

Order **PROCELLARIIFORMES**

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

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

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

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

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

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

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

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Family PROCELLARIIDAE fulmars, petrels, prions, shearwaters

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

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

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

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

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

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

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

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

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

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Procellaria lessonii Garnot, 1826, *Annls Sci. nat. Paris*, 7: 54, Pl. 4 — ‘dans les parages du Cap Horn et de la mer Pacifique par 52° de lat. sept et 85° de longit’.

Named in honour of R.P. Lesson, 1794–1849, French naval doctor and naturalist.

OTHER ENGLISH NAME White-headed Fulmar.

MONOTYPIC

FIELD IDENTIFICATION Length 40–46 cm; wingspan 109 cm; weight 580–810 g. Large, solidly built grey-and-white gadfly petrel of open ocean and shelf-break waters. Long narrow wings held bowed well forward to carpals then swept back to form sharp wing points; spreading of primaries during manoeuvres makes outer wing appear paddle-shaped. Tail appears pointed when closed, during normal flight; wedge-shaped when fully spread during manoeuvres. Prominent black patch underscoring eye on otherwise largely white head, diagnostic. From below, white head and underbody contrast noticeably with dark grey underwing. Sexes alike. No seasonal variation. Juvenile inseparable.

DESCRIPTION ADULT. Forehead and forecrown, white; rest of crown and nape finely vermiculated with pale grey. Black patch underscoring eye contrasts strikingly with much paler remainder of head. Pale grey of nape merges evenly into hoary grey of mantle, scapulars and back. In fresh plumage, upperwing, hoary grey with broad blackish M-mark from wing-tip to wing-tip joining across dark rump. Greyish tones to remiges and greater coverts significantly reduced with wear, causing upperwing to appear mainly blackish brown apart from retention of greyish triangle on inner forewing and faint suggestion of darker blackish centre to M-mark across innerwing. Rump, dark grey. Upper tail-coverts and centre of upper tail, hoary grey, like mantle and back; sides of tail and extreme tip, white. Extent of white visible in upper tail causes area to appear noticeably paler than mantle and back in dorsal views (useful distinction from Soft-plumaged Petrel even at some distance if light conditions good). Underparts, white except for narrow pale-grey half-collar on sides of upper neck, which in some birds extends well down sides almost to join in mid-line below, inviting confusion with Soft-plumaged Petrel. Lesser and median under wing-coverts, dark greyish-black except for those between base of wing and elbow that are white, varying mixed with grey, forming small whitish triangle on inner leading-edge of underwing. Greater under wing-coverts and remiges, dark silvery-grey, appearing slightly paler than lesser and medians. Basal parts of greater primary coverts and primaries, silvery grey, paler than rest of underwing lining and highly reflective, contrasting noticeably with narrow greyish-black strip on leading half of underwing lining. Iris, dark brown. Bill, stout, with tubed nostrils conspicuously raised over basal third of upper mandible, and with

large bulbous nail, entirely black. Legs and feet, pinkish flesh with brown-black on outer toe, joints of toes and distal half to one-third of webs.

SIMILAR SPECIES Most likely confusion with similarly patterned **light-phase of Soft-plumaged Petrel** *P. mollis*, but White-headed Petrel distinctly larger, with larger head and fuller chest, imparting more robust appearance. Viewed from side and especially when head-on, White-headed appears obviously white-headed even at considerable distance; at closer range, pale grey rear-crown, nape and varying collar plus diagnostic isolated black eye patch easily seen. Soft-plumaged Petrel has much darker head; dark patch under eye only subtly darker than grey of cap and much less conspicuous; slate-grey collar, broader and more extensive, almost invariably joining in mid-line below; slate-grey crown and neck-collar give much darker, almost hooded, rather than white-headed, appearance but in fresh plumage most of frons plus small supercilium, white, forming small white forecap conspicuous from front. Hoary-grey areas on upperparts of White-headed Petrel distinctly paler than slate-grey ones of Soft-plumaged. Upperside of tail in White-headed Petrel, hoary-grey, with some white at sides and tip visible even when tail closed so that whole uppertail appears distinctly paler than grey mantle and back. Upperside of tail in Soft-plumaged, much darker slate-grey, not contrasting with mantle and back or rest of upper body; no white at sides and tip, though grey and white outer rectrices may be apparent in optimum views when tail fanned. **Grey Petrel** *Procellaria cinerea* distinctly larger than White-headed and easily distinguished by grey head and grey undertail to vent area (predominantly white in White-headed). **Palest-headed light-morph Kermadec Petrel** *P. neglecta* also superficially like White-headed but dark-brown (not grey) upperparts, white or silvery-white basal parts of primaries form prominent large white ovals on largely dark underwing, and white primary shafts appear as skua-like pale streaks on outer upperwing; never has black suborbital patch of White-headed.

Primarily of pelagic and shelf-break waters, only occasionally ranging further inshore, perhaps usually when storm driven; rarely seen from land. In light winds, fly just above waves in short glides broken by series of unhurried, stiff-winged flaps and some gentle banking into wind up to 3–4 m above sea. Little or no flapping in strong winds, proceeding on

fairly direct or switchback course in series of strong and often spectacular arcs (reaching up to 50 m above sea at times) with body tilted just beyond vertical at apex of arcs. Mainly nocturnal surface feeders, showing buoyant carriage when sitting on water. Usually solitary at sea, though occasionally seen in small groups. Sometimes attracted to ships but rarely follow. At breeding grounds, birds arrive only after dark, though occasionally appear over land just before dark. Never seen from breeding islands by day. Single birds and small parties gather over colonies at night to indulge in noisy bouts of calling and display flights. Occasionally calls from ground. Apparently silent at sea. Song given mainly during aerial chases, rapidly uttered *wi-wi-wi* or *wik-wik-wik*, with variants and additional notes leading to longer phrases, e.g. *ooo-er*, *kukoowick*, *kukoowick*, etc. Sitting birds also utter stream of *si-si-si* notes.

HABITAT Marine, pelagic; mainly in subantarctic and Antarctic waters; birds breeding near Antarctic Convergence feed in Antarctic Zone (Jouventin *et al.* 1982a; Weimerskirch *et al.* 1989); possible n. movement in non-breeding season (Bierman & Voous 1950; Szijj 1967), range extending into Subtropics in some areas (Jouventin *et al.* 1982a). In Ross Sea, occur S to s. edge of Polar Front over 1.5 °C isotherm in early summer (Ainley *et al.* 1984); later in year, reach iceberg-belt (Harper 1973), to edge of, but not penetrating, pack-ice (Routh 1949); observed where sea surface-temperatures as low as -1 °C (Bierman & Voous 1950). In winter, occur in Pacific Ocean in waters of 1.9–13.0 °C (Szijj 1967). Pelagic (Cox 1976; Carter 1981; Jouventin *et al.* 1982b; Blaber 1986), but may occur inshore during gales (Cox 1976).

Breed on subantarctic islands S of NZ and in Indian Ocean; in valleys, or on plateaux, peninsulas or coastal slopes; burrow in drier soils, usually under vegetation (tussock grass, ferns or shrubs), but occasionally where only sparse cover of *Acaena* or *Azorella* (Warham 1967; Imber 1983; Brothers 1984; Weimerskirch *et al.* 1989). Avoid wetter soil, flat ground, exposed rocky terrain, and areas devoid of vegetation (Brothers 1984). Distribution within breeding islands may be determined by location of feeding areas (Weimerskirch *et al.* 1989), by distribution of preferred nesting habitat (e.g. *Poa* grassland on Macquarie I.; Brothers 1984), or by competition with Sooty Shearwaters (Warham 1967; Brothers 1984).

Undulating flight in high arcs over surface, reaching heights of 50 m or more in strong winds (Harrison 1983). In light winds, fly just above waves up to 3–4 m above sea. Flocks rest on sea, including sheltered inshore waters at breeding islands (Falla 1937). Avoid flying over land during daylight (Warham 1967).

Numbers have declined at Macquarie I. Areas heavily grazed by introduced rabbits avoided because eroded and colonized by dense mats of *Acaena*; removal of vegetation also increases susceptibility to predation by skuas and feral cats.

DISTRIBUTION AND POPULATION Circumpolar in all s. oceans from pack-ice N to c. 30°S.

At sea during summer, near Antarctic continent S of breeding colonies at 140°–180°E (van Oordt & Kruijt 1953); to ice-edge (Routh 1949); occurs Ross Sea as far S as 53–70°S (Dell 1960; Watson 1975). Fairly common subantarctic waters (Warham 1967). In Indian Ocean, S of Iles Crozet concentrated between 52° and 64°S (Jouventin *et al.* 1982a). In Pacific Ocean, between 75° and 90°W, W of Str. of Magellan (Holgerson 1957) and s. Aust. seas (Warham 1967); common in

Southern Ocean at 46°S, 128°E in Mar. (Falla 1937). In South Atlantic, consistently from 50°S, 12°E to 58°S, 3°E (Bierman & Voous 1950); numerous between 61° and 62°S, and 19° and 22°W (Harper 1973). Still found close to Antarctic mainland in autumn (Warham 1967); numerous in South Atlantic at 46°S, 8°E (Bierman & Voous 1950). In winter, absent from breeding islands for 2 months; range shifts farther N to 30°S in Indian and sw. Pacific Oceans (Szijj 1967; Salwegter 1974; Weitkowitz 1980; Jouventin *et al.* 1982a). Common South Pacific; from 48°S, 166°W to 41°S, 94°W with most s. record at 56°S and most n. at 33°S on Chilean coast (Szijj 1967); also found Tasman Sea (Fleming 1950; Jenkins 1982). Concentrated c. 320 km E of Wellington, NZ, in autumn and spring (Fleming 1950).

AUST. Frequent visitor to s. waters. Recorded all year round but least often in summer (Aust. Atlas); mainly beachcast or sightings on edge of continental shelf. **Qld.** Few records: one, beachcast, North Stradbroke I., June 1974; one beachcast, Moreton I., 13 Sept. 1984; one seen off Pt Lookout, 1 Feb. 1985 and another 25 Jan 1986 (Roberts 1977; Qld Bird Reps 1984–86). **NSW.** Scarce visitor recorded all months mainly central and s. coasts, most numerous May–Sept., mainly beachcast June (Morris *et al.* 1981; NSW Bird Reps 1983–85); occasionally blown inland such as W of Gunbar, June 1977 (Moffatt 1978). **Vic.** Visit pelagic waters off coast; records made in all months of year except Jan. and July, many of these being beachcasts; appears frequently Apr.–May, Aug.–Sept. (Vic. Atlas; Vic. Bird Reps 1981–84). **Tas.** Common Apr., May on continental shelf off SE (43–44°S, 147–151°E); small numbers off SE in Dec. (Carter 1981; Blaber 1986; Tas. Bird Rep. 1989). **SA.** Regularly straying or blown into coastal zone, often after gales; dates of beachcast birds range throughout year (Cox 1976). **WA.** Winter visitor; occasionally washed up onto sw. beaches after storms; said to range N to Dampier Arch. (Serventy & Whittell 1976).

NZ Beachcast throughout year, especially June–Sept.; most washed onto NI beaches but also records from Westland, Christchurch and Chatham Is.

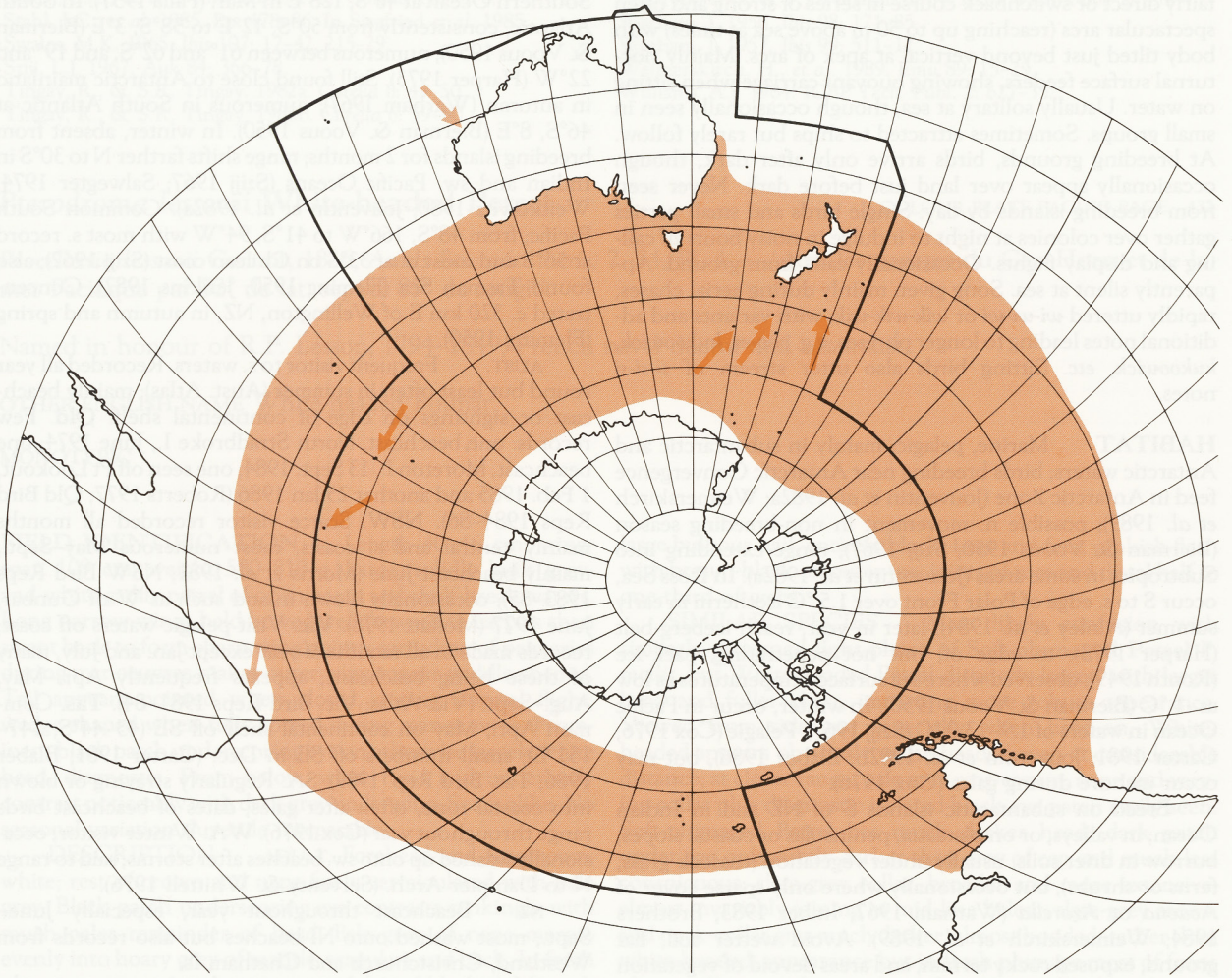
Breed on Auckland, Antipodes and Macquarie Is, Iles Kerguelen and Crozet; may breed Marion, Prince Edward and Campbell Is (Harrison 1987). On Macquarie I., breeding population 16 000 birds (Brothers 1984). On Iles Kerguelen, particularly abundant on islands of Morbihan Gulf; several tens of thousands of pairs breed in scattered groups on Courbet, Ronarch and Jeanne d'Arc Pens, with some pairs on Foch I.; absent from w. coast.; breeding distribution may be associated with location of feeding areas (Weimerskirch *et al.* 1989).

Feral cats *Felis catus* may be main cause of decline on Macquarie I., especially because White-headed Petrels present for part of winter when cats' food supply limited; black rats *Rattus rattus* and Wekas *Gallirallus australis* also problem in tussock grassland (Warham 1967; Brothers 1984).

MOVEMENTS Dispersive or migratory but completely absent from colonies for only 2 months.

DEPARTURE Leave Macquarie I., late May (Brothers 1984) to early June (latest record 3 June; Warham 1967); last record Iles Kerguelen, 22 May (Paulian 1953).

NON-BREEDING Distribution shifts N during winter (Szijj 1967) with n. limit during Aug.–Sept. in Indian and sw. Pacific Ocean 30°S (Salwegter 1974; Weitkowitz 1980; Jouventin *et al.* 1982a). Concentrations recorded during winter and early spring 320 km E of NZ (Fleming 1950) and during



July–Aug. about 800 km E of NSW (Jenkins 1982) but seen off Vic. and Tas. throughout year with peaks both June–Sept. and Jan. (D.W. Eades); probably reflects seasonal northward movement from s. islands.

RETURN First arrive Macquarie I., early Aug. (earliest 2 Aug.; Brothers 1984) but breeding cycle not closely synchronized and return spread over at least 6 weeks (Warham 1967; Brothers 1984); return Kerguelen, mid-Sept. (Paulian 1953). Usually philopatric to same burrow.

BREEDING During summer, large numbers recorded near Antarctic continent S of breeding colonies (van Oordt & Kruijt 1953), and S of Iles Crozet concentrated between 52° and 64°S during Feb. (Jouventin *et al.* 1982a), indicating possible foraging area when feeding chicks. Large numbers reported near Str. of Magellan in early Dec. (Holgerson 1957) thought to be immatures (Warham 1967) as also those over-summering W of Tas. (D.W. Eades).

FOOD Cephalopods and crustaceans recorded, but virtually unknown. **BEHAVIOUR.** Only surface-seizing recorded (3/3 obs.) (Ainley & Boekelheide 1983) but no detailed description. Recorded feeding in association with Cape Petrel *Daption capense*, Antarctic Prion *Pachyptila desolata* and Sooty Shearwater *Puffinus griseus* (Ainley & Boekelheide 1983). Activity round nests at Macquarie I. confined to night,

birds arriving and leaving during darkness (Warham 1967).

BREEDING Iles Crozet (nine stomachs; Barre 1976) crustaceans 67% freq.: mysidaceans, amphipods (Gammaridae, Lysianassidae), shrimps/prawns; cephalopods 33. At Antipodes Is recorded taking cephalopods, mysidaceans (Imber 1983) and lantern fish; at Iles Kerguelen, cephalopods (Paulian 1953).

SOCIAL ORGANIZATION Not well known; based on information provided by N. Brothers and Warham (1967). Gregarious when nesting, though solitary nesting does occur; at sea, mostly solitary or in small groups.

BONDS Monogamous, probably long lasting; return to same nest-site each year. Probably pre-laying exodus after mating (Warham 1967). Both parents incubate and tend nestling until fledging.

BREEDING DISPERSION Usually colonial, but nest burrows may be widely scattered, in small groups or solitary. Size and location of colony and density of burrows influenced by habitat (e.g. vegetation types, availability of land) and climatic conditions (e.g. wind speed and direction); at Macquarie I., mean density, 10/100 m², maximum density 19/100 m² in thick *Poa foliosa* (Poaceae) (Warham 1967; Brothers 1984). Compete with rabbits and Sooty Shearwaters *Puffinus griseus* for burrows.

ROOSTING Rest on sea, including sheltered in-shore waters at breeding islands (Falla 1937); at nest-site in breeding season. Burrows occupied continuously by single birds to maintain ownership and by courting pairs; thereafter, occupied only when either parent guarding egg or nestling.

SOCIAL BEHAVIOUR Based on Warham (1967) and material supplied by N. Brothers. Generally silent without communication at sea. No other detailed information of behaviour at sea. Calling at breeding grounds mainly while in air because on ground vulnerable to predators such as skuas *Catharacta*. Strictly nocturnal in breeding season; arrive after dark and leave before dawn, rarely seen flying over land during day. Calling usually begins 10–15 min after arrival at colony after sunset and just before dawn when departing. Rarely seen on ground after dark though occasionally seen at mouth of burrow.

AGONISTIC AND SEXUAL BEHAVIOUR No detailed information recorded. Young threaten intruders by repeatedly lunging with open bill, spitting stomach oil, hissing and flicking wings outward. From 2–3 days old able to spit stomach oil but ability declines with age and lost after 40–50 days. From c. 70 days old, scream (similar to adult's) when being handled. Before start of breeding, birds engage in high-speed nocturnal **Aerial Chases** accompanied by much calling; probably associated with advertising, courtship and mating; can involve 2–5 birds, often following each other over same route, which may take them high above colony; low-flying petrels sweep close to ground often with tails spread making white appear prominent. Warham (1967) considered that several were in pursuit of single individual and birds kept to same general area. For some time before laying, burrows occupied by single birds and by pairs for courtship and to maintain ownership of nest-site. Pair utters *si-si-si* in burrow before laying and also heard when adult enters nest at night.

RELATIONS WITHIN FAMILY GROUP Both sexes incubate but extent of contribution of each to incubation not recorded. On one occasion, egg left unattended for a day and on another left unattended twice then deserted (Warham 1967). Chick guarded for only first few days, after which visited nightly by parents when it is fed and greeted by calls. Chick becomes active at night, tapping at empty eggshell and calling. During feeding visit, adult scrabbles noisily down access tunnel in to nest; gives *si-si-si* call upon entering; chicks respond with loud chitterings. Calling stops when chick fed, by regurgitation; adult soon departs. When handled by humans, young often regurgitate food. Chick gathers material (grass fragments, moss, leaves, feathers and egg shells) into cup in which it sleeps; scratches head indirectly, over the wing. Adults stop feeding young before fledging and leave colony. Chicks start to leave burrow at night when c. 92 days old, continuing to emerge for a few nights until leaving.

VOICE Based on study at Macquarie I. (Warham 1967). Not known to call at sea; call at night at colony, mainly in air, and some calling from burrows; not recorded calling from surface. Most calling in first few hours after sunset, reaching peak after c. 40 min, and before sunrise, reaching peak just before dawn, coinciding with times of arrival and departure. Sexual differences suspected. Calls vary between individuals in quality, rate of delivery and length. Similar to calls of Great-winged Petrel *P. macroptera*

ADULT Aerial nocturnal flight-call *tewi*, *tew-i* or *wi-wi-wi* or *wik-wik-wik* or *whit-whit-whit* and *ooo-er*, *kukoowik*,

kukoowik, *kukoowik* and other variations on same theme. Such calling, if being uttered by only a few birds engaged in aerial chasing, gives impression that there are many birds calling; rarely given by single birds over island away from breeding areas. Gruff, slurred *oooo-er*, with variants, often inserted into flight call but significance of these unknown. Within burrow utter soft and squeaky *si-si-si* for 3–4 s duration, similar to calls of other *Pterodroma* species. When extracted from burrow, loud wails and screams may be uttered.

YOUNG Chicks can be heard piping just before hatching, after which gives usual piping of young petrels. Make various other chirruping and chittering sounds; at rate of about 1/s when being fed. More vehement squealing cry also used during feeding, when being attended by adult and when distressed. Young chicks give sharp hissing or chirruping sound when handled, but from about 70 days old scream like adults when alarmed.

BREEDING Studied at Macquarie I. (Warham 1967; Brothers 1984). Breed in simple pairs, colonially, but burrows can be concentrated or dispersed over large areas.

SEASON At Macquarie I., colonies reoccupied in late Aug. probable pre-laying exodus in early Nov. Laying not synchronized, from c. 20 Nov.–17 Dec. and 19 Nov.–31 Dec. At Iles Kerguelen, incubated eggs 28 Dec.–28 Jan. and very small chick 29 Jan. suggest similarity (Campbell).



SITE In large rabbit-like burrows, fairly straight, 1–2 m long, about 20 x 13 cm in cross-section, narrowing somewhat towards chamber; on flat ground, chamber 30–46 cm below surface; all above 180 m asl. on central plateau at Macquarie. Brothers (1984) found burrows all in wet soil, on sheltered slopes, coinciding with tussock grassland *Poa foliosa*, between 100 and 300 m asl, averaging 99.8 cm (40–250) long, with entrances 195 cm (160–240) x 123 (110–150) in cross-section. At Iles Kerguelen, burrows from near sea-level to 100 m asl. Same birds return to same burrows year after year.

NEST, MATERIALS Chambers lined sparsely but substantially with vegetation from near entrance (Warham 1967); with live and dead plant material, mostly grasses; added to during occupation (Brothers 1984). Entrances bestrewn with green shoots (Campbell).

EGGS Ovate to elliptical; fine-grained, glossy (Campbell), not glossy (Brothers 1984); white, dull.

MEASUREMENTS: 72.4 (0.61; 65.6–78.3; 24) x 51.4 (0.37; 47.9–55.0) (Brothers 1984).

CLUTCH-SIZE One. Sometimes two eggs in burrow, probably laid by two females (N. Brothers). Single brooded. No data on replacement laying.

INCUBATION By both adults. Shifts and share of sexes not known. **INCUBATION PERIOD.** Not exactly determined, but probably about 60 days (Warham 1967).

YOUNG Semi-altricial, nidicolous. Hatched with grey proptile; mesoptile, grey above, dull white below. Iris, dark brown. Legs, whitish flesh, webs pink, darkening distally by 47 days. Weight at hatching: 80–100 g (n=3). Attended by both parents for few days, perhaps no more than 3 days (Warham 1967). Fed by both parents by incomplete regurgitation;

first feed of night noted at about midnight.

GROWTH Primaries appear at 43–53 days; all down lost by 10 days before fledging. Ejects proventricular oil in small amounts but less liable to do so as grows older. Emerge from burrow during several nights before fledging. **NESTLING PERIOD.** Not fully established but probably about 102 days (Brothers 1984).

SUCCESS At Macquarie I., 11 of 18 eggs hatched (61%); three chicks fledged; total success 16.7%. Much menaced by skuas and cats, both taking adults and young; *Wekas* *Gallirallus australis* probably destroy eggs and chicks; rats may also destroy eggs and young (Brothers 1984), though Warham (1967) did not consider them a menace. Rabbits interfere with burrows and play havoc with general nesting area by denuding it of vegetation, so that it becomes bare, eroded and unsuitable for burrowing by petrels.

PLUMAGES

ADULT Definitive basic. Age of first breeding unknown. **HEAD AND NECK.** Forehead and front of lores, white, varying mottled brownish grey (79); feathers, brown-grey (79) with white fringes. Forecrown, white, merging to pale grey (86) hindneck and sides of foreneck, where varying half-collar; extent affected to some extent by attitude of head. Feathers, white with fine light-grey vermiculations and dark-grey (c79) shafts, occasionally causing faintly streaked appearance. Chin and throat, white. Large grey-black (82) eyepatch, broadest in front of eye, narrow above eye. **UPPERPARTS.** Mantle, back and shorter scapulars appear grey with light scalloping. Feathers, grey (84) with light-grey (c85) subterminal fringes and open pennaceous whitest tips. Longest scapulars, grey-black (82). Rump and lowermost back, dark grey with fine light scalloping; feathers, dark grey (83) with narrow light-grey (85) fringe; very narrow off-white open pennaceous tips develop with wear. Upper tail-coverts, light grey (85) with very narrow white fringes when worn. All feathers of upperparts have concealed white bases. **TAIL,** pale grey (86) above, grey-white to white below. **UPPERWING.** Primary coverts and remiges including humerals, dark to blackish grey (83–82), all with concealed light-grey inner edges. Secondary coverts, grey with light-grey (85) open pennaceous edges. Other coverts and alula, dark to blackish grey (83–82) with light-grey (85) open pennaceous edges; when worn, dark-brown (c21) tinge develops and grey tinge lost. **UNDERPARTS,** white; flank-feathers have grey-black (82) shaft-streaks. Axillaries, grey (84) with white tips and sometimes extensive white mottling, especially on lower web. **UNDERWING.** Remiges and greater under wing-coverts, dark grey (83), with pale-grey (86) gloss in some direct light. Marginal and lesser coverts, dark grey (83); inner ones have white fringes, widest near body. Lower and lesser median under wing-coverts, dark grey (83) with white tips. Coverts on leading-edge of wing between carpal joint and p11 have white fringes.

DOWNY YOUNG Protoptile, uniformly grey (Warham 1967). Mesoptile, grey (84) with white belly and breast; in skins examined, tips discolour to brownish grey (79) all over body. This seems inconsistent with Murphy & Pennoyer's (1952) description of downy young as 'fuscous grey' with throat sparsely covered with whitish down.

JUVENILE Age of first breeding unknown.

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

ADULT, JUVENILE Iris, black-brown. Bill, black

(89); adults usually have varying white markings at base of unguis. Distal third of inner web and toe, and distal two-thirds of middle toe and outer web, black (89). Top of outer toe, black (89); black markings broader on joints; also black (89) markings on top of joints of other toes. Rest of tarsus and feet, pink (7 to light-7). Claws, pink; Hall (1900) recorded horn-black claws at Iles Kerguelen.

DOWNY YOUNG Similar to adults. Toes and webs, initially completely pink. Darkening of toes begins at 40 days, of distal edge of web at 47 days (Warham 1967). At fledging, similar to adults (Warham 1967). Light-violet base to bill recorded at Iles Kerguelen (Hall 1900).

MOULTS Based on Warham (1967) at Macquarie I., except where stated.

ADULT POST-BREEDING Pre-basic. Complete. Body-moult occurs during reoccupation of burrows and incubation (Aug.–Nov.). Unknown when body-moult begins and ends. NZ beachcast adults with body-moult found in Apr., June, Sept. Moult of flight-feathers occurs at sea after chicks have fledged; perhaps delayed for some time after fledging. Flight-feathers of many Macquarie birds not fully grown when birds return in late Aug. Primaries outwards; bird photographed off Tas. (Lindsey 1986) had estimated primary moult formula $N^4 2^2 1^1 O^2$. NZ beachcasts in Aug. and Sept. usually in wing-moult.

POST-JUVENILE, SUBSEQUENT PRE-BASIC MOULTS Wing girdles found in Oct., Dec., and Feb. show primary moult; suggested that these come from different age groups, but no direct data to support this (or any other) theory. Immature beachcast in NZ in May had primary moult $N^5 1^1 O^3$.

MEASUREMENTS (1) Auckland Is, skins (NMNZ). (2) Macquarie I., 'adults' at burrows, live birds; minimum chord taken with flexible ruler over upper wing surface; bill width at base (Brothers 1984). (3) Antipodes I., live birds; flattened chord (Warham & Bell 1979). (4) Iles Kerguelen, live birds; methods unknown (Weimerskirch *et al.* 1989).

UNSEXED	
WING	(1) 314.5 (3.50; 310–319; 6) (2) 308.8 (6.63; 291.0–332.0; 44) (3) 302.6 (5.7; 22) (4) 313.2 (6.3; 300–302; 18)
8TH P	(1) 201.7 (4.86; 193–209; 10)
TAIL	(1) 126.3 (7.43; 113–135; 6) (2) 132.7 (5.24; 126–142; 44) (3) 130.6 (5.5; 10)
BILL	(1) 38.2 (1.12; 37.1–40.3; 6) (2) 38.1 (1.19; 35.3–41.0; 44) (3) 36.7 (1.2; 25) (4) 38.9 (1.6; 35–41.1; 18)
BILL W	(2) 17.1 (1.13; 15.9–18.5; 44)
TARSUS	(1) 48.0 (1.88; 45.6–50.5; 6) (2) 46.0 (1.33; 42.0–48.0; 44) (3) 44.0 (1.5; 22) (4) 46.6 (2.1; 43–50.7; 18)
TOE	(1) 63.6 (1.98; 60.3–66.7; 6) (2) 66.1 (1.66; 62.8–69.5; 44) (3) 64.2 (2.8; 16)

WEIGHTS At Antipodes I. 574 g (34; 9) (Warham & Bell

1979). At Iles Kerguelen, 698.1 g (58.6; 580–810; 18) (Weimerskirch *et al.* 1989). NZ beachcasts, thin to emaciated, 369 g (70.2; 267–525; 13) (NMNZ).

STRUCTURE Eleven primaries, p11 minute, p10 usually longest, p9 7 to –6, p8 11–24, p7 28–45, p6 50–67, p5 75–94, p4 101–123, p3 127–152, p2 154–180, p1 184–197. Tail, strongly rounded, 12 feathers. Bill, heavy; nostril tubes about quarter length of bill; maxillary unguis, hooked; mandibular unguis, slightly decurved. Tarsus rounded in cross section; outer and middle toes about equal, inner c. 80%.

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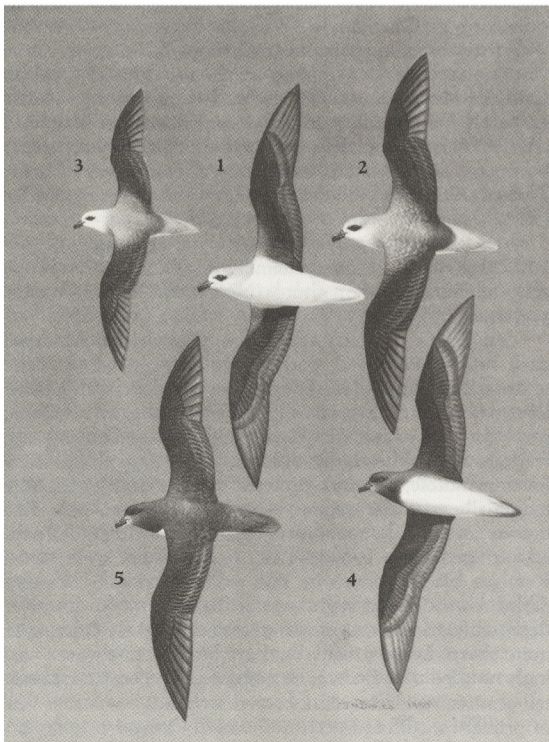
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Volume 1 (Part A), Plate 29

White-headed Petrel *Pterodroma lessonii*

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

Magenta Petrel *Pterodroma magentae*

- 4. Adult, ventral
- 5. Adult, dorsal

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