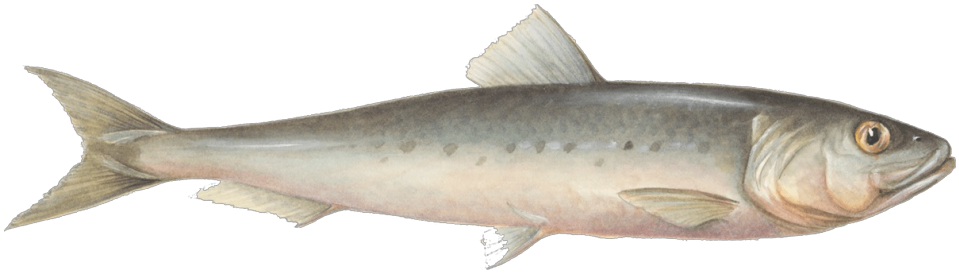
Brazilian sardinella

Sardinella brasiliensis



Brazil, Southwest Atlantic

Purse seines

Report ID 27976

January 9, 2023

Seafood Watch Standard used in this assessment: Fisheries Standard v4

Table of Contents

About Seafood Watch

Monterey Bay Aquarium's Seafood Watch program evaluates the environmental sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Seafood Watch's science-based ratings are available at www.SeafoodWatch.org. Each rating is supported by a Seafood Watch assessment, in which the fishery or aquaculture operation is evaluated using the Seafood Watch standard.

Seafood Watch standards are built on our guiding principles, which outline the necessary environmental sustainability elements for fisheries and aquaculture operations. The guiding principles differ across standards, reflecting the different impacts of fisheries and aquaculture.

- Seafood rated Best Choice comes from sources that operate in a manner that's consistent with our guiding principles. The seafood is caught or farmed in ways that cause little or no harm to other wildlife or the environment.

- Seafood rated Good Alternative comes from sources that align with most of our guiding principles. However, one issue needs substantial improvement, or there's significant uncertainty about the impacts on wildlife or the environment.

- Seafood rated Avoid comes from sources that don't align with our guiding principles. The seafood is caught or farmed in ways that have a high risk of causing harm to wildlife or the environment. There's a critical conservation concern or many issues need substantial improvement.

Each assessment follows an eight-step process, which prioritizes rigor, impartiality, transparency and accessibility. They are conducted by Seafood Watch scientists, in collaboration with scientific, government, industry and conservation experts and are open for public comment prior to publication. Conditions in wild capture fisheries and aquaculture operations can change over time; as such assessments and ratings are updated regularly to reflect current practice.

More information on Seafood Watch guiding principles, standards, assessments and ratings are available at www.SeafoodWatch.org.

Guiding Principles

Seafood Watch defines sustainable seafood as originating from sources, whether fished[1] or farmed, that can maintain or increase production in the long term without jeopardizing the structure or function of affected ecosystems.

The following guiding principles illustrate the qualities that fisheries must possess to be considered sustainable by the Seafood Watch program (these are explained further in the Seafood Watch Standard for Fisheries):

- Follow the principles of ecosystem-based fisheries management.
- Ensure all affected stocks are healthy and abundant.
- Fish all affected stocks at sustainable levels.
- Minimize bycatch.
- Have no more than a negligible impact on any threatened, endangered, or protected species.
- Managed to sustain the long-term productivity of all affected species.
- Avoid negative impacts on the structure, function, or associated biota of aquatic habitats where fishing occurs.
- Maintain the trophic role of all aquatic life.
- Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts.
- Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance, productivity, or genetic integrity of wild stocks.

These guiding principles are operationalized in the four criteria in this standard.Each criterion includes:

- Factors to evaluate and score
- Guidelines for integrating these factors to produce a numerical score and rating

Once a rating has been assigned to each criterion, Seafood Watch develops an overall recommendation. Criteria ratings and the overall recommendation are color coded to correspond to the categories on the Seafood Watch pocket guides and online guide:

Best Choice/Green: Buy first; they're well managed and caught or farmed responsibly.

Good Alternative/Yellow: Buy, but be aware there are concerns with how they're caught, farmed or managed.

Avoid/Red: Take a pass on these for now; they’re caught or farmed in ways that harm other marine life or the environment.

[1] “Fish” is used throughout this document to refer to finfish, shellfish and other invertebrates

Summary

This report addresses the Brazilian sardinella (*Sardinella brasiliensis*) purse seine fishery in the Southeast and South Regions of Brazil. This is the most iconic fishery in Brazil, which faced a severe decline in species abundance and currently displays a multispecific characteristic.

Fisheries statistics for this fishery are available at the state level, and the fishery has a management plan that was published in 2011, making sardinella one of the few target species with a management plan in Brazil. The document involved several stakeholders in the process, including a working group that formulated several actions to recover the species stock; however, most of the information used in the management plan was already outdated upon its publication. The available stock assessment is over 10 years old, but the species has a maximum sustainable yield (MSY) set at 76,000 tons/year. Annual production has been below 50,000 tons/year for the past 8 years.

This fishery is officially divided into three distinct fleets, based on the extended fishing authorization, which includes from 26 to 37 additional target species. The extended fishing authorization is an additional incentive to the closed season of Brazilian sardinella. There is no bycatch listed for this fishery; however, there are records of bycatch of 20 different species of elasmobranchs from when the observer program was active, as well as bycatch of marine mammals (until 2015). Elasmobranchs, marine mammals, and the most representative species in volume from the extended authorization list were included in the assessment; Guiana dolphin limits the score for Criterion 2 because the species is listed as "Vulnerable" by the national red list and there is uncertainty about the level of its interaction with the sardinella fishery.

Management measures for Brazilian sardinella have greatly improved in recent years (e.g., MSY, electronic monitoring, science-based updated closed season, and an active management committee that considers the second-most relevant species in the fishery in its management discussions), although these measures still do not consider the multispecies configuration of the fishery. As a result, many of the secondary species (which, depending on the year, may have catches even greater than those of Brazilian sardinella) do not have any management measure. Liza is one of the secondary species in this fishery and the only species in this report with a stock assessment, which indicates that the species is experiencing overfishing.

Purse seine gear does not affect ocean habitats and ecosystems, but there are concerns that existing management strategies do not seem to support the Brazilian sardinella's ecological role as a forage species.

The purse seine fishery targeting Brazilian sardinella is rated Red or Avoid.

Final Seafood Recommendations

SPECIES | FISHERY	C 1 TARGET SPECIES	C 2 OTHER SPECIES	C 3 MANAGEMENT	C 4 HABITAT	OVERALL	VOLUME (MT) YEAR
Brazilian sardinella | Southwest Atlantic | Purse seines | Brazil	2.644	1.732	1.000	2.828	**Avoid (1.897)**	30,000

Summary

Brazilian sardinella caught in Brazil with purse seines continues to be rated Avoid due to red **Other Species**, **Management**, and **Habitat** ratings. The stock hasn't been assessed in over a decade, and bycatch data is no longer being collected by fishery managers. In addition, based on past bycatch data, the catch of highly vulnerable or overfished species occurs, including Guiana dolphins, turtles, and elasmobranch species (sharks, rays and skates). Even though management of sardinella has greatly improved in recent years, it's rated ineffective overall because the measures are based on outdated or incomplete data. In addition, this fishery targets other vulnerable species that have no conservation measures. Brazilian sardinella is a forage fish (prey for larger predators), and there are no policies to protect this species' important role in the ecosystem. Brazilian sardinella caught in the purse seine fishery in Brazil has an Avoid rating. The Avoid recommendation is a direct result of potential interaction with red-listed Guiana dolphin and existing management measures that do not consider the fishery as multispecific.

Scoring Guide

Scores range from zero to five where zero indicates very poor performance and five indicates the fishing operations have no significant impact.

Final Score = geometric mean of the four Scores (Criterion 1, Criterion 2, Criterion 3, Criterion 4).

Best Choice/Green = Final Score >3.2, and no Red Criteria, and no Critical scores

Good Alternative/Yellow = Final score >2.2-3.2, and neither Harvest Strategy (Factor 3.1) nor Bycatch Management Strategy (Factor 3.2) are Very High Concern2, and no more than one Red Criterion, and no Critical scores

Avoid/Red = Final Score ≤2.2, or either Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern or two or more Red Criteria, or one or more Critical scores.

[2] Because effective management is an essential component of sustainable fisheries, Seafood Watch issues an Avoid recommendation for any fishery scored as a Very High Concern for either factor under Management (Criterion 3).

Introduction

Scope of the analysis and ensuing recommendation

This report assessed Brazilian sardinella (*Sardinella brasiliensis*) targeted by the purse seine fishery in the Southeast and South Regions of Brazil. This is the most iconic fishery in Brazil, which has been facing a severe decline in abundance for the past decades and now reflects a multispecies fishery.

Species Overview

Brazilian sardinella belongs to the family Clupeidae and is geographically isolated from other *Sardinella* species in the Atlantic Ocean (Cergole & Dias Neto 2011). This species is found in coastal waters, often forming compact schools that are heavily influenced by oceanographic conditions (Moraes 2012). Through a molecular analysis of mitochondrial DNA that compared specimens collected from several regions of occurrence of individuals of the genus *Sardinella*, it was verified that *S. brasiliensis* is co-specific of *S. aurita*, which is represented by genetically identifiable populations on the west coast of the South Atlantic {Tringali and Wilson Jr. 1993}. But today, there is evidence showing the existence of two different population units, considering the geographical extremes of the species' fishing area in Brazil, which are likely related to oceanographic conditions that ultimately affect distinct feeding regimes and fish growth (Schroeder et al. 2021).

Brazilian sardinella is a coastal pelagic species that prefers shallow and warm waters (22 °C or warmer) and is highly migratory. It is found in large, compact schools, swimming near the surface. Brazilian sardinella filters the zooplankton (mainly copepods) from which it feeds. Juveniles live in nursery areas, such as mangroves, and feed on phytoplankton. Reproduction occurs throughout the year, and in some regions there are two spawning periods. The spawning seasons are protected in Brazil through specific legislation (closed season), which was first established in 2009 with two closed seasons and then altered in 2020 with a single closed season from October 1 through February 28 (Brasil 2020).

Brazilian sardinella is the main small-pelagic species exploited in Brazil, and the fishery is carried out by the purse seine fleet that operates throughout the species' distribution range, between Cape São Tomé (22° S.) and the region at 32° S. in the state of Rio Grande do Sul (MAPA-SAP 2021). The southernmost section of the species' range is believed to be a recent expansion of its distribution (which was originally restricted to Cape Santa Marta at 28° S. to 29° S. in the south (Cergole & Dias Neto 2011)), also leading to the extension of fishing vessel operation (MAPA-SAP 2021).

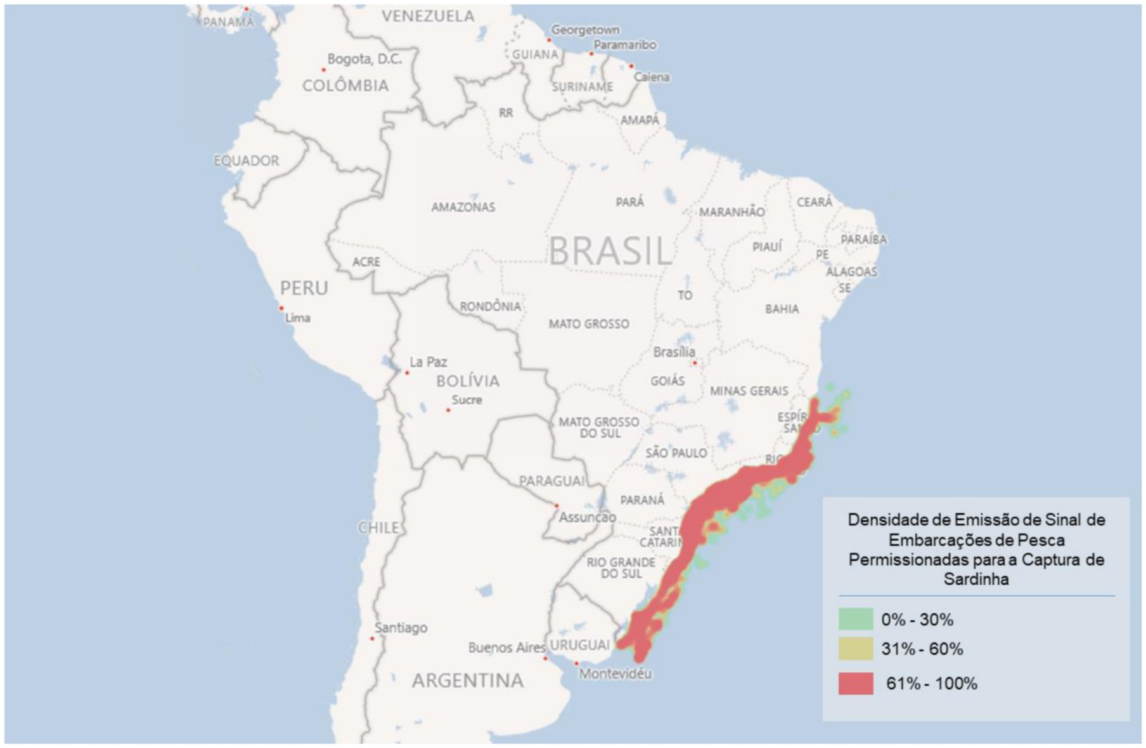


Figure 1: Density of signal emission from fishing vessels licensed to target Brazilian sardinella in 2021 (CONAB 2022).

Production Statistics

The Brazilian sardinella fishery gained industrial proportions in the 1960s, reaching a record production of 228,000 mt in 1973 (Moraes 2012). Since then, the production history has been characterized by large oscillations, including a few collapses in the late 1980s (32,000 mt) and 1990 (17,000 mt). In 2017, the main company involved in the exploration and trade of Brazilian sardinella closed temporarily due to a lack of fish (pers. comm., R. Barreto 2017). In the same year, three institutions (Universidade do Vale do Itajaí, Instituto de Pesca de São Paulo, and Fundação Instituto de Pesca do Rio de Janeiro) started to monitor landings in the Southeast and South Regions as a condition of the Oil & Gas environmental licensing (Instituto de Pesca de São Paulo 2022)(FIPERJ 2022)(UNIVALI/EMCT/LEMA 2020). These institutions were already involved in monitoring landings before 2017; however, effort was discontinuous in some states. After an extreme El Niño event, production went as low as 15,000 mt in 2019, when the federal government created a tax-free importing quota of 60,000 mt to compensate for the low production after 3 consecutive years (MAPA-SAP 2021)(Brasil 2019). For the past 2 years, production has been around 30,000 mt/year (MAPA-SAP 2021). Despite Brazilian sardinella being the main target for purse seine fisheries, other species began to be caught in these fisheries starting in the 1990s, as a response to Brazilian sardinella's stock decline (Dias 2012). Some of these species now represent great importance for this fleet, and most of them are being captured during closed seasons for the Brazilian sardinella (Cergole & Dias Neto 2011)(Dias 2012). The composition of secondary species may vary from year to year, because most of them are also targeted in other fisheries, and a variety of nontarget species can also be explained by different conservation methods used in vessels (Schroeder et al. 2022).

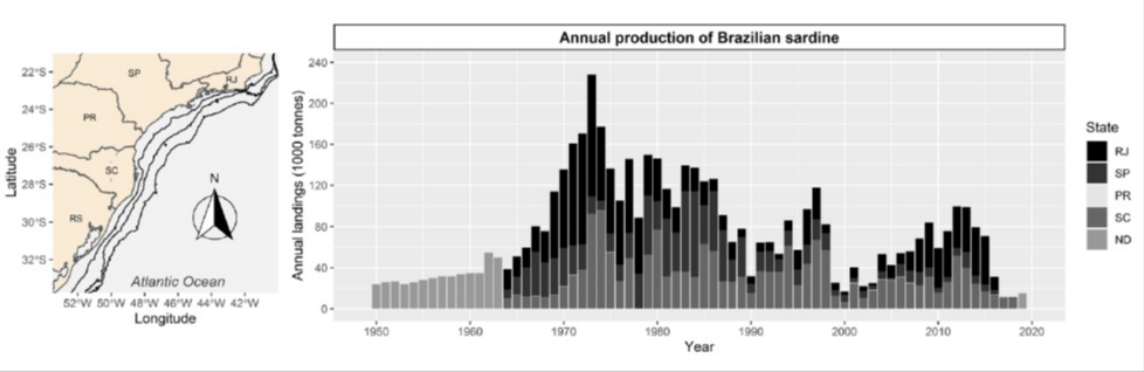


Figure 2: Historical annual production series of Brazilian sardinella. State: RJ—Rio de Janeiro; SP—Sao Paulo; PR—Parana; SC—Santa Catarina; RS—Rio Grande do Sul; ND—Total landed volume without discrimination per state (Schroeder et al. 2022).

Importance to the US/North American market.

Most of the Brazilian sardinella caught in Brazil is used in the national canning industry, but some volume is exported to the United States, mainly in frozen form, with a significant increase in 2021 (Figure 3) (COMEXSTAT 2022). Trade data from both Brazil and the United States are not differentiated by species; therefore, Brazilian sardinella may be grouped with other similar species (e.g., *Sardina pilchardus*, *Sardinops* spp., *Sardinella* spp.). Under the data category (HS Code 03035300), Brazil is only the ninth most relevant exporter to the U.S. market, being responsible for around 1% of all exports under this category in 2021 (Table 1) (U.S. Census Bureau 2022).

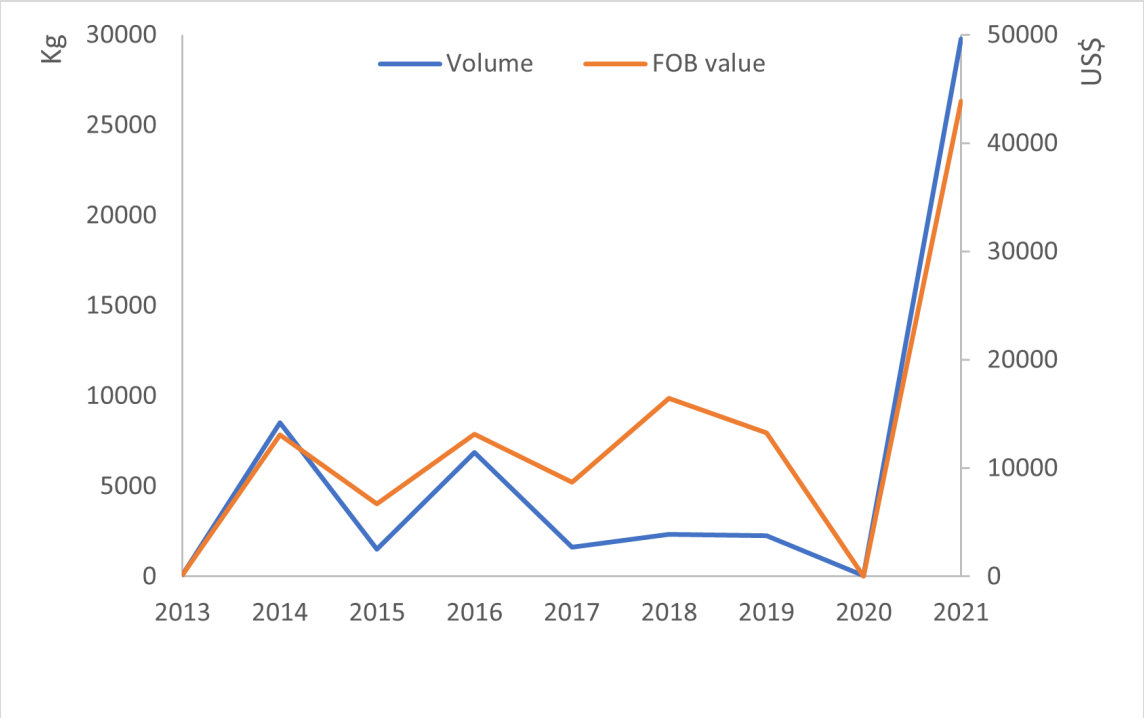


Figure 3: Volume of sardine/sardinella exports from Brazil to the United States from 2013 to 2021. Volume data (on the left) are in kilograms, and FOB export values (on the right) in USD (COMEXSTAT 2022).

Table 1. Imports of frozen sardines/sardinella by the U.S. market in 2021 (U.S. Census Bureau 2022)

Country	Customs Value (US$)	Quantity (kg)
Mali	3,888,615	7,470,292
Panama	1,217,058	419,675
Mexico	290,521	281,751
India	247,709	128,042
Iran	107,367	122,780
New Zealand	98,580	120,609
China	93,664	41,169
Slovakia	53,399	29,220
Brazil	47,564	26,150
Tunisia	45,400	23,587
Australia	45,369	22,893
Indonesia	38,280	19,125

Sudan	21,038	14,200
Bangladesh	20,211	8,560
Oman	20,000	4,212
Nicaragua	19,880	4,000
Greece	9,857	3,215
Croatia	6,992	1,364
Suriname	2,125	850
World Total	6,273,629	8,741,694

Common and market names.

Brazilian sardinella may be commonly referred to as orangespot sardine in the United States and Puerto Rico (Froese & Pauly 2017).

Primary product forms

Brazilian sardinella is sold whole, fresh/chilled, or frozen (COMEXSTAT 2022), and mainly in canned form (Cergole & Dias Neto 2011).

Assessment

This section assesses the sustainability of the fishery(s) relative to the Seafood Watch Standard for Fisheries, available at www.seafoodwatch.org. The specific standard used is referenced on the title page of all Seafood Watch assessments.

Criterion 1: Impacts on the species under assessment

This criterion evaluates the impact of fishing mortality on the species, given its current abundance. When abundance is unknown, abundance is scored based on the species' inherent vulnerability, which is calculated using a Productivity-Susceptibility Analysis. The final Criterion 1 score is determined by taking the geometric mean of the abundance and fishing mortality scores. The Criterion 1 rating is determined as follows:

- ***Score >3.2=Green or Low Concern***
- ***Score >2.2 and ≤3.2=Yellow or Moderate Concern***
- ***Score ≤2.2 = Red or High Concern***

Rating is Critical if Factor 1.3 (Fishing Mortality) is Critical.

Guiding principles

- *Ensure all affected stocks are healthy and abundant.*
- *Fish all affected stocks at sustainable level*

Criterion 1 Summary

BRAZILIAN SARDINELLA			
REGION / METHOD	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Southwest Atlantic | Purse seines | Brazil	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)

Criterion 1 Assessments

SCORING GUIDELINES

Factor 1.1 - Abundance
Goal: Stock abundance and size structure of native species is maintained at a level that does not impair recruitment or productivity.

- *5 (Very Low Concern) — Strong evidence exists that the population is above an appropriate target abundance level (given the species' ecological role), or near virgin biomass.*
- *3.67 (Low Concern) — Population may be below target abundance level, but is at least 75% of the target level, OR data-limited assessments suggest population is healthy and species is not highly vulnerable.*
- *2.33 (Moderate Concern) — Population is not overfished but may be below 75% of the target abundance level, OR abundance is unknown and the species is not highly vulnerable.*
- *1 (High Concern) — Population is considered overfished/depleted, a species of concern, threatened or endangered, OR abundance is unknown and species is highly vulnerable.*

Factor 1.2 - Fishing Mortality
Goal: Fishing mortality is appropriate for current state of the stock.

- *5 (Low Concern) — Probable (>50%) that fishing mortality from all sources is at or below a sustainable level, given the species ecological role, OR fishery does not target species and fishing mortality is low enough to not adversely affect its population.*
- *3 (Moderate Concern) — Fishing mortality is fluctuating around sustainable levels, OR fishing mortality relative to a sustainable level is uncertain.*
- *1 (High Concern) — Probable that fishing mortality from all source is above a sustainable level.*

Brazilian sardinella

Factor 1.1 - Abundance

Southwest Atlantic | Purse seines | Brazil

Moderate Concern

Brazilian sardinella is a coastal, pelagic species occurring between Cape São Tomé (22° S.) and the region at 32° S. in the state of Rio Grande do Sul (MAPA-SAP 2021). Recent studies show the existence of two different population units, considering the geographical extremes of the species' fishing area in Brazil, which are likely related to oceanographic conditions that ultimately affect distinct feeding regimes and fish growth (Schroeder et al. 2021). Despite several advances in the knowledge of the species over the recent years (e.g., (Martins et al. 2021)(Schroeder et al. 2021) (MAPA-SAP 2021)(Schwingel et al. 2022)(Schroeder et al. 2022)(CONAB 2022)), there are no recent estimates for biomass. The latest stock assessment showed a critical condition of the stock (SSB_{2010} = 62,569 mt, compared to an even older assessment, SSB_{1997} = 131,000 mt; historically, the stock biomass was estimated at 670,000 mt in the 1970s) (Cergole & Dias Neto 2011)(Cergole 1995). The species is currently listed as "Data Deficient" by the International Union for the Conservation of Nature (IUCN) (Di Dario 2018). Because of a lack of updated information regarding biomass estimates, a productivity-susceptibility analysis (PSA) was used to infer the species' vulnerability. The PSA score (2.97) indicates a medium vulnerability rating, which deems this factor a moderate concern.

Justification:

Productivity Attributes	Value	Score (1 = low risk; 2 = medium risk; 3 = high risk)	Reference
Average age at maturity; Tm (years)	1.1	1	(MAPA-SAP 2021)
von Bertalanffy (K) Fish only	0.524	1	(Vaz-dos-Santos and Schwingel 2019)
Average maximum age; Tmax (years) Inverts only when you know Lmax for finfish (Col. J)	5	1	(MAPA-SAP 2021)
Fecundity (eggs/year)	20,000–35,000	1	(Isaac-Nahum et al. 1988)
Average maximum size; Lmax (cm) (fish only)	27	1	{Froese and Pauly 2017}
Average size at maturity; Lm (cm) (fish only)	19.2	1	{Froese and Pauly 2017}
Reproductive strategy	Broadcast spawner	1	(Cergole & Dias Neto 2011)
Density dependence (inverts only)	NA		
Productivity Subscore		1	

Susceptibility Attribute	Information	Score (1 = low risk; 2 = medium risk; 3 = high risk)	Reference
Areal overlap	There is high overlap among the fishery and species.	3	
Vertical overlap	There is high overlap among the fishery and species.	3	
Seasonality	Default score was used.	3	
Selectivity	Default score was used.	2	
Post-capture mortality	Default score (species is retained).	3	
Susceptibility Subscore		2.8	
Productivity-Susceptibility Score	**2.97**		
Vulnerability Rating (high, medium, or low)	**Medium**		

Factor 1.2 - Fishing Mortality

Southwest Atlantic | Purse seines | Brazil

Moderate Concern

The most recent (2021) federal committee report for Brazilian sardinella presents a maximum sustainable yield (MSY) set at 75,985 mt (Schaefer model at 50% of carrying capacity) (MAPA-SAP 2021). Annual production has been an average of 50,000 t (1992–2021). In the past decades, two extreme El Niño events seem to have directly affected sardinella production (Figure 4) (MAPA-SAP 2021). Since 2016, annual production has been below 50,000 t, and in the past 2 years were 34,000 t (2020) and 33,000 t (2021) (MAPA-SAP 2021). Although annual production has been much lower than MSY, there is high uncertainty for forage species about setting fishing mortality thresholds low enough to prevent collapse during periods of low productivity. Therefore, this factor receives a score of moderate concern.

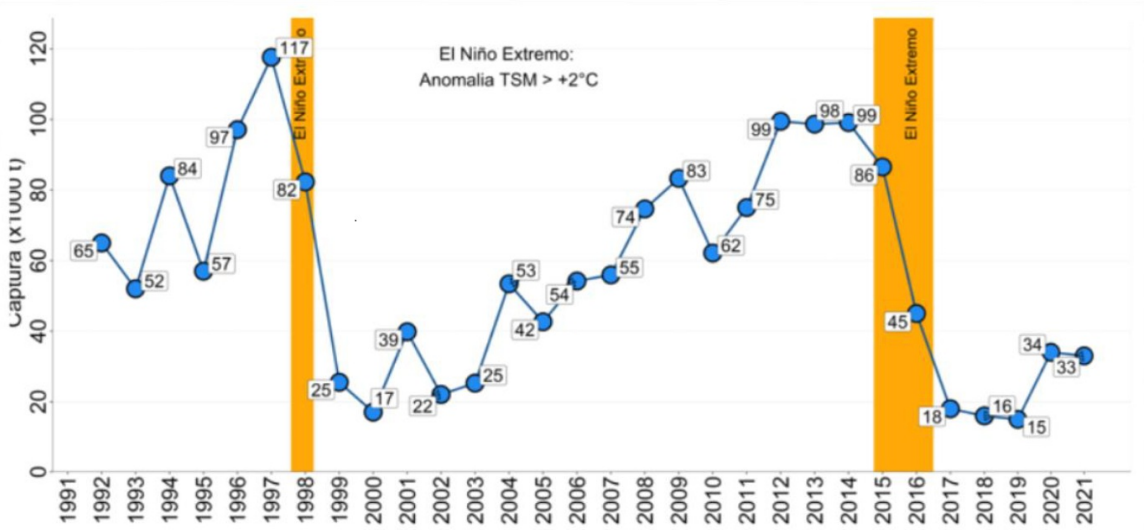


Figure 4: Annual catch of Brazilian sardinella in Brazil between 1992 and 2021 (in 1000 metric tons), and extreme El Niño events (yellow bars). From (MAPA-SAP 2021).

Criterion 2: Impacts on Other Species

All main retained and bycatch species in the fishery are evaluated under Criterion 2. Seafood Watch defines bycatch as all fisheries-related mortality or injury to species other than the retained catch. Examples include discards, endangered or threatened species catch, and ghost fishing. Species are evaluated using the same guidelines as in Criterion 1. When information on other species caught in the fishery is unavailable, the fishery's potential impacts on other species is scored according to the Unknown Bycatch Matrices, which are based on a synthesis of peer-reviewed literature and expert opinion on the bycatch impacts of each gear type. The fishery is also scored for the amount of non-retained catch (discards) and bait use relative to the retained catch. To determine the final Criterion 2 score, the score for the lowest scoring retained/bycatch species is multiplied by the discard/bait score. The Criterion 2 rating is determined as follows:

- ***Score >3.2=Green or Low Concern***
- ***Score >2.2 and ≤3.2=Yellow or Moderate Concern***
- ***Score ≤2.2 = Red or High Concern***

Rating is Critical if Factor 2.3 (Fishing Mortality) is Crtitical

Guiding principles

- *Ensure all affected stocks are healthy and abundant.*
- *Fish all affected stocks at sustainable level.*
- *Minimize bycatch.*

Criterion 2 Summary

Criterion 2 score(s) overview

This table(s) provides an overview of the Criterion 2 subscore, discards+bait modifier, and final Criterion 2 score for each fishery. A separate table is provided for each species/stock that we want an overall rating for.

BRAZILIAN SARDINELLA			
REGION / METHOD	**SUB SCORE**	**DISCARD RATE/LANDINGS**	**SCORE**
Southwest Atlantic | Purse seines | Brazil	1.732	1.000: < 100%	Red (1.732)

Criterion 2 main assessed species/stocks table(s)

This table(s) provides a list of all species/stocks included in this assessment for each 'fishery' (as defined by a region/method combination). The text following this table(s) provides an explanation of the reasons the listed species were selected for inclusion in the assessment.

SOUTHWEST ATLANTIC | PURSE SEINES | BRAZIL			
SUB SCORE: 1.732	DISCARD RATE: 1.000	**SCORE: 1.732**	
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Guiana dolphin	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Finfish	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Loggerhead turtle	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Sharks	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Atlantic anchoveta	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Atlantic bumper	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Atlantic chub mackerel	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Atlantic thread herring	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Brazilian menhaden	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Brazilian sardinella	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Liza	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

The purse seine fishery targeting Brazilian sardinella is officially divided into three distinct fleets, mainly because of each fleet's extended fishing authorization, which may vary between 26 and 37 additional species (Brasil 2011)(Brasil 2020b). Such complementary fishing authorization enables the vessels to target different species throughout the year, particularly during the Brazilian sardinella closed season that now extends for 5 months (Brasil 2020). Because the observer program has been suspended by the federal government for

more than 5 years, we relied on landings data from the states of São Paulo, Rio de Janeiro, and Santa Catarina from 2016 to 2021 and included all species with a landing volume at least 5% of the total weight reported (Table 2). These are the states with the most representative volume for this fishery (MAPA-SAP 2021)(Martins et al. 2021).

Table 2: Contribution of main species in total landings from 2016 to 2021 in the Brazilian sardinella purse seine fisheries. Species mentioned are the ones that accounted for at least 5% of total volume in a given year, based on landings data from the states of São Paulo and Santa Catarina. Sources: PMAP-Univali and Propesq-Instituto de Pesca search engines (http://propesqweb.acad.univali.br/usuarioexterno/ , http://www.propesq.pesca.sp.gov.br/usuarioexterno/).

Year	Species	Landings (mt)	Landings (% by year)
2016	*Sardinella brasiliensis*	18,865	68%
	Atlantic thread herring	3,963	14%
2017	*Sardinella brasiliensis*	11,920	37%
	Atlantic thread herring	9,493	30%
	Atlantic bumper	5,224	16%
2018	*Sardinella brasiliensis*	13,192	37%
	Atlantic thread herring	9,217	26%
	Atlantic bumper	4,392	12%
	Liza	4,775	13%
2019	Atlantic thread herring	15,585	42%
	Sardinella brasiliensis	11,023	30%
	Atlantic bumper	4,217	11%
2020	*Sardinella brasiliensis*	15,290	52%
	Atlantic thread herring	4,847	16%
	Chub mackerel	4,730	16%
	Atlantic bumper	2,868	10%
2021	*Sardinella brasiliensis*	17,302	51%
	Atlantic thread herring	6,869	20%
	Atlantic bumper	4,759	14%

Purse seines in the state of Rio de Janeiro, in both small-scale as well as industrial fishing, are responsible for the largest seafood volumes compared to other gears within the state. The methodology used to estimate production volume in Rio differs from that in other states (as shown in Table 2), because a sampling methodology is used instead of total values (FIPERJ 2022b). Therefore, depending on the region where sampling was taken, a given species might be under- or overestimated in the percentage from total volumes. Monitoring reports from Rio indicate that Atlantic anchoveta and Brazilian menhaden are important resources in the small-scale purse seine fishery in the state, whereas Atlantic anchoveta and Atlantic thread herring are also significant in volume for the industrial fleet (FIPERJ 2022b).

Although the official fishery authorization does not mention any bycatch for this fishery (Brasil 2011)(Dias 2021), observer data from up to 2015 mention catches of 20 different species of elasmobranchs (Schroeder et al. 2022). Because elasmobranchs are a poorly studied group in this fishery and many of these species are of concern, this group was also included in our analysis. The same observer data study points out other species groups (including bony fish, marine mammals, and sea turtles) that are currently either red-listed or near threatened. The species of concern mentioned in observer data are listed in Table 3.

Table 3: Species of concern (IUCN status of "Near Threatened"—NT, "Vulnerable"—VU, "Endangered"—EN, or "Critically Endangered"—CR) that interact with the Brazilian sardinella purse seine fishery. TC = total catch. Retained and Discarded are displayed as percentages. Frequency: O = occasional (<0.01% of total catch), R = rare. From (Schroeder et al. 2022).

Group	Family	Species	Common name	TC (Tonnes)	%TC	Retained	Discarded	Frequency	IUCN
Elasmobranchs	Squatinidae	*Squatina guggenheim*	Spiny angel shark			21	79	O	EN
	Odontaspididae	*Carcharias taurus*	Sand tiger shark			43	57	O	CR
	Carcharhinidae	*Carcharhinus longimanus*	Oceanic whitetip shark			33	67	R	VU
	Sphyrnidae	*Sphyrna lewini*	Scalloped hammerhead shark			29	71	O	VU
	Rhinobatidae	*Zapteryx brevirostris*	Lesser guitarfish			0	100	O	VU
	Arhynchobatidae	*Atlantoraja cyclophora*	Eyespot skate			33	67	O	VU
		Atlantoraja platana	La Plata skate			17	83	O	VU
		Rioraja agassizii	Rio skate	0.0025	0.00006	17	83	O	VU
		Sympterygia acuta	Bignose fanskate			17	83	O	VU
	Gymnuridae	*Gymnura altavela*	Spiny butterfly ray			17	83	O	VU
Bony fish	Syngnathidae	*Hippocampus erectus*	Lined sea horse			0	100	O	VU
	Serranidae	*Epinephelus marginatus*	Dusky grouper			67	33	R	VU
	Pomatomidae	*Pomatomus saltatrix*	Bluefish	0.002	0.00005	100	0	O	VU
	Lutjanidae	*Rhomboplites aurorubens*	Vermilion snapper			44	56	R	VU
	Scombridae	*Thunnus alalunga*	Albacore			50	50	R	NT

		Thunnus albacares	Yellowfin tuna			50	50	R	NT
	Xiphiidae	*Xiphias gladius*	Swordfish			28	72	R	EN
	Balistidae	*Balistes capriscus*	Grey triggerfish			83	17	O	VU
Turtle	Cheloniidae	*Caretta caretta*	Loggerhead sea turtle			0	100	O	VU
Mammal	Delphinidae	*Sotalia guianensis*	Guiana dolphin			0	100	O	NT

Following the rationale above, we assessed Atlantic thread herring, Atlantic bumper, Atlantic anchoveta, Atlantic chub mackerel, Brazilian menhaden, mullet, elasmobranchs, Guiana dolphin, loggerhead sea turtle, and finfish (comprising species of concern from the above list) for C2 species.

Guiana dolphin limits the score for Criterion 2 because the species is listed as "Vulnerable" by the national red list and there is uncertainty about the level of its interaction with the sardinella fishery.

Criterion 2 Assessment

SCORING GUIDELINES

Factor 2.1 - Abundance
(same as Factor 1.1 above)

Factor 2.2 - Fishing Mortality
(same as Factor 1.2 above)

Factor 2.3 - Modifying Factor: Discards and Bait Use
Goal: Fishery optimizes the utilization of marine and freshwater resources by minimizing post-harvest loss. For fisheries that use bait, bait is used efficiently.

Scoring Guidelines: The discard rate is the sum of all dead discards (i.e. non-retained catch) plus bait use divided by the total retained catch.

Ratio of bait + discards/landings	Factor 2.3 score
<100%	1
>=100	0.75

Atlantic anchoveta

Factor 2.1 - Abundance

Southwest Atlantic | Purse seines | Brazil

Moderate Concern

Atlantic anchoveta is one of the main species in the state of Rio de Janeiro purse seine fishery (MAPA-SAP 2021) because it is an important resource, particularly for small-scale purse seiners operating in estuaries (Jablonski et al. 2006)(FIPERJ 2013). A recent stock assessment is not available for the species (Dias 2021b). It is listed as "Least Concern" by the IUCN Red List (Munroe et al. 2015), so it is scored a moderate concern.

Factor 2.2 - Fishing Mortality

Southwest Atlantic | Purse seines | Brazil

Moderate Concern

Both Atlantic anchoveta and Brazilian menhaden are part of the main components in the purse seine fishery in the state of Rio de Janeiro (Martins et al. 2021). Atlantic anchoveta has a recent estimate for fishing mortality within one section of its range (F = 0.30 in Guanabara Bay), and this value was likely underestimated due to the gears used in the assessment (Santos et al. 2020). Fishing mortality for Brazilian menhaden is unknown. During 2018–19, which was characterized by a low production of Brazilian sardinella, particularly in the Southeast Region, Atlantic anchoveta became the main species caught by the fleet in Rio de Janeiro, whereas Brazilian menhaden was the second most caught species in 2019 there (Martins et al. 2021). These two species are traditional resources for small-scale purse seine fishers operating in estuaries, particularly in the metropolitan and south regions in the state of Rio de Janeiro (Jablonski et al. 2006)(FIPERJ 2013).

Because fishing mortality is unknown for Brazilian menhaden and likely underestimated for Atlantic anchoveta, and the likelihood of overfishing cannot be assessed, this factor receives a score of moderate concern.

Atlantic bumper

Factor 2.1 - Abundance

Southwest Atlantic | Purse seines | Brazil

Moderate Concern

Atlantic bumper is one of the most significant components of the Brazilian sardinella purse seine fishery, except for the northernmost area of its distribution (Martins et al. 2021)), along with Atlantic thread herring and chub mackerel (Petermann & Schwingel 2016). A formal stock assessment and abundance data are not available for Atlantic bumper. It is listed as "Least Concern" by the IUCN Red List (Smith-Vaniz et al. 2015c), so it is scored a moderate concern.

Factor 2.2 - Fishing Mortality

Southwest Atlantic | Purse seines | Brazil

Moderate Concern

Fishing mortality is unknown for Atlantic thread herring, Atlantic bumper, and chub mackerel. These species are the second, the third, and the fifth most relevant species, respectively, in the Brazilian sardinella fishery by landing volume (see the Criterion 2 Synthesis). From 2016 to 2021, Atlantic thread herring accounted for 16%–42% of the total landing volumes, Atlantic bumper accounted for 10%–16%, and chub mackerel accounted for 16%. Atlantic bumper is less relevant in landings in the state of Rio de Janeiro (Martins et al. 2021). Because F is unknown and overfishing cannot be inferred because of a lack of data, this factor is scored a moderate concern.

Atlantic chub mackerel

Factor 2.1 - Abundance

Southwest Atlantic | Purse seines | Brazil

Moderate Concern

Chub mackerel is one of the most significant components of the Brazilian sardinella purse seine fishery, along with Atlantic thread herring and Atlantic bumper {Petermann and Schwingel 2016}. This species is often mistaken for the Pacific chub mackerel (*Scomber japonicus*), which made some available information misleading (Collette et al. 2011). Currently, the accepted species for the Atlantic Ocean is *Scomber colias* (Eschmeyer et al. 2018). The species is listed as "Least Concern" by the IUCN (Collette et al. 2011) and by the 2018 national red list update (SiBBr 2022). The IUCN assessment is over 10 years old and the national red list is based on that assessment, so these sources are too old to use for scoring. Therefore, a productivity-susceptibility analysis (PSA) was used for the species. Some of the species information required for the PSA was unavailable. The PSA score equals 3.16, so the species is deemed to have a medium vulnerability. Detailed scoring of each attribute is shown below. Chub mackerel has as medium vulnerability (according to the PSA analysis), so abundance is scored a moderate concern.

Justification:

Productivity Attributes	Value	Score (1 = low risk; 2 = medium risk; 3 = high risk)	Reference
Average age at maturity; Tm (years)	1	1	(Magro et al. 2000)
von Bertalanffy (K) Fish only	NA		
Average maximum age; Tmax (years) Inverts only when you know Lmax for finfish (Col. J)	NA		
Fecundity (eggs/year)	NA		
Average maximum size; Lmax (cm) (fish only)	45	1	(Magro et al. 2000)

Average size at maturity; Lm (cm) (fish only)	24.7 females; 26.2 males	1	(Coelho 2015)
Reproductive strategy	Broadcast spawner	1	(Froese & Pauly 2017)
Density dependence (inverts only)	NA		
Productivity Subscore		1	

Susceptibility Attribute	**Information**	**Score (1 = low risk; 2 = medium risk; 3 = high risk)**	**Reference**
Areal overlap	Default score was used	3	
Vertical overlap	Default score was used	3	
Seasonality	Default score was used	3	
Selectivity	Juveniles are known to concentrate in the same areas where the purse seine fishery targeting Brazilian sardinella takes place (along the entire Southeast and South Regions). Studies on biological parameters usually miss younger individuals because of the purse seine fishery's pressure over them.	3	(Simãozinho 2011)
Post-capture mortality	Default score was used	3	
Susceptibility Subscore		3	
Productivity-Susceptibility Score	**3.16**		
Vulnerability Rating (high, medium, or low)	**Medium**		

Factor 2.2 - Fishing Mortality

Southwest Atlantic | Purse seines | Brazil

Moderate Concern

Fishing mortality is unknown for Atlantic thread herring, Atlantic bumper, and chub mackerel. These species are the second, the third, and the fifth most relevant species, respectively, in the Brazilian sardinella fishery by landing volume (see the Criterion 2 Synthesis). From 2016 to 2021, Atlantic thread herring accounted for 16%–42% of the total landing volumes, Atlantic bumper accounted for 10%–16%, and chub mackerel accounted for 16%. Atlantic bumper is less relevant in landings in the state of Rio de Janeiro (Martins et al. 2021). Because F is unknown and overfishing cannot be inferred because of a lack of data, this factor is scored a moderate concern.

Atlantic thread herring

Factor 2.1 - Abundance

Southwest Atlantic | Purse seines | Brazil

Moderate Concern

Atlantic thread herring is a target species of a licensed purse seine fleet, but also of a sardine fleet during sardinella's closed season (Brasil 2011)(Brasil 2020b)(Martins et al. 2021); Atlantic thread herring is considered the main alternative species to maintain the supply for the canned sardine industrial sector in the face of the decline in Brazilian sardinella catches, because Atlantic thread herring presents similar nutritional, taste, and visual qualities (Cergole et al. 2005). A formal stock assessment and abundance data are not available for the species. The species is listed as "Least Concern" by the IUCN Red List (Munroe et al. 2015b), so abundance is scored a moderate concern.

Factor 2.2 - Fishing Mortality

Southwest Atlantic | Purse seines | Brazil

Moderate Concern

Fishing mortality is unknown for Atlantic thread herring, Atlantic bumper, and chub mackerel. These species are the second, the third, and the fifth most relevant species, respectively, in the Brazilian sardinella fishery by landing volume (see the Criterion 2 Synthesis). From 2016 to 2021, Atlantic thread herring accounted for 16%–42% of the total landing volumes, Atlantic bumper accounted for 10%–16%, and chub mackerel accounted for 16%. Atlantic bumper is less relevant in landings in the state of Rio de Janeiro (Martins et al. 2021). Because F is unknown and overfishing cannot be inferred because of a lack of data, this factor is scored a moderate concern.

Brazilian menhaden

Factor 2.1 - Abundance

Southwest Atlantic | Purse seines | Brazil

Moderate Concern

Brazilian menhaden is an important secondary species in the purse seine fishery in the state of Rio de Janeiro (Martins et al. 2021). The species is listed as "Least Concern" by the IUCN Red List (Di Dario et al. 2017), so abundance is scored a moderate concern.

Factor 2.2 - Fishing Mortality

Southwest Atlantic | Purse seines | Brazil

Moderate Concern

Both Atlantic anchoveta and Brazilian menhaden are part of the main components in the purse seine fishery in the state of Rio de Janeiro (Martins et al. 2021). Atlantic anchoveta has a recent estimate for fishing mortality within one section of its range (F = 0.30 in Guanabara Bay), and this value was

likely underestimated due to the gears used in the assessment (Santos et al. 2020). Fishing mortality for Brazilian menhaden is unknown. During 2018–19, which was characterized by a low production of Brazilian sardinella, particularly in the Southeast Region, Atlantic anchoveta became the main species caught by the fleet in Rio de Janeiro, whereas Brazilian menhaden was the second most caught species in 2019 there (Martins et al. 2021). These two species are traditional resources for small-scale purse seine fishers operating in estuaries, particularly in the metropolitan and south regions in the state of Rio de Janeiro (Jablonski et al. 2006)(FIPERJ 2013).

Because fishing mortality is unknown for Brazilian menhaden and likely underestimated for Atlantic anchoveta, and the likelihood of overfishing cannot be assessed, this factor receives a score of moderate concern.

Finfish

Factor 2.1 - Abundance

Southwest Atlantic | Purse seines | Brazil

High Concern

The finfish species of concern that are known to interact with this fishery are lined seahorse, dusky grouper, bluefish, vermilion snapper, albacore, yellowfin tuna, swordfish, and grey triggerfish. All species have a status ranging from "Near Threatened" (albacore and yellowfin tuna) or "Vulnerable" (lined seahorse, dusky grouper, bluefish, vermilion snapper, and grey triggerfish) to "Endangered" (swordfish) (Schroeder et al. 2022). Lined seahorse and dusky grouper also have a "Vulnerable" status under the national red list (Brasil 2022b). Because all species in this group are of concern, this factor is scored a high concern.

Factor 2.2 - Fishing Mortality

Southwest Atlantic | Purse seines | Brazil

Low Concern

Except for lined seahorse, all species in this group are targeted in at least one other fishery (Dias 2021). According to scientific observer data, catches of these species in the purse seine fishery targeting Brazilian sardinella are quite low (<0.01% of total catch) (Schroeder et al. 2022). Some of these species, such as tunas and swordfish, have recent stock assessments: albacore is not experiencing overfishing (F_{2018}/F_{MSY} = 0.398) (ICCAT 2020); for yellowfin tuna, although its F value is below the threshold (F_{2018}/F_{MSY} = 0.96), the species has a 43% probability that overfishing might be occurring, particularly among younger individuals (ICCAT 2019); and swordfish is not experiencing overfishing (F_{2015}/F_{MSY} = 0.98) (ICCAT 2017). Stock assessments are not available for lined seahorse, bluefish, vermilion snapper, or grey triggerfish, so their fishing mortality is unknown. Because the fishery's contribution to these species' mortality is low, this factor is scored a low concern.

Guiana dolphin

Factor 2.1 - Abundance

Southwest Atlantic | Purse seines | Brazil

High Concern

Guiana dolphin is currently listed as "Vulnerable" under the national red list (Brasil 2022b). Because of this status, abundance is scored a high concern.

Factor 2.2 - Fishing Mortality

Southwest Atlantic | Purse seines | Brazil

Moderate Concern

Fishing mortality for Guiana dolphin is not available, and scientific observer data indicate that interactions with dolphins are occasional (that is, less than 0.01% of total catch) and individuals are released (post-release survival is unknown) (Schroeder et al. 2022). But in the state of Rio de Janeiro, there is evidence of an illegal purse seine fishery overlapping one of the largest Guiana dolphin aggregations in the years after the termination of the scientific observer program (MPF 2017). Because of conflicting information about this fishery's level of interaction with Guiana dolphin in part of the fishery's range, this factor is scored a moderate concern.

Liza

Factor 2.1 - Abundance

Southwest Atlantic | Purse seines | Brazil

Moderate Concern

There is a recent stock assessment for liza in Brazil, with data up to 2019. The estimated parameters suggest that the species is overfished in all evaluated scenarios (i.e., $B_{2019}/B_{MSY} < 1$ in all scenarios; see Figure 5 below) (Sant'Ana et al. 2020). The 2019 stock biomass is estimated at 30% of virgin biomass (K) and 70% of B_{MSY} on average (MSY = 6,914 t and $MSY_{95\%}$ = 6,657 t) (Sant'Ana et al. 2020). Because there is a recent stock assessment that finds the stock is 70% of B_{MSY}, this factor is scored a moderate concern.

Justification:

Liza is a valuable resource in the Southeast and South Regions of Brazil, for both its meat and roe. There are specific fisheries at both the small-scale and industrial level that target liza. Some of the fisheries targeting liza are active during spawning season, to harvest roe (Sant'Ana et al. 2020).

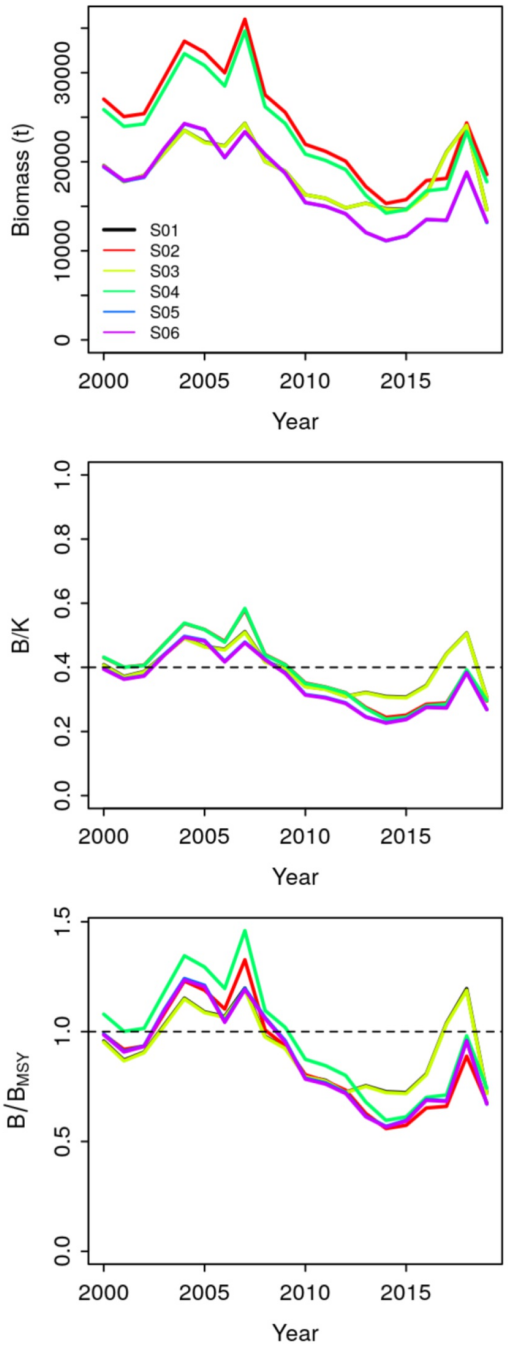


Figure 5: Distribution of biomass trends, B/K and B/B_{MSY}, for each of the adjusted models (Sant'Ana et al. 2020).

Factor 2.2 - Fishing Mortality

Southwest Atlantic | Purse seines | Brazil

Low Concern

In the most recent stock assessment for liza, it is suggested that the species is currently undergoing overfishing. According to all scenarios assessed (see Justification), there is a 51.8% probability that $F_{2019}/F_{MSY} > 1$; and, according to most scenarios, $F > F_{MSY}$ for 15 years (Sant'Ana et al. 2020). Fishing mortality is likely above a sustainable level for the species; however, the species is targeted by a different specific fishery at a much higher volume (i.e., this fishery is not a substantial contributor (Sant'Ana et al. 2020)(Brasil 2022)), so this factor is scored a low concern.

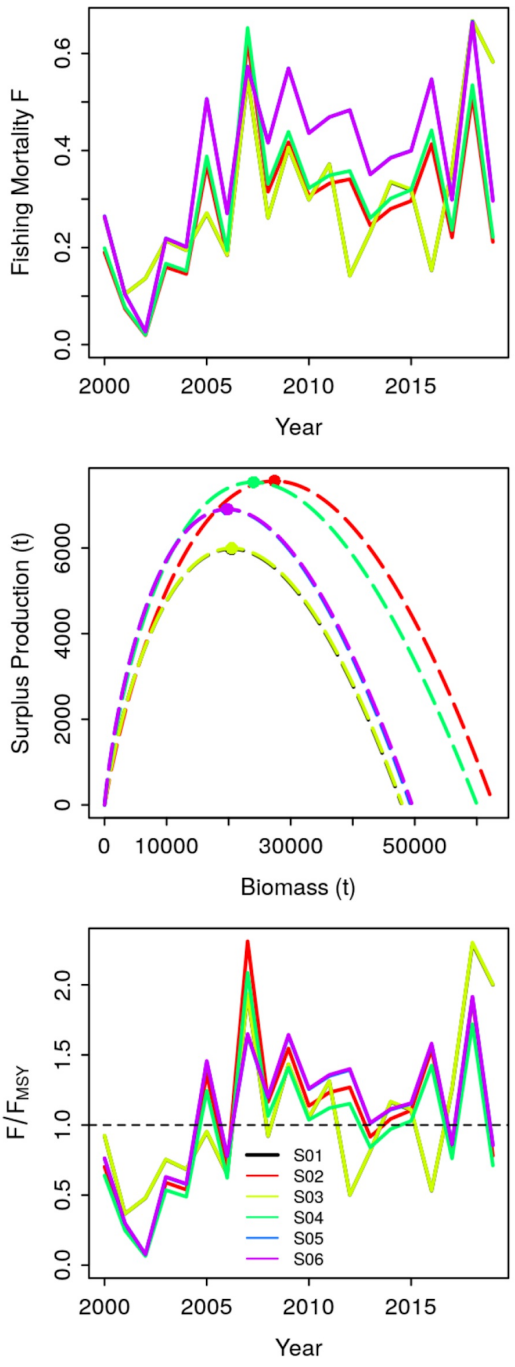


Figure 6: Distribution of fishing mortality trend, surplus production, and F/F_{MSY} for each of the adjusted models (S01–S06) (Sant'Ana et al. 2020).

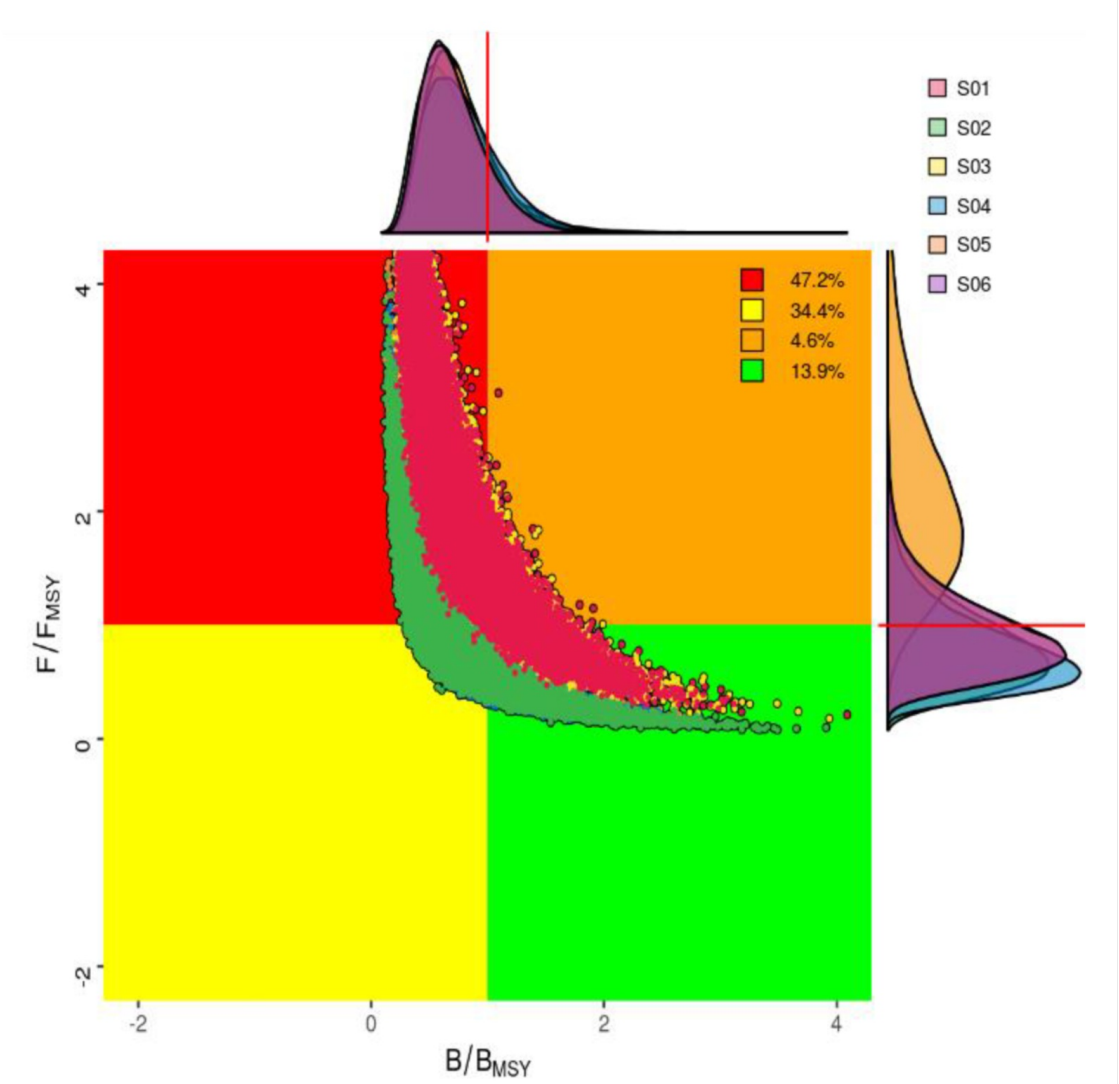


Figure 7: Composition of the posterior distributions for B/B_{MSY} and F/F_{MSY} of the adjusted scenarios for liza (Sant'Ana et al. 2020).

Loggerhead turtle

Factor 2.1 - Abundance

Southwest Atlantic | Purse seines | Brazil

High Concern

Loggerhead sea turtle in Brazil is "Vulnerable" according to the national red list and the IUCN (Brasil 2022b)(Schroeder et al. 2022). Because loggerhead turtle is a species of concern, this factor receives a score of high concern.

Factor 2.2 - Fishing Mortality

Southwest Atlantic | Purse seines | Brazil

Low Concern

Although information on fishing mortality is not available for loggerhead turtle, data available for this fishery indicate that interactions with the species are occasional (i.e., less than 0.01% of total catch) and all individuals were released (information on post-release survival is unknown) (Schroeder et al. 2022). In addition, studies have shown that mortality of sea turtles in purse seines does not tend to be high because the gear does not force the animals to be submerged, which usually occurs with other gears (Oravetz CA 1999) such as longlines (Sales et al. 2008). This factor receives a score of low concern, because the purse seine fishery is not a substantial contributor to loggerhead turtle fishing mortality.

Sharks

Factor 2.1 - Abundance

Southwest Atlantic | Purse seines | Brazil

High Concern

Although shark bycatch is not officially recognized in the Brazilian sardinella fishery (Brasil 2011), catches of elasmobranchs were reported when the observer program was still active. Data up to 2015 indicate the presence of several elasmobranch species, among sharks and rays, as occasional occurrences (Schroeder et al. 2022). From 2010 to 2015, the elasmobranch species interacting with the Brazilian sardinella fishery were: spiny dogfish, spiny angel shark, sand tiger shark, shortfin mako shark, oceanic whitetip shark, flathead shark, tiger shark, blue shark, scalloped hammerhead shark, Brazilian electric ray, lesser guitarfish, eyespot skate, La Plata skate, spade sand skate, Rio skate, bignose fanskate, pelagic stingray, and spiny butterfly ray. From this list, 50% of these species are IUCN species of concern ("Vulnerable"—oceanic whitetip shark, scalloped hammerhead shark, lesser guitarfish, eyespot skate, La Plata skate, Rio skate, bignose fanskate, and spiny butterfly ray; "Endangered"—spiny angel shark; and "Critically Endangered"—sand tiger shark) (Schroeder et al. 2022). Because there are species of concern in this group, this factor is deemed a high concern.

Factor 2.2 - Fishing Mortality

Southwest Atlantic | Purse seines | Brazil

Low Concern

Because most of the elasmobranch interactions were only listed for this fishery (i.e., without the actual weight of the specimens), the volume of such catches is unclear. When volume information was available, it always represented less than 0.05% of the total catch (Schroeder et al. 2022). Observer records (only available until 2015) also indicate that all interactions with elasmobranch species are either occasional or rare, and that 50%–100% of any elasmobranch species were discarded (Schroeder et al. 2022). Some of these species are monitored within the International Commission for the Conservation of Atlantic Tunas (ICCAT) because they have great numbers of interactions with the tuna longline fishery and have recent stock assessments, which indicate that overfishing is possibly occurring for shortfin mako shark and undetermined for blue shark (ICCAT

2018). This factor receives a score of low concern, because the fishery is unlikely a substantial contributor to this group's fishing mortality.

Factor 2.3 - Discard Rate/Landings

Southwest Atlantic | Purse seines | Brazil

< 100%

With the decline of the Brazilian sardinella population over the past decades, the usual bycatch species (not limited to, but mostly Atlantic thread herring, Atlantic cutlassfish, Atlantic moonfish, Atlantic bumper, chub mackerel, rough scad, and whitemouth drummer) are kept and sold. This is most common when the season is weak for Brazilian sardinella, so the bycatch is sold to cover expenses within the fishery (pers. comm., Cergole 2015). Observer data from when the program was running showed a discard rate of about 4% before landing, along with another 4% in the canning industry (mostly specimens with low quality for canning, followed by other species and undersized Brazilian sardinella) (Medeiros 2017).

Criterion 3: Management Effectiveness

Five factors are evaluated in Criterion 3: Management Strategy and Implementation, Bycatch Strategy, Scientific Research/Monitoring, Enforcement of Regulations, and Inclusion of Stakeholders. Each is scored as either 'highly effective', 'moderately effective', 'ineffective,' or 'critical'. The final Criterion 3 score is determined as follows:

- *5 (Very Low Concern) — Meets the standards of 'highly effective' for all five factors considered.*
- *4 (Low Concern) — Meets the standards of 'highly effective' for 'management strategy and implementation' and at least 'moderately effective' for all other factors.*
- *3 (Moderate Concern) — Meets the standards for at least 'moderately effective' for all five factors.*
- *2 (High Concern) — At a minimum, meets standards for 'moderately effective' for Management Strategy and Implementation and Bycatch Strategy, but at least one other factor is rated 'ineffective.'*
- *1 (Very High Concern) — Management Strategy and Implementation and/or Bycatch Management are 'ineffective.'*
- *0 (Critical) — Management Strategy and Implementation is 'critical'.*

The Criterion 3 rating is determined as follows:

- ***Score >3.2=Green or Low Concern***
- ***Score >2.2 and ≤3.2=Yellow or Moderate Concern***
- ***Score ≤2.2 = Red or High Concern***

Rating is Critical if Management Strategy and Implementation is Critical.

Guiding principle

- The fishery is managed to sustain the long-term productivity of all impacted species.

Five factors are evaluated in Criterion 3: Management Strategy and Implementation, Bycatch Strategy, Scientific Research/Monitoring, Enforcement of Regulations, and Inclusion of Stakeholders. Each is scored as either 'highly effective', 'moderately effective', 'ineffective,' or 'critical'. The final Criterion 3 score is determined as follows:

Criterion 3 Summary

FISHERY	MANAGEMENT STRATEGY	BYCATCH STRATEGY	DATA COLLECTION AND ANALYSIS	ENFORCEMENT	INCLUSION	SCORE
Southwest Atlantic | Purse seines | Brazil	Ineffective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	**Red (1.000)**

Criterion 3 Assessment

SCORING GUIDELINES

Factor 3.1 - Management Strategy and Implementation

Considerations: What type of management measures are in place? Are there appropriate management goals, and is there evidence that management goals are being met? Do manages follow scientific advice? To achieve a highly effective rating, there must be appropriately defined management goals, precautionary policies that are based on scientific advice, and evidence that the measures in place have been successful at maintaining/rebuilding species.

Factor 3.2 - Bycatch Strategy

Considerations: What type of management strategy/measures are in place to reduce the impacts of the fishery on bycatch species and when applicable, to minimize ghost fishing? How successful are these management measures? To achieve a Highly Effective rating, the fishery must have no or low bycatch, or if there are bycatch or ghost fishing concerns, there must be effective measures in place to minimize impacts.

Factor 3.3 - Scientific Research and Monitoring

Considerations: How much and what types of data are collected to evaluate the fishery's impact on the species? Is there adequate monitoring of bycatch? To achieve a Highly Effective rating, regular, robust population assessments must be conducted for target or retained species, and an adequate bycatch data collection program must be in place to ensure bycatch management goals are met.

Factor 3.4 - Enforcement of Management Regulations

Considerations: Do fishermen comply with regulations, and how is this monitored? To achieve a Highly Effective rating, there must be regular enforcement of regulations and verification of compliance.

Factor 3.5 - Stakeholder Inclusion

Considerations: Are stakeholders involved/included in the decision-making process? Stakeholders are individuals/groups/organizations that have an interest in the fishery or that may be affected by the management of the fishery (e.g., fishermen, conservation groups, etc.). A Highly Effective rating is given if the management process is transparent, if high participation by all stakeholders is encouraged, and if there a mechanism to effectively address user conflicts.

Factor 3.1 - Management Strategy And Implementation

Southwest Atlantic | Purse seines | Brazil

Ineffective
Brazilian sardinella

The species has a management plan published in 2011 (Cergole & Dias Neto 2011), which then stated that "the situation of the Southeast-South purse-seine fleet can be considered precarious, because its survival depends on: a) a depleted resource (Brazilian sardinella); b) other small pelagic species with no potential of providing enough biomass and profitability to support the fishery; c) seasonal occurrences, such as liza, which is also subject to unpredictable variations in their abundance; d) for some time, in the recent past, the fishery also depended on the whitemouth drummer, which should not and could not have been the target for this fishery, because it is also targeted by other fleets, and is also under controlled effort and overfishing status" (Cergole & Dias Neto 2011). The purse seine fishery, which targets Brazilian sardinella, is managed by federal legislation regarding fishing effort, fishing area, minimal catch size, and closed season (Brasil 1993) (Brasil 1997)(Brasil 2004)(Brasil 2008)(Brasil 2009)(Brasil 2020).

More recently, the Brazilian sardinella management committee set MSY at 75,985 t; however, annual production has been below this level since 2016 and 50% of MSY since 2017 (MAPA-SAP 2021). The 2016–18 seasons were marked by a severe El Niño, which contributed to a massive decline in production. In addition, a new single closed season was established in 2020, based on scientific data (Brasil 2020)(MAPA-SAP 2021). A recent study on the Brazilian sardinella population during the closed season between 2021 and 2022 has confirmed that a single closed season instead of two per year is protecting the majority of the species' reproductive season, although it seems that the spawning season will keep adjusting as a biological response to climate change (Schwingel et al. 2022). Lastly, an electronic system has 25% of the entire production being monitored by the companies responsible for the canning process (such companies own docks and are registered under the federal inspection service, SIF) (MAPA-SAP 2021). Data collected can inform the percentage of mature fish caught, the percentage of fish caught at optimal length, the change in average length, CPUE, as well as information on secondary species. It is expected that this system will cover 100% of the entire production in the coming years (MAPA-SAP 2021).

Both the Brazilian sardinella management plan and a more recent publication call attention to the need to consider secondary species as part of the fishery management plan, because of the volume caught of such species {Cergole & Dias-Neto 2011}(Dias 2021). Such species are relevant to the fisher's total revenue (MAPA-SAP 2021). A management committee for Brazilian sardinella was re-established in 2021, and now includes Atlantic thread herring (Brasil 2021b), which is the second most relevant species in volume in this fishery. Existing management measures for each of the secondary species are described below.

Liza

There is a combined management measure to prevent the Brazilian sardinella fishery from being active during the fishing season for liza (which is targeted by a different fishery) (Brasil 2022). The only secondary species with a management plan and recent stock assessment is liza and, despite management measures (which includes annual catch limits (Brasil 2022) (Sant'Ana et al. 2020)), the most recent stock assessment indicates that the species is both overfished and experiencing overfishing (Sant'Ana et al. 2020)—a status that has been persistent since previous assessments (Sant'Ana & Kinas 2016b).

Atlantic anchoveta

The species is more relevant for this fishery in the state of Rio de Janeiro (MAPA-SAP 2021) and it does not have any management measure for the stock (Dias 2021b).

Atlantic bumper

Despite being one of the most significant catches in the purse seine fishery, Atlantic bumper does not have any management measure for the stock (Dias 2021b).

Atlantic chub mackerel

The species also does not have any management measure for the stock (Dias 2021b).

Atlantic thread herring

There is a specific fishery toward Atlantic thread herring (Brasil 2011), and the number of vessels increased 22% in the past 10 years (MAPA-SAP 2021). Quite recently, the species was included in the additional fishing authorization in the Brazilian sardinella purse seine fishery because of its relevance to the total production (Brasil 2020b), particularly in years of low production of Brazilian sardinella. In addition, the Brazilian sardinella committee, when re-established in 2021, now includes management discussions of Atlantic thread herring (Brasil 2021b), and studies have shown that there is an overlap of its reproductive season with Brazilian sardinella's closed season, which likely benefits the species (MAPA-SAP 2021). The inclusion of Atlantic thread herring as a target species in the additional fishing authorization is expected to be reassessed by June 2023 (MAPA-SAP 2021).

Brazilian menhaden

The species does not have any management measure for the stock (Dias 2021b).

Even though there are important improvements in the management of Brazilian sardinella compared to the previous assessment (e.g., MSY, electronic monitoring, a science-based updated closed season, and an active management committee that includes the second most relevant species in the fishery), some of the secondary species do not have any assessment of their stocks or any management plans, and the current management plan for liza did not prevent the species from becoming overfished or experiencing overfishing in the most recent stock assessment. For these reasons, this factor receives a score of ineffective.

Factor 3.2 - Bycatch Strategy

Southwest Atlantic | Purse seines | Brazil

Moderately Effective

Although bycatch of species of concern appears on records (e.g., (Schroeder et al. 2022)), it usually makes up less than 1% of total volume.

Elasmobranchs

The most significant group of concern is elasmobranchs, with about half of caught species being red listed (Schroeder et al. 2022). From 2014 to 2019, a National Action Plan (NAP) for endangered shark species in Brazil was developed (ICMBio 2016). Since the end of this plan's first cycle, no updates on the second cycle are available, nor is any information regarding specific management measures for this fishery. The plan's release after the end of this first cycle mentions that fishing management strategies were the ones with the least progress (CEPSUL 2020).

Dolphins

Since 2019, marine mammals have had an NAP to foster conservation and mitigate impacts that affect their populations. Within the plan, reducing bycatch is among the main goals for the 2019–24 NAP term (ICMBio 2021). Before that, in 2017, the Brazilian Federal Prosecution Office (MPF) acted together with the Rio de Janeiro Environmental Agency to protect Guiana dolphin in a bay within the state. The action focused on an irregular fishery that enters the Sepetiba Bay to capture live bait using purse seine, whose enveloping movement (carried out by auxiliary boats) surrounds the shoal and closes around it to capture target species. The actions of the MPF showed that irregular industrial fishing was overlapping with the largest concentration of Guiana dolphins in the world, depriving them of their main food: sardines and croaker. In addition, such criminal acts were harming the local traditional fishing community {MPF 2022}. The NAP specific goals have several actions directed toward reducing fishing interactions and bycatch with Guiana dolphin, and positive results are expected toward the end of the term in 2024 (ICMBio 2021).

Sea turtles

Sea turtles have had their own NAP since 2010, and it is now in its second term (2017–23). But, bycatch measures within the NAP are only directed to trawls, gillnets, and longlines, which are known to cause high mortality in sea turtles (ICMBio 2017).

Finfish of concern

Other finfish species evaluated in this assessment include lined seahorse, dusky grouper, bluefish, vermilion snapper, albacore, yellowfin tuna, swordfish, and grey triggerfish, which are currently listed within risk categories by the IUCN. Except for lined seahorse, all species are targeted in different fisheries and have different levels of management measures (Dias 2021b). The fisheries with the most-developed plans are tunas and swordfish, following international guidelines (e.g., ICCAT (ICCAT 2017)(ICCAT 2019)(ICCAT 2020)).

The management plan for Brazilian sardinella only lists the current general regulations regarding bycatch and incidental catch of species of concern, without relating these to actual management actions in the Brazilian sardinella fishery {Cergole and Dias Neto 2011}.

Bycatch strategy receives a score of moderately effective, because species of concern are being captured in this fishery and, even though the volumes of such catches are quite low, uncertainties about a lack of recent records and a lack of specific management may pose an additional risk to this group of species.

Factor 3.3 - Scientific Data Collection and Analysis

Southwest Atlantic | Purse seines | Brazil

Moderately Effective

Scientific data collection in the Brazilian sardinella fishery has been conducted by research groups for some years (e.g., Sardinha project (Funbio 2016)) and, more recently, together with the canning industry (e.g., SISLATINHA (MAPA-SAP 2021)). The Sardinha project aims to make a diagnosis of the purse seine fishery, a population and stock assessment of Brazilian sardinella, and the characterization and quantification of the catch of Brazilian sardinella for bait. A stock assessment is expected to be released in the upcoming year (2023) from the same research group (MAPA-SAP 2021). Data informed from this project also supported the recent decision to change the closed season to improve the protection of the reproductive cycle (MAPA-SAP 2021)(Brasil 2020). SISLATINHA is a monitoring project that involves the canning industry in which the data collected can inform the percentage of mature fish caught, the percentage of fish caught at optimal length, the change in average length, and CPUE, and weekly samples are collected (MAPA-SAP 2021). The SISLATINHA system is expected to cover 100% of the entire production in the coming years (MAPA-SAP 2021). Within this fishery, Atlantic thread herring has also been under scientific investigation, which had recently led to the species' inclusion in the additional fishing permit, because of the species' relevance to this fishery and overlapping reproductive cycle, which also benefits the species during the sardinella closed season (Brasil 2020b)(MAPA-SAP 2021).

The National Program of Observers Onboard Fishing Fleets (PROBORDO), established by the federal government, has been inoperative for more than 5 years (Dias 2021) and may present a concern for monitoring bycatch, especially species of concern in this fishery, because the only records available in recent years are landings volume (and some catches, such as elasmobranchs, are usually discarded before landing (pers. comm., R. Barreto 2017)).

Scientific data collection and analysis receives a score of moderately effective because, although there is some data collection and analysis being performed in recent years, Brazilian sardinella is a forage species, which would require more frequent stock assessments (the last stock assessment published is over 10 years old (Cergole & Dias Neto 2011)).

Factor 3.4 - Enforcement of and Compliance with Management Regulations

Southwest Atlantic | Purse seines | Brazil

Moderately Effective

A new electronic system (SISLATINHA) that was implemented by the federal government in 2020 has 25% of the entire production of this fishery being monitored by the companies responsible for the canning process (MAPA-SAP 2021). Canning companies get a monthly proof of regularity for complying with SISLATINHA, providing data from dockside surveillance on their private docks; and the federal government intends to have 100% of the production destined for the canning industry to be part of this system in the coming years (MAPA-SAP 2021).

Harvest data collection is mandatory for all purse-seine vessels targeting Brazilian sardinella (Brasil 2014b) and, in 2021, 176 vessels were registered for this fishery (Dias 2021). The National Fishing Vessel Tracking Program is only mandatory for vessels longer than 15 meters, which means that 137 vessels (≈77.84% of the fleet) are obliged to comply (Brasil 2006)(Dias 2021).

The closed season is observed by the fleet, mainly because the canning companies could easily lose their federal inspection service (SIF) registry for lacking compliance with this rule. In addition, vessels registered in this fishery are granted an additional fishing permit that allows them to target 26 to 37 different species, particularly during the spawning season or when the annual production is low {Brasil 2011 (MAPA-SAP 2021).

There are strict sanctions imposed on the canning companies when they do not comply to SISLATINHA and the closed season. But, both SISLATINHA and other enforcement measures do not include 100% of the fleet or production, which results in an enforcement score of moderately effective.

Factor 3.5 - Stakeholder Inclusion

Southwest Atlantic | Purse seines | Brazil

Moderately Effective

The Management Committee for the Sustainable Use of Brazilian sardinella was first created in 2005 (Ordinance nº 4 of 2005/IBAMA) (Cergole & Dias Neto 2011). The Committee was a joint initiative between the federal government and stakeholders (mainly researchers, but also fisher representatives) with the goal of providing advice in decision-making about fishery management, and it is a substantial contributor to the development of the Brazilian sardinella management plan (Cergole & Dias Neto 2011). Fishing Management Committees were regulated and grouped into Permanent Committees for Fishing Management and Sustainable Use of Fishing Resources (CPGs) in 2015, with an open call for relevant stakeholders to integrate such groups (MPA-MMA 2015). After being inactive for some years because of major political changes in the country starting in 2016, all CPGs were extinguished in 2019 by a federal decree (Brasil 2019b). In June of 2021, the CPGs were restructered into a National Collaborative Network for the Sustainable Management of Fishing Resources (Rede Pesca Brasil) (Brasil 2021). Within this network, the Brazilian sardinella technical committee is a subgroup of the CPG Pelágicos SE-S, which focuses on pelagic resources in the Southeast and South Regions of Brazil. The Brazilian sardinella committee was officially re-established in September of 2021 and now includes the management of Atlantic thread herring, with

representatives from federal and state governments as well as researchers (Brasil 2021b)(MAPA-SAP 2021). The committee collaboratively released a report on the management of Brazilian sardinella and Atlantic thread herring in December 2021 (MAPA-SAP 2021). Because the political dynamics in Brazil are volatile, and stakeholder inclusion can be modified or suspended again, a moderately effective score is granted.

Criterion 4: Impacts on the Habitat and Ecosystem

This Criterion assesses the impact of the fishery on seafloor habitats, and increases that base score if there are measures in place to mitigate any impacts. The fishery's overall impact on the ecosystem and food web and the use of ecosystem-based fisheries management (EBFM) principles is also evaluated. Ecosystem Based Fisheries Management aims to consider the interconnections among species and all natural and human stressors on the environment. The final score is the geometric mean of the impact of fishing gear on habitat score (factor 4.1 + factor 4.2) and the Ecosystem Based Fishery Management score. The Criterion 4 rating is determined as follows:

- ***Score >3.2=Green or Low Concern***
- ***Score >2.2 and ≤3.2=Yellow or Moderate Concern***
- ***Score ≤2.2 = Red or High Concern***

Guiding principles

- Avoid negative impacts on the structure, function or associated biota of marine habitats where fishing occurs.
- Maintain the trophic role of all aquatic life.
- Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts.
- Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance, productivity, or genetic integrity of wild stocks.
- Follow the principles of ecosystem-based fisheries management.

Rating cannot be Critical for Criterion 4.

Criterion 4 Summary

FISHERY	FISHING GEAR ON THE SUBSTRATE	MITIGATION OF GEAR IMPACTS	ECOSYSTEM-BASED FISHERIES MGMT	FORAGE SPECIES?	SCORE
Southwest Atlantic | Purse seines | Brazil	Score: 4	Score: 0	High Concern	Yes	**Red (2.828)**

Criterion 4 Assessment

SCORING GUIDELINES

Factor 4.1 - Physical Impact of Fishing Gear on the Habitat/Substrate
Goal: The fishery does not adversely impact the physical structure of the ocean habitat, seafloor or associated biological communities.

- *5 - Fishing gear does not contact the bottom*
- *4 - Vertical line gear*
- *3 - Gears that contacts the bottom, but is not dragged along the bottom (e.g. gillnet, bottom longline, trap) and is not fished on sensitive habitats. Or bottom seine on resilient mud/sand habitats. Or midwater trawl that is known to contact bottom occasionally. Or purse seine known to commonly contact the bottom.*
- *2 - Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Or gillnet, trap, or*

bottom longline fished on sensitive boulder or coral reef habitat. Or bottom seine except on mud/sand. Or there is known trampling of coral reef habitat.

- *1 - Hydraulic clam dredge. Or dredge or trawl gear fished on moderately sensitive habitats (e.g., cobble or boulder)*
- *0 - Dredge or trawl fished on biogenic habitat, (e.g., deep-sea corals, eelgrass and maerl)*
  Note: When multiple habitat types are commonly encountered, and/or the habitat classification is uncertain, the score will be based on the most sensitive, plausible habitat type.

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts
Goal: Damage to the seafloor is mitigated through protection of sensitive or vulnerable seafloor habitats, and limits on the spatial footprint of fishing on fishing effort.

- *+1 —>50% of the habitat is protected from fishing with the gear type. Or fishing intensity is very low/limited and for trawled fisheries, expansion of fishery's footprint is prohibited. Or gear is specifically modified to reduce damage to seafloor and modifications have been shown to be effective at reducing damage. Or there is an effective combination of 'moderate' mitigation measures.*
- *+0.5 —At least 20% of all representative habitats are protected from fishing with the gear type and for trawl fisheries, expansion of the fishery's footprint is prohibited. Or gear modification measures or other measures are in place to limit fishing effort, fishing intensity, and spatial footprint of damage caused from fishing that are expected to be effective.*
- *0 —No effective measures are in place to limit gear impacts on habitats or not applicable because gear used is benign and received a score of 5 in factor 4.1*

Factor 4.3 - Ecosystem-Based Fisheries Management
Goal: All stocks are maintained at levels that allow them to fulfill their ecological role and to maintain a functioning ecosystem and food web. Fishing activities should not seriously reduce ecosystem services provided by any retained species or result in harmful changes such as trophic cascades, phase shifts or reduction of genetic diversity. Even non-native species should be considered with respect to ecosystem impacts. If a fishery is managed in order to eradicate a non-native, the potential impacts of that strategy on native species in the ecosystem should be considered and rated below.

- *5 — Policies that have been shown to be effective are in place to protect species' ecological roles and ecosystem functioning (e.g. catch limits that ensure species' abundance is maintained at sufficient levels to provide food to predators) and effective spatial management is used to protect spawning and foraging areas, and prevent localized depletion. Or it has been scientifically demonstrated that fishing practices do not have negative ecological effects.*
- *4 — Policies are in place to protect species' ecological roles and ecosystem functioning but have not proven to be effective and at least some spatial management is used.*
- *3 — Policies are not in place to protect species' ecological roles and ecosystem functioning but detrimental food web impacts are not likely or policies in place may not be sufficient to protect species' ecological roles and ecosystem functioning.*
- *2 — Policies are not in place to protect species' ecological roles and ecosystem functioning and the likelihood of detrimental food impacts are likely (e.g. trophic cascades, alternate stable states, etc.), but conclusive scientific evidence is not available for this fishery.*
- *1 — Scientifically demonstrated trophic cascades, alternate stable states or other detrimental food web impact are resulting from this fishery.*

Factor 4.1 - Physical Impact of Fishing Gear on the Habitat/Substrate

Southwest Atlantic | Purse seines | Brazil

Score: 4

The fishing gear used (purse seines) is primarily deployed in the water column on schools of Brazilian sardinella and associated species (Cergole & Dias Neto 2011). But, observer data have reported the presence of benthic taxa such as cnidarians, echinoderms, and rajidae (although such species makes up less than 0.05% of the total catch) as bycatch (Schroeder et al. 2022). As a result, purse seine gear is scored a 4 (purse seine does not commonly contact the bottom).

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

Southwest Atlantic | Purse seines | Brazil

Score: 0

The fishery does not have specific gear modifications or specific habitat protection initiatives related to this gear's impact. This results in a score of 0.

Factor 4.3 - Ecosystem-based Fisheries Management

Southwest Atlantic | Purse seines | Brazil

High Concern

Brazilian sardinella is one of the most iconic fisheries in the Southeast and South Regions of Brazil. Because of the severe decline that the stock has faced in the past decades, the fishery has a multispecific configuration, although management measures are focused on the Brazilian sardinella alone (Cergole & Dias Neto 2011)(Vaz-dos-Santos et al. 2010). Although secondary species such as liza have specific legislation {Brazil 2015}(Haimovici et al. 2016), all other species with significant catches are not regulated. Published in 2011, the management plan included minimal spatial management, focusing on both closed areas for bait fisheries (Brazilian sardinella juveniles were historically caught for bait in tuna fisheries; this has become less common due to Brazilian sardinella stock declines, and the catch can no longer support the amount of bait needed for the tuna fishery) and places where the purse seine fishery is prohibited (mostly in/around oil platforms, protected areas, islands, and beaches) (Cergole & Dias Neto 2011).

As a base resource in the food chain, Brazilian sardinella plays an important role for several species in the system, including commercially targeted species (Cergole & Dias Neto 2011), although such impacts are not measured. The Brazillian sardinella and Atlantic thread herring committee currently does not have any management strategy accounting for dependent predators of these forage species (MAPA-SAP 2021)(Brasil 2021b), and existing measures do not seem to comply to the Lenfest Forage Fish Task Force Recommendations for this ecological group (i.e., for being a low-information fishery, an upper limit to F [no higher than 0.75 F_{MSY}] and B_{LIM} should be established, with precautionary harvest strategies accounting for food web dynamics and dependent predator performance) (Pikitch et

al. 2012). Current measures do include an MSY value (currently at 75,985 t), and catches since 2016 have been below 50,000 t (roughly 0.66 of MSY) (MAPA-SAP 2021). But, such low catches are related to low production after extreme El Niño events (MAPA-SAP 2021) rather than a precautionary approach. A score of high concern is granted for this factor, because existing management strategies do not seem to support the Brazilian sardinella's ecological role as a forage species.

Acknowledgements

Scientific review does not constitute an endorsement of the Seafood Watch® program, or its seafood recommendations, on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

Seafood Watch would like to thank the consulting researcher and author of this report, Daniele Vila Nova, as well as several anonymous reviewers for graciously reviewing this report for scientific accuracy.

References

Aspectos biológicos de cinco espécies da ictiofauna associada à pesca exploratória de sardinha-verdadeira no Sudeste-Sul do Brasil (22oS e 29oS), ECOSAR 2008-2009. III Congresso Brasileiro de Oceanografia – CBO""2010. Rio Grande (RS), 02969-02971.

Brasil 1993. PORTARIA IBAMA N° 107-N, 4 DE OUTUBRO DE 1993. IBAMA. Brasília-DF.

Brasil 1997. PORTARIA IBAMA N° 8, 20 DE FEVEREIRO DE 1997. IBAMA. Brasília-DF, 2pg.

Brasil 2004. INSTRUÇÃO NORMATIVA MMA N° 29, DE 6 DE DEZEMBRO DE 2004. Brasilia-DF, 1p

Brasil 2008. PORTARIA IBAMA Nº 17, DE 30 DE MAIO DE 2008. Brasilia-DF, 2p

Brasil 2009. INSTRUÇÃO NORMATIVA IBAMA N° 15, DE 21 DE MAIO DE 2009. Brasília-DF, 4pg

Brasil 2011. Instrução Normativa MPA/MMA n. 10, de 10 de junho de 2011. Brasília-DF, 51p.

Brasil 2014. Ministério da Pesca e Aquicultura. Instrução Normativa nº 20, de 10 de setembro de 2014. Estabelece critérios e procedimentos para preenchimento e entrega de Mapas de Bordo das embarcações registradas e autorizadas no âmbito do Registro Geral da Atividade Pesqueira - RGP. Diário Oficial da União, Brasília, 11 de setembro de 2014, Seção 1, p. 42-43.

Brasil 2019. PORTARIA Nº 154, DE 6 DE FEVEREIRO DE 2019. Altera a alíquota de imposto de importação para o código 0303.53.00 da Nomenclatura Comum do Mercosul ao amparo da Lista Brasileira de Exceções à Tarifa Externa Comum. Ministério da Economia/Secretaria Especial de Comércio Exterior e Assuntos Internacionais. Brasília, DF.

Brasil 2019b. Decreto n 9759, de 11 de abril de 2019. Extingue e estabelece diretrizes, regras e limitações para colegiados da administração pública federal. DOU 70-A de 11/04/2019 Seção 1- extra, pg 5.

Brasil 2020. INSTRUÇÃO NORMATIVA Nº 18, DE 10 DE JUNHO DE 2020. Ministério da Agricultura, Pecuária e Abastecimento/Secretaria de Aquicultura e Pesca.

Brasil 2020b. **PORTARIA SAP/MAPA Nº 226, DE 14 DE SETEMBRO DE 2020.** Dispõe sobre a inclusão da sardinha-laje (Opisthonema oglinum) na Autorização de Pesca Complementar das modalidades de permissionamento 4.1, 4.2 e 4.3 da Instrução Normativa Interministerial do Ministério da Pesca e Aquicultura e do Ministério do Meio Ambiente nº 10, de 10 de junho de 2011. Brasília-DF.

Brasil 2021. Decreto n 10736, de 29 de junho de 2021. Institui a Rede Nacional Colaborativa para a Gestão Sustentável dos Recursos Pesqueiros - Rede Pesca Brasil. DOU 121 de 30/06/2021, seção 1 pg 1.

Brasil 2021b. PORTARIA SAP/MAPA Nº 385, DE 9 DE SETEMBRO DE 2021. DOU Publicado em: 10/09/2021 Edição: 172 | Seção: 2 | Página: 5

Brasil 2022. PORTARIA SAP/MAPA Nº 611, DE 28 DE FEVEDEIRO DE 2022. Estabelece a Autorização de Pesca Especial Temporária, o limite de embarcações de pesca, as cotas de captura e as medidas de

monitoramento e controle para a temporada de pesca da tainha (Mugil liza) do ano de 2022, nas regiões Sudeste e Sul do Brasil. Brasilia-DF.

Brasil 2022b. Portaria MMA no. 148, de 7 de junho de 2022. Ministério do Meio Ambiente. Brasília, DF.

Brasil, 2006. Secretaria Especial de Aquicultura e Pesca da Presidência da República, Ministério do Meio Ambiente e Ministério da Defesa. Instrução Normativa Conjunta nº 02, de 04 de setembro de 2006. Institui o Programa Nacional de Rastreamento de Embarcações Pesqueiras por Satélite - PREPS para fins de monitoramento, gestão pesqueira e controle das operações da frota pesqueira permissionada pela Secretaria Especial de Aquicultura e Pesca da Presidência da República - SEAP/PR. Diário Oficial da União, Brasília, 05 de setembro de 2006.

CEPSUL. 2020. Boletim do Plano de Ação Nacional para a Conservação dos ELASMOTÍCIAS Tubarões e Raias Marinhos Ameaçados de Extinção - PAN Tubarões. Itajaí - SC. 12p.

Cergole MC 1995. Stock assessment of the Brazilian sardine, Sardinella brasiliensis, of the south-eastern Coast of Brazil. Scientia Marina 59(3-4): 597-610.

Cergole MC, Ávila-da-Silva AO, Rossi- Wongtschowsky CLDB. 2005. (eds.). Análise das principais pescarias comerciais da região Sudeste-Sul do Brasil: dinâmica populacional das espécies em explotação. Série Doc. Revizee/Score Sul, São Paulo

Coelho Jr JBL. 2015. Biologia Reprodutiva da Cavalinha, Scomber colias, (Gmelin, 1789) na região do Cabo Frio, RJ. MSc thesis, Universidade Federal Fluminense. Rio de Janeiro-RJ

Collette B, Amorim AF, Boustany A, Carpenter KE, de Oliveira Leite Jr N, Di Natale A, Fox W, Fredou FL, Graves J, Viera Hazin FH, Juan Jorda M, Kada O, Minte Vera C, Miyabe N, Nelson R, Oxenford H, Teixeira Lessa RP, Pires Ferreira Travassos PE. 2011. Scomber colias. The IUCN Red List of Threatened Species 2011: e.T170357A6767497. http://dx.doi.org/10.2305/IUCN.UK.2011-2.RLTS.T170357A6767497.en. Downloaded on 09 May 2018.

COMEXSTAT 2022. Portal para acesso gratuito às estatísticas de comércio exterior do Brasil. Importação e Exportação Geral. Access in April 28th, 2022.

CONAB - Companhia Nacional do Abastecimento. Boletim Hortigranjeiro - edição especial pescados. Brasília, DF, v. 8, n. 4, abr. 2022.

Di Dario F, Williams JT & Palla H. 2017. Brevoortia aurea. The IUCN Red List of Threatened Species 2017: e.T195080A96611338. https://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T195080A96611338.en. Accessed on 19 May 2022

Di Dario F. 2018. *Sardinella brasiliensis* (errata version published in 2019). *The IUCN Red List of Threatened Species* 2018: e.T16466246A143834492. Accessed on 19 July 2022.

Dias M 2021. Auditoria da pesca : Brasil 2021 [livro eletrônico] : uma avaliação integrada da governança, da situação dos estoques e das pescarias - Apêndice 2 - Estoques Pesqueiros / Martin Dias, Ademilson

Zamboni, Letícia Canton. -- 2. ed. -- Brasília, DF : Oceana Brasil, 2022.

Dias M 2021. Auditoria da pesca : Brasil 2021 [livro eletrônico] : uma avaliação integrada da governança, da situação dos estoques e das pescarias - Apêndice 3 - Pescarias / Martin Dias, Ademilson Zamboni, Letícia Canton. -- 2. ed. -- Brasília, DF : Oceana Brasil, 2022.

Dias MC. 2012. Diagnóstico das pescarias industriais do Sudeste e Sul do Brasil frente aos padrões internacionais de certificação ambiental: panorama atual, ações e perspectivas. PhD dissertation. Universidade do Vale do Itajaí, Itajaí - SC, Brasil.

Eschmeyer WN, Fricke R, van der Laan R (eds). 2018. Catalog of fishes. Electronic version accessed 09 Nay 2018. [This version was edited by Bill Eschmeyer.]

FIPERJ - Fundação Instituto de Pesca do Estado do Rio de Janeiro. 2022b. Projeto de Monitoramento da Atividade Pesqueira do Estado do Rio de Janeiro (PMAP-RJ), Relatório Técnico Semestral - RTS - 02. Rio de Janeiro, 253p.

FIPERJ - Fundação Instituto de Pesca do Estado do Rio de Janeiro. Projeto de Monitoramento da Atividade Pesqueira do Estado do Rio de Janeiro (PMAP-RJ), 2016 a 2022. Search engine. Rio de Janeiro, 2022.

Funbio 2016. Projeto Sardinha: Apoio Técnico-Científico ao Plano de Gestão para o Uso Sustentável da Sardinha-Verdadeira no Sudeste do Brasil. Rio de Janeiro-RJ. Accessed in May, 2022.

Fundação Instituto de Pesca do Estado do Rio de Janeiro - FIPERJ. 2013. Diagnóstico da Pesca no Estado do Rio de Janeiro - Relatório 2013. Fundação Instituto de Pesca do Estado do Rio de Janeiro. – Niterói-RJ.

ICCAT 2017. Report of the 2017 ICCAT Atlantic Swordfish Stock Assessment Session (Madrid, Spain 3-7 July, 2017). 85Pp.

ICCAT 2019. Report of the 2019 ICCAT Yellowfin Tuna Stock Assessment Meeting (Grand-Bassam, Cote d'Ivoire, 8-16 July 2019). 118p.

ICCAT 2020. Report of the 2020 ICCAT Atlantic Albacore Stock Assessment Meeting (Online, 29 June - 8 July 2020). 93p.

ICCAT. 2018. Report of the Standing Committee on Research and Statistics (SCRS). Madrid Spain, 1-5 October 2018.

ICMBio 2017. Plano de Ação Nacional para Conservação das Tartarugas Marinhas - Sumário Executivo. Brasília, 8p.

ICMBio 2021. Plano de Ação Nacional para a Conservação de Cetáceos Marinhos - Sumário Executivo. Brasília, 8p.

ICMBio. 2016. Sumário Executivo do Plano de Ação Nacional para conservação dos tubarões e raias

marinhos ameaçados de extinção. Brasília - DF. 8p.

Instituto de Pesca de São Paulo - IPSP. Banco de dados de pesca. Secretaria de Agricultura e Abastecimento, São Paulo. Last access: September 10th, 2022.

Isaac-Nahum VJ, Cardoso R de D, Servo G, Rossi-Wongtschowski CL del B. 1988. Aspects of the spawning biology of the Brazilian sardine, Sardinella brasiliensis (Steindachner, 1879), (Clupeidae). J Fish Biol 32(3), 383–396. doi:10.1111/j.1095-8649.1988.tb05375.x

Jablonski S, Azevedo AF, Moreira LHA. 2006. Fisheries and Conflicts in Guanabara Bay, Rio de Janeiro, Brazil. Brazilian Archives of Biology and Technology Vol. 49, n. 1 : pp. 79-91.

Magro M, Cergole MC, Rossi-Wongtschowski CLDB. 2000. SÍNTESE DE CONHECIMENTOS DOS PRINCIPAIS RECURSOS PESQUEIROS COSTEIROS POTENCIALMENTE EXPLOTÁVEIS NA COSTA SUDESTE-SUL DO BRASIL: PEIXES. REVIZEE. Brasilia.

MAPA-SAP 2021. Relatório final do comitê científico de avaliação das medidas de gestão aplicadas à pesca de cerco/traineira da sardinha verdadeira (Sardinella brasiliensis) e da sardinha laje (Opisthonema oglinum). Brasília, 39p.

Martins RRM, Pereira HH, Souza GM, Schwingel PR. 2021. Diagnóstico da frota de cerco no Sudeste e Sul do Brasil: acesso formal e oferta de matéria prima ao mercado. Cadernos de Ciência & Tecnologia, Brasília, v. 38, n. 3, e26923

Medeiros SD 2017. Influência da introdução de nova tecnologia de armazenagem e conservação do pescado sobre a operação da frota de pesca industrial de cerco no Sudeste e Sul do Brasil. PhD Dissertation, Univali, 153p.

Moraes 2012. Ecologia espacial da sardinha verdadeira (Sardinella brasiliensis Steindachner 1879): padrões relacionados à variabilidade atmosférica e oceânica no Atlântico Sudoeste. PhD dissertation, Instituto Nacional de Pesquisas Espaciais, São José dos Campos - SP, Brasil.

MPA-MMA 2015. Portaria Interministerial MPA/MMA n 5, de 1 de Setembro de 2015. DOU n º 168 de 02/09/2015 – Seção 1 – pg. 54

MPF 2017. MPF/RJ investiga execução de programa para conservação do boto-cinza. Brazilian Federal Prosecution Office. Accessed on July 27, 2022.

Munroe T, Aiken KA, Brown J & Grijalba Bendeck L. 2015. Cetengraulis edentulus. The IUCN Red List of Threatened Species 2015: e.T190383A16510482. https://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T190383A16510482.en. Accessed on 19 May 2022.

Munroe T, Aiken KA, Brown J, Grijalba Bendeck L. 2015. Harengula clupeola. The IUCN Red List of Threatened Species 2015: e.T16449654A16510257. http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T16449654A16510257.en. Downloaded on September 2017.

Munroe T, Aiken KA, Brown J, Grijalba Bendeck L. 2015b. Opisthonema oglinum. The IUCN Red List of Threatened Species 2015: e.T16466100A16509612. http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T16466100A16509612.en. Downloaded on 10 May 2018.

Oravetz CA 1999. Reducing incidental catch in fisheries. In: ECKERT, K. L.; BJORNDAL, K. A.; ABREU-GROBOIS, F. A.; DONNELLY, M (Ed). Research and management techniques for the conservation of sea turtles. Pennsylvania, USA: IUCN/SSC Marine Turtle Specialist Group, n 4, 1999. Pág 189-193.

Pikitch E, Boersma PD, Boyd IL, Conover DO, Cury P, Essington T, Heppell SS, Houde ED, Mangel M, Pauly D, Plagányi É, Sainsbury K, and Steneck RS. 2012. Little Fish, Big Impact: Managing a Crucial Link in Ocean Food Webs. Lenfest Ocean Program. Washington, DC. 108 pp

Sales G, Giffoni BB, Barata PCR. 2008. Incidental catch of sea turtles by the Brazilian pelagic longline fishery. Journal of the Marine Biological Association of the United Kingdom 88, 853-864.

Sant'Ana R, Kinas PG, Mourato BL. 2020. Relatório Técnico de Avaliação do estoque da Tainha (*Mugil liza*) no Sudeste e Sul do Brasil. Projeto de Cooperação Técnica PCT/BRA/IICA/16/001 - 'Modernização Estratégica' MAPA. Univali. Itajaí, 49p.

Santos SR, Galvão KP, Adler GH, Andrade-Turbino MF, Vianna M. 2020. Spatiotemporal distribution and population biology aspects of Centregaulis edentulus (Actinopterygii: Clupeiformes: Engraulidae) in a South-Western Atlantic estuary, with notes on the local Clupeiformes community: conservation implications. Acta Ichthyologica et Piscatoria 50(2): 139-150.

Schroeder R, Correia AT, Medeiros SD, Pessatti ML, Schwingel PR. 2022. Spatiotemporal Variability of the Catch Composition and Discards
Estimates of the Different Methods of Onboard Preservation for the Brazilian Sardine Fishery in the Southwest Atlantic Ocean. Thalassas: An International Journal of Marine Sciences
https://doi.org/10.1007/s41208-022-00398-5

Schroeder R, Schwingel PR, Correia AT. 2021. Population structure of the Brazilian sardine (Sardinella brasiliensis) in the Southwest Atlantic inferred from body morphology and otolith shape signatures. Hydrobiologia 849:1367–1381.

Schwingel PR, Souza GM, Roos DH. 2022. Monitoramento da sardinha verdadeira (Sardinella brasiliensis) e sardinha-laje (Opisthonema oglinum) durante o período de defeso 2021-2022 (IN Nº18) no Sudeste e Sul do Brasil. Relatório Final. Univali, 51p.

SiBBr - Sistema da Informação sobre a Biodiversidade Brasileira. 2022. Last access on Oct, 2022.

Simãozinho PF. 2011. Idade e crescimento da cavalinha (Scomber japonicus Houttuyun, 1782) capturada pela frota de cerco no Sudeste e Sul do Brasil. Universidade do Vale do Itajaí, BSc final paper.

Smith-Vaniz WF, Brown J, Pina Amargos F, Williams JT, Curtis M. 2015c. Chloroscombrus chrysurus (errata version published in 2017). The IUCN Red List of Threatened Species 2015: e.T16437187A115358128.

http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T16437187A16510252.en. Downloaded on 07 May 2018.

Stocks and management units of Micropogonias furnieri (Desmarest, 1823) in southwestern Atlantic. Lat. Am. J. Aquat. Res., 44(5): 1080-1095.

U.S. Census Bureau 2022. Economic Indicators Division USA Trade Online. Source: U.S. Import and Export Merchandise trade statistics. Access in April 28th 2022.

UNIVALI/EMCT/LEMA. 2020. Estatística Pesqueira de Santa Catarina. Consulta On-line. Projeto de Monitoramento da Atividade Pesqueira do Estado de Santa Catarina. Laboratório de Estudos Marinhos Aplicados (LEMA), da Escola do Mar, Ciência e Tecnologia (EMCT) da Universidade do Vale do Itajaí (UNIVALI).

Vaz-dos-Santos AM, Schwingel PR. 2019. Sardinella brasiliensis Steindachner 1879 at the Southeastern Brazilian Bight (2013-2014). *In*: Vaz-dos-Santos, AM, Rossi-Wongtschowski, CLDB (Eds.). Growth in fisheries resources from the Southwestern Atlantic. São Paulo: Instituto Oceanográfico – USP. Pages