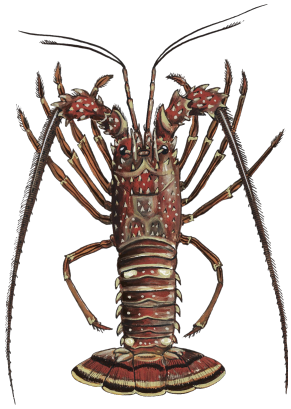
Monterey Bay Aquarium

Seafood Watch®

Caribbean spiny lobster

Panulirus argus



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Belize

Pots, Diving

December 19, 2018

Seafood Watch Consulting Researcher

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

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About Seafood Watch

Monterey Bay Aquarium's Seafood Watch program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. Seafood Watch makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from www.seafoodwatch.org. The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

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

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

Guiding Principles

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

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

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

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

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

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

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

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

Avoid/Red Take a pass on these for now. These items are overfished or caught in ways that harm other marine life or the environment.

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

Summary

The spiny lobster is a commercially fished marine invertebrate. There are several distinct species of spiny lobster located in various areas of the world. This report provides information and recommendations for the Caribbean spiny lobster (*Panulirus argus*) fished in the waters of Belize with traps, free diving, and use of hook stick and *casitas*.

The spiny lobster is moderately vulnerable to fishing pressure. They tend to mature quickly (between 2 to 3 years), compared to their life span of around 20 years in Caribbean. Recently matured spiny lobsters tend to spawn once a year, while older lobsters can spawn multiple times per year and females produce up to 2.5 million eggs, which can disperse widely.

Regular stock assessments for Caribbean spiny lobster are rare. There are no reference points to determine the stock status. The productivity-susceptibility analysis concluded that spiny lobster in Belize are not highly vulnerable; data-limited indicators in the 2010 stock assessment suggest a decline in abundance; fishing mortality is above the reference points and natural mortality. Therefore, the stock status of spiny lobster in Belize is ranked red.

Generally, the most common non-targeted species caught in the Caribbean spiny lobster trap fishery include various finfish and crab species. The total discard rate for lobster fisheries is generally between 8% and 15%, but discards include many invertebrates (which are generally returned alive) and finfish including grunts and snappers. Species of concern are caught and retained in the fisheries, including Nassau grouper and some overfished snapper species such as nutton snapper. Since species of concern are retained in the Belize trap fishery, it is ranked red.

Similarly, the free-dive fisheries (using casitas or hook stick), do not capture large numbers of non-targeted species. Even in the areas in which casitas are used, animals move freely and are still harvested by hand with the use of nets and/or hooks. Thus, the Caribbean spiny lobster fishery is extremely selective, resulting in very little incidental catch. However, species of concern are caught and retained in the fisheries, including Nassau Grouper and there is harvesting of juvenile queen conch. Since species of concern are retained in the Belize dive fishery, it is ranked red.

Management of spiny lobster has not been effective at maintaining a stable, abundant population. However, the last stock assessment was published in 2010 and considerable developments in management have occurred since the last assessment. The Caribbean spiny lobster regional management body OSPESCA and The Belize Fisheries Department mandates a suite of management measures including a minimum legal size, a closed season, the type and number of fishing gears to control the fishing effort, and Belize implemented a national Managed Access Program (MAP) in 2016. The effectiveness of the MAP is currently unknown, though trials of MAP have proven successful in two marine reserves in Belize. There are difficulties in enforcing the regulations and considerable issues with non-compliance of management measures. Studies are lacking regarding the spiny lobster stock status, bycatch, discarding, retained species, ghost fishing, and Illegal, Unregulated and Unreported (IUU) fishing. Overall, the management of the spiny lobster fisheries in Belize are ranked yellow.

The spiny lobster fisheries in Belize use traps or divers to harvest lobster. Traps and casitas result in some damage to the benthic habitat but Belize has regulations protecting some portion of habitat in reserves. The ecosystem impacts from the trap and casita based fisheries are considered moderate. The impact of the Belize spiny lobster fishery on habitats and ecosystem is ranked yellow for traps and green for diving.

There has been increasing pressure from foreign markets to ensure the supply of lobsters is sustainable. For example, in 2014, the EU had imposed a "red card" and import sanctions on Belize. Due to improvements in management and enforcement, the EU withdrew Belize from the blacklist and have since issued Belize with a green card.

Final Seafood Recommendations

SPECIES/FISHERY	CRITERION 1: IMPACTS ON THE SPECIES	CRITERION 2: IMPACTS ON OTHER SPECIES	CRITERION 3: MANAGEMENT EFFECTIVENESS	CRITERION 4: HABITAT AND ECOSYSTEM	OVERALL RECOMMENDATION
Caribbean spiny lobster Belize Caribbean Sea, Pots, Belize	Red (1.000)	Red (1.000)	Yellow (3.000)	Yellow (2.449)	**Avoid (1.646)**
Caribbean spiny lobster Belize Caribbean Sea, Diving, Belize	Red (1.000)	Red (1.000)	Yellow (3.000)	Green (3.464)	**Avoid (1.795)**

Summary

Spiny lobster from Belize receive a recommendation of "avoid" due to concerns regarding stock status and fishing mortality, and the potential impact on other species harvested alongside lobsters such as snapper, grouper, and conch.

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 report provides information and recommendations for the Caribbean spiny lobster (*P. argus*) caught in the waters of Belize and fished with traps and by skin-diving with the use of casitas.

Species Overview

The spiny lobster, of the genus *Panulirus*, contains approximately 20 different species occurring worldwide in tropical and subtropical waters (Pollack 1995). The spiny lobster can be easily distinguished by the long, spiny antennae and by the lack of claws on the first four pairs of legs (Holthuis 1991). Spiny lobsters are typically found at depths from 0 to 90 meters (m), depending upon the species (Holthuis 1991). Juvenile lobsters may spend their first few years in nearshore surfgrass or algal beds while adults favor rocky substrates and reefs areas that provide protection (GMFMC and SAFMC 2011). Spiny lobsters tend to be nocturnal, and live in shelters during the day (GMFMC and SAFMC 2011). How lobsters migrate is debated: some studies show that spiny lobsters migrate among depths, depending upon the season, and generally move deeper in winter months (Holthuis 1991). *P.argus* is considered to be a highly mobile species of spiny lobster (Herrnkind et al. 1975) (Ratchford 1999).

The Caribbean spiny lobster is found and fished along the coast of Florida, within the Gulf of Mexico, the Caribbean Sea, and the along the coast of Central and South America through Brazil ((Holthuis 1991), Figure 1). It should be noted the Caribbean spiny lobster may be composed of genetically distinct stocks in the Caribbean Sea and along the Brazilian coast, although lobsters with genetic markers from each of these stocks are found within the entire range, indicating mixing (Ehrhardt 2005).

Figure 1 Distribution of P.argus. Source: (FAO 2017).

Belize is a member of the Caribbean Regional Fisheries Mechanism (CRFM), an intergovernmental organization intended "to promote and facilitate the responsible utilization of the region's fisheries and other aquatic resources for the economic and social benefits of the current and future population of the region" (CRFM 2010). There is a regional management agreement for spiny lobster in Central America established by the Organización del Sector Pesquero y Acuícola del Itsmo Centroamericano Agreement OSP-02-09 (OSPESCA) (FAO 2015a), which mandates management measures for Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, the Dominican Republic and Panama. The agreement is essentially in accord with the regulations of each country (FAO 2015a). The Belize stock is likely shared with other countries including Mexico, Honduras and Nicaragua as the Yucatán current carries larvae upstream from Honduras and Nicaragua (Butler et al. 2008); however, Mexico is not part of OSPESCA and there is a possibility that the stock is shared with countries outside of the OSPESCA system.

The Belize Fisheries Department is responsible for fisheries management in the country since passage of the Fisheries Act of 1948. The spiny lobster fishery is the most important fishery in Belize (FAO 2015a). The primary regulations in place for spiny lobster are minimum size limits, seasonal closures, a prohibition of SCUBA gear, and a prohibition of the take of berried females or dead lobsters. Lobsters must be sold intact (Table 2). Around 90% of lobsters are harvested by wooden traps or free diving with hooks (CRFM 2012), and to a lesser extent, with casitas (FAO 2015a) (pers. comm., Larry Epstein 2018).

Acroynms

		MPA	Marine Protected Area
BFCA	Belize Fishermen Cooperative Association		
		MSY	Maximum Sustainable Yield
		NGO	Non-Governmental Organization
CL	Carapace Length	**NOAA**	National Oceanographic and Atmospheric Administration
CLME	Caribbean Large Marine Ecosystem Project		
CPUE	Catch Per Unit Effort	**OSPESCA**	Organization of the Fisheries and Aquaculture Sector of the Central American Isthmus
		PSA	Productivity-Susceptibility Analysis
ETP	Endangered, Threatened and Protected species	**SEA**	Southern Environmental Association
FAB	Fishery Advisory Board		
FAO	Food and Agricultural Organisation	**SIMP**	Seafood Import Monitoring Program
		SSB	Stock Spawning Biomass
HCR	Harvest Control Rules		
IUCN	International Union for Conservation of Nature	**TIDE**	Toledo Institute for Development and Environment

IUU	Illegal, Unreported and Unregulated		
LRP	Limit Reference Point	**TRP**	Target Reference Point
MAP	Manage Access Program	**VMS**	Vessel Monitoring System
MLS	Minimum Landing Size		

Production Statistics

Spiny lobsters are fished throughout the Caribbean and along the Central and South American coastlines. The main producers of *P.argus* in the Americas are shown below (Table 1):

Table 1. Largest producers of *P.argus*. Landings measured in tonnes in 2016. Source (FAO 2018a).

LAND AREA	PRODUCTION (TONNES)	GEARS
Bahamas	8482	Casitas, traps
Nicaragua	6450	Traps, free and assisted diving
Brazil	6100	Traps and gillnets (level of gillnet use is unknown and is illegal)
Honduras	6100	Traps (30%) and scuba diving with hooks (70%)
Cuba	4634	Casitas (62%), cages (26%), traps (14%)
USA	2350	Commercial: Traps, SCUBA, bully net. Recreational: No traps, SCUBA diving, free diving, bully net
Dominican Republic	1562	Traps, free and assisted diving
Belize	774	Traps, casitas, and skin-diving

The Caribbean spiny lobster is captured throughout its range. Global capture production has varied widely with a minimum of ~3,000 metric tons (MT) in 1950 and a maximum of 42,000 MT in 1995 and trade of Caribbean spiny lobster is worth around USD 900 million annually (FAO 2015a). Production over the last decade has fluctuated between 31,720 in 2009 to the highest reported production in 2016 at 39,326 MT (FAO 2018a).

Importance to the US/North American market.

The United States imports spiny lobster, including the Caribbean spiny lobster, from several countries in the Caribbean, Central and South America. There is a lack of species-specific imports data since Caribbean spiny lobster imports can be named "LOBSTER ROCK CARIBBEAN SPINY," "LOBSTER ROCK NSPF FROZEN," or terms to that effect. Of the total Caribbean spiny lobster recorded imports to the United States in 2017, ~4% is from Belize (NMFS 2018a).

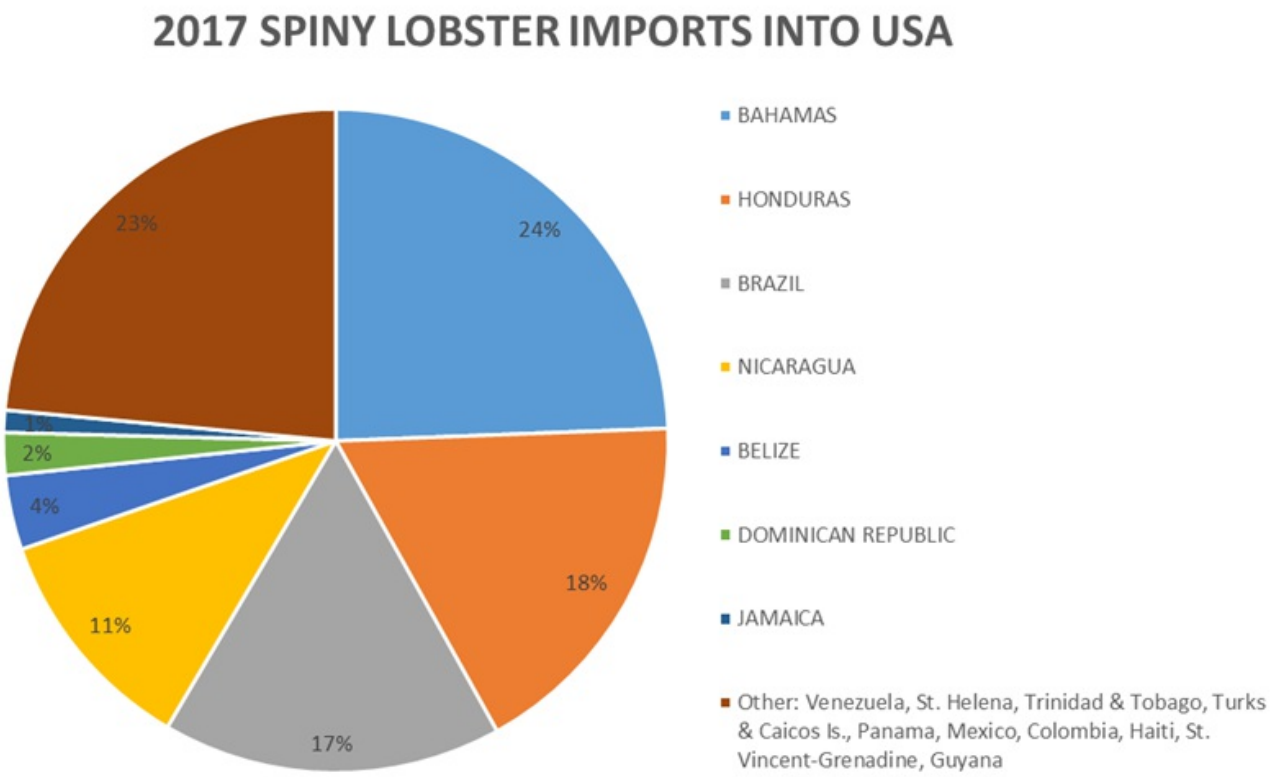

Figure 2 2017 Caribbean spiny lobster imports into USA. 'Other' includes: Mexico, Colombia, Ecuador, Antigua and Barbuda. Source: (NMFS 2018a).

Common and market names.

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

Primary product forms

Spiny lobsters are sold as fresh or frozen either in the form of raw tails, meat or whole, either blanched or fully cooked (Fishchoice 2015).

Assessment

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

Criterion 1: Impacts on the Species Under Assessment

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

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

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

Guiding Principles

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

Criterion 1 Summary

CARIBBEAN SPINY LOBSTER			
Region | Method	**Abundance**	**Fishing Mortality**	**Score**
Belize/Caribbean Sea | Pots | Belize	1.00: High Concern	1.00: High Concern	Red (1.000)
Belize/Caribbean Sea | Diving | Belize	1.00: High Concern	1.00: High Concern	Red (1.000)

The last national stock assessment was published in 2010 using data between 1999 and 2009 {Gongora 2010}. Gongora (2010) suggested that the stock was between fully and overexploited and suggested negative trends for data-limited indicators. The Caribbean spiny lobster fishery in Belize is ranked "high" concern (red).

Criterion 1 Assessment

SCORING GUIDELINES

Factor 1.1 - Abundance

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

- *5 (Very Low Concern) — Strong evidence exists that the population is above an appropriate target abundance level (given the species' ecological role), or near virgin biomass.*
- *3.67 (Low Concern) — Population may be below target abundance level, but is at least 75% of the target*

level, OR data-limited assessments suggest population is healthy and species is not highly vulnerable.

- *2.33 (Moderate Concern) — Population is not overfished but may be below 75% of the target abundance level, OR abundance is unknown and the species is not highly vulnerable.*
- *1 (High Concern) — Population is considered overfished/depleted, a species of concern, threatened or endangered, OR abundance is unknown and species is highly vulnerable.*

Factor 1.2 - Fishing Mortality

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

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

CARIBBEAN SPINY LOBSTER

Factor 1.1 - Abundance

BELIZE/CARIBBEAN SEA, POTS, BELIZE
BELIZE/CARIBBEAN SEA, DIVING, BELIZE

High Concern

The last national stock assessment (2010) suggested that the Belize spiny lobster stock was between fully-exploited and overexploited status and had experienced declining population trends between 1999 and 2009 (Gongora 2010). The stock assessment did not estimate abundance relative to reference points. In the absence of an up-to-date, quantitative stock assessment, fishery-dependent data indicators (spawning biomass, recruitment biomass, and total biomass) (Gongora 2010) have been used to assess the stock. Data used in the 2010 assessment showed that all indicators showed declines (CPUE, recruitment biomass and total biomass declined by 28%, 36.1% and 17.4% respectively). Spiny lobsters aged 2 and 3 dominated catches, suggesting high exploitation rates (Gongora 2010).

Since Belize spiny lobster was deemed to have medium vulnerability and data-limited indicators suggested a decline in the abundance, Seafood Watch deems abundance as a "high" concern.

Justification:

The stock assessment report (Gongora 2010) is now more than 5 years old; thus, the data may not reflect the current status of the stock. Data from the 2010 stock assessment showed between 1999 and 2009 CPUE had declined by 28% (from 2.7 kg/fishing day to 1.94 kg/fishing day). Lobster recruitment biomass had declined by 36.1%, (from 1.98 million individuals to 1.26 million individuals, which was the lowest value in the time-series). The stock biomass had declined by 17.4%, (from 352 tons to 292 tons). The Stock Spawning Biomass (SSB) decreased by 8.74% (from 212 tons to 193 tons).

The stock's sex-structure is skewed, potentially jeopardizing reproduction: due to the prohibition of retaining berried females, males have been disproportionately fished. This has led to a reduced spermatophore size, and a sperm limitation within the population, resulting in decreased fertilization success (Briones-Fourzan and Lozano-Alvarez 2015).

More recently, stock assessments have been conducted for two marine reserves, based on in-season recruitment and CPUE data. There were no abundance-based reference points to determine the status of the stock (Babcock et al. 2015). Abundance was estimated at 66,000–79,000 individuals (Glover's Reef) and 12,000 individuals (Port Honduras) (Babcock et al. 2015). Additionally, 20% of the reserve area is a no-take zone (Babcock et al. 2015) and both abundance and density are higher in marine reserves (FAO 2015a)(BAS 2016). Therefore, it is unknown if the abundance is representative of the stock at a national level.

There is ongoing research to determine Target Reference Points (TRP) using data-limited indicators (pre, early and late open-season CPUE), the previous season's total catch and the previous season's average tail weight) from both fishery-independent and fishery-dependent data. The TRP is the average of a ten-year data-set for each of the indicators (2005 to 2015). However these indicators have not yet been compared to the reference points (McDonald et al. 2017).

There are limited data regarding stock connectivity of Caribbean spiny lobster populations. There is some consensus suggesting the Belizean populations are connected to Mexico, Honduras, and Nicaragua since the Yucatán current carries larvae upstream from Honduras and Nicaragua (Butler et al. 2008). This has not been accounted for in stock assessments, yet is particularly important as the Honduran stock is potentially over-exploited (National Fish and Wildlife Foundation 2015).

Productivity-Susceptibiity Analysis (if Applicable):

PSA score = 2.889. For this reason, the species is deemed medium vulnerability (detailed scoring of each attribute is shown below).

PRODUCTIVITY ATTRIBUTE	RELEVANT INFORMATION	SCORE
Productivity Attribute		
Average age at maturity	2–3 years (Ehrhardt 2005)	1
Average maximum age	10 to 30 years in Caribbean (Ehrhardt 2005)	2
Fecundity	500,000 to 2 million eggs (Seudeal 2013)	1
Reproductive strategy	Brooder (Ehrhardt 2005)	2
Trophic level	2.98 (Vidal and Basurto 2003)	2
Density dependence (invertebrates only)	No density dependence suggested, but unknown (Behringer and Butler 2006)	2
Quality of habitat	Habitat has been moderately altered by non-fishing impacts. For example, in the 2018 Healthy Reef Report showed that although coral cover has increased from years 2006 to 2016, 39% of their reefs are deemed to be in a "poor" state and a further 20% are in a "critical" state (McField et al. 2018).	2
Susceptibility Attribute		

Areal overlap	>30% of the species concentration is fished, considering all fisheries	3
Vertical overlap	High degree of overlap between fishing depths and depth range of species	3
Selectivity of fishery	Species is targeted, or is incidentally encountered AND is not likely to escape the gear, BUT conditions under "high risk" do not apply. Around 10% of spiny lobsters landed are undersized (FAO 2003), though possession of undersized lobsters is illegal (FAO 2015a)	2
Post-capture mortality	Unknown	3

P= 1.714285714

P^2 = 2.93877551

S = 2.325

S^2 = 5.4056

V= 2.8886676011968

Factor 1.2 - Fishing Mortality

BELIZE/CARIBBEAN SEA, POTS, BELIZE
BELIZE/CARIBBEAN SEA, DIVING, BELIZE

High Concern

Gongora (2010) found high lobster mortalities; F_{Max} = 0.85 and $F_{0.1}$ is 0.49 (where $F_{0.1}$ is a precautionary reference point calculated as the fishing mortality rate at which the slope of the curve of yield per recruit versus F is 10% of the value at the origin). The fishing mortality rate was 1.3 in 2008. Therefore, F_{2008}/F_{Max} = 1.53 and $F_{2008}/F_{0.1}$ = 2.65. The natural mortality rate, M = 0.34. therefore, fishing mortality in 2008 was substantially above the natural mortality rate (Gongora 2010). Over the past five years, landings have been relatively stable, while effort has gradually increased (FAO 2015a).

Since fishing mortality in 2008 was above reference points F_{Max} and $F_{0.1}$, Seafood Watch deems fishing morality as a “high” concern.

Justification:

In the 2010 stock assessment, fishing mortality, was based on estimations of fishing effort as a number of fishing days (Gongora 2010). The last fishing mortality rate considered in the assessment was from 2009 but was considered to be imprecise. Therefore, the 2008 fishing mortality rate was used in its absence (Gongora 2010). It is unknown if fishing mortality rates from 2008 are comparable to current levels.

Gongora (2010) recommended that, to maintain the fishery, fishing mortality should be decreased and Babcock et al. (2015) recommended increasing the size limit from 76 mm CL to 102 mm CL to allow fishing mortality rates to be more sustainable. Juvenile and young lobsters are particularly vulnerable to overfishing

because they are found in higher densities in shallow, coastal areas where high levels of fishing can occur (Gongora 2010).

In a recent study conducted in two marine protected areas in Belize, harvest rates were estimated at 70%, which was considered higher than the reference points. However, the Glover's Reef population was not considered to be undergoing overfishing (Babcock et al. 2015). These areas receive increased levels of protection: 20% of Glover's Reef is designated as a conservation zone (Babcock et al. 2015), and therefore are not likely to reflect national harvesting rates.

Criterion 2: Impacts on Other Species

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

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

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

Guiding Principles

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

Criterion 2 Summary

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

CARIBBEAN SPINY LOBSTER - BELIZE/CARIBBEAN SEA - DIVING - BELIZE					
Subscore:	**1.000**	**Discard Rate:**	**1.00**	**C2 Rate:**	**1.000**
Species	**Abundance**	**Fishing Mortality**	**Subscore**		
Snappers	1.00:High Concern	1.00:High Concern	Red (1.000)		
Grouper (unspecified)	1.00:High Concern	1.00:High Concern	Red (1.000)		
Queen conch	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		
Corals and other biogenic habitats	1.00:High Concern	5.00:Low Concern	Yellow (2.236)		
Finfish	2.33:Moderate Concern	5.00:Low Concern	Green (3.413)		

CARIBBEAN SPINY LOBSTER - BELIZE/CARIBBEAN SEA - POTS - BELIZE					
Subscore:	**1.000**	**Discard Rate:**	**1.00**	**C2 Rate:**	**1.000**
Species	**Abundance**	**Fishing Mortality**	**Subscore**		
Snappers	1.00:High Concern	1.00:High Concern	Red (1.000)		
Grouper (unspecified)	1.00:High Concern	1.00:High Concern	Red (1.000)		

Corals and other biogenic habitats	1.00:High Concern	5.00:Low Concern	Yellow (2.236)
Benthic inverts	2.33:Moderate Concern	5.00:Low Concern	Green (3.413)
Finfish	2.33:Moderate Concern	5.00:Low Concern	Green (3.413)

Retained and bycatch species that are analyzed in this assessment have been chosen based on whether they represent 5% or more of the spiny lobster catch, or due to their conservation status (endangered, threatened, overfished, etc.), or because gear type, traps, and diving pose a potential risk to taxa in the region studied.

The bycatch and retained species caught in the Belize spiny lobster trap and dive fishery are mostly unknown, though some have been advised by expert opinion. Where bycatch is unknown, it is scored according to the Seafood Watch Unknown Bycatch Matrix (UBM), based on a synthesis of peer-reviewed literature and expert opinion on the bycatch impacts of each gear type. The Unknown Bycatch Matrix ranks the bycatch susceptibility of different taxonomic groups in various gear types. More information is available in Appendix 2 of the Seafood Watch criteria. The UBM suggests the taxa that are most likely to interact with the trap fisheries include marine mammals, benthic invertebrates, finfish, and corals. However, marine mammals have been removed from this report due to their very low risk of interactions with the trap fishery. This is because the traps are standalone structures, with no vertical lines, or horizontal lines. The traps are lifted individually since the fisher will throw a line with a small hook that catches on the trap (pers. comm., Anon 22 October 2018).

Bycatch data for the dive-caught spiny lobster fishery is incomplete. There is very little bycatch impact on other species from unassisted diving methods used to harvest lobster (pers. comm., Epstein 2017), though some species may be caught and retained in the spiny lobster fishery. Conch is not considered bycatch in the lobster fishery, though they are included as a Criteria 2 species because they are targeted alongside lobster at certain times of the year (pers. comm., McDonald 2017). Nassau Grouper are a retained species in the dive fishery in Belize and are critically endangered (Vo et al. 2014). Snapper and grouper are commercially important species and are among the most targeted finfish in Belize (Mayhew 2016) (Tewfik et al. 2017). In neighboring Mexican Caribbean spiny lobster fisheries, snapper are caught in dive fisheries (Mayhew 2016). The dive fishery may also interact with corals: casitas (which are used in the dive fishery to attract lobsters) can impact coral structures up to seven meters from where they are placed (Dahlgren 2014). The UBM assumes that the dive fishery likely has no interaction with vulnerable taxa. Therefore, species included in Criteria 2 are based on expert opinion since they are either retained in the fishery or known to be impacted by fishing gear. In summary, corals, conch, grouper, and snapper have been assessed.

For the trap fishery, grouper and snapper limit the score for Criterion 2 due to their high vulnerability, potential overfished and overfishing status, and their high potential to interact with this gear type.

For the dive fishery in Belize, grouper and snapper limit the score for Criterion 2 due to their high vulnerability, potential overfished and overfishing status, and their high potential to be caught using this fishing method.

Criterion 2 Assessment

SCORING GUIDELINES

Factor 2.1 - Abundance

(same as Factor 1.1 above)

Factor 2.2 - Fishing Mortality

(same as Factor 1.2 above)

SNAPPERS

Factor 2.1 - Abundance

BELIZE / CARIBBEAN SEA, DIVING, BELIZE
BELIZE / CARIBBEAN SEA, POTS, BELIZE

High Concern

Most of the snapper species found in Belize are not considered endangered, though mutton snapper (Lindeman et al. 2016a) and lane snapper (Lindeman et al. 2016b) are considered as near threatened and Cubera Snapper are classified as vulnerable (Lindeman et al. 2016c)**.** Mutton snapper is considered overfished in Glover's Reef marine reserve (Babcock et al. 2013).

Since many of the snapper caught in spiny lobster fisheries have an unknown stock status, and these species are assumed to be of high vulnerability, Seafood Watch automatically considers this a "high" concern.

Factor 2.2 - Fishing Mortality

BELIZE / CARIBBEAN SEA, DIVING, BELIZE
BELIZE / CARIBBEAN SEA, POTS, BELIZE

High Concern

Snapper catches are not monitored; therefore, fishing mortality of snapper in the Belizean spiny lobster fishery is unknown. Snapper are among the most commercially-important and most targeted finfish in Belize (Mayhew 2016), and in neighboring Mexican Caribbean spiny lobster fisheries, snapper are caught in dive fisheries (Mayhew 2016). However, mutton snapper are considered to be undergoing overfishing in Glover's Reef (Babcock et al. 2013).

Although it is unknown if the overfishing status of mutton snapper in Glover's Reef is representative of the national rates, and management is in place to protect the species, it is still legal to land them (Tewfik et al. 2017).

Since species that are undergoing may be caught in the Belize spiny lobster fishery, Seafood Watch deems fishing mortality a "high" concern.

Factor 2.3 - Modifying Factor: Discards and Bait Use

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

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

RATIO OF BAIT + DISCARDS/LANDINGS	FACTOR 2.3 SCORE
<100%	1
>=100	0.75

BELIZE / CARIBBEAN SEA, DIVING, BELIZE

< 100%

The free-dive and hand-harvest fisheries, including those that use casitas for lobster shelters, do not result in large numbers of non-targeted species. Even in the areas in which casitas are used, animals move freely and are still harvested by hand with the use of nets and/or hooks. The dive fishery is selective and results in very little incidental catch. Occasionally, fishers may capture stone crab species for consumption within Belize, but this does not constitute a significant part of the catch (Bert and Hochberg 1992).

Diving requires no bait use and is a very selective fishing method and therefore receives a factor score of 1.

BELIZE / CARIBBEAN SEA, POTS, BELIZE

< 100%

Discards

Total discard rates are estimated at 15% (Shester and Micheli 2011). Although this study refers to the California spiny lobster (*P. interruptus*) fishery, rather than the Caribbean spiny lobster (*P. argus*), it is possible the rates are quite similar.

There is little information about the total discard rate in the Caribbean spiny lobster fishery. Most studies have been focused on comparing percentages of bycatch in various types of traps, and not the impact on the ecosystem as a whole. However, Matthews et al. (2005) did note that the number of fish that died in traps during observations over one season was quite small (Matthews et al. 2005). In the Saba Bank, discards represented about 50% of lobster landings (~20 t of mixed fish were discarded out of 38 t of lobster landed, in 2012)(van Gerwen 2013).

Bait

The bait used in the Belizean lobster fishery is not recorded, though literature suggest that lobster traps are usually baited with coconut, chicken, or beef (Ylitalo-Ward 2016).

In the absence of discard data from Belize, studies from other Caribbean countries estimate that discarding from spiny lobster fisheries varies between 15 to 50%. There is a lack of research conducted on bait use, though it is likely that non-marine species are used as bait. Therefore, the ratio of pounds of bait used to pounds of lobster landed is assumed to be less than 100%.

GROUPER (UNSPECIFIED)

Factor 2.1 - Abundance

BELIZE / CARIBBEAN SEA, DIVING, BELIZE
BELIZE / CARIBBEAN SEA, POTS, BELIZE

High Concern

There are limited assessments to determine the stock status of grouper, but many grouper in Belize are classified as ETP species e.g., goliath grouper are classified as critically endangered (Craig 2010), Poey's grouper are vulnerable (Ferreira and Peres 2008) and Nassau grouper and black grouper are deemed to be overfished in Glover's Reef (a marine reserve in Belize) (Babcock et al. 2013). Although there have been significant increases in Nassau Grouper biomass and size in the replenishment zone of Glover's Reef, the opposite has occurred in the general use zone (Tewfik et al. 2017).

Since the specific grouper species are not recorded, abundance is scored as a "high" concern based on the possibility of interacting with endangered, threatened or overfished species.

Justification:

An estimated 26% of grouper were deemed sexually mature in 2016 (McField et al. 2018).

Factor 2.2 - Fishing Mortality

BELIZE / CARIBBEAN SEA, DIVING, BELIZE
BELIZE / CARIBBEAN SEA, POTS, BELIZE

High Concern

Grouper catches are not monitored; therefore, fishing mortality of groupers in the Belizean spiny lobster fishery is unknown. However, Nassau grouper are a retained species in the dive fishery in Belize (Vo et al. 2014) and grouper are among the most commercially-important and most targeted finfish in Belize (Mayhew 2016). Yet, Nassau grouper are considered to be undergoing overfishing in Glover's Reef (Burns and Tewfik 2016). Although it is unknown if the overfishing status of Nassau grouper in Glover's Reef is representative of the national rates, and management is in place to protect the species, it is still legal to land them (Tewfik et al. 2017).

Since groupers are known to be caught and landed in the Belize spiny lobster fishery and this can include species undergoing overfishing, Seafood Watch deems fishing mortality as a "high" concern.

Factor 2.3 - Modifying Factor: Discards and Bait Use

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

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

RATIO OF BAIT + DISCARDS/LANDINGS	FACTOR 2.3 SCORE
<100%	1
>=100	0.75

BELIZE / CARIBBEAN SEA, DIVING, BELIZE

< 100%

The free-dive and hand-harvest fisheries, including those that use casitas for lobster shelters, do not result in large numbers of non-targeted species. Even in the areas in which casitas are used, animals move freely and are still harvested by hand with the use of nets and/or hooks. The dive fishery is selective and results in very

little incidental catch. Occasionally, fishers may capture stone crab species for consumption within Belize, but this does not constitute a significant part of the catch (Bert and Hochberg 1992).

Diving requires no bait use and is a very selective fishing method and therefore receives a factor score of 1.

BELIZE / CARIBBEAN SEA, POTS, BELIZE

< 100%

Discards

Total discard rates are estimated at 15% (Shester and Micheli 2011). Although this study refers to the California spiny lobster (*P. interruptus*) fishery, rather than the Caribbean spiny lobster (*P. argus*), it is possible the rates are quite similar.

There is little information about the total discard rate in the Caribbean spiny lobster fishery. Most studies have been focused on comparing percentages of bycatch in various types of traps, and not the impact on the ecosystem as a whole. However, Matthews et al. (2005) did note that the number of fish that died in traps during observations over one season was quite small (Matthews et al. 2005). In the Saba Bank, discards represented about 50% of lobster landings (~20 t of mixed fish were discarded out of 38 t of lobster landed, in 2012)(van Gerwen 2013).

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In the absence of discard data from Belize, studies from other Caribbean countries estimate that discarding from spiny lobster fisheries varies between 15 to 50%. There is a lack of research conducted on bait use, though it is likely that non-marine species are used as bait. Therefore, the ratio of pounds of bait used to pounds of lobster landed is assumed to be less than 100%.

Criterion 3: Management Effectiveness

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

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

The Criterion 3 rating is determined as follows:

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

Rating is Critical if Management Strategy and Implementation is Critical.

GUIDING PRINCIPLE

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

Criterion 3 Summary

Fishery	Management Strategy	Bycatch Strategy	Research and Monitoring	Enforcement	Stakeholder Inclusion	Score
Fishery 1: Belize / Caribbean Sea | Diving | Belize	Moderately Effective	Highly Effective	Moderately Effective	Moderately Effective	Highly Effective	Yellow (3.000)
Fishery 2: Belize / Caribbean Sea | Pots | Belize	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Highly Effective	Yellow (3.000)

Until recently, Belizean spiny lobster fisheries were open-access, increasing their risk of illegal fishing, poor monitoring, and overfishing of the stock {Gongora 2010}. However, after the success of two pilot Managed Access Programs (MAPs) in two marine reserves {Babcock et al. 2015} {Karr et al. 2017}, Belize adopted the nationwide MAP in 2016 {Karr et al. 2017}. The effectiveness of the MAP is currently unknown since it was only recently adopted; however, its national implementation are predicted to improve monitoring and enforcement {Karr et al. 2017}, based on the program's recent success. The management measures for the Belize spiny lobster are shown in Table 2.

Of concern in the fishery are the lack of studies, particularly regarding the spiny lobster stock status (the last assessment was conducted in 2010), bycatch, discarding, retained species, ghost fishing, and IUU fishing.

Table 2 Management measures in Belize spiny lobster fishery

MEASURE	MANAGEMENT IN PLACE IN BELIZE
Gov. body	Fisheries Department {FAO 2015a}
Multi/ single species	Multi-species (diving), single-species (traps) {FAO 2015a}
Industrial/ Artisanal	100% small-scale {FAO 2015a}
Fleet size	Artisanal 543 vessels {FAO 2015a}
Fishing method	90% free diving with hooks and traps {CRFM 2012} or by free diving using casitas {FAO 2015a}
Quota	No
Size limit	4 oz (tail weight), 3 oz (minimum carapace length) {FAO 2015a}
Size limit (length)	76.2 mm CL
Closed season	15 February to 14 June of each year {FAO 2015a}
Closed season length	3 months
Berried females prohibition	Yes
Molting lobsters prohibition	Yes
Other handling laws	Ban on landing dead lobsters {van Gerwen 2013} or filet/ diced lobster tail meat, without a permit {FAO 2015a}
SCUBA prohibition	Yes {McDonald et al. 2017}
Licenses limit	No
Escape gap in traps	Yes {CRFM 2014}
Gear regulations	Gear must be removed before pre-season closure {The San Pedro Sun 2015}; Hookah, spearguns, and explosives prohibited {van Gerwen 2013}

Other	There is increased protection inside marine reserves, which are designed using a zoning scheme, allowing harvesting in the General Use Zone of marine reserves. Marine reserves also have Conservation Zone(s), prohibiting fishing {Belize Fisheries Act 2003}.
Level of IUU	10% are undersized {FAO 2003}, though the magnitude of IUU fishing is unknown, which creates uncertainty regarding the efficacy of management measures

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.

BELIZE / CARIBBEAN SEA, DIVING, BELIZE
BELIZE / CARIBBEAN SEA, POTS, BELIZE

Moderately Effective

Belize Fisheries Department manages spiny lobster and conch fisheries together. Management measures in the Belize spiny lobster fishery are shown in Table 2 and typically consist of gear restrictions, closed seasons, and technical measures (such as size restrictions).

Stock assessments are irregular (the last assessment was completed in 2010) and may be insufficient to inform management. The stock status of spiny lobster was deemed between fully exploited and overexploited, attributed to illegal fishing and poor research and monitoring (Gongora 2010). There have been significant national management changes since the last stock assessment and a National Lobster Working Group has been commissioned to provide technical advice to the Fisheries Department to improve the management of the spiny lobster fishery (TNC 2018a). There is a lack of studies to prove their efficacy. Stocks in the MAP areas generally show positive trends (based on legal-sized spiny lobster density, biomass and increased CPUEs) (Tewfik et al. 2017). Until recently, the fishery was an open-access fishery (Gongora 2010) and the national MAP was adopted for conch and spiny lobster in 2016. The MAP had undergone trials in two Belizean marine reserves and proved successful (FAO 2015a). Belize's recently designed Harvest Control Rules via an Adaptive Management Framework were management changes based on the stock status (McDonald et al. 2017). These have not yet been fully implemented, though modelling exercises suggest that the framework may help stabilize biomass and catches, even when recruitment varies (Harford et al. 2016).

IUU fishing is likely to have improved. Although the FAO (2003) suggested undersized lobsters represented 10% of landings and the EU had imposed a "red card" and import sanctions on Belize in 2014 (European Commission 2014) through improvements in management and enforcement, the EU withdrew Belize from the blacklist (European Commission 2015). Belize has now issued a green card (IUU Watch 2017).

Stock assessments discuss some environmental variability. For example, the stock assessment discussed the impacts of Hurricane Dean in 2007 on lobster recruitment (Gongora 2010); however, it did not sufficiently

account for the uncertainty of the stock. The stock assessment does not account for poaching by fishers from neighboring countries (Guatemala, Honduras, Mexico), which is known to occur, but is difficult to quantify (Perez 2009)**.**

Conch: The Queen Conch Management Plan has adopted a suite of measures to protect the stock, including Total Allowable Catch, closed seasons, minimum market clean weight and shell lengths, marine reserves, a prohibition on SCUBA diving, and the MAP (FAO 2016d). An adaptive management framework has been adopted to react to fluctuations in the stock by adjusting the harvest rules or adopting a recovery plan (Belize Fisheries Department 2017b). Although there are likely to be some effective measures in place, it is too early to tell if it has been effective in protecting the stock, and some increased precautionary management is required (See Justification).

Since the spiny lobster stock assessment is out-of-date and it is too early to tell if the new, national MAP is effective (but will likely improve nationwide management (Karr et al. 2017)), the management strategy and implementation is scored as "moderately" effective.

Justification:

The Capture Fisheries Unit (CFU) of the Belize Fisheries Department manages the conch and spiny lobster together. The CFU is "responsible for providing the necessary legislative and management interventions to facilitate the continued development and proper management of Belize's marine fisheries resources" (Economic Development Council 2016).

Management measures are available in Table 2 and have mixed effectiveness (discussed below).

The size-at-maturity (CL50%) for male *P. argus* is estimated at 92.2 (± 2.53SE) mm CL. In Belize, the minimum legal size (MLS) is smaller than this at 76 mm CL, rendering the MLS too small for a sustainable fishery (van Gerwen 2013). Spiny lobsters are caught at very small sizes, and Babcock et al. (2015) recommend that the minimum size be increased from 76 mm CL to 102 mm CL. Similarly, the current restrictions on shell length and the market clean weight may be too low to protect juvenile conch from legal harvest and is likely resulting in growth overfishing of conch (Foley and Takahashi 2017). However, conch receives further protection through conservative and enforced harvest quotas (pers. comm. Stoner 2018).

The closed season has recently proven to be successful, partly because enforcement is facilitated by the fact that two fishing cooperatives lie in the nation's capital (van Gerwen 2013) (The San Pedro Sun 2015).

The MAP was trialed out in two marine reserves; the program was proven successful for both spiny lobster and conch based on "recovery of stocks" and "increased landings" support from fishers in areas in which they had been implemented (Babcock et al. 2015) (FAO 2016d). The MAP is an area-based tenure system that sets science-based harvest controls in an adaptive management framework. This program enables a coalition of government, fishermen, and civil society organizations to end open-access fisheries and implement schemes to incentivize fishermen to adopt sustainable fishing behavior and methods (EDF 2016a). MAP has been effective in ensuring that the lobster population at Glover's Reef is not experiencing overfishing (Babcock et al. 2015). The effectiveness of the programs in these areas may not benefit surrounding areas because it may not allow sufficient spillover of the stock to other areas: Truelove (2011) suggests that the genetic connectivity between two MPAs in Belize was limited due to complex oceanographic conditions. Additionally, poaching is still known to occur outside the replenishment zones (McField et al. 2018) and both illegal and legal fishing may be undermining the effectiveness of the MPA network (Cox et al. 2017). Seasonal closures in the conch fishery are also considered to be undermined by "some degree of illegal fishing" throughout the closed season (Belize Fisheries Department 2017b). Although the suspected level of illegal fishing of conch in Belize is unknown, the amount of conch meat illegally fished in Belize, and subsequently traded to Guatemala, represents ~1.5% to 2% of the conch TAC (Belize Fisheries Department 2017b).

The government has created a network of multi-use marine reserves and it prohibits the use of SCUBA (McDonald et al. 2017). However, the purpose of the marine reserves is to protect endangered species, and they may not be as effective at protecting conch (NMFS 2014b). Prohibiting the use of compressed air protects the deeper stocks that might recruit to the back-reef areas, but this link requires investigation (NMFS 2014a) (NMFS 2014b) (CFU 2013).

Spiny lobsters in Mexico, Belize, Honduras, and Nicaragua are thought to be of the same stock, since the Yucatán current carries larvae upstream through these countries' waters (Butler et al. 2008). Due to the high connectivity of spiny lobster stocks, transboundary management is required (Truelove et al. 2015b) (Truelove et al. 2015a). The Caribbean Large Marine Ecosystem Project (CLME) strategy aspires to enhance governance systems for an ecosystem approach in the spiny lobster fisheries. Involved countries have shown improvements in data collection and stock assessments focused on improving management practices, and creating regional standardized assessments through national fishery organizations such as OSPESCA, CRFM and WECAFC (FAO 2015c). OSPESCA is a regional body that promotes development and coordinated management of Caribbean fisheries. OSPESCA formed agreements for the following countries under the Central American Integration System (SICA): Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, the Dominican Republic, and Panama. The "Regional Regulation of Caribbean Lobster Fishing (*P. argus*)," OSP-02-09 requires that all countries implement a fishery management plan and laws including minimum tail weights, a minimum closed season from 1 March to 30 June, escape gaps in lobster traps, trap limits, and the prohibited sale of lobster tail meat without a shell (FAO 2015a). The MARPLESCA Plan aims to establish a systematic process to implement Regulation OSP-02-09 (FAO 2015a); however, "current arrangements for the international governance of the spiny lobster resource are inadequate" because there is no overarching organization to "carry out and make management decisions" (Monnereau 2016).

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.

BELIZE / CARIBBEAN SEA, DIVING, BELIZE

Highly Effective

There is very little data available regarding bycatch for the Belizean spiny lobster fishery. However, dive fisheries are very selective, and therefore, bycatch will likely be low. Some finfish have been previously recorded as bycatch in spiny lobster fisheries (Babcock et al. 2013). In 2009, the Belizean Fisheries Department implemented a ban on harvesting scarids (parrotfish) and acanthurids (tang/surgeonfish/doctorfish), and a minimum and maximum size limit for Nassau grouper (Tewfik et al. 2017).

Since the fishery has a very low level of bycatch and some management measures are in place to protect species of concern, Seafood Watch deems bycatch management as "highly" effective.

BELIZE / CARIBBEAN SEA, POTS, BELIZE

Moderately Effective

Bycatch are not recorded in spiny lobster trap fisheries in Belize; however, the fishery incurs a low level of bycatch (pers. comm. Epstein 2018). Parrotfish have previously been observed as bycatch in Belizean trap

fisheries (Dahlgren and Tewfik 2015) (Dahlgren 2014). Due to the likely low level of bycatch, there is reduced need for bycatch management in the fishery. Management measures to reduce the impact of the lobster fishery on bycatch and ETP species include marine reserves, escape vents (FAO 2015a), removing all traps from the water prior to seasonal closures, prohibiting destructive harvesting methods including explosives (Table 2), and prohibitions on retaining listed species such as scarids (parrotfish) and acanthurids (tang/surgeonfish/doctorfish) (Tewfik et al. 2017). The effectiveness of these management measures is unknown.

There are no available data to show the level of ghost traps and their impacts in the Belizean fishery. Belize mandates that all traps are removed from the water prior to seasonal closures (The San Pedro Sun 2015), but the effectiveness of this policy is unknown.

Traps incur a low level of bycatch, and management is in place to further reduce the risk to bycatch; however, there is minimal management to protect against ghost fishing. Therefore, Seafood Watch deems the bycatch strategy a "moderate" concern.

Justification:

Studies conducted in other Caribbean spiny lobster fisheries show that traps can yield a significant impact on bycatch: ghost traps may destroy or damage protected corals, benthic habitats, benthic fauna and flora, disturb sediments, reduce biomass, kill foundation species, and can confine trapped animals resulting in their injury or mortality (Butler and Mathews 2015). By increasing wind speed, traps can travel further, increasing its footprint over a greater expanse of benthic environments. In Florida, fishermen report that trap loss in non-tropical cycle seasons averages 2 to 5%, whereas when winter storms/ tropical cycles occurs, this rises to 19 to 65% (Uhrin 2016). This is particularly an issue in Belize where the most significant impacts on the corals from traps are when they are dragged along the seafloor during storms (Dahlgren 2014).

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.

BELIZE / CARIBBEAN SEA, DIVING, BELIZE
BELIZE / CARIBBEAN SEA, POTS, BELIZE

Moderately Effective

Monitoring of CPUE, biological conditions, and enforcement of regulations have improved over the past 10 years (FAO 2015a). The Belize Fisheries Department collect both fishery-dependent (landings, catch and effort data) and fishery-independent (underwater visual censuses) data (Karr et al. 2017). The most recent stock assessment was conducted using fisheries-dependent data from 1999 to 2009; therefore, the last stock assessment was conducted in 2010 (Gongora 2010).

Both fishery dependent and independent data are collected for the retained species, conch. Conch surveys are considered to be "standard, well-developed methods to collect information on biomass, density and stock structure" (FAO 2016d).

There are three main data gaps in the spiny lobster fishery, including a lack of regular stock assessments; the HCR is not measured against stock health indicators and there is a lack of in-season assessments to apply adaptive management.

The dive fishery is very selective; therefore, very little bycatch monitoring is required for the dive fishery. There are currently no bycatch or ghost fishing studies conducted in trap fisheries.

Since monitoring has improved but stock assessments are conducted infrequently, and there is a lack of bycatch and ghost fishing data collected from the trap fishery, scientific monitoring and evaluation has been deemed as "moderately" effective.

Justification:

In the spiny lobster fishery, fishery-dependent data (mainly landings data) are collected from private companies (including exporters and processors) (Belize Fisheries Department 2017a), which are submitted to the Fisheries Department (Belize Fisheries Department 2017b). Each fishing cooperative is required to submit weekly reports on landings as a condition of its Memorandum of Understanding (CFU 2013). Further research on the spiny lobster fishery is conducted by the Wildlife Conservation Society, Toledo Institute for Development and Environment, the Southern Environmental Alliance, and the Environmental Defense Fund, for example, on the impact of marine reserves spiny lobster abundance ((CFU 2013)(Gongora 2012) (Babcock et al. 2015)).

Data collection has improved in the Belize spiny lobster fishery: the national data collection and monitoring system is now structured through the "Spatial Monitoring and Reporting Tool" (SMART) (Karr et al. 2017). Improved reporting and data collection has mainly occurred in the two marine reserves that are managed under the MAP, which requires fishermen to document their catch in logbooks (Babcock et al. 2013) (FAO 2015a). Further data collection systems improvements are likely, since the MAP is expanded to cover all Belizean spiny lobster fisheries (Karr et al. 2017) and MARPLESCA aims to include catch, fishing effort, biological data, vessel licensing data, fleet size, vessel details, and vessel monitoring system (VMS) data, in data collection processes (FAO 2016b).

Spiny lobster and conch fisheries are managed jointly; the fishery seasons are generally separate, but there is some overlap when the conch season opens in October (pers comm., McDonald 2017). Belize complies with the 2003 CITES recommendations to maintain monitoring, control, and periodic assessment for conch (FAO 2016d) (Belize Fisheries Department 2017b). Data collection for conch fisheries has become more consistent, survey sites have been expanded, and CPUEs are more accurate. The Belize Fisheries Department conducts biennial surveys on queen conch densities (Belize Fisheries Department 2017b). Data to determine conch abundance include landings data (monthly), fishery-dependent CPUE data (monthly), export data (monthly reports from cooperatives), a managed access daily catch log, underwater visual surveys (every two years), fishery inspector surveys to collect conch density, habitat distribution type, and biological data such as shell length and lip thickness (in the open season) (FAO 2016d) (Belize Fisheries Department 2017b).

Greater bycatch monitoring is needed, particularly in trap fisheries: traps are likely to incur low levels of bycatch (Favaro et al. 2013), and is observed to present "very little bycatch impact on other species" (pers. comm., Epstein 2017), but prohibited species have been observed as bycatch in traps (Dahlgren and Tewfik 2015).

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.

BELIZE / CARIBBEAN SEA, DIVING, BELIZE
BELIZE / CARIBBEAN SEA, POTS, BELIZE

Moderately Effective

Joint enforcement patrols are conducted by the EMU, CCU, the Belize Coast Guard, Port Authority and other enforcement agencies. The Belize Coast Guard and the Police Force enforce the Fisheries Regulations (Belize Fisheries Department 2013). Fisheries enforcement in Belize has improved, particularly in its marine reserves (FAO 2015a). As the MAP becomes nationwide, national enforcement will likely improve (Karr et al. 2017): in the two pilot MAPs, fishing violations reduced by 60% and over 90% of fishers recorded and submitted catch data (EDF 2016b). Under the MAP, every fisher is required to have a valid commercial license (Belize Fisheries Department 2016a). Logbooks are also required (Babcock et al. 2015) and marine reserves receive enhanced monitoring (through patrols on land and via vessels, an observation tower, night vision goggles and radar). Enforcement of the nationwide MAP is increasingly conducted via self-policing—which is underpinned by an education program—since it has proven successful in the two pilot marine reserves MAP (EDF 2015).

There are no recent estimates available for IUU fishing In Belize; however, multiple surveys show compliance issues (see justification).

Since the effectiveness of enforcement is unknown, it has likely improved; but enforcement is supported by self-policing and the scale of illegal fishing is unknown. Therefore, Seafood Watch deems enforcement in Belize as "moderately effective."

Justification:

In marine reserves, enforcement in reserves is conducted by reserve rangers. Patrols are prioritized to occur in illegal-activity hotspots, particularly on-board fishing vessels and campsites (Belize Fisheries Department 2013). Patrol officers regularly monitor small-scale fishery vessels in marine reserves (e.g., Glover's Reef Marine Reserve), which has resulted in improvements in compliance (Tewfik et al. 2017). Fisheries Department Enforcement Officers use the "Spatial Monitoring and Reporting Tool" (SMART) with an app to ensure that licenses are kept updated (Wildlife Conservation Society 2017). Surveillance occurs using radar, a new patrol vessel, an observation tower and equipment to observe the fishery at night (Tewfik et al. 2017). In the conch fishery, the SCUBA diving ban appears to be successful at reducing fishing mortality on conch spawners in deeper waters (FAO 2016d)).

Current levels of IUU fishing are unknown and studies have not been updated over recent years. Previous studies suggested that IUU fishing was a major problem because there was little enforcement and weak compliance of management measures (Chakalall and Cochrane 2007) and, in the early 2000s, retained undersized individuals represented up to 10% of landings (FAO 2003). Since this estimate was produced, regulations have been implemented stating that fishers cannot land undersized lobsters (FAO 2015a). Important violations in the 2016 fishing season included the possession of lobsters during the closed season, the possession of undersize lobster (Belize Fisheries Department 2016b), and fishing without a licensed boat or valid license (Belize Fisheries Department 2016a).

Other independent studies provided insight regarding compliance in the fishery: a recent survey showed that 87% of fishers interviewed claimed that illegal fishing is a problem in their fishing areas and 70% of fishers expressed concern over the absence of enforcement (particularly during closed seasons and at nighttime) (Mayhew 2016). Another survey, which conducted interviews in Belize, found that the Belize Fisheries Department conduct outreach 2 to 3 weeks prior to the opening of the spiny lobster fishery, but provide little engagement thereafter (Rice 2017). Lower compliance rates are found among trap fishers selling produce in areas that are further away from Belize City, since they attract less surveillance and are able to sell spiny lobster into the tourist industry (Monnereau 2016). Holding restrictions within Belize's retail sector is deemed ineffective because monitoring has proven difficult in the retail/wholesale sector (FAO 2015a).

The Belize Fisheries Department is addressing illegal fishing via fines or imprisonment for anyone attempting to fish, possess, buy or sell any lobster or lobster product during the closed fishing season (The San Pedro Sun 2016). Research in genetic analysis to generate DNA databases are being used to combat illegal fishing to

be able to trace individuals back to where they were caught as part of forensic evidence (Smithsonian Marine Station 2015).

Enforcement for retained species: to ensure any finfish species rules are adhered to (when finfish are retained), the Fisheries Department mandates that all fish landed as fillets must include a skin patch to ensure that they are not Nassau groupers (which must be landed whole) (Tewfik et al. 2017). Queen conch meat is only exported by registered cooperatives. Prior to export, all conch shipments require inspection and sampling by the Fisheries Department to ensure compliance and to provide CITES export certificates (FAO 2016d). Infringements may result in fines (Belize Fisheries Department 2017b).

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.

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Highly Effective

Recent progress has been made throughout the stakeholder inclusion process. This includes stakeholder consultations to develop the management strategy and implementation process and a fisheries-adaptive management framework for a lobster management plan, which had both been on-going throughout 2015 (McDonald et al. 2017). The strong connectivity and inclusiveness among main user-groups throughout the MAP process have been attributed to its success (McDonald et al. 2017).

The current most prominent stakeholder group in Belizean fisheries is the Belize Federation of Fishers (BFF), which has partnerships with a mixture of NGOs, universities, and government organizations (BFF 2018). The Belize Fishermen Cooperative Association (BFCA) was also initiated to join existing cooperatives to defend their territorial rights and gain larger bargaining power when negotiating with the government, though the organization has faced a recent decline due to the resignation of important members; therefore, its influence on fishery management has declined (Monnereau 2016).

Since there are co-operatives in the fishery and organizations that involve main user-groups throughout the management process, and encourage constructive and effective relationships within working groups and co-operatives, stakeholder inclusion is deemed as "highly" effective.

Justification:

Enforcement in the area of the two marine reserves involves fishers in the decision-making process: in 2001, a new fisheries rights-based management process called a Manage Access Program (MAP) was developed to better control fishing effort in certain areas; it has improved monitoring systems by involving local stakeholders (FAO 2015a). The MAP has since been expanded at a nationwide level in 2016 (Karr et al. 2017). Participatory and behavior change processes (led by fishermen, government officials and NGOs) were used to engage 2,000 out of 2,700 total Belizean fishers to design the national MAP (Karr et al. 2017).

Stakeholder consultations have been used to develop the management strategy and implementation process and a fisheries adaptive management framework for a lobster management plan (FAO 2015a). This framework acknowledges the relevance and importance of a wide variety of stakeholders involved in the adaptive fisheries management process to ensure management is effectively implemented and iteratively improved (McDonald et al. 2017). The process of expanding the program at a nationwide level and adopting an Adaptive Management Framework has encouraged main user-groups (including fishers, industry, scientists and conservation organizations) to constructively criticize and develop the MAP (McDonald et al. 2017).

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
Belize / Caribbean Sea / Pots / Belize	2	0	Moderate Concern	Yellow (2.449)
Belize / Caribbean Sea / Diving / Belize	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

BELIZE / CARIBBEAN SEA, DIVING, BELIZE

4

Diving involves very little interaction with the habitat. Casitas and anchors (which can be used in the process of fishing for lobsters), can result in some damage.

There is a lack of published studies on the impact of casitas on benthic ecosystems (Higgs 2016b). However, the direct impact of casitas on habitats and ecosystems are suggested to be confined to the area directly immediately beneath (Higgs 2016b). Casitas that are deployed on non-seagrass soft sediment habitat may reduce habitat complexity by smothering benthic epiphytes and epifauna and the species that rely on them. However, shelters left for long periods can act as hard substrate, which can support epifauna growth (Higgs 2016b).

Therefore, casitas may yield negative and positive direct impacts on the habitat, but their direct impact in Belize is unknown.

The spiny lobster dive fishery and queen conch fishery likely yield similar impacts to the habitat and in the queen conch fishery, "is expected to have little to no adverse direct e□ects on the physical environment in general, including *Acropora* species and their designated critical habitat" ((CFMC 2014) p. 113). Therefore, Seafood Watch considers the habitat e□ects of the fishery score to be "4."

BELIZE / CARIBBEAN SEA, POTS, BELIZE

2

Spiny lobster is generally found on rocky substrates and reefs, or wherever protection and shelter can be found (Holthuis 1991). As such, traps and casitas are deployed in a variety of habitats including on rocky reefs. Belize lobster trap fisheries are likely to come into contact with corals (Table 2 in (Bellchambers et al. 2014)). Therefore, some impact on coral reefs is expected due to traps; however, this has not been quantified. The vulnerability of habitats where fishing takes place has currently not been determined, and the impacts of the various fishing methods must be determined (Valle-Esquivel 2011).

In the Caribbean region, lobster traps have been found to significantly reduce live coral cover, damage both coral, sponges, and gorgonians in reef habitats, and reduce shoot densities in seagrass habitats (Sheridan et al. 2005) (Uhrin et al. 2005)(Lewis et al. 2009). Wind and wave-induced trap movements (particularly caused by hurricanes and winter cold front events) can create the most damage (Lewis et al. 2009). As traps disintegrate, their debris can account for up to one third of marine debris on reefs, further damaging benthic communities (Chiappone et al. 2005) (Dahlgren 2014)).

Since Belizean spiny lobster fisheries above can sometimes place traps on reefs, the fishery receives a score of 2.

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

BELIZE / CARIBBEAN SEA, DIVING, BELIZE
BELIZE / CARIBBEAN SEA, POTS, BELIZE

0

According to the 2018 Healthy Reefs Report Card, 22% of Belize's territorial sea is within an MPA (McField et al. 2018). These MPAs include replenishment zones (where no fishing is allowed to occur), which represent 3% of the territorial sea (McField et al. 2018). The other MPAs include those that are general use (which limit licences or trap fishing) or MPAs that are largely unprotected (apart from rules relating to general bans, such as prohibitions on removing Nassau grouper and herbivorous fish) (Cox et al. 2017). The Fisheries Department also manages 11 protected Spawning Aggregation Sites (NPAS 2014).

Spiny lobsters have been reported to directly benefit from marine reserves by having increased abundance and size increases in some marine reserves such as Bacalar Chico Marine Reserve and Glover's Reef (Dahlgren 2014). A variety of the studies collated for the 2018 Healthy Reefs Report Card observed increases in coral cover, commercial fish, and herbivorous fish since 2006 (McField et al. 2018). However, the percent cover of fleshy Macroalgae—caused by excess nutrients and habitat destruction—has also increased over this period (McField et al. 2018). Other marine reserves show declining abundances and that MPAs have not been effective in managing stocks (Chapman et al. 2016). Similarly, Cox et al. (2017) found no change in coral cover during their study period from 2009 to 2013 (covering 16 reefs throughout Belize). Effective MPA management is undermined by inadequate enforcement: only 14% of MPAs in Belize are deemed fully protected and it is suggested that MPAs "do not have the combination of size and effective enforcement to increase fish biomass" (Cox et al. 2017).

Some gear restrictions are applied to traps, which may alleviate some impacts from traps, though their effectiveness is unknown. No management has been implemented to mitigate impacts of casitas on habitats (MRAG Americas 2015e).

Since MPAs cover just over 20% of Belize's territorial waters, but these areas are not completely protected from fishing gear types that impact the habitat in that fishery, and there is little other mitigation in place to reduce the impacts of the trap fishery on to the habitat; therefore, Seafood Watch deems no mitigation to be in place and considers the score to be 0.

Justification:

The Belize Barrier Reef Reserve System (containing a barrier reef, pristine atolls, and sheltered seagrass meadows) is globally recognized as a World Heritage Site. Marine reserves are managed and designated by the Fisheries Department for both use and conservation. The Caribbean aims to protect and sustainably manage 20% of its coastal and marine ecosystems by the year 2020 (CCI 2016) and Belize aims to increase the proportion of its EEZ covered by a network of no-take zones from 3% to 10% by the end of 2018 (EDF 2018a).

In the dive fishery, Belize prohibits the use of SCUBA (McDonald et al. 2017). No management is applied to mitigate impacts of casitas on habitats (MRAG Americas 2015e). However, some areas act as natural refuges, for example, deep water and drop offs inhibit trap and casita-based fishing in deep reefs (Lozana-Alvarez et al. 1993).

In the trap fishery, OSPESCA requires that there are escape gaps on traps and trap limits in the fishery (Table 2). Deploying traps and casitas adjacent to coral is prohibited in a range of zones (McManus and Lacambra 2004); however, there is a lack of a comprehensive and coordinated plan to ensure that this is adequately implemented.

Factor 4.3 - Ecosystem-Based Fisheries Management

BELIZE / CARIBBEAN SEA, DIVING, BELIZE
BELIZE / CARIBBEAN SEA, POTS, BELIZE

Moderate Concern

The ecological role of spiny lobsters has not been well studied in Belize, though it may include reducing prey availability for predators such as octopus and grouper (MRAG Americas 2012), interactions between traps and coral reefs/sensitive habitats, the effects of ghost fishing on habitats and other species, and the volume of lobster removed from the ecosystem (Hervas 2017).

Some management is employed to reduce the impact of the lobster fishery on the ecosystem (see key detained rationale), the most recent being the implementation of the Managed Access Program (MAP) program, which includes a network of no-take zones and is considered an ecosystem-based management approach (Dahlgren and Tewfik 2015). These policies have mixed effectiveness: for example, some reserves have resulted in increased biomass and size of Nassau grouper (Tewfik et al. 2017), and spiny lobster populations (Dahlgren 2014); however, others have not been effective at maintaining non-spiny lobster stocks (Chapman et al. 2016).

Effectiveness of ecosystem management is often undermined by the lack of data for the fishery. For example, the last stock assessment for spiny lobster was published in 2010 (Gongora 2010). There is a lack of understanding regarding the role of spiny lobster in the ecosystem and a lack of studies conducted on bycatch, ghost fishing, and IUU.

Since the fishery lacks spatial management to protect ecosystem functioning, the ecological role of the species is unknown, but detrimental food web impacts are not likely, ecosystem-based fisheries management is deemed a “moderate” concern.

Justification:

Though the ecosystem role of spiny lobster is unknown in Belize, in neighboring Mexican Caribbean spiny lobster fisheries, benthic invertebrates have been shown to play a very important role between primary producers and higher trophic level species (MRAG Americas 2012). In coral reef ecosystems, the only recorded role that spiny lobsters play is as a prey item for octopus and grouper (MRAG Americas 2012). Therefore, by fishing spiny lobsters at high intensities, it can reduce the prey availability for top predators.

A variety of management measures are used to protect the ecosystem, including marine reserves, filleting requirements (to ensure Nassau groupers aren’t overfished) (Tewfik et al. 2017), a requirement to land Nassau grouper whole (Government of Belize 2009), size limits, closed seasons (Tewfik et al. 2017), (and a license requirement for fishing for Nassau grouper engaging in traditional fisheries in the closed season (Government of Belize 2009)), closed spawning sites, a ban on SCUBA diving, total ban on harvest of "herbivorous" fish (acanthurids, scarids) and complete protection for nurse and whale sharks. These measures have resulted in significant increases in both biomass and size in certain reserves for Nassau grouper (Tewfik et al. 2017).

There is a lack of bycatch studies in Belize. This is particularly an issue as ETP species can be caught in these fisheries, such as grouper and snapper species (Vo et al. 2014). Nassau grouper are considered to be critically endangered (Cornish and Eklund 2003) (NMFS 2014c). Spiny lobster are prey for Nassau grouper (Eggleston et al. 1997), and fishing spiny lobster to a level of full- to over-exploitation, could reduce Nassau Grouper prey availability.

The impacts of traps and casitas on the ecosystem have not been studied in Belize. Abandoned traps (ghost traps) continuously capture and harm animals and damage marine ecosystems. In Florida, spiny lobster ghost traps have caused an average mortality of 630,000 spiny lobsters per year (Butler and Mathews 2015), which represents around 12% of landed lobsters (by weight). Gutzler (2015) demonstrated how casitas in Florida can pose risks to juveniles since they venture close to the shelter to forage and are often are eaten by

predators. Casitas are a larger risk to the juvenile spiny lobster's fishing mortality than natural shelters (Gutzler et al. 2015).

Maintaining spiny lobster populations has been found to be particularly important in the role of reducing the vast growth of lionfish populations (Higgs 2016a), which are an invasive species in the Caribbean (Johnston et al. 2017). There is no formal fishery management plan for lionfish.

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Appendix A: Extra By Catch Species

QUEEN CONCH

Factor 2.1 - Abundance

BELIZE / CARIBBEAN SEA, DIVING, BELIZE

High Concern

Belize conducts biennial surveys to assess queen conch stocks and was last assessed in 2017. There is no single reference point to determine the overfished status of conch; however, three performance indicators have been used to determine abundance trends and aid the management of the Belize conch fishery (Belize Fisheries Department 2017b). These performance indicators include: mean shell length, average density of conch, total landings from the previous year, which have been compared to a Limit Reference Point (LRP) and a Target Reference Point (TRP) (more detail available in the justification) (Belize Fisheries Department 2017b). Two of the three performance indicators show a decline. In addition, the stock is heavily truncated towards juvenile conch as the majority (83.66%) of the population are considered to be of sub-legal size; only 16.34 % of the sample were considered legal size (Belize Fisheries Department 2017a).

Since data-limited indicators have shown mixed trends for the status of the stock, and the PSA deems conch as highly vulnerable, Seafood Watch deems abundance as "high" concern.

Justification:

Queen conch in Belize was declared overexploited in 1994 (NMFS 2014a). There were slight population increases in 2003-2004; however, the discovery of a deep-water stock, and high recruitment in the back reef, resulted in the 2003 CITES review to express concerns about Allee effects and reproductive failure (NMFS 2014a). Since then, the country has implemented management measures including establishing size limits and quotas, allocating quotas to fishing cooperatives, prohibiting the use of SCUBA, and creating Marine Protected Areas ((CFU 2013) (Gongora 2012) (NMFS 2014b) and a conch management plan since 2014 (Belize Fisheries Department 2017b).

Three performance indicators have been chosen in the management plan to support the adaptive management framework. These performance indicators were have been used to determine the queen conch abundance and are discussed in detail in the table below.

Table xxx. The status of the Queen Conch relative to reference points of the performance indicators that are available and shown in the Queen Conch Management Plan (Belize Fisheries Department 2017b).

PERFORMANCE INDICATOR	TRP	LRP	STATUS RELATIVE TO REFERENCE POINT
Mean shell length	Running 10-year average	N/A	Mean shell length has decreased by 10.9 % since 2016; it is currently estimated at 139.01 mm, which is below the legal size of 178 mm (Belize Fisheries Department 2017a). The 10-year average shell length for 2006 to 2016 was 147.23265 (slide 13; (Belize Fisheries Department 2017a)). Therefore, the current mean shell length is below the average.
Average density of conch	Running 10-year average	88 conch/ha	Mean stratified legal size density of conch has increased from 75/6 conch/ha (2016) to 84.21 conch/ha (2017) (Belize Fisheries Department 2017a). Therefore, the density is below the LRP.

Total landings from the previous year	Running 10-year average	N/A	Reported catch from cooperatives in 2016 was 900,000 lb (Belize Fisheries Department 2017a). Though landings data are not available for each year from a single source, total catches represent around 850,000 lb. Therefore, catches are above the 10-year average.

In addition to the performance indicators discussed above, several data sets (density ratio, lip thickness, depletion estimate, maturity, export trends, and market trends) also show abundance trends for the stock. However, the data used for the performance indicators were favored because they were more feasible to collect and analyse, were more applicable to a national scale and more representative of the population (Belize Fisheries Department 2017b). Lip thickness and market clean weight are considered to be more appropriate indicators, since they are more more sensitive and more accurate at detecting maturity (Foley and Takahashi 2017). However, there is a lack of data currently available to use lip thickness as a performance indicator in the management plan (Belize Fisheries Department 2017b).

Productivity-Susceptibility Analysis

PSA score = 3.605551. For this reason, the species is deemed highly vulnerable (detailed scoring of each attribute is shown below).

ATTRIBUTE	RESULT	SCORE
Productivity		
Average age at maturity	3 1/2 to 4 years (pers. comm., Anonymous 2016)	1
Average maximum age	30 years (NMFS 2014a)	3
Fecundity	1 million eggs (NMFS 2014a)	1
Reproductive strategy	Demersal egg layer	2
Density dependence (invertebrates only)	Density dependence. susceptible to Allee effects (NMFS 2014a)	3
Quality of habitat	Habitat has been moderately altered by non-fishing impacts. For example, in the 2018 Healthy Reef Report showed that though coral cover has increased from years 2006 to 2016, 39% of their reefs are deemed to be in a "poor" state and a further 20% are in a "critical" state (McField et al. 2018).	2
Susceptibility		
Areal overlap	>30% of the species concentration is fished, considering all fisheries	3

Vertical overlap	High degree of overlap between fishing depths and depth range of species	3
Selectivity of fishery	Species is encountered and targeted. Despite the conch and spiny lobster season operating at different times to each other, their catches do overlap and there is some evidence to show that juveniles are harvested (NMFS 2014b). The minimum size and meat weight requirements in Belize may be too low to protect juvenile conch from legal harvest; however, there is a conservative and enforced harvest quota to protect the stock (pers. comm. Stoner 2017).	3
Post-capture mortality	Retained species	3

Therefore, the productivity score is [(1+3+1+2+3+2)/6] = 2

P= 2

$$ = [(($$1 * $$2 * $$3 * $$4) − 1)/ 40] + 1

$$ = [(3 * 3 * 3 * 3) − 1) /40] + 1

S = 3

$$ = √$$² + $$²

V= √4 + 9

V= 3.605551

Factor 2.2 - Fishing Mortality

BELIZE / CARIBBEAN SEA, DIVING, BELIZE

Moderate Concern

There are no fishing mortality reference points. Although conch are targeted alongside lobster at certain times of the year (pers. comm., McDonald 2017), the level of conch landings that occur in the spiny lobster fishery is unknown.

Based on the mean shell length data, it is likely that landings mostly consist of juveniles and that the minimum harvest meat weight requirement is low (pers. comm., Stoner 2017), which may be resulting in growth overfishing (Foley and Takahashi 2017). However, the fishery is restricted using a suite of measures to reduce overfishing, including a quota that is set at 80% of the calculated Maximum Sustainable Yield (Belize Fisheries Department 2017a).

Since mortality is unknown in relation to any target or limit reference points, Seafood Watch deems the mortality of queen conch in Belize as "moderate" concern.

Factor 2.3 - Discard Rate

BELIZE / CARIBBEAN SEA, DIVING, BELIZE

< 100%

The free-dive and hand-harvest fisheries, including those that use casitas for lobster shelters, do not result in large numbers of non-targeted species. Even in the areas in which casitas are used, animals move freely and are still harvested by hand with the use of nets and/or hooks. The dive fishery is selective and results in very little incidental catch. Occasionally, fishers may capture stone crab species for consumption within Belize, but this does not constitute a significant part of the catch (Bert and Hochberg 1992).

Diving requires no bait use and is a very selective fishing method and therefore receives a factor score of 1.

CORALS AND OTHER BIOGENIC HABITATS

Factor 2.1 - Abundance

BELIZE / CARIBBEAN SEA, DIVING, BELIZE
BELIZE / CARIBBEAN SEA, POTS, BELIZE

High Concern

The Mesoamerican Reef (MAR), the largest coral reef system in the Atlantic, stretches over 1,000 km, through México, Belize, Guatemala, and Honduras (MRAG Americas 2012). Many corals are considered as ETP species in Belize; these include critically endangered species such as the staghorn coral, *Acropora cervicornis* (Aronson et al. 2008).

Corals and other biogenic habitats are assumed to have a high vulnerability and therefore, are deemed as "high" concern.

Factor 2.2 - Fishing Mortality

BELIZE / CARIBBEAN SEA, DIVING, BELIZE

Low Concern

Fishing mortality of corals and other biogenic habitats is unknown and the UBM has been used to determine the risk of fishing on corals. A score of 5 is provided for the impact of diving on corals. Therefore, Seafood Watch considers the impact of diving fisheries on corals to be a "low" concern.

Justification:

Where casitas are not used and the dive fishery does not deploy any gear to the seabed, the impact on corals is likely to be negligible: according to CFMC (2014, p. 113), queen conch harvest, which is also a dive fishery, "is expected to have little to no adverse direct e□ects on the physical environment in general, including *Acropora* species and their designated critical habitat" (CFMC 2014). Research conducted in Florida suggested that "casitas cause minor changes to the hard bottom community." These changes mainly incured a decrease in the abundance of algae and non-mobile animals around the casita. For example, algae percent cover was ~47% at 25 m away from the casita, but reduced to 27% at 7 m away from the casita (Hunt 2011a). Due to the uncertainty around whether casitas are impacting the coral in the region, we have included coral as a main species and consider the impact to be a "low" conservation concern.

BELIZE / CARIBBEAN SEA, POTS, BELIZE

Low Concern

Impacts of pot and trap fisheries on coral are considered a low conservation concern using the Seafood Watch unknown bycatch matrix. Typically pots are set in sandy habitats away from corals, however there is some concern regarding the impacts of ghost pots that can be moved by storms and currents once they have been lost.

Justification:

Lobster traps in the Caribbean region have been found to significantly reduce live coral cover and damage coral, sponges and gorgonians in reef habitats and seagrasses ((Sheridan et al. 2005)(Uhrin et al. 2005) (Lewis et al. 2009)). Hurricanes and winter storms cause traps to move over corals which causes the greatest impact (Lewis et al. 2009). Ghost traps which subsequently fragment, may constitute up to one third of marine debris on reefs, further contributing to the damage of marine communities (Chiappone et al. 2005).

Factor 2.3 - Discard Rate

BELIZE / CARIBBEAN SEA, DIVING, BELIZE

< 100%

The free-dive and hand-harvest fisheries, including those that use casitas for lobster shelters, do not result in large numbers of non-targeted species. Even in the areas in which casitas are used, animals move freely and are still harvested by hand with the use of nets and/or hooks. The dive fishery is selective and results in very little incidental catch. Occasionally, fishers may capture stone crab species for consumption within Belize, but this does not constitute a significant part of the catch (Bert and Hochberg 1992).

Diving requires no bait use and is a very selective fishing method and therefore receives a factor score of 1.

BELIZE / CARIBBEAN SEA, POTS, BELIZE

< 100%

Discards

Total discard rates are estimated at 15% (Shester and Micheli 2011). Although this study refers to the California spiny lobster (*P. interruptus*) fishery, rather than the Caribbean spiny lobster (*P. argus*), it is possible the rates are quite similar.

There is little information about the total discard rate in the Caribbean spiny lobster fishery. Most studies have been focused on comparing percentages of bycatch in various types of traps, and not the impact on the ecosystem as a whole. However, Matthews et al. (2005) did note that the number of fish that died in traps during observations over one season was quite small (Matthews et al. 2005). In the Saba Bank, discards represented about 50% of lobster landings (~20 t of mixed fish were discarded out of 38 t of lobster landed, in 2012)(van Gerwen 2013).

Bait

The bait used in the Belizean lobster fishery is not recorded, though literature suggest that lobster traps are usually baited with coconut, chicken, or beef (Ylitalo-Ward 2016).

In the absence of discard data from Belize, studies from other Caribbean countries estimate that discarding from spiny lobster fisheries varies between 15 to 50%. There is a lack of research conducted on bait use,

though it is likely that non-marine species are used as bait. Therefore, the ratio of pounds of bait used to pounds of lobster landed is assumed to be less than 100%.

BENTHIC INVERTS

Factor 2.1 - Abundance

BELIZE / CARIBBEAN SEA, POTS, BELIZE

Moderate Concern

Since there is a lack of data on benthic invertebrate bycatch in the spiny lobster fishery, Seafood Watch automatically scores invertebrates as a "moderate" concern, due to their vulnerability.

Factor 2.2 - Fishing Mortality

BELIZE / CARIBBEAN SEA, POTS, BELIZE

Low Concern

Since the UBM scores the impact of pots on benthic invertebrates as 3.5, Seafood Watch deems fishing mortality as "low" concern.

Factor 2.3 - Discard Rate

BELIZE / CARIBBEAN SEA, POTS, BELIZE

< 100%

Discards

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In the absence of discard data from Belize, studies from other Caribbean countries estimate that discarding from spiny lobster fisheries varies between 15 to 50%. There is a lack of research conducted on bait use, though it is likely that non-marine species are used as bait. Therefore, the ratio of pounds of bait used to pounds of lobster landed is assumed to be less than 100%.

FINFISH

Factor 2.1 - Abundance

BELIZE / CARIBBEAN SEA, POTS, BELIZE
BELIZE / CARIBBEAN SEA, DIVING, BELIZE

Moderate Concern

A variety of finfish are caught in spiny lobster fisheries but bycatch are not reported. In areas such as Glover's Reef, fishermen are recorded catching finfish when free-diving for lobster (Babcock et al. 2013). Hogfish (*Lachnolaimus maximus*) has been recorded as a finfish caught in the neighbouring Mexican Caribbean spiny lobster fisheries (MRAG Americas 2012). It is currently illegal to harvest scarids (parrotfish) and acanthurids (tang/surgeonfish/doctorfish) in Belize (Tewfik et al. 2017), though they continue to be a bycatch from trap fisheries (Dahlgren 2014). These species are not considered to be overfished in a recent study conducted in Glover's Reef (Babcock et al. 2013).

Since the finfish species in the catch are unknown, abundance is deemed a "moderate" concern based on their level of vulnerability.

Justification:

Although the abundance of finfish that may be caught in the spiny lobster fishery is unknown, herbivorous fish biomass has increased between 2006 and 2016 (McField et al. 2018).

Factor 2.2 - Fishing Mortality

BELIZE / CARIBBEAN SEA, POTS, BELIZE
BELIZE / CARIBBEAN SEA, DIVING, BELIZE

Low Concern

Most species assessed in a study conducted in Glover's Reef were undergoing overfishing (e.g., hogfish) (Babcock et al. 2013). The UBM has been used to determine the impact of pots on finfish, which has been scored 3.5. Therefore Seafood Watch deems fishing mortality as a "low" concern.

Factor 2.3 - Discard Rate

BELIZE / CARIBBEAN SEA, POTS, BELIZE

< 100%

Discards

Total discard rates are estimated at 15% (Shester and Micheli 2011). Although this study refers to the California spiny lobster (*P. interruptus*) fishery, rather than the Caribbean spiny lobster (*P. argus*), it is possible the rates are quite similar.

There is little information about the total discard rate in the Caribbean spiny lobster fishery. Most studies have been focused on comparing percentages of bycatch in various types of traps, and not the impact on the ecosystem as a whole. However, Matthews et al. (2005) did note that the number of fish that died in traps during observations over one season was quite small (Matthews et al. 2005). In the Saba Bank, discards represented about 50% of lobster landings (~20 t of mixed fish were discarded out of 38 t of lobster landed, in 2012)(van Gerwen 2013).

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In the absence of discard data from Belize, studies from other Caribbean countries estimate that discarding from spiny lobster fisheries varies between 15 to 50%. There is a lack of research conducted on bait use, though it is likely that non-marine species are used as bait. Therefore, the ratio of pounds of bait used to pounds of lobster landed is assumed to be less than 100%.

BELIZE / CARIBBEAN SEA, DIVING, BELIZE

< 100%

The free-dive and hand-harvest fisheries, including those that use casitas for lobster shelters, do not result in large numbers of non-targeted species. Even in the areas in which casitas are used, animals move freely and are still harvested by hand with the use of nets and/or hooks. The dive fishery is selective and results in very little incidental catch. Occasionally, fishers may capture stone crab species for consumption within Belize, but this does not constitute a significant part of the catch (Bert and Hochberg 1992).

Diving requires no bait use and is a very selective fishing method and therefore receives a factor score of 1.