



Monterey Bay Aquarium Seafood Watch

Mahi (Indonesia, Taiwan)

Coryphaena hippurus



**Pacific, Western Central, Indian Ocean, Eastern
Drifting longlines**

Seafood Watch Consulting Researcher

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Seafood Watch Standard used in this assessment: Fisheries Standard v4

Disclaimer

All Seafood Watch fishery assessments are reviewed for accuracy by external experts in ecology, fisheries science, and aquaculture. Scientific review does not constitute an endorsement of the Seafood Watch program or its ratings on the part of the reviewing scientists. Seafood Watch is solely responsible for the conclusions reached in this assessment.

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About Seafood Watch

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

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

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

- Seafood rated Best Choice comes from sources that operate in a manner that's consistent with our guiding principles. The seafood is caught or farmed in ways that cause little or no harm to other wildlife or the environment.
- Seafood rated Good Alternative comes from sources that align with most of our guiding principles. However, one issue needs substantial improvement, or there's significant uncertainty about the impacts on wildlife or the environment.
- Seafood rated Avoid comes from sources that don't align with our guiding principles. The seafood is caught or farmed in ways that have a high risk of causing harm to wildlife or the environment. There's a critical conservation concern or many issues need substantial improvement.

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

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

Guiding Principles

Seafood Watch defines sustainable seafood as originating from sources, whether fished¹ or farmed, that can maintain or increase production in the long term without jeopardizing the structure or function of affected ecosystems.

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

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

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

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

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

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

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

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

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

Summary

This report focuses on mahi mahi (*Coryphaena hippurus*) caught in the Taiwanese and Indonesian longline fisheries. Mahi mahi is both targeted and caught as a secondary species in other targeted fisheries, such as tuna and shark in Taiwan. In Indonesia, mahi mahi is caught by pelagic longlines in both the Western and Central Pacific Ocean (WCPO) and the Indian Ocean (IO), in fisheries targeting large pelagic fish such as tunas (albacore, bigeye tuna, and yellowfin tuna) and billfish, primarily swordfish.

In Indonesia, information on the status of mahi mahi is not available because limited assessments have been conducted. Other species are commonly caught along with mahi mahi, such as tunas and billfish, swordfish, and sharks. Sea turtles are also incidentally captured and mostly released. In the Indian Ocean, olive ridley is the most frequently caught turtle species. Seabird interactions in this fishery are not frequent. Bigeye tuna populations are not sustainably fished in the IO but populations are above reference points in both the IO and WCPO. Yellowfin tuna is currently overfished and subject to overfishing in the IO. The remaining tuna species along with swordfish are healthy. There are concerns over the status of some shark species, sea turtles, and seabirds caught in these fisheries.

A stock assessment for mahi mahi was recently conducted in Taiwan (Northwest Pacific Ocean), made by longline vessels targeting mahi mahi in the coastal and offshore waters of Taiwan, and through by-catch in the Taiwanese deep-sea longline vessels. The relative abundance indices and length-frequency data were from Taiwanese longline vessels targeting mahi mahi. Both bigeye and yellowfin tuna in the region have recent stock assessments indicating that the stocks are improving and above reference points. Sharks, sea turtles, and seabird species are incidentally captured in these fisheries. There are concerns over the status of these by-catch species throughout the Pacific Ocean.

The Ministry of Marine and Fisheries Affairs (MMAF) is responsible for fisheries management in Indonesia through 11 Fisheries Management Areas (FMA), and Indonesia is a member of both the Western and Central Pacific Fisheries Commission and Indian Ocean Tuna Commission. Management of target species (i.e., mahi mahi and tunas) is considered insufficient in Indonesia, mainly because there is a lack of management measures for mahi mahi and there are violations of the yellowfin tuna rebuilding plan in the IO. But, management measures for some tuna species have improved through a fishery improvement project (FIP) and National Plan of Action update. There are concerns over the management of some by-catch species due to a lack of management and data collection. Indonesia has improved vessel monitoring as well as compliance with the United States Seafood Import Monitoring Program. An ecosystem approach to fisheries management (EAFM) has been developed in the past decade by the MMAF, and its main goal is to develop new management plans for all 11 FMAs. This fishery occurs in pelagic waters using surface-set longline gears, so there are no substantial habitat impact concerns. An FIP directed at mahi mahi, cobia, and wahoo using demersal longline was started in 2021; however, because mahi mahi accounted for less than 0.5% of the overall catch composition in the recent fishing seasons, this fishery was not included in this assessment. With the development of the FIP and more detailed data being produced, this fishery may be included in an updated version of this assessment.

In Taiwan, the Fisheries Authority, Council of Agriculture oversees fisheries management. Taiwan is also a member of the Western and Central Pacific Fisheries Commission. Management of mahi mahi in

Taiwan is considered moderately effective because a set of species-specific regulations has been designed in recent years through an FIP. With the FIP, an enhanced fishing logbook to record primary, secondary, and endangered, threatened, and protected (ETP) species started to be used in 2019, and the Taiwanese observer program now covers mahi mahi fishing vessels. Management of by-catch species is considered ineffective because, even though some by-catch measures are in place, only two mitigation methods for seabirds are being used, other best practices such as by-catch caps are lacking, and observer coverage is still new and coverage rates are quite low. Stakeholder inclusion has also greatly improved from the FIP framework. Spatial management is not in place for this fishery, but an ecosystem approach has been under development by the FIP and is expected to start being implemented in 2023. This fishery targets mahi mahi in pelagic waters; therefore, there are no negative interactions with bottom habitat.

The mahi mahi longline fisheries in Taiwan and Indonesia (both from the Indian Ocean and the Western and Central Pacific Ocean) receive an Avoid recommendation, because of the by-catch of highly vulnerable species and poor by-catch management.

Final Seafood Recommendations

SPECIES FISHERY	CRITERION 1 TARGET SPECIES	CRITERION 2 OTHER SPECIES	CRITERION 3 MANAGEMENT	CRITERION 4 HABITAT	OVERALL RECOMMENDATION
Dolphinfish Eastern Indian Ocean Drifting longlines Indonesia	3.318	1.000	1.000	3.873	Avoid (1.893)
Dolphinfish Western Central Pacific Drifting longlines Indonesia	3.318	1.000	1.000	3.873	Avoid (1.893)
Dolphinfish Western Central Pacific Drifting longlines Taiwan	4.284	1.000	1.000	3.873	Avoid (2.018)

Summary

Mahi mahi caught with longlines in Taiwan and Indonesia (the Western and Central Pacific and the Indian Oceans) have an Avoid rating, because of the by-catch of highly vulnerable species and poor by-catch management.

Eco-Certification Information

A fishery improvement project (FIP) in Indonesia directed at mahi-mahi, cobia, and wahoo using demersal longline was started in 2021; however, because mahi-mahi accounted for less than 0.5% of the overall catch composition in the recent fishing seasons, this fishery was not included in this assessment. With the development of the FIP and more detailed data being produced, this fishery may be included in an updated version of this assessment.

There also is an FIP in Taiwan that has implemented a set of specific regulations for mahi mahi and initiated an observer program.

Scoring Guide

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

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

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

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

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

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

Introduction

Scope of the analysis and ensuing recommendation

This report covers longline fisheries that catch mahi mahi (*Coryphaena hippurus*) in Taiwan and Indonesia (the Western and Central Pacific Ocean and the Indian Ocean).

Species Overview

Mahi mahi is a highly migratory species that is found in tropical and subtropical waters globally. It usually occupies pelagic habitats, but adults can also be found in coastal waters. It feeds on almost all forms of fish and zooplankton, as well as on crustaceans and squid. Mahi mahi grows rapidly and reaches sexual maturity in less than half a year. The species spawns several times a year, and has a life span of about 4 years (Froese and Pauly 2019).

The Ministry of Marine Affairs and Fisheries (MMAF) oversees fisheries management in Indonesia. The area is divided into 11 Fisheries Management Areas (FMA), which cover territorial, archipelagic, and exclusive economic zone (EEZ) waters. In Taiwan, the Fisheries Authority (FA), part of the Council of Agriculture (COA), is responsible for managing fisheries in general, including for mahi mahi.

Production Statistics

Although the species has only recently been targeted in Indonesia, mahi mahi production there is now one of the three largest in the world (Veiga et al. 2018), particularly in the Western and Central Pacific Ocean (FAO 2021). In the past two decades, production in Indonesia has ranged from 1,498 t in 2004 to 15,425 t in 2019. The 2019 production represented about 16% of the world's catches (FAO 2021).

In Taiwan, mahi mahi production in the last two decades peaked in 2007 at 14,755 t (FAO 2021). In the most recent years, the annual production has oscillated at around 10,000t. In 2019, the production represented about 11% of the world's catches (FAO 2021).

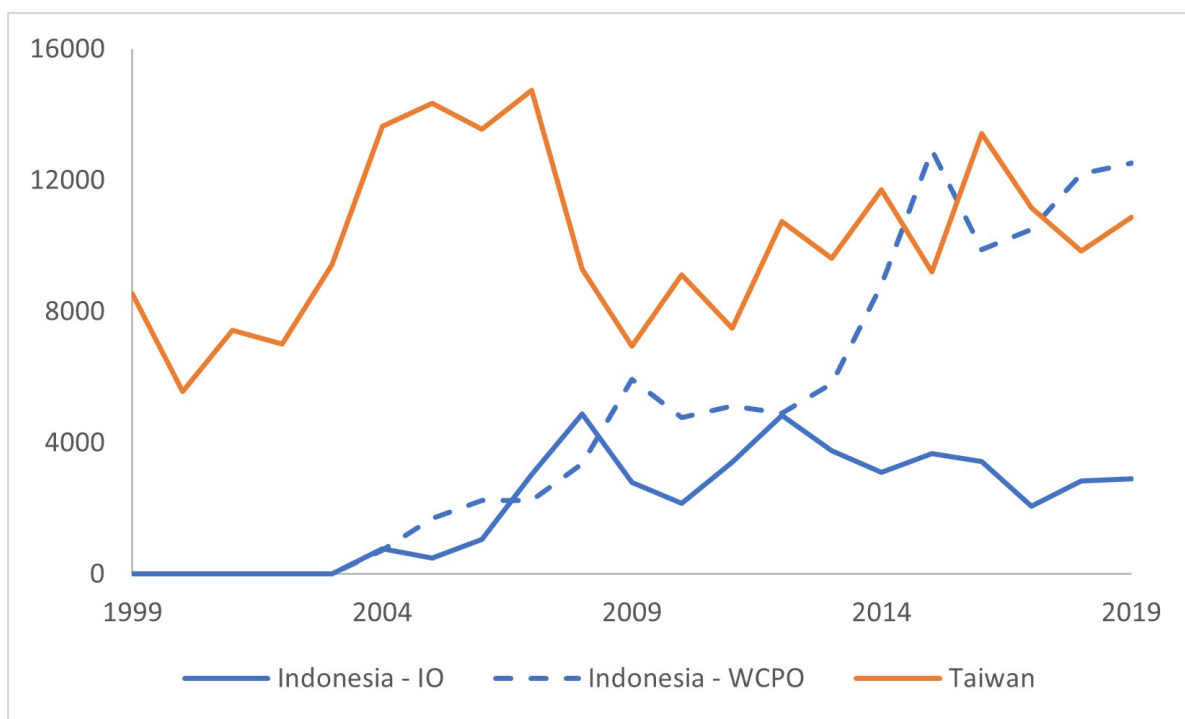


Figure 1: Indonesia (IO—Indian Ocean; WCPO—Western and Central Pacific Ocean) and Taiwan mahi mahi annual production from 1999 to 2019. Values in tonnes. (FAO 2021)

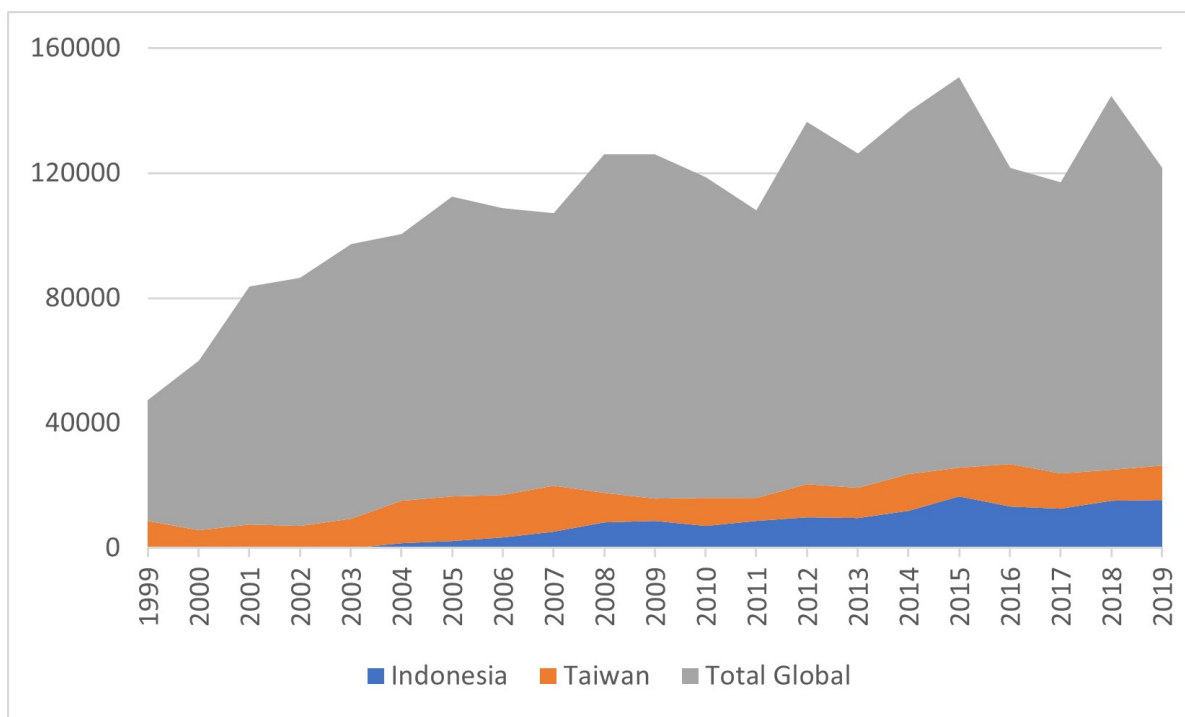


Figure 2: Indonesia and Taiwan contributions to mahi mahi global production from 1999 to 2019. Values in tonnes. (FAO 2021)

Importance to the US/North American market.

In 2020, the United States imported 19,458,316 kilos of mahi mahi. Taiwan was responsible for a little more than 14% (2,780,105 kilos) of total mahi mahi imported by the United States, whereas Indonesia was responsible for only 4% (849,608 kilos). Annual trade data show that imported mahi mahi volumes have varied from 3,000 to 26,000 tons for the past 10 years. The total trade value (here showing total cost, insurance, and freight values combined) for mahi mahi imports to the United States last year was over USD 175 billion (3.5% from Indonesia and 15% from Taiwan). From 2010 to 2020, the total trade CIF value ranged from USD 21 billion to 278 billion (USTIC DataWeb 2021).

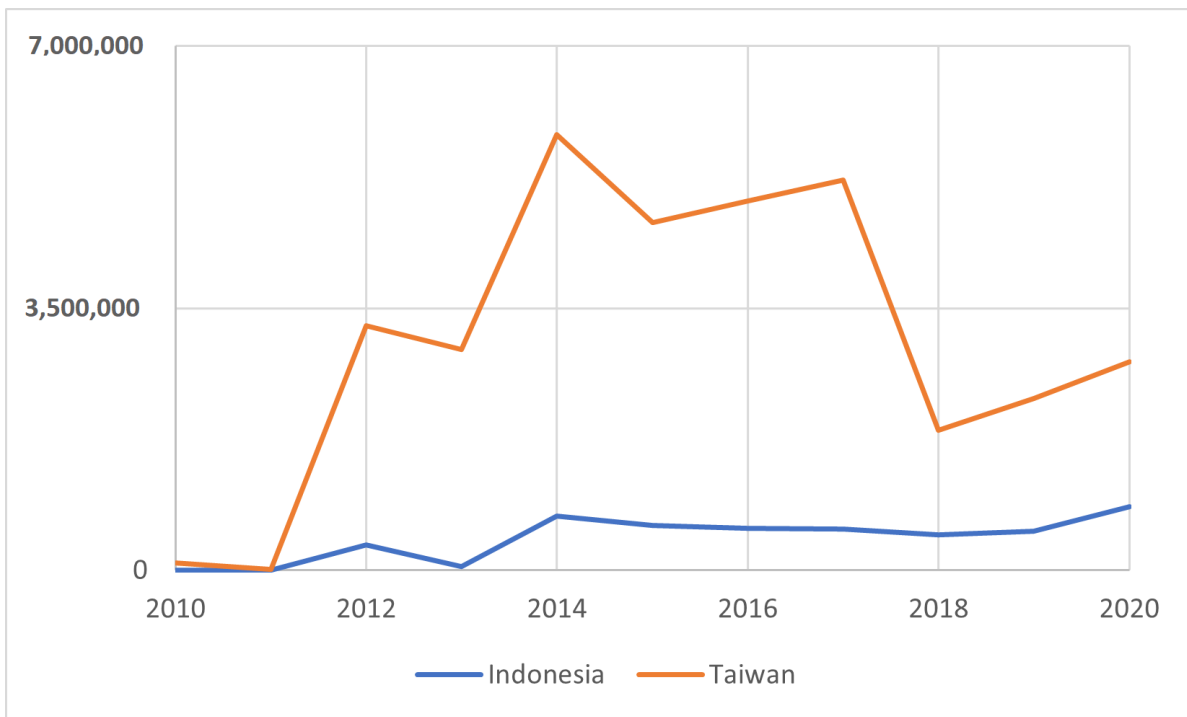


Figure 3: Indonesia and Taiwan annual mahi mahi imports (units of quantity, values in kilos). Values include imports of unspecified *Coryphaena* spp., fresh or chilled, fillets or frozen. Data extracted from USITC DataWeb (2021).

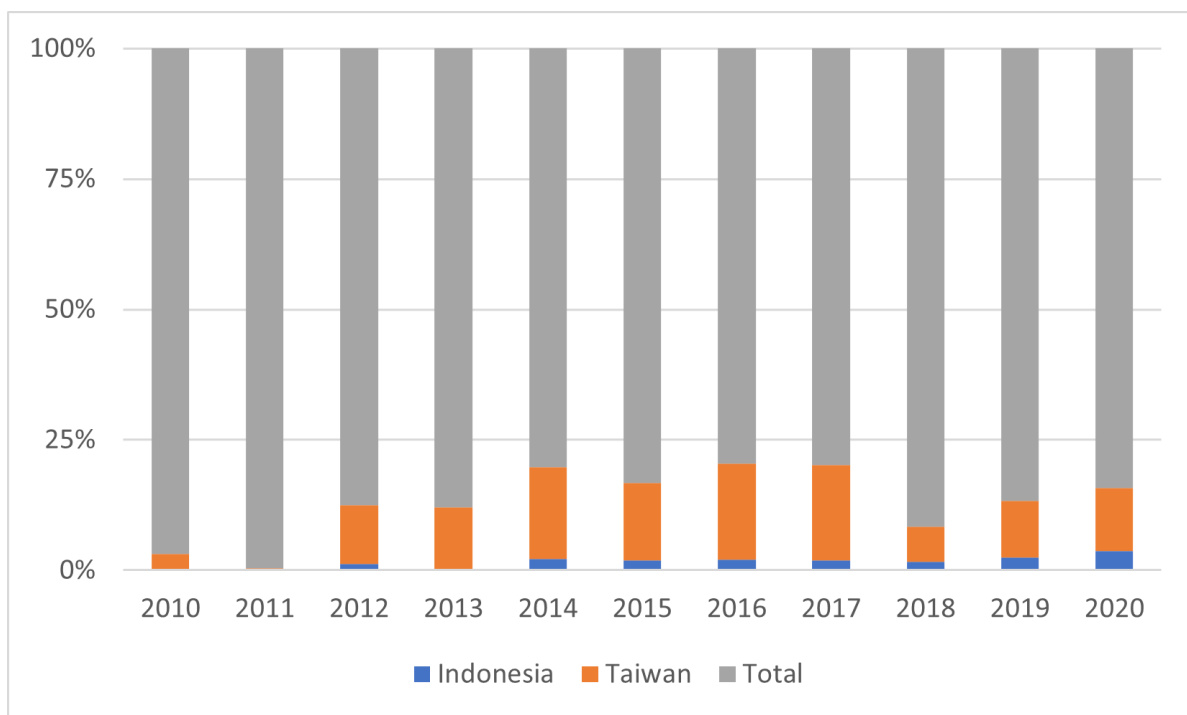


Figure 4: Total mahi mahi imports (units of quantity, proportion of values in kilos, global) and contribution of Taiwan and Indonesia. Values include imports of unspecified *Coryphaena* spp., fresh or chilled, fillets or frozen. Data extracted from USITC DataWeb (2021).

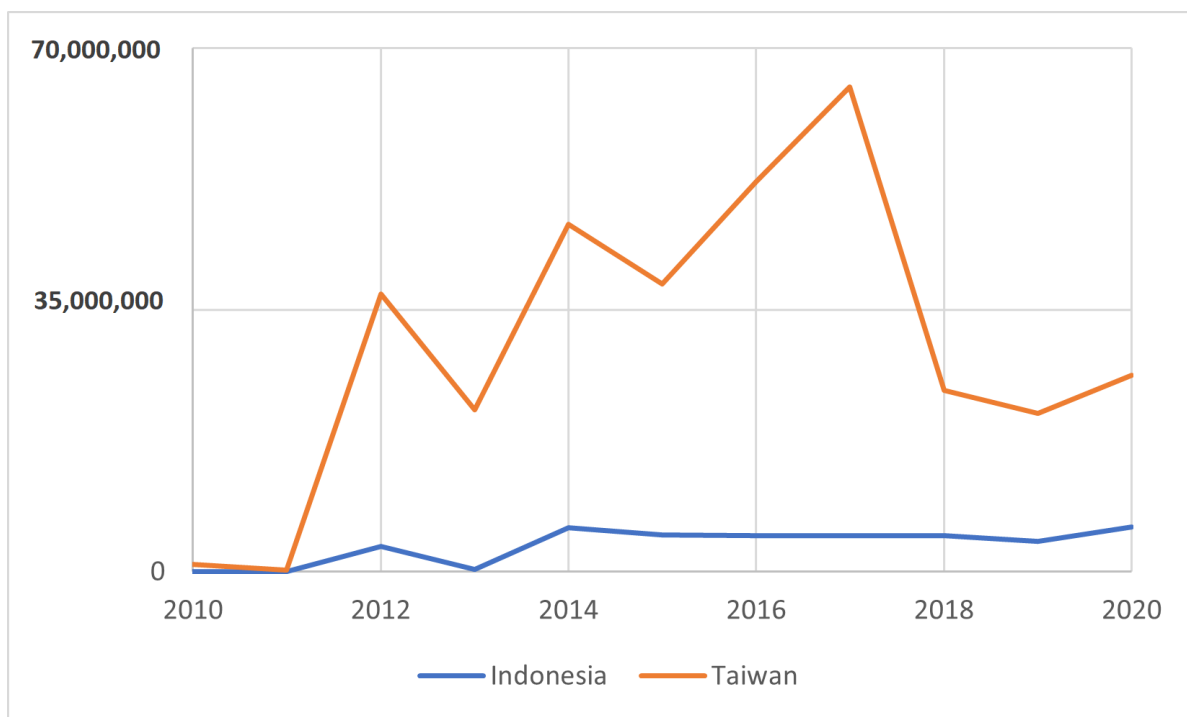


Figure 5: Indonesia and Taiwan annual mahi mahi CIF imports (in U.S. dollars). Values include imports of unspecified *Coryphaena* spp., fresh or chilled, fillets or frozen. Data extracted from USITC DataWeb (2021).

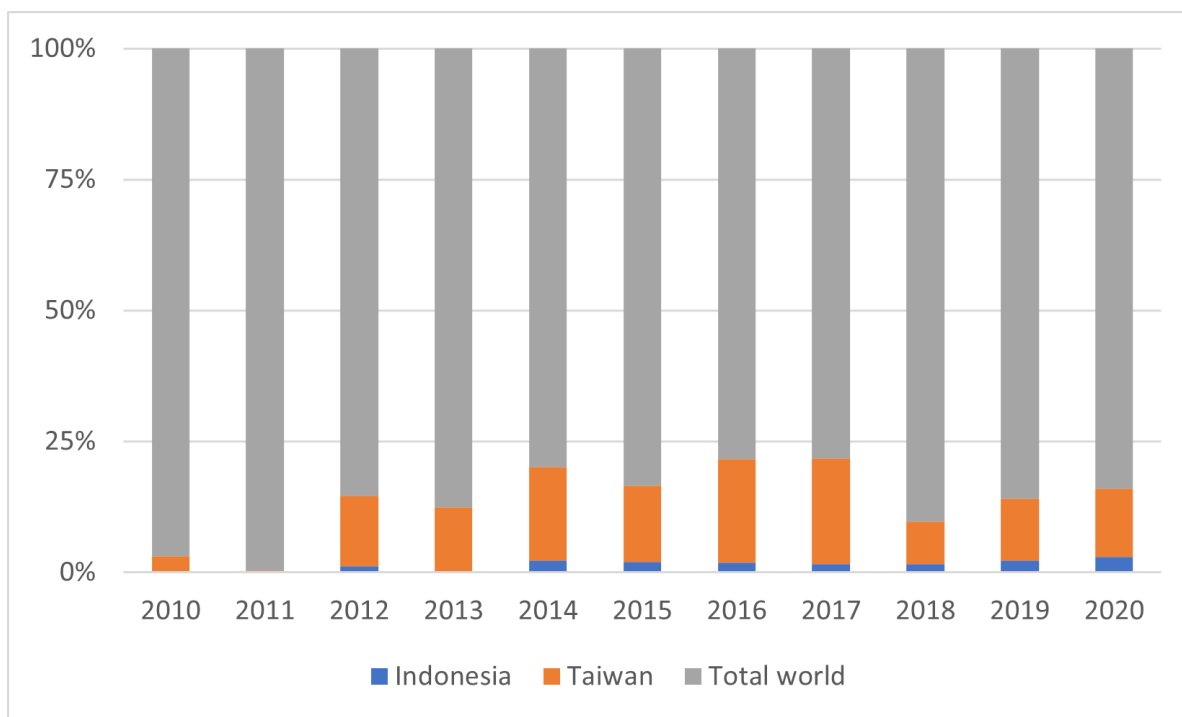


Figure 6: Total mahi mahi imports (CIF: cost, insurance, and freight; proportion of values in U.S. dollars, global) and contribution of Taiwan and Indonesia. Values include imports of unspecified *Coryphaena* spp., fresh or chilled, fillets or frozen. Data extracted from USITC DataWeb (2021).

Common and market names.

Mahi mahi is also known as dolphinfish and dorado, and its vernacular name in Indonesia's annual national capture fisheries statistical records is lemadang (or ikan lemadang).

Primary product forms

Mahi mahi is commonly sold in fresh, chilled, and frozen forms.

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
Eastern Indian Ocean Drifting longlines Indonesia	3.670: Low Concern	3.000: Moderate Concern	Green (3.318)
Western Central Pacific Drifting longlines Indonesia	3.670: Low Concern	3.000: Moderate Concern	Green (3.318)
Western Central Pacific Drifting longlines Taiwan	3.670: Low Concern	5.000: Low Concern	Green (4.284)

Criterion 1 Assessments

SCORING GUIDELINES

Factor 1.1 - Abundance

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

- *5 (Very Low Concern) — Strong evidence exists that the population is above an appropriate*

target abundance level (given the species' ecological role), or near virgin biomass.

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

Factor 1.2 - Fishing Mortality

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

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

Dolphinfish

Factor 1.1 - Abundance

Eastern Indian Ocean | Drifting longlines | Indonesia

Western Central Pacific | Drifting longlines | Indonesia

Western Central Pacific | Drifting longlines | Taiwan

Low Concern

In 2020, a fishery improvement project (FIP) in Taiwan completed a full mahi mahi stock assessment in the northwest Pacific Ocean using a stock synthesis (SS) model (Fishery Progress 2021). The SS was implemented by incorporating historical catches, length-frequency data, and standardized catch per unit effort (CPUE) series. The results of all scenarios indicated that the stock of mahi mahi in the northwest Pacific Ocean might not be overfished. But, the current spawning stock biomass was close to the levels of maximum sustainable yield (MSY) and $0.4SSB_0$ (Fishery Progress 2021). In addition, the probability of the current spawning stock biomass dropping below the MSY level (red and yellow areas in the Kobe plot) was estimated to be about 20% under the pessimistic scenario. The International Union for Conservation of Nature (IUCN) considers mahi mahi a species of "Least Concern" with a stable population trend {Collette et al. 2011}, but no update has been made since the last assessment in 2010.

There is no stock assessment available for mahi mahi in Indonesia. But, because a genetic study indicates that mahi mahi presents a low population structure level, without observed genetic differentiation within the Indo-Pacific region (Díaz-Jaimes et al. 2010)(Bayona-Vásquez et al. 2019), we consider mahi mahi a single population for the Indo-Pacific region.

Because the recent stock assessment indicates that stock biomass is near B_{MSY} and $0.4SSB_0$, abundance for mahi mahi receives a score of low concern.

Justification:

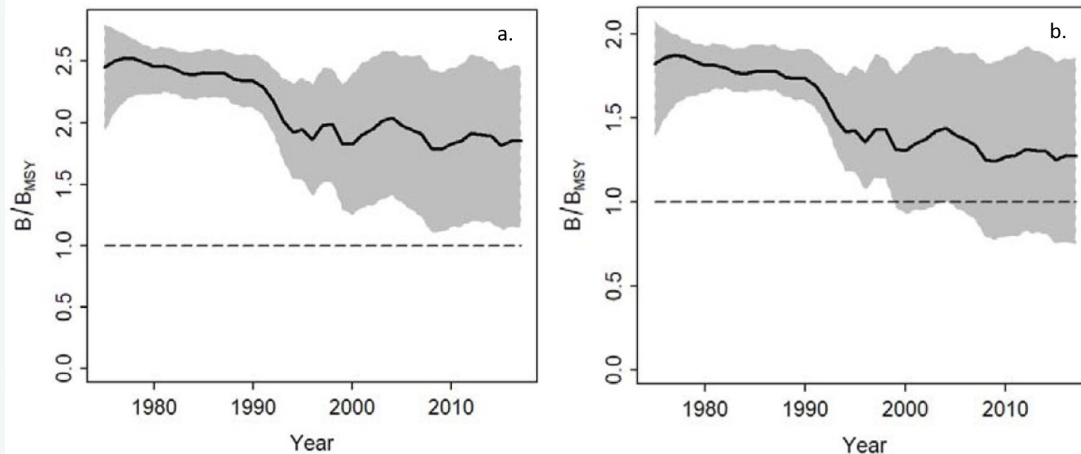


Figure 7: Relative biomass (B/B_{MSY}) trends for mahi mahi estimated by Fox (a) and Schaefer (b) models. Extracted from (Wang 2018).

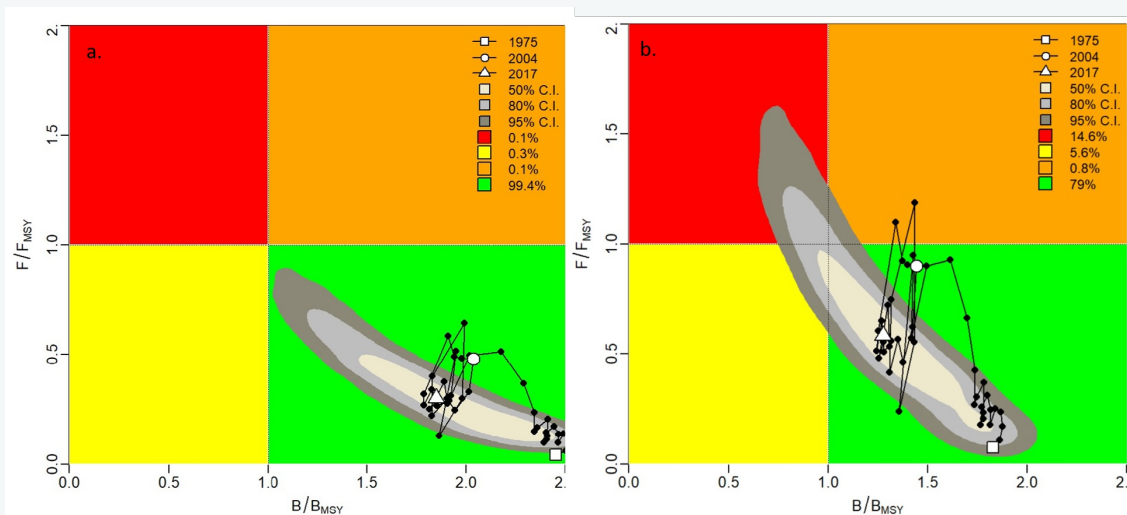


Figure 8: Kobe plot estimated by Fox (a) and Schaefer (b) models for mahi mahi in Taiwan. The elliptical areas represent the 50%, 80%, and 95% confidence intervals of the current resource status. Extracted from (Wang 2018).

Factor 1.2 - Fishing Mortality

Eastern Indian Ocean | Drifting longlines | Indonesia
Western Central Pacific | Drifting longlines | Indonesia

Moderate Concern

Mahi mahi is caught by pelagic longlines as both a target and by-catch species. Fishing mortality rates for mahi mahi in Indonesia (both Indian Ocean and Western and Central Pacific Ocean) are unknown. In the fishing port of Bitung, the production of mahi mahi from 2008 to 2017 ranged from 3.72 mt to 154.26 mt per year {PPS Bitung Statistics 2017}. An observer report for the tuna fishery in Indonesia with records from 2014 to 2019 revealed that mahi mahi catches ranged from

7 to 32 individuals per year (Fahmi et al. 2020). We have awarded a moderate concern score because fishing mortality is unknown.

Western Central Pacific | Drifting longlines | Taiwan

Low Concern

Mahi mahi is caught by pelagic longlines as both a target and by-catch species. A full stock assessment finalized in 2020 in Taiwan suggests that the stock of mahi mahi in the northwest Pacific Ocean might not be subject to overfishing, with the probability of the current fishing mortality exceeding the maximum sustainable yield (MSY) level (red and orange areas in the Kobe plot) estimated to be about 15% under the pessimistic scenario (Fishery Progress 2021). A previous report released within the fishery improvement program being developed in Taiwan for the species indicated that catch per unit effort (CPUE) slightly increased during 2000 to 2007, substantially decreased until 2009, slightly increased again during 2009 to 2012, and revealed a decreasing trend in recent years (Wang 2018). Because recent assessment does not indicate overfishing, this factor receives a score of low concern.

Justification:

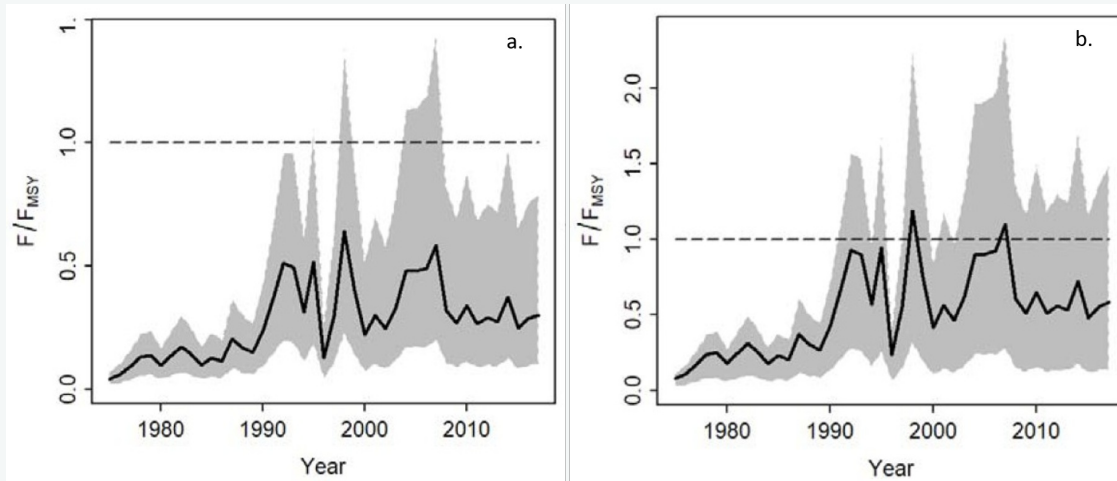


Figure 9: Relative fishing mortality (F/F_{MSY}) trends for mahi mahi estimated by Fox (a) and Schaefer (b) models. Extracted from (Wang 2018).

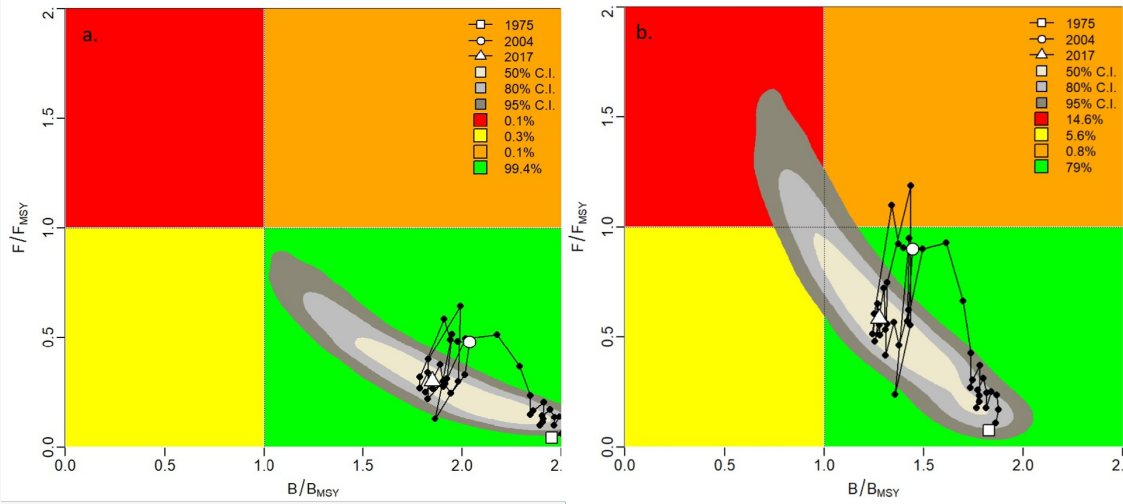


Figure 10: Kobe plot estimated by Fox (a) and Schaefer (b) models for mahi mahi in Taiwan. The elliptical areas represent the 50%, 80%, and 95% confidence intervals of the current resource status. Extracted from (Wang 2018).

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

Criterion 2 score(s) overview

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

DOLPHINFISH			
REGION / METHOD	SUB SCORE	DISCARD RATE/LANDINGS	SCORE
Eastern Indian Ocean Drifting longlines Indonesia	1.000	1.000: < 100%	Red (1.000)
Western Central Pacific Drifting longlines Indonesia	1.000	1.000: < 100%	Red (1.000)
Western Central Pacific Drifting longlines Taiwan	1.000	1.000: < 100%	Red (1.000)

Criterion 2 main assessed species/stocks table(s)

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

EASTERN INDIAN OCEAN DRIFTING LONGLINES INDONESIA			
SUB SCORE: 1.000		DISCARD RATE: 1.000	SCORE: 1.000
SPECIES	ABUNDANCE	FISHING MORTALITY	SCORE
Olive Ridley turtle	1.000: High Concern	1.000: High Concern	Red (1.000)
Yellowfin tuna	1.000: High Concern	1.000: High Concern	Red (1.000)
Albacore	3.670: Low Concern	1.000: High Concern	Red (1.916)
Bigeye tuna	5.000: Very Low Concern	1.000: High Concern	Yellow (2.236)
Escolar	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Opah	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Sharks	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Dolphinfish	3.670: Low Concern	3.000: Moderate Concern	Green (3.318)
Swordfish	5.000: Very Low Concern	5.000: Low Concern	Green (5.000)

WESTERN CENTRAL PACIFIC DRIFTING LONGLINES INDONESIA			
SUB SCORE: 1.000		DISCARD RATE: 1.000	SCORE: 1.000
SPECIES	ABUNDANCE	FISHING MORTALITY	SCORE
Sharks	1.000: High Concern	1.000: High Concern	Red (1.000)
Turtles (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Escolar	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Opah	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Dolphinfish	3.670: Low Concern	3.000: Moderate Concern	Green (3.318)
Albacore	3.670: Low Concern	5.000: Low Concern	Green (4.284)
Swordfish	3.670: Low Concern	5.000: Low Concern	Green (4.284)
Bigeye tuna	5.000: Very Low Concern	5.000: Low Concern	Green (5.000)
Yellowfin tuna	5.000: Very Low Concern	5.000: Low Concern	Green (5.000)

WESTERN CENTRAL PACIFIC DRIFTING LONGLINES TAIWAN			
SUB SCORE: 1.000		DISCARD RATE: 1.000	SCORE: 1.000
SPECIES	ABUNDANCE	FISHING MORTALITY	SCORE
Olive Ridley turtle	1.000: High Concern	1.000: High Concern	Red (1.000)
Silky shark	1.000: High Concern	1.000: High Concern	Red (1.000)
Blue shark	3.670: Low Concern	5.000: Low Concern	Green (4.284)
Dolphinfish	3.670: Low Concern	5.000: Low Concern	Green (4.284)
Shortfin mako shark	3.670: Low Concern	5.000: Low Concern	Green (4.284)
Bigeye tuna	5.000: Very Low Concern	5.000: Low Concern	Green (5.000)
Yellowfin tuna	5.000: Very Low Concern	5.000: Low Concern	Green (5.000)

In Indonesia, mahi mahi is usually caught by fisheries targeting other pelagic species, such as tuna and swordfish. Therefore, these species (tropical tunas and swordfish) are included in this report. Other species are included because they were listed in observer reports and fisheries improvement projects; however, species-specific information was not available for some groups. In the Western and Central Pacific Ocean, sharks and turtles are limiting the score for Criterion 2, particularly because sea turtle and shark species (especially silky shark) are vulnerable to fishing mortality. For the Indian Ocean section, yellowfin tuna is overfished and subject to overfishing, thus limiting the final score.

In Taiwan, a longline fishery targets mahi mahi along with other species, such as tunas and sharks. By-catch data were provided from the pelagic longline observer program. According to this program, the

most commonly caught species is the blue shark, which makes up 70%–80% of the shark species, followed by silky and shortfin mako sharks. An observer program specific to the mahi mahi fishery was launched in 2020 as part of the ongoing mahi mahi FIP, but this program has only been implemented quite recently, so it is unable to provide consistent information about secondary and endangered, threatened, and protected (ETP) species. Sea turtle interactions are mostly with olive ridley turtle, although hawksbill, green, leatherback, and loggerhead sea turtles have been incidentally captured (in far fewer numbers) (Huang 2014). Olive ridley turtle and silky shark were the limiting species driving the score for Criterion 2. Olive ridley turtle populations are vulnerable to fishing mortality, and silky shark is both overfished and experiencing overfishing.

It is worth noting that, in May 2021, the Indonesia Indian Ocean and Western and Central Pacific Ocean wahoo, cobia, and mahi mahi longline FIP was started. The pre-assessment for this FIP includes catch data from 2018 to 2020, where mahi mahi accounts for less than 0.5% of the overall catch composition (Trott 2021). This is a demersal multispecies longline fishery in which most of targeted species are groundfish (Trott 2021). Because mahi mahi composes an insignificant portion of catches in this fishery (based on recent data), we did not include this fishery in the assessment. With the development of the FIP and more detailed data being produced, this fishery may be included in an updated version of this assessment.

Criterion 2 Assessment

SCORING GUIDELINES

Factor 2.1 - Abundance

(same as Factor 1.1 above)

Factor 2.2 - Fishing Mortality

(same as Factor 1.2 above)

Factor 2.3 - Modifying Factor: Discards and Bait Use

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

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

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

Albacore

Factor 2.1 - Abundance

Eastern Indian Ocean | Drifting longlines | Indonesia

Low Concern

Albacore tuna was last assessed in the Indian Ocean in 2019 (IOTC 2019). This updated assessment indicates that the spawning biomass (SB) is higher than the levels needed to produce the maximum sustainable yield (SB_{MSY}) ($SB_{2017}/SB_{MSY} = 1.281$; range 0.574–2.071), and the population was estimated to be at around 26% of virgin levels (IOTC 2019). The stock is above both the interim target and limit reference points ($0.4 \times SB_{MSY}$), indicating that the population is not overfished (IOTC 2019). We have awarded a low concern score, rather than a very low concern score, because of a large amount of uncertainty in the stock assessment results (IOTC 2019).

Western Central Pacific | Drifting longlines | Indonesia

Low Concern

Albacore tuna in the South Pacific had its stock last assessed in 2018, with indications that the stock is not overfished. The median current spawning biomass level supports the maximum sustainable yield (MSY) ($SB_{RECENT}/SB_{MSY} = 3.3$) for the diagnostic case and range 1.45–10.74, and the established limit reference potential (LRP) set at $0.2SB_F = 0$. The median of $SB_{RECENT}/SB_F = 0 = 0.52$, ranging from 0.32 to 0.72 (Hare et al. 2020)(WCPFC 2019). The WCPFC recently agreed to use 56% of spawning biomass in the absence of fishing ($0.56SB_F = 0$) as a target reference point (WCPFC 2019). Because $SB_{RECENT}/SB_F = 0$ is above the limit reference point and more than 75% of the target reference point, we have awarded a score of low concern.

Justification:

Summary of reference points over the individual models evaluated in (WCPFC 2019).

	Mean	Median	Min	10%	90%	Max
SB_{MSY}	71407	68650	26760	39872	100773	134000
SB_0	443794	439800	308800	353870	510530	696200
SB_{MSY}/SB_0	0.16	0.17	0.07	0.1	0.21	0.23
$SB_F = 0$	469004	462633	380092	407792	534040	620000
$SB_{MSY}/SB_F = 0$	0.15	0.15	0.06	0.09	0.2	0.22
SB_{latest}/SB_0	0.55	0.56	0.33	0.42	0.69	0.74
$SB_{latest}/SB_F = 0$	0.53	0.52	0.3	0.37	0.69	0.77
SB_{latest}/SB_{MSY}	4	30.42	1.45	1.96	7.07	10.74
$SB_{recent}/SB_F = 0$	0.51	0.52	0.32	0.37	0.63	0.72
SB_{recent}/SB_{MSY}	3.88	3.3	1.58	1.96	6.56	9.67

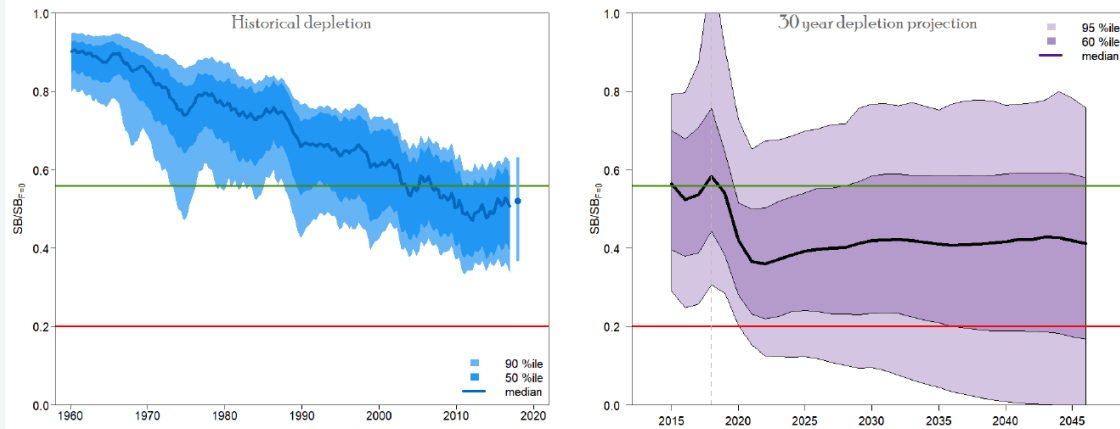


Figure 11: South Pacific albacore estimated level of depletion across the grid (left), and 30-year projected depletion based on status quo (2019 catch levels) fishing (right). The depletion target reference point is shown as a green line in the bottom plots. From (Hare et al. 2020).

Factor 2.2 - Fishing Mortality

Eastern Indian Ocean | Drifting longlines | Indonesia

High Concern

Albacore in the Indian Ocean was assessed during 2019 (IOTC 2019). Fishing mortality rates in 2017 were 135% (59%–217% range) of those needed to produce the maximum sustainable yield (MSY) (IOTC 2019). Current fishing mortality rates are above the target but below the limit reference point ($1.4 \times F_{MSY}$), so overfishing is occurring (IOTC 2019). We have therefore awarded a high concern score.

Western Central Pacific | Drifting longlines | Indonesia

Low Concern

The 2018 stock assessment (data thru 2016) for albacore in the South Pacific indicated that fishing mortality has been increasing, with F_{RECENT} (2012–2015 average) estimated to be 0.2 times the fishing mortality that will support the maximum sustainable yield (MSY). In addition, F_{RECENT}/F_{MSY} ranged from 0.06 to 0.53. Therefore, overfishing is not occurring. The median fishing impact (F_{RECENT}/F_{MSY}) was 0.2, with a 0% probability that recent fishing mortality was above F_{MSY} (Hare et al. 2020). In 2018, the total catch for albacore in the South Pacific was 80,820 mt, a 13% decrease from 2017 and a 2% decrease from the average in 2013–2017. Longline catch in 2018 (77,776 mt) was a 14% decrease from 2017 and an 8% decrease from the 2013–2017 average (WCPFC 2019). Because there is a recent stock assessment indicating that overfishing is not occurring and supporting the MSY, this factor is scored a low concern.

Justification:

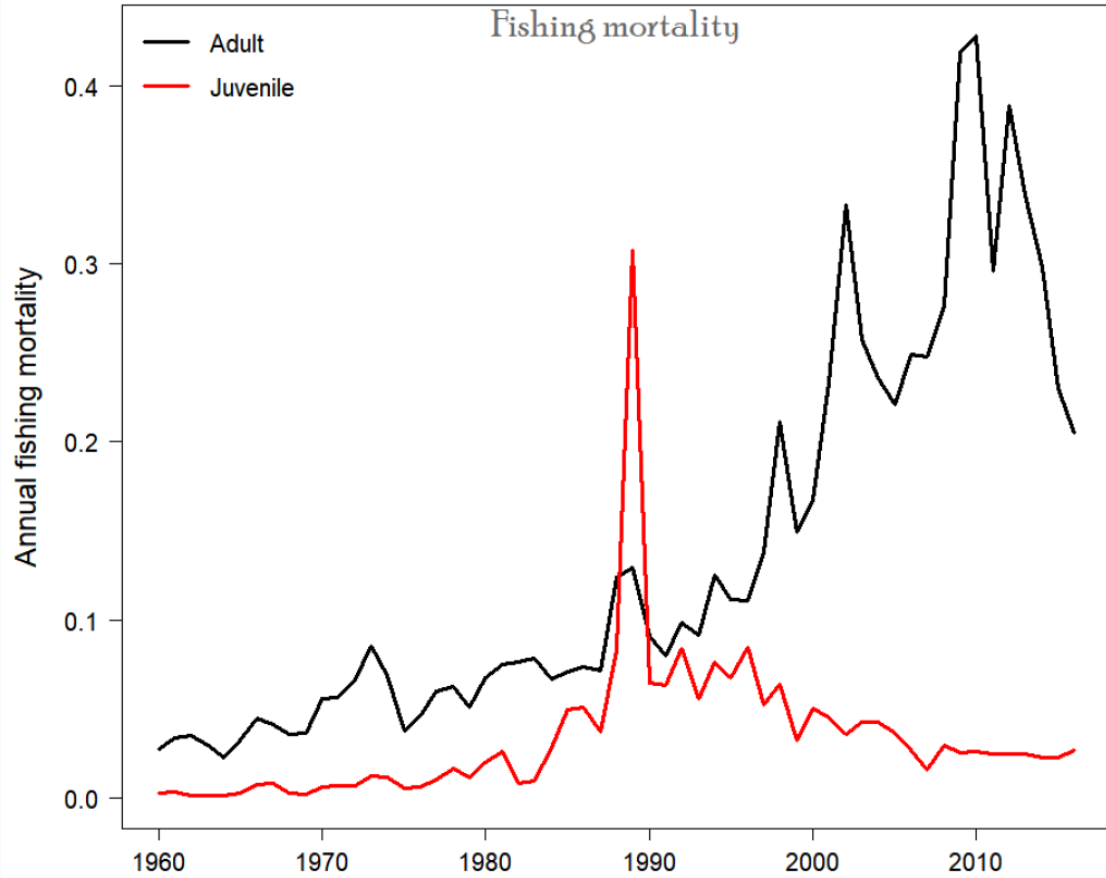


Figure 12: Annual fishing mortality for albacore in the South Pacific. From (Hare et al. 2020).

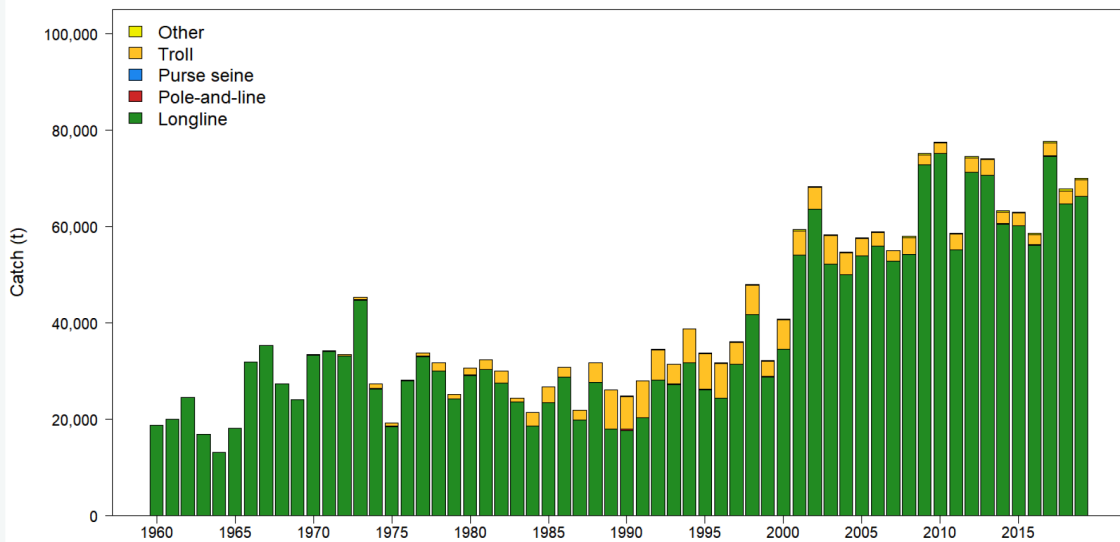


Figure 13: Albacore catch data in the South Pacific region. From (Hare et al. 2020).

Bigeye tuna

Factor 2.1 - Abundance

Eastern Indian Ocean | Drifting longlines | Indonesia

Very Low Concern

A new stock assessment for bigeye tuna was released in 2019, using the stock synthesis (SS3) model, which is a fully integrated model used to provide scientific advice for the three tropical tuna stocks in the Indian Ocean (IOTC-WPTT 2020). The spawning stock biomass in the assessment was estimated to be at 31% of the unfished levels in 2018 and 122% of the level that can support the maximum sustainable yield (MSY) [SSB_{MSY} (80% CI) = 503,000 mt (370,000–748,000 mt); $SSB_{2018}/SSB_{MSY} = 1.22$ (0.82–1.81); $SSB_{2018}/SSB_0 = 0.31$ (0.21–0.34)] (IOTC-WPTT 2020).

From the evidence available in the latest stock assessment, the bigeye tuna stock is determined to be not overfished (IOTC-WPTT 2020). This factor receives a score of very low concern because there is a recent stock assessment and biomass is above reference points.

Western Central Pacific | Drifting longlines | Indonesia

Western Central Pacific | Drifting longlines | Taiwan

Very Low Concern

In 2020, a stock assessment of bigeye tuna was carried out with data from 1952 to 2018 (Hare et al. 2020)(WCPFC 2020b). The stock has been declining for 60 years, with only one small increase during 2015–2016, with a following biomass decline (WCPFC 2020b). The biomass estimated from the last stock assessment was 590,311 mt ($MSY = 140,720$ mt) and $SB_{RECENT}/SB_F = 0 = 0.41$ (Hare et al. 2020). This value for recent biomass has a 0% probability (0 out of 24 model runs) of having breached the adopted limit reference point (LRP) (Hare et al. 2020)(WCPFC 2020b). This assessment used only the new growth estimates first utilized in the previous assessment, along with additional age-at-length information from tag recaptures, and it implemented the Richards growth model (Hare et al. 2020), so the uncertainties from the 2018 assessment were addressed. This factor receives a score of very low concern because there is a recent stock assessment and biomass is estimated to be above reference points.

Justification:

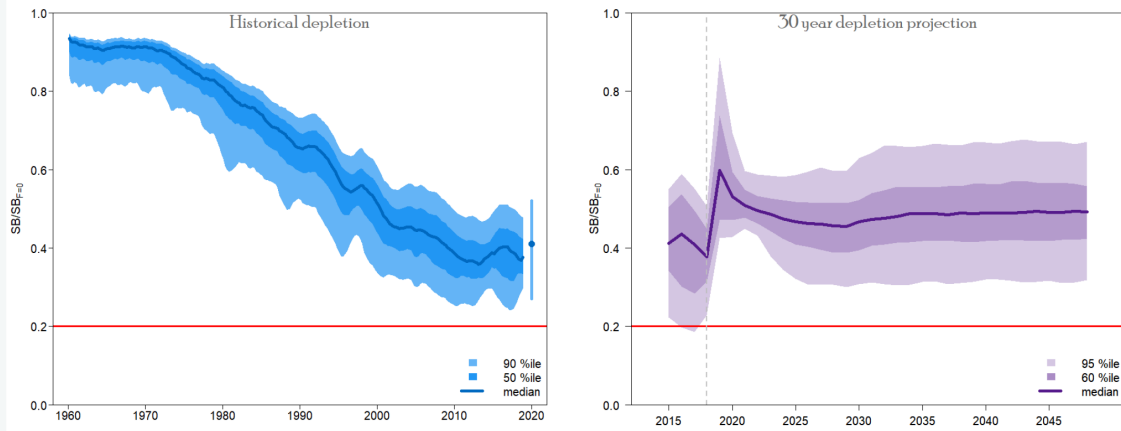


Figure 14: Bigeye tuna from the Western and Central Pacific Ocean estimated level of depletion across the grid (left), and 30-year projected depletion based on status quo (2016–2018 CPUE levels) fishing (right). From (Hare et al. 2020).

Factor 2.2 - Fishing Mortality

Eastern Indian Ocean | Drifting longlines | Indonesia

High Concern

During 2015–2019, industrial fisheries accounted for most of the bigeye tuna catches in the Indian Ocean (40% longlines, 34% purse seines), whereas coastal fisheries accounted for smaller percentages (10% coastal longline, 6% purse seine) (IOTC-WPTT 2020). The industrial longline fleet has been capturing bigeye tuna since the early 1950s: first as incidental catch, then as the target species after 1970 (IOTC-WPTT 2020). The 2019 stock assessment indicates that there is a high probability (72.8%) that fishing mortality is above F_{MSY} , and that bigeye tuna is subject to overfishing [F_{MSY} (80% CI) = 0.24 (0.18–0.36); F_{2018}/F_{MSY} = 1.20 (0.70–2.05)] (IOTC-WPTT 2020). Because the longline fishery is a substantial contributor to bigeye tuna fishing mortality in the Indian Ocean and overfishing is likely occurring, this factor receives a score of high concern.

Western Central Pacific | Drifting longlines | Indonesia

Western Central Pacific | Drifting longlines | Taiwan

Low Concern

The total bigeye tuna catch in 2019 in the Western and Central Pacific Ocean was 135,442 mt (53% longline, 35% purse seine, and the remainder split among troll, pole and line, and other gears) (Hare et al. 2020). Over the past 20 years, fishing mortality of bigeye tuna has been increasing, particularly of juveniles (Hare et al. 2020)(WCPFC 2020b). But, the longline fishery mostly catches adult fish, with a mean size of 80 lbs. and 160 cm (Hare et al. 2020). The most recent fishing mortality estimates indicate that overfishing is likely not occurring (87.5% probability $F_{\text{RECENT}} < F_{\text{MSY}}$) (Hare et al. 2020). The median recent fishing mortality ($F_{2014-2017}/F_{\text{MSY}}$) was 0.72 (WCPFC 2020b). Fishing mortality is scored a low concern because the current value is likely below F_{MSY} .

Justification:

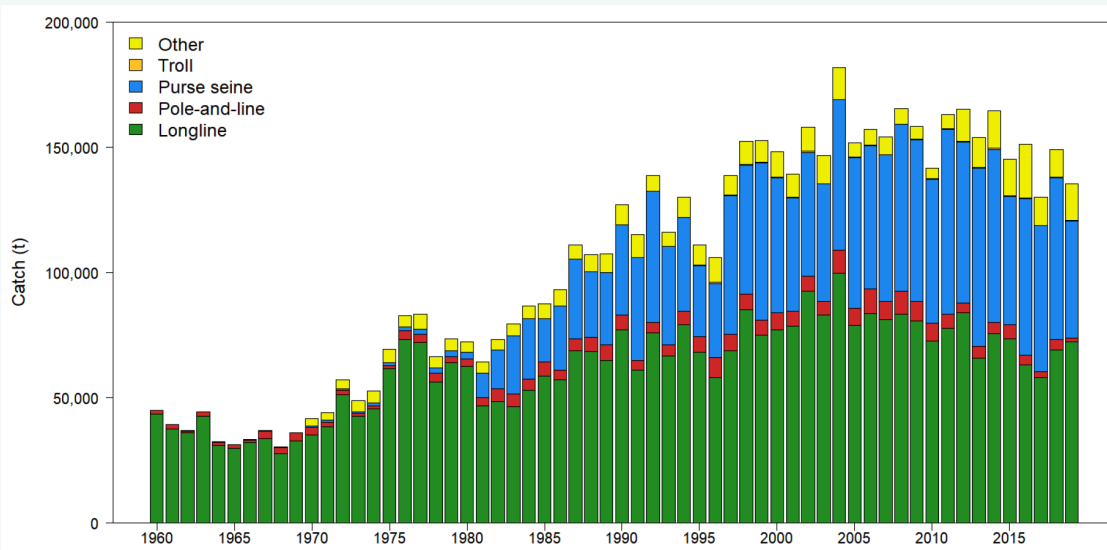


Figure 15: Bigeye tuna catch data in the Western and Central Pacific Ocean region. From (Hare et al. 2020).

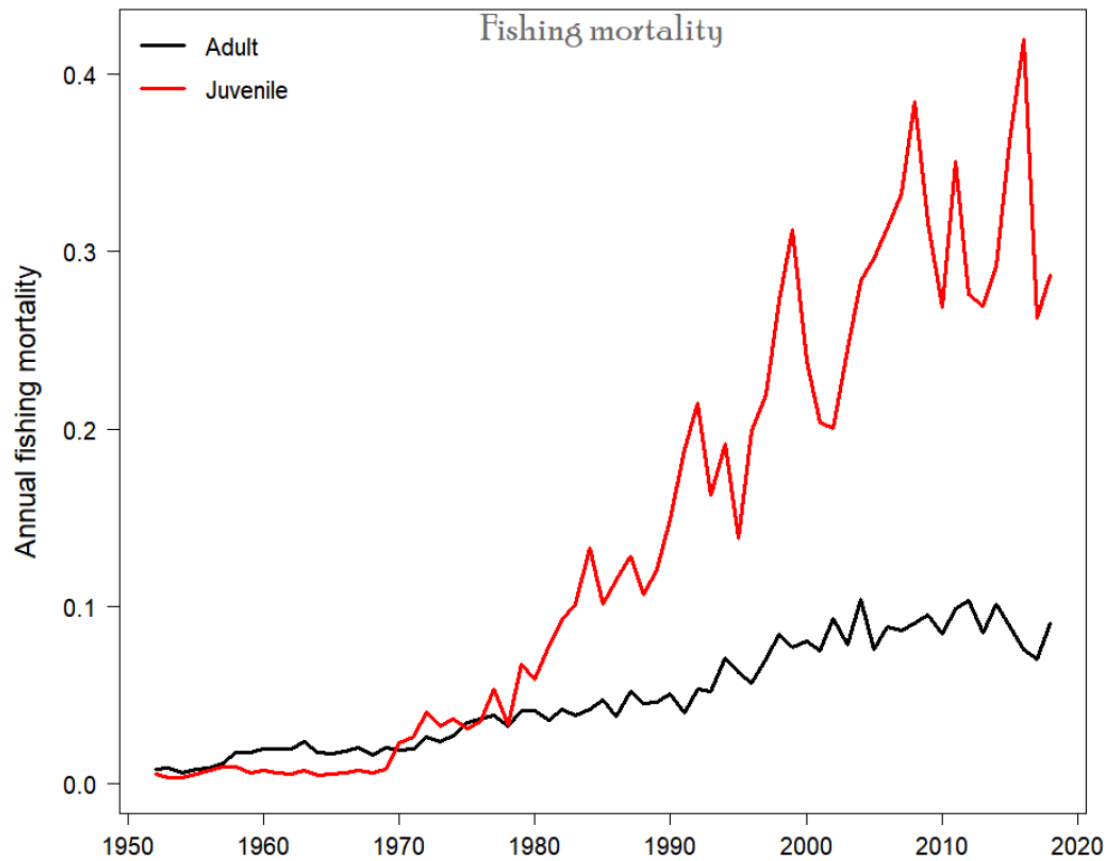


Figure 16: Annual fishing mortality for bigeye tuna in the Western and Central Pacific Ocean. From (Hare et al. 2020).

Blue shark

Factor 2.1 - Abundance

Western Central Pacific | Drifting longlines | Taiwan

Low Concern

An updated assessment of blue shark in the North Pacific Ocean was completed during 2017. According to this assessment, the population of blue shark there has increased from its lowest levels between 1990 and 1995 to near-series highs in recent years (ISC 2017). The female spawning biomass is estimated to be 71% above sustainable levels (SB_{2015}/SB_{MSY}) (ISC 2017). This indicates that the population is not overfished. But, because of the age of the data in the assessment, we have awarded a score of low concern, rather than a score of very low concern.

Factor 2.2 - Fishing Mortality

Western Central Pacific | Drifting longlines | Taiwan

Low Concern

Blue shark is widely distributed throughout the North Pacific Ocean and dominates shark catches in that region. According to the 2017 updated assessment, the fishing mortality rate estimated in recent years ($F_{2012-2014}$) was around 37% of that needed to produce the maximum sustainable yield (F_{MSY}) (ISC 2017). Therefore, overfishing is not occurring and we have awarded a score of low concern.

Escolar

Factor 2.1 - Abundance

Eastern Indian Ocean | Drifting longlines | Indonesia
Western Central Pacific | Drifting longlines | Indonesia

Moderate Concern

A stock assessment for escolar has not been conducted; however, the species is listed as "Least Concern" by the International Union for the Conservation of Nature (IUCN) (Smith-Vaniz et al. 2015b). Abundance of escolar receives a score of moderate concern, due to its IUCN "Least Concern" status.

Factor 2.2 - Fishing Mortality

Eastern Indian Ocean | Drifting longlines | Indonesia
Western Central Pacific | Drifting longlines | Indonesia

Moderate Concern

Escolar is among the most common species caught in longlines in Indonesia, accounting for 8% of by-catch (Irianto et al. 2016)(Fishery Progress 2021b). Because no assessment has been conducted for the species, fishing mortality is unknown. But, a regional observer report using catch data from 2014 to 2019 indicates that escolar catches ranged from 240 to 666 individuals per year in longlines in Indonesia (Fahmi et al. 2020). This factor receives a score of moderate concern because fishing mortality is unknown.

Olive Ridley turtle

Factor 2.1 - Abundance

Eastern Indian Ocean | Drifting longlines | Indonesia

High Concern

Olive ridley turtle is listed as "Vulnerable" by the International Union for the Conservation of Nature (IUCN) with a decreasing global population trend (Abreus-Grobois and Plotkin 2008), as "Threatened" under the United States Endangered Species Act since 1978 (FR 1978), and it is protected under Indonesian law (Kurniawan and Gitayana 2020). A recent population study across the Indonesian archipelago indicates that olive ridley turtle has limited gene flow among populations in the region (Madduppa et al. 2021), which emphasizes the importance of the number of individuals through the years. The nesting population in Indonesia raises concerns, with some reports of a spotty population increase, particularly in the Indian Ocean portion of the Indonesian archipelago (Kurniawan and Gitayana 2020). Because olive ridley turtle is a protected species/species of concern at national and global levels, this factor receives a score of high concern.

Justification:

Based on Wallace et al. (2011), the West Pacific regional management unit (or "subpopulation," in IUCN parlance) was considered "low risk-high threats," which means that the population characteristics that could be evaluated (moderate abundance, somewhat concentrated nesting distribution) suggested a viable population status, while the relative impacts of threats (including by-catch) were moderate (Wallace et al. 2011). But, several threats and population risk criteria, including recent and long-term trends, could not be assessed because of data deficiency (Wallace et al. 2011). The Northeast Indian RMUs (one for arribadas and one for solitary nesters) were assessed as "high risk-high threats," including high impacts of by-catch (Wallace et al. 2011). Currently, both the RMUs and their status are being updated by the IUCN Marine Turtle Specialist Group (pers. comm., Wallace B., November 2021).

Western Central Pacific | Drifting longlines | Taiwan

High Concern

The International Union for the Conservation of Nature (IUCN) considers olive ridley turtle to be "Vulnerable" globally with a decreasing population trend (Abreus-Grobois and Plotkin 2008). Olive ridley turtle has been listed as "Threatened" under the United States Endangered Species Act (ESA) since 1978 (FR 1978). Overall, in the Western and Central Pacific Ocean, there has been a decrease in annual nesting females of 92%, from 1,412 to 108 (Abreus-Grobois and Plotkin 2008). According to Wallace et al. (2011), the West Pacific regional management unit (RMU) is "low risk" (Wallace et al. 2011), but recent and long-term population trends were unavailable, so the risk of decline is unknown. We have awarded a score of high concern, because abundance is unknown and sea turtles are highly vulnerable to the effects of fishing mortality.

Factor 2.2 - Fishing Mortality

Eastern Indian Ocean | Drifting longlines | Indonesia

High Concern

Olive ridley turtle is caught in different fisheries in the Indian Ocean, and gillnet fisheries are responsible for the highest mortality rate among fishing gears (IOTC 2020b). In longlines, it was estimated that $\approx 3,500$ marine turtles annually can be caught in the Indian Ocean, with an estimated 75% being released alive (IOTC 2020b)(Nel et al. 2013). Stock assessments have not been carried out by the IOTC Working Party on Ecosystems and Bycatch, mainly due to a lack of data (which have not been submitted by the cooperating noncontracting parties over the years) (IOTC 2020b). A 2018 Ecological Risk Assessment (ERA) of sea turtles in the Indian Ocean suggests that mortality levels associated with incidental capture in gillnet fisheries are substantial (Williams et al. 2018). The ESA estimated that as many as 11,400 to 47,500 turtles are caught in gillnets (Williams et al. 2018). Other reports suggest more than 5,000 to 16,000 turtles were incidentally captured by India, Sri Lanka, and Madagascar each (IOTC 2018). Green sea turtles appear to be the most affected, with loggerhead, hawksbill, leatherback, and olive ridley being affected to different degrees, depending on a number of variables (e.g., season, region) (IOTC 2018). As a result of the very low observer coverage and reporting scheme in Indonesian longline fisheries, it is not possible to estimate total or individual by-catch of rare or endangered, threatened, or protected (ETP) species, including sea turtles. Consequently, population-level impacts of sea turtle by-catch cannot be determined, knowing that it is recommended for ETP and rare species to have at least 50% observer coverage (Babcock et al. 2003). Mortality from gillnet fisheries is thought to have a larger population-level impact on turtles than from gears such as longline and purse seine (IOTC 2018). There are currently no mitigation measures used to prevent the incidental capture of sea turtles in gillnets (IOTC 2018). We have awarded a high concern score because of the cumulative impacts of fishing mortality on sea turtle populations in this region.

Western Central Pacific | Drifting longlines | Taiwan

High Concern

The incidental capture of olive ridley turtles occurs worldwide, although the negative impacts from other fisheries such as trawls and gillnets appear to be greater than from longlines (Wallace et al. 2013)(Abreus-Grobois and Plotkin 2008). Data related to incidental captures are scarce because of low reporting by some countries and low observer coverage rates ($\approx 1\%$) (Brouwer and Bertram 2009)(Williams et al. 2009). But, by-catch of olive ridley turtle is reported to be especially high in some albacore fisheries operating in the South Pacific region (Huang 2014) but not others (Akroyd and McLoughlin 2017). By-catch is a high threat to the West Pacific RMU but, given the current information available about this fishery, it is not possible to estimate the total endangered, threatened, and protected (ETP) by-catch by species (including sea turtles) or the population-level impacts of by-catch (Wallace et al. 2011)(pers. comm., Wallace 2021). By-catch mitigation methods

have been put into place by some fisheries operating under the Western and Central Pacific Fisheries Commission, but there are issues with compliance, and the effectiveness of these measures is unknown (Clarke 2013). We have awarded a score of high concern, because the individual fishery's contribution is unknown and sea turtles have a high susceptibility to by-catch in longline fisheries.

Opah

Factor 2.1 - Abundance

Eastern Indian Ocean | Drifting longlines | Indonesia
Western Central Pacific | Drifting longlines | Indonesia

Moderate Concern

The status of opah in the Western and Central Pacific Ocean and the Indian Ocean is unknown. Opah is currently assessed as "Least Concern" by the International Union for the Conservation of Nature (IUCN) (Smith-Vaniz et al. 2015). Because of its IUCN status, opah receives a score of moderate concern for abundance.

Factor 2.2 - Fishing Mortality

Eastern Indian Ocean | Drifting longlines | Indonesia

Moderate Concern

The fishing mortality of opah in Indonesia is unknown; however, a regional observer report using catch data from 2014 to 2019 indicates that opah catches ranged from 13 to 60 individuals per year in longlines in Indonesia (Fahmi et al. 2020). Fishing mortality is deemed a moderate concern because fishing mortality is unknown.

Western Central Pacific | Drifting longlines | Indonesia

Moderate Concern

There is no information on fishing mortality rates for opah in the Western and Central Pacific Ocean (WCPO). Between 1987 and 2001, observers recorded a total of 6,569 opahs caught by longlines in the WCPO, primarily around Australia and New Zealand, representing 9.3% of the "other fish" catch. "Other fish" represented 7.6% of the total catch (Lawson 2001). From 1992 to 2009, 23% of opah caught in the South Pacific longline fishery were discarded and, of these, 25% were dead (OFP 2010). We have awarded a score of moderate concern because fishing mortality is unknown relative to reference points and impacts to the health of the stock.

Sharks

Factor 2.1 - Abundance

Eastern Indian Ocean | Drifting longlines | Indonesia

Moderate Concern

Shark by-catch from longlines in Indonesia in the Indian Ocean is dominated by blue shark and crocodile shark, according to a study carried out by the IOTC Working Party of Ecosystem and Bycatch (WPEB) during 2011 to 2015 (Irianto et al. 2016). The blue shark stock in the Indian Ocean was last assessed in 2017, using four models (IOTC 2020c). The following parameters were estimated: $MSY = 33,000$ mt (range 29,500–36,600 mt); $SB_{MSY} = 39,700$ (35,500–45,400); $SB_{2015}/SB_{MSY} = 1.54$ (1.37–1.72); $SB_{2015}/SB_0 = 0.52$ (0.46–0.56) (IOTC 2020c). The stock is currently not considered to be overfished; however, there are concerns that abundance will decline in the near future if current catches are maintained (IOTC 2020c). For crocodile shark, a regional stock assessment is not available for the species, which is currently listed as “Least Concern” by the International Union for the Conservation of Nature (IUCN) (Kyne et al. 2019). Because of crocodile shark’s IUCN status and the concerns about biomass decline in the near future for blue shark, this factor is scored a moderate concern.

Western Central Pacific | Drifting longlines | Indonesia

High Concern

A recent study describing common by-catch species in Indonesian tuna longlines in the WCPO area listed blue shark and silky shark as the most commonly captured shark species, followed by thresher shark and great hammerhead (Zainudin et al. 2017). Other species mentioned in the group, but at fewer than five individuals, are leafscale gulper shark, shortfin mako shark, and tiger shark (Zainudin et al. 2017). Before this study, it was unclear which shark species were incidentally captured by Indonesian vessels targeting large pelagics in the WCPO.

The last stock assessment of blue shark in the North Pacific Ocean was conducted in 2017, and the following parameters were estimated: $SSB_{1971} = 301,739$ mt (range 174,381–980,878 mt); $SSB_{2015} = 295,774$ mt (140,742–1,082,300 mt); $SSB_{MSY} = 175,401$ mt (100,984–482,638 mt); and $SSB_{2015}/SSB_{MSY} = 1.69$ (1.39–2.59), suggesting that the stock is not overfished (WCPFC 2019c)(ISC 2017). The species is currently listed as “Near Threatened” by the International Union for the Conservation of Nature (IUCN) {Rigby et al. 2019b}.

Silky shark was last assessed in 2018, with several uncertainties and a recommendation that the stock status is not a reliable representation of the true status. The stock is not considered to be overfished in the latest report (78% probability that SB_{2016} is greater than SB_{MSY}) (WCPFC 2019d); however, its uncertainties and conflicting data may suggest otherwise (see (Clarke et al. 2018)

(Rigby et al. 2017)). In addition, silky shark has a “Vulnerable” status by the IUCN (Rigby et al. 2017).

We have awarded a high concern score because there is the potential that fisheries targeting mahi mahi are catching vulnerable and/or overfished species.

Factor 2.2 - Fishing Mortality

Eastern Indian Ocean | Drifting longlines | Indonesia

Moderate Concern

Blue shark and crocodile shark in the Indian Ocean are commonly caught in longlines (coastal, deep-freezing), with most blue shark being retained and crocodile shark being discarded dead (Irianto et al. 2016). Fishing mortality parameters for blue shark in the Indian Ocean have been estimated: $F_{MSY} = 0.30$ (range 0.30–0.31); $F_{2015}/F_{MSY} = 0.86$ (0.67–1.09), with an estimate of 27.4% of the stock subject to overfishing (IOTC 2020c). It is recommended that the stock should be closely monitored, and catches decreased to maintain the stock above MSY reference levels. Fishing mortality for crocodile shark is unknown, but recorded discards from longline fisheries in the Indian Ocean have ranged from 63 to 157 individuals during 2011 to 2015 (IOTC 2020c). This factor receives a score of moderate concern, because of the close monitoring recommendation of blue shark longline catches to avoid overfishing in the near future, and the unknown status of fishing mortality of crocodile shark relative to reference points.

Western Central Pacific | Drifting longlines | Indonesia

High Concern

Blue shark is widely distributed throughout the North Pacific Ocean and dominates shark catches in that region. According to the 2017 updated assessment, the fishing mortality rate estimated in recent years ($F_{2012-2014}$) was around 37% of that needed to produce the maximum sustainable yield (F_{MSY}) (ISC 2017). Therefore, overfishing is not occurring.

A new Pacific-wide stock assessment of silky shark was recently conducted (Clarke et al. 2018) (WCPFC 2019d). The results of the assessment are not considered robust enough to determine the status of silky shark in the Pacific Ocean (Clarke et al. 2018). But, there is some indication that fishing mortality has increased considerably over the past 20 years, and this may have resulted in population declines (Clarke et al. 2018). The WCPFC report suggests that the stock is subject to overfishing (WCPFC 2019d), and the previous assessment, conducted in 2013, indicated that fishing mortality rates in 2009 (the last year of the modeled period) exceeded the levels needed to produce the maximum sustainable yield ($F_{CURRENT}/F_{MSY} = 4.48$ [1.41–7.96]). This indicates that overfishing was occurring (Rice and Harley 2013).

The status of other species caught in these fisheries is unknown. We have awarded a high concern score because of the status of silky shark.

Shortfin mako shark

Factor 2.1 - Abundance

Western Central Pacific | Drifting longlines | Taiwan

Low Concern

A stock assessment of shortfin mako shark in the North Pacific Ocean was conducted in 2018 (ISC 2018). The average (1975 to 2016) spawning abundance (SA) was estimated to be 910,000 sharks, and the current SA (2016) is estimated to be 860,200 sharks (ISC 2018). This SA is estimated to be 36% above the estimated SA at the maximum sustainable yield (ISC 2018). Based on these results, it is likely (>50%) that shortfin mako shark in the North Pacific is not overfished (ISC 2018). The International Union for the Conservation of Nature (IUCN) has listed this species globally as "Endangered," mainly because of steep population declines in the Atlantic Ocean (Rigby et al. 2019). We have awarded a score of low concern based on the stock assessment results.

Factor 2.2 - Fishing Mortality

Western Central Pacific | Drifting longlines | Taiwan

Low Concern

In 2018, a stock assessment of shortfin mako shark in the North Pacific Ocean was conducted (ISC 2018). Annual fishing intensity was estimated to be 0.16, which is 62% of the fishing intensity at maximum sustainable yield levels (ISC 2018). It is likely (>50%) that overfishing is not occurring, so we have awarded a score of low concern.

Silky shark

Factor 2.1 - Abundance

Western Central Pacific | Drifting longlines | Taiwan

High Concern

The International Union for the Conservation of Nature (IUCN) considers silky shark to be “Vulnerable” globally (Rigby et al. 2017). The first assessment of silky shark in the Western and Pacific Ocean (WCPO) was conducted in 2012 and updated during 2013 (Rice and Harley 2013). A Pacific-wide assessment was conducted in 2018 (Clarke et al. 2018). The results of this assessment are considered highly uncertain and not sufficient to provide an assessment of silky shark stock status in the Pacific Ocean (Clarke et al. 2018). But, there were several indications that the population has likely declined considerably over the past 20 years (Clarke et al. 2018)(Rigby et al. 2017). The previous 2013 assessment showed that the spawning biomass levels (abundance of mature fish) consistently declined over the modeled time period (1995 to 2009) by 67%. The spawning biomass in 2009 was far below the target levels needed to produce the maximum sustainable yield ($SB_{CURRENT}/SB_{MSY} = 0.70$ 95%; CI 0.51–1.23); therefore, the stock is overfished. We have awarded a score of high concern based on the IUCN assessment.

Factor 2.2 - Fishing Mortality

Western Central Pacific | Drifting longlines | Taiwan

High Concern

A new Pacific-wide stock assessment of silky shark was conducted in 2018 (Clarke et al. 2018). The results of the assessment are not considered robust enough to determine the status of silky shark in the Pacific Ocean (Clarke et al. 2018). But, there is some indication that fishing mortality has increased considerably over the past 20 years, and this may have resulted in population declines (Clarke et al. 2018). The previous assessment, conducted in 2013, indicated that fishing mortality rates in 2009 (the last year of the modeled period) exceeded the levels needed to produce the maximum sustainable yield ($F_{CURRENT}/F_{MSY} = 4.48$ [1.41–7.96]). This indicates that overfishing is occurring (Rice and Harley 2013). By-catch from the associated purse seine fishery has had a large impact on the stock, second only to the longline fishery, even though catches are much higher in the longline fishery (Rice 2012). For example, in the associated purse seine fishery, F increased to 0.15 by 2009, which is above F_{MSY} (0.077) (Rice and Harley 2013). In other oceans, the entanglement mortality rates of silky shark in purse seine fisheries are estimated to be 5 to 10 times the reported by-catch levels (Filmatier et al. 2013). We have awarded a score of high concern based on previous indications that fishing mortality rates are too high, combined with recent analysis that also suggests that increased fishing mortality may have resulted in biomass decreases (Rice and Harley 2013) (Clarke et al. 2018).



Swordfish

Factor 2.1 - Abundance

Eastern Indian Ocean | Drifting longlines | Indonesia

Very Low Concern

The last stock assessment synthesis for swordfish in the Indian Ocean was published in 2020, using data up to 2018 (IOTC 2020). The models (SS3, ASPIC, and JABBA) indicated that the stock was at levels that are above MSY-based reference points (i.e., current SSB is estimated to be above SB_{MSY} and above $0.4 \times SB_{MSY}$ (IOTC 2020). The current MSY is set at 33,000 mt, and SB_{MSY} at 59,000 mt (IOTC 2020). The spawning stock in 2018 is estimated to be 40–83% of unfished levels (IOTC 2020). Because the recent stock assessment estimates that the stock is not overfished and is above reference points, this factor receives a score of very low concern.

Justification:

Area ¹	Indicators		2020 stock status determination
Indian Ocean	Catch 2019 ² (MT)	32,671	98%
	Average catch 2015-2019 (MT)	31,712	
	MSY (1,000 MT) (80% CI)	33 (27–40)	
	F_{MSY} (80% CI)	0.23 (0.15–0.31)	
	SB_{MSY} (1,000 MT) (80% CI)	59 (41–77)	
	F_{2018}/F_{MSY} (80% CI)	0.60 (0.40–0.83)	
	SB_{2018}/SB_{MSY} (80% CI)	1.75 (1.28–2.35)	
	SB_{2018}/SB_{1950} (80% CI)	0.42 (0.36–0.47)	

¹ Boundaries for the Indian Ocean stock assessment are defined as the IOTC area of competence

² Proportion of 2019 catch estimated or partially estimated by IOTC Secretariat: 5%

Figure 17: Stock status of swordfish in the Indian Ocean (IOTC 2020).

Western Central Pacific | Drifting longlines | Indonesia

Low Concern

The most recent assessment for swordfish in the Southwestern Pacific Ocean was conducted in 2017 (Takeuchi et al. 2017)(WCPFC 2019b). There are no reference points adopted for this population. The assessment indicated that the stock biomass is above the limit reference points ($20\%SB_F = 0$) used for tuna. The median estimate was 0.35 (Takeuchi et al. 2017). The ratio of the latest spawning biomass to that needed to produce the maximum sustainable yield (SB_{latest}/SB_{MSY}) was 1.61 (median value) (Takeuchi et al. 2017)(WCPFC 2019b). It is likely that the stock is not overfished, but because there are no reference points in place, we have awarded a score of low concern, rather than a score of very low concern.

Factor 2.2 - Fishing Mortality

Eastern Indian Ocean | Drifting longlines | Indonesia

Low Concern

Swordfish in the Indian Ocean is caught mainly with offshore longlines (more than 60% of total catches), coastal longlines ($\approx 22\%$), and gillnets ($\approx 13\%$) (IOTC 2020). From the latest stock assessment, fishing mortality is estimated to be below the reference points (below the target of F_{MSY} and below the limit of $1.4 \times F_{MSY}$), indicating that overfishing is not occurring (IOTC 2020). Because the current fishing mortality is below reference points, this factor receives a score of low concern.

Justification:

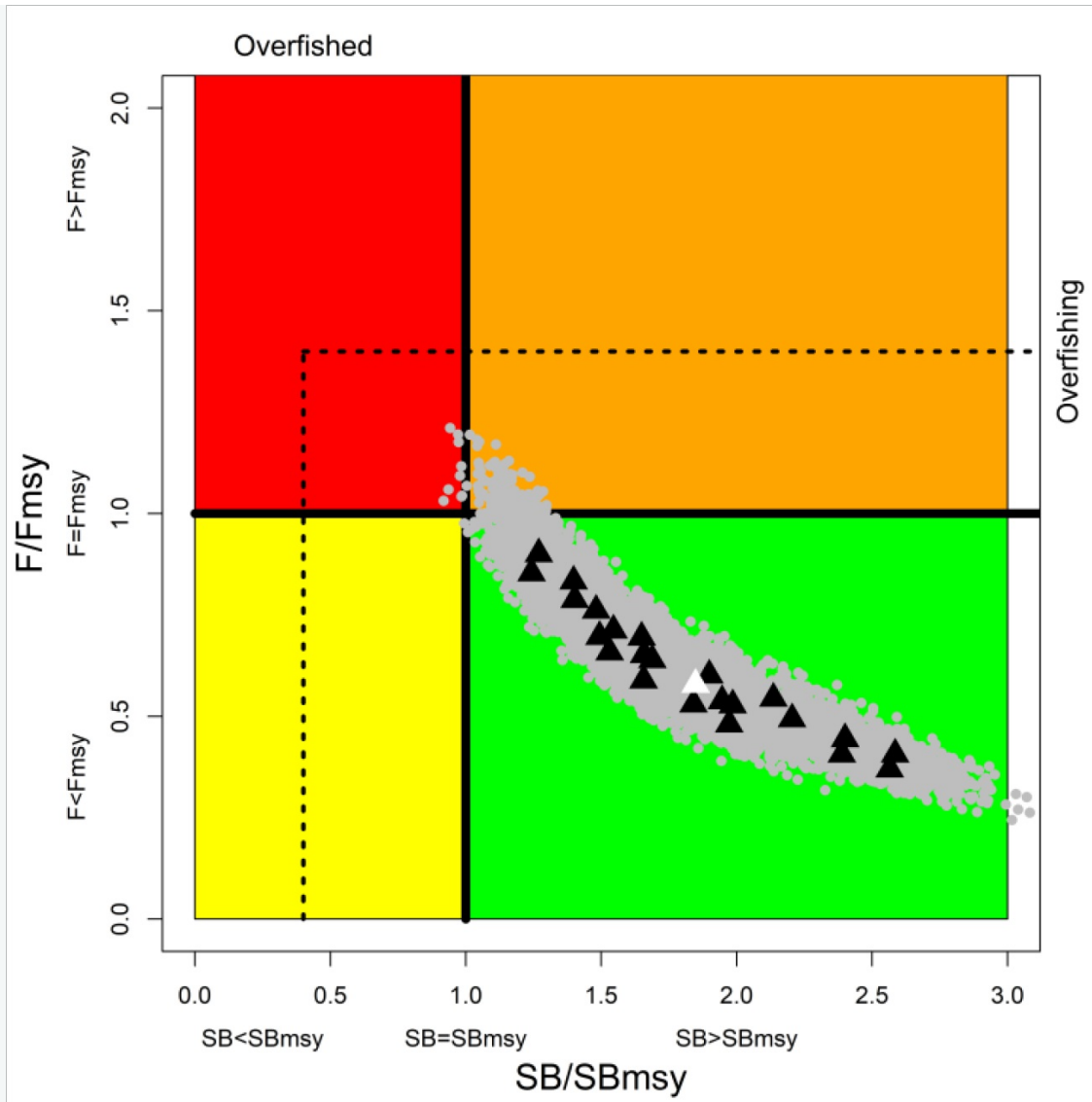
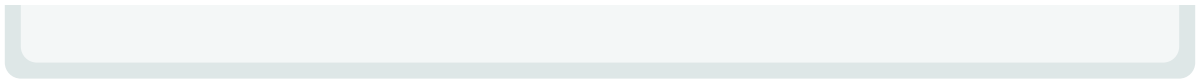


Figure 18: Current stock status of swordfish in the Indian Ocean, relative to SB_{MSY} (x-axis) and F_{MSY} (y-axis) reference points for the final model grid. Triangles represent estimates from individual models (white triangle represents the estimate from the basic model). Grey dots represent uncertainty from individual models. The dashed lines represent limit reference points ($SB_{LIM} = 0.4 SB_{MSY}$ and $F_{LIM} = 1.4 \times F_{MSY}$). Source: (IOTC 2020).

Western Central Pacific | Drifting longlines | Indonesia

Low Concern

According to the updated 2017 stock assessment of swordfish in the South Pacific Ocean, fishing mortality rates are sustainable. The ratio of recent fishing mortality rates to those needed to produce the maximum sustainable yield (MSY) was estimated to be 0.86 (0.42 to 1.46) (Takeuchi et al. 2017)(WCPFC 2019b). Overfishing is not currently occurring, so we have awarded a score of low concern.



Turtles (unspecified)

Factor 2.1 - Abundance

Western Central Pacific | Drifting longlines | Indonesia

High Concern

Five sea turtle species (green, hawksbill, leatherback, loggerhead, and olive ridley) are most frequently caught in fisheries throughout the Western and Central Pacific Ocean (WCPO) and are species of concern (particularly leatherback turtle) with severely depleted subpopulations (WCPFC 2018). Their statuses under the International Union for the Conservation of Nature (IUCN) range from "Vulnerable" (olive ridley) to "Critically Endangered" (leatherback, hawksbill, and loggerhead) (Abreus-Grobois and Plotkin 2008)(Seminoff 2004)(Mortimer and Donnelly 2008)(Tiwari et al. 2013)(Limpus and Casale 2015). The main threats to these species are related to by-catch, the destruction of nesting habitats, and climate change, among others (Wallace et al. 2011)(Wallace et al. 2013). Because all the marine turtle species listed are species of concern, this factor receives a score of high concern.

Justification:

As a result of the very low observer coverage and reporting scheme in Indonesian longline fisheries, it is not possible to estimate total or individual by-catch of rare or endangered, threatened, and protected (ETP) species, including sea turtles. Consequently, population-level impacts of sea turtle by-catch cannot be determined. Indonesian longline fishing operations occur in a highly diverse area in terms of marine turtle regional management units (RMUs) (Wallace et al. 2010), potentially overlapping with nine different RMUs of six different species, including Southeast and Northeast Indian green turtle, West Pacific/Southeast Asia and Southeast Indian hawksbill, Southeast Indian loggerhead, West Pacific and Northeast Indian leatherback, West Pacific olive ridley, and possibly Southeast Indian flatback. Furthermore, nearly all these RMUs are either at high risk or under high threats, or both (Wallace et al. 2011).

Factor 2.2 - Fishing Mortality

Western Central Pacific | Drifting longlines | Indonesia

High Concern

Globally, by-catch is a major threat to all marine turtles, particularly from gillnets, trawls, and longlines (Wallace et al. 2013). By-catch mitigation methods are mandated by the Western and Central Pacific Fisheries Commission, but their effectiveness is unknown and there are issues of compliance with these measures (Clarke et al. 2014). The available data in the Western and Central Pacific Ocean are spotty, due to low reporting by some nations and low observer coverage. We have awarded a score of high concern because the populations of all five species are depleted, by-catch mortality appears to be a factor in these depletions, and management measures may not be

currently effective.

Yellowfin tuna

Factor 2.1 - Abundance

Eastern Indian Ocean | Drifting longlines | Indonesia

High Concern

The last stock assessment performed for yellowfin tuna in the Indian Ocean is from 2018, using a model developed in the previous 2016 assessment, with updates from the WPTT (IOTC-WPTT 2020). The spawning stock biomass in the assessment was estimated to be 30% of the unfished levels in 2017 [SSB_{MSY} (80% CI) = 1,069,000 mt (789,000–1,387,000 mt); SSB_{2017}/SSB_{MSY} = 0.83 (0.74–0.97); SSB_{2017}/SSB_0 = 0.30 (0.27–0.33)] (IOTC-WPTT 2020). Although there are uncertainties in the models, the stock is determined to be overfished. Abundance of yellowfin tuna in the Indian Ocean receives a score of high concern because the latest stock assessment indicates that the stock is overfished.

Western and Central Pacific (WCP0) Stock | Western Central Pacific | Drifting longlines | Indonesia

Western Central Pacific | Drifting longlines | Taiwan

Very Low Concern

The latest assessment of yellowfin tuna in the Western and Central Pacific Ocean was released in 2020 and included data from 1952 to 2018 (Hare et al. 2020)(WCPFC 2020). All model runs ($n = 72$) estimated that recent spawning biomass levels (1,994,655 mt) are above both SB_{MSY} (1,091,200 mt) and the limit reference point (LRP) of 20% (Hare et al. 2020). Assuming the status quo of fishing conditions (maintained at the 2016–2018 average levels), there is zero probability that the stock would drop below the LRP, indicating that the stock is not overfished ($SB_{RECENT}/SB_F = 0 < LRP$) (Hare et al. 2020). Future model projections also predict a zero risk of breaching the LRP in the upcoming decades. Because there is a recent stock assessment and biomass is estimated to be above reference points, this factor receives a score of very low concern.

Justification:

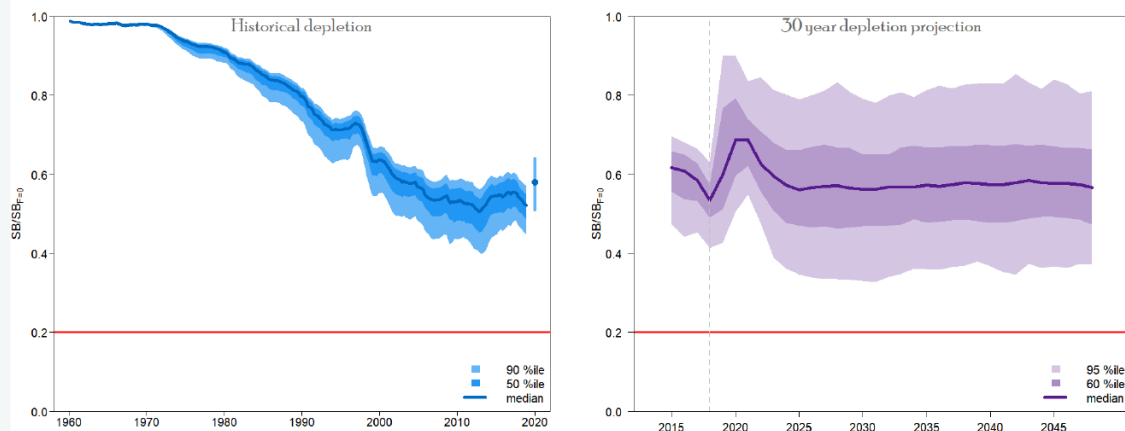


Figure 19: Yellowfin tuna from the Western and Central Pacific Ocean estimated level of depletion across the grid (left), and 30-year projected depletion based on status quo fishing (2016–2018 CPUE levels) (right). From (Hare et al. 2020).

Factor 2.2 - Fishing Mortality

Eastern Indian Ocean | Drifting longlines | Indonesia

High Concern

Yellowfin tuna is mainly caught by purse seiners and longline fisheries (about 40% of total catch) in the Indian Ocean; artisanal fisheries also put substantial pressure on the species (catches of around 200,000 mt per year since 2012) (IOTC-WPTT 2020). Yellowfin tuna is one of the main targeted tuna species in the Indian Ocean (IOTC-WPTT 2020). The 2018 stock assessment estimates F_{MSY} (80% CI) = 0.15 (0.13–0.17) and $F_{2017}/F_{MSY} = 1.20$ (1.00–1.71), indicating that the stock is subject to overfishing (IOTC-WPTT 2020). Because current fishing mortality is estimated to be 20% above the reference point of F_{MSY} (IOTC-WPTT 2020), this factor receives a score of high concern.

Western and Central Pacific (WCPO) Stock | Western Central Pacific | Drifting longlines | Indonesia

Western Central Pacific | Drifting longlines | Taiwan

Low Concern

Over the years, fishing mortality of yellowfin tuna has been increasing for both juvenile and adults in the Western and Central Pacific Ocean (Hare et al. 2020). But, current rates of fishing mortality indicate that overfishing is not occurring (0% probability $F_{\text{RECENT}} > F_{\text{MSY}}$), which is below F_{MSY} in all models used in the 2020 assessment (Hare et al. 2020). The ratio of fishing mortality to that which will support the MSY was estimated at 0.36 in the 2020 assessment (WCPFC 2020). Fishing mortality receives a score of low concern because overfishing is not occurring.

Justification:

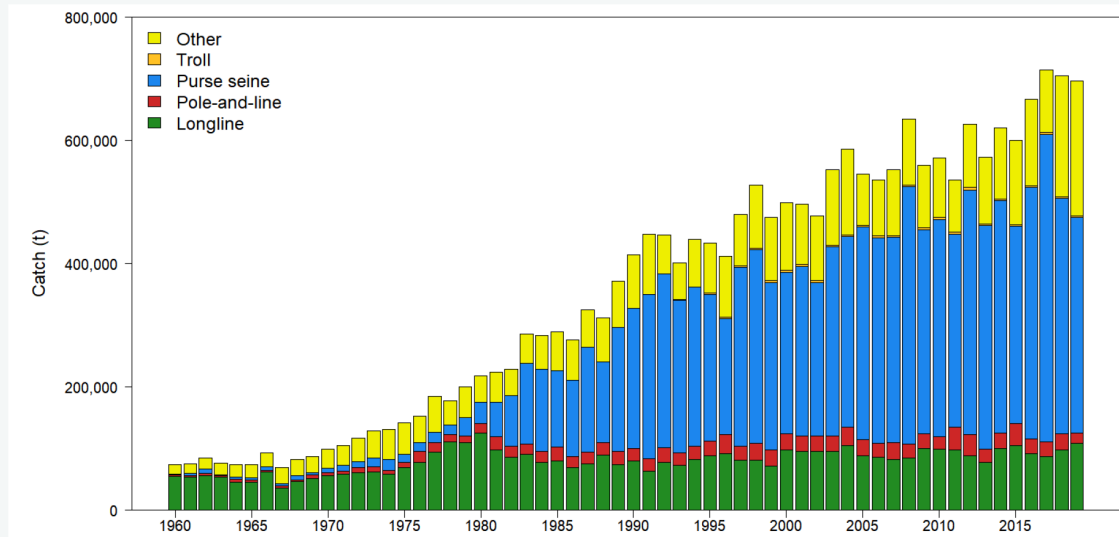


Figure 20: Yellowfin tuna catch data in the Western and Central Pacific Ocean. From (Hare et al. 2020).

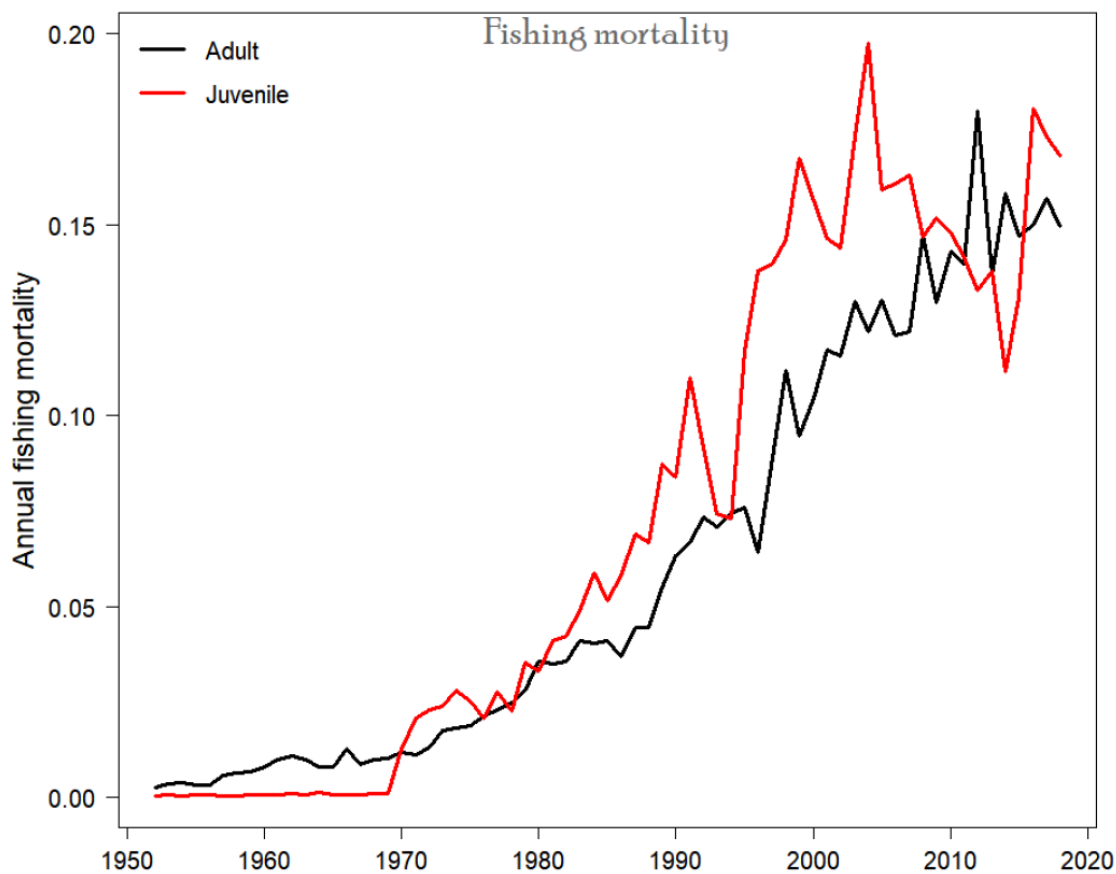


Figure 21: Annual fishing mortality for yellowfin tuna in the Western and Central Pacific Ocean. From (Hare et al. 2020).

Factor 2.3 - Discard Rate/Landings

Eastern Indian Ocean | Drifting longlines | Indonesia

Western Central Pacific | Drifting longlines | Indonesia

Western Central Pacific | Drifting longlines | Taiwan

< 100%

Information on discards is not available for mahi mahi fisheries in the Western and Central Pacific Ocean and the Indian Ocean. In Taiwan, fishers typically use live milkfish, frozen Pacific saury, and squid as bait to catch mahi mahi (Overseas Fisheries Development Council 2021), whereas in Indonesia, such information is not available for this specific fishery. In tuna longline fisheries in the region, catches of other species have not been documented in detail, and estimates of discards (weight) have only been included in total catch by species from 2017 onward (WCPFC 2019e)(OFP 2019). In addition, discards (by number) have not been documented. Recent studies have used observer data to better estimate by-catch and discards in longlines (WCPFC 2019e). Even without

specific numbers for mahi mahi fisheries, the discard rate is known to be lower than 100%.

Criterion 3: Management Effectiveness

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

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

The Criterion 3 rating is determined as follows:

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

Rating is Critical if Management Strategy and Implementation is Critical.

Guiding principle

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

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

Criterion 3 Summary

FISHERY	MANAGEMENT STRATEGY	BYCATCH STRATEGY	DATA COLLECTION AND ANALYSIS	ENFORCEMENT	INCLUSION	SCORE
Eastern Indian Ocean Drifting longlines Indonesia	Ineffective	Ineffective	Ineffective	Moderately Effective	Moderately Effective	Red (1.000)
Western Central Pacific Drifting longlines Indonesia	Ineffective	Ineffective	Ineffective	Moderately Effective	Moderately Effective	Red (1.000)

Western Central Pacific Drifting longlines Taiwan	Moderately Effective	Ineffective	Moderately Effective	Moderately Effective	Highly effective	Red (1.000)
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Criterion 3 Assessment

SCORING GUIDELINES

Factor 3.1 - Management Strategy and Implementation

Considerations: What type of management measures are in place? Are there appropriate management goals, and is there evidence that management goals are being met? Do 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.

Factor 3.2 - Bycatch Strategy

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

Factor 3.3 - Scientific Research and Monitoring

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

Factor 3.4 - Enforcement of Management Regulations

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

Factor 3.5 - Stakeholder Inclusion

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

Factor 3.1 - Management Strategy And Implementation

Eastern Indian Ocean | Drifting longlines | Indonesia

Ineffective

Indonesia has been a contracting party to the Indian Ocean Tuna Commission since 2007 (Ministry of Marine Affairs and Fisheries 2010). On January 1, 2018, as part of the United States Seafood Import Monitoring Program to prevent illegal, unreported, and unregulated (IUU) fishery products from entering the United States, the U.S. implemented regulations for 13 species, including mahi mahi, sharks, swordfish, and tunas (albacore, bigeye, skipjack, yellowfin, and bluefin) (NOAA 2021). Ideally, all data collected will allow the fishery product to be traced to the point of harvest, to check if it was lawfully harvested (NOAA 2021b).

The Indian Ocean Tuna Commission (IOTC) has adopted several management measures that affect species caught in the longline fishery:

Tunas: Longline vessels targeting tuna are encouraged to take steps to ensure the safe release of nontargeted species and to retain onboard all dead nontarget species fit for human consumption (IOTC 2019b). The 2014 Resolution for tropical tunas asks countries to establish an allocation system or other measures based on IOTC recommendations for target species (IOTC 2014). Yellowfin tuna is currently managed through an interim rebuilding plan (IOTC 2019b). The plan was adopted in 2017, and updated in 2018 and 2019. The 2017 and 2018 resolutions were determined to have been unsuccessful in reducing fishing mortality rates on yellowfin tuna (IOTC 2018b). The resolution adopted in 2019 does not meet the advice to reduce catches by 20% in order to improve the stock status to levels above the target reference point by 2027 (IOTC 2018b). The country has been keeping ongoing efforts to rebuild yellowfin tuna stocks through management procedures (IOTC 2020d). There are management recommendations to limit the catch of albacore tuna to MSY levels (38,800 t) (IOTC 2018c). Currently, interim target and limit reference points are used in the IOTC for bigeye, skipjack, and yellowfin tunas (IOTC 2015). There is a harvest control rule in place for skipjack tuna (IOTC 2016).

Swordfish: Swordfish is managed through several measures that are not species-specific but apply to target species. These include mandates to record and report information, limiting fishing capacity (IOTC 2015), and recording of active fishing vessels in the IOTC area (IOTC 2014). There are management recommendations to reduce swordfish catch to MSY (31,590 t) (IOTC 2018d).

Management strategy receives a score of ineffective, because there are no specific management regulations for mahi mahi in Indonesia, and only limited regulations are in place for other target species (e.g., the National Tuna Management Plan). Such regulations mean that fewer than 70% of the fishery's main targeted and retained species have appropriate management measures. The rebuilding plan for yellowfin tuna also calls for attention because it has failed to reduce fishing mortality rates. Finally, the low level of required observer coverage (5%) makes it difficult to assess the effectiveness of current management and recovery plans.

Western Central Pacific | Drifting longlines | Indonesia

Ineffective

The Indonesian Ministry of Marine Affairs and Fisheries (MMAF) oversees fisheries management in Indonesia. Indonesia's exclusive economic zone (EEZ) is currently divided into 11 Fisheries Management Areas (FMA). At least seven of these FMAs have no room for production expansion because of overexploited stocks. Although these FMAs were designed for fisheries management, the inherent complexities do not seem to be met by the top-down ministerial structure, resulting in poor engagement from stakeholders and an inappropriate adaptive management framework (CEA 2018). The MMAF's National Commission on Stock Assessments gathers data from species groups (e.g., demersal spp., tuna, small pelagics), so species trends are difficult to trace, and total allowable catches (TAC) are set based on these species groups (CEA 2018).

There are currently no management measures in place for mahi mahi; however, a fishery improvement project (FIP) (Indonesia Indian Ocean and Western Central Pacific Ocean tuna and large pelagics–longline) was launched in late 2019 and may indirectly benefit mahi mahi management, because mahi mahi is a secondary species in this fishery (although mahi mahi was not included in the actual FIP) (Fishery Progress 2021b). Indonesia also has had an Action Plan for Tuna Fisheries since 2011, which is currently being updated in partnership with the FIP (Fishery Progress 2021b).

Indonesia is a cooperating nonmember of the Western and Central Pacific Fisheries Commission (Ministry of Marine Affairs and Fisheries 2010), which has a set of management measures that applies to this fishery:

Tuna: A tropical bridging measure was adopted in 2017 (WCPFC 2017), and measures in place have been improved following scientific advice since then. Interim target reference points for WCPO bigeye and yellowfin tuna stocks were set in early 2021, using two sets of year ranges for average values (2012–2015 and 2000–2004) as well as recent and long-term recruitment conditions. The baseline was set under the 2016–2018 average conditions (WCPFC 2021). Under these baseline fishing conditions (2016–2018 average), both bigeye and yellowfin tuna stocks were projected to increase compared to 2012–2015 average levels, and to either remain at recent levels (2015–2018 average), for yellowfin tuna, or increase, for bigeye tuna (WCPFC 2021b). Harvest control rules are still not in place for these species (WCPFC 2021).

Marlins and Opah: There are no management measures in place for blue or black marlins or opah in the WCPO. Striped marlin in the South Pacific is managed through effort restrictions (WCPFC 2006). There are no biomass-based reference points for these species and no harvest control rules.

Swordfish: There are no formally adopted reference points for swordfish or smaller tuna species. But, in 2009, the WCPFC limited the number of vessels targeting swordfish and the catches to levels from any year between 2000 and 2005, and required this information to be reported to the Commission (WCPFC 2009).

Management strategy receives a score of ineffective, because there are no specific management regulations for mahi mahi in Indonesia, and only limited regulations are in place for other target species (e.g., the National Tuna Management Plan). Such regulations mean that fewer than 70% of

the fishery's main targeted and retained species have appropriate management measures. In addition, the low level of required observer coverage (5%) makes it difficult to assess the effectiveness of the current management and recovery plans.

Western Central Pacific | Drifting longlines | Taiwan

Moderately Effective

The agency charged with fisheries management is the Fisheries Agency, housed within Taiwan's Council of Agriculture. Taiwan's fisheries management legislation includes the Fisheries Act, regulations on the management of fishing crews, enforcement of fisheries, and regulations related to longline fisheries (FA 2021).

The mahi mahi fishery improvement project (FIP) in Taiwan established an observer program for this fishery with the support of the Taiwan Fishery Agency (Fishery Progress 2021). The first observer trips were conducted in 2020. Because the recent stock assessment indicated that the stock has not been overexploited and has not been experiencing overfishing, management strategies currently being discussed include restricting the minimum catch size (juveniles should be released alive or restricted with a maximum allowable amount) and, as a precautionary approach, limiting the total number and tonnage of licensed fishing vessels to the current level, which would increase without sufficient scientific support (Fishery Progress 2021). In the last Steering Committee meeting held in 2020, the research team of National Taiwan Ocean University stated that the preliminary development of the harvest control rule of the mahi mahi fishery is in progress, and the draft HCR will likely be presented for the consideration of the Steering Committee in the upcoming meetings. But, the development of the management strategy is scheduled to start only in 2023 (Fishery Progress 2021). The mahi mahi FIP covers about 70% of the entire mahi mahi fishery in Taiwan.

Sharks: There are no management measures in place specifically for shortfin mako shark and blue shark. Shark finning is prohibited (WCPFC 2019h). As of 2015, member countries are required to create shark management plans that include licenses and total allowable catches (TAC), and longline fisheries targeting tuna and billfish are prohibited from using either wire branchlines and leaders or shark lines (branchlines running directly off the longline floats) (Clarke S. 2016)(WCPFC 2019h). Clarke (2013) identified that compliance with implementing Western and Central Pacific Fisheries Commission-adopted management measures specific to sharks is at best 60%, and lower for some measures (Clarke 2013). There are no reference points in place for blue shark or shortfin mako shark, and no harvest control rules.

Tuna: Management measures for targeted tuna species in the Western and Central Pacific Ocean (WCPO) longline fisheries have been adopted by the Western and Central Pacific Fisheries Commission (WCPFC). For this fishery, which also catches mahi mahi, any fishery data are reported through e-logbooks, including catch and effort data. For the first 30 fish caught (for each setting recorded in the e-logbook), data on size, length, and weight are also compiled. There is also a port-sampling program that collects size data of all tuna and tuna-like species, as well as an

observer program that collects size data for all species. The WCPFC has been using the reported information for regional assessments (WCPFC 2019f). But, there are currently no recommendations specific to mahi mahi under the WCPFC.

A tropical bridging measure was adopted in 2017 (WCPFC 2017) and measures in place have been improved, following scientific advice since then. Interim target reference points for WCPO bigeye and yellowfin tuna stocks were set in early 2021, using two sets of year ranges for average values (2012–2015 and 2000–2004) as well as recent and long-term recruitment conditions. The baseline was set under 2016–2018 average conditions (WCPFC 2021). Under these baseline fishing conditions, both bigeye and yellowfin tuna stocks were projected to increase compared to 2012–2015 average levels, and to either remain at the recent levels (2015–2018 average), for yellowfin tuna, or increase, for bigeye tuna (WCPFC 2021b). Harvest control rules are still not in place for these species (WCPFC 2021).

We scored this factor as moderately effective, because measures have not been in place long enough to evaluate their success and/or are still being implemented.

Factor 3.2 - Bycatch Strategy

Eastern Indian Ocean | Drifting longlines | Indonesia

Ineffective

Indonesia has a National Plan of Action (NPOA) for Sharks, has a set of decrees prohibiting the export of sharks under CITES II (Fishery Progress 2021c), requires the retention of whole sharks (fins attached) that were incidentally captured, has a shark finning ban, and has a prohibition on targeting gravid sharks, rays, and juveniles. The only exception is thresher shark, which must be discarded, dead or alive, and registered in the logbook (regulations No. 33/PERMEN-KP/2017, No. 32/PERMEN-KP/2012, No. 13/PER-DJPRL/2018 (Fishery Progress 2021c)). Despite all the existing regulations for sharks, by-catch measures for this group seem to be ineffective, particularly for small-sized juvenile individuals (Fishery Progress 2021c)(Dermawan 2015). The NPOA for sharks and rays was in place from 2015 to 2020, and it is currently being updated (IOTC 2021b).

Marine turtles have been managed through an NPOA since 2016; however, the guidelines do not fully conform to FAO guidelines (IOTC 2021b). Circle hooks are required in the longline fishery, but there is no regulation to enforce this mitigation measure (UNDP 2020). There is also an NPOA for seabirds in the tuna longline fishery (MMAF 2016), but information regarding interactions with seabirds in the mahi mahi longline fishery was not available. A ministerial decree (No. 12/PERMEN KP/2012) states the requirement of tori lines for every longline vessel operating beyond 25° S (UNDP 2020).

E-logbooks need improvement, particularly for by-catch; in addition, there is a lack of enforcement

for this practice (UNDP 2020). Indonesia also has a low observer coverage rate (less than 5%), according to the IOTC (Fahmi et al. 2020).

The WCPFC has specific measures for by-catch management that apply to this fishery in Indonesia:

Sea turtles: Any interactions between a vessel and sea turtles must be reported to the Commission, and fishers are required to attempt proper mitigation measures, to aid in recovery when necessary, and to release all incidentally captured sea turtles. Longline vessels must carry line cutters and de-hooking devices. Countries are also requested to conduct studies on the use of circle hooks and whole finfish bait, handling techniques, and other mitigation measures (IOTC 2012).

Sharks: Oceanic whitetip shark and thresher shark are prohibited from retention, landing, and trade, and should be released if incidentally captured (IOTC 2013)(IOTC 2012b). There are shark finning measures in place. For sharks landed fresh, the fins cannot be removed onboard, while sharks landed frozen must adhere to the fins onboard not being more than 5% of the weight of sharks onboard. Because of a lack of reporting, the effectiveness of these measures cannot be assessed (Clarke 2018). Countries are supposed to try to find ways to make fishing gear more selective and to improve handling practices for releasing live sharks (IOTC 2017b).

Seabirds: All interactions with seabirds must be recorded, and countries must provide information on how they are implementing observer programs to aid in the recording and reporting of these interactions. Mitigation measures are required; south of 25° S, two pre-approved mitigation measures must be used, but mitigation methods in other areas must be used as well (IOTC 2012c).

By-catch management receives a score of ineffective, because existing sea turtle measures do not fully conform to FAO guidelines, and specific measures for elasmobranchs are likely ineffective for juvenile sharks. In addition, the fishery does not appear to implement best management practices to mitigate the by-catch of endangered, threatened, or protected (ETP) species or vulnerable species (e.g., no by-catch caps, no marine mammal avoidance measures, and unknown types of bait). The very low observer coverage ($\leq 5\%$) is inadequate to show effective implementation of the management measures that do exist or to verify that this fishery does not interact with other ETP or rare species. Species of concern are caught in this fishery and the by-catch management measures are insufficient, given the potential impacts of the fishery.

Western Central Pacific | Drifting longlines | Indonesia

Ineffective

Indonesia has a National Plan of Action (NPOA) for Sharks, has a set of decrees prohibiting the export of sharks under CITES II (Fishery Progress 2021c), requires the retention of whole sharks (fins attached) that were incidentally captured, has a shark finning ban, and has a prohibition on targeting gravid sharks, rays, and juveniles. The only exception is thresher shark, which must be discarded, dead or alive, and registered in the logbook (regulations No. 33/PERMEN-KP/2017, No.

32/PERMEN-KP/2012, No. 13/PER-DJPRL/2018 (Fishery Progress 2021c)). Despite all the existing regulations for sharks, by-catch measures for this group seem to be ineffective, particularly for small-sized juvenile individuals (Fishery Progress 2021c)(Dermawan 2015). The NPOA for sharks and rays was in place from 2015 to 2020, and it is currently being updated (IOTC 2021b).

Marine turtles have been managed through an NPOA since 2016; however, the guidelines do not fully conform to FAO guidelines (IOTC 2021b). Circle hooks are required in the longline fishery, but there is no regulation to enforce this mitigation measure (UNDP 2020). There is also an NPOA for seabirds in the tuna longline fishery (MMAF 2016), but information regarding interactions with seabirds in the mahi mahi longline fishery was not available. A ministerial decree (No. 12/PERMEN KP/2012) states the requirement of tori lines for every longline vessel operating beyond 25° S (UNDP 2020).

E-logbooks need improvement, particularly for by-catch; in addition, there is a lack of enforcement for this practice (UNDP 2020). Indonesia also has a low observer coverage rate (less than 5%), according to the IOTC (Fahmi et al. 2020).

The WCPFC has specific measures for by-catch management that apply to this fishery in Indonesia:

Sea turtles: Members of the WCPFC must implement the FAO Guidelines to Reduce Sea Turtle Mortality in Fishing Operations. Proper handling and release guidelines should be used when hardshell turtles are incidentally captured, and longline vessels must carry line cutters and de-hookers to allow for the safe handling and release of turtles. Longline fisheries are also urged to research mitigation techniques such as the use of circle hooks (WCPFC 2008).

Sharks: Members of the WCPFC are prohibited from retaining, transshipping, storing, or landing oceanic whitetip and silky sharks; any incidentally caught sharks should be released, and the incident recorded and reported (WCPFC 2012)(WCPFC 2014). Vessels must comply with one of the following mitigation measures to reduce shark interactions: prohibit carrying/using wire trace as branch lines or leaders, or prohibit the use of branch lines running directly off the longline floats, known as "shark lines" (WCPFC 2014). Members must also implement the FAO International Plan of Action for the Conservation and Management of Sharks, and National Plans of Action should have policies in place to reduce waste and the discarding of sharks. Information on catch and effort for key species should be reported, and shark finning is banned (5% ratio) (WCPFC 2010).

Seabirds: WCPFC members are asked to implement the International Plan of Action for Reducing Incidental Catches of Seabirds in Longline Fisheries. Vessels fishing north of 23° N in the Western and Central Pacific Ocean (WCPO) and the Eastern Pacific Ocean (EPO) are required to use at least two mitigation measures, including at least one of the following: side setting, night setting, tori line, or weighted branchline. Members must submit annual reports detailing the mitigation measures used, and are encouraged to undertake additional mitigation research (WCPFC 2015) (WCPFC 2017b). In the WCPO, small longliners fishing north of 23° N must use one of these mitigation measures (WCPFC 2017b). But even in these zones, the management system provides only a menu of mitigation methods to choose from. Some of those methods are known to be effective only under certain conditions but, because the fishers can choose which to use, they can

choose the least costly and likely least effective method. Therefore, meeting the mitigation requirements to the letter does not mean that effective mitigation methods are being used.

By-catch management receives a score of ineffective, because existing measures are likely ineffective for juvenile sharks and existing sea turtle measures do not fully conform to FAO guidelines. In addition, the fishery does not appear to implement best management practices to mitigate the by-catch of endangered, threatened, or protected (ETP) or vulnerable species (e.g., no by-catch caps, no marine mammal avoidance measures, and unknown types of bait). The very low observer coverage ($\leq 5\%$) is inadequate to show effective implementation of the management measures that do exist or to verify that this fishery does not interact with other ETP or rare species. Species of concern are caught in this fishery and the by-catch management measures are insufficient, given the potential impacts of the fishery.

Western Central Pacific | Drifting longlines | Taiwan

Ineffective

Taiwan has had a National Plan of Action for the conservation of sharks since 2001, and research, assessments, and management measures have been put into practice, including a ban on shark finning (but some of the main management measures, such as a catch-report scheme and TAC, are restricted to whale shark, which is not captured by this fishery) (IOTC 2021). Sea turtles (*Cheloniidae* spp., *Caretta caretta*, *Chelonia mydas*, *Eretmochelys imbricata*, *Lepidochelys olivacea* and *Dermochelys coriacea*) are entered on the List of Protected Species under the Wildlife Protection Act that was introduced in 2013. The Domestic Fisheries Management Regulation on Far Sea Fisheries requires all fishing vessels to carry line cutters, de-hookers, and hauling nets, to facilitate the appropriate handling and prompt release of caught or entangled marine turtles (IOTC 2021). Seabirds, although not recorded in the mahi mahi fishery even after the observer program was implemented in recent years, also have a National Plan of Action for Reducing Incidental Catch of Seabirds by Taiwan Longline Vessels since 2006; mandatory mitigation measures are required in areas south of 30° S and north of 23° N. In general, two mitigation methods should be applied, including at least one of the following: a bird-scaring line, night setting, weighted branchline, and side-setting. In areas south of 30° S, fishers must use two of the following mitigation methods: a bird-scaring line, night setting, and weighted branchline (IOTC 2021).

"Any prohibited species (e.g., whale shark, manta and *Mobula* spp., oceanic whitetip shark, and silky shark) promulgated by the competent authority [that is] incidentally caught by any vessel shall be released when caught alive or discarded when dead. Other than that, there is no regulation on catch releasing standards. The average percentage of retained shark and tuna species during the mahi mahi fishing season is relatively low, about 15% of the total catch in weight. The fishing vessels may use live milkfish, frozen Pacific saury, and squid as baits. In terms of the source of the baits, the live milkfish are farmed domestically; the frozen Pacific saury is supplied by the overseas fisheries; the squid is mostly caught by coastal fisheries.

According to domestic regulation, for any tuna longline fishing vessel fishing with hooks at a depth

shallower than 100 meters, the fishing vessel shall use large circle hooks or use fishes besides Cephalopods species as baits. No violation has been found since the adoption of the regulation mentioned above” (pers. comm., Tsung-Yueh, Tang 2021).

The Taiwan Hsin-Kang mahi mahi longline fishery improvement project (FIP) had formatted a fishing logbook to record primary, secondary, and endangered, threatened, and protected (ETP) species in the fishery. The fishing logbook was implemented in 2019, where records of sea turtles were collected, and the reporting rate increased (sea turtle by-catch were released unharmed). In 2020, the coastal scientific observer program from the Taiwanese Fisheries Agency was expanded to cover mahi mahi fishing vessels. Observers are now required to cover primary, secondary, and ETP species and any interaction with ETP fish, birds, sea turtles, and marine mammals. The FIP program notes some issues with the recovery rate of the logbook, leaving the observer program as the main information source for ETP species. In addition, ETP species (sharks, seabirds, and sea turtles) identification and conservation workshops were held to help fishers learn mitigation measures and approaches to facilitate the recovery and release of incidental catches (Fishery Progress 2021). The observer program only started to cover the mahi mahi fishery in 2020, with two deployments (Fishery Progress 2021): “[C]onsidering the COVID situation and the budget constraints affecting the dispatch, the coverage is lower than the most common international observer coverage requirement of 5%. There were four and one FIP vessel trips in 2020 and 2021, respectively, covered by the observer” (pers. comm., Tsung-Yueh, Tang 2021). It is expected that observer coverage in the mahi mahi fishery increases after the pandemic.

The fishery does not appear to implement best management practices to mitigate by-catch of endangered, threatened, or protected (ETP) or vulnerable species (e.g., no by-catch caps or marine mammal avoidance measures). The very low observer coverage ($\leq 5\%$) is inadequate to show effective implementation of the management measures that do exist or to verify that this fishery does not interact with other ETP or rare species. We have awarded a score of ineffective, because species of concern are caught in this fishery and the by-catch management measures are insufficient, given the potential impacts of the fishery.

Factor 3.3 - Scientific Data Collection and Analysis

Eastern Indian Ocean | Drifting longlines | Indonesia

Western Central Pacific | Drifting longlines | Indonesia

Ineffective

Indonesia has several ongoing research programs, including a port sampling and observer program. A few national research programs with species captured in this fishery were developed recently: the “Tuna Harvest Strategy Implementation” (2016–2019), and the national research programs on blue shark, billfishes, sharks, marine turtles, and thresher shark (Fahmi et al. 2019) (Fahmi et al. 2020). Indonesia’s Regional Observer Scheme from the Research Institute of Tuna

Fisheries (RITF) has been collecting data about catch, species composition, real-time fishing effort, number of settings and hooks (Fahmi et al. 2019), but observer coverage decreased over 3% in 2019 (Fahmi et al. 2020). The RITF has also been collecting catch and effort data in small-scale fisheries since 2013 (Fahmi et al. 2019). There is no specific research program for mahi mahi at a national scale, but some catch and effort data are collected (Fahmi et al. 2020). Logbook data were first submitted to the WCPFC in 2017; however, data quality control is still lacking (Teo 2018).

We have awarded an ineffective score, because the main targeted species (mahi mahi) is not consistently assessed.

Western Central Pacific | Drifting longlines | Taiwan

Moderately Effective

Taiwan has a Fisheries Research Institute, which has a Coastal and Offshore Resources Research Center that conducts biological studies on coastal and offshore fisheries. There are several studies on mahi mahi conducted in Taiwan {Tsai et al. 2016}{Chen et al. 2006}{Wu et al. 2006}{Chen et al. 1999}, including catch and effort data from both targeted and secondary species fisheries (e.g., (Lin et al. 2019)). Tuna species usually caught along with mahi mahi are also regularly assessed. The first full stock assessment was conducted and finalized in support of the Taiwan Hsin-Kang mahi mahi longline fishery improvement project (FIP) with the support of the Fisheries Agency of Taiwan (Wang 2018)(Fishery Progress 2021). By-catch data also have been systematically assessed through the FIP; however, more time might be needed to assess both the consistency and quality of data collected. Because data related to a full stock assessment have only been recently integrated and analyzed, we score this factor as moderately effective.

Factor 3.4 - Enforcement of and Compliance with Management Regulations

Eastern Indian Ocean | Drifting longlines | Indonesia

Western Central Pacific | Drifting longlines | Indonesia

Moderately Effective

Over the years, many relevant areas needed assistance in Indonesia to foster compliance in longline fisheries. Most of the available information has documented problems with transshipments, catch and effort aggregated data, vessel monitoring systems (VMS), sea turtle interactions, reporting of shark finning/release, FAD ban, catch limits, and observer data. In 2017, logbook data were submitted for the first time to the WCPFC, but data quality control is still needed (Teo 2018). Indonesia has an arrangement with Global Fishing Watch to make public the country's VMS data, and to get assistance from the WCPFC to address existing data gaps between the parties (WCPFC 2019g). Indonesia has also a small observer coverage rate (less than 5%) according to the IOTC (Fahmi et al. 2020). To mitigate issues with transshipment, Indonesia plans to pilot their

national at-sea transshipment program in 2021 (IOTC 2020d). This factor receives a score of moderately effective because, even though compliance issues are still present, there are noticeable improvements.

Western Central Pacific | Drifting longlines | Taiwan

Moderately Effective

Port sampling is conducted in domestic ports, and Taiwan has a maritime law enforcement agency (WCPFC 2019f). The current fishery improvement project (FIP) has a steering committee that is responsible for periodically evaluating and reviewing the management system. In 2021, the Taiwan Fisheries Economic Development Council agreed to conduct the external audit for the management measures being developed within the FIP {Fisheries Progress 2021}. Through the FIP, port sampling and inspection were improved with the inclusion of additional inspectors. The inspection consists of checking fishing vessel licenses before leaving the port, port exit/entry control, landing monitoring and inspection in port, fishing logbook, and assessing whether fishing vessels are in violation; in the future, it is expected to be expanded to cross-check the contents of catch reporting and landing declarations to monitor fishing mortality more effectively {Fisheries Progress 2021}.

Taiwan is also compliant with the Compliance Monitoring Scheme adopted by the WCPFC, which includes a limited number (by flag) of longline vessels targeting the species managed under the WCPFC, and submission of required reports and catch limits (WCPFC 2020c). An independent Fisheries Monitoring Control and Surveillance report highlights the difficulties of adequately monitoring the fishing activities of Taiwanese vessels, particularly on the high seas (Ganapathiraju 2017).

Because existing measures to assess enforcement of and compliance with management regulations are still being implemented, we deem this factor moderately effective.

Factor 3.5 - Stakeholder Inclusion

Eastern Indian Ocean | Drifting longlines | Indonesia

Western Central Pacific | Drifting longlines | Indonesia

Moderately Effective

Stakeholder inclusion in Indonesia is evident in some initiatives, such as the National Tuna Management plan, which was developed to improve cooperation among stakeholders (Fishery Progress 2021b). In addition, the Indonesia Indian Ocean and the Western and Central Pacific Ocean tuna and large pelagics longline fishery improvement project (FIP) has been including various stakeholders in their improvement project (Fishery Progress 2021b). Because the existing stakeholder inclusion has similar actors that are involved in the mahi mahi fishery, this factor

receives a score of moderately effective.

Western Central Pacific | Drifting longlines | Taiwan

Highly effective

Information is publicly available on fisheries regulations, and Taiwan provides information on their fisheries to the various regional fishery management organizations. In 2016, the Taiwan Hsin-Kang mahi mahi longline fishery improvement project (FIP) established a stakeholder framework that includes the Hsin-Kang Fishermen Association, the Overseas Fisheries Development Council of the Republic of China, the private sector, fishers, experts, researchers (including the Fisheries Research Institute), and fishery managers/authorities (Fisheries Agency of Taiwan and the Government of Taitung County) (Fishery Progress 2021). All stakeholders have a set of responsibilities, and such participatory processes follow Taiwan's legal framework (Fishery Progress 2016)(Fishery Progress 2016b). Stakeholder inclusion has clear roles, the decision-making process is inclusive, and the FIP covers about 70% of the entire Taiwan mahi mahi fishery, so this factor receives a score of highly effective.

Criterion 4: Impacts on the Habitat and Ecosystem

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

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

Guiding principles

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

Rating cannot be Critical for Criterion 4.

Criterion 4 Summary

FISHERY	FISHING GEAR ON THE SUBSTRATE	MITIGATION OF GEAR IMPACTS	ECOSYSTEM-BASED FISHERIES MGMT	FORAGE SPECIES?	SCORE
Eastern Indian Ocean Drifting longlines Indonesia	5	0	Moderate Concern		Green (3.873)
Western Central Pacific Drifting longlines Indonesia	5	0	Moderate Concern		Green (3.873)
Western Central Pacific Drifting longlines Taiwan	5	0	Moderate Concern	Yes	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

Eastern Indian Ocean | Drifting longlines | Indonesia
Western Central Pacific | Drifting longlines | Indonesia
Western Central Pacific | Drifting longlines | Taiwan

5

Pelagic longline fishing gear is deployed at the surface and therefore does not contact bottom habitats.

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

Eastern Indian Ocean | Drifting longlines | Indonesia
Western Central Pacific | Drifting longlines | Indonesia
Western Central Pacific | Drifting longlines | Taiwan

0

Score is not applicable because pelagic longline gear has no impact on bottom habitats.

Factor 4.3 - Ecosystem-based Fisheries Management

Eastern Indian Ocean | Drifting longlines | Indonesia
Western Central Pacific | Drifting longlines | Indonesia

Moderate Concern

For the most critical species, such as marine turtles and sharks, Indonesia developed specific

National Plans of Action. Such NPOAs have measures that benefit the recovery of critical habitats, nesting beaches, and corridors (for sea turtles), as well as measures that avoid ecosystem imbalance in the absence of elasmobranchs (Dermawan 2015)(MMAF 2016)(IOTC 2021b). Indonesia also has its entire exclusive economic zone (EEZ) divided into 11 Fisheries Management Areas (FMA) (through MMAF's decree No. PER. 01/MEN/2009) that consider the natural environment and fish resource components from each area (CEA 2018). An Ecosystem Approach to Fisheries Management (EAFM) has been developed in the past decade by the MMAF, and its main goal was to develop new management plans for all 11 FMAs (Muawanah et al. 2018). Current laws and policies in Indonesia support EAFM, although there is neither an EAFM-specific legislation nor exact wording of EAFM (Muawanah et al. 2018). Because there is spatial management being structured in recent years, and detrimental food web impacts have been more intentionally addressed with the NPOAs (although substantial benefits may take longer to be measured and to validate their effectiveness), this factor receives a score of moderate concern.

Justification:

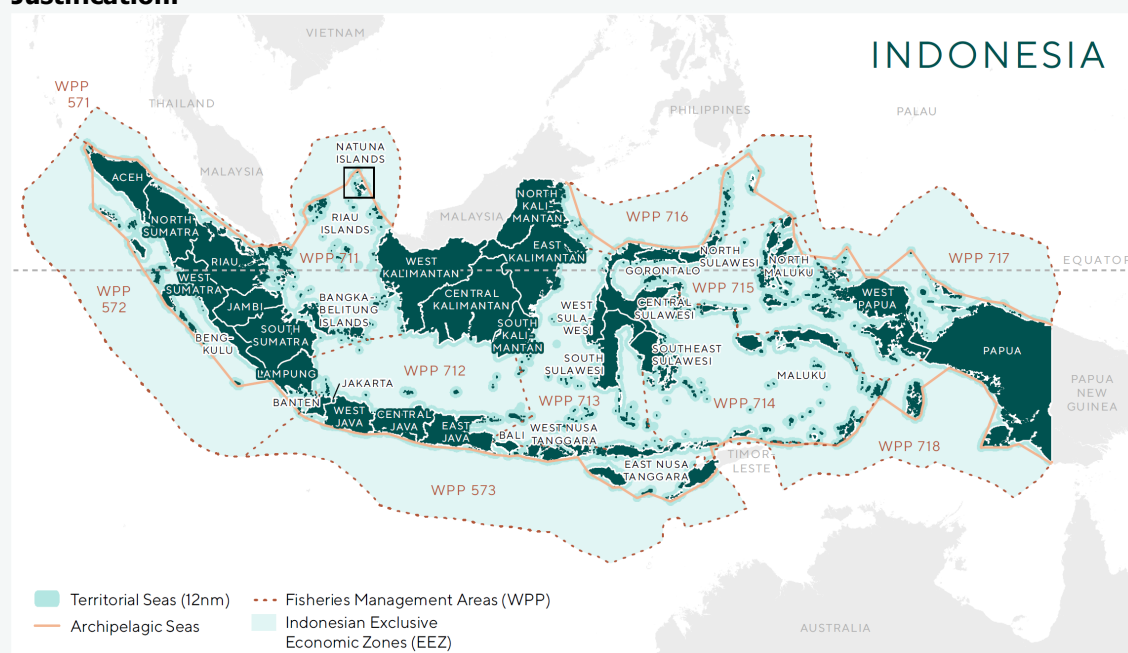


Figure 22: Division of Indonesia's EEZ into 11 Fisheries Management Areas (CEA 2018).

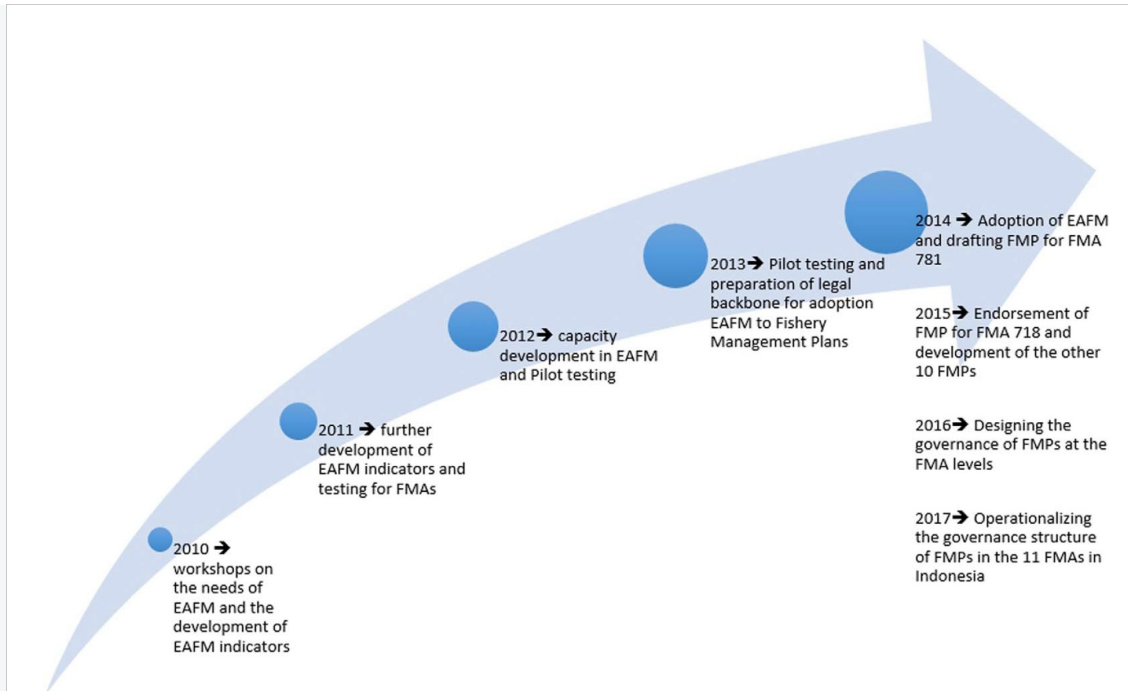


Figure 23: The development of an Ecosystem Approach to Fisheries Management in Indonesia (Muawanah et al. 2018).

Western Central Pacific | Drifting longlines | Taiwan

Moderate Concern

Pelagic longline fisheries that capture mahi mahi in Taiwan also capture a number of ecologically important species, including sharks and tunas. Sharks and tunas are top predators in many ecosystems and play a critical role in how these ecosystems are structured and function (Stevens et al. 2000)(Heithaus et al. 2008). The most recent initiatives to mitigate ecosystem impacts in the mahi mahi fishery are still being developed through the Hsin-Kang mahi mahi longline fishery improvement project (FIP), which has created a management strategy framework scheduled to start in 2023 (Fishery Progress 2021). In the meantime, some species-specific and group-specific mitigation measures are in place, such as prohibiting shark finning, a set of mandatory seabird mitigation adaptations in the gear, and proper handling and release of marine turtles (IOTC 2021) (Fishery Progress 2021).

Regarding the use of forage species, the Pacific saury used as bait by the mahi mahi fishery is currently under the management of the North Pacific Fisheries Commission (NPFC), with a comprehensive catch report system, a total allowable catch (TAC) for the species, and a national catch limit for each member country (Taiwan has been a member of the NPFC since 2015). Although the concept of a “built-in buffer” was not clearly mentioned in the conservation and management measure for Pacific saury, the NPFC has recently put major effort into the fisheries’ impacts on the ecosystem, and it established the Small Scientific Committee on Bottom Fish and Marine Ecosystems in 2020. Therefore, we believe that the recommendations made by the Lenfest Forage Fish Task Force are well addressed here” (pers. comm., Tsung-Yueh, Tang 2021).

Temporal and spatial management are not in place, ecosystem management is yet to be developed, but food web impacts are unlikely, so this factor is scored with moderate concern.

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

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