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Age and growth in pink cusk-eel (*Genypterus blacodes*) off the Chilean austral zone: evaluating differences between management fishing zones

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Summary

The von Bertalanffy (vB) growth parameters for pink cusk-eel (*Genypterus blacodes*) were estimated for the Chilean austral-zone (41°28′–57°00′S) by gender and management fishing zones. A total of 47 026 samples were collected between March 1982 and May 2004, with total length ranging from 19 to 154 cm. Age determinations, based on the reading of saggital otoliths, were between 1 and 14 years in males and between 1 and 16 years in females. Statistical differences in growth were found between the sexes and management fishing zones. For the combined sexes the vB growth parameters for the northern-austral zone (41°28′–47°00′S) were: $l_\infty = 111.452$ cm, $k = 0.186$ year^{-1}, $t_0 = -0.912$ year; and for the southern-austral zone (47°00′–57°00′S): $l_\infty = 123.447$ cm, $k = 0.147$ year^{-1}, $t_0 = -1.779$ year.

Introduction

The species forming the genus *Genyperus* are benthic-demersal fishes inhabiting the continental shelf and slope in the southern hemisphere. Although five or six species are caught for commercial purposes, most are considered bycatch. The pink cusk-eel (*Genypterus blacodes*) is the most important in terms of catch amounts and target intentions, supporting important fisheries in Australia, New Zealand, Argentina and Chile. Knowledge about the ecological processes in this species is fragmentary at best, due to a lack of basic biological and fishery information. Nevertheless, it is still possible to characterize these individuals according to their average life-span, relative low fecundity and sedentary behaviour, in which the adults spend most of their time buried in the soft bottom sediments (Ward et al., 2001).

According to the compiled logbooks, in Chilean waters the pink cusk-eel fishery is developed between Talcahuano (36°44′S) and south of Cabo de Hornos (57°00′S). Nevertheless, catches are mostly in the austral zone (41°28′–57°00′S). Historically, the pink cusk-eel has been caught as an incidental species in the demersal multispecies fishery off southern Chile, where the fishing effort is mainly directed to southern hake (*Merluccius australis*). Catches are carried out by industrial vessels operating with bottom trawls and longlines as fishing gear. As of 1992 the pink cusk-eel fishery has been managed by total allowed catch (TAC) in the austral zone. These TACs have fluctuated around 5000 tonnes per year and are divided by two management fishing zones (MFZ): the northern-austral zone (41°28′–47°00′S) and the southern-austral zone (47°00′–57°00′S).

Although Chong and Aguayo (1990) reported preliminary results on growth parameters for *G. blacodes* in Chile, these parameters are questionable principally because of the shorter temporal and spatial scales covered. For actual stock assessment framework the representative growth parameters throughout the years as well as the sex and MFZ are required (Wiff *et al.*, 2005). By using the extensive data made available by the Chilean Fishery Institute (IFOP), the principal aim of this manuscript was to estimate the von Bertalanffy (vB) growth parameters for sex and MFZ.

Materials and methods

The process included a total of 47 026 sagittal otoliths aged from March 1982 to May 2004. Total length (TL) of each fish was measured to the nearest centimetre. The samples came from two fleets and the two MFZs. Experienced readers determined the ages from the external surface whole otolith. To determine age the otoliths were remoistened in water at least 24 h before reading and their proximal surface polished. They were then immersed in water or oil on a black background and read with reflected light under a stereomicroscpe at 10×. An annulus or annual ring consisted of an opaque and translucent ring or band. The translucent rings were formed principally during the southern winter (April to September, Chong and Aguayo, 1990). For each MFZ and sex, a relationship between otolith radium (R) and TL was described by back calculation using the Fraser-Lee method (Francis, 1990). Fitted back calculation equations for the northern-austral zone were: males TL = 1.25R−9.1 ($r^2 = 0.65$); females TL = 1.45R−22.3, ($r^2 = 0.74$). For the southern-austral zone: males TL = 1.03R + 7.8 ($r^2 = 0.48$); females TL = 1.30R−8.9, ($r^2 = 0.60$). The vB growth function was used to describe fish length as a function of age of pink cusk-eel corresponding to:

$$l_t = l_\infty(1 - e^{-k(t-t_0)})$$

where l_t is the total length at age t; l_∞ is the asymptotic length; k is the growth coefficient that determines how fast l_t approaches l_∞ and t_0 is the theoretical age for $l = 0$. These parameters were estimated by using the minimum squares method. The differences between vB growth parameters for MFZs and sex were assessed by the Hotelling test (Zar, 1984), under the null hypothesis of H_0:$\Theta_1 = \Theta_2$ where Θ_1 y Θ_2 are particular vector parameters coming from the fitted models to n_1 and n_2 data sets.

Results

The fitted parameters are summarized in Table 1. In both MFZs, the oldest ages observed corresponded to 14 and

Table 1
Von Bertalanffy growth parameters fitted by management zones and sexes in pink cusk-eel, *Genypterus blacodes*

	Northern-Austral zone			Southern-Austral zone		
	Males (N = 12 311)	Females (N = 7270)	Both sexes (N = 19 581)	Males (N = 13 154)	Females (N = 14 291)	Both sexes (N = 27 445)
l_∞ (cm)	97.166 (0.249)	117.401 (0.392)	111.452 (0.273)	101.007 (0.260)	123.184 (0.292)	123.447 (0.287)
k (year^{-1})	0.241 (0.002)	0.184 (0.002)	0.186 (0.001)	0.209 (0.002)	0.165 (0.001)	0.147 (0.001)
t_0 (year)	−0.844 (0.010)	−0.591 (0.011)	−0.912 (0.009)	−1.756 (0.016)	−1.248 (0.010)	−1.779 (0.010)
Oldest age recorded (years)	14 (N = 1)	16 (N = 1)		14 (N = 2)	16 (N = 4)	
Length range sampled (cm)	29–125	19–141		31–127	11–154	

N = number of otoliths read and used for fitting the model. Standard errors shown in brackets.

16 years for males and females respectively. At any given age, the individuals from the northern-austral zone were smaller and had higher growth rates than those from the southern-austral zone (Fig. 1). In both MFZs, the females were larger and had smaller growth coefficients compared with males at the same age (Table 1). By using the Hotelling test we determined that the differences between vB parameters were statistically significant ($P < 0.05$) between sexes in the same MFZ as well for the same sex between MFZs. Comparing length at a given age, an average difference of 4.6 cm of TL was found for combined sexes between MFZs. These differences show a decrease with age. At lower ages (1–3 years) we found greater differences (8.6–5.1 cm) followed by a stabilization difference of around 4 cm from ages 4–16.

Discussion

The differential growth by sexes is also demonstrated for *G. blacodes* off both Argentina (Renzi, 1986) and New Zealand (Horn, 1993). The asymptotic lengths and maximum ages

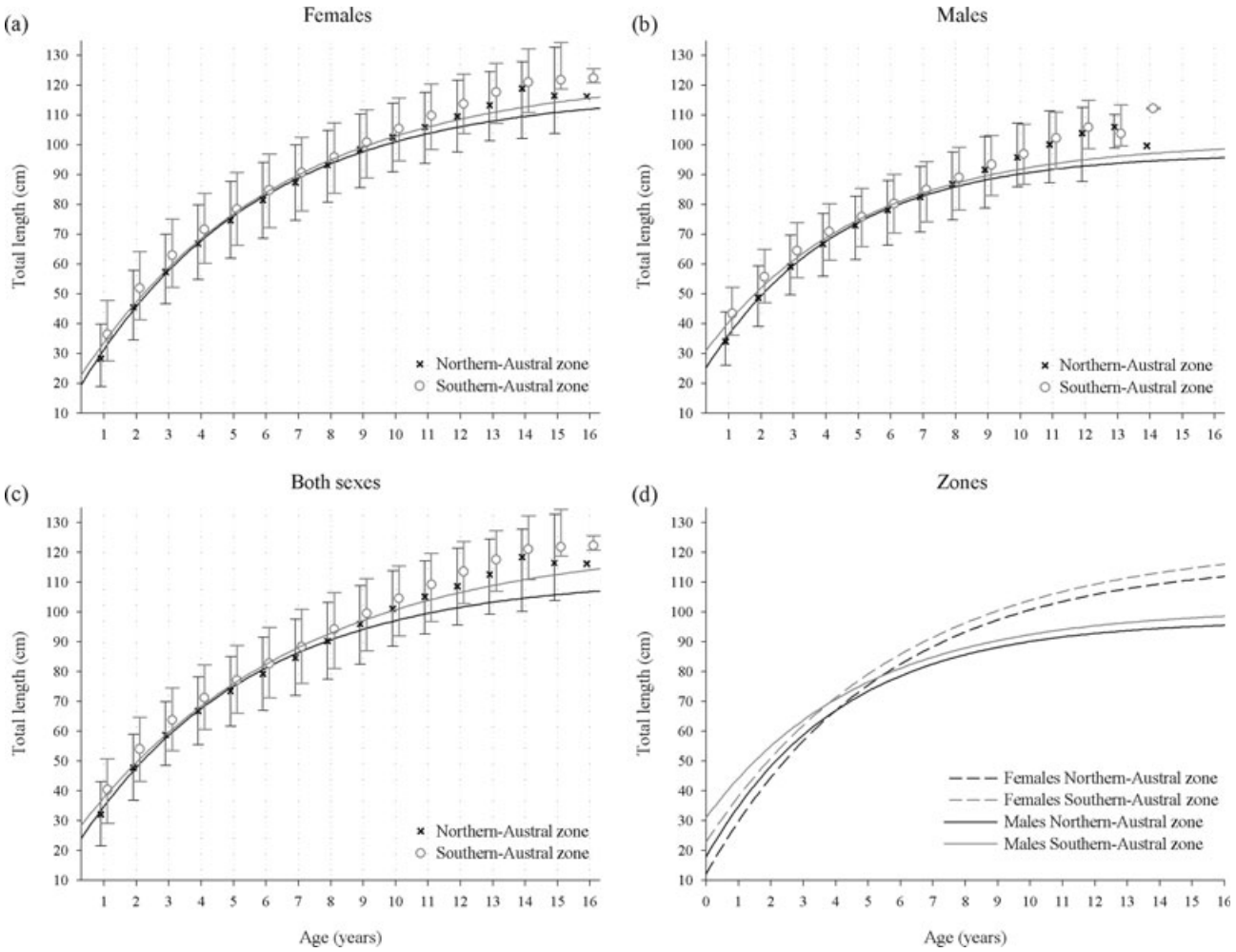

Fig. 1. Von Bertalanffy curve fitted to pink cusk-eel, *Genypterus blacodes*, in Chilean austral zone. Continuous line = model fitted; vertical lines = 5–95% percentile of length-at-age; symbol = median length at age. (a) females; (b) males; (c) both sexes combined; (d) fitted curves by sexes and management zones

estimated here were smaller than those reported for *G. blacodes* in Australia and New Zealand. In Australia the maximum age appearing routinely in the fishery is 21 years (Withell and Wankowski, 1989); in New Zealand it is 26 years in males and 27 years for females (Horn, 1993). In Chilean waters for both MFZs, we found significant proportions of 3- to 4-year-old individuals vulnerable to trawling. Although the same ages are vulnerable in New Zealand waters (Horn, 1993), in Chile it appears likely that that full recruitment does not occur until about age 6 (Wiff *et al*., 2005), while in New Zealand the full recruitment is around 14 years old.

Significant differences were found between our parameter estimations and those estimated by Chong and Aguayo (1990), who used samples registered during 1984 and non-considering separation between MFZs. In fact, the asymptotic lengths for each sex found by Chong and Aguayo (1990) are higher (134.8 cm for females; 117.5 cm for males) and the growth coefficient slightly lower (0.141 $year^{-1}$ for females; 0.179 $year^{-1}$ for males) in comparison with our estimated values. Over time, a decrease in size is often observed in heavily exploited species, which may be what is being observed in the pink cusk-eel fishery. Supporting this point, Wiff *et al*. (2005) showed a decrease in average length through the years in the trawl fishery. Between 1982 and 2004 the average length decreased from 95 to 80 cm TL in the southern-austral zone and from 85 to 78 cm TL in the northern-austral zone. For the same fishing gear and period the proportion of catch (in weight) under the length at maturity increased between 1982 and 2004, from 0.1 to 0.45 in the southern-austral zone and from 0.2 to 0.5 in the northern-austral zone. These results give an idea of the high exploitation rates of the pink cusk-eel population off southern Chile.

Differences in growth rates of *Genypterus* species from adjacent areas have been demonstrated for fishes off South Africa (Payne, 1985) and New Zealand (Horn, 1993). Off the Chilean austral zone, Wiff *et al*. (2005) estimated and compared by MFZs the population attributes such as average individual length, cohort dynamics, resilience and sex ratios. Wiff *et al*. (2005) concluded that the population dynamics for these MFZs exhibited extremely different patterns. Here we provide further evidence for this difference, showing that individual growth traits can vary by zones.

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References

Chong, J.; Aguayo, M., 1990: Determinación de edad y estimación de los parámetros de crecimiento del congrio dorado, *Genypterus blacodes* (Schneider, 1801) (*Osteichyes, Ophidiidae*) en el Pacífico Sur Oriental. Biol. Pesq. **19,** 55–67.

Francis, R. I. C. C., 1990: Back-calculation of fish length: a critical review. J. Fish Biol. **36,** 883–902.

Horn, P. L., 1993: Growth, age structure, and productivity of ling, *Genypterus blacodes* (Ophidiidae), in New Zealand waters. N. Z. J. Mar. Freshwater Res. **27,** 385–397.

Payne, A. I. L., 1985: Growth and stock differentiation of kingklip (*Genypterus capensis*) on the south-east coast of South Africa. South Afr. J. Zool. **20,** 7–14.

Renzi, M. A., 1986: Aspectos biologico-pesqueros del abadejo (*Genypterus blacodes*). Revista de Investigacion y Desarrollo Pesquero **6,** 5–19.

Ward, R. D.; Appleyard, S. A.; Daley, R. K.; Reilly, A., 2001: Population structure of pink ling (*Genypterus blacodes*) from south-eastern Australian waters, inferred from allozyme and microsatellite analyses. Mar. Freshw. Res. **52,** 965–973.

Wiff, R.; Montecinos, M.; Ojeda, V.; Farías, J., 2005: Congrio dorado en la pesquería demersal sur austral; ¿'Es plausible la hipótesis de una sola unidad poblacional?. XI Congreso Latinoamericano de Ciencias del Mar (COLACMAR), 16–20 de Mayo, Viña del Mar, Chile.

Withell, A. F.; Wankowski, J. W. J., 1989: Age and growth estimates for pink ling, *Genypterus blacodes* (Schneider), and gemfish, *Rexea solandri* (Cuvier), from eastern Bass Strait, Australia. Aust. J. Mar. Freshwater Res. **40,** 215–226.

Zar, J. H., 1984: Biostatistical analysis, 2nd edn. Prentice Hall, Upper Saddle River, NJ.

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