

# ORNITHOLOGICAL OBSERVATIONS IN THE SOUTH ATLANTIC OCEAN AND WEDDELL SEA, 1959-64

By MICHAEL H. THURSTON\*

**ABSTRACT.** Observations of oceanic birds seen during the years 1959-64 on nine voyages in the South Atlantic Ocean and Antarctic waters are presented. The voyages have been treated as transects. Positional and numerical data for the commoner species have been tabulated. During the summer months, cape pigeons were more abundant, by an order of magnitude, south of the Antarctic Convergence than further north. In the Weddell Sea sector during January and February, the distributional overlap between the cape pigeon and the Antarctic petrel was minimal. Further records of Kerguelen petrels have helped to confirm that this species has a circum-polar distribution. A British storm petrel was recorded at lat. 42°S in the south-west Atlantic Ocean. Offshore feeding aggregations have been noted east of Argentina. North of the eastern part of the Weddell Sea, northern and southern limits of species ranges showed poor agreement with the position of the pack-ice edge and may have been controlled to some extent by food availability.

THE establishment and re-supply of British Antarctic Survey stations on islands of the Scotia, on the Antarctic Peninsula and in Coats Land require considerable logistic effort. Regular sailings of ships between the United Kingdom and the Atlantic sector of the Antarctic have taken place since the Survey came under civil administration in 1947. This paper reports the results of bird watches carried out on nine such voyages between 1959 and 1964. M. H. Thurston was responsible for the collection of data on six of these voyages, C. H. Dean on two and A. Precious on one. The itineraries, dates and observers are listed in Table I. These voyages represent a total of 164 days of at-sea observations between the Equator and lat. 76°S. The observations contained in this paper are complementary to those published by Tickell and Woods (1972). Their presentation has been followed so that the results may be compared directly. For the reasons given by Tickell and Woods, an arbitrary northern limit of lat. 20°S has been adopted, but some relevant observations in tropical waters have been included.

TABLE I. SHIPS AND VOYAGES ON WHICH SEA-BIRD OBSERVATIONS WERE RECORDED

RRS <i>Shackleton</i>	Southampton (5 October 1959)—Ascension—St. Helena—Tristan da Cunha—lat. 35°S, long. 29°W—South Georgia—Rio de la Plata—Falkland Islands (22 November 1959)	M.H.T.
RRS <i>John Biscoe</i>	Falkland Islands (26 November 1959)—South Orkney Islands—South Shetland Islands—Antarctic Peninsula—South Shetland Islands—Falkland Islands (22 December 1959)	M.H.T.
RRS <i>John Biscoe</i>	Falkland Islands (30 December 1959)—South Georgia—Halley Bay (21 January 1960)	M.H.T.
MV <i>Kista Dan</i>	South Georgia (20 January 1961)—Halley Bay (29 January 1961)	A.P.
MV <i>Kista Dan</i>	Halley Bay (4 February 1962)—South Sandwich Islands—South Georgia—Falkland Islands—Rio de la Plata—Southampton (26 March 1962)	M.H.T.
MV <i>Kista Dan</i>	Southampton (6 December 1962)—Rio de la Plata—Falkland Islands—South Shetland Islands—Antarctic Peninsula—South Orkney Islands—South Georgia—Halley Bay (30 January 1963)	M.H.T., C.H.D.
MV <i>Kista Dan</i>	Halley Bay (7 February 1963)—South Georgia—Falkland Islands—Rio de la Plata—Southampton (25 March 1963)	M.H.T.
MV <i>Kista Dan</i>	Falkland Islands (7 January 1964)—South Georgia—Halley Bay (27 January 1964)	C.H.D.
MV <i>Kista Dan</i>	Halley Bay (2 February 1964)—South Georgia (12 February 1964)	C.H.D.

Observers: C. H. Dean (C.H.D.), A. Precious (A.P.) and M. H. Thurston (M.H.T.).

\* Institute of Oceanographic Sciences, Wormley, Godalming, Surrey GU8 5UB.

Watson and others (1971) summarized distributional records for Antarctic and sub-Antarctic waters. More recent studies in the South Atlantic, some of which relate bird distributions to oceanographic conditions, include papers by Cooke and Mills (1972), Tickell and Woods (1972), Lathbury (1972), Harris and Hansen (1974), Jehl (1974), Brown and others (1975), Rumboll and Jehl (1977), Kock and Reinsch (1978), and Linkowski and Rembiszewski (1978).

#### METHODS

Observations were made each day using 7×50 or 8×35 binoculars. No fixed period was set aside for observations, and the length of time spent watching birds was dependent on weather conditions and other factors. Watches lasted from 10 min to 2 h or more, and the total time on deck was rarely less than 1 h d<sup>-1</sup>. During some parts of voyages on transects 6–9, in waters south of the Falkland Islands, watches were stood throughout daylight hours to report sea ice, and bird, whale and seal sightings. Observations were recorded every 15 or 30 min. Although many of the personnel were largely untrained in this respect, they were able to report matters of interest which could be checked by more experienced observers. Most maximum numbers, and all sightings of rarer birds reported here, were confirmed in this way. The ship's noon position was recorded each day, together with other available navigational data. Adverse weather conditions which affected observations, such as gales and poor visibility, were noted, and sea-water temperatures recorded.

Observations were made on all of the transects described by Tickell and Woods (1972) with the exception of that between South Georgia and Tristan da Cunha (transect 4). Due to a medical emergency in November 1959, RRS *Shackleton*, while on passage from Tristan da Cunha to the Rio de la Plata, was diverted to South Georgia. As a consequence, only the eastern portion of transect 11 and the southern portion of transect 5 were traversed. Two additional transects, numbers 12 and 13, were covered by voyages discussed in this paper (Fig. 1).

The day-by-day counts have been reduced to a series of tables, one for each transect. The scheme used by Tickell and Woods (1972) to deal with estimated numbers has been adopted for these data. Rare species, and those of a predominantly neritic habit, have been excluded from the tables. Those days on which some or all of the observations were made in the pack ice have been marked. The table for transect 13 is presented as an appendix to this paper. Data for the remaining transects are not included but are available from the author.

No account has been taken of the seasonal and latitudinal variations of the hours of daylight, and consequently the time available for observations.

The opportunity for recording birds throughout the hours of daylight arose during part or all of the four voyages on transect 13 made in 1963 and 1964. Observations were made in 138 1° squares during these voyages. Observation periods were of 30 min in 1963 and 15 min in 1964. The number of observation periods per 1° square varied from one to 81 (average 14.4) and the number of voyages during which records were obtained from any square varied from one to three (average 1.3).

The scientific nomenclature is basically that of Watson (1975), while vernacular names are mostly those used by Tuck and Heinzel (1978). The use of the traditional names shoemaker for white-chinned petrel (*Procellaria aequinoctialis*) and pediunkker for grey petrel (*Procellaria cinerea*) follow Jehl (1974).

The original data, which provide the basis of this paper, have been deposited with the British Antarctic Survey.

#### RESULTS

##### *Transects*

*Transect 1.* Equator–Rio de la Plata (December—1 run; February–March—2 runs).

Ships sailing on this route generally kept well offshore, picking up soundings on the continental shelf in about lat. 32°S. A very characteristic feature of all three series of

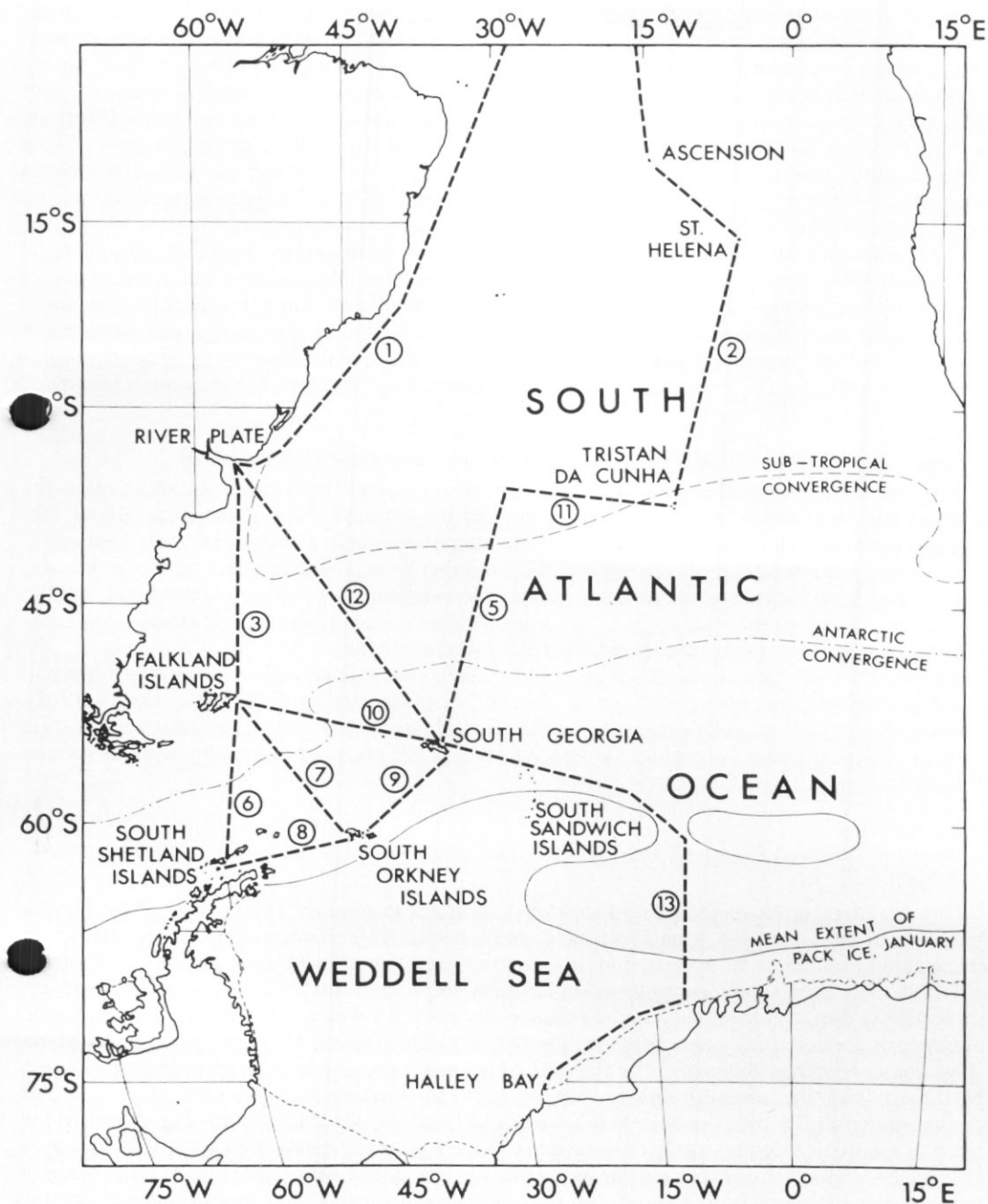


Fig. 1. Map of the South Atlantic Ocean and Weddell Sea, showing the tracks followed on all voyages and the numbering of the transects.

observations was the absence of birds between lat. 7–10°S and lat. 23–25°S, the only record between these latitudes being of a blue-faced booby (*Sula dactylatra*) at lat. 17°S in December 1962. South of this, only southern temperate species or trans-equatorial migrants were encountered, the single exception being a red-footed booby (*Sula sula*) at lat. 25°S in March 1963. The birdless zone on this transect lies entirely within the south-west flowing, plankton-poor Brazilian Current which flows strongly as far south as Cabo Frio in lat. 22°51'S (Murphy, 1936). To the south of this point, the residual northerly movement of richer waters derived from the Falkland Current becomes increasingly important, and supports a richer and more diverse avifauna. Even in these waters, however, the appearance of the Procellariiformes was rather spasmodic, only Schlegel's petrel (*Pterodroma incerta*) being at all common.

Tickell and Woods (1972) reported observations made on this transect in October and May. Significant differences are apparent between the equinoctial observations and those reported here. Great albatrosses, cape pigeons (*Daption capense*) and southern fulmars (*Fulmarus glacialisoides*) were present in October, black-browed albatrosses (*Diomedea melanophris*) in May, and in both months greater numbers of shoemakers and Wilson's storm petrels (*Oceanites oceanicus*) were seen. In contrast, Schlegel's petrels were more common in the summer months.

*Transect 2. Tristan da Cunha–St. Helena–Ascension–Equator (October—1 run).*

The mid-ocean transect from Tristan da Cunha northward lies almost entirely within the tropical and sub-tropical zones. St. Helena marked the southern limit of the tropical and sub-tropical avifauna. The first representative of the temperate fauna, a shoemaker, was seen at lat. 19°S, and by the following day, at lat. 24°S, a number of southern species, including the cape pigeon, had been recorded. The degree of overlap between the two faunas was minimal. Tristan da Cunha lies just to the south of the Sub-tropical Convergence (Deacon, 1937) and it was only within 100 miles (160 km) of the islands that birds were abundant.

The number of species recorded between lat. 20°S and Tristan da Cunha was higher in October than on either of the passages in May and June reported by Tickell and Woods (1972). The seasonal variation on this transect, and the higher numbers of individuals and species seen, compared with transect 1, was due, at least in part, to the presence of breeding species around Tristan da Cunha in late October.

*Transect 3. Falkland Islands–Rio de la Plata (November—1 run; January—1 run; February—2 runs).*

The run made in November contrasts with those made in January and February. The regular presence of black-browed albatrosses and giant petrels (*Macronectes* spp.) over the whole transect was common to both periods as was the presence of Schlegel's petrels north of lat. 47–48°S. The number of species rose significantly from seven in November to 13, 15 and 15, respectively, during the January and February passages. This increase was due, in part, to the presence of greater shearwaters (*Puffinus gravis*), sooty shearwaters (*Puffinus griseus*) and Manx shearwaters (*Puffinus puffinus*). The Antarctic-breeding cape pigeon was recorded only during November and the southern fulmar not at all. The absence in November of the greater shearwater contrasts with the observations of Tickell and Woods, and is surprising in view of the recently recorded breeding status of the species in the Falkland Islands (Woods, 1970). The near absence of Wilson's storm petrels during November compared with their relative abundance in January and February is noteworthy but the causes are unclear. The records given here for the latter period conform with those of Tickell and Woods for the same months.

*Transect 4. South Georgia–Tristan da Cunha (no observations).*



*Transect 5.* Lat. 35°S, long. 29°W—South Georgia (November—1 run).

For reasons mentioned earlier, this run commenced at lat. 35°S and lay somewhat to the east of the line of observations reported by Tickell and Woods. As they pointed out, this transect is of importance as it traverses latitudes between transects 1 and 3, and 2 and 4. Observations on this transect are made doubly important by the cessation of whaling at South Georgia and the consequent reduction of north-south sailings to and from the island. The first observations made on this transect were at a point to the north of the main position of the Sub-tropical Convergence. The location of this boundary is less well defined than that of the Antarctic Convergence (Deacon, 1960), and may, on this occasion, have been further north than usual as all of the bird species seen at lat. 35°S have strong temperate-zone affinities.

The general features of bird distributions differed little from the September records of Tickell and Woods (1972) and Rumboll and Jehl (1977), although the present observations produced much higher numbers of Wilson's storm petrels.

*Transect 6.* Falkland Islands—South Shetland Islands (December—1 run; January—1 run).

*Transect 7.* Falkland Islands—South Orkney Islands (November—1 run).

Although both of these transects cross the Antarctic Convergence, seasonal differences were more apparent than latitudinal ones. Snow petrels (*Pagodroma nivea*) were recorded only in November when they were associated with pack ice off the South Orkney Islands. Sooty shearwaters were seen in January but not earlier in the summer, and were confined to waters north of the Antarctic Convergence. Cape pigeons and southern fulmars were recorded on all three voyages, but were seen only near their Antarctic breeding grounds in January. An increase in numbers of Wilson's storm petrels from north to south was apparent in all three sets of observations.

The observations made on transect 6 in January 1963 and reported here differ little from those made in January 1961 by Tickell and Woods. Seasonal differences between these observations and those made in March–April 1962 are apparent in more northerly sightings of cape pigeons and southern fulmars during the latter period (see Tickell and Woods). On transect 7, birds were more abundant in November than in April.

*Transect 8.* South Orkney Islands—Bransfield Strait (December—1 run; January—1 run).

*Transect 9.* South Georgia—South Orkney Islands (January—1 run).

Both of these transects lie in Antarctic waters south of the Antarctic Convergence. The species observed most frequently and in the greatest numbers were those with breeding colonies in the South Orkney Islands or South Shetland Islands, i.e. giant petrels, cape pigeons, southern fulmars, snow petrels, prions (*Pachyptila* spp.) and Wilson's storm petrels. No albatrosses were seen during early December but four species were recorded on each transect in January. Both these species and the shoemaker were more abundant in lower latitudes.

*Transect 10.* Falkland Islands—South Georgia (December/January—1 run; January—1 run; February—2 runs).

This transect is comparable with transects 6 and 7 in that it lies across the Antarctic Convergence. There is some evidence in the present results for a segregation of species in relation to breeding localities. Greater and sooty shearwaters were seen only near the Falkland Islands, while light-mantled sooty albatrosses (*Phoebastria palpebrata*) and cape pigeons were confined almost entirely to the colder waters south of the Antarctic Convergence.

The observations of Tickell and Woods were made in November and May. In terms of the number of species present, their results and those given here are similar. Points of difference lie in the wider distribution of a number of species in spring and autumn, and the presence during the same period of southern fulmars. This species breeds at more southerly stations than either the Falkland Islands or South Georgia. In contrast, greater shearwaters were present in some numbers during February but not at other times of the year.

*Transect 11. Rio de la Plata—Tristan da Cunha (October—November—1 run).*

This transect lies close to the Sub-tropical Convergence. Observations are available only to the east of long.  $29^{\circ}$ W. With the exception of cape pigeons and Wilson's storm petrels, neither of which was seen within 1 000 km of Tristan da Cunha, all species which have been recorded are known to breed on these islands. The lower number of species and individuals seen in the spring compared with those reported for May by Tickell and Woods may be a reflection of the timing of breeding seasons.

*Transect 12. Rio de la Plata—South Georgia (November—1 run).*

This transect is most nearly comparable with transect 5 in that it extends from the Sub-tropical Convergence to South Georgia.

The avifauna recorded in mid-November 1959 was very similar in composition and abundance to that seen further east on transect 5 earlier in the month. Species breeding in cool-temperate regions such as Schlegel's petrel and greater shearwater were confined to waters north of the Antarctic Convergence, while the blue petrel (*Halobaena caerulea*) was confined to the zone of Antarctic surface water. The cape pigeon, which breeds almost exclusively south of the Antarctic Convergence, was seen throughout the passage.

The marked congregation of birds seen at lat.  $41^{\circ}$ S, long.  $50^{\circ}$ W is discussed in more detail on p. 100.

*Transect 13. South Georgia—Halley Bay (January—4 runs; February—3 runs).*

Transect 13 is unique among those studied in that it crosses the extensive areas of pack ice formed in the Weddell Sea. Ice conditions have a major effect on the track followed by ships re-supplying Halley Bay. In the years under consideration, Earth satellite imagery was not yet available and the track followed was based on the experience of previous voyages. In the period 1960–64, a course was set from South Georgia to pass to the north of the South Sandwich Islands, crossing lat.  $60^{\circ}$ S in long.  $9$ – $14^{\circ}$ W. The positions of the main ice edge varied considerably. Ice was encountered in January 1964 at lat.  $59^{\circ}$ S, in January 1963 at lat.  $62^{\circ}$ S, in January 1960 at lat.  $68^{\circ}$ S, while in January 1961 no significant concentrations of ice were encountered throughout the voyage. The pack-ice zone was traversed on a southerly course until the shore lead along the continental coast was reached at about lat.  $71^{\circ}$ S. In years when ice conditions were favourable, for example in February 1962, the return voyage from Halley Bay might make a northing as far west as long.  $20^{\circ}$ W and reach South Georgia having passed to the south of the South Sandwich Islands.

The bird life of the area between South Georgia and the pack-ice edge was characteristic of the Antarctic zone of surface water but occasional sightings of cold-temperate species were recorded. Although very few of the characteristic species penetrated beyond the fringes of the pack ice, the ice itself was not the only boundary affecting distribution. Even in 1961, when very little ice was encountered, the southern limits of occurrence of these species were not greatly extended. Birds characteristic of the pack ice and the open water to the south were snow petrels, Antarctic petrels (*Thalassoica antarctica*), terns (presumably Arctic terns, *Sterna paradisaea*), emperor penguins (*Aptenodytes forsteri*) and Adélie penguins (*Pygoscelis adeliae*).

*Species*

Species marked with an asterisk are not included in the appendix table or the tabulated data for the other transects.

Penguins. Only penguins identified on transect 13 are tabulated.

Concentrations of penguins close to breeding grounds in the Falkland Islands, South Georgia, South Sandwich Islands, South Orkney Islands, South Shetland Islands and the Antarctic Peninsula were observed but are not considered further here. Sight records at distances of more than 100 km from land were rare on the northern transects. Six crested penguins (*Eudyptes* sp.) were seen at lat. 45°S, long. 33°W and two chinstrap penguins (*Pygoscelis antarctica*) at lat. 62°S, long. 52°W. In contrast, many penguins were seen on transect 13 between South Georgia and the pack-ice edge. Many of the birds seen could not be identified but some at least were chinstrap penguins. On 6 January 1960, about 270 chinstrap penguins were seen on isolated ice floes at lat. 56°S, long. 28°W, north of Zavodovski Island.

Emperor penguin (*Aptenodytes forsteri*). Emperor penguins were seen in small numbers, usually ones and twos, but occasionally in groups of up to ten individuals, in the pack ice on transect 13. The most northerly record was of a single bird at lat. 59°S, long. 19°W on 9 February 1964. This species was seen only rarely near the northern edge of the pack ice. Areas of brash ice, ice cakes, very open pack ice and very close pack ice were avoided and the greatest numbers were recorded in areas of open or close pack ice with 4/10ths to 8/10ths cover of small or medium floes. Very few birds in juvenile plumage were seen.

Adélie penguin (*Pygoscelis adeliae*). This species was frequently observed on ice floes on transect 13. Numbers were usually low but on 25 January 1964 at lat. 72°S, long. 19°W 287 were seen during a 24-h period with a maximum of 40 at any one time, while on 4 February 1964 at lat. 71°S, long. 21°W 193 were recorded with up to 57 at a single observation. The high frequency of occurrence of the Adélie penguin in this sector of the Antarctic has been shown by Watson and others (1971). It is probable that most of these records are of non-breeding birds as the nearest breeding colony is over 1 000 km distant.

Wandering albatross (*Diomedea exulans*) and royal albatross (*Diomedea epomophora*). These species are not usually separable in the field (Tickell and Woods, 1972; Harper and Kinsky, 1974) and are referred to collectively as "great albatrosses" in this study. The known distribution of the royal albatross in the Atlantic Ocean is confined to the near-shore waters of southern South America (Watson and others, 1971). This distribution pattern suggests that royal albatrosses may have been seen on transects 1, 3, 6, 7, 10 and 12, but that there is a high probability that all great albatrosses seen on the remaining transects were *D. exulans*.

The most northerly record in the present series of observations was of a wandering albatross, determined by plumage state, at lat. 24°S on transect 2 in October. Great albatrosses were seen throughout the mid-ocean transects 5 and 11, in contrast to those passages closer to the South American coast, where none was seen on transect 1 in December, February or March, nor north of lat. 42°S on transect 3 in January and lat. 37°S on transect 12. The latitudinal differences between sightings off South America and in mid-ocean may be a reflection of the breeding population of *D. exulans* at Tristan da Cunha. These observations agree closely with those of Tickell and Woods (1972) with the exception of their record from lat. 23°S off Brazil in October. One or two birds were seen on transect 8 in January 1963 (this paper) and in January 1961 (Tickell and Woods, 1972), but none was recorded in December or March. The appearance of great albatrosses at these latitudes is thus a high-summer phenomenon and the transect lies close to the southern limits of the species.

Black-browed albatross (*Diomedea melanophris*). Although the black-browed albatross is reputedly the commonest in the Southern Hemisphere (Murphy, 1936), it was seen in large numbers only near the Falkland Islands, one of its major breeding localities.

The most northerly sightings were at lat. 37°S on transect 12 and lat. 39°S on transect 5 in November, and lat. 37–38°S in November, January and February on transect 3. No black-browed albatrosses were seen on transect 2 in October, nor on transect 11 in November. The presence of this species on the transects south of the Falkland Islands and South Georgia was irregular. Individuals were seen each day between the Falkland Islands and the South Orkney Islands in November, but none between the South Orkney Islands and the South Shetland Islands nor south of lat. 54°S between the Falkland Islands and the South Shetland Islands in December. In January and February, however, black-browed albatrosses were seen regularly on transects 6, 8 and 10, but never more than five at a time. Occurrences on transect 13 were also irregular, there being records on three voyages out of four in January and one out of three in February. The most southerly sighting on this transect was made in February 1963 at lat. 59°S. Tickell and Woods (1972) reported black-browed albatrosses on transects 1, 2 and 11 in May but saw none on transect 7 in September. These observations contrast with those recorded above and demonstrate seasonal changes in the latitudinal range occupied.

In view of the southern penetration of the black-browed albatross in the Ross Sea sector, where it has been recorded south of lat. 70°S (Watson and others, 1971), the absence of records south of lat. 60°S in the Weddell Sea sector is surprising. It is unlikely that this species is limited by the pack-ice edge as appears to be the case in the wandering albatross as in none of the seven voyages reported here was black-browed albatrosses seen within 200 km of the pack-ice edge.

Grey-headed albatross (*Diomedea chrysostoma*). As Tickell and Woods (1972) found, this species was never seen in great numbers but occurred most abundantly around South Georgia. It was recorded on 10 days out of 15 on transect 10 from late December to February. Northern sightings occurred at lat. 47°S on transect 5 and lat. 48°S on transect 12. Single individuals were also seen at lat. 62°S on transects 6 and 8 in January. Sightings on transect 13 were sporadic, as was the case with the black-browed albatross. Most sightings were between South Georgia and the South Sandwich Islands. Grey-headed albatrosses have been reported from the vicinity of the latter area by Bourne (1966). The most southerly record on this transect was at lat. 58°S in January 1963.

Yellow-nosed albatross (*Diomedea chlororhynchos*). This species was seen in small numbers within a narrow latitudinal band; from lat. 34°S to lat. 38°S off the Rio de la Plata on transects 1 and 3, and between lat. 35°S and lat. 43°S on transects 2, 5, and 11.

Sooty albatross (*Phoebastria fusca*). Except close to Tristan da Cunha, where up to seven individuals were seen at one time in late October, the sooty albatross was never abundant, and only on transect 5 between lat. 35°S and lat. 50°S was the species recorded at all regularly. The most northerly record, a single individual at lat. 35°S, long. 28°W, was at or close to the Sub-tropical Convergence. That this cold-temperate species does penetrate into colder waters is shown by sightings of single individuals off the north-west end of South Georgia in February, and at lat. 58°S, long. 15°W and lat. 57°S, long. 26°W on transect 13 in January. Novatti (1960) has also found this species in Antarctic waters, his southernmost record coming from lat. 61°S, long. 44°W.

Tickell and Woods (1972) recorded this species on transects 2, 4 and 11. All of their records were obtained during May when birds occupied lower latitudes (lat. 25–41°S) than was the case during the summer months.



Light-mantled sooty albatross (*Phoebastria palpebrata*). This species was seen on all transects (except transect 12) extending into the area of cold Antarctic water to the south of the Antarctic Convergence. The only records north of the Convergence were of three birds at lat. 46°S, long. 33°W in early November 1959 and one at lat. 52°S, long. 49°W in January 1964. *P. palpebrata* was never seen in large numbers, but occurred regularly around South Georgia, where it was more abundant during December and January than at other times. On transect 13, the species was recorded during five of six voyages between South Georgia and Halley Bay. Only in January 1960 was none seen. As with the wandering albatross, the southern limit of distribution was frequently more or less coincident with the edge of the pack ice, although in January 1961 when no ice was encountered, no light-mantled sooty albatrosses were seen south of lat. 59°S. In January 1964, when two east-west bands of pack ice were encountered, the single individual of this species seen at lat. 63°S, long. 9°W was the only albatross of any species to be seen in the intervening open water.

Giant petrels. No attempt was made to distinguish between *Macronectes giganteus* and *M. halli* (Bourne and Warham, 1966).

The present observations were made during the summer months and there are thus few records of giant petrels from warmer waters. On transect 3, birds were seen rather regularly in small numbers as far north as lat. 41°S in November, lat. 46°S in January and lat. 37°S on both voyages in February. None was seen in the estuary of the Rio de la Plata, which is consistent with the statement of Watson and others (1971) that *M. giganteus* rarely feeds in neritic waters. On this transect, giant petrels were most numerous off the Falkland Islands where there are small breeding colonies. On transect 12, birds were seen as far north as lat. 36°S where six followed the ship for at least 80 km north and west of the boundary of the clear blue oceanic water with the turbid green water which lay close to the edge of the continental shelf. In contrast to the relatively low latitudes of northern sightings on the two transects close to the South American coast, giant petrels were not encountered in mid-ocean on transect 5 until lat. 47°S was reached, and were only common close to South Georgia. These observations contrast with the situation in September 1958, when the only reports of giant petrels were of single individuals between lat. 35°S and lat. 39°S (Tickell and Woods, 1972). On voyages in and around the Scotia arc (transects 6-10), giant petrels were present on 30 of the 34 days on which observations were made. The most obvious feature of this distribution was an absence of the species off the Falkland Islands during the two February voyages on transect 10. With this exception, giant petrels were common, numbers frequently reaching 20-30 at a time and on one occasion about 200 were seen off the entrance of Cumberland Bay, South Georgia.

The southward penetration of giant petrels on transect 13 varied more from voyage to voyage than was the case with the albatrosses. In January 1960 and 1961, giant petrels were seen only 1-2 days steaming south and east of South Georgia, whereas in February 1963 and 1964 the southernmost sightings were made at or just to the south of the pack-ice edge in lat. 64°S and lat. 59°S, respectively. On the remaining three voyages, individuals were seen well into the pack ice or even to the south of it. The ten seen at lat. 66°S, long. 10°W during January 1963 were in an area of close pack ice of 8-9/10ths concentration 450 km south of the pack-ice edge and 400 km north of the shore lead. In February 1962, one giant petrel was seen in heavy ice at lat. 74°S, long. 23°W, possibly attracted by refuse from the ship, while on January 1964 there were sporadic reports of single birds in the shore lead off the continental coast between lat. 70°S, long. 11°W and lat. 72°S, long. 19°W. The species occasionally reaches high latitudes in the Weddell Sea as Novatti (1962) reported a bird at lat. 77°58'S, long. 38°48'W (misplotted by Watson and others (1971)).

Southern fulmar (*Fulmarus glacialisoides*). This species was not recorded on northern transects, indicating that the bulk of the population had migrated south to the breeding grounds



by mid-November, and remained in summer quarters at least until late February.

During December, January and the first part of February, all sightings were made south of the Antarctic Convergence. In the Scotia arc, birds were seen only in the vicinity of breeding colonies in the South Shetland Islands, the South Orkney Islands and the South Sandwich Islands. With the exception of three individuals seen at lat.  $54^{\circ}\text{S}$ , long.  $33^{\circ}\text{W}$  in mid-February 1963, none was seen within 200 km of South Georgia. Many of the voyages reported by Tickell and Woods (1972) on the transects crossing the Antarctic Convergence and in the cool-temperate zone were made early and late in the year, rather than during the summer months. This difference in timing is reflected in the occurrence of southern fulmars at lower latitudes in the spring and autumn.

On transect 13, southern fulmars were seen regularly south and east of the South Sandwich Islands to lat.  $58\text{--}60^{\circ}\text{S}$  on six different voyages. On three of these voyages the distribution extended south to the pack-ice edge. On two further voyages no southern fulmars were seen south of lat.  $60^{\circ}\text{S}$  and lat.  $58^{\circ}\text{S}$ , although in one case the ice edge was at lat.  $69^{\circ}\text{S}$  and in the other no pack ice was encountered. In February 1962, a single bird was encountered at lat.  $65^{\circ}\text{S}$  when the ice edge was very diffuse and open water extended beyond lat.  $68^{\circ}\text{S}$ . The paucity of records south of lat.  $60^{\circ}\text{S}$  in the area east of the South Sandwich Islands is curious in view of the many sightings recorded by Watson and others (1971). The latter may represent a post-breeding dispersal in March (Watson, 1975).

Cape pigeon (*Daption capense*). In the Atlantic sector, the cape pigeon does not breed north of the Antarctic Convergence (Watson and others, 1971); consequently sightings in lower latitudes, particularly during the summer months, were infrequent. Some were still occupying their winter range, as birds were seen at lat.  $24^{\circ}\text{S}$ , long.  $9^{\circ}\text{W}$  and two other localities south to Tristan da Cunha. Immediately to the west of these islands no cape pigeons were seen but the species was present in ones and twos between long.  $24^{\circ}\text{W}$  and long.  $29^{\circ}\text{W}$  on transect 11 in November. On those parts of transects 5 and 12 lying to the north of the Antarctic Convergence birds were seen, generally in small numbers, although up to 12 were counted at lat.  $37^{\circ}\text{S}$ , long.  $54^{\circ}\text{W}$  in November 1959 (see p. 100). Only in November was this species seen between the Rio de la Plata and the Falkland Islands, and then not north of lat.  $45^{\circ}\text{S}$ . It is not clear whether this marked latitudinal difference over a period of only 6 days was due to a southerly migration or to the decreased numbers near the South American coast postulated by Tickell and Woods (1972). On transects 6, 7 and 10 from the Falkland Islands to various parts of the Scotia arc, sightings of cape pigeons were sporadic north of the Antarctic Convergence during high summer, i.e. late November to mid-February. A characteristic of the seven voyages made during this period was that numbers were 10 to 20 times greater south of the Convergence than to the north. On four of these voyages the increase was dramatic, occurring at the Convergence, and over a time interval of an hour or two at the most. Both on these transects and those lying entirely within the area of the Antarctic Surface Water notable increases in numbers were recorded on approaching land supporting breeding colonies. This occurred in the proximity of the South Shetland Islands and South Orkney Islands, but was particularly evident at South Georgia, where, although the number of breeding birds is not large (Pinder, 1966; Prince and Payne, 1979), vast flocks were attracted to feed on the oil and debris produced by the shore-based whaling stations then operating. More recent observations of large numbers of this species around South Georgia throughout the year (Prince and Payne, 1979) suggest that factors other than whaling and sealing wastes (Morris, 1962) were also important. Most birds seen at South Georgia are probably non-breeders as the nearest large breeding sites are 500 km south-east (South Sandwich Islands) and 800 km south-west (South Orkney Islands), and the average duration of a brooding shift is only 1.6 d (Pinder, 1966). Sightings on the spring and autumn voyages reported by Tickell and Woods (1972), when compared with those on the summer voyages described in this paper, clearly demonstrate seasonal movements to and from lower latitudes.

From the records obtained during the seven voyages on transect 13, it appears that the normal southern limit of distribution of the cape pigeon to the east of the South Sandwich Islands is not determined solely by the boundary of the pack ice. On five of the voyages made between January 1960 and February 1964, ten or more birds were seen on most days while north of lat. 58-60°S. In contrast, to the south of lat. 60°S, the only sightings were of seven birds at lat. 62°S in February 1962 and two near the pack-ice edge at lat. 61°S in January 1963. In January and February 1964, when the pack-ice edge was at lat. 59°S, cape pigeons were seen in small numbers a few kilometres south of this boundary but only among low concentrations of brash ice.

Antarctic petrel (*Thalassoica antarctica*). Few records of Antarctic petrels from north of the Antarctic Convergence have been reported (Watson and others, 1971), and none was made on the present voyages.

In December 1959, a few birds were seen on transect 8 but none was reported in January 1963. On transect 13, Antarctic petrels were seen regularly on all voyages, 1-30 per day being usual. The northerly limit of distribution was only partly dependent on the position of the pack-ice edge, occurring between lat. 58°S and lat. 62°S. Birds were seen regularly in the pack ice, but in January 1960, when very bad ice conditions prevented navigation for 3 days, none was seen. A similar absence or reduction in numbers was noted on other occasions when considerable areas of close pack ice were traversed. Numbers seen were generally higher in extensive areas of open water to the south of the northern pack-ice boundary and particularly in the shore lead off the Brunt Ice Shelf. This pattern of distribution contrasts with that of the snow petrel and may indicate that the two species are not in direct competition for food. In addition, snow petrels were usually seen singly or in groups of at most three or four birds, whereas flocks of 50 or more Antarctic petrels were encountered on a number of occasions. Several small flocks were seen resting on ice floes at lat. 74°S, long. 24°W in February 1962. These birds were seen in windless conditions in an area where a number of swarms of euphausiids were reported. During the voyage to Halley Bay in January 1964 about 50 Antarctic petrels were recorded on a pool in an ice floe in a flat calm at lat. 72°S, long. 18°W, around 40 circling feeding rorqual whales (*Balaenoptera* sp.) and about 70 off the fast-ice edge of Halley Bay. The degree of overlap in range during the summer months between this species and the cape pigeon is relatively slight (see data for transect 13 in the Appendix), and is far less than might be suspected from the distributional plots given by Watson and others (1971).

Snow petrel (*Pagodroma nivea*). The distribution of this typically Antarctic bird lies entirely to the south of lat. 50°S and it has been seen north of the Antarctic Convergence only at the Falkland Islands (Watson and others, 1971).

The snow petrel is known to breed on all the island groups of the Scotia arc. South Georgia is apparently so near the normal northern limit of the summer range of this species that none was seen off the north or west coasts during any of the six voyages made on transects 5, 10 and 12. The number of pairs breeding on South Georgia is low (Prince and Payne, 1979) and it was only near the south-east end of the island that sightings of single individuals were made on transect 9 in January 1963.

With the exception of isolated sightings between South Georgia and the northern part of the South Sandwich Islands group in January and February 1963, all records on transect 13 were associated with pack ice, either with the main body or with isolated strips and patches. On five of the seven voyages made to and from the Weddell Sea, maximum numbers of snow petrels were encountered at the northern edge of the main concentration of pack ice. Numbers tended to be lower during traverses of large bodies of open water and in areas of close pack ice. Birds were observed on several occasions feeding on euphausiids injured or stranded by moving ice floes. The lower numbers in open water and in dense pack ice may therefore be a function of ease of

access to food. In open water or low ice concentrations, few euphausiids will be injured or stranded, while in dense pack ice, particularly away from the effects of wave action, ice movement will frequently be slight and access to the water surface strictly limited. Few snow petrels were seen during periods of navigation in the shore lead usually present off Coats Land. The small number of birds seen contrasts with the relatively large numbers which breed in the mountains lying inland from the coast (Fuchs and Hillary, 1958; Løvenskiold, 1960; Ards, 1964; Bowra and others, 1966; Brook and Beck, 1972). During January and early February, breeding birds spend much of their time at the nest site or feeding in the pack ice, and therefore relatively little time in the shore lead. A further possible cause of the few sightings in the shore lead may be related to meteorological conditions. Relatively low wind velocities and the damping effect of ice floes on wave action result in conditions unfavourable for gliding flight. Both this species and the Antarctic petrel use the seaward cliffs of the Brunt Ice Shelf near Halley Bay station as a flight line (Thurston, 1961). Such long-shore movements accounted for virtually all observations during the spring and autumn migration, and were only marginally less frequent during the summer months. Birds flying close to the cliffs would not normally be visible from a ship on passage in the shore lead.

Prions (*Pachyptila* spp.). No attempt was made to distinguish the various species of prion at sea and the only bird specifically identified was a broad-billed prion (*P. vittata*), which was found on board just west of Tristan da Cunha. All prion records have been combined and they can do little other than demonstrate the great number of these birds which may occur in temperate, sub-Antarctic and Antarctic waters. The dove prion (*P. desolata*) breeds on the South Orkney Islands (Tickell, 1960) but there are few records at higher latitudes (Watson and others, 1971). Transect 8 probably lies close to the normal southern limit of this species, birds being seen during voyages in January but not in December.

Blue petrel (*Halobaena caerulea*). As found by Tickell and Woods (1972), this species was less abundant than were prions. All records obtained during these voyages were from south of the Antarctic Convergence, between lat. 51°S and lat. 57°S during November, while most of those reported by Tickell and Woods occurred either in the spring or autumn. Until recently, the only recorded breeding localities of this species were in the South Indian Ocean (Watson and others, 1971). Recent observations have shown, however, that the blue petrel breeds at South Georgia in considerable numbers (Prince and Payne, 1979; Prince, 1980). Possible evidence for a southerly movement towards South Georgia is shown by observations on transect 5. Tickell and Woods recorded single individuals north of the Antarctic Convergence in September 1958, whereas up to 50 birds were encountered as little as 70 km north of South Georgia in November 1959. Although no blue petrels were recorded on transect 13, Novatti (1960, 1962) saw this species on several occasions in the north-eastern part of the Weddell Sea only a few days before the area was crossed by RRS *John Biscoe* in January 1960.

Great-winged petrel (*Pterodroma macroptera*).<sup>\*</sup> This species was recorded on three occasions, twice to the north of Tristan da Cunha at lat. 24°S, long. 9°W and lat. 32°S, long. 11°W, and once south of the Rio de la Plata at lat. 39°S, long. 57°W, where three individuals were seen feeding together with several greater shearwaters and about 100 sooty shearwaters in February 1962. The latter record confirms the observations of Tickell and Woods (1972) and Brown and others (1975) that the great-winged petrel occurs off the coast of Argentina, an area from which the species had not been reported when Watson and others (1971) compiled their distribution chart.

White-headed petrel (*Pterodroma lessoni*).<sup>\*</sup> The status of this species in the Atlantic sector is poorly known (Watson and others, 1971; Watson, 1975; Woods, 1975). The present

observations add a further three records to those previously published. Single individuals were seen on transect 13 at lat. 57°S, long. 19°W and lat. 57°S, long. 17°W in January 1963, and on transect 10 at lat. 52°S, long. 49°W in January 1964.

Schlegel's petrel (*Pterodroma incerta*). This species was seen as far north as lat. 24°S on transect 1 in March 1962 and 1963, and on transect 2 in October 1959. It was most abundant between lat. 35°S and lat. 48°S, and was one of the characteristic species of the zone of sub-Antarctic waters. On transects 3 and 5, Schlegel's petrels were moderately abundant, occurring mostly north of lat. 47°S, although occasional birds were seen just east of the Falkland Islands on transects 7 and 10 in November and December 1959, and close to the Antarctic Convergence on transect 5. Flocks totalling over 200 birds were encountered at lat. 37°S, long. 54°W on transect 12 in November 1959. In mirror calm conditions, these birds were reluctant to fly and did so only to escape from the path of the ship. Their flight was heavy and laboured, take-off requiring 50 m of pattering on the surface.

Kerguelen petrel (*Pterodroma brevirostris*). The Kerguelen petrel breeds on sub-Antarctic islands in the Atlantic and Indian Oceans, and adult birds generally remain in the vicinity of the nesting grounds. Summer records distant from the breeding grounds suggest a substantial non-breeding population possibly involved in a circum-polar movement (Harper and others, 1972). Almost all records from the Atlantic sector are associated with the Antarctic zone of surface water (Watson and others, 1971) and, with the exception of a concentration of up to 20-25 birds between lat. 46°S and lat. 50°S on transect 5, all sightings reported here were from south of the Antarctic Convergence. A single bird was seen close to the South Orkney Islands on transect 8 in January 1963. Kerguelen petrels were reported on six of the seven voyages made on transect 13. The species was particularly abundant in the area east of the South Sandwich Islands between lat. 55°S and lat. 62°S, where up to 28 individuals were recorded at one time. The degree of penetration to the south was probably affected by the positions of the pack-ice edge but not limited by it. In February 1963, on the voyage north from Halley Bay, the first representatives of this species were encountered at lat. 64°S, long. 13°W close to the ice edge, although in January of the same year three birds were seen at lat. 66°S, long. 10°W, well south of the ice edge.

Soft-plumaged petrel (*Pterodroma mollis*). The nominate sub-species of *P. mollis* breeds on sub-Antarctic islands in the Atlantic and Indian Oceans, and was seen most frequently between lat. 35°S and lat. 50°S. The occurrence of this species was sporadic, up to 40 individuals being seen between lat. 46°S and lat. 48°S on transect 3 in February 1962 but only one bird in the same area in the following February. Small numbers were present on transect 10 in February 1963 and were associated particularly with the warmer waters north of the Antarctic Convergence. The species was also seen in ones and twos on three of the seven voyages on transect 13 in the area south and south-east of the South Sandwich Islands, reaching lat. 58°S, long. 14°W in January 1963 and lat. 58°S, long. 18°W in February 1963.

Shoemaker (*Procellaria aequinoctialis*). The shoemaker, one of the characteristic birds of temperate and low Antarctic waters, breeds on islands of the Tristan da Cunha group, Gough Island, the Falkland Islands and South Georgia, in addition to other sub-Antarctic islands in the Indian Ocean and to the south of New Zealand (Watson and others, 1971).

Birds were seen, usually in small numbers, on all transects except transect 11. Only around South Georgia, where the species breeds in very large numbers (Murphy, 1936; Prince and Payne, 1979), were more than five birds seen at any one time. With the exception of trans-equatorial migrants, the shoemaker was the first of the temperate Southern Hemisphere species seen during the voyage south on transect 2 in October 1959. Single birds were seen at lat. 19°S,



long. 7°W and at lat. 24°S, long. 9°W. Only a single bird was seen on transect 1 during the three voyages in December and March which are reported in this paper. Larger numbers reported by Tickell and Woods (1972) from the southern end of this transect are indicative of a post-breeding dispersal. Southern sightings occurred at lat. 61°S, long. 49°W and at lat. 60°S, long. 44°W in January 1963. On transect 13, shoemakers were seen during five of the seven voyages. Most of these records were made close to South Georgia but the species was also seen twice at lat. 57°S to the east of the South Sandwich Islands and once, in February 1962, at lat. 59°S, long. 27°W.

The wide latitudinal distribution shown by these observations is comparable to that found by Tickell and Woods (1972). These authors recorded the species on ten of their 11 transects, having no record only on transect 8 between the South Shetland Islands and the South Orkney Islands. From the records assembled by Watson and others (1971), this transect lies at or close to the normal southern limit of distribution of this species.

Pediunker (*Procellaria cinerea*). This species was seen on only 7 days and, as with the data of Tickell and Woods (1972), suggests that the pediunker was much less abundant than the account of Murphy (1936) would suggest.

The only breeding stations in the Atlantic Ocean are Tristan da Cunha and Gough Island. In contrast to the Indian and Pacific sectors, this species is virtually confined to the cool-temperate water masses lying between the Antarctic Convergence and the Sub-tropical Convergence. The single bird recorded at lat. 53°S, long. 43°W on transect 10 in February 1963 constitutes the most southerly sighting in the Atlantic Ocean.

Cory's shearwater (*Calonectris diomedea*).<sup>\*</sup> Only recently has this species, which breeds in the warm-temperate and tropical North Atlantic Ocean, been shown to winter off Uruguay and northern Argentina (Cooke and Mills, 1972). It was recorded twice on transect 1; at lat. 32°S, long. 50°W in early March 1962 and at lat. 29°S, long. 48°W in December of the same year.

Greater shearwater (*Puffinus gravis*). Greater shearwaters were seen on all transects north of lat. 50°S, the most northerly records being of single birds at lat. 32°S in March 1962, lat. 33°S in December 1962, both on transect 1, and at lat. 32°S in October 1959 on transect 2. The only sightings on southerly voyages were on transect 10 in February 1962 and 1963. In the latter year, one bird was seen south of the Antarctic Convergence at lat. 53°S, long. 44°W.

Flocks of greater shearwaters were encountered on a number of occasions; off the Falkland Islands in February 1962 and January 1963, at lat. 37–38°S in November 1959 on transect 12 and in January and February 1963 on transect 3, and at lat. 43°S, long. 56°W in February 1962. The latter two positions correspond to areas in which Cooke and Mills (1972) recorded large feeding flocks of this and other species of oceanic birds.

The absence of this species on transect 3 in November 1959 was unusual and was the only occasion in 20 voyages (four described in this paper and 16 by Tickell and Woods) that none was seen. Many of the voyages reported by Tickell and Woods (1972), both on this and other transects, were made in the southern spring or in the late autumn, particularly in April and May. The present observations, however, were made between late October and the beginning of March. These differences are reflected in the observed latitudinal range of the greater shearwater. Tickell and Woods saw birds from close to the Equator south to the Falkland Islands, whereas on the voyages reported here the species was seen between lat. 32°S and the Antarctic Convergence. Clearly, movements into the cooler waters south and east of the Falkland Islands occur only during the summer months.

Sooty shearwater (*Puffinus griseus*). The known Atlantic sector breeding stations of this species are in Tierra del Fuego and the Falkland Islands. Most of the present records were from areas not far from South America.



Single birds were seen just north of Tristan da Cunha on transect 2 in October 1959, and at lat. 27°S on transect 1 in December 1962. Although never present in large numbers, sooty shearwaters were seen with some regularity north and east of the Falkland Islands and south to lat. 54°S. There are few records south of the Antarctic Convergence in the Atlantic sector (Watson and others, 1971) but in January 1964 a few individuals were identified east of the South Sandwich Islands, the southernmost sighting being at lat. 58°S, long. 13°W.

Murphy (1936) has described vast flocks of sooty shearwaters up and down the west coast of South America but the species seems less abundant off the east coast, although Cooke and Mills (1972) reported concentrations at lat. 44°S in January 1970. Concentrations of this species south of the Falkland Islands on transect 6 were noted in January 1961 (Tickell and Woods, 1972) and January 1963 (this paper). Other aggregations seen during the voyages under discussion were at lat. 38-39°S on transect 3 in February 1962 and February 1963. Cooke and Mills found only greater shearwaters in these latitudes in January, and it may be that the apparent northerly movement of feeding flocks marked the beginning of the annual migration into the Northern Hemisphere.

Manx shearwater (*Puffinus puffinus*). The Manx shearwater has long been known to winter off the coasts of Brazil and Uruguay and in the estuary of the Rio de la Plata (Murphy, 1936) but its occurrence further south has not been well documented. Small numbers of birds were seen off Uruguay on transect 1 and south of the Rio de la Plata on transect 3 in January and February 1963. On the voyage north from the Falkland Islands in the latter month, the first Manx shearwaters were recorded at lat. 47°S. In January 1970, Cooke and Mills (1972) reported considerable numbers of these birds at lat. 39°S and a few as far south as lat. 49°S.

Other shearwaters.\* Several small shearwaters were seen at lat. 37°S, long. 54°W in November 1959. They were noted as being smaller than Manx shearwaters and showing the flight pattern characteristic of birds belonging to the least shearwater group. It is probable that they were little shearwaters (*Puffinus assimilis*).

Wilson's storm petrel (*Oceanites oceanicus*). Wilson's storm petrels were not common on the three northern transects (1, 2 and 11). The most northerly sighting during these voyages was of a single bird at lat. 19°S, long. 7°W in late October 1959. A few individuals were recorded between lat. 28°S and lat. 33°S on transect 1 in December and March, and west of long. 24°W on transect 11 in November 1959.

On the remaining transects, with the exception of transect 13, Wilson's storm petrels were recorded more frequently than any other species, being present on 82% of the days on which observations were made. On 30% of these occasions at least ten were present.

On transect 13, birds were invariably present in the vicinity of South Georgia but the southern limit of distribution varied widely. Voyages from South Georgia to Halley Bay were made during January in 4 years out of 5 between 1960 and 1964. In 1960, this species was recorded as far as lat. 58°S, well north of the pack-ice edge. In the following year, when no pack ice was encountered, the southernmost sighting occurred at lat. 60°S. Some sea ice was present in 1963 but, in contrast to the previous years, birds were seen throughout the voyage and there were reports of one or two at Halley Bay during the unloading period. In 1964, sightings were frequent south to the ice edge at lat. 59°S but none was seen thereafter. The three voyages north from Halley Bay all took place during February. In 1962, the first Wilson's storm petrel was seen in the shore lead, while in the two following years the first encounters took place in the pack ice at lat. 67°S and lat. 62°S, respectively. It seems there is a tendency for the southern limit of distribution to occur further south in February than in January. The reasons for this are not clear but ice conditions are likely to have some influence.

Data from single voyages on transects 5, 11 and 12 suggest that, in November, Wilson's

storm petrels are more common on the west side of the Atlantic Ocean than further east. This may be due to a return of birds from the Northern Hemisphere to their breeding grounds in Graham Land, the Scotia arc, Tierra del Fuego and the Falkland Islands.

Tickell and Woods (1972) found this species to be quite abundant on transect 1, particularly in October, absent from transect 2 in May and June, and present only at the western end of transect 11 in May. Mörzer Bruyns (1971) recorded no Wilson's storm petrels during a voyage from Argentina to South Africa in May, and suggested that the northerly migration might occur along two routes, one on the west side of the ocean and the other on the east. The lack of sightings on the mid-ocean transect 5 by Tickell and Woods supports this. These observations conform in general terms to the pattern of distribution demonstrated by Roberts (1940).

Black-bellied storm petrel (*Fregetta tropica*). Although there are records of the black-bellied storm petrel from the tropical Atlantic, the distribution chart given by Watson and others (1971) shows clearly that the normal northern limit of this species is at about lat. 40°S.

The most northerly sighting made during the present voyages was at lat. 39°S on transect 5 in November 1959. Black-bellied storm petrels were seen on 28 days but were never abundant. This species was seen most frequently on transect 10, occurring on 11 out of 15 days, and south-east of South Georgia on transect 13, reaching lat. 59°S in February 1962 and January 1963. The most southerly sighting was of two individuals at lat. 62°S, long. 51°W in January 1963.

Other storm petrels.\* White-bellied storm petrels (*Fregetta grallaria*) were recorded once only, at lat. 47°S, long. 57°W on transect 3 in January 1963.

The distribution of grey-backed storm petrels (*Garrodia nereis*) as shown by Watson and others (1971) suggests that, in the south Atlantic Ocean, this species does not disperse far from the breeding colonies in the Falkland Islands and South Georgia. Single sightings at lat. 47°S, long. 57°W and lat. 43°S, long. 56°W in February 1962, two birds off Hound Bay, South Georgia, and three at lat. 55°S, long. 31°W in January 1963 conform to this pattern.

A single British storm petrel (*Hydrobates pelagicus*) was seen among the large congregations of birds on transect 12 (see p. 100). This species breeds around the North Atlantic Ocean but is known to winter in the south-east Atlantic as far south as the Cape of Good Hope (Watson, 1966). The present record, at lat. 41°39'S, long. 49°41'W, is so far outside the known range that a fuller description seems advisable. The general appearance was similar to that of Wilson's storm petrels present at the same time but differed in detail. Characters noted included slightly smaller size, more slender build, somewhat darker coloration and a more fluttering flight. Small patches of white feathers were present on the underside of each wing close to the body. At a range of as little as 20 m it was possible to establish that the legs were short and did not extend beyond the tail.

The white-faced storm petrel (*Pelagodroma marina*) breeds at Tristan da Cunha and was recorded close to these islands in October 1959.

Diving petrels.\* With the exception of two individuals seen at lat. 42°S, long. 49°W in November 1959 and one at lat. 51°S, long. 53°W in February 1963, all records were from south of the Antarctic Convergence. Diving petrels were common in the vicinity of South Georgia and flocks of up to 50 were observed off the south-east end of the island in January 1963. Small numbers were also seen on transects 10 and 13, extending, on the latter, to lat. 56°S, long. 25°W. Two species, *Pelecanoides georgicus* and *P. (urinatrix) exsul*, breed at South Georgia but could not be separated at sea.

Boobies.\* Brown boobies (*Sula leucogaster*) and blue-faced boobies (*S. dactylatra*) were seen in large numbers off Ascension Island, where they breed, and in smaller numbers north and south of the Equator on transect 1. In contrast to the reports of Tickell and Woods (1972), who

recorded brown boobies as far south as lat. 25°S in May, this species was not seen beyond lat. 8°S in December or March. On transect 1, a blue-faced booby was seen at lat. 17°S in December 1962 and a red-footed booby (*S. sula*) at lat. 25°S early in March 1963.

Cormorants.\* Blue-eyed cormorants (*Phalacrocorax atriceps*), king cormorants (*P. albiventer*) and Magellan cormorants (*P. magellanicus*) were recorded close to land, the former at islands of the Scotia arc and along the west coast of the Antarctic Peninsula, and the latter two at the Falkland Islands. All of these species are sedentary, rarely being seen more than a few kilometres from shore (Murphy, 1936). It is of interest, therefore, to note the sighting of four blue-eyed cormorants at lat. 53°30'S, long. 41°W, nearly 200 km west of South Georgia and over 70 km from Shag Rocks.

Bigua cormorants (*P. olivaceus*) were seen in the Rio de la Plata close to the Uruguayan coast.

Yellow-billed sheathbill (*Chionis alba*).<sup>\*</sup> The only records were of birds in summer quarters in the South Orkney Islands, the South Shetland Islands and in Graham Land.

South polar skua (*Catharacta maccormicki*). With the exception of sites in the South Shetland Islands, and possibly on Peter I Øy and the Balleny Islands, all known breeding localities of this species are on the Antarctic continent and Antarctic Peninsula (Watson and others, 1971). It is probable that adults rarely stray beyond the pack ice (Eklund, 1961) but Devillers (1977) has shown that immature individuals perform a regular migration into the North Pacific Ocean. A similar migration may occur into the Indian and North Atlantic Oceans (Parmelee, 1976; Devillers, 1977). During the voyages under consideration, south polar skuas were recognized only on transect 13. Records were infrequent, and all except one were obtained within 100 km of the continent. The most northerly sighting, of a characteristic light-phase bird (Devillers, 1977) was at lat. 67°S, long. 12°W.

Large skuas (*Catharacta* spp.). Large skuas were seen frequently in close proximity to the Falkland Islands, the islands of the Scotia arc and the Antarctic Peninsula, but less frequently away from land. None of the birds recorded could be determined unequivocally to species or sub-species except those listed as *C. maccormicki* on transect 13.

Birds were recorded on most transects, the more noteworthy sightings being of a single bird at lat. 10°S, long. 13°W in October 1959, five at lat. 41°S, long. 50°W, two at lat. 42°S, long. 32°W and one at lat. 48°S, long. 43°W in November 1959, one at lat. 59°S, long. 13°W in January 1963 and one at lat. 60°S, long. 11°W in February of the same year.

Arctic skua (*Stercorarius parasiticus*).<sup>\*</sup> Only one Arctic skua was seen in the Southern Hemisphere, at lat. 40°S, long. 50°W on transect 12. This contrasts with the observations of Cooke and Mills (1972), who found that the Arctic skua ranked fourth in abundance among species found off the coast of Argentina in January 1970. Tickell and Woods (1972) recorded few small skuas on transect 3, suggesting that the main concentrations of these species lie over the continental shelf rather than on a direct route between the estuary of the Rio de la Plata and the Falkland Islands.

Gulls.\* Gulls were rarely recorded out of sight of land. Most frequently seen was the southern black-backed gull (*Larus dominicanus*), which occurred in large numbers at all landfalls between the Rio de la Plata and the Antarctic Peninsula. A single bird of this species was seen in the pack ice at lat. 74°S, long. 24°W in February 1962.

Terns. Tern observations outside the tropics fall into two categories: those in temperate and Antarctic waters, and those in the pack ice on transect 13.

Black-capped, grey-mantled terns, which are notoriously difficult to identify at sea, were recorded on many occasions, most frequently in sight of land. Such terns were seen at all landfalls from St. Helena in the north, through Tristan da Cunha, Uruguay and the Falkland Islands to the islands of the Scotia arc and the Antarctic Peninsula. Few identifications were made but South American terns (*Sterna hirundinacea*) were recorded off Uruguay and at the Falkland Islands, while Antarctic terns (*S. vittata*) occurred at several localities south of the Antarctic Convergence. Unidentified terns far from land were recorded at lat. 10°S, long. 12°W in October 1959, and at lat. 49°S, long. 34°W, lat. 42°S, long. 49°W and lat. 55°S, long. 53°W in November 1959.

Murphy (1938) concluded that *S. vittata* was mainly resident at and around the breeding localities, but Watson and others (1971) believed that the species had been overlooked at sea. Despite the possibility of a more extensive dispersal than has been recognized in the past, there is no evidence to suggest that the Antarctic tern occurs in high latitudes other than at breeding stations in the Antarctic Peninsula. In contrast, the penetration of the Arctic tern (*S. paradisaea*) into the Antarctic pack-ice zone has been well documented, both by observations and specimens (Salomonsen, 1967; Watson and others, 1971). It is thus highly probable that most if not all of the terns seen in the Weddell Sea pack ice were *S. paradisaea*. In January and February 1963 a few birds were seen at sufficiently close range to be fairly confident that they belonged to this species. Birds were observed on many occasions in flocks of 10–60, resting on ice floes or icebergs, or feeding in leads in the pack ice. These terns were noted feeding on euphausiids trapped on the surface of ice floes disturbed by the passage of the ship.

Only those terns seen on transect 13 have been included in the Appendix tables.

#### DISCUSSION

The latitudinal distribution of Antarctic birds has been discussed by many authors (Murphy, 1936, 1964; Holgersen, 1957; Falla, 1964; Voous, 1965; Carrick and Ingham, 1967, 1970; Watson and others 1971; Hicks, 1973; Watson, 1975), who have emphasized the significance of the Antarctic Convergence and pack-ice limits as ecological boundaries. The general distribution of the pack-ice margin has been discussed by Mackintosh and Herdman (1940) and the U.S. Navy Hydrographic Office (1957). Heap (1963) has made a detailed examination of the pack ice in the areas east and west of the Antarctic Peninsula. These authors have stressed the variations in extent of ice cover which occur within and between years.

Table II lists the distributional limits of 18 species of birds observed during the seven voyages on transect 13. These data show that a marked change in the avifauna occurred on all seven voyages in the region of lat. 58–62°S. Within, and to the north of, this latitudinal belt the characteristic birds of the Antarctic water mass, wandering and black-browed albatrosses, giant petrels, cape pigeon, southern fulmar, prions and Wilson's storm petrel, were abundant. South of lat. 62°S these species occurred, if they did so at all, in much lower numbers. Similarly, many of the northernmost sightings of the species associated with the pack ice, Antarctic petrel, snow petrel and Arctic tern, were made between these same latitudinal limits. For most species there is some degree of constancy in the latitude of the northernmost or southernmost sighting over most or all of the voyages in question. A majority of species shows less latitudinal variation in range limits than was found for the position of the ice edge.

On three of the voyages, in January 1963 and 1964 and February 1964, the northern boundary of the pack ice lay between lat. 59°S and lat. 61°S. On three other occasions the ice edge was encountered further south, at lat. 64°S in February 1963, at lat. 66°S in February 1962 and at lat. 68°S in January 1960, while in January 1961, no significant concentrations of ice were encountered.

The seven cruises listed in Table II are arranged to reflect the progress of the summer season. Those species with northern distributions show a slight tendency to penetrate further south later



TABLE II. NORTHERN AND SOUTHERN DISTRIBUTION LIMITS OF SELECTED BIRD SPECIES ON TRANSECT 13

Year Month Days	1960 Jan 5-20	1964 Jan 13-27	1963 Jan 19-30	1961 Jan 21-28	1964 Feb 2-9 <sup>a</sup>	1962 Feb 5-16	1963 Feb 7-17
Northern edge of pack ice (lat. °S)	68	59	61	—	59	66	64
Northern limits (lat. °S)							
<i>Aptenodytes forsteri</i>	70	66	68	—	59	74	65
<i>Pygoscelis adeliae</i>	70	60	65	—	65	72	66
<i>Pagodroma nivea</i>	62	57	60 <sup>b</sup>	64	59	61	60 <sup>b</sup>
<i>Thalassoica antarctica</i>	59	58	58	59	59	62	58
<i>Sterna paradisaea</i>	70	59	61	—	64	68	64
Southern limits (lat. °S)							
<i>Diomedea exulans</i>	55	58	59	60	59	64	60
<i>D. melanophris</i>	54	57	57	—	—	—	59
<i>D. chrysostoma</i>	—	57	58	—	—	—	55
<i>Phoebastria palpebrata</i>	—	62	59	59	—	62	61
<i>Macronectes</i> spp.	55	60 <sup>c</sup>	65	55	59	61 <sup>d</sup>	64
<i>Fulmarus glacialis</i>	59	58	59	60	59	66	60
<i>Oaption capense</i>	59	59	61	60	59	62	60
<i>Pachyptila</i> spp.	59	61	62	60	59	62	61
<i>Pterodroma brevirostris</i>	59	59	65	—	62	62	63
<i>P. mollis</i>	—	58	58	—	—	—	58
<i>Procellaria aequinoctialis</i>	54	57	57	—	—	60	54
<i>Oceanites oceanicus</i>	59	60 <sup>e</sup>	73 <sup>f</sup>	60	62	74	66 <sup>f</sup>
<i>Fregetta tropica</i>	56	56	60	—	—	60	58

<sup>a</sup> Observations ceased just north of the pack-ice edge.

<sup>b</sup> Isolated birds were seen east of South Georgia and once off the South Sandwich Islands.

<sup>c</sup> Excluding occasional sightings of 1-2 birds between lat. 70°S, long. 10°W and lat. 72°S, long. 19°W.

<sup>d</sup> Excluding a single individual seen at lat. 74°S, long. 23°W.

<sup>e</sup> Excluding occasional sightings of 1-2 birds between lat. 72°S, long. 18°W and lat. 72°S, long. 20°W.

<sup>f</sup> Excluding 1-2 birds seen at Halley Bay (lat. 75°30'S, long. 26°42'W) during unloading operations.

in the season. This situation is comparable with that found by Hicks (1973) between New Zealand and the Ross Sea. Marked differences in the distribution patterns of the southern fulmar and Wilson's storm petrel between Hicks' observations and the present data can be attributed to the location of breeding colonies of the two species; southern/continental in the Australasian quadrant and northern/insular in the Atlantic quadrant. The northern range extension of southern species noted by Hicks (1973) is not apparent in the present data.

The difficulties of sighting and identifying penguins at sea are considerable, in contrast to the situation in the pack ice, where these birds are easily seen. The possibility that emperor and Adélie penguins occurred north of the pack ice must be considered but it seems unlikely in that in 11 cases out of 12 the northernmost sightings were well south of the ice edge. Furthermore, both species undergo their annual moult in January, February and March (Sladen, 1958; Prevost, 1961), during which time they do not enter the water.

Table III shows the latitudinal differences between the position of the ice edge and the position of the northernmost or southernmost sighting of the same 18 species included in Table II. Here the voyages have been arranged relative to the latitude of the ice edge. In January 1963 and January and February 1964, when the ice edge was encountered between lat. 59°S and lat. 61°S, most species seemed to have their distributional limits within one or two degrees of the ice edge. However, when the ice edge lay further south between lat. 64°S and lat. 68°S, the northern species reached their southern limits several degrees short of these latitudes. Similarly, Antarctic petrels and snow petrels were seen four or more degrees north of the ice edge. Only the Arctic tern and the two penguins did not show this pattern. It is perhaps significant that, in addition to the penguins, the Arctic tern moults flight feathers during January and February (Salomonsen, 1967), and it is these three species which are confined to the pack ice. In January 1961, when no ice was encountered, none of these species was recorded.



TABLE III. RELATION BETWEEN ICE EDGE AND LATITUDINAL DISTRIBUTION LIMITS OF SELECTED BIRD SPECIES ON TRANSECT 13

Year	1964	1964	1963	1963	1962	1960
Month	Jan	Feb	Jan	Feb	Feb	Jan
Days	13-27	2-9 <sup>a</sup>	19-30	7-17	5-16	5-20
Northern edge of pack ice (lat. °S)	59	59	61	64	66	68
<i>Difference between northernmost sighting and ice edge in degrees of latitude<sup>b</sup></i>						
<i>Aptenodytes forsteri</i>	+7	0	+7	+1	+8	+2
<i>Pygoscelis adeliae</i>	+1	+6	+4	+2	+6	+2
<i>Pagodroma nivea</i>	-2	0	-1	-4	-5	-6
<i>Thalassoica antarctica</i>	-1	0	-3	-6	-4	-9
<i>Sterna paradisaea</i>	0	+5	0	0	+2	+2
<i>Difference between southernmost sighting and ice edge in degrees of latitude<sup>b</sup></i>						
<i>Diomedea exulans</i>	-1	0	-2	-4	-2	-13
<i>D. melanophris</i>	-2		-4	-5		-14
<i>D. chrysostoma</i>	-2		-3	-9		
<i>Phoebastria palpebrata</i>	+3		-2	-3	-4	
<i>Macronectes</i> spp.	+1	0	+4	0	-5	-13
<i>Fulmarus glacialis</i>	-1	0	-2	-4	0	-9
<i>Daption capense</i>	0	0	0	-4	-4	-9
<i>Pachyptila</i> spp.	+2	0	+1	-3	-4	-9
<i>Pterodroma brevirostris</i>	0	+3	+4	-1	-4	-9
<i>P. mollis</i>	-1		-3	-6		
<i>Procellaria aequinoctialis</i>	-2		-4	-10	-6	-13
<i>Oceanites oceanicus</i>	+1	+3	+12	+2	+8	+9
<i>Fregetta tropica</i>	-3		-1	-6	-6	-12

<sup>a</sup> Observations ceased just north of the pack-ice edge.

<sup>b</sup> Positive figures indicate positions south of the latitude in which the pack ice was encountered and negative figures latitudes north of the ice edge.

Many of the northernmost and southernmost sightings during the seven voyages were recorded between lat. 58°S and lat. 62°S, and thus coincided with the Weddell Drift Divergence (Mackintosh, 1972; Deacon, 1979). The Divergence represents the main flow from the Weddell Sea (Mackintosh, 1972) and is manifest as a cold tongue of ice-laden water (Mackintosh, 1946). Although the pack-ice edge was located at lat. 61°S and lat. 64°S in January and February 1963, respectively, the 0°C isotherm lay close to lat. 60°S on both voyages. The Weddell Drift Divergence is marked by high densities of krill (*Euphausia superba*) at the surface (see Marr, 1962, figs 143 and 144; Mackintosh, 1973, fig. 14), suggesting that the latitudinal limits of bird distribution may be a function of food availability. Supporting evidence may be drawn from the tendency for some species to be present in somewhat greater numbers in these latitudes despite being close to, or at, the limit of their penetration to north or south.

Observations on transect 13 in January 1963 were made throughout daylight hours, where sightings in January 1961 were based on about three counts per day. Despite the difference in frequency of observations and the radically different ice regime, the latitudinal limits of birds seen during these two voyages were similar (Table II). The voyages made on transects 6, 8 and 9 during the first half of January 1963 paralleled closely those made in 1961 and reported by Tickell and Woods (1972). Despite this close agreement in terms of time and courses sailed, the patterns of bird numbers and distributions varied appreciably between the 2 years. Nine species were recorded on all three transects during at least one of the years under consideration. Of the 27 possible comparisons (nine species on each of three transects), similar patterns of distribution and abundance were found in only 16 cases. During the 1963 voyages, more species were recorded, and numbers of individuals tended to be higher and concentrated at the ends of transects rather than far from land. Little information is available concerning ice conditions during the 2 years but the great disparity further east on transect 13 is likely to have been reflected by differences around Graham Land and the Scotia arc. The differences observed in this

area highlight the relative constancy of distributional limits on transect 13 and emphasize the importance of the controlling factors associated with the Weddell Drift Divergence.

Casual observations made by single observers at different times of day with non-standard observation periods provide limited information about sea-bird abundances. An analysis of the sightings of the more widespread and abundant species obtained during the continuous observations made on transect 13 in 1963 and 1964 have been plotted in Figs 2 and 3. Despite differences in the lengths of observation periods, and uneven cover from degree square to degree square, several points of interest emerge. Three of the species, Antarctic petrel, snow petrel and Arctic tern, showed a wholly or predominantly southern distribution, while the remaining 13 species occurred to a large extent in lower latitudes. There is a clear indication of a faunal boundary between lat.  $58^{\circ}\text{S}$  and lat.  $61^{\circ}\text{S}$ , which only three species, giant petrel, Kerguelen petrel and Wilson's storm petrel, transgressed to any appreciable extent. On three of the four voyages, the northern edge of the pack ice lay within these latitudinal limits, thus coinciding with the Weddell Drift Divergence (Deacon, 1979). There is a tendency, shown in varying degrees by the light-mantled sooty albatross, southern fulmar, Antarctic petrel, cape pigeon, snow petrel and Wilson's storm petrel, to be more abundant at or close to the pack-ice edge.

Wandering albatross, black-browed albatross, grey-headed albatross, giant petrel and shoemaker occurred in more  $1^{\circ}$  squares and were numerically more abundant towards the north-west end of the transect. All of these species nest in considerable numbers at South Georgia (Prince and Payne, 1979) and, with the exception of the giant petrel, reach the southern limit of their breeding range in the Atlantic sector at this island. Relatively high densities of southern fulmar, and to a lesser extent, cape pigeon and prions at about long.  $25^{\circ}\text{W}$  may be a reflection of breeding populations of these species in the South Sandwich Islands.

Only three of the 16 species, Kerguelen petrel, soft-plumaged petrel and Arctic tern, do not breed within the area covered by transect 13. Both petrel species have their nearest breeding station at Gough Island. Departure from the nesting grounds of breeding soft-plumaged petrels and birds of the year does not occur until May (Watson, 1975), so that the appearance of this species south of the Antarctic Convergence in January and February must be due largely to immature birds. The earlier breeding cycle of the Kerguelen petrel suggests that the numbers of this species may be swollen by the post-breeding dispersal. Recent records of the Kerguelen petrel in the south-east Pacific Ocean and the South Atlantic Ocean (Harper and others, 1972; Prince and Payne, 1979) have demonstrated the circum-polar distribution of this species. Published data suggest, however, that numbers are higher east of long.  $25^{\circ}\text{W}$  (Watson and others, 1971; Harper and others, 1972; Lathbury, 1972), a situation confirmed by the present observations. The Arctic tern, which breeds in high northern latitudes, was seen only south of the pack-ice edge. Salomonsen (1967) has shown that the transit of migrant terns between low and high latitudes is probably fairly rapid, and that during January and February adults are undergoing wing moult in the pack ice. The weak and awkward flight of those few birds which were not at rest demonstrates the importance of the pack ice during this phase of the life cycle.

Cooke and Mills (1972) have commented on the lack of overlap in range between the black-browed albatross and the yellow-nosed albatross to the south of the Rio de la Plata. Observations on transect 3 showed a similar pattern, with almost complete latitudinal separation of the two species. In mid-ocean, however, where numbers were low, the zone of overlap was much wider.

The upwelling of nutrient-rich water, with a subsequent enhancement of phytoplankton and zooplankton production (Cushing, 1971) is known to attract flocks of feeding sea birds (Murphy, 1936; Watson, 1966; Brown and others, 1975). Feeding concentrations of sea birds, probably associated with areas of upwelling, have been reported off the coast of Argentina by Cooke and Mills (1972) and Brown and others (1975). Several of the concentrations found by these authors lay close to the edge of the continental shelf and to the edge of the north-flowing Falkland Current where upwelling might be expected (Knox, 1960).

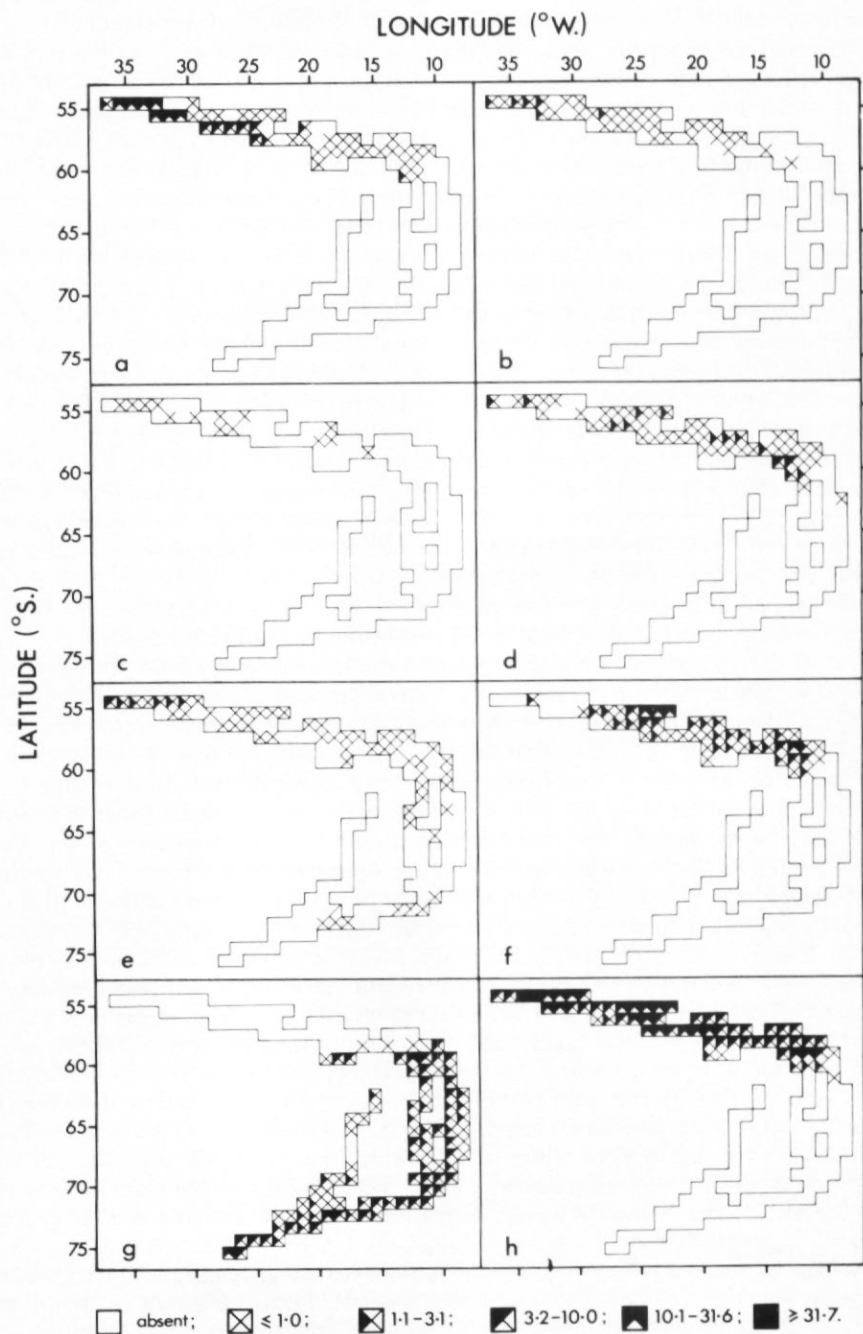


Fig. 2. Average number of birds per observation period for all observations on transect 13 during 1963 and 1964 (see text). a. Wandering albatross; b. Black-browed albatross; c. Grey-headed albatross; d. Light-mantled sooty albatross; e. Giant petrels; f. Southern fulmar; g. Antarctic petrel; h. Cape pigeon.

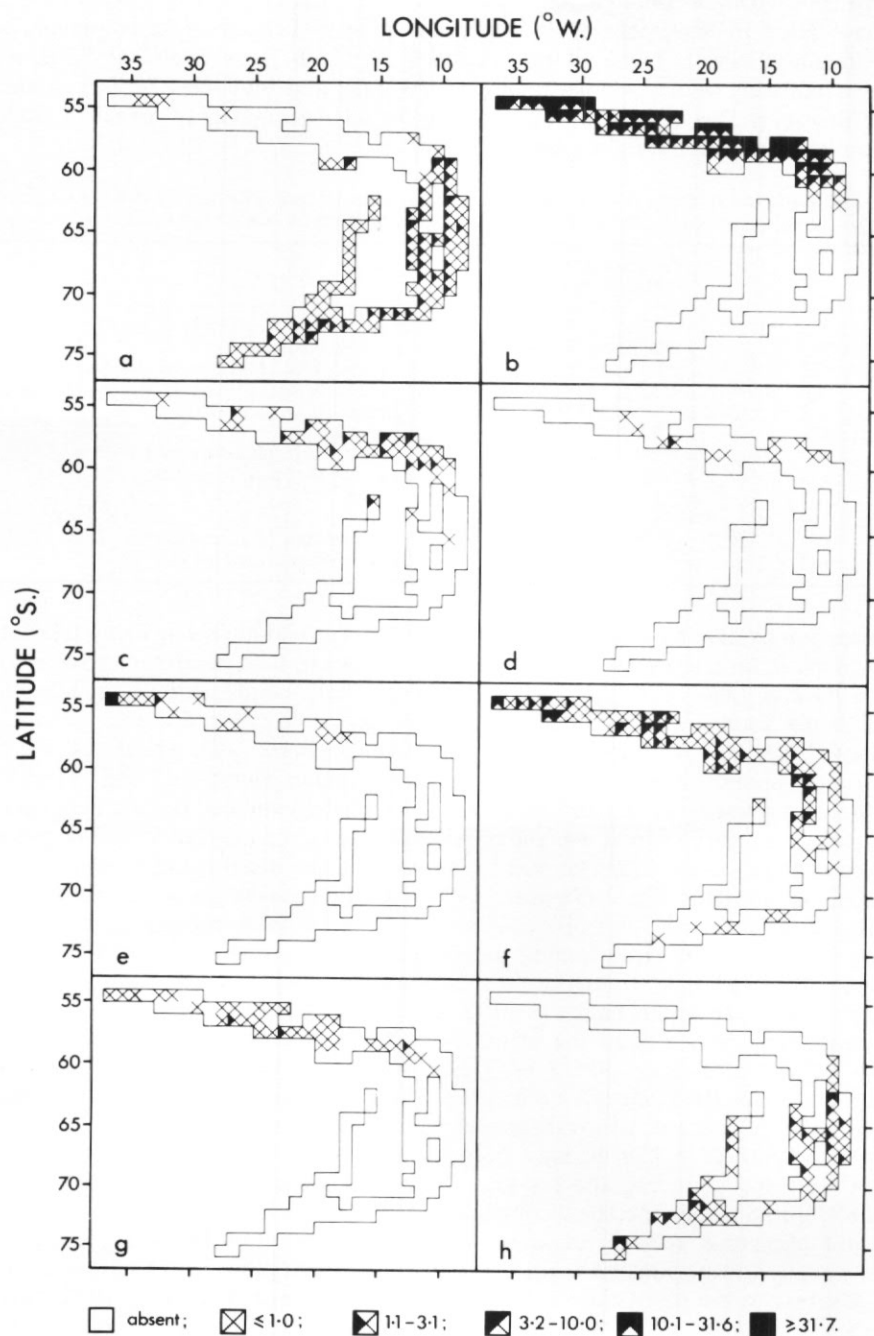


Fig. 3. Average number of birds per observation period for all observations on transect 13 during 1963 and 1964 (see text). a. Snow petrel; b. Prions; c. Kerguelen petrel; d. Soft-plumaged petrel; e. Shoemaker; f. Wilson's storm petrel; g. Black-bellied storm petrel; h. Arctic tern.

Sea-bird concentrations on transects 3 and 12 are summarized in Table IV. All observations, except those dated 13 November 1959, were made close to the edge of the continental shelf and in the Falkland Current. None of the localities at which large flocks of birds were seen corresponds precisely with positions reported by Cooke and Mills (1972), Tickell and Woods (1972) or Brown and others (1975), but this may be due to vagaries of upwelling and possible eddy formation at the edge of the Falkland Current.

TABLE IV. SEA-BIRD CONCENTRATIONS ON TRANSECT 3 (FALKLAND ISLANDS—RIO DE LA PLATA) AND TRANSECT 12 (SOUTH GEORGIA—RIO DE LA PLATA). SPECIES OF RELATIVELY MINOR IMPORTANCE ARE IN PARENTHESES

Date	Position (lat., long.)	Species
14 Nov 1959	36°33'S, 53°59'W	<i>Pterodroma incerta</i> , ( <i>Puffinus gravis</i> )
26 Feb 1962	37°26'S, 56°43'W	<i>Diomedea melanophris</i>
26 Feb 1962	38°03'S, 56°38'W	<i>D. melanophris</i> , ( <i>Oceanites oceanicus</i> )
26 Feb 1963	38°15'S, 55°14'W	<i>P. gravis</i> , <i>Puffinus griseus</i> , <i>P. incerta</i> , <i>O. oceanicus</i>
26 Feb 1962	38°37'S, 56°38'W	<i>P. griseus</i> , <i>D. melanophris</i>
13 Nov 1959	39°51'S, 51°17'W	<i>Pachyptila</i> spp.
13 Nov 1959	40°23'S, 50°51'W	<i>Pachyptila</i> spp., ( <i>O. oceanicus</i> )
13 Nov 1959	40°58'S, 50°23'W	<i>Macronectes</i> spp., <i>O. oceanicus</i>
25 Feb 1962	40°21'S, 56°10'W	<i>P. gravis</i>
13 Nov 1959	42°16'S, 49°03'W— 41°39'S, 49°41'W	<i>Pachyptila</i> spp., ( <i>O. oceanicus</i> )
25 Feb 1962	42°43'S, 56°25'W	<i>P. gravis</i> , <i>Pterodroma mollis</i>

The observations dated 13 November 1959 are less easy to interpret. From 04.00 h, before dawn, to 19.30 h, large concentrations of prions were seen, with maximum numbers of about 800 in the morning and about 200 in the afternoon. Giant petrels and Wilson's storm petrels were moderately abundant and a further 13 species were seen in small numbers. In addition to birds, many Cetacea were seen: two rorquals (*Balaenoptera* sp.), about ten killer whales (*Orcinus orca*), about 20 bottle-nosed whales (*Hyperoodon planifrons*) and several hundred common dolphin (*Delphinus delphis*). Both birds and whales exhibited feeding behaviour, so it is probable that availability of food was the proximal cause of the aggregations. The geographical coordinates of these observations lie well to the north of the mean position of the Sub-tropical Convergence as plotted in Fig. 1 (Deacon, 1937) and the position shown by Rumboll and Jehl (1977). The position of the Sub-tropical Convergence is far from constant (Deacon, 1937), so that it may be that the enhanced feeding was due to the close proximity of this boundary to the ship's track. Although this seems the most probable explanation, particularly in view of the considerable area over which flocks of birds were seen, there is a little evidence for another possible cause. In 1907, a sounding of 69 fm (126 m) in a patch of discoloured water was recorded at lat. 41°53'S, long. 50°23'W. This position lies within 30 nautical miles (56 km) of the track followed by RRS *Shackleton* in 1959. Subsequent investigations close to this position have failed to reveal a shoal, although several pinnacles, one rising 1 100 m above the abyssal sea floor to a depth of 4 700 m, have been located. In 1930, RRS *Discovery II* visited the position of the 1907 sounding and reported "... much loose kelp and flocks of birds on the supposed 69 fathom patch" (personal communication from D. J. Dixey).

There are numerous records of cape pigeons, southern fulmars, soft-plumaged petrels, Schlegel's petrels and pediunkers from the waters of the Argentine continental shelf and the Falkland Current to the east (Watson and others, 1971). Cooke and Mills (1972) saw none of these species in January 1970. With the possible exception of Schlegel's petrel, none of these species was seen by Linkowski and Rembiszewski (1978). Three of the voyages on transect 3 reported by Tickell and Woods (1972) and one in this paper were also made during January. Schlegel's petrels were recorded on a few occasions, soft-plumaged petrels only rarely, and the remaining three species not at all. This apparent disparity highlights one of the major problems



which hinder the clarification of the distribution of pelagic birds: that observations are made mainly in summer, particularly in high latitudes.

Tickell and Woods (1972) have described observations made during 36 runs on 11 transects spread over the months September to June. The present paper deals with a further 28 runs, made on 12 transects from October to March, of which only five were made at the same time of year as those of Tickell and Woods. Although the month-by-month cover on each transect was irregular, the complementary nature of the two data sets is such that some indications of seasonal movements are apparent. Species for which such movements are demonstrated include great, black-browed, sooty and light-mantled sooty albatrosses, great and blue petrels, southern fulmar, cape pigeon, dove prion, shoemaker and Wilson's storm petrel. The clear indications of seasonal movements obtained from data in this paper and those of Tickell and Woods suggest that Watson and others (1971) may have been unduly pessimistic in attempting seasonal distribution plots for no species other than the cape pigeon.

The month-by-month plots for Wilson's storm petrel (Roberts, 1940) stand as an example which could with profit be applied to many of the more abundant species in the Southern Ocean.

Increasing interest in the commercial exploitation of marine resources has resulted in plans for a greater scientific effort in the Southern Ocean (El Sayed, 1977; Scientific Committee on Antarctic Research, 1978). Direct investigations of the status of some of these resources may present considerable problems, whereas birds, which play an important role in the ecosystems of the Southern Ocean, are relatively amenable to study, and may provide convenient indices of environmental change (Croxall and Prince, 1979). At-sea observations of the distribution and density of birds would form an integral part of such studies. Ships travel many thousands of kilometres on logistic and oceanographic cruises in the Southern Ocean. There is a pressing need for continuous observations to be made on these cruises, recording feeding behaviour, distribution and numbers of birds, together with appropriate physical and biological data.

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APPENDIX DAILY MAXIMUM NUMBERS OF BIRDS OBSERVED ON TRANSECT 13, SOUTH GEORGIA—HALLEY BAY																																		continued overleaf																	
	January 1960																January 1964										January 1961								January 1963																
	5	6	7	8	9	10*	11*	12*	13*	14*	15*	16*	17*	18*	19	20	13	14	15	16	17*	18*	19*	20*	21*	22*	23*	24*	25*	26*	27	21	22	23	24	25	26	27	28	19	20	21	22	23	24*	25*	26*	27*	28	29	30
Great albatrosses	4	3															1	2	2	1											2		2	1					2	III	7	1	1								
<i>Diomedea melanophris</i>	1																4	2	3																			3	3	4	1										
<i>Diomedea chrysostoma</i>																		1	1																				2	2	2	1									
<i>Phoebetria fusca</i>																																								1											
<i>Phoebetria palpebrata</i>																	4	5	4	1			1										5	1					2	2	5	4	2								
<i>Macronectes</i> spp.	II	1															7	3	2	2	1	1					2	1			1						12	3	2	1	2	1	1	10							
<i>Daption capense</i>	3	3	2														III	III	11	III	4										12	III	3	III					8	III	III	III	III	2							
<i>Fulmarus glacialoides</i>		1	3															III	11	5	1										1	2	III	2						3	2	III									
<i>Pachyptila</i> spp.	7	2	1														III	III	III	IV	1	1									III	II	6	4					IV	4	4	III									
<i>Thalassoica antarctica</i>			14	3	2	4	7				1		1	2	2	1				10	III	7	8	1	2	6	8	IV	4	4	III				3	5	2	5	2	4											
<i>Procellaria aequinoctialis</i>	2																1	1	4																																
<i>Puffinus griseus</i>																		2	4	1																															
<i>Pterodroma brevirostris</i>			4															8	5	III	3																														
<i>Pterodroma mollis</i>																	1		2																																
<i>Pagodroma nivea</i>				4	3	3	3	1		1	1	1	1	2	2	1				1	12	5	5	4	3	4	3	III	2	4	1																				
<i>Oceanites oceanicus</i>	III	9	1														3	10	3	1	1										1			III	6																
<i>Fregetta tropica</i>		3															1	1	1																																
<i>Catharacta maccormicki</i>																2																																			
<i>Catharacta</i> spp.																															1																				
<i>Sterna paradisaea</i>							3	1													18		14	15	18	20	9	14	30	16																					
<i>Aptenodytes forsteri</i> †							1/2	1/2	2/5		1/1	1/1												2/4	2/3	5/16	4/15	10/22	7/35	2/9																					
<i>Pygoscelis adeliae</i> †							8/17	9/9	3/3						3/3	1/1								7/42	1/4	1/3	2/8	2/5	40/287	10/71																					
<i>Pygoscelis antarctica</i> †	150/270	18/18																	5/6		1/1																														
Lat. (°S)	54	56	58	62	66	69	70	71	71	71	71	71	71	71	74	76	55	55	57	58	59	61	64	66	68	69	71	73	72	73	76	55	57	59	60	64	67	70	73	54	55	57	57	59	62	64	66	67	71	73	76
Long. (°W)	36	29	23	17	17	14	11	14	15	16	15	15	15	14	22	27	32	26	19	13	10	09	09	09	09	09	11	21	19	21	27	30	24	17	09	07	07	09	20	37	32	26	20	13	09	09	10	09	11	21	27

\* Ship in pack ice for all or part of day.  
† Maximum number at one observation/total for all observations.  
Blank No birds seen.  
1–287 Number of birds counted.  
I Estimated numbers 1–2.  
II Estimated numbers 3–10.  
III Estimated numbers 11–100.  
IV Estimated numbers 101–1 000.  
V Estimated numbers over 1 000.



APPENDIX—contd.

	February 1964								February 1962												February 1963											
	9*	8*	7*	6*	5*	4*	3*	2*	16	15	14	13*	12*	11*	10*	9*	8*	7*	6*	5	17	16	15	14	13	12*	11*	10*	9*	8	7	
Great albatrosses	1								3	1		1									III	2	1	1	2							
<i>Diomedea melanophris</i>																					3	3	2	2	1							
<i>Diomedea chrysostoma</i>																					1	1										
<i>Phoebetria fusca</i>																																
<i>Phoebetria palpebrata</i>									2		1										2	1	2	4	7							
<i>Macronectes</i> spp.	1								3	1	1							1			4	1	1	2	3	1						
<i>Daption capense</i>	3								III	III	II										III	12	10	13	8							
<i>Fulmarus glacialis</i>										5	III	1									3	5	5	7	10							
<i>Pachyptila</i> spp.	1								III	1	3										III	8	8	III	III							
<i>Thalassoica antarctica</i>	12	3	2	2	4	15	2	3			4		5	2	2	15	3	3	3	2				1	III	6	5	14	8	3	4	
<i>Procellaria aequinoctialis</i>									1	1											1											
<i>Puffinus griseus</i>																																
<i>Pterodroma brevirostris</i>	1	12									2												2	III	1	1						
<i>Pterodroma mollis</i>																							2	1								
<i>Pagodroma nivea</i>	13	2	3	5	3	3	1	2			1		1	3	1	1	2	2	1	2	1	1			3	6	6	5	5	1	1	
<i>Oceanites oceanicus</i>	5	1							2	3	6	2		1			1	1		1	7	4	7	6	8	5	1	1				
<i>Fregetta tropica</i>									1	1											1	2	2	1								
<i>Catharacta maccormicki</i>																	1											1	1			
<i>Catharacta</i> spp.																					1	1			1							
<i>Sterna paradisaea</i>	III			III	3	III	III	III					1	3	1		III									12	5	12	III			
<i>Aptenodytes forsteri</i> †	1/1					3/7	1/3	3/3									5/7	1/3								2/7	7/17	7/11				
<i>Pygoscelis adeliae</i> †				4/4		57/193	5/16	11/11							1/1	1/1																
<i>Pygoscelis antarctica</i> †																										1/1		1/1				
Lat. (°S)	59	62	64	65	69	71	72	74	56	59	62	65	68	71	74	74	74	74	74	74	55	56	57	59	60	64	66	67	69	72	76	
Long. (°W)	19	16	16	17	18	21	23	24	33	27	22	20	19	22	24	24	23	23	22	24	33	29	24	18	11	13	12	12	12	20	27	

## APPENDIX—contd.

	February 1964								February 1962											February 1963											
	9*	8*	7*	6*	5*	4*	3*	2*	16	15	14	13*	12*	11*	10*	9*	8*	7*	6*	5	17	16	15	14	13	12*	11*	10*	9*	8	7
Great albatrosses	1								3	1		1									III	2	1	1	2						
<i>Diomedea melanophris</i>																					3	3	2	2	1						
<i>Diomedea chrysostoma</i>																					1	1									
<i>Phoebetria fusca</i>																															
<i>Phoebetria palpebrata</i>									2		1										2	1	2	4	7						
<i>Macronectes</i> spp.	1								3	1	1						1				4	1	1	2	3	1					
<i>Daption capense</i>	3								III	III	II										III	12	10	13	8						
<i>Fulmarus glacialis</i>										5	III	1									3	5	5	7	10						
<i>Pachyptila</i> spp.	1								III	1	3										III	8	8	III	III						
<i>Thalassoica antarctica</i>	12	3	2	2	4	15	2	3			4		5	2	2	15	3	3	3	2				1	III	6	5	14	8	3	4
<i>Procellaria aequinoctialis</i>									1	1											1										
<i>Puffinus griseus</i>																															
<i>Pterodroma brevirostris</i>	1	12									2												2	III	1	1					
<i>Pterodroma mollis</i>																							2	1							
<i>Pagodroma nivea</i>	13	2	3	5	3	3	1	2			1		1	3	1	1	2	2	1	2	1	1			3	6	6	5	5	1	1
<i>Oceanites oceanicus</i>	5	1							2	3	6	2		1			1	1		1	7	4	7	6	8	5	1	1			
<i>Fregetta tropica</i>									1	1											1	2	2	1							
<i>Catharacta maccormicki</i>																	1											1	1		
<i>Catharacta</i> spp.																					1	1			1						
<i>Sterna paradisaea</i>	III			III	3	III	III	III					1	3	1		III									12	5	12	III		
<i>Aptenodytes forsteri</i> †	1/1					3/7	1/3	3/3									5/7	1/3									2/7	7/17	7/11		
<i>Pygoscelis adeliae</i> †				4/4		57/193	5/16	11/11							1/1	1/1															
<i>Pygoscelis antarctica</i> †																										1/1		1/1			
Lat. (°S)	59	62	64	65	69	71	72	74	56	59	62	65	68	71	74	74	74	74	74	55	56	57	59	60	64	66	67	69	72	76	
Long. (°W)	19	16	16	17	18	21	23	24	33	27	22	20	19	22	24	24	23	23	22	24	33	29	24	18	11	13	12	12	12	20	27