Monterey Bay Aquarium Seafood Watch

Draft Assessment for Review

Cortez swimming crab, Arched swimming crab, Blue crab

Cortez swimming crab (*Callinectes bellicosus*)

Arched swimming crab (*Callinectes arcuatus*)

Blue crab (*Callinectes sapidus*)

Mexico/Pacific, Mexico/Gulf of Mexico

Traps, Crab rings, Scoopnets

Report ID 27878

Seafood Watch Standard used in this assessment: Fisheries Standard v3

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About Seafood Watch

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

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

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

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

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

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

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

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

Guiding Principles

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

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

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

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

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

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

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

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

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

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

Summary

This report evaluates the swimming crab fisheries in three Mexican states: two in the Gulf of California (Sonora and Sinaloa) and one in the Gulf of Mexico (GOM) (Campeche). The report examines the arched swimming crab *(Callinectes arcuatus)* and Cortez swimming crab of the Pacific *(C. bellicosus)* caught using traps and rings, and the blue crab in Campeche *(C. sapidus)* caught using scoopnets and rings.

A recent stock assessment for the swimming crab species in the Pacific found that both species are not overfished but showing signs of overfishing.

Trap, ring, and scoopnet fisheries in all the regions mostly catch swimming crab. In the case of rings and scoops, the bycatch is practically nonexistent. However, traps, especially in Sonora, have been reported to catch a significant volume of invertebrate species, particularly pink snail *(Phyllonotus erythrostomus)* which comprised more than 5% of the total catch. Still, it is not listed as a species of concern. In Campeche, *Callinectes rathbunae* has been reported as part of the catch and was included in the analysis as bycatch.

The crab fisheries are generally well-managed in Sonora and Sinaloa; however, some activities in research and monitoring could be improved. For example, landing records are not separated by species, so it is difficult to determine the actual catch volume by species. In the case of the Campeche fishery, further measures are needed to improve the current management system and knowledge of the species. The crab traps produce a relatively low impact on the physical and biological structures of the seafloor. Managers are planning to develop an environmental impact study to measure the impacts of fishing activities on the ecosystem as a whole in all the regions.

Considering the results of the most recent assessments, all the fisheries in Sinaloa and Sonora were scored as "avoid" except for the Sonora trap fishery that targets Cortez swimming crab exclusively and was deemed a "good alternative". Similarly, Blue crab in the Gulf of Mexico also reached a "good alternative" driven mostly by to concerns about the management in place and monitoring efforts.

Final Seafood Recommendations

SPECIES | FISHERY	CRITERION 1 TARGET SPECIES	CRITERION 2 OTHER SPECIES	CRITERION 3 MANAGEMENT	CRITERION 4 HABITAT	OVERALL RECOMMENDATION
Arched swimming crab | Eastern Central Pacific | Crab rings | Mexico | Sinaloa	1.916	1.916	3.000	3.000	**Avoid (2.397)**
Arched swimming crab | Eastern Central Pacific | Traps | Mexico | Sinaloa	1.916	1.916	3.000	3.000	**Avoid (2.397)**
Blue crab | Gulf of Mexico | Crab rings | Campeche	3.318	2.644	3.000	3.000	**Good Alternative (2.981)**
Blue crab | Gulf of Mexico | Scoopnets | Campeche	3.318	2.644	3.000	3.000	**Good Alternative (2.981)**
Cortez swimming crab | Eastern Central Pacific | Crab rings | Mexico | Sinaloa	1.916	1.916	3.000	3.000	**Avoid (2.397)**
Cortez swimming crab | Eastern Central Pacific | Traps | Mexico | Sonora	1.916	3.413	3.000	3.000	**Good Alternative (2.770)**
Cortez swimming crab | Eastern Central Pacific | Traps | Mexico | Sinaloa	1.916	1.916	3.000	3.000	**Avoid (2.397)**

Scoring Guide

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

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

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

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

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

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

Introduction

Scope of the analysis and ensuing recommendation

This report addresses Mexican swimming crab caught with traps and rings in Sonora and Sinaloa (the biggest state producers in Mexico) and with scoopnets and rings by fishers in the Yucatan Peninsula. Both fisheries (Sonora-Sinaloa and Yucatan) are currently involved in fisheries improvement projects (FIP). The species covered by the recommendation and their percentage of representation in the catches by region are:

Sonora: *Callinectes bellicosus* (95%) and *C. arcuatus* (5%)
Sinaloa: *Callinectes bellicosus* (57%) and *C. arcuatus* (41%)
Campeche in the Yucatan Peninsula: *C. sapidus* (89.2%) {CNP 2006}

Species Overview

In the Mexican Pacific, *Callinectes bellicosus* (Cortez swimming crab, from now on Cortez crab); and *C. arcuatus* (arched swimming crab, from now on arched crab) are the most important in terms of abundance {Cisneros-Mata et al. 2014}. Both are captured using traps in Sonora and traps and rings in Sinaloa (Figure 1). These species have a wide distribution that extends from California in the U.S. to Peru (Figure 2). The catch proportion varies by state due to their prevalence and distribution. In Sonora, 95% of the landings are represented by Cortez crab, while in Sinaloa, the proportion is 57% Cortez crab and 41% arched crab (DOF 2014); although black crab *(C. toxotes)* occurs in Sinaloa, it makes up a minor proportion of the landings and is not assessed in this report.

Figure 1: Crab traps (right) and rings used in Sonora and Sinaloa (Photo credit COBI AC)

Figure 2: Distribution of crab species in the Mexican Pacific (Image from Cisneros-Mata et al., 2014)

These crab species have an "r-type" reproductive strategy. This means they have high fecundity and relatively little investment in any individual progeny and they are typically susceptible to predation and changes in their environment (Giesel 1976). Like other organisms with "r" strategies, Cortez and arched crabs have short lifespans of 4 years {Wilcox, 2007} {Rosas-Correa & Navarrete 2009} {Rodriguez-Felix et al. 2015}, and are quick to mature. Several researchers report that these crab species can reach maturity within the first year of their life {Estrada-Valencia 1999} {Ramos-Cruz 2008} {Nevarez-Martinez et al. 2003} {Castro-Longoria et. al. 2002} {Ramirez-Felix et al. 2003}.

In the Gulf of Mexico (GOM), *Callinectes sapidus* (from now on blue crab) is the most abundant species, and the main target species for the fishery in this region (DOF 2012). Fishers in the region mostly use scoops to catch this species (Figure 3). Its distribution has been reported to be from Nova Scotia to Northern Argentina including Bermuda and the Caribbean Sea (FAO Species Fact Sheets, accessed September 2016) (Figure 4).

Figure 3: Scoops used in Campeche for the Crab fishery (Photo credit: Nakamura, 2014)

Figure 4: Distribution of Callinectes sapidus (Image from FAO, 2016)

The Campeche blue crab has similar biological characteristics to the arched crab in the Pacific. It has a relatively short life span of 4.5 years and reaches maturity between 12 and 18 months of age {Rosas-Correa and Jesus-Navarrete 2008}.

Callinectes species inhabit estuarine and coastal waters. According to Williams (1974) in {Ortiz-Leon et al. 2006}, adults are bottom dwellers found from nearshore marshes down to depths up to 40 m/130 ft. During juvenile stages, the species prefer shallow soft mud sediments where they can burrow into the substrate for protection from predators {Amador del Angel et al. 2003}.

In Mexico, the crab fisheries along both coastlines (Pacific and the Gulf of Mexico) are managed by the federal government of Mexico through the National Aquaculture and Fishing Commission (CONAPESCA) and its technical branch, the National Fisheries Institute (INAPESCA). These bodies are responsible for creating, implementing and enforcing management strategies for fishing resources in the country. In Mexico, three official documents regulate crab fishing activities. The Official Mexican Norm 039-PESC (NOM-039) that regulates crab fisheries in federal waters (Official Federal Paper {DOF 1993}; the National Federal Chart (CNP) that contains information on the status of resources, regulations and management

strategies, and the Sinaloa-Sonora Management Plan (SSMP) (DOF 2014) which contains specific regulations for crab fisheries in these two states (the ones with the highest levels of production in the country).

Production Statistics

Mexican crab is well accepted in the international market due to its taste and quality {Cisneros-Mata et al. 2014}. In the GOM, the crab fishery has been a traditional fishery for more than six decades {Chavez & Socorro-Hernadez 1980}, although in the Pacific, official reports suggested that the fishery started in the early 1980's {Cisneros-Mata et al. 2014}. Crab landings in Mexico have been relatively stable, averaging 24,000 t/year from 2004 to 2014 (Figure 5).

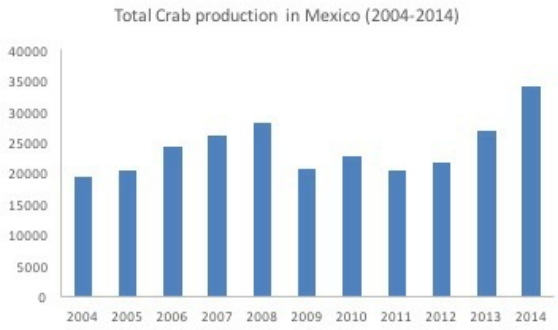

Figure 5: Mexican crab landings from 2004 to 2014 (Data from CONAPESCA)

Most of the crab production is from the Pacific. In 2014, 64% of the total production captured using all gears was landed in the Pacific (Figure 6) (CONAPESCA 2015), and more than 94% (20,500 t) of that production was landed in Sonora and Sinaloa (Figure 7) (CONAPESCA 2015).

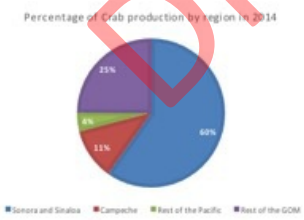

Figure 6: Percentage of crab production by region in 2014

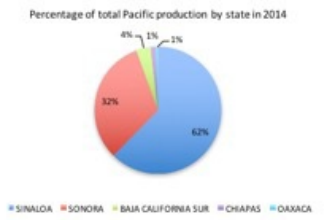

Figure 7: Percentage of crab landed by state in the Mexican Pacific in 2014

In the GOM, the fishery has been developed for more than five decades {DOF, 2014}. Veracruz, Campeche, and Tamaulipas are the most important states in terms of production, followed by Tabasco, and Yucatan (Figure 8). Although most of the production of these region stays in the domestic market, the fishery in Campeche included in this report exports 100% of its production {pers. comm., Rudy Abad, PESMAR 2016}.

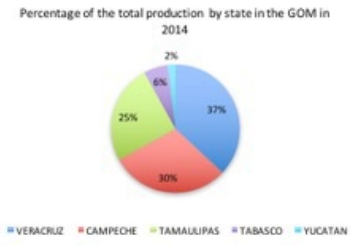

Figure 8: Percentage of Crab landed by State in the GOM in 2014 (CONAPESCA, 2015).

Importance to the US/North American market.

Import of crab meat from Mexico fluctuated between 500 t in 2016 to 875 t in 2021, with the highest level of import reached in 2012 with 1,391 t (NOAA 2022)

Year	Presentation	t	$ USD
2014	CRABMEAT SWIMMING *(CALLINECTES)*	1,225	$28,060,050
2016	CRABMEAT SWIMMING *(CALLINECTES)*	505	$5,306,366
2018	CRABMEAT SWIMMING *(CALLINECTES)*	1,007	$22,516,669
2021	CRABMEAT SWIMMING *(CALLINECTES)*	875	$22,859,450

Common and market names.

In the Gulf of California, *C. bellicosus* is also known as green crab or brown crab, and the larger size (>250 g) is known as "jaibon."
C. arcuatus is also known as blue crab. In the GOM, *C. sapidus* is known as blue crab.

Primary product forms

The primary product forms are pasteurized lump meat, special meat, and claw meat, which can be canned or frozen.

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

ARCHED SWIMMING CRAB			
REGION / METHOD	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Eastern Central Pacific | Crab rings | Mexico | Sinaloa	3.670: Low Concern	1.000: High Concern	Red (1.916)
Eastern Central Pacific | Traps | Mexico | Sinaloa	3.670: Low Concern	1.000: High Concern	Red (1.916)

BLUE CRAB			
REGION / METHOD	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Gulf of Mexico | Crab rings | Campeche	3.670: Low Concern	3.000: Moderate Concern	Green (3.318)
Gulf of Mexico | Scoopnets | Campeche	3.670: Low Concern	3.000: Moderate Concern	Green (3.318)

CORTEZ SWIMMING CRAB			
REGION / METHOD	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Eastern Central Pacific | Crab rings | Mexico | Sinaloa	3.670: Low Concern	1.000: High Concern	Red (1.916)
Eastern Central Pacific | Traps | Mexico | Sonora	3.670: Low Concern	1.000: High Concern	Red (1.916)
Eastern Central Pacific | Traps | Mexico | Sinaloa	3.670: Low Concern	1.000: High Concern	Red (1.916)

Criterion 1 Assessments

SCORING GUIDELINES

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

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

Factor 1.2 - Fishing Mortality

Goal: Fishing mortality is appropriate for current state of the stock.

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

Arched swimming crab

Factor 1.1 - Abundance

Eastern Central Pacific | Crab rings | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sinaloa

Low Concern

Recently, (Balmori et al 2021) developed a stock assessment for both of the crab species in the Mexican Pacific; the authors used 1980 to 2018 official landings to feed a Catch-Maximum Sustainable Yield (C-MSY) method to estimate the maximum sustainable yield (MSY), the biomass associated with MSY (B_{MSY}) and the fishing mortality associated with maximum sustainable yield (F_{MSY}) for both species *Callinectes bellicosus* and *C. arcuatus* in the Gulf of California.

The authors calculated the MSY and B_{MSY} values for Cortez swimming crab (19,272 t and 32,356 t, respectively) and arched swimming crab (4,479 t and 7,520 t, respectively). Based on the analysis of the data, the authors reported that for Cortez swimming crab, the biomass has been above the MSY and at least 75% of the target reference point (see image below) in recent years, including 2018; for arched swimming crab similarly, biomass has been above the B_{MSY} . The B_{MSY} for both species was declared the target reference point by the authors based on the species' ecology. It is worth mentioning that managers monitor the "health" of the fishery based on a catch per day ratio (DOF 2014) and use this proportion as a reference point.

The recent assessment can be considered adequate for the species, however, based on the fact the authors mentioned that more robust fishery-dependent and independent data would reduce uncertainties in the methodology, and considering the clear negative trend in the biomass levels for both species during the most recent years (2013 to 2018), we deemed this factor as low concern.

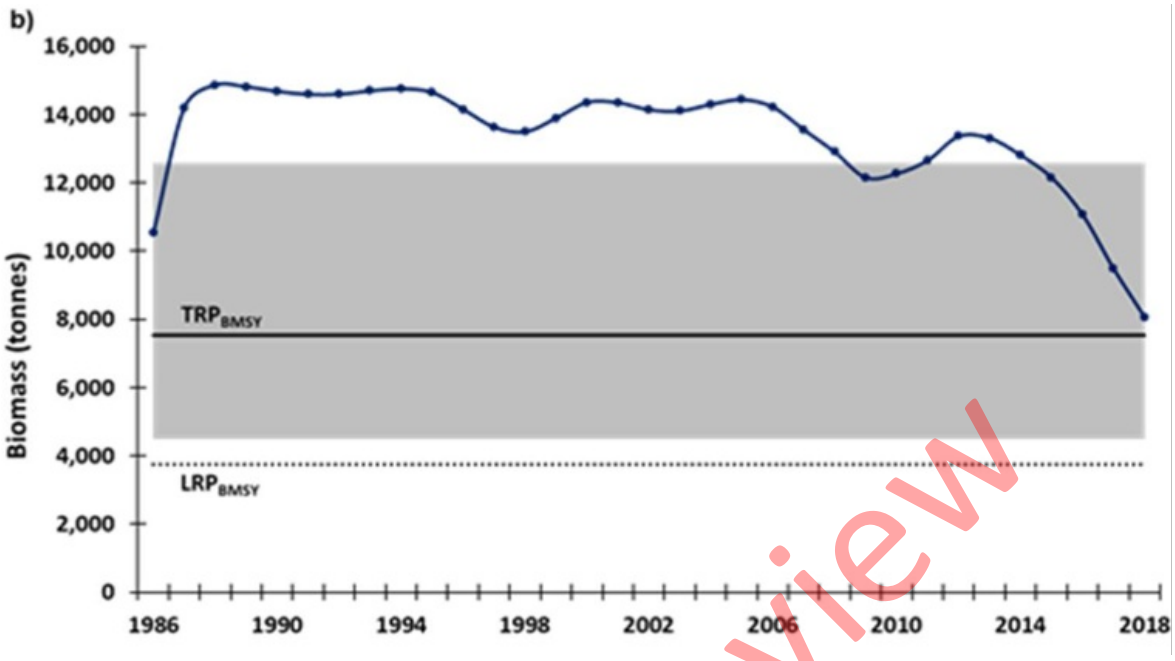

Figure 9: Arched swimming crab biomass estimates by (Balmori et al 2021)

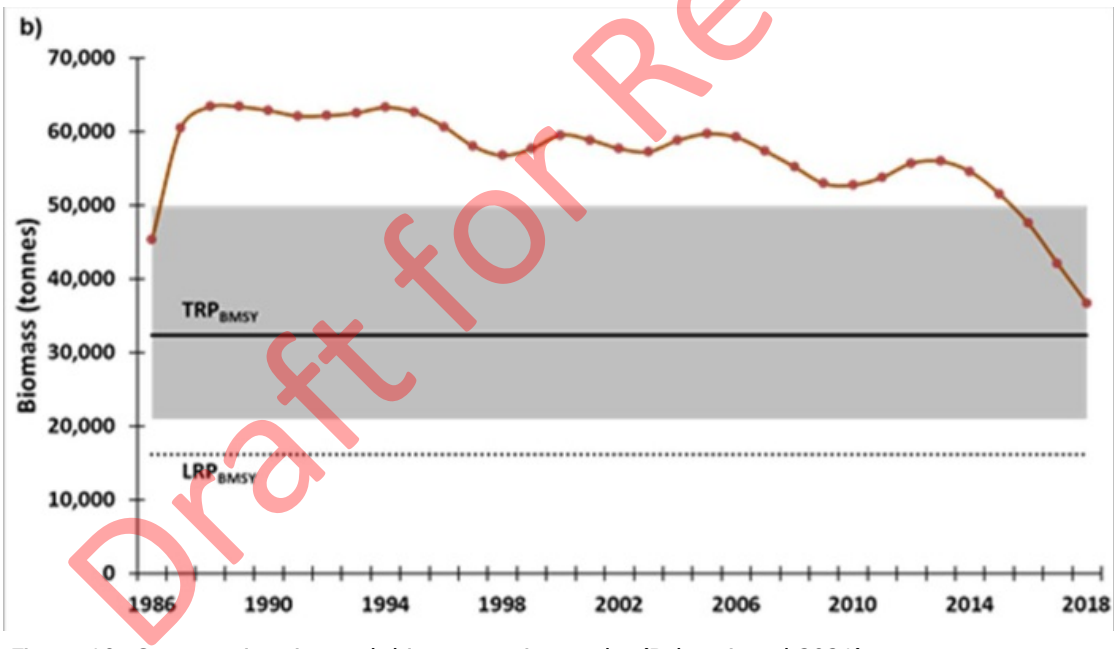

Figure 10: Cortez swimming crab biomass estimates by (Balmori et al 2021)

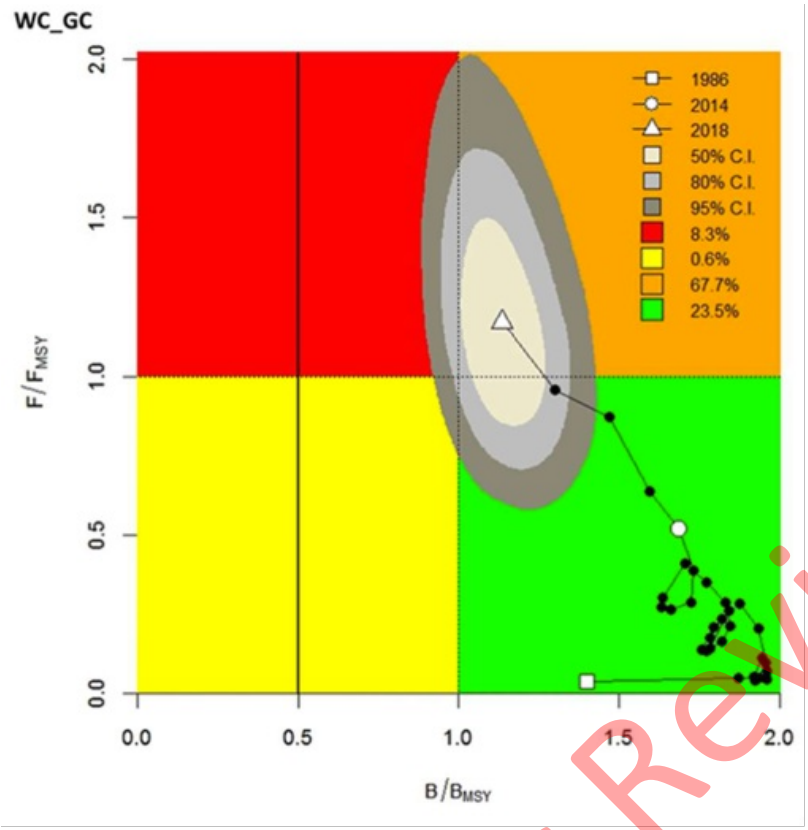

Figure 11: Kobe plot for Cortez swimming crab (Balmori et al 2021)

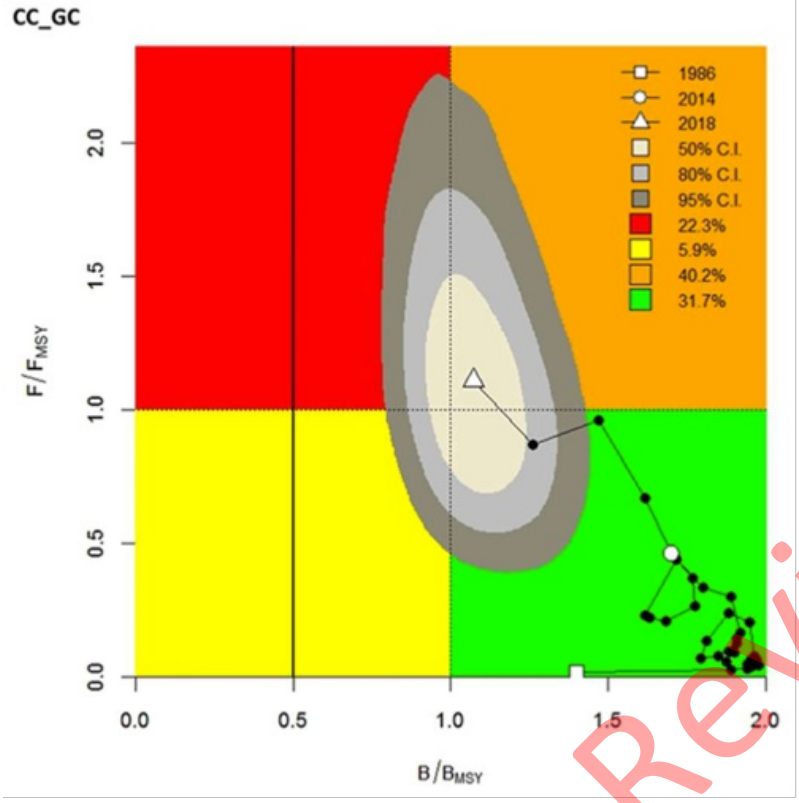

Figure 12: Kobe plot for Arched swimming crab (Balmori et al 2021)

Factor 1.2 - Fishing Mortality

Eastern Central Pacific | Crab rings | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sinaloa

High Concern

The fishing mortality values were estimated by (Balmori et al 2021) for both species in the Gulf of California. In the case of the Cortez swimming crab, landings showed a growing tendency from 2012 until 2018, close to the upper limit of the MSY. This was reflected in the fishing mortality estimates almost reaching the upper limit (of the reference point $LRPF_{MSY}$; the authors reported that the exploitation rate for 2018 reached the 1.171 value. A similar pattern was found for Arched swimming crab, with an increasing tendency starting in 2012 and reaching a value of 1.110 in 2018.

The Kobe plots place both the Cortez and Arched swimming crab stocks in the overfishing zone for the most recent year assessed. The authors reported a 67.7% probability that the Cortez swimming crab was in the orange quadrant, a 23.5% probability of it being located in the green quadrant, and an 8.3% probability of it being located in the red quadrant. For Arched crab, the uncertainty indicators show that there was a 40.2% probability that the status is in the orange quadrant, with a 31% probability of it being located in the green quadrant and a 22.3% probability of it being located in the red quadrant(Balmori et al 2021). The authors also reported that the number of boats in the Gulf of California participating in the swimming crab fishery increased by

42% in the 2011-2017 period and with exploitation rates in recent years above the LRP_{FMSY}.

Based on the amount of information available, it is Probable (>50% chance) that fishing mortality from all sources (including commercial, recreational, and subsistence) is above a sustainable level that is appropriate for the species, and considering that the authors estimate a high probability that overfishing is occurring we deemed these species a high concern for fishing mortality.

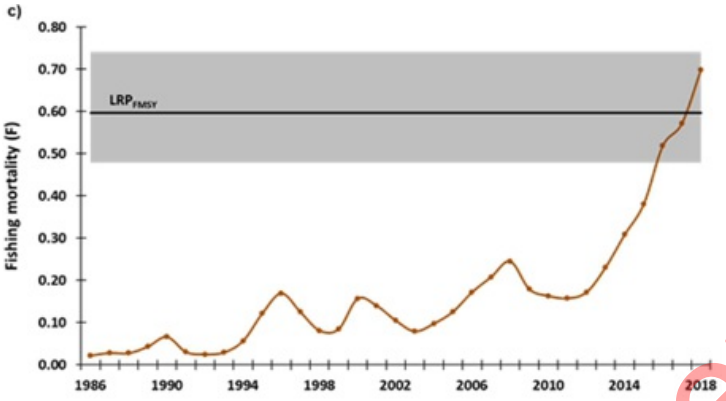

Figure 13: Warrior swimming crab fishing mortality (Balmori et al 2021)

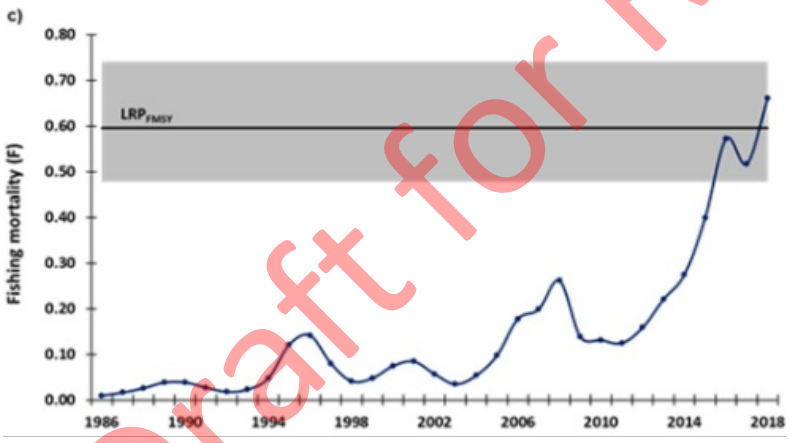

Figure 14: Arched swimming crab fishing mortality (Balmori et al 2021)

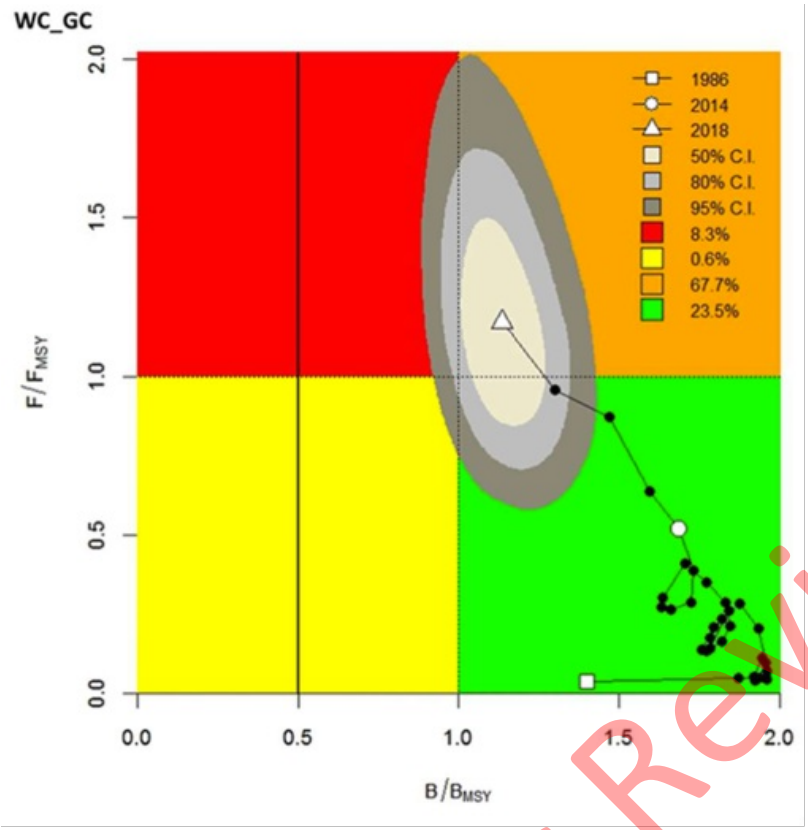

Figure 15: Kobe plot for Warrior swimming crab (Balmori et al 2021)

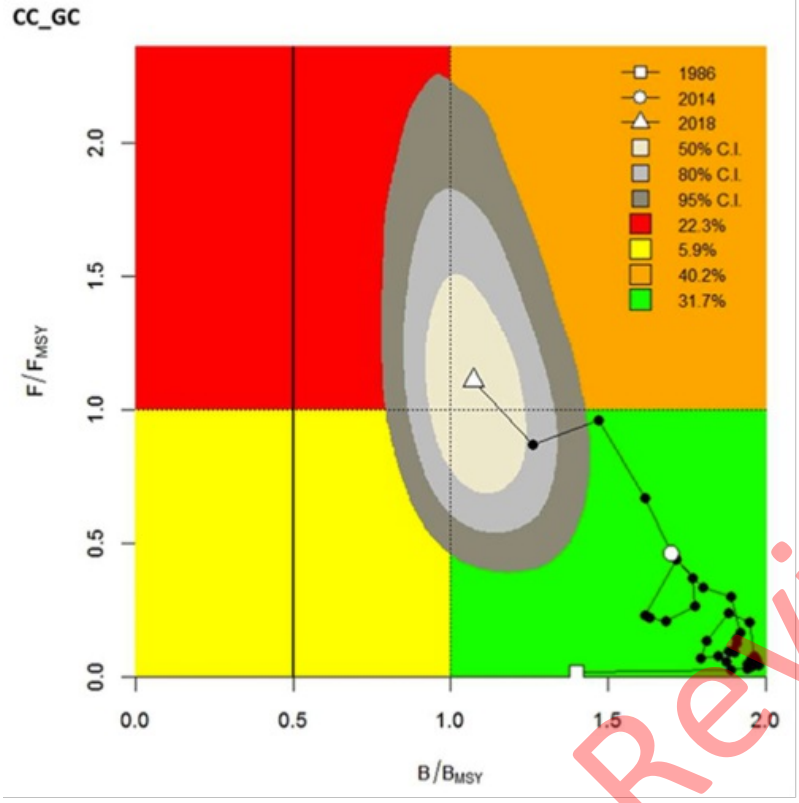

Figure 16: Kobe plot for Arched swimming crab (Balmori et al 2021)

Blue crab

Factor 1.1 - Abundance

Gulf of Mexico | Crab rings | Campeche
Gulf of Mexico | Scoopnets | Campeche

Low Concern

In 2021, (Morales-Azpeitia et al 2021) released a study that evaluated the biomass of the C. *sapidus* in the Gulf of Mexico and estimated the reference points of the species. The authors used a Catch-Maximum Sustainable Yield (C-MSY) method to estimate reference points, catch at Maximum Sustainable Yield (MSY), biomass associated with MSY (B_{MSY}), and mortality associated with MSY (F_{MSY}) using production data. Based on the results, the authors reported that the relative biomass has remained above the B_{MSY} although a tendency to decrease can be seen (see figure below). Overall, considering that the authors reported that the species is not overfished and, based on the results of the quantitative stock assessment from 2021, the biomass is above a limit reference point this factor is deemed a low concern.

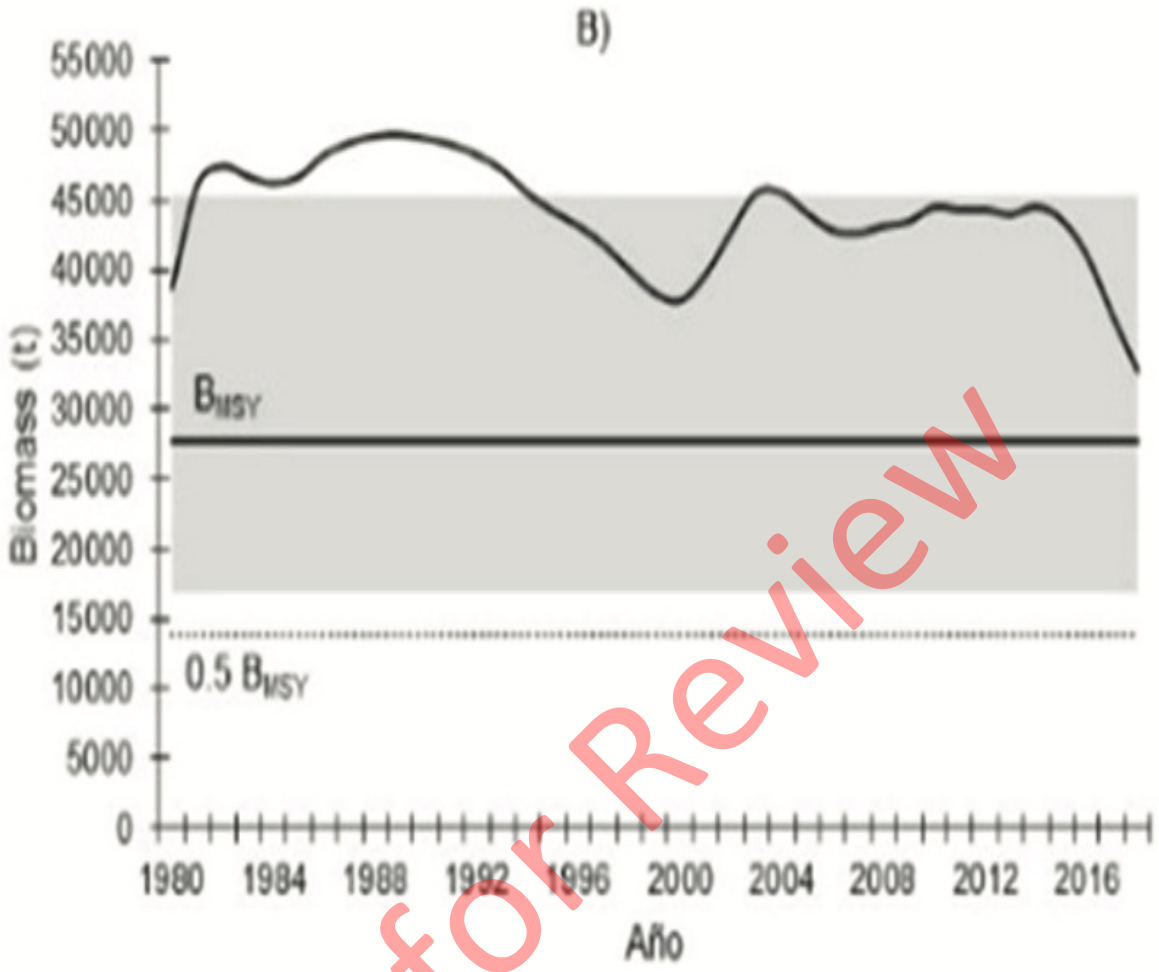

Figure 17: Blue crab biomass estimated by {Moralez-Azpeitia et al 2021}

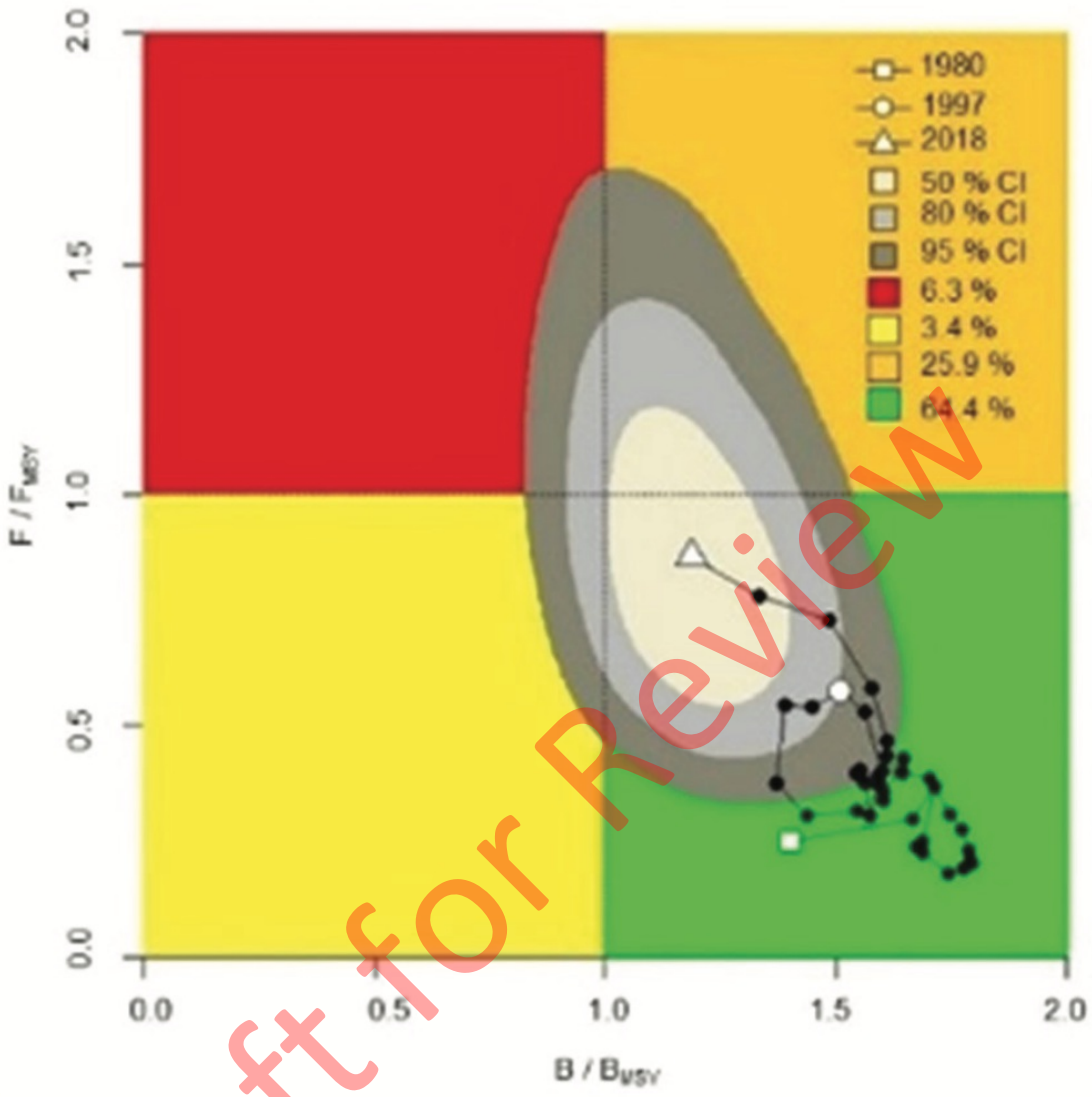

Figure 18: Blue crab kobe plot evaluated by {Moralez-Azpeitia et al 2021}

Factor 1.2 - Fishing Mortality

Gulf of Mexico | Crab rings | Campeche

Moderate Concern

{Moralez-Azpeitia et al 2021} used the production data to estimate the levels of fishing mortality for the fishery in the Gulf of Mexico, the authors used the official authorized fishing effort (~2,100 small-scale vessels){www.pescandodatos.org} and the annual landings that average 4,000 t for the last 10 years {Pescandodatos, 2021}. As part of the results, it was estimated that the annual fishing mortality remained less than half of the $LRPF_{MSY}$ value until 2014, a year when an increase in fishing mortality can be seen (See image in justification), achieving its highest point by 2018, with a value of F=0.74. Based on the results reported by (Morales-Azpeitia et al 2021), F is fluctuating around $F_{MSY,,}$ but a clear increasing tendency in recent years, years and for this reason we deem a moderate concern.

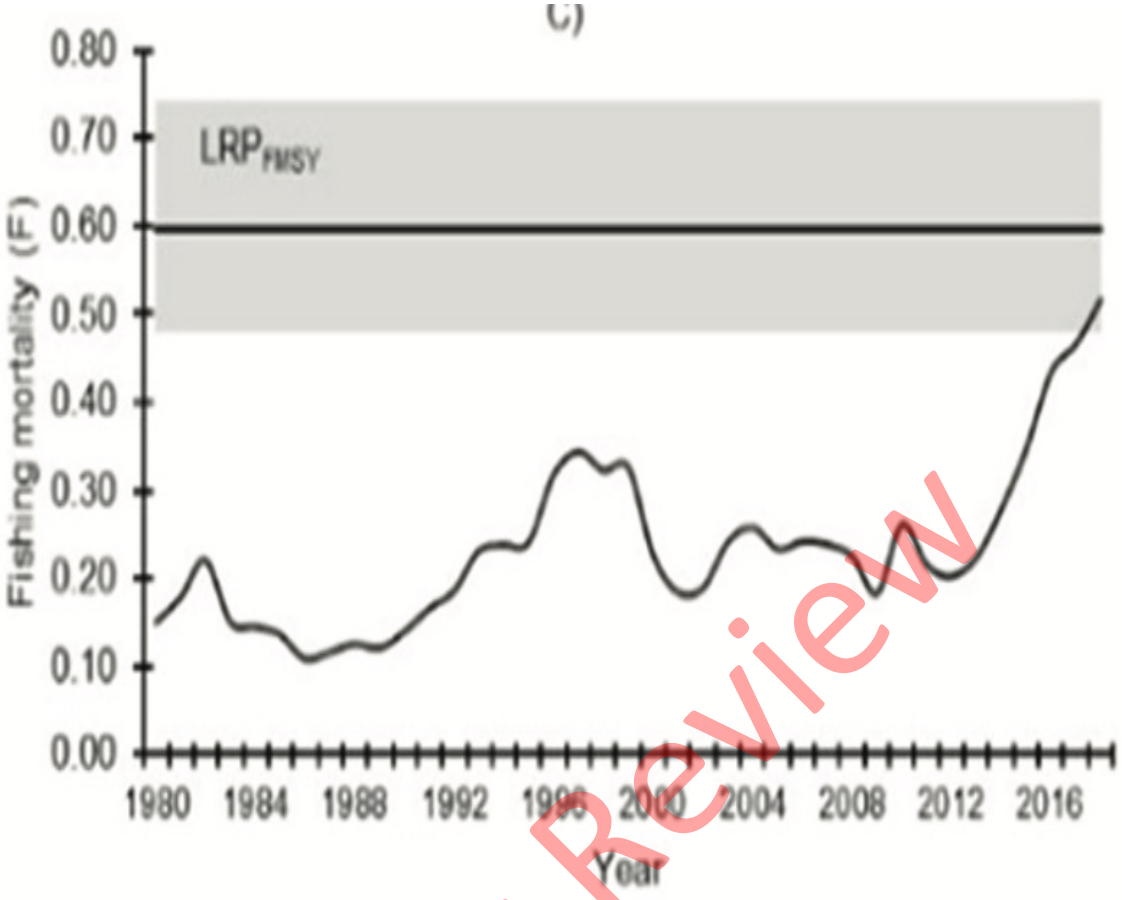

Figure 19: Blue crab fishing mortality estimated by {Moralez-Azpeitia et al 2021}

Gulf of Mexico | Scoopnets | Campeche

Moderate Concern

Currently, the fishing effort and levels of fishing mortality are unknown. For these reason, the factor is rated as "moderate" concern.

Cortez swimming crab

Factor 1.1 - Abundance

Eastern Central Pacific | Crab rings | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sonora
Eastern Central Pacific | Traps | Mexico | Sinaloa

Low Concern

Recently, (Balmori et al 2021) developed a stock assessment for both of the crab species in the Mexican Pacific; the authors used 1980 to 2018 official landings to feed a Catch-Maximum Sustainable Yield (C-MSY) method to estimate the maximum sustainable yield (MSY), the biomass associated with MSY (B_{MSY}) and the fishing mortality associated with maximum sustainable yield (F_{MSY}) for both species *Callinectes bellicosus* and *C. arcuatus* in the Gulf of California.

The authors calculated the MSY and B_{MSY} values for Cortez swimming crab (19,272 t and 32,356 t, respectively) and arched swimming crab (4,479 t and 7,520 t, respectively). Based on the analysis of the data, the authors reported that for Cortez swimming crab, the biomass has been above the MSY and at least 75% of the target reference point (see image below) in recent years, including 2018; for arched swimming crab similarly, biomass has been above the B_{MSY} . The B_{MSY} for both species was declared the target reference point by the authors based on the species' ecology. It is worth mentioning that managers monitor the "health" of the fishery based on a catch per day ratio (DOF 2014) and use this proportion as a reference point.

The recent assessment can be considered adequate for the species, however, based on the fact the authors mentioned that more robust fishery-dependent and independent data would reduce uncertainties in the methodology, and considering the clear negative trend in the biomass levels for both species during the most recent years (2013 to 2018), we deemed this factor as low concern.

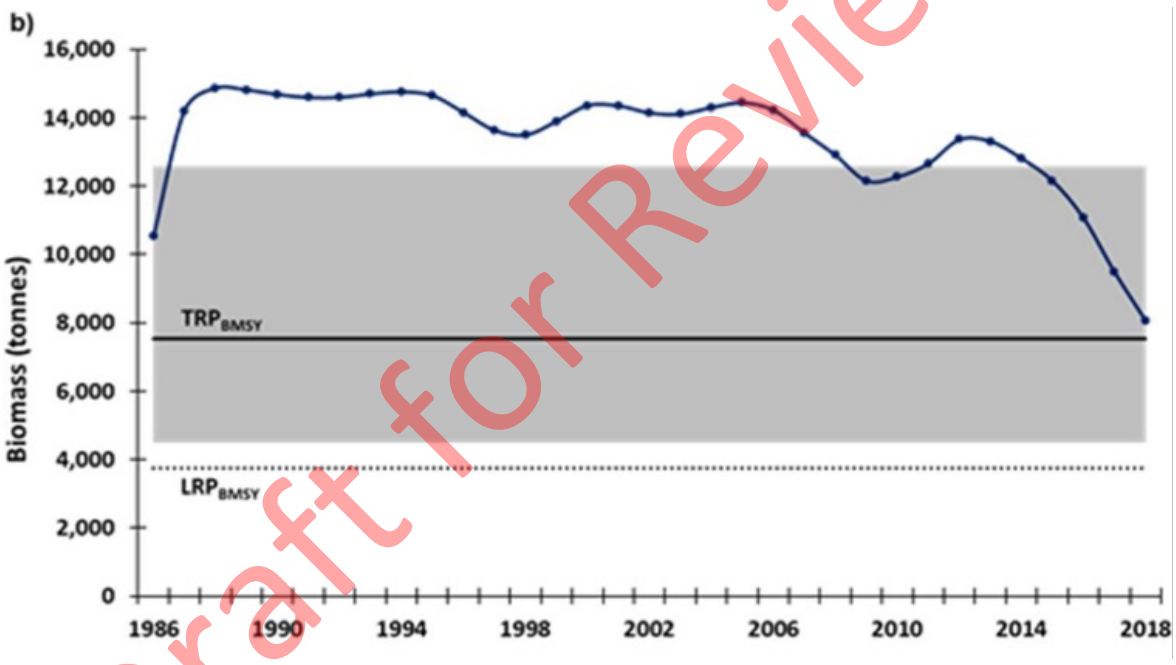

Figure 9: Arched swimming crab biomass estimates by (Balmori et al 2021)

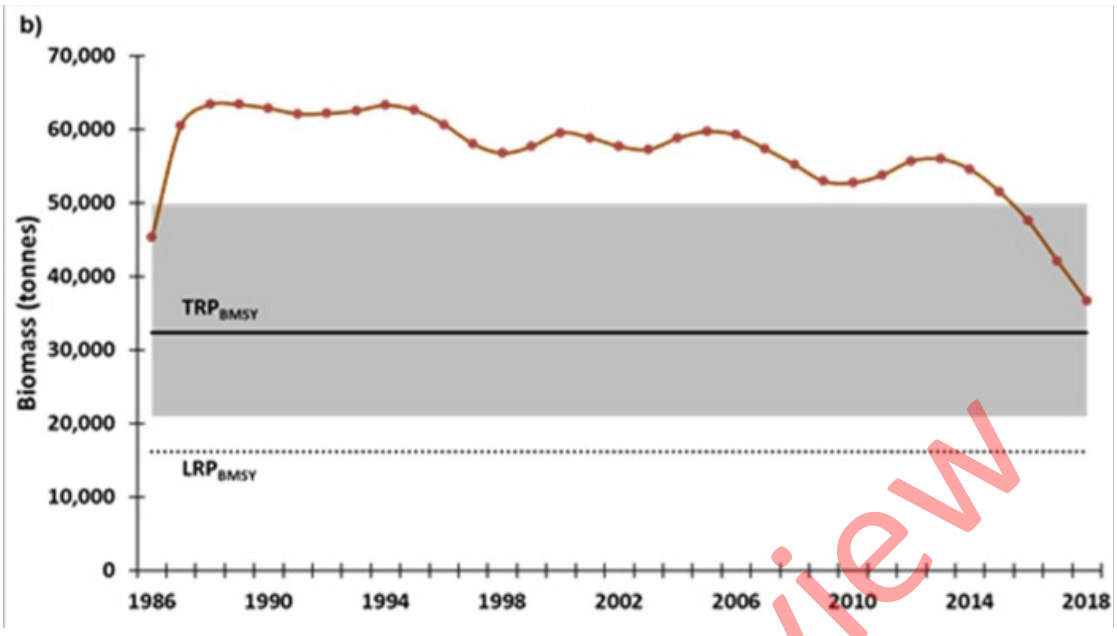

Figure 10: Cortez swimming crab biomass estimates by (Balmori et al 2021)

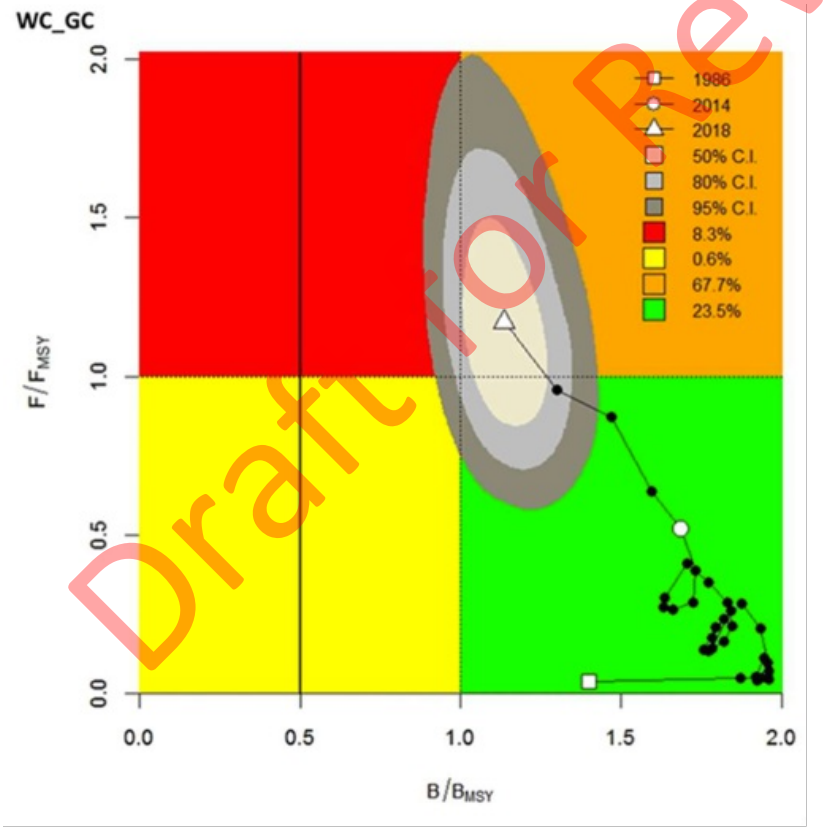

Figure 11: Kobe plot for Cortez swimming crab (Balmori et al 2021)

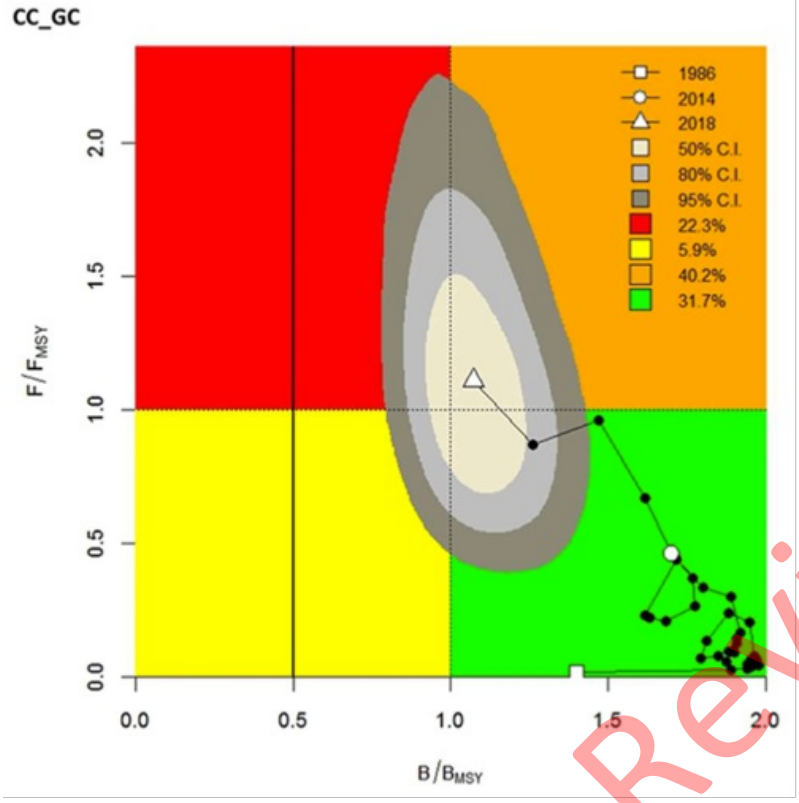

Figure 12: Kobe plot for Arched swimming crab (Balmori et al 2021)

Factor 1.2 - Fishing Mortality

Eastern Central Pacific | Crab rings | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sonora
Eastern Central Pacific | Traps | Mexico | Sinaloa

High Concern

The fishing mortality values were estimated by (Balmori et al 2021) for both species in the Gulf of California. In the case of the Cortez swimming crab, landings showed a growing tendency from 2012 until 2018, close to the upper limit of the MSY. This was reflected in the fishing mortality estimates almost reaching the upper limit (of the reference point $LRPF_{MSY}$; the authors reported that the exploitation rate for 2018 reached the 1.171 value. A similar pattern was found for Arched swimming crab, with an increasing tendency starting in 2012 and reaching a value of 1.110 in 2018.

The Kobe plots place both the Cortez and Arched swimming crab stocks in the overfishing zone for the most recent year assessed. The authors reported a 67.7% probability that the Cortez swimming crab was in the orange quadrant, a 23.5% probability of it being located in the green quadrant, and an 8.3% probability of it being located in the red quadrant. For Arched crab, the uncertainty indicators show that there was a 40.2% probability that the status is in the orange quadrant, with a 31% probability of it being located in the green quadrant and a 22.3% probability of it being located in the red quadrant(Balmori et al 2021). The authors also reported that the

number of boats in the Gulf of California participating in the swimming crab fishery increased by 42% in the 2011-2017 period and with exploitation rates in recent years above the LRP_{FMSY}.

Based on the amount of information available, it is Probable (>50% chance) that fishing mortality from all sources (including commercial, recreational, and subsistence) is above a sustainable level that is appropriate for the species, and considering that the authors estimate a high probability that overfishing is occurring we deemed these species a high concern for fishing mortality.

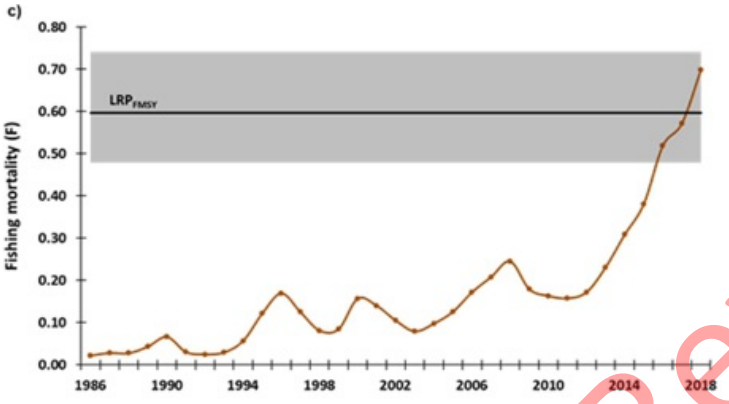

Figure 13: Warrior swimming crab fishing mortality (Balmori et al 2021)

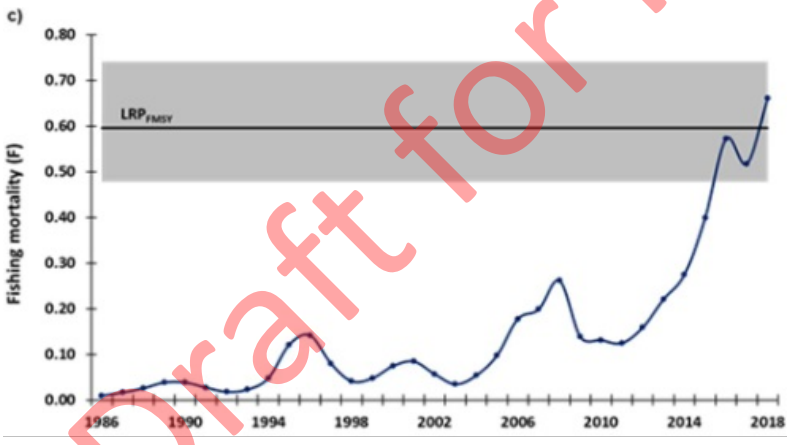

Figure 14: Arched swimming crab fishing mortality (Balmori et al 2021)

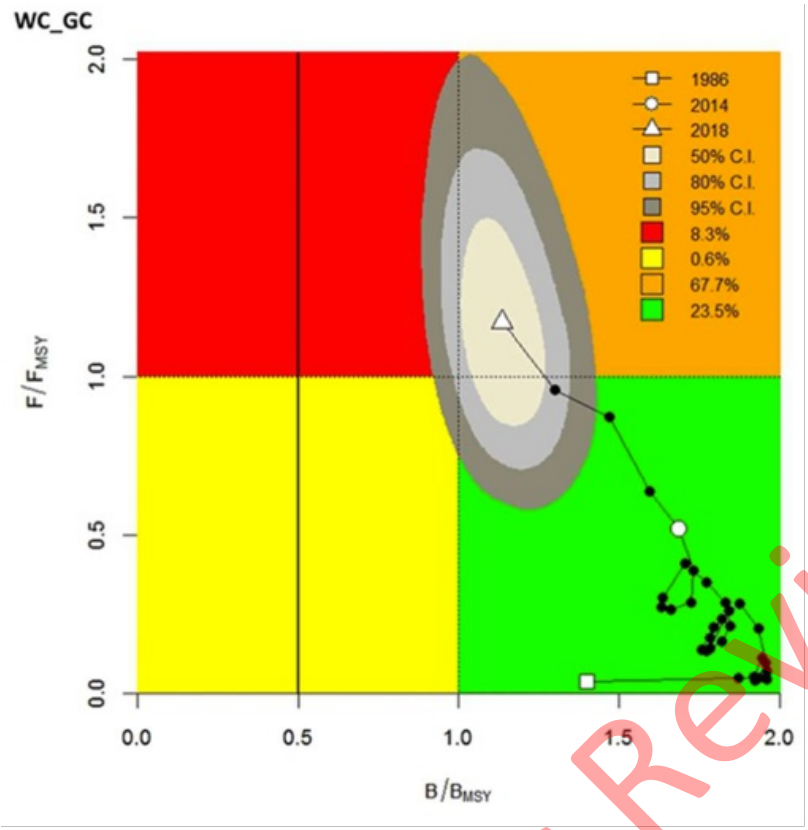

Figure 15: Kobe plot for Warrior swimming crab (Balmori et al 2021)

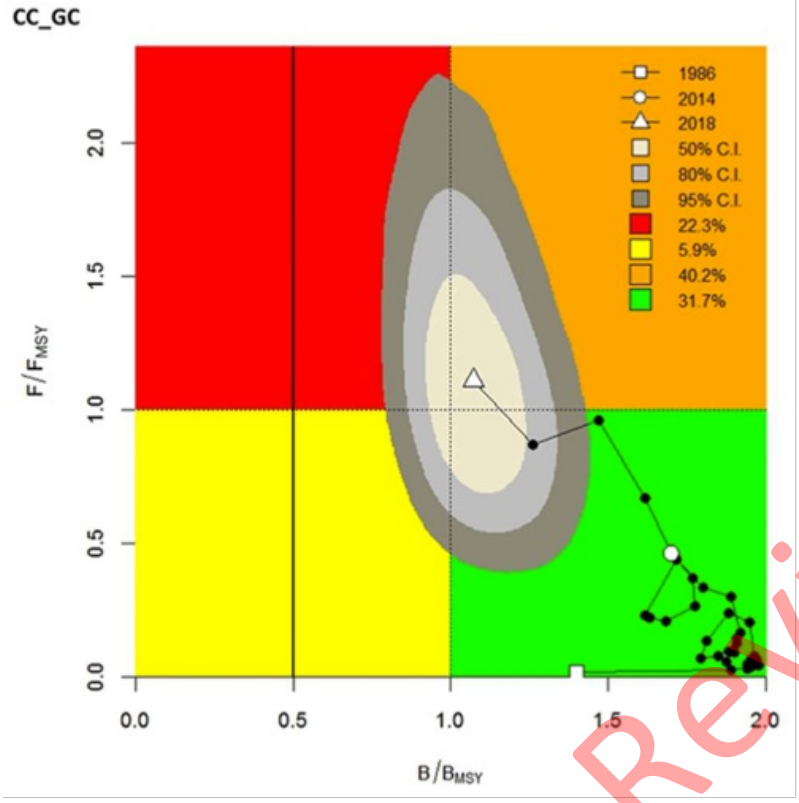

Figure 16: Kobe plot for Arched swimming crab (Balmori et al 2021)

Criterion 2: Impacts on Other Species

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

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

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

Guiding principles

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

Criterion 2 Summary

Criterion 2 score(s) overview

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

ARCHED SWIMMING CRAB			
REGION / METHOD	**SUB SCORE**	**DISCARD RATE/LANDINGS**	**SCORE**
Eastern Central Pacific | Crab rings | Mexico | Sinaloa	1.916	1.000: < 100%	Red (1.916)
Eastern Central Pacific | Traps | Mexico | Sinaloa	1.916	1.000: < 100%	Red (1.916)

BLUE CRAB			
REGION / METHOD	**SUB SCORE**	**DISCARD RATE/LANDINGS**	**SCORE**
Gulf of Mexico | Crab rings | Campeche	2.644	1.000: < 100%	Yellow (2.644)
Gulf of Mexico | Scoopnets | Campeche	2.644	1.000: < 100%	Yellow (2.644)

CORTEZ SWIMMING CRAB			
REGION / METHOD	**SUB SCORE**	**DISCARD RATE/LANDINGS**	**SCORE**
Eastern Central Pacific | Crab rings | Mexico | Sinaloa	1.916	1.000: < 100%	Red (1.916)
Eastern Central Pacific | Traps | Mexico | Sonora	3.413	1.000: < 100%	Green (3.413)
Eastern Central Pacific | Traps | Mexico | Sinaloa	1.916	1.000: < 100%	Red (1.916)

Criterion 2 main assessed species/stocks table(s)

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

EASTERN CENTRAL PACIFIC | CRAB RINGS | MEXICO | SINALOA			
SUB SCORE: 1.916	DISCARD RATE: 1.000	**SCORE: 1.916**	
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Arched swimming crab	3.670: Low Concern	1.000: High Concern	Red (1.916)
Cortez swimming crab	3.670: Low Concern	1.000: High Concern	Red (1.916)

EASTERN CENTRAL PACIFIC | TRAPS | MEXICO | SINALOA			
SUB SCORE: 1.916	DISCARD RATE: 1.000		SCORE: 1.916
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Arched swimming crab	3.670: Low Concern	1.000: High Concern	Red (1.916)
Cortez swimming crab	3.670: Low Concern	1.000: High Concern	Red (1.916)

EASTERN CENTRAL PACIFIC | TRAPS | MEXICO | SONORA			
SUB SCORE: 3.413	DISCARD RATE: 1.000		SCORE: 3.413
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Cortez swimming crab	3.670: Low Concern	1.000: High Concern	Red (1.916)
Pink-mouthed murex	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

GULF OF MEXICO | CRAB RINGS | CAMPECHE			
SUB SCORE: 2.644	DISCARD RATE: 1.000		SCORE: 2.644
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Sharptooth swimming crab	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Blue crab	3.670: Low Concern	3.000: Moderate Concern	Green (3.318)

GULF OF MEXICO | SCOOPNETS | CAMPECHE			
SUB SCORE: 2.644	DISCARD RATE: 1.000		SCORE: 2.644
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Sharptooth swimming crab	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Blue crab	3.670: Low Concern	3.000: Moderate Concern	Green (3.318)

The trap and ring fisheries in Sinaloa and the scoop nets and ring fisheries in Campeche generally catch low amounts of non-target species based on a few studies {Torre-Cosio 2002} {Balmori et al. 2012} {Cisneros-Mata et al., 2014}. In Sinaloa and Sonora, the swimming crab traps bycatch composition and proportion were assessed in 2012 as part of the Fisheries Improvement Project (FIP) that the fishery is engaged in (SFP 2015). Assessment results suggested that the crab-bycatch proportion was 1:0.31 on average for Sonora and 1:0.06 for Sinaloa {Balmori et al. 2012}. The study found greater retention of bycatch in traps (230 g on average per 1 kg of crab) as compared to rings (10 g per 1 kg of Crab) {Balmori et al 2012}. In total, 20 bycatch species were identified in the study; 80% were mollusks, 11% were fishes, and 9% were crustaceans. The primary bycatch species was the pink snail *Phyllonotus erythrostomus* (with 75% of the total weight of bycatch); some hermit crab species *(Pagurus spp)* (7% of the total bycatch) and some species of small snails from the Turridae family (5% of the total bycatch). The most commonly caught finfish species was the Spotted Sand bass *(Paralabrax maculatofasciatus)* with 4.1% of the abundance of the total bycatch) {Balmori et al. 2012}. All other species accounted for <5% of the bycatch. Of these species, only pink snail and the sand bass were reported to be retained for

commercial or personal consumption; the rest are returned alive and in good condition to the water {Balmori et al. 2012} {pers. comm., Loaiza-Villanueva 2016}. None of the species reported caught are under a special risk category, and only the pink snail in Sonora is considered for further examination.

In Campeche, managers reported *C. rathbunae* were caught in the blue crab fishery, up to almost 8% of total catches in 2006 (DOF 2006). A more recent analysis of the fishery against the Marine Stewardship Council standards reported that bycatch is minimal, and no species listed on the IUCN are caught {Nakamura et al. 2013}. However, no quantitative data on bycatch was presented in the report. Considering the limited information available, sharp-toothed crab was included as bycatch species in the Campeche fishery.

Criterion 2 Assessment

SCORING GUIDELINES

Factor 2.1 - Abundance
(same as Factor 1.1 above)

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

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

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

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

Pink-mouthed murex

Factor 2.1 - Abundance

Eastern Central Pacific | Traps | Mexico | Sonora

Moderate Concern

Managers recommended limiting the commercial extraction to about 40% of the calculated biomass (DOF 2012). However, there is no evidence that either a stock assessment has been conducted or that catch limits have been established. For this reason, a PSA was used to determined pink snails vulnerability and score abundance.

Phyllonotus erythrostomus has a "medium" vulnerability (according to the PSA analysis), and since there is no quantitative stock assessment, abundance is deemed a "moderate" concern.

Justification:

PSA score = 2.82. For this reason, the species is deemed "medium" vulnerability (based on PSA scoring tool). Detailed scoring of each attribute is shown below.

Productivity Attribute
Relevant Information
Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity
Within one year {Baqueiro, Masso and Velez 1983}
1
Average maximum age
Unknown
Fecundity
Unknown for the species. Average values of marine snails with similar ecology was used. 5,000,000 eggs (FAO 1999)
1
Reproductive strategy
Demersal egg layer
2
Trophic level
Unknown.
Density dependence (invertebrates only)
Depensatory, this species aggregate to spawn. (Cudney-Bueno and Hinojosa-Huerta 2008)
3

Susceptibility Attribute

Relevant Information

Score (1 = low risk, 2 = medium risk, 3 = high risk)

Areal overlap

(Considers all fisheries)

The area of distribution of the snail is also an area of distribution for the fishery (DOF 2014)

3

Vertical overlap

(Considers all fisheries)

Traps are set in the bottom where snails inhabit

3

Selectivity of fishery

(Specific to fishery under assessment)

In Sonora, traps were reported to catch up to 5% of the total catch in the traps {Balmori et al. 2012}

2

Post-capture mortality

(Specific to fishery under assessment)

According to managers, all of the snail is retained {Cisneros-Mata et al. 2014}

3

Factor 2.2 - Fishing Mortality

Eastern Central Pacific | Traps | Mexico | Sonora

Low Concern

There is a fishery in the region that target this species as well as black snail (*Muricanthus nigritus*). However, levels of fishing mortality are unknown for pink snail (DOF 2012).

{Arreguin-Sanchez and Huitron 2011} analyzed the exploitation status of different species in Mexico using official catch and effort data. The researchers identified the snail fishery (including

pink snail) as one of the few fisheries in the country with chances of growth (based on the ecology of the species and the catch information) {Arreguin-Sanchez and Huitron 2011}. These species are targeted by commercial divers, but gillnet fishers and trap fishers are allowed to collect them as bycatch (DOF 2012). Managers found a decrease in catches in the Baja Peninsula coast, but does not report any concern on the status in the Sonoran region. Although fishing mortality on the pink snail is unknown, the unknown bycatch matrix suggests that bycatch of invertebrates in pot and trap gear is a "low" conservation concern.

Sharptooth swimming crab

Factor 2.1 - Abundance

Gulf of Mexico | Crab rings | Campeche
Gulf of Mexico | Scoopnets | Campeche

Moderate Concern

A stock assessment relative to reference points is not available for this species. For this reason, this factor is rated using the Productivity-Susceptibility Analysis (PSA) in the next section.

As abundance is unknown and the species has a "medium" vulnerability, according to the PSA analysis (see below) this factor is deemed a "moderate" conservation.

Justification:

PSA score = 2.71. For this reason, the species is deemed "medium" vulnerability (based on PSA scoring tool). Detailed scoring of each attribute is shown below.

Productivity Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	1.75 years (Chavez and Fernandez 1976)	1
Average maximum age	3.5 years (Chavez and Fernandez 1976)	1
Fecundity	$0.7X10^6$ to $1.5X10^6$ eggs/y (Chavez and Fernandez 1976)	1
Reproductive strategy	Brooder	2
Trophic level	Unknown	
Density dependence (invertebrates only)	No depensatory or compensatory dynamics demonstrated or likely	2

Susceptibility Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	Default value used	3
Vertical overlap (Considers all fisheries)	Default value used	3
Selectivity of fishery (Specific to fishery under assessment)	According to managers and literature, scoops are highly selective for Crab species in the region (SAGARPA-INAPESCA 2013)	2
Post-capture mortality (Specific to fishery under assessment)	Organisms that are not retained (due to size) are released alive and in good condition {Nakamura et al. 2013}	3

Factor 2.2 - Fishing Mortality

Gulf of Mexico | Crab rings | Campeche
Gulf of Mexico | Scoopnets | Campeche

Moderate Concern

Currently, the fishing effort and levels of fishing mortality are unknown. For these reason, the factor is rated as a "moderate" concern.

Factor 2.3 - Discard Rate/Landings

Eastern Central Pacific | Crab rings | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sonora

< 100%

According to fishery experts, since the implementation of the standard measures for the crab traps (DOF 2012), discards of crabs are minimal; most of the organisms in the traps are above the minimum size requirement, and those that are under the minimum size are returned to the water alive and in good condition {pers. comm., Loaiza-Villanueva 2016}. Also, other bycatch species were reported to be in good condition when returned to the water {Balmori et al. 2012}. In the crab fishery, traps are baited with fish (mostly mackerel, small grouper *(Palabrax maculatofasciatus)* or chano *(Micropogonias megalops);* {Turk-Boyer et al. 2014} and on average, 500 g of bait are used per trap to obtain 1 kg of crab {pers. comm., Loaiza-Villanueva}. Based on this information, the ratio is estimated to be close to 60% or 70%.

Gulf of Mexico | Crab rings | Campeche

< 100%

Gulf of Mexico | Scoopnets | Campeche

< 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.

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

Criterion 3 Summary

FISHERY	MANAGEMENT STRATEGY	BYCATCH STRATEGY	RESEARCH AND MONITORING	ENFORCEMENT	INCLUSION	SCORE
Eastern Central Pacific | Crab rings | Mexico | Sinaloa	Moderately Effective	Highly effective	Moderately Effective	Moderately Effective	Highly effective	**Yellow (3.000)**
Eastern Central Pacific | Traps | Mexico | Sinaloa	Moderately Effective	Highly effective	Moderately Effective	Moderately Effective	Highly effective	**Yellow (3.000)**
Eastern Central Pacific | Traps | Mexico | Sonora	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Highly effective	**Yellow (3.000)**

Gulf of Mexico | Crab rings | Campeche	Moderately Effective	Highly effective	Moderately Effective	Moderately Effective	Moderately Effective	**Yellow (3.000)**
Gulf of Mexico | Scoopnets | Campeche	Moderately Effective	Highly effective	Moderately Effective	Moderately Effective	Moderately Effective	**Yellow (3.000)**

Criterion 3 Assessment

SCORING GUIDELINES

Factor 3.1 - Management Strategy and Implementation

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

Factor 3.2 - Bycatch Strategy

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

Factor 3.3 - Scientific Research and Monitoring

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

Factor 3.4 - Enforcement of Management Regulations

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

Factor 3.5 - Stakeholder Inclusion

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

Factor 3.1 - Management Strategy And Implementation

Eastern Central Pacific | Crab rings | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sonora

Moderately Effective

Managers rely on two main instruments to regulate the Crab fishery. The Mexican Official Norm (NOM) 039-PESC, which is a federal regulation that specifies the terms and conditions for the Crab fishery in the Mexican Pacific (including Sonora and Sinaloa) {DOF, 2014} and the Sinaloa and Sonora Management Plan (SSMP).

Both instruments contained specifications related to fishing mortality (e.g., dimensions and number of traps and rings per vessel and by state). Currently, the maximum number of traps and rings authorized in Sinaloa is 70,800 rings and/or traps; while in Sonora, the limit is 43,600 traps/rings {DOF, 2006} (DOF 2012). The NOM also limits the amount of time the gear can be under the water (24 hours) {DOF, 2006}.

To protect the reproductive stages, an off-season was established in 2013 {DOF 2013} based on the biological opinion generated by SAGARPA-INAPESCA (2013). This off-season prohibits the extraction of both species and sexes from May 1st to June 30 every year, with an additional restriction on female extraction from July 1st to July 9th and yearly {DOF 2013}. Managers concluded that by keeping the off-season, the crab biomass would be maintained at sustainable levels (SAGARPA-INAPESCA 2013).

In addition, crab producers in Mexico started fisheries improvement projects on both sides of the country. Producers and managers in Sonora and Sinaloa started working together to improve harvest regulations to protect the stocks {DOF, 2014}. As a result, the SSMP includes strategies to help the long-term sustainable use of the species, such as regulation on minimum retainable size (95 mm carapace width for arched crab and 115 mm for Cortez crab). The current limits are above the size at which 50% of crabs reach sexual maturity in the region (DOF 2014). The size limit ensures that crabs can spawn or reproduce before they are caught.

Although the most recent stock assessment identified MSY values for the fishery, these values are not used as reference levels by managers. Instead, a limit reference point of CPUE (350g/gear/day or 84 kg/gear/year) is used as an indicator of the status of the stock. It is unclear how managers monitor this index; it does not explain what mechanisms are in place once this target has been reached, so it is unclear whether the reference points are appropriate for the current stock status. Sonora and Sinaloa represent ~95% of the production in the Pacific, and the management measures in place clearly define fishing regulations that aim to protect the stocks. In addition, no special concern species are reported to be caught in the fisheries. However, appropriate conservation targets have not been defined (e.g., current reference points have not changed from the National Fisheries Chart of 2010). It is then considered that for most of the fishery's main primary targeted species, the management measures in place still exceed those for 'Ineffective', and although these are expected to be effective, there is a need for increased precaution,

considering the recent trends in biomass and fishing mortality reported during the most recent assessment (Balmori et al 2021)

For these reasons, management strategy is deemed a "moderately effective" score.

Gulf of Mexico | Crab rings | Campeche
Gulf of Mexico | Scoopnets | Campeche

Moderately Effective

There are no reference points or appropriate fishing level goals established for Campeche blue crab. The CNP recommends to keep production close to the "average fishing index" estimated from the total landings reported between 2000 and 2007. This index was set at 2,500 t for Campeche in 2012 (DOF 2012).

Unlike in the Pacific fishery, no formal management plan or NOM is in place for this region. The regulations in place to control fishing mortality are: a minimum size limit (110 mm carapace width), access through a permit system and a limit on the number of gear by boat (DOF 2012). However, no other rules that regulate fishing gear characteristics are in place, and no official off-seasons or other regulations are comparable to those that exist in the Pacific Coast fishery. Managers monitor the health of the fishery based on catch data from fishers' reports (DOF 2012). Managers identified the fishery as exploited to the maximum sustainable level and did not recommend increasing fishing effort in 2012 (DOF 2012). It seems that current management has been effective (based on trends in production (CONAPESCA 2015); therefore, this factor is rated as "moderately effective."

Factor 3.2 - Bycatch Strategy

Eastern Central Pacific | Crab rings | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sinaloa
Gulf of Mexico | Crab rings | Campeche
Gulf of Mexico | Scoopnets | Campeche

Highly effective
No bycatch species of concern have been identified on these fisheries. Also, no other species are reported to be caught. This factor is rated as "highly effective" for these fisheries.

Eastern Central Pacific | Traps | Mexico | Sonora

Moderately Effective
An analysis of the bycatch was developed in 2012 to measure the impact of the fishery in other species {Balmori et al. 2012}. Although no current strategy is in place to minimize the impact on pink snail (the only species considered as bycatch because of volume), this is not a species of concern. Furthermore, since no other species or stocks of concern are caught, and reported interaction and bycatch in traps is minimal, this factor is rated as "moderately effective.

Factor 3.3 - Scientific Research And Monitoring

Eastern Central Pacific | Crab rings | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sonora

Moderately Effective

In these two Gulf of California states, commercial catch-per-unit-effort data are collected by local fishing offices, and fishers deliver catch reports by area and species (DOF 2014). These catch data are used as an indicator of the current status of the populations. According to the 2012 assessment, bycatch levels were not significant. A bycatch data monitoring program is ongoing under the FIP, led by INAPESCA and with the participation of COBI and CEDO (two regional Non-government organizations), which conduct sampling every 2 years to maintain the information updated; a new report is in progress {Garcia-Caudillo 2017}.

A result of these efforts was the evaluation of the stock status developed and published by FIP participants (Balmori et al 2021) Managers as well as FIP participants consider that this data can continue to be used to monitor and maintain the stock (including monitoring of bycatch) and continue developing the data-limited assessment methodology (C-MSY) to inform the management strategies; for these reasons, this factor is rated as "moderately effective" for all the fisheries in both states.

Gulf of Mexico | Crab rings | Campeche
Gulf of Mexico | Scoopnets | Campeche

Moderately Effective

Data on Catch per unit effort (CPUE) has been monitored through the FIP for the Campeche crab fishery since 2003 (Nakamura et al., MSC Pre-assessment for Campeche Blue Crab 2014). This fishery access is managed through fishing licenses and a minimum size limit (110 mm) and limits on the number of gears allowed (maximum number of traps and pots) (DOF 2012). Although a bycatch monitoring program is not in place, the bycatch caught in the fishery is nonexistent {Nakamura et al. 2013}.

Currently, two improvement projects are active in the Yucatán Peninsula; these two projects have monitoring systems in place that aim to collect information related to the catch composition and generate biological information about the fishery to contribute to its knowledge and management. These data are used to monitor the status of the stock and assess the effectiveness of the strategies, including the generation of stock assessments for each project, including (Morales-Azpeitia et al 2021) evaluation, and the (Diaz-Lugo and Alonso-Aleman 2021). For these reasons, the factor is rated as "moderately effective" for Campeche.

Factor 3.4 - Enforcement Of Management Regulations

Eastern Central Pacific | Crab rings | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sinaloa
Gulf of Mexico | Crab rings | Campeche
Gulf of Mexico | Scoopnets | Campeche
Eastern Central Pacific | Traps | Mexico | Sonora

Moderately Effective

Federal regulations (NOM-039 specifications, management plan, and Fisheries National Chart regulations) are enforced by federal CONAPESCA agents (Inspectores Federales de Pesca), which coordinate with the Mexican Navy (DOF 2014). In 2013, coordination efforts between the CONAPESCA and the Navy were formalized with the creation of the "National Enforcement plan" (CONAPESCA b 2015). This plan is implemented along the Pacific and Gulf of Mexico coasts. The aim of this campaign is to prevent acts of illegal fishing (CONAPESCA b 2015). Specific measures include:

- Random inspections of small-scale vessels on the sea all year long but with special emphasis during off seasons
- Road checkpoints on land along most of the most important landing sites
- Inspection of storage and processing plants and other infrastructure, in order to verify inventory

CONAPESCA has also opened the opportunity to fishing organizations to be part of enforcement efforts by providing federal funds to the fishing industry through the "Enforcement and Monitoring Fishing and Aquaculture Program," which allows fishers to apply for funds up to 6 million pesos/year (approx. $320,000 USD) as a group, or 2 million ($108,000 USD) as a single person to cover costs of enforcement activities (CONAPESCA b 2015).

Although an enforcement plan and subsidy programs to improve these actions are in place, the effectiveness of these systems is uncertain, since there is no independent scrutiny of these programs. A report on illegal fishing in Mexico (IMCO et al 2013) released in 2013, recognized that enforcement actions, particularly in small-scale fisheries in Mexico have yet to be improved; however, no further information regarding enforcement activities and compliance was found. For these reasons, this factor is rated as "moderately effective."

Factor 3.5 - Stakeholder Inclusion

Eastern Central Pacific | Crab rings | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sonora

Highly effective

The process to create and evaluate the new management regulations in these two states was developed with the participation of different stakeholders involved in the fishery (SFP 2015) (DOF 2014). Stakeholders are included within official bodies called "Comite Sistema Producto Jaiba" (CSP, National Crab Production System) and its state commissions "Comite Sistema Producto Sonora" (CSPS, Sonoran Crab Production System; www.jaibasonora.org). These bodies incorporate producers, managers and all other participants in the supply chain in order to improve the fishery as a whole. Analyses of the fishery were developed and action plans were decided upon as a group (SFP 2015). Also, in 2014, managers organized and paid for workshops to build capacity within the fishing communities, where fishers learned about sustainable fishing and national and international regulations (ASEPYA 2014). Since the management process is transparent and includes stakeholder inclusion, the Sonora and Sinaloa crab fishery is deemed "highly effective" for this factor.

Gulf of Mexico | Crab rings | Campeche
Gulf of Mexico | Scoopnets | Campeche

Moderately Effective

Although management regulations are public and the participation process is open, there is no record of participation from producers or other stakeholders on regulations. Recent communications to increase involvement in the fishery started in 2013 when a FIP was launched for this fishery; (https://sites.google.com/site/yucatancrabfip/) in order to improve its sustainability. According to the FIP tracker, in 2014 FIP representatives and INAPESCA managers started collaborating to collect more information and generate a management plan for the fishery in the region (DOF 2012). Based on this information, the factor is rated as "moderately effective" for the Campeche crab fishery.

Criterion 4: Impacts on the Habitat and Ecosystem

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

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

Guiding principles

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

Rating cannot be Critical for Criterion 4.

Criterion 4 Summary

FISHERY	FISHING GEAR ON THE SUBSTRATE	MITIGATION OF GEAR IMPACTS	ECOSYSTEM-BASED FISHERIES MGMT	SCORE
Eastern Central Pacific | Crab rings | Mexico | Sinaloa	Score: 3	Score: 0	Moderate Concern	**Yellow (3.000)**
Eastern Central Pacific | Traps | Mexico | Sinaloa	Score: 3	Score: 0	Moderate Concern	**Yellow (3.000)**
Eastern Central Pacific | Traps | Mexico | Sonora	Score: 3	Score: 0	Moderate Concern	**Yellow (3.000)**
Gulf of Mexico | Crab rings | Campeche	Score: 3	Score: 0	Moderate Concern	**Yellow (3.000)**
Gulf of Mexico | Scoopnets | Campeche	Score: 3	Score: 0	Moderate Concern	**Yellow (3.000)**

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 - Impact of Fishing Gear on the Habitat/Substrate

Eastern Central Pacific | Crab rings | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sinaloa
Gulf of Mexico | Crab rings | Campeche
Gulf of Mexico | Scoopnets | Campeche
Eastern Central Pacific | Traps | Mexico | Sonora

Score: 3

The crab traps, rings, and scoops use in the crab fisheries in Mexico have a low impact on the physical and biological structures of the seafloor {Balmori et al. 2012} for Sonora and Sinaloa; {Nakamura et al. 2012} for Campeche. During fishing operations (launch and retrieval of traps) there is minimal dragging on the bottom {Loaiza-Villanueva 2016}. Mexican crab species live in sandy and muddy habitats, which are resilient habitat types {Johnston et al. 2012}. Therefore, this factor is deemed a "low" concern (3).

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

Eastern Central Pacific | Crab rings | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sinaloa
Gulf of Mexico | Crab rings | Campeche
Gulf of Mexico | Scoopnets | Campeche
Eastern Central Pacific | Traps | Mexico | Sonora

Score: 0

Currently, there are no measures in place to mitigate the impacts of fishing gear in the fishery. One of the activities included in the new management plan for Sonora and Sinaloa includes the evaluation of fishing gear modifications that reduce environmental impact (DOF 2014) action 1.3.2, but it has not been implemented. Therefore, no further credit is granted.

Factor 4.3 - Ecosystem-based Fisheries Management

Eastern Central Pacific | Crab rings | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sinaloa
Eastern Central Pacific | Traps | Mexico | Sonora

Moderate Concern

The crab fishery in Sonora and Sinaloa does not have a spatial management in place, other than the total closure of crab fishing activities during the no-fishing season. The fishery does not catch species of exceptional ecological importance for the local ecosystem {Balmori et al. 2012} (DOF 2014) and scientific assessment and management efforts to account for species' ecological roles are supposed to be completed in the coming years (DOF 2014) (see Appendix A). For these reasons, and since no food web impacts from the fishery are evident, this factor is deemed a "moderate concern" for Sinaloa and Sonora.

Gulf of Mexico | Crab rings | Campeche
Gulf of Mexico | Scoopnets | Campeche

Moderate Concern

Impacts of the Campeche crab fishery on the ecosystem have not been described. Arreguin-Sanchez and Arcos-Huitron (2011) described the Campeche bank ecosystem and its role in fisheries dynamics, but did not specifically mention whether crab fishing activities may drive change in the ecosystem. Although spatial management is lacking, according to researchers, food web impacts due to this fishery are not apparent (Arreguin-Sanchez and Arcos-Huitron 2011). For this reason, the factor is rated as "moderate concern" for the Campeche fishery.

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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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Appendix A: Review Schedule

Appendix A

Updates to the Cortez swimming crab, Arched swimming crab, and Blue crab :

This updated report is scored against the Seafood Watch Standard for Fisheries Version F3.2.

The main changes are at Criterion 1 level for all the species. Individual criterion updates are described below.

Updates included:

Cortez and arched swimming crab fisheries

C 1.1. Both Cortez and arched swimming crab were upgraded from "moderate" to "low" concern because the most recent stock assessment found that biomass is above $B_{MSY,}$ but does not meet all the requirements for very low concern. Previously, there were no stock assessments available, and the factor was scored using the results of the PSA.

C 1.2. Both Cortez and arched swimming crab were downgraded from "moderate" to "high" concern because the most recent assessment found that it is probable (>50% chance) that fishing mortality from all sources (including commercial, recreational, subsistence, and ghost fishing, if applicable) is above a sustainable level that is appropriate given the species' ecological role (and a recent study found that overfishing might be occurring);

Blue crab fishery

C 1.1. Blue crab was upgraded from "moderate" to "low" concern because the most recent stock assessment found that biomass is above $B_{MSY,}$ but does not meet all the requirements for very low concern. Previously, there were no stock assessments available, and the factor was scored using the PSA results.

C 3.3 Currently, two fishery improvement projects are collecting data to monitor the status of the fishery, including the generation of assessments for the species in the region; however, current efforts are not sufficient to meet the "highly effective" category.