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APPENDIX I

AVIFAUNAL ASSESSMENT OF NELSON LAGOON, PORT MOLLER, AND HERENDEEN BAY, ALASKA - 1977

By

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I. SUMMARY OF OBJECTIVES, CONCLUSIONS, AND IMPLICATIONS WITH RESPECT TO OCS AND GAS DEVELOPMENT.

The objectives of this, the second year of a planned two year study were:

1. To conduct general avifaunal assessments of Nelson Lagoon, Port Moller and Herendeen Bay.

   a. To determine the number and distribution of each species relative to other species, to periods of the breeding season, and to characteristics of available habitat within the colony or study area.

   b. To provide estimate of production or nesting success of principal species.

   c. Catalog colony sites and identify important feeding and roosting areas.

   d. Determine migration strategies of major shorebird and waterfowl species.

2. Identify and evaluate the importance of intertidal substrates for breeding and migratory shorebirds and waterfowl.

3. Collect, incidental to the above, observations on marine mammals and identify and map major plant communities within the study area.

4. Identify what activities associated with oil and gas development may impact these wildlife populations.

5. Recommend mitigative measures to offset negative effects of offshore and onshore development.

The Nelson Lagoon complex (consisting of Nelson Lagoon, Herendeen Bay, and Port Moller) is the largest estuarine area along the Bristol Bay shoreline. It supports a diverse avifauna found nowhere else along the Alaska Peninsula. Included are impressive numbers of Steller's and King Eiders, Emperor Geese, Oldsquaw and Black Scoter. Each fall the Lagoon also hosts some twenty species of shorebirds numbering in the 10's of thousands.

While the value of the Alaska Peninsula terrace as a breeding area can not be dismissed, its overwhelming importance is that of a staging area for migratory, post-breeding and wintering birds. These include local birds as well as birds coming from breeding grounds in arctic Alaska and Siberia.

The productivity of many of these lagoons far exceeds that of equivalent areas of the adjacent Bering Sea, and the larger lagoons have tidal exhanges equivalent to the flow volume of major rivers.

The vast meadows of aquatic vegetation and super abundant benthic faunas create an ideal situation for migratory, molting and wintering birds to obtain the energy reserves needed to sustain them through these demanding processes and periods. The physiographic nature of the estuarine areas, coupled with post-breeding changes in social structure, force birds into much greater concentrations than found on the breeding grounds. Because of this, the birds become extremely vulnerable to oil contamination from offshore and onshore spills. Similarly, onshore developments in support of mineral exploitation pose an equal threat and should be strictly regulated. The relatively deep water port capabilities and associated developments of Port Moller have, in our opinion, equal or greater potential impact to waterbird populations than those associated with offshore development and spills.

II. INTRODUCTION

A. General Nature and Scope of the Research

This report is part of a study of the population dynamics and trophic relationships of marine birds in the Gulf of Alaska and southern Bering Sea. Its objectives are 1) to evaluate the status and ecology of marine birds with emphasis on population numbers, productivity and trophic dynamics, and 2) to present information necessary to identify and evaluate potential resource impacts and develop means for preventing or mitigating adverse impacts.

The Alaska Peninsula is probably the most noticeable physiographic feature of the Alaskan land mass. The north shore shelves off gradually into the shallow waters of the Bering Sea, forming a low coastal plain with a comparatively even coastline. The rugged volcanic Aleutian Range runs the length of the Peninsula, and on the south side breaks off into the deeper waters of the Pacific Ocean. Consequently, the avifauna of the Peninsula is quite diverse and in part characteristic of the land conformations. On the south side are tremendous numbers of breeding seabirds. The area is also favored by numerous wintering seaducks as it stays ice free year round. Since expansive intertidal substrates are limited on the south side, the area receives little use by shorebirds. In contrast, the north side of the Peninsula has few colonial nesting species, excepting gulls and terns, but because of its extensive intertidal substrates the area is heavily used by vast numbers of shorebirds and waterfowl; especially during fall migration.

Despite this seemingly sharp contrast in bird use, the near and onshore habitats of both sides of the Peninsula are used by populations of certain species during both migration and winter. The west end of the Peninsula at Unimak Pass is a major thoroughfare for spring and fall bird migrations between the Gulf of Alaska and Bering Sea. Virtually the entire breeding populations of several species pass along the Peninsula and through Unimak Pass twice each year. During fall, most of these populations stop along the various estuaries of the north Peninsula to molt and build fat reserves used in their often extensive transoceanic migrations to wintering quarters in temperate and tropical latitudes. Other populations, depending on ice conditions, remain along the north Peninsula through winter and forage extensively in these estuarine systems.

Our research examines the importance of one of these estuaries and relates this system to other segments of annual avian cycles.

B. Specific Objectives

In light of the objectives listed in the summary, this study is divided into three parts: (1) We examined the temporal and spatial distribution of waterfowl and shorebirds in the Nelson Lagoon system. We identified important feeding and roosting areas used during migration and winter. (2) We also identified principal food resources supporting these populations. What items were required during migration and molt and were these items changing in the birds' diets as well as in the benthic communities? (3) We looked at migration strategies of several shorebird and waterfowl species. How long do individual birds remain in the estuary and where do they go and via what routes? Are birds using Nelson Lagoon also being exposed to potential adverse impacts from mineral development by stopping in other OCS areas, both in and out of Alaska?

C. Relevance of Problems of Petroleum Development

While multi-year studies are desired to fully understand the dynamics of a system such as Nelson Lagoon, we realize that time and monetary restraints allow us to investigate only the more relevant aspects. These in turn will hopefully allow for predictions about impacts which development of mineral resources may bring.

III. CURRENT STATE OF KNOWLEDGE

The literature is now becoming replete with accounts of the effects of oil pollution on seabirds. Bourne (1968) and Vermeer and Vermeer (1974) have summarized much of this literature; Hunt (1977) has related oil to several species of seabirds common to the Bering Sea. These reviews emphazize the high susceptibility of alcids and diving ducks to spilled oil; much more so in winter when large concentrations of these birds occur.

Except for Smith and Bleatney's (1969) discussion of an oil pollution incident in Nova Scotia involving Purple Sandpipers, the effects of oil spills on littoral zone communities and their subsequent effects on shorebirds, both direct and indirect, are poorly known. It appears that shorebirds are capable of avoiding direct contact with spilled oil but build up a thin coating of oil from wading in tide pools. We suspect that oil particle injestion by foraging shorebirds and contamination of benthic food organisms may have a greater impact on shorebird populations than has been observed to date. Much more work needs to be directed at this aspect of shorebird ecology.

Until recently, the specific bird resources which might be impacted by mineral development in the Bristol Bay and southeast Bering Sea areas were largely unknown. Previous avifaunal studies of these areas have often been cursory and confined to brief periods in late spring and early fall; none covering more than a few consecutive months.

The Alexander Stone Expedition of 1903 (Chapman 1904) represents the first effort to catalog the birds of the Port Moller-Herendeen Bay area. This was followed by the Stoll-McCracken Expedition of 1929 (Jaques 1930) which also centered its studies around the Port Moller area. Combined, the two expeditions reported on only 30 species from the Port Moller-Herendeen Bay area. Murie (1959), in his faunal survey of the Alaska Peninsula and Aleutian Islands in 1937-1938, added little new information about the bird life of this segment of the Peninsula.

McKinney (1959) was apparently the first to investigate the Nelson Lagoon area; however, his efforts were directed at only three or four species and for only a two week period in May 1958. In the mid 1950's, the U.S. Fish & Wildlife Service (FWS) began conducting spring waterfowl surveys on the Peninsula. While these have never been flown south of Ugashik they provide data from which inferences can be made about the waterfowl of the central peninsula for the same period. From 1964 there exists a spring waterfowl survey, also conducted by the FWS, with considerable information about the Port Moller-Nelson Lagoon area. It was not until the early 1970's, however, that significant data on late summer and early fall bird use of the area became available. Several aerial and ground surveys conducted by the Alaska Department of Fish and Game (Arneson 1976) and the FWS provide good quantitative data on waterfowl and other waterbird use of the area; particularly Nelson Lagoon. These references are cited as: G. V. Byrd, E. P. Bailey, and R. D. Jones, Jr., pers. comm. or unpublished data.

Pelagic and inshore avifauna off Port Moller and Nelson Lagoon have only recently been looked at (King and McKnight 1969; Bartonek and Gibson 1972). While these investigations are major contributions and increase our understanding of occurrence and abundance of birds in the Bristol Bay region, there still remain gaps in our knowledge of bird use in this area; especially in winter.

IV. STUDY AREA

The study area is located centrally along the north side of the Alaska Peninusla (Fig. 1). The combined area of 540 km2, comprised of Nelson Lagoon (100 km2), and Herendeen Bay (200 km2) represents the largest estuarine area along the northern Alaska Peninsula.

The north central portion of the Alaska Peninsula is typified by a broad lowland extending inland 10-20 km to the base of the Aleutian Range. Several river systems originating in the Aleutian Range drain out over the lowlands to Bristol Bay. The Peninsula coastline is relatively regular and comprised of numerous sand beaches, low terraces and alluvial fan deposits.

The extensive intertidal mud and sand flats are the most noticeable feature of the western Bristol Bay coastline and particularly so within the study area. Over 230 km2 of intertidal flats are exposed at MLLW (mean lower-low water) in the Port Moller-Nelson Lagoon area. Open water covers an additional 265 km2 of the study area at MLLW. Coastal sand dunes (8.2 km2), barrier islands (4.8 km2), upland heath (16 km2), and salt meadows (10 km2) comprise the remaining major habitat types within the study area.

The major freshwater source to the estuary comes from the combined discharge of the Caribou and Sapsuck Rivers and enters Nelson Lagoon at its western end. Several additional smaller drainages feed the shoreline and headlands of Herendeen and Moller Bays.

The tidal regime of the study area is typical of that along the west coast of North America with two high and two low tides occuring in a 24 hour period. The mean diurnal tide range at Port Moller is approximately 3.2m.

Weather during 1977 was quite variable. Mean monthly maximum and minimum temperatures were recorded as: May 7°, -2°C; June 11°, 6°C; July 13°, 9°C; August 13°, 9°C; September 10°, 4°C. The water temperature on 26 May at mid-channel, opposite our cabin, was 3°C. Between 15 June and 15 October water temperature ranged between 9° 10°C. By 15 October water temperature had dropped to 4°C. The estuarine waters are usually ice free between mid-April and October. Prevailing winds between May and September are from the NW and SE. Precipitation at Nelson Lagoon averages 25 inches per year. Prevailing NW and NE winds during winter keep snow cover to a minimum along the immediate coastal portions of the estuary.

V. SOURCES, METHODS AND RATIONAL FOR COLLECTING DATA

During 1977 the study was conducted from 18 April through 15 October. Seven investigators participated in the study for a total of 389 person-days.

Methods

1. Aerial Censuses. Censuses of feeding and roosting shorebirds and waterfowl were made from a Piper Super Cub and Cessna 185. Censuses were flown at an elevation of between 50 and 75 m and at an airspeed of 75 knots. The pilot plus one observer conducted most censuses. Only the observer counted shorebirds but often relied on the pilot to locate concentrations of birds. Censuses

were flown between 1.5 hours before or after low, slack tide. Census duration averaged 45 minutes. Numbers were recorded on magnetic tape and later transcribed to census forms (030 Format). Censuses were conducted by first flying the edge of the substrate/water interface since shorebirds, especially, were found concentrated along this area during early stages of each low tide. We then returned to survey other portions of each census area as we saw bird concentrations. The airplane invariably disrupted concentrations of foraging shorebirds; however, we found most concentrations re-settled within several hundred meters of their initial area. We feel duplicate counts from any one area or between areas were, therefore, at a minimum. During most of the study, birds were recorded in groups of 100's except during peak migration in September and early October when we often counted in groups of 1000's.

Shorebirds were usually identified to species except during late June through August when populations of Western Sandpipers (Calidris mauri), Dunlins (C. alpina pacifica) and Least Sandpipers (C. minutilla) occurred together over much of the study area. For purposes of this study these species were recorded as "small sandpipers" during aerial censuses. Populations of each were subsequently determined from periodic comparisons of population ratios of all three species. These were derived from ground censuses conducted usually within 72 hours of an aerial census. Only ground and aerial censuses conducted over the same area or similar substrate types were used for such comparisons. We found numbers of C. minutilla, however, to be too small and the species' occurrence too irregular to accurately evaluate use patterns for each census area.

Numbers of Short-billed (Limnidromus griseus) and Long-billed Dowitchers (L. scolapacius) were similarily derived but presented less of a problem since the two species exhibited different habitat preferences and only briefly overlapped in occurrence during the study.

2. Ground Censuses. Several fixed ground census stations were established. These were censused on the average of twice a week during migration and once a week otherwise. Counts were made with aid of 8X binoculars and a 15X wide angle spotting scope. All birds were identified to species. Numbers, activity and habitat utilization were also recorded. A second type of fixed ground census was conducted twice weekly at two hour intervals. Similar data were recorded and correlated with daily tidal cycles (038 Format).

3. Reproductive Success.

A. Common Eiders (Somateria mollissima v-nigra)

Nesting islands were searched weekly beginning in May. Nests were individually marked and re-visited weekly. Female adult eiders were individually marked to follow brood dispersal.

B. Arctic (Sterna paradisaea) and Aleutian Terns (S. aleutica)

Line transects were established within colonies and checked approximately every three weeks for Arctic Terns and monthly for Aleutian Terns. Counts of adults over each colony were obtained during each visit.

C. Glaucous-winged Gulls (Larus glaucescens)

Counts of adults in attendance at colonies were obtained from aerial and ground censuses. Several 625 m2 plots were established within colonies to monitor productivity. Rank growth of Elymus prevented us from following these to fledging.

4. Migration Studies.

Shorebirds were captured using a rocket net at high tide roosts. Birds were sexed, weighed, checked for molt, banded, and color marked. Turnover times of birds within the Lagoon were derived by noting numbers and color codes of previously marked birds. Such information is essential in deriving figures of overall bird use of a particular area or estuarine system.

5. Trophic Studies.

Two fixed 50m long intertidal transects were established and sampled every three weeks beginning in early June prior to the arrival of large numbers of migrant shorebirds and waterfowl. A total of 5, 1 liter samples was taken randomly at 5 meter intervals along each transect. Samples were rough sorted in the field and preserved in 10% buffered formalin. In conjunction, 3 each Dunlin, Rock and Western Sandpipers were collected every 2 weeks while foraging on or near the transects. Stomachs were immediately injected with 10% buffered formalin and removed. From our analysis we hope to determine 1) benthic population levels prior to and during migratory bird use, and 2) prey items used by migratory birds during molt and premigratory fat build up.

6. Weather

Weather data, including temperature, wind direction and speed, cloud cover, visibility and precipitation were recorded 5 times daily.

VI. RESULTS

A. Numbers and Activities

1. Waterfowl. Twenty-five species of waterfowl have been recorded for the study area. The combined temporal abundance of these species between May 1976 and October 1977 is presented in figure 2. Peak numbers occurred during fall migration both years but substantial numbers, mostly King

and Common Eiders, Oldsquaw, and Emperor Geese, wintered in the Lagoon system in 1976-1977. However, the Lagoon remained ice free that winter and the numbers of waterfowl recorded may be abnormally high. Individual occurrence and abundance data for the six major waterfowl species are presented in figures 4 and 5.

2. Shorebirds. Twenty-three shorebird species are known for Nelson Lagoon. The occurrence and abundance of all shorebirds is shown in figure 3, while figures 6-8 depict individual data for the nine major species using the Lagoon system. In both figures the comparatively larger number of birds recorded in 1977 is due to our including an additional census area not used in 1976. For a detailed analysis of Dunlin and Western Sandpiper use of the Lagoon see the appended paper presented at the 1978 Pacific Seabird meeting.

B. Feeding and roosting areas

1. Waterfowl. Figures 9 and 10 depict critical foraging, molting and roosting areas of Emperor Geese, Steller's and Common Eider, Oldsquaw and Black Scoter. The areas depicted represent overall use of the Lagoon by a species during its stay in the Lagoon. Shifts in foraging and roosting site preferences occur depending on time of year and weather conditions.

2. Shorebirds. A detailed description of feeding and roosting areas is appended to last years annual report(Gill et al. 1977). Little change in these patterns was detected during 1977 excepting a noted increase in the use of Mud Bay by Dunlin in September and October and by Whimbrel (*Numenius phaeopus*) in August. Figure 11 depicts major shorebird feeding and roosting areas.

C. Reproductive Success

1. Common Eider. Common Eiders were present on our arrival on 18 April. Although some courtship activity was observed in April, most birds were paired prior to our arrival. Pairs began selecting nest sites on 18 May, three weeks after the snow and ice was gone from the nesting islands.

Nests were found on 7 fox free barrier islands. Most nests (99% of 97) were surrounded by beach rye (*Elymus mollis*), the predominant vegetation on the islands. Three nests (3% of 97) were placed in stands of *Angellica lucida*.

Nests were placed an average 15 m from the beach/vegetation interface (range 0.5 to 50 m, N=97). Most islands that were used by eiders for nesting were 50 m or less wide, with the widest island 100 m wide. Thus, all nests were with in 50 m of the water.

The first Common Eider egg was laid on 18 May, and birds appeared to be well into egg laying by 30 May. Most nests were found after egg laying was completed, thus dates for clutch initiation of most nests were determined by back-dating from hatching dates. Many nests (42.7% of 75) were initiated by 29 May, 68.0% of the nests were begun by 10 June, and all nests were begun by 27 June.

The minimum clutch size at hatching ranged from 1 to 10 eggs, and averaged 4.76 eggs per clutch in 1977; an increase from the 41.7 eggs per nest over that observed in 1976 (Fig. 12). Seventy-five of 97 nests in 1977 had 1 or more eggs hatch, and averaged 4.03 eggs hatching per nest (Fig.13).

Hatching dates were bi-modally distributed, with peaks of hatching occurring on 25-29 June and on 15-19 July (Fig. 14). Nests that had eggs that hatched early had significantly more eggs per nest ($F=7.975$, $df = 1.72$, $p = 0.006$). Nests that had eggs that hatched early averaged 5.11 eggs per nest and 4.83 ducklings per nest, whereas nests that had eggs that hatched late averaged only 4.33 eggs per nest and 3.90 ducklings per nest.

2. Glaucous-winged Gulls. Gulls established territories on barrier islands prior to our arrival on 18 April, and maintained territories throughout the pre-laying period. A total of 782 nests was found among the 30,25x25 m plots. Egg laying began 23 May, and peaked on 10 June. Modal egg laying occurred 30 May to 22 June. Eggs began hatching 2 July, with most hatching 2-24 July. Only 31 nests (3.9% of 782) had one or more eggs hatch. Fledging dates of young were not determined.

D. Trophic Relationships.

Waterfowl. See appended report on Steller's and Common Eider feeding ecology.

Shorebirds. Data are presently being analyzed.

VII & VIII. DISCUSSION AND CONCLUSIONS

Our two years at Nelson Lagoon have only begun to identify, let alone bring together, the myriad of processes and principles inter-acting to make the Lagoon the important waterbird area that it is. Our first year's effort was directed at identifying the species using the Lagoon and developing occurrence and abundance patterns. From these we found noticeably different uses of littoral substrates by different groups of birds. We began a detailed study of this during fall of 1976, and continued it through October 1977. We went a step further in

1977 and began looking at the distribution of benthic food resources as a possible indicator of bird distribution. This was done in conjunction with an extensive study of bird turnover rates during summer and fall cycles, e.g. post-breeding dispersal, molt and pre-migratory staging.

While much of our data has yet to be analyzed, particularly shorebird feeding information, we can now make general, but we believe fundamental, assumptions regarding the Lagoon system and waterbird use and dependency upon this system. Chief among these is that the Nelson Lagoon complex is a unique estuarine system among the many found along the Bristol Bay and Bering Sea coastlines. This is due in part to its size, tidal regime, configuration, relationship with the deeper Herendeen and Moller Bays, and its location with respect to normal ice advance in Bristol Bay.

Nelson Lagoon and other estuaries, therefore, support somewhat different faunal groups and numbers; and while we might eventually understand the dynamics of one such system, we can not blanketly apply this knowledge to other estuarine systems in Bristol Bay or Alaska. What little comparative data we have among Port Heiden, Nelson Lagoon and Izembek Lagoon indicates the three systems support quite different avifaunas at virtually any given time of year. And while some of these populations may utilize all three systems, they apparently do so at different times. Accounting for this may be different food sources utilized in each system during different events in the avian cycle, e.g. molt versus migration. Not to be discounted, however, is the possibility that while a single species can use all three systems, each system might support a distinct subpopulation of that species. These lagoon specific populations could come from different breeding grounds and probably utilize different wintering grounds or portions thereof. Our data from Dunlin and Western Sandpiper support this.

IX. NEEDS FOR FURTHER STUDY

Further study needs are both short and long term. Needed long term (5 + years) studies include continued monitoring of use patterns of Nelson Lagoon by major waterfowl and shorebird species. Trends in numbers and temporal and spatial distribution and abundance in the system must be known before impacts from potential oil and gas development can be assessed. Of more importance, however, is the initiation of similar long term studies of adjacent Port Heiden and Izembek Lagoons to determine species dependency and interchange between and among other estuarine systems. Despite the Bering Sea/Bristol Bay lease schedule being put off indefinitly, if any continuity of data collection is to be maintained there should be continued study of these areas, even at a much reduced level. Such studies would initially entail extensive population census work coupled with large scale capture and marking programs. The latter would, as we discovered this year, provide additional information on species dependency on habitats within other OCS lease areas, both in and outside of Alaska.

A second long term study is urgently needed to better determine the relationship between benthic faunal communities and the avian communities they support. Even if birds escape the direct effects of an oil spill, their food resources could be impacted from oil contamination and supressed below a level sufficient to sustain them.

Of a short term nature (1-2 years) are studies of the importance of the Alaska Peninsula to breeding stocks of waterfowl and shorebirds. While we now have ideas of the numbers of birds using Bristol Bay littoral habitats, it remains unclear as to their natal orgins. In order to adequately assess the vulnerability of a species population to OCS activities we need to know all aspects of its annual cycle; especially for those species which winter in Alaskan OCS waters. It is also critical to know what percentage of a species population is dependent on an estuarine system such as Nelson Lagoon. For instance, we now feel that most of the Alaska breeding population of Bar-tailed Godwits is staging on Nelson Lagoon and possibly other nearby estuaries prior to its trans-pacific fall migration. Similarly, the majority of the Alaska Emperor Goose population uses Nelson Lagoon for periods each spring and fall.

X. SUMMARY OF JANUARY - MARCH QUARTER

The quarter was spent analyizing and writing up data accumulated during the past field season.

ACKNOWLEDGMENTS

We are indebted to the villagers of Nelson Lagoon for allowing us to conduct studies over much of their lands. The hospitality which they extended and the knowledge they shared with us is most appreciated.

Peter Kust, Butch Gundersen, and Don and Warren Johnson are especially thanked for their help in providing logistics and conducting aerial surveys. The Peter Pan Seafoods Co. is also thanked for making their facilities available during our stay.

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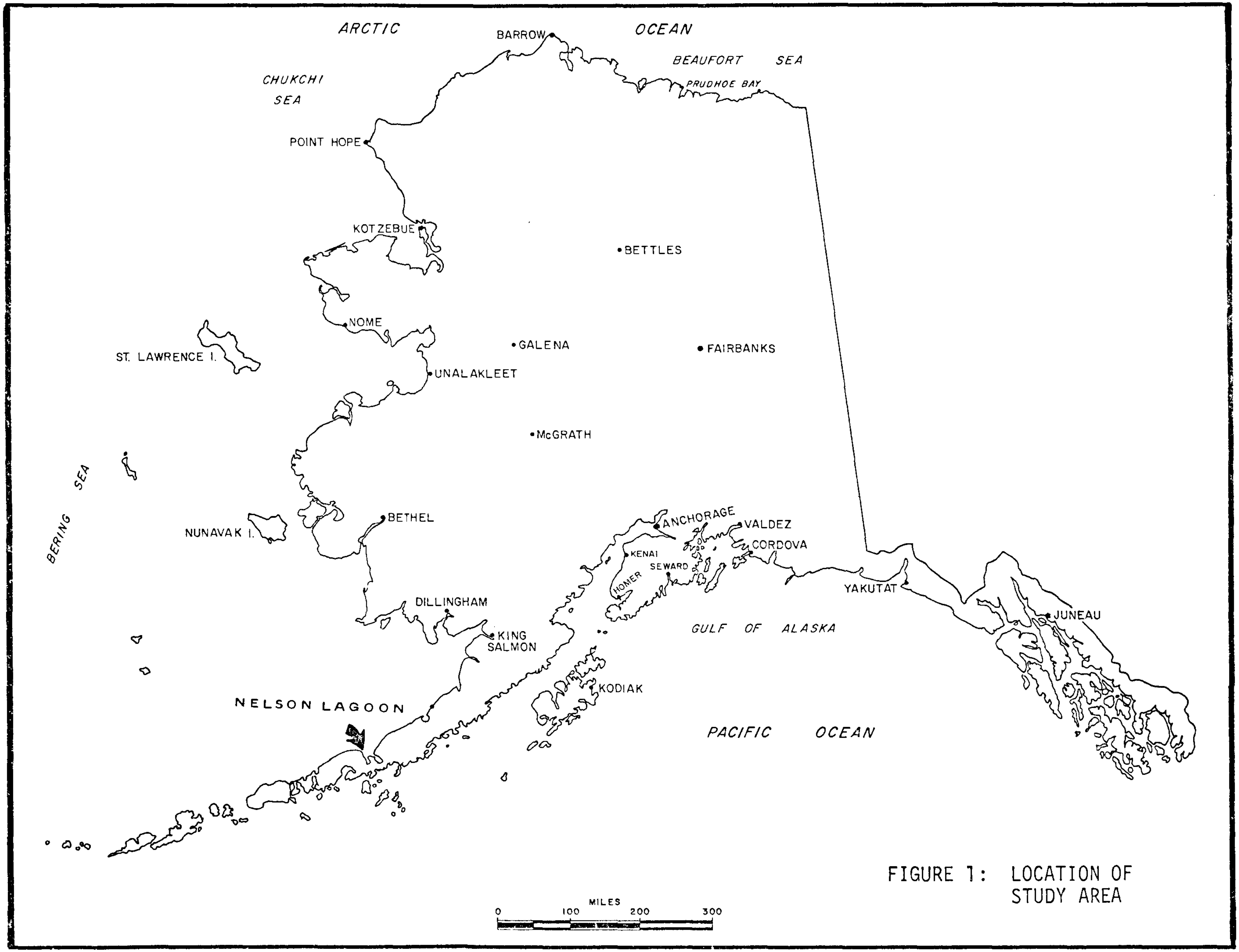


FIGURE 1: LOCATION OF STUDY AREA

FIGURE 2. Temporal abundance of waterfowl at Nelson Lagoon 1976-1977.

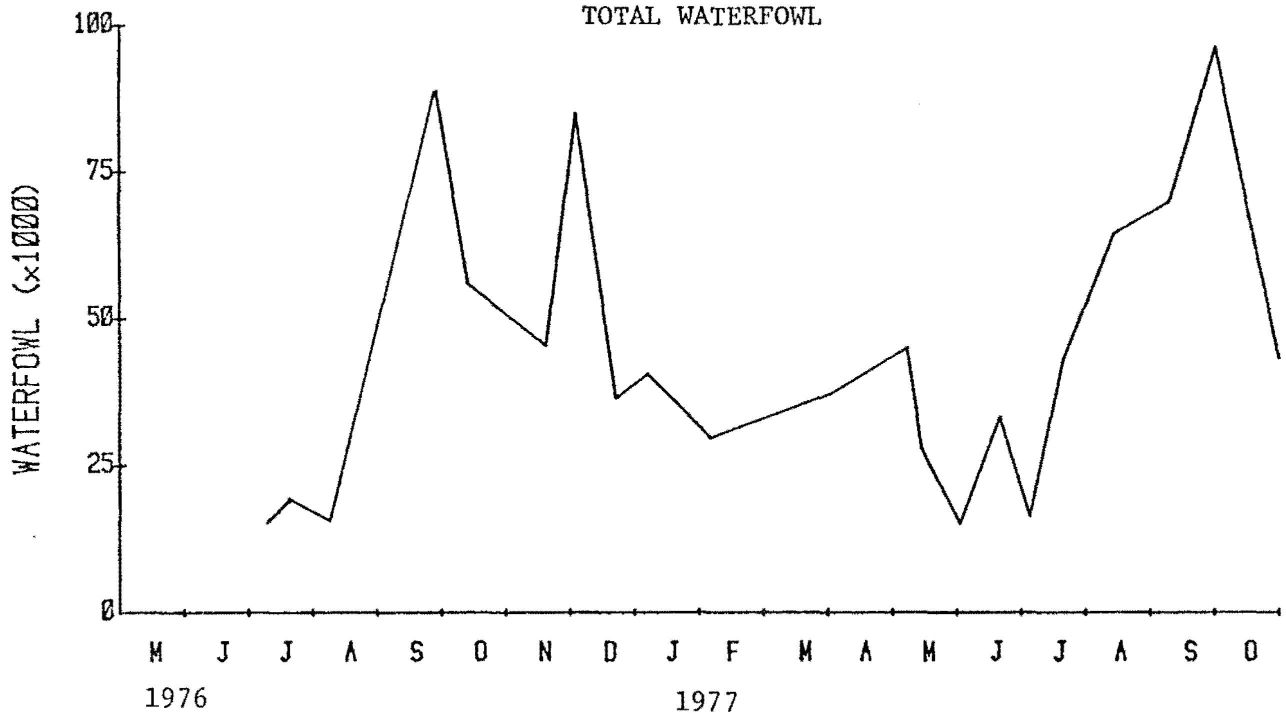


FIGURE 3. Temporal abundance of shorebirds at Nelson Lagoon 1976-1977.

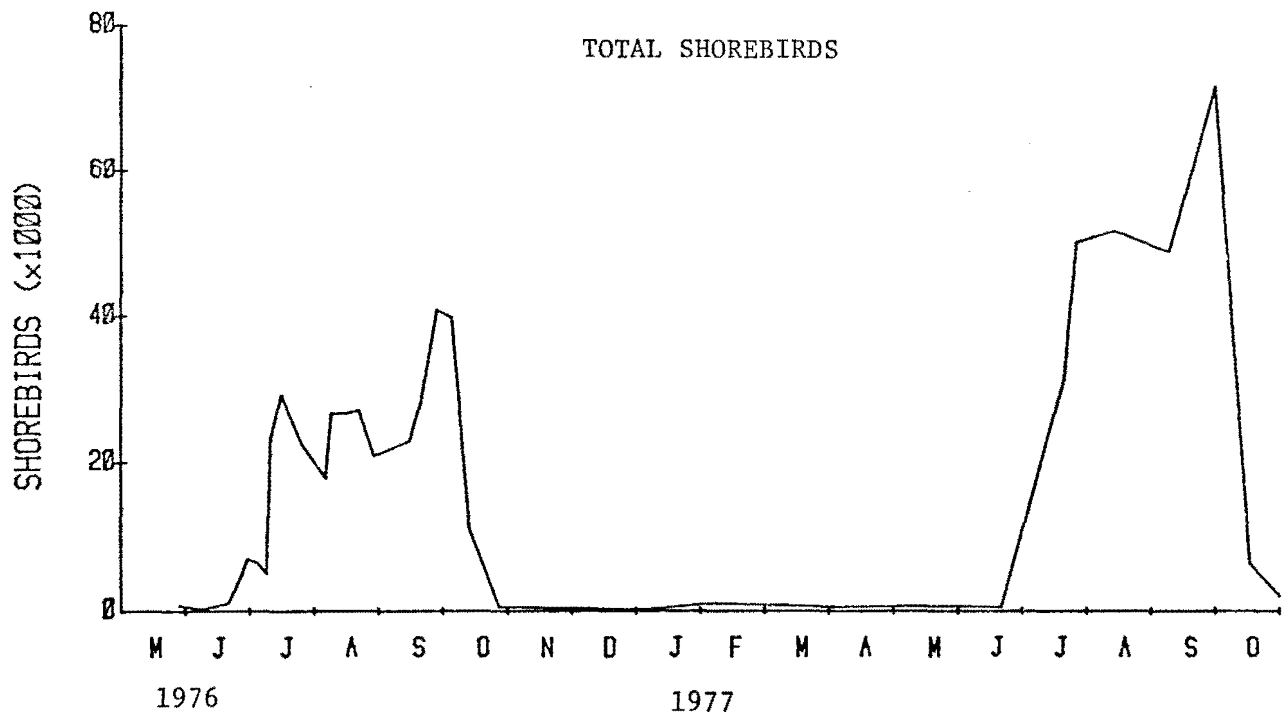


FIGURE 4. Occurrence and abundance of major waterfowl species.

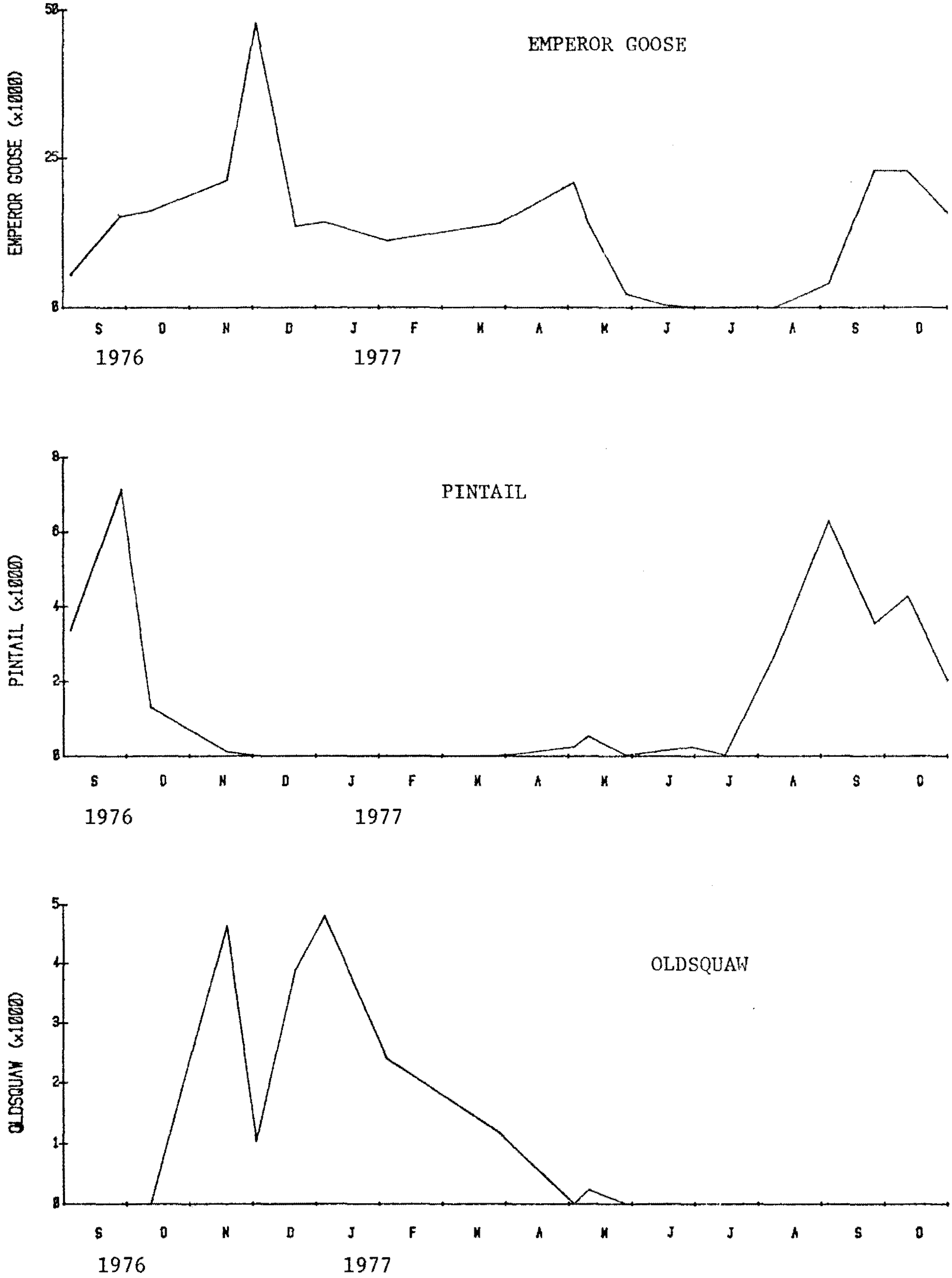


FIGURE 5. Occurrence and abundance of major waterfowl species.

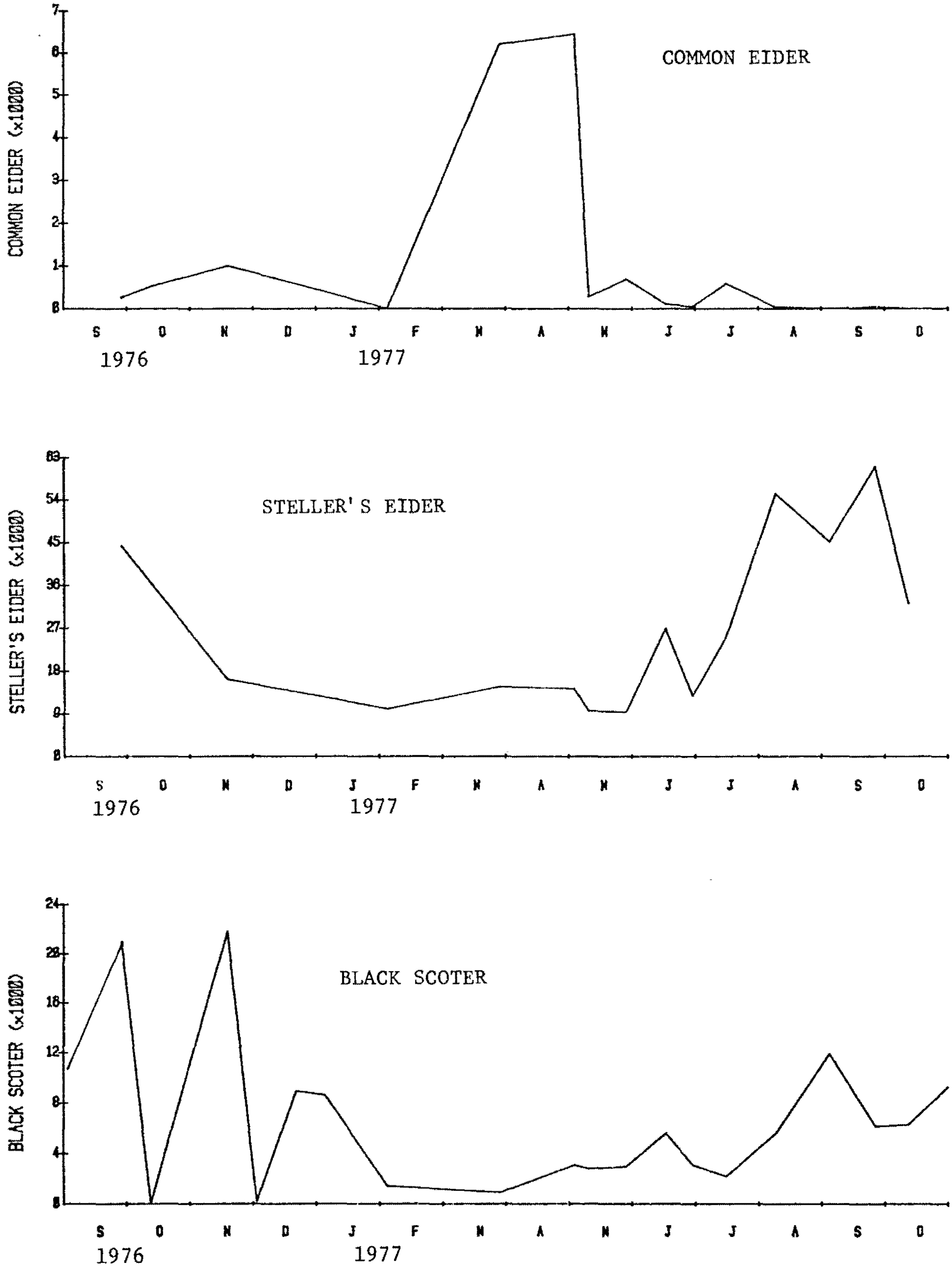


FIGURE 6. Occurrence and abundance of shorebird species at Nelson L.

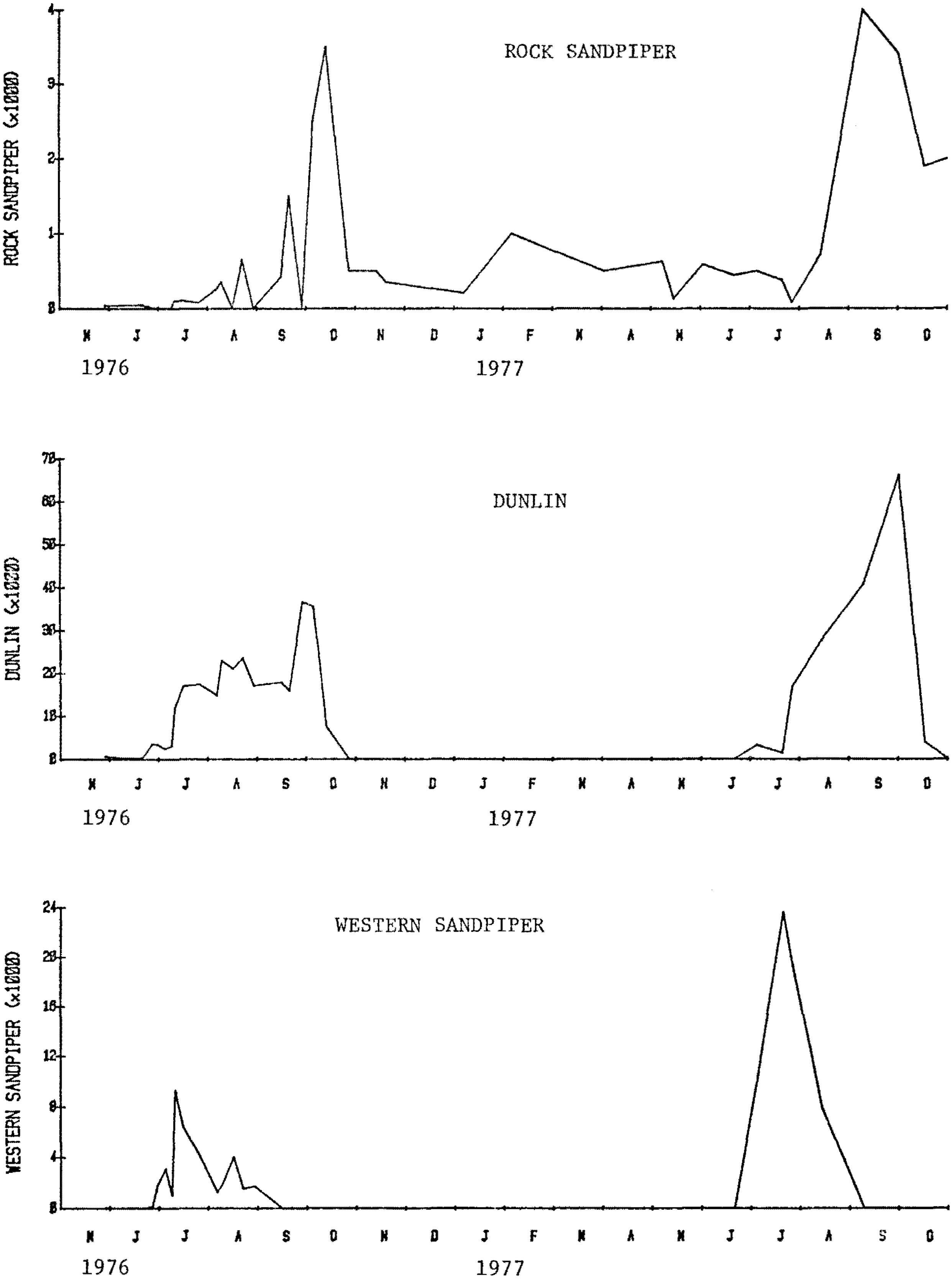


FIGURE 7. Occurrence and abundance of shorebird species at Nelson L.

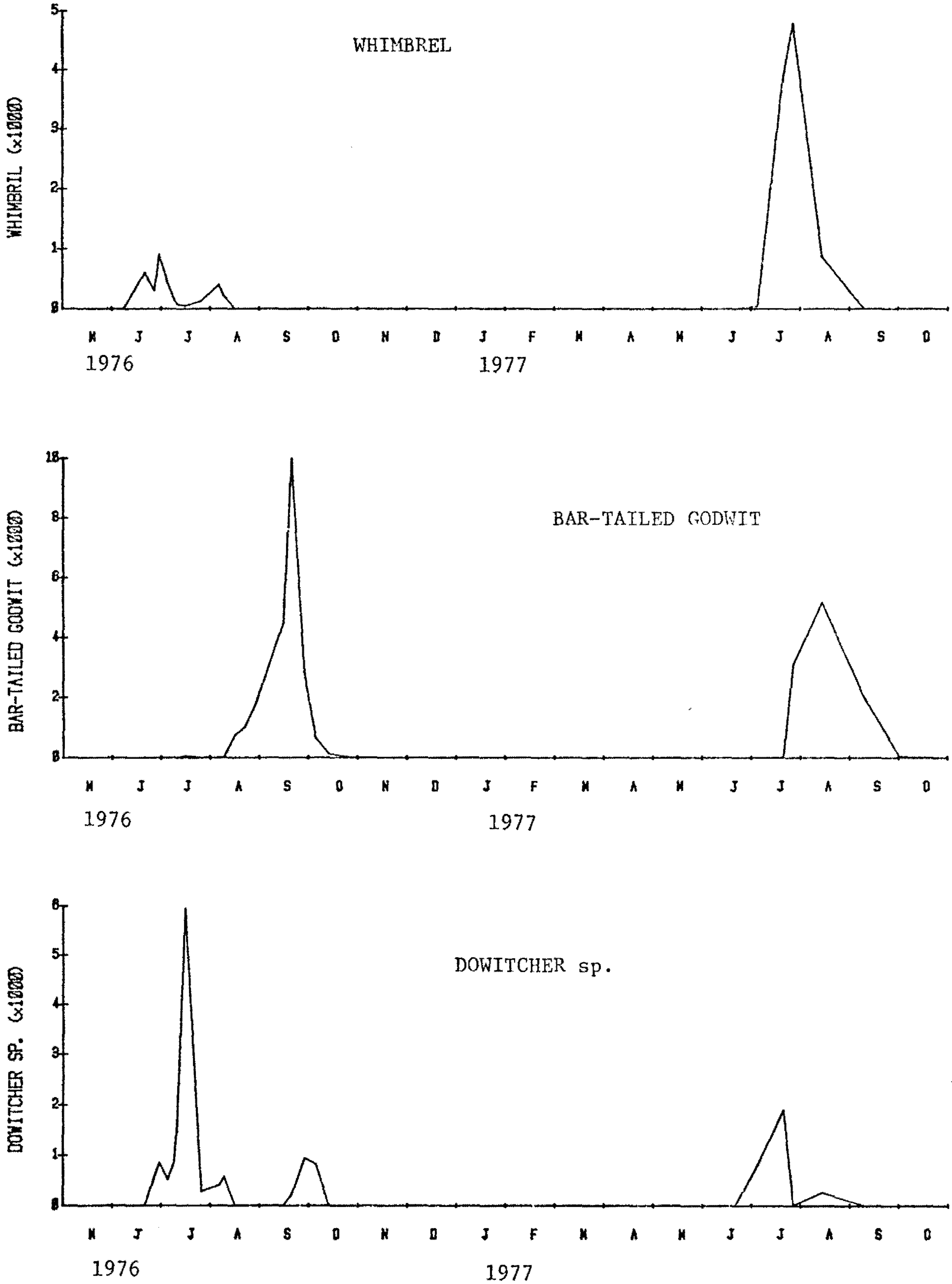
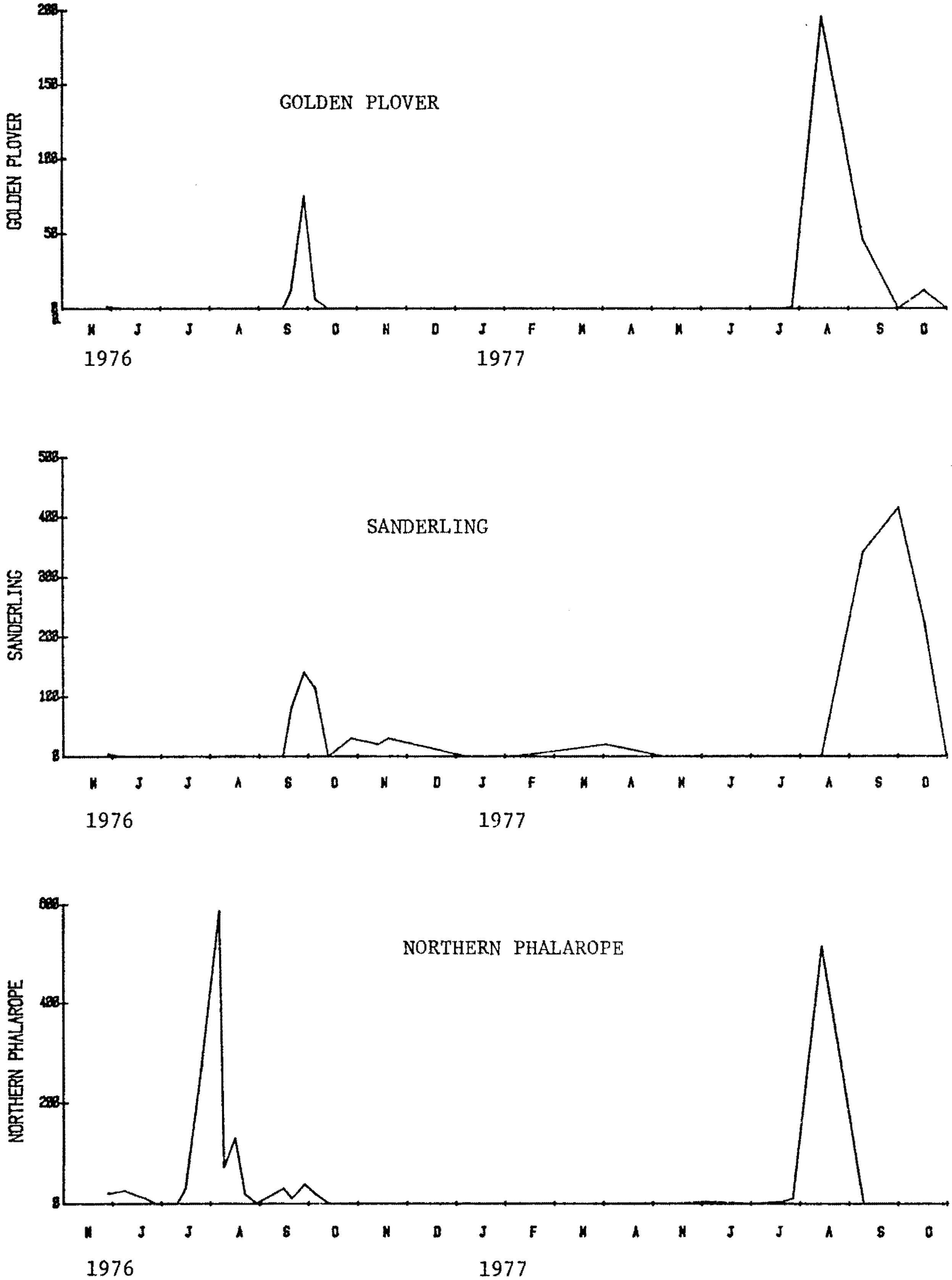


FIGURE 8. Occurrence and abundance of shorebird species at Nelson L.



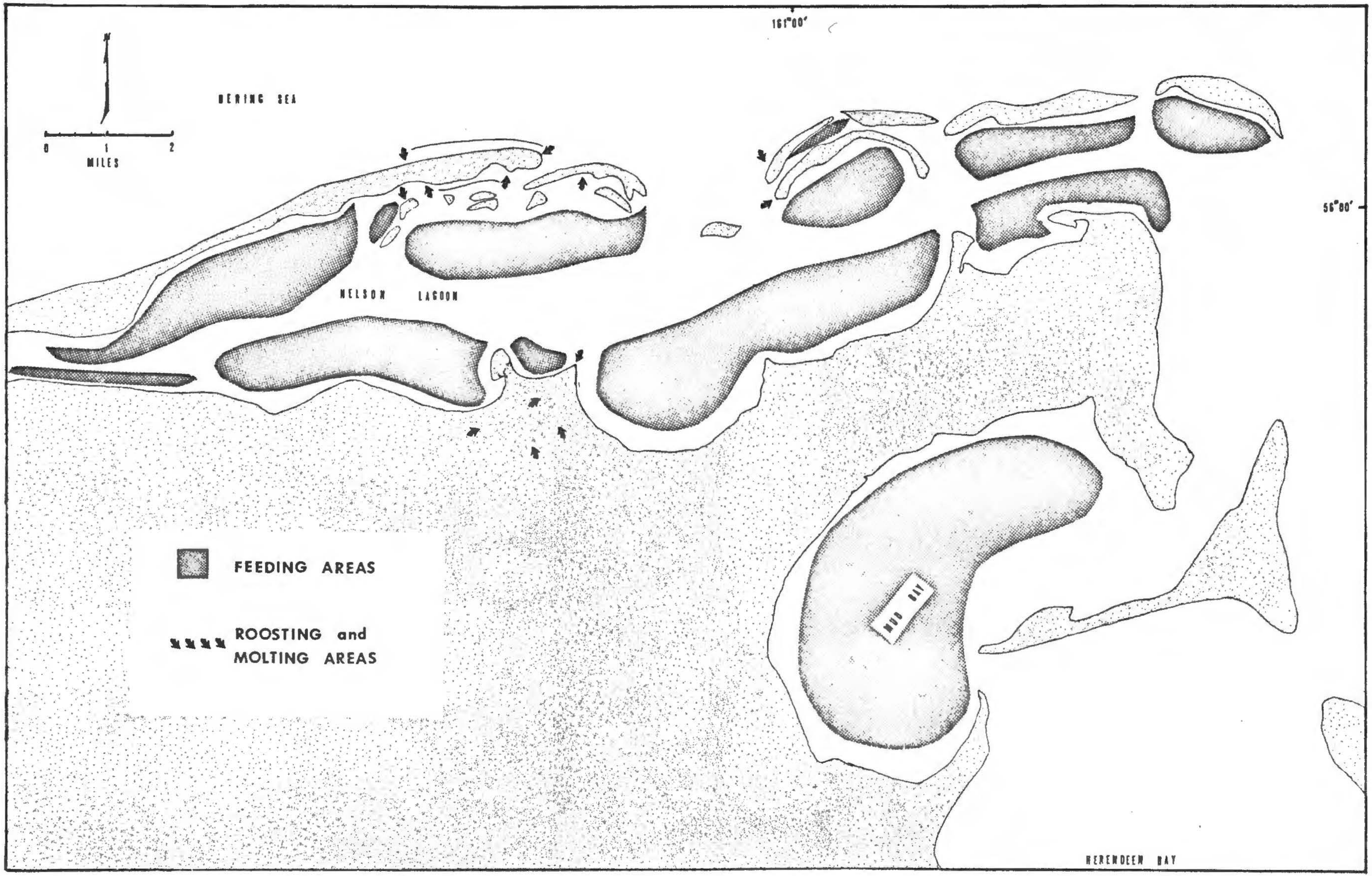


FIGURE 9. Critical feeding and roosting areas of Emperor Geese (August - May).

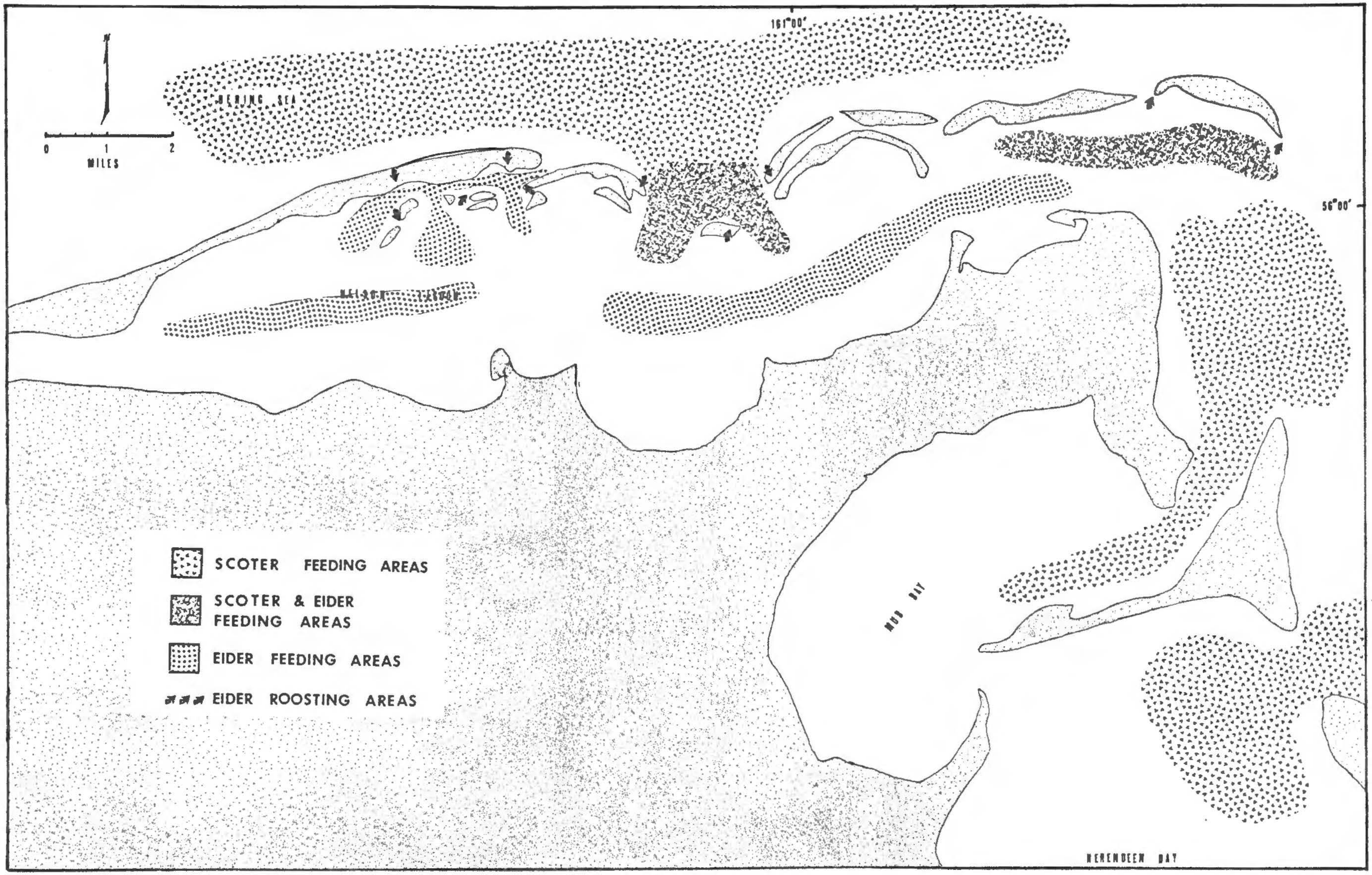


FIGURE 10. Critical feeding and roosting areas of Steller's, Common and King Eiders and Black, White-winged and Surf Scoters. Steller's Ediers and Black and White-winged Scoters molt over much of the same areas (June - August).

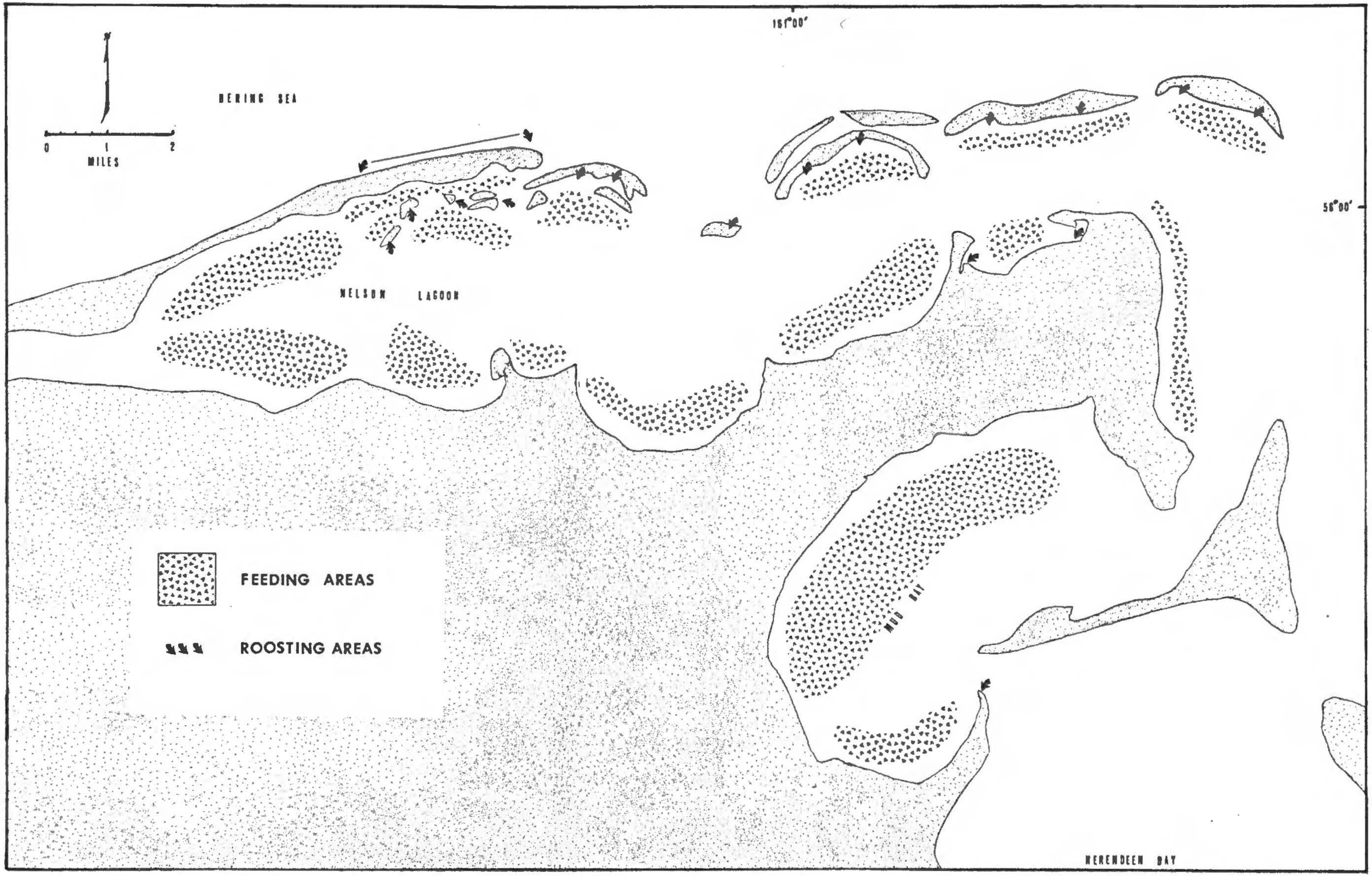


FIGURE 11. Feeding and roosting areas of Dunlin, Western and Rock Sandpipers, Bar-tailed Godwit, Whimbrel and Short- and Long-billed Dowitchers (June - October).

FIG. 12. MINIMUM CLUTCH SIZES OF COMMON EIDERS.

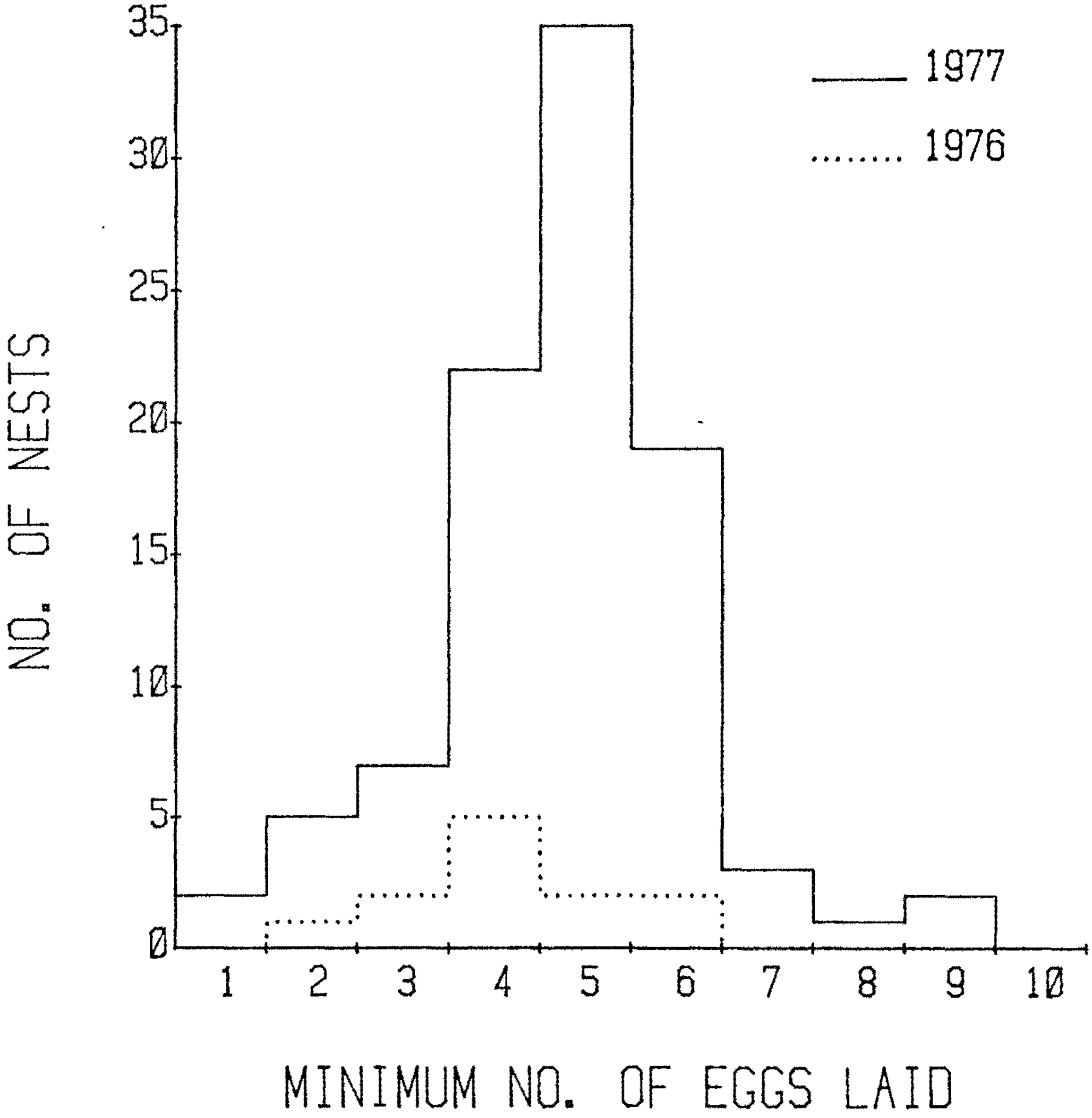


FIG. 13. NUMBER OF EGGS HATCHED PER NEST OF COMMON EIDERS.

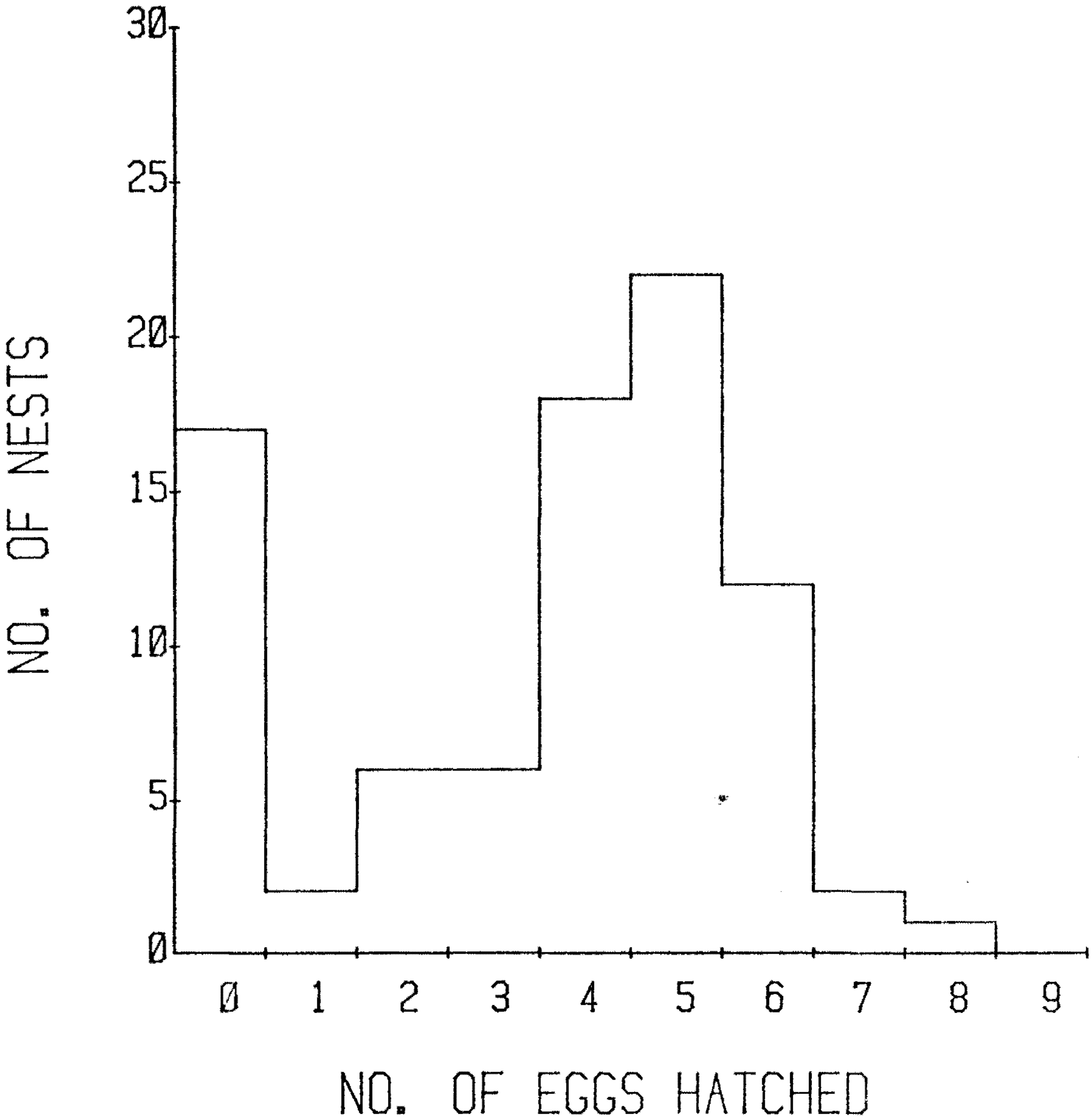
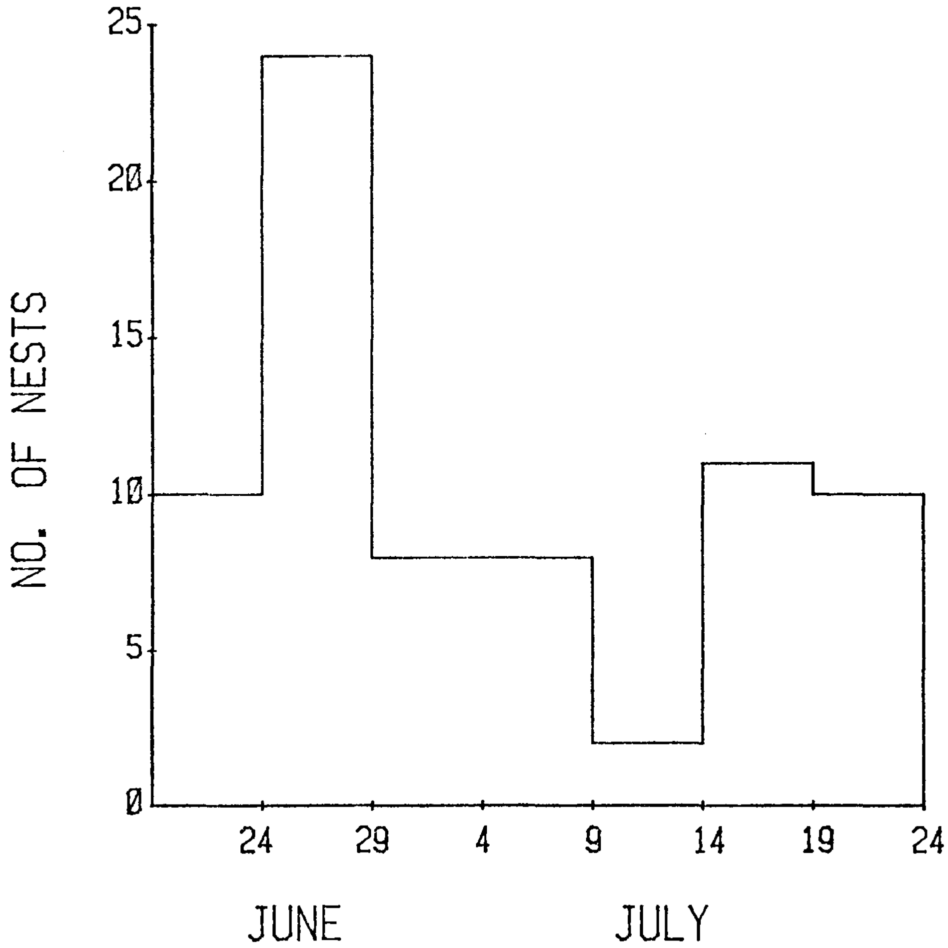


FIG. 14. HATCHING DATES OF COMMON EIDERS.



APPENDIX A

AUTUMN MIGRATION OF DUNLIN AND WESTERN SANDPIPERS FROM THE ALASKA PENINSULA

Abstract

Nelson Lagoon, along the north central Alaska Peninsula, is an important molting and staging area for autumnal migrant shorebirds (see 1976 PSG Shorebird Symposium). During 1977, approximately 1000 each Dunlin and Western Sandpipers were color banded and dyed using rocket-netting at high tide roosts as a capture technique. From these preliminary data collected at time of capture and from subsequent resightings we have developed 1) age and sex composition of birds using Nelson Lagoon, 2) turnover times of birds within the Lagoon, 3) patterns of intra-lagoon movements between roosting and foraging areas, and 4) dispersal and migration strategies of Dunlin and Western Sandpipers from the area.

Western Sandpipers use the Lagoon for approximately 30 days, build moderate fat reserves and depart in early August, following the Alaska and British Columbia coastline. Dunlin, however, use the Lagoon for approximately 110 days, go through a complete molt, build heavy fat reserves and depart in early October on, we believe, a trans-Pacific migration to Oregon and California; this being induced and aided by large anti-cyclonic low pressure systems originating in the Bering Sea each year at this time.

INTRODUCTION

In 1976 we studied the occurrence and abundance of shorebirds along the northcentral Alaska Peninsula at Nelson Lagoon. I reported our preliminary findings during the Shorebird Symposium at last year's PSG meeting.

We returned to Nelson Lagoon in April 1977 to elucidate several aspects of the ecology and population dynamics of migrant shorebirds using the Lagoon and other similar estuaries along the Alaska Peninsula. Specifically, we were interested in 1) age and sex ratios of major migrant species and the occurrence of each 2) turnover times of birds using the Lagoon 3) patterns of intra-lagoon movements between roosting and foraging areas and how these related to periods of molt and pre-migratory fat deposition, and 4) dispersal and migration strategies of birds staging on Nelson Lagoon.

During 1977 we concentrated our efforts on Dunlin and Western Sandpipers. The following data, collected between April and October, were derived from both aerial and ground censuses and from capturing and marking approximately 1200 each Dunlin and Western Sandpipers. Culmen length and plumage differences were used to sex and age both species. Birds were color-marked with picric acid and color-banded with a split red/blue plastic leg band. The color scheme and placement of the bands on the legs "knee" was changed approximately every two weeks.

RESULTS

In looking at the data we see that both Dunlin and Western Sandpipers exhibited similar occurrence patterns between 1976 and 1977 (Figure 1). The greater numbers recorded in 1977 are accounted for by our including an additional census area not used in 1976.

The natal origin of these two species populations is still questioned. Since both species breed on the Alaska Peninsula, the Dunlin more commonly so, portions of the two populations are undoubtedly local. However, recent band recovery data suggests that an unknown segment of the Western Sandpiper population is coming from breeding grounds in north Bristol Bay and possibly the Kuskokwim coast. We suspect most Dunlin are breeding on the Alaska Peninsula. As an aside, band recovery data from birds banded at Nelson Lagoon and of birds banded elsewhere but recovered at Nelson Lagoon indicate that San Francisco Bay is the wintering area for most of the Dunlin staging on Nelson Lagoon each fall.

In looking at occurrence of Western Sandpipers we find that adult males and females arrive simultaneously following breeding, however, females greatly outnumber males (Figure 2). This changes dramatically in mid-July when males become more abundant. This change in sex composition of AHY birds coincides with the arrival of the first HY birds. Adult female Westerns depart by 1 August. Most adult males also depart by early August, however, small numbers remain through the month. Birds of the year showed no significant difference in occurrence or composition between sexes (t - test, $p > 0.1$). Numbers of young birds increased steadily until departure in early September.

Adult male and female Dunlin exhibited no significant difference in occurrence and composition between sexes; however, after 1 July males predominated in all of our catches (t - test, $p > 0.1$) (Figure 3). Birds of the year first appeared in mid-August with numbers remaining relatively constant through departure in early October.

This obvious difference in use of the Lagoon by the two species prompted us to look for associated differences in their dispersal and migration patterns. We, here, present the following hypothesis regarding migration strategies of the two species: Western Sandpipers staging on Nelson Lagoon migrate to their winter quarters via the Gulf of Alaska and British Columbia coastlines. Dunlin, however, depart on an overwater migration initiated and aided by a large anti-cyclonic weather system originating in the Bering Sea each fall. We believe the following data support this hypothesis.

Sightings of banded and color-marked birds are presented in Figure 4. To date, we have received 30 "Bird-days" of sightings: 20 from Western Sandpipers and 10 from Dunlin. Of note are the two Western sightings from the Prince William Sound area and the comparatively large number of sightings from the Vancouver-northwest Washington area. Western sightings began on 4 August at Hinchinbrook Island, Prince William Sound and followed on succeeding days on a north to south gradient. Our last sighting was at Imperial Beach, San Diego County on 9 September. Since adult Western Sandpipers go through post-nuptial molt soon after arriving on their wintering grounds we expect few, if any, additional sightings of color-dyed birds.

The pattern of color-marked Dunlin was quite different from that of Western Sandpipers. Sightings of what appear to be 7 different birds occurred between 14 - 26 October: five from the

San Francisco Bay area and one each from northwest California and Oregon. We have received no reports of sightings north of Tillamook, Oregon and there was no sequential pattern in reported sighting dates as with Westerns and as one might expect if birds were migrating along the Gulf of Alaska-British Columbia coastline. Furthermore, we know from census and banding data that the Dunlin seen at Bolinas Lagoon, Marine County, California on 14 October was still at Nelson Lagoon on 9 October and not suspected of leaving the Lagoon until the 10th or 11th of October when 90% of the 60,000 + Dunlin present on the Lagoon departed. A similar mass exodus of Dunlin occurred at Nelson Lagoon between 8 - 12 October 1976. This 24 - 48 hour interval between departure from the Lagoon and arrival on the wintering grounds is important, as will be shown in later discussion.

Further support of our hypothesis lies in the recorded differences in the timing and comparative amounts of pre-migratory fat deposition between the two species. Adult Western Sandpipers began fat deposition in mid-July and continued at an increasing rate until departure in early August (Figure 5). During this period, males and females added 13 and 9 percent of their respective post-breeding body weights. Between arrival and departure at Nelson Lagoon, HY birds increased their post-fledging weights by approximately 8 percent.

Dunlin, on the other hand, did not begin to put on fat until completion of their post-nuptial molt in early September (Figure 6). Beginning the last week of September fat deposition increased rapidly in both HY and AHY birds. Compared to Western Sandpipers during this immediate pre-migratory period, both male and female adult Dunlin increased their respective post-breeding weights by an average 35 percent. HY Dunlin averaged a 23 percent increase over their immediate post-fledging weights.

If Dunlin do partake of a long, overwater migration as we propose , they would require considerable energy reserves. Using flight range formulas developed by McNeil and Cadieux, (1972 a, b) and Raveling and LeFebvre (1967) and incorporating regression equations developed by Stan Senner, U. of Alaska, to derive fat free weights given wing length and live weight, we were able to calculate theoretical flight ranges for both species immediately prior to their respective fall departures.

Figure 7 presents the flight range frequencies for a sample of AHY and HY Dunlin captured on 9 October. The histogram represents the combined ranges of male and female birds since we found no significant difference between the flight range capabilities of the two sexes. The mean range for adult birds, flying at 50 mph and unaided by winds, was 2300 statute miles. The great circle, or shortest distance between Nelson Lagoon and San Francisco Bay is approximately 2000 miles. Given this, approximately 70% of Lagoon Dunlin population could be expected to reach their wintering grounds via an overwater route without aid of winds. However, only 40% of the HY birds could make such a journey at that time. If Dunlin were using a coastal route only 25% of the adult population could complete the 2800 mile trip without having to stop to replenish fat reserves. Such a layover would require an additional 24 - 48 hours in their travel time between Nelson Lagoon and northcentral California.

The flight range of adult Western Sandpipers was considerably shorter than that of Dunlin (Figure 8). With a flight speed of 50 mph and no favorable winds, adult Westerns had a mean range of 1100 miles. Less than 5% of the population was capable of flying farther than 2000 miles at time of departure in early August. Young Westerns had a mean flight range of approximately 600 miles upon their departure in late August. While neither AHY nor HY birds, therefore, appear capable of an overwater migration similar to that of Dunlin, their energy reserves are quite adequate to take them to Prince William Sound or the Copper River Delta where they could "refuel" for the remainder of their migration. Based on the two sightings from these areas it does, indeed, appear that this is what they do.

The fact that Dunlins are capable of a long, overwater flight is further supported by their, and shorebird's in general, ability to use favorable weather systems during migration. Pressure pattern flying has been well documented for several species of shorebirds migrating each fall from the Gulf of St. Lawrence and Nova Scotia to northern South America. More applicable, however, are the data of Robert Jones of our office who has determined that Black Brant staging on Izembek Lagoon, approximately 100 miles west of Nelson Lagoon, avail themselves of a large, low pressure system on their non-stop migration across the northeast Pacific to their wintering grounds along the west coast of Baja.

From weather data taken at Nelson Lagoon and from subsequent analysis of synoptic weather charts, we know that a series of low pressure systems occur in the Bering Sea and Gulf of Alaska beginning in September each year. Such a system tracking from the southeastern Bering, through the Aleutians and into the northeast Pacific occurred between 10-12 October this year. We feel this particular low was responsible for initiating the sudden departure of the Nelson Lagoon Dunlin population. The weather before, during and after this period is presented in Figure 9. Arrows indicate wind flow and numbers reflect wind speed in mph.

Dunlin departing Nelson Lagoon on this system would have had favorable winds in excess of 35 mph from sea level to above 7,000' for approximately 3/4 of their journey. This coupled with the energy savings associated with flock or formation flying, estimated at $\geq$ 20%, would have allowed 99% of the adult Dunlin population, based on the 9 October sample, to reach its wintering grounds via a transoceanic migration route. Such a flight would require between 24 - 28 hours in the air. However, given these same conditions, still, only 55% of the HY Dunlin could have completed the migration at that time, and only 20% of the Western Sandpiper population could have made such a journey if they departed the Lagoon in August under similar weather conditions.

The comparatively small percentage of HY Dunlin capable of completing an overwater migration at the time the majority of the population departed can probably be accounted for thusly; taking into consideration the obvious higher mortality of HY birds. Although we were unable to sample the approximately 6,000 Dunlin remaining in the Lagoon following the departure of the main population, we suspect a major percentage was HY birds. Since HY birds comprised between 12-17 percent of our captures during September and October, there were, therefore, approximately 9,000 HY birds in the Lagoon during the 28 September census. If 55 percent of these were capable of completing the migration and did leave with the other birds between 11-12 October, then approximately 4,000 of the 6,000 Dunlin remaining in the Lagoon on 13 October were HY birds. At the rate both HY and AHY birds were building fat reserves, those birds remaining would have put on sufficient fat within a matter of days to allow them to depart on migration. We feel it unlikely that HY birds incapable of an overwater migration would use a coastal route and then adapt a different migration strategy in succeeding years. It follows, then, that if these late birds do eventually build sufficient fat reserves for a migration, that they, too engage in pressure pattern flying to carry them on an overwater route. Two such systems occurred over the Alaska Peninsula and Gulf of Alaska between 15-20 October this year, during which the remainder of the Dunlin capable of migrating are suspected of leaving.

Presented by R. E. Gill, USFWS, Anchorage, Alaska at the 1978 PSG meeting, Victoria, B.C. 19-22 January 1978.

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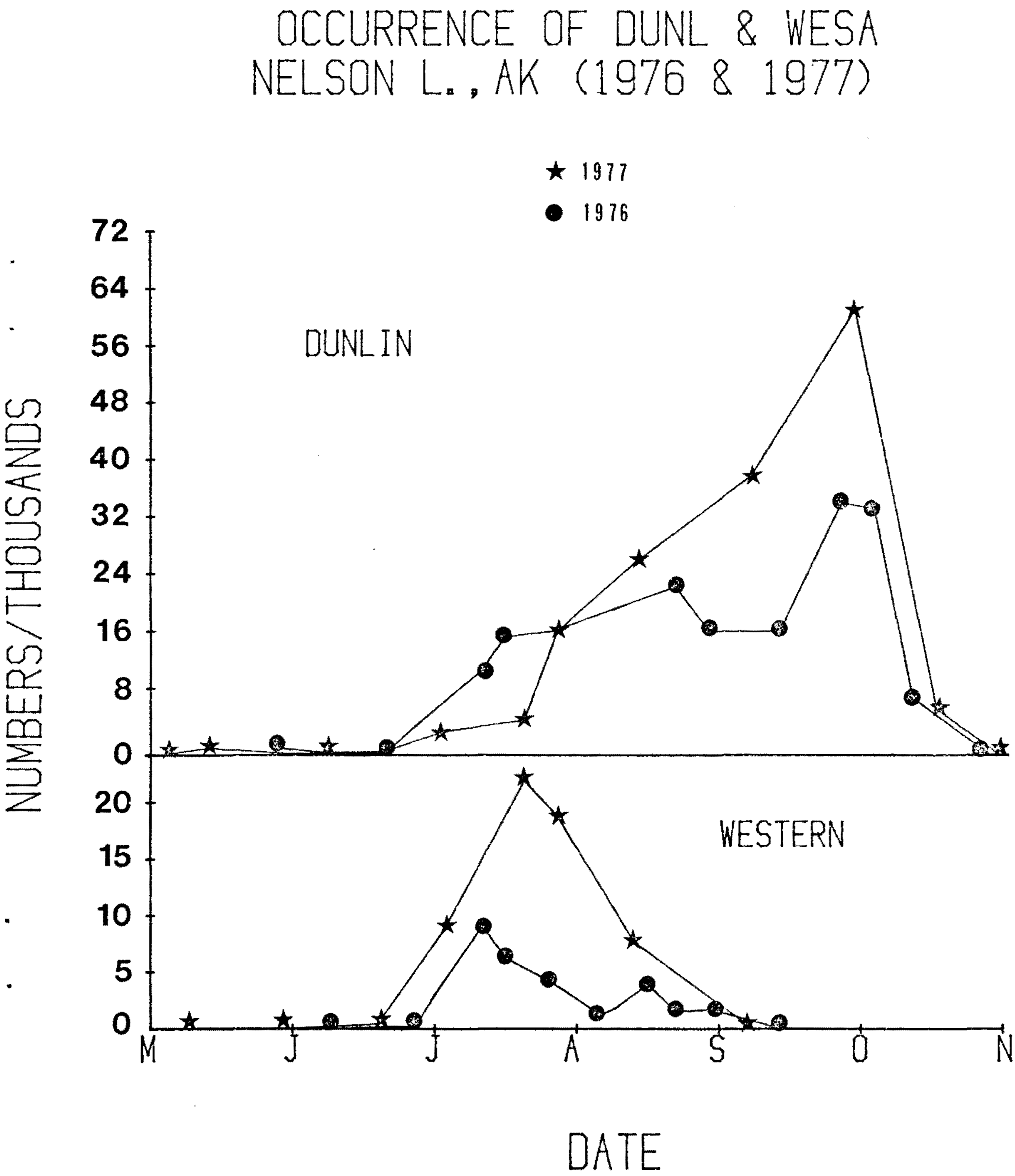
FIGURE 1.


OCCURRENCE OF DUNL & WESA
NELSON L., AK (1976 & 1977)
1977
1976
72
64
56
48
40
32
24
16
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NUMBERS/THOUSANDS
DUNLIN
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FIGURE 2.

SEX RATIO OF WESA CAPTURED
AT NELSON LAGOON, AK-1977

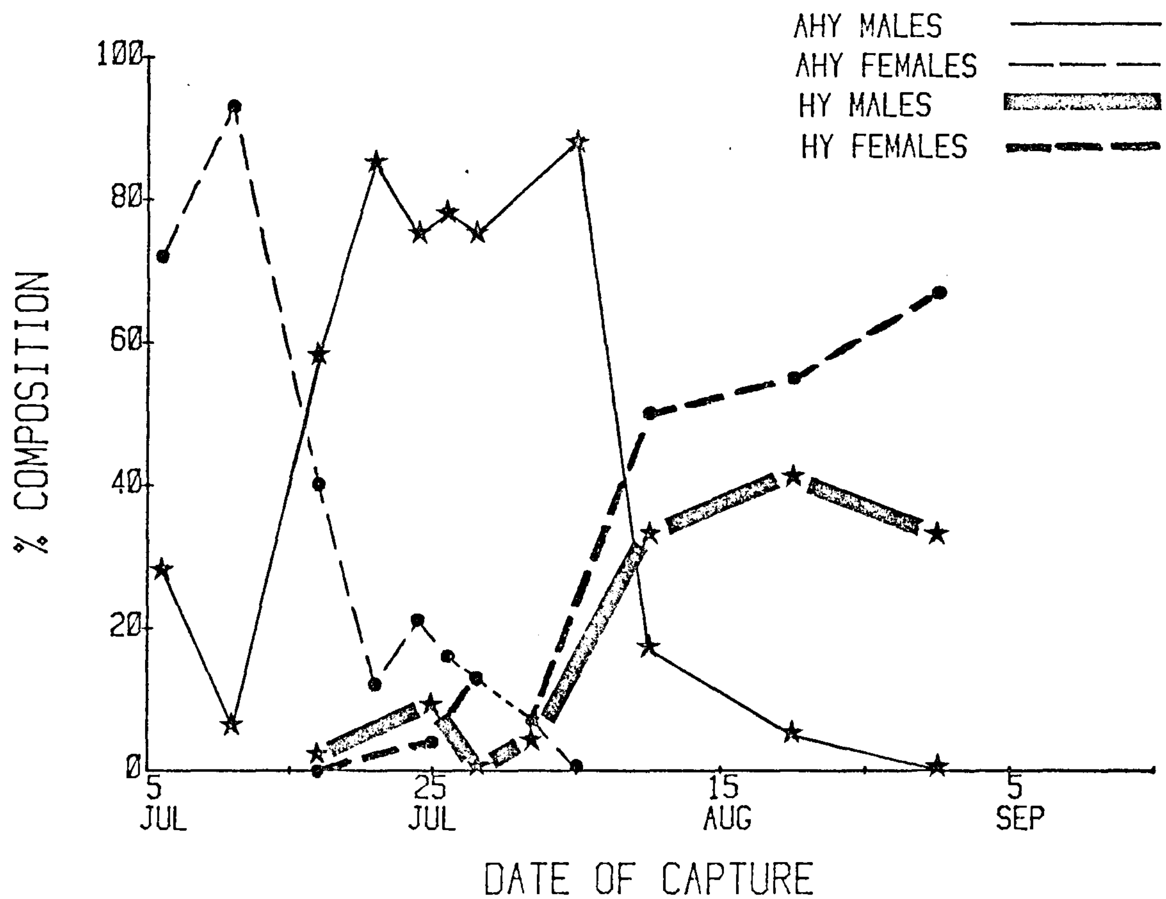
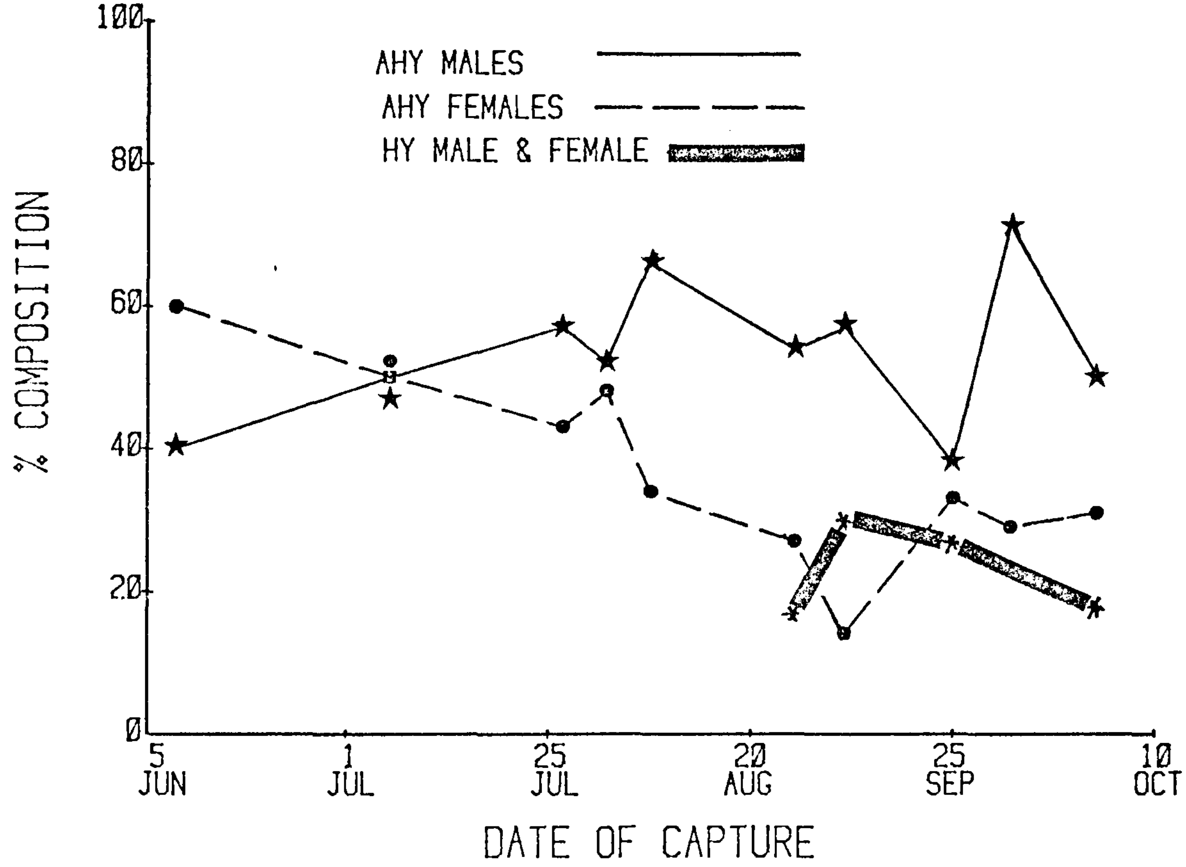


FIGURE 3.

SEX RATIO OF DUNLIN CAPTURED AT NELSON LAGOON, AK-1977



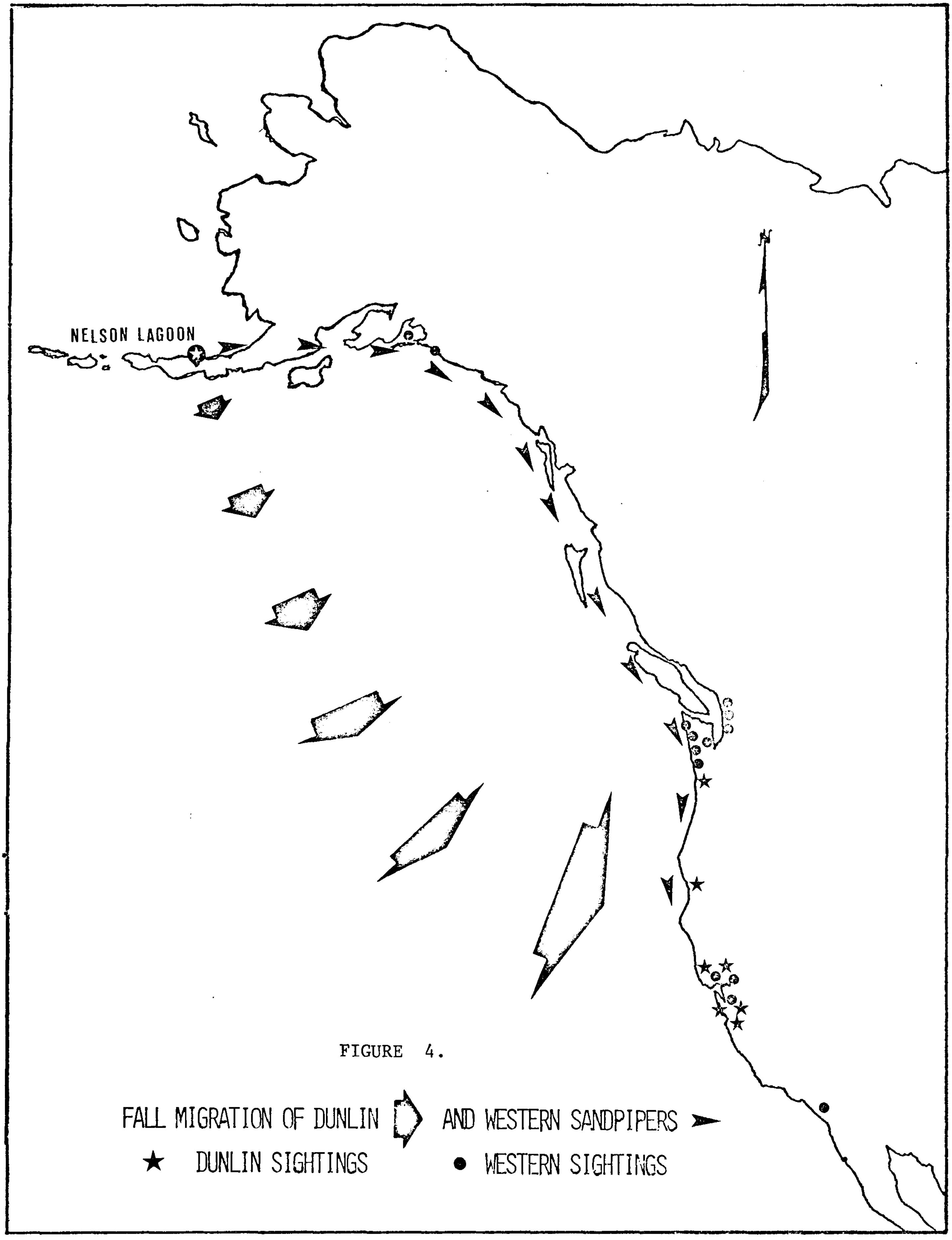
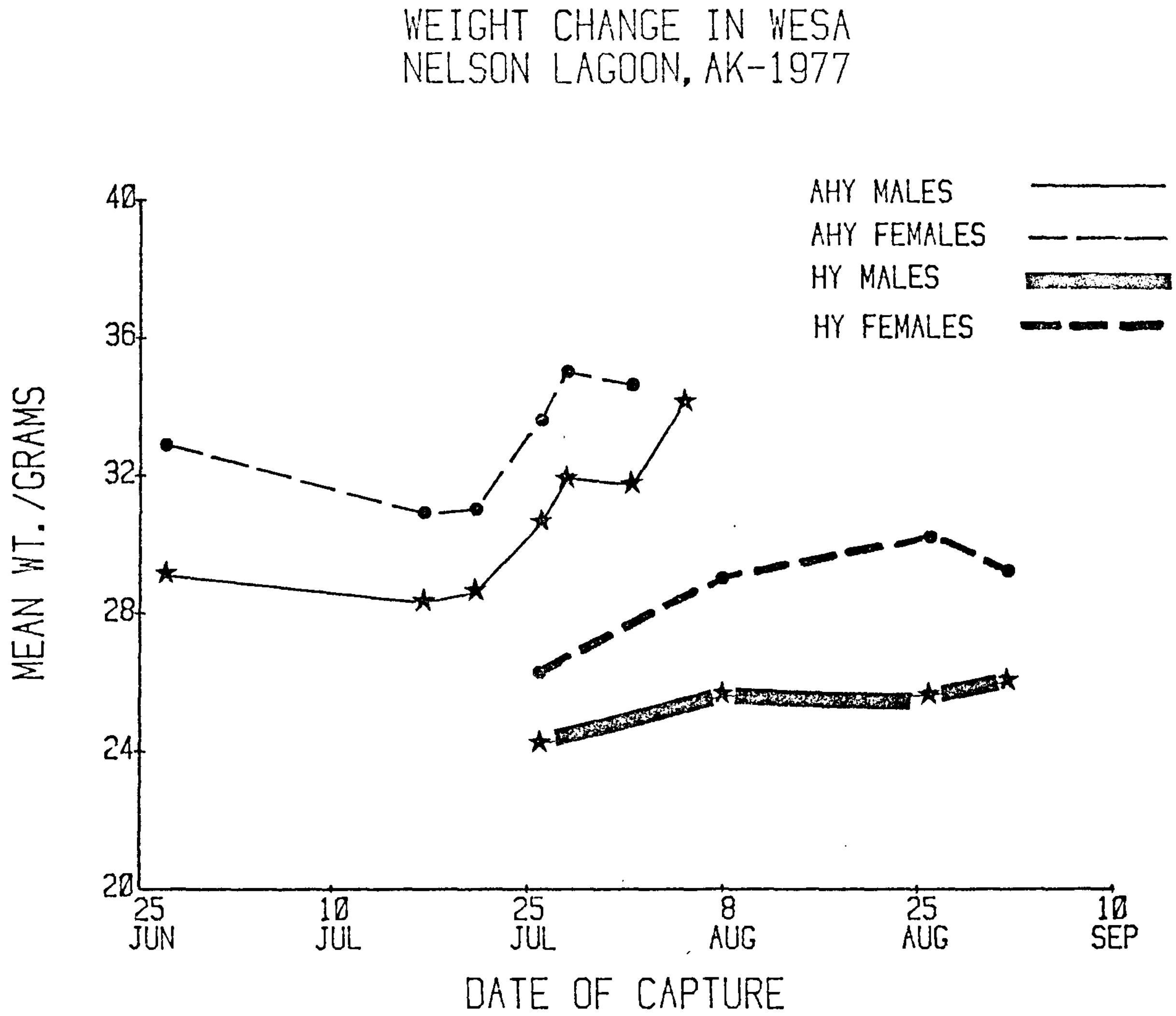


FIGURE 4.

FALL MIGRATION OF DUNLIN AND WESTERN SANDPIPERS

★ DUNLIN SIGHTINGS ● WESTERN SIGHTINGS

FIGURE 5.


WEIGHT CHANGE IN WESA
NELSON LAGOON, AK-1977
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AHY FEMALES
HY MALES
HY FEMALES
MEAN WT. /GRAMS
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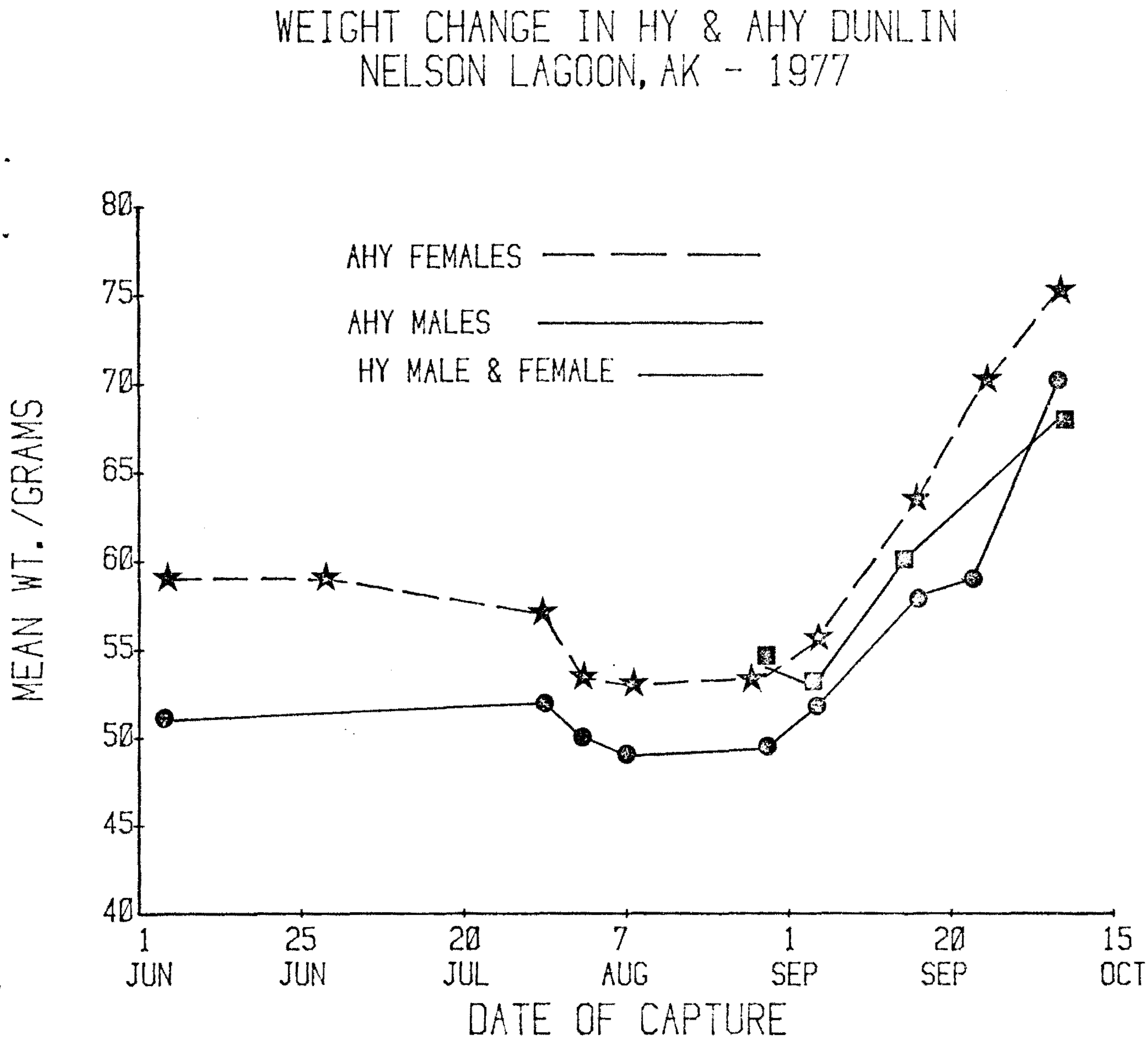
10 JUL
25 JUL
8 AUG
25 AUG
10 SEP
DATE OF CAPTURE

FIGURE 6.



WEIGHT CHANGE IN HY & AHY DUNLIN
NELSON LAGOON, AK - 1977
AHY FEMALES
AHY MALES
HY MALE & FEMALE
MEAN WT. /GRAMS
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1 JUN
25 JUN
20 JUL
7 AUG
1 SEP
20 SEP
15 OCT
DATE OF CAPTURE

FIGURE 7. Flight range of AHY and HY Dunlin, Nelson Lagoon Alaska - 1977.

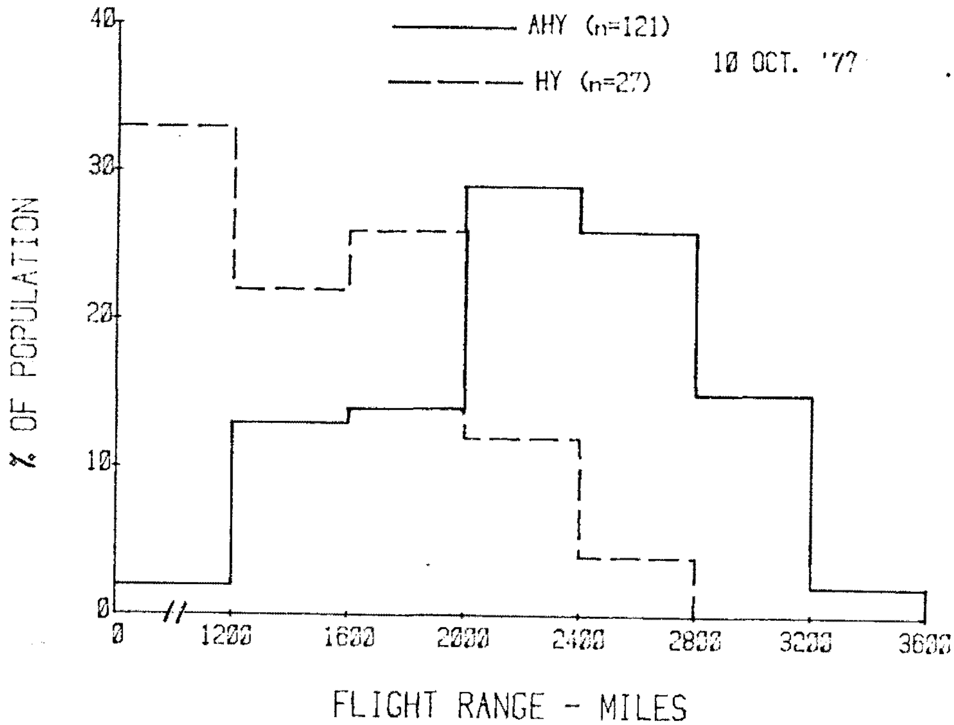


FIGURE 8. Flight range of AHY and HY Western Sandpipers, Nelson Lagoon, AK - 1977.

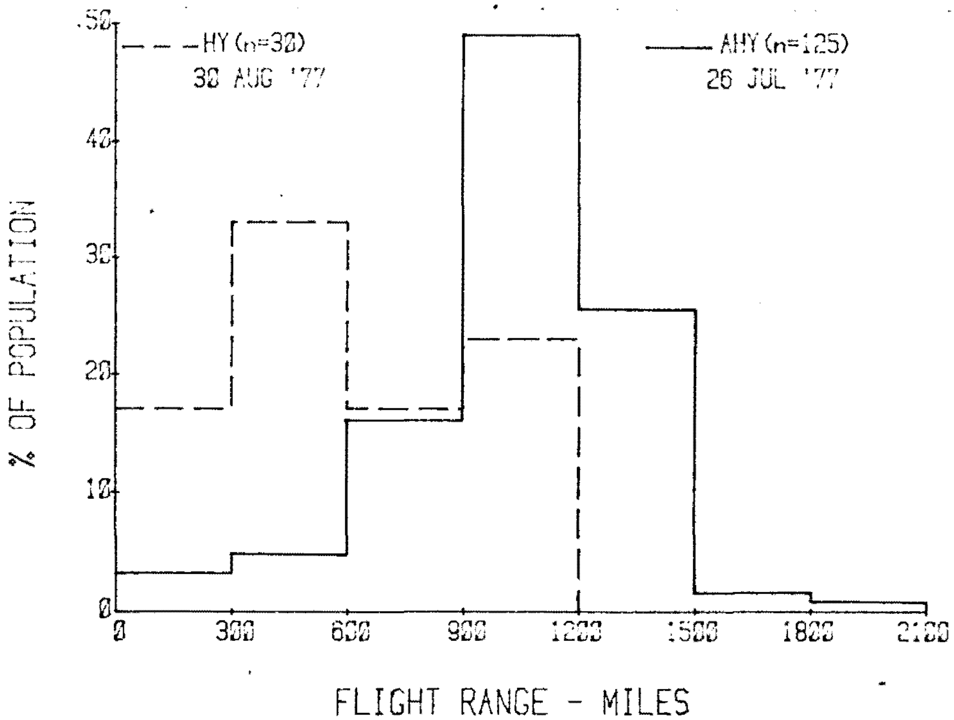
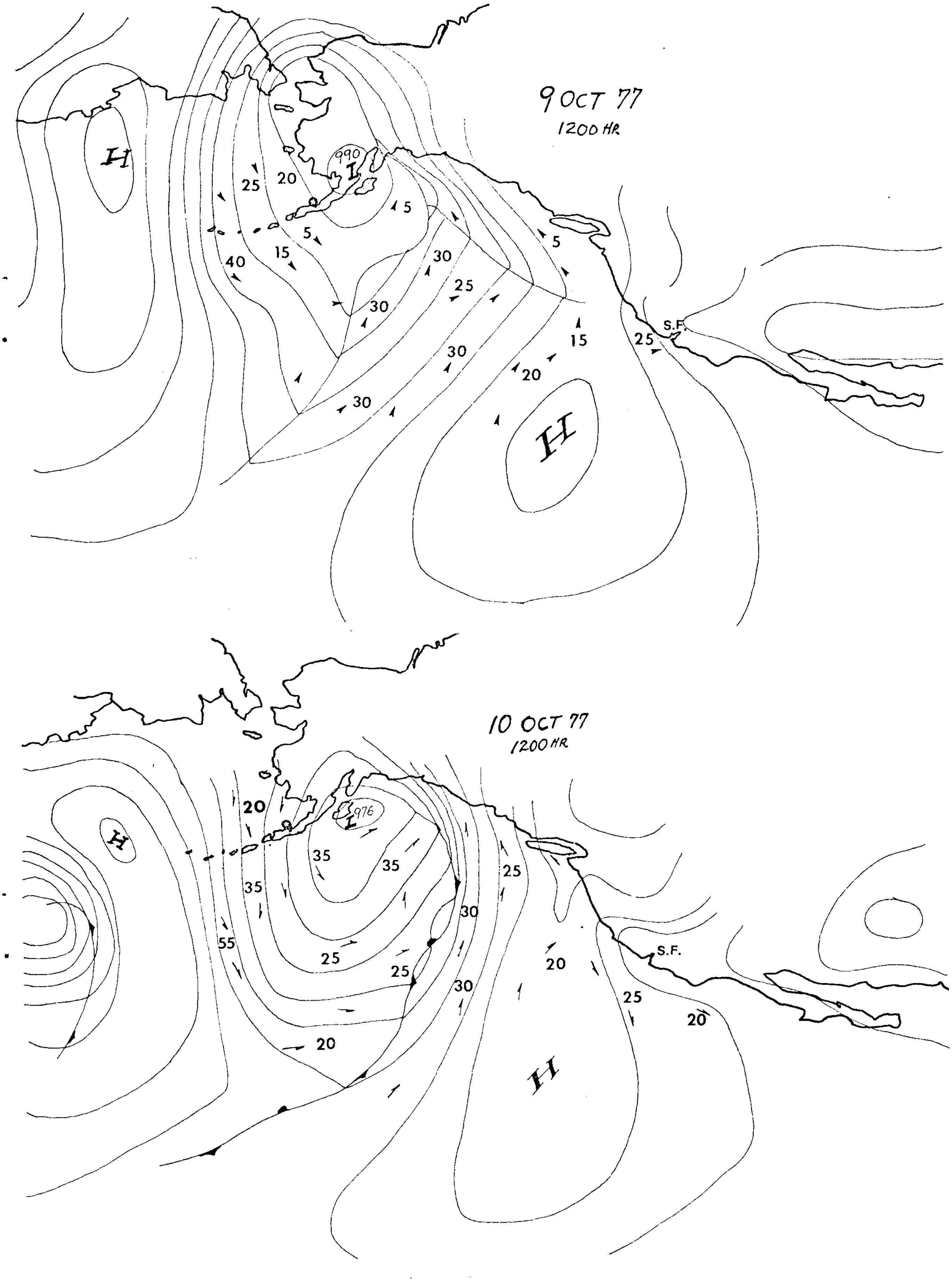


FIGURE 9.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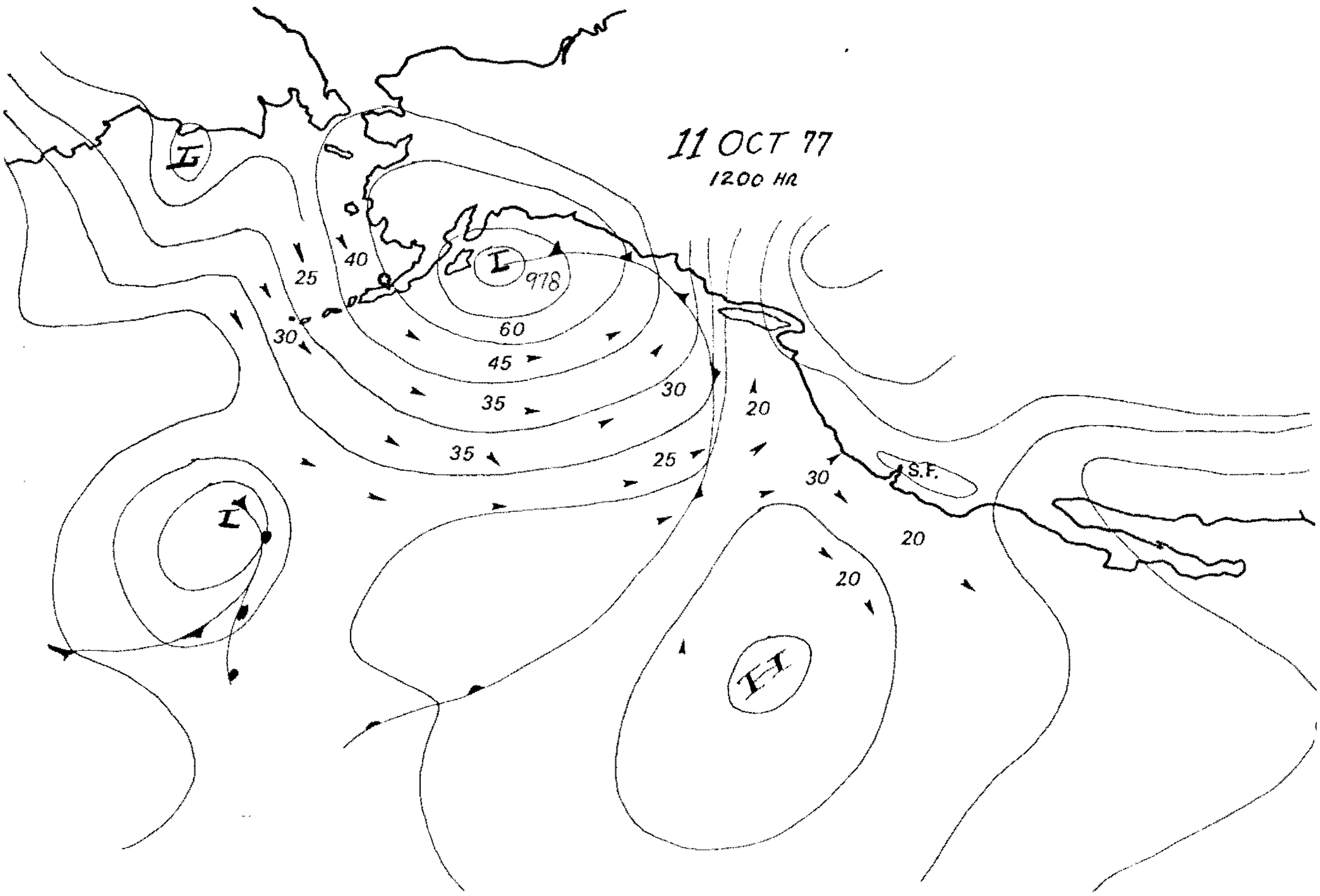
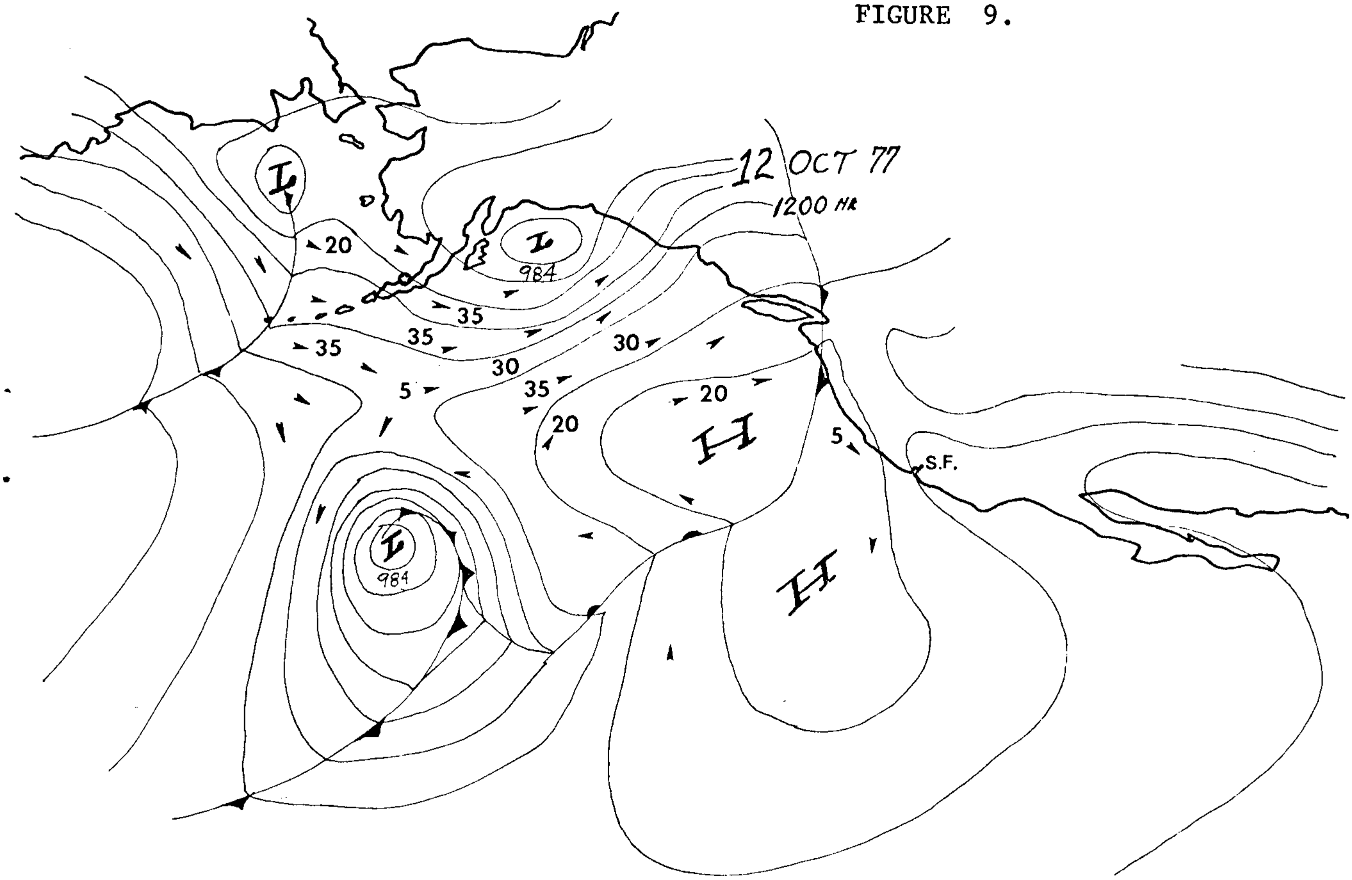


Figure 9. Weather conditions between 9-13 October 1977. We believe Dunlin departed Nelson Lagoon late on the 10th and used favorable winds through the 11th. Beginning early the 12th winds began to shift and by the 13th would have been unfavorable for any westward movement.

FIGURE 9.


12 OCT 77
1200 HR
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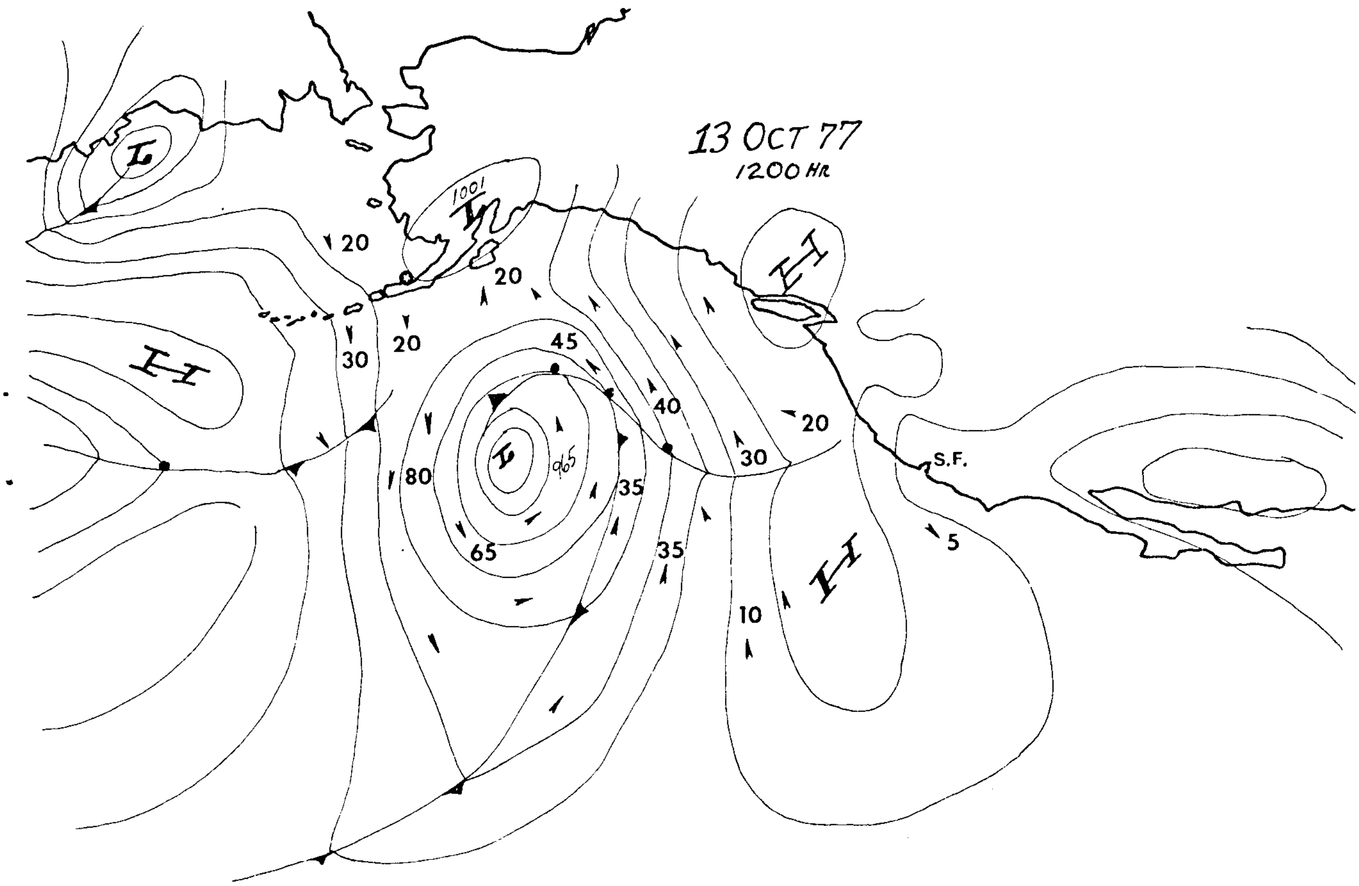
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APPENDIX B

The Feeding Ecology of Steller's Eiders

Abstract

The feeding ecology of Steller's Eiders (Polysticta stelleri) was studied 18 April to 15 October 1977 at Nelson Lagoon, Alaska (56°00'N, 161°10'W). Eiders fed by head dipping and upending in water 10 to 20 cm deep, and by diving in water to 6 m deep. Food items were taken from 40 mm below the substrate surface to immediately above the substrate surface. Feeding was timed with daily tidal fluctuations, with maximum feeding occurring at low tide when food items were most available. The method of feeding was dependent on the depth of the water during feeding.

Eiders fed primarily on Mytilus edulis and Anisogammarus pugettensis, although birds took small amounts of polychaetes, the isopod Saduria entomon the pelecypods Mya sp. and Macoma sp., shrimp, and gastropods. The type of food taken varied throughout the season, with 85.7% of the food in May being Anisogammarus pugettensis, with increasing amounts of Mytilus edulis and Macoma sp. taken until the flightless period in August and September. Eiders fed exclusively on Mytilus edulis or Macome sp. during the flightless period. Possibly, Steller's Eiders select pelecypods when flightless. After the flightless period, birds took all types of invertebrates available, reflecting the generally opportunistic nature of Steller's Eiders.

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Presented at the Pacific Seabird Group Meeting, 19-22 January 1978, Victoria, B.C.

Introduction

The Steller's Eider (Polysticta stelleri) is a common seaduck that breeds along the coasts of Alaska and Siberia, and winters in ice free areas along the Alaskan Peninsula Aleutian Islands, and Commander Islands (Dement'ev and Gladkov 1967, Kistchinski 1973, Bellrose 1976, Johnsgard 1976, Palmer 1976). Little is known about the summer moulting concentrations of subadult and adult eiders. Most studies deal with courtship behavior (Johnsgard 1960, 1962, 1964, McKinney 1965), banding returns (Jones 1964), and foods (Cottam 1939). Nelson Lagoon is one of several lagoons along the Alaskan Peninsula where spring and fall concentrations of Steller's Eiders have been reported of up to 100,000 birds (Jones 1965). Summer concentrations of 10,000's of birds were first reported at Nelson Lagoon by Gill et al (1977); other areas along the Alaskan Peninsula may have large concentrations of eiders in the summer, although adequate surveys have not been conducted.

The primary objective of this study was to determine how Steller's Eiders have adapted to a lagoon environment. Specific objectives were to 1) determine the timing of moult migration to the lagoon, 2) determine the extent of use of the lagoon by each age class and sex, 3) characterize the roosting and feeding areas utilized by the eider, and 4) determine the feeding methods and foods of Steller's Eiders.

Study Area and Methods

The study was initiated 18 April and concluded 15 October 1977, at Nelson Lagoon, Alaska. Nelson Lagoon (Fig. 1) is located on the north central Alaskan Peninsula, about 100 miles east of Cold Bay, and is part of the 540 sq. km. Port Moller-Herendeen Bay - Nelson Lagoon complex. The study was restricted to the 100 sq. km. Nelson Lagoon and adjacent barrier islands where most of the eiders are found. The tidal regime is one of 2 highs and 2 lows during each 24 hour period, with a 3.2 meter mean diurnal range. The water in the lagoon, is shallow with channels running to 10 meters deep at high tide. Substrates at Nelson Lagoon range from rock-sand intertidal to mud-sand flats, which have been previously described by Gill et al (1977).

Counts of birds were conducted at 3 week intervals from an airplane flying over the study area during the third and fifth hour of the ebb tide. Ratios of adult males to subadults were determined by ground counts. Second year males and females, and yearling males and females are lumped as subadults due to problems of seperating age classes of birds at a distance (Palmer 1976, pers. obs.). Similarly, third year males and adult males are lumped as adult males, since they are difficult to separate unless in the hand. No adult females were ever positively identified.

Feeding and roosting birds were censused every 3 days at 2 hour intervals from 0800 hours to sunset (total of 42 days). Periodic observations during the night were made with a star-light scope to determine if the birds were feeding. The age, sex, and activity of each bird was determined during each census. Feeding behavior terminology follows that of Bryant & Leng (1975).

Groups of 3 feeding birds were collected at 3 week intervals. The oesophagus, proventriculus, and gizzard of each bird was immediately injected with 10% buffered formalin after it was collected. The entire stomach was then stored in 50% alcohol for later analysis. Food data are presented as the aggregate percent volume and percent occurance (Swanson, et al 1974) for each type of food.

Results

Moult Migration and Moult - Subadults migrated to Nelson Lagoon in early May, and were present through August. Adult males began migrating to the lagoon in early August, and were present through October (Fig. 2).

Subadults peaked at 53,000 birds in August, and departed by mid-September. Adult males peaked at 54,000 birds by the end of September, and began leaving the lagoon by October. Thus, while Steller's Eiders were present in Nelson Lagoon April through October, the subadult and adult segments of the population used the lagoon during different times of the year.

Subadults moulted their flight feathers beginning 1 August, remained flightless for about 3 weeks, and left the lagoon almost immediately after they regained flight. Adult males moulted their flight feathers almost immediately after their arrival in late August, remained flightless through mid-September, and began departing the lagoon by mid- October. Although there were flightless birds in the lagoon over a 6 week period, there was little or no overlap of the timing of the subadult and adult flightless periods.

Feeding Activity - Eiders fed by diving in water to 6 meters deep, and head-dipping and up-ending in water 10 to 20 cm deep. There was no significant difference in the method as the season progressed. For those reasons, age classes and sexes of birds are lumped for each tide cycle. When feeding, eiders dived 79.5% of the time (102,656 of 129, 105 observations) and head-dipped 20.5% of the time (26,449 of 129,105 observations). Up-ending was rarely observed.

The timing of feeding by eiders was correlated with the stage of the tide; with most feeding centering around the low tide (Fig. 3). Eiders fed during the daylight hours and at night. Birds dived at any stage of the tide, but dived predominantly on a rising tide 2 to 3 hours after the low tide. Birds began head-dipping and up-ending as the tide ebbed, continued through the low tide and 2 hours after the tide flooded. Birds roosted during the high tide; generally 2 hours before the high tide and until 3 hours after high tide.

Favored roost areas of both subadults and adults were barrier islands and the lagoon spit, although sand bars subject to flooding on extreme tides were frequently used. Roost areas were adjacent to feeding areas, and birds fed as they moved off the roost areas. Roosting birds were found at or near channels, and birds were never far from "deep" water.

Foods - Pelecypoda and crusteacea were the primary foods taken by volume and by occurance during the summer (Table 1). The pelecypod *Mytilus edulis* was the primary invertebrate taken throughout the season, followed by grammarid amphipods. Most grammarid amphipods have been identified as *Anisogammarus pugettensis*. The polychaete *Eteone longa* was found in 71% of all stomachs, but only comprised 5% of the volume.

The aggregrate percent volume of pelecypods and amphipods taken by eiders changed as the season progressed (Fig. 4), with the amount of pelecypods (primarily *Mytilus edulis*) increasing until July, and the amount of amphipods decreasing until August. During the flightless period (August through mid-September), eiders took only pelecypods, and did not resume taking amphipods until after the flightless period. The average length of *Mytilus edulis* taken by eiders increased significantly until August ($F= 50.669$, $P= 0.000$) when average lengths of *Mytilus* remained around 9 mm. (Fig 5). Probably, the increasing lengths of *Mytilus* taken by eiders reflects the early summer growth of *Mytilus*. There was no consistant change in the average lengths of *Mytilus* from August to October, reflecting the largest average size of *Mytilus* Steller's Eiders take. Larger *Mytilus* were available and were taken throughout the study by Pacific Eiders (*Somateria mollissima v-nigra*), a much larger eider.

Discussion

Moult - Subadult and adult Steller's Eiders exhibit a typical moult migration pattern of migrating to a special area prior to the moult, and aggregrating in huge flocks during the flightless period as described by Salomonsen (1968). As with other eiders, Steller's Eiders are temporally segregated during the flightless period (Bellrose 1976, Johnsgard 1976, Palmer 1976). Unlike what is assumed with other eiders, subadult male and subadult female Steller's Eiders are flightless prior to the adult males, and the timing of the flightless periods do not overlap.

Possible, such segregation reduces competition for food resources, but it was not determined whether or not there were sufficient food resources at Nelson Lagoon to support both groups of flightless birds at one time. Adult males are with the breeding females until the eggs hatch, and, as suggested by Jones (1965), their timing of arrival to the moulting areas may in part reflect the timing of the breeding season, and the nesting success of breeding birds. Subadult eiders do not migrate to the breeding grounds, and their timing of migration to the moulting areas and subsequent flight feather moult may be relatively constant from year to year, and would not be influenced by the presence or absence of adult males.

Roost areas of eiders at Nelson Lagoon are normally open gravel or sand beaches and adjacent to channels, and are near feeding areas. Channels are frequently used as escape areas from avian and mammalian preadators, as well as by flightless eiders while swimming to feeding areas. Roost areas must be near feeding areas when the birds are in the primary moult, since the birds cannot fly to distant feeding areas. Possibly, the combination of open beaches, accessible escape areas, and abundant food resources are requirements of summer moulting areas for eiders.

Feeding Behavior - During the summer, Steller's Eiders take invertebrates that are abundant in the benthic and epibenthic regions of Nelson Lagoon, from 40mm below the substrate surface to immediatley above the substrate surface. Invertebrates are only available to head-dipping birds at low tide, and food organisms must be aquired by diving once the water has risen above the neck length of an eider. Birds feed when the water is shallowest during the 12 hour tide cycle; feeding when the least amount of energy need be expended to get food.

Foods - Eiders take primarily Amphipods in the early summer, pelecypods (*Mytilus edulis*) during the flightless period, and all types of available invertebrates in the late summer. Such a pattern is in part due to selection by the eiders for a particular type of food, and in part due to a variation of availability of each type of food,. Early in the summer, amphipods are the predominant food available, as *Mytilus edulis* are extremely small and unavailable in large quantities. After the *Mytilus* have grown larger, eiders take them in increasing amounts. During the flightless period, eiders apparently select *Mytilus edulis* or *Macoma* sp. as amphipods were present in the lagoon and were never found in the stomachs of flightless eiders. It should not be concluded that Steller's Eiders require pelecypods for flight feather growth, simply because that is what they take. Simmarily, whether or not eiders initiate flight feather moult in response to available necessary food is left to conjecture. After the growth of the flight feathers is completed, eiders seem to take whatever invertebrates they find, as there were wide fluctuations of the aggregrate percent of each type of invertebrates within samples of feeding birds.

Conclusions

Possibly the entire subadult segment of Steller's Eiders was in Nelson Lagoon in the summer of 1977, but to state that the observations of 1977 were "typical" of the eider, and that Nelson Lagoon is a typical feeding area could be erroneous. However, Nelson Lagoon is an important feeding area for subadult eiders during the summer, and an important moulting area for subadult and adult eiders. At Nelson Lagoon, eiders fed by diving, head-dipping, and up-ending, and feeding areas of Steller's Eiders can be characterized by 1) abundant invertebrates that are regularly available twice daily at low tide, 2) the areas used for feeding by flightless birds are within swimming distance of roost areas, and 3) the pelecypods Mytilus edulis and Macome sp. are available when eiders are moulting their flight feathers.

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Table 1.

Foods of Steller's Eiders at Nelson Lagoon -

May to October 1977

Species	Agg. %	% Occ.
Pelecypoda	50.4	96.4
Mytilus edulis	46.2	89.3
Mya sp.	trace	25.0
Macoma sp.	2.5	3.6
Clinocardium nuttallii	trace	3.6
Crustacea	41.9	78.6
Saduria entomon	trace	14.3
Crangon septemspinosa	trace	7.1
Gammarid Amphipod	40.8	75.0
Barnacle	trace	3.6
Polychaete	7.3	75.0
Eteone longa	5.0	71.4
Pectinaria sp.	2.3	17.9

N = 28 AHY birds

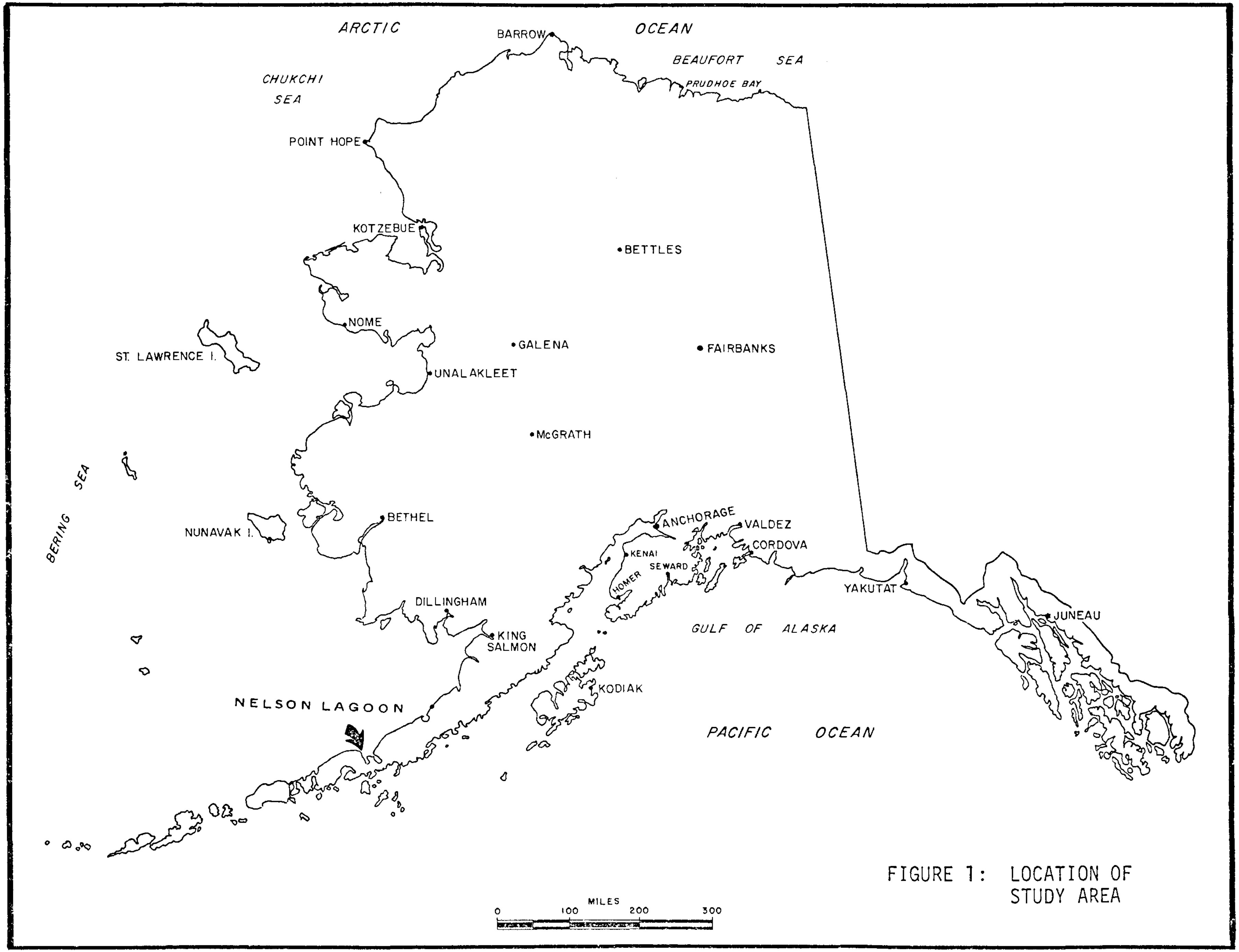


FIGURE 1: LOCATION OF STUDY AREA

Fig. 2. Numbers of subadult and adult Steller's Eiders at Nelson Lagoon.

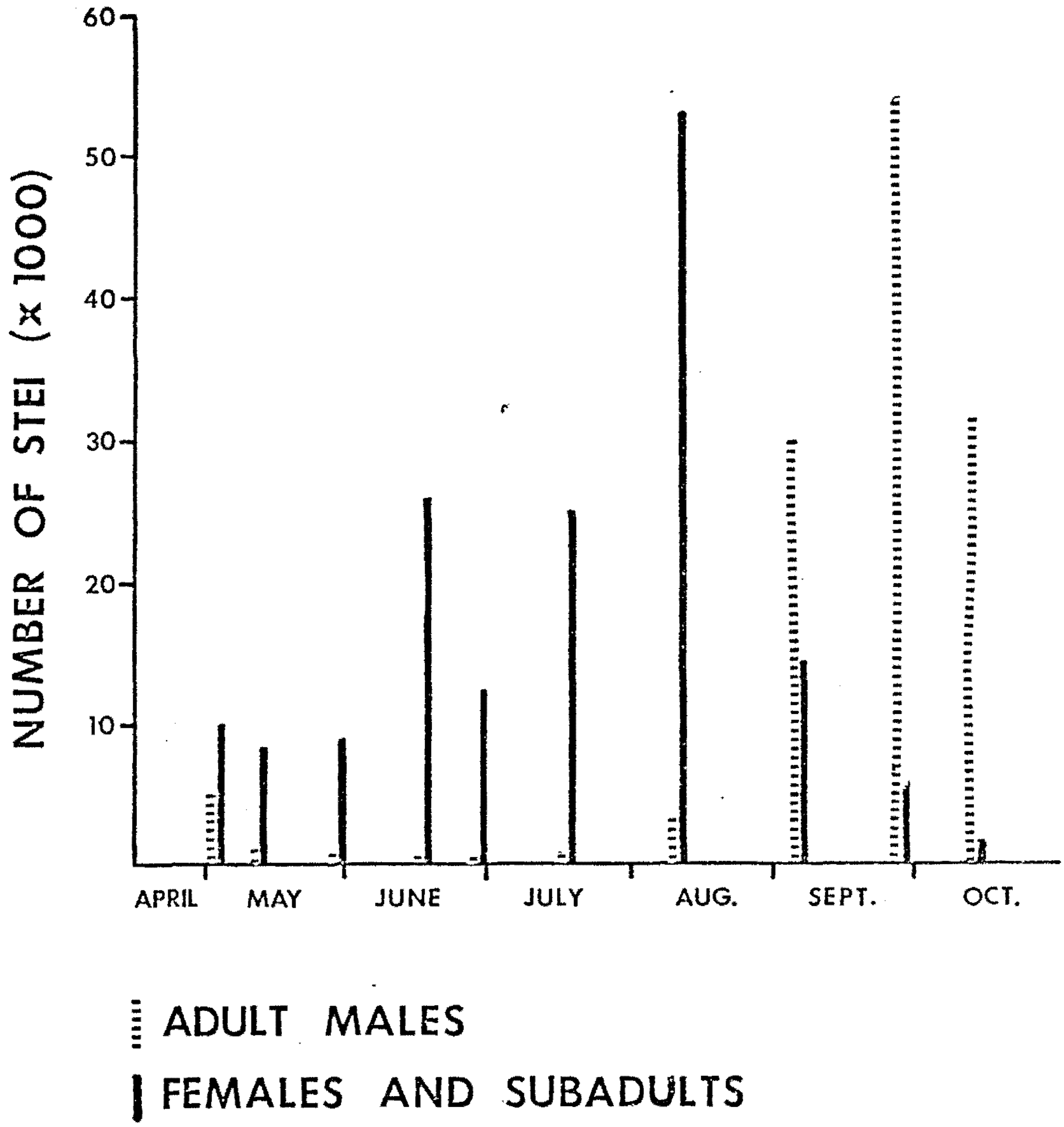


FIG. 3. ACTIVITY OF STELLER'S EIDERS AS RELATED TO TIDE STAGE

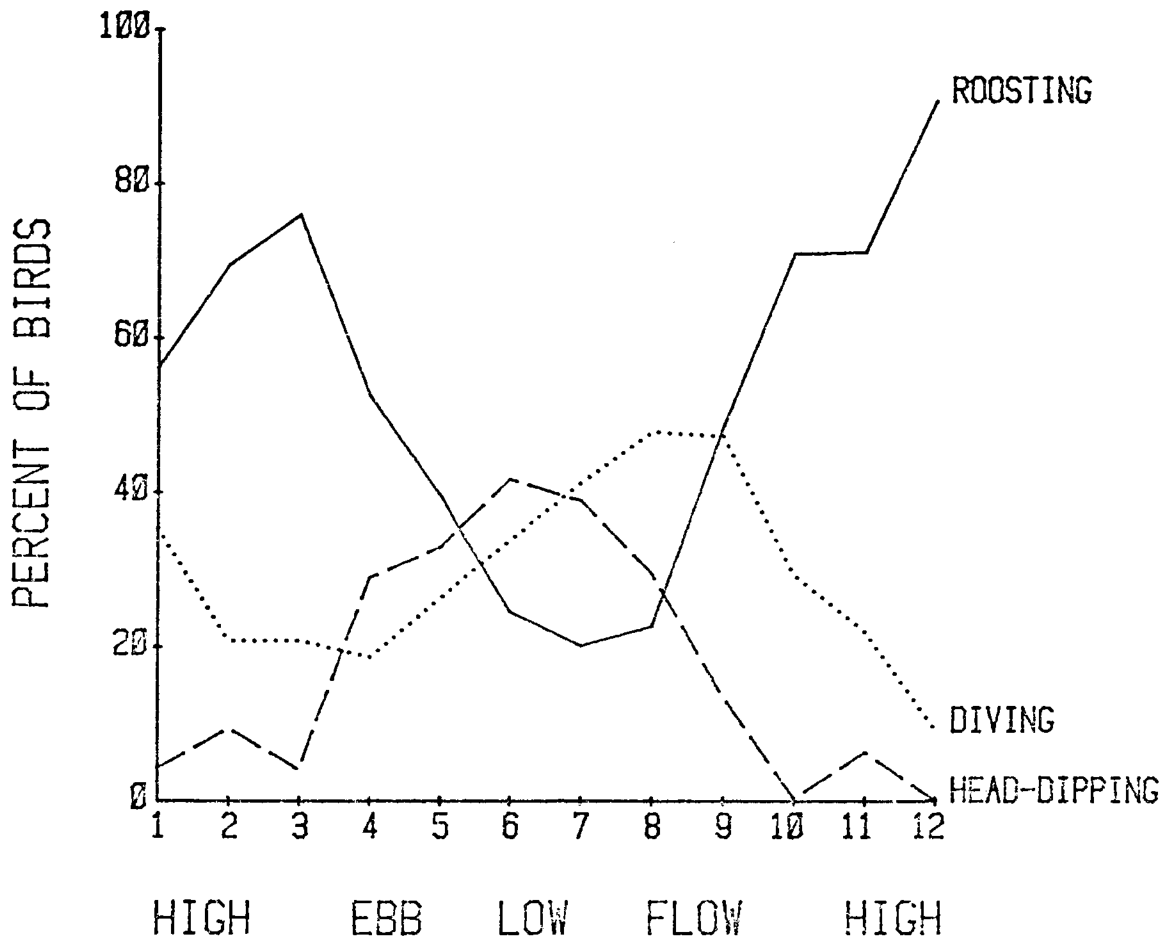
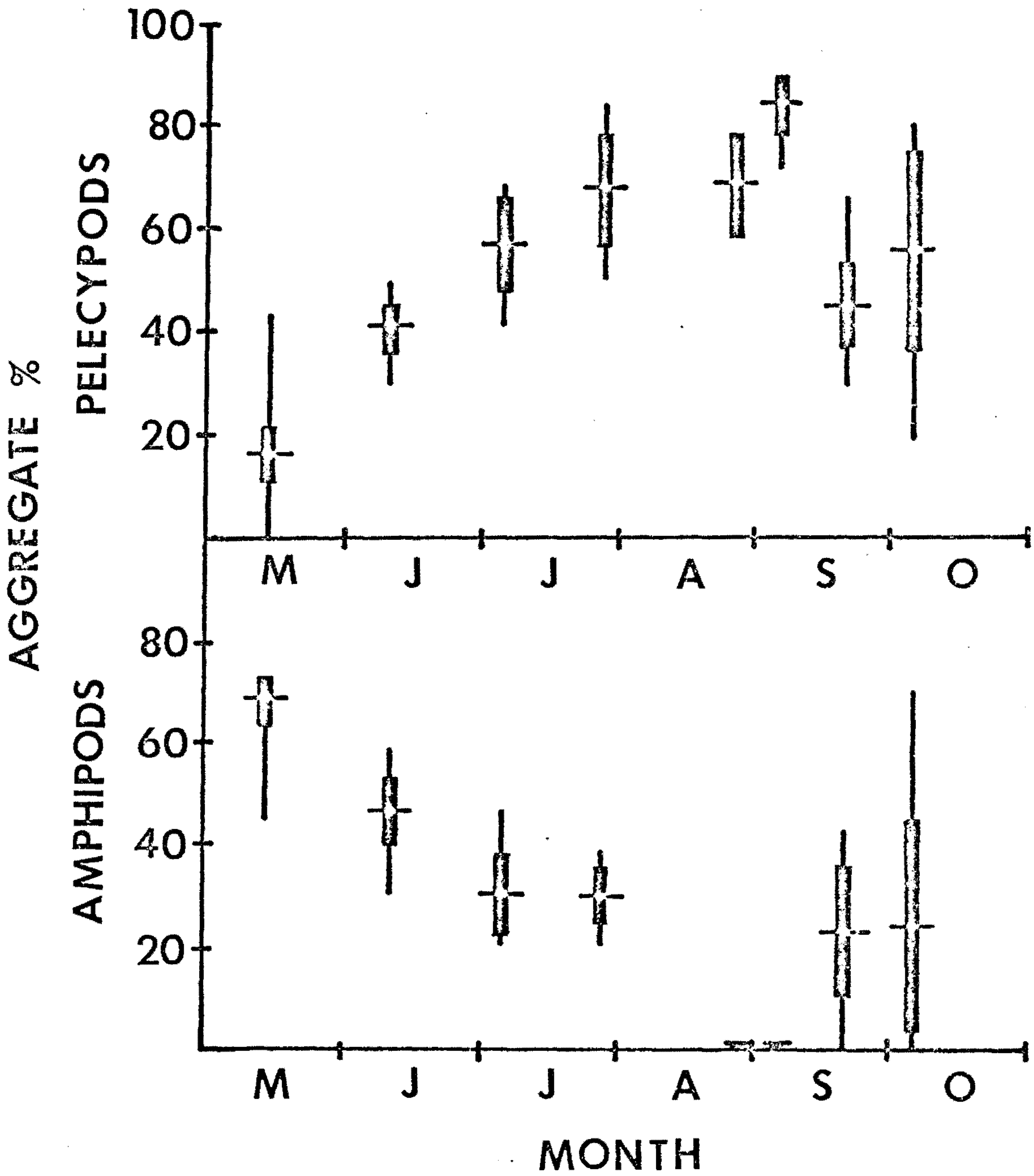
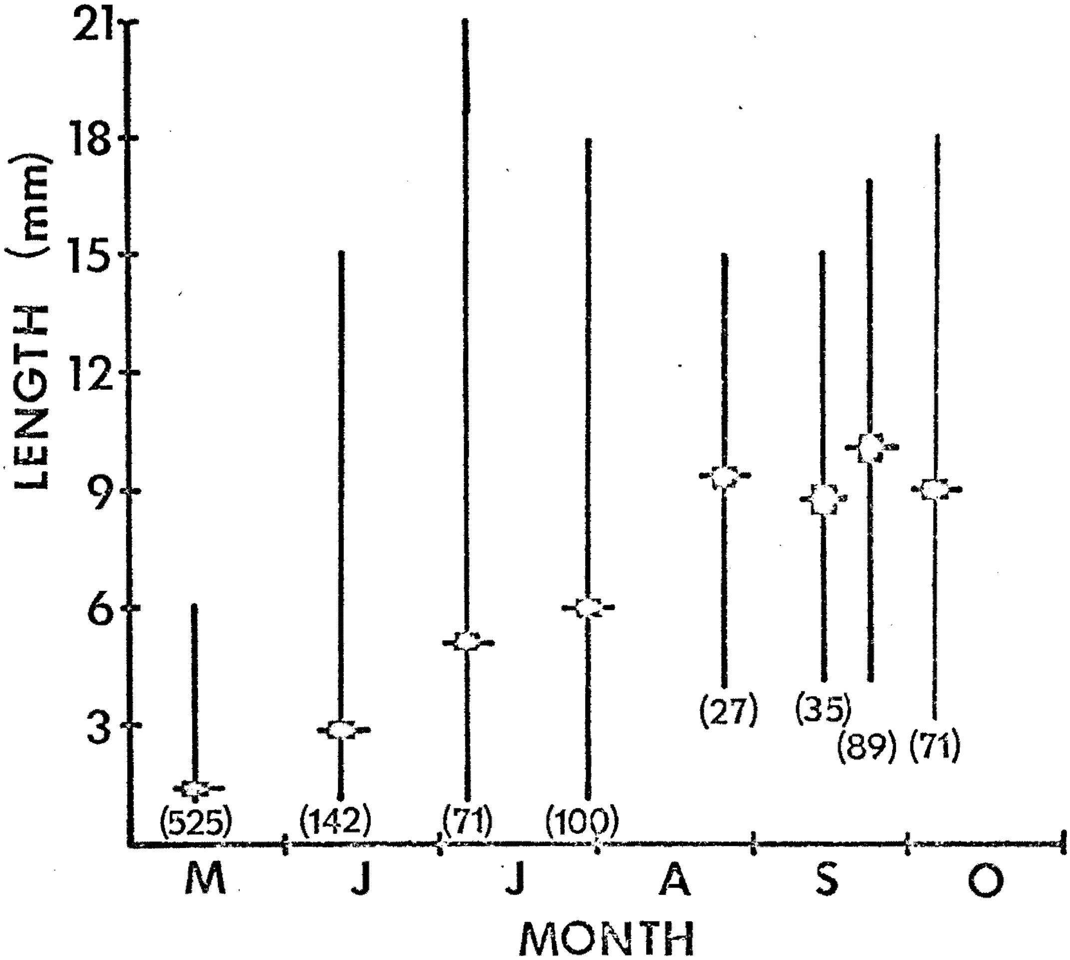


Fig. 4. Changes in foods of Steller's Eiders throughout the summer.



(range, ±2 S. E., mean)

Fig. 5. Average lengths of *Mytilus edulis* taken by Steller's Eiders.



(range, ±2 S. E., mean, no. of *Mytilus edulis* measured)

APPENDIX C

Unusual Nest Site Selection By Tufted Puffins

Despite the Tufted Puffin having the greatest breeding distribution of any North Pacific seabird, its nesting habitat preferences over this area are generally quite restricted. Nesting is confined to rocky oceanic islands or continental headlands where nests are placed in burrows or rocky crevices or occasionally on vegatated plateaus; all well above tidal influence. Nowhere did we find reference to Tufted Puffins nesting in an estuarine environment or substrate subject to tidal inundation.

We, here describe an instance of Tufted Puffins nesting in an estuary on substrate occasionally flooded by tides. Nesting chronology, nest site selection and nesting adaptation to this unique situation will be discussed.

During the summers of 1976-1977 we found Tufted Puffins nesting on four, narrow sand islands along the northcentral Alaska Peninsula at Nelson Lagoon (56°N, 161° 10'W). The islands lie approximately 1.3km inland from the Bering Sea and are protected from the sea by a long (5km), narrow sandspit. All islands have a uniformly low, flat profile averaging 1.5m above MHHW (mean higher-high water). The island banks have a moderate to near vertical slope. Each island is circumscribed by a gently sloping, narrow, sand/gravel beach, averaging less than 6 degree slope, which extends to broad intertidal mudflats. Beach rye grows over most of each island and is used as nesting cover by approximately 2000 pairs of Glaucous-winged Gulls and 200 pairs of Common Eiders. No foxes were evident on any of the islands used for nesting by Tufted Puffins.

The entire Lagoon breeding population of Tufted Puffins consists of between 14 - 18 pairs; hardly a major breeding colony. The 1977 nesting chronology is presented in (Figure 1). The first adult was observed on 8 May; the majority of adults arrived between 15 - 30 May. During this latter period "inspection flights" over the islands were common. Observed courtship behavior included bill clasping, both on the water and in front of burrows, and what I have labled as "false takeoffs" where one adult runs along the beach or on the water with its head lowered and copulation.

For fear of inducing abandonment, we did not check burrows for eggs until mid-July when we felt incubation was well along. At that time we found week old chicks in two burrows and warm eggs in three others. Those burrows with nesting cavities beyond our reach were not excavated to determine their status.

We banded and followed the growth of 7 chicks during 1977 (Figure 2). All chicks exhibited a rather uniform growth rate, averaging 19 grams per day. Fledging, for the 6 chicks which we assumed were successful, occurred at between 38 - 41 days and at an average weight of 585 grams. Fledging weights ranged between 520 and 625 grams. This nestling period is in contrast to the 47, 44 to 47, and 54 to 59 days reported by other investigators at colonies at similar latitudes in the Gulf of Alaska. Fledging weights of chicks at these other sites averaged between 35-50 grams less than those of Nelson Lagoon birds.

We collected no food habits information for Nelson Lagoon Puffins, so can only assume the comparatively faster growth rates and higher fledging weights of Nelson Lagoon birds were attributed to an abundant and non competelive food supply. Short-tailed shearwaters occurred occasionally throughout the summer.

When considering the possible reasons for the shorter nestling period it is also interesting to look at the relationship among burrow location, timing of fledging, and the occurrence of high tides and storm generated flood tides. The vertical tide range at Nelson Lagoon is approximately 5.4m. As a point of reference, MHHW was figured at 3.3m above 0.0 datum. The highest predicted high tides occur at 4.2m above datum. The mean burrow height was 87cm above MHHW, or at the approximate level of the highest high tides unaffected by winds or storms. During 1977, nine of 18 burrows had entrances lower than the highest predicted tides.

Generally, the highest high tides occur each year beginning late August and continue through December. This is also the period of the most frequent and severe storms which might compound tide height. Indeed, the observed storm tide line from the previous fall and winter on all the islands was well above all but two of the active burrows in 1977. Between 22 - 26 August 1977 the first in a series of potentially damaging high tides occurred at Nelson Lagoon. This series flooded 3 burrows and was probably responsible for the death of at least one chick. It was during, or shortly after, this same series of tides that at least 3 chicks are suspected of fledging. Another series of high tides, this one affected by strong NW winds, occurred between 15-19 September. We feel that at least two chicks, with 4 September weights of 520 and 570 grams and wing lengths of 139 and 138 mm, respectively, fledged just prior to this series of tides. During this series of tides the burrow of one of these chicks was buried under sand as a result of wave and wind action.

It, thus, appears that Tufted Puffins are at least marginally successful at nesting in this unusual situation due to accelerated chick growth probably associated with an abundant and non-competitive food supply; which in turn allows for a shorter nestling period. Fledging then occurs just prior to or during the first potentially destructive flood tides which occur in late August and early September each fall.

Presented by R. E. Gill, USFWS, Anchorage, AK at the 1978 PSG meeting Victoria, B.C. 19-22 January 1978.

TUPU NESTING CHRONOLOGY
NELSON LAGOON, AK - 1977

n = 14 pairs

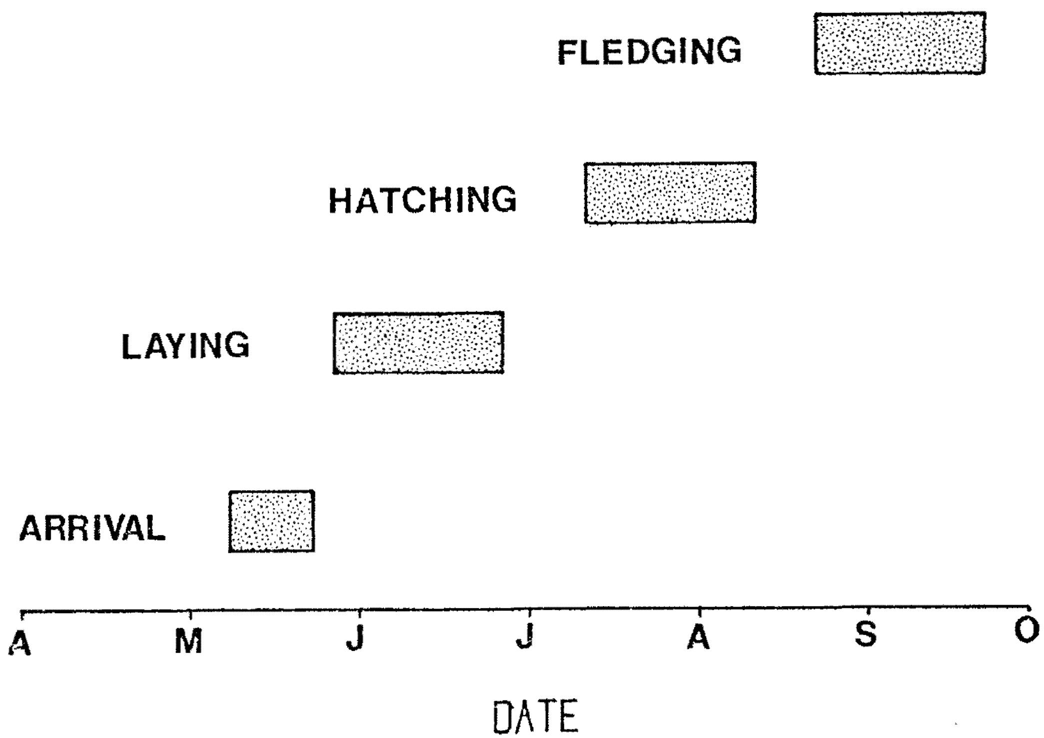


FIGURE 1.

FIGURE 2.

TUFTED PUFFIN CHICK GROWTH
NELSON LAGOON, AK - 1977