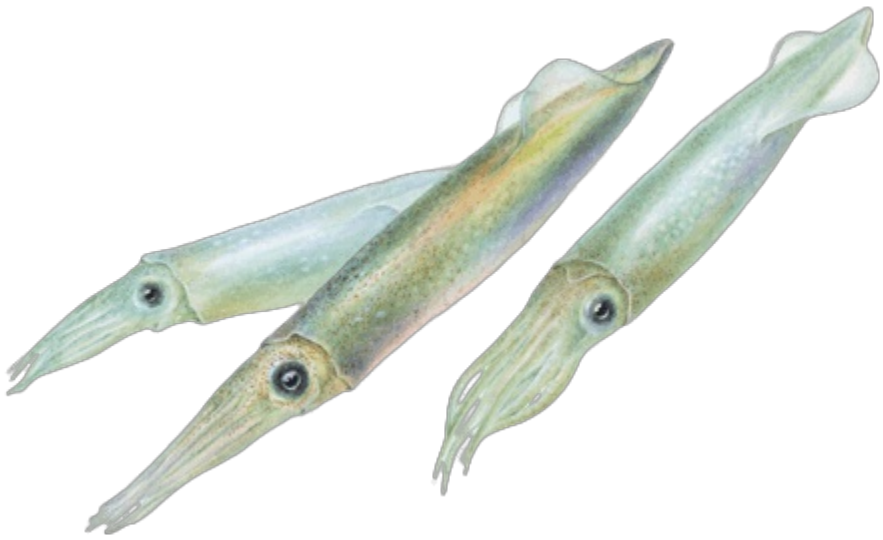
Monterey Bay Aquarium Seafood Watch

Environmental sustainability assessment of wild-caught squids from India, Indonesia, and Thailand caught using bottom trawls, cast nets, and jigs.



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Species:	Indian squid (*Uroteuthis duvaucelii*) Mitre squid (*Uroteuthis chinensis*) Swordtip squid (*Uroteuthis edulis*)
Location:	India: Indian Ocean; Thailand & Indonesia: Western Central Pacific
Gear:	Bottom trawls, Jig, Cast nets
Type:	Wild Caught
Author:	Seafood Watch
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Assessed using Seafood Watch Fisheries Standard v4

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About Monterey Bay Aquarium Seafood Watch

The mission of the Monterey Bay Aquarium is to inspire conservation of the ocean and enable a future where the ocean flourishes and people thrive in a just and equitable world. To do this, the Aquarium is focused on creating extraordinary experiences that inspire awe and wonder, championing science-based solutions, and connecting people across the planet to protect and restore the ocean. We know that healthy ocean ecosystems are critical to enabling life on Earth to exist, and that our very survival depends on them. As such, our conservation objectives are to mobilize climate action, improve the sustainability of global fisheries and aquaculture, reduce sources of plastic pollution, and restore and protect ocean wildlife and ecosystems.

The aquarium is focused on improving the sustainability of fisheries and aquaculture given the role seafood plays in providing essential nutrition for 3 billion people globally, and in supporting hundreds of millions of livelihoods. Approximately 180 million metric tons of wild and farmed seafood is harvested each year (excluding seaweeds). Unfortunately, not all current harvest practices are sustainable and poorly managed fisheries and aquaculture pose the greatest immediate threat to the health of the ocean and the economic survival and food security of billions of people.

The Seafood Watch program was started 25 years ago as a small exhibit in the Monterey Bay Aquarium highlighting better fishing practices and grew into one of the leading sources of information on seafood sustainability, harnessing the power of consumer choice to mobilize change. The program's comprehensive open-source information and public outreach raises awareness about global sustainability issues, identifies areas for improvement, recognizes and rewards best practices and empowers individuals and businesses to make informed decisions when purchasing seafood.

We define sustainable seafood as seafood from sources, whether fished or farmed, that can maintain or increase production without jeopardizing the structure and function of affected ecosystems, minimize harmful environmental impacts, assure good and fair working conditions, and support livelihoods and economic benefits throughout the entire supply chain. As one aspect of this vision, Seafood Watch has developed trusted, rigorous standards for assessing the environmental impacts of fishing and aquaculture practices worldwide. Built on a solid foundation of science and collaboration, our standards reflect our guiding principles for defining environmental sustainability in seafood.

Seafood Watch Ratings

The Seafood Watch Standard for Fisheries is used to produce assessments for wild-capture fisheries resulting in a Seafood Watch rating of green, yellow, or red. Seafood Watch uses the assessment criteria to determine a final numerical score as well as numerical subscores and colors for each criterion. These scores are translated to a final Seafood Watch color rating according to the methodology described in the table below. The table also describes how Seafood Watch defines each of these categories. The narrative descriptions of each Seafood Watch rating, and the guiding principles listed below, compose the framework on which the criteria are based.

Green	Final Score >3.2, and either criterion 1 or criterion 3 (or both) is green, and no red criteria, and no critical scores	Wild-caught and farm-raised seafood rated green are environmentally sustainable, well managed and caught or farmed in ways that cause little or no harm to habitats or other wildlife. These operations align with all of our guiding principles.
Yellow	Final score >2.2, and no more than one red criterion, and no critical scores, and does not meet the criteria for green (above)	Wild-caught and farm-raised seafood rated yellow cannot be considered fully environmentally sustainable at this time. They align with most of our guiding principles, but there is either one conservation concern needing substantial improvement, or there is significant uncertainty associated with the impacts of the fishery or aquaculture operations.
Red	Final Score ≤2.2, or two or more Red Criteria, or one or more Critical scores.	Wild-caught and farm-raised seafood rated Red are caught or farmed in ways that have a high risk of causing significant harm to the environment. They do not align with our guiding principles and are considered environmentally unsustainable due to either a critical conservation concern, or multiple areas where improvement is needed.

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.

Recommended Citation: Seafood Watch (2025) Environmental sustainability assessment of wild-caught squids from India, Indonesia, and Thailand caught using bottom trawls, cast nets, and jigs. Monterey Bay Aquarium

Guiding Principles

Monterey Bay Aquarium defines sustainable seafood as seafood from sources, whether fished or farmed, that can maintain or increase production without jeopardizing the structure and function of affected ecosystems, minimize harmful environmental impacts, assure good and fair working conditions, and support livelihoods and economic benefits throughout the entire supply chain.

As one aspect of this vision, Seafood Watch has developed trusted, rigorous standards for assessing the environmental impacts of fishing and aquaculture practices worldwide. Environmentally sustainable wild capture fisheries:

1. **Follow the principles of ecosystem-based fisheries management**

   The fishery is managed to ensure the integrity of the entire ecosystem, rather than solely focusing on maintenance of single species stock productivity. To the extent allowed by the current state of the science, ecological interactions affected by the fishery are understood and protected, and the structure and function of the ecosystem is maintained.

2. **Ensure all affected stocks[1] are healthy and abundant**

   Abundance, size, sex, age and genetic structure of the main species affected by the fishery (not limited to target species) is maintained at levels that do not impair recruitment or long-term productivity of the stocks or fulfillment of their role in the ecosystem and food web.

   Abundance of the main species affected by the fishery should be at, above, or fluctuating around levels that allow for the long-term production of maximum sustainable yield. Higher abundances are necessary in the case of forage species, in order to allow the species to fulfill its ecological role.

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[1]"Affected" stocks include all stocks affected by the fishery, no matter whether target or bycatch, or whether they are ultimately retained or discarded.

3. **Fish all affected stocks at sustainable levels**

   Fishing mortality for the main species affected by the fishery should be appropriate given current abundance and inherent resilience to fishing while accounting for scientific uncertainty, management uncertainty, and non-fishery impacts such as habitat degradation.

   The cumulative fishing mortality experienced by affected species must be at or below the level that produces maximum sustainable yield for single-species fisheries on typical species that are at target levels.

   Fishing mortality may need to be lower than the level that produces maximum sustainable yield in certain cases such as forage species, multispecies fisheries, highly vulnerable species, or fisheries with high uncertainty.

   For species that are depleted below target levels, fishing mortality must be at or below a level that allows the species to recover to its target abundance.

4. **Minimize bycatch**

   Seafood Watch defines bycatch as all fisheries-related mortality or injury other than the retained catch. Examples include discards, endangered or threatened species catch, pre-catch mortality and ghost fishing. All discards, including those released alive, are considered bycatch unless there is valid scientific evidence of high post-release survival and there is no documented evidence of negative impacts at the population level.

   The fishery optimizes the utilization of marine and freshwater resources by minimizing post-harvest loss and by efficiently using marine and freshwater resources as bait.

5. **Have no more than a negligible impact on any threatened, endangered or protected species**

   The fishery avoids catch of any threatened, endangered or protected (ETP) species. If any ETP species are inadvertently caught, the fishery ensures and can demonstrate that it has no more than a negligible impact on these populations.

6. **Are managed to sustain the long-term productivity of all affected species**

   Management should be appropriate for the inherent resilience of affected marine

and freshwater life and should incorporate data sufficient to assess the affected species and manage fishing mortality to ensure little risk of depletion. Measures should be implemented and enforced to ensure that fishery mortality does not threaten the long term productivity or ecological role of any species in the future.

The management strategy has a high chance of preventing declines in stock productivity by taking into account the level of uncertainty, other impacts on the stock, and the potential for increased pressure in the future.

The management strategy effectively prevents negative population impacts on bycatch species, particularly species of concern.

7. **Avoid negative impacts on the structure, function or associated biota of aquatic habitats where fishing occurs**

   The fishery does not adversely affect the physical structure of the seafloor or associated biological communities.

   If high-impact gears (e.g. trawls, dredges) are used, vulnerable seafloor habitats (e.g. corals, seamounts) are not fished, and potential damage to the seafloor is mitigated through substantial spatial protection, gear modifications and/or other highly effective methods.

8. **Maintain the trophic role of all aquatic life**

   All stocks are maintained at levels that allow them to fulfill their ecological role and to maintain a functioning ecosystem and food web, as informed by the best available science.

9. **Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts**

   Fishing activities must not result in harmful changes such as depletion of dependent predators, trophic cascades, or phase shifts.

   This may require fishing certain species (e.g., forage species) well below maximum sustainable yield and maintaining populations of these species well above the biomass that produces maximum sustainable yield.

10. **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**

Any enhancement activities are conducted at levels that do not negatively affect wild stocks by reducing diversity, abundance or genetic integrity.

Management of fisheries targeting enhanced stocks ensures that there are no negative impacts on the wild stocks, in line with the guiding principles described above, as a result of the fisheries.

Enhancement activities do not negatively affect the ecosystem through density dependent competition or any other means, as informed by the best available science.

Summary

This report provides recommendations for three major squid species commercially imported to the United States: Indian squid (*Uroteuthis duvaucelii*), mitre squid (*U. chinensis*), and swordtip squid (*U. edulis*). These are inshore Indo-Pacific species, extending from the west of the Indian Ocean to the western Pacific Ocean, that are targeted by a number of traditional and industrial fleets in Southern Asia. Indian squid is the most abundant squid species in Indian and Thai waters, where it is heavily exploited, representing up to 70% of the catches off central west India and up to 90% of the catches in the Gulf of Thailand. It is caught using a wide range of gears, including bottom trawls, cast nets, and jigs. Mitre squid and swordtip squid are caught in Thai and Indonesian waters using cast nets and jigs, and also bottom trawls in Thailand (bottom trawling is banned in Indonesia).

For all trawl and cast net squid fisheries in the area, the criteria combine to result in an overall red rating, while jig fisheries in Thailand and Indonesia receive a yellow rating. Criterion 1, “Impacts on the Species under Assessment,” scores red for all species in the trawl and cast net fisheries, because of the combination of “high concern” for the stock status of all the target species and “moderate concern” for fishing mortality for all species caught in cast nets and trawls across India, Thailand, and Indonesia. But squid species caught in jig fisheries receive a “moderate concern” score for both stock status and fishing mortality. Criterion 2, “Impacts on Other Species,” also scores red for all the fisheries except jig fisheries, which have no bycatch. Bottom trawl fisheries are widely recognized as having a high impact on benthic invertebrates, corals, biogenic habitats, and bycatch species such as sharks and turtles. Although cast net fisheries have low levels of bycatch, the red score in these fisheries is driven mainly by the status of the target squid species. Although fisheries management in India (including Kerala), Thailand, and Indonesia have improved in recent years with new management and regulations, Criterion 3, “Management Effectiveness,” is considered “ineffective” for all the fisheries, because of the lack of effective measures to address the overcapacity of the fleets and to reduce fishing effort, which have driven the overall overexploitation of the fishing resources in these countries. Ineffective implementation of conservation regulations also drives this red score. Finally, Criterion 4, “Impacts on the Habitat and Ecosystem,” scores green for jigs and cast nets in Thailand and Indonesia because of the minimal impact of these gears on the habitat; red for bottom trawl fisheries in Thailand because of the potential physical damage of this method on sensitive habitats; and yellow for trawl fisheries in Kerala and other areas of India: though this method also poses risks to sensitive bottom habitats, these risks are slightly mitigated by the use of off-bottom trawls, rather than fully on-bottom trawls.

Introduction

Scope of the analysis and ensuing rating

The following Seafood Watch report provides recommendations for three squid species of commercial importance for the U.S. market: Indian (*Uroteuthis duvaucelii*), mitre (*U. chinensis*), and swordtip (*U. edulis*) squids. These species are caught in Southern and Southeast Asian countries using a wide range of traditional and industrial fishing gears, such as otter and pair trawls, push and cast nets, purse seines, and hooks and lines. Considering the known distribution of these species in the Indian Ocean, the main fishing gears used to catch them, and the principal countries exporting squid from that area to the United States, seven fisheries are assessed in this report: the Indian squid trawl fishery in India; the Indian squid trawl fishery in Kerala (assessed separately from the rest of India); the Indian, mitre, and swordtip squid trawls, cast nets, and jig fisheries in Thailand; and the mitre and swordtip squid cast net and jig fisheries in Indonesia.

Species Overview

The commercial importance of cephalopod species as a fishery resource has increased over the past decades, and many cephalopod species are currently taken as both target and bycatch species in numerous fisheries around the world {Pierce and Guerra 1994}. The proportion of squid in total landings has increased steadily over the past decades—in many cases, because of the decrease of fish stocks as a consequence of overfishing {Caddy and Rodhouse 1998}(FAO 2011). In 2010, total global squid capture was 2.98 million metric tonnes (MT), which was about 82% of the total cephalopod production in that year (Arkhipkin et al. 2015).

In Southern and Southeast Asian countries, squid is a commercially important resource for coastal fisheries that fetches high domestic and export prices (Arkronrat et al. 2017). Although up to nine commercial squid species are present in the Indo-Pacific area—*Uroteuthis chinensis* {Gray 1849}; *U. duvaucelii* {Orbigny 1835}; *U. edulis* {Hoyle 1885}; *U. singhalensis* {Ortmann 1891}; *U. sibogae* {Adam 1954}; *Loliolus affinis* {Steenstrup 1856}; *L. sumatrensis* {Orbigny 1835}; *L. beka* {Sasaki 1929}; and *Sepioteuthis lessoniana* {Ferussac 1831}(Arkhipkin et al. 2015)—the three species that represent the bulk of the catches in the area are *Uroteuthis chinensis*, *U. duvaucelii*, and *U. edulis* {Hoyle 1885}(Sukramongkol et al. 2007)(Arkhipkin et al. 2015). These species are generally found together in the same geographical area, thus presumably regularly encountering one another {Chotiyaputta 1993}{Futuyma and

Agrawal 2009}{Islam et al. 2017}.

- Indian squid (*U. duvaucelii*) is an Indo-Pacific loliginid distributed in coastal waters within depths of 0 to 170 m {Bergman 2013}, from Madagascar to the Andaman Sea (West Thailand) {Jereb and Roper 2006}. Indian squid is the most abundant squid species in Indian and Thai waters (Meiyappan et al. 1993)(Sukramongkol et al. 2007), where it is heavily exploited, representing up to 70% of the catches off central west India and up to 73% of the catches in the Gulf of Thailand (Arkhipkin et al. 2015)(Sanitmajaro et al. 2018).

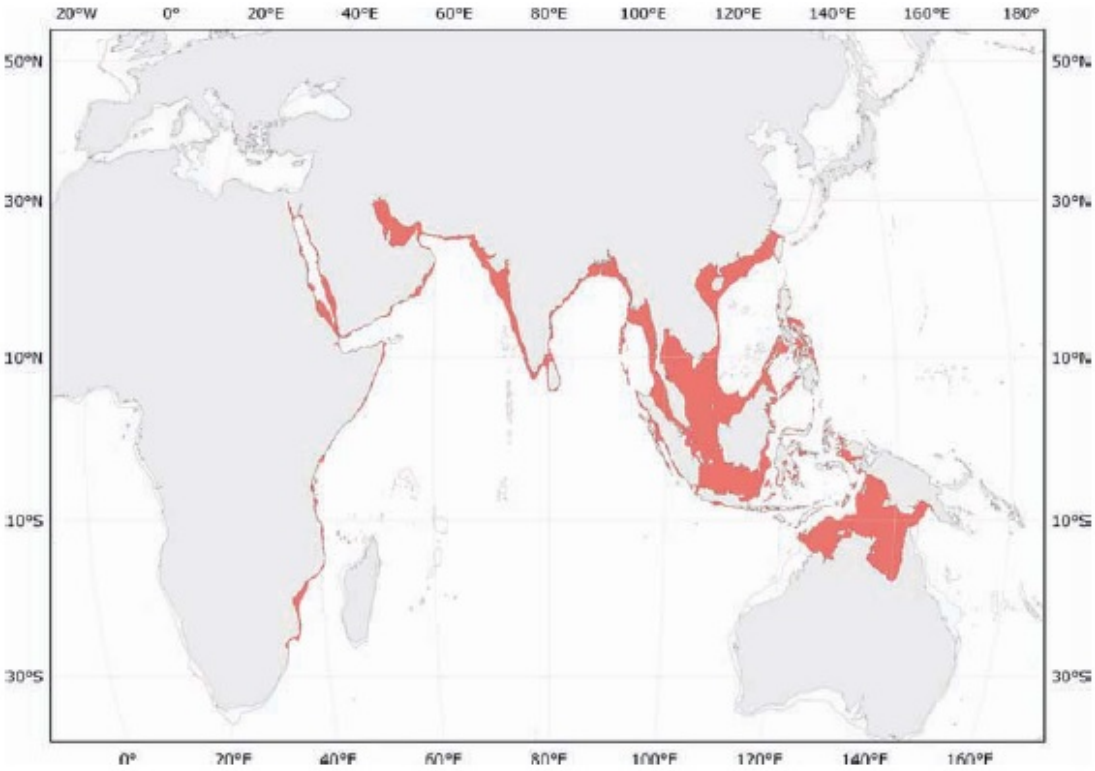

Figure 1: Indian squid distribution (Jereb & Roper 2010).

- Mitre squid (*U. chinensis*) is more abundant in shallower waters (10 to 30 m), and it has a more restricted distribution than Indian squid (Arkhipkin et al. 2015). It is an Indo-Pacific species, extending from the western Pacific Ocean (Japan, the South China Sea, Hong Kong, Philippines, Indonesia, and northern, western, and eastern Australian waters) to the Indian Ocean (the Andaman Sea, Thailand, and the Bay of Bengal) {Jereb and Roper 2010}. Mitre squid is one of the major squid species in the Gulf of Thailand, especially in the eastern portion of the Gulf, where it is taken in waters between 15 and 30 m deep and accounts for anywhere from 15% to 40–52%

of the trawl catch {Arkhipkin 2015}{Jereb and Roper 2010}(Sanitmajaro et al. 2018).

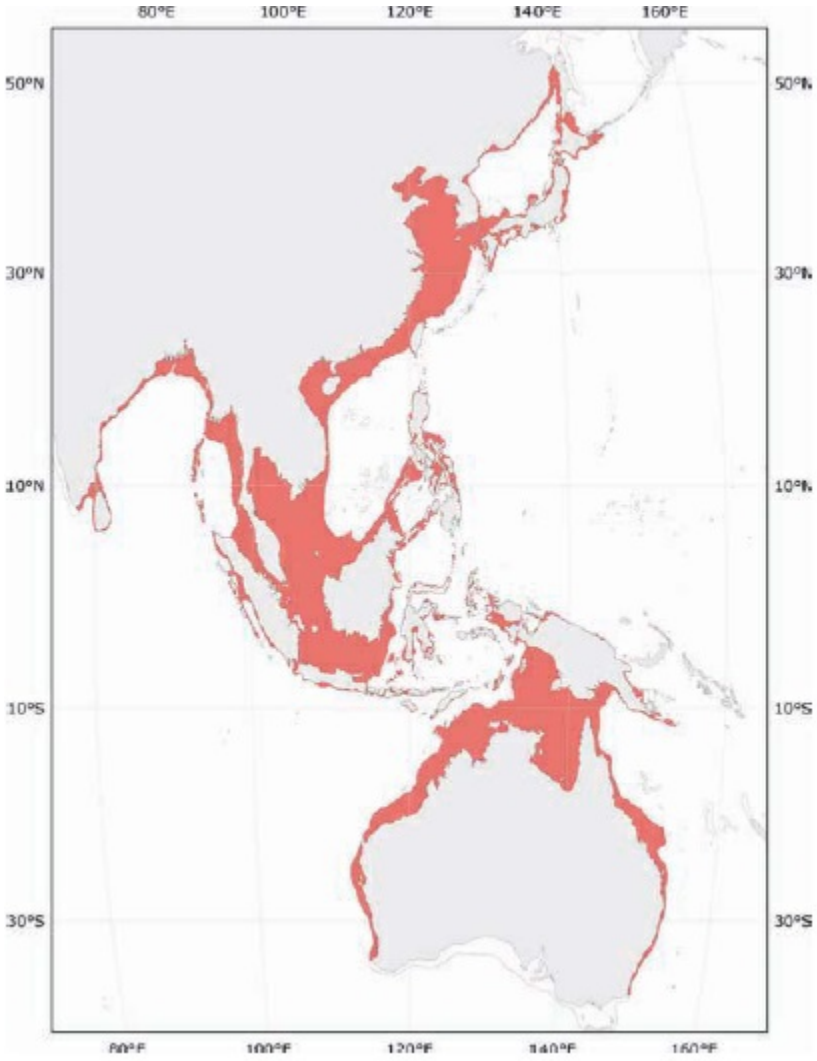

Figure 2: Mitre squid distribution (Jereb & Roper 2010).

- Swordtip squid (*U. edulis*) is relatively abundant in the western Pacific. Its range extends from northern regions (the southern Sea of Japan and the East China Sea) to tropical regions (the Java Sea and coastal waters of Indonesia, Malaysia, and Thailand) and as far south as the waters off northern Australia. Its distribution, although unclear, seems to extend throughout the Indian Ocean, from the southeastern waters to Mozambique {Jereb and Roper 2010}. The species is highly abundant in the Andaman Sea, where it represents one of the main Thai squid resources; however, it is not mentioned

among the squid resources of either India or the Gulf of Thailand {Jereb and Roper 2010}.

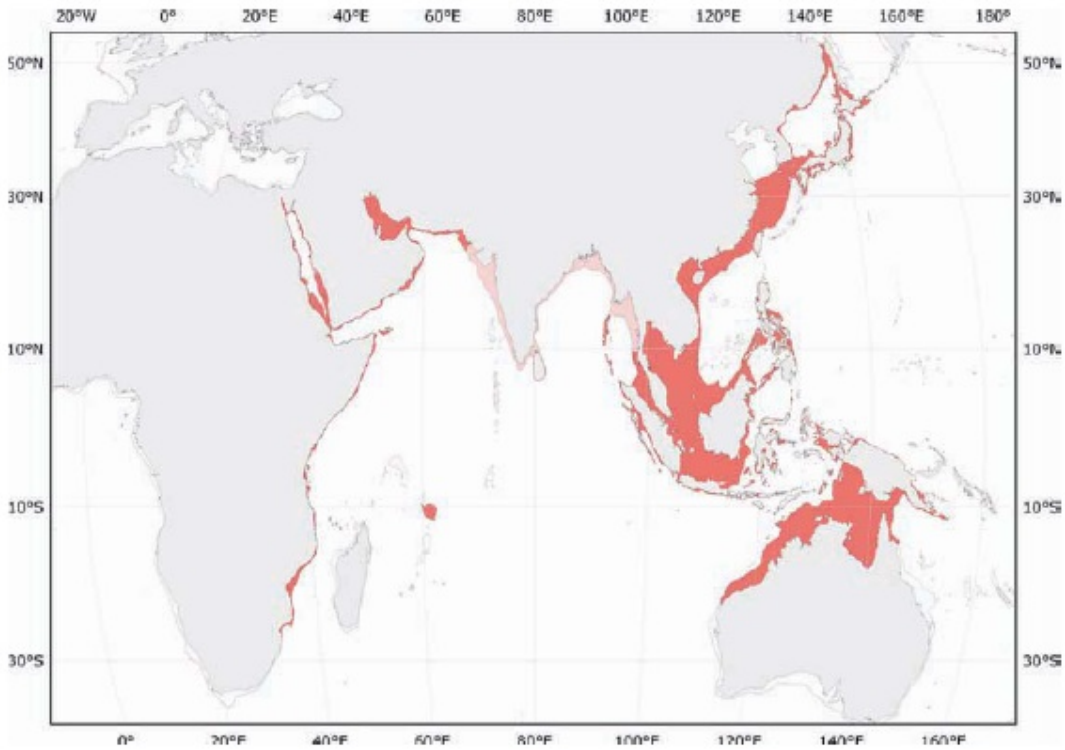

Figure 3: Swordtip squid distribution (Jereb & Roper 2010).

Production Statistics

Official landing data in Southern and Southeast Asian countries are often inaccurate due to the limited resources and systems in place to collect and report catch data. Squid species are typically not adequately identified in those countries when caught, and all the species are often pooled in the production statistics. The government of Thailand collects landings data each year, separated between the two primary fishing areas (the Andaman Sea and Gulf of Thailand), and these are reported annually. In these annual catch statistics reports and vessel survey reports, some data are reported at the species level (rather than grouped), including for some squid species (DOF 2023b). According to the FAO, the category “various squids nei, Loliginidae, Ommastrephidae,” which includes *Uroteuthis* species, made up 9% of global mollusk landings in 2020 (FAO 2022). Southern and Southeast Asian countries are responsible for a significant portion of global squid landings, and Indonesia, Thailand, and India are the countries included in this report.

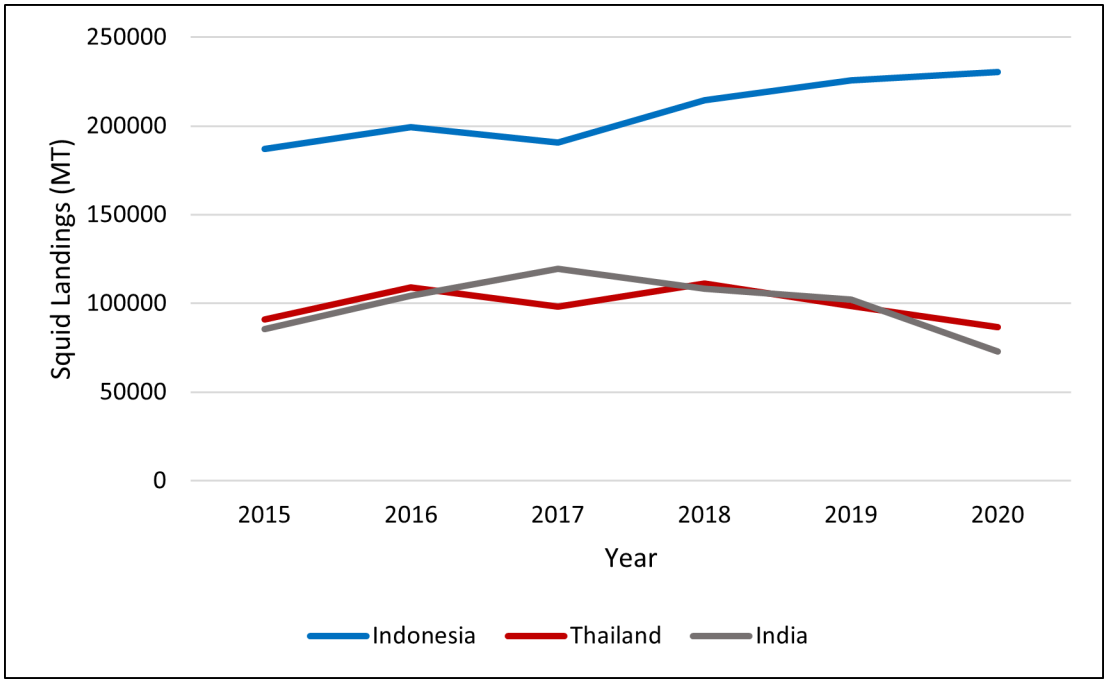

Figure 4: Annual squid landings (all species) in Indonesia, Thailand, and India from 2015 to 2020. Data sources: SEAFDEC and CMFRI.

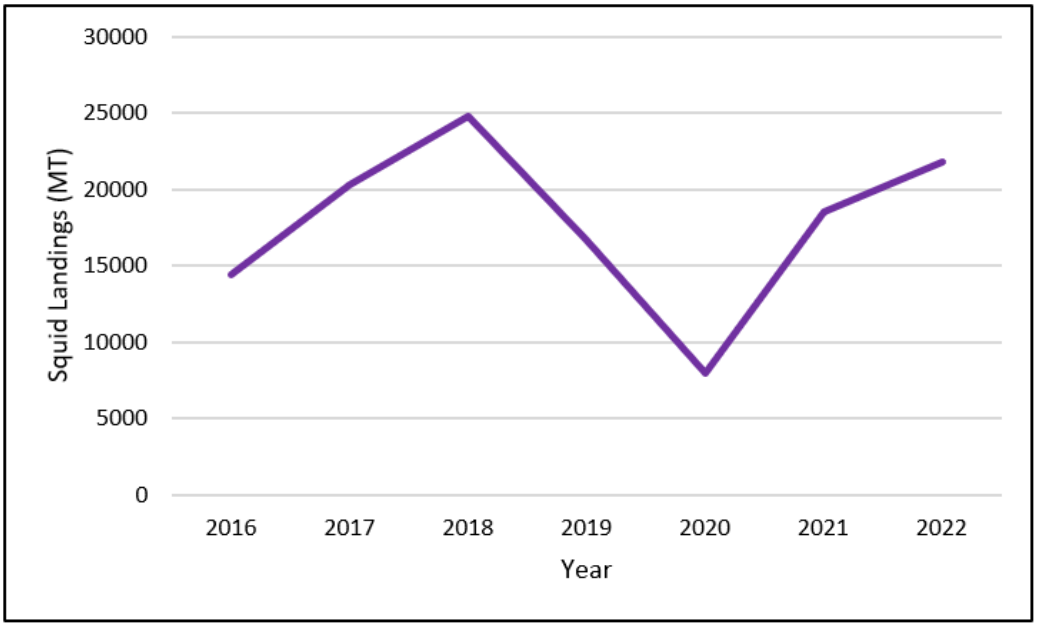

Figure 5: Annual squid landings (all species) in Kerala from 2016 to 2022. Data source: CMFRI.

According to the Fishery Statistical Bulletin of Southeast Asia, squid landings in Indonesia increased between 2015 and 2019, reaching a 20% increase in volume between 2015 and 2019 (SEAFDEC 2022). In 2019, 225,657 MT of squid were landed in Indonesia, making squid the fourth largest capture species group in the country (ibid). The Statistical Bulletin further shows that squid capture in Thailand increased 8% from 2015 to 2019, with 98,375 MT of squid landed in Thai waters in 2019 (SEAFDEC 2022b). But this increase was not consistent, with landings in both 2016 and 2018 surpassing 100,000 MT (ibid). More recent data from the Thai Department of Fisheries indicate that landings in the Gulf of Thailand increased from 2019 to 2022, while landings in the Andaman Sea decreased during the same period (e.g., see (DOF 2023b)). Approximately 90% of the Thai catch comes from the Gulf of Thailand (east of the country) and 10% from the East Andaman Sea (Arkhipkin et al. 2015).

The latest landings data for India are available via the Central Marine Fisheries Research Institute (CMFRI) in India. According to CMFRI, squid landings in 2022 were 109,253 tons (≈99,112 MT) (CMFRI 2021). In Kerala, 24,019 tons (≈21,789 MT) of squid were landed in 2022 (CMFRI 2023, pers comm). The recent average of squid species landed in Kerala is 22,026 tons (≈19,981 MT) (CMFRI 2021). The amount of Indian squid specifically landed in India is unknown, but it could represent around 70–80% of the total squid catch {Arkhipkin 2015}.

Importance to the US/North American market.

U.S. squid imports are largely not identified by species, and only four categories are used in the National Marine Fisheries Service database to refer to these species: a general category named “squid NSPF” (where “NSPF” stands for “not specifically provided for”), two specific categories for “*Loligo opalescens*” and “*Loligo pealei”* that are not relevant to this report, and finally a category for other *Loligo* species named “squid (Loligo NSPF).”

In 2021, 10,680 MT of squid were imported into the United States from Thailand, India, and Indonesia combined, valued at USD80.2 million (NOAA Fisheries 2023). Squid were imported as frozen, prepared/preserved, and dried/salted/brine (ibid). Given that the major squid species caught in Thailand, India, and Indonesia are Indian, mitre, and swordtip squid, it is assumed that the majority of the squid imports into the United States correspond to these species. The exact volume of each species cannot be determined.

Volume of squid imports into the U.S. from selected countries (MT)			
Year	**India**	**Thailand**	**Indonesia**
2016	3933	2911	447
2017	4480	2545	523
2018	5465	2662	615
2019	5205	3111	601
2020	4069	2713	691
2021	6338	3570	772
2022	8676	4134	988

Figure 6: Volume (MT) of all squid imported into the United States from India, Thailand, and Indonesia from 2016 to 2022. Data source: NOAA Fisheries Foreign Trade Database.

Value of squid imports into the U.S. from selected countries (Million USD)			
Year	**India**	**Thailand**	**Indonesia**
2016	19.2	19.5	3.5
2017	25.5	21.5	4.7
2018	32.9	21.3	5.4
2019	30	25.5	5.1
2020	22.4	22	5.9
2021	40.2	32.9	7.1
2022	69	42	9.8

Figure 7: Value (USD millions) of all squid imported into the United States from India, Thailand, and Indonesia from 2016 to 2022. Data source: NOAA Fisheries Foreign Trade Database.

Common and market names.

The commercial name used in the U.S. for squid species is simply “squid” or “calamari.” No other names have been reported.

Primary product forms

Squid is available in seafood markets or specialty grocery stores, mainly frozen (whole or tubes). Other products identified in U.S. supermarkets are canned squid in sauce (olive or sunflower oil, spiced, garlic sauce, etc.).

Final Ratings

Ratings Details	C 1 Target Species	C 2 Other Species	C 3 Management	C 4 Habitat	Rating
Indian squid India | Eastern Indian Ocean | Western Indian Ocean | Bottom trawls	1.732	1.000	1.000	2.449	Red (1.435)
Indian squid India | Kerala | Western Indian Ocean | Bottom trawls	3.318	1.000	1.000	2.449	Red (1.688)
Indian squid Thailand | Eastern Indian Ocean | Western Central Pacific Ocean | Bottom trawls	2.236	1.000	1.000	1.732	Red (1.403)
Indian squid Thailand | Western Central Pacific Ocean | Cast nets	2.236	1.732	1.000	3.464	Red (1.914)
Indian squid Thailand | Western Central Pacific Ocean | Jig	3.413	2.644	1.000	3.873	Yellow (2.431)
Mitre squid Indonesia | Western Central Pacific Ocean | Cast nets | Flag Country: Indonesia | FAO Major Area: Pacific, Western Central | Permit/License:	1.732	1.732	1.000	3.464	Red (1.795)
Mitre squid Indonesia | Western Central Pacific Ocean | Jig | Flag Country: Indonesia | FAO Major Area: Pacific, Western Central | Permit/License:	2.644	2.644	1.000	3.873	Yellow (2.281)
Mitre squid Thailand | Eastern Indian Ocean | Western Central Pacific Ocean | Bottom trawls	1.732	1.000	1.000	1.732	Red (1.316)
Mitre squid Thailand | Western Central Pacific Ocean | Cast nets | Flag Country: Thailand | FAO Major Area: Pacific, Western Central | Permit/License:	1.732	1.732	1.000	3.464	Red (1.795)

Ratings Details	C 1 Target Species	C 2 Other Species	C 3 Management	C 4 Habitat	Rating
Mitre squid Thailand | Western Central Pacific Ocean | Jig | Flag Country: Thailand | FAO Major Area: Pacific, Western Central | Permit/License:	2.644	2.644	1.000	3.873	Yellow (2.281)
Swordtip squid Indonesia | Western Central Pacific Ocean | Cast nets | Flag Country: Indonesia | FAO Major Area: Pacific, Western Central | Permit/License:	1.732	1.732	1.000	3.464	Red (1.795)
Swordtip squid Indonesia | Western Central Pacific Ocean | Jig | Flag Country: Indonesia | FAO Major Area: Pacific, Western Central | Permit/License:	2.644	2.644	1.000	3.873	Yellow (2.281)
Swordtip squid Thailand | Eastern Indian Ocean | Western Central Pacific Ocean | Bottom trawls	1.732	1.000	1.000	1.732	Red (1.316)
Swordtip squid Thailand | Western Central Pacific Ocean | Cast nets | Flag Country: Thailand | FAO Major Area: Pacific, Western Central | Permit/License:	1.732	1.732	1.000	3.464	Red (1.795)
Swordtip squid Thailand | Western Central Pacific Ocean | Jig | Flag Country: Thailand | FAO Major Area: Pacific, Western Central | Permit/License:	2.644	2.644	1.000	3.873	Yellow (2.281)

Gear and species-specific landings data for Thailand, Indonesia, and India are typically unavailable. But some production data do exist. In India as a whole, 109,253 t (˜99,112 MT) of squid were landed in 2022. In Kerala specifically, 24,019 t (˜21,789 MT) of squid were landed in 2022. Though these numbers are for all species of squid combined, it is thought that Indian squid composes up to 80% of India's squid catch. The most recent landings numbers available for Thailand and Indonesia are from 2019, in which 98,375 MT of squid were landed in Thailand and 225,657 MT of squid were landed in Indonesia (SEAFDEC 2022)(SEAFDEC 2022b).

Summary

Indian, mitre, and swordtip squid are Indo-Pacific species captured by a number of gears across Southern and Southeast Asian countries. This report covers the Indian, mitre, and swordtip squid fisheries in India, Kerala (an Indian state assessed separately from the remainder of the country), Indonesia, and Thailand using bottom trawl, cast net, and jig gears.

The jig fisheries in Thailand and Indonesia receive a yellow rating because of their lack of bycatch, the moderate impacts on squid stocks, and the lack of seafloor impacts. The cast net fisheries in Thailand and Indonesia receive a red rating for their potential impacts on finfish bycatch species and their poor management implementation. The trawl fisheries in Thailand and India receive a red rating because of their wide variety of bycatch, the impacts on the seafloor, and their poor management implementation.

Eco-Certification Information

The Kerala shrimp and cephalopod trawl fishery is engaged in a Fishery Improvement Project (FIP). Engagement in an FIP does not affect the Seafood Watch score, because our assessments are based on the current situation. The Monterey Bay Aquarium is a member organization of the Conservation Alliance for Seafood Solutions. The Alliance has outlined guidelines for credible Fishery Improvement Projects. Thus, Seafood Watch will support procurement from fisheries engaged in an FIP, provided that a third party can verify that the FIP meets the Alliance guidelines. It is not the responsibility of Monterey Bay Aquarium to verify the credibility or progress of an FIP, or to promote the fisheries engaged in improvement projects.

Assessments

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

Indian squid			
Region / Method	**Abundance**	**Fishing Mortality**	**Score**
India | Eastern Indian Ocean | Western Indian Ocean | Bottom trawls	1.000 High Concern	3.000 Moderate Concern	**Red (1.732)**
India | Kerala | Western Indian Ocean | Bottom trawls	3.670 Low Concern	3.000 Moderate Concern	**Green (3.318)**
Thailand | Eastern Indian Ocean | Western Central Pacific Ocean | Bottom trawls	1.000 High Concern	5.000 Low Concern	**Yellow (2.236)**
Thailand | Western Central Pacific Ocean | Cast nets	1.000 High Concern	5.000 Low Concern	**Yellow (2.236)**
Thailand | Western Central Pacific Ocean | Jig	2.330 Moderate Concern	5.000 Low Concern	**Green (3.413)**

Mitre squid			
Region / Method	**Abundance**	**Fishing Mortality**	**Score**
Indonesia | Western Central Pacific Ocean | Cast nets | Flag Country: Indonesia | FAO Major Area: Pacific, Western Central | Permit/License:	1.000 High Concern	3.000 Moderate Concern	**Red (1.732)**
Indonesia | Western Central Pacific Ocean | Jig | Flag Country: Indonesia | FAO Major Area: Pacific, Western Central | Permit/License:	2.330 Moderate Concern	3.000 Moderate Concern	**Yellow (2.644)**
Thailand | Eastern Indian Ocean | Western Central Pacific Ocean | Bottom trawls	1.000 High Concern	3.000 Moderate Concern	**Red (1.732)**
Thailand | Western Central Pacific Ocean | Cast nets | Flag Country: Thailand | FAO Major Area: Pacific, Western Central | Permit/License:	1.000 High Concern	3.000 Moderate Concern	**Red (1.732)**
Thailand | Western Central Pacific Ocean | Jig | Flag Country: Thailand | FAO Major Area: Pacific, Western Central | Permit/License:	2.330 Moderate Concern	3.000 Moderate Concern	**Yellow (2.644)**

Swordtip squid			
Region / Method	Abundance	Fishing Mortality	Score
Indonesia | Western Central Pacific Ocean | Cast nets | Flag Country: Indonesia | FAO Major Area: Pacific, Western Central | Permit/License:	1.000 High Concern	3.000 Moderate Concern	Red (1.732)
Indonesia | Western Central Pacific Ocean | Jig | Flag Country: Indonesia | FAO Major Area: Pacific, Western Central | Permit/License:	2.330 Moderate Concern	3.000 Moderate Concern	Yellow (2.644)
Thailand | Eastern Indian Ocean | Western Central Pacific Ocean | Bottom trawls	1.000 High Concern	3.000 Moderate Concern	Red (1.732)
Thailand | Western Central Pacific Ocean | Cast nets | Flag Country: Thailand | FAO Major Area: Pacific, Western Central | Permit/License:	1.000 High Concern	3.000 Moderate Concern	Red (1.732)
Thailand | Western Central Pacific Ocean | Jig | Flag Country: Thailand | FAO Major Area: Pacific, Western Central | Permit/License:	2.330 Moderate Concern	3.000 Moderate Concern	Yellow (2.644)

Criterion 1 Assessment

Scoring Guidelines

Factor 1.1 - Abundance

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

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

Factor 1.2 - Fishing Mortality

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

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

Indian squid *(Uroteuthis (Photololigo) duvaucelii)*

1.1 Abundance

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

Western Central Pacific | Thailand | Cast nets

High Concern

Because of the nature of their multispecies fisheries, Thai officials conduct multispecies maximum sustainable yield (MSY) assessments each year that split fishery catch into three categories: demersal species (includes squid), pelagic fishes, and anchovy. Although squids are assessed as part of the demersal group, no stock assessment exists specifically for Indian squid in Thailand (DOF 2020). Therefore, a productivity-susceptibility analysis (PSA) was performed. The PSA resulted in a score of 3.35, so this factor receives a “high concern” rating.

Supplementary Information

Table 1

Productivity Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Average age at maturity	< 1 year (Sajikumar et al. 2022)	1
Average maximum age	< 1 year (Sajikumar et al. 2022)	1
Von Bertalanffy growth coefficient	> 0.3 (Palomares and Pauly 2023a)	1
Fecundity	> 10,000 eggs/yr (Palomares and Pauly 2023a)	2
Reproductive strategy	Demersal egg layer (Sajikumar et al. 2022)	2
Density dependence	No dispensatory or compensatory dynamics at low populations	2
Total Productivity Score		**1.5**

Table 2

Susceptibility Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)

Areal overlap	Unknown—default score	3
Vertical overlap	Target species—default score	3
Seasonal availability	Unknown—default score	3
Selectivity of fishery	Target species; juveniles may be retained due to poor enforcement of mesh size restrictions (Environmental Justice Foundation 2023)	3
Post-capture mortality	Retained species	3
Total Susceptibility Score		**3**
Overall PSA Score		**3.35**

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

High Concern

A stock assessment for Indian squid in Kerala waters exists, but no other stock assessments in other Indian waters have been carried out. Because stock abundance outside of Kerala is unknown, a productivity-susceptibility analysis (PSA) was performed. The PSA indicated a score of 3.35, leading to a score of “high concern.”

Supplementary Information

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including Indian squid. But there is too much uncertainty involved in the target reference points used for shellfish in these assessments, as well as the assessment methodology and input data, to make confident conclusions about abundance and fishing mortality based on their results. Further, while the southwest, northeast, and southeast stocks were designated as not overfished in 2022, the northwest stock was designated as recovering, meaning its biomass is below a sustainable reference point (CMFRI 2023). Some other exploitation assessments have been completed, but these have not produced estimates of spawning stock biomass or total population abundance. One assessment produced stock status estimates (recovering, sustainable, or overfished) for cephalopods in all Indian coastal states, but squids, octopi, and cuttlefish contributed to this assessment, making it too broad to speak specifically to Indian squid (Sathianandan et al. 2021). Therefore, a PSA was performed to determine the score for factor 1.1.

Table 3

Productivity Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Average age at maturity	< 1 year (Sajikumar et al. 2022)	1
Average maximum age	< 1 year (Sajikumar et al. 2022)	1
Von Bertalanffy growth coefficient	> 0.3 (Palomares and Pauly 2023a)	1
Fecundity	> 10,000 eggs/yr (Palomares and Pauly 2023a)	2
Reproductive strategy	Demersal egg layer (Sajikumar et al. 2022)	2
Density dependence	No dispensatory or compensatory dynamics at low populations	2
Total Productivity Score		**1.5**

Table 4

Susceptibility Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Areal overlap	Unknown—default score	3
Vertical overlap	Target species—default score	3
Seasonal availability	Fishery is year-round, aside from a summer closure of ≈2 months (CMFRI 2022a)	3
Selectivity of fishery	Species is targeted. Net mesh size restrictions are in place in some but not all states. These restrictions are not always adequately followed or enforced (Ranjan Behera et al. 2021) (CMFRI 2022a).	3
Post-capture mortality	Retained species	3
Total Susceptibility Score		**3**
Overall PSA Score		**3.35**

Western Central Pacific | Thailand | Jig

Moderate Concern

No stock assessment exists for Indian squid in Thailand. Therefore, a PSA was performed. The PSA resulted in a score of 3.18, so this factor receives a “moderate concern” rating.

Supplementary Information

Table 5

Productivity Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Average age at maturity	< 1 year (Sajikumar et al. 2022)	1
Average maximum age	< 1 year (Sajikumar et al. 2022)	1
Von Bertalanffy growth coefficient	> 0.3 (Palomares and Pauly 2023a)	1
Fecundity	> 10,000 eggs/yr (Palomares and Pauly 2023a)	2
Reproductive strategy	Demersal egg layer (Sajikumar et al. 2022)	2
Density dependence	No dispensatory or compensatory dynamics at low populations	2
Total Productivity Score		**1.5**

Table 6

Susceptibility Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Areal overlap	Unknown—default score	3
Vertical overlap	Target species—default score	3
Seasonal availability	Unknown—default score	3
Selectivity of fishery	Target species without increased susceptibility to gear. While mechanisms such as attracting lights are used, the nature of jig fishing allows many squid to evade capture, compared to net-based fisheries.	2
Post-capture mortality	Retained species	3
Total Susceptibility Score		**2.8**
Overall PSA Score		**3.18**

Western Indian Ocean | Kerala | Bottom trawls

Low Concern

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including Indian squid on the southwest coast of India. Through these assessments, CMFRI has designated the southwest Indian squid stock as not overfished (CMFRI 2023). More detailed results of this assessment were provided by CMFRI to the Kerala FIP coordinators in a report that indicates that abundance is above the MSY level (B/B_{MSY} = 1.07) (CMFRI 2024).

Based on a data-limited stock assessment that is < 10 years old, abundance is considered a “low concern.”

Supplementary Information

Some other, earlier exploitation assessments have been completed, but these have not produced estimates of spawning stock biomass or total population abundance. One assessment produced stock status estimates (recovering, sustainable, or overfished) for cephalopods in Kerala and other states, but squids, octopi, and cuttlefish contributed to this assessment, making it too broad to speak specifically to Indian squid (Sathianandan et al. 2021). Another assessment focused specifically on Indian squid, but this research focused more on fishing yield than direct abundance estimates (Sasikumar et al., unpublished data).

1.2 Fishing Mortality

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

Western Central Pacific | Thailand | Cast nets

Western Central Pacific | Thailand | Jig

Low Concern

Although some recent assessments have been done to assess fishing pressure in Thailand, fishing mortality for specific squid species largely remains unknown. But in addition to its multispecies MSY assessments, which are used to set total allowable catches (TACs), Thailand’s Department of Fisheries also conducts some single-species assessments to monitor stock status. The most recent of these indicates that, in 2017, fishing effort for Indian squid in the Gulf of Thailand (where 90% of the Indian squid catch comes from) was “around the MSY level” (DOF 2021b). More specifically, MSY was estimated at 3,657 t, while the 2017 harvest was estimated at 3,641 t (ibid). Because the latest stock status assessment indicates that Indian squid fishing mortality is, essentially, at MSY, a score of “low concern” is assigned

Supplementary Information

More recently, the Thai Department of Fisheries (DOF) released assessments for species groups. Demersal species in this assessment include squid species. The assessment found that catch and fishing effort of demersal species were below the estimated MSY reference point and the optimal effort reference point in both the Gulf of Thailand and the Andaman Sea (Kulanujaree et al. 2020). But this species group is too broad to translate these results to specific squid species.

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

Moderate Concern

Fishing mortality in areas outside of Kerala relative to a sustainable level is unknown, so this factor scores a “moderate concern” rating.

Supplementary Information

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including Indian squid. But there is too much uncertainty involved in the target reference points, the assessment methodology, and the input data used for these assessments to make confident conclusions about abundance and fishing mortality based on their results. Some other recent assessments have attempted to characterize the level of fishing exploitation on Indian squid, but these assessments do not incorporate estimates of stock biomass. Still, they can provide some insight into fishing pressure levels on the stock. A 2021 assessment of several species and species groups in multiple Indian states suggests that cephalopods as a whole have a sustainable stock status in no states other than Kerala (which is assessed separately in this report) (Sathianandan et al. 2021). Cephalopods were found to be overfished in Tamil Nadu (on India’s east coast) and recovering in Gujarat and Karnataka (on India’s west coast). But this cephalopods group comprises not only Indian squid, but also multiple octopus and cuttlefish species. Because of the differing life histories of these cephalopods, the stock status of cephalopods as a whole cannot be translated to the stock status of Indian squid alone.

Another assessment from 2017 found that the fishing yield of Indian squid in the Arabian Sea, on India’s west coast, was “around” the maximum sustainable yield (MSY) but needed to be reduced to achieve the maximum economic yield (MEY). Typically, MEY sits at a point that involves lower fishing effort and higher biomass levels than when a stock is fished at MSY (Narayanakumar 2017). This work does

not provide an estimate of fishing mortality relative to stock biomass, but it does suggest that fishing mortality of Indian squid on India's west coast may be at a sustainable level. But the uncertainty introduced by the lack of a sustainable stock biomass (SSB) estimate to compare against the fishing effort level and a lack of fishing mortality estimate for the east coast supports a "moderate concern" rating for this factor, rather than a "low concern" rating.

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

In its most recent report for the Kerala fishery's FIP, CMFRI estimated that fishing mortality for Indian squid on the southwest coast of India is just below the MSY level ($F/F_{MSY} = 0.978$). Because this point estimate is quite close to F_{MSY}, the full confidence interval associated with it is considered in scoring (CI = 0.637–1.53). While the point estimate suggests that fishing mortality is just below a sustainable level, the confidence interval introduces some uncertainty, so fishing mortality is considered a "moderate concern."

Supplementary Information

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including Indian squid. But there was too much uncertainty involved in the target reference points, the assessment methodology, and the input data used for these assessments to make confident conclusions about abundance and fishing mortality based on their results. But the more recent CMFRI report clarified much of this uncertainty by providing exact estimates for B/B_{MSY} and F/F_{MSY}. Some other recent assessments have attempted to characterize the level of fishing exploitation on Indian squid, but these assessments do not incorporate estimates of stock biomass. Still, they can provide some insight into fishing pressure levels on the stock. A 2021 assessment of several species and species groups in multiple Indian states suggests that cephalopods as a whole have a sustainable stock status in Kerala (Sathianandan et al. 2021). But this cephalopods group comprises not only Indian squid, but also multiple octopus and cuttlefish species. Because of the differing life histories of these cephalopods, the stock status of cephalopods as a whole cannot be translated to the stock status of Indian squid alone.

Another assessment from 2017 found that the fishing yield of Indian squid in the Arabian Sea, which borders Kerala, was "around" the maximum sustainable yield

(MSY) but needed to be reduced to achieve the maximum economic yield (MEY). Typically, MEY sits at a point that involves lower fishing effort and higher biomass levels than when a stock is fished at MSY (Narayanakumar 2017). This work does not provide an estimate of fishing mortality relative to stock biomass, but it does suggest that fishing mortality of Indian squid on India's west coast may be at a sustainable level. But the uncertainty introduced by the lack of an SSB estimate in the 2017 paper to compare against the fishing effort level supports a "moderate concern" rating for this factor, rather than a "low concern" rating.

Mitre squid *(Uroteuthis (Photololigo) chinensis)*

1.1 Abundance

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

Western Central Pacific | Thailand | Cast nets

High Concern

No stock assessment exists for mitre squid in Thailand. Therefore, a PSA was used. The PSA resulted in a score of 3.35, so this factor receives a "high concern" rating.

Supplementary Information

Table 7

Productivity Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Average age at maturity	< 1 year (Jin et al. 2019)	1
Average maximum age	< 1 year (Jin et al. 2019)	1
Von Bertalanffy growth coefficient	> 0.25 (Palomares and Pauly 2023d)	1
Fecundity	3,000–20,000 (Arkhipkin et al. 2015)	2
Reproductive strategy	Demersal egg layer	2
Density dependence	No dispensatory or compensatory dynamics at low populations	2
Total Productivity Score		**1.5**

Table 8

Susceptibility Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Areal overlap	Unknown—default score	3
Vertical overlap	Target species—default score	3
Seasonal availability	Unknown—default score	3
Selectivity of fishery	Target species; juveniles may be retained due to poor enforcement of mesh size restrictions (Environmental Justice Foundation 2023)	3
Post-capture mortality	Retained species	3
Total Susceptibility Score		**3**
Overall PSA Score		**3.35**

Western Central Pacific | Indonesia | Cast nets

High Concern

No stock assessment exists for mitre squid in Indonesia. Therefore, a PSA was used. The PSA resulted in a score of 3.35, so this factor receives a “high concern” rating.

Supplementary Information

Table 9

Productivity Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Average age at maturity	< 1 year (Jin et al. 2019)	1
Average maximum age	< 1 year (Jin et al. 2019)	1
Von Bertalanffy growth coefficient	> 0.25 (Palomares and Pauly 2023d)	1
Fecundity	3,000–20,000 (Arkhipkin et al. 2015)	2
Reproductive strategy	Demersal egg layer	2
Density dependence	No dispensatory or compensatory dynamics at low populations	2

Total Productivity Score		**1.5**

Table 10

Susceptibility Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Areal overlap	Unknown—default score	3
Vertical overlap	Target species—default score	3
Seasonal availability	Unknown—default score	3
Selectivity of fishery	Target species; juveniles may be retained because minimum mesh size restriction < size of mature squid (MMAF 2011) (Palomares and Pauly 2023d)	3
Post-capture mortality	Retained species	3
Total Susceptibility Score		**3**
Overall PSA Score		**3.35**

Western Central Pacific | Indonesia | Jig
Western Central Pacific | Thailand | Jig

Moderate Concern

No stock assessment exists for mitre squid in Indonesia or Thailand. Therefore, a PSA was used. The PSA resulted in a score of 3.18, so this factor receives a “moderate concern” rating.

Supplementary Information

Table 11

Productivity Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Average age at maturity	< 1 year (Jin et al. 2019)	1
Average maximum age	< 1 year (Jin et al. 2019)	1
Von Bertalanffy growth coefficient	> 0.25 (Palomares and Pauly 2023d)	1

Fecundity	3,000–20,000 (Arkhipkin et al. 2015)	2
Reproductive strategy	Demersal egg layer	2
Density dependence	No dispensatory or compensatory dynamics at low populations	2
Total Productivity Score		**1.5**

Table 12

Susceptibility Attribute	**Relevant Information**	**Score (1 = low, 2 = medium, 3 = high)**
Areal overlap	Unknown—default score	3
Vertical overlap	Target species—default score	3
Seasonal availability	Unknown—default score	3
Selectivity of fishery	Target species without increased susceptibility to gear. While mechanisms such as attracting lights are used, the nature of jig fishing allows many squid to evade capture, compared to net-based fisheries.	2
Post-capture mortality	Retained species	3
Total Susceptibility Score		**2.8**
Overall PSA Score		**3.18**

1.2 Fishing Mortality

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

Western Central Pacific | Thailand | Cast nets

Western Central Pacific | Thailand | Jig

Moderate Concern

Although some recent assessments have been done to assess fishing pressure in Thailand, fishing mortality for specific squid species largely remains unknown. Therefore, this factor receives a “moderate concern” score.

Supplementary Information

The Thai Department of Fisheries (DOF) releases MSY assessments (for TAC-setting purposes) for species groups periodically. Demersal species in these

assessments include squid species. The most recent assessments found that catch and fishing effort of demersal species were below the estimated MSY reference point and the optimal effort reference point in both the Gulf of Thailand and the Andaman Sea (Kulanujaree et al. 2020) (DOF 2023c). But this species group is too broad to translate these results to the stock status of specific squid species.

Western Central Pacific | Indonesia | Cast nets
Western Central Pacific | Indonesia | Jig

Moderate Concern

Fishing mortality relative to a sustainable level is unknown, so this fishing mortality is considered a “moderate concern.”

Supplementary Information

As part of its latest marine fishery management plan, the Indonesian Ministry of Marine Affairs and Fisheries (MMAF) released 2022 stock statuses for several species groups, including squid. These stock statuses were determined for individual fisheries management areas, or WPPs. Squid were found to be overexploited (annual catch > estimated potential yield limit) in three WPPs and fully exploited (annual catch = 80–100% of estimated potential yield limit) in eight WPPs (MMAF 2022)(Napitupulu et al. 2022). In no WPPs were squid moderately exploited (annual catch < 80% of estimated potential yield). But these estimates are based on poor-quality catch data, and are not for individual squid species but for the species group as a whole (Napitupulu et al. 2022). While the status of squid differs between individual WPPs, it is also not clear if multiple populations of each squid population exist in Indonesian waters. Therefore, fishing mortality is considered unknown for mitre and swordtip squid in Indonesia.

Swordtip squid *(Uroteuthis (Photololigo) edulis)*

1.1 Abundance

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls
Western Central Pacific | Thailand | Cast nets

High Concern

No stock assessment exists for swordtip squid in Thailand. Therefore, a PSA was used. The PSA resulted in a score of 3.35, so this factor receives a “high concern” rating.

Supplementary Information

Table 13

Productivity Attribute*	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Average age at maturity	< 1 year (Liao et al. 2018)	1
Average maximum age	≈1 year (Palomares and Pauly 2023e)	1
Reproductive strategy	Demersal egg layer	2
Density dependence	No dispensatory or compensatory dynamics at low populations	2
Total Productivity Score		**1.5**

* Note that fecundity and the growth coefficient are unknown for this species, so they were excluded from the productivity assessment.

Table 14

Susceptibility Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Areal overlap	Unknown—default score	3
Vertical overlap	Target species—default score	3
Seasonal availability	Unknown—default score	3
Selectivity of fishery	Target species; juveniles may be retained due to poor enforcement of mesh size restrictions (Environmental Justice Foundation 2023)	3
Post-capture mortality	Retained species	3
Total Susceptibility Score		**3**

Overall PSA Score		**3.35**

Western Central Pacific | Indonesia | Cast nets

High Concern

No stock assessment exists for swordtip squid in Indonesia. Therefore, a PSA was used. The PSA resulted in a score of 3.35, so this factor receives a “high concern” rating.

Supplementary Information

Table 15

Productivity Attribute*	**Relevant Information**	**Score (1 = low, 2 = medium, 3 = high)**
Average age at maturity	< 1 year (Liao et al. 2018)	1
Average maximum age	≈1 year (Palomares and Pauly 2023e)	1
Reproductive strategy	Demersal egg layer	2
Density dependence	No dispensatory or compensatory dynamics at low populations	2
Total Productivity Score		**1.5**

* Note that fecundity and the growth coefficient are unknown for this species, so they were excluded from the productivity assessment.

Table 16

Susceptibility Attribute	**Relevant Information**	**Score (1 = low, 2 = medium, 3 = high)**
Areal overlap	Unknown—default score	3
Vertical overlap	Target species—default score	3
Seasonal availability	Unknown—default score	3

Selectivity of fishery	Target species; juveniles may be retained because minimum mesh size restriction < size of mature squid (MMAF 2011) (Palomares and Pauly 2023e)	3
Post-capture mortality	Retained species	3
Total Susceptibility Score		**3**
Overall PSA Score		**3.35**

Western Central Pacific | Indonesia | Jig
Western Central Pacific | Thailand | Jig

Moderate Concern

No stock assessment exists for swordtip squid in Indonesia or Thailand. Therefore, a PSA was used. The PSA resulted in a score of 3.18, so this factor receives a “moderate concern” rating.

Supplementary Information

Table 17

Productivity Attribute*	**Relevant Information**	**Score (1 = low, 2 = medium, 3 = high)**
Average age at maturity	<1 year (Liao et al. 2018)	1
Average maximum age	≈1 year (Palomares and Pauly 2023e)	1
Reproductive strategy	Demersal egg layer	2
Density dependence	No dispensatory or compensatory dynamics at low populations	2
Total Productivity Score		**1.5**

* Note that fecundity and growth coefficient are unknown for this species, so they were excluded from the productivity assessment.

Table 18

Susceptibility Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Areal overlap	Unknown—default score	3
Vertical overlap	Target species—default score	3
Seasonal availability	Unknown—default score	3
Selectivity of fishery	Target species without increased susceptibility to gear. While mechanisms such as attracting lights are used, the nature of jig fishing allows many squid to evade capture, compared to net-based fisheries.	2
Post-capture mortality	Retained species	3
Total Susceptibility Score		**2.8**
Overall PSA Score		**3.18**

1.2 Fishing Mortality

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

Western Central Pacific | Thailand | Cast nets

Western Central Pacific | Thailand | Jig

Moderate Concern

Although some recent assessments have been done to assess fishing pressure in Thailand, fishing mortality for specific squid species largely remains unknown. Therefore, this factor receives a “moderate concern” score.

Supplementary Information

The Thai Department of Fisheries (DOF) releases MSY assessments (for TAC-setting purposes) for species groups periodically. Demersal species in these assessments include squid species. The most recent assessments found that catch and fishing effort of demersal species were below the estimated MSY reference point and the optimal effort reference point in both the Gulf of Thailand and the Andaman Sea (Kulanujaree et al. 2020) (DOF 2023c). But this species group is too broad to translate these results to the stock status of specific squid species.

Western Central Pacific | Indonesia | Cast nets
Western Central Pacific | Indonesia | Jig

Moderate Concern

Fishing mortality relative to a sustainable level is unknown, so this fishing mortality is considered a “moderate concern.”

Supplementary Information

As part of its latest marine fishery management plan, the Indonesian Ministry of Marine Affairs and Fisheries (MMAF) released 2022 stock statuses for several species groups, including squid. These stock statuses were determined for individual fisheries management areas, or WPPs. Squid were found to be overexploited (annual catch > estimated potential yield limit) in three WPPs and fully exploited (annual catch = 80–100% of estimated potential yield limit) in eight WPPs (MMAF 2022)(Napitupulu et al. 2022). In no WPPs were squid moderately exploited (annual catch < 80% of estimated potential yield). But these estimates are based on poor-quality catch data, and are not for individual squid species but for the species group as a whole (Napitupulu et al. 2022). While the status of squid differs between individual WPPs, it is also not clear if multiple populations of each squid population exist in Indonesian waters. Therefore, fishing mortality is considered unknown for mitre and swordtip squid in Indonesia.

Criterion 2: Impacts on Other Species

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

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

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

Guiding principles

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

Criterion 2 Summary

Criterion 2 score(s) overview

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

Indian squid			
Region / Method	**Sub Score**	**Discard Rate/Landings**	**Score**
India | Eastern Indian Ocean | Western Indian Ocean | Bottom trawls	1.000	1.000: < 100%	Red (1.000)
India | Kerala | Western Indian Ocean | Bottom trawls	1.000	1.000: < 100%	Red (1.000)
Thailand | Eastern Indian Ocean | Western Central Pacific Ocean | Bottom trawls	1.000	1.000: < 100%	Red (1.000)
Thailand | Western Central Pacific Ocean | Cast nets	1.732	1.000: < 100%	Red (1.732)
Thailand | Western Central Pacific Ocean | Jig	2.644	1.000: < 100%	Yellow (2.644)

Mitre squid			
Region / Method	**Sub Score**	**Discard Rate/Landings**	**Score**
Indonesia | Western Central Pacific Ocean | Cast nets | Flag Country: Indonesia | FAO Major Area: Pacific, Western Central | Permit/License:	1.732	1.000: < 100%	Red (1.732)
Indonesia | Western Central Pacific Ocean | Jig | Flag Country: Indonesia | FAO Major Area: Pacific, Western Central | Permit/License:	2.644	1.000: < 100%	Yellow (2.644)
Thailand | Eastern Indian Ocean | Western Central Pacific Ocean | Bottom trawls	1.000	1.000: < 100%	Red (1.000)
Thailand | Western Central Pacific Ocean | Cast nets | Flag Country: Thailand | FAO Major Area: Pacific, Western Central | Permit/License:	1.732	1.000: < 100%	Red (1.732)
Thailand | Western Central Pacific Ocean | Jig | Flag Country: Thailand | FAO Major Area: Pacific, Western Central | Permit/License:	2.644	1.000: < 100%	Yellow (2.644)

Swordtip squid			
Region / Method	**Sub Score**	**Discard Rate/Landings**	**Score**
Indonesia | Western Central Pacific Ocean | Cast nets | Flag Country: Indonesia | FAO Major Area: Pacific, Western Central | Permit/License:	1.732	1.000: < 100%	Red (1.732)
Indonesia | Western Central Pacific Ocean | Jig | Flag Country: Indonesia | FAO Major Area: Pacific, Western Central | Permit/License:	2.644	1.000: < 100%	Yellow (2.644)
Thailand | Eastern Indian Ocean | Western Central Pacific Ocean | Bottom trawls	1.000	1.000: < 100%	Red (1.000)
Thailand | Western Central Pacific Ocean | Cast nets | Flag Country: Thailand | FAO Major Area: Pacific, Western Central | Permit/License:	1.732	1.000: < 100%	Red (1.732)
Thailand | Western Central Pacific Ocean | Jig | Flag Country: Thailand | FAO Major Area: Pacific, Western Central | Permit/License:	2.644	1.000: < 100%	Yellow (2.644)

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, Western Central Pacific | Thailand | Bottom trawls			
Sub Score: 1.000	**Discard Rate: 1.000**		**Score: 1.000**
Species	**Abundance**	**Fishing Mortality**	**Score**
Marine mammals	1.000: High Concern	1.000: High Concern	Red (1.000)
Rays and skates (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Sea turtles	1.000: High Concern	1.000: High Concern	Red (1.000)
Sharks	1.000: High Concern	1.000: High Concern	Red (1.000)
Mitre squid	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Swordtip squid	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Indian squid	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Finfish	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls			
Sub Score: 1.000	**Discard Rate: 1.000**		**Score: 1.000**
Species	**Abundance**	**Fishing Mortality**	**Score**
Finfish	1.000: High Concern	1.000: High Concern	Red (1.000)
Marine mammals	1.000: High Concern	1.000: High Concern	Red (1.000)
Rays and skates (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Sea turtles	1.000: High Concern	1.000: High Concern	Red (1.000)
Sharks	1.000: High Concern	1.000: High Concern	Red (1.000)
Corals and other biogenic habitats	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Indian squid	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Seabirds	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Benthic inverts	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)

Western Central Pacific | Indonesia | Cast nets			
Sub Score: 1.732	**Discard Rate: 1.000**		**Score: 1.732**
Species	**Abundance**	**Fishing Mortality**	**Score**
Mitre squid	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Swordtip squid	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Finfish	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)

Western Central Pacific | Indonesia | Jig			
Sub Score: 2.644	**Discard Rate: 1.000**		**Score: 2.644**
Species	**Abundance**	**Fishing Mortality**	**Score**
Mitre squid	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Swordtip squid	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)

Western Central Pacific | Thailand | Cast nets			
Sub Score: 1.732	**Discard Rate: 1.000**		**Score: 1.732**
Species	**Abundance**	**Fishing Mortality**	**Score**
Mitre squid	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Swordtip squid	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Indian squid	1.000: High Concern	5.000: Low Concern	Yellow (2.236)
Finfish	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)

Western Central Pacific | Thailand | Jig			
Sub Score: 2.644	**Discard Rate: 1.000**		**Score: 2.644**
Species	**Abundance**	**Fishing Mortality**	**Score**
Mitre squid	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Swordtip squid	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Indian squid	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

Western Indian Ocean | Kerala | Bottom trawls			
Sub Score: 1.000	**Discard Rate: 1.000**		**Score: 1.000**
Species	**Abundance**	**Fishing Mortality**	**Score**
Hammerhead sharks	1.000: High Concern	1.000: High Concern	Red (1.000)
Moontail bullseye	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Atlantic cutlassfish	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Olive Ridley turtle	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Largetooth sawfish	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Indo-Pacific bottlenose dolphin	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Whale shark	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Giant guitarfish	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Indian Ocean humpback dolphin	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Kadal shrimp	3.670: Low Concern	1.000: High Concern	Red (1.916)
Randall's threadfin bream	3.670: Low Concern	1.000: High Concern	Red (1.916)
Japanese threadfin bream	3.670: Low Concern	1.000: High Concern	Red (1.916)
Indian scad	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Teri anchovy	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Greater lizard fish	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Mauvelip threadfin bream	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Fourlined tonguesole	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Indian squid	3.670: Low Concern	3.000: Moderate Concern	Green (3.318)
Indian mackerel	3.670: Low Concern	3.000: Moderate Concern	Green (3.318)

Western Indian Ocean | Kerala | Bottom trawls			
Sub Score: 1.000	**Discard Rate: 1.000**		**Score: 1.000**
Species	**Abundance**	**Fishing Mortality**	**Score**
Kiddi shrimp	3.670: Low Concern	3.000: Moderate Concern	Green (3.318)
Neglected ocellate octopus	3.670: Low Concern	5.000: Low Concern	Green (4.284)
Pharaoh cuttlefish	3.670: Low Concern	5.000: Low Concern	Green (4.284)

As explained in the Introduction, Indian, mitre, and swordtip squid are largely caught via epibenthic otter trawls, nets (falling, cast nets, and purse seiners) and jigs using light-luring techniques {Jereb and Roper 2010}(Arkhipkin et al. 2015). Few specific reports on bycatch and discards are available for squid fisheries in the three countries assessed, although Thailand does publish commercial and artisanal fisheries statistics papers that broadly describe the catch composition across gear types. Scientific observer programs that would provide bycatch and discards information are also lacking in the three countries assessed.

In tropical countries like Thailand and India, the bycatch problem is a complex issue due to the multispecies and multigear nature of the fisheries (Gibinkumar et al. 2012). An exact catch profile for the commercial trawl fisheries targeting squid in India and the Gulf of Thailand has not been found. According to Zeller et al. (2017), in Southeast Asia and the western Pacific Ocean, the bulk of the catch in trawl fisheries is dominated by families that are widespread in these tropical waters, such as pony fishes (Leiognathidae, 9% of the catch), threadfin breams (Nemipteridae, 6%), lizardfishes (Synodontidae, 6%), drums (Sciaenidae, 3%) and scads [yellowstripe scad (*Selaroides leptolesis*), Carangidae, 7%] {Zeller et al. 2017}. These species may be retained or in some cases discarded, depending on their market value.

The most complete catch profile for the Thai trawl fishery is shown in Supongpan and Boonchuwong (2010). This report is based on a research trawl survey undertaken in Thai waters between 2003 and 2005. Although the catch composition varied by area, year, and the size of the trawler, cephalopod species (mainly Indian and mitre squid) represented around 20% of the catch; demersal fish, 30%; trash fish (formed by juveniles of commercial and noncommercial fish species, as well as some adults of noncommercial species), 40%; and pelagic species (scads, mackerels, etc.), 4% {Supongpan and Boonchuwong 2010}. The demersal species group comprised a mix of species, including Nemipterus (threadfin bream), Priacanthus, Saurida, Carrangidae, and Scolopsis. Of the trash fish, 75% were ponyfishes (*Leiognatus* spp.), which represented 30% of the total catch. In those surveys, the catch of rays (Rajidae spp.)

was also reported. More recent commercial fisheries statistics from the Thai government describe the catch in trawlers in 2023 as comprising 51.42% fish species used for fishmeal, 37.86% fish (primarily demersal, such as sea bream, lizardfish, and bigeye fish), 7.14% squid/cephalopods, 2.34% shrimp, and less than 1% each of crab, shellfish, and other aquatic animals (DOF 2024).

In India, threadfin breams, ribbon fishes, and penaeid prawns, followed by sciaenids, squids, and cuttlefishes, were the major groups in the trawl fishery on the west coast between 2008 and 2012 {Dishbabu 2013}. These groups represented more than 50% of the total catch. The most abundant species was Indian mackerel, which represented nearly 5% of the trawl catch (depending on the area) (Dineshbabu 2013). More recent work from CMFRI notes Indian scad, kadal shrimp, threadfin breams (multiple species), bigeye species, Indian mackerel, greater lizardfish, cuttlefish species, cutlassfishes, and Indian squid as the most important species caught in multiday trawl nets from 1985 to 2019, from both an economic perspective and for the amount of each species captured in these fisheries (Varghese et al. 2021). But this is not a complete list of all landed and captured species in multiday trawls, and it includes only Kerala-based fisheries, so it cannot be used to determine the species composition for other Indian trawl fisheries. A complete list of bycatch species in the Indian shrimp trawl fishery on the southwest coast of India can be found in Gibinkumar et al. (2012). In this report, the bycatch of more than 280 species is reported, including skates and rays, such as *Dasyatis kuhlii*, *Himantura bleekeri*, *H. uarnak*, *H. gerrardi*, and *Aetobatus narinari*; sharks, such as Carcharhinidae (*Rhizoprionodon acutus* and *Scoliodon laticaudus*) and Sphyrnidae (*Eusphyra blochii* and *Sphyrna zygaena*; invertebrates, such as shrimps, lobsters, crabs, and stomatopods (Gibinkumar et al. 2012); and sea turtles (*Lepidochelys olivacea*). Although a low percentage of the squid is caught as bycatch in the shrimp trawl fishery, this report has been used because it provides an idea of the bycatch species caught in trawl fisheries in the area. But squid-specific trawls, unlike shrimp trawls, operate more as off-bottom or midwater trawls (CMFRI 2022b). Thus, bycatch may differ slightly between shrimp and squid trawls, though squid are landed via both gears. A more recent report looking at midwater trawls on India's northwest coast noted a similar mixture of captured species to those seen in Thai trawls, including *Nemipterus*, *Priacanthus*, and *Saurida* (Abdul Azeez et al. 2021).

Because no specific stock assessment exists for many of the bycatch species in these countries, they have been grouped under the common denominations "finfish" (which includes small to medium pelagic species, such as sardines, anchovies or mackerels, as well as demersal species), "sharks," and "rays." Because the studies mentioned provide some landings information but not complete catch profiles, the unknown bycatch matrix (UBM) was used to supplement them. The UBM points to species that

may be at risk of capture in different fisheries. For trawl fisheries in these areas, the UBM additionally points to corals, benthic invertebrates, and marine mammals, all of which may not be reported in landings data because of their often-protected statuses. But because benthic invertebrates are not seen in significant quantities in Thai trawl catch data, they are excluded from the Thai trawl fishery (DOF 2024). Though marine mammals are prohibited from being landed in Thai fisheries—and must be promptly released when incidentally captured—there are no bycatch data available to indicate how often they are incidentally caught or what the post-release mortality rates are, so this species group is still included in the Thai trawl fishery. Corals are also prohibited from being captured in Thai trawls, and this species group is protected by several Thai laws, such that commercial fisheries are unlikely to interact with them. The majority of coral reefs in Thai waters (≈75%) are located within conservation areas, and the remaining reefs are in coastal zone areas where commercial fisheries are prohibited (Department of Marine and Coastal Resources 2015). The UBM also points to seabirds in West Indian Ocean trawls, so they have been included in the Indian trawl fishery. Bottom trawls certainly have an impact on corals and biogenic habitats, as well as benthic invertebrates, in both Thailand and India, though this risk may be lessened with the use of off-bottom squid trawl nets, as used in India (CMFRI 2022b). The UBM has been used in some cases to also assess taxonomic groups' fishing mortality scores.

Supongpan et al. (1992) undertook a catch analysis of the Indian squid light-luring net fishery in the Gulf of Thailand. According to that study, Indian squid represents over 50% of the catch (Supongpan et al. 1992). Other main fish species (> 3% of the catch) caught in the fishery are: Indian and short mackerels (*Rastregiller kanagurta*, which represents 10% of the total catch, and *Rastregiller brachysoma*, 3%), yellowtail and torpedo scad (*Atule mate*, 7%, and *Megalaspis cordyla*, 3%), and *Sardinella* spp., 5%. A similar catch profile is expected for the squid fishery in Indonesia. Thus, Ghofar (2002) reports that the species caught by "jala-oras" in the Alas Strait in Indonesia include squid and other species such as *Sardinella* (*Sardinella lemuru* and *Sardinella fimbriata*), scads (*Decapterus* spp.), and mackerels (*Rastrelliger* spp.) (Ghofar 2002). According to 2023 commercial fisheries statistics reporting from Thailand, the catch composition of covered nets (which includes squid and anchovy falling nets) was 72.68% fish (primarily pelagics such as anchovies, Carangidae, and Clupeidae), 17.29% fish species used for fishmeal, and 10.03% squid/cephalopods (DOF 2024). Thus, these and other studies have been used to characterize the bycatch species in cast net fisheries in both Thailand and Indonesia. The UBM was not used for cast net fisheries in this report.

As with the trawl fisheries, because no specific stock assessment exists for any of these bycatch species, they have been grouped under the common denomination

“finfish,” and the UBM has been used to assess their fishing mortality. No other bycatch species are thought to be caught in these fisheries.

Jigs are considered an environmentally friendly and highly selective gear, with very low bycatch and no interactions with sensitive or protected species (AFMA 2023). In the squid fishery, no bait is used. Thus, it is considered that no other species apart from squid are caught with jigs.

Finally, the ongoing Kerala FIP was used to identify bycatch species for the Kerala trawl fishery. These species include secondary species—namely, finfish species—and endangered, threatened, and protected (ETP) species that are known to interact with the fishery—namely, shark, ray, and marine mammal species (Appukuttan 2022). In 2021, there were also multiple reports of trawl fisheries landing stripenose guitarfish, a critically endangered species, in one Kerala port (CMFRI 2021). But it is unclear if these landings occurred in trawl fisheries targeting squid, so this species has not been included as a main species for the Kerala fishery. Giant guitarfish has been included in the Kerala fishery; most landings of guitarfish species in Kerala come from multiday trawl nets, and the dominant species (36%) of landed guitarfish is the giant guitarfish (CMFRI 2024).

Therefore, based on these reports regarding gear type, fishing area, regional expert opinion, and the Seafood Watch criteria, the likely species interactions with these gear types include:

- Indian and Thai squid trawl fisheries: benthic invertebrates (India only), corals/biogenic habitats (India only), marine mammals, finfish, sharks, rays, seabirds (India only), and sea turtles.
- Kerala trawl fishery: Atlantic cutlassfish, fourlined tonguesole, giant guitarfish, greater lizardfish, hammerhead sharks (unspecified), Indian mackerel, Indian Ocean humpback dolphin, Indian scad, Indo-Pacific bottlenose dolphin, Japanese threadfin bream, kadal shrimp, kiddi shrimp, largetooth sawfish, mauvelip threadfin bream, moontail bullseye, neglected ocellate octopus, olive ridley turtle, pharaoh cuttlefish, Randall’s threadfin bream, teri anchovy, and whale shark.
- Thai and Indonesian squid cast net fisheries: finfish.
- Thai and Indonesian jig fisheries: no bycatch.

For the Indian and Thai trawl fisheries, corals/biogenic habitats (India only), sharks, rays, marine mammals, and sea turtles limit the score for Criterion 2 because of the high vulnerability of these species and the high potential to interact with this gear type in the area.

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

Atlantic cutlassfish *(Trichiurus lepturus)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

High Concern

A recent data-limited stock assessment using trawl catch data from 1997 to 2016 looked at a number of different species and species groups captured on India's southwestern coast. This assessment found that ribbonfish (Atlantic cutlassfish) off the coast of Kerala is in a "recovering" stock state. This was concluded based on MSY reference points created during the assessment process, which found that $B/B_{MSY} < 1$, though fishing was occurring at a sustainable level (Sathianandan et al. 2021). Because biomass is suspected to be under the estimated reference point, this factor is scored a "high concern."

Supplementary Information

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single species stocks, including Atlantic cutlassfish in the southwest (CMFRI 2023). Through this assessment, CMFRI denotes this stock as not overfished; however, the assessment methodology is unknown and there is uncertainty in the input data, so further conclusions about abundance and fishing mortality cannot be made based on the assessment's quantitative results. Therefore, the previously noted 2021 assessment was used in place of the 2022 assessment, because there is less uncertainty involved in the 2021 assessment.

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

The data-limited assessment completed in 2021 found that $F/F_{MSY} < 1$, indicating that fishing mortality is taking place at a sustainable level (Sathianandan et al. 2021). But some uncertainty is introduced to this finding because the data and reference point are based on landings, not on an official observer program. Because F is likely below the calculated reference point but there is some uncertainty introduced from the data source, this factor receives a score of "moderate concern."

Supplementary Information

Because of uncertainty in the methodology and input data used in the more recent 2022 assessment, the 2021 assessment was used to score fishing mortality. In the 2021 assessment, researchers concluded that the stock is in a recovering state, because even though biomass is below the target reference point of B_{MSY}, fishing mortality is at a level that will allow the stock to rebuild. Therefore, F is considered sustainable in the assessment. A Kobe chart in the assessment suggests that F/F_{MSY} is about 0.6.

But Seafood Watch standards require a > 50% chance that fishing mortality from all sources is below a sustainable level that is appropriate for the species. Because the data used in this assessment come solely from trawl fishery landings and effort data, it cannot be said with > 50% certainty that fishing mortality is at an appropriate, sustainable level.

Benthic inverts *(Unknown benthic invertebrate spp.)*

2.1 Abundance

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

Moderate Concern

A series of studies have been undertaken in Indian waters to evaluate the impact of trawling on the ecosystem. According to Bath (2003) and Raman (2006), the epifaunal component most affected by trawling is the invertebrates group {Bath 2003}{Raman 2006}. Along the southwest coasts of India, 12% of the trawl landings comprised stomatopods and non-edible biota (Menon et al. 2006). In Kerala, the epibenthos discarded by trawlers was dominated by crabs (*Charybdis smithii*), stomatopods (*Oratosquilla nepa*), gastropods (*Turritella maculate*), and juveniles of shrimps and finfish (Kurup et al. 2004){Thomas and Kurup 2005}(Menon et al. 2006). Bottom trawling also affected the abundance and biomass of infauna, macrobenthos, and meiobenthos. Although some groups, such as bivalves, gastropods, or polychaetes, showed a general increase in abundance after trawling due to the survival of opportunistic species (Gowda 2003)(Kurup 2004), some species, such as *Cerithium* spp. or *Cavolina* spp., decreased after trawling (Kurup et al. 2004){Thomas and Kurup 2005}. In general, the diversity indices were reduced

after trawling (Zacharia 2003)(Kurup 2004)(Bharathamia et al. 2008).

A list of macroinvertebrates caught in the Indian shrimp trawl fisheries can be found in Gibinkumar et al. (2012) (see table 19 in the Justification). Although the status of all these species has not been evaluated, they are not considered highly vulnerable taxa. Therefore, based on the SFW criteria, this factor is scored a “moderate concern.”

Supplementary Information

Table 19

SHRIMPS	LOBSTERS	SHELLS	Family: Fasciolariidae	Order: VENEROIDA
Order: DECAPODA	Order: DECAPODA Family: Palinuridae	Order: ARCOIDA	*Fusinus nicobaricus* (Röding, 1798)	Family: Veneridae
Family: Penaeidae	*Palinurus homarus* (Linnaeus, 1758)	Family: Arcidae	Family: Melongenidae	*Dosinia cretacea* (Reeve, 1851)
Fenneropenaeus indicus (H. Milne Edwards, 1837)	*Palinurus ornatus* (Fabricius, 1798)	*Anadara (Cunearca) rhombea* (Born, 1780)	*Hemifusus pugilinus* (Born, 1778)	*Marcia opima* (Gmelin, 1791)
Metapenaeus affinis (H. Milne Edwards, 1837)	Family: Scyllaridae	*Anadara granosa* (Linnaeus, 1758)	*Pugilina cochlidium* (Linnaeus, 1758)	*Meretrix casta* (Chemnitz, 1782)
Metapenaeus dobsoni (Miers, 1878)	*Thenus orientalis* (Lund, 1793)	*Barbatia bistrigata* (Dunker, 1866)	Order: LITTORINIMORPHA	*Meretrix meretrix* (Linnaeus, 1758)
Metapenaeus monoceros (Fabricius, 1798)	CRABS	*Scapharca inaequivalvis* (Bruguiere, 1789)	Family: Bursidae	*Paphia malabarica* (Chemnitz, 1782)
Parapenaeopsis stylifera (H. Milne Edwards, 1837)	Order: DECAPODA	*Trisidos tortuosa* (Linnaeus, 1758)	*Bufonaria echinata* (Link, 1807)	*Paphia textile* (Gmelin, 1791)
Penaeus semisulcatus (De Hann, 1844)	Family: Lucosidae	Order: NEOGASTROPODA	Family: Ficidae	*Sunetta scripta* (Linnaeus, 1758)
Penaeus monodon (Fabricius, 1798)	*Philyra scabriuscula* (Fabricius, 1798)	Family: Babyloniidae	*Ficus ficus* (Linnaeus, 1758)	Family: Donacidae

Trachypenaeus curvirostris (Stimpson, 1860)	Family: Calappidae	*Babylonia spirata* (Linnaeus, 1758)	*Ficus gracilis* (G.B. Sowerby I, 1825)	*Donax scortum* (Linnaeus, 1758)
Family: Hippolytidae	*Calappa lophos* (Herbst, 1782)	*Babylonia zeylanica* (Bruguiere, 1789)	Family: Naticidae	Order: MYOIDA
Exhippolysmata ensirostris (Kemp, 1914)	Family: Portunidae	Family: Buccinidae	*Glossaulax didyma* (Röding, 1798)	Family: Pholadidae
Family: Sergestidae	*Charybdis feriatus* (Linnaeus, 1758)	*Cantharus spiralis* (Gray, 1839)	*Natica lineata* (Lamarck, 1838)	*Pholas orientalis* (Gmelin, 1791)
Acetes indicus (H. Milne Edwards, 1830)	*Charybdis lucifeara* (Fabricius, 1798)	Family: Turridae	*Natica vitellus* (Linnaeus, 1758)	Family: Cardiidae
Family: Alphidae	*Charybdis natator* (Herbst, 1789)	*Lophiotoma indica* (Röding, 1798)	Family: Cassidae	*Cardium flavum* (Linnaeus, 1758)
Alpheus malabaricus (Fabricius, 1775)	*Podophthalmus vigil* (Fabricius, 1798)	*Turricula javana* (Lamarck, 1816)	*Phalium canaliculatum* (Bruguiere, 1792)	Order: CAENOGASTROPODA
STOMATOPODS	*Portunus pelagicus* (Linnaeus, 1766)	*Turris amicta* (E.A. Smith, 1877)	*Semicassis bisulcata* (Schubert & Wagner, 1829)	Family: Turritellidae
Order: STOMATOPODA	*Portunus sanguinolentus* (Herbst, 1783)	Family: Harpidae	Family: Rostellariidae	*Turritella acutangula* (Linnaeus, 1758)
Family: Squillidae	*Scylla serrata* (Forskal, 1775)	*Harpa major* (Roding, 1798)	*Strombus plicatus sibbaldi* (Sowerby, 1842)	*Turritella attenuata* (Reeve, 1849)
Oratosquilla nepa (Latreille, 1828)	Family: Matutidae	Family: Clavatulidae	*Tibia curta* (G.B. Sowerby II, 1842)	Order: ARCHAEOGASTROPODA
Squilla spp.	*Ashtoret lunaris* (Forskål, 1775)	*Clavatula virgineus* (Dillwyn, 1817)	Family: Tonnidae	Family: Trochidae
CEPHALOPODS	*Matuta planipes* (Fabricius, 1798)	Family: Muricidae	*Tona dolium* (Linnaeus, 1758)	*Umbonium vestiarium* (Linnaeus, 1758)

Order: SEPIIDA	Family: Epialtidae	*Murex (Murex) carbonnieri* (Jousseaume, 1881)	ECHINODERMS	Order: DENTALIIDA
Family: Sepiidae	*Doclea ovis* (Fabricius, 1787)	*Rapana bulbosa* (Solander, 1817)	Order: PAXILLOSIDA and CLYPEASTEROIDA	Family: Dentaliidae
Sepia aculeata (Van Hasselt, 1835)	*Doclea rissoni* (Leach, 1815)	*Rapana rapiformis* (Born, 1778)	Family: Astropectinidae and Laganidae	*Dentalium octangulatum* (Donovan, 1804)
Sepia pharaonis (Ehrenberg, 1831)			*Astropecten* spp.	
Sepiella inermis (Van Hasselt, 1835)			*Laganum depressum* Lesson, 1841	

Note that squid trawls may operate more as off-bottom trawls than on-bottom trawls, so their catch composition may differ slightly from that of shrimp trawls. But squid trawls still operate near the seafloor and may operate on it, especially in mixed trawl fisheries.

2.2 Fishing Mortality

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

Moderate Concern

Using the unknown bycatch matrix from the SFW criteria, the impact of bottom tropical fish trawl fisheries on benthic invertebrates is scored as “2,” which would result in a score of “high concern” for fishing mortality. According to Dineshbabu, the fishery uses high-speed trawls in mid- and deep water, which decreases the impact on the bottom fauna, and pair trawling has also been banned since 2018 (A.P. Dineshbabu, pers. comm. 2019). These measures moderate the level of concern somewhat, resulting in a “moderate concern” rating.

Supplementary Information

Although shrimp trawls operate exclusively on the seafloor, squid trawls in India

tend to be positioned more as off-bottom or even midwater gear types. This alleviates some concerns about the capture of benthic species. Squid are targeted in multispecies fisheries (i.e., trawls targeting squid, finfish, and shrimp), but different trawl nets are meant to be used for different target species.

Corals and other biogenic habitats *(Unknown coral spp.)*

2.1 Abundance

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

High Concern

As a species group, corals are considered to have high inherent vulnerability, leading to a score of “high concern” for this factor.

Supplementary Information

Coral reefs are some of the most diverse and valuable ecosystems along the 8,000 km coastline of India. The major reef formations in India are restricted to the Gulf of Mannar, Palk Bay, the Gulf of Kutch, the Andaman and Nicobar Islands, and the Lakshadweep islands (Saroj et al. 2016). The west coast of India between Mumbai and Goa is also reported to have submerged banks with isolated coral formations {Nair and Qasim 1978}. A total of 199 species of coral have been found in Indian waters; the richer biodiversity is found in the coral reefs of the Andaman and Nicobar Islands, with 135 species identified, versus the 29 and 37 species found on the west coast of Kerala/Tamil Nadu and in the Gulf of Kutch, respectively. In India, coral reefs face a number of anthropogenic threats such as bleaching, destructive fishing, pollution, and climate change (Saroj et al. 2016). In general, the condition of the coral reefs in nearshore waters is poor and declining (Saroj et al. 2016). A recent survey of corals in several areas along the Indian coastline found that hard coral cover declined between 2019 and 2021 (CMFRI 2021).

Figure 8: Coral reefs in India (Saroj et al. 2016).

2.2 Fishing Mortality

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

Moderate Concern

Fishing mortality rates for coral species are unknown, so the UBM was used to score this factor. The UBM points to a “high concern” rating for bottom trawls. But trawls targeting squid tend to operate more as off-bottom and semi-pelagic gear types, allowing this rating to be modified to “moderate concern.”

Supplementary Information

No protection has been established for the coral reef patches on the west coast of India, where the majority of squid trawl fishing occurs (Saroj et al. 2016). Along the west coast of India, coral patches are normally avoided by bottom trawlers to protect their valuable nets {A.P. Dineshbabu, pers. comm. 2019}. Moreover, high-speed bottom trawling adopted by trawl fishers has enabled the trawlers to exploit coral patches while reducing the impact on the bottom {A.P. Dineshbabu et al. 2016}

{A.P. Dineshbabu, pers. comm. 2019}. Although the impact on the corals may have been reduced in recent times, the trawl fishery that is still working in these areas does present a significant risk to corals. A recent assessment of coral resilience in several Indian waters found that overfishing and destructive fishing were the primary threats to corals in these areas (CMFRI 2021). Directed squid trawls operate off-bottom, rather than fully on-bottom like shrimp trawls, though squid are still landed via both gear types. Therefore, corals are still included in this report, but the risk to them is thought to be less than in on-bottom shrimp trawls.

Finfish *(Unknown finfish spp.)*

2.1 Abundance

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

Moderate Concern

The Thai trawl fishery has been shown to catch both semi-pelagic species, such as squid, and bottom-dwelling fish species (Environmental Justice Foundation 2023). The Thai government performs stock assessments for the Gulf of Thailand and the Andaman Sea, but these assessments group species into three broad groups: pelagic species, demersal species, and anchovies (DOF 2020). WIthout a full list of relevant species, and without reference points or indicators of stock status, this factor receives a score of “moderate concern,” per the UBM.

Supplementary Information

The catch composition of the Thai trawl fishery was studied between 2003 and 2005 {Supongpan and Boonchuwong 2010}. Cephalopod species represented around 20% of the total catch, demersal fish 30%, trash fish 40%, and pelagic species 4% {Supongpan and Boonchuwong 2010}. The demersal species group comprised a mix of species, including *Nemipterus* (threadfin bream), *Priacanthus*, *Saurida*, *Scolopsis*, and Carrangidae. Orangefin ponyfish (*Photopectoralis bindus*), whipfin ponyfish (*Equulites leuciscus*), and splendid ponyfish (*Eubleekeria splendens*) were the only fish species that represented more than 5% of the catch. Slender lizardfish (*Saurida elongata*), brushtooth lizardfish (*S. undosquamis*), lattice monocle bream (*Scolopsis taeniopterus*), and dark-barred goatfish (*Upeneus luzonius*) represented more than 2% of the catch {Supongpan and Boonchuwong 2010}. While this study is not an exhaustive list of all species caught in Thai trawls,

it does provide a good sample of captured species. A few of these species have been evaluated by the IUCN Red List, exhibiting low to moderate vulnerability to fishing, though some of these evaluations are > 10 years old. There are no stock assessments, reference points, and/or no evidence to suggest that individual stocks are either above or below reference points.

The latest Thai Marine Fisheries Management Plan suggests that demersal fish as a species group in the Gulf of Thailand are overfished, but overfishing is not occurring (DOF 2020). The same management plan suggests that demersal fish in the Andaman Sea are being fished at MSY. But it is difficult to apply these results to each species included in this broad group, given fishes' differing life histories and vulnerabilities.

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

High Concern

Finfish captured in Indian trawls include species such as threadfin breams, mackerels, moontail bullseye, and croakers (Gibinkumar et al. 2012)(Dineshbabu 2013)(Abdual Azeez et al. 2021). While some of these species lack stock assessments, the status of others were recently assessed in various Indian states. The findings of this work suggest that some species, such as Atlantic cutlassfish, may be overfished in certain state waters (Sathianandan et al. 2021). Because some finfish may have a biomass under B_{MSY}, this factor is scored a "high concern."

Supplementary Information

Productivity-susceptibility analyses (PSAs) for species such as moontail bullseye and some threadfin bream species suggest that they have a moderate vulnerability to fishing (see the Kerala fishery answers for specific species' PSAs). But this moderate vulnerability is outweighed by the suggestion that other species are overfished ($B/B_{MSY} < 1$ and $F/F_{MSY} > 1$) in some Indian waters.

Western Central Pacific | Indonesia | Cast nets

Moderate Concern

Small finfish are typically captured as bycatch in cast nets targeting squid species. MMAF assesses the exploitation status of broad species categories, including small

pelagic fishes, in its individual fisheries management areas (WPPs), but no reference points or stock assessments exist for individual finfish species. Without these abundance indicators or assessments, finfish are scored a “moderate concern” for this factor, per the UBM.

Supplementary Information

A study of cast nets used in Indonesia exhibited that small pelagic finfish such as mackerels and scads were captured alongside squid, with small pelagic fishes typically increasing in catch percentage when squid catch percentages were lower (Ghofar 2002). Another study of a similar squid fishing method, locally known as bouke ami, described 17% of the catch as bycatch that comprised species such as anchovy, sardinella, and queenfish (Gumilang and Susilawati 2020). Bouke ami, like cast nets, is a method using lift nets, though the mechanics of a bouke ami net do differ from a typical cast net, because bouke ami are set to one side of a vessel {Gumilang and Susilwati 2020}.

In Indonesia, MMAF assesses broad species categories approximately every 5 years, producing its latest assessment in 2022. Small pelagic species were found to be moderately exploited (annual catch < 80% of potential yield limit) in four WPPs, fully exploited (annual catch = 90−100% of potential yield limit) in six WPPs, and overexploited (annual catch > potential yield limit) in one WPP (Napitupulu et al. 2022). The estimation of potential yield limits and annual catch numbers are based on fishery landings data, which are often of poor quality (ibid). These exploitation rates also speak more to fishing pressure levels than stock abundance estimates; thus, the stock abundance for typical finfish bycatch species is uncertain.

Western Central Pacific | Thailand | Cast nets

Moderate Concern

Several studies of cast net fisheries suggest that finfish—mostly pelagic, though some demersal as well—are captured in squid cast nets (Ghofar 2002)(Kaewnuratchadasorn et al. 2003)(Arkronrat et al. 2017). Non-squid species include mullet, scad, mackerel, and others. While “pelagic fish” and “demersal fish” as species groups have stock assessments in Thailand, the majority of individual finfish species do not. Without formal reference points or abundance analyses, finfish are scored a “moderate concern” for this factor, per the UBM.

Supplementary Information

A study in Indonesia found that cast nets there (jala oras) captured both squid and small pelagic species, such as scads and mackerels (Ghofar 2002). An earlier study in the Gulf of Thailand showed that cast nets caught both Indian squid and fish species such as Indian mackerel, sardinella species, scad species, and others (Supongpan et al. 1992). A preliminary study of Indian squid cast net catch composition in Pakklong, Thailand found that pelagic fish and, to a lesser extent, demersal fish were also caught alongside squid (Kaewnuratchadasorn et al. 2003). Finally, a more recent study of Thai cast nets fishing for *Loligo* species found that these gear types also captured other cephalopods, a number of marketable finfish, and some nonmarketable finfish (Arkronrat et al. 2017). While these studies describe examples of finfish that are caught alongside squid, they are not considered a comprehensive list, so the catch-all “finfish” species group was used to include these bycatch species.

The latest Thai Marine Fisheries Management Plan suggests that pelagic fish as a species group in the Gulf of Thailand and the Andaman Sea are being fished at MSY (DOF 2020). The same management plan suggests that demersal fish in the Andaman Sea are being fished at MSY but are overfished (with no overfishing occurring) in the Gulf of Thailand. But it is difficult to apply these results to each species included in this broad group, given fishes’ differing life histories and vulnerabilities.

A 2017 assessment did compare some species’ catch to their MSY, concluding that fishing effort in the Andaman Sea and the Gulf of Thailand was either “around," “under,” or “over” F_{MSY} (Nootmorn 2021). But this assessment speaks more to fishing pressure levels than to quantitative estimates of population abundance.

2.2 Fishing Mortality

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

Moderate Concern

The latest Thai Marine Fisheries Management Plan notes that demersal fish in the Gulf of Thailand and the Andaman Sea are being fished at 76.7% of F_{MSY} and 74.7% of F_{MSY}, respectively (DOF 2020). Here, MSY is calculated based on total fishing hours, which does not account for the exact fishing pressure based on factors such as fishing capacity and engine power in trawl vessels (Environmental Justice Foundation 2023). Because the way in which MSY is calculated introduces

some uncertainty, fishing mortality is considered unknown for this taxonomic group, resulting in a “moderate concern” rating.

Supplementary Information

While some studies on trawl catch composition in Thailand exist, these are not considered comprehensive lists of all landed species. The number of species landed in bottom trawlers in India and Thailand often exceeds 100 (Dineshbabu 2013)(Sathianandan et al. 2021). Squid trawlers are most likely capturing primarily demersal finfish, because nets operate on the seafloor or fairly close to the seafloor, but the semi-pelagic nature of some squid trawl nets suggests that some pelagic finfish may be captured as well. Because not all individual finfish species landed by Thai trawlers are known, and the calculation of F_{MSY} by the Thai government does not address vessel capacities or fishing pressure relative to population levels, the use of the UBM is appropriate for scoring this factor.

The Thai government introduced a goal of reducing fishing effort on demersal species by 40% in the Gulf of Thailand and 10% in the Andaman Sea, following findings in the previous Marine Fisheries Management Plan that fishing effort on demersal species in both areas exceeded F_{MSY} (DOF 2015). While effort as a percentage of F_{MSY} has decreased from 2015 to 2019, the total catch in the Gulf of Thailand, in tons, has increased during the same period, despite a reduction in MSY in tons. In the Andaman Sea, catch in tons has slightly decreased, but to a lesser extent than MSY in tons. These numbers suggest that, while fewer fishing hours are taking place, this does not translate to a reduction in weight of fish caught; thus, fishing hours may not be a reliable estimate of fishing mortality/effort.

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

High Concern

Fishing mortality is largely unknown for finfish species in Indian waters. But one recent assessment suggests that some species, such as Indian mackerel, are overfished in certain states. Because some species likely have fishing mortality rates that exceed the estimated F_{MSY}, this factor is rated a “high concern.”

Supplementary Information

Indian mackerel is thought to be overfished ($B/B_{MSY} < 1$ and $F/F_{MSY} > 1$) in Maharashtra, Odisha, and Karnataka (Sathianandan et al. 2021). Similarly,

lizardfishes are thought to be overfished in Gujarat, Andhra Pradesh, and Maharashtra, and ribbonfish are overfished in Gujarat and Puducherry (Sathianandan et al. 2021). But this same assessment did find that some finfish species seem to have healthy statuses in relevant Indian states. For example, croakers were found to have $F < F_{MSY}$ in all assessed states. While some finfish caught in trawls may be fished at appropriate levels, others may be overfished, which requires more precaution in scoring this factor. Though these results differ in a more recent (2022) series of stock assessments, the methodology for these assessments is unknown, so the 2021 assessment is used, due to increased confidence in its results.

Western Central Pacific | Indonesia | Cast nets

Moderate Concern

The latest Indonesian stock assessment research notes that, as of 2021, small pelagic fish are being exploited, as a group, to varying degrees across WPPs, as detailed in factor 2.1 for this fishery (Napitupulu et al. 2022). In one WPP, this species group is considered overexploited, but in most WPPs, exploitation rates are near estimated potential limits. There is some uncertainty in this assessment, because the data for it come from somewhat unreliable fishery catch information, rather than an estimate of abundance and/or an official observer program. Cast nets are a small-scale fishing method that is not included in the UBM, and fishing mortality for this taxonomic group is considered unknown due to the uncertainty in the MMAF assessments, resulting in a “moderate concern” rating.

Western Central Pacific | Thailand | Cast nets

Moderate Concern

The latest Thai Marine Fisheries Management Plan notes that pelagic fish in the Gulf of Thailand and the Andaman Sea are being fished at 84.9% of F_{MSY} and 66.0% of F_{MSY}, respectively (2020–22 management plan). Here, MSY is calculated based on total fishing hours, which does not account for the exact fishing pressure based on factors such as fishing capacity and engine power in trawl vessels (EJF report). Because the way in which MSY is calculated introduces some uncertainty, but cast nets are a small-scale fishing method that is not included in the UBM, fishing mortality for this taxonomic group is considered unknown, resulting in a “moderate concern” rating.

Supplementary Information

Cast nets are typically used at smaller scales in Thailand and Indonesia. Cast nets are a falling net gear that uses attracting lights to bring squid to the surface, after which nets are dropped onto the squid (Arkronrat et al. 2017). No similar fishing methods appear in the UBM, so, given the small-scale nature of this fishery, the UBM is not appropriate for scoring this group.

Two studies on cast net fishing in Thailand suggest that pelagic species such as mackerel and scad are captured alongside squid (Supongpan et al. 1992)(Kaewnuratchadasorn et al. 2003)(Arkronrat et al. 2017). While these studies describe examples of finfish that are caught alongside squid, they are not considered a comprehensive list, so the catch-all “finfish” species group was used to include these bycatch species.

A 2017 assessment did compare some species’ catch to their MSY, concluding that fishing effort in the Andaman Sea and the Gulf of Thailand was either “around," “under,” or “over” F_{MSY} (Nootmorn paper). This research found that Indian mackerel in the Andaman Sea was being fished over F_{MSY}, while short mackerel in the same area was being fished under F_{MSY}. Similar to the latest management plan, F_{MSY} and fishing effort here are determined by hours spent fishing, rather than total fishing pressure via catch relative to abundance. Given the uncertainty this method introduces, the differing results for individual finfish produced by this assessment, and the lack of fishing mortality assessments for all bycatch finfish species, fishing mortality for this group is considered unknown.

Fourlined tonguesole *(Cynoglossus bilineatus)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

There are no current or recent estimates of stock abundance for fourlined tonguesole in Kerala, so a PSA was performed. The PSA indicated a score of 2.97, leading to a “moderate concern” rating for this factor.

Supplementary Information

Table 20

Productivity Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Average age at maturity	≈2 years, based on similar species (Katayama & Yamamoto 2012)	1
Von Bertalanffy growth coefficient (K)	0.84–1.08 (females); 0.89–1.06 (males) (Zahid & Simanjuntak 2009)	1
Fecundity	2,323 to 225,557 eggs (Zahid & Simanjuntak 2009)	1
Average maximum size	44 cm (Froese and Pauly 2023a)	1
Average size at maturity	30 cm (Froese and Pauly 2023a)	1
Reproductive strategy	Broadcast spawner	1
Productivity Score		**1**

Table 21

Susceptibility Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Areal overlap	Unknown—default score	3
Vertical overlap	Unknown—default score	3
Seasonal availability	Unknown—default score	3
Selectivity of fishery	Species is incidentally caught but does not have increased susceptibility to fishing gear	2
Post-capture mortality	Unknown—default score	3
Susceptibility Score		**2.8**
Overall PSA Score		**2.97**

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

Fishing mortality for fourlined tonguesole, like population abundance, is unknown, so this factor is scored a “moderate concern.”

Supplementary Information

A 2021 stock status assessment found that soles as a species group in Kerala had a sustainable stock status ($F/F_{MSY} < 1$ and $B/B_{MSY} > 1$) (Sathianandan et al. 2021). But because multiple species of soles are found in Kerala waters, this status cannot be used as an indicator for one specific sole species.

Giant guitarfish *(Rhynchobatus djiddensis)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

High Concern

Giant guitarfish is considered “Critically Endangered" by the IUCN, so this factor is scored a “high concern.”

Supplementary Information

This species was last assessed by the IUCN Red List in 2018 and was found to be “Critically Endangered” with a decreasing population trend (Kyne et al. 2019). Globally, the giant guitarfish population is situated in the Indo-West Pacific, where its population is thought to have been reduced by over 80% in the past five decades (ibid). In India, giant guitarfish is listed on Schedule 1 of the Wildlife Protection Act, which covers endangered species and provides protections for them (Parliament of India 1972).

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

Fishing mortality for giant guitarfish in Kerala is unknown, so this factor receives a “moderate concern” rating.

Supplementary Information

Targeted fishing and incidental catch of giant guitarfish have been leading causes of population decline, because the species is used for fin consumption. Specific landings and discards for most Indian states are not available. But a 2024 report

details guitarfish landings in Kerala, noting that landings are highest in multiday trawlers (69% of landings from 2007 to 2022), such as those used in the squid fishery (CMFRI 2024). While landings have decreased in recent years (13 t each in 2021 and 2022), a sustainable level of guitarfish catch is not known, so there is no threshold to compare these landings to. Of all guitarfish recorded in landings in Kerala, the largest percentage (36%) were identified as giant guitarfish (ibid).

Greater lizard fish *(Saurida tumbil)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including greater lizardfish in the southwest (CMFRI 2023). Through this assessment, CMFRI denotes this stock as not overfished. But the assessment methodology is unknown, and there is uncertainty in the input data, so further conclusions about abundance and fishing mortality cannot be made based on the assessment's quantitative results. Greater lizardfish is also listed as "Least Concern" by the IUCN (Russell and Smith-Vaniz 2016). Because the Indian management body considers this stock not to be overfished and the IUCN lists the stock as "Least Concern," abundance is scored a "moderate concern."

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

Fishing mortality for greater lizardfish, like population abundance, is unknown, so this factor is scored a "moderate concern."

Supplementary Information

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including greater lizardfish in the southwest. But the assessment methodology is unknown, and there is uncertainty in the input data, so conclusions about fishing mortality cannot be made with confidence based

on the assessment's quantitative results.

A 2021 stock status assessment found that lizardfishes as a species group in other southwest Indian coast waters (Goa and Karnataka, both north of Kerala) had a sustainable stock status ($F/F_{MSY} < 1$ and $B/B_{MSY} > 1$) (Sathianandan et al. 2021).

The report also found that lizardfishes in northwest Indian coast waters (Gujarat and Maharashtra) had an overfished stock status ($F/F_{MSY} > 1$ and $B/B_{MSY} < 1$).

Because multiple species of lizardfishes are found in Indian waters and no assessment for Kerala lizardfishes was performed as part of this work, these stock status cannot be used as an indicator for Kerala greater lizardfish.

Another assessment from 2015 found that the exploitation level of greater lizardfish in Kerala was above the optimum exploitation level, indicating that the stock was overexploited (Najmudeen et al. 2015). But this study used data from 2007 to 2011, making its results too outdated to speak to current fishing levels.

Hammerhead sharks *(Sphyrna spp.)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

High Concern

Three species of hammerhead sharks are present in Kerala waters, though it is not known which specific hammerhead species interact with the multispecies trawl fishery. The status of the three species ranges from "Vulnerable" to "Critically Endangered," so this factor is rated a "high concern."

Supplementary Information

Smooth, scalloped, and great hammerhead sharks are present in Kerala. According to the IUCN Red List, smooth hammerhead has a "Vulnerable" status, while scalloped and great hammerheads are both "Critically Endangered" (Rigby et al. 2019a)(Rigby et al. 2019b)(Rigby et al. 2019c). All three species were last assessed by the IUCN in 2018.

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

High Concern

Fishing mortality for hammerhead sharks is unknown, and the specific species of hammerheads that interact with the Kerala fishery are also unknown. Therefore, the UBM was used, resulting in a score of “high concern.”

Supplementary Information

Hammerhead shark species are threatened by both targeted and incidental catch in various fishing gears. While gears such as longlines, purse seines, and gillnets tend to catch more hammerheads, they are sometimes captured in trawls as well. Fishing interactions have not been quantified for Kerala’s multispecies trawl fishery and hammerhead sharks. The UBM points to a “high concern” score for sharks in trawls in this area.

Indian mackerel *(Rastrelliger kanagurta)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

Low Concern

A recent data-limited stock assessment using trawl catch data from 1997 to 2016 looked at a number of different species and species groups captured on India’s southwestern coast. This assessment found that Indian mackerel off the coast of Kerala is in a “sustainable” stock state. This was concluded based on MSY reference points created during the assessment process, which found that $B/B_{MSY} > 1$ (Sathianandan et al. 2021). Because biomass is above the estimated reference point and a data-limited approach was used, this factor is scored a “low concern.”

Supplementary Information

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including Indian mackerel in the southwest (CMFRI 2023). Through this assessment, CMFRI denotes this stock as not overfished. But the assessment methodology is unknown, and there is uncertainty in the input data, so further conclusions about abundance and fishing mortality cannot be made based on the assessment’s quantitative results. Therefore, the 2021 assessment referred to in the preceding explanation was used in place of the 2022 assessment, because there is less uncertainty involved in the 2021 assessment.

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

The data-limited assessment completed in 2021 found that $F/F_{MSY} < 1$, indicating that fishing mortality is taking place at a sustainable level (Sathianandan et al. 2021). But some uncertainty is involved in this conclusion, because only fishery landings/effort data are used (versus an observer program) and no exact estimates of F are provided. Because F is likely below the calculated reference point, but the results of the assessment are somewhat uncertain, this factor receives a score of "moderate concern."

Supplementary Information

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including Indian mackerel in the southwest. But the assessment methodology is unknown, and there is uncertainty in the input data, so conclusions about fishing mortality cannot be made with confidence based on the assessment's quantitative results.

Researchers concluded in the 2021 assessment that the stock is in a sustainable state because i) biomass is above the target reference point of B_{MSY}, and ii) fishing mortality is at a level that will allow the stock to maintain an appropriate size. Therefore, F is considered sustainable in the assessment. A Kobe chart in the assessment indicates that F/F_{MSY} is about 0.5 (Sathianandan et al. 2021). While we can be confident that overfishing is not taking place, there is some uncertainty if total F from all sources is truly sustainable, primarily because only landings data were used to reach this conclusion.

Indian Ocean humpback dolphin *(Sousa plumbea)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

High Concern

The Indian Ocean humpback dolphin is listed as “Endangered” on the IUCN Red List, so this factor is scored a “high concern.”

Supplementary Information

This species was last assessed in 2015 and was found to be “Endangered” with a decreasing population trend (Braulik et al. 2017). Fisheries mortality and habitat degradation are thought to be responsible for this decline.

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

Fishing mortality for the Indian Ocean humpback dolphin is unknown, so this factor is rated a “moderate concern.”

Supplementary Information

Fishing mortality in small-scale, coastal fisheries, especially those using gillnets, is the primary threat to this species (Braulik et al. 2017). But, it has also been identified as an ETP species that interacts with the Kerala multispecies trawl fishery (Appukuttan 2022).

Indian scad *(Decapterus russelli)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including Indian scad in the southwest (CMFRI 2023). Through this assessment, CMFRI denotes this stock as not overfished. But the assessment methodology is unknown, and there is uncertainty in the input data, so further conclusions about abundance and fishing mortality cannot be made based on the assessment’s quantitative results. Because the management body considers this stock not to be overfished, abundance is scored a “moderate concern.”

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

Fishing mortality for Indian scad, like population abundance, is unknown, so this factor is scored a “moderate concern.”

Supplementary Information

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including Indian scad in the southwest. But the assessment methodology is unknown, and there is uncertainty in the input data, so conclusions about fishing mortality cannot be made with confidence based on the assessment’s quantitative results.

A 2021 stock status assessment found that scads as a species group in Kerala had an overfished stock status ($F/F_{MSY} > 1$ and $B/B_{MSY} < 1$) (Sathianandan et al. 2021). But because multiple species of scads are found in Kerala waters, this status cannot be used as an indicator for one specific scad species.

Indo-Pacific bottlenose dolphin *(Tursiops aduncus)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

High Concern

The IUCN Red List designates the Indo-Pacific bottlenose dolphin as “Near Threatened,” so this factor receives a “high concern” rating.

Supplementary Information

The IUCN last assessed this species in 2019. While the Indian portion of the bottlenose dolphin’s range has not been surveyed, surveys of other portions of the global range have led to its categorization as “Near Threatened” with an unknown population trend (Braulik et al. 2019).

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

The majority of marine mammal interactions in Indian fisheries are not quantified. Indo-Pacific bottlenose dolphin fishing mortality is unknown, so this factor receives a "moderate concern" rating.

Supplementary Information

This species is one of several ETP species that are determined to have interactions with Kerala's multispecies trawl fishery (Appukuttan 2022). It is thought, based on conversations with relevant stakeholders and fishers, that interactions with bottlenose dolphin are minimal; however, data quantifying these interactions or interactions with other fisheries are lacking.

Japanese threadfin bream *(Nemipterus japonicus)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

Low Concern

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including Japanese threadfin bream in the southwest (CMFRI 2023). Through this assessment, CMFRI denotes this stock as not overfished. A further report from CMFRI estimates that biomass is below the MSY level but above 75% of that level (B/B_{MSY} = 0.919) (CMFRI 2024). Based on a data-limited stock assessment indicating that biomass is between 75% and 100% of MSY, abundance is considered a "low concern."

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

High Concern

The most recent CMFRI report assessing Japanese threadfin bream on India's southwest coast estimated fishing mortality to be just above the MSY level (F/F_{MSY}

= 1.02) (CMFRI 2024). Because a data-limited assessment suggests that fishing mortality is slightly above a sustainable level, a score of “high concern” is assigned.

Kadal shrimp *(Metapenaeus dobsoni)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

Low Concern

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including kadal shrimp (denoted as brown shrimp in the 2022 assessments) on the southwest coast of India. Through these assessments, CMFRI has designated the southwest kadal shrimp stock as not overfished (CMFRI 2023). CMFRI produced a further report that estimated that this kadal shrimp stock has a biomass just above the MSY level (B/B_{MSY} = 1.01) (CMFRI 2024). Because this point estimate is so close to 1, the confidence interval surrounding it is considered for scoring (CI = 0.755–1.3). The majority of this CI is above 1, and the full CI is above 0.75, suggesting that the results of this data-limited stock assessment allow a score of “low concern.”

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

High Concern

The recent CMFRI report determined that fishing mortality for kadal shrimp along the southwest Indian coast is above the MSY level (F/F_{MSY} = 1.11) (CMFRI 2024). Based on a data-limited assessment < 10 years old indicating that fishing mortality is above a sustainable level, fishing mortality is considered a “high concern.”

Kiddi shrimp *(Parapenaeopsis stylifera)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

Low Concern

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including kiddi shrimp (denoted as coromandel shrimp in the 2022 assessments) on the southwest coast of India. Through these assessments, CMFRI has designated the southwest kiddi shrimp stock as not overfished (CMFRI 2023). A further report from CMFRI estimated that kiddi shrimp biomass is above the MSY level (B/B_{MSY} = 1.14) (CMFRI 2024). Based on the results of this data-limited stock assessment, abundance is considered a "low concern."

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

CMFRI's recent assessment of stocks on the southwest coast of India estimated that fishing mortality for kiddi shrimp is below the MSY level (F/F_{MSY} = 0.952) {CMFRO 2024}. Because this point estimate is close to 1, the confidence interval surrounding it is also considered for scoring purposes (CI = 0.564–1.54). The confidence interval is evenly split both above and below 1, introducing some uncertainty into the point estimate, so a score of "moderate concern" is assigned.

Largetooth sawfish *(Pristis microdon)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

High Concern

The largetooth sawfish is listed as "Critically Endangered" on the IUCN Red List, so this factor is scored a "high concern."

Supplementary Information

Largetooth sawfish was last assessed in 2022 by the IUCN. While it is possibly extinct from some portions of its former range in the Indo-Pacific, the species remains extant in Indian waters (Espinoza et al. 2022). In addition to its endangered status, the population has a declining trend.

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

Fishing mortality for largetooth sawfish in Kerala is unknown, so this factor receives a “moderate concern” rating.

Supplementary Information

The majority of reported landings of largetooth sawfish in India have come from Maharashtra, which sits north of Kerala (Espinoza et al. 2022). Although the last landing of the species in Maharashtra was reported in 2017, largetooth sawfish has been identified as an ETP species that interacts with Kerala’s multispecies trawl fishery (Appukuttan 2022)(Espinoza et al. 2022). But these interactions have not been quantified.

Marine mammals *(Mammalia)*

2.1 Abundance

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

High Concern

According to the IUCN Red List, there are 27 marine mammal species present in Thai waters. Of these, 14.8% are “Vulnerable,” 7.4% are “Endangered,” and 7.4% are “Near Threatened” (IUCN 2023). Because marine mammals are considered to have high inherent vulnerability, and a number of marine mammals in Thai waters are endangered or vulnerable, this factor receives a score of “high concern.”

Supplementary Information

Marine mammals present in Thai waters include a number of dolphins and whales, as well as one species of porpoise (IUCN 2023). The majority of these species are listed as “Least Concern,” but the blue whale and Irrawaddy dolphin are “Endangered.”

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

High Concern

According to the IUCN Red List, there are 29 species of marine mammals in Indian waters. Of these, 13.8% are “Vulnerable,” 13.8% are “Endangered,” and 6.9% are “Near Threatened” (IUCN 2023). Because marine mammals are considered to have high inherent vulnerability, and a number of marine mammals in Indian waters are endangered or vulnerable, this factor receives a score of “high concern.”

Supplementary Information

Marine mammals present in Indian waters include a number of dolphins and whales, as well as one porpoise species and the dugong (IUCN 2023). The majority of these species are listed as “Least Concern” globally, but some, such as the blue whale and Irrawaddy dolphin, are “Endangered.”

2.2 Fishing Mortality

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

High Concern

Both bottom and midwater trawls risk entangling marine mammals while fishing for target species. While marine mammals that are incidentally caught cannot be landed and must immediately be released, the impact of these incidental capture and release instances is unknown (Ministry of Agriculture and Cooperatives 2016). The UBM points to a score of “high concern” for marine mammals caught in trawl nets in the East Indian Ocean.

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

High Concern

Both bottom and midwater trawls risk entangling marine mammals while fishing for target species. The UBM points to a rating of “high concern” for marine mammals caught in trawl nets in the Indian Ocean.

Supplementary Information

Fishing for squid in India occurs both in the East Indian Ocean (on India’s east coast) and the West Indian Ocean (on India’s west coast), though the majority of squid trawling takes place on the west coast. According to the UBM, bottom trawls

in the East Indian Ocean score 1 for marine mammals, and midwater trawls in the area score 2, both of which point to a “high concern” rating. Bottom trawls in the West Indian Ocean score 3 for marine mammals (pointing to a “moderate concern” rating), while midwater trawls score 2. Because three of the four relevant UBM scores point to a “high concern” rating, this has been chosen as the final score for this factor.

Mauvelip threadfin bream *(Nemipterus mesoprion)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

There are no current or recent stock abundance estimates for mauvelip threadfin bream in Kerala, so a PSA was performed. The PSA indicated a score of 3.03, so this factor receives a “moderate concern” rating.

Supplementary Information

A recent data-limited assessment using catch data to assess the stock status of several species and species groups found that threadfin breams were overfished ($F/F_{MSY} > 1$ and $B/B_{MSY} < 1$) in the west coast states of Gujarat and Karnataka, indicating that stock abundance is lower than the sustainable level in these states (Sathianandan et al. 2021). Gujarat sits on the northwestern coast of India, while Kerala and Karnataka are in the southwest. It is not known if threadfin bream species have separate stocks across Indian states, so this assessment’s conclusions cannot be extended to Kerala. Therefore, a PSA was performed.

Table 22

Productivity Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Average age at maturity	≈1 year, based on similar species such as Japanese threadfin bream (Acharya 1990)	1
Von Bertalanffy growth coefficient (K)	0.8 (Froese and Pauly 2023e)	1
Fecundity	1,213 (Froese and Pauly 2023e)	2

Average maximum size	14 cm (Froese and Pauly 2023e)	1
Average size at maturity	10.3 cm (Froese and Pauly 2023e)	1
Reproductive strategy	Broadcast spawner	1
Total Productivity Score		**1.17**

Table 23

Susceptibility Attribute	**Relevant Information**	**Score (1 = low, 2 = medium, 3 = high)**
Areal overlap	Unknown—default score	3
Vertical overlap	Unknown—default score	3
Seasonal availability	Unknown—default score	3
Selectivity of fishery	Species is incidentally caught but does not have increased susceptibility to fishing gear	2
Post-capture mortality	Unknown—default score	3
Total Susceptibility Score		**2.8**
Overall PSA Score		**3.03**

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

Fishing mortality, like stock abundance, is unknown for all threadfin bream species off the coast of Kerala. Because F is unknown, this factor is scored a “moderate concern.”

Supplementary Information

A 2021 data-limited assessment using catch data to assess the stock status of several species and species groups found that threadfin breams were overfished ($F/F_{MSY} > 1$ and $B/B_{MSY} < 1$) in the west coast states of Gujarat and Karnataka (Sathianandan et al. 2021). Gujarat sits on the northwestern coast of India, while Kerala and Karnataka are in the southwest. It is not known if threadfin bream

species have separate stocks across Indian states, so this assessment's conclusions cannot be extended to Kerala.

Moontail bullseye *(Priacanthus hamrur)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

There are no current or recent estimates of stock abundance for moontail bullseye in Kerala, so a PSA was performed. The PSA indicated a score of 3.03, so this factor receives a "moderate concern" rating.

Supplementary Information

Table 24

Productivity Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Average age at maturity	< 5 years (Seetha et al. 2018)	1
Von Bertalanffy growth coefficient (K)	0.58 (Seetha et al. 2018)	1
Fecundity	13,133 eggs (Froese and Pauly 2023f)	2
Average maximum size	45 cm (Froese and Pauly 2023f)	1
Average size at maturity	22 cm (Froese and Pauly 2023d)	1
Reproductive strategy	Broadcast spawner	1
Total Productivity Score		**1.17**

Table 25

Susceptibility Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Areal overlap	Unknown—default score	3
Vertical overlap	Unknown—default score	3
Seasonal availability	Unknown—default score	3
Selectivity of fishery	Species is incidentally caught but does not have increased susceptibility to fishing gear	2

Post-capture mortality	Unknown—default score	3
Total Susceptibility Score		**2.8**
Overall PSA Score		**3.03**

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

High Concern

A 2018 study used catch data from 2007 to 2015 to assess the status and exploitation rate of moontail bullseye off Kerala's coast. This study found that the current exploitation rate was greater than the optimum exploitation rate, suggesting that fishing mortality is too high (Seetha et al. 2018). Because the stock is being exploited above optimum levels, this factor is rated a "high concern."

Supplementary Information

The 2018 study created estimates for total mortality, natural mortality, optimum exploitation rate, and current exploitation rate. The authors concluded that the current exploitation rate was 0.69, which is greater than the optimum exploitation rate of 0.5 (Seetha et al. 2018). The authors also noted that exploitation of moontail bullseye off Kerala's coast has increased in recent years and suggested that more caution be taken to avoid overexploitation of the stock.

Neglected ocellate octopus *(Amphioctopus neglectus)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

Low Concern

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including neglected ocellate octopus in the southwest. Through these assessments, CMFRI has designated the southwest neglected ocellate octopus stock as not overfished (CMFRI 2023). A further report from CMFRI estimated that biomass is well above the MSY level (B/B_{MSY} = 1.43) (CMFRI 2024). Based on a data-limited stock assessment < 10 years old indicating that biomass is above a sustainable target, abundance is considered a "low

concern."

Supplementary Information

In addition, a 2021 assessment produced stock status estimates (recovering, sustainable, or overfished) for cephalopods in Kerala and other states; however, squids, octopi, and cuttlefish all contributed to this assessment, making it too broad to speak specifically to the neglected ocellate octopus (Sathianandan et al. 2021).

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Low Concern

The recent data-limited assessment from CMFRI estimated that fishing mortality was below the MSY level ($F/F_{MSY} = 0.836$) (CMFRI 2024). Because a data-limited stock assessment < 10 years old indicates that fishing mortality is below a sustainable level, a score of "low concern" is assigned.

Olive Ridley turtle *(Lepidochelys olivacea)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

High Concern

According to SFW standards, sea turtles are considered to have high inherent vulnerability. Based on their vulnerability status, abundance is scored a "high concern."

Supplementary Information

Although more abundant than other sea turtle species, olive ridley sea turtle is listed as "Vulnerable" on the IUCN Red List. Olive ridley populations have significantly declined over the past several decades, largely due to anthropological threats (Caceres-Farias et al. 2022). Last assessed by the IUCN in 2008, the species is considered to be "Vulnerable" with a decreasing population trend (Abreu-Grobois and Plotkin 2008). But this assessment is > 10 years old, so it cannot be used to score this factor. Further, olive ridley sea turtle is listed on Schedule 1 of India's

Wildlife Protection Act, which provides federal protection due to the species' sensitive status (Parliament of India 1972).

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

Fishing mortality for olive ridley turtle in Kerala is unknown, so this factor receives a "moderate concern" rating.

Supplementary Information

Historically, the majority of fishing-related olive ridley turtle deaths in India have come from the Odisha coast, where olive ridleys have a recurring mass nesting event (Caceres-Farias et al. 2022). Odisha lies on India's east coast, far from Kerala on the west side of the country. Interactions with general ETP species in Kerala trawl fisheries are thought to be rare, though this conclusion is based on fisher-reported landings data rather than landings and discard data or an official observer program (Appukuttan 2022). Given the uncertainty in reported landings data, fishing mortality is considered unknown, and it is not clear that Kerala trawls are not significant contributors to olive ridley mortality in India. While cultural beliefs in Kerala often lead fishers to attempt to release turtles alive, these efforts are voluntary and are only successful if captured turtles are alive and unharmed after they are discovered by fishers. Fishers are also required by law, via the Wildlife Protection Act, to not harm olive ridley turtle, but considering that it is still recorded in fishery interactions, the efficacy of this regulation is uncertain (Parliament of India 1972).

Pharaoh cuttlefish *(Sepia)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

Low Concern

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including pharaoh cuttlefish in the southwest. Through these assessments, CMFRI has designated the southwest pharaoh

cuttlefish stock as not overfished (CMFRI 2023). A further report from CMFRI estimates that biomass of this stock is above the MSY level (B/B_{MSY} = 1.16) (CMFRI 2024). Based on a data-limited stock assessment < 10 years old indicating that biomass is above a sustainable target, abundance is considered a “low concern.”

Supplementary Information

In addition, a 2021 assessment produced stock status estimates (recovering, sustainable, or overfished) for cephalopods in Kerala and other states; however, squids, octopi, and cuttlefish all contributed to this assessment, making it too broad to speak specifically to pharaoh cuttlefish (Sathianandan et al. 2021).

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Low Concern

The recent CMFRI report estimated that fishing mortality for pharaoh cuttlefish in Kerala is below the MSY level (F/F_{MSY} = 0.84) (CMFRI 2024). Based on these results from a data-limited stock assessment <10 years old, fishign mortality is considered a “low concern.”

Randall's threadfin bream *(Nemipterus randalli)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

Low Concern

Regional-based stock assessments using trawl catch data were performed in 2022 for a number of single-species stocks, including Randall’s threadfin bream in the southwest (CMFRI 2023). Through this assessment, CMFRI denotes this stock as not overfished. A further report from CMFRI estimated that biomass was just below the MSY level (B/B_{MSY} = 0.935) (CMFRI 2024). Based on a data-limited stock assessment indicating that biomass is between 75% and 100% of a sustainable level, abundance is considered a “low concern.”

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

High Concern

The recent CMFRI report estimated that fishing mortality for Randall's threadfin bream on India's southwest coast is just above a sustainable level (F/F_{MSY} = 1.03). Based on the results of a data-limited stock assessment, a score of "high concern" is assigned.

Rays and skates (unspecified) *(Rajidae spp.)*

2.1 Abundance

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

High Concern

As a species group, rays and skates are considered to have high inherent vulnerability, leading to a score of "high concern" for this factor.

Supplementary Information

The latest shark and rays survey work in Thailand notes 92 species of rays in Thai waters (for sharks, see factor 2.1 for sharks for this gear type). According to the IUCN Red List, 34.8% of rays in Thai waters are "Vulnerable," 39.4% are "Endangered," and 13.6% are "Critically Endangered."

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

High Concern

As a species group, skates and rays are considered to have high inherent vulnerability, leading to a score of "high concern" for this factor.

Supplementary Information

According to the IUCN Red List, 24.7% of ray species in Indian waters are "Vulnerable," 30.1% are "Endangered," and 23.3% are "Critically Endangered"

(IUCN 2023). A recent assessment of species and species groups in individual Indian coastal states suggests that rays as a group have a range of stock statuses across states, including sustainable status, recovering status, and overfished status (Sathianandan et al. 2021). Given the multiple overfished and recovering statuses, alongside the IUCN Red List trends, the automatic high score for ray species is appropriate for this factor.

2.2 Fishing Mortality

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

High Concern

Both shark and ray fishing mortality are unknown in Thailand, so the UBM was used to score this factor. The UBM points to a “high concern” rating for trawls.

Supplementary Information

From 2000 to 2009, Thailand reported an average of 20,749 MT of shark catches per year to FAO. The reported catches declined considerably from 14,409 MT in 2003 to 1,424 MT in 2011 (DOF 2021). According to Krajangdara, trawls represented more than 80% of both shark and ray landings (Krajangdara 2014). Survival in these fisheries is affected by several factors, including the duration of the trawl, the size of the catch, and the amount of time used to sort the catch {Cosandey-Godin and Morgan undated}.

The DOF established the first NPOA-Sharks of Thailand in 2005 (Krajangdara 2014). According to the latest (2020–24) NPOA for sharks, these species accounted for 0.72% of total catches in Thailand from 2002 to 2014 (though this does not include discards) (DOF 2021). But presently, the only shark management measure in Thailand relates to whale shark (*Rhincodon typus*), whose capture in fisheries is prohibited (ibid). The most landed species of sharks and rays in Thai ports are spottail shark (*Carcharhinus sorrah*), which is “Near Threatened” (Pillans et al. 2009); grey carpetshark (*Chiloscyllium punctatum*), “Near Threatened” (Dudgeon et al. 2016); grey bamboo shark (*C. griseum*), “Near Threatened” {Lisney and Cavanagh 2003}; Kuhl’s maskray (*Neotrygon kuhlii*); sharpnose stingray (*Telatrygon zugei*), “Near Threatened” (White 2016); scaly whipray (*Brevitrygon imbricata*); *Himantura walga*; and *H. gerrardi* (Krajangdara 2014).

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

High Concern

Fishing mortality for individual ray species is unknown in India, so the UBM was used to score this factor. The UBM points to a “high concern” rating for trawls.

Supplementary Information

According to CMFRI figures, landings of elasmobranch species in the country peaked at 74,943 MT in 1998; then they started to decline {CMFRI 2017}. Some of this decline is likely attributable to the cessation of targeted whale shark hunting in 2001 (CMFRI 2022b). In 2016, 52,840 MT of elasmobranchs were reported in the country, 51% of them corresponding to rays. The major ray families were Dasyatidae, Mobulidae, Myliobatidae, Gymnuridae, and Rhinopteridae (Zacharia and Najmudeen 2017).

Sea turtles *(Dermochelyidae, Cheloniidae)*

2.1 Abundance

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

High Concern

As a taxonomic group, sea turtles are considered to have high inherent vulnerability, leading to a score of “high concern” for this factor.

Supplementary Information

Five species of sea turtles are present in Thailand, including leatherback turtle, green turtle, hawksbill turtle, loggerhead turtle, and olive ridley turtle (Mai Khao Marine Turtle Foundation 2014). Leatherback turtle is considered endangered in Thailand (Kuhakan 2020). Hawksbill populations have continued to decline since 1999, and the losses in numbers in the Southeast Asia area are of particular concern {Mortimer and Donnelly 2008}. According to the IUCN Red List, 20% of sea turtle species in Thailand are “Critically Endangered,” 60% are “Vulnerable,” and 20% are “Endangered" (IUCN 2023). Given these statuses, there is not sufficient evidence to override the automatic high score for sea turtle species.

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

High Concern

As a taxonomic group, sea turtles are considered to have high inherent vulnerability, leading to a score of “high concern” for this factor.

Supplementary Information

Five species of sea turtles are present in India, including leatherback turtle, green turtle, hawksbill turtle, loggerhead turtle, and olive ridley turtle (Sea Turtles of India 2023). This last species is known to congregate in especially large numbers along the coast of Orissa in East India (Savio Lobo 2007). The status of the Northeast Indian Ocean population of leatherback turtle is unknown (Wallace et al. 2013). Hawksbill populations have continued to decline since 1999, and the losses in numbers in the Southeast Asia area are of particular concern {Mortimer and Donnelly 2008}. Although olive ridley turtle is globally decreasing, no evidence of decline has been observed in Indian rookeries {Abreu-Grobois and Plotkin 2008}. According to the IUCN Red List, 25% of sea turtle species in India are “Critically Endangered,” 50% are “Vulnerable,” and 25% are “Endangered” (IUCN 2023). Given these statuses, there is not sufficient evidence to override the automatic high score for sea turtle species.

2.2 Fishing Mortality

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

High Concern

Fishing mortality is unknown for sea turtles in Thailand, so the UBM was used to score this factor. The UBM points to a “high concern” rating for trawls.

Supplementary Information

Fishing activity is thought to be one of the main causes of decline in the turtle population of Thailand (Polunin 1975), although little data are available to estimate the rate of mortality of these species (Aureggi 2018). Along the Andaman Sea coast, 214 stranded turtles were recorded between 1991 and 2002; 26.2% of these turtles were washed ashore by gillnets and another 7% by miscellaneous fishing gear {Adulyanukosol and Ruangkaew 2002}. Fisheries bycatch, associated with

entanglement in drift nets, shrimp trawling, long-lines, etc., has been classified as one of the highest threats to sea turtles globally (Wallace et al. 2013)(Seminoff 2004)(Mortimer 1998). In response to the United States shrimp embargo in 1996, SEAFDEC, in collaboration with Thailand and other countries in the area, conducted a regional collaborative program on the development and application of turtle excluder devices (TEDs) in shrimp trawls (Chokesanguan 2008). The major activities included the design, development, and implementation of the “Thai Turtle Free Device" (TTFD) in shrimp trawl fisheries and experiments on various designs of TEDs. It is unclear if the TEDs are currently in use in all the trawl fisheries in the country, and the current mortality of sea turtles in Thai trawl fisheries in unknown. In addition, though sea turtles are prohibited from being landed in Thai fisheries and must immediately be released, the incidental interaction rates are not available, and post-release mortality is unknown (Ministry of Agriculture and Cooperatives 2016).

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

High Concern

Fishing mortality for sea turtles in India is unknown, so the UBM was used to score this factor. The UBM points to a “high concern” rating for trawls.

Supplementary Information

The Indian government announced that it would begin an assessment for marine mammals and sea turtles in 2020, but the project is yet to be completed (Onmanorama 2020). Sea turtle landings in trawls are thought to be rare due to cultural reverence for these species (Jeyabaskaran and Kripa 2018). But the amount of discards is unknown.

Seabirds *(Aves)*

2.1 Abundance

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

High Concern

Seabirds are considered to have high inherent vulnerability, so they receive a “high concern” rating for this factor.

2.2 Fishing Mortality

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

Moderate Concern

The UBM points to a score of 4 for bottom and midwater trawls in the East Indian Ocean and a score of 3 for bottom and midwater trawls in the West Indian Ocean. Therefore, a “moderate concern” rating is assigned to this factor.

Supplementary Information

The majority of Indian squid fishing occurs on the western Indian coast, though fishing does take place in eastern states as well. Because the UBM scores differ between the two coasts, the more precautionary score of 3 is used for this factor.

Sharks *(Selachimorpha)*

2.1 Abundance

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

High Concern

As a taxonomic group, sharks are considered to have high inherent vulnerability, leading to a score of “high concern” for this factor.

Supplementary Information

The latest shark survey notes 86 species of sharks in Thai waters (Krajangdara 2019). According to the IUCN Red List, 38.2% of sharks in Thai waters are “Vulnerable,” 29.1% are “Endangered,” and 10.9% are “Critically Endangered” (IUCN 2023). An assessment of shark status in Thailand using CPUE data from 2004 to 2014 indicated that sharks as a group may have been fished at levels greater than MSY in the Andaman Sea (Krajangdara 2019).

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

High Concern

As a taxonomic group, sharks are considered to have high inherent vulnerability,

leading to a score of “high concern” for this factor.

Supplementary Information

Around 160 species of sharks are reported in Indian waters (Akhilesh et al. 2010), though not all of these are captured in trawl fisheries. Generally, *Rhizoprionodon* spp. and *Scoliodon laticaudus* dominate shark landings in Indian trawls (CMFRI 2022b). Shark landings along the northwest coast of the country are dominated specifically by the milk sharks (*Rhizoprionodon oligolinx* and *R. acutus*) and spade-nose shark (*Scoliodon laticaudus*). Landings along the southwest and southeast coasts are dominated by requiem sharks of the genus *Carcharhinus*. Landing of thresher and mackerel sharks and the oceanic white tip shark (*Carcharhinus longimanus*) have been found to be increasing in recent years, with increased operations in oceanic waters (Kizhakudan et al. 2015). But these species are more likely to be captured by gillnets and longlines than trawls (CMFRI 2022b). The contribution of trawl fisheries to total catches between 1985 to 2013 ranged from 19% in West Bengal to around 60% in Tamil Nadu state and Puducherry (Kizhakudan et al. 2015). The distribution of Indian sharks classified under IUCN Red List categories indicates that 22.4% of the species in Indian waters are “Near Threatened,” 30.6% are “Vulnerable,” 18.8% are “Endangered,” and 9.4% are “Critically Endangered” (IUCN 2023). A recent assessment of species and species groups in individual Indian coastal states suggests that sharks as a group have a sustainable status in most states but are recovering ($B/B_{MSY} < 1$ and $F/F_{MSY} < 1$) in Gujarat and West Bengal (Sathianandan et al. 2021). Given these stock statuses and the IUCN “Endangered” and “Critically Endangered” statuses for several shark species, there is not sufficient evidence to override the automatic high score for shark species.

2.2 Fishing Mortality

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

High Concern

Both shark and ray fishing mortality are unknown in Thailand, so the UBM was used to score this factor. The UBM points to a “high concern” rating for trawls.

Supplementary Information

From 2000 to 2009, Thailand reported an average of 20,749 MT of shark catches per year to FAO. The reported catches declined considerably from 14,409 MT in

2003 to 1,424 MT in 2011 (DOF 2021). According to Krajangdara, trawls represented more than 80% of both shark and ray landings (Krajangdara 2014). Survival in these fisheries is affected by several factors, including the duration of the trawl, the size of the catch, and the amount of time used to sort the catch {Cosandey-Godin and Morgan undated}.

The DOF established the first NPOA-Sharks of Thailand in 2005 (Krajangdara 2014). According to the latest (2020–24) NPOA for sharks, these species accounted for 0.72% of total catches in Thailand from 2002 to 2014 (though this does not include discards) (DOF 2021). But presently, the only shark management measure in Thailand relates to whale shark (*Rhincodon typus*), whose capture in fisheries is prohibited (ibid). The most landed species of sharks and rays in Thai ports are spottail shark (*Carcharhinus sorrah*), which is "Near Threatened" (Pillans et al. 2009); grey carpetshark (*Chiloscyllium punctatum*), "Near Threatened" (Dudgeon et al. 2016); grey bamboo shark (*C. griseum*), "Near Threatened" {Lisney and Cavanagh 2003}; Kuhl's maskray (*Neotrygon kuhlii*); sharpnose stingray (*Telatrygon zugei*), "Near Threatened" (White 2016); scaly whipray (*Brevitrygon imbricata*); *Himantura walga*; and *H. gerrardi* (Krajangdara 2014).

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

High Concern

Fishing mortality for individual shark species is unknown, but recent research suggests that $F < F_{MSY}$ for sharks as a group in all Indian states except Kerala, which is assessed separately in this report (Sathianandan et al. 2021). But some uncertainty is introduced into this finding because the data and reference points for individual states are based on landings and not an official observer program. In addition, the individual species that are part of the shark group in the assessment and the individual species of sharks affected by squid trawl fisheries are not known, so overlap between the two groups is unknown. Because the species of sharks affected and involved in the 2021 assessment are unknown, the UBM was used, which points to a score of "high concern."

Teri anchovy *(Stolephorus commersonnii)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

There are no current or recent estimates of stock abundance for teri anchovy in Kerala, so a PSA was performed. The PSA indicated a score of 3.03, so this factor receives a “moderate concern” rating.

Supplementary Information

A recent data-limited assessment using catch data to assess the stock status of several species and species groups found that anchovies were overfished ($F/F_{MSY} > 1$ and $B/B_{MSY} < 1$) in Kerala, indicating that stock abundance is lower than the sustainable level in these states (Sathianandan et al. 2021). There are multiple species of anchovy found in this area, so this assessment’s conclusions cannot be extended to a single anchovy species. Therefore, a PSA was performed.

Table 26

Productivity Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Average age at maturity	< 3 years (Nair et al. 2020)	1
Von Bertalanffy growth coefficient (K)	0.98 (Nair et al. 2020)	1
Fecundity	≈5,134 (Sululu et al. 2020)	2
Average maximum size	11.2 cm (Froese and Pauly 2023h)	1
Average size at maturity	7 cm (Froese and Pauly 2023h)	1
Reproductive strategy	Broadcast spawner	1
Total Productivity Score		**1.67**

Table 27

Susceptibility Attribute	Relevant Information	Score (1 = low, 2 = medium, 3 = high)
Areal overlap	Unknown—default score	3
Vertical overlap	Unknown—default score	3
Seasonal availability	Unknown—default score	3
Selectivity of fishery	Species is incidentally caught but does not have increased susceptibility to fishing gear; study suggests that undersize and nonmature individuals are not captured (Nair et al. 2020)	2

Post-capture mortality	Unknown—default score	3
Total Susceptibility Score		**2.8**
Overall PSA Score		**3.03**

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

Fishing mortality, like stock abundance, is unknown for teri anchovy off the coast of Kerala. Because F is unknown, this factor receives a score of “moderate concern.”

Supplementary Information

A recent data-limited assessment using catch data to assess the stock status of several species and species groups found that anchovies were overfished ($F/F_{MSY} > 1$ and $B/B_{MSY} < 1$) in Kerala (Sathianandan et al. 2021). There are multiple anchovy species in Kerala waters, so this assessment’s conclusions cannot be used for one specific anchovy species in the area.

Whale shark *(Rhincodon typus)*

2.1 Abundance

Western Indian Ocean | Kerala | Bottom trawls

High Concern

According to the IUCN, whale shark is “Endangered” on a global scale. Due to its “Endangered” status, whale shark receives a score of “high concern” for this factor.

Supplementary Information

Whale shark was last assessed in 2016 by the IUCN Red List (Pierce and Norman 2016). This assessment notes that whale shark populations have declined by 63% over the past three generations in Indo-Pacific waters. The most recent data for whale shark in the central and western Indian Ocean shows that sightings increased from 1991 to 2000 but decreased from 2000 to 2007 (Sequeira et al. 2013). The current population trend in Indian waters is unknown.

2.2 Fishing Mortality

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

Landings data suggest that this fishery has minimal interactions with whale shark (Appukuttan 2022). But self-reported landings data are often not as reliable as observer data or landings and discards data together. Therefore, some uncertainty is introduced. This uncertainty leads the fishery to receive a “moderate concern” rating for this factor.

Supplementary Information

According to the Kerala fishery’s Fishery Improvement Project pre-assessment, 750 kg of whale sharks (i.e., one to two juvenile individuals) have been landed in a recent 3-year period (Appukuttan 2022). This suggests minimal interactions with whale shark, as well as a lack of broader population impacts. But whale shark is a protected species that is not meant to be landed, and the amount of discards of whale shark in the fishery are unknown. The historic population decline in this species is largely due to targeted fishing and bycatch in net fisheries, primarily gillnets and purse seines (Pierce and Norman 2016). Although many targeted fisheries closed in the 1990s and early 2000s, some still exist, but not in India.

2.3 Discard Rate/Landings

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

< 100%

Research on the composition of trawl catches in Thailand has found that the proportion of fish that have economic value (targeted species) is 33.3%, and the remaining 66.7% is trash fish {Supongpan and Boonchuwong 2010}(Nettasna 2014). In Thailand, as in other countries in the area, this trash fish (bycatch) is largely utilized for animal feed and it is not discarded {Chanrachkij 2015}. Therefore, this bycatch is considered to be part of the total catch, and the discard rate in the fishery is thought to be lower than 100%.

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

< 100%

A study of bycatch and discard rates across Indian states showed that discards in multiday trawl operations ranged from 10% to 30% of total landings from 2017 to 2019 (Dineshbabu et al. 2022). Maharashtra, Karnataka, Odisha, and West Bengal had the lowest percentages of discards. Based on this research, it is considered that the discard rate in Indian trawl fisheries is lower than 100%.

Western Central Pacific | Indonesia | Cast nets

< 100%

Squid fishing most often takes place at night when fishers use overhead lights to lure the squid, and other small pelagic species, to concentrate them near the boat. Falling nets (i.e., cast nets) and lifting nets are then used to catch them. The lights also attract predator species, such as small tuna or cuttlefish, that prey on these small fish and squid and are also retained when caught. Although information about the catch composition of the Indonesian cast net fishery for squid is not available, this is an environmentally friendly gear in which few nontarget species are caught. Therefore, the discard rate in this fishery seems to be low.

Western Central Pacific | Thailand | Cast nets

< 100%

In a catch analysis of the Indian squid cast net fishery in the Gulf of Thailand undertaken by Supongpan et al. (1992), Indian squid represented approximately 50.1% of the catch (Supongpan et al. 1992). Other species retained in the fishery included commercially important fish such as Indian mackerel and yellowtail scad, which represented around 10% and 7% of the catch, respectively. Noncommercially important fish species, which are assumed to be discarded in these fisheries, made up less than 6% of the total catch. Thus, discard rates are likely well below 100% of the landings. No bait is used in cast net fishing.

Western Central Pacific | Thailand | Jig
Western Central Pacific | Indonesia | Jig

< 100%

Jig fisheries have low discard rates, because this is a highly selective method

that catches few bycatch species {Kelleher 2005}. No bait is used in squid jigging. Therefore, the discard rate/landings in this fishery is considered lower than 100%.

Western Indian Ocean | Kerala | Bottom trawls

< 100%

A recent bycatch and discards study found that multiday trawl nets in Kerala averaged 10% to 25% discards from 2017 to 2019 (Dineshbabu et al. 2022). Thus, discards are below 100% of landings.

Supplementary Information

A minimum legal size (MLS) was put in place for catches in trawls in Kerala in 2017, which was meant to reduce the incidence of juvenile capture. But from 2018 to 2019, juvenile bycatch decreased while discards increased in Kerala, suggesting that juveniles are still being caught but are increasingly discarded rather than landed (Dineshbabu et al. 2022). Still, this increase in discards did not bring their percentage relative to landings above or close to 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 And Implementation	Bycatch Strategy	Scientific Data Collection and Analysis	Enforcement of and Compliance with Management Regulations	Stakeholder Inclusion	Score
Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls	Ineffective	Ineffective	Moderately Effective	Moderately Effective	Highly effective	Red (1.000)
Eastern Indian Ocean, Western Indian Ocean | Bottom trawls	Ineffective	Ineffective	Moderately Effective	Ineffective	Moderately Effective	Red (1.000)
Western Central Pacific | Indonesia | Cast nets	Ineffective	Moderately Effective	Moderately Effective	Ineffective	Moderately Effective	Red (1.000)
Western Central Pacific | Indonesia | Jig	Ineffective	Highly effective	Moderately Effective	Ineffective	Moderately Effective	Red (1.000)
Western Central Pacific | Thailand | Cast nets	Ineffective	Moderately Effective	Moderately Effective	Moderately Effective	Highly effective	Red (1.000)
Western Central Pacific | Thailand | Jig	Ineffective	Highly effective	Moderately Effective	Moderately Effective	Highly effective	Red (1.000)
Western Indian Ocean | Kerala | Bottom trawls	Ineffective	Ineffective	Moderately Effective	Moderately Effective	Moderately Effective	Red (1.000)

Criterion 3 assesses the effectiveness of management in ensuring that there are conservation goals and that those goals are being met. The criterion comprises five components, as seen in the preceding table column headings. When factor 3.1 Management Strategy and/or factor 3.2 Bycatch Strategy are deemed “ineffective,” the remaining factors (3.3–3.5) do not contribute to the overall Criterion 3 score (for all fisheries in this assessment).

Criterion 3 Assessment

Scoring Guidelines

Factor 3.1 - Management Strategy and Implementation

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

have been successful at maintaining/rebuilding species.

Factor 3.2 - Bycatch Strategy

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

Factor 3.3 - Scientific Research and Monitoring

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

Factor 3.4 - Enforcement of Management Regulations

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

Factor 3.5 - Stakeholder Inclusion

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

3.1 Management Strategy And Implementation

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls
Western Central Pacific | Thailand | Cast nets
Western Central Pacific | Thailand | Jig

Ineffective

Though Thailand's fisheries were formerly open access, some progress has been made in improving their management. Some reference points have been developed, and new regulatory objectives are in place to limit fishing effort. But the effectiveness of these recent reforms is unclear, and methods to control fishing pressure may still result in overfishing and other detrimental impacts. Therefore, this factor is rated "ineffective."

Supplementary Information

Thailand's marine fisheries are managed by the Department of Fisheries (DOF) of the Ministry of Agriculture and Cooperatives (MOAC), which is responsible for new vessel registration, vessel permit renewal, change of vessel lists, etc. (DOF 2015). Management of the marine environment is the responsibility of the Department of Marine and Coastal Resources (DMCR) under the Ministry of Natural Resources and Environment (MNRE) (DOF 2015).

Thailand's governance and fisheries management framework was structurally reformed between 2015 and 2016 to promote sustainable and responsible practices throughout the sector (OECD 2018). These changes included the Adoption of the Royal Ordinance on Fisheries (ROF) B.E. 2558 in 2015, and a 2017 amendment to the ROF. The ROF's primary aim was to empower authorities to combat illegal, unreported, and unregulated (IUU) fishing and unlawful labor practices in the fishing and seafood industries (OECD 2018). The new law was designed to achieve its objectives through five mechanisms: a licensing system, a vessel monitoring system (VMS), vessel inspection, a traceability system, and effective law enforcement (Seafdec 2018). A National Plan of Action to Prevent, Deter, and Eliminate IUU Fishing was also adopted, while a Command Centre for Combating Illegal Fishing (CCCIF) was established under the leadership of the Royal Thai Navy (OECD 2018).

A Marine Fisheries Management Plan, which aimed to tackle overfishing and overcapacity of the Thai fishing fleet, was also implemented in 2015 (DOF 2015),

and it stayed in place until 2019. It froze new trawl vessel registration from 2015 and introduced a vessel buyback scheme, more stringent gear regulations, limits on days at sea, and total allowable catch (TAC) limits with a maximum sustainable yield (MSY) objective. A 2020–22 fisheries management plan was developed after the initial 2015 plan, and focuses on similar goals and builds upon existing progress since the 2015 plan was initiated. In 2022, the Thai government fully banned new trawl vessel registration and introduced a decommissioning program in addition to the vessel buyback program (Blue Ventures and Environmental Justice Foundation 2022). It is currently still too early to determine the effectiveness of these efforts on reducing overall fishing pressure, though the number of Thai trawls has decreased by over 600 from 2016 to 2023 (DOF 2023d). In addition, an evaluation of the initial (2015–19) fisheries management plan has been conducted. This evaluation found that, in 2021, 52% of key management objectives from the FMP had been completed, while 47% were still in progress (1% were not implemented) (DOF 2021b). Almost all fishing effort reduction goals were met (via limits on fleet sizes).

To further limit fishing pressure, the government has developed MSY estimates for three broad groups: demersal species, pelagic species, and anchovies. These estimates are based on fisheries catch and effort data and are translated to TACs (set at 95% of MSY), which are then translated into total allowable effort (TAE) quotas (Kulanujaree et al. 2020). TAEs are divided between vessels and control fishing effort based on time at sea. MSY assessments are done at this broad level due to the multispecies nature of many Thai fisheries. Recent MSY species group assessments suggest that no broad groups are experiencing overfishing (based on MSY relative to fishing effort expressed as a number of fishing time across vessels) (DOF 2020) (DOF 2023c). This approach, while a step in the right direction, leaves room for fishing pressure to still exceed sustainable levels for individual species. Setting TACs at 95% of MSY is precautionary, but only slightly so, and the Thai catch documentation system allows for a 20% margin of error, so MSY could be exceeded under this system (Environmental Justice Foundation 2023). Also, although not all individual species in a multispecies fishery can be expected to be fished at a sustainable level, the lack of species-specific catch data and species-specific MSY indices precludes the ability to calculate what percentage of landed species are fished at a sustainable level. Further, controlling effort via time at sea does not account for the fishing capacity of different vessels. Thailand has reduced its fishing effort—in terms of days at sea—to more than 30% below the level needed to achieve MSY (DOF 2020), but the average gross tonnage of Thai vessels has increased during the same period, meaning that individual vessels have the capacity to catch more fish (Environmental Justice Foundation 2023). Finally, MSYs are not developed for individual species. A species-specific approach is

difficult in multispecies trawl fisheries, but combining individual species into broad groups does not fully protect them from overfishing.

But some species are assessed on an individual level in an effort to understand stock status relative to harvest levels, and 11 individual species (including Indian squid) had stock status assessments performed in both the Gulf of Thailand and the Andaman Sea in 2018 (DOF 2020)(Nootmorn 2021)(DOF 2021b). Although these do not cover all species captured in the trawl, jig, and cast net fisheries in Thailand, and single-species reference points were not adopted from this work, it is a strong start in the government's goal of developing science-based management for its fisheries (Kulanujaree et al. 2020). The DOF is also focused on other sustainability goals, such as improving and raising awareness of ecosystem-based fisheries management, restoring stocks to healthy levels, and improving the enforcement and implementation of regulations.

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

Ineffective

While there has been considerable effort to update and improve fisheries management in India over the past few years, there are no comprehensive stock assessments for individual squid species, and reference points have not been determined for many of the squid trawl fisheries' landed species. Despite some indications of overexploitation, few limitations in effort and few harvest control rules are in place for these species. Therefore, management strategy for the country's squid fisheries is considered "ineffective."

Supplementary Information

According to the constitution of India, the central government's Department of Animal Husbandry Dairying & Fisheries (DADF), under the Ministry of Agriculture, has jurisdiction over the fisheries in the exclusive economic zone (EEZ), while the state/provincial governments have jurisdiction over fisheries in the territorial waters (ICSF 2014). The squid trawl fishery operates in both waters. A review of economic, social, and environmental performance undertaken by the World Bank in 2010 suggested that fisheries management in India, focused on increasing fish production, was meeting only a few policy outcomes against the goals established by the government (World Bank 2010). Despite attaining a reasonably good rate of growth in primary fisheries production and exports in the country, the marine fisheries sector in India faces several problems, such as the overcapacity in

territorial waters for all maritime states, conflicts between artisanal and commercial fisheries, reduction in capital investment in the artisanal fisheries, and overexploitation of several marine resources (Baiju 2013).

In 2017, the Government of India published the new “National Policy on Marine Fisheries, 2017” (NPMF), which provides guidance for promoting the “Blue Growth Initiative” in the country. The overarching goal of the NPMF is to ensure the health and ecological integrity of the marine living resources of India’s EEZ through sustainable harvests for the benefit of present and future generations of the nation (NFMS 2017). The strategy of this NPMF is based on seven pillars: sustainable development, socioeconomic upliftment of fishers, the principle of subsidiarity, partnership, intergenerational equity, gender justice, and a precautionary approach. These seven pillars will guide the actions of various stakeholders in meeting the vision and mission set for the marine fisheries sector of the country (NFMS 2017). According to this document, to extract the full potential of marine fisheries, management will focus to control fishing effort, optimize fleet size, develop species- and area-specific management plans, promote conservation of ecologically and biologically significant areas (EBSAs), protect vulnerable marine ecosystems (VMEs) and endangered and threatened (ETP) species, and implement the ecosystem approach to fisheries management (EAFM) (ibid). This approach to fisheries management (“blue revolution”) in the country seems to continue in the same line, and it is not addressing overexploitation or contributing to more positive economic and social outcomes, especially for inshore fisheries (Scroll.in 2018). Target species are overexploited, and reductions of effort and more management measures to protect species and habitats have been suggested by various authors (Mohamed 1996)(Mohamed & Rao 1997)(Karnik et al 2003)(Thomas & Kizhakudan 2006)(Mohan 2007)(Sasikumar & Mohamed 2012)(Saroj et al. 2016).

More recently, though, research has been done to begin working toward addressing species’ exploitation statuses in Indian waters. Recent work applied a standardized CPUE method to over 20 species in each Indian coastal state. This work determined B_{MSY} and F_{MSY} based on fisheries catch and effort data, then further determined current B and F compared to B_{MSY} and F_{MSY} (Sathianandan et al. 2021). But the appropriateness of these reference points is somewhat uncertain, given that a) the data used come from reported landings, not an official observer program, and b) the study determined separate reference points for each Indian state, but some species may have populations that span more than one state. Further, reference points for species groups such as “cephalopods” may not be appropriate to apply to individual species in these groups, given their differing life histories.

Individual state governments have also made attempts to control fishing exploitation levels with the introduction of minimum legal sizes (MLS) to trawl fisheries. These have been introduced in Kerala, Tamil Nadu, Karnataka, and Malabar (CMFRI 2022a)(Dineshbabu et al. 2022). Implementing MLS for capture species is meant to reduce pressure on juveniles, allowing for better population growth and recovery. But there are concerns that MLS are not an effective way to protect juveniles if they are not paired with the implementation of minimum mesh sizes (Dineshbabu et al. 2022). Mesh size regulations have been implemented in some areas but have not been effective, and mesh sizes in trawls are often smaller than the permitted size, suggesting poor enforcement of these restrictions (CMFRI 2022a). In addition, trawl fishers are not required to disclose low-value bycatch (LVB, which may include juveniles below commercial size) landings, thus allowing juveniles captured in states with MLS to be discarded or unreported as LVB. ICAR does randomly sample trawl vessels across Indian states, but onboard observer programs do not exist.

Finally, one successful method of limiting fishing pressure in India is the implementation and enforcement of annual trawl bans. These bans typically last 45–60 days and occur during the monsoon season (CMFRI 2022a). There do not seem to be enforcement issues with these seasonal fishery closures. But recent research suggests that annual trawl closures may be better suited at other times of the year, based on stock productivity and juvenile growth rates (Appukuttan 2022).

Western Central Pacific | Indonesia | Cast nets
Western Central Pacific | Indonesia | Jig

Ineffective

Although it is considered that fisheries management has improved in recent years in Indonesia, there are no comprehensive stock assessments for individual squid or fish species, and no reference points have been set. Stock assessments in Indonesia are performed for species groups and are based on catch data that are often not reliable or completely accurate (Napitupulu et al. 2022). Therefore, fisheries management is rated “ineffective.”

Supplementary Information

The Ministry of Marine Affairs and Fisheries (MMAF), along with its counterparts, the fisheries services at the provincial and district levels controlled by local governments, is the main government agency responsible for the administration and management of capture and culture fisheries in Indonesia (OECD 2013).

Governance in the sea is shared between regional provinces and local authority provinces. Fishing management in Indonesia is traditionally established according to the distance to the coast: coastal waters up to 4 nm were managed by municipalities; waters from 4 to 12 nm were controlled by provinces; and the whole of the EEZ is managed by the national government. But some jurisdictional overlap exists with the nearshore fisheries and marine resources, particularly between subnational governments and the MMAF (Nurhidayah 2010)(CCIF 2013). A 2014 law shifted fisheries authority in waters 12 nm and farther from the coastline from local authorities to regional provinces (Republic of Indonesia 2014). Squid is caught in both nearshore and offshore areas. Fisheries management and stock assessments are also broken into 11 zones, called WPPs, across Indonesian waters (Jaya et al. 2022).

The main laws regulating fisheries in Indonesia are Law 31/2004 and its amendment law 45/2009. These laws provide a legal basis for a range of fishery management measures in marine, brackish, and public inland waters, including effort control through licensing and quota, and gear restrictions (OECD 2013)(CCIF 2013). Law 31/2004 set out the requirement for fishery management areas and fishery management plans. It specifically stated the responsibility of the Minister in allocating catches based on fisheries' potential and sustainability issues (Dudley & Ghofar 2007). Marine protected areas in Indonesia have also been established under conservation law 5/1990 and are managed by the Ministry of Forestry (OECD 2013). Many other regulations apply to the fishing activity in the country: defining fishery management areas, designating periods where fishing is limited, and regulating the fishing gears permitted in each area (MMAF 2011). That regulation further provides a framework for monitoring and evaluating fishing activities, and contains provisions relating to sanctions for offenses of the fishing regulations (FAOLEX 2012)(CCIF 2013). Regulation 36 of 2023 defines specific types of fishing gears and related restrictions; e.g., mesh sizes and vessel gross tonnage limits (MMAF 2023a). This regulation also further clarifies which management levels are responsible for monitoring and evaluation of fishing gear types within different areas.

In 2014, maritime and fisheries policy became a central priority for the Indonesian government (OECD 2018). In 2020, the president of MMAF shifted the organization's focus to increasing production, walking back many of the conservation regulations that had been put in place in the preceding years (Napitupulu et al. 2022). But most of these regulations, such as the ban on destructive trawl fishing and the existence of the national stock assessment committee (Komnas KAJISKAN), have since been reinstated. The MMAF's 2015–

2019 strategic plan highlighted sustainability, sovereignty, and prosperity as its three major pillars (CEA 2018). A Presidential Task Force has been created to combat illegal fishing and to coordinate the actions of all the administrative bodies involved in this area (OECD 2018). In 2014 and 2015, a permanent moratorium on fishing by ex-foreign vessels operating within the EEZ and a ban on transshipment at sea were adopted, and the budget of the MMAF doubled (OECD 2018). A quota-based fisheries system began in 2022, which is meant to help ensure the sustainability of fish stocks and increase Indonesian fisheries production (Napitupulu et al. 2022). This system involves determining the estimated potential of fish resources, TACs, and levels of utilization. Regulation 11 of 2023 sets quotas for each of six defined fishing zones, places restrictions on fisheries, activates a vessel monitoring system, and discusses traceability issues (MMAF 2023b).

But a number of constraints affect fisheries management in Indonesia, including overlapping and conflicting laws regarding marine and coastal management, unclear roles and responsibilities of institutions managing marine and coastal resources, lack of coordination and capacity of local governments, lack of financial support and infrastructure, weak monitoring, surveillance, and enforcement (MCS), lack of public participation, low income and standard of living for fishers and fish farmers, and poor quality fishery data (Nurhidayah 2010)(CCIF 2013)(FAO 2017)(Napitupulu et al. 2022). Despite reducing the level of IUU fishing by foreign vessels, the new fisheries management regime has had very limited success in reducing illegal fishing by nationals (including the use of destructive fishing practices) and limiting fishing effort in EEZ waters (CEA 2018), and overfishing in both marine and inland nearshore fishing resources is still a problem (Nurhidayah 2010)(CEA 2018). While the trawl ban has been in place for the majority of the past decade, illegal trawling remains a large problem in Indonesian waters (Ramdhani 2022). Further, vessel and catch monitoring are constrained by 1) a large number of unpermitted/unregistered fishing vessels, and 2) unmet goals for adoption of e-logbooks by Indonesian vessels (Jaya et al. 2022)(Napitupulu et al. 2022).

The government releases national stock assessments every few years, with the latest assessment released in 2022. These assessments define statuses as underexploited, fully exploited, or overexploited for several species groups, including small pelagics, large pelagics, demersal fish, reef fish, penaeid shrimp, lobster, crab, blue swimming crab, and squid (MMAF 2022)(Napitupulu et al. 2022). Statuses are determined by comparing the potential exploitation level and TAC to the current exploitation level. These assessments, while a step in the right direction for Indonesian fisheries management, do not make use of typical scientific reference points and are not for individual species of squid or fish. Compared to

2017 statuses, squid stocks do look to have improved in 2022, but there is uncertainty in this conclusion, given the nature of the assessments and the unreliability of the fishery catch data that inform these assessments (Napitupulu et al. 2022).

Western Indian Ocean | Kerala | Bottom trawls

Ineffective

Progress has been made in Kerala toward improving the sustainability of the state's fisheries management approach, including the development of some reference points (B_{MSY} and F_{MSY}) for a few species and species groups. But the most recent (2017) changes to the Kerala Marine Fisheries Regulation Act (KMFRA) are still being implemented, and other regulatory changes have yet to be fully enforced and complied with. Because management measures that may improve the sustainability of the fishery are not yet implemented or fully complied with, and there are concerns about the status of some landed species, this factor is rated "ineffective."

Supplementary Information

Fisheries management in India is shared between the national government and state-level institutions. In Kerala, the Department of Fisheries carries out the stipulations of the KMFRA. This act, originally codified in 1980, was amended in 2017, bringing changes such as new comanagement structuring and periodic reviews of management measures (Kerala DOF 2017)(Appukuttan 2022). But the updates stipulated in the 2017 amendment have not been fully implemented, so their effectiveness cannot yet be determined. The act also outlines licensing and registration requirements for fishing vessels (Kerala DOF 2017).

Other recent regulatory changes in Kerala have focused on trawls. A minimum legal size (MLS) was put in place for Kerala trawlers in 2017, which applies to Indian squid and 57 other capture species in the multispecies trawl fishery (Dineshbabu et al. 2022). It is meant to reduce incidences of juvenile capture, and there is some evidence that the MLS has been adhered to since its inception. Bycatch of juvenile species in Kerala trawls decreased after 2017, which may be attributable to the MLS (ibid). But discards also increased during this time, which may suggest that trawlers are simply discarding juveniles rather than landing them, in order to comply with the MLS (ibid). In addition, in 2020, the mean lengths of landed Indian squid in Kerala were less than the optimum length of capture (optimum length being above the MLS for the species) (CMFRI 2021).

Fishers and other stakeholders have expressed concerns that an MLS will not be effective without also introducing minimum mesh size requirements, which are expensive to implement (Dineshbabu et al. 2022). A 2016 study of Kerala trawls found that none of the vessels in the study adhered to the in-place cod mesh-end size regulation of 35 mm (Sayana et al. 2016). In 2022, authorities also found a large number of vessels using nets with mesh sizes below the stipulated minimum size (The Hindu 2022). The FIP for the Kerala trawl fishery also notes that mesh size restrictions have not been properly implemented and that their enforcement process is unclear, though the authorities are working to increase patrolling and enforcement, as well as punishment, for this issue and are making progress in doing so (Appukuttan 2022)(The Hindu 2022).

Finally, some progress has also been made in Kerala in determining reference points for landed species in the fishery. Recent work applied a standardized CPUE method to 25 species/species groups in Kerala. This work determined B_{MSY} and F_{MSY} based on fisheries catch and effort data, then further determined current B and F compared to B_{MSY} and F_{MSY} (Sathianandan et al. 2021). But the appropriateness of these reference points is somewhat uncertain, given that a) the data used come from reported landings, not an official observer program, and b) the study determined separate reference points for each Indian state, but some species may have populations that span more than one state. Further, reference points for species groups such as “cephalopods” may not be appropriate to apply to individual species in these groups, given their differing life histories.

3.2 Bycatch Strategy

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

Ineffective

As part of its fisheries reforms beginning in 2015, Thailand has taken some steps to address bycatch issues. But no formal bycatch management plan is in place for trawls. Bycatch remains an issue in Thai trawl fisheries, so this factor is rated “ineffective.”

Supplementary Information

Trawl fishing was introduced in Thai waters by the Fisheries Act B.E. 2490 in 1947 to increase catches in the country (Nettasna 2014). Thailand is reported to be a participant of the Convention on International Trade in Endangered Species of Wild

Flora and Fauna (CITES) and the United Nations Convention on Law of the Sea (UNCLOS), and it is a signatory to the Convention on Biodiversity. Thailand has taken action to address the International Plans of Action (IPOA-sharks) for conservation and management of sharks through the implementation of statistics collection, biological studies, and development of a national plan of action {DOF 2015b}. Since 1972, the Department of Fisheries has issued legal measures to control fishing trawlers, prohibiting the use of this gear and push nets in some fishing areas, establishing closed areas in the Gulf of Thailand, and extending the coastal conservation zone (Nettasna 2014).

In 2013, the authorities proposed to enlarge the minimum trawl mesh size to 4 cm in order to reduce the amount of trash fish (non-economically viable species, juveniles, and degraded individuals) caught during fishing operations, and the possession of trawl nets with cod-end mesh sizes less than 5 cm was prohibited by the National Council for Peace and Order's (NCPO) Order No. 24/2558 in 2015. This measure was later reviewed and the minimum allowed cod-end mesh size was changed from 5 cm to 4 cm (Nettasna 2014). A series of other measures (closed seasons and areas) are also in place to protect spawners and juveniles (DOF 2015). But in a study undertaken under the REBYC-II CTI Project (FAO 2017), it was found that 87% of the fishers interviewed still used cod end of less than 4 cm. It is still thought that the 4 cm minimum is largely not adopted, and enforcement of the regulation is considered poor by some (Environmental Justice Foundation 2023). But enforcement mechanisms are in place, including port-in and port-out control centers, random gear checks, and monitoring via VMS of larger vessels (> 30 GT), and violations of mesh sizes or other gear restrictions can result in license suspensions or IUU listings.

Recent reforms in Thai fisheries management have focused on input controls, and the primary control for trawl catches is the use of total allowable effort (TAE) via limiting time at sea per vessel (Kulanujaree et al. 2020). This is meant to reduce overall fishing pressure but has no specific focus on reduction of trash fish catch or other bycatch. In the Gulf of Thailand, catches of trash fish, in terms of CPUE, by otter board squid vessels increased by 24% from 2016 to 2020 (Environmental Justice Foundation 2023). The Thai government has also noted in its most recent management plan that reducing the amount of trash, small, and low-value fish caught in multispecies fisheries remains a challenge (DOF 2020).

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

Ineffective

The main management measures implemented by the Indian government to manage trawl fisheries and reduce the impact on target and nontarget species during spawning are seasonal trawl closures, MLS in some states, and mesh size regulations. But these measures have not consistently been effective in reducing bycatch, with low-value bycatch (LVB) amounts reaching as high as 40% of total landings in some states (Dineshbabu et al. 2022). Because there are no specific bycatch mitigation plans in place, and current measures are not effectively enforced or working to reduce bycatch, this factor is rated “ineffective.”

Supplementary Information

A combination of regulatory measures, such as MLS, mesh size regulation, temporary closures or moving rules for areas with a high proportion of juveniles, and licensing to limit the number of vessels, in addition to the seasonal ban, has been proposed by several authors (Kumar and Deepthi 2006)(Dineshbabu 2013). The use of bycatch reduction devices (BRDs) has also been suggested, but these have not been widely adopted by trawl vessels. Some states have implemented MLS for species caught in trawls, but there are concerns that MLS is not an effective way to reduce bycatch without concurrent restrictions on cod-end mesh sizes (Dineshbabu et al. 2022). A regulation for 35 mm cod-end mesh size exists but is often not adhered to, because many vessels are still found to use 10–25 mm cod-end mesh size on their trawl nets (Dineshbabu et al. 2022). Further, the implementation of MLS may simply move juvenile bycatch species from the category of landed bycatch to that of discarded bycatch (ibid).

Bycatch in Indian trawls can be categorized into commercially important species and LVB. One recent study found that 35 commercially valuable species were caught as bycatch in multiday shrimp trawls, which operate similarly to multiday squid trawls (Ranjan Behera et al. 2021). These species can bring economic value at market, so there is incentive to continue landing and selling them. LVB, on the other hand, comprises non-commercially valuable species, degraded fish that are crushed during the fishing process, and juveniles of commercial species. A strong market demand also exists for LVB in India as a result of the increased demand from fishmeal plants operating in the country, which has encouraged the landings of low value/trash fish, putting more pressure on the ecosystem (Dineshbabu 2013). Generally, measures to attempt to reduce bycatch are more focused on reducing bycatch of juvenile species rather than general bycatch reduction and mitigation, and the nonselective nature of trawls makes them susceptible to high levels of bycatch (Ranjan Behera et al. 2021).

Shark bycatch is a known issue in Indian trawls, and some work has gone into reducing incidental capture of sharks. One recent consultative paper provides recommendations for improving elasmobranch conservation in India, suggesting the development of a national plan of action (NPOA) for sharks in the country (Akhilesh et al. 2023). A draft NPOA for sharks was completed in February 2024, with input from multiple stakeholder parties, but it has yet to be officially adopted by the Indian government (Krishnan et al. 2024).

Western Central Pacific | Indonesia | Cast nets

Moderately Effective

Bycatch is generally low in the cast net fishery, though some finfish are still incidentally caught alongside squid. Limited management measures have been implemented specifically for the cast net fishery. Because bycatch is low but bycatch management measures could be improved, this factor is rated “moderately effective.”

Supplementary Information

As indicated in the management strategy section, a series of management measures have been implemented in Indonesia to reduce the impact of trawls and purse seines on fish resources, such as a minimum mesh size, permitted areas, and the trawl ban. But management measures are more limited for cast net fisheries. Though these small-scale, generally environmentally friendly nets have a smaller impact than trawl fisheries, they do still capture some finfish bycatch species alongside target squid species (Supongpan et al. 1992)(Ghofar 2002)(Arkronrat et al. 2017). A minimum mesh size of 1 inch is in place for cast nets (MMAF 2011), which may help reduce bycatch of juvenile species. Some further gear restrictions for cast nets are laid out in MMAF Decree 36 of 2023, though these are not specifically focused on bycatch reduction, but on gear capacity generally (MMAF 2023a). Cast nets are a fairly selective gear type, because they are set by hand on groups of squid attracted to the lights that fishers employ, but this does not fully prevent finfish incidental capture. Therefore, bycatch management could be strengthened in this fishery.

Western Central Pacific | Thailand | Cast nets

Moderately Effective

Bycatch is generally low in the cast net fishery, though some finfish are still incidentally caught alongside squid. Limited management measures have been implemented specifically for the cast net fishery. Because bycatch is low but bycatch management measures could be improved, this factor is rated “moderately effective.”

Supplementary Information

As indicated in the management strategy section, a series of management measures have been implemented in the country to reduce the impact of trawls on trash fish, such as a minimum mesh size and closed areas. But management measures are more limited for cast net fisheries, though they do have a minimum legal mesh size in place of 3.2 cm. Though these small-scale, generally environmentally friendly nets have a smaller impact than trawl fisheries, they do still capture some finfish bycatch species alongside target squid species (Supongpan et al. 1992)(Arkronrat et al. 2017). Large cast nets are considered a highly selective gear type in Thailand, but they do not exclusively capture target squid species (Arkronrat et al. 2017). Therefore, bycatch management could be strengthened in this fishery.

Western Central Pacific | Thailand | Jig
Western Central Pacific | Indonesia | Jig

Highly effective

A jig is a type of grapnel (or grappling hook), which is attached to a fishing line. Jigging for squid is done at night with lights to attract the squid closer to the surface (SFW 2018). Although other species, such as small pelagics, can be attracted by the lights used to lure squid, the hooks used in this fishery are not baited and there is virtually no bycatch. Therefore, a score of “highly effective” is assigned.

Western Indian Ocean | Kerala | Bottom trawls

Ineffective

The main management measures implemented by the Kerala government to manage trawl fisheries and reduce the impact on target and nontarget species during spawning are a trawl closure during the monsoon season, MLS for some secondary species, and mesh size and shape regulations. But these measures

have not been consistently implemented in the fishery, and bycatch still occurs. Because the effectiveness of measures is uncertain and measures are not fully implemented, this factor is rated “ineffective.”

Supplementary Information

Up to 254 bycatch species have been identified in Kerala’s trawl fisheries (Dineshbabu et al. 2022). The FIP for the multispecies Kerala trawl fishery has noted both secondary species and ETP species that interact with the fishery. Although ETP species interactions are thought to be minimal, no official, scientific observer program exists to confirm this. Better bycatch monitoring is needed, especially for interactions with juvenile shark species (Appukuttan 2022). In November 2023, officials in Kerala began a questionnaire program that will help improve understanding of interactions with sawfish and juvenile sharks, but this work is still in progress and data results are not yet available (CMFRI 2024).

In 2017, Kerala implemented MLS for a number of species, with a goal of reducing juvenile bycatch in its trawl fisheries. There is some evidence that the MLS has helped reduce juvenile bycatch, with bycatch’s contribution to total landings decreasing after 2017 (Dineshbabu et al. 2022). But this same period exhibited an increase in discards, suggesting that the impact on bycatch species may still be felt, because survival rates of discards are unknown. The impact of MLS is also strengthened when used alongside minimum mesh size regulations. Mesh size regulations have been put in place (i.e., square cod-end mesh size of 35 mm) but are not yet fully implemented, reducing the potential protection for juveniles (Appukuttan 2022). The enforcement of MLS could also be strengthened in Kerala (ibid).

Other work has begun to improve the management of bycatch species in Kerala. As part of the FIP, efforts are being made to improve understanding of bycatch concerns among fishers and to encourage the use of MLS and BRDs, but this work is ongoing and its success thus far is not clear. Recent research will be used to define biological fishing limits for secondary species in the fishery and create management plans for these species, but this is not yet complete (Appukuttan 2022). Finally, other recent research exhibits that the trawl ban would be more effective in protecting the ecosystem and species if it were moved to winter months, and though this suggestion has been recommended to the government, the change has not been implemented.

3.3 Scientific Data Collection and Analysis

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

Western Central Pacific | Thailand | Cast nets

Western Central Pacific | Thailand | Jig

Moderately Effective

Before 2015, Thai fisheries were largely open-access, and little data were collected as part of fisheries management schemes. Since fisheries management was reformed in 2015, catch data have been used to create MSY assessments regularly, though these assessments are only performed regularly for broad groups rather than individual species (Kulanujaree et al. 2020). Some vessels are equipped with VMS (required for all vessels > 30 GT). Catch data for economically important species come from fisher logbooks, where regulations allow for a margin of error up to 20%, but catch statistics are built using landings declarations data. Some research surveys are performed, but there is a lack of data from independent fisheries observers. Although data collection and stock analysis methods are improving, fishery-dependent data could be more accurate, and fishery-independent data are largely lacking, resulting in a “moderately effective” score.

Supplementary Information

In 2015, 2017, and 2019, MSY assessments were carried out for demersal species, pelagic species, and anchovies. These assessments are part of the Royal Ordinance of 2015’s stipulation that fishing effort in Thailand must be based on “science-based management aligned with MSY” (Kulanujaree et al. 2020). These assessments are then used to set reference points for TAC purposes for 2 years at a time, unless changes in fishing effort suggest the need for more frequent updates. CPUE data and length-based data are used to assess the status of these groups, which has helped the Thai government’s efforts to limit its fishing pressure. But single-species stock assessments are only regularly performed for some species. One assessment was performed for 11 species in 2018, using 2017 data, but this kind of assessment is not performed regularly across all relevant species (DOF 2020). Thailand still lacks data about individual stocks, and Global Fishing Index has noted that the majority of Thai fish catch stems from unassessed species with unknown stock status (Environmental Justice Foundation 2023).

CPUE data used in assessments may be obtained through logbooks, which are required on all commercial vessels over 10 GT (Kulanujaree et al. 2020). But logbook data are not always accurate, because regulations allow for actual catch to

be as much as 20% greater than estimated catch in logbooks (Environmental Justice Foundation 2023). Further, logbooks often lack the level of detail needed for proper catch statistics, so they are more useful for Thai officials as a surveillance mechanism. Landings declarations include the weight of landings, which are stored in Thailand's catch certification system and are used to create national catch statistics (DOF 2023b). Random sampling is also used to collect field survey data at fishing ports across Thailand (Kulanujaree et al. 2020). Surveys are also used to collect artisanal fishery data. Commercial vessels over 30 GT have been required to use VMS since 2015, which accounted for 52% of all commercial vessels in 2023 (DOF 2023d). Other data sources include an e-licensing system to account for the number of active fishing vessels, port entry and exit data stored in Thailand's Fishery Information System, and surveys from the Marine Fisheries Research and Development Division on fishing effort (DOF 2023b). Finally, data also come from research vessel surveys, which are conducted quarterly across five vessels in various Thai waters (Kulanujaree et al. 2020). Thailand has begun work on a fishing management information system (FMIS) for collecting and housing fishery data in one place, but this work is still ongoing.

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

Moderately Effective

Some fishery-dependent data are collected, almost exclusively from trawl fisheries, and are used to develop data-limited stock assessments for individual species and species groups. But no fishery-independent data are collected or used in these assessments, and they are not carried out regularly, nor are they all peer-reviewed. Because stock assessments and data collection could be more robust and thorough, this factor is rated "moderately effective."

Supplementary Information

The most recent stock assessment in India was released in 2023, providing estimated stock statuses for 2022. This assessment was not peer reviewed, because it was published internally through CMFRI, and it provides results but not methodology. The assessment used catch data (including amount captured and length-frequency data) from trawl landings for a number of species, including Indian squid, across India's coasts (CMFRI 2023). Similar to other stock assessments in India, this report did not include the use of fishery-independent data, such as separate abundance data or survey data. Another recent stock assessment used several decades of trawl landings data, up to 2016, to develop stock status updates

for a number of individual species and species groups (e.g., cephalopods) on India's coasts. This report was peer reviewed and published in an external journal, but again did not use fishery-independent data (Sathianandan et al. 2021). Generally, there is not a consistent schedule for developing peer-reviewed, robust stock assessment updates for India's fisheries.

India's fishery-dependent data largely lack landings data collected outside the trawl industry, where nets are sampled using a multistage, stratified random sampling design (CMFRI 2022b). This design began in certain areas of India's coasts in 1959 and has since been expanded (Mini 2014). The number of vessels sampled in each landing center is determined via the total number of vessels landing in that area, because not all vessels are able to be sampled in major port areas (ibid). CMFRI staff who conduct these surveys are given training over multiple months. Not all catch data are produced down to the species level, and LVB species that are crushed in nets sometimes cannot be identified (Dineshbabu et al. 2022). Bycatch data come from fisher logs rather than onboard observers, and trawl discards are typically not monitored, creating a reliance on fishers for obtaining discard data (ibid).

Western Central Pacific | Indonesia | Cast nets
Western Central Pacific | Indonesia | Jig

Moderately Effective

In Indonesia, fisheries catch data are collected via a sampling program and are analyzed by the national government for each of the 11 WPPs. Stock assessments are performed for each WPP every 5 years and are based on fishery catch and effort data. But catch data are considered unreliable because of species misidentification, a lack of monitoring of catch from small vessels, inaccurate fishery statistics, and a lack of standardization for fishery data collection (Jaya et al. 2022)(Napitupulu et al. 2022). Stock assessments are also not consistently performed at the species level. Because some fishery data are collected and used for stock assessments, but data and assessments are not considered fully reliable, this factor is rated "moderately effective."

Supplementary Information

In Indonesia, the fisheries sampling program was started in 1973 {BOLBME 2012}. The system was based on a sampling scheme that collected data by species and fishing gear (FAO 2011). Monitoring of fish landings is undertaken at landing sites

and fishing villages by district officers using census data and interviews (BOBLME 2012). This data is later sent to the Directorate General of Fisheries in Jakarta, which publishes it by WPP (FAO 2011). Indonesia also employs a logbook and e-logbook program, though these are not used fully across vessels, and e-logbook goals have not been met since their implementation (Napitupulu et al. 2022). Historically, vessels under 10 GT have not been monitored for catch data, creating a gap in data coverage.

MMAF is currently working to improve its data collection systems for fisheries with the support of international and local NGOs (CEA 2018). A one-data policy for fisheries was introduced in 2016 to standardize data collection methods and promote the open access nature of fisheries data, but this work is not completed (trends in marine resources). The MMAF also established a national committee for fish stock assessment in 2005 (Komnas KAJISKAN), with the principal task of assessing the impact of fishing on marine resources (CEA 2018). This committee provides recommendations for MSY, exploitation levels, and TACs (Jaya et al. 2022). These are typically provided for species groups (e.g., small pelagics, cephalopods) rather than individual stocks of species.

Western Indian Ocean | Kerala | Bottom trawls

Moderately Effective

Some fishery-dependent data are collected, almost exclusively from trawl fisheries, and are used to develop data-limited stock assessments for individual species and species groups. But no fishery-independent data are collected or used in these assessments, and they are not carried out regularly, nor are they all peer reviewed. Because stock assessments and data collection could be more robust and thorough, this factor is rated “moderately effective.”

Supplementary Information

Stock assessments are performed by CMFRI at the state level, and the most recent assessment that includes status updates for southwest Indian stocks was released in 2023. The assessment used catch data (including amount captured and length-frequency data) from trawl landings for a number of species, including Indian squid (CMFRI 2023). Similar to other stock assessments in India, this report did not include the use of fishery-independent data, such as separate abundance data or observer data. Another recent stock assessment used several decades of trawl landings data, up to 2016, to develop stock status updates for a number of

individual species and species groups (e.g., cephalopods) on India's coasts, including Kerala. This report was peer reviewed and published in an external journal, but again did not use fishery-independent data. In general, there is not a consistent schedule for developing peer-reviewed, robust stock assessment updates for Kerala's fisheries.

India's fishery-dependent data largely lacks landings data collected outside the trawl industry, where nets are sampled using a multistage, stratified random sampling design (CMFRI 2022b). This design began in certain areas of India's coasts in 1959 and has since been expanded (Mini 2014). The number of vessels sampled in each landing center is determined via the total number of vessels landing in that area, because not all vessels are able to be sampled in major port areas (ibid). CMFRI staff who conduct these surveys are given trainings over multiple months. Not all catch data are produced down to the species level, and LVB species that are crushed in nets sometimes cannot be identified (Dineshbabu et al. 2022). Bycatch data come from fisher logs rather than onboard observers, and trawl discards are typically not monitored, creating a reliance on fishers for obtaining discard data (ibid). In Kerala, managers are trying to improve discards monitoring, which currently relies on fisher logs, through the ongoing FIP work (Appukuttan 2022). There is also a new effort in Kerala to improve knowledge of sawfish and juvenile shark interactions, beginning with a questionnaire program that started in November 2023 (CMFRI 2024).

3.4 Enforcement of and Compliance with Management Regulations

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

Western Central Pacific | Thailand | Cast nets

Western Central Pacific | Thailand | Jig

Moderately Effective

Thailand has a history of poor regulatory enforcement and IUU fishing occurring in its waters, but with the 2015 fisheries reforms, it has begun correcting these issues (Kulanujaree et al. 2020). A National Fishing Fleet Survey was performed in 2015, which helped reduce the number of unlicensed vessels, and all fishing vessels must now be registered. Other regulatory and enforcement tactics include VMS requirements, logbooks, port-in port-out procedures, and at-sea inspections. There is less evidence of a lack of compliance since the 2015 reforms, but proper enforcement of all new regulations is still uncertain, leading to a score of

“moderately effective.”

Supplementary Information

After the 2015 fleet survey was performed, all unregistered and/or unlicensed vessels were banned from continuing to fish, and vessels with incorrect licensed activities were made to remedy their paperwork (Kulanujaree et al. 2020). An NPOA for IUU fishing was also developed in 2015, and the Thai government notes that it has made significant progress in cracking down on IUU fishing through its 2015–2019 national FMP (DOF 2020)(Kulanujaree et al. 2020). Increasing penalties for IUU fishers is one method that the Thai government has used to achieve this progress (DOF 2020). Current registration requirements are in place for all commercial vessels; those over 10 GT must submit logbooks, and those over 30 GT must adhere to port-in port-out procedures and install VMS onboard (Kulanujaree et al. 2020). But logbooks are not necessarily independently verified and are allowed a catch amount margin of error of up to 20% (Environmental Justice Foundation 2023). Some at-sea inspections are performed, primarily by the DOF and the Royal Thai Navy, for regulations such as mesh sizes.

Most fishery policies apply only to commercial vessels, which make up just 15–18% of total Thai fisheries (Environmental Justice Foundation 2023). The MSY-based TAE is divided among commercial vessels as a way to maintain a sustainable fishing pressure, but there is no strict enforcement of disciplining vessels that exceed their allotted TAE if the VMS and port-in port-out procedures do not apply to them (ibid). If vessels > 30 GT reach their allocated effort during a season (based on the MSY group assessments), they are prohibited from porting out, which is monitored via VMS. Thus, compliance with TAE regulations may be compromised in smaller vessels. Fishing pressure is also being managed through regulations such as cod-end mesh size restrictions for certain gear types. Since the 2015 reforms, pair trawls have been instructed to implement minimum mesh sizes of 4 cm, but this requirement has not been formally adopted or appropriately enforced by officials (ibid). Coastal fishing pressure is also managed by the implementation of provincial areas where only artisanal vessels are allowed to fish, but the Thai government has noted that this is difficult to police, which suggests that enforcement could be inefficient (DOF 2020).

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

Ineffective

Harvest control rules and fishery regulations in India include seasonal closures,

gear restrictions, and catch size restrictions (Dineshbabu et al. 2022). Although seasonal trawl closures are effectively enforced and complied with, mesh size restrictions and minimum legal size (MLS) regulations often lack full compliance. Vessels lack VMS and onboard observers, and states such as Kerala have noted issues in enforcement capacity. Because compliance around some regulations is poor and enforcement resources are lacking, this factor is rated “ineffective.”

Supplementary Information

Trawl vessels in India are licensed and registered with state governments and undergo some inspections via random sampling (Appukuttan 2022). But consistent, onboard compliance verification via VMS and/or independent observers is lacking, and compliance with bycatch restrictions and landings restrictions is often confirmed solely by fisher logbooks and reporting. Some states have implemented MLS to reduce juvenile bycatch. This has resulted in decreases in juvenile landings, suggesting that MLS are adhered to. But this has also resulted in increases in discards, suggesting that undersized juveniles may still be captured, but are discarded rather than landed, reducing the effectiveness of MLS regulations (Dineshbabu et al. 2022).

Experts and fishers have noted concerns that MLS regulations are not effective without mesh size restrictions. Minimum mesh sizes in trawls have been implemented in some states, but there is evidence of widespread noncompliance with these restrictions (Ali et al. 2014)(Mohammed 2015)(Sayana et al. 2016). A lack of funding, patrol resources, and personnel has also created difficulties in ensuring compliance with fishing regulations (Appukuttan 2022).

Western Central Pacific | Indonesia | Cast nets
Western Central Pacific | Indonesia | Jig

Ineffective

Current Indonesian enforcement measures include onboard observer programs and vessel permitting programs (Jaya et al. 2022). Small-scale vessels, which were historically excluded from required permitting, are now required to have certain registration and permitting documents onboard. But many vessels remain unregistered, despite laws requiring them to do so. IUU fishing has historically been a widespread problem in Indonesia, across both foreign and domestic vessels in the country’s waters (Napitupulu et al. 2022). Although recent government efforts have been aimed at cracking down on IUU fishing by foreign vessels, illegal trawling still

occurs in Indonesian waters, despite the ban on trawling that was reinstated in 2021 (Ramdhani 2022). Because there are known issues with enforcement of permitting laws and compliance with fishing regulations, this factor is rated “ineffective.”

Supplementary Information

Province and district-level fisheries services use a network of community-based surveillance groups, known as Pokmaswas, which report violations of fisheries regulations to law enforcement agencies (OECD 2013). Budget constraints have prevented the fisheries ministry from implementing the number of patrol boats it needs to properly monitor Indonesian waters, making these community volunteer groups especially useful in detecting illegal and destructive fishing practices (Gokkon 2022). But a larger, formal enforcement program is also needed to further prevent noncompliance among fishing vessels, especially given Indonesia’s widespread, historic IUU issues (JALA and Environmental Justice Foundation 2007).

Since 2002, all Indonesian flag vessels over 60 GT have been obligated by law to install a transmitter of a satellite-based vessel monitoring system (VMS). An off-line VMS, which transmits position data when the vessel returns to harbor, is also operated by MMAF for vessels between 30 and 60 GT (OECD 2013). In an effort to enhance transparency, in July 2017 Indonesia became the first country to share its VMS data, with support from Global Fishing Watch (CEA 2018). In addition to VMS installation, larger vessels are also required to obtain permits and registrations from the government. More recently, the regulation Permen-KP No. 25/2020 put in place requirements for small-scale fishing vessels and vessels under 30 GT to obtain and have onboard vessel measurement documents, a vessel deed, vessel permit, fishing registration, fishery business license, and a fishing license (Napitupulu et al. 2022). Many of these vessels remain unregistered.

Western Indian Ocean | Kerala | Bottom trawls

Moderately Effective

In Kerala, vessels are licensed and registered under the KMFRA, which also lays out other harvest control rules such as trawl fishing closures and trawl mesh size restrictions. The FIP process in Kerala has noted some flaws in the current enforcement and compliance of fisheries regulations in Kerala. There is evidence, though, of good compliance with new rules for preventing juvenile landings, with bycatch of juveniles decreasing since the 2017 MLS was put in place (Dineshbabu

et al. 2022). Also, there is evidence of management officials enforcing state-level fishing regulations via patrols and fines for violations in 2022 and 2023 (DOF 2023). Although enforcement of the KMFRA and other regulations is in place, there is some uncertainty about the effectiveness of this enforcement, given that there are still instances of noncompliance, leading to a “moderately effective” score.

Supplementary Information

Regulations are printed in the local gazette but are not always routinely enforced or monitored on vessels. A lack of VMS and observers onboard vessels also contributes to uncertainty around proper enforcement of and compliance with regulations (Appukuttan 2022). Kerala has issues with finances, personnel, and boat capacity for properly enforcing its regulations (ibid). The FIP action plan aims to address these issues, but this work is still ongoing. The government in Kerala is also working to publish an enforcement handbook and hold enforcement officer training sessions (ibid). This handbook had a draft deadline in 2021, but an official handbook has not yet been published. Noncompliance data have not been analyzed by the Department of Fisheries, creating uncertainty around compliance levels in Kerala trawl fisheries. But there is some evidence to support improvements in both enforcement and compliance. Since the MLS was introduced in 2017, landings of undersized species have gone down in Kerala, suggesting that fishers are complying with this regulation by discarding or avoiding catch of juveniles. Further, from April 2022 to January 2023, officials in Kerala conducted 2,357 patrols that resulted in 238 violations that were enforced via fine payments by fishers (DOF 2023). Also, 230 vessels were impounded based on these violations (ibid). The FIP work has also resulted in a clearer understanding of the role the DOF in Kerala must play in enforcing regulations, as well as management council meetings to discuss reviews of management policies and the effectiveness of regulations and their enforcement (Fishery Progress 2024).

3.5 Stakeholder Inclusion

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

Western Central Pacific | Thailand | Cast nets

Western Central Pacific | Thailand | Jig

Highly effective

As part of the 2015 fishery reforms, the Thai government developed three new committees that consult on fisheries management. One of these committees, the

MSY consultation committee, brings together scientists, academics, and fishers (Kulanujaree et al. 2020). The government has also developed two levels of fisheries committees: provincial committees and a national committee. Much of the national and provincial-level management in Thailand is focused on commercial fisheries. These committees comprise government officials, experts in relevant fields (fisheries associations, aquaculture processing, coastal fisheries, etc.), and members with knowledge of natural resources and the environment (Royal Ordinance on Fisheries 2015). Artisanal fisheries, on the other hand, are managed by comanagement schemes between communities, local governments, and NGOs (DOF 2020). The 2015 fishery reform legislation also lays out an explicit requirement for national fisheries management plans to include “an approach to the resolution of conflicts of interests between artisanal and commercial fishing operations” (Royal Ordinance on Fisheries 2015). Because management plans include mechanisms to address conflict, and relevant stakeholders are included in the fisheries committees, stakeholder inclusion is “highly effective.”

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

Moderately Effective

CMFRI conducts stakeholder awareness meetings, trainings, and consultation meetings each year (CMFRI 2020)(CMFRI 2021). Those who participate in these gatherings include fishers (both artisanal and industrial), scientists, boat owners, seafood traders, seafood associations, and government officials (CMFRI 2021). CMFRI also releases its draft national fisheries policies to the public for suggestions and input, with a goal of stakeholder consensus on final policies (ibid). But it is not clear how public input is incorporated into policies, and there are no clear mechanisms to address conflicts between users. While the Indian government does account for input from relevant stakeholders, it seems to lack conflict resolutions, earning a score of “moderately effective” for this rating.

Western Central Pacific | Indonesia | Cast nets
Western Central Pacific | Indonesia | Jig

Moderately Effective

Indonesian fisheries have a long history of community-based management (Bailey and Zerner 1992). But comanagement and community-based management systems are typically hyper-local or focused on specific, small fisheries, rather than being

universally built into national-level management systems stemming from MMAF. While fisheries management in Indonesia has become more decentralized in recent years, stakeholder input and participation in management systems can still be improved. Recent management policies have also introduced some conflict, especially between artisanal and commercial fishers, which has not been effectively addressed by MMAF or other government agencies. Because conflict resolution and comprehensive stakeholder participation need to improve, this factor is rated "moderately effective."

Supplementary Information

When Fisheries Law No. 31 came into effect in 2004, the fisheries management regime in Indonesia shifted from a centralized top-down management to a decentralized bottom-up regime {Courtney et al. 2017}. MMAF considers it essential to collaborate with stakeholders in fisheries management {FAO 2011a}. A series of projects recently undertaken in the country (FAFI project and USAID Oceans' program, among others) have strengthened collaboration between government and different stakeholders in the fish value-chain sector (Wageningen 2018){SEAFDEC 2018}, and it seems that stakeholder consultation processes are regularly undertaken when implementing new fisheries legislations or creating new protected areas (Marine Spatial Planning 2018). Other recent projects involve collaboration with external groups like the FAO and Blue Ventures (Blue Ventures and Environmental Justice Foundation 2022)(iwlearn news CITE). These and other stakeholder engagement and comanagement projects have focused on specific fisheries or villages and have not extended to overall fisheries management in Indonesia. Formal comanagement arrangements between government and communities remain poorly defined, and institutions need to be strengthened to support comanagement. There is a need to develop nested management systems, incorporating them into fishery management planning and law, and defining clear roles of stakeholders on the national, provincial, district, and local bases (Dudley & Ghofar 2007). MMAF did pass a regulation in 2021 that focuses on the development of fisheries management plans (RPPs) and calls for the inclusion of multiple levels of government, plus other stakeholders (academics and experts) in the formation of draft fishery management plans (MMAF 2021). This regulation also discusses the roles of fisheries management councils and working groups, as well as principles of fisheries management, which include community participation (ibid). Social conflict is noted as something taken into account when considering the socioeconomic status of fisheries, but conflict mitigation and resolution mechanisms are not defined.

The government does encourage continuous communication with stakeholders through national committees that have been established for the main targeted seafood species {FAO 2011a}. Also, Indonesia has the largest number of and longest enduring traditional, community-based coastal resource management systems in Southeast Asia {Buchary et al. 2007}. Law 31/2004 set out the principles of comanagement to acknowledge the role of traditional fisheries management systems and the importance of incorporating ecological knowledge in managing fisheries {OECD 2013{Courney et al. 2017}. Some of these traditional management systems, such as “Sasi” (in Maluku and Irian) and “Awig-awig” (in West Nusatenggara and Bali), have been incorporated into local regulation and stakeholder engagement projects (Dudley & Ghofar 2007)(OECD 2013)(Blue Ventures and Environmental Justice Foundation 2022). But recent fisheries policy changes have created conflict among fishing groups, with many stakeholders claiming that these changes undermine the rights and participation of artisanal fishers while favoring commercial fishers (Gokkon 2023). With the majority of Indonesian fisheries being small-scale, critics say that policies like the new quota-based system subtract from the ability of local governments and fishing communities to participate in fishery resource management (ibid).

Western Indian Ocean | Kerala | Bottom trawls

Moderately Effective

On a national level, CMFRI conducts stakeholder awareness meetings, trainings, and consultation meetings each year (CMFRI 2020)(CMFRI 2021). Those who participate in these gatherings include fishers (both artisanal and industrial), scientists, boat owners, seafood traders, seafood associations, and government officials (CMFRI 2021). In Kerala, public meetings are held to discuss proposed fishing regulation amendments, though it is not clear how stakeholder input from these meetings is incorporated into regulatory changes (Appukuttan 2022). The 2017 amendment to KMFRA requires the government to develop participatory management councils at the village, district, and state levels, but this process has not been formalized because the amendment is not fully implemented (Appukuttan 2022). But a state fishery management council has been formed and has met five times since 2020 (as of March 2023), and district management councils have also been formed and met (Fishery Progress 2024). Village councils, though, have yet to be formed. The KMFRA does have built-in tools for resolving legal disputes and outlines the rights of traditional fishers in order to minimize conflict between the traditional and mechanized fishing sectors. Although the Kerala government does

account for input from relevant stakeholders via the 2017 KMFRA Amendment, this process is not yet fully developed, earning a score of “moderately effective” for this rating.

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	Physical Impact of Fishing Gear on the Habitat/Substrate	Modifying Factor: Mitigation of Gear Impacts	Ecosystem-based Fisheries Management	Forage Species?	Score
Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls	Score: 1	Score: 0	Moderate Concern	No	Red (1.732)
Eastern Indian Ocean, Western Indian Ocean | Bottom trawls	Score: 2	Score: 0	Moderate Concern	No	Yellow (2.449)
Western Central Pacific | Indonesia | Cast nets	Score: 4	Score: 0	Moderate Concern	No	Green (3.464)
Western Central Pacific | Indonesia | Jig	Score: 5	Score: 0	Moderate Concern	No	Green (3.873)
Western Central Pacific | Thailand | Cast nets	Score: 4	Score: 0	Moderate Concern	No	Green (3.464)
Western Central Pacific | Thailand | Jig	Score: 5	Score: 0	Moderate Concern	No	Green (3.873)
Western Indian Ocean | Kerala | Bottom trawls	Score: 2	Score: 0	Moderate Concern	No	Yellow (2.449)

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.*

4.1 Physical Impact of Fishing Gear on the Habitat/Substrate

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

Score: 1

Commercial trawl fisheries for squid species most often employ shallow bottom trawls that catch squid populations during the day when squid is close to the seabed. Trawls designed for squid fishing generally have a higher head rope than is usual for finfish, avoiding the contact of the gear with the substrate {FAO 2005} {Stobutzki et al. 2006}(Thomas et al. 2006). But this is a mixed fishery, in which squid is caught as bycatch of the target fish fishery, and it is considered that the gear come in direct contact with the benthos. Although some areas have been protected in Thailand to protect vulnerable habitats, information is limited and there is the potential for the gear to contact sensitive habitat. Therefore, a score of “1” is given for the Thai trawl fisheries in this section.

Supplementary Information

The impact of bottom trawling on the habitat is well documented. All the components involved in trawling (doors, chain, weights, etc.) have the capability to affect the seabed, destroying benthic ecosystems (Oceana 2008). Bottom trawling reduces habitat complexity, species richness, and biomass, and increases the presence of opportunistic species by altering the species composition {Morgan and Chuenpagdee 2003}. Homogenization of habitats risks the loss of ecological function and natural heritage values, reducing resilience, thereby predisposing the system to sudden and dramatic change (Hiscock et al. 2006).

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls Western Indian Ocean | Kerala | Bottom trawls

Score: 2

Directed squid trawl fisheries in India employ off-bottom and semi-pelagic trawls (CMFRI 2022b) that catch squid populations during the day when squid is close to the seabed. Trawls designed for squid fishing generally have a higher head rope than is usual for finfish, avoiding the contact of the gear with the substrate {FAO 2005}{Stobutzki et al. 2006}(Thomas et al. 2006). Although squid catches originated in India as bycatch in shrimp trawls, fishers now employ separate, squid-specific gear to target Indian squid. But some squid catches still come from on-bottom

shrimp trawls. The FIP for Kerala trawls notes that, while there is no evidence of the fishery interacting with vulnerable marine ecosystems (VMEs), there is also no evidence that it does not interact with VMEs. Because of the potential threat that off-bottom and semi-pelagic trawls present to the seafloor, a score of “2” is given for the Indian trawl fisheries.

Western Central Pacific | Thailand | Cast nets
Western Central Pacific | Indonesia | Cast nets

Score: 4

Squid fishing is usually done at night, using lights to attract the squid to the surface. When the squid is concentrated around the fishing boat, falling nets (cast nets) or lift nets are used to catch it. A cast net catches the squid by falling and closing in on them (FAO 2018), and although it can contact the seabed when used in shallow waters, the impact of this net on the habitats seems to be low or nonexistent.

Western Central Pacific | Thailand | Jig
Western Central Pacific | Indonesia | Jig

Score: 5

Jigging for squid is usually done at night, using lights to attract the squid to the surface where it is caught with a kind of grappling hook attached to a fishing line. This fishing method is considered environmentally responsible: there are virtually no habitat impacts, because the lines do not contact the seafloor (SFW 2018).

4.2 Modifying Factor: Mitigation of Gear Impacts

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

Score: 0

Thailand has put in place a range of management and technical measures through the Fisheries Act B.E. 2558 (2015). The technical management measures implemented include controlling the number and size of fishing gears (trawls and other gears), freezing the number of trawl licenses, protecting spawning stock and juveniles through closed seasons and areas and demarcation zones between artisanal and commercial fisheries, and increasing the mesh size to reduce the

catch of juveniles (DOF 2015). Marine Protected Areas (MPAs) have been declared in the country, covering 7.3% of the total marine area (DOF 2020). But as explained in the previous sections, these measures are not adequately enforced in the country. The benefit of closed seasons/closed areas in terms of fishing capacity reduction is small, because fishing vessels moving to operate in other fishing grounds worsen the problem of overfishing in other areas; as soon as the closed area is opened, they move back to fish in their usual fishing grounds (Khemakorn 2015). Therefore, it is considered that mitigation of gear impacts in this fishery is not adequate, and no extra points are given.

Supplementary Information

Thailand currently has 25,593 km^2 of its marine waters under some form of MPA (fish reserve areas, environment protected areas, marine national parks, nonhunting areas, and wetlands). As of 2020, Thailand also had 2,550.34 km^2 of mangrove and biosphere reserve areas along its coasts (DOF 2020). But approximately 80% to 90% of mangrove forests had disappeared in the previous 20 to 30 years along the Gulf of Thailand, and 20% disappeared along the Andaman coast (DOF 2015). From 2015 to 2017, the country had 238.33 km^2 and 255.73 km^2 of coral reef and seagrass beds, respectively; however, it was estimated that, in the Andaman Sea coast, only 12% of that coral reef was in good condition. All these habitats were threatened by overexploitation, physical modification of the area due to trawling, nutrient and sediment pollution, etc. (DOF 2015).

Although closed areas can be reopened, this reopening may only be partial, because closures can remain in place for aspects such as fish migration and avoiding concentrated fishing effort. VMS on larger vessels are used to monitor their locations, which helps ensure that they are not fishing in closed areas, but as noted in Criterion 3, vessels under 30 GT are not required to install VMS.

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

Score: 0

The Indian authorities have implemented a series of management measures to reduce the impact of the trawl fishery on the habitat. The technical management measures implemented include seasonal closures for mechanized vessels and depth restrictions; however, these seasonal fishing bans are not adequately enforced. A series of alternative measures (closures or moving rules for areas with a high proportion of juveniles) have been proposed by several authors but are not

yet implemented {Kumar and Deepthi 2006}(Dineshbabu 2013). In 2015, there were a total of 128 Marine Protected Areas in India. Of these, there were 4 Marine National Parks; 67 Marine Sanctuaries, National Parks, and Wild Life Sanctuaries; and 3 Marine Biosphere Reserves (Laxmilatha et al. 2015). These MPAs protect coral reefs, seagrass beds, mangroves, and other areas. But more work is still necessary to assess the status of the resources and the habitats in India and monitor the impact of the conservation measures implemented within the protected areas (Laxmilatha et al. 2015). Although institutions and laws are, in theory, sufficient to manage and protect these features in Indian waters, authorities have taken little effective action in implementing these laws, which has resulted in an increasing rate of destruction to these marine habitats (Saroj et al. 2016). Therefore, it is considered that mitigation of gear impacts in this fishery is not adequate ,and no extra points are given.

Western Central Pacific | Indonesia | Cast nets
Western Central Pacific | Indonesia | Jig

Score: 0

Cast nets and jigs do not impact the seabed, or they have a minimal impact on it. Therefore, this factor is not scored.

Supplementary Information

Indonesia’s most recent regulatory changes and suggestions have a goal of placing 20% of each WPP’s marine area in MPAs, but this is still in the early stages (Jaya et al. 2022).

Western Central Pacific | Thailand | Cast nets
Western Central Pacific | Thailand | Jig

Score: 0

Cast nets and jigs do not impact the seabed, or they have a minimal impact on it. Therefore, this factor is not scored.

Western Indian Ocean | Kerala | Bottom trawls

Score: 0

Work in Kerala to understand the impacts of the trawl fishery on the benthic habitat is ongoing. Mapping of coastal habitats to understand where sensitive habitats are located is one of the first steps in this process, and the FIP began working toward this goal alongside the Fishery Survey of India in 2022 (Fishery Progress 2023). The Indian government is considering the creation of a conservation plan for sensitive habitats in Kerala and other states, but this work has so far only resulted in a road map for what this process might look like (ibid). Currently, no mitigation measures are in place that allow for the improvement of trawl impacts on benthic habitat in Kerala.

4.3 Ecosystem-based Fisheries Management

Eastern Indian Ocean, Western Central Pacific | Thailand | Bottom trawls

Western Central Pacific | Thailand | Cast nets

Western Central Pacific | Thailand | Jig

Moderate Concern

Thailand's governance and management framework for fisheries and aquaculture was structurally reformed to promote sustainable and responsible practices through the new Royal Ordinance on Fisheries B.E. 2558 (2015) adopted in November 2015. One of the key objectives of that law specifically refers to the EBFM's "use of best available scientific evidence to achieve long-term economic, social, and environmental sustainability, in line with the ecosystem-based approach and precautionary approach, to ensure that fisheries resources are maintained or restored to a level that can produce the maximum sustainable yields" (Royal Ordinance on Fisheries 2015). Much of this work is still ongoing and remains in the early stages of goal and priority setting. In 2021, the Thai marine ecosystem showed "few signs" of recovery despite reforms in place since 2015 (Environmental Justice Foundation 2023). Thus, there is some ecosystem-based management, and plans for EBFM are in place; however, stronger, fully implemented policies are needed to wholly protect the ecological role of squid and other capture species. Therefore, this factor is rated a "moderate concern."

Supplementary Information

A series of measures aiming to protect the ecosystem are in place in Thailand, such as closed areas and closed seasons, including limitations for certain fishing methods; a reserved zone within 3 km from shoreline where engine-powered boats cannot fish, to preserve nursing areas of juvenile fish and invertebrates; and

installation of artificial reef to obstruct trawling. A Marine Fisheries Management Plan was also developed, and more stringent gear regulations were implemented, including limits on days at sea and total allowable catch (TAC) limits based on the maximum sustainable yield (MSY), with the objective of reducing overfishing and overcapacity of the Thai fleet (DOF 2015){OECD 2017}. The most recent (2020–22) Thai marine fisheries management plan maintains EBFM as a key principle. The DOF is also working to implement Ecosystem Approach to Fisheries Management programs in various coastal communities via consultations and training, with a goal of implementing five projects per year (DOF 2020).

Eastern Indian Ocean, Western Indian Ocean | Bottom trawls

Moderate Concern

The Indian government has implemented several research projects that will be used to increase the use of EBFM in its fisheries. International organizations such as the FAO have also implemented projects in countries such as India toward this end. Some management measures are in place to protect ecosystem functioning, but stronger policies based on the results of ongoing projects are needed to fully prevent detrimental food web impacts. Because EBFM policies should be strengthened, this factor receives a “moderate concern” rating.

Supplementary Information

A number of FAO projects, such as the Bay of Bengal Large Marine Ecosystem project (BOBLME) or the Strategies for Trawl Fisheries Bycatch Management (REBYC II CTI), introduced the EBFM concept in South Asia, including India, thorough a series of initiatives on EBFM for scientist and fisheries managers in South Asia, including India {Muralidharan 2017}. In 2018, the Indian government embarked on the “Blue Revolution: Integrated Development and Management of Fisheries” initiative, which aims to achieve economic prosperity for the country and the fishers and fish farmers, as well as contribute toward food and nutritional security through full potential utilization of water resources for fisheries development in a sustainable manner, while keeping in view biosecurity and environmental concerns (DAHD 2018).

More recent research projects from the Indian government include biomass dynamics modeling and ecosystem assessment benchmarks. Modeling studies have been used to look at how predator-prey dynamics, environmental variables, and fishing pressure affect the biomass of several species often caught in multiday

trawls (CMFRI 2021). Similar modeling has been used to create management suggestions for 223 fish stocks across Indian coastal states, though some of these reference points are for species groups rather than individual species, and they are derived from fishery landings data (ibid). The government also continues to work on creating indicators and guidelines for EBFM. The first step of this process has been to expand its database of captured species, which dates back as far as 1985 for some states (ibid). This allows researchers to examine potential ecosystem impacts based on changing catch dynamics, and it will eventually be used to create suggestions for EBFM, though this process is not complete.

Some management measures aimed to protect the ecosystem have been implemented in the country, such as protected areas, a trawl ban during the monsoon season, and a new ban for ring seiners in Kerala and other areas. The CMFRI has also undertaken a series of studies to understand the impact of fisheries on marine resources and the ecosystem (CMFRI 2018). Although it cannot be considered that EBFM is fully implemented in the country, some policies aimed to protect the ecosystem have been implemented. But their effectiveness has not yet been proved, and it often appears that the laws aimed to protect the ecosystem are not adequately enforced by the authorities (Saroj et al. 2016).

Western Central Pacific | Indonesia | Cast nets
Western Central Pacific | Indonesia | Jig

Moderate Concern

The Indonesian government has made some progress toward implementing EBFM in its approach to fisheries. Scientific assessments and management efforts to account for ecological roles of marine species in Indonesia are underway. The sustainability of marine ecosystems has become a major concern to the Indonesian government (Kirana et al. 2016). But it seems that regulations to support the adoption and implementation of EBFM have not yet been fully implemented in the country, and current efforts are not always properly enforced. Though there is some ecosystem-based management in place, detrimental food web impacts are possible because stronger policies are needed to fully protect the ecological role of squid. Therefore, this factor is rated a “moderate concern.”

Supplementary Information

The Indonesia Coral Triangle Initiative on Coral Reefs (CTI-CFF) National Coordinating Committee (NCC) was formed in 2009 to lead the in-country

implementation of the CTI-CFF Regional Plan of Action and the Indonesia CTI-CFF National Plan of Action (NPOA), a multigovernment partnership aiming to safeguard the region's marine and coastal resources (Pomeroy et al. 2013). Under this initiative, six countries in the area adopted a regional plan of action with five overarching goals: 1) strengthening management of seascapes; 2) applying an ecosystem approach to fisheries management (EAFM); 3) developing and strengthening the management of marine protected areas; 4) implementing climate change adaptation measures; and 5) protecting threatened marine species. Specifically, the CTI-CFF agreed to work collaboratively to "develop a common regional framework for legislation and policy that would support EAFM and strengthen regional and national legislation, policies, and regulations" (Pomeroy et al. 2013).

The government of Indonesia is implementing a roadmap toward EAFM, the progress of which is supported by key stakeholders including the Ministry of Marine Affairs and Fisheries, Marine and Fisheries Research Agency, district and provincial fisheries agencies, scientific institutes, universities, and NGOs. At the national level, the NCC has led the following successful efforts: identification of priority seascapes; completion of zoning regulations for fishing gears that support sustainable fisheries; designating a 1.2 million-hectare marine park as a protected area; conducting community information campaigns on climate change; development of a school for marine conservation; and the institutionalization of a marine protected area training curriculum (Coral Triangle Initiative 2018). About 23 million hectares of Indonesia's waters lie within MPAs, though these are a mixture of no-take zones and areas where fishing is meant to be more closely monitored (Jaya et al. 2022). Staff and budget limitations have reduced the efficacy of these areas in protecting marine fauna (Napitupulu et al. 2022). The government has also stated that individual provinces must develop marine spatial plans that will lead to MPAs, but this work has not been completed (Jaya et al. 2022). A national-level goal of placing 10% of the country's waters (32.5 million hectares) in MPAs by 2030 is in place, but enforcement of protections and rules within these areas needs to come with this extension of protected areas (Napitupulu et al. 2022). EAFM is discussed as one of the guiding principles for fisheries management in Regulation 22 of 2021, but details for achieving EAFM are lacking (MMAF 2021). Some fishery management plans in Indonesia have begun to incorporate elements of EAFM, but this has not been done for squid fisheries, which generally lack harvest strategies and species-specific fishery management plans, and thus do not account for squids' ecological role.

Western Indian Ocean | Kerala | Bottom trawls

Moderate Concern

The Indian and Kerala governments have embarked on several research projects to increase the use of EBFM in fisheries. Some management measures are in place to protect ecosystem functioning, and goals of increasing these measures are also in place, but stronger, actionable policies are needed to fully prevent detrimental food web impacts. Because policies should be strengthened, this factor receives a “moderate concern” rating.

Supplementary Information

Kerala trawls capture many different finfish, cephalopod, and invertebrate species. Many of these are prey species for larger predators in the local marine ecosystem. Detrimental food web impacts are possible, though there is not evidence to suggest that they are particularly likely. Fishers are flexible in which species they primarily target, based on perceived abundance shifts (Appukuttan 2022). Through the ongoing FIP, the Kerala trawl industry is working to improve its adoption of EBFM.

Recent research projects from the Indian government include biomass dynamics modeling and ecosystem assessment benchmarks. Modeling studies have been used to look at how predator-prey dynamics, environmental variables, and fishing pressure affect the biomass of several species often caught in multiday trawls (CMFRI 2021). Similar modeling has been used to create management suggestions for 223 fish stocks across Indian coastal states, though some of these reference points are for species groups rather than individual species, and they are derived from fishery landings data (ibid). The government also continues to work on creating indicators and guidelines for EBFM. The first step of this process has been to expand its database of captured species, which dates back as far as 1985 for Kerala (ibid). The expansion of this database was initiated by Kerala through an EBFM project based there. This allows researchers to examine potential ecosystem impacts based on changing catch dynamics, and it will eventually be used to create suggestions for EBFM, though this process is not complete.

In 2021, an EBFM case study was completed in Kerala. This study developed an Ecopath with Ecoism (EwE) model for Kerala’s marine fishery ecosystem, which was done with the help of the Lenfest Program (Kuriakose et al. 2021). Results from this work have been used to recommend management changes to the government, but no changes have been made thus far. In Kerala, like in other Indian states, a trawl fishery closure is in place during the monsoon season, from June 15 to July 31

(Appukuttan 2022). Although this closure helps protect the marine ecosystem during the summer, the EwE model suggests that the closure would provide more protection if it were moved to November–December. Currently, a mechanized trawl ban is also in place in inshore areas (within 12 nm of the coast) of Kerala (ibid). Otherwise, pressure on the ecosystem is limited via fishing effort limitations put in place by the moratorium on construction of new fishing vessels over 12 m in length (ibid).

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Appendix A: Update to the Indian, Mitre, and Swordtip Squid Report

Updates to the March 2, 2020 Indian, mitre, and swordtip squid report were made on February 3, 2025.

The overall recommendations for Indian, mitre, and swordtip squid caught by trawls in Thailand and India, as well as by cast nets in Thailand and Indonesia, maintained a red rating. The newly assessed Kerala trawl fishery also received a red rating. Jig fisheries in Thailand and Indonesia improved from red to yellow ratings. Changes within individual criteria are outlined in the following:

Updates included:

- Overall: The Kerala trawl fishery was added as a new fishery to this report. Kerala is assessed separately from the rest of India's fisheries because it is undergoing a Fishery Improvement Project, so information and data availability, as well as regulations, differ from the rest of India.
- Introduction: Figures and text were updated using more recent landings and trade data.
- Criterion 1: Productivity-susceptibility analyses (PSAs) were updated, resulting in a shift from red to yellow scores for jig fisheries. Fishing mortality scores were also updated to reflect the lack of up-to-date fishing mortality estimates for squid fisheries in this report.
- Criterion 2: Several bycatch species were added via the use of the Unknown Bycatch Matrix (UBM) in fisheries where full catch composition data are unavailable (trawls in Thailand and India), although additional information on Thai landings was used to modify UBM species in these fisheries. Some updates were made to fishing mortality and abundance scores, based on recent stock assessments and information from managers. Finfish and forage fish were merged into a single "finfish" category.
- Criterion 3: Cast nets were lowered from a "highly effective" score to a "moderately effective" score for factor 3.2 because of their known bycatch of finfish species. Scores were added for factors 3.3 to 3.5, even though they do not contribute to the overall Criterion 3 score because factor 3.1 remained "ineffective" for all fisheries.
- Criterion 4: India's trawls were changed in factor 4.2 from a score of 1 to 2, following information from managers that squid trawls in India operate more as off-bottom gear than shrimp trawls, which operate directly on the bottom.

This information and the subsequent change does not apply to Thai trawl fisheries.