

# Monterey Bay Aquarium Seafood Watch®

## Dolphinfish



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## Peru/Southeast Pacific

## Drifting longlines

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### **Disclaimer**

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

# **Table of Contents**

About Seafood Watch .....	3
Guiding Principles .....	4
Summary .....	5
Final Seafood Recommendations .....	6
Introduction .....	7
Assessment .....	10
<i>Criterion 1: Impacts on the Species Under Assessment</i> .....	10
<i>Criterion 2: Impacts on Other Species</i> .....	14
<i>Criterion 3: Management Effectiveness</i> .....	29
<i>Criterion 4: Impacts on the Habitat and Ecosystem</i> .....	34
Acknowledgements .....	37
References .....	38
Appendix A: Extra By Catch Species .....	46

## **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](http://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<sup>1</sup> 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.

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<sup>1</sup> "Fish" is used throughout this document to refer to finfish, shellfish and other invertebrates

## **Summary**

Dolphinfish or mahi mahi (*Coryphaena hippurus*) is found worldwide in tropical and subtropical waters. This assessment focuses on the mahi mahi longline fishery operating in Peru. Mahi mahi is short-lived, highly fecund, and therefore moderately resistant to fishing pressure. In 2016, an exploratory stock assessment for dolphinfish in the southeastern Pacific Ocean (off Peru and Ecuador) was developed with the support of the Inter-american Tropical Tuna Commission (IATTC). No reference points were defined in this stock assessment, but in 2019, the IATTC presented potential reference points and harvest control rules that could be considered for the species in the EPO.

The Peruvian mahi mahi fishery also catches some species of sharks, including blue sharks (*Prionace glauca*, IUCN near-threatened) and shortfin mako sharks (*Isurus paucus*, IUCN vulnerable). The fishery also interacts with threatened and endangered species of sea turtles and some fishery-related mortality of seabirds has been documented.

This fishery has been involved in a Fishery Improvement Project that aims to generate more information, implement management measures, and improve its sustainability overall. According to the most recent information shared on the project platform and a recent audit (developed in 2018), the FIP has created an international Working Group to assess the mahi mahi stock, measures and training to identify and reduce impacts on sea turtles, and a push for an onboard observer program. However, the effectiveness of these measures has not been reported, and several actions have not yet been implemented (*e.g.*, observer program or the analysis of the results of the pilot study during the 2017-2018 season). Effective improvements in bycatch, enforcement of regulations, and stakeholder inclusion are needed. Therefore, the final recommendation for mahi mahi caught in Peru by longline is "avoid."

## Final Seafood Recommendations

<b>SPECIES   FISHERY</b>	<b>CRITERION 1:</b> Impacts on the Species	<b>CRITERION 2:</b> Impacts on Other Species	<b>CRITERION 3:</b> Management Effectiveness	<b>CRITERION 4:</b> Habitat and Ecosystem	<b>OVERALL RECOMMENDATION</b>
<b>Dolphinfish</b> Peru/Southeast Pacific   Drifting longlines	Green (3.413)	Red (1.000)	Red (1.000)	Green (3.873)	<b>Avoid (1.906)</b>

### Summary

Dolphinfish caught in the Peruvian drifting longline fishery have been rated red (avoid) due to bycatch of vulnerable threatened and endangered sea turtles, seabirds, and sharks and lack of implementation of proven mitigation methods for sea turtles and seabirds.

### 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 Concern<sup>2</sup>, 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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<sup>2</sup> 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**

Dolphinfish or mahi mahi (*Coryphaena hippurus*) is a pelagic species found worldwide in tropical and subtropical waters. This assessment focuses on the artisanal mahi mahi fishery in Peru that uses drifting longlines. The main export market for Peru mahi mahi is the USA, although there is a significant level of consumption in the domestic market (Amoros et al 2017).

## **Species Overview**

*Coryphaena hippurus* is one of two species in the family Coryphaenidae, along with the pompano dolphinfish (*C. equiselis*). Both species have a global distribution, and though pompano dolphinfish are typically smaller than mahi mahi, they share a similar morphology and coloration (Froese and Pauly 2018). Accordingly, pompano dolphinfish are often mistaken for juvenile mahi mahi (Froese and Pauly 2018) and are sometimes sold as mahi mahi (Whoriskey et al 2011).

Mahi mahi are mid-trophic level predators, feeding primarily on other fishes and occasionally, crustaceans and squid (Polovino et al. 2009)(Froese and Pauly 2017). They are found worldwide in tropical and subtropical waters warmer than 20°C (FAO 2004). This species is extremely fast growing and reaches sexual maturity in the first year of life. Size at maturity varies throughout its range (Collette et al 2011). Females are highly fecund, producing as many as 1.5 million eggs per spawning event, and short-lived, with a typical lifespan of less than 5 years (Collette et al 2011) (Froese and Pauly 2018). Mahi mahi are sexually dimorphic, with males significantly larger than females; in the tropical Pacific, maximum sizes of 149 cm fork length (FL) for males and 137 cm FL for females have been recorded (Uchiyama and Boggs 2006). Mahi mahi school in feeding aggregations, and these schools are commonly associated with floating objects; hence, they are often captured near fish aggregation devices (FADs) (Olson and Galvan-Magaña 1996). In the eastern Pacific Ocean, the Inter-American Tropical Tuna Commission (IATTC) is charged with the management of tuna and tuna-like species, including mahi mahi. Peru can follow the recommendations and management guidelines set forth by this organization, but the Ministry of Production (PRODUCE) has full autonomy to manage mahi mahi under the recommendations they receive from the Marine Institute of Peru (IMARPE).

## **Production Statistics**

The fishery in Peru increased its landings in the early 1980s when fishing effort increased significantly as a result of the high market demand for mahi mahi, and the introduction of longlining as a fishing method (Solano et al 2011). By the early 1990s, landings were averaging 3,000 t, reaching a peak in 1998, due to the higher availability of mahi mahi associated with the El Niño phenomenon (FCI 2012). By the early 2000s, annual landings reached levels above 30,000 t, and surpassed 50,000 t in 2008 and 2009 (Figure1). Peru accounts for the highest landings of the Eastern Pacific countries (Figure 1).

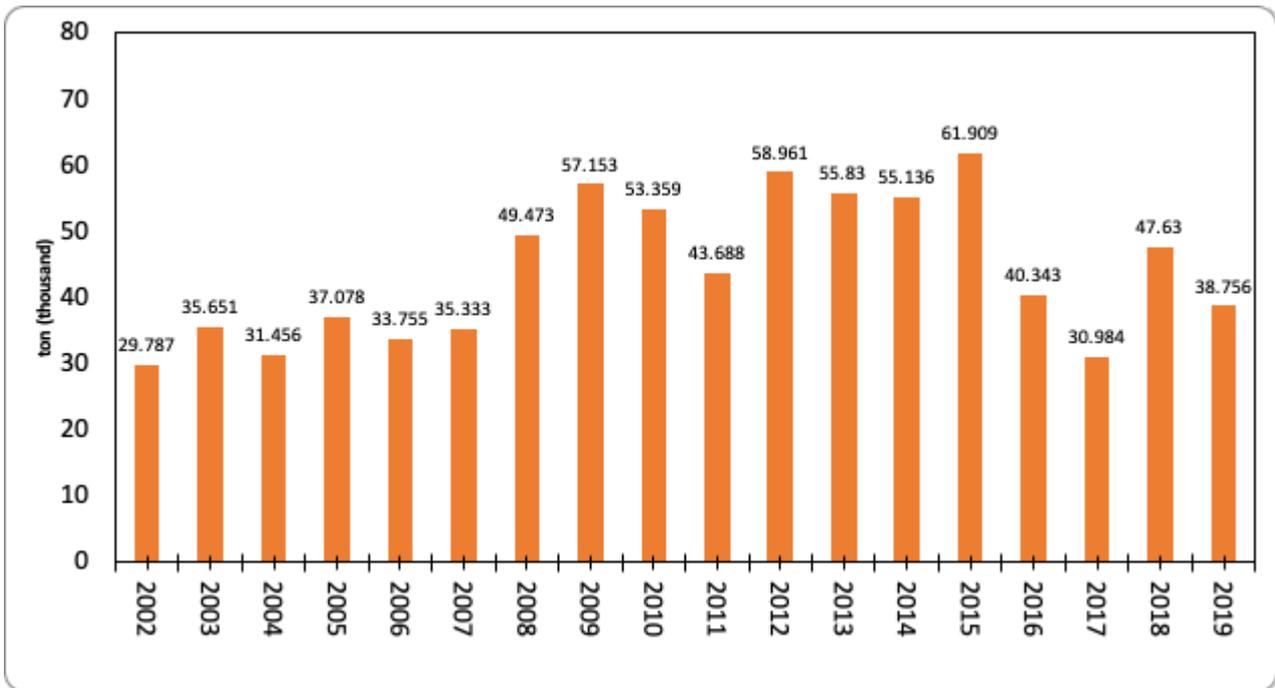


Figure 1 Official mahi mahi landings from 2002-2019 (PRODUCE)

### Importance to the US/North American market.

The majority of mahi mahi available in the United States comes from imports from Central and South America. Peru's most important international market is the USA (Figure 2). Between 2016 and 2019, Peru exported to the USA, more than 9,500 tons with an average value of \$84 million USD of FOB (Figure 3).

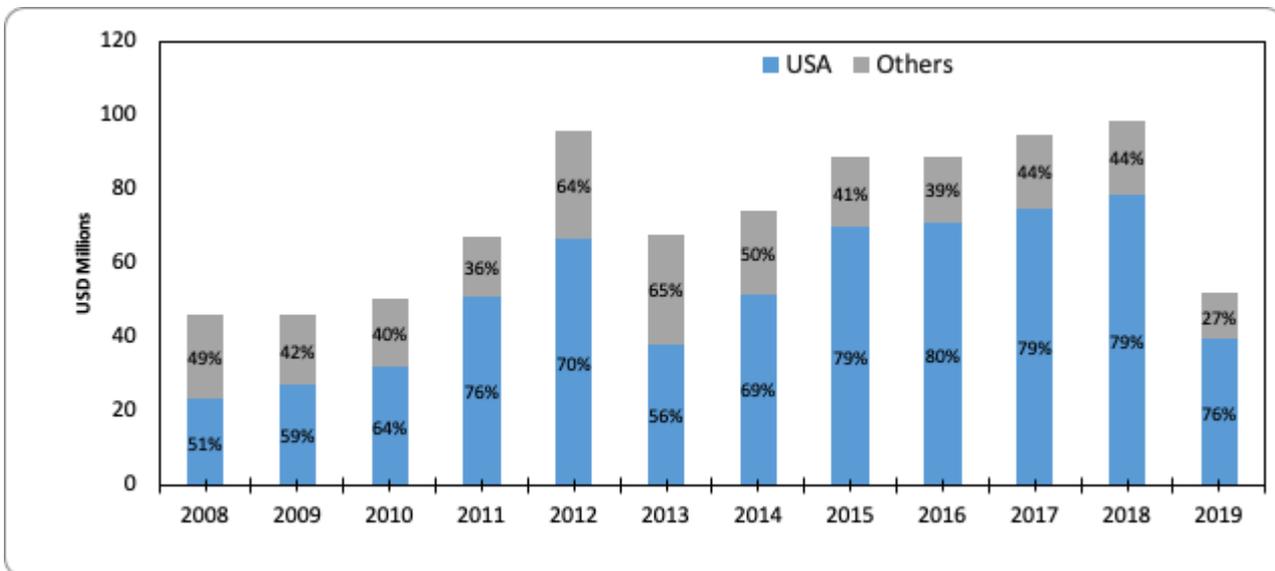


Figure 2 Percentage of export mahi to the USA market (PRODUCE 2020)

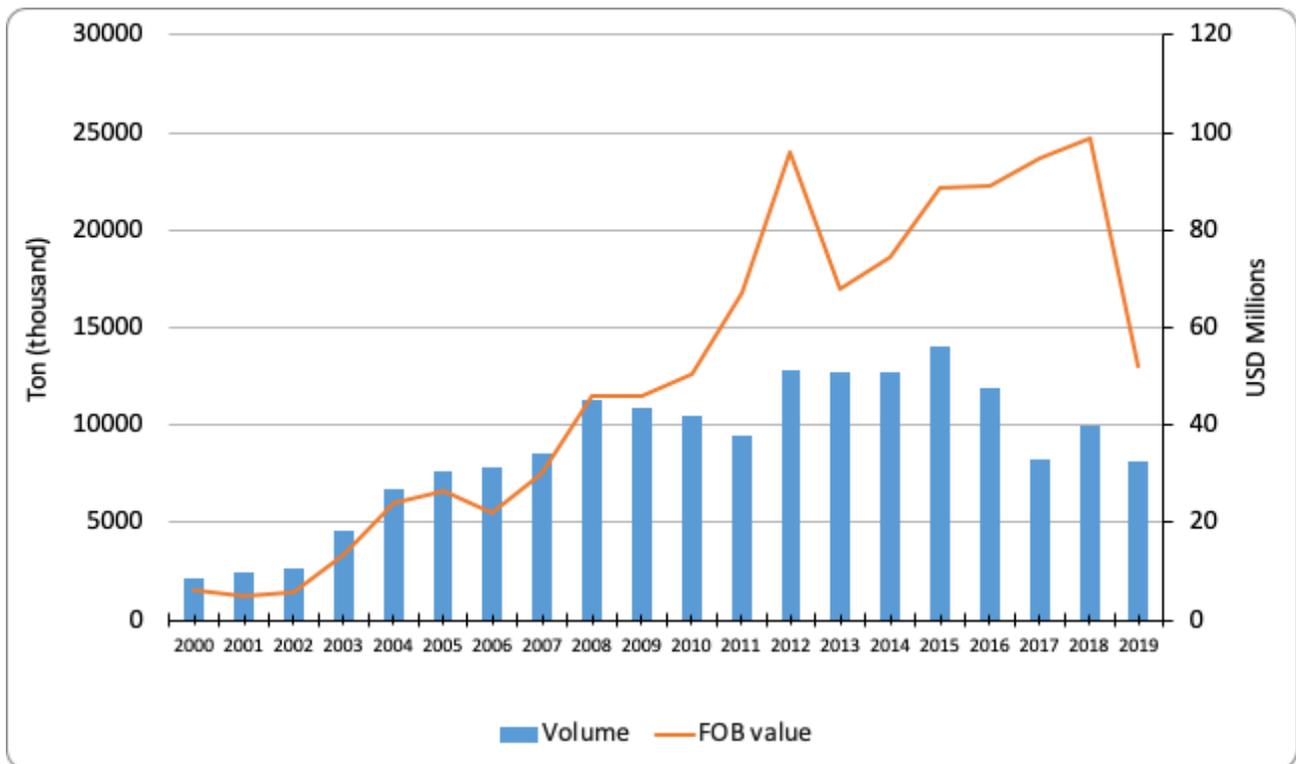


Figure 3 Value and volume of mahi exported to the USA

**Common and market names.**

*C. hippurus* is most commonly marketed as mahi mahi or dolphinfish in the United States, although it is also known as dorado throughout Latin America and perico in Peru.

**Primary product forms**

Mahi mahi in the US market is primarily available as frozen fillets.

## Assessment

This section assesses the sustainability of the fishery(s) relative to the Seafood Watch Standard for Fisheries, available at [www.seafoodwatch.org](http://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

DOLPHINFISH			
Region   Method	Abundance	Fishing Mortality	Score
Peru/Southeast Pacific   Drifting longlines	2.33: Moderate Concern	5.00: Low Concern	Green (3.413)

#### 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.

## DOLPHINFISH

### **Factor 1.1 - Abundance**

#### **PERU/ SOUTHEAST PACIFIC**

Drifting Longlines

#### **Moderate Concern**

An exploratory stock assessment was conducted on mahi mahi in the southeastern Pacific Ocean in 2016, which is considered the "core" region of the stock in the EPO (Aires da Silva et al 2016). The regional fishery management organization, Inter-American Tropical Tuna Commission (IATTC), has begun developing an assessment plan. The spawning stock biomass (time series 2007 to 2015) has remained fairly stable since 2007, with a slight decrease in 2010 (Aires da Silva et al 2016).

There are no reference points defined for mahi mahi in the eastern Pacific Ocean. Some common reference points used for species such as tuna were assessed for mahi mahi. According to these reference points, the spawning stock biomass ratio to that of the unfished stock has averaged 0.20 for the time series (Aires da Silva et al 2016). The IUCN has assessed mahi mahi as a species of "The Least Concern" (Collette et al 2011). Because there are no reference points or other indications of abundance for the mahi mahi stock, a Productivity and Susceptibility analysis (PSA) was conducted. The PSA score = 2.81 (see justification section for PSA details), which suggests a medium susceptibility to fishing; therefore we have awarded a score of "moderate" concern for abundance.

#### **Justification:**

Productivity attribute	Relevant information	Score (1= low risk, 2= medium risk, 3= high risk)
Average age at maturity	0.5 years (Beardsley 1967)	1
Average maximum age	4 years (Uchiyama et al 1986)	1
Fecundity	85,000 eggs (Froese and Pauly 2018)	1
Average maximum size (fish only)	210 cm (Collette 1999)	2
Average size at maturity (fish only)	55 cm (Beardsley 1967)	2
Reproductive strategy	Broadcast spawner (Froese and Pauly 2018)	1

Trophic level	4.4 (Froese and Pauly 2018)	3
Density dependence (invertebrates only)	-	-
<b>Total Productivity (average)</b>		<b>1.57</b>

Susceptibility attribute	Relevant information	Score (1= low risk, 2= medium risk, 3= high risk)
Areal overlap (Considers all fisheries)	There is areal overlap between the fishery and mahi mahi.	3
Vertical overlap (Considers all fisheries)	There is areal overlap between the fishery and mahi mahi.	3
Selectivity of the fishery (Specific for fishery under assessment)	The selectivity is not available	2
Post-capture mortality (Specific for fishery under assessment)	Post-capture mortality information is unknown.	3
Total susceptibility (multiplicative)		2.33

PSA score for mahi mahi in the Peruvian longline fishery is calculated as follows: Vulnerability (V) =  $\sqrt{(P2 + S)^2}$

$$V = \sqrt{(1.57 + 2.33)^2}$$

$$V = 2.81$$

## Factor 1.2 - Fishing Mortality

### PERU/SOUTHEAST PACIFIC

Drifting Longlines

#### Low Concern

Fishing mortality rates for mahi mahi in the eastern Pacific Ocean compared to reference points are unknown. However, the Inter-American Tropical Tuna Commission (IATTC) conducted an exploratory stock assessment that suggests fishing mortality rates have decreased slightly since 2007 and the fishing mortality needed to produce the maximum sustainable yield is two times more than current levels (Aires da Silva et al 2016)

The IUCN does not consider there to be any major threats to mahi mahi from commercial fishing (Collette et al 2011). Preliminary analysis shows variable, but somewhat steady, catch-per-unit effort (CPUE) trends in abundance (IATTC 2013). We have awarded a score of "low" concern because commercial fishing does not appear to be a major threat, the CPUE has been somewhat stable over time, and the preliminary stock assessment shows current fishing mortality rates of 50% of the maximum sustainable yield.

#### Justification:

Mahi mahi are caught as bycatch and targeted in longline fisheries (along with coastal gillnet and purse seine fisheries) in the eastern Pacific Ocean (IATTC 2013) (Alfaro-Shigueto et al 2010). The analysis of catch data of the fleet that works in the EPO between 2009 and 2014, showed that mahi mahi was the most important bycatch species of FAD purse seines (ICCAT presentation 2016).

## **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 Critical

### **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.

<b>DOLPHINFISH</b>					
Peru/Southeast Pacific   Drifting Longlines					
<b>Subscore:</b>	<b>1.000</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>1.000</b>
<b>Species   Stock</b>	<b>Abundance</b>	<b>Fishing Mortality</b>	<b>Subscore</b>		
Loggerhead turtle	1.00:High Concern	1.00:High Concern	Red (1.000)		
Hawksbill turtle	1.00:High Concern	1.00:High Concern	Red (1.000)		
Leatherback turtle	1.00:High Concern	1.00:High Concern	Red (1.000)		
Green sea turtle	1.00:High Concern	1.00:High Concern	Red (1.000)		
Olive ridley turtle	1.00:High Concern	1.00:High Concern	Red (1.000)		
Shortfin mako shark	1.00:High Concern	1.00:High Concern	Red (1.000)		
waved albatross	1.00:High Concern	1.00:High Concern	Red (1.000)		
Galapagos petrel	1.00:High Concern	1.00:High Concern	Red (1.000)		
Chatham albatross	1.00:High Concern	1.00:High Concern	Red (1.000)		
Blue shark	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		

Smooth hammerhead	2.33:Moderate Concern	3.00:Moderate Concern	Yellow (2.644)
Skipjack tuna	3.67:Low Concern	3.00:Moderate Concern	Green (3.318)
Yellowfin tuna	3.67:Low Concern	5.00:Low Concern	Green (4.284)

Managers consider the Peruvian mahi mahi fishery to be a small-scale fishery that targets only dolphinfish, but it also impacts a variety of other species. The fishery has been in a Fishery Improvement Project (FIP) since 2013. According to the MSC Pre-assessment Report, the fishery's main impacts on other species include smooth hammerhead sharks (*Sphyrna zygaena*), blue sharks (*Prionace glauca*) and short-finned mako sharks (*Isurus oxyrinchus*). The last two are listed on the IUCN Red List as near threatened (Rigby et al c 2019) and vulnerable (Rigby et al 2019) respectively. In addition, several ETP species including marine turtles and seabirds were identified as directly impacted by the fishery (FCI 2012).

The 2018 FIP Audit Report anticipated that the implementation of a "Turtle Handling and Release Code" (developed by managers and FIP participants) in addition to the use of circle hooks would reduce sea turtle mortality (ECOS 2018). Regarding seabird interactions, in 2014 Ayala and Sanchez reported minimal interactions of the fishery with these species (Ayala and Sanchez 2014). The authors, however, concluded that the implementation of a monitoring program is required, considering the massive amount of fishing effort (700-2,500 vessels) and the need to implement management measures to mitigate its impacts on sea birds, mammals, and turtles (Ayala and Sanchez 2014), (Castillo et al 2018). The report was based on one year of data from two onboard observers (trained captains) and four months of data from seven logbooks to estimate the catch, effort, and bycatch of the longline fishery in Central Peru (Ayala and Sanchez 2014).

For these reasons, we included the following sea turtle species: leatherback, olive ridley, green, hawksbill, and loggerheads since all are found in Peruvian waters (IAC 2017), as well as waved albatros (*Phoebastria irroratase*), Galapagos petrel (*Pterodroma phaeopygia*) (both critically endangered) and the Chatham albatross (*Thalassarche eremita*), a vulnerable seabird that have been identified as impacted by the fishery (ECOS 2019). Finally, since it is reported that the targeted mahi mahi fishery may also catch large amounts of blue and hammerhead sharks, and is commonly found with the Skipjack tuna (*Katsuwonus pelamis*) and the Yellowfin tuna (*Thunnus albacares*) (PAN Perico 2012) we also have included these species in the analysis.

## 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)

### LOGGERHEAD TURTLE

#### **Factor 2.1 - Abundance**

##### **PERU/ SOUTHEAST PACIFIC**

Drifting Longlines

**High Concern**

Worldwide, loggerhead sea turtle populations are in decline. Under the US Endangered Species Act (ESA), loggerhead sea turtles are divided into Distinct Population Segments (DPSs), five of which are listed as endangered and four as threatened (NMFS 2013). Loggerheads in the North Pacific and South Pacific Ocean are listed as Endangered under ESA (NMFS 2013). The North Pacific Loggerhead Turtle DPS nests only on the coasts of Japan. This population has declined 50 to 90 percent during the last 60 years. The South Pacific loggerhead turtle DPS nests primarily in Australia with some nesting in New Caledonia. In 1977 about 3,500 females may have nested in the South Pacific—today there are only around 500 per year (NOAA Species directory 2020). Due to the listing of loggerhead sea turtles by the ESA the abundance is of high concern.

## Factor 2.2 - Fishing Mortality

### PERU/SOUTHEAST PACIFIC

Drifting Longlines

#### High Concern

The greatest cause of decline and the continuing primary threat to loggerhead turtle populations worldwide is bycatch in fishing gear, primarily in trawls, longlines, and gillnets (NMFS 2019). In the eastern Pacific Ocean, bycatch in longline fisheries is thought to be low impact, but interactions are a high risk to the population size overall (Wallace et al 2013).

The Peruvian, artisanal mahi mahi fleet does not use circle hooks because experimental results showed an unacceptable decrease in mahi mahi catch (Andraka et al 2013), (Valqui et al 2016), Sea turtle bycatch rates appear to be low in this fishery (~0.21 turtles/1000 hooks)(Ayala and Sanchez 2014). However, the size of the fleet is very large (700-2500 vessels) and national fishing effort for the Peruvian longline vessels was ~80 million hooks annually with an estimate of 80,000 fishing trips annually (Mangel 2012). More recent data on fishing effort and effectiveness of handling techniques (post-release survival) are unknown and because the fleet does not use circle hooks we have awarded a score of "high" concern.

#### Justification:

Peru implemented a monitoring program, that used vessel observers to record sea turtle bycatch (ACOREMA 2017) and between 2004-2009 circle hooks were tested in the fishery as an alternative to reduce turtle interactions. The circle hooks were effective at reducing turtle interactions (36.7% C-14 and 25% C-15) than with "J" hooks (63.3% J-14 and 75% J-15) (Valqui et al 2017). The report also found that mahi catches were reduced when using circle hooks (from 65.1% to 34.9% with size 14 and 66.7% to 33.3% with size 15) (Valqui et al 2017). This factor and the cost associated with the switch from "J" hooks" to circle hooks led participants to approach turtle bycatch problems with a training program, that allow fishers to correctly handling and release techniques (Valqui et al 2016).

There have been issues with compliance in other regions of the Pacific Ocean (Clarke 2013). According to Andraka et al. (2013), 99% of individual sea turtles caught in surface longlines in the EPO are alive (Andraka et al 2013). However, the severity of the interaction and chances of post-release survival depend on the type of interaction, the manipulation of the individual, and release techniques (Parga 2012)(Parga et al 2015). For example, entanglements in the line can increase the mortality rate in some cases (Parga 2012).

## 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

## PERU/ SOUTHEAST PACIFIC

Drifting Longlines

### < 100%

Discard rates are unknown for the mahi mahi fisheries in Peru. The average discard rate in tuna longline fisheries worldwide is 22% (Kelleher 2005). We have awarded a score of <100%.

## HAWKSBILL TURTLE

### Factor 2.1 - Abundance

## PERU/ SOUTHEAST PACIFIC

Drifting Longlines

### High Concern

The IUCN has classified hawksbill turtles as "Critically Endangered," with a decreasing population trend (Mortimer and Donnelly 2012) Hawksbill turtles have been listed in the Convention on International Trade in Endangered Species (CITES) since 1977 and are currently listed in CITES Appendix 1, meaning they are threatened with extinction and international trade is prohibited (Mortimer and Donnelly 2008). It has been estimated that populations in the Pacific Ocean have declined by over 75% over three generations (Mortimer and Donnelly 2012) (Mortimer and Donnelly 2012). We have awarded a score of "high" concern based on the IUCN listing and evidence of declining population size.

### Factor 2.2 - Fishing Mortality

## PERU/ SOUTHEAST PACIFIC

Drifting Longlines

### High Concern

Incidental capture of hawksbill turtles has been identified as adversely affecting their recovery worldwide, although declines in the population of hawksbill turtles is mainly a factor of historical targeting (Mortimer and Donnelly 2012). Hawksbill sea turtles are reported as incidentally captured in longline fisheries in the Eastern Pacific Ocean (IAC 2012). The bycatch impacts in this region are considered low, but a high risk to the population size (Wallace et al 2013).

The Peruvian, artisanal mahi mahi fleet does not use circle hooks because experimental results showed an unacceptable decrease in mahi mahi catch (Andraka et al 2013), (Valqui et al 2016), Sea turtle bycatch rates appear to be low in this fishery (~0.21 turtles/1000 hooks)(Ayala and Sanchez 2014). However, the size of the fleet is very large (700-2500 vessels) and national fishing effort for the Peruvian longline vessels was ~80 million hooks annually with an estimate of 80,000 fishing trips annually (Mangel 2012). More recent data on fishing effort and effectiveness of handling techniques (post-release survival) are unknown and because the fleet does not use circle hooks we have awarded a score of "high" concern.

**Justification:**

Peru implemented a monitoring program, that used vessel observers to record sea turtle bycatch (ACOREMA 2017) and between 2004-2009 circle hooks were tested in the fishery as an alternative to reduce turtle interactions. The circle hooks were effective at reducing turtle interactions (36.7% C-14 and 25% C-15) than with "J" hooks (63.3% J-14 and 75% J-15) (Valqui et al 2017). The report also found that mahi catches were reduced when using circle hooks (from 65.1% to 34.9% with size 14 and 66.7% to 33.3% with size 15) (Valqui et al 2017). This factor and the cost associated with the switch from "J" hooks" to circle hooks led participants to approach turtle bycatch problems with a training program, that allow fishers to correctly handling and release techniques (Valqui et al 2016).

**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

**PERU/ SOUTHEAST PACIFIC**

Drifting Longlines

**< 100%**

Discard rates are unknown for the mahi mahi fisheries in Peru. The average discard rate in tuna longline fisheries worldwide is 22% (Kelleher 2005). We have awarded a score of <100%.

LEATHERBACK TURTLE

**Factor 2.1 - Abundance**

**PERU/ SOUTHEAST PACIFIC**

Drifting Longlines

**High Concern**

Leatherback sea turtles have been listed as Endangered on the U.S. Endangered Species Act (ESA) since 1970 (Miller et al 2013). In 2000, the IUCN classified leatherback turtles as Critically Endangered, with a decreasing population trend. Leatherback turtles have been listed on Convention on International Trade in Endangered Species (CITES) since 1975 and are currently listed on CITES Appendix 1 (NMFS 2013), meaning that they are threatened with extinction and international trade is prohibited. Over the past 25 years, the population of leatherbacks in the Pacific Ocean has decreased significantly (Spotila et al 1996). Recent estimates from the Pacific Ocean suggests a population size of 294,068 turtles, and out of these, 6,199 are adults (Jones et al 2012). We have awarded a score of high concern based on the ESA, IUCN and CITES listings.

**Factor 2.2 - Fishing Mortality**

## PERU/ SOUTHEAST PACIFIC

### Drifting Longlines

#### High Concern

Fishing mortality is believed to be a major threat to leatherback turtles, especially for juveniles and adults that can be incidentally captured in fisheries along their migration routes (Wallace et al 2013). In the Eastern Pacific Ocean, bycatch in longline fisheries is thought to be a low impact, but interactions are a high risk to the population size overall (Wallace et al 2013).

The Peruvian, artisanal mahi mahi fleet does not use circle hooks because experimental results showed an unacceptable decrease in mahi mahi catch (Andraka et al 2013), (Valqui et al 2016), Sea turtle bycatch rates appear to be low in this fishery (~0.21 turtles/1000 hooks)(Ayala and Sanchez 2014). However, the size of the fleet is very large (700-2500 vessels) and national fishing effort for the Peruvian longline vessels was ~80 million hooks annually with an estimate of 80,000 fishing trips annually (Mangel 2012). More recent data on fishing effort and effectiveness of handling techniques (post-release survival) are unknown and because the fleet does not use circle hooks we have awarded a score of "high" concern.

#### Justification:

Peru implemented a monitoring program, that used vessel observers to record sea turtle bycatch (ACOREMA 2017) and between 2004-2009 circle hooks were tested in the fishery as an alternative to reduce turtle interactions. The circle hooks were effective at reducing turtle interactions (36.7% C-14 and 25% C-15) than with "J" hooks (63.3% J-14 and 75% J-15) (Valqui et al 2017). The report also found that mahi catches were reduced when using circle hooks (from 65.1% to 34.9% with size 14 and 66.7% to 33.3% with size 15) (Valqui et al 2017). This factor and the cost associated with the switch from "J" hooks to circle hooks led participants to approach turtle bycatch problems with a training program, that allow fishers to correctly handling and release techniques (Valqui et al 2016).

## 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

## PERU/ SOUTHEAST PACIFIC

### Drifting Longlines

#### < 100%

Discard rates are unknown for the mahi mahi fisheries in Peru. The average discard rate in tuna longline fisheries worldwide is 22% (Kelleher 2005). We have awarded a score of <100%.

## GREEN SEA TURTLE

## Factor 2.1 - Abundance

### PERU/ SOUTHEAST PACIFIC

Drifting Longlines

#### High Concern

The International Union for Conservation of Nature (IUCN) has classified green sea turtles as "Endangered" with a decreasing population trend (Seminoff 2004). Green sea turtles have been listed in the Convention on International Trade in Endangered Species (CITES) since 1975 and are currently listed in Appendix 1; this means they are threatened with extinction and international trade is prohibited (Seminoff 2004). The East Pacific DPS extends from the California-Oregon border to central Chile (NOAA et al 2015).

In the most recent status review of the species by NOAA in 2015, nesting abundance was ranked with a low risk of extinction. Authors reported that based on a 25-year trend line from the largest nesting aggregation in the East Pacific DPS (in Mexico)—it is clear that green turtle nesting has increased since the population's low point in the mid-1980s. In addition to Mexico, data from the Galápagos Archipelago do not suggest a declining trend, and the largest-ever nesting numbers reported in Costa Rica suggest this site may be on the increase as well (NOAA et al 2015). However, although the situation has improved, authors concluded that given the conservation dependence of the species, without mechanisms in place to continue conservation efforts and funding streams in this DPS, some threats could increase and population trends could be affected. For this reason, we scored this factor as high concern.

## Factor 2.2 - Fishing Mortality

### PERU/ SOUTHEAST PACIFIC

Drifting Longlines

#### High Concern

The incidental capture in fisheries is considered a major threat to green sea turtles worldwide (Seminoff 2004), but there are regional differences. Green sea turtles are reported as incidentally captured in longline fisheries in the eastern Pacific Ocean and are one of the three most commonly captured sea turtles in the Ecuadorian mahi mahi fishery (Martinez-Ortiz and Zuñiga-Flores 2012). The bycatch impacts in this region are considered low, but a high risk to the population size (Wallace et al 2013).

The Peruvian, artisanal mahi mahi fleet does not use circle hooks because experimental results showed an unacceptable decrease in mahi mahi catch (Andraka et al 2013), (Valqui et al 2016), Sea turtle bycatch rates appear to be low in this fishery (~0.21 turtles/1000 hooks)(Ayala and Sanchez 2014). However, the size of the fleet is very large (700-2500 vessels) and national fishing effort for the Peruvian longline vessels was ~80 million hooks annually with an estimate of 80,000 fishing trips annually (Mangel 2012). More recent data on fishing effort and effectiveness of handling techniques (post-release survival) is unknown, and because the fleet does not use circle hooks we have awarded a score of "high" concern.

#### Justification:

Peru implemented a monitoring program, that used vessel observers to record sea turtle bycatch (ACOREMA 2017) and between 2004-2009 circle hooks were tested in the fishery as an alternative to reduce turtle interactions. The circle hooks were effective at reducing turtle interactions (36.7% C-14 and 25% C-15) than with "J" hooks (63.3% J-14 and 75% J-15) (Valqui et al 2017). The report also found that mahi catches were reduced when using circle hooks (from 65.1% to 34.9% with size 14 and 66.7% to 33.3% with size 15)

(Valqui et al 2017). This factor and the cost associated with the switch from J" hooks" to circle hooks led participants to approach turtle bycatch problems with a training program, that allow fishers to correctly handling and release techniques (Valqui et al 2016).

### 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

#### PERU/ SOUTHEAST PACIFIC

Drifting Longlines

**< 100%**

Discard rates are unknown for the mahi mahi fisheries in Peru. The average discard rate in tuna longline fisheries worldwide is 22% (Kelleher 2005). We have awarded a score of <100%.

### OLIVE RIDLEY TURTLE

#### Factor 2.1 - Abundance

#### PERU/ SOUTHEAST PACIFIC

Drifting Longlines

#### High Concern

The IUCN considers the population of olive ridley sea turtles to be Vulnerable (Abreu-Grobois and Plotkin 2008). In the Eastern Pacific Ocean, estimates of the total number of nests range from 608 protected nests in Mexico to 33,530-68,753 nests in Nicaragua (Abreu-Grobois and Plotkin 2008). Female population size has been estimated to range from 8,768 in Panama to 1,013,034 in Mexico (Abreu-Grobois and Plotkin 2008). The annual nesting female sub-population size has decreased by 99% in some regions in Mexico, increased substantially in others and not changed at all in areas such as Nicaragua (Abreu-Grobois and Plotkin 2008). Overall, the annual nesting female sub-population size in the eastern Pacific Ocean has declined to around 35% over time (Abreu-grobois and Plotkin 2008), but the risk to populations from longline fishing in this region is considered low (Wallace et al 2013). A score of high concern is awarded based on the IUCN classification and that despite the increases in numbers, given their life history characteristics, olive ridley turtles are highly vulnerable to interactions with fisheries..

#### Factor 2.2 - Fishing Mortality

#### PERU/ SOUTHEAST PACIFIC

Drifting Longlines

## High Concern

Incidental capture of olive ridley sea turtles occurs worldwide. Impacts from other fisheries, such as trawls and gillnets, appear to have a larger negative impact in many areas compared to longlines, except in the Eastern Pacific Ocean (EPO) (Abreu-Grobois and Plotkin 2008)(Wallace et al 2013). Within this region, the impact from incidental captures in longline fisheries is considered high (Wallace et al. 2013). For example, during 2000, the Japanese reported the incidental capture of 6,000 sea turtles, the majority of which were olive ridleys (exact number not provided) (IATTC 2013).

The Peruvian, artisanal mahi mahi fleet does not use circle hooks because experimental results showed an unacceptable decrease in mahi mahi catch (Andraka et al 2013), (Valqui et al 2016), Sea turtle bycatch rates appear to be low in this fishery (~0.21 turtles/1000 hooks)(Ayala and Sanchez 2014). However, the size of the fleet is very large (700-2500 vessels) and national fishing effort for the Peruvian longline vessels was ~80 million hooks annually with an estimate of 80,000 fishing trips annually (Mangel 2012). More recent data on fishing effort and effectiveness of handling techniques (post-release survival) are unknown and because the fleet does not use circle hooks we have awarded a score of "high" concern.

### Justification:

Peru implemented a monitoring program, that used vessel observers to record sea turtle bycatch (ACOREMA 2017) and between 2004-2009 circle hooks were tested in the fishery as an alternative to reduce turtle interactions. The circle hooks were effective at reducing turtle interactions (36.7% C-14 and 25% C-15) than with "J" hooks (63.3% J-14 and 75% J-15) (Valqui et al 2017). The report also found that mahi catches were reduced when using circle hooks (from 65.1% to 34.9% with size 14 and 66.7% to 33.3% with size 15) (Valqui et al 2017). This factor and the cost associated with the switch from J" hooks" to circle hooks led participants to approach turtle bycatch problems with a training program, that allow fishers to correctly handling and release techniques (Valqui et al 2016).

There have been issues with compliance in other regions of the Pacific Ocean (Clarke 2013). According to Andraka et al. (2013), 99% of individual sea turtles caught in surface longlines in the EPO are alive (Andraka et al 2013). However, the severity of the interaction and chances of post-release survival depend on the type of interaction, the manipulation of the individual, and release techniques (Parga 2012)(Parga et al 2015) For example, entanglements in the line can increase the mortality rate in some cases (Parga 2012).

## 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

### PERU/ SOUTHEAST PACIFIC

Drifting Longlines

< 100%

Discard rates are unknown for the mahi mahi fisheries in Peru. The average discard rate in tuna longline fisheries worldwide is 22% (Kelleher 2005). We have awarded a score of <100%.

## SHORTFIN MAKO SHARK

### **Factor 2.1 - Abundance**

#### **PERU/SOUTHEAST PACIFIC**

Drifting Longlines

#### **High Concern**

In the southern Pacific, data on Shortfin mako sharks are limited and there is no stock assessment. We have awarded a "high" concern score because the status is unknown and shortfin mako is listed by the IUCN as endangered with a decreasing trend (Rigby et al 2019).

#### **Justification:**

According to the most recent report from the International Scientific Committee for the Tuna and Tuna-like species (ISC), a single stock of shortfin mako sharks is assumed in the North Pacific Ocean based on evidence from tagging studies and lower catch rates of shortfin makos near the equator relative to temperate areas (ISC 2018).

### **Factor 2.2 - Fishing Mortality**

#### **PERU/SOUTHEAST PACIFIC**

Drifting Longlines

#### **High Concern**

Currently, the primary source of known shortfin mako shark fishing intensity is oceanic longline fisheries targeting swordfish and tuna, including mostly shallow-set longline fisheries in temperate waters, and deep-set longline fisheries in more tropical areas. In the Southeast Pacific, shark fisheries are poorly monitored and regulated, due to limited resources by the management agencies that focus on dominant fisheries (e.g. small pelagics) and ignore shark catches (Velez-Zuazo et al 2015). Peru is the top shark fishing nation in the Southeast Pacific (Fischer et al 2012). Blue shark and short fin mako are the most commonly caught shark species in Peru (Gonzalez-Pestaña et al 2016). The fleet that normally targets mahi mahi between December and February (that have incidental catch of these sharks) also targets these shark species during the March to November season (Doherty et al 2014).

Fishing mortality levels during the mahi mahi season for shortfin mako shark have not been estimated, however, considering the endangered status due to decreasing levels of the population reported by IUCN, the existence of a targeted fishery, and the fact that the species comprises more than 5% of the mahi mahi catches (ECOS 2018) it is suspected that fishing mortality from all sources is above a sustainable level that is appropriate for the species. For these reasons we are scoring this factor as 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

## PERU/SOUTHEAST PACIFIC

Drifting Longlines

### < 100%

Discard rates are unknown for the mahi mahi fisheries in Peru. The average discard rate in tuna longline fisheries worldwide is 22% (Kelleher 2005). We have awarded a score of <100%.

## WAVED ALBATROSS

### Factor 2.1 - Abundance

## PERU/SOUTHEAST PACIFIC

Drifting Longlines

### High Concern

Waved albatrosses are long-lived and do not reproduce until 4-6 years of age (BirdLife International 2012). Chicks experience high mortality and mortality rates increase for both adults and chicks during ENSO years (Awkerman et al 2006). Additionally, waved albatrosses practice obligate, bi-parental care (BirdLife International 2018), so the loss of one member of a breeding pair reduces the effective population size by two individuals. Waved albatrosses are ranked as critically endangered by the World Conservation Union (BirdLife International 2018). Consequently, we have scored abundance as 'high concern'.

#### Justification:

With few exceptions, the entire breeding population of waved albatrosses resides on Isla Española in Galápagos National Park, Ecuador and forages primarily off the coasts of southern Ecuador and northern Peru (Jiménez-Uzcátegui et al 2006), (Anderson et al 2003). Accordingly, the entirety of the wild population is vulnerable to local environmental perturbations. The total number of waved albatrosses was estimated at 34,694 adults in 2001 (Anderson et al 2003), with observed declines in the number of breeding pairs in subsequent years (Birdlife International 2019).

### Factor 2.2 - Fishing Mortality

## PERU/SOUTHEAST PACIFIC

Drifting Longlines

### High Concern

The limited information available suggests that longline fisheries account for much of the observed mortality of adult waved albatrosses (44%) and hooking and entanglement in fishing gear poses a serious risk to the survival of this species (Jiménez-Uzcátegui et al 2006).

According to the 2018 audit, IMARPE reports low interactions of the fishery with seabirds (ECOS 2018). However, report results were not available, and their accuracy is unclear. Also, there is no indication that the fishery implements seabird bycatch mitigation best practices. For these reasons, this factor is scored as high concern.

**Justification:**

The incidental catch of a variety of seabirds with pelagic longline gear has been well-documented. Birds attempting to forage on baited hooks often become hooked or entangled in the lines and ultimately drown as the gear sinks. Jahncke et al. (2001) estimate 5-13% of the pooled population of waved and Chatham Island albatrosses are caught in Peru’s artisanal longline fisheries per year. In addition to the risk associated with interaction with gear, Pro Delphinus (2006) reported targeted capture and consumption of waved albatrosses, and other seabirds by Peruvian gillnet crews. While this practice may not be widespread, the estimated hunting of a few hundred birds per year (Pro Delphinus 2006) can nonetheless have egregious population consequences.

Reducing adult mortality associated with fishery bycatch is crucial to waved albatross recovery (Anderson et al 2011). Using fresh or thawed bait, blue-dyed bait, tori lines and setting hooks at night have been demonstrated to greatly reduce incidental seabird capture (Jahncke et al 2001)(Gilman 2011)

**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

**PERU/ SOUTHEAST PACIFIC**

Drifting Longlines

**< 100%**

Discard rates are unknown for the mahi mahi fisheries in Peru. The average discard rate in tuna longline fisheries worldwide is 22% (Kelleher 2005). We have awarded a score of <100%.

GALAPAGOS PETREL

**Factor 2.1 - Abundance**

**PERU/ SOUTHEAST PACIFIC**

Drifting Longlines

**High Concern**

According to the International Union for Conservation of Nature (IUCN), Galapagos petrel is classified as "Critically endangered" with a decreasing population trend (BirdLife International 2018). Due to the "Critically endangered" IUCN status and high vulnerability to fishing interactions leads to a Seafood Watch score of "high" concern.

## Factor 2.2 - Fishing Mortality

### PERU/ SOUTHEAST PACIFIC

Drifting Longlines

#### High Concern

Seabird bycatch in Peru's surface fishery for dolphinfish was estimated at 0.021 (+/- 0.043) seabirds per 1000 hooks (range from 0 to 0.1333, n=591) (Mangel 2012). The available national fishing effort for the Peruvian longline vessels was ~80 million hooks annually with an estimate of 80,000 fishing trips annually. The author estimated that combined longline fisheries in Peru catch ~5,000 seabirds annually. Mangel (2012) concluded that more regional research and monitoring/observer data are needed.

(Awkerman et al 2006) estimated, through mark-recapture data, that annual adult survival from 1995-2005 was lower than historical estimates. The same study reported data from 30 observed trips - 8 in Callao and 22 in Salaverry. In Callao there were no albatrosses, and in Salaverry, 3 out of the 22 trips reported albatross with 1, 2 and 9 albatrosses each (a total of 12 albatross). However, fishing effort has increased significantly in recent years and information on the interaction of longlines with protected birds species is mainly qualitative (FCI 2012).

Considering that the most recent, annual, global estimate of seabird mortality in longline fisheries is ~160,000, that a large portion of those are albatrosses and large petrels (Anderson et al 2011), that albatross and petrel populations are highly vulnerable to fisheries interactions, and this fishery's contribution is unknown, we are scoring this factor as high concern.

#### Justification:

Bycatch of seabirds in longline fisheries occurs when birds attack baited hooks and become hooked and drown as the line sinks (Brothers 1991). This is particularly more common with albatrosses and large petrels due to their nature to scavenge on food items near the sea surface (Brothers et al 2010).

The volume and reliability of bycatch information is still limited for many fisheries, particularly artisanal fisheries (Phillips et al 2016). In Peru, the FIP-related observer program reported that interaction of the mahi mahi fishery with bird species is "very rare" (ECOS 2018) but quantitative information was not available.

## 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
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<100%	1
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>=100	0.75
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### PERU/ SOUTHEAST PACIFIC

Drifting Longlines

< 100%

Discard rates are unknown for the mahi mahi fisheries in Peru. The average discard rate in tuna longline fisheries worldwide is 22% (Kelleher 2005). We have awarded a score of <100%.

## CHATHAM ALBATROSS

### **Factor 2.1 - Abundance**

#### **PERU/SOUTHEAST PACIFIC**

Drifting Longlines

#### **High Concern**

According to the International Union for Conservation of Nature (IUCN), Chatham albatross is classified as "Vulnerable" with a stable to increasing population trend (BirdLife International 2018). The vulnerable listing is due to its very small breeding range - it is restricted to one breeding site, rendering it susceptible to stochastic events and human impacts (Birdlife International 2020). Despite the stable/increasing population, the "Vulnerable" IUCN status and high vulnerability to fishing interactions leads to a Seafood Watch score of "high" concern.

### **Factor 2.2 - Fishing Mortality**

#### **PERU/SOUTHEAST PACIFIC**

Drifting Longlines

#### **High Concern**

Seabird bycatch in Peru's surface fishery for dolphinfish was estimated at 0.021 (+/- 0.043) seabirds per 1000 hooks (range from 0 to 0.1333, n=591) (Mangel 2012). The available national fishing effort for the Peruvian longline vessels was ~80 million hooks annually with an estimate of 80,000 fishing trips annually. The author estimated that combined longline fisheries in Peru catch ~5,000 seabirds annually. Mangel (2012) concluded that more regional research and monitoring/observer data are needed.

(Awkerman et al 2006) estimated, through mark-recapture data, that annual adult survival from 1995-2005 was lower than historical estimates. The same study reported data from 30 observed trips - 8 in Callao and 22 in Salaverry. In Callao there were no albatrosses, and in Salaverry, 3 out of the 22 trips reported albatross with 1, 2 and 9 albatrosses each (a total of 12 albatross). However, fishing effort has increased significantly in recent years and information on the interaction of longlines with protected birds species is mainly qualitative (FCI 2012).

Considering that the most recent, annual, global estimate of seabird mortality in longline fisheries is ~160,000, that a large portion of those are albatrosses and large petrels (Anderson et al 2011), that albatross and petrel populations are highly vulnerable to fisheries interactions, and this fishery's contribution is unknown, we are scoring this factor as high concern.

#### **Justification:**

Bycatch of seabirds in longline fisheries occurs when birds attack baited hooks and become hooked and drown as the line sinks (Brothers 1991). This is particularly more common with albatrosses and large petrels due to their nature to scavenge on food items near the sea surface (Brothers et al 2010).

The volume and reliability of bycatch information is still limited for many fisheries, particularly artisanal fisheries (Phillips et al 2016). In Peru, the FIP-related observer program reported that interaction of the mahi mahi fishery with bird species is "very rare" (ECOS 2018) but quantitative information was not available.

### 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

#### PERU/SOUTHEAST PACIFIC

Drifting Longlines

**< 100%**

Discard rates are unknown for the mahi mahi fisheries in Peru. The average discard rate in tuna longline fisheries worldwide is 22% (Kelleher 2005). We have awarded a score of <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**

<b>Fishery</b>	<b>Management Strategy</b>	<b>Bycatch Strategy</b>	<b>Research and Monitoring</b>	<b>Enforcement</b>	<b>Stakeholder Inclusion</b>	<b>Score</b>
Fishery 1: Peru/Southeast Pacific   Drifting longlines	Moderately Effective	Ineffective	NA	NA	NA	Red (1.000)

Peru is taking actions to manage the primary targeted and retained species and these are expected to be effective, but evidence that the strategy is being implemented successfully is lacking. Because this fishery does not implement circle hooks or seabird bycatch mitigation techniques, and the post-release survival of sea turtles and impacts to seabirds is unknown, we have scored bycatch strategy as ineffective.

The ineffective score for bycatch management (C3.2) drives the score for the entire Management Criterion to be red. It also prevents the scoring of C3.3-3.5). Therefore, information on Scientific Research and Monitoring, Enforcement, and Stakeholder inclusion (Criteria 3.3-3.5) are described below.

#### **C3.3: Scientific Research and Monitoring**

The Inter-American Tropical Tuna Commission (IATTC) has been working on a stock assessment of mahi mahi in the eastern Pacific Ocean {IATTC 2014}. Catch and effort data are reported to the IATTC by individual countries including Peru and Ecuador {IATTC 2014}. On a national level, although progress to design and

implement an observer program has been made through the FIP, the observer program is not currently in place {ECOS 2018}{Fisheryprogress.org 2020}. In addition, the IATTC has started a collaborative research plan for mahi mahi in the eastern Pacific Ocean (EPO) and binational meetings have been held between Peru and Ecuador to improve the regional management of the common fishery. Historical information regarding landings and catch rates trends are available and a National Management Plan (PAN Perico-Peru) aims to develop a sustainable mahi mahi fishery in Peru. Finally, catches are monitored at fishing sites by managers {PRODUCE 2016}.

Despite the great amount of research developed in country and regional level (through the IATTC), the scientific research and monitoring still lacks of some elements, such as an appropriate bycatch monitoring system, adequate observer coverage or video monitoring to ensure that goals are being met for both bycatch and retained species.

#### C3.4 Enforcement

The artisanal mahi fishery has a high level of informality along the supply chain, including a high number of vessels and fishers that have not been officially considered part of the fleet (see executive summary). In addition, the scarcity of control or appropriate follow-up to the extractive activity encourages the entry of informal or illegal seafood into formal and legal channels of the supply chain {Amoros et al. 2017}. In this regard, the 2018 FIP audit suggested to pay special attention to the impacts of the Legislative Decree that promotes the formalization of the artisanal fishing activity (DL N ° 1392-2018) through the Artisanal Fishery Formalization System (known in Spanish as SIFORPA), which although it seeks to advance the formalization of the informal fleet, it also encourages the construction of new vessels by increasing the potential fishing effort of the mahi mahi fleet.

Finally, according to the same audit report, the FIP recommended a number improvement actions to enforcement of regulations as follows: 1) an analysis of the inefficiencies of the system, 2) increases in the capacity of fishery inspectors, 3) review of and updates to the sanction mechanisms, and 4) incorporation of CCTV at landings points and creation of workshops to raise awareness among fishers of fishing regulations {ECOS 2018}. Based on the most recent review of progress, authors confirmed that enforcement and/or monitoring is believed to be inadequate.

#### C3.5 Stakeholder Inclusion

There is an international cooperative framework between countries of the IATTC that includes a set of agreements and policies that govern the actions of all the authorities and actors involved (IATTC).

On a national level, the General Fisheries Law (LGP) has mechanisms of conflict resolution and respect for fishers' rights, although the effectiveness of this process is unclear. As part of the FIP, a participatory process was developed for creating the mahi mahi FIP Action Plan {ECOS 2018}, but the National Action Plan (PAN-Perico) was developed by managers with no participation of other stakeholders. Finally, although there is a formal consultation processes that provides the opportunity to all stakeholders to provide feedback, this seems ineffective.

### **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 managers 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.*

## PERU/ SOUTHEAST PACIFIC

### Drifting Longlines

#### **Moderately Effective**

Although currently there is no mahi mahi management plan in place in Peru, some measures have been taken to try to reduce the impact of the fleet on recruitment. One of these measures includes the minimum landing size of 70 mm fish fork length (Ministerial Resolution No 249-2011-Produce). Also, in 2013, a National Fishery Improvement Project (FIP) was launched, the FIP aims to bring the fishery to the levels of an MSC certification. As part of this FIP, a Fishery Action Plan for Dolphinfinch (or PAN Perico for its name in Spanish) was also launched in 2016 (PRODUCE 2016).

There has been progress since the implementation of the Peruvian mahi mahi FIP, in July 2014, a closed season was implemented for the mahi mahi fishery (Ministerial Resolution N° 245-2014-PRODUCE) from May 1st to September 30th (PRODUCE 2016).

Longline fleets are also managed regionally by the Inter-American Tropical Tuna Commission (IATTC). The IATTC has recently addressed the broader ecosystem implications of some EPO fishing practices and has supported several measures to reduce the impacts of longline fishers on shark populations (IATTC 2013). Among these are a prohibition on the retention and sale of oceanic white tip sharks (Resolution C-11-10, 2011), catch restrictions for longline caught silky shark (Resolution C-16-06), and the soliciting of funding to support the development of technologies to allow for the release, and post-release monitoring of sharks and rays (Resolution C-04-05, 2016) (IATTC 2016). As a member of IATTC, Peru is bound by these guidelines.

The shark fishery in Peru is regulated by the Ministerial Resolution (RM) N° 209-2001-PE from the Ministry of Production, Vice-Ministry of Fisheries. It establishes the shark minimum length that can be landed, the maximum tolerance of captured individuals under the minimum length. The minimum length at capture applies to five species and one genus: blue shark, shortfin mako, smooth-hounds (*Mustelus whitneyi*, *M. mento*), spotted hound shark (*Triakis maculata*) and species of the genus *Carcharhinus* (Gonzalez-Pestaña et al 2016). Finally, although the IATTC is committed to support the research related to the mahi in the region, it is clear that management based on that research relies on the individual countries (SC 2019). In addition, the supreme decree #021-2016-PRODUCE established several measures to control shark fishing in Peru, among the most important, shark finning is prohibited, as well as the specific landings sites (Decree 021-2016-PRODUCE 2017)

We have awarded a score of "moderate" concern because Peru is taking actions to manage the main primary targeted and retained species, and these are expected to be effective, but evidence that the strategy is being implemented successfully is lacking.

#### **Justification:**

The objectives of both the FIP and the PAN are:

- Promote the implementation of effective frameworks for biological, ecological and fisheries research on the resource.
- Design and implement an information, follow-up, monitoring and evaluation system for the production chain of the dolphin fish
- Strengthen the regulatory framework by developing fisheries management measures.
- Reduce by-catch of non-target fisheries.
- Contribute to the protection of biological diversity and the structure and function of the ecosystem.
- Identify and evaluate threats to the species population, as well as determine and protect their habitats and
- Encourage the development of education, training, and technical assistance programs that promote

conservation and sustainable use of the resource (PRODUCE 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.*

#### PERU/SOUTHEAST PACIFIC

Drifting Longlines

##### Ineffective

Peru has implemented a law that protects threatened marine turtles (Decree No. 004-2014-MINAGRI 2014) and prohibits the use of the species for commercial purposes. Since 1995, Ministry Resolution No.103-95-PE also prohibits targeting of these species. In addition, in 1999, Peru ratified its commitment to the Inter American Convention to the Protection and Conservation of Marine Turtles (CIT). Finally, and most recently, the National Action Plan for the Conservation of Marine Turtles in Peru was launched in 2019 (SERFOR 2019). The main goal is to decrease turtle mortality from anthropogenic sources, in particular as part of fishing activities (specific objective 1 of the Plan) (SERFOR 2019).

Peru implemented a monitoring program, that used vessel observers to record sea turtle bycatch (ACOREMA 2017) and between 2004-2009 circle hooks were tested in the fishery as an alternative to reduce turtle interactions, as a result fewer sea turtles interacted with the circle hooks interacted (36.7% C-14 and 25% C-15) than with "J" hooks (63.3% J-14 and 75% J-15) (Valqui et al 2017). The report also found that mahi catches were reduced when using circle hooks (from 65.1% to 34.9% with size 14 and 66.7% to 33.3% with size 15) (Valqui et al 2017). This factor and the cost associated with the switch from "J" hooks to circle hooks led participants to approach turtle bycatch problems with a training program to implement proper handling and release techniques (Valqui et al 2016). There is no information on the effectiveness or post-release survival of the handling techniques.

Regarding seabird bycatch, according to (Ayala and Sanchez 2014) impacts are minimal (*e.g.*, the report mentioned interaction with only two petrels during one year); however, the report only followed nine vessels, which represented ~1.3% of the fishing effort. There are no seabird bycatch mitigation measures in place.

No information is available on ghost fishing or measures to retrieve lost gear in this fishery.

Although the sea turtle handling techniques may be effective, evidence of their effectiveness is not available. Because this fishery does not implement circle hooks or seabird bycatch mitigation techniques, and the post-release survival of sea turtles and impacts to seabirds is unknown, we have scored bycatch strategy as ineffective.

### Factor 3.3 - Scientific Research and Monitoring

*Considerations: How much and what types of data are collected to evaluate the fishery's impact on the species? Is there adequate monitoring of bycatch? To achieve a Highly Effective rating, regular, robust population*

*assessments must be conducted for target or retained species, and an adequate bycatch data collection program must be in place to ensure bycatch management goals are met.*

### **Factor 3.4 - Enforcement of Management Regulations**

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

### **Factor 3.5 - Stakeholder Inclusion**

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

## **Criterion 4: Impacts on the Habitat and Ecosystem**

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

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

### **GUIDING PRINCIPLES**

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

*Rating cannot be Critical for Criterion 4.*

### **Criterion 4 Summary**

<b>Region   Method</b>	<b>Gear Type and Substrate</b>	<b>Mitigation of Gear Impacts</b>	<b>EBFM</b>	<b>Score</b>
<b>Peru/Southeast Pacific   Drifting longlines</b>	5	0	Moderate Concern	Green (3.873)

### **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**

**PERU/ SOUTHEAST PACIFIC**

Drifting Longlines

**5**

Pelagic longline gears fish in the middle of the water column and therefore do not impact bottom habitats. We have therefore awarded a score of "no impact."

**Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts**

**PERU/ SOUTHEAST PACIFIC**

Drifting Longlines

**0**

Pelagic longline fishing gear does not come in contact with bottom habitats; therefore, no mitigation methods are needed.

**Factor 4.3 - Ecosystem-Based Fisheries Management**

**PERU/ SOUTHEAST PACIFIC**

Drifting Longlines

**Moderate Concern**

Pelagic longline fisheries that operate in the eastern Pacific Ocean and target mahi mahi catch ecologically important species including other tunas and sharks. Sharks are apex predators in many ecosystems and play a critical role in how these ecosystems are structured and function (Piraino 2002). The loss of these predators can cause many changes, such as to prey abundances, which can lead to a cascade of other affects (Myers et al 2007)(Duffy 2003)(Ferreti et al 2010) and behavioral changes (Heithaus et al 2007). In addition, impacts on turtles are unknown but could be substantial, considering the endangered status of some of them. Also, Mahi is the most commonly reported fish species caught incidentally in the EPO purse-seine and longline fisheries and it is also one of the most important species caught in the artisanal fisheries of the coastal nations of the EPO, which led to an exploratory stock assessment in 2016 (Aires da Silva et al 2016).

It does not appear that Peru has included ecosystem management into fishery management plans, but they are a party to the IATTC. IATTC has objectives that address incorporating ecosystem considerations into management (IATTC 2019), and work has been done within IATTC to create ecosystem-based models and other types of analysis. IATTC considered management measures aimed at protecting dolphins, sea turtles, and seabirds as addressing ecosystem considerations (IATTC 2012). We have therefore awarded a score of "moderate" concern, instead of "high" concern.

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## **References**

- Abreu-Grobois, A & Plotkin, P. (IUCN SSC Marine Turtle Specialist Group). 2008. *Lepidochelys olivacea*. The IUCN Red List of Threatened Species 2008: e.T11534A3292503.
- ACOREMA, 2017. Informe sobre la aplicabilidad del manual para el manejo y liberación de tortugas marinas para pescadores.
- Aires da Silva, A., Valero, J.L., Maunder, M., Mente-Vera, C., Lennert-Cody, C., Roman, M.H., Martinez-Ortiz, J., Torrejon-Magallanes, E.J. and Carranza, M.N. 2016. Exploratory stock assessment of dorado (*Coryphaena hippurus*) in the southeastern Pacific Ocean. Seventh Meeting Scientific Advisory Committee.
- Alfaro-Shigueto, J., et al., Where small can have a large impact: Structure and characterization of small-scale fisheries in Peru. *Fish. Res.* (2010), doi:10.1016/j.fishres.2010.06.004
- Amorim, A., Baum, J., Cailliet, G.M., Clò, S., Clarke, S.C., Fergusson, I., Gonzalez, M., Macias, D., Mancini, P., Mancusi, C., Myers, R., Reardon, M., Trejo, T., Vacchi, M. & Valenti, S.V. 2009. *Alopias superciliosus*. The IUCN Red List of Threatened Species 2009: e.T161696A5482468.
- Amorós, S., Gozzer, R., Melgar, V. y Rovegno, N. 2017. La pesquería del perico (*Coryphaena hippurus*) en el Perú: caracterización y análisis de la cadena productiva. Programa Marino de WWF-Perú. Lima-Perú.
- Anderson, D., K. Huyvaert, D. Wood, C. Gillikin, B. Frost, H. Mouritsen. 2003. At-sea distribution of waved albatrosses and the Galapagos Marine Reserve. *Biological Conservation* 110: 367-373.
- Anderson, David & Huyvaert, Kathryn (Kate) & Wood, Dana & Gillikin, Cynthia & Frost, Barrie & Mouritsen, Henrik. (2003). At-sea distribution of Waved Albatrosses and the Galápagos Marine Reserve. *Biological Conservation*. 110. 367-373. 10.1016/S0006-3207(02)00238-0.
- Anderson, O. R. J., Small, C. J., Croxall, J. P., Dunn, E. K., Sullivan, B. J., Yates, O., et al. (2011). Global seabird bycatch in longline fisheries. *Endanger. Species Res.* 14, 91–106. doi: 10.3354/esr00347
- Andraka, S., Mug, M., Hall, M., Pons, M. et al. 2013. Circle hooks: developing better fishing practices in the artisanal longline fisheries of the eastern Pacific Ocean. *Biological Conservation* 160:214-223.
- AWI. 2018. International shark finning bans and policies. Animal Welfare Institute.
- Awkerman, Jill & Huyvaert, Kathryn (Kate) & Mangel, Jeffrey & Alfaro Shigueto, Joanna & Anderson, David. (2006). Incidental and intentional catch threatens Galápagos waved albatross. *Biological Conservation*. 133. 483-489. 10.1016/j.biocon.2006.07.010.
- Awkerman, J.A., Huyraert, K.P, Mangel, J., Alfaro Shingueto, J.A. (2006). Incidental and intentional catch threatens Galapagos waved Albatross. *Biological Conservation* 133, 483- 489.
- Ayala L. & R. Sánchez-Scaglioni. 2014. Captura, esfuerzo y captura incidental de la pesca con espinel en el centro de Perú. *Revista peruana de biología* 21(3): 243 - 250 (Diciembre 2014). doi: <http://dx.doi.org/10.15381/rpb.v21i3.10898>
- Baum, J., Clarke, S., Domingo, A., Ducrocq, M., Lamónaca, A.F, Gaibor, N., Graham, R., Jorgensen, S., Kotas, J.E., Medina, E., Martinez- Ortiz, J., Monzini Taccone di Sitizedano, J., Morales, M.R., Navarro, S.S., Pérez, J.C., Ruiz, C., Smith, W., Valenti, S.V. & Vooren, C.M. 2007. *Sphyrna lewini* (Eastern Central and Southeast Paci??c

subpopulation). The IUCN Red List of Threatened Species. Version 2014.3.

Beardsley, G.L., 1967. Age, growth, and reproduction of the dolphin, *Coryphaena hippurus*, in the Straits of Florida. *Copeia* 1967(2):441-451. [https://www.jstor.org/stable/1442132?seq=1#page\\_scan\\_tab\\_contents](https://www.jstor.org/stable/1442132?seq=1#page_scan_tab_contents)

BirdLife International 2018. *Pterodroma phaeopygia*. The IUCN Red List of Threatened Species 2018: e.T22698020A132619647. <https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22698020A132619647.en>.

BirdLife International 2018. *Phoebastria irrorata*. The IUCN Red List of Threatened Species 2018: e.T22698320A132641638. <https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22698320A132641638.en>. Downloaded on 17 March 2020.

BirdLife International 2018. *Thalassarche eremita*. The IUCN Red List of Threatened Species 2018: e.T22698393A132644476. <https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T22698393A132644476.en>.

Brothers, N.P. (1991). Albatross mortality and associated bait loss in the Japanese longline fishery in the Southern Ocean. *Biol Conserv* 55:255–268

Brothers N., Duckworth A.R., Safina C., Gilman E.L. (2010). Seabird Bycatch in Pelagic Longline Fisheries Is Grossly Underestimated when Using Only Haul Data. *PLoS ONE* 5(8): e12491. <https://doi.org/10.1371/journal.pone.0012491>

Cailliet, G.M., Cavanagh, R.D., Kulka, D.W., Stevens, J.D., Soldo, A., Clo, S., Macias, D., Baum, J., Kohin, S., Duarte, A., Holtzhausen, J.A., Acuña, E., Amorim, A. & Domingo, A. 2009. *Isurus oxyrinchus*. The IUCN Red List of Threatened Species 2009: e.T39341A10207466.

Castillo, G., Fernandez J., Medina, A., and Guevara-Carrasco, R. 2018. Tercera encuesta estructural de la pesquería artesanal en el litoral peruano. Resultados generales. Instituto del Mar del Perú INFORME ISSN 0378-7702 Volumen 45, Número 3, Julio - septiembre 2018 [Inf. Inst. Mar Perú 45(3)]

Clarke, S. 2013. Towards and integrated shark conservation and management measure for the Western and Central Pacific Ocean. Pacific Islands Regional Office and National Oceanic and Atmospheric Administration. WCPFC-SC9-2013/EB-WP-08.

Collette, B.B., 1999. *Coryphaenidae*. Dolphinfishes, "dolphins". p. 2656-2658. In K.E. Carpenter and V.H. Niem (eds.) *FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Volume 4. Bony fishes part 2 (Mugilidae to Carangidae)*. FAO, Rome.

Collette, B., Acero, A., Amorim, A.F., Boustany, A., Canales Ramirez, C., Cardenas, G., Carpenter, K.E., de Oliveira Leite Jr, N., Di Natale, A., Fox, W., Fredou, F.L., Graves, J., Viera Hazin, F.H., Juan Jorda, M., Minte Vera, C., Miyabe, N., Montano Cruz, R., Nelson, R., Oxenford, H., Schaefer, K., Serra, R., Sun, C., Teixeira Lessa, R.P., Pires Ferreira Travassos, P.E., Uozumi, Y. & Yanez, E. 2011. *Coryphaena hippurus*. The IUCN Red List of Threatened Species 2011: e.T154712A4614989.

Decree #195 2018. Pesquería del tiburón martillo *Sphyrna zygaena* y proyecciones de pesca 2018

Decree 021-2016-PRODUCE 2017. Decreto Supremo que modifica el Decreto Supremo N° 021-2016-PRODUCE, que establece medidas de ordenamiento para la pesquería del recurso tiburón

Decreto Supremo que aprueba la actualización de la lista de clasificación y categorización de las especies amenazadas de fauna silvestre legalmente protegidas.

- Delgado-Trejo, C. & Alvarado-Diaz. 2012. Current conservation status of the black sea turtle in Michoacan, Mexico. In: Seminoff, J.A. & B.P. Wallace (Eds.). *Sea Turtles of the Eastern Pacific: Advances in Research and Conservation*. University of Arizona Press, Tucson. 386 pp.
- Doherty PD, Alfaro-Shigueto J, Hodgson DJ, Mangel JC, Witt MJ, Godley BJ (2014) Big catch, little sharks: insight into Peruvian small-scale longline fisheries. *Ecol Evol* 4: 2375-2383
- Duffy, J.E. 2003. Biodiversity loss, trophic skew and ecosystem functioning. *Ecology Letters* 6:680-687.
- ECOS 2018. Third Review of the Peru Mahi Mahi FIP. Peru Mahi mahi (*Coryphaena hippurus*) Fishery Improvement Project (FIP). December 2018.
- El Peruano, 2018. Establecen los límites de captura del recurso tiburón martillo aplicable a las actividades extractivas efectuadas por la flota artesanal correspondiente al período 2018 RESOLUCIÓN MINISTERIAL N° 188-2018-PRODUCE
- El Peruano, 2020. Establecen límite de captura del recurso tiburón martillo, correspondiente al período 2020. RESOLUCIÓN MINISTERIAL N° 127-2020-PRODUCE
- FAO. 2004. Species Fact Sheet: *Coryphaena hippurus*.
- Food Certification International Ltd. FCI. Peruvian Artisanal Long Line Mahi Mahi Fishery. Final Pre-Assessment Report. December 2012.
- FCI, 2012. MSC SUSTAINABLE FISHERIES CERTIFICATION Peruvian Artisanal Long Line Mahi Mahi Fishery Final Pre-Assessment Report
- Ferretti, F., B. Worm, G.L. Britten, M.R. Heithaus, H.K. and Lotze. 2010. Patterns and ecosystem consequences of shark declines in the ocean. *Ecology Letters*, 13: 1055– 1071.
- Fischer J, Erikstein K, D'Offay B, Guggisberg S, Barone M (2012) Review of the implementation of the International Plan of Action for the Conservation and Management of Sharks. FAO, Rome
- FR. 2015. Endangered and threatened species; identification and proposed listing of eleven distinct population segments of green sea turtles (*Chelonia mydas*) as endangered or threatened and revision of current listings. FR 80 FR 15271.
- Froese R., D. Pauly. 2018. Fishbase. .
- Gilman, E. 2011. Bycatch governance and best practice mitigation technology
- Gonzalez-Pestana A, Kouri J. C and Velez-Zuazo X. Shark fisheries in the Southeast Pacific: A 61-year analysis from Peru [version 2; peer review: 1 approved, 2 approved with reservations] *F1000Research* 2016, 3:164 (<https://doi.org/10.12688/f1000research.4412.2>)
- Heithaus, M.R., Frid, A., Wirsing, A.J., Dill, L.M., Fourqurean, J.W., Burkholder, D., Thomson, J. and Bejder, L. 2007. State-dependent risk taking by green sea turtles mediates top-down effects of tiger shark intimidation in a marine ecosystem. *Journal of Animal Ecology* 76:837-844.
- Inter-American Convention for the Protection and Conservation of Sea Turtles PERU. Annual Report 2017

IATTC. 2012. Ecosystem considerations. Document SAC-02-12.

Inter-American Tropical Tuna Commission (IATTC). 2013d. Bycatch management. 4th Meeting of the Scientific Committee, 29 April - 3 May, 2013, La Jolla, CA.

IATTC. 2014. Report of the 1st technical meeting on dorado. Inter-American Tropical Tuna Commission. Available at:

IATTC. 2016. Updated stock status indicators for silky sharks in the eastern Pacific Ocean (1994-2015). Document SAC-07-06b.i. Seventh Meeting of the Scientific Advisory Committee, 9-13 May, 2016.

IATTC. 2017. Tunas, billfishes and other pelagic species in the eastern Pacific Ocean. Fishery Status Report 15. Available at: [http://www.iattc.org/PDFFiles/FisheryStatusReports/\\_English/FisheryStatusReport15.pdf](http://www.iattc.org/PDFFiles/FisheryStatusReports/_English/FisheryStatusReport15.pdf)

IATTC. 2018. Tunas billfishes and other pelagic species in the eastern Pacific Ocean in 2017.

IATTC 2019. REPORT ON THE TUNA FISHERY, STOCKS, AND ECOSYSTEM IN THE EASTERN PACIFIC OCEAN IN 2018

IATTC. 2019a. Stock status indicators for yellowfin tuna in the Eastern Pacific Ocean. Document SAC-10-08.

IATTC. 2019b. Status of yellowfin tuna in the EPO in 2018 and outlook for the future. SAD-10-07

IATTC. 2019c. Stock status indicators for skipjack tuna in the Eastern Pacific Ocean. Document SAC-10-09.

IATTC. 2020c. Benchmark Assessment for yellowfin tuna in the EPO, 2019.

IATTC. 2020b. Risk analysis for management of the tropical tuna fishery in the EPO, 2020.

Inter-American Tropical Tuna Commission (IATTC). 2013. Stock status of the silky shark in the Eastern Pacific Ocean. 4th Meeting of the IATTC Scientific Advisory Meeting, 29 April - 3 May, 2013, La Jolla, Ca.

IATTC b. 2012. Status of the tuna and billfish stocks in 2010. Stock assessment report 12. Inter-American Tropical Tuna Commission.

IATTC. 2018b. Status of yellowfin tuna in the eastern Pacific Ocean in 2017 and outlook for the future. Document SAC-09-06.

ICCAT 2016. Comisión Interamericana del Atún Tropical Colección y manejo de los datos de dorado en la pesquería atunera con red de cerco en el Océano Pacífico oriental (OPO).

ISC. 2015. Indicator-based analysis of the status of shortfin mako shark in the North Pacific Ocean. Report of the Shark Working Group. Available at:

ISC. 2017. Stock assessment and future projections of blue shark in the north Pacific Ocean through 2015. International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean.

ISC. 2018. Stock assessment for swordfish (*Xiphias gladius*) in the western and central north Pacific Ocean through 2016. Report of the Billfish Working Group.

ISC. 2018b. Stock assessment of shortfin mako sharks in the North Pacific Ocean through 2016. WCPFC-SC14-

Jahncke, J, Goya, E., Guillen, A., 2001. Seabird bycatch in small-scale longline fisheries in Northern Peru. *Waterbirds* 24, 137-141.

Jiménez-Uzcátegui, Gustavo & Mangel, Jeffrey & Alfaro Shigueto, Joanna & Anderson, Dave. (2006). Fishery bycatch of the waved albatros *P. irrorata*, a need for implementation of agreements. *Galapagos Research*. 64. 7-9.

Jones, T.T., Bostrom, B.L., Hastings, M.D., Van Houtan, K.S., Pauly, D. and Jones, D.R. 2012. Resource requirements of the Pacific leatherback turtle population. *PLoS ONE* 7:e45447/dpi:10.1371/journal.pone.0045447.

Kelleher, K. 2005. Discards in the world's marine fisheries an update. *FAO Fisheries Technical Paper* 470.

Mangel, J.C. 2012. Interactions of Peruvian small scale fisheries with threatened marine vertebrate species. Thesis for the degree of Doctor of Philosophy in Biological Sciences. University of Exeter. Cornwall, UK. 169 pp.

Martínez-Ortiz, j. & M. Zuniga-flores (eds.) 2012 case study. Current state of knowledge of the gold resource (*Coryphaena hippurus*) Linnaeus, 1758 in waters of the Southeast Pacific Ocean (2008-2011). Ministry of agriculture, livestock and fisheries (MAGAP) - Marine Stewardship Council (MSC) - School of fisheries in the Eastern Pacific (EPESPO). Manta, Ecuador: 121 pp

Maunder, M. 2017. Updated indicators of stock status for skipjack tuna in the eastern Pacific Ocean. Document SAC-08-04c.

McBride R.S., D.J.G. Snodgrass, D.H. Adams, S.J. Rider, J.A. Colvocoresses. 2012. An indeterminate model to estimate egg production of the highly iteroparous and fecund fish, dolphinfish *Coryphaena hippurus*). *Bulletin of Marine Science* 88: 283-303.

Miller, M. H., Carlson, J., Cooper, P., Kobayashi, D., Mannack, M. and Wilson, J. 2013. Status review report: scalloped hammerhead shark (*Sphyrna lewini*). National Marine Fisheries Service.

Minte-Vera, C., Aires-da-Silva, A. and Maunder, M. 2017. Status of yellowfin tuna in the eastern Pacific Ocean in 2016 and outlook for the future. Document SAC-08-04b.

Mortimer, J.A & Donnelly, M. (IUCN SSC Marine Turtle Specialist Group). 2008. *Eretmochelys imbricata*. The IUCN Red List of Threatened Species 2008: e.T8005A12881238.

Mortimer, J.A & Donnelly, M. (IUCN SSC Marine Turtle Specialist Group). 2008. *Eretmochelys imbricata*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2.

Myers, Baum, Shepherd, Powers, and Peterson. 2007 Cascading Effects of the Loss of Apex Predatory Sharks from a Coastal Ocean. 30 MARCH 2007 VOL 315 *SCIENCE* www.sciencemag.org

NMFS 2013. Estimated Loggerhead and Unidentified Hard-shelled Turtle Interactions in Mid-Atlantic Gillnet Gear, 2007-2011. NOAA Technical Memorandum NMFS-NE-225

NMFS. 2014. Scalloped hammerhead shark (*Sphyrna lewini*). NOAA Fisheries Office of Protected Resources.

NMFS. 2015. Pelagic thresher shark. Southwest Fisheries Science Center.

NMFS 2019. Species Directory, Loggerhead Turtle.

National Marine Fisheries Service. 2020. Fisheries Statistics and Economics Division. Foreign Trade

NOAA, TM, NMFS, and SWFSC, 2015. Status review of the green turtle (*Chelonia mydas*) under the endangered species act. NOAA Technical Memorandum NMFS.

Olson R.J., F. Galván-Magaña. 1996. Food habits and consumption rates of common dolphinfish (*Coryphaena hippurus*) in the eastern Pacific Ocean. *Ciencias Marinas* 100: 279-298.

Oxenford, H. A. 1999. Biology of the dolphinfish (*Coryphaena hippurus*) in the western central Atlantic: a review, *Sci. Mar.*, 63(3-4): 277-301.

Parga. 2012. Hooks and sea turtles: a veterinarian's perspective. *Bulletin of Marine Science* 88:731-741. doi: 10.5343/bms.2011.1063

Parga, M.L, Pons, M., Andracka, S., Rendon, L., Mituhasi, T., Hall, M., Pacheco, L., Segura, A., Osmond, M. and Vogel, N. 2015. Hooking locations in sea turtles incidentally captured by artisanal longline fisheries in the eastern Pacific Ocean. *Fisheries Research* 164:231- 237.

R.A. Phillips, Gales B., Baker, G., Double M.C., Favero, M., Quintana F., Tasker, M.L., Weimerskirch, H., Uhart M., and Wolfaardt A. 2016. The conservation status and priorities for albatrosses and large petrels. *Biological Conservation* 201 (2016) 169–183

Piraino, S., Fanelli, G., Boero, F. 2002. Variability of species roles in marine communities: change of paradigms for conservation priorities. *Marine Biology* 140:1067-1074.

Polovina, J.J., M. Abecassis, E.A. Howell, P. Woodworth. 2009. Increases in the relative abundance of mid-trophic level fishes concurrent with declines in apex predators in the subtropical North Pacific , 1996 – 2006. *Fishery Bulletin*: 523-531.

Pro Delphinus, 2006. ASSESSMENT OF SEABIRD BYCATCH IN PERUVIAN ARTISANAL FISHERIES Final Report to the British Petroleum Conservation Programme.

PRODUCE 2016. Plan de Accion Nacional para la conservacion y manejo del recursos perico en el Peru (PAN Perico-Peru).

Reardon, M., Márquez, F., Trejo, T. & Clarke, S.C. 2009. *Alopias pelagicus*. The IUCN Red List of Threatened Species 2009: e.T161597A5460720.

Rigby, C.L., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Francis, M.P., Jabado, R.W., Liu, K.M., Marshall, A., Pacoureaux, N., Romanov, E., Sherley, R.B. & Winker, H. 2019. *Isurus oxyrinchus* . The IUCN Red List of Threatened Species 2019: e.T39341A2903170. <https://dx.doi.org/10.2305/IUCN.UK.2019-1.RLTS.T39341A2903170.en>. Downloaded on 18 March 2020.

Rigby, C.L., Sherman, C.S., Chin, A. & Simpfendorfer, C. 2017. *Carcharhinus falciformis*. The IUCN Red List of Threatened Species 2016: e.T39370A2909465.

Rigby, C.L., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Herman, K., Jabado, R.W., Liu, K.M., Marshall, A., Pacoureaux, N., Romanov, E., Sherley, R.B. & Winker, H. 2019. *Sphyrna zygaena* . The IUCN Red List of Threatened Species 2019: e.T39388A2921825. Downloaded on 18 March 2020.

- Rigby, C.L., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Francis, M.P., Herman, K., Jabado, R.W., Liu, K.M., Marshall, A., Pacoureaux, N., Romanov, E., Sherley, R.B. & Winker, H. 2019. *Prionace glauca*. The IUCN Red List of Threatened Species 2019: e.T39381A2915850.
- Schwenke K.L., J.A. Buckel. 2008. Age, growth and reproduction of dolphinfish (*Coryphaena hippurus*) caught off the coast of North Carolina. *Fisheries Bulletin* 106: 82-92.
- Seminoff, J.A. (Southwest Fisheries Science Center, U.S.). 2004. *Chelonia mydas*. The IUCN Red List of Threatened Species 2004: e.T4615A11037468.
- SERFOR. 2019. Plan Nacional de Conservación de las Tortugas Marinas en el Perú. Periodo 2019-2029.
- Solano-Sare A, Tresierra-Aguilar A, García-Nolasco V, Dioses T, Marín W, Sánchez C, et al. *Biología y pesquería del Perico*. Instituto del Mar Del Perú. 2008; 23.
- Spotila, J.R., Dunham, A.E., Leslie, A.J., Steyermark, A.C., Plotkin, P.T. and Paladino, F.V. 1996. Worldwide population decline of *Dermochelys coriacea*: are leatherback turtles going extinct? *Chelonian Conservation and Biology* 2:209-222
- Tsai, W., Liu, K. and Joung, S. 2010. Demographic analysis of the pelagic thresher shark, *Alopias pelagicus*, in the north-western Pacific using a stochastic stage-based model. *Marine and Freshwater Research* 61:1056-1066.
- Uchiyama J.H., C. Boggs. 2006. Length-weight relationships of dolphinfish, *Coryphaena hippurus* and wahoo, *Acanthocybium solandri*: Seasonal effects of spawning and possible migration in the Central North Pacific." *Marine Fisheries Review* 68: 19-29.
- Uchiyama, J.H., R.K. Burch and S.A. Kraul Jr., 1986. Growth of dolphins, *Coryphaena hippurus* and *C. equiselis* in Hawaiian waters as determined by daily increments on otoliths. *Fish. Bull.* 84(1):186-191.
- Valero J., Aires-da-Silva, A., and Maunder M. 2019. Potential Reference Points and Harvest Control Rules for Dorado (*Coryphaena hippurus*) in their Eastern Pacific Ocean. INTER-AMERICAN TROPICAL TUNA COMMISSION SCIENTIFIC ADVISORY COMMITTEE TENTH MEETING San Diego, California (USA) 13-17 May 2019
- Valqui, M., M. Pons, L. Rendón, S. Andracka, S. Amorós y M. Hall. 2016. Reducción de la captura incidental de tortugas marinas por la flota espinelera artesanal del Perú 2004-2009. Resumen del informe técnico. WWF-Perú/WWF LAC. 78 pp.
- Velez-Zuazo X, Alfaro-Shigueto J, Mangel J, Papa R, Agnarsson I (2015) What barcode sequencing reveals about the shark fishery in Peru. *Fish Res* 161:34-41
- Villagran et al. 2012. International Symposium on circle hooks in research, management and conservation - abstracts. *Bulletin of Marine Science* 88:791-815
- Wallace, B.P., Kot, C.Y., MiMatteo, A.D., Lee, T., Crowder, L.B. and Lewison, R.L. 2013. Impacts of Fisheries bycatch on marine turtle populations worldwide: toward conservation and research priorities. *Ecosphere* 4:40.
- Western Central Pacific Fisheries Commission, 2016. Assessment of blue shark in the southwestern Pacific. SCIENTIFIC COMMITTEE TWELFTH REGULAR SESSION Bali, Indonesia 3–11 August 2016. WCPFC-SC12-2016/SA-WP-08 REV1

Western Central Pacific Fisheries Commission. 2019. Stock Assessment of skipjack tuna in the western and central Pacific Ocean.

Whoriskey S., R. Arauz, J.K. Baum. 2011. Potential impacts of emerging mahi-mahi fisheries on sea turtle and elasmobranch bycatch species. *Biological Conservation* 144 (6): 1841-1849.

## **Appendix A: Extra By Catch Species**

### **SMOOTH HAMMERHEAD**

#### **Factor 2.1 - Abundance**

##### **PERU/ SOUTHEAST PACIFIC**

Drifting Longlines

##### **Moderate Concern**

Smooth hammerhead sharks have a widespread distribution in temperate and tropical seas (Froese and Pauly 2018). In the Eastern Pacific it has been reported from northern California to Chile. Due to its life history characteristics, the species has a low resistance to fishing exploitation, and the IUCN classified the species as vulnerable (Rigby et al 2019). In Peru, IMARPE reported that the population status indicators derived from the model determined that the hammerhead shark stock in Peruvian waters is at levels comparable to the optimum level of exploitation (Ministerial Resolution #127-2020-PRODCE) (El Peruano 2020). Researchers estimated the MSY at 510.5 t. Considering that the species is around the MSY (according to the Peruvian authorities) and the IUCN listing as vulnerable with a decreasing trend, we scored this factor as moderate concern for smooth hammerhead.

#### **Factor 2.2 - Fishing Mortality**

##### **PERU/ SOUTHEAST PACIFIC**

Drifting Longlines

##### **Moderate Concern**

IMARPE's 2018 "Report on the fishing activity of the hammerhead shark resource (*Sphyrna zygaena*) during 2017 and fishing projection 2018" (Decree #195 2018), concluded that the average biomass of Smooth hammerhead was below the biological reference point of  $K/2$  (El Peruano 2018). Based on this, PRODUCE decreed a precautionary TAC corresponding to  $2/3$  of  $F_{MSY}$  (in 442 t). By 2020, IMARPE researchers determined that the hammerhead shark stock in Peruvian waters was at levels comparable to the optimum level of exploitation (510.5 t) (El Peruano 2020). Based on this, managers recommended that the annual catch of the hammerhead shark (*Sphyrna zygaena*) should not exceed that obtained with a fishing mortality equivalent to  $2/3$   $F_{MSY}$  (453.7 t), a value that meets the objective of maintaining the annual catch levels of the species within a risk level of 35.6% (less than 50%).

Based on this information, it is likely that  $F$  is fluctuating around  $F_{MSY}$ , and for this reason, we scored this factor as moderate concern.

#### **Factor 2.3 - Discard Rate**

##### **PERU/ SOUTHEAST PACIFIC**

Drifting Longlines

##### **< 100%**

Discard rates are unknown for the mahi mahi fisheries in Peru. The average discard rate in tuna longline fisheries worldwide is 22% (Kelleher 2005). We have awarded a score of <100%.

### **BLUE SHARK**

## Factor 2.1 - Abundance

### PERU/ SOUTHEAST PACIFIC

Drifting Longlines

#### High Concern

The stock assessment for South Pacific blue sharks was attempted in 2016 by the Scientific Committee (SC) of the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPO)(WCPFC 2016) The authors concluded that the report can not be used to offer management advice due to uncertainties in the model parameters. Considering that the IUCN report, listed the species as near threatened with a decreasing population trend (Rigby et al 2019), the fact that there is conflicting information about stock status (based on the WCPO report) and there is no clear reason to suggest one set of information is more valid, we are scoring this factor as high concern concern.

#### Justification:

The SC was not able to calculate biological reference points for the species or estimate MSY due to substantial differences in unexploited stock size for model runs based on different historical catch estimates (WCPO 2016). Authors mentioned the need to improve the historical data and continue to collect catch, effort and size data, as well to improve information about biological parameters specific to blue shark in the South Pacific Ocean (WCPO 2016).

## Factor 2.2 - Fishing Mortality

### PERU/ SOUTHEAST PACIFIC

Drifting Longlines

#### Moderate Concern

The most recent attempt to assess the stock of blue sharks in the South Pacific was conducted in 2016 (WCPFC 2016). The Scientific Committee in charge of the report noted that the 2015 catch of south Pacific blue shark was 26% lower than in 2014, and 34% less than the average for 2010-14 (WCPO 2016). However, authors reported the need for more appropriate representation of fishing effort, especially regarding under-reporting of catches and the grouping of catches of all shark species into a generic 'shark' category (SCPO 2016). Overall, current levels of fishing mortality are unknown, but it is not clear if the levels are above a sustainable level that is appropriate for the species, for this reason we are scoring this factor as moderate concern.

## Factor 2.3 - Discard Rate

### PERU/ SOUTHEAST PACIFIC

Drifting Longlines

#### < 100%

Discard rates are unknown for the mahi mahi fisheries in Peru. The average discard rate in tuna longline fisheries worldwide is 22% (Kelleher 2005). We have awarded a score of <100%.

## YELLOWFIN TUNA

### Factor 2.1 - Abundance

## PERU/ SOUTHEAST PACIFIC

Drifting Longlines

### Low Concern

Annual recruitment of yellowfin has been near or below average since 2003 (IATTC 2019a), (IATTC 2019b), (IATTC 2018). The 2020 full assessment for yellowfin tuna estimated that  $SB_{2020}$  ranged from 49% - 219% of the target reference point  $SB_{MSY}$ . The probability that the spawning biomass at the beginning of  $SB_{2020}$  is lower than  $SB_{MSY}$  is 50% or less for 13/48 models. The risk analyses for yellowfin with model estimates aggregated indicate there is a 12% chance overall that  $SB_{2020}$  is lower than  $SB_{MSY}$  (IATTC 2020b) and the probability that the  $SB_{2020}$  is below the  $SB_{LRP}$  ranges from 0% - 2% (IATTC 2020c).

There are considerable discrepancies in results depending on selected model attributes and the steepness of the stock-recruit curve. Additional uncertainty relates to spatial structure and differing trends by fishery (longline, purse seine type, etc.) There are still models that estimate the yellowfin stock may be overfished (IATTC 2019a), however most model runs in aggregate indicate this is highly unlikely (IATTC 2020b; IATTC 2020c). In summary, there is some conflicting information about stock status; however the majority of models indicate this stock is not overfished, and yellowfin tuna receive a "low concern" score for abundance in the EPO.

### Justification:

Yellowfin tuna in the eastern Pacific Ocean were last fully assessed during the 2017 cycle (IATTC 2018). At that time, there was a high degree uncertainty concerning recent and future recruitment and biomass levels, with the potential for three different regimes since 1975 (IATTC 2018). In 2019, the IATTC was unable to reconcile the trend data for the full assessment model, so the assessment and management for 2019/20 yellowfin tuna abundance is based on a set of proxy indicators for the most recent year. Indicators from 2019 of relative abundance (CPUE across gear types, length) have been at low levels since 2010, however the average length of fish has increased (IATTC 2019a).

## Factor 2.2 - Fishing Mortality

### PERU/ SOUTHEAST PACIFIC

Drifting Longlines

### Low Concern

The average fishing mortality rate has been increasing for all age classes of yellowfin tuna since 2009 (IATTC 2019b), in large part due to increasing effort from object associated fisheries. The point estimate of the fishing mortality in 2017-2019 ranged from 40% - 168% of the  $F_{MSY}$  (IATTC 2020c). The probability that the fishing mortality of yellowfin in 2017-2019 is higher than the  $F_{MSY}$  level is 50% or more for only 14/48 models. The risk analyses with aggregated model runs indicates that there is only 9% chance that  $F > F_{MSY}$  (IATTC 2020b). Additionally, the point estimate of the  $F_{2017-2019}$  ranged from 22% - 65% of the LRP (IATTC 2020c). The probability that the fishing  $F_{2017-2019} > F_{LRP}$  was estimated to be zero for all models (IATTC 2020b). In summary, the majority of models indicate that  $F$  is within target and limit reference points, and yellowfin tuna receive a "low concern" score for fishing mortality.

## Factor 2.3 - Discard Rate

### PERU/ SOUTHEAST PACIFIC

Drifting Longlines

< 100%

Discard rates are unknown for the mahi mahi fisheries in Peru. The average discard rate in tuna longline fisheries worldwide is 22% (Kelleher 2005). We have awarded a score of <100%.

## SKIPJACK TUNA

### **Factor 2.1 - Abundance**

#### **PERU/ SOUTHEAST PACIFIC**

Drifting Longlines

#### **Low Concern**

Due to the complexity associated with skipjack tuna stock assessments (neither biomass or fishing mortality reference points are available), the latest skipjack tuna assessment is based on indicators to assess relative trends in biomass. According to the indicators tracked and associated simplistic stock assessment, both skipjack biomass and recruitment have been increasing over the past 20 years, and were above their respective upper reference levels in 2015 and 2016. However, the average skipjack weight was at or below its lower reference level 2015-2017. A high degree of uncertainty exists with regards to stock status, however, most indicators and model-estimates suggest the skipjack population is moderately stable (it does not appear to be any indication the population is overfished) (IATTC 2019c), and skipjack tuna receives a "low concern" score for abundance.

#### **Justification:**

Skipjack tuna are a challenging species to assess due to high and variable productivity (annual recruitment is a large proportion of total biomass) and challenges around estimating the impacts of fishing mortality (IATTC 2019c). In response, the IATTC evaluates eight indicators to track skipjack tuna biomass and recruitment relative to historic levels. Indicators include: skipjack catch, standardized effort (sum of days of fished for FAD and NOA fisheries), catch per unit effort (CPUE). A simple stock assessment is also used to estimate proxies of biomass, recruitment and exploitation rates (IATTC 2019c).

### **Factor 2.2 - Fishing Mortality**

#### **PERU/ SOUTHEAST PACIFIC**

Drifting Longlines

#### **Moderate Concern**

Similar to biomass for skipjack tuna, fishing mortality is tracked via a suite of indicators (including catch, days fished) to assess exploitation rates. The standardized effort indicator of exploitation rate increased starting in the early 1990s and has been above the average level since about 2000. The most recent skipjack stock indicator assessment (2019) suggests the long-term pattern in reduced average skipjack weight may be "due to increasing fishing mortality resulting from the increasing number of sets." However, it is unknown if the current fishing mortality levels are appropriate because there are no reference points for skipjack tuna in the EPO (IATTC 2019c). The report goes on to add that any continued decline in average length is a concern with regards to fishing mortality. Recruitment and biomass indicators used to determine the status of skipjack tuna in the EPO have not generally indicated significant negative effects to the population from increased fishing (Maunder 2017), however, due to the high degree of uncertainty and increasing exploitation rates, skipjack tuna in the EPO receive a "moderate concern" score for fishing mortality.

### **Factor 2.3 - Discard Rate**

## **PERU/ SOUTHEAST PACIFIC**

Drifting Longlines

**< 100%**

Discard rates are unknown for the mahi mahi fisheries in Peru. The average discard rate in tuna longline fisheries worldwide is 22% (Kelleher 2005). We have awarded a score of <100%.