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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 Pelecaniformes. 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 fedges 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 Diomedeidae. 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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Procellaria cinerea Grey Petrel

COLOUR PLATE FACING PAGE 592

Procellaria cinerea Gmelin, 1789, Syst. Nat. 1: 563; based on 'Cinereous Fulmar' of Latham, 1785, Gen. Synop. Birds 3: 405 — within the Antarctic Circle = New Zealand *fide* Mathews, 1912, Birds Aust. 2: 123.

Cinerea or ashy grey describes the general upper plumage of this species.

OTHER ENGLISH NAMES Black-tailed Shearwater or Petrel, Brown, Bulky or Great Grey Petrel, Nighthawk, Pediunker, Cape Dove.

None of the English names is specially appropriate but **Grey Petrel** is entrenched in the literature of the New World and is conventional, separating this species from the black procellarians. It is a pity to lose **Pediunker** which is the name given to it at Tristan da Cunha, perhaps derived from its call or song (Murphy).

MONOTYPIC

FIELD IDENTIFICATION Length 50 cm; wingspan 115–130 cm; weight c. 1 kg. Second smallest *Procellaria*. Close in size to Cory's Shearwater *Calonectris diomedea* but smaller-headed, with more thickset body, shorter tail, narrower wings and shorter, more slender bill. Noticeably larger than White-headed Petrel *Pterodroma lessonii*. Large, heavy-bodied petrel with rather small head, short wedge-shaped tail, narrow, finely pointed wings and slender bill, giving general impression of large, tubby-bodied shearwater. Wings look slender in relation to body; usually held stiffly and rather straight, enhancing shearwater-like jizz. Tail appears small in relation to body, narrow-based and usually held partly fanned in manner characteristic of *Procellaria*. Tips of feet project a short distance beyond tip of tail. Combination of large size, shearwater-like jizz, slender greenish-yellow bill, uniform ashy-grey dorsum and mainly white underbody contrasting with dark-grey underwings and undertail, diagnostic. Sexes alike; no seasonal variation. Juvenile inseparable.

DESCRIPTION ADULT. Upperparts uniform ashy grey, shading to darker slate-grey on cap and sides of face, imparting dark-headed appearance. Upperwings and upper tail may appear slightly darker than grey of upper body in some lights. In fresh plumage, scapulars and inner wing-coverts show narrow pale fringes. Upperparts reflective in strong light, often appearing pale frosty or silvery grey, particularly on nape and hindneck. Upperparts wear to greyish brown; remiges and tail darken to blackish and contrast with grey-brown of upper wing-coverts and upper tail-coverts. Grey of cap shades across cheeks into whitish chin and throat, giving somewhat hooded appearance, especially in subdued light or at distance. Underbody mostly white with grey patches on flanks and faint grey wash on chin and throat when fresh; ashy-grey lateral and distal under tail-coverts and blackish underside of tail form dark rear-end, contrasting sharply with white abdomen. Underwing dark grey, remiges with glossy sheen, shading to paler silvery grey on bases; whole underwing strongly reflective, especially paler bases of primaries, which show as diffuse silvery flash on wing-tip. Bill more slender and shearwater-like in shape than other *Procellaria*, with tubed nostrils raised prominently over basal third of upper mandible; horn to greenish-yellow with black nostrils, culmen saddle and sulcus. Iris, dark brown. Legs and feet, fleshy grey, darker on joints, outer side of tarsus and outer toe; webs, yellowish.

SIMILAR SPECIES Unmistakable, by combination of slender greenish-yellow bill, rather uniform ashy grey dorsum and mainly white underbody contrasting with dark grey underwings and undertail. **White-headed Petrel** most readily distinguished by mainly white head; without dark undertail area contrasting sharply with white abdomen; obviously patterned above; rather pale greyish-white tail contrasting strongly with pale-grey saddle; contrasting dark open M across entire span when fresh; when worn, marked contrast between pale-grey saddle and darker brownish-black upperwings. Jizz and flight also different: Grey Petrel has smaller, finer head and narrower wings usually held straighter, imparting shearwater-like jizz rather than characteristic gadfly-jizz of White-headed. Grey Petrel has smoother albatross-like wheeling, soaring and banking flight with steadier, more direct track; White-headed, more buoyant and impetuous, with tighter bounding arcs and more meandering track. **Cory's Shearwater**: a little bigger, with larger head, slimmer body, slightly longer tail, broader wings, with carps held farther forward, and longer thicker bill; appears greyish brown above (not uniform ashy grey), showing subtle darker M across upperwings, obvious pale fringes to mantle, back and scapulars producing more scaled appearance to saddle; may have white tips to longest upper tail-coverts forming pale horseshoe above contrasting blackish tail. Mainly white underwing (not wholly grey) sharply bordered and broadly tipped black. Bill brighter yellow with black subterminal band. Flight slower, more languid. **Pink-footed Shearwater** *Puffinus creatopus*: smaller with shorter, broader wings; greyish-brown upperparts; dark-tipped pinkish bill; always with white on underwing lining, from narrow dirty central stripe to mostly white with dark triangle in wing-pit; flight slower, more lumbering, keeping lower to surface of sea.

Markedly pelagic at all seasons; rarely seen from land away from breeding islands. Always fly rapidly and confidently. In light winds, periods of sustained gliding, gentle arcing and shearwatering low over water broken by occasional brief bursts of rapid duck-like wing-beats; slender, pointed wings held stiffly and rather straight during glides, slightly flexed when banking and shearwatering. In windier conditions, adopt powerful albatross-like soaring, wheeling and swooping, often high above sea, with long soaring ascent to peak of arc followed by long, gently sloping glide; wings often held more strongly flexed than in light winds. Feed by surface-

seizing and pursuit-plunging (from heights up to 10 m asl); swim well underwater using wings. Characteristically associates with cetaceans. Usually solitary or in small groups at sea; sometimes gather in large rafts. Regularly but somewhat shyly follow ships; attend trawlers to scavenge for refuse and dive for bait. Breed colonially on well-vegetated subantarctic islands. At breeding grounds, commonly fly over land, sail along cliff faces and occasionally alight on ground in broad daylight. Occasionally seen from breeding islands by day. Vocal on land at breeding colonies, giving a low calf-like moan followed by extended rattle; sometimes call from burrows by day but main chorus is after dark; call given either from burrow or top of tussock. Apparently silent at sea.

HABITAT Marine; mainly in subantarctic waters including cool e. boundary currents off s. continents (Murphy; Clark 1986). Range extends into subtropical waters N to 31–34°S in May–Sept. and into Antarctic waters, S to 62°S in Feb.–Mar. (Summerhayes 1969; Hansen 1978; Jouventin et al. 1982). Evidence of sexual segregation in foraging areas during breeding season; adult females and immatures predominant in subtropical waters N of Subtropical Convergence (Bartle 1990). Observed where sea-surface temperature 2.6–19.1 °C (Summerhayes 1969; Rumboll & Jehl 1977; Clark 1986; Eakin et al. 1986). Mainly pelagic; generally avoid continental shelves throughout year (Jehl 1974; Rumboll & Jehl 1977), except off Argentina in autumn (Eakin et al. 1986). In Aust., 6 of 25 (24%) sightings over shelf and shelf-break waters, 19 (76%) over pelagic waters (D.W. Eades); other Aust. sight-records from pelagic zone and edge of continental shelf (Cox 1976; Vic. Atlas).

Breed on subantarctic islands; on plateaux, steep slopes, ridges (Warham & Bell 1979); on Gough I., on exposed ridges and plateaux (Swales 1965); on Tristan da Cunha, on very steep, seaward precipices (Elliott 1957). Nest from 20 m asl (Antipodes I.; Warham & Bell 1979) to 600 m asl (Tristan da Cunha; Elliott 1957). Burrow among tussock-grass (*Poa*), clumps of *Azorella*, *Acaena* or Kerguelen cabbage *Pringlea*

antiscorbutica (Falla 1937; Rand 1954; Warham & Bell 1979; Weimerskirch et al. 1989).

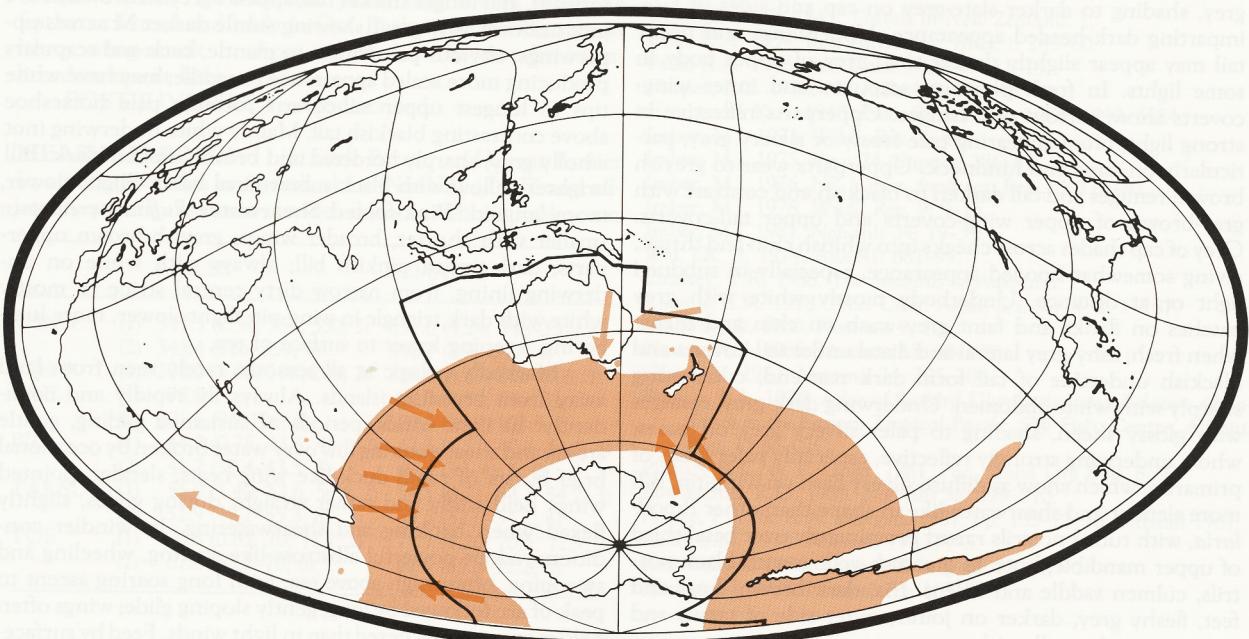
Soar and dive from heights up to 8 m (Murphy). Pursue food underwater to unknown depths. Flocks seen resting on water towards nightfall (Murphy).

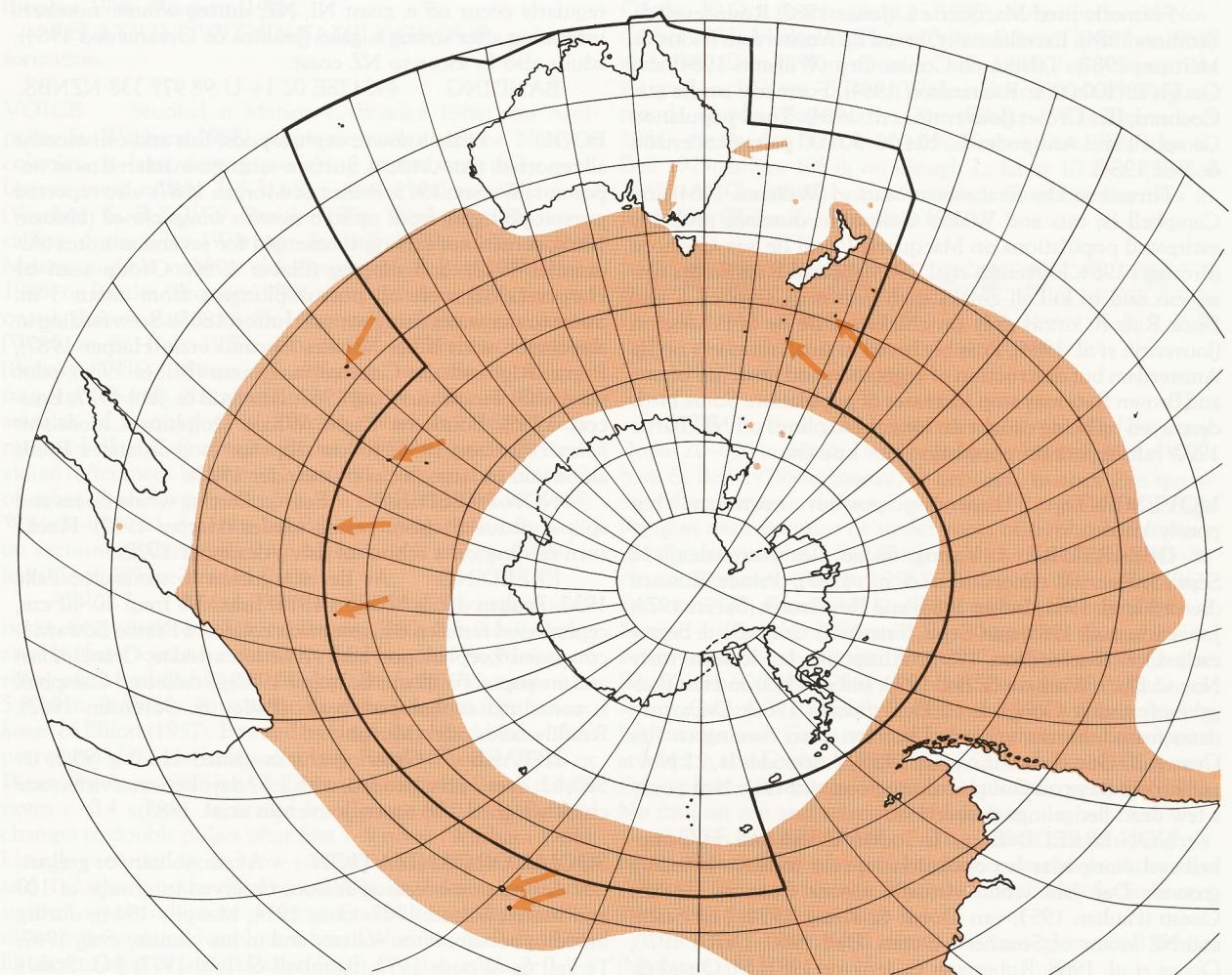
Adult females concentrate in subtropical waters, where commercial fishing vessels operate, and so vulnerable to being caught on fishing lines (Bartle 1990).

DISTRIBUTION AND POPULATION Pelagic range circumpolar, usually between 32–58°S. Breeds on cool temperate and subantarctic islands between 37–49°S. Common S and E of NZ and said to straggle to Antarctic ice-pack. Small numbers recorded Aust. and NZ.

In subantarctic waters throughout year. Occurs farther S, to 57–62°S, in Feb.–Mar. in Indian Ocean (Falla 1937; Jouventin et al. 1982; Stahl 1987); to 56–62°S from Jan. to June in Pacific (Wilson 1907; Gain 1914; Lowe & Kinnear 1930; Watson et al. 1971; Clark 1986). Does not extend beyond 53–54°S in S. Atlantic (Vanhöffen 1901; Ozawa et al. 1964; Thurston 1982; Bourne & Curtis 1985). Extends N of Subtropical Convergence, usually from May to Sept., to 31–34°S (Wilson 1907; MacGillivray 1920; Peakall 1960; Summerhayes 1969; Hansen 1978; Jouventin et al. 1982). Rarely farther N: in S. Atlantic recorded to 18°S (Paessler 1909; MacGillivray 1920; Watson et al. 1971); in Indian Ocean to 20–25°S (Bourne & Dixon 1973, J.-C. Stahl). One near Ascension I., 8°S (Godman 1907–1910). Extension along Humboldt Current uncertain; reported N to 6°S off Peru (Johnson 1965) but recent records sparse and none N of 33°S (Szijj 1967; Jehl 1973; Brown et al. 1975; Clark 1986). Regular visitor along Humboldt Current to Chile and s. Peru (Murphy); also occur off Argentina, Uruguay and s. Brazil (Blake 1977). Rare visitor off s. African coast, as far N as Port Nolloth and Mozambique Channel (Maclean 1985; McLachlan & Liversidge 1978). Unsubstantiated report before 1853 off Monterey, California (AOU 1983).

AUST. Records or specimens (44) between 1860 and 1984, all from s. regions. NSW. One beachcast, Ballina, 2 Feb.





1985 (NSW Bird Rep. 1985). Vic. Six, w. coast between Barwon Heads and Portland. Tas. Two, Bass Str., in Tas. waters; one, King I.; 18, off s. and w. coasts. SA. Eight; four specimens in SE, between Sleaford Bay and Beachport; three sightings S of 40°S; one near 37°S 130°E. WA. Six: specimens from Twilight Cove (Congreve 1983) and Busselton (Whittell 1942), latter incorrectly stated as having been found at Bunbury. Three sightings at sea S of 36°S, and one at 31°58'S 111°10'E.

NZ Common in seas S and E of NZ; rare in Tasman Sea. Occasionally recorded off coast of main islands (Falla et al. 1987; Oliver; M.J. Imber). In Nov. to May, rarely found N of 44°S (Robertson & Jenkins 1981; Jenkins 1981; Clark 1986; J.A. Bartle); in June to Oct. range extends further N; observations at 32–34°S (N of East Cape) (Summerhayes 1969), 34°S 179°E (Hansen 1978), and off e. coast of NI at 36–41°S (Fleming 1950). Irregular in winter in Bay of Plenty and off East Cape, but exceptional numbers between East Cape and C. Turnagain in July 1984, after period of strong SSW winds (Jenkins & Greenwood 1984). Beach patrols between 1960 and 1987 have recovered 83 beachcast specimens (Powlesland 1989). NI. Highest rates of recovery (birds/100 km) in Bay of Plenty, followed by Auckland West and East Coast regions. Other recoveries in Taranaki, Wellington and Auckland East

regions. SI. Two recoveries on Canterbury coast during regular patrols. Also one picked up, L. Ellesmere, 3 Jan. 1973; one, live, Manapouri, 25 May 1988 (CSN 20,36).

MACQUARIE I. Former breeding site. Thirteen specimens or sight records from Macquarie I. Since 1949, six specimens taken, plus five sight records (Keith & Hines 1958; Jones 1980).

BREEDING In all s. oceans: localities and population estimates in Table 1.

Table 1.

LOCALITY	YEAR	ESTIMATE	REF.
Prince Edward Is	<1984	1000s	1
Iles Crozet	1981–82	1000s	2
Iles Kerguelen	1984–87	5000–10,000	3
Campbell I.		not in great numbers	4
Antipodes Is			5

(1) Williams (1984); (2) Jouventin et al. (1984); (3) Weimerskirch et al. (1989); (4) Bailey & Sorensen (1962); (5) Robertson & Bell (1984).

Formerly bred Macquarie I. (Jones 1980; Rounsevell & Brothers 1984). Extralimitally, breed Ile Amsterdam (Roux & Martinez 1987), Tristan da Cunha Grp (Williams 1984) and Gough I. (100 000s; Richardson 1984). Formerly on Ile aux Cochons, Iles Crozet (Jouventin et al. 1984). Total population Campbell and Antipodes Is, 10 000–50 000 pairs (Robertson & Bell 1984).

Threatened by feral cats at Marion (Williams 1984) and Campbell Is; cats and Wekas *Gallirallus australis* probably extirpated populations on Macquarie I. and Ile aux Cochons (Brothers 1984; Jouventin et al. 1984). Brown Rats *Rattus norvegicus* said to kill all chicks each year on Campbell I. and Black Rats *R. rattus* prey on chicks on Ile de la Possession (Jouventin et al. 1984). Possibly breed in small numbers on Ile Amsterdam but destruction of vegetation and presence of cats and Brown Rats may stop increases of population. Some birds destroyed by being caught on long fishing lines off NZ (Bartle 1990) but impact on population not known.

MOVEMENTS Dispersive, possibly migratory, but poorly known.

DEPARTURE Young fledge Iles Kerguelen, 10 Sept.–5 Dec. (Weimerskirch et al. 1989), Prince Edward (Berutti et al. 1981; Imber 1983) and Iles Crozet (Barrat 1974; Jouventin et al. 1985) mid-Sept., Tristan da Cunha, late Sept.–early Oct. (Richardson 1984), Antipodes Is, at least early Nov.–1 Dec. (Warham & Bell 1979; Imber 1983) and last fledgeling found at Gough I. 10 Dec. (Swales 1965). Departure dates for adults not recorded but last seen coming to Iles Crozet, 20 Oct. (Jouventin et al. 1985), Antipodes Is, 21 Nov. and no sightings on Gough I. during one visit early Nov., only a few dead fledglings (Imber 1983).

NON-BREEDING In Indian Ocean and on Campbell and Antipodes Is populations appear to leave breeding grounds Dec.–Jan. when virtually absent from sw. Indian Ocean (Paulian 1953; van Oordt & Kruijt 1954; J.-C. Stahl) and NZ sector of Southern Ocean (Dell 1960; Darby 1970; Ozawa et al. 1968; Robertson & Jenkins 1981; McQuaid & Ricketts 1984) though some remain near Gough I. in summer (Harris & Batchelor 1980). Sightings during non-breeding season mostly restricted to sw. Atlantic Ocean from 32° to 42°S (Murphy 1914), S. African waters (Ozawa et al. 1964; Brooke & Sinclair 1978), se. Indian Ocean from 46° to 52°S (Wilson 1907; Mochizuki & Kasuga 1985) and se. Pacific from 40° to 60°S (Gain 1914; Meeth & Meeth 1986; Harper 1987), which suggests segregation of non-breeding populations. Most birds seen se. Indian Ocean during Nov. were in wing-moult (Wilson 1907).

RETURN Arrive Antipodes Is (Warham & Bell 1979), Iles Crozet (Jouventin et al. 1985) and Iles Kerguelen (Weimerskirch et al. 1989) early Feb.; Tristan da Cunha (Richardson 1984) and Gough I. (Swales 1965) late Feb.

BREEDING Winter distribution in Indian and Pacific Oceans farther N than summer but patterns of movement of breeding adults and pre- or non-breeders not understood. In se. Indian Ocean (MacGillivray 1920; Alexander 1922; Peakall 1960) and se. Pacific Ocean (Buller 1892; Lowe & Kinnear 1930; Szijj 1967; Clark 1986) records during breeding season almost certainly non-breeding birds only. Similarly, though recorded in Aust. waters in all months except Nov., most records May–Sept. during breeding season (Vic. Atlas; D.W. Eades). All records from Macquarie I., Mar.–July, including at least one that returned a year later (Warham 1969). Individuals, including breeding adults (Bartle 1990),

regularly occur off e. coast NI, NZ, during winter, numbers increasing after strong s. gales (Jenkins & Greenwood 1984); adults also fly close to NZ coast.

BANDING 49S178E 02 1+ U 98 977 338 NZNBS.

FOOD Little known; cephalopods, fish and crustaceans all reported. **BEHAVIOUR** Surface-seizing considered most important (Watson 1975; Prince & Morgan 1987); also reported pursuit-plunging from up to 8 m with wings closed (Hutton 1865), sometimes staying submerged for several minutes (Alexander 1922), and dipping (Blaber 1986). Group seen by Harper (1987) were all pursuit-plunging from about 3 m. Swim under water using wings (Hutton 1865). Seen feeding in association with Killer Whales *Orcinus orca* (Harper 1987), Pygmy Right-whales *Caperea marginata* (Blaber 1986), pilot whales *Globicephalus* (Szijj 1967; Rumboll & Jehl 1977; Enticott 1986), Southern Right Whale Dolphins *Lissodelphis peronii* (Enticott 1986); follow ships for long distances. Feeds alone and in large flocks (Alexander 1922).

NON-BREEDING Seen collecting whale faeces and spilt euphausiids from beside whales (Harper 1987). Flocks seen feeding on a school of fish (Alexander 1922).

BREEDING At Iles Kerguelen (6 stomachs; Falla 1937; Paulian 1953; Mougin 1975) fish 33% freq. 10–12 cm, cephalopod remains 83; a stomach collected Prince Edward I. contained 9 cephalopod beaks (Histiotheuthidae, Cranchiidae) and an isopod (Williams & Imber 1982); 3 collected Campbell I. contained cephalopod beaks (Bailey & Sorenson 1962). Readily takes offal (Murphy).

INTAKE Growing chicks gained 112.0 g (93.7; 0–590; 63) over 24 h when fed, with 1.67 days between visits (one chick weighed 118 times; Jouventin et al. 1985).

SOCIAL ORGANIZATION At sea, solitary or gregarious during non-breeding season; observed in groups of 100 and more (Wilson 1907; Gain 1914; Murphy 1914); during breeding season, often solitary and in low density (Szijj 1967; Tickell & Woods 1972; Rumboll & Jehl 1977; J.-C. Stahl), although reports of great flocks (Alexander 1922) and congregations round vessels (Buller 1892) or whales (Szijj 1967; Rumboll & Jehl 1977). Gregarious on breeding grounds. Associates to feed with other procellariiforms behind vessels or round schools of cetaceans (Murphy 1914; Enticott 1986).

BONDS Probably monogamous, but no data on pair-bonds or on age of first pairing. Incubation and feeding of chicks probably by both partners, but no precise data. Chicks independent at fledging.

BREEDING DISPERSION Colonial. Burrow density at Marion I. less than 1/100 m², possibly reduced as result of predation by cats (Brooke 1986). Territorial only when breeding.

ROOSTING No data. Does not come ashore outside breeding season (Jouventin et al. 1985).

SOCIAL BEHAVIOUR No detailed studies, and almost totally unknown. Observation of displays difficult as mostly nocturnal and within burrows (though some activity outside burrows at Antipodes I.; Warham 1988).

AGONISTIC BEHAVIOUR No data.

SEXUAL BEHAVIOUR Only one advertising display described: **Head-swinging**: birds squatted on top of tussocks, with bills wide open and swinging heads from side to side while emitting bleat call outside burrows during pre-laying period (Warham & Bell 1979). No aerial displays

(Brooke 1986; Warham 1988).

RELATIONS WITHIN FAMILY GROUP No information.

VOICE Studied at Marion I. (Brooke 1986) and Antipodes Is (Warham 1988). Apparently silent at sea. Noisy at colonies, at least during pre-laying period and early incubation; most calling 2–3 h after sunset and towards dawn (Warham & Bell 1979; Brooke 1986; Warham 1988); some calling during day (Warham & Bell 1979). Calls include Moans, audible only at close range; loud Bleats (Warham 1988) or Rattles (Brooke 1986); short quacking calls and resonant, throaty alarm call. Does not call in flight over colonies (Warham & Bell 1979). No sexual differences detected (Brooke 1986). Moans of different individuals vary in frequency bands, distribution of energy within bands and amount of frequency modulation (Warham 1988); recognition of Bleat Call of mate (Brooke 1986) suggests also individual differences in latter. Calls similar in structure to those of other *Procellaria* but repertoire smaller (Warham 1988). Whistle-like calls described in Palmer (1962) apparently based on account of Campbell from Macquarie I. and probably referable to White-headed Petrel.

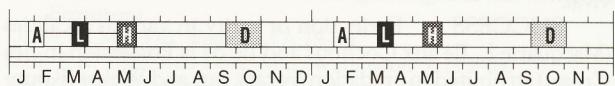
ADULT **Moan** (Warham 1988) usually consists of 3 notes, first inhalatory, last expiratory (both 0.5–0.6 s), separated by brief central note (0.05–0.07 s), each beginning on rising pitch and ending on falling pitch; frequency range 0.3–5.8 kHz. Probably equivalent to melodious *aaargh-hoo-err-hooer* of Elliott (1957). Emitted by single or paired birds, often preceding bleat; no function given. **Rattle** (Brooke 1986) or **Bleat** (Warham 1988) lasts 5–22 s consisting of series of pulsed notes c. 0.4 s long, separated by silences of 0.05 s. Pattern changes to double pulses after first 7–9 notes (Warham 1988). Usually preceded by 1–3 low-pitched moans (last inhalatory) and 1–2 short notes (Warham 1988); at Antipodes Is, described as introductory wheezy moan (inhalation) leading directly to sustained explosive bray (Warham & Bell 1979), likened to bleat of lamb (Hutton 1865). Frequency range 0.3–5 kHz. Emitted by both sexes within burrows (warning off intruders) and at entrance of or outside burrow (possibly mostly by males advertising possession of burrow or availability as partner). Apparently used also for individual recognition as birds respond to playback of calls of either sex, but not to call of partner (Brooke 1986). **Quacking**: birds disturbed in burrows may emit short calls (Warham 1988); alarm call described as a resonant throaty droning *grrrir* (Richardson 1984).

YOUNG Chicks utter thin piping *hi hi hi hi* (Richardson 1984); other juvenile call described as *ok-ok-ok-ok-eee-aargh* (Elliott 1957).

BREEDING No detailed studies. Partial data from Tristan da Cunha (Elliott 1957; Richardson 1984) and Iles Crozet (Barrat 1974; Jouventin et al. 1985). Colonial breeder on cool temperate and subantarctic islands, usually on steep vegetated slopes.

SEASON Feb. to Sept.–Dec. Laying Mar.–July. Arrival at colonies: Iles Crozet, (Jouventin et al. 1985), Iles Kerguelen (Weimerskirch et al. 1989), Antipodes (Warham & Bell 1979) and Inaccessible Is (Fraser et al. 1988), early Feb.; Tristan da Cunha (Richardson 1984), late Feb.; Ile Amsterdam (Roux & Martinez 1987), Feb. Pre-laying period c. 45 days at Iles Crozet (Jouventin et al. 1985). No data on pre-laying exodus. Latest sightings of adults at colonies: at Iles

Crozet, 20 Oct. (Jouventin et al. 1985); at Antipodes, 21 Nov. (Imber 1983). Fledglings leave: Prince Edward Is (Imber 1983) and Iles Crozet (Jouventin et al. 1985), mid-Sept.; Iles Kerguelen, 10 Sept.–5 Dec. (Weimerskirch et al. 1989); Tristan da Cunha, Sept.–early Oct. (Elliott 1957; Richardson 1984); Antipodes Is, at least early Nov.–1 Dec. (Warham & Bell 1979; Imber 1983); on Gough I., latest 10 Dec. (Swales 1965). At Campbell I., non-breeders found in burrows in June–July (Bailey & Sorensen 1962).



(Iles Crozet)

SITE Burrows dug in dry soil, usually on steep slopes 20–600 m asl; also on flat ground at Antipodes Is (Warham & Bell 1979); at base of, or between, tussock *Poa* spp or *Azorella* cushions, or among *Acaena*, Kerguelen Cabbage *Pringlea antiscorbutica* or under roots of fennel. Burrows usually not straight, 1.5–3.0 m long with nest-chamber 45–80 cm in diameter (Paulian 1953; Bailey & Sorensen 1962; Prévost 1970; Barrat 1974). Some nests under boulders at Marion I. (Brooke 1986) and Iles Kerguelen (Barrat 1974). Burrows of White-chinned Petrels *P. aequinoctialis* used at Iles Crozet (Despin 1976), of Sooty Shearwaters *Puffinus griseus* at Campbell I. (Bailey & Sorensen 1962). Share nesting habitat also with Great-winged Petrel *Pterodroma macroura* at Marion and Crozet (Rand 1954; J-C. Stahl); with Common Diving-Petrel *Pelecanoides urinatrix* at Iles Crozet (J-C. Stahl). No data on use and selection of burrows.

NEST, MATERIALS Truncated cone, only slightly rising above floor of nest-chamber; material includes dry *Azorella*, fern and tussock (Paulian 1953; Bailey & Sorensen 1962). No data on building.

EGGS Rounded ovate; without gloss; dull white (Mathews 1933).

MEASUREMENTS:

Tristan da Cunha 82.7 (79.0–85.2; 7) x 55.9 (53.0–58.0) (Mathews 1933; Richardson 1984).

Iles Crozet 78.4 x 55.2, 80.0 x 57.2 (Barrat 1974).

Iles Kerguelen 81 x 52, 81 x 56 (Barrat 1974).

Marion I. 81.0 (2.41; 78.4–86.1; 8) x 55.4 (1.50; 52.8–57.0) (M. de L. Brooke)

WEIGHTS:

Iles Kerguelen: one egg weighed 110 g (Barrat 1974).

CLUTCH-SIZE

One.

LAYING Tristan da Cunha, mid-Mar.–early July (Richardson 1984; Elliott 1957); Prince Edward Is, late Mar.–early Apr. (Brooke 1986); Iles Crozet, second half of Mar. (Jouventin et al. 1985); Iles Kerguelen, late Mar. (Weimerskirch et al. 1989). No data on replacement laying and breeding intervals.

INCUBATION Probably by both sexes; no data on incubation stints. **INCUBATION PERIOD**. Between 52 and 61 days (Barrat 1974), not precisely known.

NESTLING Chicks brooded for few hours, guarded for 24–72 h (Jouventin et al. 1985). Chick probably fed by both parents; no data on feeding method. Dependence on parents stops at fledging. No data on plumage and weight of chick at hatching. At Iles Crozet, maximum weight 1447 g (216; 1200–1600; 3) or 137% adult weight reached after 75–94 days; weight at fledging, 1207 g (136; 1050–1290; 3) or 112% adult

weight (Jouventin *et al.* 1985). At Tristan da Cunha, maximum weight at least 1400 g (n=1) or 135% adult weight (Richardson 1984). Tarsus, culmen and flight-feathers almost fully grown at fledging (Barrat 1974). NESTLING PERIOD: at Tristan da Cunha, 82 days (n=1) of Elliott (1957) in error, recalculated as 102+ days by Imber (1983); at Iles Crozet, 110–120 days (Jouventin *et al.* 1985).

FLEDGING TO MATURITY No data on age of first pairing, first breeding, breeding success and annual survival.

SUCCESS Extinction or rarity in various localities (Macquarie I., Ile aux Cochons and Ile de la Possession in Iles Crozet) attributed to predation by cats, rats and Wekas (Rounsevell & Brothers 1984; Jouventin *et al.* 1984). Breeding success on Campbell I. appears severely affected by Norway Rats.

PLUMAGES Based on birds from Macquarie I.

ADULT Age of first breeding unknown. In fresh plumage: HEAD AND NECK. Crown and hindneck, dark brown (121), broadly fringed grey (84). Short white filoplumes on nape; base of feather to three-quarters of length, white; white bases often exposed when feathers disarrayed. Sides of head and neck, pale dark-brown (121). Chin, throat and foreneck, dull white, sometimes with light grey-brown (119D) shade. When worn, feathers of throat have square-cut appearance and obvious white bases. Similarly, fringes on feathers of forehead mostly lost. UPPERPARTS, grey (84) with brown-grey (80) shade, fringed brown-grey (79). With wear, fringes become dark brown (119A). Scapulars, black-brown (119). Concealed bases of feathers on upperparts, very light grey-brown (119D); those on rump and mantle sometimes exposed when feathers disarrayed. TAIL, black-brown (119); rachis, dark brown (121) basally, merging to grey-black (82). UPPERWING. Alula and remiges, black-brown (119). Basal inner webs of remiges, pale dark-brown (121). Primaries extend 32–54 mm beyond tip of tail, when wings closed. All coverts, grey (84) with brown-grey (80) shade, narrowly fringed brown-grey (79). When worn, fringes, dark brown (119A). UNDERPARTS, mostly dull white. At shoulder, wash of grey-brown (91) on distal webs; feathers, narrowly tipped white. When worn, white tips lost. Outer and lower flank-feathers, and under tail-coverts, dark brown (119A); grey (84) on outer webs. Axillaries, dark brown (119A). UNDERWING. Marginal coverts, dark brown (119A). Greater primary and greater coverts, pale brown-grey (79). Rest of coverts, brown (119B); lesser and median coverts narrowly fringed light grey-brown (119D).

DOWNTY YOUNG Medium grey, paler on chin and breast (Watson 1975). Unknown whether two downy stages occur. Fledgeling at NMNZ has light grey-brown (119D) down remaining on body.

JUVENILE Similar to adult; differs in: HEAD AND NECK. Crown grey (84) with brownish tinge. UPPERPARTS, pale-grey (86) fringes to feathers. UPPERWING. Coverts, dark brown-grey (79). Greater primary coverts and greater coverts, fringed pale grey (86). Greatest difference from adult is more uniform appearance, without dark brown (119A) fringes, when plumage fresh.

BARE PARTS Based on photos in Lindsey (1986), except where stated.

ADULT Iris, dark brown (219). Culminicorn and nostril tubes, grey-black (82). Latericorn and ramicorn, pearl-grey (81); also described as light horn (skins at NMNZ). Max-

illary unguis, dark grey; mandibular unguis, black. Outer tarsus and outer toe, dark grey; rest of feet, except webs, flesh-grey; webs, paler (skins at NMNZ). Bailey & Sorensen (1962) describe latericorns as bluish light-grey with yellow tinge. Another commonly recorded colour is pea-green (e.g. Murphy); apparently some variation occurs. Full discussion of bare parts in Whitlock & Whittell (1942).

DOWNTY YOUNG, JUVENILE Undescribed.

MOULTS

ADULT POST-BREEDING May more aptly be regarded as pre-breeding. Complete; primaries moult outwards. Duration of moult, unknown. Breeding birds shed contour feathers when nesting, and undergo body-moult (Swales 1965). At Antipodes Is, birds arriving mid-Feb. to Mar., completing growth of remiges, and also in tail-moult (Murphy; Warham & Bell 1979). Hagen (1952) observed birds in late stages of moult in Mar. Theca of bill also shed Feb.-Mar. (Hagen 1952).

POST-JUVENILE Undescribed.

MEASUREMENTS 1–6. Summary from various breeding localities; methods unknown (Barrat 1974): (1) NZ; (2) Macquarie I.; (3) Iles Kerguelen; (4) Iles Crozet; (5) Marion I.; (6) Gough I. (7) NZ, source unlisted, presumably live birds; methods unknown (Harper 1978). (8) Iles Crozet, live; standard methods (Jouventin *et al.* 1985). (9) Iles Kerguelen, adults; standard methods (Weimerskirch *et al.* 1989). (10) From Table 2, Barrat (1974). (11) Adults (juveniles excluded), skins (QVM, NMNZ).

	UNSEXED	
WING	(1)	347 (340–355; 12)
	(2)	339 (335–344; 6)
	(3)	338 (320–354; 10)
	(4)	348 (335–364; 8)
	(5)	313 (290–326; 3)
	(6)	327 (314–340; 4)
	(7)	358.3 (1.9; 9)
	(8)	345.0 (4; 340–350; 5)
	(9)	344.1 (8.2; 327–358; 37)
TAIL	(1)	116.0 (110–124; 12)
	(2)	118.0 (112–129; 6)
	(3)	117.0 (113–123; 7)
	(5)	112.0 (108–115; 3)
	(6)	113.5 (109–122; 4)
	(7)	115.2 (1.4; 9)
	(1)	46.6 (45–49.4; 12)
BILL	(2)	46.2 (45–48; 6)
	(3)	47.5 (46–49.5; 10)
	(4)	47.2 (46–49; 8)
	(5)	47.3 (47–48; 3)
	(6)	46.5 (45–48; 4)
	(7)	47.1 (0.7; 9)
	(8)	46.3 (1.9; 44.5–49; 5)
	(9)	47.0 (1.8; 41.9–50.4; 37)
TARSUS	(1)	59.6 (57.6–63.5; 12)
	(2)	60.8 (55–65; 6)
	(3)	60.2 (57–63; 10)
	(4)	61.0 (58–62.5; 8)
	(6)	50.4 (49–52; 4)
	(7)	64.0 (0.9; 9)
	(8)	64.0 (3.4; 62–70; 5)
	(9)	59.5 (1.4; 56.1–62.6; 37)
	(7)	77.5 (0.6; 9)

	MALES	FEMALES
WING	(10) 342.0 (329-350; 15)	337.0 (290-355; 13)
	(11) 351.2 (10.34; 331-364; 7)	354.7 (5.75; 349-360.5; 2)
8TH P	(11) 197.3 (8.94; 183-210; 9)	211.0 (4.96; 207-218; 3)
	(10) 116.0 (110-124; 13)	113.0 (102-118; 13)
TAIL	(11) 109.0 (3.5; 103-114; 8)	114.6 (3.68; 110-119; 3)
	(10) 47.6 (45-49.5; 15)	46.4 (44-49.4; 13)
BILL	(11) 47.4 (0.80; 45.4-48.2; 9)	45.1 (0.29; 44.8-45.5; 3)
	(10) 60.2 (57-63.5; 15)	58.4 (55-62.5; 11)
TARSUS	(11) 61.4 (1.81; 58.8-64.4; 9)	61.3 (1.57; 59.2-62.9; 3)
	(10) 79.6 (2.78; 76.4-84.9; 7)	79.4 (2.20; 76.8-82.2; 3)

Full details of growth rates of chicks in Barrat (1974) and Despin (1976).

WEIGHTS 1-5. Various breeding localities (Barrat 1974): (1) Macquarie I.; (2) Iles Kerguelen; (3) Iles Crozet; (4) Marion I.; (5) Gough I. (6) Iles Crozet (Jouventin et al. 1985). (7) Iles Kerguelen (Weimerskirch et al. 1989). (8) Campbell and Macquarie Is, adults, skins, June-July (label data from QVM, NMNZ). (9) From Table 2, Barrat (1974).

	UNSEXED	
	MALES	FEMALES
(1)	525 (450-600; 4)	
(2)	1102 (960-1250; 7)	
(3)	1000 (950-1050; 2)	
(4)	1003 (990-1016; 2)	
(5)	851 (766-936; 2)	
(6)	1073 (137; 950-1220; 3)	
(7)	1131 (133; 900-1520; 37)	
(8)	1034.5 (46.8; 985-1105; 4)	1092
(9)	1073 (950-1217; 4)	989 (960-1016; 3)

Additional weights in Imber (1983). Full details of changes of weight in chicks in Barrat (1974), Despin (1976) and Jouventin et al. (1985).

STRUCTURE Wing, long and narrow. Eleven primaries. P10 longest, p9 1-5 mm shorter, p8 17-21, p7 39-47, p6 67-79, p5 95-107, p4 123-138, p3 153-171, p2 178-203, p1 201-229, p11 minute. No emarginations. Under tail-coverts end c. 4 mm short of tip of tail. Tail slightly rounded; 12 rectrices, t1 longest, t6 23-34 mm shorter. Bill, slender; maxillary unguis, hooked. Nostrils c. 40% of length of bill. Nostrils point forward; nasal tubes divided by septum. Outer and middle toes about equal in length, inner c. 85% of middle, hind (claw only) c. 10%.

RMO

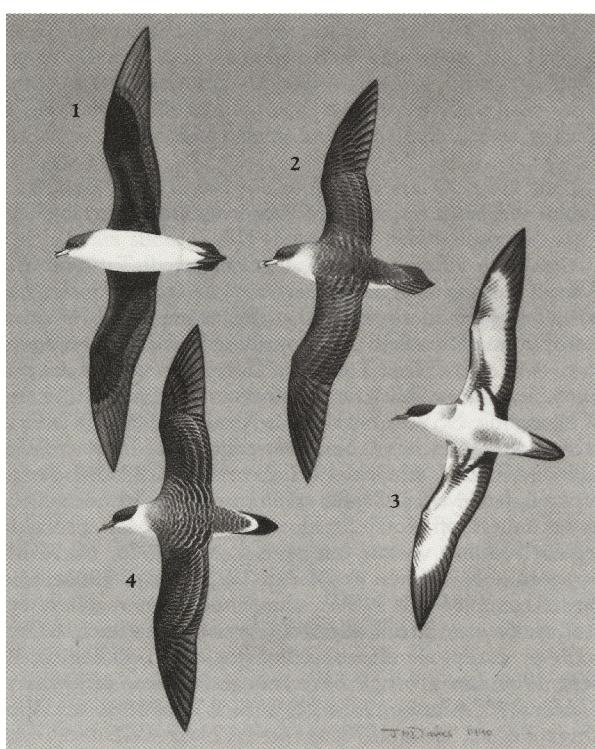
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Grey Petrel *Procellaria cinerea*

1. Adult, ventral
2. Adult, dorsal

Great Shearwater *Puffinus gravis*

3. Adult, ventral
4. Adult, dorsal

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