Length/mass relationships, energetic content and the otoliths of Antarctic cod *Paranotothenia magellanica* (Notothenioidae: Pisces) at sub-Antarctic Marion Island

T. Hecht and J. Cooper

Department of Ichthyology and Fisheries Sciences, Rhodes University, Grahamstown and FitzPatrick Institute of African Ornithology, University of Cape Town, Cape Town

Relationships between otolith length and fish length, wet and dry mass and total energy are described for Antarctic cod *Paranotothenia magellanica* from Marion Island (sub-Antarctic Indian Ocean). The relationships were all highly significant and allow for more detailed and quantitative studies of the trophic structure of the area.

S. Afr. J. Zool. 1986, 21: 294 – 296

Verhoudings tussen otolietlengte en vislengte, nat en droë massa en totale energie word beskryf vir *Paranotothenia magellanica* van Marioneiland (sub-antarktiese Indiese Oseaan). Alle verhoudings was statisties hoogs betekenisvol en kan aangewend word om meer kwantitatiewe studies oor die trofiese struktuur van die gebied te onderneem.

S.-Afr. Tydskr. Dierk. 1986, 21: 294 – 296

T. Hecht*
Department of Ichthyology and Fisheries Science, Rhodes University, Grahamstown, 6140 Republic of South Africa

J. Cooper
Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch, 7700 Republic of South Africa

*To whom correspondence should be addressed

Received 19 September 1985; accepted 29 April 1986

Three species of notothenioid fishes are known to occur in the inter and subtidal zone around Marion Island (Prince Edward Islands, sub-Antarctic Indian Ocean). These include *Paranotothenia magellanica* (Nototheniidae), *Notothenia coriiceps* (Nototheniidae) and *Harpagifer georgianus* (Harpagiferidae). The antarctic cod *P. magellanica* appears to be the most abundant of the three species and forms part of the winter diet of gentoo penguins (*Pygosceles papua*) at the island (La Cock, Hecht & Klages 1984). Also, although to a lesser degree, *P. magellanica* is preyed upon by *N. corriceps*, while cannibalism also occurs (Blankley 1982)

Fish otoliths are largely species-specific (Hecht 1978), and their size is closely related to fish length and mass. Owing to their chemical composition (Degens, Deuser & Haedrich 1969) and their resultant resistance to digestion, they are often the only recognizable remains of fishes found in the stomachs or regurgitated pellets of piscivorous predators. In order to attain a more detailed and quantitative understanding of the feeding ecology of marine predators it is most useful to relate the dimensions of otoliths found in their stomachs to the length and mass of the animal eaten. (e.g. Martini 1964; Fitch & Brownell 1971; Blaber 1982; La Cock *et al.* 1984; Smale & Bruton 1985).

This paper describes the length/mass relationship, the relationship between otolith length and fish length, the water and energy content, the wet mass/dry mass relationship, the fish length/dry mass relationship, the relationship between dry mass and energy and finally the relationship between otolith length and total energy of *P. magellanica*.

Taxonomic note

DeWitt (1970) showed that *P. macrocephala* (Günter, 1881) is a junior synonym of *P. magellanica* (Forster, 1801).

Methods

A total of 133 specimens of *P. magellanica* were collected in the inter- and subtidal zones in Transvaal Bay, Marion Island (46°50′S / 37°45′E) during 15 – 17 November 1983. All fish were weighed to the nearest 0,1 g on an electronic balance and standard length (L_s) was measured to the nearest mm. The fish ranged in size from 82 to 333 mm and in mass from 12,7 to 895 g. After the fish were weighed and measured they were frozen and kept for further analysis. Of the 133 specimens returned to our laboratories, ten were kept for water content analysis and microbomb calorimetry. These ranged in length from 88 to 205 mm. To determine the water content, the fish were wiped dry of surface water, weighed and then dried to constant mass in a forced draught oven set at 60°C.

The energy content of each of the ten fish was determined on an ash-free dry-mass basis by replicate analysis (n = 3 to 5) in a microbomb calorimeter.

The sagittal otoliths of 82 specimens ranging in L_s from 82 to 333 mm were removed and measured for maximum length along the anterior/posterior plane, accurate to 0,01 mm using vernier calipers.

Results and Discussions

The relationship between otolith length (OL) and standard length (L_s) was found to be best described by the power curve:

$$L_s = 30{,}96\ OL^{1{,}801}\ (r^2 = 0{,}75;\ p < 0{,}05;\ n = 82).$$

The standard length (L_s)/wet mass (WM) relationship is expressed by:

$$WM = 2{,}19 \times 10^{-5}\ L_s^{3{,}00}\ (r^2 = 0{,}99;\ p < 0{,}01;\ n = 133).$$

The exponential constant of the equation is indicative of isometric growth over the entire size range sampled.

The water and energy content of *P. magellanica* are given in Table 1. There was no relationship between size or mass on the one hand and per cent water or energy content on the other hand (in all cases $p > 0{,}01$). The wet mass (WM)/dry mass (DM) relationship is described by the linear equation:

$$DM = 0{,}201\,WM + 0{,}584\ (r^2 = 0{,}99;\ p < 0{,}001;\ n = 10),$$

whereas the length (L_s)/dry mass (DM) relationship is expressed by the power curve:

$$DM = 2{,}98 \times 10^{-5}\ L_s^{2{,}63}\ (r^2 = 0{,}98;\ p < 0{,}01;\ n = 10).$$

Table 1 Percentage water content and energetic value of Antarctic cod *Paranotothenia magellanica* from Marion Island

Water content[a] (%)	Energy content[a] (kJ/g ash-free dry mass)	Sample size
77,9 ± 1,3	24,2 ± 1,2	10
(76,0 – 79,9)	(22,4 – 27,0)	10

[a]Figures given are means ± standard deviation; the range is given in parentheses.

The relationship between total energy content (TE) and dry mass (DM), was linear:

$$TE = 24{,}16\ DM + 0{,}000244\ (r^2 = 1{,}0;\ n = 10).$$

Considering the high levels of significance between the various data sets it was considered justified to calculate a relationship between otolith length (OL) in mm and total energy content (TE) in kJ/g ash-free dry mass. The relationship was best described by the power curve:

$$TE = 5{,}99\ OL^{4{,}74}\ (r^2 = 1{,}0;\ n = 10)\ \text{(Figure 1)}.$$

In order to facilitate identification of the fish species consumed by predators in the inshore regions around Marion Island, the otoliths of the three species, *P. magellanica*, *N. coriiceps* and *H. georgianus*, are illustrated in Figure 2.

The otoliths of the three species can easily be distinguished from each other. The otoliths of *P. magellanica* have a distinctive 'bow tie'-shaped sulcus acusticus which opens onto the anterior margin and in most cases also onto the posterior margin. They also have a deep and very distinct V-shaped dorsal area, bordered on each side by robust cristae superior.

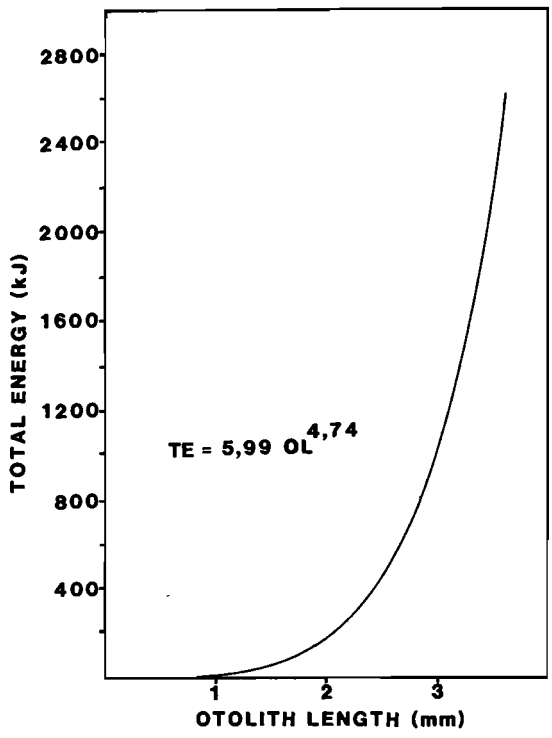

Figure 1 The relationship between otolith length and total energy content of *Paranotothenia megellanica*.

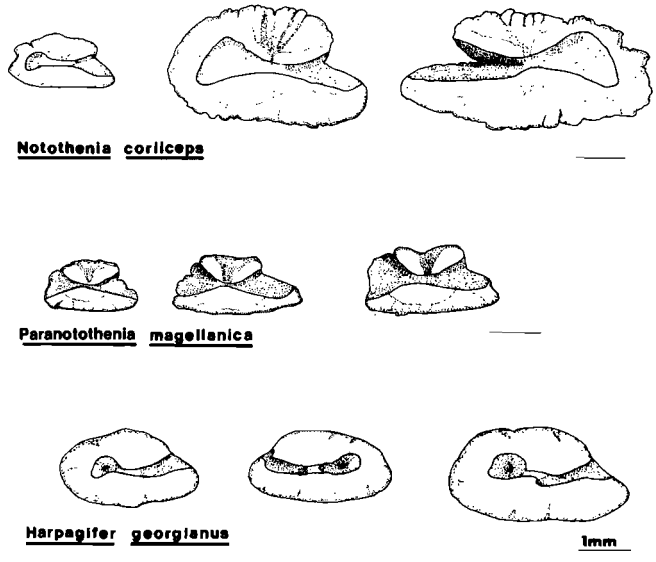

Figure 2 The sagittal otoliths of *Notothenia coriiceps*, *Paranotothenia magellanica* and *Harpagifer georgianus*.

The otoliths of *N. coriiceps* are characterized by a sulcus acusticus which is closed posteriorly and by a poorly defined crista superior. The otoliths of *H. georgianus* are medially extremely convex. The sulcus acusticus is poorly developed, narrow and has an elevated column between the ostium and the cauda. The terminology used in these descriptions is that of Hecht (1978).

Hopefully the data presented in this short note will act as a catalyst and serve to stimulate more detailed and quantitative studies of both the biology of *P. magellanica* and the foodweb around Marion Island.

Acknowledgements

Research at Marion Island is conducted under the auspices

of the South African Scientific Committee for Antarctic Research with the financial and logistical support of the Department of Transport. We thank C.R. Brown, M.T.T. Davies, N. Klages and L. Laurenson for their help.

References

BLABER, S.J.M. 1982. The ecology of *Sphyraena barracuda* (Osteichthyes: Perciformes) in the Kosi system with notes on the *Sphyraenidae* of other Natal estuaries. *S. Afr. J. Zool.* 17: 171 – 176.

BLANKLEY, W.O. 1982. The feeding ecology of three inshore fish species at Marion Island (Southern Ocean). *S. Afr. J. Zool.* 17: 164 – 170.

DEGENS, E.T., DEUSER, W.G. & HAEDRICH, R.L. 1969. Molecular structure and composition of fish otoliths. *Mar. Biol.* 2: 105 – 113.

DEWITT, H.H. 1970. A revision of the fishes of the genus *Notothenia* from the New Zealand region, including Macquarie Island. *Proc. Calif. Acad. Sci.* 38: 229 – 340.

FITCH, J.E. & BROWNELL, R.L. 1971. Fish otoliths in cetacean stomachs and their importance in interpreting feeding habits. *J. Fish. Res. Bd Can.* 25: 2561 – 2574.

HECHT, T. 1978. A descriptive systematic study of the otoliths of the Neopterygean marine fishes of South Africa. Part 1. Introduction. *Trans. roy. Soc. S. Afr.* 43: 191 – 197.

LA COCK, G.D., HECHT, T. & KLAGES, N. 1984. The winter diet of gentoo penguins at Marion Island. *Ostrich* 55: 188 – 191.

MARTINI, E. 1964. Otolithen in den Gewöllen der Raubseeschwalbe (*Hydropygne caspia*). *Bonn. Zool. Anz.* 15: 59 – 71.

SMALE, M.J. & BRUTON M.N. 1985. Predation and prey selectivity by *Argyrosomus hololepidotus* (Osteichthyes : Sciaenidae) in south-eastern Cape waters of South Africa. *S. Afr. J. Zool.* 20: 97 – 108.