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 **HYDROBATIDAE (OCEANITIDAE) storm-petrels**

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

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

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

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

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

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Oceanodroma leucorhoa Leach's Storm-Petrel

COLOUR PLATE FACING PAGE 665

Procellaria leucorhoa Vieillot, 1817, *Nouv. Dict. Hist. nat., nouv. éd.*, 25: 422 — coast of Picardy, France.

The generic name is compounded of the Greek ὠκεανός (ocean) and δρόμος (running) = ocean-runner. The specific name means *white-rumped* from the Greek λευκός and ὄρρος (rump), badly transcribed.

OTHER ENGLISH NAMES Fork-tailed Storm-Petrel, Leach's Petrel, Leach's Fork-tailed Petrel.

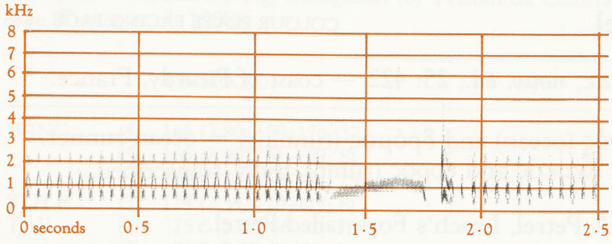
English name honours Dr W.E. Leach (1790–1836) of British Museum, who bought a specimen 'of an undescribed Petrel with forked tail' at auction of William Bullock's collection in 1819, for £5.15.0. Bullock had collected specimen at St Kilda in 1818. Temminck named this bird *Procellaria Leachii* in 1820 but later it was found that Vieillot had already described the species in 1817 (Mearns & Mearns *Biogr. Birdwatch.* 1988).

POLYTYPIC Nominate *leucorhoa*, Atlantic and N. Pacific birds; three other subspecies (*beali*, *chapmani* and *socorroensis*) described from North American coasts between se. Alaska and Revillagigedo Is, Mexico.

FIELD IDENTIFICATION Length 19–22 cm; wing-span 45–48 cm; weight 48.4 g. Medium-sized storm-petrel, accidental in A'asian region; all-dark except for white rump; tail, forked; wings, long angular and pointed. Sexes alike. No seasonal changes. Juveniles as adults.

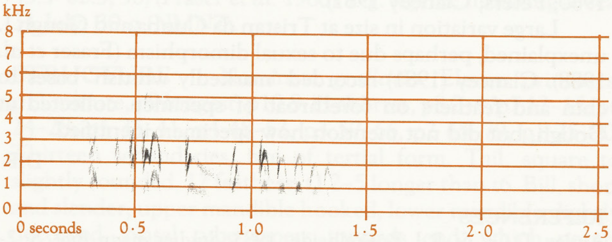
DESCRIPTION ADULT. All blackish brown with grey bloom in fresh plumage; blackest on crown, lesser upper wing-coverts, primaries and their coverts, outer secondaries and tail. Throat and face, slaty grey. Pale diagonal bar on upperwing from carpal joint to posterior wing base formed by middle and greater upper coverts, inner secondaries and longest scapulars, which grey-brown, some fringed whitish when new. White patch on rump formed by white tips of lower rump-feathers, white upper tail-coverts, white base to outer tail feathers and by white outer webs and tips of some adjacent flank feathers. Dark central line through white patch formed by dark tips to longest central feathers; white upper tail-coverts have dark shafts. Black tail, long and moderately forked. Underparts, browner, underwing ashy brown. Bill, black. Iris, brown. Legs and feet, black, not extending beyond tail in flight.

SIMILAR SPECIES Difficult to distinguish from other black storm-petrels with white rumps and identification often based more on differences in proportions and flight-style than plumage differences. In our region, only likely to be confused with **Wilson's Storm-Petrel** *Oceanites oceanicus*, which is smaller and darker, with shorter broader wings with rounded tips; no pronounced bend at carpal joint characteristic of *Oceanodroma* storm-petrels. When close, distinguished by long black legs and yellow webs extending beyond square tail whereas in Leach's legs shorter, not extending past forked tail. Broad white band on rump of Wilson's Storm-Petrel more obvious than V-shaped pattern of Leach's; grey central line through rump of Leach's Storm-Petrel may be visible. Upper wing-bar of Wilson's appears shorter and broader than Leach's. Flight of Wilson's erratic, fluttering and bat-like whereas Leach's fast, direct and strong with deep wing-beats interspersed with glides on bowed wings, but in travelling flight, Wilson's more direct than that of Leach's with faster shallower wing-beats and shorter glides (Harrison 1983b). Foraging flights very different: Wilson's hold wings in V, high over back, foot-pattering across surface, whereas Leach's hold wings slightly above back (up to 20°) and usually just above horizontal. Wilson's Storm-Petrel regularly follow ships unlike Leach's. **British Storm-Petrel** *Hydrobates pelagicus* and **Madeiran Storm-Petrel** *O. castro* are closely similar in plumage and best distinguished by flight and jizz, but neither has yet occurred in our region.



A Recordist unknown; Bay of Fundy, Canada; B981

Oceanic, pelagic. Flight, fast, direct and strong with deep wing-beats interspersed with glides on bowed wings. During foraging flight, wings held only slightly above back and usually just above horizontal. Strictly surface feeder, foot-pattering and splashing across water, occasionally walking (Harrison 1983b); observed foraging at night (Gordon 1955) and during day (Watanuki 1986). Strictly nocturnal at breeding colonies, activity depending on intensity of moonlight (Imber & Lovegrove 1982; Watanuki 1986). Call in flight, at sea, over breeding grounds or in burrows and calls important in detection of this species outside its normal range: two calls reported by Palmer (1962) and Randall & Randall (1986); most common call consists of staccato ticking, ending in slurred trill (Palmer 1962; sonagram A); also crooning, chuckling (sonagram B, recorded in flight) and purring calls. Scream call used when in burrows (Randall & Randall 1986). Flight-call may be given at sea. The above calls all noted at Chatham Is (Imber & Lovegrove 1982).



B Recordist unknown; Bay of Fundy, Canada; B981

HABITAT Marine, pelagic; n. hemisphere breeding species; in cool or cold waters fringing Subarctic, and associated with convergences and upwelling in lower latitudes (BWP). In non-breeding season, migrate to tropical and subtropical waters, even to Subantarctic Zone (BWP). Off California, more abundant seaward of continental slope than over shelf, particularly in waters of S-flowing California Current, which are clearer, warmer and fresher than coastal waters. Shoreward limit of distribution, increased temperature gradients at outer edge of coastal upwellings (Briggs *et al.* 1987).

Breed on islands in North Pacific and Atlantic Oceans, using crevices in rock outcrops, talus or ruins, or burrows in soft soil or among tree roots. At Chatham I., two birds engaged in pre-breeding activity; one found in burrow among *Cyperus-Embergeria*, 0.5 m high (Imber & Lovegrove 1982).

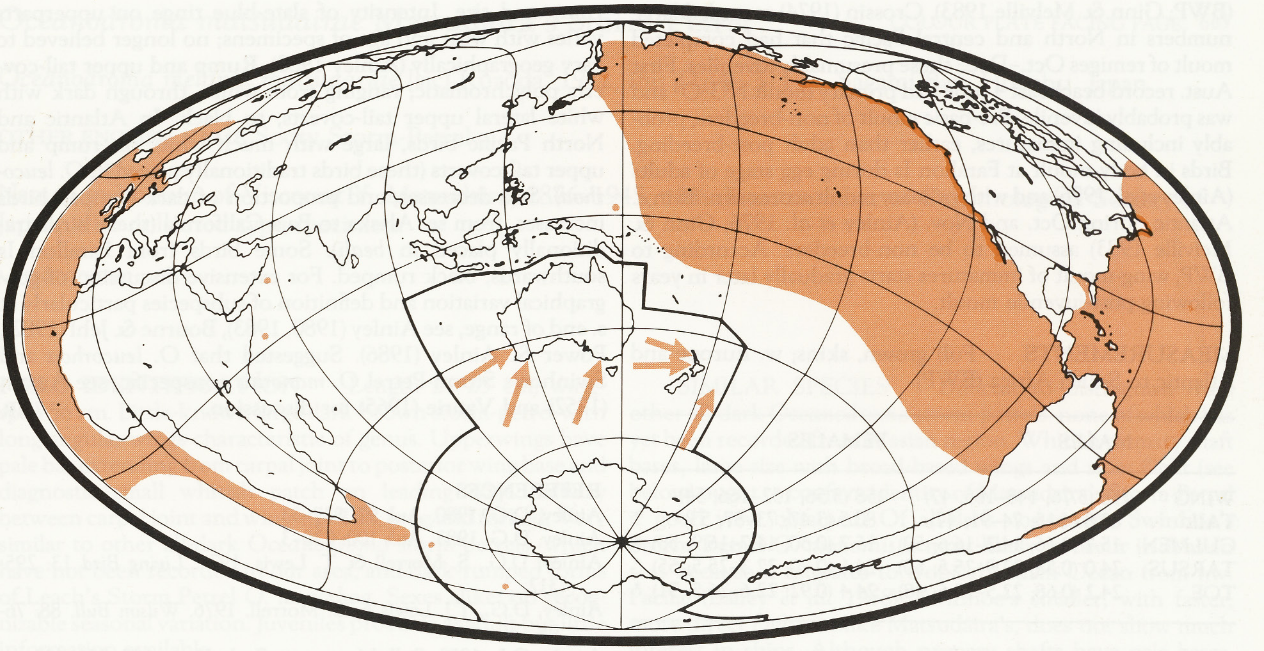
When feeding, fly immediately above water. During migration, rest on sea (Crossin 1974).

DISTRIBUTION Breed n. hemisphere, Pacific and Atlantic Oceans, mainly between 40°N and 70°N moving S in non-breeding season to tropical and subtropical waters, few reaching Subantarctic Zone (BWP). In winter, occasionally found N in Indian Ocean (Harrison 1983a), and once in Southern Ocean, 57°40'S, 05°00'E (Bierman & Voous 1950); adult of North Pacific race recorded in May off n. PNG (N.G. Cheshire). Accidental to our region.

AUST. Vagrant. One beachcast, Tower Hill, Vic., 4 June 1965 (MV B8423); one beachcast, Pelican Pt, WA, 16 Apr. 1978 (Broadhurst 1979); one sighted off Fremantle, WA, May 1979 (RAOU 1988); one exhausted (later died), Bremer Bay, WA (9 km from sea), 18 July 1984 (Johnstone 1985).

NZ Vagrant. One beachcast, W Auckland coast, Aug. 1922 (NZCL; Oliver); one specimen beachcast near Waharoa, Waikato, Apr. 1978 (Fooks 1978); one beachcast near Dargaville, Auckland w. coast in Aug. 1978 (Veitch 1980). Two, Rabbit I., Chatham Is, Nov. 1980 and possibly prospecting for nest-sites (Imber & Lovegrove 1982); one seen off Chatham I., 2 Dec. 1983 (M.J. Imber).

MOVEMENTS Migrant to Tropics from breeding sites in North Pacific and North Atlantic. Though present in central Pacific throughout year, numbers start to increase Sept., high over s. summer and decline again Mar. onwards, reaching s. winter levels late Apr. (Crossin 1974). Move S from n. Atlantic Sept. onwards, some down w. side to winter off Brazil, rest down e. side to Gulf of Guinea, returning N, Mar.–mid Apr., with some, presumably pre-breeders, remaining in Tropics over summer (BWP). Few Atlantic birds travel so far as Benguela region, some apparently rounding South Africa and migrating N in Indian Ocean (Harrison 1983a), few over-



shooting into Southern Ocean (Bierman & Voous 1950). Vagrants recorded Aust. and NZ thought to be from Atlantic population (Imber & Lovegrove 1982) but could be from Pacific. May be becoming established in s. hemisphere: birds at Rabbit I., NZ, had adjusted moult cycle and behavioural patterns to s. hemisphere conditions (Imber & Lovegrove 1982); records of birds at potential breeding islands off South Africa confined to late Oct. to late Jan., though possibly all of one bird (Randall & Randall 1986). Other A'asian records (see Distribution) have been Apr., May, July and Aug. Adult of North Pacific race recorded in May off n. PNG (N.G. Cheshire).

PLUMAGES Nominate *leucorhoa* from Atlantic and North Pacific.

ADULT Definitive pre-basic; age of first breeding at least 4 years (Grubb 1973). **HEAD AND NECK.** Mostly black-brown (c119) fading to dark brown (c119A), with brownish-grey forehead, front of lores, and chin. **UPPERPARTS.** Mostly black-brown (c119) fading to dark brown (c119A), with strong slate-blue (pale 87) tinge when fresh. Longest scapulars have narrow white tips. White patch on lower rump and upper tail-coverts often partly or completely divided by black-brown central streak, broadest near tail. Shafts of upper tail-coverts, dark brown (c119A). Upper tail-coverts often have blackish brown (c121) markings near tip of each web, broadest in central feathers; size of markings varies and central upper tail-coverts may be all dark (BWP). **TAIL.** Blackish; sometimes with concealed white at base of outer feathers. **UPPERWING.** Tertials, secondary and median secondary coverts, grey-brown (light 119A) with narrow creamy-brown (119D) tips and outer edges. Alula, black brown with grey-brown (light 119A) tips. Other coverts and remiges, black-brown; primary shafts, black-brown (c119) merging to concealed white base. **UNDERPARTS.** Blackish brown; when fresh, slate-blue (pale 87) tinge strongest on upper breast. Lateral under tail-coverts, white with blackish-brown (119A) shafts; some longer lateral under tail-coverts have white outer webs, but most black-brown. **UNDERWING.** Black-brown. Remiges and greater under wing-coverts have light-grey (85) gloss in some lights.

JUVENILE Light edges of tertials, secondary, and secondary median coverts, broader than adult. Outer primary pointed at tip (rounded in adult); plumage wear and intermediates make this characteristic hard to use (BWP).

BARE PARTS

ADULT, JUVENILE Iris, dark brown (22). Bill, tarsus and feet, black (89).

MOULT Based on Ainley *et al.* (1976) at Farallon Is, California, except where stated. Additional information in Mayaud (1949–50), Palmer (1962), Crossin (1974), Harris (1974), Ainley *et al.* (1974), BWP and Ginn & Melville (1983). Timing of moult presumably different in winter breeding population from Gaudalupe I.

ADULT PRE-BREEDING Pre-basic. Complete. Protracted body-moult begins mid-June, about time of hatching, and finishes about Mar., 8–9 months later, about week after completion of primary and secondary moult. Tail-moult begins about 29 days after body-moult; duration about 75 days; nearly complete before wing-moult begins. Tail feathers most commonly lost in sequence 6, 4, 2, 1, 3, 5; in some birds, all rectrices may be in varying stages of growth. Outwards primary moult begins second half Aug., about 70 days after start of body-moult, and continues through winter; few complete moult at start of pre-egg stage, between mid-Feb. and mid-Apr., but most complete moult before returning to breeding grounds. No records of birds growing more than two primaries per wing at one time, save for bird mentioned in Bourne (1982) growing 4–5 primaries. Secondaries inwards from s1 and s5; centrifugal centre at s11 and s12. Moult apparently later in Atlantic, where body-moult first recorded end of breeding season; beachcasts in Oct.–Nov. in early stages of wing- and tail-moult.

POST-JUVENILE In Atlantic, complete; remiges start about Apr. of second year, completed by Oct.–Dec.

(BWP; Ginn & Melville 1983). Crossin (1974) recorded large numbers in North and central Pacific that had completed moult of remiges Oct.–Dec.; these presumably juveniles. First Aust. record beachcast 4 June had primary moult $N^63^1O^3$ and was probably juvenile. Pre-basic moult of non-breeders, probably including immatures, earlier than adult post-breeding. Birds in body-moult at Farallon Is during egg stage of adults (Ainley *et al.* 1976) and with primary moult scores of *c.* 35 in e. Atlantic during Oct. and Nov. (Ainley *et al.* 1976; Ginn & Melville 1983) assumed to be non-breeders. According to BWP, wing-moult of immatures starts gradually later in years following post-juvenile moult.

MEASUREMENTS Full grown, skins; w. Europe and Atlantic to South Africa (BWP).

	MALES	FEMALES	
WING	158 (3.76; 148–165, 47)	158 (3.56; 152–166; 54)	*
TAIL	80.8 (4.15; 74–91; 47)	80.5 (3.47; 73–87; 53)	*
CULMEN	15.7 (0.46; 14.2–16.6; 50)	15.7 (0.50; 14.7–16.9; 56)	*
TARSUS	24.0 (0.58; 22.9–25.5; 50)	24.1 (0.70; 22.3–25.5; 55)	*
TOE	24.2 (0.68; 22.5–25.6; 48)	24.4 (0.92; 22.6–26.5; 51)	*

Females slightly larger than males (Crossin 1974; Ainley 1980).

For measurements of Pacific skins, especially at breeding colonies, see Loomis (1918), Crossin (1974), Ainley (1980); for measurements of live Atlantic birds see BWP, Love (1978), Furness & Baillie (1981).

WEIGHTS

ADULT St. Kilda, UK, May 44.9 (2.0; 41–48; 8); end June–mid Aug. 45.0 (3.5; 39–55; 28) (Waters 1964). Farallon Is; pre-egg mean 41.9; end nesting season, mean when chicks nearly full grown, 38.7 (Ainley *et al.* 1974). Wintering Aug.–Apr. in Atlantic, including juveniles, 39.9 (4.89; 33–52; 14; BWP).

JUVENILE Netherlands beachcasts 29.5 (4.39; 26–37; 6; BWP). Further information in Gross (1935), Palmer (1962), Harris (1974), Love (1978), Furness & Baillie (1981).

STRUCTURE Mostly from BWP; further information on wing formulae and depth of tail-fork in Ainley (1980). Eleven primaries, p9 longest, p11 minute, p10 5–12, p8 1–5, p7 9–15, p6 20–28, p1 76–92 shorter. Fourteen secondaries. Tail, forked, 12 feathers, t6 19.0 (2.1;50) 16–26 longer than t1. Bill, rather slender, decurved, nasal tubes *c.* 40% bill-length. Tarsus and toes, slender and scutellated; tarsus and middle toe of about equal length; outer toe, almost equals middle toe, inner toe, *c.* 20% shorter. Claws, narrow and pointed.

GEOGRAPHICAL VARIATION Mostly in colour of rump and size. Intensity of slate-blue tinge on upperparts varies with wear and age of specimens; no longer believed to vary geographically (Ainley 1980). Rump and upper tail-coverts polychromatic, ranging from white, through dark with white lateral upper tail-coverts, to black. In Atlantic and North Pacific birds, large with much white on rump and upper tail-coverts (these birds traditionally placed in *O. leucorhoa*). Size decreases, and proportion of dark rumped birds increases, from se. Alaska to Baja California (these birds traditionally placed in *beali*). Some birds from Farallon Is southwards, black rumped. For extensive discussion of geographical variation and definition of subspecies particularly at s. end of range, see Ainley (1980, 1983), Bourne & Jehl (1982), Power & Ainley (1986). Suggested that *O. leucorhoa* and Swinhoe's Storm-Petrel *O. monorhis* conspecific, see Austin (1952) and Vaurie (1965) for discussion.

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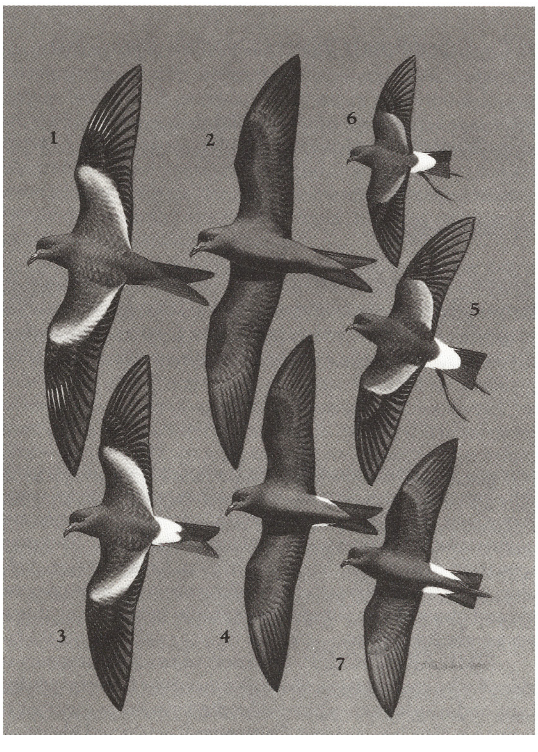

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Matsudaira's Storm-Petrel *Oceanodroma matsudairae*
1. Adult, dorsal
2. Adult, ventral

Leach's Storm-Petrel *Oceanodroma leucorhoa*
3. Adult, dorsal
4. Adult, ventral

Wilson's Storm-Petrel *Oceanites oceanicus*
5. Adult, dorsal, fresh
6. Adult, dorsal, worn
7. Adult, ventral