

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 Tubinaves). 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 (Nectris) nativitatis Streets, 1877, *Bull. US natn. Mus.* 7: 29 — Christmas Island, Pacific Ocean.

Specifically named after type-locality, *nativitas* being the Latin for 'birth' (of Christ).

MONOTYPIC

FIELD IDENTIFICATION Length 35–38 cm; wing-span 71–81 cm; weight 340 g. A medium-sized all-dark shearwater of the tropical Pacific; smaller than any other all-dark shearwater occurring in A'asian region; slightly larger than (bi-coloured) Fluttering *Puffinus gavia* or Hutton's *P. huttoni* Shearwaters. Wings, short and rounded, broader than Short-tailed Shearwater *P. tenuirostris* but more slender than Wedge-tailed Shearwater *P. pacificus*. Tail rounded or slightly wedge-shaped, of moderate length. Feet do not trail beyond tail. Sexes alike. No seasonal variation. Immature resembles adult.

DESCRIPTION ADULT. Uniform sooty-brown, appearing all-dark in field, including entire underwing (no white on coverts). Throat sometimes pale grey. Rarely, primaries may be reflective in strong sunlight. Bill, black; long and slender, moderately stocky for a shearwater, with nostrils slightly raised above base of upper mandible. Iris, brown. Legs and feet, entirely dark brown.

SIMILAR SPECIES All-dark plumage combined with all-dark legs and feet diagnostic, but colour of feet hard to see in field. The only medium-sized all-dark shearwater recorded from A'asian region, although **Heinroth's Shearwater** *P. heinrothi* (a little-known e. NG species) could occur in n. Aust. waters; Heinroth's is much smaller with a pale stripe through central underwing coverts; some have a pale patch in centre of the belly. Heinroth's also has much thinner bill (bill of Christmas Shearwater appearing stockier

in proportion to length), pale flesh-pink legs and feet and fledgelings (at least) have pale blue irides, the only shearwater to possess this feature (see photographs in Hadden 1981; Coates 1985). **Short-tailed** and **Sooty** *Puffinus griseus* Shearwaters are larger, have paler under wing-coverts, and shorter tails with feet extending beyond tip of tail; bill of Christmas Shearwater similar to Short-tailed. **Wedge-tailed Shearwater** is larger and paler brown (not dark brown), with much longer wedge-shaped tail, broader forward-bowed wings and more leisurely style of flight with less flapping. **Flesh-footed Shearwater** *P. carneipes* is much larger than Christmas Shearwater with robust pale bill and pale feet. All-dark members of the genera *Pterodroma* and *Bulweria* have short stout bills and flap less in flight.

Mainly confined to n. and central tropical Pacific, where range overlaps with transient Sooty and Short-tailed Shearwaters and resident Wedge-tailed Shearwater. Rare vagrant to A'asian region. Pelagic, but often seen close to breeding islands. Flight buoyant, close to the sea, with more fast, stiff wing-flapping and less gliding and banking than is typical for Sooty, Short-tailed and Wedge-tailed Shearwaters (Pyle & Engbring 1987; N.G. Cheshire). Associate with feeding flocks of noddies *Anous* spp and other shearwaters. Feed by pursuit-diving and pursuit-plunging. Birds observed in flight over breeding colonies at all times of day but most flights occur before sunset and at night. No reports of calls at sea; pairs call during courtship flights over island, uttering plain-

tive sighs and whines.

HABITAT Marine; in tropical and subtropical waters of central Pacific Ocean; pelagic distribution poorly known. Birds never seen feeding close to shore at Christmas I. (Pac.); thought to travel to feeding grounds several hundred kilometres away (Ashmole & Ashmole 1967); in Nov., abundant in Equatorial Countercurrent at 7°N, up to 400 km from land (Bruyns 1965). However, in e. Polynesia, birds rarely observed more than 30 km from breeding colonies (Holyoak & Thibault 1984). During El Niño Southern Oscillation, increased surface-temperature, deepened thermocline, high sea-level and heavy rainfall led to decline in numbers and breeding failure at Christmas I. (Schreiber & Schreiber 1984). Breed in tropical and subtropical Pacific Ocean, on islands, atolls, and rocky or coralline islets. Nest in cavities in rocky areas, or in scrapes or burrows under trees, bushes or leaf litter (Gallagher 1960; Holyoak & Thibault 1984; Harrison & Jehl 1988). Low soaring and banking flight (Gallagher 1960); swim underwater to catch prey (Ashmole & Ashmole 1967).

Some breeding sites destroyed during World War II, by clearing and construction of military installations and airstrips. Introduced vermin on some breeding islands.

DISTRIBUTION Vagrant to A'asia. Pelagic distribution poorly understood. Most often seen at sea near breeding colonies where, in tropical regions, may remain throughout year; absent from subtropical breeding islands during non-breeding season (King 1967). In e. Pacific Ocean, scattered sightings generally N of equator, between 0° and 20°N and 160°W and 90°W, including off coasts of sw. Mexico and central America (Pitman 1986).

Breed extraliminally on tropical and subtropical islands in mid-Pacific Ocean, N and S of equator: Marshall, Hawaiian, Johnston, Line (including Christmas I.), Phoenix, Marquesas, Austral, Iles Gambier, Pitcairn and Easter Is *inter alia*; formerly, farther W (Bonin, Marcus, Wake Is) (Peters; Harrison 1985).

Only one record for HANZAB area (despite good coverage of n. Coral Sea and nw. Aust.): single, beachcast, Dargaville, NI, NZ, 29 Feb. 1976 (Crockett 1977). One other unconfirmed and unpublished observation, in equatorial waters of PNG, 4 Aug. 1985 (1°20'N, 150°E) (N.G. Cheshire).

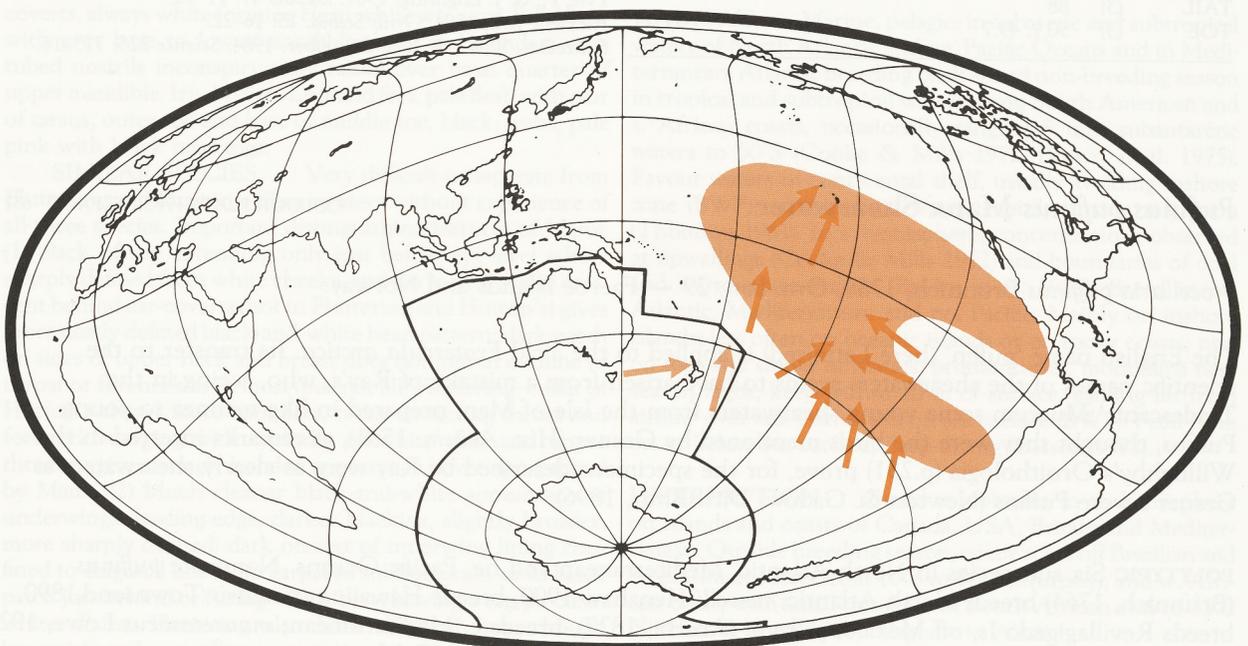
MOVEMENTS Apparently largely local within tropical Pacific though birds from Easter I. may travel to coastal Peru when not breeding (Harrison 1985).

PLUMAGES

ADULT Age of first breeding unknown. In fresh plumage: **HEAD AND NECK.** Chin and throat, pale dark-brown (121); concealed feather bases, light grey-brown (119C). Rest of head and neck, dark brown (121). **UPPERPARTS,** entirely dark brown (121); all feathers except scapulars have narrow open pennaceous fringes of slightly paler dark-brown (c119A). Rachis on upperparts, dark brown (119A) merging to black-brown (119) distally. **TAIL,** black-brown (119). **UPPERWING.** Remiges and marginal coverts, black-brown (119). Greater, median and lesser coverts, dark brown (121) with open pennaceous fringes slightly paler. Greater primary coverts and alula, dark brown (121). Rachis on remiges, dark red-brown (221A). Inner webs of remiges, pale dark-brown (121). **UNDERPARTS,** similar to upperparts; fringes narrower; feathers long, and rather loose on flanks. Concealed feather bases on breast, light grey-brown (119D); rachis of breast feathers, brown (121C), merging to dark brown (121) distally. **UNDERWING.** Greater primary coverts and greater coverts, glossy brown-grey (79). Median and lesser coverts, dark brown (119A). Marginal coverts, dark brown (121), fringed dark brown (119A); rachis, dark brown (219). In worn plumage: fringes of mantle, brown (119B). Greater, median and lesser upper wing-coverts, fringed light grey-brown (119C) through wear.

DOWNY YOUNG Down, sooty black.

JUVENILE Undescribed. Period of fledging noted



by Harrison (1985) as unknown. Harrison & Jehl (1988) visited Sala Y Gomez in Mar. and remarked that a few birds were ready to fledge at this time.

BARE PARTS

ADULT Iris, brown. Bill, black. Legs and feet, dark brown.

DOWNY YOUNG, JUVENILE Undescribed.

MOULTS Largely undescribed.

ADULT POST-BREEDING Breeders moult primaries during later weeks of feeding chicks; completed after leaving colony.

POST-JUVENILE Undescribed.

MEASUREMENTS Few data. (1) Easter I., adult skins; methods unknown (Johnson *et al.* 1970). (2) Single adult male (NMNZ; AM). (3) Adults, unsexed (NMNZ; AM). (4) Hawaiian Is, Apr.-Aug., fresh birds; methods unknown (Harrison *et al.* 1983).

	MALE	FEMALE
WING	(1) 260, 251	240, 250
	(2) 256	
BILL	(1) 24, 23	22, 23
	(2) 33.4	
	(4) 32.3 (1.26; 10)	
TARSUS	(1) 38, 41	
	(2) 45.3	35, 41
TAIL	(1) 94, 92	90, 95
	(2) 88	
TOE	(2) 51.5	
	UNSEXED	
WING	(3) 254, 250	
BILL	(3) 30.2, 31.5	
TARSUS	(3) 42.5, 44.4	
TAIL	(3) 88	
TOE	(3) 50.1, 49.7	

Ranges for wing-length (Johnson *et al.* 1970): Christmas I. (Pac.) (239-245; 8); Hawaiian Is (239-257; 20); Leeward Is (236-250; 32); Wake & Marshall Is (233-250; 6); Johnston Atoll (235-256; 8); Phoenix Is (223-253; 14). Feeding- and growth-rates of chicks given in Ricklefs (1984).

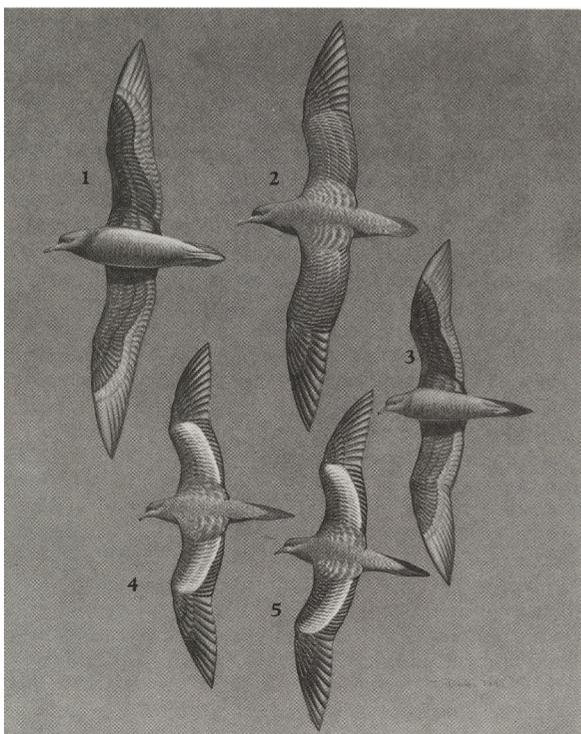
WEIGHTS Few data. At Hawaiian Is, 356 (29.84; 280-415; 99) (Harrison *et al.* 1983; details as above); at Christmas I. (Pac.), 340 (19; 10) (Ricklefs 1984).

STRUCTURE Wing, short narrow. 11 primaries: p10 longest, p9 1-6 mm shorter, p8 18-23, p7 31-40, p6 51-59, p5 69-77, p4 89-98, p3 107-113, p2 127-129, p1 143 (n=1), p11 minute. No emarginations. 19 secondaries, 4 of tertial form. Tail short and rounded; 12 rectrices, t1 longest, t6 c. 25 mm shorter. Bill, long and slender. Nares shallow, near base of culmen; 25% of bill length. Legs, slender. Feet, webbed. Outer and middle toes about equal, inner c. 73% of middle, hind, claw only c. 5.

RMO

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Volume 1 (Part A), Plate 41

Christmas Shearwater *Puffinus nativitatis*

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

Bulwer's Petrel *Bulweria bulwerii*

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

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