

Order PROCELLARIIFORMES

A rather distinct group of some 80–100 species of pelagic seabirds, ranging in size from huge to tiny and in habits from aerial (feeding in flight) to aquatic (pursuit-diving for food), but otherwise with similar biology. About three-quarters of the species occur or have been recorded in our region. They are found throughout the oceans and most come ashore voluntarily only to breed. They are distinguished by their hooked bills, covered in horny plates with raised tubular nostrils (hence the name Tubinares). Their olfactory systems are unusually well developed (Bang 1966) and they have a distinctly musky odour, which suggest that they may locate one another and their breeding places by smell; they are attracted to biogenic oils at sea, also no doubt by smell. Probably they are most closely related to penguins and more remotely to other shorebirds and waterbirds such as Charadriiformes and Pelecaniiformes. Their diversity and abundance in the s. hemisphere suggest that the group originated there, though some important groups occurred in the northern hemisphere by middle Tertiary (Brodkorb 1963; Olson 1975).

Structurally, the wings may be long in aerial species and shorter in divers of the genera *Puffinus* and *Pelecanoides*, with 11 primaries, the outermost minute, and 10–40 secondaries in the Oceanitinae and great albatrosses respectively. The tail varies in length, being forked in *Oceanodroma*, forked to pointed in other forms, usually with 12 rectrices but up to 16 in fulmars. The tarsi are light and cylindrical in aerial forms; strong and laterally compressed with legs set far back in aquatic ones. The front toes are webbed; hind toe small or absent. The proventriculus is long and glandular; the gizzard small and twisted; and the small intestine often spiral in *Pterodroma*, presumably to aid absorption of the unusual lipids in their food. Chicks are helpless and covered in down, with two coats except in some Oceanitinae. Some larger species have a darker immature plumage, and the female is often darker than the male in the great albatrosses. The male is usually larger than the female, though smaller in the Oceanitinae and some other small species. Otherwise there is little difference in appearance with sex or age, except that young birds may have more pronounced pale or dark edges to the feathers. Many have simple counter-shaded markings that often appear to have given rise to uniformly dark or, less often, to pale derivatives; some species in most groups are dimorphic or polymorphic. The more complex groups have often developed distinctive markings of the extremities.

Breed more or less colonially on offshore islands, coastal cliffs, or on hills and deserts inland, where they perform complex vocal and aerial displays. The nest is a simple scrape or cup in a burrow or natural hole, sometimes under vegetation. The s. albatrosses build large cone-shaped nests in the open; may be lined with any debris available in the area. Smaller species visit it only at night, though larger ones and those breeding on remote islands may come to nests in the open by day. Parents incubate for spells of several days in turn and generally leave the chick alone soon after it hatches, only returning at long intervals to feed it by regurgitation. In consequence the chick is vulnerable to introduced predators and some species are now greatly reduced and at least two are now extinct. Some species also periodically liable to have unsuccessful breeding seasons. Many young or even old birds may be wrecked ashore and die when they meet bad weather or suffer shortage of food on migration or in the winter. Though it has been claimed that they are also vulnerable to all sorts of pollution, the evidence is weak (Bourne 1976). There is at present anxiety about the effect of some fishing methods, such as long-lining, which may be endangering species such as the great albatrosses.

All species feed at sea on a variety of fish, cephalopods and small marine invertebrates, either socially or alone; larger species may scavenge all sorts of offal or prey on other birds. Most, except perhaps *Pelecanoides*, can digest the complex lipids formed by some marine animals (Clarke & Prince 1976), and may eject them to soil the plumage of their enemies with lethal results (Swennen 1974). Some species can digest wax (Obst 1986). Many now take wastes from whaling and fishing operations (Fisher 1952). All have long life-cycles in proportion to their size; they disperse on fledging and then prospect for nest-sites for 2–12 years in their youth. They usually lay a single large white egg annually; though a successful breeding cycle may be completed in less than a year in at least one tropical species, *Puffinus lherminieri*, it may take 2 years in larger southern ones. Before laying, the birds court for weeks or months, then go to sea for feeding. Incubation lasts 6–8 weeks, and fledging 2–9 months. Once the fat chick fledges it fends for itself, even in species that immediately make a long migration, sometimes to the opposite hemisphere.

Tendency for failed breeders and non-breeders to begin moult before successful breeders. Five strategies of wing-moult in breeding adults: (1) In albatrosses, remiges replaced in staffelmauser interrupted while breeding; in nearly all other species, primaries moulted outwards; possibly simultaneously in some diving-petrels. (2) In most subantarctic and temperate species, moult begins soon after breeding and is completed shortly before next breeding season. (3) In most tropical species, moult aseasonal, between breeding attempts; resumption of breeding apparently depends on when moult completed. (4) In trans-equatorial migrants, wing-moult delayed until they reach non-breeding quarters, where it is completed; moult rapid but no satisfactory evidence for flightlessness. In

some species, body-moult also in winter quarters; in others, at breeding grounds. (5) In some species of high latitudes, rapid moult completed in summer when they breed; some begin moult long before breeding finished.

The history of the classification of the Order is very confused, as is seen by comparing Timmermann's (1965) discussion of their Mallophagan parasites with that by Klemm (1969) of their leg muscles and that by Harper (1978) of their proteins, but it is now widely agreed that the Order is best divided into four families: Diomedidae or large to huge aerial albatrosses; Procellariidae or medium-sized, mainly aerial but sometimes aquatic, petrels, shearwaters and prions; Hydrobatidae or small to tiny, aerial storm-petrels; and Pelecanoididae or small aquatic diving-petrels.

References

- Bang, B.G. 1966. *Acta anat.* 65: 305-415.
 Bourne, W.R.P. 1976. Pp 403-502. In: Johnston 1976.
 Brodkorb, P. 1963. *Bull. Flor. St. Mus. biol. Sci.* 7: 179-293.
 Clarke, A., & P.A. Prince. 1976. *J. Exp. mar. Biol. Ecol.* 23: 15-30.
 Fisher, J. 1952. *The Fulmar*.
 Harper, P.C. 1978. *NZ J. Zool.* 5: 509-549.
 Johnston, R. (Ed.). 1976. *Marine Pollution*.
 Klemm, R.D. 1969. *S. Ill. Univ. Monogr. Sci. Ser.* 2.
 Obst, B.S. 1986. *Wilson Bull.* 98: 189-95.
 Olson, S.L. 1975. *Smithson. Contr. Paleobiol.* 23.
 Swennen, C. 1974. *Ardea* 62: 111-117.
 Timmermann, G. 1965. *Abh. Verh. naturwiss. Vereins Hamburg NF* 8, Suppl. 1-249.

Family HYDROBATIDAE (OCEANITIDAE) storm-petrels

Storm-petrels are the smallest seabirds, distinguished by having prominent united nostrils with a single opening, wings with a longer second functional primary, and often with a white rump, varying in closely related forms and assumed to serve as an important interspecific recognition-signal. They feed by picking small animals from the surface and fall into two groups.

(1) The sub-family Oceanitinae consists of seven fairly distinct species in five genera, of which five species occur in our region. Characterized by short wings with only ten secondaries, more or less square tails, elongated skulls, and tarsi longer than the toes. They progress by hopping and fluttering over the surface. Some species are said to have only one coat of nestling down. Adults are all polymorphic to some extent. Six species are usually white below; only one has an entirely black breast (Murphy & Snyder 1952). Most breed in the s. hemisphere and only the normally dark-breasted species, Wilson's Storm-Petrel *Oceanites oceanicus*, migrates far N of the equator, where an ancestor might have given rise to the second group (Palmer 1962).

(2) The sub-family Hydrobatinae consists of some 14 fairly closely related species in three genera; in our region only two of these species (in *Oceanodroma*) have been recorded, as accidentals. This group is characterized by having longer wings than the other, wedge-shaped or more usually forked tails, short skulls and bills, tarsi usually about equal in length to the toes, and a swooping flight, walking but not hopping along the surface. They have two coats of nestling down. Adults are usually dark and not polymorphic, though one species is grey and another southern one is white below. Most breed in the north but some breed, or migrate a short distance, south of the equator.

In general, plumage is black or grey above; the rump and underparts may be grey or white. Wing with 11 primaries, p₉ longest, p₁₁ minute; 10-11 secondaries, rather short, diastataxic. Tail quite long, forked, square or rounded; 12 feathers. Bill rather small, strongly hooked; nostrils fused with single opening, often upwards. Tarsus, rounded; three forward toes, webbed; hind toe, rudimentary; claws, sharp; flattened in some. Oil-gland feathered. Peculiar musky odour. Sexes similar and juveniles like adults.

Cosmopolitan in all oceans; strictly pelagic, coming to shore only to breed and then usually by night. Very little knowledge of distribution, behaviour and requirements of most species when at sea, because birds are so hard to find and identify. On land, crouch on tarsi and move with shuffling gait. Flight erratic, usually close to surface, characterized by bouncing, fluttering, swooping and skimming progress. Feed mostly on planktonic crustaceans, molluscs and small fish; some species habitually follow ships, scavenging in wake; obtain food mostly by flight-feeding while hovering, pattering or walking on water; seldom dive. Gregarious or solitary at sea. Long-term monogamous pair-bond, probably maintained only at nest-sites by reason of fidelity to site. Little knowledge of social behaviour but birds evidently not specialized for visual displays; sexual communications probably by tactile (allopreening), olfactory and vocal means. Churring or purring calls are a notable feature of breeding colonies. Nest colonially in holes or burrows. Eggs, ovate, mat, white. Clutch-size, invariably one. Single-brooded and probably no replacement laying or very seldom. Incubation by both sexes in alternate shifts of up to 6 days; single median brood-patch. Incubation period, 40-50 days. Eggshells usually left in nest. Young, semi-altricial, nidicolous; hatched in down. Guarded and brooded for 5-7 days before being left alone during day and fed at night, by incomplete regurgitation. Nestling period, 59-73 days; not deserted by parents in last days in nest. Maturity attained in some species at 4-5 years of age.

REFERENCES

- Murphy, R.C., & J.M. Snyder. 1952. *Am. Mus. Novit.* Palmer, R.S. 1962. *Handbook of North American Birds*. 1. 1596.

Oceanites oceanicus Wilson's Storm-Petrel

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Pro.[cellaria] oceanica Kuhl, 1820, *Beitr. Zool. vergl. Anat.* 2: 136 — no locality, restricted to South Georgia *apud* Murphy, 1918.

The scientific names are tautological (the oceanbirds associated with the ocean), the generic being compounded of the Greek *ὠκεανός* and the suffix *-ite* (denoting a connexion).

OTHER ENGLISH NAMES Flat-clawed or Yellow-webbed Storm-Petrel, Mother Carey's Chicken.

Named in honour of Alexander Wilson (1766–1813), Scottish weaver and poet, who emigrated to USA in 1794 and became one of the pioneers of American ornithology, eventually producing the ambitious and innovative *American Ornithology* (Mearns & Mearns, *Biogr. Birdwatch.*, 1988).

POLYTYPIC Nominate *oceanicus* breeds on subantarctic islands; *exasperatus* Mathews, 1912, on Antarctic mainland and Scotia Sea islands. White-breasted ('Pealea' phenomenon) *maorianus* (Mathews, 1932) described from three specimens taken off NZ in mid-nineteenth century (Oliver; Murphy & Snyder 1952) has not been reported since.

FIELD IDENTIFICATION Length 15–19 cm; wing-span 38–42 cm; weight 35 g. Very small blackish storm-petrel with proportionately short rounded wings, square tail (often carried in shallow dihedral) and long thin legs. Feet usually project well beyond tail in travelling flight, at other times dangling or not extended. Entirely blackish brown apart from usually pronounced pale bar on proximal upperwing and prominent U-shaped white band across rump. Wide-ranging but most often seen within continental-shelf waters; habitually follows ships. Sexes alike; no seasonal variation other than that caused by feather wear. Juveniles not usually separable.

DESCRIPTION ADULT. Head and upperparts, blackish brown with slightly darker remiges and tail. Wings appear fairly short, broad, rounded at tips with nearly straight trailing edge; paler greyish or greyish-brown greater secondary coverts form usually pronounced pale bar across innerwing, contrasting with blackish remiges. Broad U-shaped band of white across lower rump and upper tail-coverts extends broadly onto coverts and lower flanks. Tail, blackish and square-ended. Underparts, including underwing, blackish brown; chin, sometimes paler; many show pronounced pale flush on inner under wing-coverts. Bill, very small, black, with prominently raised nostrils. Iris, dark brown. Legs and feet, long and thin; legs and toes, black; webs, yellow or with partly yellowish centres but not normally visible in flight. Some birds have grey centre to rump with white patch on each side of base of tail (Bourne 1987). **JUVENILE.** Feathers of belly and lores have white edgings but these probably wear rapidly and rarely of use as field marks.

SIMILAR SPECIES Intermediate in size between smaller, slimmer Grey-backed Storm-Petrel *Garrodia nereis* and the larger, distinctly fatter-bodied *Fregetta* storm-petrels; differs from all of these, except darkest morphs of White-bellied *F. grallaria*, by lack of white on belly and underwings; for distinctions from dark-morph White-bellied, see that account. Distinguished from Matsudaira's Storm-Petrel *Oceanodroma matsudairae* by much smaller size, white rump and squarish tail and completely different jizz; from Leach's Storm-Petrel *Oceanodroma leucorhoa* by shorter, more rounded wings, squarish tail, long legs (projecting beyond tip

of tail) and flight actions (see Leach's Storm-Petrel for details).

Wide-ranging but usually seen within waters of continental shelf. Feet project beyond tail in travelling flight, at other times dangling or not extended. Travelling flight strong, direct (at times up to 3 m above waves), with rapid wing-beats interspersed with short glides; flight-action recalls that of hirundines. Feeding flight is much slower: patter, walk and jump on surface with wings held high over back in V and legs dangling. Also stand on surface, facing into wind with wings rigid and feet acting as anchors. Usually feed by dipping, pattering, less often by surface-seizing and more rarely by shallow-plunging and surface-diving. Follow moving boats and circle stationary craft, drilling platforms, etc.; take scraps and offal. Occur singly or in loose flocks, sometimes in hundreds, occasionally in thousands at whaling stations. Usually silent at sea but sometimes give chirping calls, particularly at night.

HABITAT Marine; breed in Subantarctic and Antarctic Zones, and migrate to n. hemisphere (mainly Atlantic and Indian Oceans) in non-breeding season. In breeding season, most abundant near breeding sites; range extends a few degrees into Subtropical Zone where breed close to Subtropical Convergence (Jouventin *et al.* 1982a). In Ross Sea in summer, most birds within 500 km of nesting grounds; occur from 0.5 °C isotherm along n. edge of iceberg belt, S to Antarctic Continent; mainly in open water N of pack-ice, particularly where icebergs occur. Near C. Hallett and C. Adare, concentrate over continental slope of Ross Sea. Density lower in pack-ice, even over continental slope (Ainley *et al.* 1984). Within pack-ice, frequent light pack; more often seen over wide leads and pools than near ice-floes or brash-ice (Cline *et al.* 1969; Zink 1981; Ainley *et al.* 1984). Concentrations observed at edge of pack (Routh 1949; Darby 1970). Forage close to breeding sites; in inshore waters of sound at Iles Kerguelen (Falla 1937); at Heard I., immediately beyond surf-zone in bays (Downes *et al.* 1959). At Iles Crozet, occur in pelagic (>3 km offshore) waters and inshore (<3 km) over continental shelf; forage closer inshore as breeding season progresses; in Nov.–Dec., all birds observed beyond kelp (*Macrocystis*) zone; in Jan., enter kelp-

zone; in Feb., occur inshore to calm sea between kelp and surf (Jouventin *et al.* 1982b, 1985). On Antarctic Continent, occasionally seen well inland (Johnstone *et al.* 1973; Ainley *et al.* 1978).

Pelagic on migration in Indian and Pacific Oceans (Bailey 1968; Crossin 1974), though first-year birds may follow coasts of s. continents (Murphy). In Aust. waters, most records from edge of continental shelf (Aust. Atlas); birds often congregate and feed at ocean fronts where water masses of different temperature and salinity meet (N.G. Cheshire); occasionally occur inshore (Eckert 1969). In non-breeding season, mainly in tropical and subtropical waters; also cooler waters of N. Atlantic. Occur over edges of continental shelves (Bailey 1966; Summerhayes *et al.* 1974; Powers 1983), edges but not centres of coastal, cool-water upwellings (Bailey 1966, 1968), and cool, w. boundary currents (Jehl 1973). In w. Atlantic, associated with *Sargassum* rafts along convergence front and eddies of Gulf Stream (Haney 1986).

Breed on Antarctic Continent and Pen., and Antarctic and subantarctic islands, in snow- and ice-free areas; on cliffs, scree slopes, moraines, rocky headlands, hills, and broken or boulder-strewn low-lying ground, in fissures or crevices (Falla 1937; Beck & Brown 1972; Johnstone *et al.* 1973; Cowan 1979; Weimerskirch *et al.* 1989). Breeding distribution in high latitudes may be limited by extent of ice-free land and ratio of snowfall to ablation (Roberts 1940).

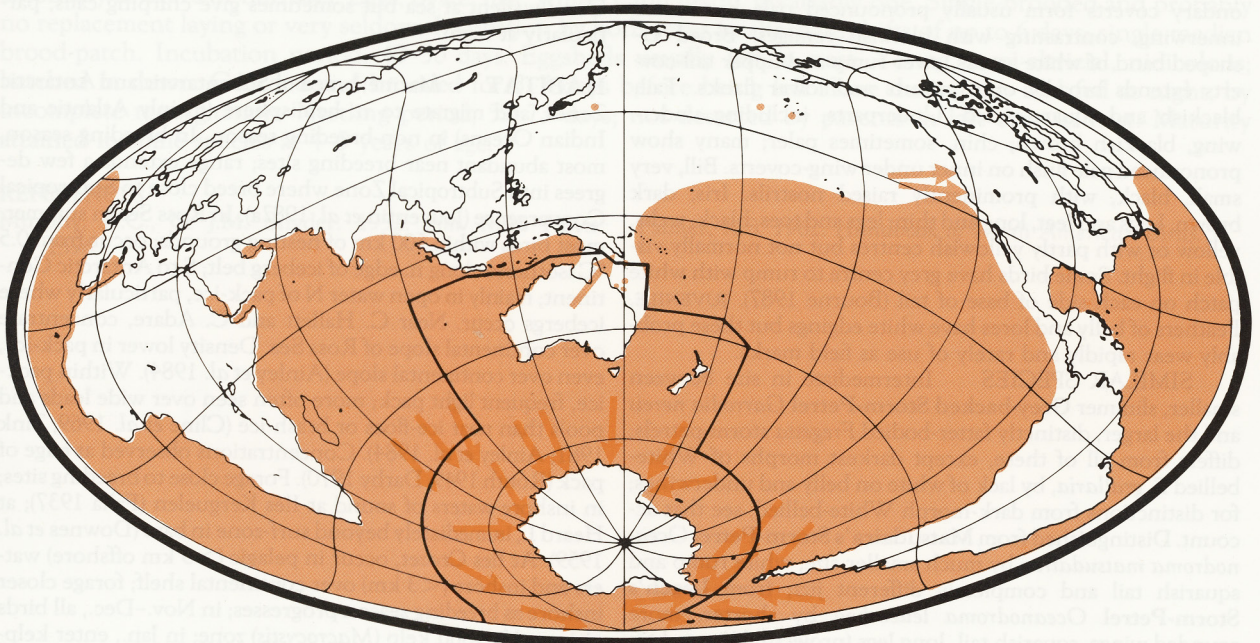
Feed in lowest level of airspace, taking prey from sea surface or from depths shallower than 10–15 cm (Croxall & North 1988); follow windward slopes of wave troughs, which are sheltered from strong winds (Roberts 1940). In pack-ice, rest on ice-floes and fly in shelter of floes during gales (Rough 1949).

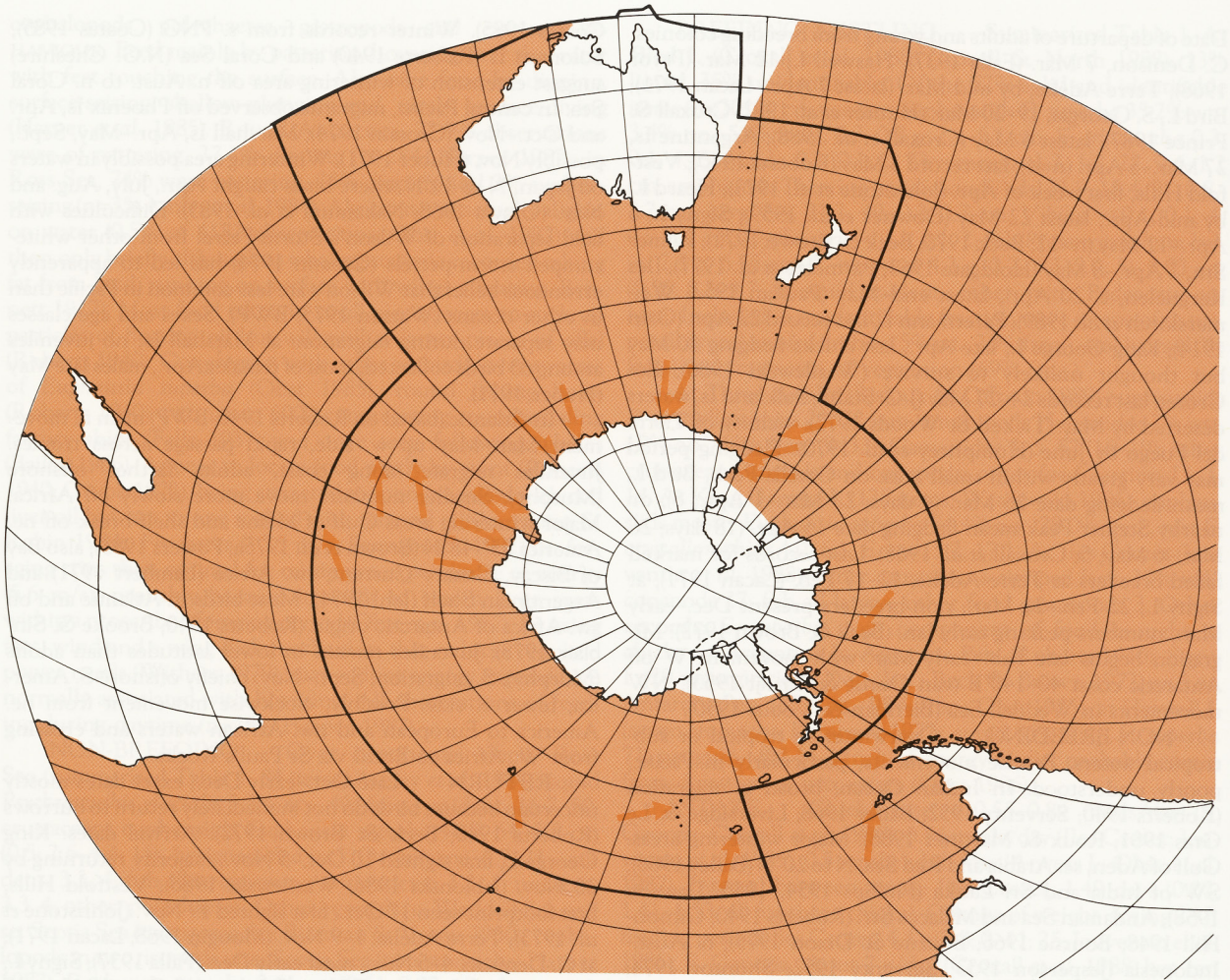
DISTRIBUTION AND POPULATION Breed on Antarctic continent and surrounding islands, N to Subantarctic Zone. In summer, pelagic range circumpolar, mostly restricted to Southern Ocean, S of 50°S; further N to 40°S in sw. Atlantic and sw. Indian Oceans, to 30°S off w. S. America

(Paessler 1911, 1913; Ozawa *et al.* 1964, 1968; Tickell & Woods 1972; Brown *et al.* 1975b; Flora 1981; Jouventin *et al.* 1982a; McQuaid & Ricketts 1984; Stahl 1987). Rare in se. Pacific Ocean (Holgersen 1957; Zink 1981); also a few present off w. and s. Africa (Roberts 1940; Brooke & Sinclair 1978) and se. Arabia (Bailey 1966). Migrate N in autumn, crossing equator in all oceans. Northernmost records, in Atlantic Ocean, 77°N (Vader & Barrett 1984), in Indian Ocean, Persian Gulf (Simpson 1987), in Pacific Ocean, Japan and Washington, nw. USA (Ozawa 1968; AOU 1983). Occasional in Southern Ocean in winter (Duhamel 1981; Bourne & Curtis 1985).

AUST. Most reports from edge of continental shelf during autumn and from all coasts; reported to range continuously from Torres Str. to Kimberley region, July–Aug. (Serventy 1952), including Arafura Sea but few verified reports. Large numbers, up to 1200, between Irian Jaya and Aru and Kai Is, July–Aug. 1984 (Cadée 1985); recorded Gulf of Carpentaria (Serventy 1952). Rare on Qld coasts but may represent lack of observers at appropriate time (Aust. Atlas); two, two and one, E of Townsville, Oct. 1985 (D.W. Eades); at least five, E of Tully, 19 Apr. 1987 (P. Britton); one, one and five birds seen 26–27 June 1988, 14°17'S 145°36'E outside Great Barrier Reef (N.G. Cheshire); single, 50 km NE of Townsville, 23 Oct. 1988 (R. Johnson). NSW: greatest numbers seen, Apr.–June and Sept.–Nov., correspond to n. and s. migration (Aust. Atlas); Vic., Tas., SA, reported regularly. WA, NT, w. and n. coastal records mainly from ship-board observations along coast during migration.

NZ Few records, despite regular occurrence in w. Tasman Sea; on shelves and s. plateaux, rarely N of 54°S (1966–78; J.A. Bartle); not recorded 1969–79 (NZ Atlas) nor in coastal and offshore waters 1971–80 (N.G. Cheshire). Fourteen records to 1988. NI: beachcast, Gisborne, 31 May 1933 (Serventy 1952); probable sighting of single bird, Whangerei, no date (CSN 1941–42); Hamilton, Mar. 1950 (NZCL); single beachcast, Tauranga, 9 Feb. 1953 (CSN 5); three sighted, 8 km W of C. Colville, 23 May 1979 (CSN 26); single sighted,





between Great and Little Barrier Is, 28 May 1986 (CSN 34); single sighted offshore Rurima Is, 6 Apr. 1987 (CSN 35); single sighted, 130 km E of Great Barrier I., 8 Nov. 1962 (Norris 1965). SI: single captured on fishing boat, Croisilles, 9 Nov. 1966 (CSN 19); Makarewa, s. Southland, Apr. 1969 (NZCL); single captured live, Kaikoura, 5 Apr. 1975 (Horning 1976); single, Lords R., Stewart I., 26 Nov. 1984 (CSN 32).

BREEDING Queen Maud Land: Shirmacher Hills; Ongul I. (Haga 1961; Konovalov 1962); Proclamation I. (Falla 1937).

Mac.Robertson Land: Scullin Monolith (Falla 1937); Rauer Is; Vestfold Hills (Konovalov 1962).

Davis Sea area: Gaussberg (Vanhöffen 1904); Haswell I.: 500 pairs (Starck 1980).

Wilkes Land: Bunger Hills; Casey (Wilkes) Stn (Cowan 1979; Korotkevich 1964).

Terre Adélie (2355 pairs; Thomas 1986); C. Hunter, C. Denison (Falla 1937).

Ross Sea Sector (total population est. 128 000 pairs; Ainley *et al.* 1984); Scott I. (Harper *et al.* 1984); C. Adare (Wilson 1907); C. Hallett; Maubray Bay/Edisto Inlet; Felsite I.; Greater Cirque (Ricker 1964); Franklin I. (Harper *et al.* 1984); Inexpressible I. (Ricker 1964); possibly Balleny I. (Robertson *et al.* 1980).

Marie Byrd Land: Peter I I. (Holgensen 1957).

Antarctic Pen. (total population est. 10^5 - 6 pairs; Croxall *et al.*

1984b); Hope Bay (Andersson 1905); Tower I.; Base Gabriel Gonzalez Videla; Wiencke I.; Cormorant, Anvers, Dream Is (Watson *et al.* 1971); Booth I. (Menegaux 1907); Petermann I. (Gain 1914); Argentine Is; Detaille, Horseshoe Is (Watson *et al.* 1971); Leonie, Jenny Is (Gain 1914); Dion I. (Cendron 1953); Avian I. (Watson *et al.* 1971).

S. Shetland Is (10^6 pairs; Croxall *et al.* 1984b).

S. Orkney Is (10^4 pairs; Croxall *et al.* 1984b).

S. Georgia (6×10^5 birds; Croxall *et al.* 1984a).

S. Sandwich Is (10^{4-5} pairs; Croxall *et al.* 1984a).

Iles Crozet ($> 10^4$ pairs; Jouventin *et al.* 1984; Milon 1962).

Iles Kerguelen (2 - 5×10^5 pairs; Weimerskirch *et al.* 1989).

Heard I. (Downes *et al.* 1959).

Bouvetøya (Holdgate *et al.* 1968).

Extraliminally, breed C. Horn area (Schlatter 1984) and Falkland Is (Croxall *et al.* 1984a).

Status, satisfactory but subject to possible predation by rats and cats on Iles Crozet and Kerguelen (Jouventin *et al.* 1984). Pesticide residues and traces of heavy metals are potentially threatening (Harper *et al.* 1984; Croxall *et al.* 1984b).

MOVEMENTS Migratory from Antarctica to N of equator in all oceans.

DEPARTURE Mar. to late-May, dates varying greatly between sites and years (Roberts 1940), possibly as result of fluctuations in food supplies (Beck & Brown 1972).

Date of departure of adults and young from breeding colonies: C. Denison, 7 Mar. (Falla 1937); Haswell I., 12 Mar. (Pryor 1968); Terre Adélie, by mid-Mar. (latest 7 Apr.; Lacan 1971); Bird I., S. Georgia, 19–20 Mar. (Hunter *et al.* 1982; Croxall & Prince 1987), latest 6 May (Croxall *et al.* 1988); Argentine Is, 27 Mar.–5 Apr. (n=4), last record 3 May (Roberts 1940); Vestfold Hills, first week of Apr. (Johnstone *et al.* 1973); Heard I., by mid-Apr., latest 22 May (Downes *et al.* 1959); Signy I., 6 Apr.–12 May (n=12; Beck 1970; Beck & Brown 1972); Palmer Stn, 2 Apr.–8 May (Holdgate 1963; Parmelee *et al.* 1977); Iles Kerguelen, c. 20 Apr., latest end-May (Paulian 1953; Weimerskirch *et al.* 1989); Petermann I., last record 22 Apr. (Gain 1914); King George I., late Apr., last chicks fledging 10 May but thought unlikely to survive (Wasilewski 1986); Iles Crozet, last records 24–27 May (J.-C. Stahl); Falkland Is, waters deserted by May (Tickell & Woods 1972); vicinity of Tierra del Fuego by June (Humphrey *et al.* 1970). Fledging period may vary greatly within small area: on Gazella Peak, Bird I., mean fledging date 26 Mar. (4 days; 23 Mar.–1 Apr.; 8), on nearby Stejner Peak mean fledging date 15 Apr. (18 days; 26 Mar.–6 May; 5; Croxall *et al.* 1988). Last records for marked failed breeders at Terre Adélie, 12–17 Feb. (Lacan 1971), at Signy I., 22 Feb.–21 Mar.; non-breeders present Dec.–early Mar., numbers peaking early Jan. (Beck & Brown 1972). Migration begins late Feb.–early Mar. with movement W off Antarctic coast 40–140°E (van Oordt & Kruijt 1953), NW movements in Weddell Sea (Bierman & Voous 1950).

NON-BREEDING Overwinter in tropical or subtropical waters. Precise movements, particularly in Pacific, poorly understood. In Indian Ocean, broad n. migration (Roberts 1940; Serventy 1952; Bailey 1968; Liversidge & Le Gras 1981; Roux & Martinez 1986). Major wintering areas: Gulf of Aden, se. Arabia and Red Sea, N to 20°N (Bailey 1966); SW of India and Sri Lanka (Phillips 1954, 1955; Dawson 1958); Andaman Sea and Malacca Str. (Roberts 1940; Gibson-Hill 1948; Bourne 1966; Bourne & Dixon 1975); n. Aust.-Indonesia (Jespersen 1933; Serventy 1952; Shuntov 1974; Cadée 1985; Dunlop *et al.* 1988) possibly as far W as w. Torres Str. (Ingram 1976). Birds of both Antarctic and subantarctic origin winter off se. Arabia (Bailey 1966). S. migration, Sept.–Nov. on broad front in mid-ocean (Bailey 1968). Possibly also clockwise movement from Arabia (Harrison 1983), where large concentrations in Aug. and start of departure Sept. (Bailey 1966), to sw. India and Sri Lanka, where mass departure reported early Nov. (Phillips 1954). However large concentration observed off C. Gardafui, Somalia, early Nov. (Bryson 1949).

In seas off s. Aust., most observations during autumn (Aust. Atlas). Both n. and s. migrations along coast of NSW (Morris *et al.* 1981) and there are records from Great Barrier Reef, 20–22 May (Stokes & Corben 1985). Several distinct patterns of migration in Pacific. Subantarctic birds, probably of Magellanic origin, migrate along Humboldt Current to wintering area off central and S. America between 18°N and 40°S (Paessler 1911, 1913; Murphy; Jehl 1973, 1974; Crossin 1974), possibly extending W to 120°W along equator (Meeth & Meeth 1986) and further N to Monterey Bay, California (Aug.–Nov.) during years of El Niño disruption off Peru (Ainley 1976). Possibly two distinct streams of Antarctic birds through sw. and central Pacific; particularly scarce NZ waters at all times of year (J.A. Bartle; N.G. Cheshire). In sw. Pacific observed on passage off New Caledonia, Mar.–June (Roberts 1940; Hannecart & Letocart 1983), Vanuatu, Oct., Solomon Is, Apr. and New Guinea, May and Sept.–Nov. (Roberts 1940;

Coates 1985). Winter records from s. PNG (Coates 1985), Solomon Is (Roberts 1940) and Coral Sea (N.G. Cheshire) suggest extension of wintering area off n. Aust. to n. Coral Sea. In central Pacific, migrants observed off Phoenix Is, Apr. and Oct.–Nov. (Crossin 1974), Marshall Is, Apr.–May, Sept., possibly Nov. (Huber 1971). Wintering area possibly in waters off Japan, N to 39°N where birds caught Apr., July, Aug. and Nov. (Ozawa 1968; Nakamura *et al.* 1983). Difficulties with field separation of Wilson's Storm-Petrel from other white-rumped storm-petrels (Crossin 1974) has led to apparently erroneous belief that Wilson's are less common in Pacific than in other oceans (Watson 1975; BWP). Sexes and age classes may separate during migration: at Marshall Is, no juveniles among 63 birds collected; most of females Apr., males late May (Huber 1971).

In Atlantic (based on Roberts 1940; BWP) main n. movement Mar.–May up w. side, rapid passage across tropics. Juveniles migrate along coast, adults farther offshore (Murphy). Smaller numbers move more slowly off Africa. Major wintering areas Gulf of Maine and shelf-break off ne. America 35°–48°N (Brown *et al.* 1975a; Powers 1983); also Bay of Biscay, Canary Current, sw. Africa (Lambert 1971) and Argentinian Shelf (Jehl 1974). Most birds in Atlantic and off sw. Africa of Antarctic origin (Roberts 1940; Brooke & Sinclair 1978). Juveniles remain in lower latitudes than adults (Murphy). S. migration, Sept.–Nov. chiefly offshore S. America, fewer e. side. Possibly, clockwise movement from ne. America to European and nw. African waters and crossing from W. Africa to Brazil via St Paul's Rocks.

RETURN Late Oct.–early Dec.; exact dates mostly uncertain because birds do not immediately return to burrows (Roberts 1940; Beck & Brown 1972). Arrival dates: King George I., first sighted 10 Oct.–5 Nov., majority returning by 20 Nov. (Jablonski 1986; Wasilewski 1986); Vestfold Hills, first footprint seen 17 Oct., first sighted 19 Nov. (Johnstone *et al.* 1973); Terre Adélie, 1–9 Nov. (Mougin 1968; Lacan 1971); at C. Denison, 4–5 Nov., most early Dec. (Falla 1937); Signy I., first return to burrows 7 Nov. (5.0 days; 19 Oct.–18 Nov.; 17 seasons), most birds arriving by end Nov. (Beck & Brown 1972; Rootes 1988); Haswell I., 10 Nov. with most back 14 Nov. (Pryor 1968); Argentine Is, first seen 11–24 Nov. (Roberts 1940; Beck & Brown 1972); S. Georgia, first sightings 12–25 Nov. with most arriving by early Dec. (Copestake & Croxall 1985); Casey Stn, 15 Nov. (Cowan 1979); Palmer Stn, 16–25 Nov. with most back by end of Nov. (Holdgate 1963; Parmelee *et al.* 1977); Iles Crozet, 16–27 Nov. (Jouventin *et al.* 1985; J.-C. Stahl); Iles Kerguelen, 21 Nov.–13 Dec. (Paulian 1953; Beck & Brown 1972); Petermann I., 23 Nov. (Gain 1914); Heard I., first returns 1 Dec. but most usually not until mid-Dec. (Downes *et al.* 1959); arrives Falkland Is waters by Nov. (Tickell & Woods 1972; Thurston 1982; Bourne & Curtis 1985); off Tierra del Fuego by Dec. (Humphrey *et al.* 1970).

BREEDING During summer, some immatures remain in tropics (BWP) but adults distributed within 750 km of breeding sites (Ainley *et al.* 1984). Maximum foraging range of breeding birds at S. Georgia estimated as 189–250 km (Croxall & Prince 1980, 1987) and at Antarctic Pen., 744 km (Obst 1985).

Seldom beachcast. Only one major wreck recorded, 28–30 Aug. 1893, when thousands were washed up on coast of N. Carolina (Pearson 1899).

FOOD Largely pelagic crustaceans and fish with some

cephalopods, polychaetes, gastropods and carrion. BEHAVIOUR. Feed mainly by pattering, hovering over the water with feet touching the surface. Also take food by dipping, surface-seizing, shallow-plunging and, rarely, surface-diving (Harper *et al.* 1985). Round Antarctica, 72.9% observations were of pattering, 27.1% dipping (n=284; Harper 1987); in Ross Sea, 74% were pattering, 23% dipping and 3% surface-seizing (n=35; Ainley *et al.* 1984). Almost never actually alights on water (0.5% of 4182 observations; Obst *et al.* 1987) and then only briefly although at whaling stations recorded taking fat from land, running on surface with wings vibrating (Bennett 1927). Most food taken in small pieces; seem to suck up particles of floating oil but will pull at larger pieces of offal (Roberts 1940). Congregate, with other seabirds, over swarms of *Euphausia superba* (Obst 1985), round fishing boats (Roberts 1940) with up to 6000 congregating round whaling factory ships (Falla 1937) and once seen following whales (Bailey 1966). Appear to locate food partly by scent (Roberts 1940; Grubb 1972), being attracted to sponge soaked with cod liver oil but not to one soaked with mineral oil (Jouventin & Robin 1984). Fly faster (10.5 m/s; Pennycuick 1982) on foraging trips than optimal for minimum expenditure of energy (5.6 m/s), probably because it needs to search large areas within a proscribed foraging period (Obst *et al.* 1987). By using feet, wind and a wing-flick mechanism that reduces required power needs (Withers 1979), may reduce energy expenditure normally associated with hovering. All observations of feeding during daytime (n=284; Harper 1987).

NON-BREEDING Over continental slope, Ross Sea (summarized Table 1; 84 items; Ainley *et al.* 1984): squid *Psychroteuthis glacialis* 3.3% no., 4% freq.; unident. 26.7, 50; crustaceans euphausiids *Euphausia superba* 46.7, 64, 3.5 cm (0.5; 2.6–4.4; 15), Lysianassidae incl. *Orchomene*, 6.7, 21; unident. 3.3, 4; fish *Pleuragramma antarcticum* 3.3, 4, unident. 3.3, 4; other: polychaetes. **Other records:** e. Weddell Sea and se. Scotia Sea (two stomachs; Bierman & Voous 1950), cephalopods in two, isopods one; Scotia Sea (two stomachs; Harper 1987), *Euphausia superba* 0.61 cm (0.51–0.97; 60); Antarctica (seven stomachs; Falla 1937), squid 29% freq., euphausiids 14, other crustaceans 29, scum from whaling ships 29; Iles Kerguelen, amphipods (*Themisto*; Falla 1937) and squid (Paulian 1953); C. Verde Is (three stomachs; Murphy 1918), fish otoliths; Arabia (two stomachs; Bailey 1966), gelatinous egg case; off Peru (several stomachs; Murphy), fish, numerous nereid worms, feathers, seaweed, possibly eggs of mollusc. Also scavenges, particularly on oil slicks, both in Antarctic (Falla 1937; Roberts 1940; Beck & Brown 1972) and off Arabia (Bailey 1966).

BREEDING, NESTLING Summarized Table 1. At **Bird I.** (Croxall *et al.* 1988; Croxall & North 1988): 13% liquid, 35% unidentifiable. Of the 52% solid and identifiable items (n=2013), crustaceans euphausiids *E. superba* 35.2% wt., 3.4% no., 51% freq., 0.2–0.7 g, 2.4–5.1 cm, *E. triacantha* 0.3, 0.1, 4, *E. frigida* 0.3, 0.1, 2, *Thysanoessa* 1.3, 1.7, 22, 0.6–1.2 cm; amphipods *Themisto gaudichaudii* ads. 21.9, 18.4, 71, 0.8–2.2 cm, juvs. 8.4, 71.2, 49, 0.2–0.7 cm, *Vibilia* <0.1, 0.1, 4, 0.9–1.2 cm, *Cyphocaris* <0.1, 0.1, 2; fish *Protomyctophum bolini* 2.3 g, 6.75 cm, *P. normani* 4.2 g (0.7; 3.3–5.0; 5), 9.03 cm (0.58; 8.3–9.7; 5); squid unident.; other: mites *Podocarus auberti*. Included in unidentifiable fraction were scraps of tissue, possibly seal or bird flesh (<5% wt., 20% freq.), seal hairs (10% freq.) and fragments of vegetation (69% freq.).

At **Terre Adélie** (Ridoux & Offredo 1989) euphausiids *E. crystallorophias* 23–32 mm; amphipods Hyperiididae 2% wt., 10% no., 43% freq. (9–33), Gamariidae 3, 5, 57 (16–19); other crustaceans isopods and copepods; other food carrion 13, 1, 14. At **King George I.** (125 items; Wasilewski 1986): euphausiids mostly *Euphausia superba* 74.4% no., 78.0% freq., rest *E. crystallorophias* 4.0, 6.1, *E. sp.* 15.2, 17.1. At **Iles Crozet** (Jouventin *et al.* 1988): other crustaceans cirriped larv. 37% vol., copepods 27; fish all larvae; other food gastropods 3. **Other records:** *E. superba* main component of food brought to chicks on Argentine Is, Antarctic Pen. (Roberts 1940), Signy I. (20 regurgitations Dec., Jan.; Beck & Brown 1972) and on Antarctic Pen. (85% wt., 95% freq.; Obst 1985); at Haswell I. (seven stomachs; Kamenev 1977), squid 86% freq., *E. superba* 71, penguin offal 14. Much of energy in diet probably comes from digestion of wax esters (Obst 1986).

INTAKE Chicks receive 0.55–0.84 meals/day (S. Georgia; Croxall *et al.* 1988), 0.56 meals/day (Iles Crozet; Jouventin *et al.* 1985), 0.5 meals/adult/day (Anvers I.; Obst *et al.* 1987). Interval between meals: Iles Crozet, 1.49 days (0.07; 1.41–1.53; 45 for three chicks). Change of weight during 24 h feeding period: Iles Crozet, 4.4 g (2.8; 0–11; 25; Jouventin *et al.* 1985), S. Georgia, about 7 g/day (Croxall *et al.* 1988) but can survive starvation for at least 20 days (Roberts 1940).

SOCIAL ORGANIZATION Gregarious when feeding at sea, on migration and when breeding.

BONDS Monogamous. Of 46 breeding pairs in 1 year at Signy I., bonds maintained in following season in 24 pairs (52%), broken through absence of one or both birds in 16 (35%), and through divorce in six (13%). Of 14 pairs of non-breeding birds keeping company in burrows, equivalent values were six (43%), six (43%) and two (14%) (Beck & Brown 1972). Re-mating and laying following failure of partner to

Table 1. Diet of Wilson's Storm-Petrel

Percentages	wt.			vol.	no.				freq.			
	1	2	3		1	2	3	4	1	2	3	4
SQUID	46	2	-	-	30	<1	-	-	54	2	-	-
CRUSTACEANS	36	68	49	81	57	99	87	99	≥64	100	≥86	≥78
EUPHAUSIIDS	-	37	37	10	53	6	70	94	≥64	≥51	86	≥78
AMPHIPODS	-	30	5	7	-	90	15	6	-	≥71	≥57	4
OTHER	-	-	7	64	3	-	2	-	4	-	28	-
FISH	15	28	39	16	7	1	11	1	7	42	57	1
OTHER	3	2	13	3	7	<1	1	-	25	6	14	-

Non-breeding: (1) Ross Sea, n=28 (Ainley *et al.* 1984); **Breeding:** (2) Bird I., n=51 (Croxall *et al.* 1988; Croxall & North 1988); (3) Terre Adélie, n=7 (Ridoux & Offredo 1989); (4) King George I., n=82 (Wasilewski 1986); (5) Iles Crozet, n=15 (Jouventin *et al.* 1988).

return can take place in same season. Apparent intermittent breeding mostly caused by impending breakdown of pair-bond (Beck & Brown 1972). No data on age when first return to colony; at Signy I., two birds bred when 3 years old (J.P. Croxall). Both parents incubate and tend young until fledging, though male may make more feeding visits (75% of 227 recorded visits; Beck & Brown 1972).

BREEDING DISPERSION At Signy I., 12.5 nests/100 m² (n=184 nests), but only c. 5 occupied burrows/100 m² (n=70; Beck & Brown 1972). At S. Georgia, in scree bank, 33.3 burrows/100 m² (n=3200) in optimum habitat. Estimated average density in scree was c. 24 pairs/100m² (Copestake *et al.* 1988).

ROOSTING At nest-sites in breeding season; on sea at other times.

SOCIAL BEHAVIOUR Only detailed studies by Roberts (1940) and Beck & Brown (1972). Difficult to observe as events occur at night, except at southernmost colonies, and easily interrupted by torch-light (Beck & Brown 1972).

AGONISTIC BEHAVIOUR Nest defended by nocturnal calling (see Voice) from Nov. to Feb., peaking in mid-Dec. immediately before laying (Beck & Brown 1972). Most calling by single males at or near nest, advertising ownership and single status of bird; nest apparently not physically defended against visits of intruding non-breeders (Beck & Brown 1972), but at Haswell I. physical aggression, warning *squeaks* (see Voice) and ejection of stomach oil occasionally used in defence of nest (Pryor 1968).

SEXUAL BEHAVIOUR Birds advertise with calling (see above). **Aerial Display:** birds visiting nests fly in circuits of diminishing radius for several minutes. During courtship flights birds land at burrow entrance once every 2-3 min and call (see Voice) if mate in burrow; mate in burrow answers. Not known if birds call outside empty burrows (Roberts 1940). Aerial chases recorded at Argentine Is and regarded as important part of courtship activity (Roberts 1940), but displays not observed at Signy I. (Beck & Brown 1972) nor S. Georgia (P.A. Prince). Aerial Display also recorded at sea, at dusk (Oct.), 'dashing hither and thither, shooting upwards then plunging down at high speed' (Murphy). **COURTSHIP:** in burrow, after period of allopreening, one bird grasped bill of mate and both birds made a harsh, chattering call (see Voice) two or three times; sequence repeated (Roberts 1940). 'Leap-frog' flights outside burrow by three birds recorded twice (Beck & Brown 1972). **GREETING:** at nest, change-over of incubating birds at night, observed once by Roberts (1940) and Beck & Brown (1972). Both birds call when relieving bird enters, probably initiated by incubating bird. Birds clasped bills and called *aark-aark* (see Voice) (Beck & Brown 1972 and cf. Roberts' description of courtship); relieved bird left after c. 1.5 min; relieving bird continued to call loudly from half way to burrow entrance for c. 10 min. However Roberts (1940) states that pair called together for about 10 min before relieved bird (female) left. Calling and display possibly occur each night because incubating bird probably visited each night by mate, regardless of change-over. **ALLOPREENING** of head during pre-laying period (Roberts 1940; Beck & Brown 1972). **COPULATION** (not described) takes place in burrow (Beck & Brown 1972; Copestake & Croxall 1985).

RELATIONS WITHIN FAMILY GROUP Both parents incubate in alternate stints of c. 48 h (Roberts 1940). Chick brooded 1-2 days after hatching and then abandoned

by day, thereafter fed irregularly by both parents. Independent after fledging.

VOICE Account based on Roberts (1940) and Beck & Brown (1972). Generally silent at sea though Roberts reports calls heard occasionally. Apparently silent in flight over breeding colonies. Nocturnal calling at breeding colonies from or near nest-hole. Vocabulary consists of single harsh disyllabic call and range of chatters and peeps, less frequently heard. Call throughout breeding season (Argentine Is); on Signy I., call heard from Nov. to Feb., with peak before laying in mid-Dec. No sexual or individual differences noted. No geographical variation noted.

ADULT (1) Generally only one call heard at breeding colonies. Described as harsh wheezing double note (S. Georgia; J.P. Croxall) or a nasal grating disyllabic *aark-aark* (Signy I.); sonagram A shows three such calls. A variant *aark-aark-uh-ah-ah-uh-uh* heard less often, generally terminating long bout of calls (Signy I.). Call repeated monotonously. Roberts, probably referring to same call, described it as harsh chattering. Generally not heard when both birds are at burrow or during incubation, except at change-over. Call used for defence of nest and advertisement; during allopreening in burrow; and during change-over when incubating (Ro-

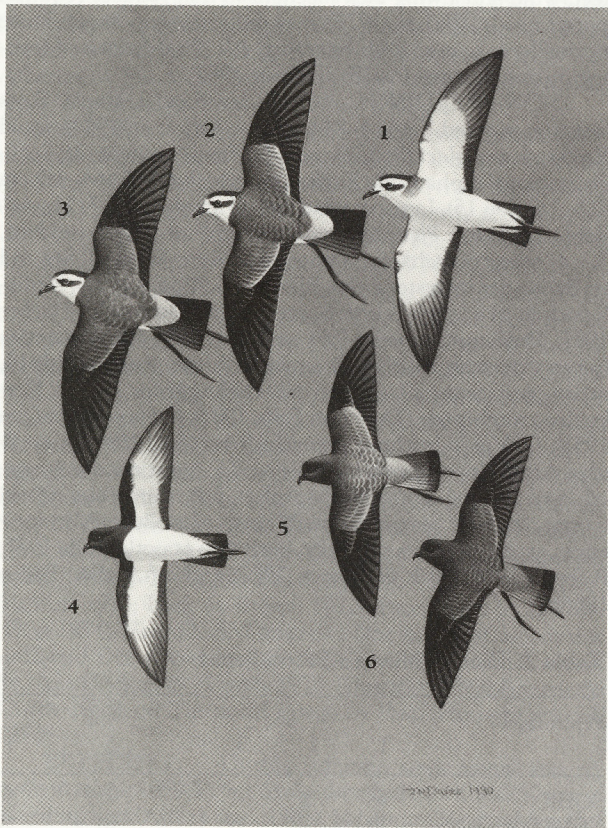
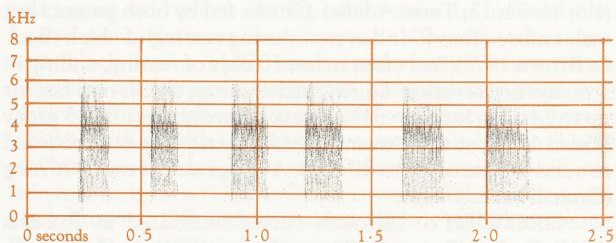


Plate 51

White-faced Storm-Petrel
Pelagodroma marina
Subspecies *dulciae*
1. Adult, ventral
2. Adult, dorsal, fresh
3. Adult, dorsal, worn

Grey-backed Storm-Petrel
Oceanites nereis
4. Adult, ventral
5. Adult, dorsal, fresh
6. Adult, dorsal, worn



K. Green; Davis, E. Antarctica, Nov.-Dec. 1984; B909

berts 1940; Beck & Brown 1972). Birds calling near burrow entrances mostly single males, defending burrow and advertising single status. Both sexes call during change-over and courtship. Incubating bird called if hand placed in entrance to burrow. (2) Occasionally, sparrow-like chattering, when feeding at sea. Frequency of repetition varying, increasing when excited at abundant food; occasionally heard at breeding colonies. (3) At Argentine Is, a rapid series of high-pitched peeps; reported when birds handled; heard when pairs call to each other, one inside and one outside burrow. Possibly functions as contact and alarm call; not reported Signy I. (4) At Haswell I., uttered warning squeaks when physically defending nests (Pryor 1968).

YOUNG No description of calls.

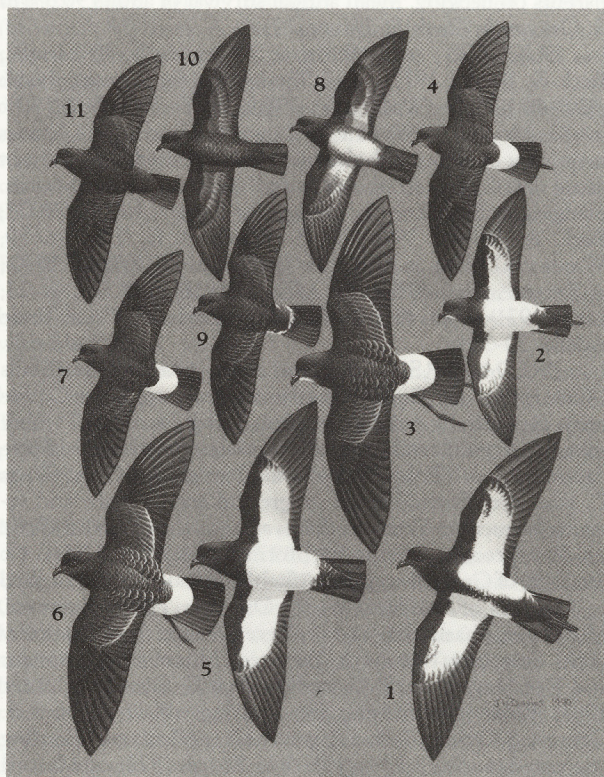
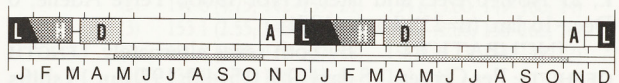


Plate 52
 Black-bellied Storm-Petrel
Fregatta tropica
 1. Adult typical, ventral
 2. Adult white-bellied, ventral
 3. Adult, dorsal, fresh
 4. Adult, dorsal, worn

White-bellied Storm-Petrel *Fregatta grallaria*
 5. Adult, light morph, ventral, fresh
 6. Adult, light morph, dorsal, fresh
 7. Adult, light morph, dorsal, worn
 8. Adult, intermediate morph, ventral
 9. Adult, intermediate morph, dorsal
 10. Adult, dark morph, ventral
 11. Adult, dark morph, dorsal

BREEDING Well known. Detailed studies: Iles Crozet (Jouventin *et al.* 1985), Bird I., S. Georgia (Copestake & Croxall 1985; Croxall *et al.* 1988), Signy I., S. Orkney Is (Beck & Brown 1972), King George I., S. Shetland Is (Wasilewski 1986), Argentine Is, Antarctic Pen. (Roberts 1940), Terre Adélie (Mougin 1968; Lacan 1971). Information supplied by J.P. Croxall, J-C. Stahl. Breed in simple pairs, colonially, usually on scree slopes and among broken rocks; partially associating with prions *Pachyptila* spp, Cape Petrels *Daption capense* and Snow Petrels *Pagodroma nivea* at Iles Crozet and Terre Adélie (Lacan 1971; J-C. Stahl).

SEASON Broadly Nov.-Dec. to Mar.-May. Arrival of first birds generally throughout range, 1-25 Nov. (see details under Movements). Main influx usually c. 2 weeks after first arrivals; dates not correlated with those of break-up of pack-ice in S. Orkney Is (Beck & Brown 1972, *contra* BWP). Males tend to be found at nests before females (52 v. 29%, n=21; Beck & Brown 1972), though both sexes apparently arrive on breeding ground in equal numbers. In 2 years at S. Orkney Is, period from first arrival to laying, 34.4 days (14-44; 26). Both sexes or pair together visit sites for 13-18 days before laying. Pre-laying exodus by females for 10.4 days (3.3; 6-18; 31) but appreciable difference from year to year (Beck & Brown 1972).



SITE Usually in holes and crevices in cliffs, screes, rocky banks, outcrops; also exposed or under overhanging rocks, in burrows in volcanic ash (Lacan 1971; Beck & Brown 1972), crevices in turf or among roots of *Notofagus* (Reynolds 1935) and in burrows in moss banks (Roberts 1940) and tussock grassland (Copestake & Croxall 1985). In s. parts of range, most nest chambers within 15-30 cm of surface at end of tunnels 20-50 cm long; farther N, chambers may be up to 100 cm from surface and tunnels equally long. Same site used year after year (Roberts 1940). Site probably selected by male (Beck & Brown 1972). At S. Georgia in screes in optimum habitat, density 1 nest/3 m² or c. 3200 nests/ha. Breeding areas coastal, up to 800 m inland (Downes *et al.* 1959); from sea-level to 700 m asl (Iles Kerguelen; Weimerskirch *et al.* 1989). At Graham Land and Signy I., breeding areas sheltered from prevailing winds, mostly N- or NW-facing (Roberts 1940; Beck & Brown 1972).

NEST, MATERIALS Sometimes nil; usually feathers, moss used to line chamber; where material plentiful, complete nest-cup may be formed (Roberts 1940).

EGGS Rounded ovate; unglossed; dull white, usually with red-brown and lilac dots at blunt end (Roberts 1940).

MEASUREMENTS:
 Iles Crozet 31.5 (1.1; 30.0-33.1; 16) x 22.9 (0.8; 21.2-24.3) (Jouventin *et al.* 1982)
 Iles Kerguelen 32.8 (29.9-34.6; 9) x 23.5 (22.6-25.2) (Beck & Brown 1972)
 S. Georgia 33.3 (1.0; 31.8-34.8; 19) x 23.4 (0.8; 22.1-24.4) (Copestake & Croxall 1985)
 S. Orkney Is 34.8 (33-36; 15) x 24.7 (24-26) (Beck & Brown 1972)
 S. Shetland Is 34.9 (30.2-36.0; 58) x 24.5 (23.5-24.8) (Jablonski 1986)
 Argentine Is 33.6 (1.3; 30.6-35.5; 12) x 23.5 (0.7; 22.5-24.7)

(Copestake & Croxall 1985)

Terre Adélie 33.4 (32.1–35.3; 9) x 23.6 (22.0–24.4) (Mougin 1968).

WEIGHTS: (source as Measurements)

Iles Crozet 9.6 (1.6; 8–15; 16)

S. Georgia 9.9 (0.9; 9.0–11.7; 13)

S. Orkney Is 11 (10.0–12.5; 8)

S. Shetland Is 10.2 (7.4–13.5; 58)

Terre Adélie 10.1 (8.5–11.0; 8)

Dimensions reflect latitudinal differences in size of adults.

CLUTCH-SIZE One. Strong circumstantial evidence of replacement laying in S. Orkney Is (Beck & Brown 1972).

LAYING Not well synchronized. At all sites extended over long period compared with other Antarctic Procellariiformes. Peaks or spread of laying: Iles Crozet, 2 Jan. (10 days; 18 Dec.–15 Jan.; 20) (Jouventin *et al.* 1985); Iles Kerguelen, late Dec.–7 Feb. (Beck & Brown 1972; Weimerskirch *et al.* 1989); Heard I., 15 Jan. (8 days; 7–22 Jan.; 3) (Downes *et al.* 1959); S. Georgia, 6 Jan. (11 days; 15 Dec.–27 Jan.; 27) (Copestake & Croxall 1985); S. Orkney Is, 9 Jan. (8 days; 28 Dec.–1 Feb.; 68) (Beck & Brown 1972); S. Shetland Is, peak 31 Dec.–9 Jan. (8 Dec.–8 Feb.; 165) (Wasilewski 1986); Argentine Is, 25 Dec. (5 days; 17 Dec.–2 Jan.; 8) (Roberts 1940); Haswell I., 27 Nov.–6 Dec. and later (Pryor 1968); Terre Adélie, 6 Dec.–16 Jan. (n=23) (Lacan 1971).

INCUBATION By both sexes alternately. **LENGTH OF SHIFTS:** Iles Crozet: 1.8 days (0.9; 0.5–4.0; 197) but 15 shifts interrupted by desertions of 1.2 days (0.4; 1–2) and 48 shifts followed by desertions of 1.7 days (1.1; 1–6) (Jouventin *et al.* 1985); S. Orkney Is: 2.5 days (0.6; 1.5–4.0; 209) but some longer shifts interrupted during daytime (Beck & Brown 1972); Argentine Is: 2.0 days (0.6; 1–3; 11) (Roberts 1940); Terre Adélie: av. 1.6 days (n=451), but some shifts interrupted by desertions for up to 21 h (Lacan 1971). In S. Shetland Is, during total incubation time of 1750 h, desertions accounted for 32% of time, with maximum of 48 h in successful breeders (Pefaur 1974). **DATES OF HATCHING:** records at Iles Crozet, S. Georgia, S. Orkney Is, S. Shetland Is, Argentine Is, Terre Adélie have all been between 20 Jan. and 25 Mar., with peaks from 8 to 21 Feb. (Jouventin *et al.* 1985; Beck & Brown 1972; Copestake & Croxall 1985; Roberts 1940) and mostly for samples of few eggs (1–36), except 131 in S. Shetland Is. In Terre Adélie, however, hatching recorded between 15 Jan. and 15 Feb. with peak at 24 Jan. (n=27; Lacan 1971). Pipping to emergence 1–2 days (max. 3). **INCUBATION PERIOD:** determinations of laying to hatching of 75 eggs in small samples (3–32) from Iles Crozets, S. Georgia, S. Orkney Is, S. Shetland Is, Argentine Is, Adelaide I., Terre Adélie on average ranged from 40.3 to 49.7 days with extreme of 38 to 59. At Crozet and S. Orkney Is, calculations made to exclude periods when egg was deserted, giving 35.7 days (1.8; 33–38; 6; Jouventin *et al.* 1985) and 40.2 days (1.6; 38–42; 8) (Beck & Brown 1972).

NESTLING Semi-altricial, nidicolous. Hatched with pale grey-brown down, paler below. Weight at hatching: S. Georgia, 6.7 (0.3; 6.4–7.0; 4); S. Shetland Is, av. 7.5 (n=56; Wasilewski 1986); at Terre Adélie, 6.8 (5.5–7.5; 4) (Lacan 1971). Brooded for 1–4 days (Jouventin *et al.* 1985; Lacan 1971); 3–5 days (Beck & Brown 1972). Dates of departure at Kerguelen, S. Georgia, S. Orkney, S. Shetland and Argentine Is between 23 Mar. and 12 May (see details under Movements). **NESTLING PERIOD:** apparently varies considerably: recorded as 78 days (64–97; S. Georgia), 60 (54–69; 12; S. Orkney Is), 59 (55–65; 14; S. Shetland Is), 52 (once; Argentine Is), 47.7

(1.3; 46–51; 12; Terre Adélie). Chicks fed by both parents but males more often found at nest during rearing of chick (Beck & Brown 1972); less often in last 10 days of rearing, ending in 3–5 days of starvation. During bad weather, chicks may fast for up to 24 days, losing c. 54% of original weight at 1.6–2.5 g/day (Lacan 1971); at this extreme, chicks usually die but recorded to survive fasts of up to 20 days. Average size of meals c. 7.0 g (Croxall *et al.* 1988).

GROWTH Growth curves illustrated in Roberts (1940), Beck & Brown (1972) and Lacan (1971). At S. Georgia, mean peak weight 49 g or 140% adult mass at 48 days old; mean fledging weight 35 g or 100% adult mass (Croxall *et al.* 1988). At S. Orkney Is, mean peak weight 73 g (62–81; 7) or 192% (163–213) adult mass at c. 52 days old; mean fledging weight 55.3 g (49–64; 15) or 145% adult mass but 11% difference (57.8 v. 51.5 g) in two successive seasons (Beck & Brown 1972). At S. Shetland Is, mean peak weight 60.8 or 156% adult mass at 43 days old; mean fledging weight 49.7 g (35–66; 12) or 127% adult mass (Wasilewski 1986). At Argentine Is, mean peak weight 63 g (5; 54–51; 6) or 152% adult mass. At Terre Adélie, mean peak weight 76 g (9.3; 66–88; 12) at 31 days old (7.5; 20–40) or 177% (153–205) adult mass; fledging weight 45–82 g or 105–191% adult mass, having lost 40–63% of peak weight (Lacan 1971).

FLEDGING TO MATURITY Independent of parents on fledging. Mean annual survival of adults 90.8% in S. Orkney Is (Beck & Brown 1972).

SUCCESS Hatching: at S. Orkney Is, 35% (n=82; Beck & Brown 1972); at S. Shetland Is for 2 years, 44.6% (38.8–49.1; 165) (Wasilewski 1986); at Terre Adélie, 50% (n=10; Mougin 1968) and 59% (n=39; Lacan 1971). Losses mainly by blocking of holes by snow, reported as important cause of failure in all studies from S. Orkney Is, southwards. Fledging: at S. Orkney Is, average for 3 years, 46% (0–73; 35; Beck & Brown 1972); at S. Shetland Is, 28% (n=50; Wasilewski 1986); at Argentine Is, 35% (n=20; Roberts 1940); at Terre Adélie, 40% (n=5; Mougin 1968) and 52% (n=23; Lacan 1971). Total success: at S. Shetland Is, 10.3%; at Terre Adélie, 20–31%.

PREDATORS Eggs and chicks taken by sheathbills *Chionis* spp, Kelp Gulls *Larus dominicanus* and skuas *Catharacta* spp, also by rats *Rattus rattus* and *R. norvegicus* where they occur. Adults taken mostly by skuas; few records of predation by South Polar Skua *C. maccormicki* but Great Skuas *C. skua* take Storm-Petrels on ground and in flight and remains frequent in Skuas' middens at many sites (Burton 1968). At Iles Crozet, remains of Storm-Petrels found in 0.4% (n=1198) of Great Skua pellets (Stahl & Mougin 1986); at Bird I., in 0.1% of middens (n=38; Osborne 1985). However, Murphy emphasized that adults were immune from attacks by skuas. Some may be taken by Southern *Macronectes giganteus* and Northern *M. halli* Giant-Petrels at S. Georgia (Hunter 1983). Birds with missing feet and legs reported from S. Georgia, S. Orkney Is and Argentine Is, perhaps representing attempted predation by fish (Beck & Brown 1972); one record of predation by shark (Ritchie 1966).

PLUMAGES

ADULT Definitive basic. **HEAD AND NECK**, black-brown (c119), with medium grey wash to forehead, front of lores, chin and throat. All feathers have concealed grey (84) bases. Some birds have few white feathers with black-brown (c119) tips in proximal half of lores. **UPPERPARTS**, black-brown (c119) with sharply defined white patch on lower rump

and upper tail-coverts joining white sides to lower flanks. Lower rump-feathers, black-brown (c119) with white tips. **TAIL**, black-brown (c119); inner webs of outer remiges have concealed white bases. **UPPERWING**. Marginal coverts, brown-black (c119) with off-white fringes. Secondary coverts, brown (c119A) with greyish (79) tips and narrow pale-brown (119D) to whitish outer edge. With wear almost entire outer web may fade to pale brown (119D). Other coverts, alula and remiges, black-brown (c119) with concealed, slightly paler inner edge. Remiges have concealed white bases. Proximal half of primary shafts, white. **UNDERPARTS**, mostly black-brown (c119). Belly, dark brown (c119A); sometimes fresh feathers have narrow white tips. Lower flanks and lateral under tail-coverts white, some feathers with dark brown (c21) subterminal spots; central under tail-coverts, black-brown (c119), sometimes with white spots. **UNDERWING**. Marginal coverts, blackish brown with pale brown (119C) fringes. Lesser and median coverts, grey brown with narrow white tips. Greater coverts, dark grey-brown, appearing grey (c84) in some reflected light; fringes of greater coverts, non-reflective grey-brown (c119C), narrowest on outer primary under wing-coverts. Remiges, dark grey-brown (c84), appearing grey (c84) in some reflected light, primaries have slightly darker tegmen.

DOWNY YOUNG At hatching, forehead, lores, chin and area round eyes bare. Down grey-brown (c21) above, slightly paler below; filaments have concealed greyish (brownish 85) bases. A chick with black-brown down photographed Iles Crozet (J-C. Stahl). Roberts (1940) could not distinguish two generations of down.

JUVENILE Similar to adult, but concealed whitish spot on lores more common (Roberts 1940). All juveniles have narrow white tips to belly feathers that soon wear off. Tip of outer primary pointed (tends to be rounded in adult) (BWP).

BARE PARTS

ADULTS, JUVENILES Iris, dark brown. Bill, black (82). Tarsus and toes, black (82). Webs, orange-yellow with black tips.

DOWNY YOUNG At hatching, culmen tipped black; bare skin on bill and face 'not pigmented' (Roberts 1940). Tarsus and toes, pale brown-pink (light 5); webs, pale pinkish-buff (light 6), claws, black. Feet and bill still darkening at 40 days; see Roberts (1940) for details.

MOULTS

ADULT POST-BREEDING Definitive pre-basic. Unknown if birds moulting at this time include non-breeders. Complete; moult of flight-feathers occurs in winter quarters. In Atlantic, and most of Pacific, moult of flight-feathers begins after arrival in May (Murphy 1918; Roberts 1940; Huber 1971; BWP). Bird collected at sea near L. Moreton, Qld, with primary moult 1² 0⁸ of unknown age. Birds collected off Peru, probably breeding Tierra del Fuego, all moulting flight-feathers in May and June (Murphy), suggesting they moult earlier. Moult of flight-feathers at least 2 months later in Indian Ocean, where many specimens moulting flight- and body-feathers, Oct.-early Nov. (Bourne 1960; Palmer 1962). Primaries outwards; about three adjacent central primaries grow at one time; s1-s4 inwards, s5-s9 centripetal. Moult of tail begins when primaries nearly complete and finishes later; Murphy (1918) believed tail-moult centrifugal but Mayaud (1949-50) found it irregular but symmetrical. Body-moult often said to begin at wintering grounds (e.g. BWP) but Beck

& Brown (1972) found seven adults in body-moult at Signy I. in Feb. and Mar. Body-moult completed at least a month after flight-feathers (Roberts 1940). Primary coverts moult with primaries; secondary coverts replaced before primary moult complete. Tail-coverts moult at about same time as tail. Other details of body moult sequences unclear, some information in Murphy (1918), Roberts (1940), Mayaud (1941, 1949-50) and Beck & Brown (1972).

POST-JUVENILE, OTHER MOULTS Juveniles do not moult in North Atlantic or Pacific during first winter (Murphy 1918; Roberts 1940; Mayaud 1949-50). Birds of unproved age have been collected in moult of flight- and body-feathers in tropical areas in Oct., Nov., Jan., Mar. (Roberts 1940; Mayaud 1949-50; NMNZ) and May (BWP); these probably include adults but unknown if subsequent moults occur at same time as adult post-breeding.

MEASUREMENTS (1) Antarctic continent, skins; juveniles excluded (NMNZ; MV). (2) Antarctic continent, skins; juveniles excluded (Roberts 1940; only birds measured by Roberts used; duplicate measurements noted by Beck &

		MALES	FEMALES		
WING	(1)	156.4 (2.90; 150-162; 12)	154.3 (4.75; 146-164; 12)	*	
	(2)	151.8 (4.75; 142-159; 21)	154.6 (3.00; 149-160; 14)	*	
	(3)	153.1 (2.55; 148-156.5; 10)	158.4 (1.86; 156-162; 10)	**	
	(7)	150.8 (2.96; 143-157; 18)	155.0 (3.23; 151-161; 22)	**	
	(10)	139.1 (2.71; 136-143; 9)	142, 143		
	8TH P TAIL	(1)	118.8 (3.26; 113-125; 13)	117.0 (3.86; 111-124; 13)	*
		(1)	71.7 (3.69; 68-79; 7)	68.0 (2.25; 65-73; 9)	**
		(2)	69.0 (3.39; 61-74; 21)	70.9 (2.81; 63-75; 14)	*
		(3)	72.1 (1.87; 69-74; 10)	73.7 (2.05; 71-76; 10)	*
		(10)	58.2 (1.87; 54.5-60.4; 9)	61.6, 63.4	
BILL	(1)	12.4 (0.39; 11.8-12.9; 7)	12.3 (0.74; 11.1-13.4; 9)	*	
	(2)	12.2 (0.45; 11-13; 21)	12.2 (0.46; 11.5-13; 13)	*	
	(3)	12.8 (0.49; 12.1-13.6; 10)	12.1 (0.64; 11.1-13.3; 10)	**	
	(7)	12.3 (0.32; 11.8-12.7; 18)	12.6 (0.29; 12.2-13.7; 21)	**	
	(10)	11.1 (0.46; 10.6-11.5; 9)	10.3, 11.1		
	TARSUS	(1)	34.8 (0.81; 33.7-36.1; 7)	34.5 (0.86; 33.1-36.3; 9)	*
		(2)	33.6 (1.22; 31.5-36.5; 21)	34.4 (0.72; 32.5-35.5; 14)	*
(3)		34.8 (1.15; 33.1-37.0; 10)	34.9 (1.19; 33.3-37.4; 10)	*	
(7)		34.2 (0.92; 32.1-35.6; 17)	35.4 (1.05; 33.2-37.3; 21)	**	
(10)		34.9 (0.46; 10.6-11.5; 9)	35.1, 35.5		
TOE		(1)	28.2 (0.59; 27.3-29; 5)	27.5 (0.71; 26.2-27.3; 7)	*
	(2)	28.0 (1.06; 26.5-31; 21)	29.4 (1.02; 27.5-31; 14)	**	
	(3)	27.9 (0.92; 26.8-29.6; 10)	26.9 (1.22; 33.3-37.4; 10)	*	
	(10)	27.1 (0.81; 26.4-28.4; 9)	27, 27.7		
<hr/>					
		UNSEXED			
WING	(4)	146.7 (2.61; 142-151; 13)			
	(5)	151.4 (3.91; 142-160; 155)			
	(6)	148.9 (4.2; 139-164; 288)			
	(8)	142.7 (5.2; 132-149; 14)			
	(9)	143 (4; 134-154; 29)			
TAIL	(4)	66.8 (2.14; 63-70.5; 13)			
	(5)	69.6 (2.30; 61-75; 69)			
BILL	(4)	12.6 (0.47; 12-13.5; 13)			
	(5)	12.6 (0.68; 11.0-14.5; 69)			
	(8)	12.4 (1.1; 11.3-15; 14)			
TARSUS	(9)	12.1 (0.4; 11.4-13.0; 30)			
	(4)	35.0 (1.34; 32-36.5; 13)			
	(5)	34.2 (1.12; 31.55-36.5; 69)			
	(8)	35.4 (1.5; 33-38; 14)			
	(9)	34.8 (1.1; 32.5-37.0; 30)			
TOE	(4)	28.7 (1.10; 26-30; 13)			
	(5)	29.6 (0.98; 27-32; 69)			

Brown 1972 excluded). (3) Antarctic continent, fresh specimens; adults excluded (NMNZ). (4) Signy I., skins; juveniles excluded (Beck & Brown 1972, who also give Graham Land measurements closely similar to those of Roberts 1940). (5) Signy I., live birds; juveniles excluded (Beck & Brown 1972). (6) S. Georgia, live birds, mist-netted and presumably including non-breeders (Copestake & Croxall 1985) (7) S. Georgia, live breeding adults (Copestake & Croxall 1985; see Roberts for S. Georgia skins). (8) Iles Kerguelen, live birds; methods unknown (Weimerskirch 1985). (9) Iles Crozet; methods unknown (Jouventin *et al.* 1985). (10) South America, skins (Murphy in Roberts 1940; tail measurements taken by Murphy tend to be a little short [W.R.P.Bourne]).

WEIGHTS

ADULT Subspecies *exasperatus*, Signy I. (Beck & Brown 1972). Arrive moderately fat in Nov.; during pre-laying period males 39.2 (2.11; 36–43.5; 32), females 40.0 (2.18; 33–45; 33). Weight lower during most of breeding season; in Jan. 37.6 (2.29; 33–43; 75). Rapid increase in Apr. to 46.4 (2.38; 42–50; 14), when much (assumed pre-migratory) fat stored. On Antarctic continent, Dec.–Mar., juveniles excluded; males 36.5 (4.25; 26.5–40.5; 10), females 40.0 (6.31; 32.2–50; 10) (NMNZ).

Nominate *oceanicus*, S. Georgia, breeding pairs, weighed early in incubation: males 33.6 (1.90; 30–38; 16), females 36.2 (2.68; 31–43.5; 18) (Copestake & Croxall 1985). Iles Kerguelen, unknown when weighed, 34.2 (7.0; 28–48; 14) (Weimerskirch *et al.* 1989). Iles Crozet, unknown when weighed, 32 (3; 27–39; 31) (Jouventin *et al.* 1985).

Little information on weights while migrating or wintering; moulting female, July, off Surinam, 27.5 (probable *exasperatus*; BWP); two adults in body-moult in Arabian Sea c. 24; moulting male, Nov., off ne. Aust., 25 (BWP).

DOWNY YOUNG Chick growth information in Roberts (1940), Mougín (1968), Beck & Brown (1972), and Jouventin *et al.* (1985).

STRUCTURE Eleven primaries; p9 longest, p10 7–10, p8 1–5, p7 12–16, p6 23–29, p5 33–42, p4 47–54, p3 56–67, p2 69–77, p1 77–87. Carpal joint rather close to body; 11 secondaries. Tail square or slightly forked; t6 2–9 longer than t1 in subspecies *exasperatus*, 0–5 in nominate *oceanicus*. Bill rather short, broad at base; nasal tube c. 40% of bill length. Nostril points forwards and upwards, c. 30° from line of bill; septum does not reach opening. Tarsus long, slender, holothecal; longer than toes. Outer toe about 1 mm, and inner toe about 4 mm, shorter than middle. Claws flattened, broadest point closer to tip than base.

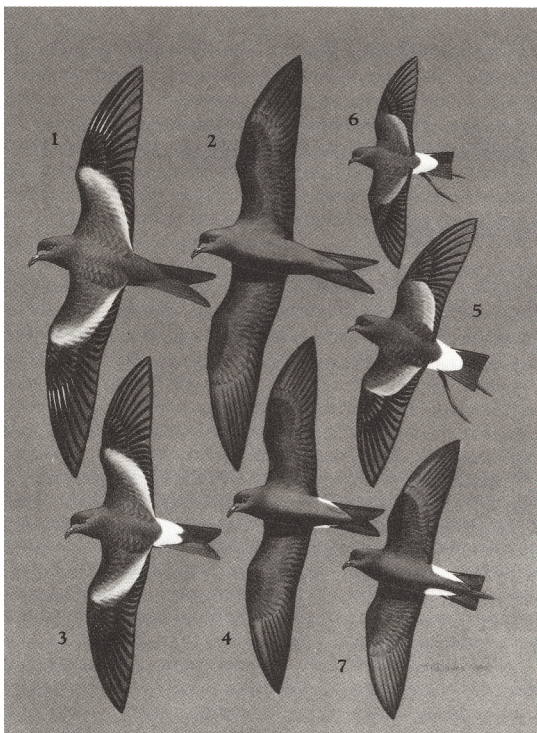
GEOGRAPHICAL VARIATION No variation in plumage. Three white-breasted specimens (subspecies *maorianus*) discussed by Murphy & Snyder (1952) probably showed rare form of individual variation. Two subspecies usually recognized; nominate *oceanicus*, breeding N of, and *exasperatus*, S of, Antarctic Convergence. Subspecies *exasperatus* has longer wing and tail. Birds from Signy I. seem to be intermediate in size between Antarctica and S. Georgia, suggesting clinal variation in size; this suggestion unproved for reasons given by Copestake & Croxall (1985). Roberts (1940) claimed that Kerguelen birds had shorter tails than those from S. Georgia; however his Kerguelen skins were measured by Falla (1937) who sometimes took erroneously short tail measurements (Harper 1980).

DIR

REFERENCES

- Ainley, D.G. 1976. *Western Birds* 7: 33–68.
 Ainley, D.G., E.F. O'Connor & R.J. Boekelheide. 1984. *AOU orn. Monogr.* 32.
 Ainley, D.G., R.C. Wood & W.J.L. Sladen. 1978. *Wilson Bull.* 90: 492–510.
 Andersson, K.A. 1905. *Wiss. Ergebn. Schwed. Sudpol. Exped., 1901–1903, Bd. 5 Zool. I, Leif.* 2:1–57.
 AOU (American Ornithologists Union). 1983. *Checklist of North American Birds.* 6th Ed.
 Bailey, R. 1966. *Ibis* 108: 224–64.
 Bailey, R.S. 1968. *Ibis* 110: 493–519.
 Beck, J.R. 1970. Pp. 542–50. In: Holdgate 1970.
 Beck, J.R., & D.W. Brown. 1972. *Scient. Rep. Br. Antarct. Surv.* 69: 1–54.
 Bennett, A.G. 1927. *Emu* 26: 259–63.
 Bierman, W.H., & K.H. Voous. 1950. *Ardea* 37 (Suppl.): 1–123.
 Bourne, W.R.P. 1960. *Sea Swallow* 13: 26–39.
 Bourne, W.R.P. 1966. *Sea Swallow* 18: 8–39.
 Bourne, W.R.P. 1987. *Sea Swallow* 36: 64.
 Bourne, W.R.P., & T.J. Dixon. 1975. *Sea Swallow* 24: 65–88.
 Bourne, W.R.P., & W.F. Curtis. 1985. *Sea Swallow* 34: 18–28.
 Brooke, R.K., & J.C. Sinclair 1978. *Cormorant* 4: 10–17.
 Brown, R.G.B., D.N. Nettleship, P. Germain, C.E. Tull & T. Davis. 1975a. *Atlas of Eastern Canadian Birds.*
 Brown, R.G.B., F. Cooke, P.K. Kinnear & E.L. Mills. 1975b. *Ibis* 117: 339–56.
 Bryson, A.G.S. 1949. *J. Bombay nat. Hist. Soc.* 48: 362–4.
 Burton, R.W. 1968. *Br. Antarct. Surv. Bull.* 15: 9–28.
 Cadée, G.C. 1985. *Ardea* 73: 183–8.
 Cendron, J. 1953. *Oiseau Revue fr. Orn.* 23: 212–20.
 Cline, D.R., D.B. Siniff & A.W. Erickson. 1969. *Auk* 86: 701–16.
 Coates, B.J. 1985. *The Birds of Papua New Guinea.*
 Copestake, P.G., & J.P. Croxall. 1985. *Br. Antarct. Surv. Bull.* 66: 7–17.
 Copestake, P.G., J.P. Croxall & P.A. Prince. 1988. *Polar Biol.* 8: 271–9.
 Cowan, A.N. 1979. *Aust. Bird Watcher* 8: 69–90.
 Crossin, R. 1974. Pp 154–205. In: *Pelagic Studies of Seabirds in the Central and Eastern Pacific Ocean.* (Ed. W.B. King).
 Croxall, J.P. (Ed.) 1987. *Seabirds: Feeding Ecology and Role in Marine Ecosystems.*
 Croxall, J.P., & A.W. North. 1988. *Br. Antarct. Surv. Bull.* 78: 37–42.
 Croxall, J.P., & P.A. Prince. 1980. *Biol. J. Linn. Soc.* 14: 103–31.
 Croxall, J.P., & P.A. Prince. 1987. Pp. 347–68. In: *Seabirds: Feeding Ecology and Role in Marine Ecosystems.* (Ed. J.P. Croxall 1987).
 Croxall, J.P., H.J. Hill, R. Lidstone-Scott, M.J. O'Connell & P.A. Prince. 1988. *J. Zool., Lond.* 216: 83–102.
 Croxall, J.P., S.J. McInnes & P.A. Prince. 1984a. *ICBP Tech. Publ.* 2: 271–91.
 Croxall, J.P., P.A. Prince, I. Hunter, S.J. McInnes & P.G. Copestake. 1984b. *ICBP Tech. Publ.* 2: 637–66.
 Darby, M.M. 1970. *Notornis* 17: 28–55.
 Dawson, E.W. 1958. *J. Bombay nat. Hist. Soc.* 55: 562–4.
 Downes, M.C., E.H.M. Ealey, A.M. Gwynn & P.S. Young. 1959. *ANARE Rep. (B)* 1: 1–135.
 Duhamel, G. 1981. *Alauda* 49: 241–9.
 Dunlop, J.N., R.D. Wooller & N.G. Cheshire. 1988. *Aust. J. mar. freshwater Res.* 39: 661–9.
 Eckert, J. 1969. *S. Aust. Orn.* 25: 110.
 Falla, R.A. 1937. *Rep. BANZ Antarct. Res. Exped. (B)* 2: 1–288.
 Flora, M.D. 1981. *Cormorant* 9: 3–7.
 Gain, L. 1914. *Deux. Exped. Ant. franc. (1908–1910) Oiseaux Antarctiques:* 1–200.
 Gibson-Hill, C.A. 1948. *J. Bombay nat. Hist. Soc.* 47: 443–9.
 Grubb, T.C., Jr. 1972. *Nature* 237: 404–5.
 Haga, R. 1961. *Antarct. Rec. (Tokyo)* 11: 146–8.
 Haney, J.C. 1986. *Auk* 103: 141–51.
 Hannecart, F., & Y. Letocart. 1983. *Oiseaux de Nouvelle-Calédonie et*

- des Loyautés.
- Harper, P.C. 1980. *Notornis* 27: 235-86.
- Harper, P.C. 1987. *Notornis* 34: 169-92.
- Harper, P.C., G.A. Knox, E.B. Spurr, R.H. Taylor, G.J. Wilson & E.C. Young. 1984. *ICBP Tech. Publ.* 2: 593-608.
- Harper, P.C., J.P. Croxall & J. Cooper. 1985. *BIOMASS Handbook* 24: 1-22.
- Harrison, P. 1983. *Seabirds: An Identification Guide*.
- Holdgate, M.W. 1963. *Br. Antarct. Surv. Bull.* 2: 45-51.
- Holdgate, M.W. (Ed.) 1970. *Antarctic Ecology*.
- Holdgate, M.W., P.J. Tilbrook & R.W. Vaughan. 1968. *Br. Antarct. Surv. Bull.* 15: 1-7.
- Holgerson, H. 1957. *Scient. Res. Bratigg Exped. 1947-1948*.
- Horning, D.S. 1976. *Notornis* 23: 119.
- Huber, L.N. 1971. *Notornis* 18: 38-42.
- Humphrey, P.S., D. Bridge, P.W. Reynolds & R.T. Peterson 1970. *Birds of Isla Grande (Tierra del Fuego)*.
- Hunter, S. 1983. *J. Zool., Lond.* 200: 521-38.
- Hunter, I., J.P. Croxall & P.A. Prince. 1982. *Br. Antarct. Surv. Bull.* 56: 49-67.
- Ingram, G. 1976. *Sunbird* 7: 67-76.
- Jablonski, B. 1986. *Polish Polar Res.* 7: 217-66.
- Jehl, J.R. Jr. 1973. *Auk* 90: 114-35.
- Jehl, J.R. Jr. 1974. *Auk* 91: 681-99.
- Jespersen, P. 1933. *Vidensk. Med. Dansk naturl. Foren.* 94: 187-221.
- Johnstone, G.W., D.J. Lugg & D.A. Brown. 1973. *ANARE Rep. B (I)*, 123.
- Jouventin, P., & J.P. Robin. 1984. *Emu* 84: 46-68.
- Jouventin, P., J.-L. Mougouin, J.-C. Stahl, J.A. Bartle & H. Weimerskirch. 1982a. *Com. natn fr. Rech. antarct.* 51: 427-36.
- Jouventin, P., J.-L. Mougouin, J.-C. Stahl & H. Weimerskirch. 1982b. *Com. natn fr. Rech. antarct.* 51: 457-67.
- Jouventin, P., J.-C. Stahl, H. Weimerskirch & J.-L. Mougouin. 1984. *ICBP Tech. Publ.* 2: 609-25.
- Jouventin, P., J.-L. Mougouin, J.-C. Stahl & H. Weimerskirch. 1985. *Notornis* 32: 157-220.
- Jouventin, P., V. Ridoux, J.-C. Stahl & H. Weimerskirch. 1988. *Rev. Ecol. (Terre et Vie)* 43: 357-66.
- Kamenev, W.M. 1977. *Sov. Antarct. Exped. Inf. Bull.* 94: 49-57.
- Kononov, Y.S. 1962. *Sov. Antarct. Exped. Inf. Bull.* 4: 371-5.
- Korotkevich, E.S. 1964. *Sov. Antarct. Exped. Inf. Bull.* 1: 149-52.
- Lacan, F. 1971. *Oiseau Revue fr. Orn.* 41 (Spec. No.): 65-89.
- Lambert, K. 1971. *Beitz. Vogelk. Leipzig* 17: 1-32.
- Liversidge, R., & G.M. Le Gras. 1981. *Proc. Symp. Birds of Sea and Shore*: 149-67.
- Mayaud, N. 1941. *Oiseau Revue fr. Orn.* (Spec. No.): 44-6.
- Mayaud, N. 1949-50. *Alauda* 17-18: 222-33.
- McQuaid, C.D., & L.H. Ricketts. 1984. *Cormorant* 12: 14-28.
- Meeth, P., & K. Meeth. 1986. *A'sian Seabird Grp Newsl.* 23: 15-35.
- Menegaux, A. 1907. *Exped. Ant. Franc. 1903-1905, Sci. Nat.: Doc. Sci., Oiseaux*: 1-75.
- Milon, P. 1962. *TAAF, Paris* 19-20: 30-32.
- Morris, A.K., A.R. McGill & G. Holmes. 1981. *Handlist of Birds in New South Wales*.
- Mougouin, J.-L. 1968. *Oiseau Revue fr. Orn.* 38 (Spec. No.): 1-52.
- Murphy, R.C. 1918. *Bull. Am. Mus. nat. Hist.* 38: 117-46.
- Murphy, R.C., & J.P. Snyder. 1952. *Am. Mus. Novit.* 1596: 1-15.
- Nakamura, K., Y. Tanaka & M. Hasegawa. 1983. *Bull. Biogeog. Soc. Japan* 38: 125-8.
- Norris, A.Y. 1965. *Notornis* 12: 80-105.
- Obst, B.S. 1985. *Auk* 102: 540-9.
- Obst, B.S. 1986. *Wilson Bull.* 92: 189-95.
- Obst, B.S., K.A. Nagy & R.E. Ricklefs. 1987. *Physiol. Zool.* 60: 200-210.
- Osborne, B.C. 1985. *Br. Antarct. Surv. Bull.* 66: 57-73.
- Ozawa, K. 1968. *Misc. Rep. Yamashina Inst. Orn. Zool.* 5: 411-13.
- Ozawa, K., K. Mimura, H. Egoshi & K. Nagano. 1964. *J. Tokyo Univ. Fish.* 7 (Spec. Ed): 1-42.
- Ozawa, K., T. Yamada, M. Kira & T. Shimizu. 1968. *J. Tokyo Univ. Fish.* 9 (Spec. Ed): 51-100.
- Paessler, R. 1911. *J. Orn.* 59: 41-51.
- Paessler, R. 1913. *J. Orn.* 62: 272-8.
- Palmer, R.S. 1962. *Handbook of North American Birds*. 1.
- Parmelee, D.F., W.R. Fraser & D.R. Nielson. 1977. *Antarct. J. US* 12: 14-21.
- Paulin, P. 1953. *Mem. Inst. scient. Madagascar (A)* 8: 111-234.
- Pearson, T.G. 1899. *Auk* 16: 246-50.
- Pefaur, J.E. 1974. *Wilson Bull.* 86: 16-22.
- Pennycuik, C.J. 1982. *Phil. Trans. R. Soc. Lond.* B300: 75-106.
- Phillips, W.W.A. 1954. *J. Bombay. nat. Hist. Soc.* 52: 334-48.
- Phillips, W.W.A. 1955. *J. Bombay. nat. Hist. Soc.* 53: 132-3.
- Powers, K.D. 1983. NOAA Tech. Memo., NMFS-F/NEC-27.
- Pryor, M.E. 1968. Pp 57-82. In: *Antarctic Bird Studies*. (Ed. O.L. Austin).
- Reynolds, P.W. 1935. *Ibis* (13) 5: 65-101.
- Ricker, J. 1964. *Emu* 64: 21-7.
- Ridoux, V., & C. Offredo. 1989. *Polar Biol.* 9: 137-45.
- Ritchie, G.S. 1966. *Sea Swallow* 18: 64-5.
- Roberts, B. 1940. *Sci. Rep. Br. Graham Ld Exped.* 1: 141-94.
- Robertson, C.J.R., J.R. Gilbert & A.W. Erickson. 1980. *Rec. natn. Mus. NZ* 1: 271-9.
- Rootes, D.M. 1988. *Br. Antarct. Surv. Bull.* 80: 87-119.
- Routh, M. 1949. *Ibis* 91: 577-606.
- Roux, J.-P., & J. Martinez. 1986. *Cormorant* 14: 3-19.
- Schlatter, R.P. 1984. *ICBP Tech. Publ.* 2: 261-9.
- Serventy, D.L. 1952. *Emu* 52: 105-16.
- Shuntov, V.P. 1974. *Seabirds and the Biological Structure of the Ocean*.
- Simpson, D.M. 1987. *Sea Swallow* 36: 15-19.
- Stahl, J.-C. 1987. *TAAF-MR* 84-01: 175-90.
- Stahl, J.-C., & J.-L. Mougouin. 1986. *Oiseau Revue fr. Orn.* 56: 193-208.
- Starck, W. 1980. *Polish Polar Res.* 1: 183-96.
- Stokes, T. & C. Corben. 1985. *Corella* 9: 25-9.
- Summerhayes, C.P., P.K. Hofmeyr & R.H. Rioux. 1974. *Ostrich* 45: 83-109.
- Thomas, T. 1986. *Oiseau Revue fr. Orn.* 56: 349-68.
- Thurston, M.H. 1982. *Br. Antarct. Surv. Bull.* 55: 77-103.
- Tickell, W.L.N., & R.W. Woods. 1972. *Br. Antarct. Surv. Bull.* 31: 63-84.
- Vader, W., & R.T. Barrett. 1984. *Ardea* 72: 235.
- van Oordt, G.J. & J.P. Kruijt. 1953. *Ibis* 95: 615-37.
- Vanhöffen, E. 1904. *Zeitschr. Ges. Erdkunde, Berlin*: 362-70.
- Wasilewski, A. 1986. *Polar Polish Res.* 7: 173-216.
- Watson, G.E. 1975. *Birds of the Arctic and Subantarctic*.
- Watson, G.E., J.P. Angle, P.C. Harper, M.A. Bridge, R.P. Schlatter, W.L.N. Tickell, J.C. Boyd & M.M. Boyd. 1971. *Birds of the Antarctic and Subantarctic*. Antarctic Map Folio Ser. 14.
- Weimerskirch, H., R. Zotier & P. Jouventin. 1989. *Emu* 89: 15-29.
- Wilson, E.A. 1907. *Nat. Antarct. Exped. 1901-1904* 2 *Zool. Pt.* 2: 1-121.
- Withers, P.C. 1979. *J. Exp. Biol.* 80: 83-91.
- Zink, R.M. 1981. *Wilson Bull.* 93: 1-20.



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Matsudaira's Storm-Petrel *Oceanodroma matsudairae*

1. Adult, dorsal
2. Adult, ventral

Leach's Storm-Petrel *Oceanodroma leucorhoa*

3. Adult, dorsal
4. Adult, ventral

Wilson's Storm-Petrel *Oceanites oceanicus*

5. Adult, dorsal, fresh
6. Adult, dorsal, worn
7. Adult, ventral

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