

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 PROCELLARIIDAE fulmars, petrels, prions, shearwaters

The family Procellariidae represents the main radiation of medium-sized 'true petrels', characterized by having united nostrils with a median septum and the outer functional primary at least as long as the next. It tends to be dominant among the birds of the Southern Ocean, though in the n. hemisphere the Charadriiformes are more numerous. The giant-petrels *Macronectes* have also developed as large scavengers and predators, showing some convergence in appearance and behaviour with the Diomedidae. The Procellariidae may be divided into four main groups with some intermediate species, which makes it hard to draw distinctions between them.

(1) The fulmars *Macronectes*, *Fulmarus*, *Thalassoica*, *Daption* and *Pagodroma* consist of seven species of surface predators and filter-feeders of rather varying structure and appearance (Voous 1949) that breed in high latitudes but may migrate along cool currents into much lower ones. *Fulmarus* appears to have colonized the n. hemisphere in the Tertiary. Six of the seven species are essentially confined to our region.

(2) The gadfly-petrels *Pterodroma* are a large series of some 30 agile species; 16 breed in our region and another six occur rarely or rather rarely. Their short sturdy bills are adapted for seizing soft prey at the surface, and their twisted intestines, for digesting marine animals with an unusual biochemistry, which are also found throughout the warmer oceans (Imber 1985). They show complex markings of face and wings that must serve as interspecific recognition-marks (Murphy & Pennoyer 1952). Some species placed in this group have an intermediate structure and intergrade with all other groups distinguished here: *Pterodroma (Lugensa) brevirostris*, which moves S in winter, has distinctly big eyes like *Pagodroma*; *Halobaena caerulea* has a plumage similar to that of prions; *Bulweria* has some structural resemblance to shearwaters. At present it is difficult to determine their precise relationships.

(3) The prions *Pachyptila* are a specialized group of six (perhaps five) very numerous species, all in our region, that show a progressive adaptation of a small, agile, cryptically coloured, fulmarine form for filter-feeding on zooplankton. There has been dispute over their classification (Cox 1980; Harper 1980) but the arrangement discussed by Fleming (1941) seems best except that the Broad-billed Prion *P. vittata* appears to intergrade with Salvin's Prion *P. salvini* through *macgillivrayi* of Ile St Paul; so they may be better treated as subspecies of the same species.

(4) The shearwaters *Procellaria*, *Calonectris* and *Puffinus* include some 20 agile species with long bills adapted to catch prey more or less under water throughout the warmer seas (Kuroda 1954); 13 species breed in our region, some migrating into the n. hemisphere; six others are chance or perhaps regular visitors. From the fossil record (Brodkorb 1963; Olson 1975); they seem to have been particularly common in the great Tethys Ocean of the middle latitudes of the n. hemisphere in the Tertiary, so this development of aquatic habits may have occurred there without competition from penguins with a subsequent return S by the more successful forms.

General features of the family are: body, ovate, or elongate in shearwaters; wings, long and narrow, 11 primaries, p10 longest, p11 minute; 20-29 secondaries, short, diastataxic; tail, short, 12 feathers; bill, heavy (*Macronectes*), slender (shearwaters), broad (prions) or stubby (gadfly-petrels), hooked, formed of several horny plates; nostrils in dorsal tube of varying length; legs set far back, laterally flattened but round in gadfly-petrels; three toes, webbed, hind toe vestigial, raised. Oil-gland feathered. Peculiar musky odour. Sexes similar, male usually larger than female. Plumage, black or grey above, white below, or all dark; light and dark morphs in some species. Juveniles and immatures usually like adults.

Cosmopolitan throughout the oceans, essentially pelagic; more abundant in cool or cold waters rich in plankton and mostly away from ice. Swim well but usually aerial except when feeding or resting. Fly with alternate swooping and flapping action close to the surface but often arcing high in some gadfly-petrels. Gait on land, a shuffling crouch, being unable to walk properly with feet set so far back; generally avoid open areas on land, being thus vulnerable to predators. Nest colonially; for the most part in burrows and cavities in all sorts of terrain, sometimes far from the sea and in mountainous areas but some species, e.g. *Macronectes*, nest on open ground. Hole-nesters usually nocturnal at colonies, when often extremely vocal, though generally silent at sea. Migratory and dispersive. Some species divide the year between s. and n. hemisphere, often migrating in large flocks that may settle on the sea in huge dense rafts. Feed mostly on fish, cephalopods and crustaceans obtained by flight-feeding, plunge-diving, surface feeding, surface-diving and underwater pursuit; hydroplaning (Murphy) is a characteristic method used particularly by prions.

Probably all defend small nesting territories to which they return regularly while undisturbed; certainly so in some hole- and burrow-nesting forms. Agonistic and sexual behaviour of nocturnal, hole-nesting species very poorly known but generally seem to have little specialization for visual displays. Tactile actions such as allopreening and billing used but olfactory and vocal communication is probably important. Breeding is usually seasonal, generally with synchronized laying, often after a pre-laying exodus but some may not nest annually; some have shorter

cycles or nest continually. For the most part, little attempt to make substantial nests. Eggs, ovate, mat, white. Clutch-size, invariably one; single-brooded; no replacement laying. Incubation by both sexes in alternate spells of 1-11 days. Single median brood-patch. Incubation period, 45-55 days. Eggshells probably always trampled in nest. Young, semi-altricial, nidicolous; hatched in down. Rarely left alone in nest for first 1-2 weeks. Cared for and fed by incomplete regurgitation by both parents. Nestling period generally shorter in cliff- and ledge-nesting species than in hole-nesters. Young attain greatest weight, often well above that of adult, some days before fledging, by which time weight has been reduced to about the same as an adult, but no clear evidence that young are totally deserted for last few days in nest. Adults and young of most species liable to eject stomach-oil in defence. Young independent at fledging. Maturity reached at minimum of 3-4 years, in some 6-12 years.

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Fulmarus glacialoides Southern Fulmar

COLOUR PLATE FACING PAGE 400

Procellaria glacialoides Smith, 1840, *Illus. Zool. S. Afr. Aves* 2: Pl. 51 — seas off Cape of Good Hope.

Generic name is Latinized version of two Gaelic or Hebridean words: *full* (foul) and *mar* (a gull). Specific name *glacialoides* means like *glacialis* (icy, frozen) and refers to similarity of this species to Northern Fulmar *F. glacialis*.

OTHER ENGLISH NAMES Antarctic or Slender-billed Fulmar, Silver-grey Petrel.

Epithet **Southern** preferred because it provides better contrast with Northern Fulmar (*pace* Fisher 1952) than does **Antarctic**, *glacialis* not being truly Arctic species. British literature now proposes Northern Fulmar for *glacialis*. **Petrel** inappropriate and not informative for species of fulmars.

MONOTYPIC

FIELD IDENTIFICATION Length 45–50 cm; wingspan 115–120 cm; weight 700–1000 g. Medium large, strong-billed, bull-headed, robust, grey-and-white petrel with gull-like plumage-pattern unlike that of shearwaters; proportions and flight more like a diminutive albatross *Diomedea* spp. One of the most common birds of circumpolar pack-ice; in winter, range far N, even to tropics along w. coast of South America. Sexes similar. No seasonal variation in plumage. Juvenile inseparable.

DESCRIPTION ADULT. Head and underparts, white. Mantle, rump and upper-tail, light grey. Primaries mostly white with blackish tips forming dark trailing-edge,

continuing along tips of secondaries. Primary coverts and alula, fairly dark grey, contrasting with white or whitish bases of primaries, which thus form conspicuous and characteristic rectangular patch on upperwing with black-and-white 'fingers'. Some individuals show more black than usual on coverts and primaries. Bill, mainly pink with dark tip; feet, pinkish.

SIMILAR SPECIES Generally unmistakable in s. oceans, where most other birds black or brown. Distinguished from **White-headed Petrel** *Pterodroma lessonii* by pale bill, dark trailing-edges to pale upperwings, white underwings and stiff straight-set wing-beats; from **Grey Petrel** *Pro-*

cellaria cinerea by white head and underparts, patterned upperwings and steady graceful flight. In poor light paleness can resemble **Snow Petrel** *Pagodroma nivea* but patterned upperwings conspicuous, even at great distance.

Essentially gregarious. Patrol breeding sites in effortless gliding flights. Settle on sea and swim well and can take off from water without wind. On land, extremely ungainly, weakest of all the fulmarine petrels on its feet; squat on tarsi and rarely attempt to walk but when very excited may shuffle short distances using wings for support, in quadrupedal fashion. When landing, sideslip and flop down in 'pancake' landing rather than on its feet. When taking off, tumble into air off steep terrain. Glide on straight flat wings for long periods, interspersed with bursts of fast wing-beats. Soar with slight rocking of wings; at times flight erratic and twisting. Manoeuvre well, even in calm air. Feed while swimming and from surface in flight; by surface-seizing and surface-plunging. Follow ships, but less persistently than Cape Petrel *Daption capense*. Gather round fishing or whaling vessels and take off. Often feed nocturnally.

HABITAT Circumpolar in Antarctic and subantarctic waters, in open water and pack-ice. Summer range includes pack-ice and nearby open waters (Falla 1937; Johnstone & Kerry 1976); in winter, pelagic in southern seas, reaching subtropical and occasionally tropical waters where N-flowing cold currents along continental coasts e.g. Humboldt Current (Murphy). In Ross Sea in summer, almost all observed over oceanic waters within few hundred kilometres of breeding sites; very few over continental shelf and slope. Prefer waters affected by pack-ice (surface-temperature -1.5°C to 0.5°C and salinity low, 33.8–34.0‰) (Ainley *et al.* 1984). Most abundant in waters near pack or within outer edge (Ainley *et al.* 1984; Montague 1988); uncommon in interior (Cline *et al.* 1969; Ainley *et al.* 1978; Zink 1981; Ainley *et al.* 1984). Suggestions that common throughout pack-ice (Murphy; Johnstone & Kerry 1976) may refer to outer edge or birds crossing ice to

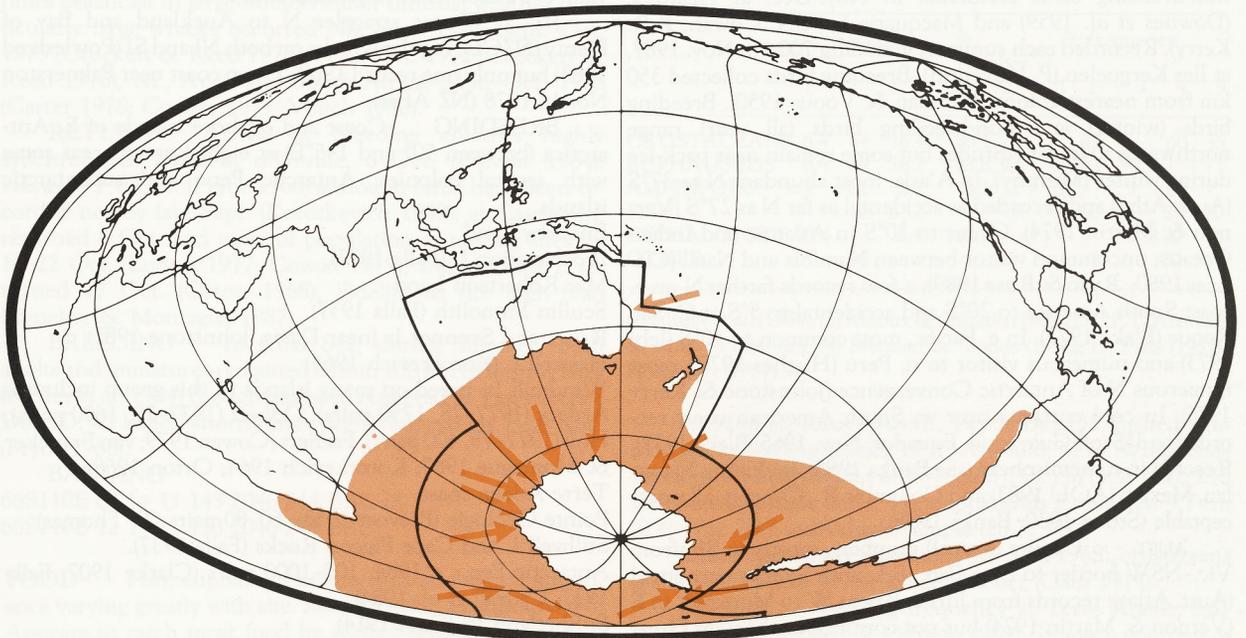
feeding grounds (Ainley *et al.* 1984). Within edge of pack, prefer loose pack and open water, avoid heavy pack; most numerous in 12–25% ice-cover (Ross I. to Anvers I.; Zink 1981); 0–25% (Prydz Bay; Montague 1988). Most observations over centres of leads. In open water N of pack, associated with iceberg-belt (Ainley *et al.* 1984). In winter range in low latitudes, pelagic; occasional influxes into inshore and shelf waters in s. Aust. and NZ (Carter 1978) and bays of Heard I. (Downes *et al.* 1959). In S. America, thought to concentrate over upwellings of cold water near continental shores, and common in inshore waters in harbours, channels, bays, fiords (Murphy).

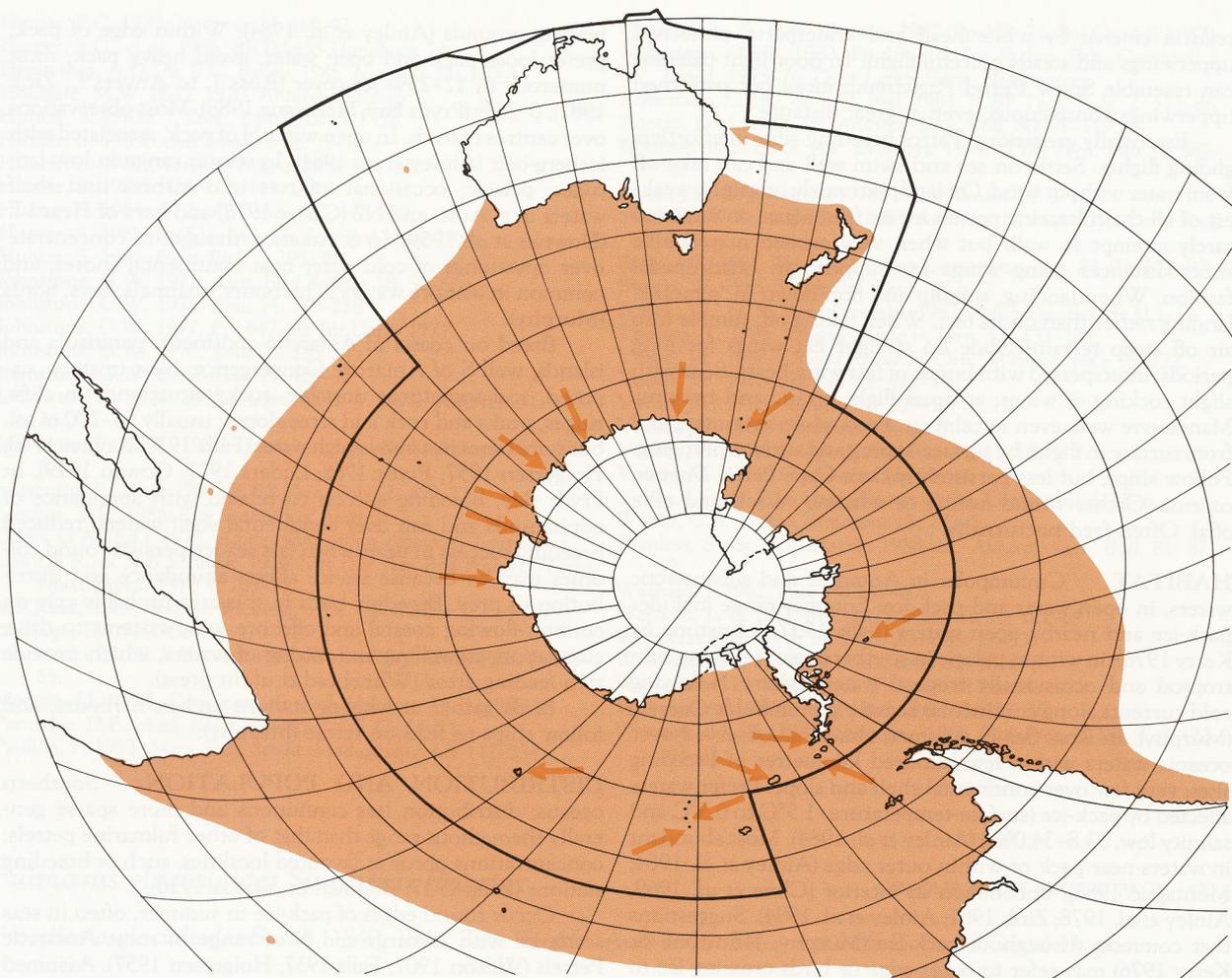
Breed on coasts of Antarctic continent, peninsula and islands, well S of Antarctic Convergence. Nest in steep, exposed, and sometimes unstable, rocky situations; on cliffs, ridges, peaks and rock and scree slopes; usually 65–200 m asl, but sometimes just above high water (Falla 1937; Rayner 1940; Holgersen 1957; Pryor 1968; Luders 1977; Cowan 1979). In Prydz Bay, breeding success correlated with abundance of euphausiids and fish over continental shelf waters; reduced breeding success in years when fast sea-ice persists round colonies may be because sea-ice affects abundance and distribution of prey. Breeding birds in this area probably rely on counter-flowing coastal and offshore wind-systems to drive circulation, upwelling and mixing of waters, which provide rich feeding areas (Whitehead *et al.* in press).

Birds gather at whaling stations and in harbours, and follow ships to feed on refuse (Murphy).

DISTRIBUTION AND POPULATION Southern oceans; distribution less continuous and more sparse generally throughout range than that of other fulmarine petrels; concentrations occur at favoured localities, such as breeding stations (Falla 1937; Bierman & Voous 1950).

Occur round edges of pack-ice in summer, often in seas scattered with icebergs and N of range of most Antarctic Petrels (Wilson 1907; Falla 1937; Holgersen 1957). Assumed





non-breeding birds accidental in Nov.-Dec. at Heard I. (Downes *et al.* 1959) and Macquarie I. (A.N. Cowan; K.R. Kerry). Recorded each summer, including 700+ in Nov. 1987, at Iles Kerguelen (P. Jouventin). Breeding birds collected 350 km from nearest colony (Bierman & Voous 1950). Breeding birds (winter) and non-breeding birds (all year) range northwards to lower latitudes but some remain near pack-ice during winter (Murphy). In A'asia, most abundant N to 37°S (Aust. Atlas) and recorded as accidental as far N as 27°S (Vernon & Martin 1974). Occur to 30°S in Atlantic and Indian Oceans; uncommon visitor between Namibia and Natal (Clancey 1980; Ryan & Rose 1989); a few records farther N on e. coast South America to 20°S and accidental to 5°S at C. Sao Roque (Blake 1977). In e. Pacific, most common to 40°S (Jehl 1973) and numerous visitor to n. Peru (Hughes 1970); most numerous N of Antarctic Convergence (Johnstone & Kerry 1976). In cool currents near w. South American coast recorded to 3°S (off Guayaquil, Ecuador, Nov. 1965; Blake 1977). Records in n. hemisphere (see Banks 1988), including Mazatlan, Mexico (AOU 1983) and Columbia R., Oregon, all unacceptable (Stone 1930; Banks 1988).

AUST. Occurs in small numbers, mostly in SE, from Vic.-NSW border to Eyre Pen., SA, with wrecks occasional (Aust. Atlas); records from Jurien Bay in W to Morton I. in E (Vernon & Martin 1974) but not continuous through Great Aust. Bight (Aust. Atlas). Single beachcast, Eyre Bird Obser-

vatory, 24 Oct. 1984 (Dymond 1988).

NZ Winter straggler N to Auckland and Bay of Plenty (NZCL); regular wrecks on both NI and SI (Powlesland 1983) but only one record 1969-79, on coast near Palmerston North, 1978 (NZ Atlas).

BREEDING Coast and offshore islands of E. Antarctica (between 50° and 145°E) at eight known areas some with several colonies; Antarctic Pen., and subantarctic islands.

Enderby Land

Proclamation I. (Falla 1937),

Mac.Robertson Land

Scullin Monolith (Falla 1937)

Rauer and Svenner Is (near Davis; Johnstone 1982)

Haswell I. (Korotkevich 1964)

Windmill Is: breed on many islands in this group including Ardery (1977-78, 1750 pairs), Odbert (1977-78, 1600 pairs), Holl (1977-78, 400 pairs), Fraziers (Cowan 1979; van Franeker & Montague 1987; Korotkevich 1964; Orton 1968)

Terre Adélie coast

Pointe Géologie (Prévoist 1953); 60-80 pairs (T. Thomas)

Stillwell I. and Cape Pigeon Rocks (Falla 1937).

Antarctic Pen.: <1984: 100-1000 pairs (Clarke 1907; Falla 1937; Croxall *et al.* 1984)

S. Shetland Is: (Gain 1914)

Elephant I. <1984: 71 000 pairs (Croxall *et al.* 1984)

Bouvetoya (Bierman & Voous 1950; Holgersen 1947; Solyanik 1964)

Balleny Is (Dawson *et al.* 1965)

Peter Ist I. (Holgersen 1951, 1957)

S. Orkney Is: <1984: 100 000- 1 000 000 pairs (Croxall *et al.* 1984; Clarke 1906)

S. Sandwich Is: <1984: 1 000 000 pairs (Croxall *et al.* 1984; Kemp & Nelson 1931; Wilkinson 1956, 1957; Watson *et al.* 1971).

Reported breeding at Vestfold Hills (Korotkevich 1964) incorrect (Johnstone *et al.* 1973).

Status, satisfactory; only long-term threat appears to be competition with commercial fishing operations.

MOVEMENTS Migratory, most birds wintering N of Antarctic Convergence.

DEPARTURE Adults leave Haswell I., first week in Apr. (Nudelman 1962; Pryor 1968), Terre Adélie, 15 Apr.-10 May (Prévost 1964; Mougin 1968), chicks having fledged Haswell I. early Mar. (Nudelman 1962; Pryor 1968), Terre Adélie, Mar. 12-28 (Prévost 1964); still abundant near Bouvetoya 12 Apr. (Bierman & Voous 1950). Non-breeders leave Terre Adélie, late Dec. (Prévost 1964), some still remain S. Shetland Is, 28 Jan. (Furse 1976).

NON-BREEDING During autumn, when pack-ice begins to surround entire breeding area, birds disperse N. Northward migration of thousands observed Palmer Stn, late Apr.-early May, with few birds present at other times of year (Parmelee *et al.* 1977); does not visit Antarctic coast during winter (Mougin 1967). Most birds follow cold currents N (Watson 1975), crossing Antarctic Convergence. However, rarely recorded N of 40°S (Szijj 1967; Watson *et al.* 1971; Jehl 1973) except along w. coast of South America (Szijj 1967) where some may cross Equator (Blake 1977). Infrequent visitor to South Africa (Cooper 1979), NZ (Veitch 1980) and Aust. (Aust. Atlas), records peaking during Sept., although frequency may be increasing (Cox 1976). Most visiting South African waters probably immatures (Cooper 1979). Sometimes beachcast in large numbers after unusual weather. Particularly large wrecks occurred NZ, Sept. 1973, Sept.-Oct. 1975 (Crockett & Reed 1976), Peru, Oct. 1972 (Crockett & Reed 1976), NZ, Aust. and South Africa, Sept.-Oct. 1978 (Carter 1978; Cooper 1979; Veitch 1980).

RETURN Arrival at breeding colonies highly synchronized: Dumont d'Urville, 6 Oct. (Prévost 1964); Haswell, 7-8 Oct. (Pryor 1968) although birds have been recorded nearby late Sept. (Korotkevich 1959); at Casey Stn, returned 8 Oct. and most of population at nesting sites by 11-22 Oct. (Luders 1977; Cowan 1979); and at Lewis I. returned 17 Oct. (Orton 1968). Fidelity to site high (van Franeker & Montague 1987).

BREEDING In Ross Sea, during summer, both adults and immatures remained within 100 km of nesting sites (Ainley *et al.* 1984) though has been observed in Tas. waters 2 Dec. (D.W. Eades) shortly after pre-laying exodus 7-28 Nov. (Pryor 1968).

BANDING

66S110E 02 1+ U 143 2046 244 BBL x3

66S110E 12 1+ U 133 2046 244 BBL

FOOD Fish, euphausiid crustaceans and squid, importance varying greatly with site. **BEHAVIOUR.** Descriptions few. Appears to catch most food by surface-seizing, occasionally surface-diving (Harper *et al.* 1985). All birds seen feeding Ross

Sea were taking food while swimming on surface (6; Ainley *et al.* 1984) as were a flock of thousands observed off South America (Jehl 1973). Gregarious when feeding (Watson 1975). At Terre Adélie, feed out at sea, flying at high altitude to and from nesting sites, and have never been observed foraging along coastlines (Jouventin & Robin 1984). Near Antarctic Pen., congregate with other seabirds over schools of euphausiids (Obst 1985) but not at carrion. At least when feeding young, appear to feed at night (Furse 1976).

NON-BREEDING Summarized Table 1. In **South Atlantic** (ten stomachs; Bierman & Voous 1950) other food was gastropods 10, whale offal 10; near Antarctica, sample size 20 (Falla 1937; Holgersen 1957). **Other records:** cephalopods (Murphy) incl. *Spirula spirula* (Crockett & Reed 1976); crustaceans barnacles *Balanus* (Murphy), euphausiids (Linkowski & Rembiszewski 1978), hippas anomurans *Emerita analoga* (Murphy), *Pleuroncodes monodon* (Jehl 1973); fish vertebrae; feathers, entrails and trachea of cormorant (Murphy), prions *Pachyptila*, incl. Fairy Prion *P. turtur* (Crockett & Reed 1976); traces of seaweed (Murphy). There may be regional differences in diet, with more euphausiids being taken in Scotia Sea-Antarctic Pen. region than in other Antarctic regions (Obst 1985).

BREEDING Summarized Table 1. In **n. Ross Sea** (13 stomachs, incubating birds; Ainley *et al.* 1984) cephalopods were *Gonatus antarcticus* 4.7% no., 69% freq., 125 g (25; 22), 18.0 cm (2.5; 22), *Psychroteuthis glacialis* 5.6, 77, *Galiteuthis glacialis* 3.3, 62, 36 g (10; 13), 18.0 cm (3.0; 13); crustaceans euphausiids *Euphausia superba* 4.0 cm (0.4; 108), amphipods Lysianasidae.

At **Terre Adélie** (12 stomachs, birds feeding chicks; Ridoux & Offredo 1989) euphausiids were *Euphausia crystallophias* 2% wt., 10% no., 8% freq., 2.7 cm, *E. superba* 62, 82, 73, 3.5-5.2 cm, the amphipods Hyperiididae -, 3, 17 (*Themisto gaudichaudii* 1.4-1.5 cm), Gamaridae -, -, 8 (*Cylopus lucasii*), other food carrion.

Table 1. Diet of Southern Fulmar

	% weight			% number		% frequency				
	1	2	3	1	2	1	2	3	4	5
CRUSTACEANS	6.4	64	36.4	86.1	-	-	83	-	60	35
EUPHAUSIIDS	6.4	64	36.2	85.8	92	69	83	97	-	-
AMPHIPODS	<1	<1	0.2	0.3	3	10	-	9	60	-
FISH	-	16	63.2	-	5	-	58	100	20	10
CEPHALOPODS	93.6	-	0.4	13.6	-	-	-	9	100	75
OTHER	-	20	-	-	-	-	8	-	20	-

(1) Ainley *et al.* (1984); (2) Ridoux & Offredo (1989); (3) J.P.Y. Arnould & M.D. Whitehead; (4) Bierman & Voous (1950); (5) Falla (1937), Holgersen (1957).

At **Hop I., Rauer Arch., Prydz Bay** (35 flushed samples, adults feeding chicks; J.P.Y. Arnould; M.D. Whitehead) fish were *Pleuragramma antarcticum* 14.2 cm (3.3; 104) 3.18 individuals/sample (1.57; 34), euphausiids *E. superba* 4.7 cm (0.4; 176), 28.7 individuals/sample (20.7; 34).

Other records: cephalopods (Mougin 1968), crustaceans (Falla 1937; Furse 1976), whale blubber (Gain 1914).

INTAKE Feeding frequency at Terre Adélie, 0.61 meals/day (64; Ridoux & Offredo 1989). Stomach contents of adults while feeding chicks Prydz Bay 72.7 g (32.4; 35; J.P.Y.

Arnould; M.D. Whitehead), Terre Adélie 14.9 g (15.9; 46; Ridoux & Offredo 1989); incubating 70 g (Ross Sea; Ainley *et al.* 1984).

SOCIAL ORGANIZATION Information supplied by A.N. Cowan. Gregarious when feeding at sea and when breeding. In non-breeding season often singly or in shifting and changing flocks and dispersed congregations. Feeding flocks may number many hundreds according to occurrences of food, especially at whaling operations. When flocking at carcasses, much squabbling with conspecifics and birds of other species but structure of flocks by age, sex, spacing, ranking not known and probably impossible to determine.

BONDS Monogamous. Pair-bonds long-lasting; fidelity to nest-site strong: six of 15 banded birds still at same site, two of 14 still with same mate for seven breeding seasons. Changes usually caused by death, though divorces occur, often because male is absent for 1 or more years (Mougin 1975). Sex ratio, not known. Pairs form at 6 years old (Lacan *et al.* 1969; Mougin 1975). Both parents incubate and tend young until fledging (see Breeding).

BREEDING DISPERSION Colonial, from hundreds of nests together to small groups. Sometimes densely packed, often near or associated with colonies of Antarctic, Cape and Snow Petrels but segregated by use of different terrains and nest-sites (Pinder 1966; Watson 1975; Luders 1977; Cowan 1979; see Breeding). Nest-site territory only; consists of nest and area within pecking distance from nest; used for courtship, mating, nesting, feeding young, take-off and landing. Arriving birds crash-land awkwardly. Details of density of nests in colonies not reported.

ROOSTING At nest-sites early in breeding seasons; on snow-banks and on sea at other times; details not known.

SOCIAL BEHAVIOUR This account based on studies at Haswell I. (Pryor 1968); Terre Adélie (Prévost 1953, 1964; Mougin 1967, 1975); Windmill Is, Wilkes Land (Orton 1968; Luders 1977; Cowan 1979) and additional information in Murphy; information supplied by A.N. Cowan. When dispersed at sea or feeding in flocks on plankton zones, generally silent without communication or squabbling between individuals; in concentrations, as at whaling operations, aggressive and rapacious to conspecifics and other species, uttering harsh grunting sounds. Though at breeding colonies mostly during daylight and nesting in exposed sites (unlike many Antarctic and subantarctic procellariiforms), behaviour not well known. Sexes similar in plumage and behaviour, which makes interpretation of behaviour difficult. Ritualized displays apparently not well developed and calls not specialized, in contrast to nocturnal procellariiforms. Conspicuous flight- and site-advertising calls not recorded.

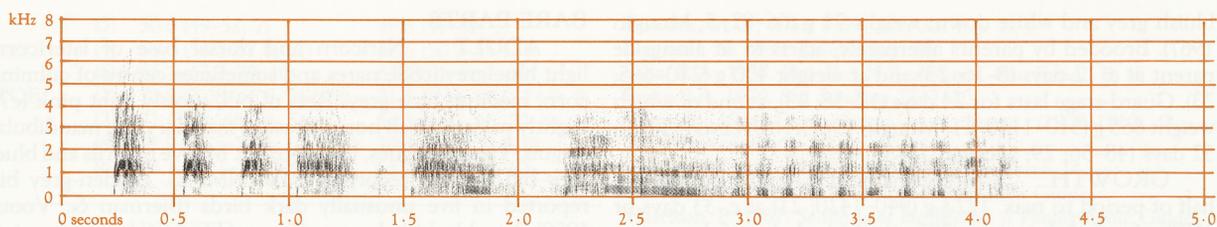
AGONISTIC BEHAVIOUR **AERIAL ACTIVITY.** Regularly fly round and round in front of nesting areas, silently, often using upcurrents, in prospecting flights, no doubt inspecting nest-sites, rivals, potential mates; stall and hover at possible sites with or without occupants, glide away; eventually may land and perform with occupant. Occupation of site usually uncontested at first; as colony fills, intruders, approaching occupied sites and displaying, provoke aggression by occupying male who attacks with bill; the two birds, bills locked, struggle till intruder leaves or both may roll to foot of cliff, locked together. Owner may face intruder with slightly spread wings and spit orange oil, clear at first but after

several ejections mixed with fragments of food. Generally spit less readily than Cape or Snow Petrels and bill often held open without spitting; both members of pair spit; rivals spit back. Spitting increases as season progresses, especially after laying. Generally unconcerned with observer. Early in season, close approach causes bird to leave; soon they sit tight, raise head, open bill, give raucous call; on closer approach, when bird cannot escape, it turns side-on, watches silently and, if handled, pecks. Generally said to be little aggression towards Antarctic Petrel but Orton (1968) reported that Southern Fulmars, arriving late, ousted Antarctic Petrels from nest-sites in fierce grapples, fluttering down to sea-ice with bills locked and wings thrashing. However, Pryor (1968) said that Antarctic Petrels, returning after exodus, quickly and efficiently routed any Southern Fulmars that had moved in during their absence.

SEXUAL BEHAVIOUR On arrival, pair-formation and courtship begins without delay; birds sit with folded wings, breast resting on ground and feet, head retracted, face to face or half-face, side by side or head to tail. Commonest displays are: **Fencing**. Only display for about 10 days after arrival; one bird moves head from side to side, touching bill of other bird alternately on either side; become agitated with rate of four strops/s and loud calls (Luders 1977). **Head-sweeping**. Starts after about 10 days; assumed male stretches neck forward with partly open bill, gives loud regular cackling call; other bird replies; head then swung laterally from side to side with feathers of head and neck raised; assumed female sits watching, sometimes opening bill or calling mutedly. Whole display becomes more intense and agitated as days pass with lateral sweeps of head through 120° at rate of one per second; displaying reduced during Nov. Performance interrupted while one bird flies over nest as other sits and displays (Luders 1977). Females also perform Head-sweeping. Other behaviours at sites between mates include **Allopreening** (Nibbling), **Bill-opening** with wide gape as head tilted back and **Copulation**. Apparent combination of **Head-sweeping** and **Bill-opening** described (Murphy). **COPULATION** starts with repeated abortive attempts. After vigorous fencing, male mounts using bill and wings for support; female stretches wings half-out and folds feet under body. Male fences while treading female for 30–90 s; both birds fan tails and move from side to side till female holds tail to left, male to right, both drop their wings and cloacal contact made. Event takes 2 min; accompanied by harsh cries from male. No post-copulatory display. Birds rarely together at site once incubation starts. Little ceremony at nest-relief.

RELATIONS WITHIN FAMILY GROUP No detailed knowledge. Chick brooded continuously and alternately by parents for c. 12 days and guarded continuously for another 12 days (see Breeding). Feeding methods as for Snow Petrel; chick rubs bill on adult's bill, then places bill inside adult's during regurgitation. Begging call of chicks: *che-che*, typical of fulmarine petrels. Eject oil at intruders when alarmed (P. Jouventin).

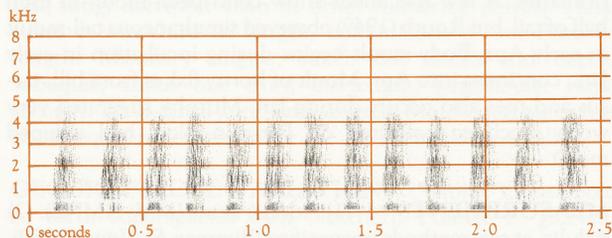
VOICE Not well studied. Calls consist of variations on simple repeated cackling or rattling call. Vocal at sea when quarrelling over food. Call often at breeding sites early in season but decrease later (Luders 1977). Calls used in pair-formation and maintenance. Use undescribed agonistic call before spitting oil (P. Jouventin). Male calls probably deeper and louder than those of female (Prévost 1953). Cackling (Dis-



A T. Howard; Rauer Is, E. Antarctica, Jan. 1988; X192

play) call similar to that of Cape Petrel (*P. Jouventin*). No information on geographical variation. NON-VOCAL SOUNDS include bill-clashing during fencing and bill-stropping during copulation.

ADULT Display Call. Described as maniacal (Cowan 1979), involving loud cackling, which ends with weakening guttural sounds (Prévost 1953); see sonagram A. Sitting side by side or face to face, one bird stretches neck and utters long penetrating expiratory call with bill scarcely open; call repeated, with same intensity, by partner; then move head alternately to right and left without definite rhythm, bill half-open and feathers somewhat raised, call changing to rolling chuckle; call ends with increasingly attenuated sounds made in throat with bill closed (Prévost 1953). Calls often given in rapid succession, five or six consecutively; sometimes chuckle while in sleeping position (Prévost 1953). **Recognition Display** accompanied by rapid calling, *kerk-kerk-kerk* at 5–6/s (Luders 1977); see sonagram B. Fencing and Head-sweeping



B T. Howard; Rauer Is, E. Antarctica, Jan. 1988; X192

accompanied by calls at rate of at least 6/s and sometimes as shrill rapid cackle; given by assumed male with female occasionally opening bill and responding with muted call (Luders 1977). Duetting often occurs during ecstatic displays. Copulation possibly occurs after climax of calling and followed by mild display and calling (Luders 1977). No calls given during bill-opening defence of nest (Luders 1977).

YOUNG Beg with typical fulmarine repeated *che-che* (*P. Jouventin*).

BREEDING Fairly well known; studied at Terre Adélie (Prévost 1953, 1958, 1964; Mougín 1967, 1975), Haswell I. (Pryor 1968), and Windmill Is, Wilkes Land (Luders 1977; Cowan 1979); additional information in Falla (1937). Information supplied by A.N. Cowan. Breed in simple pairs, colonially, often in company of Snow, Antarctic and Cape Petrels.

SEASON Pairs arrive separately but often on same day or up to 3 days apart during Oct. Occupation of sites varies according to weather; after first arrival birds present on 40% of days till end Oct., more often in pairs than singly (3:2); mean length of attendance at this time 2.5 days; daily occu-

pation of sites from nil to 81%; during blizzards birds go to sea (Mougín 1967). Copulation starts about 25 Oct., peaks first week Nov. **PRE-LAYING EXODUS:** 60% of birds absent on 7 Nov., 90% on 8 Nov.; 40% had returned by 15 Nov., all by 28 Nov.; some single birds defending nests in last 2 weeks (15–28 Nov.) (Pryor 1968). Laying during first 2 weeks of Dec., hatching last half of Jan., departure about mid-Mar. to Apr. Little geographical variation.



SITE Generally on steep slopes, cliffs and steeper terrain than other fulmarine petrels; often on unstable scree or loose ground; exceptionally on level rocks; often on ledge or corner with vertical wall behind, sometimes open on all sides or in semi-hidden chamber. Always with free drop in front, allowing easy access and take-off; mostly 65–200 m asl. Density of nests in colonies not reported. Generally protected from wind and often facing north, so that snow not blown away but melts; but exposure of site to wind recorded by Luders (1977). On arrival, sites often snow-covered; bill used to remove snow in pronounced ritualized manner.

NEST, MATERIALS Simple scrape on flat rock or gravel; usually lined with stones or gravel. Debris (feathers, etc.) in some nests probably deposited by melt-water, characteristic of steep slopes. Stones, gravel near nest picked up over the shoulder, apparently in ritualistic manner, and may be cast away. Role of sexes in this not recorded.

EGGS Ovoid; granular surface, not glossy; white.

MEASUREMENTS:

Haswell I.: 76 (72–80; 10) x 50 (48–52) (Pryor 1968)

Dumont d'Urville: 75 (71–79; 17) x 50 (42–54) (Mougín 1967);

76 (72–80; 12) x 51 (49–53) (Falla 1937).

WEIGHTS: 103 (81–123; 17; Mougín 1967).

CLUTCH-SIZE One. Single brooded. No replacement laying.

LAYING Highly synchronized; starts in first week Dec., completed in 2 weeks.

INCUBATION By both sexes in alternate shifts. Female leaves within a day of laying, male taking first shift of av. 6 days (4–9). Shifts shorter as hatching approaches; males 4 days (3–6; 13); females, 3 days (3–4; 13). Total number of shifts during period, 7–15 (Mougín 1967, 1975). **INCUBATION PERIOD:** average 45 days (43–50) but only 40 days reported between first egg and first chick found (Prévost 1964).

YOUNG Semi-altricial, nidicolous. Hatched with

bluish grey and white down; weight 71 g (66–82; 5; Mougin 1967). Brooded by parents alternately; starts to sit alongside parent at c. 12 days (8–16; 23) and at weight 430 g (210–685; 23). Guard-stage lasts for 24 days (17–38; 23), at end of which weight 865 g (510–1150; 11; Mougin 1967). **NESTLING PERIOD:** 52 days (48–56; 29; Mougin 1975).

GROWTH Chick gains weight rapidly during first half of period to max. 1223 g (940–1420; 21) at c. 33 days or 158% of av. adult weight (775 g); within 1 day of departure, weight 869 g (745–1045; 19) (Mougin 1967; Prévost 1964). Body, bill, legs grow rapidly in first half of period, then more slowly to near adult dimensions at departure; wings, tail grow slowly at first, then rapidly and again slowly and still growing at departure. Measurements at departure (% of adult): wing 290 (72%), tail 115 (92%), culmen 43.8 (98%), tarsus 54.1 (104%), toe 73.1 (104%) (n=7; Mougin 1967, 1975). Primaries appear at 12 days, burst sheaths at 18 days; plumage complete c. 2 days before departure. Chicks stay in nest till they leave but stretch and exercise wings from 3 weeks old. Not abandoned in nest before departure. Eject oil at intruders when alarmed. Independent after departure.

SUCCESS At Dumont d'Urville (Mougin 1975), eggs lost by desertion, rolling off nest, freezing, snowing up, inundation by melt water; most early in incubation (8/14 eggs lost during first 10 days). Chicks lost by cold, starvation, landslides, falling out of nest; mostly during guard-stage (6/11 chicks lost during first 10 days). In four seasons 29% (23–45) eggs lost; 18% (0–29) chicks lost; total loss 42% (24–61). Losses highest among inexperienced birds. Skuas probably take only abandoned eggs and some weak chicks.

PLUMAGES

ADULT Basic. **HEAD AND NECK.** Forehead, white, merging to pale-grey (86) nape and hindneck. Ear-coverts and sides of neck, grey white. Lores, chin and throat, white. Small patch of bristle-like blackish (82) feathers in front of and above eye. **UPPERPARTS.** Mantle, back, rump and scapulars, light grey (85). Upper tail-coverts pale grey (86). All upperpart feathers have blackish (82) shafts. **TAIL,** pale grey (86); rachis white. **UPPERWING.** Marginal, median and lesser coverts, light grey (85). Inner web of secondary coverts, pale grey (86); outer web, blackish (82) in outer feathers merging to light grey in inner feathers. Most primary coverts, light grey (85) with dark-grey (83) outer web, but innermost, pale grey (86) with glaucous (80) outer web. Alula, dark grey (83) to blackish (82). Secondaries, dark grey (83) to blackish (82); distal third of inner webs, light grey (85); most of inner web, concealed and white. Inner primaries, white, including rachis, with pale-grey (86) outer webs and blackish tips. Tips more extensive outwards, especially on outer webs; outer primaries, blackish (82), including rachis, with white basal half to inner web. Dark wing-tips considerably larger in some individuals (Harrison 1985, 1987). This variation perhaps caused by bleaching of old feathers (Routh 1949). **UNDERPARTS,** white; sometimes pale-grey wash across upper breast caused by narrow pale-grey tips. **TAIL,** grey-white; rachis white. **UNDERWING.** Axillaries and under wing-coverts, white; outermost median and lesser primary under wing-coverts have grey tips. Remiges as upper-wing, but rachis of outer primaries white.

DOWNY YOUNG Protoptile, mostly white with blue-grey wash on back. Mesoptile, light (85) to pale-grey (86) upperparts and hindneck fade to white forehead, forecrown and underparts. Flanks and thighs, pale grey (86).

JUVENILE. As adult.

BARE PARTS

ADULT Naricorn and dorsal base of latericorn, light blue-grey (c88); nares and sometimes centre of culmicorn, medium blue-grey. Rest of bill, mostly light pink (c7); slightly paler pinkish horn at base of maxillary and mandibular unguis. Tips to unguis, blackish (82). Mauve nostrils and blue-grey bill tip also recorded (MV; NMNZ). Leaden-grey bill reported in five unusually dark birds (Bierman & Voous 1950). Iris, blackish brown. Tarsus, blue-grey outside, pink inside. Outer toe and web, and outside of middle toe, blue-grey; rosy also reported (Bierman & Voous 1950). Inner toe and web, and inside of middle toe, pink. Sometimes tarsus entirely bluish grey; tarsus and outer toe often have irregular dark markings. Claws blackish (82); one bird with pinkish claws also reported.

DOWNY YOUNG No information in protoptile. In mesoptile, bill similar to adult, but mandibular unguis, blackish (82) with pale-pink (c7) patch in centre. Iris, hazel-brown. Feet, flesh-coloured.

JUVENILE Apparently as adults, despite suggestions that bill is darker.

MOULTS Based on Bierman & Voous (1950) and skins (NMNZ), except where stated.

ADULT POST-BREEDING Outwards primary moult from late Dec. to late Mar. or early Apr. Murphy found that moult continued through Apr. into early May in Magellanic Region. At least five inner primaries may be dropped at once. Secondaries moult with primaries. Tail-moult begins when primary moult nearly complete, completed shortly after primaries. A few specimens show centripetal moult in each half of tail, but Routh (1949) observed simultaneous tail-moult in early Apr. Body-moult begins during incubation in early Jan.; continues into Apr. Moult of horny flakes from bill, tarsus and toes also occurs during Jan. Murphy suggested very worn specimen collected off Peru in Nov. had skipped moult.

MEASUREMENTS (1) Adults, skins (MV, NMNZ). (2) Adults, at sea; methods unspecified (Bierman & Voous 1950). (3) At sea; ages and methods unspecified (Holgerson 1957). (4) Dumont d'Urville, adults, live; methods unspecified (Mougin 1967). (5) Dumont d'Urville, juveniles, live; methods unspecified (Mougin 1967). (6) S. Shetland Is and s. South America; methods unspecified (Murphy).

	MALES	FEMALES
WING	(1) 340 (8.4; 326–348; 8)	339 (3.7; 333–346; 8)
	(2) 339 (7.25; 331–348; 5)	325 (5.76; 315–332; 6)
	(3) 334 (321–347; 7)	328 (316–336; 5)
	(4) 345 (325–360; 12)	335 (325–350; 9)
	(6) 348 (330–351; 10)	332 (325–341; 10)
	8th P	(1) 206 (12.9; 190–226; 8)
TAIL	(1) 124 (7.0; 117–139; 8)	121 (4.6; 117–129; 8)
	(2) 132 (5.00; 127–137; 5)	124 (4.23; 41.5–47.0; 6)
	(3) 117 (111–121; 7)	114 (109–119; 5)
	(4) 130 (116–139; 12)	125 (115–131; 9)
BILL	(1) 44.6 (1.70; 42.0–47.4; 8)	43.9 (1.64; 41.1–46.0; 8)
	(2) 46.4 (0.57; 44.5–47.5; 5)	44.3 (1.86; 41.5–47; 6)
	(3) 44 (42–46; 6)	43.6 (41–46; 5)
	(4) 45.9 (44.2–47.9; 11)	42.5 (40.8–44.2; 9)
	(6) 44.2 (41.3–46.5; 10)	42 (39.3–44; 10)
	TARSUS	(1) 52.1 (1.05; 49.9–53.9; 8)
(2) 54.7 (2.02; 51.5–57; 5)		51.6 (1.51; 50–54; 6)

	(3)	50.6 (49-52; 7)	49.8 (47-52; 5)
	(4)	54.6 (52.2-57.8; 12)	52.6 (50.2-55.1; 9)
	(6)	66.1 (62.7-70; 10)	63.7 (61-66.7; 10)
TOE	(1)	70.8 (2.08; 66.8-74.6; 8)	71.5 (2.35; 68.0-74.9; 8)
	(2)	71 (3.08; 66-74; 5)	66.3 (1.97; 65-70; 6)
	(4)	72.9 (67.5-76.2; 12)	70.8 (66.9-77.8; 9)
	(6)	66.1 (62.7-70; 10)	63.7 (61-66.7; 10)

UNSEXED

WING	(5)	290 (275-310; 7)
TAIL	(5)	115 (105-125; 7)
BILL	(5)	48.8 (42.7-46.1; 7)
TARSUS	(5)	54.1 (51.8-56.4; 7)
TOE	(5)	73.1 (69.9-77.5; 7)

WEIGHTS At sea, Jan.-Apr.: males: 795 (125.6; 720-940; 3), females: 740 (18.0; 720-755; 3) (Bierman & Voous 1950). Thin to emaciated beachcast birds: males 531 (102.3; 436-717; 11), females: 486.9 (66.1; 398-598; 14) (MV, NMNZ). At breeding grounds at Dumont d'Urville: males: 845 (740-1030; 12), females: 745 (670-855; 9). Prévost (1953) weighed pair during incubation; on 13 Dec., male 868, female 662; on 23 Dec., male 803, female 746.

STRUCTURE Wing, long and narrow. Eleven primaries; p10 longest; p9 3-14 shorter; p8 16-30; p7 34-51; p6 59-75; p5 86-100; p4 113-131; p3 140-158; p2 167-181; p1 190-201. Twenty-one secondaries, five of tertial form; four short humerals. Tail slightly rounded; t1 c. 24 longer than t6. Bill, long; narrower than in other fulmarine petrels. Nasal tubes c. one-third of length; culminicorn c. one-third of length. Maxillary unguis, small. Bill width and depth, subequal, about one third bill-length. Mandibular rami, straight. Tibio-tarsal joint, unfeathered. Middle and outer toe, about equal in length; inner toe 80-90%; hallux small.

GEOGRAPHICAL VARIATION None. Considered to form superspecies with Northern Fulmar *F. glacialis* (Voous 1949).
DIR

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Volume 1 (Part A), Plate 27

Antarctic Petrel *Thalassoica antarctica*

- 1. Adult, ventral, fresh
- 2. Adult, dorsal, fresh
- 3. Adult, dorsal, worn

Snow Petrel *Pagodroma nivea*

- 4. Adult, ventral

Southern Fulmar *Fulmarus glacialisoides*

- 5. Adult, ventral
- 6. Adult, dorsal

Cape Petrel *Daption capense*

- 7. Adult, ventral
- 8. Adult, subspecies *capense*, dorsal
- 9. Adult, subspecies *australis*, dorsal

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