# Order PROCELLARIIFORMES

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

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

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

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

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

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

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

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# Family PROCELLARIIDAE fulmars, petrels, prions, shearwaters

The family Procellariidae represents the main radiation of medium-sized 'true petrels', characterized by having united nostrils with a median septum and the outer functional primary at least as long as the next. It tends to be dominant among the birds of the Southern Ocean, though in the n. hemisphere the Charadriiformes are more numerous. The giant-petrels *Macronectes* have also developed as large scavengers and predators, showing some convergence in appearance and behaviour with the Diomedeidae. The Procellariidae may be divided into four main groups with some intermediate species, which makes it hard to draw distinctions between them.

(1) The fulmars *Macronectes, Fulmarus, Thalassoica, Daption* and *Pagodroma* consist of seven species of surface predators and filter-feeders of rather varying structure and appearance (Voous 1949) that breed in high latitudes but may migrate along cool currents into much lower ones. *Fulmarus* appears to have colonized the n. hemisphere in the Tertiary. Six of the seven species are essentially confined to our region.

(2) The gadfly-petrels *Pterodroma* are a large series of some 30 agile species; 16 breed in our region and another six occur rarely or rather rarely. Their short sturdy bills are adapted for seizing soft prey at the surface, and their twisted intestines, for digesting marine animals with an unusual biochemistry, which are also found throughout the warmer oceans (Imber 1985). They show complex markings of face and wings that must serve as interspecific recognition-marks (Murphy & Pennoyer 1952). Some species placed in this group have an intermediate structure and intergrade with all other groups distinguished here: *Pterodroma* (*Lugensa*) *brevirostris*, which moves S in winter, has distinctly big eyes like *Pagodroma*; *Halobaena caerulea* has a plumage similar to that of prions; *Bulweria* has some structural resemblance to shearwaters. At present it is difficult to determine their precise relationships.

(3) The prions *Pachyptila* are a specialized group of six (perhaps five) very numerous species, all in our region, that show a progressive adaptation of a small, agile, cryptically coloured, fulmarine form for filter-feeding on zooplankton. There has been dispute over their classification (Cox 1980; Harper 1980) but the arrangement discussed by Fleming (1941) seems best except that the Broad-billed Prion *P. vittata* appears to intergrade with Salvin's Prion *P. salvini* through *macgillivrayi* of Ile St Paul; so they may be better treated as subspecies of the same species.

(4) The shearwaters *Procellaria, Calonectris* and *Puffinus* include some 20 agile species with long bills adapted to catch prey more or less under water throughout the warmer seas (Kuroda 1954); 13 species breed in our region, some migrating into the n. hemisphere; six others are chance or perhaps regular visitors. From the fossil record (Brodkorb 1963; Olson 1975); they seem to have been particularly common in the great Tethys Ocean of the middle latitudes of the n. hemisphere in the Tertiary, so this development of aquatic habits may have occurred there without competition from penguins with a subsequent return S by the more successful forms.

General features of the family are: body, ovate, or elongate in shearwaters; wings, long and narrow, 11 primaries, p10 longest, p11 minute; 20–29 secondaries, short, diastataxic; tail, short, 12 feathers; bill, heavy (*Macronectes*), slender (shearwaters), broad (prions) or stubby (gadfly-petrels), hooked, formed of several horny plates; nostrils in dorsal tube of varying length; legs set far back, laterally flattened but round in gadfly-petrels; three toes, webbed, hind toe vestigial, raised. Oil-gland feathered. Peculiar musky odour. Sexes similar, male usually larger than female. Plumage, black or grey above, white below, or all dark; light and dark morphs in some species. Juveniles and immatures usually like adults.

Cosmopolitan throughout the oceans, essentially pelagic; more abundant in cool or cold waters rich in plankton and mostly away from ice. Swim well but usually aerial except when feeding or resting. Fly with alternate swooping and flapping action close to the surface but often arcing high in some gadfly-petrels. Gait on land, a shuffling crouch, being unable to walk properly with feet set so far back; generally avoid open areas on land, being thus vulnerable to predators. Nest colonially; for the most part in burrows and cavities in all sorts of terrain, sometimes far from the sea and in mountainous areas but some species, e.g. *Macronectes*, nest on open ground. Hole-nesters usually nocturnal at colonies, when often extremely vocal, though generally silent at sea. Migratory and dispersive. Some species divide the year between s. and n. hemisphere, often migrating in large flocks that may settle on the sea in huge dense rafts. Feed mostly on fish, cephalopods and crustaceans obtained by flight-feeding, plunge-diving, surface feeding, surface-diving and underwater pursuit; hydroplaning (Murphy) is a characteristic method used particularly by prions.

Probably all defend small nesting territories to which they return regularly while undisturbed; certainly so in some hole- and burrow-nesting forms. Agonistic and sexual behaviour of nocturnal, hole-nesting species very poorly known but generally seem to have little specialization for visual displays. Tactile actions such as allopreening and billing used but olfactory and vocal communication is probably important. Breeding is usually seasonal, generally with synchronized laying, often after a pre-laying exodus but some may not nest annually; some have shorter

cycles or nest continually. For the most part, little attempt to make substantial nests. Eggs, ovate, mat, white. Clutch-size, invariably one; single-brooded; no replacement laying. Incubation by both sexes in alternate spells of 1–11 days. Single median brood-patch. Incubation period, 45–55 days. Eggshells probably always trampled in nest. Young, semi-altricial, nidicolous; hatched in down. Rarely left alone in nest for first 1–2 weeks. Cared for and fed by incomplete regurgitation by both parents. Nestling period generally shorter in cliff- and ledge-nesting species than in hole-nesters. Young attain greatest weight, often well above that of adult, some days before fledging, by which time weight has been reduced to about the same as an adult, but no clear evidence that young are totally deserted for last few days in nest. Adults and young of most species liable to eject stomach-oil in defence. Young independent at fledging. Maturity reached at minimum of 3–4 years, in some 6–12 years.

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## *Puffinus gavia* Fluttering Shearwater

COLOUR PLATE FACING PAGE 657

*Procellaria gavia* J.R. Forster, 1844, *Lichtenstein's Descr. Anim. Itin. Mar. Aust. Terras*: 148 — Queen Charlotte Sound, New Zealand.

Newton & Gadow (*Dict. Birds*, 1896) say that *gavia* seems to be an Italian word signifying 'gull' though the derivation *gabbiano* is more commonly used. It has long been used in ornithology in several senses: as equivalent to *Larus* for unspecified waterbirds (J.R. Forster), for lapwings (Gloger), etc. It has been adopted as the generic name for species of loons or divers and is also used in the familial and ordinal forms. However, Forster named this shearwater *gavia* because according to Pliny (*lib.* 10, *cap.* 48) a bird of this name nested among rocks, as does this bird.

OTHER ENGLISH NAMES Brown-beaked or Forster's Petrel or Shearwater.

**Fluttering** refers to the hasty dashing flight of this species, with frequent wing-beats, which contrasts with the swooping gliding flight and fewer wing-beats of typical shearwaters.

MONOTYPIC

**FIELD IDENTIFICATION** Length 32–37 cm; wingspan 76 cm; weight 230–415 g. Small slender-billed shearwater with dark brown upperparts and white underparts; almost identical in size, shape and appearance to Hutton's Shearwater *P. huttoni*, which is, on average, slightly larger and longer-billed but differences discernible only with both together. Smaller than most shearwaters, though noticeably larger than Little Shearwater *P. assimilis*; similar size to Audubon's Shearwater *P. lherminieri* and noticeably smaller than Manx Shearwater *P. puffinus*. Head, small on long slender neck; wings appear short and narrow for body, compared to larger shearwaters; held nearly straight or slightly angled back from carpal. Tail, short and wedge-shaped; often spread when taking off or landing; tips of feet project noticeably beyond tip of tail. Appearance varies markedly with light conditions. Sexes alike. No seasonal plumage changes. Juvenile inseparable.

DESCRIPTION ADULT. Upperparts, greyish black; greater and median secondary coverts often fringed pale grey when fresh; white notch on either side of base of tail (formed

by white feathers of flanks overlapping lateral upper tail-coverts). Upperparts look brown in direct sunlight, grey when back lit and black in dull light; become browner with wear, even rusty brown when very worn. Underbody mostly white; dark of cap extends just below eye where sharply demarcated from clean white lower cheeks, chin and throat along nearly straight line from base of lower mandible to rear of ear-coverts. Dark of hindneck extends broadly downwards and forwards to form sloping half-collar of varying size and darkness; often hard to see, head appearing mainly white with narrow strip of dark along crown, or sometimes more obvious, giving hooded appearance. Rest of underbody, white except for small dark patch on thigh and dark grey rectrices, forming narrow dark rim round tip of tail. Underwing. Remiges, dark grey but reflective, forming narrow blackish trailing-edge and large dark tip, sharply demarcated from mainly white lining. Outerwing lining, white except for thin irregular dark leading-edge between carpal joint and base of outer primary. Area of dark on innerwing lining, varies. All have marginal coverts, greyish brown forming narrow dark leading-edge joining small greyish-black pre-axillary notch at base of wing. On palest birds, lesser coverts, mottled greyish brown, and combine with dark brown subhumerals to form narrow diagonal line across lining, from carpal joint to base of trailing-edge, which borders white triangle in wing-pit (outlined in front by dark leading-edge). On darkest birds, mottling on lesser coverts darker and more extensive, joining with subhumerals to give bolder diagonal line across lining; median subhumeral coverts, greyish brown, reducing area of clean white in wing-pit; general impression is of pale-centred dirty-brown triangle in wing-pit. Innerwing lining behind dark diagonal line, white. At distance or when strongly lit, underwing lining or whole underwing, can appear white. Bill, long and slender; dark slate-grey with varying purplish or cream base on lower mandible (which may include most of bill except for culmen and ungues). Iris, dark brown. Legs and feet, mainly fleshy-white.

SIMILAR SPECIES Almost identical with **Hutton's Shearwater**, which, though generally larger, overlaps with Fluttering in all dimensions. At sea, typical Hutton's appears slightly darker and blacker above; demarcation of dark cap and white of lower cheeks, chin and throat, more diffuse and collar typically broader and extending farther towards midline, giving distinctly hooded appearance regardless of light. Underwing of typical Hutton's differs by (1) darker wing-pit triangle with white restricted to small diffuse patch in centre; (2) greyish brown streaking on lesser primary coverts; and (3) grey greater coverts; these confine area of clear white on lining to narrow central stripe (even darkest Fluttering have larger and cleaner area of white on lining). In the field, certain identification exceptionally difficult (even when together) because great variation in Hutton's, effects of light on appearance of both and lack of objectively diagnostic features of Fluttering. When seen together, Hutton's may stand out by larger size, bigger head, bulkier body (broader across back), more pronounced collar and dirtier underwing lining; Hutton's rarely have underwing lining so unmarked as typical Fluttering though dark streaks on primary coverts often extremely difficult to see and effects of moult may increase area of white in wing-pit. For differences from vagrant **Manx Shearwaters** and **Audubon's Shearwaters**, *q.v.* At sea, **Little Shearwater**, smaller and blacker above, tending to fly with more rapid flickering wing-beats and shorter glides on proportionately shorter, broader and more rounded wings; no dusky half-collar; boundary between dark cap and white face passes above (not below) eye, leaving face clear white with dark eye prominent (though darker-faced subantarctic form of Little Shearwater *P.a. elegans* has black extending below eye); underwing lining, white, without dark markings in wing-pit; dark on wing-tip confined to narrow dark border, leaving bases of primaries, white (whole of primaries dark on Fluttering forming larger black wing-tip); feet, blue (not fleshy white).

Usually in inshore waters; spend much time on water, as with other diving shearwaters. On land, typical hunched shearwater gait; swim and dive very well; use wings for underwater propulsion. Flight typically low and direct, particularly in calm conditions, with rapid crisp wing-beats and short glides on stiff wings; in stronger winds, arc higher, flap less. Feed by pursuit-plunging and pursuit-diving, usually in flocks; surfacing birds leap-frog over flock, following prey as it advances. Highly gregarious, usually in flocks of tens to thousands; occasionally solitary. Often feed in mixed-species flocks with terns, Silver Gulls *Larus novaehollandiae*, other shearwater species, Australasian Gannets *Sula serrator* and Spotted Shags *Stictocarbo punctatus*. Ignore boats, including trawlers. Vocal over breeding colonies, where main flight call loud *ka-how-ka-how ka-how ka-hek ka-hek ka-hek ka-hek ka-hek errr*; usually silent at sea, though may cackle quietly when in flocks; flight call occasionally given at dusk near breeding islands.

**HABITAT** Marine, pelagic; mainly in subtropical waters; in warm water (23.87–23.94 °C) of intermediate to high salinity (35.14–35.20 ‰) (Dunlop *et al.* 1988). Frequent waters of continental shelf (Norris 1965; Bartle 1974; Cox 1976; Marchant 1977; Milledge 1977; Dunlop *et al.* 1988); pelagic only on migration. Common in inshore zone, readily entering harbours, inlets, bays and straits (Bartle 1974; Harper 1987). Gather to feed over tidal eddies, where water masses come together, seaweed clumps along current lines, and at sewage outfalls (Norris 1965; Corben *et al.* 1974; Barton 1977; Milledge 1977).

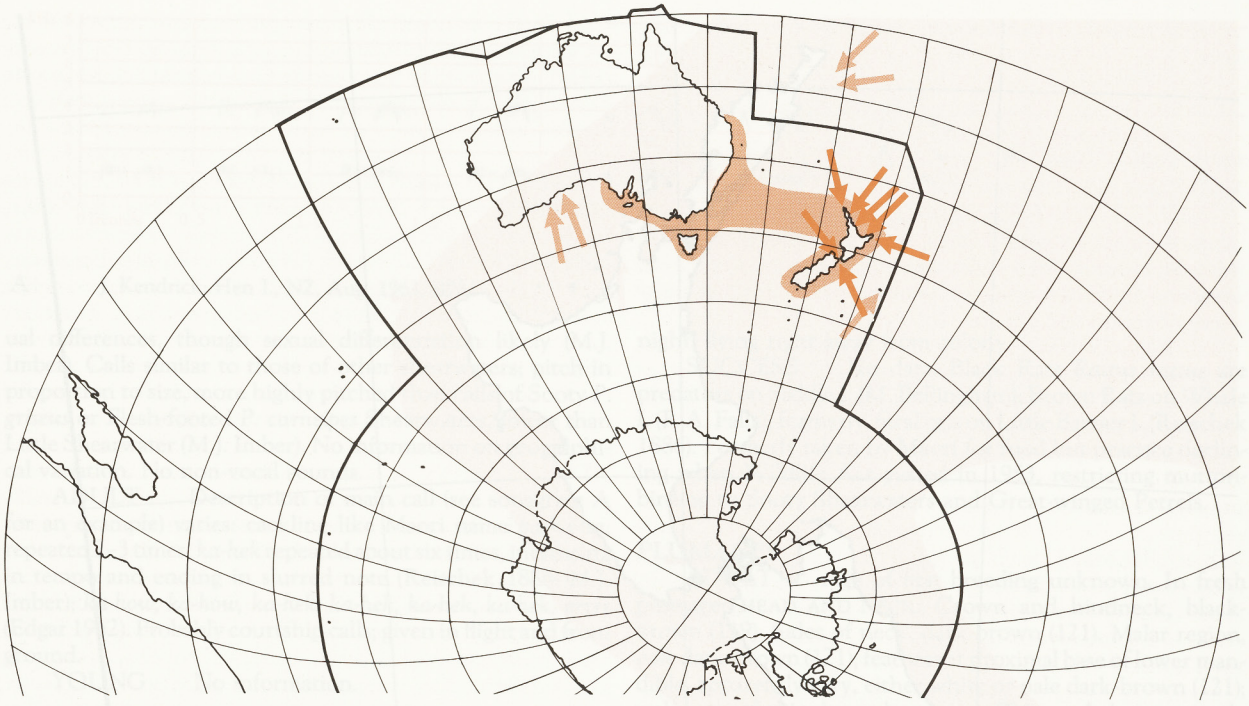
Breed on vegetated coastal islands and islets off NZ; in burrows or cavities in coastal slopes, cliffs and boulder beaches, often under grass, shrubs or trees (Edgar 1962; Skegg 1963; Thorensen 1967).

Feed mostly by pursuit-plunging, pursuing prey underwater to depths of >10 m (Brown *et al.* 1978). Loaf, preen and sleep on sea-surface. During moult when power of flight reduced, adults from Bay of Plenty move into sheltered waters of Hauraki Gulf (Vooren 1972).

Some colonies have been destroyed by feral cats and Brown Rats *Rattus norvegicus* introduced to breeding islands (R.A. Falla; M.J. Imber).

**DISTRIBUTION AND POPULATION** Breed NZ region, ranging through NZ seas, W to s. Aust.; vagrant to New Caledonia and Vanuatu (Peters). More n. distribution than Hutton's in NZ, occurring commonly round NI, Cook Str. and Marlborough Sounds. In Aust., Fluttering mainly recorded from SE, whereas Hutton's recorded from all coasts.

AUST. Locally common non-breeding visitor to coastal and pelagic waters of s. and e. Aust. at least as far N as 24°S. **Qld**. Common visitor se. Qld waters N to 24°05'S, June–Aug., rare or uncommon other months (Qld Bird Reps 1984–85; Storr 1984). **NSW**. Locally common visitor in NSW waters,



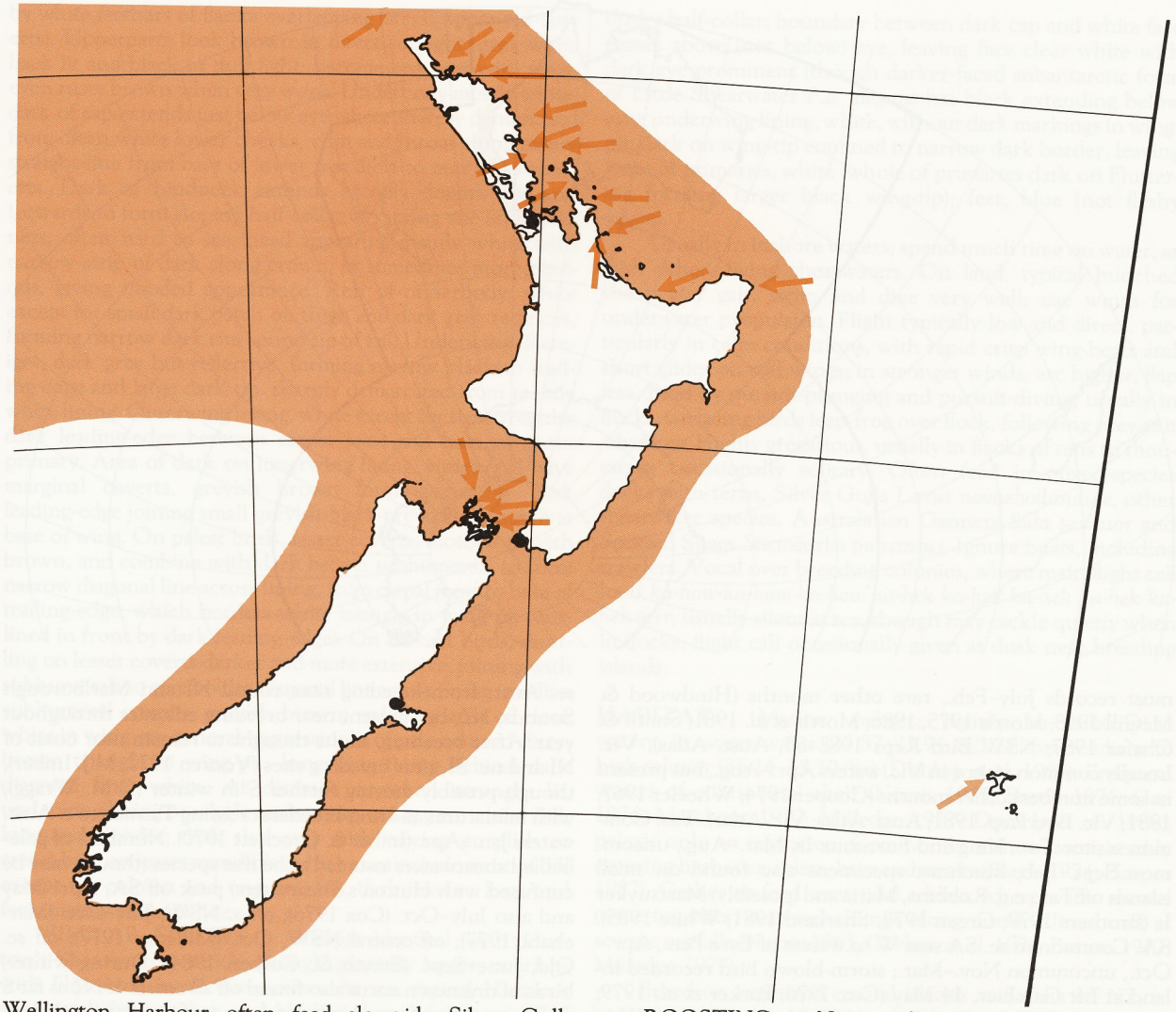
most records July–Feb., rare other months (Hindwood & McGill 1958; Morris 1975, 1986; Morris *et al.* 1981; Smith & Chafer 1987; NSW Bird Reps 1982–83; Aust. Atlas). **Vic.** Locally common visitor in Vic. waters Apr.–Aug., but present in some numbers other months (Cooper 1974; Wheeler 1967, 1981; Vic. Bird Rep. 1981; Aust. Atlas; Vic. Atlas). **Tas.** Common visitor Tas., King and Furneaux Is, Mar.–Aug., uncommon Sept.–Feb; beachcast specimens also found on small islands off Tas., e.g. Robbins, Maria and (possibly) Maatsuyker Is (Brothers 1979; Green 1977; Sharland 1981; White 1985). **SA.** Common in se. SA seas W to waters of Eyre Pen., Apr.–Oct., uncommon Nov.–Mar.; storm-blown bird recorded inland at Mt Gambier, 14 May (Cox 1976; Parker *et al.* 1979; Robinson 1973; SA Bird Reps 1977–81; Aust. Atlas). **WA.** Vagrant or regular but rare visitor to se. WA; beachcast, Eyre: 27 Feb. 1981, 17 Nov. 1985, and Esperance, Feb. 1981, 8 Apr. 1981 (Aust. Atlas; Storr 1987).

NZ During breeding season, common seas and islands round n. NZ, mostly Three Kings Is, S to East Cape and Marlborough Sounds, Cook Str. Non-breeding season, range extends farther S, mostly along e. coast to s. Canterbury Bight (and to e. Aust.); rarely further S and E to Chatham Is. Most numerous E of main islands, Mar.–Sept., with most adults not moving far; also enter deeper inlets and harbours; beachcast specimens from w. NZ mostly immature birds during trans-Tasman movements.

BREEDING Only in NZ, round NI; no estimates of population (M.J. Imber). Three Kings, Motorua, Stephenson, Cavalli, Poor Knights, Bream, Hen and Chickens, Mokohinau, Channel, Little Tiri, Mercury, Alderman, Slipper, Plate, Rurima Rocks, between East Cape and Portland (at least four islands), Cook Str. (including Stephens I., Chetwode and Trio Is), Queen Charlotte Sound (several islands). Formerly Little Barrier and Chatham Is (Falla *et al.* 1981; NZCL; R.J. Scarlett; M.J. Imber).

**MOVEMENTS** Partial migrant to waters off SI, NZ, and se. Aust. from breeding sites round NI and Marlborough Sounds, NZ, but present near breeding colonies throughout year. After breeding, adults thought to remain near coast of NI and ne. SI, near breeding sites (Vooren 1972; M.J. Imber), though possibly moving further S in winter (G.M. Wragg), with immatures and non-breeders crossing Tasman to e. Aust. waters Jan.–Apr. (Imber & Crockett 1970). Numbers of pale-bellied shearwaters assumed to be this species (though may be confused with Hutton's Shearwater) peak off SA, Apr.–May and also July–Oct. (Cox 1976); off s. NSW, July–Oct. (Marchant 1977); off central NSW, Oct. (Milledge 1977); off se. Qld, June–Sept. (Smyth & Corben 1984). During winter, birds of unknown status also found off all coasts of NZ as far S as Foveaux Str. Some birds, perhaps in first year or slightly older (Robinson 1973) remain in Aust. waters over summer (Milledge 1977; Marchant 1977) when numbers appear to peak in Bass Str. (Simpson 1972) and when the only records have been made in sw. Aust. (Aust. Atlas) but during summer round NZ mostly confined to waters off NI and Marlborough Sounds (M.J. Imber). Most wrecks occur on NZ beaches early Mar. when adults moulting (M.J. Imber) and Aug.–Sept., time of high mortality for most seabirds (Veitch 1980; Powlesland 1986, 1987).

**FOOD** Mostly fish, particularly pilchards and sprats, with some coastal krill. BEHAVIOUR. Most prey caught by pursuit-plunging (Brown *et al.* 1978) and pursuit-diving with some surface-seizing. Before pursuit-diving for fish, usually submerge head while paddling slowly forwards; when prey sighted paddle forward strongly, lifting front of body high out of water before diving and wing-rowing out of sight with partly opened wings (Harper 1987). Repeated shallow-diving recorded in birds following fishing gannets (Calvert 1972). In Bay of Plenty, often seen feeding in association with Flesh-footed *P. carneipes* and Buller's *P. bulleri* Shearwaters, Silver Gulls *Larus novaehollandiae* and White-fronted Terns *Sterna striata* (Vooren 1973; Oliver); round Three Kings Is and in



Wellington Harbour often feed alongside Silver Gulls (Turbott & Bull 1954).

BREEDING, NON-BREEDING Seen taking fish *Engraulis* and other species in inshore waters (Falla 1934); small fish in Wellington Harbour (Harper 1987); one caught in fishing net off Kaikoura Pen. contained fish 5 cm long (Tarburton 1981a); at Bay of Plenty take small crustaceans and 'fish of the pilchard type' (Oliver); at Marlborough Sounds listed among predators of clupeid fish *Sardinops neopilchardus* (Baker 1972) and one regurgitation on Three Kings Is entirely euphausiid crustacean *Nyctiphanes australis* (Turbott & Bull 1954).

INTAKE Crop content of one bird, 75 g (Tarburton 1981a).

**SOCIAL ORGANIZATION** Gregarious, usually in flocks, though no details of size and composition; no reported differences between breeding and non-breeding season.

BONDS Probably monogamous with long-term bonds. No information on timing or age of bonding.

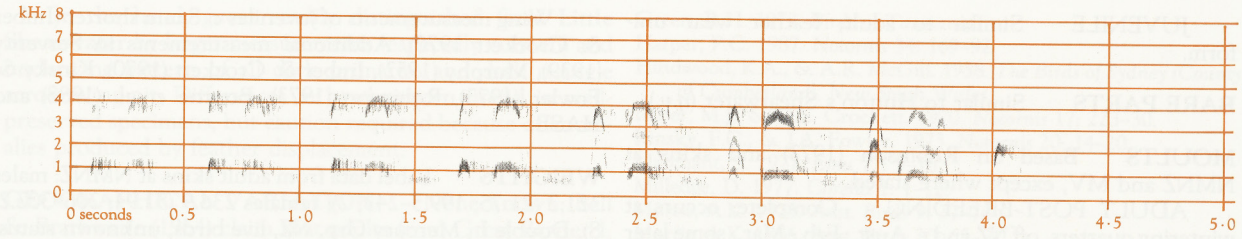
BREEDING DISPERSION Usually colonial, occasionally solitary (M.J. Imber). Distance between nest entrances 0.2–10 m; *c.* 1 burrow/m$^2$ (G.M. Wragg). Probably maintain breeding territories only round nest-site.

ROOSTING Nocturnal roosting throughout year, probably at sea and certainly at colonies during breeding season. Diurnal loafing on sea. Birds roost in burrow during breeding season (if breeding). Pairs (probably non-breeders) roost together on surface at breeding colonies during breeding season (Wragg 1985). Arrive at breeding colony shortly after dusk, departing shortly before dawn.

**SOCIAL BEHAVIOUR** No detailed studies. Difficult to observe because bird nocturnal and usually in burrow. Displays not conspicuous. Flocks when feeding, resting and roosting; possibly some courtship behaviour in flocks. Little information on behaviour at site. Allopreening not reported, but probable. Copulation at nest or burrow, but no data on timing in relation to laying.

RELATIONS WITHIN FAMILY GROUP No information, other than that both parents feed young (Turbott & Bull 1954).

**VOICE** Not well known; no studies. Information supplied by M.J. Imber. Generally silent at sea, occasionally cackles heard from flocks at sea (M.J. Imber). Noisy at colonies, especially if colony large. One varying call, given in flight and from ground. No information on sexual or individ-




A J. Kendrick; Hen I., NZ, Aug. 1963; B981

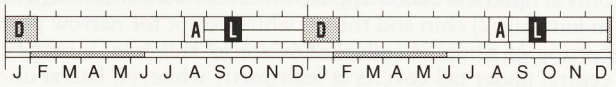
ual differences, though sexual differentiation likely (M.J. Imber). Calls similar to those of other shearwaters; pitch in proportion to size, more highly pitched than calls of Sooty *P. griseus* or Flesh-footed *P. carneipes* Shearwaters, lower than Little Shearwater (M.J. Imber). No information on geographical variation. No non-vocal sounds.

ADULT Description of main call (see sonagram A for an example) varies: cackling like Maori name *pa-ka-ha*, repeated 2–3 times; *ka-hek* repeated about six times, increasing in tempo and ending in slurred note (Reischek 1886; M.J. Imber); *ka-how, ka-how, ka-hek, ka-hek, ka-hek, ka-hek, errrr* (Edgar 1962). Probably courtship calls; given in flight and from ground.

YOUNG No information.

**BREEDING** Very poorly known. Some information from Reischek (1886), Falla (1934) and Oliver. Information supplied by M.J. Imber. Usually colonially but solitary nests occasional; often mixed with other petrels, e.g. Great-winged Petrel *Pterodroma macroptera* and Common Diving Petrel *Pelecanoides urinatrix*; on forested islands and those with coastal scrub or exposed grassy slopes.

SEASON Broadly, Aug.–Feb., but no precise data. Laying, end Sept.–early Oct. (Falla 1934). Pre-laying exodus not recorded. Departure from colonies from end Dec. through Jan. at Three Kings Is (Turbott & Bull 1954); late Jan. at colonies of Auckland Pen. (Falla 1934); Feb. from colonies in Cook Str. (B.D. Bell). Visits colonies during non-breeding season (D. Bettesworth).




SITE Colonies on islands, below 360 m asl; under coastal forest or scrub or on exposed grassy headlands, on gentle to steep slopes. Burrows in soil under vegetation or rocks, or nests among rockfalls or in caves.

NEST, MATERIALS Little data on burrows, nest or materials. Burrows said to be 0.5–1.0 m long (Oliver; G.M. Wragg), 10–13 cm in diameter. Nest-chamber said to be lined with dead leaves, grass, twigs and feathers (HASB; G.M. Wragg). No data on excavation of burrows, traditional use.

EGGS Oval; smooth textured, not glossy; white.

MEASUREMENTS: 57 (53–61; 13) x 40 (38–42) (HASB).

CLUTCH-SIZE One.

LAYING No information.

INCUBATION No information but said to be by both sexes (HASB).

YOUNG No information, except feeding by both parents by incomplete regurgitation.

FLEDGING TO MATURITY Chicks leave at night, flying right away from colony.

SUCCESS No data. Black Rats *Rattus rattus* are predators on Saddle I. (M. Bellingham); Brown Rats on Whale I. (R.A. Falla); formerly, feral cats on Little Barrier I. (Reischek 1886). Formerly taken by Maori for food but practice declining when Wildlife Act passed in 1953, restricting muttonbirding to Sooty Shearwaters and Great-winged Petrels.

## PLUMAGES

ADULT Age of first breeding unknown. In fresh plumage: HEAD AND NECK. Crown and hindneck, black-brown (119). Sides of neck, dark brown (121). Malar region, pale dark-brown (121); feathers at proximal base of lower mandible, apparently vary, either white or pale dark-brown (121); unknown if this depends on age. Chin and throat, mostly white; feathers of throat have mottled subterminal pale dark-brown (121) band, narrowly tipped white; when worn, have square-cut appearance and white bases obvious; in centre of foreneck, subterminal band on feathers less mottled. Generally, foreneck has slight mottled appearance, apparently less extensive than in Hutton's Shearwater, when large series of specimens compared (Robinson 1973). UPPERPARTS, mostly black-brown (119). Open pennaceous fringes on mantle and rump, dark brown (121). Concealed bases of feathers on upperparts, very light grey-brown (119D); bases sometimes exposed on rump and mantle when feathers disarrayed. TAIL, black-brown (119); rachis, dark brown (121) basally, merging to grey-black (82). Basal inner web of rectrices, pale dark brown (121). UPPERWING. Alula and remiges, black-brown (119). Basal inner webs of remiges, pale dark brown (121). All coverts, dark brown (121); marginal, lesser and median coverts, have narrow open pennaceous, paler dark brown (121) fringes; when worn, tips of greater, median and lesser coverts, dark brown (119A). UNDERPARTS, mostly white. Sides of breast, dark brown (121), feathers narrowly tipped white; when worn, tips of feathers at shoulder, brown (119B), white tips lost. Flanks, white, distal halves of feathers, dark brown (121), narrowly tipped white; rachis, white basally, black-brown (119) distally. Thighs and under tail-coverts, white. Axillaries, dark brown (121), tipped white. UNDERWING. Greater primary and greater coverts, combination of glossy brown-grey (79) and light grey (85), narrowly tipped white; innermost greater coverts tipped white on inner web only; bases, white. Rest of primary coverts, entirely white. Rachis on underside of primaries, light grey-brown (119C), merging to grey-black (82) distally. Marginal coverts, pale dark brown (121), narrowly fringed white. Rest of coverts, pale dark brown (121), narrowly tipped white, towards inner wing from carpal joint; extent of white apparently varies and is illustrated in Robinson (1973).

DOWNY YOUNG Similar to Hutton's Shearwater (*q.v.*).

JUVENILE Similar to adult; feather wear uniform.

**BARE PARTS** Similar to Hutton's Shearwater (*q.v.*).

**MOULTS** Based on Robinson (1973) and skins at NMNZ and MV, except where stated.

ADULT POST-BREEDING Complete; occurs at wintering quarters, off NZ and e. Aust., Feb.–Mar.; some later (May–Apr.), even June (Falla 1934), and may represent late breeders. Primaries moult outwards; up to three adjacent inner primaries lost simultaneously.

POST-JUVENILE Complete; birds in body moult, Oct.; remiges, early Nov. onwards. In NZ, birds have not yet been recorded moulting Oct.–Nov.; young birds may be absent at least for first year of life from near-shore areas. Moult must extend to Jan. because two specimens found on 3 Jan. still moulting primaries. Particularly vulnerable when moulting during storms.

**MEASUREMENTS** (1) Kaikoura Pen., NZ, adults, recently dead; methods unknown (Tarburton 1981a). (2) NZ and Aust. (locality details given), unknown status, skins; methods unknown (Serventy 1939). (3) NI, NZ, adults, skins, beachcasts (NMNZ).

| | | MALES | FEMALES | |
|---|---|---|---|---|
| WING | (1) | 218.0 (3.9; 211–226; 17) | 218.0 (4.1; 211–221; 9) | |
| | (2) | 204.8 (8.70; 180–221; 17) | 207.5 (4.78; 200–215; 9) | |
| | (3) | 211.6 (1.69; 210–214; 3) | 208.0 (7.32; 194–217; 6) | |
| TAIL | (1) | 71.0 (3.5; 64–76; 17) | 69.0 (2.7; 66–75; 9) | |
| | (2) | 61.5 (2.78; 58–68; 17) | 63.1 (1.66; 61–66; 9) | |
| | (3) | 62.0 (0.81; 61–63; 3) | 63.0 (2.90; 56–67; 9) | |
| BILL | (1) | 34.7 (1.5; 31.5–37; 17) | 33.2 (0.9; 31.9–34.4; 9) | * |
| | (2) | 33.6 (0.96; 32–35; 17) | 32.4 (1.70; 30–35; 9) | * |
| | (3) | 34.0 (2.14; 30.9–37.4; 6) | 32.4 (1.58; 29.1–35.1; 11) | |
| TARSUS | (2) | 41.0 (2.18; 36–46; 17) | 41.0 (1.63; 37–43; 9) | |
| | (3) | 45.3 (2.02; 41.5–47.3; 6) | 42.6 (1.24; 40.1–45; 11) | * |
| TOE | (1) | 50.7 (1.2; 48.3–53.0; 17) | 50.0 (1.5; 48.3–52.0; 9) | |
| | (2) | 49.6 (1.91; 45.5–51.1; 6) | 47.5 (1.86; 43.2–50.8; 11) | |

Unsexed birds. (4) Double I., Mercury Grp, NZ, unknown status, live (A.J.D. Tennyson; G.A. Taylor). (5) Stack N of Stanley I., Mercury Is, unknown status, live; methods as in Baldwin *et al.* (1931), flattened wing, bill depth and width at base (A.J.D. Tennyson; G.A. Taylor; P. Scofield).

| | | UNSEXED |
|---|---|---|
| WING | (4) | 210.4 (4.77; 210–216; 7) |
| | (5) | 209.5 (5.76; 204–219; 4) |
| TAIL | (4) | 60.6 (1.49; 58.4–62.4; 7) |
| | (5) | 61.6 (0.70; 60.7–62.4; 4) |
| BILL | (4) | 33.2 (1.25; 31.1–35.1; 7) |
| | (5) | 32.7 (1.17; 31.4–34.3; 4) |
| BILL D | (5) | 9.6 (0.65; 9–10.7; 4) |
| BILL W | (5) | 8.7 (0.38; 8.4–9.4; 4) |
| TARSUS | (4) | 42.9 (0.50; 42.4–43.8; 7) |
| | (5) | 42.3 (1.88; 39.4–44.6; 4) |
| TOE | (4) | 49.3 (1.86; 47.3–52; 7) |
| | (5) | 49.2 (0.14; 49.1–49.5; 4) |

Wing measurements of juveniles *c.* 8 mm shorter (Imber & Crockett 1970). Additional measurements in Serventy (1939), Murphy (1952), Imber & Crockett (1970), Kinsky & Fowler (1973), Robinson (1973), Bourne *et al.* (1988) and HASB.

**WEIGHTS** Label data from adult skins at NMNZ: males 221.2 (21.75; 199.5–243; 2); females 236.9 (31.94; 206–302.2; 8). Double I., Mercury Grp, NZ, live birds, unknown status, 1–3 Nov. 1988: 308.1 (11.15; 300–330; 5) (A.J.D. Tennyson; G.A. Taylor). Stack N of Stanley I., Mercury Is, 7 Nov. 1988: 324.0 (28.24; 286–360; 4) (A.J.D. Tennyson; G.A. Taylor; P. Scofield). Additional weights in Serventy (1939). No details on seasonal changes.

**STRUCTURE** Similar to Hutton's Shearwater (*q.v.*).

**RECOGNITION** Fluttering and Hutton's Shearwaters closely similar. Measurements of each overlap considerably making identification difficult, except at extremes (Imber & Crockett 1970; Tarburton 1981a; Wragg 1985); separation by length of bill (HASB) also not clear cut because overlap 4 mm between shortest-billed *huttoni* and longest-billed *gavia* (Wragg 1985). In sample of 100 *huttoni* at breeding colony, three birds had entirely white under tail-coverts, as in *gavia*, but had dark under wing-coverts, normally found in *huttoni*, indicating no one character sufficient for identification (Tarburton 1981b); in another sample of 100 *huttoni* and 300 *gavia*, 10% of *huttoni* had no dark markings on under tail-coverts and 5% of *gavia* had dark markings (Wragg 1985). Wragg (1985) found *gavia* and *huttoni* could be separated accurately using ratio of skeletal measurements; premaxillary length (distal end of nasal opening to tip of bill) divided by skull length (back of skull to tip of bill) as percentage: *gavia* $\leq$33% (range 29–33%), *huttoni* $\geq$33% (range 33.5–37%); measure eliminated confusion of large *gavia* and small *huttoni* and useful for skins and beachcast specimens; combined with other characters (e.g. under tail-coverts, underwing pattern) gives 100% separation. In the hand, following characters found in all *gavia* and diagnostic in combination; not combined in all or most Hutton's (C. Corben): (1) bill rami meet only at tips (rami closely applied for distal two-thirds of length in *huttoni*); (2) chin and throat, white except for narrow grey barring of some juveniles (off-white in *huttoni*); (3) longest central under tail-coverts at least partly white; (4) lateral undertail coverts entirely white (in *huttoni*, lateral under tail-coverts have outer vane black or grey, or both); (5) greater under primary coverts, except outermost, pure white or only faintly tinged with very pale grey (in *huttoni*, greater and median primary coverts and greater secondary coverts, pale grey with dark shafts); (6) median and lesser under primary coverts, except outermost, pure white or with only very fine shaft-streaks (in *huttoni*, median secondary coverts and subhumerals, dark brownish grey); (7) greater under secondary coverts, subhumerals, most axillaries and their coverts white-tipped, at least narrowly (axillaries, brown, pointed, rarely with white tips) (C. Corben). Many *gavia* have broad white tips to greater under secondary coverts and subhumerals and probably safely identifiable on this feature. Most *gavia* have almost entirely white under-primary coverts with few, if any, very fine dark shafts on more distant medians. Such pattern rare in *huttoni*. Identification characters discussed further in Serventy (1939), Falla (1965), HASB, Kinsky & Fowler (1973) and Robinson (1973).

In the hand, *gavia* readily distinguished from **Little Shearwater** by larger measurements (especially culmen) and underwing pattern of all dark primaries and dark triangle across wing-pit. Differences in head pattern useful in well-preserved specimens, but caution required because of anomalies produced by feather displacement.

**GEOGRAPHICAL VARIATION** None known; Bell & Brathwaite (1964) claim that adults from Great Barrier I. consistently smaller than birds from Cook Str., but measurements appear to fall within range (R. O'Brien). Formerly regarded as conspecific with Hutton's Shearwater (e.g. Serventy 1939; Oliver) or Manx Shearwater (e.g. Murphy 1952). Forms superspecies with Manx Shearwater and Hutton's Shearwater (Peters). Usually regarded as distinct species on basis of biology (e.g. Bourne *et al.* 1988).

RMO

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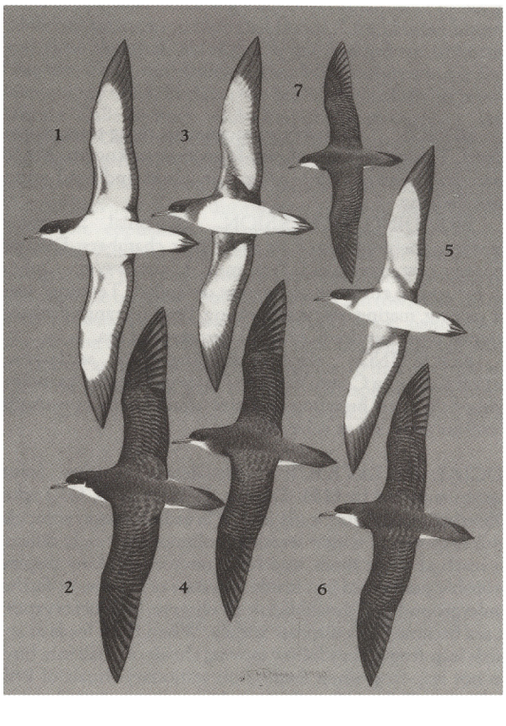


**Volume 1 (Part A), Plate 48**

Manx Shearwater *Puffinus puffinus*
**1.** Adult, ventral
**2.** Adult, dorsal

Hutton's Shearwater *Puffinus huttoni*
**3.** Adult, ventral
**4.** Adult, dorsal

Fluttering Shearwater *Puffinus gavia*
**5.** Adult, ventral
**6.** Adult, dorsal
**7.** Adult, dorsal, worn