

## 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: Diomedeidae 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.

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## 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.

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## *Fregatta tropica* Black-bellied Storm-Petrel

COLOUR PLATE FACING PAGE 681

*Thalassidroma tropica* Gould, 1844, *Ann. Mag. nat. Hist.* 13: 366 — equatorial regions of Atlantic Ocean = 6°33'N, 18°06'W from 'a' type in British Museum (Natural History).

*Fregata* is a modern Latinization from the French *frégate* and is applied as a generic name to the tropicbirds. *Fregatta* is an apparently deliberate variation of spelling to create a separate name. The specific name is of course chosen geographically.

OTHER ENGLISH NAME Gould's Storm-Petrel

**Black-bellied** is now the most widely used name.

POLYTYPIC Nominate *tropica* breeds on islands of Scotia Arc., of s. Indian Ocean and New Zealand; *melanoleuca* Salvadori, 1908, said to breed Gough I. though status uncertain (see Geographical Variation).

**FIELD IDENTIFICATION** Length 20 cm; wingspan 45–46 cm; weight 50–58 g. Medium-sized storm-petrel with conspicuous white sides to abdomen, central underwings, flanks and rump. Breed on subantarctic islands and migrate to s. tropical waters in Aust. winter. Diagnostic black central belly stripe from breast to undertail separates most Black-bellied Storm-Petrels from very similar White-bellied Storm-Petrel *F. grallaria* where ranges overlap in winter. Sexes alike;

juveniles and immatures as adults. No seasonal variation.

**DESCRIPTION ADULT.** Head, back and upperwings, black, darkest on head and flight-feathers. Upperwing has inconspicuous paler grey-brown bar from carpal joint to base of wing at rear. Rump, white, extending round flanks to underparts. Black tail, square or slightly rounded. Chin, mottled white or black. Throat and upper breast, blackish, extending as black line down centre of abdomen to black



under tail-coverts and undertail. Paler birds have this stripe reduced or none (Bourne 1960). Sides of lower breast, abdomen and flanks, white. Under wing-coverts, white, bordered by broad blackish leading-edge and black flight-feathers. Bill, black. Iris, brown. Legs and feet, black. Feet project slightly beyond tail in flight. Juveniles and adults in fresh plumage have pale fringes to dorsal feathers, giving slight scaly pattern.

**SIMILAR SPECIES** Black stripe on abdomen diagnostic, but this can be difficult to see and 'white-bellied' forms lack stripe. For distinctions from **White-bellied Storm-Petrels**, see that account. **Wilson's Storm-Petrel** *Oceanites oceanicus* has similar distribution to Black-bellied Storm-Petrel but smaller with all dark underparts and underwing.

Breed on subantarctic islands and migrate to s. tropical waters in Aust. winter. Flight erratic and zigzagging; do not patter on sea surface (c.f. Wilson's Storm-Petrel) but use feet to skip off sea. Feed by skipping over surface, swinging wildly from side to side with wings outspread just above horizontal. Wing-beats slower and less bat-like than Grey-backed Storm-Petrel *Oceanites nereis*. Wilson's Storm-Petrels hold wings higher above back when feeding, with feet pattering on sea surface. Black-bellied Storm-Petrels tend to be attracted to ships but not so much as Wilson's Storm-Petrels; often fly ahead or to one side of ship. Take little notice of scraps. Silent at sea. Nocturnal at breeding sites, calling in air and at burrows. At nest, give distinctive high-pitched whistle lasting about 4 s.

**HABITAT** Marine, pelagic; in subantarctic and Antarctic waters in breeding season, migrating to tropical and subtropical waters in non-breeding season; winter visitor to Aust. waters. Breeding distribution from subantarctic S to 0.5 °C isotherm (Ainley *et al.* 1984). Except round subantarctic breeding islands, seldom occur N of Antarctic Convergence in breeding season (Bierman & Voous 1950; Brown *et al.* 1975). In Ross Sea in summer, pelagic in open water within 100 km of n. edge of icebergs. Thought to feed within short

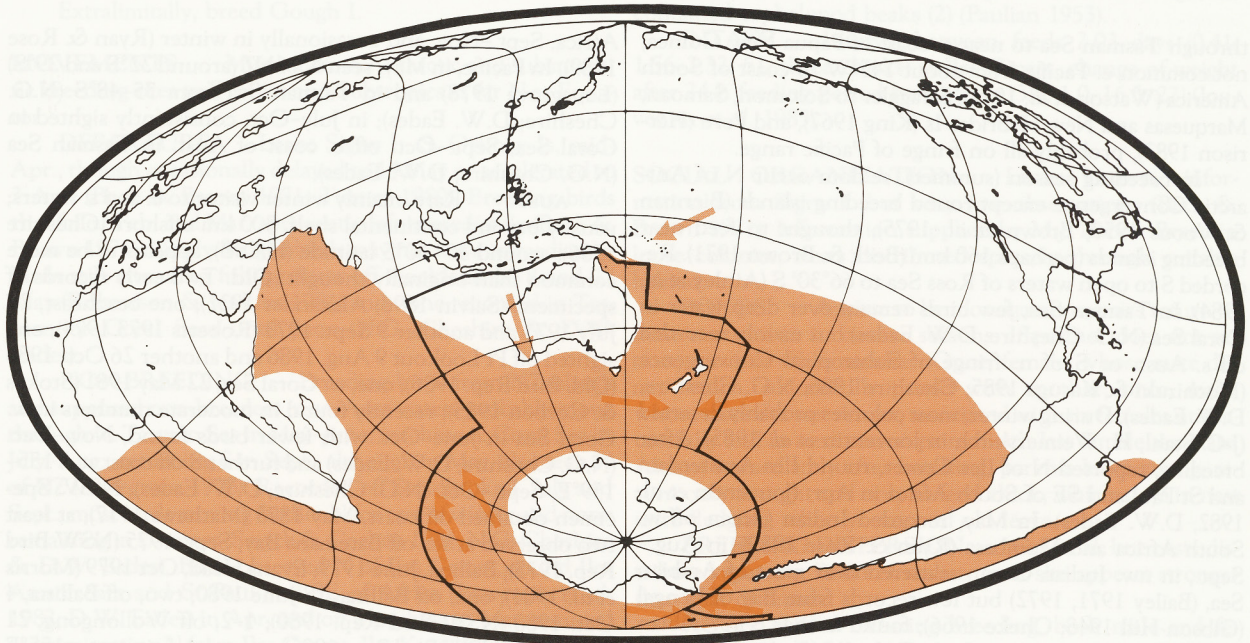
distance of breeding islands (perhaps 160 km) (Beck & Brown 1971). At Iles Crozet, occur over continental slope and in pelagic waters but not shoreward of kelp (*Macrocystis*) zone (Jouventin *et al.* 1982, 1985).

May be associated with cool currents. SE of Tas., more abundant in Apr. on cooler side of front (<13.6 °C) over sea-mounts; extension of cool e. Aust. current in this area may be followed by migrating birds, or may allow subantarctic birds to range farther (Blaber 1986). South Atlantic birds reach Peru along Humboldt current (Harrison 1983). Pelagic in non-breeding season and rarely on inshore waters (Heard I.) (Downes *et al.* 1959). In Aust. waters, seen beyond continental shelf, 300 km offshore, depth 4150–5200 m, surface-temperature 13.4–14.8 °C, salinity 34.7–35.2‰ (Cheshire 1986). Yet, in tropical Indian Ocean, rarely found in coastal areas of upwelling; all records >50 km offshore, in warm oceanic waters, surface-temperature 24–27 °C (Bailey 1966).

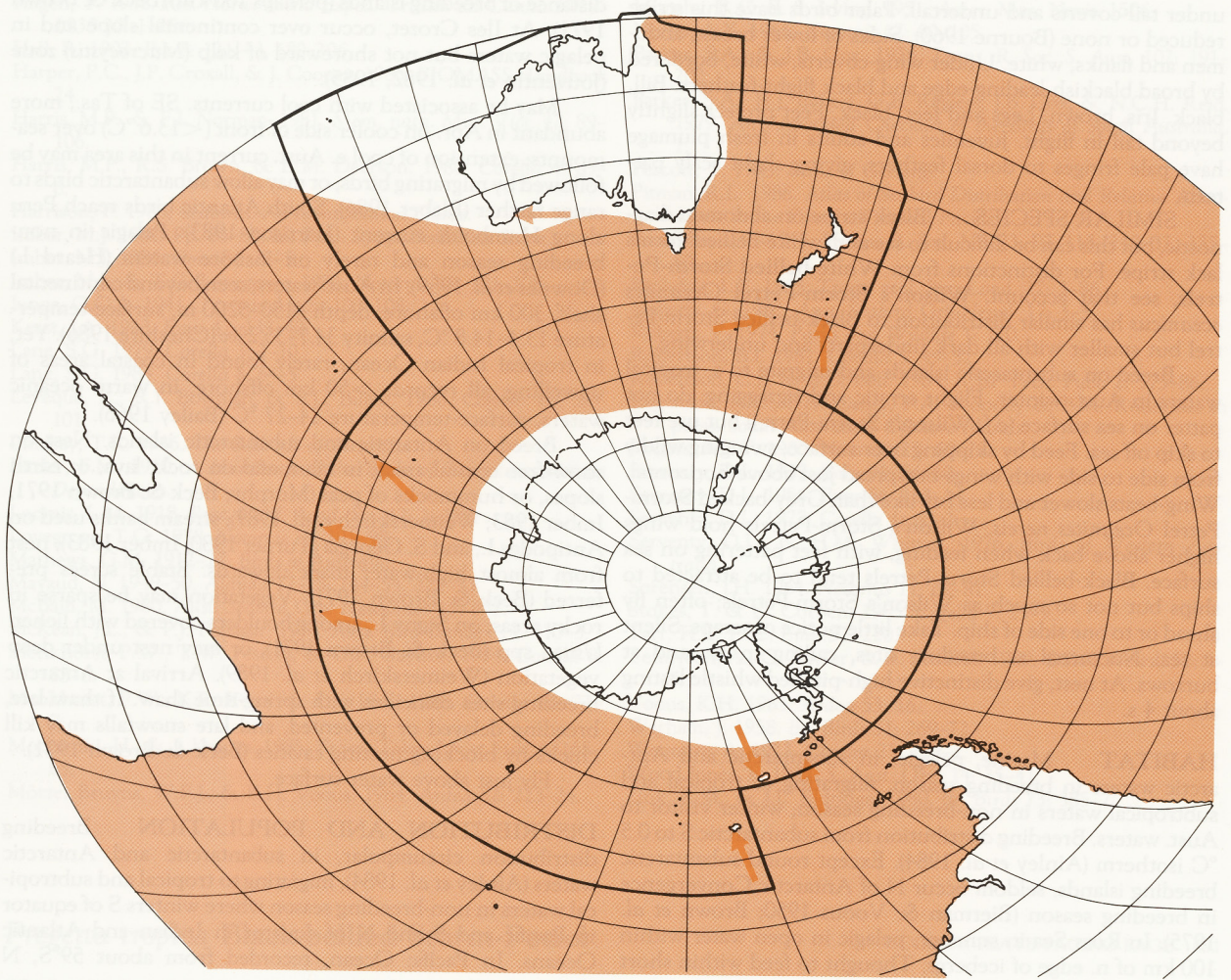
Breed on Antarctic and subantarctic islands. Nest on snow-free coastal areas, in talus, and on rock, lava, or earth slopes, or hummocks of peat (Murphy; Beck & Brown 1971; Imber 1983; Weimerskirch *et al.* 1989); stream banks used on Antipodes I., and S. Georgia (Turner 1980; Imber 1983); nest from almost high-water mark upwards. Stable screes preferred (Beck & Brown 1971). Vegetation may be sparse in rocky areas; on Signy I., among boulders covered with lichen *Usnea* spp (Beck & Brown 1971), or may nest under deep vegetation (Weimerskirch *et al.* 1989). Arrival at Antarctic breeding sites coincides with spring-time thaw. If thaw late, breeding delayed or prevented, and late snowfalls may kill chicks by blocking nesting cavities (Beck & Brown 1971).

Fly just above water surface.

**DISTRIBUTION AND POPULATION** Breeding distribution circumpolar, in subantarctic and Antarctic waters (Ainley *et al.* 1984), migrating to tropical and subtropical waters in non-breeding season where winters S of equator in Pacific and S and N of equator in Indian and Atlantic Oceans. In Pacific Ocean, recorded from about 59°S, N







through Tasman Sea to near s. coast of Papua New Guinea; not common e. Pacific from about 145°W to coast of South America (Watson *et al.* 1971). Straggler to Solomon, Samoan, Marquesas and New Hebrides Is (King 1967), and Peru (Harrison 1983), probably all on fringe of Pacific range.

In breeding season (summer), seldom occur N of Antarctic Convergence except round breeding islands (Bierman & Voous 1950; Brown *et al.* 1975); thought to feed near breeding islands (perhaps 160 km) (Beck & Brown 1971). Recorded S to open waters of Ross Sea to 66°30' S (Ainley *et al.* 1984). In Tasman Sea, few birds remain over deep water in Coral Sea (N.G. Cheshire; D.W. Eades) but mainly recorded off s. Aust. or S of n. fringe of Subtropical Convergence (Mochizuki & Kasuga 1985; Cheshire 1986; N.G. Cheshire; D.W. Eades). During winter, most colonies probably deserted (J-C. Stahl; H. Weimerskirch in Jouventin *et al.* 1985). After breeding, reported N of Iles Crozet, round Iles Amsterdam and St Paul and SE of South Africa in Apr. (Jouventin *et al.* 1982; D.W. Eades). In May, recorded Indian Ocean off w. South Africa and Mombasa (Ryan & Rose 1989); in Aug.-Sept., in nw. Indian Ocean scattered over most of Arabian Sea, (Bailey 1971, 1972) but few records from Bay of Bengal (Gibson-Hill 1948; Cheke 1966); found farther S in Arabian Sea, off East Africa, during Sept. (Bailey 1968); seen off South

Africa, Sept.-Nov. and occasionally in winter (Ryan & Rose 1989). In Pacific, in May, seen N of NZ (around 22°S and 29°S) (Lovegrove 1978) and in Tasman Sea from 35-48°S (N.G. Cheshire; D.W. Eades); in July-Oct. consistently sighted in Coral Sea; Sept.-Oct. off e. coast of Aust. in Tasman Sea (N.G. Cheshire; D.W. Eades).

**AUST.** Rare, mainly winter visitor to e. and s. waters; usually beyond continental shelf, 300 km offshore (Cheshire 1986), around 30°-60°S latitude (HASB); appears to be more common than originally thought. **Qld.** Two early records of specimens (Salvin 1896; Alexander 1922); one beachcast, 22 July 1973 and another 9 Sept. 1973 (Roberts 1973 1974); one sighted off Pt Lookout 9 Aug. 1986 and another 26 Oct. 1986 (Qld. Bird Rep. 1986); one, w. Coral Sea, 22 May 1981 (Stokes & Corben 1985); recently found in moderate numbers in w. Coral Sea in June-Oct. with fewer birds found, Nov.-Dec. (N.G. Cheshire; D.W. Eades) and further S off coast at c. 155-159°E, Sept.-Oct. (N.G. Cheshire; D.W. Eades). **NSW.** Specimen obtained off coast, May 1875 (Mathews 1917); at least two observed at sea off Batemans Bay, Sept. 1975 (NSW Bird Rep. 1975); Ballina, June 1979; Evans Head, Oct 1979 (Morris *et al.* 1981); one, off Ballina, 18 June 1980; two, off Ballina, 4 Oct. 1980 (NSW Bird Rep. 1980); 1-2, off Wollongong, 21 Sept. 1985 (NSW Bird Rep. 1985); several sightings at c. 155°E



during Sept. (N.G. Cheshire; D.W. Eades). Vic. Two seen in vicinity of 39°S, 148°E, e. Bass Str., 6 Feb. 1985 (Vic. Bird Rep. 1985). Tas. First recorded off NW, when one seen 9 May 1984. Single birds seen in 1984: off SE, 25 Nov.; e. coast, 30 Nov.; w. coast 3 Dec., (two, 4 Dec.) (Tas. Bird Rep. 1987). Ten seen off Tasman Is, 5 Dec. 1984 (Tas. Bird Rep. 1987); ESE offshore, either side of Soela Seamount (43°50'S, 150°25'E), Apr. 1985 (number not given) (Blaber 1986); seven off SE, 3, 12, 16 Dec. 1988; one seen slope waters, 11 Dec. 1988 (Tas. Bird Rep. 1988). SA. Only recorded Nov. 1984, when sighted on 16 occasions at sea near 40°30'S, 139°30'E (Cheshire 1986). WA. One beachcast, Albany, 15 Apr. 1985 (Johnstone 1985). NT. Salvin (1896) lists specimen labelled Port Essington, however record well outside expected range and should be investigated further.

NZ. Rare. First recorded Great Barrier I., 1868; specimens found Mokohinau, 1886; and recorded as straggler to Chatham Is (Oliver; Fleming 1953). One beachcast: Campbell I., Feb. 1963; Wellington South, May 1975; Wellington West, June 1975; Southland, Nov. 1977; Oreti Beach, Jan. 1981 (Powlesland 1983). Observed in large numbers to S (Oliver). No evidence to indicate suggestions of breeding Bounty Is (Beck & Brown 1971; Robertson & van Tets 1982). Sight records: in small numbers, 52°30'S to 48°S, McMurdo-NZ, Mar. 1973; from 10 km off Snares Is to 15 km off Big South C., 3 Mar. 1977 (CSN 20, 24).

**BREEDING** Iles Crozet; Iles Kerguelen; Auckland and Antipodes Is; S. Georgia; S. Orkney Is, Signy I, estimated between 100–200 pairs (Beck & Brown 1969), Larson Is, Laurie I.; S. Shetland — Deception, Elephant Is — and Prince Edward Is. Possibly breed S. Sandwich Is and Bouvetoya, Marion and Heard Is. Although breeding widespread, do not seem to be abundant at any but a few sites (e.g. Elephant I.; Prince Edward I.). On Antipodes and Auckland Is, widely dispersed, thus seeming scarce though total numbers large (M.J. Imber). Beck & Brown (1971) reviewed breeding distribution of nominate subspecies; breeding has since been confirmed on Antipodes Is (Imber 1983) and Prince Edward Is (Berruti *et al.* 1981).

Extraliminally, breed Gough I.

**MOVEMENTS** Migrant from Antarctic and subantarctic breeding sites to Tropics and Subtropics as far N as Equator.

**DEPARTURE** Leave Signy I., S. Orkney Is, mid-Apr., though occasionally delayed to 14 May or accelerated to 2 Apr. (Beck & Brown 1971; Turner 1980). Breeding birds that failed Feb. and Mar. apparently left immediately (Beck & Brown 1971). Newly fledged birds may not leave immediately; birds still attending fishing fleets off Auckland Is, 8 and 13 May (Robertson & Jenkins 1981) and none recorded in Tasman or Coral Seas until June (N.G. Cheshire & D.W. Eades).

**NON-BREEDING** Breeding birds from NZ islands and supposed non-breeders in se. Aust waters probably move through w. Tasman Sea in May–June, reaching n. Coral Sea in July–Aug., returning S in Sept.; although in May, also seen N of NZ (Lovegrove 1978). Recorded off Stradbroke I. July and Sept., most birds moving farther N for rest of winter and none remaining in s. waters (Smyth & Corben 1984; N.G. Cheshire & D.W. Eades). Birds observed N of Iles Crozet, round Iles Amsterdam and St Paul and SE of Africa (Jouventin *et al.* 1982; D.W. Eades) in Apr. and off Mombasa in May assumed to be migrating N from Iles Crozet, Iles Kerguelen and Prince

Edward I. to n. Indian Ocean where abundant off Arabia, Aug.–Sept. (Bailey 1971). Those breeding South Atlantic travel up both coasts of South America and w. Africa as far N as Peru and Gulf of Guinea (Harrison 1983).

**RETURN** Prince Edward I., early Sept. (Imber 1983), Iles Crozet 27 Sept 1981 (Jouventin *et al.* 1985); Signy I. not until 16.6 Nov. (7.9 days; 6–27 Nov.; 9 seasons) (Beck & Brown 1971).

**BREEDING** During summer, occur in Ross Sea to 66°30'S (Ainley *et al.* 1984) and estimated foraging range 189 km (Croxall & Prince 1987). Some individuals, assumed to be pre-breeders, remain over deep water in Coral Sea (N.G. Cheshire & D.W. Eades); others recorded Nov.–Mar. in shelf-break waters off se. Aust. or in cold waters S of n. fringe of Subtropical Convergence (Mochizuki & Kasuga 1985; Cheshire 1986; N.G. Cheshire & D.W. Eades) must also be non-breeding birds.

**FOOD** Little known. Includes small fish and cephalopods in tropics. Nothing known of food taken while breeding. **BEHAVIOUR** Most food taken by dipping and pattering (Harper *et al.* 1985; Harper 1987) but this differs from method and behaviour of sympatric Wilson's Storm-Petrel, wings being held just above horizontal while birds travel across water surface in series of skips, legs swinging from side to side (Beck & Brown 1971), periodically shallow-plunging, breast first (Harrison 1983). Occasionally follow whales (Southern Right Whale *Balaena glacialis*, Killer Whale *Orcinus orca*) (Enticott 1986) and feed at euphausiid schools in association with other birds (Obst 1985). More likely to travel ahead of than behind ships (Harrison 1983). Appear to detect food by smell; strongly attracted to cod liver oil (Leveque *et al.* 1989).

**NON-BREEDING** Birds collected at sea contained remains of fish and small cephalopods (two stomachs) (Bierman & Voous 1950).

**BREEDING** Thought to take mostly crustaceans; composition of diet at S. Georgia estimated to be 40% *Euphausia superba*, 40% amphipods, 10% copepods and 10% fish (Croxall & Prince 1987), but samples from Iles Kerguelen contained cephalopod beaks (2) (Paulian 1953).

**INTAKE** Interval between feeds 2.03 days (0.41; 1.56–2.32; 51, three chicks) at Iles Crozet, change of weight after 24-h feeding period being 6.6 g (3.6; 1.0–16.5; 22) (Jouventin *et al.* 1985).

**SOCIAL ORGANIZATION** Little known; information from Signy I. but very few observations (Beck & Brown 1971). Information supplied by M.J. Imber. Breed in loose colonies, nests distributed sparsely through suitable habitat.

**BONDS** Appear to be monogamous; pairs return to same nest-site in successive seasons. If partner does not return, survivor takes another. Once, female, whose mate did not return, successfully paired with another; once, male, whose mate did not return, associated with six females unsuccessfully and in next season paired with last female associate. Almost immediately after hatching, parents leave young; return only at night and only to feed chick, which stays in nest until fledging, when young and old leave.

**BREEDING DISPERSION** Colonial, but nests distributed sparsely. Bond of male to nest-site appears stronger than that of female.

**ROOSTING** During breeding, both male and female at nest during day. Not known at other times.



**SOCIAL BEHAVIOUR** Not studied in detail; at Signy I., strictly nocturnal but at S. Shetland Is, aerial displays observed in late evening; behaviour in nest burrows, other than vocalizations, undescribed. Information from Signy I. and S. Shetland Is (Beck & Brown 1971) and supplied by M.J. Imber. Nocturnal; most vocal behaviour at night though birds call during day; activity greatest on calm nights; vocal activity decreases during bad weather.

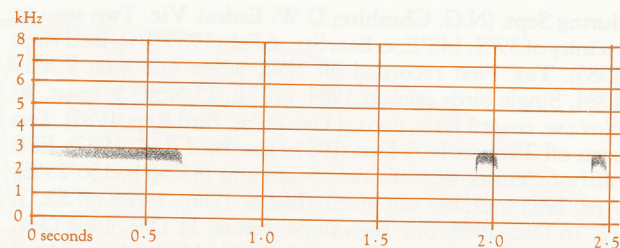
**AGONISTIC BEHAVIOUR** No information.

**SEXUAL BEHAVIOUR** Birds give high-pitched whistle (Voice) from inside nest or standing at entrance to burrow. Probably functions to ADVERTISE presence of unmated males in possession of nest-site. At Signy I., advertising begins when birds arrive Nov. until mid-Apr., decreasing in Jan.-Feb. Continued calling through season may be from unmated males. Another call, *pee-eeep* (Voice), given by one bird when pair was in nest; only noted when both members of pair present and probably associated with COURTSHIP or possibly GREETING. Corresponding behaviour not observed. **Aerial Display.** At Deception I., S. Shetland Is, pairs gained height, then turned and glided down together, one bird maintaining position slightly above and behind other (Beck & Brown 1971); birds called (Voice) throughout display. Display similar to that of Snow Petrel *Pagodroma nivea*.

**RELATIONS WITHIN FAMILY GROUP** Little known. Before laying, male more often at nest but both birds present at nest during day; female departs before laying, during which period male continues to visit nest. Incubation shared equally, usually in shifts of 3 days. Chick not brooded after hatching, parents visiting only to feed chick and only at night. Chick is generally active throughout nestling period, though may become torpid if starved (Beck & Brown 1971).

**VOICE** Only detailed study from Signy I. (Beck & Brown 1971), on which account based; some information from M.J. Imber. Apparently silent at sea (P.J. Fullagar). At breeding islands, characteristic musical call is reliable means of identification, in particular when compared with call of Wilson's Storm-Petrel (Beck & Brown 1971). Main call, high-pitched whistle, reminiscent of flight call of Golden Plover *Pluvialis apricaria*, given by birds at nest cavities or from ground near entrance to sites. 'This call might be imitated on a piccolo *fife* in the key of G or F' (Eaton 1879). No evidence that this call given in flight (*contra* Eaton 1879), but see later. Calls late at night (at Signy I.) and audible up to 300 m in favourable conditions. Ventriloquial quality of call noted by Beck & Brown (1971). Human imitation not difficult and may bring birds in to land nearby (Beck & Brown 1971). Calling heard at breeding colonies from spring through summer to mid-Apr.; less often in late Feb. and Mar. High wind and snowfall depresses calling frequency. Softer version given intermittently by one of pair when in nest with mate. No details of sexual, individual or geographical variations.

**ADULT** (1) Thin high-pitched whistle *huuuuu*, lasting about 4 s. (2) Softer version of call (1), where typical sequence would be *PEE-EEP-pip-pip-pip-PEE-EEP-pip-pip* repeated at about 4 s intervals. Sonagram A shows a sequence: *PEE-EE-pip-pip*. Louder *PEE-EEP* note sounds like distant call of Pied Oystercatcher *Haematopus longirostris*. Assumed to be associated with courtship at nest-site (Beck & Brown 1971). Reported as given during Aerial Display (see Social Behaviour) on one occasion at Deception I. (Beck & Brown 1971).



Recordist unknown; B1005

**YOUNG** Not described.

**BREEDING** Little known. One study of six nests at Signy I., S. Orkneys (Beck & Brown 1971). Information supplied by M.J. Imber. Loosely colonial breeder in snow-free areas; breeding groups perhaps 10-20 pairs.

**SEASON** At Signy I., birds returned on 6 Nov. in one year and between 12-27 Nov. in seven other years; return not correlated with conditions of sea-ice but apparently synchronized and less protracted than in Wilson's Storm-Petrel. Before laying, male in occupation of site more often than female (17/42 inspections *v.* 10/42). Pre-laying exodus of 8 and 15 days by female observed, whereas male continues to visit site, perhaps to keep it free of snow. At Iles Crozet, attendance before laying in cycles of  $15.5 \pm 1.5$  days, final pre-laying exodus of 9.8 days (Jouventin *et al.* 1985). At Signy I. pre-laying exodus of 8 and 15 days recorded (Beck & Brown 1971). Laying between 25 Dec. and 31 Jan., probably affected by weather; most Jan. dates in one year after fairly severe winter. Fledging and departures in mid-Apr., when adults give up visiting sites, but late fledging in mid-May in season after severe winter. Failed breeders desert sites and leave breeding grounds soon after failure. At Iles Kerguelen, newly hatched young recorded by 25 Jan. (Studer 1889), where breeding could be earlier, and at Auckland Is, slightly incubated eggs on 1 Feb. (Oliver), where breeding could be later, than at Signy I.



**SITE** At Signy I., in snow-free areas, in stable screes of small boulders, 20 cm in diameter, with cover of thick lichen; well hidden in small crevices with entrances just large enough to admit birds; fairly close together, two nests 0.5 m apart. Elsewhere, mostly in broken rocks but at Antipodes and Auckland Is in burrows 0.5 m long in soil of earth banks (Oliver) and in peaty hummocks. Same sites used by same birds in successive years at Signy I.

**NEST, MATERIALS** Merely slight depression on rock or dead moss of floor of cavity; usually without material except perhaps for little lichen, or some fine dry grass in Auckland Is (Oliver).

**EGGS** Elongated oval, not glossy; dull white, minutely speckled at one end with black, grey and reddish-brown spots and faint reddish streaks.

**MEASUREMENTS:** Signy I.: 37 (35-38; 8) x 27 (26-29).

**WEIGHTS:** Fresh: 15 (13-16.5) or *c.* 26.5% of mean female weight.

**CLUTCH-SIZE** One.



**LAYING** Data not enough to assess synchronization.

**INCUBATION** By both sexes equally in spells lasting 48–96 h; 72 h usually (75% of 52 spells) and variation may have been caused by periods of drifting snow that hampered relief by mates. Loss of weight by incubating birds, 2.5 g/24 h or c. 12% of av. body-weight during one 72-h shift. **INCUBATION PERIOD.** At Signy I.: 38, 38 and 44 days but last determination perhaps affected by desertion during period of drifting snow; 35 days (Turner 1980).

**YOUNG** Semi-altricial, nidicolous. Hatched with eyes closed and with light-grey protoptile except on facial area (throat to upper neck and sides of face), completely bare; soft parts initially dark flesh-coloured. Left alone almost immediately after hatching and subsequently visited by parents only for feeding and only at night. **NESTLING PERIOD.** Twice determined at Signy I.: 65, 71 days; 69 days (Turner 1980).

**GROWTH** Data on one chick at Signy I.: weight 15 g on day after hatching, reaching 53 g by 14 days; egg-tooth lost by 6 days; eyes visible by 8 days and open by 10 days. Quills, 4 mm long and about to burst by 18 days. By 23 days, heavier than av. adult and stayed so till departure. By 27 days, longest primary 17 mm out of sheath and tail visible. Down began to thin about 35 days, when black contour-feathers bursting from sheaths; soft parts then almost black. By 45 days, feathering of facial area complete. Max. weight (110 g) reached by 50 days; growth of soft parts stopped but wings and tail reached full length just before fledging; loss of down continued rapidly until little remained (on head, flanks, under tail-coverts) at fledging at 65 days. Periods of drifting snow prevented parents from feeding chick, which went into torpidity, and probably accounted for long nestling period of 71 days (above).

**FLEDGING TO MATURITY, SUCCESS** No information.

**PLUMAGES** *Nominate tropica.*

**ADULT** In fresh plumage: **HEAD AND NECK.** Entire head and hindneck, black-brown (119); rest of neck, dark brown (221); chin and throat, paler; often white bases of feathers exposed when ruffled or with wear, giving mottled appearance. **UPPERPARTS.** Mantle and back, dark brown (221); rump, black-brown (119); feathers broadly fringed white on rump, narrowly on mantle. Scapulars, broad and webs, rounded at tips, dark brown (221). Upper tail-coverts, white. **TAIL,** black-brown (119). **UPPERWING.** Tertiaries, secondaries, primaries and alula, black-brown (119). Outer secondaries slightly tipped white. Primaries extend 21–30 mm beyond tip of tail when wing closed. All upper wing-coverts, dark brown (221); greater, narrowly fringed white, median, less so; marginal with narrow dark-brown (119A) fringes. In worn plumage, white fringes lost; greater and median coverts, dark brown (119A). **UNDERPARTS,** vary greatly (see Fig. 1). Breast to upper abdomen, dark brown (221) contrasting with varying belly and flanks: sometimes, sharp demarcation between dark upper abdomen and all-white belly and flanks; or dark brown (221) line runs down centre of belly, or belly streaked (*Pealea* phenomenon: from time to time, mainly in South Pacific, specimens of storm-petrels have been collected with underparts varyingly streaked blackish on white. In past, some of these were placed in own genus *Pealea*; Oliver put three collected off Banks Pen. in separate species *Oceanites maorianus*. Now seems that most or all of these merely colour phases of Black-bellied Storm-Petrels; see Murphy & Snyder [1952] for de-

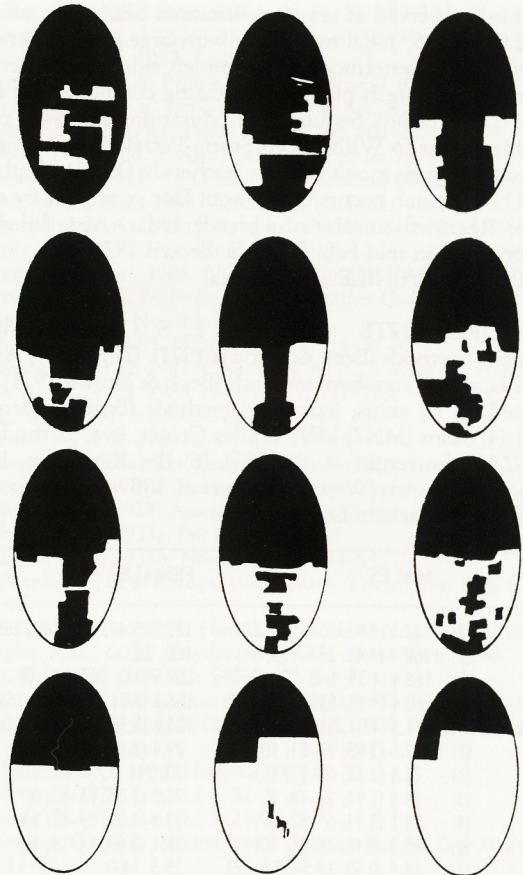


Fig. 1 Variation in area of dark and white on breast and abdomen

tails.) Thighs, usually white. Under tail-coverts, dark brown (221); outer feathers, narrowly fringed white. Tips of under tail-coverts, c. 1 mm short of tail tip. **UNDERWING.** Underside of primaries and secondaries, dark brown-grey (79). Greater under primary coverts, similar, with broad white fringes. Median and lesser under primary coverts, pale dark-brown (221) at base, rest white. Marginal under wing-coverts, dark brown (221); lesser, median and axillaries, white.

**DOWNY YOUNG** Body covered in light-grey down; facial area extending from throat to upper neck, including sides of face, bare. Feathering of facial area, complete by 45 days. See Beck & Brown (1971) for full details of plumage acquisition to juvenile.

**JUVENILE** Differs from adult in that some feathers at posterior of lores, tipped white. Primaries pointed in juveniles, rounded in adults.

**BARE PARTS** Based on photos in Lindsey (1986), unless stated.

**ADULT, JUVENILE** Iris, dark brown (221). Bill, legs and feet, grey-black (82).

**DOWNY YOUNG** Eyes visible at 8 days; open at 10 days. Bare parts, initially dark flesh; egg-tooth, white, lost by 6 days. At 18 days, darkening of bare parts; almost black by 35 days (Beck & Brown 1971).

**MOULTS**

**ADULT POST-BREEDING** Presumably complete; occurs in Tropics (winter quarters) from about June onwards.



Two birds observed at sea over Britannia Seamount, off se. Qld, 2 Oct. 1985, in tail-moult; one with large gap in centre of tail, other with outermost rectrix on left side three-quarters grown; both in fresh plumage indicating completion of full moult (D.W. Eades). Sequence and duration unknown, presumably similar to White-faced Storm-Petrel (*q.v.*). At Signy I., breeding female moulting body feathers in Dec. De-feathering of brood patch occurs throughout Dec.; complete by end of Dec. Regrowth in successful breeders Mar.-Apr.; failed or non-breeders in mid-Feb. (Beck & Brown 1971).

POST-JUVENILE No data.

**MEASUREMENTS** (1) Signy I., S. Orkney Is, live; 'standard' methods (Beck & Brown 1971). (2) Bounty, Antipodes Is, skins; 'standard' methods (Beck & Brown 1971). (3) S. Shetland Is, skins; 'standard' methods (Beck & Brown 1971). (4) Skins (MNZ; MV). (5) Iles Crozet, live; methods as HANZAB (Jouventin *et al.* 1985). (6) Iles Kerguelen, live; methods unknown (Weimerskirch *et al.* 1989). (7) Antipodes Is (Murphy; Warham & Bell 1979).

	MALES	FEMALES
WING	(1) 162.3 (4.92; 154-170; 10) (2) 160.9 (4.42; 155-169; 16) (3) 166.4 (4.35; 160-173; 9) (4) 160.4 (4.75; 150.5-169; 19)	170.8 (5.47; 164-183; 16) * 160, 168 167.5 (3.0; 165-173; 6) 166.3 (3.61; 159-172; 15) *
8TH P TAIL	(1) 121.5 (4.01; 116-127; 14) (2) 77.6 (3.98; 73-83; 10) (3) 71.4 (2.11; 68-77; 16) (4) 74.4 (1.92; 72-78; 9) (5) 73.1 (3.94; 65-82; 19)	124.9 (3.35; 117-128; 12) * 79.4 (3.48; 71-84; 16) 70, 74 77.0 (3.08; 73-82; 6) 77.3 (4.04; 69-82; 15) *
BILL	(1) 15.3 (0.48; 15-16; 10) (2) 14.4 (0.50; 13.5-15.5; 16) (3) 15.3 (0.56; 14.5-16.0; 9) (4) 14.5 (0.48; 13.7-15.5; 19)	15.1 (0.68; 14-16; 16) 15.5, 14.0 15.1 (0.57; 14.5-16.0; 6) 14.9 (0.61; 14-16.3; 16) *
TARSUS	(1) 39.6 (0.84; 39-41; 10) (2) 39.5 (1.10; 37.5-40.5; 16) (3) 39.6 (0.73; 38.5-40.5; 9) (4) 40.7 (1.75; 37.6-44; 19)	40.8 (1.17; 39-43; 16) * 40, 41.5 39.2 (0.68; 38.5-40.5; 6) 42.3 (1.38; 40.1-44.4; 15) *
TOE	(1) 29.2 (1.14; 27-31; 10) (2) 28.8 (0.92; 27-30; 16) (3) 29.5 (0.99; 28.5-31.0; 9) (4) 27.2 (1.10; 25.3-29.5; 18)	29.3 (1.39; 27-31; 16) 29.5, 29.0 29.1 (0.79; 28.5-29.5; 6) 28.2 (1.17; 25.7-30; 15) *
UNSEXED		
WING	(5) 163.0 (5; 155-175; 54) (6) 171.4 (6.9; 162-190; 13) (7) 162 (154-169; 36)	
TAIL	(7) 74.5 (72-78; 36)	
BILL	(5) 15.4 (0.6; 14.2-17; 54) (6) 15.8 (1.2; 14.6-17.3; 13) (7) 15.1 (14.0-15.8; 36)	
TARSUS	(5) 40.9 (1.4; 38.2-44.5; 54) (6) 42.5 (1.8; 38.4-45.5; 13) (7) 41.5 (40-44; 36)	
TOE	(7) 29.0 (28-31; 36)	

For additional measurements see Murphy & Snyder (1952). Oliver (methods unknown) gives measurements of skins from Antipodes Is: bill 14-15, wing 160-170, tail 70-77, tarsus 38-42 and toe 28-29. Females larger than males in wing-length and tail-length (Murphy & Snyder 1952; Beck & Brown 1971). For details of growth rates of chicks see Beck & Brown (1971) and Jouventin *et al.* (1985).

**WEIGHTS** (1) Signy I., live birds (Beck & Brown 1971). (2) NZ, Auckland and Antipodes Is, skins (NMNZ; MV). (3) Iles Kerguelen, live birds (Weimerskirch *et al.* 1989). (4) Iles Crozet, live birds (Jouventin *et al.* 1985). (5) Antipodes Is (M.J. Imber). (6) Antipodes I., (Murphy; Warham & Bell 1979).

	MALES	FEMALES
(1)	56.0 (5.41; 49-63; 10)	56.5 (3.59; 48-61; 15)
(2)	51.7 (2.67; 46.3-57; 15)	54.2 (5.38; 43-63; 15)
UNSEXED		
(3)	54.4 (6.1; 46-63; 15)	
(4)	52.0 (3; 43-59; 38)	
(5)	53.9 (50-58.9; 10)	
(6)	53.9 (50-58.9; 10)	

Loss of weight occurs during incubation shifts of adults; mean loss 2.5 g/24 h; 16% of body weight lost during 96 h, 20% maximum for 120 h (Beck & Brown 1971). At fledging, weight c. 110 g. For details of changes of weight in chicks see Beck & Brown (1971). Evidence of torpidity period in chicks (Beck & Brown 1971).

**STRUCTURE** Wing, short and narrow. Eleven primaries: p9 longest, p10 8-11 mm shorter, p8 1-3, p7 11-16, p6 22-27, p5 33-39, p4 46-52, p3 58-65, p2 70-76, p1 81-86, p11 minute. No emarginations. Primaries pointed in juveniles, rounded in adults. Twelve secondaries, three of tertial form. Tail, square; 12 rectrices, t1 longest, t6 0-2 mm shorter. Bill, short and narrow. Nasal tube free at proximal end and upturned, c. 50% length of bill. Brood patch in both sexes (Beck & Brown 1971; Imber 1983). Legs and feet, thin and rather long, toes joined by webs. Claws, flattened; sharp in fresh plumage, blunt when worn. Outer toe slightly longer than middle, inner c. 96%, hind reduced, claw only. For further details on structure, see Mathews 1933a,b).

**SEXING, AGEING** Adults sexed on cloaca (Serventy 1956; Beck & Brown 1971). During breeding, females identifiable by thicker and bulbous cloacal lips (Beck & Brown 1971). Adults distinguished on measurements (see above). Juveniles have pointed primaries, rounded in adults.

**RECOGNITION** Confusion likely between White-bellied Storm-Petrel *F. grallaria* and white-bellied forms of Black-bellied Storm-Petrels *F. tropica*. Characters that distinguish Black-bellied are (1) feathers of chin and throat with concealed white bases (*F. grallaria* lacks white bases); (2) feet extend c. 1 cm beyond tip of tail (do not extend beyond tail in *F. grallaria*); (3) tarsi holothecal (scutellated in *F. grallaria*); (4) little white fringing on upperparts (Murphy & Snyder 1952) (marked white fringes to feathers of upperparts when plumage fresh in *F. grallaria*); (5) bill, tarsus and toes longer than in *F. grallaria*; (6) mid-toe and claw longer than outer toes, which are subequal (in *F. grallaria*, all toes sub-equal; Oliver; but see Structure). These characters examined for nominate *F.t. tropica* and nominate *F.g. grallaria* and *F.g. segethi*; no specimens of *F.t. melanoleuca* or *F.g. titan* or *leucogaster* were examined and thus these characters need to be evaluated for all subspecies of *F. grallaria* and *F. tropica* (e.g. Clancey [1981] questions



value of white bases of feathers of chin and throat for identification).

**GEOGRAPHICAL VARIATION** Appearance of underparts of Black-bellied Storm-Petrel varies markedly (see Plumages). Two subspecies have been recognized: *tropica* and *melanoleuca*, the latter has a white belly and is restricted to Gough I. (Peters). However, status of *Fregetta* storm-petrels from Gough I. (and possibly Tristan da Cunha) uncertain, and populations need to be critically examined to determine the status and validity of *melanoleuca*.

Original description of *Fregetta melanoleuca* ('a new species of petrel'; Salvadori 1908) from Tristan da Cunha states: much larger (than *F. grallaria*), upperparts uniform brownish-black, no white margins to feathers of back and with concealed white bases to feathers of chin and throat. Salvadori did not consider *melanoleuca* a subspecies of *F. tropica* though Peters did, presumably on basis of characters listed by Salvadori (see Recognition). However, White-bellied Storm-Petrels *F.g. leucogaster* (q.v.) also said to breed Tristan da Cunha and Gough.

Confusion over status of *melanoleuca* obvious in literature: has been considered subspecies of White-bellied Storm-Petrel (e.g. Bourne 1960; Swales 1965); others consider only White-bellied Storm-Petrels occur Tristan da Cunha and Gough (e.g. Imber 1983; Fraser *et al.* 1988); Peters considers both White-bellied (*F.g. leucogaster*) and Black-bellied (*F.t. melanoleuca*) occur there (Clancey 1981; Imber 1983).

Some clinal variation in size from S. Shetland Is to NZ area, in accord with Bergmann's Rule; see Beck & Brown (1971) for details.

RMO

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Volume 1 (Part A), 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

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