ATLAS OF MARINE BONY FISH OTOLITHS (SAGITTAE) OF SOUTHEASTERN- SOUTHERN BRAZIL
PART I: GADIFORMES (MACROURIDAE, MORIDAE, BREGMACEROTIDAE, PHYCIDAE AND MERLUCCIIDAE); PART II: PERCIFORMES (CARANGIDAE, SCIAENIDAE, SCOMBRIDAE AND SERRANIDAE)

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ABSTRACT

The drawings, detailed pictures, precise descriptions and measurements that characterize otoliths must be made available for studies in various areas, including taxonomy, phylogeny, ecology, fisheries, paleontology, diversity, predator-prey relationships and modeling. The Collection of Teleostei Fish Otoliths of Southeastern-Southern Brazil (COSS-Brasil) of IOUSP contains 45,000 pairs of otoliths from 210 species. This publication is the first in a series that will constitute an atlas of Teleostei otoliths for southeastern-southern Brazil and presents the results of the morphologic and morphometric analyses of 11 Gadiformes and 36 Perciformes species by means of the most commonly used features, measurements and indices. Three otoliths of each species were illustrated and photographed whenever possible. The frequency of occurrence was calculated for each characteristic by total length classes (TL), and the ontogenetic differences were analyzed (multiple $\chi 2$ test; significance 0.05). Morphometric analyses were conducted for each characteristic per total length (TL) class and for the whole sample, and the ontogenetic differences were analyzed.

RESUMO

A disponibilidade de desenhos, fotos detalhadas, descrições precisas e medidas que caracterizem os otólitos são ferramentas imprescindíveis para diversas áreas: taxonomia, filogenia, ecologia, pesca, paleontologia, diversidade, relações presa/predador e modelagem. Da Coleção de Otólitos de Peixes Teleósteos da Região Sudeste-Sul do Brasil (COSS-Brasil), IOUSP, constam quarenta e cinco mil pares relativos a 210 espécies. Esta publicação é a primeira de uma série que constituirá um atlas de otólitos para Teleostei da região sudeste-sul brasileira e apresenta os resultados de análises morfológicas e morfométricas de 11 espécies de Gadiformes e 36 de Perciformes das medidas e índices usualmente realizados. Foram desenhados e fotografados três otólitos de cada espécie sempre que possível. A frequência de ocorrência foi calculada por classes de comprimento total (TL) e para toda a amostra, e diferenças ontogenéticas foram analisadas.

Descriptors: Otoliths, Morphology, Morphometry, Southwestern Atlantic, Brazil.
Descritores: Otólitos, Morfologia, Morfometria, Atlântico Sudoeste, Brasil.

INTRODUCTION

Otoliths are concretions composed of calcium carbonate (95.0%, mainly crystallized in the form of aragonite), organic matter (3.0-5.0%) and trace elements (CAMPANA, 2004), are present in the auditory capsule of bony fish and are part of a system related to the mechanisms for equilibrium and hearing (MOYLE; CECH Jr., 2004). Bony fish have three pairs of symmetrical otoliths, the *sagitta*, *lapillus* and *asteriscus*, and various studies have indicated that the *sagittae* are the largest and most utilized in most species.

Otoliths grow through the addition of concentric layers of calcium carbonate on a protein base, which results in an asymmetrical structure in which the different rates of organic and inorganic deposits become zones with different optical properties over time. These depositions are the result of alterations in growth, temperature fluctuations, diseases, reproductive activity and food resource availability and consumption, among others. Otoliths are, therefore, one of the most important structures in the understanding of the life cycle of fish and their populations (CAMPANA, 2004), and several studies (SECOR et al., 1995; VOLPEDO; ECHEVERRÍA, 2003; ASSIS, 2004; CAMPANA, 2005; MONTEIRO et al., 2005; VOLPEDO et al., 2008; GREEN et al., 2009) have summarized the utilization of these structures.

The importance of the use of otoliths in the study of fish populations has been extensively documented in the literature; over the last 30 years, it has become entirely possible to understand the birth, growth, age and mortality of the species studied through these structures (JONES, 2010). However, according to this author, minimal attention has focused on comparing these structures between species or families, although these differences are notable for showing life patterns, resilience, susceptibility to fishing and changes due to anthropogenic causes.

During the 4th International Otolith Symposium, which occurred in 2009 in Monterey, California, the numerous studies that were presented by renowned scientists allowed for the evaluation of the multiple applications of otolith studies in many fields, including taxonomy, phylogeny, comparisons of lifespans and energy budgets in different fish populations and studies investigating the chronology of direct (metabolism) or indirect (food resource availability) environmental events,

larval dispersion, larval periods and mortality, recruitment failure, larval retention patterns, the exposure of fish to contaminants, anthropogenic processes (which cause changes in the abundance and diversity of the components of an ecosystem), bioindicators of environmental pulses/changes, the effects of protected areas in fishery management, the determination of the origin of species, the diversity of environmental colonization, the introduction and invasion of new species, the identification of fish in the diet of other species, metamorphosis, the proportion of distinct populations, life history, geolocation (retrospective displacement studies, especially for estuarine fish), archeology, physiology, contamination (by selenium and mercury), phylogenetic relationships, the characteristics of otoliths and trophic niches, ecomorphology, the effects of a change in diet (in aquaculture), panmixia, transoceanic migrations, signs of nesting and nursery areas, reconstruction of the migration of juveniles, segregation, parasitism, the understanding of the state of fisheries (in time series), trophic position, the differentiation between forms of species living in shallow or deep waters, population structures, mortality estimation (natural tags) and population connectivity.

The following attributes contribute to the use of otoliths in various fields of study: (i) otolith forms are characteristic for each species of fish (CAMPANA, 2004; GALLEY et al., 2006), and variations in the patterns could be the result of genetic, ontogenetic, phylogenetic and environmental factors; (ii) the life history is recorded and retained because the *sagittae* are present in fish at hatching and absorption or decalcification does not occur at any point in the life cycle; and (iii) the life history can also be evaluated from the chemical variations that occur in the trace elements of these structures.

The collection of otoliths in well-organized collections constitutes, therefore, the *sine qua non* for their utilization in studies of diverse natures (CAMPANA, 2005). Using these collections, many researchers have organized otolith guides in institutions devoted to research and teaching for utilization across multiple fields (e.g. WILLIAMS; McELDOWNEY, 1990; VOLPEDO; ECHEVERRÍA, 2000; ASSIS, 2004; CAMPANA, 2004; BAREMORE; BETHEA, 2005; LOMBARTE et al., 2006; FURLANI et al., 2007; TUSET et al., 2008).

Various studies have included evolutionary histories written on the basis of the knowledge of fish otoliths, the most complete of them including those of Hecht (1987), Assis (2004) and Tuset et al. (2008). Below we present some of the notable facts of this evolution, though our presentation is not exhaustive.

In the previous decades of the 19th century, E. Koken organized a collection of otoliths from Mediterranean fish, which permitted the identification of the fish fossils of that region. The series of monographs prepared by Koken was an essential turning point in the study of otoliths because it described their basic morphology and proposed a terminology for their constituent parts (KOKEN, 1891).

Until the 1920s, the illustrations of the otolith morphological characteristics of recent species were imprecise and insufficient. Although there were periods of fluctuating production, a considerable advance was made in morphological studies between 1920 and 1960, these including those by Frost, Sanz-Echeverría, Chaine and Duvergier, Chaine, Weiler and Bauzá-Rullán, among others (TUSET et al., 2008).

In the late 1960s and early 1970s, new perspectives on the use of otoliths arose, and researchers began to use them to determine the age of fish and in regard to predator-prey feeding relationships. This tendency turned otoliths into one of the most utilized anatomical components of fish, and this resulted in the reappearance of descriptive and anatomical otolith studies in the literature (TUSET et al., 2008).

As from the end of the 1970s, numerous studies were published that were relatively extensive, either general or specific, at the family, genus or species level, and contained detailed illustrations or photographs of these structures. Otolith catalogues have recently been added to these studies, which has allowed for specific species identification (BAREMORE; BETHEA, 2005). The *AFORO* database has been created more recently, and is an interactive catalogue that includes an automatic system of species identification based on the mathematical description of the otolith characteristics (LOMBARTE et al., 2006; 2010).

Currently, based on geography, there are various catalogues regarding otoliths: Schmidt (1968) covering the fish of the eastern Atlantic; Morrow (1977; 1979) about the fish on the American north Atlantic coast; Nolf (1985) describing species of wide distribution, and fossils; Härkönen (1986) covering fish from the North Sea; Hecht (1987) and Smale et al. (1995) on species of South Africa; Williams and McEldowney (1990) about species of the Australian Antarctic region; Rivaton and Bourret (1999) concerning species in the Indo-Pacific; Naveda (2001) dealing with species from Peru; Volpedo and Echeverría (2000) concerning species from Argentina; Assis (2000; 2004) covering species from the coastal regions, estuaries and rivers of Portugal; Campana (2004) devoted to North American species; and Furlani et al. (2007) on species from Australia.

The above-mentioned studies specifically address otoliths; however, there are many other authors who acknowledge the importance of the morphology of these structures and include images and/or detailed descriptions of otoliths in their studies, even when their studies have alternative objectives. Among these studies, we cite the most recent ones that involve this subject matter: Rodríguez-Roda (1980); Gauldie (1988); Messieh et al. (1989); Lombarte and Castellón (1991); Lombarte (1992); Popper and Platt (1993); Campana and Casselman (1993); Lombarte and Morales-Nin (1995); Nielsen (1995); Aguirre and Lombarte (1999); Lychakov and Rebane (2000); Volpedo and Echeverría (2000; 2003); Ramcharitar et al. (2001; 2004); Morales-Nin and Panfili (2002); Aguirre (2003); Assis (2003; 2004; 2005); Tuset et al. (2003a; 2003b; 2006; 2008); Cardinale et al. (2004); Cruz and Lombarte (2004); Lychakov et al. (2006) and Lombarte and Cruz (2007) (more studies are quoted in LOMBARTE et al., 2006).

In Brazil, studies aimed exclusively at characterizing the otoliths of Teleost species of the southeastern-southern shelf have been conducted by various researchers: Braga and Goiten (1985) described the otoliths of the bluewing searobin, *Prionotus punctatus*, of the Anchieta Island region in São Paulo; Bastos (1990) analyzed the teleost fish of this region; Corrêa and Vianna (1992/93), Lemos et al. (1992/93) and Abilhôa and Corrêa (1992/93) described the otoliths of the sciaenids, gerreids and carangids of the Paraná coast, respectively; Monteiro *et al*. (2005) analyzed the otoliths of sciaenids from Rio de Janeiro.

The Laboratory of Ichthyofauna and Growth of IOUSP (Laboratório de Ictiofauna e Crescimento – LABIC) has produced several publications, including Vaz-dos-Santos et al. (2007), Bellucco (2008), Siliprandi (2009) and Santificetur et al. (2010).

The LABIC has organized the *Collection of Otoliths of Teleost Fish of Southeastern-southern Brazil* (Coleção de Otólitos de Peixes Teleósteos da Região Sudeste-Sul do Brasil – COSS-Brasil), which is composed of more than 45,000 pairs of *sagittae* from approximately 210 species that are distributed among 70 families and 20 orders. Information concerning the origins of the otoliths (the georeferenced data of the capture points and biological data collected) is stored in a database.

The goal of the LABIC is to be a center for the development and improvement of studies involving the morphology of otoliths and a depository for the *sagittae* of Southeastern-Southern Atlantic fish, and to make its collection available to the national and international communities that use these structures in different research areas.

Based on COSS-Brasil, we intend to develop a practical guide to these structures which will serve as an important instrument for studies related to the knowledge of the ichthyofauna of the region and as a basis for phylogenetic studies, the identification of species in archeological sites and studies on predator-prey relationships. In the future, this guide will be available as a website, which is currently under development.

In order to quickly disclose the results obtained we intend to publish it in parts, as soon as they are ready. In this article we present the otolith descriptions of 11 species of Gadiformes (Part I) and 36 of Perciformes (Part II).

Sampling Area

In relation to its fauna, this region is a section of the Argentinian Zoogeographic Marine Province, which is delineated in the north by Cabo Frio (22ºS) and by the Valdez Peninsula in Argentina (42°S) in the south. This area represents a region of faunal transition and contains both tropical and temperate species of fish, in addition to endemic species (FIGUEIREDO, 1981).

The area (Fig. 1) comes under the influence of three water masses: Tropical Water (TW) with a temperature (T) > 20ºC and salinity (S) > 36.4; Central Southern Atlantic Water (CSAW) with a T < 20ºC and S < 36; and Coastal Water (CW), which is a mixture of continental and saltwater that has a low salinity (T > 20°C and S < 36). The internal area of the shelf primarily consists of CW; however, on the external portion of the shelf, the upper portion consists of TW, whereas the lower portion mainly consists of CSAW. In the summer, CSAW enters the intermediate and internal shelf with fluctuating intensities, which causes resurgences (CASTRO; MIRANDA 1998).

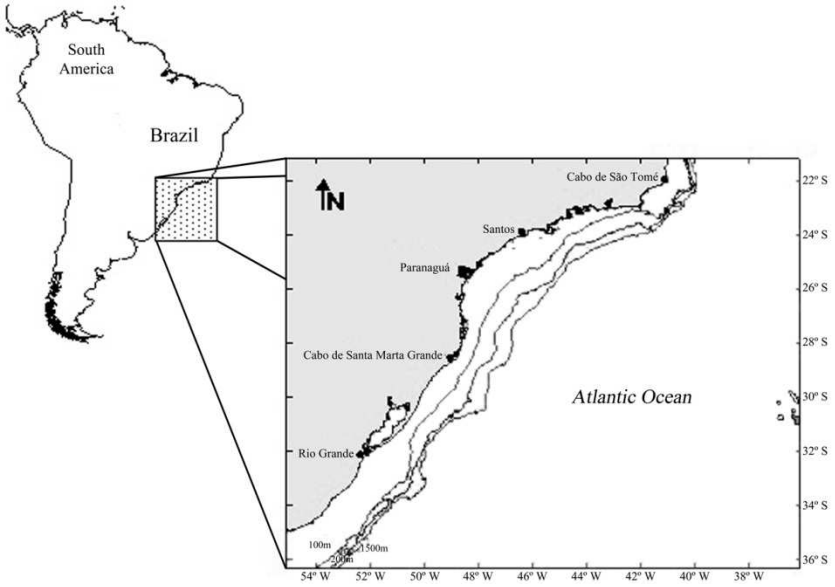


Fig. 1. Map showing the area where the otoliths were collected.

MATERIAL AND METHODS

The fish and their otoliths were collected in various fishing surveys conducted on the Brazilian continental shelf and slopes between 22ºS and 34ºS:

●The REVIZEE Program - "Evaluation of the Sustainability Potential of the Living Resources in the Exclusively Brazilian Economic Zone" (BRASIL, 2006) performed between 1996 and 2005 between 100 and 1200 m deep;

●ECOSAR II and III Projects - "Brazilian Sardine Hydroacoustic Projects" (MADUREIRA; ROSSI-WONGTSCHOWSKI, 2005) conducted in 2005 between 10 and 500 m deep;

●Integrated Project (Projeto Integrado – PI) - "Rational utilization of coastal ecosystems in the Brazilian tropics - State of São Paulo" (PIRES-VANIN et al., 1993; ROSSI-WONGTSCHOWSKI; PAES, 1993; ROCHA; ROSSI-WONGTSCHOWSKI, 1998) conducted between 1985 and 1988 between 10 and 75 m deep;

●ECOSAR IV, V, VI and VII Project - "Brazilian Sardine Hydroacoustic Project" developed in 2008, 2009 and 2010 between 30 and 100 m deep (CERGOLE; DIAS-NETO, 2011); and
●OGX I, II, III and IV Project - "Acoustics prospection, eggs, larvae and adult fish surveys in an area undergoing oil drilling" (OGX; IO-FURG; IOUSP, 2013)

The teleost species were identified in accordance with Figueiredo and Menezes (1978; 1980; 2000), Menezes and Figueiredo (1980; 1985), Figueiredo et al. (2002), Menezes et al. (2003), Bernardes et al. (2005) and Nelson (2006).

The left otolith of each pair was used for the measurements and photographs. Whenever they were available in the collection, 3 representative otoliths of the smallest, intermediate and largest fish were selected for the illustrations and photographs to describe the ontogenetic variations. The otoliths were covered with graphite powder to bring out their features, and illustrations of the internal and external sides and profile of the ventral region of these structures were drawn.

The illustrations were made with the aid of a light box under incident light and subsequently drawn with ink on tracing paper using the pointillism technique. The drawings were then digitized, and the plates were organized for each species. Subsequent to illustration, the otoliths were photographed in identical positions using Discovery V12 Carl Zeiss equipment.

The morphological analysis was conducted by randomly selecting 10 otoliths per total length (TL) class of each species, whenever they were available in the collection, which covered the range of fish sizes available. When the number of otoliths in a length class was less than 10, all of the specimens of that class were analyzed.

The criteria for the evaluation of the otoliths' characteristics followed the terminology of Assis (2004) and Tuset et al. (2008). Each otolith was analyzed by 3 researchers using a stereomicroscope, and the following features were examined: 1) the otolith's shape, 2) the shape of the anterior region, 3) the shape of the posterior region, 4) the dorsal and ventral edges, 5) the position of the *sulcus acusticus*, 6) the orientation of the *sulcus acusticus*, 7) the opening of the *sulcus acusticus*, 8) the morphology of the *sulcus acusticus*, 9) the morphology of the *colliculum*, 10) the morphology of the *ostium*, 11) the morphology of the *cauda*, 12) the otolith's profile, 13) the orientation of the *rostrum* and *antirostrum*, 14) the development of the *rostrum* and *antirostrum* and 15) the development of the *pseudorostrum* and *pseudo-antirostrum*. Following the analysis of the otolith set by the 3 researchers, the results obtained for each characteristic were organized into tables and graphs. For each of the 15 characteristics, the frequency of occurrence according to the length class and total were calculated, and a multiple χ^2 test, with confidence level of 0.05 (ZAR, 2010), was applied to identify the possible structural differences throughout the development of a species (when $n \geq 10$).

In this atlas the highest percentages for the characteristics mentioned are shown in parentheses with the measurement variations. Unless stated otherwise, the values refer to 100% of the cases.

The same otoliths used in the morphological analysis were also used for the morphometric analysis of the *sagittae*. Data for length (OL – the greatest distance of the anteroposterior axis), height (OH – the greatest distance of the dorsoventral axis), thickness (OT – the maximum width of the otolith), perimeter and area were obtained from the photographs of the inside and ventral profiles of the structures. Data collection was assisted by the AxioVision 4.8 software, which is available with the Discovery V12 Carl Zeiss equipment. An analysis of the measurements obtained for each species was conducted according to the method proposed by Tuset et al. (2006; 2008).

The perimeter and area data were used to calculate the circularity (Ci) and/or rectangularity (Re) indices: $Ci = C^2/A$ (where Ci= circularity, C= perimeter, and A= area) and $Re=A/(OL \times OH)$ (where Re= rectangularity, A= area, OL= otolith length, and OH= otolith height).

Shape indices were calculated using the ratios of the measurements of the otoliths; namely, the lengths of the otoliths and the lengths of the fish: OL/TLx100 (where OL=otolith length and TL=total length of the fish), OL/OHx100 (where OH=otolith height), OL/OTx100 (where OT=otolith thickness) and OH/OTx100.

In the plates the otolith's identification (ID) is shown according to the fish's reference in the COSS-Brasil database.

The diagnostic characteristics of the families that belong to the Gadiformes and Perciformes orders and an identification key for the genera represented by more than one species are shown after the species' descriptions.

RESULTS

PART I: GADIFORMES (MACROURIDAE, MORIDAE, PHYCIDAE, BREGMACEROTIDAE and MERLUCCIIDAE)

Family MACROURIDAE

This family has a prevalence of otoliths with an elliptic shape, a supramedian position and homosulcoid morphology of the *sulcus acusticus.* The *colliculum* is homomorphic.

Coelorinchus marinii **Hubbs 1934 - Plate 1**

Maximum Size:	380 mm (TL) (BERNARDES et al., 2005)
Distribution:	southwestern Atlantic Ocean from southeastern Brazil to South Georgia Island (BERNARDES et al., 2005)
Habitat:	benthopelagic, between 200 and 600 m deep (BERNARDES et al., 2005)
Diet:	foraminifera, polychaetes, crustaceans, mollusks and teleosts (MUTO et al., 2005)
Collection:	1900 pairs of otoliths (TL ranging from 120 to 315 mm)
Sample:	63 left otoliths categorized into 9, 20 mm classes (from 120 to 300 mm)

Shape: elliptic (80.95%), oblong to elliptic or cuneiform to elliptic; ***Anterior region*****:** oblique to angled-round (50.79%), angled-round or oblique-round; ***Posterior region:*** peaked-round (88.89%) or oblique-round; ***Dorsal edge:*** lobed to sinuate (85.71%) or lobed; ***Ventral edge*****:** lobed to sinuate (36.51%), sinuate to entire (36.51%), sinuate or entire; ***Profile:*** biconvex; ***Rostrum and antirostrum orientation:*** in agreement; ***Rostrum:*** undeveloped (87.30%) or developed; ***Antirostrum****:* undeveloped (55.56%) or absent; ***Pseudorostrum:*** absent (77.78%), undeveloped or developed; ***Pseudo-antirostrum:*** absent; ***Sulcus acusticus:*** *position:* supramedian (88.89%) or median; *orientation:* slightly ascending (66.67%) or horizontal; *opening:* para-ostial (44.44%), ostial, ostio-caudal or pseudo-ostio-caudal; *morphology:* homosulcoid; *colliculum:* homomorphic; *ostium:* elliptic; and *cauda:* elliptic.

Significant differences ($p<0.05$) were observed among some length classes for otolith shape, anterior and posterior regions, dorsal and ventral edges, position, orientation and opening of the *sulcus acusticus* and otolith *rostrum*. Only the posterior region of the otolith showed significant differences along the growth development.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	3.49 ± 0.49	2.92	6.46
OH/OL (%)	62.82 ± 6.12	54.73	96.69
OT/OL (%)	21.17 ± 1.42	17.98	24.25
OT/OH (%)	33.92 ± 3.32	25.08	42.01
Circularity	16.67 ± 0.88	14.7	18.83
Rectangularity	0.70 ± 0.04	0.46	0.75

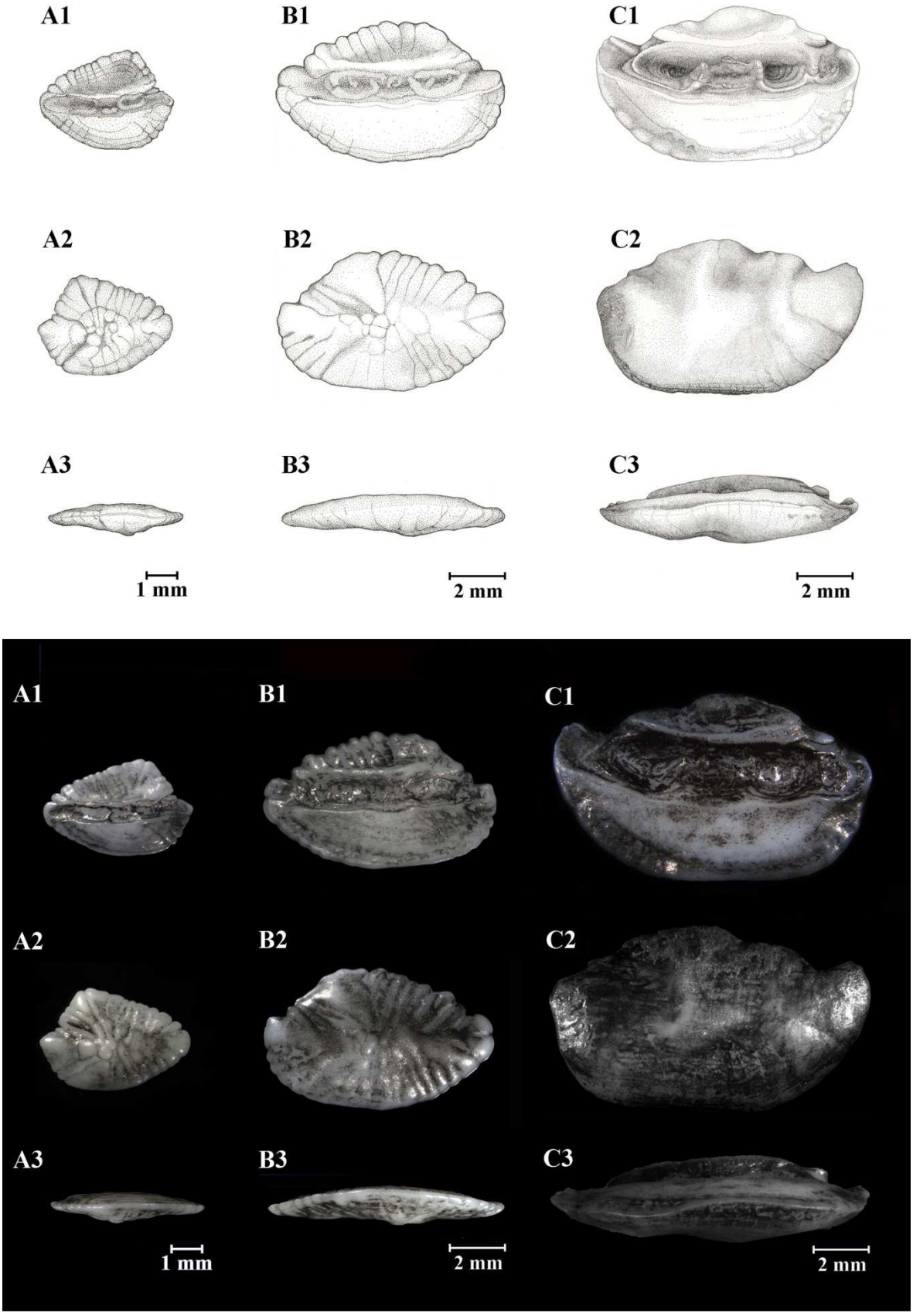


Plate 1. Illustrations (above) and photographs (below) of *Coelorinchus marinii* otoliths from fish with total lengths: **A.** 132 mm (REV.AF.1002.1), **B.** 210 mm (REV.AF.1013.30) and **C.** 315 mm (REV.AF.607.1). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3 (Illustrators: Jessica Falchi Caçador and Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Malacocephalus laevis **(Lowe 1843) - Plate 2**

Maximum Size:	700 mm (TL) (BERNARDES et al., 2005)
Distribution:	Atlantic, Indian and Pacific oceans. In the western Atlantic Ocean, from the Gulf of Mexico to southern Brazil (BERNARDES et al., 2005)
Habitat:	bathydemersal, between 200 and 1000 m deep (BERNARDES et al., 2005)
Diet:	crustaceans and squid (BERNARDES et al., 2005)
Collection:	61 pairs of otoliths (TL ranging from 211 to 424 mm)
Sample:	36 left otoliths categorized into 9, 20 mm classes (from 200 to 420 mm)

Shape: elliptic; ***Anterior region:*** oblique to peaked (52.78%), oblique to peaked-round, oblique to angled-round; ***Posterior region:*** oblique-round (75%) or oblique to peaked-round; ***Dorsal edge:*** lobed to sinuate (83.33%), lobed or sinuate; ***Ventral edge:*** lobed to sinuate (66.67%), lobed or sinuate to entire; ***Profile:*** plano-convex (69.44%) or biconvex; ***Rostrum and antirostrum orientation:*** in agreement; ***Rostrum:*** undeveloped; ***Antirostrum:*** undeveloped (63.89%) or absent; ***Pseudorostrum:*** undeveloped; ***Pseudo-antirostrum:*** absent; ***Sulcus acusticus:*** *position:* supramedian; *orientation:* slightly ascending (61.11%), horizontal or ascending; *opening:* ostio-caudal (58.33%), caudal, pseudo-ostio-caudal or para-ostial; *morphology:* homosulcoid; *colliculum:* homomorphic; *ostium:* elliptic; and *cauda:* elliptic.

Significant differences ($p<0.05$) among the length classes were observed for the posterior region, dorsal and ventral edges, orientation and opening of the *sulcus acusticus* and otolith profile. There was no significant difference along the growth development.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	3.13 ± 0.30	2.8	4.47
OH/OL (%)	57.69 ± 3.17	50.66	63.24
OT/OL (%)	18.44 ± 1.52	15.72	22.01
OT/OH (%)	32.01 ± 2.59	26.51	36.52
Circularity	17.45 ± 0.86	15.7	19.38
Rectangularity	0.72 ± 0.01	0.7	0.77

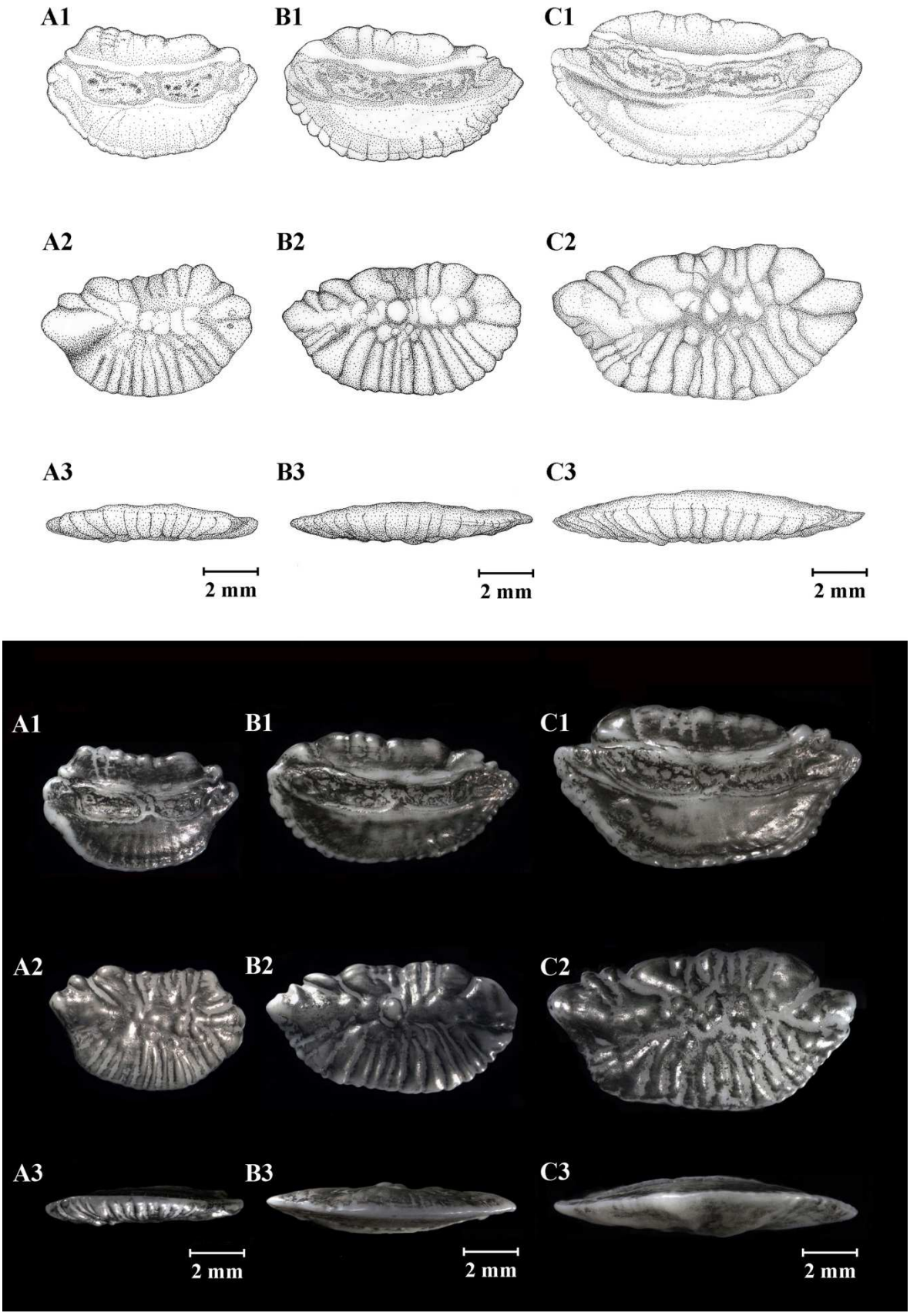


Plate 2. Illustrations (above) and photographs (below) of *Malacocephalus laevis* otoliths from fish with total lengths: **A**. 294 mm (REV.AF.1002.2), **B**. 345 mm (REV.AF.1142.1) and **C**. 424 mm (REV.AF.1129.1). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3. (Illustrator: Jessica Falchi Caçador; Photos: Cesar Santificetur).

Malacocephalus occidentalis **Goode & Bean 1885 - Plate 3**

Maximum Size:	530 mm (TL) (BERNARDES et al., 2005)
Distribution:	northern and southern Atlantic Ocean. In the western Atlantic, from Cape Cod to Argentina (BERNARDES et al., 2005)
Habitat:	benthopelagic, between 200 to 1950 m deep (BERNARDES et al., 2005)
Diet:	crustaceans, teleosts and cephalopods (MUTO et al., 2005)
Collection:	1033 pairs of otoliths (TL ranging from 157 to 523 mm)
Sample:	113 left otoliths categorized into 20, 20 mm classes (from 140 to 520 mm)

Shape: elliptic (95.58%) or trapezoidal to elliptic; ***Anterior region:*** peaked-round (33.63%), angled-round (30.09%), oblique to angled-round, oblique to peaked-round, oblique to peaked or round; ***Posterior region:*** oblique to peaked-round (35.40%), oblique-round (32.74%), oblique to blunt-round or oblique to peaked; ***Dorsal edge:*** lobed to sinuate (96.46%) or sinuate. *From 260 mm (TL) or greater, the otoliths of this species present a protuberance on the dorsal edge of the posterior region (49.56%)*; ***Ventral edge:*** lobed to sinuate (17.7%) in small specimens, and sinuate to entire (50.44%), sinuate or entire in larger specimens; ***Profile:*** biconvex; ***Rostrum and antirostrum orientation:*** in agreement (94.69%) or in disagreement; ***Rostrum:*** undeveloped (96.46%) or developed; ***Antirostrum:*** absent (66.37%) or undeveloped; ***Pseudorostrum:*** absent (51.33%), developed or undeveloped; ***Pseudo-antirostrum:*** absent; ***Sulcus acusticus:*** *position:* supramedian (96.46%) or median; *orientation:* slightly descending (49.56%), horizontal or descending; *opening:* ostio-caudal (53.98%), caudal, ostial, para-ostial or pseudo-ostio-caudal; *morphology:* homosulcoid; *colliculum:* homomorphic; *ostium:* elliptic; and *cauda:* elliptic.

Significant differences ($p<0.05$) were observed among some length classes for otolith shape; the anterior and posterior regions; dorsal and ventral edges; position, orientation and opening of the *sulcus acusticus*; *rostrum* and *antirostrum* orientations; and the *rostrum*, *antirostrum* and *pseudorostrum* of the otoliths. There were significant differences along the growth development for the anterior and posterior regions, ventral edge and *pseudorostrum*.

Shape índices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	3.07 ± 0.35	2.61	4.93
OH/OL (%)	55.70 ± 4.71	46.59	69.56
OT/OL (%)	18.94 ± 1.76	13.18	23.04
OT/OH (%)	34.27 ± 4.42	21.57	44.39
Circularity	17.99 ± 1.60	14.64	23.49
Rectangularity	0.70 ± 0.01	0.62	0.74

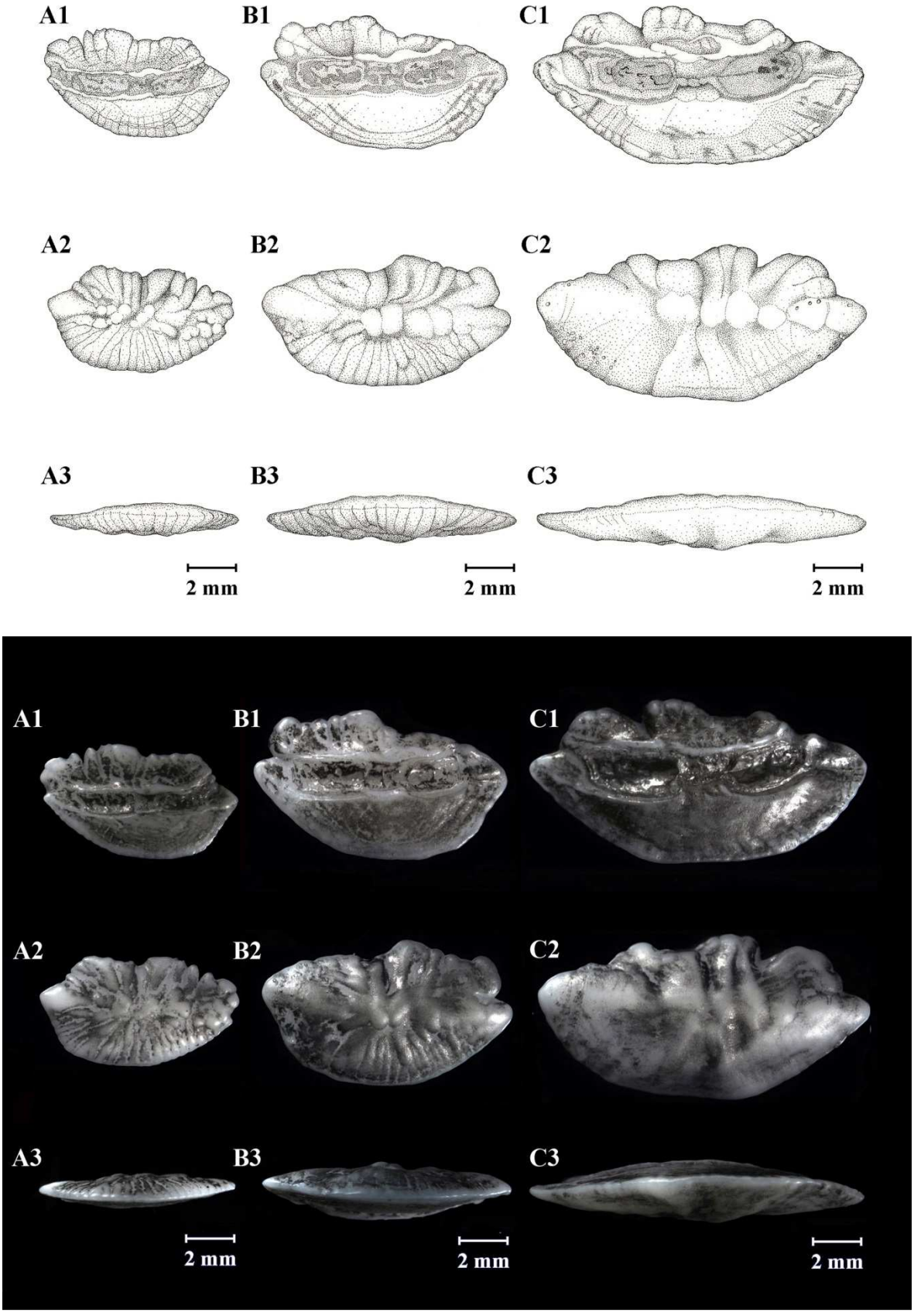


Plate 3. Illustrations (above) and photographs (below) of *Malacocephalus occidentalis* otoliths from fish with total lengths: **A.** 179 mm (REV.AF.611.2), **B.** 410 mm (REV.AF.614.2) and **C.** 523 mm (REV.AF.615.1). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3. (Illustrator: Jessica Falchi Caçador; Photos: Cesar Santificetur).

Ventrifossa macropogon **Marshall 1973 - Plate 4**

Maximum Size:	450 mm (TL) (BERNARDES et al., 2005)
Distribution:	tropical western Atlantic Ocean, extending from Florida to southern Brazil and in Australian Antarctic waters (BERNARDES et al., 2005)
Habitat:	benthopelagic, between 320 and 1000 m deep (BERNARDES et al., 2005)
Diet:	---
Collection:	170 pairs of otoliths (TL ranging from 164 to 389 mm)
Sample:	67 left otoliths categorized into 12, 20 mm classes (from 160 to 380 mm)

Shape: elliptic; ***Anterior region:*** oblique-round (58.21%), oblique to angled-round or oblique to peaked-round. *There is a protuberance on the dorsal-anterior edge in 88.06% of otoliths*; ***Posterior edge:*** oblique-round (83.58%), oblique to blunt-round or round; ***Dorsal edge:*** lobed to sinuate (32.84%), sinuate to entire (31.34%), lobed to entire or sinuate; ***Ventral edge:*** lobed to sinuate (50.75%), sinuate or sinuate to entire; ***Profile:*** biconvex; ***Rostrum and antirostrum orientation*:** in agreement; ***Rostrum:*** undeveloped; ***Antirostrum:*** undeveloped (76.12%), developed or absent; ***Pseudorostrum and pseudo-antirostrum:*** absent; ***Sulcus acusticus*:** *position:* supramedian; *orientation:* slightly ascending (61.19%) or horizontal; *opening:* para-ostial (52.24%), ostio-caudal, ostial or pseudo-ostio-caudal; *morphology:* homosulcoid; *colliculum:* homomorphic; *ostium*: elliptic; and *cauda:* elliptic.

Significant differences ($p<0.05$) were observed among some length classes for the anterior and posterior regions, dorsal and ventral edges, opening of the *sulcus acusticus* and *antirostrum* of the otoliths. There were significant differences along the growth development for the dorsal and ventral edges' characteristics.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	3.28 ± 0.23	2.5	3.85
OH/OL (%)	63.10 ± 3.74	56.31	73.39
OT/OL (%)	19.98 ± 1.32	17.65	25.29
OT/OH (%)	31.71 ± 1.98	27.92	37.61
Circularity	16.23 ± 0.73	14.46	18.73
Rectangularity	0.72 ± 0.02	0.66	0.79

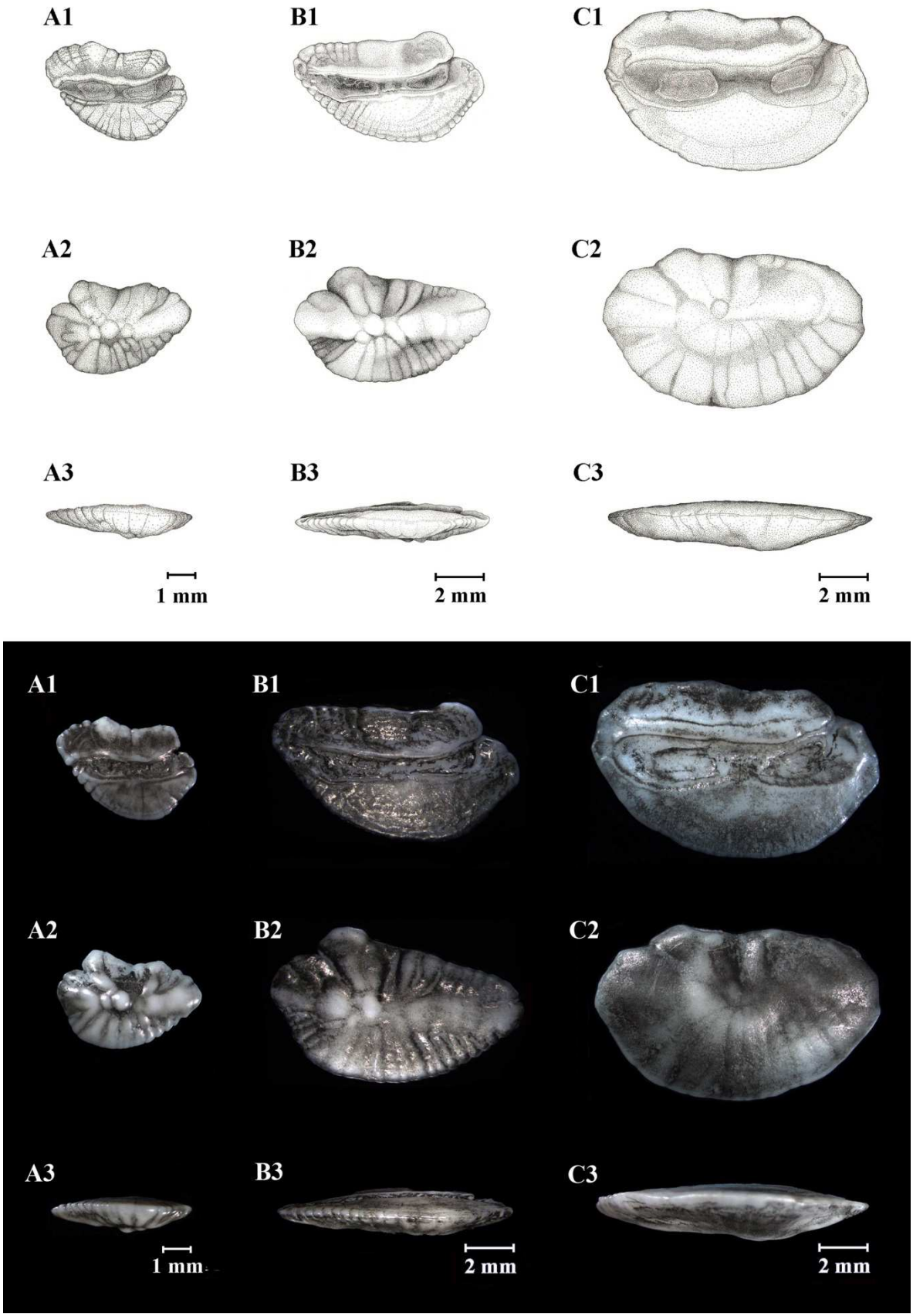


Plate 4. Illustrations (above) and photographs (below) of *Ventrifossa macropogon* otoliths from fish with total lengths: **A**. 164 mm (REV.AF.614.11), **B**. 277 mm (REV.AF.607.20) and **C**. 387 mm (REV.AF.607.17). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3. (Illustrator: Jessica Falchi Caçador; Photos: Cesar Santificetur).

Family MORIDAE

The shape is sagittiform. The *rostrum* and *antirostrum* are absent, the *pseudorostrum* and *pseudo-antirostrum* are developed, the *sulcus acusticus* is in an inframedian position, and there is a caudal opening. The species of this family have a collicular crest in the region of the *sulcus acusticus*, which extends to the posterior region beyond the limits of the otolith; there are depressions (*upper* and *lower* "*depressione areae*") on the dorsal and ventral edges of the otolith. Assis (2004) noted that these characteristics are important for identifying members of this family.

Gadella imberbis **(Vaillant 1888) - Plate 5**

Maximum Size:	310 mm (TL) (BERNARDES et al., 2005)
Distribution:	western Atlantic Ocean, from Cape Cod to Rio Grande do Sul, Brazil (BERNARDES et al., 2005)
Habitat:	benthopelagic, between 200 and 800 m deep (BERNARDES et al. 2005)
Diet:	---
Collection:	17 pairs of otoliths (TL rangin from 174 to 370 mm)
Sample:	15 right otoliths categorized into 7, 20 mm classes (from 160 to 370 mm)

Shape: sagittiform; ***Anterior region:*** peaked; ***Posterior region:*** lanceolated-round; ***Dorsal anterior edge:*** entire (71.43%) or sinuate to entire; ***Dorsal posterior edge:*** sinuate to entire (78.57%) or entire; ***Ventral edge:*** entire; ***Profile:*** plane-convex; ***Rostrum and antirostrum:*** absent; ***Rostrum and antirostrum orientation:*** does not apply; ***Pseudorostrum and pseudo-antirostrum:*** developed; ***Sulcus acusticus:*** *position:* inframedian; *orientation:* horizontal; *opening:* caudal; *morphology:* heterosulcoid; *colliculum:* absent; *ostium:* elliptic; and *cauda:* elliptic.

There were no significant differences ($p<0.05$) among the length classes or along the growth development.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	2.74 ± 0.39	1.74	3.52
OH/OL (%)	27.50 ± 2.90	24	34.1
OT/OL (%)	36.70 ± 1.90	31.9	40.6
OT/OH (%)	134.70 ± 14.00	113	154.2
Circularity	32.86 ± 2.72	28.93	37.46
Rectangularity	0.56 ± 0.04	0.49	0.64

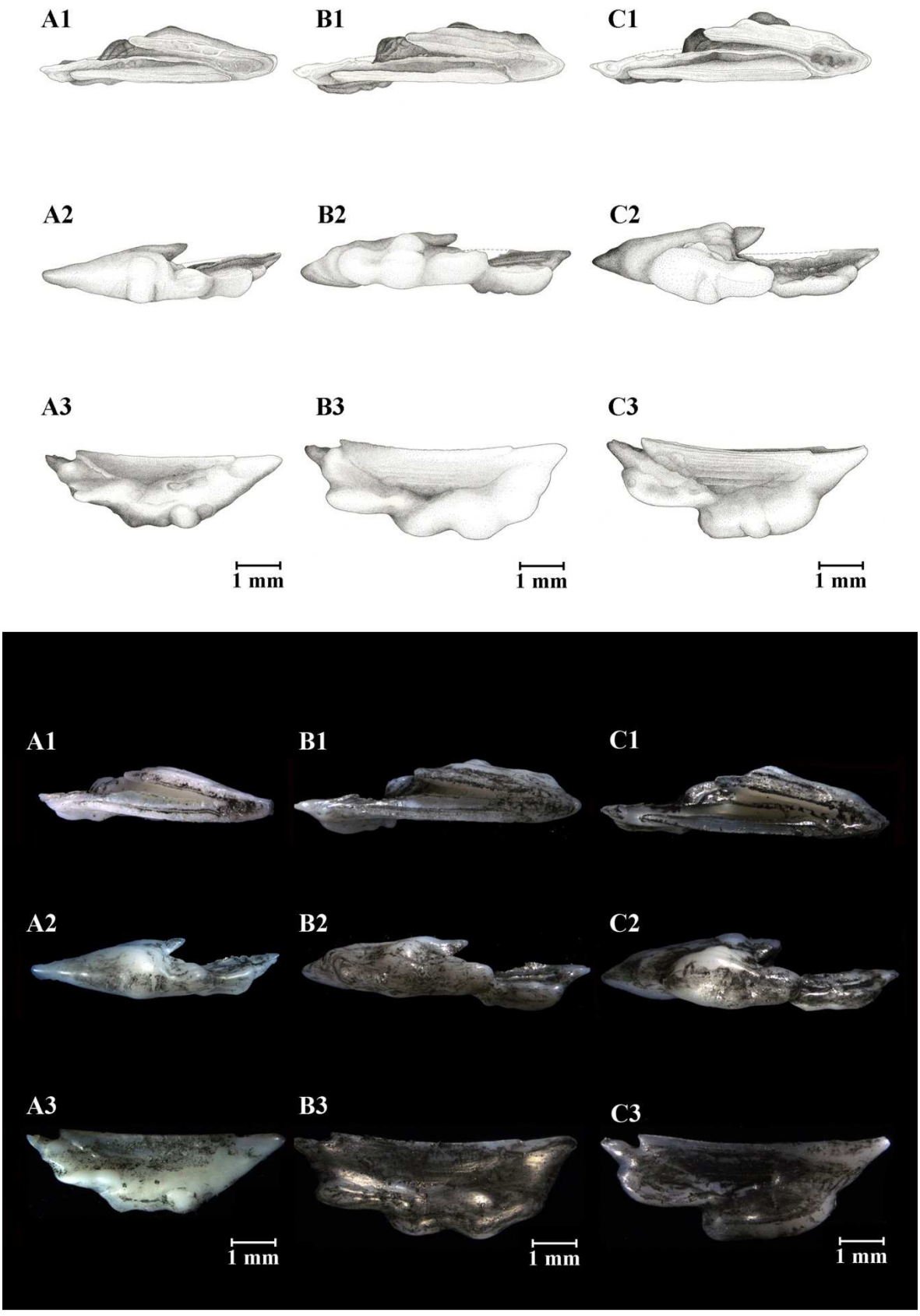


Plate 5. Illustrations (above) and photographs (below) of *Gadella imberbis* otoliths from fish with total lengths: **A**. 192 mm (REV.AF.613.5), **B**. 246 mm (REV.AF.613.3) and **C**. 293 mm (REV.AF.1015.1). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3. (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Laemonema goodebeanorum **Meléndez C. & Markle 1997 - Plate 6**

Maximum Size:	48 cm (TL) (BERNARDES et al., 2005)
Distribution:	western Atlantic Ocean from Canada to southern Brazil, including the Gulf of Mexico (BERNARDES et al., 2005)
Habitat:	benthopelagic, between 180 and 720 m deep (BERNARDES et al., 2005)
Diet:	---
Collection:	12 pairs of otoliths (TL ranging from 186 to 298 mm)
Sample:	12 left otoliths categorized into 5, 20 mm classes (from 18)

Shape: sagittiform; ***Anterior region:*** oblique-round; ***Posterior region:*** lanceolated; ***Dorsal anterior edge:*** sinuate; ***Dorsal posterior edge:*** entire; ***Ventral edge:*** entire; ***Profile:*** plane-convex; ***Rostrum and antirostrum:*** absent; ***Rostrum and antirostrum orientation:*** does not apply; ***Pseudorostrum and pseudo-antirostrum:*** developed; ***Sulcus acusticus*****:** *position:* median (83.33%) or inframedian; *orientation:* slightly ascending; *opening:* caudal (83.33%) or ostio-caudal; *morphology:* heterosulcoid; *colliculum:* heteromorphic, when present; *ostium:* oval (83%) or elliptic; and *cauda:* tubular, slightly curved.

There were no significant differences ($p<0.05$) among the length classes or along the growth development.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	3.70 ± 0.24	3.32	4.17
OH/OL (%)	37.36 ± 1.24	35.43	39.74
OT/OL (%)	37.71 ± 4.33	31.09	46.53
OT/OH (%)	101.13 ± 12.88	82.4	129.05
Circularity	21.96 ± 0.49	21.13	22.97
Rectangularity	0.66 ± 0.02	0.63	0.7

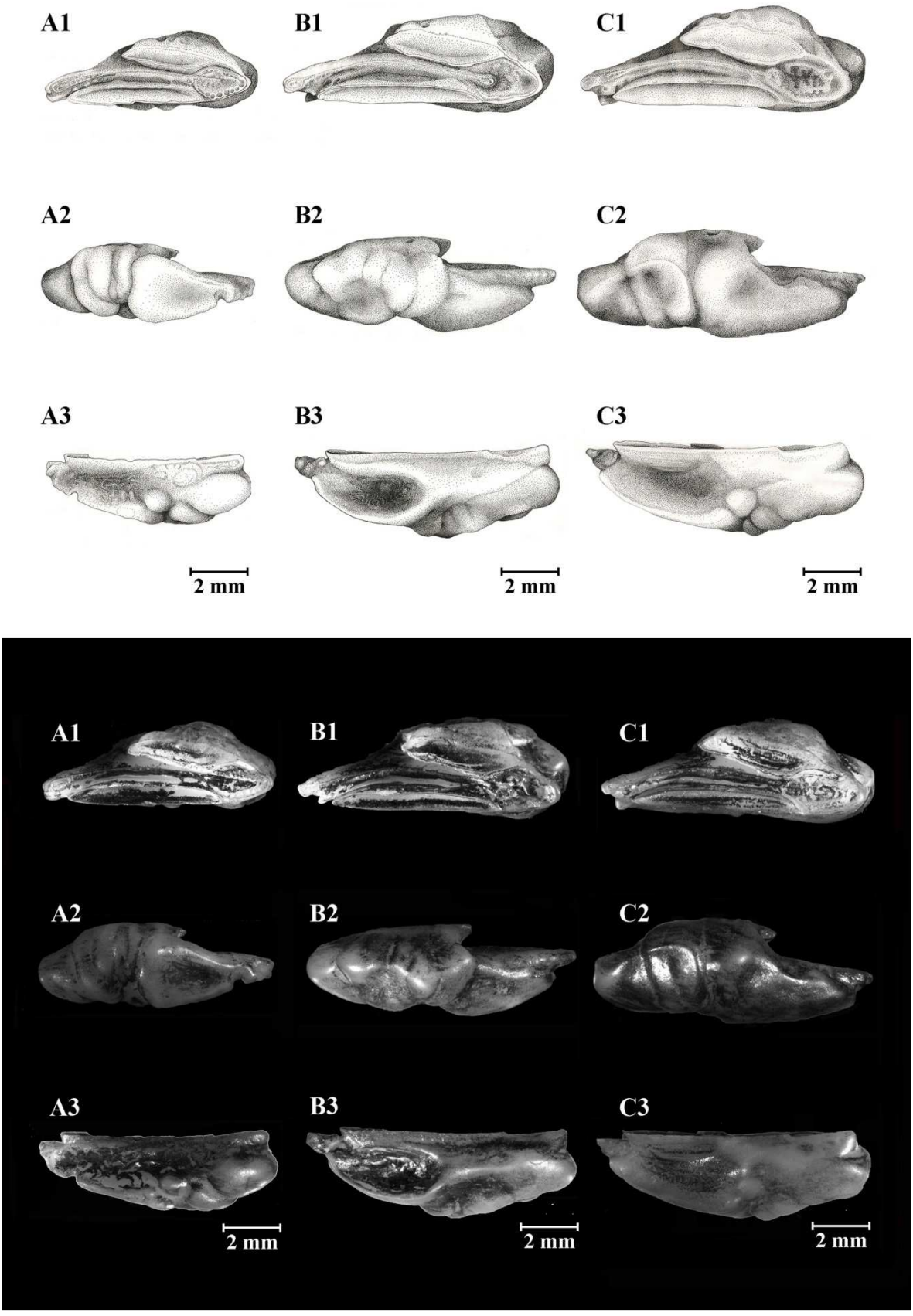


Plate 6. Illustrations (above) and photographs (below) of *Laemonema goodebeanorum* otoliths from fish with total lengths: **A.** 186 mm (PADCT.AF.6628.7), **B.** 248 mm (PADCT.AF.6628.2) and **C.** 298 mm (PADCT.AF.6628.9). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3. (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Family PHYCIDAE

Otoliths with an oblong to lanceolated shape predominate, the morphology of the *sulcus acusticus* is archaesulcoid, and the morphology of the *colliculum* is unimorphic. There are narrow, well-marked depressions over the *sulcus acusticus* on both the superior and inferior portions.

Urophycis brasiliensis **(Kaup, 1858) - Plate 7**

Maximum Size:	600 mm (TL) (BERNARDES et al., 2005)
Distribution:	southeastern and western Atlantic Ocean in southeastern Brazil, Uruguay and northern Argentina (BERNARDES et al., 2005)
Habitat:	bottom-dwelling, from coastal to 190 m deep (BERNARDES et al. 2005)
Diet:	shrimps and other crustaceans (FROESE; PAULY, 2013)
Collection:	36 pairs of otoliths (TL ranging from 197 to 466 mm)
Sample:	30 left otoliths categorized into 13, 20 mm classes (from 180 to 460 mm)

Shape: oblong to lanceolated; ***Anterior region:*** oblique to peaked (60%), oblique to peaked-round or oblique to angled-round; ***Posterior region:*** lanceolated-round; ***Dorsal edge:*** sinuate to entire (90%) or lobed to entire; ***Anterior ventral edge:*** lobed to sinuate (60%), lobed or sinuate; ***Posterior ventral edge:*** sinuate to entire (56.67%) or sinuate; ***Profile:*** concave-convex (93.33%) or plane-convex; ***Rostrum and antirostrum orientation:*** in agreement; ***Rostrum:*** undeveloped; ***Antirostrum:*** absent; ***Pseudorostrum and pseudo-antirostrum:*** absent; ***Sulcus acusticus:*** *position:* supramedian, *orientation:* slightly ascending (86.67%) or horizontal; *opening:* para-ostial (70%) or pseudo-ostio-caudal; *morphology:* archaesulcoid; and *colliculum:* unimorphic.

There were significant differences ($p<0.05$) among some length classes for the dorsal edge, orientation and opening of the *sulcus acusticus* and otolith profile. However, there were no differences along the growth development.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	3.83 ± 0.35	3.26	4.45
OH/OL (%)	35.29 ± 1.94	32.5	40.2
OT/OL (%)	16.28 ± 2.04	13.98	22.49
OT/OH (%)	46.15 ± 5.24	38.99	61.4
Circularity	21.27 ± 1.16	19.06	24.35
Rectangularity	0.72 ± 0.02	0.67	0.76

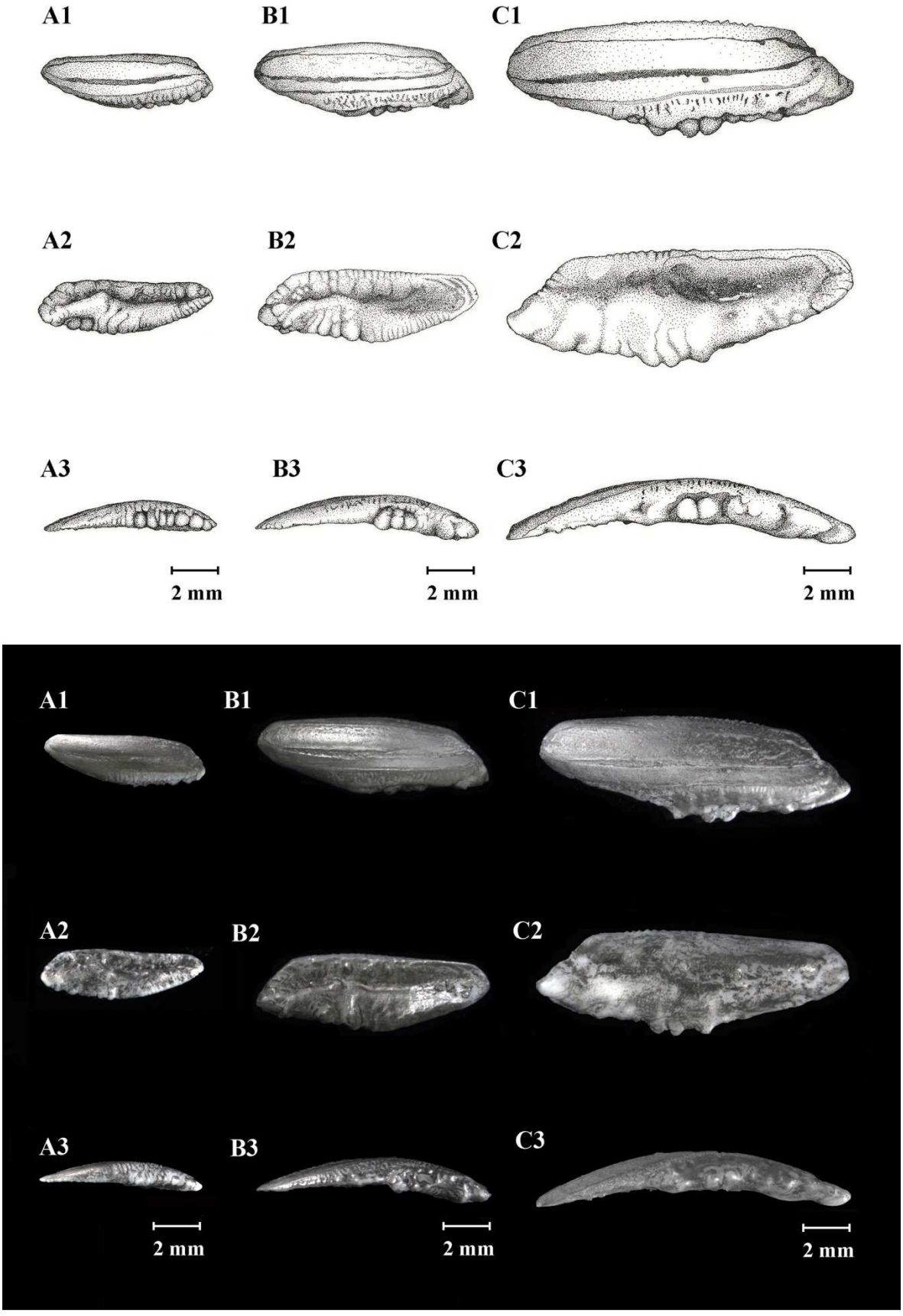


Plate 7. Illustrations (above) and photographs (below) of *Urophycis brasiliensis* otoliths from fish with total lengths: **A.** 286 mm (RA1G.C.E15.L1.3), **B.** 295 mm (RA1G.C.E29.L1.3) and **C.** 466 mm (RA1G.C.E2.L2.1). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3. (Illustrator: Jessica Falchi Caçador; Photos: Cesar Santificetur).

Urophycis mystacea **Miranda Ribeiro 1903 - Plate 8**

Maximum Size:	700 m (TL) (BERNARDES et al., 2005)
Distribution:	southwestern Atlantic Ocean from Rio de Janeiro to Argentina (BERNARDES et al., 2005)
Habitat:	demersal, at depths of more than 200 m (BERNARDES et al., 2005)
Diet:	---
Collection:	2,894 pairs of otoliths (TL ranging from 186 to 676 mm)
Sample:	159 left otoliths categorized into 23, 20 mm classes (from 180 to 660 mm)

Shape: oblong to lanceolated (92.45%) or spindle-shaped to lanceolated; ***Anterior region:*** oblique-round (66.67%) or oblique to angled; ***Posterior region:*** lanceolated to peaked (96.23%) or lanceolated-round; ***Dorsal edge:*** entire (62.89%) or sinuate to entire. *The lobed to entire form was frequently encountered in the smaller specimens*; ***Anterior ventral edge:*** lobed to sinuate (44.65%), sinuate or entire. *The smaller otoliths had a lobed edge*; ***Posterior ventral edge:*** in the small specimens, lobed to sinuate (10.69%) or lobed to entire; in the larger specimens, entire (33.33%), sinuate to entire (31.45%) or sinuate; ***Profile:*** concave-convex; ***Rostrum and antirostrum:*** absent; ***Rostrum and antirostrum orientation:*** does not apply; ***Pseudorostrum and pseudo-antirostrum:*** absent; ***Sulcus acusticus*****:** *position:* supramedian; *orientation:* lightly ascending (93.71%) or horizontal; *opening:* pseudo-ostio-caudal (60.38%), para-ostial or ostio-caudal; *morphology:* archaesulcoid; and *colliculum:* unimorphic.

There were significant differences ($p<0.05$) among some length classes in the otolith shape; anterior and posterior regions; dorsal, ventral and posterior ventral edges; and orientation and opening of the *sulcus acusticus*. There was a significant difference in the dorsal, anterior ventral and posterior ventral edges along the growth development.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	3.62 ± 0.44	2.32	4.64
OH/OL (%)	38.26 ± 1.83	33.85	44.1
OT/OL (%)	21.24 ± 1.60	17.03	24.97
OT/OH (%)	55.67 ± 4.74	44.62	67.39
Circularity	20.03 ± 2.16	17.53	30.77
Rectangularity	0.73 ± 0.02	0.69	0.81

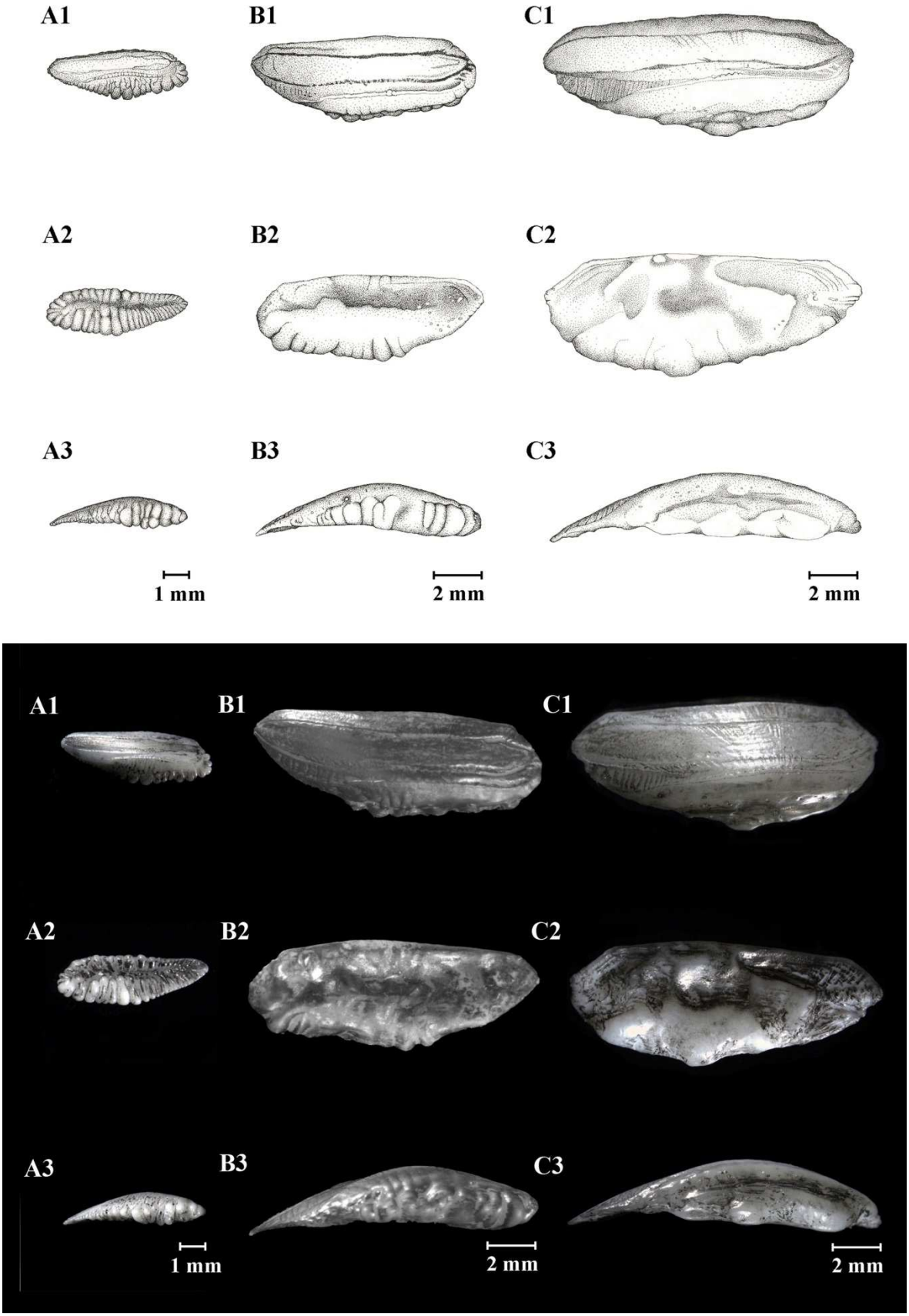


Plate 8. Illustrations (above) and photographs (below) of *Urophycis mystacea* otoliths from fish with total lengths: **A.** 196 mm (REV.AF.1007.8), **B.** 400 mm (PP.EF.506089.14) and **C.** 630 mm (REV.AF.1135.17). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3. (Illustrator: Jessica Falchi Caçador; Photos: Cesar Santificetur).

Family BREGMACEROTIDAE

The otolith's shape is square to discoidal, and the position of the *sulcus acusticus* inframedian, mesial.

Bregmaceros atlanticus **Goode & Bean 1886 - Plate 9**

Maximum Size:	90 mm (TL) (BERNARDES et al., 2005)
Distribution:	all of the oceans in both tropical and temperate waters (BERNARDES et al., 2005)
Habitat:	pelagic, between 500 and 600 m deep (BERNARDES et al., 2005)
Diet:	phyto and zooplankton, particularly crustaceans (FIGUEIREDO et al. 2002)
Collection:	104 pairs of otoliths (TL ranging from 28 to 75 mm)
Sample:	32 left otoliths categorized into 8, 5 mm classes (from 25 to 60 mm)

Shape: square to discoidal (68.75%); however, the larger specimens tend to be hexagonal to discoidal; ***Anterior region:*** flattened-round (65.63%), round, flattened to angled-round or angled to round; ***Posterior region:*** round (46.88%), flattened-round or angled to round; ***Dorsal edge:*** sinuate (62.50%), crenate or sinuate to entire; ***Ventral edge:*** entire (62.50%) or sinuate to entire; ***Anterior edge:*** entire (56.25%) or sinuate to entire; ***Posterior edge:*** entire (37.50%), sinuate to entire (37.50%) or sinuate; ***Profile:*** biconvex (62.50%) or plane-convex; ***Rostrum* and *antirostrum:*** absent; ***Rostrum and antirostrum orientation*:** does not apply; ***Pseudorostrum* and *pseudo-antirostrum:*** absent; ***Sulcus acusticus*:** *position:* inframedian; *orientation:* horizontal, slightly descending; *opening:* mesial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* oval (75%) or elliptic; and *cauda:* elliptic.

There were significant differences ($p<0.05$) within and among of the length classes for the anterior region; dorsal, ventral and posterior edges; and *ostium* morphology. There was a significant difference in the dorsal and posterior edges of the otolith along the growth development.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	3.34 ± 0.20	2.86	3.68
OH/OL (%)	98.24 ± 4.14	81.53	106.8
OT/OL (%)	29.55 ± 2.35	23.59	34.72
OT/OH (%)	30.14 ± 2.76	24.47	37.5
Circularity	14.68 ± 0.31	14.21	15.63
Rectangularity	0.73 ± 0.04	0.69	0.91

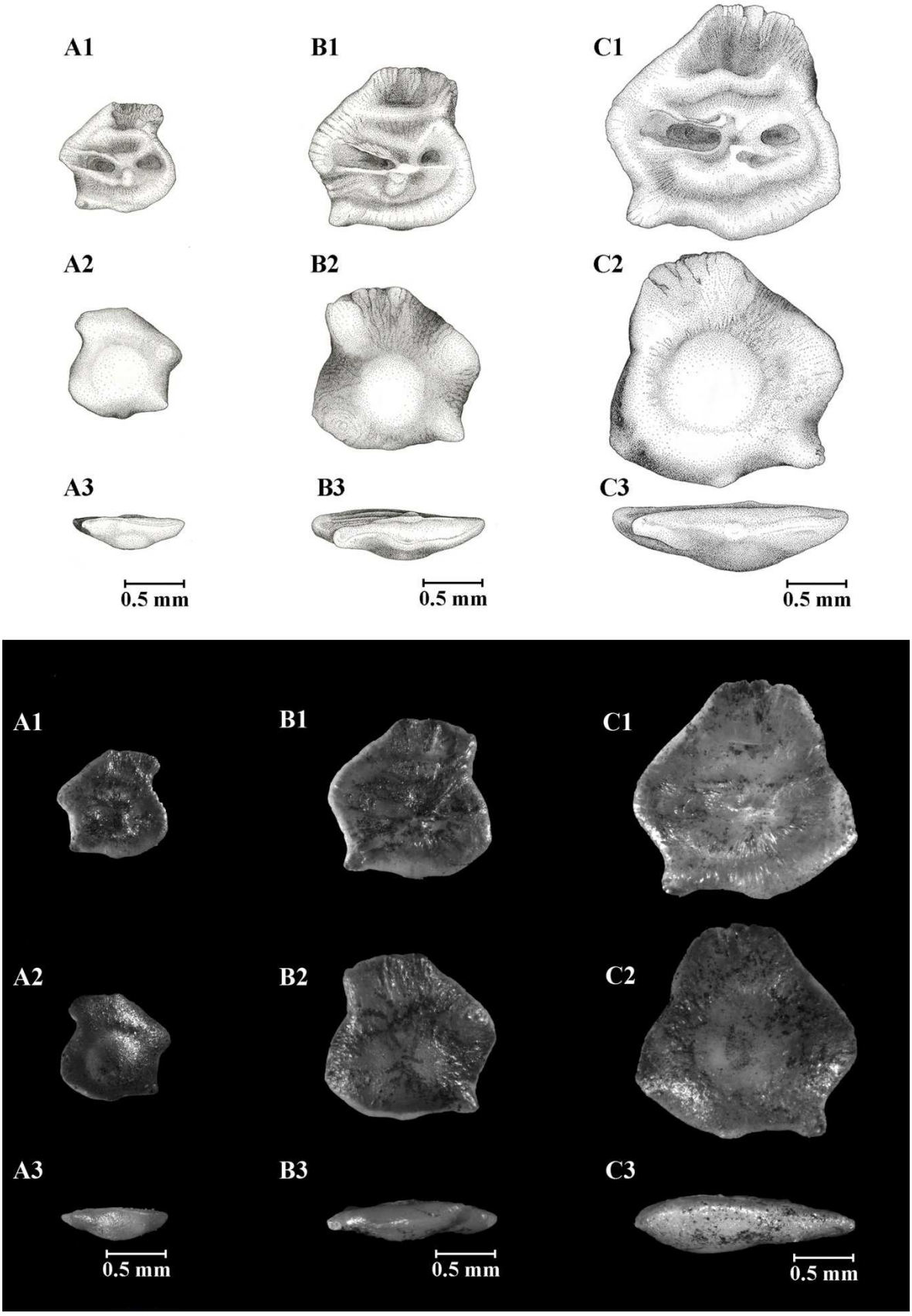


Plate 9. Illustrations (above) and photographs (below) of *Bregmaceros atlanticus* otoliths from fish with total lengths: **A.** 29 mm (SARVI.AM.L15.31), **B.** 46 mm (SARVI.AM.L15.3) and **C.** 60 mm (SARVI.AM.L15.33). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3. (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Bregmaceros cantori **Milliken & Houde 1984 - Plate 10**

Maximum Size:	76 mm (TL) (BERNARDES et al., 2005)
Distribution:	western Atlantic Ocean from the Gulf of Mexico to southern Brazil (BERNARDES et al., 2005)
Habitat:	pelagic, in waters far from the coast (FIGUEIREDO et al. 2002)
Diet:	---
Collection:	651 pairs of otoliths (TL ranging from 28 to 78 mm)
Sample:	83 left otoliths categorized into 11, 5 mm classes (from 25 to 75 mm)

Shape: square to discoidal (81.93%); however, the larger individuals tend to be hexagonal to discoidal; ***Anterior region:*** flattened-round (75.86%), angled-round or round; ***Posterior region:*** round (45.78%), angled-round or flattened-round; ***Dorsal edge:*** sinuate (85.54%) or sinuate to entire; ***Ventral edge:*** entire (75.9%) or sinuate to entire; ***Anterior edge:*** entire (59.04%) or sinuate to entire; ***Posterior edge:*** sinuate to entire (65.06%), sinuate or entire; ***Profile:*** plane-convex (65.06%) or biconvex; ***Rostrum* and *antirostrum:*** *absent*; ***Rostrum and antirostrum orientation:*** does not apply; ***Pseudorostrum* and *pseudo-antirostrum:*** absent; ***Sulcus acusticus*:** *position:* inframedian; *orientation:* horizontal (68.67%) or slightly descending; *opening:* mesial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* oval (62.65%) or elliptic; and *cauda:* elliptic.

There were significant differences ($p<0.05$) among some of the length classes for the otolith shape; anterior and posterior regions; the dorsal, ventral, anterior and posterior edges; the orientation of the *sulcus acusticus*; morphology of the *ostium*; and otolith profile. There was a significant difference along the growth development only in the posterior region.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	3.25 ± 0.23	2.65	3.74
OH/OL (%)	95.55 ± 6.05	78.85	105.93
OT/OL (%)	27.64 ± 3.86	19.38	33.9
OT/OH (%)	28.82 ± 2.73	23.33	33.33
Circularity	14.98 ± 0.59	13.91	16.45
Rectangularity	0.73 ± 0.01	0.69	0.77

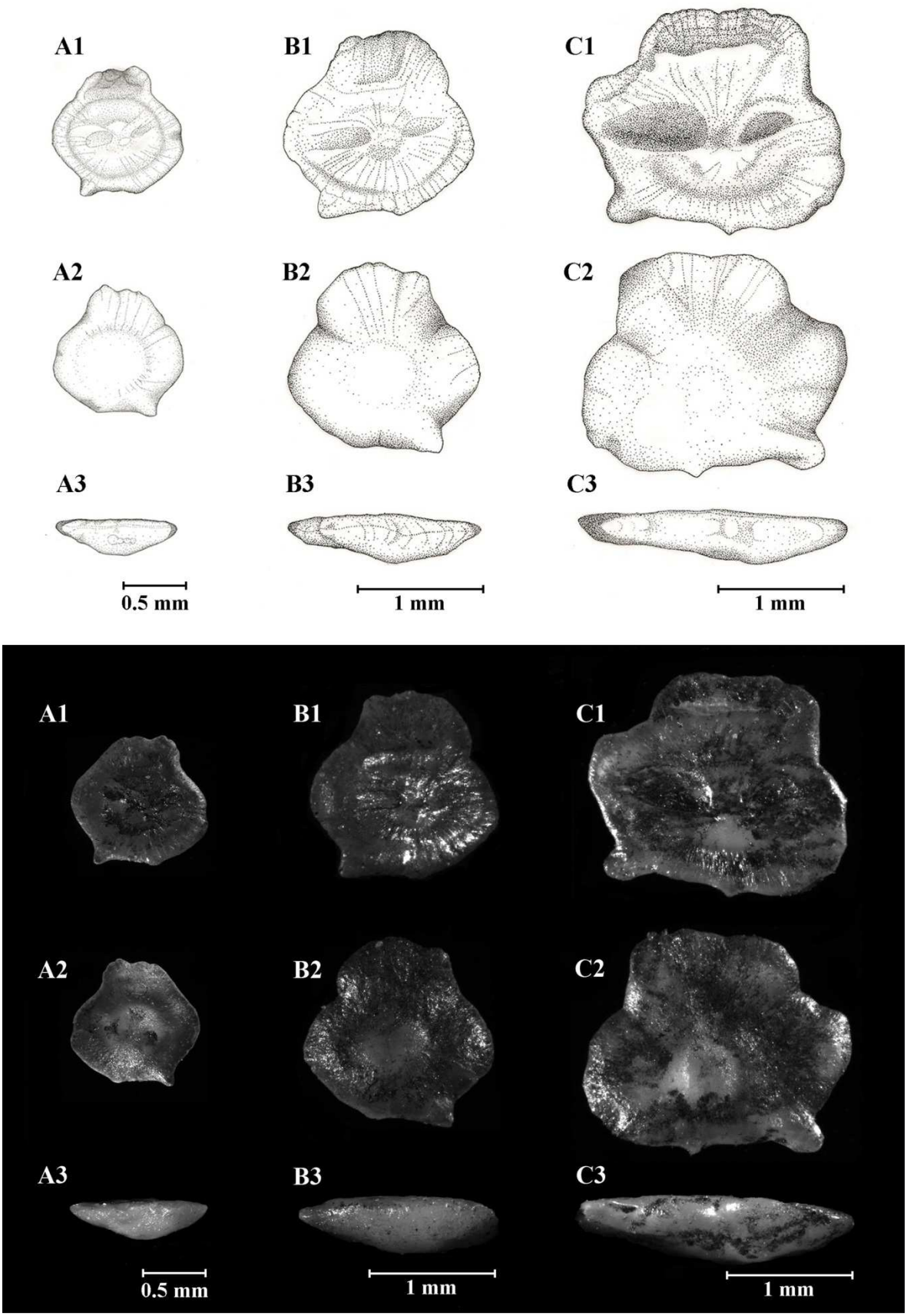


Plate 10. Illustrations (above) and photographs (below) of *Bregmaceros cantori* otoliths from fish with total lengths: **A.** 28 mm (SARVII.AM.L14.24), **B.** 52 mm (REVP.AM.L337.56) and **C.** 73 mm (REF5.AM.L6.5). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3. (Illustrator: Thais Tiemi Mizutami; Photos: Cesar Santificetur).

Family MERLUCCIIDAE

Merluccius hubbsi **Marini 1933 - Plate 11**

Maximum Size:	1 m (TL) (BERNARDES et al., 2005)
Distribution:	southwestern Atlantic Ocean from Rio de Janeiro to 54°S in Argentina (BERNARDES et al., 2005)
Habitat:	inhabits the continental slope, between 50 and 500m deep (BERNARDES et al., 2005)
Diet:	The juveniles consume pelagic crustaceans, and the adults consume squid and other fish (FIGUEIREDO et al. 2002)
Collection:	4,237 pairs of otoliths (TL ranging from 49 to 597 mm)
Sample:	221 left otoliths categorized into 27, 20 mm classes (from 40 to 580 mm)

Shape: *the smaller otoliths are elliptic, and the largest are lanceolated to elliptic* (88.69%); ***Anterior region:*** oblique-round (84.16%), oblique to angled-round or oblique to peaked-round; ***Posterior region:*** the smallest otoliths are peaked-round, the largest are lanceolated-round (71.95%) or lanceolated; ***Dorsal edge:*** lobed to sinuate (52.94%) or lobed; ***Ventral edge:*** lobed to sinuate (45.25%), sinuate to entire, lobed, lobed to entire or sinuate; ***Profile:*** plane-convex (70.59%) or flattened; ***Rostrum and antirostrum orientation:*** in agreement; ***Rostrum:*** absent (80.09%) or undeveloped; ***Antirostrum:*** absent (81%) or undeveloped; ***Pseudorostrum* and *pseudo-antirostrum:*** absent; ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal (95.02%) or slightly ascending; *opening:* mesial (91.86%) or pseudo-ostial; *morphology:* homosulcoid; *colliculum:* homomorphic; *ostium:* elliptic; and *cauda:* elliptic.

Some otoliths of this species had a protuberance on the dorsal-anterior region, and some otoliths, particularly the larger ones, had an excisura on the anterior region.

There were significant differences ($p<0.05$) among some of the length classes in the otolith shape, anterior and posterior regions, dorsal and ventral edges, orientation and opening of the *sulcus acusticus*, otolith profile, and *rostrum* and *antirostrum* of the otolith. Significant differences along the growth development occurred for the otolith shape, anterior and posterior regions, dorsal and ventral edges, otolith profile, and *rostrum* and *antirostrum*.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	4.89 ± 0.53	3.25	11.13
OH/OL (%)	42.12 ± 3.47	32.49	55.85
OT/OL (%)	10.18 ± 2.07	6.68	15.46
OT/OH (%)	24.04 ± 3.67	17.57	34.45
Circularity	25.12 ± 4.65	17.36	47.83
Rectangularity	0.69 ± 0.03	0.63	0.96

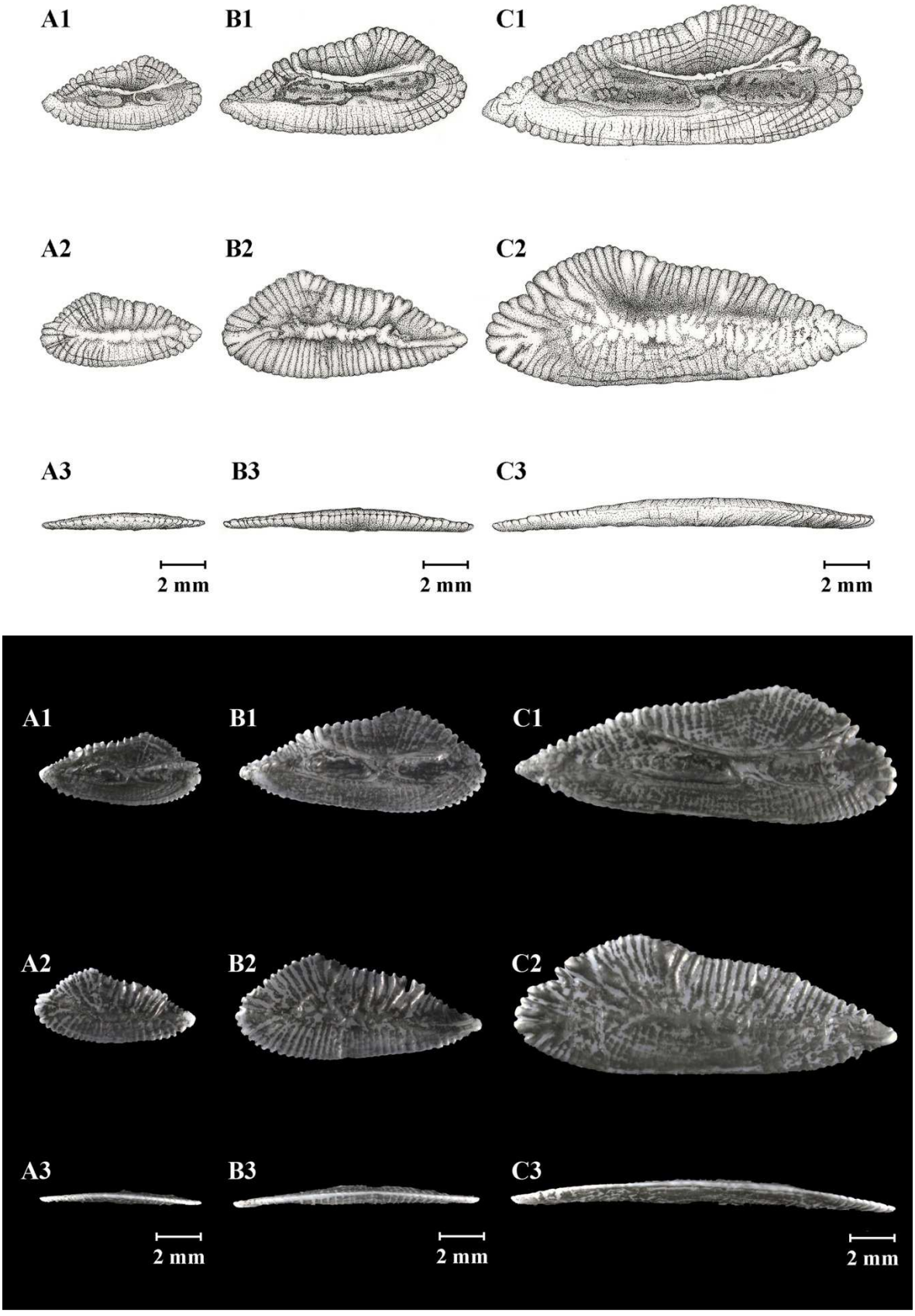


Plate 11. Illustrations (above) and photographs (below) of *Merluccius hubbsi* otoliths from fish with total lengths: **A**. 158 mm (PADCT.AF.6634.26), **B**. 244 mm (REF6.AM.6014.3) and **C**. 395 mm (REF6.AM.6014.1). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3. (Illustrator: Jessica Falchi Caçador; Photos: Cesar Santificetur).

IDENTIFICATION KEY

Family MACROURIDAE

Genus *Malacocephalus*

The angle between the posterior and median regions of the ventral edge is slightly accentuated (approximately 100°); the otolith medial and lateral faces are rough, throughout development…….*Malacocephalus laevis*
The angle between the posterior and median regions of the ventral edge is accentuated (approximately 120°); the end of the posterior region of the dorsal edge has a marked protuberance……...…*Malacocephalus occidentalis*

Family PHYCIDAE

Genus *Urophycis*

The anterior region is predominantly oblique to peaked; the *rostrum* is undeveloped; the *antirostrum* is absent; the opening of the *sulcus acusticus* is predominantly para-ostial……...…….*Urophycis brasiliensis*
The anterior region is oblique-round; the *rostrum* and *antirostrum* are absent; the opening of the *sulcus acusticus* is mostly pseudo-ostio-cauda……...……..*Urophycis mystacea*

Family BREGMACEROTIDAE

Genus *Bregmaceros*

The posterior region of the dorsal edge is entire; the lateral face has an obvious round protuberance that remains throughout development……..……...….*Bregmaceros atlanticus*
The posterior region of the dorsal edge has an accentuated groove; the round protuberance of the external face tends to diminish in larger otoliths……..*Bregmaceros cantori*

PART II: PERCIFORMES (CARANGIDAE, SCIAENIDAE, SCOMBRIDAE and SERRANIDAE)

Family CARANGIDAE

Otoliths with elliptic to lanceolated shape predominate, but with variations as rectangular, spindle-shaped and hour glass. The most common profile is the concave-convex.

Chloroscombrus chrysurus **(Linnaeus 1766) - Plate 12**

Maximum Size:	30 cm (TL) (MENEZES; FIGUEIREDO, 1980)
Distribution:	from Massachusetts to Argentina (MENEZES et al., 2003)
Habitat:	coastal areas, preferably bays and estuaries, forming large shoals (MENEZES; FIGUEIREDO, 1980)
Diet:	planktonic organisms, mainly crustaceans (MENEZES; FIGUEIREDO, 1980)
Collection:	682 pairs of otoliths of this species from fishes with TL ranging from 104 to 372 mm
Sample:	95 left otoliths categorized into 13, 20 mm classes (100 to 340 mm)

Shape: elliptic to lanceolated (97.89%), elliptic. ***Anterior region***: lanceolated (55.79%), lanceolated-round, peaked-round. ***Posterior region***: angled-round (78.95%), angled, round. ***Dorsal edge***: lobed to sinuate (45.26%), sinuate (42.11%), sinuate to entire. ***Ventral edge***: sinuate (47.37%), lobed, lobed to sinuate, serrate to sinuate, sinuate to entire. ***Profile***: concave-convex. ***Rostrum and antirostrum orientation***: in disagreement (97.89%), in agreement. ***Rostrum***: developed. ***Antirostrum***: developed (55.79%), underdeveloped, absent. ***Pseudorostrum and pseudo-antirostrum***: absent. ***Sulcus acusticus***: *position:* supramedian; *orientation:* horizontal; *opening:* ostial; *morphology:* heterosulcoid; *colliculum:* absent; *ostium:* funnel like; *cauda:* tubular strongly curved (64.21%), tubular markedly curved.

Among some length classes, there were significant differences ($p<0.05$) in the otolith shape, anterior and posterior regions, dorsal and ventral edges, *cauda* morphology, *rostrum* and *antirostrum* orientation and the *antirostrum*. Differences were found along the growth development in the dorsal and ventral edges.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	2.41 ± 0.29	1.61	2.98
OH/OL (%)	47.64 ± 4.27	39.08	57.6
OT/OL (%)	17.13 ± 1.81	12.77	16.49
OT/OH (%)	11.63 ± 1.81	8.41	16.49
Circularity	36.18 ± 4.63	25.29	47.31
Rectangularity	0.63 ± 0.02	0.59	0.68

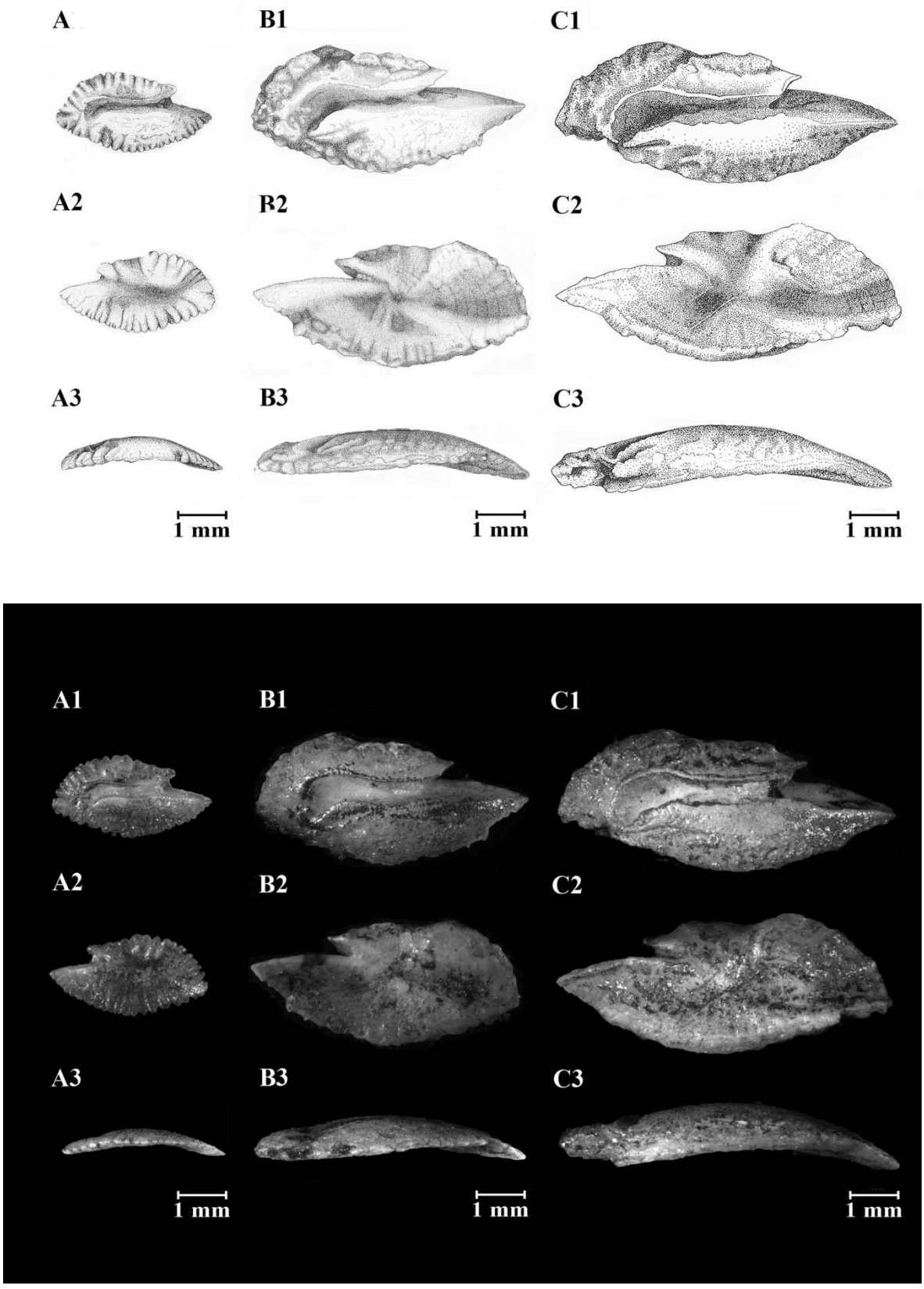


Plate 12. Illustrations (above) and photographs (below) of *Chloroscombrus chrysurus* otoliths from fish with total lengths: **A.** 115 mm (SARIV.AM.L9.7), **B.** 242 mm (SARV.AM.L13.7) and **C.** 354 mm (SARVI.AM.L13.1). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Decapterus punctatus **(Cuvier 1829) - Plate 13**

Maximum Size:	30 cm (TL) (MENEZES; FIGUEIREDO, 1980)
Distribution:	Canada to the State of Santa Catarina, Brazil (MENEZES et al., 2003)
Habitat:	open waters and forming shoals (MENEZES; FIGUEIREDO, 1980)
Diet:	planktonic copepods (MENEZES; FIGUEIREDO, 1980)
Collection:	93 pairs of otoliths (TL ranging from 158 to 243 mm)
Sample:	28 left otoliths categorized into 5, 20 mm classes (from 160 to 240 mm)

Shape: elliptic to lanceolated (78.57%), elliptic. ***Anterior region:*** lanceolated-round (71.43%), angular-round. ***Posterior region:*** angular-round (89.29%), round. ***Dorsal edge***: sinuate to entire. ***Ventral edge:*** sinuate to entire (75%), sinuate. ***Profile:*** concave-convex. ***Rostrum and antirostrum orientation:*** in disagreement (71.43%), in agreement. ***Rostrum:*** developed. ***Antirostrum:*** underdeveloped (89.29%) or absent. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* supramedian; *orientation:* horizontal; *opening*: ostial (96.43%), or ostiocaudal; *morphology:* heterosulcoid; *colliculum: absent*; *ostium:* funnel like; *cauda:* tubular slightly curved.

There were significant differences ($p<0.05$) among otoliths of some length classes in the shape, anterior and posterior regions, ventral edge, sulcus acusticus opening, *rostrum* and *antirostrum* and *antirostrum* orientation and *antirostrum*. No differences were found along the otolith development.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	2.52 ± 0.16	2.26	3.04
OH/OL (%)	50.28 ± 2.96	43.2	55.84
OT/OL (%)	18.58 ± 2.05	14.93	22.86
OT/OH (%)	37.04 ± 4.37	29.8	45.34
Circularity	19.20 ± 0.78	17.86	21.32
Rectangularity	0.64 ± 0,03	0.56	0.68

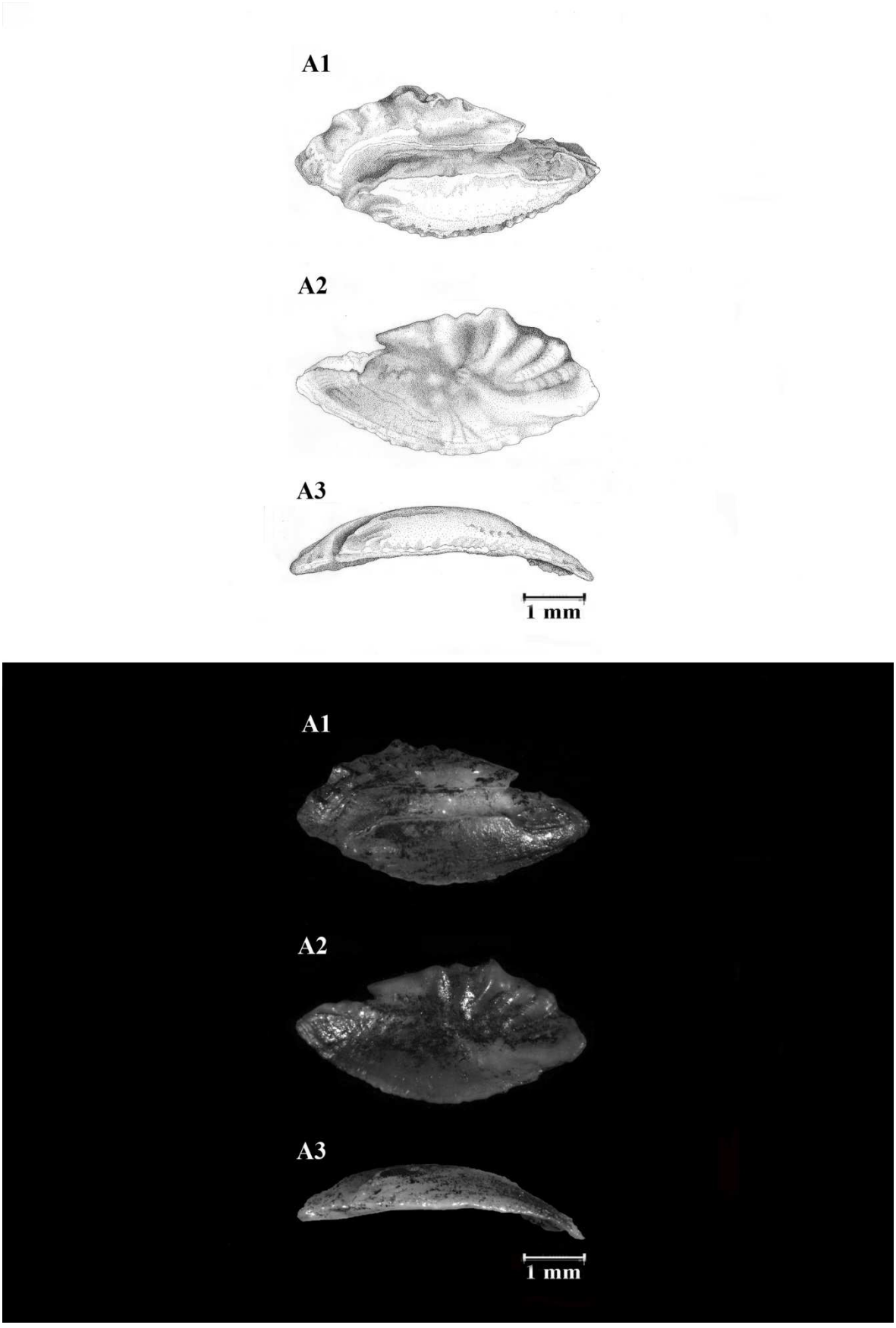


Plate 13. Illustrations (above) and photographs (below) of *Decapterus punctatus* otolith from a fish with total length of 181 mm (SARV.AM.L15.21). The medial face is shown in A1; the lateral face in A2; and the ventral profile in A3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Decapterus tabl **Berry 1968 - Plate 14**

Maximum Size:	41 cm (TL) (MENEZES; FIGUEIREDO, 1980)
Distribution:	western Atlantic from North Carolina to southern Brazil, Bermuda and the Caribbean (BERNARDES et al., 2005)
Habitat:	deeper waters, having been captured at (as far down as) almost 400 m (FIGUEIREDO et al., 2002)
Diet:	---
Collection:	19 pairs of otoliths (TL ranging from 123 to 146 mm)
Sample:	7 left otoliths categorized into 4, 5 mm classes (120 to 145 mm)

Shape: elliptic to lanceolated. ***Anterior region:*** peaked to lanceolated. ***Posterior region:*** angular-round. ***Dorsal edge:*** lobed to sinuate. ***Ventral edge:*** lobed to sinuate. ***Profile:*** concave-convex. ***Rostrum and antirostrum orientation:*** does not apply. ***Rostrum:*** developed. ***Antirostrum:*** absent. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; o*pening:* ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* tubular slightly curved.

The small number of otoliths did not permit statistical analysis of the data but their morphometric characteristics values are shown below:

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	2.35 ± 0.08	2.23	2.47
OH/OL (%)	45.01 ± 1.61	41.83	46.54
OT/OL (%)	12.65 ± 0.71	11.67	13.57
OT/OH (%)	28.17 ± 2.42	25.36	32.45
Circularity	24.53 ± 0.61	23.76	25.51
Rectangularity	0.65 ± 0.02	0.62	0.69

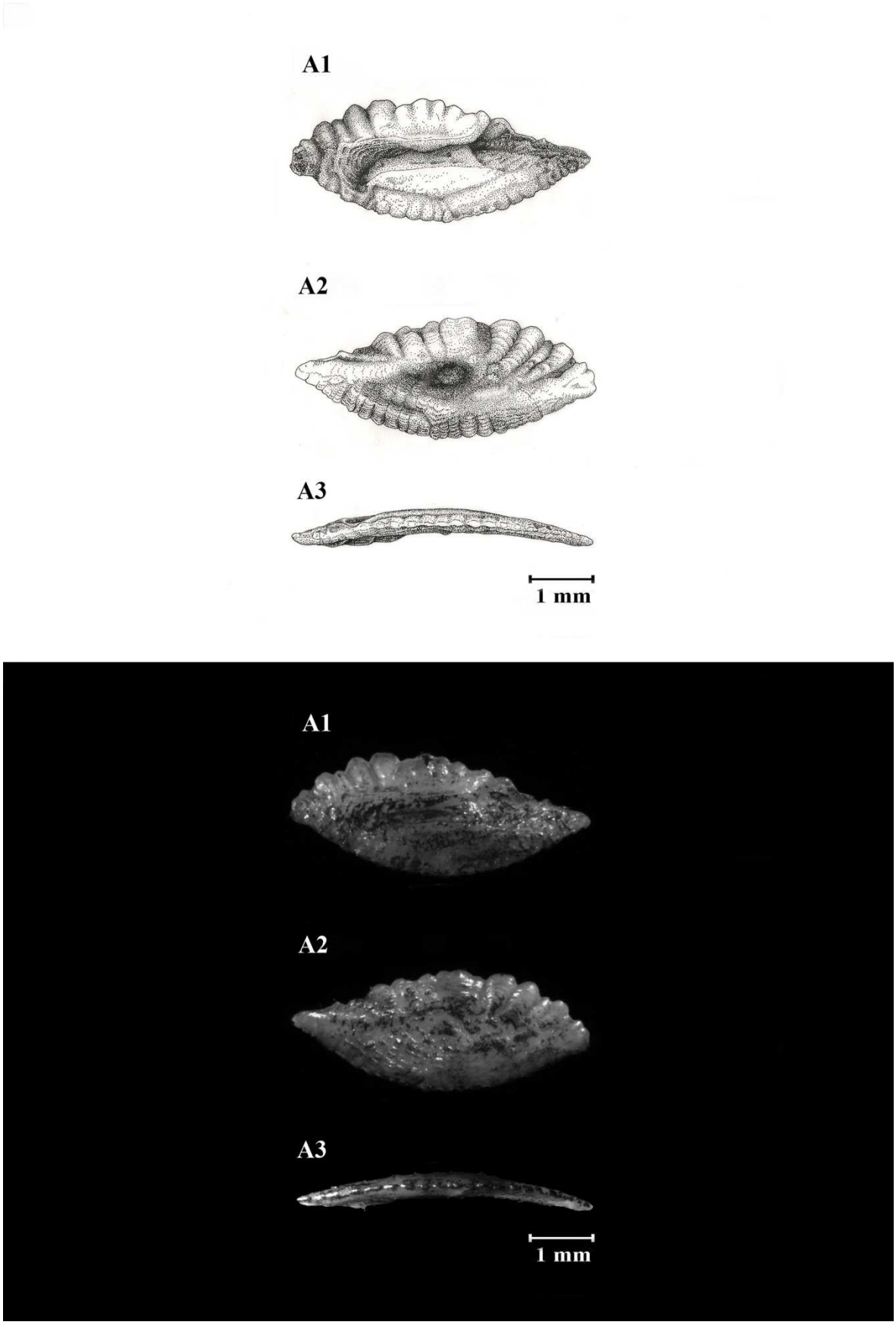


Plate 14. Illustrations (above) and photographs (below) of *Decapterus tabl* otolith from a fish with total length of 146 mm (REVP.AM.L345.9). The medial face is shown in A1; the lateral face in A2; and the ventral profile in A3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Hemicaranx amblyrhynchus **(Cuvier 1833) – Plate 15**

Maximum Size:	40 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	North Carolina to the State of Santa Catarina, Brazil (FIGUEIREDO; MENEZES, 1980)
Habitat:	generally in brackish waters, juveniles are associate with jellyfish (FIGUEIREDO; MENEZES, 1980)
Diet:	zoobenthos (FROESE; PAULY, 2013)
Collection:	4 pairs of otoliths (TL ranging from 306 to 376 mm)
Sample:	4 left otoliths categorized into 3, 20 mm classes (300 to 360 mm)

Shape: lanceolated. ***Anterior region:*** lanceolated. ***Posterior region:*** round. ***Dorsal edge:*** sinuate. ***Ventral edge:*** sinuate. ***Profile:*** concave-convex. ***Rostrum and antirostrum orientation:*** in agreement. ***Rostrum:*** developed. ***Antirostrum:*** developed. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* supramedian; *orientation:* horizontal; *opening:* ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* tubular slightly curved.

The small number of otoliths did not permit statistical analysis of the data but their morphometric characteristics values are shown below:

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	1.70 ± 0.10	1.58	1.79
OH/OL (%)	42.53 ± 1.42	40.88	43.82
OT/OL (%)	17.79 ± 2.98	15.48	21.99
OT/OH (%)	41.72 ± 5.85	37.02	50.18
Circularity	25.56 ± 1.14	24.53	26.89
Rectangularity	0.63 ± 0.01	0.62	0.64

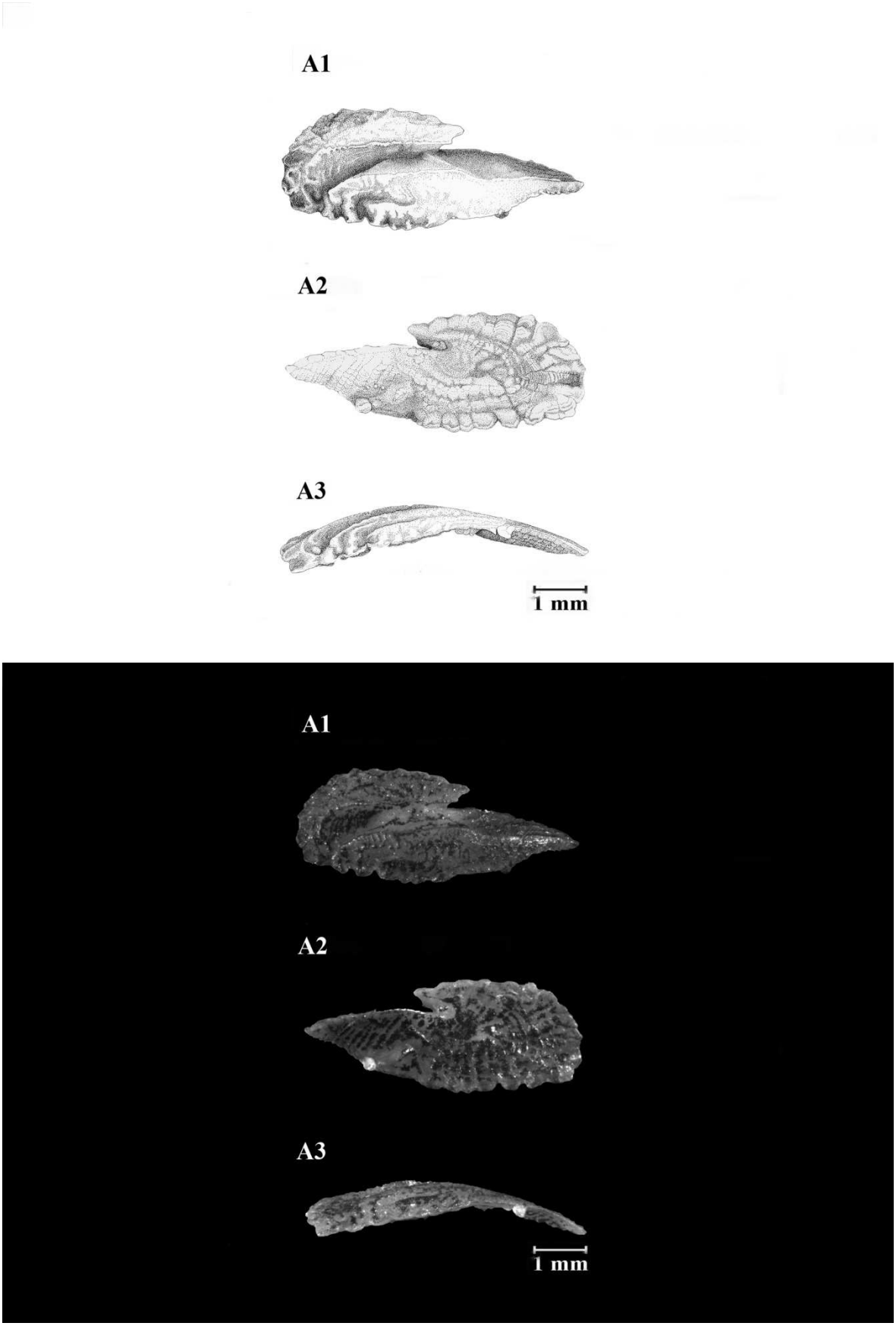


Plate 15. Illustrations (above) and photographs (below) of *Hemicaranx amblyrhynchus* otolith from a fish with total length of 314 mm (SARIV.AM.L15.4). The medial face is shown in A1; the lateral face in A2; and the ventral profile in A3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur)

Naucrates ductor **(Linnaeus 1758) – Plate 16**

Maximum Size:	70 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	circumtropical, occurring in the western Atlantic from Nova Scotia to northern Argentina (FIGUEIREDO; MENEZES, 1980)
Habitat:	waters off the coast (FIGUEIREDO; MENEZES, 1980)
Diet:	animals' carcasses and ectoparasites of sharks and rays, and small fish and turtles (FIGUEIREDO; MENEZES, 1980)
Collection:	one pair of otoliths (278 mm TL)
Sample:	one left otolith (278 mm TL)

Shape: hour glass. ***Posterior region:*** notched. ***Anterior region:*** notched. ***Dorsal edge:*** sinuate. ***Ventral edge:*** sinuate. ***Profile:*** plane-convex. ***Rostrum and antirostrum orientation:*** in agreement. ***Rostrum:*** developed. ***Antirostrum:*** developed. ***Pseudorostrum:*** developed. ***Pseudo-antirostrum:*** underdeveloped. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* ostiocaudal; *morphology:* pseudo-archaeosulcoid; *colliculum:* holomorphic; *ostium:* funnel like; *cauda:* elliptic.

The morphometric data of the specimen are given below:

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	0.77 ± 0	0.77	0.77
OH/OL (%)	57.28 ± 0	57.28	57.28
OT/OL (%)	15.49 ± 0	15.49	15.49
OT/OH (%)	27.05 ± 0	27.05	27.05
Circularity	23.28 ± 0	23.28	23.28
Rectangularity	0.63 ± 0	0.63	0.63

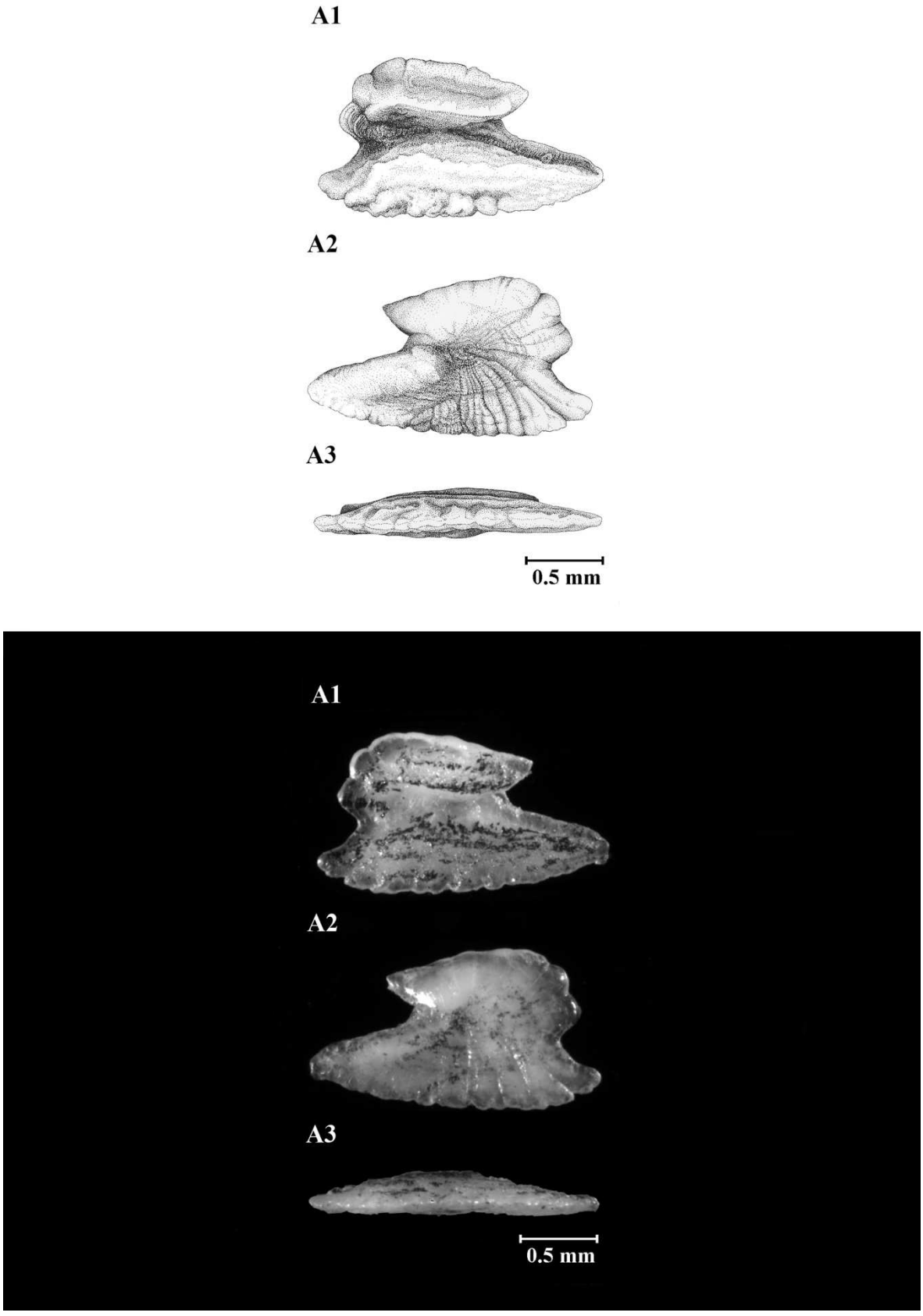


Plate 16. Illustrations (above) and photographs (below) of *Naucrates ductor* otolith from a fish with total length of 278 mm (SARVII.CE.L13.1). The medial face is shown in A1; the lateral face in A2; and the ventral profile in A3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Oligoplites saliens **(Bloch 1793) – Plate 17**

Maximum Size:	50 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	Honduras to Uruguay (FIGUEIREDO; MENEZES, 1980)
Habitat:	coastal waters near the surface (FIGUEIREDO; MENEZES, 1980)
Diet:	zooplankton (planktonic crustaceans) (FROESE; PAULY, 2013)
Collection:	358 pairs of otoliths (TL ranging from 149 to 635 mm)
Sample:	92 left otoliths categorized into 16, 20 mm classes (140 to 500 mm)

Shape: elliptic to lanceolated (65.22%), lanceolated, hour-glass. ***Anterior region:*** lanceolated-round (65.22%), notched or lanceolated. ***Posterior region:*** oblique to angled (35.87%), notched (32.61%), oblique-round (31.52%). ***Dorsal edge:*** sinuate to entire (64.13%), sinuate. ***Ventral edge:*** sinuate (53.26%), sinuate to entire. ***Profile:*** concave-convex (96.74%), plane-convex. ***Rostrum and antirostrum orientation:*** not in agreement (93.48%), in agreement. ***Rostrum:*** developed. ***Antirostrum:*** developed (77.17%), underdeveloped. ***Pseudorostrum:*** absent (48.91%), underdeveloped, sometimes developed. ***Pseudo-antirostrum:*** absent (48.91%), underdeveloped, sometimes developed. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* ostial (50%), ostiocaudal (50%); *morphology:* heterosulcoid; *colliculum:* absent; *ostium:* funnel like; *cauda:* tubular slightly curved (83.70%), tubular strongly curved.

Among the length classes, significant differences ($p<0.05$) were observed only for the otolith shape, anterior and posterior regions, dorsal and ventral edges, *cauda* morphology, *rostrum* and *antirostrum* orientation, the *antirostrum*, *pseudorostrum* and pseudo-*antirostrum*. Differences along the growth development were observed in the dorsal edge and the *antirostrum*.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	1.02 ± 0.10	0.67	1.24
OH/OL (%)	48.77 ± 5.52	36.96	71.77
OT/OL (%)	14.94 ± 2.00	11.53	20.44
OT/OH (%)	30.71 ± 3.07	23.33	39.78
Circularity	27.80 ± 5.89	18.97	45.92
Rectangularity	0.62 ± 0.05	0.54	0.88

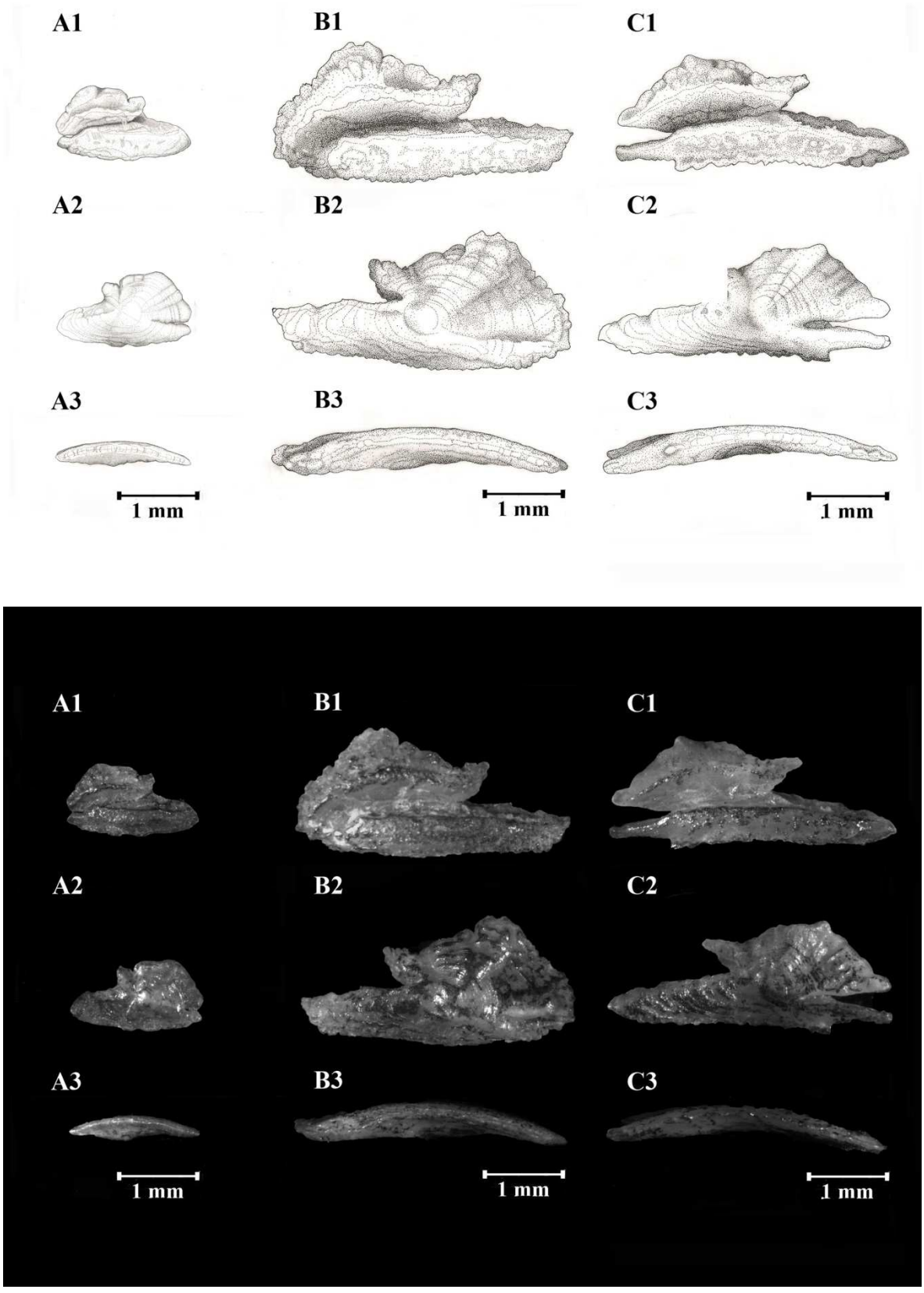


Plate 17. The illustrations (above) and photographs (below) of *Oligoplites saliens* otoliths from fish with total lengths: **A.** 154 mm (SARVII.AM.L7.31), **B.** 392 mm (SARIV.AM.L15.31) and **C.** 503 mm (SARV.AM.L16.2). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3 (Illustrator: Thais Tieme Mizutani; Photos: Cesar Santificetur).

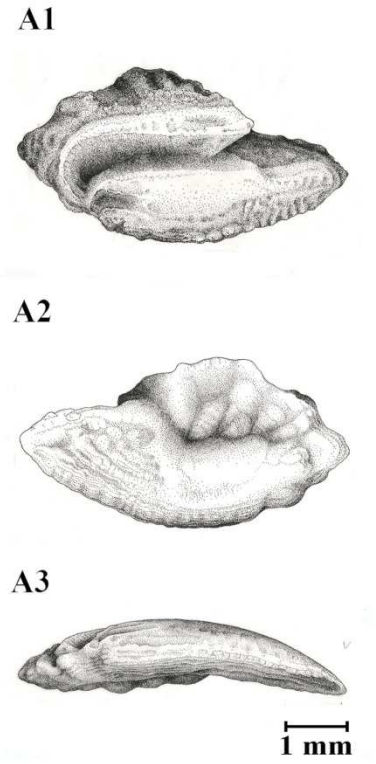
Selar crumenophthalmus **(Bloch 1793) – Plate 18**

Maximum Size:	40 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	western Atlantic from Nova Scotia to the coast of São Paulo, Brazil (FIGUEIREDO; MENEZES, 1980)
Habitat:	tropical and subtropical oceans, forming shoals (FIGUEIREDO; MENEZES, 1980)
Diet:	planktonic and benthic invertebrates, and occasionally fish (FIGUEIREDO; MENEZES, 1980)
Collection:	5 pairs of otoliths (TL ranging from 185 to 209 mm)
Sample:	one left otolith (209 mm TL)

Shape: elliptic. ***Anterior region:*** peaked-round. ***Posterior region:*** angled-round. ***Dorsal edge:*** sinuate. ***Ventral edge:*** sinuate. ***Profile:*** concave-convex. ***Rostrum and antirostrum orientation:*** does not apply. ***Rostrum:*** developed. ***Antirostrum:*** absent. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* supramedian; *orientation:* horizontal; *opening:* ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* tubular slightly curved.

The morphometric data of the specimen are given below:

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	2.53 ± 0	2.53	2.53
OH/OL (%)	53.60 ± 0	53.6	53.6
OT/OL (%)	22.35 ± 0	22.35	22.35
OT/OH (%)	41.70 ± 0	41.7	41.7
Circularity	19.11 ± 0	19.11	19.11
Rectangularity	0.64 ± 0	0.64	0.64



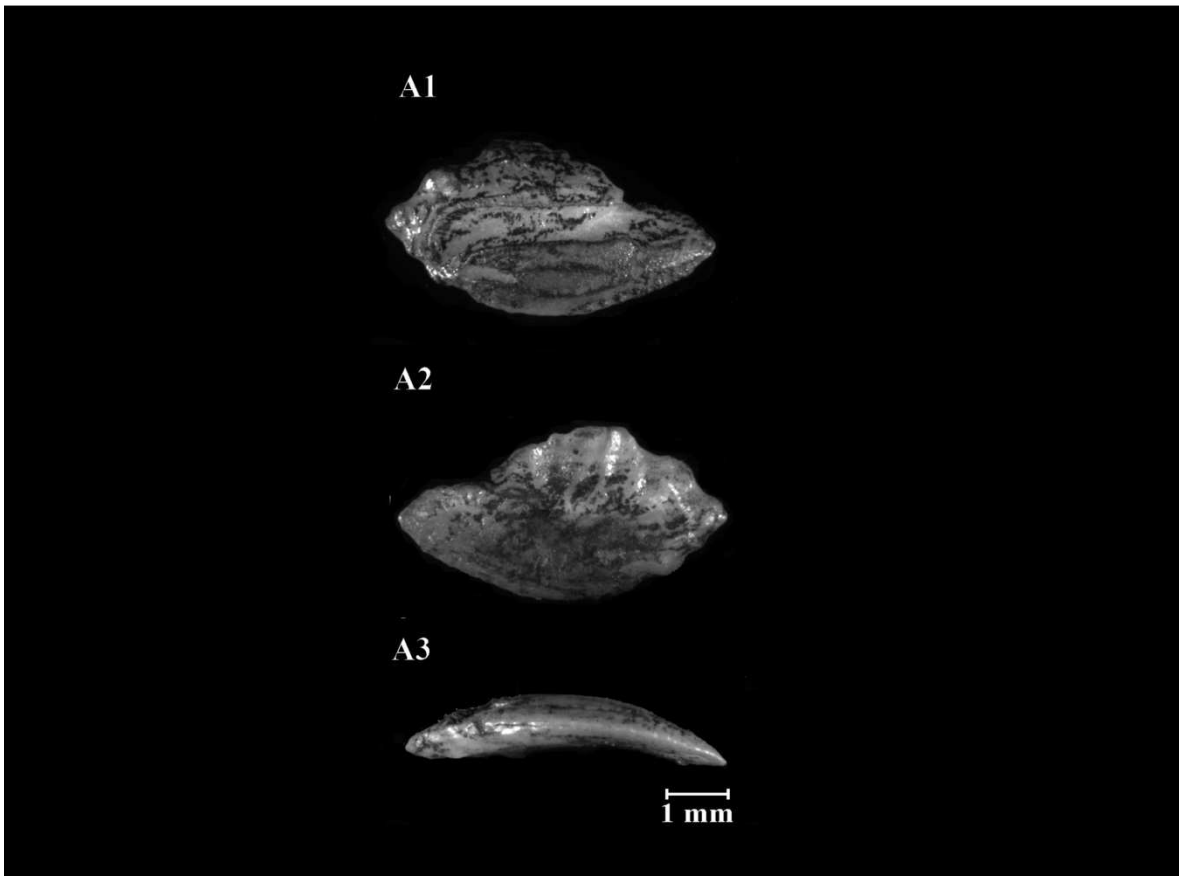


Plate 18. Illustrations (above) and photographs (below) of *Selar crumenophthalmus* otolith from fish with total length of 209 mm (SARIV.AM.10.1). The medial face is shown in A1; the lateral face in A2; and the ventral profile in A3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Selene setapinnis **(Mitchill 1815) – Plate 19**

Maximum Size:	40 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	western Atlantic from Nova Scotia to northern Argentina (FIGUEIREDO; MENEZES, 1980)
Habitat:	near the bottom forming shoals. Individuals of small and medium sizes are common in shallow areas of bays and estuaries (FIGUEIREDO; MENEZES, 1980)
Diet:	small fish and crustaceans (FIGUEIREDO et al., 2002)
Collection:	152 pairs of otoliths (TL ranging from 33 to 442 mm)
Sample:	29 left otoliths categorized into 11, 20 mm classes (120 to 440 mm)

Shape: elliptic (72.41%), elliptic to rectangular, rectangular. ***Anterior region:*** peaked-round (62.07%), round. ***Posterior region:*** angled-round (48.28%), round, flattened. ***Dorsal edge:*** sinuate (51.72%), lobed to sinuate, sinuate to entire. ***Ventral edge:*** lobed to sinuate (58.62%), sinuate. ***Profile:*** concave-convex. ***Rostrum and antirostrum orientation:*** in agreement. ***Rostrum:*** developed. ***Antirostrum:*** developed. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* supramedian; *orientation:* horizontal (72.41%), descending; *opening:* ostial; *morphology:* heterosulcoid; *colliculum:* absent; *ostium:* funnel like; *cauda:* tubular slightly curved (55.17%), tubular strongly curved.

Among some length classes, there were significant differences ($p<0.05$) in the dorsal edge, sulcus acusticus orientation and the *cauda* morphology. Differences were not found along the growth development.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	2.31 ± 0.30	1.77	2.78
OH/OL (%)	58.85 ± 4.17	51.37	67.73
OT/OL (%)	22.79 ± 2.21	18.74	28.06
OT/OH (%)	38.86 ± 4.16	32.19	47.41
Circularity	22.33 ± 1.67	19.17	24.93
Rectangularity	0.66± 0.03	0.61	0.71

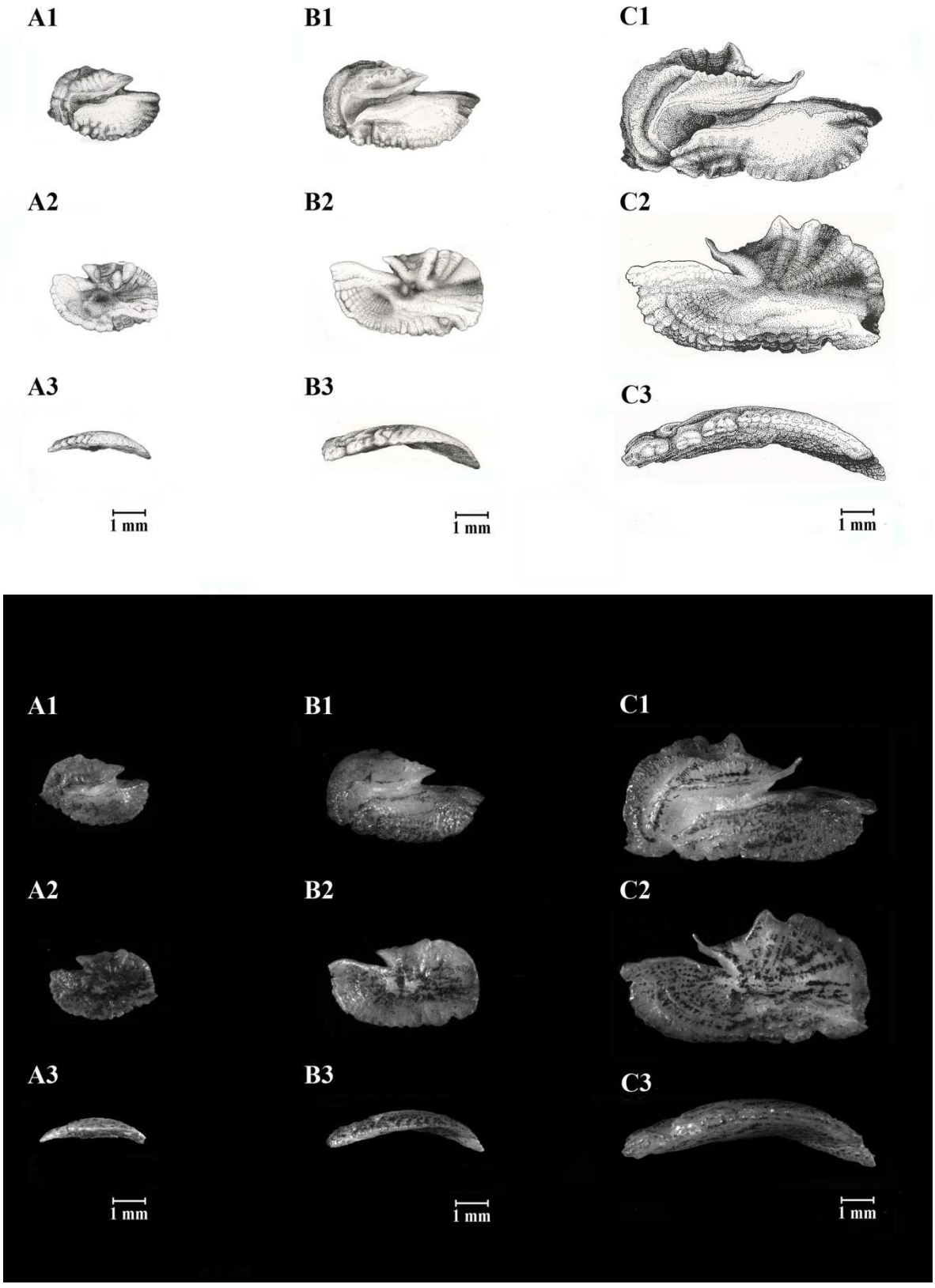


Plate 19. Illustrations (above) and photographs (below) of *Selene setapinnis* otoliths from fish with total lengths: **A.** 135 mm (SARIV.AM.L9.1), **B.** 231 mm (SARV.AM.L18.10) and **C.** 442 mm (SARVII.AM.L4.1). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Selene vomer **(Linnaeus 1758) – Plate 20**

Maximum Size:	50 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	from Gulf of Maine to Uruguay (FIGUEIREDO; MENEZES, 1980)
Habitat:	sand or stone shallow water, close to the bottom forming small shoals (FIGUEIREDO MENEZES, 1980)
Diet:	fish and crustaceans (FIGUEIREDO; MENEZES, 1980)
Collection:	21 pair of otoliths (TL ranging from 28 to 445 mm)
Sample:	14 left otoliths categorized into 6, 20 mm classes (20 to 440 mm)

Shape: elliptic (50%), rectangular (50%). ***Anterior region:*** peaked-round (42.86%), flattened, angled-round, round. ***Posterior region:*** round (92.86%), angled-round. ***Dorsal edge:*** lobed to sinuate (50%), sinuate, sinuate to entire. ***Ventral edge:*** lobed to sinuate (50%), sinuate (50%). ***Profile:*** concave-convex (50%), plane-convex (50%). ***Rostrum and antirostrum orientation:*** in agreement. ***Rostrum:*** developed. ***Antirostrum:*** developed. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* supramedian; *orientation:* descending; *opening*: ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* tubular slightly curved (50%), tubular strongly curved (50%).

There were significant differences ($p<0.05$) among otoliths of some length classes in the otolith shape, anterior and posterior regions, dorsal and ventral edges, *cauda* morphology and otolith profile. Differences along the growth development were found in the otolith's shape, anterior region, dorsal and ventral edges, *cauda* morphology and otolith profile.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	2,45 ± 0,83	1.52	3.43
OH/OL (%)	64.11 ± 9,12	52.45	76.47
OT/OL (%)	22.53 ± 1,94	18.04	25
OT/OH (%)	35.59 ± 4.52	31.08	45.57
Circularity	19.85 ± 2.70	16.46	23.78
Rectangularity	0.71 ± 0,02	0.67	0.76

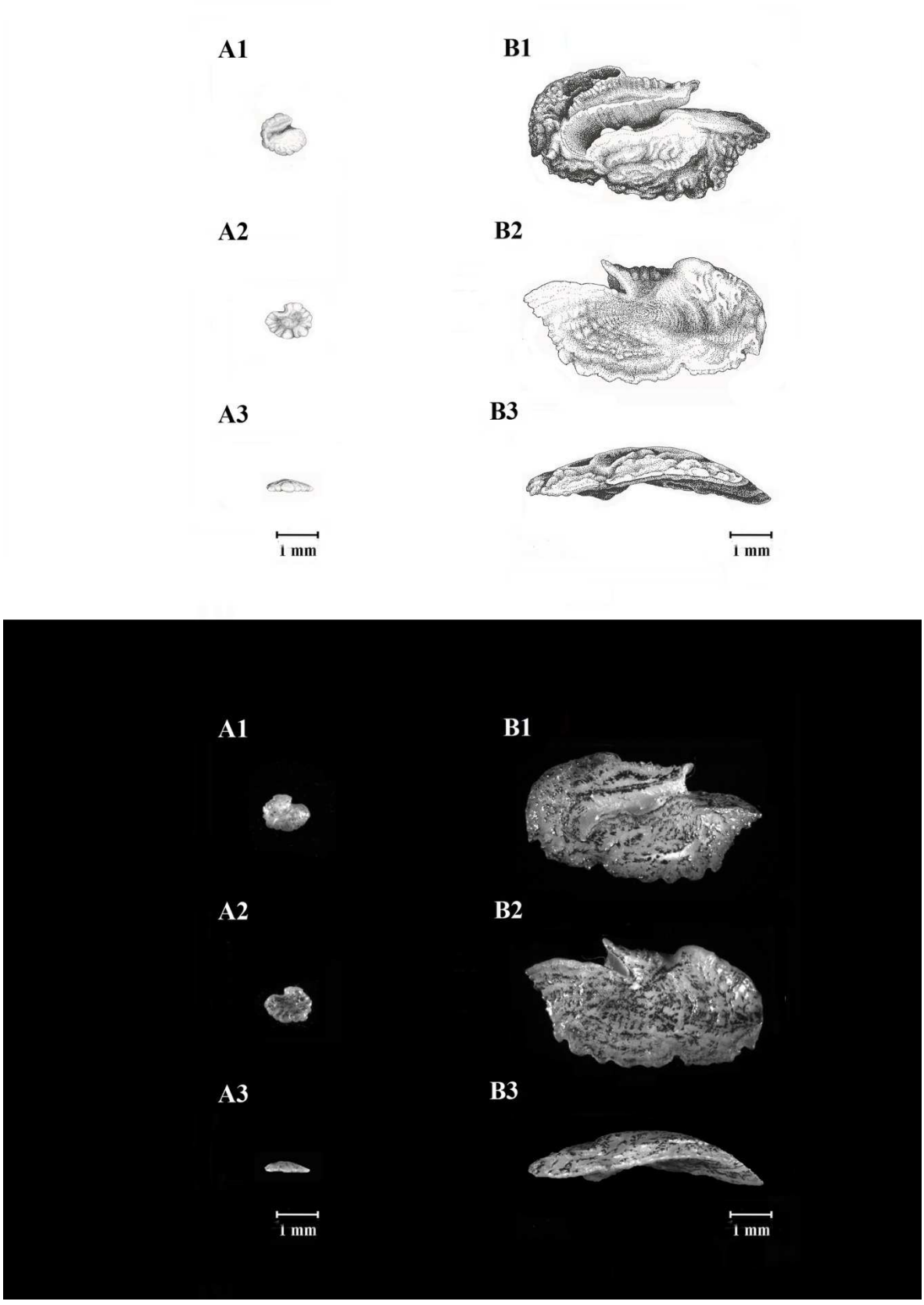


Plate 20. Illustrations (above) and photographs (below) of *Selene vomer* otoliths from fish with total lengths: **A.** 37 mm (SARVII.AM.L8.3) and **B.** 443 mm (SARVII.AM.L7.2). The medial face is shown in A1 and B1; the lateral face in A2 and B2; and the ventral profile in A3 and B3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Trachinotus goodei **Jordan & Evermann 1896 – Plate 21**

Maximum Size:	50 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	Massachusetts to Argentina (FIGUEIREDO; MENEZES, 1980)
Habitat:	shallow waters of unprotected beaches (FIGUEIREDO; MENEZES, 1980)
Diet:	small invertebrates (FIGUEIREDO; MENEZES, 1980)
Collection:	4 pairs of otoliths (TL ranging from 459 to 580 mm)
Sample:	2 left otoliths from the right side categorized into 2, 20 mm classes (560 to 580 mm)

Shape: spindle-shaped. ***Anterior region:*** round. ***Posterior region:*** round. ***Dorsal edge:*** sinuate to irregular. V***entral shape:*** crenate to irregular (50%), crenate (50%). ***Profile:*** concave-convex. ***Rostrum and antirostrum orientation:*** in agreement. ***Rostrum:*** developed. ***Antirostrum:*** underdeveloped. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* supramedian; *orientation:* horizontal; *opening:* ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* tubular slightly curved.

The morphometric data of the specimen are given below:

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	1.47 ± 0.00	1.46	1.47
OH/OL (%)	39.07 ± 1.95	37.7	40.45
OT/OL (%)	14.45 ± 1.42	13.45	15.45
OT/OH (%)	36.93 ± 1.78	35.67	38.19
Circularity	44.62 ± 4.49	41.45	47.8
Rectangularity	0.64 ± 0.02	0.62	0.66

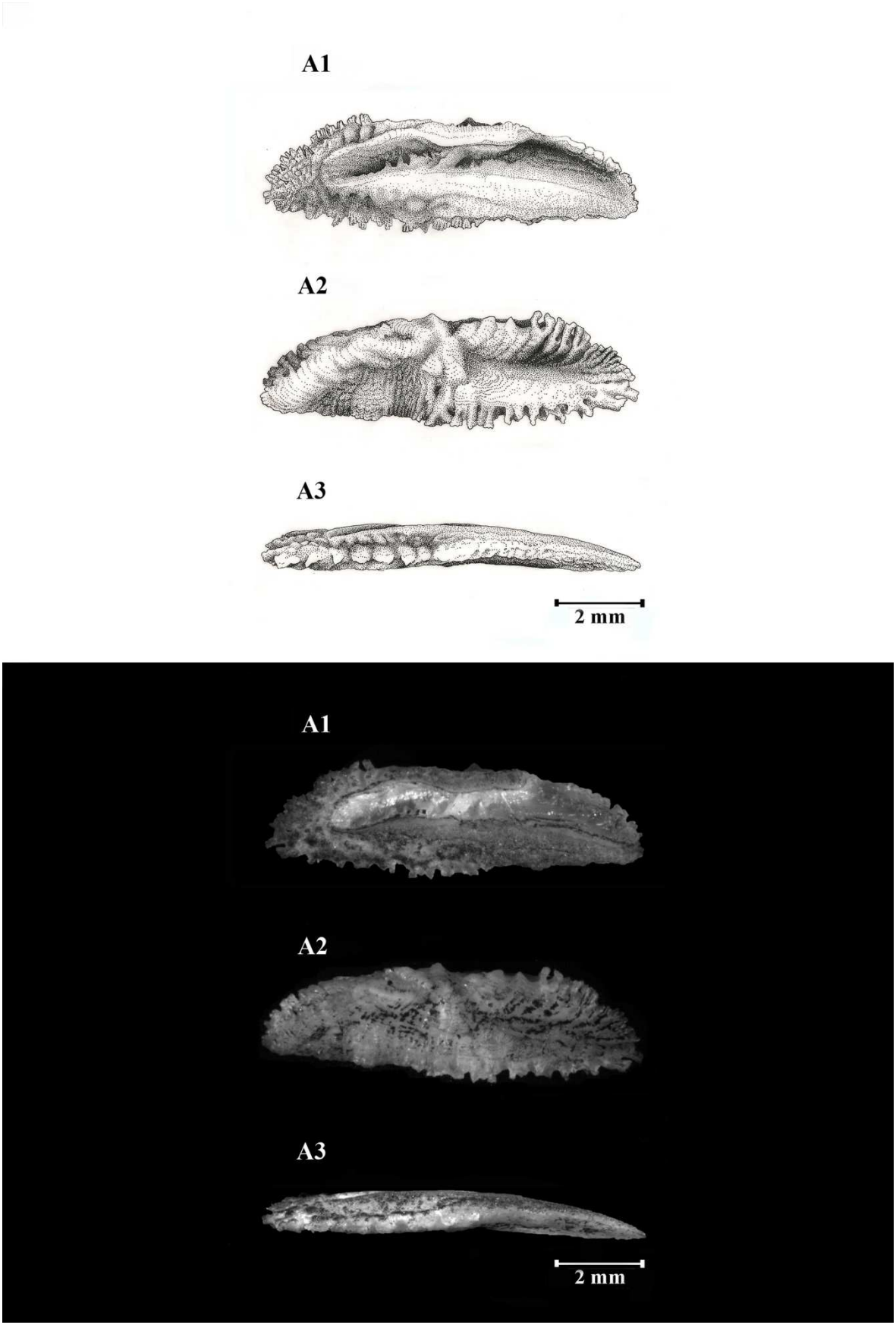


Plate 21. Illustrations (above) and photographs (below) of *Trachinotus goodei* otolith from a fish with total length of 580 mm (SARIV.AM.L19.1). The medial face is shown in A1; the lateral face in A2; and the ventral profile in A3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Trachurus lathami **Nichols 1920 – Plate 22**

Maximum Size:	40 cm (TL) (BERNARDES et al., 2005)
Distribution:	from Gulf of Maine to northern Argentina (BERNARDES et al., 2005)
Habitat:	large shoals in waters off the coast (FIGUEIREDO et al., 2002)
Diet:	small invertebrates (FIGUEIREDO; MENEZES, 1980)
Collection:	2061 pairs of otoliths (TL ranging from 17 to 208 mm)
Sample:	91 left otoliths categorized into 10, 20 mm classes (20 to 200 mm)

Shape: elliptic (75.82%), elliptic to lanceolated. ***Anterior region:*** peaked-round (43.96%), angled-round, lanceolated-round. ***Posterior region:*** angular-round (50.55%), round, peaked-round. ***Dorsal edge:*** lobed to sinuate (63.74%), sinuate to entire. ***Ventral edge:*** lobed to sinuate (50.55%), sinuate to entire, sinuate, lobed. ***Profile:*** concave-convex (63.74%), plane-convex. ***Rostrum and antirostrum orientation:*** in agreement. ***Rostrum:*** developed (71.43%), underdeveloped. ***Antirostrum:*** absent (93.41%), underdeveloped. ***Pseudorostrum and pseudoantirostrum:*** absent. ***Sulcus acusticus:*** *position:* supramedian (90.11%), median; *orientation:* horizontal; *opening:* ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* tubular slightly curved (74.73%), tubular strongly curved.

Statistical differences ($p<0.05$) among some length classes were obtained in the otolith's shape, anterior and posterior regions, dorsal and ventral edges, sulcus acusticus position, *cauda* morphology, profile, *rostrum* and *antirostrum*. Along the growth development, statistical differences were found in the otolith's shape, anterior and posterior regions, dorsal and ventral edges, the otolith profile and the *rostrum*.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	3.88 ± 0.35	3.07	5.97
OH/OL (%)	57.20 ± 5.90	45.98	71.67
OT/OL (%)	18.64 ± 2.08	13.36	24.68
OT/OH (%)	32.53 ± 2.95	21.25	40.37
Circularity	18.39 ± 1.30	15.75	22.64
Rectangularity	0.65 ± 0.02	0.61	0.69

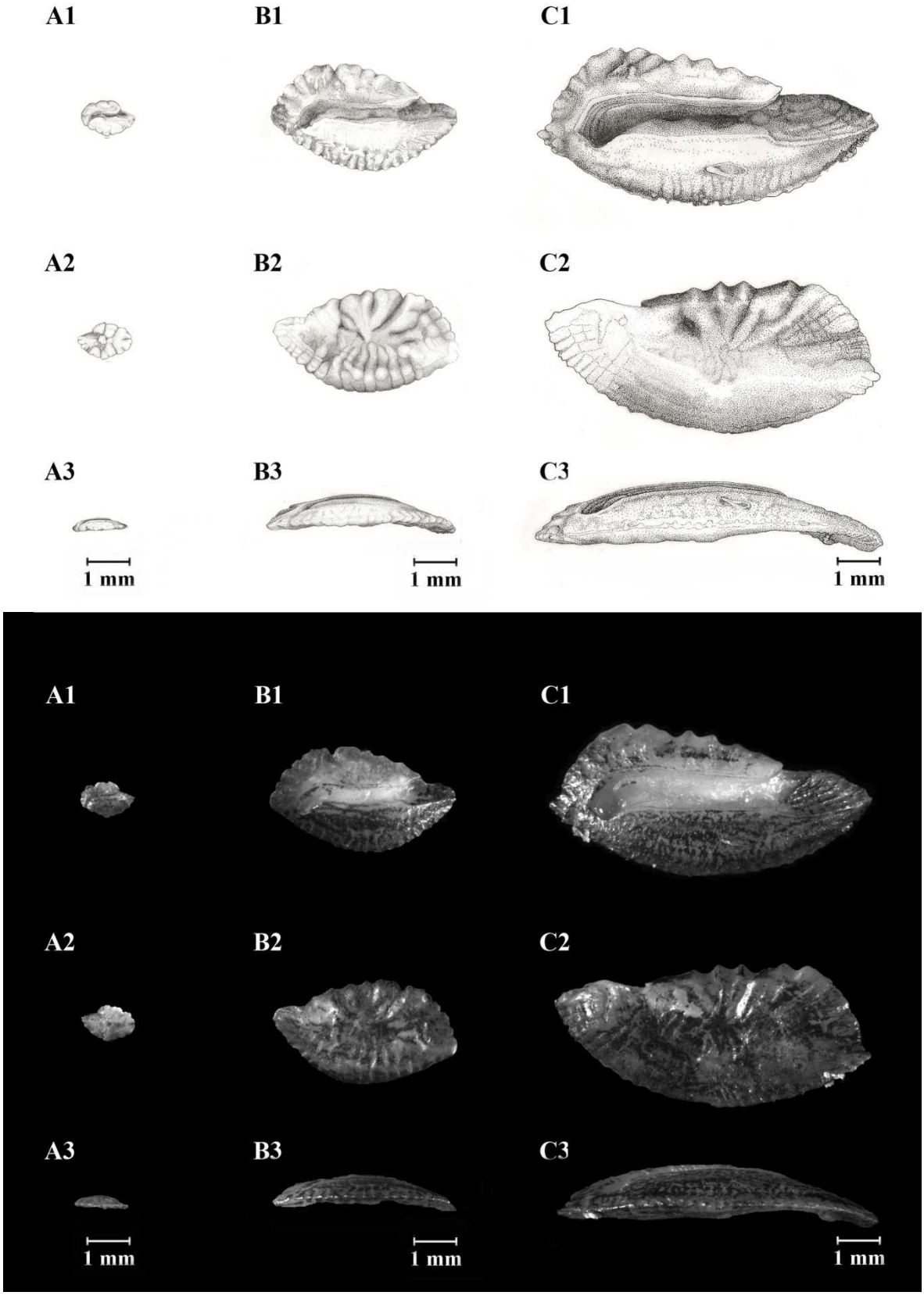


Plate 22. Illustrations (above) and photographs (below) of *Trachurus lathami* otoliths from fish with total lengths: **A.** 27 mm (SARV.AM.L14.15), **B.** 126 mm (SARVI.AM.L8.3) and **C.** 208 mm (SARIV.AM.L20.1). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Uraspis secunda **(Poey 1860) – Plate 23**

Maximum Size:	50 cm (TL) (MENEZES; FIGUEIREDO, 1980)
Distribution:	east American coast of New Jersey to the state of São Paulo (Brazil) (MENEZES et al. 2003)
Habitat:	circumglobal, near the islands far from the coast (MENEZES; FIGUEIREDO, 1980)
Diet:	---
Collection:	one pair of otoliths (225 mm TL)
Sample:	one right otolith (225 mm TL)

Shape: elliptic to lanceolated. ***Anterior region:*** lanceolated. ***Posterior region:*** round. ***Dorsal edge:*** sinuate to entire. ***Ventral edge:*** sinuate to entire. ***Profile:*** concave-convex. ***Rostrum and antirostrum orientation:*** in agreement. ***Rostrum:*** developed. ***Antirostrum:*** developed. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* supramedian; *orientation:* horizontal; *opening:* ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* tubular slightly curved.

The morphometric data of the specimen are given below:

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	1.99 ± 0	1.99	1.99
OH/OL (%)	48.21 ± 0	48.21	48.21
OT/OL (%)	19.64 ± 0	19.64	19.64
OT/OH (%)	40.74 ± 0	40.74	40.74
Circularity	28.00 ± 0	28	28
Rectangularity	0.65 ± 0	0.65	0.65

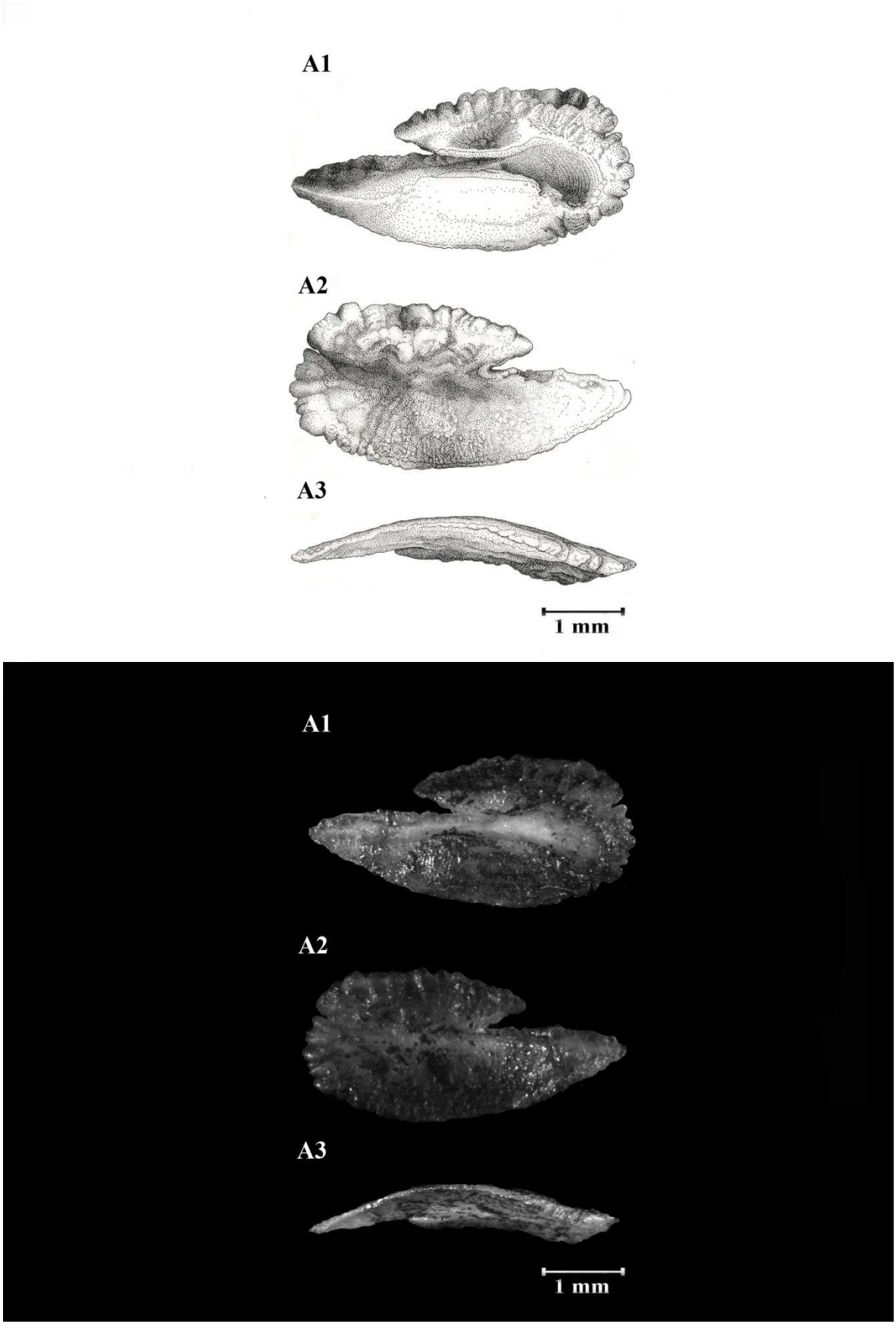


Plate 23. Illustrations (above) and photographs (below) of *Uraspis secunda* otolith from a fish with total length of 225 mm (SARVII.CE.L4.1). The medial face is shown in A1; the lateral face in A2; and the ventral profile in A3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Family SCIAENIDAE

This family presents different otolith shapes, but it is mainly characterized by the round large *ostium* and the curled tubular *cauda.*

Ctenosciaena gracilicirrhus **(Metzelaar 1919) - Plate 24**

Maximum Size:	20 cm (TL) (MENEZES; FIGUEIREDO, 1980)
Distribution:	Central America to southern Brazil (MENEZES; FIGUEIREDO, 1980)
Habitat:	coastal waters of the continental shelf, usually on sandy or mud bottoms (MENEZES; FIGUEIREDO, 1980)
Diet:	fish and shrimps (SOARES et al., 2008)
Collection:	367 pairs of otoliths (TL ranging from 65 to 183 mm)
Sample:	63 left otoliths categorized into 7, 20 mm (60 to 180 mm)

Shape: discoidal. ***Anterior region:*** round. ***Posterior region:*** round. ***Dorsal edge:*** entire (82.54%), sinuate to entire, lobed to sinuate. V***entral edge:*** entire (77.78%), sinuate to entire, lobed to sinuate. ***Profile:*** biconvex. ***Rostrum and antirostrum:*** absent. ***Rostrum and antirostrum orientation:*** does not apply. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* supramedian; *orientation:* horizontal; *opening:* pseudo-ostial (95.24%), para-ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* lateral; *cauda:* tubular curled.

Differences ($p<0.05$) were obtained among some length classes for the otoliths' dorsal and ventral edges and the *sulcus acusticus* opening. Along the growth development only the ventral edge showed any significant difference.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	4.75 ± 0.32	4.3	5.94
OH/OL (%)	80.56 ± 5.64	67.31	89.92
OT/OL (%)	35.66 ± 2.06	31.07	40.98
OT/OH (%)	44.56 ± 4.96	35.83	57.14
Circularity	13.40 ± 0.69	11.04	17.93
Rectangularity	0.77 ± 0.01	0.75	0.79

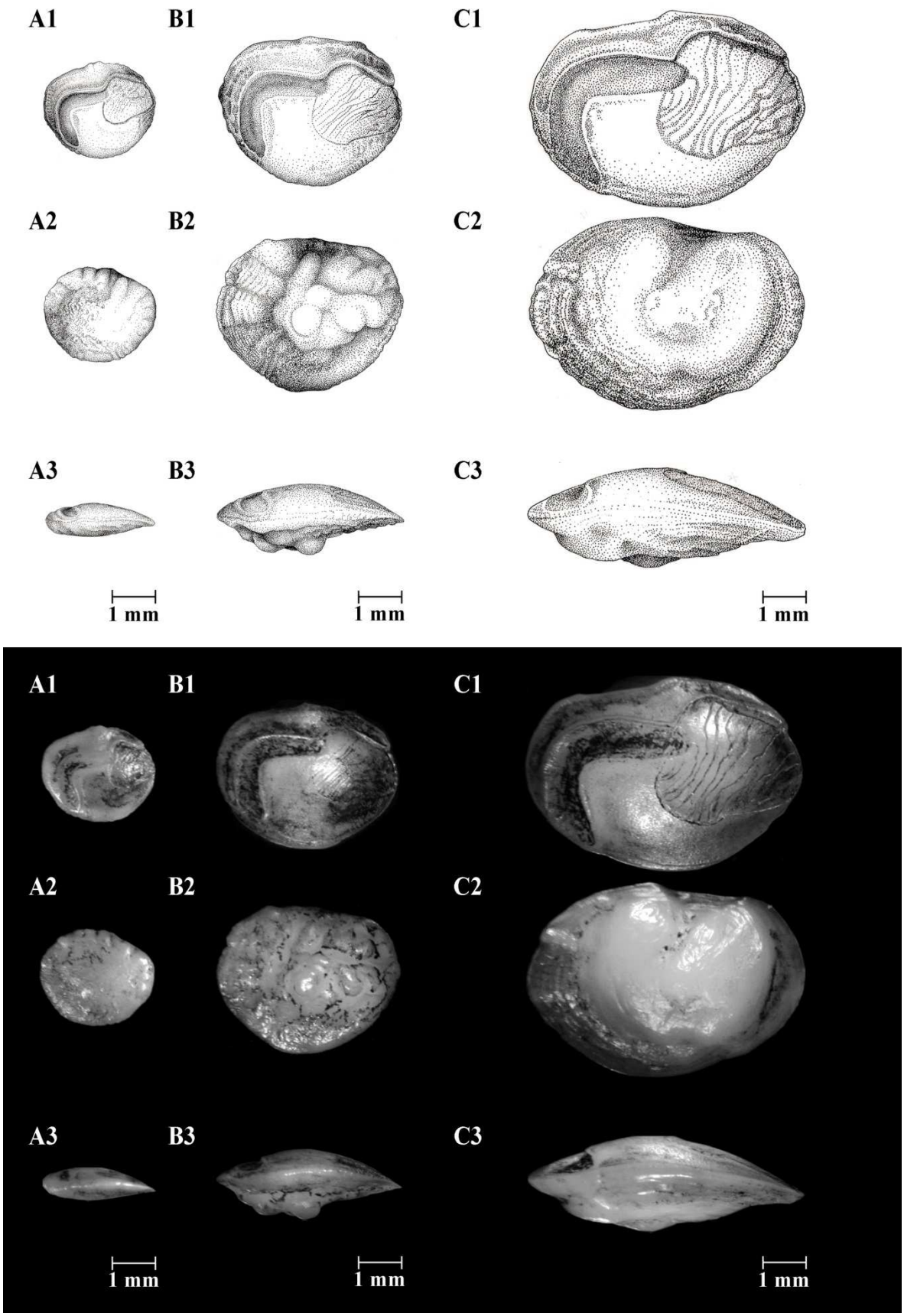


Plate 24. Illustrations (above) and photographs (below) of *Ctenosciaena gracilicirrhus* otoliths from fish with total lengths: **A**. 69 mm (PI.AF.L9.1), **B**. 124 mm (SARIV.AM.L18.7) and **C**. 183 mm (SARVII.AM.L4.9). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Cynoscion guatucupa **(Cuvier 1830) - Plate 25**

Maximum Size:	50 cm (TL) (BERNARDES et al., 2005)
Distribution:	western South Atlantic from Rio de Janeiro, Brazil, to Argentina (FIGUEIREDO et al., 2002)
Habitat:	from the coast to 194 m deep waters on muddy and sandy bottoms (MENEZES; FIGUEIREDO, 1980)
Diet:	fish or pelagic prey (SOARES et al., 2008)
Collection:	17 pairs of otoliths (TL ranging from 137 to 383 mm)
Sample:	13 left otoliths categorized into 6, 20 mm classes (120 to 260 mm)

Shape: elliptic. ***Anterior region:*** round. ***Posterior region:*** round. ***Dorsal edge:*** entire (76.92%), sinuate to entire. ***Ventral edge:*** sinuate to entire (46.15%), entire, lobed to sinuate. ***Profile:*** biconvex. ***Rostrum and antirostrum:*** absent. ***Rostrum and antirostrum orientation*** does not apply. ***Pseudorostrum and pseudoantirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* pseudo-ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* lateral; *cauda:* tubular strongly curved.

No differences ($p<0.05$) were found among some length classes or along the growth development.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	4.67 ± 0.25	4.28	5.17
OH/OL (%)	58.20 ± 3.45	53.98	66.38
OT/OL (%)	27.06 ± 1.21	25.52	29.26
OT/OH (%)	46.62 ± 3.07	38.94	50.48
Circularity	15.59 ± 0.50	14.48	16.36
Rectangularity	0.75 ± 0.21	0.68	1.44

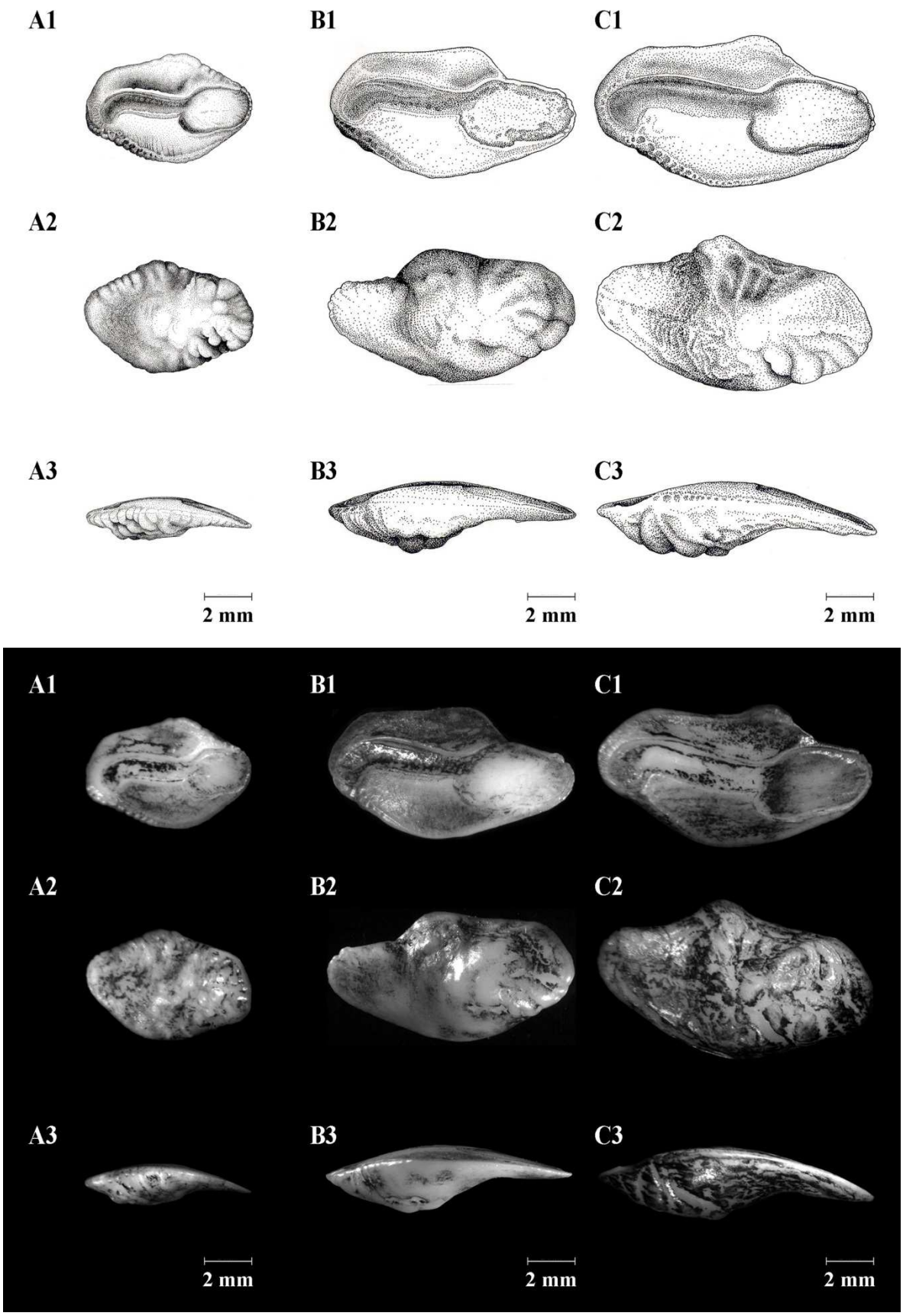


Plate 25. Illustrations (above) and photographs (below) of *Cynoscion quatucupa* otoliths from fish with total lengths: **A**. 137 mm (REV.AF.608.12), **B**. 243 mm (REV.AF.407.2) and **C**. 260 mm (REV.AF.608.7). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Cynoscion jamaicensis **(Vaillant & Bocourt 1883) - Plate 26**

Maximum Size:	50 cm (TL) (BERNARDES et al., 2005)
Distribution:	western Atlantic from the Caribbean to Argentina (MENEZES et al., 2003)
Habitat:	shallow coastal areas to 100 m deep, on sandy or muddy bottoms (FIGUEIREDO; MENEZES, 1980)
Diet:	fish and pelagic preys (SOARES et al., 2008)
Collection:	210 pairs of otoliths (TL ranging from 48 to 313 mm)
Sample:	76 right otoliths categorized into 11, 20 mm classes (40 to 240 mm)

Shape: elliptic. ***Anterior region:*** round. ***Posterior region:*** oblique-round (57.89%), round. ***Dorsal edge:*** sinuate to entire (52.63%), entire, lobed, lobed to entire, lobed to sinuate. ***Ventral edge:*** entire (44.74%), sinuate to entire, lobed, lobed to entire, lobed to sinuate. ***Profile:*** plane-convex (81.58%), biconvex. ***Rostrum and antirostrum:*** absent. ***Rostrum and antirostrum orientation:*** does not apply. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* pseudo-ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* lateral; *cauda:* tubular curled (68.42%), tubular slightly curved, tubular strongly curved.

There were significant differences ($p<0.05$) among some length classes and along growth development for the posterior region, dorsal and ventral edges, *cauda* morphology and the otolith profile.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	5.37 ± 0.2.9	4.71	6.01
OH/OL (%)	59.62 ± 7.45	49	75.07
OT/OL (%)	25.00 ± 2.15	20.96	30.19
OT/OH (%)	42.35 ± 4.60	33.21	53.71
Circularity	15.91 ± 1.14	14.33	20.4
Rectangularity	0.74 ± 0.02	0.71	0.78

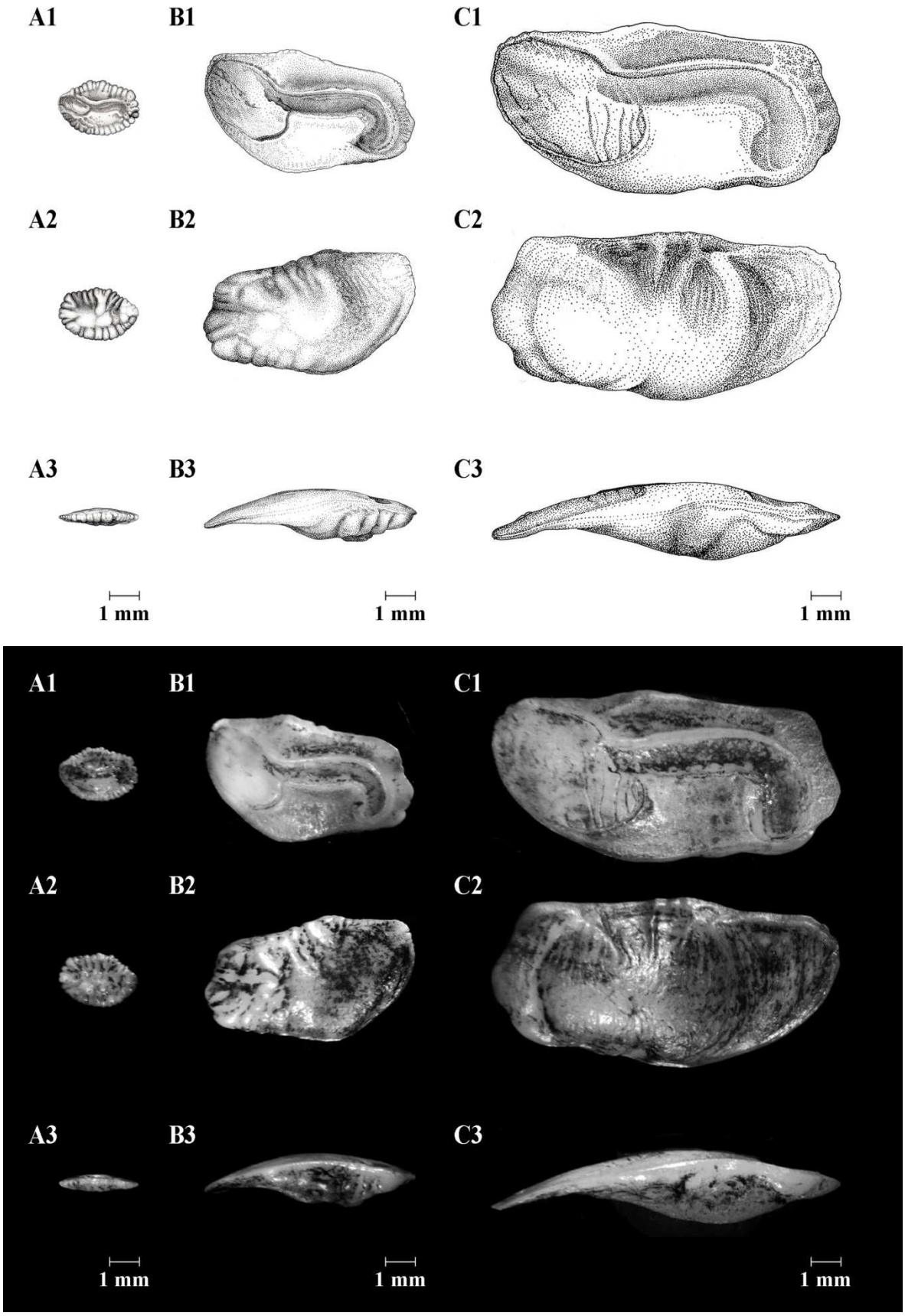


Plate 26. Illustrations (above) and photographs (below) of *Cynoscion jamaicensis* otoliths from fish with total lengths: **A.** 48 mm (PI.AF.L6.3), **B.** 142 mm (PI.AF.L15.10) and **C.** 250 mm (PI.AF.L4.1). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Cynoscion virescens **(Cuvier 1830)** – **Plate 27**

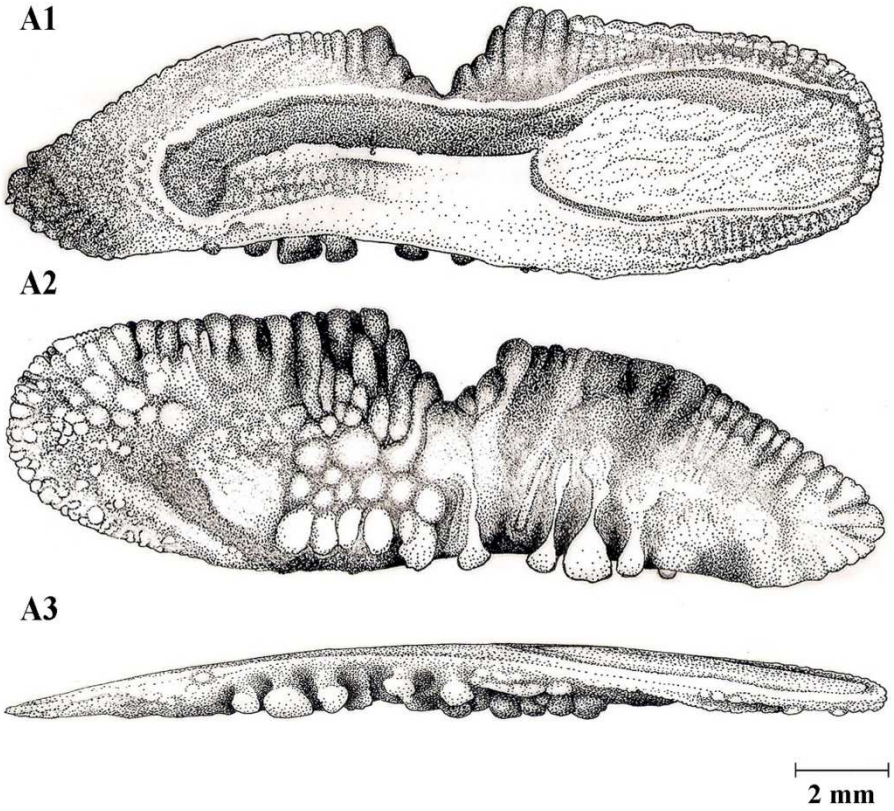
Maximum Size:	1 m (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	Panama to southern Brazil (FIGUEIREDO; MENEZES, 1980)
Habitat:	coastal waters near rivers but also up to 70 m deep, on muddy or sandy bottoms (FIGUEIREDO; MENEZES, 1980)
Diet:	pelagic crustaceans and small fish (SOARES et al., 2008)
Collection:	one pair of otoliths (350 mm TL)
Sample:	one left otolith (350 mm TL)

Shape: oblong. ***Anterior region:*** round. ***Posterior region:*** oblique-round. ***Dorsal edge:*** lobed to sinuate. ***Ventral edge:*** irregular to sinuate. ***Profile:*** concave-convex. ***Rostrum and antirostrum:*** absent. ***Rostrum and antirostrum orientation:*** does not apply. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* pseudo-ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* oval; *cauda:* tubular strongly curved.

The otolith presents a dorsal notch in its medium region.

The morphometric data of the specimen are given below:

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	5.41 ± 0	5.41	5.41
OH/OL (%)	30.38 ± 0	30.38	30.38
OT/OL (%)	11.25 ± 0	11.25	11.25
OT/OH (%)	37.04 ± 0	37.04	37.04
Circularity	32.33 ± 0	32.33	32.33
Rectangularity	0.73± 0	0.73	0.73



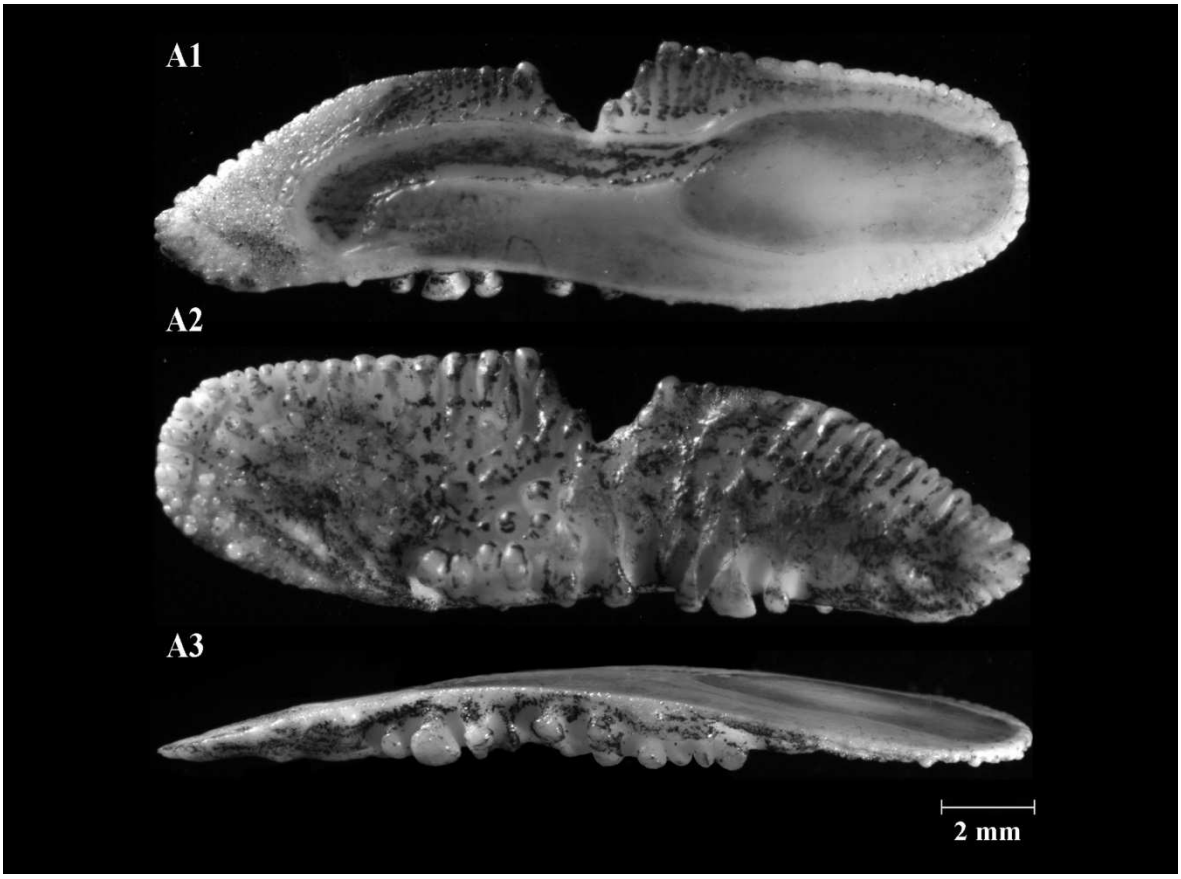


Plate 27. Illustrations (above) and photographs (below) of *Cynoscion virescens* otolith with total length of 350 mm (PI.AF.L3.1). The medial face is shown in A1; the lateral face in A2; and the ventral profile in A3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Isopisthus parvipinnis **(Cuvier 1830)** – **Plate 28**

Maximum Size:	25 cm (TL) (MENEZES; FIGUEIREDO, 1980)
Distribution:	Costa Rica to southern Brazil (MENEZES; FIGUEIREDO, 1980)
Habitat:	shallow coastal waters (up to 50 m) on sandy or muddy bottoms, in estuarine waters (MENEZES; FIGUEIREDO, 1980)
Diet:	fish or pelagic prey (SOARES et al.; 2008).
Collection:	70 pairs of otoliths (TL ranging from 83 to 170 mm)
Sample:	31 left otoliths categorized into 5, 20 mm classes (80 to 160 mm)

Shape: oblong. ***Anterior region:*** round (51.61%), oblique-round, flattened. ***Posterior region:*** flattened (83.87%), round, oblique-round. ***Dorsal edge:*** sinuate to entire (38.71%), lobed to entire (38.71%), lobed to sinuate, sinuate, entire. ***Ventral edge:*** entire (96.77%), sinuate to entire. ***Profile:*** plane-convex. ***Rostrum and antirostrum:*** absent. ***Rostrum and antirostrum orientation:*** does not apply. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* para-ostial (74.19%), pseudo-ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* lateral; *cauda:* tubular strongly curved.

Differences were found ($p<0.05$) among some length classes and along the growth development for the anterior and posterior regions, dorsal and ventral edge and the *sulcus acusticus opening*.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	5.03 ± 0.25	4.7	6.17
OH/OL (%)	62.16 ± 3.88	54.49	70.8
OT/OL (%)	25.26 ± 1.73	22.13	28.89
OT/OH (%)	40.79 ± 3.72	33.44	47.93
Circularity	15.56 ± 0.45	14.36	16.34
Rectangularity	0.76 ± 0.01	0.74	0.79

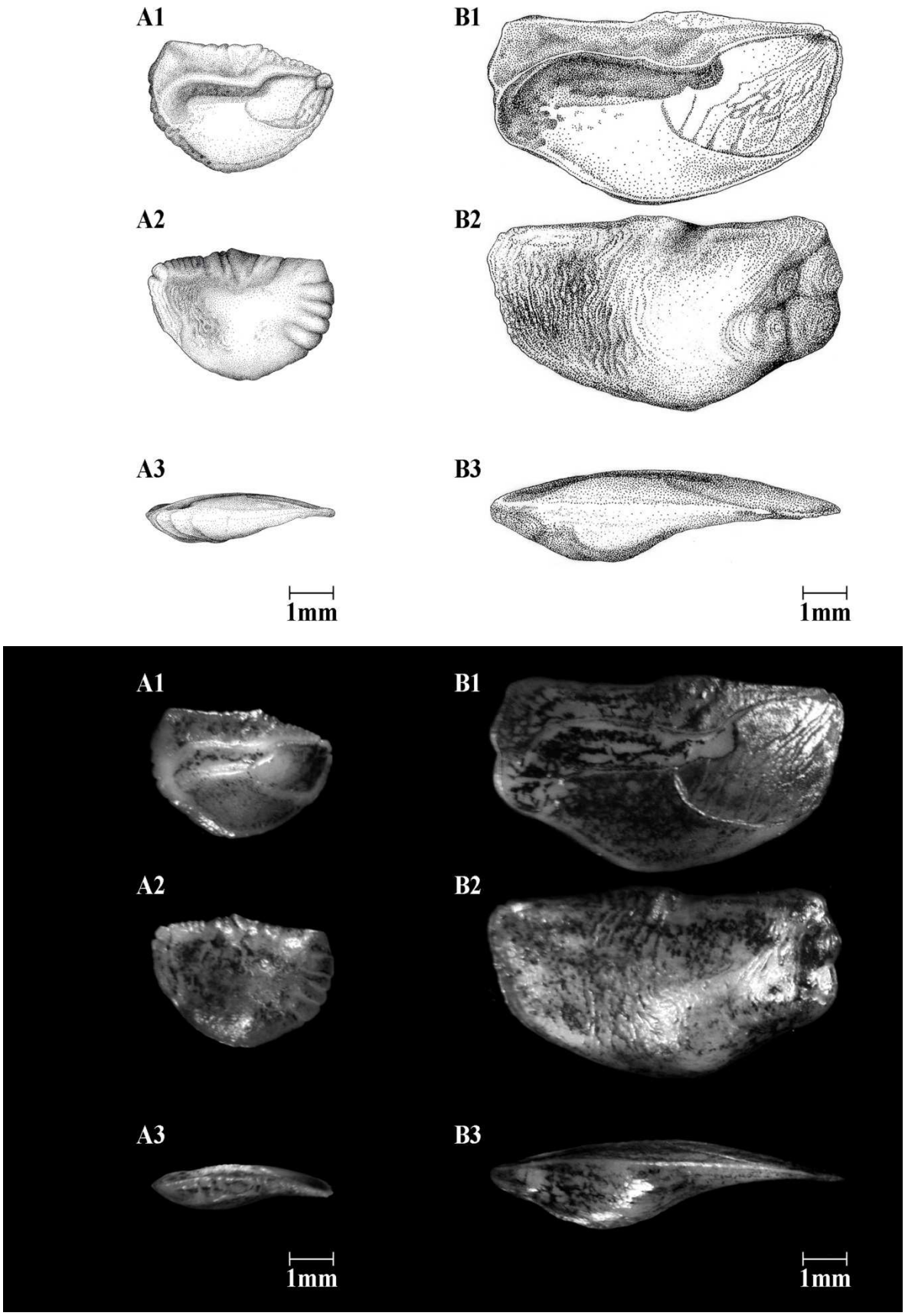


Plate 28. The illustrations (above) and photographs (below) of *Isopisthus parvipinnis* otoliths from fish with total lengths: **A.** 85 mm (PI.AF.L3.33) and **B.** 170 mm (PI.AF.L2.1). The medial face is shown in A1 and B1; the lateral face in A2 and B2; and the ventral profile in A3 and B3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Larimus breviceps **Cuvier 1830 – Plate 29**

Maximum Size:	30 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	Antilles and Central America (Costa Rica) to the coast of Santa Catarina (Brazil) (FIGUEIREDO; MENEZES, 1980)
Habitat:	coastal waters in depths less than 50 m, on sandy and muddy bottoms and also in estuaries (FIGUEIREDO; MENEZES, 1980)
Diet:	fish or pelagic prey (SOARES et al., 2008)
Collection:	95 pairs of otoliths (TL ranging from 67 to 185 mm)
Sample:	40 left otoliths categorized into 7, 20 mm classes (60 to 180 mm)

Shape: elliptic. ***Anterior region:*** round. ***Posterior region:*** entire (85%), round. ***Dorsal edge:*** entire (82.5%), sinuate to entire, lobed. ***Ventral edge:*** sinuate to entire (52%), entire, lobed to entire, lobed. ***Profile:*** biconvex. ***Rostrum and antirostrum:*** absent. ***Rostrum and antirostrum orientation***: does not apply. ***Pseudorostrum and pseudoantirostrum:*** absent. ***Sulcus acusticus:*** *position:* median (65%), supramedian; *orientation:* ascending (77.50%), horizontal; *opening:* para-ostial (87.50%), pseudo-ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* lateral; *cauda:* tubular curled.

Differences ($p<0.05$) among some length classes and along the growth development were found in the: posterior region, dorsal and ventral edges, *sulcus acusticus position, orientation and opening.*

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	6.23 ± 0.25	5.57	6.72
OH/OL (%)	67.58 ± 2.26	6.71	72.73
OT/OL (%)	41.40 ± 3.17	33.1	47.91
OT/OH (%)	61.37 ± 5.53	45.78	72.12
Circularity	15.09 ± 0.43	14.4	16.64
Rectangularity	0.76 ± 0.01	0.73	0.8

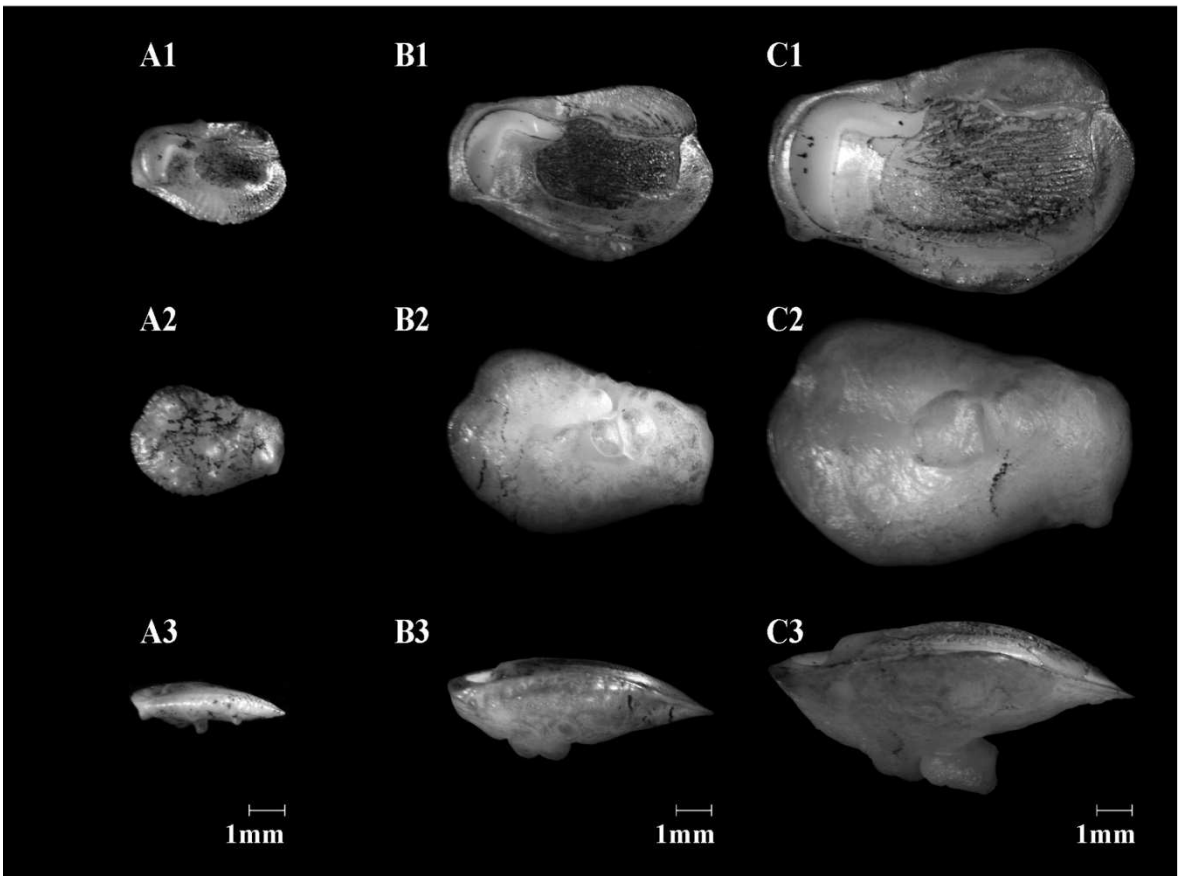


Plate 29. Illustrations (above) and photographs (below) of *Larimus breviceps* otoliths from fish with total lengths: **A**. 67 mm (PI.AF.L21.4), **B**. 125 mm (PI.AF.L2.2) and **C**. 185 mm (PI.AF.L9.7). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Macrodon atricauda **(Günther 1880) – Plate 30**

Maximum Size:	45 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	Venezuela to Argentina (FIGUEIREDO; MENEZES, 1980; CARVALHO-FILHO et al., 2010)
Habitat:	coastal, on sandy and muddy bottoms, in depths up to 60 m (FIGUEIREDO; MENEZES, 1980)
Diet:	shrimp and small fish (SOARES et al., 2008)
Collection:	38 pairs of otoliths (TL ranging from 108 to 247 mm)
Sample:	26 left otoliths categorized into 6, 20 mm classes (140 to 240 mm)

Shape: oblong. ***Anterior region:*** round. ***Posterior region:*** round (69.23%), oblique-round. ***Dorsal edge:*** sinuate to entire (61.54%), sinuate, entire. ***Ventral edge:*** lobed to sinuate (53.85%), lobed to entire, lobed. ***Profile:*** concave-convex. ***Rostrum and antirostrum:*** absent. ***Rostrum and antirostrum orientation:*** does not apply. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* pseudo-ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* rectangular; *cauda:* tubular curled.

Differences ($p<0.05$) among some length classes were found in relation to the otolith's posterior region, dorsal and ventral edges. Differences along the growth development were found only for the ventral edge.

Shape indices	Mean ± sd	Minimum	Maximum
OL/TL (%)	4.82 ± 0.29	4.41	5.53
OH/OL (%)	43.48 ± 1.24	41.89	46.31
OT/OL (%)	14.52 ± 1.60	11.26	18.71
OT/OH (%)	33.40 ± 3.56	26.34	41.76
Circularity	21.23 ± 1.47	18.92	24.01
Rectangularity	0.76 ± 0.01	0.74	0.78

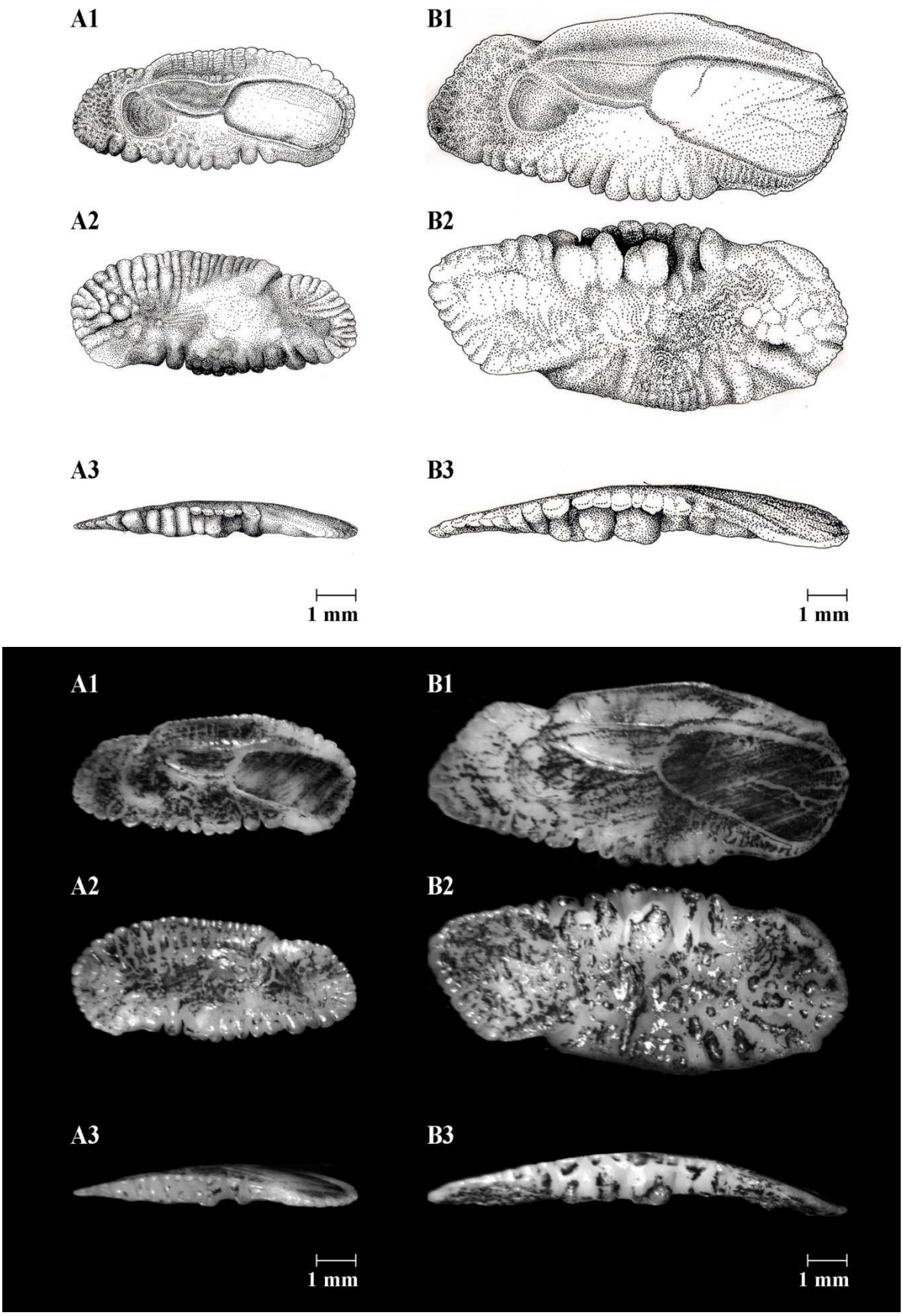


Plate 30. Illustrations (above) and photographs (below) of *Macrodon atricauda* otoliths from fish with total lengths: **A**. 155 mm (PI.AF.L6.6) and **B**. 247 mm (PI.AF.L3.2). The medial face is shown in A1 and B1; the lateral face in A2 and; and the ventral profile in A3 and B3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Menticirrhus americanus **(Linnaeus 1758)** – **Plate 31**

Maximum Size:	50 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	Florida (USA) to Argentina (MENEZES et al., 2003)
Habitat:	coastal waters between 15 and 85 m deep and also in estuarine areas, usually on muddy and sandy bottoms (FIGUEIREDO; MENEZES, 1980)
Diet:	worms and benthonic crustaceans (FIGUEIREDO; MENEZES, 1980)
Collection:	129 pairs of otoliths (TL ranging from 77 to 400 mm)
Sample:	82 left otoliths categorized into 16, 20 mm classes (60 to 380 mm)

Shape: bullet-shaped. ***Anterior region:*** round. ***Posterior region:*** oblique to peaked (63.51%), picked-round***. Dorsal edge:*** entire (75.61%), sinuate to entire. ***Ventral edge:*** entire (82.93%), sinuate to entire. ***Profile:*** plane-convex (93.90%), concave-convex. ***Rostrum and antirostrum:*** absent. ***Rostrum and antirostrum orientation:*** does not apply. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* pseudo-ostial (51.22%), para-ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* lateral; *cauda:* tubular curled.

Differences ($p<0.05$) among some length classes were found in posterior region, dorsal and ventral edges and the otolith profile. Along the growth development differences were found in posterior region, dorsal edge and the otolith profile.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	3.64 ± 0.33	2.99	5
OH/OL (%)	39.27 ± 4.32	32.5	50.83
OT/OL (%)	23.11 ± 1.93	15.76	27.83
OT/OH (%)	59.59 ± 8.19	38.55	80.33
Circularity	19.41 ± 1.61	15.97	22.62
Rectangularity	0.75 ± 0.03	0.71	0.94

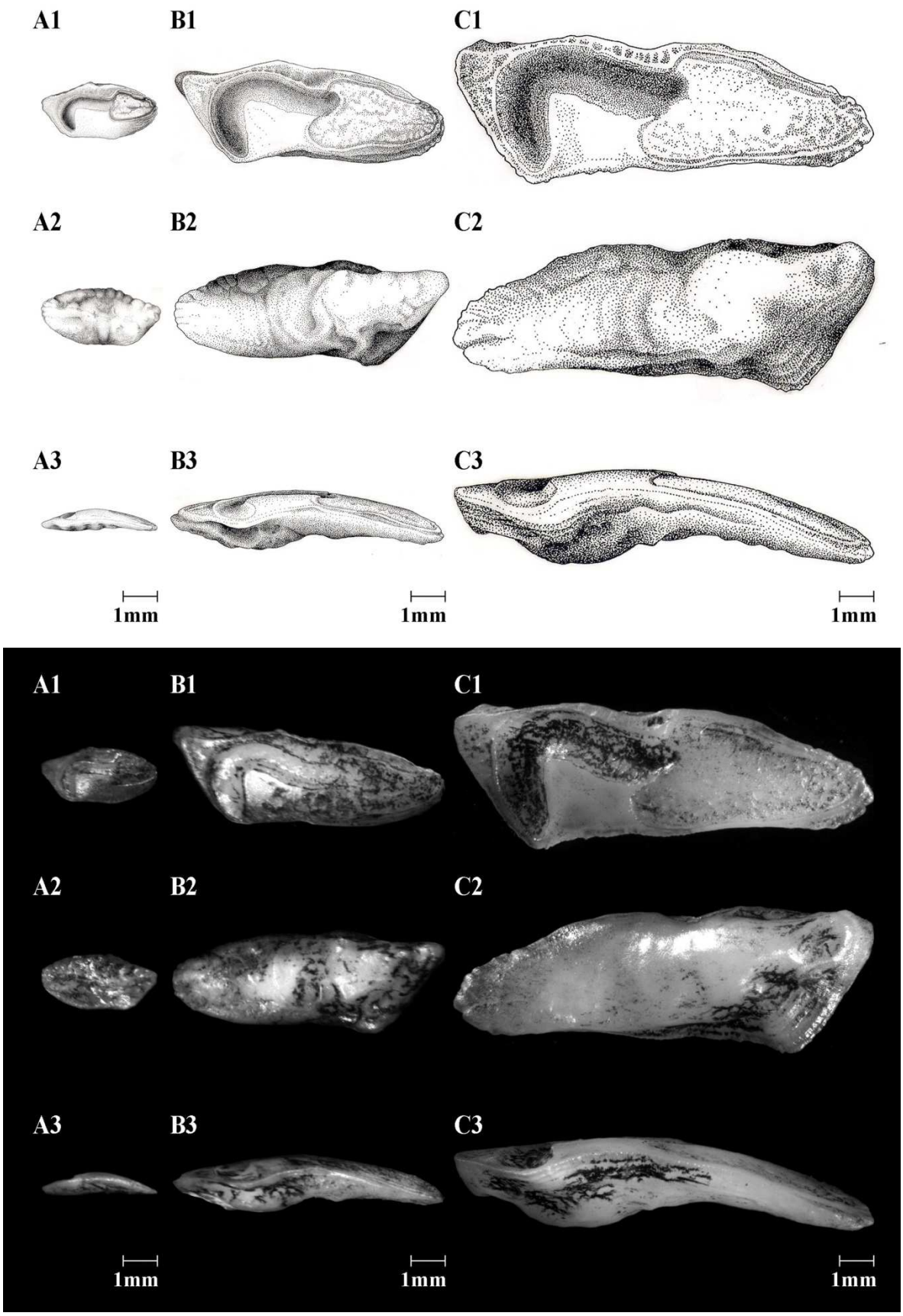


Plate 31. Illustrations (above) and photographs (below) of *Menticirrhus americanus* otoliths from fish with total lengths: **A**. 77 mm (PI.AF.L21.23), **B**. 224 mm (PI.AF.L5.5) and **C**. 400 mm (PI.AF.L9.4). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

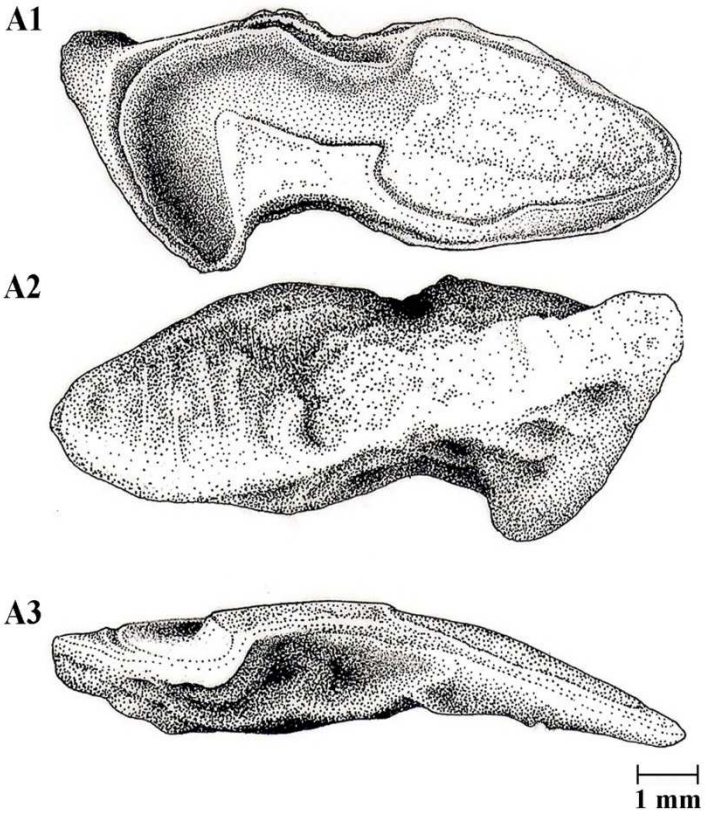
Menticirrhus littoralis **(Holbrook 1847)** – **Plate 32**

Maximum Size:	45 cm (TL) (MENEZES; FIGUEIREDO, 1980)
Distribution:	South Florida (United States) to south of Brazil (MENEZES; FIGUEIREDO, 1980)
Habitat:	sandy and muddy sediments in the coastal region, especially on sandy beaches (MENEZES; FIGUEIREDO, 1980)
Diet:	fish and shrimp (MENEZES; FIGUEIREDO, 1980)
Collection:	2 pairs of otoliths (TL ranging from 361 to 388 mm)
Sample:	2 left otoliths categorized into 2, 20 mm classes (360 to 380 mm)

Shape: bullet-shaped. A***nterior region:*** round. ***Posterior region:*** oblique. ***Dorsal edge:*** sinuate to entire. ***Ventral edge:*** sinuate to entire. ***Profile:*** biconvex. ***Rostrum and antirostrum:*** absent. ***Rostrum and antirostrum orientation:*** does not apply. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* ascending; *opening:* pseudo-ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* lateral; *cauda:* tubular markedly curve.

The morphometric data of the specimen are given below:

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	2.86 ± 0.18	2.73	2.99
OH/OL (%)	43.54 ± 2.14	42.02	45.05
OT/OL (%)	27.00 ± 5.26	23.28	30.73
OT/OH (%)	61.80 ± 9.05	55.41	68.2
Circularity	21.07 ± 0.45	20.75	21.39
Rectangularity	0.71 ± 0.01	0.7	0.72



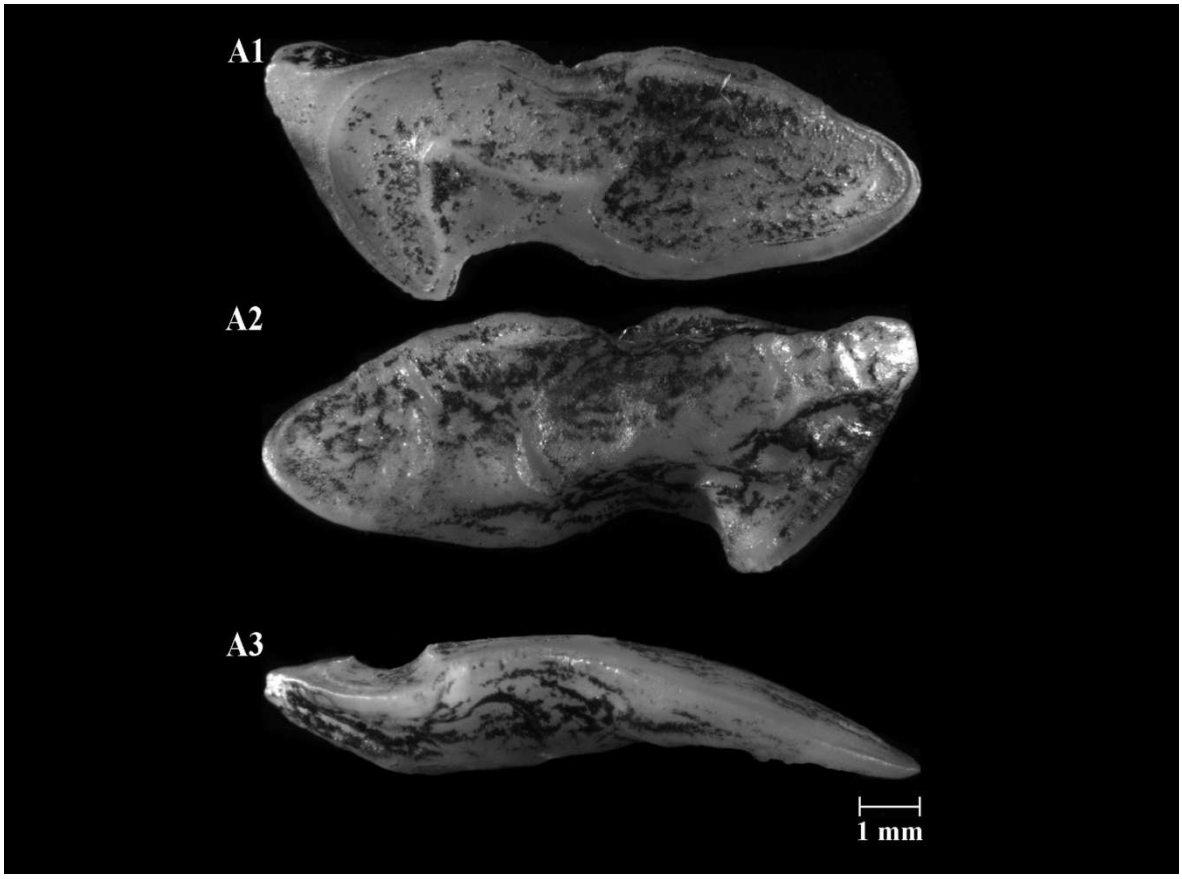


Plate 32. Illustrations (above) and photographs (below) of *Menticirrhus littoralis* otolith from a fish with total length of 361 mm (PI.AF.L42.2). The medial face is shown in A1; the lateral face in A2; and the ventral profile in A3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

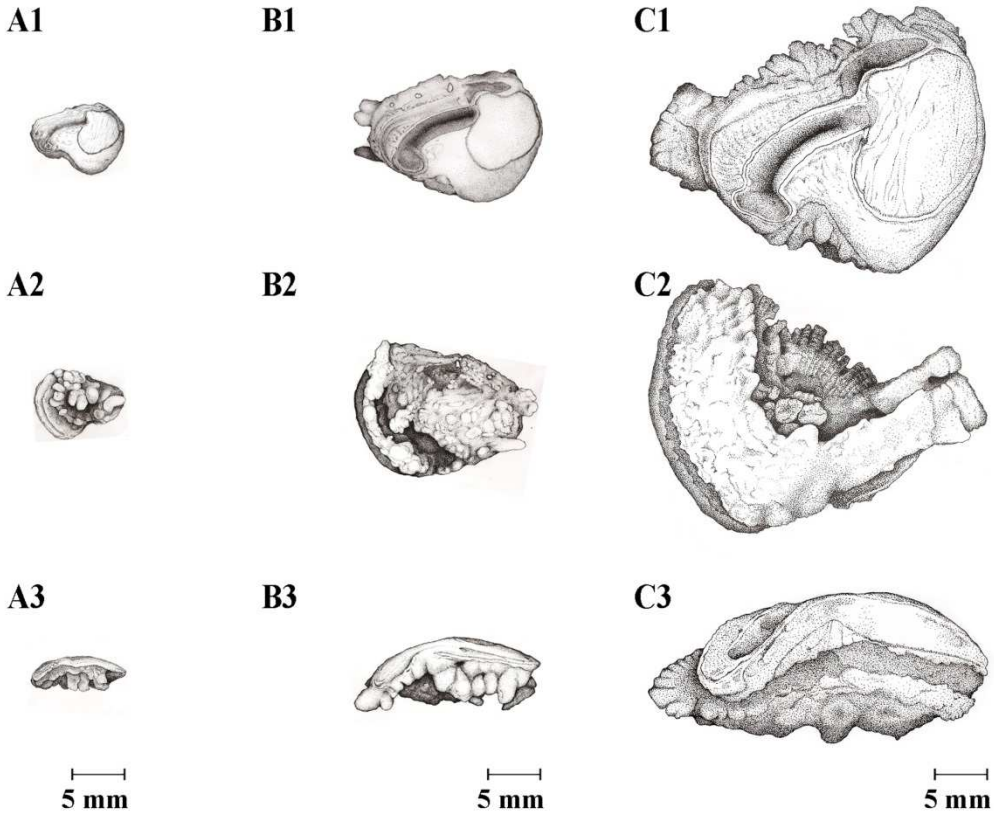
Micropogonias furnieri **(Desmarest 1823)** – **Plate 33**

Maximum Size:	60 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	Antilles and Central America (Costa Rica) to Argentina (BERNARDES et al., 2005)
Habitat:	muddy and sandy bottoms, up to 100 m deep (FIGUEIREDO; MENEZES, 1980)
Diet:	crustaceans and polychaeta (SOARES et al., 2008)
Collection:	14 pairs of otoliths (TL ranging from 177 to 601 mm)
Sample:	11 left otolith categorized into 7, 20 mm classes (160 to 600 mm)

Shape: pyriform. A***nterior region:*** round. ***Posterior region:*** round. ***Dorsal edge:*** sinuate to entire (54.55%). ***Ventral edge:*** entire (81.82%). ***Profile:*** biconvex. ***Rostrum and antirostrum:*** absent. ***Rostrum and antirostrum orientation:*** does not apply. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* pseudo-ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* bent-concave; *cauda:* tubular strongly curved.

Differences among some length classes ($p<0.05$) were found for the ventral edge of the otoliths. No differences appear along growth development.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	4.6 ± 0.30	4.13	5.12
OH/OL (%)	73.81 ± 4.22	65.07	78.94
OT/OL (%)	44.28 ± 4.37	36.67	50.14
OT/OH (%)	59.95 ± 4.07	50.99	65.04
Circularity	15.80 ± 1.29	14.27	19.02
Rectangularity	0.72 ± 0.03	0.67	0.77



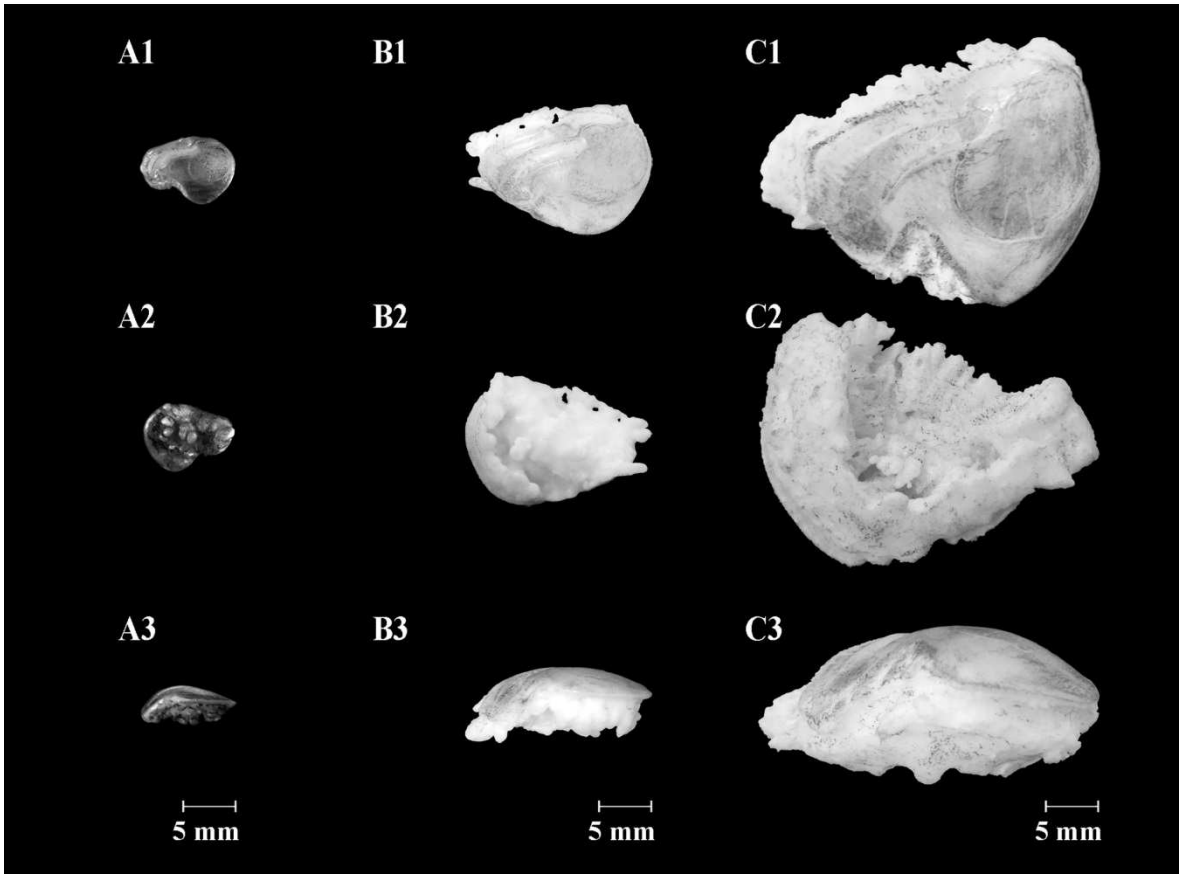


Plate 33. Illustrations (above) and photographs (below) of *Micropogonias furnieri* otoliths from fish with total lengths: **A.** 177 mm (SARVII.CE.L7.2), **B.** 343 mm (SARIV. AM.L3.2) and **C.** 601 mm (SARVII.AM.L11.1). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3 (Illustrators: Alexandre Arackawa, Jessica Falchi Caçador, Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Paralonchurus brasiliensis **(Steindachner 1875)** – **Plate 34**

Maximum Size:	30 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	Panama to Argentina (FIGUEIREDO; MENEZES, 1980)
Habitat:	coastal, usually on sandy and sandy-muddy bottoms, at depths less than 100 m (FIGUEIREDO; MENEZES, 1980)
Diet:	crustaceans and polychaeta (SOARES et al., 2008)
Collection:	416 pairs of otoliths (TL ranging from 55 a 242 mm.
Sample:	88 left otoliths categorized into 11, 20 mm classes (40 to 240 mm)

Shape: oblong. ***Anterior region:*** oblique-round (95.45%), blunt-round. ***Posterior region:*** round. ***Dorsal edge:*** sinuate to entire (56.82%), entire, lobed to entire, lobed to sinuate. ***Ventral edge:*** entire (81.82%), sinuate to entire. ***Profile:*** biconvex. ***Rostrum and antirostrum:*** absent. ***Rostrum and antirostrum orientation*** does not apply. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* slightly ascending; *opening:* pseudo-ostial (96.59%), para-ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* lateral; *cauda:* tubular curled.

Differences ($p<0.05$) among some length classes were found in the otolith's anterior region, dorsal and ventral edges and the *sulcus acusticus* opening. Along the growth development differences appeared in the dorsal and ventral edge of the otolith.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	4.45 ± 0.46	3.13	7.14
OH/OL (%)	41.90 ± 4.47	33.16	53.79
OT/OL (%)	30.26 ± 3.66	23.86	38.26
OT/OH (%)	72.75 ± 9.56	50.23	93.41
Circularity	18.32 ± 1.27	11.55	20.44
Rectangularity	0.79 ± 0.03	0.74	0.92

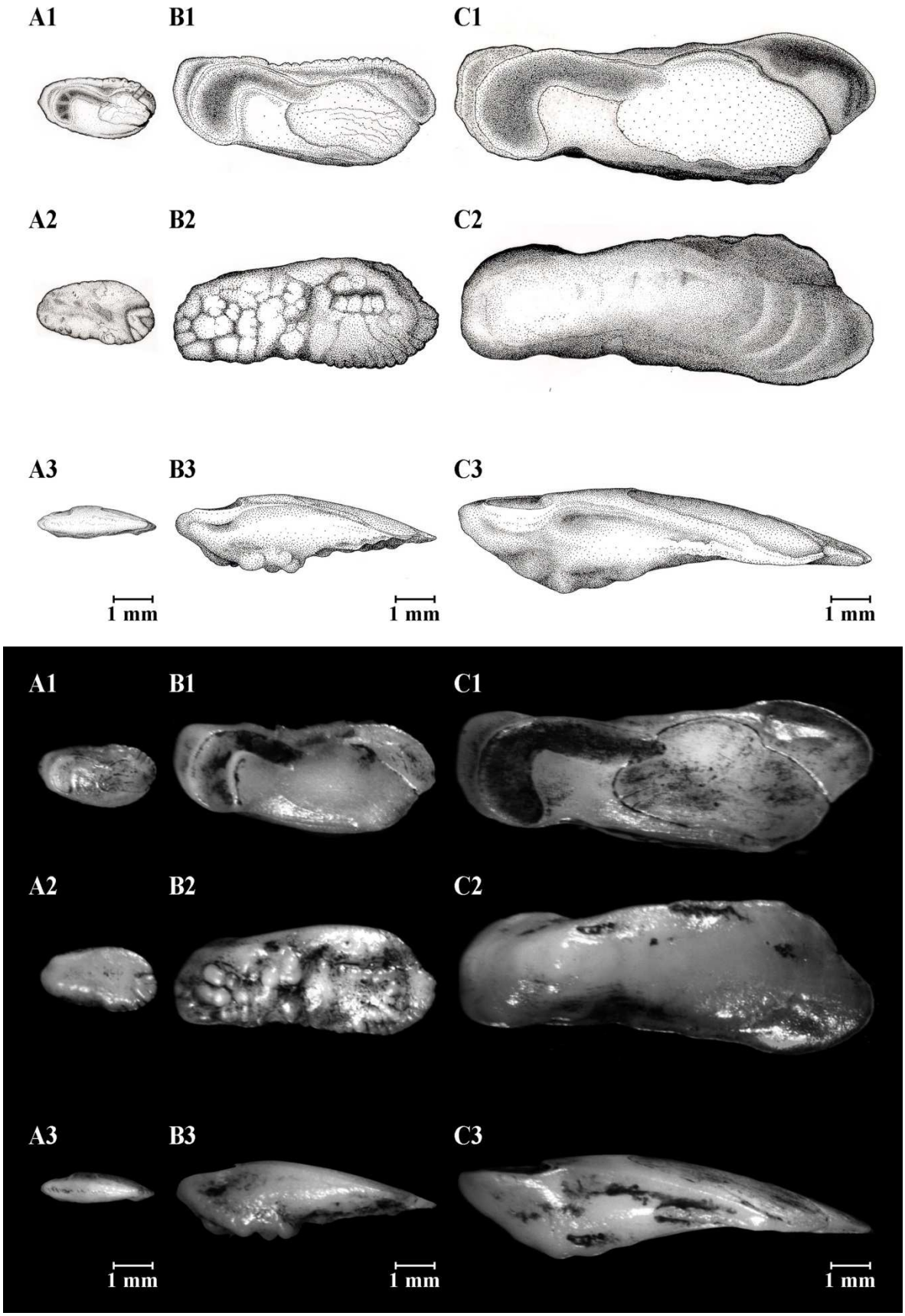


Plate 34. Illustrations (above) and photographs (below) of *Paralonchurus brasiliensis* otoliths from fish with total lengths: **A.** 55 mm (PI.AF.L6.63), **B.** 145 mm (PI.AF.L4.31) and **C.** 242 mm (PI.AF.L4.1). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Stellifer brasiliensis **(Schultz 1945) – Plate 35**

Maximum Size:	18 cm (TL) (MENEZES; FIGUEIREDO, 1980)
Distribution:	Brazilian coast between the states of Bahia and São Paulo (MENEZES et al. 2003)
Habitat:	sandy and muddy sediments commonly in estuarine areas where juveniles are found in large numbers (MENEZES; FIGUEIREDO, 1980)
Diet:	fish or pelagic prey (SOARES et al., 2008)
Collection:	114 pairs of otoliths (TL ranging from 81 to 174 mm)
Sample:	45 left otoliths categorized into 5, 20 mm classes (80 to 160 mm)

Shape: rectangular. ***Anterior region:*** peaked-round. ***Posterior region:*** oblique-round. ***Dorsal edge:*** entire. ***Ventral edge:*** entire. ***Anterior edge:*** entire. ***Posterior edge:*** entire. ***Profile:*** plane-convex. ***Rostrum:*** absent (68.89%), underdeveloped. ***Antirostrum:*** developed. ***Rostrum and antirostrum orientation*****:** in agreement. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* ascending; *opening:* pseudo-ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* discoidal; *cauda:* tubular curled.

Differences ($p<0.5$) among some length classes and along the growth development were found only in the otolith's *rostrum.*

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	4.06 ± 0.28	3.75	5.12
OH/OL (%)	61.73 ± 2.10	56.68	65.62
OT/OL (%)	41.48 ± 3.69	23.96	48.82
OT/OH (%)	67.24 ± 5.93	39.21	78.72
Circularity	16.64 ± 0.42	15.86	17.93
Rectangularity	0.70 ± 0.02	0.65	0.73

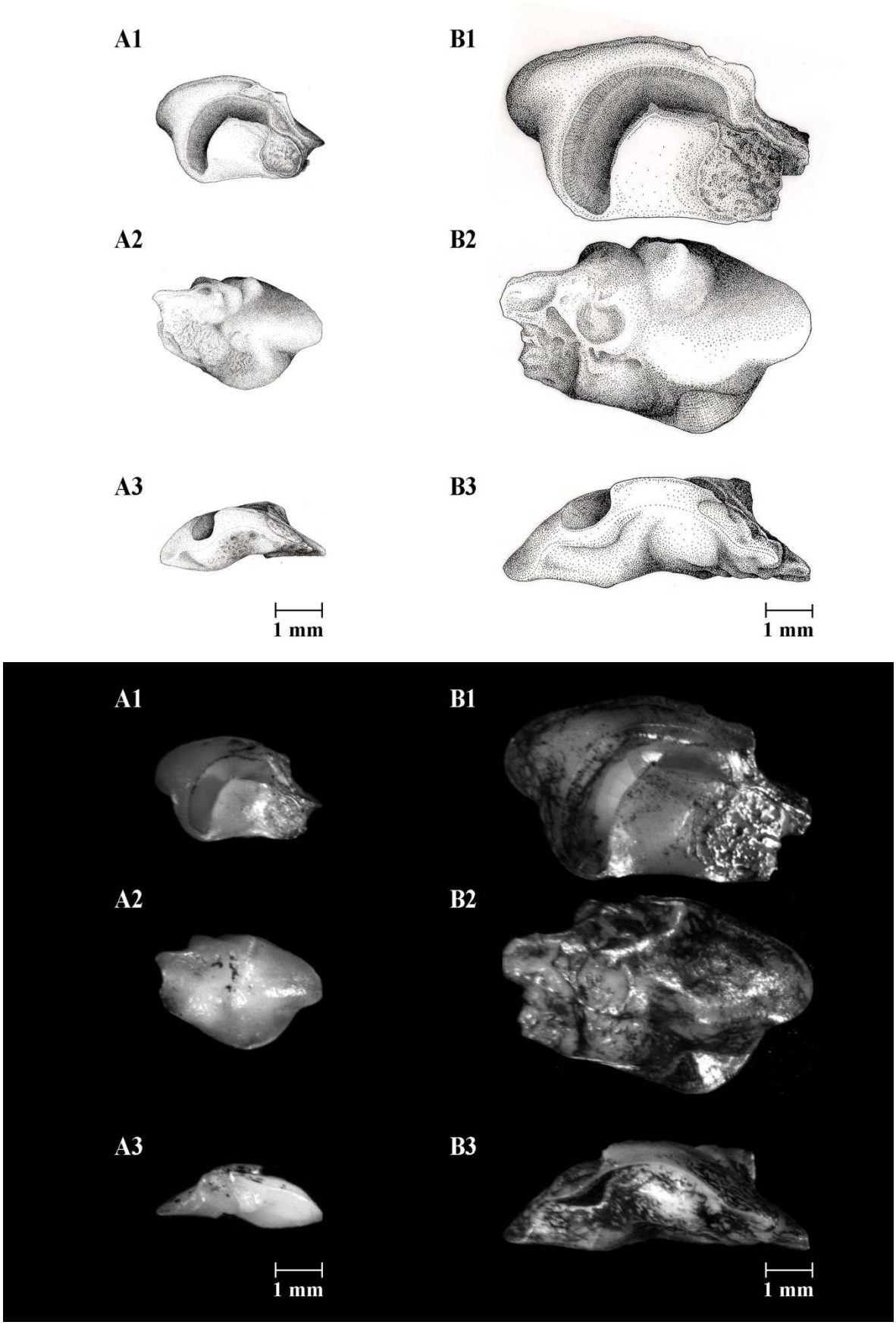


Plate 35. Illustrations (above) and photographs (below) of *Stellifer brasiliensis* otoliths from fish with total lengths: **A.** 82 mm (PI.AF.L3.32) and **B.** 173 mm (PI.AF.L9.65). The medial face is shown in A1 and B1; the lateral face in A2 and B2; and the ventral profile in A3 and B3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Stellifer rastrifer **(Jordan 1889) – Plate 36**

Maximum Size:	20 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	Colombia to southern Brazil (Santa Catarina State) (FIGUEIREDO; MENEZES, 1980)
Habitat:	coastal waters over sandy or muddy bottoms, especially in estuarine areas (FIGUEIREDO; MENEZES, 1980)
Diet:	pelagic crustaceans and fish (SOARES et al., 2008)
Collection:	18 pairs of otoliths (TL ranging from 51 to 150 mm)
Sample:	16 left otoliths categorized into 6, 20 mm classes (40 to 140 mm)

Shape: rectangular. ***Anterior region:*** double-peaked. ***Posterior region:*** oblique. ***Dorsal edge:*** entire (81.25%), sinuate to entire. ***Ventral edge:*** entire. ***Anterior edge:*** irregular. ***Posterior edge:*** entire. ***Profile:*** plane-convex. ***Rostrum:*** absent. ***Antirostrum:*** underdeveloped. ***Rostrum and antirostrum orientation:*** does not apply. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* ascending; *opening:* pseudo-ostiocaudal; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* discoidal; *cauda:* tubular curled.

Differences ($p<0.05$) among some length classes and along the growth development were found only in the dorsal edge.

Shape indices	Mean± Sd	Minimum	Maximum
OL/TL (%)	4.06 ± 0.42	3.51	5
OH/OL (%)	73.45 ± 4.65	69.07	83.54
OT/OL (%)	48.21 ± 4.21	40.61	57.59
OT/OH (%)	65.67 ± 4.34	57.77	72.25
Circularity	16.29 ± 0.44	15.66	16.99
Rectangularity	0.76 ± 0,02	0.73	0.78

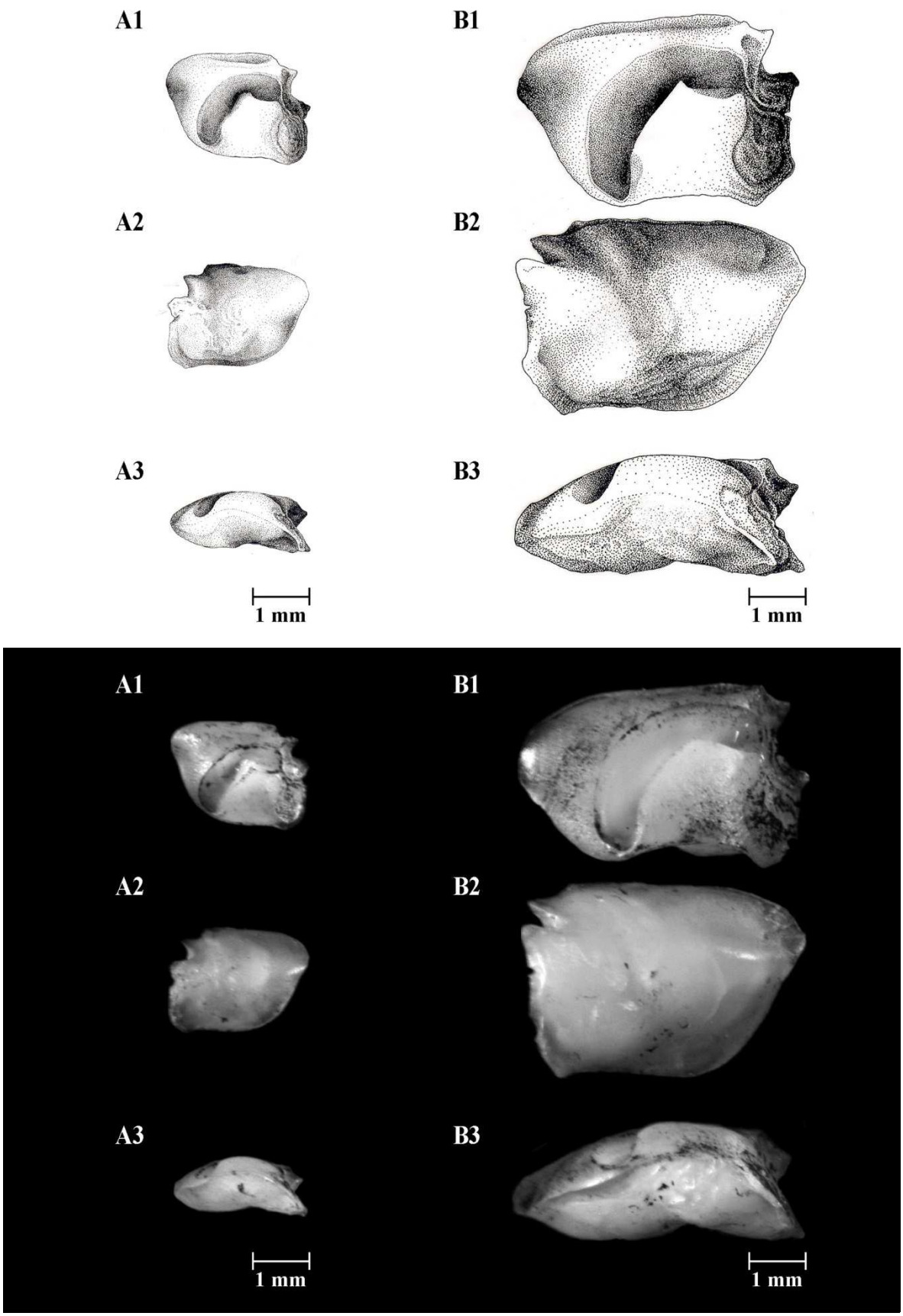


Plate 36. Illustrations (above) and photographs (below) of *Stellifer rastrifer* otoliths from fish with total lengths: **A.** 51 mm (PI.AF.L21.18) and **B.** 150 mm (PI.AF.L21.1). The medial face is shown in A1 and B1; the lateral face in A2 and B2; and the ventral profile in A3 and B3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Umbrina canosai **Berg 1895 – Plate 37**

Maximum Size:	40 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	Cabo de São Tomé (Rio de Janeiro State, Brazil) (BERNARDES et al., 2005)
Habitat:	from the coast to 200 m deep on muddy or sandy sediments (FIGUEIREDO; MENEZES, 1980)
Diet:	benthic invertebrates (polychaeta, brittle stars and crustaceans) (SOARES et al., 2008)
Collection:	255 pairs of otoliths (TL ranging from 133 to 445 mm)
Sample:	123 left otoliths categorized into 16, 20 mm classes (120 to 440 mm)

Shape: discoidal to rectangular. ***Anterior region:*** round (91.06%), oblique-round. ***Posterior region:*** oblique-round (78.05%), round. ***Dorsal edge:*** entire (73.17%), sinuate to entire. ***Ventral edge:*** entire (87.80%), sinuate to entire. ***Profile:*** biconvex. ***Rostrum and antirostrum:*** absent. ***Rostrum and antirostrum orientation:*** does not apply. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* pseudo-ostial (60.16%), para-ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* lateral; *cauda:* tubular curled.

Differences ($p<0.05$) among some length classes were found in the anterior and posterior regions, dorsal and ventral edges and the *sulcus acusticus opening*. Along the growth development differences were found in posterior region, dorsal and ventral edges and the *sulcus acusticus opening.*

The morphometric data of the specimen are given below:

Shape indices	Mean± Sd	Minimum	Maximum
OL/TL (%)	3.77 ± 0.34	2.9	4.89
OH/OL (%)	65.69 ± 4.46	45.66	76.76
OT/OL (%)	42.69 ± 3.47	32.32	51.93
OT/OH (%)	65.22 ± 6.22	51.76	87.13
Circularity	14.15 ± 0.30	13.46	15.12
Rectangularity	0.81 ± 0.05	0.62	1.14

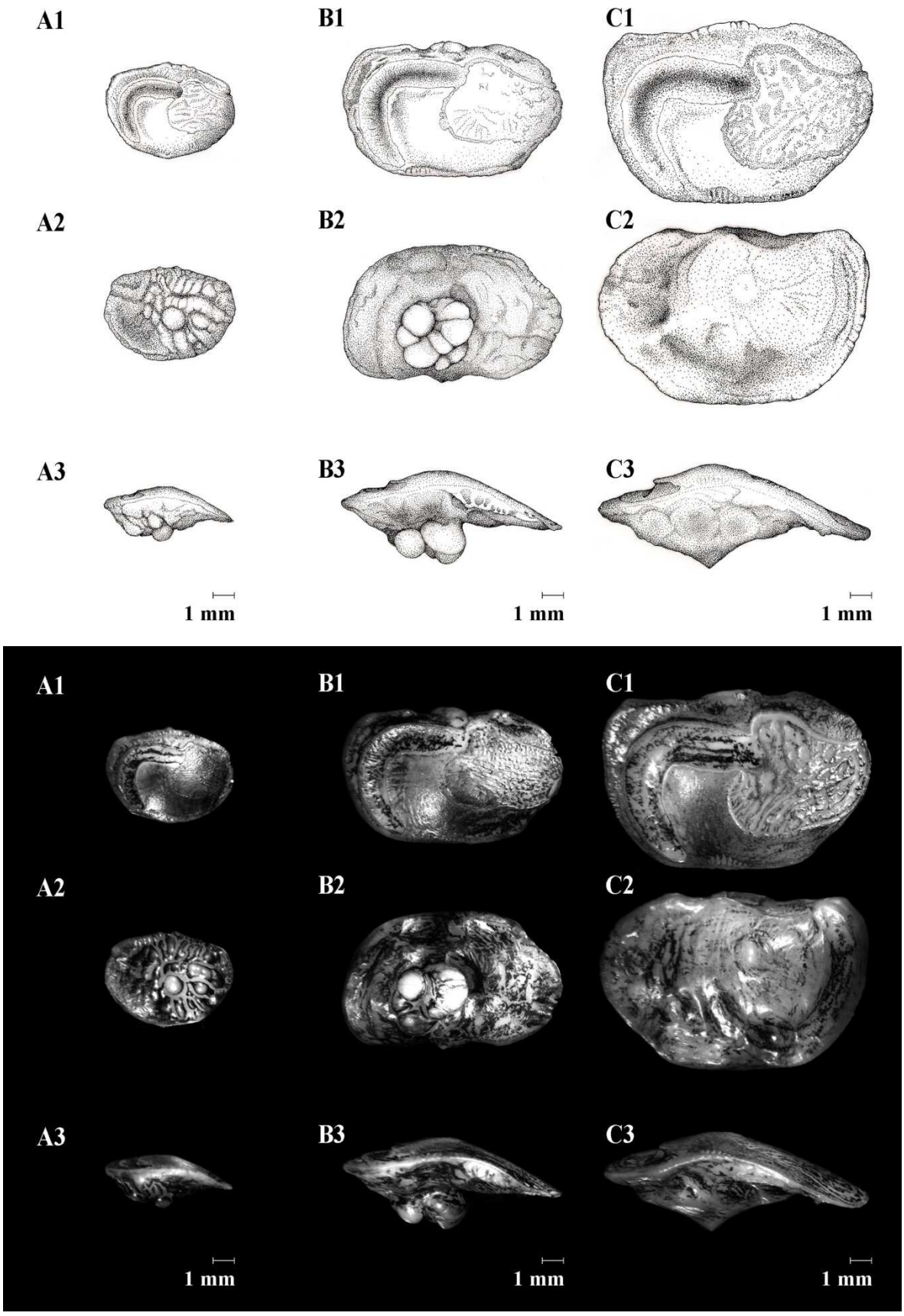


Plate 37. Illustrations (above) and photographs (below) of *Umbrina canosai* otoliths from fish with total lengths: **A**. 133 mm (REV.AF.407.5), **B**. 290 mm (REV.AF.408.2) and **C**. 445 mm (REV.AF.1021.22). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3 (Illustrator: Jessica Falchi Caçador; Photos: Cesar Santificetur).

Umbrina coroides **Cuvier 1830 – Plate 38**

Maximum Size:	35 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	Gulf of Mexico, from northern Florida (USA) to the Antilles and from Panama to southern Brazil (Santa Catarina State) (FIGUEIREDO; MENEZES, 1980)
Habitat:	coastal shallow waters, on sandy or muddy sediments and also in estuarine regions (FIGUEIREDO; MENEZES, 1980)
Diet:	benthic organisms (FIGUEIREDO; MENEZES, 1980)
Collection:	5 pairs of otoliths (TL ranging from 113 to 230 mm)
Sample:	5 left otoliths categorized into 5, 20 mm classes (100 to 220 mm)

Shape: oval. ***Anterior region:*** round. ***Posterior region:*** round. ***Dorsal edge:*** entire. ***Ventral edge:*** entire. ***Profile:*** biconvex. ***Rostrum and antirostrum:*** absent. ***Rostrum and antirostrum orientation:*** does not apply. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* pseudo-ostial (60%), para-ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* discoidal; *cauda:* tubular curled.

The morphometric data of the specimen are given below:

Shape indices	Mean± Sd	Minimum	Maximum
OL/TL (%)	4.28 ± 0.74	3.7	5.56
OH/OL (%)	72.38 ± 6.38	66.74	81.61
OT/OL (%)	43,08 ± 5.46	33.67	47.31
OT/OH (%)	59.61 ± 7.00	50.34	66.91
Circularity	14.14 ± 0.23	13.79	14.4
Rectangularity	0.77 ± 0.01	0.77	0.79

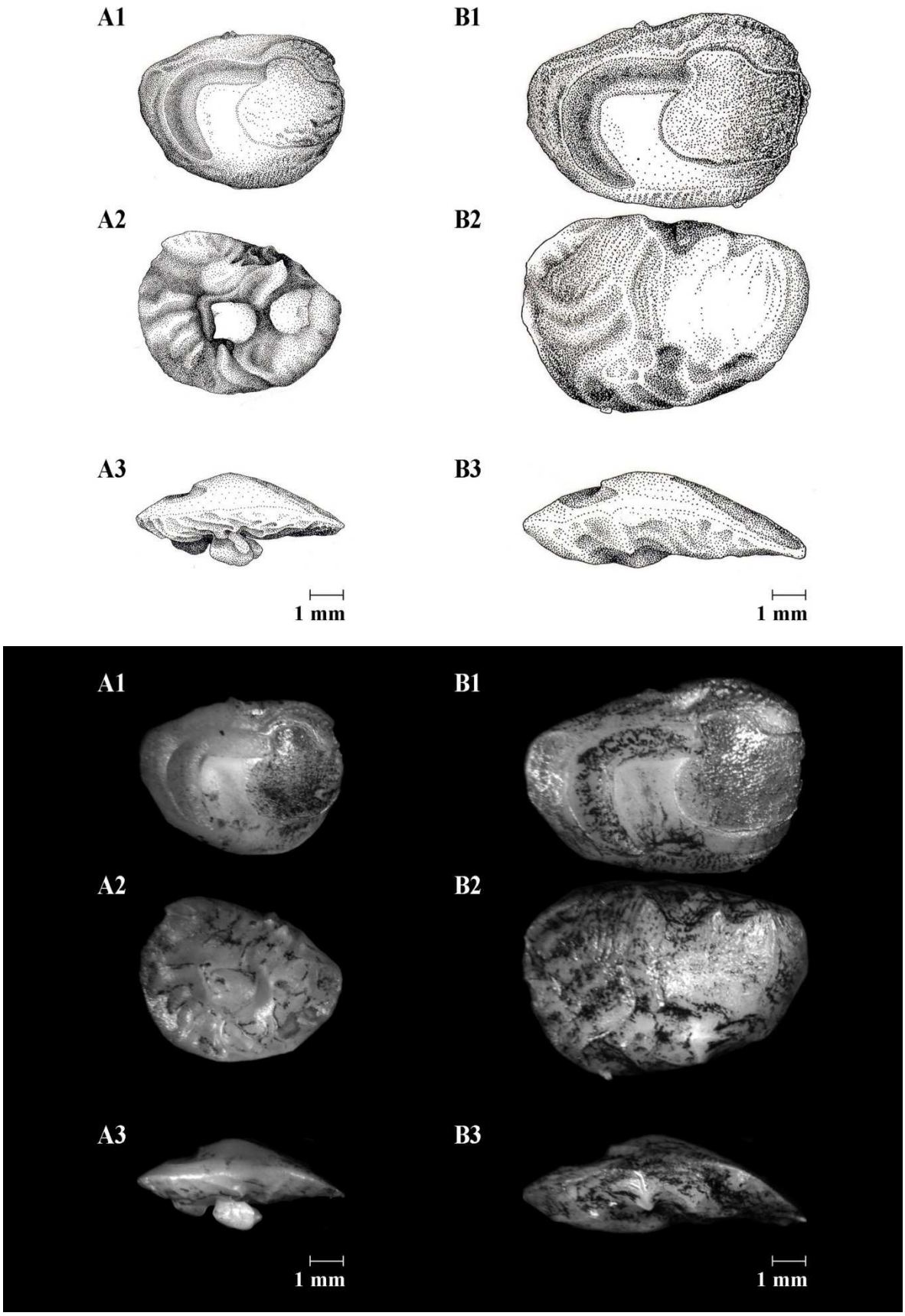


Plate 38. Illustrations (above) and photographs (below) of *Umbrina coroides* otoliths from fish with total lengths: **A.** 113 mm (PI.AF.L27.2) and **B.** 230 mm (PI.AF.L23.1). The medial face is shown in A1 and B1; the lateral face in A2 and B2; and the ventral profile in A3 and B3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Family SCOMBRIDAE

Euthynnus alletteratus **(Rafinesque 1810) – Plate 39**

Maximum Size:	1 m (TL) (BERNARDES et al., 2005).
Distribution:	tropical and subtropical waters of the Atlantic and the Mediterranean (MENEZES et al, 2003)
Habitat:	surface waters from the coast to offshore (FIGUEIREDO; MENEZES, 1980)
Diet:	crustaceans, fish, squid and tunicates (FIGUEIREDO; MENEZES, 1980)
Collection:	6 pairs of otoliths (TL ranging from 240 to 431 mm)
Sample:	one left otolith (240 mm TL)

Shape: rectangular. ***Anterior region:*** flattened. ***Posterior region:*** oblique. ***Dorsal edge:*** sinuate to entire. ***Ventral edge:*** sinuate. ***Anterior edge:*** sinuate to entire. ***Posterior edge:*** sinuate. ***Profile:*** flattened. ***Rostrum and antirostrum orientation:*** does not apply. ***Rostrum and antirostrum:*** absent. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* supramedian; *orientation:* horizontal; *opening:* ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* elliptic.

The morphometric data of the specimen are given below:

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	0.87 ± 0	0.87	0.87
OH/OL (%)	55.29 ± 0	55.29	55.29
OT/OL (%)	22.60 ± 0	22.6	22.6
OT/OH (%)	40.87 ± 0	40.87	40.87
Circularity	19.87 ± 0	19.87	19.87
Rectangularity	0.75 ± 0	0.75	0.75

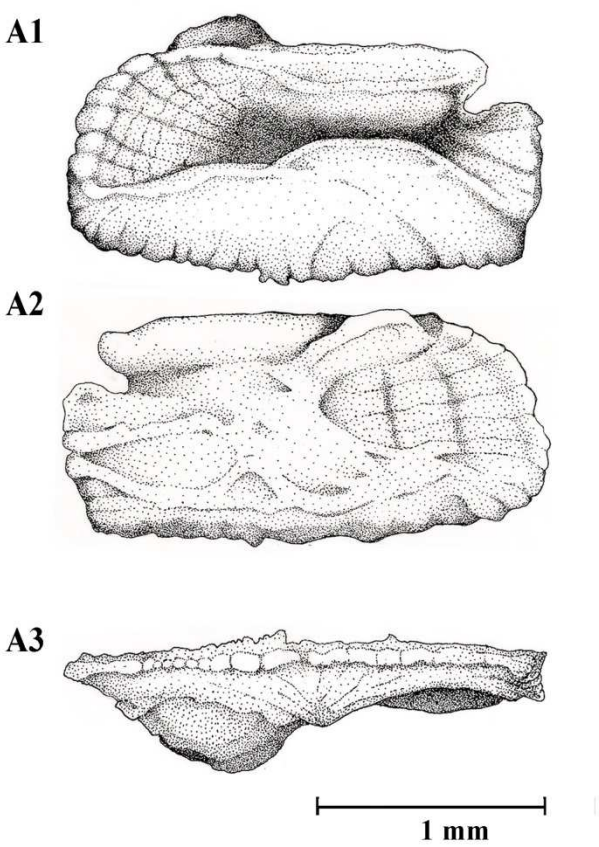


Plate 39: The illustrations of *Euthynnus alleterattus* otolith with total length: A. 240 mm (SARVII.CE.L5.3). The medial face is shown in A1; the lateral face in A2; and the ventral profile in A3 (Illustrator: Alexandre Arackawa).

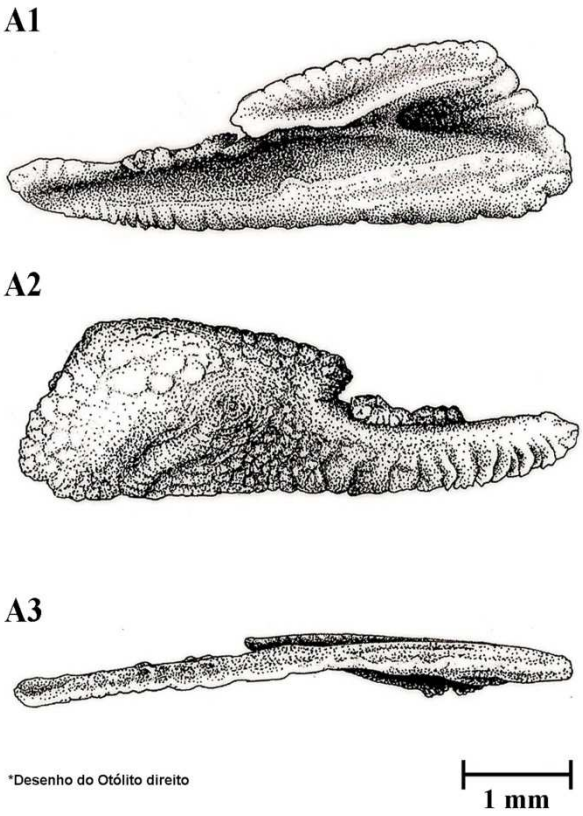
Sarda sarda **(Bloch 1793) – Plate 40**

Maximum Size:	90 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	tropical and temperate waters of the Atlantic, Mediterranean and Black Sea (BERNARDES et al., 2005)
Habitat:	surface of coastal waters (FIGUEIREDO; MENEZES, 1980)
Diet:	small fish, squid and shrimp (FIGUEIREDO; MENEZES, 1980)
Collection:	4 pairs of otoliths (TL ranging from 414 to 500 mm)
Sample:	2 right otoliths categorized into 2, 20 mm classes (440 to 460 mm)

Shape: triangular. A***nterior region:*** peaked. ***Posterior region:*** oblique. ***Anterior dorsal edge:*** lobed to sinuate. ***Posterior dorsal edge:*** sinuate. ***Ventral edge:*** crenate to sinuate. ***Profile:*** concave-convex. ***Rostrum and antirostrum orientation:*** in disagreement. ***Rostrum:*** developed. ***Antirostrum:*** developed. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* slightly ascending; *opening:* ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* elliptic.

The morphometric data of the specimen are given below:

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	1.11 ± 0.12	1.03	1.19
OH/OL (%)	35.59 ± 4.95	32.08	39.07
OT/OL (%)	12.49 ± 0.44	12.19	12.8
OT/OH (%)	35.38 ± 3.69	32.77	37.99
Circularity	31.71 ± 2.68	29.81	33.6
Rectangularity	0.61± 0.02	0.59	0.62



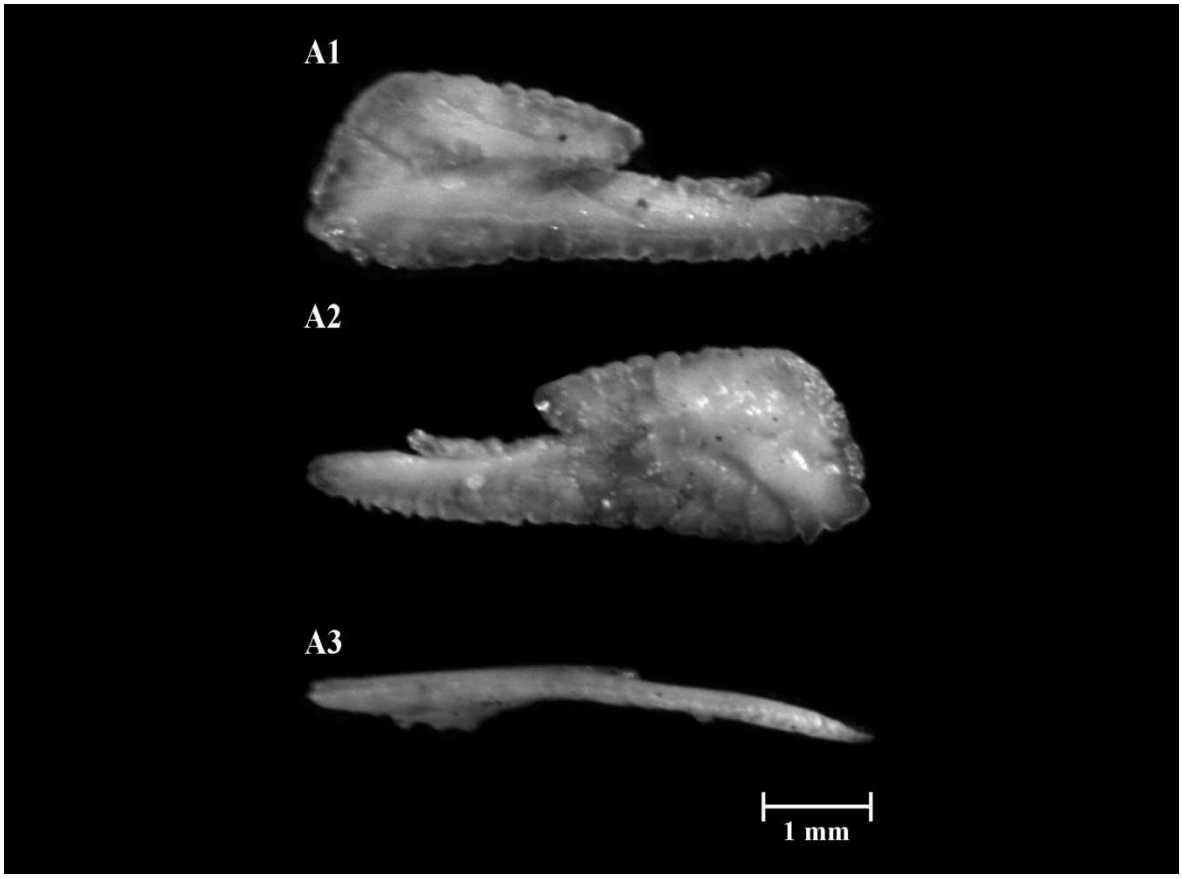


Plate 40. Illustrations (above) and photographs (below) of *Sarda sarda* otolith from a fish with total length of 468 mm (SARVI.AM.L12.1) (illustration from the right *sagitta* and picture from the left *sagitta*). The medial face is shown in A1; the lateral face in A2; and the ventral profile in A3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Scomber colias **Gmelin 1789 – Plate 41**

Maximum Size:	70 cm (TL) (FIGUEIREDO et al., 2002)
Distribution:	Nova Scotia to Argentina (BERNARDES et al., 2005; INFANTE et al., 2007)
Habitat:	coastal, up to 300 m deep (FIGUEIREDO; MENEZES, 1980)
Diet:	crustaceans, fish and squid (FIGUEIREDO; MENEZES, 1980)
Collection:	199 pairs of otoliths (TL ranging from 72 to 299 mm)
Sample:	47 left otoliths categorized into 9, 20 mm classes (80 to 280 mm)

Shape: rectangular. ***Anterior region:*** peaked. ***Posterior region:*** oblique (68.09%), oblique-round. ***Dorsal edge:*** sinuate to entire (76.60%), sinuate, entire. ***Ventral edge:*** sinuate to entire (80.85%), entire. ***Posterior edge:*** sinuate to entire (74.47%), entire. ***Profile:*** concave-convex. ***Rostrum and antirostrum orientation:*** in agreement. ***Rostrum:*** underdeveloped (85.11%), developed or absent. ***Antirostrum:*** developed (63.83%), underdeveloped, absent. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* ostial (85.11%), ostiocaudal; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* tubular slightly curved (53.19%), tubular strongly curved. *In this species, the colliculum exceeds the anterior edge of the otolith.*

Differences ($p<0.05$) among some length classes were found in: the posterior region, the dorsal, ventral and posterior edges, the *sulcus acusticus opening*, *cauda morphology*, *the rostrum* and *antirostrum*. Along the growth development differences were found in the dorsal edge and the *sulcus acusticus opening*.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	1.81 ± 0.14	1.4	2.09
OH/OL (%)	40.59 ± 2.33	35.32	45.51
OT/OL (%)	22.66 ± 3.32	15.56	30.99
OT/OH (%)	55.93 ± 8.22	39.33	74.85
Circularity	25.43 ± 2.12	21.07	29.47
Rectangularity	0.66 ± 0.04	0.57	0.74

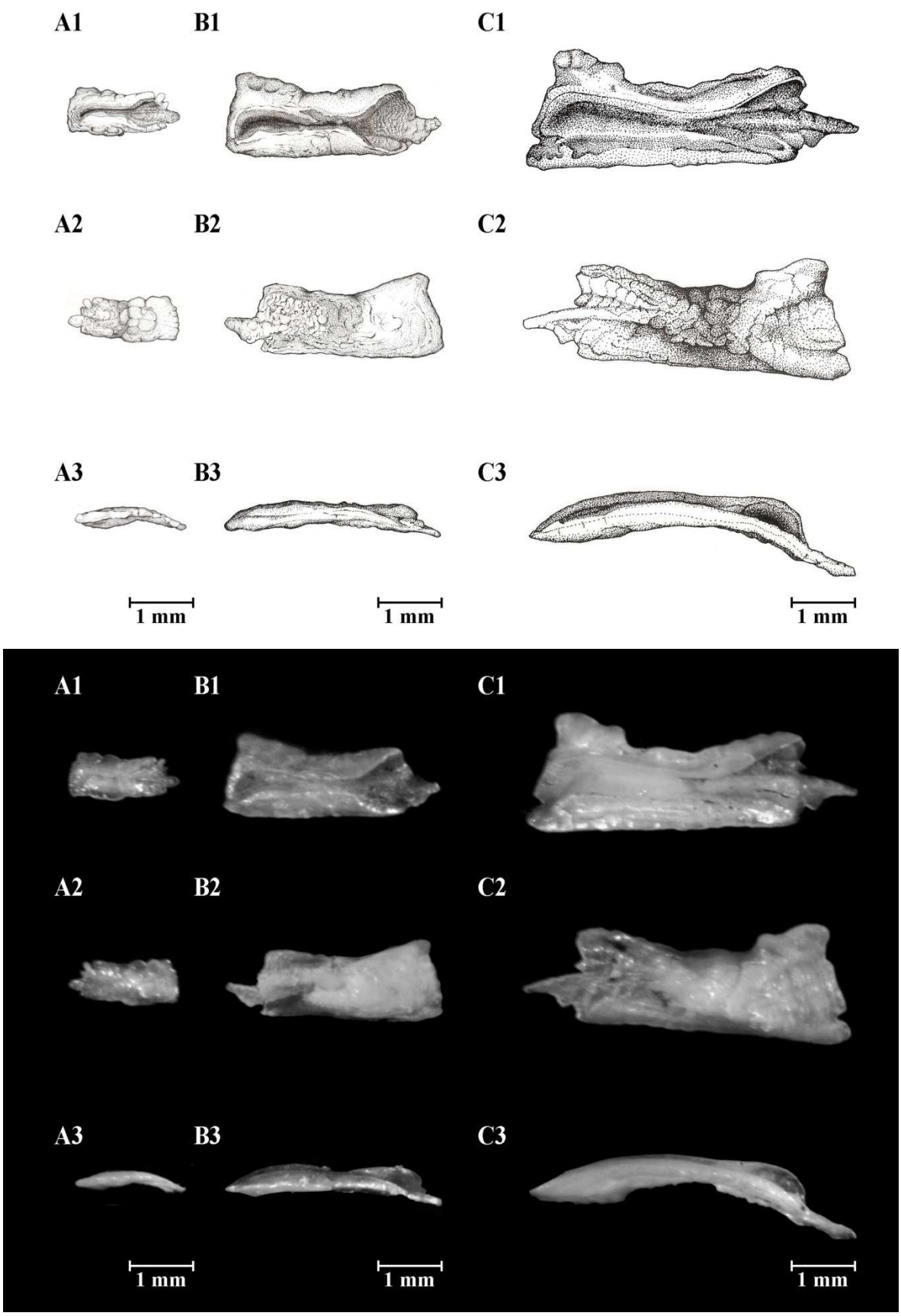


Plate 41. Illustrations (above) and photographs (below) of *Scomber colias* otoliths from fish with total lengths: **A.** 85 mm (SARVI.AM.L16.1), **B.** 183 mm (SARIV.AM.L8.11) and **C.** 280 mm (SARVI.CE.L1.12). The medial face is shown in A1, B1 and C1; the lateral face in A2, B2 and C2; and the ventral profile in A3, B3 and C3 (Illustrators: Alexandre Arackawa, Jessica Falchi Caçador; Photos: Cesar Santificetur).

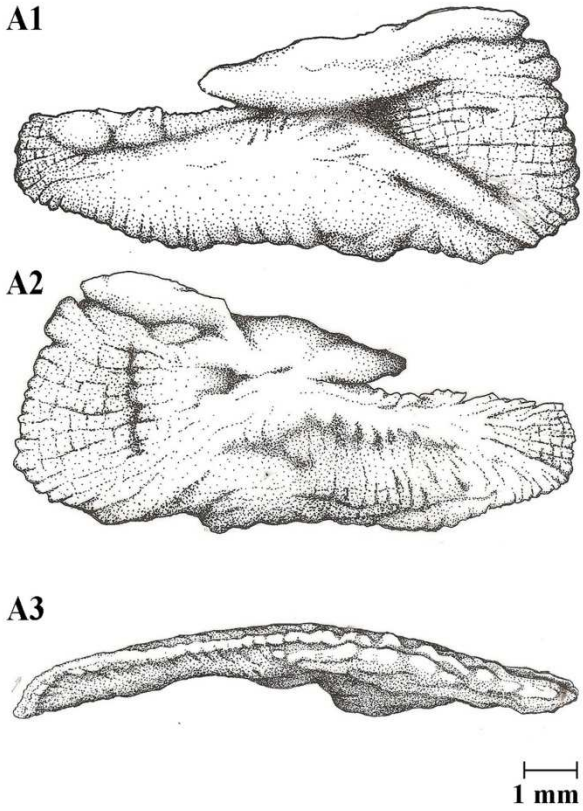
Scomberomorus brasiliensis **Collete, Russo & Zavalla-Camin 1978 – Plate 42**

Maximum Size:	120 cm (TL) (MENEZES; FIGUEIREDO, 1980)
Distribution:	Central America to southern Rio Grande do Sul, Brazil (MENEZES; FIGUEIREDO, 1980)
Habitat:	epipelagic, found up to 130 m deep (FROESE; PAULY, 2013)
Diet:	cephalopods, fish and planktonic crustaceans (FROESE; PAULY, 2013)
Collection:	one pair of otoliths (757 mm TL)
Sample:	One right otolith (757 mm TL)

Shape: triangular. ***Anterior region:*** peaked-round. ***Posterior region:*** oblique. ***Anterior dorsal edge:*** entire. ***Posterior dorsal edge:*** lobed. ***Ventral edge:*** crenate to sinuate. ***Profile:*** concave-convex. ***Rostrum and antirostrum orientation:*** not in agreement. ***Rostrum:*** developed. ***Antirostrum:*** developed. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* supramedian; *orientation:* slightly ascending; *opening:* ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* elliptic.

The morphometric data of the specimen are given below:

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	1.45 ± 0	1.45	1.45
OH/OL (%)	46.27 ± 0	46.27	46.27
OT/OL (%)	15.45 ± 0	15.45	15.45
OT/OH (%)	33.40 ± 0	33.4	33.4
Circularity	26.06 ± 0	26.06	26.06
Rectangularity	0.66 ± 0	0.66	0.66



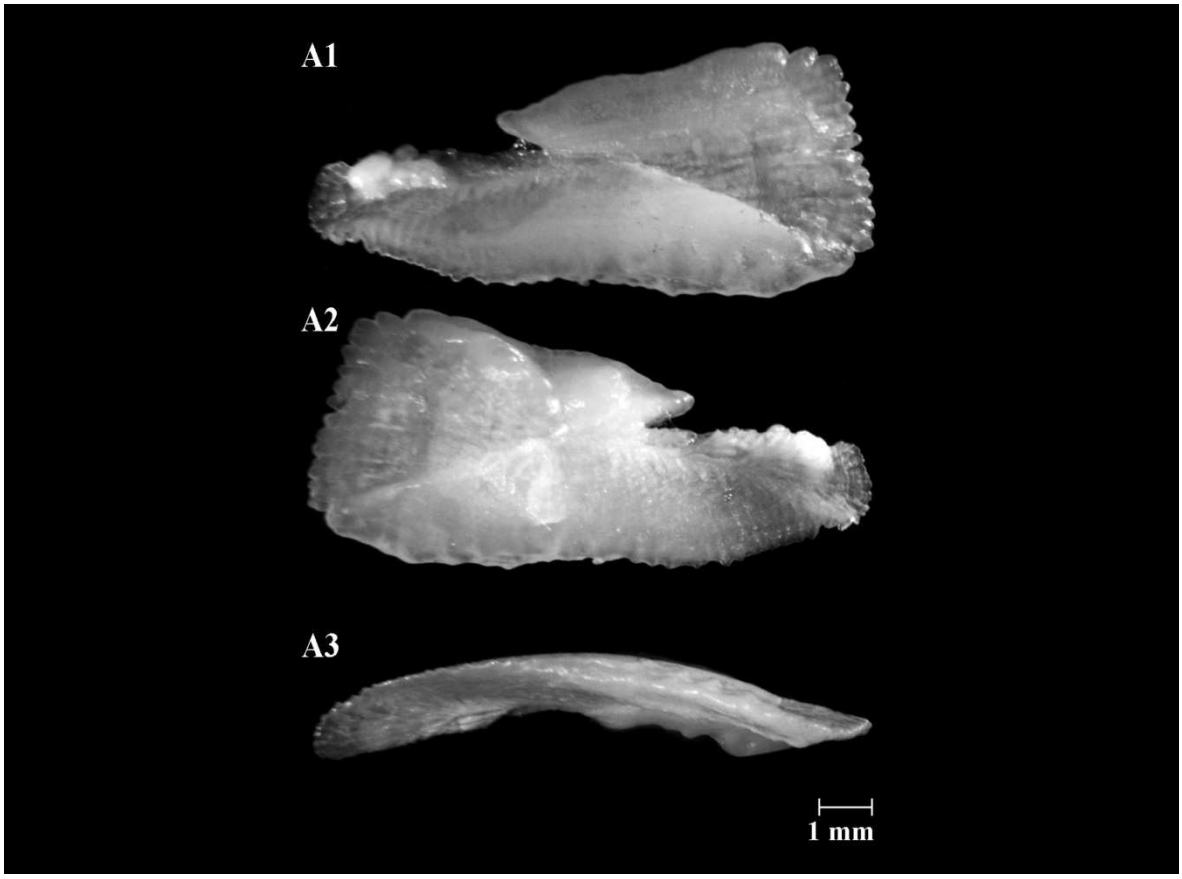


Plate 42. Illustrations (above) and photographs (below) of *Scomberomorus brasiliensis* otolith from a fish with total length of 757 mm (SARV.AM.L12.1). The medial face is shown in A1; the lateral face in A2; and the ventral profile in A3 (Illustrator: Alexandre Arackawa; Photos: Cesar Santificetur).

Family SERRANIDAE

The otolith's shape can be oblong, elliptic or fusiform. The anterior region is commonly peaked-round. The *antirostrum* when present is underdeveloped.

Anthias menezesi **Anderson & Heemstra 1980 –Plate 43**

Maximum Size:	28 cm (TL) (FROESE; PAULY, 2013)
Distribution:	western South Atlantic, from Maranhão State (Brazil) to Uruguay (MENEZES et al., 2003)
Habitat:	reef-associated, between 160 and 260m deep (FROESE; PAULY, 2013)
Diet:	---
Collection:	52 pairs of otoliths (TL ranging from 80 to 230 mm)
Sample:	35 left otoliths categorized into 8, 20 mm classes (80 to 220 mm)

Shape: elliptic. ***Anterior region:*** peaked round (94.29%), peaked. ***Posterior region:*** round. ***Dorsal edge:*** entire. ***Ventral edge:*** entire (91.43%), sinuate to entire. ***Profile:*** concave-convex. ***Rostrum and antirostrum orientation:*** does not apply. ***Rostrum:*** developed. ***Antirostrum:*** absent. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* tubular straight (94.29%), tubular slightly curved.

Differences ($p<0.05$) among some length classes and also along the growth development were found in: anterior region, ventral edge and *cauda* morphology.

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	4.22 ± 0.43	3.42	4.92
OH/OL (%)	60.21 ± 2.47	54.9	66.06
OT/OL (%)	21.87 ± 2.19	18.78	29.55
OT/OH (%)	36.37 ± 3.72	30.65	48.57
Circularity	16.34 ± 0.97	14.75	18.48
Rectangularity	0.67 ± 0.01	0.64	0.69

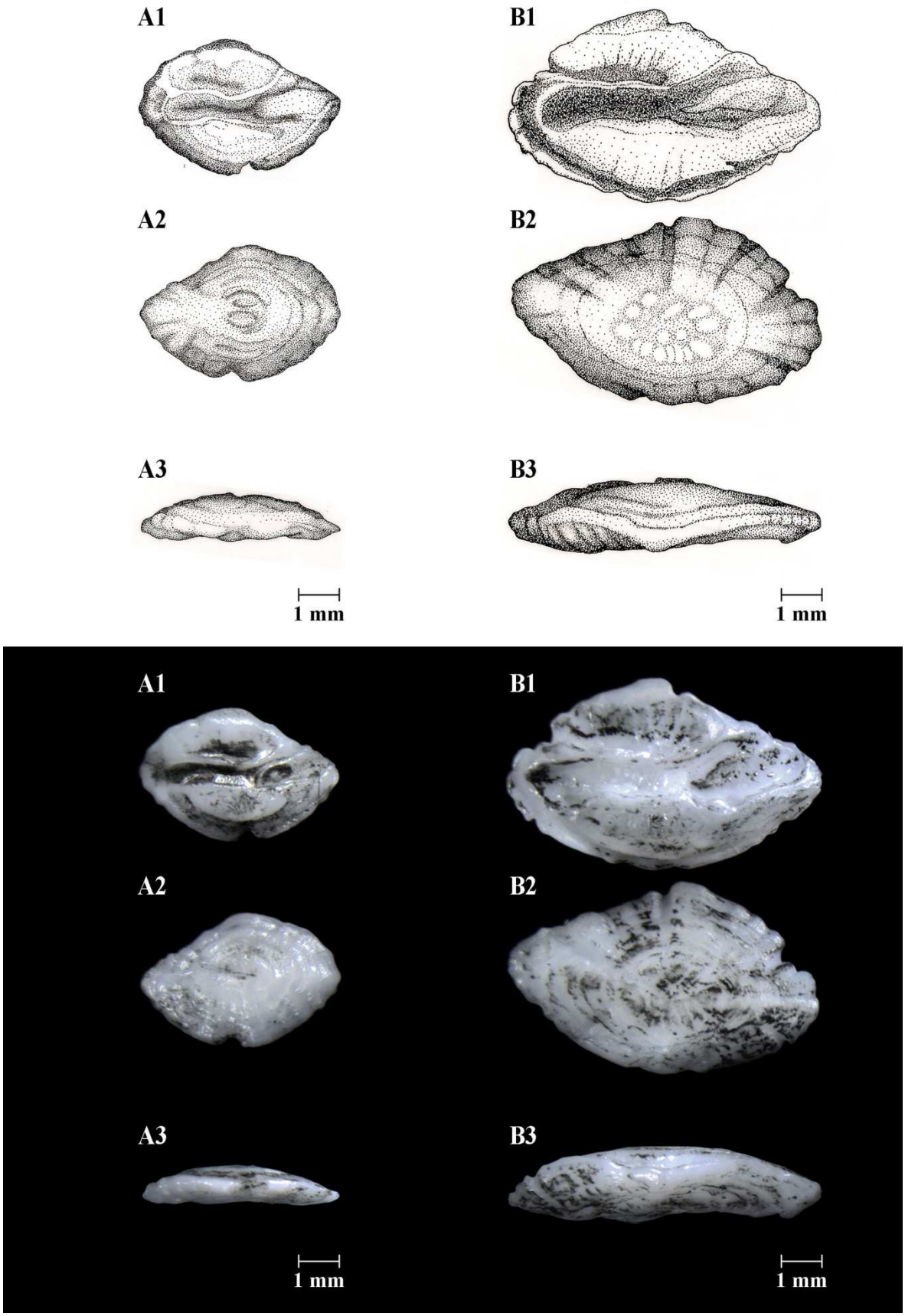


Plate 43. Illustrations (above) and photographs (below) of *Anthias menezesi* otoliths from fish with total lengths: **A**. 100 mm (REV.AF.1126.37) and **B**. 230 mm (REV.AF.1126.3). The medial face is shown in A1 and B1; the lateral face in A2 and B2; and the ventral profile in A3 and B3 (Illustrator: Alexandre Arackawa; Photos: Cesar Santificetur).

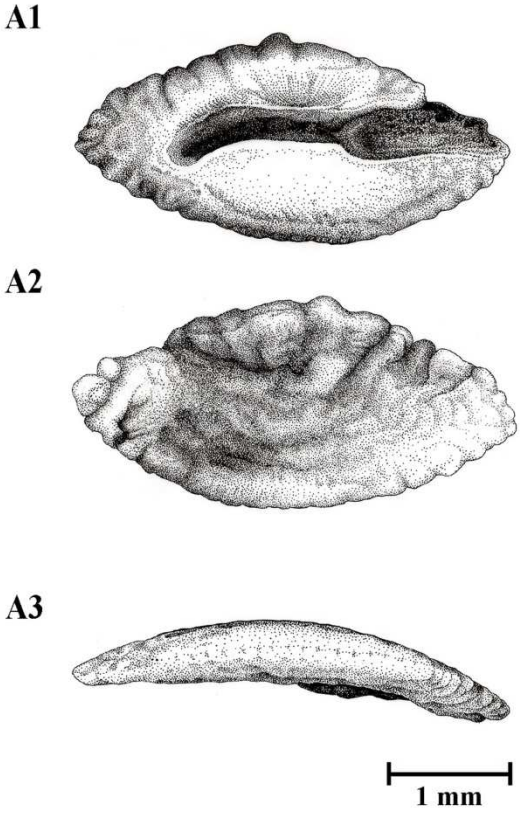
Diplectrum formosum **(Linnaeus 1766) – Plate 44**

Maximum Size:	30 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	Virginia (United States) to Uruguay (FIGUEIREDO; MENEZES, 1980)
Habitat:	from the coast to 80 m depth (FIGUEIREDO; MENEZES, 1980)
Diet:	fish and shrimp (SOARES *et al*., 2008)
Collection:	5 pairs of otoliths (TL ranging from 86 to 151 mm)
Sample:	one left otolith (86 mm TL)

Shape: elliptic. ***Anterior region:*** peaked-round. ***Posterior region:*** peaked-round. ***Dorsal edge:*** lobed to sinuate. ***Ventral edge:*** sinuate to entire. ***Profile:*** concave-convex. ***Rostrum and antirostrum orientation:*** does not apply. ***Rostrum:*** developed. ***Antirostrum:*** absent. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* tubular strongly curved.

The morphometric data of the specimen are given below:

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	4.34 ± 0	4.34	4.34
OH/OL (%)	46.92 ± 0	46.92	46.92
OT/OL (%)	20.91 ± 0	20.91	20.91
OT/OH (%)	44.57 ± 0	44.57	44.57
Circularity	18.25 ± 0	18.25	18.25
Rectangularity	0.68 ± 0	0.68	0.68



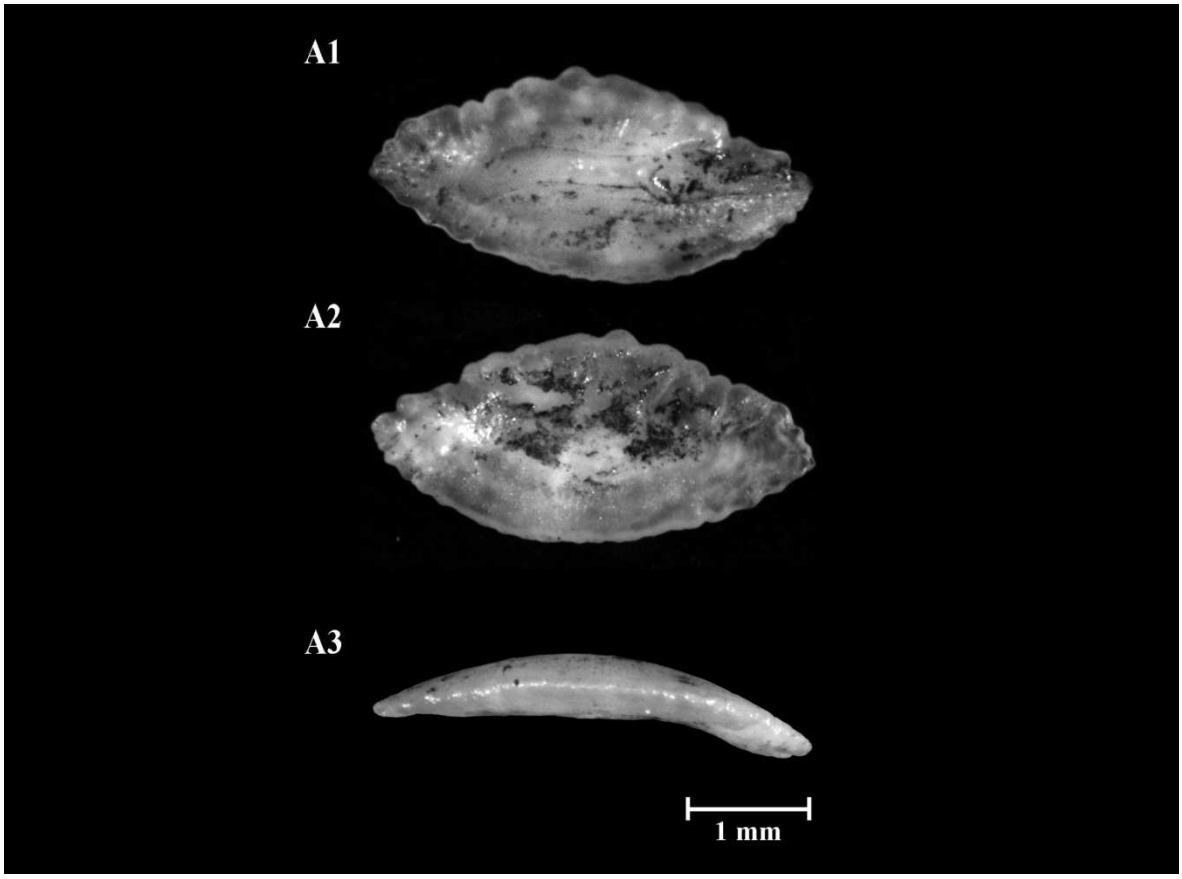


Plate 44. Illustrations (above) and photographs (below) of *Diplectrum formosum* otolith from a fish with total length of 86 mm (PI.AF.L20.5). The medial face is shown in A1; the lateral face in A2; and the ventral profile in A3 (Illustrator: Silvia de Almeida Gonsales; Photos: Cesar Santificetur).

Diplectrum radiale **(Quoy & Gaimard 1824) – Plate 45**

Maximum Size:	20 cm (TL) (MENEZES; FIGUEIREDO, 1980)
Distribution:	Florida (United States) to Uruguay (MENEZES; FIGUEIREDO, 1980)
Habitat:	coastal and estuarine regions (MENEZES; FIGUEIREDO, 1980)
Diet:	fish and shrimp (SOARES et al., 2008)
Collection:	20 pairs of otoliths (TL ranging from 158 to 249 mm)
Sample:	12 left otoliths categorized into 5, 20 mm classes (140 to 240 mm)

Shape: fusiform (83.33%), lanceolated. ***Anterior region:*** peaked-round (83.33%), peaked. ***Posterior region:*** peaked-round (50%), peaked (50%). ***Dorsal edge:*** entire (50%), sinuate to entire, sinuate. ***Ventral edge:*** sinuate to entire (58.33%), sinuate. ***Profile:*** concave-convex. ***Rostrum and antirostrum orientation:*** in agreement. ***Rostrum:*** developed. ***Antirostrum:*** underdeveloped. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* tubular slightly curved.

Differences ($p<0.05$) among some length classes were found in: anterior and dorsal edge of the otolith. Along the growth development differences were detected in the dorsal edge.

The morphometric data of the specimen are given below:

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	3.83 ± 0.20	3.39	4.2
OH/OL (%)	41.68 ± 2.63	38.47	48.95
OT/OL (%)	18.83 ± 1.65	16.21	21.68
OT/OH (%)	45.27 ± 4.13	37.97	53.45
Circularity	21.34 ± 1.09	20.2	23.32
Rectangularity	0.64 ± 0.02	0.61	0.67

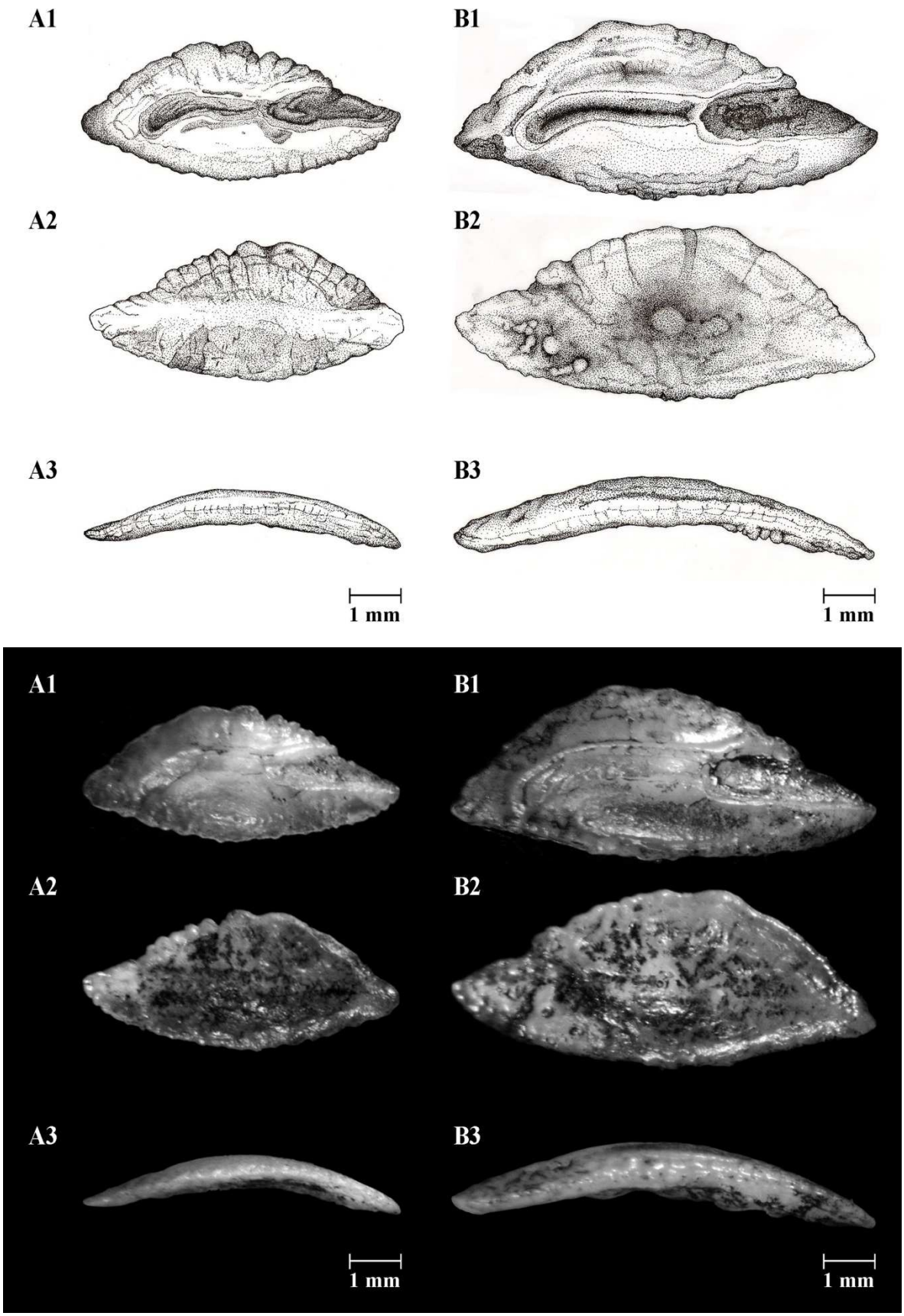


Plate 45. Illustrations (above) and photographs (below) of *Diplectrum radiale* otoliths from fish with total lengths: **A**. 169 mm (PI.AF.L9.5) and **B**. 249 mm (PI.AF.L9.1). The medial face is shown in A1 and B1; the lateral face in A2 and B2; and the ventral profile in A3 and B3 (Illustrators: Alexandre Arackawa, Jessica Falchi Caçador; Photos: Cesar Santificetur).

Dules auriga **Cuvier 1829 – Plate 46**

Maximum Size:	20 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	Rio de Janeiro (Brazil) to Argentina (FIGUEIREDO; MENEZES, 1980)
Habitat:	from 15 to 135 m deep (FIGUEIREDO; MENEZES, 1980)
Diet:	Brachyura, Ophiuroidea, Gammaridea, Polychaete, Cumacea and Teleostei (SOARES et al., 1993)
Collection:	313 pairs of otoliths (TL ranging from 52 to 163 mm)
Sample:	46 left otoliths categorized into 7, 20 mm classes (40 to 160 mm)

Shape: fusiform. ***Anterior region:*** peaked-round. ***Posterior region:*** round. ***Dorsal edge:*** sinuate to entire (50%), entire, sinuate, lobed to sinuate. ***Ventral edge:*** sinuate to entire (63.04%), entire, lobed to sinuate, sinuate. ***Profile:*** concave-convex. ***Rostrum and antirostrum orientation:*** in agreement. ***Rostrum:*** developed. ***Antirostrum:*** underdeveloped or absent. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* slightly curved.

Differences ($p<0.05$) among some length classes were found in: dorsal and ventral edge. Along the growth development differences were found only in the ventral edge of the otoliths.

The morphometric data of the specimen are given below:

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	4.63 ± 0.50	3.74	5.85
OH/OL (%)	46.52 ± 2.45	42.05	52.42
OT/OL (%)	19.13 ± 3.02	13.33	26.07
OT/OH (%)	41.16 ± 6.43	29.75	52.14
Circularity	19.14 ± 1.22	16.78	22.24
Rectangularity	0.67 ± 0.02	0.62	0.71

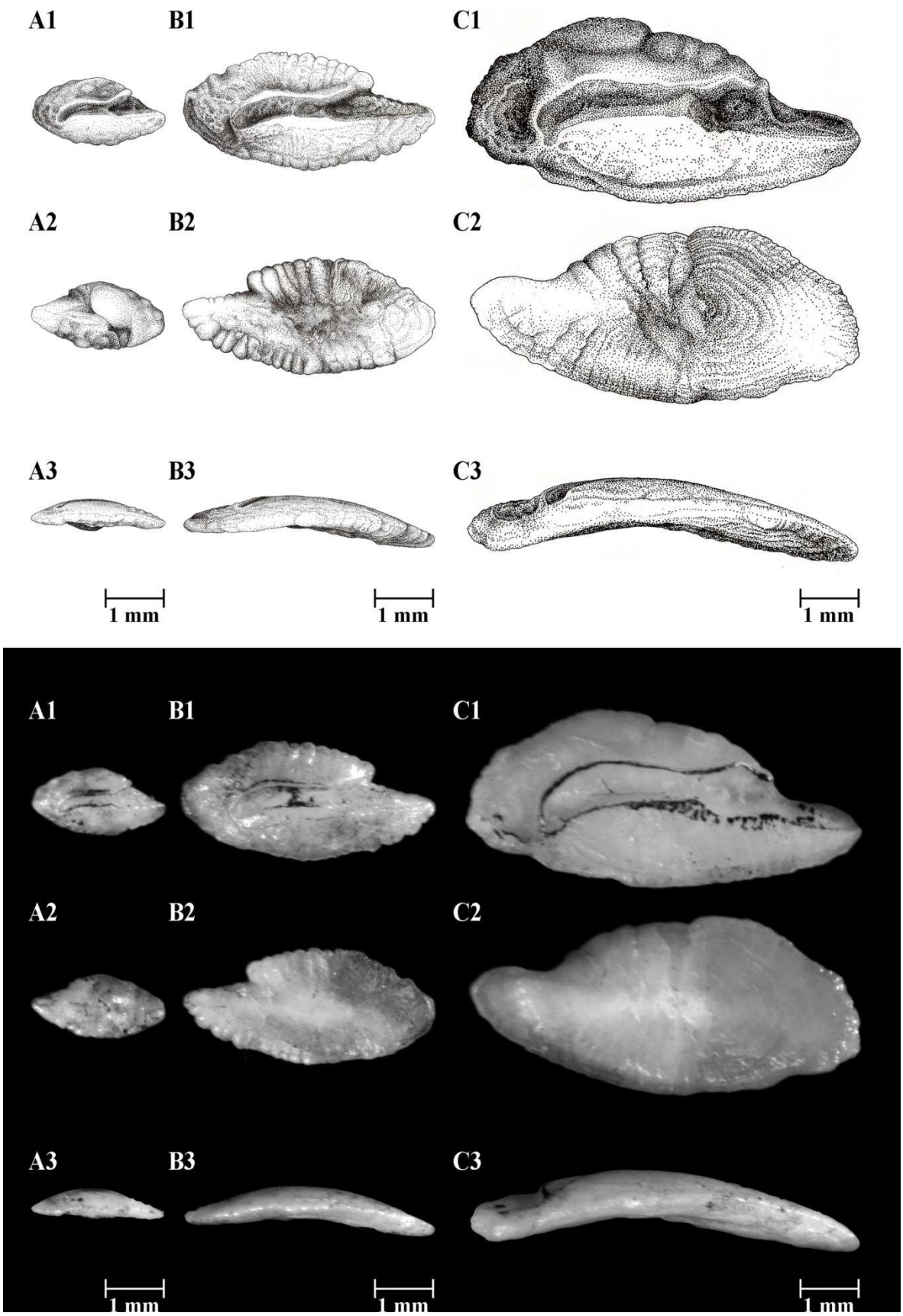


Plate 46. Illustrations (above) and photographs (below) of *Diplectrum radiale* otoliths from fish with total lengths: **A**. 169 mm (PI.AF.L9.5) and **B**. 249 mm (PI.AF.L9.1). The medial face is shown in A1 and B1; the lateral face in A2 and B2; and the ventral profile in A3 and B3 (Illustrators: Alexandre Arackawa, Jessica Falchi Caçador; Photos: Cesar Santificetur).

Serranus atrobranchus **(Cuvier 1829) – Plate 47**

Maximum Size:	19 cm (TL) (FIGUEIREDO; MENEZES, 1980)
Distribution:	Texas to Rio Grande do Sul (Brazil) (FIGUEIREDO; MENEZES, 1980)
Habitat:	between 30 and 270 m deep (FIGUEIREDO; MENEZES, 1980)
Diet:	---
Collection:	30 pairs of otoliths (TL ranging from 100 to 180 mm)
Sample:	20 left otoliths categorized into 5, 20 mm classes (100 to 180 mm)

Shape: elliptic to lanceolated. ***Anterior region:*** peaked-round. ***Posterior region:*** angular-round. ***Dorsal edge:*** sinuate to entire. ***Ventral edge:*** entire (85%), sinuate to entire. ***Profile:*** concave-convex. ***Rostrum and antirostrum orientation:*** in agreement. ***Rostrum:*** developed. ***Antirostrum:*** underdeveloped or absent. ***Pseudorostrum and pseudo-antirostrum:*** absent. ***Sulcus acusticus:*** *position:* median; *orientation:* horizontal; *opening:* ostial; *morphology:* heterosulcoid; *colliculum:* heteromorphic; *ostium:* funnel like; *cauda:* tubular slightly curved.

Differences ($p<0.05$) among some length classes and along the growth development were found in the ventral edge of the otolith.

The morphometric data of the specimen are given below:

Shape indices	Mean ± Sd	Minimum	Maximum
OL/TL (%)	4.04 ± 0.16	3.71	4.24
OH/OL (%)	47.82 ± 1.87	44.78	52.54
OT/OL (%)	17.46 ± 1.62	14.22	20
OT/OH (%)	36.54 ± 3.37	29.03	42.39
Circularity	17.87 ± 0.58	16.82	19.29
Rectangularity	0.68 ± 0.01	0.66	0.71

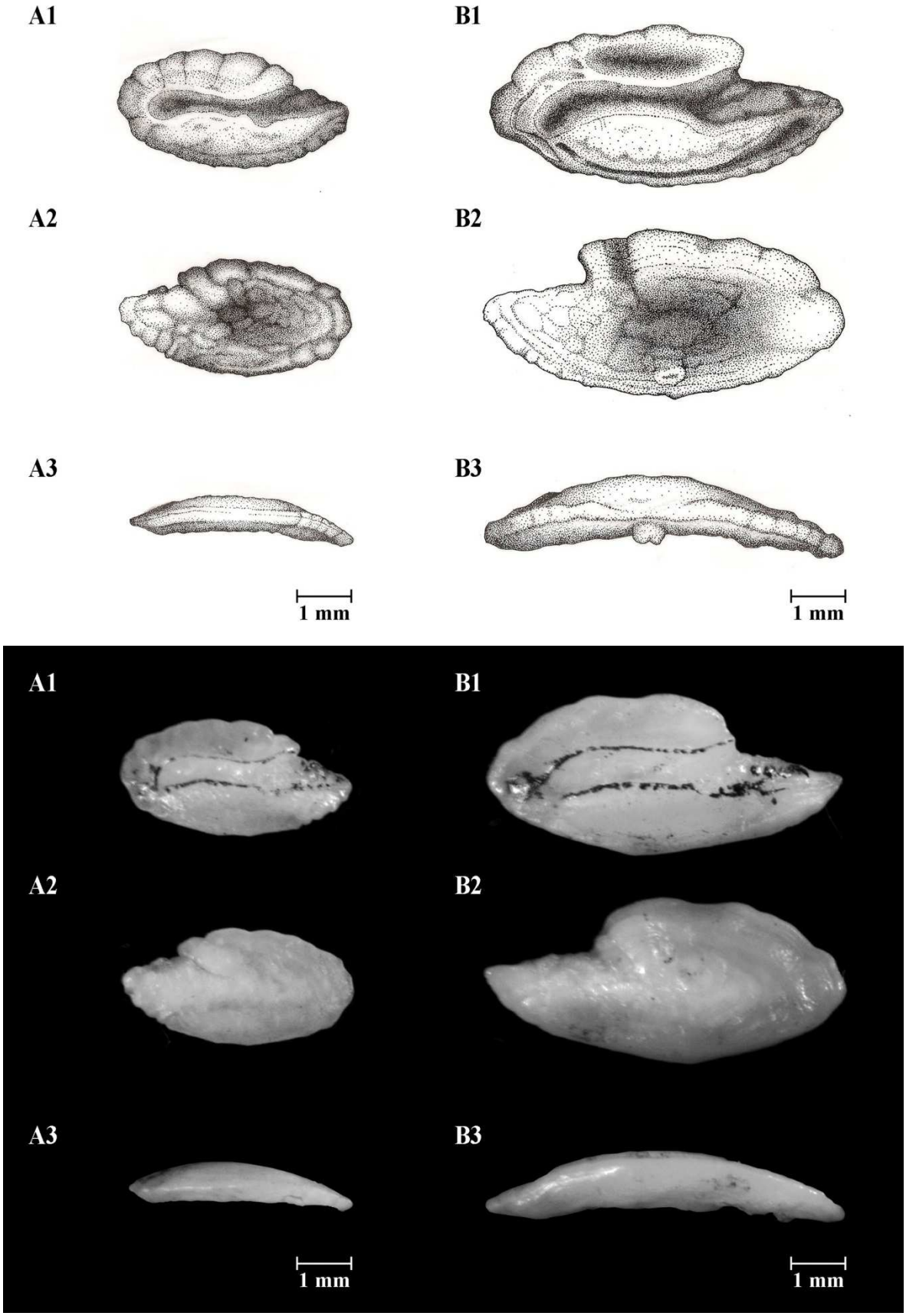


Plate 47. Illustrations (above) and photographs (below) of *Serranus atrobranchus* otoliths from fish with total lengths: **A**. 107 mm (REV.AF.534.21) and **B.** 180 mm (REV.AF.534.2). The medial face is shown in A1 and B1; the lateral face in A2 and B2; and the ventral profile in A3 and B3 (Illustrator: Alexandre Arackawa; Photos: Cesar Santificetur).

IDENTIFICATION KEY

Family CARANGIDAE

Genus *Decapterus*

The anterior region is lanceolated-round or angular-round; the dorsal and ventral edges are sinuated to entire; the *antirostrum* is underdeveloped or absent.....*Decapterus punctatus*
The anterior region is peaked-round; the dorsal and ventral edges are lobed to sinuate; the *antirostrum* is absent.....*Decapterus tabl*

Genus *Selene*

The posterior region is angular-round, with a prominent tip in the ventral posterior; the *cauda* of the *sulcus acusticus* ending closer to the ventral edge.....*Selene setapinnis*
The posterior region is round; the *cauda* of the *sulcus acusticus* ending furthermost from the ventral edge.....*Selene vomer*

Family SCIAENIDAE

Genus *Cynoscion*

Presents a hump on the dorsal margin, towards the *collum* (where the *ostium* and the *cauda* join); strongly curved tubular *cauda*.....*Cynoscion guatucupa*
Presents a slight ledge on the dorsal edge, toward the *collum*; curled tubular *cauda*.....*Cynoscion jamaicensis*
The otolith's shape is oblong and presents a deep dorsal notch in the medium region of its dorsal margin.....*Cynoscion virescens*

Genus *Menticirrhus*

Ventral region with straight in the middle portion of the *cauda;* lower *ostium* wall longer than the upper.....*Menticirrhus americanus*
Ventral region with a notch in the middle portion of the *cauda;* lower and upper *ostium* wall of equal size.....*Menticirrhus littoralis*

Genus *Stellifer*

The *rostrum* is absent or underdeveloped; the *antirostrum* is developed; the *ostium* is as wide as it is high; the posterior dorsal margin is developed.....*Stellifer brasiliensis*
The *rostrum* is absent; the *antirostrum* is underdeveloped; has a tip in the upper anterior region; the *ostium* is higher than it is wide.....*Stellifer rastrifer*

Genus *Umbrina*

Discoidal to rectangular shape; the *ostium* is lateral, thus presents well marked bends in the wall, both above and below its connection to the *cauda*.....*Umbrina canosai*
Oval shape; the *ostium* is discoidal, the lower bend is larger and rounder.....*Umbrina coroides*

Family SERRANIDAE

Genus *Diplectrum*

Elliptic or lanceolated shape; the *antirostrum* is absent; tubular strongly curved *cauda*.....*Diplectrum formosum*
Fusiform shape; the *antirostrum* is underdeveloped; tubular slightly curved *cauda*.....*Diplectrum radiale*

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The idea of this otolith collection arose many years ago in the mind of the now deceased Prof. Gelso Vazzoler who realized its importance. The number of otoliths has gradually increased in the course of several projects carried out with the collaboration of researchers and students from various research institutions. The organization of the collection and the analysis of the otoliths began its consolidation four years ago when substantial financial support was received from the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP Process-2010/51631-2) which permitted us to improve the laboratory and the equipment and to add to the human resources of the LABIC. Many thanks to everyone who has participated in this long process, especially to Jessica Falchi Caçador, Luana Kushnir Safranauskas, Thais Tiemi Mizutami, Karina Lie Wakassuqui, Amanda Alves Camargo, Deborah Faria Nardi, Marina Casare Mussolini and Alexandre Y. Gomes Arackawa, who (all of whom) helped by making the drawings and taking the measurements of the otoliths.

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