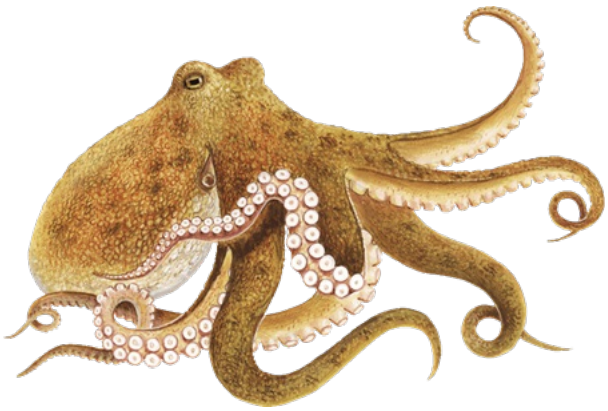
Monterey Bay Aquarium Seafood Watch®

Octopus

Octopus vulgaris
Octopus insularis
Octopus maya



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Mexico

Trolling lines

November 4, 2019

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

In the Yucatan Peninsula, the octopus fishery is one of the most important in terms of volume and value. According to managers' official records, the fishery targets two species: red octopus (*Octopus maya)* and common octopus (*Octopus vulgaris*). However, recent genetic studies (Lima et al. 2017)(Flores-Valle et al. 2018) (Gonzalez-Gomez et al. 2018) suggested that a third species, a genetic variant of the Brazilian reef octopus (*O. insularis*), inhabits the region and may be misreported by producers as *O. vulgaris* (Lima et al. 2017). This report assesses the octopus fisheries in the states of Campeche (composed mostly by *O. maya*) and Yucatan (*O. maya* represents around 70% and 30% *O. vulgaris*) (DOF 2014) developed by fishers that use baited trolling lines (known as "jimbas").

Abundance assessments are conducted for red octopus only, which are used to estimate annual harvest quotas; however, common octopus does not have this type of harvest limit, and in the case of *O. insularis*, the species is not currently considered as part of the catches. Based on the information available, and the use of PSA analysis, *O. common* and *O. insularis* species scored as "high" concern for abundance. In relation to fishing mortality, despite the fact that the fishery seems to be experiencing steady landing rates, official landings for red octopus have constantly surpassed the assigned quota, which could be a concern for the species, especially considering that species misreporting seems to be a common practice and current fishing mortality efforts could be higher. For these reasons, fishing mortality for red octopus was scored as a "high" concern, while scored as "moderate" for *O. vulgaris* and *O. insularis*.

Octopus trolling lines are highly selective, and no interactions with other species have been reported. However, there are some concerns that producers use horseshoe crabs—a protected species—as bait, although there was no information available to confirm this or to estimate the level of impact in the species.

In relation to management, a federal fishery management plan and a Mexican Official Norm are in place. These management tools contain specifications related to minimum size limit, the annual quota for red octopus, and a no-fishing season that runs from 16 December to 31 July. These regulations apparently have been partially effective, considering that landings have been relatively stable despite the fact that red octopus quota has been surpassed in several years. It is also important to consider that researchers have found misreporting to be an issue and the current status of the species could be worse than is believed. In addition, managers recognized that enforcement is a difficult task and illegal actions (e.g., the use of non-authorized gears) occurs.

Finally, the gear used in the octopus fisheries in the Yucatan Peninsula has minimal impact on the benthic habitat due to its contact with the bottom, but some spatial regulations are in place to keep those impacts to a minimum. The ecosystem impacts from the trolling lines fishery are considered low. Overall, the fisheries in Campeche and Yucatan that target common octopus (*O. vulgaris*), the variant of Brazilian reef octopus (*O. insularis*), and red octopus (*O. maya*) are considered "red" or "avoid."

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
Brazil reef octopus Mexico/Gulf of Mexico | Trolling lines	Red (1.732)	Red (1.526)	Red (2.000)	Green (3.464)	**Avoid (2.068)**
Common octopus Mexico/Gulf of Mexico | Trolling lines	Red (1.732)	Red (1.526)	Red (2.000)	Green (3.464)	**Avoid (2.068)**
Mexican four-eyed octopus Mexico/Gulf of Mexico | Trolling lines	Red (1.526)	Red (1.732)	Red (2.000)	Green (3.464)	**Avoid (2.068)**

Eco-Certification Information

There is a comprehensive FIP for this fishery, launched in 2019 and led by SFP: Mexico Yucatan octopus–drift rod and line. The FIP volume is 10,000 t.

Link to fishery progress page for this FIP: https://fisheryprogress.org/fip-profile/mexico-yucatan-octopus-drift-rod-and-line

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

This Seafood Watch report provides recommendations for red octopus (*Octopus maya*), common octopus (*Octopus vulgaris*) and the genetic variant of Brazilian reef octopus (*Octopus insularis*) targeted in the Yucatan Peninsula, Mexico. This fishery is undertaken mainly by small scale producers in the states of Yucatan and Campeche (Salas et al. 2019). These producers use baited lines (known as *jimbas*) that drift on the bottom of the sea from their vessels or *alijos* (small non-motorized canoes carried onboard medium size vessels, see Figure 2). A fishery improvement project for Yucatan was recently launched in 2019.

Species Overview

Red octopus (*O. maya*) is an endemic benthic species living in shallow waters of the continental shelf of the Yucatan (INAPESCA 2014). Its known distribution extends from the waters adjacent to Isla del Carmen in Campeche to Isla Mujeres in Quintana Roo (DOF 2014). One single stock is exploited based on genetic studies. This species has been extensively studied in the region, due to its high value and importance for the regional economy.

The common octopus (*O. vulgaris)* has a wide distribution in tropical and subtropical regions throughout the world. In Mexico, it is distributed throughout the Gulf of Mexico and is found from the coastline up to 400 m deep, but it is more abundant below 100 m and its abundance decreases as depth increases. It is exploited in the Yucatan Peninsula and Veracruz (DOF 2014) (see Figure 1).

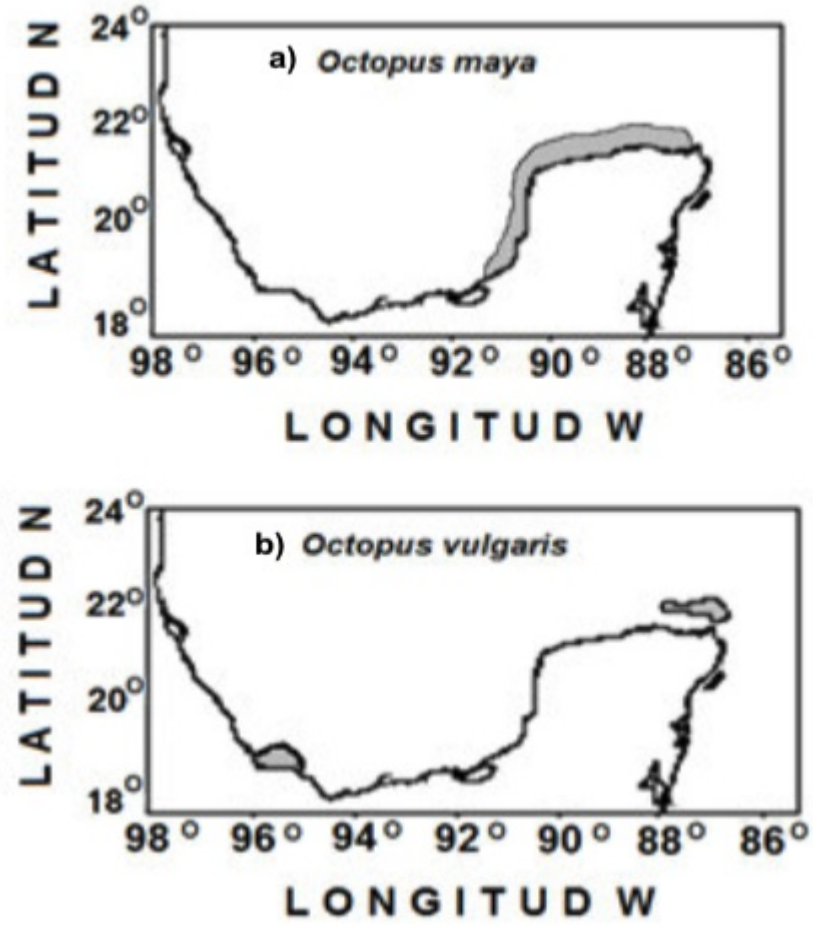

Figure 1 Fishing areas for a) Red octopus and b) Common octopus in the Yucatan Peninsula (INAPESCA 2014)

Once they hatch, red octopus juveniles behave like adults, capturing live prey and remaining hidden when they are not active (Solis-Ramirez et al. 1997). Reproduction is continuous with greater intensity towards the end of each year. Fecundity fluctuates between 1,500 and 2,000 eggs per female (Silva et al 2002). Because almost all mature females and those who have spawned are less likely to feed, the fishing method employed in the Yucatan Peninsula is considered a very conservative method, since it could capture more males than females (DOF 2014) (see figure 2). Overall, red octopus is a species with rapid growth and short life cycle (Solis-Ramirez and Chavez 1986). The maximum age has been estimated at around 12 months (Solis-Ramirez and Chavez 1986) and 18 months (Arreguin-Sanchez 1992). (Angeles-Gonzalez et al. 2018) analyzed the spatio-temporal variability of the reproductive maturation for red octopus and report that high temperatures (close and above 27 C) have a significant impact on the distribution and spawning of the species. In addition, it has been reported that the reproductive strategy of red octopus females ensure that an important fraction of eggs would hatch, which, combined with the existence of two annual recruitment events, contribute to the population biomass (Duarte et al 2018).

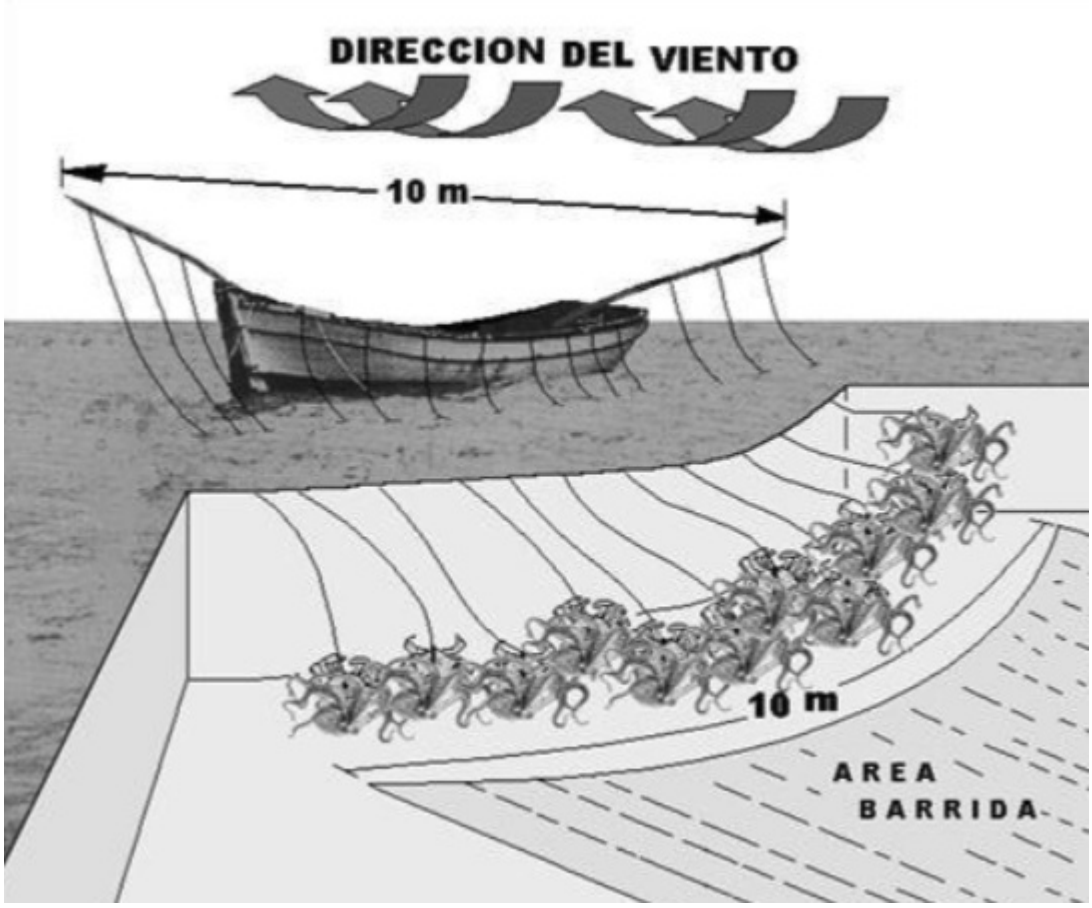

Figure 2 Fishing vessels with Jimbas (bamboo sticks) with baited trolling lines

On the other hand, common octopus is a cosmopolitan species, distributed in tropical and subtropical waters around the world. It can be found from the sea surface to a depth of 150 m. It lives in waters with temperatures between 6 C and 33 C, being more common between 10 C and 30 C (INAPESCA b 2014).

Solis-Ramirez (1997) mentioned that common octopus reaches its sexual maturity at 8 to 10 months of age when they measure 80 mm of mantle length (ML) (Solis-Ramirez et al. 1997). However, it has been suggested that the size of sexual maturity is different between sexes. In the Gulf of Mexico, Jimenez-Badillo (2008) found

the same pattern described in the Mediterranean, where the minimum size of sexual maturity in males was 248 g and in females 612 g (Jimenez-Badillo 2008). On average, most males reach sexual maturity at 110 mm LM with 700 g total weight, while the females reached it at 140 mm ML with 1,400 g total weight (Silva et al 2002). Spawning period is continuous throughout the year in tropical and subtropical waters. A female specimen can deposit between 100,000 and 500,000 eggs during its short lifetime (Perez et al 2007). This high level of fecundity coincides with the reported by (Hernandez-Garcia et al. 2002) in the Canary Islands, where the authors found that the real fecundity oscillated between 31 and 106 eggs spawned per gram of female body weight (Hernandez-Garcia et al 2002).

Growth estimates for the Gulf of Mexico suggest slower growth than in the Mediterranean and a maximum age of 2.2 years (Diaz-Alvarez and Jimenez-Badillo 2009).
Tropical species *O. insularis* is found in the warm waters of the north and northeast Brazilian coast and oceanic islands (Leite et al. 2009); however, (Lima et al. 2017) suggested that its geographical distribution was not fully understood and confirmed in their genetic study that species misidentification was observed in octopus of the tropical Northwestern Atlantic. Particularly, specimens in the Caribbean Sea that have been recorded as *O. vulgaris* but shared the same haplotype as *O. insularis*, indicate that these octopuses are *O. insularis*. Based on this, it has been concluded that at least three different species are being economically exploited in this area (Lima et al. 2017).

Production Statistics

In Yucatan state, octopus captures have varied over time. From 1998 to 2000, landings remained between 14,000 and 15,000 tons (t), and from 2001 to 2003 less than 10,000 t per year was recorded. During the 2004 to 2010 period, there was an alternation between low (2005, 2008) and high (2004, 2006, 2009) levels of capture. In 2006 the historical maximum of the series was obtained with around 20,000 t, which was very close during the 2009 season. On the other hand, Campeche landings increased steadily from 1998 to 2001 reaching the historical maximum of 8,107 t in 2001. Since 2002, annual catches have remained above 5,000 t, except for the 2009 season, when the catch decreased to 3,946 t (Figure 3).

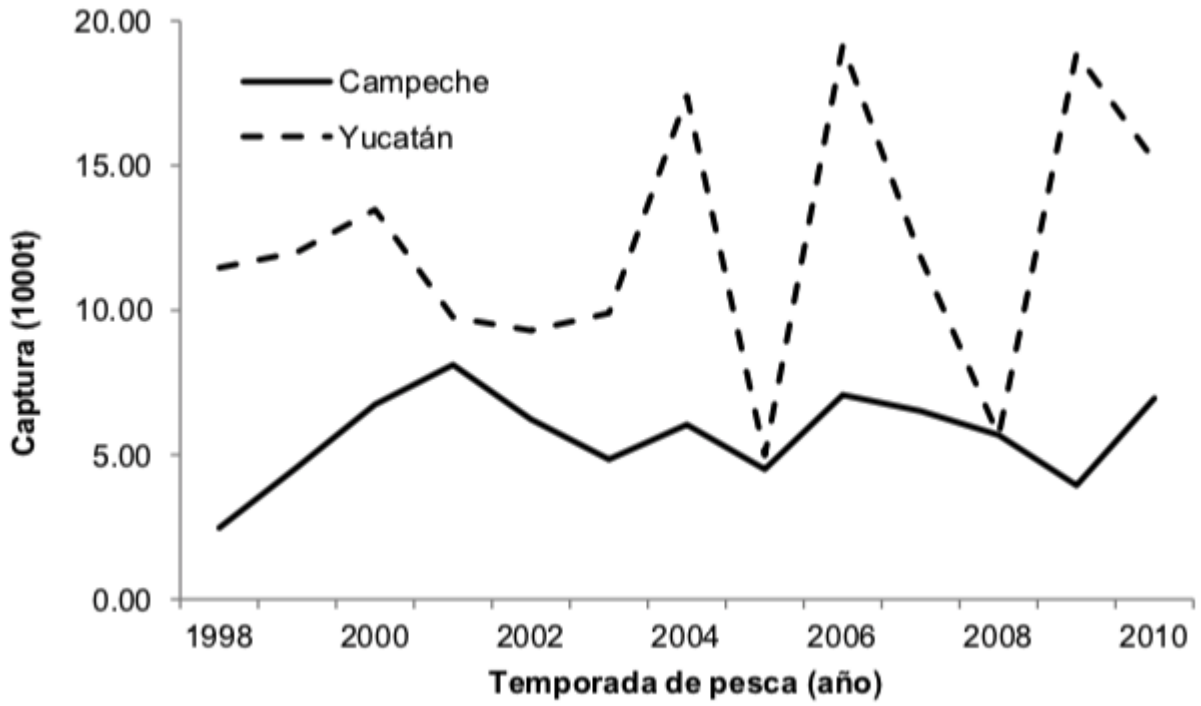

Figure 3 Yucatan and Campeche octopus historical landings

According to CONAPESCA landing data, in Campeche, production is dominated by red octopus, while in Yucatan ~70% is red octopus and 30% is common octopus (see figures below).

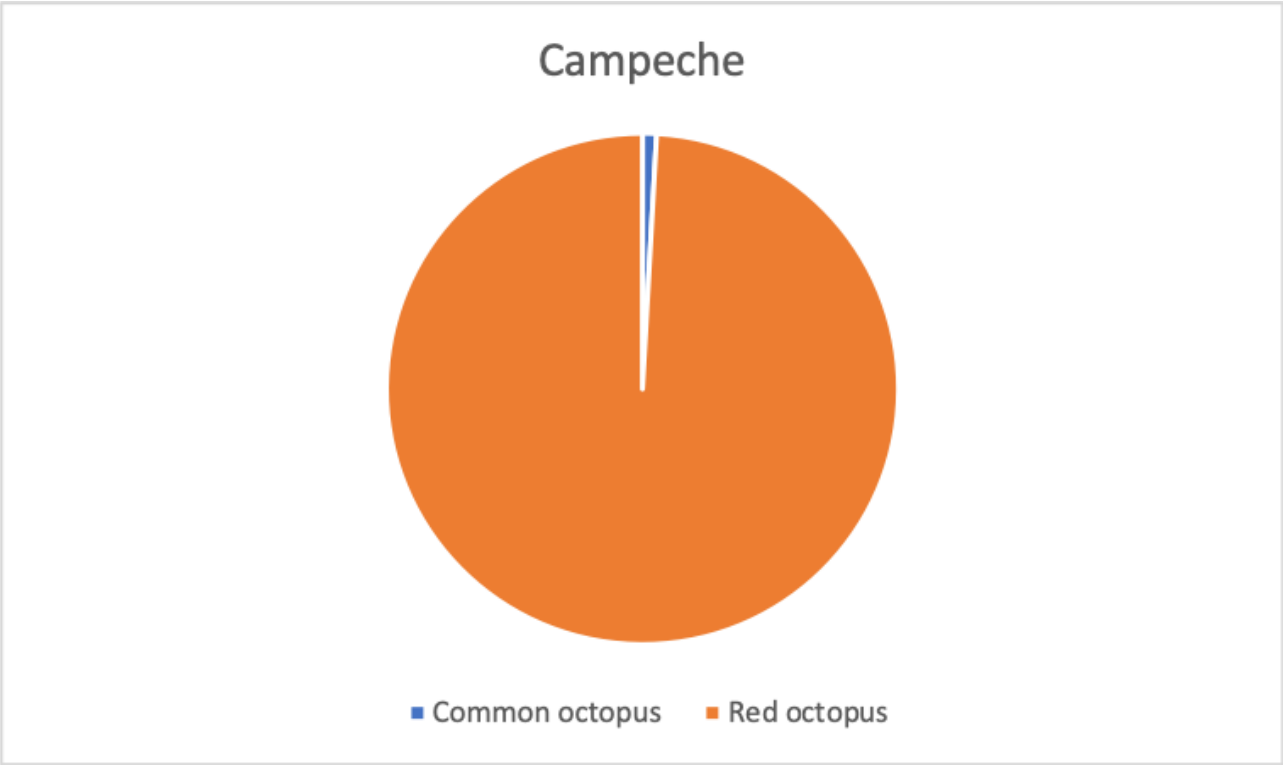

Figure 4 Octopus catch composition in Campeche in 2014

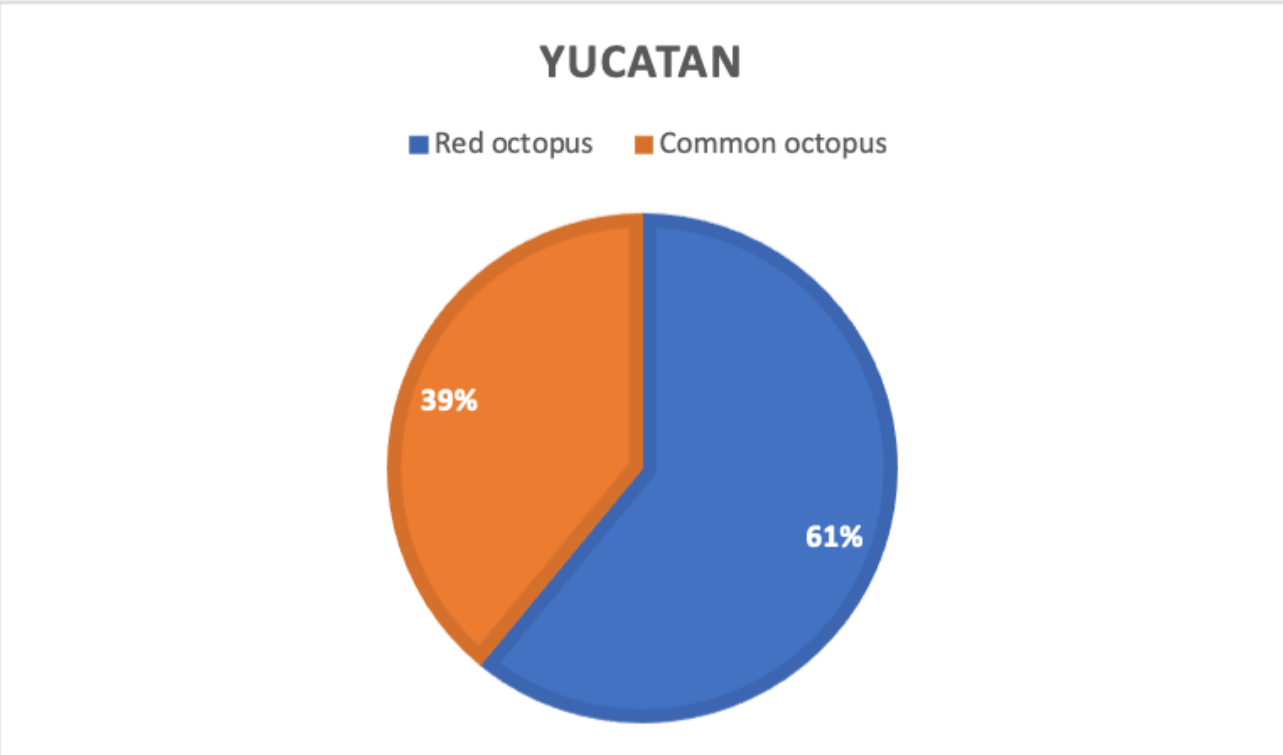

Figure 5 Octopus catch composition in Yucatan in

2014

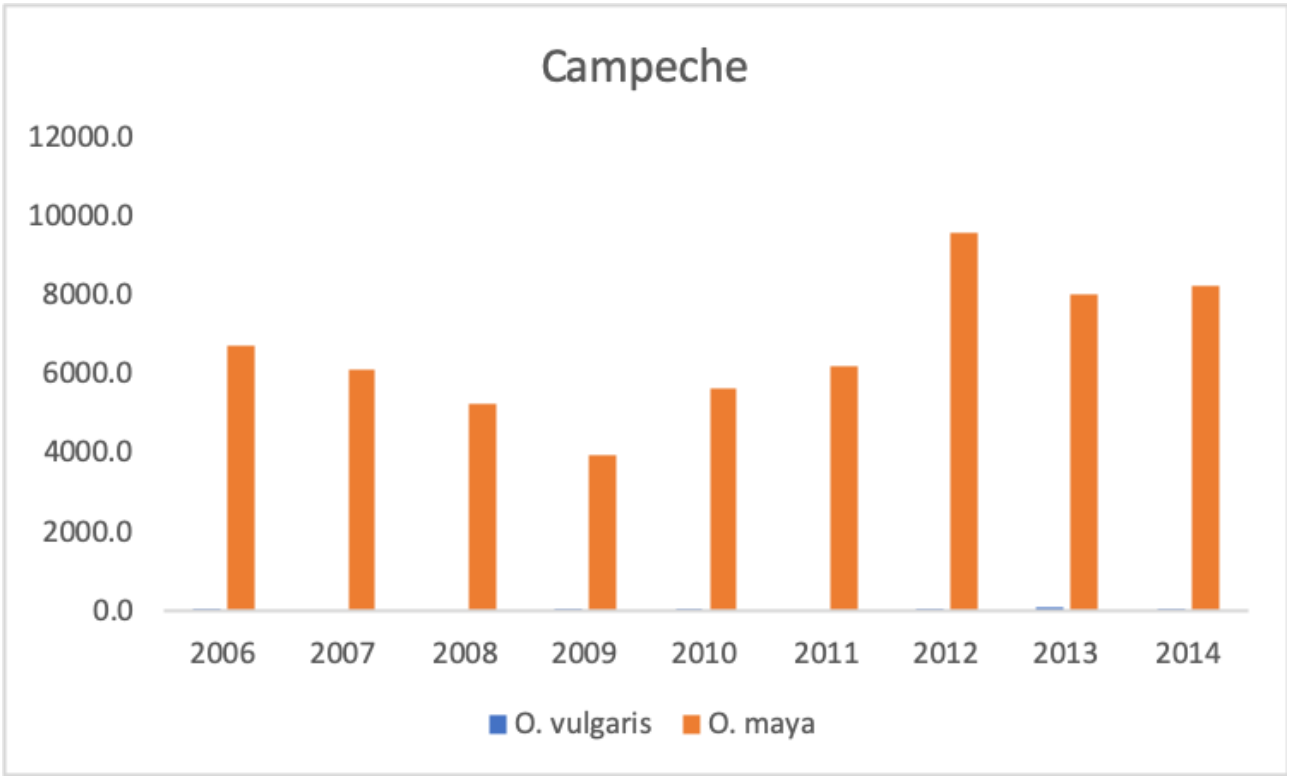

Figure 6 Red and common octopus landings in Campeche from 2006 to 2014

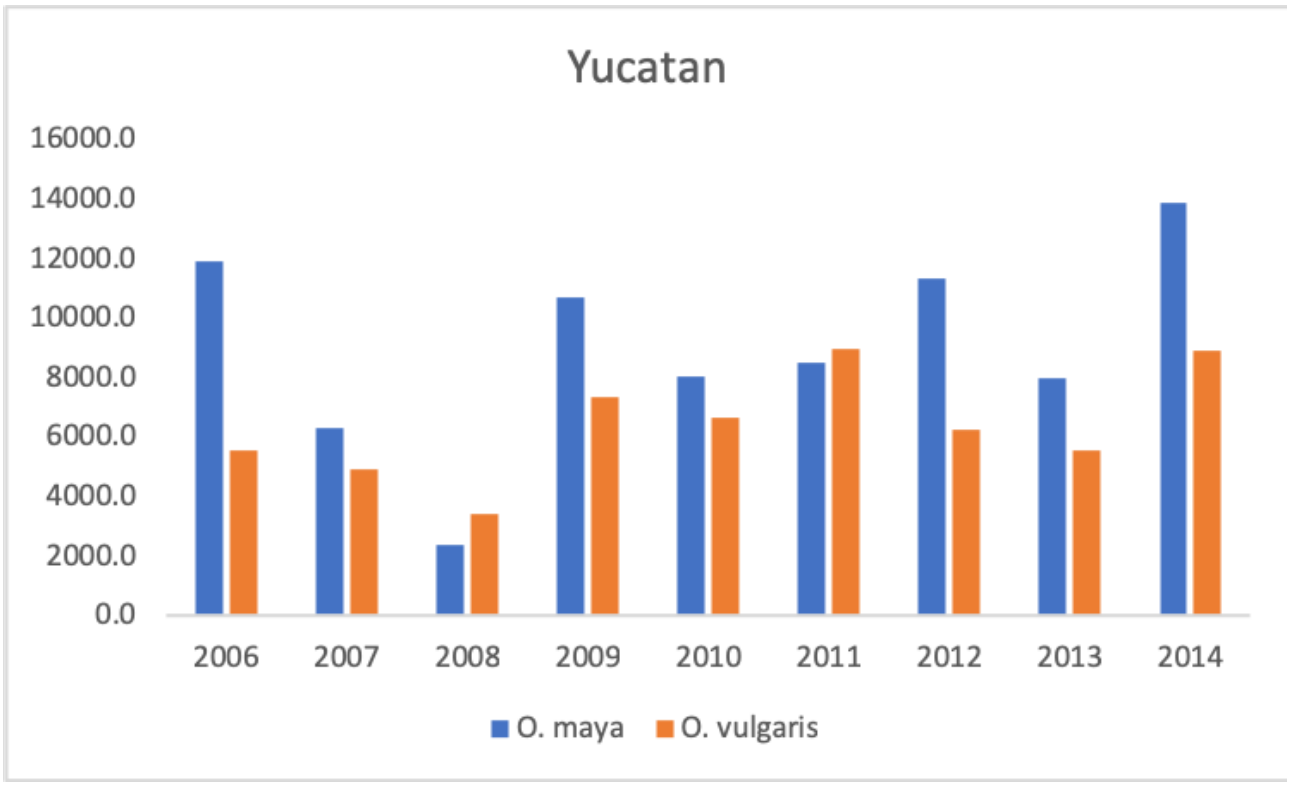

Figure 7 Red and common octopus landings in Yucatan from 2006 to

2014

Production for *O. insularis* is unknown.

Importance to the US/North American market.

According to FAO, Mexico is the third-largest producer of octopus in the world (95% of octopus come from the Yucatan Peninsula). Exports are destined mainly for Spain, Italy, the US (FAO 2017), and Japan.

The majority of this product went to the US. According to NMFS, the US imported 6,300 t, 5,900 t, and 6,600 t of octopus in 2016, 2017, and 2018 respectively (NMFS 2019).

Common and market names.

Red octopus (*Octopus maya*) is also known as octopus maya in Mexico or Mexican four-eye octopus (Fishsource 2019). *Octopus vulgaris* is known as octopus common (*comun* in Spanish) in Mexico, and common octopus in the US (FDA 2018). The common name for *Octopus insularis* is Brazilian reef octopus.

Primary product forms

Octopus landed in the Yucatan Peninsula is available at on the local, national, and international markets (Salas et al 2009). Whole octopus, fresh and iced is marketed domestically. Exported octopus is whole frozen and packed in 20 kg boxes. Octopuses are classified by an organism's size. Octopus trade is carried out by permit holders, retailers, and middlemen in the Yucatan Peninsula,as well as national seafood traders. Principal consumers are hotels, restaurants and minor traders. However, the number of people involved in the market is unknown, and a lack of updated octopus value chain evaluations constrains the assessment of this resource (CINVESTAV et al. 2008).

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

BRAZIL REEF OCTOPUS			
Region | Method	**Abundance**	**Fishing Mortality**	**Score**
Mexico/Gulf of Mexico | Trolling lines	1.00: High Concern	3.00: Moderate Concern	Red (1.732)

COMMON OCTOPUS			
Region | Method	**Abundance**	**Fishing Mortality**	**Score**
Mexico/Gulf of Mexico | Trolling lines	1.00: High Concern	3.00: Moderate Concern	Red (1.732)

MEXICAN FOUR-EYED OCTOPUS			
Region | Method	**Abundance**	**Fishing Mortality**	**Score**
Mexico/Gulf of Mexico | Trolling lines	2.33: Moderate Concern	1.00: High Concern	Red (1.526)

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.*

BRAZIL REEF OCTOPUS

Factor 1.1 - Abundance

MEXICO/GULF OF MEXICO
Trolling Lines

High Concern

Abundance of *O. insularis* in Mexico is unknown, considering that it was recently identified as a genetic variant of the Brazilian reef octopus in the region (Lima et al. 2017). Since neither a stock evaluation nor abundance data were available, a PSA analysis was conducted (see justification below). As a result, the species was scored with high vulnerability (scored as 3.43).

Taking into consideration the PSA results and the currently unknown abundance, *O. insularis* scores as "high" concern for this factor.

Justification:

Productivity Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	< 1 year (Lima et al. 2014)	1
Average maximum age	12 months (Lima et al. 2017)	1
Fecundity	~93,000 eggs (Lima et al. 2017)	1
Average maximum size (fish only)	N/A	
Average size at maturity (fish only)	N/A	
Reproductive strategy	Small hatchlings with pelagic paralarvaes. (Lima et al. 2017)	2
Trophic level	~3.74	3
Density dependence (invertebrates only)	Unlikely (highly mobile species) (Mather and Scheel 2014)	2
Habitat Quality	N/A	
Total Productivity (average)	1.66	

Susceptibility Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	The species distribution in the Gulf of Mexico has not been defined, although according to (Lima et al. 2017), its geographic distribution reaches from Brazil to the Caribbean. Due to the lack of more specific data, the default value was used.	3
Vertical overlap (Considers all fisheries)	According to (Lima et al. 2017) the species is found in warm shallow waters, on reefs and rocky bottoms, ranging from 0 to 30 m. According to managers, the small-scale fleets that target octopus in Campeche and Yucatan reach up to 37 m in depth (DOF 2014) and for these reasons, this factor scores as high risk.	3
Selectivity of fishery (Specific to fishery under assessment)	Brazilian reef octopus reaches maturity around 6 cm of mantle length (Lima et al. 2014). Mexican federal legislation established a minimum legal size of 11 cm of mantle length (DOF 2016). For this reason it is believed that all organisms within the landings are adults; therefore, individuals smaller than size at maturity are not regularly caught. However, similarly to other octopus species, O. insularis is semelparous, with males and females dying shortly after spawning or brooding (Sealife Base 2019) and for this reason, this factor scores as high risk.	3
Post-capture mortality (Specific to fishery under assessment)	Since O. insularis is believed to be caught with common octopus, in order to ensure its capture the fishing gear carries a hook at the end of the line, since fishing is in deeper waters and the octopus could escape when the line is lifted (INAPESCA 2014). If smaller sizes are caught they could be released; however, the hook might slightly decrease its survival. Also, there is no evidence of a post-capture release,; for this reason, this factor scores as high risk.	3
Total Susceptibility (multiplicative)		3

PSA score for O. insularis is calculated as follows:

Vulnerability (V) =√(P^2+ S^2)

V = √1.66 〖〗 ^2+ 〖1.66^2+(3^2))

V = 3.43

Factor 1.2 - Fishing Mortality

MEXICO/GULF OF MEXICO
Trolling Lines

Moderate Concern

The species has been recently identified as one of the potential main components of the catch (Lima et al. 2017). Official landings do not report this species and for this reason, levels of fishing mortality are unknown. According to the 2018 National Fisheries Chart, the octopus fishery is at its maximum and recommends to not increase fishing effort (DOF 2018). Considering that landings have remained relatively stable (see abundance) and other estimates for fishing mortality are not available, this factor is scored as "moderate" concern for *O. insularis*.

COMMON OCTOPUS

Factor 1.1 - Abundance

MEXICO/GULF OF MEXICO
Trolling Lines

High Concern

The abundance of common octopus in Mexico is unknown but likely fluctuates annually, since its biology is directly related to environmental conditions and offspring survival (INAPESCA b 2014). Since neither a stock evaluation nor data on the abundance of common octopus was available, a PSA analysis was conducted (see justification below). As a result, the species is scored for its high vulnerability (scored as 3.43).

Taking into consideration the PSA results and the currently unknown abundance, *O. vulgaris* scores as "high" concern for this factor.

Justification:

Productivity Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	8 to 10 months (Solis-Ramirez et al 1997)	1
Average maximum age	24 months (Case 1999) 2–3 years for females and 3–4 years for males (Nixon, 1969)	1
Density Dependence	Unlikely (highly mobile species) (Mather and Scheel 2014)	2
Fecundity	100,000–500,000 eggs (Perez et al. 2007)	1
Average maximum size (fish only)	N/A	
Average size at maturity (fish only)	N/A	
Reproductive strategy	Common octopus is a simultaneous terminal spawner, laying on average 350,000 eggs in sheltered places between 20 and 120 m depth (Rocha et al. 2001) (Silva et al. 2002); could be considered a demersal egg layer	2
Trophic level	3.74	3
Habitat Quality	N/A	
Total Productivity (average)	1.66	

Susceptibility Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	The species is distributed throughout the Gulf of Mexico in Mexican waters; according to managers, fishing areas are focused in specific zones. The default score is used here because it is unclear what percentage of the area remains unfished.	3
Vertical overlap (Considers all fisheries)	The fleets that target this species fish between 11 and 37 m in depth (DOF 2014), using a baited hooked monofilament or twine (mainly baited with crab and spider crab). The species depth range is from 0 to 400 m; therefore, encounterability is restricted to the shallowest part of the range, or about 15% of its range. According to managers, greater abundances of this species are found beyond the 100-meter depths.	3
Selectivity of fishery (Specific to fishery under assessment)	Maturity is reached around 80 mm (Solis-Ramirez et al. 1997), minimum legal size is established as 110 mm (DOF 2016), and around 12% of organisms in landings are below the minimum legal size; therefore, individuals smaller than the size at maturity might be regularly caught. However, because this species is semelparous, with males and females dying shortly after spawning and brooding this factor scores as high risk.	3
Post-capture mortality (Specific to fishery under assessment)	In order to ensure its capture, the fishing gear for common octopus carries a hook at the end of the line, since fishing is in deeper waters and the octopus could escape when the line is lifted (INAPESCA 2014). If smaller sizes are caught they could be released; however, the hook might slightly decrease its survival. Also, there is no evidence of a post-capture release, increasing the susceptibility score.	3
Total Susceptibility (multiplicative)		3

PSA score for Common octopus fishery is calculated as follows:

Vulnerability (V) =√(P^2+ S^2)

V = √1.66 〖〗 ^2+ 〖1.66^2+(3^2))

V = 3.43

Factor 1.2 - Fishing Mortality

MEXICO/GULF OF MEXICO
Trolling Lines

Moderate Concern

Fishing mortality reference points have not been set for the octopus fishery (neither for red nor common octopus) in the Gulf of Mexico. According to the 2018 National Fisheries Chart; the fishery is at its maximum and no increase in effort is recommended (DOF 2018). On the last report, ten medium scale vessels and more than 1,700 small-scale boats were actively fishing in Campeche, while ~380 medium-scale and more than 3,300 small-scale vessels were also actively fishing in Yucatan (DOF 208).

According to the management plan, each medium-scale vessel is allowed to carry up to 12 *alijos* (small non motorized vessels). However, it is not possible to know if this fishing effort in place is adequate or not. Considering that landings have remained relatively stable (see abundance) and other estimates for fishing mortality are not available; this factor is scored as "moderate" concern for common octopus.

MEXICAN FOUR-EYED OCTOPUS

Factor 1.1 - Abundance

MEXICO/GULF OF MEXICO
Trolling Lines

Moderate Concern

Scientific surveys and catch data have been used to estimate the abundance of red octopus in the past. Managers have in place annual monitoring programs to estimate and suggest annual quotas (DOF 2014). During the monitoring exercises octopus are counted, measured, and weighed, and the data collected is used to calculate the spatial-temporal size structure. The data is used by managers to feed a Schaefer model to help them estimate the maximum sustainable yield (MSY). The model uses a combination of abundance index data based on the biomass surveys carried out annually, CPUE data (as a second relative abundance data), and the annual landings (INAPESCA 2014).

The most recent available report (2014), estimated that the system carrying capacity (k) for red octopus is 75,032 t, and the biomass to reach the maximum sustainable yield (B_{MSY}) or K/2 is = 37,516 t. However, no estimates of the biomass were provided in the 2014 report; instead, biomass estimates from previous years were listed (see table below). According to those estimates, it could be inferred that the status of the red octopus could be close to or below B_{MSY} in most recent years (see table below).

Table 1. Biomass and % of biomass against the carrying capacity calculated by INAPESCA (INAPESCA 2014)

Year	Biomass estimated	% of K
2011	24,142	32.2
2012	19,321	25.8

2013	17,400	23.2

According to studies carried out in recent years, reproduction of *O. maya* is continuous, with two annual peaks of maturity and spawning that occur, one in spring and one of greater intensity in autumn (DOF 2014), producing two annual cohorts that recruit into the fishery, the first during the closed season and the second during the fishing season. This production pattern might explain why landings have been stable. However it is not clear if the stock is overfished. Considering that managers stated the fishery is at its maximum level and landings have remained relatively stable (see production statistics), this factor is scored as a "moderate" concern.

Factor 1.2 - Fishing Mortality

MEXICO/GULF OF MEXICO
Trolling Lines

High Concern

For *Octopus maya*, an estimated and suggested quota is determined based on adult abundance, recruitment, and growth data estimates (INAPESCA 2014) (INAPESCA b 2014) (Perez et al. 2007). According to managers, these quotas are typically set based on the maximum sustainable yield (MSY), a level of fishing that allows the population to persist. The goal is to allow 50% of the population to escape the fishery and survive to reproduce (INAPESCA b 2014). However, according to official data, this quota has been surpassed on several occasions (see table below).

Managers and some research studies have indicated that fishing mortality on red octopus is near or at MSY, i.e., nearly or fully exploited (DOF 2018). However, an older research report suggested that past fishing levels were above MSY and the fishery was showing signs of overexploitation (Arreguin-Sanchez et al. 2000).

Considering that red octopus is endemic to the region, prefers shallow habitats (which is where fishing occurs so is more vulnerable to over-exploitation), and that between 2006 and 2013 quotas were exceeded in all years except 2008, and based on recent studies (Lima et al. 2017) (Gonzalez-Gomez et al. 2018) misreporting of *O. maya* as *O. vulgaris* might be occurring, we have awarded a "high" concern for fishing mortality regarding this species.

Justification:

Temporada de pesca	Cuota de captura (t)	Captura registrada (t)*	Diferencia entre cuota de captura recomendada y captura registrada (%)
2002	13,000	12,425	-4.42
2003	11,000	9,415	-14.41
2004	12,000	16,535	37.79
2005	10,500	7,206	-31.37
2006	11,270	20,138	78.69
2007	10,200	13,200	29.41
2008	8,100	7,939	-1.99
2009	8,195	15,289	86.56
2010	11,609	14,371	23.79
2011	12,071	14,745	22.15
2012	10,000	16,835	68.35
2013	10,000	13,027	30.27

*Incluye la captura registrada en Campeche y Yucatán.

Figure 8 Suggested quota and landings for red octopus during the 2002-2013 period, source INAPESCA, 2014

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.

BRAZIL REEF OCTOPUS
Mexico/Gulf Of Mexico | Trolling Lines

Subscore:	**1.526**	**Discard Rate:**	**1.00**	**C2 Rate:**	**1.526**

Species | Stock	**Abundance**	**Fishing Mortality**	**Subscore**
Mexican four-eyed octopus	2.33:Moderate Concern	1.00:High Concern	Red (1.526)
Common octopus	1.00:High Concern	3.00:Moderate Concern	Red (1.732)

COMMON OCTOPUS
Mexico/Gulf Of Mexico | Trolling Lines

Subscore:	**1.526**	**Discard Rate:**	**1.00**	**C2 Rate:**	**1.526**

Species | Stock	**Abundance**	**Fishing Mortality**	**Subscore**
Mexican four-eyed octopus	2.33:Moderate Concern	1.00:High Concern	Red (1.526)
Brazil reef octopus	1.00:High Concern	3.00:Moderate Concern	Red (1.732)

MEXICAN FOUR-EYED OCTOPUS Mexico/Gulf Of Mexico | Trolling Lines					
Subscore:	**1.732**	**Discard Rate:**	**1.00**	**C2 Rate:**	**1.732**

Species | Stock	Abundance	Fishing Mortality	Subscore
Common octopus	1.00:High Concern	3.00:Moderate Concern	Red (1.732)
Brazil reef octopus	1.00:High Concern	3.00:Moderate Concern	Red (1.732)

The trolling lines or *jimbas* employed by the octopus fishery are a highly selective method for which no incidental catch is recorded. For that reason, no bycatch species are included in the recommendation. Because the octopus species included in this report are sometimes caught together, each is included as a Criterion 2 species for the other octopus species.

Although it has been reported that one of the species used as bait is the endangered horseshoe crab (Smith et al 2017), a species protected under Mexican federal legislation (NOM-059), the level of impact on horseshoe crabs from this fishery is unclear so it is not included in the assessment.

2.4 - Discards + Bait / Landings

MEXICO/GULF OF MEXICO
Trolling Lines

< 100%

The fishing technique used in the octopus fishery is very selective and no incidental catch is recorded. However, according to the management plan, several crab species are the main groups used as bait (DOF 2014). Despite the lack of available information on the volume and species for bait in the fishery, experts suggested that bait species are likely to represent less than 5% of the catch.

One of the bait species mentioned in the literature was the horseshoe crab (*Limulus polyphemus)*, a protected species under Mexican legislation, within the NOM-059. Although recent information to corroborate this was not available, according to Smith et al. (2017) there were increasing reports of small-scale poaching of horseshoe crab adults used solely as an alternative to commercial bait species in the artisanal octopus fishery of Campeche and Yucatan. However, based on the feedback received by our peer reviewers, the use of these species is not as common, in particular to its protected status. The species was not included as a potential C2 species; however, the lack of adequate information on the impacts of the fishery on bait species and in particular the endangered crab is addressed in the management section of the assessment (see Criterion 3.2).

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: Mexico/Gulf of Mexico | Trolling lines	Moderately Effective	Highly Effective	Moderately Effective	Ineffective	Highly Effective	Red (2.000)

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.

MEXICO/GULF OF MEXICO Trolling Lines
Moderately Effective

The current management strategies in place for the octopus fishery are based mostly on red octopus data and scientific information. A limited amount of information (e.g., landing data) is collected for common octopus as well as the recently identified variant of *O. insularis*. Access is controlled with the use of fishing licenses, and there is a minimum size limit of 110 cm, which applies to all octopus species in the Gulf of Mexico and Caribbean (DOF 2016), to allow organisms to breed or reproduce before they are caught (DOF 2016) (DOF 2014). The federal red and common octopus fishery management plan (OFMP) includes an annual closed fishing season that runs from December to July (DOF 2014) and a recommended catch limit or quota for red octopus (DOF 2016). These recommended quotas for red octopus are set each year based on species population assessments and are designed to take less than half of the reproductive population. However, there have been no population assessments for the common octopus, and no catch quotas are set for this species.

Although all these regulations are in place, non-compliance by fishers is a known problem (DOF 2014). There are regular reports of fishers catching octopus with prohibited gears, catching octopus below the legal minimum size limit, or fishing during the closed season (Salas et al 2009) (DOF 2014). In addition, the recommended catch quotas for red octopus are often exceeded (DOF 2014).

Considering that some appropriate management regulations are in place, but concerns about compliance and enforcement make the real impact of the regulations uncertain; management strategy and implementation scores as "moderately effective" for the fishery.

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.

MEXICO/GULF OF MEXICO
Trolling Lines

Highly Effective

According to the information available, the trolling lines or *jimbas* have no interaction with other species and for that reason a bycatch strategy is unecessary. This factor is scored as "highly effective."

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.

MEXICO/GULF OF MEXICO
Trolling Lines

Moderately Effective

Scientific research and monitoring for the octopus fishery in Mexico are limited; the current management strategies are primarily based on data collected on one of the three fished species, red octopus. There is an annual red octopus abundance survey (which may not have included the two recruitment events into its calculus), and there are no abundance estimates for the common octopus or the recently identified species, *O. insularis*. A limited amount of information is collected within the fishery (e.g., landing data). Based on recent

findings that *O. insularis* is being caught and landed as common octopus, there is a need to determine the magnitude of the catch for each species. Considering the status of the common octopus as a reference, the scientific research and monitoring scores as "moderately effective."

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.

MEXICO/GULF OF MEXICO
Trolling Lines

Ineffective

The federal agency in charge of enforcement activities is CONAPESCA. Fisheries federal agents sometimes coordinate with federal (army and navy) and local officials (police) to take enforcement actions. Violations to the regulations are sanctioned based on the terms of the General Law of Fishing and Sustainable Aquaculture.

Inspections are supposed to be conducted at sea and on land. Unfortunately, reports on the effectiveness of these actions were not available. Based on the information reviewed, some of the regulations (catch quotas, size limit, fishing season) are ignored by legal and illegal fishermen or not properly enforced by managers (Ponce-Diaz et al. 2009) (Salas et al. 2009).

During the creation of the new management plan in 2014, plans were made to estimate illegal fishing, to develop new trap technologies to reduce illegal diving and to improve efforts to monitor and comply with quotas (DOF 2014). It is unclear if these enforcement measures and activities are in place or if they have been effective. Considering that there is no evidence that management regulations are enforced and that illegal activities regularly occur within the octopus fishery, this factor is rated "ineffective."

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.

MEXICO/GULF OF MEXICO
Trolling Lines

Highly Effective

The Comite Estatal Sistema Producto (CESP) was created for the octopus fishery in Yucatan (FIS 2008). The CESP is a legal body recognized by managers that coordinates planning, communication, and builds agreements between the various participants in the fishery and supply chain (CONAPESCA 2019). Legal entities (e.g., civil associations), and other fishery stakeholders actively participate in the CESP meetings and create strategic planning instruments (e.g., master programs, guiding plans and multi-year planning sheets) to improve their competitiveness and expand market participation (CONAPESCA 2019). One example of this collaboration was the management plan (DOF 2014), as well as the update to the official norm (DOF 2016), that have been developed in coordination with scientists and other stakeholders, including the CESP.

Due to the successful involvement of diverse stakeholder groups in fishery management, this factor is scored as "highly effective."

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
Mexico/Gulf of Mexico | Trolling lines	4	0	Moderate Concern	Green (3.464)

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

MEXICO/GULF OF MEXICO
Trolling Lines

4

The octopus fishery in the Gulf of Mexico uses trolling lines or *jimbas* that have minimal impact on the bottom. The bait normally comes in contact with the seafloor (DOF 2016) (DOF 2014). Fishing lines are pulled in by hand, so the gear has no mechanical elements. Considering that the different species of octopus prefer either seagrass, rocky, and coral reef habitats, fishing may occur over these areas (DOF 2014); however, because the gear does not damage bottom habitats, this factor is scored as 4 based on the SFW Fisheries Standard.

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

MEXICO/GULF OF MEXICO
Trolling Lines

0

In the Gulf of Mexico and the Mexican Caribbean, there are protected areas (under different categories, e.g., National Park, or Biosphere Reserves) with differing levels of protection; in some instances, certain fishing gears are banned, or fishing may be prohibited. However, no specific restrictions are in place for the octopus fishery beyond those included in the NOM and the Management Plan. For these reasons, no mitigation credit is awarded.

Factor 4.3 - Ecosystem-Based Fisheries Management

MEXICO/GULF OF MEXICO
Trolling Lines

Moderate Concern

Octopus species that are actively targeted have high trophic levels, and have a primarily carnivorous diet (e.g., crabs, mollusks and fish). All three species are also an important food source for other species in the ecosystem, like groupers and snappers. (Arreguin- Sanchez 2000) (DOF 2016).

Commercially important spiny lobster and red grouper share habitat with octopus, and these species are all connected through the food web. Octopuses are an important prey item for red grouper, and both red grouper and octopus are predators of spiny lobster. Fishing and management regulations for any of these species will likely have some effect on the others (Lasseter 2006) (Arreguin-Sanchez 2000). Unfortunately, the roles of the octopus species in the food web are not well studied. Also, there has been no assessment of the fishery's effects on resources commonly used for bait (e.g., crabs). Since there is no management or assessment of ecosystem impacts, but octopuses are not considered to be playing an exceptionally large role in the ecosystem, this factor is rated as "moderate" concern.

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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.

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