Order PELECANIFORMES

Medium-sized to very large aquatic birds of marine and inland waters. Worldwide distribution. Six families all breeding in our region. Feed mainly on aquatic animals including fish, arthropods and molluscs. Take-off from water aided by hopping or kicking with both feet together, in synchrony with wing-beat. Totipalmate (four toes connected by three webs). Hind toe rather long and turned inwards. Claws of feet curved and strong to aid in clambering up cliffs and trees. Body-down evenly distributed on both pterylae and apteria. Contour-feathers without after shaft, except slightly developed in Fregatidae. Pair of oil glands rather large and external opening tufted. Upper mandible has complex rhamphotheca of three or four plates. Pair of salt-glands or nasal glands recessed into underside of frontal bone (not upper side as in other saltwater birds) (Schmidt-Nielson 1959; Siegel-Causey 1990). Salt-glands drain via ducts under rhamphotheca at tip of upper mandible. Moist throat-lining used for evaporative cooling aided by rapid gular-flutter of hyoid bones. Tongue rudimentary, but somewhat larger in Phaethontidae. Throat, oesophagus and stomach united in a distensible gullet. Undigested food remains are regurgitated. Only fluids pass pyloric sphincter.

Sexually dimorphic plumage only in Anhingidae and Fregatidae. Selection of nest-site and initiation of pair-formation by male, but in Pelecanidae female first leads several males in a male-selection (or persistence) chase as in ducks. Nest built by female with material brought to nest-site mainly by male. Copulation normally on nest-site. Both sexes take turns guarding nest-site, incubating eggs, and brooding and feeding chicks. Eggs unicoloured with chalky finish except for Phaethontidae. Webbed feet used to warm eggs. Chicks hatch naked (except in Phaethontidae) and blind. Later fully covered with down for several weeks. Newly hatched chicks take fluid food from tip of parental bill. Older chicks take partly digested food from parental gullet, except in Phaethontidae, in which parent inserts bill into gullet of chick. Chicks become independent usually within a few weeks after fledging and at fledging in gannets *Sula* spp. At nesting colonies severe loss of eggs and chicks may result from human disturbance, parents being forced off nests, so that eggs and chicks become cold or overheat or are taken by predators.

Anatomical and behavioural similarities suggest close phylogenetic affinities between Pelecaniformes and Ciconiiformes, which could perhaps be united. Cottam (1957) found skeletal characters that suggest that the Shoe-billed Stork *Balaeniceps rex*, only member of the African family Balaenicipitidae, ought to be in Pelecaniformes rather than Ciconiiformes. Linnaeus (1758) included all pelecaniform birds known to him, except those in *Phaethon*, in the genus *Pelecanus*, from which Brisson (1760) removed the genera *Sula*, *Anhinga*, *Phalacrocorax* and *Fregata*. Subsequently these genera became the bases of six families in the order Pelecaniformes, formerly known as the Steganopodes. Over the last 200 years there has been debate about whether *Phaethon* and even *Fregata* ought to be included, and whether *Anhinga* ought to be in the same family as *Phalacrocorax*. There is ample behavioural (van Tets 1965), osteological and palaeontological (Olson 1985) evidence to demonstrate that there are six distinct extant families in the Pelecaniformes.

REFERENCES

Brisson 1760. *Orn.* 1: 60, 6: 511.
Cottam, 1957. *Bull. Br. Mus. nat. Hist. Zool.* 5: 49–72.
Linnaeus, C. 1758. *Systema Naturae Ed.* 10, Vol. 1.
Olson, S.L. 1985. *Av. Biol.* 8: 79–238.
Schmidt-Nielson, K. 1959. *Sci. Am.* 200: 109–16.
Siegel-Causey, D. 1990. *Auk* 107: 110–18.
van Tets, G.F. 1965. *AOU orn. Monogr.* 2.

Family PHALACROCORACIDAE cormorants and shags

Medium-sized to large aquatic birds of marine and freshwater habitats. Worldwide, 30–40 species, depending on recognition of forms as full species or subspecies. Many isolated insular forms are sensibly regarded as full species. Here we recognize 19 species occurring in our region; after Peters, placed in a single genus *Phalacrocorax*. However, latest arrangements (Siegel-Causey 1988; G.F. van Tets) are more elaborate and divide the family into two sub-families: Phalacrocoracinae (cormorants) with two genera (*Phalacrocorax* or macrocormorants and *Microcarbo* or microcormorants) and Leucocarbinae (shags) with three genera (*Stictocarbo* or cliff-shags, *Nannopterum* or island-shags and *Leucocarbo* or trek-shags). The genus *Phalacrocorax* has two sub-genera: *Phalacrocorax* (*s.s.*) of two species, *carbo* occurring in our region, and *Hypoleucos* of five species, *varius* and *sulcirostris* occurring in our region. *Stictocarbo* has seven species, *punctatus* and *featherstoni* forming a superspecies in our region. *Nannopterum* has 15 or more species, 12 of which belong to our region; their distribution and association in superspecies is most easily shown on Fig. 1. *Leucocarbo* has six species but only *fuscescens* occurs in our region. Long broad head with patterns of tuft-like crests, which are the origin of the term 'shag'; rather long serpentine neck; broad elongate body; wings broad at base, less broad in outer part, with 11 primaries (p8 and 9 longest) and 17–23 secondaries, diastataxic; stiff wedge-shaped tail, short in shags and long in cormorants, 12–14 feathers. Bill, sub-conical, strong, medium-long, hooked, laterally compressed, without serration; nostrils closed. Gular skin, bare, varying in extent and colour in different species. Tarsus, thick; long toes with outermost longest, totipalmate; middle toe, pectinate. Tibia, feathered. Oil-gland, feathered. Plumage, black, often with metallic sheen, or black above and white below. Sexes similar with some seasonal changes, mostly affecting crests and facial colours. Juveniles recognizable by colour-patterns of plumage; attain adult plumage when 1–4 years old.

Stance upright; gait waddling, legs being set far back towards tail; cormorants, but not shags, able to perch in trees, on wire and similar thin perches. Swim well, body low in water and even partly submerged, tail flat on water; on surface use feet alternately but under water use both feet together in unison. Plumage is permeable under water and sheds air so that buoyancy is reduced; out of water, plumage repels the water, traps air and increases thermal insulation. Thus, swimming in cold water limited to less than 30 min, otherwise hypothermia sets in. Some species reduce buoyancy further by swallowing pebbles (van Tets 1968, 1976). Indigestible matter regurgitated as pellet about once a day with repetitive *gock-gock-gock...* sound that attracts gulls *Larus* spp for scavenging. In some species, distinctive posture held with wings spread on either side of body during loafing when out of water; thought to be mainly for drying wings but plumage is thoroughly waterproof and oil gland often used when preening. Some hours each day may be spent flying between colonies or roosts and feeding areas. Flight powerful with alternating periods of wing-beats and gliding as in gannets; adopt V-formation in travelling flight. Where colonies far from feeding areas, females leave to feed in mornings, males in afternoon. Much of day spent loafing and so plenty of time for courtship rituals, which take up a major part of activities all year in some species. Feed mostly on fish, caught by surface-diving or pursuit-swimming; sometimes co-operatively and often in dense flocks. Migratory and dispersive; movements probably usually by day. However, island shags seem to be entirely sedentary.

Pair-bond monogamous, maintained mostly or entirely at nest-site. Male selects site and advertises for mate; once accepted, female builds nest with material brought by male. Copulation takes place on nest. Advertising displays by male specially well developed. Movements by both sexes associated with ritualized take-off, landing and locomotion postures and include Pre- and Post-take-off postures, Kink-throating, Circle-flying, Hopping with Pre- and Post-hop postures, and Penguin-walking, which is particularly noticeable in females in search of mate and in males seeking nesting material. Allopreening and entwining of necks occur, probably to maintain pair-bond. Calls are mostly unspecialized; males generally give a variety of croaks, grunts, and groans, whereas females hiss or are relatively silent; calling usually confined to breeding colonies. Bathing in groups may be spectacular and has been misidentified as display (van Tets 1965). Comfort-behaviour consists of gular fluttering to dissipate heat; direct head-scratching; true yawning and jaw-stretching.

Typically breed colonially. Defend small nest-territory. Nests often densely packed and associated with other species such as herons, ibises and spoonbills. Season extended but least so in temperate latitudes. Nests on ground, on cliffs and in trees; used from year to year; built of any available plant material, seaweed and debris to form substantial heap but sometimes nothing more than a scrape in the ground. Tend to continue building during incubation and nestling periods. Eggs, elongate oval, pale blue or green with white chalky coating. Clutch-size, usually 2–4 (1–7 extremes); single-brooded but replacements laid after loss. Incubation by both sexes in approximately equal shares; change-overs at least once or twice a day. Incubation starts with first egg; eggs incubated on feet. Incubation period, 27–31 days. Eggshells removed from nest. Hatching asynchronic. Young

altricial, nidicolous; hatched naked but develop a single coat of dense white, brown or black down. Cared for by both parents; brooded continuously while small; fed by incomplete regurgitation; in cormorants, but not in shags, adults may bring water to young in hot weather. Nestling period, *c.* 70 days at most but usually 48–53 days. Young attended and fed by both parents for 2–3 months or more after fledging.

REFERENCES

Siegel-Causey, D. 1988. *Condor* 90: 885–905.
van Tets, G.F. 1965. *AOU orn. Monogr.* 2.
van Tets, G.F. 1968. *Emu* 67: 224.
van Tets, G.F. 1976. *Emu* 76: 151–2.

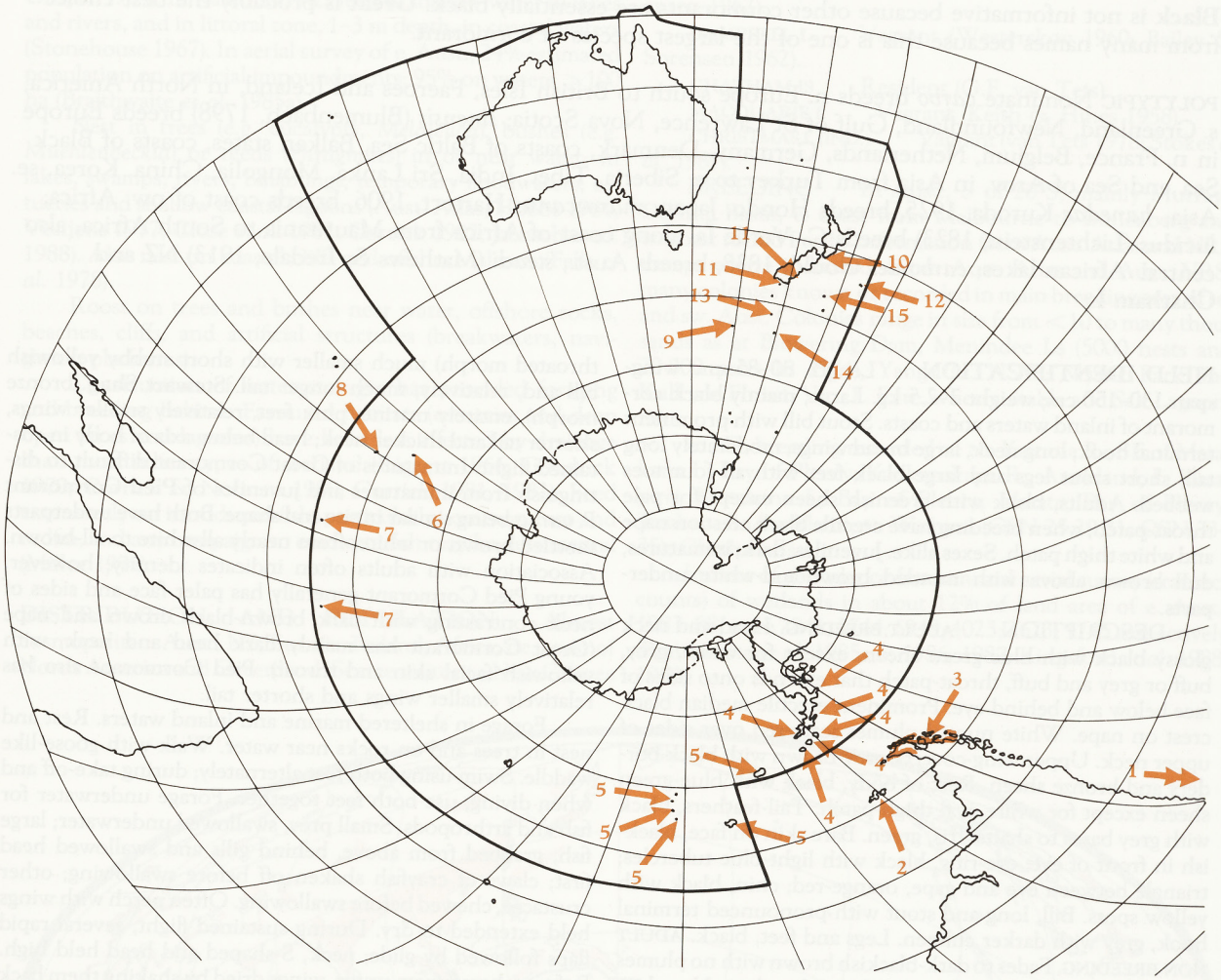


Fig. 1. Distribution of island forms of *Phalacrocorax*.

1 *harrisi* (Galapagos Is)
2 *albiventer*
3 *atriceps*
4 *bransfieldensis*
5 *georgianus*
6 *nivalis*
7 *melanogenis*
8 *verrucosus*
9 *purpurascens*
10 *carunculatus*
11 *chalconotus*
12 *onslowi*
13 *colensoi*
14 *campbelli*
15 *ranfurlyi*

Pelicanus [sic] punctatus Sparrman, 1786, *Mus. Carlsonianum*, fasc. 1, no. 10 and pl. — Queen Charlotte Sound, South Island, New Zealand.

Generic name compounded of Greek στικτός (marked, spotted) and Latin *carbo* (charcoal, black); specific name, Latin for 'spotted'. Subspecies *steadi* Oliver, 1930, named in honour of E.F. Stead (1881–1949), field naturalist of Christchurch, New Zealand, but preoccupied by *Carbo carbo steadi* Mathews & Iredale, 1913.

OTHER ENGLISH NAMES Crested or Ocean Shag, Flip-flap, Parekareka and Padeggadegga, Blue Shag (for subspecies *oliveri*).

POLYTYPIC NZ endemic. Nominate *punctatus* NI and SI, NZ; *oliveri* Mathews, 1930, from Stewart I. and Westland.

FIELD IDENTIFICATION Length 64–74 cm; wingspan 91–99 cm; weight 0.7–1.2 kg. Small slender marine shag occurring round the three main islands of NZ. long and very slender bill with small terminal hook. Long and sinuous neck. Slim body, long slender wings, short stubby tail. Legs and feet, yellow or orange. Sexes alike. Seasonal differences in plumage. Immatures separable.

DESCRIPTION ADULT BREEDING. Crown and hindneck, black glossed with green. Long black crests curl forward on forehead and nape. Broad white stripes start round eyes and extend down sides of head and neck to base of wing; stripe widest near nape and reduced by varying amounts of grey during breeding season. Mantle, scapulars and upperwings, light brownish-grey, each feather with prominent black spot at tip; primaries, browner. Back, rump and upper tail-coverts, as crown. Long white filoplumes scattered over head, neck, back, rump and thighs. Tail, black with pale-grey bases to shafts. Chin, throat, upper foreneck, abdomen, flanks and thighs, as crown. White line along base of throat in some birds. Lower foreneck and breast, grey. Under tail-coverts, black. Underwing, brownish black. Bill, long and very slender, orange-brown with dark culmen and cream bar at base of lower mandible. Facial skin in front of, round and below eye, bright blue-green; gular pouch dark blue. Eye-ring, blue. Iris, dark brown. Legs and feet, orange. ADULT NON-BREEDING. Plumage duller. Crests, much reduced and no white filoplumes. White stripes on side of head and neck obscured by dark feathers. Facial skin, grass green. Legs and feet, orange. JUVENILE. Dark grey with small white filoplumes above, pale grey below. Upper wing-coverts, grey-brown with thin black borders and terminal spots. Soft parts, brownish yellow. Eye-ring, pale green. Iris, green. IMMATURE. Most of upperparts, grey-brown, feathers of mantle, scapulars and upper wing-coverts with dark tip. Small grey crest on forehead. Pale-grey stripe along side of head and neck. Upper foreneck and hindneck, dark grey-brown. Back, rump, and tail, ashy brown. Thighs, ashy brown. Rest of underparts, greyish white or cream. Bill, yellow-pink. Facial skin and eye-ring, yellow. Iris, dark brown. Legs and feet, yellow.

SIMILAR SPECIES Slender build and greyish plumage quite unlike other NZ shags and cormorants. Cormorants have much longer tails and, in sustained flight, their necks S-shaped with heads held high. **King Shag** *P. carunculatus* and **Stewart Shag** *P. chalconotus*, heavier with thicker necks and shorter wings. **Pitt Shag** *S. featherstoni* does not occur round main islands of NZ.

Usually forage in open sea (2–16 km from shore; Stonehouse 1967) but enter inlets and estuaries to feed and roost. Rest and nest on narrow ledges of steep cliffs. Flocks often roost on low rocks or man-made structures at high tide. Walk with fairly rapid, high-stepping gait, upright body leaning slightly forward. Swim with feet alternating at surface, and with both feet moving together during take-off and when diving. Feed on several kinds of fish and a few invertebrates. Flight rapid, with head and neck stretched forward. Often fly in long lines or in V-formation of up to 50 birds, near sea surface but rising regularly. Usually fly, feed, rest and nest in small groups. At nest, males utter loud grunt-like call; females silent.

HABITAT Marine; in coastal waters of NI, SI and Stewart I., NZ. Concentrated round breeding sites when

breeding; disperse to other coastal areas in winter (Owen & Sell 1985). Feed in water >10 m depth, between 2–16 km from coast; probably in zone of upwelling where crustacea and small fish abundant (Stonehouse 1967). Often enter bays, inlets and estuaries (Owen & Sell 1985; G.F. van Tets); at Waimea Inlet, occur in winter; numbers highest when birds in poor condition entered inlet to rest and feed (Owen & Sell 1985). Nest on headlands and rocky shores of main islands and inshore islands of NZ; on ledges and fissures in cliffs. Roost on offshore rock stacks, islands, breakwaters, often traditionally in same place for many years (Stonehouse 1967; Owen & Sell 1985).

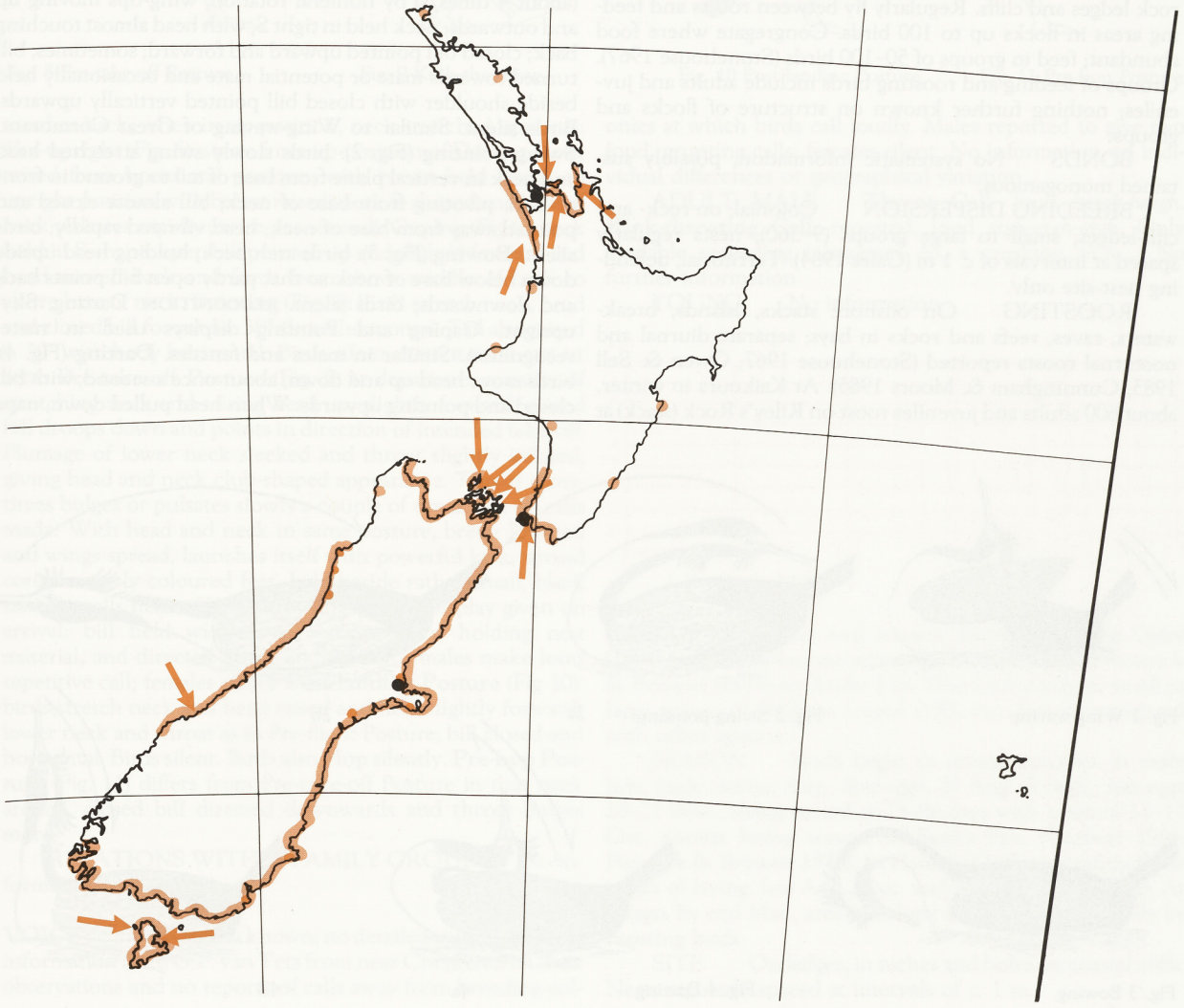
DISTRIBUTION AND POPULATION NZ endemic. Coast and coastal waters of NI, SI and Stewart Is (NZ Atlas). Reported to forage 2–16 km from shore (Stonehouse 1967).

NI. Locally common about breeding colonies: (1) Hauraki Gulf, Noises to Waiheke, Tarakihi and Ponui Is. and E to islets off Coromandel Pen.; (2) Auckland West coast, Oaia I., Ihumoana I., Te Hanga and Girdwood Pt; (3) Somes and Ward Is in Wellington Harbour. In winter, on coasts of Manawatu, Wellington and Wairarapa (possibly from SI colonies). Vagrants occasionally to Far North. SI. Abundant on Cook Str. coast, between C. Farewell and Marlborough Sound; in Marlborough Sound, nesting groups on all headlands where habitat suitable (B.D. Bell). Also abundant on e. coast, especially round Goose Bay, coasts of Banks Pen. (10 000 nests counted in 1960s; B.D. Bell), S. Canterbury and Otago coasts, and Otago Pen.; Southland coast between Nugget Point and Te Waewae Bay. Also on Stewart I., Codfish and Centre Is (B.D. Heather; B.D. Bell).

BREEDING Hundreds of colonies throughout range.

POPULATION Total population estimated 60 000–150 000 breeding pairs (Robertson & Bell 1984; B.D. Bell). Apparently, many colonies in Noises Is were extirpated by shooting (Cunningham & Moors 1985). On Noises Is, including David Rock, populations have fluctuated though with general decline (Cunningham & Moors 1985). Shooting and increasing recreational boating and fishing pressure could affect populations in Hauraki Gulf (Cunningham & Moors 1985). Nests round Ashburton were systematically destroyed after number of fishing huts increased there (CSN 1975).

MOVEMENTS Mostly small local movements but banded birds have been recovered up to 500 km away. Move from breeding colonies in Marlborough Sound to nearby



Waimea Inlet, May–Sept. where Fifeshire Rock has been roosting place for at least 59 years (Owen & Sell 1985); birds breeding Banks Pen. move much, reaching Tasman and Golden Bays (B.D. Bell).

BANDING

41S174E 07 P U 04 501 000 NZNBS
41S174E 12 P U 12 251 045 NZNBS
43S172E 12 P U 02 241 023 NZNBS
43S172E 12 P U 04 241 023 NZNBS x 2
43S172E 12 P U 05 241 023 NZNBS

FOOD Almost nothing known but appear to feed mainly on planktonic crustaceans and possibly small fish (Buller 1888; Stead 1932; Oliver; Stonehouse 1967). BEHAVIOUR. When diving, first jump in the air (G.F. van Tets). Average length of dive in coastal NZ, 30 s (31 observations) with 12 s between dives (30 observations; Stonehouse 1967). Forage alone or in flocks (Oliver). Adult recorded regurgitating reddish crustaceans, fish *Engraulis australis* (Falla 1932), gastropod molluscs *Zethalia zelandica* and algae *Ulva* (Wright 1975).

SOCIAL ORGANIZATION Little known. Gregarious; feed and roost in small to large groups; nest colonially on rock ledges and cliffs. Regularly fly between roosts and feeding areas in flocks up to 100 birds. Congregate where food abundant; feed in groups of 50–100 birds (Stonehouse 1967). Groups of feeding and roosting birds include adults and juveniles; nothing further known on structure of flocks and groups.

BONDS No systematic information, possibly sustained monogamous.

BREEDING DISPERSION Colonial; on rock- and cliff-ledges; small to large groups (9–360); nests regularly spaced at intervals of *c.* 1 m (Gales 1984). Territorial, defending nest-site only.

ROOSTING On offshore stacks, islands, breakwaters, caves, reefs and rocks in bays; separate diurnal and nocturnal roosts reported (Stonehouse 1967; Owen & Sell 1985; Cunningham & Moors 1985). At Kaikoura in winter, about 600 adults and juveniles roost on Riley's Rock (stack) at night, on rocks near quay during day (Stonehouse 1967); 500 birds roost on Fifeshire Rock (stack), several hundreds roost on Nelson Harbour breakwater, up to 2000 roost Pepin I. (Owen & Sell 1985); 30–40 roosting on reefs (Cunningham & Moors 1985). Roost at breeding colony sites during non-breeding season, up to 200 adults and juveniles recorded at David Rock. During breeding period, assumed to roost at nest-site.

SOCIAL BEHAVIOUR Little known; limited observations by G.F. van Tets near Christchurch. Displays obvious. Flocks integrated in flight; up to 100 birds fly in V-formation or in lines (Moors & Cunningham 1985). During breeding, crests on forehead and along nape permanently erect. Tail raised *c.* 45° above horizontal during most displays which performed on or beside nest-site and when walking near site.

AGONISTIC BEHAVIOUR THREAT: (as in Great Cormorant *P. carbo*) body held horizontal with wings partly spread and tail raised; head moved back and forth and sideways with bill wide open and throat bulging; males call loudly; females silent.

SEXUAL BEHAVIOUR Males advertise with Wing-waving, Swing-pointing and Bowing displays. **Wing-waving** (Fig. 1): partly folded wings rapidly raised and lowered (about 4 times/s) by humeral rotation, wing-tips moving up and outwards; neck held in tight S, with head almost touching back; closed bill pointed upward and forward; sometimes, bill turned towards mate or potential mate and occasionally held beside shoulder with closed bill pointed vertically upwards. Birds silent. Similar to Wing-waving of Great Cormorant. **Swing-pointing** (Fig. 2): birds slowly swing stretched head and neck in vertical plane from base of tail to ground in front of bird, pivoting from base of neck; bill almost closed and pointed away from base of neck; head vibrated rapidly; birds silent. **Bowing** (Fig. 3): birds arch neck, holding head upside down below base of neck so that partly open bill points back and downwards; birds silent. RECOGNITION. Darting, Sky-upright, Gaping and Pointing displays used in mate-recognition. Similar in males and females. **Darting** (Fig. 4): birds move head up and down, about once a second, with bill closed and pointing upwards. When head pulled down, nape

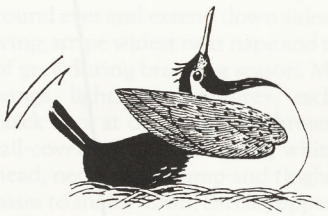


Fig. 1 Wing-waving

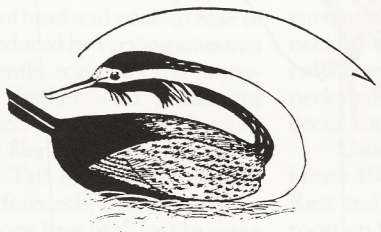
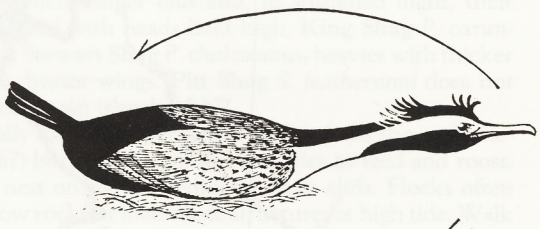


Fig. 2 Swing-pointing 2a



2b

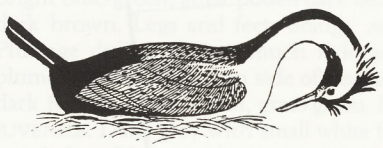


Fig. 3 Bowing

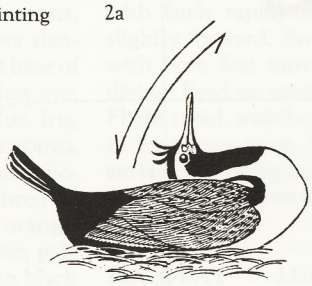


Fig. 4 Darting 4a

4b

Fig. 5 Sky-upright

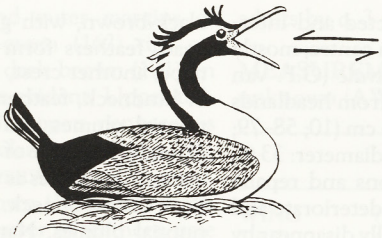


Fig. 6 Gaping

Fig. 7 Pointing

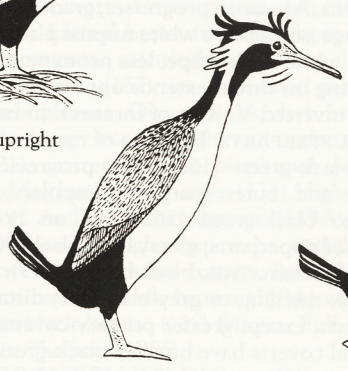


Fig. 8 Pre-take-off Posture

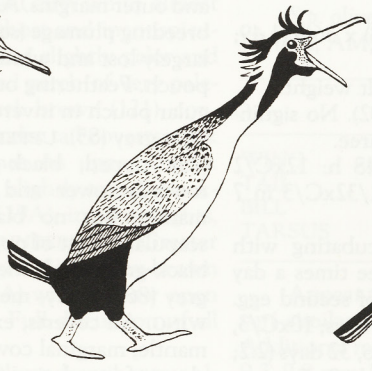


Fig. 9 Kink-throating

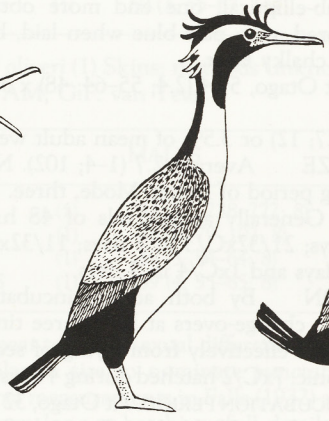


Fig. 10 Post-landing Posture

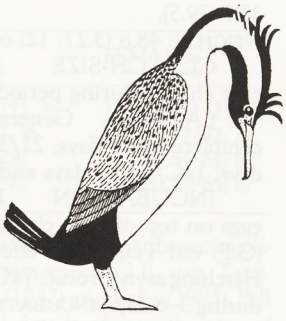


Fig. 11 Pre-hop Posture

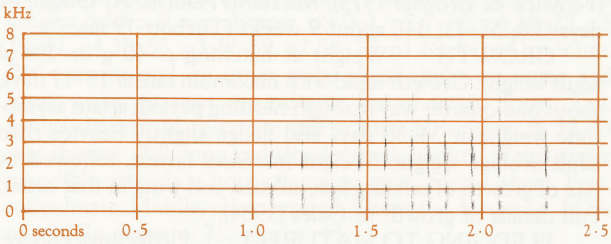
touches back; when in up-position, neck stretched upwards. **Sky-upright** (Fig. 5): starts from up-position of Darting; body raised from horizontal position, with breast held down, to upright position with breast raised; neck S-shaped and base of neck pulsates rapidly (twice per second). **Gaping** (Fig 6): neck held in S-shape, open bill pointed up and slightly forward and head moved back and forth from above middle of back to above base of neck. **Pointing** (Fig. 7): birds stretch neck, head and closed bill forward *c.* 30° above horizontal. Tail also raised *c.* 30° with body horizontal. Birds silent. OTHER DISPLAYS AT SITE. **Pre-take-off Posture** (Fig. 8) at departure, consists of stretching neck and raising head up, slightly forward; closed bill droops down and points in direction of intended take-off. Plumage of lower neck sleeked and throat slightly inflated, giving head and neck club-shaped appearance. Throat sometimes bulges or pulsates slowly a couple of times, but no calls made. With head and neck in same posture, breast lowered and wings spread, launches itself with powerful kick; spread conspicuously coloured feet, held beside rather small, black tail. No calls made. **Kink-throating** (Fig. 9) display given on arrival: bill held wide open, except when holding nest material, and directed down and forward; males make loud repetitive call; females silent. **Post-landing Posture** (Fig 10): birds stretch neck and head raised and held slightly forward; lower neck and throat as in Pre-flight Posture; bill closed and horizontal. Birds silent. Birds also **Hop** silently. **Pre-hop Posture** (Fig. 11) differs from Pre-take-off Posture in that neck arched, closed bill directed downwards and throat bulges more.

RELATIONS WITHIN FAMILY GROUP No information.

VOICE Very poorly known; no detailed studies. Limited information from G.F. van Tets from near Christchurch. Few observations and no reports of calls away from breeding colonies at which birds call loudly. Males reported to give two loud, grunting calls; females silent. No information on individual differences or geographical variation.

ADULT MALE **Threat Call**: loud *hergh-hergh*. **Kink-throating Call**: repeated, loud *ergh-ergh-ergh*. Only available recording (sonagram A), a creaking t-t-t. . . No further information.

YOUNG No information.



A J. Kendrick; P100

BREEDING Not well known. Based mostly on Gales (1984) from study for one season on Otago coast and Fenwick & Browne (1975) on Banks Pen. Breed colonially in small to large groups (9–360) on coastal cliffs, not directly associated with other species.

SEASON Birds begin to attend colonies in early July, build during Aug.; first eggs, 29 Aug.–9 Sept.; last eggs 19–25 Nov.; laying period of 73–86 days with mean of 13–17 Oct. Similar laying season on Banks Pen. (Turbott 1956; Fenwick & Browne 1975). In Hauraki Gulf, apparently three peaks of laying: late Aug., Dec. and Mar. (Turbott 1956). At Otago, by end Mar., area of colony attended at night only by roosting birds.

SITE On ledges, in niches and holes on coastal cliffs. Nests regularly spaced at intervals of *c.* 1 m.

NEST, MATERIALS Well-constructed and interwoven, roughly circular structure with bowl in centre; mostly made of seaweed or ice-plant *Dysphema australe* (G.F. van Tets); birds gather grass and other vegetation from headlands near colony (B.D. Bell). Outside diameters: 64 cm (10; 58–79; 26) x 51 (9; 42–59); height 25 (5; 19–33); inside diameter: 33 (6; 22–41); depth of bowl: 11 (4; 5–16). Additions and repairs made during incubation. After hatching nests deteriorate and actively dismantled by chicks so that they usually disappear by time chicks 2–3 weeks old. No further information.

EGGS Sub-elliptical, one end more obtuse than other; rough-textured, mat; pale blue when laid, becoming coated with white chalky layer.

MEASUREMENTS: at Otago, 59.4 (2.4; 55–64; 48) x 36.8 (1.49; 32.7–39.5).

WEIGHTS: 48.8 (3.27; 12) or 3.5% of mean adult weight.

CLUTCH-SIZE Average 2.7 (1–4; 102). No significant change during period of laying. Mode, three.

LAYING Generally at intervals of 48 h: 12xC/2 completed in 3 days; 21/32xC/3 in 5 days; 11/32xC/3 in 7 days; 1xC/4 in 7 days and 1xC/4 in 9 days.

INCUBATION By both adults, incubating with eggs on top of feet; change-overs at least three times a day (G.F. van Tets). Start effectively from laying of second egg. Hatching asynchronic: 7xC/2 hatched during 4 days; 10xC/3, during 3–6 days. INCUBATION PERIOD. At Otago, 32 days (2.2; 28–35; 13); at Banks Pen., 28–31 days (Fenwick & Browne 1975). Eggshells trampled in nest.

YOUNG Altricial, semi-nidicolous. Hatched naked, eyes closed, dark-grey skin. Eyes open at 3 days old. Sparse grey down appears on caudal area at 4–5 days and covers all body but not head and underwing by 2 weeks old, down then grey above and white below and quills have emerged. Egg-tooth lost by 12–13 days. Crown, bald till 18–24 days; primaries develop 25–29 days. Brooded and guarded by both parents, diminishing after about 2 weeks. Fed by both parents by incomplete regurgitation; about four feeds per day (Fenwick & Browne 1975). NESTLING PERIOD. At Otago, 62 days (3.8; 57–71; 34); about 9 weeks (Turbott 1956).

GROWTH Weight at hatching *c.* 40 g or 3% of adult weight. Growth rapid with maximum rate at 15–17 days, about one-quarter way through nestling period; attain asymptotic weight at 34–38 days and fledge slightly heavier than adult average weight. Weight increases fastest, followed by rate of growth of tarsus, claw, culmen and wing in that order. Full details of growth in Gales (1984).

FLEDGING TO MATURITY Fledgelings congregate on slopes below colony but have all dispersed by late Mar. No information regarding independence from parents, age at first breeding or pairing.

SUCCESS At Otago, of 256 eggs laid, 185 hatched and 129 young fledged, for total success of 54.4%; 1.9–2.15 young fledged per successful nest; or 1.12–1.45 for all nests. Two-egg clutches were significantly more successful than three-egg clutches; clutches laid in Oct. were more successful than those laid in Sept. and Nov. (1.69; 1.33: 0.80 chick/clutch respectively). In season before Gales' (1984) study, breeding at Otago failed almost completely. Losses of eggs almost entirely caused by Silver Gulls *Larus novaehollandiae*, especially when adult shags put off nests by intruders.

PLUMAGES

ADULT BREEDING Age of first breeding, 2 years (Lalas 1983). HEAD AND NECK. Crown to base of hindneck, black-brown, with glossy black-green (162) sheen. At forehead, feathers form crest, 23–30 mm long; at hindcrown, nape, another crest, 30–45 mm long. Between nape and base of hindneck, feathers dense and profusely covered in white nuptial plumes and filoplumes. Narrow white supercilium extends from base of culmen, above loral skin, broadens above eye and continues as white stripe along upper margin of side of neck to base of neck. Among white stripe, profuse short white nuptial plumes. Narrow white supercilium in front of eye sometimes absent (see Geographical Variation). Throat to mid-foreneck, black-brown (119) with glossy black-green (162) sheen; some scattered white nuptial plumes on lower and outer margins. As season progresses, gradually attain non-breeding plumage (see below): white nuptial plumes and crest largely lost and white neck stripe, less prominent. Bare gular pouch. Feathering on throat extends onto bottom quarter of gular pouch in inverted V. Rest of foreneck to base of neck, light grey (85). UPPERPARTS. Feathers of mantle, brown-grey (79); tipped, black-green (162); tips progressively larger towards lower and outer margins. Scapulars, similar to mantle, but no black-green (162) tips on broader subscapulars. Rest of upperparts, glossy blue-black (90) with pale black-green (162) sheen. TAIL, black-brown (119); rachis, pale grey (86) basally, merging to grey-black (82) distally. UPPERWING. All coverts, except greater primary-coverts, similar to mantle; marginal coverts have broader black-green (162) tips, almost fringed; tips progressively larger from lesser to greater coverts. Greater primary-coverts lack black-green (162) tips. Remiges, black-brown (119) and lack tips. Alula, similar to marginal coverts. UNDERPARTS. Upper breast to abdomen, light grey (85). Outer margins of breast, adjoining mantle and meeting base of white neck stripe, dull pale-grey (86). Lateral breast-feathers, dull pale-grey (86) and moderately short; conceal patch of very pale-grey (86) semiplumes. Outer flanks, concealed when wing closed, and thighs, glossy blue-black (90) with pale black-green (162) sheen; both with scattered short white nuptial-plumes and filoplumes. Vent and under tail-coverts, like thighs but duller and lacking gloss. Tibiotarsal feathers, similar to mantle feathers, but black-green (162) tips less distinct and almost black-brown (119). Axillaries, dark brown (121) tipped black-green (162). UNDERWING. Greater primary coverts and greater coverts, light grey-brown (80). Rest of coverts, dark brown (121) tipped glossy black-green (162).

ADULT NON-BREEDING Begins to develop late in breeding season. Similar to adult breeding, differs in having lengths of crests somewhat reduced or absent; short white filoplumes on hindneck, foreneck, flanks and thighs; no nuptial plumes; white neck-stripe less prominent (see Moults).

DOWNY YOUNG Eyes open at 3 days; sparse grey down emerges on caudal region at 4–5 days. Down, thick at age of 2 weeks; dorsum, grey; venter, white; rectrices and remiges, visible. White ventral down said to have grey-brown spots (G.F. van Tets). At 4 weeks, primary feathers, well developed. At 6 weeks, nestling down, restricted to head and neck. (Gales 1984).

JUVENILE (subadult of Turbott [1956]). HEAD AND NECK. Crown to hindneck, dark brown (119A); numerous white filoplumes on lower hindneck. Throat, dull white merging to light grey-brown on upper foreneck, extending to base of neck. Feathers on throat extend onto bottom quarter of gular pouch in inverted V. No crests. UPPERPARTS. Feathers of mantle, dark brown (119A) and brown-grey (79), tipped black-green (162); in field, tips appear black (89); tips

progressively larger towards lower and outer margins of mantle. Scapulars, similar; no black-green (162) tips on broader subscapulars. Back and rump, dark brown (121); in some lights, pale black-green (162) gloss evident. Upper tail-coverts, short, dark brown (119A), with open pennaceous paler fringes. TAIL, black-brown (119); calamus, pale grey (86), merging to grey-black (82) distally. UPPERWING. All coverts, similar to mantle, except tips black-brown (119); with wear, brown (119B); also with wear, distal quarter of feathers, pale grey (86); marginal coverts, fringed black-brown (119) rather than tipped; tips progressively larger from lesser to greater coverts. Remiges, dark brown (221); none tipped. Alula, similar to marginal coverts. UNDERPARTS, dull dirty white, almost pale grey (86). Lateral breast feathers, short and inconspicuous, similar to outer mantle-feathers, but slightly paler and lacking black-green (162) tips; concealed patch of very pale-grey (86) semiplumes. Outer flanks, dark brown (121), concealed when wing closed. Thighs and under tail-coverts, dark brown (121); scattered white filoplumes on upper thighs. Tibio-tarsal feathers, dark brown (121), slightly tipped black-brown (119). Axillaries, dark brown (119A); in some lights, pale black-green (162) gloss on webs. UNDERWING. Greater primary-coverts and greater coverts, light glossy grey-brown (80). Rest of coverts, dark brown (119A) with narrow open pennaceous black-brown (119) fringes. Full discussion of all plumages in Turbott (1956).

ABERRANT PLUMAGES Oliver describes two albinos.

BARE PARTS Based on photos in NZRD, Soper (1976) and NZDOC library, except where stated,

ADULT BREEDING Iris, dark brown (219). Eye-ring and loral skin, green-blue (64). Bill, dark brown (119A); nail, slightly paler. Gular pouch, grey-black (82) with narrow wart-like lines of green-blue (164). Legs and feet, light brown (223D) with buff (123D) shade; hind-tarsus, joints and fringes on webs, brown (119B).

ADULT NON-BREEDING Similar to breeding except colours fade about time of laying; further study required of colour changes.

DOWNY YOUNG Naked at hatching. Newly hatched birds have grey skin. At hatching, bill, legs and feet, dark grey. By end of third week, bill and feet lighten in colour. Grey bill and yellow feet, same as adult, assumed at fledging (Gales 1984).

JUVENILE, IMMATURE Oliver (under immature) states: bill, dark-yellow, brown on culmen; facial skin, orange; feet, orange-brown. NZRD states: iris, green; eye-ring, pale green; bill, face, legs and feet, brown-yellow.

MOULTS Breeding season protracted and varying (Turbott 1956; NZCL). Details given here for SI.

ADULT Staffelmauser. Pre-nuptial plumage at end of July (Gales 1984). Lalas (1983) recorded this plumage Aug.–Sept., sometimes Oct. Pre-nuptial plumage characterized by acquisition of crests and nuptial plumes. As nest building progresses, in Oct., attain nuptial plumage; characterized by loss of nuptial plumes and partial loss of crest feathers. Post-nuptial moult occurs Nov. during chick rearing; involves loss of crest-feathers and body moult. Primaries moult outwards. Duration and onset of moult series, undescribed.

POST-JUVENILE Begins Jan. of second year, 12–14 months after fledging. Culmination of post-juvenile moult is adult pre-nuptial plumage; this precedes pre-nuptial moult of adults by *c.* 3 months (Lalas 1983).

MEASUREMENTS *S.p. punctatus.* (1) Skins; methods unknown (AWMM, CM, NMNZ, AM; G.F. van Tets).

		MALES	FEMALES
WING	(1)	248 (9; 235–264; 17)	244 (9; 233–266; 29)
TAIL	(1)	87 (8; 70–97; 17)	85 (8; 78–99; 29)
BILL	(1)	61 (4; 56–70; 17)	60 (3; 56–61; 29)
TARSUS	(1)	60 (3; 55–67; 16)	60 (3; 59–66; 29)

S.p. oliveri (1) Skins; methods unknown (AWMM, CM, NMNZ, AM; G.F. van Tets).

		MALES	FEMALES
WING	(1)	251 (12; 238–272; 8)	243 (9; 231–255; 8)
TAIL	(1)	86 (8; 79–102; 8)	83 (4; 77–92; 8)
BILL	(1)	59 (3; 54–64; 8)	57 (2; 54–61; 8)
TARSUS	(1)	59 (4; 55–65; 8)	58 (3; 54–64; 8)

Appear to be no sexual differences in size; subspecies *oliveri* similar in size to nominate *punctatus* (G.F. van Tets). Additional measurements in Falla (1932) and Lalas (1983). Bill 9.3–9.8 mm long at hatching; full details of growth rates of chicks in Gales (1984).

WEIGHTS Few data; in kg. Label data, adult skins (NMNZ): males 1.21 (0.2; 0.85–1.67; 14), females 1.16 (0.27; 0.77–1.61; 8). Adults (Lalas 1983): 1000–1900 (n=8); emaciated birds, 700–1100. Label data (G.F. van Tets): nominate *punctatus*: two males 1.00, 1.10; females 0.90 (0.20; 0.70–1.20; 7); *oliveri*: female 1100. No details on seasonal weight changes. Full details of weight changes of chicks in Gales (1984).

STRUCTURE Wing, broad. Eleven primaries: p8 longest, p10 *c.* 9 mm shorter, p9 0–2, p7 7–10, p6 18–27, p5 29–47, p4 38–58, p3 47–69, p2 58–77, p1 69–87, p11 minute. P10 emarginated on inner web; p9-p8 slight on outer and inner webs. Sixteen secondaries, six of tertial form. Tail, wedge-shaped; 12 rectrices; stiff at base; t1 longest, t6 38–43 mm shorter. Bill, long and slender; nail, hooked at tip; upper mandible extends as horny flange to gape. Tarsus, short. Feet, totipalmate. Middle, claw serrated. Outer toe, longest *c.* 142% of middle, inner *c.* 71, hind *c.* 43.

SEXING, AGEING Gales (1984) estimates ages of chicks based on plumage and figures from logistic growth models. Growth-curve of wing provides best estimate, followed by bill, weight and tarsus.

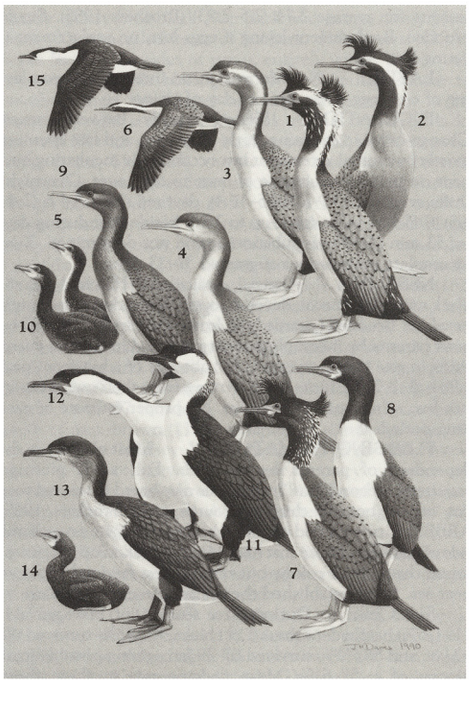
GEOGRAPHICAL VARIATION Two subspecies recognised: *punctatus* breeds **NI**: islands of Hauraki Gulf, along west coast of Auckland and in Wellington Harbour; **SI**: in Marlborough Sounds and on D'Urville I., Banks Pen., Otago Pen. and cliffs east of Palmerston (Turbott 1956; Peters); *oliveri* breeds Stewart, Codfish, and Centre Is and w. coast of SI (three colonies known: Steeples, Perpendicular Pt, Open Bay Is) (Oliver; NZCL). Subspecies separated on basis of white supercilium extending in front of eye. Lalas (1983) questioned validity of *oliveri* because supercilium appears to vary between pre-nuptial and nuptial plumage, supercilium not

extending in front of eye in about one-third of a sample of population. Slight regional variation in birds in pre-nuptial plumage in Otago, Foveaux Str. and Stewart I. and w. coast of SI; these have only narrow or no white supercilium; also, more n. populations had white forehead (Lalas 1983). Based on osteological characters, Siegel-Causey (1988) regarded *P. punctatus* as monotypic. Pitt Shag sometimes considered conspecific (Peters).

RMO

REFERENCES

Buller, W.L. 1888. *A History of the Birds of New Zealand.*
Cunningham, D.M., & P.J. Moors. 1985. *Notornis* 32: 221–243.
Falla, R.A. 1932. *Rec. Auck. Inst. Mus.* 1: 139–54.
Fenwick, G.D., & W.M.M. Browne. 1975. *J. R. Soc. NZ* 5: 31–45.
Gales, R. 1984. Unpubl. M.Sc. thesis, Univ. Otago.
Lalas, C. 1983. Unpubl. Ph.D. thesis, Univ. Otago.
Owen, K.L., & M.G. Sell. 1985. *Notornis* 32: 271–309.
Robertson, C.J.R., & B.D. Bell. 1984. *ICBP Tech. Publ.* 2: 573–86.
Siegel-Causey, D. 1988. *Condor* 90: 885–905.
Soper, M.F. 1976. *New Zealand Birds.*
Stead, E. 1932. *Life Histories of New Zealand Birds.*
Stonehouse, B. 1967. *Ibis* 109: 600–605.
Turbott, E.G. 1956. *Rec. Auck. Inst. Mus.* 4: 343–63.
Wright, A. 1975. *Notornis* 22: 130.



Volume 1 (Part B), Plate 62

Spotted Shag *Phalacrocorax punctatus*
1. Adult breeding, courtship
2. Adult breeding, subspecies *oliveri*
3. Immature
4. Juvenile
5. Downy young
6. Adult

Pitt Shag *Phalacrocorax featherstoni*
7. Adult breeding
8. Adult non-breeding
9. Juvenile
10. Downy young

Black-faced Shag *Phalacrocorax fuscescens*
11. Adult breeding
12. Adult non-breeding
13. Juvenile
14. Downy young
15. Adult