THE DISTRIBUTION AND ABUNDANCE OF BIRDS IN THE EASTERN CHUKCHI SEA IN LATE SUMMER AND EARLY FALL

by

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Final Report
Outer Continental Shelf Environmental Assessment Program
Research Unit 196

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PREFACE

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The majority of the fieldwork reported on in this report was obtained through the OCSEAP Arctic Project Office at the University of Alaska. D. Norton, of that office, provided moral and scientific support to this project. Logistical coordinators D. Kennedy, T. Flesher and D. Brooks assisted with the scheduling of space on vessels. The U.S. Coast Guard provided space on board icebreakers. The Alaska Office of NOAA's Ocean Assessments Division allowed participation on the 1986 cruise.

Observers who conducted or assisted Divoky with pelagic observations include S. Allison, R. J. Boekelheide, A. E. Good, R. Rohleder, G. E. Watson and D. A. Woodby. Data entry following the fire was completed by M. Donovan.

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

I. Objectives

The objective of this research unit, with regard to this report, was to describe the distribution and abundance of the pelagic birds of the Chukchi Sea during the period when extensive open water is present (July through October). Using data on vessels of opportunity we sought to determine the relative densities and frequencies of the principal bird species occupying the Chukchi in order to provide a broad-scale assessment of the Chukchi avifauna. Population estimates were derived to provide a measure of the importance of the Chukchi to pelagic seabirds and allow comparisons with other Alaskan seas.

II. Conclusions

The Chukchi Sea was found to have a pelagic avifauna containing both arctic and subarctic components, reflecting the transitional nature of the Chukchi waters from Bering Sea influence in the south to the Arctic Basin water in the north. From late July to late August murres (*Uris* spp.), Black-legged Kittiwakes (*Rissa tridactyla*) and phalaropes (*Phalaropus* spp.) are the most numerous pelagic Chukchi seabirds. The former two are the most abundant cliff-nesting species found in the Chukchi and the latter the most abundant breeders on tundra adjacent to the Chukchi. After late August the number of Bering Sea species increases greatly as shearwaters and smaller numbers of Parakeet (*Cyclorrhynchus psittacula*), Least (*Aethia pusilla*) and Crested Auklets (*A. cristatella*) move north into the southern and central Chukchi. An estimated 2 million shearwaters may occupy the Chukchi from late August to late September making them the most abundant bird in the region during the period reported on in this report. From late September the most common species in the northern and central Chukchi are Ross' and Ivory Gulls and Black Guillemot, all high arctic breeders that winter in association with pack ice.

The density and diversity of seabirds in the Chukchi Sea were found to be intermediate between the abundant and diverse avifauna of the Bering Sea and the low densities and number of species in the Beaufort sea. The number of seabirds using the pelagic waters of the Chukchi is estimated at almost five million individuals. For a number of high arctic species and tundra-nesting migrants, the Chukchi densities were found to be the

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111. Implications with respect to OCS oil and gas development

The information provided here allows resource managers to anticipate the magnitude of effects of oil and gas development on pelagic bird populations in the Chukchi Sea. It provides valuable comparisons with the Bering and Beaufort seas that allow the assessment of the magnitude and broad-scale distributions of Alaskan pelagic seabird populations in summer and fall.

1 INTRODUCTION

1.1 General Nature and Scope of Study

Determining the distribution and abundance of the pelagic birds of Alaska's outer continental shelf was a major objective of OCSEAP (Outer Continental Shelf Environmental Assessment Program). Seabirds are the most visible manifestations of marine biological productivity, occupying the top position in oceanic food webs and having the mobility to readily respond to spatial and temporal changes in prey abundance. When birds become oiled in the course of an oilspill, the associated effects can be highly conspicuous..

The Chukchi Sea is one of the two Alaskan arctic seas. While ice coverage in the Chukchi is nearly complete for nine months of the year, from mid-July through mid-October much of the area from the Bering Strait to the latitude of Point Barrow is ice free. We report here on observations of pelagic birds made on nine cruises during the three–month period when the Chukchi is navigable.

This report completes the characterization of Alaskafs pelagic avifauna in summer and fall when seabird densities could be expected to be highest. The pelagic seabirds of the Gulf of Alaska and Bering Sea have been described by Gould et al. (1982) and those of the Beaufort Sea by Divoky (1984). Pelagic waters are defined here as waters exceeding 20 m in depth. It is important to note that this report does not include the Chukchi nearshore and that many of the species discussed here can be expected to be common to abundant in nearshore and littoral habitats.

1.2 Specific Objectives

The specific objectives are:

1. To describe the distribution and abundance of marine birds in the pelagic waters of the Chukchi Sea.

2. To identify the seasonal and geographic variation in these distributions and abundances.

3. To provide estimates of the pelagic populations for the common marine birds in Chukchi Sea.

1.3 Relevance to problems of oil development

In order to limit the environmental effects associated with the exploration and development of oil from Alaska's outer continental shelf an initial requirement is a description of the spatial and temporal patterns of distribution and abundance of the species occupying the waters over the shelf. Such information allows resource managers to make decisions on the location and timing of human activities with the intent of limiting impacts on biotic systems. It also allows the nature and magnitude of human-related effects to be anticipated when and where development does occur.

It is important to note that the information presented here cannot be used to monitor the effects of industrial development. The high annual variability of the densities and distributions in the Chukchi Sea is similar to what has been found in virtually all multi-year pelagic seabird studies. Such variability precludes the use of pelagic densities to monitor pollution. Multi-year studies at seabird colonies on breeding population size, breeding success and feeding ecology provide a more useful method of utilizing seabirds to monitor marine systems (Springer et al. 1982).

2 CURRENT STATE OF KNOWLEDGE

Prior to the onset of studies sponsored by the BLM/MMS/NOAA Outer Continental Shelf Environmental Assessment Program in 1975 there was a paucity of accounts on the pelagic birds of the Chukchi Sea and essentially all accounts were non-quantitative in nature. These earlier narratives began with Nelson (1883, 1887) who reported on birds seen on a cruise in the summer and early fall of 1881. There was then an almost 50 year hiatus until the summer of 1928 when Jacques (1930) observed birds from late July through August. In August 1960 observations centered in the southern Chukchi were conducted by Swartz (1967). Watson and Divoky conducted observations at the ice edge in late September and early October 1970 (Watson and Divoky 1972, Divoky 1972). These latter observations have been converted to a density format comparable to OCSEAP observations and are presented in this report.

The paucity of cruises in the Chukchi has meant that much of what is known about Chukchi seabird distribution had to be inferred from incidental sightings of pelagic birds by land-based observers. Such observations come principally from Point Barrow where observations have occurred on an intermittent basis for the last century. These land-based observations are summarized in Bailey (1948), Gabrielson and Lincoln (1959), Pitelka (1974) and Kessel and Gibson (1978).

Reports dealing with pelagic birds in the Chukchi Sea include the aerial surveys conducted by Harrison (1977) and Drury and Ramsdell (1985). A synthesis of information on the marine and coastal birds of the Barrow Arch, which includes most of the Chukchi north of Point Hope, was written by Roseneau and Herter (1984). The two OCSEAP reports describing the pelagic birds of the Alaskan seas adjacent to the Chukchi, the Bering (Gould et al. 1982) and Beaufort seas (Divoky 1984), are important sources for interpreting information from the Chukchi.

3 STUDY AREA

3.1 Physical and Biological Oceanography

The Chukchi Sea contains both arctic and subarctic components. While it occupies part of the arctic basin and ice covers most areas for well over six months of the year, its physical and biological oceanography are dominated by the flow of subarctic water north through the Bering Strait. The transport of water through the Bering Strait has been described in Coachman et al. (1975) and Coachman and Aagaard (1981) and summarized in Lewbel and Gallaway (1984). Briefly, two water masses (Alaska Coastal Water and Bering Sea Water) move through the Bering Strait into the Chukchi. One of the principal effects of this intrusion is the accelerated rate of melting of ice in the southern and central Chukchi. Sea surface temperatures in the arctic basin are typically near 0°C and rarely exceed 5°C in summer but temperatures in the southern Chukchi can reach 10-15 °C.

The pelagic ecosystem of the Chukchi is influenced by Bering Sea water in a number of ways. Nutrients, zooplankton and fish are transported northward with the Bering Sea water (Truett 1984a). As the Bering Sea water moves northeast up the Alaskan Chukchi coast it creates areas of upwelling and eddies (Lewbel and Gallaway 1984). The lower trophic levels of the Chukchi have been described in Truett (1984a), the fish resources in Craig (1984), and the coastal and offshore ecosystems in Truett (1984b).

3.2 Geographic Divisions

For the purpose of examining bird distributions the Alaskan Chukchi Sea, east of the USSR convention line and south of the mean extent of 5 eighths ice cover for September (Brewer et al. 1977), has been divided into four areas (Fig 10). Three of these are pelagic areas; the southern, central and northern Chukchi. Kotzebue Sound and the areas directly adjacent to it are treated as a separate region.

Southern Chukchi Sea

The southern region is north of 66°N and south of the latitude of Cape Lisburne (68°45'N). It contains 55 thousand sq. km. of pelagic waters. Its surface temperatures are greatly affected by the movement of Bering Sea water through the Strait and August temperatures can reach 15°C. This area has the longest period of open water of the Chukchi with extensive open water from June through November. It is the only region of the Chukchi where we failed to encounter ice during our observations.

The only seabird cliff colonies in the Alaskan Chukchi Sea are in this area, most notably at Cape Thompson and Cape Lisburne. The total number of colonial nesting seabirds in the region is over 500 thousand (Sowls et al. 1978) and our observations in this region could be expected to include birds breeding at these colonies. The numbers and breeding biology of the seabirds at Capes Thompson and Lisburne have been studied for the last decade (e.g., Springer et al. 1982).

The southern limit of 66°N was chosen to exclude the large numbers of birds breeding in the Bering Strait (Sowls et al. 1978) as well as the large numbers of migrant birds found in and adjacent to the Strait (Drury and Ramsdell 1985).

Central Chukchi Sea

The central Chukchi is the area north of Cape Lisburne and south of 71°55'N. It contains 140 thousand sq. km of pelagic waters. Our sampling in the central Chukchi spans the entire open water period with observations from 16 July through 12 October.

With the exception of cliff-nesting species in the area of Cape Lisburne almost all birds encountered in the region will be either nonbreeders, migrants or birds that have dispersed northward after breeding. The area is adjacent to major lagoonal systems and associated barrier islands in the Chukchi nearshore. Sea surface temperatures and ice cover are intermediate between the southern and central Chukchi.

Northern Chukchi Sea

The northern Chukchi is the area north of 71°55'N. The amount of open water in this region can vary greatly. In years of minimum ice retreat the ice edge is near 72°N. Sea surface temperatures in this region could be expected to show only minor effects of the Bering Sea water since the current parallels the Chukchi coast northeast to Point Barrow. The area is north of any nearby land mass and is not in the migratory pathway that birds could be expected to take from the pelagic or nearshore Beaufort through the Chukchi. Our sampling in this area is limited but does provide comparisons with the adjacent areas of the central Chukchi.

Kotzebue Sound

The waters of Kotzebue Sound and adjacent areas of the Chukchi Sea are shallower (depths of less than 20 m) and less saline than other areas of the Alaskan Chukchi. Horned Puffins breed in numbers at Chamisso Island. The region is 12 thousand sq. km including waters less than 20 m.

4 SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

4.1 Sources

Observations were conducted on nine cruises during the period when icebreaking vessels are able to navigate the Chukchi Sea (mid-July through mid-October). The dates when observations were conducted and the names of the vessels are presented in Table 1. The cruise tracks where seabird censusing was conducted are presented in Figures 1 to 9.

The cruises fall into three periods: 16 July to 20 August, 24 August to 22 September and 22 September to 17 October. There is one day of overlap in the last two periods since one cruise ending on that date in the Bering Strait is included in the earlier period while another cruise beginning at Point Barrow on that date is included in the latter. Maps showing the locations of observations in each of these periods are presented in Figure 10. The number of observation periods in each region by time period and the percent of the observation periods when ice was visible from the ship are presented in Table 2.

The time periods fall into three divisions. The first period is during the time when ice is absent from the southern Chukchi, present but rapidly decomposing in the central Chukchi and covering most of the northern Chukchi. Much of the migration of tundra-nesting migrants occurs during this period especially during the first three weeks of August.

The second time period is one of maximum retreat of the pack ice with the ice edge usually present north of the central Chukchi. This is the period of major migration of Oldsquaw (*Clangula hyemalis*) and loons (*Gavia* spp). Most cliff nesting species complete their breeding activities during this time.

From late September to early October ice formation could be expected to be occurring in most areas of the northern and north central Chukchi. Most species that winter south of the subarctic have migrated out of the Chukchi by the second week in October.

4.2 Methods

1. Field techniques

Censusing of birds was conducted using the same methods described in Divoky (1984) and Gould et al. (1982). Observations were made in 15-minute intervals when the ship was steaming at more than four knots. These 15-minute periods are referred to as both “transects” and “observation periods" in this report. Observations from the 1970 cruise were conducted in 20-minute periods. One or two observers conducted observations from the flying bridge of the vessel (average height 18 m above sea level). All birds observed to 300 m to one side of the vessel were identified to species or species group. Information on age, sex, and activities were recorded whenever possible. The total area censused in each transect was determined and a density of birds per sq. km was computed for each species or species group.

For each transect, information on location, observation conditions and certain meteorological and oceanographic parameters were also recorded. All information was coded into the National Oceanographic Data Center's (NODC) "033" format for cruises from 1975 through 1978. This information has been digitized and is stored at the NODC.

2. Data Analysis and Presentation

a. General cautions

Dedicated ship time for pelagic bird observations has not been available in the Chukchi Sea. As was typical of most OCSEAP cruises, the cruises reported on here had a suite of projects that focused on sampling at a set of oceanographic stations. The number of cruises we report on compensates somewhat for the random timing and location of our observations. For certain seasons and areas we have only limited data from a single cruise, however. While the type of sampling reported on here allows an acceptable preliminary large-scale assessment of the avifauna of a region (i.e. Gould et al. 1982, Divoky 1984) its limitations need to be recognized by those using the data. In almost all cases where site-specific information is needed, dedicated ship or plane time is required.

b. Data presented

In order to characterize and describe the pelagic avifauna of the Chukchi, three measures are presented for each region or analysis: average density, maximum density and percent frequency, Average density is simply the average for a set of transects. Maximum density is the highest density encountered and is important in interpreting the average density. It also presents an indication of how concentrated a species can become. In terms of environmental assessment a maximum density allows a "worst case scenario" to be evaluated with regard to the highest possible density a site-specific pollution event could be expected to impact. Frequency of occurrence is the percentage of transects on which a species was encountered. It provides an indication of dispersal of a species and a way to further compare species with similar average densities. Frequency of occurrence can be assumed to be similar to the probability of an environmental hazard, such as an oil spill, affecting a species.

4.3 Population estimates

While a density of birds per sq. km provides a useful way of comparing the importance of marine areas to seabirds, in some cases it is not as useful as an estimate of the total pelagic population using a large geographic area. Colony censuses provide estimates of breeding birds and in combination with estimates of pelagic populations allow assessment of total marine bird populations. Hunt et al. (1981) published pelagic population estimates for the eastern Bering Sea and Gould et al. (1982) did the same for the Bering Sea and Gulf of Alaska. The latter estimates were called "population indices" to emphasize the problems involved in obtaining an estimate based on simply multiplying a density times an area, with only minor stratification of the area or observations and no corrections for biases known to be inherent in population estimates.

Population estimates for the period of maximum abundance are presented for those species regularly encountered in the Chukchi. Population estimates for the southern and central Chukchi were computed by multiplying the average density by the area of the region. In most cases these were simply added to provide an estimate for the entire Chukchi. The northern Chukchi is not included since our censusing in that region was so limited and the total amount of open water in that region is so variable. Kotzebue Sound was not included since our information from that area is from a single cruise. For some species the sample size and geographic coverage of the region has to be taken into account and the estimate modified. This is always done to reduce what appeared to be unreasonably high population totals. The estimates are for an instantaneous population and not the total number of individuals that could be expected to use the pelagic waters in a year. This latter figure could be substantially higher than our instantaneous estimates especially for species with protracted migrations, such as phalaropes (Phalaropus spp.) and jaegers (Stercorarius spp.).

5 SPECIES ACCOUNTS

5,1 LOONS

Table 3. Figure 11.

Three species of loon migrate through the Chukchi Sea. Observations in the Beaufort Sea (Divoky 1984) and on the North Slope tundra (King 1979) show that Pacific Loons (Gavia pacifica) comprise 80 percent, Red-throated Loons (G. stellata) 18 percent and Yellow-billed Loons (G.adamsi) 2 percent of the loons in arctic Alaska.

Loons were uncommon in the pelagic Chukchi until late August. They become regular in pelagic waters adjacent to the nearshore during September. While we saw loons as early as 16 July, 86 percent of our sightings came after 28 August. Few were seen after 27 September and the last observation in the pelagic Chukchi was on 6 October. The dates of our observations agree with findings from the nearshore Beaufort and Point Barrow showing westward migration beginning in the last week of August (Divoky 1984) with the bulk of fall loon migration occurring in the first three weeks of September (Timson 1976, Divoky unpubl.) . In the Point Barrow region fall migration is usually over by the first week in October (Divoky, unpubl.).

The density values presented in Table 5 are of limited value since the majority of the loons observed in the pelagic Chukchi were migrants flying over but not occupying offshore habitats. In such cases a value of birds per time is more appropriate than that one of birds per area (Divoky 1984). Both the average density and frequency of occurrence for loons show that loons were rare in all areas of the pelagic Chukchi until late August and early September when they became regular. They were absent or uncommon in the northern Chukchi.

Loons are migrating southwest and south through the Chukchi from Canadian and North Slope nesting grounds to the Pacific Basin wintering areas. Our observations indicate that loons move through the pelagic Chukchi primarily adjacent to the nearshore until they reach the Lisburne peninsula. South of Point Hope loons are common over pelagic waters as they apparently head for the Bering Strait. That there is still considerable coastal movement is evidenced by the numbers seen at the mouth of Kotzebue Sound.

We identified too few individuals to determine the percentages of the three species, but can assume that the percentages mentioned above also apply to the Chukchi migrants. Previous pelagic observers have rarely observed loons in the Chukchi and only close to shore (Swartz 1967).

In the pelagic Beaufort and Bering seas loons were also found to be uncommon until the fall (Divoky 1984, Gould et al. 1982).

5.2 NORTHERN FULMAR

Table 4. Figure 12.

Northern Fulmars (Fulmarus glacialis) do not breed in the Chukchi Sea and birds observed there in the summer are either nonbreeders or failed breeders. Fulmars breed in numbers as far north as Saint Matthew Island in the Bering Sea (Sowls et al. 1978) with smaller numbers being found on the southern Chukchi Peninsula north to Providence Bay (Portenko 1981).

Fulmars were found to be regular in the open water of the southern Chukchi Sea during the entire sampling period with average densities over .3 birds per sq. km and frequencies near 20 percent. While present in the central Chukchi before late August they become more common in that region from late August to mid-September but were absent from the central Chukchi after late September. One observation of a fulmar was made in the northern Chukchi at 72°30'N in August 1986 when the ice edge was extremely far north.

Fulmars have been shown to be rare in the pelagic Beaufort (Divoky 1984) which is not surprising given the paucity of records from the central Chukchi. While fulmars are certainly more abundant in the Bering Sea than in the Chukchi our density of .5 birds per sq. km in August approximates what Gould et al. (1982) found for average densities on the Bering Sea shelf. Nowhere did we encounter a maximum density of over 10 birds per sq. km, whereas Bering Sea shelf maximum densities are all over 500 birds per sq. km for spring, summer and fall.

Previously published Chukchi observations are in general agreement with those presented here. They report fulmars uncommon or rare in pelagic waters except for Jacques (1930) who saw fulmars regularly south of 68°30′ N.

We estimate 45 thousand fulmars in the Chukchi sea from late August to late September. Gould et al. (1982) estimated 2.1

million fulmars in the Bering Sea in summer and much higher numbers in fall.

5.3 SHEARWATERS

Table 5. Figure 13.

While many of the shearwaters observed could not be identified to species they were almost certainly all Short-tailed Shearwaters (*Puffinus tenuirostris*). Short-tailed shearwaters breed in the southern hemisphere during the austral summer and occupy the waters of the North Pacific and Bering Sea from May through November. It is the most abundant species in the Bering Sea with population estimates as high as 30 million (Hunt et al. 1981).

Because Short-tailed Shearwaters are most abundant in the Bering Sea, the. presence of the shearwaters north of the Bering Strait can be expected to be closely tied to the presence of Bering Sea water at the surface of the Chukchi.

Shearwaters were found to be common to abundant in the Chukchi during the period of maximum ice retreat from late August to late September. They are most abundant and regular in the southern Chukchi. The density of over 3 thousand birds per sq. km encountered on a transect near the Bering Strait is by far the highest pelagic density encountered in the Chukchi. Their distribution in the central Chukchi can be expected to reflect the presence of zooplankton prey patches. The concentration north of 71°N was in an area where Crested Auklets other zooplankton feeding birds were abundant. While shearwaters were gone from the central Chukchi in late September and early October, they are common in the extreme southern Chukchi adjacent to the Bering Strait until mid-October (Divoky 1972). None were seen in the northern Chukchi or Kotzebue Sound.

While shearwaters can be abundant in the Chukchi the densities there do not approximate those encountered on the Bering Sea shelf (Gould et al. 1982) where densities averaged over 150 and 50 birds per sq. km for summer and fall, respectively. Observations in the Beaufort Sea show that shearwaters occur irregularly east to Harrison Bay and are associated with Bering Sea water (Divoky 1984).

Based on shearwaters occurring regularly only in the southern Chukchi 2 million birds is a reasonable minimum population estimate for the Chukchi. In certain years, however,

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Determining the distribution and abundance of the pelagic birds of Alaska's outer continental shelf was a major objective of OCSEAP (Outer Continental Shelf Environmental Assessment Program). Seabirds are the most visible manifestations of marine biological productivity, occupying the top position in oceanic food webs and having the mobility to readily respond to spatial and temporal changes in prey abundance. When birds become oiled in the course of an oilspill, the associated effects can be highly conspicuous..

The Chukchi Sea is one of the two Alaskan arctic seas. While ice coverage in the Chukchi is nearly complete for nine months of the year, from mid-July through mid-October much of the area from the Bering Strait to the latitude of Point Barrow is ice free. We report here on observations of pelagic birds made on nine cruises during the three–month period when the Chukchi is navigable.

This report completes the characterization of Alaskafs pelagic avifauna in summer and fall when seabird densities could be expected to be highest. The pelagic seabirds of the Gulf of Alaska and Bering Sea have been described by Gould et al. (1982) and those of the Beaufort Sea by Divoky (1984). Pelagic waters are defined here as waters exceeding 20 m in depth. It is important to note that this report does not include the Chukchi nearshore and that many of the species discussed here can be expected to be common to abundant in nearshore and littoral habitats.

1.2 Specific Objectives

The specific objectives are:

1. To describe the distribution and abundance of marine birds in the pelagic waters of the Chukchi Sea.

2. To identify the seasonal and geographic variation in these distributions and abundances.

3. To provide estimates of the pelagic populations for the common marine birds in Chukchi Sea.

1.3 Relevance to problems of oil development

In order to limit the environmental effects associated with the exploration and development of oil from Alaska's outer continental shelf an initial requirement is a description of the spatial and temporal patterns of distribution and abundance of the species occupying the waters over the shelf. Such information allows resource managers to make decisions on the location and timing of human activities with the intent of limiting impacts on biotic systems. It also allows the nature and magnitude of human-related effects to be anticipated when and where development does occur.

It is important to note that the information presented here cannot be used to monitor the effects of industrial development. The high annual variability of the densities and distributions in the Chukchi Sea is similar to what has been found in virtually all multi-year pelagic seabird studies. Such variability precludes the use of pelagic densities to monitor pollution. Multi-year studies at seabird colonies on breeding population size, breeding success and feeding ecology provide a more useful method of utilizing seabirds to monitor marine systems (Springer et al. 1982).

2 CURRENT STATE OF KNOWLEDGE

Prior to the onset of studies sponsored by the BLM/MMS/NOAA Outer Continental Shelf Environmental Assessment Program in 1975 there was a paucity of accounts on the pelagic birds of the Chukchi Sea and essentially all accounts were non-quantitative in nature. These earlier narratives began with Nelson (1883, 1887) who reported on birds seen on a cruise in the summer and early fall of 1881. There was then an almost 50 year hiatus until the summer of 1928 when Jacques (1930) observed birds from late July through August. In August 1960 observations centered in the southern Chukchi were conducted by Swartz (1967). Watson and Divoky conducted observations at the ice edge in late September and early October 1970 (Watson and Divoky 1972, Divoky 1972). These latter observations have been converted to a density format comparable to OCSEAP observations and are presented in this report.

The paucity of cruises in the Chukchi has meant that much of what is known about Chukchi seabird distribution had to be inferred from incidental sightings of pelagic birds by land-based observers. Such observations come principally from Point Barrow where observations have occurred on an intermittent basis for the last century. These land-based observations are summarized in Bailey (1948), Gabrielson and Lincoln (1959), Pitelka (1974) and Kessel and Gibson (1978).

Reports dealing with pelagic birds in the Chukchi Sea include the aerial surveys conducted by Harrison (1977) and Drury and Ramsdell (1985). A synthesis of information on the marine and coastal birds of the Barrow Arch, which includes most of the Chukchi north of Point Hope, was written by Roseneau and Herter (1984). The two OCSEAP reports describing the pelagic birds of the Alaskan seas adjacent to the Chukchi, the Bering (Gould et al. 1982) and Beaufort seas (Divoky 1984), are important sources for interpreting information from the Chukchi.

3 STUDY AREA

3.1 Physical and Biological Oceanography

The Chukchi Sea contains both arctic and subarctic components. While it occupies part of the arctic basin and ice covers most areas for well over six months of the year, its physical and biological oceanography are dominated by the flow of subarctic water north through the Bering Strait. The transport of water through the Bering Strait has been described in Coachman et al. (1975) and Coachman and Aagaard (1981) and summarized in Lewbel and Gallaway (1984). Briefly, two water masses (Alaska Coastal Water and Bering Sea Water) move through the Bering Strait into the Chukchi. One of the principal effects of this intrusion is the accelerated rate of melting of ice in the southern and central Chukchi. Sea surface temperatures in the arctic basin are typically near 0°C and rarely exceed 5°C in summer but temperatures in the southern Chukchi can reach 10-15 °C.

The pelagic ecosystem of the Chukchi is influenced by Bering Sea water in a number of ways. Nutrients, zooplankton and fish are transported northward with the Bering Sea water (Truett 1984a). As the Bering Sea water moves northeast up the Alaskan Chukchi coast it creates areas of upwelling and eddies (Lewbel and Gallaway 1984). The lower trophic levels of the Chukchi have been described in Truett (1984a), the fish resources in Craig (1984), and the coastal and offshore ecosystems in Truett (1984b).

3.2 Geographic Divisions

For the purpose of examining bird distributions the Alaskan Chukchi Sea, east of the USSR convention line and south of the mean extent of 5 eighths ice cover for September (Brewer et al. 1977), has been divided into four areas (Fig 10). Three of these are pelagic areas; the southern, central and northern Chukchi. Kotzebue Sound and the areas directly adjacent to it are treated as a separate region.

Southern Chukchi Sea

The southern region is north of 66°N and south of the latitude of Cape Lisburne (68°45'N). It contains 55 thousand sq. km. of pelagic waters. Its surface temperatures are greatly affected by the movement of Bering Sea water through the Strait and August temperatures can reach 15°C. This area has the longest period of open water of the Chukchi with extensive open water from June through November. It is the only region of the Chukchi where we failed to encounter ice during our observations.

The only seabird cliff colonies in the Alaskan Chukchi Sea are in this area, most notably at Cape Thompson and Cape Lisburne. The total number of colonial nesting seabirds in the region is over 500 thousand (Sowls et al. 1978) and our observations in this region could be expected to include birds breeding at these colonies. The numbers and breeding biology of the seabirds at Capes Thompson and Lisburne have been studied for the last decade (e.g., Springer et al. 1982).

The southern limit of 66°N was chosen to exclude the large numbers of birds breeding in the Bering Strait (Sowls et al. 1978) as well as the large numbers of migrant birds found in and adjacent to the Strait (Drury and Ramsdell 1985).

Central Chukchi Sea

The central Chukchi is the area north of Cape Lisburne and south of 71°55'N. It contains 140 thousand sq. km of pelagic waters. Our sampling in the central Chukchi spans the entire open water period with observations from 16 July through 12 October.

With the exception of cliff-nesting species in the area of Cape Lisburne almost all birds encountered in the region will be either nonbreeders, migrants or birds that have dispersed northward after breeding. The area is adjacent to major lagoonal systems and associated barrier islands in the Chukchi nearshore. Sea surface temperatures and ice cover are intermediate between the southern and central Chukchi.

Northern Chukchi Sea

The northern Chukchi is the area north of 71°55'N. The amount of open water in this region can vary greatly. In years of minimum ice retreat the ice edge is near 72°N. Sea surface temperatures in this region could be expected to show only minor effects of the Bering Sea water since the current parallels the Chukchi coast northeast to Point Barrow. The area is north of any nearby land mass and is not in the migratory pathway that birds could be expected to take from the pelagic or nearshore Beaufort through the Chukchi. Our sampling in this area is limited but does provide comparisons with the adjacent areas of the central Chukchi.

Kotzebue Sound

The waters of Kotzebue Sound and adjacent areas of the Chukchi Sea are shallower (depths of less than 20 m) and less saline than other areas of the Alaskan Chukchi. Horned Puffins breed in numbers at Chamisso Island. The region is 12 thousand sq. km including waters less than 20 m.

4 SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

4.1 Sources

Observations were conducted on nine cruises during the period when icebreaking vessels are able to navigate the Chukchi Sea (mid-July through mid-October). The dates when observations were conducted and the names of the vessels are presented in Table 1. The cruise tracks where seabird censusing was conducted are presented in Figures 1 to 9.

The cruises fall into three periods: 16 July to 20 August, 24 August to 22 September and 22 September to 17 October. There is one day of overlap in the last two periods since one cruise ending on that date in the Bering Strait is included in the earlier period while another cruise beginning at Point Barrow on that date is included in the latter. Maps showing the locations of observations in each of these periods are presented in Figure 10. The number of observation periods in each region by time period and the percent of the observation periods when ice was visible from the ship are presented in Table 2.

The time periods fall into three divisions. The first period is during the time when ice is absent from the southern Chukchi, present but rapidly decomposing in the central Chukchi and covering most of the northern Chukchi. Much of the migration of tundra-nesting migrants occurs during this period especially during the first three weeks of August.

The second time period is one of maximum retreat of the pack ice with the ice edge usually present north of the central Chukchi. This is the period of major migration of Oldsquaw (Clangula hyemalis) and loons (Gavia spp). Most cliff nesting species complete their breeding activities during this time.

From late September to early October ice formation could be expected to be occurring in most areas of the northern and north central Chukchi. Most species that winter south of the subarctic have migrated out of the Chukchi by the second week in October.

4.2 Methods

1. Field techniques

Censusing of birds was conducted using the same methods described in Divoky (1984) and Gould et al. (1982). Observations were made in 15-minute intervals when the ship was steaming at more than four knots. These 15-minute periods are referred to as both “transects” and “observation periods" in this report. Observations from the 1970 cruise were conducted in 20-minute periods. One or two observers conducted observations from the flying bridge of the vessel (average height 18 m above sea level). All birds observed to 300 m to one side of the vessel were identified to species or species group. Information on age, sex, and activities were recorded whenever possible. The total area censused in each transect was determined and a density of birds per sq. km was computed for each species or species group.

For each transect, information on location, observation conditions and certain meteorological and oceanographic parameters were also recorded. All information was coded into the National Oceanographic Data Center's (NODC) "033" format for cruises from 1975 through 1978. This information has been digitized and is stored at the NODC.

2. Data Analysis and Presentation

a. General cautions

Dedicated ship time for pelagic bird observations has not been available in the Chukchi Sea. As was typical of most OCSEAP cruises, the cruises reported on here had a suite of projects that focused on sampling at a set of oceanographic stations. The number of cruises we report on compensates somewhat for the random timing and location of our observations. For certain seasons and areas we have only limited data from a single cruise, however. While the type of sampling reported on here allows an acceptable preliminary large-scale assessment of the avifauna of a region (i.e. Gould et al. 1982, Divoky 1984) its limitations need to be recognized by those using the data. In almost all cases where site-specific information is needed, dedicated ship or plane time is required.

b. Data presented

In order to characterize and describe the pelagic avifauna of the Chukchi, three measures are presented for each region or analysis: average density, maximum density and percent frequency, Average density is simply the average for a set of transects. Maximum density is the highest density encountered and is important in interpreting the average density. It also presents an indication of how concentrated a species can become. In terms of environmental assessment a maximum density allows a "worst case scenario" to be evaluated with regard to the highest possible density a site-specific pollution event could be expected to impact. Frequency of occurrence is the percentage of transects on which a species was encountered. It provides an indication of dispersal of a species and a way to further compare species with similar average densities. Frequency of occurrence can be assumed to be similar to the probability of an environmental hazard, such as an oil spill, affecting a species.

4.3 Population estimates

While a density of birds per sq. km provides a useful way of comparing the importance of marine areas to seabirds, in some cases it is not as useful as an estimate of the total pelagic population using a large geographic area. Colony censuses provide estimates of breeding birds and in combination with estimates of pelagic populations allow assessment of total marine . bird populations. Hunt et al. (1981) published pelagic population estimates for the eastern Bering Sea and Gould et al. (1982) did the same for the Bering Sea and Gulf of Alaska. The latter estimates were called "population indices" to emphasize the problems involved in obtaining an estimate based on simply multiplying a density times an area, with only minor stratification of the area or observations and no corrections for biases known to be inherent in population estimates.

Population estimates for the period of maximum abundance are presented for those species regularly encountered in the Chukchi. Population estimates for the southern and central Chukchi were computed by multiplying the average density by the area of the region. In most cases these were simply added to provide an estimate for the entire Chukchi. The northern Chukchi is not included since our censusing in that region was so limited and the total amount of open water in that region is so variable. Kotzebue Sound was not included since our information from that area is from a single cruise. For some species the sample size and geographic coverage of the region has to be taken into account and the estimate modified. This is always done to reduce what appeared to be unreasonably high population totals. The estimates are for an instantaneous population and not the total number of individuals that could be expected to use the pelagic waters in a year. This latter figure could be substantially higher than our instantaneous estimates especially for species with protracted migrations, such as phalaropes (Phalaropus spp.) and jaegers (Stercorarius spp.).

5 SPECIES ACCOUNTS

5,1 LOONS

Table 3. Figure 11.

Three species of loon migrate through the Chukchi Sea. Observations in the Beaufort Sea (Divoky 1984) and on the North Slope tundra (King 1979) show that Pacific Loons (Gavia pacifica) comprise 80 percent, Red-throated Loons (G. stellata) 18 percent and Yellow-billed Loons (G.adamsi) 2 percent of the loons in arctic Alaska.

Loons were uncommon in the pelagic Chukchi until late August. They become regular in pelagic waters adjacent to the nearshore during September. While we saw loons as early as 16 July, 86 percent of our sightings came after 28 August. Few were seen after 27 September and the last observation in the pelagic Chukchi was on 6 October. The dates of our observations agree with findings from the nearshore Beaufort and Point Barrow showing westward migration beginning in the last week of August (Divoky 1984) with the bulk of fall loon migration occurring in the first three weeks of September (Timson 1976, Divoky unpubl.). In the Point Barrow region fall migration is usually over by the first week in October (Divoky, unpubl.).

The density values presented in Table 5 are of limited value since the majority of the loons observed in the pelagic Chukchi were migrants flying over but not occupying offshore habitats. In such cases a value of birds per time is more appropriate than that one of birds per area (Divoky 1984). Both the average density and frequency of occurrence for loons show that loons were rare in all areas of the pelagic Chukchi until late August and early September when they became regular. They were absent or uncommon in the northern Chukchi.

Loons are migrating southwest and south through the Chukchi from Canadian and North Slope nesting grounds to the Pacific Basin wintering areas. Our observations indicate that loons move through the pelagic Chukchi primarily adjacent to the nearshore until they reach the Lisburne peninsula. South of Point Hope loons are common over pelagic waters as they apparently head for the Bering Strait. That there is still considerable coastal movement is evidenced by the numbers seen at the mouth of Kotzebue Sound.

We identified too few individuals to determine the percentages of the three species, but can assume that the percentages mentioned above also apply to the Chukchi migrants. Previous pelagic observers have rarely observed loons in the Chukchi and only close to shore (Swartz 1967).

In the pelagic Beaufort and Bering seas loons were also found to be uncommon until the fall (Divoky 1984, Gould et al. 1982).

5.2 NORTHERN FULMAR

Table 4. Figure 12.

Northern Fulmars (*Fulmarus glacialis*) do not breed in the Chukchi Sea and birds observed there in the summer are either nonbreeders or failed breeders. Fulmars breed in numbers as far north as Saint Matthew Island in the Bering Sea (Sowls et al. 1978) with smaller numbers being found on the southern Chukchi Peninsula north to Providence Bay (Portenko 1981).

Fulmars were found to be regular in the open water of the southern Chukchi Sea during the entire sampling period with average densities over .3 birds per sq. km and frequencies near 20 percent. While present in the central Chukchi before late August they become more common in that region from late August to mid-September but were absent from the central Chukchi after late September. One observation of a fulmar was made in the northern Chukchi at 72°30'N in August 1986 when the ice edge was extremely far north.

Fulmars have been shown to be rare in the pelagic Beaufort (Divoky 1984) which is not surprising given the paucity of records from the central Chukchi. While fulmars are certainly more abundant in the Bering Sea than in the Chukchi our density of .5 birds per sq. km in August approximates what Gould et al. (1982) found for average densities on the Bering Sea shelf. Nowhere did we encounter a maximum density of over 10 birds per sq. km, whereas Bering Sea shelf maximum densities are all over 500 birds per sq. km for spring, summer and fall.

Previously published Chukchi observations are in general agreement with those presented here. They report fulmars uncommon or rare in pelagic waters except for Jacques (1930) who saw fulmars regularly south of 68°30′ N.

We estimate 45 thousand fulmars in the Chukchi sea from late August to late September. Gould et al. (1982) estimated 2.1

million fulmars in the Bering Sea in summer and much higher numbers in fall.

5.3 SHEARWATERS

Table 5. Figure 13.

While many of the shearwaters observed could not be identified to species they were almost certainly all Short-tailed Shearwaters (*Puffinus tenuirostris*). Short-tailed shearwaters breed in the southern hemisphere during the austral summer and occupy the waters of the North Pacific and Bering Sea from May through November. It is the most abundant species in the Bering Sea with population estimates as high as 30 million (Hunt et al. 1981).

Because Short-tailed Shearwaters are most abundant in the Bering Sea, the. presence of the shearwaters north of the Bering Strait can be expected to be closely tied to the presence of Bering Sea water at the surface of the Chukchi.

Shearwaters were found to be common to abundant in the Chukchi during the period of maximum ice retreat from late August to late September. They are most abundant and regular in the southern Chukchi. The density of over 3 thousand birds per sq. km encountered on a transect near the Bering Strait is by far the highest pelagic density encountered in the Chukchi. Their distribution in the central Chukchi can be expected to reflect the presence of zooplankton prey patches. The concentration north of 71°N was in an area where Crested Auklets other zooplankton feeding birds were abundant. While shearwaters were gone from the central Chukchi in late September and early October, they are common in the extreme southern Chukchi adjacent to the Bering Strait until mid-October (Divoky 1972). None were seen in the northern Chukchi or Kotzebue Sound.

While shearwaters can be abundant in the Chukchi the densities there do not approximate those encountered on the Bering Sea shelf (Gould et al. 1982) where densities averaged over 150 and 50 birds per sq. km for summer and fall, respectively. Observations in the Beaufort Sea show that shearwaters occur irregularly east to Harrison Bay and are associated with Bering Sea water (Divoky 1984).

Based on shearwaters occurring regularly only in the southern Chukchi 2 million birds is a reasonable minimum population estimate for the Chukchi. In certain years, however, large numbers are present well into the north central Chukchi. Land-based observations at Point Barrow in mid and late September 1984 (Divoky unpubl.) showed that extremely large numbers passed into the Beaufort Sea in mid-September with an estimated 100 thousand birds moving east past the Point in one day. This agrees with the statements of Bailey (1948) that shearwaters can be abundant in the Point Barrow area in early fall.

5.4 EIDERS

Table 6. Figure 14.

Three species of eider, the King (Somateria spectabilis), Common (Somateria mollissima) and Spectacle (Somateria fischeri), migrate through the Chukchi Sea. Eider migrate westward from the Beaufort from July though September (Divoky 1984).

Large flocks of eider adjacent to the 20 m isobath were encountered during the entire sampling period but only after 22 September did eider move offshore. After that date they were still most common adjacent to the nearshore but small numbers were regularly encountered well offshore in the central Chukchi. The distribution of eiders in the pelagic Chukchi is similar to what has been found in the Beaufort where eiders were present on 1 percent of pelagic transects in August and September (Divoky 1984).

5.5 OLDSQUAW

Table 7. Figure 15.

Oldsquaw (Clangula hyemalis) are a ubiquitous part of the nearshore avifauna of arctic Alaska. Our observations showed they are uncommon in the central Chukchi until late September when they are common to abundant within 25 nautical miles of land. While we have sightings as early as 17 July, 93 percent of the sightings were made after 18 September. Most observations were of migratory flocks, although small flocks and individuals were seen sitting on the water.

Oldsquaw migration in the pelagic Beaufort is first observed in the last week in August (Divoky, 1984) and at Point Barrow in the first week in September (Timson 1976). Because birds are certainly moving through the nearshore Chukchi as early as the first week in September it is interesting that theyarenot encountered in the pelagic Chukchi until late September. It may be that the freezing of the nearshore waters in late September causes birds to move further offshore.

The distribution maps show that while some dispersal to offshore habitats occurs, the majority of Oldsquaw are seen in a migratory pathway near the 20 m isobath. Given this primarily nearshore distribution the rarity of Oldsquaw in Kotzebue Sound is surprising.

Previous pelagic observers have either failed to see Oldsquaw or have seen only single individuals offshore, probably because most observations were conducted in August. Bailey (1948) first saw large flocks off Icy Cape on 7 September and found them abundant offshore on 1 October.

5.6 PHALAROPES

Table 8. Figure 16.

Both Red (Phalaropus fuliacaria) and Red-necked Phalaropes (P. lobatus) breed in arctic Alaska and large post-breeding concentrations are found in littoral habitats. Red Phalaropes are most abundant north of Point Lay while Red-necked Phalaropes are more common along the Lisburne Peninsula (Roseneau and Herter 19,84). The majority of phalaropes we observed were not identified to species but the majority can be assumed to be Red Phalaropes.

Phalaropes were present during the entire census period with no obvious change in density or frequencies during the three-month sampling period. Phalaropes numbers in the littoral zone show major changes during this period being common to abundant in the nearshore from July until late August with numbers decreasing in early September (Connors et al. 1979) and it is surprising that no similar change in numbers occurs in the pelagic Chukchi.

The distribution of phalaropes almost certainly reflects the availability of zooplankton in surface waters. Before late August phalaropes were most common in the area west and north of Icy Cape as well as being regular in the extreme southern Chukchi adjacent to the Bering Strait. From late August to late October phalaropes were most regularly encountered in waters directly north of the Bering Strait and west of the Lisburne peninsula. They were most common in early October 1976 when high densities were encountered over a 75 nautical mile transect. Phalaropes were also common in late 1986 in the central Chukchi at

71°N,165°W where large numbers of shearwaters and Crested Auklets were encountered.

The lack of phalarope sightings in the northern Chukchi Sea indicates that movement of birds from the Beaufort is to the southwest from the Beaufort and that little northward dispersal occurs.

Phalarope densities in the Chukchi are higher than the majority of the Beaufort (Divoky 1984), except for the extreme western Beaufort where the average density was 16.5 birds per sq. km. Densities for the Bering Sea shelf are considerably lower than the Chukchi in both the summer and fall being .6 and .8 birds per sq. km., respectively. The minimum pelagic population estimate for the Chukchi is 1 million individuals. Between 1 and 2 million phalaropes are estimated to be in the Bering Sea during the post-breeding migration (Gould et al. 1982)

5.7 JAEGERS

Table 9. Figure 17.

Three species of jaegers, the Pomarine (*Stercorarius pomarinus*), Parasitic (*S. parasiticus*) and Long-tailed (*S. longicaudus*) migrate through the Chukchi Sea. Since many jaegers are unidentified during shipboard observations jaegers are considered here as a group.

Jaegers were found to be common in the Chukchi until late September after which they are rare. Our last sighting was on 29 September 1970. We found jaegers most abundant in late July of 1981 when the average density in the central Chukchi was 1.3 birds per sq. km and jaegers were seen on 44 percent of all observation periods. Because we have only one cruise in July it is unclear if the large numbers were due to seasonal or annual variation. That there may be years of high jaeger densities in the Chukchi is supported by the findings of Jacques (1930), who believed Pomarine Jaegers were at times the most abundant seabird species in the western Chukchi. Because the number of jaegers breeding on the tundra varies annually in response to prey populations (Maher 1970), it is reasonable to assume that jaeger densities in pelagic waters adjacent to the tundra would be higher in years when the number of breeding jaegers is low.

Jaegers were well dispersed over all areas sampled with no obvious areas of concentration. They were slightly more common in the central than the southern Chukchi and uncommon in the northern Chukchi. None were seen in Kotzebue Sound

Jaeger densities in the Chukchi are apparently the highest of the three Alaskan seas, The majority of the Beaufort has considerably lower densities with the exception of the extreme western Beaufort where densities approximate those in the Chukchi (Divoky 1984). Bering Sea shelf densities are comparable to the southern Chukchi (.2 birds per sq. km in summer and fall) but lower than central Chukchi densities before late September.

We estimate approximately 100 thousand jaegers in the Chukchi from late July to late August. Gould et al. (1982) estimated 195 to 341 thousand in the Bering Sea in summer.

5.8 GLAUCOUS GULLS

Table 10. Figure 18.

Glaucous Gulls (Larus hyperboreus) are regular in a wide range of habitats in northern Alaska and not surprisingly we found them to be moderately common in all areas of the pelagic Chukchi.

From late July to late September Glaucous Gulls were most common in the central Chukchi, especially in the eastern central Chukchi from Icy Cape to Point Barrow within 70 km of shore. From late August to late September they were more evenly distributed although they were still uncommon in the northern Chukchi. After late September densities and frequencies increase in all areas presumably coinciding with the end of breeding and, perhaps, the freezing of nearshore waters.

The relatively low maximum densities for all areas and time periods are an indication of the low prey densities in the Chukchi since Glaucous Gulls are quick to gather at food sources. A minimum of several hundred birds are present at the Barrow dump during most of the summer and fall (Divoky unpubl.)

Except in the central Chukchi in August average densities in the Chukchi are lower than for the Beaufort where densities approximate .5 birds per sq. km for most areas (Divoky 1984). In mid-September Beaufort densities increase to over 1 bird per sq. km. Glaucous Gull densities are not available for the Bering Sea shelf during the late summer and fall. Gould et al. (1982) do present information for combined large Larus gulls, however. Comparing this to our Glaucous Gull information shows that Bering Sea densities are slightly higher in summer (.7 birds per sq. km) and comparable to the Chukchi in fall (.6 birds per sq. km).

We estimate the pelagic population to be 125 thousand birds from late September to late October. This is approximately twice the estimated late July to late August pelagic population. Gould et al. (1982) estimated from 17 to 153 thousand in summer and fall for the Bering Sea. Sowls et al. (1978) estimated only 30 thousand breed in coastal seabird colonies in the state demonstrating that most breeding occurs in inland freshwater habitats.

5.9 IVORY GULL

Table 11. Figure 19.

Ivory Gulls (Pagophila eburnaea) breed north of 72°N on high arctic islands adjacent to the pack ice. They do not breed near the Chukchi Sea with the closest locations being in the Canadian Arctic Archipelago (MacDonald and McPherson 1962) and north of western Siberia (Golovkin 1984). Ivory Gulls are regular in the Bering Sea in winter (Divoky in prep.) and it appears that individuals from both the eastern and western arctic pass through the Chukchi in fall.

While we had observations of single birds as early as 18 July, Ivory Gulls were rare until 22 September. From late September until the end of our observations on 12 October, they were common to abundant in areas where ice was present. They were most abundant adjacent to an ice island at 72°N,162°W.

The location of the ice edge is an important factor in determining the distribution of the species and our lack of sightings in the southern Chukchi is almost certainly due to the absence of ice during our observations there. Ivory Gulls can be expected to be present in the southern Chukchi as the ice edge advances in the late fall.

Ivory Gulls were uncommon to rare on pelagic cruises in the Beaufort Sea (Divoky 1984). Observations at Point Barrow indicate that some Ivory Gulls fly east into the Beaufort Sea in early fall prior to returning to the Chukchi in late fall (Divoky unpubl.) The cruises reported on by Gould et al. (1982) did not occur during the period when Ivory Gulls could be expected to be common in the Bering Sea. "Ice edge cruises from April and March being analyzed by Divoky (in prep.) show that Ivory Gulls are regular and common at the Bering Sea ice edge in spring. No population estimate for the species will be made until the Bering Sea winter data are analyzed.

5.10 BLACK-LEGGED KITTIWAKE

Table 12. Figure 20.

The Black-legged Kittiwake (*Rissa tridactyla*) is an abundant subarctic larid with the Pacific population having its center of breeding abundance in the Gulf of Alaska and Bering Sea (Sowls et al. 1978). They breed as far north as Cape Lisburne in the Alaskan Chukchi Sea and Wrangel Island in the Soviet Chukchi (Gabrielson and Lincoln 1959). Approximately 65 thousand kittiwakes breed in the Alaskan Chukchi (Sowls et al. 1978)

Black-legged Kittiwakes were common from mid-July until late September in all regions except the northern Chukchi. From mid-July to late August densities in the central and southern Chukchi exceeded 1 bird per sq. km and increased to >2 birds per sq. km from late August to early September. After late September densities decreased to <1 bird per sq. km. as kittiwakes left the Chukchi. The uniformity of kittiwake distribution in the Chukchi is striking and an indication of a similar uniformity of forage fish distribution.

The densities of kittiwakes in the Chukchi are similar to the western Beaufort Sea (>1 bird per sq. km) but higher than the remainder of the Beaufort where densities are <1 bird per sq. km (Divoky 1984). Average densities for the southern and central Chukchi from late August to late September are comparable to the Bering Sea (2.3 birds per sq. km). Densities increase in the Bering Sea in fall (to 3.5 birds per sq. km) (Gould et al. 1982) when they are dropping in the Chukchi.

We estimate a population of over 400 thousand Black-legged Kittiwakes for the pelagic Chukchi. Gould et al. (1982) estimated the Bering Sea pelagic population between 1.2 and 2.6 million birds.

5.11 ROSS' GULL

Table 13. Figure 21.

Ross' Gull's (*Rhodostethia rosea*) have a limited breeding range on the wet tundra of river deltas in north central Siberia (Cramp 1983). Little is known about the species' pelagic distribution except for the passage at Point Barrow in September and October (Bailey 1948). The wintering grounds of the species remain unknown.

While we had two sightings of Ross' Gull in August we did not find the species common until two late September cruises at the ice edge. The frequency and average and maximum densities when the species is present are notably high. The species is most abundant at the ice edge although small numbers were seen well south of the ice.

The ice edge in the northern Chukchi is the area with the highest recorded pelagic densities of Ross' Gulls and appears to be used annually in late September and early October. Ross' Gulls extend into the extreme western Beaufort Sea (Divoky 1984) but their movements after they leave the Point 'Barrow area are unknown.

5.12 OTHER LARIDS

Sabine's Gulls (Xema sabini) and Arctic Terns (Sterna paradisaea) are both tundra-nesting larids that migrate from Alaskan and Canadian breeding grounds through the Beaufort and Chukchi seas to Pacific wintering grounds. Both species are relatively common migrants throughout the pelagic Beaufort with the highest densities (>2 birds per sq. km) and frequencies (>10 percent) for both species occurring in the western Beaufort (Divoky 1984).

Both species were surprisingly rare in the Chukchi, each being present during less than 1 percent of the observation periods. Most observations were within 25 nautical miles from shore. Both these species are common to abundant migrants in the Chukchi nearshore (Divoky 1978) and the lack of sightings offshore indicates that unlike in the Beaufort, migration occurs primarily landward of the 20 m isobath. This pattern of migration contrasts with that of phalaropes, which although abundant in the nearshore disperse to the pelagic Chukchi during migration.

5.13 MURRES

Table 14. Figure 22.

Murres (Uris spp.) are the most abundant breeding seabirds in Alaska. In the Alaska Chukchi both Common (U. aalge) and Thick-billed (U. lomvia) Murres breed as far north as Cape Lisburne in Alaska and to Wrangel Island in Soviet waters (Gabrielson and Lincoln 1959). Approximately 520 thousand murres breed at southern Chukchi colonies in Alaska (Sowls et al. 1978).

Murres were most abundant in the southern and south central Chukchi with densities decreasing after 20 August. The exceptionally high average density for the southern Chukchi in August is probably not representative of the entire region since much of our censusing occurred in close proximity to the breeding colonies at Capes Thompson and Lisburne. The genus is exceptionally common in the area, however, being encountered on every observation period.

Murre densities show a steady decline during the sampling period. It is surprising that a species that winters so far north apparently begins to depart the Chukchi as early as late August. After 24 August few are seen north of 70°N.

While murres are common in the Chukchi as far north as 72°N they are not a regular part of the Beaufort pelagic avifauna where they were present during only 1 percent of the pelagic observations (Divoky 1984)Bering Sea shelf densities in-summer are higher than most of the Chukchi, averaging 11.3 birds per sq. km in summer. In fall Bering Sea shelf densities average 4.3 birds per sq. km (Gould et al. 1982).

We estimate that between 500 thousand and one million murres occupy the pelagic Chukchi in August. The estimation is hindered by the limited sampling in the southern Chukchi during August when murres are most abundant. The Bering Sea at-sea populations are estimated between 2.7 and 6.9 million (Gould et al. 1982).

5.14 BLACK GUILLEMOT

Table 15. Figure 23.

Black Guillemots (Cepphus grylle) breed from Cape Thompson north through the Chukchi Sea with an estimated 500 breeding birds being present in the region (Roseneau and Herter 1984). At Cooper Island, 35 km east of Point Barrow in the Beaufort Sea there is a colony of 400 breeding guillemots and an additional 400 nonbreeding birds. During the early part of the breeding season the Cooper Island population makes extensive use of the Chukchi adjacent to Point Barrow (Divoky unpubl.). The Pigeon Guillemot (C. columba) breeds in small numbers as far north as Cape Thompson (Springer et al. 1982) and is rare north of that locality.

Black Guillemots showed an affinity for arctic waters being rare in the southern Chukchi and regular in low densities in the central and northern Chukchi when ice was present.

Black Guillemots are rare in the pelagic Beaufort (Divoky 1984) and it appears that the Chukchi Sea is the center of abundance in the western Arctic during the summer and fall. Gould et al. (1982) did not record them in the Bering Sea but late winter and spring observations at the Bering Sea ice edge showed guillemots to be common (Divoky in prep.).

Our population estimate for the pelagic Chukchi is 70 thousand birds based on the extensive sampling in the decomposing pack ice in July and August. The post-breeding population can be expected to be only slightlyy higher because of the few breeding birds in the region. Our sampling during the post-breeding period does not provide an average density suitable for a population estimate since most observations were made at the ice edge where guillemot densities were high. The estimated total population is ‘ surprisingly large since the Alaskan breeding population does not exceed 2 thousand birds and the Soviet Chukchi breeding population is not thought to greatly exceed 3 hundred birds (Golovkin 1984). The large pelagic population may be nonbreeders from the East Siberian Sea where more than 40 thousand birds are present (Golovkin 1984).

5.15 KITTLITZ'S MURRELET

Table 16. Figure 24.

Kittlitz's Murrelets (<u>Brachyramphus brevirostris</u>) are solitary nesters that typically breed on alpine tundra, frequently some distance inland. The species is most common from the-Gulf ‘of Alaska west through the Aleutian Islands (Sowls et al. 1978). In the Chukchi Sea it is known to breed as far north as the Cape Lisburne-Cape Thompson area (Thompson et al. 1966). The species occurs on a regular basis as far north as Point Barrow (Bailey 1948).

Kittlitz's Murrelet is rare in the pelagic Chukchi Sea until late August when it becomes regular but uncommon. The two cruises on which the species was regularly observed were in late September 1970 and late August and early September 1986. The species’ absence from other cruises in the same areas during these time periods indicates that there are annual factors affecting the species’ occurrence in the pelagic Chukchi. None were seen in 1976 even though extensive sampling in all areas occurred that year. Because it is principally a subarctic species its almost complete absence on cruises in the southern Chukchi is surprising as is its abundance in the northern Chukchi in late August 1986.

Previous observers have failed to encounter the species with the exception of Swartz (1967) who had four sightings of single birds north of Cape Lisburne.

While Kittlitz's Murrelets have been regularly observed at Point Barrow, there are no records from the Beaufort Sea (Divoky 1984). Shipboard observers in the Bering Sea found that Brachyramphus murrelets were rarely encountered in pelagic waters (Gould et al. 1982)

An estimated 15 thousand Kittlitz's Murrelets are present in the Chukchi Sea in early fall with the majority of these being in the central Chukchi.

5.16 PARAKEET AUKLET

Table 17. Figure 25.

Parakeet Auklets breed as far north as Little Diomede Island in the Bering Strait (Sowls et al. 1978). Except in the area adjacent to the Bering Strait breeding colonies, Parakeet Auklets in the Chukchi Sea are nonbreeders or birds that have dispersed north after breeding.

We found Parakeet Auklets to be uncommon in the Chukchi until late August when they become common in the southern Chukchi. By late September Parakeet Auklets were again uncommon in all areas of the Chukchi. It appears that the species moves north into the Chukchi after breeding but that most birds only remain for less than a month. Our increase in numbers from August to September is similar to the increase in the pelagic Bering Sea shelf where densities increase from <.1 to .6 birds per sq. km (Gould et al. 1982).

An estimated 40 thousand Parakeet Auklets are present in the Chukchi Sea in September. Over 60 thousand breed in Bering Strait colonies (Sowls et al. 1978).

5.17 LEAST AUKLET

Table 1.8. Figure 26.

Least Auklets are the most abundant breeding birds in the Bering Strait with over one million present (Sowls et al. 197%). None breed in Alaska north of the Bering Strait. We found least auklets to be common in the Bering Strait region before late August. From late August to late September they were most common in the western central Chukchi in 1986 in an area where a large feeding aggregation of a number of species was present. Smaller numbers were present in the central Chukchi after late September and few were seen after 1 October.

The minimum population from late August to late September, when Least Auklets are most widely distributed in the Chukchi, is 40 thousand.

5.18 CRESTED AUKLET

Table 19. Figure 27.

Crested Auklets are abundant breeders in the Bering Sea but like the other talus-nesting auklets do not breed north of the Bering Strait. Approximately 170 thousand Crested Auklets breed in the Bering Strait (Sowls et al 1978) and could be expected to be encountered in the extreme southern Chukchi during the breeding season. Aside from birds associated with the Bering Strait colonies all other auklets in the Chukchi are nonbreeders or birds that have moved north after breeding.

Until late August Crested Auklets were found only in the southern Chukchi and only in small numbers. In late August and early September there is movement from the Bering Sea into the central Chukchi and they were regularly encountered there from 27 August until the first week in October.

Crested Auklets were patchily distributed and it is likely that their distribution reflects the availability of zooplankton. This was most obvious in late August and early September 19.86 when high densities were encountered between 71 and 72°N west of 163°W. On three separate days from 27 August to 2 September Crested Auklets were found in 93 percent of 43 15-minute observation periods and averaged 17.3 birds per sq. km. During the same cruise observers found them to be absent or rare in other areas of the Chukchi. A concentration of this size and extent may be somewhat atypical for the central Chukchi since 1986 was a year when the intrusion of Bering Sea water into the Chukchi was more pronounced than in most years (C. P. McRoy, pers. comm.). Smaller scale patches are probably present on an annual basis, however, since observations in late September and early October from two other years (1970 and 1976) showed small concentrations of Crested Auklets in the southern and central Chukchi.

Previous observers have either failed to find the species or have sighted it rarely, apparently because most of their observations occurred in August.

We estimate 100 thousand Crested Auklets regularly occupy the Chukchi in late September and early October. The numbers present from late August to late September may be substantially higher. Our sampling for that period is biased by the large feeding aggregation encountered on the 1986 cruise precluding an estimate. Approximately 172 thousand Crested Auklets breed in the Bering Strait, 140 thousand of them on Little Diomede Island (Sowls et al. 1978).

5.19 TUFTED PUFFIN

Table 20. Figure 28.

Tufted Puffins (*Fratercula cirrhata*) are most abundant in the Gulf of Alaska and Aleutian Islands. They breed in very small numbers in the Alaskan Chukchi (approximately 100 birds) as far north as Cape Lisburne (Sowls et al. 1978).

We found Tufted Puffins to be present in small numbers in the central and southern Chukchi and regular in only the latter region. Previous observers have also found it to be rare.

5.20 HORNED PUFFIN

Table 21. Figure 29.

Horned Puffins (*Fratercula corniculata*) are subarctic breeders that in Alaska breed as far north as Cape Lisburne. Over 18 thousand breed in Alaskan Chukchi colonies (Sowls et al. 1978). We found Horned Puffins to be regular in small numbers in the southern Chukchi Sea until late September. Few birds were seen in the central Chukchi in August but numbers increased in September after the end of the breeding season. Most of our sightings in the central Chukchi were in the area of Cape Lisburne with none being seen in the northern Chukchi. Observations from land show the species is regular as far as Point Barrow, however (Divoky 1984).

Swartz (1967) found Horned Puffins common in the southern Chukchi Sea and in the area of Cape Lisburne but other observers failed to find it far from shore. An estimated 10 thousand Horned Puffins are present in pelagic waters of the southern Chukchi from late August to late September.

5.21 SMALL UNIDENTIFIED ALCIDS

Table 22. Figure 30.

A substantial number of small alcids could not be identified to species. Least, Parakeet and Crested Auklets and Kittlitz's Murrelet could be expected to comprise the bulk of these unidentified birds. The distribution of small unidentified alcids reflected the pattern found in auklets being present in the Bering Strait region until late August, common in the central Chukchi from late August to late September and uncommon in all areas after late September. The number of small alcids present in the south and central Chukchi from late August to late September would be increased by over 90 thousand when small unidentified alcids are taken into account.

5.22 TOTAL BIRDS

Table 23. Figure 31.

The total birds per sq. km can be taken as a general index of the importance of an area or a habitat to birds. In most cases, however, additional information on the species in an area would be required in order to interpret the total densities. While the average densities and percent frequency allow comparisons between cruises and habitats the maximum density of total birds is less useful since high maximum densities are frequently the product of large flocks of migrating waterfowl.

Average densities and percent frequencies for total birds showed a north-south gradient being highest in the southern Chukchi for all time periods. Both the northern and central Chukchi showed increases in average total density through the sampling period. In the case of the central Chukchi the increase is due in large part to waterfowl moving offshore and inflating the average densities. Kotzebue Sound had an average density of less than a tenth that of the southern Chukchi during the time period.

Total bird densities for the northern and central Chukchi approximate those found in the most of the Beaufort Sea. With the exception of the extreme western Beaufort, where densities over 30 birds per sq. km were found, the Beaufort has average densities of less than 10 birds per sq. km (Divoky 1984). Gould et al. (1982) found average densities of total birds on the Bering Sea shelf to be over 200 birds per sq. km in summer and over 80 birds per sq. km in fall.

6 DISCUSSION

6.1 Characterization of avifauna by region

The densities and frequencies by region and time period of all species present on at least one percent of the transects are listed in Tables 24 and 25. This allows comparisons between regions and species and demonstrates changes in a region's avifauna over the three censusing periods.

6.1.1 Northern Chukchi

Censusing in the northern Chukchi was limited to two cruises and few conclusions can be drawn from our censusing. The high density of Kittlitz's Murrelet in the late August to late September period is probably the result of the atypically large influx of Bering Sea water in 1987. In most years it is likely that the Black Guillemot is the most abundant species in the northern Chukchi until late September,

The sampling in the northern Chukchi from late September to late October is probably more representative. Ross' and Ivory Gulls are probably abundant annually in the region in late fall.

The northern Chukchi is notable for the absence or low densities of species that are common to abundant in the south and central Chukchi. Shearwaters, phalaropes and murres, the three most abundant species in the Alaskan Chukchi were not observed in the region.

6.1.2 Central Chukchi

Sampling in the Central Chukchi was the most complete of any region. The only shortcoming of the censusing in this region is the late August to late September period having a large percentage of its observations from 1986 when the influence of Bering Sea water may have been atypically pronounced.

From mid-July to late August the principal species in the central Chukchi are the two most abundant colonial nesting seabirds in the southern Chukchi (murres and Black-legged Kittiwake) and the most abundant tundra-nesting migrant (phalaropes). With the exception of a small number of Northern Fulmars the area lacks species characteristic of the Bering Sea.

From late August to late September the influence of the Bering Sea becomes more pronounced with shearwaters and Crested Auklets becoming the most abundant species and a number of other species with Bering Sea affinities moving into the area. Two of the most abundant birds in the previous month (phalaropes and kittiwakes) become slightly more common but murres drop drastically in number. Low murre densities were found on both late August to late September cruises (1976 and 1986).

After late September the central Chukchi pelagic community is dominated by high arctic species with Ross', Ivory and Glaucous Gulls and Black Guillemot being the four most abundant species. Small numbers of the species most abundant during the previous two months still remain in the area so that species diversity is greatest during this period.

6.1.3 Southern Chukchi

The southern Chukchi, unlike the northern and central regions, had one species dominating the pelagic avifauna in each time period. Murres, the most abundant breeders in the region, were also abundant at sea from late July to late August. From late August to late September shearwaters become the most abundant birds, due to an influx of shearwaters and an apparent deprture of murres. From late September on phalaropes are the most abundant birds although shearwater numbers remain high. During all these time periods the remainder of southern Chukchi pelagic community is a composed of relatively low densities of both Chukchi and Bering Sea species.

6.1.4 Kotzebue Sound

Sampling in Kotzebue Sound was limited to a single time period in a single year and figures presented in Table 25 should be used with caution. It appears that of the pelagic species in the southern Chukchi only the Black-1egged Kittiwake is common in Kotzebue Sound.

6.2 General overview of Chukchi avifauna

The pelagic avifauna of the Chukchi Sea was found to have both arctic and subarctic components, as has been found for other species groups in the Chukchi (Truett 1984a). The total pelagic seabird population in summer and fall is substantial, totaling almost five million birds (Table 26). While the Chukchi's populations and densities are much less than the Bering Sea (Gould et al. 1982), they are considerably higher than the majority of the Beaufort Sea (Divoky 1984 and in prep.). Densities of total birds in the Chukchi decrease with increasing latitude reflecting the decreasing influence of subarctic waters. While the pelagic Beaufort was found to be almost completely devoid of diving species, the Chukchi has large alcid populations in summer and fall. This almost certainly reflects the higher density of the Chukchi fish biomass compared to the Beaufort (Truett 1984b) due in large part to the extensive continental shelf area underlying the Chukchi and the narrow shelf area in the Beaufort.

The seabird species in the pelagic Chukchi can be divided into four groups: cliff-nesters breeding in the Chukchi, high arctic species, Bering Sea species, and tundra-nesting migrants.

Black-legged Kittiwakes and murres are the most abundant breeding seabirds in the southern Chukchi. While both were common to abundant in the southern Chukchi near breeding colonies, they were also regular well north of the breeding cliffs.

Species common in the Chukchi that are typically associated with high arctic waters include Ivory and Ross' Gulls and Black Guillemot. These species were most common in areas where pack ice was present. They were absent from the southern Chukchi but could be expected there later in the fall. All are uncommon to rare in other Alaskan seas and the Chukchi appears to be a critical area for the western arctic populations of these species. It is probable that the majority of the world's population of Ross' Gull is found in the Chukchi in fall. For Black Guillemots the Chukchi appears to be an important summering area for nonbreeding Siberian birds.

Species that breed or summer in the Bering but have portions of their populations move to the Chukchi during periods of maximum ice retreat include the Northern Fulmar and Short-tailed Shearwater, and the Parakeet, Least and Crested Auklets. These species are most common in the southern Chukchi and are found in the central Chukchi only during the period of maximum ice retreat in late August and early September. Based on observations at Point Barrow it appears that shearwaters may in some years be more abundant in the Chukchi than murres, although their occupancy time in the area is certainly much less. The northward movement of auklets after breeding is surprising given the supposedly higher prey densities in the Bering Sea. It appears that in some years, as in 1986, of Crested Auklets are one of the most abundant species in the Chukchi.

Tundra-breeding species that migrate through or disperse to the pelagic Chukchi after breeding include phalaropes, jaegers, and the Glaucous Gull. They were well dispersed throughout the central and southern Chukchi. The densities of jaegers and phalaropes encountered indicate that the pelagic Chukchi is a major post-breeding staging area for these species. Surprisingly, Sabine's Gull and Arctic Tern were rare in the Chukchi. Both of these species are common to abundant in the pelagic Beaufort in areas of high prey availability.

Table 1. Dates, vessels and number of observation periods for cruises in the Chukchi Sea.

Dates of observations	Vessel	Observation Periods
16-25 JULY 1981	POLAR STAR	260
1-20 AUGUST 1975	GLACIER	359
7-14 AUGUST 1976	"	133
7-8 AUGUST 1977		43
24 AUG. - 8 SEPT. 1986	OCEANOGRAPHER	215
11-22 SEPT. 1976	DISCOVERER	141
22 SEPT. - 1 OCT. 1976	GLACIER	162
24 SEPT. - 17 OCT. 1970	"	187
7-9 OCT. 1976	"	34
	Total observation periods	1534

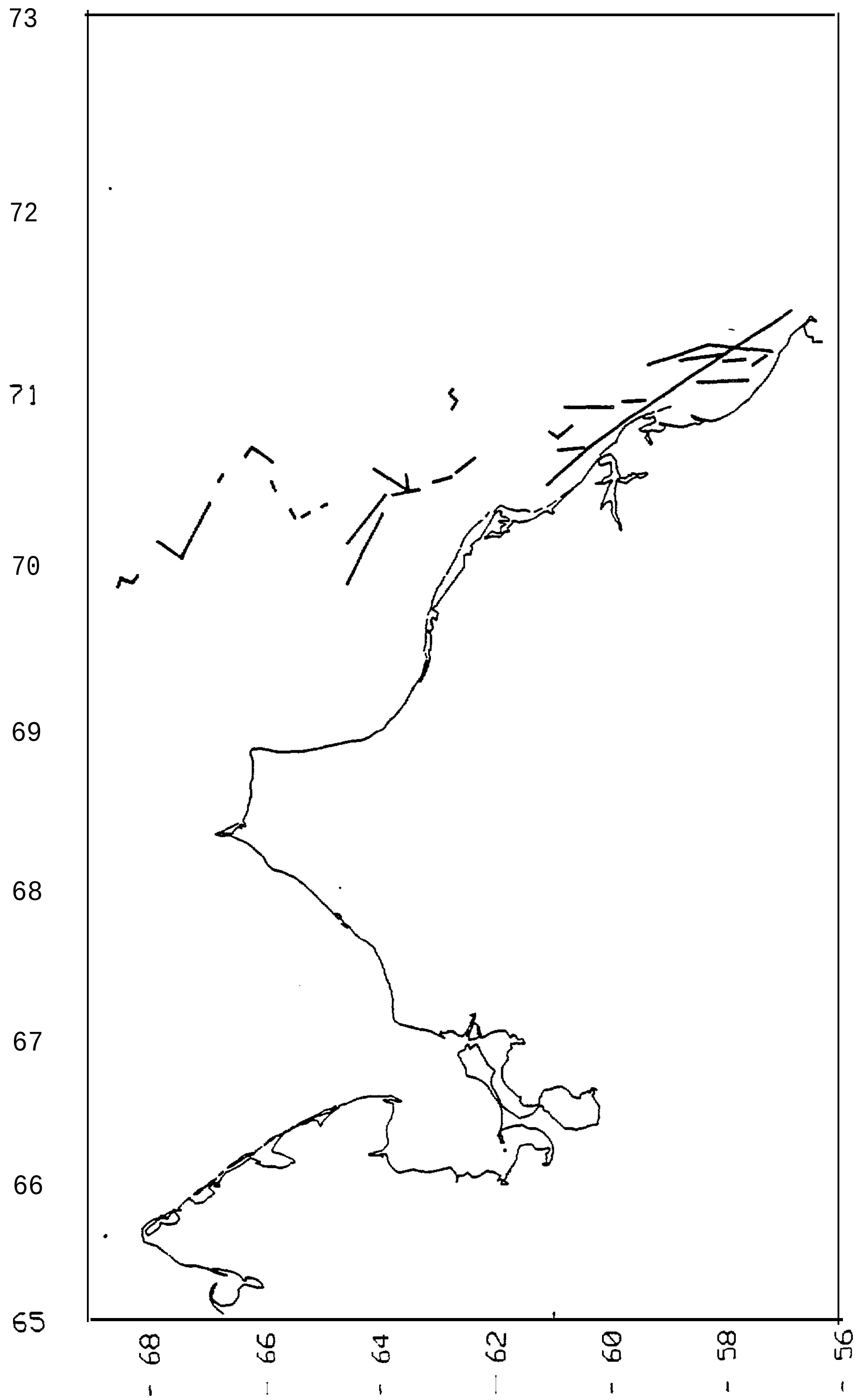


Figure 1. Cruise track where seabird censusing was conducted from 16-25 July 1981.

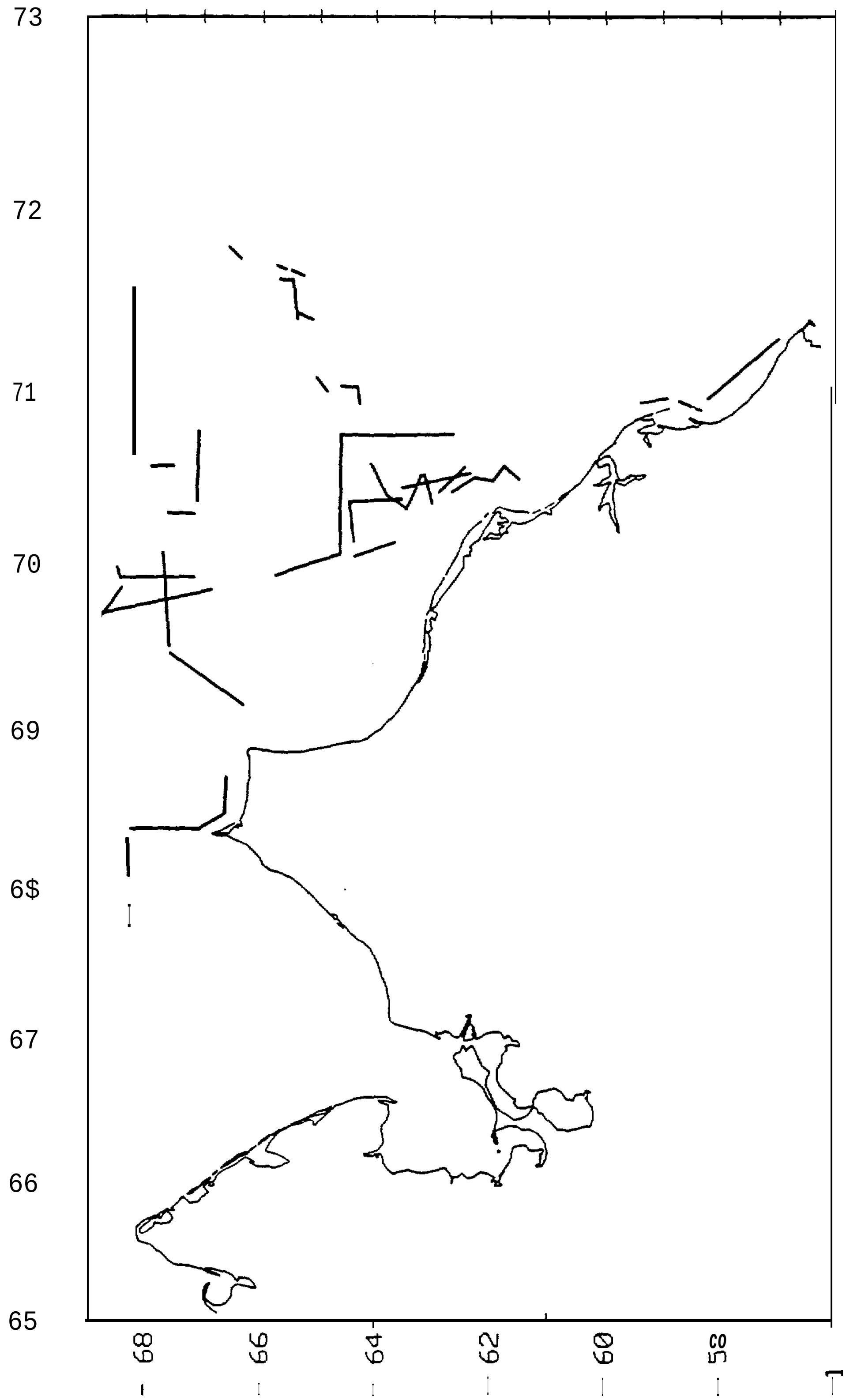


Figure 2. Cruise track where seabird censusing was conducted from 1-20 August 1975.

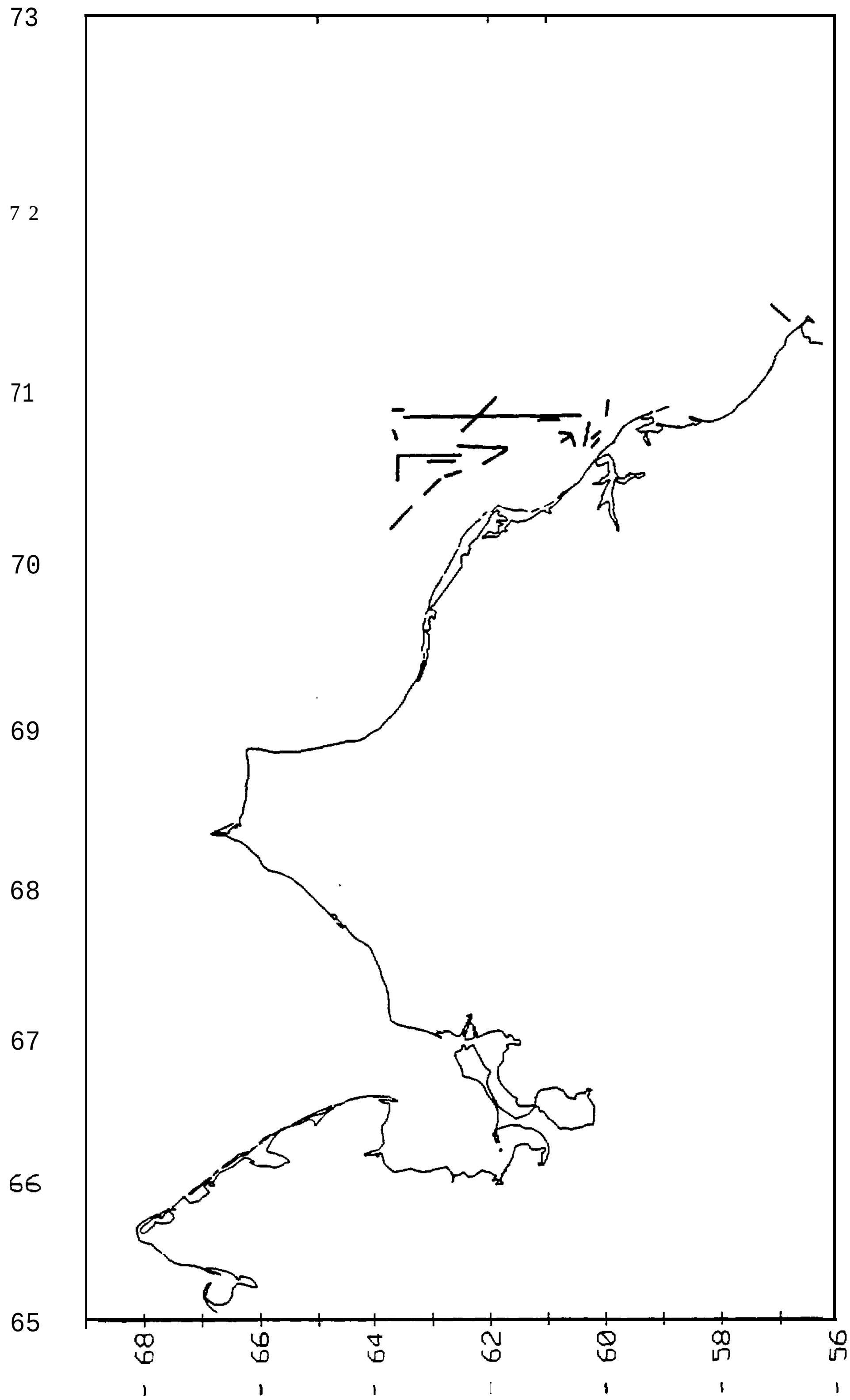


Figure 3. Cruise track where seabird censusing was conducted from 7-14 August 1976.

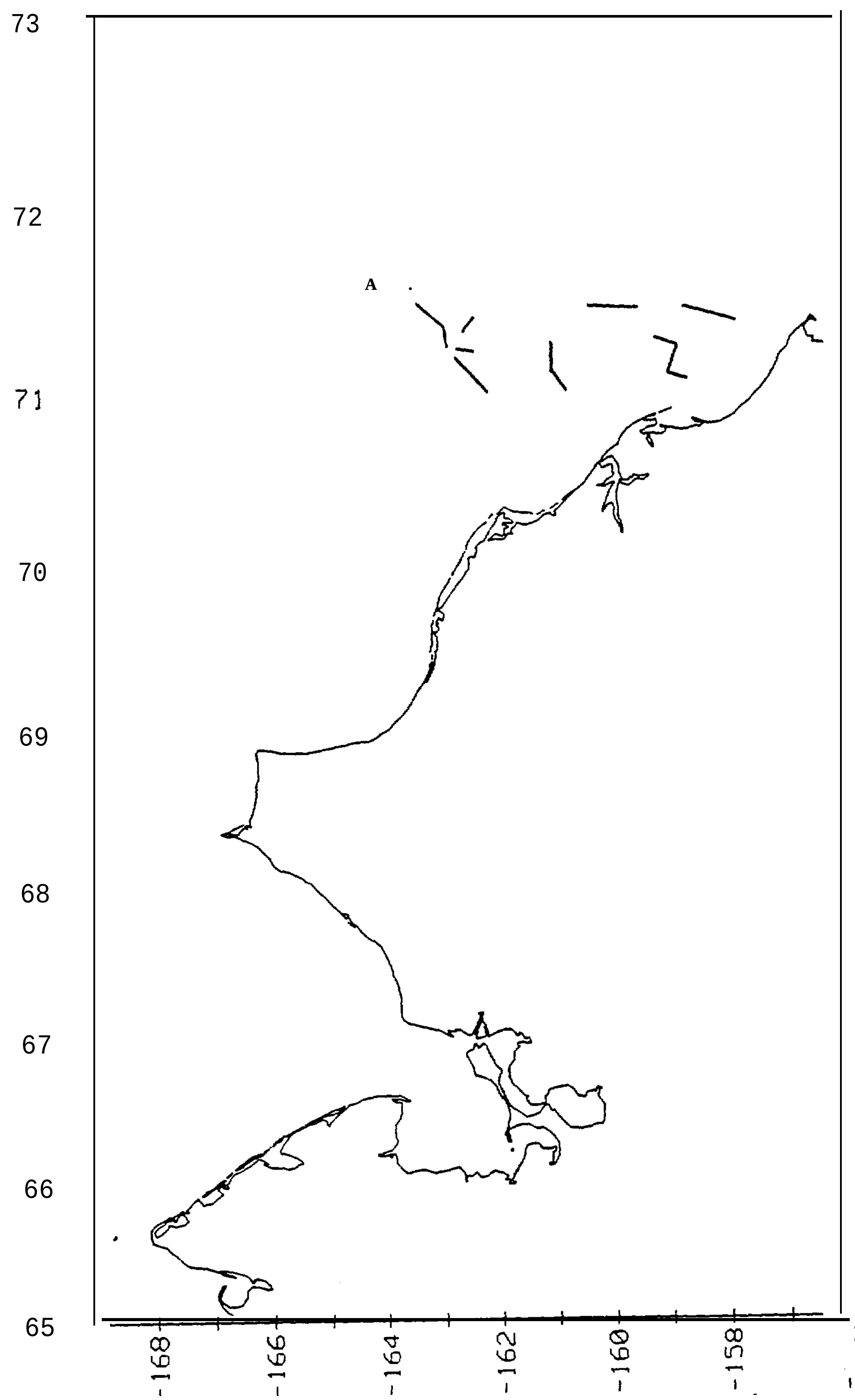


Figure 4. Cruise track where seabird censusing was conducted from 7-8 August 1977.

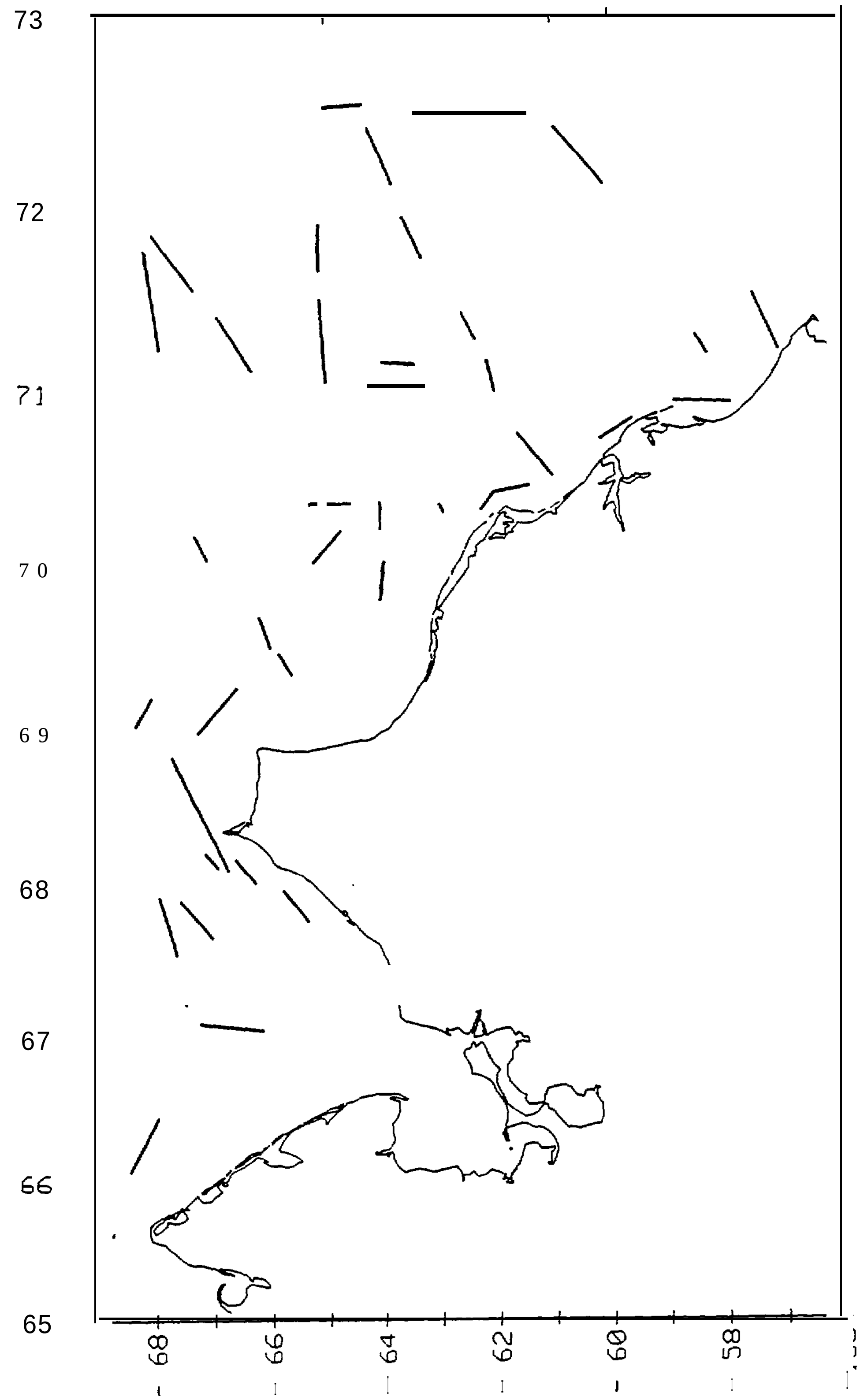


Figure 5. Cruise track where seabird censusing was conducted from 24 August - 8 September 1986.

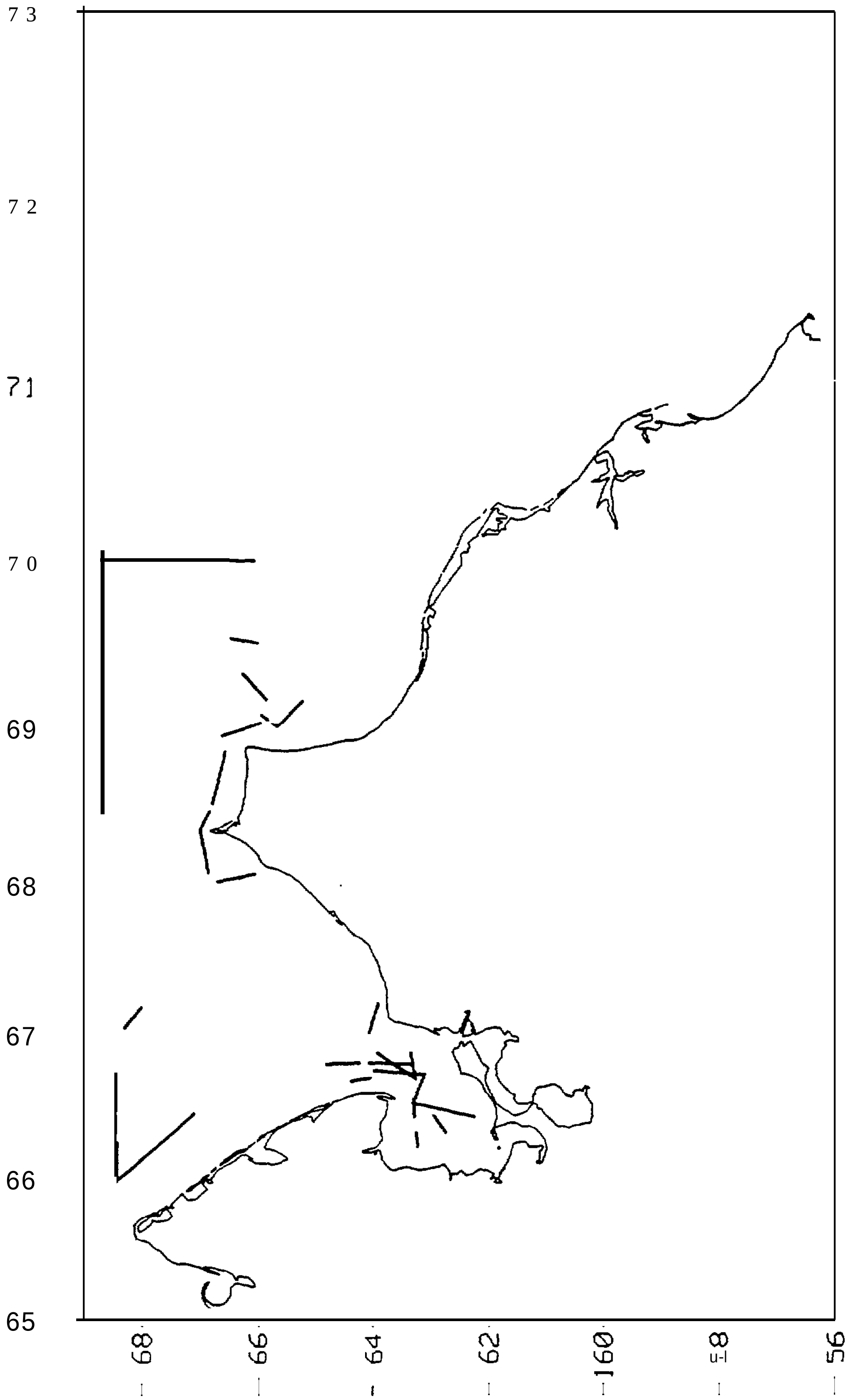


Figure 6. Cruise track where seabird censusing was conducted from 11-22 September 1976.

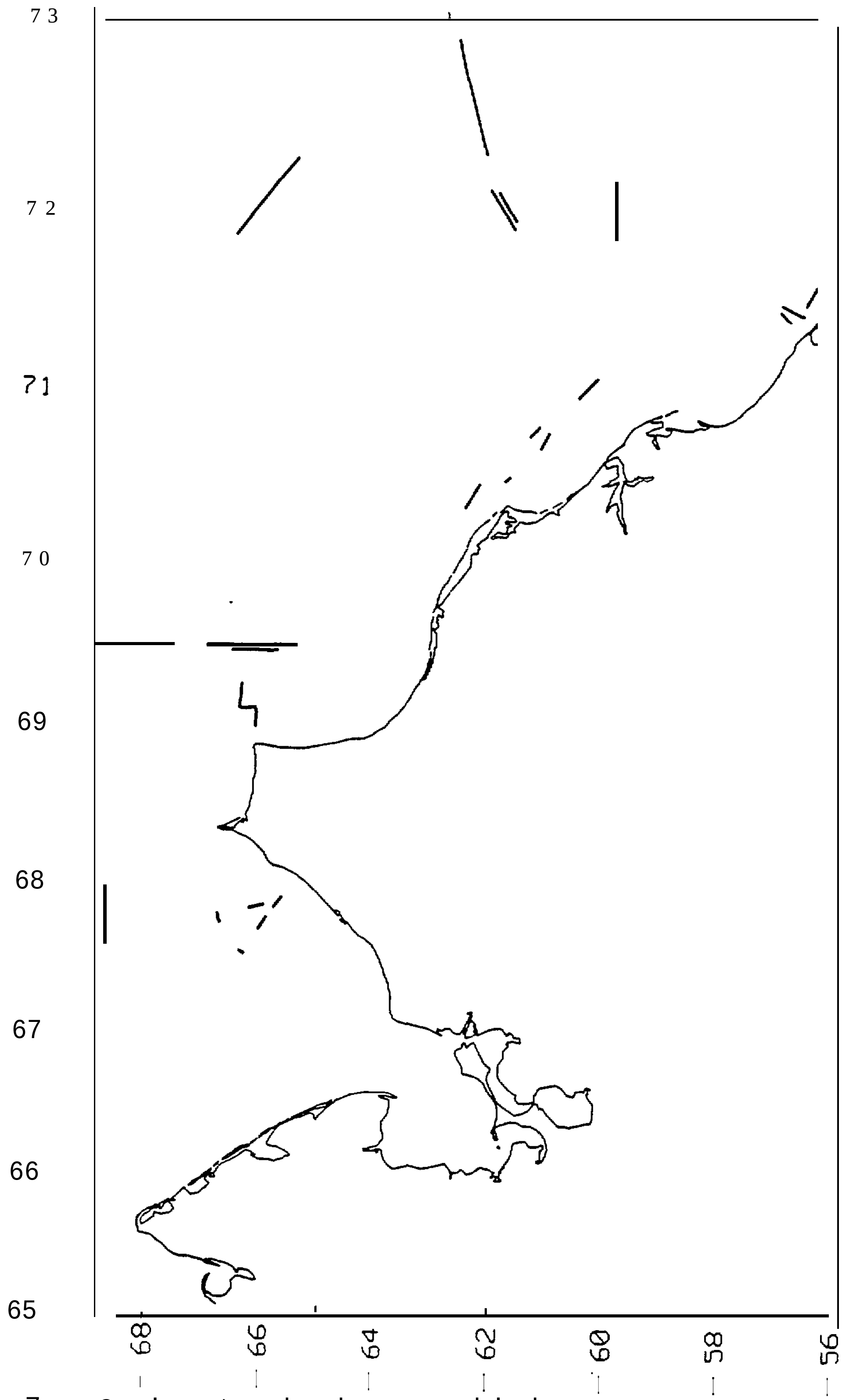


Figure 7. Cruise track where seabird censusing was conducted from 22 September - 1 October 1976.

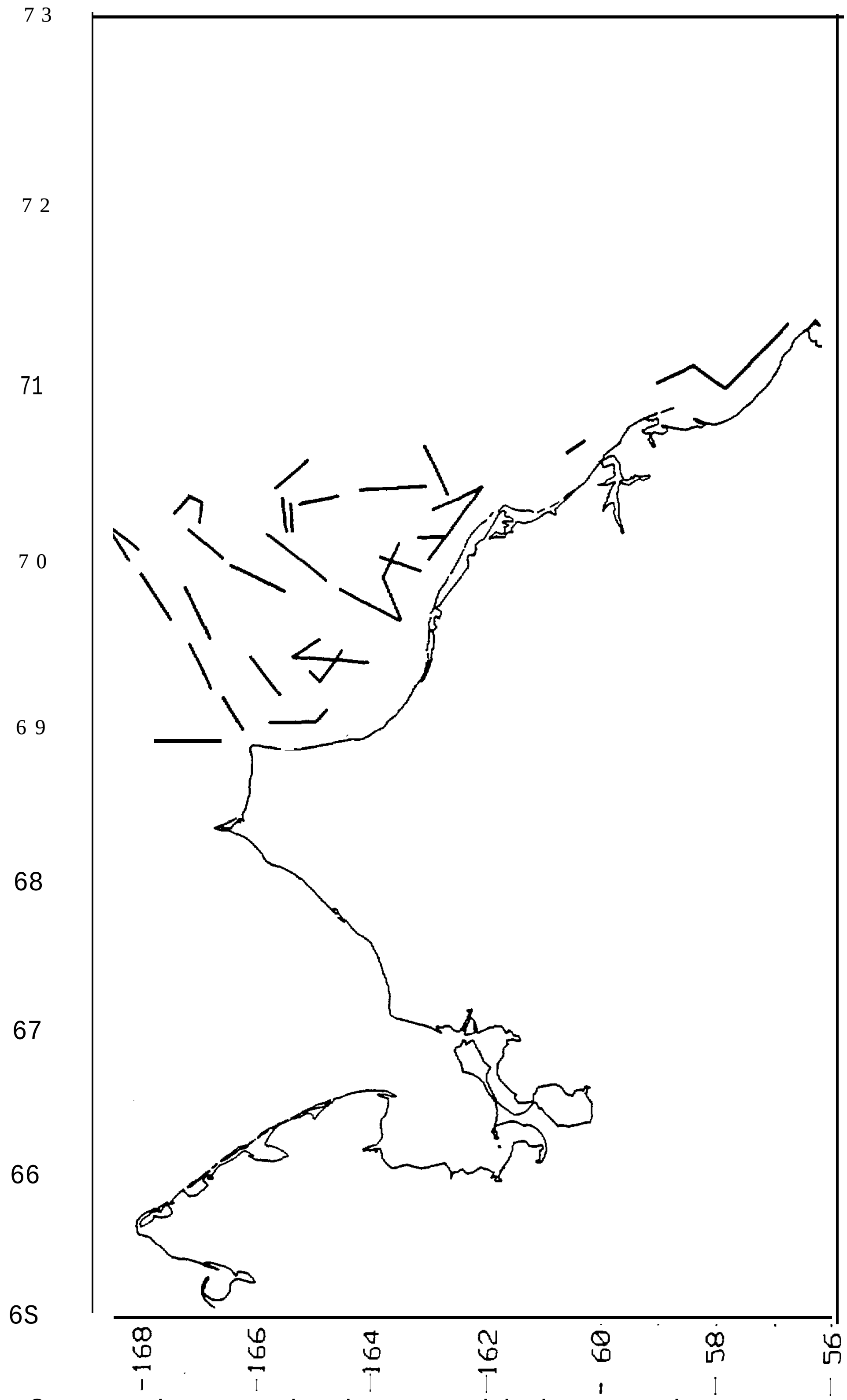


Figure 8. Cruise track where seabird censusing was conducted from 24 September - 17 October 1970.

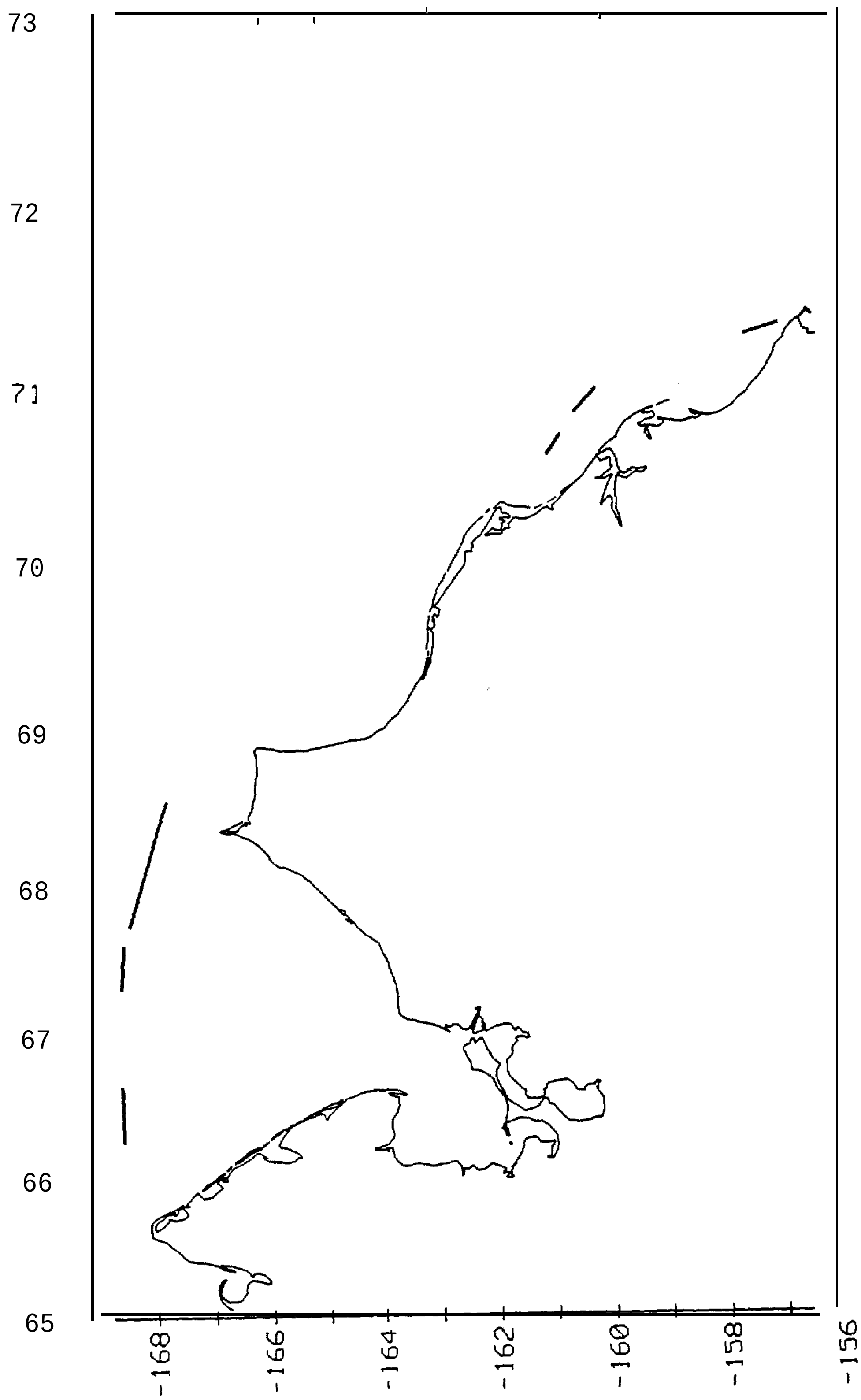


Figure 9. Cruise track where seabird censusing was conducted from 7-9 October 1976.

Table 2. Number of observation periods and percent observation periods with Ice visible by region and time period.

Number of observation periods

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
North	0	28	60
Central	749	167	261
Southern	46	102	62
Kotzebue Sound	0	59	0

Percent observation periods with ice visible

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
North	-	56%	85%
Central	53%	0%	55%
Southern	0%	0%	0%
Kotzebue Sound		0%	

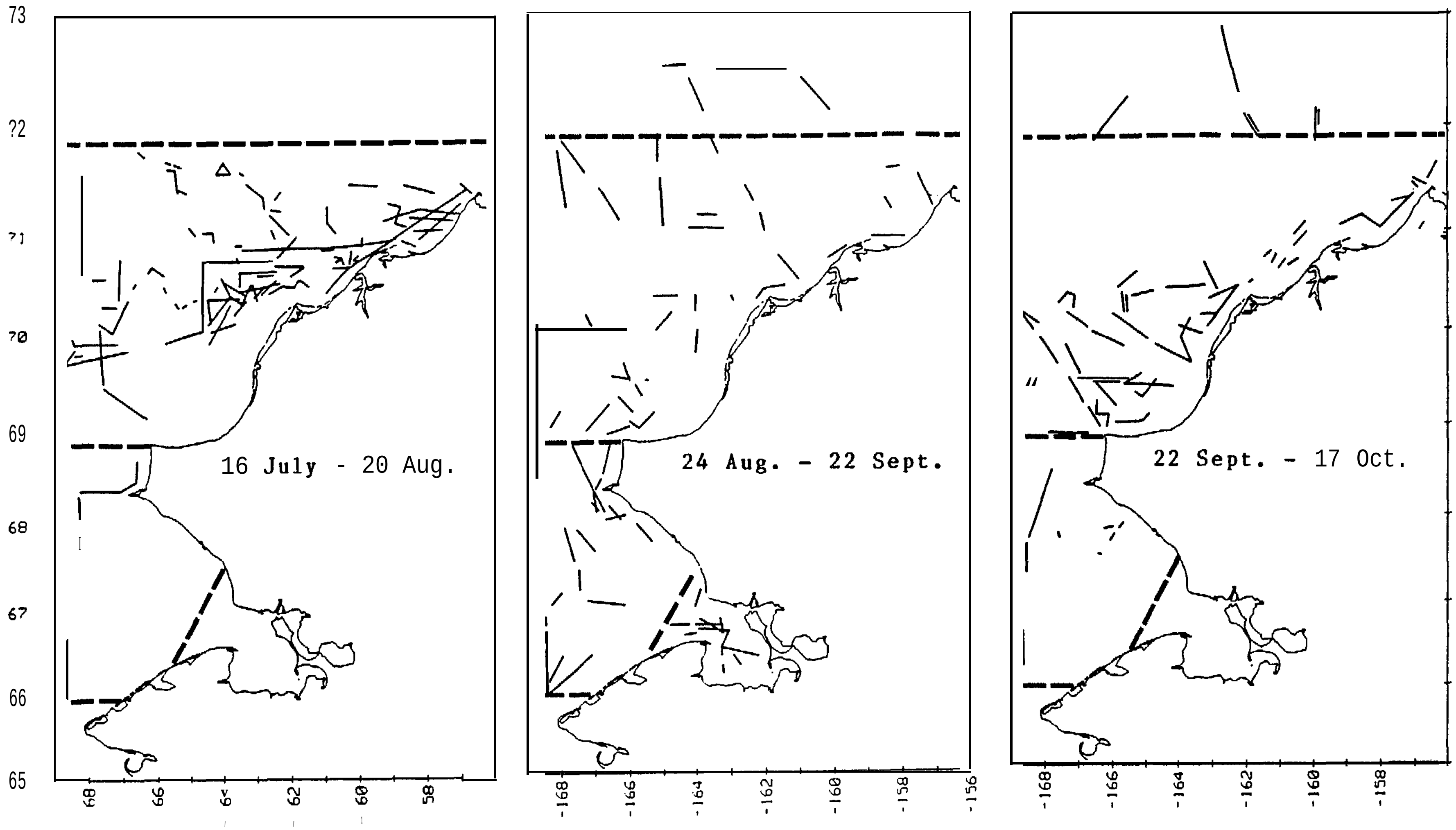


Figure 10. Divisions of eastern Chukchi Sea and location of cruise tracks.

LOONS

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North	-	.0	.1
Central	.1	.3	.5
Southern	.0	.2	.2
Kotzebue	-	.5	
Percent Frequency			
North		0%	2%
Central	3%	18%	17%
Southern	0%	31%	18%
Kotzebue	-	34%	
Maximum Density (per sq. km)			
North	-	.0	.9
Central	3.7	4.4	9.5
Southern	.0	4.4	2.1
Kotzebue	-	5.5	

Table 3. Average density, percent frequency, and maximum density of loons by region and time period.

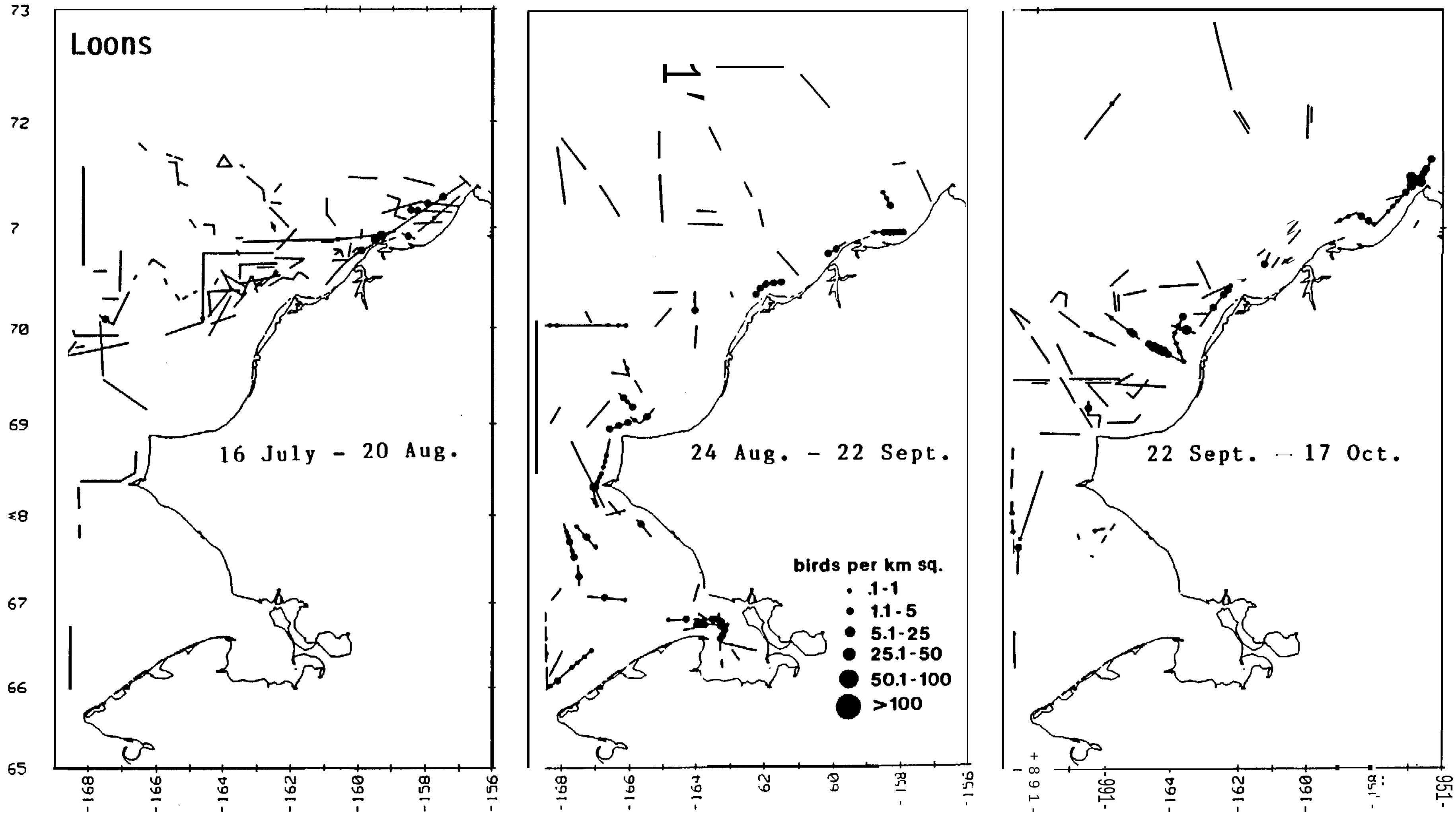


Figure 11. Densities of loons in the eastern Chukchi Sea.

NORTHERN FULMAR

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North		<.1	.0
Central	<.1	.2	.0
Southern	.5	.3	.4
Kotzebue		.0	
Percent Frequency			
North		4%	0%
Central	2%	12%	0%
Southern	22%	15%	23%
Kotzebue		0%	
Maximum Density (per sq. km)			
North	-	.5	.0
Central	1.8	1.4	.0
Southern	7.2	9.2	4.2
Kotzebue		.0	

Table 4, Average density, percent frequency, and maximum density of Northern Fulmar by region and time period.

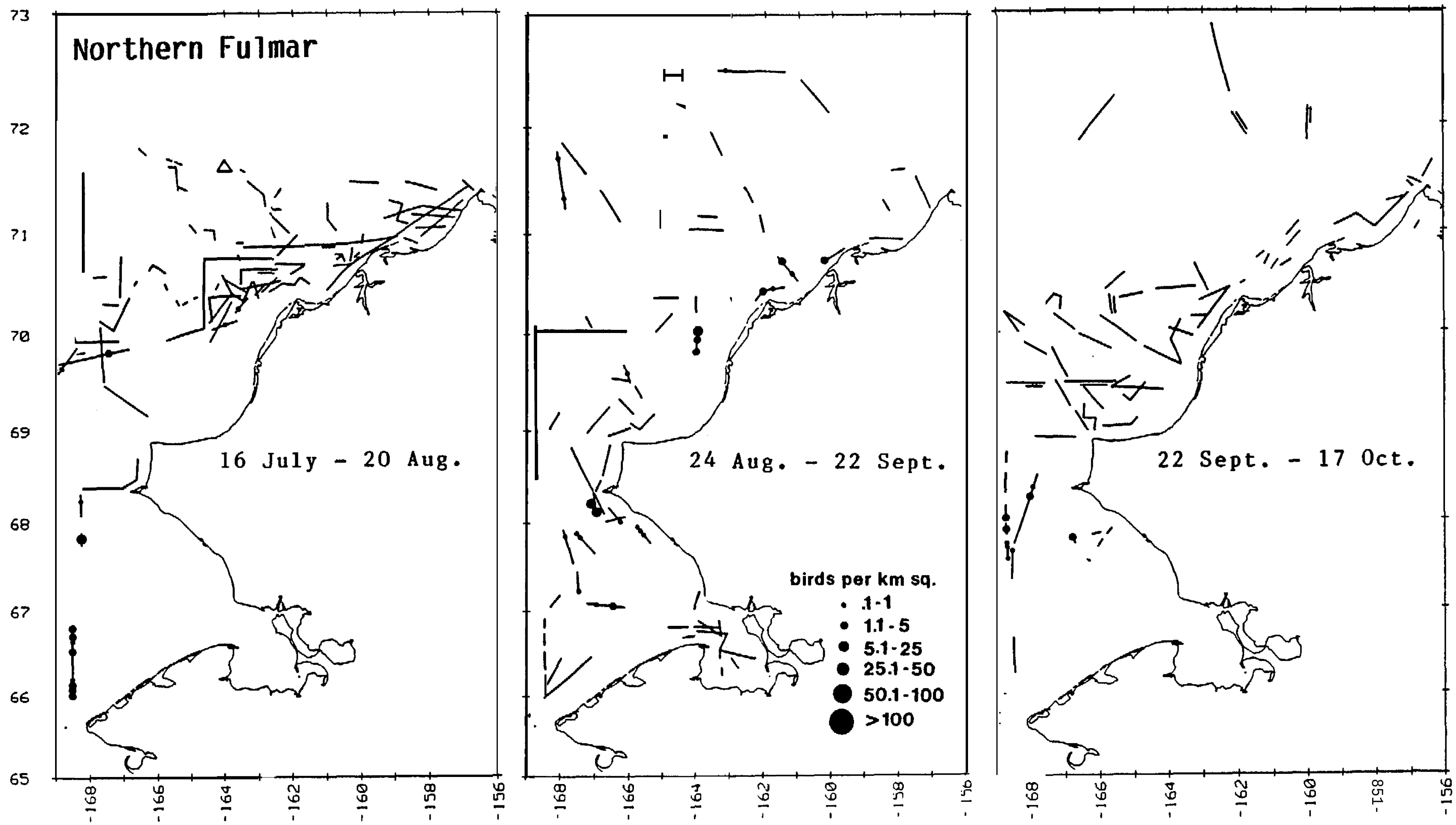


Figure 12. Densities of Northern Fulmar in the eastern Chukchi Sea.

SHEARWATERS

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-1? Ott.
Average Density (per sq. km)			
North	-	.0	.0
Central	.0	5.4	.3
southern	.0	44.1	9.2
Kotzebue	-	.1	
percent Frequency			
North		0%	0%
Central	0%	23%	11%
southern	0%	64%	44%
Kotzebue	-	3%	
Maximum Density (per sq. km)			
North	-	.0	.0
Central	.0	221.4	6.6
southern	.0	3334.1	3.6
Kotzebue	-	3.6	

Table 5. Average density, percent frequency, and maximum density of shearwaters by region and time period.

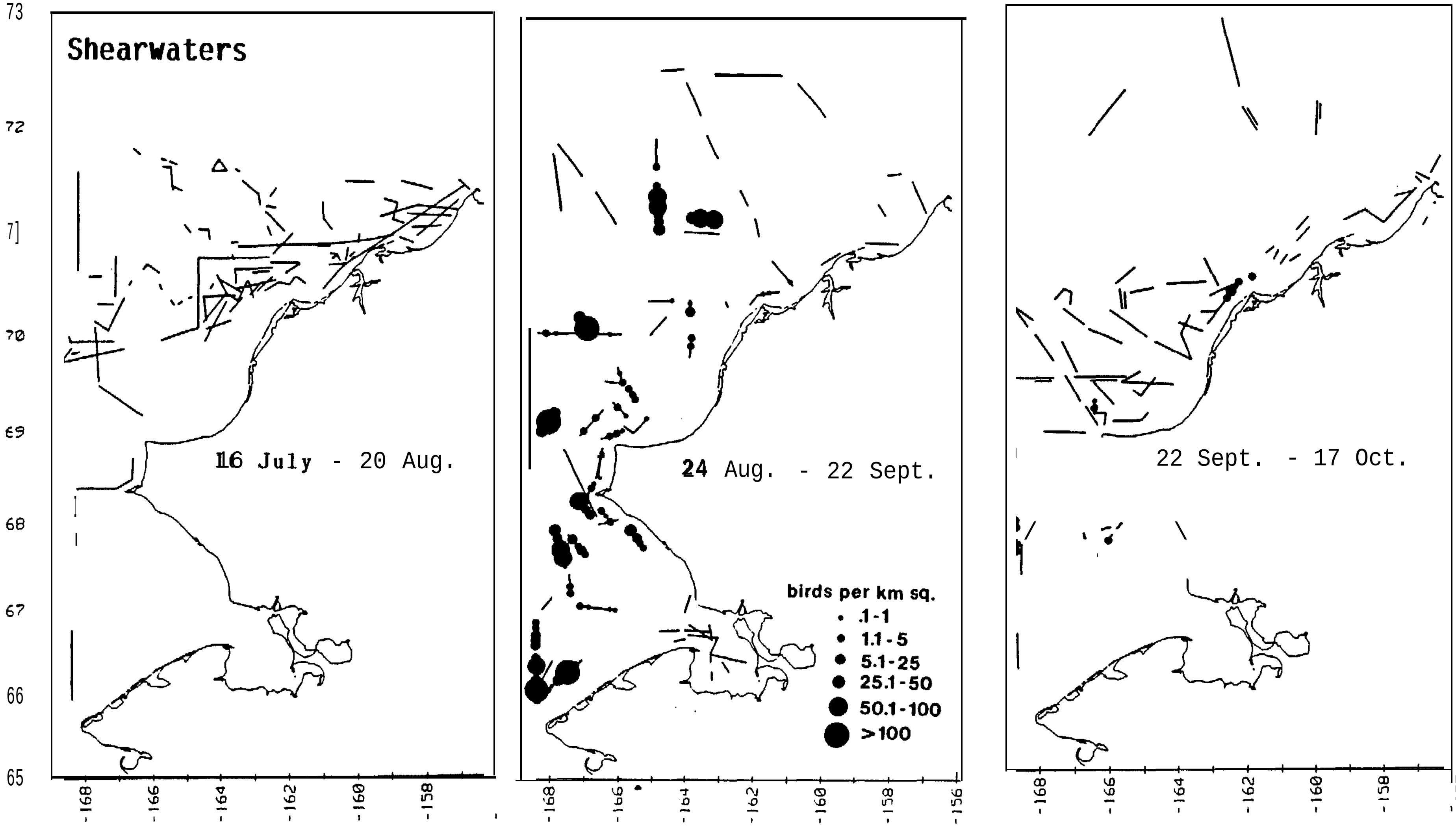
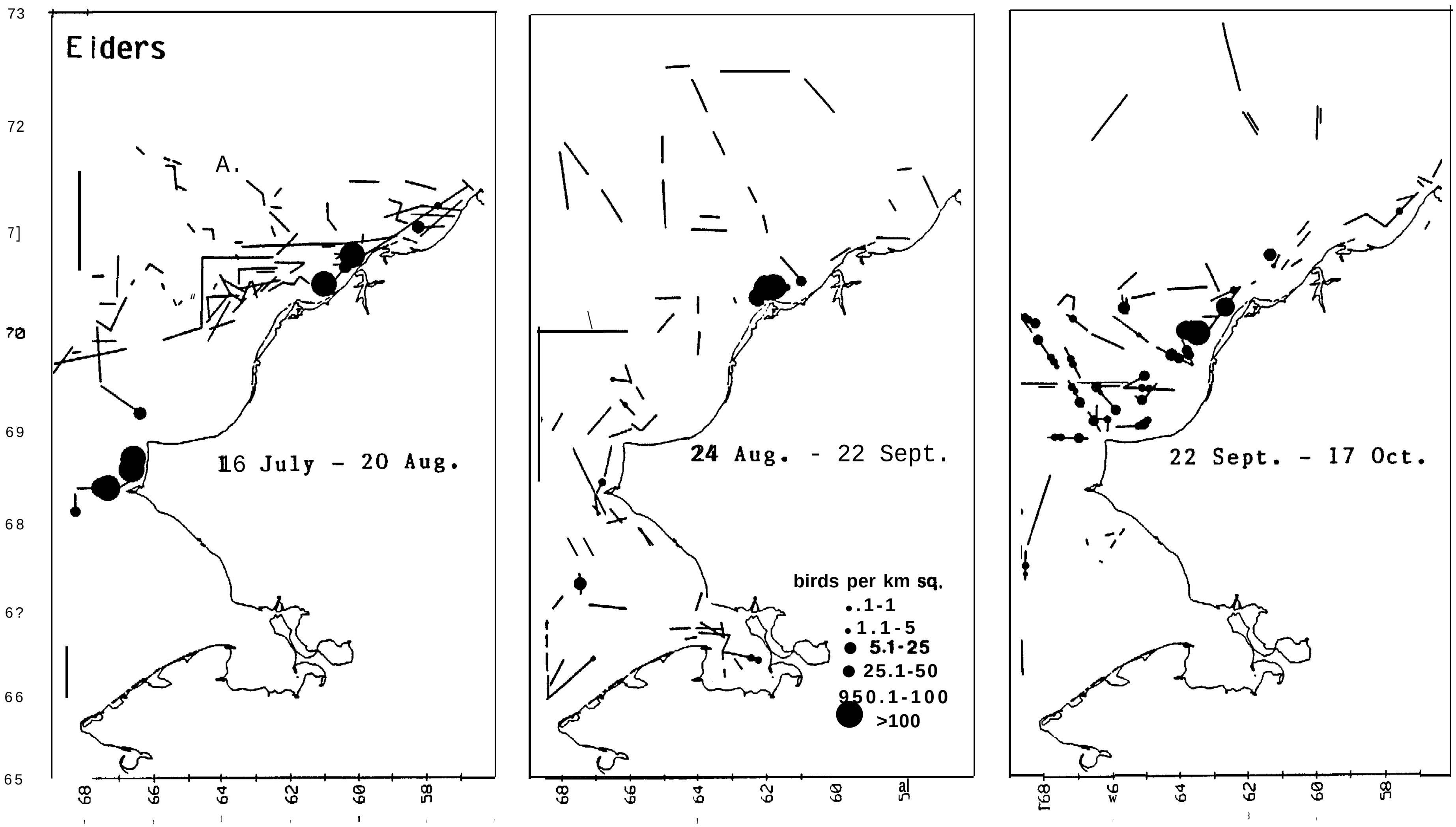


Figure 13. Densities of shearwaters in the eastern Chukchi Sea.

EIDERS

		16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)				
	North		.0	.0
	Central	1:8	2.1	4.3
	Southern	19.2	<.1	.4
	Kotzebue	-	.1	
Percent Frequency				
	North		0%	0%
	Central	3%	7%	19%
	Southern	20%	1%	13%
	Kotzebue	-	2%	
Maximum Density (per sq. km)				
	North	-	.0	.0
	Central	120.0	131.1	270.0
	Southern	284.0	22.6	8.4
	Kotzebue	-	4.5	

Table 6. Average density, percent frequency, and maximum density of eiders by region and time period.



50

Figure 14. Densities of eider in the eastern Chukchi Sea.

OLDSQUAW

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North		.0	.1
Central	<.1	.2	11.6
Southern	.0	.2	.8
Kotzebue	-	.0	
Percent Frequency			
North		0%	3%
Central	1%	7%	25%
Southern	0%	4%	15%
Kotzebue	-	0%	
Maximum Density (per sq. km)			
North	-	.0	2.2
Central	10.8	12.4	720.0
Southern	.0	12.4	31.2
Kotzebue	-	.0	

Table 7. Average density, percent frequency, and maximum density of Oldsquaw by region and time period.

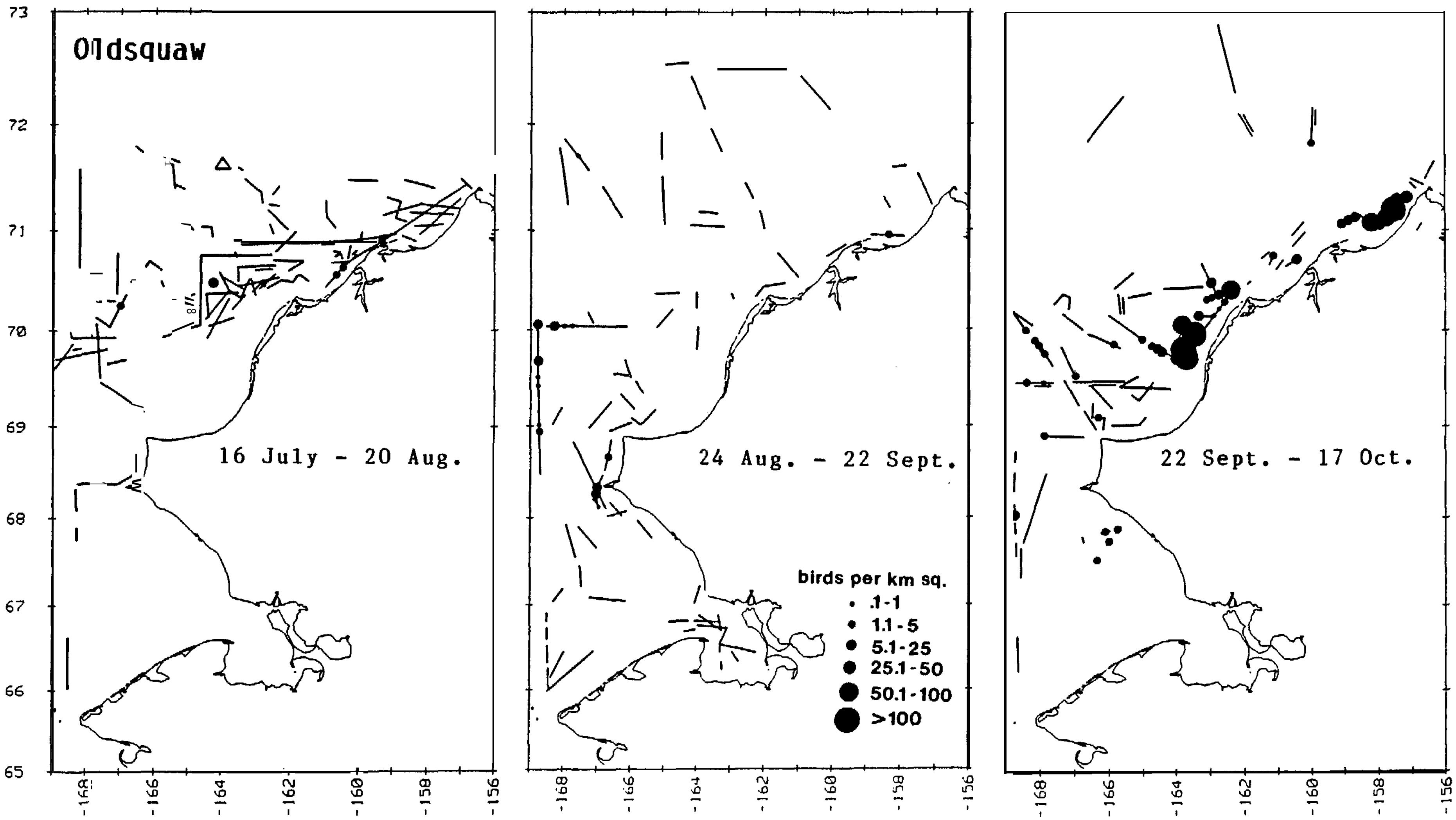


Figure 15. Densities of Oldsquaw in the eastern Chukchi Sea.

PHALAROPES

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North	-	.0	.0
Central	1.0	1.9	.2
Southern	3.1	.3	25.3
Kotzebue	-	.8	-
Percent Frequency			
North	-	0%	0%
Central	10%	23%	10%
Southern	30%	16%	49%
Kotzebue	-	7%	-
Maximum Density (per sq. km)			
North	-	.0	.0
Central	125.0	49.3	24.0
Southern	31.2	9.9	217.4
Kotzebue	-	40.7	-

Table 8. Average density, percent frequency, and maximum density of phalaropes by region and time period.

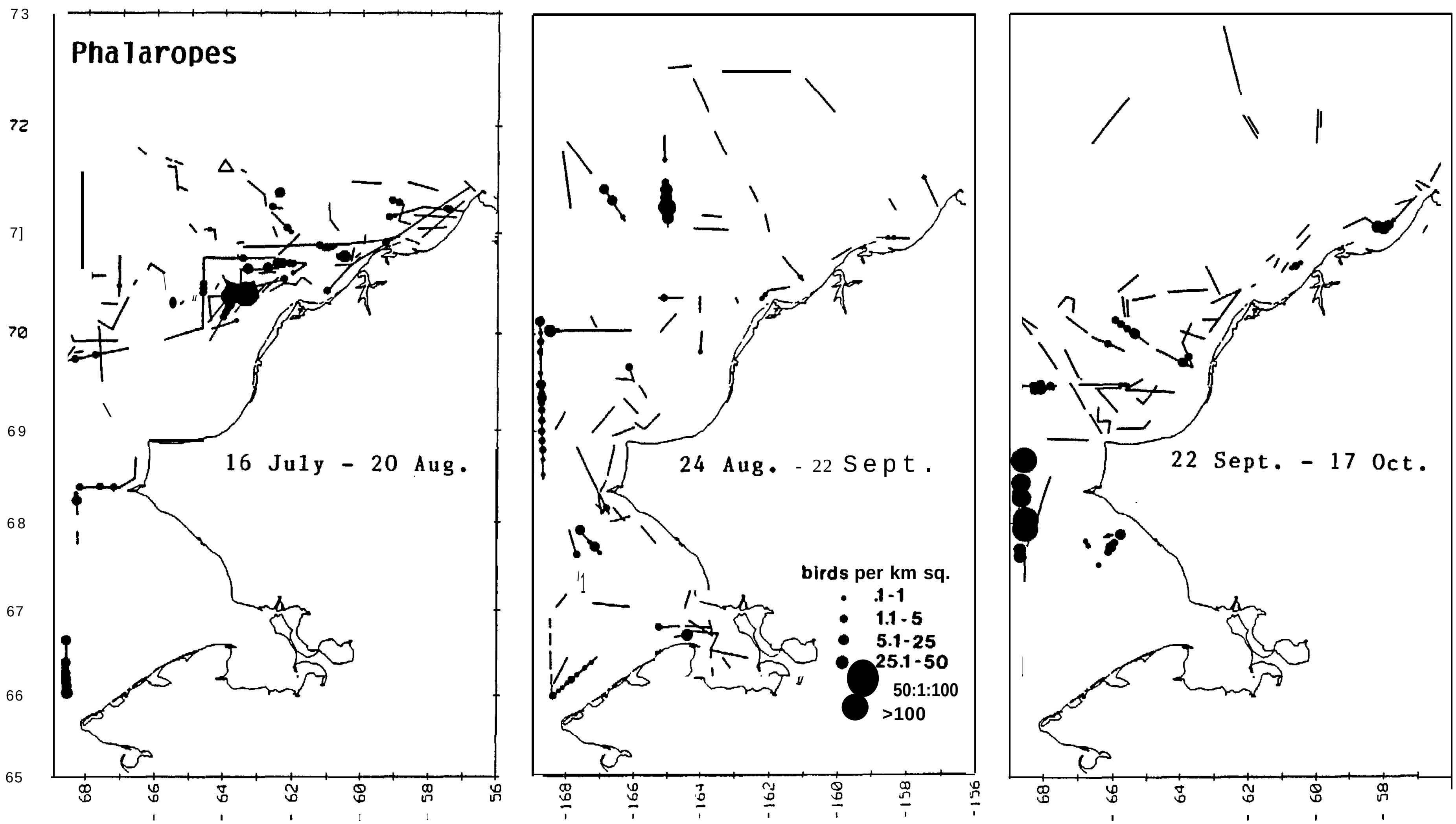


Figure 16. Densities of phalaropes in the eastern Chukchi Sea.

JAEGERS

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North	-	.1	.2
Central	.7	.5	.1
Southern	.2	.2	.0
Kotzebue		.0	
Percent Frequency			
North	-	18%	3%
Central	28%	26%	1%
Southern	15%	20%	0%
Kotzebue		0%	
Maximum Density (per sq. km)			
North		1.5	1.1
Central	21.6	10.8	4.5
Southern	3.0	2.7	.0
Kotzebue		.0	

Table 9. Average density, percent frequency, and maximum density of jaegers by region and time period.

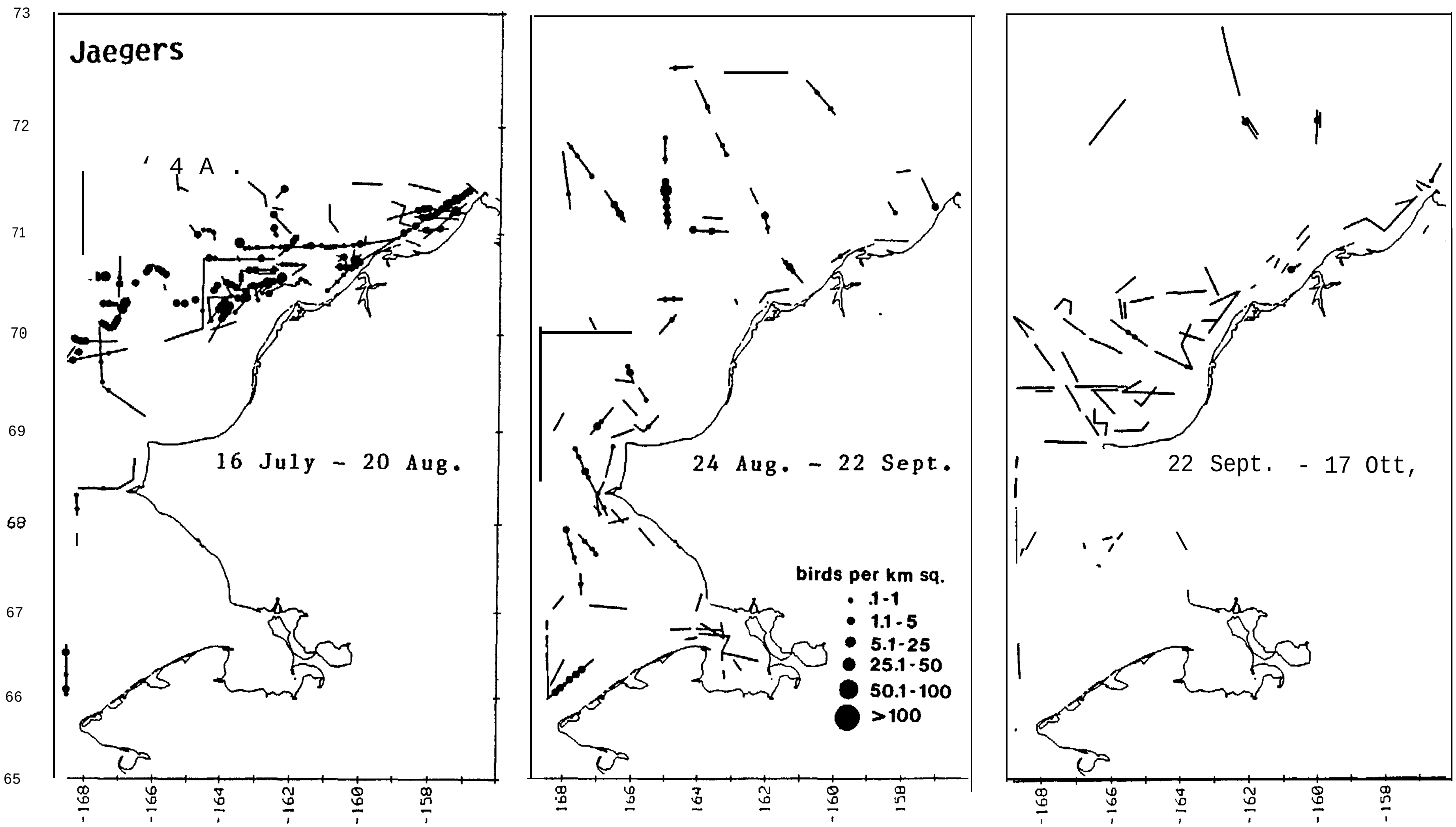


Figure 17. Densities of jaegers in the eastern Chukchi Sea.

GLAUCOUS GULL

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North	-	<.1	.8
Central	.5	.3	.7
Southern	.1	.1	.5
Kotzebue	-	.1	
Percent Frequency			
North		4%	80%
Central	22%	28%	32%
Southern	11%	1;;	33%
Kotzebue			
Maximum Density (per sq.km)			
North	-	1.5	11.1
Central	21.6	10.8	13.6
South	.8	1.8	4.2
Kotzebue	-	2.1	

Table 10. Average density, Percent frequency, and maximum density of Glaucous Gull by region and time period.

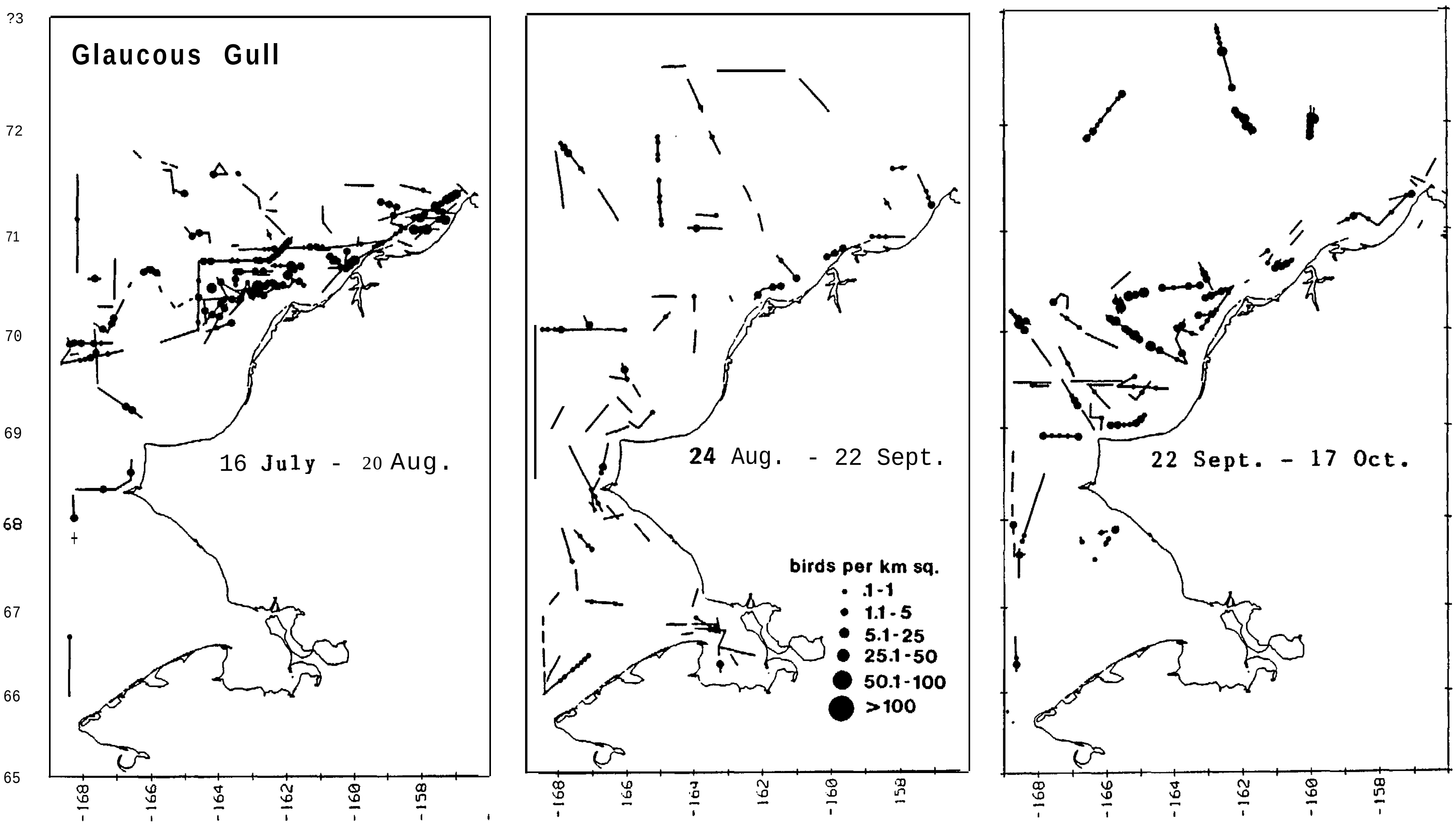


Figure 18. Densities of Glaucous Gull in the eastern Chukchi Sea.

IVORY GULL

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North		.1	2.4
Central	<.1	.0	.9
Southern	.0	.0	.0
Kotzebue	-	.0	
Percent Frequency			
North		4%	18%
Central	<1%	0%	28%
Southern	0%	0%	0%
Kotzebue	-	0%	
Maximum Density (per sq. km)			
North	-	1.6	110.0
Central	.8	.0	35.0
Southern	.0	.0	.0
Kotzebue	-	.0	

Table 11. Average density, percent frequency, and maximum, density of Ivory Gull by region and time period.

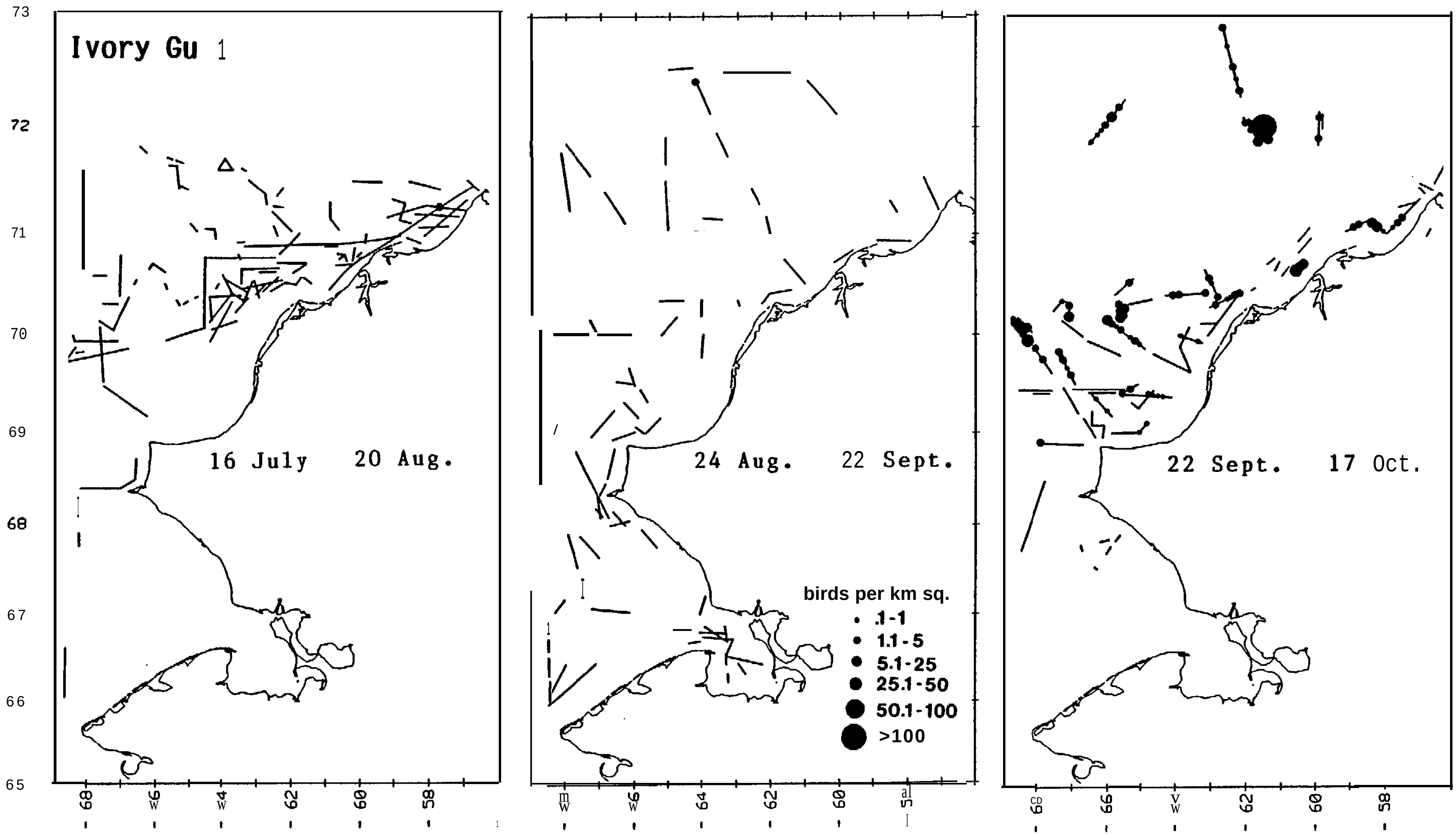


Figure 19. Densities of Ivory Gull in the eastern Chukchi Sea.

BLACK-LEGGED KITTIWAKE

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North		.1	.2
Central	1:5	2.2	.3
Southern	1.1	2.5	.6
Kotzebue	-	.9	
Percent Frequency			
North		11%	12%
Central	47%	57%	20%
Southern	41%	68%	34%
Kotzebue	-	49%	
Maximum Density (per sq. km)			
North	-	.5	3.7
Central	28.6	43,7	9.0
Southern	24,5	55.4	17.8
Kotzebue	-	14.5	

Table 12. Average density, percent frequency, and maximum density of Black-legged Kittiwake by region and time period.

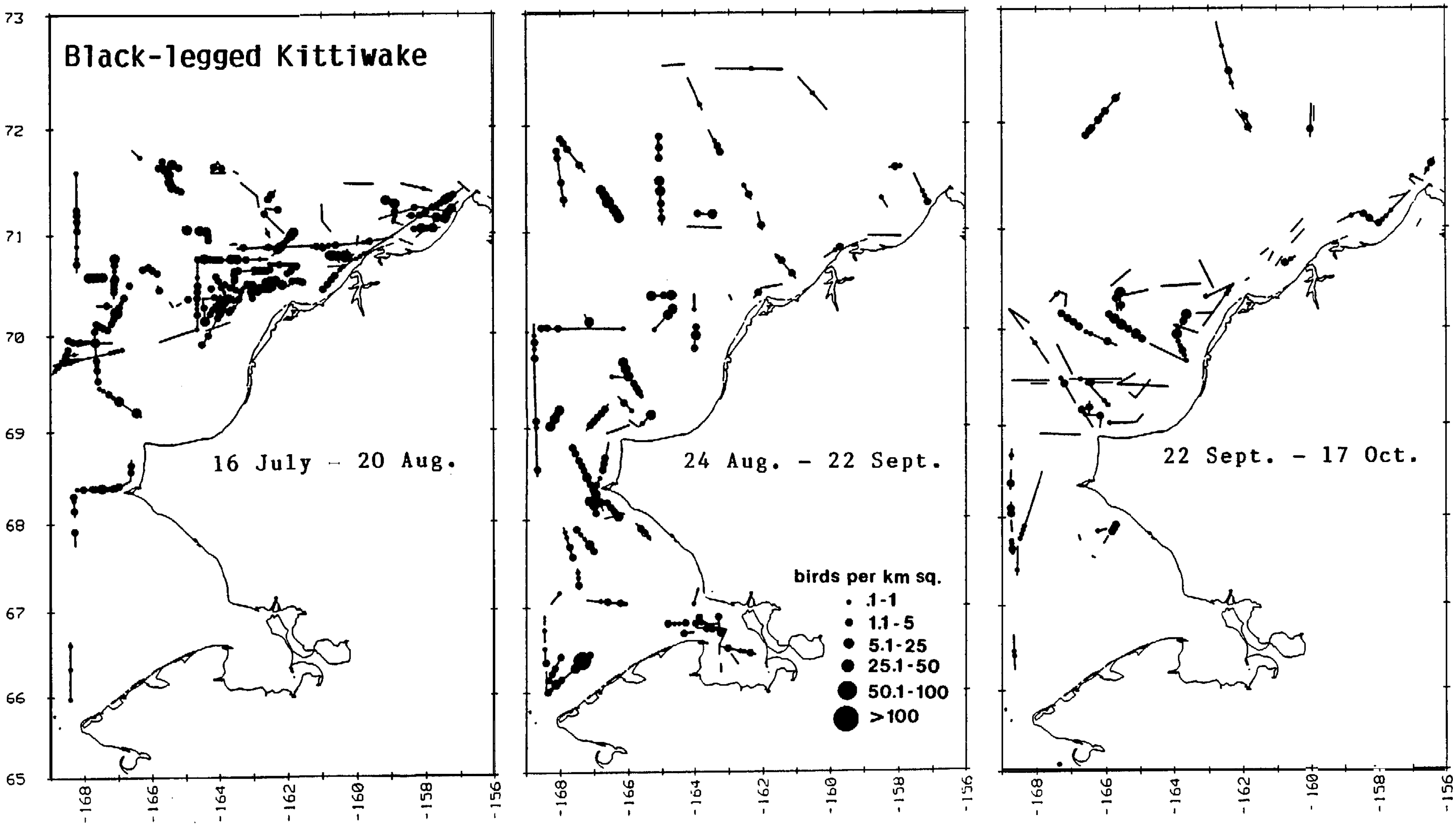


Figure 2°. Densities of Black-legged Kittiwake in the eastern Chukchi Sea.

ROSS' GULL

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North		.0	4.0
Central	<.1	.0	2.9
southern	.0	.0	.1
Kotzebue	-	,0	
percent Frequency			
North		0%	40%
Central	<1%	0%	33%
southern	0%	0%	6%
Kotzebue	-	0%	
Maxi mum Density (per sq. km)			
North	-	.0	94.2
Central	1.6	.0	120.0
southern	.0	.0	1.8
Kotzebue	-	.0	

Table 13. Average density, percent frequency, and maximum density of Ross' Gull by region and time period.

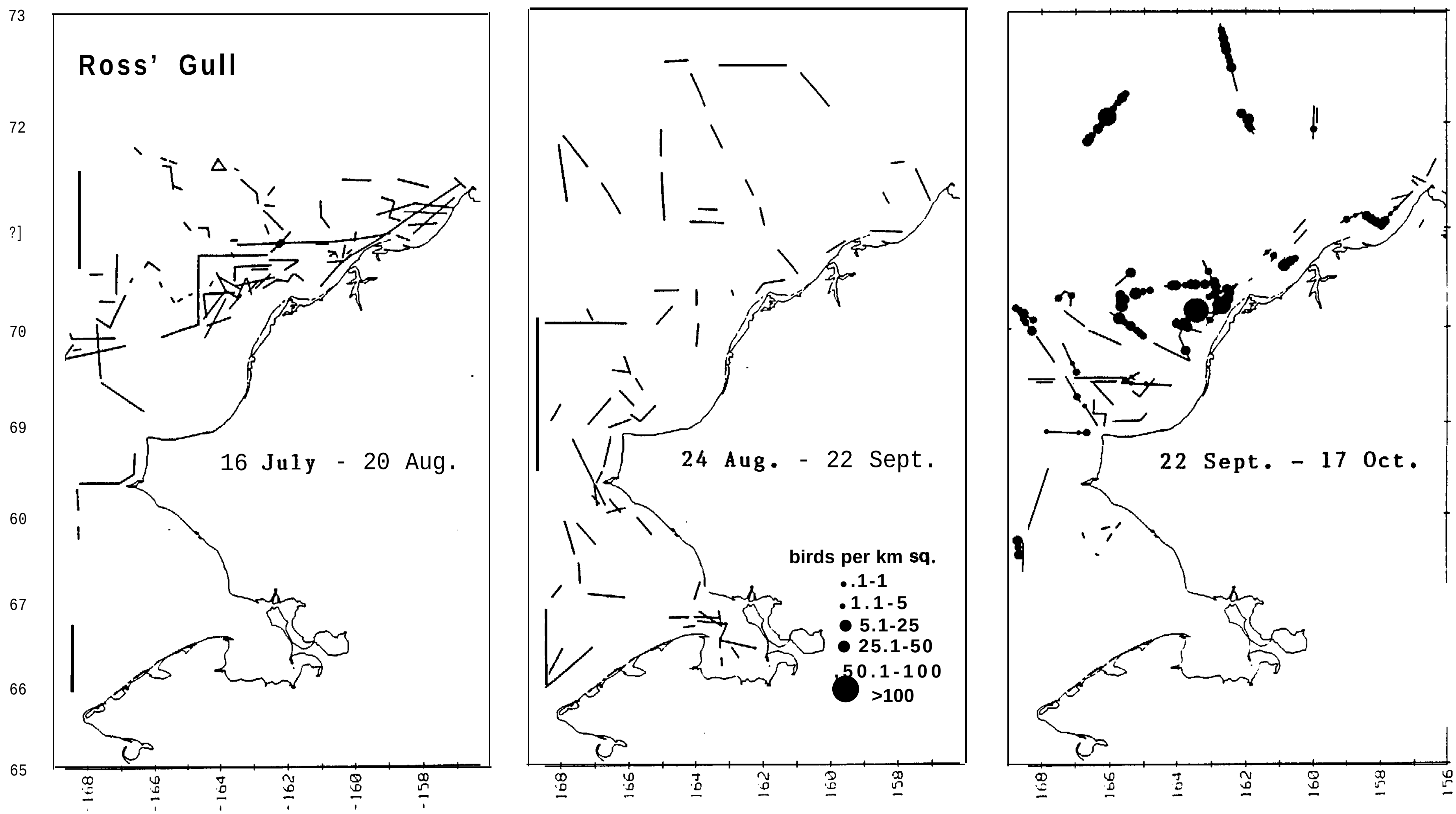


Figure 21. Densities of Ross' Gull in the eastern Chukchi Sea.

MURRES

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North	-	.0	.0
Central	2.3	.6	.2
southern	20.0	2.7	.1
Kotzebue	-	.1	-
Percent Frequency			
North		0%	0%
Central	46%	19%	10%
Southern	100%	67%	12%
Kotzebue		10%	
Maximum Density (per sq. km)			
North	-	.0	.0
Central	59.3	4.1	10.0
southern	199.9	35.7	23.4
Kotzebue	-	2.7	

Table 14. Average density, percent frequency, and maximum density of murres by region and time period,

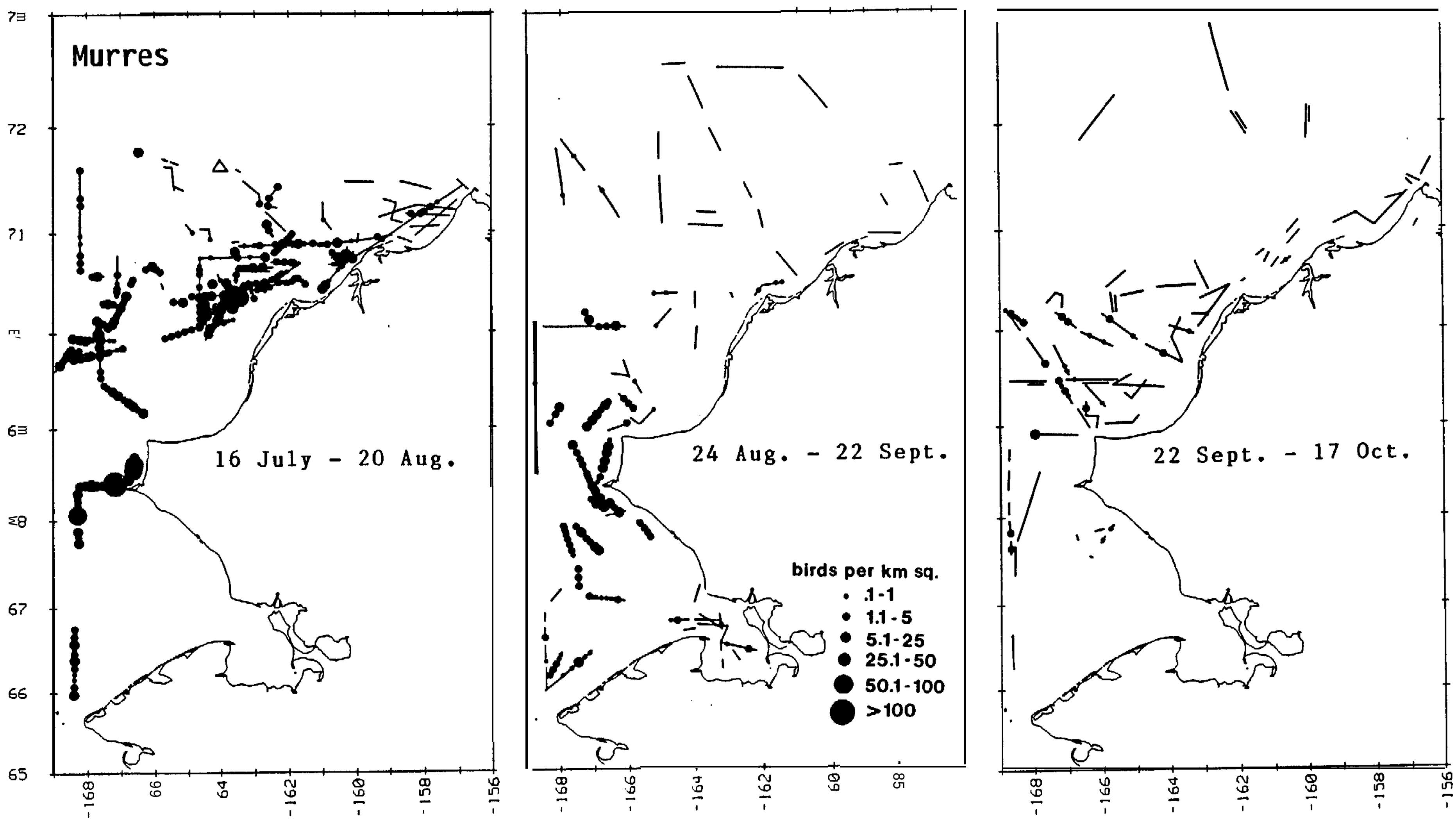


Figure 22. Densities of murres in the eastern Chukchi Sea.

BLACK GUILLEMOT

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North	-	.3	.2
Central	.5	<.1	1.2
Southern	.1	.0	.0
Kotzebue	-	.0	
Percent Frequency			
North		7%	10%
Central	18%	1%	20%
Southern	2%	0%	0%
Kotzebue	-	0%	
Maximum Density (per sq. km)			
North	-	3.9	3.7
Central	12.8	1.2	35.0
Southern	1.2	.0	.0
Kotzebue	-	.0	

Table 15. Average density, percent frequency, and maximum density of Black Guillemot by region and time period.

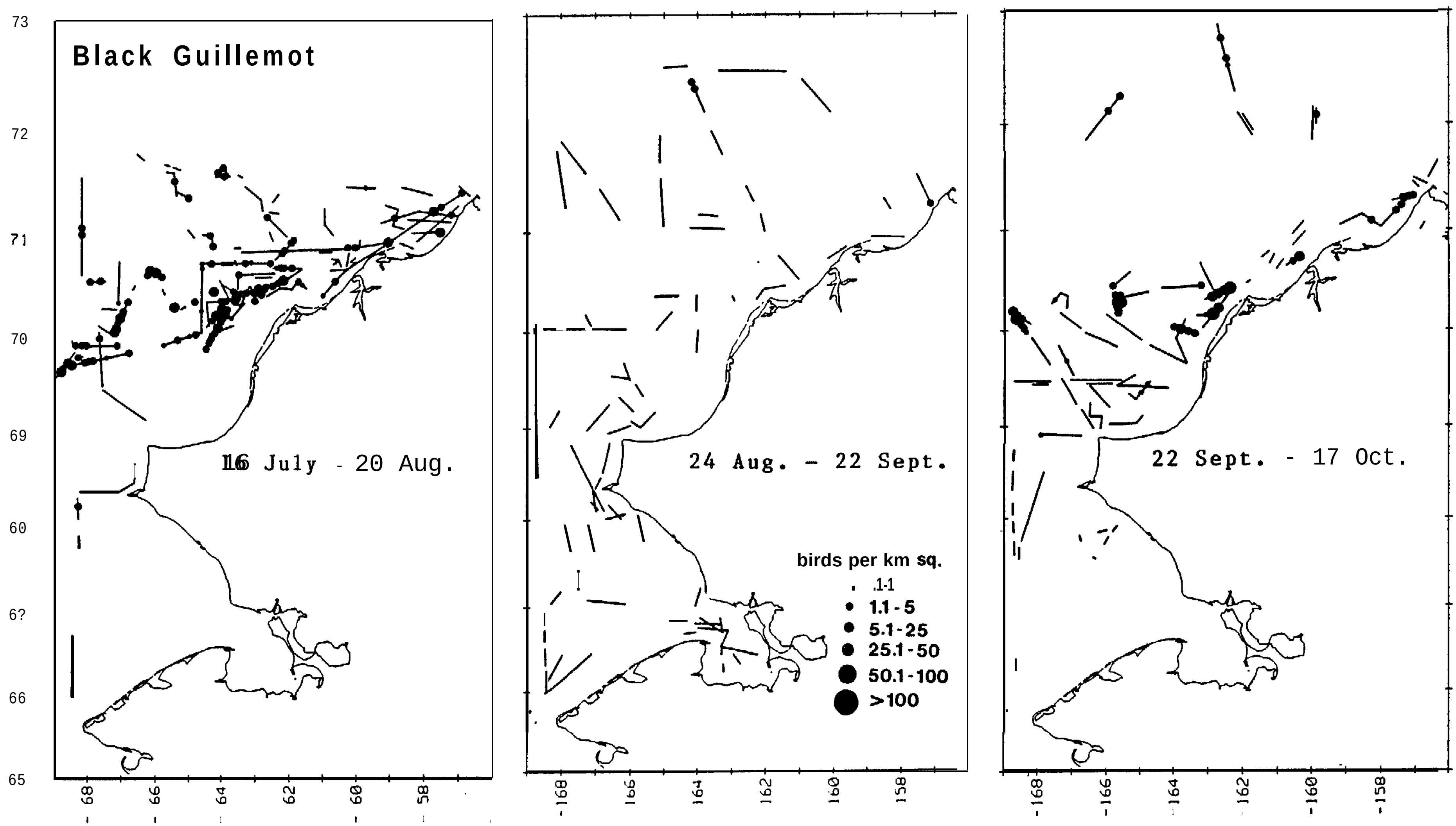


Figure 23. Densities of Black Guillemot in the eastern Chukchi Sea.

KITTLITZ'S MURRELET

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North		.8	.0
Central	<.1	<.1	.1
Southern	.0	<.1	.0
Kotzebue	-	.1	
Percent Frequency			
North		18%	0%
Central	<1%	2%	5%
Southern	0%	1%	0%
Kotzebue	-	2%	
Maximum Density (per sq. km)			
North	-	12.9	.0
Central	.7	2.2	8.1
Southern	.0	1.5	.0
Kotzebue	-	.5	

Table 16. Average density, percent frequency, and maximum density of Kittlitz's Murrelet by region and time period,

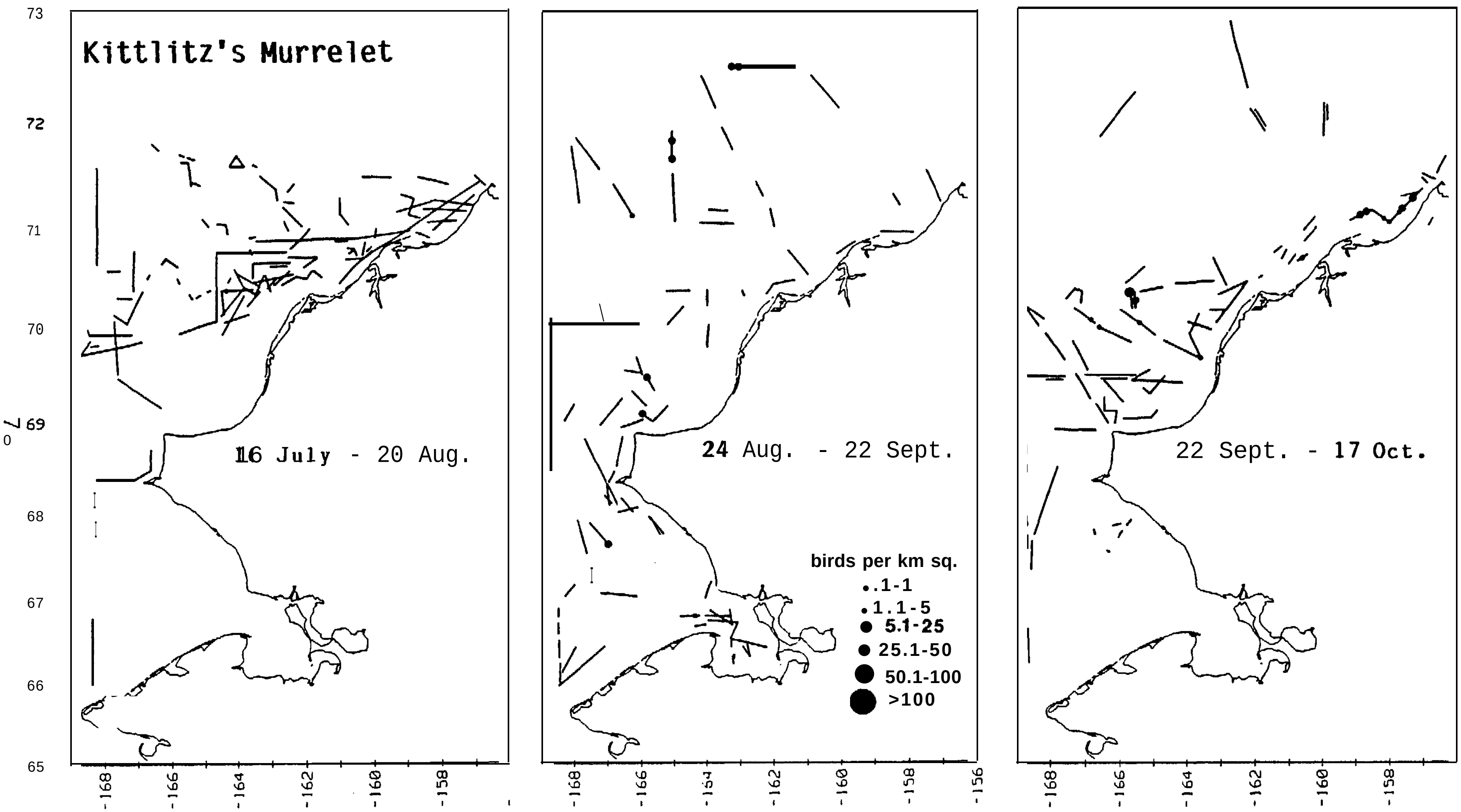


Figure 24. Densities of Kittlitz's Murrelet in the eastern Chukchi Sea.

PARAKEET AUKLET

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North		.0	.0
Central	<.1	.1	<ml
Southern	<.1	.5	.1
Kotzebue	-		
Percent Frequency			
North		0%	0%
Central	<.1%	9%	1%
Southern	2%	17%	5%
Kotzebue	-		
Maximum Density (per sq. km)			
North	-	.0	.0
Central	.5	2.8	.5
Southern	.6	13.8	2.1
Kotzebue	-	.0	

Table 17. Average density, percent frequency, and maximum density of Parakeet Auklet by region and time period.

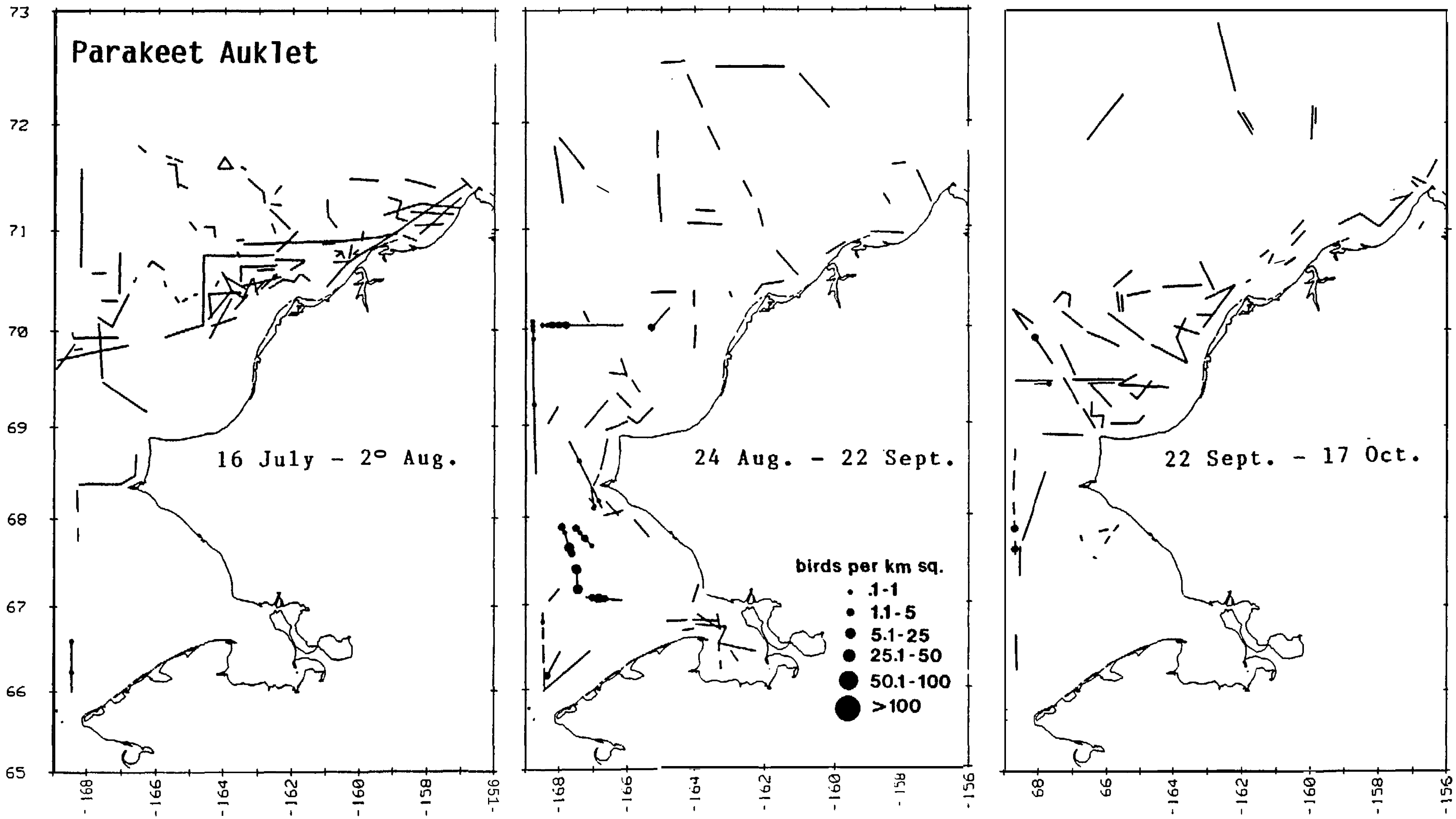


Figure 25. Densities of Parakeet Auklet in the eastern Chukchi Sea.

LEAST AUKLET

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17Oct.
Average Density (per sq. km)			
North	-	.0	.0
Central	.0	.3	<.1
Southern	.5	<.1	<.1
Kotzebue	-	.0	
Percent Frequency			
North		0%	0%
Central	0%	14%	4%
Southern	17%	1%	7%
Kotzebue	-	0%	
Maximum Density (per sq. km)			
North	-	.0	.0
Central	.8	8;;	.7
Southern	11.4		2.0
Kotzebue	-	.0	

Table 18. Average density, percent frequency, and maximum density of Least Auklet by region and time period.

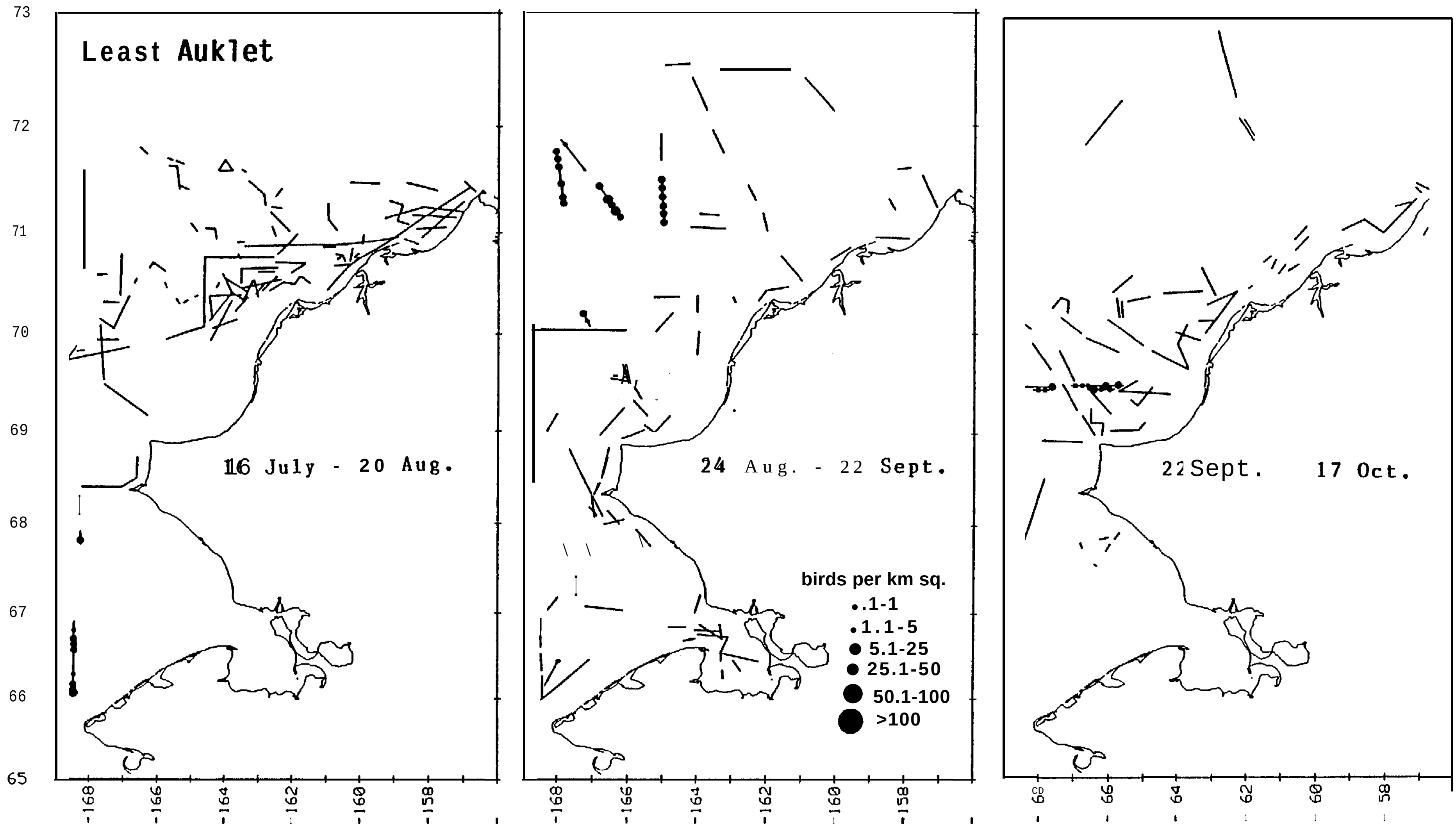


Figure 26. Densities of Least Auklet in the eastern Chukchi Sea.

CRESTED AUKLET

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North	-	.1	.0
Central	.0	5.2	.7
Southern	.4	.1	.3
Kotzebue	-	.0	
Percent Frequency			
North		7%	0%
Central	0%	26%	12%
Southern	11%	1%	18%
Kotzebue	-	0%	
Maximum Density (per sq. km)			
North	-	1.0	.0
Central	.0	126.0	90.0
Southern	.6	.5	4.2
Kotzebue	-	.0	

Table 19. Average density, percent frequency, and maximum density of Crested Auklet by region and time period.

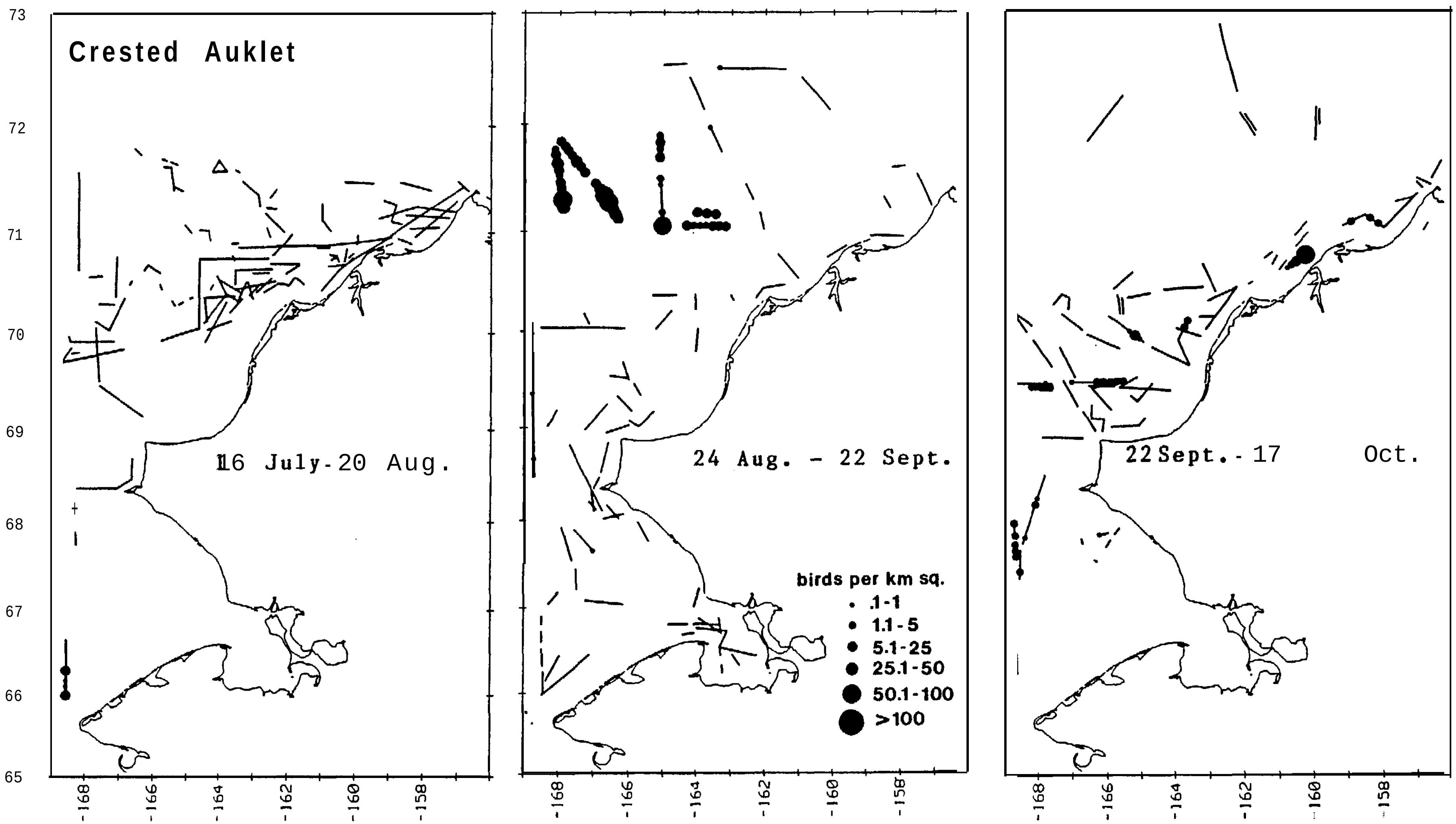


Figure 27. Densities of Crested Auklet in the eastern Chukchi Sea.

TUFTED PUFFIN

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North		.0	.0
Central	<.1	<.1	.0
Southern	.2	<.1	.0
Kotzebue	-	.0	
Percent Frequency			
North		0%	0%
Central	1%	2%	0%
Southern	13%	2%	0%
Kotzebue	-	0%	
Maximum Density (per sq. km)			
North	-	.0	.0
Central	2.2	.5	.0
Southern	2.2	1.1	.0
Kotzebue	-	.0	

Table 20. Average density, PerCent frequency, and maximum density of Tufted Puffin by region and time period.

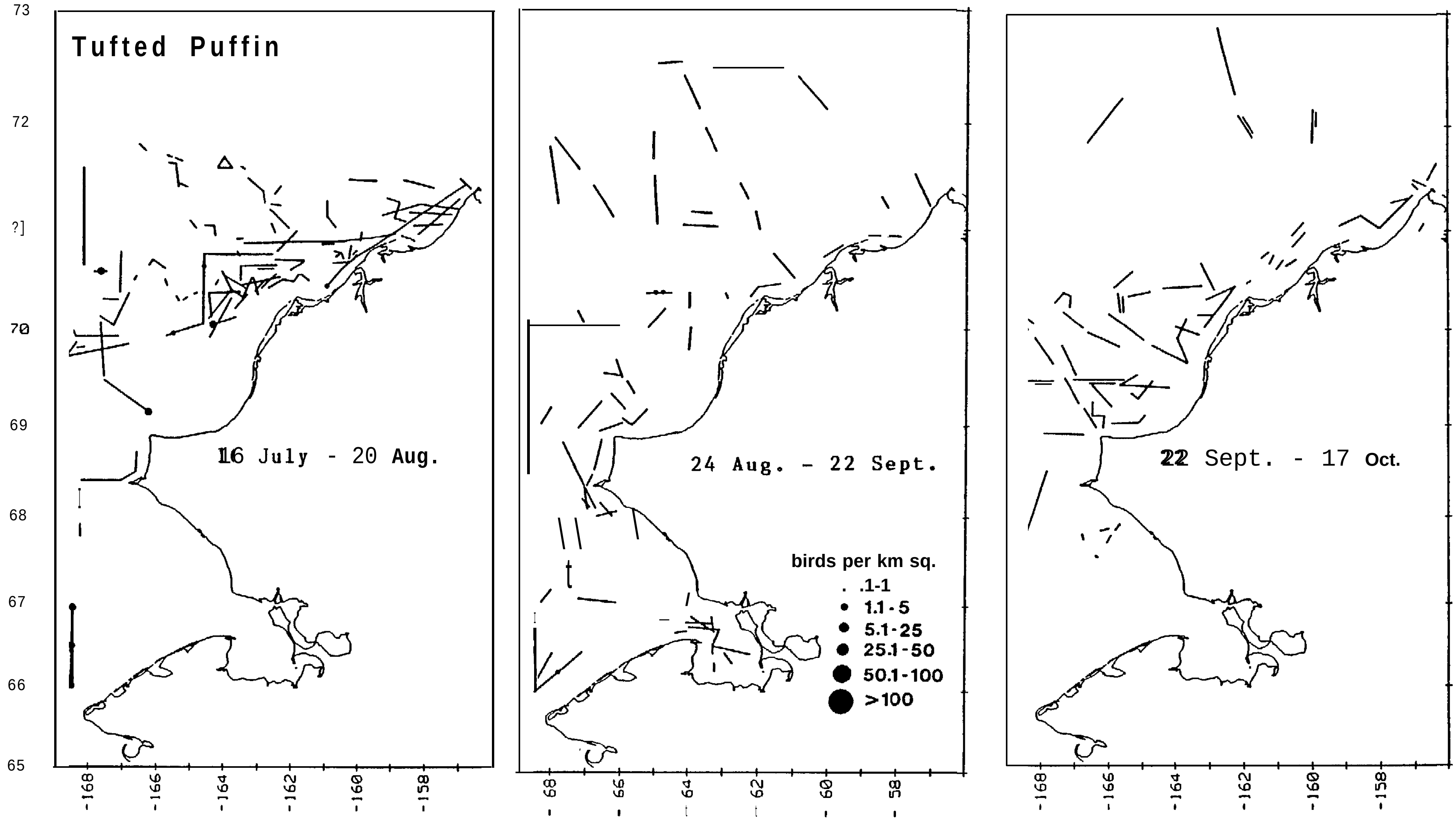


Figure 28. Densities of Tufted Puffin in the eastern Chukchi Sea.

HORNED PUFFIN

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North		.0	.0
Central	<.1	<.1	.2
Southern	.4	.2	.0
Kotzebue	-	.2	
Percent Frequency			
North		0%	0%
Central	<1%	1%	4%
Southern	24%	15%	0%
Kotzebue	-	12%	-
Maximum Density (per sq. km)			
North	-	.0	.0
Central	.0	.0	39.2
Southern	1.2	1.7	.0
Kotzebue	-	6.7	

Table 21. Average density, percent frequency, and maximum density of Horned Puffin by region and time period.

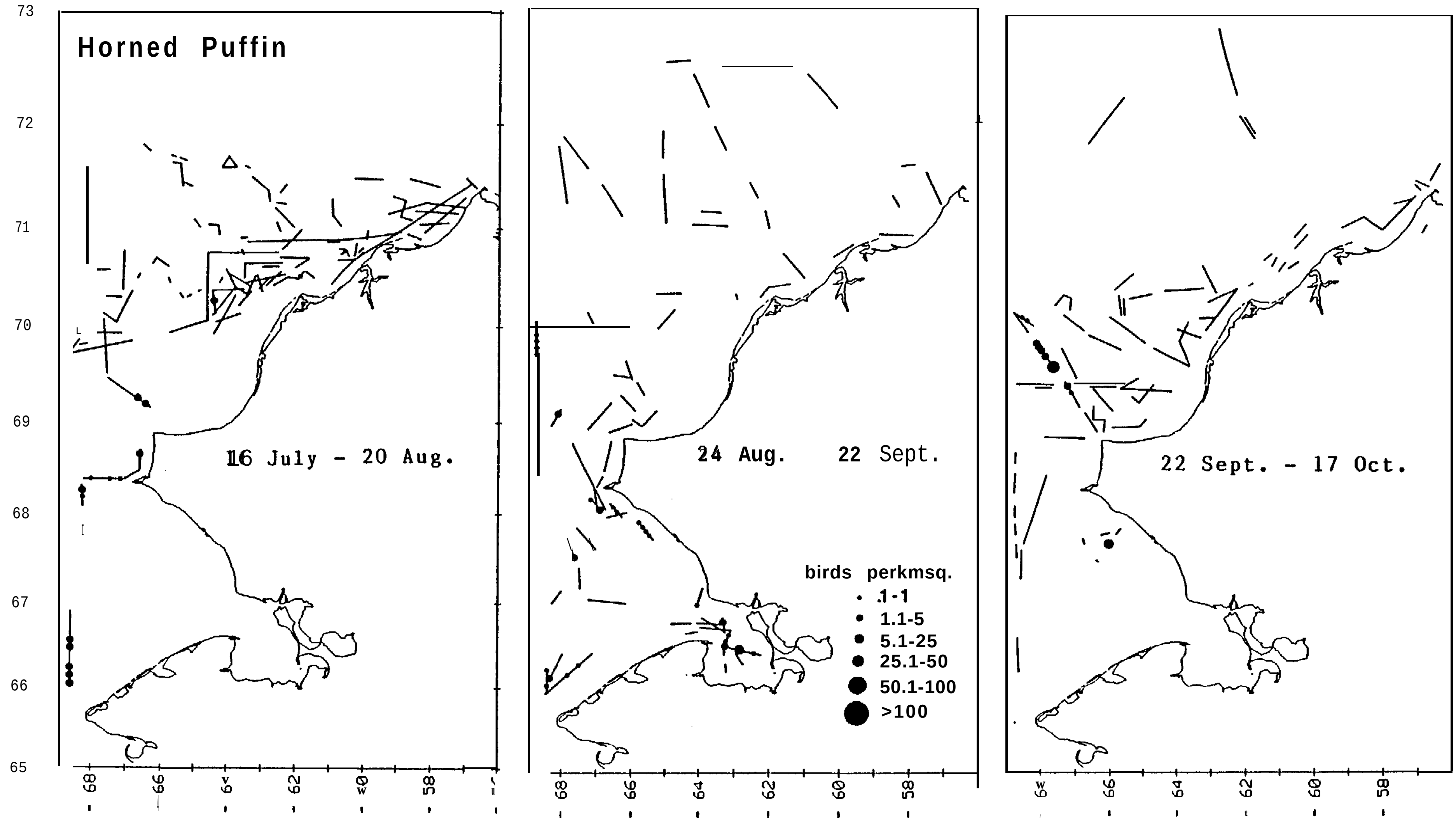


Figure 29. Densities of Horned Puffin in the eastern Chukchi Sea.

UNIDENTIFIED SMALL ALCID

		16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)				
	North	-	.15	.00
	Central	.01	.47	.04
	Southern	1.10	.53	.14
	Kotzebue	-	.10	
Percent Frequency				
	North		11%	0%
	Central	1%	14%	<1%
	Southern	15%	15%	18%
	Kotzebue	-	9%	
Maximum Density (per sq. km)				
	North	-	2.6	0.0
	Central	3.3	13.3	1.8
	Southern	21.0	13.1	4.2
	Kotzebue	-	3.6	

Table 22. Average density, percent frequency, and maximum density of unidentified small alcids by region and time period.

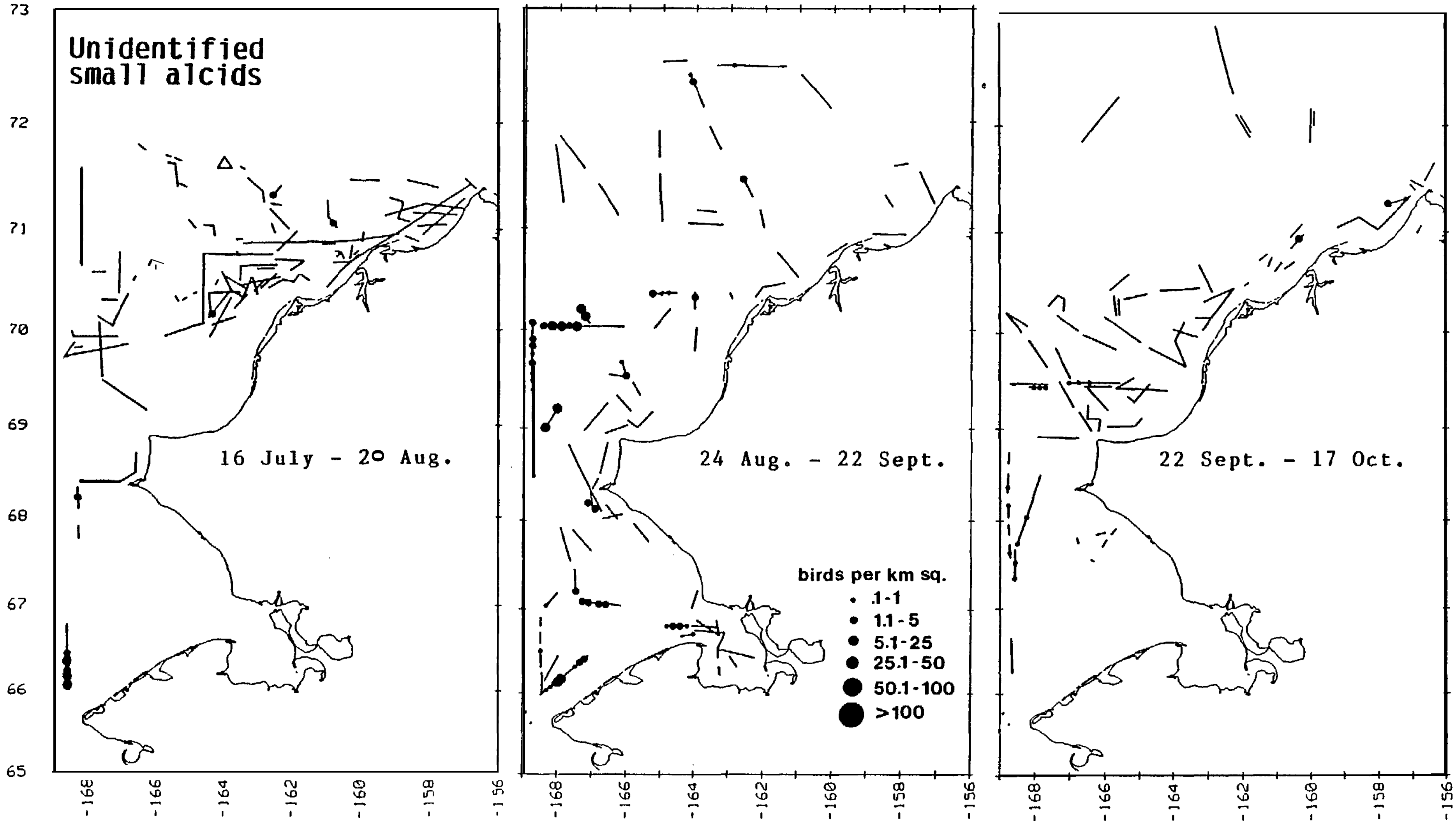


Figure 30. Densities of unidentified small alcids in the eastern Chukchi Sea.

TOTAL BIRDS

	16 July-22 Aug.	24 Aug.-22 Sept.	22 Sept.-17 Oct.
Average Density (per sq. km)			
North		1.5	7.8
Central	8.9	19.9	27.6
Southern	48.1	52.0	29.7
Kotzebue		3.2	
Percent Frequency			
North		57%	73%
Central	84%	95%	93%
Southern	100%	98%	90%
Kotzebue		80%	
Maximum Density (per sq. km)			
North		12.9	151.7
Central	246.0	237.6	870.6
Southern	413.7	3334.1	227.8
Kotzebue		42.5	

Table 23. Average density, percent frequency, and maximum density of total birds by region and time period.

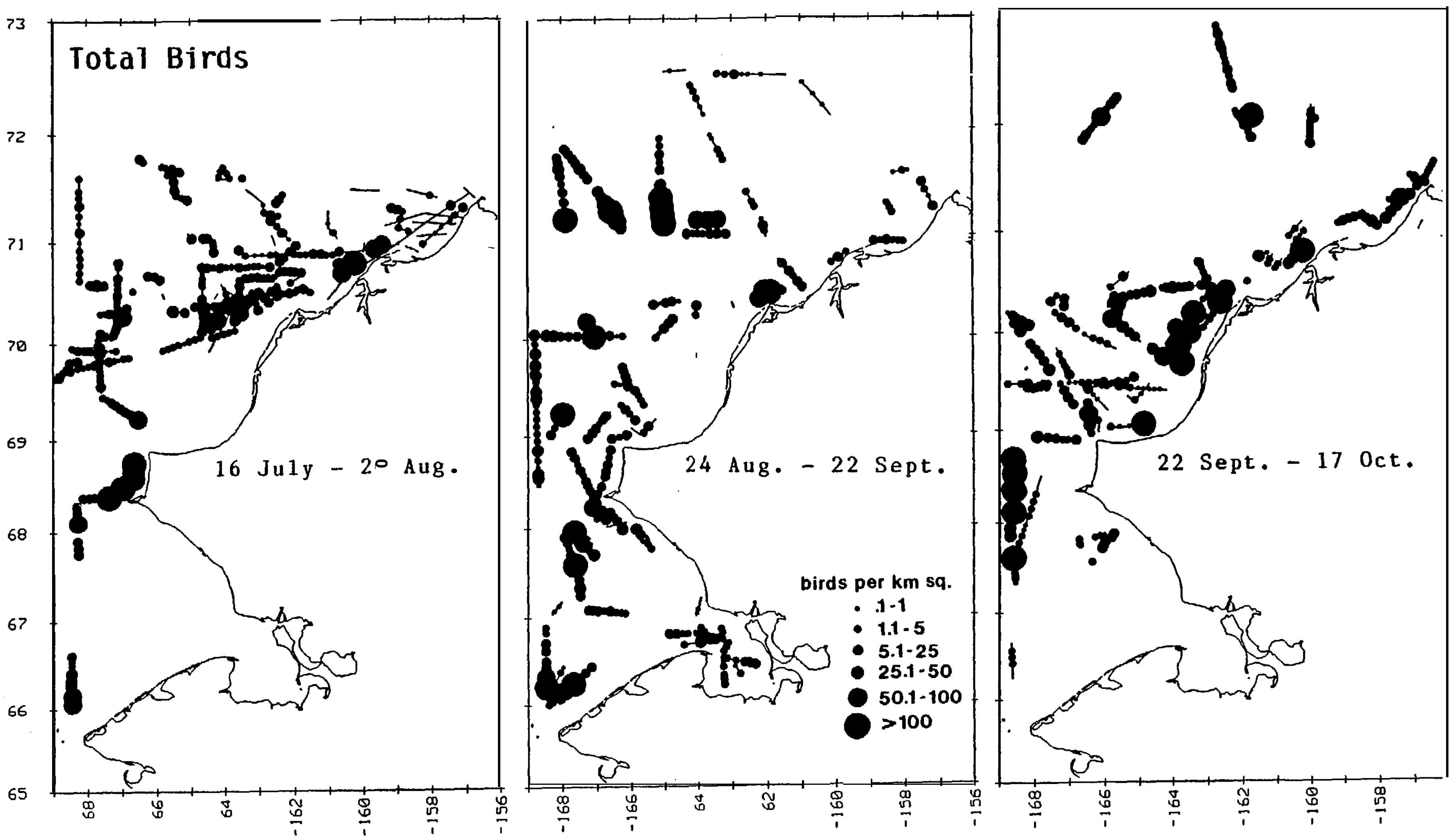


Figure 31. Densities of total birds in the eastern Chukchi Sea.

Table 24. Average densities (birds per sq. km) and percent frequencies of seabird species in the three pelagic regions of the eastern Chukchi Sea by time period (n=observation periods).

NORTHERN CHUKCHI

16 July - 22 August, n= 0

species	density	freq.
no sampling		

24 August - 22 Sept., n= 28

species	density	freq.
Kittlitz's Murrelet	.8	18%
Black Guillemot	.3	7%
Small unid. alcid	.2	11%
Jaegers	.1	18%
Bl.-legged Kittiwake	.1	11%
Crested Auklet	.1	7%
Ivory Gull	.1	4%
Northern Fulmar	<.1	4%
Glaucous Gull	<.1	4%

22 Sept. - 17 Oct., n= 60

species	density	freq.
Ross' Gull	4.0	40%
Ivory Gull	2.4	18%
Glaucous Gull	.8	80%
Bl.-legged Kittiwake	.2	12%
Black Guillemot	.2	10%
Jaegers	.2	3%

CENTRAL CHUKCHI

16 July - 22 August, n= 749

species	density	freq.
Murres	2.3	46%
Bl.-legged Kittiwake	1.5	47%
Phalarope	1.0	10%
Jaegers	.7	28%
Glaucous Gull	.5	22%
Black Guillemot	.5	18%
Northern Fulmar	<.1	2%
Tufted Puffin	<.1	2%

24 August - 22 Sept., n= 167

species	density	freq.
Shearwaters	5.4	23%
Crested Auklet	5.2	26%
Bl.-legged Kittiwake	2.2	57%
Phalaropes	1.9	23%
Small unid. alcid	.5	14%
Murres	.6	19%
Jaegers	.5	26%
Glaucous Gull	.3	28%
Least Auklet	.3	14%
Northern Fulmar	.2	12%
Parakeet Auklet	.1	9%
Kittlitz's Murrelet	<.1	2%
Horned Puffin	<.1	1%

22 Sept. - 17 Oct., n= 261

species	density	freq.
Ross' Gull	2.9	33%
Black Guillemot	1.2	20%
Ivory Gull	.9	28%
Glaucous Gull	.7	32%
Crested Auklet	.7	12%
Bl.-legged Kittiwake	.3	20%
Shearwaters	.3	11%
Phalaropes	.2	10%
Murres	.2	10%
Crested Auklet	.2	9%
Horned Puffin	.2	4%
Kittlitz's Murrelet	.1	5%
Jaegers	.1	1%
Least Auklet	<.1	4%
Parakeet Auklet	<.1	1%

SOUTHERN CHUKCHI

16 July - 22 August, n= 46

species	density	freq.
Murres	20.0	100%
Phalaropes	3.1	30%
Bl.-legged Kittiwake	1:1	41%
Unid. small alcids	1.1	15%
Northern Fulmar	.5	22%
Shearwaters	.5	22%
Least Auklet	.5	17%
Horned Puffin	.4	24%
Crested Auklet	.4	11%
Jaegers	.2	15%
Tufted Puffin	.2	13%
Glaucous Gull	.1	11%
Black Guillemot	.1	1%
Parakeet Auklet	<.1	2%

24 August - 22 Sept., n= 102

species	density	freq.
Shearwaters	44.1	64%
Murres	2.?	67%
Bl.-legged Kittiwake	2.5	68%
Parakeet Auklet	.5	17%
Unid. small alicds	.5	15%
Phalaropes	.3	16%
Northern Fulmar	.3	15%
Jaegers	.2	20%
Horned Puffin	.2	15%
Glaucous Gull	.1	19%
Crested Auklet	.1	1%
Tufted Puffin	<.1	2%
Least Auklet	<.1	1%

22 Sept. - 17 Oct., n= 62

species	density	freq.
Phalaropes	25.3	49%
Shearwaters	9.2	44%
Bl.-legged Kittiwake	.6	34%
Glaucous Gull	.5	33%
Northern Fulmar	.4	23%
Crested Auklet	.3	18%
Unid. small alcids	.10	18%
Murres	.1	12%
Jaegers	.1	12%
Parakeet Auklet	.1	5%
Least Auklet	.1	7%
Ross' Gull	.1	6%

Table 25. Average densities (birds per sq. km) and percent frequencies of seabird species in Kotzebue Sound,

24 August - 22 Sept.

observation periods=59

species	density	freq.
Bl.-legged Kittiwake	.9	49%
Phalaropes	.8	7%
Loons	.5	34%
Horned Puffin	.2	12%
Murres	.1	1 0%
Unid. small alcid	.1	10%
Glaucous Gull	.1	7%
Shearwaters	.1	3%
Cormorants	<.1	2%

Table 26. Estimates of Chukchi pelagic populations of numerically important species during period of maximum abundance (this study) and of Bering Sea pelagic populations (Gould et al. 1982).

Species	Period of estimate	Chukchi Sea pelagic POP. (thousands)	Bering Sea pelagic pop. (thousands)
Northern Fulmar	Aug. -Sept.	45	2,100
Short-tailed Shearwater	Aug.-Sept.	2,000	12,000
Phalaropes	July-Oct.	1,000	1,()):
Jaegers	July-Aug.	100	
Glaucous Gull	Sept.-Ott.	125	17
Black-legged Kittiwake	Aug. -Sept.	400	2,600
Ross' Gull	Sept.-Oct	25	-
Murres	July-Aug.	750	2,700
Black Guillemot	July-Aug.	70	
Kittlitz's Murrelet	Sept.-Ott.	15	
Parakeet Auklet	Aug. -Sept.	40	
Least Auklet	Aug. -Sept.	40	
Crested Auklet	Sept.-Ott.	100	
Horned Puffin	Aug. -Sept.	10	
Total		4,710	

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