

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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Procellaria parkinsoni **Black Petrel**

COLOUR PLATE FACING PAGE 561

Procellaria parkinsoni G.R. Gray, 1862, *Ibis* (1) 4: 245 — New Zealand.

Named in honour of S. Parkinson, 1745–1771, draughtsman to Sir J. Banks on HMS 'Endeavour'.

OTHER ENGLISH NAMES Black Fulmar, Parkinson's Petrel.

MONOTYPIC

FIELD IDENTIFICATION Length 46 cm; wingspan 115 cm; weight males 720 g, females 680 g. Medium-sized stocky, uniformly sooty black petrel with black legs and feet and thick yellowish-horn bill, patterned and conspicuously tipped with greyish-black. Smallest species of *Procellaria*; jizz similar to that of Westland *P. westlandica* and White-chinned *P. aequinoctialis* Petrels, with angular chest profile and small short rather narrow-based wedge-shaped tail, usually held partly fanned and carried in shallow dihedral but Black shows finer, more rounded head, more slender neck and body, and more slender-winged appearance. Sexes alike; no seasonal plumage differences. Juveniles separable at close range by bill colour.

DESCRIPTION ADULT. Entire body plumage, sooty black (may show few white feathers on chin or interramal region, but rarely discernible); head may appear darker than rest. Upperwing, sooty black. Marginal, lesser and median under wing-coverts, solid sooty black contrasting with slightly paler, glossier greater coverts and remiges; paler greyish basal parts of latter two tracts form diffuse silvery area towards tip of underwing. In fresh plumage, upperparts (particularly upperwings) have silvery bloom. Whole plumage wears to blackish brown, imparting patchy dorsal and barred ventral aspect. Bill, short and rather compact, with tubed nostrils set prominently over basal third of upper mandible; tip not obviously bulbous and strongly hooked. Much of nostrils, latericorn and ramicorn, horn-coloured with pale yellowish or greenish-yellow tinge; appear paler whitish at distance. Basal edge of nostrils, naricorn, culmen saddle, sulcus and distal half or more of maxillary unguis, dull black; varying amount of basal maxillary unguis, yellowish-horn as side plates, typically appearing as narrow pale bar over base of nail; pale bar blends into greyish hind margin of black distal ridge and hook of unguis and can appear much larger, reducing apparent size of black tip (area of clear black then largely confined to distal ridge and hook of maxillary unguis). Mandibular unguis, wholly dull black in some, but usually with yellowish-horn cutting edge and basal spot (abutting black sulcus), with black half-moon covering rest. Legs and feet, black. **JUVENILE.** Plumage as freshly moulted adult. Bill, as adult, except pale parts ivory with distinct blue-grey tinge; dark areas slightly paler greyish-black in some. Bill gradually changes to yellowish-horn coloration of adult during first five years (M.J. Imber). Legs and feet, black.

SIMILAR SPECIES **Flesh-footed Shearwater** *Puffinus carneipes* also has all-dark plumage and pale dark-tipped bill, but is c. 10–15% smaller, less bulky and with shorter wings; stands out by browner plumage, with narrow pale scapular fringes. Flesh-coloured legs and feet diagnostic but, when not visible, separated by: (1) less rounded, more angular and flatter-crowned head-profile and longer, thinner neck; (2)

less deep, angular chest-profile; (3) slimmer body without pot-bellied appearance; (4) tail less wedge-shaped, usually held tightly folded; (5) tips of feet not projecting beyond tip of tail and not enhancing wedge-shape of tail; (6) slightly narrower shorter wings; (7) longer and thinner bill; (8) bill pinkish-horn with wholly black unguis forming larger, more obvious black tip; dusky sulcus paler and less outstanding. Greatest confusion likely with **Westland Petrel**: also has all-dark plumage and similar pattern of black on bill, but larger (20%) and bulkier, broader-winged, with coarser, less rounded head and thicker neck, giving bull-necked appearance; similar chest-profile but more robust and not so pot-bellied; wings distinctly broader and longer; more laboured flight: these characters combine to produce heavier, more thickset jizz. Bill, larger and heavier, paler cream-coloured or whitish but at distance or in strong light appears little different. For distinctions from **White-chinned Petrel**, see that account.

Prefer shelf-break and pelagic waters; rarely sighted over inshore waters except near breeding islands; never seen from land. More pelagic during non-breeding season. Flight recalls Westland and White-chinned Petrels, also Flesh-footed Shearwater; appears slightly easier, less laboured than first two, very similar to last but wing-beats slightly slower and deeper. In light winds, periods of relaxed shearwatering low above water (1–8 m) broken by low glides followed by brief burst of 3–5 unhurried wing-beats on rising into arc; in gliding attitude, wings held in shallow anhedral, innerwings gently bowed forward to carpals, outerwings swept back little and tapering to long fine points. Flight more confident and powerful at higher wind-speeds, then progressing in shearwater-like arcs (to 10 m or more; wings held strongly flexed) or stronger albatross-like soaring, wheeling and banking motions; sometimes soar to 20 m when following ships. Swim well, buoyantly with neck often upstretched (emphasizing small rounded head); wing-tips extend well beyond tail-tip. Feed mainly at night but also diurnally, by surface-seizing, surface-diving and pursuit-plunging. Usually solitary at sea during non-breeding season; sometimes more gregarious during breeding season when may form small flocks (of up to 20). Regularly follow ships and attend trawlers; regularly associate with cetaceans. Strictly nocturnal at colonies. Usually silent in flight over colonies; main call, given from ground or burrows, is staccato rapid *clack, clack, clack*. Usually silent at sea (but see Voice).

HABITAT Marine, pelagic. In breeding season, occur mainly E from breeding islands in subtropical waters (Norris 1965; Imber 1976); after breeding, disperse into e. tropical Pacific Ocean, inhabiting offshore and pelagic waters off n. South and Central America, and along equator (Jehl 1974; Pitman & Unitt 1981). Generally avoid inshore waters.

Breed on Great and Little Barrier Is in Hauraki Gulf, NZ, in Subtropical Zone; at high altitude in forested, mountainous country; most burrows on high ridges, above 300 m asl. Breed in virgin forest of podocarp and mixed broadleaf vegetation, including *Metrosideros* spp, or where regeneration after burning well advanced (Reed 1972; Imber 1978, 1987). Formerly bred inland on mountain ranges of main islands, NZ; up to at least 1200 m asl, mainly under tall forest but also in tussock grassland above tree-line (Olsen 1987; J.A. Bartle).

Usually fly just above water when feeding, but soar up to 20 m when following ships (M.J. Carter).

Probably extinct on main islands NZ, and breeding range now very restricted; estimated population only 3000–4000 birds. Need virgin forest for breeding; on Great Barrier I., clearing and burning has destroyed some forest habitat, but birds have spread within unburnt forest and population appears to be stable (Imber 1987). Colonies difficult to protect as island widely settled and farmed and has many introduced predators (Imber 1973). Pressure from cats on Little Barrier I. may have led to preference for nesting in burrows; open cavities among tree roots used more on Great Barrier I., where cats less of a menace (Imber 1973). Colonies on mainland may have succumbed to clearing for farmland and pine plantations (Olsen 1987), and to introduced predators.

DISTRIBUTION AND POPULATION Confined to Pacific Ocean. During breeding season, frequent subtropical waters round NI, NZ, ranging into Tasman Sea. Non-breeding visitor to tropical e. Pacific off Central American coast.

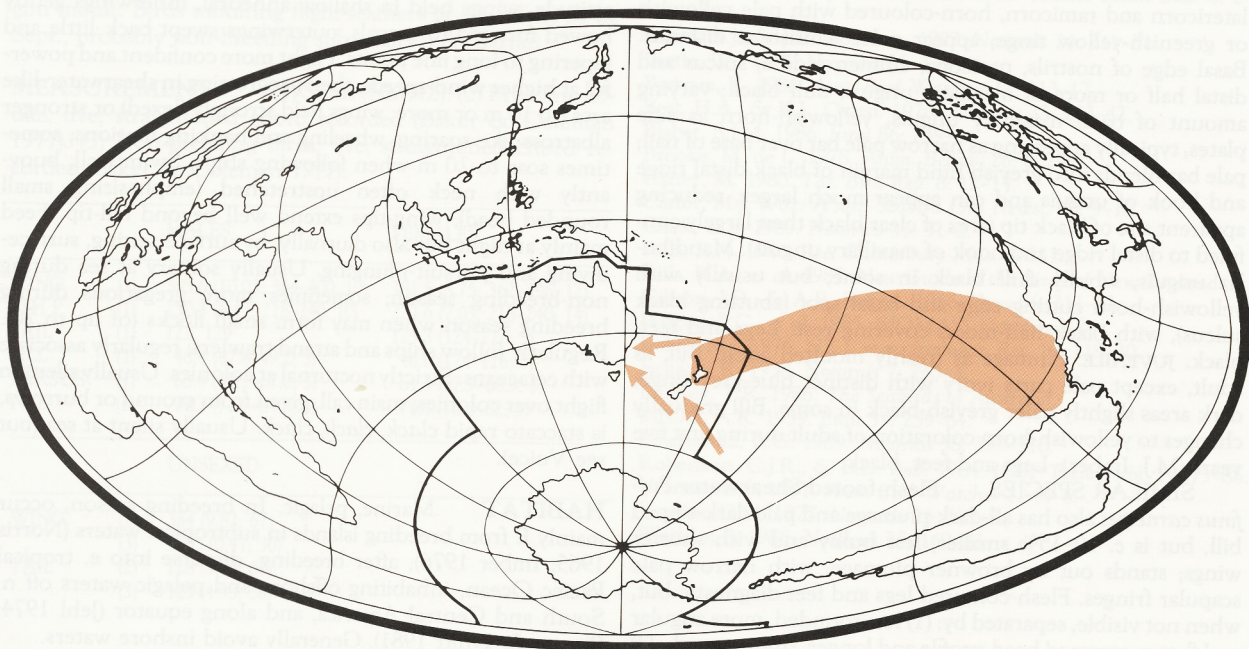
During breeding season, seen at sea between 30°S and 42°S and from 150°E to c. 175°W (Imber 1976, 1987; T.G. Lovegrove; D.W. Eades). Outside breeding season, occur in tropical regions of e. Pacific Ocean between 14°N and 5°S, off coasts of Ecuador, Panama, Costa Rica, Guatemala and possibly Mexico, west to c. 100°W (Jehl 1974; Imber 1976; AOU 1983; J.A.F. Jenkins). Observed at sea off Galápagos Is (Murphy; Pitman 1986).

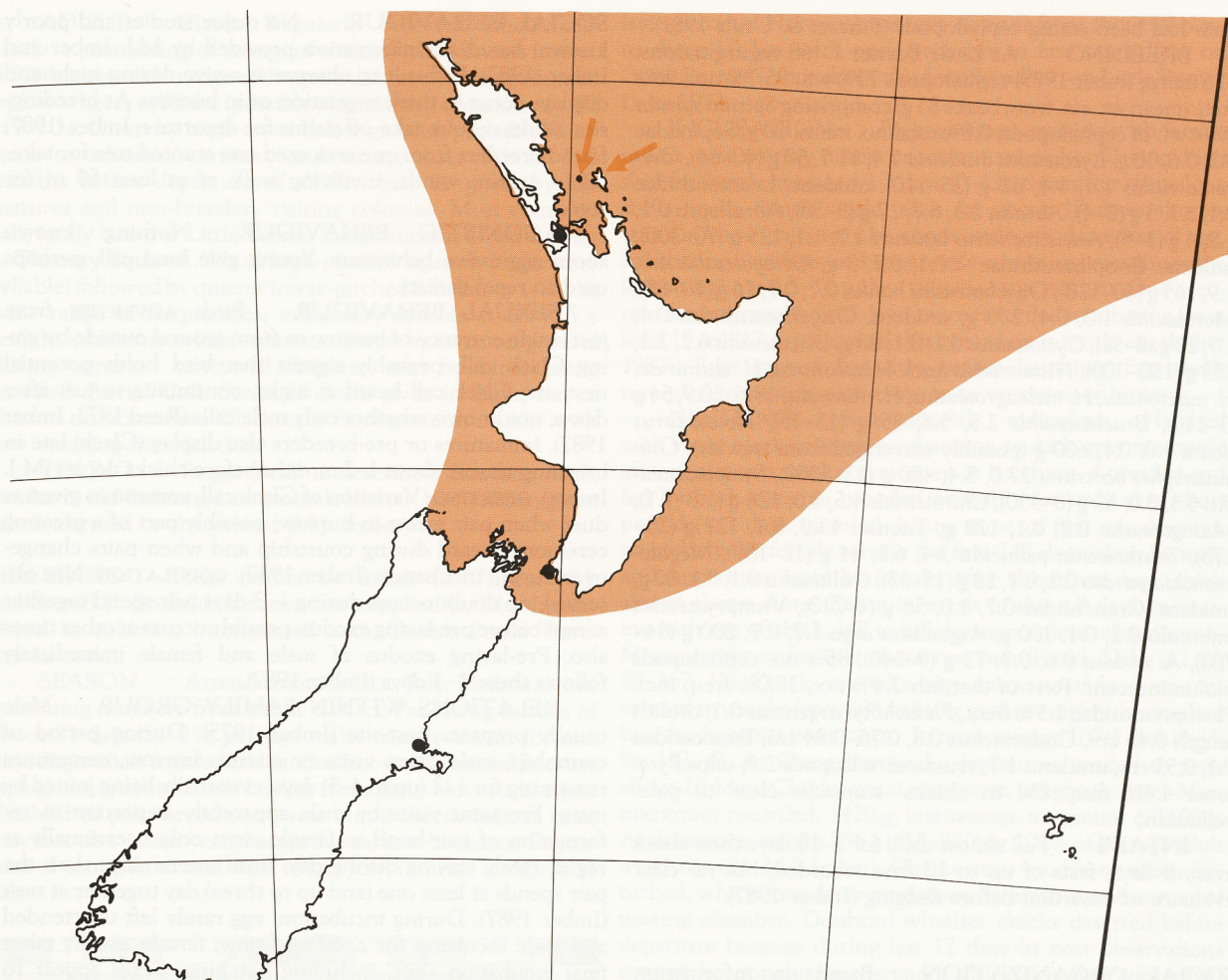
AUST. Probably regular visitor off e. coast in small numbers. NSW specimen collected near Sydney Heads, May 1875 (Hindwood 1940). Sight records at sea: off Sydney Heads: single, 26 Nov. 1983; two, 27 Oct. 1984; single, 24 Nov. 1984; two, 27 Apr. 1985; off Wollongong: single, 24 Feb. 1985; between Wollongong and Jervis Bay: two, 9 Feb. 1985 (NSW Bird Reps 1983–5; unfortunately published without supporting details); twenty, due E of Sydney at 157°E, 10 Nov. 1987 (T. Reid). Unconfirmed reports off Wollongong, 1988 (RAOU Newsl. 79). Vic. Offshore, off e. Gippsland (e. Bass Str.), two, 37°S 150°E, 38°S 149°E, 38°S 150°E, 3–4 Feb. 1985, no supporting details; one, 37°38'S, 150°17'E, 28 Nov. 1984, acceptably published with photographs (Vic. Bird Reps 1984, 1985).

NZ Rare. Most sight records and recoveries of beachcast specimens near breeding colonies. Published sightings round ne. of NI; especially off Bay of Plenty and East Cape. In regular beach patrols, 1960–1986, 146 beachcast specimens found; recovered rarely between 1960 and 1971, but in almost every year since. Highest rates of recovery (birds/100 km) in Auckland East and Bay of Plenty regions. Also recovered from Auckland West and Wellington regions of NI, and North Coast and Otago regions of SI (Powlesland 1989).

BREEDING Restricted to Great Barrier I. (c. 1000 breeding pairs, 2000 non-breeding birds) and Little Barrier I. (c. 100 breeding pairs, 200 non-breeding birds) (Imber 1987; P. Scofield). Breeding range has contracted. Formerly bred on ranges of NI (until at least 1956; Medway 1960) and nw. SI (until at least 1936; J.A. Bartle): Waitakere Ra. (Reischek 1886); Tutamoe Ra. (Olsen 1987); Kaitake Ra. (Medway 1960); Taranaki (Mt Egmont) (Dieffenbach 1843); Rimutaka Ra. (Oliver); mountains at headwaters of Karamea R. (Buller 1905; J.A. Bartle). According to unpublished European and Maori accounts, also bred near L. Taupo on volcanic plateau; in Urewera district; and in Ruahine Ra. (J.A. Bartle).

Populations on Great Barrier I. survive with little interference from rats and feral cats. Birds may still occasionally be





killed for food by Maori residents of island. By 1980, once large population on Little Barrier I. was almost exterminated by cats; cats have recently been eradicated and population increasing slowly by 1987. Known to scavenge behind fishing vessels. Small quantities of plastic debris occasionally ingested. Fledgelings on first flight may become grounded when attracted to lights (Imber 1975).

MOVEMENTS Migratory with bulk of population moving to e. tropical Pacific during non-breeding season.

DEPARTURE Most non-breeders leave Little Barrier I. during Mar., latest 3 Apr. (M.J. Imber); adults leave breeding islands late Apr.-early July (Imber 1987) and chicks fledge 15 Apr.-21 July, peak departure date for adults and chicks being 15-22 May (M.J. Imber).

NON-BREEDING Reach e. tropical Pacific off central and n. South American coast during non-breeding season (Loomis 1918; Jehl 1974; Pitman & Unitt 1981) from 110°W to coast from Guatemala to Peru with concentrations off Punta Mala, Panama; 280 km SW of Galápagos; and from 2°N to 2°S near 85°W (Pitman & Unitt 1981) where present Mar. to at least Nov. (R.L. Pitman; J. Farrand).

RETURN First return Little Barrier I. about 10 Oct. with numerous birds present by early Nov. Breeding season extended, however, and some may not return until Dec. (Imber 1987).

BREEDING Must fly ≥ 60 km from Little Barrier I. to feeding grounds at edge of continental shelf (Imber 1987), probably much farther (Imber 1975). Most beachcast birds have been on NZ beaches N of breeding colonies (M.J. Imber) and also summer records from far e. Bass Str. (Vic. Atlas; D.W. Eades).

BANDING Only two recoveries away from colonies: one, banded as pullus on Great Barrier I., 1978, recovered dead near Guayaquil, Ecuador, 1984; one juvenile, banded Great Barrier I., 1988, recovered alive near Auckland within two weeks.

FOOD Cephalopods with some fish and a few crustaceans. **BEHAVIOUR** Few observations as most food taken at night (Imber 1975) but surface-seizing, pursuit-plunging and surface-plunging recorded (Prince & Morgan 1987). Often scavenge behind ships (Jehl 1974; Pitman & Unitt 1981; Imber 1987). Recorded feeding in association with Black-winged Petrel *Pterodroma nigripennis*, Flesh-footed Shearwater *Puffinus carneipes* and Sooty Shearwater *P. griseus* (Ainley & Boekelheide 1983) and, in e. tropical Pacific, often associated with small odontocete cetaceans including Bottlenosed Dolphin *Tursiops truncatus* (26% of 68 observations; Pitman & Unitt 1981). Storms may interrupt feeding (M.J. Imber).

NON-BREEDING In e.tropical Pacific, one speci-

men had been eating cephalopods (Pitman & Unitt 1981).

BREEDING At Little Barrier I. (68 regurgitations, 726 items; Imber 1975) cephalopods 73% wt., 95.7% no., 96% freq. (mean wt. est. from beaks 83 g) comprising *Spirula spirula* 0.1% wt. of cephalopods, 0.8% total no. items, 10 g, Sepiolidae 0.2, 0.6, 30 g, *Lycoteuthis diadema* 7.4, 11.7, 50 g (40–64), *Oregoniateuthis* 1.1, 1.4, 62 g (35–110), unident. Lycoteuthidae 0.1, 3.3, 3 g (2–4), *Abralia* 2.3, 6.7, 27 g (5–50), *Abraliopsis* 0.1, 1.9, 4 g (3–5), *Ancistrocheirus lesueurii* 1.7, 1.1, 125 g (70–200), unident. Enoplateuthidae <0.1, 0.7, 3 g, *Octopoteuthis* 4.0, 1.9, 165 g (60–120), *Onychoteuthis banksi* 0.7, 0.7, 76 g (70–83), *Moroteuthis* 1.0, 0.4, 200 g, unident. Onychoteuthidae 0.4, 1.7, 20 g (8–52), *Cycloteuthis* 0.1, 0.1, 80 g, *Discoteuthis* 6.2, 2.2, 225 g (150–300), *Histioteuthis* (incl. *H. atlantica*, *H. eltaninae*, *H. macrohista*, *H. meleagroteuthis*, *H. miranda*) 13.6, 20.9, 54 g (3–215), *Brachioteuthis* 2.5, 5.6, 35 g (15–75), *Nototodarus sloani* 1.0, 0.1, 600 g (possibly scavenged from trawler), *Ommastrephes bartrami* 27.0, 5.4, 400 g (22–3000), *Symplectoteuthis* 5.3, 8.0, 53 g (8–350), *Chiroteuthis* 4.5, 3.0, 124 g (1.8–7.1), *Mastigoteuthis* 0.2, 0.1, 120 g, *Taonius* 13.0, 8.1, 127 g (23–175), *Teuthowenia pellucida* 3.4, 6.2, 44 g (12–150), *Megalocranchia pardus* 0.2, 0.7, 23 g (15–33), *Galiteuthis* 0.1, 0.1, 80 g, unident. Cranchiidae 0.7, 1.0, 56 g (4–210), *Vampyroteuthis infernalis* 0.2, 0.1, 100 g, *Argonauta argo* 1.7, 0.7, 200 g (34–700), *A. nodosa* 0.6, 0.7, 72 g (9–240). 85% no. cephalopods bioluminescent. Rest of diet fish 2.3% no., 25.0% freq. incl. Petromyzontidae 1.5% freq., *Photichthys argenteus* 0.1, otolith length 0.43 cm, *Coelorinchus* 0.3, 0.75–0.84 cm, Exocoetidae 0.1, 0.53 cm, unident. 1.7; crustaceans isopods 2.9; salps *Pyrosoma* 4.4% freq. Oil in chicks' stomachs clear to pale-yellowish.

INTAKE Fed almost daily for 1–15 days then about every 3 days; fasts of up to 10 days recorded, but no clear evidence of desertion before fledging (Imber 1987).

SOCIAL ORGANIZATION Based on information provided by M.J. Imber and Imber (1987). Solitary at sea; small parties may congregate round ships; do not flock with other species of marine birds (Pitman & Unitt 1981; M.J. Imber). Found feeding with smaller cetaceans at times (R.L. Pitman).

BONDS Long-term monogamous, disrupted by death or divorce. Feral cats destroy pair-bonds by killing adults and nestlings. Divorce related to breeding success is apparently precipitated if nestling killed; female probably usually leaves mate, and male takes new partner and breeds in same nest (Imber 1987). Age of first pairing from 5 years old onwards; immatures or pre-breeders visit breeding colonies and display, giving Clack call; may even secure nest-sites and mates (M.J. Imber). Established pair appears to rendezvous annually, 1–3 days before pre-laying exodus. Pre-laying exodus not synchronized throughout colony. Pair remain away from nest-site for c. 21–24 days (Imber 1987). Both sexes incubate and tend young until just before fledging.

BREEDING DISPERSION Loosely colonial. Distance between nests from 2 m to 100 m or more (M.J. Imber). Territorial, defending nest-site including area round entrance.

ROOSTING Outside breeding season, roost solitarily, assumed diurnal; probably on sea and, as with other nocturnal procellariiforms, resting on wing probably occurs. During breeding, incubating bird sleeps for most of its incubation stint; at sea same as for non-breeding.

SOCIAL BEHAVIOUR No major studies and poorly known; based on information provided by M.J. Imber and Imber (1987). Difficult to observe as active during night and displays occur in thick vegetation or in burrow. At breeding-site, adults require take-off points for departure; Imber (1987) found breeders from one area used one stunted tree for take-off in certain winds, involving walk of at least 50 m for some.

AGONISTIC BEHAVIOUR Nothing known about aggressive behaviour. Young give loud call, perhaps used to repel threats.

SEXUAL BEHAVIOUR Birds ADVERTISE from just inside entrance of burrow or from ground outside by giving Clack call; probably signals that bird holds potential nest-site; Clack call heard at night, continuing to just after dawn; not known whether only male calls (Reed 1972; Imber 1987). Immatures or pre-breeders also display (Clack) late in breeding season, about 1–2 months before chicks depart (M.J. Imber). **GREETING.** Variation of Clack call, sometimes given as duet when pair meets in burrow; possibly part of a greeting ceremony; heard during courtship and when pairs change-over during incubation (Imber 1987). **COPULATION.** Not observed; no doubt occurs during 1–3 days pair spend together at nest before pre-laying exodus; possibly occurs at other times also. Pre-laying exodus of male and female immediately follows these 1–3 days (Imber 1987).

RELATIONS WITHIN FAMILY GROUP Male usually prepares nest-site (Imber 1975). During period of courtship, male often visits or attends burrow, sometimes remaining for 1–2 (up to 4–5) days, eventually being joined by mate. Frequent visits by male apparently important in re-formation of pair-bond as female visits only occasionally at night, rarely staying during day, until meets male; then the pair spends at least one (and up to three) day together at nest (Imber 1987). During incubation, egg rarely left unattended and male incubates for c. 60% of time; female usually takes final incubation shift, including hatching. Sexes appear to share rest of duties. One observation of desertion, by male, probably too immature to incubate although old enough to mate (Imber 1987). Two to four days before hatching, piping of chicks can be heard. Guard chick for up to 10 days after hatching, though usually female only broods for less than one day. After this, adult only attends during nocturnal feeding visits. Chicks begin to emerge from burrow at least 10–15 nights before departure; they exercise wings, search for take-off points (tree, bluff or high point providing clear horizontal flight path) or sit and rest. Using bill, claws and wings, chick climbs to potential take-off site, then flaps vigorously and rises off perch, rests, then flaps again, before attempting to take-off. Parental care finished before fledging when young c. 107 days old; however some parents visit nest close to, perhaps even after, departure of fledgeling.

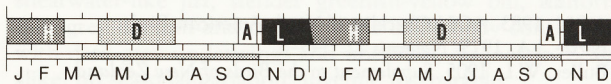
VOICE Reasonably well known but less so than other *Procellaria*; detailed study by Warham (1988) with additional information supplied by M.J. Imber. Generally silent; loud, harsh, far-carrying calls, from ground and in flight, at breeding colonies. Three calls described: Clack, Throaty Squawk and Aerial Calls. Most calling in 2–3 h after sunset, calling declining through night and increasing again towards dawn when birds leave colony. Most calling during summer breeding season (Oct.–early Apr.). Calls similar to those of other *Procellaria*. No information on individual or sexual differences, but suggested that males call more (M.J. Imber).

ADULT Clack. Regularly repeated *clack-clack-clack* . . . ; consisting of strings of staccato pulsed notes (rate c. 0.9/s) across wide range of frequencies, sometimes preceded by low wheezy syllables (possibly inspiratory); duration of calls c. 7–10 s. Given by birds on or below ground; probably functions to advertise territory and attract mate. About 1–2 months before departure of chicks, may be given by immatures and non-breeders visiting colonies. Most common call; rarely heard at Little Barrier I., common at Great Barrier I. **Throaty Squawk.** Loud high-pitched squawk (expiratory syllable) followed by quieter lower-pitched inhalatory syllable; wide range of frequencies; exhalatory syllable c. 0.3–0.5 s length; inhalatory syllable shorter. Given by birds on ground during apparent territorial disputes, and by birds being handled. **Aerial Call.** Series of *clacks* given in flight, but of shorter duration than Clack calls from ground; usually with low moaning introduction.

YOUNG Begging call undescribed. Startling *honk*, similar to old-fashioned automobile hooter, but quieter, given when alarmed or threatened (M.J. Imber).

BREEDING Field studies by Imber (1987) and M.J. Imber and P. Scofield. Information supplied by M.J. Imber. Breed in colonies, interspersed with Cook's Petrel *Pterodroma cookii*.

SEASON Attend colonies Oct.–July. Birds arrive in increasing numbers from about 10 Oct. Pre-laying exodus of about 23 days (21–25); perhaps males usually absent for one day longer than females but exodus not synchronized because laying not synchronized. Laying from early Nov. to late Jan. Established pairs breed every year but, if successful one year, may not do so next year, except for earliest breeders. Departure of young from mid-Apr. to late July, but rare in Apr. and July.



SITE On Great Barrier I., restricted to virgin forest on high central ridges and steep hillsides, where nest in burrows, in hollow logs, in cavities under banks and among roots of trees; on Little Barrier I., on ridges, in burrows, banks and under bases of trees. Burrows usually 1–3 m long, with entrance 20 cm wide, 17 cm high; nesting chamber near end much larger but varies greatly in size. Once noted in hollow kauri stump, 1.5 m vertically down from top. Used traditionally from year to year. New burrows rarely dug by established breeders. Sometimes use burrows of Cook's Petrels.

NEST, MATERIALS Nest near end of burrow in shallow bowl, sparsely lined with dead twigs; on Little Barrier I., leaves of *Dracophyllum pyramidale* preferred. Chamber either above or below level of entrance; remains dry except after unusually heavy rain. Because male spends most time in burrow before laying, probably he cleans out old nest and makes new one, at night.

EGGS Oval or ovate, occasionally pyriform (P. Scofield); at first smooth, becoming polished and glossy; white. **MEASUREMENTS:** 69.3 (2.17; 65.8–72.0; 9) x 50.5 (2.10; 46.8–54.2) (Imber 1987).

WEIGHT: day after laying: 98.8 (88.7–108.5; 9) or 13% of average adult weight (Imber 1987).

CLUTCH-SIZE One. No replacement of losses.

LAYING At night, within 12 h of return from pre-

laying exodus. Not synchronized; extends from about 10 Nov. to about 20 Jan. with peak probably in first week Dec. on Great Barrier I., but about third week in Dec. on Little Barrier I., in 1972.

INCUBATION By both sexes, starting with female unless male waiting at nest or returns on night of laying. First shift by female averaged 2.3 days (0–13); thereafter three long shifts (male, female, male) each for about 17 days; shorter stints in some pairs may be connected with desertion of egg. Incubating bird fasts and apparently covers egg continuously; loses weight at 9.5–12 g/day. **INCUBATION PERIOD.** One accurate determination: 56.5 days; twice recorded incubating for at least 15 and 17 days beyond this period on infertile egg (Imber 1987). Eggs pipped 2–4 days before hatching. Egg shells trampled in nest or cast aside or to entrance of burrow.

NESTLING Semi-altricial, nidicolous. Hatched with sooty black protoptile, changing to dark-grey mesoptile after about two weeks; eyes open at hatching. Attended and fed by both parents; brooded probably for only very short period (<1 day); guarded during most of first ten days but irregularly, by female mostly for first 2–4 days, then by male and sometimes again by female; after about ten days, chick almost always alone. Fed at intervals of about 3 days, increasing with age of chick, bill to bill, by incomplete regurgitation. Mean weight of feeds at about one month old, 120 g (22.34; 89–167; 12). Chicks can take large amounts of food; one increased in weight from 385 to 810 g in three nights, having had four feeds. **NESTLING PERIOD.** In nest: average 107.3 days (8.43; 96–122; 6). At Great Barrier I., departures tended to peak about 20 May. Chicks attain maximum weight in Apr.–May; maximum recorded, 1420 g, but average maximum c. 1100 g. At departure, weight 756 g (615–820) or 108% of average adult weight (n=24; M.J. Imber). Chicks utter loud *honk* when disturbed, which may deter predators; defecate in one corner of nesting chamber. Doubtful whether chicks deserted before departure because during last 12 days in nest observations cannot be conclusive; certainly chicks receive substantial meals within this period but generally lose weight at 15.6–19.0 g/day. Many chicks emerge from burrows for 10–15 nights before departure and may move up to 50 m from burrow (Imber 1987).

FLEDGING TO MATURITY Chicks leave at night from take-off points such as trees, bluffs or any high point with clear horizontal flight-path. First pairing when five years old, first breeding when six years old and first successful breeding (chick reared) when eight years old (n=1 for each category; M.J. Imber). One bird known to have lived for at least 17 years.

SUCCESS At Little Barrier I. (1971–7): 55 eggs laid, 48 (87%) hatched, 9 (16%) fledged; (1978–83): 15 eggs laid, 11 (73%) hatched, 9 (60%) fledged. Fertility of 66 candled eggs, 92.4%. On Little Barrier I., until 1980, feral cats were chief menace but on Great Barrier I., cause few losses (Imber 1987) where also Black Rats *Rattus rattus* cause little damage beyond taking few eggs. Formerly Maori took young for food. Avianpox virus affects 1–2% of chicks, causing some deaths.

PLUMAGES

ADULT HEAD AND NECK. In fresh plumage: black-brown (119); few birds have some white feathers on chin. **UPPERPARTS,** black-brown (119) with open pennaceous dark-brown (121) fringes; fringes, broader on mantle; concealed bases of feathers, light grey-brown (119D). When worn, fringes dark brown (119A). **TAIL,** black-brown (119); rachis,

grey-black (82). UPPERWING, similar to upperparts. Some outermost greater primary coverts have short dull-white streaks on webs, adjacent to rachis, but not forming complete shaft-streak. Remiges, black-brown (119). UNDERPARTS, pale black-brown (119), with very narrow pale dark-brown (121) fringes. Successful breeders often tinged russet, particularly on belly (M.J. Imber). Axillaries, pale black-brown (119). UNDERWING. Underside of remiges, pale dark-brown (119A). Greater primary coverts and greater coverts, dark brown (119A); rachis, white. Marginal, lesser and median coverts, dark brown (219); rachis, black (89).

DOWNY YOUNG Protoptile, slate-grey; mesoptile, paler and longer (M.J. Imber). Mesoptile on skin (AM), pale dark-brown (119A).

JUVENILE Similar to adult in fresh plumage; distinguished by more uniform wear of feathers, particularly on upperparts, and bill colour (see Bare Parts).

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

ADULT Iris, dark brown (219). Latericorn, rami-corn and nostrils, cream (92); tips of unguis, dark grey (83). Rest of bill, including sulcus, grey-black (82). Bartle (1975) describes rami-corn and latericorn as intermediate between buff (53) and yellow (55), *pace* HASB where described as bluish-white. Feet, black (Falla 1934).

DOWNY YOUNG Undescribed.

JUVENILE Bill, black, horn-grey on sides and unguis. Feet, black (Oliver). Bill of fledgelings, ivory to blue-white, gradually changing to pale yellow-horn during first five years (M.J. Imber). Similarly, Murphy states that bill ivory-white in juveniles. Occasionally (<10% birds), bill as adult (M.J. Imber).

MOULTS

ADULT POST-BREEDING Complete; primaries moult outwards; up to four inner primaries growing simultaneously. Birds moult in wintering area, e. Tropical Pacific, from Mar.-Nov. Loomis (1918) recorded males undergoing complete moult in May and June, and female replacing feathers of head and body in Oct. Birds in wintering area in heavy wing-moult in Apr., assumed to be non-breeders; breeders moult later.

POST-JUVENILE Undescribed.

MEASUREMENTS (1) Little Barrier and Great Barrier Is, adults (juveniles excluded), skins (NMNZ). (2) NZ and adjacent waters, assumed to be skins; methods unknown

(Murphy). (3) Great Barrier I., NZ, live birds; methods unknown (Harper 1978).

UNSEXED

WING	(3)	357.0 (3.7; 8)
TAIL	(3)	106.1 (1.7; 8)
BILL	(3)	41.2 (0.3; 8)
TARSUS	(3)	54.9 (0.8; 8)
TOE	(3)	70.8 (1.0; 8)

Additional measurements in Falla (1946).

WEIGHTS Few data. During courtship, Little Barrier I.: males 723 (77.1; 620-855; 9), females 682 (57.4; 587-791; 8) (Imber 1987). Label data from adult skins at NMNZ, Little Barrier and Great Barrier Is, Dec., Mar. and May: males 732.5 (7.5; 725, 740; 2); female 778.0. No data on seasonal changes.

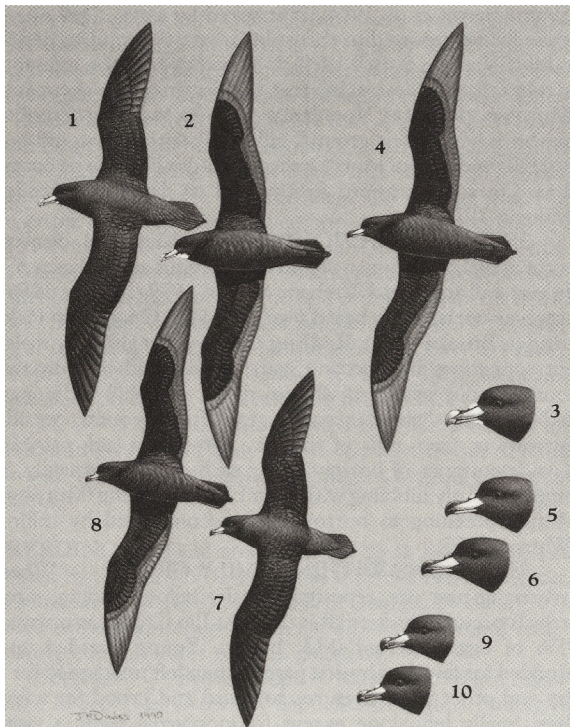
STRUCTURE Wing, long and narrow. Eleven primaries: p10 longest, p9 4-7 mm shorter, p8 20-24, p7 46-48, p6 70-76, p5 98-107, p4 124-136, p3 154-164, p2 179-190, p1 197-211, p11 minute. No emarginations. Twenty-two secondaries, three of tertial form. Six humerals. Twelve rectrices, t1 longest, t6 11-24 mm shorter. Bill, slender but robust. Nostrils point forwards, c. 34% of bill length. Maxillary unguis, strongly curved. Legs and feet, slender; tarsus, laterally compressed. Feet, webbed. Outer and middle toe about equal, inner c. 82% of middle, hind (claw only) c. 11%.

RMO

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	MALES	FEMALES
WING	(1) 347.5 (2.50; 354, 350; 2) (2) 343.4 (326-359; 8)	351.0 (4.24; 348-357; 3) 340.7 (336-347; 4)
8TH P	(1) 201.0 (5.00; 196, 206; 2)	210.0 (4.49; 205-216; 3)
TAIL	(1) 98.0 (2) 101.1 (93-106; 8)	97.0 (2.94; 94-101; 3) 100.6 (95.9-102.5; 8)
BILL	(1) 44.3 (0.75; 43.6, 45.1; 2) (2) 41.7 (39.4-43.5; 8)	42.3 (1.51; 40.4-44.1; 3) 40.4 (39-41.2; 4)
TARSUS	(1) 55.0 (1.40; 53.6, 56.4; 2) (2) 52.9 (49.2-55.3; 8)	54.1 (0.71; 53.1-54.7; 3) 53.5 (52.6-54.2; 4)
TOE	(1) 70.8 (0.85; 70, 71.7; 2) (2) 67.8 (62.3-70; 8)	71.7 (1.20; 70.5, 72.9; 2) 67.9 (65.8-71.2; 4)



Volume 1 (Part A), Plate 42

White-chinned Petrel *Procellaria aequinoctialis*

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

Westland Petrel *Procellaria westlandica*

- 4. Adult, ventral, fresh
- 5. Adult
- 6. Juvenile

Black Petrel *Procellaria parkinsoni*

- 7. Adult, dorsal, fresh
- 8. Adult, ventral, fresh
- 9. Adult
- 10. Juvenile

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