Observations of wing-feather moult and summer feeding ecology of Steller's Eiders at Nelson Lagoon, Alaska

MARGARET R. PETERSEN

Introduction

Large concentrations of moulting Steller's Eiders *Polysticta stelleri* have been reported from Karaginski Island and Litke Strait, USSR (Gerasimov in Kistchinski 1973); Izembek Bay, Alaska (Jones 1965); and Nelson Lagoon, Alaska (R. E. Gill pers. com.); and smaller flocks of up to a few hundred birds have been reported from Saint Lawrence Island, Alaska (Fay 1961). However, the Steller's Eider is the least studied of the eider group, and no published information is available on population structure, moult phenology, and feeding ecology of eiders moulting in lagoon systems. Information on food habits of Steller's Eiders is primarily from birds taken on breeding grounds or wintering areas (Cottam 1939), or from general observations of birds on migration (Murdock 1885). Similarly, feeding behaviour in summer is little known except for general observations by McKinney (1965).

This study was designed to gain an understanding of the ecology of Steller's Eiders moulting in a lagoon system. Specific objectives were to determine: 1) the numbers, age, and sex of eiders in the lagoon; 2) their moult phenology; and 3) their foods and feeding behaviour before and during the moult.

Study area

The 100 sq km Nelson Lagoon study area (Figure 1) is on the north-central Alaska Peninsula, 160 km east of Cold Bay and was described by Gill & Jorgensen (1979). Nelson Lagoon is shallow, with extensive flats (47% of the lagoon) exposed at mean low or lower water. Intertidal substrates vary from mud to sand-gravel. The daily tidal regime is two lows and two highs with a 3·2 m mean diurnal range.

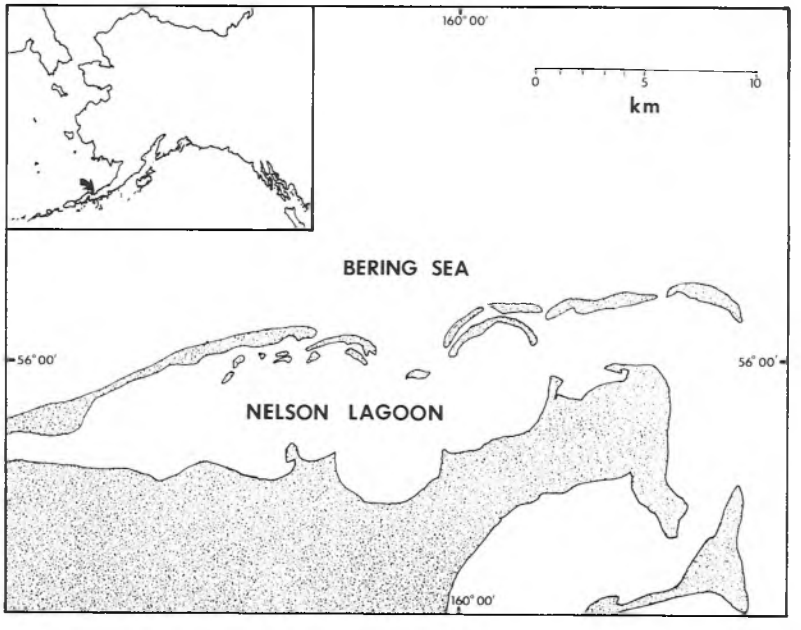

Figure 1. The Nelson Lagoon study area in the north-central Alaska Peninsula.

Wildfowl 31 (1980): 99–106

Methods

Populations, age and sex identification

The total number of eiders in the lagoon system was determined at 3 week intervals between 15 April and 15 October 1977 by counting birds from an aeroplane flown at 50–75 m over the lagoon between 1·5 hours before or after low tide. Sex and age ratios were determined by observing birds on the water from the porch of the cabin with a spotting scope. Subadults were considered as one group, because yearling and second year birds were difficult to distinguish except when in alternate plumage or in the hand (Palmer 1976). Adult and third year males were distinguishable from yearling and second year birds in all plumages. Third year males in basic plumage were not distinguishable from older males, and were included in the adult category. No adult females were identified or collected in 1977.

Feeding behaviour

Observations of feeding and roosting birds were made with a spotting scope from the porch of the cabin every 3 days from 17 April to 15 October 1977. The activity of each bird was recorded every 2 hours from 0800 hours to sunset (N = 42 days), and periodic observations made with a starlight scope at night. Descriptive terminology of feeding methods is that used by Bryant & Leng (1975).

Food habits

Forty-three Steller's Eiders were collected to determine types of foods eaten. Samples of 3 birds each from feeding flocks were taken every 3 weeks between 17 April and 15 October 1977, and samples of 9 and 4 birds were taken in September and October 1976 and 1978, respectively. Immediately after collection, the oesophagus, proventriculus, and ventriculus of each bird were injected with 10% buffered formalin, to halt digestion and preserve food items, and stored in 50% alcohol.

Food items were sorted and identified to species when possible. Data are presented as the mean of volumetric percentages (aggregate percentage) and percent frequency of occurrence (see Swanson *et al.* 1974) for each sampling period.

Intertidal invertebrates

Populations of invertebrates, primarily *Mytilus edulis*, in intertidal areas were sampled along two, 50 m transects established on the eiders's feeding area. Each transect was sampled once every 4 weeks from June to September 1977. Five, 1 m^2 areas along each transect were randomly selected for each sampling, then each was sampled by taking five random samples of 0·5 litres each. Samples were taken to 7 mm below the surface with a commercial clam gun 9·6 cm in diameter. All invertebrates from each sample were preserved in 10% buffered formalin and stored in 50% alcohol.

Results

Population and moult chronology

Three classes of Steller's Eiders used Nelson Lagoon in 1977: migrating pairs of adults, subadult males and females, and adult males. Age classes were temporally segregated (Figure 2): migrating adult pairs left the area by early May, moulting subadults peaked at 53,000 birds in early August, and moulting adult males peaked at 54,000 birds in late September.

All age classes of subadult males were in alternate plumage in May and early June, and all birds in the lagoon were in basic plumage by 5 July. Age classes of subadult females are not distinguishable by plumage, but comparisons of the bursa of Fabricius (Elder 1946; Hanson 1962; Peterson & Ellarson 1978) of birds collected suggested that two classes were present. Five of 6 females collected on 13 May 1977 had bursa depths of 7–13 mm ($\bar{X}$ = 10), and 1 female had a bursa depth of 21 mm. Three of 5 females collected between 5 and 27 July 1977 had bursa depths of 20 mm, 21 mm, and 19 mm, and 2 had bursa depths of 12 mm. It is likely that birds with bursa depths of 19–20 mm were yearlings, and those with bursa depths of 7–13 mm were second year females.

Wing-feather moult of subadults began on 29 July. Most birds became flightless by 7 August and regained flight capability by late August. After being flightless for about 3 weeks, they left the study area as they regained flight.

Adult males in basic plumage began arriving at the study area in late August, became flightless soon after their arrival, and regained flight capability beginning

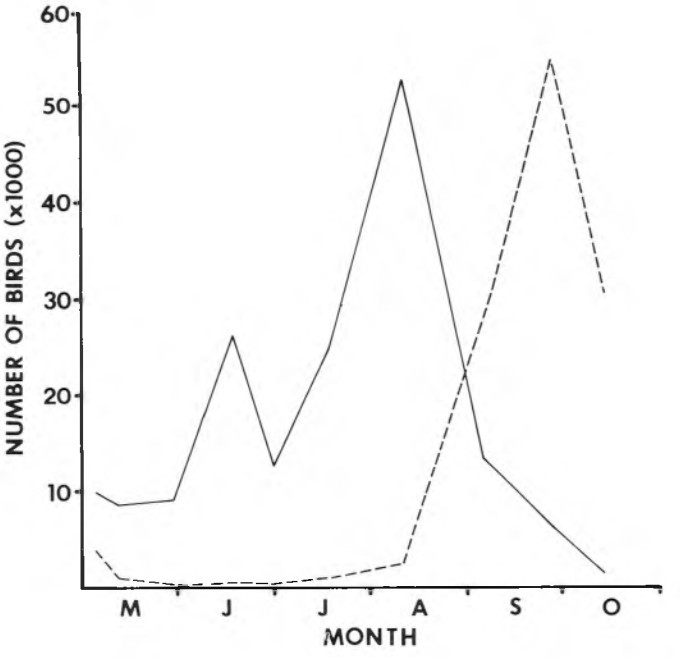

Figure 2. Numbers of Steller's Eiders at Nelson Lagoon, Alaska in 1977. Solid lines represent the number of subadult females and males, and the dashed lines represent the number of adult males.

mid September. Adult males began leaving the study area by early October but 30,000 were still present on 13 October when the last aerial count was made.

Feeding behaviour

Eiders fed by diving or raft-feeding (Campbell 1978) in waters to 6 m deep, up-ending in waters slightly deeper than their extended neck length (about 20 cm), and head-dipping in waters 10–20 cm deep. There was no apparent difference in the method of feeding between adults and subadults as age groups feed in mixed flocks. When feeding, eiders dived 80% of the time, head-dipped 20% of the time, and up-ended rarely (never during observation periods). Before and during wing-feather moult, there was no significant change in the methods of feeding (Table 1). However, following the wing-feather moult eiders dived more frequently and only a few birds head-dipped ($X^2 = 17{\cdot}772$, $df = 2$, $p < 0{\cdot}001$). Eiders fed more often (51%) during the wing-feather moult than before (32%), and fed most frequently (61%) after the wing-feather moult.

During the two daily tide cycles the height and stage of the tide influenced

Table 1. Activity of Steller's Eiders during summer 1977.

	Number of birds observed		
	Feeding		Roosting
	Diving	Head-dipping	
Before wing-feather moult (1 May–29 July)	35,311	18,877	113,301
During wing-feather moult (1 Aug.–15 Sept.)	3,271	2,469	5,477
After wing-feather moult (16 Sept.–15 Oct.)	64,474	5,093	44,816
Whole season	103,056	26,439	163,594

feeding activity, most birds feeding at low tide (Figure 3), irrespective of the time of day or stage in the wing-feather moult. They dived at any stage of the tide, but most birds dived on a flowing tide 2 to 3 hours after the low tide. Head-dipping occurred primarily during, and 2 hours before and after, low tide. Birds stopped feeding 2 hours before high tide, and began again 3 hours after high tide.

Food habits

Bivalved mollusca (pelecypoda) and crustacea were the primary groups of invertebrates eaten by Steller's Eiders from May to October (Table 2). Pelecypoda, primarily *Mytilus edulis*, were found in nearly all of the birds collected, and were the major food item by volume. The sand-hopper *Anisogammarus pugettensis* (Amphipoda) was the most common crustacean taken. Worms (Nemertinea and Polychaeta), sea-spiders (Pycnogonida) and sea-slugs (Nudibrancha) were also taken, but were minor components of the diet.

Male and female eiders ate similar foods in similar amounts; there was no significant difference between the aggregate percentage of amphipoda eaten nor of pelecypoda eaten by males and females. Similarly, there was no significant difference between the aggregate percentate of amphipoda or of pelecypoda eaten by adults and subadults when both were present.

In 1977, the aggregate percentage of pelecypods increased from May to July, and that of *Anisogammarus pugettensis* decreased from May to August (Figure 4). There was no significant difference between the aggregate percentage of *A. pugettensis* and pelecypoda taken by eiders after the wing-feather moult in late September through October in 1977. Similarly, in September and October 1976 and October 1978 birds feed on both in widely varying amounts.

Average lengths of *A. pugettensis* eaten by eiders varied significantly ($F_{5, 581} = 137{\cdot}753$, $p < 0{\cdot}001$) from 14 mm in May to 6 mm in July (Figure 5) due to an emergence of recently hatched sand-hoppers in early July. Eiders continued to eat amphi-

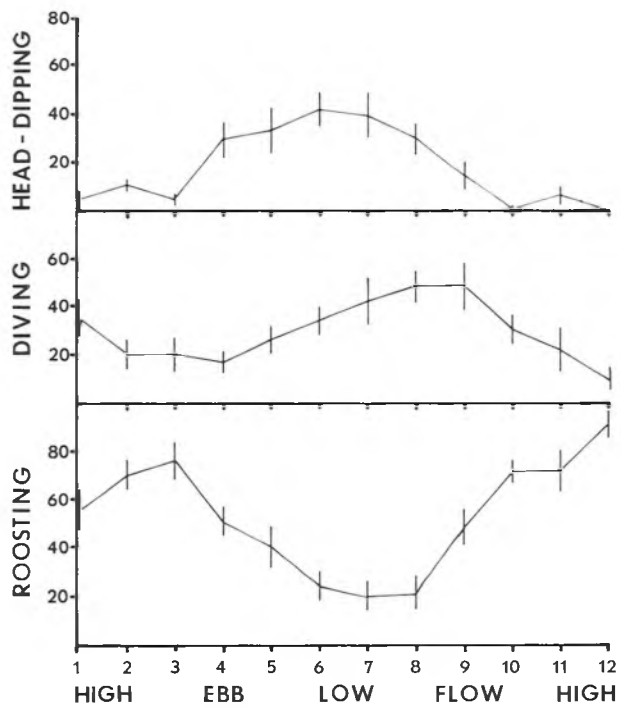

Figure 3. Activity of Steller's Eiders related to tide stage. Data are average percent of birds engaged in each activity during each hour of the tide stage as determined from 190 counts of birds from 17 April to 15 October 1977. Vertical bars represent ±S.E.

Table 2. Food items of 43 Steller's Eiders at Nelson Lagoon, Alaska—May to October.

Food item	Aggregate % vol.	% frequency of occurrence
Nudibranch		
Onchidoris bilamellata	trace*	4·7
Nemertinea	trace	2·3
Pelecypoda	48·5	86·0
Mytilus edulis	41·7	83·7
Clinocardium nuttallii	trace	2·3
Macoma balthica	6·0	9·3
Mya arenaria	trace	18·6
Polychaeta	8·2	65·1
Spionidae	trace	2·3
Mediomastus sp.	trace	2·3
Eteone longa	5·0	55·8
Syllidae	trace	2·3
Nephtys ciliata	trace	9·3
Owenia sp.	trace	4·2
Cistena granulata	2·3	14·0
Crustacea	43·0	72·1
Cirripedia	trace	2·3
Saduria entomon	trace	9·3
Atylus collingi	trace	2·3
Anisogammarus pugettensis	41·3	69·8
Caprellidea	trace	7·0
Crangon septemspinosa	trace	4·7
Pycnogonia	trace	9·3

* Trace amounts are less than 1 percent.

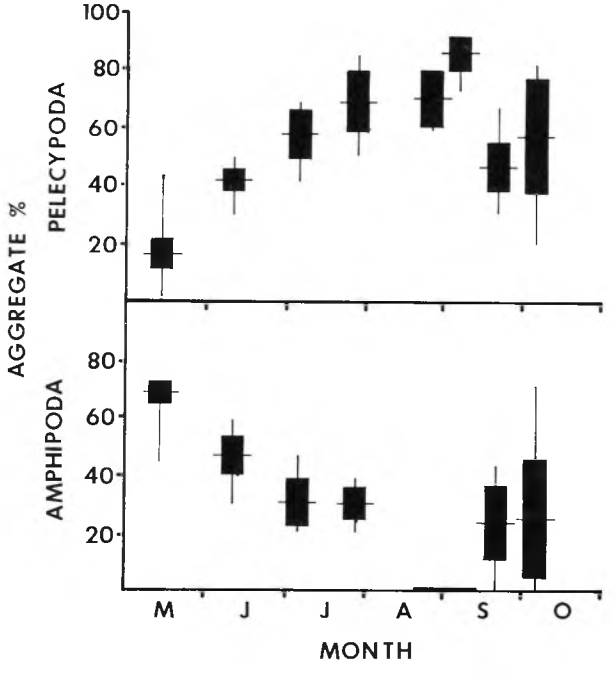

Figure 4. Changes in aggregate percentage of major food items of Steller's Eiders through summer 1977. Range, mean, and standard error.

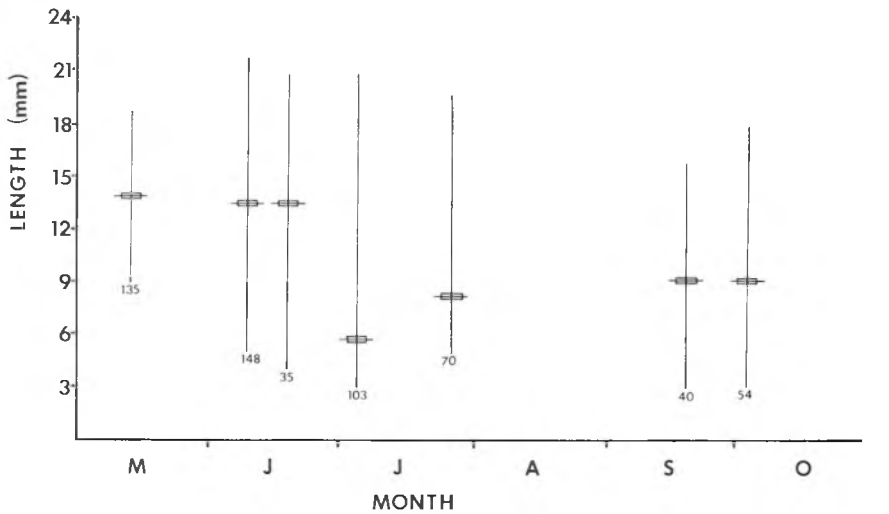

Figure 5. Lengths of *Anisogammarus pugettensis* **eaten by Steller's Eiders from May to October 1977.** Range, mean, standard error, and sample size.

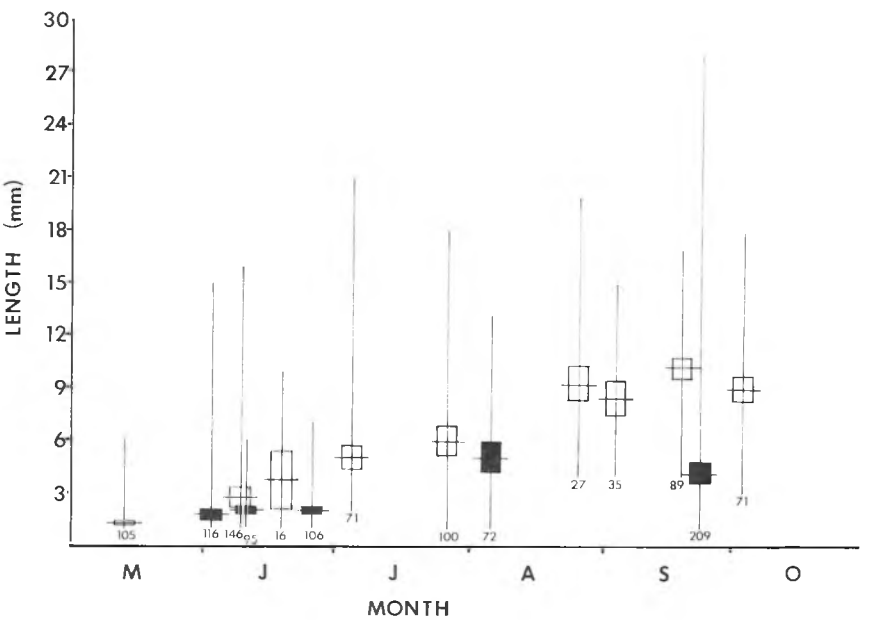

Figure 6. Lengths of *Mytilus edulis* **eaten by Steller's Eiders** (open blocks) **and available in the feeding areas** (solid blocks) **throughout summer 1977.** Range, mean, standard error, and sample size.

poda in July, although they were eating smaller volumes of amphipoda and greater volumes of pelecypoda (Figure 4).

Corresponding with the increase in the amounts of pelecypoda taken by eiders in 1977 was a significant increase in the lengths of *Mytilus edulis* ($F_{4,433} = 50{\cdot}669$, $p < 0{\cdot}001$), from 1 mm in May to 10 mm in August. Thereafter, eiders ate *M. edulis* in the 9–10 mm size range (Figure 5). Few longer than 10 mm were taken before August, but from August to October such shells comprised 36·8%. All *M. edulis* eaten by the eiders were in their first growing season, as none had annual grooves.

Intertidal samples

Lengths of *M. edulis* collected in substrate samples were consistently smaller than those eaten by Steller's Eiders (Figure 6). *M. edulis* continued to grow throughout the summer; the decrease in average lengths on the tidal flats in September resulting from a large hatch. Newly hatched *M. edulis* were found in all of the substrate samples.

Discussion

The timing of arrival, plumage at arrival, and timing of wing-feather moult of adult male Steller's Eiders at Nelson Lagoon is similar to that at Izembek Bay (Jones 1965), and is typical of that generally exhibited by eiders (Salomonsen 1968). However, the pattern of the timing of moult migration and wing-feather moult of subadult Steller's Eiders differs from that described for the Common Eider *Somateria mollissima* in Denmark (Joensen 1973). As with subadult Common Eiders, subadult Steller's Eiders gather in large dense flocks before the wing-feather moult. However, at Nelson Lagoon, subadult Steller's Eiders remained in large, dense flocks during the flightless period, and become flightless before the adults. The temporal separation of the moult of adult males and subadults may reduce competition for food resources, although it was not determined whether food was a limiting factor. The timing of arrival and moult of adult males was probably related to phenology of the nesting season (Jones 1965; Salomonsen 1968). The moult of subadults is independent of the latter since subadults do no normally migrate to the breeding areas until sexually mature (Palmer 1976).

Age classes of Steller's Eiders are also spatially separated. Adult females were infrequently observed moulting at Nelson Lagoon (only in September and October 1978) and subadults apparently do not moult at Izembek Lagoon (Jones 1965). Presumably, such segregation during the moult further reduces competition for available food resources (Sterling & Dzubin 1967), but information on the food resources, food habits, and feeding behaviour of birds moulting in the different lagoon systems is needed.

Steller's Eiders at Nelson Lagoon fed on animal material from May through October. The most common foods taken were amphipoda and pelecypoda, as Cottam (1939) reported for wintering birds. Eiders at Nelson Lagoon appear to take amphipoda in the spring and early summer, pelecypoda during the wing-feather moult, and both amphipoda and pelecypoda after the wing-feather moult. Such a pattern reflected a general availability of amphipoda, the growth of *Mytilus edulis* through the summer, and the opportunistic feeding pattern of the eider. More information on the energetic cost to the eider to obtain amphipoda and pelecypoda, the energetic needs of eiders when in pre-basic and pre-alternate moults and when growing remiges, and the energy available to eiders from pelecypoda and amphipoda are needed to fully understand the changes in foods eaten by Stellar's Eiders during the summer.

Although eiders do not alter their feeding methods when flightless, they fed more, possibly reflecting a need for more food when growing remiges. Eiders fed most after they regained flight capability and fed almost exclusively by diving, possibly reflecting a change in the distribution and abundance of desired food resources.

Whereas the patterns of feeding behaviour of Common Eiders can be influenced by the tide (Dementiev & Gladkov 1952; Gorman 1970; Pounder 1971; Cantin *et al.* 1974; Milne 1974; Campbell 1978) or exhibit a diurnal rhythm (Pethon 1967; Dunthorne 1971), all feeding is done during the daylight hours. In Sweden, during winter, Steller's Eiders are reported to exhibit a diurnal pattern of feeding (Högström 1977). However, during the summer at Nelson Lagoon, Steller's Eiders fed during the low tide irrespective of time of day. Presumably, such a feeding pattern results in the least amount of energy expended to obtain food.

Acknowledgments

I thank R. E. Gill, Jr. for use of his unpublished data on eiders from 1976 and 1978, and use of the substrate samples from 1977. V. F. Hironaka and A. K. Fukuyama identified invertebrates. H. Jones identified and verified identifications of polycheata, G. A. Sanger and K. Coyle identified the amphipoda, and G. McDonald identified the nudabranchs. I thank D. V. Derksen, D. G. Raveling, and C. P. Dau for reviewing this paper. This study was supported by the Bureau of Land Management under contract to

the National Oceanic and Atmospheric Administration as part of the Outer Continental Shelf Environmental Assessment Program.

Summary

The population size, moult chronology, food habits, and feeding behaviour of Steller's Eiders *Polysticta stelleri* were studied at Nelson Lagoon, Alaska from May to October 1977. Subadults were flightless from late July to late August and the adult males were flightless from late August to mid September. Adult females were rarely flightless at Nelson Lagoon but commonly flightless at Izembek Bay.

Steller's Eiders ate primarily bivalve mollusca and amphipod crustacea, with *Mytilus edulis* and *Anisogammarus pugettensis* the most important foods. Eiders took amphipoda prior to the wing-feather moult, bivalves during the wing-feather moult, and both types of invertebrates after the wing-feather moult. Steller's Eiders fed primarily at the low tide by diving (flock-feeding) or head-dipping, both during the day and at night. There was no difference in feeding behaviour between ages or sexes. Eiders fed almost exclusively by diving after the wing-feather moult and apparently fed more as the season progressed.

References

Bryant, D. M. & Leng, L. 1975. Feeding distribution and behaviour of Shelduck in relation to food supply. *Wildfowl* 26: 20–30.

Campbell, L. H. 1978. Diurnal and tidal behaviour of Eiders wintering at Leith. *Wildfowl* 29: 147–52.

Cantin, M., Bedard, J. & Milne, H. 1974. The food and feeding of Common Eiders in the St. Lawrence estuary in summer. *Can. J. Zool.* 52: 319–34.

Cottam, C. 1939. Food habits of North American diving ducks. *U.S. Dept. of Agri., Tech. Bull.* 643.

Dementiev, G. P. & Gladkov, N. A. 1952. *Birds of the Soviet Union.* Vol. 4. Moscow.

Dunthorne, A. A. 1971. The predation of cultivated mussels by Eiders. *Bird Study* 18: 107–12.

Elder, W. H. 1946. Age and sex criteria and weights of Canada Geese. *J. Wildl. Mgmt.* 10: 93–111.

Fay, F. H. 1961. The distribution of waterfowl to St. Lawrence Island, Alaska. *Wildfowl* 12: 70–80.

Gill, R. E., Jr. & Jorgenson, P. D. 1979. A preliminary assessment of timing and migration of shorebirds along the North-central Alaska peninsula. *Studies of Avian Biology* 2: 110–20.

Gorman, M. L. 1970. The daily pattern of display in a wild population of Eider Duck. *Wildfowl* 21: 105–7.

Hanson, H. C. 1962. Characters of age, sex, and sexual maturity in Canada Geese. *Ill. Natural History Survey, Biological Notes* 49.

Högström, S. 1977. Alforradarens *Polysticta stelleri* beteende under vintern. *Vår Fågelvärld* 36: 250–9.

Joensen, A. H. 1973. Moult migration and wing-feather moult of seaducks in Denmark. *Danish Review of Game Biology* 8: 1–42.

Jones, R. D., Jr. 1965. Returns from Steller's Eiders banded in Izembek Bay, Alaska. *Wildfowl Trust Ann. Rep.* 16: 83–85.

Kistchinski, A. A. 1973. Waterfowl in north-east Asia. *Wildfowl* 24: 88–102.

McKinney, F. 1965. The spring behaviour of wild Steller Eiders. *Condor* 67: 273–90.

Milne, H. 1974. Breeding numbers and reproductive rate of eiders at the Sands of Forvie National Nature Reserve, Scotland. *Ibis* 116: 135–52.

Murdock, J. 1885. Part IV. Natural History. II. Birds, pp 104–128 in *Report of the International Polar Expedition to Point Barrow, Alaska, in response to the resolution of the (U.S.) House of Representatives of December 11, 1884.*

Palmer, R. S. (ed.). 1976. *Handbook of North American Birds*, Vol. 3. New Haven: Yale University Press.

Peterson, S. F. & Ellarson, R. S. 1978. Bursa, reproductive structures, and scapular color in wintering female Oldsquaws. *Auk* 95: 115–21.

Pethon, P. 1967. Food and feeding habits of the Common Eider. *Nyatt Magasin for Zoologi* 15: 97–111.

Pounder, B. 1971. Wintering Eiders in the Tay estuary. *Scot. Birds* 6: 407–19.

Salomonsen, F. 1968. The moult migration. *Wildfowl* 19: 5–24.

Sterling, T. & Dzubin, A. 1967. Canada Goose moult migrations to the Northwest Territories. *Trans. N. Am. Wildl. and Nat. Res. Conf.* 32: 355–73.

Swanson, G. A., Krapu, G. L., Bartonek, J. C., Serie, J. R. & Johnson, D. H. 1974. Advantages in mathematically weighting waterfowl food habits data. *J. Wildl. Mgmt.* 38: 302–7.

Margaret R. Petersen, US Fish and Wildlife Service, Biological Services Program-Coastal Ecosystems, 1011 E. Tudor Road, Anchorage, Alaska 99503, USA.