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Waterbird Migration Near the Yukon and Alaskan Coast of the Beaufort Sea:
II. Moult Migration of Seaducks in Summer

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ABSTRACT. Westward moult migrations of seaducks were studied in the summers of 1972 and 1975 (northern Yukon) and 1977-78 (west of Prudhoe Bay, Alaska). Methods used were visual observations from the coast, aerial surveys, and (in 1975) DEW radar. Many male Oldsquaws (*Clangula hyemalis*) fly west near the north coast of Alaska in early July. Most seem to travel only a short distance; tens of thousands subsequently moult in various lagoons along northern Alaska. Few of the male eiders (*Somateria* spp.) that leave the Beaufort Sea in summer travel west along the coast past the two study areas. Instead, the main route may be seaward of the barrier islands until the eiders approach Point Barrow. In late June and July, several thousand male Surf Scoters (*Melanitta perspicillata*) fly west near the Yukon and Alaskan coast to moulting areas in lagoons. This flight, unlike moult migrations of most scoters, is not directed toward the wintering areas.

Key words: seaducks, moult migration, Beaufort Sea, Alaska, Yukon, seawatches, Oldsquaw, eider, scoter

RÉSUMÉ. Les migrations de mue vers l'ouest de canards marins ont été sujets d'études lors des étés de 1972 et de 1975 dans le nord du Yukon, et de 1977 et de 1978, à l'ouest de la baie de Prudhoe en Alaska. L'observation visuelle de la côte, les levées aériennes et, en 1975, l'emploi du radar DEW furent les méthodes employées. Nombre de canards à longue queue (*Clangula hyemalis*) volent vers l'ouest de la côte nord de l'Alaska au début de juillet. La plupart semble n'effectuer que de courts déplacements; des dizaines de milliers muent ensuite dans diverses lagunes le long du nord de l'Alaska. Peu d'eiders mâles (*Somateria spp.*) qui quittent la mer de Beaufort au cours de l'été ne se déplacent le long de la côte plus loin que les deux régions étudiées. La route principale préférée peut être du côté extérieur des îles-barrières, jusqu'à ce que les eiders approchent la pointe de Barrow. Vers la fin de juin et en juillet, plusieurs milliers de macreuses à large bec mâles (*Melanitta perspicillata*) volent vers l'ouest près de la côte du Yukon et de l'Alaska vers des régions de mue dans des lagunes. Ce vol, par opposition aux migrations de mue de la plupart des macreuses, n'est pas en direction des régions d'hivernement.

Mots clés: canards marins, migration de mue, Mer de Beaufort, Alaska, Yukon, surveillance marine, canard à long bec, eider, macreuse
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INTRODUCTION

Breeding male seaducks abandon the incubating females in early summer and congregate at communal moulting areas. Moulting areas used by males sometimes are coasts or lakes near the breeding areas, but frequently are hundreds or even thousands of km away (Salomonsen, 1968). Often these areas are distinct from wintering as well as nesting areas, and the movement to moulting areas constitutes a "moult migration" distinct from both spring and fall migration. The males are incapable of flight for several weeks as they shed and regrow their flight feathers. Nonbreeding immatures (age 1-2 yr) and some non- or failed-breeding females may join these males, but most breeding females do not undertake a well-defined moult migration. Instead, most of these females moult near their nesting areas during the brood-rearing period later in the summer.

In his review of moult migration, Salomonsen (1968) distinguishes several categories of movements. These depend on distance and direction travelled, and on geographical distinctness of the moulting area from nesting and wintering areas. The best-defined moult migrations are those to special moulting areas that are far off the direct line between nesting and wintering areas. However, midsummer flights of male seaducks to special moulting areas that are more or less toward the wintering areas are generally considered to be moult migrations provided that the distance travelled is substantial (Salomonsen, 1968).

A spectacular westward moult migration of several hundred thousand male King Eiders, *Somateria spectabilis*, occurs at Point Barrow, Alaska, during July and early August (Murdoch, 1885; Thompson and Person, 1963; L.L. Johnson, 1971). These birds are *en route* from breeding areas in and east of the Beaufort Sea area to moulting areas believed to be in the Chukchi or northern Bering Sea. The westward flight in July is conspicuous at Cape Bathurst, N.W.T., in the eastern Beaufort (Anderson, 1937) as well as at Point Barrow. However, moult migration seems to be less conspicuous along much of the intervening coast (Brooks, 1915; Dixon, 1943; Schmidt, 1973; Hall, 1975; Schamel, 1978).

Westward migration of male Common Eiders, *Somateria mollissima*, is conspicuous at Cape Bathurst, N.W.T., in mid- to late July (Anderson, 1937) and has also been reported along the coast of NE Alaska (Brooks, 1915; Dixon, 1943). However, Common Eiders comprise only ~5% of the westbound eiders at Point Barrow in summer (Johnson, 1971). Whether many males leave the Beaufort area in July by another route is unknown.

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The Oldsquaw, *Clangula hyemalis*, is the other abundant seaduck in the Beaufort area; about 240 000 flew west past Point Barrow during part of the 1975 fall migration season (Timson, 1976). Male Oldsquaws do not leave the Beaufort Sea via Point Barrow during summer, but some westward movement may occur in late June and July within the Beaufort area (Brooks, 1915; Anderson, 1937; Schmidt, 1973; Gavin, 1980). Males of most other populations of Oldsquaws do not undertake long moult migrations, but northward moult movements to Wrangel Island and North Greenland have been reported (Portenko, 1959; Salomonsen, 1972).

Surf and White-winged scoters (*Melanitta perspicillata* and *M. deglandi*) nest north to the Mackenzie Delta and the Brooks Range, but not along most of the Yukon and Alaskan north slope. Males begin to congregate in the Mackenzie Delta in mid-June (Porsild, 1943), and some move northwest to the coasts of the Yukon and NE Alaska. Several thousand Surf Scoters moult annually at Herschel Island, Y.T., in July and early August (Vermeer and Anweiler, 1975; Salter *et al.*, 1980). The NW moult migration of these scoters takes them away from their wintering areas.

This paper provides the first systematic information about the summer movements of seaducks along the south coast of the Beaufort Sea east of Point Barrow. It is based primarily on daily migration watches at coastal vantage points near Komakuk, Y.T., in 1972 and 1975, and at Simpson Lagoon, AK, in 1977-78 (Fig. 1). Data collected after 10 August, when female eiders begin to move west, will be considered in a later paper on "autumn" migration; this paper concerns primarily the male seaducks.

STUDY AREAS AND ICE CONDITIONS

A general description of our 1975 and 1977-78 study areas appears in Richardson and Johnson (1981). Table 1 lists the locations and dates of shore-based observations.

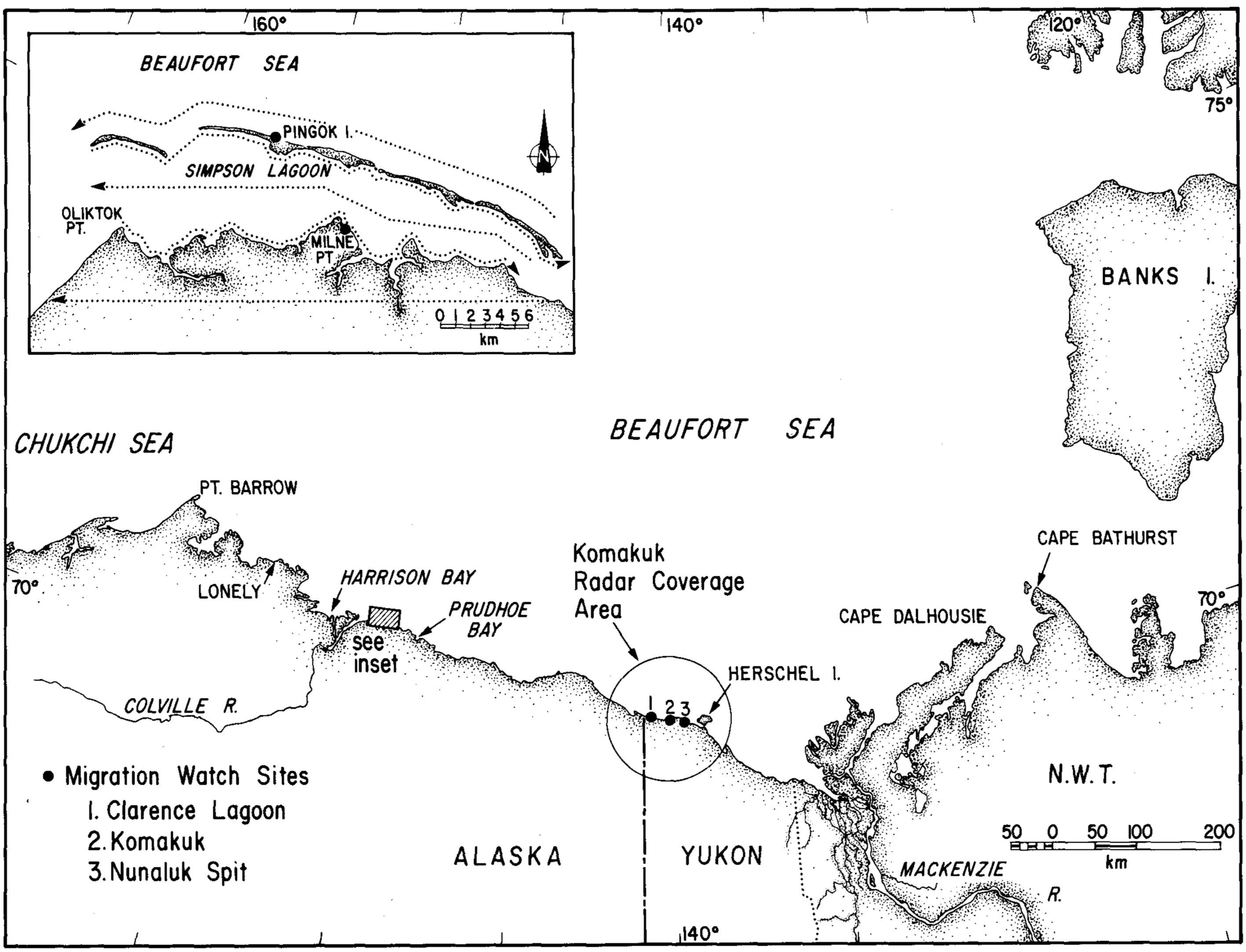

FIG. 1. The Beaufort Sea area, showing migration watch sites, the Komakuk radar coverage area (circle of radius 75 km), and details of the Simpson Lagoon area of Alaska (inset). Dotted lines on inset are the standard aerial survey transects.

In 1972, LGL personnel observed migration from the base of Nunaluk Spit, 14 km east of Komakuk, Y.T. (Gollop and Davis, 1974). Nunaluk Spit is a gravel spit 11 km long and ~45 m wide; it projects ESE parallel to shore and protects a shallow (2 m) lagoon off the mouth of the Malcolm River. Griffiths *et al.* (1975) described ice breakup around Nunaluk Spit.

In 1975, landfast ice completely covered nearshore waters off the observation site at Komakuk until 16 June, when a lead opened several km offshore and cracks formed within 1 km of shore. On 30 June, a shorelead several hundred metres wide opened at Komakuk. A small shorelead appeared at the second observation site, Clarence Lagoon (23 km west of Komakuk), by 19 May. The lagoon became ice-free on 1 July, but the sea ice remained in place until 5 July.

In 1977 and 1978 at Simpson Lagoon, shoreleads began to form along both sides of the barrier islands and along the mainland shore in mid-June. The lagoon ice began to break up on 9 July 1977 and 5 July 1978, and the lagoon was almost ice-free within 1-2 d. Ice in the Beaufort Sea north of the barrier islands disappeared later in July or in early August.

TABLE 1. Locations, dates and durations of systematic migration watches during the moult migration period

Location	Extent of observations: Period	Hours	Height of observer (m ASL)
Nunaluk Spit, Y.T.	10 July - 10 Aug. 1972[a]	136	?
Komakuk, Y.T.	16 June[b] - 7 July 1975	81	8
Clarence Lagoon, Y.T.	16 June[b] - 9 July 1975	185	3
Pingok Island, AK	26 June - 25 July 1977	41	6
Milne Point, AK	16 June[b] - 28 July 1978	131	6

[a] Data from dates after 10 August are presented by Gollop and Davis (1974) and Johnson and Richardson (1981).

[b] Data from dates before 16 June are presented by Richardson and Johnson (1981).

METHODS

Field and analysis methods for the moult migration period were similar to those used in spring (Richardson and Johnson, 1981). This section summarizes the main approaches and mentions procedures that differed from those utilized in spring.

The date of onset of westward moult migration is not always clear, and is not the same for all species. Rather than using a single, arbitrary date to separate the spring and moult migration periods, we have chosen species-specific dates as the starting points for our tabulations. For similar reasons, some late-June data from our spring migration paper (Richardson and Johnson, 1981) are repeated here to show the seasonal continuity of migration in this area.

Visual Watches

In 1975 and 1978, systematic daily watches were conducted from coastal vantage points (Table 1). In 1977, a systematic daily schedule of watches could not be maintained in summer, but we conducted a total of 41 h of watches on 15 days from the north side of Pingok Island, using our standard methods. During both 1977 and 1978, migrating flocks noted outside the systematic watch periods were also recorded. Only birds that were in sustained flight on an eastward (30°-150°) or westward (210°-330°) course were treated as migrants.

In 1972, five 1-h watches were conducted at Nunaluk Spit, Y.T., on most days from 10 July to 1 August, and there were seven 1-h watches daily on 2-15 August (Gollop and Davis, 1974). Watches were usually spaced evenly from 09:00-22:00 YST. In the 1972 study, time, species, flock size and flight direction were recorded for each flock.

Other Methods

From 9 May to 9 July 1975, radar data were obtained from the Komakuk Distant Early Warning radar (Richardson *et al.*, 1975). Data from the latter part of this period were analyzed as in spring (Richardson and Johnson, 1981).

Also in 1975, we conducted reconnaissance surveys of the Yukon sector of the Beaufort Sea on 26 June and on 3 and 9 July. The 9 July survey extended over 175 km offshore; the other surveys extended about 65 km offshore. The Twin Otter aircraft with two observers changed course to follow leads and ice edges, so overall densities and numbers present cannot be estimated.

In 1977-79, we repeatedly surveyed five transects in the Simpson Lagoon area (Fig. 1, inset). The total length of each survey was 169 km; transect width was 400 m. Surveys were conducted by two observers in a Cessna 206 fixed-wing aircraft or a turbine helicopter flown at 30 m ASL and 160 $km \cdot h^{-1}$. Counts on the three transects in Simpson Lagoon itself were used to estimate total numbers of ducks in the lagoon. Densities of ducks on transects along the north, central and south parts of the lagoon (Fig. 1, inset) were multiplied by the areas of the shallow (<1.8 m) north, deeper (>1.8 m) central, and shallow south parts of the lagoon (22, 102 and 36 km^2, respectively), and the results were summed. For densities and calculation details, see Johnson and Richardson (1981).

RESULTS

In each of the four years of study, the most conspicuous movements of birds near the coast in late June and July were westward movements of male seaducks—Oldsquaws, eiders and scoters. Along the Yukon coast in 1972 and 1975, scoters (primarily Surf Scoters) were the most numerous westbound seaducks. Few Oldsquaws and almost no eiders were seen (Table 2). Along the Alaskan coast in 1977-78, Oldsquaws were the most numerous westbound seaducks; however, some Common Eiders, King Eiders and (in 1978 only) Surf Scoters also moved west.

Timing

Oldsquaws. During both 1977 and 1978 the westward migration of male Oldsquaws was first noted on 26 June. This was the only day with systematic watches in late June of 1977, but migration had not been obvious during casual observations on previous days. In 1978 there were daily watches in late June. Peak numbers of Oldsquaw moved west on 2-4 July in 1977 and on 3-7 July in 1978 (Fig. 2). In addition, aerial surveys and casual observations showed an influx of many thousands of Oldsquaws into Simpson Lagoon during early July of 1977 and 1978 (see below). Thereafter, westward movement continued at least sporadically until late July. There was little westward movement of Oldsquaws along the Yukon coast in 1972 or 1975 (Fig. 2).

Eiders. The westward migration of male Common and King Eiders through Simpson Lagoon was first noted on 2 July 1977 and 24 June 1978 and continued until approximately 31 July 1977 and 12 August 1978. During August of 1977 and 1978 the only data obtained were from casual observations. Most westward movement by eiders occurred

TABLE 2. Total numbers of diving ducks seen flying west and east near the Beaufort Sea coast during systematic watches in the 16 June[a] - 10 August period[b]

	Yukon coast				Simpson Lagoon area			
	Nunaluk 1972		Kom/Clar[c] 1975		Pingok Is. 1977		Milne Pt. 1978	
Species	West	East	West	East	West	East	West	East
Oldsquaw	646	349	168	185	1659	88	8403	653
Eiders	160	68	6	8	1471	8	766	58
Common	—[d]	—	6	8	289	6	361	31
King	—	—	0	0	977	2	82	22
Spectacled	0	0	0	0	6	0	6	0
Unidentified	—	—	0	0	199	0	317	5
Scoters	959	269	1440	110	0	0	893	23
White-winged	—[d]	—	75	3	0	0	19	0
Surf	—	—	535	92	0	0	720	22
Black	—	—	0	4	0	0	0	0
Unidentified	—	—	830	11	0	0	154	1
Scaup	22	115	4	0	0	0	18	84
Red-breasted Merganser	49	38	21	40	0	0	13	17
Dates with data	10 July - 10 Aug.		16 June[a] - 9 July		26 June - 25 July		16 June[a] - 28 July	
Hours of observation 16 June - 10 Aug. period	135.9		236.4[c]		33.5		129.8	
21 June - 10 Aug. period	135.9		163.6[c]		33.5		109.8	

[a] For Oldsquaws and eiders, whose eastward spring migration ended about 20 June, the table includes data from 21 June - 10 August.

[b] Includes migrants seen at all distances from shore during systematic watches. Watches when the visibility was <3 km were excluded in 1975-78.

[c] Yukon data for 1975 include observations from both Komakuk and Clarence Lagoon; some birds were probably counted twice, once at each site.

[d] Data for individual species of eiders and scoters not available for 1972.

after the lagoon ice had broken up and had been flushed westward out of the study area. Peak numbers of eiders were seen moving west on 21-25 July 1977 and on 3-11 and 27-30 July 1978. During the last of these peak periods there were almost no systematic watches (Fig. 2), but about 400 westbound Common Eiders were noticed. A few female and/or immature male eiders accompanied the westbound males. No significant migration of eiders occurred along the Yukon coast (Fig. 2).

Scoters. Along the Alaskan coast, male Surf Scoters and a few male White-winged Scoters moved west in July 1978, simultaneously with the westward migration of Oldsquaws. Three White-winged Scoters flying NNE were seen on 28 June, but the first westbound scoters of both species appeared on 1 July. Peak westward migration was on 4-12 July, with a second peak (Surf Scoters only) on 24-25 July (Fig. 2). Almost all these scoters were males; the only females identified were six Surf Scoters seen on 3-5 July. No migrating scoters were seen during the corresponding period in 1977, and only one scoter was seen during aerial surveys of Simpson Lagoon in July 1977.

In the northern Yukon, Surf Scoters began migrating west on 18 June in 1975, and White-winged Scoters began by 21 June. In 1972, many scoters flew west along the Yukon coast in mid-July, and a few as late as 30 July (Fig. 2). Almost all scoters seen during the 1975 moult migration were males; of those whose sex was recorded, only four Surf Scoters, seen on 7 July, were females and those were not flying west.

Numbers

Yukon coast. Westbound Oldsquaws and eiders were much less numerous along the Yukon coast during 1972 and 1975 than at Simpson Lagoon in 1978. Rates of scoter migration in the two areas were more similar (Fig. 2). If the net rates of westward migration along the Yukon coast shown in Fig. 2 are applied to all hours in the 16 June-31 July period, an estimated 8129 scoters flew west within sight of coastal observers toward Alaska. The 8129 estimate is based on incomplete but complementary results from two years; it could be biased in either direction if migration timing were different in the two years.

Simpson Lagoon. We cannot precisely estimate total numbers of seaducks migrating through Simpson Lagoon during summer: systematic watches were not conducted every day, and only one watch site was used each year. During the summer of 1977, the only migration watch station used was on Pingok Island (Fig. 1, inset); movements along the lagoon (especially its north side) and over the nearshore Beaufort Sea seaward of the barrier island were detectable. During 1978, the one migration watch station was on the mainland and many birds migrating along the north side of the lagoon and seaward of the barrier islands likely were missed.

Total numbers actually seen to migrate west through the Simpson Lagoon area during the 26 June-31 July period

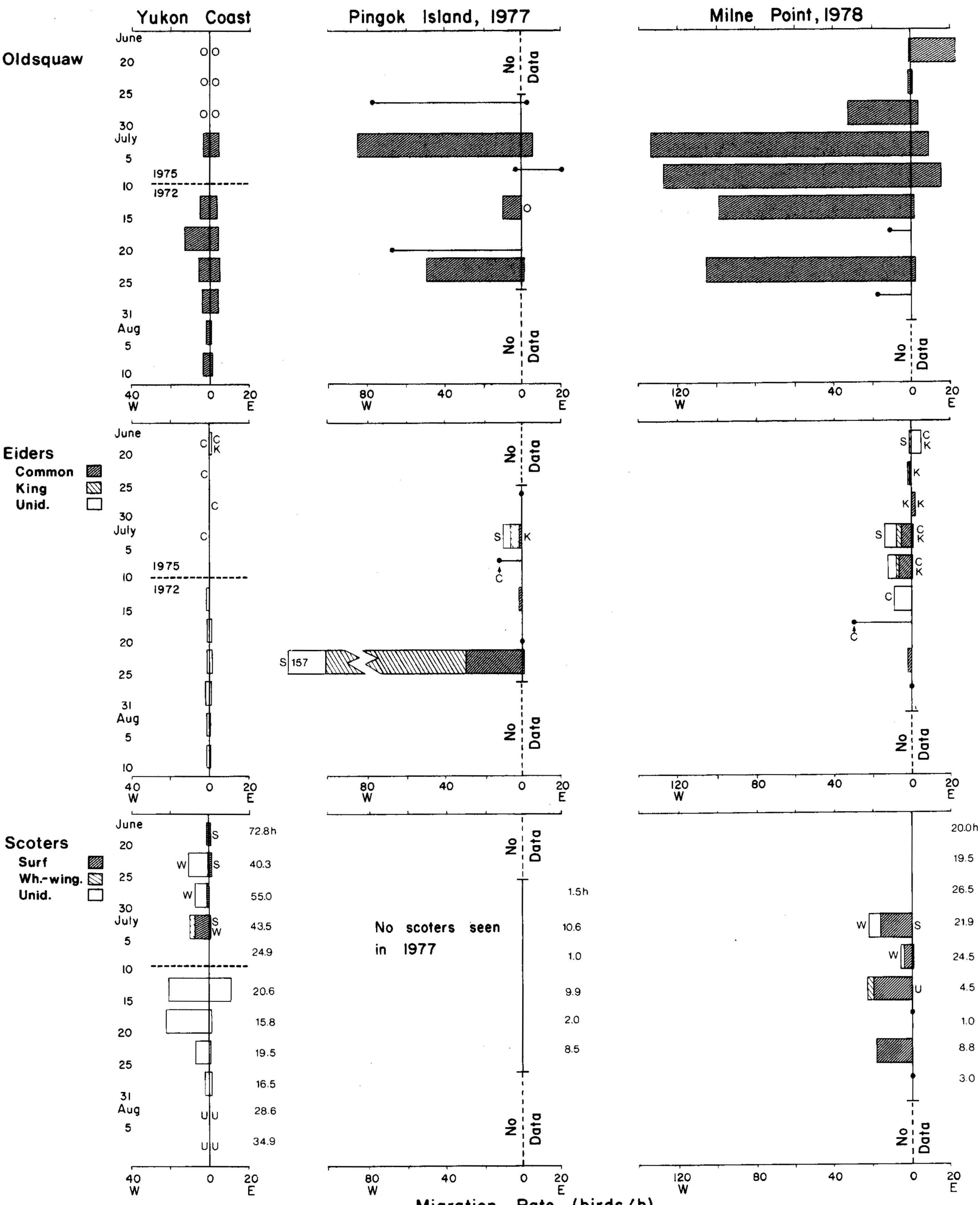

FIG. 2. Hourly rates of coastal migration of Oldsquaws, eiders and scoters by 5-day period during the moult migration period. Westward migration is to left of baseline; eastward is to right. Includes birds at all distances from shore. For 5-d periods in which there were observations on only 1 or 2 d, rates are shown by lines rather than bars. Letters represent first initial of species name and mean "seen but rate too low to be plotted" (in eider section, S = Spectacled Eider). The number of hours of observation in each 5-day period is given in the "scoter" section (periods with visibility <3 km omitted in 1975-78).

were as follows: Oldsquaws — 2774 in 1977 and 9072 in 1978; eiders — 4073 and 1343; scoters — 0 and 1079. These totals include casual observations, but nonetheless represent only an unknown fraction of the total migration through the area.

More realistic minimum estimates are possible for 1978 because, during the 26 June-10 July period, there were daily systematic watches totalling 72.9 h of observation. If observed migration rates for these three 5-d periods (Fig. 2) apply to all hours in those periods, and if actual numbers seen on 11-31 July are added, minimum estimates of about 34 000 Oldsquaws, 3600 eiders and 3700 scoters are obtained (Table 3). These figures are net values (i.e. westward minus eastward movement), and are undoubtedly underestimates because values for 11-31 July are incomplete and because observers at Milne Point (Fig. 1) could not detect all ducks migrating over the north side of the lagoon (3-5 km away).

Flight Paths and Behavior

Most Oldsquaws seen flying west along the Alaskan coast before the ice left Simpson Lagoon were flying along shoreleads near the mainland or island shores, or over the lagoon ice. After the ice cleared from the lagoon in early July, the Oldsquaws that were seen flew along the lagoon. Flight paths were generally straight, not circuitous. Only a few of the Oldsquaws seen in 1978 flew west over the mainland south of Milne Point. Migrating Oldsquaws flew in flocks of widely varying sizes, including one flock estimated to contain 1000 birds (Fig. 3). Almost half (46%) of those seen were ≤2 m above the water or ice; the others flew at various heights up to at least 250 m (Fig. 3).

Before breakup along the Alaskan coast, most eiders seen flying west were moving along shoreleads and over the lagoon ice. After breakup of the lagoon ice, most of those seen were over the lagoon. However, there was also westward movement over the Beaufort Sea north of the barrier islands during late July 1977, following breakup of the sea ice. Eider flocks ranged widely in size, and 88% of the eiders flew at estimated altitudes below 10 m (Fig. 3).

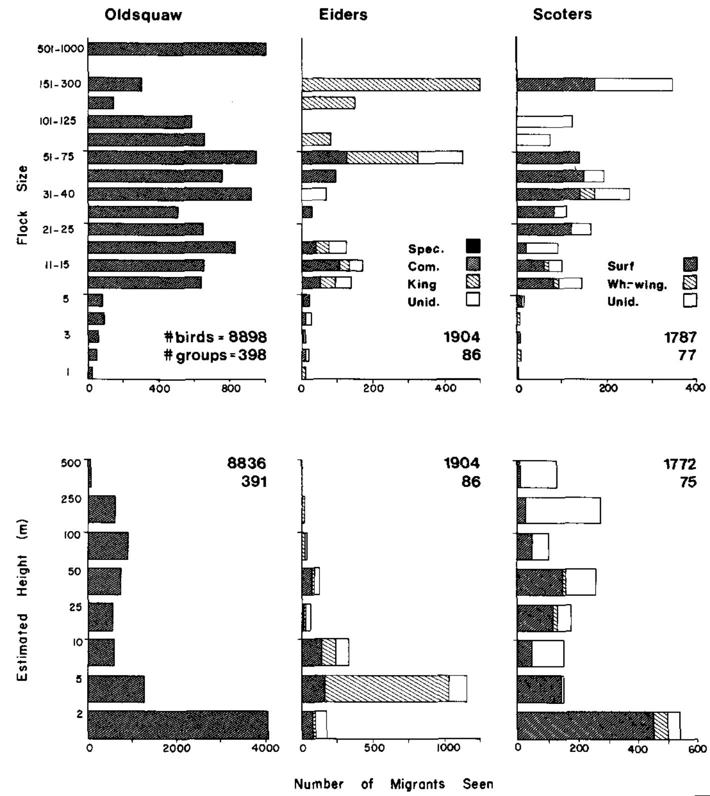

FIG. 3. Flock sizes and estimated heights (m) of seaducks migrating west during the moult migration period. Oldsquaw and eider data are from the Simpson Lagoon area, 25 June-31 July 1977-78. Scoter data are from the Yukon coast (16 June-9 July 1975) as well as Simpson Lagoon. The only birds considered are those that flew continuously and westward within 3 km from shore during systematic watches. Note that the vertical scale is non-linear.

TABLE 3. Minimum estimates of numbers of seaducks flying west through Simpson Lagoon, Alaska, 26 June - 31 July 1978

Species	26 June - 10 July, estimate[a]	11 - 31 July, no. seen[b]	Minimum estimate of total
Oldsquaw	32 210	1743	33 953
Common Eider	1416	483	1899
King Eider	228	0	228
Spectacled Eider	32	0	32
Unident. Eiders	1323	120	1443
All eiders	2999	603	3602
All scoters	3239	426	3665

[a] Net rates of westward migration (i.e. west rate minus east rate) shown in Fig. 2 are assumed to apply to all hours in the respective 5-day periods.

[b] Actual number seen flying west (both during watches and at other times) minus number seen flying east. These net figures undoubtedly are underestimates.

Most westbound scoters seen in 1978 from Milne Point were flying over shoreleads, ice or open water in Simpson Lagoon; however, some were over the mainland south of Milne Point. Similarly, in the Yukon in 1975 most westbound scoters seen were over the sea, but a minority were flying west overland. Some of those seen from Milne Point in 1978 were over the central part of the lagoon; had they been there in 1977, some should have been detectable from Pingok Island. Thus it is unlikely that the choice of observation site was the sole reason for their scarcity in 1977. Flocks of migrating scoters, the largest of which consisted of Surf Scoters, ranged in size up to 175 birds in the Yukon in 1975 and 75 birds at Simpson Lagoon in 1978 (Fig. 3). About 30% flew at estimated altitudes of ≤2 m; others were up to ~300 m (Fig. 3).

The Komakuk radar showed virtually continuous W and NW migration along the Yukon north slope and adjacent parts of the southern Beaufort Sea in late June and early July 1975. Much smaller numbers flew W and NW over the foothills and mountains south of the coastal plain (Richardson *et al.*, 1975). There was also continuous eastward movement (species unknown) at this time. The density of westward migration within a few km of the coast was usually greater than densities offshore and inland but many flocks did fly west far beyond the visual range of a coastal observer. Most radar echoes from these westbound birds had characteristics typical of seaduck flocks, but some of the other types of birds in the area (geese, Pintails (*Anas acuta*), shorebirds and perhaps jaegers) can produce similar echoes. Thus we do not know what proportion of the birds flying west far offshore or far inland were seaducks. Aerial surveys in late June and July of 1974-75 showed that some Oldsquaws, eiders and scoters were present offshore, although eiders and scoters were most numerous in the cracks and leads closest to land (Table 4; Searing *et al.*, 1975).

TABLE 4. Numbers of seaducks seen offshore during reconnaissance aerial surveys north of the Yukon in 1975

Species	26 June	3 July	9 July
Oldsquaw	104	220	69
Common Eider	33[a]	8[a]	21
King Eider	20[a]	1	5
Eider spp.	1[a]	1	7
White-winged Scoter	27[a]	137[a]	35[b]
Surf Scoter	14[a]	82[a]	4
Black Scoter	30[a]	0	0
Scoter spp.	19[a]	290[a]	2
Length of survey (km)	367	329	545

[a]Along shoreleads or edge of landfast ice <20 km from shore.
[b]Among pan ice 180 km from shore.

TABLE 5. Estimated numbers of seaducks in Simpson Lagoon, AK, during early and mid-summer[a]

Date	1977	1978	1979
OLDSQUAWS			
June 20-23	34	22	60
July 5	959	2482	—[b]
July 15	—[b]	29 309	—
July 25-29	51 375[c]	12 769	23 192
Aug 5	—	12 068	—
Aug 15	41 759[c]	16 116	—
Aug 25-31	21 935	9304	35 609
EIDERS			
June 20-23	10	3	15
July 5	57	28	—
July 15	—	9	—
July 25-29	62	35	68
Aug 5	—	0	—
Aug 15	44[c]	22	—
Aug 25-31	7	0	46
SCOTERS			
June 20-23	0	0	0
July 5	1	59	—
July 15	—	89	—
July 25-29	0	1190	0
Aug 5	—	0	—
Aug 15	0[c]	0	—
Aug 25-31	0	42	0

[a]Based on aerial surveys (see Methods).
[b]Dash means no survey on this date in this year.
[c]This value may be underestimated — incomplete survey.

Utilization of Simpson Lagoon

Oldsquaws made only moderate use of Simpson Lagoon during the period of peak westward migration in early July. Only shoreleads were present throughout the period of peak movement in 1977 (2-4 July), but general breakup of the lagoon ice occurred during the peak period in 1978 (3-7 July). In both years the nearshore Beaufort Sea north of the barrier islands remained frozen (except for shoreleads) throughout the period of peak westward moult migration. Large numbers of moulting Oldsquaws concentrated in the lagoon later in July (Table 5). Based on aerial surveys, the estimated numbers of Oldsquaws in Simpson Lagoon on 5 July in 1977 and 1978 were only about 1000 and 2500, respectively (Table 5). By 15 July 1978, about 29 000 were estimated to be present, and in late July the estimates for 1977-79 were about 51 000, 13 000 and 23 000, respectively.

These results suggest that during the peak of migration in early July, most male Oldsquaws that pass over Simpson Lagoon do not stop for any significant period (if at all). Later in July, after the lagoon ice breaks up and leaves the lagoons, large numbers of moulting Oldsquaws — mostly males (Johnson and Richardson, 1981) — concentrate in the lagoon. The lack of pronounced westward movement in mid- to late July suggests that many of the male Oldsquaws then appearing in the lagoon breed locally and exhibit only a short (or no) moult migration. Alternatively, some may undertake an early moult migration to areas that break up early (e.g. Harrison Bay off the mouth of the Colville River), and subsequently move into nearby areas that break up later, such as Simpson Lagoon. Oldsquaws also concentrate in other lagoons along the north coast of Alaska both east and west of Simpson Lagoon during July and August (Harrison, 1977; Divoky, 1978; Johnson and Richardson, 1981; Spindler, 1981).

Few eiders used waters in or near Simpson Lagoon during the moult migration period (Table 5). During our aerial surveys in July, small numbers of eiders were seen near the barrier islands (where Common Eiders nest) and near the mainland shore, but none were seen in mid-lagoon. In late July of each year, during breakup of ice seaward of the barrier islands, a few Common Eiders were seen along the transect several km seaward of the barrier islands.

During most aerial surveys of Simpson Lagoon, few or no scoters were seen (Table 5). However, on 25 July 1978, near the end of the moult migration period of scoters, about 750 Surf Scoters (mostly males) were seen near the south shore of Pingok Island. In addition, scoters were seen during our aerial surveys of eastern Harrison Bay (just west of Simpson Lagoon) in July-September 1978. In 1971, Hall (1975) observed 200-300 Surf Scoters in Harrison Bay during August, and Gavin (1976) indicates that scoters occur in the Simpson Lagoon area in "fall" (dates not stated). Thus, it appears that male scoters not only migrate west through Simpson Lagoon, but that a few hundred also remain in the area to moult. Similarly, scoters (mostly Surf) utilize lagoons in extreme northeastern Alaska and in the Canadian Beaufort Sea in summer (see Introduction).

Small numbers of Greater Scaup (*Aythya marila*) flew through Simpson Lagoon and along the Yukon coast, mainly eastward, during summer (Table 2). They were never recorded during aerial surveys of the lagoon in July, but small numbers of scaup were seen in Harrison Bay on 5 and 15 July 1978.

In summary, during late June and July male Oldsquaws migrate west through Simpson Lagoon in moderate or large numbers (over 30 000), and male eiders and scoters do so in small numbers. In some years, tens of thousands of Oldsquaws and some Surf Scoters remain in Simpson Lagoon to moult. Small numbers of scaup may also moult in the area.

DISCUSSION

The summer moult migration of adult male eiders past Point Barrow is well known (e.g. Thompson and Person, 1963; Johnson, 1971). Moult migrations of Oldsquaws and scoters in the Beaufort Sea area and elsewhere are much less well documented. However, even in the case of eiders there are significant gaps in knowledge.

Eiders

The above-cited studies at Point Barrow did not begin until mid-July (14 July 1953 and 13 July 1970). However, eider hunting at Barrow began in early July in 1970 (Johnson, 1971), and westward migration of eiders at Simpson Lagoon begins then (Fig. 2). Thus the early part of the eider moult migration has not been included in previous systematic studies.

The routes of westbound eiders in areas east of Point Barrow are poorly known. Anderson (1937) reported a large flight past the tip of the Bathurst Peninsula, N.W.T., in July of 1912; he does not give total numbers, but the implication is that many thousands were seen. In contrast, few eiders move west along the Yukon coast in July (Fig. 2), and Brooks (1915) and Schmidt (1973) implied that only modest numbers move west along the coast of NE Alaska. Our results show that the numbers migrating through Simpson Lagoon in July are only in the thousands, in great contrast to the hundreds of thousands that pass Point Barrow at this time. Similarly, Hall (1975) and Schamel (1978) observed no major westward migration of eiders through nearshore waters in the Simpson Lagoon area. These studies indicate that a major westward moult migration occurs at Cape Bathurst in the extreme eastern Beaufort Sea and at Point Barrow in the extreme west, but there is no evidence of a concentrated flight along the intervening south coast of the Beaufort Sea from the Mackenzie Delta west to Simpson Lagoon.

Radar evidence about the routes of eiders is inconclusive, but is consistent with the possibility that eiders fly west on a broad front over the Beaufort Sea with little concentration along the coast. According to radar observations during early July near the Yukon-Alaska border, broad-front WNW migration occurs over the coastal plain and southern Beaufort Sea (Richardson *et al.*, 1975). However, scoters and perhaps Oldsquaws must account for at least a portion of that movement. At Lonely, between Barrow and Simpson Lagoon (Fig. 1), radar showed broad-front westward migration over the coastal plain on one July occasion when westward migration of eiders was visible along the coast (Flock, 1973). However, in neither of these radar studies is it certain that eiders were the birds responsible for the broad-front movements, although eiders engaged in moult migration do fly overland at Baffin Island (Wynne-Edwards, 1952) and in Denmark (Salomonsen, 1968; Schmidt, 1976).

Broad-front migration may be even more prevalent than the radars suggested. Many of the ducks migrating along the coast were at low altitudes (Fig. 3). If height distributions are similar over offshore waters, much of the offshore migration would be below the radar horizon and thus undetectable.

Although available evidence is meagre, it is likely that many westbound male eiders bypass the south-central coast of the Beaufort Sea by flying over the sea. An aerial survey of the Canadian Beaufort Sea during 3-7 July 1974 showed eiders as far as 115 km from shore, although most of those seen were <60 km offshore (Searing *et al.*, 1975). A total of 721 eiders were seen along ~4200 km of transects ($0.44 \cdot km^{-2}$). Numbers present offshore decreased later in July. Surveys of the Alaskan Beaufort Sea during summer have found few or no eiders far offshore (Bartels, 1973; Frame, 1973; Harrison, 1977; Divoky, 1978), but often have found eiders just seaward of the barrier islands. Although most of these Alaskan surveys were conducted after the period of peak moult migration by male eiders, the results do suggest that the main route across the Alaskan Beaufort Sea may be over relatively shallow water just north of the barrier islands.

Westbound eiders must concentrate near the coast somewhere between Simpson Lagoon and Point Barrow. Visual and radar observations at Point Barrow indicate that most eiders approach the point in a stream near the shore (Johnson, 1971; Flock, 1973).

Relative abundances of Common and King Eiders during moult migration vary markedly from place to place. At

Point Barrow, 95% of the westbound eiders seen and shot from mid-July to early September 1970 were King Eiders (Johnson, 1971). King Eiders also predominated in other years (Murdoch, 1885; Thompson and Person, 1963). However, of the westbound eiders seen during systematic watches at Simpson Lagoon, 62% were King and 38% Common. Westbound Spectacled Eiders (*Somateria fischeri*) and Steller's Eiders (*Polysticta stelleri*) together comprise <1% of the flight at both Point Barrow and Simpson Lagoon. At Cape Bathurst, N.W.T., Anderson (1937) found that King Eiders predominated initially, but by 18 July "there were about as many Pacific [Common] Eiders as King Eiders". Of the 840 eiders identified during aerial surveys of the southeastern Beaufort Sea in July 1974, 51% were King and 49% Common (Searing *et al.*, 1975: 20).

The total number of Common Eiders in the Beaufort Sea area is not well known. T.W. Barry estimated that one-fourth of the eiders there, or about 275 000, are Common Eiders (cited in Bellrose, 1976). The disproportionate abundance of King Eiders at Point Barrow during the moult migration suggests that proportionately more Common than King Eiders remain in the Beaufort Sea area to moult. Some moulting Common Eiders have been seen there in summer (Porsild, 1943; Höhn, 1955; Smith, 1973; Ward, 1979; S.R. Johnson, unpubl. 1979 data).

Oldsquaw

Few Oldsquaws move west past Point Barrow before late August (Thompson and Person, 1963; Johnson, 1971; *cf.* Timson, 1976). In the Simpson Lagoon—Prudhoe Bay area, flocks of moulting Oldsquaws have been seen during summer, but no major westward migration has been reported (Hall, 1975; Schamel, 1978). Farther east, near the Alaska-Yukon border, small numbers of westbound Oldsquaws have been seen in late June and July (Brooks, 1915; Schmidt, 1973; Gollop and Davis, 1974). Similarly, Anderson (1937) saw a few Oldsquaws moving west at Cape Bathurst, N.W.T., in mid-July.

This study documents the magnitude and timing of the westward moult migration of male Oldsquaws along the Alaskan north coast, and the relationship of this movement to the appearance of moulting Oldsquaws in the coastal lagoons. There are few well-documented cases of moult migrations of Oldsquaws elsewhere in their circumpolar range (see Introduction).

The peak of the moult migration through Simpson Lagoon in 1977 and 1978 was in the first half of July, with a secondary, smaller peak later in July (Fig. 2). The systematic migration watches at Point Barrow did not begin until mid-July, so the first peak might have been missed there. However, Divoky (1978:482) did not record a westward moult migration there in late June or early July of 1976. It seems highly unlikely that any major westward movement in late June or early July could have passed unnoticed by Divoky (1978) and the numerous others who have worked at Barrow.

Thus, Oldsquaws that move west through Simpson Lagoon in early July probably either remain in the western Beaufort Sea to moult, or bypass Point Barrow. Many Oldsquaws are present between Simpson Lagoon and Barrow during July and August, the moult and post-moult periods (this study; Divoky, 1978:432). However, scattered groups also occur offshore in the western Beaufort Sea in July (Harrison, 1977). This suggests that some moult migrants do not follow the coast, and thus may bypass Point Barrow. The diving ability of Oldsquaws (perhaps to 60 m—Palmer, 1976) and the shallow depths of much of the southern Beaufort Sea would allow Oldsquaws to feed on benthic organisms even during migration across some areas far from shore. Oldsquaws may also be able to feed on ice-associated invertebrates (Johnson and Richardson, 1981:284), an ability that would further lessen their dependence on shallow nearshore waters during moult migration.

Numbers of Oldsquaws seen migrating west along the Yukon coast in June and July (Fig. 2) are much too low to account for the appearance of tens of thousands of Oldsquaws along the north coast of Alaska during July. Many male Oldsquaws that appear along the Alaskan coast probably move to the sea from the adjacent mainland, where the Oldsquaw is a widespread and abundant nesting species. Individuals that migrate west through Simpson Lagoon in early summer may be engaged in a short-distance moult migration within the Alaskan Beaufort Sea region. However, Oldsquaws were also widely distributed in small numbers offshore in the eastern Beaufort Sea during late June and early July of 1974 and 1975 (Table 4; Richardson *et al.*, 1975; Searing *et al.*, 1975). Although ice conditions in 1974 were atypically severe, these results and the sightings offshore in the western Beaufort Sea in July (Harrison, 1977) suggest that there may be a significant westward moult migration of Oldsquaws over offshore waters.

Scoters

Surf and White-winged scoters are common nesting birds north to the Mackenzie Delta (Porsild, 1943; Cowan, 1948). They also nest sparingly in the interior of northern Alaska (Irving, 1960), but not to any significant extent along the arctic coast. The Black Scoter (*Melanitta nigra*) is uncommon in the Beaufort Sea area even as a non-breeding visitant.

Male scoters in the Mackenzie Delta begin to congregate in mid-June (Porsild, 1943; Cowan, 1948), and some move west along the Yukon coast into Alaska in late June and July (Fig. 2; see also Andersson, 1973). Surf Scoters and smaller numbers of White-winged Scoters were common moult migrants at Simpson Lagoon in 1978 but not in 1977. Few scoters move as far west as Point Barrow (Bailey, 1948; Pitelka, 1974). Fewer scoters occur in the Simpson Lagoon—Prudhoe Bay area during the moulting period than occur along the coast of extreme northeastern Alaska and the northern Yukon; especially large numbers of Surf Scoters moult near Herschel Island, Y.T. (4500 estimated by Vermeer and Anweiler, 1975; see also Andersson, 1973; Gollop and Richardson, 1974; Gollop *et al.*, 1974; Ward and Sharp, 1974; Salter *et al.*, 1980). In addition, many scoters moult along the coast east of the Mackenzie Delta (Searing *et al.*, 1975). No major eastward return migration has been reported along the coast of the Beaufort Sea in late summer or autumn, so autumn migration is probably overland.

The moult migrations and other movements of scoters in North America are poorly understood (Bellrose, 1976; Palmer, 1976). The west and northwest moult migration along the south coast of the Beaufort Sea is in a direction different from that of the subsequent fall migration regardless of whether the birds winter on the Pacific coast, as is generally assumed (Palmer, 1976), or in eastern North America. In contrast, the westward moult migrations of eiders and Oldsquaws in the Beaufort Sea area and the well-known moult migrations of Black and White-winged scoters in northern Europe are generally toward the wintering areas (Salomonsen, 1968; Cramp and Simmons, 1977; Zhalakevicius, 1977).

Importance of Lagoons to Moult Migrants

During their westward moult migrations some Oldsquaws and smaller numbers of eiders and scoters land in lagoons along the north coast of Alaska and the Yukon. However, the peak of the Oldsquaw moult migration occurs in early July, around the time of breakup of the lagoon ice. In many years there is little open water (shoreleads only) in most lagoons during peak Oldsquaw movement. The very large numbers of male Oldsquaws that moult in some lagoons do not appear until later in July, after breakup and after the peak of westward moult migration (Table 5). Thus many Oldsquaws that moult in the lagoons probably nest nearby and do not engage in long-distance moult migration.

The lagoons may be of only moderate importance to ducks during moult migration *per se*, but are of great importance as destinations for moulting seaducks. The lagoons provide shelter from wind, waves and pack ice for tens (possibly hundreds) of thousands of moulting male Oldsquaws and for much smaller numbers of male scoters. Food is abundant and highly available in the shallow lagoons (Griffiths and Dillinger, 1981; Johnson and Richardson, 1981), the barrier island beaches provide roosting areas for the moulting birds, predators are relatively scarce, and the large numbers of males do not compete for food with females and broods on adjacent tundra ponds and small lakes. Thus barrier island-lagoon systems along the Beaufort Sea coast provide most of the advantages that Salomonsen (1968) describes as necessary for moulting seaducks.

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