Short Communications

Diet of the Imperial Cormorant *Phalacrocorax atriceps* at sub-Antarctic Marion Island

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The Imperial Cormorant *Phalacrocorax atriceps* is an inshore foraging, diving seabird (Cooper 1985) distributed throughout the southern hemisphere south of 45°S (Watson 1975). A brief description of the diet of the Imperial Cormorant at Marion Island has been published (Blankley 1981). We present here a more comprehensive report based on food samples collected throughout the year.

Methods

The study was conducted at Marion Island (46°52'S, 37°51'E), southern Indian Ocean, where there is an estimated population of 285 breeding pairs of Imperial Cormorants (Williams *et al.* 1979). Food sampling was carried out in all months from April 1984 to March 1985 inclusive. Roosting adults were caught on an opportunistic basis and stomach-pumped using a water-offloading technique (Wilson 1984). Stomach samples were immediately drained through a 0.5 mm sieve. At the laboratory, drained samples were weighed and sorted into major prey components, which were then weighed individually. Otoliths were removed from fish brain cases for subsequent measurement and identification. Loose fish otoliths and cephalopod beaks were separated from soft material by sorting under water. In addition, fresh regurgitation casts were collected at colonies in October and November during the breeding season. During the non-breeding season, rapid scavenging of casts by Lesser Sheathbills *Chionis minor* made collection impossible. Regurgitation casts were pulled apart using tweezers and recovered items sorted into prey classes. Prey remains recovered from casts consisted largely of hard parts and comprised fish otoliths, octopod beaks, polychaete mandibles and crustacean exoskeletons. Unidentified items from both stomach samples and regurgitation casts were stored in alcohol for subsequent identification. Otolith diameters (OD) were measured, enabling mass and standard length (SL) of the prey items to be estimated from appropriate regressions (Hecht & Cooper 1986; Hecht 1987). All means are given as ± 1 standard deviation.

Results

Mean mass of food samples recovered was 58 ± 85 g (range 11-310 g, n = 47). Thirty-eight of the 50 regurgitation casts collected contained identifiable hard parts. Fish made up the largest proportion of the diet when considered on a percent-mass basis from stomach samples and on a percent-number basis from regurgitation casts (Table 1). However, the comparatively small crustaceans (mean length 29.5 ± 5.9 mm, range 19.8-39.5 mm, n = 15)

TABLE 1 Composition of the diet of Imperial Cormorants at Marion Island.

Prey Type	Stomach samples (n = 47)			Regurgitation casts (n = 38)	
	% frequency of occurrence	% numbers	%mass	% frequency of occurrence	% numbers
Fish	85.1	8.3	71.4	54.0	93.0
Nauticaris marionis	46.8	87.5	18.8	34.0	nd*
Octopods	4.3	0.5	7.1	30.0	5.6
Polychaetes	6.6	2.7	2.4	30.0	nd*
Holothuroids	4.3	1.0	0.3	—	—
Crab	—	—	—	4.0	1.4

* no data

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comprised the largest proportion of stomach samples on a percent-number basis. Other prey types were of minor importance. We could not assess the numbers of crustaceans and polychaetes that contributed to the remains recovered from regurgitation casts. Variation in the proportion of prey classes recovered from stomach samples throughout a single year is plotted in Figure 1. The proportion of fish in the diet increased from a minimum of 46% in April-May to a maximum of 97% in Febuary-March. This increase was accompanied by a decrease in the proportion of crustaceans.

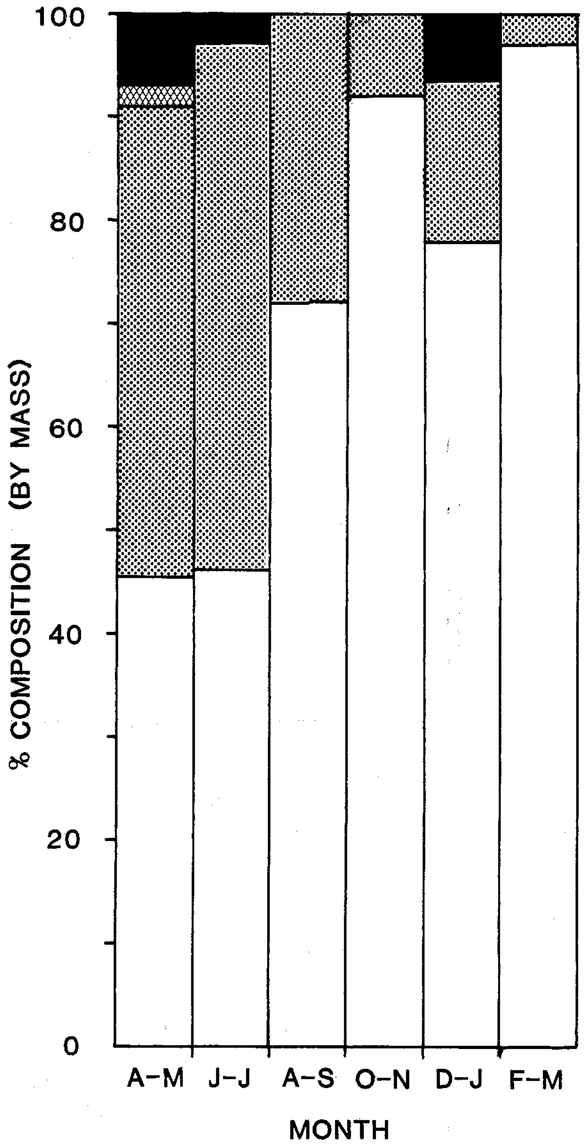

FIGURE 1 Variation in the composition of stomach samples of the Imperial Cormorant at Marion Island through a single year. Unshaded segment: fish; stippled segment: crustaceans; croshatched segment: cephalopods; shaded segment: polychaetes.

Notothenia squamifrons comprised much the largest portion of the fish component of the diet assessed from the contents of both stomachs and regurgitations (Tables 2 and 3). The size frequency distribution of *N. squamifrons* was bimodal (Fig. 2), although all fish consumed were juveniles (Duhamel & Ozouf-Costaz 1985). *Nauticaris marionis* was the only crustacean found in stomach samples. Most crustacean remains recovered from regurgitation casts could not be positively identified but were almost certainly of this species.

TABLE 2 Relative abundance of the fish component of the diet of the Imperial Cormorant at Marion Island.

Species	% number
Notothenia squamifrons	79.7
Paranotothenia magellanica	0.9
Muraenolepis sp.	2.3
Unidentified fish	17.0

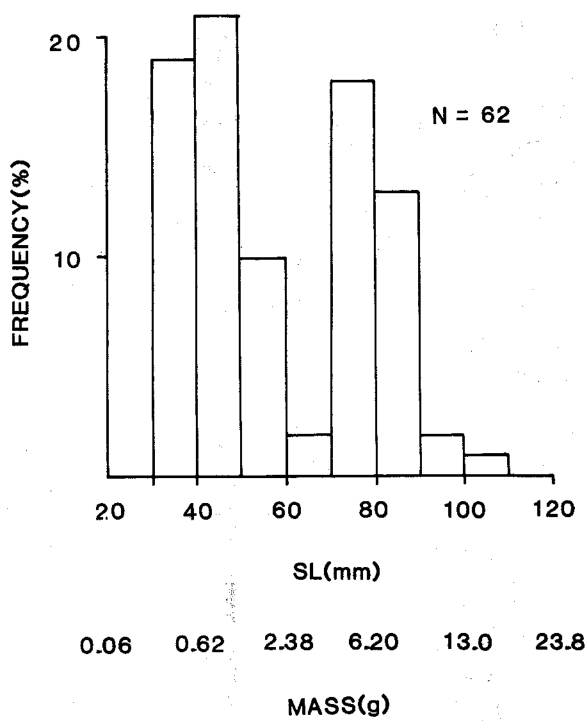

FIGURE 2 Size frequency distribution of *Notothenia squamifrons* consumed by Imperial Cormorants at Marion Island.

Discussion

Food samples obtained directly from stomachs will largely represent the remains of prey collected for the last feeding bout (see Wilson *et al.* 1985; Jackson & Ryan 1986; Jobling & Breiby 1986). In contrast, regurgitation casts may contain accumulated hard parts concentrated from a number of meals and will therefore over-estimate the importance of more digestive-resistant fish otoliths (Jobling & Breiby 1986) and cephalopod beaks (Furness *et al.* 1984) when expressed on a percent-numbers basis (Table 1). Nevertheless, casts may provide useful information particularly for largely piscivorous birds (Duffy & Laurensen 1983).

Based on analysis of stomach samples, 71% by mass of the diet of the Imperial Cormorant comprised fish, of which at least 80% were *Notothenia squamifrons.* Juvenile fish of this species are pelagic for their first year, but at the Crozet Islands fish of similar size to those consumed by Imperial Cormorants at Marion Island were restricted to neritic, bottom waters (Duhamel & Ozouf-Costaz 1985). The two other species of fish recovered from the stomach samples are considerably less important. *Muraenolepis* spp. is probably *M. marmoratus*, a species frequently found at depths between 30 and 570 m around Kerguelen (Hureau 1979). *Paranotothenia magellanica* is found to depths of at least 20 m around the coast of Marion Island (Blankley 1982). The only identified crustacean in the diet of Imperial Cormorants, adult *Nauticaris marionis*, has been recovered from the stomachs of *P. magellanica* (Blankley 1982) and is a common component of dredges from depths of 30 to 270 m around Marion Island (G.M. Branch pers. comm.). Boden & Parker (1986) have confirmed the presence of a large, benthic community of *N. marionis* at Marion Island. The octopod species from the stomach samples remained unidentified. Lu & Mangold (1978) report the presence of *Octopus dolfleini* in the vicinity of the Prince Edward Islands but the beaks we recovered during this study are clearly different. Based on beak size, the octopods recovered were much larger than the small, pelagic octopods found in diet samples from Gentoo Penguins *Pygoscelis papua* (Adams & Klages unpubl.) and Rockhopper Penguins *Eudyptes chrysocome* (Brown & Klages 1987) at Marion Island. Polychaetes, crabs and holothurians accounted for only a small portion of the Imperial Cormorant's diet, and in common with other prey species are benthic in origin.

The entirely benthic nature of the diet of the Imperial Cormorant has previously been noted at Marion Island (Blankley 1981) and Macquarie Island (Brothers 1985). The most important prey item by mass recorded by Blankley (1981), the Antarctic Plunderfish *Harpagifer bispinis*, was surprisingly not found in this study. La Cock *et al.* (1984) incorrectly identified *Notothenia squamifrons* in Gentoo Penguin stomach samples as *H. bispinis* and the species may have been similarly misidentified by Blankley (1981). However, *H. bispinis* occurred in the diet of Imperial Cormorants at Macquarie Island, although *Paranotothenia magellanica* was the major prey (47.3% by mass) (Brothers 1985). Nototheniid fish also comprised the bulk of the bird's diet at Heard Island (*N. cyanobrancha*) (Downes *et al.* 1959) and the South Shetland Islands, Antarctica (Schlatter & Moreno 1976). Bahamonde (1955) and Derenne *et al.* (1976) merely mentioned the predominance of fish in the diet of Imperial Cormorants in Chile and at the Crozet Islands respectively. Thus, the Imperial Cormorant is largely piscivorous throughout its range. At Marion Island, Imperial Cormorants are primarily solitary feeders (Cooper 1985). However, at sites where the species is abundant, flock foraging may be more common (Woods 1975) and cormorants may feed on pelagic shoaling prey farther offshore (Cooper 1985).

There is considerable overlap in the diets of the Gentoo Penguin and the Imperial Cormorant at Marion Island (Adams & Klages unpubl.), consistent with their restriction to similar inshore feeding areas (Cooper 1985, Adams & Wilson 1987) and pursuit diving foraging techniques (Harper *et al.* 1985). *Notothenia squamifrons* of similar size classes are the single most important dietary component by mass in both bird species at Marion Island and, in addition, the crustacean *Nauticaris marionis* is common to the diets of both. Temporal trends in 1984-85 also coincided: the proportion of nototheniid fish in the diet of the Gentoo Penguin and Imperial Cormorant were highest over summer (Adams & Klages unpubl.). Differences between the two species lie in the generally higher proportion of fish

TABLE 3 Summary of otolith diameter (OD), estimated standard length (SL) and estimated mass of fish recovered from Imperial Cormorants at Marion Island.

		OD (mm)			Estimated SL (mm)			Estimated mass (g)		
Species	*n*	Mean	*s.d.*	Range	Mean	*s.d.*	Range	Mean	*s.d.*	Range
Notothenia squamifrons	62	2.03	± 0.82	(1.09-4.10)	53.3	± 22.3	(22.6-109.0)	3.4	± 2.9	(0.5-12.9)
Paranotothenia magellanica	7	2.04	± 0.67	(0.94-2.83)	115.4	± 54.9	(87.5-201.6)	53.0	± 61.0	(0.5-201.6)

and, more particularly, in the absence of pelagic crustaceans and pelagic fish in the diet of the Imperial Cormorant at Marion Island. This suggests a marked difference in foraging habitat between the two, with the Imperial Cormorant confined to exploiting prey on or near the seabed. Imperial Cormorants are capable of diving to at least 25 m (Conroy & Twelves 1972) and possibly down to 50 m (Brothers 1985). This limitation may largely restrict potential foraging range to the small area of relatively shallow water in the immediate vicinity of Marion Island (see Cooper 1985).

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References

Adams, N.J. & Wilson, M.-P. (1987). Foraging parameters of Gentoo Penguins *Pygoscelis papua* at Marion Island. *Polar Biol.* **7**, 51-56.

Bahamonde, N. (1955). Alimentacion de cormoranes o cuervos marinos (*Phalacrocorax atriceps; Ph. magellanicus* u *Ph. olivaceus olivaceus*). *Invest. Zool. Chil.* **2**, 132-134.

Blankley, W.O. (1981). Marine food of Kelp Gulls, Lesser Sheathbills and Imperial Cormorants at Marion Island (Subantarctic). *Cormorant* **9**, 77-84.

Blankley, W.O. (1982). Feeding ecology of the three inshore fish species at Marion Island (Southern Ocean). *S. Afr. J. Zool.* **17**, 164-170.

Boden, B.P. & Parker, L.D. (1986). The plankton of the Prince Edward Islands. *Polar Biol.* **5**, 81-94.

Brothers, N.P. (1985). Breeding biology, diet and morphometrics of the King Shag *Phalacrocorax albiventer purpurascens* at Macquarie Island. *Aust. Wildl. Res.* **12**, 81-94.

Brown, C.R. & Klages, N.T. (1987). Seasonal and annual variation in the diets of Macaroni and southern Rockhopper Penguins at sub-Antarctic Marion Island. *J. Zool.*, (Lond.) **212**, 7-28.

Conroy, J.W.H. & Twelves, E.L. (1972). Diving depths of the Gentoo Penguin (*Pygoscelis papua*) and the Blue-eyed Shag (*Phalacrocorax atriceps*) from the South Orkney Islands. *Br. Antarct. Surv. Bull.* **30**, 106-108.

Cooper, J. (1985). Foraging behaviour of nonbreeding Imperial Cormorants at the Prince Edward Islands. *Ostrich* **56**, 96-100.

Derenne, P., Mary, G. & Mougin, J.-L. (1976). Le cormoran a ventre blanc *Phalacrocorax albiventer melanogenis* (Blyth) de l'Archipel Crozet. *CNFRA*. **40**, 191-220.

Downes, M.C., Ealey, E.H.M., Gwynn, A.M. & Young, P.S. (1959). The birds of Heard Island. *ANARE Sci. Rep. Ser BI Zool.* **1**, 124-127.

Duffy, D.C. & Laurenson, L.J.B. (1983). Pellets of Cape Cormorants as indicators of diet. *Condor* **85**, 305-307.

Duhamel, G. & Ozouf-Costaz, C. (1985). Age, growth and reproductive biology of *Notothenia squamifrons* Gunther 1880 from the Indian sector of the Southern Ocean. *Polar Biol.* **4**, 143-153.

Furness, B.L., Laugksch, R.C. & Duffy, D.C. (1984). Cephalopods and studies of seabird diets. *Auk* **101**, 619-620.

Harper, P.C., Croxall, J.P. & Cooper, J. (1985). A guide to foraging methods used by marine birds in Antarctic and sub-Antarctic seas. *BIOMASS Handbook* **24**, 1-22.

Hecht, T. (1987). A guide to the otoliths of Southern Ocean fishes. *S. Afr. J. Antarct. Res.* **17**, in press.

Hecht, T. & Cooper, J. (1986). Length/mass relationships, energetic content and otoliths of Antarctic cod *Paranotothenia magellanica* (Nototheniidae: Pisces) at sub-Antarctic Marion Island. *S. Afr. J. Zool.* **21**, 294-296.

Hureau, J.C. (1979). La faune ichthyologique du sector indien de l'ocean antarctique et estimation du stock de poissons autour des iles Kerguelen. *Mem. Mus. Nat. Hist. Nat., Sér. C Sci. Terre.* **43**, 235-247.

Jackson, S. & Ryan, P.G. (1986). Differential digestion rates of prey by White-chinned Petrels. *Auk* **103**, 617-619.

Jobling, M. & Breiby, A. (1986). The use and abuse of fish otoliths in studies of feeding habits of marine piscivores. *Sarsia* **71**, 265-274.

La Cock, G.D., Hecht, T. & Klages, N. (1984). The winter diet of Gentoo Penguins at Marion Island. *Ostrich* **55**, 188-191.

Lu, C.C. & Mangold, K. (1978). Cephalopods of the Kerguelenian Province of the Indian Ocean. In: *Proceedings of the International Symposium on Marine Biogeography and Evolution in the Southern Hemisphere.* DSIR Information Series **137**, 567-574.

Schlatter, R.P. & Moreno, C.A. (1976). Habitos alimentarios del Cormoran Antarctico, *Phalacrocorax atriceps bransfieldensis* (Murphy) en Isla Green, Antartica. *Ser. Cient. Inst. Antarct. Chileno* **4**, 69-88.

Watson, G.E. (1975). *Birds of the Antarctic and sub-Antarctic.* American Geophysical Union, Washington D.C.

Williams, A.J., Siegfried, W.R., Burger, A.E. & Berruti, A. (1979). The Prince Edward Islands: a sanctuary for seabirds in the Southern Ocean. *Biol Conserv.* **15**, 59-71.

Wilson, R.P. (1984). An improved stomach pump for penguins and other seabirds. *J. Field Ornithol.* **55**, 109-112.

Wilson, R.P., La Cock, G.D., Wilson, M.-P. & Mollagee, F. (1985). Differential digestion of fish and squid in Jackass Penguins *Spheniscus demersus. Ornis Scand.* **16**, 77-79.

Woods, R.W. (1975). *The Birds of the Falkland Islands.* Nelson, Oswestry.