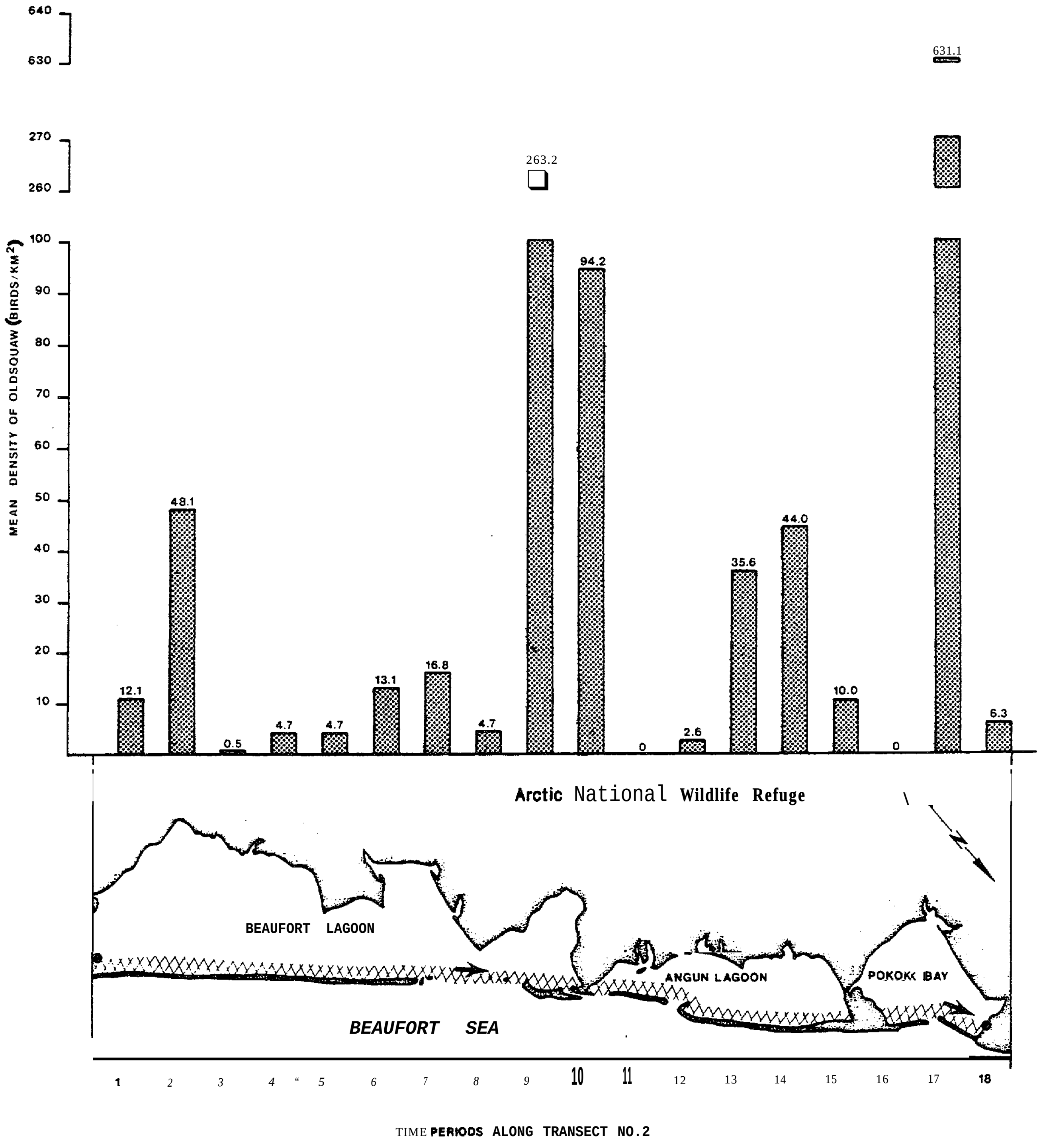

Figure 2-5. Mean density of oldsquaws on 30-sec time periods along Transect 2 (hatched area is 400-m wide strip) south of the barrier islands and spits in the Beaufort Lagoon study area during four surveys (n=4) in 1982.

oldsquaws recorded in time periods not on or adjacent to entrances (Mann-Whitney U-test; $n_1 n_2=18$, $P>0.05$).

This result was influenced by our earlier-described observation of relatively higher densities of oldsquaws at mid-lagoon and mainland shoreline locations? rather than along the barrier islands or spits. The reader is cautioned, however, that other similar studies of oldsquaw distribution in ANWR lagoons by the USFWS (1983:68) indicate that oldsquaws do tend to concentrate along the barrier islands, in a manner similar to that recorded in lagoons along the central Beaufort Sea coast (Johnson and Richardson 1981, Troy et al. 1983).

A notable result of the lagoon surveys on 8 August and 22 and 23 September was the presence of relatively large numbers of red-breasted mergansers, especially along the mainland shoreline transect (Transect 4). The 30 birds recorded on 8 August appeared to be flightless and were probably molting. Red-breasted mergansers prey on fish (Palmer 1976) and may have been concentrating in the shallower clear water near river and stream deltas in the study area to feed on small fish. The USFWS (1982, 1983) did not mention red-breasted mergansers as molting birds in ANWR lagoons, and none were recorded in their aerial surveys of lagoons in August of 1981 and 1982.

Shoreline Surveys

Phalaropes

Our shoreline surveys in the Beaufort Lagoon area paralleled the findings of others who have studied shorebirds in the Alaskan Beaufort Sea (Connors and Risebrough 1977, 1978; Johnson and Richardson 1981; Troy and Johnson 1982; USFWS 1982, 1983): shorebirds, primarily phalaropes, were the most abundant birds using barrier island beach and shoreline habitats during August and September. The only occasion in this study when another species occurred along shoreline habitats in densities greater than those of phalaropes, was during the 2-8 August sampling period when a flock of 200 molting male oldsquaws was recorded roosting on a shoreline transect (Table 2-12).

Although the numbers and densities of phalaropes on barrier island shoreline transects in the Beaufort Lagoon study area were smaller and lower, respectively, than in other parts of the Alaskan Beaufort Sea (Table 2-18), the proportion of red-necked (northern) phalaropes was notably greater (50-90%) than has been recorded at locations farther west, in Simpson Lagoon and near Prudhoe Bay, and near Barrow (10-25%) (Connors and Risebrough 1977, 1978; Johnson and Richardson 1981; Troy and Johnson 1982). These results are consistent with what is known about the distribution of red and red-necked phalaropes along the Arctic Coastal Plain of Alaska and the adjacent Yukon Territory. Red-necked phalaropes are more common as nesters and migrants than are red phalaropes at low latitudes in the Arctic (Johnson et al. 1975). Salter et al. (1980) review the status of both of these species along the Arctic Coastal Plain of the Yukon Territory and they confirm that red-necked (northern) phalaropes were much more abundant in this relatively low Arctic (69°N) location than were red phalaropes. In contrast, Connors and Risebrough (1977) found the opposite at Pt. Barrow, Alaska (71°N), where red phalaropes far outnumbered red-necked phalaropes.

One notable result of the shoreline surveys in September was the relatively large influx of red phalaropes to barrier island habitats in late September. Most of these birds (96 individuals) were recorded along the lagoon side of one transect on 21 September. On this date, winds were from the NEat about 40 km/h and a thick bank of ice was packed against the seaward beaches of the barrier islands. It is possible that the red phalaropes had come ashore to find shelter. During aerial surveys of marine waters on 18 September, three small frocks of phalaropes were recorded between 8 and 25 km offshore on three transects in the eastern half of the study area. Two more small flocks of phalaropes were recorded offshore during aerial surveys on 22 September. Late September records of red phalaropes along this portion of the Alaskan Beaufort Sea coast have not been recorded previously.

Other Species

Sanderlings were the second most abundant shorebird recorded along shoreline transects in the Beaufort Lagoon study area (Table 2-10). They

Table 2-18. A comparison of average linear densities of phal aropes along shoreline transects at various locations in the Alaskan Beaufort Sea, August 19’76-82.

Location	Beach Type		
	Barrier Island/Spit Oceanside Beach	Barrier Island/Spit Lagoonside Beach	Mainland Beach
Pt. Barrow (Connors and Risebrough 1977)			
1976	73.5*	-*	
Simpson Lagoon (Johnson and Richardson 1981)			
1977	45.3	22.2	9.9
1978	20.1	22.4	0.6
Prudhoe Bay (Troy and Johnson 1982)			
1981	1.3	29.4	1.1
Beaufort Lagoon (This study)			
1982	2.6	7*9	2.4

*This value (73.5 birds/km) was calculated from data given in Connors and Risebrough (1977:411-440) and is for all littoral zone transects (20.7 km) near Pt. Barrow. Some transects were exposed to the ocean and more were on the Elson Lagoon-side of Barrow Spit.

were recorded only on barrier island shoreline transects and were more common in August than in September. In contrast, almost no sanderlings were recorded along shoreline transects in the Simpson Lagoon (central Beaufort) study area in 1977 and 1978 until very late August and early September. The largest number of sanderlings recorded in the Simpson Lagoon area was during mid-September in 1977, which was the only Year in that study when shoreline surveys were conducted as late as late September (Johnson and Richardson 1981 :382).

Glaucous gulls were most abundant along the mainland shoreline transect in Beaufort (Nuvagapuk) Lagoon in August 1982 (Table 2-12). At least two pairs nested along this transect and large groups of these gulls often roosted on or near the two brackish lakes adj’scent to this transect. No large concentrations of these gulls, similar to those recorded in Simpson Lagoon during late September 1977 (Johnson and Richardson 1981:300), were observed in the Beaufort Lagoon study area during late September 1982.

The number of polar bear tracks (seven separate sets) recorded along shoreline transects on 16 and 18 September was markedly different from results of similar shoreline surveys in Simpson Lagoon and suggests a possible greater use by this species of this eastern section of the Alaskan Beaufort Sea coast compared to the central section. USFWS (1982) reports two confirmed and one possible polar bear den within 16 km of our Beaufort Lagoon study area. Polar bears become most common and are observed most regularly along the Beaufort Sea coast during fall as females begin to search for den sites along the coast (USFWS 1982).

Feeding Studies

Oldsquaws

Of the 22 oldsquaws collected for stomach analysis during the 1-8 August sampling period in the Beaufort Lagoon area, 11 were flightless males and 11 were females that had not yet molted (Table 2-13). The timing of the male oldsquaw molt period in the Beaufort Lagoon area was similar to that of male oldsquaws collected in Simpson Lagoon during 1977 and 1978 (Johnson and Richardson 1981:255) and for male oldsquaws collected near Thetis Island in 1980 (Johnson 1982:2 I). Similarly, the weights and subcutaneous fat thicknesses for male and female oldsquaws collected in the Beaufort Lagoon study area (Table 2-13) during 1-8 August (male molt period) are very similar to those recorded along the central Beaufort Sea coast in earlier studies (Johnson and Richardson 1981:255, Johnson 1982:21).

All of the oldsquaws collected for stomach analyses during the 15-23 September sampling period had regained flight and had considerably less subcutaneous fat than recorded on birds collected during the peak of the molt in the early August sampling period. Only one of the males collected during this period was an adult, which suggests that most adult males had departed coastal lagoons by this time (see Divoky 1983). All of these trends are consistent with those recorded for oldsquaws collected in Simpson Lagoon in 1977 and 1978 (Johnson and Richardson 1981:255).

The diet of oldsquaws collected in the Beaufort Lagoon area during August and September 1982 was similar in many respects to oldsquaw diets in Simpson Lagoon in 1977 and 1978 (Johnson and Richardson 1981). Although epibenthic invertebrates (primarily mysids and amphipods) comprised significant proportions of the diets of oldsquaws in both Simpson and Beaufort lagoons (Table 2-19), small fish (cottidae) apparently were the most important prey of oldsquaws collected in the Beaufort Lagoon study area during 1982 (see Table 2-19). Of the nearly 100 pairs of fish otoliths taken from oldsquaw stomachs, the majority were from small Myoxocephalus quadricornis and Icelus sp.; both are epibenthic sculpins.

The rates-of-passage of otoliths through bird stomachs may vary with the species of bird and type of otolith. The current feeling among some experts (Bradstreet, LGL Ltd., pers. comm. 1983) is that otoliths pass through bird stomachs relatively quickly. Therefore, the number present in an oldsquaw stomach at any one time is probably representative of the number of fish recently consumed.

If the rates of passage of sculpin otoliths are considerably slower than those of other prey remnants, the results of our stomach analyses may have overemphasized the importance of fishin oldsquaw diets. But, the reader is cautioned that studies comparing passage rates of fish otoliths through bird stomachs with passage rates of other prey have not been done.

Table 2-19. A comparison of the diets* of oldsquaws collected in Simpson Lagoon during the summers of 1977 and 1978 and in Beaufort Lagoon during the summer of 1982.

Taxa	Simpson Lagoon 1977 (n=54)	Simpson Lagoon 1978 (n=72)	Beaufort Lagoon 1982 (n=24)
Mysids	67.6	79.7	37.7
Amphipods	15.9	12.4	13.1
Fish	2.7	0.4	46.6
Bivalves	9.6	6.2	0.3
Others	4.2	1*3	2.3
TOTAL	100".0	100.0	100.0

*Presented as % composition (wet weight).

Gammarus spp. (primarily Gammarus setosus) formed the largest proportion of the amphipod diet of oldsquaws in Beaufort Lagoon in 1982, whereas, Onisimus formed the largest proportion in the diet of oldsquaws in Simpson Lagoon in 1977 and 1978.

It is remarkable that no fish were caught in the drop net samples taken at locations where feeding oldsquaws were collected. Griffiths (LGL Ltd., pers. comm. 1983) suggested that the distribution of small cottids may not be uniform; schools of these small sculpins may be patchily distributed and therefore may not be reliably detected by a sampling program such as ours (see "METHODS"). But regardless of the possible problems and sources of error in our sampling procedures, it is clearly evident that small sculpins form a significant proportion of the diet of oldsquaw ducks in the Beaufort Lagoon area but represented a relatively insignificant part of the oldsquaw diets in Simpson Lagoon.

Phalaropes

The samples of feeding phalaropes collected in the Beaufort Lagoon area during August 1982 suggested the ratio of red-necked to red phalaropes in this area to be about 4:1, or exactly the reverse of that recorded in Simpson Lagoon during August of 1977 and 1978 (Johnson and Richardson 1981). This ratio is consistent with that recorded during shoreline transects where up to 90% of the phalaropes recorded were red-necked.

All 10 of the individuals collected during this study were juvenile males. Other studies (Connors and Risebrough 1977, Johnson and Richardson 1981, Martin and Moitoret 1981, USFWS 1982) indicate that phalaropes that congregate to feed along beaches and spits during August, prior to fall migration, are mainly juveniles. That all ten specimens were males is probably a coincidence, although more juvenile males than females also were collected in samples in Simpson Lagoon during August of 1977 and 1978 (Johnson and Richardson 1981:2 91-292).

The average fatness of juvenile phalaropes collected in early August in Beaufort Lagoon was similar to that recorded in August in Simpson Lagoon (about 2.8-3.0: Johnson and Richardson 1981:292).

The diet of phalaropes collected in the Beaufort Lagoon study area in 1982 consisted of large proportions of small cottid fish (32%), amphipods (35%) and mysids (33%) (see Table 2-16). Phalaropes collected in Simpson Lagoon in 1977 and 1978 had no fish but large volumes of copepods and amphipods in their stomachs (Table 2-20). In comparison, Connors and Risebrough (1977:449) found that phalaropes near Pt. Barrow were feeding heavily on copepods, amphipods, decapod zoea, pteropods and chaetognaths in 1975 and 1976.

Phalaropes feeding in the Beaufort Lagoon area tended to select more amphipods and fewer mysids than were present in the general area where they were feeding (see Table 2-16), and they selected a larger ProPortion of fish than appeared in samples from their feeding habitats.

RELEVANCE TO PROBLEMS OF PETROLEUM DEVELOPMENT

The coastal lagoons and nearshore waters of the eastern Alaskan Beaufort Sea (Barter Island to the U.S.-Canada border) have been characterized as supporting an assortment of marine birds and mammals similar to that found in the region farther west, near Prudhoe Bay and Simpson Lagoon. Diving ducks, primarily oldsquaws, and phalaropes and glaucous gulls are the key species of birds present in both regions, but relatively smaller numbers of all of these are found in the eastern regions. Nevertheless, the vulnerabilities of these birds to petroleum related developments are similar in both regions (see Johnson and Richardson '1981). There is ample evidence of reduced flushing rates of eastern Beaufort Lagoons compared with those farther west (Schell, this volume; Kozo, this volume; Hachmeister and Vinelli, this volume) and there is justification for concern that contaminants or toxic substances introduced into these eastern lagoons could remain longer, possibly affecting a larger proportion of the populations of birds present, compared with lagoons farther west.

The most significant issue relevant to petroleum development along this eastern portion of the Alaskan Beaufort coast is the large concentration of bowhead whales recorded there during late September. Unlike areas farther to the west, where bowheads generally remain farther offshore in waters deeper than 18 m, some individuals (including an adult

Table 2-20. A comparison of the diets of phalaropes collected in Simpson Lagoon during the summers of 1977 and 1978 and in Beaufort Lagoon during the summer of 1982.

	Simpson Lagoon		Beaufort Lagoon
Taxa	1977 (n=46)	1978 (n=26)	1982 (n=10)
Mysids	8.1	2.3	32.6
Amphipods	20.2	95.8	34.9
Copepods	65.3	0.0	0.0
Fish	0.0	0.0	31.9
Pteropods	4.0	1.9	0.3
Others	2.4	1.9	0.3
TOTAL	100.0	100.0	100.0

*Presented as % composition (wet weight).

and young-of-the-year) were recorded very close to shore, in waters as shallow as 10 m. On a single date, over 125 bowheads were recorded within 20 n mi of this section of the Alaskan Beaufort coast. Native hunters from Kaktovik typically take bowheads during autumn in waters relatively close to shore. There is justification for concern that ship-, aircraft- and ground-based activities by the petroleum and associated service industries may affect the distribution and behavior of these whales, thereby having a negative effect on the whales themselves and on the subsistence harvest.

LITERATURE CITED

Bradstreet, M.S. W. 1976. Summer feeding ecology of seabirds in eastern Lancaster Sound, 1976. Unpub. rep. by LGL Ltd., for Norlands Petroleums Ltd., Calgary, Alberta. 187 p.

Bradstreet, M.S.W. 1977. Feeding ecology of seabirds along fast-ice edges in Wellington Channel and Resolute Passage, N.W.T. Unpub. rep. by LGL Ltd., for Polar Gas Project, Toronto, Ontario. 149 p.

Bradstreet, M.S.W. 1979. Feeding ecology of seabirds in Northwest Baffin Bay, 1978. Unpub. rep. by LGL Ltd., for Petro-Canada, Calgary, Alberta. 65 p.

Burns, J.J. and K.J. Frost. 1979. The natural history and ecology of the bearded seal, Erignothus barbatus. Final Rep. OCSEAP Contract 02-5-022-53. Alaska Dept. Fish and Game, Fairbanks, Alaska. 77 p.

Connors, P.G. and R.W. Risebrough. 1977. Shorebird dependence on arctic littoral habitats. Ann. Rep. Prin. Invest. BLM/NOAA,OCSEAP. Boulder, Co. 112 p.

Connors, P.G. and R. Risebrough. 1978. Shorebird dependence on arctic littoral habitats. Ann. Rep. Prin. Invest. BLM/NOAA,OCSEAP. Boulder, Co. 81 p.

Davis, R.A., W.R. Koski and G.W. Miller. 1983. Preliminary assessment of the length-frequency distribution, life history and gross annual recruitment rate of the Western Arctic bowhead whale as determined with low-level aerial photography. Unpub. rep. by LGL Ltd., for Nat. Marine Fish. Serv., Nat. Marine Mammal Lab., Seattle, Wash. (Preliminary draft.) 93 p.

Davis, R.A., W.R. Koski, W.J. Richardson, C.R. Evans and W.G. Alliston. 1982. Distribution, numbers and productivity of the Western Arctic stock of bowhead whales in the eastern Beaufort Sea and Amundsen Gulf, summer 1981. Unpub. rep. by LGL Ltd., for Sohio Alaska Petroleum Co. and Dome Petroleum Ltd. (co-managers). 134 p.

Divoky, G.W. 1983. The pelagic and nearshore birds of the Alaskan Beaufort Sea. Environ. Assess. of Alaskan Cont. Shelf. Final Rep. of Prin. Invest. BLM/NOAA,OCSEAP. Juneau, Ak. 116 p.

Frost, K.J. and L.F. Lowry. 1981. Feeding and trophic relationships of bowhead whales and other vertebrate consumers in the Beaufort Sea. Unpub. Rep. to Nat. Marine Fish. Serv., Nat. Marine Mammal Lab., Seattle, Wash. 106 p. + appendices.

Griffiths, W.B. and R.E. Dillinger. 1981. Beaufort Sea barrier island-lagoon ecological process studies: Final Rep., Simpson Lagoon. Part 5* Invertebrates. Pages 1-198. In: Environ. Assess. Alaskan Cont. Shelf, Final Rep. Prin. Invest. Vol. 8. BLM/NOAA,OCSEAP. Boulder, CO.

Harrison, C.S. 1977". Seasonal distribution and abundance of marine birds. Part 2. Aerial surveys of marine birds. Ann. Rep. Prin. Invest. BLM/NOAA,OCSEAP. Boulder, Co. 189 P.

Hufford, G.L. 1974. An apparent upwelling in the southern Beaufort Sea. J. Geophys. Res. 79:1305-1306.

Harwood, L.A. and J.K.B. Ford. 1983. Systematic aerial surveys of bowhead whales and other marine mammals in the southeastern Beaufort Sea, August-September 1982. Unpub. Rep. by ESL Environmental Sciences Ltd., Sidney, B.C., for Dome Petroleum Ltd. and Gulf Canada Resources Inc. Calgary, Alberta. 76 P.

Johnson, S.R. 1982. Continuing investigations of oldsquaws (Clangula ~ v e '- L.) during the molt period in the Alaskan Beaufort Sea. Unpub. Rep. by LGL Alaska Research Associates, Inc., to Office of Marine Pollution Assess. OCSEAP/NOAA. U.S. Dept. Commerce. Juneau, Ak. 87 p.

Johnson, S.R. In Press. Prey selection by oldsquaws (Clangula hyemalis L.) in a Beaufort Sea Lagoon. In: Nettleship, D.N., G. Sanger and P.F. Springer (Eds.). Marine Birds: their feeding ecology and commercial fisheries. Canadian Wildlife Service Special Publication. Ottawa, Canada.

Johnson, S.R. and W.J. Richardson. 1981. Barrier island-lagoon ecological process studies: Final Rep., Simpson Lagoon. Part 3. Birds. Pages 109-383. In: Environ. Assess. Alaskan Cont. Shelf, Final Rep. Prin. Invest. Vol. 7. BLM/NOAA,OCSEAP. Boulder, Co.

Johnson, S.R., W.J. Adams and M.R. Morrell. 1975. The birds of the Beaufort Sea. Dept. of Environment (Canada), Victoria, British Columbia. 310 p.

Kingsley, M., W. Calvert and I. Stirling. 1982. Abundance of seals in the eastern Beaufort Sea, Northern Amundsen Gulf and Prince Albert Sound, 1981. Unpub. Rep. by the Canad. Wildl. Serv. for Dome Petrol. Ltd., Esso Resources Canada Ltd. and Gulf Canada Resources Inc., Calgary, Alberta. 19 p*

Ljungblad, D.K. 1981. Aerial surveys of endangered whales in the Beaufort Sea, Chukchi Sea and Northern Bering Sea. Tech. Dec. 449, Naval Ocean Systems Center, San Diego, Ca. 302 p.

Ljungblad, D.K., S.E. Moore, P.R. Van Schoik and C.S. Winchell. 1982. Aerial surveys of endangered whales in the Beaufort, Chukchi and Northern Bering seas. Report to U.S. Dept. of Interior, Minerals Management Service, Anchorage, Alaska, by Naval Ocean Systems Center. Tech. Dec. 486. San Diego, CA. 406 p.

Ljungblad, D. K., M.F. Platter- Rieger and F.S. Shipps, Jr. 1980. Aerial surveys of bowhead whales, North Slope, Alaska. Tech. Dec. 314. Naval Ocean Systems Center, San Diego., Ca. 181 p.

Lowry, L.F. and J.J. Burns, 1980. Foods utilized by bowhead whales near Barter Island, Alaska, autumn 1979. Mar. Fish. Rev. 42:88-91.

Martin, P.D. and C.S. Moitoret. 1981. Bird populations and habitat use, Canning River Delta, Alaska. Xerox rep. in files of U.S. Fish and Wildlife Service, Fairbanks, Alaska.

Palmer, R.S. 1976. Handbook of North American birds. Vol. 3. Waterfowl (concluded). Yale Univ. Press, New Haven, Connecticut and London, England. %O p.

Renaud, W.E. and R.A. Davis. 1981. Aerial surveys of bowhead whales and other marine mammals of the Tuktoyaktuk Peninsula, N.W.T., August-September 1980. Unpub. rep. by LGL Ltd., for Dome Petroleum Ltd., Calgary, Alberta. 55 p.

Richardson, W.R. 1982. (Ed.). Behavior, disturbance responses and feeding of bowhead whales _Balaena mysticetus_ in the Beaufort Sea, 1980-1981. Unpub. Rep. by LGL Ecological Research Associates, Inc., for Bureau of Land Management, Washington, D.C. 456 p.

Stirling, I., M. Kingsley and W. Calvert. 1982. The distribution and abundance of seals in the eastern Beaufort Sea, 1974-79. Canad. Wildl. Serv. Occas. Paper 47. Ottawa, Ontario. 25 p.

Troy, D.M., D.R. Herter and R.M. Burgess. 1983. Prudhoe Bay Waterflood Project bird monitoring program. Unpub. Rep. by LGL Alaska Research Associates, Inc., for the U.S. Army, Corps of Engineers, Alaska District, Anchorage, Ak.

Troy, D.M. and S.R. Johnson. 1982. Prudhoe Bay Waterflood Project bird monitoring program. Unpub. Rep. by LGL Alaska Research Associates, Inc., for the U.S. Army Corps of Engineers, Alaska District, Anchorage, Ak.

Truett, J.C. 1982. Nearshore Arctic symposium, 29 September-1 October 1981, workshop rep. Unpub. rep. by LGL Ecological Research Associates, Inc. for Outer Continental Shelf Environmental Assessment Program, Arctic Project Office, Fairbanks, Ak. 19 p. + attachment.

U.S. Fish and Wildlife Service. 1982. Arctic National Wildlife Refuge Coastal Plan Resource Assessment. Initial rep. of baseline study of the fish, wildlife, and their habitats. U.S. Dept. Interior, Fish and Wildlife Service, Region 7, Anchorage, Ak. 507 p. + maps.

U.S. Fish and Wildlife Service. 1983. Arctic National Wildlife Refuge Coastal Plain Resource Assessment. 1982 update rep. of baseline study of the fish, wildlife and their habitats. U.S. Dept. Interior, Fish and Wildlife Service, Region 7, Anchorage, Ak. 379 P.

Wursig, B., C.W. Clark, E.M. Dorsey, M.A. Fraker and R.S. Payne. 1982. Normal behavior of bowheads. In: W.J. Richardson (Ed.). Behavior, disturbance responses and feeding of bowhead whales *Balaena mysticetus* in the Beaufort Sea, 1980-1981. Chapter by New York Zool. Society, an unpub. rep. by LGL Ecological Research Associates, Inc., Bryan, Tx. , for U.S. Bureau of Land Management. Washington, D.C.

APPENDIX 2-I. Coordinates of the 12 nearshore transects* surveyed on 1, 4 and 8 August and on 15, 18 and 22 September 1982, between Barter Island and the Alaska-Canada border.

Transect #	Start Point Latitude (°N)	Start Point Longitude (°N)	End Point Latitude (°N)	End Point Longitude (°W)
1	70°08'N	143°45'W	70°28'N	143°45'W
2	70 28.5	143 30	70 08.5	143 30
3	70 09	143 15	70 29	143 15
4	70 25.5	143	70 05.5	143
5	70 03	142 45	70 23	142 45
6	70 18.5	142 30	69 58.5	142 30
7	69 54	142 15	70 14	142 15
8	70 10	142	69 50	142
9	69 48	141 45	70 08	141 45
10	70 03.5	141 30	69 43.5	141 30
11	69 41	141 15	70 01	141 15
12	69 59	141 W	61 39	141 W

*All 12 transects were 1.6 km wide and 35.2 km long (56.3 km^2). The survey altitude was about 150 m and the survey speed was about 210 km/h.

APPENDIX 2-II. Descriptions of aerial lagoon surveys in the Beaufort Lagoon area of Alaska, 1982.

Survey Date and Transect #	Start Time of Survey (ADT)	Time Periods #	Time Periods # With Ice	Ice on Transect (x̄ %)	Location of Ice	Estimated Wind Speed (km/h)	Estimated Wave Height (m)
2 August							
1	16:05	16	12	<1	Throughout	40 NW	0.5
2	16:14	18	0	0	None	40 NW	0.9
3	16:24	18	0	0	None	40 NW	0.7
4	16:34	25	0	0	None	40 NW	0.7
8 August							
1	13:38	14	14	30	Throughout	15 NW	0.1
2	13:46	18	6	<1	Throughout	15 NW	0.3
3	13:56	16	7	<1	Angun L., Beaufort L.	15 NW	0.3
4	14:04	22	7	<1	Angun L., Beaufort L.	15 NW	0.3
27 September							
1	12:25	16	16	90	Throughout	Calm	<0.1
2	12:35	18	1	<1	Beaufort L.	Calm	<0.1
3	12:45	14	3	<1	Angun L.	Calm	<0.1
4	12:53	18	3	<1	Beaufort L.	Calm	<0.1
23 September							
1*	11:27	15	15	45	Throughout	o Calm	<0.1
2	11:34	18	8	4	Throughout	Calm	<0.1
3	11:44	14	4	20	Near Shores	Calm	<0.1
4	11:52	22	18	10	Near Shores	Calm	<0.1

*The location of this transect on 22 September was 200 m rather than 1.6 km N of the seaward beach. During the earlier three surveya, transect 1 was 1.6 km N of the seaward Beach in the study area.

APPENDIX 2-111. Detailed comparisons of organisms consumed by feeding oldsquaws and organisms found in habitat samples collected where birds were feeding when collected, Beaufort Lagoon, Alaska, 1982.

Taxon	Number		Estimated* Wet Weight (mg)		Estimated Ash-free Dry Weight (mg)		Estimated Kcal/gm AFDW	
	Stomach	Habitat	Stomach	Habitat	Stomach	Habitat	Stomach	Habitat
Gammarus spp.	196	163	5,547.7	2151	615.8	238.7	2.0	0.1
Gammaracanthus loricatus	33	10	3,439.4	95	381.8	10.6	3.2	1.2
Boekosimus spp.	16	12	129.6	47	25.5	9.3	0.1	<0.1
Onisimus spp.	6	93	71.2	301	14.0	59.3	0.1	0.3
Other amphipods	54	176	252.5	348	42.0	34.7	0.7	0.2
Unidentified amphipods	10	10	1,236.8	61	243.7	12.0	1.2	0.1
ALL AMPHIPODS	315	464	10,677.2	3003	1322.8	364.6	7.3	1.9
Mysis relicta	709	201	29,879.1	2563	3436.1	294.8	18.8	1.6
Mysis spp.	219	10	359.2	99	110.9	11.4	0.6	0.1
ALL MYSIDS	989	211	31,159.0	2662	3546.0	306.2	19.4	1.7
Small fish (Cottidae)	174	0	38,497.7	0	5,774.7	0	31.8	0
Isopods (_Saduria_ spp.)	48	59	1,137.6	1097	277.0	219.0	1.2	1.2
Gastropod	107	308	659.5	1595	66.0	160.0	0.3	0.8
ALL EPIFAUNA	239	1042	82,131.0	8357	6,117.7	1049.8	33.3	9.8
Bivalves (_Cyrtodaria kurriana_ and _Yoldiella_ (_Portlandia_) _arctica_	28	194	292.8	879	29	88	0.2	0.5
Ostracods	53	2380	10.6	430	1	43	<0.1	0.2
Cumaceans	21	95	77.7	320	8	32	<0.1	0.2
Polychaete worms	0	3790	0	5953	0	585	0	3.2
Sipunculid worms	0	101	0	145	0	15	0	0.1
Others	0	166	0	45	0	5	0	<0.1
ALL INFAUNA	102	6726	381.1	7672	38	768	0.3	4.2
TOTAL	341	7768.0	82,512.1	16,029	6115.7	1,817.8	33.5	14.0

*Estimates of wet weight (mg), ash-free dry weight (mg) and Kcal/gm are based on linear and exponential equations presented in Griffiths and Dillinger (1981) and Bradstreet (1976, 1977, 1979, pers. comm. 1983).

APPENDIX 2-IV. Detailed comparisons of organisms consumed by feeding phalaropes* and organisms found in habitat samples+ collected where birds were feeding, Beaufort Lagoon, Alaska, 1982.

Taxon	Number		Wet Weight (mg)		Ash-free Dry Weight (mg)		Kcal/g AFDW	
	Stomach	Habitat	Stomach	Habitat	Stomach	Habitat	Stomach	Habitat
Onisimus spp.	84	1	410.9	2.0	80.9	0.4	0.4	0.1
Gammarus setosus	1	4	2.8	48.0	0.3	5.3	<0.1	<0.1
ALL AMPHIPODS	85	5	413.7	50.0	81.2	5.7	0.4	<0.1
Mysis litoralis	15	36	80.0	109.0	9.2	12.6	0.1	0.1
Mysis relicta	2	1	12.4	18.0	1.4	2.1	<0.1	<0.1
Mysis spp.	54	0	293.2	0	33.7	0	0.2	0
ALL MYSIDS	71	37	385.6	127.0	48.9	14.7	0.2	0.1
Calanus spp.	0	3	0	1.0	0	0.2	0	<0.1
Ctenophores	0	2	0	7.0	0	<0.1	0	<0.1
Gastropod	0	3	0	1.0	0	<0.1	0	<0.1
Insects	20	0	4.4	0	0.4	0	<0.1	0
Small Fish (Cottidae)	4	1	380.3	48	57.2	7.2**	0.3++	0.1++
Total	180	51	1184.0	234.0	187.7	27.8	0.9	0.2

* n = 10 phalarope stomachs.
+ n = 5 habitat samples.
**AFDW (mg) = approximately 15% wet weight (mg).
++Kcal/gm ash-free dry weight (AFDW) = approximately 5.5 (AFDW x 10^{-3}) for small fish.