SUMMER BIRDS OF THE PACK ICE IN THE WEDDELL SEA, ANTARCTICA

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Severe pack ice conditions have greatly limited scientific investigations in the Weddell Sea, that expanse of water east of the Antarctic Peninsula. Since the sea's discovery by the British navigator James Weddell in 1823, it has presented a formidable obstacle to explorers and scientists alike. As participants in the 1968 International Weddell Sea Oceanographic Expedition (IWSOE), we were given an unusual opportunity to obtain information on the wildlife species frequenting this remote part of the world. Our investigations were carried out from aboard the USCGC 'Glacier,' an icebreaker capable of operating continuously in heavy pack ice, which enabled us to reach parts of the Weddell Sea never before visited by man. This venture was undertaken and financed by the United States Antarctic Research Program (USARP) of the National Science Foundation. Although our primary concern was a population study of antarctic seals, a considerable amount of time was also spent observing birds. This paper reports the occurrence, distribution, and relative density of the bird species we encountered in pack ice of the Weddell Sea during the 1968 austral summer.

The information was obtained during 95 hours of census taking between 30 January and 15 March 1968. Counts were made on 35 of the expedition's 44-day cruise between 62°09′ and 75°28′ S and 38°07′ and 60°09′ W (Figure 1).

Sladen and Friedman (1961), among others, revealed that considerable attention has already been given various aspects of antarctic ornithology, but Voous (1965) emphasized that details of the pelagic distribution, specific behavioral differences, and the seasonal vicissitudes of most species are still incompletely known.

Szijj (1967) considered the Antarctic Convergence as the transition area between bird faunas of the southern ocean, but with much blending and mixing between truly antarctic and subantarctic species obscuring this division. According to Voous (1965), at least 33 species of birds frequent antarctic waters during the summer. Of these 17 nest on the antarctic continent (Sladen and Friedman, 1961).

Little has been reported on the avifauna of the Weddell Sea, especially in areas of pack ice. Clarke (1907) summarized the findings of biologists aboard the 'Scotia' during the Scottish National Antarctic Expeditions of 1903 and 1904, and Novatti (1962) discussed the pelagic distribution of 24 species of birds in the Weddell Sea during the summers of 1955–56

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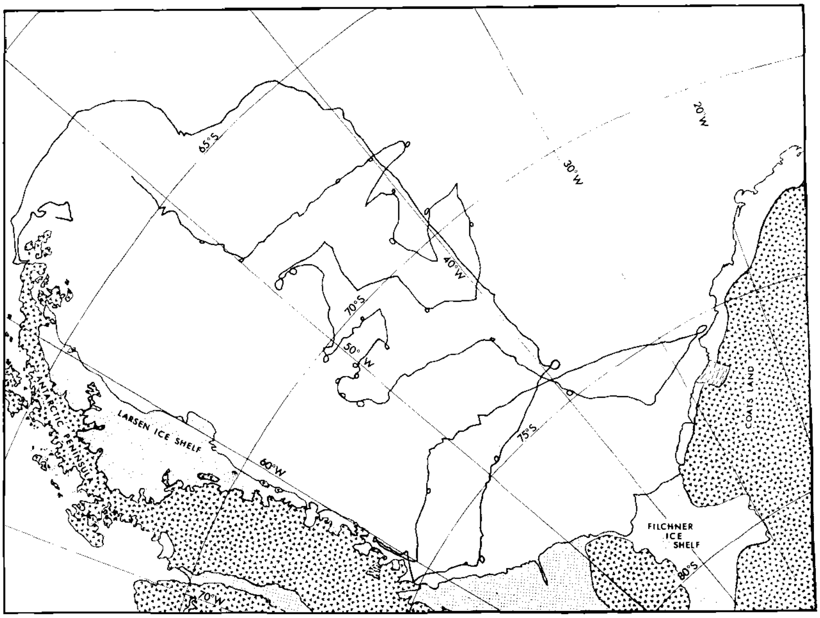

Figure 1. Map of the Weddell Sea showing track of the USCGC 'Glacier' during the 1968 IWSOE.

and 1959–60. Novatti's observations were made between 59°09′ and 77°58′ S and 14°23′ and 46°15′ W whereas Clarke's summaries pertained to bird life south of the 60th parallel and between 12° and 45° W. Both workers included in their discussions species typical of onshore as well as pelagic distributions. This study considers only those species found associated with pack ice.

The Weddell Sea is a large expanse of water southeast of the southernmost tip of South America, bounded on the west by the Antarctic Peninsula and on the east by Queen Maud Land. To the north lie the Scotia Sea and Drake Passage; the massive ice walls of the expansive Filchner Ice Shelf form its southern boundary (Figure 1). Ronne (1956) and El-Sayed (1966) have provided the most thorough discussion of the Weddell Sea and its environs. Klepikov (1963) presented a comprehensive discussion of the history of exploration in the area as well as the sea's hydrography. The brief description below is primarily from El-Sayed (1966).

The Weddell Sea is a large depression (graben) lying between the eastern and western sectors of Antarctica. It averages between 4,500 and 4,700 m in depth except near land; maximum depth is reported at 8,268 m. The sea's floor is formed by one of the largest continuous abyssal plains discovered to date, being over 300 km wide from north to south. The tide is both diurnal and semidiurnal with a double amplitude ranging between 0.6–3.2 m.

Prevailing winds averaging 6.9 m/sec (15.4 mph) off the coast are southeasterly and produce a well-defined clockwise circulation of surface waters. This causes the eastern and southeastern borders of the sea to become ice-free in summer with the drifting floes compacting under tremendous pressure along the Antarctic Peninsula to the west and northwest. Thus a combination of meteorological, hydrological, and geographical factors causes the unusually heavy concentrations of ice normally prevailing in the western sectors of the Weddell Sea.

El-Sayed and Mandelli (1965) conducted a biological productivity investigation of the northern and eastern parts of the Weddell Sea by studying primary production and standing crop of phytoplankton in the euphotic zone. During the 1968 IWSOE 40 oceanographic stations were occupied at local apparent noon in the virtually unknown southern and western parts of the Weddell Sea. Preliminary analysis of the data (El-Sayed, 1968a) indicates that despite conspicuous variations in the productivity of the areas visited, the southwest and western regions of the Weddell Sea are, by and large, far more productive than the central and southern regions. The average primary productivity for the stations occupied during the IWSOE is 0.44 $gC/m^2/day$, which compares favorably with Steemann Nielsen's (1954) figure of 0.5 $gC/m^2/day$ for the English Channel and far surpasses the summer average of 0.01 $gC/m^2/day$ for the Arctic Ocean (Ryther, 1963). Only arbitrary comparisons can be made of such data, because productivity measurements show a high degree of variability within specific water bodies and at different times of the year. This can be related to the inherent complexities of different water masses and current systems and makes comparisons between water bodies extremely difficult (Ryther, 1963).

On 10 February we encountered a very thick bloom of phytoplankton over approximately 6,000 square miles near the Filchner Ice Shelf in the southwestern Weddell Sea. Surface chlorophyll *a* up to 123.6 mg/m^3 and primary production up to 82.41 $mgC/m^3/hr$ were reported from a station occupied in the area of bloom (El-Sayed, 1968b). The integrated chlorophyll *a* and primary production values in the euphotic zone at this station were 81.47 mg/m^2 and 1.4 $gC/m^2/day$. In the northwest Pacific Ocean, Sorokin and Koblentz-Mishke (1958) found productivity extremely variable and stated that the higher values were usually associated with "cold spots" presumably indicative of local vertical turbulence.

The tabular icebergs conspicuous in certain parts of the Weddell Sea reportedly calve primarily from the Filchner and Larson Ice Shelves.

Figure 2. Open water areas break up the homogeneity of the pack ice and serve as important feeding grounds for sea birds and mammals.

Huge bergs the size of the state of Connecticut and well over 150 km in length have been sighted.

Open water areas (polynyas) are frequently encountered within the pack and vary in size from a few hundred yards to several miles across. Leads also tend to break up the homogeneity of the pack. These stretches of open water are of extreme importance to marine birds and mammals in that they provide feeding grounds in what most of them would otherwise find an inaccessible and unattractive environment (Figure 2).

METHODS

Bird observation periods were scheduled simultaneously with those for censusing seals. To determine possible diurnal variations in vertebrate activity patterns, 2-hour census periods were established within the 24-hour days as follows: 24:00–02:00, 06:00–08:00, 12:00–14:00, and 18:00–20:00, G.m.t. Lengthening periods of darkness as the cruise progressed necessitated abandonment of the midnight census period after only four counts.

Observations were made from the flying deck of the 'Glacier,' 52 feet above the waterline while the ship traversed the pack ice. Two observers were normally present during each count, but when traversing areas where seals and birds were few, one investigator was able to accomplish a census by standing amidships and counting on both sides of the vessel. The transect width was ¼ mile or 220 yards out on either side of the ship. Several counts of penguins were attempted by use of the ship's H-19 helicopter, but the data were limited and are not discussed.

A simple rangefinder device (Siniff et al., 1969) was used to delimit transect boundaries and only those birds sighted within the transect were tallied (Figure 3).

RANGE FINDING BOARD TO DETERMINE WIDTH OF CENSUS STRIP

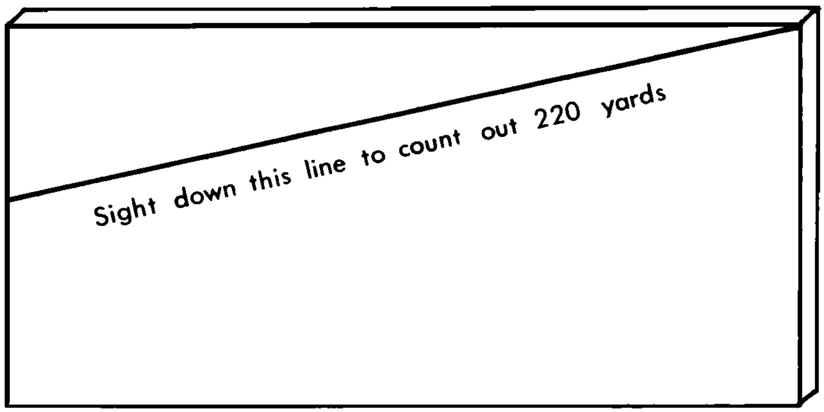

Figure 3. A simple rangefinder device for determining transect boundaries from 52 ft above the water line (see text).

The device was made from a 5 × 15 inch piece of ⅜-inch plywood with angle lines drawn on each side to indicate line of sight. The top edge of the board was first sighted at the horizon, then the outer boundary of the census strip was determined by sighting along the angle line. Some difficulty was encountered in using this device when birds were located near the edge of the census strip. In such instances several sightings were taken before a determination was made either to accept or reject the birds involved.

During each count an attempt was made to identify and count all birds sighted. Birds were recorded whether on the wing or resting on the ice or water. In certain situations exact counts were not possible, as when birds circled fore and aft of the ship or were crowded together on the ice in flocks. At such times total numbers were estimated to avoid duplications. Hence the population estimates of the more abundant species may be somewhat conservative.

Alexander's "Birds of the ocean" (1928) was used as an identification guide with Murphy's "Oceanic birds of South America" (1936) used for verifications. Nomenclature is after Peters' "Check-list of birds of the world" (1931, 1934). Binoculars (7 × 50) were used to aid in identification.

Bird numbers and distributions were evaluated on the basis of possible influence by such environmental factors as cloud cover, air and surface water temperature, wind direction and velocity, and sea ice concentrations. The environmental data were recorded hourly by the ship's meteorological personnel. Cloud cover and pack ice concentrations were classified as tenths coverage, with 1.0 representing 100 per cent coverage.

Hourly ship's positions obtained via polar orbiting satellite were used to determine the distance (statute miles) traveled in each census period. In those instances when position readings were not obtained or appeared to be in error, average ship's speed for a particular period was determined and used to compute the distance.

Heavy cloud cover, blowing snow, fog, and dim light occasionally interfered with accurate census taking, as did ice hummocks which often obstructed an open view of penguins on ice floes. Whenever visibility was reduced to 220 yards or less censusing was discontinued.

RESULTS

Our findings revealed a paucity of bird species within the pack ice environment of the Weddell Sea; only 11 were identified. Of these the following 5 were considered as primary species based on their greater abundance and frequency of occurrence and are listed in declining order of abundance:

Adélie Penguin, *Pygoscelis adeliae*
Snow Petrel, *Pagodroma nivea*
Arctic Tern, *Sterna paradisaea*
Emperor Penguin, *Aptenodytes forsteri*
Antarctic Petrel, *Thalassoica antarctica*

The remaining six were infrequently encountered and were classified as secondary species of the pack. They are listed in declining order of abundance:

Wilson's Petrel, *Oceanites oceanicus*
Cape Petrel, *Daption capensis*
Dove Prion, *Pachyptila desolata*
Chinstrap Penguin, *Pygoscelis antarctica*
Giant Petrel, *Macronectes giganteus*
Southern Skua, *Catharacta* sp.

These latter birds are generally considered more typical of either open seas or onshore habitats, but they frequent pack ice on occasion during their summer travels. Both species of Southern Skua (*Catharacta maccormicki* and *C. lonnbergi*) occur in the Weddell Sea, but as they are difficult, if not impossible to distinguish at a distance, we have used only their generic name. Undoubtedly other antarctic birds might be encountered occasionally over ice in the Weddell Sea, but none were identified during this study.

Although the Adélie Penguin was by far the most numerous of the 11 species encountered, both the Snow Petrel and Emperor Penguin were sighted on the greatest number of cruise days (Table 1). The Arctic Tern and Antarctic Petrel were observed on about half the days, while the six secondary species were seen infrequently. Density figures showed the Adélie Penguin to average 28 individuals per square mile (Table 2). On 15 March a peak count of 1,360 Adélies was made off the tip of the Antarctic Peninsula in a 1 hour period. This represented a population of

TABLE 1

NUMBER OF BIRDS SIGHTED DURING 35 DAYS OF SHIPBOARD CENSUS IN THE WEDDELL SEA 28 JANUARY TO 15 MARCH 1968

Species	Number	Per cent	Number of days sighted	Per cent of total days
Adélie Penguin	6,571	69.53	25	71.4
Snow Petrel	1,686	17.84	29	82.8
Arctic Tern	567	6.00	18	51.4
Emperor Penguin	310	3.28	28	80.0
Antarctic Petrel	202	2.14	17	48.6
Wilson's Storm Petrel	31	0.33	2	5.7
Cape Petrel	25	0.26	3	8.6
Dove Prion	24	0.25	1	2.9
Chinstrap Penguin	23	0.24	4	11.4
Giant Petrel	8	0.09	3	8.6
Southern Skua	4	0.04	2	5.7
TOTAL	9,451	100.00	35	—

235 birds per square mile. Other than the Snow Petrel, which reached a peak density of approximately 121 individuals per square mile, the remaining species were widely dispersed.

Ice concentrations appeared to influence bird distributions and densities. This becomes obvious when the number of sightings per hour for the various species was considered in relation to four arbitrary concentrations of ice; i.e. open water (0), light ice concentration (0.1–0.3), medium concentration (0.4–0.6), and heavy concentration (0.7–1.0). In the open water of the larger polynyas and leads the typically pelagic Wilson's Petrel and Dove Prion reached greatest numbers (Table 3). The three penguin species occurred only on the perimeter of these open water areas. Light ice concentrations with more than 50 per cent open water proved attrac-

TABLE 2

BIRD SPECIES DENSITY IN SQUARE STATUTE MILES, WEDDELL SEA, 28 JANUARY TO 15 MARCH 1968

Species	Total number counted	Mean density	Maximum density	Date of maximum density	Position of maximum density
Adélie Penguin	6,571	28.4	235.2	15 Mar.	64.06 S/50.02 W
Snow Petrel	1,686	7.3	120.9	1 Feb.	62.22 S/54.03 W
Arctic Tern	567	2.5	36.0	14 Feb.	74.37 S/37.45 W
Emperor Penguin	310	1.3	13.8	7 Feb.	74.51 S/48.16 W
Antarctic Petrel	202	0.9	7.7	1 Feb.	62.09 S/52.12 W
Wilson's Storm Petrel	31	0.1	4.0	1 Feb.	62.22 S/54.03 W
Cape Petrel	25	0.1	4.4	1 Feb.	62.22 S/54.03 W
Dove Prion	24	0.1	5.1	7 Mar.	68.36 S/41.32 W
Chinstrap Penguin	23	0.1	3.3	1 Feb.	62.22 S/54.03 W
Giant Petrel	8	0.03	0.7	1 Feb.	62.22 S/54.03 W
Southern Skua	4	0.02	0.7	1 Feb.	62.22 S/54.03 W

TABLE 3

NUMBERS OF BIRDS OF VARIOUS SPECIES SIGHTED PER HOUR WITHIN VARIOUS CONCENTRATIONS OF PACK ICE, WEDDELL SEA, 1968

	Ice concentration			
	0	1–3	4–6	7–10
Adélie Penguin	—	4.2	20.7	109.0[1]
Snow Petrel	11.0	60.1[1]	15.3	12.7
Arctic Tern	1.25	12.2	15.0[1]	2.0
Emperor Penguin	—	3.5	4.8[1]	2.9
Antarctic Petrel	3.6	7.6[1]	0.9	1.5
Wilson's Storm Petrel	0.9[1]	0.5	0.1	0.3
Cape Petrel	0.1	—	0.1	0.4[1]
Dove Prion	3.0[1]	—	—	—
Chinstrap Penguin	—	2.5[1]	—	—
Giant Petrel	0.1[1]	0.1[1]	0.05	0.08
Southern Skua	—	0.1[1]	—	0.05
TOTALS	3	5	2	2

[1] Peak frequency/hour for species.

tive to the most species. The Snow petrel and Antarctic Petrel were the most noticeable, and the Chinstrap Penguin, Giant Petrel, and Southern Skua, although few in number, were also noted more frequently there. In areas of medium ice concentration the Arctic Tern and Emperor Penguin reached greatest numbers, while the Adélie Penguin seemed to prefer heavy pack ice with less than 30 per cent open water. The Cape Petrel also reached peak abundance in areas of heavy ice, but this was obviously biased by a single high count, for the species is typically found over open water. The Giant Petrel and Southern Skua were sighted so infrequently that nothing precise can be stated of their environmental preferences; both seem to range widely over ice of varying concentrations.

Time of day seemed to have little influence on the number of birds observed, although the maximum number of sightings (for all birds) was made during the morning (06:00–08:00) census period (Table 4). Much more needs to be learned of species activity patterns before optimum census periods can be determined. Of greater importance to accurate counting than time of day were weather conditions that influenced observability. On overcast days with wind or fog birds tended to sit tighter and to be less conspicuous. Weak light at evening or dawn made accurate censusing difficult.

NOTES ON THE PRIMARY SPECIES

ADÉLIE PENGUIN (*Pygocelis adeliae*)

The Adélie Penguin is a highly successful species and completely circumpolar in distribution south of 60° S. Falla (1964) notes that the

TABLE 4

AVERAGE NUMBER OF BIRDS OF VARIOUS SPECIES OBSERVED WITHIN DAILY CENSUS PERIODS

Species	Census periods			
	24:00–02:00	06:00–08:00	12:00–14:00	18:00–20:00
Adélie Penguin	54.8	107.4[1]	9.9	52.7
Snow Petrel	24.3	7.2	43.4[1]	17.3
Arctic Tern	28.9[1]	1.0	12.9	3.3
Emperor Penguin	6.3[1]	2.1	1.9	4.4
Antarctic Petrel	2.0	1.3	2.5	3.0[1]
Wilson's Storm Petrel	—	0.05	1.7[1]	0.2
Cape Petrel	—	0.05	1.5[1]	0.03
Dove Prion	—	0.5[1]	0.4	—
Chinstrap Penguin	—	—	—	0.7[1]
Giant Petrel	—	0.1	0.2[1]	0.03
Southern Skua	—	0.03[1]	0.2	—
TOTALS	116.3	119.73	74.6	81.66
Total census time (hr)	8	39	14	34
Number of species for which peak count was obtained	2	3	4	2

[1] Peak count for species.

species occupies a variety of niches in Antarctica and attributes this to the fact that the birds are adapted to nest on almost any well-drained site along the coast.

Adélies were commonly observed on the lee sides of ice hummocks and pressure ridges in flocks of 10 to 25 individuals. The snow around them was generally stained with their excreta and accumulations of feathers showed the birds were molting. Our observations tend to support Penney's (1967) thesis that most Adélies molt on floating pack ice after dispersing from the breeding rookeries in early February. He describes their molt as normally requiring about 3 weeks to complete, during which time they may experience a weight loss of up to 45 per cent. He relates their sedentary behavior during the molt to thermoregulation and notes that they move from sheltered areas only when disturbed. We found this to be true on the pack ice also, for the birds did not move from their "molting stations" until the ship approached to within 100 yards of them. By late February we often saw flocks of Adélies swimming in the water of open leads, showing they had completed their molt and had resumed feeding in the sea. Some Adélies were still conspicuously in molt at the end of the study period in mid-March.

Figure 4 depicts the uneven distribution and density of the species. In contrast to the Emperor Penguin, Adélies reached greater densities toward the northern limits of the pack ice. Many of these birds could have come

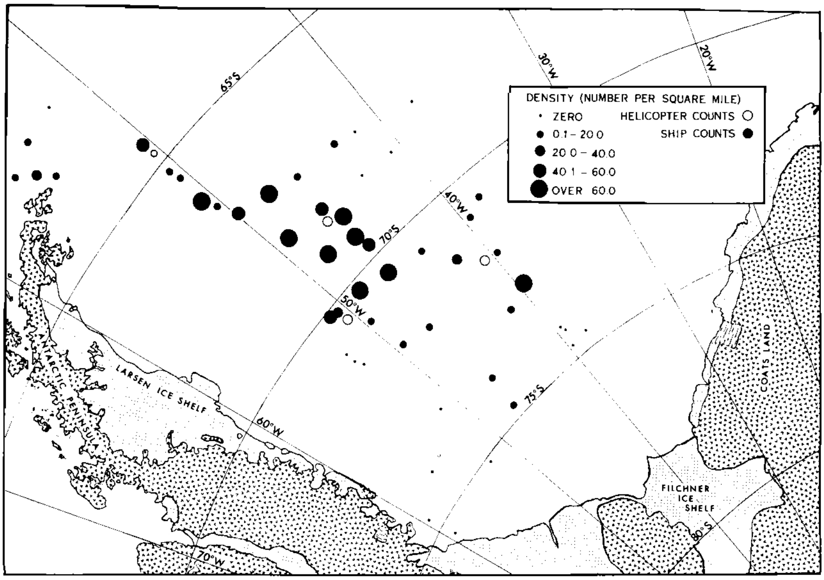

Figure 4. Density distribution of Adélie Penguins in the Weddell Sea, January–March, 1968.

from the large rookeries near the tip of the Antarctic Peninsula or from those on islands in the Scotia Sea to the north.

SNOW PETREL (*Pagodroma nivea*)

Clarke (1907) found the Snow Petrel to be one of the most abundant and frequently observed birds during the 'Scotia' Expedition to the Weddell Sea. It proved to be the most numerous flying bird we encountered.

With the possible exception of the Southern Skuas, the Snow Petrel has the most southerly distribution of any bird (Maher, 1962). It has been reported to breed from South Georgia (Falla, 1964) to nunataks and rock exposures 300 km inland from antarctic coasts (Lövenskjöld, 1960). The smallest and most delicate of the fulmarine petrels, it is seldom found over the open sea, but instead prefers to forage in the pack ice (Falla, 1964).

Snow Petrels were sighted on all but 6 days of the cruise. Not uncommonly a few of these birds circled closely about the ship throughout the day, and it was the only species that alighted on the open decks of the ship.

Like other fulmars the Snow Petrel is apparently well-adapted to scavenge food materials from its environment. We often saw individuals pick food items from the water, and twice we noted birds feeding on the excrement of Crabeater Seals (*Lobodon carcinophagus*). When we were on the ice working with the seals we commonly noted macroscopic marine invertebrates floating on the water surface between floes, probably the result of the grinding action of shifting ice. Falla (1964) suggests that a great deal of the food of the Snow Petrel is undoubtedly dead or injured macroplankton and their parts picked up between the floes.

ARCTIC TERN (*Sterna paradisaea*)

We found the Arctic Tern, famous as the champion long distance migrant, the third most numerous species in the pack ice environment. Salomonsen (1967) states that the antarctic pack ice zone constitutes the main wintering area of the species and that hundreds of thousands of individuals may be found there, especially from about 150° E westwards to the eastern Weddell Sea (about 30° W). From the Weddell Sea westward to the Ross Sea the bird is reportedly extremely scarce, and in most localities completely absent. Clarke (1907) reports seeing thousands at 72°31′ S on 5 March 1904 and that many were seen while the 'Scotia' was beset in pack ice 9–13 March of that year.

This bird can be mistaken in the field for the Antarctic Tern (*Sterna vittata*) which is known to breed on the west coast of the Antarctic Peninsula south to at least 68°. As we did no collecting, our sight identifications may be questioned, but Salomonsen (1967) points out that "the two species have completely separate ranges, the Arctic Tern keeping to the ice-edge, and the Antarctic Tern requiring icefree sea or areas with only a very slight coverage of ice near its breeding place on firm land." The Arctic Tern's presence in the Weddell Sea has been definitely established from collections made by the 'Scotia' expedition of 1904 (Clarke, 1907) and the William Barendsz Expedition 1946–47 and 1947–48 (Bierman and Voous, 1950). We are confident, therefore, that the terns we sighted were indeed Arctic Terns, although additional collecting in this area should be encouraged.

We saw numerous loose flocks of terns either resting on the ice or flying over the open waters of polynyas and leads. They seldom approached the ship as closely as most of the other species and usually moved away as the ship approached. On days with heavy fog or strong winds Arctic Terns frequently rest on ice floes. Fog may restrict their normal feeding activities, for Hawksley (1957) notes that in arctic breeding grounds their chicks gain weight on clear days but generally lose weight on foggy days.

The pack ice environment offers this species an attractive wintering environment which is in many ways homologous to its breeding grounds in the Arctic. In antarctic waters the birds reportedly feed on surface dwelling crustaceans (Clarke, 1907), including euphausids (Voous, 1965), and rest on ice floes between feeding forays and during their wing and tail feather molt from January to March. The species probably has few, if any, enemies during its sojourn in the pack ice, some 18,000 km south of its breeding grounds in the northern hemisphere.

EMPEROR PENGUIN (*Aptenodytes forsteri*)

Korotkevich (1963) estimates the world population of Emperor Penguins to be 350,000 breeding in at least 29 rookeries. We sighted these majestic birds on 83 per cent of the cruise days, most commonly as lone individuals or in pairs. While working on the ice it was not uncommon to hear their braying calls in the distance, and occasionally one or more birds wandered up to investigate our presence.

Emperor Penguins have only a short pause in a breeding cycle that extends from mid-March to mid-January (Prévost, 1961). We found them rather scarce in the northern part of their range during this period and recorded peak numbers in the southwestern sector of the Weddell Sea (Figure 5). Falla (1964) postulates that if it can be demonstrated that Emperors breed every year "it would mean that their pelagic life would depend mainly on distance from breeding place." Small numbers of juveniles and subadults do appear annually during the molting period as far north as the Beagle Channel in Tierra del Fuego (Falla, 1964). This could explain the presence of Emperors sighted in northern reaches of the Weddell Sea early in the study period. Only two birds were collected at sea; both were immatures just completing their molt. The beaks of cephalopods along with numerous gneiss pebbles were identified among the green mass of material in their stomachs.

ANTARCTIC PETREL (*Thalassoica antarctica*)

The fifth most common species of the pack ice, the Antarctic Petrel is another truly antarctic bird of circumpolar distribution (Falla, 1964). Clarke (1907) reports seeing it almost daily in the ice fields. The bird is reported to feed primarily on crustaceans found on the water surface (Murphy, 1964).

We most commonly observed this bird winging past the ship in small groups of from two to five individuals. Like the Snow Petrel, the birds occasionally circled the ship. Small groups were also occasionally seen roosting on ice floes. Bierman and Voous (1950) report that the bird likes to rest on the tops of huge icebergs, often in flocks of hundreds. We saw no such large concentrations, and approximately eight individuals per square mile was the peak density we recorded.

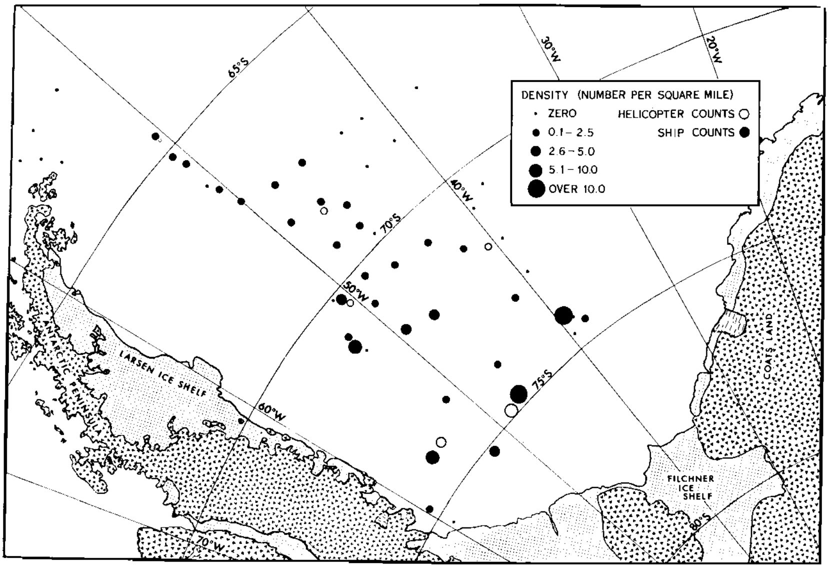

Figure 5. Density distribution of Emperor Penguins in the Weddell Sea, January–March, 1968.

Discussion and Conclusions

Abundance of selected food organisms is believed the primary biogeographic control of most birds (Lack, 1954). Voous (1965) considered summer pelagic distribution records for antarctic birds as reflecting food abundance and the primary reason for the mingling of birds of the subantarctic with those of the antarctic zone during the austral summer. Jesperson (1930) demonstrated that numbers of birds at sea tend to be directly proportional to density of plankton. Apparently many birds, together with seals and whales, follow the retreating ice southward in summer feeding as they go. Routh (1949) believes that most feeding takes place close to the edge of the pack ice where quantities of drifting zooplankton accumulate.

The work of oceanographers aboard the 'Glacier' showed that waters within the pack were often as productive as those far removed from drifting ice. Invertebrate organisms including euphausids were often so conspicuously abundant it was not surprising to find various vertebrates exploiting them for food. Although the paucity of bird species is obvious in such regions, some species often reached high densities. The drifting floes offer the birds a stable substrate on which to rest or sleep in the immediate vicinity of a ready food supply. The drifting ice also enables the flightless penguins to disperse widely from their breeding rookeries into regions relatively free from predators (and probably disease). Here they can accomplish their feather molt in the shelter of ice hummocks and pressure ridges.

Within the pack ice the distribution and density of the various birds is influenced by the ice concentration. We found the majority of species most abundant in medium ice concentrations with ample open water for feeding between the floes. Such common species as the Adélie and Emperor Penguins and the Snow Petrel ranged widely over ice of varying concentrations but reached highest densities in heavier ice. Emperors were most abundant in southern reaches of the pack and were replaced in numbers to the north by Adélies.

Only four specimens were collected during the expedition, two Adélie and two Emperor Penguins. These are in the collections of the James Ford Bell Museum of Natural History, Minneapolis, Minnesota.

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SUMMARY

The icebreaker 'Glacier' enabled us to determine the occurrence, distribution, and density of birds within the little-explored pack ice areas of the Weddell Sea, Antarctica. On 35 days during the summer of 1968 a total of 11 species of birds were sighted. Five of these we considered as primary species of the pack based on their frequency of occurrence and total numbers seen. The others were seen only occasionally and generally near the edge of the pack. The Adélie Penguin was the most abundant of all birds encountered, and the Snow Petrel was the most frequently sighted.

Concentration of pack ice influenced both bird distribution and abundance. Most species were found in greatest numbers in areas where ice concentration was less than 50 per cent, though the Adélie Penguin reached greatest densities in heavy ice concentrations (± 70 per cent coverage).

Scattered ice floes within the pack provide a stable substrate on which birds can rest, sleep, and molt in an environment relatively free from enemies and usually close to a plentiful supply of food in open polynyas and leads. The drifting and grinding action of the ice appears to disable and concentrate various invertebrate organisms and make them more readily available to birds.

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