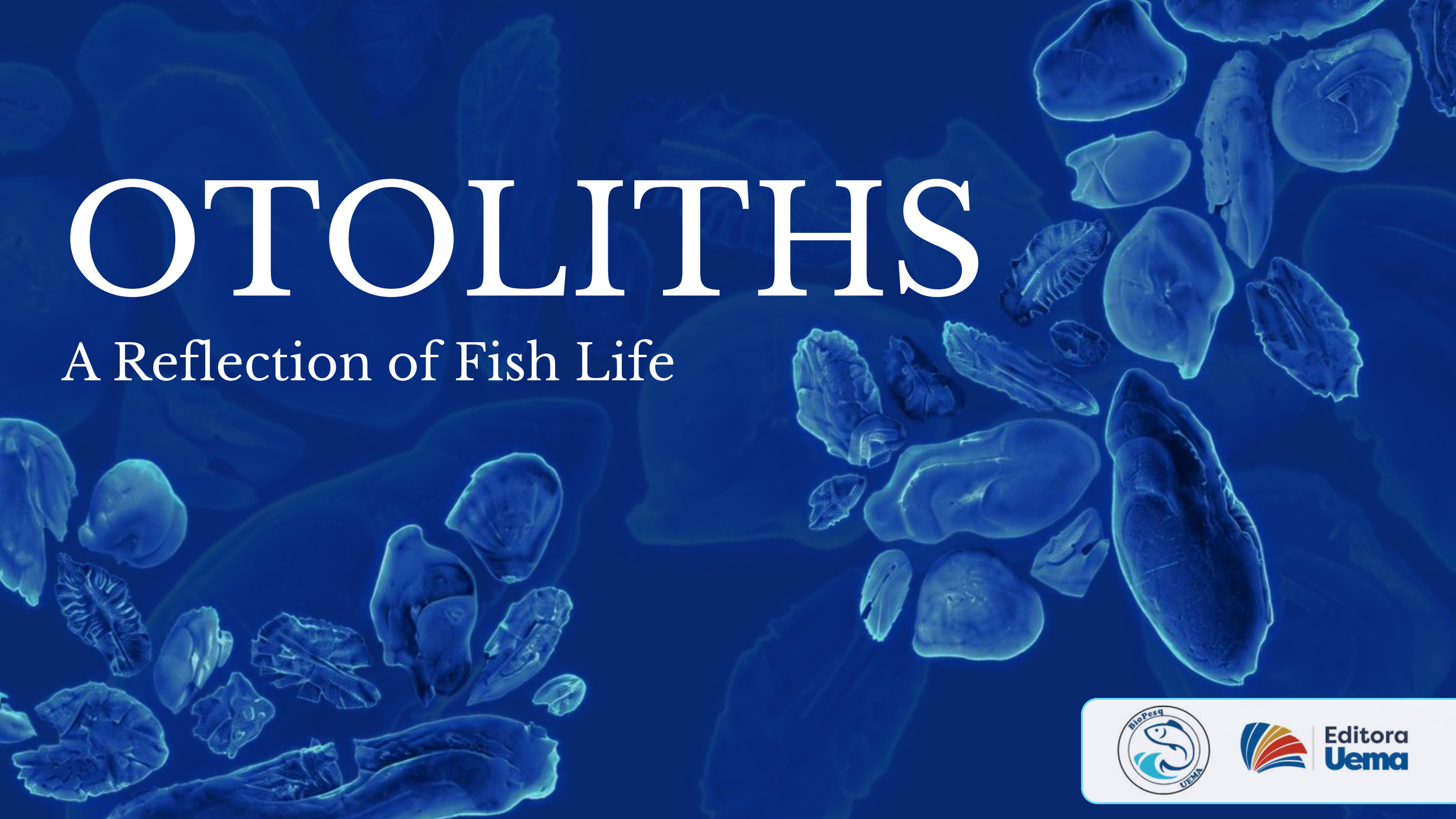
OTOLITHS

A Reflection of Fish Life



BioPesq UEMA

Editora Uema

Otolith: projection of fish life V.2 [recurso eletrônico]./ Carine Mendes Silva, Pedro Leonardo Ribeiro Feitosa; Maira Wilson Paiva Gonçalves, Hozana Sousa Soares, Thiago Campos de Santana, Breno Richard Monteiro Silva, Carla Suelene Garcês Ximendes, Iara Camara e Camara, Willyam Rodrigo Coimbra Teixeira, Ligia Tchaicka, Elmary da Costa Fraga, Marina Bezerra Figueiredo - São Luís, MA: EDUEMA, 2026.

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PRESENTATION

This booklet is the second edition of material developed based on research conducted at the Laboratory of Fisheries Biology (BIOPESQ) at the State University of Maranhão (UEMA). In this edition, the content has been revised and expanded to include new fish species from the "Golfão Maranhense" (the large gulf region of Maranhão) and their respective otoliths.

Through this booklet, we aim to make scientific knowledge more accessible to the fishing community by showing how the small "stones" in a fish's head, known as otoliths, can provide vital information about the fish's growth and life history.

The booklet uses accessible scientific language, complemented by illustrations, to help readers better understand the information presented.

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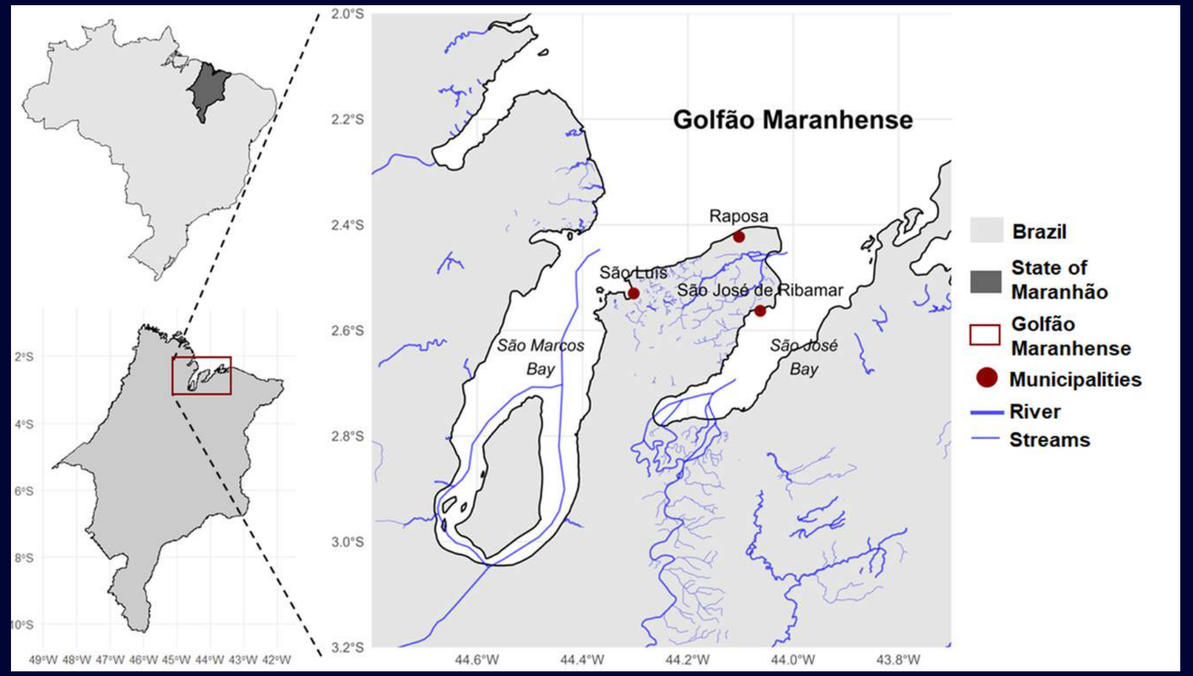
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INTRODUCTION

The "Golfão Maranhense" is one of the most significant estuarine complexes along Brazil's northern coast. It is influenced by the waters of the southwestern South Atlantic and several rivers that flow primarily into the bays of São Marcos and São José (Figure 1). The interaction between freshwater and marine environments, combined with extensive mangrove coverage and large tidal ranges, creates conditions that support a wide diversity of fish. This makes the region an essential nursery area and a vital habitat for various marine and estuarine species (Castro, 1997; Santana *et al*., 2025).

Figure 1. Location of the Golfão Maranhense, State of Maranhão, Brazil.



Source: Own work, 2026.

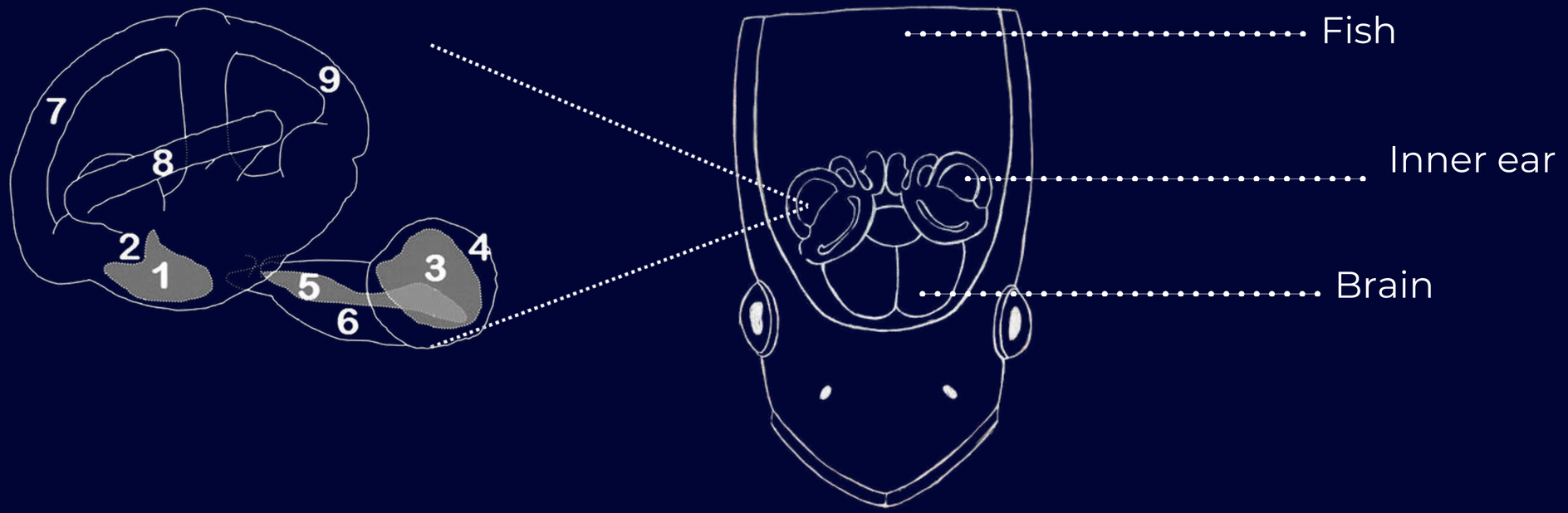
This rich biological diversity supports local artisanal fishing by traditional communities, who rely on these resources for their subsistence and income (Ribeiro *et al*., 2024). However, the region's mangroves face pressures from deforestation, uncontrolled urbanization, pollution, and climate change (Ribeiro *et al*., 2024). This environmental vulnerability underscores the urgent need for studies that expand our knowledge of the local ichthyofauna and help design effective measures to protect threatened species.

In this context, research over the last decade has shifted this landscape, broadening our understanding of fish diversity in the "Golfão Maranhense" (the large gulf region of Maranhão). These include faunal inventories, new records, and the identification of commercially important species (Santana *et al*., 2019, 2025; Vidigal *et al*., 2023; Brito *et al*., 2024; Ferreira *et al*., 2025). Throughout this process, various fish structures, such as otoliths, have proven valuable for species characterization.

Otoliths are crystalline structures found in the inner ear of bony fish. They are composed primarily of calcium carbonate (as aragonite) and organic materials, such as proteins. They develop within the auditory capsules, compartments of the membranous labyrinth, and occur in three symmetrical pairs: the *sagitta* (located in the sacculus), the *lapillus* (in the utriculus), and the *asteriscus* (in the lagena) (Figure 2) (Maciel; Júnior; Lanna, 2021; Dubox *et al*., 2023). Beyond maintaining body balance and perceiving sound, these structures can identify species and inform research on various aspects of a fish's life history (Vaz *et al*., 2023).

Among the three pairs, the sagitta is the most frequently used in research. In most species, it is larger and has more morphological features that facilitate characterization and identification (Oliveira *et al*., 2014). Figures 3 and 4 illustrate the location of the *sagitta* otolith within the saccule during extraction from a *Micropogonias furnieri* specimen (known locally as "cururuca").

Figure 2. Structure of the inner ear of a teleost fish.



Source: Sánchez and Martínez 2017.

1: *Lapillus*, 2: Utricle, 3: *Asteriscus*, 4: Lagena, 5: *Sagitta*, 6: Saccule, 7: anterior semicircular canal, 8: Horizontal semicircular canal, 9: Posterior semicircular canal (Sánchez and Martínez 2017).

Sagitta otolith extraction can be performed in two primary ways: ventral or dorsal. In the dorsal approach, access is gained through the top of the head by opening the cranium to expose the region housing the otoliths (Wakefield; Boddington; Newman, 2016). In the meagre (*Argyrosomus regius*), for instance, the procedure involves two cuts—one longitudinal and one transverse—that remove the top of the head and expose the cranial cavity; the otoliths, located in the posterior ventrolateral region, can then be removed using forceps (Prista *et al*., 2009).

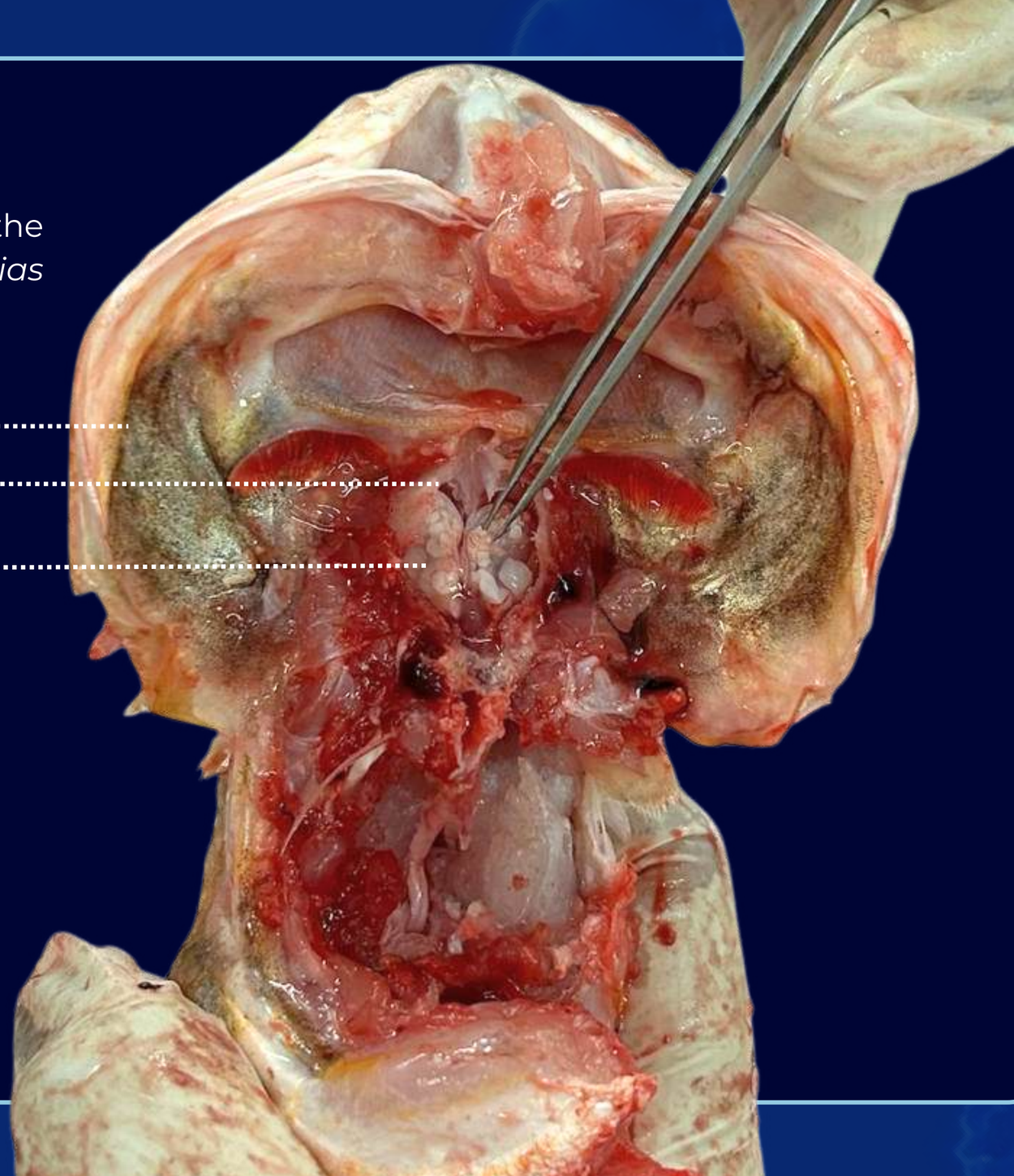
In Figure 3, the opening was made through the top of the head of the *Micropogonias furnieri* specimen without removing the head entirely, allowing visualization of the saccule and the *sagitta* otolith before removing them with forceps. The ventral approach (Figure 4), by contrast, provides access to the otic capsule by removing the gills (Wakefield; Boddington; Newman, 2016).



Figure 3. Representative image showing the extraction of the sagitta otolith from the whitemouth croaker (*Micropogonias furnieri*) through the upper part of the head.

Source: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Figure 4. Representative image showing the extraction of the sagitta otolith from the whitemouth croaker (*Micropogonias furnieri*) through the ventral approach.



Source: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Otoliths grow as concentric layers of calcium carbonate are deposited throughout a fish's development. Environmental characteristics such as depth, substrate type, and water temperature influence this growth, along with diet and the organism's physiological condition, often estimated using a condition factor (Oliveira *et al*., 2009). This environmental influence, combined with interspecific differences, results in characteristic variations in otolith morphology (Mereles *et al*., 2021).

In general, otoliths feature concave, elliptical surfaces; they are laterally compressed and possess a longitudinal acoustic groove (sulcus acusticus) (Oliveira *et al*., 2009). Researchers describe these structures using biometric measurements such as otolith length, height, perimeter, and area, along with measurements of the acoustic groove (Figure 5). Among these variables, otolith length and area are key parameters for estimating fish size (Morales; Lumayno; Babaran, 2025), expanding the utility of otoliths in growth and population characterization studies.

Figure 5. The most commonly used biometric measurements of otoliths.



Source: Lombarte and Tuset (2015).

(A) External outline and acoustic sulcus of the *sagitta* otolith on the inner face. (B) Otolith measurements: OL = otolith length, OH = otolith height, RL = rostrum length, OP = otolith perimeter, OA = otolith area. (C) Acoustic sulcus measurements: SsL = sulcus length, SH = sulcus height, OsL = ostium length, CaL = cauda length, SP = sulcus perimeter, SA = sulcus area, OsA = ostium area, CaA = cauda area. (D) Dorsal view of the outline of the *sagitta* otolith of the sciaenid Otolithes ruber, GO = otolith thickness. A = anterior, D = dorsal, I = inner face (Lombarte and Tuset, 2015).

Beyond their dimensions, otoliths exhibit a wide variety of shapes across species, including oval, elliptical, fusiform, lobed, and discoid forms, among others (Figure 6). This diversity in shape and features makes morphology an important tool for distinguishing between species.

Figure 6. Otolith shapes.



Source: Adapted from: COSS-Brasil. Available at: https://www.usp.br/cossbrasil/index.php.

Consequently, researchers use otoliths in various fields, including morphology, growth, paleoichthyology, stock identification, and systematics (Barzotto *et al*., 2023). Reference catalogs have advanced this field by compiling information on otolith morphology and occurrence across species, including estuarine and marine fish from Ceará (Araújo, 2024).

Compiling and organizing information on the otoliths of fish species found in the Golfão Maranhense (the large gulf region of Maranhão) helps expand our understanding of the region's ichthyofauna and provides easier access to morphological and biometric data. This booklet presents images and characteristics of otoliths from different species, serving as a reference for studies and activities related to identifying and characterizing fish diversity in the Golfão Maranhense.

We invite you to explore these small, precious "stones" found within fish and, through their shapes and contours, glimpse the history and diversity of the Golfão Maranhense ichthyofauna.

Achirus achirus (Linnaeus, 1758)

Common name: Solha



1 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, outer face

Otolith shape: Discoidal

Albula vulpes (Linnaeus, 1758)

Common name: Ubarana-focinho-de-rato



1 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Oblong

Anableps anableps (Linnaeus, 1758)

Common name: Tralhoto



1 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *sagitta* otolith, outer face

Otolith shape: Elliptical

Anchoa spinifer (Valenciennes, 1848)

Common name: Sardinha-amarela



1 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Elliptical

Atherinella brasiliensis (Quoy & Gaimard, 1825)

Common name: João-duro



1 mm

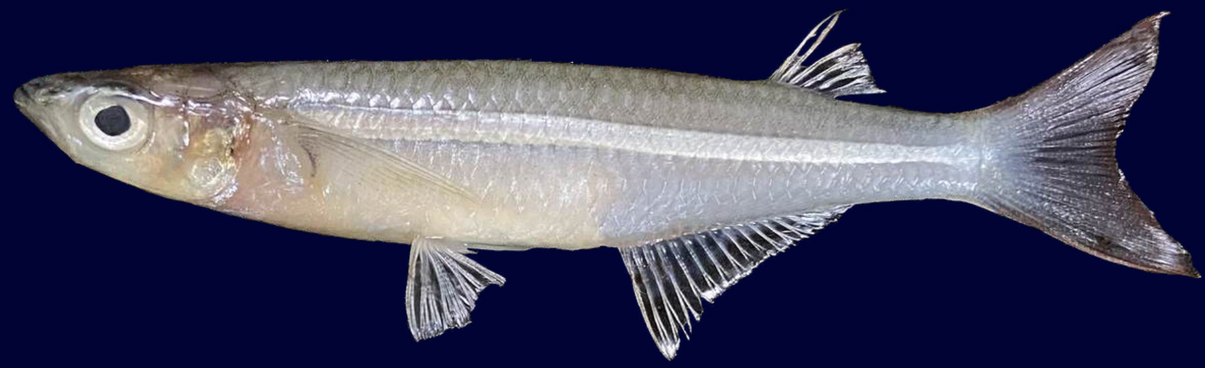


Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Elliptical

Bagre bagre (Linnaeus, 1766)

Common name: Bandeirado



2 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *lapillus* otolith

Otolith shape: Pentagonal

Batrachoides surinamensis (Bloch & Schneider, 1801)

Common name: Pacamão



1 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Reniform

Caranx crysos (Mitchhill, 1815)

Common name: Guarajuba



1 mm



FoFoto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *sagitta* otolith, outer face

Otolith shape: Fusiform

Cathorops agassizii (Eigenmann & Eigenmann, 1888)

Common name: Uriacica-branco



2 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *lapillus* otolith

Otolith shape: Oblong

Cathorops spixii (Agassiz, 1829)

Common name: Uriacica-amarelo



2 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *lapillus* otolith

Otolith shape: Oblong

Cetengraulis edentulus (Cuvier, 1829)

Common name: Sardinha-boca-torta



1 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Pentagonal

Chaetodipterus faber (Broussonet, 1782)

Common name: Paru



1 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Reniform

Chloroscombrus chrysurus (Linnaeus, 1766)

Common name: Favinha



1 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Lanceolate

Conodon nobilis (Linnaeus, 1758)

Common name: Jiquiri-listrado



1 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Elliptical

Cynoscion acoupa (Lacepède, 1801)

Common name: Pescada-amarela



2 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Reniform

Cynoscion leiarchus (Cuvier, 1830)

Common name: Pescada-branca



1 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Elliptical

Cynoscion microlepidotus (Cuvier, 1830)

Common name: Corvina-uçu



2 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Fusiform

Cynoscion virescens (Cuvier, 1830)

Common name: Corvina-cobra



1 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Rod-shaped

Dactylopterus volitans (Linnaeus 1758)

Common name: Coió



1 mm



Left *sagitta* otolith, inner face

Otolith shape: Irregular

Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Genyatremus luteus (Bloch, 1790)

Common name: Peixe-pedra



1 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Square

Gobionellus oceanicus (Pallas, 1770)

Common name: Muré



1 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Square

Gymnothorax funebris (Ranzani, 1839)

Common name: Moreia-verde



1 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Semicircular

Gymnothorax vicinus (Castelnau, 1855)

Common name: Moreia



1 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Lanceolate

Lobotes surinamensis (Bloch, 1790)

Common name: Crauaçu



2 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Rectangular

Lutjanus synagris (Linnaeus, 1758)

Common name: Ariacó



2 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Coniform

Lycengraulis grossidens (Spix & Agassiz, 1829)

Common name: Sardinha-manjuba



1 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Fusiform

Macrodon ancylodon (Bloch & Schneider, 1801)

Common name: Pescada-gó



1 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Rectangular

Menticirrhus cuiaranensis Marceniuk *et al.* (2020)

Common name: Boca-de-rato



1 mm

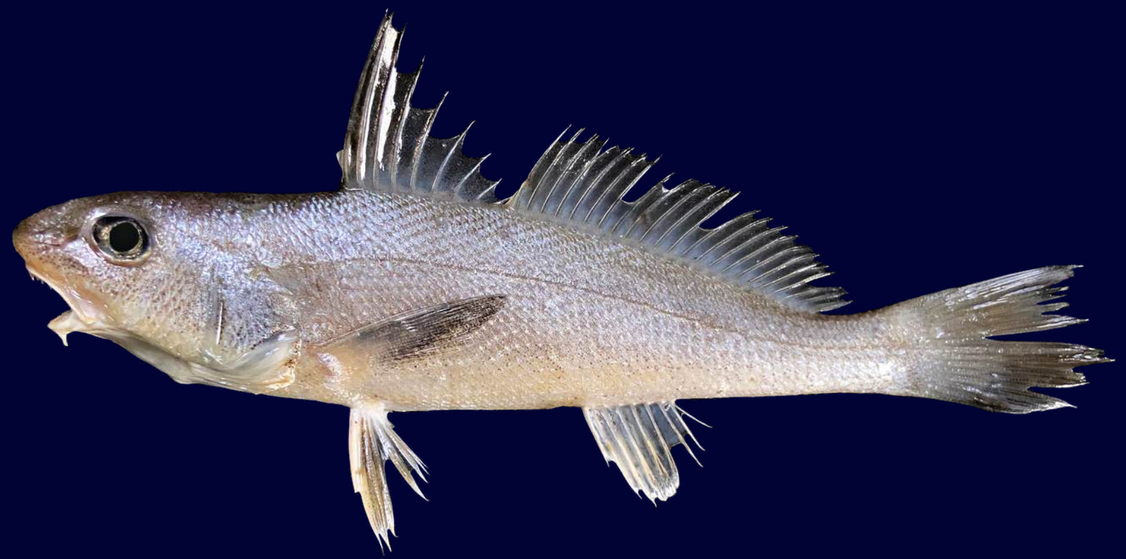


Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Oblong

Micropogonias furnieri (Desmarest, 1823)

Common name: Cururuca



2 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Oval

Mugil brevirostris (Valenciennes, 1836)

Common name: Tainha-pitiua



1 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *sagitta* otolith, inner face
Otolith shape: Elliptical

Mugil curema (Ribeiro, 1915)

Common name: Tainha-sajuba



1 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Elliptical

Mugil incilis (Hancock, 1830)

Common name: Urixoca



1 mm



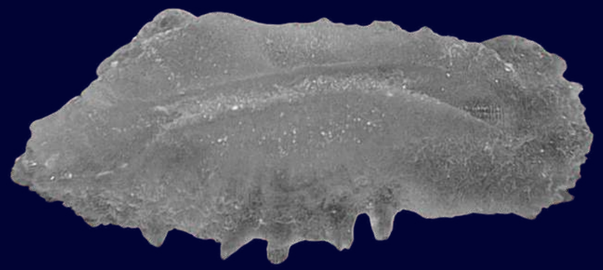
Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Elliptical

Mugil rubrioculus (Harrison, 2007)

Common name: Tainha-sajuba



2 mm

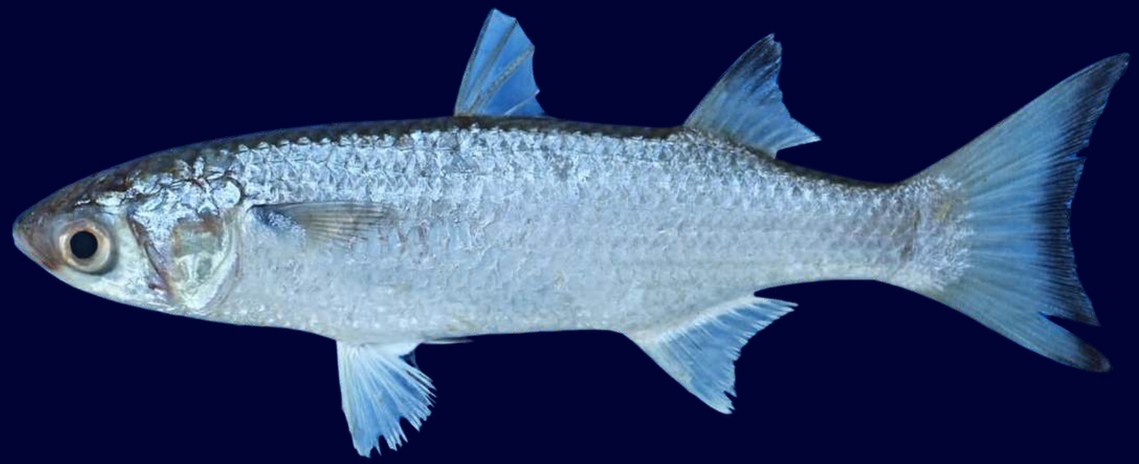


Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face
Otolith shape: Elliptical

Nebris microps (Cuvier, 1830)

Common name: Amor-sem-olho



2 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Rectangular

Notarius rugispinis (Valenciennes, 1840)

Common name: Jurupiranga



2 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *lapillus* otolith

Otolith shape: Triangular

Pellona flavipinnis (Valenciennes,1837)

Common name: Sardinhão



1 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Irregular

Peprilus crenulatus (Cuvier, 1829)

Common name: Arriba-saia



1 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Fusiform

Pomatomus saltatrix (Linnaeus, 1766)

Common name: Enchova



1 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *sagitta* otolith, inner face
Otolith shape: Trapezoidal

Sciades herzbergii (Bloch, 1794)

Common name: Guribu



2 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *lapillus* otolith

Otolith shape: Pentagonal

Sciades proops (Valenciennes, 1840)

Common name: Uritinga



1 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *lapillus* otolith

Otolith shape: Pentagonal

Scomberomorus brasiliensis (Collette, Russo & Zavala-Camin, 1978)

Common name: Peixe-serra



1 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Cuneiform

Selene vomer (Linnaeus, 1758)

Common name: Peixe-galo



1 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Rectangular

Stellifer naso (Jordan, 1889)

Common name: Cabeçudo-preto



1 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Oval

Symphurus tessellatus (Quoy & Gaimard, 1824)

Common name: Linguado



1 mm



Foto: Thiago Santana, Laboratório de Biodiversidade Molecular (LaBiMol-UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Discoidal

Trichiurus lepturus (Linnaeus, 1758)

Common name: Guaravira



1 mm



Foto: Laboratório de Biologia Pesqueira (BioPesq/UEMA).

Left *sagitta* otolith, inner face

Otolith shape: Fusiform

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