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# Diet of coastal black shags (*Phalacrocorax carbo)*

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**Abstract** The diet of black shags (*Phalacrocorax carbo*) at Pencarrow, New Zealand, during April – October 1999 is described from otoliths, jawbones and pharyngeal tooth plates found in 119 regurgitated pellets of adults and four stomachs and two regurgitations of chicks. Black shags were primarily marine foragers, with only one freshwater item, crayfish (*Paranephrops planifrons*) among 420 food items identified. Half of the diet comprised spotty (*Notolabrus celidotus*), but in total, 22 species were found in the pellets, including 17 fish species. The size of fish otoliths indicated significant differences in the length of the 11 most frequently occurring fish species. These ranged from an estimated length of 106 mm to 275 mm (mean length 220 mm) and were similar to those reported from other NZ studies. The mean length of fish taken by adults in winter was smaller compared with those in autumn and spring.

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## INTRODUCTION

The black shag (*Phalacrocorax carbo*) is widely distributed through Asia, Australia, Africa, Europe, Iceland, and eastern Canada (Johnsgard 1993) and the subspecies *novaehollandiae* (Turbott 1990) is found throughout New Zealand in inland and coastal regions (Bull *et al.* 1985).

The diets of black shags in New Zealand, mainly from freshwaters, have been described by several authors. Falla & Stokell (1945) found that the stomach contents of black shags on Lakes Taupo and Rotorua contained mainly trout (*Salmo* sp.) and eels (*Anguilla* sp.). However, Dickinson (1951) concluded that native bully (*Gobiomorphus* sp.), carp (*Carassius carassius*) and freshwater crayfish (*Paranephrops planifrons*) were their most common prey. The diets of shags in Otago lakes and rivers comprised mostly brown trout (*Salmo trutta*), perch (*Perca fluviatilis)* and crayfish (*Paranephrops* zealandicus) (Scott & Duncan 1967; Duncan 1968).

Coastal colonies of black shags have received less attention. Along the Otago coast, Lalas (1983) found their main prey species, yellow-eyed mullet (*Aldrichetta forsteri*) comprised ≥ 50% of the diet, but on the Chatham Islands eels (*Anguilla* sp.) were their main prey, constituting 25-50% of the diet. Our study investigated the diets of black shags at the coastal Pencarrow colony, Wellington, during the breeding season (April-October). The study's objectives were to determine composition of the diet, and to record any diet changes over the breeding season.

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## STUDY SITE AND METHODS

The black shag colony at Pencarrow was located east of Wellington city. It was approximately 1 km from the ocean in a forested gully on the west face of Link Ridge (41° 23'S, 174° 52'E), overlooking Lake Kohangatera. Black shags roosted and nested primarily in karaka (*Corynocarpus laevigatus)* trees covering one side of the gully but also used small pockets of karaka in an adjacent gully.

This colony has been known since 1925 when Stidolph (1971) saw young shags in beech (*Nothofagus* sp.) trees. Falla & Stokell (1945) observed it periodically; they counted 40 occupied nests in 1930, 20 in 1932, 12 in 1934 and none in 1942. The site was recolonised, and held 11 nests by 1965 (P. Williams, in Powlesland & Reese, 1999). Between 1994 and 1998 nests numbered 25-30 during April – May (Powlesland & Reese, 1999)

**Table 1** Equations of otoliths and estimated mean length (mm) of the six most frequently occurring fish prey in regurgitated pellets of black shags at Pencarrow colony, April – October 1999. Key: x = otolith length, (TL) = total length of fish from snout to end of tail, (FL) = fork length from snout to fork in tail (Lalas 1983), * equation number represents different measurements that are taken from dentition, depending on condition of jawbones (Lalas 1983).

| Family | Common name | | (*) Equation number | Length (mm) | Mean length (mm) (± *se*, *n*) |
|---|---|---|---|---|---|
| Moridae | Rock Cod | (TL) | | 19.0 ($x^{1.05}$) | 275 (6, 42) |
| Moridae | Red Cod | (TL) | | 8.35 ($x^{1.534}$) | 211 (23,15) |
| Carangidae | Mackerel | (FL) | | 26.96 ($x^{1.068}$) | 239 (9, 15) |
| Mugilidae | Yellow-eyed mullet | (FL) | | 29.13 ($x^{1.031}$) | 106 (11, 31) |
| Soleidae | Sole | (TL) | | 24.82 ($x^{1.711}$) | 156 (13, 22) |
| Labridae | Spotty | (TL) | 1 | 28.51 + (12.93 x) | 234 (4, 167) |
| | | | 2 | 63.97 + (13.17 x) | |
| | | | 3 | 51.08 + (11.14 x) | |
| | | | 4 | 97.84 + (7.73 x) | |
| | | | 5 | 97.61 + (11.68 x) | |

when the number of breeding pairs was at its highest. During April – May 1999, when nesting was at its peak, 15 laid eggs.

Between April and October 1999, regurgitated pellets were collected weekly from the ground below the colony. The pellets were preserved in 70% ethanol, a method that may have caused some corrosion of otoliths (C.Lalas unpubl. data) and had a small effect on fish lengths and weights estimated from otolith measurements. Fish and invertebrates were identified to family and, where possible, species using Hopkins (1970), Paul (1986) and Roberts (1996). Taxonomy of fish species follows Paulin *et al.* (1989).

Fish otoliths were measured (± 0.1mm) using vernier calipers and their sizes used to estimate fish length (mm) using equations from Lalas (1983) (Table 1). However, for spotty (*Notolabrus celidotus),* measurements were taken from jawbones (Lalas 1983), and for butterfish (*Opax pullus*) from the lower pharyngeal tooth plate. The otoliths of triplefins (Tripterugiidae) were too eroded for accurate measurements to be taken; for these fish the lengths are presented as nominal total length.

The stomach contents from four dead chicks collected from the ground were examined. Otoliths found in the stomach were identified and measured, and equations (Lalas 1983) applied to determine fish length. Two regurgitations were collected when chicks were being weighed.

All statistical analyses were done using SAS 6.12 analysis of variance (ANOVA).

## RESULTS

### Composition of diet

Because adult shags, but not chicks, were seen regurgitating pellets, it was assumed that adults produced all pellets collected from below the nest trees. The 119 pellets contained 22 prey types, of which 19 were identified (Table 2). Fish were overwhelmingly the primary prey type, with 17 species found, of which 14 were identified. Remains of five identified types of invertebrates were also recovered from the pellets, as well as numerous pieces of unidentified mollusc. The only freshwater prey was a North Island freshwater crayfish (*Paranephrops planifrons*); all other items were of marine origin. Three nematodes, presumed to be shag gut parasites, were associated with three pellets.

Spotty were 50 % of the items found. Lesser amounts of rock cod (*Lotella phycis*) (12.1%), yellow-eyed mullet (*Aldrichetta forsteri*) (7.4%), sole (Pleuronectiforms) (5.2%), and red cod (*Pseudophycis* spp.) and mackerel (*Trachurus* spp.) (3.6%) were found. The highest single occurrence of a species in a pellet comprised 15 yellow-eyed mullet. Invertebrates combined made up 7.2% with parasitic isopods and chitons the most frequent items.

The stomach contents of four dead chicks aged 10-11 days included fish (yellow-eyed mullet ($n$ = 2) and sole ($n$=5), invertebrates, molluscs, nematodes, seaweed, small stones, and small bits of wood. The fresh regurgitations from two chicks aged 15 and 20 days contained only one otolith, from a sole.

### Prey items per pellet

Most pellets contained few prey; 13 (10.9%) pellets held six or more items and 62 (52.1%) comprised two-three prey (Fig. 1). The greatest number of prey in one pellet was 19 of which 15 were yellow-eyed mullet. The mean number of prey items per pellet was 3.4 ± *se* 0.2.

There was no significant difference ($P > 0.1$) in the mean number of prey items per pellet per month during the eight months they were

**Table 2** Prey of black shags at Pencarrow colony identified from remains in 119 regurgitated pellets, April – October 1999.

| Common name | Family / Order | Species | No. of items | Number of items/pellet | Proportion of total prey eaten (%) |
|---|---|---|---|---|---|
| Pilchard | Clupeidae | *Sardinops neopilchardus* | 2 | 1 | 0.5 |
| Rock Cod | Moridae | *Lotella phycis* | 51 | 1 – 3 | 12.1 |
| Red Cod | Moridae | *Pseudophycis* sp. | 15 | 1 – 3 | 3.6 |
| Common roughy | Trachichthyidae | *Paratrachichthys traili* | 4 | 1 | 1.0 |
| Jock Stewart | Scorpaenidae | *Helicolenus percoides* | 1 | 1 | 0.2 |
| Gurnard | Triglidae | *Chelidonichthys kumu* | 1 | 1 | 0.2 |
| Mackerel | Carangidae | *Trachurus* sp. | 15 | 1 – 3 | 3.6 |
| Spotty | Labridae | *Notolabrus celidotus* | 210 | 1 – 12 | 50.0 |
| Butterfish | Odacidae | *Odax pullus* | 4 | 1 | 1.0 |
| Yellow-eyed mullet | Mugilidae | *Aldrichetta forsteri* | 31 | 1 – 15 | 7.4 |
| Opalfish | Percophidae | *Hemerocoetes* sp. | 3 | 1 | 0.7 |
| Blue Cod | Pinguipedidae | *Parapercis colias* | 2 | 1 | 0.5 |
| Triplefins | Tripterygiidae | - | 1 | 1 | 0.2 |
| Sole | Pleuronectiforms | - | 22 | 1 – 11 | 5.2 |
| Unidentified fish | | 3 species | 28 | 1 – 5 | 6.6 |
| Chiton | | - | 10 | 1 – 2 | 2.5 |
| Parasitic isopod | | - | 10 | 1 – 2 | 2.5 |
| Ostracod | | - | 4 | 1 – 2 | 1.0 |
| Decapod crustacean | | - | 5 | 1 | 1.2 |
| Freshwater crayfish | | *Paranephrops planifrons* | 1 | 1 | 0.2 |
| Total | | | 420 | | 100 |

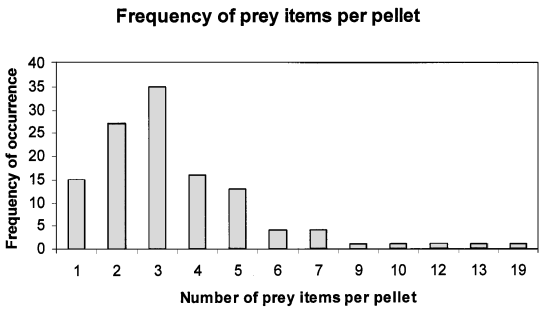


**Figure 1** Frequency of number of prey found in 119 pellets regurgitated by black shags at Pencarrow colony, April - October 1999.

collected. The mean number of prey items per pellet per month ranged from 4.6 ± *se* 1.1 in July to 2.7 ± *se* 0.5 in April.

### Length of Prey

The 11 most frequently occurring fish species were used to assess the length of prey taken by the shags. When comparing the sizes of the different fish species there was a significant difference ($F$= 25.4, $P < 0.0001$). The mean lengths of the six most frequently occurring species are given in Table 1. The length of the 11 most frequently occurring species the fish eaten ranged from a mean of 106 mm for yellow eyed mullet to 275 mm for rock cod.

### Adult diet over breeding season

The mean number of prey per pellet did not differ between seasons (autumn 2.9 ± *se* 0.3, winter 3.8 ± *se* 0.3, spring 3.4 ± *se* 0.3; $F$= 1.22, $P > 0.2$). The mean length of spotty taken by the shags varied significantly ($P< 0.05$) over the three seasons (Table 3), being shortest in winter. The mean length of red cod and rock cod did not differ significantly between the seasons.

For all fish species combined there was a highly significant difference ($F$ = 12.3, $P < 0.0001$) in the mean lengths of fish taken by black shags between the three seasons. The mean length of fish eaten in winter (190 ± *se* 7 mm) was significantly shorter than those on autumn (243 ± *se* 7 mm) and spring (236 ± *se* 5 mm) (Tukey's test, $P< 0.01$).

## DISCUSSION

### Composition of diet

The diet of shags is commonly determined from stomach contents, or from regurgitated pellets. The use of regurgitated pellets is a non-destructive method and enables a larger sample size to be obtained (Suter 1997). However, neither method gives a complete record of diet because some prey items are completely digested (Zijlstra & Van Eerden 1995; Suter 1997; Casaux *et al.* 1998). Zijlstra & Van Eerden (1995) evaluated pellet composition using captive black shags fed a known diet. They recovered 52% of the otoliths from the larger fish fed, retrieved identifiable

**Table 3** Mean length (mm) of three fish prey species in regurgitated pellets from black shags at the Pencarrow colony and collected during autumn, winter and spring 1999.

| Species | Season | Length (mm) Mean | S.E. | number |
|---|---|---|---|---|
| Spotty | Autumn | 242.4 | 7.9 | 36 |
| | Winter | 215 | 5.4 | 66 |
| | Spring | 248 | 5.3 | 65 |
| Rock Cod | Autumn | 310.6 | 18.3 | 7 |
| | Winter | 254.2 | 11.5 | 11 |
| | Spring | 273.7 | 6.7 | 26 |
| Red Cod | Autumn | 202.5 | 31.5 | 6 |
| | Winter | 219 | 76.7 | 4 |
| | Spring | 214.3 | 28.5 | 5 |

remains from only two of five species provided, and found greater losses (84%) of otoliths of ruffe (*Gymnocephalus cernuus)* 10 cm in length than those of 20 cm (50%). This suggests that while 50% of black shag diet at the Pencarrow colony was identified as spotty, it is possible that spotty made up even more of the diet because small individuals were completely digested and undetected, or that small fish of other species went undetected for the same reason.

Although black shags feed on both pelagic and demersal fish, our results, and those of Lalas (1983), indicates they take prey of mainly one species at a time. This characteristic has been documented elsewhere. For example, in Ireland, 60% of the diet by weight was wrasse (*Labridae* sp.) (West *et al*. 1974) and in North America, 57.8% of the diet in spring was sculpin (*Myoxocephalus*) (Ross 1977).

Scott & Duncan (1967) noted freshwater crayfish in the diet of black shags in inland Otago, but only one freshwater crayfish was identified in the 119 pellets from the Pencarrow colony. This, and several sightings of black shags diving on Lake Kohangatera near the Pencarrow colony, was the only evidence that Pencarrow shags fed in freshwater habitats. The Wainuiomata River several kilometres east of the colony, is a popular trout fishing area (C. Paulin pers. comm.), yet no trout otoliths were recovered from pellets, which suggests that if there is any feeding in this river it is infrequent.

Some items found in regurgitated pellets and stomach contents, e.g small fish and invertebrates, may not be primary prey but secondarily derived from fish eaten by the birds. This phenomenon has been reported by Lalas (1983), Barrett *et al.* (1990), and Casaux *et al.* (1997).

There was no significant difference in the mean number of prey items per pellet for autumn, winter and spring 1999 during the breeding season.

**Length of prey**

The lengths of the 11 fish species most frequently encountered ranged from 106 to 275 mm (mean 220 mm). Winkler (1983) suggested that black shags preferred fish approximately 130 mm in length. Lalas (1983) found that black shags ate fish 110-230 mm in length on the Otago coastline, and 90-180mm on Chatham Island. Eels, the main prey eaten by black shags on Chatham Island had a mean length of 320 mm (Lalas 1983). This suggests that variable prey size is common.

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**LITERATUARE CITED**

Barrett, R. T.; Røv, N.; Loen, J.; Montevecchi, W. A. 1990. Diets of shags *Phalacrocorax aristotelis* and cormorants *Phalacrocorax carbo* in Norway and possible implications for gadoid stock recruitment. *Marine ecology-progress series 66 (3)*: 205-218.

Bull, P. C.; Gaze, P. D.; Robertson, C. J. R. 1985. *The atlas of bird distribution in New Zealand*. Wellington, Government Printer..

Casaux, R. J.; Barrera-oro, E. R.; Favero, M.; Silva, P. 1998. New correction factors for the quantification of fish represented in pellets of the imperial cormorant *Phalacrocorax atriceps. Marine ornithology 26*: 35-39.

Casaux, R. J.; Favero, M.; Coria, N.; Silva, P. 1997. Diet of the imperial cormorant *phalacrocorax atriceps*: comparison of pellet and stomach contents. *Marine ornithology 25*: 1-4.

Cramp, S. (Ed.). 1980. *Handbook of the birds of Europe, the Middle East and North Africa: The birds of the western Palearctic*. Oxford, Oxford University Press.

Dickinson, P. 1951. Stomach contents of New Zealand inland shags. *Australian journal of marine and freshwater research 1-2*: 245-253.

Duncan, K.W. 1968. The food of the black shag (*Phalacrocorax carbo novaehollandiae*) in Otago inland waters. *Transactions of the Royal Society of New Zealand 2*: 9-23.

Falla, R. A.; Stokell, G. 1945. Investigations of the stomach contents of New Zealand fresh-water shags. *Transactions of the Royal Society of New Zealand 74*: 320-331.

Hopkins, C. L. 1970. Systematics of the New Zealand freshwater crayfish *Paranephrops* (Crustacea: Decapoda: Parastacidae). *New Zealand journal of marine and freshwater research 4*: 278-291.

Johnsgard, P. A. 1993. *Cormorants, darters and pelicans of the world*. Smithsonian Institution Press. Washington & London.

Lalas, C. 1983. Comparative feeding ecology of New Zealand marine shags (*Phalacrocoracidae*). Unpubl. Ph.D., University of Otago, Dunedin, New Zealand.

Paul, L. J. 1986. *New Zealand fishes: An identification guide*. Reed Methuen Ltd., Auckland.

Paulin, C.; Stewart, A.; Roberts, C.; McMillan, P. 1989. *New Zealand fish: A complete guide.* Wellington, Government Printer.

Powlesland, R. G.; Reese, P. J. 1999. Aspects of the breeding biology of black shags (*Phalacrocorax carbo*) near Lake Kohangatera, Wellington. *Notornis 46*: 485-497.

Roberts, C. D. 1996. Coastal fishes of Kapiti and Mana Island: 1996 Museum survey. *Seafood New Zealand 4*: 88-92.

Ross, R. K. 1977. A comparison of the feeding and nesting requirements of the great cormorant (*Phalacrocorax carbo* L.) and the double-crested cormorant (*P. auritus* Lesson) in Nova Scotia. *Proceedings of the Nova Scotia Institute 1974-1976. 27: 112-114.*

Scott, D.; Duncan K. W. 1967. The function of freshwater crayfish gastroliths and their occurrence in perch, trout and shag stomachs. *New Zealand journal of marine and freshwater research 2*: 99-104.

Stidolph, R. H. D. 1971. *The birds around us: From a diary of bird observations in New Zealand over a period of 50 years, 1921-1971*. Masterton, Hedley's Bookshop Ltd.,

Suter, W. 1997. Roach rules: Shoaling fish are a constant factor in the diet of cormorants *Phalacrocorax carbo* in Switzerland. *Ardea 85*: 9-27.

Turbott, E. G. (convener). 1990. *Checklist of the birds of New Zealand and the Ross Dependency, Antarctica.* Wellington, Random Century New Zealand Ltd.

West, B.; Cabot, D.; Greer-Walker, M. 1974. *Proceedings of the Royal Irish Academy* 75: 285-304. "(quoted in Cramp *et al* , 1980)".

Winkler, H. 1983. *The ecology of cormorant (genus Phalcrocorax)* In: F.Schiemer (ed) *Limnology of Parakrama Samudra – Sri Lanka*. Junk, Der Haag. "(quoted in Johnsgard, 1993)".

Zijlstra, M.; Van Eerden, M. R. 1995. Pellet production and the use of otoliths in determining the diet of cormorants *Phalacrocorax carbo sinensis*: trails with captive birds. *Ardea 83*: 123-131.