MONITORING BEAUFORT SEA WATERFOWL AND MARINE BIRDS

ANNUAL PROGRESS REPORT

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Paul L. Flint and Richard B. Lanctot
U.S. Geological Survey
Alaska Biological Science Center
1011 East Tudor Road
Anchorage, Alaska 99503

J. Christian Franson and Tuula Hollmén
U.S. Geological Survey
National Wildlife Health Center
6006 Schroeder Road
Madison, Wisconsin 53711

Julian Fischer
U.S. Fish and Wildlife Service
Migratory Bird Management,
Waterfowl Branch
1011 East Tudor Road
Anchorage, Alaska 99503

James B. Grand and Mark Howell
Alabama Cooperative Fisheries and
Wildlife Research Unit
331 Funchess Hall
Auburn University
Auburn, AL 36849

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ABSTRACT

In summer 2000 we completed the second season of a combined research program designed to assess long-term trends in numbers of waterfowl and marine birds using the lagoons and near-shore waters of the Beaufort Sea. This project combined aerial surveys with ground-based studies to assess changes and interpret factors causing any changes. The study area was split into '*industrial'* and '*control'* (i.e., undeveloped) areas based on a previous study design. Statistical analyses of aerial survey data for long-term trends are pending; however, general patterns of abundance, density, and distribution are apparent. Specifically, Long-tailed Ducks and Common Eiders used barrier island habitat extensively, whereas abundance and densities of these species was relatively low in other near-shore habitats. In contrast, Spectacled and King Eiders were distributed in offshore waters, generally West of Oliktok Point. We found little evidence for differences in productivity of Common Eiders between study areas in terms of nest initiation dates, clutch size, nesting success, or duckling survival. Foraging behavior and body composition of Long-tailed Ducks varied across study areas. However, the patterns of variation were inconsistent with disturbance being a causative factor. A virus was isolated in association with mortality of Long-tailed Ducks at the Eastern study area. Exposure to this virus may explain some of the variation in body condition and foraging behavior. Long-tailed Ducks have a fairly consistent diurnal pattern of roosting on or along the barrier islands at night, and foraging out in the lagoon during the day. Experimental disturbance appeared to have little influence on this pattern. Further analyses of all data sets and planning for summer 2001 are ongoing.

INTRODUCTION

The Outer Continental Shelf Lands Act and its amendments include provisions for post-lease monitoring studies designed to identify changes in quality and productivity of leased environments, establish trends in the lease areas, and design experiments to identify the causes of any changes (Johnson and Gazey 1992). Industrial development in the Northstar, Liberty, and Sandpiper units in the Beaufort Sea began in winter 2000. Associated with this development, a significant increase in industrial activity (helicopter overflights and barge traffic) is anticipated at the east end of Simpson Lagoon and in the offshore development areas. Levels of industrial activity are expected to exceed 2,000 helicopter overflights and 250 barge trips per season. This level of activity has the potential to impact abundance and/or distribution of sea ducks and other marine birds. The potential for oil spills to impact breeding, molting, and migrating birds in the lagoons, near-shore, and offshore waters of the project area is also high. Thus, the overall objectives of this project represent a series of interrelated studies designed to answer questions regarding the effects of disturbance on distribution and abundance of waterfowl and marine birds. The primary focus involves aerial surveys designed to describe abundance and distribution of Long-tailed Ducks (*Clangula hyemalis*) using several lagoons. Additionally, we surveyed offshore areas to describe the abundance and distribution of seabirds (primarily eiders) using areas of potential development. Finally, we expanded on the aerial survey work and conducted ground-based studies designed to enhance the interpretation of the aerial surveys.

The specific objectives of this study are:

1) Monitor Long-tailed Ducks and other species within and among *industrial* and *control* areas in a manner that will allow comparison with earlier surveys using Johnson and Gazeys' (1992) study design.

    a. Perform replicate aerial surveys of five previously established transects based on existing protocol (OCS-MMS 92-0060).

    b. Expand the area from original surveys to include near-shore areas along the Beaufort Sea coastline between the original "*industrial*" (Jones-Return Islands) and "*control*" (Stockton-Maguire-Flaxman Islands) areas.

    c. Define the range of variation for area waterfowl and marine bird populations. Correlate this variation with environmental factors and oil and gas exploration, development, and production activities.

2) Expand aerial monitoring approximately 60 km offshore. Surveys will target Spectacled (*Somateria fischeri*), Common (*S. mollissima*) and King eiders (*S. spectabilis*). The goal is to sample areas potentially impacted by oil spills from the Liberty, Northstar, and/or Sandpiper Units.

3) Develop a monitoring protocol for birds breeding on barrier islands, particularly Common Eiders. These data will be compared to historic data summarized by Schamel (1977) and Moitoret (1998).

4) Examine relationships between life-history parameters (e.g., fidelity, annual survival, productivity) and ranges of variation in Long-tailed Duck and Common Eider distribution and abundance to enhance interpretation of cross-seasonal effects of disturbance. That

is, the combination of aerial and ground-based work has the potential to both document changes in abundance/distribution and describe those changes in terms of movements of marked individuals. Parameters will be examined in relation to disturbance using the two-tiered approach developed by Johnson and Gazey (1992).

5) Recommend cost-effective and feasible options for future monitoring programs to evaluate numbers and species of birds potentially impacted by oil spills involving ice-free and ice periods in both inshore and offshore waters.

STUDY AREA

This study was conducted in Simpson Lagoon formed by the Jones and Return island complexes (hereafter referred to as the Western Area) as an *industrial* area, an unnamed lagoon formed by the Stockton, Maguire, and Flaxman island complexes (hereafter referred to as the Eastern Area) as a comparable *control* area, and the near-shore waters between these two lagoons. Field camps were established on Flaxman and Bodfish islands, each consisting of several weatherports and smaller sleeping tents. Personnel traveled within the lagoon system in 16 and 18 foot aluminum boats, and smaller inflatable rafts. An all-terrain vehicle was used to travel between Bertoncini and West Long Islands. The study area included the barrier islands that define these lagoons and waters contained within the lagoons as well as offshore waters in that portion of the Beaufort Sea. Our ‘control’ area is not a true control in the sense that some limited development has occurred in the area. However, a significant increase in industrial activity is expected in and around Simpson Lagoon during the course of these studies, thereby, increasing the absolute difference in disturbance levels among lagoons. Additionally, Johnson and Gazey (1992) noted that there is no *a priori* reason to expect equal densities among *industrial* and *control* lagoons. Therefore, we really are concerned with differences in trends among lagoons.

AERIAL SURVEYS

In September 1983, MMS and NOAA co-sponsored a workshop to develop a marine bird monitoring strategy for the Beaufort Sea. This workshop identified the Long-tailed Duck as an ideal species to monitor due to its abundance, relatively sedentary behavior, ease in counting, and historical database. MMS subsequently contracted LGL Ltd. to develop a monitoring protocol for Long-tailed Ducks in the Beaufort Sea (Johnson and Gazey 1992). The protocol they designed standardized data collection and data analysis, and provided a means to test the following hypotheses regarding effects of industrialization on marine bird abundance and distribution:

H_o1: There is no detectable change in relative densities of marine birds in “Industrial” vs. “Control” areas.

H_o2: Changes in marine bird distribution patterns are not related to OCS oil and gas development activity.

We adopted the monitoring protocol described by Johnson and Gazey (1992) to conduct near-shore marine bird surveys in 1999 and 2000. As a result, we can compare our findings with comparable historical data to test the hypotheses outlined above.

The near-shore survey may be an effective way to monitor trends in marine bird populations close to shore; however, our understanding of bird use of offshore waters is poor. Radio telemetry studies have demonstrated that Spectacled Eiders, a threatened species, use offshore waters extensively. Given the potential for oil to spread offshore in the unlikely event of a spill, we designed an offshore survey to assess abundance and distribution of eiders and other marine birds.

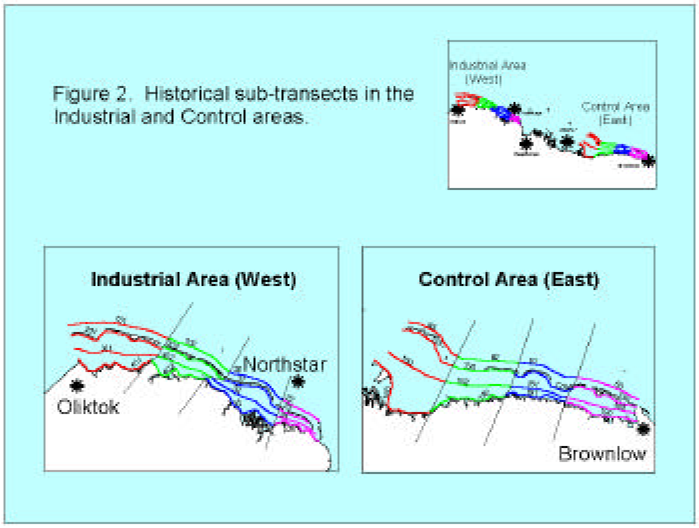


Figure 2. Historical sub-transects in the Industrial and Control areas.

AERIAL SURVEY: METHODS

Near-shore Survey

We completed 12 near-shore aerial surveys from 1999-2000 using a standard protocol (OCS-MMS 92-0060). These surveys were designed to monitor marine birds in the barrier island lagoons and inshore marine waters from Oliktok Point to Brownlow Point (Figure 1). Specifically, we surveyed 32 sub-transects designed by LGL Ltd. LGL Ltd. established these transects in two distinct areas for a study to detect effects of industrialization on Long-tailed Ducks (Johnson and Gazey 1992). The western “Industrial” area spanned from Oliktok Point to the West Dock causeway, just west of Prudhoe Bay, while the eastern “Control” area included waters east of Tigvariak Island to Brownlow Point (Figure 2).

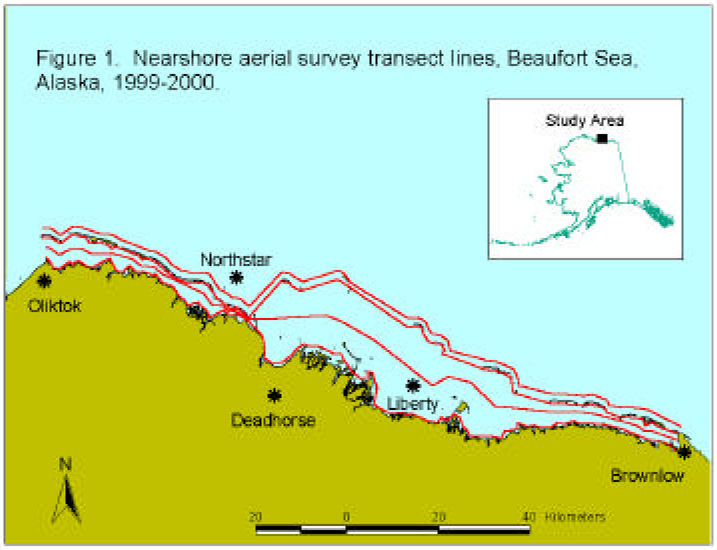


Figure 1. Nearshore aerial survey transect lines, Beaufort Sea, Alaska, 1999-2000.

In addition to replicating these transects, we expanded survey coverage to include the near-shore waters between the “Industrial” and “Control” areas. In 1999, we surveyed an additional transect 5 km north of the barrier islands between Oliktok Point and Brownlow Point. This transect, however, was dropped from the survey protocol in 2000 due to safety concerns relative to operation of single engine aircraft over broken ice.

Transects were designed to monitor densities in four distinct habitats. These habitats included:

1) Inshore Marine (1.5 km north of the barrier islands)
2) Barrier Island (200 m south of the barrier islands)
3) Mid Lagoon (Midway between barrier islands and mainland shoreline)
4) Mainland Shoreline (200 m north of the mainland)

We completed 12 near-shore surveys between mid-July and early September 1999 and 2000 (6 each year). This period corresponds with the Long-tailed Duck flightless molt when populations are relatively stable. To sample this period evenly, we attempted to space our replicates approximately 1 week apart. Although we scheduled surveys in this manner, occasional inclement weather precluded strict adherence to the 7-day sampling interval.

We used a single engine Cessna as a sample platform for 10 of the 12 replicates. Due to mechanical difficulties with the Cessna during 2 surveys in 1999, however, we used a twin-engine Aero Commander. We maintained survey altitude and speed at approximately 100 ft and 100 mph, respectively. While on transect we recorded all birds within 200 m of either side of the aircraft. In addition to bird observations, we recorded a suite of survey conditions that may influence density estimates (Table 1).

We improved the data recording protocol described by Johnson and Gazey (1992) by implementing standard aerial survey procedures used by the Division of Migratory Bird Management, US Fish and Wildlife Service. Specifically, our data recording technique uses direct voice input into an onboard computer that receives continuous position data from a `Global Positioning System (GPS). This technique provides position coordinates for all observations, along with seconds-past-midnight time data. Rather than recording data during 30-second intervals, as described by Johnson and Gazey (1992), we recorded continuously along transects, enabling greater accuracy in mapping of bird distribution. Moreover, we used the system's moving map to display and navigate along fixed "electronic" transects for more precise replication.

Only experienced aerial observers participated in this study. Prior to surveys, observers practiced estimating flock size with computer simulation software called "Wildlife Counts". To accurately estimate transect width we used markings on the aircraft wing struts that were calibrated with clinometers.

Offshore Survey

The offshore survey was designed specifically to monitor Spectacled Eider use of waters north of the near-shore survey area. Accordingly, transects were established in areas of known Spectacled Eider presence as determined from telemetry studies (Petersen et al. 1999). This

Table 1. Independent variables to be incorporated into ANOVA and ANCOVA models.

Independent Variable	Classes
Ice Cover	Recorded as %
Wave Height	Recorded in ft.
Wind Speed	Recorded in mph
Sky Cover	Overcast, Broken, Scattered, Clear
Wind Direction	N, NE, E, SE, S, SW, W, NW
Disturbance (<1km of transect)	Boat, Aircraft, Human
Habitat	Inshore Marine, Barrier Island, Mid-Lagoon, Mainland Shoreline
Area	"Industrial"-west, Central, "Control"-east
Year	1999, 2000
West-East	1-8
Time block	Morning, Midday, Afternoon, Evening

area was encompassed in 36 transects surveyed in 1999 that spanned from Cape Halkett to Bullen Point. Given the need to use this survey to assess distribution and abundance for a wide range of species, however, we extended coverage east to Brownlow Point in 2000 with the addition of 7 transects. Unlike the near-shore survey, offshore transect lines ran perpendicular to shore to an extent of approximately 60 km (Figure 3). Transects were spaced 5.4 km apart; thus the standard sampling width of 400 m allowed for a 7.4% sample of the study area.

We completed 6 offshore surveys between 1999 and 2000 (3 each year). The surveys were conducted at the end of June, July, and August in each year. The timing of the surveys was planned to coincide with estimated peaks of offshore abundance for local breeding Spectacled Eiders (i.e., exodus of breeding males (late June), failed or non-breeding females (late July), and successful breeding females with broods (late August). Timing of surveys for King and Common Eiders was expected to be similar.

We contracted a twin-engine Aero Commander as a survey platform for the offshore survey. Survey altitude and speed varied. The June, 1999 and August, 2000 surveys were flown at approximately 300 ft and 150 mph. The remaining surveys, in contrast, were flown at 150 ft and 100 mph. Data recording methods were similar to the near-shore survey. Specifically, we recorded bird observations directly as voice inputs into onboard computer systems interfaced with GPS; we used a computerized moving map to navigate along fixed “electronic” transects for precise replication; and we tracked survey conditions that may influence density estimates.

Data Analysis

Following each survey, we transcribed digital voice recordings using customized software. In this process, bird observations were linked to position data, covariates and weather variables. We then checked all entries for accuracy. Next, we subjected the data files to a customized computer check program that identified missing or miscoded data, interpolated positions where latitude and longitude data were missing, calculated distance and area surveyed, and performed a datum shift on position data to adjust GPS data collected in NAD83 to correspond with USGS NAD27 maps.

After verifying the accuracy of our data, we generated ArcInfo coverages from bird location files. We then imported these coverages into ArcView to produce distribution maps. Finally, we summarized and tabulated abundance and density estimates. Analysis procedures in 2001 will involve stratifying offshore transects by habitat, performing data transformations where appropriate, and modeling our density estimates using general linear models. To achieve this, we will use analysis of variance and analysis of covariance as outlined in Johnson and Gazey (1992). We will use the results of these steps to address hypotheses regarding the effects of industrialization on marine

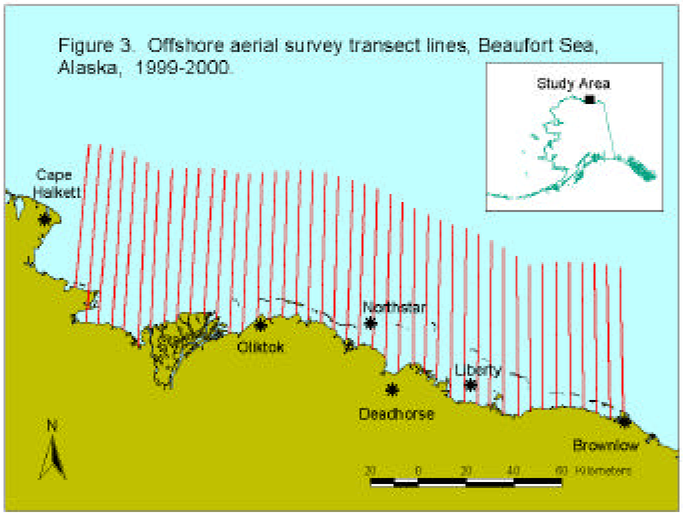


Figure 3. Offshore aerial survey transect lines, Beaufort Sea, Alaska, 1999-2000.

bird abundance and distribution.

AERIAL SURVEY: RESULTS

Near-shore

We identified 34 bird taxa during 12 Near-shore surveys in 1999 and 2000 (Table 2). The total number of birds per survey ranged from 3,602 to 22,098, with a mean of 9,765. Results for the two most abundant species, Long-tailed Duck and Common Eider are summarized below.

Long-tailed Ducks were the most numerous species observed on the near-shore surveys (Table 2). Counts of this species ranged from 2,437 to 18,317, with a mean of 7,712. Long-tailed Ducks were widely distributed across the entire study area but were seen in the highest abundance along the lagoon side of the barrier islands (Appendix 1). High numbers of Long-tailed Ducks in this habitat are reflected in the mean density estimate of 70.76 birds per sq. km (Table 3). In contrast, mean density was just 2.01 birds per sq. km in the Inshore Marine habitat. Results from the subset of historical LGL transects revealed the highest densities of Long-tailed Ducks in the Barrier Island habitat, particularly in the eastern portion of the study area (Appendix 2).

Common Eiders were second to Long-tailed Ducks in abundance, with counts ranging from 182 to 1,175 per survey, with a mean of 561 (Table 2). As with Long-tailed Ducks, Common Eiders were distributed across the entire study area, but were concentrated near barrier islands (Appendix 3). There, mean density was 6.17 birds per sq. km, whereas, fewer than 1 bird per sq. km were detected in other habitats (Table 4). When density estimates are broken down into the subset of historical LGL transects, it appears that the eastern portion of the study area supported higher densities of Common Eiders in all habitats (Appendix 4).

Table 2. Total counts of birds observed on 12 near-shore aerial surveys, Beaufort Sea, Alaska, 1999-2000.

	1999						2000						
Species	22-Jul	30-Jul	11-Aug	26-Aug	2-3-Sep	8-Sep	21-Jul	1-Aug	7-Aug	15-Aug	24-Aug	31-Aug	Mean
Yellow-billed loon	6	10	13	2	0	2	12	9	5	4	4	1	5.7
Pacific loon	60	105	50	55	54	58	82	40	72	17	93	72	63.2
Red-throated loon	11	26	18	9	8	26	1	17	13	6	26	6	13.9
Loon *spp*.	0	0	0	0	0	5	0	0	0	0	0	0	0.4
Grebe *spp*.	0	0	0	0	1	0	0	0	0	0	0	0	0.1
Tundra swan	0	12	0	4	3	2	2	2	8	0	2	18	4.4
White-fronted goose	100	101	55	33	0	4	147	192	213	79	114	107	95.4
Snow goose	1	1	41	0	20	0	80	20	110	67	25	0	30.4
Canada goose	64	0	0	50	15	0	110	235	33	161	15	83	63.8
Black brant	56	5	77	45	26	0	12	20	86	0	0	0	27.3
Northern pintail	10	483	39	29	62	36	346	153	53	95	6	140	121.0
Northern shoveler	0	0	0	0	0	0	0	1	0	0	0	0	0.1
Scaup *spp*.	90	1	0	0	0	61	0	0	12	1	5	0	14.2
Common Eider	452	667	510	1330	1089	1175	200	272	445	193	182	211	560.5
King eider	41	97	50	2	3	0	1	0	0	0	0	0	16.2
Eider *spp*.	29	0	88	0	0	46	5	8	26	71	172	15	38.3
Black scoter	0	0	0	0	0	59	15	2	20	8	0	0	8.7
White-winged scoter	2	0	0	2	0	0	72	0	8	0	10	2	8.0
Surf scoter	148	341	0	52	11	2	30	36	4	63	246	116	87.4
Scoter *spp*.	0	0	105	113	0	1	0	2	29	25	5	23	25.3
Long-tailed Duck	10572	13741	7726	3720	18317	2892	7348	2437	8808	2326	9726	4993	7717.2
Red-breasted merganser	5	10	2	44	25	338	0	8	3	0	4	1	36.7
Phalarope *spp*.	0	0	0	0	3	0	0	0	0	0	0	0	0.3
Large shorebird *spp*.	0	1	0	0	0	0	0	0	0	0	0	0	0.1
Small shorebird *spp*.	0	32	694	623	1811	135	86	1071	74	113	54	633	443.8
Pomarine jaeger	0	0	0	1	0	0	0	0	0	0	0	0	0.1
Parasitic jaeger	0	0	4	2	0	0	0	0	0	0	0	0	0.5
Jaeger *spp*.	0	0	2	3	9	0	0	0	1	0	0	0	1.3
Glaucous gull	311	251	243	375	636	269	642	463	130	359	446	306	369.3
Sabine's gull	0	1	42	0	0	0	2	1	0	12	4	0	5.2
Arctic tern	6	5	8	5	5	15	2	3	1	2	2	1	4.6
Black guillemot	0	0	1	0	0	0	0	0	0	0	0	0	0.1
Gyr falcon	0	0	0	0	0	0	0	0	0	0	0	1	0.1
Common raven	20	0	0	0	0	0	0	0	0	0	0	0	1.7
#birds/survey	11984	15890	9768	6499	22098	5126	9195	4992	10154	3602	11141	6729	9764.8

Table 3. Densities and numbers of Long-tailed Ducks observed in 4 near-shore habitat strata during 12 replicate surveys, Beaufort Sea, 1999-2000.

Transect	2		3		4		5		Survey Total	
Habitat	Inshore Marine		Barrier Island		Mid-Lagoon		Mainland Shoreline		All Habitats	
Length (km)	178.4		186.3		166.5		194		725.2	
Area (sq. km)	71.36		74.52		66.6		77.6		290.08	
	Density	#Indiv	Density	#Indiv	Density	#Indiv	Density	#Indiv	Density	#Indiv
DATE										
22-Jul-1999	1.71	122	100.25	7471	5.59	372	33.60	2607	36.45	10572
30-Jul-1999	0.80	57	86.23	6426	31.31	2085	66.66	5173	47.37	13741
11-Aug-1999	0.31	22	85.61	6380	6.07	404	11.86	920	26.63	7726
26-Aug-1999	1.74	124	32.37	2412	11.95	796	5.00	388	12.82	3720
2-3-Sep-1999	0.87	62	208.79	15559	3.72	248	31.55	2448	63.14	18317
8-Sep-1999	0.73	52	24.26	1808	11.23	748	3.66	284	9.97	2892
21-Jul-2000	0.21	15	68.44	5100	2.18	145	26.91	2088	25.33	7348
1-Aug-2000	1.23	88	17.43	1299	7.01	467	7.51	583	8.40	2437
7-Aug-2000	0.53	38	69.83	5204	10.41	693	37.02	2873	30.36	8808
15-Aug-2000*	0.74	50	16.74	1190	5.50	366	9.28	720	8.02	2326
24-Aug-2000	2.75	196	105.50	7862	2.48	165	19.37	1503	34.39	9726
31-Aug-2000	12.53	894	33.64	2507	9.68	645	12.20	947	17.21	4993
n	12		12		12		12		12	
mean	2.01		70.76		8.93		22.05		26.60	
sd	3.39		54.25		7.79		18.27		16.95	
cv	1.68		0.77		0.87		0.83		0.64	

*Transects 2 and 3 were truncated due to fog on 15-Aug-2000; on that day transect 2 was 168.9 km in length with 67.56 sq. km surveyed and transect 3 was 177.7 km in length with 71.08 sq. km surveyed.

Table 4. Densities and numbers of Common Eiders observed in 4 near-shore habitat strata during 12 replicate surveys, Beaufort Sea, 1999-2000.

Transect	2		3		4		5		Survey Total	
Habitat	Inshore Marine		Barrier Island		Mid-Lagoon		Mainland Shoreline		All Habitats	
Length (km)	178.4		186.3		166.5		194		725.2	
Area (sq. km)	71.36		74.52		66.6		77.6		290.08	
DATE	Density	#Indiv	Density	#Indiv	Density	#Indiv	Density	#Indiv	Density	#Indiv
22-Jul-1999	0.00	0	5.25	391	0.11	7	0.70	54	1.56	452
30-Jul-1999	3.36	240	4.28	319	1.35	90	0.23	18	2.30	667
11-Aug-1999	0.11	8	6.12	456	0.63	42	0.05	4	1.76	510
26-Aug-1999	0.01	1	17.47	1302	0.39	26	0.01	1	4.58	1330
2-3-Sep-1999	0.01	1	14.05	1047	0.00	0	0.53	41	3.75	1089
8-Sep-1999	0.42	30	13.89	1035	1.65	110	0.00	0	4.05	1175
21-Jul-2000	0.52	37	1.62	121	0.30	20	0.28	22	0.69	200
1-Aug-2000	2.06	147	1.30	97	0.03	2	0.34	26	0.94	272
7-Aug-2000	0.64	46	3.93	293	0.60	40	0.85	66	1.53	445
15-Aug-2000*	0.00	0	2.56	182	0.17	11	0.00	0	0.67	193
24-Aug-2000	0.17	12	2.08	155	0.00	0	0.19	15	0.64	182
31-Aug-2000	0.27	19	1.53	114	0.27	18	0.77	60	0.73	211
n	12		12		12		12		12	
mean	0.63		6.17		0.46		0.33		1.93	
sd	1.03		5.68		0.54		0.31		1.43	
cv	1.64		0.92		1.17		0.94		0.74	

*Transects 2 and 3 were truncated due to fog on 15-Aug-2000; on that day transect 2 was 168.9 km in length with 67.56 sq. km surveyed and transect 3 was 177.7 km in length with 71.08 sq. km surveyed.

Offshore

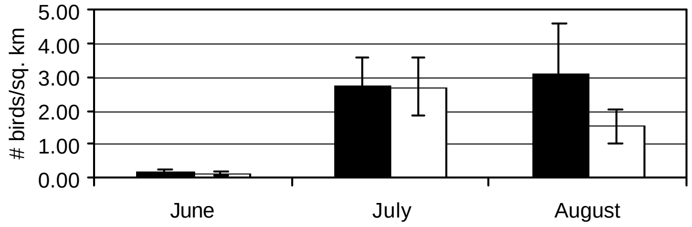
We identified 31 bird taxa during 6 offshore surveys in 1999 and 2000 (Table 5). Numbers of birds were highly variable, ranging from 762 to 6,093 per survey, with a mean of 3,314. As in the near-shore survey, Long-tailed Ducks and eiders were the most abundant taxa. Results for these species are reported below.

Table 5. Total counts of birds observed during 6 offshore aerial surveys, Beaufort Sea, Alaska, 1999-2000.

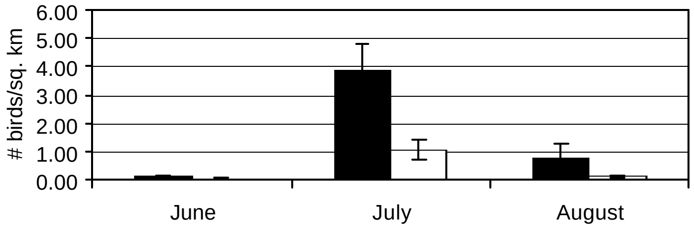
	1999			2000			
Species	June	July	August	June	July	August	Mean
Yellow-billed loon	1	16	0	8	0	2	4.5
Pacific loon	23	40	45	58	72	45	47.2
Red-throated loon	0	7	14	17	21	6	10.8
Loon *spp*.	0	0	0	0	1	0	0.2
Shearwater *spp*.	0	0	0	0	0	37	6.2
Tundra swan	9	0	2	8	0	2	3.5
White-fronted goose	16	100	0	18	5	29	28.0
Snow goose	0	25	0	0	0	0	4.2
Canada goose	0	8	7	10	0	0	4.2
Black brant	22	0	0	14	50	0	14.3
Northern pintail	2	40	0	130	1	0	28.8
Scaup *spp*.	0	88	66	0	0	0	25.7
Common Eider	120	127	72	434	172	4	154.8
King eider	124	3225	751	44	1202	147	915.5
Spectacled Eider	0	0	4	0	144	0	24.7
Eider *spp*.	6	0	29	0	144	154	55.5
Black scoter	0	0	0	0	39	7	7.7
White-winged scoter	0	0	0	38	164	2	34.0
Surf scoter	0	117	377	102	340	96	172.0
Scoter *spp*.	96	0	0	37	370	39	90.3
Long-tailed Duck	184	2213	2722	139	1916	1629	1467.2
Red-breasted merganser	0	0	23	2	0	0	4.2
Phalarope *spp*.	0	0	31	0	0	0	5.2
Large shorebird *spp*.	15	0	0	1	0	0	2.7
Small shorebird *spp*.	0	2	178	6	0	16	33.7
Long-tailed jaeger	1	1	1	0	2	0	0.8
Jaeger *spp*.	0	3	7	28	3	6	7.8
Glaucous gull	143	79	117	290	171	106	151.0
Arctic tern	0	2	1	28	4	16	8.5
Black guillemot	0	0	0	2	0	0	0.3
Auklet *spp*.	0	0	3	0	0	0	0.5
#birds counted/survey	762	6093	4450	1414	4821	2343	3313.8

Figure 4. Mean densities (±SE) of Long-tailed Ducks and eiders on offshore transects 1999 (solid bars, n=36) and 2000 (open bars, n=43).

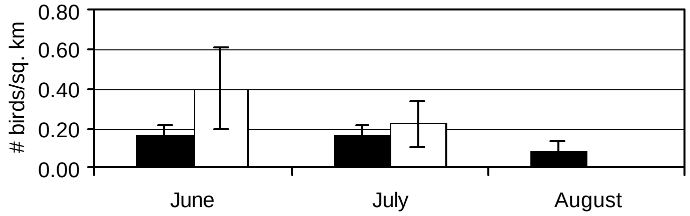
Long-tailed Ducks



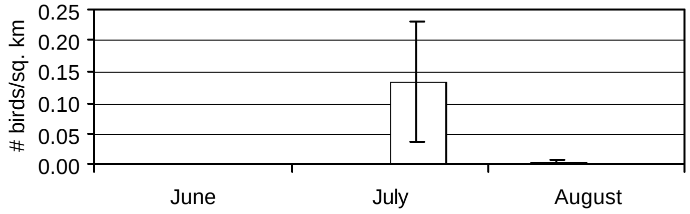
King Eider



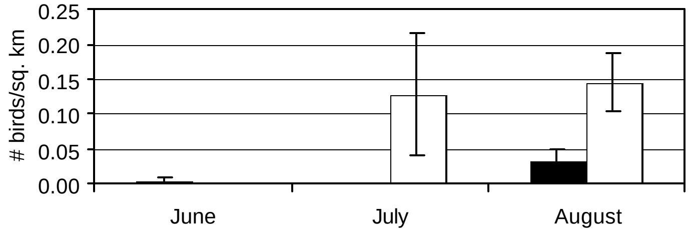
Common Eider



Spectacled Eider



Unidentified eider



Long-tailed Ducks were the most abundant species on offshore surveys. Numbers ranged from 139 (0.13 birds per sq. km) in June, 1999 to 2,722 (3.15 birds per sq. km) in August, 1999 (Table 5, Appendix 5). Long-tailed Ducks were distributed from east to west and from the mainland to the northern extent of the transects (Appendix 6). Although distributed widely, this species was concentrated within the lagoon system and near the Colville River.

The second most abundant species on offshore surveys was the King Eider. Numbers of this species ranged from 44 (0.04 birds per sq. km) in June, 2000 to 3,225 (4.09 birds per sq. km) in July, 1999 (Table 5, Appendix 7). The highest concentrations of this eider species occurred west of the Colville River (Appendix 8).

Following king eiders, Common Eiders were relatively abundant in offshore waters. As with other marine birds, Common Eider numbers varied by month, ranging from 4 (0.004 per sq. km) in August, 2000 to 434 (0.41 per sq. km) in June, 2000 (Table 5, Appendix 9). While Common Eiders were observed throughout the study area, highest concentrations occurred within 20 km of shore, and east of the Colville River (Appendix 8).

Spectacled Eiders were observed during only 2 of the 6 offshore surveys. Four individuals (0.005 per sq. km) were seen during the August, 1999 survey, and 144 (0.16 per sq. km) were seen in July, 2000 (Table 5, Appendix 10). All sightings of these birds occurred west of Oliktok Point (Appendix 8).

In addition to these species, a portion of observed eiders were identified to the genus *Somateria*. Numbers of this taxa ranged from 6 (0.007 per sq. km) in June, 1999 to 144 (0.17 per sq. km) in

July, 2000 (Table 5, Appendix 11). These eiders were distributed widely throughout the study area (Appendix 8) and probably represented failed or post-breeding female Common, King and Spectacled Eiders.

AERIAL SURVEY: DISCUSSION

Near-shore

Long-tailed Ducks and Common Eiders were not uniformly distributed in the near-shore environment. Inshore Marine and Mid-lagoon habitats had relatively low numbers and densities of marine birds. Barrier islands, in contrast, appear to be an important habitat for these species. This result is highlighted in transect summaries and distribution maps that show high densities and overall numbers along the barrier islands. Of secondary importance was Mainland Shoreline habitat, particularly in the eastern portion of the study area.

Although Mainland Shoreline habitat was rarely used in the Industrial area, it is premature to attribute this result to industrialization. Indeed, there is no *a priori* reason to expect equal densities among "Industrial" and "Control" lagoons (Johnson and Gazey 1992). Rather, change in relative densities in the two study areas is a better indication of industrial effects on marine birds. To detect a change in relative densities we will examine the significance of the Year*Area interaction term in ANOVA and ANCOVA models (Johnson and Gazey 1992). Moreover, we will examine how immediate effects of disturbances such as boat traffic influence density estimates of marine birds. Such disturbances would presumably occur at higher rates near industrial sites.

As highlighted in the 1999 Annual Report, variation in density estimates may be influenced by factors such as type of survey platform. Although preliminary analyses of 1999 data suggest that this was not a significant source of variation, we reduced the potential for bias in 2000 by completing all replicates in 2000 with a single engine Cessna aircraft as a survey platform.

Offshore

Prior to producing quantitative results of marine bird abundance and distribution in offshore waters, we must first stratify transect lines into appropriate habitat and regional groups; however, existing distribution maps reveal general trends. For example, large groups of Long-tailed Ducks appeared to congregate primarily within the barrier island lagoons and near the Colville River delta (Appendix 1). Small groups, however, were not limited to this region and were observed throughout the study area. Large flocks of king eiders, in contrast, were seen more than 20 km offshore and tended to occur west of Oliktok Point, rarely using the barrier island lagoons (Appendix 1). Conversely, Common Eiders used the lagoons to a much greater extent than other marine birds.

Although distribution maps may reveal general patterns, readers should also carefully examine density estimates to help understand how marine birds use offshore waters. Unlike the Near-shore survey where the transect length was fixed, some transect lengths varied between offshore surveys due to persistent fog conditions in some months (Appendix 1). For that reason, density estimates rather than absolute counts, provide a more accurate measure of abundance.

Unlike the near-shore survey, the offshore survey was, by design, composed of 2 counts (1999, 2000) of three summer periods (June, July, August). Due to the limited sample, therefore, the confidence in inferences we make will be largely dependent on the degree of correlation between field seasons. Although statistical analyses are pending, there are apparent correlations between field seasons (Figure 4). Specifically, in both years, Long-tailed Ducks were relatively absent in June and were common in July and August. Similarly, king eider densities peaked in July in both years. Likewise, Common Eiders showed high June and July densities in both years but diminished in August. Spectacled Eiders, and unidentified eiders had low densities in all months with high associated variance making comparisons difficult.

MOLTING ECOLOGY OF LONG-TAILED DUCKS

Previous studies of the Beaufort Sea coastal lagoons indicate that Long-tailed Ducks undergoing postnuptial wing molt and premigratory staging are one of the most dominant species present (Gollop and Richardson 1974, Johnson and Richardson 1981, Johnson and Herter 1989). Long-tailed Ducks molting in these lagoons are presumed to concentrate in these lagoons from Alaskan and Canadian nesting areas (Salter et al. 1980). Knowledge of the movements of ducks within the lagoons and behavior are important to predict potential effects of pollution and disturbance from oil exploration upon Long-tailed Ducks using the coastal lagoon system. Direct experimental testing of boat traffic will also elucidate how Long-tailed Ducks respond to such disturbance.

The objective of this study was to document local movement, site tenacity and feeding patterns of Long-tailed Duck in response to season, time of day, weather and experimental disturbance.

MOLTING ECOLOGY METHODS

Capture

Using methodologies developed in 1999 (Petersen et al. 1999), Long-tailed Ducks were trapped at Cottle Island in the western region (hereafter called the Cottle Island Capture Area), and at Northstar and Flaxman Islands in the eastern region (hereafter called the Maguire and Flaxman Island capture areas, respectively). Ducks were captured by driving flocks of flightless adults into coral traps set along beaches where they were known to roost. All captured ducks were weighed and measured (culmen, tarsus, 9th primary), and a sub-sample had blood collected for genetic and contaminant analyses. An additional sub-sample was equipped with 15 gram radio transmitters that were glued and anchored to their backs with subcutaneous arrow attachments (Pietz et al. 1995). Radio transmitters had mortality sensors (8 hrs) and a 60 pulse per minute signal. Signals could be detected about 7 km from the radio telemetry towers. A final sub-sample of ducks was collected and frozen for later analyses to investigate changes in body composition relative to stage of molt and presence of disturbance.

Radio Telemetry

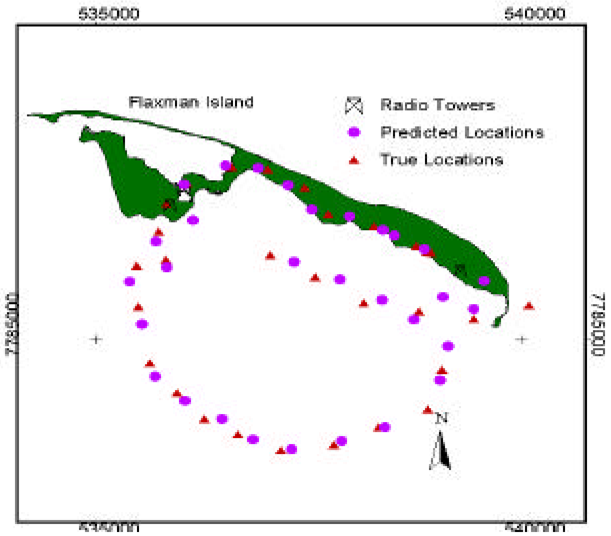


Figure 5. GPS and radio triangulation locations of test transmitters near Flaxman Island, Beaufort Sea, Alaska, 2000. Geometric location depicted in Universal Transverse Mercator values.

Signals from radio-equipped Long-tailed Ducks were detected from three towers at each capture location that consisted of two 4-element yagi antennas mounted on 25’ poles and connected to radio receivers on the ground via coaxial cables. Signals from these receivers were monitored by observers or automatically with data collection computers (DCC). We used two observers to monitor radio frequencies simultaneously at two towers. Each observer listened for radio frequencies sequentially until each radio at that particular capture location was monitored (typically for a 30 sec period) once during a given hour. Antennas were arranged on these towers so personnel could record the directional bearings from the towers to the radio-equipped ducks. Because signal strength depends on the distance and geographic position of the radio relative to the towers, two bearings were obtained for each radio signal, representing the margin of error surrounding the duck’s true location. These bearings were later averaged to obtain one bearing per bird per hour from each tower. When a duck was detected at two towers within the same hour, the individual’s location (X, Y position in Universal Transverse Mercator units) was estimated via triangulation (see SAS program in White and Garrott 1990, p. 55). We used a value of 1.26 degrees for the standard deviation of the directional bearings (i.e., the measurement error surrounding the bearings recorded by observers). This deviation was determined by placing test transmitters in spots frequented by Long-tailed Ducks in the Flaxman Island Capture Area and comparing geometrically calculated bearings between test transmitters and tower locations with bearings determined by observers using radio transmitter signals (see discussion in White and Garrott 1990, p. 80). We also overlaid the true location (i.e., GPS-derived coordinates) of test transmitters with coordinates derived from the radio triangulation program onto an Arc View hydrography coverage of the Flaxman area (Figure 5; Universal Transverse Mercator projections provided by BP Exploration [Alaska] Inc.). These overlays indicated bearings from two radio towers could reliably estimate the location of test transmitters in most instances. In addition to recording the directional bearing from the tower to the duck, observers recorded when ducks were feeding based on the radio signals. Because feeding Long-tailed Ducks dive below the surface of the water, their radio transmitter signals become attenuated in the water, preventing observers from hearing a signal for up to 20 seconds as they dive. Thus, a radio frequency that was heard, disappeared, and then was heard again was interpreted as being a feeding duck.

The DCC approach relied on programmable computers to record the presence and pulse rate of each radio transmitter located at a capture area. Unlike the previous set-up, these towers could not rotate and the two antennas on top of the towers were fixed in opposing directions to maximize coverage. A single tower arrangement like this was placed at each of the three capture locations, allowing ducks to be detected if they were within about 7 km of the tower. The direction ducks were located from the tower could not be determined with the non-directional telemetry towers and receivers controlled with DCCs. We programmed the DCCs to search for each radio frequency for 30 seconds and then switch to the next frequency, until all frequencies were scanned. In this way, radio frequencies were monitored between 5 and 6 times per hour throughout the day and night. Because radio transmitters were programmed to emit 30 transmissions per minute, we considered radio frequencies with 26 pulses or less during a 30 second scan to represent ducks feeding. Frequencies with 26-34 pulses were considered ducks present but not feeding, and frequencies with more than 34 pulses were considered erroneous readings (see Figure 6). High pulse rates may have been caused by competing radio frequencies from two or more ducks close to the radio towers, or erroneous pulses coming from observers using hand-held marine radios near towers. Since we could not determine the exact nature of these signals, we did not consider them reliable indicators of the presence or behavior of ducks.

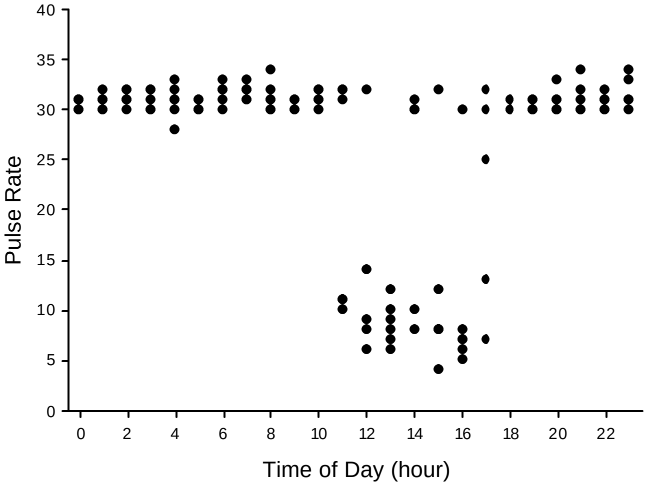


Figure 6. Pulse rate of radio transmitter 4069 placed on a Long-tailed Duck on the Cottle / W. Long barrier islands of the Beaufort Sea, Alaska. Data are from the 29 July 2000. Pulse rates below 26 signified a bird that was feeding whereas pulse rates from 26 to 34 signified a bird that was not feeding.

Disturbance

We implemented experimental disturbances at two of the three capture areas. On the Flaxman Island Capture Area, we drove a 18' aluminum boat throughout the lagoon following a grid pattern with 300 m distances between travel lines. This disturbance was conducted four times between the 3 and 6 of August. In addition, personnel used boats to collect ducks on the 8 and 9 August. At the Cottle Island Capture Area, experimental disturbances occurred more irregularly and were timed so that people were able to collect location and feeding data on ducks from telemetry towers before and after a disturbance event. The Maguire Islands Capture Area was considered undisturbed and all boat traffic to the islands was minimized and generally restricted to the ocean side of the lagoon. Unfortunately we could not control other boating and aerial activities that occurred throughout the lagoon system.

Movement Patterns and Behavior Analyses

Because bays within the Beaufort Sea lagoon system may vary in habitat quality, we conducted a separate analysis for each capture location. These analyses were further subdivided into observer and automated DCC monitoring data. Because ducks are represented multiple times within and across days and thus may violate assumptions of independence required for most statistical tests, we do not provide statistical probabilities for most of our analyses.

Observer Monitoring

To document movement patterns of ducks, we first overlaid the location of ducks on to an Arc View hydrography coverage using X, Y coordinates generated from the SAS radio triangulation programs. A plot of all duck locations generated from radio triangulation indicated nine of the 2,287 total locations were placed in unlikely positions (e.g., many kilometers inland or out in the ocean). These nine locations were excluded from further analyses. The location of ducks was then subdivided into the following classes: within 300 m of a barrier island, greater than 300 m from a barrier island or mainland shore but within the lagoon system, greater than 300 m from a barrier island but in the ocean, and within 300 m of the mainland coast. The percentage of ducks within 300 m of a barrier island and within the lagoon system were then related to the time of day and behavior of each duck to determine diurnal movement patterns and feeding locations (these two categories accounted for 90% of the data). For these analyses, repeated observations of the same individual within each hour were used.

Automated DCC Monitoring

Because the automated DCC telemetry antennas were stationary and could only detect ducks out to about 7 km, we used the DCC radio receptions to indicate the presence and absence of radio-equipped ducks near the tower. In this way, we documented movements of ducks into and out of the area surrounding each DCC tower. To estimate the percentage of time individual Long-tailed Ducks spent feeding, we calculated the percentage of records within each hour that each duck was classified as feeding. These values were then averaged together across all radio-equipped ducks that were monitored during a given hour to investigate daily patterns in feeding. Individual ducks in this analysis are represented once per hour during each day.

Table 6. Number of Long-tailed Ducks captured and radio-marked on three barrier islands of the Beaufort Sea, Alaska, during 2000.

	Western Region	Eastern Region	
	Cottle Island	Maguire Islands	Flaxman Island
Number Captured	45	119	129
Number (%) of Males	37 (82.2)	114 (95.8)	129 (100)
Number Radioed	20	26	26
Capture Dates	July 28, 31; Aug. 4, 6, 7	July 31	July 29, 30

Table 7. Sampling results for radio-equipped Long-tailed Ducks monitored by people at three capture areas in the Beaufort Sea, Alaska, using directional antenna tower set-ups in 2000.

	Western Region	Eastern Region	
	Cottle Island	Maguire Islands	Flaxman Island
Sampling (days)	11	7	10
Sampling (hours)	129	47	91
Number of Radios	18	25	25
Fixes/radio	48.6 ± 27.5	19.7 ± 11.7	37.3 ± 21.4
Total Fixes	872	492	933
Disturbance Type	Before/After	None	Regular

MOLTING ECOLOGY: RESULTS

Capture

We captured 45, 119, and 129 Long-tailed Duck on the shorelines of Cottle, Northstar, and Flaxman Islands, respectively, within the Beaufort Sea Lagoon system between the 28 July and 7 August 2000 (Table 6). Most captured ducks were males (97.2% overall, Table 6). Of these, 20, 26, and 26 males, respectively, had radio-transmitters attached. Only one radio emitted a mortality signal within a few days of capture suggesting this duck may have died.

Location and Behavior

Observer Monitoring

Observers monitored radio-equipped ducks from telemetry towers for 7 to 11 days at each capture area extending from the 30 July to the 13 August. People manned two towers simultaneously for a total of 260 hours during this time. Of the initial sample of radio-equipped ducks, four ducks (2 in each region) did not have sufficient data to radio-triangulate any positions after capture. The remaining ducks with radios were detected between 20 to 48 times on average, depending on the capture area and sampling duration (Table 7).
Most radio-equipped ducks were located either near the barrier islands or in the lagoon itself, whereas smaller numbers were located in the ocean and near the mainland (Figure 7).

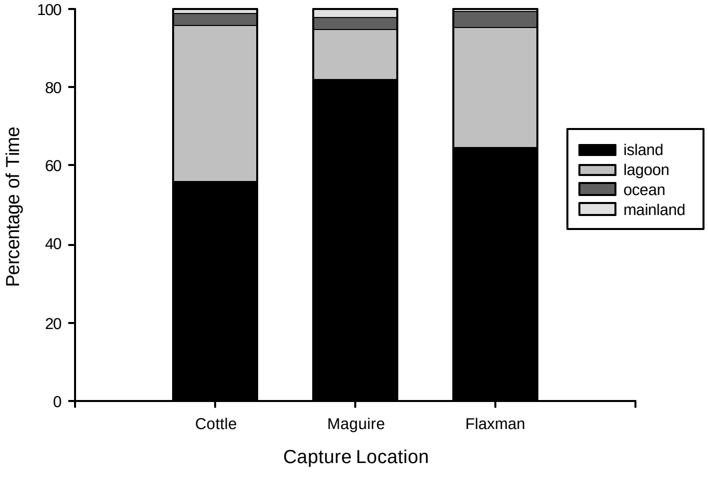


Figure 7. Percentage of time where Long-tailed Ducks were found near barrier islands, within lagoons, in the ocean, and along the mainland of the Beaufort Sea, Alaska, 2000. Data based on radio triangulation locations plotted on ArcView hydrography coverages.

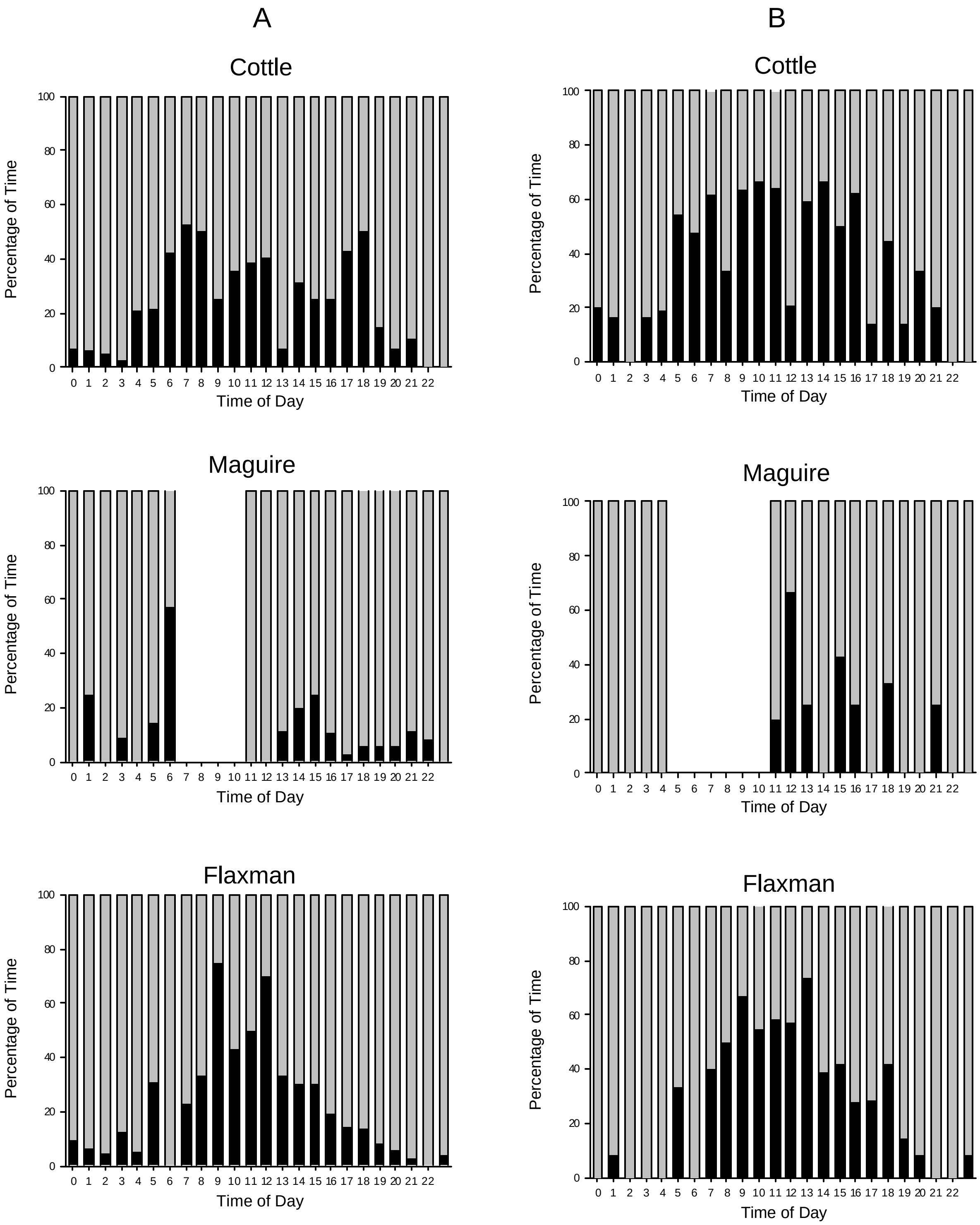


Figure 8. Percentage of time Long-tailed Ducks are located near the barrier islands (column A), and within the lagoons (column B) of the Beaufort Sea, Alaska, 2000. Black and gray bars represent birds that were and were not feeding, respectively. Data based on people recording radio transmitter signals used to triangulate bird locations and determine behavior (see text for details).

This was true for all three-capture areas. An analysis restricted to ducks near islands and in the lagoon (>90% of the observations) indicated ducks moved between the island and lagoon during the day, spending the evening hours predominately near the barrier islands and the afternoon hours in the lagoon (Figure 9). This was true for all three capture areas, although less so at the Maguire Islands Capture Area. Nevertheless, some portion of the Long-tailed Duck population was always in the lagoon and near the islands, regardless of the time. We next conducted an analysis to determine whether ducks were more likely to be feeding when near the islands or in the lagoon (Figure 8). These data suggest ducks spend a much higher percentage of their time feeding during the middle of the day than at night, regardless if they are located near the barrier islands or in the lagoon. This pattern was particularly strong at the Flaxman and Cottle capture areas. Missing data at the Maguire Islands Capture Area from 07:00 to 10:00 hrs made it difficult to detect such a pattern, although this feeding regimen appeared to be stronger for ducks located in the lagoon than near the islands.

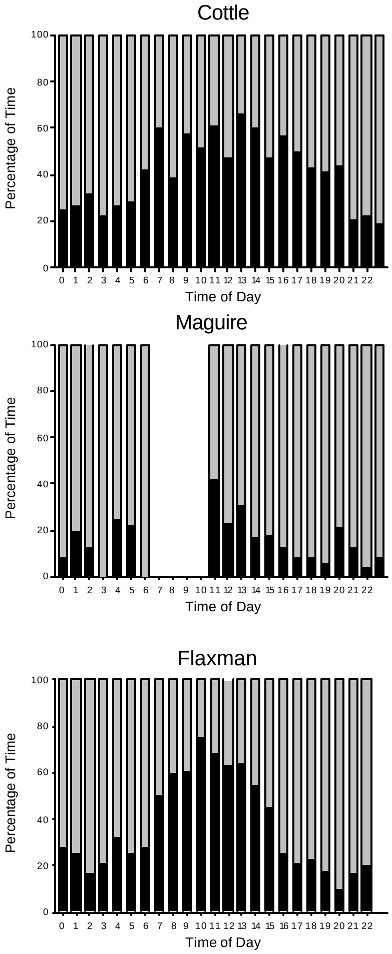


Figure 9. Percentage of time Long-tailed Ducks were located near barrier islands (gray) and within the lagoon (black) portions of the Beaufort Sea, Alaska, 2000. Data based on radio triangulation locations plotted on ArcView hydrography coverages.

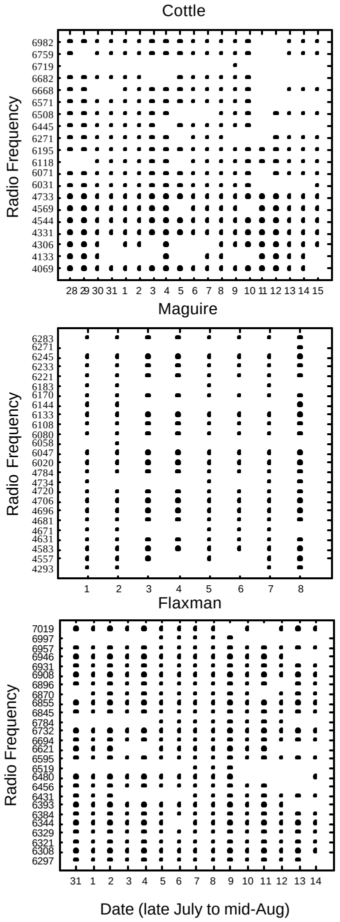


Figure 10. Site tenacity of radio-equipped Long-tailed Ducks at three capture areas on the Beaufort Sea, Alaska, 2000. Each dot indicates a duck was detected with Data Collection Computers during that day.

Automated DCC Monitoring

Data collection computers monitored radio-equipped ducks from telemetry towers for 8 to 19 days at each capture area extending from 28 July to 15 August (Table 8). Over 750 hours of data were collected during this time. Of the initial sample of radio-equipped ducks, only one was not heard after capture. The remaining radio-equipped ducks were detected between 474 and

917 times on average, depending on the capture area and sampling duration (Table 8).

The DCC monitoring system was unable to provide a location for the radio-equipped ducks. We could, however, determine when a duck left and entered the reception range of the DCC telemetry towers (approximately a 7 km distance from the tower). This approach provided a rough estimate of site tenacity (Figure 10).

Of the 71 ducks equipped with radios, 46% (33) were present at their respective capture area throughout the DCC monitoring period. As the sampling period at each capture area increased (i.e., from 8 days on Maguire to 19 days on Cottle), the percentage of ducks remaining at the capture area decreased (68% at Maguire to 20% at Cottle). When the data were standardized across capture areas for the shortest sampling period (1-8 August on Maguire), the percentage of birds exhibiting site tenacity throughout these 8 days increased from West to East (55% on Cottle, 68% on Maguires, and 76% on Flaxman). Thirty-two percent (23) of the 71 radio-equipped ducks were lost and then detected again at their original capture area at a later date. A severe storm that hit the barrier islands during the evening of 10 August may have resulted in ducks leaving their original capture area. Indeed, nine ducks at the Cottle Capture Area disappeared that night. Six of the nine eventually returned to Cottle by 15 August. Only two ducks

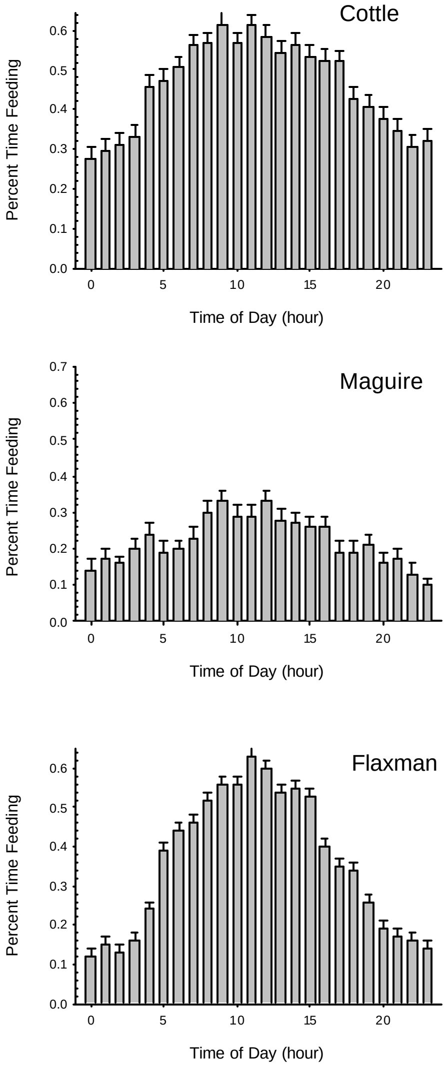


Figure 11. Average (+SE) percent time feeding by Long-tailed Ducks at three capture areas on the Beaufort Sea, Alaska, 2000. Data were based on pulse rates of radio transmitters collected automatically with Data Collection Computers.

Table 8. Sampling results for radio-equipped Long-tailed Ducks monitored by DCC at three barrier islands in the Beaufort Sea, Alaska, using non-directional antenna tower set-ups in 2000.

	Western Region	Eastern Region	
	Cottle Island	Maguire Islands	Flaxman Island
Sampling (days)	19	8	15
Sampling (hours)	419	150	202
Number of Radios	20	25	26
Fixes/radio	917.1 ± 140.0	473.8 ± 60.8	562.3 ± 55.3
Range of Fixes/radio	1 to 2,084	1 to 758	6 to 880
Total Fixes	18,342	11.944	14.610
Disturbance Type	Before/After	None	Regular

left the Flaxman Capture Area during the storm; no data were directly available from the Maguire Islands Capture Area. However, observers in the Flaxman Island Capture Area subsequently detected five radio-equipped ducks originally captured on the Maguires. Pulse rates collected by the DCC monitoring system allowed us to detect a daily pattern in feeding rates at each capture area (Figure 11). These feeding patterns were similar to those detected by people at telemetry towers (compare Figures 9 and 11). Again, the percentage of time ducks spent feeding was higher during the middle of the day than at night. There was a large difference among capture areas, however, with ducks at the Maguire Islands Capture Area having much lower feeding rates overall and less of a daily pattern. Ducks at the Flaxman Island Capture Area showed the strongest diurnal pattern.

Disturbance

Analyses of the effects of disturbance on Long-tailed Duck location and movement patterns are not yet completed. Initial indications are that duck movements associated with disturbance are less than we can accurately measure with radio triangulation using current methods (see Future Research and Study Limitations in Discussion). We are in the process of analyzing our data to look for changes in feeding rates due to disturbance.

MOLTING ECOLOGY: DISCUSSION

The use of radio transmitters in this study provided some of the first direct information on daily movements, site tenacity and feeding behavior of individual Long-tailed Ducks recorded for the Beaufort Sea lagoon system. The majority of studies in the past have relied on aerial surveys or observations from island shorelines to record such movements (Johnson and Richardson 1981, Johnson 1982, Johnson and Gazey 1992). Only one other study of radio-marked Long-tailed Ducks has been conducted in the Beaufort Sea (Bartels et al. 1983). This study, conducted at Tapkauruk Lagoon 24 km east of Barter Island, successfully tracked nine Long-tailed Ducks through molt until they either disappeared or were detected west of the capture area. The use of very large transmitters (28 g), however, led to the loss of 7 of 16 ducks equipped with radios, and may have biased the behavior of the remaining nine birds. Our much smaller radios (15 g) appeared to have negated these problems.

Location and Movements

Radio triangulation of Long-tailed Ducks indicated most occupied areas near the barrier islands or in the lagoon. Transmitter detection distance, however, may have limited our ability to detect birds that moved to the mainland or ventured far into the ocean. Aerial radio telemetry searches would have been necessary to document the location of ducks after they left our capture areas. For the birds within detection distance of the telemetry towers, there appeared to be a strong daily movement between the barrier island shorelines at night and the middle of the lagoon during the day. This pattern was very strong on the Flaxman and Cottle Island capture areas and slightly weaker on the Maguires. Bartels et al. (1983) also found a high proportion of their radio-equipped birds in lagoons or within 400 m of land while in the ocean environment. Johnson (1982) observed Long-tailed Ducks from blinds on Thetis Island and noted a strong diurnal movement pattern, with peak numbers of birds occurring on or near roost sites near midnight. These authors and others (e.g., Johnson and Richardson 1981) suggest that Long-tailed Ducks move from the lagoons to ocean areas as molt is completed and the westward migration begins. Unfortunately, we were unable to collect location data on our radio-equipped ducks long enough to verify these movement patterns.

Site-Tenacity

The DCC data suggested a relatively high site tenacity to capture areas. Although our analysis was limited by how long each capture area was monitored, a preliminary analysis suggest that birds in the eastern region of our study areas were more site faithful. These patterns may be reflection of local geomorphology (e.g., the barrier islands essentially end at the Flaxman Island Capture Area) or other unknown variables. Duck fidelity to capture areas was also affected by the severe Arctic storm that hit the islands on 10 August. At least nine and five ducks left the Cottle and Maguire Islands capture areas during this storm. Few ducks, in contrast, left the Flaxman Island Capture Area. These movements were not unexpected given the lack of cover on the Maguires, and the ability of Cottle ducks to move east to other islands with the strong southwest winds. The ducks on Flaxman had no islands to the east to retreat to, and thus were forced to stay near the capture area. Bartels et al. (1983) also reported a relatively high level of site tenacity in their study. Almost half of their ducks remained in their capture area, while 35.7% drifted to the east and 17.3% occurred west of the capture areas.

Feeding Behavior

Long-tailed Ducks exhibited a daily feeding pattern with birds spending the highest percentage of their time feeding during the afternoon. Similar patterns were found by observers monitoring transmitter signals and by interpretation of the DCC data. These patterns indicate that ducks follow a day/night feeding regiment despite the fact that for much of the molting period there is sufficient light to allow feeding 24 hours a day (see below). There were surprising differences among capture areas in the percentage of time ducks spent feeding overall. Ducks at the Maguire Islands Capture Area fed at much lower levels relative to the other two capture areas. These ducks also exhibited less of a daily pattern. We currently do not have an explanation for these differences but anticipate exploring whether differences in capture areas exist in regards to health indices of ducks and background contaminant levels.

Disturbance

The analyses to date provide little information on the effects of disturbance on the molting ecology of Long-tailed Ducks. Although we were able to determine rough locations of ducks using radio-triangulation, we feel it necessary to refine these techniques before we can measure changes in duck locations due to real or experimental disturbances (see Future Research and Study Limitations below).

At a general level, the ducks at the experimentally disturbed (Flaxman) and undisturbed (Maguires) capture areas differed in several ways. The ducks at the Maguire Islands Capture Area had lower site fidelity, irregular daily movement patterns, and much lower and irregular feeding patterns. In contrast, ducks at the Flaxman Island Capture Area exhibited high site fidelity, strong daily movements between islands and lagoons, high feeding rates, and a strong diurnal pattern of feeding. These patterns are the opposite of what we might predict given the role disturbance is expected to play. This suggests that other factors, besides our regular boating disturbance, may be influencing duck activity.

Future Research and Study Limitations

The first improvement that we foresee in the coming year is the development of a radio telemetry system that will provide more information, and if possible, more accurate determination of duck locations. Our radio triangulation abilities were hampered in the year 2000 by using two towers to triangulate instead of three. The additional tower would allow aberrant radio bearings to be detected and provide a much smaller error polygon surrounding our predicted duck locations. Alternatively, we are exploring the use of a series of automated telemetry towers that would be placed along a large portion of the barrier island shoreline. We could then employ DCCs in combination with towers outfitted with multiple antennas connected to multiplexors. Such an arrangement would provide information on presence/absence, movement along the shoreline, feeding behavior, and general direction to the radioed bird. A system similar to this has been employed on knots (*Calidris canutus*) in the western Dutch Wadden Sea with success (van Gils 2000).

The automated system proposed above has several advantages over having people monitor transmitter signals. First, more data are collected over a longer period of time (i.e., more days and throughout the day). Second, data are collected without regard to weather or logistical constraints that may prevent personnel from reaching telemetry towers. The major disadvantage to the automated system is that it is less accurate at determining duck locations, especially when compared to a three tower triangulation setup. In addition, automated systems are costly to purchase and take a lot of effort to construct. However, once such systems are purchased and are in place, they will soon offset the costs associated with having large field crews employed to operate towers.

Conclusions

The methods employed during the summer of 2000 to monitor the molting ecology of Long-tailed Ducks proved to be very effective overall. The use of radio transmitters allowed us to collect some of the first information on individual ducks. This approach indicated that ducks residing within different lagoons vary in their movements and behavior. Such information is critical when evaluating the effects of disturbance, especially when this disturbance may be unevenly distributed across a region. Although our abilities to investigate direct effects of disturbance were limited, we anticipate exploring this variable in more detail this coming winter and summer.

BODY CONDITION OF MOLTING LONG-TAILED DUCKS

Waterfowl are particularly vulnerable to predation and catastrophe when flightless. Furthermore, molt and feather growth may be nutritionally stressful (Hohman et al. 1992). However, studies have shown that some waterfowl can meet the nutritional requirements of molt from environmental sources (i.e., foods) without depleting nutritional reserves (Ankney 1979). Body condition and muscle mass dynamics are of particular importance to understanding the vulnerability of molting Long-tailed Ducks to disturbance. Additional industrial disturbance may result in reduced time available for Long-tailed Ducks to feed and meet the nutritional demands of feather growth, thus increasing the duration of the flightless period. Because of this potential vulnerability, Johnson and Gazey (1992) identified Long-tailed Ducks as a potential indicator species to monitor the effects of oil exploration in the lagoons off the northern coast of Alaska. Our objectives were to:

1. Compare the duration and timing of the flightless period of molting Long-tailed Ducks between sites before and during industrial development.

2. Compare the dynamics of muscle mass and body composition of molting Long-tailed Ducks at developed and control sites in lagoons on the North Slope of Alaska prior to and during the development periods.

3. Document the food habits of molting Long-tailed Ducks collected at each site.

BODY CONDITION: METHODS

This study is being conducted at Eastern and Western study areas previously described. We attempted to obtain comparable samples of birds from each site representing all stages of the wing molt from just prior to flight feather loss through feather growth and reattainment of flight. Specimens were obtained by euthanizing birds captured during banding operations or by shooting in accordance with Auburn University animal care and use committee guidelines. We recorded culmen length and width, tarsus length, and total weight from freshly collected specimens. We froze and transported them back to Auburn University for laboratory analysis.

During the 2000 field season we divided each site into undisturbed and disturbed areas to assess the effects of boat activity on Long-tailed Duck behavior for collection purposes. Sites were divided to more accurately quantify the disturbance to collected birds. We attempted to collect birds from each area within each site during three collection periods: initiation of molt, feather regrowth half-completed, and as birds began to regain flight. Due to adverse weather conditions the final collection of birds was not completed at the Western study site.

Laboratory analysis closely followed procedures described by Thompson and Drobney (1996) and Brown and Saunders (1998). We measured wing surface area by tracing the right wing and using a 1-cm^2 dot grid. We then estimated the degree of body molt in 8 regions: (1) head and neck, (2) back and rump, (3) breast, (4) belly, (5) flank, (6) greater wing coverts, (7) lesser wing coverts, and (8) tail. We used a dissecting probe and estimated the proportion of emerging contour feathers in the blood-quill stage (Taylor 1995). We categorized the degree of molt in each of the 8 areas as 0%, 1-25%, 26-50%, 51-75%, or 76-100% new feathers. Four estimates were made for each feathered area.

We then plucked each bird and removed and weighed the right breast muscles (*M. pectoralis* and *M. supracoracoideus*), right leg muscles (*gastrocnemius*, *iliotibialis cranalis*, *peroneus longus*, and *tibialis cranialis*), heart, empty gizzard, and empty digestive tract (see Bailey 1985, Thompson and Drobney 1996, and Brown and Saunders 1998). A small portion of the heart muscle ($\leq$ 1 g) was removed and preserved for DNA analysis. We also measured the length of the keel as a further index of skeletal size.

Specimens were ground to a homogenized mixture with a Hobart meat grinder. A homogenized subsample weighing approximately 100 g was removed and oven-dried for 72 hours at 90° C. A 10-g subsample of dried homogenate was used to determine lipid and ash content. Subsamples were placed in a Soxhlet apparatus with petroleum ether for 8 hours to remove lipids. The remaining lipid-free material was dried and reweighed to determine lipid content. The dried lipid free subsample was combusted in a muffle-furnace at 550° C for 3 hours and the remainder weighed to determine ash (mineral) content.

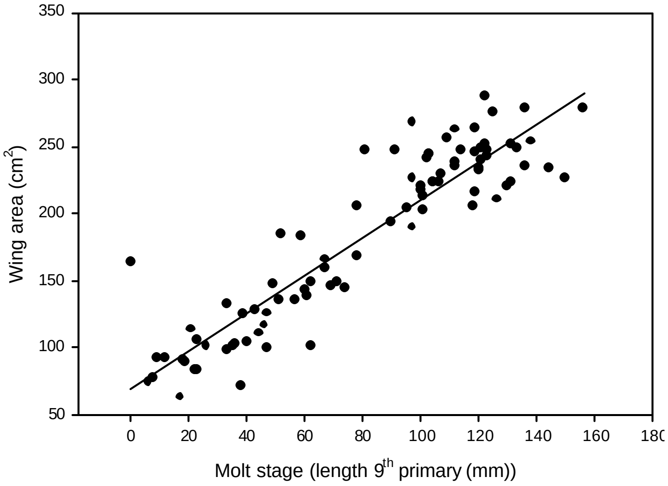


Figure 12. Relation between length of 9th primary and wing surface areas of molting Oldsquaw.

To determine the efficacy of using 9th primary length as an indicator of molt stage, we examined the relationship between 9th primary length and wing area using log-linear regression (Figure 12). We used correlations with body mass to determine which morphological variables (tarsus length, bill width, culmen length, keel length) were likely indicators of overall body size. We used residuals from the regression between the dependent variable body mass and the independent variable bill width (i.e., size) to estimate size-adjusted body mass and nutritional status. We examined the relations between residuals from the above regressions analyses versus molt stage using linear and polynomial models of molt status including potential differences between sites, and an interaction between site and molt status. We selected the models that best fit our data based on ΔAIC $\leq$ 2.0 (Burnham and Anderson 1998). We examined the relations among molt stage and size-adjusted mass of the pectoral muscle, leg muscles, and empty gizzard weight using simple correlation.

BODY CONDITION: RESULTS AND DISCUSSION

We collected 110 Long-tailed Ducks during the 1999 field season and 122 during the 2000 field season. Of these, 214 were males and the remaining 19 were females. In this report, we include the analysis of data from only the birds collected during the 1999 field season for which laboratory analyses have been completed (sample sizes are indicated for all analyses). Examination of upper digestive tracts immediately after collection and subsequently in the laboratory yielded few distinguishable food items, and it will not be possible to examine food habits for the birds collected in this study.

The natural log of the length of the 9th primary explained 87% of the variation in wing surface area (Figure 12). Thus, 9th primary length was a good indicator of molt status and wing surface area. We were concerned that variation in the size of individuals might mask changes in condition related to the stage of molt; therefore, we compared bill width, tarsus, and culmen with measurements of fresh body mass (Table 9). Bill width was the only variable correlated with body mass, and we used residuals from the regression of body mass and bill width (i.e., adjusted body mass) to examine changes in mass related to stage of molt (Figure 13). Bill width was correlated with tarsus and culmen length and size index [ln(culmen + tarsus)], which indicates that size adjustments based on principle components analysis may be an important consideration in future analyses.

To examine the relationships between condition (i.e. body mass, protein level, lipid level, and ash level) and stage of molt, we compared linear models for the dependent (*y*) variable: adjusted mass, percent protein, percent lipid, percent ash and the independent (*x*) variables: length of the 9th primary and squared length of the 9th primary. We also examined potential differences among sites by including site, and an interaction between site and length of 9th primary in some models. The models that fit our data best (ΔAIC $\leq$ 2.0) suggested that the stage of molt was an important explanatory variable for variation in body condition (Table 10). Models for protein and lipid explained a large portion of the variation in composition. However, there was little variation in ash content; consequently the models had little explanatory power. Furthermore, these relationships were somewhat nonlinear for mass, lipid content and protein content, but not ash (i.e., inclusion of the squared length of the 9th primary in the best models) (Figure 14). There was some evidence for differences in the relationship between adjusted body mass and stage of molt for the 2 sites (i.e. inclusion of the interaction term) (Table 10).

Table 9. Pearson correlation coefficient (*P* > *R*), for body mass, bill width, tarsus length, culmen length, collection date, and size index [*ln*(tarsus+culmen)] of Long-tailed Ducks (*n* = 97) collected from Eastern and Western study areas 1999.

	Bill width	Tarsus length	Culmen length	Collection date	Size index
Body mass	0.3438 (<0.001)	-0.1125 (0.27)	-0.0801 (0.46)	-0.0545 (0.60)	-0.1332 (0.19)
Bill width		0.2548 (0.01)	0.1634 (0.11)	0.0280 (0.79)	0.2761 (0.01)
Tarsus length			0.2543 (0.01)	0.0550 (0.59)	0.9574 (<0.001)
Culmen length				-0.0925 (0.37)	0.5123 (0.51)
Collection date					0.0260 (0.80)

We subsequently examined the relations between molt stage and size-adjusted mass of the pectoral muscle, leg muscles, and empty gizzard weight. It was our expectation that these data would follow the patterns observed for Blue-winged Teal (*Anas discors*) by Brown and Saunders (1998). They found that during feather growth molt pectoral (flight) muscle mass declined as leg (swimming) muscle mass increased. We found no correlation between the molt stage and these variables (Table 11) suggesting that Long-tailed Ducks do not experience disproportionate atrophy of wing muscle or hypertrophy of leg muscle during wing molt.

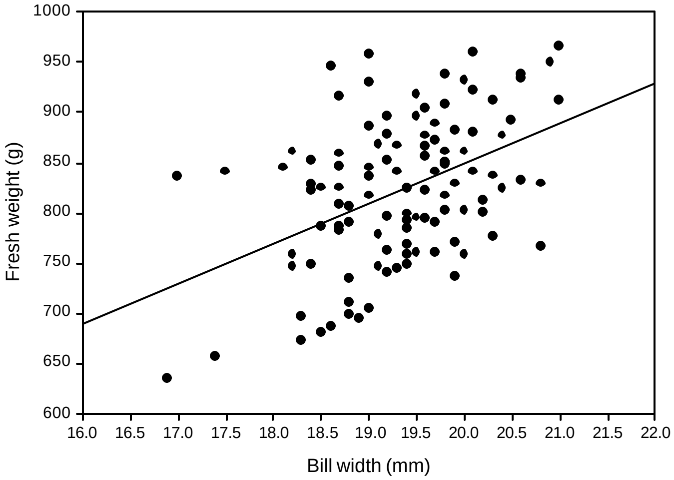


Figure 13. Relation between fresh body mass and bill width of Long-tailed Ducks collected at Beaufort Sea study sites Eastern and

Finally, we determined the extent of body molt concurrent with wing molt (Table 12). Based on the specimens we examined, nearly all birds were undergoing body molt concurrent with the wing molt in every region we examined except the head and neck. In future analyses we will examine the intensity of molt in each of these feathered regions.

Table 10. AIC, correlations coefficient (R^2), and number of parameters (*p*) for best linear models of indexes to condition for Long-tailed Ducks (*n* = 97 for adj. body mass; *n* =43 for protein, lipid, and ash).

Dependent Variable	Model [1]	p	R^2	AIC	?AIC
Adjusted Mass (g)	9th	1	0.11	791.5	0.0
	9th, 9th^2	2	0.12	791.6	0.1
	Site, 9th, site*9th	3	0.13	792.8	1.3
	Site, 9th, site*9th, 9th^2	4	0.15	792.9	1.4
	Site, 9th	2	0.11	793.5	2.0
Protein (%)	9th, 9th^2	2	0.52	-253.5	0.0
	Site, 9th, site*9th, 9th^2	4	0.54	-253.46	0.04
	Site, 9th, 9th^2	3	0.52	-252.5	1.0
Lipid (%)	9th, 9th^2	2	0.48	-240.9	0.0
	Site, 9th, 9th^2	3	0.49	-240.4	0. 5
	Site, 9th, site*9th, 9th^2	4	0.49	-239.7	1.2
Ash (%)	9th	1	0.01	-312.7	0.0
	Site	1	-0.02	-311.6	1.1
	Site, 9th	2	-0.01	-311.1	1.6
	9th. 9th^2	2	-.01	-311.1	1.6

We plan to complete laboratory and statistical analyses of the 233 specimens collected in 1999/2000 field seasons during the summer of 2001. We anticipate our samples after the 2000 field season will allow us to examine the influence of disturbance on body condition and mass dynamics in early and late molt. We propose to drop the objective to address food habits since it seems unlikely that specimens collected for the study of muscle mass and nutritional dynamics will yield adequate samples.

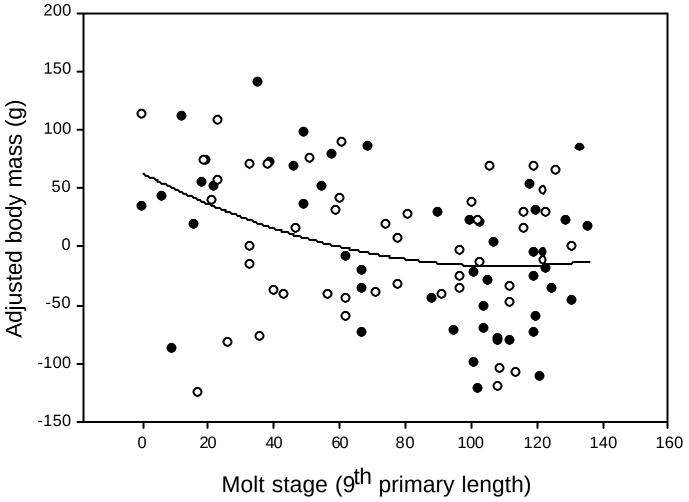


Figure 14. Polynomial model of relation between adjusted body mass and stage of molt (length of ninth primary) for Long-tailed Ducks collected at Simpson Lagoon and Flaxman Island study sites in 1999.

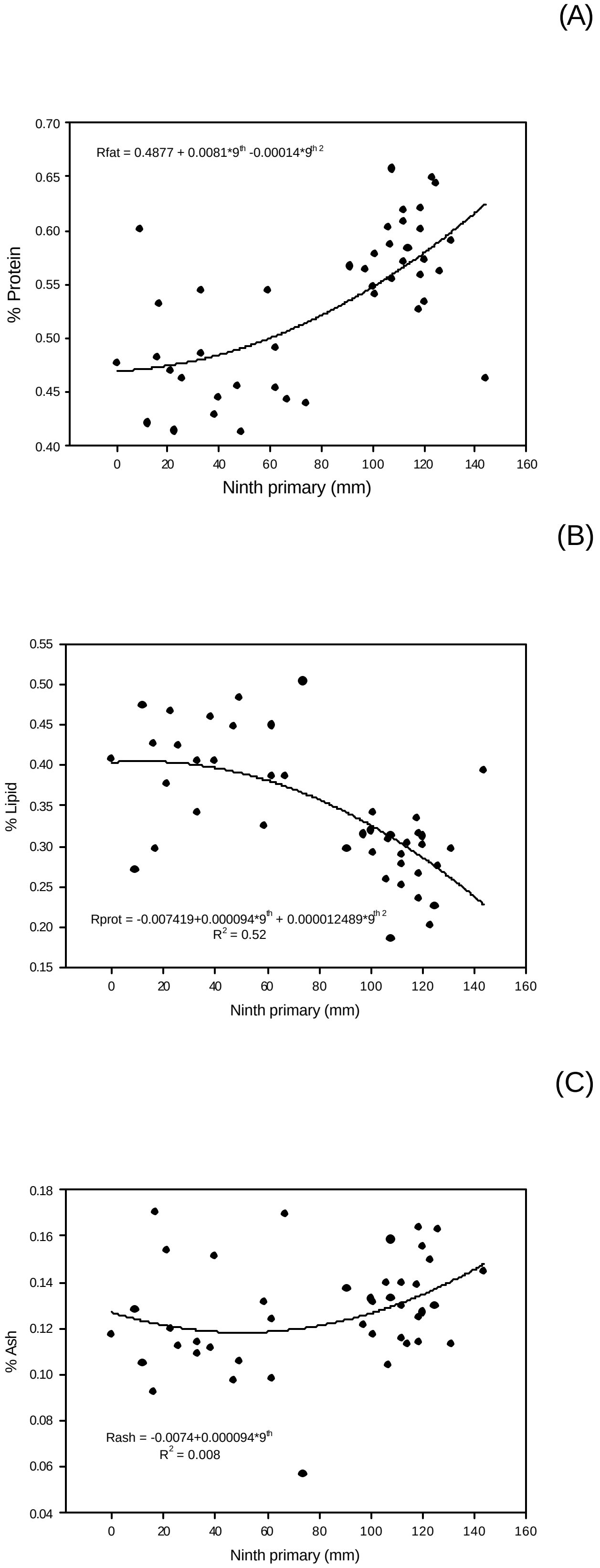


Figure 15. Polynomial model of relation between size-adjusted protein (A), lipid (B), and ash (C) content versus stage of molt (length of ninth primary) for Long-ailed Ducks collected at Simpson Lagoon and Flaxman Island study sites in 1999.

Table 11. Pearson correlation coefficient (*P* > *R*), and sample sizes for adjusted body mass (g), pectoralis muscle (g), leg muscle (g), and gizzard of
Long-tailed Ducks collected at Flaxman Island and Simpson Lagoon study areas, 1999.

Name	body	pectoralis	leg muscle	gizzard
9th Primary	-0.3255 (0.001) (*n* = 97)	0.2426 (0.47) (*n* = 11)	-0.1453 (0.67) (*n* = 11)	0.1252 (0.71) (*n* = 11)
Adjusted Body Mass		0.4653 (0.15) (*n* = 11)	0.51466 (0.11) (*n* = 11)	0.30236 (0.34) (*n* = 11)
Pectoralis Mass			-0.05907 (0.86 (*n* = 11)	0.00908 (0.98) (*n* = 11)
Leg Muscle Mass				-0.13301 (0.70) (*n* = 11)

Table 12. Frequency of birds molting feathers in each body region (*n* = 30 birds).

Region	*n*
Head and Neck	1
Back and Rump	30
Breast	25
Flank	29
Belly	22
Greater Coverts	26
Lesser Coverts	22
Tail	25

BREEDING ECOLOGY OF COMMON EIDERS

Common Eiders of the Pacific sub-species breed on the un-vegetated barrier islands of the Beaufort Sea (Schamel 1977). We sought to examine the ecology of this breeding population for comparison with other breeding populations and between the “industrial” and “control” areas along the Beaufort Sea. Further, we sought to establish the basis for a simple population model by determining levels of productivity and annual survival.

Clutch size, hatching success of eggs, and nest success are important parameters for determining recruitment in waterfowl populations (Johnson et al. 1992). Juvenile survival is a critical, yet highly variable, component of waterfowl productivity (Johnson et al. 1987, 1992). Further, Coulson (1984) concluded that recruitment had a strong influence on Common Eider population dynamics in Britain. Milne (1974) demonstrated considerable annual variation in the proportion of ducklings surviving to fledging and linked years of high duckling survival to subsequent increases in population size. Estimates of the proportion of Common Eider ducklings surviving to fledging vary from 10% in Scotland to 24% in Nova Scotia (Milne 1974, Mendenhall and Milne 1985). Estimates of the number of ducklings fledged per female varied from 0.47 in the Netherlands to 0.89 in Finland (Hilden 1964, Swennen 1983). Thus, brood rearing may be a bottleneck in annual productivity, and low duckling survival may be a major determinant of recruitment.

BREEDING ECOLOGY: METHODS

We searched all islands from Brownlow Point through the Maguire Islands (East Area) and from Stump to Spy Island (West Area). Teams of observers searched islands by systematically examining all potential nesting cover in sufficient detail to detect nests not attended by females. Nest searches began as soon as incubation was detected during spot checks of suitable nesting habitat.

We recorded the location of all nests using GPS and active nests (i.e., eggs present) were marked with a lathe placed 5m North of the nest bowl. We numbered and candled each egg to determine viability and stage of incubation (Weller 1956). Habitat information describing the landform (i.e., gravel, tundra), distance to water, height above water, and abundance and size of driftwood within 1 meter of the nest was recorded. Nests were revisited at irregular intervals to determine success. During each visit to a nest, we recorded the presence of the female, condition and number of eggs, and stage of incubation. After hatch, we visited nests and determined egg fates from nest contents. We subtracted depredated and unhatched eggs from the number of eggs laid into the nest to determine the number of ducklings produced. We calculated nest initiation dates by subtracting the estimated age of embryos, as determined by candling, plus the number of eggs laid into the nest from the date of discovery.

We only used nests containing eggs that showed signs of embryonic development in the analyses of nest initiation date, and nest success. Only nests that survived to incubation were used to calculate clutch sizes. We defined clutch size as the number of eggs laid into a nest, partial depredation as the number of eggs missing from nests that remained active, and successful nests as those in which at least one egg hatched. We used daily survival rates (DSR) to examine nest success (Johnson 1979). Nests found destroyed, abandoned or hatched, and those for which an accurate initiation date could not be determined, were not used in the analysis of nest success.

We used radio-telemetry to monitor mortality of duckling and adult female Common Eiders. We trapped females on their nests 0 to 5 days before hatch using a mist net, a dip net, or a string-activated bow-net (Sayler 1962). Captured females were weighed and the lengths of the culmen and total tarsus were measured. All birds were marked with metal U.S. Fish and Wildlife Service tarsus bands. A sub-sample of females was fitted with a 15-g subcutaneously anchored radio transmitter (Pietz et al. 1995). Initial brood size was assumed to be equal to the number of eggs present in the nest on the last visit prior to hatch.

Figure 16. Distributions of Common Eider nest initiation dates, by study site during summer 2000.

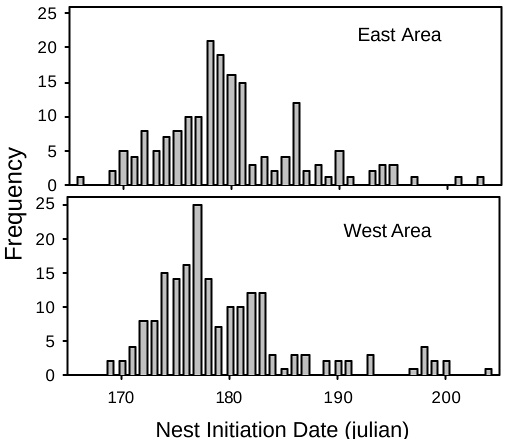


Table 13. Number of nests found by species and study area in summer 2000.

	# of nests found	
Species	East Area	West Area
Common Eider	228	218
King Eider	1	6
Unknown Eider[1]		17
Long-tailed Duck	2	2
Northern Pintail	4	
Black Brant		4
Canada Goose	2	
Arctic Tern		3
Glaucous Gull	19	47

[1] Unknown Eider results from nests found after having failed. No female was observed.

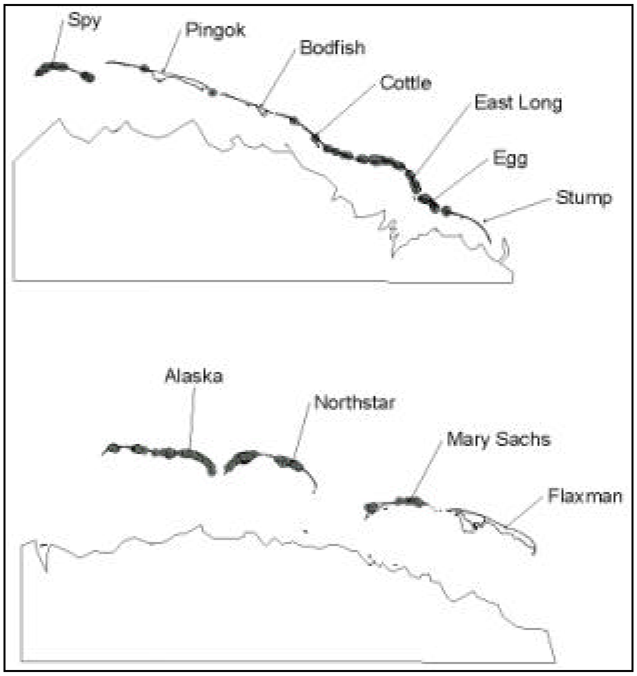


Figure 17. Areas searched by study site (Eastern on bottom, Western on top) and general locations of Common Eider nests on the barrier islands of the Beaufort Sea, Alaska, 2000.

Using boats, we attempted to determine the location of radio-marked females remaining on each study area approximately bi-weekly. When unable to locate females on the study area, we searched accessible areas within the lagoon and open water areas of the Beaufort Sea within 2 km of the barrier islands using boats. To estimate duckling survival rates, we counted ducklings in eider broods with radio-marked females from boats at approximately 30-days post-hatching.

BREEDING ECOLOGY: RESULTS

We found a total of 555 nests across both study areas. Total number of nests by species are given in Table 13. Nest sites at the West Area tended to be lower, relative to the water line, than nests at the East Area ($P<0.01$). There was no difference in other nest site characteristics between study areas ($P>0.11$). There was no difference in the distribution of nest initiation dates between study areas (Figure

Table 14 Estimates of nesting success for Common Eiders and Glaucous Gulls at each study site.

	East Area	West Area
Common Eiders		
Number of nests	193	190
Exposure Days	2385	2803
No. Hatched	48	47
Daily Survival Rate	0.9392	0.9489
Hatching success	0.1523	0.2078
95% CI	0.11-0.20	0.15-0.27
Glaucous Gulls		
Number of nests	19	14
Exposure Days	243	146
No. Hatched	14	11
Daily Survival Rate	0.9794	0.9794
Hatching success	0.5359	0.5364
95% CI	0.30-0.93	0.25-1.0

16). Clutch size declined with nest initiation date at a rate of 0.10 ± 0.02 eggs per day ($F_{1,306}$=63.00, P=0.001). The slope of this decline varied between study areas ($F_{1,303}$=3.96, P=0.0475); clutch size, adjusted for initiation date, varied between study areas ($F_{1,303}$=4.40, P=0.0367). Mean clutch size at the Eastern Area was 3.13 ± 0.08, and 3.53 ± 0.09 in the Western Area. We only had sufficient sample size to estimate nesting success for Common Eiders and Glaucous Gulls (*Larus hyperboreous*) . Nests were not uniformly distributed across the study areas; both study sites had small areas with very high nesting densities (Figure 17). Nest success estimates, using the Mayfield method did not differ between study sites for either eiders or gulls (Table 14). The most common cause of nest failure was predation at both sites. Arctic fox (*Alopex lagopus*) and Glaucous Gulls were the primary predators. Additionally, nests were lost at the Eastern site due to being buried in drifting sand, and flooding at the Western site.

A total of 47 and 66 females were captured at hatching at the Eastern and Western areas, respectively. There was no difference in the weights of females captured at hatch between sites. A sub-sample of 31 and 30 of these females were marked with radio-transmitters. The estimated duckling survival at the Eastern site was 4.6%; we were unable to estimate duckling survival at the Western site due to problems observing broods.

BREEDING ECOLOGY: DISCUSSION

We found very little evidence of geographic variation in nesting productivity. The only metric that varied between study sites was clutch size. Timing of nesting in 2000 may have been delayed due to a late spring break-up. Other studies have suggested that years with delayed reproduction result in smaller clutch sizes as females are forced to utilize stored reserves while waiting for nest sites to become available. While we found no difference in nest initiation dates between areas, birds nesting at the Western site may have had access to some open water and thus were able to forage and maintain body condition. Alternatively, difference in clutch size between lagoons may be due to differences in age structure of the breeding populations as younger eiders typically lay smaller clutches. We have no data that will allow us to distinguish between these 2 hypotheses.

Our study of duckling survival was severely compromised by methodological problems. First, radio-tagged females dispersed widely and many females were never observed after leaving nesting islands. Patterns of movement were unanticipated and some broods traveled directly to the mainland and moved onto fresh-water wetlands. Additionally, the extensive boat travel required to observe radio-tagged broods conflicted with the goal of minimizing disturbance to molting Long-tailed Ducks. Unfortunately, an approved aircraft was not available to use as an alternative means of gathering data. Thus, we modified our sampling schedule and intended to obtain final estimates of the number of ducklings surviving at 30 days after hatching. However, a severe storm affected both study areas in early August. Following this storm, dead Common Eider ducklings were found on several islands. Only, one female eider was observed with ducklings following this storm event. We suspect that this storm may have resulted in the mortality of essentially all juvenile Common Eiders on both areas. Additionally, all of our boats at Simpson Lagoon were destroyed during this storm making it impossible to confirm brood rearing status of females at this site. Given this storm event, we suspect that our estimate of duckling survival is not representative of productivity at either site in a typical year.

Our duckling survival estimates assumed that radio-tagged females that could not be located, lost all their young (either to mortality or adoption) and dispersed from the breeding area. Radio-marked females without ducklings were regularly observed on the study area; however, these females were usually in flocks of >4 birds. Additionally, these flocks frequently flushed when approached by boat. Based on this observed segregation between brood rearing and non-brood rearing females, it seems likely that other non-brood rearing females moved beyond the range of our detection. Therefore, we assumed that all missing females had lost all their young. Alternatively, if our failure to locate a female was actually caused by radio-transmitter loss or failure, then our estimates of duckling survival are biased low; we have no data to test this assumption.

The tendency of Common Eiders to form crèches (Munro and Bèdard 1977) complicates the estimation of duckling survival. The method of Flint et al. (1995) allows for mixing of young among broods and does not require the assumption that the survival probability of ducklings within broods was independent. However, this technique requires the assumption that we were equally likely to observe increases and decreases in brood size as a result of brood mixing (Flint et al. 1995). Gorman and Milne (1972) suggested that crèche attendance by females was not random but was related to relative hatch date such that later hatching females were more likely to attend crèches. Whereas, Bustnes and Erikstad (1991) demonstrate that females in better body condition were more likely to attend crèches. Therefore, in our specific application, we made two basic assumptions: (1) we assumed we marked a random, representative sample of females with regard to crèche attendance, (2) we calculated an average brood size for radio-marked females observed in crèches and therefore, our estimates assumed that we were equally likely to over- and under-estimate true brood size of females associated with crèches. If we marked females that were more likely to attend crèches regardless of the presence of their ducklings, we will overestimate duckling survival, and vice versa. To account for this potential bias we attempted to distribute the sample of radio transmitters among hatch dates. Capture of females for application of radio transmitters was done without regard to clutch size (i.e., initial brood size), thus we have no reason to suspect a bias resulting from averaging of brood sizes within a crèche. Further, most crèche sizes were small (e.g., 2 females) reducing the potential magnitude of this bias. Overall, we assumed that we radio-marked a random, representative sample of females; this assumption is common to radio telemetry studies and we have no reason to suspect that we violated it.

CONTAMINANTS AND VIRUS EXPOSURE

Many contaminants enter arctic environments through atmospheric transport and releases associated with mining and the use and transport of oil and gas resources. The latter source has been of particular concern near the Beaufort Sea coast. Concentrations of several contaminants were higher in sediments from the Beaufort Sea in comparison to reference areas (Meador et al. 1994). Although lead shot was banned for waterfowl hunting in the United States in 1991, lead exposure continues to occur in eiders and Long-tailed Ducks in Alaska (Flint et al. 1997, Franson et al. 1998). Additional trace elements, including selenium and cadmium, have been reported in tissues of waterfowl in Alaska (Franson et al. 1995, Franson et al. 1999). On Alaska's North Slope, high concentrations of selenium and detectable levels of arsenic, barium, cadmium, lead, and mercury have been found in the blood of adult eiders (M. Petersen, pers. comm.). Few data are available concerning organic contaminants in arctic populations of Common Eiders, although DDE was recently found in eggs of Common Eiders in Finland (Franson et al. 2000). In Alaska, organochlorines were found in seabird eggs collected in the 1970s and, more recently, in the eggs of Bald Eagles (*Haliaeetus leucocephalus*) collected from the Aleutian archipelago in the late 1990s (Anthony et al. 1999). Accordingly, investigation of various contaminants in sea ducks has been identified as a high priority need by the USFWS and the Circumpolar Eider Conservation Strategy and Action Plan (CAFF 1997, USFWS 1999) and evidence already exists to indicate that Common Eiders and Long-tailed Ducks in Alaska are exposed to lead (Flint et al. 1997). Further, the USFWS has requested additional information on mortality sources for these species. Outbreaks of disease have been found to cause catastrophic die-offs in Common Eiders and certainly disease is one potential factor that may be influencing these species at the population level.

OBJECTIVES

(1) Determine the prevalence of viruses in nesting Common Eiders and molting Long-tailed Ducks.

(2) Determine concentrations of selected contaminants in blood and eggs of nesting Common Eiders, and blood of molting Long-tailed Ducks.

(3) Evaluate biochemistry parameters in relation to evidence of virus infection and exposure to contaminants.

CONTAMINANTS AND VIRUS: METHODS

Blood samples (via jugular venipuncture) and cloacal swabs were collected from 66 incubating Common Eider hens (30 at the Eastern area and 36 at the Western area) and 84 molting male Long-tailed Ducks (42 each at each study site). Blood samples were split between heparinized tubes and tubes without anticoagulant (VACUETTE®, Greiner Meditech, Inc., Bel Air, MD) for tests requiring whole blood and serum, respectively. Hematocrits were determined in the field with a battery-operated centrifuge (Compur M1100, Bayer Corp., Mishawaka, IN). Portions of heparinized whole blood were saved for the analysis of trace element concentrations and for the activity of delta-aminolevulinic acid dehydratase (ALAD), an enzyme that is a sensitive indicator of the physiologic effects of lead exposure (Burch and Siegel 1971, Pain 1996). Whole blood without anticoagulant was allowed to clot and serum was harvested. Cloacal swabs from incubating Common Eider females and molting male Long-tailed Ducks were collected in transport media (Hanks' balanced salt solution with 0.5% gelatin and 1,500 IU penicillin, 1,500 µg streptomycin, 100 µg gentamicin, and 100 IU mycostatin per ml). Blood and serum samples and cloacal swabs were frozen in liquid nitrogen in the field.

The serum samples were sent to Marshfield Laboratories, Marshfield, WI, for analysis of the following biochemistries using a Hitachi® 911 (Roche Diagnostics, Indianapolis, IN) analyzer: glucose, aspartate aminotransferase, alanine aminotransferase, gamma-glutamyl transferase, alkaline phosphatase, creatine kinase, lactate dehydrogenase, cholesterol, total protein (and protein electrophoresis), phosphorus, calcium, sodium, potassium, chloride, carbon dioxide, uric acid, betahydroxybutyrate, and triglyceride.

Eggs were collected from 46 Common Eider nests (20 from the Eastern area and 26 from the Western area) and were weighed, measured, wrapped in aluminum foil, and stored chilled in the field. In the laboratory, the egg contents were removed and frozen at –20 C in pre-cleaned glass jars (I-Chem®, Nalge Nunc International, Rochester, NY). Blood samples and eggs were archived at the National Wildlife Health Center, pending contaminants analysis.

Birds found dead in the field, including six Common Eider ducklings, two adult eider hens, and two male Long-tailed Ducks were frozen and later necropsied. The Long-tailed Duck carcasses were picked up during a mortality event that occurred in late summer of 2000 at the Eastern study site. Samples from carcasses were collected for disease testing and tissues were archived for contaminants analysis.

Tissues collected from carcasses for virus isolation included liver, spleen, lung, small intestine, and bursa of Fabricius from Common Eider ducklings, liver and spleen from one Common Eider female, and liver, spleen, lung, small intestine, and cloaca from two Long-tailed Duck males. Approximately 1 g of each tissue was homogenized in virus transport media, and tissue suspensions were centrifuged at 800 g for 30 min. Sixty-four cloacal swabs from Common Eider females and 58 cloacal swabs from Long-tailed Duck males were processed for virus isolation by centrifugation at 800 g for 15 min. Supernatants from each sample were inoculated into Muscovy Duck (*Cairina moschata*) embryo fibroblast monolayers, incubated at 37 C, and followed daily for viral cytopathic effects for 7 days. If cytopathology was not detected, the samples were freeze-thawed and passaged to new cell cultures twice before determined to be negative. Positive cultures are currently being evaluated by negative staining transmission electron microscopy. A standard virus neutralization assay (Hollmén et al. 2000) was used to test serial two-fold dilutions of heat inactivated serum samples for viral antibodies.

CONTAMINNANTS AND VIRUS: RESULTS

Virology

Viruses were isolated from bursal tissues of two Common Eider ducklings collected near the Western study site and from the small intestine and cloaca of a male Long-tailed Duck collected from the Eastern study site. Preliminary findings also indicate that approximately 2% of cloacal swabs collected from nesting Common Eider females and approximately 50% of cloacal swabs collected from molting Long-tailed Ducks at the Eastern site are positive for viruses. The results from the second Long-tailed Duck carcass are equivocal (possible toxicity of tissue suspension), and the results from Long-tailed Ducks live-trapped at the Western site are pending.

The cytopathological characteristics of the viruses isolated from tissues of Long-tailed Ducks resemble those caused by adenoviruses. The prevalence of titers to the virus isolated from the dead Long-tailed Duck was greater in sera of molting Long-tailed Ducks at the Eastern (86%) than at the Western site (10%) ($P<0.01$). Furthermore, significantly higher titers were detected in sera of Long-tailed Ducks molting at the Eastern area as compared to the birds captured at the Western area ($P<0.01$).

Biochemistry

Of 36 blood samples analyzed to date for ALAD activity, values ranged from 137-303 and 103-313 in Long-tailed Ducks (n = 20) and Common Eiders (n = 16), respectively (one unit of ALAD activity is defined as an increase in absorbance of 555 nm of 0.10, with a 1.0 cm light path, per ml of erythrocytes per hour, at 38 C).

All serum samples have been analyzed for biochemistries identified in METHODS, above, and data analysis is in progress. A preliminary comparison of serum biochemistries between eiders nesting at Eastern and Western areas suggest that protein and glucose levels are potentially lower in Common Eiders nesting in the Eastern area, whereas triglyceride levels may be higher in eiders nesting in the Western area.

CONTAMINANTS AND VIRUS: DISCUSSION

Virology

The isolation of a virus in association with a die-off of Long-tailed Ducks molting near the Eastern study area raises a question about the potential of viruses as mortality factors in this species. Necropsy findings in the virus-positive carcass included intestinal lesions similar to those previously found to be associated with adenoviruses (McFerran and Adair 1977; Kilpi et al. 1999). Findings in cloacal swabs suggest that as many as 50% of Long-tailed Ducks molting at the Eastern area were shedding virus, facilitating bird-to-bird transmission and spread of infection within flocks. Comparison of antibody titers in serum samples collected from Long-tailed Ducks live-trapped at the Eastern versus those collected the Western area, where no mortality was observed, indicate differences in virus exposure and infection rates between the two locations. High antibody titers were detected only at the Eastern study site, suggesting recent exposure and active infections in Long-tailed Ducks at this location. However, negative or relatively low titers were detected in sera of Long-tailed Ducks molting in the Western study site. Although these birds may have been previously exposed to the virus, there was little likelihood of recent exposure and active infections during the study period. Our findings support the hypothesis that the newly isolated virus was involved in the mortality observed at the Eastern study site in 2000.

Laboratory findings from tissue samples collected in 2000 indicate that Common Eider females and ducklings in the Beaufort Sea also are infected with viruses. The characteristics of the eider isolates are currently being evaluated in the laboratory, and their significance for eider health needs to be evaluated with further research.

Biochemistry.

Based on preliminary ALAD results indicating that maximum activities were about 300% greater than minimum activities in Common Eiders and 220% greater in Long-tailed Ducks, we predict that lead exposure is having a mild physiological effect on both species. A complete evaluation of the effects of lead on ALAD requires completing the remainder of the enzyme determinations and obtaining the results of blood lead analysis.

OVERALL SYNTHESIS

Given the analyses conducted to date, we found very little evidence for a large scale effect of disturbance. Analyses regarding long-term trends in numbers of Long-tailed Ducks molting in different portions of the lagoon are pending, however, at the broad scale, there has been no dramatic decline in birds in any specific area. We found no evidence for variation in productivity of Common Eiders between study areas. There appear to be differences in foraging behavior and body condition of molting Long-tailed Ducks between areas. However, the patterns were not consistent between years. Further, the variation is inconsistent with disturbance as a causative factor. A virus outbreak in molting Long-tailed Ducks at the Eastern study site may have been responsible for a die-off of unknown magnitude and may have influenced behavior and body condition. The effects of our manipulated disturbance appeared to be minor. The unusual storm that stuck both study areas in August 2000 resulted in major alteration of the barrier islands. Almost all islands suffered severe erosion and a substantial portion of the driftwood present on the islands was washed away. This driftwood is certainly selected as cover by nesting Common Eiders and their behavior in the absence of this wood is unpredictable. Understanding the variation in foraging behavior and body mass dynamics of molting Long-tailed Ducks will require further research. Certainly, the role of virus exposure on this variation deserves further consideration. Similarly, if virus exposure is a regular, major cause of mortality for molting Long-tailed Ducks, then changes in numbers and or distributions of molting birds may be caused by this mortality as opposed to disturbance.

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