

Order PROCELLARIIFORMES

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

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

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

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

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

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

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

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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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Pterodroma nigripennis **Black-winged Petrel**

COLOUR PLATE FACING PAGE 489

Oestrelata nigripennis Rothschild, 1893, *Bull. Br. Orn. Club* 1: 57 — Kermadec Islands.

The specific name (*niger*, black, and *penna*, feather) chosen by Rothschild as differing from all its congeners in the 'almost total absence of white on the inner webs of the outer primaries beneath the under wing-coverts, with the exception of a rather wide margin, being white as well as the axillary feathers'.

MONOTYPIC

FIELD IDENTIFICATION Length 28–30 cm; wing-span 63–71 cm; weight 170–200 g. Small, rather compact gadfly petrel with generally grey-and-white plumage, almost complete grey collar, short, stubby black bill, small head, slender body, longish gently wedge-shaped tail (usually tightly folded and appearing pointed), diagnostic underwing pattern. Sexes alike; no seasonal variation. Juvenile inseparable.

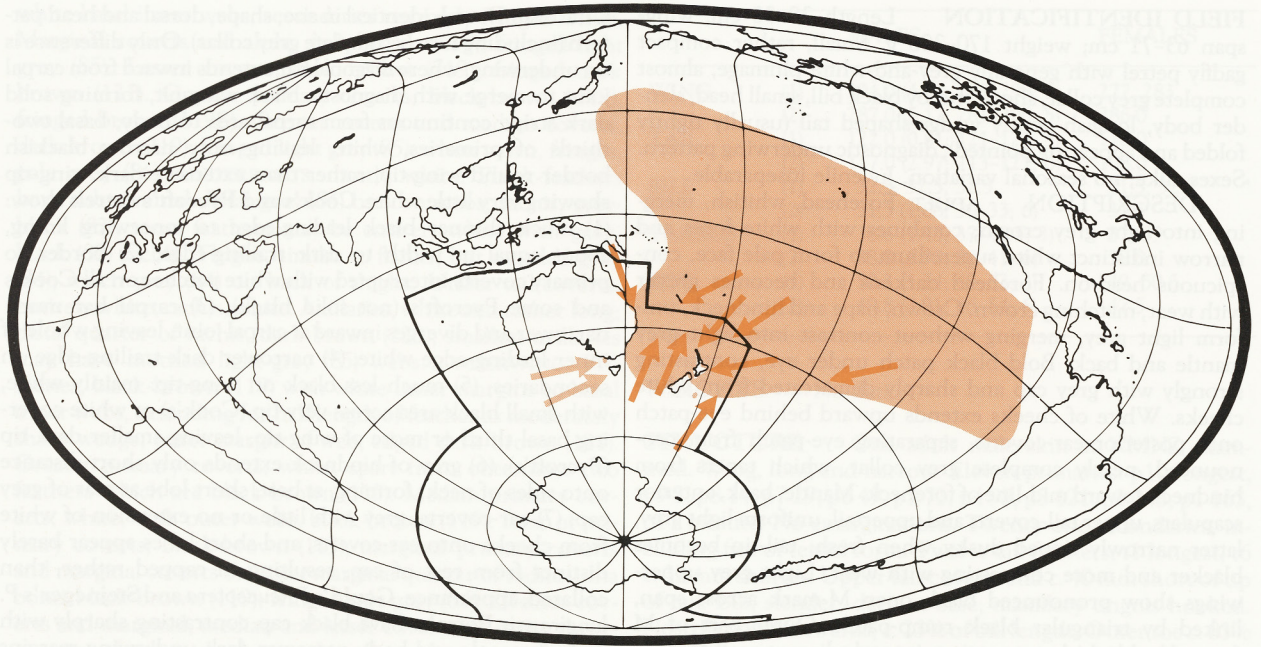
DESCRIPTION ADULT. Forehead, whitish, merging into light grey crown; combines with white lores and narrow indistinct white supercilium to form pale face, conspicuous head-on. Forehead darkens and becomes greyer with wear, matching crown. Crown, nape and hindneck, uniform light grey, merging without contrast into light grey mantle and back. Bold black patch under eye, contrasting strongly with grey cap and sharply demarcated from white cheeks. White of cheeks extends upward behind eye-patch onto posterior ear-coverts, separating eye-patch from pronounced, nearly complete grey collar, which tapers from hindneck toward mid-line of foreneck. Mantle, back, anterior scapulars, upper tail-coverts and uppertail, uniform light grey, latter narrowly tipped dusky when fresh; tail-tip becomes blacker and more contrasting with wear. Light grey upperwings show pronounced black open M-mark across span, linked by triangular black rump-patch. Outer part of M formed by blackish outer primaries and adjacent coverts, contrasting with grey-toned inner ones; inner part, by diagonal blackish bar tapering across innerwing coverts from carpal area to longest scapulars, contrasting with light grey coverts along inner forewing and with grey-toned secondaries and all but a few inner greater and median secondary coverts. Upperwing darkens with wear and clarity of M-mark reduced till barely apparent; upperwing then contrasts strongly with light grey of mantle, back and innermost forewing. Underparts, white except for nearly complete grey collar. Grey of upper sides of neck extends to basal leading-edge of underwing, forming small pre-axillary notch; sometimes continues as narrow band tapering onto anterior flanks, a pattern unique among grey-capped small *Pterodroma*. Dark tips of rectrices show as narrow dark rim round tip of tail, contrasting with white under tail-coverts. Underwing, white apart from thick, solid-black band along anterior edge, starting at base of outermost primary and extending inward past carpal joint to about elbow before diverging inward across lining to form bold diagonal bar (tapering from carpal joint to mid-way between it and posterior base of wing); inner leading-edge, wing-pit and axillaries, white. Secondaries, blackish, forming thick dark trailing-edge (slightly narrower than black band along anterior border). Primaries, mainly blackish (white only on bases), forming extensive dark wing-tip. Bill, black; short and stubby, with tubed nostrils raised prominently over basal third of upper mandible. Legs and basal third of feet, fleshy-pink (rarely bluish-flesh); outer toe and distal two-thirds of outer toes and webs, black.

SIMILAR SPECIES Black-winged Petrel readily distinguished from other small *Pterodroma*, by combination of grey cap (uniform with grey of saddle), nearly complete grey collar and on underwing, much thicker black margins, tip and carpal bar. In our region, likely to be confused only with Chatham *Pterodroma axillaris*, Cook's *P. cookii* and Pycroft's Petrels *P. pycrofti*, all of which share grey cap uniform with grey of mantle and back (as on Black-winged). Similar in size and shape to Cook's and Pycroft's Petrels but with proportionately shorter wings and longer tail than former, slightly fuller body and distinctly more robust bill than either.

Chatham Petrel: identical in size, shape, dorsal and head pattern (including nearly complete grey collar). Only difference is on underwing, where diagonal bar extends inward from carpal joint to merge with diagnostic black wing-pit, forming solid dark stripe continuous from carpal area to body; basal two-thirds of primaries, white, leaving only narrow blackish border round wing-tip, rather than extensive dark wing-tip showing very little white. **Cook's and Pycroft's Petrels show:** (1) much thinner black leading-edge to innerwing lining, about equal in width to dark trailing-edge; (2) border to primary coverts interrupted with white patches on all Cook's and some Pycroft's (not solid black); (3) carpal bar much narrower and diverges inward at carpal joint, leaving whole of inner leading-edge white; (4) narrower dark trailing-edge on secondaries; (5) much less black on wing-tip: mainly white, with small black area across very tip (Cook's) or white covering basal third or more of wing-tip, leaving smaller dark tip (Pycroft's); (6) grey of hindneck extends only short distance onto sides of neck, forming, at best, short lobe at rear of grey cap; (7) ear-coverts, grey with little or no extension of white from cheeks onto ear-coverts, and short lobes appear barely distinct from rest of cap, resulting in capped rather, than collared, appearance. **Gould's *P. leucoptera* and Stejneger's *P. longirostris* Petrels:** have black cap contrasting sharply with grey of mantle and back; narrower dark underwing margins and carpal bar; less extensive dark wing-tip.

Markedly pelagic but occasionally range into shelf-break waters. Avoid land except when breeding, though sometimes sighted from coast when storm-driven. In light winds, flight recalls that of prions *Pachyptila* spp; gentle roller-coaster progression interspersed with brief bursts of rapid crisp wing-beats followed by short glides. In calm conditions, sometimes interrupt normal roller-coaster progression to engage in frenzied sprint across surface, weaving and twisting erratically with fast jerky wing-beats. In strong winds, flight more buoyant and vigorous, combining periods of tight bounding and swooping with sudden sharp turns; occasionally soar high over ocean, hanging motionless into wind. Feed by surface-seizing, dipping and pattering; frequently join mixed-species feeding flocks, often in association with other small *Pterodroma* and larger *Pterodroma* spp. Solitary or in small loose groups at sea, sometimes forming larger flocks (up to 20) when feeding. Usually ignore ships but, at times, will closely accompany or follow, often in considerable numbers. During breeding season (Oct.–Feb.), pairs or small groups engage in spectacular display flights over open ocean, colonies, other islands or headlands; close-contact pursuit-chases accompanied by loud calling. Breed colonially on well-vegetated tropical and subtropical islands. Strictly nocturnal at some colonies and markedly diurnal at others where numbers over colonies peak during late afternoon. Flight call, loud shrill *weet-weet-weet* or *reep-wee-wee*, usually only three-syllabled, sometimes followed immediately by mewing calls, which also uttered separately; both calls also given from ground.

HABITAT Marine, pelagic; in subtropical and tropical sw. and central Pacific Ocean, migrating to n. central Pacific in non-breeding season. In A'asian region, observed over waters of 21–24 °C (Jenkins 1970, 1971), range extending into cooler seas in intrusions of warm water (Jenkins 1971), but flocks observed over Gascoyne Seamount in Tasman Sea, where low sea surface-temperature (20.3 °C) indicated upwelling of nutrient-rich water (Barton 1980). In n. hemisphere, also in tropical and subtropical waters where sea surface-



temperatures 22.4–28 °C (Gould 1983; Tanaka *et al.* 1985). In e. Pacific, concentrated along s. edge of North Equatorial Current, over upwelling associated with current divergence (Pitman 1986).

Breed on subtropical and tropical islands and islets in sw. Pacific Ocean, nesting in burrows or rock crevices on vegetated coastal slopes or rugged terrain inland; under scrub (e.g. *Olearia*), tussocks (e.g. *Mariscus*) or grassy mats (e.g. *Microlaena*) (Oliver; Merton 1970, 1984; Jenkins & Cheshire 1982).

Fly in high arcs over surface (Barton 1980); during spectacular courtship flights over sea or breeding islands may fly as low as 0.3 m or soar up to 50 m above cliffs (Klapste 1981).

Although feral cats kill birds on some breeding islands, largest colonies free of introduced predators, and becoming established or expanding colonies in recently discovered breeding islands. However, establishment on some potential breeding sites may be prevented by heavy predation by cats, see Distribution for further details (Jenkins & Cheshire 1982).

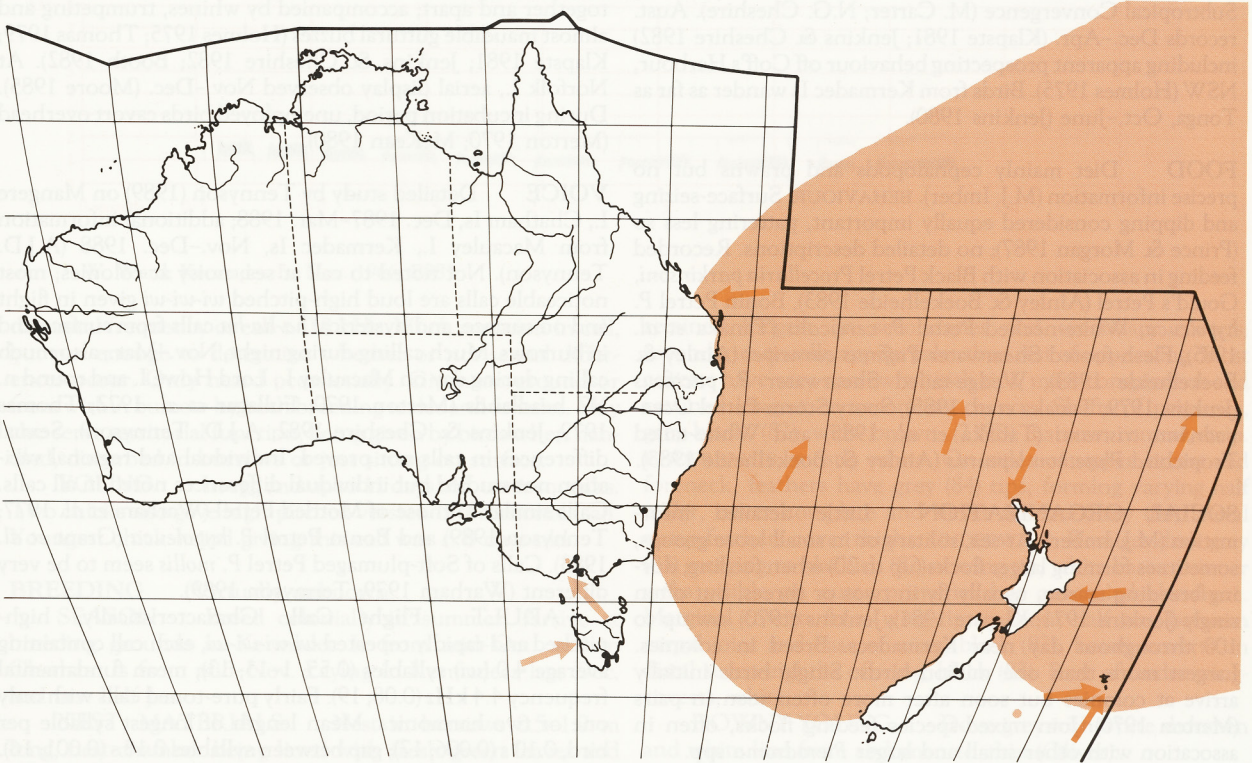
DISTRIBUTION AND POPULATION During breeding season, mainly n. and e. of NI, NZ, from W of Auckland Pen. to Chatham Is. Often recorded in Tasman Sea during austral summer, mostly between 30–40°S, with occasional sightings as far N as 27°S and as far S as 47°S (Jenkins & Cheshire 1982). After breeding, often recorded in Fijian waters (Clunie *et al.* 1978) and not uncommon round Tonga (Jenkins 1980); extend into central Pacific. Recorded from Kiribati, Marshall Is, Cook Is, Society Is and Marquesas (Pratt *et al.* 1987). During non-breeding season, found in n., e. and central Pacific to SE of Japan, Hawaii and off Baja California and Central America; in e. Pacific, between 160° and 110°W, generally between 0° and 20°N, including Hawaiian waters. Most numerous between 5° and 15°N. E of 110°W, distribution extends S to 15°S (Pitman 1986).

AUST Qld. First recorded Heron I., 7 Jan. 1962 (Reid 1964); often subsequently, but breeding unconfirmed (Kikkawa & Boles 1976). Singles, beachcast: Southport Spit,

Bribie I., 1 Jan. 1971 (Aust. Atlas); North Stradbroke I., 25 and 31 Jan. 1974 (Ingram 1975; Corben 1975); Fraser I., 8 Jan. 1976 (Barry & Vernon 1976); Perigian Beach, 18 Feb. 1977 (Jenkins & Cheshire 1982). Single sightings: North West I., Capricorn Grp, 20 Dec. 1979 (Griffin 1980); Pt Lookout, 29 Dec. 1983 (Stewart 1984). NSW. Single, beachcast, Byron Bay (Morris *et al.* 1981); one beachcast Durras Beach, Batemans Bay, 7 Mar. 1973 (Morris 1974); sightings: Cronulla, 2 Feb. 1964 (Hindwood 1965); Newcastle, Apr. 1968 (Holmes 1975); ≥6, Muttonbird I., regularly recorded between Jan. 1975 and Dec. 1982 but breeding unconfirmed (Holmes 1975, 1977; NSW Bird Reps 1982, 1983, 1984); one near n. Solitary I., 8 Mar. 1976 (Rogers 1977); one off Eden, Feb. 1978 (D. Barton in Morris *et al.* 1981); two offshore between Port Stephens-Batemans Bay, 22 Dec. 1984 (NSW Bird Rep. 1984); one off Wollongong, 20 Apr. 1985 (NSW Bird Rep. 1985); one c. 22 km off Sydney, 27 Apr. 1985 (NSW Bird Rep. 1985). Vic. Singles: You Yangs (14 km inland), 14 April 1974 (Smith 1975); beachcast, Eastern View, 6 Apr. 1985 (Vic. Bird Rep. 1985). Tas. One beachcast, Henty R., Ocean Beach, 22 Feb. 1983 (Tas. Bird Rep. 1983). No records SA, WA, NT.

NZ In NZ, wrecks occurred Apr. 1968, Hawkes Bay, Cook Str., where >40 derelicts recovered (Falla *et al.* 1987) and in 1983 on NI when at least 30 recovered (Powlesland 1985). Recent expansion into region has resulted in increase of beachcasts. NI. Regularly seen northwards from North Cape and E of East Cape to Wairarapa, but a few from Bay of Plenty. Of 114 beach derelicts found in regular surveys since 1964, 85 birds recovered from Auckland West beaches, nine from Auckland East, two from Bay of Plenty, six from East Coast, four from Taranaki, four from Wellington West, three from Wellington South. SI. Not often recorded. Since 1964, two beachcast: one, Canterbury North; one, Canterbury South. Occasionally recorded as far S as Invercargill (CSN 26). Small numbers sometimes recorded at sea off Fiordland (Jenkins & Cheshire 1982).

BREEDING In recent decades, has expanded breeding range westwards in A'asian region (Klapste 1981; Powlesland 1985).



Norfolk I., a few unsuccessful attempts (Hermes *et al.* 1986); **Philip I.**, 50–100 pairs (Tarburton 1981), several hundred birds (Hermes *et al.* 1986).

Lord Howe I., 100–1000 pairs (Fullagar & Disney 1975); Balls Pyramid, 'in some strength' (Fullagar *et al.* 1972).

Kermadec Is., Raoul I., small numbers; Herald Islets: N. and S. Meyer Islets (many thousands), Napier Islet (several hundred pairs), Dayrell Islet, N. and S. Chanter Islets ('plentiful') (Merton 1970); Macauley I., >1.1 million birds (P.J. Moors); Curtis I. (OSNZ);

Chatham Is., South East I. (Merton 1984); North I.; Portland I., nine burrows (Eagle 1980);

Three Kings Is., Great King I., (Turbott 1951); South West I., large colony (J.A. Bartle).

Breeding suspected but not confirmed at: **Heron I.**, Qld (Kikkawa & Boles 1976); Mutton Bird I., NSW (Holmes 1977); recently observed flying over C. Maria Van Dieman (CSN 35), North Cape (CSN 25) and Cuvier I. (T.G. Lovegrove in Jenkins & Cheshire 1982), possibly prospecting for new breeding sites (Jenkins & Cheshire 1982); **Three Kings Is.**, West and North East Is (J.A. Bartle); **Poor Knights Is** (Aorangi) (OSNZ); **East I.** (Jenkins & Cheshire 1982); **Chatham Is** (Mangere I., Pitt I., Star Keys, Forty Fours Is); extraliminally, breed New Caledonia (Imber & Jenkins 1981) and islets off Rapa I., Austral Grp (Holyoak & Thibault 1984).

Adversely affected by impact of European settlement. Cats prey heavily on Black-winged Petrels on Raoul I. (Merton 1970), Norfolk I. (Klapste 1981; de Ravin 1975; Hermes *et al.* 1986), Lord Howe I. (Fullagar *et al.* 1972), Pitt I. and NZ mainland. Single cat-midden (9 m radius) on Raoul I. contained remains of 44 Black-winged Petrels (Merton 1970); c. 160 cat-killed corpses recovered on Pitokuku Hill (CSN 30). On Norfolk I., cats principal predator (Klapste 1981). Decline

in numbers on Kermadecs coincided with accidental introduction of *Rattus norvegicus* (Crockett 1975). Also thought sensitive to impact of feral pigs and goats on Lord Howe I. (Fullagar & Disney 1975).

MOVEMENTS Migratory from breeding grounds in sw. Pacific to n. and e. Pacific.

DEPARTURE Young fledge Kermadec Is, late Apr. (Oliver). Last chick seen Norfolk I., 2 May, all adults leaving by late May (Hermes *et al.* 1986). Young probably fledge Lord Howe I. throughout May (Holmes 1975). Non- or failed breeders leave Tasman Sea from Mar., withdrawing from w. Tasman Sea by Apr. Breeders leave during May though few stragglers remain N of NZ until June (latest record 24 June) (Jenkins & Cheshire 1982) and near Fiji until late June (Jenkins 1986).

NON-BREEDING Recorded to N and E of breeding islands but no information on routes taken. Numbers increase central Pacific, May (King 1970) and abundant between Hawaii and Peru (Meeth & Meeth 1985, 1986; Pitman 1986). Also common July–Sept. in nw. Pacific between 2°–40°N and 140°–160°E (Tanaka *et al.* 1985) and, in late Oct., sighted up to 31°N, N of Hawaii (Gould 1983). Numbers in central Pacific appear to increase in Oct. then rapidly decline (King 1970).

RETURN Return: Norfolk I., Oct. (Hermes *et al.* 1986); Kermadec Is, mid.–Oct. (M.J. Imber); in waters round Fiji, late Oct. (Jenkins 1986); breeding islands near NZ, first 2 weeks Nov.; only recorded date 17 Nov. at South East I., Chatham Is (Imber 1978), apparently having travelled quickly from central Pacific.

BREEDING Present at breeding islands preparing burrows Nov. then spread widely across Tasman in pre-laying exodus during Dec. (Jenkins & Cheshire 1982) as far S as

Subtropical Convergence (M. Carter; N.G. Cheshire). Aust. records Dec.–Apr. (Klapste 1981; Jenkins & Cheshire 1982) including apparent prospecting behaviour off Coff's Harbour, NSW (Holmes 1975). Birds from Kermadec Is wander as far as Tonga, Oct.–June (Jenkins 1980).

FOOD Diet mainly cephalopods and prawns but no precise information (M.J. Imber). **BEHAVIOUR.** Surface-seizing and dipping considered equally important, pattering less so (Prince & Morgan 1987); no detailed descriptions. Recorded feeding in association with Black Petrel *Procellaria parkinsoni*, Gould's Petrel (Ainley & Boekelheide 1983), Bonin Petrel *P. hypoleuca*, White-necked Petrel *P. cervicalis* (Tanaka *et al.* 1985), Flesh-footed Shearwater *Puffinus carneipes* (Ainley & Boekelheide 1983), Wedge-tailed Shearwater *P. pacificus* (Jenkins 1979; Tanaka *et al.* 1985), Sooty Storm-Petrel *Oceanodroma tristrami* (Tanaka *et al.* 1985) and White-tailed Tropicbird *Phaethon lepturus* (Ainley & Boekelheide 1983).

SOCIAL ORGANIZATION Little detailed information (M.J. Imber). At sea, solitary or in small loose groups, sometimes forming larger flocks (up to 20) when feeding; during breeding season, usually fly in twos or threes, but often singly (Jenkins 1971; Klapste 1981); Jenkins (1970) saw up to 100 throughout day near Kermadecs. Breed in colonies. Largest more than one million birds. Single birds initially arrive at colonies but soon after more often seen in pairs (Merton 1970). Join mixed-species feeding flocks, often in association with other small and larger *Pterodroma* spp.

BONDS No information.

BREEDING DISPERSION Colonial nester, with burrows 1 m apart on Portland I. (Eagle 1980); on South Meyer I., av. density of 1.56/m² (0.3–2.2) (Merton 1970). Colonies may be situated at edge of Wedge-tailed Shearwater colonies; shearwaters often chased away from petrel colony (Holmes 1975).

ROOSTING During breeding season, return to Lord Howe I. and Kermadecs during afternoon and, at latter, continue flying and calling at night (Edgar *et al.* 1965; Klapste 1981); at Norfolk I., many seen over colonies at dusk and smaller numbers during day (Moore 1985); at Muttonbird I., NSW, Heron I., Qld, and Chatham Is. activity strictly nocturnal — probably in response to predation by White-bellied Sea-Eagles *Haliaeetus leucogaster*, Peregrine Falcons *Falco peregrinus* and skuas (Holmes 1977; Aust. RD).

SOCIAL BEHAVIOUR No detailed studies. At breeding colonies, easy to capture just after landing (Klapste 1981). During breeding season at Norfolk I., usually seen in pairs flying in close formation (de Ravin 1975). At times, birds in burrows or on ground call vigorously. On one occasion, Black-winged Petrel observed to approach White-capped Noddy *Anous minutus* rapidly and fly close above it causing it to drop nest material; then Petrel flew away (Klapste 1981).

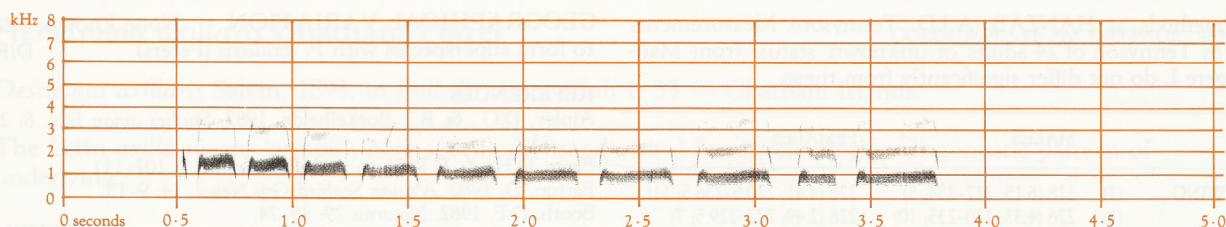
AGONISTIC BEHAVIOUR Not known. Birds disturbed at burrow give territorial call, see Voice.

SEXUAL BEHAVIOUR **AERIAL DISPLAY, COURTSHIP.** During breeding season, pairs or small groups engage in spectacular close-contact pursuit-chases over sea, colonies, other islands or headlands. Consists of complicated manoeuvres: rolling and banking from side to side; fast horizontal flights above ground or sea (to as low as 30 cm) with frequent rapid vertical changes when they soar to more than 50 m; flights characterized by birds constantly weaving

together and apart; accompanied by whines, trumpeting and almost inaudible guttural buzzes (Holmes 1975; Thomas 1979; Klapste 1981; Jenkins & Cheshire 1982; Booth 1982). At Norfolk I., aerial display observed Nov.–Dec. (Moore 1985). During incubation period, unemployed birds cavort overhead (Merton 1970; McKean 1980).

VOICE Detailed study by Tennyson (1989) on Mangere I., Chatham Is, Dec. 1987–Mar. 1988; additional information from Macauley I., Kermadec Is, Nov.–Dec. 1988 (A.J.D. Tennyson). Not noted to call at sea; noisy at colonies; most noticeable calls are loud high-pitched *wi-wi-wi* given in flight and on surface, and hysterical *ha-ha-ha* calls from surface and in burrows. Much calling during night, Nov.–Mar.; also much calling during day on Macauley I., Lord Howe I. and round n. NZ headlands (Merton 1970; Fullagar *et al.* 1972; Thomas 1979; Jenkins & Cheshire 1982; A.J.D. Tennyson). Sexual differences in calls not proved. Individual and regional variation not studied but individual differences noted in all calls. Calls similar to those of Mottled Petrel (Warham *et al.* 1977; Tennyson 1989) and Bonin Petrel *P. hypoleuca* (Grant *et al.* 1983). Calls of Soft-plumaged Petrel *P. mollis* seem to be very different (Warham 1979; Tennyson 1989).

ADULT Flight Call. Characteristically, high-pitched and rapidly repeated *wi-wi-wi-wi*, each call containing average 4.0 (*wi*) syllables (0.55; 1–13; 13); mean fundamental frequency 4.4 kHz (0.08; 19). Fairly pure-toned calls with only one or two harmonics. Mean length of longest syllable per bird, 0.10 s (0.006; 17); gap between syllables 0.18 s (0.001; 16). *Wi-wi-wi-wi* call often, but not always, preceded by lower-pitched syllables, which could be described as *ahh-oo*, with mean frequency of 0.8 kHz (0.1; 7) and mean length of 0.32 s (0.06; 7). *Ahh* portion of call higher-pitched than *oo* portion, followed very closely by *wi* portion of call (mean distance, 0.09 s [0.01; 6]). *Ahh-oo* varied: *oo*, *eh-ahh-oo*, *ee-oor* and *eeew-eeow*. This call presumably same as *tee-tee-tee* and *ti-ti* described elsewhere (e.g. Falla *et al.* 1987; Imber 1985). Often given in flight, especially when two or more birds engaged in aerial chasing; aerial calls heard up to c. 500 m. Also given on surface, though less often than in flight (only one sexed breeding male noted giving this call). *Ahh-oo wi-wi-wi-wi* call could easily be sexually dimorphic but not established whether female ever gives this call. Probably used for sexual advertisement because commonly given in air. Because given on several occasions by pairs of birds engaged in aerial chasing, both sexes probably give call. Probably non-breeders give most of aerial calls at time when breeders incubating eggs or raising chicks (mid-Jan.–Mar. on Mangere I.). **Territorial Call.** Hysterical rapidly repeated *ha-ha-ha* or *haa-ha-ha-ha*; syllables (*ha*) usually repeated many times in rapid succession (sonagram A). Mean number of syllables given in call 17.4 (2.1; 1–47; 16); mean fundamental frequency, 0.9 kHz (0.4; 16); pure-toned with up to 15 or more harmonics. Mean length of longest syllable, 0.39 s (0.03; 16); mean gap between syllables, 0.09 s (0.006; 16). Most common call from ground; usually by birds disturbed in burrows but also often given on surface and heard once or twice from flying birds; given by both breeding males and females and no sexual differences found. Occasionally, Flight Call given after this call. Thought to have territorial function because virtually only given on ground, often from within burrows and often by birds being disturbed. **Orrrrrr.** Quiet low-pitched monotonous *orrrrrr*, lasting 0.42–3.56 s; on spectrograph, normally appeared as wide-band noise reaching up to 10 kHz. When pure tones apparent, fun-



A W. Ward; Kermadec Is, Nov. 1966; B981

damental frequency of call c. 0.3 kHz. Much variation in call, but not enough to determine whether or not sexual differences occur. Only heard occasionally. Given on ground or from within burrow by both breeding males and females. May also serve territorial function, being given by birds when handled, disturbed in burrows or just sitting on surface.

YOUNG In egg and up to 11 days old, utter squeaks. Two chicks also gave high-pitched version of Territorial Call. Youngest chick heard giving this call was c. 8 days old.

BREEDING Virtually unknown.

SEASON Breed colonially in summer. Arrive at breeding grounds in Kermadec Is from mid-Oct. and in Chatham Is from mid-Nov. Laying in Kermadecs late Dec. and first half Jan.

NEST, MATERIALS Nest in burrows 0.5–1.0 m long, nest-chamber being lined with fresh green leaves and litter. Also nest in crevices in rocks. Investigate burrows of Broad-billed Prions *Pachyptila vittata* in Chatham Is. Density of nests on Meyer I., Kermadec Is, c. 1.5/m² (Merton 1970).

EGGS White.

MEASUREMENTS: 51 (49–53; 11) x 37 (35–39).

CLUTCH-SIZE One.

NESTLING Semi-altricial, nidicolous.

No information on other aspects of breeding.

PLUMAGES

ADULT, JUVENILE Age of first breeding unknown. **HEAD AND NECK.** Forehead, usually dark grey (83) scalloped white; feathers, dark grey (83) with grey-black (82) shafts and white fringes; in fresh plumage, fringes broad and forehead can appear predominantly white; when worn, fringes almost lost and rest of forehead feathers develop browner tinge. Crown, ear-coverts and hindneck appear grey (84) when fresh, slightly browner (c79) when worn; feathers, mostly dark grey (83), grey (84) near end, with very narrow white tips; tips lost with wear, and dark-grey areas develop slightly brownish tinge. Grey-black (82) eye-patch most extensive in front of and below eye. Chin, throat, front of lores, crescent in lower ear-coverts and narrow white supercilium, white. **UPPERPARTS,** mostly grey (84) when fresh, becoming slightly darker when worn; feathers as crown. Longest scapulars and narrow band across rump, grey-black (82), forming part of distinctive M-mark (see Field Id). Upper tail-coverts, grey (84) to light grey (85). **TAIL,** outer feather, grey (84) with extensive white base on inner web, seldom visible in field. Other feathers, grey (light 84) with concealed white bases and grey-black tips broadest in central rectrices. **UPPERWING,** mostly black-brown (c119). Marginal coverts and innermost lesser coverts have strong grey (87) bloom. When fresh, outer webs of all other feathers have grey (83) gloss; strongest and

retained longest on secondaries and secondary coverts; secondaries usually appear paler than rest of upperwing. Most coverts have very narrow whitish tips, most conspicuous and retained longest on secondary coverts. Shafts of primaries, grey-black (82) with brown (219B) narrow central strip. **UNDERPARTS,** mostly white. On sides of upper breast and foreneck, feathers have grey (84) tips, forming varying half collar, never complete and never absent. Grey (84) lateral rump-feathers cover thighs. **UNDERWING.** Remiges dark grey (83) merging to blackish (82) at wing tip; white bases to inner webs visible on outer primaries but concealed elsewhere. Marginal coverts from wing-tip to about half way between carpal joint and base of wing, black (82). Lesser coverts on distal seven-eighths of wing, black (82). Rest of underwing-coverts, white.

DOWNY YOUNG Dove-grey with white abdomen and white line from abdomen to chin (Oliver).

ABERRANT PLUMAGES Adult from South-East I., Chatham Is, has black shafts to axillaries (NMNZ).

BARE PARTS

ADULT, JUVENILE Iris, black-brown (119). Bill, black (89). Upper surface of outer toe, claws, and distal two-thirds of other toes and webs, black (89). Rest of feet and legs, pink (108D). Bluish feet recorded in some birds.

DOWNY YOUNG No information.

MOULTS Based on skins (NMNZ).

ADULT POST-BREEDING Complete, at sea, outside breeding season. Forty adults (breeding status unknown) collected at Kermadec and Chatham Is, from Nov. to Mar. show no wing-moult or heavy body-moult; most had slight primary wear. Three birds of unknown status with primary moult N⁹⁴ collected Chatham Is (16 Jan.), Rarotonga (early Feb.) and New Caledonia (18 Dec.).

POST-JUVENILE, SUBSEQUENT MOULTS Bird collected Suva, 4 June was probably completing post-juvenile moult. Primary moult N⁹⁴; beginning centrifugal tail-moult. Body plumage fresh; older rectrices had synchronic fault-bars. Two immatures (aged on gonads, precise age unknown) beachcast NI, NZ, 3 Apr. had neck-moult.

MEASUREMENTS (1) Kermadec Is, recently dead, juveniles excluded (NMNZ). (2) Chatham Is, skins, juveniles excluded. (3) Chatham Is, recently dead, juveniles excluded; methods as HANZAB. (4) Kermadec Is, skins, juveniles excluded (NMNZ). (5) Macauley I., Kermadec Is; live adults of unknown status; minimum chord, bill depth at junction of feathering, bill width at base of latericorn. (A.J.D. Tennyson; P. Schofield). (6) Mangere I., Chatham Is, live birds, breeding adults including seven breeding pairs,

methods as HANZAB (A.J.D. Tennyson). Measurements by Tennyson of 24 adults of unknown status from Mangere I. do not differ significantly from these.

		MALES	FEMALES	
WING	(1)	228 (6.15; 217-234; 5)	226 (4.41; 220.5-236.5; 11)	
	(3)	226 (4.33; 220-235; 10)	226 (2.49; 222-229.5; 7)	
	(1)	152.5 (4.67; 146-164; 13)	162.1 (6.37; 149-170; 8)	**
8TH P	(2)	155.6 (6.48; 148-166; 8)	152.0 (3.65; 149-159; 7)	
	(1)	102.8 (3.08; 99-107; 9)	103.1 (1.82; 101-106; 11)	
TAIL	(3)	102.1 (2.91; 96-106; 10)	105.1 (3.36; 98-108; 7)	
	(1)	25.3 (1.07; 23.6-26.7; 6)	24.8 (0.99; 23.0-26.5; 11)	*
	(3)	24.5 (2.06; 21.229.2; 10)	24.7 (0.64; 24.0-25.6; 7)	
BILL	(1)	31.6 (0.79; 30.8-33.1; 6)	32.2 (0.85; 30.4-33.2; 11)	
	(3)	31.2 (0.92; 29.4-32.6; 10)	30.5 (0.89; 29.2-31.6; 7)	
TARSUS	(1)	37.4 (1.87; 35.5-40.7; 5)	36.2 (1.08; 35.0-38.0; 10)	
	(3)	36.7 (1.36; 34.9-38.9; 10)	35.7 (0.63; 35.0-36.8; 7)	

		UNSEXED	
WING	(4)	224 (5.38; 215-230; 10)	
	(5)	226 (4.00; 218-234; 30)	
	(6)	226 (4.56; 219-233; 15)	
TAIL	(4)	101.6 (2.35; 99-107; 9)	
	(5)	100.6 (2.74; 95.1-106.8; 30)	
	(6)	98.6 (2.42; 94.1-102.3; 15)	
BILL	(4)	24.2 (0.74; 22.9-25.3; 9)	
	(5)	24.6 (0.85; 23.0-26.2; 30)	
	(6)	23.8 (0.81; 22.8-25.2; 15)	
BILL W	(5)	10.6 (0.62; 9.7-12.2; 30)	
	(6)	9.9 (0.45; 9.2-10.5; 15)	
BILL D	(5)	11.4 (0.38; 10.8-12.2; 30)	
	(6)	11.2 (0.36; 10.5-11.8; 15)	
TARSUS	(4)	30.8 (0.82; 29.5-31.9; 9)	
	(5)	31.0 (0.83; 29.8-32.9; 30)	
	(6)	30.4 (0.76; 29.1-31.9; 15)	
TOE	(4)	36.8 (1.58; 34.7-38.9; 8)	
	(5)	37.4 (0.93; 35.7-39.5; 29)	
	(6)	36.2 (1.41; 33.8-38.8; 15)	

WEIGHTS Macauley I., Kermadecs, 30 Nov., adults of unknown status 162.8 (10.94; 132.5-185; 30) (A.J.D. Tennyson, P. Schofield). Mangere I., Chatham Is, Jan.-Mar. breeding adults 185.3 (19.6; 156-228; 15); adults of unknown status, 182.1 (13.6; 158-221.5; 22) (A.J.D. Tennyson). Chatham Is, fat to very fat birds; males excluding juveniles 169.6 (19.5; 131-194.5; 5.9) (NMNZ), females excluding juveniles 165.9 (13.35; 145-183; 7) (NMNZ). NI beachcasts 118.2 (17.2; 100-150.9; 10).

STRUCTURE Wing, long and narrow. Eleven primaries; p10 longest, p9 0-5, p8 13-17, p7 20-27, p6 32-44, p5 53-63, p4 72-84, p3 93-105, p2 108-122, p1 125-137, p11 minute. Twenty secondaries, including four tertials. Tail, rounded; 12 feathers; t1 18-26 longer than t6. Bill, short, rather narrow and deep. Upper mandible, hooked at tip; tip of lower mandible curves below level of base of maxillary unguis. Nostrils point forwards, separated by narrow septum, nasal tubes about one-quarter length of bill. Tarsus, rounded. Outer toe longest, middle toe 0-3 mm shorter, inner toe 4-6 mm shorter.

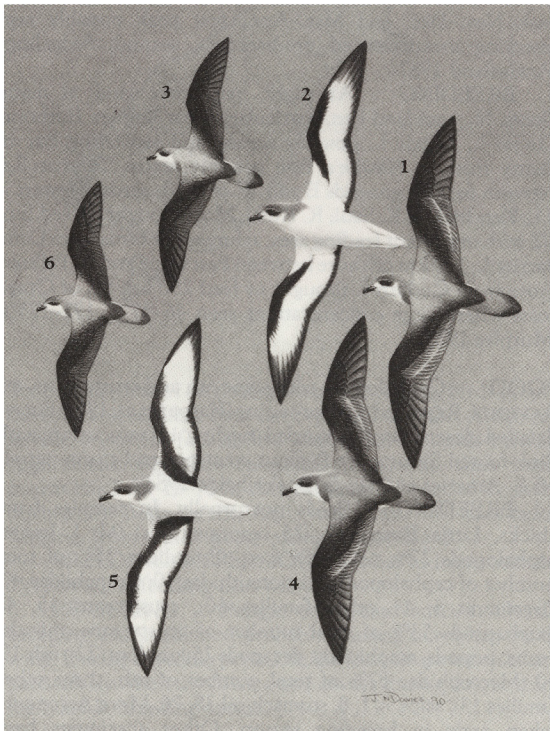
GEOGRAPHICAL VARIATION None known; said to form superspecies with *P. axillaris* (Peters). DIR

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Volume 1 (Part A), Plate 36

Black-winged Petrel *Pterodroma nigripennis*

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

Chatham Petrel *Pterodroma axillaris*

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

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