Growth in fisheries resources from the Southwestern Atlantic

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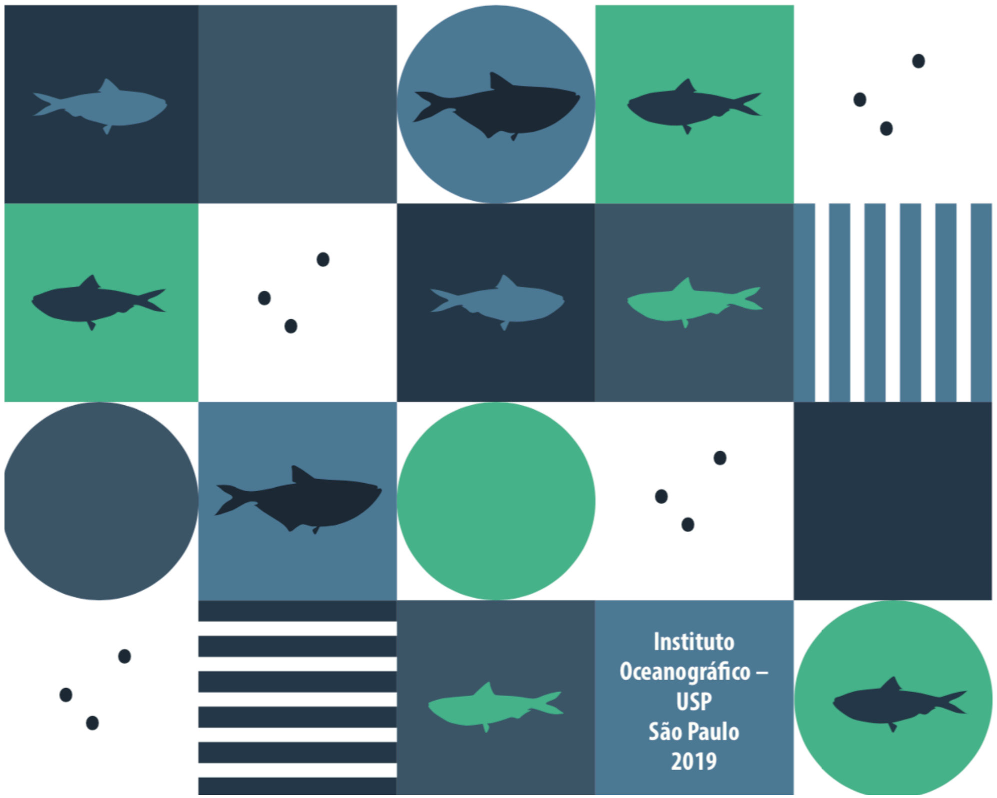
(Editors)



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Doryteuthis plei Blainville 1823
at the Northern coast of São Paulo state

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Context of the study:

This study was developed in the context of two research projects conducted at the Oceanographic Institute of the University of São Paulo: ***"Squid (Cephalopoda: Loliginidae) as a fishing resource of the Northern coast of the State of São Paulo: population dynamics, fisheries oceanography and the associated human dimension"*** and: ***"Population dynamics, fishing oceanography, and the human dimension of the squid fisheries (Cephalopoda: Loliginidae) in islands off the North coast of São Paulo".*** Data were obtained in São Sebastião and Ubatuba (Figure 1).

Here, we describe the growth curve obtained for *Doryteuthis plei* by interpreting the daily growth increments deposited in the statoliths. Length data and growth parameters will contribute to a better understanding of the squid population structure. The adopted protocol may help further sampling preparation for squid growth studies and the interpretation of increments or rings on statoliths.

Sampling:

Samples of *D. plei* were obtained from commercial fisheries (artisanal bottom trawls, Japanese-style pound nets (kaku-ami) and scientific surveys (hand-jigging and dip-nets under light attraction), at 4-30 m depth, from September 2011 to March 2013. Figure 1 shows the sampling sites at the northern coast of São Paulo state, mainly located at São Sebastião Island (23°70'S, 45°50'W) and Ubatuba (23°33'S, 45°06'W).

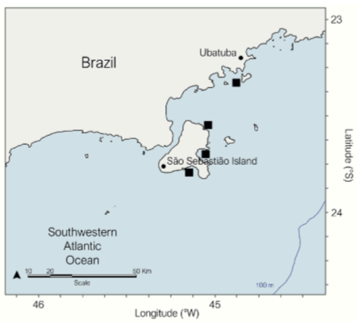

Figure 1.
Doryteuthis plei: sampling sites (squares) in this study.

Biological samples:

A total of 333 specimens of *D. plei*, ranging from 26- to 267 mm in mantle length (ML), mean±standard deviation 101.6±59.9 mm and median 80 mm (Figure 2).

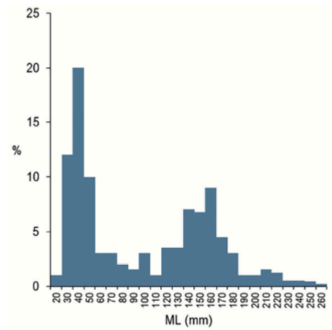

Figure 2.
Doryteuthis plei: frequency (%) of specimens per total mantle length class (ML).

Age and growth analysis:

Method: The age was estimated by counting the number of growth increments on squid statoliths. For this, the statolith pair of each specimen was extracted through a ventral incision in the back of the head cartilage (Sifner 2008, Jackson & Forsythe 2002, Aguiar *et al.* 2012). One statolith of each pair was considered and prepared to estimate the age. The concave side of each statolith was polished until the core and the edge boundary of the dorsal dome was visible under microscope. The polished side was embedded in a colorless resin on a glass slide.

From the ring of birth to the edge of the dome (A: growth axis, Figure 3) the growth increments (a paired dark and light band) were counted for each statolith under a light microscope (400× and 1000× objective zooms).

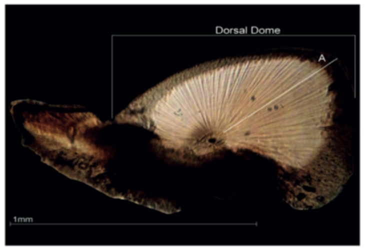

Figure 3.
Doryteuthis plei: statolith view under a microscope (A: reading axis of the incremental growth, 63× zoom).

Validation and ring formation: Growth increment are formed by biomineralization produced over 24 hours (Bettencourt & Guerra 2000). Jackson & Forsythe (2002) and Aguiar *et al.* (2012) estimated growth patterns of *D. plei* and confirmed that the deposits of growth increments on statolith are performed daily.

Age structure: The age structure per size is shown in Table 1, predominating of individuals of 7-9 months old sampled.

Table 1. *Doryteuthis plei:* frequency (%) of individuals at age per mantle length class (N = number of individuals per class).

ML (mm)	Age in months											N
	1	2	3	4	5	6	7	8	9	10	11	
20				67	33							3
30				27	73							40
40				16	71	13						67
50				15	53	24	8					33
60				20	40	10	30					10
70					10	80	10					10
80					14	43	29	14				7
90							80	20				5
100					11	34	22	22	11			10
110							50	25	25			3
120							27	37	27	9		12
130							18	36	10	36		12
140						5	24	29	37	5		23
150							40	10	40	10		23
160						3	29	8	38	16	6	30
170						6	7	40	27	20		15
180							30	10	30	20	10	10
190								33	34	33		3
200									100			3
210							40	20			40	5
220							25		50	25		4
230										100		2
240							50			50		1
250							33	67				1
260									100			1

Growth model: The logistic model (r^2= 0.77) represented the growth of *D. plei* in the region studied (Figure 4):

$$ML = 182.58 / [1 + e^{-0.8814\,(t - 6.16)}]$$

Where ML is the total mantle length, L_∞ = 182.58 mm, k = 0.8814 mm day^{-1} and t_0 = 6.16 days.

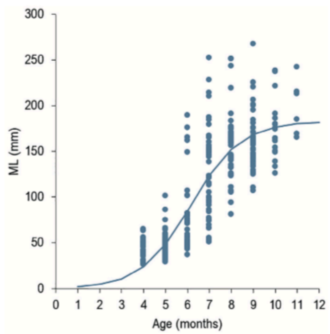

Figure 4.
Doryteuthis plei: growth curve fitted by the logistic model (continuous line) showing the relationship between age (months) and size (mantle length, ML in mm).

Comments:

The Tropical arrow squid, *Doryteuthis plei*, is a semelparous species (Boyle & Rodhouse 2005), being considered a keystone species of the South Brazil Bight marine ecosystem. It is an active predator on several fish, squid, and crustacean species as well as an important prey item that has been found in stomachs of a wide variety of fishes, marine mammals and seabirds (Jereb & Roper 2010, Gasalla *et al*. 2010). *D. plei* is also one of the main cephalopods currently targeted by some small-scale fisheries (Perez 2002, Boyle & Rodhouse 2005, Postuma & Gasalla 2014).

Age composition and growth rate in squid populations are essential to understand the population dynamics and life cycle of their exploited stock. For effective fisheries monitoring the knowledge on growth parameters related to squid size is often required (Sifner 2008), especially to undertake a stock assessment.

Our estimate showed a wider size range of *D. plei* in comparison with previous studies (Aguiar 2002, Perez *et al.* 2002a, 2006). However, not all size classes were obtained. Jackson & Forsythe (2002) suggested an exponential model, while Aguiar (2002) suggested a power model for this species. Barcellos *et al*. (in review) suggest that *D. plei* growth is better represented by a sigmoid curve to evidence changes in the growth pattern.

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