Monterey Bay Aquarium Seafood Watch®

Dolphinfish

Coryphaena hippurus

Ecuador/Eastern Central Pacific

Drifting longlines

May 6, 2019

Seafood Watch Consulting Researcher

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

Table of Contents

About Seafood Watch

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

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

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

Guiding Principles

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

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

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

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

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

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

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

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

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

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

Summary

Mahi mahi (*Coryphaena hippurus*) is found worldwide in tropical and subtropical waters. This assessment focuses on the mahi mahi longline fishery operating in Ecuador. The artisanal longline fishery targeting large, pelagic species including mahi mahi has expanded into offshore, oceanic waters west of the Galapagos (Martinez-Ortiz et al. 2015). This fleet is made up of a mother ship (*nodriza*) with towed fiber glass skiffs called *fibras* operating the longlines (Martinez-Ortiz et al. 2015). Catch in this fishery varies by season, with mahi mahi being targeted when cool waters (<25 degrees) come from the south and offshore (Martinez-Ortiz et al. 2015). During warmer water seasons the fishery switches to target tuna, billfish, and sharks (Martinez-Ortiz et al. 2015).

Mahi mahi is short lived, highly fecund, and therefore moderately resistant to fishing pressure. However, the current status of mahi mahi in the eastern Pacific Ocean is unknown. The mahi mahi fishery in Ecuador also captures target species such as tuna and billfish and catches several species of shark. In addition, this fishery does have interactions with threatened and endangered species of sea turtles. However, the available data from the Ecuadorian mahi mahi fishery suggests that sea turtles are captured infrequently. Mahi mahi is a highly seasonal fishery and this species is the primary component of the catch in these fisheries.

The final recommendation for mahi mahi caught in Ecuador by longline is "good alternative."

Final Seafood Recommendations

SPECIES/FISHERY	CRITERION 1: IMPACTS ON THE SPECIES	CRITERION 2: IMPACTS ON OTHER SPECIES	CRITERION 3: MANAGEMENT EFFECTIVENESS	CRITERION 4: HABITAT AND ECOSYSTEM	OVERALL RECOMMENDATION
Dolphinfish Ecuador Southeast Pacific, Drifting longlines, Ecuador	Green (3.413)	Red (1.000)	Yellow (3.000)	Green (3.873)	**Good Alternative (2.509)**

Scoring Guide

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

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

- **Best Choice/Green** = Final Score >3.2, and no Red Criteria, and no Critical scores
- **Good Alternative/Yellow** = Final score >2.2-3.2, and neither Harvest Strategy (Factor 3.1) nor Bycatch Management Strategy (Factor 3.2) are Very High Concern2, and no more than one Red Criterion, and no Critical scores
- **Avoid/Red** = Final Score ≤2.2, or either Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern or two or more Red Criteria, or one or more Critical scores.

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

Introduction

Scope of the analysis and ensuing recommendation

Mahi mahi (*Coryphaena hippurus*) is found worldwide in tropical and subtropical waters. This assessment focuses on the longline mahi mahi fishery in Ecuador.

Species Overview

Coryphaena hippurus is one of two species in the family Coryphaenidae, along with the pompano dolphinfish (*C. equiselis*) (Olson and Galvan-Magana 1996) (Uchiyama and Boggs 2006) (Polovina et al. 2009) (Whoriskey et al. 2011). Both species have a global distribution and, though pompano dolphinfish are typically smaller than mahi mahi, they share a similar morphology and coloration. Accordingly, pompano dolphinfish are often mistaken for juvenile mahi mahi (Froese and Pauly 2017) and are sometimes sold as mahi mahi .

Mahi mahi are mid-trophic level predators, feeding primarily on other fishes and occasionally, crustaceans and squid (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 (for a summary, see (Collette et al. 2011)). For example, in the western central Atlantic, female mahi mahi mature at approximately 41.9 cm (50%, 16.5 in; (McBride et al. 2012) and males mature at approximately 47.6 cm (50%, 18.7 in; (Schwenke and Buckel 2008), whereas in the eastern Caribbean, 50% of males and females mature at 91 cm and 83 cm, respectively (Oxenford 1999). 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 2017). 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. 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) .

In the eastern Pacific Ocean, the Inter-American Tropical Tuna Commission (IATTC) is charged with the management of tuna and bycatch species, including mahi mahi. Ecuador is bound by the recommendations and management guidelines set forth by the IATTC. The Ecuadoran mahi mahi fishery is managed through the Sub-Secretariat of Fisheries Resources (SRP). The Ecuadoran government is currently working towards establishing sustainable fishing practices for highly migratory and straddling stocks in accordance with the United Nations Convention on the Law of the Sea (UNCLOS) (CNDM 2009) and the FAO. In February 2011, Ecuador adopted a national plan of action (NPOA) that sets forth a number of management guidelines for the conservation and management of the mahi mahi fishery.

Production Statistics

In Ecuador, mahi mahi is a very important large, pelagic species. It represents more than 65% of pelagic fish landings in the region and 35 to 45% of exports (Marintez-Ortiz et al. 2015). Total catches of mahi mahi from the eastern tropical Pacific make up between 47 to 70% of all mahi mahi landings worldwide (between 2001 and 2012) (Solano-Sare et al. 2008). During 2015, 19,023 mt of mahi mahi were caught in the eastern Pacific Ocean, with 1,168 t of mahi mahi reported caught in longline fisheries (IATTC 2017).

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

and Southeast Asia, with over 73% originating in Ecuador (26.0%, of total imports), Peru (24.3%) or Taiwan (23.3%). Other major trade partners include Costa Rica (3.5%) and Mexico (3.0%) (NMFS 2011). In 2010, domestic landings comprised less than 5% of the mahi mahi available in the US marketplace that year (NMFS 2010). In recent years, the US has not exported or re-exported mahi mahi (NMFS 2011). Ecuador exports 96% of its mahi mahi to the United States (IATTC 2014).

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 is primarily available as fresh or 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. 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**
Ecuador/Southeast Pacific | Drifting longlines | Ecuador	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

ECUADOR/SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Moderate Concern

An exploratory stock assessment was conducted on mahi mahi from the southern eastern Pacific Ocean in 2016, which is considered the "core" region of the stock in the EPO (Aires-da-Silva 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 during 2010 (Aires-da-Silva 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 2016). The IUCN has assessed mahi mahi as a species of "Least Concern" (Collete 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 2017)	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 2017)	1

Trophic level	4.4 (Froese and Pauly 2017)	3
Density dependence (invertebrates only)	-	-
Total Productivity (average)		**1.57**
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 vertical overlap between the fishery and mahi mahi.	3
Selectivity of fishery (Specific to fishery under assessment)	The selectivity is not available	2
Post-capture mortality (Specific to fishery under assessment)	Post-capture mortality information is unknown.	3
Total Susceptibility (multiplicative)		**2.33**

PSA score for mahi mahi in the Guatemala 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

ECUADOR/SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

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 2016). In 2008, Guatemala estimated a fishing mortality rate of 4.53 for mahi mahi (Bran 2010) and an exploitation rate (for the artisanal fishery) of 0.36 (Ixquiac and Juarez 2014).

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 IUCN does not consider there to be any major threats to mahi mahi from commercial fishing (Collete et al. 2011). Preliminary analysis shows variable, but somewhat steady, catch per unit effort 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 catch per unit effort has been somewhat stable over time, and the preliminary stock assessment shows current fishing mortality rates of 50% of the maximum sustainable yield.

Criterion 2: Impacts on Other Species

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

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

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

Guiding Principles

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

Criterion 2 Summary

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

DOLPHINFISH - ECUADOR/SOUTHEAST PACIFIC - DRIFTING LONGLINES - ECUADOR					
Subscore:	**1.000**	**Discard Rate:**	**1.00**	**C2 Rate:**	**1.000**

Species	Abundance	Fishing Mortality	Subscore
Bigeye thresher shark	1.00:High Concern	1.00:High Concern	Red (1.000)
Pelagic thresher shark	1.00:High Concern	1.00:High Concern	Red (1.000)
Silky shark	1.00:High Concern	3.00:Moderate Concern	Red (1.732)
Shortfin mako shark	1.00:High Concern	3.00:Moderate Concern	Red (1.732)
Green sea turtle	1.00:High Concern	3.00:Moderate Concern	Red (1.732)
Olive ridley turtle	1.00:High Concern	3.00:Moderate Concern	Red (1.732)
Hawksbill turtle	1.00:High Concern	3.00:Moderate Concern	Red (1.732)
Yellowfin tuna	3.67:Low Concern	1.00:High Concern	Red (1.916)
Blue shark	3.67:Low Concern	5.00:Low Concern	Green (4.284)
Swordfish	3.67:Low Concern	5.00:Low Concern	Green (4.284)

Information on bycatch specific to the mahi mahi fishery is limited for the Ecuadorian fishery. The Agricultura, Ganaderia, Acuacultura y Pesca reported sharks make 0.81% of the total catch, other fish make up 0.23% of the catch, sea turtles, 0.043%, and sea birds, 0.0007% of the total catch (AGAP 2014). Other studies have reported overall bycatch in the fishery is around 1.1% (Martinez-Ortiz and Zuniga-Flores 2012) (Martinez-Ortiz et al. 2015). We have included sharks and sea turtles in this analysis. Kemps ridley, leatherback, olive ridley, green, hawksbill, and loggerhead sea turtles are all found in Ecuadorian waters (IAC 2017). The three most commonly captured turtle species are green, olive ridley, and hawksbill (Martinez-Ortiz and Zuniga-Flores 2012) (Martinez-Ortiz and Zuniga-Flores 2015). There are very few interactions with sea birds (AGAP 2014), so they have not been included in this assessment. The targeted mahi mahi fishery may also catch large amounts of swordfish, yellowfin tuna, escolar, thresher, blue and silky sharks (Marintez-Ortiz et al. 2015). We have therefore included these species in this 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)

BIGEYE THRESHER SHARK

Factor 2.1 - Abundance

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

High Concern

Stock assessments for bigeye thresher sharks have not been conducted. The International Union for the Conservation of Nature (IUCN) has listed bigeye and pelagic thresher sharks as "Vulnerable" due to global declining populations (Amorim et al. 2009). We have awarded a score of "high" concern to account for the IUCN listing.

Factor 2.2 - Fishing Mortality

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

High Concern

Estimates of fishing mortality for bigeye thresher sharks are not available but they are reported to be captured in a number of longline fisheries (Amorim et al. 2009). The two species of thresher shark are reported to be two of the most common bycatch species in the Ecuadorian longline fishery (Martinez-Ortiz et al. 2015) (Martinez-Ortiz and Zuniga-Flores 2012). We have awarded a score of "high" concern because fishing mortality rates are unknown and we therefore rely on the Seafood Watch Unknown Bycatch Matrix, which scores the susceptibility to longline capture of sharks 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

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

< 100%

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

PELAGIC THRESHER SHARK

Factor 2.1 - Abundance

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

High Concern

No full stock assessment of pelagic thresher sharks has been conducted in the eastern Pacific Ocean (NMFS 2015b). However, a demographic analysis of this species in the northwestern Pacific Ocean has been conducted. The results suggest pelagic thresher sharks are overexploited (Tsai et al. 2010). The IUCN has listed this and all thresher shark species as "Vulnerable" with declining population trends (Reardon et al. 2009). We have awarded a score of "high" concern due to the IUCN rating.

Factor 2.2 - Fishing Mortality

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

High Concern

Pelagic thresher sharks are taken as bycatch in a number of fisheries operating in the eastern Pacific Ocean (Reardon et al. 2009). They are considered to be highly vulnerable to overexploitation (Tsai et al. 2010). No full stock assessment has been conducted so fishing mortality rates in this region are unknown. However, demographic modeling in the northwestern Pacific indicates that the current fishing pressure will lead to a population decline of 43.3% over the next 20 years (Tsai et al. 2010). Pelagic thresher sharks are one of the most common shark bycatch species in this fishery (Martinez-Ortiz et al. 2015) (Martinez-Ortiz and Zuniga-Flores 2012). We have awarded a score of "high" concern because fishing mortality rates are unknown and therefore the Seafood Watch Unknown Bycatch Matrix is used, which suggests there is a high concern for sharks being susceptible to longline capture.

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

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

< 100%

Discard rates are unknown for the mahi mahi fisheries in Ecuador. 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

Fishery	Management Strategy	Bycatch Strategy	Research and Monitoring	Enforcement	Stakeholder Inclusion	Score
Fishery 1: Ecuador / Southeast Pacific | Drifting longlines | Ecuador	Moderately Effective	Moderately Effective	Moderately Effective	Highly Effective	Moderately Effective	Yellow (3.000)

A management plan for the Ecuadorian mahi mahi fishery has been adopted and includes comprehensive policies regarding catch parameters, bycatch mitigation, scientific oversight, and enforcement. The overriding goal of Ecuador's National Plan of Action is a holistic approach to mahi mahi fishery management and the formation of a framework whereby fisheries managers, scientists and various stakeholder groups all are participants in the management process. This plan is very encouraging, but its efficacy remains to be seen.

Criterion 3 Assessment

Factor 3.1 - Management Strategy and Implementation

Considerations: What type of management measures are in place? Are there appropriate management goals, and is there evidence that management goals are being met? Do manages follow scientific advice? To achieve a

highly effective rating, there must be appropriately defined management goals, precautionary policies that are based on scientific advice, and evidence that the measures in place have been successful at maintaining/rebuilding species.

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Moderately Effective

The Ministry of Agriculture, Livestock, Aquaculture and Fisheries (MAGAP) is in charge of managing Ecuadorian fisheries. Ecuador developed a National Plan of Action for the management of mahi mahi in 2011, which is reviewed on an annual basis (IATTC 2014). The plan includes the following suggested regulations: 1) establishment of a decision-making process, 2) minimum capture size, 3) fishery closure (June-November), 4) improved communication and education of fishermen, and 5) stipulations for scientific research (IATTC 2014). Ministerial Agreement 055 of 2011, established the Dolphinfish Consultative Council, whereby the public and private sectors can discuss issues related to mahi mahi with the MAGA) (MAGAP 2011). There is a seasonal closure for the targeted mahi mahi fishery from 1 July to 7 October each year (MAGAP 2011b). During the closure season, there is a minimum size limit of 80 cm for bycaught mahi mahi (MAGAP 2011b). Ecuador has also established a vessel monitoring system (VMS) and voluntary logbooks (Trumble 2015). Ecuador has a policy in place called Governance by Results (GBR) where achievements are logged and a view of progress against expected results is undertaken (Trumble 2015). Mahi mahi are also managed regionally by the Inter-American Tropical Tuna Commission (IATTC), but there are currently no management measures in place through the IATTC. We have awarded a score of "moderate" concern because Ecuador is taking some action to develop plans to manage mahi mahi.

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.

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Moderately Effective

Ecuador has a Ministerial Agreement (234) that endorsed the Sea Turtle Conservation National Plan in 2014 (IAC 2017). Ecuador's NPOA for the mahi mahi fishery aspires to a fleet-wide switch from J-hooks to circle hooks to mitigate sea turtle bycatch. The Ecuadorian fleet uses both J hooks and 15/0 circle hooks (AGAP 2014); however, Ecuador has implemented a program to exchange J with circle hooks, which is part of the Dorado Action Plan, but it is unclear what percentage of the fleet has switched hook types (IAC 2017). Information on bycatch is collected through the Fishing Resources Undersecretary, and there is an observer program in place, with about 7% coverage rates (IATTC 2017) (IAC 2017). The SRP has a training program in to teach crew members safe handling and release guidelines for sea turtles (IAC 2017). BirdLife International is trying to implement bycatch mitigation measures in some regions such as the Santa Rosa and Santa Elana Province (IAC 2017), although sea bird interactions are rare in this fishery (AGAP 2014). Ecuador banned directed fishing for sharks in 2004 but does allow sharks caught outside of Ecuadorian waters to be landed in Ecuador. Shark finning is also banned (AWI 2018). We have awarded a score of "moderately effective" because Ecuador is doing some things to address bycatch in this fishery.

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.

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Moderately Effective

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 IATTC by individual countries including Ecuador (IATTC 2014). There is an observer program in place that currently covers about 7% of longline trips in 2016 (IATTC 2017). Catches are monitored at fishing sites by the government (MRAG 2013). We have awarded a score of "moderately effective" because there is research and monitoring in this fishery.

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.

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Highly Effective

Enforcement is carried out by SRP in concert with the Ecuadorian Navy. The aforementioned fisheries inspectors assess whether fishers are complying with the NPOA regulations (MRAG 2013). SRP monitors fishing sites and companies for enforcement actions (MRAG 2013). Ecuador has a vessel monitoring system in place and has implemented a voluntary logbook program (Trumble 2015). We have awarded a score of "highly effective" because enforcement is in place, regulations are independently verified, and there is enforcement capacity to ensure 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.

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Moderately Effective

The stated goals of the NPOA include ensuring positive job creation and the sustained profitability of the artisanal fishing sector. To this aim the government has made fisher education and communication a key component of the mahi mahi management plan (MRAG 2013). The Dolphinfish Consultative Council was set up to allow a discussion between private and public sectors and the MAGAP (MAGAP 2011b). A number of stakeholders are involved in the Ecuadorian mahi mahi fishery improvement project (FIP) (https://fisheryprogress.org/node/90/info), but this FIP covers only a portion of the fishery. We have awarded a score of "moderately effective" because it appears there is some stakeholder inclusion in this fishery.

Criterion 4: Impacts on the Habitat and Ecosystem

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

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

GUIDING PRINCIPLES

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

Rating cannot be Critical for Criterion 4.

Criterion 4 Summary

Region / Method	Gear Type and Substrate	Mitigation of Gear Impacts	EBFM	Score
Ecuador / Southeast Pacific / Drifting longlines / Ecuador	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

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

5

Pelagic longline gears fish at the surface 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

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

0

Pelagic longline gear does not come into contact with bottom habitats.

Factor 4.3 - Ecosystem-Based Fisheries Management

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Moderate Concern

Pelagic longline fisheries that operate in the eastern Pacific Ocean and target mahi mahi catch ecologically important species including other tunas, billfish, and sharks. In particular, sharks are considered top predators in many ecosystems and play a critical role in how these ecosystems are structured and function (Piraino et al. 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) (Ferretti et al. 2010) and behavioral changes (Heithaus et al. 2007).

It does not appear that Ecuador 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, 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 sea birds as addressing ecosystem considerations (IATTC 2012). We have therefore awarded a score of "moderate" concern, instead of "high" concern.

Acknowledgements

Scientific review does not constitute an endorsement of the Seafood Watch® program, or its seafood recommendations, on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

Seafood Watch would like to thank the consulting researcher and author of this report, Alexia Morgan, as well as several anonymous reviewers for graciously reviewing this report for scientific accuracy.

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.

AGAP. 2017. El recurso dorado (Coryphaena hippurus) en el Ecuador. Agricultura, Ganaderia, Acuacultura y Pesca. Available at: http://www.iattc.org/Meetings/Meetings2014/Oct/_English/TALK2-Dorado-resource-Ecuador-Molke-Mendoza-Avila.pdf

Aires da Silva, A., Valero, J.L., Maunder, M., Minte-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.

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. http://dx.doi.org/10.2305/IUCN.UK.2009-2.RLTS.T161696A5482468.en.

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. http://dx.doi.org/10.2305/IUCN.UK.2009-2.RLTS.T161696A5482468.en.

AWI. 2018. International shark finning bans and policies. Animal Welfare Institute. Available at: https://awionline.org/content/international-shark-finning-bans-and-policies

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 Sitizano, 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. http://www.iucnredlist.org/details/39385/0

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. http://dx.doi.org/10.2305/IUCN.UK.2009-2.RLTS.T39341A10207466.en

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. http://dx.doi.org/10.2305/IUCN.UK.2009-2.RLTS.T39341A10207466.en

CNDM. 2009. Migratorias y transzonales de interes comercial para el Ecuador y su importancia dentro de la adhesiòn a la COVEMAR: 6-64. http://www.cndm.gob.ec/.

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. http://dx.doi.org/10.2305/IUCN.UK.2011-2.RLTS.T154712A4614989.en.

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. http://dx.doi.org/10.2305/IUCN.UK.2011-2.RLTS.T154712A4614989.en.

DELGADO-TREJO, C. & J. 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.

Duffy, J.E. 2003. Biodiversity loss, trophic skew and ecosystem functioning. Ecology Letters 6:680-687.

FAO. 2004. Species Fact Sheet: Coryphaena hippurus. http://www.fao.org/fishery/species/3130/en.

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.

FP. Action 4.3 conversions of longline fishery to circle hooks. Fishery Progress

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; public hearings; extension of comment period. 80 FR 34594.

Froese R., D. Pauly. 2017. Fishbase. http://www.fishbase.org.

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.

IAC. 2017. 2017 Ecuador annual report. IAC Sea Turtle

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

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

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. 2014. Report of the 1st technical meeting on dorado. Inter-American Tropical Tuna Commission. Available at: http://www.iattc.org/Meetings/Meetings2014/Oct/_English/DOR-01-Meeting-Report-ENG.pdf

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

IATTC. 2017. Ecuador annual report. IATTC Scientific Advisory Committee Eighth Meeting. Document SAC-08

INFA(i). Available at: http://www.iattc.org/Meetings/Meetings2017/SAC-08/PDFs/INF/_English/SAC-08-INF-A(i)_Ecuador-Annual-report-2016.pdf

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

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: http://isc.fra.go.jp/pdf/ISC15/Annex12-SMA_stock_assessment_report(2015).pdf

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. Available at: https://www.wcpfc.int/system/files/SC13-SA-WP-10%20Stock%20Assessment%20and%20Projections%20Blue%20Shark.pdf

Kelleher, K. 2005. Discards in the world's marine fisheries an update. FAO Fisheries Technical Paper 470. Available at:http://www.fao.org/docrep/008/y5936e/y5936e00.htm

MAGAP. 2011. Acuerdo Ministerial 023 (Plan de Acción Nacional para la Conservación y Manejo del recurso Dorado).

MAGAP. 2011b. Acuerdo Ministerial 70 (Establécese una veda total para la pesca objetivo del recurso Dorado (Coryphaena hippurus), desde el 1° de julio hasta el 7 de octubre de cada año).

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

Martinez-Ortiz, j., Aires-da-Silva, A. M., Lennert-Cody, C. E., & M.N. Maunder. 2015 The Ecuadorian artisanal fishery for large pelagics: species composition and spatio-temporal dynamics. PloS one, 10 (8), e0135136.

Martinez-Ortiz, J., Aires-da-Silva, A.M., Lennert-Cody, C.E. and Maunder, M. 2015. The Ecuadorian artisinal fishery for large pelagics: species composition and spatio-temporal dynamics. PLoS ONE 10(8): e0135136.

Marinez-Ortiz, J., Garci-Dominguez, M., Gilces-Anchundia, M. 2015. Using the circular hooks C15 in the artisinal fishery resource mahi-mahi Coryphaena hippurus (Perciformes: Coryphaenidae) surface longline. Muisne (Emeraldas)(2013-2014). World Wildlife Fun.

McBride R.S., D.J.G. Snodgrass, D.H. Adams, S.J. Rider, J.A. Colvocoresses. 2012. An indeterminant model to estimate egg production of the highly iteroparous and fecud 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. http://www.nmfs.noaa.gov/pr/species/Status%20Reviews/scalloped_hammerhead_sr_2013.pdf

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. Available at: http://www.iattc.org/Meetings/Meetings2017/SAC08/PDFs/SAC-08-04b-YFT-Assessment-of-yellowfin-2016.pdf

Mortimer, J.A & Donnelly, M. (IUCN SSC Marine Turtle Specialist Group). 2008. Eretmochelys imbricata. The IUCN Red List of Threatened Species 2008: e.T8005A12881238. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T8005A12881238.en.

MRAG. 2013. Updated action plan for Ecuador mahi mahi Fishery Improvement Project with recommendations. MRAG America's Incl. November 2013. Available at: http://fisheryimprovementprojects.org/wp-content/uploads/Ecuador-Mahi-Mahi_FIP_Action-Plan_November2013.pdf

NMFS. 2014. Scalloped hammerhead shark (Sphyrna lewini). NOAA Fisheries Office of Protected Resources. http://www.nmfs.noaa.gov/pr/species/fish/scalloped-hammerhead-shark.html

NMFS. 2015b. Pelagic thresher shark. Southwest Fisheries Science Center. Available at: https://swfsc.noaa.gov/textblock.aspx?ParentMenuId=123&id=21437

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.

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.

Reardon, M., Márquez, F., Trejo, T. & Clarke, S.C. 2009. Alopias pelagicus. The IUCN Red List of Threatened Species 2009: e.T161597A5460720. http://dx.doi.org/10.2305/IUCN.UK.2009-2.RLTS.T161597A5460720.en.

Reardon, M., Márquez, F., Trejo, T. & Clarke, S.C. 2009. Alopias pelagicus. The IUCN Red List of Threatened Species 2009: e.T161597A5460720. http://dx.doi.org/10.2305/IUCN.UK.2009-2.RLTS.T161597A5460720.en.

Rigby, C.L., Sherman, C.S., Chin, A. & Simpfendorfer, C. 2017. Carcharhinus falciformis. The IUCN Red List of Threatened Species 2016: e.T39370A2909465. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T39370A2909465.en

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. http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T4615A11037468.en

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.

Trumble, R. J. 2015. A review of the Ecuador mahi mahi fishery improvement project - 2015 update and conversion to CR V2.0.

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. http://www.publish.csiro.au/mf/mf09303

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.

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.http://dx.doi.org/10.1980/ES12-00388.1

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

BLUE SHARK

Factor 2.1 - Abundance

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Low Concern

The north Pacific stock of blue shark was assessed in 2017. According to the assessment, the biomass has remained near an all time high since 2005. The female spawning biomass in 2015 was 71% above levels needed to produce the maximum sustainable yield (SB2015/SBMSY) (ISC 2017). The population of blue shark in the north Pacific is therefore not overfished. We have awarded a score of "low" concern based on the current assessment results.

Factor 2.2 - Fishing Mortality

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Low Concern

Blue sharks are widely distributed throughout the North Pacific and dominate shark catches in that region. The last assessment of this species in the North Pacific was conduced in 2017. Current fishing mortality rates are estimated to be well below levels needed to produce the maximum sustainable yield (F2012 to 2014/FMSY) (ISC 2017). Overfishing is therefore not occurring and we have awarded a score of "low" concern.

Factor 2.3 - Discard Rate

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

< 100%

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

SILKY SHARK

Factor 2.1 - Abundance

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

High Concern

Silky sharks are assessed as "Vulnerable" with a decreasing population trend by the International Union for Conservation of Nature (IUCN) (Rigby et al. 2017). We have awarded a score of "high" concern based on the IUCN status combined with their high vulnerability to fishing and unknown population status.

Justification:

The Inter-American Tropical Tuna Commission has begun conducting an assessment of silky sharks in the eastern Pacific Ocean (EPO). Preliminary results were presented in early 2013 (IATTC 2013). According to these results, the abundance of silky sharks caught in purse seine sets made on floating objects in the

southern region decreased dramatically in the late 1990's, remained stable thereafter, but has been increasing slightly in more recent years. In the southern region, declines occurred into the early 2000's and have been stable, although increasing slightly in 2008 to 2010. Abundance of silky sharks caught in the northern region on both dolphin and unassociated sets have varied from the early to mid 2000's and increased dramatically in 2010. In the southern region, abundance in dolphin sets has been variable with no real trend, and on unassociated sets have been fairly low since the late 1990's, although an increase in 2010 is evident (IATTC 2013).

Purse seine indices of abundance were updated in 2015, which indicated an increase in silky sharks (index) during 2015, compared to 2014, in the northern area (IATTC 2016). However, environmental variables such as El Niño may have contributed to this increase and it may not be the result of actual population increases (IATTC 2016).

Factor 2.2 - Fishing Mortality

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Moderate Concern

Silky sharks are caught as bycatch in purse seine and longline fisheries operating in the eastern Pacific Ocean, but are also targeted, in small amounts, in some longline fisheries (IATTC 2013) (IATTC 2016). The most recent attempt at an assessment for this species indicated that the current fishing mortality rates are unknown (IATTC 2016). We have awarded a score of "moderate" concern because, although fishing mortality rates are unknown, there is a stock assessment available.

Factor 2.3 - Discard Rate

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

< 100%

Discard rates are unknown for the mahi mahi fisheries in Ecuador. 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

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Low Concern

Yellowfin tuna in the eastern Pacific Ocean was last assessed during 2017 (IATTC 2018b). There is some uncertainty concerning recent and future recruitment and biomass levels, with the potential for three different regimes since 1975 (IATTC 2018b). The spawning biomass ratio (SBR) was at or below maximum sustainable yield (MSY) levels between 2005 and 2017 (except during 2008 to 2010) (IATTC 2018b). The SBR at the start of 2018 was above MSY, with the ratio of the current biomass to that supporting MSY being 1.35 (IATTC 2018b). Yellowfin tuna in the eastern Pacific Ocean are not overfished; therefore, we have awarded a score of "low" concern. We have not awarded a score of "very low" concern due to the uncertainty surrounding recruitment and biomass estimates (IATTC 2018b).

Factor 2.2 - Fishing Mortality

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

High Concern

According to the 2017 assessment of yellowfin tuna in the eastern Pacific Ocean, current fishing mortality rates are slightly above maximum sustainable yield (MSY) levels (IATTC 2018b). The average fishing mortality rates has been increasing for all age classes since 2009, with a slight decline in 2017 (IATTC 2018b). The ratio of recent catches to those needed to produce the maximum sustainable yield is 0.85 (IATTC 2018b). The F multiplier is estimated to be 0.99 because fishing morality rates are above MSY levels (IATTC 2018b). The F multiplier is $F_{msy}/F_{current,}$ so anything less than 1 indicates $F_{current}$ is above $F_{msy.}$ We have awarded a score of "high" concern because overfishing is occurring.

Factor 2.3 - Discard Rate

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

< 100%

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

SWORDFISH

Factor 2.1 - Abundance

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Low Concern

The IATTC considers two populations of swordfish, one in the Western and Central Pacific (subregion 1), which includes part of the eastern Pacific Ocean and one population only in the Eastern Pacific (subregion 2). An assessment was conducted in 2011 for swordfish in the southern portion of the eastern Pacific Ocean. The spawning biomass ratio for this population (ratio of the spawning biomass to unfished levels) was close to 50% above the carrying capacity and substantially above levels needed to produce the maximum sustainable yield. Therefore, the population is not overfished (IATTC 2017). We have awarded a score of "low" concern because the population is healthy throughout the EPO region.

Factor 2.2 - Fishing Mortality

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Low Concern

Catches in the southwestern eastern Pacific Ocean have been around sustainable levels (IATTC 2016f). Exploitation rates in this region are considered sustainable. The ratio of recent catches to maximum sustainable yield values is 0.57 (IATTC 2012). There are no reference points in place but fishing mortality rates are currently considered sustainable (IATTC 2012). We have awarded a score of "low" concern because overfishing is not occurring (see detailed section for additional information).

Justification:

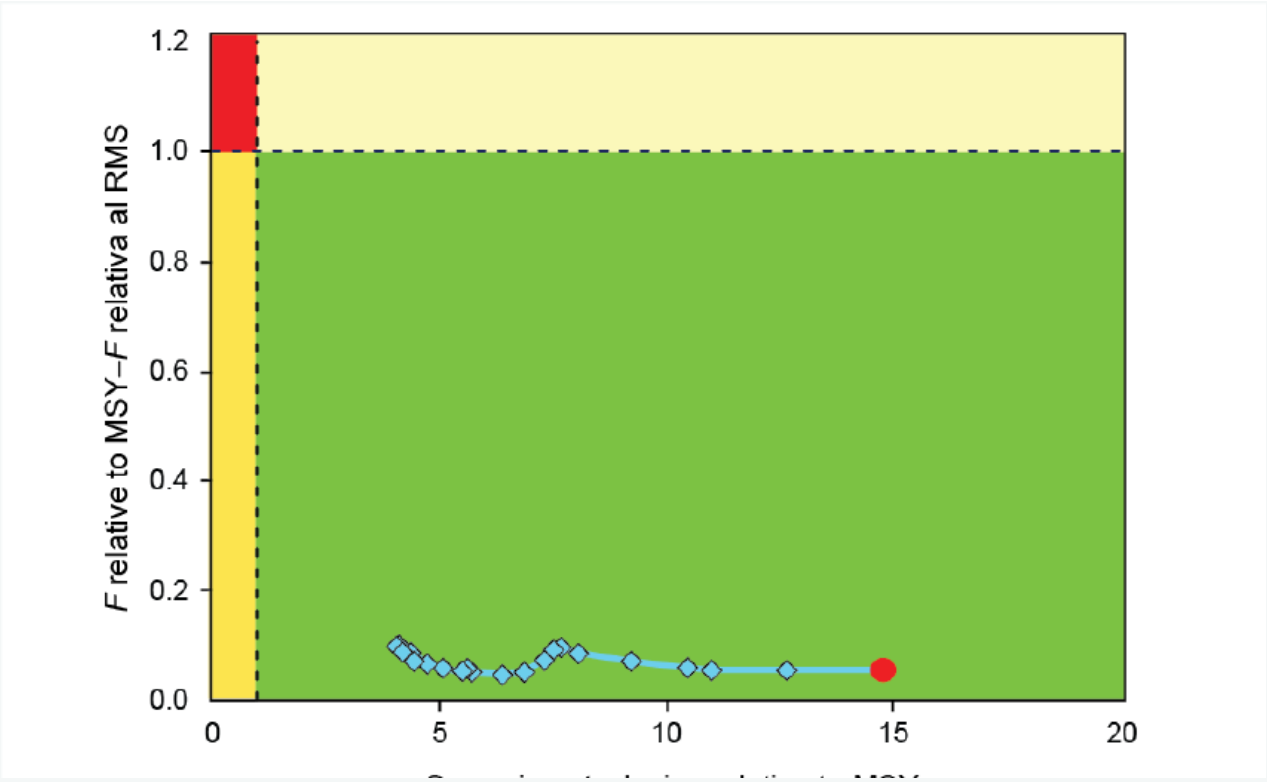

Figure 1 The relationship between spawning stock biomass relative to maximum sustainable yield (MSY) and fishing mortality rate (F) to MSY (IATTC 2012).

Factor 2.3 - Discard Rate

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

< 100%

Discard rates are unknown for the mahi mahi fisheries in Ecuador. 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

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

High Concern

An indicator-based analysis of the status of shortfin mako sharks in the North Pacific was conducted in 2015 (ISC 2015). Four indicators were developed and tested: 1) proportion of positive sets, 2) abundance indices, 3) sex-ratio, and 4) size composition (ISC 2015). Abundance trends showed a stable or increasing trend for two indices, although the third index showed a decreasing trend in abundance. No trends in sex-ratio could be determined. Size composition appeared to remain stable over time (ISC 2015). Overall, the status of shortfin mako sharks in the North Pacific could not be determined (ISC 2015). The International Union for Conservation of Nature (IUCN) has listed this species as "Vulnerable" (Cailliet et al. 2009). We have awarded a score of "high" concern based on the IUCN rating.

Factor 2.2 - Fishing Mortality

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Moderate Concern

In 2015 an indicator based analysis of shortfin mako sharks in the North Pacific was conducted (ISC 2015). This assessment did not assess current fishing mortality rates (ISC 2015). The analysis therefore did not determine if overfishing was occurring and we have awarded a score of "moderate" concern based on a lack of information.

Factor 2.3 - Discard Rate

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

< 100%

Discard rates are unknown for the mahi mahi fisheries in Ecuador. 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

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

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). However, this assessment is ten years old and more recent information suggests that populations in Mexico have been increasing (Delgado-Trejo and Alvarado-Dias 2012). A recent analysis of the Eastern Pacific Distinct population segment by the US Endangered Species Act found the DPS should be considered "Threatened" and not "Endangered" (FR 2015). However, we have awarded a score of "high" concern based on the ESA "Threatened" listing and the IUCN classification.

Factor 2.2 - Fishing Mortality

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Moderate 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 et al. 2015) (Martinez-Ortiz and Zuniga-Flores 2012). The bycatch impacts in this region are considered low, but a high risk to the population size (Wallace et al. 2013). Ecuador does not require circle hooks to be used but offers a tax incentive for fishers who use them (AGAP

2017). Acceptance by fishers to switch from J to circle hooks has been mixed (FP 2019) (Martinez-Ortiz 2015). Bycatch rates of sea turtles, based on observer data (~7% coverage (IATTC 2017)), appear to be low (0.049% of the total catch) in this fishery (AGAP 2017). However, overall there is limited data available and we have therefore awarded a score of "moderate" concern.

Factor 2.3 - Discard Rate

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

< 100%

Discard rates are unknown for the mahi mahi fisheries in Ecuador. 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

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

High Concern

The International Union for Conservation of Nature (IUCN) considers the population of olive ridley sea turtles to be "Vulnerable" (Abreu-Grobois et al. 2008). In the eastern Pacific Ocean, estimates of the total number of nests range from 608 protected nests in Mexico to 33,530 to 68,753 nests in Nicaragua. Female population size has been estimated to range from 8,768 in Panama to 1,013,034 in Mexico (Abreu-Grobois et al. 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. Overall, the annual nesting female subpopulation size in the eastern Pacific Ocean has declined around 35% over time (Abreu-Grobois et al. 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.

Factor 2.2 - Fishing Mortality

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Moderate Concern

The incidental capture of olive ridley sea turtles occurs worldwide. There is some thought that impacts from other fisheries, such as trawls and gillnets, appear to have a larger negative impact compared to longlines in many areas except for 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). Circle hooks are not required but there is a tax incentive for fishers that use circle hooks (AGAP 2017). Acceptance by fishers to switch from J to circle hooks has been mixed (FP 2019) (Martinez-Ortiz 2015). Olive ridley sea turtles are one of the most commonly captured sea turtle species in this fishery (Martinez-Ortiz et al. 2015) (Martinez-Ortiz and Zuniga-Flores 2012), although interactions (observed) appear to be low (0.0429% of the total catch) (AGAP 2017). We have awarded a score of "moderate" concern because information on sea turtle interactions in this fishery is limited (~7% observer coverage (IATTC 2017)), and there is not enough information to determine the overall impact to the species.

Factor 2.3 - Discard Rate

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

< 100%

Discard rates are unknown for the mahi mahi fisheries in Ecuador. 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

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

High Concern

The IUCN has classified hawksbill turtles as "Critically Endangered," with a decreasing population trend (Mortimer and Donnelly 2008). 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; this means that they 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 2008). We have awarded a score of "high" concern based on the IUCN listing and evidence of declining population size.

Factor 2.2 - Fishing Mortality

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

Moderate 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 2008). Hawksbill 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 turtle species in the Ecuadorian mahi mahi fishery (Martinez-Ortiz et al. 2015) (Martinez-Ortiz and Zuniga-Flores 2012). Circle hooks are not required but there is a tax incentive to fishers who use them (AGAP 2017). Acceptance by fishers to switch from J to circle hooks has been mixed (FP 2019) (Martinez-Ortiz 2015). The bycatch impacts in this region are considered low, but a high risk to the population size (Wallace et al. 2013). Based on observer data, interactions with sea turtles in this fishery is not very high (0.0429% of the total catch) (AGAP 2017). We have awarded a score of "moderate" concern because information on bycatch of sea turtles (~7% observer coverage (IATTC 2017)) in this fishery is limited and the impact on populations is not fully understood (AGAP 2017).

Factor 2.3 - Discard Rate

ECUADOR / SOUTHEAST PACIFIC, DRIFTING LONGLINES, ECUADOR

< 100%

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