

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 HYDROBATIDAE (OCEANITIDAE) storm-petrels

Storm-petrels are the smallest seabirds, distinguished by having prominent united nostrils with a single opening, wings with a longer second functional primary, and often with a white rump, varying in closely related forms and assumed to serve as an important interspecific recognition-signal. They feed by picking small animals from the surface and fall into two groups.

(1) The sub-family Oceanitinae consists of seven fairly distinct species in five genera, of which five species occur in our region. Characterized by short wings with only ten secondaries, more or less square tails, elongated skulls, and tarsi longer than the toes. They progress by hopping and fluttering over the surface. Some species are said to have only one coat of nestling down. Adults are all polymorphic to some extent. Six species are usually white below; only one has an entirely black breast (Murphy & Snyder 1952). Most breed in the s. hemisphere and only the normally dark-breasted species, Wilson's Storm-Petrel *Oceanites oceanicus*, migrates far N of the equator, where an ancestor might have given rise to the second group (Palmer 1962).

(2) The sub-family Hydrobatinae consists of some 14 fairly closely related species in three genera; in our region only two of these species (in *Oceanodroma*) have been recorded, as accidentals. This group is characterized by having longer wings than the other, wedge-shaped or more usually forked tails, short skulls and bills, tarsi usually about equal in length to the toes, and a swooping flight, walking but not hopping along the surface. They have two coats of nestling down. Adults are usually dark and not polymorphic, though one species is grey and another southern one is white below. Most breed in the north but some breed, or migrate a short distance, south of the equator.

In general, plumage is black or grey above; the rump and underparts may be grey or white. Wing with 11 primaries, p9 longest, p11 minute; 10–11 secondaries, rather short, diastataxic. Tail quite long, forked, square or rounded; 12 feathers. Bill rather small, strongly hooked; nostrils fused with single opening, often upwards. Tarsus, rounded; three forward toes, webbed; hind toe, rudimentary; claws, sharp; flattened in some. Oil-gland feathered. Peculiar musky odour. Sexes similar and juveniles like adults.

Cosmopolitan in all oceans; strictly pelagic, coming to shore only to breed and then usually by night. Very little knowledge of distribution, behaviour and requirements of most species when at sea, because birds are so hard to find and identify. On land, crouch on tarsi and move with shuffling gait. Flight erratic, usually close to surface, characterized by bouncing, fluttering, swooping and skimming progress. Feed mostly on planktonic crustaceans, molluscs and small fish; some species habitually follow ships, scavenging in wake; obtain food mostly by flight-feeding while hovering, pattering or walking on water; seldom dive. Gregarious or solitary at sea. Long-term monogamous pair-bond, probably maintained only at nest-sites by reason of fidelity to site. Little knowledge of social behaviour but birds evidently not specialized for visual displays; sexual communications probably by tactile (allopreening), olfactory and vocal means. Churring or purring calls are a notable feature of breeding colonies. Nest colonially in holes or burrows. Eggs, ovate, mat, white. Clutch-size, invariably one. Single-brooded and probably no replacement laying or very seldom. Incubation by both sexes in alternate shifts of up to 6 days; single median brood-patch. Incubation period, 40–50 days. Eggshells usually left in nest. Young, semi-altricial, nidicolous; hatched in down. Guarded and brooded for 5–7 days before being left alone during day and fed at night, by incomplete regurgitation. Nestling period, 59–73 days; not deserted by parents in last days in nest. Maturity attained in some species at 4–5 years of age.

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Pelagodroma marina White-faced Storm-Petrel

COLOUR PLATE FACING PAGE 680

Procellaria marina Latham, 1790, *Index orn.* 2: 826 — southern oceans = off mouth of Rio de la Plata.

The scientific names are tautological, compounded of the Greek πέλαγος (open or high sea) and δρόμος (running); the marine runner of the high seas.

OTHER ENGLISH NAMES Frigate Petrel, White-breasted Storm-Petrel, Storm-Petrel, Mother Carey's Chicken.

POLYTYPIC Nominate *marina*, Tristan da Cunha and South Atlantic; *dulciae* Mathews, 1912, w. and s. Aust., Indian Ocean; *maoriana* Mathews, 1912, NZ area and s. and e. Pacific; *albiclunis* Murphy & Irving, 1951, (doubtfully distinct) possibly Kermadec Is. Extraliminally, *hypoleuca*, Moquin-Tandon, 1841, Selvagens and *eadesi* Bourne, 1953, C. Verde Is.

FIELD IDENTIFICATION Length 18–21 cm; wing-span 42–43 cm; weight 40–70 g. Medium-sized, distinctively patterned storm-petrel, common over inshore and pelagic waters round s. Aust. and NZ. Tail, square-cut or with shallow fork. Feet and part of tarsi project well beyond tail in travelling flight. White forehead and supercilium, contrasting with sooty grey crown and with narrow dark band underscoring eye, forms diagnostic head pattern. Sexes alike; no seasonal differences in plumage. Juveniles not recognizable in field.

DESCRIPTION **ADULT.** Crown and nape, sooty grey, forming dark cap contrasting with mid-grey hindneck and white forehead, supercilium, lores, chin and throat. Distinctive facial pattern enhanced by narrow dark sub-orbital band extending from before eye to rear of ear-coverts. Mantle, back and scapulars, mid-grey, contrasting with much paler-grey rump and upper tail-coverts. Square-cut or slightly forked tail, black, contrasting sharply with pale-grey rump and upper tail-coverts. Inner wing-coverts, brownish grey with conspicuous narrow pale rear border formed by diffuse white tips and fringes of greater secondary coverts. Primary coverts and remiges, black. Grey of hindneck, mantle, back, scapulars and inner wing-coverts wears rapidly to greyish-brown; greater secondary coverts especially prone to wear and fading, appearing as conspicuous pale-brown or buffish panels on proximal innerwing, offset by black remiges. Underbody, white apart from mid-grey half-collar on sides of upper breast, formed by extension of grey from hindneck and mantle; underside of tail, black. Underwing lining, white, narrowly margined with black along leading edge from base of outermost primary inwards to about elbow. Undersurface of remiges, blackish, forming large dark wing-tip and trailing edge. Bill, black, slender, strongly down-curved at tip, with tubed nostrils prominently raised over basal third of upper mandible. Iris, brown. Extraordinarily long legs, black; outsides of toes, black; webs cream. **JUVENILE.** Fledgelings (Mar.–May) similar to fresh-plumaged adults but with crisp white tips and fringes to secondaries, inner primaries and greater secondaries of upperwing slightly broader and more prominent; pale grey of rump and upper tail-coverts narrowly overlaid with fine white bars in some.

SIMILAR SPECIES Readily distinguished from other storm-petrels by combination of brown upperparts (with contrasting black primary-coverts, remiges and tail), mostly white underparts and diagnostic facial pattern. For fuller distinctions from superficially similar **Grey-backed Storm-Petrel** *Garrodia nereis* see that account. When swimming or flying (with erratic weaving and banking actions),

beware confusion with prions, which differ by paler grey dorsum marked with narrow blackish open M across upperwings, proportionately longer wings and tail and more buoyant arcing flight. White-faced Storm-Petrel usually recognizable at long range by distinctly grey-brown dorsal aspect and, when foraging or feeding, by slow hopping or faster, more erratic bounding flight.

During breeding season, commonly encountered within continental shelf waters though rarely seen close inshore and only exceptionally from land; also occur commonly in shelf-break and slope waters. Markedly pelagic during non-breeding season. Rarely observed sitting on sea but buoyant when doing so. Travelling flight erratic, weaving and prion-like, with strong banking actions on stiffly held wings, interspersed with brief bursts of jerky rhythmic wing-beats followed by level glide on stiff, down-bowed wings; legs held under tail in travelling flight, feet and part of tarsi projecting well beyond tip of tail. Distinctive foraging and feeding flight more varied: in light winds, glide slowly forwards with wings held outstretched horizontally, legs dangling, gently hopping every few seconds, using both feet to push off surface; do not walk across surface like Wilson's Storm Petrel *Oceanites oceanicus* but touch water with both feet, giving impression of rapid hopping or springing progression over sea-surface. When pattering, will also 'stand' on water, facing into wind with wings held rigid and tail well-spread. In higher winds, progress in series of strong pendulum-like bounding movements, swinging to left and right at intervals of about 2 s using feet to push off sea-surface, appearing to dance over tops of waves. When moving between foraging sites, appear to skid rapidly across sea-surface, sailing on stiffly held wings in series of tight bounding arcs with one leg lowered and angled at 45° to body; kick off sea-surface every few seconds. Feed by aerial- and contact-dipping, in latter, interrupting hopping or bounding progression with rapid series of breast-first collisions with surface; also by pattering, more rarely by surface-seizing and surface-plunging. Singly or, more usually, in small parties and loose flocks near breeding colonies; occasionally in larger numbers when feeding over concentrations of food. Do not normally follow ships but often forage off bows and to sides of stationary fishing trawlers; occasionally forage round groups of feeding procellariiforms. Often feed in association with Fairy Prions *Pachyptila turtur*, hover over surfacing fur seals. Breed in dense colonies on well-vegetated offshore islands; when approaching burrow, flit along ground with wings extended rather than walking. Gregarious at colonies where strictly nocturnal. Silent at sea. At colonies, calls heard only

from birds in burrows or on surface; occasionally from burrows by day. Main call mournful *woooo*, repeated about once per second; sometimes extended to siren-like moan *oooo-aaa-ooo*.

HABITAT Marine; pelagic in breeding and non-breeding seasons. Foraging range from breeding sites at Chatham Is, 250–370 km (Rogers 1980); not observed in inshore waters of Whero I. (Richdale 1965). Along ne. coast of NI, observations in Oct.–Nov. over waters of 180 m depth (Norris 1965); in SA, uncommon in inshore waters, except round breeding islands (Parker *et al.* 1979). In non-breeding season, may move to tropical waters of Indian and Pacific Oceans: common in Indian Ocean, 80–160 km offshore, beyond coastal cool-water upwellings over continental shelf; most observations in waters of 24 °C (Bailey 1966). In e. Pacific, birds may follow cool Humboldt Current N to Galápagos region (Crossin 1974); highest densities over S. Equatorial Current, W of Galápagos (Pitman 1986). Suggestion that birds from e. Aust. colonies winter near South Tropical Convergence, N of NZ based on few records (Imber 1984). Some birds remain in non-breeding season along continental shelf in Aust.

Breed on islands; Aust.: on low granite islands covered by sandy loam, sandy limestone islands, steep rocky outcrops or low sand hummocks; in Port Phillip Bay, Vic., on artificial South Channel I. Most islands offshore, but Mud I. and South Channel I. in shallow bay. Colony sites usually flat, in shallow friable soil, and vegetated; on steep islands, often on saddles between peaks. Vegetation of low halophytic species. In e. Bass Str., nest among deep *Poa* swards or under mats of succulents or succulents draped round *Stipa* tussocks (Gillham 1963); in other places, more halophytic; *Atriplex*, *Chenopodium*, *Tetragonia* and succulent herbs may be dominant; especially where guano concentration in soil increased by high temperature and low rainfall (WA islands) or by low water retention in porous soils (South Channel I.; Gillham 1963). On Tullaberga I., Vic., highest burrow density in areas dominated by *Rhagodia baccata*, lower in *Atriplex cinerea*, lower still in *Poa poiformis*; bare sand and scrub of *Acacia*, *Coprosma* and *Myoporum* avoided (Harris *et al.* 1980). On Mud I., inundation, grazing by rabbits and human disturbance allowed invasion by introduced annuals (e.g. *Conyza*, *Glaucium flavum*) and huge increase in breeding colony of Silver Gulls *Larus novaehollandiae* has resulted in coprophilous species (e.g. *Lavatera plebia*) becoming dominant. In NZ region, birds on Chatham Is burrow under grass, nettles, bracken, shrubs or tall forest (Fleming 1939); on Whero I., most numerous in *Muehlenbeckia* and sedge vegetation, and least common in *Stilbocarpa lyallii* (Richdale 1965). Fly close above sea.

In Five Is Grp, NSW, reduction in breeding population coincided with great increase in numbers of breeding Silver Gulls, attracted by increased human settlement and scavenging opportunities on adjacent mainland (Gibson 1979). Breeding Gulls have also increased greatly on Mud I. but decline there occurred before large numbers of Gulls began nesting and was caused largely by erosion (Harris & Norman 1981; Menkhorst *et al.* 1988; T.W. Pescott); interference by Gulls may prevent recolonization. Control of rabbits has led to spread of *Atriplex* and *Lavatera*, but this may not adversely affect Storm-Petrels because they have nested under these plants on Mud I. and still do elsewhere (T.W. Pescott). Decline may have followed destruction of vegetation and erosion caused by removal of guano (before early 1900s), inundation,

grazing by rabbits, and trampling of burrows by humans (Gillham & Thomson 1961; Menkhorst *et al.* 1988). Massive erosion in the 1950s and early 1960s may have resulted from altered currents round island after obstructions to shipping removed from entrance to Port Phillip Bay (Menkhorst *et al.* 1988). Rabbit-control program has been largely successful. In e. Bass Strait islands, tracks made by stock allow Storm-Petrels to construct burrows in apparently impenetrable vegetation (Gillham 1963). Some banded birds from Mud I. are known to have subsequently bred on nearby South Channel I. where little erosion or inundation and no rabbits but there too threatened by development and easier access. On SA islands, grazing stock once trampled burrows (Wood Jones 1937) but most islands are now reserves and stock has been removed (P. Menkhorst). Fires destroy vegetation and may harm breeding birds.

DISTRIBUTION AND POPULATION Temperate and subtropical regions of Atlantic, Indian and s. Pacific Oceans. Breed on islands round NZ, s. Aust. and in Atlantic Ocean.

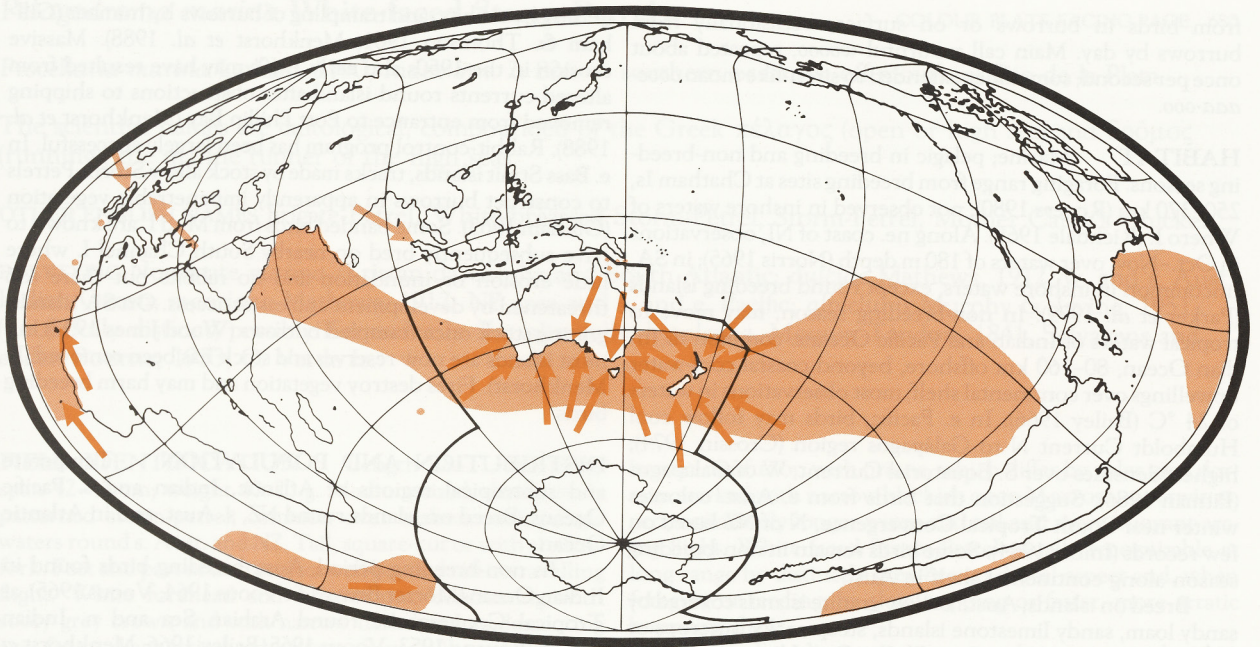
In non-breeding period, Aust. breeding birds found in Indian Ocean (Mörzer Bruyns & Voous 1964; Voous 1965), at Tropical Convergence round Arabian Sea and n. Indian Ocean (Bourne 1953; Voous 1965; Bailey 1966; Menkhorst *et al.* 1984), some in sw. Pacific (Imber 1984); NZ birds found e. and s. Pacific Ocean extending to Galápagos and Ecuador and off South American coast (Loomis 1918; Beebe 1926; Wetmore 1923; Murphy; Crossin 1974; Imber 1984; specimen NMNZ).

AUST. Qld: outer Great Barrier Reef and Coral Sea (Stokes & Corben 1985). NSW: from near Coffs Harbour, S along coast to Vic. All Vic. and Tas. to near Flinders I., SA. WA: from Recherche Arch., W and N to Freycinet Estuary. NT: no records.

NZ Recorded from round Kermadec Is (Sorensen 1964) to 50°08'S between Auckland and Campbell Is (Darby 1970). Most common off ne. NI: very numerous round Hauraki Gulf, outer Coromandel coast and in Bay of Plenty. Between 1974 and 1986, 107 beachcast specimens collected from Auckland West beaches. Few collected from other NI regions. Rare e. Cook Str. despite proximity to breeding colonies (Bartle 1974). One hundred beachcast birds collected from Canterbury South beaches by regular beach patrols between 1964 and 1986, but five from all other SI coasts in same period. Seen continuously from Chatham Is to 120 km SE thereof; in smaller numbers to 250 km SE; and absent 370 km SE, probably reflecting foraging range from Chatham Is (Rogers 1980).

BREEDING Between 30°S and 50°S. Extraliminally in Tristan da Cunha and possibly Gough I.; Salvages, C. Verde Is, North Atlantic.

AUST. Widespread S of 32°S; on e. coast S from Broughton I., NSW, and on w. coast S from Pelsart I., WA. Details of most known breeding places may be found in Seabird Islands Reports *passim* in *Corella* 2–13. In summary: NSW. Breed on nine islands with most of population on Tollgate Is (7000–8000 pairs). Vic. Tullaberga I and Mud and S. Channel Is in Port Phillip Bay. Tas. On many islands in Furneaux Grp most importantly, and along e. coast as far S as The Nuggets. Perhaps not on w. coast, though records before 1976 (Aust. Atlas). Claimed to have bred on mainland at Croppies Pt (Ashby 1928) but no later confirmation. SA. Sir Joseph Banks and Investigator Grps, and Nuyts Arch. (Parker

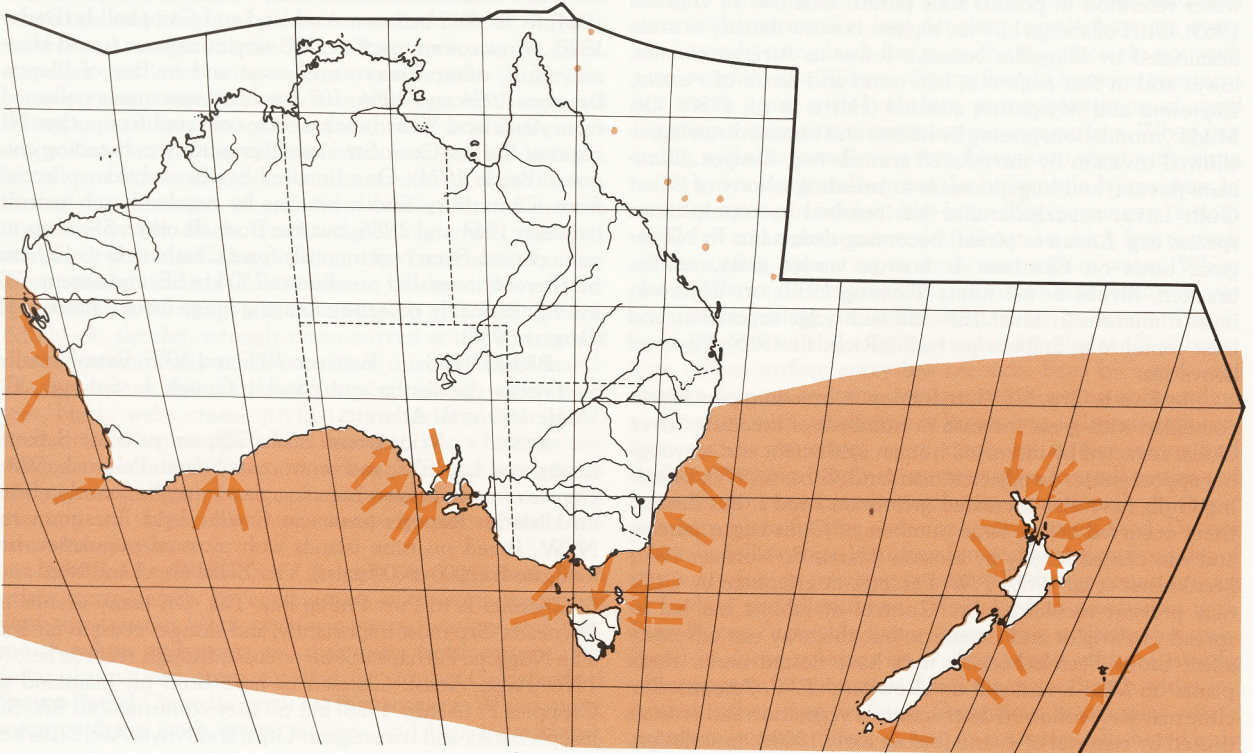


et al. 1979). WA. Islands of the Recherche Arch. and islands along w. coast N to Houtman Abrolhos.

NZ NI. Widespread on many islands including Three Kings (possibly), Moturoa Is, Cavalli, Poor Knights, Mokohinau, Noises, Motuokino, Cow, Mercury, Alderman, Mounau, Motumahunga (Tennyson *et al.* 1989; Adams 1971; Cunningham & Moors 1985; Blackburn 1970; NZCL; NZ Wildl. Service; CSN). SI. Sentinel Rock., Cook Str., Motunau I., Canterbury (Cox *et al.* 1967; M.J. Imber; A.J.D.

Tennyson). Stewart & Chatham Is: widespread in each group (Imber & Lovegrove 1982; M.J. Imber; A.J.D. Tennyson) with estimated 10^5 - 10^6 pairs on South East (Rangitira) I. in 1989 (J.A. West). Auckland Is: breeding reported 1943 (C.A. Fleming) but no recent confirmation. Kermadec Is. (Macauley I.) Probable (Tennyson *et al.* 1989).

POPULATION Population in NSW and Vic. estimated as 11 000 and 33 000 pairs respectively during 1970s (Lane 1979; Harris *et al.* 1980); in Tas., SA and WA, no



adequate estimates but substantial numbers in each State (10^4 - 6). Status, stable but damage to colonies in Aust. by grazing sheep and goats which trample burrows (Aust. Atlas). Disturbance by tourists in Port Phillip Bay, Vic. Rats and mice are threat in NZ (Robertson & Bell 1984) and introduction of rats in Furneaux Grp, Tas., has resulted in increased mortality of adults, nestlings and eggs (N.P. Brothers).

MOVEMENTS Migratory from temperate breeding sites to tropical and subtropical waters.

DEPARTURE Fledge n. NZ, mid Feb.-mid Mar.; Chatham Is, Mar.; islands off s. NZ, late Mar.-mid-Apr.; Whero I., NZ, 1940-45, Mar. 3 (8.7 days; 14 Feb.-7 Apr; 275; [92% 14 Feb.-15 Mar.]; Richdale 1965); Port Phillip Bay, Vic., late Jan.-late Feb. (Menkhorst *et al.* 1984); Bird I., NSW, Feb. (Fullagar 1973); Broughton I. and Big I. (formerly), NSW, soon after 26 Jan. (Bassett Hull 1911; Keast 1943; HLW.); Sir Joseph Banks Grp, SA, late Feb.-Mar. (Wood Jones 1937). Immatures may not leave waters near breeding islands immediately: several birds in fresh plumage seen S of Tas. and s. Indian Ocean, sw. of sw. Aust., mid-Apr. (D.W. Eades).

NON-BREEDING Specimens of *dulciae* collected in n. Indian Ocean and Arabian Sea indicate part of Aust. population winters there May-Sept. (Mörzer Bruyns & Voous 1964; Voous 1965; Bailey 1966). Wintering birds usually well offshore in small loose-knit flocks, their distribution in Indian Ocean being different from that of more coastal Wilson's Storm-Petrel *Oceanites oceanicus* (Bailey 1966). Seen off se. Arabia, May-July and passing Laccadive Is, May (Bailey 1966). The three long-distance recoveries (130, 440 and 3070 km) of birds banded at Mud I. have been to W, which suggests that birds from Mud I. migrate to Indian Ocean (Menkhorst *et al.* 1984). Most distant recovery, alive off Geraldton, WA, not officially [ABBBS] accepted because band was only partly legible. One beachcast *dulciae* found n. NZ during May, 15 sightings at sea (M.J. Imber) and 36 seen in Coral Sea, 16-22 May (Stokes & Corben 1985), suggest that some also migrate to sw. Pacific, perhaps wintering near s. Tropical Convergence between Fiji and Kermadec Is (M.J. Imber). Birds from NZ (*maoriana*) appear to overwinter in e. tropical Pacific (Bourne 1967; Crossin 1974; Pitman 1986) where seen July and Aug. between Ecuador and Galápagos (Leveque *et al.* 1966), Aug. and Sept. NW of Galápagos (Crossin 1974) and Sept., 160 km S of Galápagos (Leveque *et al.* 1966). Sightings and beachcast specimens (Mathews 1912-27; Cave 1931; Roberts 1974, 1982; Lovegrove 1978) suggest that some may remain in s. Aust. waters in winter.

RETURN Mercury I., by 2 Sept. at latest (Edgar 1962) probably mid.-Aug.; islands off s. NZ, mid-Sept.; Dongara-Lancelin Is, sw. Aust., mid.-late Aug. (Ford 1965); Bird I., NSW, Sept. (Fullagar 1973); seen off Vic., mid-Aug. (D.W. Eades).

BREEDING Foraging range from Chatham Is during summer, 250-370 km (Rogers 1980). Birds seen well S of breeding colonies, Jan., Feb. (Mochizuki & Kasuga 1985) presumably non-breeders.

BANDING

36S175E 01 1+ U 116 154 293 NZNBS
38S144E 01 P U 2 440 267 (Chandler 1959)
38S144E 01 P U 22 129 242 ABBBS
43S173E 02 1+ U 83 899 113 NZNBS
44S176W 11 1+ U 12 895 270 NZNBS
44S176W 11 1+ U 157 899 270 NZNBS X 6

FOOD Pelagic crustaceans, small fish and other small surface plankton. **BEHAVIOUR** Observed feeding by aerial-dipping (25% observations), contact-dipping (35%), pattering (30%) and surface-seizing (10%; 20 observations; D.W. Eades); suggestion that pursuit-dives common (Harper *et al.* 1985) possibly an error. Move more slowly and deliberately than Wilson's Storm-Petrel, possibly only when feeding in areas where food scarce (Bailey 1968). Most feeding may occur at night (Edgar 1962; Imber 1981). Seldom follow ships.

NON-BREEDING Little information on diet away from breeding colonies. In n. Indian Ocean (three stomachs; Bailey 1968; Mörzer Bruyns & Voous 1964) fish otoliths up to 0.3 cm length recorded, one sw. Aust. cephalopod beak (Serventy 1937) and one from e. Tropical Pacific had eaten insects, bugs *Halobates* (Beebe 1926).

BREEDING At Chatham Is, (22 regurgitations, 1803 items; Imber 1981) crustaceans 70.0% wt., 97.6% no., fish 30.0, 2.4. Of the crustaceans: barnacles imm. *Lepas australis* 0.5, 8.4, 1.7-4.5 cm, copepods *Calanus tonsus* <0.1% wt., 0.1% no., 0.3 cm, stomatopods imm. *Heterosquilla spinosa* 1.2, 0.8, 1.4-2.1 cm, imm. *Squilla armata* 2.4, 0.9, 1.8-2.9 cm, mysidaceans *Tenagomysis tenuipes* 2.8, 3.1, 1.2-1.7 cm, isopods *Idotea metallica* 0.6, 0.3, 0.7-2.2 cm, amphipods *Hyperia spinigera* 0.5, 0.4, 9-16, *Hyperoche mediterranea* 0.9, 6.2, 4-5, *Themisto australis/gaudichaudii* 0.8, 1.5, 7-10, *Cylopus macropis* 0.5, 1.0, 0.8-0.9 cm, *C. magellanicus* 5.2, 12.4, 7-9, *Vibilia armata* 1.7, 4.8, 5-8, *V. stebbingi* <0.1, 0.2, 6-8, euphausiids *Euphausia lucens* 0.1, 0.1, 1.5 cm, *E. similis* 0.6, 0.3, 1.4-2.2 cm, *Nematoscelis megalops* 10.4, 8.8, 1.3-1.8 cm, *Nyctiphanes australis* 34.7, 44.4, 0.7-1.5 cm, *Thysanoessa gregaria* 0.4, 0.3, 1.4-1.6 cm, crabs imm. *Nectocarcinus antarcticus* 6.6, 3.7, 0.6-0.9 cm, unident. decapod larvae <0.1, 0.1, 1.4 cm; the fish were *Maurolicus muelleri* 8.4, 1.7, 4.6-4.8 cm, *Lamphichthys procerus* 4.3, 0.1, 7.0 cm, unident. 17.3, 2.2, 1.6-2.3 cm.

Other records: at Mud I., about equal numbers of amphipods and decapods in pellets (Campbell 1933) and pelagic crustaceans, presumably euphausiids (Campbell & Mattingley 1907); at Whero I., NZ, mainly euphausiids with remains of one barnacle larva and one cephalopod (Richdale 1943); other sites NZ, minute crustaceans, cephalopods (Falla 1934); Tristan da Cunha, numerous copepods, a few euphausiids (Hagen 1952).

INTAKE Mean weight of meals throughout nestling period 6.4 g (4.6; 0-25; 314 meals, eight young) with size of meal peaking at 7.5 g/meal between 17 and 32 days old, dropping to 4.5 g during the last 9 days before fledging when rate of feeding fell from 0.68 to 0.32 visits per night. Some parents brought small meals often, others returned less often but with larger meals. Occasionally both parents fed their young on same night (Richdale 1965).

SOCIAL ORGANIZATION Gregarious in small (2-50) parties of unknown social composition when at sea. Larger flocks (several hundreds) reported near breeding colonies before laying. Little information on behaviour at sea.

BONDS Monogamous. Pair bonds sustained for more than one breeding season (B.I. Robertson). In NZ, pairs remained together for average 1.4 years and up to 4 years (n=174 breeding birds); 36% of breeders re-united with same mate in following breeding season (Richdale 1965). Not known if pair bonds maintained outside breeding season. Age at pair formation unknown, but probably >3 years because banded young first visit breeding colony at that age (Menk-

horst *et al.* 1984). Pre-breeders visit colonies perhaps for 2 or 3 years before they breed. Sex ratio unknown. Each mate occupies burrow before laying and presumably helps to prepare it and nest chamber. Both parents incubate and tend young until fledging.

BREEDING DISPERSION Colonial. Territory consists of nest burrow only. When two or more burrows connect, only one pair occupies each nest chamber, but seem tolerant of neighbours entering burrow. Burrow densities measured at five colonies: Mud I.: 0.1–1.3/m², South Channel I.: 2.05/m², Tullaberga I.: 0.24–1.37/m² (Harris & Norman 1981), Chalky I.: 1.5/m² (Robertson 1981); at Motunau I., Canterbury, NZ, 1958–62, average c. 50 burrows/600 m² (Cox *et al.* 1967). Territory presumably established when burrows cleaned out in late Sept. and early Oct.

ROOSTING Said to roost sometimes in rafts on sea (Harrison 1985). No other information.

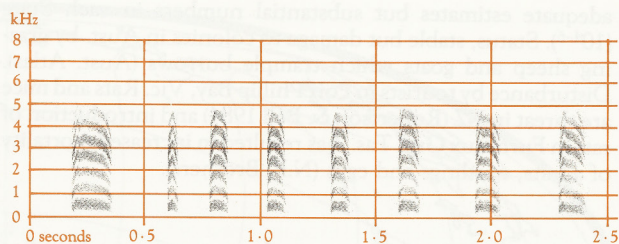
SOCIAL BEHAVIOUR Strictly nocturnal when visiting land; colony activity may decrease in bright moonlight (Menkhorst *et al.* 1984; B.I. Robertson) probably because pre-breeders stay away. Once moon sets or obscured, rapid increase in numbers of birds flying over colony. However, Richdale (1965) found evidence for this conflicting. At Motunau I., birds return to colony at 21:47 (21:10–23:20; 7 nights) (Cox *et al.* 1967).

BEHAVIOUR AT SITE Little information, largely because birds only come to land after dark and most interactions between mates take place in burrows. Mates share burrow before laying and for up to 3 h at change-over during incubation. Much calling takes place once birds have entered burrows.

RELATIONS WITHIN FAMILY GROUP Both parents incubate in shifts lasting 3–6 days; chick brooded for 2–4 days after hatching then left alone during day. Young fed nightly, by both parents, probably on alternate nights. Unlikely that parents and offspring associate at sea.

VOICE Not studied in detail and poorly known. Apparently silent at sea; vocal at breeding colonies but rarely noisy even at large colonies (P.J. Fullagar). Silent in flight over colonies at night, calls heard only from birds in burrows and on surface (Campbell & Mattingley 1907; Campbell 1933; Warham 1958; Imber & Lovegrove 1982; P. Menkhorst); however, Richdale (1965), apparently in error, reported considerable calling when large numbers in flight over Whero I. and reports of low cries given when taking flight (Campbell & Mattingley 1907) doubtful (P. Menkhorst); occasionally call from burrows during day (Wood Jones 1937; Warham 1958). Activity decreases on moonlit or stormy nights (Richdale 1965). Range of calls not known; a variety of calls generally described as repeated mournful *coo* or *wooo*. No information on sexual differences, individual differences and geographical variation.

ADULT Best description from Lancelin I.; main call described as a mournful *woooo*; repeated about once per second; sometimes extended to siren-like moan *oooo-aaa-ooo* (Warham 1958); similar calls given by birds breeding Mud and South Channel Is (P. Menkhorst). Calls from Tollgate I. consist of rapid staccato *i-i-i-i-i* (Buckingham & Jackson 1983; see sonagram A). When handled, one bird gave low fluty *chee-ur* (Campbell 1933). Plaintive call given by one bird attacked by another (Richdale 1965). No further information. Meagre information for extralimital populations in BWP.

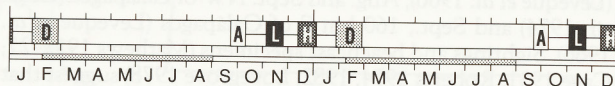


A N. Robinson; Tollgate Is, NSW, Nov. 1959; B584

YOUNG Plaintive *squeaks*, faint up to 1 week old (Campbell 1933; Richdale 1943, 1965); mouse like *squeaking* described by Littler (1910) was probably given by young. When older, *purr* when adult enters burrow (Campbell & Mattingley 1907); said to make noise like chicken while being fed (Mathews 1912–27).

BREEDING Not well known. Studied at Chalky I. (B.I. Robertson) and Fisher I. (Brothers 1981), Tas.; Mud I., Vic. (Menkhorst *et al.* 1984); islands off s. Aust. (Wood Jones 1937); Whero I., NZ, but only after laying (Richdale 1943, 1965). Breed in simple pairs; colonially; on islands with sufficient depth of soil and often well vegetated.

SEASON Extended. Return to colonies not exactly known but judged to be late Sept.–early Oct. at Mud I. and certainly before 19 Aug. at Lancelin I., WA (Ford 1965); early Oct. at Whero I. Laying starts: Fisher I., before Dec.; Mud I., early Nov. (Tarr 1952); Recherche Arch., WA, by 2 Nov. (Lane 1984; S.G. Lane); Lancelin I., early Oct. (Ford 1965); n. WA colonies, c. 7 Oct. (HASB); at Whero I., estimated from hatching dates and incubation period, on average c. 16 Nov. (31 Oct.–21 Dec.; five seasons), hatching, 5 Jan. (8.8 days; 20 Dec.–9 Feb.; 276 eggs, five seasons). Fledging: Big I., NSW, (formerly) soon after 20 Jan. (Keast 1943); Mud I., late Jan. to late Feb. (Campbell 1933; Pescott 1983; Menkhorst *et al.* 1988); Sir Joseph Banks Grp, SA, late Feb. into Mar. (Wood Jones 1937); Whero I., 2.7 Mar. (8.7 days; 14 Feb.–7 Apr.; 275 fledgelings, five seasons). Thus, probable pre-laying attendance of c. 6–7 weeks. Season apparently about one month earlier in w. than in e. Aust. and in n. than in s. colonies in WA.



(Mud I., Victoria)

NEST, MATERIALS In shallow burrow 30–120 cm long, less than 20 cm below surface; at Whero I., angled very steeply; entrances c. 5–8 cm in diameter; usually in thick vegetation, where available; at Whero I., often blocked when not used e.g. when incubating. In friable soils, burrows straight or nearly so; in hard or rocky soils, may twist round obstacles (Wood Jones 1937); on Mud I., twist round roots of *Lavatera plebia* and often interconnected with several entrances. Where little depth of soil, burrows may be merely channels covered by dense mats of vegetation. In Furneaux Grp, Tas., burrows not necessarily associated with bare ground and may pass through 15 cm of compacted grass before reaching ground. At Fisher I., three nests recorded in bases of tussocks of *Poa poiformis*, two in rock crevices (Gillham 1963; Brothers

1981). Nest chamber up to 20 cm wide, 15 cm high, usually well lined with dry vegetation, which may be used to cover eggs when adults absent (Brothers 1981). Birds may return to same burrow in successive years (Brothers 1981; B.I. Robertson).

EGGS White, sometimes with fine red flecks or brown blotches on larger end; oval to elliptical, smooth, mat. At Whero I., usually with pink spots at larger end.

MEASUREMENTS

Mud I., Vic. 36.7 (34.7–38.8; 6) x 27.1 (26.3–27.7) (VORG)
Chalky I., Tas. 36.3 (34.2–39.0; 16) x 26.4 (25.2–27.3)
Fisher I., Tas. 36.4 (34.0–39.2; 22) x 26.0 (24.6–26.8)
Reevesby I., SA 35.8 (34.5–38.0; 16) x 25.7 (24.5–26.5) (Wood Jones 1937)
Whero I., NZ 35.9 (1.12; 33.0–38.8; 100) x 26.0 (0.8; 23.5–27.8)

WEIGHTS: Chalky I.: 13.7 (11.3–15.0; 16); Fisher I.: 14, 17; Mud I., 12, 12, 15. Whero I., 11.8 (1.24; 9.0–14.5; 54, all ages).

CLUTCH-SIZE One. Single brooded. No replacements. Richdale reported two eggs frequently observed in nests but erroneous.

LAYING Not synchronized. Not fully known at any site but start limited as follows: Fisher I., 17 of 25 eggs before 1 Dec., last on 14 Dec.; Mud I., just started 3–8 Nov. (Tarr 1952); Sir Joseph Banks Grp, new laid to well-incubated eggs 6 Dec. (Wood Jones 1937); Recherche Arch., few eggs 3 Nov., 57 of 95 occupied burrows with eggs 3 Dec. (Lane 1984; S.G. Lane); Lancelin I., no eggs 3 Oct 1959, about half burrows examined with fresh eggs 7 Oct. 1961, with similar less exact evidence from other islands (Ford 1965); n. colonies in WA, c. 7 Oct. (HASB). Laying not observed at Whero I. but estimated (from date of hatching and estimated incubation period) c. 16 Nov. (31 Oct.–21 Dec.).

INCUBATION By both sexes in alternate shifts. Female usually begins incubation, for at least one day after laying; then in shifts of 4.4 days (3–5) for females and 5.0 days (3–6) for males; if periodic, natural and temporary desertions are credited to previous occupant, these means become 4.7 days for females, 5.7 days for males. Females apparently inclined to desert egg almost three times more often than males. Egg can withstand desertion for at least 3 days (Brothers 1981); Richdale recorded hatching after desertions of 24 h and 92 h. At Whero I., average incubation period for both sexes 3.6 days (1.75; 1–9; 36 periods, seven nests); average total time of desertion 2.25 days (1.49; 1–4; eight periods); desertion probably due to late return of partner. **INCUBATION PERIOD:** not determined for Aust. populations or at Whero I. However, at Whero I., Richdale had number of minimum times in excess of 45 days and one of 59 days; estimated incubation period to be c. 50 days.

NESTLING Semi-altricial; nidicolous. Covered in light neutral grey down (one coat only); top of head, bald, bright flesh-coloured. Bill, dark violet-grey. Legs, light violet-grey; webs, pale pink (Richdale 1965). Pipping to emergence c. 24 h (Richdale 1943, 1965). Nestlings spit out pure red oil (Fleming 1939). Egg-shell left in nest and crushed. Dates of hatching: at Whero I., 5 Jan. (8.8 days; 20 Dec.–9 Feb.; 276 eggs, five seasons); mean dates of hatching for five seasons were: 6 Jan., 1.7 Jan., 7.2 Jan., 31.9 Dec. and 11.5 Jan.; hatching spread over a period of 29 to 42 days but varies from season to season. Downy young recorded: Recherche Arch., 15 Jan.; N. and S. Fisherman Is, WA, recently hatched, 12 Dec. (Ford 1965); Jurien Bay, 18 Nov. (Serventy & Whittell 1976); Hout-

man Abrolhos, 20 Oct. (Hall 1902). At Whero I., brooded by both parents for 2.4 days (1–5; 14) after hatching; then abandoned by day. At Fisher I. first nightly arrival of adults 20:50–21:30; peak activity c. 21:30–23:00, declining till 01:00–02:55, when all birds depart abruptly within 10 min. Activity much reduced on moonlit nights. Feeding by incomplete regurgitation by one or both parents, nightly; recorded as less regular at Fisher I. Dates of departure: Big and Broughton Is, NSW (formerly), soon after 26 Jan. (Keast 1943; HLW); Mud I., late Jan. to late Feb.; Sir Joseph Banks Grp, late Feb. into Mar. (Wood Jones 1937). At Whero I., 2.7 Mar. (8.7 days; 14 Feb.–7 Apr.; 275 fledgelings, five seasons); 92% of chicks departed 14 Feb.–15 Mar. with only stragglers after mid-Mar.; chicks that left early had much more down on them. At Whero I., chicks probably do not come to mouth of burrow till the night before or night of fledging and when leaving, do so before it is dark. Fledgelings not deterred by moonlight or rough weather; after leaving burrow remain on surface for a few minutes before climbing up vegetation with wings beating quickly (Richdale 1965). **NESTLING PERIOD:** not determined for Aust. populations. At Whero I. in 1941–42 season, 57.3 days (2.8; 52–67; 40); chick not abandoned before departure, but may not be fed every night during last 8 days in burrow.

GROWTH At Whero I.: weight at hatching: 8.5–9.5 g; average weight 1–4 days old, 13 g (9–19.8; 25) or 27.5% average adult weight; maximum weight 65 g (50.5–76.5; 32) or 137.8% av. adult weight achieved at 33–36 days old and remains thereabouts till 53–56 days old, then declining; weight at fledging (i.e. at 9 pm on night left burrow): 53.7 g (6.0; 42–68; 40) or 113.8% av. adult weight. Mean weight of meals fed to chicks was 6.4 g (4.6; 0–25; 314 meals, eight chicks); average weight of food per day 4.6 g (4.2–5.0; 8 chicks); but naturally increased from average 3.1 when 1.4 days old to 7–8 when 17–32 days old. Post-fledging: young do not return to colonies (Mud I.) until at least 3 years old and first breeding not recorded before this age.

SUCCESS On Spence's Reef, Furneaux Grp: 1980–81, 36 eggs in Dec. produced 22 chicks in Feb. (61%); 1981–82, 20 chicks raised from 33 eggs (66%); 1982–83, nine chicks raised from 23 eggs (39%) (I.J. Skira). In two seasons at Whero I., of 18 chicks, 16 (89%) fledged and of 52, 47 (90%) fledged. Survival: Mud I., 44 of 8232 nestlings banded (0.4%) recovered dead nearby within 1 month of fledging; 40 others recaptured in colony 3–21 years after banding (Menkhorst *et al.* 1984; P. Menkhorst); at Whero I., of 222 chicks banded 1941–42 to 1944–45, one banded 13 Jan. 1944 recovered on surface 14 Jan. 1950, status unknown. **PREDATION.** Remains of adult at nests of two Pacific Gulls *Larus pacificus* in area of colony at Chalky I. suggest low rate of predation; Gulls also reported as predators at Spence's Reef (Gillham 1963), Fisher I. and on SA islands (Wood Jones 1937; S.G. Lane). Kelp Gull *Larus dominicanus* suspected of causing decline of birds in Five Is, NSW (Battam 1976). At Whero and Chatham Is, skuas *Catharacta* take many: swallowed whole and head first; regurgitated remains with characteristic long legs protruding from bolus (Richdale 1943, 1965; M.J. Imber). At Whero I., eggs and chicks excavated from burrows by Slender-billed Prions *Pachyptila belcheri* and less often by Common Diving-Petrels *Pelecanoides urinatrix*. At Maria I., NZ, Marsh Harriers *Circus approximans* take some birds (D.V. Merton). Adult remains at feeding stations of Peregrine Falcons *Falco peregrinus* on Toll-gate Is (McKean & Fullagar 1976) and on Cull I. (S.G. Lane) no doubt taken at sea. Predation by Barn Owls *Tyto alba*

noted on Dorothee I. (Parker & Cox 1978) and probably occurs Reevesby I. (Robinson *et al.* in press) and Mud and South Channel Is (P. Menkhorst). Water Rats *Hydromys chrysogaster* and Black Rats *Rattus rattus* may have taken adults on Fisher I. but latter exterminated by 1974 (Serventy 1977; Brothers 1981). Feral cat killed adults on Muttonbird I. and may have prevented Storm-Petrels from establishing colony. Adults found in stomachs of Tiger Snakes *Notechis ater* on Reevesby I. (Wood Jones 1937). Adult impaled on thorns of African Boxthorn *Lycium ferocissimum* on South Channel and Mud Is (J.R. Wheeler; P. Menkhorst; Aust. NRS); beach-cast bird with plumage matted by sticky seeds of *Acaena* (McBain 1980). Previously, adults trapped in gunpits and colony area much trampled by man, South Channel I. (Harris *et al.* 1980).

PLUMAGES *Subspecies dulciae.*

ADULT In fresh plumage; **HEAD AND NECK.** Forehead, proximal lores, chin and throat, white; feathers basally dark brown (119A). Crown, black-brown (119), forming dark cap. Forehead, paler; tipped white. Directly below eye, large dark-grey (83) sub-orbital patch extends from distal lores to ear-coverts; black-brown (119) proximally. Very narrow line of white feathers below lower eyelid. White supercilium from lores, broadens behind eye and extends to distal ear-coverts. Hindneck and sides of neck, dark grey (83); rest white. **UPPERPARTS.** Mantle, back and scapulars, dark brown (119A), narrowly tipped grey (84). Concealed white bases of feathers often exposed on mantle. Rump and upper tail-coverts, light grey (85), tipped white; bases of feathers white. Outer margins of breast, grey (84), forming incomplete collar; extent varies (similarly in subspecies *maoriana*). **TAIL,** black-brown (119). **UPPERWING.** Remiges and alula similar, former merging to white at base of inner webs; narrowly tipped white. All upper wing-coverts, dark brown (119A); greater with white tips. **UNDERPARTS,** white; flanks with varying light-grey (85) shaft-streaks and under tail-coverts varying mottled light-grey (85). **UNDERWING.** Marginal coverts, dark brown (119A) with white tips, from base of p11 to carpal joint; rest of coverts and axillaries, white.

In worn plumage (most often seen in A'asia) pale fringes of forehead and feathers surrounding bill, worn, exposing dark-brown (119A) bases. Similarly, pale tips of mantle, back, rump, upper tail-coverts and greater upper wing-coverts, lost. Greater upper wing-coverts, brown (119B) and most often worn. White tips of remiges lost.

DOWNY YOUNG One down only; pale brown-grey (79). Down on lores, chin and upper throat, thin; on upperparts, long thick and fluffy, shorter and paler on underparts. Down on crown conceals bald spot. For full details of plumage acquisition to juvenile plumage in *P.m. maoriana* see Richdale (1943, 1965).

JUVENILE Similar to adult in fresh plumage, differences only described here. Rump and upper tail-coverts, light grey (85) narrowly barred white; some with subterminal bars with broad white tips. Lower flanks and under tail-coverts varying barred light grey (85). White tips to upperparts, remiges and greater upper wing-coverts broader and more prominent than in adults. Tip of p10 pointed; rounded in adults; intermediates may occur, as in *P.m. hypoleuca* (BWP).

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

ADULT, JUVENILE Iris, dark brown (219). Bill, grey-black (82). Legs and outer margins of toes, grey-black

(82); cream (54) webs with grey-black (82) margins; patch on webs may function as lure for capture of prey (Zink & Eldridge 1980). For additional details of bare parts, see Parker & Cox (1978).

DOWNY YOUNG Similar to *P.m. maoriana* described by Richdale (1943, 1965): eyelid, dark greyish-brown. Bill, dark shades of violet grey; egg-tooth, prominent, white. Bald patch on crown, bright flesh. Legs, tarsi and toes, light to medium violet-grey; webs, pale pink; claws, dark blue.

MOULTS

ADULT POST-BREEDING Some moult of body feathers before end of breeding season, completed in winter quarters. Complete; in *dulciae* adults from Apr. to Aug; *maoriana*, May to Aug; unknown if moulting birds include non-breeders at this time. No data for *P.m. albiclunis* (see Geographical Variation). Remiges moult soon after arrival in winter quarters. Inner primaries moult outwards, replaced quickly with three adjacent primaries growing at once; outer ones slower. Secondaries replaced quickly. Rectrices moult after major wing moult (BWP). Actual duration and timing of moult unknown; however, specimens collected at sea in Aug., round Galápagos, in final stages of complete moult (Crossin 1974). See additional information and details given in Junge (1941) and Mayaud (1949-50).

POST-JUVENILE No data.

MEASUREMENTS *P.m. dulciae.* (1) North I., Tollgate Is, NSW, free-flying, 22 Nov. 1969; methods unknown (H. Battam; ABBBS). (2) As for 1, except 4 Dec. 1979 & 5 Jan. 1980 (A. Leishman; ABBBS). (3) Flinders I., Five Is, NSW, free-flying, 9 Dec. 1969; methods unknown (H. Battam; ABBBS). (4) Skins; methods described (Imber 1984). (5) Skins (QVM, MV, NMNZ).

UNSEXED		
WING	(2)	155.4 (4.79; 147-167; 29)
	(3)	158.1 (3.18; 153-163; 29)
	(4)	158.3 (151.0-168.0; 46)
BILL	(1)	18.1 (0.57; 16.7-19.4; 103)
	(2)	18.7 (0.71; 17.8-19.5; 3)
	(3)	17.7 (0.60; 16-18.9; 29)
	(4)	16.9 (15.2-18.0; 46)
TARSUS	(1)	43.0 (1.10; 40-45.1; 103)
	(2)	42.5 (0.67; 41.9-43.5; 3)
	(3)	42.1 (1.18; 40-44.3; 29)
	(4)	42.1 (39.0-45.0; 46)
TAIL	(2)	72.6 (3.83; 63-78; 29)
	(4)	74.0 (69.0-83.0; 46)
TOE	(4)	36.8 (34.0-42.0; 46)
MALES		
FEMALES		
WING	(5)	157.4 (3.27; 152-162; 6)
8TH P	(5)	116.4 (6.01; 104-123; 10)
BILL	(5)	17.4 (0.70; 16-18.4; 11)
TARSUS	(5)	41.8 (1.22; 40.2-44; 11)
TAIL	(5)	70.1 (3.30; 65-76; 10)
TOE	(5)	37.5 (1.24; 35.5-39.9; 11)
		37.2 (1.08; 35.6-39; 9)

P.m. maoriana: (6) Skins; methods described (Imber 1984). (7) Skins (NMNZ).

UNSEXED		
WING	(6)	157.2 (149.0-169.0; 42)

BILL	(6)	15.8 (14.6-17.0; 42)
TARSUS	(6)	40.7 (37.8-43.0; 42)
TAIL	(6)	75.6 (67.0-85.7; 42)
TOE	(6)	35.2 (32.0-40.9; 42)

	MALES	FEMALES
WING	(7) 155.0 (7.12; 145-167; 10)	156.8 (5.80; 148-173; 17)
8TH P	(7) 114.5 (5.31; 103-121; 8)	115.3 (3.96; 108-122; 8)
BILL	(7) 15.9 (0.98; 14.2-17.9; 13)	16.1 (0.84; 14.7-17.8; 19)
TARSUS	(7) 41.2 (1.82; 37.6-44.5; 13)	41.2 (1.87; 38.3-44.2; 19)
TAIL	(7) 73.5 (6.45; 65-85; 12)	78.3 (4.41; 66-87; 19)
TOE	(7) 35.6 (0.91; 34.3-37; 11)	35.3 (1.01; 33.5-36.8; 18)

P.m. albiclunis: (8) Skins; methods described (Imber 1984).

	UNSEXED
WING	(8) 156.4 (144.0-166.0; 16)
BILL	(8) 16.6 (15.3-17.7; 16)
TARSUS	(8) 41.2 (37.5-43.1; 16)
TAIL	(8) 71.2 (66.0-76.0; 16)
TOE	(8) 37.0 (35.2-39.3; 16)

Females have longer wings and tails than males. Measurements of *albiclunis* similar to *dulciae*; for discussion see Imber (1984). For additional measurements of adult *dulciae* see Bourne (1953), HASB; for *maoriana* see Richdale (1943, 1965), Bourne (1953), Oliver. In *maoriana*, fledgelings attain full lengths of wing and tail after leaving burrow; length of bill attains maximum after fledging; other characters similar to adult (Richdale 1943, 1965). For full details of growth rates of chicks in *maoriana* see Richdale (1943, 1965).

WEIGHTS *P.m. dulciae*: Key as for measurements.

	UNSEXED	MALES	FEMALES
(1)	54.9 (6.39; 41-68; 103)		
(2)	61.3 (5.91; 50-72; 62)		
(3)	48.7 (2.25; 45-56; 29)		
(5)	46.8 (12.48; 30-70; 8)	63.6 (3.63; 59-70; 6)	*

P.m. maoriana: (7) As for measurements; (9) Live adults, unknown status; techniques described (Richdale 1943, 1965).

	MALES	FEMALES
(7)	40.2 (4.53; 30-46.3; 11)	41.4 (3.06; 35-47.8; 17)
(9)	47.2 (4.0; 40-62; 100)	

No data on seasonal changes. No starvation period (Richdale 1943, 1965). Weights of chicks vary; see Richdale (1943, 1965) for details.

STRUCTURE Wing, short and narrow. Eleven pri-

maries: p9 longest, p10 8-18 mm shorter, p8 1-5, p7 10-15, p6 20-28, p5 32-40, p4 43-53, p3 55-65, p2 65-75, p1 74-84, p11 minute. No emarginations. Tail, square and slightly forked in *dulciae* and *albiclunis*; very forked in *maoriana*. Twelve rectrices; in *dulciae*, t6 longest, t1 3-5 mm shorter; in *maoriana*, t1 9-12. Bill, short and slender, nasal tubes c. 30% of bill-length; maxillary unguis, strongly curved. Nasal tubes point slightly upwards at tip; septum behind nasal opening. Claws flattened and curved; broadest basally. Legs and feet, slender; tarsi, scutellate. Outer toe c. 88% of middle, inner c. 72%, hind very reduced, claw only.

SEXING, AGEING Adults sexed on cloaca (Serventy 1956); females longer in wing and tail (see Measurements). Age categories on basis of plumage; juveniles with pointed tip to p10, rounded in adults; intermediates possible (see Plumages). See criteria in Richdale (1943, 1965) for ageing chicks.

GEOGRAPHICAL VARIATION Three subspecies in A'asia: *dulciae* breeds s. and se. coasts of Aust.; *maoriana* on islets off NZ; *albiclunis* possibly on Kermadec Is but breeding not verified (Peters; M.J. Imber). Subspecies *maoriana* differs from *dulciae* in having strongly forked-tail; *albiclunis* differs from former two subspecies by being white-rumped (Murphy & Irving 1951). However, *albiclunis* doubtfully distinct and may represent worn plumaged *dulciae*; for discussion see Imber (1984), who states that synonymy remains premature, until validity of *albiclunis* can be disproved. N. hemisphere subspecies have longer tarsi and bills and less forked tails. Bourne (1953) suggests *maoriana* should be united with nominate *marina*, but retains *dulciae* (despite its similarity to *hypoleuca*) on basis of distribution. For full details of subspecies see Murphy & Irving (1951), Bourne (1953) and BWP.

RMO

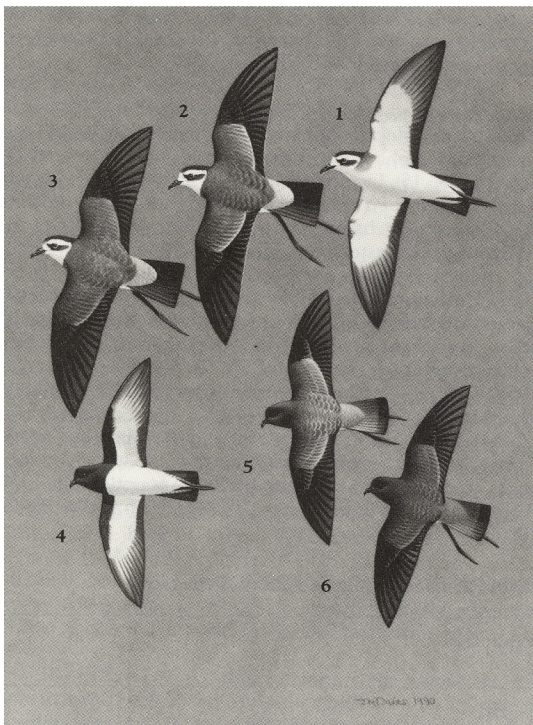
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Volume 1 (Part A), Plate 51

White-faced Storm-Petrel *Pelagodroma marina* Subspecies *dulciae*

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

Grey-backed Storm-Petrel *Oceanites nereis*

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

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