ZOOLOGIA 34: e20475
ISSN 1984-4689 (online)
zoologia.pensoft.net

RESEARCH ARTICLE

Age structure and growth of the rough scad, *Trachurus lathami* (Teleostei: Carangidae), in the Southeastern Brazilian Bight

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http://zoobank.org/87858997-8113-4717-A67A-673CD99E3D52

ABSTRACT. The rough scad, *Trachurus lathami* Nichols, 1920, is a small pelagic species distributed along the West Atlantic coast. It is most abundant in the Southern Brazil (28°30'–34°S) and in the Southeastern Brazilian Bight (SEBB, 22°–28°30'S). The rough scad is fished by purse seines, which main target is the Brazilian sardine, *Sardinella brasiliensis* (Steindachner, 1879). Age and growth are vital to understand the life cycle of a species, to fishery management and ecosystem modeling. This study aimed to assess the age and growth of *T. lathami*, to identify its age structure in the SEBB, and to evaluate what causes the wide differences among *Trachurus* species in terms of body size and growth parameters. Data available on *T. lathami* was attained between 2008 and 2010 from surveys at SEBB. A total of 278 whole otoliths of *T. lathami*, total length between 27 mm and 208 mm, were analyzed and compared with the only other source of otolith data, from 1975. Three blind readings were performed and assessed using traditional methods to study fish age and growth. Zero up to eight rings were found, each ring corresponding to one year in the life of an individual of this species. The von Bertalanffy growth model parameters were L_∞ = 211.90 mm and K = 0.319 year-1. The results of the analyses have shown similarities between 1975 and 2008-2010, indicating that the otolith development, the growth pattern and the age structure remained stable. *T. lathami* is the smallest species of *Trachurus* and it has the highest growth rates among them. This is probably related to the different temperatures where larvae/juvenile and adult grow, to the absence of a strong fishing pressure and to decadal population variability.

KEY WORDS. ECOSAR, otolith, sclerochronology, von Bertalanffy.

INTRODUCTION

In the Atlantic Ocean, the rough scad, *Trachurus lathami* Nichols, 1920, is a pelagic species distributed between the United States and North of Argentina, mainly on the continental shelf. It occurs between 50 and 100 m in depth, where it forms schools (Smith-Vaniz 2002). In Brazil, their largest concentrations have been recorded both in the Southeastern Brazilian Bight (SEBB, between 22° and 28°30'S) and in the Southern region (between 28°30' and 34°S) (Saccardo and Haimovici 2007). In these areas, the rough scad is an important fishery resource in purse seines, along with other important pelagic species such as the *Sardinella brasiliensis* (Steindachner, 1879) and *Opisthonema oglinum* (Lesueur, 1818) (Saccardo and Haimovici 2007, UNIVALI 2011).

In the SEBB, rough scad landings varied a lot until the end of the 1990's (Valentini and Pezzutto 2006), a period when this fish was caught in association with the Brazilian sardine (*S. brasiliensis*) (Fig. 1). When there were fewer sardines, purse seine fleets would capture and land the rough scad (Saccardo et al. 2005). After this period, sardine landings increased and rough scad landings dropped, without a clear association between them. Between 2005 and 2008, rough scad landings were around 700 t/year, with a later reduction to an average of 88 t (2009–2010) (MMA 2007a, b, 2008, UNIVALI 2009, 2011, Instituto de Pesca

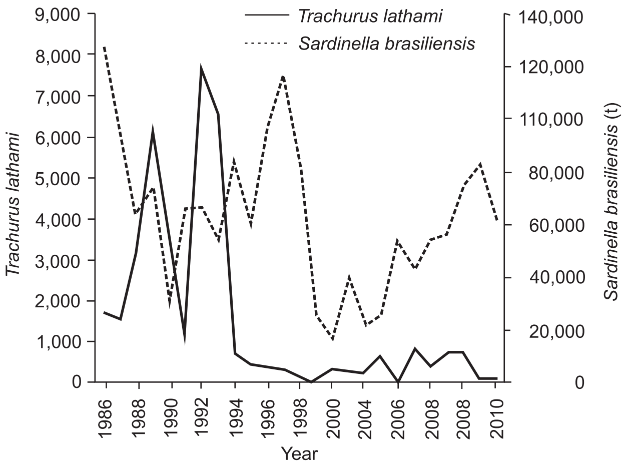


Figure 1. Commercial landings of *Trachurus lathami* and *Sardinella brasiliensis* in the Southeastern Brazilian Bight (SEBB). Data of 2008, 2009 and 2010 are restricted to states of Paraná and São Paulo that representing 95% of the total landings. Data source: Valentini and Pezzutto 2006, MMA 2007a, b, 2008 UNIVALI 2009, 2010, 2011, Instituto de Pesca 2013.

2013). Historically, this species has presented intense population fluctuations (Katsuragawa and Ekau 2003), oscillations that are also common to the other species of *Trachurus* Rafinesque, 1810, related to climate and environmental conditions, fishing pressure, biological elements (feeding, reproduction, growth, recruitment) and the combination of those (Arancibia and Neira 2002, Espino 2013, Geist et al. 2015).

There is a single stock of the rough scad at the SEBB (Saccardo and Haimovici 2007). Its life cycle and fishery (Saccardo 1987, Saccardo and Kasturagawa 1995, Saccardo et al. 2005); growth (Saccardo and Katsuragawa 1995); diet (Meneghetti and Alves 1971, Carvalho and Soares 2006); parasites (Braicovich et al. 2012); and larvae and juveniles (Katsuragawa and Matsuura 1992, Katsuragawa and Ekau 2003, Campos et al. 2010) have been investigated. Some biological aspects can be summarized from those studies, as follow. The rough scad breeds throughout the year, with a peak between October and December (springtime). The larvae are distributed all over the continental shelf. Individuals grow up to a total length of 200-250 mm (TL), with the first maturation at 115–132 mm TL, living up to 8–9 years. The rough scad is mainly a zooplankton feeder, despite some records of predatory behavior. The otoliths were studied in terms of age and growth (Saccardo and Katsuragawa 1995) and morphology (Siliprandi et al. 2014).

Studies on age and growth provide an essential tool to understand the biology and ecology of fish, providing a foundation for population dynamics assessments (King 2007). Growth parameters have multiple applications in fishery management (Beverton and Holt 1993, Froese and Binohlan 2000, Sponaugle 2010), and their estimates through the analysis of otoliths provide precise and accurate results (Green et al. 2009). Several studies on age and growth, based on otoliths, have been conducted on different species of *Trachurus* (Webb and Grant 1979, Horn 1993, Karlou-Riga and Sinis 1997, Karlou-Riga 2000, Araya et al. 2001, Waldron and Kesrtan 2001, Kasapoglu and Duzgunes 2013, among others), mainly in view of their commercial relevance (Checkley et al. 2009). From these studies, it is possible to conclude that age and growth are very different among *Trachurus* species, and that otolith analysis is useful, allowing the comprehension of their biological patterns (Karlou-Riga 2000, Abaunza et al. 2003).

The significance of the small pelagic fisheries at SEBB led the Brazilian government to promote evaluation and monitoring programs of these resources. Although they were not continuous, the most recent initiative was the ECOSAR Program (Prospection and assessment of the sardine stock biomass in the Southeastern coast by the use of hydro-acoustic methods) carried out between 2008 and 2010 (Cergole and Dias Neto 2011). Even though the target species was *S. brasiliensis*, other representative species captured during the surveys, among which is *T. lathami*, were also accounted for. This study aimed to assess the age and growth of *T. lathami*, to identify its age structure in the Southeastern Brazilian Bight, and to evaluate what causes the wide differences among *Trachurus* species in terms of body size and growth parameters.

MATERIAL AND METHODS

Four survey cruises were carried out between 20 and 100 m deep with the OV Atlântico Sul by FURG during January-February 2008 (Summer), November 2008 (Spring), September-October 2009 (Spring) and February-March 2010 (Summer) in the Southeastern Brazilian Bight (22°–28°30'S). Transects in perpendicular profiles, oblique to the coast, were followed. The echo sounder (Simrad EK500) was employed and when shoals were detected, both pelagic trawling and purse seine were carried out. Details on the methodology are available in Rossi-Wongtschowski et al. (2014). *Trachurus lathami* were caught in 17 fishing operations (Fig. 2). On board, samples were frozen. In the laboratory, the total length (TL, mm) of individuals was measured and their *sagittae* otoliths were removed, washed, dried and stored in microtubes (FAO 1981).

Whenever possible, ten otoliths of *T. lathami* were selected from each survey by total length class (10 mm) (Araya et al. 2001). Images of the entire left otolith under water (Fig. 3) were obtained using a stereomicroscope coupled with an image analyzer, and the length (measurement of the horizontal projection of its ends in relation to the longer axis – OL, mm) and height (measurement of the vertical projection in relation to the higher axis of the structure – OH, mm) of the otolith were recorded. The weight of the otolith (OW, g) was obtained with an analytical balance. In order to describe otolith growth in relation to body growth, the allometric (potential) model (Huxley 1993) was used to fit regressions among the total length and the measurements of the otoliths (Vaz-dos-Santos 2015a). The adequacy of

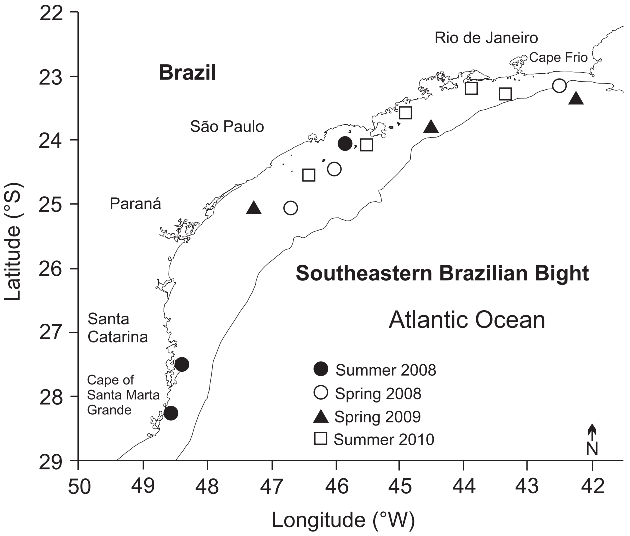


Figure 2. Map of the Southeastern Brazilian Bight (SEBB) showing the locations of fishing hauls with *Trachurus lathami* catches by period (n = 17, some points are overlapped in the map).

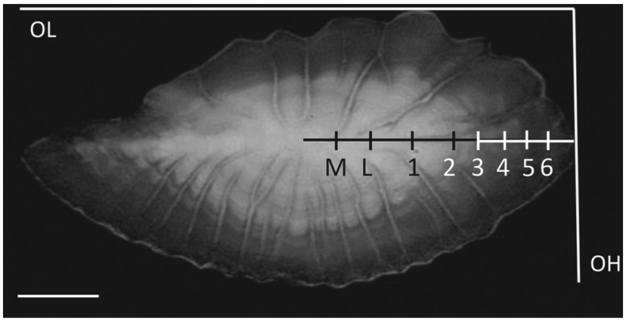


Figure 3. *Trachurus lathami*: external surface of a left otolith showing measurements (OL = otolith length and OH = otolith height) and ring analysis (M and L are rings formed before the first annual one; more details in the text). Scale bar: 1 mm.

the regressions was checked by the values of the coefficient of determination (r^2) and the residual analysis (Bervian et al. 2006, Vaz-dos-Santos and Rossi-Wongtschowski 2013).

In order to study age and growth, the annual growth zones of the otoliths (macrostructural analysis) were analyzed (Brothers 1987). Whole otolith images were used to identify the central opaque nucleus and, from this, in the posterior axis to the posterior edge (otolith radius, Ro, mm), the translucent zones. The complete and continuous translucent zones were counted and measured from the beginning of their formation (Fig. 3) (Saccardo and Katsuragawa 1995, Karlou-Riga and Sinis 1997, Waldron and Kerstan 2001). Three blind readings were carried out by the same reader, whose consistency was checked by the average percentage error (APE) (Beamish and Fournier 1981) and the value of the coefficient of variation (CV) (Campana 2001). In order to check the consistency of the ring analysis, box plot and constancy analysis were applied (Vaz-dos-Santos 2015b). A box plot of the ring radius by the ring (category) was built in order to check whether there is overlap among measurements. After checking the assumptions, ANOVA followed by post-hoc Tukey test were performed to compare the averages of the radius. A constancy analysis (scatter plot between total length and the rings radius) was applied, and the linearity of each ring group was tested using regression analysis (except for rings 7 and 8, with a narrow range of total length). All statistical procedures followed Zar (2010) with 5% of significance. The ring counts and edge patterns allowed age attribution, since the formation of an annual ring had been previous validated, occurring between October and December (Saccardo and Katsuragawa 1995). Two rings are formed during the first year of life, before the first annual ring (Saccardo and Katsuragawa 1995). Whenever possible, these rings were recorded, but they were not used in any analysis.

The von Bertalanffy growth model parameters (VBGM) (L_∞, K, t_0) were estimated from observed lengths per age and by the average lengths per age using the least-squares iterative method (Aubone and Wöhler 2000). From the growth parameters, the inverse VBGM was used to estimate the age of the entire sample of *T. lathami*. Although the value of the theoretical age at zero length has been estimated, it was not used to estimate the age with the inverse VBGM. Next, an age length key (frequencies of individuals by age and TL class) was built and the space-time distributions by ages were analyzed in the surveyed periods using maps.

RESULTS

The total length of 1,312 *T. lathami* individuals sampled varied between 27 mm and 208 mm, resulting in bimodal distributions in each period surveyed, one of juveniles (20 to 60 mm) and a second mode composed of adults (>115 mm TL), which predominated in the seasons analyzed (Fig. 4). The few numbers of fish sampled between 100-140 mm TL resulted from the selectivity of the fishing gear employed.

Following the selection criteria, 282 otoliths of *T. lathami* were analyzed (it was not always possible to attain ten otoliths from each survey by TL class). The regressions among the otolith measurements (Table 1) represented properly the development of the structure ($p < 0.001$ in the three regressions, $0.970 < r^2 < 0.979$), thus enabling the use of the otoliths in the growth study. In the adjusted models (TL vs. OL, TL vs. OH, TL vs. OW), residuals did not show any bias. The best fit was presented by the TL vs. OL model ($r^2 = 0.979$), showing that the otolith length provides the best representation of fish growth, following the anterior-posterior axis.

After three readings, 278 otoliths were considered legible (98.6%) and four non legible (1.4%), which were not considered in the following analysis. The average percentage error among

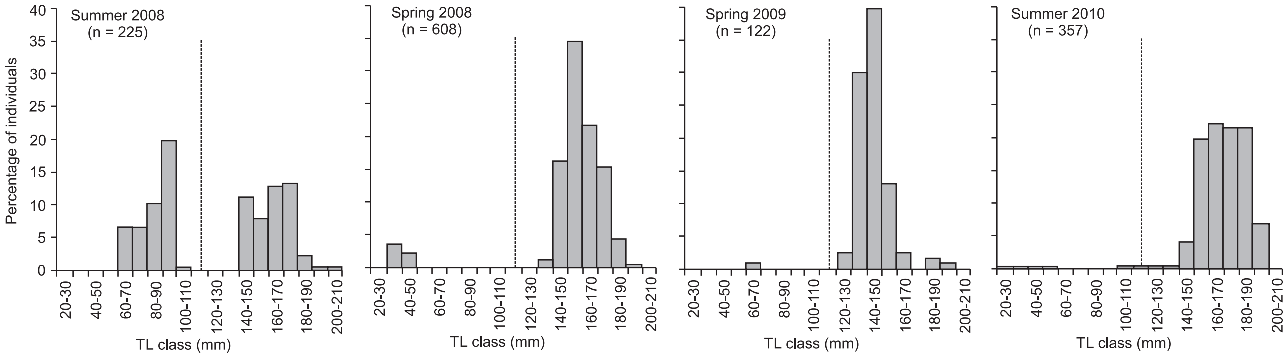


Figure 4. *Trachurus lathami*: length frequency distribution by period (dashed line indicates the average length of first maturity, L_{50} = 115 mm).

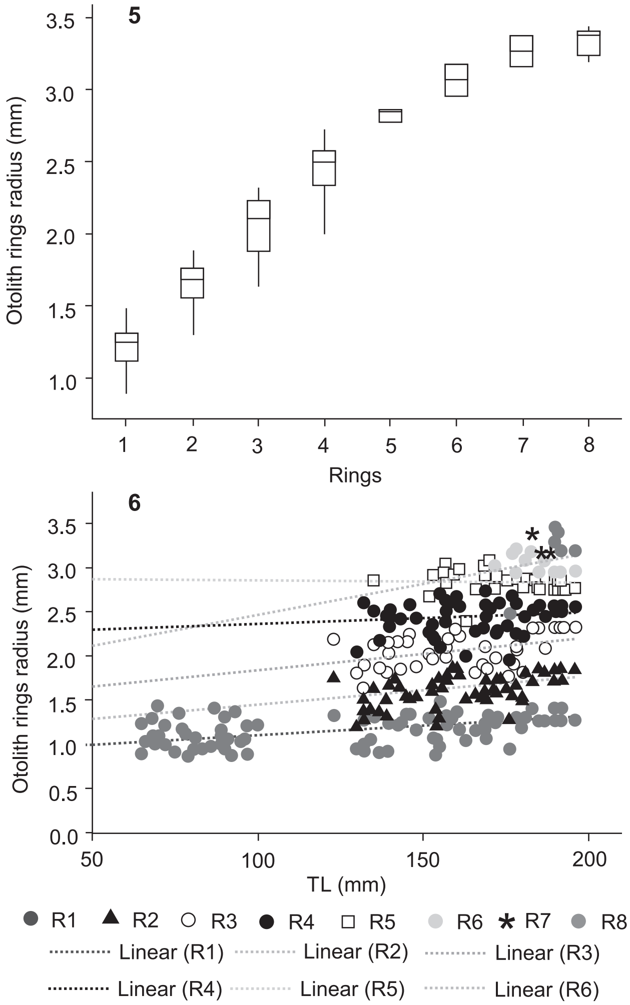
Table 1. *Trachurus lathami:* coefficients of potential regressions between total length (TL, mm) and otolith length (OL, mm), height (OH, mm) and weight (OW, g). (r^2) Coefficient of determination, n = 282.

Regression	a ± $IC_{95\%}$	b ± $IC_{95\%}$	r^2
TL vs. OL	0.041 ± 0.003	0.991 ± 0.017	0.979
TL vs. OH	0.050 ± 0.004	0.825 ± 0.017	0.970
TL vs. OW	$3.96.\ 10^{-8} \pm 8.84.\ 10^{-9}$	2.524 ± 0.052	0.971

the three readings was 4.1%, and the coefficient of variation was 5.4%. Otoliths with up to eight rings were observed with high precision and consistency, revealed by the box plot and constancy analysis (Figs 5, 6). In relation to the box plot analysis, the average radius of rings was significantly different (ANOVA F = 1527.76, $p < 0.001$), except for rings 7 and 8 ($p > 0.05$). Linearity tested in the constancy analysis was not significant in all cases ($p > 0.05$). Fish with only two rings were not found. The age determination resulted in fishes with age zero up to eight years old.

The von Bertalanffy growth model parameters were L_∞ = 211.90 mm, K = 0.319 $year^{-1}$ and t_0 = -0.576 years for observed lengths per age, and L_∞ = 206.31 mm, K = 0.336 $year^{-1}$ and t_0 = -0.578 years for average lengths per age. When considering the maximum length obtained in the sampling (208 mm), the parameters estimated through the average lengths were disregarded, and the parameters fitted from observed lengths per age were adopted to estimate fish age (Fig. 7). The sample had fish from 0 to 8 years old or above (Table 2).

In relation to the space-time distributions, in the summer of 2008, the rough scad schools were concentrated closer to the coast at 27°–28°S (89%), with all ages represented, and a predominance of one-year old fish (Fig. 8), associated with the Cabo Frio upwelling (22°–23°S), around 100 m isobath. Another school was found at the continental shelf 24°–25°S (Fig. 9), similar to the summer of 2009 (Fig. 10). In the summer of 2010, the rough scad was more concentrated between 23°–24°S, and its school was composed mainly of 4-year old fish, or older (Fig. 11).



Figures 5–6. *Trachurus lathami:* (5) Box plot of ring radius (whiskers = minimum and maximum, box = interquartile range, bar = mean). (6) Constancy graph showing the position of rings radius (R) against total length (TL) (n = 278).

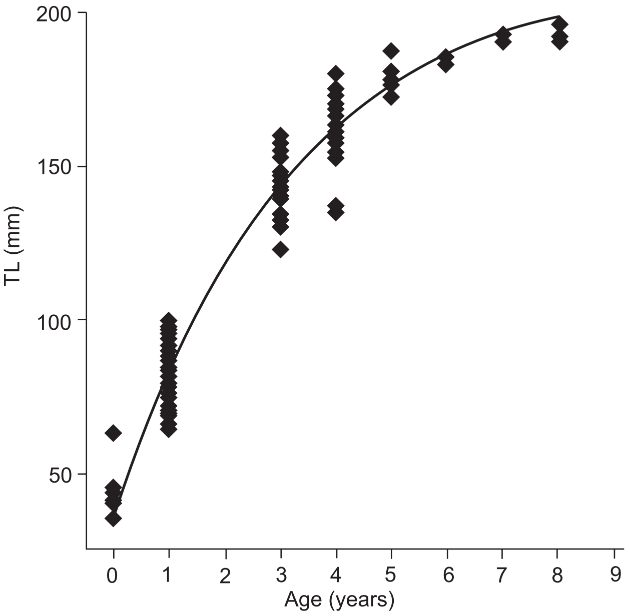


Figure 7. *Trachurus lathami:* von Bertalanffy growth curve fitted (line) to observed total lengths (points) by age (n = 278).

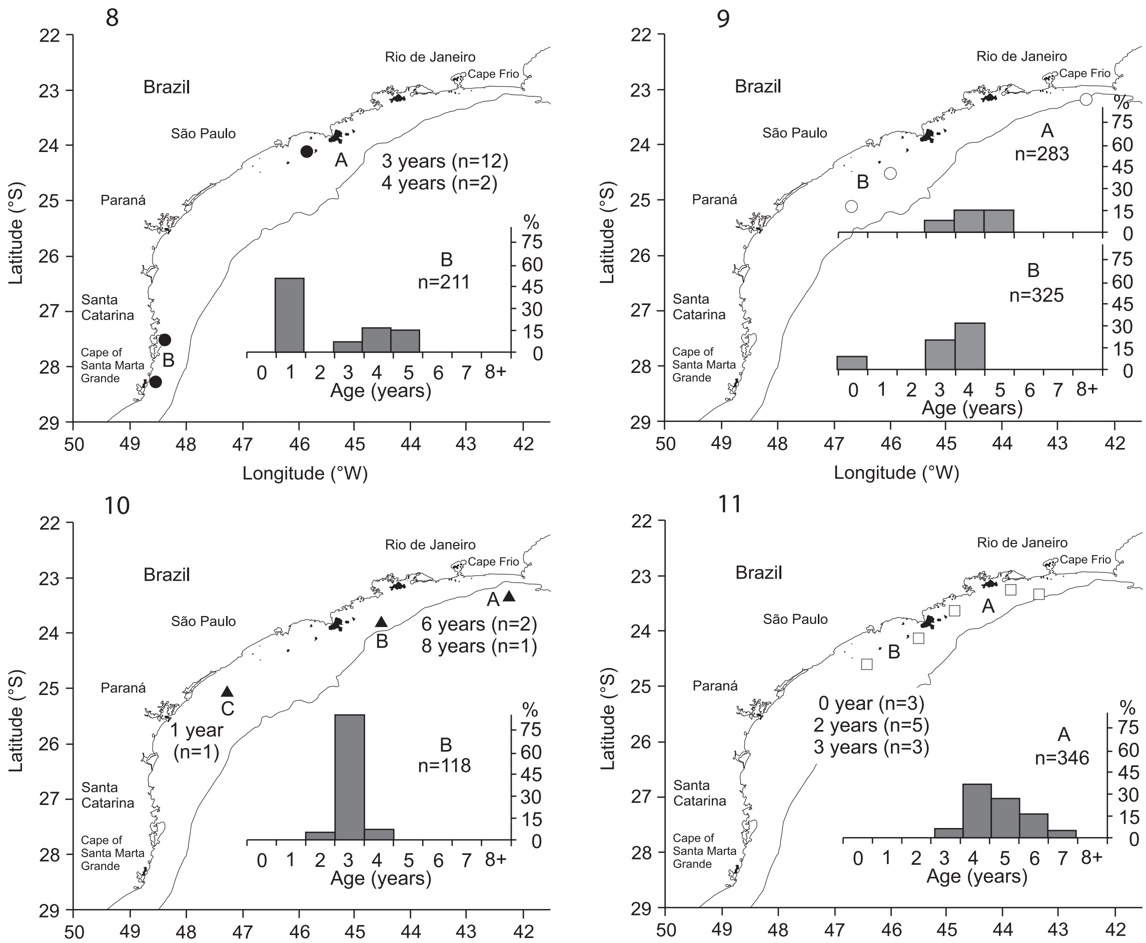
DISCUSSION

The growth parameters estimated for *T. lathami* in this study are the most recent after 1975 (Saccardo and Katsuragawa 1995). They originate from the only biological data available for this species in the Southwestern Atlantic (Cergole and Dias Neto 2011), and represent the population and the sampling adequately, due to the total length range analyzed. Previous information on the presence of up to 400 mm TL rough scads at the SEBB (Menezes and Figueiredo 1980) denotes very rare individuals, never recorded again. Historically, the longer total lengths recorded for the rough scad in the SEBB were 260 mm (Saccardo 1987), 207 mm (Figueiredo et al. 2002), 240 mm (Saccardo et al. 2005) and 261 mm (Bernardes et al. 2005). In all these studies, as well as in our results, individuals larger than 200 mm were seldom recorded. This indicates that *T. lathami* in the study area have smaller size structure (usually up to 180 mm SL) than in the Caribbean Sea (330 mm SL) (Smith-Vaniz 2002), but similar size structure to that found for the Uruguayan and Argentinean coasts (between 80-230 mm TL) (Cousseau and Perrotta 2004). Thus, the size structure analyzed in this work was representative of the stock, even in the absence of larger individuals.

The development of the otoliths of *T. lathami* had only been analyzed by Saccardo and Katsuragawa (1995), whose details are

Table 2. *Trachurus lathami:* age-length key in the Southeastern Brazilian Bight during 2008–2010: percentage (from the total) of individuals by length class and age; number of ages estimated through otolith readings and with the inverse von Bertalanffy Growth Model (VBGM).

Total length class (mm)	Age (years)									Otolith readings	Inverse VBGM	Total
	0	1	2	3	4	5	6	7	8+			
20–30	100%									–	2	2
30–40	100%									11	13	24
40–50	100%									15	–	15
50–60	100%									–	1	1
60–70		100%								16	–	16
70–80		100%								10	5	15
80–90		100%								10	13	23
90–100		100%								10	52	62
100–110			100%							1	1	2
110–120			100%							–	1	1
120–130			100%							3	1	4
130–140			7%	93%						18	27	45
140–150				100%						38	160	198
150–160				28%	72%					40	276	316
160–170					94%	6%				33	212	245
170–180						100%				30	171	201
180–190						25%	75%			27	84	111
190–200								80%	20%	16	14	30
200–210									100%	–	1	1
Total	42	116	10	328	458	244	83	24	7	278	1034	1312



Figures 8–11. *Trachurus lathami:* space-time distribution of age groups in the Southeastern Brazilian Bight during (8) summer of 2008 (January-February), (9) spring of 2008 (November), (10) spring of 2009 (September-October) and (11) summer of 2010 (February–March).

available only in the unpublished thesis of Saccardo from 1980. Using these sources and Saccardo (1987), the visual inspection of scatter plots of the total length of individuals and otolith measurements (regression models were not adjusted in these former studies), it was possible to verify that otolith development has kept a similar pattern between the 1975 and 2008-2010. Namely, OL, OH and OW in relation to TL, respectively, showed similar values. In the present results, the allometric models and residual analysis did not show noticeable changes in the pattern of otolith development, indicating a single-phase growth (Bervian et al. 2006). Previously, it was evidenced a change in otolith thickness (two phases of otolith development) close to 130 mm TL (Saccardo and Katsuragawa 1995), due to the first gonadal maturation (Saccardo et al. 2005), which was not evidenced here probably due to the few numbers of individuals between 100-140 mm TL.

The quantitative elements (APE, CV, box plot, constancy analysis) used to evaluate otolith readings indicated that the ring radius presented high precision and does not vary much (Campana 2001). Accuracy was also high, i.e., the position of the rings in the otoliths was similar to values reported previously (Saccardo and Katsuragawa 1995). These authors described the formation of two rings adjacent to the nucleus in 13% and 28% of the 1,908 otoliths analyzed, respectively. The material in this study hardly presented those rings and no clear patterns (at least in the macrostructural analysis); therefore, they were not taken into consideration. To investigate them, a microstructural analysis of the otoliths of *T. lathami* needs to be carried out.

The use of whole otoliths, sectioned otoliths or both, to count rings and to estimate age has been broadly discussed (Webb and Grant 1979, Karlou-Riga and Sinis 1997, Stewart and Ferrell 2001, Waldron and Kerstan 2001, Kerkich et al. 2013, Costa 2004, Dioses 2013, Goicochea et al. 2013, among others). Previous studies on *Trachurus* postulated that, when using whole otoliths, the following considerations need to be taken into account: (i) whole otoliths are suitable for estimating the age of fish smaller than 250 mm TL (Costa 2004); (ii) only complete, continuous and thicker rings should be counted (Dioses 2013); (iii) the precision (sensu Campana 2001) must be acceptable (Lyle et al. 2000); (iv) otoliths of adults must not show multi-ring formation (Karlou-Riga and Sinis 1997). These four considerations can be safely applied to our data and results. Actually, the analysis of whole otoliths in *Trachurus* is not recommended in older fish with thicker otoliths (Horn 1993, Karlou-Riga and Sinis 1997, Karlou-Riga 2000, Lyle et al. 2000). In the case of *T. lathami*, a smaller species than its congenerics, this was not an issue. Added to this, the present study was also looking for comparisons with the previously one (Saccardo and Katsuragawa 1995).

The lack of self-validation, which was not possible in view of our sample design, does not compromise our results. The previously adopted validation was correctly performed, based on 399 otoliths (21% of the total) with coincident ring analysis by Saccardo and Katsuragawa (1995). It was based on the percentage of the edge pattern (Panfili and Morales Nin 2002) and on the average lengths by age (Campana 2001), methods that are accepted for validation. Moreover, the resemblance found in the regressions and in the ring analysis between 1975 (Saccardo and Katsuragawa 1995) and 2008-2010 (present study) suggests that the development pattern of the otolith has remained stable. This could also be considered in the case of growth ring formation.

The growth parameters (L_∞, K) estimated with observed lengths per age were most suitable to describe the growth of *T. lathami*, since that obtained from the average lengths per age underestimated the maximum length values. The estimated theoretical age at zero length, is inconsistent in biological terms, since the rough scad hatches around 1.5 mm long (Katsuragawa and Ekau 2003), corresponding to seven days of age using the VBGM adjusted in this study. This value seldom has a biological meaning, since it would represent the zero length age whenever the growth continues following the same pattern described by the equation (Pauly 1984), which is not true. Several authors (Abaunza et al. 2003, Yankova et al. 2010, Yoda et al. 2014), working on *Trachurus*, also found inconsistent t_0 values due to the lack of small fish in their samples. In the present study, the t_0 value led to overestimated ages, and it should not be used.

Comparison of the growth parameters obtained here with previous estimates in Brazil (Table 3) showed that the growth pattern and age structure of *T. lathami* have been stable (Saccardo and Katsuragawa 1995, Saccardo et al. 2005). However, the rough scad has historically presented seasonal displacements within the SEBB, resulting in variations in the space-time distribution of the individuals in each age (Saccardo 1987, Saccardo and Haimovici 2007). Except for the summer of 2008, the typical spring-summer pattern (September to March), when the rough scad schools usually concentrated between 23° and 26°S for spawning, was observed. Such movement coincides with the most productive period in terms of water column eutrophication (Castro et al. 2006) and biological productivity (Pires-Vanin et al. 1993), which favors the rough scad in terms of their feeding habits (Carvalho and Soares 2006) and conditions for larval growth (Katsuragawa and Matsuura 1992).

Comparison with the nine congeneric species, considering the parameters of VBGM for sex pooled and based on the total length available at the FishBase (Froese and Pauly 2015), confirmed that the age and growth of species of the genus are broadly different (Webb and Grant 1979, Araya et al. 2001). *Trachurus lathami* presented the lowest value of the maximum theoretical length (L_∞ = 211.90 mm), together with other lower estimates of this parameter for the species in Brazil (previously mentioned in the text). Although the inverse relationship between L_∞ and K is well known, some considerations about this can be done, as follows.

Worldwide, environmental conditions play an important role in the growth of *Trachurus* species (Geist et al. 2013, Sassa et al. 2014). In the FishBase (Froese and Pauly 2015), the growth parameters of other *Trachurus* species were associated with low water temperature (average = 14.4 °C, n = 50). This indicates that most of these species grow in cold waters, which also applies to most *T. lathami*. The temperature of the SEBB continental shelf is usually higher than 20 °C (Castro et al. 2006) and values lower than 20 °C are restricted to the upwelling areas, mainly in the spring and summer (October to March) (Braga and Niencheski 2006), when the spawning and initial growth of *T. lathami* larvae take place (Saccardo and Katsuragawa 1995). On the other hand,

Table 3. *Trachurus lathami:* growth parameters estimated and average total length at age for the species in the Southeastern Brazilian Bight.

Method	Growth parameters			Average length at age (mm)								
	L	K	t_0	TL_0	TL_1	TL_2	TL_3	TL_4	TL_5	TL_6	TL_7	TL_8
Otoliths (1975)[a]	258.97	0.160	-1.85	66	94	118	139	157	172	184	195	205
Back-calculation (1975)[a]	228.46	0.250	-0.56	30	74	108	135	155	172	184	194	202
Otoliths (1975)[b]	252.00	0.170	-1.73	64	94	118	139	157	172	184	195	204
ELEFAN (1997–1998)[b]	270.00	0.250	–	0	60	106	142	171	193	210	223	233
Otoliths (2008–2010)[c]	211.90	0.319	–	40	79	–	145	164	179	184	190	191
All sample (2008–2010)[c]	211.90	0.319	–	39	86	121	145	160	175	184	191	198
General average length[d]	–	–	–	48	81	114	141	161	177	188	198	205

Sources: [a]Saccardo and Katsuragawa 1995, [b]Saccardo et al. 2005, [c]present study, [d]average length of the data in the table part of the adult stock can be found in deeper and colder waters (11.5–18.5 °C) (Haimovici et al. 2008). Larvae and juveniles grow in different environmental conditions of the adults, fact that may cause variations in the length and age structure, which could not be evaluated here.

Another factor that may explain the differences in body size and growth parameters (between 1975 and 2008-2010, and in relation to the congeneric species) is fishing. In Brazil, during the 1970s, the fishing pressure on *T. lathami* was quite strong (Saccardo and Katsuragawa 1995, Saccardo et al. 2005), but this has changed: since 1997, the species has been fished accidentally, as accessory fauna (Saccardo and Haimovici 2007). All other *Trachurus* species, on the other hand, are target species of fisheries, and are under an intense pressure (Araya et al. 2001). Usually, growth parameters are influenced by density dependent and independent causes (Cardoso and Haimovici 2011). In the present case, the reduction in body size and the increase in growth rates could be due to an increase in the density of the *T. lathami* population, which apparently has not been overfished in the period analyzed.

Decadal shifts in the populations of pelagic fish (Alheit et al. 2009), similar to the idea suggested by the visual aspect in Fig. 1 (although it only expresses the landings instead of abundance, density or biomass), deserve further inspection. The growth parameters estimated here are essential elements for the management of small pelagic species at SEBB, and this should not be ignored in future assessments. Besides, the fishing statistics in Brazil are limited and there is no tradition of sampling biological landings. The lack of biological data series is notorious. As long as such deplorable historic situation persists, basic and fundamental studies of auto-ecology like this will remain scanty. Undoubtedly, the next study on the age and growth of the *T. lathami* cannot wait 40 years.

ACKNOWLEDGMENTS

We thank IBAMA/ICMBio for funding ECOSAR surveys, Lauro S.P. Madureira (FURG) and their staff during surveys and all students who processed the biological samples. We express our gratitude to Maria Cristina Cergole, Suzana Anita Saccardo, Carmen Lúcia Del Bianco Rossi Wongtschowski, Antônio Olinto Ávila da Silva, Marcus Rodrigues da Costa and Teodoro Vaske Júnior. To CAPES for the scholarship granted to the first author. For referees and their valuable recommendations. The first author expresses his gratitude to CNPq due to the research grant 305403/2015-0.

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Submitted: 16 August 2016
Received in revised form: 16 December 2016
Accepted: 20 March 2017
Editorial responsibility: Cassiano Monteiro Neto

Author Contributions: LCR and AMVS contributed equally to this work.

Competing Interests: The authors have declared that no competing interests exist.