

Order PROCELLARIIFORMES

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

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

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

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

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

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

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

References

- Bang, B.G. 1966. *Acta anat.* 65: 305-415.
- Bourne, W.R.P. 1976. Pp 403-502. In: Johnston 1976.
- Brodkorb, P. 1963. *Bull. Flor. St. Mus. biol. Sci.* 7: 179-293.
- Clarke, A., & P.A. Prince. 1976. *J. Exp. mar. Biol. Ecol.* 23: 15-30.
- Fisher, J. 1952. *The Fulmar*.
- Harper, P.C. 1978. *NZ J. Zool.* 5: 509-549.
- Johnston, R. (Ed.). 1976. *Marine Pollution*.
- Klemm, R.D. 1969. *S. Ill. Univ. Monogr. Sci. Ser.* 2.
- Obst, B.S. 1986. *Wilson Bull.* 98: 189-95.
- Olson, S.L. 1975. *Smithson. Contr. Paleobiol.* 23.
- Swennen, C. 1974. *Ardea* 62: 111-117.
- Timmermann, G. 1965. *Abh. Verh. naturwiss. Vereins Hamburg NF* 8, Suppl. 1-249.

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.

REFERENCES

- Brodkorb, P. 1963. *Bull. Flor. St. Mus. biol. Sci.* 7: 179-293.
- Cox, J.B. 1980. *Rec. S. Aust. Mus.* 10: 91-121.
- Fleming, C.A. 1941. *Emu* 41: 134-55.
- Harper, P.C. 1980. *Notornis* 27: 235-86.
- Imber, M.J. 1985. *Ibis* 127: 197-229.
- Kuroda, N. 1954. *On the classification and phylogeny of the order Tubinares, particularly the shearwaters (Puffinus), with special consideration on their osteology and habit differentiation.* Tokyo.
- Murphy, R.C., & J.M. Pennoyer. 1952. *Am. Mus. Novit.* 1580.
- Olson, S.L. 1975. *Smithson. Contr. Paleobiol.* 23.
- Voous, K.H. 1949. *Ardea* 37: 113-22.

Puffinus assimilis Gould, 1838, Syn. *Birds Aust.* 4 Append.:7 — New South Wales = Norfolk Island, *vide* Mathews, 1912, *Birds Aust.* 2: 50.

The specific name means 'similar' and, according to Gould, 'very closely allied to *Puffinus obscurus* but considerably smaller'. *Puffinus obscurus* was a name once used for the northern hemisphere subspecies of *P. assimilis*.

OTHER ENGLISH NAMES Allied, Dusky or Gould's Petrel or Shearwater.

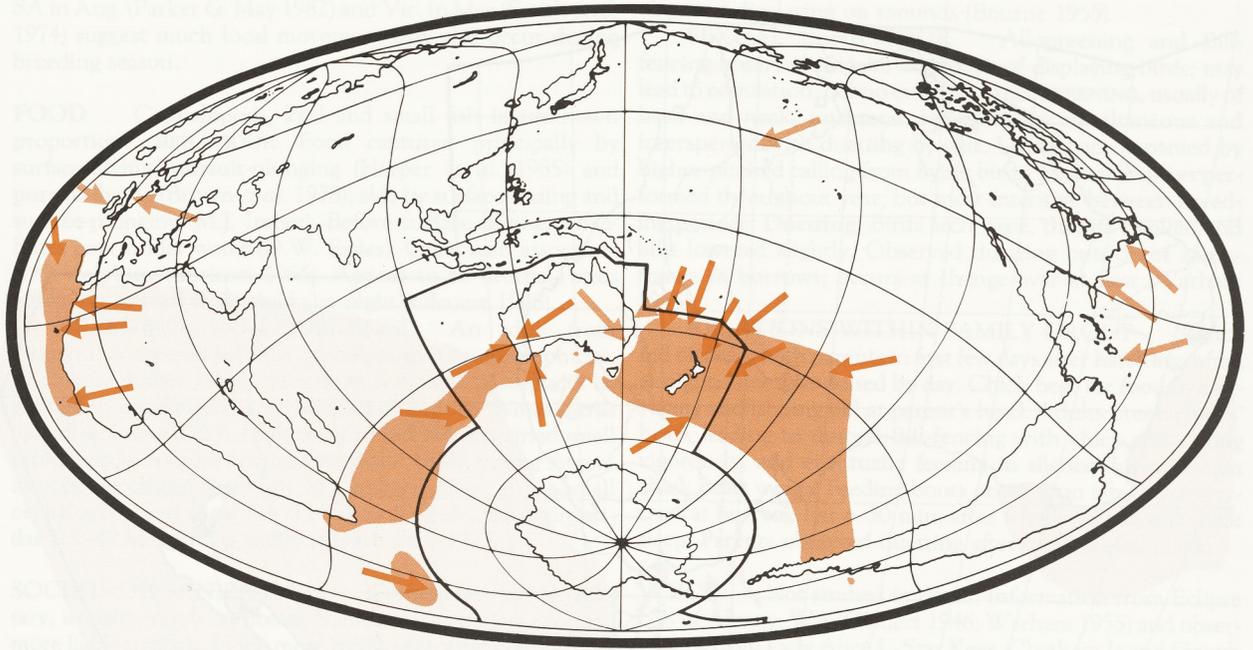
POLYTYPIC Nominate *assimilis* breeds Norfolk and Lord Howe Is; *tunneyi* Mathews, 1912, offshore islands sw. Aust; *kermadecensis* Murphy, 1927, Kermadec Is; *haurakiensis* Fleming & Serventy, 1943, islands off ne. NI, NZ; *elegans* Giglioli & Salvadori, 1869, Chatham and Antipodes Is and Tristan da Cunha Grp and Gough I. in South Atlantic. Extralimitally: *baroli* Bonaparte, 1857 breeds North Atlantic Ocean; *myrtae* Bourne, 1959, in Austral Grp, s. central Pacific Ocean.

FIELD IDENTIFICATION Length 25-30 cm; wingspan 58-67 cm; weight 220-260 g. Smallest shearwater; resembles other members of 'fluttering' group in structure, but more compact with shorter, more slender bill and shorter broader wings with rounder tips. Black above, white below; division line between black cap and white cheeks passes above eye in most subspecies giving a more white-faced appearance than other small shearwaters. Underwing, white with only thin dark trailing edge and wing-tip. Sexes alike. No seasonal variation. Juvenile inseparable from adult.

DESCRIPTION ADULT. Entire upperparts, slaty black with greyish bloom in fresh plumage. Lores and cheeks, white, freckled grey; line separating black cap and white face starts at naricorn and passes just above, through or just below eye. Many have small dusky patch on ear-coverts, isolated from blackish crown and nape. Rest of underparts, white, without dusky half-collar. Under tail-coverts, white; narrow black tip to undertail formed by black undersides of rectrices. Underwing lining, clean white with thin dark border along trailing-edge and round wing-tip formed by dark tips to

remiges; no noticeable black on leading-edge of underwing. Bill, long and very slender, nasal tubes only slightly raised above base of upper mandible. Nasal tubes, culminicorn and unguis, black; latericorn and ramicorn, light blue to lead-grey, appearing dark at sea. Iris, dark brown. Legs and feet, light blue; webs, pale yellow to flesh coloured; outer side of outer toe and claws black. Subspecies probably indistinguishable at sea except for *elegans*.

SIMILAR SPECIES Easiest of small shearwaters to identify, by combination of small size, white face and underparts and nearly pure-white underwing; no other member of genus has blue legs and feet. **Fluttering** *P. gavia* and **Hutton's** *P. huttoni* Shearwaters larger with browner upperparts, darker heads and upper breasts giving slightly hooded appearance, and dusky brown triangles across wing-pit. Little Shearwater also less gregarious, usually seen singly or in small groups within normal range of Fluttering and Hutton's. **Manx Shearwater** *P. puffinus* has similar markings to Little, but is much larger, with longer wings and darker face; Manx flies more strongly, with less flapping and more shearwater-



ing, banking higher above sea. **Audubon's Shearwater** *P. herminieri* larger with darker face, diagnostic black under tail-coverts, broad black margins round entire underwing, longer tail, flesh-pink legs and different flight-style with more horizontal gliding and fewer bursts of flapping. **Diving Petrels** *Pelecanoides* spp share blue legs with Little Shearwater but are much smaller, with stubby bills, short necks, chunkier bodies, very short rounded wings and rapid whirring wing-beats without shearwatering or gliding.

Solitary or in small groups; larger flocks occur near major colonies. Swim and dive well, using partly folded wings to pursue prey underwater. Flight-style similar to other small shearwaters, but with less gliding and more frequent bursts of 4-6 rapid wing-beats. Keep close to surface, skimming over wave crests and flying along troughs. Wing-beats shallow, stiff-winged. In calm conditions, wing-beats separated by short glides with wings horizontal; in stronger winds, more shearwatering and banking, but still keep closer to waves than other shearwaters. Feed by plunge-diving, surface-seizing and pattering across surface with wings raised above back. Usually ignore ships. Breed colonially under forest or tussock on small islands. Usually silent at sea; wide variety of calls in flight over colony and from ground, including high-pitched whistles, screams and dove-like cooing; main song described as throaty, asthmatical *wah-i-wah-i-wah-i-wah-ooo* with sobbing intake and spluttered termination, heard mainly during courtship.

HABITAT Marine, pelagic; in subantarctic, subtropical and occasionally tropical waters of Atlantic, Pacific and Indian Oceans. Frequent continental shelf waters (nw. Aust.; Dunlop *et al.* 1988a). Race *elegans* probably pelagic, but birds feed in sheltered inshore waters of Auckland I. in winter (Imber 1983). In sw. Aust. and NZ region, breed on subtropical and subantarctic islands, where soft soil suitable for burrowing; in tussock grassland, shrubland, woodland, or under mats of succulents (e.g. *Carpobrotus*, *Nitraria*, *Rhagodia*, *Atriplex*, *Tetragonia*, *Melaleuca*), or among loose rocks in talus (Warham 1955; Edgar 1962; Fullagar 1978; Lane 1978; Smith

& Johnstone 1987; Dunlop *et al.* 1988b). Fly close to sea surface; in high seas, progress down centres of wave troughs. Dive readily for food (Brown *et al.* 1978). Settle on surface to loaf, sleep and preen.

Development of resorts and erosion of dunes on Penguin I., WA, has led to loss of nesting habitat, and visitors disturb breeding birds (Dunlop *et al.* 1988b). Introduced predators may have caused desertion of breeding colonies on Lord Howe, Norfolk, Raoul and Chatham Is; birds now breed mainly on lesser offshore islands. Cannot survive in presence of Brown Rats *Rattus norvegicus*, feral cats, Wekas *Gallirallus australis* or dogs.

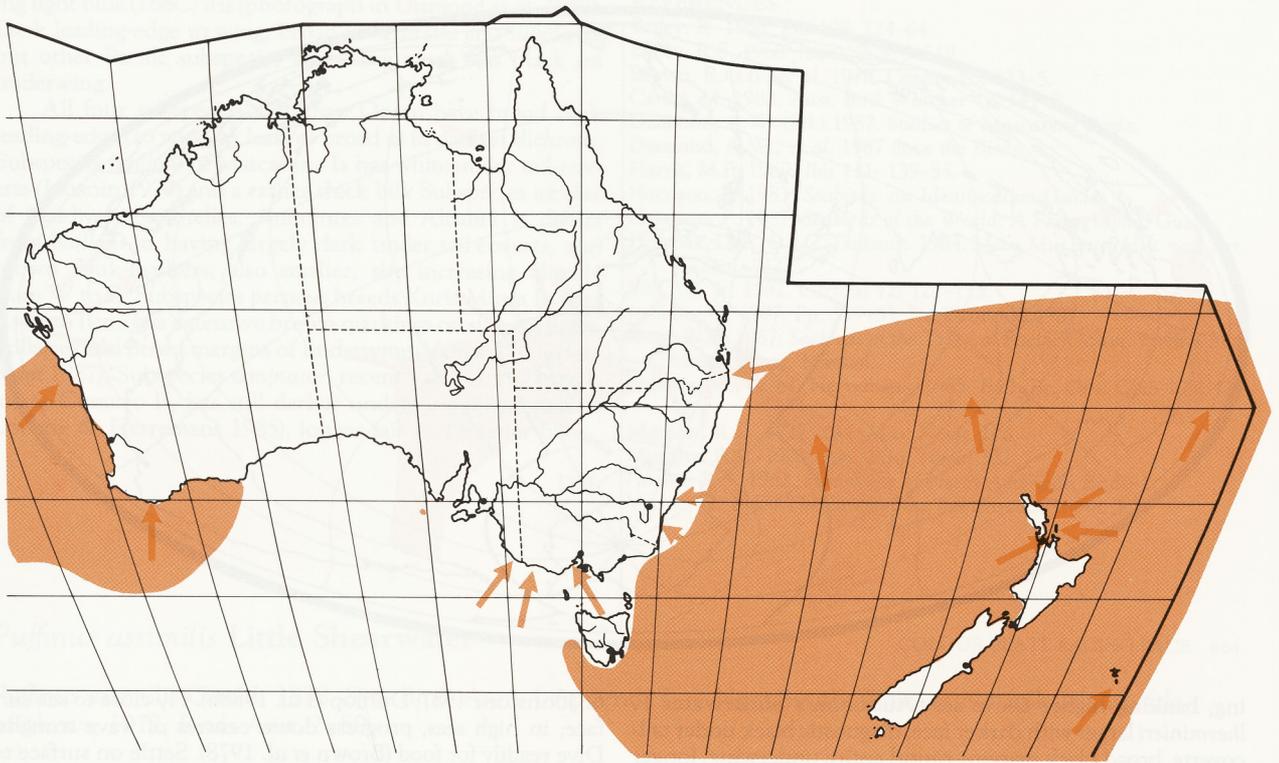
DISTRIBUTION AND POPULATION S. Indian, Pacific and Atlantic Oceans, generally N of Antarctic Convergence and reaching n. hemisphere (c. 40°N) in Atlantic Ocean.

Distribution, circumpolar. Reasonably common in seas off sw. Aust., Kermadec Is and far se. NZ (Bounty to Antipodes and Auckland Is); less common elsewhere in our region as most subspecies appear to be sedentary, remaining in seas adjacent to breeding colonies (M.J. Imber), though birds occurring off w. NI, NZ, probably from Kermadec Is (M.J. Imber).

BREEDING Summarized below. In our region, on islands off sw. Aust., Lord Howe, Norfolk and Kermadec Is, islands off ne. coast of NI, NZ, and Chatham and Antipodes Is.

AUST. (from *Seabird Islands Series*, Corella, unless indicated)

Bellinger I.	1986	150	
Eclipse I.	1938-73	<2000	(Fullagar & van Tets 1976)
Hood I.	1977	100s	
Inshore I.	1986	20	
MacKenzie I.	1981	28 nests	
Penguin I.	1982-present	10-20	
Saint Alouarn I.	1976	50	
S. Fisherman I.	1961	but not since	



HASB also list, without details: Recherche Arch. (Combe, Wedge, Lion, Boxer Is), Saddle I., Rottnest I. (Parakeet I.), islands between Fremantle and Dongara (Buller, Whittell, Green, Cervantes, Escape, Favourite Is) and Abrolhos Grp (Pelsart, Rat, Wooded, Morley, Suomi, West Wallaby Is).

NZ

NI

Stephenson I.
Cavalli Is
Poor Knights Is
Hen & Chickens Grp: Lady Alice I. (few hundred pairs; M.J. Imber), Coppermine I., Hen I., possibly Whatupuke
Mokohinau Grp
Mercury Is: Red Mercury, Green, Double, Middle, Korapuki, and possibly Kawitihu

Ohena Is

KERMADEC IS

Raoul I. (Oliver); doubtful (M.J. Imber)
Herald Grp
Macauley I.: several hundred pairs (Tennyson *et al.* 1989)
Curtis I. (c. 100 000 pairs) (A.J.D. Tennyson; G.A. Taylor).

NORFOLK I.

Philip I.: 100-1000 pairs (Schodde *et al.* 1983)
Nepean I.: offshore stacks

LORD HOWE I.: 4000 pairs (Fullagar *et al.* 1974)

Roach I.: offshore stacks, islets

CHATHAM IS

Star Keys: 100+ pairs (M.J. Imber)
Little Mangere: rare, assumed to breed there (J.A.D. Flack).

ANTIPODES IS: not on main island; on nearly all others (M.J. Imber).

Extralimittally, breed Gough I. (Swales 1965), Tristan da Cunha Grp (Fraser *et al.* 1988) and islands of North Atlantic (BWP) Rapa I., Austral Grp (Holyoak & Thibault 1984) and La Quille, Ile St Paul (Tollu 1984).

Status, stable but few accurate data on original breeding

distribution. Breeding colonies on Raoul (Kermadec Is), Norfolk, Lord Howe, Chatham Is and elsewhere have probably been wiped out; now mostly on small and lesser islands of these groups. Introduced predators and humans have affected breeding distribution; can survive, probably in reduced numbers, in presence of Polynesian Rats *Rattus exulans*.

MOVEMENTS

Most races considered virtually sedentary, being present at breeding colonies for 10 months of year, except for *elegans*, some of which probably migrate from Antipodes Is to Chilean coast in non-breeding season (Imber 1983).

DEPARTURE Near NZ (Falla 1934) and off sw. Aust. (Glauert 1946) a winter breeder, young fledging late Oct.-early Nov. but at Antipodes Is, young fledge late Dec.-mid Feb. and possibly later at Gough I. (Imber 1983, *contra* Swales 1965). Though at least some adults present in burrows in daytime soon after young have fledged at Hen and Chicken Grp, NZ, in late Oct.-early Nov., none recorded after late Nov. (Dunnett 1984).

NON-BREEDING After breeding most birds probably stay near breeding colonies but collections from Chilean coast (Murphy 1927; Jehl 1973) and sightings between 50°S, 155°W and 48°S, 94°W in mid-Apr. (Clark 1988) suggest at least part of Antipodes Is population moves there in winter (Imber 1983). Observations Nov.-Feb. of either *tunneyi* or *assimilis* in Tas. and Vic. waters (D.W. Eades) probably of pre-breeding birds. Records of *tunneyi* and *elegans* from coast of South Africa show no seasonal trends and may also be pre-breeders (Sinclair *et al.* 1982).

RETURN Recorded in nesting burrows at Eclipse I., sw. Aust. during Jan. (Glauert 1946), at Gough I., early Apr. (Imber 1983); at islands near NZ, Apr. (Falla 1934); at Norfolk I., Apr.-May (Hermes *et al.* 1986). Collections of *tunneyi* from

SA in Aug. (Parker & May 1982) and Vic. in May (Smith *et al.* 1974) suggest much local movement may also occur during breeding season.

FOOD Cephalopods, krill and small fish in unknown proportions. **BEHAVIOUR.** Food captured principally by surface-diving, pursuit-plunging (Harper *et al.* 1985) and pursuit-diving (Brown *et al.* 1978); also by surface-seizing and surface-plunging (M.J. Imber). Before surface-seizing, sometimes peer under water (D.W. Eades). Once seen associated with dolphins (Enticott 1986). Appear to be diurnal, birds returning to feed their chicks at night (Glauert 1946).

BREEDING, NON-BREEDING An adult from Gough I. contained juvenile cephalopods (Ommastrephidae, *Todarodes*; Imber 1983); chick from Bollons I., Antipodes Is, contained euphausiids and small cephalopods (*Nototodarus* juveniles; Imber 1983); birds from round NZ contained small cephalopods, minute crustaceans (Falla 1934), young *Argonauta* octopods and small fish (M.J. Imber); off sw. Aust., small cephalopods and shoal fish (HASB); off Chile, fish Stomiidae (25–40 mm) and possibly jellyfish (Jehl 1973).

SOCIAL ORGANIZATION Dispersion varies: solitary, in pairs, rarely in flocks. Some subspecies (e.g. *elegans*) more liable to flock. Flock more in waters round colony. Disperse at sea after breeding but, like other non-migratory petrels, later pay nocturnal visits to nesting places well before next breeding season. Warham (1955) recorded shearwaters on Eclipse I. for 10 months of year, being plentiful and noisy at night at least 4 months before laying. Do not usually associate with other species when feeding (M.J. Imber).

BONDS Monogamous; probably long-term. Both parents incubate and tend young until several days before fledging.

BREEDING DISPERSION Colonial, loose to dense colonies depending on size of population and subspecies. Nest close together in large colonies where soil suitable for tunnelling, but more scattered on rocky ground; no measures of nest densities. Defend nest site (i.e. burrow) only, for up to four months before laying.

ROOSTING Rest and sleep in or near burrow when ashore; otherwise on sea. Observed resting and preening during day, sleeping at night.

SOCIAL BEHAVIOUR Based mainly on Warham (1955, 1958). Arrive at colony after dusk, depart before dawn. Chases, with much calling, occur between opposite sexes over colony while in flight; shown mainly by younger pre-breeding birds. Differ from incoming flights of birds locating burrows, when several trial passes made, then wings fluttered through small angle before bird stalls and falls to ground.

AGONISTIC BEHAVIOUR Birds of unknown sex observed fighting at night for possession of burrow. Warham (1958) records individual holding wing of another partly within tunnel entrance and accompanied by growling by both birds; attacked bird eventually staggered away, leaving attacker free to enter burrow. Some attack human intruders by jabbing with bill and lifting half-open wings from body, whereas others docile when handled. Between breeding seasons, silent in burrow during day, but may call if observer ventures close to burrow. At night, birds heard and seen calling, either in groups of two or more on ground or as lone individuals in trees. On Eclipse I., pairs or trios observed displaying (Warham 1958); on Cape Verde Is, up to seven

observed displaying on mounds (Bourne 1955).

SEXUAL BEHAVIOUR Allopreening and Bill-fencing observed in pairs or groups of displaying birds; may lead to copulation, but no evidence. **ALLOPREENING**, usually of head and neck, unilateral, reciprocal or simultaneous and interspersed with duetting by pair. Usually accompanied by higher-pitched calling from flying birds. Mutual displays performed throughout year, but most intensive between breeding periods. **Duetting.** Birds arch nape, throats swollen and bills lowered slightly. Observed duetting outside or at entrance to burrows; occurs at change-over at nest (Warham 1955).

RELATIONS WITHIN FAMILY GROUP Chick fed often by both parents in first few days after hatching, often at night; later abandoned by day. Chick begs for food by *chirruping* and jabbing bill at parent's head. Adults preen chicks' head, leading to mutual Bill-fencing with chick still calling vigorously, and eventually feeding in silence during which chick beats wings. Feeding bouts occur soon after parent arrives at burrow, last c. 30 min, after which parent and chick sleep. Parents observed duetting after one had fed chick.

VOICE Not studied in detail. Information from Eclipse I., S of Albany, WA (Glauert 1946; Warham 1955) and observations from Lady Alice I., Star Keys, Chatham Is and Gough I. by M.J. Imber. Apparently silent at sea; noisy at colonies at night though less so after laying; occasional calls from burrows during day (Warham 1955). Birds call in flight and from ground. Varying, generally loud and rather harsh calls; similar to those of congeners, but higher pitched; particularly in *P.a. elegans* and apparently in *P.a. haurakiensis* (M.J. Imber). Birds call only at breeding colonies; particularly when returning after sunset (Glauert 1946) or just before dawn (M.J. Imber). Level of noisiness varies with moonlight; very vocal on moonless nights, reported to call continuously in flight, other birds responding from ground; can be silent on clear moonlit nights (Glauert 1946). Breed, and thus call, mainly during winter; in WA, from late Jan. to late Oct. (Glauert 1946; Warham 1955). **DUETS.** At Eclipse I., pairs observed Duetting at change-over at nest, outside or in entrance to burrows, both birds using Main Call; observations were made during nestling period (Warham 1955). No sexual differences noted. No information on individual differences or geographical variation. No reports of non-vocal sounds.

ADULT Main Call. At Eclipse I.: hoarse, asthmatic *wah-i-wah-i-wah-ooo* (sonagram A) repeated several times; first syllable given on exhalation, others during inhalation, then



A P.J. Fullagar; Eclipse I., WA, Aug. 1973; B791

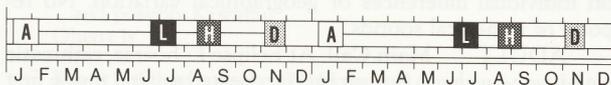
repeated; call splutters to end (Warham 1955). Given in flight above colonies and from ground, in burrows and from surface (Glauert 1946; Warham 1955). Aerial calls consisted of series of high-pitched notes, almost whistles, in closely repeated sets

of 3-4 syllables (M.J. Imber). Most often heard during pre-laying period; reported occasionally during feeding of young (Warham 1955). Probably functions in advertising, mate-attraction and courtship (Warham 1955; M.J. Imber). Duetting, using this call, reported during nestling period: at change-over at nest, outside or in entrance to burrows (Warham 1955). Main Call probably same as *cackles* described by Glauert (1946) given by birds greeting each other at nest. Glauert (1946) also quotes call at change-over as 'a quiet sound, like the call of a male dove parading around his lady, though more throaty'. **Growl.** In WA, raucous growls accompany fighting or when handled. Probably functions as threat call. Reported given sometimes during feeding of young (Warham 1955).

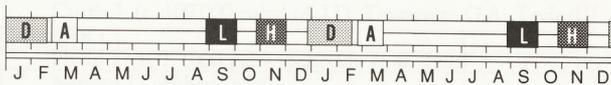
YOUNG Chicks give repeated *chittering* or liquid *chirrup*s when parent arrives at nest, when begging and when Bill-fencing with parent (Warham 1955). Parent feeds young and cycle repeated.

BREEDING Poorly known. Information in Glauert (1946), Warham (1955), Imber (1983) and Oliver. Breed colonially, on rocky or forested islands or on those with tussock grasslands. In NZ sometimes associated with Pycroft's Petrel *Pterodroma pycrofti* with some competition for burrows; also sometimes with Tuataras *Sphenodon punctatus*.

SEASON Birds at colonies for almost whole year. Soon after leaving at end of breeding, visit colonies again, which is probably related only indirectly to main breeding activity between May-June and Nov.-Jan. Thus, in WA, return to colonies in early Jan. (Glauert 1946); in Antipodes Is, from late Feb. (Warham & Bell 1979) but real preparation for breeding not until July (M.J. Imber). On Eclipse I., WA, earliest eggs 21-26 June (Glauert 1946), latest eggs probably about mid-July and exceptionally till Sept. On Raoul I., Kermadec Is, laying from about 10 June to mid- or late July (Oliver). In NI, NZ, early July to mid-Aug. (Oliver). In Chatham and Antipodes Is, end Aug. to early Oct. (Imber 1983). No determination of pre-laying exodus. Departure of young: in WA, during Nov. (Glauert 1946); on Kermadec Is, mid Oct.-c. 7 Dec. (Merton 1970); in NI, NZ, mid-Nov.-end Dec.; on Chatham and Antipodes Is, late Dec.-mid-Feb. (Imber 1983).



a) sw. Aust.



b) Antipodes I.

SITE On slopes of islands, in rocky, stony and sandy areas and in areas of tussock grass, under forest and coastal scrub. In burrows, crevices and cavities between rocks and wherever there is enough soil or sand (Glauert 1946; M.J. Imber). No information on measurements or density of burrows except length, 0.3-2.0 m and not deep, often in rather shallow soil (M.J. Imber). Same burrows used year after year; may be shared with Pycroft's and Black-winged *Pterodroma nigripennis* Petrels in NZ colonies and with skinks *Egernia kingii* in WA. No further details.

NEST, MATERIALS No information. Egg in nest-

chamber at end of burrow. Excavated at night; role of sexes not known.

EGG Elongated to short oval, varying in shape; smooth textured, not glossy; white.

MEASUREMENTS:

WA 52.3 (49-56; 10) x 35.6 (34-37) (HASB);

Raoul I. 53.7 (51-56; 3) x 36.3 (34.5-37.5) (Oliver);

NI, NZ 54.4 (52.8-56.5; 3) x 37.6 (37-38.3) (Oliver).

CLUTCH-SIZE One.

LAYING No data. No replacement laying.

INCUBATION By both sexes, perhaps relieving one another about every second day (Glauert 1946). **INCUBATION PERIOD:** determined in WA 52-58 days (n=4; Glauert 1946). Eggshells trampled in nest.

YOUNG Semi-altricial, nidicolous. No description of protoptile. In NI, NZ, mesoptile grey to dark grey with band of white from throat to wide patch of white on abdomen (M.J. Imber). In WA chicks have dark-grey bill; front of legs and webs, grey-blue; sides of legs and toes, grey (HASB). **NESTLING PERIOD:** 70-75 days without further details (Glauert 1946). No information on growth. Brooding, guarding by parents not observed or recorded but guarding said to occur for 'a few days' (HASB). Both parents feed chick, by incomplete regurgitation; perhaps normally every second night, parents coming to burrow singly or together, for first two weeks after hatching; then only once or twice in every five nights (Glauert 1946); this needs confirming with more precise observations, as does possibility of desertion of chick by parents before fledging, which Glauert claimed was for a period of 8-10 days.

FLEDGING TO MATURITY Chicks leave at night, fully able to fly and independent of parents. No data on age of first pairing or breeding.

SUCCESS No information. **PREDATORS.** In WA, skinks may take eggs and small chicks. On Raoul I., feral cats and rats *Rattus norvegicus*, *R. exulans* are exterminating colonies. In most NZ colonies, some predation of eggs and chicks by *R. exulans*, which probably limits size of some colonies, e.g. on Chikens Is (M.J. Imber). On all islands S of NZ, skuas *Catharacta* spp kill adults and sometimes dig out chicks (Imber 1983; M.J. Imber). Formerly some colonies, especially in NI, NZ, have been affected by agricultural activity and burning.

PLUMAGES Subspecies *kermadecensis*.

ADULT Definitive basic. Age of first breeding unknown. **HEAD AND NECK.** Top of head, and hindneck, grey-black (82); feathers of crown develop narrow brown (119C) tips with wear. Junction of dark forehead and white lores runs above eye towards junction of nostrils and latericorin. Occasional dark-grey (83) mottling under eye. Short supercilium and area of ear-coverts, white, usually with dark-grey (83) wash or smudged streaks, least distinct on crescent behind ear coverts; feathers, white with dark-grey (83) rosethorns. Chin and throat, white. **UPPERPARTS,** grey-black (82), said to get slightly browner with wear (Fleming & Serventy 1943). Some birds have narrow white tips to feathers of upperparts; rapidly lost with wear. Feathers have grey wash when very fresh; lost before breeding season. **TAIL,** grey-black (82) above. **UPPERWING,** mostly blackish (82). Primaries have broad concealed white inner edges. Secondary coverts have narrow white tips and remiges have grey gloss. Remiges, especially tips of primaries and outer webs of inner secondaries, develop brown (119A) tinge with wear. **UNDERPARTS,** mostly white, dark grey

(83) or mottled dark-grey (83) at extreme sides of upper breast where feathers white with dark-grey (83) tips. Most axillaries white; those closest to wing have small varying grey (84) markings at centre and tip. Darkest axillaries of some birds have large bold oblong marking on upper web. Small dark-grey (83) pre-axillary notch. Grey-black feathers of rump often cover thighs. TAIL, grey-black (82) with grey (84) gloss. UNDERWING. Remiges, blackish (82); primaries and outer secondaries have broad white inner edges. Coverts mostly white but dark leading-edge formed by dark-grey (83) to grey-black (82) marginal coverts, outermost primary lesser coverts, median covert and primary coverts; these feathers have white tips.

DOWNY YOUNG Protoptile: no information for subspecies *kermadecensis*. In subspecies *haurakiensis*, light grey with white throat, breast and abdomen (Falla 1934). In subspecies *baroli* upperparts grey with brown wash, down shorter on underparts grading to white in middle, with narrow grey-brown patch on vent (BWP). Mesoptile: crown and neck, dark grey (83). Upperparts, uniform grey (84). Underparts mostly light grey (brownish 85); in most birds abdomen white and white stripe runs along centre of breast from abdomen to lower throat.

JUVENILE Similar to adults but, before birds leave breeding grounds, upperparts and feathers of wing have slaty (c87) bloom, strongest in mantle and hindneck. No grey bloom on blackish fringes of longer scapulars but strong bloom in centre of feather; grey bloom lost with wear. In *elegans*, contour feathers of upper surface show many white tips (M.J. Imber).

BARE PARTS Based on photos from Lindsey (1986) and unpublished (A.J.D. Tennyson).

ADULT, JUVENILE Iris, black-brown (c119). Eyering, narrow dark grey (83). Bill, grey-black (82), often merging to dark grey-blue base. Latericorn and ramicorn sometimes grey (84). In *elegans* latericorn and mandibular rami, blue-grey (Warham & Bell 1979). Ungues sometimes have pale-grey (86) markings at base. Tarsus and feet mostly blue (168B). Outer toe, claws, underside of all toes, hind and outer edge of tarsus, black (89). Webs, pink (7) to light brownish pink (light 5) with varying amounts of blue (168B) at sides of toes. Cream webs also reported in *tunneyi* (HLW; WAM); yellowish flesh and yellowish white in *haurakiensis* and *kermadecensis* respectively (NMNZ).

DOWNY YOUNG Iris, black-brown. Bill, grey-black (82). In *tunneyi*, upper parts of legs and webs, grey-blue, sides of legs and toes, dark grey (Warham 1955).

MOULT

ADULT POST-BREEDING Pre-basic. Complete. Primaries outwards. In *tunneyi* and *assimilis*, moult, apparently at sea, shortly after leaving chicks. Similar strategy found in better known *baroli* (Mayaud 1931; Jouanin 1964; BWP). In *tunneyi*, most moult probably occurs Nov.-Dec., because small sample of adults (unknown status) collected Jan.-Oct. show no moult. Specimen of *assimilis* collected Nov. had primary moult N⁸⁴1¹. No direct information on moult of adult *haurakiensis* and *kermadecensis*, but no moult recorded in breeding season, when wear of primaries similar to that of breeding *tunneyi* and *assimilis*. No information on *elegans* in NZ region. At Gough I. and Tristan da Cunha, heavy moult of adults, including body, observed Mar.-Apr. Complete wing-moult said to occur Nov.-Dec. (Watson 1975) but probably pre-breeders.

POST-JUVENILE, SUBSEQUENT PRE-BASIC MOULTS No direct information. Influx of birds to breeding grounds shortly after breeding completed recorded in *tunneyi* (Glauert 1946), *haurakiensis* (Dunnet 1984), *baroli* (Jouanin 1964), probably *assimilis* (AM; HLW) and *elegans* (Imber 1983). These include birds with no moult or indications of recent moult, which suggests that timing differs from adults.

MEASUREMENTS (1) *P.a. tunneyi* from WA breeding grounds and beaches, *assimilis* from Lord Howe I., other races from breeding colonies, juveniles excluded, skins; BD MIN = minimum bill depth at culminicorn, BILL D = bill depth at junction of culmen and forehead feathers, BILL W = bill width at base of latericorn. (*tunneyi*: WAM, HLW; *assimilis*: AM, HLW; other races: NMNZ; measured by D.I. Rogers). (2) *P.a. tunneyi* sample includes WA birds, breeding birds, skins, some beachcast birds in *P.a. tunneyi* sample; BILL W and BILL D as above, other methods unknown (Fleming & Serventy 1943). (3) Breeding grounds, juveniles excluded, recently dead (NMNZ). (4) Kermadec Is, adults of unknown status, live and recently dead; minimum chord, other measurements as above (A.J.D. Tennyson & G.A. Taylor). (5) Mercury Grp, adults of unknown status, live; methods as for source (4). (6) Antipodes Is, live; flattened chord (Warham & Bell 1979). (7) Samples as for source (6), skins; methods as for source (6) (Warham & Bell 1979). (8) Tristan da Cunha, live (Fraser *et al.* 1988). (9) Gough I., live; methods unknown (Swales 1965). (10) Skins (BWP). (11) Great Salvage I., live; minimum chord (Robertson & James 1988). Other measurements in Jehl (1973).

Subspecies *tunneyi*

	MALES	FEMALES
WING	(1) 177.7 (2.16; 176-182; 6)	174.6 (2.78; 171-179; 8)
8TH P	(1) 114.3 (3.20; 111-118; 6)	112.1 (2.09; 110-116; 8)
TAIL	(1) 67.3 (2.07; 65-70; 6)	65.5 (2.34; 62-68; 8)
BILL	(1) 23.7 (0.79; 22.6-25.0; 6)	23.5 (0.84; 21.9-24.6; 8)
BD MIN	(1) 5.97 (0.532; 5.1-6.5; 6)	5.33 (0.337; 4.9-5.8; 7)
BILL W	(1) 9.40 (0.938; 8.0-10.3; 5)	8.64 (1.91; 7.6-11.2; 8)
TARSUS	(1) 37.5 (0.57; 36.8-38.4; 6)	36.7 (1.08; 34.8-38.6; 8)
TOE	(1) 42.6 (1.15; 41.2-44.4; 5)	42.3 (1.79; 40.1-45.8; 6)

UNSEXED

WING	(2) 173.5 (3.44; 169-184; 26)
TAIL	(2) 65.7 (2.18; 62-69; 31)
BILL	(2) 23.7 (0.95; 21.9-25.5; 25)
TARSUS	(2) 36.2 (1.36; 34-39; 31)
TOE	(2) 43.1 (1.61; 40-46; 25)

Subspecies *kermadecensis*

	MALES	FEMALES
WING	(3) 192.8 (2.49; 189-195; 4)	190.3 (3.44; 185-194.5; 4)
8TH P	(1) 120.0 (3.37; 116-125; 6)	115.7 (4.97; 109-121; 4)
TAIL	(3) 70.0 (1.66; 68.5-72.5; 4)	70.0 (0.61; 69.5-71; 4)
BILL	(3) 25.6 (0.51; 25-26.4; 4)	26.0 (0.85; 25.2-27.3; 4)
BILL D	(1) 8.4 (0.3; 8.0-8.8; 6)	8.4 (0.4; 8.0-9.0; 4)

BD MIN	(1)	6.18 (0.04; 6.1-6.2; 4)	5.58 (0.19; 5.3-5.8; 4)
BILL W	(3)	9.80 (1.21; 8.0-11.4; 4)	9.70 (0.37; 9.1-10.1; 4)
TARSUS	(3)	40.2 (1.04; 39.1-41.6; 4)	40.4 (1.25; 39.6-42.1; 4)
TOE	(3)	44.6 (0.98; 43.6-45.6; 4)	43.3 (0.74; 42.2-44.0; 4)

Subspecies *kermadecensis*. Unsexed birds.

UNSEXED

WING	(2)	189.9 (5.22; 180-195; 8)
	(4)	187.7 (3.20; 184-195; 9)
TAIL	(2)	68.5 (2.00; 66-71; 8)
	(4)	67.2 (2.47; 62.6-71.3; 9)
BILL	(2)	25.3 (0.71; 24-26; 8)
	(4)	24.9 (0.74; 24-26.4; 8)
BILL D	(2)	8.00 (0.38; 7.5-8.5; 8)
	(4)	8.59 (0.52; 7.8-9.1; 7)
BILL W	(2)	8.48 (0.38; 8.0-9.0; 8)
	(4)	8.03 (0.48; 7.5-8.7; 7)
TARSUS	(2)	39.9 (0.83; 39-41; 8)
	(4)	39.6 (0.93; 38.5-41.4; 9)
TOE	(2)	44.0 (1.69; 42-47; 8)
	(4)	45.7 (1.12; 43.7-47.8; 9)

Subspecies *baroli*

MALES

FEMALES

WING	(10)	184 (4.93; 176-190; 7)	179 (5.01; 170-185; 6)
	(11)	177.5 (2.5; 174-180; 4)	178.6 (6.4; 175-186; 3)
TAIL	(11)	76.3 (2.5; 74-79; 3)	71.4 (5.8; 63-78; 5)
BILL	(10)	26.1 (0.97; 24-28; 8)	25.0 (0.55; 24-26; 6)
	(11)	25.3 (0.94; 23.7-26.7; 24)	25.1 (0.66; 23.7-26.3; 17)
BILL D	(11)	9.2 (0.39; 8.4-9.8; 24)	8.8 (0.21; 8.5-9.2; 17)
TARSUS	(11)	36.8 (1.06; 34.7-39.0; 24)	36.1 (0.73; 34.4-37.0; 17)

Subspecies *baroli*. Unsexed birds.

UNSEXED

TAIL	(10)	71.8 (3.66; 67-78; 14)
TARSUS	(10)	37.2 (1.12; 36-39; 14)
TOE	(10)	40.9 (1.80; 37-44; 12)

Nominate *assimilis*. Unsexed birds.

UNSEXED

WING	(1)	181.7 (8.08; 173-189; 3)
	(2)	182.6 (4.88; 174-186; 5)
8TH P	(1)	111.5 (7.33; 103-119; 4)
TAIL	(1)	64.8 (5.56; 59-70; 4)
	(2)	69.0 (1.87; 66-71; 5)
BILL	(1)	23.4 (0.45; 22.9-23.8; 4)
	(2)	23.3 (0.89; 22.0-24.3; 5)
BD MIN	(1)	5.13 (0.46; 4.8-5.9; 4)
BILL W	(1)	8.55 (0.70; 7.4-9.1; 4)
TARSUS	(1)	37.0 (1.44; 35.1-38.2; 4)
	(2)	35.8 (0.84; 35-37; 5)
TOE	(2)	43.4 (0.89; 42-44; 5)

Subspecies *aurakiensis*. Unsexed birds.

UNSEXED

WING	(2)	192.1 (5.81; 181-200; 16)
	(5)	192.6 (3.86; 186-201; 19)
8TH P	(1)	121.4 (2.88; 117-126; 8)
TAIL	(2)	69.3 (3.05; 63-72; 16)
	(5)	69.0 (2.49; 65.0-73.2; 19)
BILL	(2)	26.4 (1.45; 23-29; 16)
	(5)	25.8 (0.71; 24.6-27.1; 19)
BILL D	(1)	8.69 (0.63; 8.2-9.4; 7)
	(2)	8.47 (0.43; 8.0-9.0; 16)
	(5)	8.96 (0.30; 8.4-9.4; 8)
BD MIN	(1)	6.07 (0.33; 5.5-6.4; 6)
BILL W	(2)	9.13 (0.39; 8.5-10; 16)
	(5)	8.34 (0.26; 7.9-8.8; 8)
TARSUS	(2)	40.9 (1.0; 40-43; 16)
	(5)	40.5 (0.97; 38.7-42.6; 19)
TOE	(2)	44.6 (0.89; 43-46; 16)
	(5)	46.4 (0.96; 44.4-48.0; 18)

Subspecies *elegans*. Unsexed birds.

UNSEXED

WING	(1)	188.0 (3.32; 182-192; 6)
	(3)	187.6 (7.88; 170-197; 7)
	(6)	187.6 (2.5; 183-190; 5)
	(7)	184.4 (3.3; 5)
	(8)	186.2 (5.0; 180-190; 5)
	(9)	190.5 (1.12; 158-203; 94)
8TH P	(1)	113.5 (2.00; 112-118; 8)
TAIL	(1)	68.5 (0.50; 68-69; 2)
	(3)	66.9 (3.53; 61-71; 5)
	(6)	71.0 (0.9; 70-72; 5)
	(7)	70.0 (0.6; 5)
	(8)	69.2 (3.4; 63-73; 10)
	(9)	67.9 (3.12; 59-79; 94)
BILL	(1)	24.5 (0.85; 23.6-26.0; 7)
	(6)	24.5 (1.0; 23.0-26.0; 5)
	(7)	24.9 (0.7; 5)
	(8)	26.9 (1.8; 25.5-32.0; 11)
	(9)	26.2 (1.13; 23-28; 94)
BILL D	(8)	9.9 (0.4; 9.5-10.5; 11)
	(9)	9.54 (0.58; 8-11; 94)
BD MIN	(1)	6.59 (0.59; 5.8-7.5; 8)
	(8)	7.3 (0.6; 6.0-8.0; 11)
BILL W	(3)	11.5 (0.05; 11.4-11.5; 2)
	(8)	9.8 (0.5; 9.0-10.5; 11)
TARSUS	(1)	40.1 (0.62; 39.4-40.7; 5)
	(3)	40.5 (1.12; 39.2-42.2; 8)
	(6)	39.8 (1.1; 38.5-41.0; 5)
	(7)	39.6 (1.1; 5)
	(8)	39.3 (1.6; 37.5-40.5; 11)
	(9)	35.8 (1.28; 33-40; 94)
TOE	(1)	47.7 (1.68; 45.6-49.8; 5)
	(3)	48.1 (1.27; 46-50; 9)
	(6)	50.7 (1.5; 49.0-53.0)
	(7)	48.1 (2.2; 5)
	(8)	46.7 (2.8; 41-50; 11)
	(9)	48.9 (2.0; 44-55; 94)

Differences between sexes significant for BD MIN of *kermadecensis* and *tunneyi*, BILL D and tarsus of *baroli*. Bill of

juveniles noticeably more slender than those of adults; in unsexed *kermadecensis* juvenile skins (NMNZ), BILL D 7.52 (0.545; 6.8–8.0; 5), BD MIN 4.76 (0.416; 4.3–5.2; 5). Unknown when bill stops growing.

WEIGHTS Subspecies *kermadecensis*: fat to very fat adults at Kermadecs, 2 Sept.: 176.5 (15.07; 160–202.7; 6; NMNZ); from 15 to 20 Sept., adults of unknown status: 174.4 (21.9; 154–207.5; 6; A.J.D. Tennyson & G.A. Taylor); NI beachcasts: 101.8 (16.61; 85.5–123; 4; NMNZ).

Subspecies *haurakiensis* at breeding colonies: 218.9 (13.46; 191–242; 19; A.J.D. Tennyson, G.A. Taylor).

Subspecies *elegans* adults from Antipodes Is in Feb.: 238.4 (12.46; 226–256; 5; NMNZ); one bird in Dec.: 266. At Gough I.: 226 (170–275; 91; Swales 1965). No useful data for *tunneyi* or *assimilis*. Other weights for extralimital subspecies in Fraser *et al.* (1988) and Robertson & James (1988).

STRUCTURE Subspecies *kermadecensis*. Eleven primaries, p11 minute, p10 longest, p9 0–6, p8 5–11, p7 20–23, p6 32–36, p5 43–49, p4 56–61, p3 67–75, p2 82–88, p1 93–99. Tail, slightly rounded. Bill, small and slender (see also Geographical Variation). Nasal tubes, one-third to one-quarter length of bill; oval nostrils separated by broad septum, point forwards, open upwards. Maxillary unguis and nares only emerge slightly over line of culminicorn. Tarsus slender, laterally compressed.

GEOGRAPHICAL VARIATION Subspecies *kermadecensis*, described above, breeds Kermadec Is. Plumages of subspecies *tunneyi*, *assimilis* and *haurakiensis* similar. Subspecies *tunneyi* breed islets off coast of sw. Aust.; smaller than all other subspecies except perhaps *assimilis*. Subspecies *assimilis* breeds Lord Howe and Norfolk Is; said to be larger than *tunneyi* and smaller than *kermadecensis* (Fleming & Serventy 1943); however, their samples of *assimilis* small; small sample measured by D.I. Rogers (see Measurements) does not differ significantly from *tunneyi*. Subspecies *haurakiensis* breeds islands in outer Hauraki Gulf, NI; slightly larger than *kermadecensis*, with significantly deeper and wider bill and longer wing (Fleming & Serventy 1943; A.J.D. Tennyson; G.A. Taylor; Measurements above). Axillary-patterns reported to differ between subspecies above. Range of variation in subspecies *kermadecensis* also found in *tunneyi* and *assimilis*. Pattern similar in subspecies *haurakiensis*, but darkest axillaries of some have more dark-grey marking on lower web than on upper web. White inner edges of primaries less clearly defined than in above subspecies (Fleming & Serventy 1943).

Subspecies *baroli* breeds e. Atlantic from Azores to Canary Is. Similar to *kermadecensis*, but white inner edges of primaries narrower, with fine grey sprinkling and mottling. Most birds have dusky wash on outer vanes of lateral under tail-coverts (Murphy 1927) and a few grey spots or streaks on flanks (BWP).

Subspecies *elegans* breeds Chatham and Antipodes Is, Tristan da Cunha and Gough I. Largest subspecies but with shorter wings, darker face and axillaries and often has white tips to feathers of upperparts. Shorter winged than *haurakiensis* and *kermadecensis*, but with more robust bill. Head darker than subspecies above; border of dark crown meets white face at or below level of eye. Lores mostly grey (84), save for white border to latericorn. Auricular region behind eye mostly grey (84) to dark grey (83) with a little white mottling; feathers grey (84) to dark grey (83) with narrow white tips.

Axillaries darker grey than in above subspecies; inner vane dark grey (83) with white bases, outer vane white with dark-grey flecking most intense near end, often with narrow white tip. All feathers of upperparts and upper wing-coverts have white tips when fresh, giving juveniles in first autumn distinctive scalloped appearance. White tips lost with wear. Jehl (1973) claimed that *elegans* from Chatham Is, Antipodes, and near Chiloe I. differed from other populations in having blue-grey cast to dorsum; perhaps this unusual statement based on failure to identify juveniles.

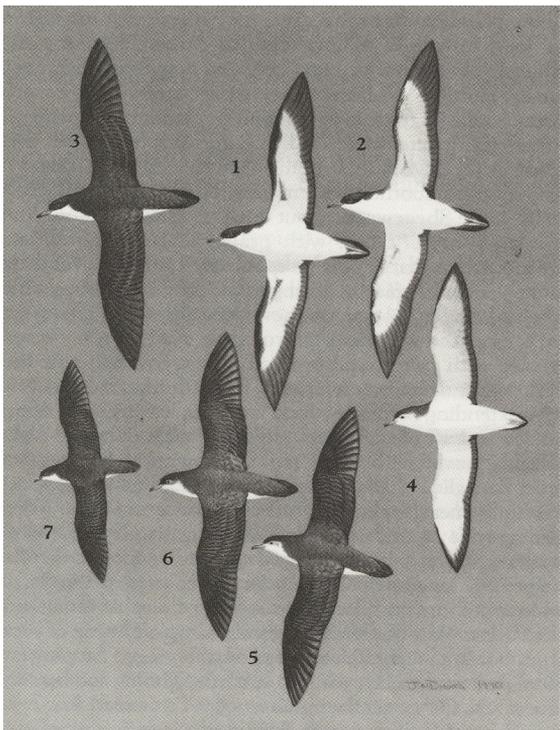
Subspecies *myrtae* known from one specimen from Rapa I. Similar to *elegans*, but apparently slightly larger, with disproportionately longer tail (Bourne 1959). Three birds collected at sea near Chiloe I. similar to *elegans* but with differences in bill shape; Jehl (1973) suggested they may be from population breeding on Chiloe I.

In the hand, *tunneyi* smaller than nominate *assimilis*, with shorter wings; the three NZ-breeding subspecies larger than *assimilis* and *tunneyi*, and have grey markings on axillaries (white in *assimilis* and *tunneyi*); *kermadecensis* has dark spots on axillaries and larger in bill, wing and tarsus; *haurakiensis* similar in size to *kermadecensis*, but longer-winged and usually has white-tipped greater upper wing-coverts forming thin band across upperwing.

DIR

REFERENCES

- Bourne, W.R.P. 1955. *Ibis* 97: 508–56.
 Bourne, W.R.P. 1959. *Emu* 59: 212–14.
 Brown, R.G.B., *et al.* 1978. *Condor* 80: 123–5.
 Clark, G. 1988. *The Totorore Voyage*.
 Dunlop, J.N., *et al.* 1988a. *Aust. J. mar. freshwat. Res.* 39: 661–9.
 Dunlop, J.N., *et al.* 1988b. *Corella* 12: 93–8.
 Dunnett, G.M. 1984. *Notornis* 31: 180–1.
 Edgar, A.T. 1962. *Notornis* 10: 1–15.
 Enticott, J.W. 1986. *S. Afr. J. Antarct. Res.* 16: 25–8.
 Falla, R.A. 1934. *Rec. Auck. Mus.* 1: 245–60.
 Fleming, C.A., & D.L. Serventy. 1943. *Emu* 43: 113–25.
 Fraser, M.W., *et al.* 1988. *Cormorant* 16: 7–33.
 Fullagar, P.J. 1978. *Corella* 2: 21–23.
 Fullagar, P.J., & G.F. van Tets. 1976. *West. Aust. Nat.* 13: 136–44.
 Fullagar, P.J., *et al.* 1974. Pp. 55–72. In: Recher & Clark 1974.
 Glauert, L. 1946. *Emu* 46: 187–92.
 Harper, P.C., *et al.* 1985. *BIOMASS Handbook* 24.
 Hermes, N., *et al.* 1986. *Notornis* 33: 141–9.
 Holyoak, D.T., & L.J.C. Thibault. 1984. *Mem. Mus. natn. Hist. nat., A, Zool.*, 123: 1–209.
 Imber, M.J. 1983. *Notornis* 30: 283–98.
 Jehl, J.R. 1973. *Auk* 90: 114–35.
 Jouanin, C. 1964. *Bol. Mus. Mun. Funchal* 18: 141–57.
 Lane, J.A.K. 1978. *Corella* 2: 36–37.
 Lindsey, T.R. 1986. *The Seabirds of Australia*.
 Mayaud, N. 1931. *Alauda* 3: 230–49.
 Merton, D.V. 1970. *Notornis* 17: 147–99.
 Murphy, R.C. 1927. *Am. Mus. Novit.* 276.
 Parker, S.A., & I.A. May. 1982. *S. Aust. Orn.* 28: 213–16.
 Recher, H.F., & G.S. Clark. 1974. *Envir. Study Lord Howe I. Rep. to Lord Howe I. Board, Sydney*.
 Robertson, H.A., & P.C. James. 1988. *Bull. Br. Orn. Club* 108: 79–Schodde, R., *et al.* 1983. *ANPWS Spec. Publ.* 8.
 Sinclair, J.C., *et al.* 1982. *Cormorant* 10: 19–26.
 Smith, F.T.H., *et al.* 1974. *Aust. Bird Watcher* 5: 187.
 Smith, L.A., & R.E. Johnstone. 1987. *Corella* 11: 95–6.
 Swales, M.K. 1965. *Ibis* 107: 17–42, 215–29.
 Tennyson, A.J.D., *et al.* 1989. *OSNZ News* 52: 4–5.
 Tollu, B. 1984. *Oiseau Revue fr. Orn.* 54: 79–85.
 Warham, J. 1955. *West. Aust. Nat.* 5: 31–9.
 Warham, J. 1958. *Br. Birds* 51: 393–7.
 Warham, J., & B.D. Bell. 1979. *Notornis* 26: 121–69.
 Watson, G.E. 1975. *Birds of the Antarctic and Sub-Antarctic*.



Volume 1 (Part A), Plate 49

Audubon's Shearwater *Puffinus lherminieri* Subspecies *dichrous*

1. Adult, typical, ventral
2. Adult, light, ventral
3. Adult, dorsal

Little Shearwater *Puffinus assimilis*

4. Adult, subspecies *assimilis*, ventral
5. Adult, subspecies *haurakiensis*, dorsal
6. Adult, subspecies *elegans*, dorsal, fresh
7. Adult, subspecies *elegans*, dorsal, worn

© Jeff Davies