LATITUDINAL DISTRIBUTION OF SEABIRDS BETWEEN NEW ZEALAND AND THE ROSS SEA, DECEMBER 1970

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ABSTRACT

The distribution and behaviour of the seabirds observed from New Zealand to the Ross Sea are described. Information was obtained in December 1970 from an eight day traverse of the USCGC *Staten Island* which covered 39 degrees of latitude. Seabird distributions appeared to be governed by such hydrological features as the Antarctic Convergence and the 0°C sea surface isotherm (northern pack-ice edge). Analysis of published data indicate a progressive breakdown in the zonal distribution of seabirds from early to late summer. Summer warming leads to both the increased southward penetration of some subantarctic species, and the increased northward spread of some Antarctic species.

INTRODUCTION

During the last eight days (23-31) of December 1970, I voyaged to the Antarctic aboard the USCGC *Staten Island* to participate in the N.Z. Oceanographic Institute's 1970-71 NZARP activities. The voyage provided the opportunity to record the seabirds occurring between Wellington, New Zealand, and the Ross Sea, Antarctica. One brief supply call was made at Campbell Island (52°30'S, 169°00'E) on 26 December. The ship followed roughly the 169°-174° meridians (Fig. 1). From just off Beaufort Island (76°57'S, 166°55'E) I was flown by helicopter the remaining 78 kilometers to McMurdo NAF.

Ten minutes of each daylight hour were spent birdwatching and the number of each species was recorded. Daily details of noon position, sea and air temperatures, barometric pressure and wind speed and direction were taken from the ship's log (Table 1). Northern and southernmost sightings of the various bird species are based on the ship's noon position.

PREVIOUS WORK

Two major contributions to our knowledge of the latitudinal distribution of seabirds in the area of ocean from New Zealand to the Antarctic have been made (Dell 1960; Darby 1970). Dell's two traverses followed direct courses from New Zealand to the Ross Sea, confined between the 170°E and 180° meridians, while Darby's four extensive traverses along the 160°, 170° and 180°E meridians made landfalls at the Chatham, Bounty, Campbell, Enderby and

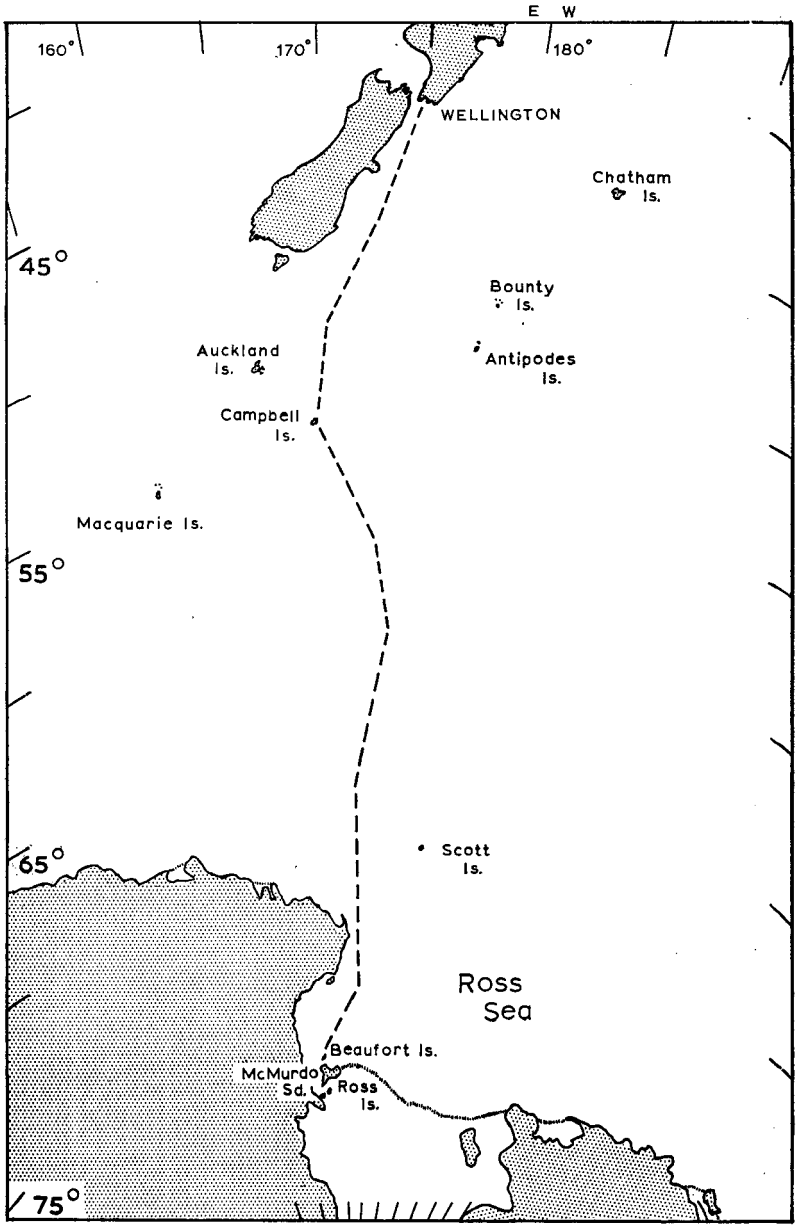

FIGURE 1 — Track of the USCGC *Staten Island,* December 1970.

Macquarie Islands. Isolated observations on the birds breeding at, and within range of the subantarctic islands have been made in many cases (e.g. Westerskov 1960 — for Campbell Island), while Carrick & Ingham (1967) and Watson *et al.* (1971) review the extensive literature concerned with southern seabird biology, including latitudinal distributions. The present study covered 39 degrees of latitude and is useful in providing additional distributional records.

OBSERVED LATITUDINAL DISTRIBUTION AND BEHAVIOUR OF SEABIRDS

Wandering Albatross *(Diomedea exulans):*

The first birds observed, out of Cook Strait, were in the 'leopard stage' E and/or F of Fleming (1950). The numbers observed at each sighting increased as we proceeded south until the southernmost sighting on 28 December, when 12 birds all corresponding to Fleming's 'fledgling' plumage phases (A and B) were seen surface feeding at 61°51'S. I saw none about Campbell Island or to 57°S and Westerskov (1960) states that wanderers are rare breeders on Campbell Island.

Darby (1970) observed that *D. exulans* was confined north of the Antarctic Circle in the region south of New Zealand and her southernmost record was on her second (late January) traverse at 66°21'S. Dell (1960) also observed a southernmost limit of 66°S but maintains that extreme variability in range occurs. My southernmost record conforms to Dell's statement that in December (1957) and March (1958) the southern limits appeared to be considerably to the north of 66°S.

Black-browed Mollymawk *(Diomedea melanophris):*

This species and the Cape Pigeon *(Daption capensis)* were the species most consistently observed at sea between New Zealand and the northern limits of the pack-ice. Black-browed Mollymawks wake followed for long periods, often coming very close to the ship and feeding on galley scraps thrown overboard.

Black-browed Mollymawks were most abundant just south of their breeding area, Campbell Island, where groups of up to 15 to 18 birds followed the ship. These large groups persisted to the south with a gradual reduction in numbers as we began to penetrate iceberg seas. Once we entered the pack-ice at about 66°S, *D. melanophris* all but disappeared with occasional individuals occurring until my southernmost sighting of an immature bird on 29 December at 66°25'S.

On 24 December we had a strong following wind (Table 1) which was accompanied by an absence of big birds (e.g. albatrosses and mollymawks) very close to the ship. These large birds probably found it difficult to maintain their position behind the ship, but with the westerly the next day larger numbers of these birds were recorded.

TABLE 1: DAILY NOON POSITION AND WEATHER DETAILS FOR THE USCGC STATEN ISLAND TRAVERSE, DECEMBER 1970.

DATE	NOON POSITION		TEMPERATURE (°C)			WIND		PRESSURE
	Latitude (°'S)	Longitude (°'E)	Sea	Air (dry)	Air (wet)	Speed (knots)	Direction	(millibars)
23 December 1970	Inside Wellington Hbr. (41°S)		-	-	-	-	-	-
24 " "	45 22	172 59	12.6	16.7	14.5	17	N	1010.8
25 " "	49 46	170 37	9.7	11.2	8.6	14	W	997.6
26 " "	52 30	169 30	8.2	10.3	9.2	12	SW	1002.3
27 " "	57 02	172 47	7.2	11.1	8.9	19	W	991.7
28 " "	61 51	174 39	3.2	4.7	3.3	10	SE	938.8
29 " "	66 25	172 57	-0.7	0	-1.5	8	SE	996.5
30 " "	71 24	173 00	-0.9	1.1	0	10	SE	993.4
31 " "	75 16	171 27	0.5	0.6	-0.9	11	SW	997.1

Darby states that *D. melanophris* is not found north of its northernmost breeding area, the Antipodes Islands. I recorded what was probably the northern race *impavida* (Falla, Sibson & Turbott 1970) at 45°S while the more southern individuals were probably *melanophris* from Macquarie Island.

Dell records this species as far south as 66°S in February 1959 but Darby observed it at 70°S on an occasion when the northern edge of the pack-ice was at this latitude. Darby remarked on the generally solitary nature of *D. melanophris* which is unlike the large groups I observed south of Campbell Island.

Grey-headed Mollymawk *(Diomedea chrysostoma):*

This Mollymawk tended to be a solitary species rarely being observed in pairs or larger groups. The Grey-headed Mollymawk exhibited the same latitudinal range as *D. exulans,* its southernmost record being on 27 December at 61°S. An individual crossed the ship's bows in Perseverance Harbour (Campbell Island) and it is surprising not more were seen, since thousands of them breed on Courrejolles Point (Westerskov 1960).

Murphy (1964) records four individuals as far south as 67°S in the Bellingshausen Sea and considers the species to enter the pack-ice much more freely than *D. melanophris.* South of New Zealand, Dell recorded *D. chrysostoma* at 63°S while Darby's southernmost sighting was in January 1968 at 68°22′S.

Light-mantled Sooty Albatross *(Phoebetria palpebrata):*

My first encounter with this graceful albatross was on 24 December at 45°22′S, 172°59′E. They usually appeared as solitary birds often following the ship very closely, but three individuals were observed flying together in Perseverance Harbour and on 27 December a pair were seen at 57°S.

The Light-mantled Sooty Albatross is not common north of its subantarctic breeding islands and Falla, Sibson & Turbott (1970) indicate that this species only rarely reaches 40°S. Darby's northern limit was 49°S while Summerhayes (1969) recorded the northernmost sighting at 30°S in the northern Tasman Sea (177°E).

Dell's suggestion that *P. palpebrata* ranges between 60°-68°S in December with a more southerly limit (72°-76°S) occurring in late summer (February-March) is supported by my southernmost sighting in December at 66°S and Darby's February southernmost record of 72°S.

Giant Petrel *(Macronectes giganteus):*

This species ranges widely and I recorded it from within Wellington Harbour (41°S) to 75°S. Both Dell and Darby observed a marked patchiness in the distribution of *M. giganteus* but during my traverse individuals were recorded consistently each day between 23-31 December. Occasional pairs were evident but generally solitary birds were the rule.

Distinct plumage variation between the northern (dark phase) and southern (white phase) birds, observed by Darby and again in

the present traverse has been described in detail by Bourne & Warham (1966). These authors suggest that because of the pronounced ecological differences the dark phase represents *M. halli* which breeds on the New Zealand subantarctic islands and whose foraging range extends mainly north of the Antarctic Convergence, while the white phase represents the southern *M. giganteus* known to breed on Macquarie Island and foraging mainly south of the Convergence. The breeding range of these two species overlaps at some of the islands on or near the Antarctic Convergence.

Distribution of these two species at sea is little known (Watson *et al.* 1971) as most observations have only been recorded as *M. giganteus.* During my voyage no attempt was made to separate the two species as many birds had doubtfully distinct plumage. However two definitely dark phased individuals were observed as far south as 75°S on the last day of my traverse. The flexibility in the distributional range of the Giant Petrels must therefore be noted.

Summerhayes (1969) recorded a northern limit of *M. giganteus* at 25°31'S but Falla, Sibson & Turbott (1970) maintain that it is not commonly found north of 30°S. Dell's southernmost observation of this species was at 72°S in December 1958 whereas that of Darby was 77°45'S on her fourth traverse (February 1968).

An oceanographic station was occupied on 1 February 1971 in McMurdo Sound (77°51'25" S, 166°36'50"E) after the seasonal ice breakout on 23 January 1971. While on this station three individual Giant Petrels were recorded. These observations would seem to establish a southern limit of this predominantly subantarctic species.

Cape Pigeon *(Daption capensis):*

This species was the most consistent wake follower throughout our voyage, appearing as individual birds or in groups of up to a dozen every day until the southernmost sighting on 29 December at 66°25'S. Commonly, the Cape Pigeon was one of the first birds to appear when garbage was thrown overboard. Although not breeding on Campbell Island (Westerskov 1960), a flock of 12-18 *D. capensis* followed the ship out of Perseverance Harbour.

While my data show the species occurring every day of the traverse to its southernmost recording of 66°S, both Dell and Darby commented on the paucity of Cape Pigeons in mid-latitudes (55°-61°S). The lack of breeding islands and division into northern and southern feeding populations are factors advanced as explaining this disjunct distribution. Southernmost record for *D. capensis* by both Dell and Derby is 73°S.

Antarctic Fulmar *(Fulmarus glacialoides):*

Unlike previous records (Watson *et al.* 1971), this species was not encountered until entering the pack-ice (66°S) but remained, commonly in pairs or up to eight individuals, with the ship until

71°S. The Antarctic Fulmar was most often seen passing, but sometimes followed the ship closely with groups of Antarctic Petrels *(Thalassoica antarctica)* and Snow Petrels *(Pagodroma nivea)*.

Although my northern limit of *F. glacialoides* was 66°S, stragglers are common to the New Zealand coast (Falla, Sibson & Turbott 1970). It appears (Watson *et al.* 1971) that the northward migration of *F. glacialoides* is a response to the harsh winter conditions after the summer breeding and moulting on the Antarctic continent. Thus in summer the species would usually be confined below the Antarctic Circle.

During the present voyage my southernmost observation was at 71°S, while Dell recorded Fulmars as far south as 73°S with some venturing into McMurdo Sound.

Snow Petrel *(Pagodroma nivea)*:

The northward distribution of this species is the northern edge of the pack-ice (e.g. Dell 1960; Darby 1970).

Solitary *P. nivea* were first seen once we entered the pack-ice at approximately 66°S on 29 December. This attractive species persisted as individuals or in small groups flying with Antarctic Petrels around the ship until 75°S. On each occasion this species came very near to the ship and often settled in our wake when garbage was thrown overboard. The Snow Petrel has all the 'fulmarine propensity for scavenging organic debris' (Falla 1964) and voraciously attacks discarded galley scraps as well as being noted feeding on crushed macroplankton picked up by diving between pack-ice floes. The species was noticeably reduced or absent over open sections of the Ross Sea, probably because the easy pickings obtainable from the pack-ice zone are not as available in open water.

I noted a small group of *P. nivea* flying over Beaufort Island on my helicopter flight into McMurdo NAF, and Darby has recorded this species within McMurdo Sound (77°45'S, 164°48'E) probably ranging from their breeding localities in the Western Victoria Land Mountains.

Antarctic Petrel *(Thalassoica antarctica)*:

Together with *P. nivea*, the Antarctic Petrel was the most common bird between latitudes 66°25'S and 75°16'S. During the present voyage this latitudinal belt was characteristically that of the pack-ice and the partially ice-free Ross Sea lying further to the south. It is undeniably a pack-ice inhabitant often observed feeding in open ice leads at the water/ice interface or congregating, often in large numbers (up to 60 birds), on large ice-floes and bergs.

The Antarctic Petrel is conspicuous by its similar gross appearance to the Cape Pigeon although larger in size, with a simpler plumage design and a more gregarious nature.

At 1800hrs on 29 December I noticed a flock of 18 birds flying high above the bridge of the ship. They had darker, less distinct plumage with grey underparts (probably in new plumage) and were similar to those reported by Falla (1937).

Darby's southernmost record was 74°03'S on her first traverse (January 1968), while both Dell and I have recorded *T. antarctica* at 75°S.

Prions (*Pachyptila* spp.):

Giant Petrels and Prions were the most widely distributed birds observed. Individuals were often seen to alight between ice floes and feed, at times immersing the bill in the water for periods of up to 10 seconds which gave me the impression that they were ' straining ' the water for zooplankters. This feeding procedure generally lasted only 2-3 minutes before they skipped off along open leads between the thicker pack-ice.

Groups of Prions remained characteristically far from the ship and close to the water, making positive indentification difficult. However at 66°S a small group of 15 birds were within close range and allowed detailed field drawings to be made. Distinctive characters noticed were —

(1) stout thick-set body
(2) characteristic black "W" on wings
(3) extension of dorsal pigment into a 'collar'
(4) darker suborbital pigmentation.

These drawings when compared with Harper's (1972) descriptive notes and photographs correspond to the Antarctic Prion *(P. desolata)*. This species ranged to 71°24'S, 173°00'E and it is thought probable that they were *P. desolata* although Harper mentioned that the species has not been observed at all in the Ross Sea. The prior southernmost limit of *P. desolata* in this area was at 67°24'S, 179°53'W on USNS *Eltanin* Cruise 27, 2 February, 1967.

Since they breed on Scott Island (67°24'S, 179°55'W) it is possible that they do range some distance into the Ross Sea sector.

Sooty Shearwater *(Puffinus griseus)*:

On 24 December after a thick morning fog lifted, a large flock of an estimated 600-800 birds was sighted flying low, some settling on the water for brief periods but then flying off. From then on only occasional individuals were noted but at 1400hrs on 28 December, just after crossing the Antarctic Convergence another large group of about 400 constantly active birds was observed. Darby has reported such large flocks and Westerskov (1960) recorded about 5000 birds on Perseverance Harbour. All these recordings of large flocks correlate with weather conditions such as low cloud and fog. These large flocks are probably migrant birds (Westerskov 1960), becoming highly gregarious during adverse weather conditions.

Although *P. griseus* do not breed further south than Macquarie Island (55°S) (Falla, Sibson & Turbott 1970), both Falla (1937) and Murphy (1964) have observed great numbers adjacent to the pack-ice between their breeding seasons (November-January). A late (February) southwards movement of Sooty Shearwaters has been

recorded in East Antarctica (Falla 1964) but it is not known whether this movement is composed of adults that have bred that season in the subantarctic or of non-breeding adults.

Dell's observations and my data show a southern limit of 61°-62°S in December while Darby's log show a southernmost record of 68°22'S in late January and 67°26'S in late February. Thus it appears that a southward extension of this species in late summer also occurs in the Ross Sea sector.

White-chinned Petrel *(Procellaria aequinoctialis)*:

During my voyage the southernmost observations of three *P. aequinoctialis* was made outside Perseverance Harbour (52°30'S), the species also being noted once earlier at 1600hrs on 23 December. Neither Dell nor Darby recorded this species in their southern traverses, yet Alexander (1955) mentions it as one of the commonest petrels of the Southern Ocean. Falla (1937) gave a southernmost eastern sector limit of 61°S.

Breeding sites of the White-chinned Petrel in the Ross Sea sector lie north of the Antarctic Convergence on the subantarctic islands of Macquarie, Campbell, Antipodes and Auckland Islands (Falla, Sibson & Turbott 1970). Since they lay their eggs in November-December (Carrick & Ingham 1967) the conspicuously low numbers of this species far from breeding islands are not surprising.

Mottled Petrel *(Pterodroma inexpectata)*:

This species was only recorded on two occasions (27 and 28 December). Sightings were normally of individual birds but at 1900hrs on 28 December four *P. inexpectata* were observed flying together amongst icebergs. The Mottled Petrel has a wide oceanic range, southward from New Zealand to the pack-ice (68°-73°S, Alexander 1955; Dell 1960; Falla, Sibson & Turbott 1970; Watson *et al.* 1971) but is only rarely encountered on sea voyages.

Wilson's Storm Petrel *(Oceanites oceanicus)*:

This species was commonly observed from 66°S until my embarkation by helicopter from the USCGC *Staten Island* at 75°S. Individuals were occasionally seen flying high above the ship (about 50 metres), but their typical flight pattern was skipping across open water leads picking up specimens of the larger zooplankton. During the southern winter *O. oceanicus* ranges far into the northern hemisphere (Alexander 1955; Falla 1964).

Wilson's Storm Petrels were only observed as solitary birds, even when rarely feeding on discarded garbage, yet Falla (1937) reported up to 6000 birds attending a factory ship and feeding on whale oil scum. Their occurrence, however, was reduced over heavy pack-ice, remaining a characteristically ice lead and open water species. The greatest number of individual *O. oceanicus* within a given time (30 within 10 minutes) was recorded in the open Ross Sea, once through much of the pack-ice belts.

While Dell mentioned this storm petrel to be occasionally observed flying over sea-ice in McMurdo Sound, I recorded two individuals feeding at the ice-shelf/water interface while undertaking oceanographic studies (77°51′25″S, 166°36′50″E — see above under Giant Petrel). This appears to be the southernmost record for the species in this region.

Black-bellied Storm Petrel *(Fregetta tropica):*

I observed a single *F. tropica* about two hours outside Perseverance Harbour, recognisable by its distinctive white flank feathers and erratic zig-zag flight over the sea surface.

According to Dell, the Black-bellied Storm Petrel is fairly scarce during the summer months in the Ross Sea sector of the Southern Ocean. Darby did not see it, but Oliver (*in* Westerskov 1960) recorded it near Campbell Island.

Although this species is known to breed at the Auckland, Bounty and Antipodes Islands (Falla, Sibson & Turbott 1970) and has been recorded widely at sea elsewhere (Watson *et al.* 1971), the lack of summer distributional observations other than around breeding islands is probably due to their breeding cycle — egg laying and hatching occurring in December and January (Carrick & Ingham 1967). It is conceivable that there are some, as yet, unlocated breeding localities on Campbell Island, suggested by both Oliver's and my own records.

DISCUSSION

Generally the distribution of Antarctic and subantarctic seabirds can be said to be related to their feeding and nesting habits. The rich and dependable seasonal food supply of plankton and nekton in these regions must ultimately dictate the patterns of reproduction and overall distribution (Carrick & Ingham 1967).

However, caution has been stressed by these authors when correlations between seabird distribution and the pelagic food organisms are drawn. Ekland (*see* "Discussion" *in* Falla 1964) suggested that temperature regime as well as food availability may limit bird distribution. He stated that down to latitude 65°-66°S is considered subantarctic (0°C isotherm) and south of this as strictly Antarctic.

Effects of the pack-ice on seabird distribution:

The seasonal variation in the extent of the Antarctic pack-ice is well documented (e.g. Mackintosh & Herdman 1940) and the controlling nature of the pack-ice on seabird distribution is also well known (Carrick & Ingham 1967; Watson *et al.* 1971). Maximum ice cover occurs in September; in summer the northern limit of the pack-ice retreats southward until the refreeze begins to take place about March.

Most authors agree that the pack-ice is a significant life-zone boundary and determines the ultimate southward extension of many of the wider ranging pelagic birds (e.g. Falla 1964; Murphy 1964;

Watson *et al.* 1971). Some, such as the Emperor and Adelie Penguins, and the Snow and Antarctic Petrels, are confined to a restricted life zone predominantly in the pack-ice around the continent.

Throughout my traverse the controlling nature of the pack-ice front was evident. *Pagodroma nivea,* in particular, appears to have its northward distribution convincingly governed by the northern edge of the floating pack during all seasons (also noted by Dell 1960 and Darby 1970). Although Murphy (1964: 353) has stated that *Phoebetria palpebrata* is ". . . familiar in pack-ice at high latitudes," the present data indicate that *P. palpebrata* and *Diomedea melanophris* have their southern limits strictly dictated by the pack-ice. Darby considered *Diomedea exulans* and *Daption capensis* to have their southward distribution limited by the pack-ice, but on my traverse this was not confirmed. The Wandering Albatross reached its southernmost observed limit north of the Antarctic Convergence and well north of the pack-ice (66°S — Fig. 2). Although Cape Pigeons did not penetrate far into pack-ice seas, some individuals were seen to alight in leads between ice floes and feed on crushed zooplankton, behaving in much the same way as the truly Antarctic species of *P. nivea* and *Oceanites oceanicus.*

The tolerance to lower levels of ambient air and sea temperature and the necessary behavioural modifications in feeding habits required for successful habitation of the pack-ice zone are presumed to be the factors which ultimately limit the ranging into pack-ice seas of many of the Subantarctic seabird species. Contrary modifications would, I suspect, be required for success at northward extension by such typically pack-ice inhabitants as *P. nivea* and *Thalassoica antarctica.*

Variation of distributional range in summer:

For the present study two fundamental hydrological features appear to determine the latitudinal spread of the main seabird species —

(1) The Antarctic Convergence which is the frontal system separating Antarctic water to the South and Subantarctic water to the north and is situated near the 3°C surface isotherm — Houtman (1967).

(2) The position of the 0°C surface isotherm which usually demarcates the northern limit of the pack-ice.

As the USCGC *Staten Island* crossed the Antarctic Convergence at 61°51'S the sea surface temperature dropped to 3.2°C (Table 1). This latitude corresponds with a marked termination of three widely ranging species: *D. exulans, D. chrysostoma* and *Puffinus griseus.* Further south at 66°S the southward spread of such species as *D. melanophris, P. palpebrata* and *D. capensis* ceased as the 0°C surface isotherm was crossed. As abruptly as these species disappeared the truly 'Antarctic element' of *P. nivea, T. antarctica, Fulmarus glacialoides* and the usually wider northward ranging species *O. oceanicus* become evident (Fig. 2).

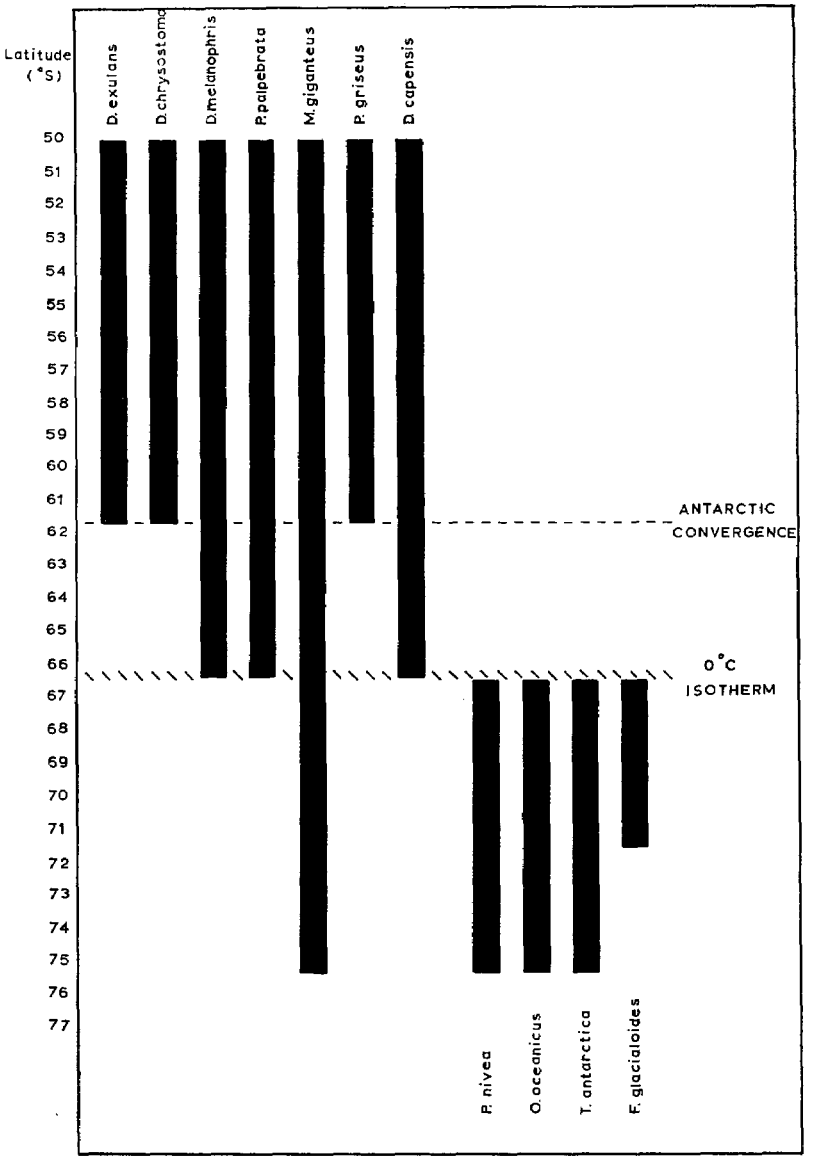

FIGURE 2 — Latitudinal distribution of the seabirds between New Zealand and the Ross Sea in December. Data from the present traverse (northern limits of 'pre-Convergence' birds not considered).

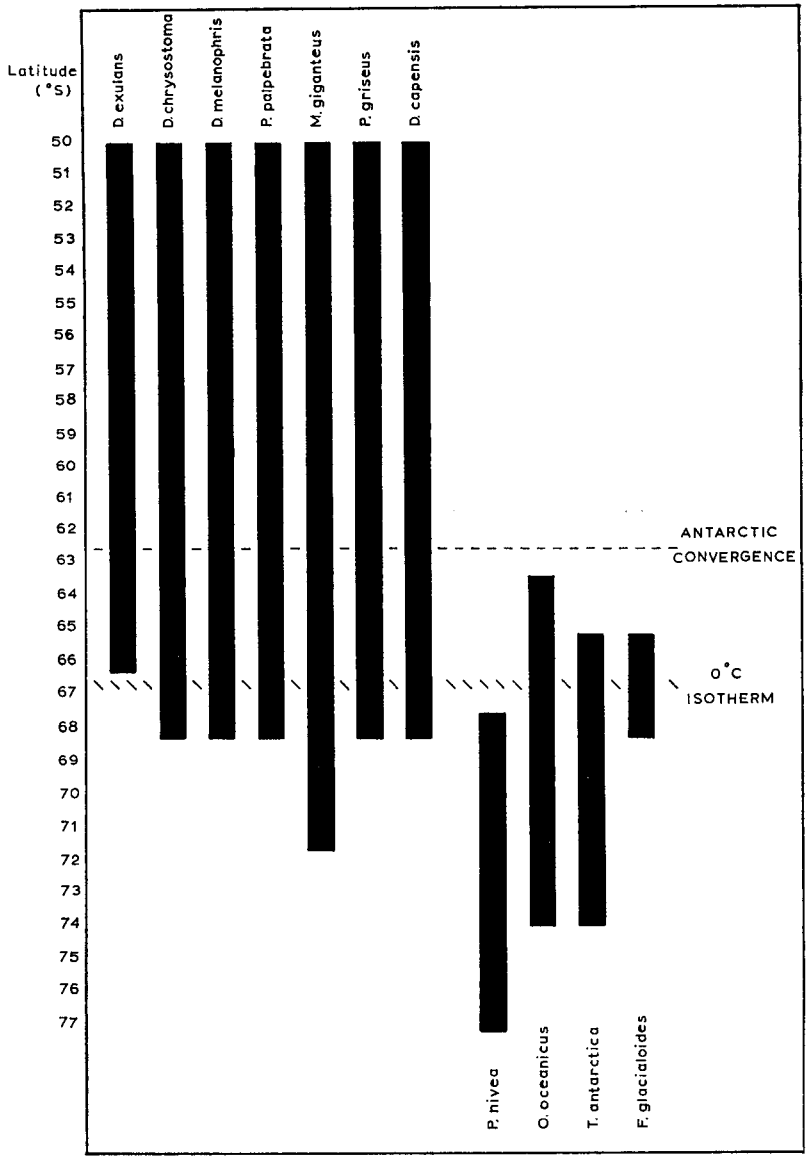

FIGURE 3 — Latitudinal distribution of the seabirds between New Zealand and the Ross Sea in January. Data from Darby 1970 (northern limits of ' pre-Convergence ' birds not considered).

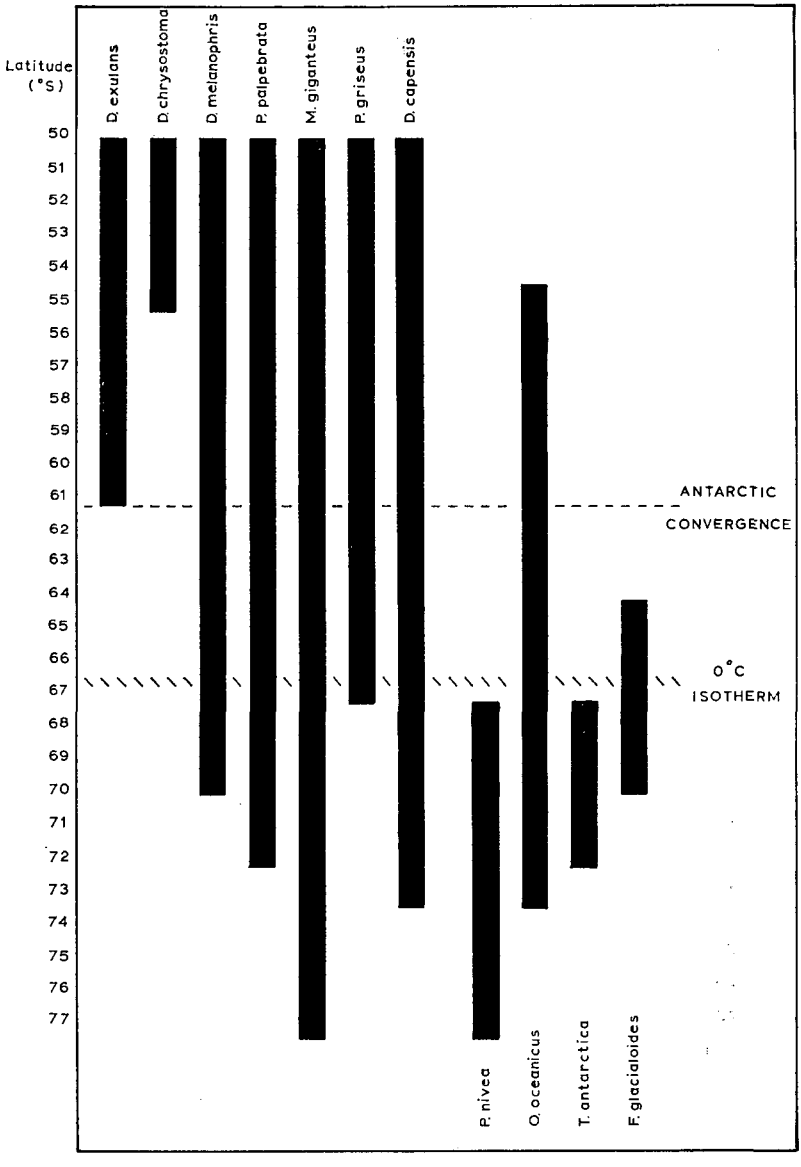

FIGURE 4 — Latitudinal distribution of the seabirds between New Zealand and the Ross Sea in February. Data from Darby 1970 (northern limits of ' pre-Convergence ' birds not considered).

My observations during December show distinct zonal patterns of distribution. Correlation of these data with Darby's for the following two months suggests that there is a progressive tendency towards azonality with distributions appearing to be less affected by zonal hydrological boundaries at this time.

The Antarctic Convergence appears to have little effect in January. The 'pre-Convergence' birds extend south to between latitudes 66°-68°S, while *D. melanophris, P. palpebrata* and *D. capensis* retain a similar range as observed in December, although crossing the 0°C isotherm (Fig. 3). *Fulmarus glacialoides, T. antarctica* and *O. oceanicus* extend further northward but *P. nivea* retains its typical 0°C northern limit.

The situation in February becomes clearly azonal (Fig. 4). Some of the large albatrosses, mollymawks and the Cape Pigeon, previously extending no further than about 68°S, now range well south into the Ross Sea. The beginnings of the autumnal migration to the Northern Hemisphere of *O. oceanicus* (Alexander 1955) is evident by its increasing northward range from 66°25'S in December to 54°41'S in February.

Diomedea exulans, D. chrysostoma and *T. antarctica* have restricted ranges again in February but these appear to be little affected by existing hydrographic conditions.

Although seabirds actually seem to be too dynamic in their distribution habits to permit a satisfactory explanation in this respect (i.e. the extended ranges from December to February and the relations with ice and hydrographic conditions), it is clear that specific differences exist. Two factors arising from the present data, however, are worth consideration —

(1) In general, the majority of Antarctic and Subantarctic seabirds have egg-laying periods between October and late December and, thus, adult breeding birds are bound to the nest during this time (Carrick & Ingham 1967). From December onwards hatching occurs and it is at this time that adults begin their wide ranging foraging for the young.

(2) Coincidental with the above is rising temperature during December and January. Thus, with the melting and southward retreat of the pack-ice edge, the barrier effects of the pack-ice or 0°C isotherm become less important and southward extension of foraging range becomes possible. An extreme example of this increased range can be seen in *M. giganteus* whose egg-laying and incubation period is from October to mid-December. In February this species reaches its southernmost recorded position (77°51'S, 166°36'E), and it is possible that birds observed at this position were foraging adults.

Various authors (e.g. Hurley 1961) have noted the zonal distribution of seabird food organisms as being governed by such

physical features as the Subtropical and Antarctic Convergences, Antarctic Divergence and the relative position of the pack-ice edge. Euphausids are known to become most abundant in January near the Antarctic Convergence (Watson *et al.* 1971), while in late January and February a greater biomass is found nearer to the Antarctic Continent. The comparable zonal pattern of seabird distribution could, thus, be due to either the direct physical effects of abrupt temperature changes and/or to temperature changes which indirectly affect the birds by dictating the distribution of particular important food organisms.

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APPENDIX 1

SUMMARY OF LATITUDINAL DISTRIBUTION OF SEABIRDS, DECEMBER 1970.

	NORTHERNMOST SIGHTING		SOUTHERNMOST SIGHTING	
Emperor Penguin (*Aptenodytes forsteri*)	29 Dec.	66°25'S, 172°57'E	31 Dec.	75°16'S, 171°27'E
Adelie Penguin (*Pygoscelis adeliae*)	29 Dec.	66°25'S, 172°57'E	31 Dec.	McMurdo NAF
Yellow-eyed Penguin (*Megadyptes antipodes*)	26 Dec.	52°30'S, 169°30'E		
Rockhopper Penguin (*Eudyptes crestatus*)	26 Dec.	52°30'S, 169°30'E		
Wandering Albatross (*Diomedea exulans*)	23 Dec.	Out of Cook Strait	28 Dec.	61°51'S, 174°39'E
Royal Albatross (*D. epomophora*)	23 Dec.	Out of Cook Strait	26 Dec.	52°30'S, 169°30'E
Black-browed Mollymawk (*D. melanophris*)	24 Dec.	45°22'S, 172°59'E	29 Dec.	66°25'S, 172°57'E
Grey-headed Mollymawk (*D. chrysostoma*)	23 Dec.	Out of Cook Strait	28 Dec.	61°51'S, 174°39'E
Buller's Mollymawk (*D. bulleri*)	24 Dec.	45°22'S, 172°59'E		
Light-mantled Sooty Albatross (*Phoebetria palpebrata*)	24 Dec.	45°22'S, 172°59'E	29 Dec.	66°25'S, 172°57'E

APPENDIX 1 (cont'd)

Giant Petrel (*Macronectes giganteus*)	23 Dec.	Inside Wellington Hbr.	31 Dec.	75°16'S, 171°27'E
Cape Pigeon (*Daption capensis*)	23 Dec.	Out of Cook Strait	29 Dec.	66°25'S, 172°57'E
Antarctic Fulmar (*Fulmarus glacialoides*)	29 Dec.	66°25'S, 172°57'E	30 Dec.	71°24'S, 173°00'E
Snow Petrel (*Pagodroma nivea*)	29 Dec.	66°25'S, 172°57'E	31 Dec.	75°16'S, 171°27'E
Antarctic Petrel (*Thalassoica antarctica*)	29 Dec.	66°25'S, 172°57'E	31 Dec.	75°16'S, 171°27'E
Blue Petrel (*Halobaena caerulea*)	28 Dec.	61°51'S, 174°39'E		
Prions (*Pachyptila* spp.)	23 Dec.	Out of Cook Strait	30 Dec.	71°24'S, 173°00'E
Sooty Shearwater (*Puffinus griseus*)	24 Dec.	45°22'S, 172°59'E	28 Dec.	61°51'S, 174°39'E
Grey Petrel (*Procellaria cinerea*)	26 Dec.	52°30'S, 169°30'E		
White-chinned Petrel (*P. aequinoctialis*)	23 Dec.	Out of Cook Strait	26 Dec.	52°30'S, 169°30'E
Grey-faced Petrel (*Pterodroma macroptera*)	24 Dec.	45°22'S, 172°59'E		

APPENDIX 1 (cont'd)

Mottled Petrel (*P. inexpectata*)	27 Dec.	57°02'S, 172°47'E	28 Dec.	61°51'S, 174°39'E
Wilson's Storm Petrel (*Oceanites oceanicus*)	29 Dec.	66°25'S, 172°57'E	31 Dec.	75°16'S, 171°27'E
Black-bellied Storm Petrel (*Fregetta tropica*)	26 Dec.	52°30'S, 169°30'E		
Campbell Island Shag (*Phalacrocorax campbelli*)	26 Dec.	52°30'S, 169°30'E		
Southern Skua (*Catharacta lönnbergi*)	26 Dec.	52°30'S, 169°30'E	27 Dec.	57°02'S, 172°47'E
Antarctic Skua (*C. maccormicki*)	30 Dec.	71°24'S, 173°00'E	31 Dec.	McMurdo NAF
Southern Black-backed Gull (*Larus dominicanus*)	23 Dec.	Inside Wellington Hbr.	26 Dec.	52°30'S, 169°30'E
Red-billed Gull (*L. scopulinus*)	23 Dec.	Inside Wellington Hbr.	26 Dec.	52°30'S, 169°30'E
Antarctic Tern (*Sterna vittata*)	26 Dec.	52°30'S, 169°30'E		
White-fronted Tern (*S. striata*)	23 Dec.	Inside Wellington Hbr.		

(1. 4 Emperor Penguins, 2 of which were subadults in moult, seen on annual sea-ice of McMurdo Sound, 77°52'30"S, 166°24'00"E on 14 January 1971.

2. 3 Giant Petrels, 2 Wilson's Storm Petrels and numerous Adelie Penguins observed from an oceanographic station in McMurdo Sound, 77°51'25"S, 166°36'50"E on 1 February 1971.)