THE PELAGIC BIRDS AND MAMMALS OF THE CHUKCHI SEA IN FALL

THESIS FOR THE DEGREE OF
MASTER OF SCIENCE

GEORGE J. DIVOKY

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ABSTRACT

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By

George Joseph Divoky

As part of an ecological survey conducted by the U. S. Coast Guard, observations of pelagic birds and mammals were made in the eastern Chukchi Sea between 22 September and 17 October 1970. Additional observations were made in the Bering Strait on 18 October. Sightings of these animals were plotted on maps and compared with previous published observations from the area. Some southward migration had already occurred, and no Arctic Terns or Grey Whales were observed. Other species including loons, phalaropes and jaegers were seen only during the first weeks of the study. Species seen throughout most of the study include Oldsquaw, eider, Glaucous and Ivory Gulls, Black-legged Kittiwake, Ross' Gull, Black Guillemot and walrus. Birds were collected for stomach analysis, and observations of the feeding behavior of gulls were correlated with the distribution data and stomach content findings.

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My participation was made possible through special funding from the Smithsonian Oceanography and Limnology Program.

George J. Wallace, chairman of my graduate committee, critically reviewed an early draft of this thesis as did Rollin H. Baker and Bertram G. Murray. Special thanks are due Miss Susy Fidelman who helped with the preparation of text and maps, and whose patience during the course of this work is greatly appreciated.

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INTRODUCTION

Oil pollution of the world's oceans has increased in recent years with the development of offshore drilling and the increasing size of tankers. The discovery of oil at Prudhoe Bay on Alaska's North Slope has been a major concern for environmentalists. The transporting of oil to refineries will have to be accomplished by pipelines or, less likely, supertankers. Though the use of a pipeline will lessen the chances for major oil pollution of the Arctic Ocean, there will undoubtedly still be a sizeable quantity of oil entering the marine environment. One of the shortcomings of most studies on the effects of oil pollution is the lack of data prior to the onset of pollution. In order that the full impact of oil pollution in the area of Prudhoe Bay can be measured, the United States Coast Guard contacted various agencies to participate in the Western Beaufort Sea Ecological Cruise (WEBSEC). Through the Smithsonian Institution, I was given the opportunity to assist in the censusing of birds and mammals. The USCGC GLACIER was made available in late September and early October 1970 for this survey. Heavy ice conditions in the Beaufort Sea forced a change in the study area to the eastern Chukchi Sea. Although the Chukchi coast is not receiving the extensive exploitation now being undertaken on the Beaufort Sea coast, exploratory drilling is taking place and oil development will undoubtedly occur in the future.

DESCRIPTION OF STUDY AREA

The Chukchi Sea is a shallow basin of the Arctic Ocean, lying north of the Bering Strait (Figure 1). It extends east to Point Barrow, west to Wrangel Island and north to the 100 fathom line (approximately 73°-74°N). Depths throughout most of the Chukchi vary from 10 to 30 fathoms with the bottom composed of silty sands and clayey mud and having no prominent features. A strong warm current enters the Chukchi through the Bering Strait, and continues north to the area of Point Hope where it divides into two branches: one moving northeast to the area of Point Barrow while the other moves northwest. There is little movement of water south through the Bering Strait (Zenkevitch, 1963). Details of the bottom contours, sediments, currents and seawater chemistry encountered in the primary study area covered by this paper may be found in Barnes (in prep.) and Ingham and Rutland (in prep.). Midwater trawls conducted during this study found the eastern Chukchi Sea to be a gigantic "nursery" for Arctic Cod (Boreogadus saida) and Sand Lance (Ammodytes hexapterus). These were the principle species taken in most of the study area. In the area of Cape Lisburne, however, Arctic Cod were less numerous and a more diverse fish fauna was present (Quast, in prep.). Invertebrate sampling revealed species and individuals to be abundant (Wing, in prep.).

Weather conditions were exceptional for early fall in the area and fog and snow rarely hindered observations. Days were generally overcast but cloud cover was high and visibility was seldom less than seven miles. Daytime air temperatures ranged from 3.2°C to -8.6°C during the first week to -6.6°C to -16.6°C in the last week. Temperatures dropped about 4°C when the ship approached extensive areas of pack ice. Winds were predominantly from the northwest during the first week of the cruise

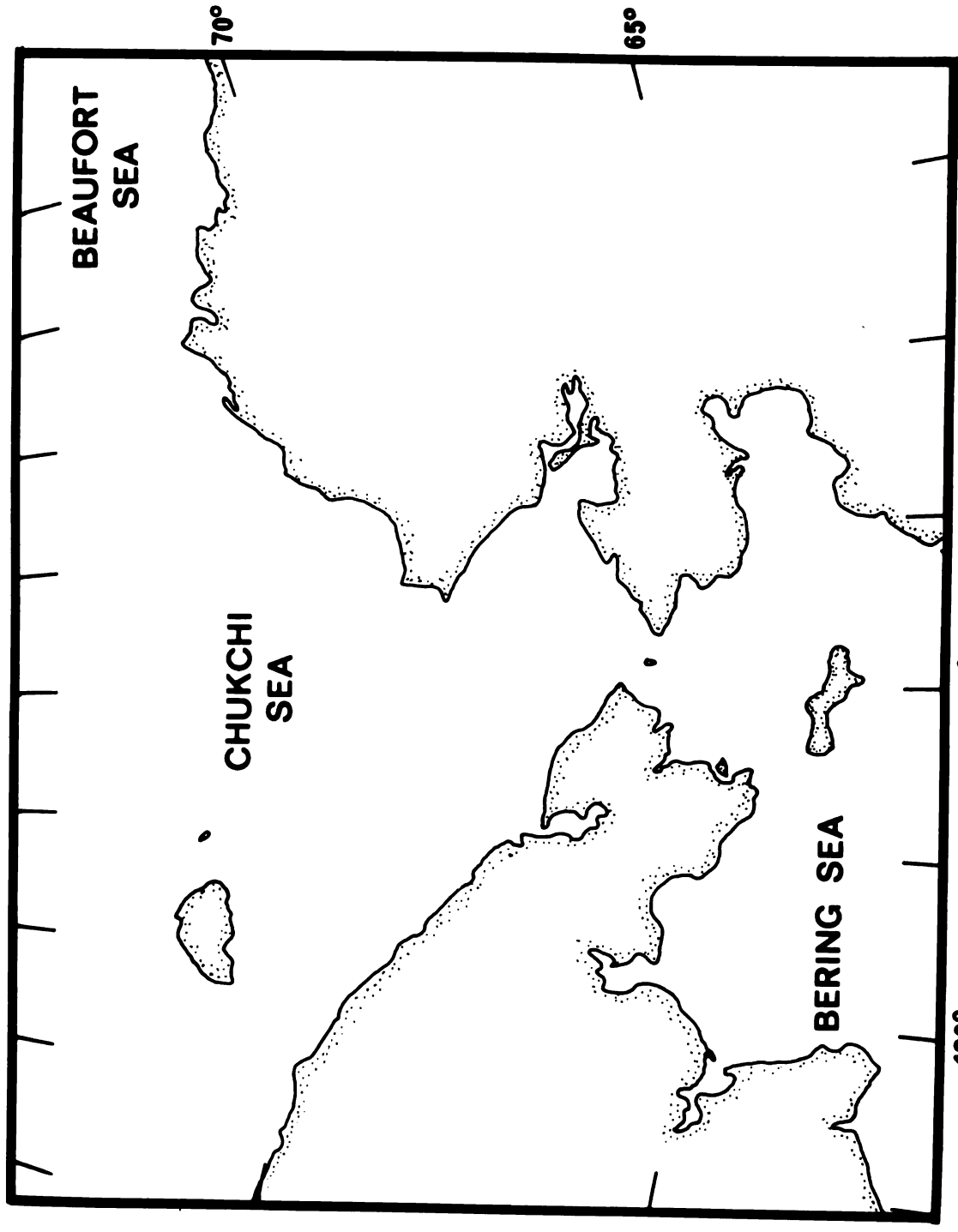

Figure 1. The Chukchi Sea and adjacent waters.

after which they were predominantly from the northeast. Winds were seldom more than 25 knots, and seas were moderately calm throughout the cruise due to the close proximity of ice. Surface water temperatures ranged from 4.0°C in ice-free areas early in the cruise to -1.8° later when grease ice began to form in the primary study area. In the Bering Strait on 18 October, air temperatures ranged from -0.8°C to -1.7°C while the sea surface temperature varied from 1.2°C to 2.4°C. Winds and waves were moderate, and visibility was excellent except for a few small patches of snow squalls.

Daylight hours decreased almost twenty-five percent during the cruise. There were 12 hours, 19 minutes of daylight at the start of the cruise and this decreased by 8 to 9 minutes a day so that on 18 October there were only 8 hours 50 minutes of daylight.

Ice covers the Chukchi Sea from late October to early May. During the summer the pack ice edge is usually present off shore at Barrow and approximately ten miles off shore at Icy Cape. The ice edge then swings northwest to the area of Herald and Wrangel Islands and then south to the Siberian coast. The ice conditions encountered during the cruise are shown in Figure 2. The approximate edge of the pack is shown by a dotted line. Observations of ice coverage away from the pack are shown as octaves or eighths of the total surface area. Pack ice closed in on the study area from the north and west during the course of the survey.

The nature of the northwest coast of Alaska affects the breeding distribution of certain species of seabirds. From Cape Lisburne northeast to Cape Beaufort, a distance of approximately fifty miles, the Brooks Range runs directly to the sea and provides the most northerly breeding sites in Alaska for cliff nesting species. The cliffs at Cape Lisburne are 900 feet high and there is a gradual decrease in elevation

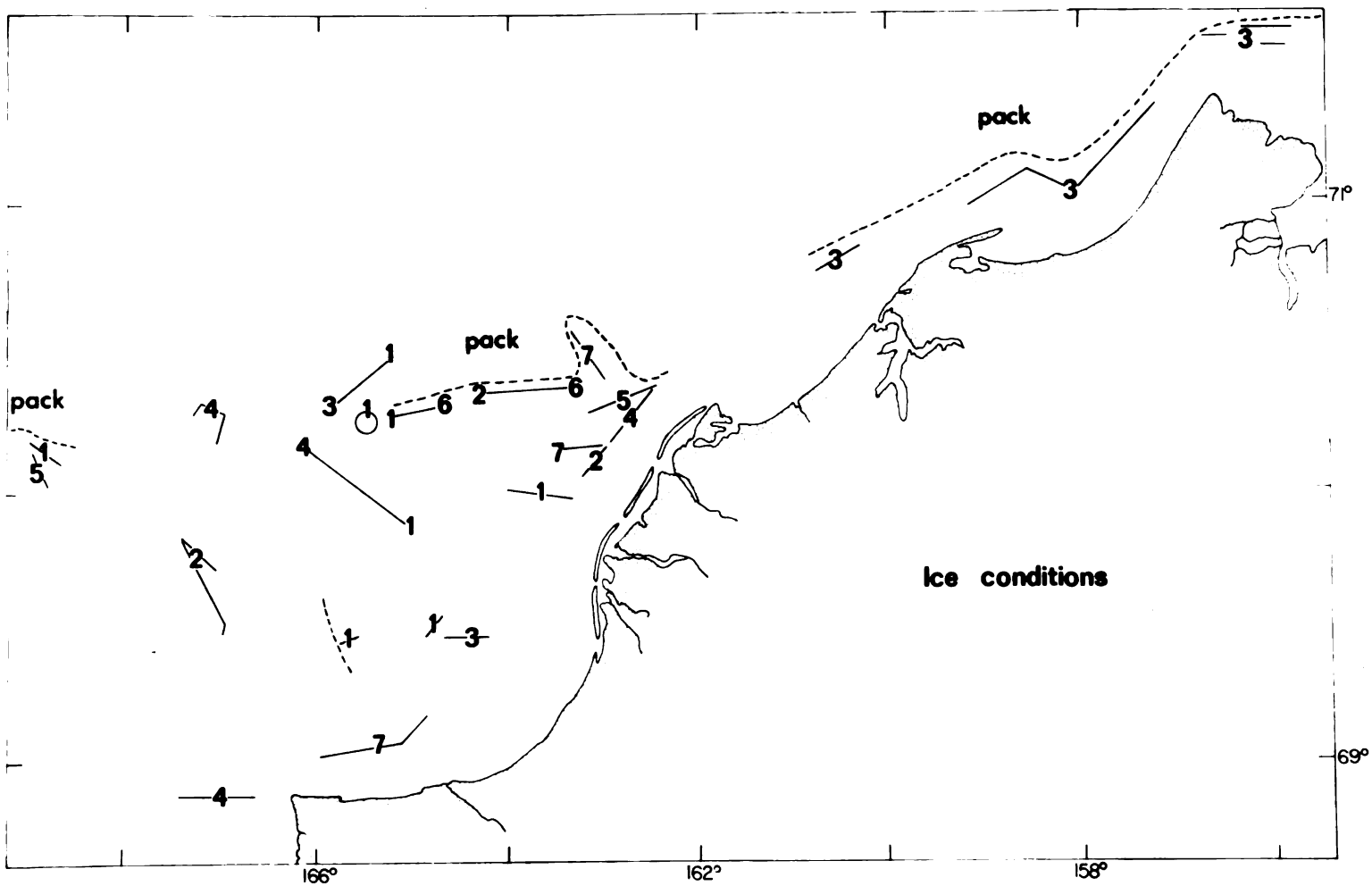

Figure 2. Ice coverage encountered during the cruise expressed as eighths (octaves) of total surface area. Edge of pack ice shown by dotted line.

north along the coast. Northeast of Cape Beaufort the coastal relief is not as great and cliffs, when present, are composed of soil and gravel that erodes into the sea during the summer months (Shepard and Wanless, 1971; 480-484). Such cliffs are unsuitable for cliff nesting species. However, Skull Cliff extending some fifty miles southwest of Barrow has mud cliffs as high as seventy feet. These cliffs apparently have been the sight of a few successful breeding attempts by cliff nesting species. These will be mentioned in the species accounts. The Seashore Islands, mentioned at various times in this paper, lie at the southwest end of Skull Cliff. Inland from the coast, the wet tundra of the coastal plain provides breeding sites for numerous species of waterbirds.

METHODS AND CRUISE TRACK

Whenever the ship was underway during the daylight hours, a watch for birds and marine mammals was maintained. The great majority of all observations were made from the flying bridge of the GLACIER (48 feet above waterline). Severe weather conditions caused some observations to be made from the crow's nest (74 feet above waterline) or rarely the pilot house (39 feet above waterline). Visibility was good in all directions except astern from the pilot house. The barrier islands at Point Lay were visited on 26 September and 5 October for the purpose of observing and collecting birds. Species, numbers, time and behavioral notes were recorded on sealog sheets at the time of observation. Tracks and positions of the ship were plotted later from bridge navigation data. Weather conditions, sea state, water temperatures and ice conditions were recorded every three hours by the ship's marine science technicians. When on station the presence and abundance of birds were recorded, and whenever possible specimens were collected from the small boats. A few

specimens were caught from the fantail on baited fishlines. Sixty-six specimens were collected (Table 1), most being frozen for later use, but a few were prepared as study skins aboard ship.

Stomach contents from specimens prepared aboard ship were preserved immediately in formalin. The remainder of the stomachs were removed later and preserved in 70% alcohol and glycerine. Ectoparasites were collected aboard ship and Mallophaga were given to Dr. K. C. Emerson for identification.

All specimens not prepared as study skins aboard ship were given to Drs. Lucille F. Stickel and Eugene H. Dustman of the Patuxent Wildlife Research Center, Laurel, Maryland. They removed tissue and organs for analysis of chlorinated hydrocarbons, polychlorinated biphenols and heavy metals. Carcasses were returned to the Smithsonian Institution for museum specimens.

Figures 3 and 4 present only stations and transects where observations were made. The entire cruise track and all station coordinates are presented in Ingham and Rutland (in prep.). The station numbers are the same as those used for oceanographic, geological and marine biological sampling in other phases of the survey. In this paper the term "study area" denotes the zone of intensive investigation between Icy Cape and Cape Lisburne (stations 8-91 and transects 9-41), which was surveyed from 25 September to 17 October. Observations were also made while the ship was anchored and in transit in the area of Point Barrow on 22-23 September (stations 1', 1 and transects 1-3), in transit to Icy Cape on 23-24 September (stations 5-7 and transects 4-8) and in the Bering Strait enroute to Nome, 18 October, (transect 42) (Figure 4).

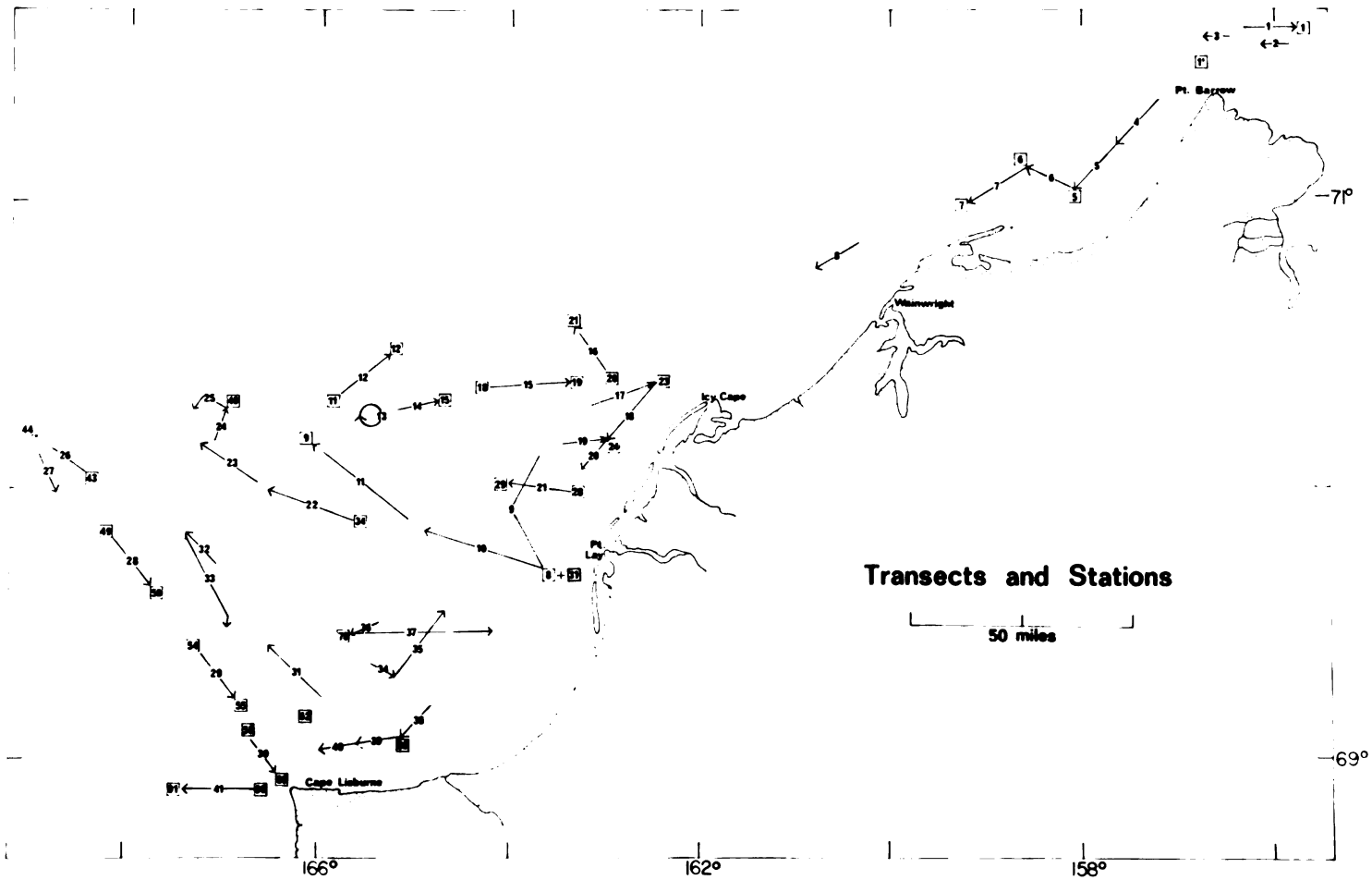

Figure 3. Transects (numbered arrows) and stations (numbered squares) on which birds and mammals were observed or collected between 21 September and 17 October 1970.

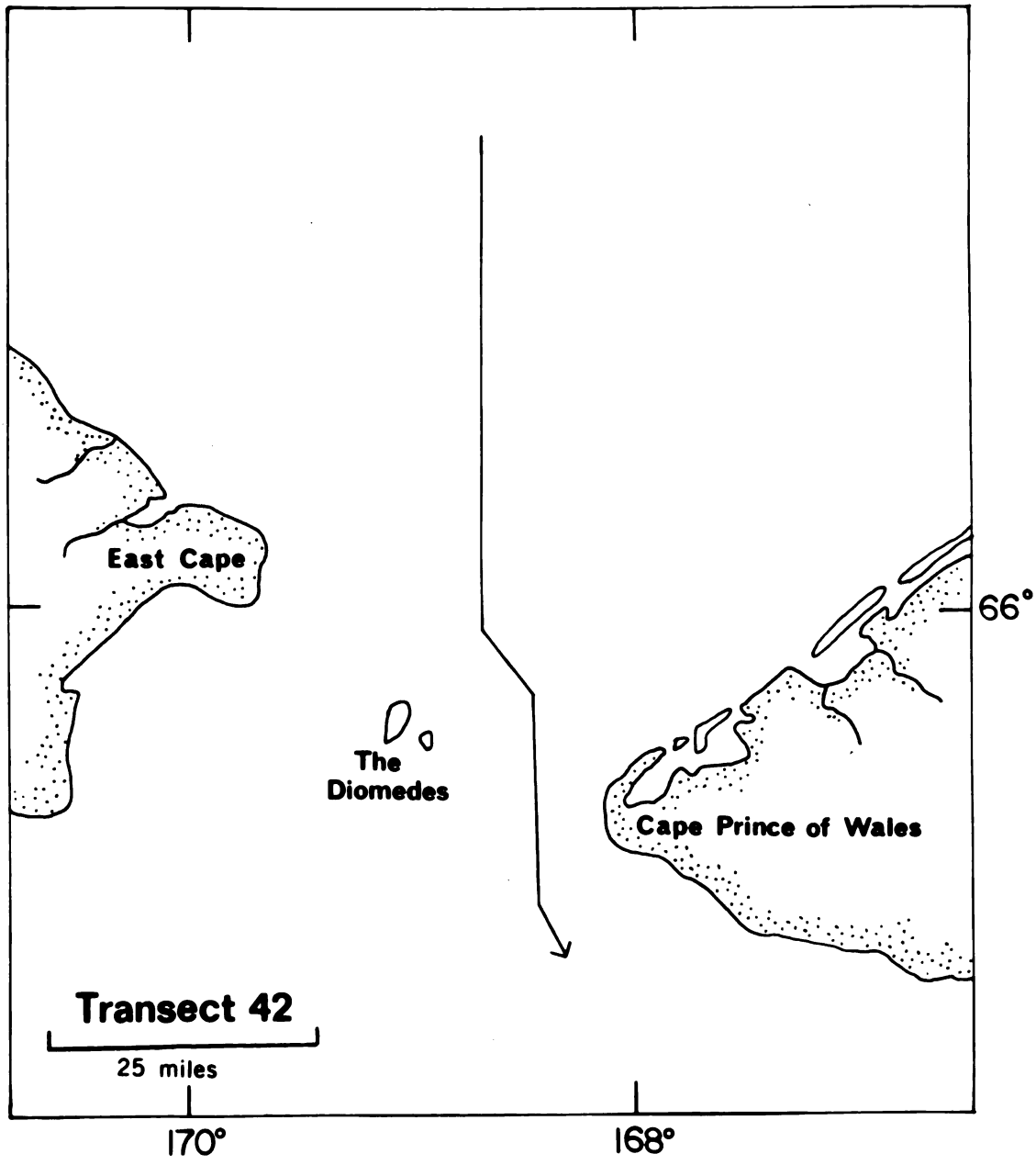

Figure 4. Transect 42 through the Bering Strait on 18 October 1970.

Sightings were plotted on maps (Figures 5 to 34) with all mammals and birds, except gulls and tubinares, seen during each 20-minute interval or station being summed. Abundance is indicated by symbols keyed in powers of three (see Figures 5 and 6 for key). Gulls, Fulmars and shearwaters had varying tendencies to be attracted to the ship and the actual number seen in a 20-minute interval could not be obtained. These species were censused by taking the highest count in each 20-minute interval and at each station as an index of abundance.

Marine science technicians aboard the GLACIER recorded bird observations sporadically and collected three specimens from 18 August to 21 September 1970 while the ship was engaged in geological sampling in the Chukchi Sea. In 1971, I boarded the GLACIER at Long Beach, California, and made observations while the ship was enroute to Barrow from 2-14 August. When these observations augment my 1970 findings, they will be included in the species accounts.

PREVIOUS STUDIES ON MARINE BIRDS AND MAMMALS

The lack of shipping routes through the Chukchi Sea has limited knowledge of the distribution and abundance of pelagic birds for this area. There are only three published accounts of extensive at-sea observations. E. W. Nelson (1883, 1887) entered the Chukchi aboard the U. S. revenue steamer CORWIN on 30 June 1881, and except for a short time in the Bering Sea, stayed until 14 September of the same year. His exact cruise course is not clear, but he visited the Siberian coast as far west as North Cape, including Herald and Wrangel Islands, and the Alaskan coast as far east as Point Barrow. F. L. Jacques (1930) was in the Chukchi aboard the schooner MORRISSEY from 30 July to 25 August 1928 as part of the Stoll-McCracken Expedition. Most of the

cruise track was south and east of Herald Island. His most easterly position was approximately 164°W and the most northerly, 73°N. Swartz (1967) published at-sea observations obtained by E. J. Willoughby aboard the research vessel BROWN BEAR from 6 to 28 August 1960. Most of the cruise was south of Point Hope and in the Kotzebue Sound area; only a small portion was north of Cape Lisburne with 70°N being the most northerly position. Swartz's detailed account is the only one of the three that attempts to deal with observations on a quantitative basis. In addition to these accounts, Stresemann (1949) published the account of birds observed and collected on Captain Cook's last voyage. The RESOLUTION and DISCOVERY were in the Chukchi Sea from 11 August to 3 September 1778 and from 5 to 31 July 1779. Cook sailed up the Siberian and Alaskan coasts until he encountered ice. An expedition from Harvard University, aboard the power schooner POLAR BEAR, sailed through the Chukchi Sea from Cape Serdze, Siberia to Cape Lisburne and then north to Point Barrow in July 1913. Brooks (1915) and Dixon (1943) reported extensively on land observations in Siberia and on the Beaufort Sea coast of Alaska, before and after their Chukchi crossing, but they recorded few at-sea observations. Alverson, Wilimovsky and Wilke (1960) made casual observations in August 1959 from Cape Lisburne to Kotzebue Sound while engaged in fisheries research (Alverson and Wilimovsky, 1966).

Much of the information on seabirds in the Chukchi Sea has been obtained by land-based observers and has been summarized by Bailey (1948), and Gabrielson and Lincoln (1959). Barrow has been the center of ornithological work in arctic Alaska. Harting (1871) collected in the area of Barrow and in Kotzebue Sound from 1852-1854. Murdoch (1885) collected at Barrow from 1881 to 1883 as part of the International Polar Expedition. McIlhenny (Stone, 1900) spent parts of 1897 and 1898 doing

extensive collecting at Barrow. In 1921 and 1922 A. M. Bailey and R. W. Hendee (Bailey, 1948) collected along the entire Arctic coast of Alaska with the most intensive work being done in the area of Wainwright. From 1922 to 1945 Charles Brower (Bailey, 1948) collected at Barrow and greatly increased the number of species known for that area. Pitelka and his students have amassed a number of unpublished "opportunistic" records of seabirds for the Barrow area during studies of shorebird and tundra ecology. Their only publications on seabirds, however, are Pitelka, Tomich and Treichel (1955a, 1955b), MacLean and Verbeek (1968) and Maher (1970). Ornithological records from the Barrow-Wainwright area southwest to Point Hope are few and scattered. Tarelton Bean (1882) collected along the Siberian and Alaskan shores of the Chukchi Sea in 1880 as did F. S. Hersey (1917) in 1914. Benjamin Sharp visited points along the Alaskan coast in the summer of 1895 as did Seale (1898) in 1896. The Cape Thompson and Kotzebue Sound areas have been more intensively studied. Grinnell (1900) spent a year in Kotzebue Sound in 1897 and 1898 collecting birds. During the Project Chariot Program (Wilimovsky and Wolfe, 1966), the birds of the Cape Thompson region were studied from 1959 to 1961 (Williamson, Thompson and Hines, 1966; Swartz, 1966). Bird observations for the Siberian side of the Chukchi Sea have been summarized by Pleske (1928) and Dementiev and Gladkov (1969).

Studies of marine mammals in the Chukchi Sea area are likewise few. The whales, seals, walrus and bears that are utilized for skins, oil and food by the Eskimos move north with the edge of the pack ice in summer and are mainly hunted during migration in the fall and spring or from the ice in winter. The major sources of general information on northern Alaskan marine mammals are Bailey and Hendee (1926), Brooks (1954) and Bee and Hall (1956).

Table 1. Bird Specimens Collected in the Chukchi Sea

SPECIES	7	Pt Lay 26 Sep	8	9	11	15	19	21	23	44	49	50	86	91
Clangula hyemalis		1-i												
Somateria mollissima													1-i	1-i
Larus hyperboreus			2-a			2-i	1-i		1-a 1-i					
Larus argentatus						1-i								
Pagophila eburnea	3-a			3-a 4-i	2-i		1-a			1-a				
Rissa tridactyla	1-i								1-i		1-i	1-a		
Rhodostethia rosea	7-a 2-i			6-a 2-i			1-i	1-i	2-a 5-i			1-a		
Uria aalge												1-a		
Cepphus grylle						1-a					1-i	1-i		
Plectrophenax nivalis		5-a 1-i												

a = adult

i = immature

Table 2. Stomach Contents of Birds Collected in the Chukchi Sea

SPECIES	Stomachs Examined	Arctic Cod	Crustaceans	Tunicates	Gastropods	Ship Refuse	Plant Material	Empty
Clangula hyemalis	1	0	0	0	0	0	0	1(100%)
Somateria mollissima	2	0	0	0	1(50%)	0	1(50%)	1(50%)
Larus hyperboreus	6	5(83%)	1(17%)	2(33%)	1(17%)	1(17%)	0	0
Larus argentatus	1	1(100%)	0	0	0	0	0	0
Pagophila eburnea	14	12(86%)	1(7%)	1(7%)	0	1(7%)	2(14%)	1(7%)
Rissa tridactyla	4	4(100%)	0	0	0	0	0	0
Rhodostethia rosea	24	19(79%)	13(54%)	0	0	0	0	0
Uria aalge	1	1(100%)	1(100%)	0	0	0	0	0
Cepphus grylle	3	3(100%)	1(33%)	0	0	0	0	0

SPECIES ACCOUNTS

The sequence of species and nomenclature in the following accounts follow the American Ornithologists' Union Check List (1957) for birds, and Rice and Scheffer (1968) for mammals. Terms used to describe feeding methods of birds are based on Ashmole and Ashmole (1967).

Contact dipping - The bird remains airborne and forward motion does not stop as it snatches its prey from the water.

Hovering - The bird remains airborne and forward motion ceases as the bird, with wings beating, picks its prey from either the water or ice.

Plunge to surface - The bird partly folds its wings and drops to the water's surface. Complete submersion of the bird's body may occur, but there is no underwater pursuit.

Surface feeding - The bird swims on the surface and picks up its prey on, or just below the surface.

Surface diving - The bird, while sitting on the surface, dives and pursues its prey underwater.

Loons *Gavia* sp.

The Yellow-billed (*Gavia adamsi*), Arctic (*G. arctica*), and Red-throated Loons (*G. stellata*) breed on the Arctic coast of Alaska, while the Common Loon (*G. immer*) breeds only as far north as Kotzebue Sound. All four species winter from the Aleutians and southern Alaska southward. Loons are rarely found far from land during the summer and at-sea observations are few during that season. Bailey (1948) found that most of the loon migration took place in early and mid-September. Of the 112 loons I observed (Figure 5), one seen between Barrow and Wainwright on 24 September was identified as *G. adamsi*. The Common Loon was seen twice: one north of the usual breeding grounds 20 miles northwest of Point Lay on 4 October, and another in the Bering Strait on 18 October (Figure 32). The remainder of the loons were either *G. arctica* or *G. stellata*. The similarity of the two species in winter plumage and the distance from which most birds were observed did not allow positive identification, but on the basis of flight characteristics, I thought that the majority were Arctic Loons.

Loons were common in the area of Barrow and along the coast to the study area (Figure 5). In the study area, loons were observed primarily within 40 miles of land and the majority were heading southwest. The largest number (54 in three and one-half hours) was seen on 27 September on transects 10 and 11 extending northwest from Point Lay. No loons were observed in the study area after 6 October.

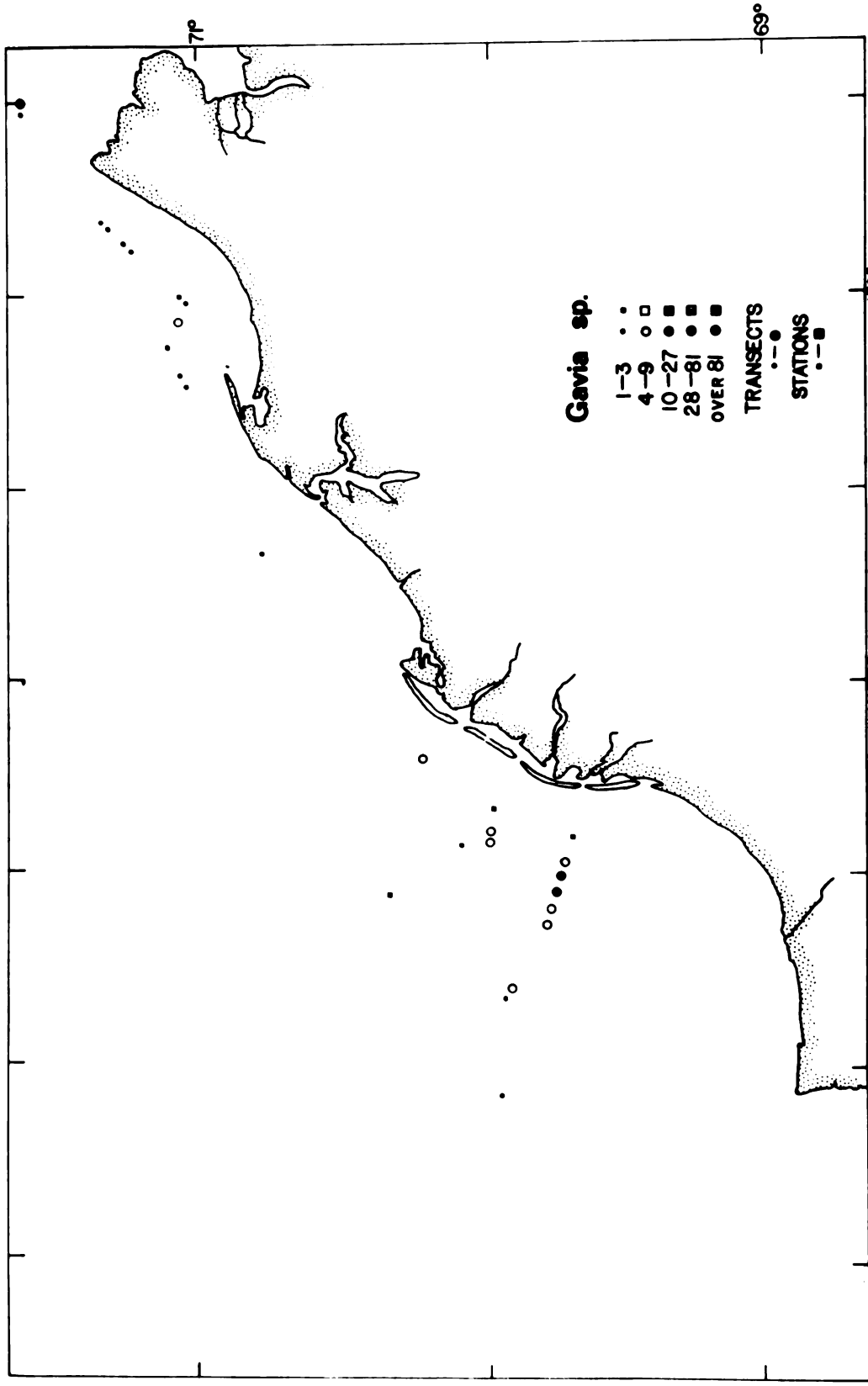

Figure 5. Distribution of Gavia sp. in the east central Chukchi Sea. Abundance key applies to all other east central Chukchi Sea maps.

Northern Fulmar — Fulmarus glacialis

The Fulmar has been the subject of an extensive monograph by Fisher (1952). In the Pacific the Northern Fulmar breeds north to St. Lawrence Island in the Bering Sea. Birds observed in the Chukchi Sea in the summer are probably all nonbreeders. It winters from the Aleutians southward. Summer observers have all recorded this species from the Chukchi. Nelson (1887) found it abundant along the Siberian coast, but rare in the eastern Chukchi. He mentions it breeding on Herald Island but subsequent investigations have failed to find evidence of nesting. Jacques (1930) saw it occasionally south of 71°N, and abundantly south of 68° 30'N in late August. Both Swartz (1967) and Alverson et al (1960) found it uncommon in the southeast Chukchi in August. There is a specimen from Wainwright as early as 14 June and a specimen collected on 11 September is the latest for Barrow (Bailey, 1948). Fulmars were observed in early September by marine science technicians aboard the GLACIER. Their most northerly sighting was made at 72° 22'N, 167° 22'W on 6 September, and their last observation was made on 17 September at 71° 22'N, 167° 15'W. I did not observe Fulmars in the study area, but they were present in the Bering Strait throughout the day on 18 October (Figure 6). Eighteen of the 20 20-minute intervals on which it was seen had less than five individuals. The other two each had ten individuals. Fulmars were common in the Bering Strait on 13 August 1971, and small numbers were present on 14 August in the Chukchi Sea north to 70° 16'N, 163° 35'W.

All 1970 observations for the Bering Strait were of light phase birds. In the Pacific, dark phase individuals predominate in the southern portion of the breeding range and do not breed north of the Pribilofs.

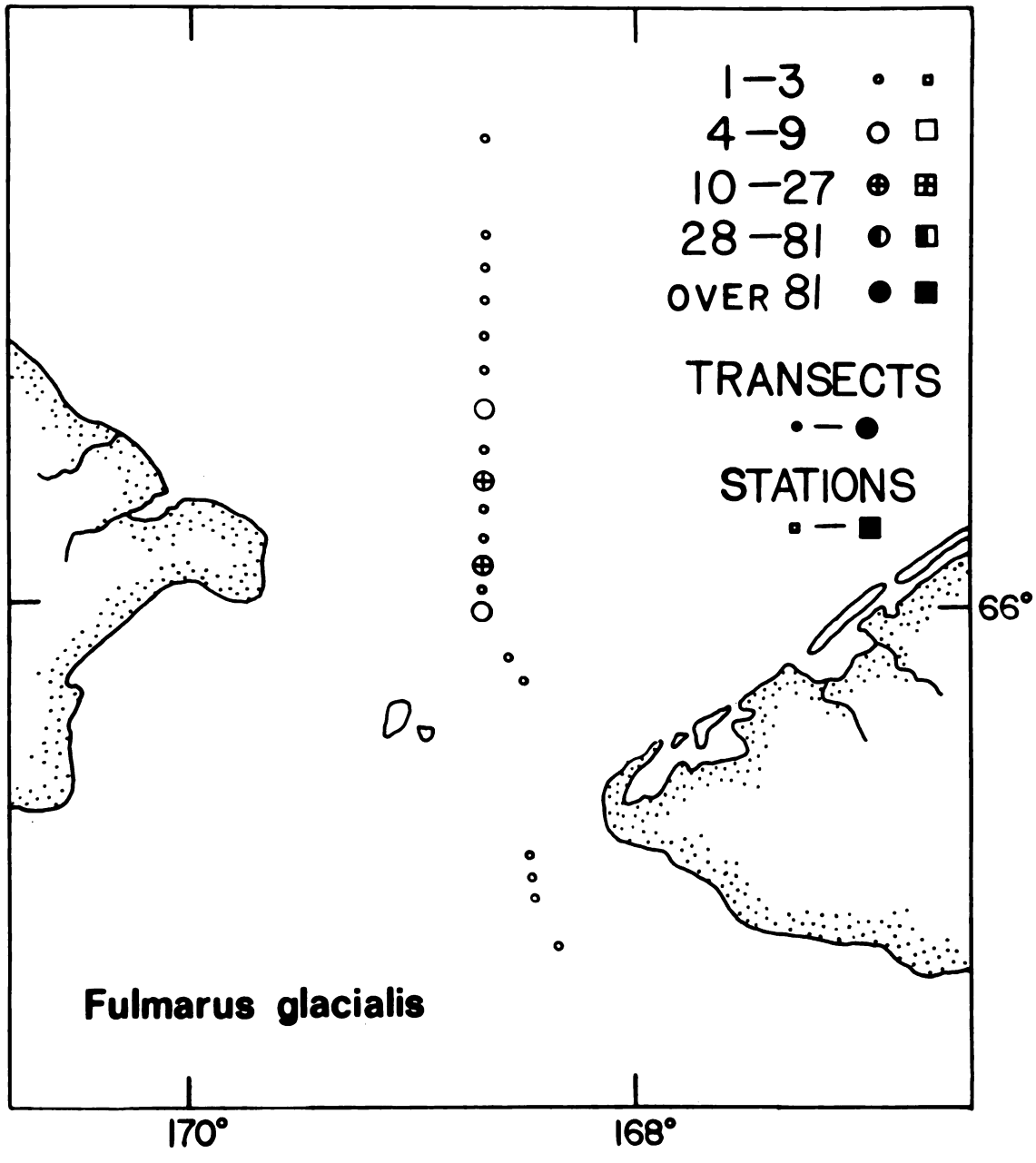

Figure 6. Distribution of Fulmarus glacialis in the Bering Strait. Abundance key applies to all other Bering Strait maps.

Jacques (1930) is the only observer to see dark phase birds in the northern Chukchi. They constituted roughly one percent of the Fulmars he observed. Nelson (1887) observed dark phase birds just northwest of the Bering Strait. On 13 August 1971 I observed them in the Bering Strait north to 66° 30'N.

Slender-billed Shearwater *Puffinus tenuirostris*

The Slender-billed Shearwater breeds on islands in the southwest Pacific Ocean from September to May and migrates to the northern hemisphere from June to October. The figure-eight migration route of this species is presented in Marshall and Serventy (1956). It is abundant in the Bering Sea in the summer and fall while smaller numbers are found in the Chukchi Sea from July to November. Observations from this area in autumn are probably of nonbreeding individuals. Nelson (1887) saw a number of birds just northwest of Bering Strait on 31 August that he believed to be of this species. Jacques (1930) found it extremely abundant in the western Chukchi in late August. Swartz (1967) reported it most frequently from the Point Hope and Cape Thompson area with one of the sightings a flock of 500 to 1000 individuals. Alverson *et al* (1960) observed it in increasing numbers in the month of August and groups of 200 to 300 were seen at the end of the month. Marine science technicians aboard the GLACIER observed Slender-billed Shearwaters in the Chukchi in early and mid-September. Their most northerly sighting was made on 17 September at 71° 21'N, 167° 35'W, and their last sighting on 20 September at 68° 22'N, 167° 54'W.

I only saw this species south of 67°N in the Bering Strait on 18 October when it was observed on twelve of the 30 20-minute intervals (Figure 7). Nine of these observations were of less than five individuals though flocks of up to 100 birds were observed on two occasions, east of East Cape and west of Cape Prince of Wales. My lack of sightings in the study area indicates that most Slender-billed Shearwaters had left that area by late September. It occasionally stays later since Brower observed thousands at Barrow in September and October associated with the ice (Bailey, 1948).

No individuals of this species were observed in the Chukchi in August 1971. Although extremely abundant just south of the Aleutians in the area of Unimak Pass on 9 August, few were seen in the Bering Sea. My most northerly sighting was on 12 August at 63° 30'N, 167° 35'W, 80 miles south of the Bering Strait.

Pelagic Cormorant — Phalacrocorax pelagicus

The Pelagic Cormorant breeds commonly in and south of the Bering Strait, but it is found only sparingly in the Chukchi Sea. On the Alaskan coast the northern extent of its breeding distribution is probably determined by the availability of suitable nesting cliffs. When the Cape Thompson cliffs were censused in 1961, they found to support 23 pairs (Swartz, 1966). Like other cormorants it is not commonly found far from land and has been observed only infrequently by pelagic observers. Nelson (1883) saw birds in the area of Wrangel and Herald Islands and at Cape Beaufort. Jacques (1930) did not encounter it north of the Bering Strait. Swartz (1967) reported four observations, two in the Bering Strait and two further north in the

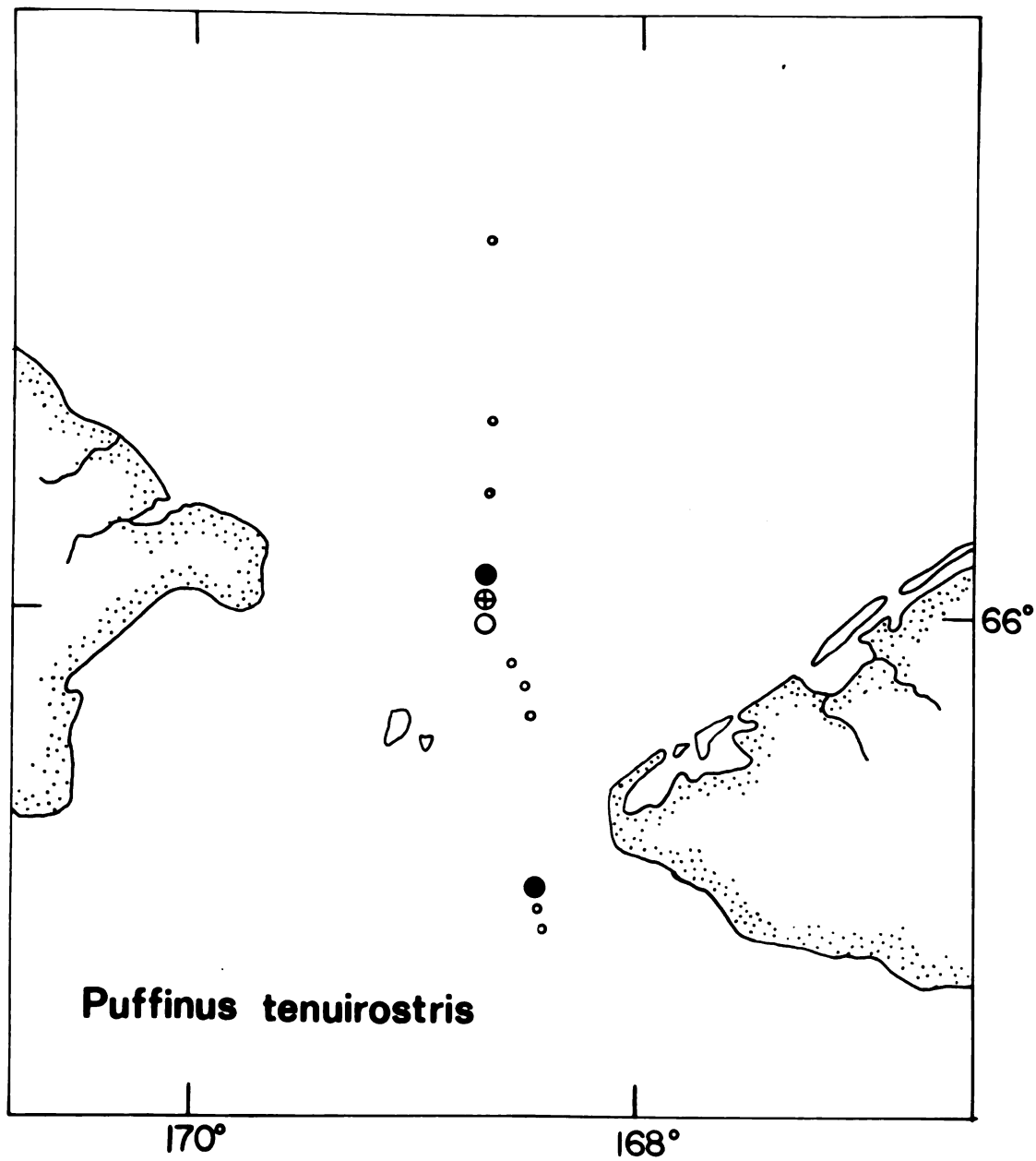

Figure 7. Distribution of Puffinus tenuirostris in the Bering Strait.

Chukchi, all near nesting cliffs. There are five records for Barrow in the summer and fall and a January record for Wainwright (Bailey, 1948). I saw this species only once in 1970 when two birds were observed flying approximately 15 miles south of Cape Prince of Wales (Figure 32) on 18 October. In 1971, a single individual was observed on 14 August at 70° 50'N, 161° 27'W.

Oldsquaw *Clangula hyemalis*

The Oldsquaw is circumpolar north of 50°N in its breeding distribution and nests abundantly on both sides of the Chukchi Sea. It is rarely observed far from land during summer. The only fall migration data for the Arctic coast are those of Bailey (1948) who first saw large flocks off Icy Cape on 7 September. He observed it for the rest of September and on 1 October found it abundant offshore. His last observation was made on 19 October. It usually winters well south of the breeding range, but individuals have been reported at Barrow as late as early December (Gabrielson and Lincoln, 1959). Bartonek (1969) has estimated that over 300,000 Oldsquaw migrate along the Arctic coast of Alaska.

This species was observed throughout the cruise (Figure 8). The larger flocks were all observed close to shore with the majority in the area of Point Lay where 2,400 were seen in a three-hour transect on 25 September and smaller numbers on 4 October. Presumably some of the unidentified ducks seen at a distance in the study area were Oldsquaws (Figure 12). A flock of 24 Oldsquaws was observed off Cape Sabine on 16 October when new ice covered 7/8 of the water's surface. It appears

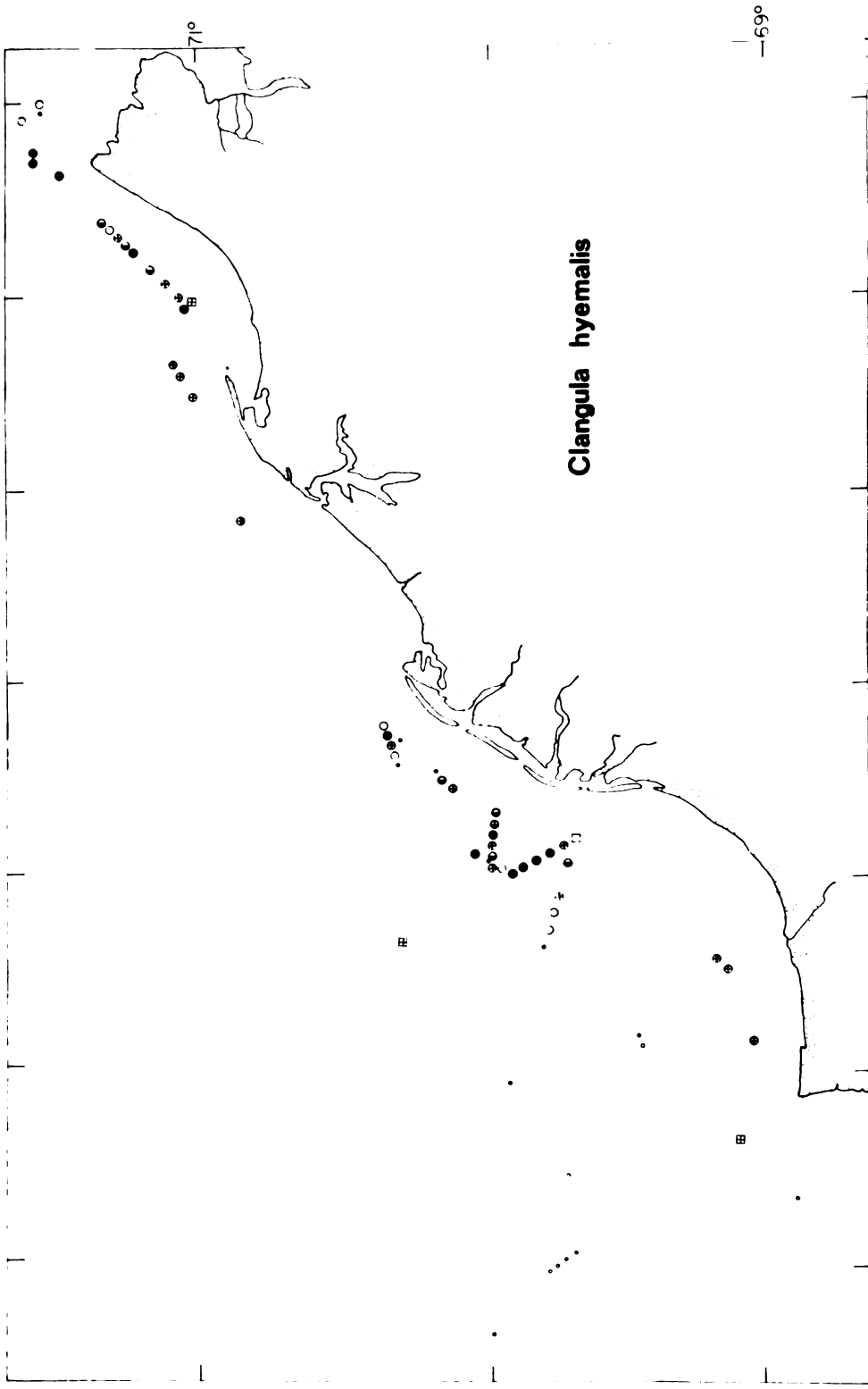

Figure 8. Distribution of Clangula hyemalis in the east central Chukchi Sea.

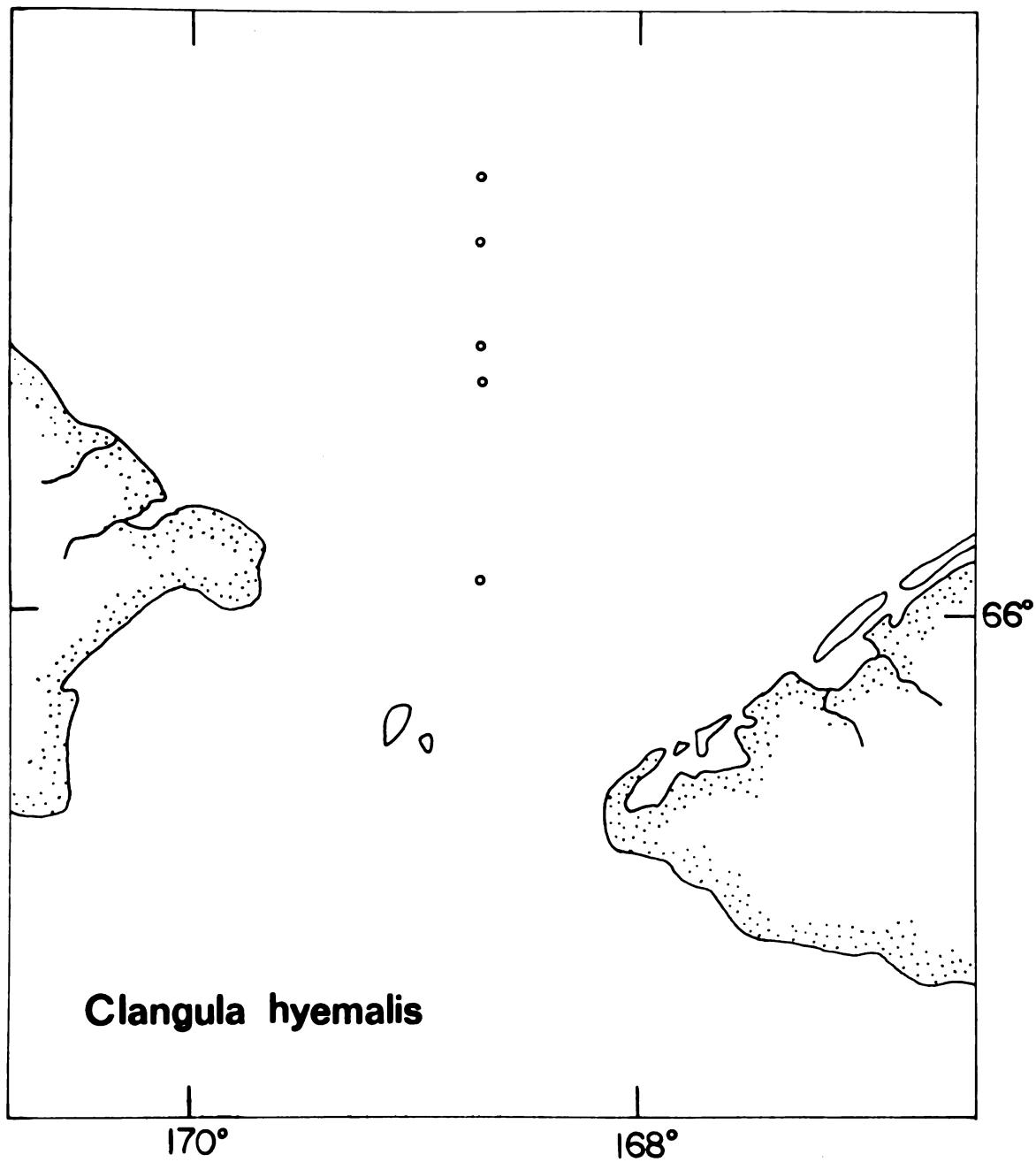

Figure 9. Distribution of Clangula hyemalis in the Bering Strait.

that a few individuals remain in the Chukchi Sea until driven out by the formation of new ice. Small numbers were observed in the northern part of the Bering Strait on 18 October (Figure 9). The stomach of a single immature specimen collected at Point Lay (Table 1) contained only grit (Table 2). Other studies have found molluscs and crustaceans to be the primary foods.

Eiders — *Somateria* sp., *Lampronetta fischeri*

Three species of eider were observed. Positive identification was possible only of a few males and of females that came near the ship. The Common Eider (*Somateria mollissima*) breeds commonly along the entire Alaskan Arctic coast. Most Alaskan breeding records for the King Eider (*S. spectabilis*) come from the area of Barrow. The main breeding grounds of the Spectacled Eider (*Lampronetta fischeri*) in northern Alaska lie to the east of Barrow. Male eiders migrate south before females and young and pass Barrow from late June until early August. The majority of eiders passing Barrow after mid-August are females and young. An estimated one million migrated south past Point Barrow in 1953 (Thompson and Person, 1963).

Only a single eider was seen in the area of Barrow, and only one flock of six was seen between Barrow and the study area (Figure 10). The greatest numbers were seen on 25 and 26 September when large flocks were observed inshore in the area of Point Lay. Smaller flocks were observed in the same locations on 4 October. Eider were seen throughout the study area and small numbers were observed far from land. Some of the "unidentified ducks" seen at a distance in the study area were

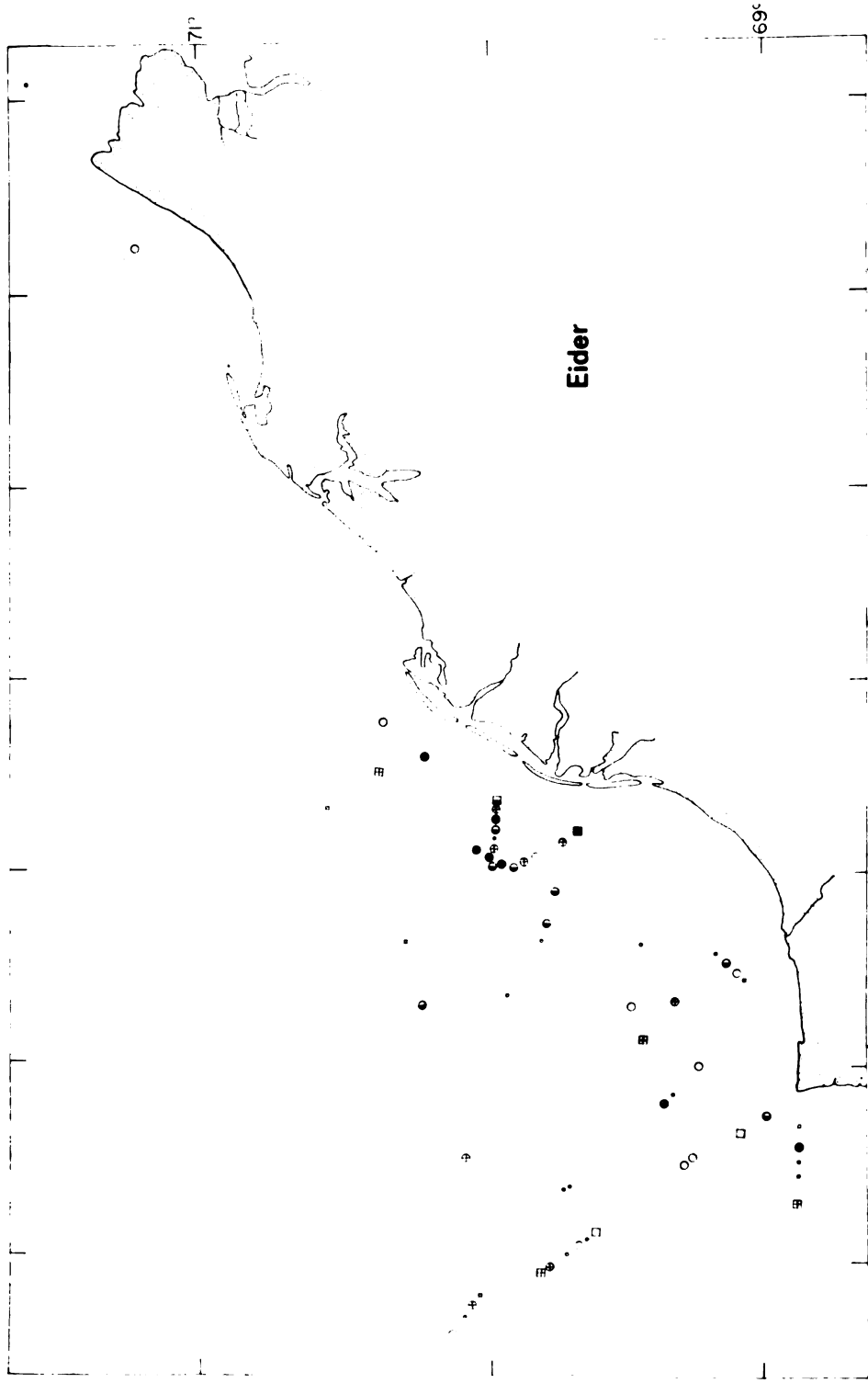

Figure 10. Distribution of eider in the east central Chukchi Sea.

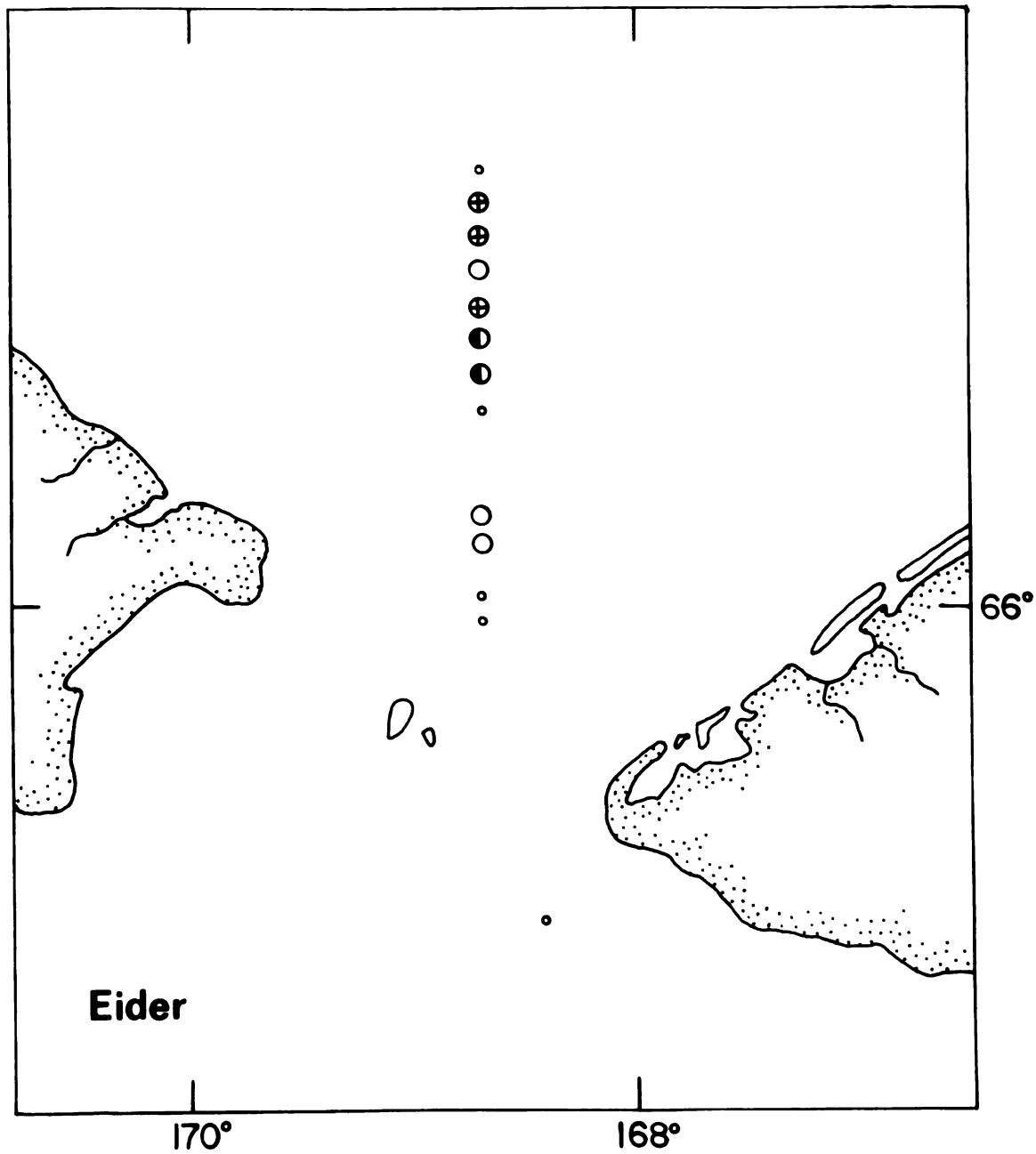

Figure 11. Distribution of eider in the Bering Strait.

eiders (Figure 12). One was observed in a lead during the deepest penetration into heavy pack ice while small flocks were also found off Cape Sabine when new ice covered 7/8 of the water's surface. Of the approximately 1,300 eiders seen in the study area, only 100 or 7.7 percent were males. Four of the males were identified as King Eiders and the remainder were either Common or Spectacled. Eiders were seen in the northern part of the Bering Strait on 18 October (Figure 11).

Eider feed by surface diving for benthic molluscs and crustaceans. The stomach of one of the two immature specimens of Common Eider collected (Table 1) contained two columella from gastropod shells and plant material (Table 2), the other was empty except for gravel.

Common Scoter — Oidemia nigra

The Common Scoter is circumpolar north of 45°N in its breeding distribution, but is uncommon on the Arctic coast of Alaska. I observed it on two occasions: a flock of 300 individuals on 24 September near Wainwright, and a flock of 25 west of Point Lay on 27 September (Figure 31).

Red-breasted Merganser — Mergus serrator

The Red-breasted Merganser is a rare breeder on the Arctic coast of Alaska, but is common south of Kotzebue Sound. It was recorded only twice in the study area: one individual seen from the barrier island at Point Lay on 26 September, and another at sea 20 miles northwest of Point Lay on 27 September (Figure 31). In the small boat harbor at Nome on 19 October, a single bird was observed swallowing a fish.

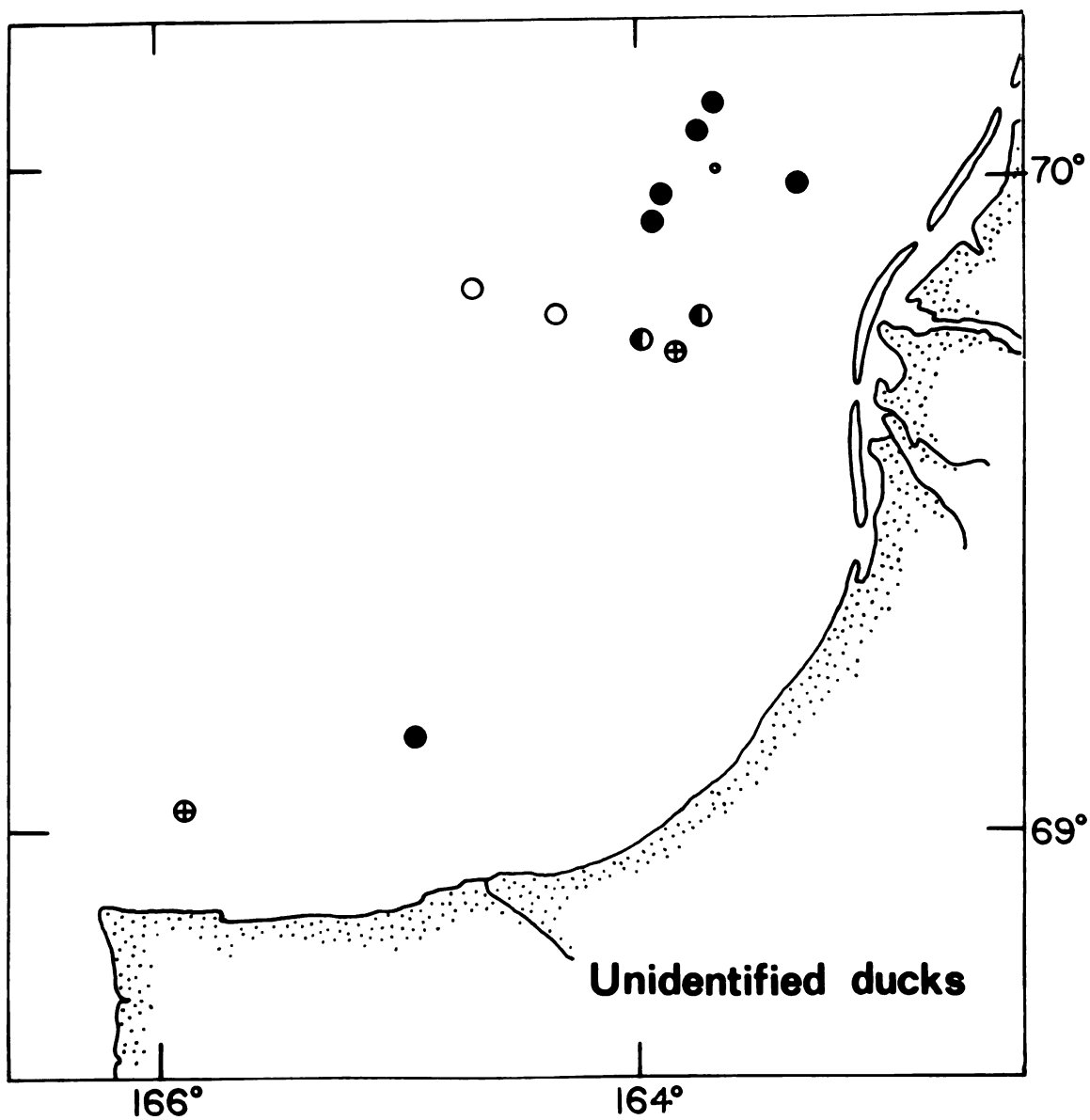

Figure 12. Distribution of unidentified ducks in the east central Chukchi Sea.

Sparrow Hawk — Falco sparverius

The Sparrow Hawk is an uncommon breeding bird in south and central Alaska. Vagrants have been recorded as far north as Barrow. I observed a single individual at Nome on 19 October.

Red Phalarope — Phalaropus fulicarius

The Red Phalarope is circumpolar north of 50°N in its breeding distribution and is found in abundance on both the Siberian and Alaskan sides of the Chukchi Sea. Unlike other shorebirds, it spend the nonbreeding season in pelagic environments, wintering in the southern hemisphere. Fall migration begins as early as July. Summer observers have found it abundant throughout the Chukchi. Both Nelson (1883) and Jacques (1930) encountered large concentrations at the edge of the ice. Swartz (1967) mentions 59 sightings of phalaropes with no areas of large concentrations. From the abundance of summer pelagic observations in the Chukchi it appears that individuals disperse to the open ocean after breeding rather than immediately migrating southward along the coast. Coastal concentrations may occur at times, however, as Bailey (1948) found 100 in the shallows at Wainwright during the first week in September. From 15 to 17 August 1971, I found them to be abundant along the shore at Barrow.

Eleven sightings of phalaropes were made between Point Barrow and Icy Cape, and nine sightings were obtained in the study area. Most observations were of flocks of ten individuals or less (Figure 13). All phalaropes were identified as P. fulicarius although it is possible some were the Northern Phalarope (Lobipes lobatus), a less pelagic species

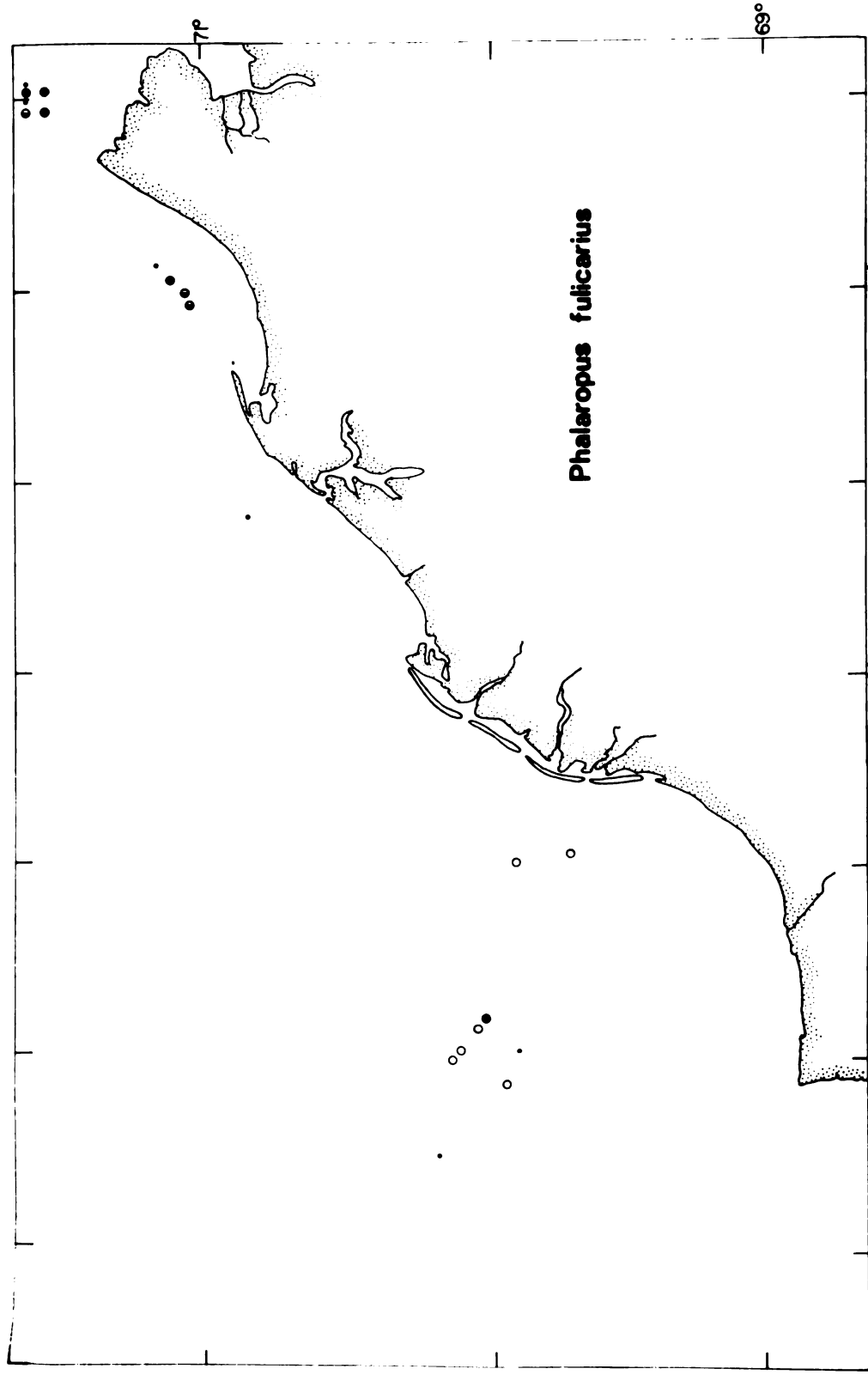

Figure 13. Distribution of Phalaropus fulicarius in the east central Chukchi Sea.

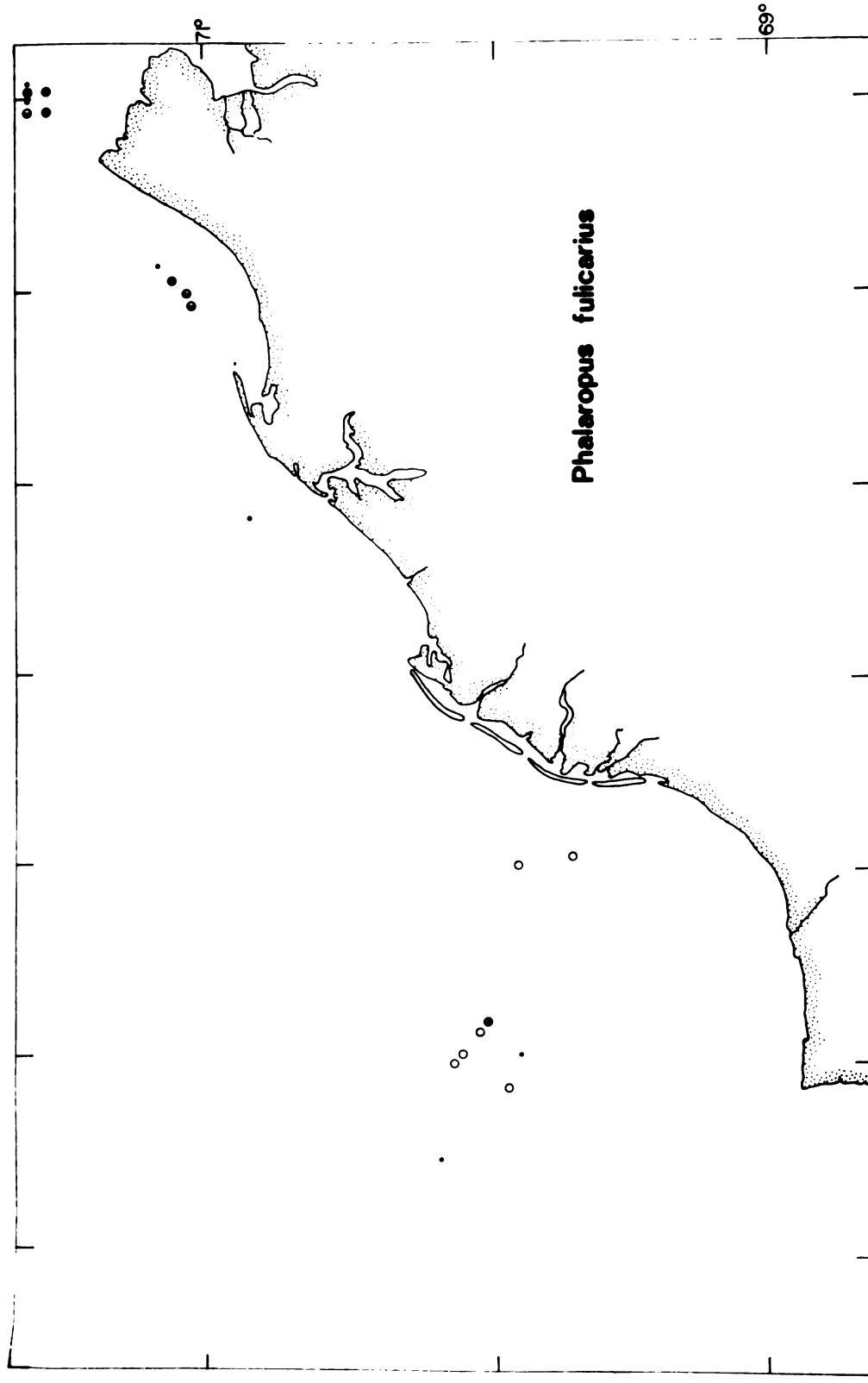

Figure 13. Distribution of Phalaropus fulicarius in the east central Chukchi Sea.

but frequent in Alaskan coastal waters. My few sightings indicate that most P. fulicarius had left the arctic by late September. I last observed it in the study area on 7 October but it has been recorded at Barrow as late as 16 October (Murdoch, 1885b). While my number of observations is too small to demonstrate an ice affinity that other observers have commented on, the largest flocks were close to the pack ice in the area of Barrow and Wainwright. A single bird was observed on 18 October in the Bering Strait (Figure 32).

South Polar Skua — Catharacta maccormicki

While I was collecting birds from one of the ship's small boats at 70° 18'N, 164° 41'W (Figure 31) on 29 September, a large all dark bird with a conspicuous white patch at the base of the primaries passed directly overhead. The bird's dark greyish brown breast and uniformly dark back, lead Dr. George E. Watson (who was familiar with skuas both in the North Atlantic and Antarctic) to conlcude that it was a dark phase South Polar Skua from the Antarctic rather than a Northern Skua (C. skua)from the Atlantic. Three Ross' Gulls harried the skua and drove it away from the area of the boat. This is the first record of any skua in arctic Alaska. There are two skua records from just south of the Aleutians. A specimen of the South Polar Skua was collected by Max Thompson on 16 October 1965 (USNM 496196) at 45° 20'N, 172° 00'E. A skua was reported south of Adak Island in July 1969 (Sanger in Gibson, 1970).

Jaegers *Stercorarius* sp.

All three species of jaeger, the Pomarine (*Stercorarius pomarinus*), the Parasitic (*S. parasiticus*), and the Long-tailed (*S. longicaudus*), are found in arctic Alaska. They winter in temperate and tropical seas, beginning southward migration as early as mid-July.

The Pomarine has the most restricted breeding range in Alaska with most records coming from the Barrow area where Brower considered it to be more coastal than the other species (Bailey, 1948). Outside of the breeding season, jaegers obtain much of their food by robbing other birds so that their distribution at sea and during migration is somewhat dependent on the presence of other species. Nelson (1883) observed the Pomarine Jaeger in scattered areas close to shore in the Chukchi. He found it more common on the Siberian side than the Alaskan side, except at Barrow where it was abundant. Jacques (1930) considered it, at times, to be the most abundant bird in the western Chukchi. Swartz (1930) reported seven sightings all north of 67°N.

I observed Pomarine Jaegers on seven occasions, totaling twelve individuals (Figure 14). In early September observers aboard the GLACIER saw jaegers more frequently and my observations are of the last of the fall migration. None was observed in the study area after 29 September. A single individual was seen in the Bering Strait on 18 October (Figure 32). Most of the sightings were in ice areas where large concentrations of other birds were present. One case of harassment of gulls was recorded, two Pomarine Jaegers chasing an Ivory Gull. Five of the seven Pomarine Jaegers closely observed were in dark phase.

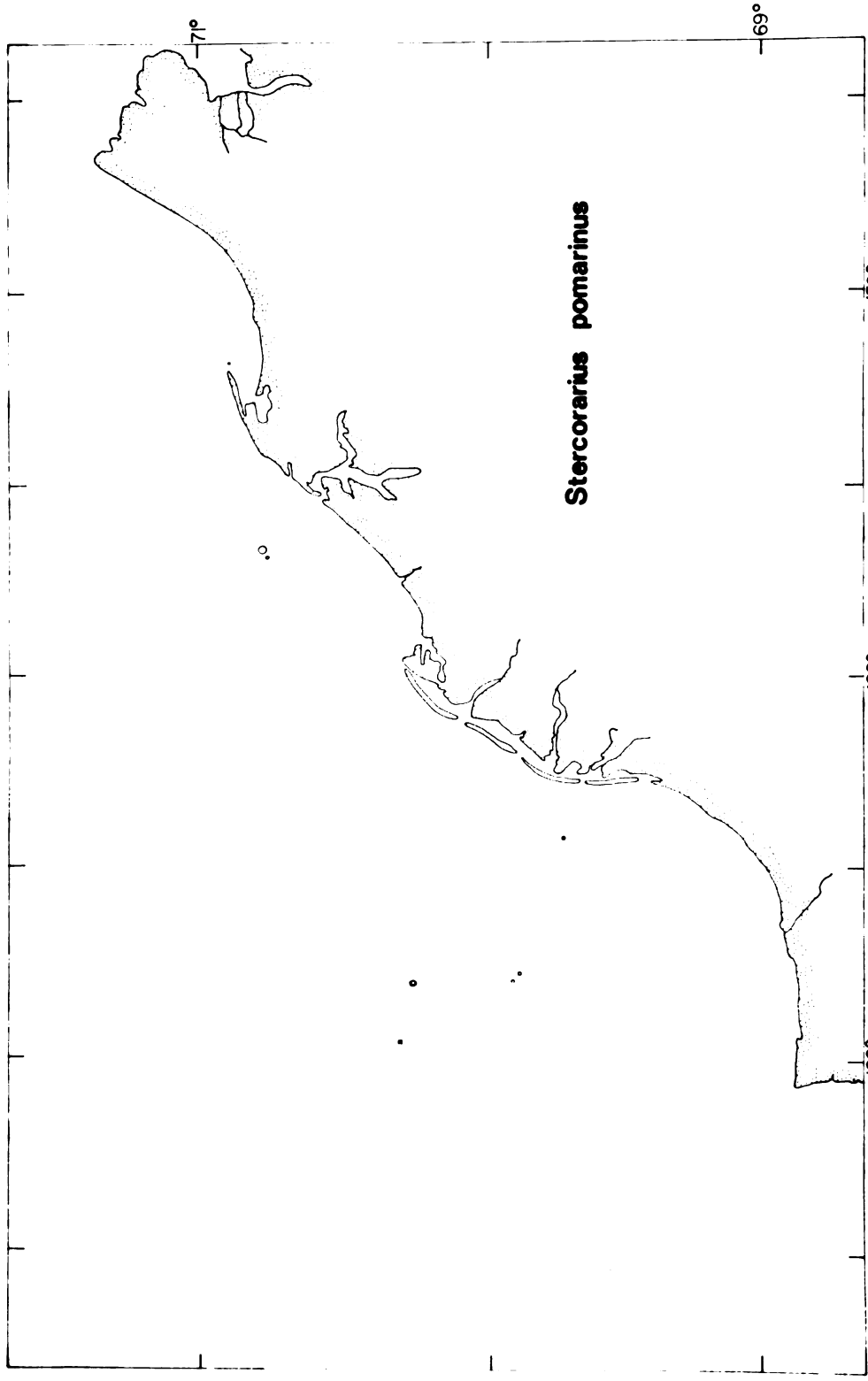

Figure 14. Distribution of Stercorarius pomarinus in the east central Chukchi Sea.

A single Parasitic Jaeger was observed on 30 September (Figure 31). This is the least abundant jaeger in the Barrow area (Bailey, 1948). Both Nelson (1883) and Swartz (1967) reported this species from the Chukchi. Swartz's twelve observations were all north of 67°N. No Long-tailed Jaegers were encountered. Summer observers in the Chukchi have found it uncommon. An unidentified jaeger was seen on land at Barrow on 22 September.

Glaucous Gull — Larus hyperboreus

The Glaucous Gull is a common to abundant breeder on both sides of the Chukchi Sea and at Herald and Wrangel Islands. Its scavenging and predatory habits cause breeding individuals to concentrate at seabird cliffs; 150 pairs bred at Cape Thompson in 1961 (Swartz, 1966). During the breeding season it remains near land and is not commonly seen far out at sea. Nelson (1883) mentions no pelagic observations; Jacques (1930) found it present but uncommon north to Herald Island. Most observations reported by Swartz (1967) were within 25 miles of land. There are few fall migration data for the Arctic coast. Birds which breed inland move to the coast where both adults and young stay until driven south by ice and lack of food. Bailey (1948) observed hundreds passing Wainwright on 16 September. The latest date he recorded the species was 19 October.

Glaucous Gulls were observed through the cruise (Figure 15). They were abundant at Barrow on 23 September when a flock of forty individuals followed the ship while it was just south of the pack ice. From Barrow to the study area only small infrequent flocks were seen.

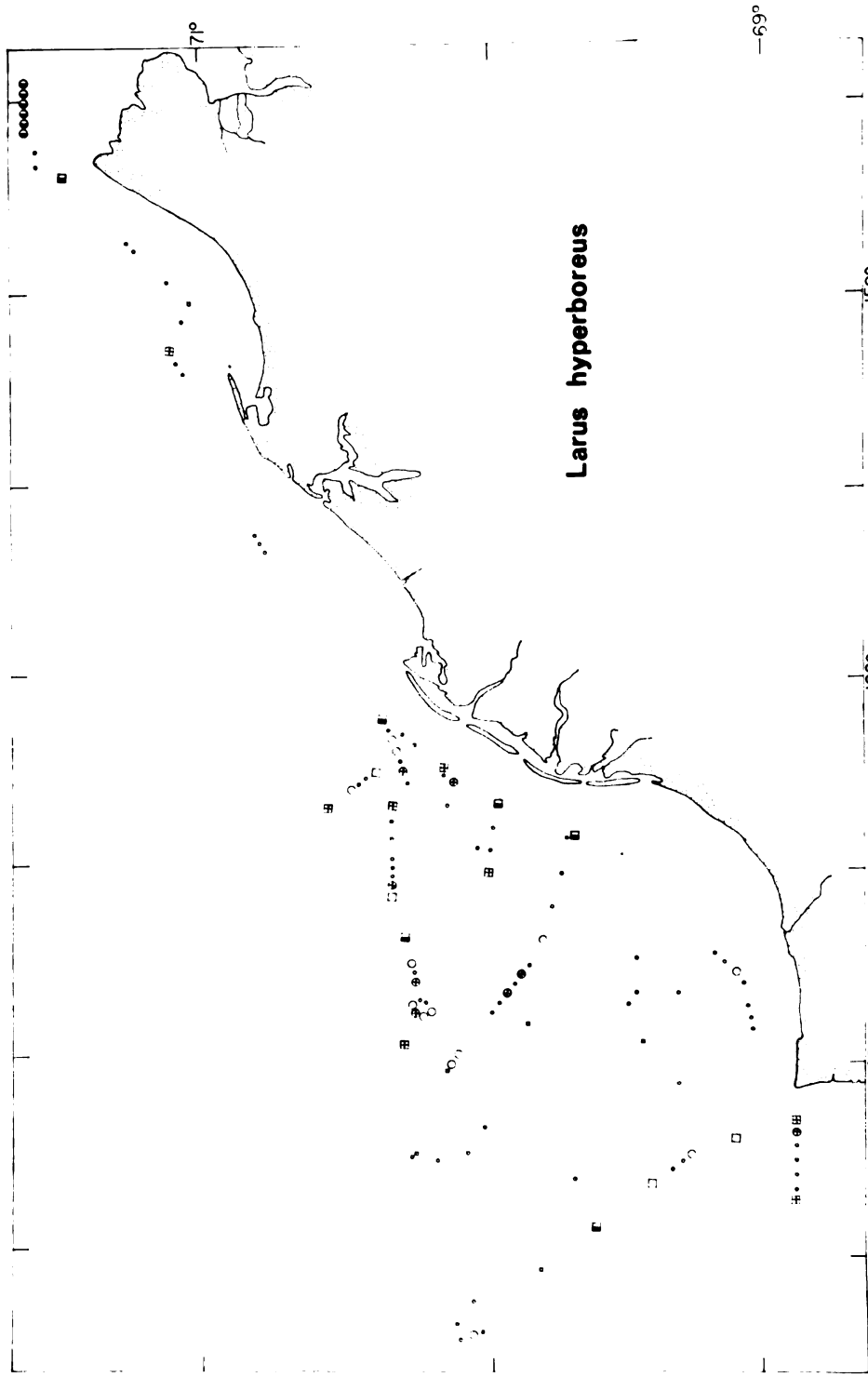

Figure 15. Distribution of Larus hyperboreus in the east central Chukchi Sea.

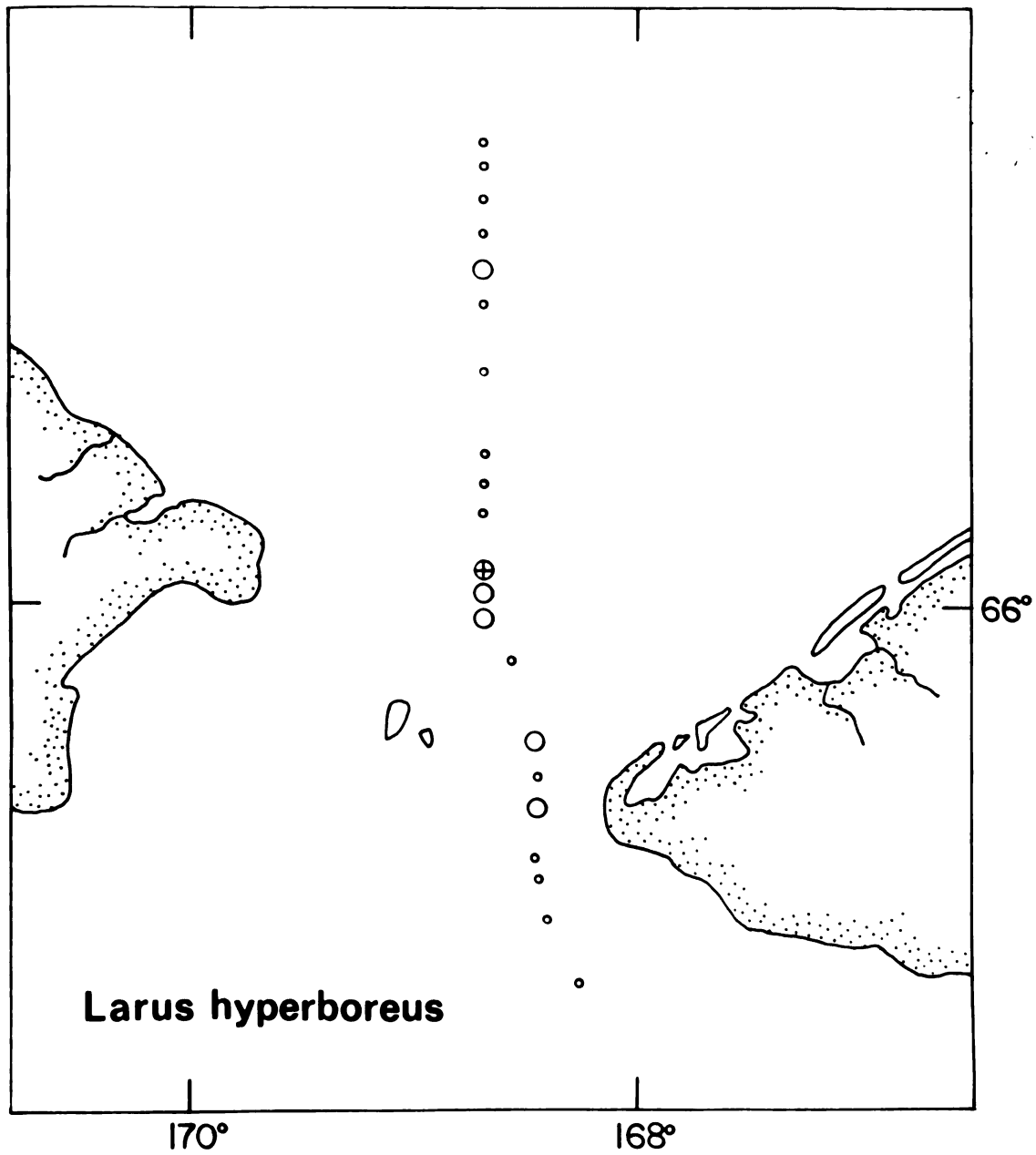

Figure 16. Distribution of Larus hyperboreus in the Bering Strait.

Table 3. Flocking of Gulls on Transects and Stations in the Study Area.

Observations during 208 20-minute intervals on transects

Species	Intervals with gulls seen	Mean no. gulls/interval when present	Single gull intervals
Larus hyperboreus	74	3.3	32
Pagophila eburnea	61	4.3	28
Rissa tridactyla	44	2.8	22
Rhodostethia rosea	70	18.8	7

Observations at 28 stations

	Stations with gulls seen	Mean no. gulls/station when present
Larus hyperboreus	22	18.7
Pagophila eburnea	19	14.3
Rissa tridactyla	12	5.9
Rhodostethia rosea	20	22.6

TABLE 4. Ice Affinities of Gulls

Species:	ICE Present	ICE Absent	OPEN WATER Present	OPEN WATER Absent	X^2	Significant at 99.5%
TRANSECTS						
Larus hyperboreus	48	88	11	39	2.98	No
Pagophila eburnea	55	81	2	48	22.8	Yes
Rissa tridactyla	21	115	22	28	16.77	Yes
Rhodostethia rosea	50	86	7	43	8.9	Yes
STATIONS						
Species:						
Larus hyperboreus	15	2	7	3	1.38	No
Pagophila eburnea	13	4	6	4	.81	No
Rissa tridactyla	2	15	9	1	15.96	Yes
Rhodostethia rosea	12	5	7	3	.001	No

They were present throughout the study area but were most common in the northeast portion and at other stations close to the shore. The species was noted throughout the day in the Bering Strait (Figure 16). It displayed no obvious affinity for ice areas (Table 4). Approximately 25 percent of all birds seen were immatures.

Glaucous Gulls tended to flock less than other gulls and single individuals were frequently seen on transects. On the other hand large numbers gathered about the ship on stations (Table 3) to accept scraps thrown over the side. Most of their food is probably live fish and crustaceans, but I also saw it feeding on walrus dung. Hovering, contact dipping and surface feeding were all observed for this species. Examination of stomach contents indicates that fish may be the major food during this time of year (Table 2). Three of the seven specimens collected were adults (Table 1).

Slaty-backed Gull — *Larus schistisagus*

On 25 September approximately 20 miles northwest of Point Lay, a large dark-backed gull was observed that was probably a Slaty-backed Gull (Figure 31). This is a species of the Siberian Pacific coast and not common in Alaskan waters. Most Alaskan records are for the Aleutian Islands although it is also regular in Norton Sound in September. A specimen collected by Bailey at Icy Cape on 16 September 1921 was thought to be this species (Bailey, Brower and Bishop, 1933) but according to Bailey (1948) further investigation proved it to be the Siberian Lesser Black-backed Gull (*Larus fuscus*). A straggler has also been reported for Herald Island (Nelson 1883).

Herring Gull *Larus argentatus*

The Herring Gull is found throughout most of the northern hemisphere including the Canadian Arctic and Siberia, but does not breed on the Arctic coast of Alaska. In fall, and probably in spring, it is a regular but uncommon migrant in northern Alaska. I observed this species five times in the study area (Figure 17). Three of the six individuals seen were immatures. In the Bering Strait, two sightings were made; a single bird at 66° 22'N and a group of five at approximately 66° 04'N.

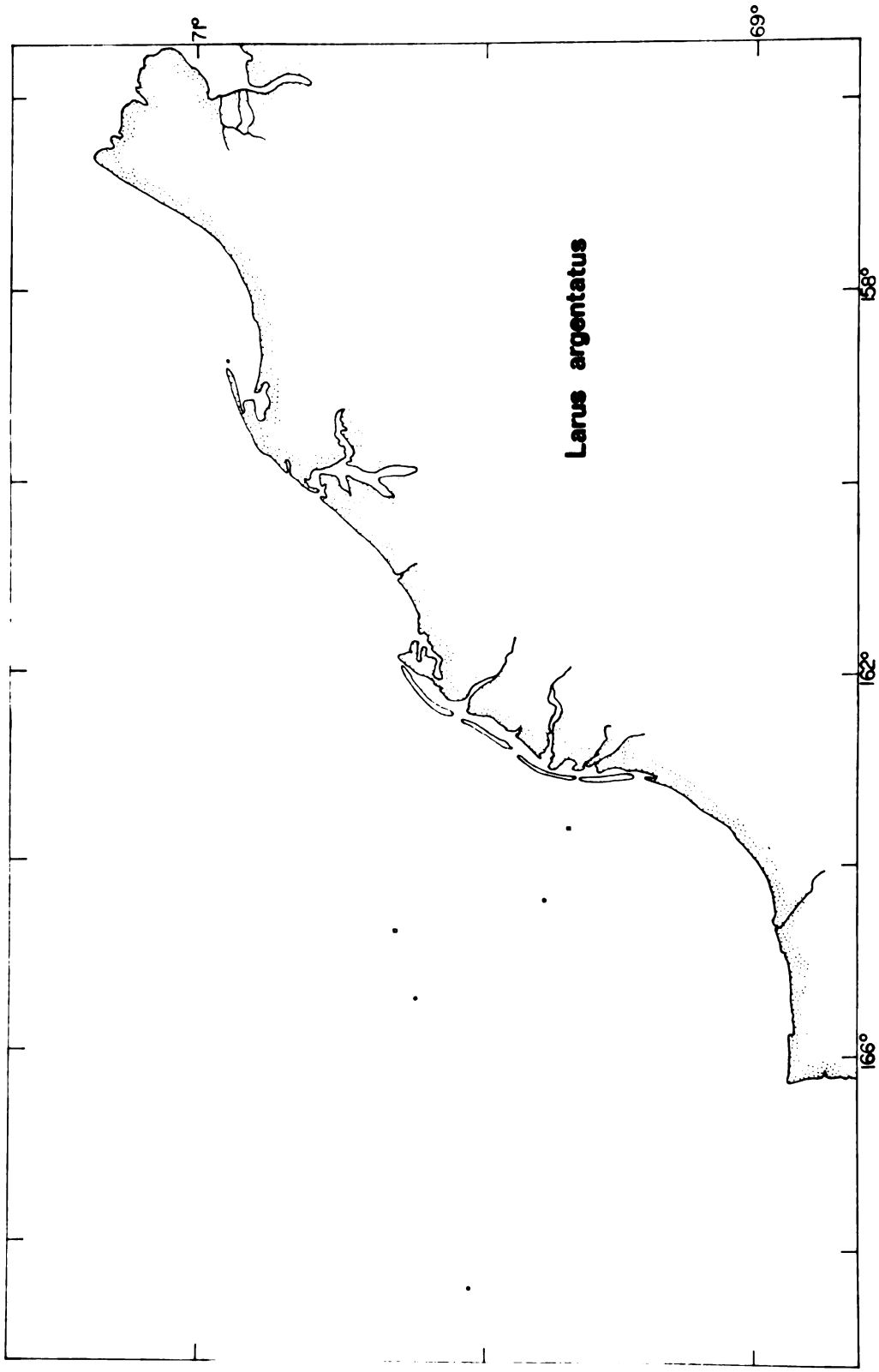

Figure 17. Distribution of Larus argentatus in the east central Chukchi Sea.

Ivory Gull Pagophila eburnea

The Ivory Gull is a high Arctic species that breeds north of 70°N. The known breeding grounds closest to the study area are at Herald Island and in the Canadian Archipelago. The known breeding sites in Canada have been listed by MacDonald and Macpherson (1962). Pagophila eburnea is a bird of the pack ice. Breeding sites are situated close to the pack ice and the southern extent of its wintering range is largely determined by the southern margin of the ice. The most northerly record is that of an individual at 86°N (Collett and Nansen, 1900). Ivory Gulls move through the Chukchi Sea to the Bering Sea with the ice in spring and fall. Small numbers are probably present in leads in the Chukchi throughout the winter. The pelagic habits of this species have caused land observers to underestimate its abundance in this area (Gabrielson and Lincoln, 1959). It was reported common in the "frozen" Chukchi Sea on Cook's last voyage from August to September 1778 and in July 1779 (Stresemann, 1949). No other summer observers have encountered Ivory Gulls at sea though all have come in contact with the pack ice. Jacques (1930) observed birds at Herald Island as did Newcomb, the naturalist of the "Jeanette" (Nelson, 1883).

I observed few Ivory Gulls in the Barrow area although they were common near Wainwright (Figure 18). In the study area this species was largely associated with the ice (Table 4). Large flocks assembled at stations with smaller groups being observed on transects (Table 3). The marine science technicians saw a pair tentatively identified as this species at 71°25'N, 167°13'W on 17 September 1970 when ice surrounded the ship. None were observed south of the study area. Immatures constituted roughly one quarter of all individuals observed. Six of the fourteen specimens collected were immatures (Table 1).

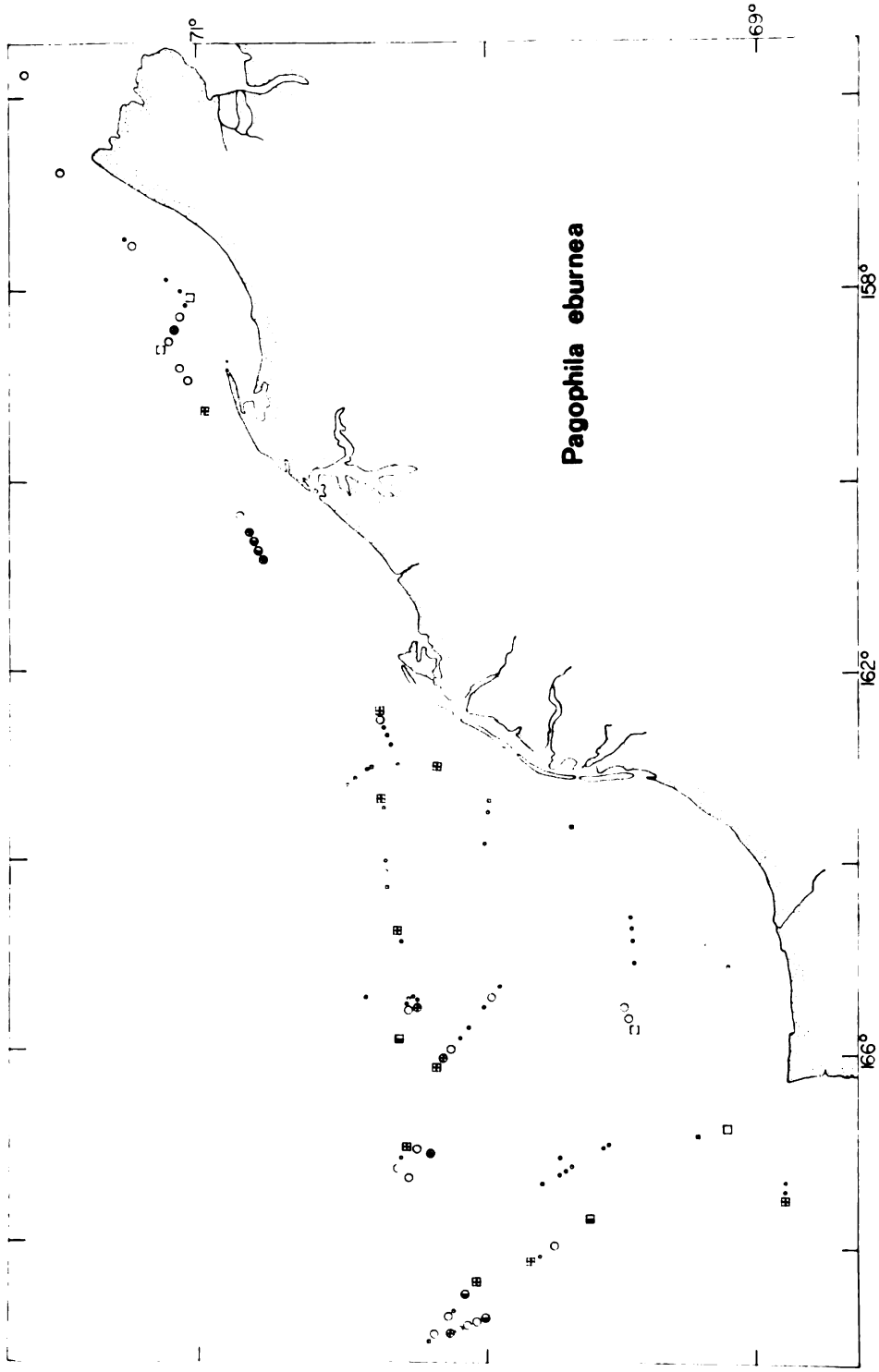

Figure 18. Distribution of Pagophila eburnea in the east central Chukchi Sea.

Food of Ivory Gull

Outside of the breeding season the Ivory Gull is thought to be primarily a scavenger, feeding to a great extent on the remains of seals killed by Polar Bears (Thalarctos maritimus). The breeding population of P. eburnea on Spitsbergen has declined since the turn of the century (Bateson and Plowright, 1959; Birkenmajer, 1969) and Birkenmajer believes this may be due to a corresponding decrease in the Polar Bear population. No Ivory Gulls were observed in close proximity to the few Polar Bears I encountered. Aside from feeding on the ship's garbage, the only instances of scavenging observed were small flocks flying over whales on two occasions, and a single individual feeding on Walrus dung on an ice floe.

Ivory Gulls were observed feeding by hovering and contact dipping. This species' habit of rarely wetting its plumage limits it to these feeding methods. Feeding was done primarily next to ice cakes and Arctic Cod appear to be the major food obtained in this way (Table 2). The contents of the stomachs I examined varied principally in the degree of digestion of the fish. A single amphipod Apherusa glacialis was present in one of the stomachs and remains of two or three tunicates were in another. Garbage from the ship, a small amount of gravel, and remains of seaweed constitute the other items found in the stomach.

Little research has been done on the feeding habits of the Ivory Gull. Almost all authors mention its fondness for carrion, primarily seal carcasses. Studies on stomach contents have found crustaceans to constitute a large amount of its food. An individual collected in the summer off Greenland contained 115 Thysanoessa inermis, a schizopod, and five Apherusa glacialis. Arctic Cod was also present, but constituted only one percent of the total volume (Cottam, 1936). T. inermis was the

only food in the stomach of a bird collected at Spitsbergen in an area where a glacier entered the water (Hartley and Fisher, 1936). Kumlien (1879) found only small crustaceans in the stomachs he examined. Montague (1926) studied this species at its breeding sites on Spitsbergen and found the stomachs of most specimens to be empty, though a few contained fish and carrion.

Winter may be the season when Ivory Gulls are most dependent on carrion for a source of food. During the summer and fall, fish and crustaceans appear to be of primary importance. If the number of Ivory Gulls is declining, it could well be due to a general decrease in numbers of all mammals associated with the pack ice and not just the Polar Bear, as Birkenmajer suggests. Many of the pinniped species, whose placentas provide food for Ivory Gulls in the winter, have also declined since the turn of the century.

Black-legged Kittiwake

The Black-legged Kittiwake breeds throughout the Chukchi Sea wherever suitable nesting cliffs exist, almost as far north as Barrow. It was the third most abundant species at the Cape Thompson cliffs in 1960 with 13,000 breeding pairs (Swartz, 1966). This most pelagic of all gulls feeds far out to sea in all seasons. Summer observers have found it common in the Chukchi. Nelson (1883) saw it in all parts of the Chukchi, with large numbers present at Herald Island smaller numbers at Wrangel Island. Jacques (1930) found it sometimes abundant. Swartz (1967) reported it most common near the breeding cliffs in the Point Hope - Cape Thompson area. The species probably winters at sea from the Aleutians southward but there is no evidence of mass migration.

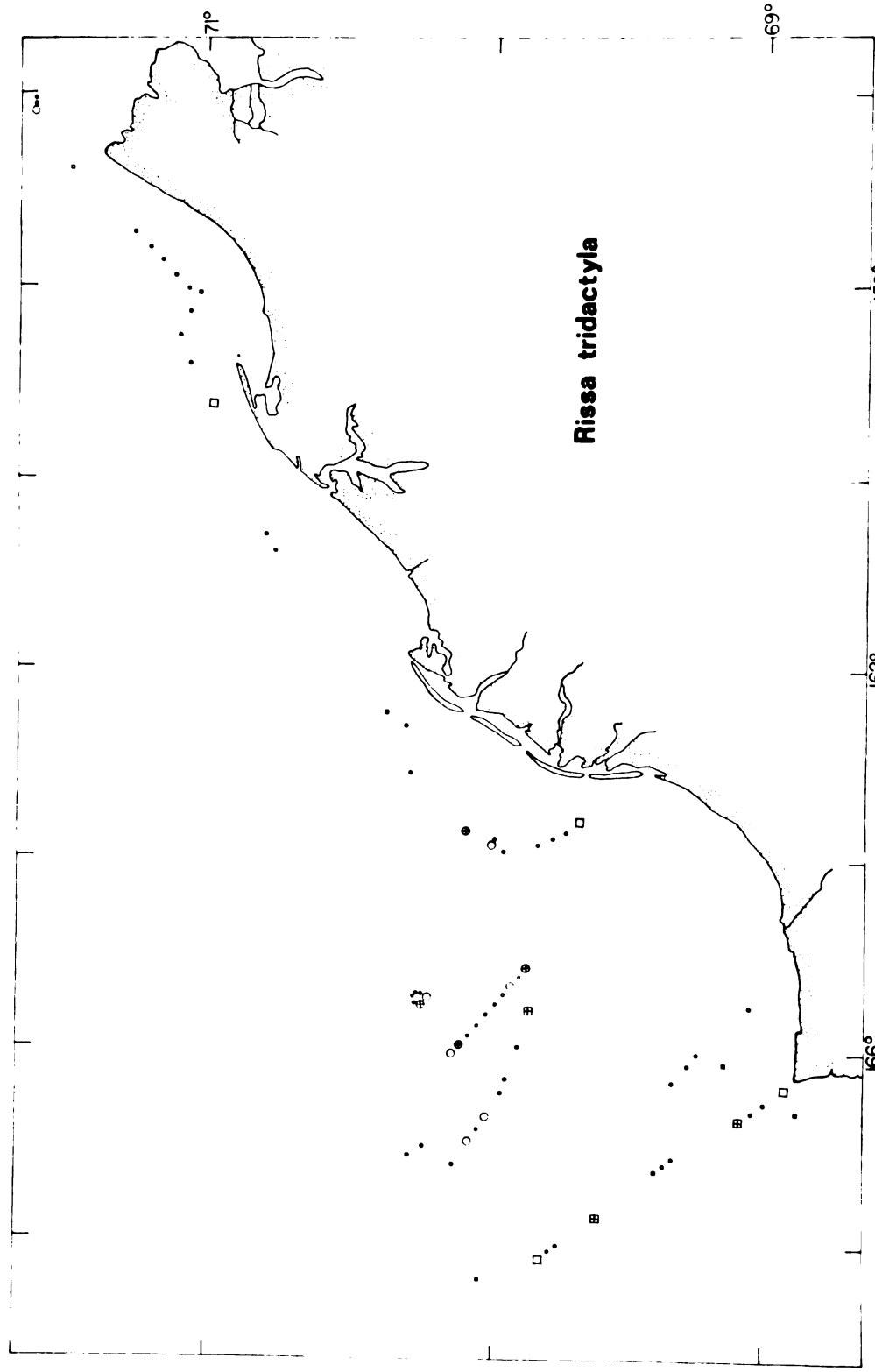

Figure 19. Distribution of Rissa tridactyla in the east central Chukchi Sea.

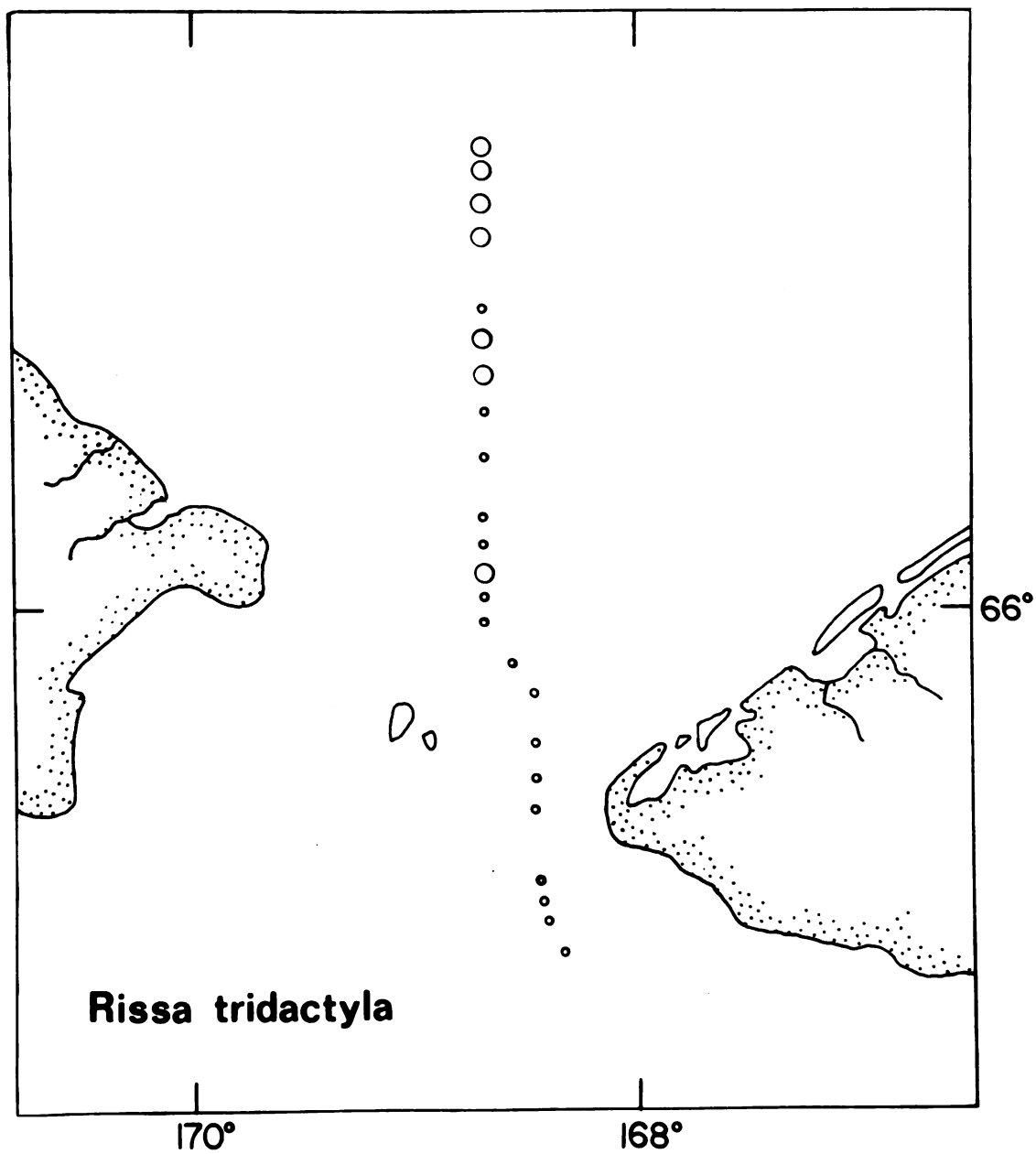

Figure 20. Distribution of Rissa tridactyla in the Bering Strait.

Kittiwakes were present in small numbers in the area of Barrow and along the coast to the study area. In the study area this was the least common of the major species of gulls I observed (Figure 19), and tended to flock less than the others (Table 3). It showed affinity for areas of open water (Table 4) and in the Bering Strait it was seen throughout the day of October 18 (Figure 20). Approximately three quarters of all individuals observed throughout the cruise were immatures.

Plunging to the surface was the most common mode of feeding observed for this species. On the few occasions when it was observed in ice areas, individuals were seen feeding while hovering near ice cakes. The stomachs of the four specimens collected (Table 1) contained remnants of Arctic Cod (Table 2).

Ross' Gull — Rhodostethia rosea

The Ross' Gull has a highly restricted breeding ground on the wet tundra of the Kolyma and Indigirka River deltas in northern Siberia (62°27'-70°30'N, 142°-162°E). There are scattered records of pairs of birds elsewhere in the arctic during spring and early summer, but only one definite breeding record outside of northern Siberia; a nest found on Disko Bay in western Greenland (70°N, 53°W) (Dalgleish, 1886). This record was in some doubt until Ticehurst (1933) published the details of the collecting of an egg and a pair of birds at the nest so that the record now appears to be valid. There are four summer records for northern Alaska. An adult male was taken at Barrow on 9 June 1898 (Stone, 1900). Hendee collected an adult male out of a flock of five birds he observed at Wainwright on 24 July 1922. Brower collected two

pairs at the Seahorse Islands on 16 June 1935. These four birds were all in breeding plumage although none had bare brood patches. Brower also took a single bird in the summer just east of Point Barrow (no date given) (Bailey, 1948).

Individuals arrived on the nesting ground in late May and early June. The first young hatch in late June, and all birds have departed from the breeding grounds by the end of July with some colonies being deserted as early as 11 July (Buturlin, 1906). In the late summer and early fall, there are records from the New Siberian Islands and the DeLong Archipelago to the north and northwest of the breeding grounds. Observers there have found them most commin in early and mid-September (Pleske, 1928). In late summer and early fall, Ross' Gulls move eastward through the Chukchi Sea. R. L. Newcomb, the naturalist of the "Jeanette" expedition, collected a number of individuals in late June and a single bird on 7 October all near Herald Island (DeLong, 1884). Nelson (1887) saw a single immature off Wrangel Island in August. Jacques (1930) saw a total of eight birds in mid and late July; all were north of 70°N near Herald and Wrangel Islands.

In September and October, Ross' Gulls are commonly seen in the area of Point Barrow where Eskimos used to shoot them in numbers for food. Murdoch (1885a) was the first to report them for this location. From 28 September to 22 October 1881, he found them sometimes exceedingly abundant. The following year Murdoch observed them from 21 September to 9 October. The McIlhenny expedition found them to be less common and collected only two fall specimens; on 9 and 23 September 1897 (Stone, 1900). Bailey in 1921 was the next ornithologist to observe them in the Barrow area, and Brower took many specimens in subsequent

years. The earliest date they recorded was 19 September and the latest 27 October. Both Abbott (1929) and Bent (1929) reported on the flight of 1928 when the peak of abundance was 26 September. All Alaskan records away from Barrow are for the Bering Sea. There are three records of single birds for St. George Island, one of the Pribilofs, in March, May and September (Preble and McAtee, 1923; Kenyon and Phillips, 1965). There is a single specimen from St. Paul Island in June. Nelson (1883) took a single bird on 10 October at St. Michaels, Norton Sound. Fay and Cade (1959) report that the Eskimos of St. Lawrence Island are familiar with a "pink gull" that arrives in November and December. The occurrence of Ross' Gull at St. Lawrence Island has recently been confirmed by the observation of a flock seen in early December (Sealy, Fay, Bedard and Udvardy, 1971). In addition to these Alaskan Bering Sea records, a specimen has been taken on Bering Island, one of the Commander Islands, on 10 December (Stejneger, 1898).

Ross' Gulls were present in the area of Barrow and along the coast to Icy Cape, but only in the study area were large flocks observed (Figure 21). It was most common in the northeast portion of the study area where the ice coverage was the greatest. Flocks of approximately 120 birds were observed on two occasions; southwest of Icy Cape and at one of the most westerly stations northwest of Cape Lisburne. This was the most social of the gulls I observed and only 10 percent of the 70 20-minute interval counts were of single individuals (Table 3). All single individual records were made in the last week spent in the study area. It is not known whether this was due to Ross' Gulls leaving the Chukchi, or because the last week was spent in the southern part of the study area away from heavy pack ice. Approximately one-half of all birds seen were immatures.

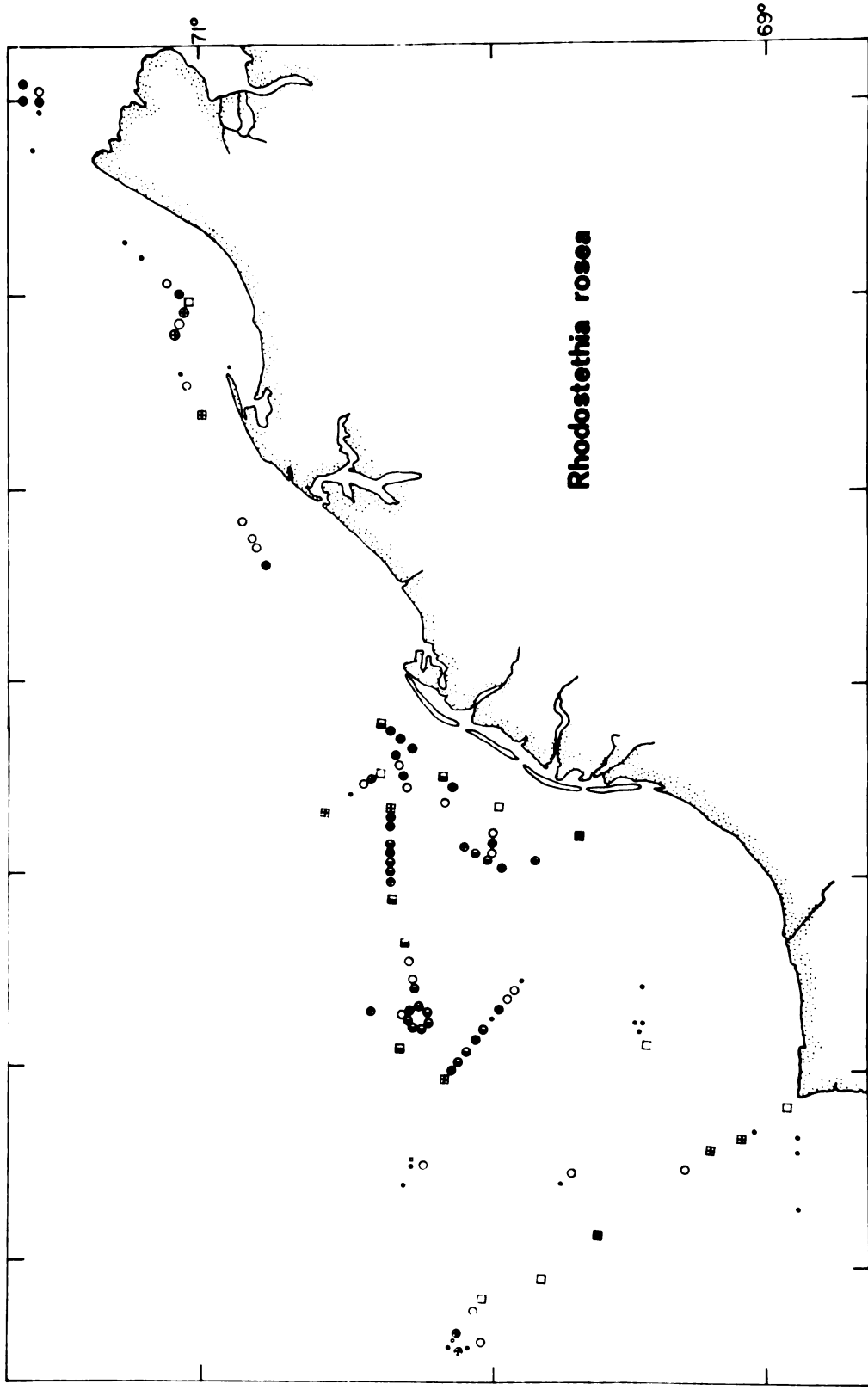

Figure 21. Distribution of Rhodostethia rosea in the east central Chukchi Sea.

Food of Ross' Gull

This species was observed feeding by three different methods. Like other gulls individuals fed by hovering in the area of ice cakes, whereas in more open water they plunged to the surface. Flocks sitting in leads in the ice were seen feeding on the surface. One instance of an individual hovering while feeding on Walrus dung was observed. Arctic Cod and crustaceans appear to be of equal importance as food items (Table 2 and Table 5). The amphipod Apherusa glacialis (Hansen) is by far the most abundant crustacean found in the stomachs. They ranged in size from six to fourteen millimeters. The three Anonyx nugax (Phipps) ranged in size from 20 to 40 millimeters. The single Atylus bruggeni Gurjanova and the two Gammarus locusta (Linneaus) were 20 millimeters. The pieces of a coleoptera exoskeleton had apparently persisted from the breeding season when insects make up much of its food (Buturlin, 1906). The only previous information on the at-sea food of the Ross' Gull is that of Collett and Nansen (1900) who collected eight young birds at 81°00N, 127°00E in heavy ice conditions. All of their specimens contained remnants of Hymenodora glacialis and cod otoliths. Gammarus locusta was found in one of the stomachs.

Sabine's Gull Xema sabini

Sabine's Gull is circumpolar between 65°N and 80°N in its breeding distribution and breeds locally on the Arctic coast of Alaska. In summer, when there are few at-sea records, it obtains most of its insect food by contact dipping in tundra ponds. After breeding it feeds on invertebrates cast up on the shore and fish that it captures by contact dipping. Nelson (1883) did not observe it in the Chukchi. Jacques

Table 5. Food Items Present in Rhodostethia rosea Stomachs.

STATION 7		INVERTEBRATES	FISH
Field Number			Arctic Cod
187002	3	Anonyx nugax (Phipps)	x
187003	1	Apherusa glacialis (Hansen)	x
187004			x
187005			x
187006			x
187007			x
187008			x
187009			x
187010	1	Atylus bruggeni Gurjanova	x
STATION 9			
187032			x
187033	1	Apherusa glacialis	x
187034	160	Apherusa glacialis	x
187035			x
187037	80	Ampherusa glacialis	x
187038	80	Ampherusa glacialis	
	2	Gammarus locusta (Linneaus)	
STATION 19			
187045	80	Apherusa glacialis	
STATION 23			
187049	40	Apherusa glacialis	
187050	60	Apherusa glacialis and coleoptera exoskeleton	
187051		Unidentifiable crustaceans	x
187052		Unidentifiable crustaceans	x
187053	90	Apherusa glacialis	
187054	5	Apherusa glacialis	x
187055			x
STATION 50			
187065			x

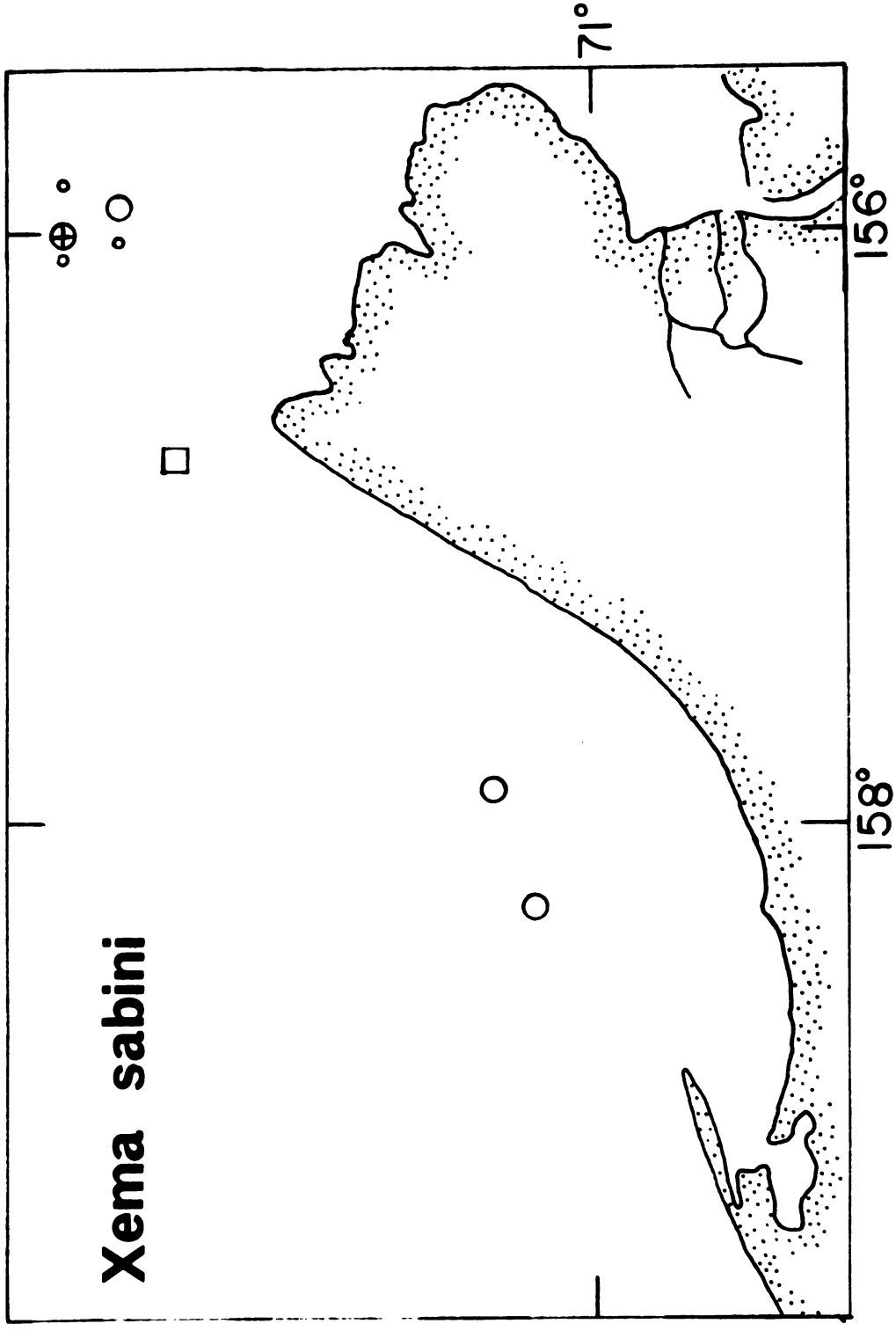

Figure 22. Distribution of Xema sabini in the east central Chukchi Sea.

(1930) saw adults on six days during August and juveniles on 22 and 25 August south of Wrangel Island. Swartz (1967) reported six scattered observations in the eastern Chukchi. This species winters in the southern hemisphere. Birds have been observed at Wainwright as late as mid-September (Bailey, 1948) and 22 October at Barrow (Murdoch, 1885b), but the bulk of migration probably takes place earlier, since Gabrielson and Jewett (1940) mention a large movement off the Oregon coast on 30 August. I observed Sabine's Gull only in the area of Barrow and Wainwright on 23 and 24 September (Figure 22). Eight flocks were observed near ice cakes with the largest flock containing ten individuals. The northerly location of these observations and the lack of subsequent observations at more southerly locations, during the cruise, indicate that migration in this area takes place close inshore. Gabrielson and Lincoln (1959) thought that the lack of fall records for the Alaskan coast suggested that migration takes place well offshore although they were discussing more southern Alaskan locations.

Murres *Uria* sp.

Both species of murre breed in the Chukchi Sea. The Thick-billed Murre (*Uria lomvia*) is more northern in its breeding distribution than the Common Murre (*U. aalge*). Both species breed in the Bering Strait and at Cape Thompson, while *U. lomvia* also nests at Herald and Wrangel Islands and rarely at Barrow (Stone, 1900). Murres are the most abundant birds at Cape Thompson. In 1960, 118,000 pairs of Thick-billed and 78,500 pairs of Common Murre were breeding on the cliffs (Swartz, 1966). Flocks of *U. lomvia* that pass Barrow in the spring and fall (Bailey, 1948) presumably nest in the western Canadian Arctic where

suitable cliffs exist. The only known breeding site is that of a colony of 100 pairs nesting at Cape Parry, south of Banks Island (Hohn, 1955).

Summer observers in the Chukchi have found murres primarily in the waters around breeding cliffs. Swartz (1967) reported that during the breeding season U. lomvia constituted 90 percent of all murres seen further than five miles from shore. Since 60 percent of the murres breeding on the cliffs are U. lomvia, he believed that U. aalge fed closer to the shore, at least during the breeding season. He found few murres feeding more than 40 miles from the cliffs. Murres do not have a well-defined migration and most winter in open water south of the pack ice. Some individuals winter in leads in the pack ice and an individual has been taken at Barrow in December (Murdoch, 1885a). Swartz (1966) found some murres staying in the area of Cape Thompson throughout the year.

I made scattered sightings of single birds in the eastern portion of the study area but only on the most westerly transects were murres observed in numbers (Figure 23). Murres could not be identified to species. The similarity of murres and the Horned Puffin at a distance, caused me to list some birds as large black and white alcids (Figure 29). Murres were seen throughout the day on 18 October in the Bering Strait (Figure 24). The stomach of the one Common Murre collected (Table 1) contained remnants of Arctic Cod and a larval hermit crab (Pagurus sp.) (Table 2).

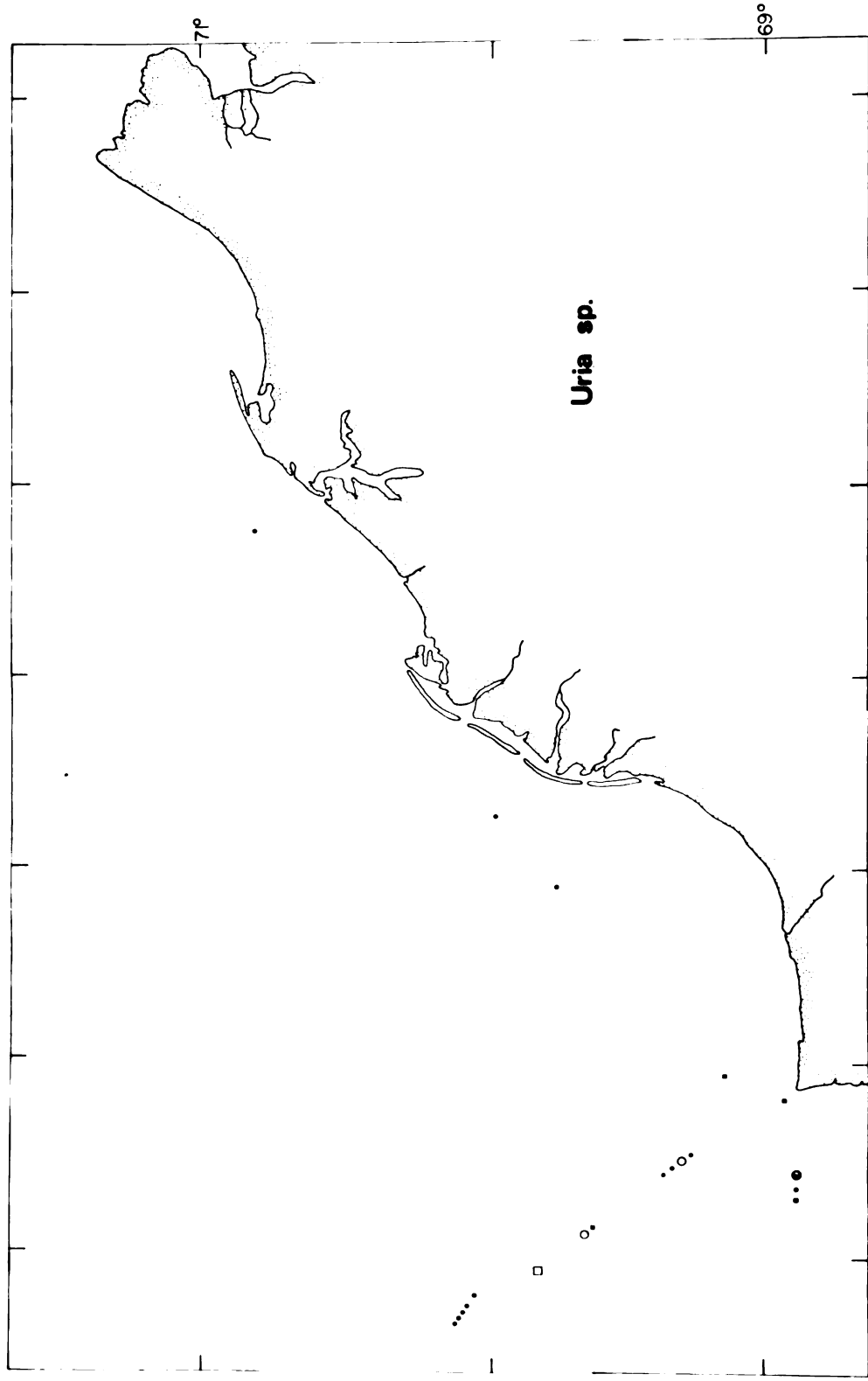

Figure 23. Distribution of Uria sp. in the east central Chukchi Sea.

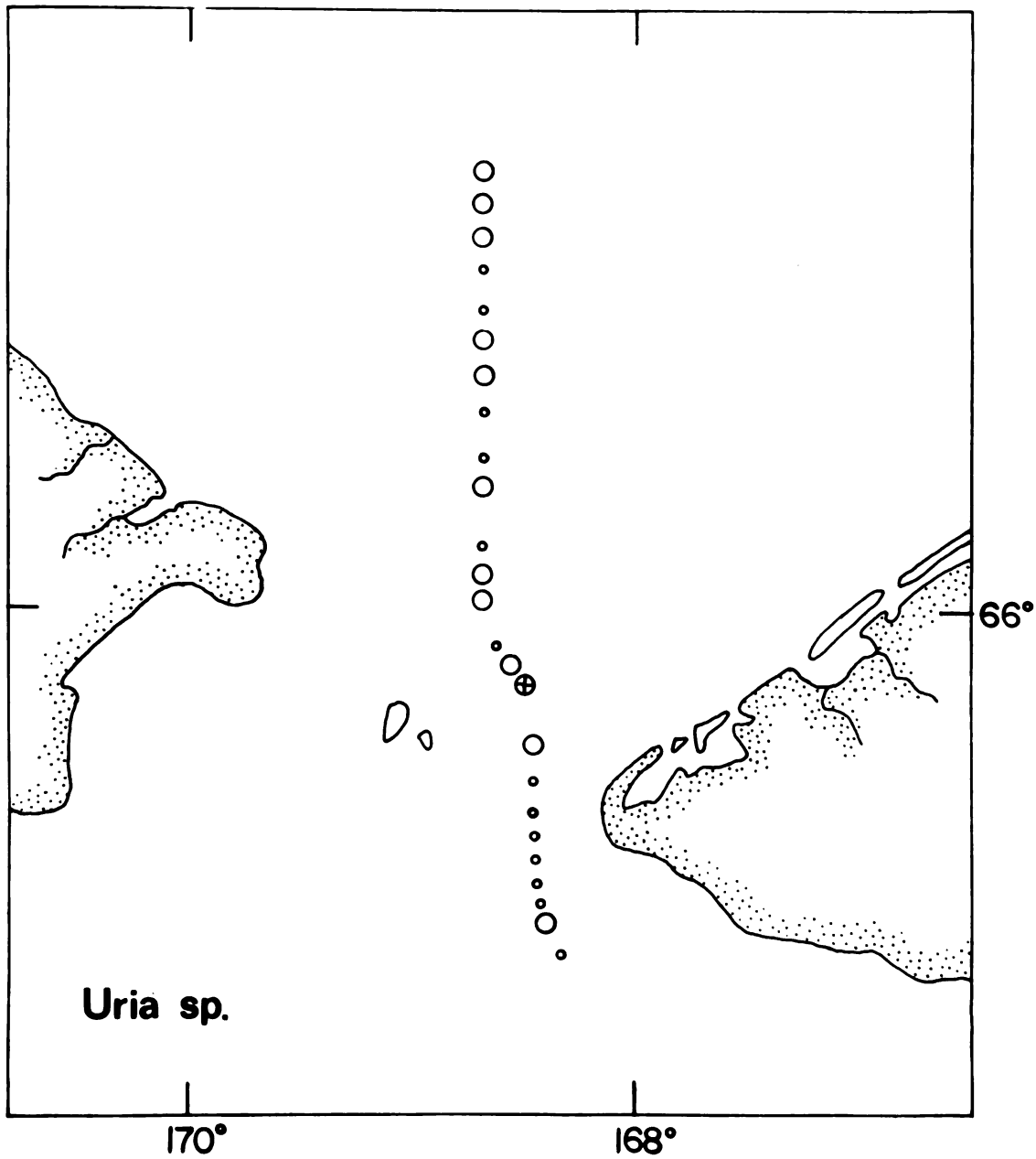

Figure 24. Distribution of Uria sp. in the Bering Strait.

Guillemots *Cepphus* sp.

Both Black (*Cepphus grylle*) and Pigeon Guillemots (*C. columba*) breed in the Chukchi Sea. The Black Guillemot is also found in the North Atlantic and Arctic Oceans, but the Pigeon is restricted to the Pacific sector. The Chukchi is the only area where the two species are sympatric, with both breeding on Herald and Wrangel Islands and at Cape Thompson. The Pigeon Guillemot also nests in the Bering Strait area while the Black Guillemot probably nests north along the Alaskan coast wherever suitable cliffs exist. Bailey (1948) believes Black Guillemots may breed in the area of Skull Cliff and has obtained immature birds off Barrow in June. Recently Black Guillemots have been found utilizing oil drums and old buildings as nesting sites in the Point Barrow area (MacLean and Verbeek, 1968). Swartz (1966) found fewer than eight pairs of either species breeding at Cape Thompson but, unlike other alcids, guillemots rarely breed anywhere in dense concentrations.

Summer observers in the Chukchi give conflicting reports on the status of these two sibling species that are not easy to separate at sea. Nelson (1883) observed both species and considered the Pigeon Guillemot to be the more common of the two. He found it to be the most abundant bird at Herald Island where he also saw numerous Black Guillemots. Jacques (1930) did not observe the Pigeon Guillemot north of the Diomedes but found the Black Guillemot common north of 69°N. He found it to be abundant at Herald Island and at the edge of the ice. In the eastern Chukchi, Swartz (1967) reported only the Pigeon Guillemot. One of his two sightings was off Cape Lisburne and the other at the edge of the pack ice at 70° 50'N, 165° 30'W. Black

Guillemots are present at Barrow throughout the winter in leads in the ice.

All guillemots I observed were in winter plumage and were identified as C. grylle (Figure 25). The only possible C. columba was an immature individual west of Cape Lisburne. Although it was not common at Barrow, a flock of thirty individuals was observed in that area. Lesser numbers were seen on transects 4 to 8 from Barrow to the study area.

In the study area, the great majority of observations were on the most northerly transects near the edge of the pack ice. The largest concentrations were in the eastern portion of the study area. None was seen in the Bering Strait. Fish are the primary food of guillemots, but crustaceans sometimes also constitute a large portion of the diet. The stomachs of the three Black Guillemots collected (one adult, 2 immature; Table 1) all contained remnants of Arctic Cod (Table 2). One of the stomachs also contained four gammarids: two Gammaracanthus loricatus (Sabine) (one 43 mm. and one 25 mm.), one Gammarus locusta (Linneaus) (17 mm.) and one Weyprechtia pinguis (Kroyer) (20 mm.).

Kittlitz's Murrelet — Brachyramphus brevirotre

Kittlitz's Murrelet breeds in scattered coastal locations in Alaska from Leconte Bay possibly north to Point Barrow and on the Chukchi Peninsula in Siberia, but is rare north of the Bering Strait. This small alcid nests on inland mountains and its breeding has probably been overlooked by investigators. Brower took many at Barrow, but although Bailey (1948) believed suitable nesting sites existed between the Seahorse Islands and Barrow, there is still no proof of nesting. The only previous pelagic observations are those reported by Swartz (1967):

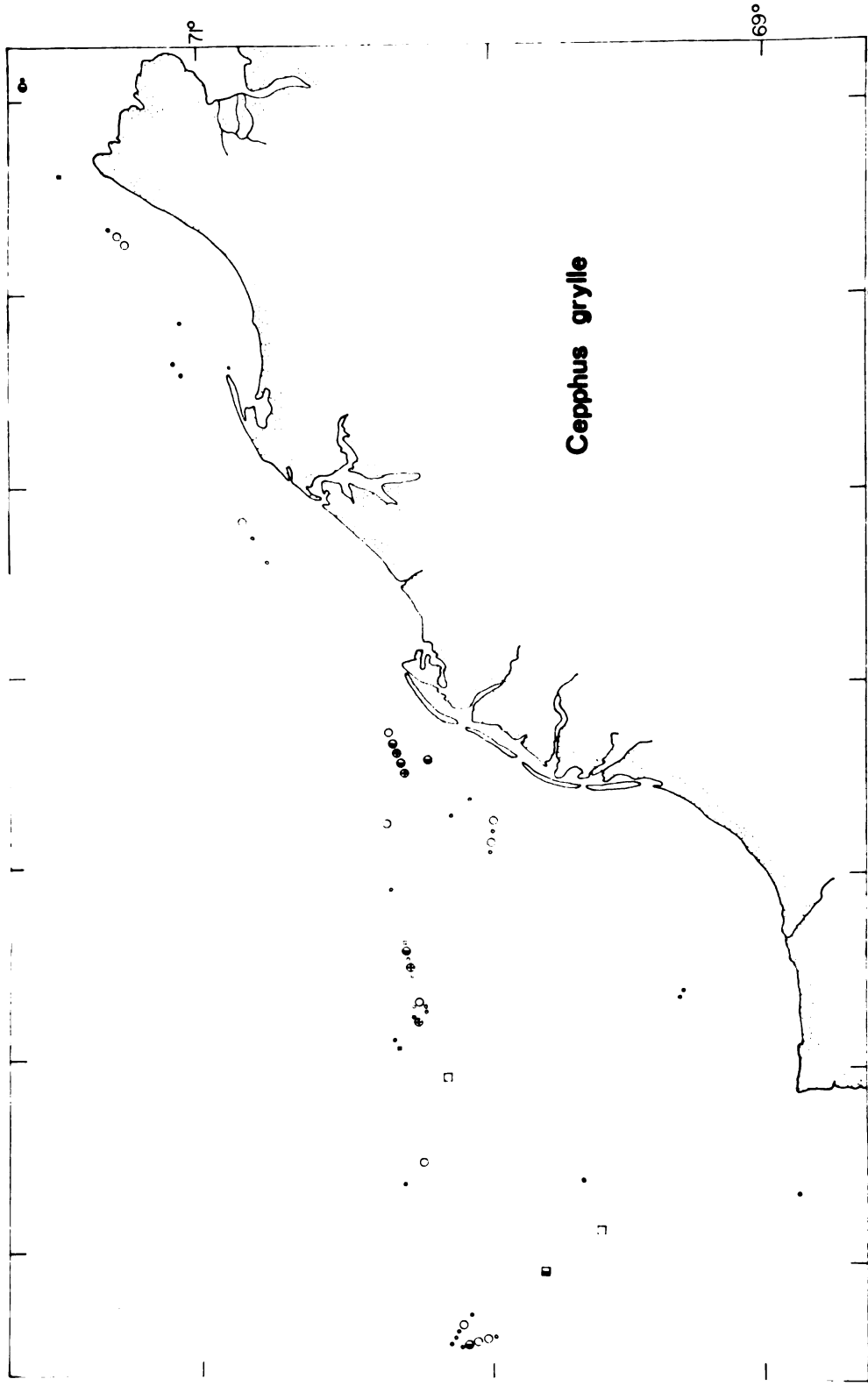

Figure 25. Distribution of Cephus grylle in the east central Chukchi Sea.

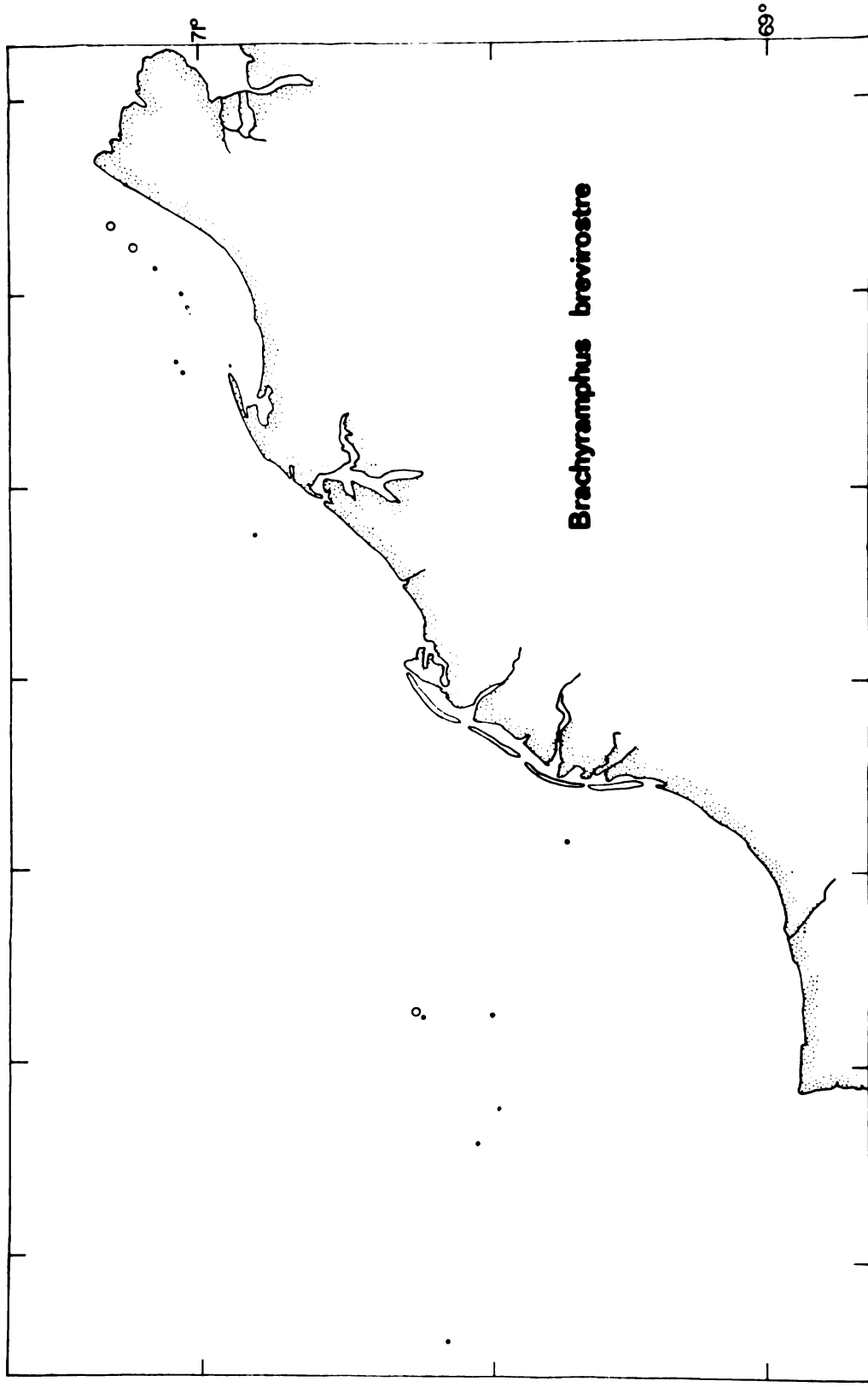

Figure 26. Distribution of Brachyramphus brevirostre in the east central Chukchi Sea.

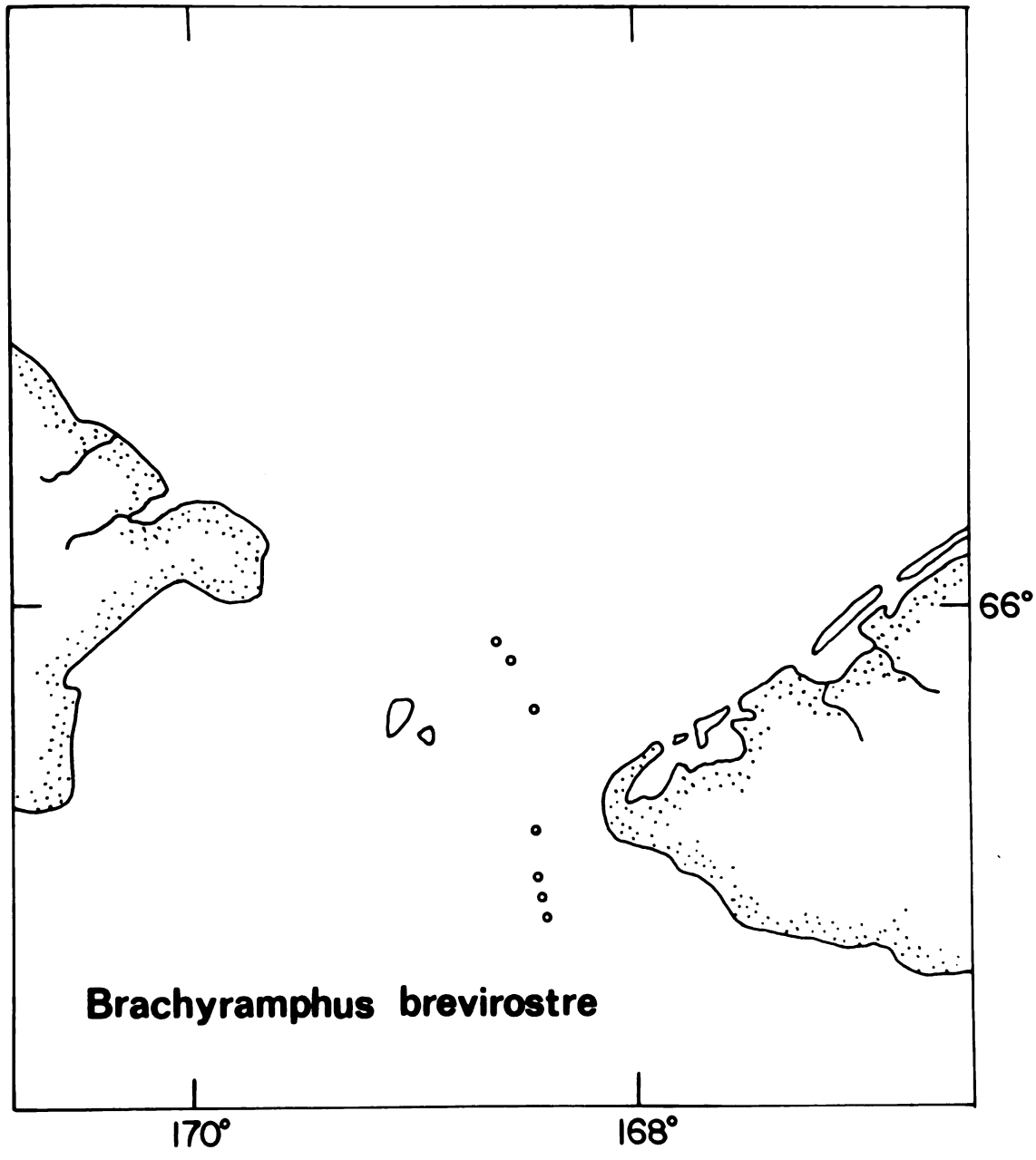

Figure 27. Distribution of Brachyramphus brevirostre in the Bering Strait.

three sightings, totaling four birds, north of Cape Lisburne. Little is known of the migration of this species. There are records for the Barrow-Wainwright area from May to October.

I recorded 15 sightings of Kittlitz's Murrelet between 24 September and 8 October, eight of them between Barrow and Icy Cape. The remainder were in the northern part of the study area. It was never abundant, with 12 of the sightings being of three or less individuals (Figure 26). Small numbers were also seen in the southern part of the Bering Strait on 18 October (Figure 27). The latest previous record for Alaska is that of a specimen collected at Barrow on 4 October 1927.

Parakeet Auklet — Cyclorrhynchus psittacula

The Parakeet Auklet breeds from the area of the Bering Strait south to the Aleutian Islands. Small nesting colonies occur on the Siberian coast in the western Chukchi Sea (Koslova, 1957) but none on the Alaskan Chukchi coast. It winters off the Pacific coast of Canada and the United States. Jacques (1930) saw several flocks of small auklets at 69° 40'N, 170° 00'W on 14 August which may have included this species. Grinnell (1900) found it common in Kotzebue Sound on 1 June, but Swartz (1967) reported only one sighting of several individuals there in August. There are only three records for Barrow: 12 September 1896 (Seale, 1898) 3 October 1932, and 27 July 1942 (Bailey, 1948). Three individuals were observed in the study area at 69° 47'N, 167° 50'W on 9 October (Figure 31). A single bird was seen in the Bering Strait on 18 October (Figure 32).

Crested Auklet — Aethia cristatella

The Crested Auklet has the same general breeding range as the Parakeet Auklet. It is one of the most abundant species breeding on the Diomedes, but is not known to breed in Alaska north of the Bering Strait. Bailey (1948) listed a number of summer records for Barrow and Wainwright from May to October and believed a few individuals might nest on Arctic coastal boulder fields. Jacques' (1930) only possible sighting was of unspecified auklets at 69° 40'N, 170° 00'W on 14 August. Swartz (1967) had two sightings 18 miles west of Cape Thompson. This species winters just south of the pack ice, especially near the Pribilofs, Aleutians and Kodiak. Seven of my twelve sightings were north of the study area between Point Barrow and Icy Cape (Figure 28). The largest concentration was a group of more than one hundred individuals swimming among the ice cakes, suggesting a considerable northward movement after breeding or that immature birds summer north of the breeding sites. None was observed after 27 September. This is the only alcid in which a large flock (30 individuals) was observed sitting on the ice.

Horned Puffin — Fratercula corniculata

The Horned Puffin is a north Pacific species found breeding in the Chukchi Sea from the Bering Strait north to Cape Lisburne. Nelson (1883) and Jacques (1930) reported it from Herald Island, but there are no definite breeding records. Swartz (1966) found 950 pairs breeding at the Cape Thompson cliffs in 1960. Summer observers have reported Horned Puffins primarily from Point Hope and Kotzebue Sound. Swartz (1967) thought they probably utilized the same feeding areas as murres. They winter in ice-free waters in and somewhat south of the breeding grounds.

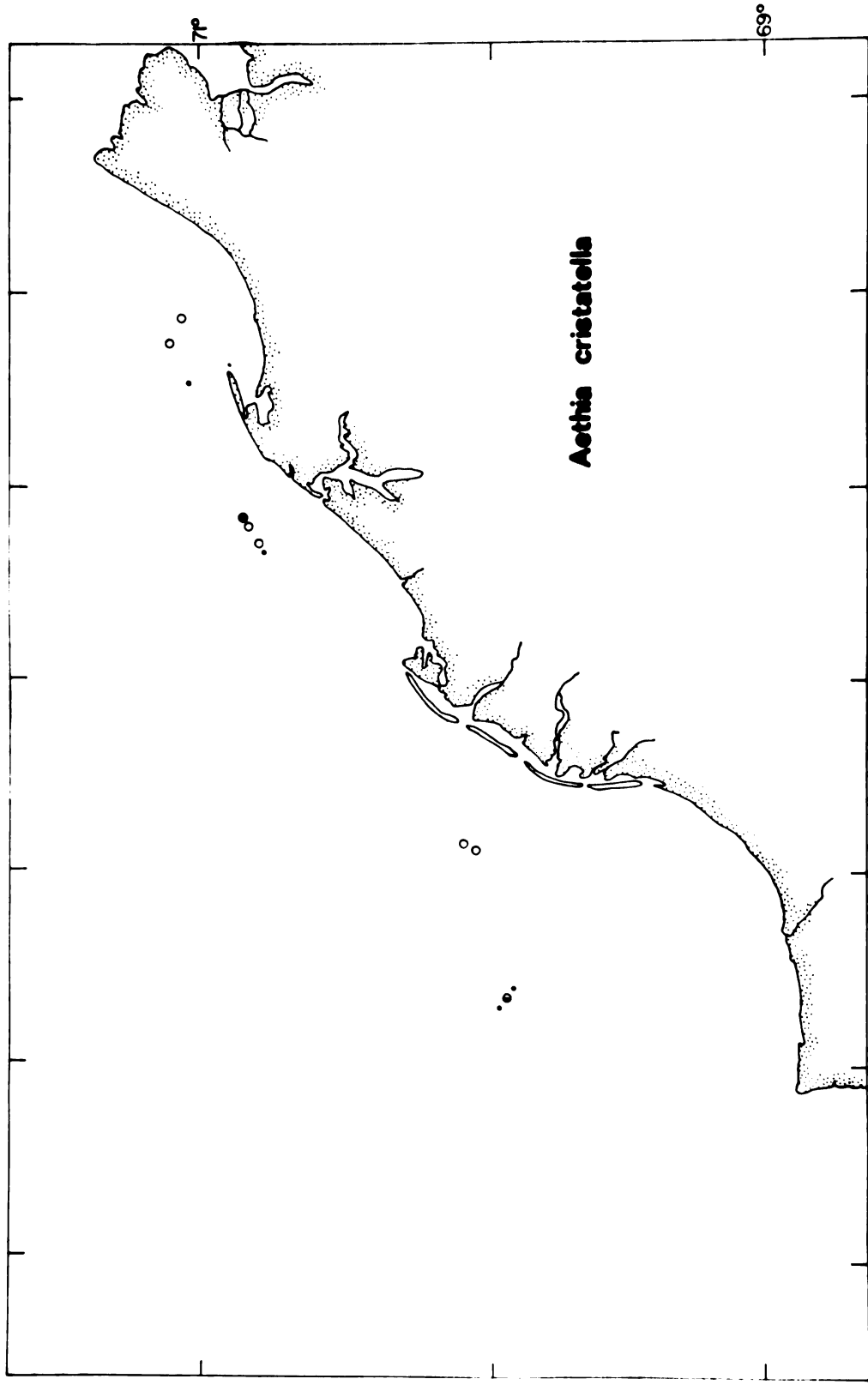

Figure 28. Distribution of Aethia cristatella in the east central Chukchi Sea.

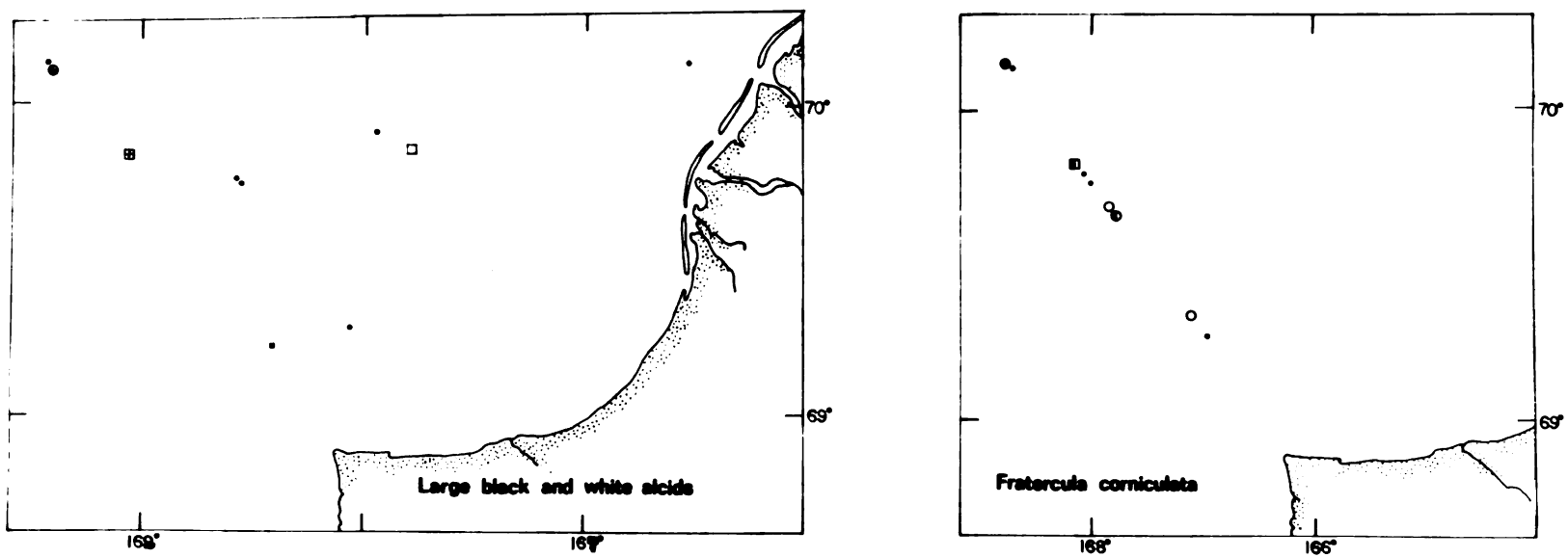

Figure 29. Distribution of unidentified large black and white alcids and Fratercula corniculata in the east central Chukchi Sea.

Snowy Owl — Nyctea scandiaca

While passing through the Bering Strait within sight of both Alaskan and Siberian coasts on 18 October, Snowy Owls were observed nine times in a period covering nearly four hours (Figure 30). Though only one bird was observed at a given time, differences in plumage and direction of flight indicated that at least four individuals were involved. Glaucous Gulls and Kittiwakes drove the owls away from the ship, otherwise they might have landed in the rigging. Although my Bering Strait observations are probably of individuals migrating between the two continents, it may be that Snowy Owls are rather frequently found at sea when ice is present and affords a suitable roosting site. Irving, McRoy and Burns (1970) had six observations in the ice-covered Bering Sea in March, and in 1971 I observed a first year Snowy Owl 45 miles from land in the western Beaufort Sea.

Raven — Corvus corax

On 17 October, 10 miles west of Cape Lisburne, a Raven flew over the ship (Figure 31). This species is a year round resident throughout arctic Alaska.

Yellow Wagtail — Motacilla flava

A Yellow Wagtail in winter plumage landed on the deck of the ship in the Bering Strait 20 miles east of East Cape on 18 October and remained aboard for about five minutes (Figure 32). The Yellow Wagtail is primarily an Old World species but also breeds in western and northern Alaska. Individuals migrate across the Bering Strait in the spring and fall and five previous pelagic observations have been

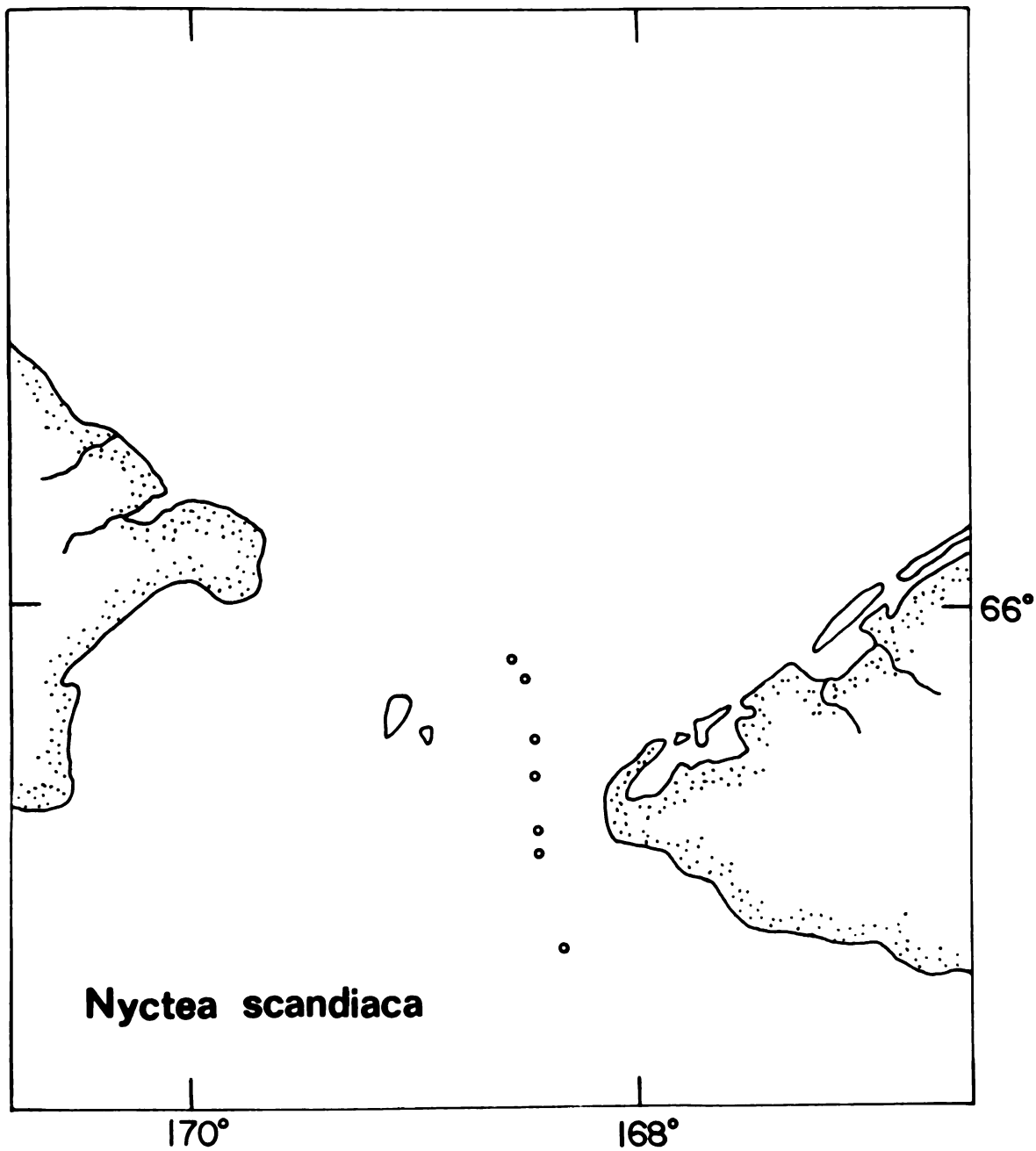

Figure 30. Distribution of Nyctea scandiaca in the Bering Strait.

reported for this region. On Cook's last voyage one was reported in the Bering Strait at 66° 00'N on 3 September 1778 (Stresemann, 1949). An individual was observed in the Bering Sea west of St. Matthew Island on 10 August 1866 (Dall and Bannister, 1869). Swartz (1967) reported three observations in the Chukchi Sea: one off Point Lay on 7 August and two southwest of Point Hope on 10 and 13 August. In addition there have been a number of records from the islands in this area. A specimen was collected on Little Diomede on 13 July 1958 (Kenyon and Brooks, 1960). Flocks with as many as 200 birds have been seen on St. Lawrence Island in August (Sealy et al 1971). There is a record for St. Paul Island on 31 August 1957 and July, August and September records for Nunivak Island (Gabrielson and Lincoln, 1959).

My observation is an extremely late record for this area; most individuals leave Alaska in late August and early September. A record for St. Michael on 21 September (Gabrielson and Lincoln, 1959) is the latest previous record for the mainland and a bird on Attu Island, the most westerly of the Aleutian Islands, on 8 October 1880 (Turner, 1886) is the latest previous record for the state.

Savannah Sparrow — Passerculus sandwichensis

The Savannah Sparrow is a common nesting species in arctic Alaska. A specimen of this species was collected by marine science technicians aboard the GLACIER at 72° 59'N, 167° 36'W 110 miles from the nearest land on 6 September. On 24 September a bird, presumed to be this species, circled the ship ten miles northwest of Wainwright (Figure 31).

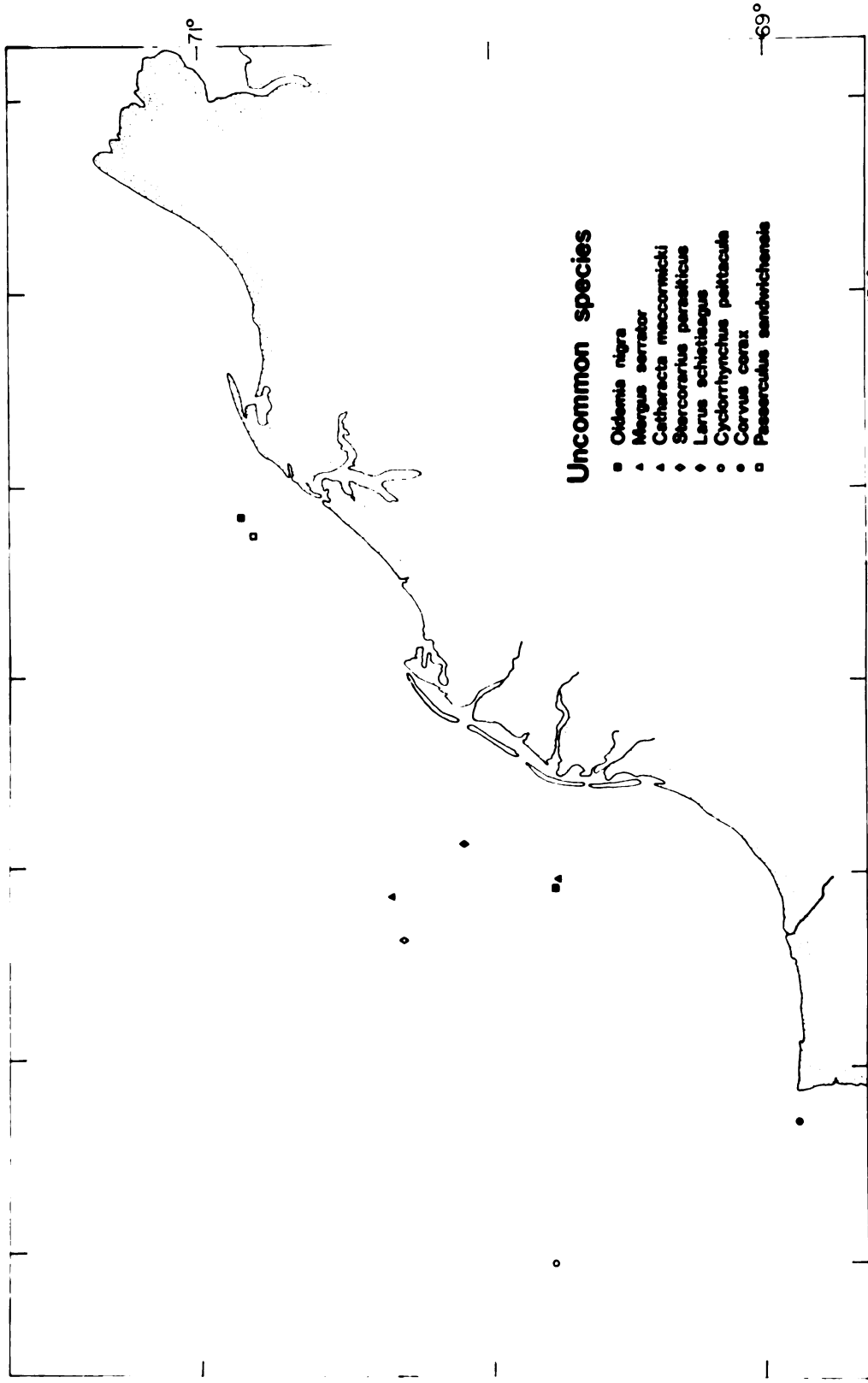

Figure 31. Distribution of uncommon species in the east central Chukchi Sea.

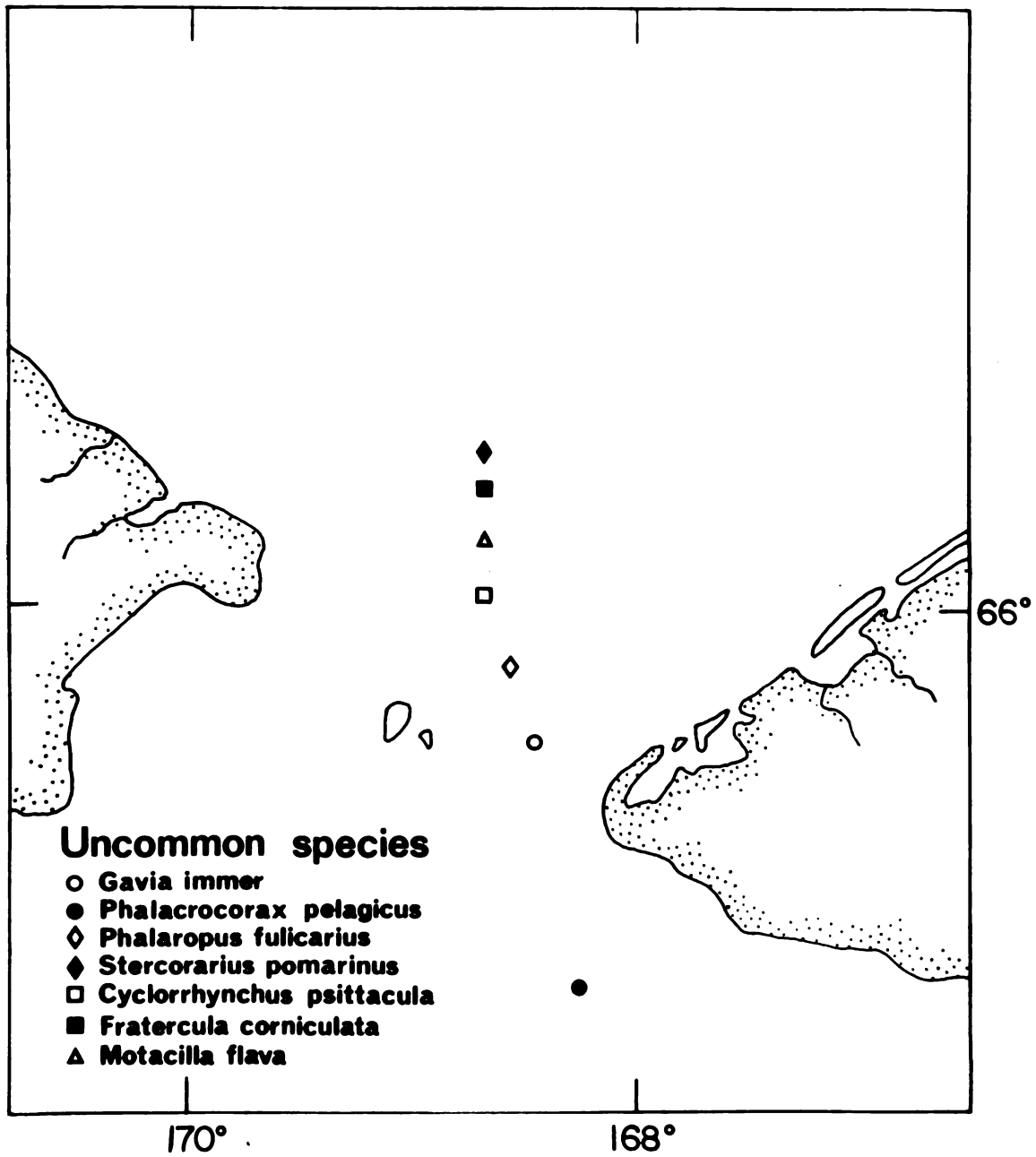

Figure 32. Distribution of uncommon species in the Bering Strait.

Snow Bunting — Plectrophenax nivalis

On 26 September a flock of 15 Snow Buntings was observed on the barrier island at Point Lay. They were feeding on Beach Ryegrass (Elymus mollis), the only conspicuous vegetation on the frozen beach. Six specimens, one an immature, were collected (Table 1). This species was not observed on a second visit to Point Lay on 5 October when snow coverage was greater than on the earlier visit. Most Snow Buntings leave arctic Alaska on migration by mid-September. The latest recorded date for this region is 5 October, when Bailey (1948) saw two birds at Wainwright.

MAMMALS

Polar Bear — Thalarctos maritimus

Polar Bears live on the pack ice throughout the year and are usually found close to areas of water where seals can be obtained. Polar Bears were observed on four occasions, either on the pack ice or swimming next to it. Two lone individuals were seen near Point Barrow on 23 September. On 24 September three bears, presumably a mother and two nearly full-grown young were seen at 71° 08'N, 158° 55'W. A single bear was seen during our deepest penetration into the pack ice at 70° 34'N, 163° 16'W on October 1.

Walrus — Odebenus rosmarus

The Chukchi Sea is the main summering ground of the Pacific Walrus. Most females and young stay in the western Chukchi while the majority of individuals near Barrow are males. Walrus move north in the spring and early summer on ice floes, reaching Point Barrow in mid-July, and

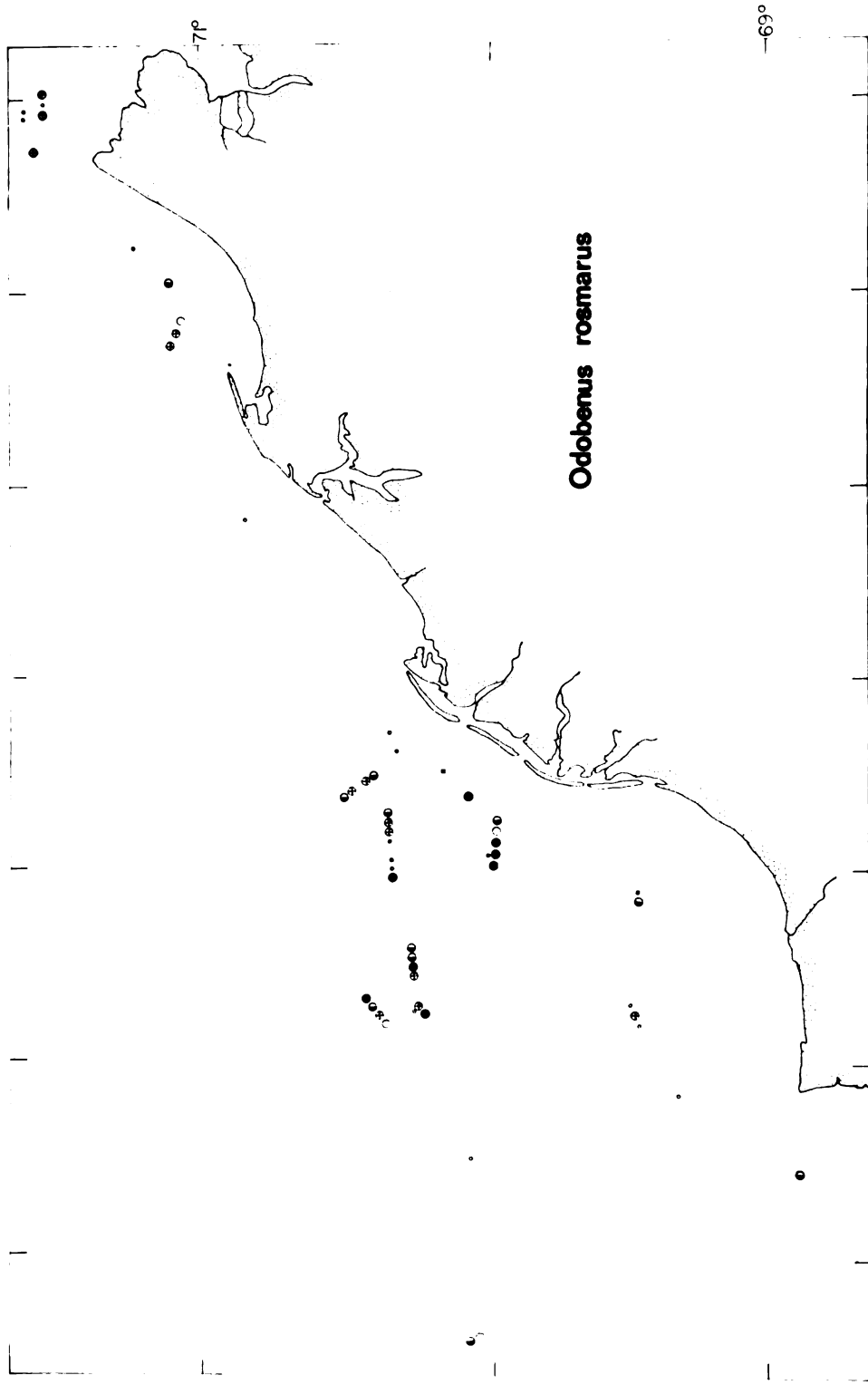

Figure 33. Distribution of Odobenus rosmarus in the east central Chukchi Sea.

start their southward migration toward the Bering Sea in mid-September (Brooks, 1954).

Walrus were observed primarily in the northeast portion of the study area (Figure 33). All large groups were seen in ice areas and most were hauled out on ice floes. The largest single sighting was a group of approximately 525 individuals seen twenty-fice miles northwest of Point Lay. Females with young were observed on six occasions.

Walrus feed by foraging for benthic organisms in water up to 40 fathoms deep. Thus, most of the Chukchi Sea and all of the study area provide suitable depths for feeding. Bivalve molluscs usually constitute the bulk of the food and Mya truncata is the primary food in the waters off Barrow (Brooks, 1954).

Seals Phocidae

Seals were seen throughout the cruise though few were observed well enough to be identified to species (Figure 34). Most seals observed swimming in ice areas were identified as the Ringed Seal (Pusa hispida). Harbor Seals (Phoca vitulina) were seen in the open water off the barrier island at Point Lay. Most of the seals hauled out on the ice during the last days of the cruise were identified as Bearded Seals (Erignathus barbatus). No Ribbon Seals (Histriophoca fasciata), rare visitors to the Chukchi, were observed.

Whales Cetacea

Whales were observed on three occasions. At 71° 08'N, 158° 55'W on 24 September and at 70° 34'N, 163° 16' W on 1 October, single whales

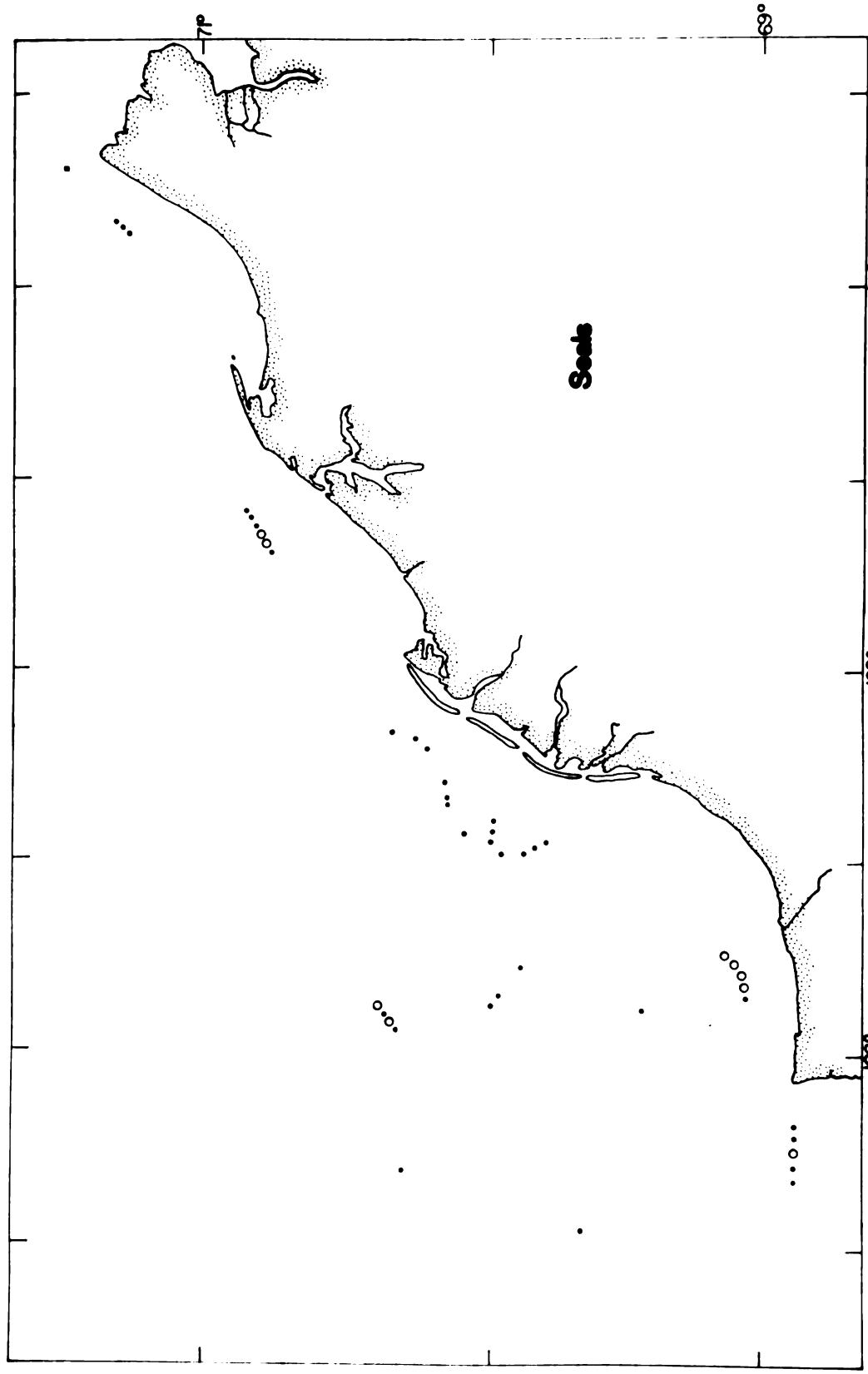

Figure 34. Distribution of seals in the east central Chukchi Sea.

tentatively identified as Bowhead Whales (Balaena mysticetus) were observed. Both individuals were next to the pack ice. The Bowhead Whale is a species usually associated with the pack ice and is more common throughout the Chukchi Sea in the winter. The Grey Whale (Eschrichtius gibbosus) is found in the Chukchi in the summer, but it migrates south in late August and none were observed in the fall of 1970. In 1971, I observed a single Grey Whale in the Bering Strait on 13 August and a herd of five on 14 August ten miles north of Cape Lisburne. Both the Bowhead and Grey Whales are baleen whales which feed on plankton. A group of five to eight Killer Whales (Orcinus orca) was observed in a lead in the ice at 70° 05'N, 168° 53'W on 8 October. A number of Walrus were present in and around the lead and the whales appeared to be pursuing a female walrus with a young on her back.

DISCUSSION

Movements and Migration

Since no land lies directly north of the central Chukchi, any seabirds seen far offshore in fall are either north of their breeding grounds or have moved into the Chukchi from the east or west. Much of the migration of such species as loons, Oldsquaw, eider and other waterfowl occurs inshore and most flocks seen at sea migrate parallel to the shoreline. The species I observed that were north of their breeding grounds include the Slaty-backed Gull, Black-legged Kittiwake and most alcids. In addition to these, the South Polar Skua was observed far north of its usual range. Kittiwakes observed far from the breeding cliffs during the summer are probably primarily non-breeding birds (Swartz, 1967). My observations in September and October undoubtedly also included adults that had moved north after breeding. Murres and Horned Puffins present in the study area had apparently dispersed north and west from the Cape Lisburne cliffs. Murres in the eastern part of the study area could be individuals migrating south from the breeding colony in western Canada. Parakeet and Crested Auklets were considerably north of their nearest breeding grounds in the Bering Strait. Probably most of the Black Guillemots observed had bred in the area of the Cape Lisburne cliffs. Some could also have followed the ice edge eastward from the area of Herald and Wrangel Islands or been among the few birds that nest in the more northerly locations on the Alaskan Chukchi coast.

Most other species I observed had moved into the central Chukchi from either the east or west. Glaucous Gulls are uncommon at sea in

the summer, but my observations show that as they migrate southward, they disperse to the open sea. This is due, in part, to their being freed from ties with land at the end of the breeding season. As fall progresses the southward migration of other avian species decreases the predatory and scavenging opportunities on the tundra and Glacous Gulls can probably find more food at sea.

Ivory Gulls had probably moved into the Chukchi from the Canadian Arctic though it is possible some had also come from breeding colonies on islands north of Siberia. They then move southward later in the fall as the ice edge advances into the Bering Sea. Ross' Gulls had dispersed into the Chukchi from the west and on 25 September, flocks were observed moving in an easterly direction. At most other times, flocks circled the ship and no direction of movement was apparent . It is not known if Ross' Gulls remain in the Chukchi Sea through the winter or continue east to the Canadian Arctic or move circumpolarly in the Arctic Ocean all winter.

Much of the southward migration had already taken place when my observations began on 22 September. No Arctic Terns (Sterna paradisaea) or Grey Whales were seen. The Tufted Puffin (Lunda cirrhatta),which in August 1971, I found to be more common in the Chukchi than Horned Puffin, was not seen in 1970. The Slender-billed Shearwater and Northern Fulmar had already withdrawn southward from the study area and were seen only in the Bering Strait. The Least Auklet is the most abundant small alcid breeding on the Diomedes, but none was seen in the Bering Strait on 18 October.

Between 11 and 17 October, pack ice moved in on much of the study area and new ice began forming in areas of open waters. These

conditions rendered it impossible for some species to find food and cause them to migrate southward. Table 6 lists those species of sea-birds seen between 22 September and 10 October, but not seen in the study area in the last week spent there. Several of these species were encountered again in the Bering Strait on 18 October, but in rather small numbers. The species listed in Table 7 are capable of spending the winter in more northern waters and were seen in the study area during the last week spent there. Of these, the Glaucous Gull, murre and Black Guillemot are known to winter in the Chukchi. Probably the Ivory and Ross' Gulls winter there also. The species listed in Table 7 appear to be the ones found next to and around the ice in the Bering and Chukchi Seas; Irving et al 1970, observed most of them in the ice-covered Bering Sea in March. They did not, however, observe Ross' Gull and they saw the Pigeon Guillemot rather than the Black Guillemot.

Ice Affinities and Feed Habits

The ice edge offers a variety of benefits for the birds associated with it, although the primary one is the availability of prey organisms. The concentration of plankton associated with the ice may be due to a variety of factors. Barnard (1959) found that certain crustaceans, which are usually benthic in inshore areas are closely associated with the ice under surface in the Arctic Basin. This "inverted benthic fauna" is dispersed by meltwater in warmer months. The colder, less saline, meltwater apparently acts, in some instances, to concentrate crustaceans at the water's surface. Hartley and Fisher (1936) found large numbers of copepods swarming and being fed

Table 6. Seabirds seen between 22 September and 10 October 1970, but not seen in the study area after 10 October.

SPECIES	LAST DATE SEEN IN STUDY AREA
Gavia, sp.	6 October
Oidemia nigra	27 September
Mergus serrator	27 September*
Phalaropus fulicarius	7 October
Stercorarius pomarinus	29 September
Stercorarius parasiticus	30 September*
Catharacta maccormicki	29 September*
Larus schistisagus	25 September*
Larus argentatus	8 October
Xema sabini	24 September
Brachyramphus brevirostre	8 October
Cyclorrhynchus psittacula	9 October*
Aethia cristatella	27 September
Fratercula corniculata	10 October

*Single sighting.

Table 7. Seabirds seen after 10 October in the study area.

Clangula hyemalis

Eider sp.

Larus hyperboreus

Pagophila eburnea

Rissa tridactyla

Rhodostethia rosea

Uria sp.

Cepphus grylle

upon by Thysanoessa inermis swarming where a glacier entered the water. The concentration of plankton may be due to the differences in salinity between meltwater and the surrounding seawater. In a situation which did not involve ice, Belopolskii (1961) observed an aggregation of plankton in an area where fresh and salt water came into contact during a tidal movement. In addition to the ice creating conditions that bring crustaceans to the surface, certain species are usually only found associated with the ice and are adapted to living under the pack. Apherusa glacialis is one of these species. The primary fish found associated with the ice is the Arctic Cod. I observed Arctic Cod commonly close to the surface at the edge of ice floes. Frequently the ice would extend under the water where the cod was located, rendering them conspicuous from above. The actual concentration of organisms under the ice is poorly known due to the difficulty of making quantitative horizontal tows in such areas. Fish and invertebrates sampling done during the course of WEBSEC 70 was carried out principally in areas of open water, thus not allowing a comparison of the abundance of organisms found in ice and open water areas.

In addition to food, the ice also provides roosting spots and acts as a windbreak, making surface winds less than in open water. Swells are also dampened by the ice which lets prey organisms be closer to the surface.

Of the species that displayed an affinity for ice, the most obvious was the Black Guillemot. Its close association with pack ice edge is shown by comparing the Black Guillemot distribution map (Figure 25) with the ice condition map (Figure 2). Cepphus grylle is

found in the littoral zone during the breeding season and during the winter, leads in the ice offer a substitute for this zone when the true littoral zone cannot be occupied due to shore ice. Both provide a community of invertebrates and fish associated with a substrate (or actually a superstrate in the case of ice). The distribution of gulls relative to ice was analyzed by dividing stations and 20-minute intervals from the study area into two categories: those with ice and those in open water when no ice was visible from the ship. Observations made in fog were disregarded as were those made in short-lived ice conditions, such as grease and pancake ice. On transects, Ivory and Ross' Gulls showed a preference for ice areas, Glaucous Gulls showed no preference and Kittiwakes were seen primarily in areas of open water (Table 4). At stations, Glaucous, Ivory and Ross' Gulls showed no preference while Kittiwakes again showed a preference for open water. The conflicting figures for Ivory and Ross' Gulls may be due to the resemblance that a large stationary white icebreaker has to an ice floe. Stations at times lasted as long as two days, thus increasing the chances that a species would be observed. Transect observations, therefore, probably present a truer picture of birds' ice preference or tolerance since, in general, the ship is moving through the water and encountering birds rather than sitting at a fixed spot and attracting them. That the Ivory and Ross' Gulls showed ice affinities is not surprising since both are high arctic species. The Ivory Gull's association with the ice is well known. Its habit of rarely sitting on the water forces it to remain close to the ice which provides roosting sites. The carcasses and feces of mammals of the pack ice also

are a major food source for this species. Plankton and fish crushed by the grinding action of ice floes could provide food for the Ivory Gull. Falla (1964) thought that much of the food of the Snow Petrel (Pagodroma nivea) a bird of the Antarctic pack ice, might be made up of crushed plankton. While I did not notice any material floating between ice floes, I did observe Arctic Cod being stranded on top of floes by the shifting of the ice under the icebreaker. Such fish were eaten by both Glaucous and Ivory Gulls. Arctic Cod could presumably be stranded on ice when swells next to the pack ice are moderately high. The Ivory Gull's association with the ice extends even to the breeding season when adults may fly from breeding sites to the pack ice in order to obtain food for the young (Montague, 1926). Breeding colonies have also been found on ice islands (MacDonald and Macpherson, 1962). Ross' Gull is apparently associated with the ice for much of the non-breeding season. The lack of any observations of large flocks after the passages at Barrow in September and October indicates that Ross' Gulls winter primarily around leads in the northern pack ice rather than utilizing the full extent of the pack ice as does the Ivory Gull. Aside from the species, I observed associated with the ice, summer observers have found Red Phalaropes congregating at the ice edge before their southward migration (Nelson, 1883; Jacques, 1930).

The other gull species did not show a preference for ice areas. The generalized feeding habits of the Glaucous Gull allowed it to find food in areas of both ice and open water. The Kittiwake is the most truly pelagic of the gulls and its occurrence in areas of open water is to be expected. It does not require the ice for a roosting site and it was the

only gull that did not have difficulty flying in the high winds found in open water areas. The absence of Kittiwakes from ice areas is not easily explained since Arctic Cod, the only food present in the stomachs examined was closer to the surface next to the ice.

The feeding methods utilized by the four species of gull, however, may be a major factor in their distribution with regard to ice and open water. In water away from the ice, swells are higher and prey organisms occur at greater depths from the surface. Both the Glaucous Gull and Kittiwake were found in open water and are capable of feeding below the surface. The Glaucous Gull can thrust its head underwater while surface feeding and thus feed relatively far from the surface. The Kittiwake is able to submerge all of its body when it feeds by plunging to the surface. The two species I observed primarily around ice, the Ivory and Ross' Gull, are both limited to feeding on organisms at or just below the surface. The Ivory Gull is restricted to aerial feeding methods and the Ross' Gull does not submerge to any extent when plunging to the surface or surface feeding. The differences in the feeding methods of the two species associated with the ice may explain the difference in the food items found in the stomachs. Ivory Gulls are known to feed on crustaceans when they are available, but crustaceans were almost completely absent from the Ivory Gull stomachs I examined. The regular occurrence of Apherusa glacialis in the stomachs of Ross' Gull may indicate that A. glacialis was deep enough to be unavailable to the Ivory Gull. Ross' Gull was able to obtain A. glacialis since surface feeding allows the capturing of organisms at greater depths than aerial feeding. Arctic Cod, equally common in both

Ivory and Ross' Gull stomachs, were presumably present just below the surface, since Ivory Gulls could obtain them by hovering and contact dipping.

Arctic Cod was the primary food utilized by the seabirds other than the Oldaquaw and eider in the study area. Its presence as a prey organism was frequently indicated by otoliths found in bird stomachs. Otoliths are retained in bird stomachs for a while after the muscles and bones of a fish are digested. They vary in shape and size between fish species and are often diagnostic for specific identification. No evidence of Sand Lance, the second most common fish in the study area, was found in bird stomachs. This may be due, in part, to the minute size of the Sand Lance otolith which would let it be easily broken and digested. The Arctic Cod has a relatively large otolith and though it is frequently broken in the stomach, pieces persist and are identifiable. In order to see what size fish were being eaten by the gulls, the intact otoliths present in the stomachs were measured. No difference between bird species was found in the range of the length of otolith present in the stomachs. The stomachs of all 4 species of gull contained otoliths as small as one millimeter, and as large as 6.5 millimeters. Dissection of Arctic Cod showed that a one millimeter otolith is present in a fish of approximately 40 millimeters and an otolith of 6.5 millimeters in a fish of 140 millimeters. The wide range in size of fish taken by the gulls is most interesting with regard to the Ross' Gull. The Ross' Gull is a small gull with a rather weak bill, but it apparently feeds commonly on fish as large as 120 to 140 millimeters.

Oil Pollution and Seabirds

It will be extremely difficult to use the data presented in this thesis in any quantification of oil pollution effects. Bird migration and pack ice phenomena vary from year to year so it is possible that future studies in the Chukchi in the fall may obtain results that differ from mine. The effects of oil pollution on North Slope waterfowl populations could best be monitored by yearly counting of the southward migration past Barrow in the late summer and early fall (see, for instance, Thompson and Person, 1963). Seabirds nesting on cliffs provide the most accurate data on changes in their populations since breeding birds are concentrated and censusing is relatively easy. Unfortunately, no censusing of the cliffs in the area of Cape Lisburne has been done. The censuses of the Cape Thompson cliffs, done by Swartz (1966), will provide excellent baseline data if oil drilling is ever done in the Kotezbue Sound area. The observations I made do show the Chukchi Sea to have large numbers of birds in the fall that could be affected by oil pollution. Many of the species I observed are among those that have been most affected by oil pollution in the North Atlantic (Clark and Kennedy, 1968). These include Gavia sp., Fulmarus glacialis, Clangula hyemalis, Somateria mollissima, Oidemia nigra, Larus spp., Uria sp., and Fratercula sp. The effects of oil pollution in the arctic could be much more severe and longer lived than in warmer waters. The bacteria found in seawater that are capable of degrading oil may be incapable of doing so in the low temperature of arctic seawater (Glaeser and Vance, 1971). Spills might persist for extended periods and continue to affect avian populations.

The work that has been done on the behavior of oil under ice (Glaeser and Vance, 1971) has shown that oil spreads out under a floe and fills the crevices on the floe's undersurface. The importance of the ice undersurface as a habitat for various organisms has already been mentioned. The paucity of species (partly compensated by abundance of individuals) in arctic ecosystems renders predators that are dependent on specialized sources of prey particularly vulnerable to man-made disasters. If oil pollution greatly decreased the population of Arctic Cod or the crustaceans the cod feed on, the major food source for migrant seabirds in the Chukchi could be eliminated.

SUMMARY

The observations presented here are the only at-sea fall observations for the birds and mammals of the Chukchi Sea. Migration was well underway by 22 September when my observations started. The less tolerant species, including loons, phalaropes, jaegers and some species of gulls were seen only in the first part of the cruise and only in small numbers. Oldsquaw, eider and Black Guillemot were seen throughout the cruise. Glaucous, Ivory and Ross' Gulls were common. Black-legged Kittiwakes were seen in lesser numbers. Most noteworthy of the distributional records are a single South Polar Skua and a large concentration of Crested Auklets. The ice edge proved to be an important feeding zone for the Ivory and Ross' Gulls and the Black Guillemot. These species were not seen commonly any distance from the ice. Glaucous Gulls were found throughout the study area and Kittiwakes avoided ice areas. The primary food of almost all species collected

was Arctic Cod, though the amphipod Apherusa glacialis was equally common in the stomachs of Ross' Gull. The Chukchi Sea was found to have many species present in the fall that could be adversely affected by oil pollution.

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