

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 inexpectata J.R. Forster, 1844. *Descr. Anim. Itin. mar. aust. Terras*: 204 — Antarctic Ocean.

Specifically named 'unexpected' because the first specimen gave Forster the unexpected joy of a new species, never before seen ('*inexpectatum nobis gaudium decit novae speciei, ante nunquam visae*').

OTHER ENGLISH NAMES Rainbird, Scaled or Peale's Petrel.

MONOTYPIC

FIELD IDENTIFICATION Length 35 cm; wingspan 85 cm; weight 315 g. Medium-sized gadfly petrel, similar in size and structure to Soft-plumaged Petrel *P. mollis* and intermediate between much larger Great-winged Petrel *P. macroptera* and smaller, superficially similar, dark morph Collared Petrel *P. brevipes*. Virtually unmistakable because of combination of frosty grey upperparts with dark M-mark across upperwings, white underparts with large grey belly patch, and mainly white underwing marked with broad black diagonal bar across secondary coverts. Sexes alike. No seasonal plumage changes. Juveniles inseparable from adults.

DESCRIPTION ADULT. Crown, slate grey, with dense white scaling on forehead, reduced by wear; narrow white supercilium; cheeks, lores, chin and throat, white, contrasting with large black patch below eye. Upperwings, medium grey with distinct and fairly narrow blackish M-mark across span, joined by blackish band across back and rump, grading slightly into medium grey of surrounding areas. Slate-grey nape merges into paler medium-grey mantle, scapulars, back and uppertail. Tip of tail, blackish; outermost tail feathers, whitish. In fresh plumage, whole upperparts appear frosty grey in field, though each feather narrowly fringed white and subterminally dark, giving scaled appearance when viewed closely. Frostiness of upperparts, palest on trailing half of innerwing behind dark M-mark. In some, slate grey of hindneck extends part way down sides of neck to form short incomplete collar and grey sometimes extends along sides of breast to join with diagnostic dark-grey belly patch. Breast, white, contrasting with belly, with narrow zone of grey scaling at anterior edge of solid dark-grey belly covering rest of breast, belly and flanks next to wing pit. White bases to grey feathers of underbody increasingly exposed with wear forming irregular white patches on some individuals. White vent and under

tail-coverts sharply separated from belly patch. Primaries, largely white with very narrow greyish line along trailing-edge, broadening slightly towards tip. Very thin grey leading-edge to outer primary. All exposed secondaries, white. Underwing-coverts, white with striking broad black leading-edge along outer primary coverts. Black continues into innerwing from carpal joint along leading-edge for a few centimetres, then diagonally across secondary coverts into centre of innerwing in broad tapering line. In dull light, whole bird can appear dark grey except for prominent white posterior half of underwing. Iris, dark brown. Bill, black, short and stubby with large nail, and with conspicuously raised nostrils over basal third of upper mandible. Legs and feet, pale flesh; outer side of outer toe plus distal two thirds of foot, black. **FLEDGELING.** As adult but has broader white edges to contour feathers on upperparts, enhancing scaled appearance.

SIMILAR SPECIES Combination of grey upperparts, white throat, white vent and undertail, grey belly patch and white underwing with thin grey trailing-edge and broad black diagonal bar, makes Mottled Petrel unmistakable. In brief or distant views may be confused with some **Soft-plumaged Petrels** that have dark breast-bands and heavy grey smudging on underparts. Clear view of black-and-white patterned underwing (*cf* wholly dark in Soft-plumaged Petrel) easily distinguishes Mottled. Only likely to be confused with dark morph of **Collared Petrel** *P. brevipes* but easily distinguished by noticeably smaller size and less stocky body; blackish cap contrasting with mid-grey mantle; mainly dark upperwings without obvious M-mark; exposed remiges on underwing almost entirely blackish; and narrower black carpal bar on underwing.

Highly pelagic, most likely to be seen on or beyond continental shelf, no sightings from shore in Aust. Flight action

dashing. Continuous arcing and long glides often interspersed with few crisp shallow wing-beats, weaving impetuously and arcing higher in strong winds. Solitary, pairs or small groups, rarely in large flocks. Do not normally follow ships. At breeding grounds, only arrive during darkness. Silent at sea. Above colonies and on ground gives two main calls: sharp *ti-ti-ti* and deeper *gor-wik*.

HABITAT Marine, pelagic. Antarctic and subantarctic waters; migrating rapidly through Tropics to far n. waters in non-breeding season. Abundant in open water and iceberg belt in Antarctic Zone (Hicks 1973; Ainley *et al.* 1984); s. movement limited by edge of pack-ice, -0.5°C isotherm or shallow shelf-waters of Antarctic continent (Ainley *et al.* 1984); concentrate at edge of pack-ice and associated brash-ice (Routh 1949; Harper 1987). In Ross Sea, less abundant N of 4°C isotherm (Ainley *et al.* 1984), but small numbers recorded off Tas. in waters of surface-temperature 13°C (D.W. Eades). In North Pacific Ocean, recorded over waters that range in surface-temperatures from 5.0 to 18.3°C (Kuroda 1955; Nakamura & Tanaka 1977; Gould 1983; Ogi *et al.* 1986); after migration, concentrate over cool ($8-10^{\circ}\text{C}$) currents along central Subarctic Front (Nakamura & Tanaka 1977; Ogi *et al.* 1986). Abundance in Bering Sea attributed to scarcity of other competing pelagic seabirds in n. summer (Ogi *et al.* 1986). May be excluded from Arctic Zone by shallow shelf-waters of Bering Sea (Ainley & Manolis 1979). Pelagic throughout range; rarely observed <50 km from land (Warham 1967; Ainley & Manolis 1979; Ogi *et al.* 1986).

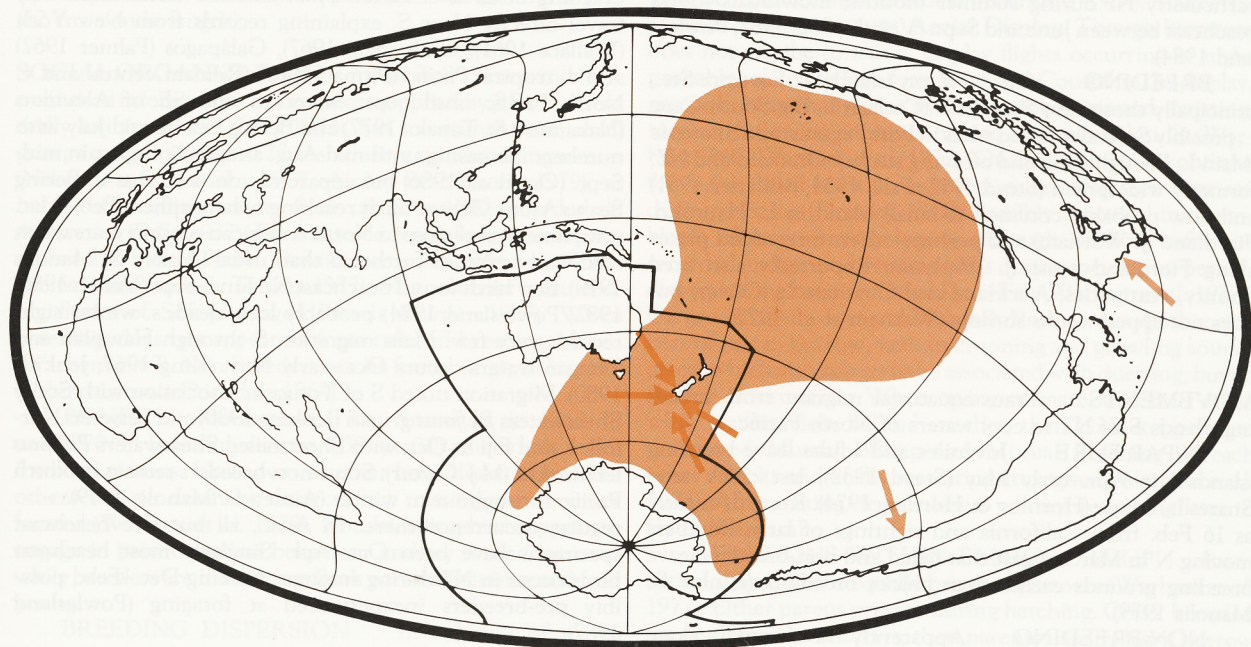
Breed on islands, and on stacks and islets off s. NZ; on SI, NZ. Nest in burrows, rock crevices or caves; usually on rocky terrain such as cliff tops, rock faces, steep coastal slopes, and mountain spurs (Wilson 1959; Blackburn 1965; Horning & Horning 1974; Warham *et al.* 1977); from just above sea level (Horning & Horning 1974) to 350 m asl (Blackburn 1968). Nests may be placed under tussock grass, shrubs or forest (Wilson 1959; Warham *et al.* 1977), but on Snares Is, closed-canopy *Olearia-Senecio* forest avoided (Warham *et al.* 1977).

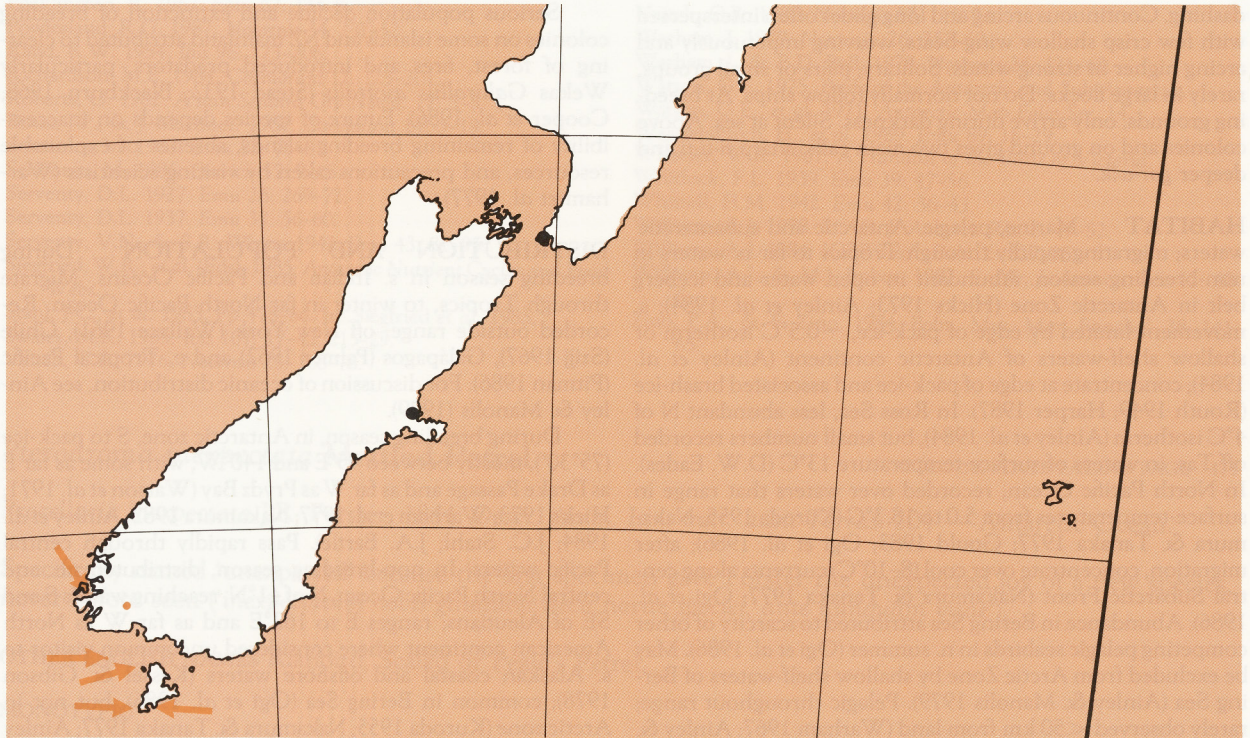
Serious population decline and extinction of breeding colonies on some islands and NZ mainland attributed to clearing of forest, fires and introduced predators, particularly Wekas *Gallirallus australis* (Stead 1932; Blackburn 1968; Cooper *et al.* 1986). Future of species depends on inaccessibility of remaining breeding islands, absence of exploitable resources, and precautions taken by visiting scientists (Warham *et al.* 1977).

DISTRIBUTION AND POPULATION During breeding season in s. Indian and Pacific Oceans. Migrate through Tropics, to winter in far North Pacific Ocean. Recorded outside range: off New York (Wallace 1961), Chile (Szij 1967), Galápagos (Palmer 1962) and e. Tropical Pacific (Pitman 1986). For discussion of oceanic distribution, see Ainley & Manolis (1979).

During breeding season, in Antarctic zone, S to pack-ice ($75^{\circ}30'$), mostly between 95°E and 140°W , with some as far E as Drake Passage and as far W as Prydz Bay (Watson *et al.* 1971; Hicks 1973; Warham *et al.* 1977; Nakamura 1982; Ainley *et al.* 1984; J.C. Stahl; J.A. Bartle). Pass rapidly through central Pacific waters. In non-breeding season, distributed ne. and central North Pacific Ocean, N of 41°N , reaching waters S and SE of Aleutians; ranges E to 162°E and as far W as North American continent where considered uncommon visitor to s. Alaskan coastal and offshore waters (Kessel & Gibson 1978); common in Bering Sea (Ogi *et al.* 1986), but not in Arctic zone (Kuroda 1955; Nakamura & Tanaka 1977; Ainley & Manolis 1979). Breeds on SI, NZ, and islands S of NZ.

AUST. Accidental to se. waters. **NSW.** Singles beachcast: Dec. 1920, Bondi; Nov. 1966, Port Kembla; Apr. 1967, Coledale; Jan. 1969, Long Reef; Oct. 1972, Mona Vale; Jan. 1976, Lennox Head; Mar. 1976, Jervis Bay; 3 Nov. 1981, Port Kembla; 2 Nov. 1984, South Ballina; 2 Nov. 1984, S of Sandon, Yuraygir NP; 8 Nov. 1984, Dee Why Beach (AM. 0.58124); 18 Dec. 1984, S Wollongong Beach. Sight record 25 km off Botany Bay, 7 Nov. 1984 (Morris *et al.* 1981; NSW Bird Repts 1981, 1984). **Vic.** Singles beachcast: Jan. 1955, Lakes Entrance; Jan. 1965, Phillip I. (Wheeler 1967); 29 Dec. 1981,





Lakes Entrance (MV); 17 June 1982, Corringale Beach (MV). Tas. Singles beachcast: 6 Feb. 1890, Circular Head (Mathews 1915); W coast (Andrews 1969); 4 Jan. 1977, Swan R. mouth; 14 Feb. 1981, Wynyard; 11 Dec. 1983, Waterhouse Beach (Tas. Bird Repts 1977, 1981, 1983). Sight records: 1984, two 6 July, five 5 Sept., two 11 Sept., three 27 Nov. in ne. waters; 1988, one 14 Dec. and four 16 Dec. off se. coast (Tas. Bird Repts 1984, 1988). SA. Beachcast near Victor Harbour, 9 Mar. 1974 (Paton 1974).

NZ. Rarely seen at sea; beachcasts found in many parts particularly NI during summer months; individuals found beachcast between June and Sept. (Veitch 1980, 1982; Powlesland 1984).

BREEDING Off s. NZ on islands in Foveaux Str., principally those near Stewart I. (Codfish I., Big South Cape I., possibly Solander Is and islets in Port Pegasus) and Snares Is (Main I., Broughton I. and off-lying stacks). On mainland NZ, formerly widespread (Stead 1932; Falla 1934; Millener 1981) and now probably confined to small island in L. Hauroko, Fiordland (J. Warham) and perhaps other unrecorded places along Fiordland coast (J. Warham). Reportedly also bred Bounty, Antipodes, Auckland and Chatham Is (Oliver) but does not appear to do so now (Warham *et al.* 1977).

MOVEMENTS Trans-equatorial migrant from breeding islands S of NZ to cool waters of North Pacific.

DEPARTURE Juveniles and adults leave breeding islands late Apr.–early May (Stead 1932), last chick seen Snares Is, 8 June (Horning & Horning 1974). Records as early as 16 Feb. from California and sightings of large numbers moving N in Mar. suggest that failed and non-breeders leave breeding grounds earlier than chicks or adults (Ainley & Manolis 1979).

NON-BREEDING Apparently travel rapidly along

diagonal path through Hawaiian waters to Gulf of Alaska (Ainley & Manolis 1979), usually travelling alone or in pairs rather than flocks (Jenkins 1980). Birds seen migrating N near Tonga 16 Mar.–10 May (Jenkins 1980), Fiji 26 Mar.–10 May (Clunie *et al.* 1978; Jenkins 1980, 1986), SE of Hawaii late Mar. (Ainley & Manolis 1979), S of Hawaii late Mar. (Meeth & Meeth 1985, 1986), Hawaii Apr. and early May (King 1967) and North Pacific between 40°N and 45°N 12 and 22 May (Nakamura & Tanaka 1977). Later birds were probably adults, those seen in Mar. failed or non-breeders (Ainley & Manolis 1979). Non-breeding birds at e. extremity of summer distribution may travel directly N or S, explaining records from New York (Wallace 1961), Chile (Szijj 1967), Galápagos (Palmer 1962) and e. tropical Pacific (Pitman 1986). Remain central and e. North Pacific until Sept., waters S and SE of Aleutians (Nakamura & Tanaka 1977) and Bering Sea by mid-July with numbers increasing until mid-Aug. and declining again mid-Sept. (Ogi *et al.* 1986) but apparently do not cross n. Bering Sea to Arctic Ocean. Birds reaching n. hemisphere Feb.–Mar. sometimes travel close to North American coast in years when cold water extends further S than usual (Ainley & Manolis 1979). Few birds found beachcast NZ June–Sept (Veitch 1980, 1982; Powlesland 1984) probably long dead; s. winter sight records very few. Main migration S through Hawaiian and Tongan waters occurs Oct.–early Nov. (King 1967; Jenkins 1980). Migration noted S of Tonga in association with Sooty Shearwaters *Puffinus griseus* (Jenkins 1980) and between Norfolk I. and Fiji in Oct. with Short-tailed Shearwaters *Puffinus tenuirostris* (M.J. Carter). Some non-breeders remain in North Pacific throughout n. winter (Ainley & Manolis 1979). regular occurrence there. In Aust., all but two beachcast specimens have been Oct.–Apr. Similarly most beachcast birds occur in NZ during summer, peaking Dec.–Feb., possibly pre-breeders inexperienced at foraging (Powlesland 1987).

RETURN First arrive Snares Is 24 Oct. (Horning & Horning 1974) with most back early to mid-Nov. (Warham *et al.* 1977); at Big South Cape I. birds were clearing burrows 20 Nov. (Stead 1932) but may have arrived some time previously. Adults strongly philopatric to mate and nest-site (Warham *et al.* 1977).

BREEDING During summer, occur as far S as pack-ice (Nakamura 1982; Ainley *et al.* 1984), mostly between 95°E and 140°W with some as far E as Drake Passage (Watson *et al.* 1971). Breeding birds could easily make 2200–4000 km round-trip to Antarctic waters during incubation period (Warham *et al.* 1977) but three collected Ross Sea were all non-breeders (Ainley *et al.* 1984). Pairs and individuals totalling about 5000 birds recorded in coastal waters off Terre Adélie late Jan.–early Feb., particularly when 21–24 m/s katabatic winds blowing from SE (Thomas & Bretagnolle 1988). Sightings southwards from Tas., Dec. and Mar. (D.W. Eades), suggest

FOOD Mostly cephalopods with some euphausiid crustaceans and fish. **BEHAVIOUR.** Food taken by surface-plunging, surface-seizing, pursuit-plunging or dipping (Harper *et al.* 1985). Ainley *et al.* (1984) saw two birds pursuit-plunging, one surface-seizing; at night, Harper (1987) recorded single bird dipping for food (ten times) and another surface-seizing (four times). In North Pacific, recorded surface-seizing and hovering above water like storm-petrels in daytime (Dementiev & Gladkov 1968; Kuroda 1955; Nakamura & Tanaka 1977). In Antarctic, associates with Sooty Shearwaters (Ainley & Boekelheide 1983).

NON-BREEDING Off Kamchatka, seen taking dead pollack (Kuroda 1955).

BREEDING In n. Ross Sea (three stomachs) (Ainley *et al.* 1984) cephalopods 98.4% wt.: *Psychroteuthis glacialis* 37.0% no., 67% freq.; *Gonatus antarcticus* 6.5, 33, 33 g (35; 3), dorsal mantle 10.5 cm (4.5; 3); *Galiteuthis glacialis* 11, 33, 26 g (15; 5), 14.0 cm (3.0; 5); unident. 24.0, 100; fish 0.9% wt.: *Pleurogramma antarcticum* 1.9, 33, 28.5 g, 16.8 cm; crustaceans, euphausiids 0.7% wt.: *Euphausia superba* 17.5, 100, 4.4 cm; unident. shrimp Pasapheidae 1.9, 33. Two birds seen by Harper (1987) took cephalopods incl. *Moroteuthis ingens* (12 cm mantle length).

SOCIAL ORGANIZATION Not well known and little published information. Information supplied by J. Peter. Generally solitary at sea (Hicks 1973), but sometimes pairs, small groups or flocks of up to 22 seen during non-breeding season (Nakamura & Tanaka 1977; Ainley & Manolis 1979); at height of breeding season, flock of up to 1000 recorded off Antarctica (Falla 1937). Encountered irregularly in company of Leach's Storm-Petrel *Oceanodroma leucorhoa* in North Pacific (Nakamura & Tanaka 1977). May associate with feeding flocks of Soft-plumaged Petrels (Harper 1987). When breeding, does not appear to form rafts off breeding islands (Warham 1967). Non-breeders can be found singly or in pairs within burrows (Richdale 1964).

BONDS Monogamous. On Snares Is, in 1969–70 and 1970–71 breeding seasons, 83% (n=30) pair-bonds intact for both seasons. Unknown whether breakdown of bond of others due to death or divorce, but missing partners not located (Warham *et al.* 1977). Non-breeding birds appear to engage in pair-formation behaviour and try to find burrows while breeders are incubating. Both parents incubate and feed young.

BREEDING DISPERSION In colonies of up to

tens of thousands of pairs, which sometimes have high nesting densities e.g. three nests within 1 m² on Snares Is (Warham *et al.* 1977), although may be sparsely distributed at other colonies e.g. Codfish I. (Blackburn 1968). Often in association with Fairy Prions *Pachyptila turtur* (Warham *et al.* 1977). No information on territorialism.

ROOSTING. At sea, rest on surface of water (Warham *et al.* 1977). During breeding, nocturnal roosting at colonies, arriving after dark (Blackburn 1965). On Snares Is, synchronized arrival suggests birds assemble offshore, but rafts not recorded; first heard over colony about 53 min after sunset; arrival time influenced by light intensity, birds arriving earlier as day-length decreases; and arrive earlier on cloudy days than on clear days. Start landing 15 min after first heard, but most land after 30 min (Warham *et al.* 1977). Leave roost by 04:45 (Blackburn 1965).

SOCIAL BEHAVIOUR Little known. Information supplied by J. Peter. Before landing at colonies at night, circle noisily overhead then usually land close to nest-site; hover momentarily before alighting and, after landing, often pause with outstretched wings; on landing, may call, often stimulating birds in nearby burrows to reply (Warham 1967; Warham *et al.* 1977).

AGONISTIC BEHAVIOUR Unaggressive throughout year and adults do not spit stomach oil defensively (Warham *et al.* 1977; Ogi *et al.* 1986). Probably only defend area round entrance to nesting-burrow. If intruder approaches too near burrow entrance, occupant appears at opening and calls; if intruder calls near burrow, may be attacked by occupant. Will FIGHT over burrows, at which time harsh rasping calls heard. When handled, either silent or scream. When intruders approach chick, it may try to climb out of sight, using bill, or lunge forward, sometimes spitting stomach oil; some call when being handled (Warham *et al.* 1977).

SEXUAL BEHAVIOUR Non-breeding single birds and pairs found in burrows during breeding season may be associated with pair-formation behaviour, though some may be unsuccessful breeders (Richdale 1964). **PAIR-FORMATION AND COURTSHIP.** **Aerial Display.** Though literature does not ascribe function, display flights occurring at night probably related to Pair-formation and Courtship. In display, pairs or occasionally trios fly 2–3 m above ground, twisting, turning, following contours of land and calling loudly (Warham 1967; Warham *et al.* 1977). On Snares Is, may continue for 5–6 h, until birds leave before dawn; also seen over sea during evening (Fleming 1948). Possibly practised in assemblages offshore from colonies, although offshore rafts not recorded; or by non-breeding birds during incubation period, display having been recorded Dec.–Feb (Warham *et al.* 1977). On ground, pairs duet and **Mutually Preen**; when both members of pair in burrow, various crooning and growling sounds given, which also appear to be associated with duetting, but no further information. When trying to mate, one bird called while trailing close behind another; then both stopped and performed Mutual Billing and Mutual Preening of each other's necks and finally mounting attempted (Warham *et al.* 1977). After mating, female leaves colony, returning later to lay (J. Warham).

RELATIONS WITHIN FAMILY GROUP Incubation shared about equally between partners (Warham *et al.* 1977). Either parent present during hatching. Chick brooded for few hours to c. 2 days, then parents usually leave burrow

during day. Generally chick fed within first two hours after dark. Often parents take turns to feed young but some chicks fed on two or three successive nights by same parent (see Breeding).

VOICE Studied on Snares Is by Warham *et al.* (1977), on which account based. Not known to call at sea outside breeding season; during breeding season, noisy at colonies at night; from breeding island, birds could be heard calling at sea after dark; at first, a few birds heard, calling gradually approaching colony and becoming louder as more birds began calling near the island; birds were calling in flight over colonies about 15 min after first bird heard with increasing numbers heard at sea; first birds landed about 15 min after first heard over island. Often called on landing, stimulating others nearby to call. Main calls are loud cries consisting of repeated staccato notes given in flight and from ground; also various other lower-pitched calls, not all of which were described and many of which may be variations of one type of call. Aerial activity and calling usually continued uninterrupted through night (5–6 h). Main call similar to those of other species of *Pterodroma*. Pairs duet when on ground, mostly using calls 1 and 2 (below); probably function in various circumstances such as territorial defence, greeting and alarm. Warham *et al.* (1977) felt there may be some sexual differences in pitch of calls and that there may be consistent individual variation but no data. No information on geographical variation.

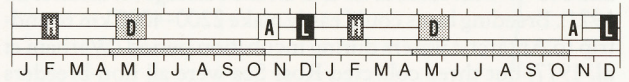
ADULTS (1) Most commonly heard call, loud complex strident hysterical giggle or chatter, described by Stead (1932) as far-carrying *ti-ti-ti-...* calls begin quietly, rise in pitch and volume, become quieter and low-pitched at end. Calls consist of 8–15 rapidly repeated staccato (*ti*) notes with quiet low-pitched introductory and terminal syllables (undescribed); each note with strong harmonics, delivered at fixed rates with gaps of 50–70 ms between notes, though rate of delivery decreases towards end; frequency range from c. 700 Hz to 6.5 Hz. Duration of call c. 2.0–2.5 s, and call often repeated after brief pause. Given during Aerial Display, on ground, from surface or burrow, and when disturbed. (2) Often utter deep resonant *quurrrr, quurrrr* (Warham 1967), *goo-oo* (HASB) or *gor* (Warham *et al.* 1977); described as resonant bugle note (Stead 1932) and said to resemble 'rich tone of a pipe organ' (Warham *et al.* 1977). Either given before or after *ti-ti-ti-* call or given alone, when usually followed by abrupt *-wik* note, call becoming longer *gor-wik*, with emphasis on first syllable. Heard only at close range; delivered with great distension of throat. **OTHER CALLS.** Warham *et al.* (1977) state Mottled Petrels have diverse repertoire and they were not able to record all calls or determine circumstances of use of calls. Sibillant disyllabic cry *tor-wit*. A variety of crooning and growling sounds when pair in burrow; once, in duet, one bird gave high-pitched growl, spread over wide band of frequencies, and other bird gave *ti-ti-ti* call. Harsh rasping cries given when fighting over burrows. Wild frenzied scream sometimes emitted when birds handled.

YOUNG When disturbed, give high-pitched squeak; a few give louder strident cry that strongly resembles *ti-ti-ti* call of adults when disturbed.

BREEDING Only partly known. Account based on Warham *et al.* (1977) from Snares Is. Information provided by J.R. Starks. Breed colonially on islands only in NZ region; may share burrows with Fairy Prion *Pachyptila turtur*.

SEASON At Snares Is, earliest record of returning

birds, 24 Oct. (calls); first seen on land, 15 Nov. Pre-laying exodus of 9–16 days immediately precedes laying. Peak of laying, c. 19 Dec. (14–26 Dec.) with exceptionally early eggs 7 and 8 Dec. and one late between 2 and 10 Jan. Possibly lay week earlier at Big South Cape I., 100 km N of Snares Is (Stead 1932). Hatching mid-Feb. and departure of adults and young, May to 8 June (Richdale 1964; Horning & Horning 1974). At Dusky Sound, breeding Nov.–Dec. (CSN 35).



SITE At Snares Is, mostly in tussock grassland *Poa astonii*, growing on deep peat on tops of cliffs and ledges, and down steep slopes; generally avoid dense *Olearia* forest (6 m high) on main part of island but found among scrub of *Hebe elliptica* (3 m high) and on fringes of *Olearia* forest (Warham 1967; Warham *et al.* 1977). Burrows usually in contact with rock, which forms roof or walls of tunnels or chambers; burrows also below tree roots and tussocks, and nests in crevices and caves. Burrows dug horizontally or nearly so into slopes, ending in enlarged chamber, often against rock. No precise measurements, but tunnels narrower than those of Sooty Shearwater, often barely admitting one's hand, and c. 1 m long. Burrows closely spaced (e.g. three in 1 m²) but no

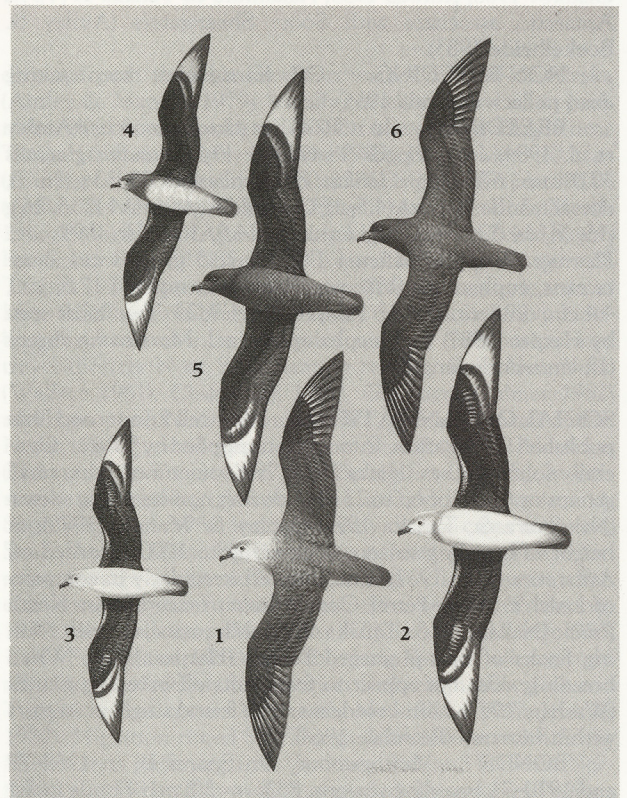


Plate 31

Marmadec Petrel *Pterodroma neglecta*

1. Adult, light morph, dorsal
2. Adult, light morph, ventral
3. Adult, white-headed light morph, ventral
4. Adult, intermediate morph, ventral
5. Adult, dark morph, ventral
6. Adult, dark morph, dorsal

detailed assessment of density (Warham *et al.* 1977).

NEST, MATERIALS In enlarged chamber at end of tunnel but some nests in deep clefts between boulders, where visible from above (Richdale 1964; Warham *et al.* 1977). Most chambers in darkness or nearly so. Poorly concealed entrance to burrows blocked with vegetation. Shallow hollow in chamber liberally strewn with grass and well drained. Birds apparently crop vegetation round entrance, as in Sooty Shearwater, but not seen to do so. Same burrow used by same birds in successive years.

EGGS Short, sub-elliptical, slightly tapered at one end; smooth-surfaced, slightly glossy; dull white (Oliver).

MEASUREMENTS: South Cape I.: 58.6 (1.5; 55.5–60.5; 10) x 42.7 (0.77; 41.5–44.0) (Richdale 1964); Snares Is: 60.53 (2.06; 55.5–64.4; 62) x 43.9 (1.30; 41.8–48.9) (Warham *et al.* 1977).

WEIGHT: 53.2 (3.2; 47.5–57.5; 8; incubated eggs; Richdale 1964); 61.1 (0.52; 54.6–68.5; 10; fresh eggs; Warham *et al.* 1977) or 18.6% of av. adult mass. Loss of weight during incubation: 0.21–0.23 g/day or 16.7% in 49 days from laying to pipping.

CLUTCH-SIZE One. No replacement after loss.

LAYING Well synchronized in 12 days between 14 and 26 Dec. but two early eggs laid 7 and 8 Dec. and one late between 2 and 10 Jan. Eggs laid on night of arrival, female not coming ashore before dark.

INCUBATION By both sexes. On morning after

laying, only one adult in burrow; female on 36/47 occasions, staying on egg till next night when male took over, but some males took over on night of laying. Share of sexes about equal (41 spans by male averaged 12.8 days; 35 by female, 13.8 days). Typically each sex undertook two long shifts during incubation period. Thus incubating birds tended to be of one sex on particular day. **INCUBATION PERIOD:** judged from mean date of laying (19.1 Dec.) to mean date of hatching (6.9 Feb.) was 49.8 days; for 21 individual determinations, av. 50.45 days (1; 48.5–53.0). Two eggs, uncovered for 3–5 days during period, hatched. One incubating adult lost 90 g in 13 days. Egg shells trampled in nest.

NESTLING Semi-altricial, nidicolous. Hatched with eyes open but vision apparently poor; protoptile down, rather uniform, dense, medium grey with brownish cast, slightly lighter below and sometimes with whitish bib on chin and breast. Protoptile longest (c. 16 mm) on back and sides; shortest (8–10 mm) on crown and belly. Hatching takes 4.2 days (2–6; 19) from pipping to completion. Little information on parental care. Chick brooded by either adult for 1–2 days; usually alone thereafter but occasionally adult may stay with chick during day until 12 days old. Both parents rarely found with chick. Alternation of duties probably continues in same way from incubation. Judged from weights of chicks, chicks apparently not fed nightly but fast for 1–3 days between meals. Chicks may eject copious proventricular oil at intruder but about 50% did not do so. **NESTLING PERIOD:** no full determination but estimated as 90–105 days.

GROWTH One chick weighed 50 g at 2 days old and 116 g at 6 days old (Richdale 1964). At age 18 days, three chicks averaged 221 g or 67% of av. adult mass (Warham *et al.* 1977). Egg-tooth lost at c. 8 days old (3–16; 18).

FLEDGING TO MATURITY No information.

SUCCESS At Snares Is: 79 eggs laid, 51 (65%) hatched, 26 (33%) deserted, two uncertain result.

PREDATORS Skuas may be worst or only serious predator. On Codfish I., introduced Wekas kill many birds (Blackburn 1968). Chicks on Snares Is hosts to ticks *Ixodes uriae* and may be infested by amphipods, probably *Orchestria* sp., on heads, causing baldness.

PLUMAGES

ADULT Age of first breeding unknown. In fresh plumage: **HEAD AND NECK.** Feathers of crown, dark grey (83), concealed bases of feathers, white. Forehead, narrowly fringed white, giving scalloped appearance; when worn, fringes largely lost or narrow. Hindneck, dark brown (121), fringed dark grey (83); concealed bases, white, and sometimes exposed. Near base of bill, lores, white; farther away from bill, dark grey (83) and broadly tipped white. Sub-orbital patch, grey-black (82). Malar region, side of neck and ear-coverts, white tipped grey (84) with brown-grey (79) shade. Chin to base of foreneck, white. **UPPERPARTS.** Mantle and upper back, dark brown (121) with broad dark-grey (83) subterminal fringes, narrowly tipped white; concealed bases of feathers, white. Rest of back and rump, dark grey (83) with brown-grey (79) shade and fringed dark brown-grey (79); contrasts with rest of upperparts forming middle of M-shaped marking when wings spread. Upper tail-coverts, grey (84) with pale-grey (86) to dull-white tips. Scapulars, black-brown (119) with rounded webs. When worn, white tips on upperparts largely lost or narrow; feathers appear dark brown (121) with darker shade across middle of back. **TAIL.** T1–5, grey (84); t6, pale dark-brown (121) on outer web, inner web white with subterminal

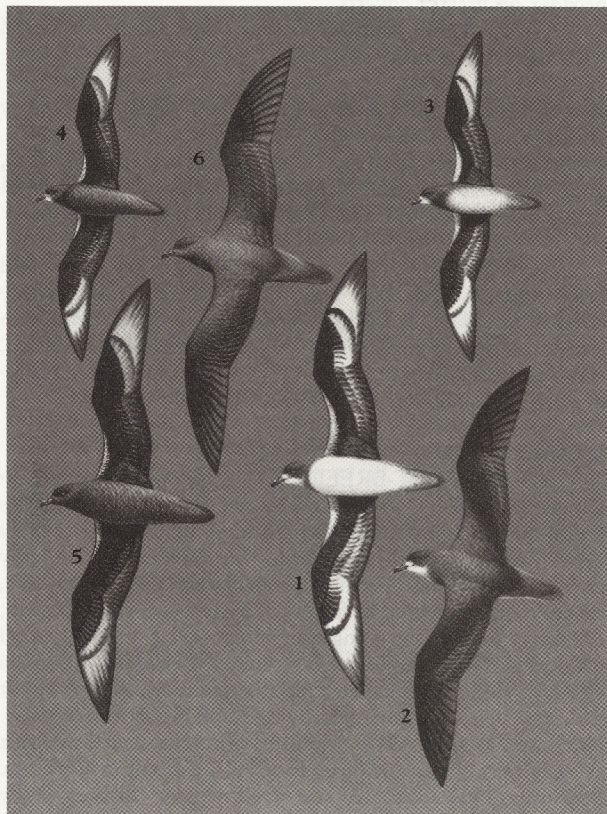


Plate 32

Herald Petrel *Pterodroma arminjoniana*
Subspecies *heraldica*

- 1. Adult, light morph, ventral
- 2. Adult, light morph, dorsal
- 3. Adult, intermediate morph, ventral

- 4. Adult, white-throated dark morph, ventral
- 5. Adult, dark morph, ventral
- 6. Adult, dark morph, dorsal

pale dark-brown (121) mottling or slight barring; rachis, light grey-brown (119C). When worn, dark brown (121) (Fig. 1). **UPPERWING.** Primaries, black-brown (119) but, at base, inner margins of inner webs, white and exposed when wing spread (see underwing); when worn, dark brown (119A). Secondaries, grey (84) edged white on outer web; inner web, white for three-quarters length; rachis, grey-black (82) and white at base. Tertiaries, black-brown (119), narrowly tipped white. All primary-coverts, including alula, dark brown (121); greater primary-coverts narrowly tipped white. Marginal- and lesser-coverts, black-brown (119) and form part of M-shaped marking when wing spread. Median- and greater-coverts, grey (84) fringed white; fringe narrow on median and broader on greater. When worn, white fringes and tips largely lost or narrow. **UNDERPARTS.** Breast-feathers, white, narrowly tipped grey (84) with light grey-brown (119C) shade; tips broaden towards abdomen. Feathers at outer margins of breast, white barred grey (84) with light grey-brown (119C) shade at tips. White bases of feathers on underparts often exposed, giving mottled appearance; when worn, tips sometimes lost and underparts appear white as far as abdomen (Loomis 1918). Flank feathers, white with narrow subterminal light-grey (85) shaded brown-grey (79) barring; vent-feathers similar. Under tail-coverts, white with lateral feathers faintly barred grey (84), mostly on outer webs. Axillaries, dark brown (121), tipped white; smaller axillaries, white with tips barred dark brown (121). **TAIL.** Underside of tail, light grey (85); rachis, white. **UNDERWING.** Primaries, black-brown (119) with contrasting white wedge on inner web extending three-quarters of length; wedge formed by white inner margin edged dark brown (121) on outer margin. Greater primary-coverts, white, but outermost feather pale dark-brown (121). All other greater coverts, white. Outermost median primary-covert, dark brown (121); remaining feathers, pale dark-brown (121) on outer web, varying mottled white at tip and white on inner web varying mottled or barred pale dark-brown (121) at tip. Median coverts, white with tips varying barred pale dark-brown (121). Innermost (for half length of radius/ulna bone) lesser and marginal coverts, white. Rest of coverts, dark brown (121), fringed dark grey (83); some marginal coverts near carpal joint, dark brown (121) fringed white or white tipped dark-brown (121). Dark coverts on underwing form contrasting moderately broad diagonal bar from axillaries to carpal joint, and extending along median, lesser and marginal coverts to median primary-coverts.

DOWNY YOUNG Protoptile, medium-grey, brownish in some lights, slightly lighter underneath. Some birds have whitish chin and breast, sometimes belly white. Down c. 10 mm long on crown and 8 mm on belly. Down short on chin and round base of bill (Warham *et al.* 1977). Mesoptile, darker grey. Photo of mesoptile in Lindsey (1986) shows down to be dark brown (219). At Snares Is, NZ, birds fledge when 90–105 days old (Warham *et al.* 1977).

JUVENILE Similar to adult but paler, *contra* Buller (1895), who stated that juveniles darker, which subsequently led to most authors quoting this (e.g. Oliver). Skins at NMNZ indicate distinct differences from adult (R. O'Brien), *contra* Watson (1975), who states that no characters known to distinguish juveniles. Differs from adult in: **HEAD AND NECK.** Narrow white fringes extend to hindcrown and sometimes nape. **UPPERPARTS.** Appear generally paler; subterminal fringes on mantle, grey (84) to light grey (85), white tips broader. Central part of M-mark, paler. **TAIL.** T4, grey (84) with tip of webs and edge of inner web, white; white webs,



Fig. 1



Fig. 2

adult and juvenile tail-feathers.

varyingly mottled pale dark-brown (121), tip of outer web, slightly barred pale dark-brown (121). T5, white with fine pale dark-brown (121), irregular, short, subterminal barring on webs; outer web similarly barred but pale grey. T6, pale grey on outer web with irregular short subterminal dark-brown (121) bars; inner web, mostly white. Occasionally, tip of t3–2, white on outer web with narrow subterminal pale dark-brown (121) bars; basal inner webs mottled white (see Fig. 2). **UPPERWING.** Coverts paler, M-shaped marking paler; fringes broader on greater coverts.

ABERRANT PLUMAGES Specimen recorded with 13 rectrices (Loomis 1918).

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

ADULT, JUVENILE Iris, dark brown (121). Bill, grey-black (82). Legs and feet, pink (7); outer tarsus and distal two-thirds of toes and webs, dark grey (83); claws grey-black (82).

DOWNY YOUNG At hatching, eyes open and bright blue; eye-lids, blue-grey. Bill, black. Egg tooth, white and lost at 8 days (3–16; 18). Tarsus, pale grey to white with lilac tinge, darker grey on feet and toes, webs flesh-coloured, claws blackish (Warham *et al.* 1977). In mesoptile: iris, black-brown (119); bill, black (89). Rest, no data.

MOULTS

ADULT POST-BREEDING Complete; occurs in winter quarters in North Pacific, from Apr.–Nov. Primaries moult outwards. By analogy with other *Pterodroma*, probably up to three innermost primaries lost simultaneously; Murphy & Pennoyer (1952) mention probable early moulting bird, where moult occurred as far as p3. Male taken near Kiska I., Alaska, in June, undergoing complete moult; several taken off California, Nov., showed some renewal of feathers (Loomis 1918). Failed breeders and non-breeders probably moult earlier, as moulting birds seen flying N, off Hawaii during Mar. (Ainley & Manolis 1979). Moult of primaries seems to occur as early as mid-Feb., as birds E of NZ in moult (Murphy & Pennoyer 1952) and may be pre-breeders; further study required.

POST-JUVENILE Undescribed.

MEASUREMENTS (1) NZ, unknown status, including birds taken at sea, skins; methods unknown (Loomis 1918). (2) Unknown status, skins; methods unknown (Murphy & Pennoyer 1952). (3) Unknown status, skins; straightened wing

(Palmer 1962). (4) Big South Cape I. (near Stewart I.), NZ, adults, skins (NMNZ).

	MALES	FEMALES
WING	(1) 256.5 (5.04; 247-267; 16) (2) 255.2 (248-260; 10) (3) 250.0 (242-259; 4) (4) 263.8 (5.69; 257-273; 6)	254.1 (4.74; 244-259; 10) 255.1 (248-262; 9) 253.0 (247-268; 4) 263.1 (5.56; 251-271; 9)
TAIL	(1) 102.0 (2.96; 95-107; 16) (2) 103.0 (97.2-107.5; 10) (3) 102.0 (98-105; 4) (4) 105.8 (3.62; 101-112; 6)	98.5 (2.57; 96-104; 10) * 101.4 (97-103.7; 9) 105.0 (102-108; 4) 106.2 (2.14; 102-109; 9)
BILL	(1) 26.8 (0.71; 25.9-28.1; 16) (2) 26.0 (25.1-27.3; 10) (3) 26.2 (25-27; 4) (4) 28.2 (0.41; 27.6-28.8; 6)	27.0 (0.71; 26.1-28.4; 10) 26.4 (24.6-27.5; 9) 27.0 (26-29; 4) 27.3 (1.29; 25-29.8; 9)
TARSUS	(1) 32.1 (1.47; 30.1-35; 16) (2) 33.5 (32.2-35.4; 10) (3) 34.2 (34-35; 4) (4) 36.3 (0.94; 34.6-37.6; 6)	32.0 (1.37; 30.1-35; 10) 33.9 (33-35.1; 9) 35.2 (34-36; 4) 35.1 (1.07; 33.4-36.6; 9)
TOE	(1) 43.7 (1.77; 40.7-46.7; 16) (2) 42.1 (40.4-43.6; 10) (4) 45.3 (1.03; 44-46.7; 6)	43.1 (1.77; 41.2-47; 10) 42.7 (40-45.1; 9) 44.2 (1.13; 42.6-45.9; 9)

Additional measurements in Richdale (1964) and Warham *et al.* (1977).

WEIGHTS Label data from adult skins (NMNZ), Big South Cape I., some fat to very fat, Feb.: males 302.0 (68.9; 205-375; 6); females 335.1 (55.2; 247-437; 9). At Big South Cape I., NZ, unsexed birds 316.2 (32.1; 247-441; 89) (Richdale 1964). At Snares Is, NZ, Jan., unsexed birds 329 (31.2; 42) (Warham *et al.* 1977). Loss of weight during incubation (length of shift: 13 days) *c.* 6.9 g/day (*n*=1; Warham *et al.* 1977). At Snares Is, NZ, chicks reached mean weight of 221 at 18 days, 67% of mean adult weight (Warham *et al.* 1977). No details on seasonal changes.

STRUCTURE Wing, long and narrow. Eleven primaries: p10 longest, p9 1-8 mm shorter, p8 12-23, p7 28-41, p6 47-58, p5 67-79, p4 91-102, p3 112-125, p2 132-148, p1 147-164, p11 minute. Primaries tapering; no emarginations. Primaries extend 13-28 mm beyond tip of tail. Tail rounded; 12 rectrices, t1 longest, t6 16-30 mm shorter. Under tail-coverts end *c.* 6 mm short of tip of tail. Bill, robust; maxillary unguis, hooked. Nostrils, rounded and point forwards; nostrils *c.* 27% of length of bill. Legs and feet, slender; tarsus, laterally compressed. Feet, webbed. Outer and middle toes about equal in length, inner *c.* 77% of middle, hind (claw only) *c.* 11%.

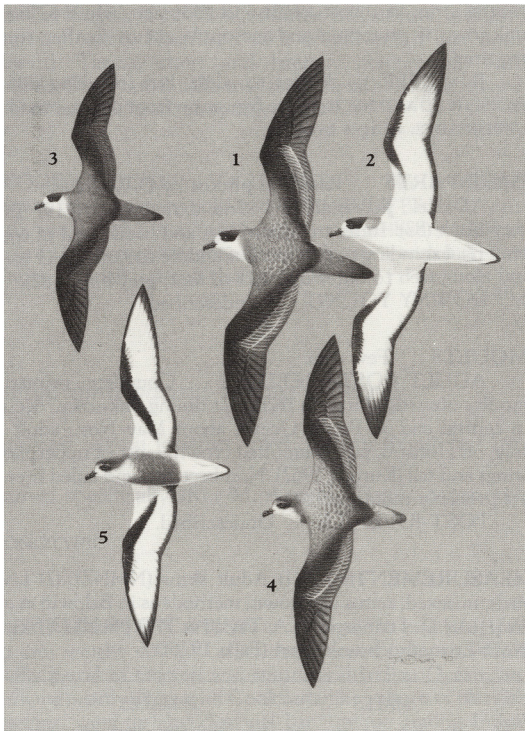
GEOGRAPHICAL VARIATION Probably forms superspecies with *P. ultima*, *P. brevirostris* and *P. mollis* (Peters).

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J. N. DAVIES 90



Volume 1 (Part A), Plate 34

Barau's Petrel *Pterodroma barau*

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

Mottled Petrel *Pterodroma inexpectata*

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

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