THE PELAGIC AND NEARSHORE BIRDS OF THE ALASKAN BEAUFORT SEA

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I. Summary of objectives, conclusions and implications with regard to OCS oil and gas development

In order to delineate large scale patterns of seabird distribution and abundance in the Alaskan Beaufort Sea, bird observations were conducted on nine cruises during the period of maximum bird abundance (early August through mid-September). The six pelagic (waters deeper than 20 m) cruises and three nearshore (waters inside the 20 m contour) cruises produced over 500 hr of observation and censused over 1400 sq. km. The pelagic and nearshore regimes were divided into longitudinal sections (five for the pelagic and six for the nearshore) in order to demonstrate the bird use of the resulting eleven regions. The activities of birds were examined by analyzing migration rates and the number of birds sitting on the water so that bird density data could be better interpreted.

The pelagic regime was found to consist primarily of surface feeding species (gulls, terns, phalaropes and jaegers) with almost no use by diving species, except as a migratory area. The extreme western Beaufort was found to have high bird densities, apparently due to increased productivity caused by the Bering Sea Intrusion.

Nearshore waters contained large numbers of Oldsquaw, loons and migrant eiders with low densities of surface feeders approximating those found in pelagic waters. All nearshore regions have rather similar densities of diving species, with the exception of Harrison Bay which had consistently low densities. Like pelagic waters, surface feeding species were most abundant in the extreme western Beaufort.

Stomach contents indicate that the primary prey for species in the pelagic regime is Arctic Cod. In the nearshore diving species prey primarily on epibenthic crustaceans while surface feeding species prey on zooplankton.

This report shows the nearshore Beaufort to have a bird community that would be quite vulnerable to oil spills in that it contains high densities of diving species. Pelagic waters, with their low densities in most areas and lack of diving species, have a bird community that is much less likely to be affected by a spill.

A broad scale survey of this sort is perhaps most important in allowing site and region specific studies to be put into perspective with regard to distributions and activities throughout the Beaufort. This permits the resource manager to determine the importance of an area in the framework of a much large area. .

II. Introduction

A. General nature and scope of study

OCSEAP Research Unit 3/4 was originally intended to deal primarily with birds associated with sea ice, specifically ice edges. The lack of a well-defined ice edge in the Alaskan Beaufort, and the minor role that sea ice plays in affecting large scale distributions during the period of maximum bird abundance (late July through early September) were factors in changing the scope of our research in this region. We attempted instead to document the large scale distributions and abundance of seabirds in the pelagic and nearshore Alaskan Beaufort and to determine those factors affecting these distributions. While OCSEAP was conducting such large area surveys in sub-arctic waters, primarily through the U.S. Fish and Wildlife Service, no such survey was specifically planned for the Beaufort.

With bird densities obtained on six pelagic and three nearshore cruises the large scale distribution patterns of the numerically important seabird species were determined. Information on the birds' activities, especially feeding and timing of migration was gathered to assist in the interpretation of the distribution and abundances.

While the time period covered by these cruises is limited (early August through mid-September), it covers the time of post-breeding staging, dispersal and migration, when densities of almost all species could be expected to be at their maximum for Beaufort marine waters. The large scale distributions presented here are valuable for interpreting the many site and region specific ornithological studies conducted in the last ten years.

B. Specific objectives

1. To determine the large scale patterns of distribution and abundance of seabirds in the pelagic and nearshore Alaskan Beaufort Sea during the post-breeding period (August through mid-September).

2. To determine, whenever possible, the major factors affecting these distributions and abundances.

3. To describe the activities of the numerically important bird species during their residency in the Beaufort Sea.

4. To identify the areas of critical importance to seabirds in the two regimes.

C. Relevance to problems of OCS petroleum development

The impacts that oil exploration and exploitation can have on birds are by now well known. They include direct mortality from oiling, degradation of critical habitats resulting in the disruption of annual cycles and depletion of prey populations. Specific potential impacts of oil development on birds in the Alaskan Beaufort Sea have been discussed in Weller et al. (1978). The characterization of the Beaufort avifauna presented here allows state and federal administrators to predict the species and approximate numbers of birds that would be impacted by development. With a knowledge of seabird distribution over much of the Alaskan Beaufort, these impacts can be put into a better perspective than is provided by a site specific study.

Seabirds occupy the terminal end of marine trophic systems and are usually more easily and efficiently sampled than other components of the system. For this reason areas we have identified as having high densities of feeding birds can be expected to be areas of high biological productivity. This is useful to the resource manager who is attempting to minimize the impacts of oil development. It also provides insights into which areas and systems would be most fruitful for further development-related studies.

III. Study Area.

A. Physical Setting

The Beaufort Sea is usually defined as that part of the Arctic Ocean east of the Canadian Arctic Archipelago and west of Point Barrow with its northern boundary being a line from Point Barrow to Land's End on Prince Patrick Island, N.W.T. This report will treat all sightings north of Alaska and east of Point Barrow ($156^{o}30'W$) as being in the Alaskan Beaufort.

A good appreciation of the Beaufort Sea's position in the world's oceans is not afforded by a map of the State of Alaska which, unfortunately, is the way it is most frequently viewed. A much better perspective is provided by a polar Projection where the Beaufort is seen to be part of the rim of the Arctic Basin (Figure 1). The Gulf of Alaska and Bering Sea are clearly part of the Pacific Basin, and the southern Chukchi, although part of the Arctic Ocean, has its physical and biological oceanography dominated by Bering Sea water. The Beaufort is the most truly "arctic" of the seas adjoining Alaska. This is true not only in its geographic setting but in its oceanography as well. The surface waters of the Beaufort are comprised almost entirely of pure polar water making it high arctic (Tuck, 1960). Only in the extreme western Beaufort do subarctic waters mix at the surface with polar water making that area low arctic. The boundary between high and low arctic areas corresponds well with the $5^{o}C$ surface isotherm in August. The productivity and biota of the Beaufort reflect the high arctic characteristics seen in its physical oceanography.

The coastal features of the land adjacent to the Beaufort have played a role in determining the seabirds that utilize its waters. Rock cliffs and talus slopes that support large seabird colonies over much of the Alaskan coast are absent from the Beaufort. They are found in the Chukchi as far north as Cape Lisburne in Alaska (480 km southwest of Pt. Barrow) and at' Herald and Wrangel Islands in the western Chukchi. The only colony of cliff nesting seabirds in the Beaufort is the small Thick-billed Murre (Uris lomvia) colony at Cape Parry, Banks Island, N.W.T. (600 km east of the Alaskan Beaufort).

While the Beaufort lacks the large seabird colonies that Alaska is famous for, it is an important migratory pathway and staging area for large numbers of tundra nesting species. The North Slope of Alaska, much of the Canadian Arctic Archipelago and the adjacent Canadian mainland have major expanses of moist and wet tundra that support large numbers of breeding waterfowl, gulls and shorebirds (Pitelka, 1974; King, 1979; Bergman et al., 1977; Porsild, 1943). Many of these species use the Beaufort as a migratory pathway and staging area (Frame, 1973; Watson and Divoky, 1974; Richardson and Johnson, 1981; Connors et al., 1979).

B. Marine Zones and Geographic subdivisions

The Alaskan Beaufort is divided into two regimes, pelagic and nearshore, with the 20 m isobath as a boundary (Figure 2). Bird observations made by R.U. 196 fall into three groups that correspond well with three distinct habitats used by birds. These are:

Pelagic: Waters deeper than 20 m and extending out to the slope of the continental shelf. Most of our observations in the pelagic regime are in the waters from 20 to 200 m.

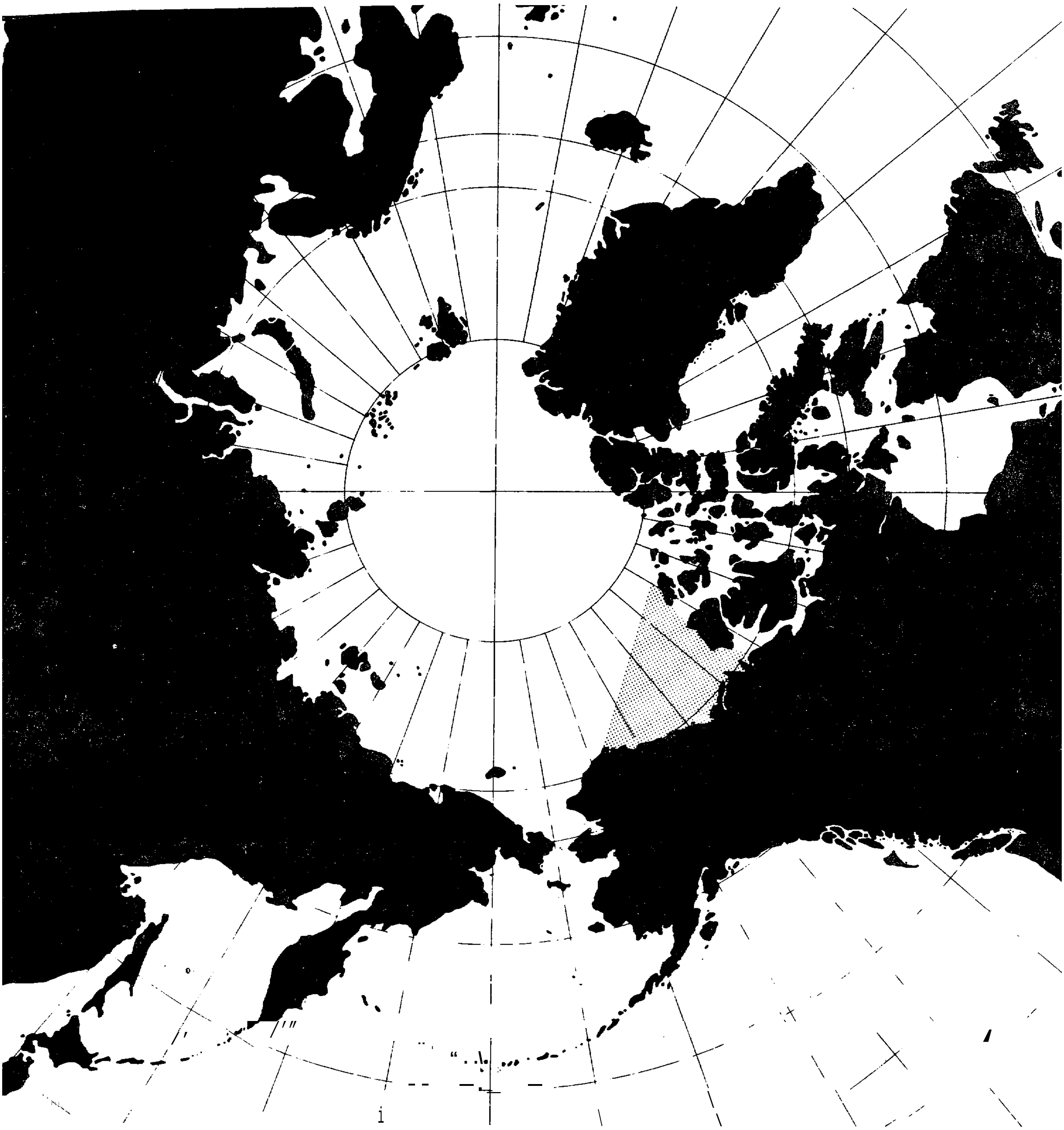


Figure 1. Polar projection showing the location of the Beaufort Sea.

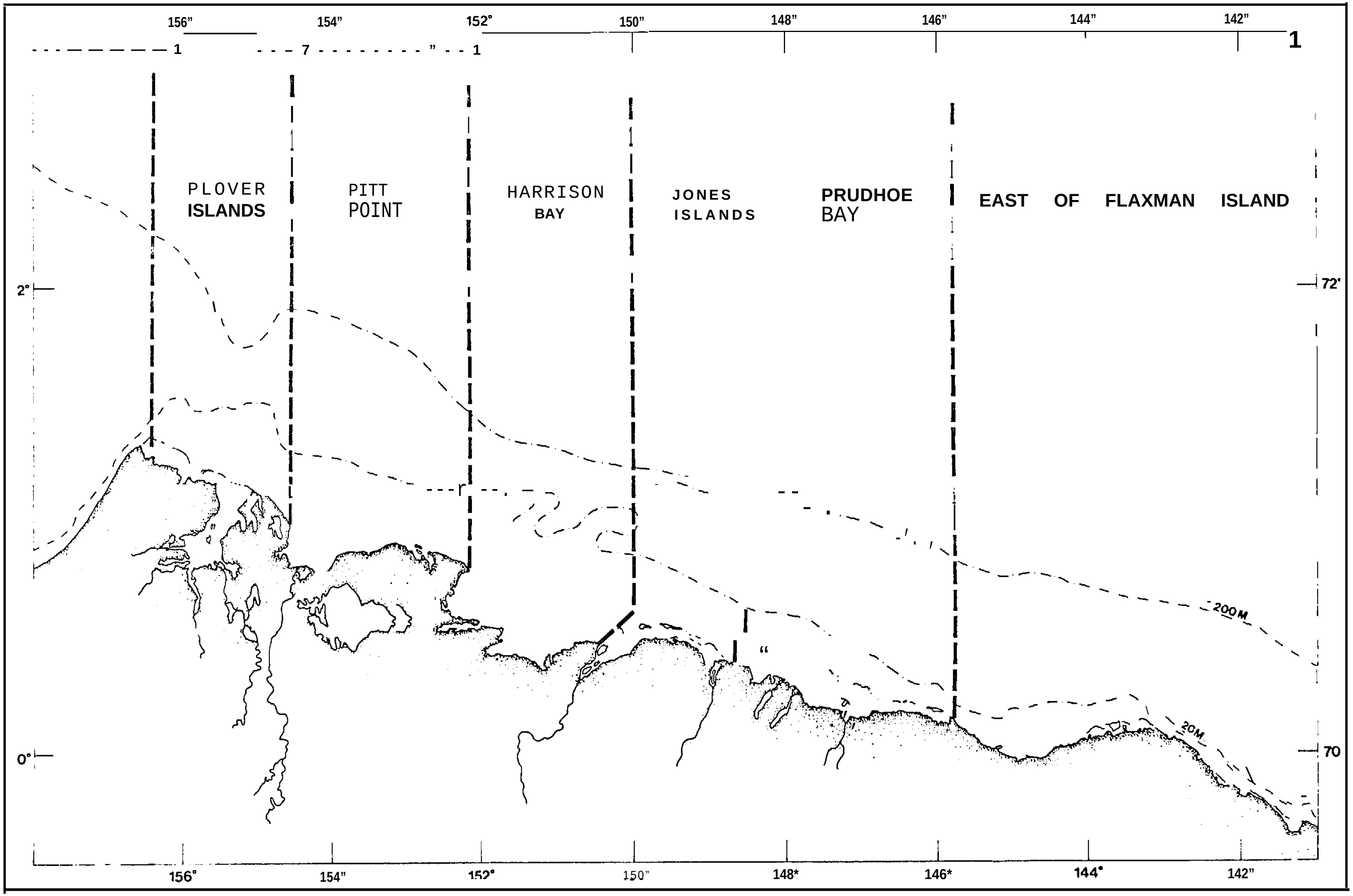


Figure. 2. The five pelagic and six nearshore regions of the Alaskan Beaufort Sea. The pelagic and nearshore regimes are separated by the 20 m contour.

Nearshore: Waters shallower than 20 m but not within 300 m of land. Most of our nearshore observations are in waters less than 10 m. In the western Beaufort the 20 m contour is 35 km from shore and in the eastern Beaufort as close as 10 km from shore.

Littoral: Beach habitats including water and land habitats within 300 m of the land/water interface. These observations have been summarized in Divoky (1978a) and Divoky (1979 b). They will be mentioned in this report only when they relate to nearshore and offshore observations.

Pelagic and nearshore areas are sampled by icebreaker and small boat respectively, while the littoral zone is censused by observers on foot. Each of these zones also has characteristics that separate them from the others. The documentation of the characteristics and differences of the bird communities of the pelagic and nearshore regime is the goal of this report.

The bulk of the Alaskan Beaufort coast is composed of four major chains of barrier islands and three major bays. For purposes of this report we have divided the Beaufort into five longitudinal sections. This was done to provide a stratification of our Beaufort data that will allow us to show differences between regions, and also to provide information for those concerned with birds in a specific part of the Beaufort. The five sections are based on oceanographic and coastal features. These sections are shown in Figure 2 and listed below. The name we have given to each area is in quotes and is taken from a prominent coastal feature. More information on each section is presented in the data presentations and discussions.

Section A - "Plover Islands" - Point Barrow to Cape Simpson (156°30'W to 154°30'W). The coast is composed primarily of the Plover Islands which enclose Elson Lagoon. The lagoon is unlike others in the Beaufort in that it has no major rivers entering it. Meade River enters into Dease Inlet, which is connected with Elson Lagoon, but the Meade River Delta is some 30 km from Elson. The offshore waters regularly have the highest sea surface temperatures in the Alaskan Beaufort due to the Bering Sea Intrusion (Johnson, 1956). An eddy of Bering Sea water is also frequently present (G. Hufford, pers. comm.). It is in this section where the surface effects of the Bering Sea Intrusion can be expected to be most pronounced. The Plover Islands are named after the H.M.S. Plover which anchored near them and has no direct connection to the shorebirds known as plovers.

Section B - "Pitt Point" - Cape Simpson to Cape Halkett (154°30'W to 152°10'W). This section lacks barrier islands and *lagoons* and is rather featureless except for Smith Bay and the adjacent Ikpikpuk River Delta in the western part of the section. Sea surface temperatures in the offshore area frequently show the effects of the Bering Sea Intrusion.

Section C - "Harrison Bay" - Cape Halkett to Thetis Island (152°10'W to 150°10'W). This section encloses Harrison Bay, the largest embayment on the Alaskan Beaufort coast. It also has the largest river, the Colville, flowing into it.

Section D - "Jones Islands" - Thetis Island to Egg Island ($150^{\circ}10'$W to $148^{\circ}30'$W). The coast from Thetis Island to Egg Island consists of a chain of barrier islands enclosing Simpson Lagoon and Gwydyr Bay. One major river, the Kuparuk, enters into this section as do a number of small streams. The mainland to the south is land owned by the State of Alaska and has already seen much oil related development.

Section E - "Prudhoe Bay" - Egg Island to Brownlow Point ($148^{\circ}30'$W to $145^{\circ}50'$W). For presentation of pelagic data, this area is lumped with the Jones Islands region to the west. This pelagic region frequently has ice near the 20 m contour in August when areas to the west and east are ice free. For nearshore data the two regions are treated separately for the following reasons. The Jones Island region has a shallow (2 to 3 m) , narrow (less than 9 km wide) lagoon, while the Prudhoe Bay region has a deeper (maximum 7 m), broader (maximum 20 km) inshore area. The barrier islands in the Prudhoe Bay area are not in a coherent chain and the only area that is strictly a lagoon is the area south of Flaxman Island.

Section F - "East of Flaxman Island" ($145^{\circ}50'$W to $141^{\circ}00'$W). The western part of this region is comprised of Camden Bay, a poorly defined bay with rather high vertical relief near the shore where the foothills of the Brooks Range come within 35 km of the coast. In the east a narrow, discontinuous lagoonal system is present from Barter Island to the Canadian border. The 20 m depth contour is as close as 7 km from land in the eastern part of this region. Thus, what we refer to as the pelagic regime, in this report (waters deeper than 20 m), is quite close to the shore and the barrier islands. The mainland and islands in this region are part of the Arctic National Wildlife Refuge. Both the waters of the refuge and the refuge itself have been the objects of much interest from the oil and gas industry in recent years.

Sections A through C all border the Naval Petroleum Reserve in Alaska (NPR-A), a federal oil reserve. The eastern boundary of the Reserve is the west bank of the Colville River. Section D is adjacent to State of Alaska lands, much of which have been exploited for oil. Section F is adjacent to the Arctic National Wildlife Refuge, administered by the U.S. Fish and Wildlife Service.

C. Ice

1. General Effects

Sea ice is such a constant and dominant presence in the high arctic marine system that all seabird species that are regularly found in the high arctic have had at least part of their life histories influenced by the effects of sea ice. Ice can have a number of effects on seabirds and productivity that affects seabirds. These have been discussed previously (Divoky, 1979a) but will be summarized here. Effects of sea ice on seabirds can be grouped into negative and positive effects.

Negative Effects

a. Decreases the surface area of the water.

Sea ice acts as a barrier on the ocean's surface restricting the access of birds to prey in the water column and benthos. Surface feeders are most severly affected, since their potential feeding area is directly reduced by the amount of ice cover. Diving species can still have access to much of the potential prey in the water column and benthos, if open water is scattered throughout the ice.

b. Reduces primary productivity in the water column.

Ice inhibits phytoplankton blooms in the water column by decreasing light penetration of the water column and increasing the stability of the water column. The decrease of light penetrating the water column is caused by light being reflected by ice and snow and light being absorbed by algae in the ice. This reduction in light reduces the depth of the euphotic zone. Ice stabilizes the water column by preventing wind mixing and by forming a surface layer of meltwater in the spring and summer (Dunbar, 1968) . This stabilization of the water column prevents nutrients from being upwelled to the euphotic zone.

c. Reduces benthic and intertidal biota.

In shallow waters ice freezes to the bottom for much of the year and prevents the establishment of plant and animal populations. In addition, keels on ice floes can scour the bottom as they move through the water (Reimnitz and Barnes, 1974). Sessile benthic populations are reduced in areas where ice scour is intense, although motile species can migrate into scoured areas during ice-free periods. Mollusk, kelp and eelgrass (Zostera marina) beds are all important food sources for birds in areas south of the pack ice. They are greatly reduced in the Alaskan arctic due to ice scour.

d. Provides terrestrial predators access to breeding sites.

In the spring before water surrounds the nearshore islands of the Beaufort and Chukchi seas, Arctic Fox (Alopex Lagopus) can visit the islands by traveling over the ice. Their presence can greatly reduce breeding success. For this reason islands near river mouths have the highest breeding populations, since river runoff surrounds them early in the year and hastens ice decomposition (Divoky, 1978b).

Positive Effects

e. Provides a matrix and substrate for an in-ice algae bloom and an associated under-ice fauna.

An-in-ice algae bloom occurs in sea ice in spring. The importance of this bloom in the energy budgets of arctic and subarctic seas has only recently been recognized (Alexander, 1974; McRoy and Goering, 1974). An under-ice zooplankton fauna composed of copepods and amphipods is found directly under the ice throughout much of the year (Mohr and Geiger, 1968). Two species of fish, polar cod (Arctogadus glacialis) and arctic cod (Boreogadus saida), are also found directly under ice feeding on the zooplankton.

f. Provides hauling out space for marine mammals.

Marine mammals can provide scavenging opportunities to seabirds by leaving feces, placentas and carcasses on the ice. This does not, however, appear to be an important food source in the Beaufort Sea. Walrus could be expected to provide the best scavenging opportunities and they are present in the Beaufort only as stragglers.

g. Provides roosting sites.

Ice provides hard substrate that allows seabirds to leave the water to roost. This allows such species as the Larus gulls, which typically roost on hard substrates, to occur in numbers well offshore.

h. Reduces wind chill.

The upper surface of pack ice typically has many ridges which act to reduce wind speed directly over the ice. This provides a microhabitat with a reduced wind chill for birds sitting on or next to the ice.

i. Decreases wave action.

Surface disturbance of the water by wind is reduced by the presence of ice. Although swells pass through areas with ice cover, waves do not. In addition, the lee side of ice floes and cakes usually has little surface disturbance. These reductions in surface disturbance may allow surface feeders to more easily locate prey.

2. Yearly cycle of ice in the Beaufort

The ice environment of the Beaufort Sea is best described by discussing the yearly cycle from complete ice cover in winter and early spring, through decomposition, to formation of new ice in fall. The ice features and events discussed will be those of most importance to birds. More detailed information on ice features and dynamics can be found in Weeks and Kovacs (1977). In the following discussion and the remainder of the report two primary ice zones will be recognized: shorefast ice and pack ice. Shorefast ice is that part of the nearshore ice that is in continuous contact with the bottom (bottomfast ice) and the seaward extension of this ice (floating fast ice), that extends out to approximately the 15 m isobath (Shapiro and Barry, 1978). All ice seaward of the floating fast ice will be called pack ice.

Maximum ice cover

Ice cover is complete or nearly so from late fall (approximately 1 November) through late May. The time of freeze up or extensive ice cover varies greatly from year to year (Brewer et al. , 1977). From December through

April the pack ice edge is in the central to southern Bering Sea and birds are essentially absent from the Chukchi and Beaufort seas due to ice cover. During winter leads in the ice form as winds and currents act on the pack ice but, typically, they quickly refreeze. In areas where conditions cause leads to form on a constant and regular basis a predictable area of open water can develop. Such a chronic lead system can provide stable wintering habitat since some open water will almost always be available as leads constantly form and refreeze in a given area. Such a system exists in the Chukchi Sea from Wainwright to Point Barrow (Nelson, 1969) and extends to a small extent into the Beaufort. This is the only location where seabirds could be expected to regularly winter in the Alaskan Beaufort.

Ice decomposition

The first major event of importance to birds in the decomposition of ice is the formation of a lead extending from the central Bering Sea through the Bering Strait, north to Cape Lisburne and then northeast to Point Barrow. The lead is a flaw lead, being formed between the shorefast ice and the pack ice. It forms at Point Barrow from early to mid-May and is an important migratory pathway for certain species of marine mammals and seabirds that winter at the edge and to the south of the Bering Sea pack ice (Woodby and Divoky, 1982). While the lead is well defined as far north as Point Barrow it does not extend any distance into the Beaufort. Instead, a diffuse system of leads extends to the northeast. These leads are less well defined than the flaw lead and are much further offshore. The nature of the lead system in the Beaufort also makes it more likely to refreeze and can result in spring migrants being unable to find open water (Barry, 1968).

The first important event that occurs in the decomposition of shorefast ice in the Beaufort is the breakup of the North Slope rivers. Rivers usually begin to flow in the last week of May. When the river runoff reaches the sea it runs both over and under the shorefast ice adjacent to the river mouth or delta. The water's weight, temperature, movement and the detritus it leaves on the ice all act to hasten shorefast ice decomposition near rivers. The river runoff remains on top of the ice for as long as two weeks before it flows down through the ice. Runoff contains much detritus which is left on top of the ice and decreases the albedo increasing melting. The flow of the water under the ice also weakens the ice and further increases decomposition. Because of these effects nearshore waters near river mouths can be ice free in early to mid-June, up to one month before areas without rivers or large streams. This is important to species that feed and rest in nearshore waters and those that breed on barrier islands. Barrier islands near river deltas are surrounded by water earlier and thus isolated from Arctic Fox predation.

Nearshore areas without major river input have ice decomposition occur at a slower rate. Solar radiation absorbed by the mainland beach and the barrier islands melts the adjacent ice forming moats of open water that first appear in mid-June and increase in width during June and early July. At the same time meltponds form on the surface of the shorefast ice as the snow and surface ice are melted by the sun. In time, some of these meltponds become continuous with the seawater below the ice. Over half of the surface of the ice can be covered by meltponds before large cracks appear in the ice in late June or early July. Once cracks are large enough to allow waves to form, ice decomposition can be quite rapid. This is due in large part to most of the nearshore ice being first-year ice that is not as dense or thick as multi-year ice. Areas behind barrier islands usually become ice free between early and mid-July. Shorefast ice directly outside barrier islands usually decomposes about two weeks later than ice inshore of the islands. Once much of the shorefast ice has decomposed, cakes or small floes from the pack ice can be blown into nearshore areas. Such ice is usually discernible from shorefast ice by its vertical relief and blue color that identifies it is multi-year ice and distinguishes it from the flat, white first-year ice. All but the large floes of pack ice blown into nearshore waters decompose within a few days and many of the small pieces are carried onto the beach by swells. At Cooper Island, an island unaffected by river runoff, where we have done our most intensive and long term field work we recognize four ice periods. These periods are based on observations made from the island from June through September.

Shorefast ice - the period of time when moat formation and meltpond formation are occurring and no major areas of open water are present.

Shorefast breakup - from the first formation of major cracks in the ice to the period when all shorefast ice has either decomposed or been carried out of the nearshore area by currents or wind. This period typically lasts from the first week of July to the third week of July.

Drifting pack ice - after the shorefast ice decomposes, the predominant NE winds can then move the pack ice into the nearshore area. The presence and concentration of ice in the nearshore area during this time depends to a great extent on wind and the ice conditions in the offshore Beaufort. This period typically begins the last week in July and lasts for from one to three weeks.

Open water - the open water period typically occurs after the drifting ice is no longer present in the nearshore zone either due to wind or melting. Pack ice is frequently present on the horizon during this time (approximately 13 km from shore) and is apparently grounded. This period can begin as early as late July but typically begins the second to third week of August.

Decomposition of the pack ice is less dynamic than the shorefast ice. There is a steady, slow melting from June through September. In June and July ice cover is usually 90 percent in all areas. Areas northeast of Point Barrow, typically, are open earlier due to the flaw lead extending in from the Chukchi. By early August the southern edge of the pack ice has moved offshore leaving a strip of water adjacent to the coast. The width of the zone depends on wind conditions and the degree of melting. The pack ice can be next to the shore for the entire length of the Alaskan Beaufort as it was in 1975, or as much as 200 km offshore as it was in 1977. In August of the years 1976-78 pack ice was close to the 20 m contour in the area from Harrison Bay to Flaxman Island. The offshore areas to the east and west typically have the ice further from shore apparently due to the Bering Sea Intrusion to the west and the Mackenzie River outflow to the east. Annual average ice conditions are summarized in Brewer et al. (1977).

Ice formation

Ice typically begins to form in the Beaufort in October although it may occur as early as mid-Septeniber. Inshore areas protected by islands or spits have faster ice formation since there is less wave action. Offshore there is freezing and subsequent breaking into pancake ice caused by the action of swells. Once ice cover becomes extensive enough to stop the formation of swells ice cover becomes complete.

IV. PREVIOUS ORNITHOLOGICAL STUDIES

While native eskimo knowledge of the birds of the Beaufort Sea and the adjacent mainland has been extensive for some time, western cultures have only recently begun to obtain information from this area. Knowledge of the occurrence and relative abundance of northern Alaskan birds has for a long time been based on their status at Barrow (Bailey, 1948; Pitelka, 1974). Unfortunately, the pelagic species seen near Barrow are more representative of the Chukchi Sea than the Beaufort. The discovery of oil at Prudhoe Bay in the late 1960's and the efforts to find more oil under the North Slope and near-shore Beaufort led to large scale surveys and site intensive studies east of Barrow that have provided much information on the status of birds east of Point Barrow.

The presence of ice in much of the Beaufort throughout the year has kept commercial and research vessel traffic to a minimum. Whaling vessels were common in the Beaufort in the late 1800's and early 1900's, but almost no published information on seabirds resulted from these cruises. Bodfish (1936), however, mentions incidental observations obtained while whaling in the Beaufort. All systematic observations of Beaufort pelagic seabirds comes from oil-related studies. Frame (1973) observed birds following the U.S.C.G. Staten Island in August 1969. A series of Western Beaufort Sea Ecological Cruises were initiated by the U.S. Coast Guard in 1970 when it appeared that supertankers might be entering the Beaufort to transport oil from Prudhoe Bay. Ice cover prevented the U.S.C.G.C. Glacier from entering the Beaufort in 1970 and a survey of the northern Chukchi Sea was done instead (Watson and Divoky, 1972). In August 1971 and 1972 cruises in the Beaufort did occur, with the observations being summarized in Watson and Divoky (1974). Results from these cruises are presented in this report. No other pelagic censusing of the Alaskan Beaufort was conducted until the initiation of OCSEAP in 1975. Other than this research unit (R.U. 196) the only OCSEAP project to conduct pelagic censusing of the Beaufort was R.U. 337 which conducted aerial surveys in 1975 and 1976 (Harrison, 1977).

Shore based studies have primarily centered on tundra habitats but the littoral zone inshore waters have received much attention in recent years. The following summary of coastal and tundra bird research proceeds from west to east.

Point Barrow to Oliktok Point

Bailey (1948) reported on his extensive work in the Barrow area as well as all previous information. Pitelka (1974) summarizes the avifauna of the Barrow region and North Slope in an excellent review of knowledge to 1973. King (1979) conducted aerial surveys on the Naval Petroleum Reserve south of Barrow from 1977 to 1979. Derksen et al. (1979 and 1981) studied waterbirds and wetland habitats in the same area during the same period.

Connors (OCSEAP R.U. 172) conducted surveys of shorebirds in the littoral zone at Barrow from 1975 - 1978 and at Pitt Point (adjacent to the Lonely DEWline site) in 1976 and 1977 {Connors et al., 1979). He studied bird use of a salt marsh adjacent to Harrison Bay in 1980 (Connors, in prep.). James Helmrichs (Colville Village, c/o Barrow, AK 99723) a bush pilot living on the Colville River delta has made incidental but regular observations in the course of his work.

Oliktok Point to Brownlow Point

This section of coast has been the site of numerous studies following the discovery of oil at Prudhoe Bay and in anticipation of the Joint State-Federal Lease Sale of 1979. Hall (1975) made incidental observations of birds while conducting oceanographic studies in Simpson Lagoon. Flock (1973) conducted radar observations of coastal bird movement at Oliktok Point as well as other northern Alaska coastal locations from 1969 to 1972.

Schamel spent the summers of 1971 and 1972 on Egg Island (13 km west of Prudhoe Bay) studying Common Eider (Somateria mollissima) breeding biology (Schamel, 1974). In 1972 he also gathered information on bird use of the Gwydyr Bay - Egg Island area, which was analyzed through OCSEAP (R.U. 215) (Schamel, 1978).

An extensive survey of bird use of Simpson Lagoon was conducted in 1978 and 1979 (R.U. 467) as part of an ecological process study (Johnson and Richardson, 1981 and 1982; Richardson and Johnson, 1981). At Point Storkerson (13 km west of Prudhoe Bay) the U.S. Fish and Wildlife Service conducted a number of studies in the early 1970's. Their primary emphasis was on coastal wetlands with incidental observations of nearshore birds (Bartels, 1973; Bergman et al., 1977; Bergman and Dirksen, 1977).

Prudhoe Bay has been the site of a number of studies. Norton et al. (1975) studied inland tundra avifauna as part of the Tundra Biome Program. Gavin (1979 and unpublished) has conducted surveys of the Prudhoe Bay area and adjacent nearshore Beaufort since 1969. Connors (1979) studied use of littoral zone at Prudhoe Bay in 1978.

Brownlow Point to Demarcation Point

The U.S. Fish and Wildlife Service has conducted a number of studies in this area as part of a biological assessment of Arctic National Wildlife Range. Aerial surveys of nearshore waters have been conducted by Spindler (1981). Spring and fall migration past Nuvagapak Point and bird use of Beaufort Lagoon were studied by J. Levison (in prep.) in 1980. C. Moitoret (in prep.) studied bird use of shoreline habitats on the Canning River delta in 1980. Andersson (1973) studied habitat preferences of birds in the Nuvagapak Point area. Birds on coastal tundra habitats were studied by Schmidt (1973), Spindler (1981) and Philip Martin (in prep.).

Canadian Studies

As in Alaska, studies of Canadian Beaufort seabirds have only begun in recent years in response to the promise of oil. Johnson et al. (1975) present a summary of all previous Beaufort bird information (Alaska and Canada) as well as information on the spring 1975 migration on the Canadian coast.

V. Sources, methods of data collection

A. Sources

A total of six pelagic and three nearshore cruises are reported on here. The dates of these cruises, the names of the vessels, and the three numeral designation used to identify the cruises in this report are given in Table 1. The number of observation intervals (20-minutes intervals for 1971 and 1972 and 15-minutes intervals for 1976-78) are given in Tables 2 and 3. A composite of all the cruise tracks reported on in this report is presented in Figure 3. This composite is most useful in showing the extent of sampling in a given area. Specific cruise tracks from the 1976-78 cruises are presented in Divoky (1978a and 1979b) with information on bird densities.

B. Methods

Seabird censusing of the pelagic regime has been done from icebreakers while nearshore censusing has been done from small (< 50 feet) research vessels. Other than the difference in the height of the observer above the sea (18 m vs. 6 m), the sampling techniques are the same for both regimes. Censusing was done in 20-minute intervals on the cruises in 1971 and 1972 and 15-minute intervals in 1976-78.

All birds observed out to 300 m to one side of the vessel are identified to species or species group and counted, with notes taken on age, sex and activities whenever possible. The area censused in each transect (distance x .3 km) is computed and the density (birds per km sq.) obtained for each species. For the discussion of biomass density (kg per km sq.) the birds per km sq. is multiplied by the average weight of the species. Average weights of the species discussed in this report are presented in Table 4 and have been obtained from specimens collected for stomach contents or from the literature.

Ship followers, which can artificially inflate or deflate densities depending on the circumstances, can be a major problem in the pelagic Beaufort. An icebreaker can attract large flocks of ship followers when Arctic Cod (Boreogadus saida) are washed onto the ice by propwash and the shifting of ice during icebreaking. At such times it can become difficult to accurately census certain species, primarily Glaucous Gulls, Black-legged Kittiwakes, and jaegers. In addition, the large amount of garbage thrown overboard from icebreakers can attract large flocks of scavenging' Glaucous Gulls. While every attempt is made to count only those individuals that would be present irrespective of the ship, the error in censusing these species in pelagic waters is larger than for others. Such problems do not occur in the nearshore since no icebreaking or major garbage disposal occurs.

Densities are most useful for those birds that are sitting, feeding or searching for prey and less valid for situations where active migration is taking place. Because migration is a function of time (birds per hr.) and our conversion factor for transect observations is based on area, a constant rate of migration will result in varying densities as the speed of the ship varies. Because of this migration phenomena have been separated from density discussions whenever possible. The density figures given by cruise and region for each species include all birds encountered on transects. It is mentioned

	Cruise	Dates	Vessel
Pelagic			
	871	18 Aug.-16 Sept. 1971	C.G.C. Glacier
	872	2 Aug.- 9 Sept. 1972	"
	876	17 Aug.- 3 Sept. 1976	"
	976	6 -18 Sept. 1976	"
	877	7 Aug.- 5 Sept. 1977	"
	878	26 Aug.-15 Sept. 1978	C.G.C. Northwind
Nearshore			
	876	19-30 Aug. 1976	R.V. Alumiak
	877	2-26 Aug. 1977	"
	878	5-29 Aug. 1978	" and R.V. Natchik

Table 1. Dates and vessels of cruises reported on in this report.

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	20	25	41	134	43
872	4	50	36	82	58
876	30	28	23	32	0
877	74	61	77	61	131
878	19	0	24	55	81
976	52	42	28	0	0
TOTAL	199	206	229	364	313

TOTAL FOR FIVE REGIONS = 1311

Table 2 . Number of 20-minute transects (1971-1972) and 15-minute transects (1976-78) with bird observations in the five regions of the Alaskan Beaufort sea pelagic regime.

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	11	8	14	45	27	28
877	47	32	29	34	23	37
878	50	36	39	53	78	-
TOTAL	108	76	82	132	128	65

TOTAL FOR SIX REGIONS = 591

Table 3. Number of 15-minute transects with bird observations in the six regions of the Alaskan Beaufort Sea nearshore regime.

in the text when these densities principally represent birds that are migrating.

Stomach contents reported on here were presented earlier (Divoky, 1978c). For the purposes of this report the stomach contents of each species have been separated into two groups, pelagic and nearshore. Data on contents are presented by computing the percentage each prey species or species group contributes to the total weight and by computing the percentage of the stomachs in which the prey species or species group was found.

VI. Species Accounts

The following species accounts present data gathered on the nine cruises in the Alaskan Beaufort during the period of post-breeding dispersal and migration. In order to put these August and September densities and distributions in perspective the period of spring migration and breeding is briefly discussed.

The average densities for each region for each cruise are presented in the species accounts for the commonly encountered species. Averages by region for all cruises are combined and presented in Table 34 for pelagic observations and Table 35 for the nearshore. The average densities presented for each region by cruise are useful in demonstrating whether an area has consistently high or low densities and how much annual variation occurs. To interpret the data on a cruise by cruise basis the reader should be aware of the dates of observations for each cruise presented in Table 1. Pelagic cruises that sampled primarily in September could be expected to have lower densities of many species than cruises that sampled in early and mid-August.

Maximum densities (the highest density encountered in each region on each cruise) are also presented in the species accounts for the commonly encountered species. These figures demonstrate the degree to which a species can congregate in a given region. For many species the maximum density can result from a single flock. For those species *that* are utilizing an area for feeding or by sitting in the water (as opposed to flying migrants) the maximum density provides an indication of the maximum number of birds per km that could be expected to be impacted by an oil spill or other similar impact. Such information is useful when developing "worst case" scenarios.

In addition to average and maximum densities, the frequency of occurence is given for the regularly encountered species. Frequency of occurence is the percentage of transects in a region on which a species was encountered. Frequency of occurence helps in interpreting average density information by showing the degree to which a species is dispersed in a region. Species having a moderate average density and a low frequency of occurence in a region could be expected to have large numbers of birds occupying a small area of the region. Knowing the pattern of dispersion o-f a species is important when assessing potential impacts of development related activities. Average frequencies of occurrence for each region are presented in Table 36 for the pelagic regime and Table 37 for the nearshore regime.

When migration rates (bird per hour) are important in describing the activities of a species, the major features of our migration observations are presented. These include bird per hour and the direction of flight, shown by the percentage of the birds moving in each of the primary" compass directions.

A. Loons

Loons are large diving birds that nest on freshwater habitats, but are found feeding in both the nearshore zone and freshwater during the breeding season. Outside of the breeding season, they are primarily marine, occupying coastal littoral habitats in ice-free areas of the subarctic and temperate zones. Three species of loons are regular in the Alaskan Beaufort; the Yellow-billed (Gavia adamsi), Arctic (G. arctica) and the Red-throated (G. stellata). The Common Loon immer) is a rare migrant (Bailey, 1948).

The Arctic Loon is the most abundant breeding loon in northern Alaska. King (1979) found that 70 to 80 percent of all loon sightings on aerial censusing of NPR-A were this species. Seventy-five percent of all loon broods encountered by Derksen et al. (1981) on ground surveys of the same area were Arctic Loons. Red-throated Loons comprise the bulk of the remainder of loons in northern Alaska. Yellow-billed Loons are frequently seen at coastal and inland sites but no records of nesting densities or abundance are available. It is safe to say that Yellow-billed Loons comprise much less than ten percent of the loons utilizing the Alaskan Beaufort Sea and adjacent tundra.

Because loons usually migrate singly or in small flocks, estimates of population sizes are harder to obtain than for many other Beaufort species. King (1979) estimated 20 thousand loons breed on NPR-A. Timson (1976) estimated the number of fall migrants passing Pt. Barrow between 27 August and 16 September to be over 50 thousand. Much loon migration takes place after her observations and it is reasonable to assume that the total number of loons that use the Alaskan Beaufort Sea is well in excess of 100 thousand.

1. Spring migration

Loons migrate to the Beaufort Sea in spring from wintering areas in the northern Pacific. Observers in coastal locations in northern Alaska have found most migration to occur from early to mid-June (Bailey, 1948; Richardson and Johnson, 1981; Woodby and Divoky, 1982). The extent that loons utilize marine habitats in the arctic during spring migration is not known, but it is likely that the flaw lead in the Chukchi and offshore leads in the Beaufort are used primarily as migratory pathways with few birds sitting or feeding in the leads except when held up by weather. Spring migration observations from a number of coastal localities indicate that Yellow-billed Loons are either an earlier migrant than Arctics and Red-throateds or that some inland migration of the latter two species may occur. Yellow-billed Loons comprise the majority of loons observed at a number of coastal sites and a large percentage at others. Flock and Hubbard (1979) found that Yellow-billed Loons were the commonest loon passing Cape Prince of Wales (Bering Strait) from 20 May to 3 June with lesser numbers of Red-throateds and only one sighting of Arctics. At the flaw lead at Pt. Barrow this research unit saw 28 loons and of the 9 identified, all were Yellow-billed Loons (Woodby and Divoky, 1982). Aerial censusing of the flaw lead during the same time (5 June) produced sightings of nine Yellow-billed Loons. No other loons were seen on that flight. 5 June can be assumed to be a date when much loon movement is occurring based on dates of arrival at mainland sites (Bergman et al., 1977).

The high percentage of Yellow-billeds observed could be related to an earlier migration for this species than for Arctics. Richardson and Johnson (1981) found that the peak period of abundance for Yellow-billeds passing

Simpson Lagoon to be 3-9 June whereas Arctics peaked from 9-13 June. The same authors estimated, however, that approximately equal numbers of both species passed Simpson Lagoon from 9 May - 25 June. This supports the view that Yellow-billeds, as a species, are more coastal in spring migration than Arctics.

2. Breeding

Arctic Loons breed primarily on lakes that contain fish while Red-throated Loons nest on ponds and fly to marine habitats or lakes to feed (Bergman and Derksen, 1977). For this reason during the breeding season the Red-throated Loon could be expected to be relatively more common in the Beaufort than the Arctic Loon. Schamel (1978) found that total loon densities in nearshore waters surrounding a barrier island peaked on 16 June and decreased steadily until 7 August when his study ended. We found loons to be uncommon during the breeding season in the nearshore Beaufort based on aerial surveys but ground observations from islands and beaches during the same period have found them to be regular and not uncommon (Divoky, 1978a Divoky , 1979b). Loons complete breeding activities on the tundra in mid-August and move to marine habitats at that time.

3. Post-breeding dispersion and fall migration

a. Pelagic observations

While loons are common in the nearshore Beaufort during the entire summer, they are not found in pelagic waters until post-breeding dispersion and fall migration begin. Of the 475 loons we have seen in the pelagic Beaufort only eight percent have been sitting on the water and thus rates of movement are more important than densities when describing these observations.

Only 33 percent of the loons seen in the pelagic zone were identified to species. Of those identified, Arctics comprised 80 percent, Red-throateds 17 percent and Yellow-billeds 3 percent. Most of the Red-throateds were seen within 30 km of shore while Arctics and unidentified loons were common to 70 km from shore.

Loons were essentially absent from the pelagic regions in early August (Table 5). The one bird that was seen was adjacent to the nearshore zone, 7 km from shore. Beginning on 14 August loons became much more common with .2 per hour being observed. The flight directions during the 14-23 August period indicate that loons are dispersing to pelagic waters but that westward migration is not yet the major activity. After 24 August the number of loons in the pelagic regime increases greatly with an average passage rate of 1.7 per hour and major westward movements. Migration rates increase steadily until 18 September when our observations cease (Figure 4) and it is possible that loon use of the pelagic Beaufort is highest after that date.

Because the fall migration of loons occurs over a broad front in pelagic waters, densities showed only minor differences from one region to another (Table 6). The limited use of densities when describing migration phenomena makes Table 6 of little utility except to provide “potential densities” should migrating birds sit on the water. One area which regularly had higher passages of migrants was the 20 m isobath from north of the Jones Islands westward to north of Pitt Point. In 1971, 1977 and 1978 migrant individuals and flocks were regularly encountered in this area. On 16 September, 1977 a migratory rate of 42 birds per hour (n = 1.5 hr.) was observed.

Dates:	2-13 August	14-23 August	24 August-18 September
Hr. of observation:	44	98	239
Total flying loons:	1	15	395
Loons/hr.:	.02	.2	1.7
Flight direction: (percent of total)			
N			4
NE		7	1
E	-	27	1
SE	100	7	2
S	-	11	6
Sw	-	27	17
W		20	64
Nw	-		6

Table 5. Rates of movement and direction of flight of *loons* observed in the pelagic zone of the Beaufort Sea.

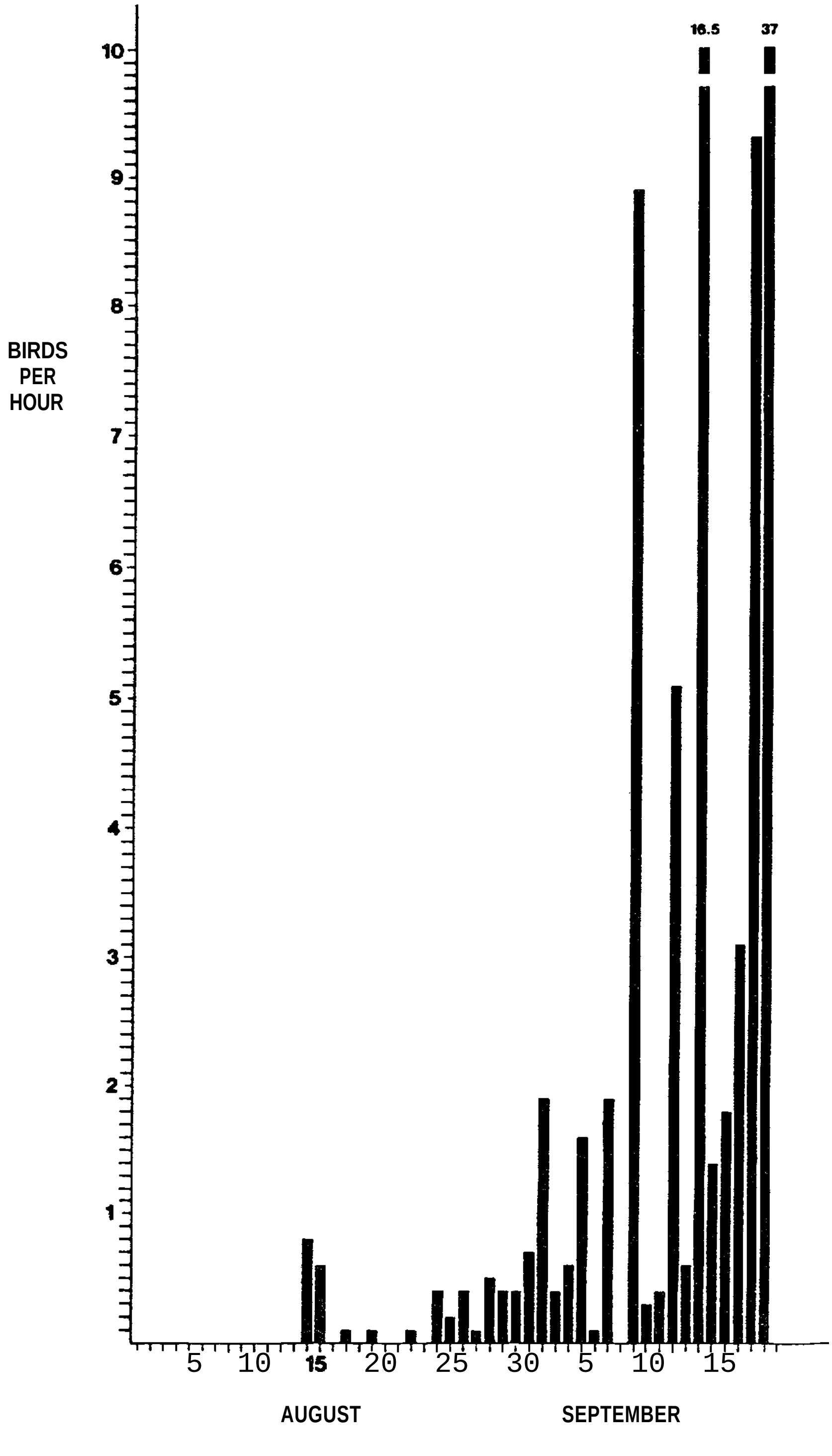


Figure 4. Migration rates of loons in the pelagic regime of the Alaskan Beaufort Sea.

AVERAGE DENSITY (birds/km²)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	.1	.1	.2	.5	0
872	0	< .1	0	0	n
876	< .1	.2	0	< .1	-
877	.2	.1	.3	.1	.1
878	.6		2.9	.4	.9
976	.6	1.8	1.6		

PERCENT TRANSECTS WHEN PRESENT

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	05	04	17	11	0
872	00	06	00	00	()(I
876	07	11	00	09	
877	17	08	17	07	02
878	42	-	29	15	36
976	25	26	17		

MAXIMUM DENSITY $(birds/km^2)$

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	1.4	2.4	3.0	13.6	0
872	0	.9	0	0	0
876	1.6	3.7	0	1.8	
877	4.3	2.1	2.4	2.9	.8
878	2.4		29	4.4	in.4
976	7.0	22.8	43.8		

Table 6 . Average densities, percent transects when present and maximum densities of Loons in the five regions of the Alaskan Beaufort Sea pelagic regime.

b. Nearshore observations

Loons were found in the nearshore Beaufort during the entire month of August. Loons use the nearshore regime both for feeding and for migratory and dispersion movements. Birds sitting on the water accounted for 32 percent of the 457 loons seen in nearshore waters. Sixty-eight percent of all loons were identified to species with the species composition being essentially identical to pelagic waters. Arctics comprised 81 percent, Red-throateds 17 percent and Yellow-billeds 2 percent of all identified loons. These percentages are very similar to what has been found for breeding populations on the tundra (King, 1979).

Major changes occur during August in the activities of loons in the nearshore regime. From 2 through 18 August, .2 loons per km sq. are sitting on the water (n = 103 km sq.). After 18 August this increases to 1.4 loons per km sq. (n = 301 km sq.). The increase coincides with the approximate time when loons are completing breeding activities on the tundra and moving to marine waters.

The movement to nearshore waters precedes the start of the major fall migration by approximately a week. Loons flying over nearshore waters do not begin moving west in numbers until 26 August (Table 7). Surprisingly, the number of loons flying over the nearshore Beaufort is the same in both the dispersion and migration periods (1.8 per hr.) with only the flight direction changing. Our nearshore observations do not include the period of major westward migration of loons in September, however. Observations by Timson (1976) at Pt. Barrow indicate that rates of passage for nearshore areas are equal or greater than what we encountered in the pelagic zone.

Because loons both sit in and fly over the nearshore Beaufort the densities presented in Table 8 are of use in demonstrating differences between areas and years. Three areas had consistently high loon densities; the Plover Islands, Pitt Point and Harrison Bay. The higher densities and frequence of occurrence in these areas may be due to the large area of ponds and lakes to the south. Areas where tundra ponds and lakes are common could be expected to have, higher loon populations than areas where less standing water is present. The amount of wet tundra and lakes and ponds adjacent to the Alaskan Beaufort decreases to the east and fewer loons would be moving to the coast east of Harrison Bay.

Similar densities of loons in nearshore waters were found in 1976 and 1978, but 1977 had lower densities and frequencies in almost all areas censused. King (1979) observed 2.5 as many loon broods in 1978 as in 1977 and the low densities we encountered inshore in 1977 may also reflect this low breeding productivity.

B. Northern Fulmar

The Northern Fulmar (Fulmarus glacialis) does not breed north of the Bering Sea but non-breeders are present in the Chukchi Sea in summer where they are uncommon south of Cape Lisburne and irregular from Cape Lisburne north to Pt. Barrow (Swartz, 1967; Divoky, in prep.). Our observations show that fulmars only rarely enter the Beaufort. An individual was seen on 5 September 1977 at 71°36′ N, 155°55′ W in the pelagic waters north of the Plover Islands. We have two records from Cooper Island; a fulmar recently killed by a Peregrine Falcon (Falco peregrinus) was found on 1 July 1981. On 4 September 1981 a number (less than 10) were observed north of the island associated with a flock of Short-tailed Shearwaters (Puffinus tenuirostris). All fulmars encountered have been dark phase.

Dates:	2-25 August	26-30 August
Hr. of observation:	106	47.3
Total flying loons:	195	86
Loons/hr. :	1.8	1.8
Flight direction: (percent of total)		
N	20	5
NE	7	
E	9	2
SE	7	
S	32	12
SW	7	1
W	14	73
NW	6	7

Table 7. Rates of movement and direction of flight of loons observed in the inshore zone of the Beaufort Sea.

AVERAGE DENSITY (birds/km^2)

Cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	2.3	1.6	2.1	.5	.8	.3
877	.5	.3	.9	.5	.4	.4
878	2.4	2.2	2.5	.6	1.0	

PERCENT TRANSECTS WHEN PRESENT

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	55	50	79	31	37	21
877	21	19	24	26	07	14
878	72	56	67	21	54	

MAXIMUM DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	11.7	8.6	8.3	4.2	3.6	3.5
877	3.7	1.8	5.1	3.9	8.8	6.0
878	11.5	10.3	18.0	6.6	4.0	

TABLE 8 . Average densities, percent transects when present and maximum densities of Loons in the six regions of the Alaskan Beaufort Sea inshore regime.

C. Short-tailed Shearwater

The Short-tailed Shearwater breeds in the southern hemisphere and spends the austral winter in the subarctic North Pacific. Sanger and Baird (1977) estimated that this species, along with lesser numbers of Sooty Shearwaters (P. griseus), number more than 10 million individuals in the Bering Sea in summer. Shearwaters are most abundant in the southern and central Bering Sea with lesser numbers north of St. Lawrence Island.

A very small percentage of the shearwaters present in the Bering Sea move north through the Bering Strait into the Chukchi from late July through September. They are most frequent north to Cape Lisburne and irregular and uncommon from Cape Lisburne to Pt. Barrow (Swartz, 1967; Divoky, in prep.). When shearwaters are in Alaskan seas they are not tied to nest sites and are thus good indicators of prey availability.

The occurrence of Short-tailed Shearwaters in the Beaufort is dependent on the oceanographic conditions in the northern Chukchi Sea and western Beaufort. The location of shearwater observations and oceanographic conditions at these locations indicate that most shearwaters in the Beaufort are associated with the Bering Sea Intrusion (Table 9). Shearwaters are irregular but sometimes abundant in the pelagic waters north of the Plover Islands in September (Table 10, Figure 5). On one cruise (1972) they were encountered in the Pitt Point region with our furthest east sighting at 71°40′ N, 153°40′ W. They have been reported as far east as Flaxman Island (Bodfish, 1936). On 6 September 1981 flocks were reported in the nearshore waters north of Pingok Island (L. Lowry, pers. comm.) .

Because the area where we have encountered shearwaters has not been of interest for its potential oil reserves there is little physical oceanographic data to correlate with our sightings. In 1971 and 1972 physical oceanographic studies were conducted concurrent to our observations (Hufford et al., 1974) and allow some general comparisons between the two years. In 1971 when we failed to observe Shearwaters the core temperature of the warm water layer in the Beaufort did not exceed 3°C. In 1972 when shearwaters were encountered, a large area of the pelagic Beaufort west of 150° W had a core temperature of 5°C or higher. Unfortunately no detailed oceanographic data is available from 1978 when we observed large numbers of shearwaters. The birds were seen in 1978 in an area where the sea surface temperature rose from 0°C to 3.3°C in 15 minutes. This was the highest sea surface temperature encountered in the Beaufort that year. Similar changes in temperature were recorded with the 1976 and 1977 sightings.

The presence of the Bering Sea Intrusion alone is not enough to guarantee that numbers of shearwaters move into the Beaufort. In 1977 when a major pulse of water warmer than 7°C was present north of the Plover Islands only one shearwater was encountered. Because shearwaters apparently follow pulses of Bering Sea water north from the southern Chukchi to the Beaufort, the presence of shearwaters in the Beaufort is probably related to the size and depth of these pulses and prey populations associated with them.

While the densities of shearwaters can be among the highest in the pelagic regime, the number of individuals in the Beaufort is very low when compared to many other species. This is related not only to the limited geographic area where shearwaters are found but also to the low turnover rate of shearwaters. While many species have much lower densities than shearwaters they maintain these low densities over an extended period of migration (from 6 to 8 weeks) so that the total number of birds moving through the Beaufort is quite high. The shearwater population of the Beaufort probably has little if any turnover.

Table 9. Short-tailed Shearwater sightings in the pelagic Alaskan Beaufort Sea.

<u>1972</u>
6-7 September
Total birds = 102
Transects when observed = 10
Average density (birds per km sq.) = 7.7
Oceanographic conditions: Sea surface temp. 3°C. On western edge of 6°C pulse at 10m depth extending from 153030' W to 150°30' W (Hufford et al., 1974)

<u>1976</u>
14 September
Total birds = 2
Transects when observed = 2
Average density (birds per km sq.) = 4.8
Oceanographic conditions: Sea surface temp. 1.3°C. Highest temperature encountered on cruise.

<u>1977</u>
4 September
Total birds = 1
Transects when observed = 1
Average density (birds per km sq.) = 1
Oceanographic conditions: Sea, surface temp. 6.7°C adjacent to area with 9.1°C.

<u>1978</u>
15 September
Total birds = 3659
Transects when observed = 13
Average density (birds per km sq.) = 225
Oceanographic conditions: Sea surface temp. 3.3°C adjacent to area with 0°C.

Table 10. Average densities, percent transects when present and maximum densities of Short-tailed Shearwaters in Plover Islands and Pitt Point regions of the Alaskan Beaufort Sea pelagic regime. No shearwaters seen east of the Pitt Point region.

cruise	871	872	876	877	878	976
Plover Islands						
Average density (birds per km sq.)	0	13.7	0	.1	106.9	.1
Percent transects when present	00	75	00	01	68	04
Maximum density	0	29.4	0	1.0	996	.9
Pitt Point						
Average density	0	.5	0	0	0	0
Percent transects when present	00	14	00	00	00	00
Maximum density	0	10.5	0	0	0	0

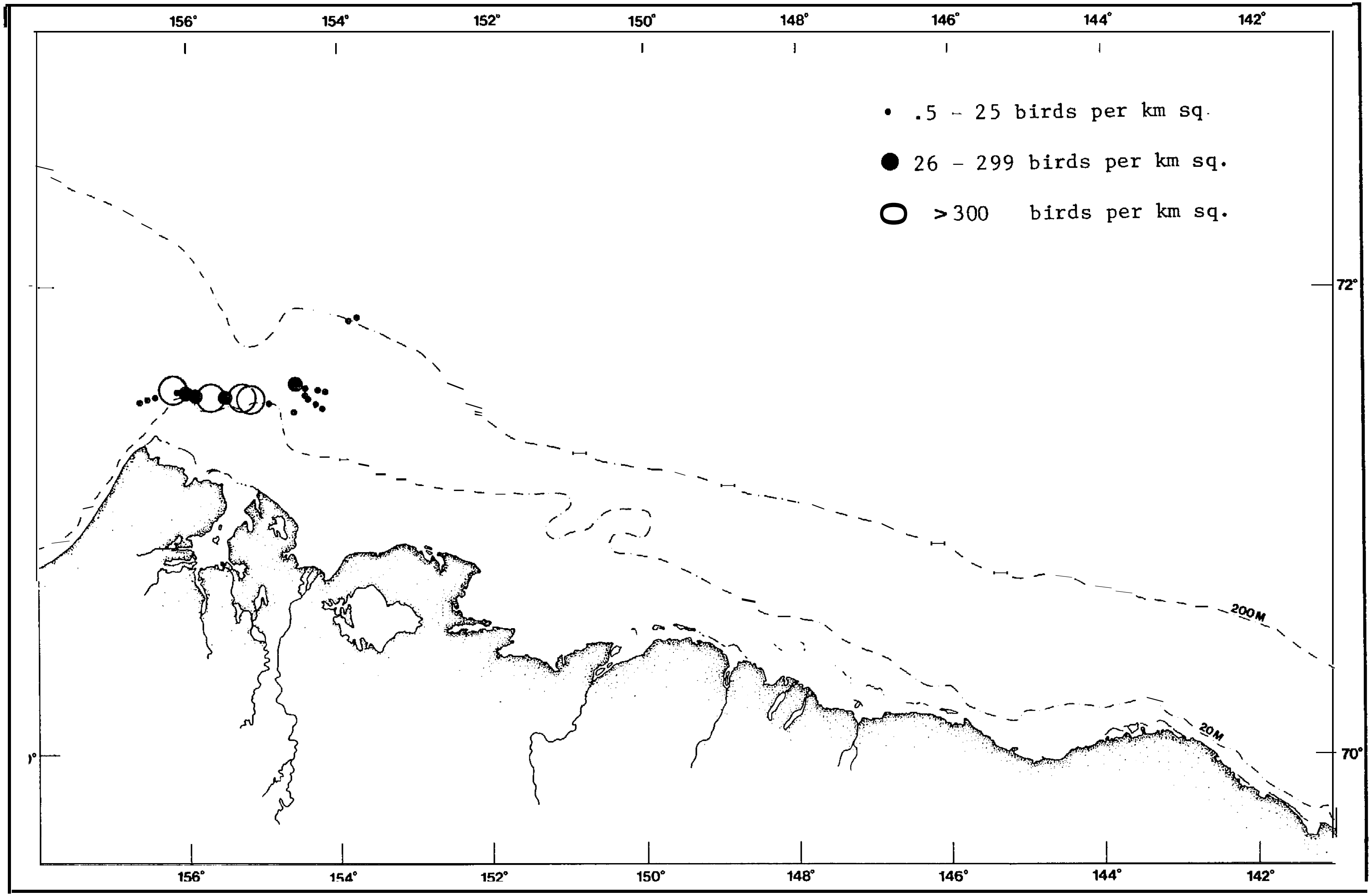


Figure 5. Densities of Short-tailed Shearwaters in the Alaskan Beaufort Sea.

We have not collected shearwater stomach samples in the Beaufort. The prey present in the Bering Sea Intrusion that attracts shearwaters is most likely the euphausiid Thysanoessa raschii, based on stomach contents of other species feeding directly on Intrusion waters. The area north of the, Plovers occasionally has an abundance of euphausiids as is evidenced by the numbers that wash up on the beaches of the Plover Islands. Sanger (in prep.) found euphausiids to be the primary prey item of shearwaters in the Bering sea in summer.

D. Black Brant

Black Brant (*Branta bernicla nigricans*) are the most marine of the geese species present on the North Slope. They breed in small numbers on barrier islands. A total of 54 nests were found on the Alaskan Beaufort barrier islands in 1976 (Divoky, 1978b) Brant feed on grasses in salt marshes during pre-migratory staging and are common in the littoral zone where salt marshes are present. They could not be expected to occur in nearshore or pelagic habitats except as flying migrants. No Brant were seen in pelagic waters and they were present on only ten nearshore transects. Most of the sightings were south of Flaxman Island and in the area of Barter Island and all were adjacent to the mainland or barrier islands.

E. Oldsquaw

Oldsquaw are circumpolar in distribution and are a common to abundant breeder on the Alaskan North Slope (Bergman et al., 1979; Derksen et al., 1982). They are ubiquitous in nearshore habitats from the time moats and leads first appear in June until freeze-up (Schamel, 1978; Johnson and Richardson, 1981; Divoky, 1978 a)

1. Spring migration and early summer

Oldsquaw enter the Beaufort by way of the flaw lead in the Chukchi Sea. The bulk of the migration apparently takes place in June since observations at the lead at Pt. Barrow found few Oldsquaw passing until 3 and 4 June (Woodby and Divoky, 1982).

Oldsquaw numbers in the nearshore are low through most of June but start to increase in late June and then increase steadily through July (Schamel, 1978; Johnson and Richardson, 1981; Divoky, 1978a) Male Oldsquaws molt between 15 July and 15 August. During this time Oldsquaw are most abundant near lagoon systems where barrier islands provide roosting sites (Johnson and Richardson, 1981).

2. August and September

a. Pelagic observations

Aerial surveys and limited shipboard observations have shown that small numbers of Oldsquaw are present in pelagic waters in July (Harrison 1977; Divoky, unpubl.). They apparently leave by early August since our first sighting in pelagic waters is on 19 August and they remain uncommon until the last week of August.

Of the 1623 Oldsquaw observed in the pelagic regime 50 percent have been sitting on the water and of those sitting on the water, 92 percent were sitting on the 20 m contour. Densities of sitting Oldsquaw in the pelagic regime are as follows:

Dates	birds per km sq.
2-23 August	.01
24-31 August	.4
1-18 September	.8

Over 90 percent of the migrant Oldsquaw in the pelagic regime have been on or near the 20 m contour. Of the 810 migrant Oldsquaw, 80 percent were moving westward indicating that the birds are migrating over pelagic waters and not just dispersing from nearshore habitats.

The rates of movement by date are shown in Figure 6 and indicates that the highest rates of movement may occur after our last observations on 18 September.

The densities given in Table 11 must be interpreted with caution since half of the birds encountered were migrants. The percent transects when present show that Oldsquaw have been more commonly encountered in the western regions. It is unclear if this is due to the dates of sampling or if, as in many other species, the western pelagic regions support higher densities.

b. Nearshore observations

Oldsquaw are common to abundant in the nearshore Beaufort (Table 12). Because they are still molting in August they are most common in coastal regions containing lagoons and barrier islands where prey and roosting sites are available.

All flocks of Oldsquaw with more than 25 birds encountered in nearshore waters are shown in Figure 7. It should be noted that a flock of 25 Oldsquaw is not large. Oldsquaw flocks encountered on transects are rarely large, however, since only birds seen out to 300 m on one side of the ship are counted. Thus while the number of birds represented in Figure 7 is not large, the location of the relatively small flocks give an indication of where Oldsquaw are most abundant. Three lagoonal areas had flocks of over 300 birds and consistently had flocks over 25 birds: Elson Lagoon, Simpson Lagoon (including the area south of Thetis Island) and the lagoon south of Flaxman Island. In late August Oldsquaw become more common in non-lagoonal areas and our sightings of flocks in Smith Bay, north of Pitt Point, and Camden Bay are for the last few days of August when birds have moved away from molting areas and are beginning to migrate.

Observations of flying Oldsquaw in the nearshore have shown that the month of August can be divided into two parts, based on rates and direction of movement (Table 13). Until 23 August the rate of movement is not high (5.4 birds per hr) with 15 percent moving westward indicating that migration has not started. The majority of Oldsquaw seen flying during this period were in the area of Thetis Island and Simpson Lagoon and it is not known if the east and south movements observed there are typical for the rest of the coast.

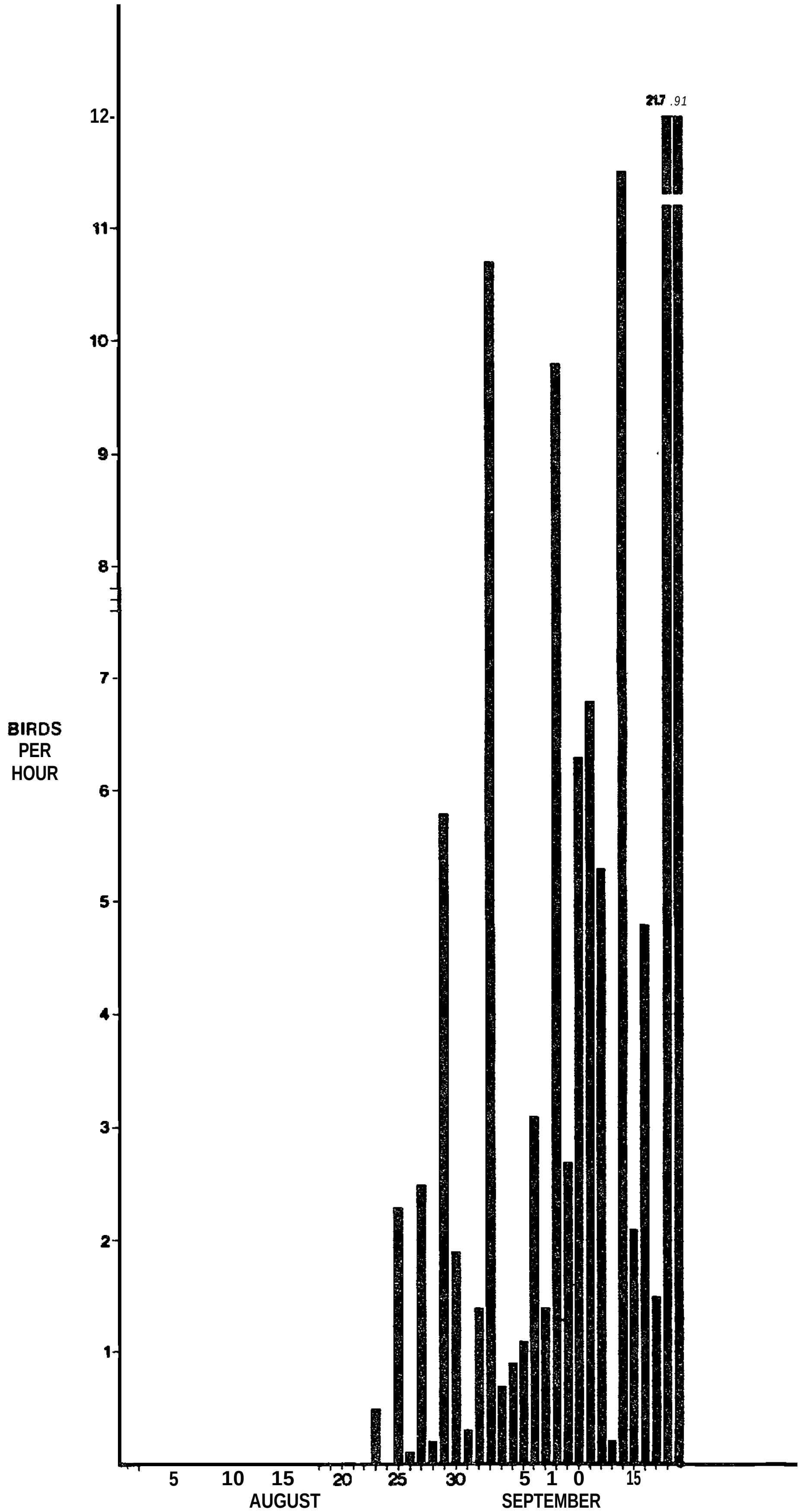


Figure 6. Migration rates of Oldsquaw in the pelagic regime of the Alaskan Beaufort Sea.

AVERAGE DENSITY (birds/km*)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	14	.4	.6	1.3	< .1
872	.9	7.2	0	0	0
876	.9	1.2	0		
877	< .1	< .1	< .1	< .1	1.6
878	2.1		2.7	1.3	1.7
976	4.8	.7	.3		

PERCENT TRANSECTS WHEN PRESENT

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	10	08	15	10	02
872	50	24	00	00	00
876	13	11	00	00	-
877	04	02	01	02	11
878	42	-	13	22	10
976	19	19	07		

MAXIMUM DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	280	7.8	17	77.4	.7
872	1.8	233	0	0	0
876	15.8	19.3	0	0	
877	2.2	.7	.8	21	108-
878	7.2		49	12	54
976	49.9	10.2	7.1		

Table 11. Average densities, Percent transects when Present and maximum densities-of Oldsquaw in the five regions of the Alaskan Beaufort Sea pelagic regime.

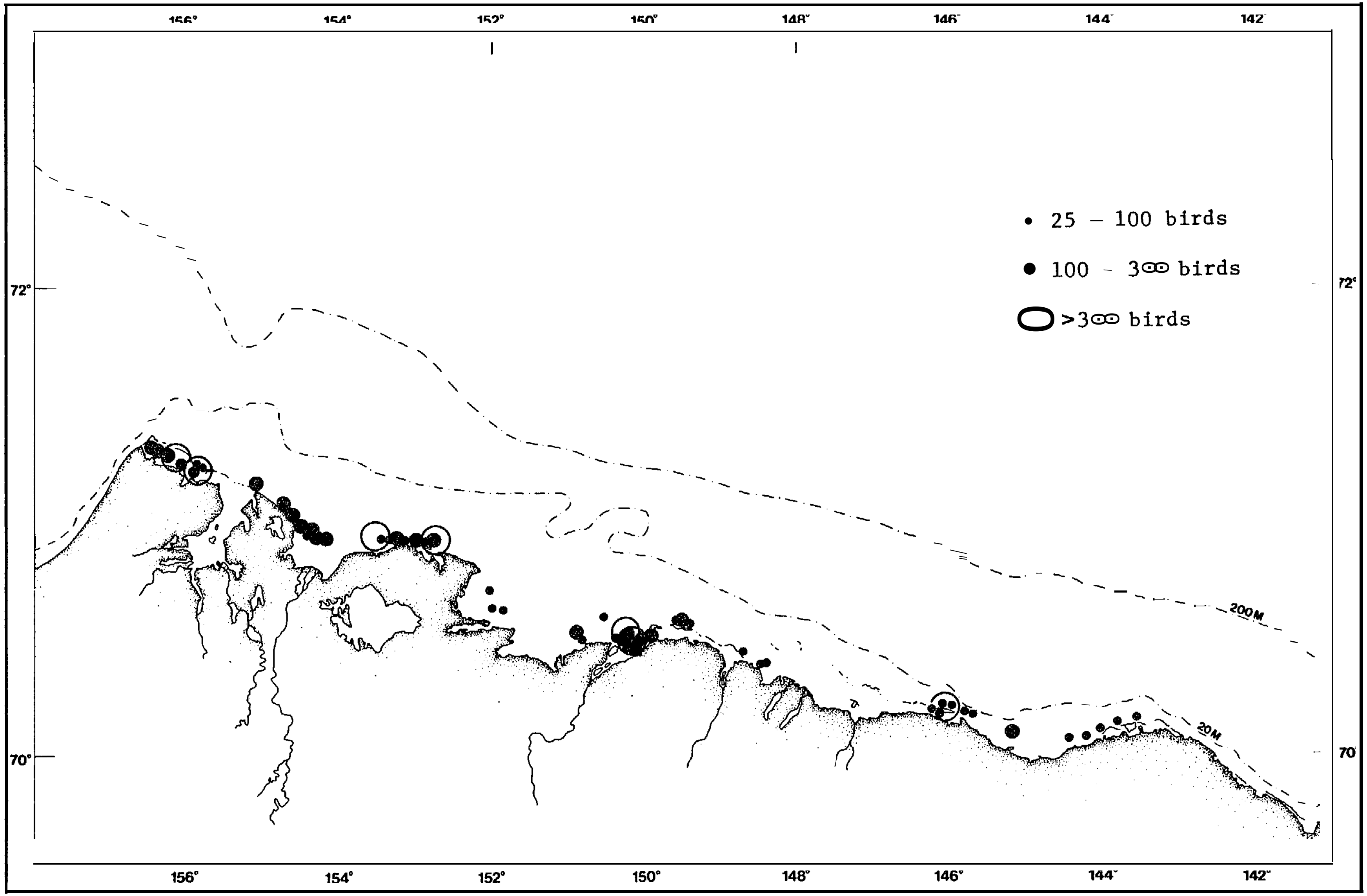


Figure 7. Location and size of all Oldsquaw flocks of more than 25 birds observed in the nearshore regime of the Alaskan Beaufort Sea.

AVERAGE DENSITY (birds/km²)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	3	3	2	45	114	42
877	26		.1		1	.4
878	76	12;	2(I	1;:	31	

PERCENT TRANSECTS WHEN PRESENT

cruise						
876	36	13	14	71	52	89
877	36	19	07	29	17	05
878	54	78	54	63	59	

MAXIMUM DENSITY (birds/km²)

cruise						
876	18	23	13	244	1218	189
877	191	167	3	247	15	13
878	629	1049	236	1907	418	

Table 12. Average densities, percent transects when present and maximum densities of Oldsquaw in the six regions of the Alaskan Beaufort Sea inshore regime.

Dates:	2-22 August	23-30 August
Hr. of observation:	96	57.3
Total flying Oldsquaw:	521	1784
Oldsquaw/hr.:	5.4	31.3
Flight direction: (percent of total)		
N	2	10
NE	1	5
E	28	10
SE	38	17
s	16	16
Sw	1	10
w	4	25
Nw	10	6

Table 13. Rates of movement and direction of flight of Oldsquaw in the nearshore zone of the Beaufort Sea.

After 23 August Oldsquaw movement increases to 31 birds per hour with westerly movements constituting 41 percent of the total, indicating that some migration is taking place.

F. Eider

Two species of eider, the Common (Somateria mollisima) and King (S. spectabilis) are regular and common in the Alaskan Beaufort. Two other species, Steller's Eider (Polysticta stelleri) and Spectacle Eider (S. fischeri) are rarely seen in the Alaskan Beaufort though they are regular but uncommon breeders on the coastal North Slope tundra (Pitelka, 1974). Of the King and Common, the former is much more abundant with the total number migrating westward past Pt. Barrow estimated to be over one million birds (Thompson and Person, 1963). T.W. Barry (in Bellrose, 1976) estimated the Beaufort Sea Common Eider population to be 275 thousand birds. The two species differ in their breeding habits in that King Eiders breed on wet tundra, while Common Eiders breed on islands and at other coastal marine locations.

1. Spring migration

In late May eiders move north from the Bering Sea and other North Pacific locations to breeding grounds in the arctic. The lead that forms in the ice from the Bering Strait north to Pt. Barrow is a major migratory pathway for King and Common Eiders. This research unit conducted the first systematic observations at the edge of the lead at Pt. Barrow, from 6 May to 4 June 1976 (Woodby and Divoky, 1982). King Eiders were first seen at the lead on 16 May but were uncommon until 26 May when 360 thousand passed within a ten hour period with a projected total of 500 thousand for the 24-hour period. This large pulse of birds was associated with the first warm southwest (following) winds after a period of cold weather and north and east winds. The eiders observed on 26 May must have been staging south of Cape Lisburne since an aerial survey of the lead between Pt. Barrow and Cape Lisburne on 19 May revealed only 5 thousand eider in a narrow partially refrozen lead. The eiders were apparently in the southern Chukchi Sea or northern Bering waiting for suitable weather. King Eiders continued to pass Pt. Barrow until 4 June when our observations ceased. The projected passage for the 30-day sampling period was 800 thousand King Eiders. Males comprised the majority of birds in the major flight on 26 May with females more abundant towards the end of the observations. 65 percent of the birds seen on 4 June were females.

Common Eiders are later spring migrants than Kings. A projected total of 875 Common Eiders passed from 6 May to 3 June. On 4 June, 10 thousand passed north-eastward over the lead and it is likely much Common Eider migration took place after 4 June.

After passing Pt. Barrow eiders move in an ENE direction (Flock, 1973) rather than following the coast. The flaw lead that the eiders follow to Pt. Barrow ends northeast of the Point. A series of poorly defined offshore leads are present in the Beaufort and eiders continue their migration over them. No censusing of these leads in Alaska has been done but it is reasonable to assume that birds do not usually sit in them except when held up by weather or when in the vicinity of nesting grounds. Searing et al. (1975) found over 75 thousand Common Eiders in a single lead in the eastern Beaufort on 21 May 1974. In springs when unseasonably late freezing occurs the refreezing of these leads can cause major eider mortality as it did in 1964 when an estimated 100 thousand eiders starved (Barry, 1968).

2. Breeding

Because King Eiders breed on wet mainland tundra, the species has little or no contact with marine waters during breeding. Common Eiders, however, nest on islands and spits and are residents of the nearshore regime during breeding. In both species males leave the female shortly after eggs are laid and fly westward to molting areas (Johnson and Richardson, 1982).

Common Eiders are found breeding in the Alaskan Beaufort from Thetis Island east to Demarcation Bay on islands and spits that are surrounded by river runoff in late May and June. The number of nests in the Alaskan Beaufort is not large. A 1976 survey found 420 nests (Divoky, 1978 b). The area where Common Eider nests are most numerous (Jones Islands and Prudhoe Bay regions) can be expected to have regular use of nearshore waters during the breeding season by breeding Common Eiders, non-breeding females associated with the breeding colonies , and newly hatched young. Schamel (1974 and 1978) provides information on Common Eider numbers and habitat use in the vicinity of Egg Island.

3. Post-breeding dispersion and migration

Male King and Common Eiders begin their westward molt migration in late June and early July (Johnson and Richardson, 1982). Eiders passing Pt. Barrow are primarily males until approximately 15 August when females become the majority. Females and young of the year continue to pass Pt. Barrow until at least late October (Bailey, 1948).

Aerial surveys conducted by this research unit (Divoky 1979b) and others (Johnson and Richardson, 1981; Spindler, 1981) have shown that eiders are uncommon in the nearshore waters of the Alaskan Beaufort except as migrants. Prior to August, when our observations from vessels begin the only areas having numbers of sitting eiders are adjacent to islands with breeding colonies. It thus appears that eiders do little if any staging in the nearshore Alaskan Beaufort prior to their westward movement.

Our August and September vessel observations corroborate aerial data in showing that eiders use the Alaskan Beaufort primarily as migrants with few instances of resting or staging. More than any other species eiders move through the Alaskan Beaufort in a narrow migratory corridor so the frequency with which one encounters eiders is dependent on proximity to the migratory corridor. The location of this corridor will be discussed after some general comments about eiders in the pelagic and nearshore regimes.

a. Pelagic observations

Eiders in the pelagic regime are found almost exclusively adjacent to nearshore waters. Of the 2 thousand eiders we have observed in pelagic waters all but 100 (5 percent) were within 5 km of the 20 m isobath. Of the 2 thousand eider, 72 percent were actively migrating with movement being almost exclusively westward. Five flocks totalling 1380 birds comprised the majority of all eiders encountered. The presence of eider in the pelagic zone does not appear to vary with time during the period we sampled.

Table 14 presents eider densities for the five regions of the pelagic Beaufort. It should be remembered that those densities are principally of flying migrants. The low densities and frequencies demonstrate the few eiders present in the pelagic regime. All high densities are from areas directly adjacent to the nearshore zone.

b. Nearshore observations

As with pelagic observations eiders in the nearshore regime are primarily migrants. Of the 10 thousand eider observed on nearshore cruises, 87 percent have been actively migrating with almost all movement being westward. Table 15 shows that the densities and-frequencies of eider in the nearshore regime are much higher than in the pelagic. High densities and frequencies are primarily indicative that censusing was conducted in the migratory corridor and thus comparisons between years and areas are of questionable value. Information on densities of eiders sitting on the water is presented after the discussion of the migratory corridor.

c. Migratory corridor of eiders

The path that migratory eiders take along the Alaskan Beaufort has been in question for some time. While the eider pass at Pt. Barrow is known to be major (Thompson and Person, 1963; Johnson, 1971) at other localities less movement is observed, i.e. Simpson Lagoon (Johnson and Richardson, 1981). Bartels (1973) used pelagic and aerial nearshore observations to attempt to locate migrating eiders, and believed most migration occurred 13 to 16 km from shore. The geographic location of Bartel's sightings are not given and thus they cannot be integrated with our data.

In order to locate the principal migration corridor of eiders in the Alaskan Beaufort we plotted all observations of migrating flocks of 25 birds or more that have been observed on pelagic and nearshore cruises (Fig. 8). These observations will be discussed on a west to east basis and will be supplemented by other observations when appropriate.

In the Plover Islands eiders pass westward on a relatively broad front. Observations from Cooper Island indicate that much movement occurs near the south shore of Elson Lagoon. Our 1978 censusing of Elson Lagoon confirmed this since most eiders were seen "off transect" to the south. This is also consistent with observations of where eiders cross the Pt. Barrow spit. "Duck Camp," where most eider hunting occurs, is located at the junction of the spit and the mainland. Most of our nearshore sampling from vessels has been just north of the Plover Islands and only minor movement has been observed there. Few observations in the pelagic waters north of the Plovers have been made but a flock of 500, 8 km from shore on 17 September 1976, indicates that flocks occasionally pass by well north of the islands. Flock's (1973) radar observations showed eider flocks passing both north and south of the islands before turning southwest into the Chukchi. Incidental observations of eider migration near Cooper Island in 1982 showed that eiders pass over the island most frequently when winds are from the southeast.

Observations of flocks made from Tangent Pt. to Cape Simpson show that eider pass within 5 km of the shore. Many apparently enter Elson Lagoon near

AVERAGE DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	.5	0	.7	.7	1.2
872	0	0	.2	.9	15.3
876	0	0	0	< .1	
877	< .1	< .1	.8	0	.3
878	0		0	.2	12.9
976	4.4	< .1	0		

PERCENT TRANSECTS WHEN PRESENT

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	05	00	02	03	09
872	00	00	03	02	10
876	00	00	00	03	
877	01	02	01	00	02
878	00	-	00	02	11
976	10	02	00		

MAXIMUM DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	10.2	0	30	63	48
872	0	0	6.6	42	478
876	0	0	0	1	-
877	5.8	3.6	57.6	0	28.8
878	O "		0	11.5	828
976	200	3.5	0		

Table 14. Average densities, percent transects when present and maximum densities of Eider in the five regions of the Alaskan Beaufort Sea pelagic regime.

AVERAGE DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
867	9	.2	69	2	3	3
877	21	10	3	.1	111	8
878	15	1 46	5	6	9	

PERCENT TRANSECTS WHEN PRESENT

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	36	13	79	11	15	07
877	24	16	07	03	22	16
878	48	34	15	11	18	

MAXIMUM DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	65	2	323	33	44	75
877	725	227	65	5	1370	90
878	198	1200	66	113	155	

Table 15. Average densities, percent transects when present, and maximum densities of Eider in the six regions of the Alaskan Beaufort Sea inshore regime.

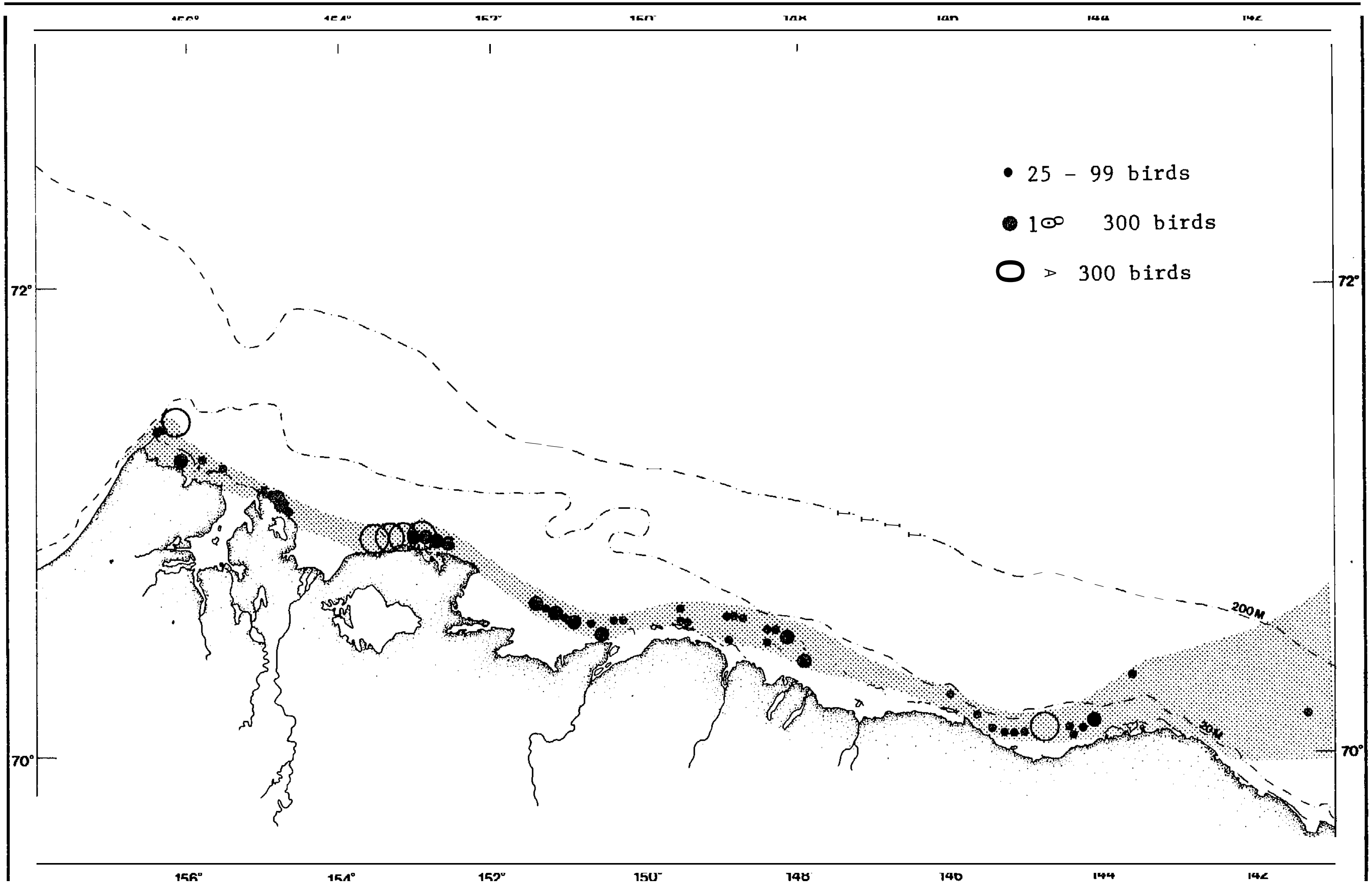


Figure 8. The location and size of all flying eider flocks of more than 25 birds. Shading delineates the apparent location of the migratory corridor used by eiders.

Tangent Pt. moving west past Christie and Scott Points.

Limited censusing has been done at the mouth of Smith Bay but there is little doubt that birds move northwest across the mouth. The area from Pitt Point to Cape Halkett has produced a number of sightings; some of very large flocks. On 8 August 1978 three hours of observation averaged over 15 hundred birds per hour. This includes only birds on transects within 300 m of the vessel. The migration was occurring 2 to 3 km from shore.

Censusing in Harrison Bay shows that migrating eider are absent from the bay's interior but move WNW on a line from Thetis and Spy Islands to Cape Halkett. While extensive sampling of the lagoonal areas in the Jones Islands and Prudhoe Bay regions has been conducted from vessels, we have not observed a migrant eider flock of over 25 birds inside of the islands. Censusing done outside of the islands show that eiders migrate between the barrier islands and the 20 m isobath. Observations in Camden Bay show birds are commonly passing along the 20 m isobath. Far fewer eiders are seen to the north and south.

East of Barter Island we lack nearshore censusing and have not seen eider on pelagic transects at the 20 m isobath. The 20 m isobath is so close to shore in this area (5 to 6 km) that large eider flocks in the nearshore regime would be obvious from some of the pelagic transects. Two sightings offshore west of Barter Island are of interest. The only two eider flocks larger than 25 birds we have seen well offshore have both been in this area. Both flocks were moving southwest. This indicates that some eider from the Canadian arctic islands are moving southwest to the area of Camden Bay. That an offshore migration occurs that bypasses the section of the southeastern Beaufort adjacent to the Mackenzie River Delta is supported by the observation of large numbers of eiders seen passing Cape Bathhurst (on the eastern edge of the Mackenzie River Delta) (Anderson, 1937) and from the paucity of sightings from further west in Canada (Johnson and Richardson, 1982; Salter et al., 1980).

It is possible that some eiders move over the eastern and central Beaufort at high altitudes (out of sight of observers) and descend in the western Beaufort where they then pass Pt. Barrow. On 8 August 1978 during a day of particularly intense eider migration, a flock of 200 eider was observed at an altitude of 1 to 2 km just north of Pitt Point. Almost all observations of eiders migrating through the Beaufort are of birds between 1 and 10 m high. Our sighting of a flock migrating at quite a high altitude suggests that some eiders may move over the eastern and central Beaufort at altitudes where they are too high to be detected by observers. This would help to explain the difference between the large eider flocks seen at Pt. Barrow and the lesser numbers to the east. This difference is partially explained, however, by our delineation of the migratory corridor.

d. Sitting Eiders

Of all eiders seen on cruises in the nearshore and pelagic Beaufort the percentage seen sitting on the water is 28 percent in the pelagic regime and 13 percent for the nearshore. The locations of all sitting eider flocks of more than 10 birds are shown in Figure 9. These flocks account for all but 6 percent of our observations of eiders on the water. Over 99 percent of the eiders sitting on pelagic waters are on or adjacent to the 20 m isobath. These observations are merged with nearshore censusing in Table 16. Regions listed correspond to the six nearshore regions used throughout this report but certain regions have been subdivided to provide greater resolution.

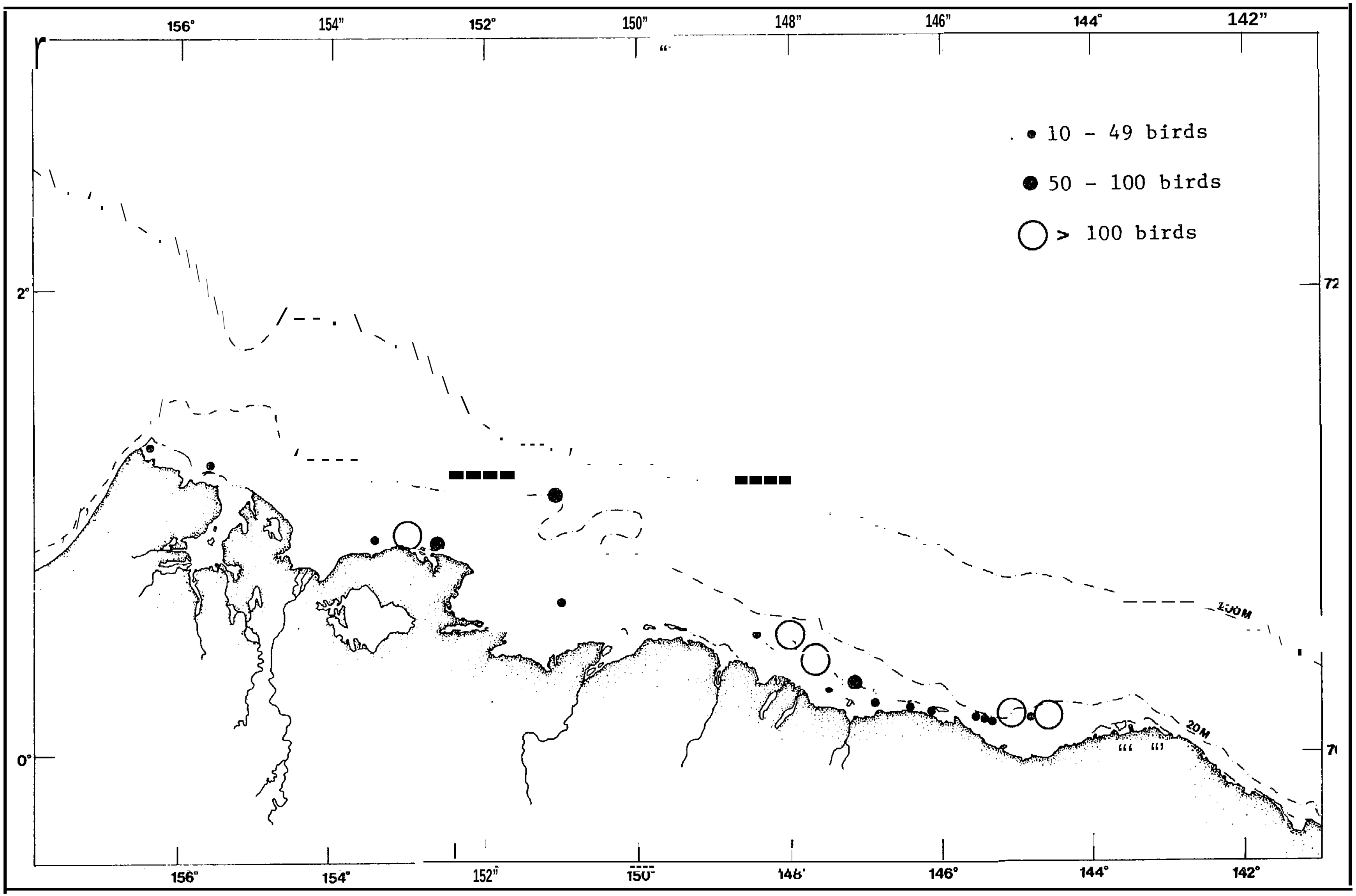


Figure 9. The location and size of all sitting eider flocks of more than ten birds.

	1976	1977	1978
North of Plover Islands	1.7	0.2	3.7
Elson Lagoon			.5
Smith Bay		0	.9
Pitt Point	.8	8.5	.4
Harrison Bay	3.1	0	0
North of Jones Islands	.1	1.2	.6
Simpson Lagoon	0	0	0
Prudhoe Bay	2.9	61.8	2.7
Camden Bay	1.0	0	36.0
Barter Island	0	0	

Table 16. Densities of eiders (birds per km sq.) sitting on water in the nearshore Beaufort Sea.

Regular but low densities of sitting eiders were found north of the Plovers each year. Observations from Cooper Island show that a small number of King Eider (usually less than 50) are present on and north of the island during August. No flock larger than 15 birds has been observed on the water in this region. The Pitt Point region has regular low to moderate densities on what we have delineated as the principal migratory corridor in the area. While eiders cross the mouth of Harrison Bay in numbers they rarely sit there since we have recorded only two flocks. Many of the eider encountered east of Harrison Bay are associated with breeding colonies on barrier islands. Our sampling in the Jones Island/Simpson Lagoon area shows that birds are regular and uncommon north of the islands and absent from the lagoon. The Prudhoe Bay area consistently had eiders on the water both landward and seaward of the islands. While most of these birds are associated with breeding colonies, "migrant" flocks of 350 and 370 have been seen resting seaward of the islands.

In Camden Bay we have encountered two large eider flocks, one of 120 birds in 1972 and one of 300 in 1978, associated with a pingo-like shoal. The flock in 1978 appeared to be feeding. If eiders are moving west and southwest over the offshore Canadian Beaufort to the Alaskan coast, Camden Bay may be their first landfall and thus possibly a staging area before moving west down the coast.

In summary, the areas near eider breeding islands in the Jones Island and Prudhoe Bay regions have regular and moderate numbers of eiders on the water during August. Because migrating eiders occasionally sit down in the Beaufort large sitting flocks can be expected anywhere in the migratory corridor, although we have found them to be more common in the eastern Alaskan Beaufort. The Plover Islands, where eiders do not breed and no large sitting flocks have been encountered, has small numbers of molting males that use the islands as roosting sites.

G. Scoters

Sightings of scoters have been made on only 11 transects, all in nearshore waters. Surf Scoters (Melanitta perspicillata) have been seen on nine transects and White-winged Scoters (M. deglandi) on two. All sightings, but one, have been confined to a remarkably small region encompassing the area south of Thetis Island and western Simpson Lagoon, all within 20 km of Oliktok Pt. All these sightings were of less than five birds. The only sighting out of the Oliktok Pt. area is of a flock of 33 birds near Barter Island. Six of our sightings are from 1978 when Johnson and Richardson (1982) found them to be common molt migrants in the Simpson Lagoon area. Surf Scoters are abundant further east in the Canadian Beaufort where large numbers molt near Herschel Island (Vermeer and Anweiler, 1975).

H. Phalaropes

Phalaropes are the smallest seabirds present in the pelagic Beaufort, weighing approximately 50 g. Both Red (Phalaropus fulicarius) and Northern (P. lobatus) Phalaropes occur in the Alaskan Beaufort. Red Phalaropes are the most commonly encountered species although Northerns may be occasionally common in the littoral (Connors, 1979). Northern Phalaropes are common in nearshore habitats in the Canadian Beaufort (Vermeer and Anweiler, 1975). Phalaropes are frequently difficult to identify to species when observed from vessels and all sightings presented here are treated simply as phalaropes. There seems little doubt that Red Phalaropes constitute the majority of phalaropes we have observed. Collecting from small boats during cruises has produced only Red Phalaropes. Phalaropes breed circumpolarly on tundra and winter, in temperate and tropical marine waters.

1. Spring migration and breeding season

Phalaropes move through the Bering Sea in late May (Divoky, in prep.) and arrive on the coastal tundra of the Alaskan Beaufort the first week in June (Bergman et al., 1977). They are not observed in numbers over the flaw lead in the Chukchi (Flock and Hubbard, 1979; Woodby and Divoky, 1982) and it is likely the final stages of migration are overland. Some birds may move offshore, however, since Schamel (1978) saw phalaropes approaching the Beaufort coast from the north. Female phalaropes leave the breeding grounds shortly after egg-laying and in late June and early July small numbers of females are seen near barrier islands (Schamel, 1976; Divoky, 1978a). Phalaropes remain uncommon in the nearshore until late July and early August when large numbers of males and young are present in the littoral (Connors, 1979; Divoky, 1978a).

2. Post-breeding dispersion and migration

a. Pelagic observations

Phalaropes are common and regular in the Plover Islands region averaging 16.5 birds per km sq. and present on 40 percent of the pelagic transects (Tables 17, 34 and 36). Regions to the east have overall densities of <1 bird per km sq. with the exception of Pitt Point which averages 1.1 per km sq. Frequencies of occurrence for regions east of the Plovers are <13 percent. The large numbers of phalaropes present in the pelagic waters north of the Plovers and the lesser numbers to the east may indicate that 1) phalaropes move westward in nearshore areas until they reach the Plovers and then move offshore to feed, or 2) phalaropes migrate quickly through most of the pelagic Beaufort until they reach the Plover Island area where they then begin feeding. Densities of phalaropes in the Plover Islands pelagic region can exceed 300 birds per km sq. (Table 17).

b. Nearshore observations

The average phalarope density in the nearshore Plover Islands region approximates that for the pelagic area of same region (17.9 vs 16.5 birds per km sq.)(Tables 18 and 35). Three regions to the east (Pitt Point, Jones Islands and Prudhoe Bay) have substantially higher nearshore than pelagic densities. Both Harrison Bay and the East of Flaxman regions have little difference in their nearshore and pelagic densities. Our nearshore censusing east of Flaxman Island is primarily in Camden Bay and higher phalarope densities could be expected east of Barter Island near Icy Reef. Harrison Bay and the East of Flaxman region have low frequencies of occurrence for phalaropes (11 and 8 percent respectively) while the other four regions have higher frequencies (29 to 37 percent) (Tables 18 and 37).

AVERAGE DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	45.7	0	.5	.7	0
872	2.7	1.1	.7	< .1	.7
876	38.5	.6	0	0	-
877	2.1	.1	1.1	4.8	.1
878	1.8		0	0	.5
976	19.5	3.3	.2		

PERCENT TRANSECTS WHEN PRESENT

cruise					
871	40	00	02	04	(')0
872	25	18	11	0?	17
876	53	11	00	00	
877	27	11	17	20	05
878	32		00	00	09
976	54	19	04		

MAXIMUM DENSITY (birds/km^2)

cruise					
871	366	0	20	12	0
872	10.8	19.6	8.8	2.8	13.5
876	301	8.8	0	0	-
877	32.4	.7	26.4	94.3	6.5
878	13.6	-	0	0	10.4
976	166.8	66.5	5.8		

Table 17. Average densities, percent transects when present and maximum densities of Phalaropes in the five regions of the Alaskan Beaufort Sea pelagic regime.

AVERAGE DENSITY (birds/km*)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	114	53	.3	4	1.4	.8
877	12	4.6	.8	2	.2	.5
878	2.3	.9	.5	7	13	

PERCENT TRANSECTS WHEN PRESENT

cruise						
876	72	100	14	42	15	11
877	38	31	14	12	04	05
878	14	28	08	28	44	

MAXIMUM DENSITY (birds/km^2)

cruise						
876	883	201	2	32	34	16
877	99	14	15	70		9
878	36	7	11	156	7?:	

Table 18. Average densities, percent transects when present and maximum densities of Phalaropes in the six regions of the Alaskan Beaufort Sea inshore regime.

I. Jaegers

The three species of jaegers, Pomarine (Stercorarius pomarinus), Parasitic (S. parasiticus), and Long-tailed (S. longicaudus) all occur in the Beaufort Sea. When at sea the first two species regularly pirate prey from other birds (kleptoparasitism). The Parasitic also regularly eats small birds, such as phalaropes. The Long-tailed eats primarily aquatic prey which it obtains directly. All three species winter offshore in tropical and temperate waters and breed on tundra habitats where they are linked to terrestrial and freshwater systems (Ashmole, 1970).

1. Spring migration and breeding season

Jaegers become common in the Bering Sea in late May (Divoky, in prep.) and arrive in the Alaskan arctic in the last days of May (Bailey, 1948). Migration to arctic breeding grounds apparently takes place largely overland (Dean et al., 1975). Few are seen in migration over the flaw lead at Pt. Barrow (Woodby and Divoky, 1982) but coastal locations further east in the Beaufort have sizeable jaeger migrations (Richardson and Johnson, 1981).

The number of jaegers breeding in a given year is dependent on lemming cycles (Pitelka et al., 1965) with large fluctuations being common. The jaeger population for NPR-A was found to be between 54 and 65 thousand in 1977 and 1978 (King, 1980). Unlike many other species, jaegers were as common in the southern (well drained) area of NPR-A as in the coastal sections with large areas of wet tundra, demonstrating the jaegers' dependence on terrestrial prey during the breeding season.

Observations at nearshore locations show that jaegers are typically present in low numbers in June and July (Divoky, 1978a; Schamel, 1978). In certain years (apparently when low prey densities prevent many birds from breeding) rather large westward movements can occur in late June and early July (Divoky, in prep.). At Cooper Island, Parasitic Jaegers regularly pirate fish from terns and prey on eggs of terns and Oldsquaws. Jaegers can be expected to occur offshore in small numbers in June and July wherever gulls and terns provide opportunities for piracy. Limited shipboard censusing in July found small numbers of Parasitic Jaegers (Divoky, unpubl.). Aerial surveys in June and July did not find jaegers offshore, however (Harrison 1977).

2. August and September

a. Pelagic observations

Jaegers are attracted to icebreakers because of the large numbers of gulls feeding in the wake and the cod made available by icebreaking. For that reason jaeger densities obtained in the pelagic regime may be somewhat inflated (Table 19). Jaegers are well distributed in the pelagic regime (Table 34) with each region having an overall average of .1 bird per km sq. or higher. The Plover Islands have the highest average density (.3 birds per km sq.). Jaegers are present on 20 percent of all transects in the Plover Islands and between 7 and 13 percent of the transects in regions to the east. Jaegers are nowhere abundant with 6.7 birds per km sq. the highest density encountered.

AVERAGE DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	.8	.2	< .1	.2	< .1
872	0.0	< .1	.1	.3	.2
876	.7	.3	.3	.2	
877	.2	< .1	< .1	< .1	.1
878	< .1		0.0	.2	.1
976	.3	.5	.2		

PERCENT TRANSECTS WHEN PRESENT

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	55	24	05	17	05
872	00	04	08	16	16
876	27	11	09	06	-
877	12	02	09	10	09
878	05		00	09	09
976	22	24	07	-	-

MAXIMUM DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	3.4	1.4	1.4	3.1	2.1
872	0.0	2.2	1.4	2.8	2.8
876	6.7	5.0	4.4	4.0	
877	3.8	.8	1.2	1.5	3.6
878	.8		0.0	2.2	2.4
976	3.1	5.3	3.5		

Table 19. Average densities, percent transects when present and maximum densities of Jaegers in the five regions of the Alaskan Beaufort Sea pelagic regime.

b. Nearshore observations

Unlike the pelagic regime where jaegers are rather evenly distributed, the nearshore of the Plover Islands region has a high average density (.6 birds per km sq.) and a high frequency of occurrence (20 percent) while regions to the east all average .1 bird per km sq. with the exception of the East of Flaxman region where no jaegers were seen. Frequency of occurrence in the four central nearshore regions averaged between 4 and 8 percent(Tables 20, 35 and 37.).

J. Glaucous Gulls

The Glaucous Gull is the common "Larus" gull found in arctic Alaska. It is circumpolar in its breeding distribution and breeds as far south as the Yukon-Kuskokwim Delta. Glaucous Gulls are a ubiquitous part of wet tundra habitats on the North Slope and much of the Beaufort Sea. The species is highly opportunistic in its feeding habits (Ingolfsson, 1967) which include scavenging on natural carrion and human garbage; preying on fish, zooplankton and small birds and mammals. Plentiful food sources can attract large flocks (i.e. the garbage dump at Barrow).

1. Spring migration

Glaucous Gulls winter as far north as Kotzebue Sound (Swartz, 1966) but are most common in subarctic waters from the Bering Sea ice edge (Divoky, in prep.) south with vagrants seen as far south as California.

Glaucous Gulls are early migrants. Observations at the flaw lead at Pt. Barrow (Woodby and Divoky, 1982) conducted by this research unit showed that Glaucous Gulls were present on 6 May when observations began and that 50 percent of the 3500 birds seen between 6 May and 4 June had passed by 23 May. ‘Richardson Johnson (1981) found most movement past Oliktok and Milne Pts. occurred in late May and early June. Sub-adult birds do not move into Beaufort waters until the latter part of the migration.

2. Breeding

Glaucous Gulls breed on both tundra habitats and barrier islands. King (1979) found between 12 and 19 thousand “gulls” breeding on NPR-A in 1977 and 1978. This included both Glaucous and Sabine's Gulls but Glaucous Gulls comprised over 85 percent of the total. Breeding on barrier islands occurs primarily between Harrison and Camden Bay on islands surrounded by river runoff. A 1976 census of all Beaufort islands found a total of 445 nests. Glaucous Gulls are early nesters with eggs being laid in the first week of June. Successful adults remain in nesting areas until late August(Divoky, 1978b).

Glaucous Gulls do not breed until at least their third summer and have thus had a large non-breeding population. The size of the sub-adult population is determined by recent breeding success and mortality of young. It is likely that most Glaucous Gulls seen in the pelagic regime in August and, with the exception of the Prudhoe Bay, the nearshore region, are part of this non-breeding population or are failed breeders. The age composition of Glaucous Gulls seen on two pelagic and three nearshore cruises shows that the majority of birds we have observed have obtained adult plumage, indicating that many birds do not breed their first year after having obtained adult plumage(Table 21). The Glaucous Gull

AVERAGE DENSITY (birds/km*)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	.4	0	< .1	.1	.2	0
877	.4	.1	.2	0	0	0
878	.9	< .1	< .1	< .1	.1	

PERCENT TRANSECTS WHEN PRESENT

cruise						
876	27	00	07	04	15	00
877	11	06	10	00	00	00
878	26	06	03	06	08	

MAXIMUM DENSITY (birds/km^2)

cruise						
876	1.8	0.0	.9	3.6	3.0	0.0
877	9.4	1.8	2.4	0.0	0.0	0.0
878	10.1	1.2	1.6	1.6	2.4	

Table 20. Average densities, percent transects when present and maximum densities of jaegers in the six regions of the Alaskan Beaufort Sea nearshore regime.

	Pelagic		Nearshore		
	1977	1978	1976	1977	1978
Total aged	383	295	33	102	133
Percent adult	76	74	91	60	67
Percent sub-adult	23	26	9	40	31
Percent hatching year	0	1			2

Table 21. Age composition of Glaucous Gulls observed on two pelagic and three nearshore cruises.

non-breeding population is not tied to nest sites and is able to respond to locally abundant food resources.

3. August and September

a. Pelagic observations

Aerial censusing in June and July shows that Glaucous Gulls are present offshore in densities of < .1 per km sq. (Divoky 1979b; Harrison 1977). Densities during this time are almost certainly dependent on the amount of open water available. Glaucous Gulls are, however, able to feed in areas with complete ice cover by scavenging marine mammal feces and carrion.

More than any other species, except perhaps the Black-legged Kittiwake, Glaucous Gulls are attracted to the icebreakers that we use for observation platforms in the pelagic regime. During icebreaking operations where Arctic Cod are made more available as they are washed onto the ice and brought to the surface in the ship's prop wash, large flocks of Glaucous Gulls will gather to feed behind the ship. The amount of cod made available and the number of birds following the ship depends on the method of icebreaking. For this reason counting only ship followers, as Frame (1973) did, gives values that are greatly affected by the ice conditions and the activity of the ship. In addition, garbage thrown from the ship is a substantial food source when one considers the more than 200 crewmen aboard most icebreakers. Because Glaucous Gulls are attracted to icebreakers, the densities obtained for them are less reliable than for most other species. There is little doubt that in certain cases densities are exaggerated, but the attraction of the ship can also result in deflated densities. A ship sitting on station for 24 hours can attract many of the Glaucous Gulls that are usually dispersed over a large area. When the ship steams away from the garbage and bird observations begin, few if any Glaucous Gulls would be encountered since they are all behind the ship preying on cod or have remained with the garbage.

Densities of Glaucous Gulls in the pelagic regime are presented in Tables 22 34. In August densities are between .2 and .8 birds per km sq. with maximum densities of less than 7 birds per km sq. On the two cruises that censused to mid-September (878 and 976) densities were higher than 1 bird per km sq. in the central and western Alaskan Beaufort and a high of 14.4 birds per km sq. Like many surface feeding species the Glaucous Gull is most abundant in the western Alaskan Beaufort. The average density for the Plover Islands region is twice that for the East of Flaxman Island region (.8 vs. .4 birds per km sq.). The frequency of occurrence of Glaucous Gulls is rather constant throughout the Beaufort being found on approximately one quarter of the transects in each region (Tables 22 and 36).

The movements of Glaucous Gulls in pelagic waters can be. divided into two periods (Table 23). From 7 to 27 August the rate of bird movement is low (.4 per hr.) and not primarily westerly. Movements during this period are predominantly to the south and east, the significance of which is not clear. From 28 August to 18 September movement was 1.8 birds per hour and 62 percent of these were moving westward. Movement from 14 - 18 September was 2.5 birds per hour and it appears that rates of a movement offshore are highest after our observations cease. Bailey (1948) mentions major movements past Barrow

AVERAGE DENSITY (birds/km*)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	.2	.3	.3	.7	.4
872	.4	.7	.6	.4	.3
876	.8	.5	.4	.4	-
877	.2	.3	.4	.4	.2
878	1.2		.9	.5	.6
976	1.7	1.1	1.0		

PERCENT TRANSECTS WHEN PRESENT

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	25	36	22	41	26
872	25	42	25	17	16
876	27	15	09	09	-
877	12	18	21	17	10
878	37	-	46	22	38
976	52	33	29		

MAXIMUM DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	1.4	1.4	4.2	12	1.8
872	1.4	5.6	5.5	5.4	5.4
876	6.0	3.5	6.6	4.0	
877	2.4	4.3	7.2	3.0	7.2
878	14.4		3.6	4.8	3.6
976	10.4	7.3	9.6		-

Table 22. Average densities, percent transects when present and maximum densities of Glaucous Gulls in the five regions of the Alaskan Beaufort Sea pelagic regime.

	7-27 August	28 August-18 September
Dates:	7-27 August	28 August-18 September
Hr. of observation:	71	121.5
Total Glaucous Gulls recorded with flight direction:	28	214
Glaucous Gulls/hr:	.4	1.8
Flight direction: (percent of total)		
N	7	5
NE	0	3
E	21	6
SE	32	4
S	14	9
Sw	4	10
W	21	43
Nw	0	9

Table 23. Rates of movement and direction of flight of Glaucous Gulls in the pelagic zone of the Beaufort Sea.

after mid-September.

b. Nearshore observations

Glaucous Gulls are present in the nearshore in June and July both in areas with breeding colonies (Schamel, 1978; Johnson and Richardson, 1981) and in areas without colonies (Divoky, 1978a, Divoky, 1979b). The numbers present in the latter areas depend on food resources. On Cooper Island in 1978, numbers of dead Parathemisto libellula washed onto the island during moat formation in July and over 100 Glaucous Gulls congregated at this food source. In most areas there is a steady increase in Glaucous Gull numbers peaking in early and mid-September (Divoky, 1978a; Johnson and Richardson, 1981) and being most abundant in the littoral zone.

Nearshore observations of Glaucous Gulls from vessels are not complicated by the factors discussed for pelagic observations from icebreakers. The 30 to 60 foot vessels used in the nearshore do not break ice or dump large quantities of garbage. For that reason the values obtained for the nearshore are more reliable than for the pelagic regime.

Nearshore observations from vessels (Table 24 and 35) show that the Plover Islands region has the highest densities for the Beaufort with an average density of 3.0 birds per km sq. All other regions average less than 1 bird per km sq. with the exception of Prudhoe Bay when in 1978 a large flock was present near the "West Dock." Large flocks are uncommon except in the Plover Island region with most areas having maximum densities of 10 birds per km sq.

The three western regions had Glaucous Gulls present on an average of 26 to 39 percent of all transects. The three eastern regions had frequency percentage averaging between 13 and 22 percent. (Tables 24 and 37)

The analysis of movements in the nearshore is complicated by the large numbers of birds encountered in the Plover Island region. Table 25 shows that from 2 to 16 August there is little westerly movement. The rate of movement during this period is high (1.5 per hr.) because of sampling in the Plovers where large numbers of gulls have congregated and are searching for food. Westward movement appears to begin on 17 August with 54 percent of all birds seen past that date moving in a westerly direction. This indicates birds in the nearshore begin to move west before those in the pelagic regime.

Our nearshore observations do not occur in September when Glaucous Gulls are at their highest densities on spits and barrier islands (Divoky 1979) and areas containing spits or barrier island chains have their highest Glaucous Gull densities at that time.

K. Other Larus gulls

While the vast majority of Larus gulls seen in the Alaskan Beaufort are Glaucous Gulls, some gulls with dark wing-tips are encountered. Both Herring Gulls (Larus argentatus) and Thayer's Gulls (Larus thayeri) are present in the Beaufort but many birds cannot be identified to species. Larus gulls with dark wing-tips have been seen on 3 percent of the pelagic transects and 1 percent of nearshore transects. The majority of our sightings have been in late August and early September.

AVERAGE DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
867	1.5	.5	.8	.2	.4	.5
877	2.0	.7	.7	.1	.9	.2
878	4.4	.5	.8	.6	1.5	

PERCENT TRANSECTS WHEN PRESENT

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	36	25	57	13	30	11
877	40	31	38	09	39	14
878	36	2 2	33	21	15	

MAXIMUM DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	6.3	1.9	4.2	3.3	3.0	9.5
877	24.3	5.4	2.4	1.7	2.6	1.7
878	126.7	3.6	5.4	9.4	85.2	

Table 24. Average densities, percent transects when present and maximum densities of Glaucous Gulls in the six regions of the Alaskan Beaufort Sea inshore regime.

Dates:	2-16 August	17-30 August
Hr. of observation:	52.3	100.3
Total Glaucous Gulls recorded with flight direction:	80	72
Glaucous Gulls/hr:	1.5	.7
Flignc Direction: (percent of total)		
N	18	11
NE	21	8
E	5	17
SE	15	3
S	18	7
Sw	6	12
W	11	31
Nw	6	11

Table 25. Rates of movement and direction of flight of Glaucous Gulls in the nearshore zone of the Beaufort Sea.

L. Ivory Gull

The Ivory Gull (Pagophila eburnea) is a circumpolar high arctic breeder that is typically associated with pack ice throughout the year. Breeding has been recorded on the Canadian Arctic Archipelago (MacDonald and McPherson, 1962) and apparently some of these birds move through the Beaufort to and from wintering areas in the Bering Sea (Divoky, in prep.).

1. Spring migration

Ivory Gulls enter the Chukchi Sea in early May and are regular at Wainwright during mid and late May (Bailey, 1948). The number that move northeast past Pt. Barrow into the Beaufort is not known. Brewer (in Bailey, 1948) considered them common at Barrow in the spring but observations at the lead in 1976 from 6 May to 4 June failed to produce any sightings (Woodby and Divoky, 1982).

No sightings of Ivory Gulls have been made in the Alaskan Beaufort in June and July (Divoky 1979b; Harrison, 1977).

2. August and September

a. Pelagic observations

Ivory Gulls are rare in the pelagic Alaskan Beaufort during the period of our shipboard observations (Table 26). They have been seen on 2 percent of all transects with a total of 19 sightings. In two of the five years none were seen. No influx into the Beaufort in September, as one would expect, was observed. All sightings were between 10 and 31 August. Thus the birds we encountered may be non-breeders summering in the Beaufort. All were in adult plumage, however. Frame (1973) saw two Ivory Gulls in the Beaufort in early August. No Ivory Gulls have been seen in the nearshore or littoral zones.

M. Black-legged Kittiwake

The Black-legged Kittiwake (Rissa tridactyla) is the most truly pelagic of the gulls found in arctic Alaska. It nests on rock cliffs as far north as Cape Lisburne (Springer et al., 1982) and winters in subarctic waters from the Bering Sea ice edge south. The bulk of the kittiwakes encountered in the Beaufort Sea are apparently non-breeders, based on their presence in the Beaufort during the breeding season, although approximately half have obtained adult plumage. Banding studies in Great Britain have shown that some non-breeding birds from British colonies spend the summer at the ice edge off Greenland (Coulson, 1966) and our observations at the Chukchi and Beaufort ice edge show a similar pattern for western arctic kittiwakes. The kittiwakes present in the Beaufort Sea in summer are not tied to nest sites and their distribution and abundance is related almost solely to prey availability.

In most situations kittiwakes are not a common ship follower since they do not eat garbage. In the ice-covered areas of the Beaufort, however, large flocks of kittiwakes will gather behind the ship to feed on Arctic Cod made available by the icebreaking activities of the ship. These flocks reduce the

AVERAGE DENSITY (birds/km*)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	0.0	< .1	.1	< .1	0.0
872	0.0	0.0	0.0	< .1	< .1
876	0.0	0.0	0.0	0.0	0.0
877	< .1	0.0	< .1	0.0	< .1
878	0.0	0.0	0.0	0.0	0.0
976	0.0	0.0	0.0	0.0	0.0

PERCENT TRANSECTS WHEN PRESENT

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	00	04	07	06	00
872	00	00	00	01	02
876	00	00	00	00	-
877	02	00	01	00	02
878	00	00	00	00	00
976	00	00	00	00	

MAXIMUM DENSITY (bird/km*)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	0.0	1.4	2.4	3.4	0.0
872	0.0	0.0	0.0	3.6	1.4
876	0.0	0.0	0.0	0.0	-
877	2.8	0*0	1.0	0.0	.8
878	0.0	0.0	0.0	0.0	0.0
976	0.0	0.0	0.0	0.0	

Table 26. Average densities, Percent transects when present and maximum densities-of Ivory Gulls in the five regions of the Alaskan Beaufort Sea pelagic regime.

AVERAGE DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of
871	.5	.3	.1	.2	.1
872	7.0	1.8	2	.3	< .1
876	1.6	3.2	.6	.5	-
877	.9	< .1	.4	< .1	.1
878	1.0	[illegible]	0.0	< .1	.1
976	.8	1.4	.5	[illegible]	-

PERCENT TRANSECTS WHEN PRESENT

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of
871	25	20	10	12	05
872	75	42	19	13	05
876	48	14	17	09	-
877	35	06	33	05	02
878	53	-	00	02	04
976	33	45	21	-	-

MAXIMUM DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of
871	3.4	3.0	.8	11.2	1.4
872	15.3	16.8	1.4	5.4	1.8
876	3.5	3.0	5.0	7.0	-
877	14.4	1.3	3.3	1.5	3.6
878	5.6	[illegible]	0.0	2.9	1.4
976	5.6	7.0	4.8	[illegible]	-

Table 27. Average densities, percent transects when present and maximum densities of Black-legged Kittiwake in the five regions of the Alaskan Beaufort Sea pelagic regime.

	Pelagic	Nearshore
Dates:	7 August - 18 September	2 - 30 August
Hr. of observation:	228.8	153.3
Total Kittiwakes recorded with flight direction:	120	33
Kittiwakes/hr.:	.5	.2
Flight direction: (percent of total)		
N	10	6
NE	7	0
E	19	3
SE	19	6
S	22	15
SW	9	3
W	9	27
NW	5	39

Table 28. Rates of movement and direction of flight of Black-legged Kittiwakes in the pelagic and nearshore Beaufort Sea.

AVERAGE DENSITY (birds/km*)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
867	1.7	0.0	0.0	< .1	0.0	0.0
877	.3	.2	0.0	.1	0.1	0.0
878	.9	.3	0.0	0.0	.2	

PERCENT TRANSECTS WHEN PRESENT

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	82	00	00	02	00	00
877	09	06	00	03	04	00
878	16	14	00	00	03	

MAXIMUM DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	3.8	0.0	0.0	1.8	0.0	0.0
877	5.8	4.8	0.0	1.9	1.8	0.0
878	11.5	10.8	0.0	8.4		

Table 29. Average densities, percent transects when present and maximum densities of Black-legged Kittiwakes in the six regions of the Alaskan Beaufort Sea inshore regime.

quality of our bird density data from pelagic waters. Densities can be increased due to birds flying into the transect as they are attracted to the feeding flock, or decreased since all the birds from an area may be attracted to the ship, reducing the frequency with which kittiwakes are encountered. The type of icebreaking and the amount of cod made available has a marked effect on the number of ship followers (especially kittiwakes) and thus comparisons of ship followers between areas and/or years is not possible. Nearshore densities are not affected by icebreaking problems.

1. May through July

Black-legged Kittiwakes are present in the Beaufort as early as May. Observations in May at the flaw lead at Pt. Barrow show that small numbers move into the Beaufort during that month (Woodby and Divoky, 1982). Kittiwake numbers probably gradually increase in June and July as more open water becomes available, Single birds and small flocks are regular but infrequent in the Plover Islands region during this time period (Divoky, in prep.). Harrison (1977) encountered them in July north of the Plovers.

2. August and September

a. Pelagic observations

August and early September, the period with least ice cover, can be expected to be the time of maximum abundance for Black-legged Kittiwakes in the Beaufort. As with many other surface feeding species kittiwakes are most regular and abundant in the western Beaufort (Table 27&34) But unlike most surface feeding species the Plover Islands and Pitt Point regions are equally important with overall average densities of 1 bird per km sq. The three regions to the east have overall densities of .3 birds per km. Kittiwakes are most frequently encountered in the Plover Island region being on almost 40 percent of all transects with frequencies of 20 percent for Pitt Point and Harrison Bay, Jones Island/, Prudhoe Bay and the East of Flaxman Island region have frequencies of 9 and 4 percent respectively. Maximum densities of kittiwakes are not exceptionally high in any region. The largest flock encountered on transect was a feeding flock of 20 associated with a convergence line north of the Plovers. Flocks of ship followers can become quite large. During a day of much icebreaking in the Pitt Point region a flock of over 200 birds was following the ship throughout the day.

The 120 kittiwakes recorded with a flight direction (Table 28) demonstrate that there is little directed movement and that a considerable percentage of birds are moving east and south. This indicates that westward movement out of pelagic waters occurs after our observations cease in mid-September.

b. Nearshore observations

As one would expect for a highly pelagic species, nearshore densities are less than for pelagic waters (Tables 29 and 35). The Plover Island region is the only area where kittiwakes are common in the nearshore, averaging .7 birds per km sq. and present on 20 percent of the transects (Table 37). While not uncommon in the Pitt Point region (averaging .2 birds per km sq. and on 9 percent of the transects), regions from Harrison Bay east have densities of < .1 bird per km sq. with kittiwakes seen on 3 percent of all transects.

Littoral zone observations show that as many as 400 kittiwakes can congregate at Cooper Island. Few are seen in the littoral zone to the east (Divoky, in prep.; Johnson and Richardson, 1981).

Kittiwake movements in the nearshore are less than in pelagic waters (Table 28) and 69 percent of all birds are moving westward. This directional movement may be due to kittiwakes moving westward with feeding flocks of terns and other surface feeding species, rather than being actual migration.

N. Ross' Gull

Ross'" Gulls (Rhodostethia rosea) breed primarily in northern Siberia (Dementiev and Gladkov, 1969) although small numbers breed sporadically in high arctic locations in Canada and Greenland (MacDonald, 1978; Hjort, 1980). Although they breed and feed on freshwater habitats during the summer they occupy marine habitats for the remainder of the year. Ross' Gulls move from their Siberian breeding grounds eastward into the Chukchi Sea (Pleske, 1928). They begin arriving in small numbers in mid-August (Divoky, in prep.) and are present in large numbers by late September (Watson and Divoky, 1972). From early September through October, Ross' Gulls are commonly seen in the littoral and nearshore areas from Wainwright to Pt. Barrow (Bailey, 1948). Little is known of their movements or distribution after October.

1. Pelagic observations

Ross' Gulls do not enter the pelagic Beaufort until mid-September. Our earliest sighting is on 11 September and it appears they are probably most common after 18 September when our observations cease. Our sightings show them to be abundant in the Plover Islands region. If they are moving eastward they could be more widely distributed in the Beaufort later in September and in October. On the only mid-September cruise that adequatley censused the pelagic waters north of the Plovers (976), Ross' Gulls were found on 15 per-' cent of all transects and averaged .5 birds per km sq. The Pitt Point region had a frequency of 2 percent and an average density of .1 birds per km sq. Only two other sightings of Ross' Gull have been made, both in 1971; one bird in the Harrison Bay region and two in the Pitt Point region.

Since nothing is known of Ross' Gulls movements once they pass the Pt. Barrow area" it is not possible to say how long they may remain in the Beaufort. It is possible that some birds could stay until open water becomes severely limiting in November.

2. Nearshore observations.

Our vessel observations in the nearshore do not extend into September when Ross' Gulls are present in the Beaufort and thus we have no density information for that regime. Infrequent observations of Ross' Gulls have ' been obtained from Cooper Island in late August and early September (Divoky, in prep.).

O. Sabine's Gull

Sabine's Gull (Xema sabini) is a small black-headed gull that breeds circumpolarly primarily on tundra habitats. It winters in biologically productive offshore areas in the southern hemisphere. Pacific Basin birds are found in the Humboldt Current on the west side of South America (Chapman, 1969). Migration to and from wintering areas usually occurs well offshore. Sabine's Gulls have been little studied compared to most arctic species due to a small total population, localized breeding, and migrating and wintering offshore.

1. Spring migration and breeding

Sabine's Gulls arrive in arctic Alaska the last week in May. Little information is available on Sabine's Gull movements in the spring and, like Arctic Terns, they appear to complete their migration to the arctic at high altitudes. There are few Bering Sea records for late May (Divoky, in prep.) and they have not been observed at the flaw lead in late May or early June at Cape Prince of Wales (Flock and Hubbard, 1978) or Pt. Barrow (Woodby and Divoky, 1982). Late migrants, presumably non-breeders, may migrate at lower altitudes since Bailey (1948) saw many passing Cape Prince of Wales on 16 June. Once in the Beaufort some low altitude coastal migration does occur as evidenced by observations in Canada (Richardson and Johnson, 1981).

Sabine's Gulls breed primarily on mainland tundra habitats. King (1979) found an estimated 2 to 3 thousand breeding on NPR-A. Brower (in Bailey, 1948) states that they are uncommon on the coast but found in colonies on lakes further inland. Sabine's Gulls are rare on Alaskan Beaufort barrier islands with a total of three nests being found in 1976 on a census of all islands (Divoky, 1978b). There is little use of nearshore habitats during the breeding season (Divoky , 1979b) and probably virtually no use of the pelagic regime (Harrison ., 1977). In June and July on Cooper Island, small numbers (<10) of breeding and non-breeding Sabine's Gulls feed primarily in brackish tundra ponds where spring-tails (Collembolla) are a major food source.

2. Post-breeding dispersion and migration

a. Pelagic observations

Sabine's Gull appears to be one of the few species that migrates westwara through the Alaskan Beaufort primarily in pelagic waters. Both densities and rates of movements are higher for that regime than for the nearshore. As with many other surface feeding species the pelagic waters north of the Plover Islands have the highest densities, averaging 2 birds per km sq. (Tables 30 and 34). The three central regions have overall average densities between .4 and .5 birds per km sq. The East of Flaxman region has an overall density of much less than .1 birds per km sq. Sabine's Gulls are found on 11 percent of all transects in the Plover Islands region. Frequencies to the east decline from 6 percent in the Pitt Point region to <1 percent in the East of Flaxman Island.

Data on the pelagic movements of Sabine's Gulls have been obtained only on the last four cruises (all those after 1972). Movement was 1.5 birds per hour and of the 332 birds recorded with a flight direction, 71 percent were moving westward. Migration was most pronounced in the last week of August and the first week of September.

AVERAGE DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	.5	0	.3	.1	0
872	0.0	.3	.1	.2	< .1
876	8.9	.9	< .1	.2	
877	.1	< .1	1.0	0.0	0.0
878	0.0		0.0	0.0	0.0
976	2.2	.8	.6		

PERCENT TRANSECTS WHEN PRESENT

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	15	00	05	01	00
872	00	08	06	07	05
876	37	07	04	13	-
877	04	02	03	00	00
878	00	-	00	00	00
976	10	14	11		

MAXIMUM DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	6.8	0	6.8	13	0
872	0	11	3.3	5.6	2.8
876	112	12	1.2	2.0	
877	7.2	3.6	40.	0.0	0.0
878	0.0		0.0	0.0	0.0
976	49.6	24.7	0.0		

Table 30. Average densities, percent transects when present and maximum densities of Sabine's Gulls in the five regions of the Alaskan Beaufort Sea pelagic regime.

b. Nearshore observations

Sabine's Gulls show a marked affinity for the nearshore Plover Island region compared to the regions to the east. The Plovers have an average of .8 Sabine's Gulls per km sq. with sightings on 14 percent of all transects from that region. Regions to the east all average .1 per km sq. with no region having Sabine's Gulls on more than 3 percent of the transects (Tables 31 and 35).

Littoral zone observations also demonstrate the marked difference between the Plover Islands and regions to the east. In years when drifting pack ice provides large quantities of zooplankton, linear densities of Sabine's Gulls at Cooper Island are over 80 birds per km sq. (up to a total of 900 birds). Few Sabine's Gulls are seen in the littoral zone to the east (Johnson and Richardson, 1981; Divoky , 1979 b).

Movement of Sabine's Gulls in the nearshore is .3 birds per hour. Of the 48 birds recorded with direction only 46 percent are moving westward indicating that while some migration is occurring there is also much dispersion.

P. Arctic Tern

Arctic Terns (Sterna paradisaea) breed circumpolarly in the arctic and subarctic. They nest both on inland, freshwater habitats and coastally on spits and barrier islands. Outside of the breeding season marine habitats are used exclusively. The species winters at the edge of the Antarctic pack ice and migrates in the offshore waters of both the Atlantic and Pacific Oceans (Salomonson, 1967).

In northern Alaska breeding occurs primarily on tundra ponds and lakes. King (1979) estimated the tern population of the coastal tundra of NPR-A to be between 45,000 and 50,000 birds, based on aerial surveys. Few breed on Alaskan Beaufort barrier islands with a 1976 census finding less than 100 pairs (Divoky, 1978 b).

1. Spring migration and breeding season

Arctic Terns arrive in arctic Alaska in the last days of May through the first week in April (Bailey, 1948; Bergman et al., 1977). Arctic terns make little use of the Alaskan Beaufort Sea during spring migration. They apparently do not pass over coastal waters for the last part of their migration since observations in late Nay and early June at the edge of the flaw lead at Cape Prince of Wales (Bering Strait) and Pt. Barrow have failed to observe migrating terns (Flock and Hubbard, 1978; Woodby and Divoky, 1982). Shipboard observations in the Bering Sea in May have failed to find them in numbers (Divoky, in prep.) and it is likely they complete their migration to the high arctic at very high altitudes. Brewer (in Bailey, 1948) commented on their sudden appearance in the spring with no migration being noted (Bailey, 1948). There are records of coastal movements in the Canadian Beaufort, however. Johnson et al. (1975) saw terns moving east past coastal locations on the west side of the Mackenzie River Delta as did Searing et al. (1975) on the east side.

During the period of shorefast ice and shorefast breakup, terns are breeding and are uncommon in the nearshore regime in most areas (Divoky, 1979b; Johnson and Richardson, 1981) except near islands with breeding colonies (Divoky, 1978 a; Schamel, 1978). Use of pelagic areas is also low based on aerial surveys in July (Harrison , 1977).

AVERAGE DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	2.9	1.0	0.0	0.1	.2	< .1
877	.9	0.0	(?.0	0.0	0.0	0.0
878	.3	< .1	0.0	0.0	< .1	

PERCENT TRANSECTS WHEN PRESENT

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	45	13	00	02	07	04
877	11	00	00	00	00	00
878	10	03	00	00	03	

MAXIMUM DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
876	15.4	7.6	0.0	3.3	3.8	.9
877	19.7,	0.0	0.0	0.0	0.0	0.0
878	6.0	1.2	0.0	0.0	2.4	

Table 31. Average densities, percent transects when present and maximum densities of Sabine's Gulls in the six regions of the Alaskan Beaufort Sea inshore regime.

2. Post-breeding dispersion and fall migration

Flying juvenile Arctic Terns appear in the nearshore Beaufort as early as the last week in July (Divoky and Boekelheide, in prep.) although some young do not fledge until the last week in August (Divoky, in prep.). Movement of adults and young occurs from late July until mid-September and is eastward to Pt. Barrow and then south to the Pacific Basin. There are areasin the Alaskan Beaufort where terns concentrate because prey and roosting sites are most available. Terns gather in these areas to build fat reserves before continuing their migration (Divoky, in prep.). Thus the Beaufort is not used only as a migratory pathway but also a staging area.

a. Pelagic observations

Arctic Terns are uncommon migrants over much of the pelagic Beaufort (Fig. 10). Densities in all regions east of the Plover Islands average 1 bird per km sq. (Tables 32 and 34), with the lowest densities being east of Flaxman Island. The Plover Islands have an average density of 2.5 birds per km sq., but tern distribution in that area is patchy. In two years they were not encountered and overall have been seen on only 14 percent of the transects in that area. This patchiness is probably linked to the Bering Sea Intrusion and associated eddies.

Terns were most common within 70 km of shore although they were encountered as far as 250 km offshore over the Arctic Basin.

The movements of terns in pelagic waters provides more indication that the area affected by the Bering Sea Intrusion is important for feeding. In the area east of where the Bering Sea Intrusion directly affects sea surface temperatures (east of 152° W), 79 percent of the 267 terns seen were moving westward. In the area where sea surface temperatures are frequently affected by the Intrusion only 31 percent of 157 terns were moving westward indicating that birds are searching for and responding to food sources.

Only 53 Arctic Terns seen in pelagic waters were aged with the following percentages being found:

Dates	Percent adult	Percent juvenile
2 - 17 August	94	6
18 August - 1 September	76	24
2 - 18 September	47	53

These ratios agree with those observed at Cooper Island where the percentage of juvenile birds increases steadily during migration and can constitute over 90 percent of early September flocks (Boekelheide, 1980; Divoky, in prep.).

b. Nearshore observations

Nearshore censusing shows that the difference between tern densities in the Plover Island region and the remainder of the Alaskan Beaufort is even

AVERAGE DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	2.8	.4	.7	.1	.2
872	0.0	< .1	1.0	.6	.2
876	2.2	4	.2	.7	[illegible]
877	4.2	1.5	1.1	.3	< .1
878	0.0	-	0.0	.3	0
976	1.3	[illegible]	< .1	-	-

PERCENT TRANSECTS WHEN PRESENT

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	20	12	[illegible]	01	03
872	00	02	[illegible]	07	07
876	22	07	[illegible]	25	-
877	16	16	[illegible]	02	<01
878	00	-	[illegible]	05	00
976	10	00	[illegible]	[illegible]	-

MAXIMUM DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	E. of Flaxman Island
871	49.0	6.8	30	6.8	6.4
872	[illegible] 0	2.4	12.6	17.6	5.2
876	3[illegible] 2	7.4	4.8	7.4	-
877	216.	10.8	45.6	18	3.6
878	[illegible] 0	-	0.0	11.3	0.0
976	31.2	0.0	1.8	-	-

Table 32. Average densities, percent transects when present and maximum densities of Arctic Terns in the five regions of the Alaskan Beaufort Sea pelagic regime.

AVERAGE DENSITY (birds/km^2)

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	Flaxman Island
876	20.4	1.1	.1	.5	3.9	.2
877	10.9	1.2	.3	1.0	.2	.4
878	6.1	.3	.1	.8	.4	[illegible]

PERCENT TRANSECTS WHEN PRESENT

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	Flaxman Island
876	100	18	07	09	15	04
877	49	13	03	09	09	11
878	30	08	03	06	09	-

MAXIMUM DENSITY (bird/km^2

cruise	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	Flaxman Island
876	85.0	7.6	1.1	9.9	57.7	4.2
877	133.0	14.4	9.5	26.9	2.1	6.4
878	88.7	5.2	3.3	26.3	8.3	-

Table 33. Average densities, percent transects when present and maximum densities of Arctic Terns in the six regions of the Alaskan Beaufort Sea inshore regime.

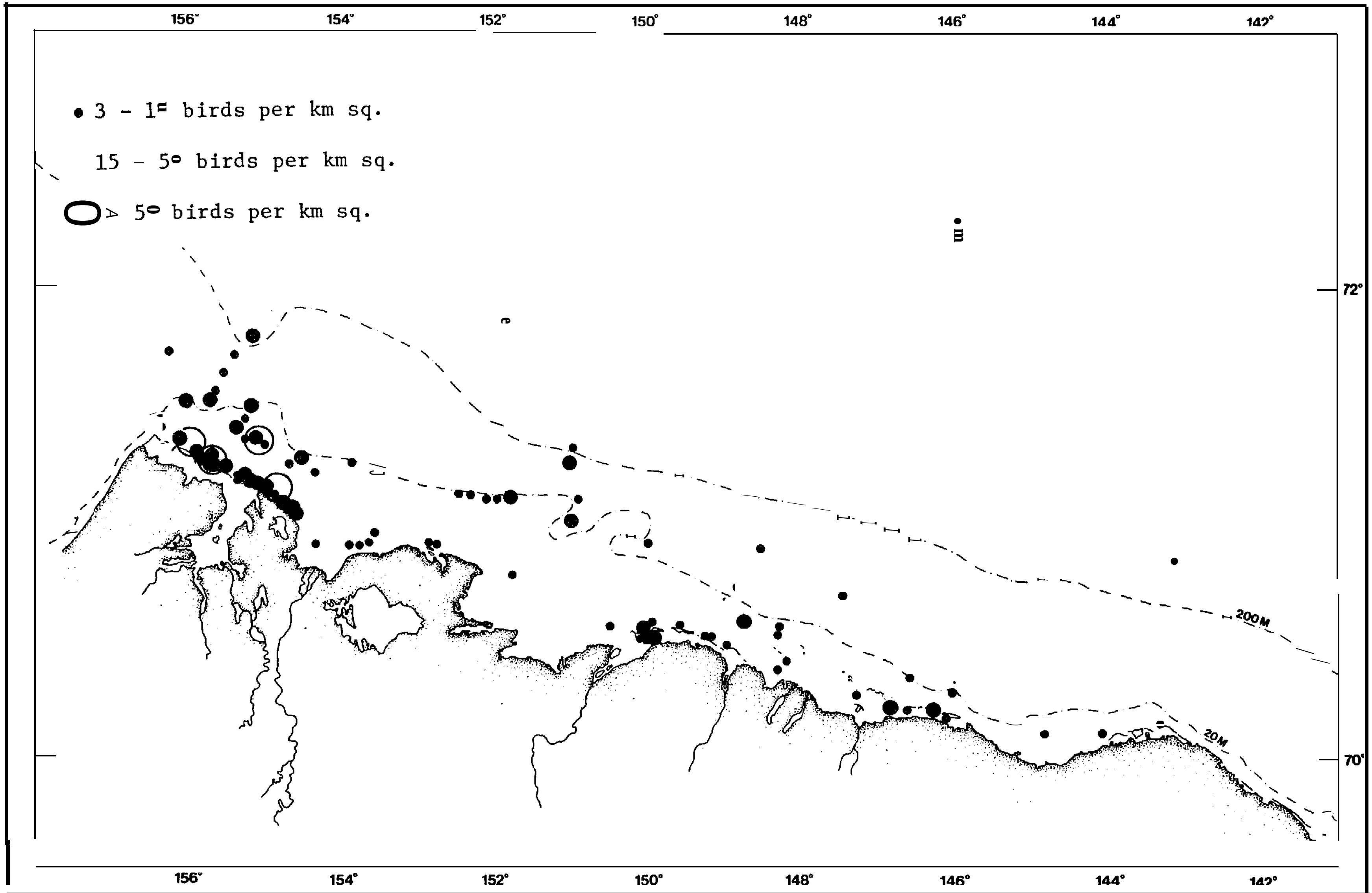


Figure 10. The location and density of all Arctic Tern densities of more than 3 birds per km sq.

more marked in the nearshore than in the pelagic regime (Tables 33 and 35). The average density in the Plover Islands is 9.6 birds per km sq. and to the east it averages <1 bird per km sq. The maximum densities for each year were always found in the Plover Islands region. Terns are well distributed in the nearshore Plover Islands being seen on 45 percent of all transects. They are present on <11 percent of transects for the regions to the east.

Tern movements in the nearshore show that birds are moving primarily to the west in all areas with 66 percent of the 325 directional birds moving westward. That this percentage is not higher indicates that many terns are dispersing and/or looking for food sources rather than just migrating.

Because. terns do not regularly sit on the water staging areas have to provide spits and islands near productive waters with high prey densities. The Plover Islands and Pt. Barrow spit appears to be the only area in the Beaufort that fulfills these requirements. Icy Cape and Pt. Franklin in the Chukchi are also important staging areas. Observations from the Plover Islands in 1979 when apparently little prey was available for surface feeding species show that the islands were still important roosting sites even though birds were feeding well offshore when they were feeding at all.

Q. Murres

The two murre colonies closest to the Alaskan Beaufort are at Cape Parry (600 km to the east) (Hohn, 1955) and Cape Lisburne (480 km to the southwest) (Springer et al., 1982). The approximately 150 Thick-billed Murres (Uris lomvia) that breed at Cape Parry pass through the Beaufort from wintering grounds in the Pacific Basin. Apparently far more birds than the Cape Parry breeding population enters the Beaufort in the spring. Hendee (in Bailey, 1948) saw many hundreds passing Wainwright and moving toward the Beaufort. Lesser numbers were seen by Woodby and Divoky (1982) at Pt. Barrow, but their findings corrobate the view that the number of murres entering the Beaufort is not minimal. Once in the Beaufort the movements of the birds is not known but it is likely they follow offshore leads to the Canadian Beaufort. Apparently some of the birds leave the Beaufort shortly after they arrive. In mid-June 1981 a flight of over 1000 murres passed westward over Cooper Island (Divoky, in prep.). This major emigration may indicate that murres that enter the Beaufort but do not breed at Cape Parry do not remain in the Beaufort.

There is little evidence of murres in the Alaskan Beaufort in June and July. Aerial surveys have failed to see them (Harrison ., 1977) and they are regular but rare stragglers near the Plover Islands (Divoky, in prep.).

1. Pelagic observation

Murres were found to be rare in the pelagic waters of the Alaskan Beaufort being seen on 1 percent of all transects. Eight of our sightings are from 1977 when the pack ice was far offshore indicating that ice cover may play a role in reducing murre numbers. No east-west trend is present and the average for all regions combined is .01 birds per km sq.

2. Nearshore observations

It is surprising that murres, a species usually found in offshore waters, are more common in the nearshore than the pelagic Beaufort. Murres were regular in the Plover Islands region being present on 15 percent of the transects and averaging .8 birds per km sq. Pitt Point had a density of .1 per km sq. and a 6 percent frequency. East of Pitt Point densities are .05 birds per km sq. and frequencies less than 3 percent.

R. Black Guillemot

The Black Guillemot (Cepphus grylle) is a circumpolar species that nests in cavities and is typically associated with rock cliffs and talus. Because they are able to exploit a wide range of cover for nest sites (Storer, 1958) guillemots have been able to breed on the Alaskan Beaufort coast by utilizing man-made debris (Divoky et al., 1975; Divoky, 1978b). While the number of nests on the Plover Islands is approximately 200, there are probably less than 10 pairs between the Plover Islands and the Canadian border.

Black Guillemots winter in leads in the ice from the northern Bering Sea north. They are known to occur in the chronic lead system off Wainwright and Pt. Barrow in winter (Nelson, 1970; Bailey, 1948). The lead system extends slightly into the extreme western Beaufort and Black Guillemots are one of the few species that can be expected to winter in the Beaufort. The bulk of the Alaskan Beaufort lacks chronic lead systems, however, and the number of guillemots present in winter can be expected to be low and their distribution restricted.

Because Black Guillemots winter relatively near their breeding sites, little migration occurs. Observations at the lead off Pt. Barrow in spring show that guillemots are present as early as 6 May and numbers increase in late May. Birds fly both north and south over the lead and no net movement northeast into the Beaufort is evident (Woodby and Divoky, 1982) . In June and July Black Guillemots can be expected to be rare stragglers in the Alaskan Beaufort in June and July, except in the Plover Islands where they are common breeding birds arrive at breeding colonies in early June and non-breeders arrive in numbers in July.

1. August and September

a. Pelagic observations

Black Guillemots are rare offshore in the Alaskan Beaufort. They were seen on 1 percent of all transects with none seen east of the Harrison Bay region. The Plover Islands, Pitt Pt. and Harrison Bay regions had densities of .04, .02 and <.01 birds per km sq. respectively. While guillemots may be absent from the eastern Alaskan Beaufort, Frame (1973) saw scattered birds in the Canadian Beaufort.

Black Guillemots are much more regular in the pelagic waters of the Chukchi Sea than in the Beaufort and this may be an indication of the difference in prey availability in the two seas (Divoky, in prep.) .

b. Nearshore observations

Guillemots are almost as rare in the nearshore as in the pelagic regime, being present on 2 percent of all transects. They are not uncommon in the Plover Islands (avg. density of .3 birds per km sq. and a frequency of 11 percent). There are only two sightings east of the Plovers; one in the Pitt Point region and one near Prudhoe Bay. Small numbers could be expected to be present anywhere where cover is available for nesting.

	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	East of Flaxman Islands
Loons	.3	.5	.6	.3	.3
Short-tailed Shearwater	10.5	.1	0.0	0.0	0.0
Eider	1.2	<.1	.4	.5	6.5
Oldsquaw	3.0	2.1	.4	.7	1.1
Phalaropes	16.5	1.1	.6	.9	.3
Jaegers	.3	.2	.1	.2	.1
Glaucous Gull	.8	.6	.5	.5	.4
Black-legged Kittiwake	1.0	1.2	.3	.2	.1
Ross' Gull	.1	<.1	0.0	0.0	0.0
Sabine s Gull	2.0	.4	.5	.1	<.1
Arctic Tern	2.5	.6	.7	.3	.1
TOTAL	38.1	6.9	4.1	3.7	9.0

Table 34. Average densities of numerically important species in the five regions of the Alaskan Beaufort Sea pelagic regime.

	Plover Islands	Pitt Point	Harrison Bay	Jones Island	Prudhoe Bay	East of Flaxman Islands
Loons	1.6	1.3	1.9	.5	.9	.4
Eider	17	73.4	15	3.1	26	5.9
Oldsquaw	46.8	60	9.9	59.6	43	18.3
Phalaropes	17.9	7.9	.6	4.7	8.3	.6
Jaegers	.6	.1	.1	.1	.1	0
Glaucous Gull	3.0	.6	.8	.3	1.2	.3
Black-legged Kittiwake	.7	.2	0	<.1	.1	0.0
Sabine's Gull	.8	.1	0	<.1	.1	<.1
Arctic Tern	9.6	.8	.2	.7	1.0	.3
Murres	.8	.1	0	<.1	<.1	<.1
B. Guillemot	<.1	<.1	<.1	0	0	0
TOTAL	98.9	144.6	28.6	69.2	80.8	25.9

Table 35. Average densities of numerically important species in the six regions of the Alaskan Beaufort nearshore regime.

	Plover Islands	Pitt Point	Harrison Bay	Jones Islands/ Prudhoe Bay	East of Flaxman Islands
Loons	18	11	14	08	10
Short-tailed Shearwater	09	03	00	00	00
Eider	01	01	01	02	07
Oldsquaw	14	13	05	08	08
Phalaropes	40	13	08	05	08
Jaegers	20	11	07	13	10
Glaucous Gull	29	29	24	26	21
Black-legged Kittiwake	38	25	20	09	04
Ross' Gull	04	01	00	00	00
Sabine's Gull	11	06	05	03	.1
Arctic Tern	14	08	04	05	04
ALL BIRDS	89	69	60	55	55

Table 36. Frequency of occurrence (percent transects when present) of the numerically important bird species and all birds in the five regions of the Alaskan Beaufort Sea pelagic regime.

	Plover Islands	Pitt Point	Harrison Bay	Jones Island	Prudhoe Bay	East of Flaxman Islands
Loons	48	40	53	26	42	17
Eider	36	24	23	09	18	12
Oldsquaw	44	46	30	57	50	41
Phalaropes	30	37	11	29	31	08
Jaegers	20	05	06	04	08	00
Glaucous Gull	38	26	39	15	22	13
Black-legged Kittiwake	20	09	00	01	03	00
Sabine's Gull	14	03	00	01	03	02
Arctic Tern	45	11	04	08	10	08
ALL BIRDS	99	96	71	85	86	64

Table 37. Frequency of occurrence (percent transect when present) of the numerically important bird species and all birds in the five regions of the Alaskan Beaufort Sea nearshore regime.

VII. Trophies

The stomach contents of birds collected in the Beaufort Sea were reported on earlier (Divoky, 1978c). For this final report, the same data is being presented, but with the data separated by regime for each species in order to delineate differences between the pelagic and nearshore.

A. Surface feeding species

The numerically important surface feeders in the Alaskan Beaufort include the phalaropes, jaegers, gulls and Arctic Tern. Stomach contents data for these species are presented in Tables 38 through 44.

All of the phalaropes collected have been Red Phalaropes. Phalarope stomach contents are frequently in the form of crustacean thyme weighing less than .1 g. Because of this percent, weight is difficult to compute and only frequency of occurrence is given (Table 38). The average length of whole prey items is also given. The eight stomachs collected in the pelagic regime did not differ from the 68 from the nearshore and the data were pooled. Gammarid amphipods, especially Apherusa glacialis, appear to be the primary prey items. Connors and Risebrough (1977) found copepods, Apherusa glacialis, and decapod zoea to be the major prey items in the littoral zone at Point Barrow. At Simpson Lagoon, phalaropes took primarily copepods, amphipods and mysids (Johnson and Richardson, 1981).

No jaeger stomach contents were collected. The two larger jaegers are frequent ship followers in the pelagic regime where they pirate Arctic Cod from Glaucous Gulls and kittiwakes. Long-tailed Jaegers could be expected to take Arctic Cod and zooplankton directly. Parasitic Jaegers will regularly take phalaropes.

Glaucous Gulls in pelagic waters were taking primarily small birds and Arctic Cod (Table 39). Because small birds (phalaropes) are uncommon over most of the pelagic Beaufort it is likely that cod is the primary prey in most areas. In nearshore waters cod are an important item but amphipods and euphausiids are frequent in stomachs. The Glaucous Gull is a highly opportunistic feeder (Ingolfsson, 1967) and could be expected to prey on whatever food source is most abundant and available.

Black-legged Kittiwakes, Sabine's Gulls and Arctic Terns all demonstrate similar differences between nearshore and pelagic stomachs contents. Birds in pelagic waters prey to a great extent on Arctic Cod with zooplankton usually being of less importance. Few cod are taken in the nearshore where zooplankton are of primary importance. This division is most extreme for kittiwakes and less marked for Sabine's Gulls(Tables 40-- 42).

B. Diving species

Because diving species are frequently harder to collect than surface feeders, we have fewer stomachs from most species. Two loons collected near Barrow in July contained only amphipods (Divoky, 1978 c)but it is clear that cod are also important, at least as prey returned to chicks still on tundra ponds. Adult loons are frequently seen returning to the mainland with Arctic Cod in their bills.

No shearwaters have been collected in the Beaufort but they feed on both fish and zooplankton in the Bering Sea (Sanger, in prep.).

Oldsquaw were found to be feeding on a wide range of invertebrates (Table 43) with epibenthic species being of major importance. Johnson and Richardson (1981) found mysids and amphipods to be the primary prey in Simpson Lagoon. Common and King Eiders appear to have similar diets with large isopods being the major prey item (Table 44).

The stomach contents of birds collected in the Beaufort demonstrate two important points.

1) Arctic Cod is a major prey item in pelagic waters for surface feeding birds, with the exception of phalaropes, but these same species prey primarily on zooplankton in the nearshore.

2) The common diving species prey on epibenthic crustaceans and are restricted to the nearshore.

Both of these points demonstrate the differences in the pelagic and nearshore regimes. Arctic Cod are apparently the most available prey at the surface of pelagic waters while zooplankton is more available in nearshore waters. The diving species that prey principally on epibenthic crustaceans are limited to the nearshore indicating that their prey is less abundant or available in the pelagic regime.

These trophic differences in the two regimes and factors relating to them will be discussed later in this report.

	Percent frequency	Size of prey (mm)
Unidentified gammarid amphipods	31	5
Unidentified crustaceans	30	-
Apherusa glacialis	18	8
Mysis sp.	13	14
Copepods	11	2.5
Thysanoessa sp.	5	11
Larval fish	1	15

Table 38. Frequency of occurrence and average length of prey items in Red Phalarope stomachs collected in the pelagic and nearshore Beaufort. Number of stomachs = 76.

	PELAGIC		NEARSHORE	
	n= 9 wt=20g		n= 9 wt=98g	
	% Wt	% freq	% wt	% freq
Arctic Cod	17	56	60	33
Small birds	75	22	--	--
Amphipods	1	22	1	22
Thysanoessa sp.	--	--	13	33
Saduria entomon	--	--	12	11

Table 39. Percent of total weight and frequency of occurrence of prey items in Glaucous Gull stomachs collected in the pelagic and nearshore Beaufort Sea.

	PELAGIC		NEARSHORE	
	n=25 wt=134g		n=14 =11. 2g	
	% wt	% freq	% wt	% freq
Arctic Cod	95	92	5	27
Amphipods	--	12	67	7
Shrimp	--	04	--	--
Apherusa glacialis	- -	--	14	28
Mysis sp.	--	--	11	14

Table 40. Percent of total weight and frequency of occurrence of prey items in Black-legged Kittiwake stomachs collected in the pelagic and nearshore Beaufort Sea.

	PELAGIC		NEARSHORE	
	n= 6 wt=15g		n=32 wt=60.6g	
	% Wt	% freq	% wt	% freq
Arctic Cod	13	67	4	3
Thysanoessa sp.	13	17	4	3
Parathemisto sp.	53	17	--	--
Shrimp	3	17	--	--
Apherusa glacialis	--	--	49	56
Mysis sp.	--	--	24	28
Unid. amphipods	1	17	6	19

Table 41 . Percent of total weight and frequency of occurrence of prey items in Sabine's Gull stomachs collected in the pelagic and nearshore Beaufort Sea.

	PELAGIC n=27 wt=40.4g		NEARSHORE n=48 wt=78.6g	
	% Wt	% freq	% Wt	% freq
Arctic Cod	64	78	20	21
Thysanoessa sp.	35	22	23	23
Amphipods	1	4	22	38
Mysis sp.	--	--	13	29
Apherusa glacialis	--	--	9	17
Sand Lance	--	--	12	2

Table 42. Percent of total weight and frequency of occurrence of prey items in Arctic Tern stomachs collected in the pelagic and nearshore Beaufort Sea.

OLDSQUAW

n=93
wt=317.8g

	% Wt	% freq
Amphipods	23	38
Molluscs	22	59
Mysis sp.	20	16
Thysanoessa sp.	17	13

Table 43. Percent of total weight and frequency of occurrence of prey items in Oldsquaw collected in the nearshore Beaufort Sea.

	COMMON EIDER		KING EIDER	
	n=3 wt=42g		n=16 wt=178.6g	
	% wt	% freq	% Wt	% freq
Saduria entomon	83	67	89	63
Mysis	15	33		
Molluscs	1	66	2	31
Amphipods	1	33	2	19

Table 44. Percent of total weight and frequency of occurrence of prey items in Common and King Eider stomachs collected in the nearshore Beaufort Sea.

VIII. Biomass Densities

The conversion of birds per km sq. to biomass per km sq. (obtained by multiplying the birds per km sq. by the average weight of the bird) allows one to compare regions and regimes with regard to the avian biomass supported by prey populations in an area. To do this it is necessary to consider only those species that are feeding or potentially feeding in an area. Because surface feeding species can search for prey while migrating, all surface feeding species are included in biomass densities. The common surface feeding species in the Beaufort include phalaropes, jaegers, gulls and terns. Of the diving species regularly encountered in the nearshore all loons and Oldsquaw observed are considered in biomass calculations because they are regularly seen sitting on the water. Because the majority of eider seen in the nearshore are flying, only sitting birds are used to compute biomass densities. In the pelagic regime loons, Oldsquaw and eider are absent until migration begins in late August and few birds are seen sitting on the water. Thus the only diving species considered in biomass calculations for the pelagic regime is the Short-tailed Shearwater. While loons, Oldsquaw and eider almost certainly do some feeding in pelagic waters the frequency of feeding is low and most of it occurs in close proximity to the 20 m contour.

Total biomass densities by region for the pelagic and nearshore regimes are shown in Table 45. Species biomass densities by region by regime are presented in Figures 11 through 13 .

The pelagic regime of the Alaskan Beaufort Sea is characterized by an almost complete lack of diving species in most areas and a marked east-west gradient in total biomass with the extreme western region having over ten times the biomass of the extreme eastern. Although diving species made up 69 percent of the biomass in the pelagic waters north of the Plover Islands, diving biomass was extremely low in all other regions. The high density of diving species in the Plover Islands is due primarily to one loose flock of Short-tailed Shearwaters seen on 15 September 1978. Short-tailed Shearwaters have been seen on only 9 percent of all transects conducted in pelagic waters of the Plover Islands region and most of the sightings are from 1978. For all other years the biomass density of diving species in the Plover Islands region was similar to the rest of the pelagic Beaufort. Biomass of surface feeding species was high for the Plover Islands region ($\geq$ 3 kg km $^{-2}$, and low in the central and eastern regions ($\leq$ 1 kg km-2).

Biomass of surface feeders in pelagic waters showed a marked east-west gradient. Glaucous Gulls constituted over 50 percent of the biomass of surface feeders. The extreme eastern Beaufort was found to support low biomass levels of all species.

Total avian biomass supported in the nearshore Alaskan Beaufort is over ten times the amount present in pelagic waters. Except for Harrison Bay and the area east of Flaxman Island the nearshore had rather consistent values of between 49 and 65 kg km^{-2}. The low values for Harrison Bay are probably valid since extensive sampling was done in that area. Our sampling east of Barter Island in the east of Flaxman Island region has not been as thorough, however, and the diving biomass data are partially based on Spindler's (1981) data which are not directly comparable to ours. The densities for this area should be considered minimum estimates. While no east-west trend is evident in diving species in the nearshore, surface feeding species had their highest total density in the Plover Island area (6.2 kg km^{-2}) with low values (.5 to 2 kg km^{-2}) for areas in the east.

	Plover Islands	Pitt Point	Harrison Bay	Jones Islands	Prudhoe Bay	E. of Flaxman Island
Pelagic						
surface	3.0	1.5	1.0		1.0	.6
diving	6.3	< .1	<.1		<.1	<.1
total	9.3	1.5	1.0		1.0	.6
Nearshore						
surface	6.2	1.3	1.0	.8	2.0	.5
diving	43.7	56.6	12.2	48.8	63.0	33.7
total	49.9	57.9	13.2	49.6	65.0	34.2

Table 45. Biomass densities (kg per km sq.) in the five pelagic and six nearshore regions of the Alaskan Beaufort Sea.

Oldsquaw constitute 80 percent of the diving biomass inshore with loons and eiders making up the remainder. While loons had their highest densities in the western portion of the Alaskan Beaufort, Oldsquaw and eiders showed no such trend. Murres were common in the Plover Islands in 1978 giving them a relatively high average biomass for that region. Guillemots were found only in the Plover Islands (.2 kg km-2).

Surface feeding species present in the nearshore are the same as those found in the pelagic regime. All reach their highest densities in the Plover Islands. The decrease to the east in the total biomass of surface feeding species is similar to that found in pelagic waters with the exception of the Prudhoe Bay region having a density higher than any of the others east of the Plover Islands. As in pelagic waters Glaucous Gulls constituted more than 50 percent of the surface feeding biomass.

The avian biomass densities show the two regimes to differ greatly with a low biomass pelagic community composed primarily of surface feeders and a higher biomass nearshore community composed of diving species with a smaller surface feeding component. In both regimes surface feeding biomass showed a marked east-west gradient with the extreme western Beaufort having the highest densities. Diving biomass in the nearshore showed no such gradient and showed little variability between regions except for Harrison Bay which consistently had low diving biomass densities.

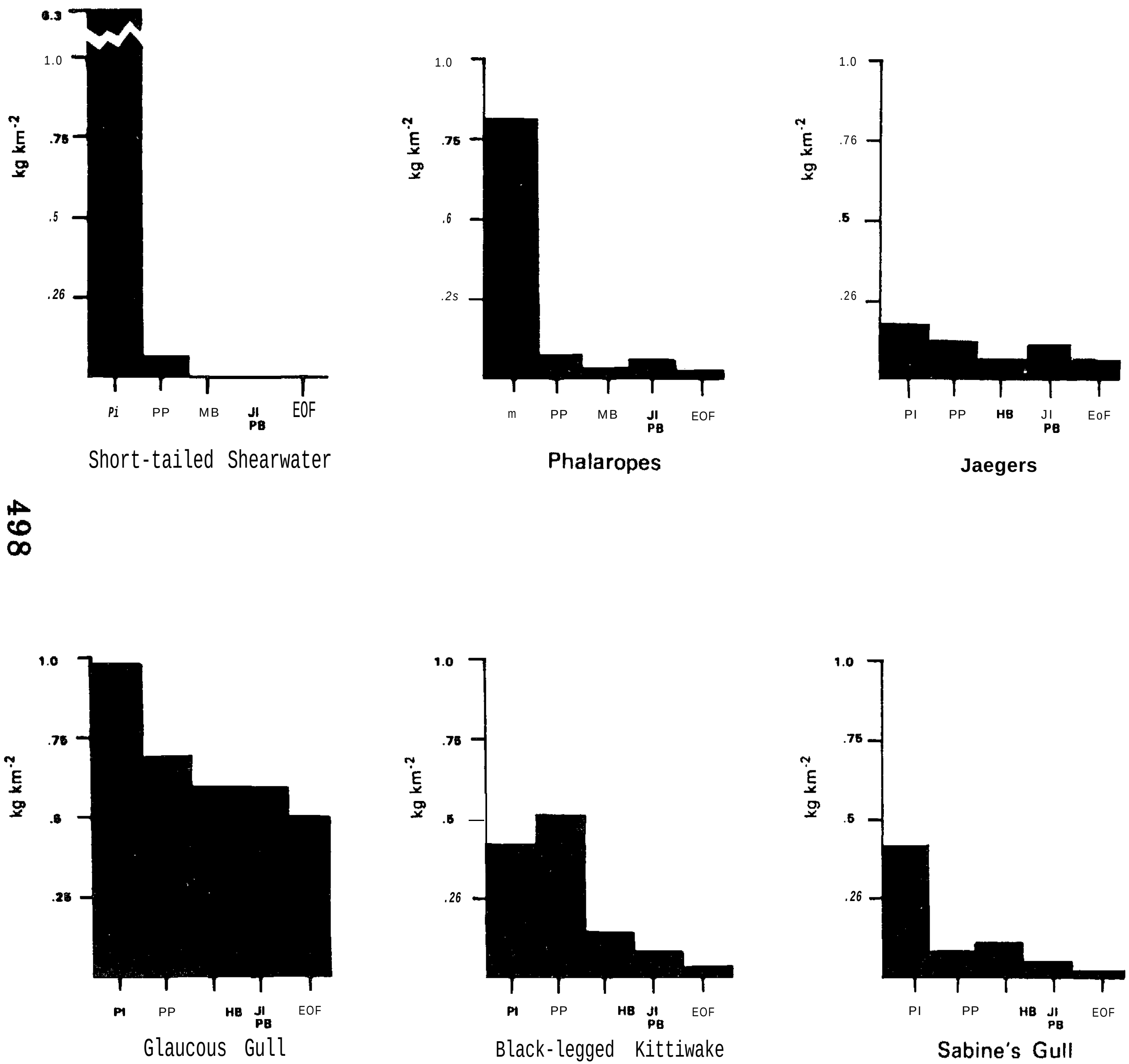
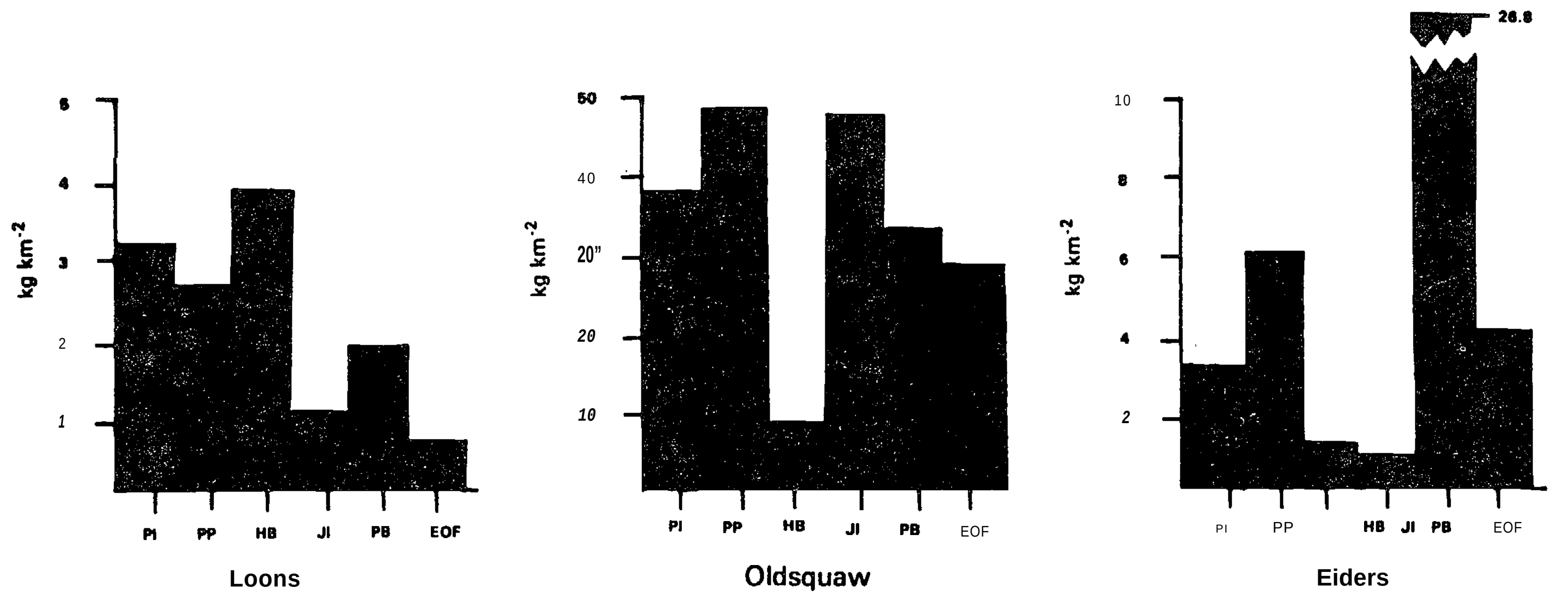


Figure 11. Biomass densities of the common species in the five regions of the Alaskan Beaufort Sea pelagic regime.



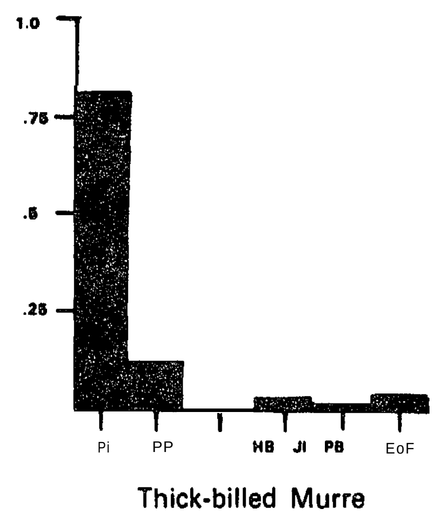


Figure 12. Biomass densities of the common diving species in the six regions of the Alaskan Beaufort Sea nearshore regime.

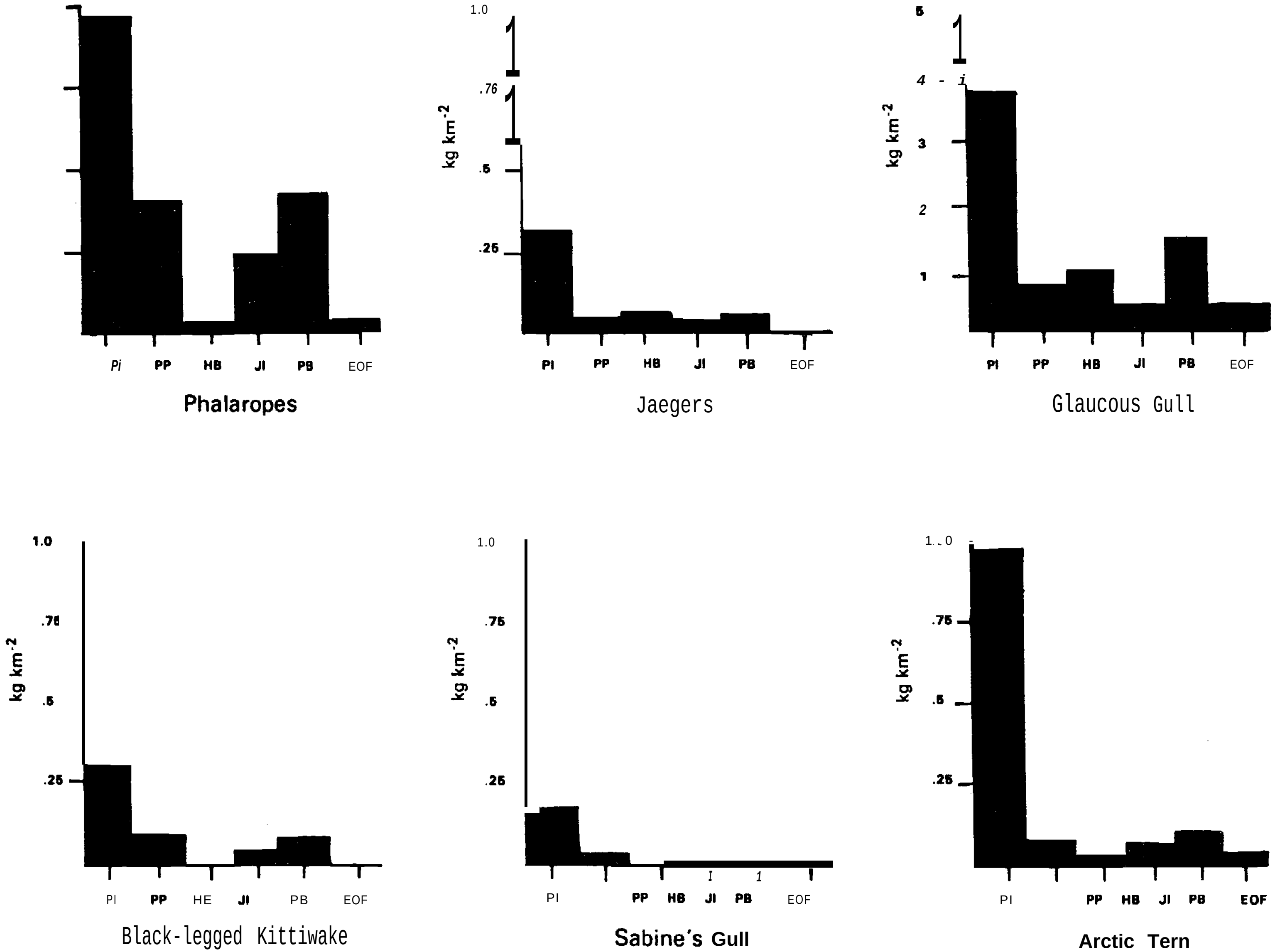


Figure 13. Biomass densities of the common surface feeding species in the six regions of the Alaskan Beaufort Sea nearshore regime.

IX. Discussion

This report presents much species specific data that make important contributions to the knowledge of the distribution, abundance and activities of the species regularly encountered in the Beaufort. The major outcome of this research, however, has been the delineation of broad-scale trends and characteristics of the Alaskan Beaufort avifaund. These trends allow the many recent site and region specific findings to be put in perspective and also are important when considering the overall impacts of development-related activities in the Alaskan Beaufort.

These major findings are:

1) The nearshore and pelagic regimes are quite different in the amount of biomass of diving species present, and in the prey of surface feeders in each regime.

2) Surface feeders in both the nearshore and pelagic regimes show a marked last-west gradient, with the Plover Islands region having the highest densities of most species. The eastern regions have extremely low densities of many surface feeding species.

A. Characteristics of the two regimes

The Alaskan Beaufort was found to have a high biomass (>45 kg km sq.) nearshore avian community composed primarily to diving species (loons, Oldsquaw, eider) feeding on epibenthos. The pelagic regime has a low biomass avian community composed almost exclusively of surface feeding species. While the same surface feeding species are present in both regimes, Arctic Cod are the main prey in pelagic waters while zooplankton are the primary prey in the nearshore.

In general the diving component of the nearshow varies little between regions. This indicates that the epibenthic system that supports these species (Johnson and Richardson 1982) varies little between regions (Table 45). This is consistent with the findings of benthic sampling (Carey et al. 1982). Harrison Bay is the one region with regular low biomass of diving species which is probably related to the shallowness of the bay (averaging < 10 m) and the major input of turbid fresh water from the Colville River that diving species feeding on epibenthos are essentially limited to the nearshore is probably primarily due to the energy required for diving more than 20 m. There is, however, a change in the benthic populations of amphipods and molluscs at 20 m (Carey et al. 1982) which may relate to the lack of epibenthic feeders in deeper water.

The pelagic regime is characterized by an almost complete lack of diving species and, for most regions, extremely low densities. The bird densities encountered are almost certainly the lowest for any of the shelf regions adjacent to Alaska.

The low numbers of birds supported by the pelagic waters can be at least partially attributed to the low annual primary productivity of the Beaufort, which averages between 15 and 30 g C per m sq. (Schell et al. 1982), and resulting low prey densities (Homer, 1981). The lack of diving species in most areas of the pelagic Alaskan Beaufort is another indication of low prey density. Surface feeders are able to feed where prey densities are low because they can search for food while flying, while diving species require more abundant and reliable food sources. In general, diving species in pelagic waters are over the continental shelf and the narrow shelf of the Alaskan Beaufort provides little suitable habitat.

The difference in prey consumed by surface feeders in the regimes is an indication that two separate systems are present. The difference can be partially explained by the greater ice cover of the pelagic regime. While no sampling has been conducted to demonstrate that Arctic Cod are more abundant in ice-covered waters, they are almost certainly more available to birds. Zooplankton could be expected to be more abundant in the nearshore which can average 5°C warmer than pelagic waters. Redburn (1972) estimated that zooplankton biomass in the warmer coastal waters is roughly an order of magnitude higher than for the colder central Arctic. The low percentage consumed by birds is due to both low densities and short residency time. Estimates of the total annual production of smaller fish consumed by large predators, including seabirds, was estimated to be 10 percent in the North Sea (Evans, 1971) and 8 percent in the North Pacific (Sanger, 1972).

Aside from low densities and a paucity of diving species in the pelagic regime the most striking aspect of the Alaskan Beaufort bird community is the difference between the relatively high densities of surface feeding species found west of Cape Halkett (Plover Islands and Pitt Point regions) and the low densities present to the east. During the period of observations there is a post-breeding movement of most surface feeding species west to Point Barrow and then southwest to the Pacific Basin. Many of these species undertake long migrations after leaving the arctic and require abundant prey resources that permit the accumulation of fat reserves before beginning those migrations. The results presented here, as well as other information on bird movements in pelagic waters (Divoky, in prep.), show that birds move west through the Alaskan Beaufort until they reach the area west of Cape Halkett where they begin to actively feed and search for food. Birds accumulate in this area, resulting in high densities, before continuing their post-breeding migration.

Three species, the Short-tailed Shearwater, Glaucous Gull and Black-legged Kittiwake have pelagic populations that are not involved in breeding activities and are able to respond to prey abundance during the entire summer and early fall period. These species show a similar distributional pattern with the highest densities occurring west of Cape Halkett.

It appears that the higher bird densities in the western Beaufort are due to the input of warm subarctic water resulting in higher prey densities for pelagic birds. The advection of Bering Sea water into Beaufort Sea (the Bering Sea Intrusion) has been discussed by Johnson (1956), Hufford (1974), Hufford et al. (1974) and Mountain (1974) and consists of two water masses, Alaskan Coastal Water and Bering Sea Water. The former water mass mixes with arctic surface water soon after it passes Point Barrow and is not clearly identifiable east of 148°W. The latter moves east to at least 143°W. Satellite photos indicate that when the Intrusion meets the water moving westward in the Beaufort Gyre and the nearshore regime, eddies are formed in the Plover Island and Pitt Point regions.

While the importance of the Bering Sea Intrusion to Beaufort Sea biological oceanography was recognized by Johnson (1956), the studies related to oil development in the central Alaskan Beaufort were usually too far from the major affects of the Intrusion to provide further information on it. Schell et al. (1982) in a synthesis of available annual primary productivity data shows a tongue of high productivity (45 g C per m sq.) from Point Barrow east to 152°W along the 20 m contour and speculates that eddies north of the Plover Islands have annual production rates approaching 50 g C per m sq. Areas east of 151°W have annual productivity rates between 30 and 37.5 g C per m sq.

While zooplankton sampling has demonstrated the presence of Bering Sea species and higher densities of other species in the Intrusion, no clear evidence of higher total zooplankton abundance in the Intrusion is available. Johnson (1956) found the area from Point Barrow to 150°W to have copepods characteristic of the Bering Sea. The arctic copepod (Arcatia longiremis) was most common west of 150°W and barnacle larvae reached their highest densities directly north of Point Barrow. McConnell (1977) in an analysis of zooplankton collected in 1971 east of 150°W found only one species, a pteropod (Clione limacina), with a distinctly western distribution, but did find an area of high zooplankton diversity and abundance at 148°W which she attributed to a pulse of Bering Sea water. Data collected by Homer (1981) in 1973 and 1976-78 showed barnacle larvae to be most abundant in the Intrusion but failed to find any other affect of the Intrusion on zooplankton densities or larval fish. Lowry and Frost (1981) showed that Arctic Cod were most common west of 148°50'W although their data are from bottom tows and of use in explaining the densities of surface feeders only in showing a general trend. Marine mammal distribution reflects the influence of the Intrusion. Bowhead whales (Balaena mysticetus) concentrate in the fall in the area north of the Plover Islands (Braham and Krogman, 1977) as do Belukha Whales (Delphinapterus leucas) (J. Burns, pers. comm.). Seals present on the shorefast ice have been shown to be most common west of 153°W (Burns and Harbo, 1972; Bums and Eley, 1978).

The importance of Bering Sea water, and its associated higher productivity, to seabirds in the Chukchi Sea has been recognized by Springer et al. (1982) for cliff-nesting species and Divoky (in prep.) for pelagic populations.

If the Bering Sea Intrusion is the primary factor causing high prey abundance in the extreme western Beaufort, the distribution and abundance of prey could be expected to be patchy in space and time and poorly sampled by opportunistic zooplankton tows. Bering Sea water moves into the Beaufort in pulses and the strength of the Intrusion shows yearly variability (Johnson, 1956; Hufford et al., 1974). Physical oceanographic sampling in the Plover Island and Pitt Point regions demonstrate that certain stations show no effects of the Intrusion and that the temperatures and depth of the Bering Sea water varies greatly among stations where the Intrusion is observed (Homer, 1981). In addition the location of eddies would increase the patchiness of zooplankton. For these reasons it is not surprising that the available zooplankton data fail to agree with that for marine birds and mammals.

The patchiness of bird densities in the Plover Island region is demonstrated by observations made on 4 September 1977. Transects began at 72°10'N, 155°00'W and went south to 71°33'N. All transects were in ice-free waters. In the first 4.25 hr of observation the average biomass was .4 kg per km sq. Approaching the 20 m contour a feeding flock of 300 Arctic Terns, 20 Black-legged Kittiwakes, 10 Sabine's Gulls, five Red Phalaropes and two Pomarine Jaegers was observed. The flock was over a convergence line that caused enough chop for it to be clearly visible on the ship's radar as sea clutter. The east side of the convergence had a secchi depth of 9 m while the west side had a secchi depth of 6 m with both sides having 8°C water in the entire water column (27 m) (Homer, 1981). Stomach samples showed that Arctic Terns were taking primarily euphausids while Sabine's Gulls were taking hyperiid amphipods. Bongo tows on both sides of the convergence showed only moderate densities of either prey species. Bird censusing conducted next to and over the convergence produced an average of 6.9 kg per km sq. in 1.75 hr of observation with a high of 30.7 kg per km sq. directly over the convergence. Densities to the east and west of the convergence were low with .5 kg km sq. in 4.5 hr of observation.

The location of this feeding flock may regularly be a site of high bird densities since a flock of 300 Arctic Terns was" observed there on 18 August 1976.

The processes by which the Intrusion increases prey abundance are not known but could include:

1. Increasing vertical mixing thus bringing nutrients to the surface and increasing primary productivity.

2. Bringing water with higher nutrient and/or phytoplankton levels into the Beaufort, thus increasing primary productivity and/or providing food for zooplankton.

3. Bringing water with high zooplankton standing stocks into the Beaufort, thus directly providing prey.

Major wash-ups of dead and dying *Thysanoessa raschii* that occur regularly on the Plover Islands (Boekelheide, 1980; Divoky, in prep.) may be composed of Pacific expatriates that perish as the Bering Sea water looses its integrity in the Beaufort. An integrated study of the physical and biological components of the extreme western Beaufort is needed in order to delineate the processes involved.

B. Vulnerability of species and areas

The following is a synopsis of the times and areas when Beaufort seabirds are most vulnerable to development related impacts (primarily oil spills). In general, during species are more vulnerable to oil spills since they can become oiled by diving through and surfacing in spills. Surface feeders are usually able to avoid spills.

Loons - During spring migration Yellow-billed Loons appear to be the primary loon species utilizing leads for migration. Yellow-billed Loons moving through the Chukchi to the Beaufort could be expected to be affected by a spill in the f1 w lead in the Chukchi. When the first patches of open water begin to form in the nearshore in mid-June loons are regularly seen, and they continue to be common in the nearshore until at least mid-September. While loons are regular in most nearshore areas and for most of the summer and early fall, the number of loons impacted by any given spill could be expected to be low since loons do not gather into large flocks, unlike Oldsquaw and eiders. The period from mid to late August when most loons have left the tundra for nearshore waters and migration has not yet begun would probably be the time when loons as a group are most vulnerable.

Oldsquaw - Oldsquaw are present in the nearshore from the first moat formation in June until freeze-up. It is doubtful if a spill in the nearshore would not result in the oiling of a quantity of Oldsquaws. There are locations and times when the magnitude" of the impacts on Oldsquaw would be large. In late June and early July a spill in the small areas of open water occupied by Oldsquaw could be expected to result in high mortality since the areas available to Oldsquaw is limited. In late July arid for much of August, lagoonal areas have the highest Oldsquaw densities and because many of these birds are moulting, they are flightless and less able to avoid spills. Beginning in late August and, apparently through September, Oldsquaw move to non-lagoonal nearshore areas in numbers and during this time the species would be vulnerable in all nearshore areas.

Eiders - In spring migration the eiders moving to the Beaufort apparently wait in the Bering/Chukchi fl w lead for following winds. The location of this staging area isn't known but any oil spill in the area in May could be expected to greatly impact the Beaufort eider population. The spring migration in the Beaufort is probably too far offshore and too diffuse to be impacted by oil spills. From June through August the area between Harrison and Camden Bays, where breeding colonies are located, would be the primary area where eiders could be expected to be affected by oil spills. Migratory flocks appear to set down so infrequently in the Alas a Beaufort that they would be able to avoid spills.

Surface feeders - Phalaropes, jaegers, gulls and terns are all less likely to be directly oiled than diving species. They can be indirectly affected by the loss of habitat or through impacts on prey or the systems that provide the prey. Except for the terns and gulls breeding on barrier islands, surface feeding species do not concentrate in the nearshore or pelagic regimes until late July. They then remain common until late August. During this period the areas shown to have large numbers of surface feeding species (the Plover Islands nearshore and pelagic regions, and the Pitt Point pelagic region) are the locations where the largest number of surface feeding species would be affected by a spill.

Because the pelagic regime has lower bird densities than the nearshore and because diving species are essentially absent from the pelagic regime, while they are common to abundant in the nearshore, oil spills would have a far greater impact in nearshore than in pelagic' waters. The impact of a spill in pelagic waters would depend on how far west the spill occurred. In pelagic waters east of Harrison Bay the affect of a spill on birds could be expected to be minimal.

While a spill in the nearshore would almost certainly impact numbers of birds wherever it occurred there are two areas that appear especially sensitive:

1) The Jones Island nearshore area containing Simpson Lagoon and the area south of Thetis Island appears to have the largest concentrations of Oldsquaw in the Alas a Beaufort.

2) The nearshore area north of the Plover Islands consistently has the highest concentrations of gulls, terns and phalaropes and maintains these high concentrations during much of August while birds feed and stage in this area. Both of the above mentioned areas contain important feeding areas for the species involved as well as roosting areas on barrier islands. Human activities on the islands and impacts to the marine system could both be expected to interfere with the birds in these areas.

X. Needs for further studies

A large scale survey of this sort(5 years of cruises and over 500 hours of observations) helps to delineate the major patterns of bird distributions in the Alaskan Beaufort. Areas where we consistently found low bird densities (such as the central and eastern pelagic regime) probably require little more in the way of bird surveys. Areas where higher bird densities have been found do need further study when it is anticipated that development related impacts might occur. Such studies have been conducted in Simpson Lagoon and are being conducted on the Arctic National Wildlife Range coast. Site or region specific studies allow small scale patterns of distribution and abundance to be determined. Such information allows development to occur with the minimum amount of disturbance to birds. The data presented in this report cannot take the place of such studies.

While our coverage of the Beaufort has been rather complete, given the problems of shipboard censusing in a sea like the Beaufort, Figure 3 shows a number of areas where censusing has not taken place. The nearshore east of Flaxman Island has already been mentioned as an area in need of further study. The bird studies currently being conducted there (1982) will hopefully fill that gap. The largest area that we have been unable to census is the broad nearshore area from Harrison Bay west. On the basis of observations north and south of this area it may be an important staging and feeding area for seabirds. This would be especially true in the Plover Islands area. A study in this area would also help to delineate the differences between the pelagic and nearshore regimes. Few of our observations have crossed the boundary between the two regimes (the 20 m contour) and a series of transect lines crossing the boundary would show how sharp the division is.

Further studies in the pelagic regime would be best done in the Plover Islands region. This is not only the area where birds are most vulnerable in the pelagic Beaufort, it also appears to be one of the most interesting in terms of biological oceanography due to the influence of the Bering Sea Intrusion and its associated eddies. The large number of higher vertebrates that are found in the Plover Island pelagic region would justify a study of prey populations in the area.

The short time that birds are present in the Beaufort and the even shorter time when vessels can effectively move through the Beaufort, means that a data base is built slowly through time. This is clear from the decade that has passed since the first cruise reported on in this report was conducted. The long time involved in effectively censusing the Beaufort was recognized by the OCSEAP Arctic project Office when this study was first funded by OCSEAP in 1975. The pace of development is now so fast that time will rarely permit data to be gathered on vessels, where fog and mechanical failures can greatly shorten the few ice-free weeks of available census time. Because of this it is good to mention that much of the information on bird activities presented in this report (migration rates, flight directions, percent birds sitting on the water) could not have been obtained from aerial surveys. Biological oceanographers will continue to use icebreakers and smaller vessels for platforms when conducting research in the Beaufort and, although the amount of bird observations obtained on a given cruise might be small, those who are interested in Beaufort seabirds or in need of development related data would do well to put a bird observer on board.

XI. Acknowledgements

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Observers on pelagic cruises included the author, G. E. Watson, D. A. Woodby, K. Wilson, D. Forsell, T. Sharffenberg and M. Phillips. Nearshore observations were conducted primarily by A. E. Good, with some assistance from D. Forsell and the author.

The cooperation and assistance of the captains and crews of the vessels used as observation platforms was essential to the gathering of the large volume of data reported on in this report. Personnel aboard the U. S. Coast Guard icebreakers Glacier and Northwind and the Naval Arctic Research Laboratory's Alumiak and Natchik assisted in many ways.

This project has been helped on innumerable instances by the staff of the Arctic Project Office of OCSEAP. Logistical coordinators D. Kennedy, T. Flesher and D. Brooks made many arrangements that permitted successful field efforts. D. Norton has provided guidance and encouragement through all aspects of this project.

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