

## Order PROCELLARIIFORMES

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

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

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

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

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

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

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

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## Family PROCELLARIIDAE fulmars, petrels, prions, shearwaters

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

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

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

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

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

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

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

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

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

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## *Puffinus huttoni* Hutton's Shearwater

COLOUR PLATE FACING PAGE 657

*Puffinus reinholdi huttoni* Mathews, 1912, *Birds Aust.* 2: 47 (in key), 77 — Snares Island.

Named in honour of F.W. Hutton FRS, 1836–1905, Curator, Canterbury Museum, Christchurch, New Zealand.

### MONOTYPIC

**FIELD IDENTIFICATION** Length 36–38 cm; wingspan 72–78 cm; weight 365 g. Small black-and-white shearwater, almost identical in shape and flight to slightly smaller, shorter-billed Fluttering Shearwater *P. gavia* (*q.v.*). Typical Hutton's differ from Fluttering by less sharp demarcation between cap and white of chin and throat, broader collar extending farther towards mid-line, and darker underwing. Much overlap in field characters. Sexes alike. No seasonal plumage changes. Juveniles inseparable.

**DESCRIPTION ADULT.** Upperparts, uniform brownish black. Dark brown of cap extends below eye, merg-

ing into white of chin and throat. Dark of hindneck extends broadly down behind cap to form broad collar, which almost encircles neck and upper breast, giving distinctly hooded appearance. Rest of underbody, from lower breast to under tail-coverts, white except for small dark patch on thigh and greyish black rectrices, showing as narrow dark rim round tip of tail. Underwing: remiges, greyish black and greater coverts, grey; form broad dark trailing-edge and large dark tip. Lining varies; typically, outerwing has thin dark greyish brown leading-edge between carpal joint and base of outermost primary and greyish brown streaks radiating across white lesser pri-

mary coverts (visible only when close); on innerwing, coverts in front of line between carpal joint and base of trailing-edge, mostly dark greyish brown, forming pronounced dark triangle in wing-pit with varying diffuse pale centre; median coverts, clean white, forming narrow white stripe down centre of wing. Some have more white in centre of wing-pit and very pale streaking on primary coverts, so that area of white on underwing lining greater, and underwing pattern overlaps with darkest Fluttering Shearwaters. Bill, long and slender, dark grey. Iris, dark brown. Inside of leg, light to dark pink and mauve, outside of leg, pink and dark grey; toes, black, webs, pink.

**SIMILAR SPECIES** Very similar to **Fluttering Shearwater**, which has almost identical size, structure and jizz; *q.v.* for full discussion. For distinctions from **Little P. assimilis**, vagrant **Manx P. puffinus** and **Audubon's P. lherminieri** Shearwaters, see those texts.

Breed only in alpine areas of n. SI, NZ. Pelagic when not breeding; even during breeding season (late Aug. to mid-Apr.) prefer open ocean feeding grounds from Otago Pen. along e. coast of SI, through Cook Str. to Wellington w. coast (*c.f.* Fluttering Shearwater which often feed in sheltered coastal waters). On land have awkward shuffling gait. Float buoyantly when swimming; dive using partially folded wings for propulsion. Long neck and short tail give off-balance appearance in flight, more bulk in front of, than behind, wings. Over land, fly with strong fast even wing-beats. At sea, flight low and direct in calm conditions, with short glides interspersed with rapid, stiff wing-beats; in stronger winds arc higher and do more shearwatering, with fewer wing-beats. Often encountered in flocks or small groups flying in same direction without any particular formation. Feed by pursuit-diving, often plunging into sea in mid-flight at front of feeding flock; surfacing birds run along surface to assist take-off, before plunging into mêlée again. Prey swallowed before surfacing. Highly gregarious, sometimes forming feeding flocks of up to 20 000 birds but more often in loose flocks of 50–500, spread across sea and flying in similar direction. Sometimes forage in company of Silver Gulls *Larus novaehollandiae* or White-fronted Terns *Sterna striata*, working shoals of krill or pilchards. In evening during breeding season, large quiet floating flocks (up to 20 000) build up about 1 km offshore from the Kaikoura Pen. before flying inland to breeding grounds after dusk. Fearless of humans at sea if offal thrown overboard or if occupied in feeding frenzy, otherwise shy of humans and ignore boats. Silent at sea apart from occasional excited cackle. Noisy on breeding colonies and while flying to and from sea; main flight-call rapid cackly *kouw kouw kouw kouw kee kee kee kee aaah*; last part of call somewhat drawn out and wheezy; sequence repeated until landing made. Chicks make high-pitched wail to which parents respond with deep croon.

**HABITAT** Marine, pelagic; in waters round NZ and Aust; mainly Subtropical, but also ranging S of Subtropical Convergence. In e. Indian Ocean, observed in waters of surface-temperature 20.48–24.16 °C and salinity 34.80–35.45 ‰ (Dunlop *et al.* 1988). Favour waters of continental shelf (Cox 1976; Harrow 1976; Dunlop *et al.* 1988); occasionally close inshore in bays, river mouths, kelp beds beside rocky shores, and near beaches; in rough weather feed further offshore (Harrow 1976). In Cook Str., feeding concentrations at tide-rips and channels between islands and coast (Falla 1965).

Breed in coastal watersheds of Kaikoura Ra., NZ, from 1200–1800 m asl and 12–18 km inland. Nest on gentle or steep

mountain slopes, usually on or near ridges; under tussock grass or low alpine scrubland (*Poa*, *Chionochloa*, *Aciphylla*, *Dracophyllum*); avoid rocky areas or shingle soils (Harrow 1976).

Take food from on or below sea surface, diving to unknown depths.

Introduced Stoats *Mustela erminea* take birds in breeding areas. Red Deer *Cervus elaphus*, Chamois *Rupicapra rupicapra* and goats trample burrows and graze vegetation, but their numbers have been reduced since 1970 and tussock grass has regenerated (Harrow 1976).

**DISTRIBUTION AND POPULATION** Breed on ne. SI, NZ, at 1200–1800 m asl, adult birds remaining in e. NZ waters, but regular movement of mostly immature birds to Aust. seas (Peters). More southerly distribution in NZ than Fluttering Shearwater; Hutton's mainly recorded off e. approaches of Cook Str., Kaikoura and Canterbury coasts. Occur round entire coast of Aust.

**AUST.** Uncommon non-breeding visitor to coastal and pelagic waters of s. Aust., with migratory movement round Aust., apparently following edge of continental shelf, and coastal waters off n. Aust. (see Movements) **Qld.** Rare visitor SE, Dec.–Aug.; records from ne. Qld (since May 1971)

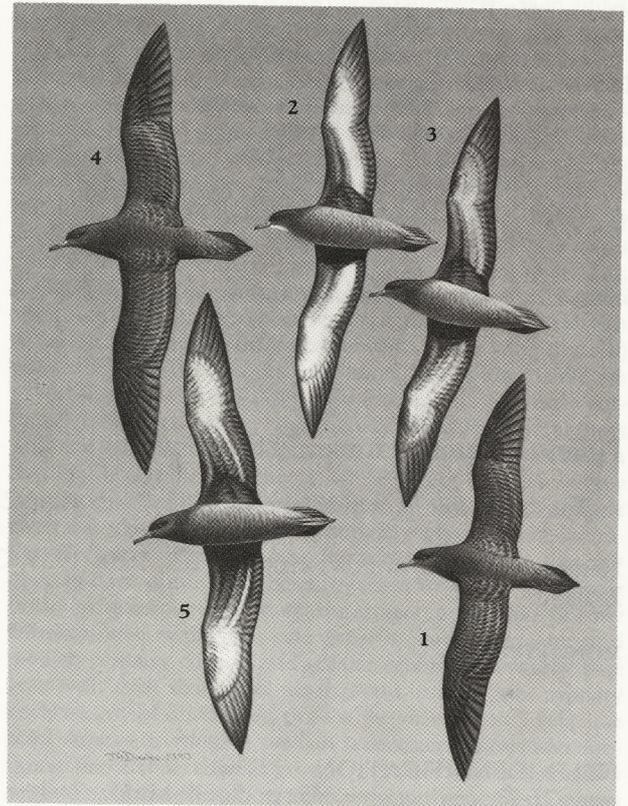


Plate 47

Short-tailed Shearwater *Puffinus tenuirostris*

1. Adult, dorsal
2. Adult, light morph, ventral
3. Adult, dark morph, ventral

Sooty Shearwater *Puffinus griseus*

4. Adult, dorsal
5. Adult, ventral

and Torres Str. (Booby I., first recorded 3 Apr.-July) (Draffan *et al.* 1983; Corben *et al.* 1974; Ingram *et al.* 1986; Vernon 1977; Warham 1981; Qld Bird Reps 1983, 1984; Aust. Atlas). NSW. Uncommon, Sept.-Feb., regular but rare other months (Morris 1975; Morris *et al.* 1981; NSW Bird Reps 1979-80, 1982-84; Aust. Atlas). Vic. Scarce to uncommon, recorded all months (Wheeler 1981; Vic. Bird Rep. 1981; Aust. Atlas; Vic. Atlas). Tas. Rare, in summer; at least ten records 1973, most Jan.-Mar. (Green 1977; Sharland 1981; Tyson & White 1977). SA. Uncommon, in SE, W to waters of s. Eyre Pen., July-Mar. (Condon 1969; Halse 1981; Parker *et al.* 1979; Aust. Atlas). WA. Common passage migrant moving N-S, recorded N to 22°30'S, Apr.-Dec., uncommon along coasts of sw. WA, one record from coastal se. WA, Eyre 27 Feb. 1981 (Halse 1981; Serventy & Whittell 1976; Storr 1984; Storr & Johnstone 1988; Warham 1981; Aust. Atlas). NT. Vagrant: one storm-blown straggler found inland at Katherine, n. NT, 6 June 1981 (Reed & McKean 1982).

NZ Common in seas of e. SI, Cook Str. and round NI, Apr.-Aug., uncommon w. SI, and other months. Colonies in alpine zone and snowed in for up to 8 months of year, and birds away, Apr.-Aug.

**BREEDING** NZ; 3.5-4 km inland from coast on Seaward Kaikoura Ra., ne. SI; discovered in 1965. Two col-

onies known: at headwaters of Kowhai R. (c. 160 000 breeding pairs) and at Shearwater Streams (no estimate) (G.H. Sherley).

Apparently formerly bred Mt Tapuenuku, Inland Kaikoura Range (G.M. Wragg). Originally described from Snares Is but based on specimens of doubtful provenance (Falla *et al.* 1981; Harrow 1965, 1976; Imber & Crockett 1970; NZCL

**MOVEMENTS** Migrant at least as far as nw. Aust. but exact movements not known.

**DEPARTURE** Adults depart breeding colonies early Feb. with few staying till late Mar.-early Apr. Young fledge Feb.-early Apr., depending on extent and duration of snow cover early in breeding season (Harrow 1976).

**NON-BREEDING** Large-scale wrecks have not been noted in NZ in May-Aug., which suggests that adults and immatures absent in winter (Wragg 1985; Halse & Halse 1988); immatures possibly spend 1-2 years in Aust. waters (Harrow 1976). Timing of Aust. records confusing. Specimens collected Apr. and May from Torres Str. (Vernon 1977; Draffan *et al.* 1983), Katherine, NT, June (Reed & McKean 1982) and sighting of large flocks flying S near Pt Cloates, WA, 30 July-9 Aug. (Halse 1981) have suggested anti-clockwise circumnavigation of Aust. (Warham 1981) but pattern confused by sightings in Qld waters in most months, particularly Feb.-Aug. (Corben *et al.* 1974; Smyth & Corben 1984; Qld Bird Rep. 1986) and records from WA mid-July to early Sept. with some birds moving N as well as S (Halse & Halse 1988). Perhaps some birds move N into Coral Sea but most travel clockwise round s., w., nw., and n. Aust. as far as Booby I., at w. edge of Torres Str., which could be e. limit of population off n. Aust. Concerted observation Apr. and May at Booby I. (A. Williams & R. Hindmarsh) has failed to see passing shearwaters and passage of large numbers of shearwaters through well-frequented and densely populated areas of Torres Str. unlikely to go unreported.

**RETURN** First recorded at breeding sites 27 Aug. but most return mid-Sept. with beachcast birds common along w. coast NI during spring (Wragg 1985) and passing through Cook Str., Sept.-Oct. (Secker 1969). Will return to nest-site even when it is still deep in snow but will not dig through deep drifts. Pre-laying exodus occurs mid-Oct. but duration unknown (Harrow 1976).

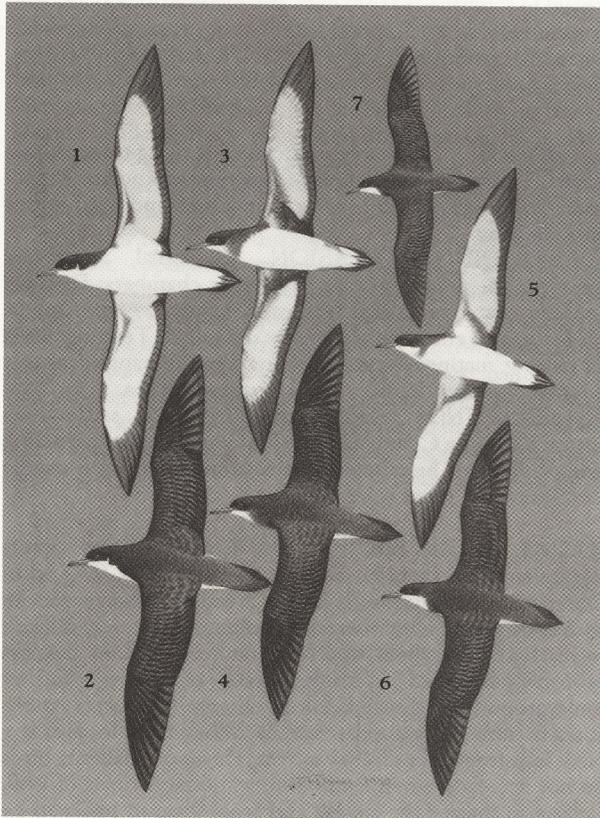


Plate 48

- |   |   |
|---|---|
| Manx Shearwater <i>Puffinus puffinus</i>    | Fluttering Shearwater <i>Puffinus gavia</i> |
| 1. Adult, ventral                           | 5. Adult, ventral                           |
| 2. Adult, dorsal                            | 6. Adult, dorsal                            |
| Hutton's Shearwater <i>Puffinus huttoni</i> | 7. Adult, dorsal, worn                      |
| 3. Adult, ventral                           |   |
| 4. Adult, dorsal                            |   |

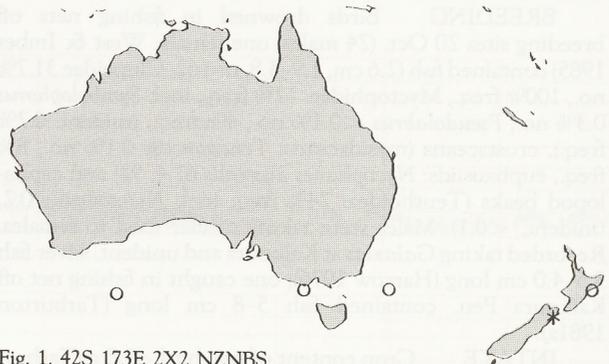
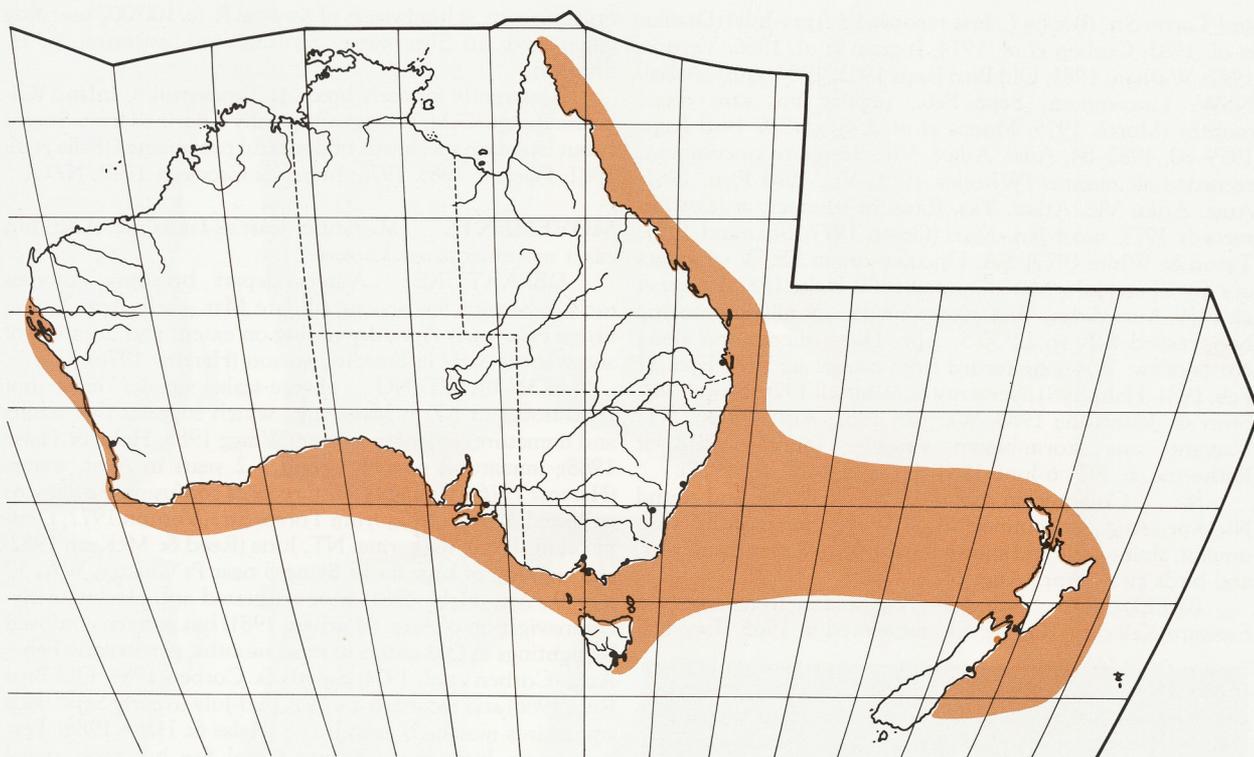


Fig. 1. 42S 173E 2X2 NZNBS

**BREEDING** Movements in summer unknown but appear to feed further S in late summer, possibly following movement S of Subtropical Convergence. Most feeding within 70 km of shore, often just off coast opposite breeding sites (G. Harrow). Many records of immatures beachwashed in



summer in s. Aust. suggest they remain in Aust. waters for at least one breeding season.

**BANDING** Returns from n. SI, NZ (NZNBS) summarized Fig. 1.

**FOOD** Mostly small fish and krill. **BEHAVIOUR.** Food caught by plunge-diving or surface-diving with wings partly open (Harrow 1976) to depths of 0.6–2.4 m (West & Imber 1985). Occasionally hydroplane before diving (G. Sherley; G. Harrow; G. Taylor). Seen feeding in association with fish (c. 50 cm long; Halse & Halse 1988). Most feeding appears to be during daylight.

**NON-BREEDING** One collected off WA contained fish  $\leq 3$  cm long (Halse 1981).

**BREEDING** Birds drowned in fishing nets off breeding sites 20 Oct. (24 males, one female; West & Imber 1985) contained fish (2.6 cm, 1.9–3.8, n=162; Clupeidae 31.7% no., 100% freq., Myctophidae: 12% freq., incl. *Symbolophorus* 0.3% no., *Pseudolabrus* <0.1% no., 4% freq., unident. 0.2% freq.), crustaceans (mysidaceans: *Tenagomysis* 0.1% no., 8% freq., euphausiids: *Nyctiphanes australis* 67.4, 92) and cephalopod beaks (Teuthoidea: 24% freq. incl. *Nototodarus* 0.2, unident. <0.1). Males were taking similar food to females. Recorded taking *Galaxias* at Kaikoura and unident. silver fish 3.5–4.0 cm long (Harrow 1976); one caught in fishing net off Kaikoura Pen. contained fish 5–8 cm long (Tarburton 1981a).

**INTAKE** Crop content of one bird, 42.5 g (Tarburton 1981a).

**SOCIAL ORGANIZATION** Gregarious at breeding colonies and often at sea, but probably solitary over parts of range when foraging. Congregate at food; often seen feeding offshore on small shoaling fish.

**BONDS** Probably monogamous, long-term or sustained. Timing and age of pair-formation unknown. No cooperative breeding. Both parents incubate and tend young until fledging.

**BREEDING DISPERSION** Colonial. Sometimes common openings into 2 or more nest chambers. Distance between nest entrances 0.3–10 m; c. 2 burrows/m<sup>2</sup>. Only c. 0.5 m<sup>2</sup> round entrance to burrow defended. Territory used for pairing, mating, rearing of young. Feeding range probably extends over hundreds square kilometres of sea.

**ROOSTING** During breeding season, settle at sea just off Kaikoura Coast (Ward to Oaro) in large flocks, before flying inland to breeding colonies at nightfall; presumably roost on open sea at other times.

**SOCIAL BEHAVIOUR** No detailed studies. Information supplied by G.H. Sherley, G. Harrow & G. Taylor. Observations difficult: early part of breeding season coincides with extremes of winter weather; colonies extremely difficult to reach at these times, and birds nocturnal. Many displays probably performed just inside entrance of burrow or farther underground and thus difficult to observe. Few observations at sea because birds disperse widely. When flock feeds at sea, birds leap-frog as they follow moving shoals of small fish; birds do not leap-frog when feeding on stationary shoals of krill. Calling in flight over colony and from ground likely to be important part of breeding biology, but actual relevance of calls not studied.

**AGONISTIC BEHAVIOUR** Little or no agonistic behaviour between roosting birds nor between members of pair together: birds sit very close to each other, apparently without conflict. Some aggressive behaviour observed between presumed adults in flight, in which there was contact between bills and wings (observations in early Aug.–Sept. and

Dec.-Jan.). Breeding birds defend burrow against failed breeders, unmated and immature birds; however, few threat displays noticed and observations probably biased because birds react to observer. Some calls from within burrows probably deter intruders. **THREAT DISPLAY.** Less aggressive behaviour involves raising feathers of neck, back and tail. Burrows actively defended by **FIGHTING:** territory holder makes rapid charge at intruder, biting and scratching; full combat includes Bill-fencing and biting, sometimes drawing blood; much calling during fights. **ESCAPE.** Vanquished bird backs away quickly, closes wings tightly and scuttles down hill. **Triumph Display.** Winner flaps wings and Cackles. No information on appeasement behaviour, submissive displays.

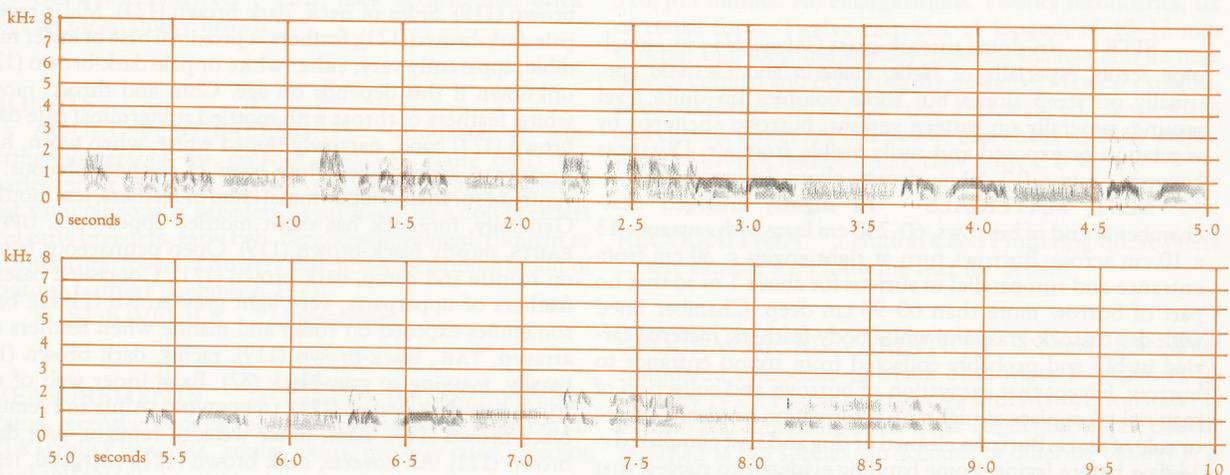
**SEXUAL BEHAVIOUR** **ADVERTISING:** birds call with loud cackles outside burrow; single birds calling outside burrow possibly males Advertising for mate or ownership of site; observed throughout breeding season, but especially Sept. to mid-Oct. **Aerial Display:** when birds arrive at colony at night, circle colony one to three times before landing, uttering Aerial Call, which is higher and more drawn-out than calls made on ground; there may be many birds calling at same time and display may be communal in nature. Advertising observed throughout courtship, laying and nesting periods. **PAIR-FORMATION.** Early in season, in initial stages of pair-formation, potential mates face each other at entrance of burrow while calling to re-establish pair bonds. Later, birds sit quietly and close together, side-by-side; may allopreen. **GREETING.** Displays, if any, not observed. Possibly vocal greeting in flight over colony when birds arrive, but many birds fly to burrow silently. Calls between adults and chicks in burrows. **ALLO-PREENING.** Usually preen top third of body, particularly head and nape; generally unilateral, usually with male preening female when sex has been determined; occurs at night, from Oct. to Nov.; observed during later stages of and after pair-formation, copulation and laying. Bill-snapping observed once with Allopreening. **COPULATION.** Pair sit side by side, facing up-hill next to burrow; if snow still covers ground, pair will copulate on snow above entrance of burrow; male usually preens female before scrambling on her back, using toes to grip leading edge of female's wing near ulna; males use wings to balance and may remain mounted for 10 min or more; several cloacal contacts may be made. Conspicuous; occurs at night from Oct. to Nov., generally outside burrow. During

copulation, territory defended if other birds approach within pecking distance.

**RELATIONS WITHIN FAMILY GROUP** Both parents clean burrow, incubate and feed young; male probably takes first incubation shift. Fledging occurs when chick fully feathered and parents stop bringing food; chick independent of parents after fledging. No direct observations of begging by chicks; utter high-pitched *piping* when begging; adults respond with deep *croons* and Bill-clicking. Parents apparently feed chicks through regurgitation. Possible that calls function in identification between parent and chick but no data. In Mar.-early Apr., newly-fledged birds seen in groups at sea along Kaikoura coast with adults.

**VOICE** Poorly known; no detailed studies. Information supplied by G.H. Sherley, G. Harrow & G. Taylor. Generally quiet at sea but cackling calls reported; very noisy at breeding colonies, in air and on ground; also call in flight from sea to breeding sites. Vocalizations important in Social Behaviour. Mostly variations of one main call; a few other calls noted. Calls vary greatly and observations indicate that specific vocalizations used at different times of breeding season and in different circumstances, but no details. Calling restricted to breeding season, from Sept.-Feb. Calls from ground and in flight similar in form but aerial calls more highly pitched. Calls very similar to those of Fluttering Shearwater *P. gavia* and similar to those of Sooty Shearwater *P. griseus*. No individual or sexual differences reported, but suggested that individual recognition possible.

**ADULT** (1) **Cackle:** described as *kouw kouw kouw kouw kee kee kee kee aaah*, last syllable wheezy. Sonagram A shows calls of two birds, the second starting at about 2.8 s. Given from burrows and from surface in front of burrows. Given during Threat Display, fights, Triumph Ceremony, advertising and Pair-formation. Noticeable early in breeding season when established pairs re-establish pair bonds and again during Nov.-Feb., when pre-breeders may be establishing pair-bonds. (2) **Flight Call** (but see [3]). Variation of Cackle but more highly pitched; given in flight over colony; birds call repeatedly as they circle colony until they land. Often uttered by many birds at once. May function as aerial Greeting Call. (3) **Aerial call** reported from birds flying through mountainous country from sea to breeding colonies; has high flute-

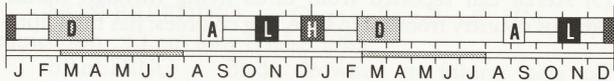


like quality. Especially prevalent when cloudy or misty; may function as echo-location mechanism to assist navigation (G. Harrow), not yet substantiated; may function as Contact Call. **Other Calls:** (4) **Greeting Call.** Loud chuckles uttered by both birds as greeting when mates join each other in burrow. (5) **Croon.** Adults reported to making crooning call when greeting chick at nest. (6) **Alarm/Distress Call.** Adults give undescribed, but completely different, call when handled by humans and possibly in other threatening circumstances; but not as part of Threat Display. (7) At sea, reported to make excited Cackles. **NON-VOCAL SOUNDS:** include **Bill-clicking**, heard during Copulation, during fights between pre-breeding birds and when parents respond to begging calls of young in burrow. **Bill-snapping** observed once when birds allopreening.

**YOUNG** Chicks beg with high-pitched piping or sibilant whistle. Undescribed Alarm Call when young are handled. Juveniles quiet when outside burrows.

**BREEDING** Little known. Only published accounts by Harrow (1965, 1976) and Falla (1965). Information supplied by G.H. Sherley, G. Harrow and G. Taylor. Breed colonially, not in association with other birds; in alpine tussock grassland and subalpine scrub at 1200–1800 m asl in Seaward Kaikoura Ra., NZ; historical records from Inland Kaikoura Ra. in 1880s (Wragg 1985).

**SEASON** From end Aug. to mid-Apr. Breeding birds arrive from third week Aug. to mid-Sept., reaching area 90–115 min after sunset or later during fully moonlit nights. Pre-laying exodus shown by fewer numbers during mid-Oct. but details not established. First egg recorded 25 Oct.; latest, 8 Dec., but may lay later still in years of late snow; usual laying period last week Oct. and first half Nov. At lower altitudes laying may be 1–3 weeks earlier than at higher. Chicks leave late Feb. to mid-Apr., according to conditions and site of sub-colony. Non-breeders probably present until mid-Mar. but this needs confirmation. Adult breeders leave colony about 1.5 h before dawn, perhaps almost at dawn on fully moonlit nights; unoccupied birds, 2–2.5 h before dawn but quickly leave if moon comes out of heavy overcast. Fledgelings leave soon after dark.



**SITE** In alpine tussock-grass *Chionochloa* sp., subalpine scrub, especially of *Hebe*, *Hoheria* and *Cassinia* spp, usually on steep slopes but some colonies on quite level ground; generally on eastern versant; burrows sheltered by vegetation or exposed and easily visible from air. Distances between nests c. 0.3–10 m; density about 2 burrows/m<sup>2</sup>.

**NEST, MATERIALS** In slightly enlarged nest-chamber at end of burrows, 60–250 cm long with entrance 13 x 10 cm across. Burrows turn at right angles c. 30 cm from entrance and run parallel to surface for about 1 m so that no part of burrow more than 60–90 cm deep. Chamber lined with dry tussock-grass and white body-feathers; material carried in bill and probably collected from round entrance to burrow. Except that excavation of burrows and collection of material takes place at night, no information on choice of site or role of sexes. Burrows cleaned or dug and nest completed c. 14 days before laying. Some banding evidence to suggest that same pair uses same burrow year after year.

**EGGS** Ovoid; smooth textured; white.

**MEASUREMENTS:**

found on surface: 61.1 (52.3–64.5; 17) x 38.4 (36.2–42.7); from nest-chamber: 59.8 (54.0–65.2; 10) x 40.9 (37.5–46.9).

**CLUTCH-SIZE** One. No replacement laying.

**LAYING** Synchronized within sub-colonies; in snow-free years, 25 Oct. to 18 Nov. with median of 10 Nov.; in years of heavy snow and late thaw may be delayed for 3–4 weeks and may also vary in different parts of same colony according to snow-cover. No further information.

**INCUBATION** By both adults; first shift possibly by male. **INCUBATION PERIOD.** Estimated as 50–60 days; no quantified data. No further information. Eggshells probably trampled in nest and dead chicks not removed.

**YOUNG** Semi-altricial, nidicolous. Hatched with well developed mid-grey down; eyes open. Brooded or guarded by one adult until c. 1 week old (c. 80 g weight), then deserted during daytime. Both parents alternately feed chick, by incomplete regurgitation. **NESTLING PERIOD** estimated as c. 80 days. Parents and older chicks defend themselves by pecking and scratching vigorously. No nest sanitation when chick small, later defecation at entrance to burrow.

**GROWTH** Minimum weight at hatching 58 g. Maximum weight in early Feb., 605 g. No further information.

**FLEDGING TO MATURITY** Fledgelings always leave at night, perhaps mostly before midnight. Totally independent of parents on departure and fully able to fly. First pairing thought to be when c. 3 years old; first breeding, 4–6 years old. No further information.

**SUCCESS** No information except that at Kowhai R. colony (Mar. 1988) 1048 nests produced 34% fledged young. Climatic factors such as late snow probably affect successful fledging. **PREDATORS.** No adequate information regarding predation or losses. Potential enemies are Swamp Harriers *Circus approximans*, NZ Falcons *Falco novaeseelandiae* and Stoats. Historically, Maoris probably took chicks of this species among those of other shearwaters. In general, introduction of Red Deer, Chamois, Hares *Lepus europeus* and Brush-tailed Possums *Trichosurus vulpeca* has probably damaged habitat and encouraged erosion.

**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 with mottled subterminal pale dark-brown (121) band; narrowly tipped white; when worn, have square-cut appearance; white bases of feathers obvious. At centre of foreneck, subterminal band of feathers, less mottled. Generally, foreneck has slight mottled appearance. **UPPER-PARTS,** mostly black-brown (119). Open pennaceous fringes on mantle and rump, dark brown (121). Concealed bases of feathers of 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. Short white filoplumes between median and lesser coverts. When worn, tips of greater, median and lesser coverts, dark brown (119A). **UNDERPARTS**, mostly white. Outer breast-feathers, dark brown (121), narrowly tipped white; when worn, tips of feathers at shoulder, brown (119B) and white tips lost. Flanks, white, distal halves of feathers dark brown (121), narrowly tipped white; rachis white basally, black-brown (119) distally. Thighs and longest under tail-coverts, dark-brown (121), with basal half of feathers, white. Smallest lateral under tail-coverts, white with outer web mostly dark brown (121). Rest of under tail-coverts, white, varying mottled dark-brown (121) at distal tips. Axillaries dark brown (121), pointed and tipped white; sometimes without white tips. **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 of feathers white. Rachis on underside of primaries, light grey-brown (119C), merging to grey-black (82) distally. Outer median and lesser primary coverts, dark brown (121) on outer webs, white on inner; progressively white towards innermost. All marginal coverts, pale dark-brown (121), narrowly fringed white. Rest of coverts, pale dark-brown (121), narrowly tipped white.

**DOWNY YOUNG** Proptoptile, mid-grey; mesoptile, light grey (Harrow 1976). Birds fledge late Feb.-Mar., depending on timing of thaw in previous spring; latest fledging 3 Apr. (Harrow 1976).

**JUVENILE** Similar to fresh plumaged adult except has narrow pale dark-brown (121) tips on white underparts.

**ABERRANT PLUMAGES** Skin (MV), has scattered white feathers on crown and hindneck. Aberrant axillary, having one web with alternate brown and white barring; barring 1 mm wide; recorded in sample (n=100) at breeding colony (Tarburton 1981b).

**BARE PARTS** Based on photos in NZRD, except where stated.

**ADULT, JUVENILE** Iris, black-brown (119). Bill, dark brown (219). Outer margin of tarsus and toes, dark grey (83). Inner margin of tarsus and webs, pink-brown (219D); inner margin of tarsus varies from light pink to dark pink or mauve (Harrow 1976).

**DOWNY YOUNG** Iris, dark brown. Bill, black. Legs and feet, dusky brown.

## MOULTS

**ADULT POST-BREEDING** Complete; at wintering quarters, off nw. coast of Aust. (e.g. Halse 1981). Primaries moult outwards; up to three adjacent inner primaries lost simultaneously. Breeders begin mid-Mar.; non-breeders and early breeders, early Feb. Beachcast specimen, thought to be immature, found at Surfers Beach, SA, beginning moult of contour feathers (Robinson 1973).

**POST-JUVENILE** Undescribed.

**MEASUREMENTS** (1) Kaikoura Pen., NZ, unknown status, recently dead; methods unknown (Tarburton 1981a). (2) Kaikoura Pen., NZ, adults, skins, recently dead breeding birds (NMNZ).

	MALES	FEMALES
WING	(1) 227.0 (4.4; 221-232; 4) (2) 217.3 (5.38; 203-228; 18)	226.0 (3.4; 223-233; 5)
TAIL	(1) 72.0 (4.7; 68-79; 4) (2) 69.4 (3.04; 65-78; 18)	73.0 (2.7; 68-75; 5)
BILL	(1) 36.4 (1.1; 35.4-38; 4) (2) 37.6 (1.48; 34.2-40; 18)	36.4 (0.9; 31.9-37.4; 5)
TARSUS	(2) 43.2 (1.74; 38.2-45; 18)	
TOE	(1) 51.3 (1.2; 50.2-53; 4) (2) 49.8 (2.19; 46.9-55.7; 18)	50.8 (2.4; 47.9-53.7; 5)

(3) Locality details given, birds with bill > 34 mm, skins, beachcast; methods unknown (Robinson 1973). (4) Kowhai R. colony, live birds, Dec. (Wragg 1985).

	UNSEXED
WING	(3) 218 (5.81; 206-223; 6) (4) 224 (3.79; 217-232; 40)
TAIL	(3) 68 (1.91; 66-71; 6) (4) 65 (2.5; 58-70; 40)
BILL	(3) 36.5 (1.22; 34.6-38; 6) (4) 37.2 (1.45; 32.7-40.1; 40)
TARSUS	(3) 41.2 (1.07; 40-42.5; 6) (4) 43.2 (1.20; 40.7-46.8; 40)
TOE	(3) 47.2 (0.98; 46-48.5; 6)

Additional measurements in Serventy (1939), Murphy (1952), Imber & Crockett (1970), Harrow (1976) and Bourne *et al.* (1988).

**WEIGHTS** Mean body weight of 17 live adults at Wharékiri colony, 23 Sept.: 364.1 g (Harrow 1976). Adults from burrows at Kowhai colony, 5 Feb., 345 (22.13; 305-370; 5) (Harrow 1976). Label data from adult beachcast skins (NMNZ): birds emaciated to fat; males 285.8 (40.84; 242-378; 9); females 258.6 (34.70; 205-328; 12). No data on seasonal changes. Details of weights of chicks in Harrow (1976).

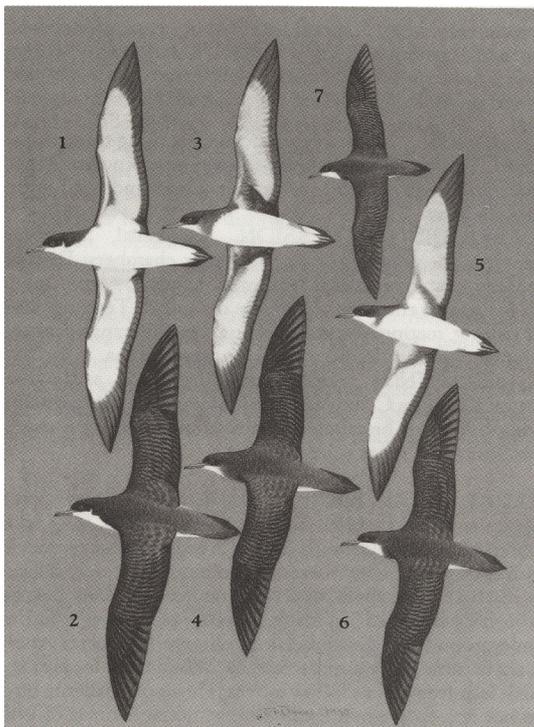
**STRUCTURE** Wing, slender and narrow. Eleven primaries: p10 longest, p9 3-4 mm shorter p8 13-15, p7 27-29, p6 41-42, p5 57-58, p4 71-72, p3 84-86, p2 101-102, p1 115-116, p11 minute. No emarginations. Twenty secondaries, six of tertial form. Twelve rectrices, t1 longest, t6 10-13 mm shorter. Bill, long and slender; nostrils, shallow and lie near base of culmen and point slightly upwards. Maxillary unguis, hooked. Tarsus laterally flattened. Feet, webbed. Claws, sharp and curved. Outer toe and middle toes about equal in length, inner c. 81% of middle, hind, claw only, c. 8%.

**RECOGNITION** Hutton's and Fluttering Shearwaters closely similar; see Fluttering text for details.

**GEOGRAPHICAL VARIATION** None. Sometimes considered subspecies of Manx Shearwater *P. puffinus* (e.g. Murphy 1952). Forms superspecies with Manx Shearwater *P. puffinus* and Fluttering Shearwater *P. gavia* (Peters). Usually regarded as full species, on account of differing biology (e.g. Bourne *et al.* 1988).

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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

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