

## Order PROCELLARIIFORMES

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

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

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

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

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



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

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

### References

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



## Family 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.

#### REFERENCES

- Brodkorb, P. 1963. *Bull. Flor. St. Mus. biol. Sci.* 7: 179-293.
- Cox, J.B. 1980. *Rec. S. Aust. Mus.* 10: 91-121.
- Fleming, C.A. 1941. *Emu* 41: 134-55.
- Harper, P.C. 1980. *Notornis* 27: 235-86.
- Imber, M.J. 1985. *Ibis* 127: 197-229.
- Kuroda, N. 1954. *On the classification and phylogeny of the order Tubinares, particularly the shearwaters (Puffinus), with special consideration on their osteology and habit differentiation.* Tokyo.
- Murphy, R.C., & J.M. Pennoyer. 1952. *Am. Mus. Novit.* 1580.
- Olson, S.L. 1975. *Smithson. Contr. Paleobiol.* 23.
- Voous, K.H. 1949. *Ardea* 37: 113-22.



*Halobaena caerulea* Blue Petrel

*Procellaria caerulea* Gmelin, 1789, *Syst. Nat* 1: 560 — Southern Ocean, 47° to 58°S.

The generic name is compounded of the Greek ἅλς (salt, sea) and βαίνειν (to go, walk); *caeruleus* is the Latin for 'dark blue', 'azure' — thus 'the blue sea-walker'.

## MONOTYPIC

**FIELD IDENTIFICATION** Length 26–32 cm; wing-span: 62–71 cm; weight: c. 200 g. Small prion-like petrel with slender black bill and square tail, latter unique among Procclariidae. Similar in size, bulk and proportions to larger prions *Pachyptila* spp but with slightly longer and narrower wings, outerwing tending to appear longer, finer and more pointed in most attitudes. Predominantly pale bluish-grey above, with narrow black open M across upperwings and prominent black cap offset by large white forehead patch; grey tail shows narrow dusky subterminal band abutting broad white tip (last unique among Procclariidae). White below except for obvious but incomplete dark collar tapering down sides of breast. Easily distinguished from prions and smaller gadfly petrels *Pterodroma* spp by diagnostic broad white tip to square tail. Flight, fast buoyant variously recalling prions or smaller gadfly petrels. Sexes alike; no seasonal variation apart from that caused by wear. Juvenile inseparable.

**DESCRIPTION ADULT.** Forehead and lores, white, becoming speckled with dark along anterior border of dark forehead and centrally in narrow line between latter and base of nostrils. White of forehead extends back as narrow fore-supercilium terminating over eye. Crown, nape, anterior ear coverts and patch underscoring eye, greyish-black, forming neat blackish cap contrasting with white forehead and bluish-grey hindneck; cap wears to brownish-black. Bluish-grey of hindneck extends well down sides of neck and upper breast as pronounced but incomplete dark collar. Shape of collar varies, at times appearing as broad-based forward-sloping collar tapering abruptly over distal third towards mid-line, at others (when head tucked well into body), as broad, roughly square-ended one. At most angles, bottom half of collar appears blackish like cap. White of cheeks extends upwards behind dark of ear coverts to form prominent white notch between latter and hindneck collar. Mantle, back, rump and upper tail-coverts, uniform bluish-grey. Tail, square, bluish-grey for most of length, shading to narrow greyish-black subterminal band abutting broad white tip; outer pair of rectrices, almost entirely white, appearing as conspicuous white strips down sides of tail when exposed during flight. Upperwings, bluish-grey, marked with narrow dusky open M formed by blackish outer four primaries and adjacent primary coverts and slightly paler diagonal bar across innerwing coverts from carpal to longest scapulars. Longest scapulars, broadly fringed with white. Trailing half of upperwing behind M, often appears slightly paler than darker grey areas in front; also looking noticeably translucent when lit from behind. In fresh plumage, narrow dusky bar across innerwing coverts appears rather pale and indistinct but soon darkens to blackish (matching darkness of outer primaries) as narrow grey fringes wear; effects of wear and fading cause M to appear brownish by end of breeding season; white scapular fringing then also reduced or absent but white tip to tail always

retained. Except for dark half-collar, underbody entirely white. Underwing appears entirely white in most views. In close view, however, a few small dark patches show along leading-edge between carpal and base of outermost primary, and shadowy greyish band extends diagonally inwards from carpal over inner wing-lining. Bill, small, slender, with tubed nostrils raised conspicuously over basal third of upper mandible (profile of bill recalls that of some Cookilaria gadfly petrels more than prions) black, with bluish-white ramal stripe (rarely visible in the field). Legs and feet, cobalt-blue with creamy or fleshy webs.

White tip to tail unique among petrels and prions; can be surprisingly conspicuous, even in poor light or at distance when other features obscure. Separation from prions otherwise confirmed by combination of white forehead, much darker blackish cap, pronounced dark half-collar, and slender, mainly black bill; slender, white notch separating dark ear-coverts from half-collar also distinctive (lacking on prions). Other ready distinctions from prions: lack of pale supercilium behind eye; white undertail (lacking blackish tail-tip or streak on central coverts so obvious in ventral views of *Pachyptila* spp); white (not grey) outer tail-feathers; square (not wedge-shaped) tail and less erratic, more buoyant flight that recalls *Pterodroma* spp. In n. part of range in A'sian waters and South Pacific, can be confused with small, black-capped gadfly petrels, **Gould's Petrel** *Pterodroma leucoptera* and especially **Stejneger's Petrel** *P. longirostris* (which has similar head-pattern). Both separable from Blue Petrel by slightly darker grey dorsum, blackish rump-triangle, grey or dusky tip to wedge-shaped tail and obvious blackish border round underwing that extends inwards over white lining from carpal as tapering diagonal bar.

Flies buoyantly, resembling to some extent a large prion, otherwise a small gadfly petrel. In light winds, flight rather prion-like though less erratic, with more frequent glides on stiff bowed wings low to surface, broken by periods of gentle arcing and turning. At other times and especially in higher winds, occupies markedly higher air-space than prions, often rising to fair height above waves during higher arcs, followed by sustained glides and tight circling manoeuvres with little flapping, flight then recalling smaller *Pterodroma*. Mainly restricted to cold, open waters of Southern Ocean, S to edge of pack-ice, ranging N in winter to about 30°S in our area. Normally pelagic but ranges into shelf-break waters in n. part of range and sometimes seen over inshore waters or inland when storm-driven. Gregarious, usually in small loose flocks of up to 100 but sometimes in thousands close to breeding islands. Often joins flocks of prions. Occasionally follows ships, unlike prions (Harrison 1983); also associates with cetaceans. Feeds by surface-seizing, dipping, surface-diving and occasionally by shallow-plunging. Alights clumsily on surface; swims readily. Gregarious at colonies where strictly nocturnal. Silent



at sea but noisy at colonies where main call given from ground or burrows is a pigeon-like *kuk, kuk, coo-oo*.

**HABITAT** Marine; in subantarctic and Antarctic seas. In summer, mainly over waters of  $-2$  to  $+2$  °C surface-temperature (Bierman & Voous 1950), but ranging S to edge of pack-ice and N to approximately 30°S, or farther in cool currents (Humboldt Current; Meeth & Meeth 1977). Prefers open water; in Antarctic generally avoids pack-ice, only occasionally approaching ice-edge (Routh 1949). Feeds round base of icebergs (Routh 1949; Bierman & Voous 1950); gather at surface swarms of krill (Bierman & Voous 1950), however, showed little interest in swarms at Antarctic Divergence (Griffiths 1982). Generally pelagic (Jouventin *et al.* 1985); at Iles Kerguelen, feed inshore in kelp-zone (*Macrocystis*) and sheltered coastal waters only during rough weather (Falla 1937). May be driven inshore by strong onshore winds (Downes *et al.* 1959; Reed 1981; Brown *et al.* 1986).

Breed on subantarctic islands, breeding range extending S of Antarctic Convergence at S. Georgia; on coastal lowlands below 500 m, offshore rock stacks and islets; nest in rock crevices or burrow in deep dry soil with low vegetation (e.g. *Cotula*, *Colobanthus*, *Acaena*, *Azorella*, *Poa*) (Brothers 1984; Fugler *et al.* 1987; Weimerskirch *et al.* 1989). On Marion I., mainly on steep vegetated slopes overlooking seas; burrow densities highest in *Cotula* herbfield, lower in *Poa* grassland

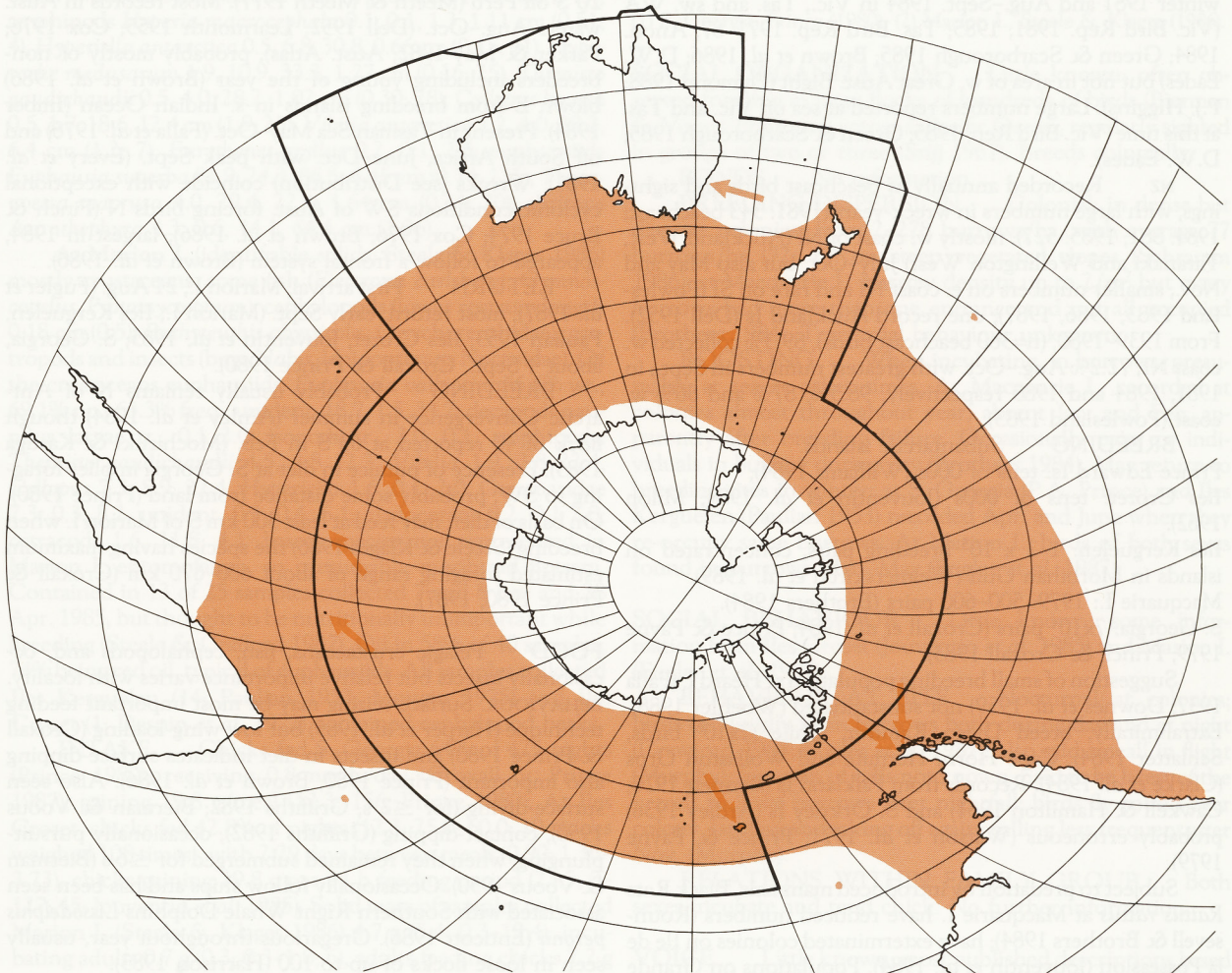
and *Acaena* herbfield (Schramm 1986). Low-altitude, coastal nest-sites subject to sea spray and heavy swell (Brothers 1984; Fugler *et al.* 1987).

In strong winds fly very low over waves where wind speed reduced, using upward air-currents on leeward side of waves for lift (Routh 1949).

On many breeding islands, numbers reduced and breeding distribution limited by predation of feral cats, rats and Wekas *Gallirallus australis* (Brothers 1984; Jouventin *et al.* 1984; Croxall *et al.* 1984). On Macquarie I., birds are particularly threatened because they remain in winter when other species not available for predators (Brothers 1984). At Prince Edward I., where no cats, burrows more widely distributed, in greater variety of habitats, and density higher than at Marion I., where there are cats (Fugler *et al.* 1987).

**DISTRIBUTION AND POPULATION** Circumpolar. Uncommon winter and spring visitor to Aust., NZ.

Some birds remain at breeding sites throughout year (e.g. Macquarie I., Brothers 1984). Ranges S to edge of pack-ice and N to 30°S; reaches 20°S in Humboldt Current off Peru in winter (Meeth & Meeth 1977). Recorded almost continually across s. Pacific Ocean in winter cruise, most s. record just N of Antarctic Convergence (Sziij 1967); however, not recorded s. Pacific Ocean in summer (Rogers 1980) nor off se. NZ, summer 1970 (Vooren 1973). To 1982, 14 specimen- and eight





sight-records accepted for South Africa; recorded Jun.–Dec. to 27°S (Every *et al.* 1981; Cooper 1982; Brooke 1983).

Until about 1950, regarded as rare straggler to seas and coasts of s. Aust. and NZ, with 14 records in Aust. of single beachcast specimens (Mordialloc, Vic.; Tas.; Port Willunga, SA; and 11 from sw. WA) (Dell 1952; Learmonth 1955; Green 1962) and 21 in NZ, mostly on NI (Dell 1952). Since then, increasing numbers of records (Learmonth 1955; Vic. Bird Rep. 1981–85; Powlesland 1983, 1986, 1987; D.W. Eades) show that the species is now quite regular, if not common, in s. Aust. and NZ waters. The apparent change in status must surely be due to increased observation by beach-patrols and pelagic tours.

**AUST.** Recorded from e. Gippsland, Vic., to Perth area, WA, but few records in Great Aust. Bight from Kangaroo I. to Esperance; recorded regularly in small numbers Vic. and Tas.; rarely N of 37°S on e. coast and not N of 32°S in SW; occurrences predominantly July–Sept. (Cooper 1970; Tas. Bird Rep. 1971–87; Vic. Bird Rep. 1981–85; Newman *et al.* 1984; McGarvie & Templeton 1974; Cox 1976; Parker & May 1982; Close 1982; Robinson 1971; Carpenter 1984 a, b; Serventy & Whittell 1976; D.W. Eades). Only NSW records: seven beachcast, 13–18 July 1954, between Maroubra and Coledale after cyclone, with two later in same year (Hindwood & McGill 1955); 2, Sydney area, 13–14 July 1973 (Finch & Bruce 1974; Rogers 1974). Spectacular wrecks reported in winter 1981 and Aug.–Sept. 1984 in Vic., Tas. and sw. WA (Vic. Bird Rep. 1981, 1985; Tas. Bird Rep. 1971–87; Anon. 1984; Green & Scarborough 1985; Brown *et al.* 1986; D.W. Eades) but not in area of w. Great Aust. Bight (Dymond 1988; P.J. Higgins). Large numbers reported at sea off Vic. and Tas. at this time (Vic. Bird Rep. 1985; Green & Scarborough 1985; D.W. Eades).

**NZ** Recorded annually as beachcast birds and sightings, with large numbers in wreck-years (1981: 343 beachcast; 1984: 881; 1985: 527); mostly w. coast of NI (Auckland West, Taranaki and Wellington West) July–Oct. but also May and Nov.; smaller numbers on e. coast NI and rare on SI (Powlesland 1983, 1986, 1987); one record Auckland Is (Dell 1952). From 1939–1980, (n=360 beachcast birds), 89.3% collected w. coast NI, 72.2% Aug.–Oct. with greatest numbers in Sept.; in 1981, 1984 and 1985 respectively, 98.5%, 87% and 86% w. coast (Powlesland 1983).

#### BREEDING Subantarctic islands.

Prince Edward Is: tens of 000s (Williams 1984);

Iles Crozet: tens of 000s (Jouventin *et al.* 1984; Milon 1962).

Iles Kerguelen: 1–2 x 10<sup>5</sup> breeding pairs, concentrated on islands in Morbihan Gulf (Weimerskirch *et al.* 1989).

Macquarie I.: 1979: 500–600 pairs (Brothers 1984).

S. Georgia: 7x10<sup>4</sup> pairs (Croxall *et al.* 1984; Prince & Payne 1979; Prince & Croxall 1983).

Suggestion of small breeding population at Heard I. (Falla 1937; Downes *et al.* 1959) not substantiated (Woehler 1988). Extraliminally, breed Diego Ramirez, Chile (2x10<sup>6</sup> birds, Schlatter 1984), Cape Horn, Hermite and Wollaston Grps (Clarke *et al.* 1984). Records from Falkland Is (Bennett 1926; Cawkell & Hamilton 1961) and S. Orkney Is (Ardley 1936) probably erroneous (Watson *et al.* 1971; Prince & Payne 1979).

Subject to predation by introduced mammals. Black Rats *Rattus rattus* at Macquarie I. have reduced numbers (Rounsevell & Brothers 1984); have exterminated colonies on Ile de la Possession (Jouventin *et al.* 1984). Populations on Grande

Terre (Iles Kerguelen) and Prince Edward Is threatened by feral cats (Weimerskirch *et al.* 1989; Fugler *et al.* 1987); House Mice on Marion I. apparently pose no threat (N. Klages). Plastic pellets found in stomachs (Ryan 1987). Sometimes fly into lights at night during misty conditions, particularly fledgelings (S. Hunter).

**MOVEMENTS** Status uncertain, timing of movements away from breeding grounds poorly documented and adults may be largely sedentary.

**DEPARTURE** Fledging reported Iles Kerguelen, late Feb.–early Mar. (Paulian 1953) but only few there 12 Feb. (Downes *et al.* 1959) with no adults 15 Feb. and an abandoned chick 17 Feb. (Falla 1937); mean fledging date Bird I., S. Georgia, 28–29 Jan. (22 Jan.–4 Feb.; Prince 1980; Hunter *et al.* 1982; Croxall & Prince 1987); Iles Crozet, 29 Jan.–7 Feb. (Jouventin *et al.* 1985), Marion I. 25 Jan.–14 Feb. (Fugler *et al.* 1987).

**NON-BREEDING** Adults may disperse only to adjacent waters. Pelagic surveys found petrels dispersed away from Iles Crozet, Feb. (Stahl *et al.* 1985) but at Iles Kerguelen pairs in burrows by day Apr.–May, declining June; from end of June–early Sept., adults absent (Paulian 1953). Similar pattern on Marion I. with last bird recorded 14 June (Fugler *et al.* 1987). At Macquarie I. adults occasionally return to nesting chambers throughout winter (Brothers 1984). Non-breeders move N from pack-ice in winter to about 30°S although up to 20°S off Peru (Meeth & Meeth 1977). Most records in Aust. waters Aug.–Oct. (Dell 1952; Learmonth 1955; Cox 1976; Parker & May 1982; Aust. Atlas), probably mostly of non-breeders including young of the year (Brown *et al.* 1986) blown E from breeding islands in s. Indian Ocean (Imber 1984). Present in Tasman Sea May–Oct. (Falla *et al.* 1978) and off South Africa, June–Dec. with peak Sept. (Every *et al.* 1981). Wrecks (see Distribution) coincide with exceptional cyclonic conditions SW of Aust. forcing birds N (Finch & Bruce 1974; Cox 1976; Brown *et al.* 1986); largest in 1984, appeared to follow a frontal system (Brown *et al.* 1986).

**RETURN** First arrival, Marion I., 21 Aug. (Fugler *et al.* 1987); most return, early Sept. (Marion I.; Iles Kerguelen, Paulian 1953; Iles Crozet, Jouventin *et al.* 1985; S. Georgia, about 4 Sept., Croxall & Prince 1980).

**BREEDING** Probably usually remains N of Antarctic Convergence in summer (Ainley *et al.* 1984) though flock of 40 reported at 63°S in Feb. (Mochizuki & Kasuga 1985). Presence of pumice in diet at S. Georgia implies foraging to SW, probably some distance from land (Prince 1980). On basis of diet, may feed at least 300 km S of Marion I. when breeding (Steele & Klages 1986) the species having maximum estimated foraging range of about 600–670 km (Croxall & Prince 1980, 1987).

**FOOD** Pelagic crustaceans, fish, cephalopods and, occasionally insects but relative importance varies with locality. **BEHAVIOUR.** Surface-seizing may be most important feeding technique (Harper *et al.* 1985) but low wing-loading (Croxall & Prince 1980) and insects in diet indicates surface-dipping also important (Prince 1980; Brown *et al.* 1986). Also seen surface-diving (for  $\leq 2$  s, Griffiths 1982; Bierman & Voous 1950), contact-dipping (Griffiths 1982), occasionally pursuit-plunging, when they remained submerged for  $\leq 6$  s (Bierman & Voous 1950). Occasionally follow ships and has been seen associated with Southern Right Whale Dolphins *Lissodelphis peronii* (Enticott 1986). Gregarious throughout year, usually seen in loose flocks of up to 100 (Harrison 1983).



**NON-BREEDING** Live birds sampled S. Sandwich Is. (six stomachs; Bierman & Voous 1950) contained crustaceans euphausiids 67% freq., cephalopods 33 as did others sampled by Murphy. Birds beachcast in Vic., 1984 (45 gizzards; Brown *et al.* 1986) contained insects ( $3.3 \pm 5.0$  per gizzard): bugs *Oechalia schellenbergii* 24, other Pentatomidae 9; beetles Carabidae 24% freq., *Adoryphorus couloni* 20, other Scarabaeidae 11, *Copelatus australiae* 4, *Lancetes lanceolatus* 4, *Eretes australis* 22, other Dytiscidae 2, *Berosus* 2, other 2; lepidopterans Noctuidae 2, other 2; hymenopterans 7; fish otoliths 7; cephalopods (lenses 22, beaks 22 [Sepiidae 2, Gonatidae 7, Histiotteuthidae 2]); plant remains (*Cakile maritima* seeds 7). **Tas.** casualties (same wreck; Green & Scarborough 1985) also contained some beetles *Adoryphorus couloni* as well as cephalopod beaks. Insects, largely of freshwater origin, may have been taken near coast by starving birds just before death (Brown *et al.* 1986) but see below. Birds beachcast NZ (27; Reed 1981) contained cephalopod beaks 93% freq., kowhai seed 4; a few had vegetable matter.

**BREEDING** Summarized Tables 1 and 2. At **Bird I., S. Georgia** (Prince 1980) oil 38.6% wt., unidentified food 33.4, identified 28.0. If unidentifiable solids all fish (Prince & Morgan 1987), diet largely fish (small Myctophidae and Nototheniidae) with most of remainder crustaceans and cephalopods (*Psychroteuthis*). Of crustaceans copepods 1.4% wt., 13.4% no., 1.9% freq.: *Calanoides acutus*, *Rhincalanus gigas*; mysidaceans *Antarctomysis maxima* 3.5, 4.7, 10.9, 2.84 cm (0.44; 43); amphipods *Hyperia macrocephala* 0.1, 0.1, 1.3, 1.11 cm (0.51; 4), *Hyperiella antarctica* 0.5, 6.8, 30.8, 0.66 cm (0.15; 41), *Hyperoche medusarum* 1.9, 10.9, 33.3, 1.27 cm (0.16; 25), *Themisto gaudichaudii* 0.5, 4.0, 28.2, 1.02 cm (0.30; 28), *Cyolopus lucasii* 0.5, 1.7, 18.6, 12.4 cm (1.9; 23), *Vibilia antarctica* 1.2, 4.0, 28.2, 6.4 cm (1.2; 7), *Eurythenes gryllus* 0.2, 0.1, 2.6; euphausiids *Euphausia superba* 81.9, 24.3, 86.5, 4.45 cm (0.74; 135), *Thysanoessa macrura* 4.0, 29.4, 22.4, 1.64 cm (0.24; 30); shrimps *Acanthephyra* 4.3, 0.6, 14.1, 64.4 cm (1.06).

At **Marion I.** (identifiable solids; Steele & Klages 1986) mostly crustaceans, some fish (*Electrona carlsbergi*, *Gymnoscopelus*, *Protomyctophum*), cephalopods (lower rostrum length 0.18 cm (0.5); *Bathyteuthis abyssicola*, Onychoteuthidae), gastropods and insects (bugs *Nabis*, lepidopterans Noctuidae). Of the crustaceans euphausiids: *Euphausia vallentini* 56.6% wt., 69.1% no., 63.3% freq.; unident. 18.7, 1.5, 34.7; decapods nauplius larvae tr., 0.1 2.0; isopods tr., 2.0, 0.1; amphipods: *Themisto gaudichaudii* 4.5, 4.8 12.2, *Vibilia* 1.9, 2.8 22.4, *Cyolopus* 7.3, 8.9, 22.4, *Hyperiella* 1.6, 0.1, 2.0, Gammaridae 7.3, 0.3, 8.2, unident. 0.3, 0.4, 6.1; cladocerans 0.2, 0.1 2.0; ostracods 1.6, 11.8, 4.1. Insect species not represented in Marion I. entomofauna, so presumably moribund flotsam. Contained in 13 of 25 samples collected 7 and 8 Jan. and 28 Apr. 1985, but thought to be nutritionally unimportant while breeding (Steele & Crafford 1987). Oil in 58% of 40 samples, 74% being red oil, typical of euphausiids. All samples collected Iles Kerguelen (14; Paulian 1953; Mougouin 1975) and Iles Crozet (1; Despin *et al.* 1972) contained cephalopod beaks.

**INTAKE** Chicks fed S. Georgia 64% of 425 nights (Prince 1980), receiving 0.8 meals/day (Croxall & Prince 1987), gaining 19.8 g/meal (12.3; 156; Prince 1980). At Iles Crozet, chicks fed 42.8% of nights (12.3; 25.0–60.0; 10 chicks weighed 108 times), with 2.29 days between meals (0.90; 1.36–3.73), chicks gaining 29.8 g per 24 h feeding period (23.5; 0–127; 45; Jouventin *et al.* 1985). Solid mass of samples collected Marion I. (Steele & Klages 1986) 4.7 g (5.4; 0.3–19.4): incubating adults 0.7 g (0.3; 0.3–1.0; 6), adults feeding chicks 7.2 g

(5.4; 0.5–19.4; 34). Oil vol. 1.0 ml (1.2; tr.–5.0).

**Table 1.** Breeding diet of the Blue Petrel.

	%wt. %no.		% freq.	
	1	2	2	1 2
FISH	58.5	21.2	3.4	83.3 53.1
CRUSTACEANS	41.2	59.5	92.1	97.4 100.0
CEPHALOPODS	0.3	15.7	1.5	6.4 34.7
GASTROPODS	—	tr.	0.1	— 2.0
INSECTS	—	3.6	2.9	— 26.5

(1) S. Georgia, n=156, Prince (1980); (2) Marion I., n=49, Steele & Klages (1986).

**Table 2.** Crustaceans in breeding diet of Blue Petrel.

	%wt.		% no.	
	1	2	1	2
EUPHAUSIIDS	85.9	75.3	63.7	70.6
AMPHIPODS	4.9	22.9	27.6	17.3
DECAPODS	4.3	tr.	0.6	0.1
OTHER	4.9	1.8	18.1	13.9
UNIDENTIFIED	—	—	4120	1393

(1) S. Georgia, Prince (1980); (2) Marion I., Steele & Klages (1986).

**SOCIAL ORGANIZATION** Little known; often observed foraging in large flocks of hundreds of birds (Bierman & Voous 1950) and, across s. Pacific Ocean, regularly sighted in groups of two or three (Sziij 1967). Breeds colonially.

**BONDS** No information.

**BREEDING DISPERSION** Colonial; in dense but discrete colonies, from 2–278 burrows/ha, with average 77 burrows/ha (72; 13) on steep vegetated slopes (Schramm 1986); at Macquarie I., burrow density up to 2/m<sup>2</sup> but many burrows had more than one entrance and not all occupied (Brothers 1984). Territorial behaviour unknown.

**ROOSTING** When incubating, in burrows; presumably at sea at other times. At Macquarie I., recorded at colonies almost throughout year, absent Jan. and Feb. apparently after breeding failure. Occasionally pairs or individuals in burrow during day (Brothers 1984). May return to breeding sites in winter: at S. Georgia (P.A. Prince) and Iles Kerguelen (Paulian 1953) recorded Apr. and June when they re-occupy same burrows. At Marion I., birds of both sexes found in burrows Mar.–May (Fugler *et al.* 1987).

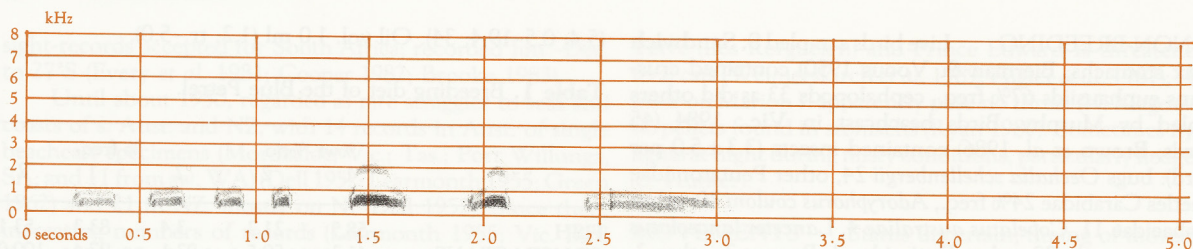
**SOCIAL BEHAVIOUR** Little known; some information from Iles Crozet (Jouventin *et al.* 1985) and Marion I. (Fugler *et al.* 1987).

**BEHAVIOUR AT SITE** Nocturnal at colonies; birds call loudly from burrows both during day and at night (Crawford 1952; Fugler *et al.* 1987); also said to call in flight (Murphy); function of calls not known. Said to be latest of the petrels to leave burrows after nightfall; birds fly round over colony, landing and taking off again; calling less frequent after Nov. (Murphy).

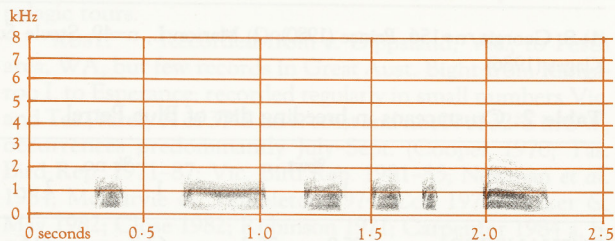
**RELATIONS WITHIN FAMILY GROUP** Both sexes incubate and tend chick. No further information.

**VOICE** Little known; most published descriptions based





A D. Turner; Bird I., S. Georgia, Dec. 1973; C129



B Recordist unknown; B1005

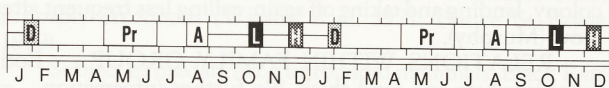
on Eaton (1879) and Murphy. Apparently silent at sea; noisy at breeding colonies at night, calling in flight and from burrows (Murphy; Crawford 1952; Fugler *et al.* 1987); but said to be usually quiet in flight over colony; at Marion I., call continuously in Apr. (Rand 1954). No detailed information on the nature of calls; characteristic, pigeon-like cooing reported, similar to calls of prions; however, Eaton states that while calls of Blue Petrel and prions similar, the flight call is distinctly different; reported as chirping loudly in burrows (Crawford 1952). At Iles Kerguelen, call less often after Nov. (Murphy). No information on sexual differences, individual differences or geographical variation.

**ADULT** Call said to resemble cooing of pigeons *kuk-kuk-kuk coo-coo* (Murphy); see sonagrams A and B, function of calls unknown. Reported as Chirping in burrows (Crawford 1952).

**YOUNG** No information.

**BREEDING** Not very well known. Information from Iles Kerguelen (Paulian 1953), Marion I. (Rand 1954; Fugler *et al.* 1987), Iles Crozet (Jouventin *et al.* 1985) and S. Georgia (P.A. Prince). Information supplied by P.A. Prince. Breeds in simple pairs, colonially.

**SEASON** At Iles Kerguelen and S. Georgia, after chicks fledge in late Jan.–early Feb. birds depart; return to burrows late Apr.–late June (P.A. Prince); then absent till Sept. when pairs return; pre-laying exodus in early to mid-Oct. when birds no longer in burrows by day and little calling at night; then mated pair in burrow till laying (Murphy). At Iles Crozet and Marion I., total absence mid-Feb. to mid-Mar. for moult; return Apr. to 14 June at latest and again absent till first return 21 Aug. with bulk in Sept.; laying 19–27 Oct.; fledging and departure late Jan. to early Feb.



(S. Georgia)

(Pr - present in breeding area)

**SITE** At Marion I., on slopes below 500 m asl; in herbfield of *Cotula plumosa* on lower seaward-facing slopes in spray-zone and in *Poa cookii* tussock grassland higher and on slopes facing away from sea. Manuring by birds promotes luxuriant growth, which is a good indicator of burrowing areas. At Bird I., S. Georgia, in dense tussock grassland on slopes usually of 10–40° gradient but favouring flatter ground than prions *Pachyptila* spp.

**NEST, MATERIALS** In burrows, 15–37 cm below surface, about 6 cm in diameter (Murphy), varying in length from 30 to 100 cm (200 cm at Iles Kerguelen) and ending in nest-chamber c.18x18 cm. At Marion I., nest-chamber 115 mm high (10; 80–150; 10) x 151 mm wide (21; 120–260); burrow distinguishable by having entrances larger than those of Lesser Broad-billed Prions *Pachyptila salvini*. At S. Georgia, aspects of burrows predominantly SW to N (I. Hunter, BAS). Nest merely a shallow depression in peat but at Iles Kerguelen, chamber said to be lined with fibres, leaves or twigs (Murphy). Birds excavate own burrows, both members of pair co-operating. At Marion I., on steep vegetated slopes, mean density 77 ± 254 burrows/ha; densities highest in *Cotula* herbfield (189 ± 162 burrows/ha), lower in *Poa* tussock grassland (105 ± 317 burrows/ha) and *Acæna* herbfield (23 ± 119 burrows/ha); 5488 burrows estimated in 71 ha of steep vegetated slopes, 596 in 397 ha of vegetated lava hummocks (Schramm 1986). At S. Georgia, in optimum habitat, density of occupied burrows reached 2.5/10 m<sup>2</sup>, of all burrows 4.7/10 m<sup>2</sup>; highest density 7.2 burrows/10 m<sup>2</sup> (I. Hunter, BAS). Over whole breeding area at Bird I. density was 2.7/10 m<sup>2</sup> but only 1.4/10 m<sup>2</sup> occupied. At Macquarie I., on offshore stacks, density 2/m<sup>2</sup> (Brothers 1984).

**EGGS** Varying in shape but generally ovate; finely granular surface; white, often becoming soiled.

**MEASUREMENTS:**

Marion I.: 51.6 (1.9; 48.0–56.5; 86) x 37.8 (1.0; 34.4–40.2) (Fugler *et al.* 1987)

Iles Crozet: 51.1 (1.4; 48.5–54.5; 21) x 37.7 (1.0; 35.5–39.1) (Jouventin *et al.* 1985).

Iles Kerguelen: 52.2 (2.1; 50–54; 3) x 36.8 (2.0; 35–39.5) (Paulian 1953);

S. Georgia: 51.3 (1.2; 49.0–54.6; 20) x 37.7 (2.1; 31.3–39.4) (P.A. Prince);

**WEIGHTS:**

Marion I.: fresh, 42.0 (3.5; 38.1–47.2; 5) (Fugler *et al.* 1987)

Iles Crozet: 38.3 (2.6; 33–43; 20) or 17.6% of ad. weight (Jouventin *et al.* 1985).

S. Georgia: 36.3 (27.7; 31.1–41.5; 18) in late Nov. (P.A. Prince).

Last two sets of weights no doubt include incubated eggs.

**LAYING** Well synchronized. At Marion I., mean 23 Oct. (2.2 days; 19–27 Oct; 18); at Iles Crozet, 27 Oct. (2 days;



23–31 Oct.; 23); at Iles Kerguelen, peak laying 30 Oct.–2 Nov. but Kidder (1875) saw first young on 12 Nov., which meant laying in Sept.; at S. Georgia, mean laying c. 28 Oct., calculated from mean fledging date (P.A. Prince); at Iles Crozet, in 23 nests, five females returned on night of laying, 13 on night before laying and five two nights before laying (Jouventin *et al.* 1985).

**INCUBATION** By both sexes; female takes first shift; male and female then alternate; at Iles Crozet, six shifts in all; mean length of shift, 7.8 days (3.2; 1–16; 34); for females 6.8 days (3.2; 1–11; 19); for males 8.9 days (2.9; 4–16; 15). On average, eggs deserted twice during incubation (0.8; 1–3; 4) for period of 2.9 days (1.9; 1–5; 8) each; total time of desertion 5.6 days (1.7; 4–8; 4) (Jouventin *et al.* 1985). At S. Georgia, excluding first and last shifts, mean number of shifts c. 9, mean duration c. 5 days (Croxall 1984). Hatching: at Marion I., 9 Dec. (2.9 d; 84); at Iles Crozet, 18 Dec. (1 d; 16–20 Dec.; 8); at Iles Kerguelen, c. 17 Dec.; at S. Georgia, 12 Dec. (2 days; 8–16 Dec.; 10). Usually two days from pipping to hatching (P.A. Prince). **INCUBATION PERIOD:** at Marion I., 49 days (2.0; 47–52; 7); at Iles Crozet, from laying to hatching, 52 days (n=1) but period of actual incubation 46 days (n=1); at Iles Kerguelen and S. Georgia, 45–47 days (each n=1).

**YOUNG** Semi-altricial, nidicolous. At hatching, 33.3 g (30–36; 3); covered in blue-grey protoptile, which later grows out and replaced by lighter-grey mesoptile; bill, black with prominent white egg-tooth, which usually disappeared by 7 days old. Brooded for c. 3 days but at three nests deserted after only 24 h (P.A. Prince); thermoregulation attained usually a few hours after hatching (Jouventin *et al.* 1985). Departure at all localities given as about 20 Jan. to 14 Feb. but at Iles Kerguelen said to be late Feb. to early Mar. (Paulian 1953), which seems unlikely given laying and hatching dates. **NESTLING PERIOD:** at Marion I., 53 days (2.5; 48–60; 41); at Iles Crozet, 43 days (n=2); at S. Georgia, 47 days (4; 11). Fed by both parents at regular intervals but not necessarily every night (0.8 meals/day and c. 35 g/day received) (P.A. Prince). At Iles Crozet, throughout nestling period, parents visited on average 42.8% of nights (12.3; 25–60; 108) at intervals of 2.29 days (0.5; 1.36–3.73), more often before than after peak in weight of young (Jouventin *et al.* 1985).

**GROWTH** At S. Georgia, chicks attain peak weight of 275 g at c. 40 days old; fledge 7–8 days later, when 26% lighter. Chicks grow particularly rapidly, fledging as quickly as Antarctic Prion *P. desolata* though heavier in mass. Asymptote weight, 290 g; growth constant ( $K_L$ ), 0.136;  $t_{10}$ – $t_{90}$ , 33 d; mean daily weight gain, 7.2 g or 2.61% of asymptote weight (Croxall 1984; P.A. Prince). At Marion I., peak mass c. 210 g at c. 40 days old, declining until fledging. More details of growth in Fugler *et al.* (1987).

**SUCCESS** At Marion I., 17 eggs laid, 11 hatched, four young fledged for total success of 24%. In 124 other nests, followed from part way through incubation, 47 eggs and 36 chicks lost for total success of 33%; most eggs disappeared or did not hatch (37/47); young disappeared (18), starved or died of cold, disease, ticks (9) or were lost to skuas *Catharacta* spp. House Mice *Mus musculus* may have taken some eggs or chicks. At Macquarie I., probably few chicks fledge, being taken by Black Rats *Rattus rattus* and skuas (Brothers 1984; Rounsevell & Brothers 1984); Skuas also dig up burrows. At Iles Crozet, heavy predation by skuas on chicks (Despin *et al.* 1972). At all breeding sites skuas take adults. Giant-petrels *Macronectes* spp take adults at sea (Hunter 1983; S. Hunter).

## PLUMAGES

**ADULT** Age of first breeding unknown. **HEAD AND NECK.** In fresh plumage: forehead, anterior of lores, and outer margin of forecrown, white. Rest of forecrown, dark brown (119A), narrowly fringed white. Rest of crown, grey-black (c82); rachis, dark brown (119A); concealed feather bases, white. Sub-orbital patch and posterior of lores, grey-black (82); proximal outer margins of sub-orbital patch, white with narrow dark-grey (83) tips; ear-coverts, dark-grey (83), narrowly tipped white. Entire foreneck, including interramal space, white, except outer margins of lower neck, dark-grey (83). Malar area, white; extends to posterior of ear-coverts. Hindneck, grey (84); concealed feather bases, white. **UPPER PARTS.** Mantle and back, grey (84); on lower back, feathers narrowly tipped dark-grey (83); form central part of indistinct darker M-mark, continuous with upperwing; rachis, thin, black brown (119). Rump, similar to mantle; rachis, dark grey (83); outermost feathers, white mottled light grey (85) and pale grey (86). Scapulars, small and rounded; uppermost similar to mantle, lowermost, progressively bigger, dark grey (83) and broadly tipped white; webs on lowermost often have pale dark-brown (121) shade. Upper tail-coverts, dark grey (83); longest with faint black-brown (119A) shade at distal tip; this portion of feather overlies dark tail-band. **TAIL,** grey (84), merging to dark-brown (121) near tips; at distal tip, white webs form moderately wide band, c. 12 mm wide. Width of band varies; average width in males 12.7 mm (1.93; 19); in females, 13.3 (2.43; 22) (Brown *et al.* 1986). T1–t3 have this white band, slight on t4; rachis, dark brown (121) on t4, dark brown (221) with white tip on t1–t3; t5, grey (84), inner web basally mottled white; t6 also grey (84); tip of outer web and basally on inner, mottled light grey (85); rachis, dark brown-grey (79). **UPPER-WING.** Outer web of p10, narrow, c. 1 mm wide near tip; rachis, dark brown (219). Outer webs of p10–p7, black brown (c119); inner, white, faintly mottled light grey (85) near shaft. P7–p1, grey (84); mottling sparse towards tips. P7–p1, narrowly tipped white. Greater coverts, black-brown (119); innermost narrowly tipped white. Alula and marginal coverts, dark brown (121); marginal coverts, narrowly fringed grey (83). Lesser coverts, dark brown (121); rachis, grey black (82). Median coverts, grey (84), narrowly fringed pale grey (86); rachis, grey-black (82). Greater coverts, similar but tipped white; rachis, pale grey-black (82). Longest tertials, similar to scapulars, broadly tipped white. Inner webs of remiges, white, mottled grey (85). **UNDERPARTS,** almost entirely white. Outer breast, dark grey (83), forming half-collar. Demarcation with white underparts, sharp; at borders, feathers mottled pale grey (86). Axillaries, mostly white; longest feathers, finely mottled light grey (85) on webs; rachis, white, brown-grey (80) near mottled areas. **UNDERWING.** Most coverts, white. Outermost median coverts, dark brown (121) on outer webs, white on inner. Marginals, from p11 to carpal joint, dark brown (121), narrowly fringed white; inner webs, white, mottled light grey (85). In worn plumage, white fringes on forehead largely lost. White tips on outer primaries, greater coverts and scapulars, either lost or reduced. A dark-brown (121) shade to scapulars and greater upper wing-coverts.

**DOWNY YOUNG** At S. Georgia, first down, blue grey; second down, lighter grey (P.A. Prince); down on a fledgeling recorded as pale mouse-grey (Falla 1937).

**JUVENILE** Described as slightly brownish with ashy forehead (Watson 1975).

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



**ADULT, JUVENILE** Iris, black-brown (119). Bill, grey-black (82); latericorn with slight violet (170B) shade. Bill described as olive-black with pale bluish edge on tomium of latericorn (Falla 1937); mandibular rami of lower mandible recorded as bluish or pinkish (Bierman & Voous 1950). Tarsus and inner toes, pale light-blue (170D). Outer toe and distal margin of webs, dark-brown (121); rest of webs, pink-brown (221D).

**DOWNY YOUNG** Bill, black (P.A. Prince).

**MOULTS** Based on Bierman & Voous (1950), except where stated.

**ADULT POST-BREEDING** Begins towards end of breeding season, when advanced young being fed. Specimens in Jan. in advanced moult of body-feathers and remiges; moult of secondaries and greater upper wing-coverts recorded as early as 22 Dec. Up to three innermost primaries shed at one time; primaries moult outwards. A young female recorded as having centripetal tail moult, recorded during Dec. and Jan. when breeding. Birds, returning to Bird I., S. Georgia, in early May in fresh plumage suggest late Feb.-Mar. as likely moult period (P.A. Prince). One beachcast bird collected June-Sept. had pin feathers on rump and upper breast. Beachcast wings (July, Aug.), growing primaries; replacement of upper wing-coverts follows sequence: greater, median, lesser, as indicated by two specimens found in July. Skins from Macquarie I. at MV (n=11), showed no moult Sept.-Oct. (Brown *et al.* 1986). Full details of feather wear for beachcast birds, given in Brown *et al.* (1986).

**POST-JUVENILE** No data.

**MEASUREMENTS** (1) S. Georgia, adults, live (P.A. Prince); (2) Prince Edward Is, adults, live (A. Berruti); (3) S. Georgia, juveniles (P.A. Prince); (4) Macquarie I., adults, live; minimum chord (Brothers 1984); (5) Marion I. (Rand 1954); (6) Iles Kerguelen (Falla 1937); (7) Iles Kerguelen (Paulian 1953); (8) Vic., adults, beachcast (Brown *et al.* 1986); (9) Macquarie I., adults, skins (MV).

	(9) 216.6 (1.24; 215-218; 3)	216.0 (2.44; 213-220; 5)
8TH P	(9) 139.6 (2.86; 136-143; 3)	142.6 (3.55; 136-146; 5)
TAIL	(5) 81.0 (79-91; 13)	87.0 (77-90; 10)
	(6) 90, 93	90.0 (87-95; 3)
	(8) 87.7 (3.87; 19)	89.4 (4.38; 22)
	(9) 86.6 (1.88; 84-88; 3)	84.6 (1.85; 82-87; 5)
BILL	(5) 27.0 (25-28; 13)	26.0 (25-27; 10)
	(6) 25, 26	25.0 (24-27; 3)
	(7) 27.0 (26-28; 12)	25.0 (25.5-26; 25)
	(8) 27.0 (0.88; 19)	26.7 (0.75; 22)
	(9) 26.4 (0.33; 26-26.8; 3)	25.7 (1.18; 23.6-26.9; 5)
BILL W	(8) 10.7 (0.44; 19)	10.5 (0.61; 21)
BILL D	(8) 10.7 (0.44; 19)	10.5 (0.61; 21)
THL	(8) 68.2 (1.57; 19)	67.5 (2.49; 21)
TARSUS	(5) 31.0 (29-33; 13)	31.0 (29-33; 10)
	(6) 30, 31	32.0 (30-33; 3)
	(7) 32.0 (30-33; 12)	30.5 (28-32; 4)
	(8) 34.3 (0.95; 19)	34.2 (0.86; 22)
	(9) 34.1 (0.57; 33.4-34.8; 3)	32.9 (0.76; 31.9-33.9; 5)
TOE	(8) 41.9 (1.58; 18)	41.0 (1.88; 22)
	(9) 43.9 (0.26; 43.6-44.2; 3)	43.3 (1.09; 42.3-45.3; 5)

Additional measurements in Bierman & Voous (1950), Oliver, Fugler *et al.* (1987) and Jouventin *et al.* (1985).

**WEIGHTS** (1) Vic., beachcast birds (Brown *et al.* 1986); (2) S. Georgia, adults (P.A. Prince); (3) Prince Edward Is, adults (A. Berruti); (4) S. Georgia, juveniles (P.A. Prince).

	MALES	FEMALES
	(1) 134.0 (16.49; 18)	124.4 (10.47; 21)
	UNSEXED	
	(2) 187.0 (18.6; 152-244; 108)	
	(3) 206.6 (17.5; 163-251; 75)	
	(4) 177.1 (12.3; 158-198; 29)	

Jouventin *et al.* (1985) provide a summary of adult weights for Iles Crozet.

**STRUCTURE** Wing, short and pointed; wing-loading, 364.7 (sd=13.3) (Brown *et al.* 1986). Eleven primaries; p10 longest, p9 2-4 mm shorter, p8 9-14, p7 21-29, p6 35-45, p5 50-60, p4 67-78, p3 85-97, p2 101-113, p1 116-125, p11 minute. No emarginations. Tail, square; 12 rectrices, t1 longest, t6 3-7 mm shorter. Bill, slender; maxillary unguis, hooked at tip. Latericorn slightly bowed. Middle claw long and curved; slight sharp ridge on inner side. Nostrils point upwards; 14% of bill length. Outer and middle toes about equal, inner c. 80% of middle, hind, claw only c. 10%.

RMO

#### REFERENCES

- Ainley, D.G., E.F. O'Connor & R.J. Boekelheide. 1984. *AOU orn. Monogr.* 32.  
 Anon. 1984. *WA Bird Notes* 31: 1.  
 Ardley, R.A.B. 1936. *Discovery Repts* 12: 349-76.  
 Bennett, A.G. 1926. *Ibis* 306: 333.  
 Bierman, W.H. & H.J. Voous. 1950. *Ardea* 37 Suppl.: 1-123.  
 Brooke, R.K. 1983. *Cormorant* 11: 67.  
 Brothers, N.P. 1984. *Aust. Wildl. Res.* 11: 113-31.  
 Brown, R.S., F.I. Norman & D.W. Eades. 1986. *Emu* 86: 228-38.  
 Carpenter, G. 1984a. *S. Aust. Orn. Assoc. Newsl.* 111: 9-12.  
 Carpenter, G. 1984b. *S. Aust. Orn. Assoc. Newsl.* 112: 6-10.  
 Cawkell, E.M. & J.E. Hamilton. 1961. *Ibis* 103A: 1-27.  
 Clarke, G.S., A.J. Goodwin & A.P. von Meyer. 1984. *Notornis* 31: 320-4.

	UNSEXED	
WING	(1) 221.3 (4.3; 208-230; 34)	
	(2) 217.2 (5.8; 198-233; 75)	
	(3) 220.3 (5.1; 211-228; 30)	
	(4) 216.4 (5.18; 205-228; 133)	
TAIL	(1) 87.2 (3.7; 81-94; 34)	
	(2) 91.6 (3.0; 88-89; 75)	
	(3) 89.0 (4.0; 82-96; 30)	
	(4) 88.2 (4.03; 81-97; 133)	
BILL	(1) 26.3 (1.4; 23.9-27.8; 34)	
	(2) 26.6 (1.3; 22-29.5; 75)	
	(3) 26.6 (0.97; 24.7-28.8; 30)	
	(4) 26.1 (2.99; 21.9-29.1; 133)	
BILL W	(4) 10.7 (0.57; 9.1-12.2; 133)	
TARSUS	(1) 33.8 (1.1; 31.9-35.9; 34)	
	(2) 34.5 (1.2; 31.3-37.1; 75)	
	(3) 34.6 (0.93; 32.7-36.5; 30)	
	(4) 32.6 (1.03; 29.5-35; 133)	
TOE	(4) 41.3 (1.49; 36.2-46; 133)	
	MALES	FEMALES
WING	(5) 213.0 (205-221; 13)	213.0 (206-218; 10)
	(6) 220, 222	215.0 (208-223; 10)
	(7) 217.0 (210-221; 12)	216.0 (211-221; 4)
	(8) 220.4 (4.52; 19)	219.4 (5.17; 22)



- Close, D.H. 1982. *S. Aust. Orn.* 28: 210-13.
- Cooper, R.P. 1970. *Aust. Bird Watcher* 3: 239-45.
- Cooper, J. 1982. *Cormorant* 10: 55.
- Cox, J.B. 1976. *S. Aust. Orn.* 27: 26-82.
- Crawford, A.B. 1952. *Emu* 52: 73-85.
- Croxall, J.P. (Ed.) 1987. *Seabirds: Feeding Ecology and Role in Marine Ecosystems*.
- Croxall, J.P., 1984. Pp. 553-618. In: *Laws* 1984.
- Croxall, J.P., & P.A. Prince. 1980. *Biol. J. Linn. Soc.* 14: 103-31.
- Croxall, J.P., & P.A. Prince. 1987. Pp. 347-68. In: *Croxall* 1987.
- Croxall, J.P., P.A. Prince, I. Hunter, S.J. McInnes & P.G. Copestake. 1984. *ICBP Tech. Publ.* 2: 637-66.
- Dell, R.K. 1952. *Emu* 52: 147-54.
- Despin, B., J.L. Mouglin & M. Segonzac. 1972. *Com. nat. fr. Rech. antarct.* 31:1-106.
- Downes, M.C., E.H.M. Ealey, A.M. Gwynn, & P.S. Young. 1959. *ANARE Rep.* (B) 1.
- Dymond, N. 1988. *RAOU Rep.* 38: 13-66.
- Eaton, A.E. 1879. *Phil. Trans. Roy. Soc. Lond.* 168: 101-62.
- Enticott, J.W. 1986. *S. Afr. J. Antarct. Res.* 16: 25-8.
- Every, B., L.W. Hosten & R.K. Brooke. 1981. *Cormorant* 9: 19-22.
- Falla, R.A. 1937. *Rep. BANZ Antarctic Research expeditions* (B) 2: 1-288.
- Falla, R.A., R.B. Sibson & E.G. Turbott. 1978. *The New Guide to the Birds of New Zealand*.
- Finch, B.W. & M.D. Bruce. 1974. *Aust. Birds* 9: 32-5.
- Fugler, S.R., S. Hunter, I.P. Newton & W.K. Steele. 1987. *Emu* 87: 103-10.
- Green, R.H. 1962. *Emu* 62: 215.
- Green, R.H. & T. Scarborough. 1985. *Tas. Nat.* 81: 1-2.
- Griffiths, A.M. 1982. *Cormorant* 10: 9-14.
- Harper, P.C., J.P. Croxall & J. Cooper. 1985. *BIOMASS Handbook* 24: 1-22.
- Harrison, P. 1983. *Seabirds: An Identification Guide*.
- Hindwood, K.A. & A.R. McGill. 1955. *Emu* 55: 154.
- Hunter, I., J.P. Croxall & P.A. Prince. 1982. *Br. Antarct. Surv. Bull* 56: 49-67.
- Hunter, S. 1983. *J. Zool., Lond.* 200: 521-38.
- Imber, M.J. 1984. *Notornis* 31: 89-91.
- Jouventin, P., J-C. Stahl, H. Weimerskirch & J-L. Mouglin. 1984. *ICBP Tech. Publ.* 2: 609-25.
- Jouventin, P., J-L. Mouglin, J-C. Stahl & H. Weimerskirch. 1985. *Notornis* 32: 157-220.
- Kidder, J.H. 1875. *Bull. US Natn. Mus., Ornith.* 1(2): 1-47.
- Laws, R.M. (Ed.) 1984. *Antarctic Ecology*.
- Learmonth, N.F. 1955. *Emu* 55: 99-104.
- Lindsey, T.R. 1986. *The Seabirds of Australia*.
- McGarvie, A.M. & M.T. Templeton. 1974. *Emu* 74: 91-6.
- Meeth, P. & K. Meeth. 1977. *Ardea* 65: 90-1.
- Milon, P. 1962. *TAAF, Paris* 19-20: 30-32.
- Mochizuki, H. & I. Kasuga. 1985. *Trans. Tokyo Univ. Fish.* 6: 155-65.
- Mouglin, J.L. 1975. *Com. nat. fr. Rech. Antarct.* 36: 1-195.
- Newman, O.M.G., R.M. Patterson & W.C. Wakefield. 1984. *Tas. Bird Rep.* 13: 3-14.
- Parker, S.A. & I.A. May. 1982. *S. Aust. Orn.* 28: 213-16.
- Paulian, P. 1953. *Mem. Inst. scient. Madagascar* (A) 8: 111-234.
- Powlesland, R.G. 1983. *Notornis* 30: 125-35.
- Powlesland, R.G. 1986. *Notornis* 33: 171-84.
- Powlesland, R.G. 1987. *Notornis* 34: 237-52.
- Prince, P.A. 1980. *J. Zool., Lond.* 190: 59-76.
- Prince, P.A. & J.P. Croxall. 1983. *Br. Antarct. Surv. Bull.* 59: 15-27.
- Prince, P.A. & M.R. Payne. 1979. *Br. Antarct. Surv. Bull.* 48: 103-18.
- Prince, P.A. & R.A. Morgan. 1987. Pp. 135-71. In: *Croxall* 1987.
- Rand, R.W. 1954. *Ibis* 96: 173-206.
- Reed, S. 1981. *Notornis* 28: 239-40.
- Robinson, R.D. 1971. *S. Aust. Orn.* 26: 18-22.
- Rogers, A.E.F. 1974. *Birds* (J. NSW FOC) 8: 97-119.
- Rogers, A.E.F. 1980. *Notornis* 27: 69-78.
- Rounsevell, D.E. & N.P. Brothers. 1984. *ICBP Tech. Publ.* 2: 587-92.
- Routh, M. 1949. *Ibis* 91: 577-606.
- Ryan, P.G. 1987. *Mar. Environ. Res.* 23: 175-206.
- Schlatter, R.P. 1984. *ICBP Tech. Publ.* 2: 261-69.
- Schramm, M. 1986. *Polar Biol.* 6: 63-70.
- Serventy, D.L. & H.M. Whittell. 1976. *Birds of Western Australia*.
- Siegfried, W.R., P.R. Condy & R.M. Laws (Eds) 1985. *Antarctic Nutrient Cycles and Food Webs*.
- Stahl, J.C., P. Jouventin, J.L. Mouglin, J.P. Roux & H. Weimerskirch. 1985. Pp. 478-86. In: *Siegfried et al.* 1985.
- Steele, W.K. & J.E. Crafford. 1987. *Cormorant* 15: 93-4.
- Steele, W.K. & N.T. Klages. 1986. *S. Afr. J. Zool.* 21: 253-6.
- Szjij, L.J. 1967. *Auk* 84: 366-78.
- Vooren, C.M. 1973. *Notornis* 20: 301-10.
- Watson, G.E. 1975. *Birds of the Antarctic and Sub-antarctic*.
- Watson, G.E., J.P. Angle, P.C. Harper, M.A. Bridge, R.P. Schlatter, T.L.N. Tickell, J.C. Boyd & M.M. Boyd. 1971. *Antarct. Mag. Folio Ser.* 14.
- Weimerskirch, H., R. Zotier & P. Jouventin. 1989. *Emu* 89: 15-29.
- Williams, A.J. 1984. *ICBP Tech. Publ.* 2: 627-35.
- Woehler, E.J. 1988. *ANARE News* 54: 5.





Volume 1 (Part A), Plate 39

Blue Petrel *Halobaena caerulea*  
 1. Adult, ventral  
 2. Adult, dorsal

Slender-billed Prion *Pachyptila belcheri*  
 3. Adult, ventral  
 4. Adult, dorsal, fresh  
 5. Adult, dorsal, worn  
 6. Adult, head

Fairy Prion *Pachyptila turtur*  
 7. Adult, ventral  
 8. Adult, dorsal  
 9. Adult, head

Fulmar Prion *Pachyptila crassirostris*  
 10. Adult, dorsal  
 11. Adult, head

© Jeff Davies