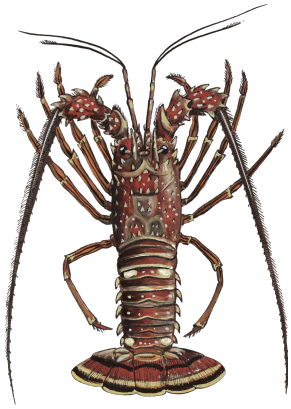
Monterey Bay Aquarium

Seafood Watch®

Caribbean spiny lobster

Panulirus argus



Brazil

Pots

December 19, 2018

Seafood Watch Consulting Researcher

Seafood Watch Standard used in this assessment: Standard for Fisheries vF3

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About Seafood Watch

Monterey Bay Aquarium's Seafood Watch program evaluates the ecological 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. Seafood Watch makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from www.seafoodwatch.org. 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.

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Watch Assessment. Each assessment synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species, then evaluates this information against the program's conservation ethic to arrive at a recommendation of "Best Choices," "Good Alternatives" or "Avoid." This ethic is operationalized in the Seafood Watch standards, available on our website here. In producing the assessments, Seafood Watch seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch Research Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch's sustainability recommendations and the underlying assessments will be updated to reflect these changes.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Watch assessments in any way they find useful.

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, we develop an overall recommendation. Criteria ratings and the overall recommendation are color coded to correspond to the categories on the Seafood Watch pocket guide and online guide:

Best Choice/Green: Are well managed and caught in ways that cause little harm to habitats or other wildlife.

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

Avoid/Red Take a pass on these for now. These items are overfished or caught 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

The spiny lobster is a commercially fished marine invertebrate. There are several distinct species of spiny lobster located in various areas of the world. This report provides information and recommendations for the Caribbean spiny lobster (*Panulirus argus*) fished in Brazil waters with traps called *manzuá.* The other fishing methods used to harvest spiny lobsters in these waters include bottom gillnets called *caçoeira* (the most popular fishing method), free diving and diving with compressors (the most popular fishing methods), and in recent years, using the artificial lobster attractor devices, called *marambaias.*" However, the only legal fishing method are traps.

The Caribbean spiny lobster is moderately vulnerable to fishing pressure. They tend to mature quickly (around 3 years), compared to their life span of around 18 years in the Caribbean. Recently matured spiny lobsters tend to spawn once a year, while older lobsters can spawn multiple times per year and females produce around 3 million eggs; larvae can disperse widely upon hatching. The most recent stock assessments for the species in Brazil were published in 2016, 2017, and 2018. The Brazilian fishery is heavily overfished: the stock is fluctuating around a very low level compared to the 1990s. There has been a gradual decline in landings since the 1990s, though fishing mortality is nearly more than double that of natural mortality. Hence, the stock is undergoing overfishing. The impact of the commercial fishery on the Caribbean spiny lobster in Brazil is ranked red.

Bycatch information are limited in Brazil, though bycatch is thought to be low. There are no national bycatch studies, though a recent bycatch study in Cearà suggested that traps used in the fishery are non-selective. The main bycatch species are snapper and white grunts. Some endangered, threatened and protected (ETP) species are caught, for example, guitarfish. There are no recent discard rates available for the Brazil spiny lobster fishery, though discard rates in lobster fisheries are generally between 8% and 15%. Discards include many invertebrates, which are generally returned alive. The most common gear types used to catch spiny lobsters include gillnets and diving, which are illegal and are inadequately monitored and managed. Gillnets are non-selective, catching a variety of species including mainly corals, but can also result in the entanglement of whales and locally endangered species. About a third of Brazilian coasts are covered in coral reefs, which are vulnerable and susceptible to gillnets. Dive fisheries could be more selective but are not monitored or managed and are utilized in shallow waters where juveniles are more abundant. The impact of the fishery on other species is ranked red for Brazil.

Management of spiny lobster in Brazil has not been effective at maintaining a stable, abundant population. Recent stock assessment studies conclude that the stock is heavily overfished with evidence showing that the stock may be close to collapse, but there is some evidence to show that their decline has stabilised. Brazil mandates a minimum legal size and a 6-month closed season, though poor compliance rates and high rates of "Illegal," "Unregulated," and "Unreported" (IUU) fishing significantly undermine their progress. Overall, the management of the spiny lobster fisheries in Brazil are ranked as critical due to the high levels of IUU fishing.

The only legal fishing gear used to catch spiny lobsters in Brazil are traps; however, the most utilized gears are diving and gillnets. Although diving poses a small threat to the habitat, gillnets—which are found in rocky habitats—pose a risk to corals, particularly through ghost fishing. Traps result in some damage to the benthic habitat but there are some regulations to protect some portion of habitat in reserves. The ecosystem impacts from the trap-based fisheries are considered moderate. The impact of the fishery on habitats and ecosystems is ranked yellow.

The spiny lobster fishery in Brazil is engaged in a Fishery Improvement Project (FIP), which is limited to the analysis of data provided by export organizations, and no official monitoring program is being conducted. Engagement in a FIP does not affect the Seafood Watch score since we base our assessments on the current scientific evidence.

Final Seafood Recommendations

SPECIES/FISHERY	CRITERION 1: IMPACTS ON THE SPECIES	CRITERION 2: IMPACTS ON OTHER SPECIES	CRITERION 3: MANAGEMENT EFFECTIVENESS	CRITERION 4: HABITAT AND ECOSYSTEM	OVERALL RECOMMENDATION
Caribbean spiny lobster Brazil Southwest Atlantic, Pots, Brazil	Red (1.000)	Red (1.299)	Critical (0.000)	Yellow (2.449)	**Avoid (0.000)**

Summary

Spiny lobster from Brazil are given an "avoid" rating because most of the lobsters are caught and landed using illegal fishing methods (diving and gillnets) resulting in a critical score for fishery management.

Eco-Certification Information

A fishery improvement project is in place to improve the sustainability of the Brazilian lobster fishery; it is being implemented by CeDePesca.

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.

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[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

The spiny lobster is a commercially fished marine invertebrate. There are several distinct species of spiny lobster located in various areas of the world. This report will provide information and recommendations for the Caribbean spiny lobster, *Panulirus argus,* fished within Brazil using traps. This lobster is fished mainly using gillnets and diving (free-diving and SCUBA diving and there is an increasing use of lobster attractor devices (LADs), though the only legal method of fishing for lobster is traps.

It should be noted that a recent study has shown that spiny lobster caught off Brazil are genetically distinct from those found in the Caribbean and have been identified as a separate species, *Panulirus meripurpuratus;* however this distinction has yet to be made by the US Food and Drug Administration (which governs the labeling of seafood in the US) or the FAO (which records global landings). Therefore, we continue to use the previous nomenclature. Several spiny lobsters species are found in Brazil, these include (*Panulirus laevicauda)* and *P. echinatus* (Andrade 2015), which are not considered in the scope of this assessment.

Species Overview

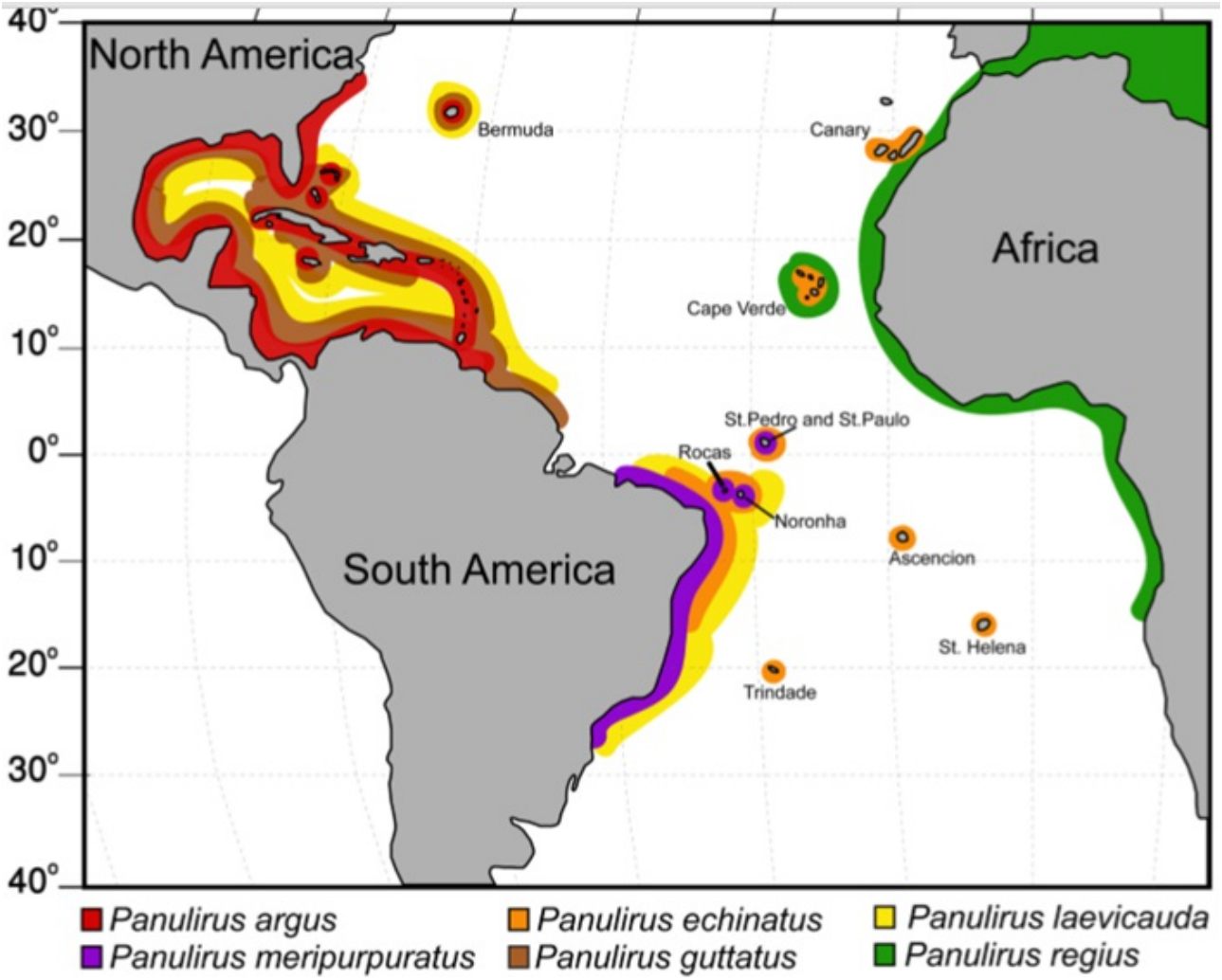

Figure 1 Map showing the distribution of species within the genus Panulirus. Source: (Giraldes and Smyth 2016)

The spiny lobster, of the genus *Panulirus,* contains approximately 20 different species occurring worldwide in

tropical and subtropical waters (Pollack 1995). The spiny lobster can be easily distinguished by the long, spiny antennae and by the lack of claws on the first four pairs of legs (Holthuis 1991). Spiny lobsters are typically found at depths from 0 to 90 meters (m), depending upon the species (Holthuis 1991). Juvenile lobsters may spend their first few years in nearshore surfgrass or algal beds, while adults favor rocky substrates and reefs-areas that provide protection (GMFMC and SAFMC 2011). Spiny lobsters tend to be nocturnal, and live in shelters during the day (Giraldes and Smyth 2016). How lobsters migrate is debated: some studies show that spiny lobsters migrate among depths, depending upon the season, and generally move deeper in winter months (Holthuis 1991).

Brazil has a Lobster Management Plan and the key management measures to manage spiny lobster include a minimum carapace length, season closures, various gear restrictions, license limits and MPAs (FAO 2015a). However, compared with many other countries that catch Caribbean spiny lobster, Brazil lacks in measures, such as prohibitions of harvesting berried and molting lobster and escape gaps in traps (FAO 2015a). New measures are expected to be implemented under the Fishery Management Plan (SCC/CGPL 2017).

The spiny lobster fisheries have been managed by various governmental institutions, which has created uncertainty and hindered progress in the management of the spiny lobster fishery. In the last fifteen years, a shared process between the Ministry of Fisheries an Aquaculture (MPA) and the Ministry of Environment (MMA) was established. The MPA was dissolved in 2015 and replaced by the Secretary of Agriculture of Fisheries, now integrating the structure of the Precedence of the Republic (SEAP/PR). The management system includes a participatory body, the Management Committee for Spiny Lobster Fishery (CGPL), and incorporates a scientific, technical spiny lobster subcommittee working group that includes many stakeholders (FAO 2003); however, the working group is considered to be ineffective, due to the lack of support from the Government to implement a proposed monitoring program for the fishery (SCC/CGPL 2017).

The Brazilian lobster fishery is predominantly formed of small-scale fisheries (FAO 2015a) and mid-sized boats for gillnets, hookas, or traps and drums (Tallaksen and Pocklington 2013). Traps (called *manzuá* in Brazil) are the only legal fishing gear that can be used to harvest lobsters in Brazil. The fishery used traps until the early 1990s, though their popularity reduced due to their perceived low productivity and low profitability. Traps were replaced by bottom gillnet; free diving and compressor diving, and more recently with *marambaias,* which are artificial lobster attractor devices (LAD) and are similar to *casitas* which are found in other Caribbean spiny lobster fisheries. They are mainly constructed using empty oil drums and are modified to a "box" shape to act as an attractant and shelter for lobsters (FAO 2015a). Currently, fishing in most areas is dominated by bottom gillnet gear (FAO 2015a). There are considerable issues with illegal harvesting in Brazilian fisheries, which are estimated to represent over 85% of the Brazilian catch (Andrade 2015).

Production Statistics

Spiny lobsters are fished throughout the Caribbean and along the Central and South American coastlines.

Since the *Panulirus meripurpuratus sp. nov.* species found in Brazil has only been recently defined, the production statistics of both the *Panulirus meripurpuratus sp. nov.* and *P.argus* have been shown below as the Caribbean spiny lobster (Table 1):

Table 1. Largest producers of the Caribbean spiny lobster. Landings measured in tonnes in 2016. Source (FAO 2018a).

LAND AREA	PRODUCTION (TONNES)	GEARS
Bahamas	8482	Casitas, traps

Nicaragua	6450	Traps, free and assisted diving
Brazil	6100	Traps and gillnets (level of gillnet use is unknown and is illegal)
Honduras	6100	Traps (30%) and scuba diving with hooks (70%)
Cuba	4634	Casitas (62%), cages (26%), traps (14%)
USA	2350	Commercial: Traps, SCUBA, bully net. Recreational: No traps, SCUBA diving, free diving, bully net
Dominican Republic	1562	Traps, free and assisted diving
Belize	774	Traps, casitas and skin-diving

The Caribbean spiny lobster is captured throughout its range. Global capture production has varied widely with a minimum of ~3,000 metric tons (MT) in 1950 and a maximum of 42,000 MT in 1995; trade of Caribbean spiny lobster is worth around USD 900 million annually (FAO 2015a). Production over the last decade has fluctuated between 31,720 in 2009 to the highest reported production in 2016 at 39,326 MT (FAO 2018a). The catch production from Brazil fluctuates around 7,000 MT for the past decade (FAO 2018a). The amount of landings from each gear is unknown in Brazil since the catch is mostly harvested using illegal gear (FAO 2015a).

The largest area of production within Brazil is the Cearà state, producing around 60% of Brazilian spiny lobster catches and 80% of its exports (Tallaksen and Pocklington 2013).

Importance to the US/North American market.

The United States imports spiny lobster, including the Caribbean spiny lobster, from several countries in the Caribbean, Central and South America. There is a lack of species-specific imports data since Caribbean spiny lobster imports can be named "LOBSTER ROCK CARIBBEAN SPINY," "LOBSTER ROCK NSPF FROZEN," or terms to that effect. The major producers are Bahamas, Brazil, Honduras, and Nicaragua. Of the total spiny lobster imports to the United States in 2017, approximately 24% is from the Bahamas, 18% from Honduras, 17% from Brazil, and 11% is from Nicaragua (NMFS 2018a). Brazil exports most of its spiny lobster to the United States (MDICT-ALICEWEB 2018) (FAO 2015a).

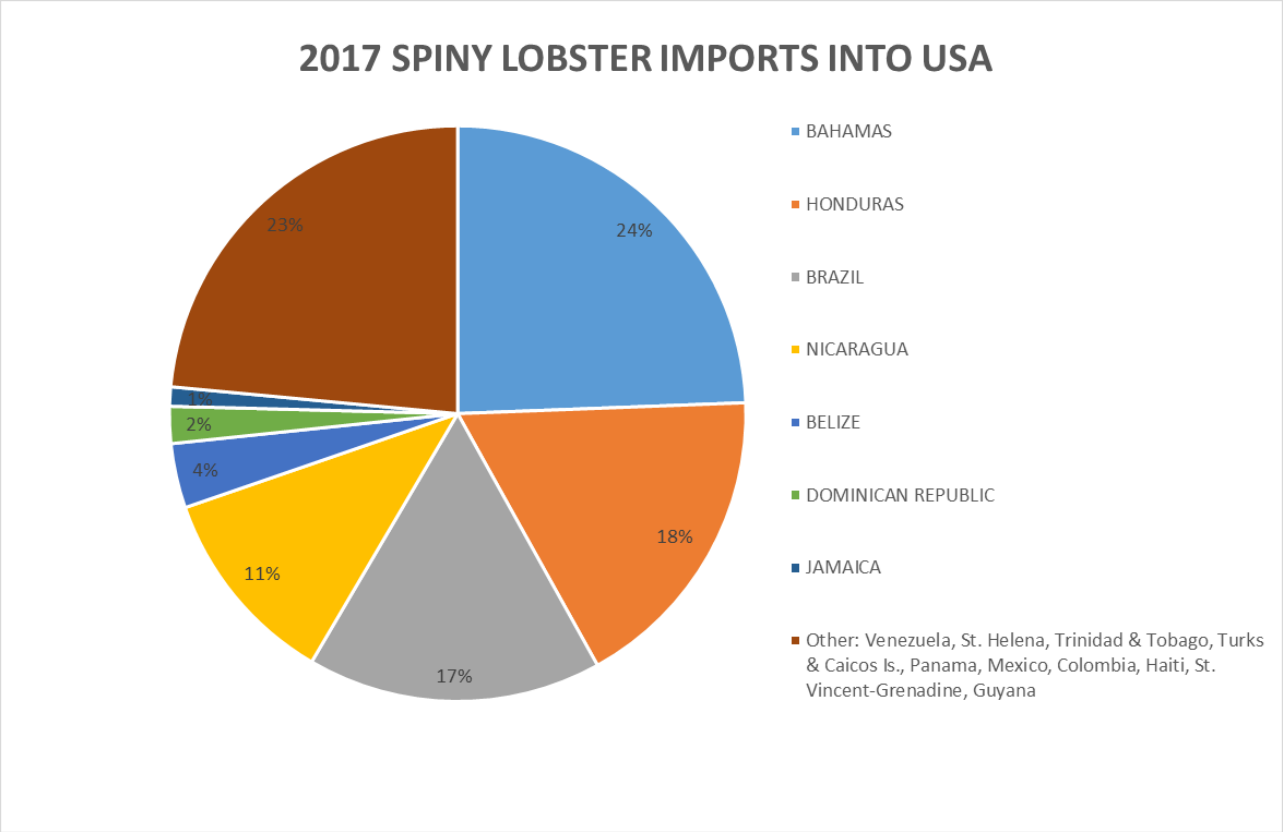

Figure 2 2017 Caribbean spiny lobster imports into USA. 'Other' includes: Dominican Republic, Mexico, Colombia, Ecuador, Antigua and Barbuda. Source: (NMFS 2018a).

Common and market names.

Spiny lobsters are also known as rock lobsters. The Caribbean spiny lobster is also known as Bermuda spiny lobster, common spiny lobster, crawfish, crayfish, Florida (spiny) lobster, bug, West Indian langouste, and West Indian spiny lobster (Holthuis 1991) (NOAA 2015).

Primary product forms

Spiny lobsters are sold as fresh or frozen either in the form of raw tails, meat or whole, either blanched or fully cooked (FishChoice 2017).

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

CARIBBEAN SPINY LOBSTER			
Region | Method	**Abundance**	**Fishing Mortality**	**Score**
Brazil/Southwest Atlantic | Pots | Brazil	1.00: High Concern	1.00: High Concern	Red (1.000)

Overfishing of spiny lobsters in Brazil is believed to have begun 40 years ago {Andrade 2015}. The two most recent stock assessments (a report published in 2017 and a stock assessment, in press) concluded that both the reproductive biomass and fishing mortality are fluctuating around a level that is considered to be very low. The stock structure is unstable and lobsters below the minimum legal size, berried, and older individuals have been highly exploited. The fishing mortality rate is more than double that of the estimated natural mortality rate {CedePesca 2017a} {Aragao and Cintra 2018}. A trend in decreasing exports indicate stock overexploitation {CedePesca 2018a}, a decrease in landings and CPUE, and a high level of fishing effort indicate overexploitation of the stock {Aragao and Cintra 2018}.

Although there have been recent stock assessments for the Brazil spiny lobster fishery, there are significant data gaps that limit the understanding of the stock status. Very little fishery-independent data are available and stock assessments rely on fishery-dependent data, mainly from IBAMA and exporter organisations. Many issues have been identified with the data and there is considerable uncertainty within the stock assessment {Aragao and Cintra 2018}. Although the trap fishing is the only legal harvesting method, more than 90% of catches come from illegal gears (including bottom gill nets and diving using aggregation devices in shallow waters where there is a high abundance of juvenile lobsters {SCC/CGPL 2017} {Cruz et al. 2013} {Aragao and Cintra 2018}.

The Caribbean spiny lobster fishery in Brazil is ranked "high" concern (red).

Criterion 1 Assessment

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.*

CARIBBEAN SPINY LOBSTER

Factor 1.1 - Abundance

BRAZIL/SOUTHWEST ATLANTIC, POTS, BRAZIL

High Concern

Three recent stock assessments have been used to score abundance. The stock assessments produce slightly differing results as they use different indicators and data. The first one, Andrade (2015), was based on catch and CPUE data obtained from Brazilian governmental organizations; the second, CedePesca (2017a), is based on age and weight data for the period 2004 to 2016, converted from export data and provided by an exporter organization. The third, Aragao and Cintra (2018), is based on a combination and consolidation of the IBAMA database and data provided by the exporter organisations.

Andrade (2015) suggested that the stock was in a critical state since the early 2000s (Andrade 2015). Although a value for B/B_{MSY} has not been provided, Figure 3 shows that B/B_{MSY} in the terminal year is about 0.5. The assessment considered CPUE as a valid indicator for abundance, which decreased throughout the time-series (Andrade 2015).

The CedePesca stock assessment (CedePesca 2017a) suggested that biomass is fluctuating around the LRP, where the LRP was defined as 20% of the non-fished population, SSB_0. The $SSB_{2016}/SSB_0 = 0.2008$ and reproductive biomass has been declining since 2013 (Figure 4) (CedePesca 2017a). The 2016 population has an unstable structure and is strongly dependent on recruitment: the stock is largely (77%) formed of age-1

and 2 individuals (CedePesca 2017a).

Aragao and Cintra (2018) showed that biomass is far below previous MSY estimates produced in (Fonteles-Filho 1992) and the degree of uncertainty in estimates of population size and biomass is relatively high, as analyses are strongly based on fishery-dependent data (catches). More accurate fishing-effort data are needed to reduce these uncertainties.

Since the first stock assessment considers that the stock is in "critical" condition, the second assessment suggests the reproductive biomass is fluctuating around the LRP, and the third also suggests the stock is at very low levels and the stock has an unstable structure, Seafood Watch deems abundance as a "high" concern.

Justification:

Andrade (2015) used CPUE as an indicator of abundance CPUE has decreased over the time series from ~800 ton/million pots-days (mpd) in the mid-1960s to 400 ton/mpd in the early 1970s, to <200 ton/mpd 1980s and the 2000s (Andrade 2015). The B/B_{MSY} in the terminal year is about 0.5 (Figure 3).

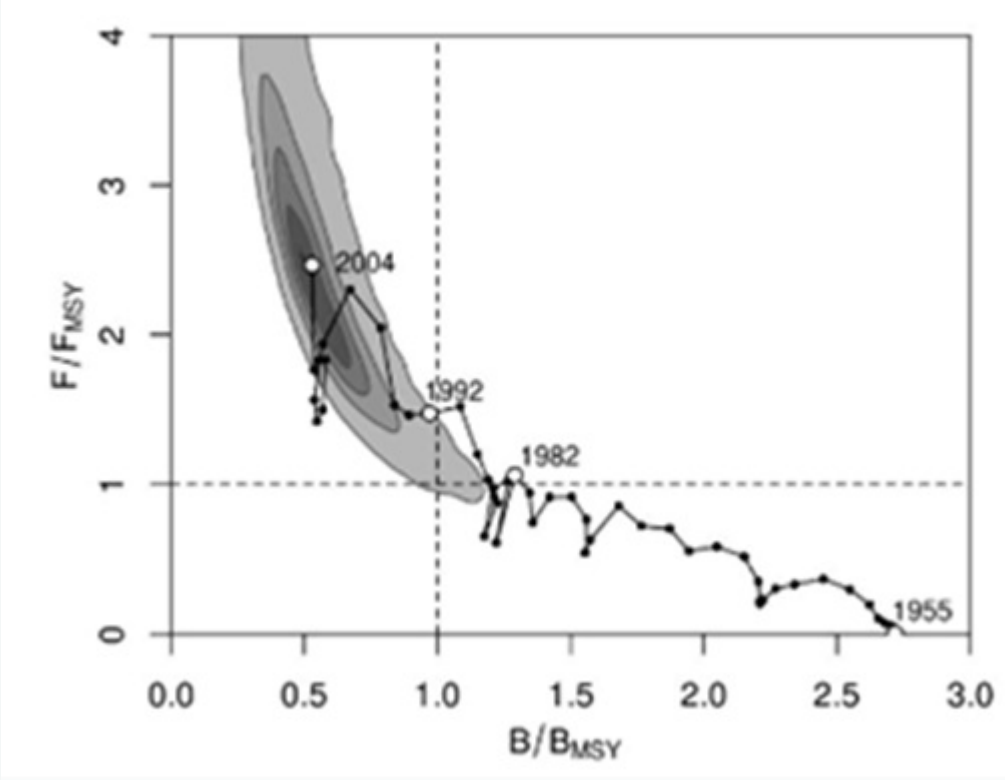

Figure 3 Phase plot for the exploitation of the red spiny lobster (Panulirus argus) in eastern South America between 5°N and 20°S. Contour lines are at 0.025, 0.25, 0.50, 0.75 and 0.975 of the largest density. (Andrade 2015)

CedePesca (2017a) suggested that biomass is fluctuating around the LRP (Figure 4).

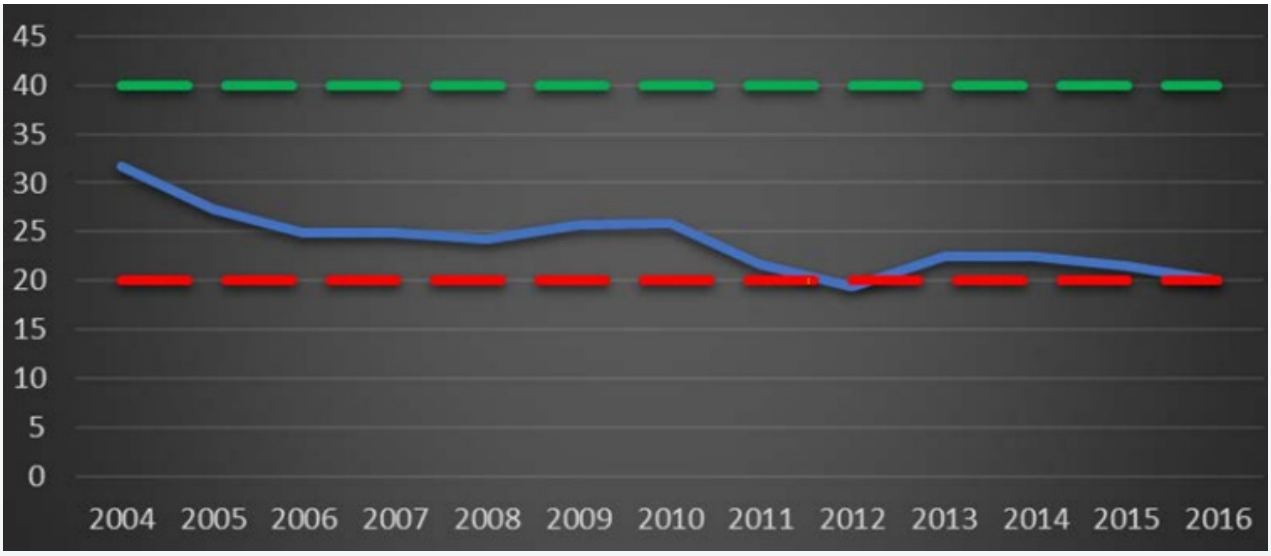

Figure 4 The reproductive biomass against reference points: limit reference point (red dashed line) and target reference point (dashed green line). Source: (CedePesca 2017a).

The most recent stock assessment (Aragao and Cintra 2018) uses sequential population analysis. The data are based on age-composition of the catch (from export data), biological samples, catch statistics, and estimated fishing effort between 2005 and 2015. Despite the high rates of fishing mortality and an impaired age/length structure of the population, the stock biomass and abundance has showed some signs of stability. The estimated biomass relative to virgin biomass is an average of 18%. Reproductive biomass has increased in 2014 and 2015 to around 24%. The biomass is estimated to be between 19,426 and 26,988 MT, with an average of 22,827 t (Figure 8). The export data shows that lobster average tail weight had been declining through 2009, though it has slightly recovered in recent years. Similarly, abundance of age-groups have also stabilized or started to increase and the current age-structure is now dominated by ages 1 to 3. Aragao and Cintra (2018) suggests that there is some evidence of population recovery (based on the relative stability of abundance). Aragao and Cintra (2018) showed that the CPUE (estimated from nominal fishing effort) has had a decreasing trend throughout the time series (Figure 9) (Aragao and Cintra 2018).

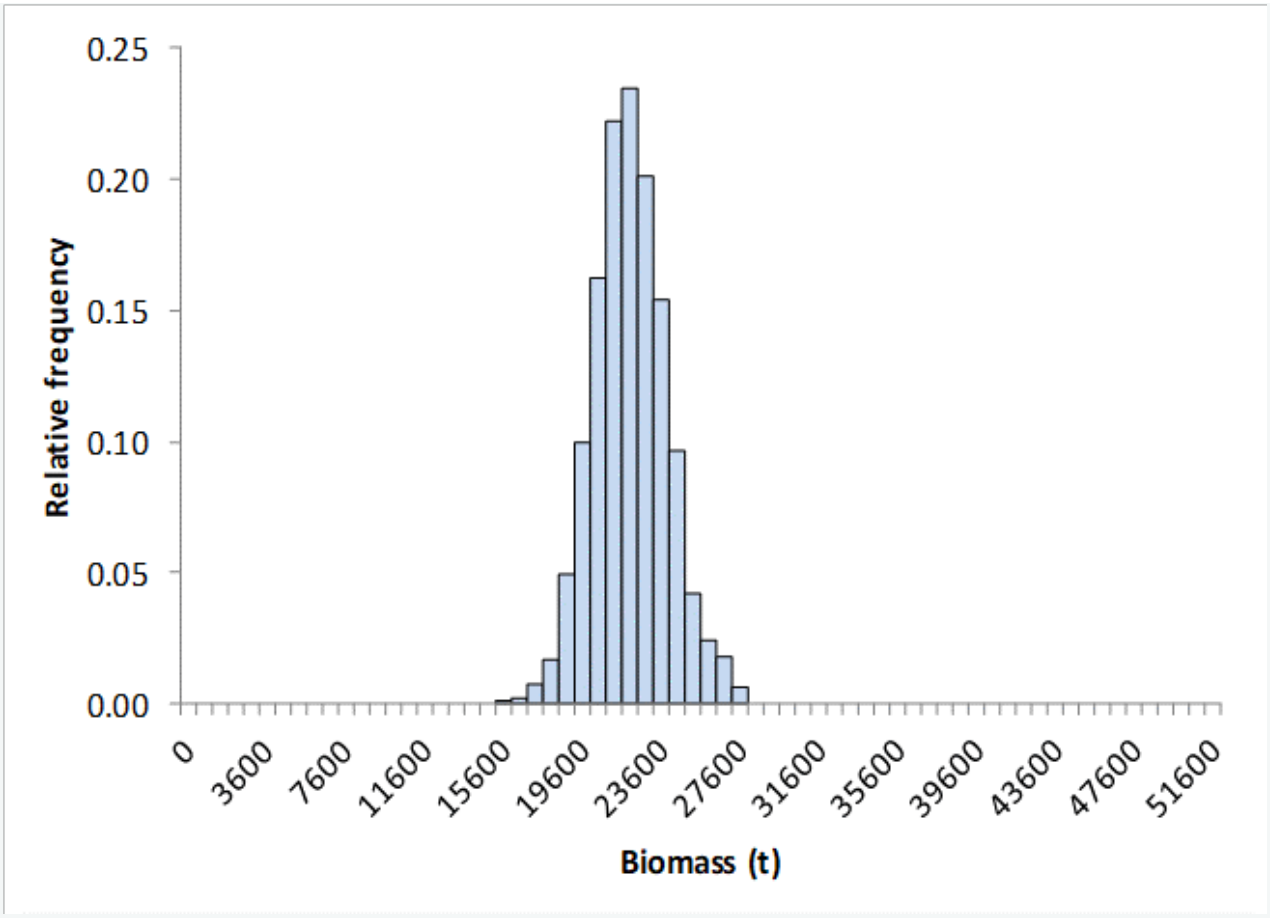

Figure 5 Estimated stock biomass and confidence interval for the Brazilian lobster fishery. Source: (Aragao and Cintra 2018)

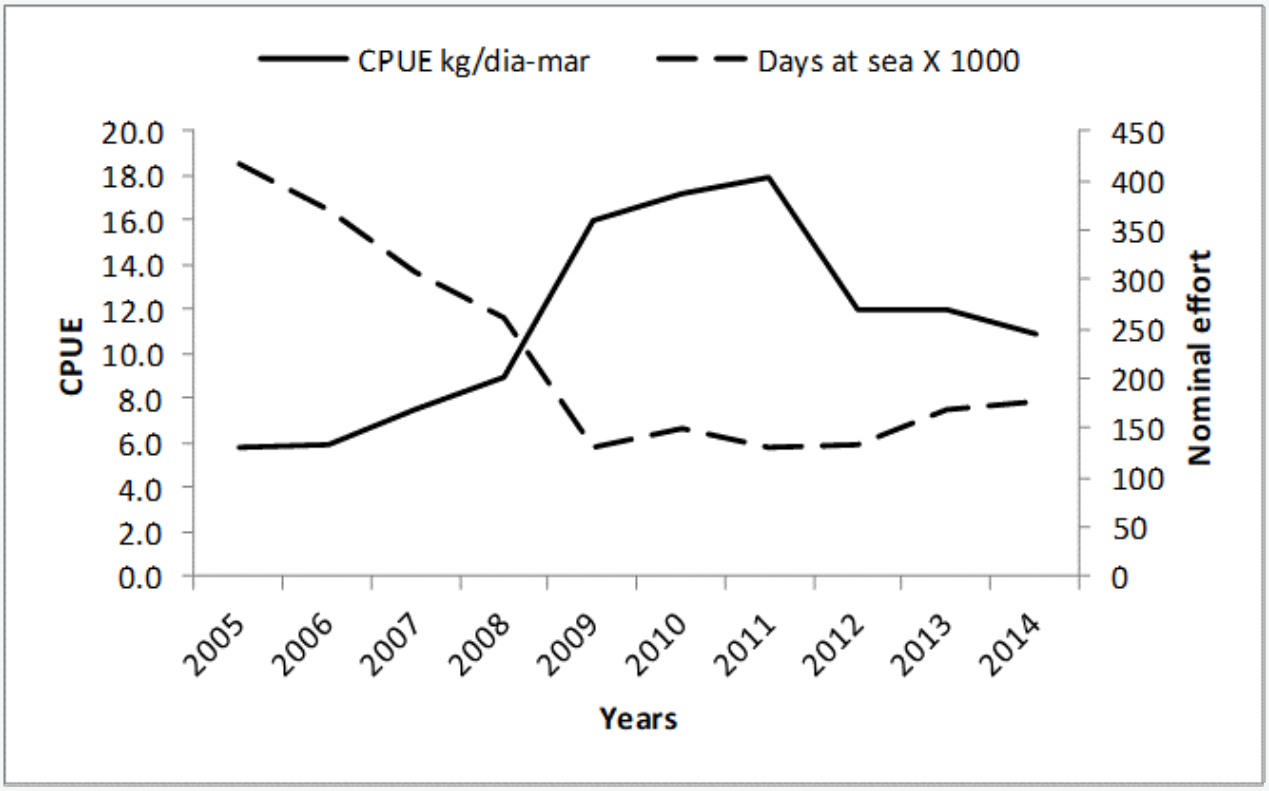

Figure 6 Nominal fishing effort (days at sea) and CPUE (kg per day at sea) in the lobster fishery in Brazil.

Source: (Aragao and Cintra 2018)

In addition to national stock assessments considered above, there are regional differences in biomass that are important to consider in the stock assessments: for example, the Northern spiny lobster fishing area in Brazil has been considered as fully-exploited, while the Northeast areas were deemed as overexploited (FAO 2015a). This is particularly important as there may be several spiny lobster species considered and removed in these fisheries (Giraldes 2016).

Factor 1.2 - Fishing Mortality

BRAZIL/SOUTHWEST ATLANTIC, POTS, BRAZIL

High Concern

Two recent stock assessments have been used to score fishing mortality. The stock assessments produced slightly differing results since they were based on different indicators and data.

The first one, Andrade (2015) suggested that overfishing began over 40 years ago and that overfishing continued at the time of assessment (Andrade 2015). An estimate of F/F_{MSY} was not provided, but Figure 3 shows that F/F_{MSY} in the terminal year was around 2.5. The second assessment, CedePesca (2017a) showed that fishing mortality has decreased and has just fallen below the LRP of the 2017 stock assessment $F_{2016}/F_{lim} = 0.97$, where $F_{2016} = 0.610$ and $F_{lim} = 0.6262$. F_{lim} is defined as 2* M, where M = 0.313 (CedePesca 2017a) (Figure 5). Fishing mortality rates have decreased since 2009, when the closed season was increased (Table 4; (CedePesca 2017a)). Aragao and Cintra (2018) showed that, although fishing mortality decreased from 2011 to 2013, it has subsequently increased, which is probably due to the intensification of the dive fishery (Aragao and Cintra 2018) (Figure 10).

Despite signs of decreasing fishing mortality in the most recent assessment, important sources of fishing mortality do not appear to be accounted for, particularly regarding illegal fishing, which previous assessments suggest is substantial (over 85% of the stock is considered to be illegally harvested) (Andrade 2015). Lobsters below the minimum legal size (≤75 mm carapace length [CL]) face particularly high exploitation rates, where the average length at first capture is 61 mm CL (Cruz et al. 2013). Older lobsters, which produce relatively more eggs (Cruz et al. 2014), also face high exploitation rates (CedePesca 2017a) (Aragao and Cintra 2018). A recent source notes that a trend in decreasing landings and CPUE in recent years suggests the stock is undergoing overexploitation (CedePesca 2018a) (Aragao and Cintra 2018).

Since fishing mortality is still near double that of natural mortality, is fluctuating around the limit reference point or at very low levels, and the recent stock assessment does not account for the high levels of fishing effort and significant levels of illegal fishing in the fishery, Seafood Watch deems fishing mortality as a "high" concern.

Justification:

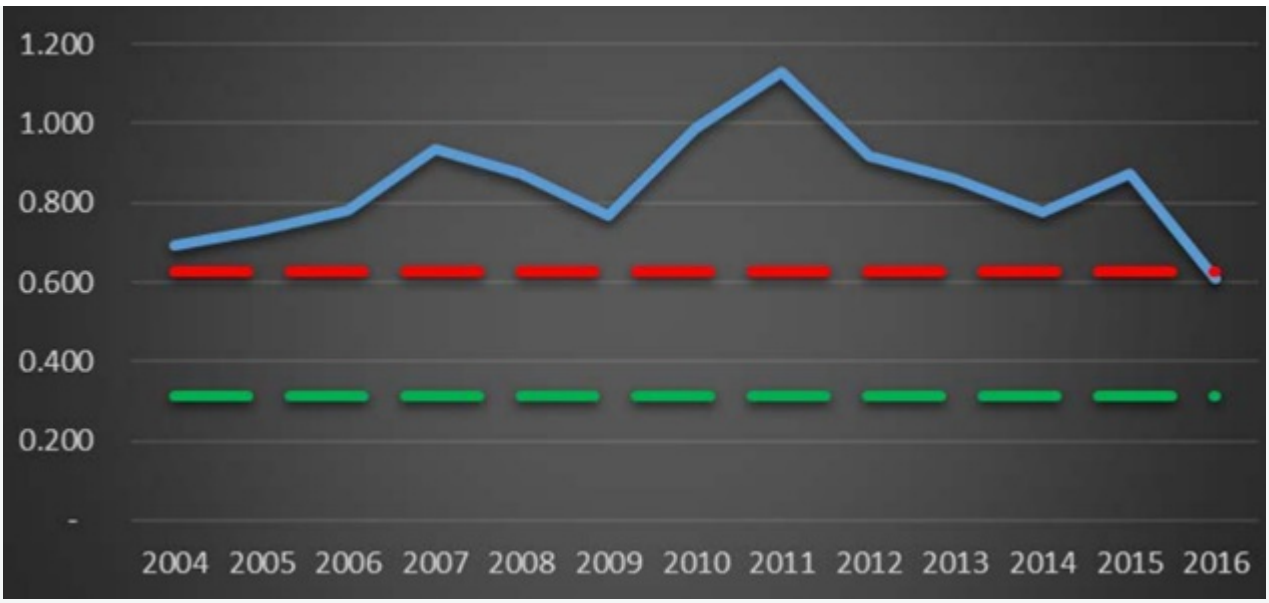

Figure 7 Fishing mortality for lobsters aged 3-6. The blue line is the weighted fishing mortality for ages 3 to 6. The green line represents natural mortality. The red line is double the natural mortality to reflect the reference point of Flim. Source: (CedePesca 2017a)

The following information is from the Aragao and Cintra (2018) assessment. Aragao and Cintra (2018) found that catches have generally fluctuated over the years but have generally declined. Although this decline may be partly attributed to changes in legislation, e.g., the ban on nets. This can be observed in the fishing mortality estimates, which exceed natural mortality rates (0.32). Fishing mortality rates have fluctuated, but have generally decreased, from 2005 (where it was estimated at 0.83 per year) to most recently when it was estimated at 0.5. The post-2009 fluctuations in fishing mortality may be attributed to abundance of the resource. Fishing effort reduced between 2005 and 2014 (from 4,161 to 1,770 days at sea). However, there has been a strong inconsistency between fishing mortality and fishing effort, which suggests that fishing effort has been either under- or over-estimated and that fishing power has increased greatly. Also, some important catches are not considered in the stock assessment; for example, the use of illegal gears, which is not reflected in the nominal effort data (in terms of days at sea) (Aragao and Cintra 2018).

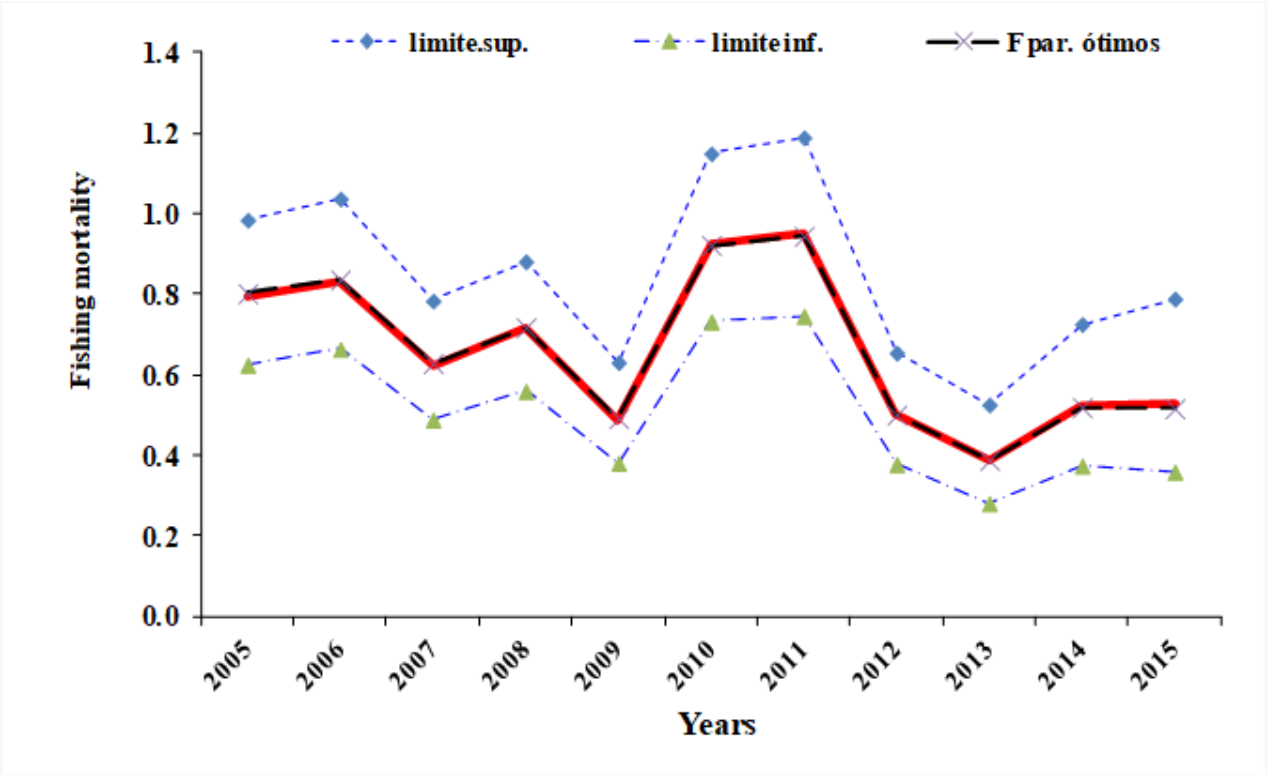

Figure 8 Estimated fishing mortality and confidence interval for the estimation of Brazilian lobster fishing mortality. Source: (Aragao and Cintra 2018).

Aragao and Cintra (2018) suggest that there may be growth overfishing, which is corroborated by Cruz et al. (2013) (Cruz et al. 2013).

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

Only the lowest scoring main species is/are listed in the table and text in this Criterion 2 section; a full list and assessment of the main species can be found in Appendix A.

CARIBBEAN SPINY LOBSTER - BRAZIL/SOUTHWEST ATLANTIC - POTS - BRAZIL					
Subscore:	**1.732**	**Discard Rate:**	**0.75**	**C2 Rate:**	**1.299**

Species	Abundance	Fishing Mortality	Subscore
Snappers	1.00:High Concern	3.00:Moderate Concern	Red (1.732)
Grouper (unspecified)	1.00:High Concern	3.00:Moderate Concern	Red (1.732)
Brazilian guitarfish	1.00:High Concern	3.00:Moderate Concern	Red (1.732)
Finfish	1.00:High Concern	5.00:Low Concern	Yellow (2.236)
Corals and other biogenic habitats	1.00:High Concern	5.00:Low Concern	Yellow (2.236)
Benthic inverts	2.33:Moderate Concern	5.00:Low Concern	Green (3.413)

Retained and bycatch species that are analyzed in this assessment have been chosen based on whether they represent 5% or more of the spiny lobster catch, or due to their conservation status (endangered, threatened, overfished, etc.) or their susceptibility to traps (when data are lacking). In this region, the Southwest Atlantic, the vulnerable taxa are benthic invertebrates, corals, and finfish.

There is a lack of bycatch data available for Brazilian fisheries, though the 4th SCC / CGPL meeting stated that red and green lobster likely represent 95% of total catches in the trap fleet (SEAP/MDICT/ MMA 2017). There is a high incidence of illegal gears used in the fishery; therefore, bycatch data available may not reflect the true outcome. In the absence of bycatch data, the unknown bycatch matrix was used to determine species that are at risk to trap fisheries in the Southwest Atlantic region. Bycatch data from a regional bycatch study in Ceará (the state that catches the majority of Brazilian spiny lobster) (Santana et al. 2015), has been used to determine additional potential bycatch species. In addition, a study from 1996 showed that bycatch is very diverse and includes fish, non-target lobster species, crabs, and mollusks (Ivo et al. 1996) in (Cruz et al. 2013b).

For the trap fishery in Brazil, guitarfish, grouper, and snapper limit the score for Criterion 2 due to their high vulnerability, unknown stock status, and high potential to interact with this gear type.

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)

SNAPPERS

Factor 2.1 - Abundance

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

High Concern

Snappers are caught in Brazilian trap fisheries and mainly include lane snapper and mutton snapper (Santana et al. 2015). However, there are no full, recent, and nationwide stock assessments for these species and many snapper remain data-limited species. Some snapper species are considered to be ETP: *L. analis, L. synagris,* and *L. chrysurus* are being overexploited and have a low resilience (Begossi et al. 2012). Also, some snapper fisheries (e.g., red snapper) show signs of being overfished and are overexploited (Dias 2013).

Since some species are in areas considered to be overfished and overexploited in the region, Seafood Watch deems them a "high" concern.

Factor 2.2 - Fishing Mortality

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

Moderate Concern

There are no data available about snapper species caught, though available data show that they represent less than 5% of total catch in traps. Since fishing mortality is unknown, Seafood Watch deems fishing mortality a "moderate" concern.

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

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

≥ 100%

Discards

A recent study shows that there are very low or no discards as bycatch in Brazilian spiny lobster fisheries, since bycatch is either retained to be sold, used as bait, or is consumed on board (Cruz et al. 2013b). In lieu of discard estimates, total discard rates given in Shester and Micheli (2011) for spiny lobster trap fisheries are presented as 15%. Although this study refers to the California spiny lobster (*P. interruptus*) fishery, where traps are considered to be selective. Conversely, in Brazil, baited traps are not considered selective (Santana et al. 2015).

Bait

There are no quantitative figures estimating bait use in Brazil. However, a study that included interviews with Brazilian fishers showed that 42% reported using sea catfish, 11% used piramutaba catfish heads (*Brachyplatystoma vaillantii*), 6% used unidentified small fish, 4% used unidentified fish heads, 2% used ray and 2% used shrimp heads. Additionally, fishermen reported using non-seafood-related products including bacon (18%), coconut shells (9%) and cow hooves (6%) (Santana et al. 2015).

In the absence of estimates of bait use in Brazil, estimates from other spiny lobster fisheries have been considered. Studies from other lobster fisheries globally have shown that volumes of bait regularly exceed the volume of the target species landed (Harnish and Willison 2009) (Waddington and Meeuwig 2009) (SCS 2011). Bait use is generally quite high in lobster fisheries (for one season in the Punta Abreojos and Bahia Tortugas cooperatives in Mexico, bait use was equal to approximately 4,500 to 5,000 t while landings fluctuated around 1500 t (SCS 2011) (therefore bait use is equal to over 300% of landings).

With no accurate information available from the Caribbean spiny lobster fishery, the ratio of pounds of bait used to pounds of lobster landed is assumed to be greater than 100%. Therefore, bait plus discards is scored as >100%.

GROUPER (UNSPECIFIED)

Factor 2.1 - Abundance

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

High Concern

Groupers are known to interact with Brazilian trap fisheries (Santana et al. 2015), though this is not recorded to species level. Due to their high vulnerability, Seafood Watch considers groupers as a "high" concern.

Factor 2.2 - Fishing Mortality

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

Moderate Concern

There are no data available on the fishing mortality of groupers in the spiny lobster fishery; therefore, Seafood Watch deems fishing mortality to be a "moderate" concern.

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

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

≥ 100%

Discards

A recent study shows that there are very low or no discards as bycatch in Brazilian spiny lobster fisheries, since bycatch is either retained to be sold, used as bait, or is consumed on board (Cruz et al. 2013b). In lieu of discard estimates, total discard rates given in Shester and Micheli (2011) for spiny lobster trap fisheries are presented as 15%. Although this study refers to the California spiny lobster (*P. interruptus*) fishery, where traps are considered to be selective. Conversely, in Brazil, baited traps are not considered selective (Santana et al. 2015).

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fluctuated around 1500 t (SCS 2011) (therefore bait use is equal to over 300% of landings).

With no accurate information available from the Caribbean spiny lobster fishery, the ratio of pounds of bait used to pounds of lobster landed is assumed to be greater than 100%. Therefore, bait plus discards is scored as >100%.

BRAZILIAN GUITARFISH

Factor 2.1 - Abundance

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

High Concern

The spiny lobster trap fishery is known to interact with guitarfish (*Rhinobatos* spp.) in Ceará (Santana et al. 2015); however, species-specific data haven't been collected on guitarfish species. The IUCN considers that the Brazilian guitarfish "Critically Endangered" (Lessa and Vooren 2016) and populations are either unknown or declining.

Since some guitarfish species that interact with the spiny lobster fishery are known to be ETP species, Seafood Watch scores abundance to be a "high" concern.

Factor 2.2 - Fishing Mortality

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

Moderate Concern

Fishing mortality of guitarfish in the Brazilian spiny lobster fishery is unknown. Therefore, Seafood Watch deems fishing mortality as a "moderate" concern.

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

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

≥ 100%

Discards

A recent study shows that there are very low or no discards as bycatch in Brazilian spiny lobster fisheries, since bycatch is either retained to be sold, used as bait, or is consumed on board (Cruz et al. 2013b). In lieu

of discard estimates, total discard rates given in Shester and Micheli (2011) for spiny lobster trap fisheries are presented as 15%. Although this study refers to the California spiny lobster (*P. interruptus*) fishery, where traps are considered to be selective. Conversely, in Brazil, baited traps are not considered selective (Santana et al. 2015).

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With no accurate information available from the Caribbean spiny lobster fishery, the ratio of pounds of bait used to pounds of lobster landed is assumed to be greater than 100%. Therefore, bait plus discards is scored as >100%.

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.

Criterion 3 Summary

Fishery	Management Strategy	Bycatch Strategy	Research and Monitoring	Enforcement	Stakeholder Inclusion	Score
Fishery 1: Brazil / Southwest Atlantic | Pots | Brazil	Critical	NA	NA	NA	NA	Critical (0.000)

The main issues encountered in the Caribbean spiny lobster fishery in Brazil are the poor stock status, high incidence of illegal fishing, and the lack of data available.

Management measures adopted in the fishery are shown in Table 2 and include: gear restrictions (the only legal gear are traps, yet the most commonly used gears are bottom gillnets, diving (both free and SCUBA), and more recently LADs); a minimum mesh size of 5 cm between knots on traps; a closed season (6 months: 1 Dec to 31 May); fishing is forbidden within 4 miles from the coast), and a minimum legal size for lobster {FAO 2015a}. Marine reserves have been increasing in size in Brazil {UN Environment 2018}, though none appear specifically designated to protect spiny lobster. Although a new management plan has been published, measures are not adequately enforced and more management is required to ensure that the stock can rebuild {Dias Neto 2017}.

Effective management of the stock is limited due to the political instability of government. In March 2017, the Brazilian federal government declared that the Secretariat of Fisheries and Aquaculture would be moved from

the Ministry of Agriculture, Livestock, and Food (MAPA) to the Ministry of Industry, Development, and Commerce (MDIC). Despite political turmoil, the Fishery Improvement Project (FIP) has made agreements to improve the management in the fishery {CedePesca 2018a}. Under the FIP agreement, new measures expected to be implemented in 2019 include a Total Allowable Catch, a prohibition for marketing lobster in the domestic market in the last four months of the closure, and a requirement that lobster must be delivered to processing plants alive {CedePesca 2018a}.

Monitoring of the stock has improved over recent years. Stock assessments are produced regularly; however, the Brazil spiny lobster fishery is data-limited, assessments rely on fishery-dependent data and the time-series are intermittent and host considerable uncertainty. Further improvements to monitoring are likely to occur: for example, the landings monitoring program will resume in 2018 {CedePesca 2018a}. Very little data are collected related to bycatch, discards, and ETP species.

Enforcement and compliance in the fishery is deemed ineffective. The illegal harvest is estimated to represent 85% of the total harvest in Brazil. The seasonal closure appears to be enforced {Buesa 2018}; however, there are generally few enforcement programs in place {CedePesca 2018a}.

Since there is substantial illegal fishing, management effectiveness is ranked red.

Table 2. Management measures per country

MANAGEMENT	
Gov. body	IBAMA
Multi/ single species	Unknown
Industrial/Artisanal	Mainly small scale {FAO 2015a}
Fleet size	2,986 small-scale fishing vessels {FAO 2015a}
Fishing method	Mostly illegal gillnets, diving with compressor and artificial lobster attractors {FAO 2015a}
Quota	No {FAO 2015a}, but TACs are expected to be implemented in 2019 {CedePesca 2018a}.
Size limit (tail weight lbs.)	See size limits below
Size limit (length)	130 mm whole length or 110 mm tail length
Closed season	1 December to 31 May {FAO 2015a}
Closed season length	6 months and nursery grounds closed {FAO 2015a}
Berried females prohibition	No
Molting lobsters prohibition	No
Other handling laws	Ban on selling filetted/diced lobster tail meat {IBAMA 2014} {Circuitomatogrosso 2015}

SCUBA prohibition	Yes {CedePesca 2018a}.

Licenses limit	Yes {Cruz et al. 2013b}
Escape gap in traps	No {FAO 2015a}
Gear regulations	Minimum mesh size of 5 cm for the netting used in traps. Prohibition of gillnets to catch lobsters {FAO 2015a}
Other	Fishing not permitted within 4 mi from coast {FAO 2015a}
Level of IUU	>85% {Andrade 2015}

Criterion 3 Assessment

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.

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

Critical

Management of the spiny lobster fisheries in Brazil is undergoing significant challenges, including illegal fishing, a poor stock status and a lack of fishery-independent data to accurately assess the stock. The main organisations involved in the management of the fishery include CedePesca, IBAMA, the Marine Laboratory (LABOMAR), the CGPL and various ministries (CedePesca 2018a). The lack of effective management has been attributed to national political instability and frequent changes to the governmental institutions managing the stock (CedePesca 2017a).

Few measures have been implemented in the Brazil spiny lobster fishery, and those that have, have often been deemed inadequate due to their low compliance rates and weak enforcement (Andrade 2015). For example, although traps are the only legal way to fish spiny lobster (FAO 2015a), an estimated 85% of the total Brazilian catch is harvested illegally: lobster continue to be caught via bottom gillnets or via diving with "hooka" or SCUBA (Buesa 2018) (FAO 2015a). In addition, the Ceará region—which harvests a large proportion of Brazil's total landings—is deemed an "open access" fishery (Santana et al. 2015). The 2017 stock assessment considers that there are no effective management measures other than the seasonal closure (CedePesca 2017a).

A Management Plan (2017) has recently been published for the Brazil spiny lobster fishery. The Management Plan has stated that the management appears to having a positive impact on the recovery of the spiny lobster (Aragao and Cintra 2018) (Dias Neto 2017), attributed to the prohibition of the use of the nets, the extension of the seasonal closure and the requirement for the United States to import lobsters above the minimum size (Dias Neto 2017). However, the Management Plan also stated that the recovery of spiny lobsters has been limited since fishing effort is well above that advised by the SCC and that measures "were not properly implemented" (Dias Neto 2017). Additionally, the Management Plan stated that the lack of data collected in the fishery has precluded an appropriate evaluation of the effectiveness of management in place (Dias Neto

2017). Therefore, the Management Plan has recommended a further review, with urgent improvement, in order to ensure stock survival (Dias Neto 2017).

The lack of adequate management and enforcement has resulted in high fishing mortality rates, above those that are scientifically recommended (CedePesca 2017a) (CedePesca 2018a). Since 2011, fishing mortality has improved slightly, attributed to market behavior. Current fishing mortality levels will not permit the reproductive biomass to considerably exceed the LRP (CedePesca 2017a). Therefore, fishing mortality reductions are required to protect the stock.

Since a high proportion of spiny lobster landings in Brazil are caught using illegal fishing methods (85%) and management is not effective in rebuilding populations, the management strategy and evaluation is deemed "critical."

Justification:

A recent Management Plan was implemented in the Brazil spiny lobster fishery, with the objective: "to promote the recovery and maintenance of the sustainable use of lobsters in Brazil, considering the bioecological, social, economic, and related aspects of sustainability with environmental education and legal aspects, in a short, medium and long term vision" (Dias Neto 2017). Although there have been some improvements in the stock, the stock is still at very low levels (see Criteria 1). The Management Plan has therefore recommended further catch reductions and improvements in the objectives (Dias Neto 2017).

Major political changes have occurred in the fishery in recent years, which have delayed the progress of the management of the fishery. Fisheries were managed by Ministry of Fisheries (MPA) until 2015, when it was replaced by the Secretariat of Fisheries within the Ministry of Agriculture, Livestock, and Food. In turn, this Secretariat was replaced in early 2017 by the Secretariat of Fisheries and Aquaculture to the Ministry of Industry, Development, and Commerce (MDIC). However, the Secretariat was granted Ministry status by late 2017. Additionally, the government of Ceará is defunct, as of 2016 (CedePesca 2018a).

Management measures in place are often considered inadequate or have low compliance rates. For example, although size-at-maturity (CL50%) for male *P. argus* is estimated at 92.2 (± 2.53SE) mm CL, the minimum legal size (MLS) is 75 mm CL (Neves et al. 2016), rendering the MLS too small. The MLS has been deemed to be insufficient in protecting stock numbers (Giraldes et al. 2015). The undersized proportion of the catch is expected to represent the majority (>50%) of the catch (Santana et al. 2015). The closed season was lengthened to 6 months in 2007 but there is a lack of data to suggest whether this has been effective (Andrade 2015).

The recent stock assessments and various literature have recommended that a suite of measures and adequate enforcement is needed to protect the stock, in particular (the following are from (Cruz et al. 2013b)):

- escape gaps for traps
- a ban on using undersized lobsters as attractants
- to cease the use of illegal gears
- an increase in MLS (80 mm CL for all spiny lobster species)
- a maximum legal size (135 mm CL for *P. argus*)
- a prohibition on harvesting berried females
- a closed season to protect ovigerous females
- marine reserves to protect juveniles
- an effective effort and catch monitoring system.

A Fishery Improvement Project (FIP) has enabled some improved management in the fishery. The FIP

agreement was signed by CeDePesca and SINDFRIO in 2011 and is based in the Ceará region (CedePesca 2018a). However, few of the planned management measures have been adopted. For example, in 2015 the FIP agreed to adopt two measures (a requirement to bring lobsters to processing plants alive as of 2017, and limits for domestic trade of lobster during the closure season), but these have not been implemented (CedePesca 2018a). The FIP has intended to adopt further management measures in 2019, including a TAC for red and green lobster, a prohibition of marketing lobster on the domestic market in the 4 months leading to the fishery closure and a requirement that lobster must be delivered alive to processing plants. A compulsory landing system and a requirement to report lobster catches in real-time have been advised to ensure the TAC is complied with and monitored (CedePesca 2018a).

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.

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

Region / Method	Gear Type and Substrate	Mitigation of Gear Impacts	EBFM	Score
Brazil / Southwest Atlantic / Pots / Brazil	2	0	Moderate Concern	Yellow (2.449)

Spiny lobster is generally found on rocky substrates and reefs, or wherever protection and shelter can be found {Holthuis 1991}. As such, traps are deployed in a variety of habitats including rocky reefs. The impact of traps on coral reefs has not been quantified. The vulnerability of habitats where fishing takes place has currently not been determined, and the impacts of the various fishing methods must be determined {Valle-Esquivel 2011}.

Abandoned traps (ghost traps) continuously capture and harm animals and damage marine ecosystems {Adelir-Alves et al. 2016}. There is a lack of information regarding the impact of traps on ghost fishing in Brazil. Minimal management are applied to Brazilian trap fisheries to reduce their impact on the habitat and ecosystem. Fishing with traps is not permitted within four miles from the coast, and traps are required to have a minimum mesh size of 5 cm for the netting used in traps {FAO 2015a}. However, other countries that fish for spiny lobster, such as Florida, mandate and enforce degradable wooden panels to reduce the risk of ghost fishing {Briones-Fourzán and Lozano-Álvarez 2015}.

The role of the spiny lobster in Brazilian ecosystems is not well studied and the spiny lobster is currently overfished. Some spatial management is in place to protect spiny lobster and other species; however, less than a quarter of MPAs are expected to meet their minimal objectives {Magris et al. 2013}, thereby reducing their efficacy.

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

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

2

Spiny lobster is generally found on rocky substrates and reefs, or wherever protection and shelter can be found (Holthuis 1991). A recent study found traps in reef habitats (Adelir-Alves et al. 2016).

Since traps can be set on rocky or reef structures, Seafood Watch deems factor 4.1a as a score of 2.

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

0

Brazil has protected 24.5% of its territorial seas through Marine Protected Areas (UN Environment 2018). It is not clear if these MPAs protect lobster habitat. Measures are in place, such as seasonal closures to reduce the amount of habitat damage caused by fisheries, and fishing is not permitted within four miles from coast (FAO 2015a). However, there are few measures to limit effort: there are vessel licenses, though no limits on quota; few gear modifications required and less than a quarter of MPAs are expected to meet their minimum objectives (Magris et al. 2013). The lack of enforcement and low compliance rates significantly reduced the potential efficacy of mitigation measures. Ghost fishing gear has been found in fishing exclusion zones (Adelir-Alves et al. 2016), which cause significant impacts to habitats (Adelir-Alves et al. 2016), and over 85% of the stock is estimated to be harvested through illegal methods (Andrade 2015).

Since 24.5% of Brazil's territorial seas have MPAs, but it isn't clear if the MPAs aim to protect lobster habitat, MPA effectiveness is perceived to be low, and there are very few measures in place to reduce the impact of gears on the habitat, Brazil receives a score of no mitigation (0).

Justification:

Marine Protected Areas (MPAs) are the popular tool in Brazil for managing coastal ecosystems and species, particularly through no-take MPAs, since they encourage exploited populations to recover and increase spillover and recruitment (Salz 2015).

Brazil hosts one of the largest MPAs in the world and around 300 MPAs, but very few aim to protect marine habitats (Araújo and Bernard 2016). However, a study attempting to analyze the efficacy of MPAs in Brazil

found that only 23% of ecosystems were meeting minimum objectives (Magris et al. 2013). Abandoned, lost, and discarded gear are found in MPAs, where it is illegal for them to be used (Adelir-Alves et al. 2016).

Factor 4.3 - Ecosystem-Based Fisheries Management

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

Moderate Concern

The ecological role of spiny lobsters has not been well studied, and there is an absence of ecological information for the species (Giraldes et al. 2015). Therefore, the impacts of the spiny lobster fishery on the ecosystem are unknown, though ecosystem impacts likely include the interactions between traps and coral reefs/sensitive ecosystems, the effects of ghost fishing, and the potential harm of invasive species.

There is spatial management in place to protect ecosystems: as of 2018, 24.5% of Brazil's territorial waters are protected by MPAs (UN Environment 2018), though it is unknown if these are protecting spiny lobster and less than a quarter of MPAs are expected to achieve their minimum objectives (Magris et al. 2013).

Since there is a lack of information regarding the spiny lobster and its ecological role, a lack of policies in place to protect ecosystem functioning—but some spatial management is in place to protect that functioning—and detrimental food web impacts are unlikely, Seafood Watch deems Ecosystem-based Fisheries Management as a "moderate" concern.

Justification:

In other Caribbean coral reef ecosystems, the only identified role that *P. argus* plays is as a prey item for octopus and grouper. Therefore, by fishing it at high intensities, it can reduce the prey availability for top predators (Higgs 2016b).

The overexploitation of spiny lobster likely indirectly affects the ecological role of Brazil's tropical coastal reefs (Giraldes et al. 2015): there are concerns with the removal of detrivores/omnivorous decapods and the impact of their overexploitation on fishes and corals and other benthic organisms (Giraldes et al. 2015). Many species studied in Brazilian waters are already overexploited (Chaves et al. 2013a), and prolonged periods of overexploitation can result in the collapse of ecosystems (Neubauer et al. 2013). Continuous removal of primary and secondary consumers throughout food webs may cause large scale ecological imbalance in the coastal reef system and potentially is already impacting trophic relationships (McConkey and O'Farrill 2015). This is exacerbated by the use of illegal gears, such as gillnets, which can cause irreversible change in the coastal reef ecosystem (Smith et al. 2011) and trophic cascades (Säterberg et al. 2013).

There is limited information regarding ghost fishing as a result of gear lost in the Brazil spiny lobster fishery; however, in the Florida spiny lobster fishery, Butler and Matthews (2015) proposed that 637,622 lobsters are killed each year by ghost traps. Ghost traps also destroy or damage protected corals, benthic habitats, benthic fauna and flora; they disturb sediments, reduce biomass, kill foundation species, entangle marine mammals and turtles, and confine trapped animals, resulting in their injury or mortality (Butler and Mathews 2015).

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Appendix A: Extra By Catch Species

FINFISH

Factor 2.1 - Abundance

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

High Concern

The status of the populations of finfish caught by the spiny lobster fishery is of moderate conservation concern due to the unknown factors surrounding this bycatch group. Some finfish have been identified in a bycatch study based in Ceará (the state with the highest production and exporting of spiny lobster) (Santana et al. 2015). Finfish such as white grunt (which form one of the main bycatch species in Ceará) (Santana et al. 2015), have no stock assessment nor data-limited indicators to assess the abundance of the stock. However, some ETP species can be caught, such as some species of parrotfish (*Sparisoma* spp.) (Santana et al. 2015).

There is a lack of information regarding the abundance of finfish; however, some ETP species may be caught. Therefore, Seafood Watch scores finfish as "high" concern.

Justification:

Greenback parrotfish are endemic to Brazil. There are no current abundance estimates for greenback parrotfish, nationally for the species, though there have been previous assessments for specific reef locations (Salz 2015). However, the IUCN considers the species as "Endangered" with a declining population (Padovani-Ferreira et al. 2012). Since the species are considered to be endangered, Seafood Watch deems them as a "high" concern.

Factor 2.2 - Fishing Mortality

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

Low Concern

The Unknown Bycatch Matrix deems that fishing mortality of unknown finfish, when caught with traps is scored a “low” concern.

Factor 2.3 - Discard Rate

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

≥ 100%

Discards

A recent study shows that there are very low or no discards as bycatch in Brazilian spiny lobster fisheries, since bycatch is either retained to be sold, used as bait, or is consumed on board (Cruz et al. 2013b). In lieu of discard estimates, total discard rates given in Shester and Micheli (2011) for spiny lobster trap fisheries are presented as 15%. Although this study refers to the California spiny lobster (*P. interruptus*) fishery, where traps are considered to be selective. Conversely, in Brazil, baited traps are not considered selective (Santana et al. 2015).

Bait

There are no quantitative figures estimating bait use in Brazil. However, a study that included interviews with Brazilian fishers showed that 42% reported using sea catfish, 11% used piramutaba catfish heads (*Brachyplatystoma vaillantii*), 6% used unidentified small fish, 4% used unidentified fish heads, 2% used ray and 2% used shrimp heads. Additionally, fishermen reported using non-seafood-related products including bacon (18%), coconut shells (9%) and cow hooves (6%) (Santana et al. 2015).

In the absence of estimates of bait use in Brazil, estimates from other spiny lobster fisheries have been considered. Studies from other lobster fisheries globally have shown that volumes of bait regularly exceed the volume of the target species landed (Harnish and Willison 2009) (Waddington and Meeuwig 2009) (SCS 2011). Bait use is generally quite high in lobster fisheries (for one season in the Punta Abreojos and Bahia Tortugas cooperatives in Mexico, bait use was equal to approximately 4,500 to 5,000 t while landings fluctuated around 1500 t (SCS 2011) (therefore bait use is equal to over 300% of landings).

With no accurate information available from the Caribbean spiny lobster fishery, the ratio of pounds of bait used to pounds of lobster landed is assumed to be greater than 100%. Therefore, bait plus discards is scored as >100%.

CORALS AND OTHER BIOGENIC HABITATS

Factor 2.1 - Abundance

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

High Concern

Many corals are considered as ETP species in Brazil; these include critically endangered species such as the staghorn coral, *Acropora cervicornis* (Aronson et al. 2008). Corals and other biogenic habitats are assumed to have a high vulnerability and , are therefore deemed as "high" concern.

Factor 2.2 - Fishing Mortality

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

Low Concern

Fishing mortality of corals and other biogenic habitats is unknown; therefore, the Unknown Bycatch Matrix scores fishing mortality as a "low" concern.

Factor 2.3 - Discard Rate

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

≥ 100%

Discards

A recent study shows that there are very low or no discards as bycatch in Brazilian spiny lobster fisheries, since bycatch is either retained to be sold, used as bait, or is consumed on board (Cruz et al. 2013b). In lieu of discard estimates, total discard rates given in Shester and Micheli (2011) for spiny lobster trap fisheries are presented as 15%. Although this study refers to the California spiny lobster (*P. interruptus*) fishery, where traps are considered to be selective. Conversely, in Brazil, baited traps are not considered selective (Santana et al. 2015).

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In the absence of estimates of bait use in Brazil, estimates from other spiny lobster fisheries have been considered. Studies from other lobster fisheries globally have shown that volumes of bait regularly exceed the volume of the target species landed (Harnish and Willison 2009) (Waddington and Meeuwig 2009) (SCS 2011). Bait use is generally quite high in lobster fisheries (for one season in the Punta Abreojos and Bahia Tortugas cooperatives in Mexico, bait use was equal to approximately 4,500 to 5,000 t while landings fluctuated around 1500 t (SCS 2011) (therefore bait use is equal to over 300% of landings).

With no accurate information available from the Caribbean spiny lobster fishery, the ratio of pounds of bait used to pounds of lobster landed is assumed to be greater than 100%. Therefore, bait plus discards is scored as >100%.

BENTHIC INVERTS

Factor 2.1 - Abundance

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

Moderate Concern

The status of the populations of benthic invertebrates caught by the spiny lobster fishery is of moderate conservation concern due to the unknown factors surrounding this bycatch group.

Some invertebrates have been identified in a bycatch study based in Ceará (Santana et al. 2015), such as crabs and seashells; however, specific species have not been identified.

Seafood Watch scores the vulnerability of benthic invertebrates a "moderate" concern.

Factor 2.2 - Fishing Mortality

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

Low Concern

Fishing mortality of benthic invertebrates is unknown; therefore, the Unknown Bycatch Matrix scores fishing mortality as a “low” concern.

Factor 2.3 - Discard Rate

BRAZIL / SOUTHWEST ATLANTIC, POTS, BRAZIL

≥ 100%

Discards

A recent study shows that there are very low or no discards as bycatch in Brazilian spiny lobster fisheries, since bycatch is either retained to be sold, used as bait, or is consumed on board (Cruz et al. 2013b). In lieu of discard estimates, total discard rates given in Shester and Micheli (2011) for spiny lobster trap fisheries are presented as 15%. Although this study refers to the California spiny lobster (*P. interruptus*) fishery, where traps are considered to be selective. Conversely, in Brazil, baited traps are not considered selective (Santana et al. 2015).

Bait

There are no quantitative figures estimating bait use in Brazil. However, a study that included interviews with Brazilian fishers showed that 42% reported using sea catfish, 11% used piramutaba catfish heads (*Brachyplatystoma vaillantii*), 6% used unidentified small fish, 4% used unidentified fish heads, 2% used ray and 2% used shrimp heads. Additionally, fishermen reported using non-seafood-related products including bacon (18%), coconut shells (9%) and cow hooves (6%) (Santana et al. 2015).

In the absence of estimates of bait use in Brazil, estimates from other spiny lobster fisheries have been considered. Studies from other lobster fisheries globally have shown that volumes of bait regularly exceed the volume of the target species landed (Harnish and Willison 2009) (Waddington and Meeuwig 2009) (SCS 2011). Bait use is generally quite high in lobster fisheries (for one season in the Punta Abreojos and Bahia Tortugas cooperatives in Mexico, bait use was equal to approximately 4,500 to 5,000 t while landings fluctuated around 1500 t (SCS 2011) (therefore bait use is equal to over 300% of landings).

With no accurate information available from the Caribbean spiny lobster fishery, the ratio of pounds of bait used to pounds of lobster landed is assumed to be greater than 100%. Therefore, bait plus discards is scored as >100%.