Blue swimming crab

Portunus pelagicus

India: Indian Ocean

Gillnets and entangling nets, Bottom trawls

Report ID 911

August 1, 2022

Seafood Watch Standard used in this assessment: Fisheries Standard v4

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About Seafood Watch

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

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

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

- Seafood rated Best Choice comes from sources that operate in a manner that's consistent with our guiding principles. The seafood is caught or farmed in ways that cause little or no harm to other wildlife or the environment.

- Seafood rated Good Alternative comes from sources that align with most of our guiding principles. However, one issue needs substantial improvement, or there's significant uncertainty about the impacts on wildlife or the environment.

- Seafood rated Avoid comes from sources that don't align with our guiding principles. The seafood is caught or farmed in ways that have a high risk of causing harm to wildlife or the environment. There's a critical conservation concern or many issues need substantial improvement.

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

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

Guiding Principles

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

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

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

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

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

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

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

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

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

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

Summary

Blue swimming crab (BSC) is a brachyuran crab in the Portunidae family. It is common throughout the Indo-Pacific region, occupying inshore and continental shelf habitats including sand, mud, algae, and seagrasses near reefs and mangroves, and it is found in the intertidal region to depths of 50–70 m. This report assesses the sustainability of BSC (*Portunus pelagicus*) caught using bottom-set gillnets/entangling nets and bottom trawls in India. The most significant BSC fisheries are in the southeastern state of Tamil Nadu, in a region known as Palk Bay. To a lesser extent, the BSC is also caught in India along the west coast (in the states of Kerala, Karnataka, Goa, Maharashtra, and Gujarat) and along the east coast north of Tamil Nadu (in the states of Andhra Pradesh, Odisha, and West Bengal). The state of Tamil Nadu ranks highest in its landings of BSC. Approximately 74% of the landings from the state between 2007 and 2017 were caught using gill nets, and 36% by trawl nets.

A recent stock assessment of BSC in the Palk Bay fishery of Tamil Nadu was conducted in 2019, using data from 2007 to 2017. These data indicate that BSC in Tamil Nadu is overfished, but the stock is in the rebuilding stage, and is not currently experiencing overfishing. No other stock assessments of BSC have been conducted from Karnataka or other locations in India in the last 10 years.

Gillnets are considered selective gear, whereas trawl nets are nonselective; however, both gear types are capable of catching nontarget species. By-catch data from the BSC gillnet fishery in Palk Bay showed that a few endangered, threatened, and protected (ETP) species were incidentally caught in the nets, including stingrays, sharks, and sea cucumbers. Further, gillnets also have a high probability of catching ETP species such as sea turtles and seahorses found in the region. Because no catch composition data were available for the other BSC fisheries in India, the Seafood Watch Unknown By-catch Matrix was used to determine potential incidental threats to ETP species. No harvest control rules are in place in any of the BSC fisheries in India to ensure that the stock is managed appropriately, and no by-catch reduction strategies are in place to ensure that incidental catch of ETP species is reduced.

Trawls typically have a larger impact on the habitat and ecosystem than gillnets, and this impact is higher in seagrass meadows and coral reefs where BSC is occasionally fished.

Overall, all the BSC fisheries in India have been rated as red or Avoid, due to concerns about management and by-catch in all the BSC fisheries, and the impact of trawls on habitats and ecosystems in regions where BSC fisheries use trawl nets.

Final Seafood Recommendations

SPECIES | FISHERY	CRITERION 1 TARGET SPECIES	CRITERION 2 OTHER SPECIES	CRITERION 3 MANAGEMENT	CRITERION 4 HABITAT	OVERALL RECOMMENDATION
Blue swimming crab | Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra	2.644	1.000	0.000	0.000	**Avoid (0.000)**
Blue swimming crab | Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal	2.644	1.000	0.000	2.000	**Avoid (0.000)**
Blue swimming crab | Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu	3.413	1.000	1.000	1.414	**Avoid (1.482)**
Blue swimming crab | Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra	2.644	1.000	0.000	2.449	**Avoid (0.000)**
Blue swimming crab | Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal	2.644	1.000	0.000	3.000	**Avoid (0.000)**
Blue swimming crab | Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu	3.413	1.000	1.000	3.000	**Avoid (1.789)**

Summary

Fisheries for blue swimming crab (BSC) in India are given an Avoid rating by Seafood Watch. Although the stock status in Tamil Nadu is improving, and is currently not experiencing overfishing, management and by-catch need to be addressed in all the BSC fisheries. The impact of trawls on habitats and ecosystems in regions where BSC fisheries use trawl nets is also a cause for concern.

Eco-Certification Information

There is a fishery improvement project (FIP) in place in the blue swimming crab Tamil Nadu gillnet fishery. The FIP was launched in 2019 and has currently completed its second year of operation. The FIP is a tripartite initiative that brings together fishing communities, government authorities, and seafood processors to improve the biological and ecological status of the fishery and to implement management

measures that will ensure a sustainably managed fishery now and in the future.

Scoring Guide

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

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

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

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

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

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

Introduction

Scope of the analysis and ensuing recommendation

This report includes recommendations for blue swimming crab (*Portunus pelagicus*), a large-bodied benthic crustacean, caught by bottom-set gillnets/entangling nets and bottom trawls in India. The most significant blue swimming crab fisheries are in the southeastern state of Tamil Nadu, in a region known as Palk Bay. To a lesser extent, the blue swimming crab is also caught in India along the west coast (in the states of Kerala, Karnataka, Goa, Maharashtra, and Gujarat), and along the east coast north of Tamil Nadu (in the states of Andhra Pradesh, Odisha, and West Bengal).

Species Overview

Species background

Blue swimming crab (BSC) is a brachyuran crab in the Portunidae family. Crabs from this family are usually recognized by their flat, disc-shaped hind legs, used as paddles for swimming, and by the nine spikes or horns along their carapace, on either side of their eyes (Kangas, M. I. 2000)(Government of Western Australia, Department of Fisheries 2011). BSC shows sexual dimorphism: the male is bright blue in color with white spots and characteristically long chelipeds, whereas the female is a duller green or brown, with a more rounded carapace (Kangas, M. I. 2000)(Jose et al. 2019). BSC is common throughout the Indo-Pacific, occupying inshore and continental shelf habitats including sand, mud, algae, and seagrasses near reefs and mangroves, and is found in the intertidal region to depths of 50–70 m (Ingles, J. A. 2004)(Kangas, M. I. 2000)(De la Cruz, M. T. et al 2015). It has a rapid growth rate and a short lifespan of about 3 years {Jose, J & N. G. Menon 2007}(Jose et al. 2019).

BSC matures quickly (in about 1 year); the male attains sexual maturity at a mean size of approx. 82.25 mm carapace width (CW), and the female attains sexual maturity at a mean size of approx. 120.43 mm CW (Jose et al. 2019). The species is a continuous breeder with high fecundity and can spawn multiple times a year in tropical regions {Jose, J & N. G. Menon 2007}(Jose et al. 2019). In Tamil Nadu, berried females were observed in trawl catches throughout the year, but from April to July, most females encountered were berried, indicating that this could be the peak spawning season along the southeast coast of India {Jose, J & N. G. Menon 2007}. In contrast, the peak breeding season along the west coast of India was observed by Sukumaran (1999) to be from January to February and in September, and by Dineshbabu et al. (2008) to be from February to March and from May to June (Sukumaran, K. K. 1999) (Dineshbabu A. P. et al. 2008). The female BSC mates only during molting, with the male crab carrying and protecting it until molting and mating occurs (Kangas, M. I. 2000). After mating, the female stores sperm in the spermatheca (Kangas, M. I. 2000). Spawning usually takes place in the night; fertilization is external and the eggs are attached to the pleopods of the mother till they are hatched (Kangas, M. I. 2000). In Tamil Nadu, the total number of days of incubation ranged from 8 to 10 (Jose et al. 2019) and generally depends on the water temperature (Kangas, M. I. 2000). Spawning generally takes place in the ocean, at the entrance of estuaries or in coastal waters (Kangas, M. I. 2000). The females is thus ovigerous and a partial brooder (Kangas, M. I. 2000). The fecundity of females in Tamil Nadu ranges between 60,000 and 1,976,398 in crabs with carapace widths of 100 to 190 mm (Jose, J. 2013). Similarly, along the west coast of India, the fecundity was found to range between 44,000 to 1,190,000 eggs (Sukumaran, K. K. 1999).

Overall, BSC is an opportunistic omnivore, bottom-feeding carnivore, and scavenger, with a preference for animal food (Jose, J. 2011b) (Kangas, M. I. 2000). From studies in the Palk Bay, the diet of BSC comprises crustaceans, mollusks, fishes, unidentifiable matter, and debris, with crustaceans being the dominant food source (Jose, J. 2011b). Nevertheless, in larger-sized adults, fish and miscellaneous material composed the dominant food source (Jose, J. 2011b). Predators of BSC include sea jellies, other crabs, sharks, rays, and birds (Kangas, M. I. 2000)(Government of Western Australia, Department of Fisheries 2011).

Background of the blue swimming crab fishery in India

BSC is an important species in many regional fishing industries in South and Southeast Asia; such as in Indonesia, the Philippines, Vietnam, Cambodia, Malaysia, Thailand, India, and Sri Lanka (Ingles, J. A. 2004)(Jose et al. 2019)(Creech, S. 2014)(De la Cruz, M. T. et al 2015)(FAO 2022) (Figure 1).

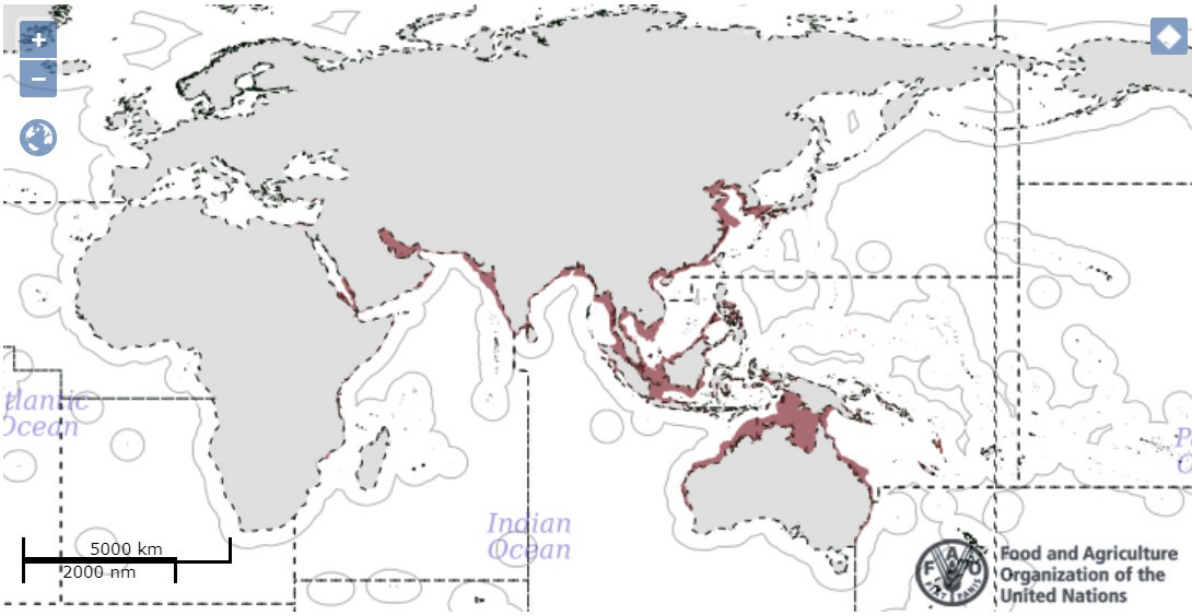

Figure 1. Global distribution of BSC. Taken from (FAO 2022).

In India, BSC is an economically valuable crab, and most of its products are exported to the United States (Jose et al. 2019). The state of Tamil Nadu along the southeastern coast is the largest producer of BSC in India; in particular, most of these crabs are caught in Palk Bay, an area which forms a shallow sea that spans 13,892 km^2 between India and Tamil Nadu (Jose et al. 2019). In Palk Bay, the harvested BSC is sold directly to processing companies that collect crabs from collection centers at landing sites (Jose et al. 2019). The average wholesale price of BSC is INR 250–300/kg (Jose et al. 2019). Landed crab are steam-cooked when fresh at collection centers (Jose et al. 2019); thereafter, the cooled, cooked crabs are transported to processing units, where the crab meat is picked, further processed, and subjected to quality control protocols (Jose et al. 2019). The crab meat is then graded, packed, and stored until it is shipped (Jose et al. 2019). Currently, the export price of BSC from India is USD 10–11 US$ per can (Jose et al. 2019). In contrast, in the western state of Karnataka, the local demand for BSC is high because it is considered a delicacy (Sukumaran, K. K. 1999).

Management

In India, the Department of Fisheries, under the Ministry of Fisheries, Animal Husbandry and Dairying, develops overarching marine fisheries policies to manage resources up to 200 nautical miles from the coastline, within India's exclusive economic zone (EEZ) (Government of India 2021). Further, each of the nine coastal states in India is responsible for developing fisheries policies, and managing and enforcing the fisheries resources within the 12 nautical miles of its territorial waters, through State Fisheries Departments. The Marine Police of each coastal state also plays an important role in fisheries enforcement. In addition, in certain regions, local institutions play a role in fisheries management and enforcement (Jentoft, S. et al. 2009)(Salagrama, V. 2014). The State Forest Departments are responsible for enforcing rules per the Indian Wildlife Protection Act (1972), to protect and conserve Schedule species.

FIP

The Indian BSC fishery improvement plan (FIP) was initiated by the Crab Meat Processors Association (CMPA) in 2019. The CMPA acts as a focal point for FIP work, oversees and coordinates FIP activities, and engages stakeholders involved in the FIP, including (1) seafood companies; (2) government departments and institutions such as the state Department of Fisheries, the Central Marine Fisheries Institute (CMFRI), and the Marine Products Export Development Authority (MPEDA); (3) nongovernmental organizations such as WWF-India and OMCAR Palk Bay Environmental Education and Research Center; and (4) academic organizations such as the Tamil Nadu Dr. J. Jayalalithaa Fisheries University and the M. S. Swaminathan Research Foundation. The aim of the FIP is to gather all those associated with the Indian BSC fishery to create and implement a local plan that will improve the economic, social, and ecological sustainability of the fishery.

Production Statistics

The global capture production of BSC has steadily increased since the early 1950s, highlighting the importance of this fishery worldwide (FAO 2021) (Figure 2). In 2018, the total global live weight capture production of BSC was 298 thousand tonnes (FAO 2020).

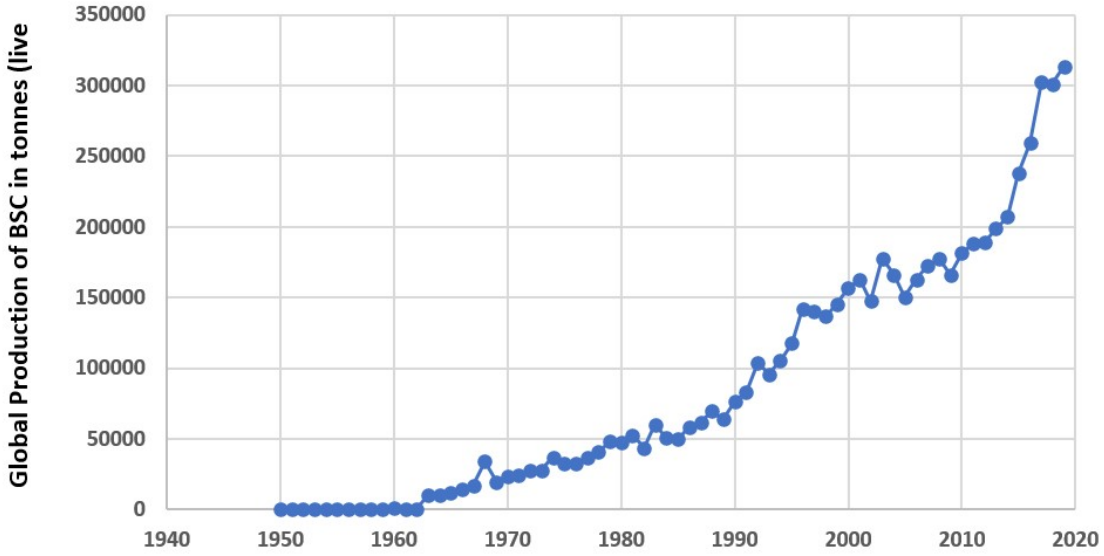

Figure 2. Global capture production of BSC from 1950–2019. Data taken from (FAO 2021).

BSC is also an important part of the crustacean fishery in India {Jose, J & N. G. Menon 2007}, where it is targeted in small-scale fisheries and caught as by-catch in trawl nets along the east and west coasts (Jose et al. 2019). In 1975, the total landings of BSC from India were 19,893 tonnes; by 2017, landings increased to 53,476 tonnes (Jose et al. 2019) (Figure 3).

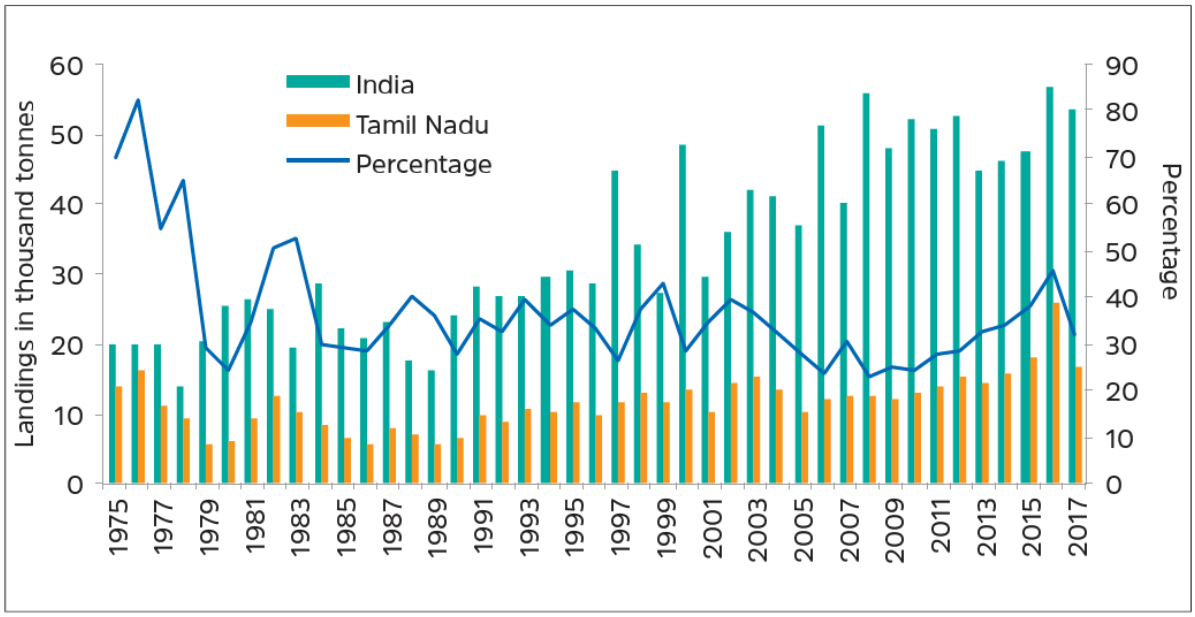

Figure 3. Total BSC landings in India from 1975–2017. Taken from (Jose et al. 2019).

The state of Tamil Nadu in the southeast ranks highest in its landings of BSC; Palk Bay and the Gulf of Mannar in particular contribute the major share of the fishery, which operates year-round (Figure 4, inset) {Jose, J & N. G. Menon 2007}(Jose et al. 2019). BSC is fished in the coastal districts of Ramanathapuram, Pudukkottai, and Thanjavur that border Palk Bay (Figure 4) (Jose et al. 2019). The

fisher population in this region is approximately 250,000; most of these fishers belong to traditional fishing families, and are designated as "BPL" or "Below Poverty Line" (Jose et al. 2019).

The total landings of BSC in the state from 2007–2017, a period of 11 years, were 75,843 tonnes, of which 74% were caught using gillnets and 36% by trawl nets (Jose et al. 2019). The annual average landings of BSC from the state were 8,900 tonnes from 2007–2017 (Jose et al. 2019). In Tamil Nadu, BSC is targeted in traditional bottom-set gillnets or entangling nets known as *nanduvalai*, and are also caught as by-catch in trawl nets (Figures 5, 6, and 7) (Jose et al. 2019).

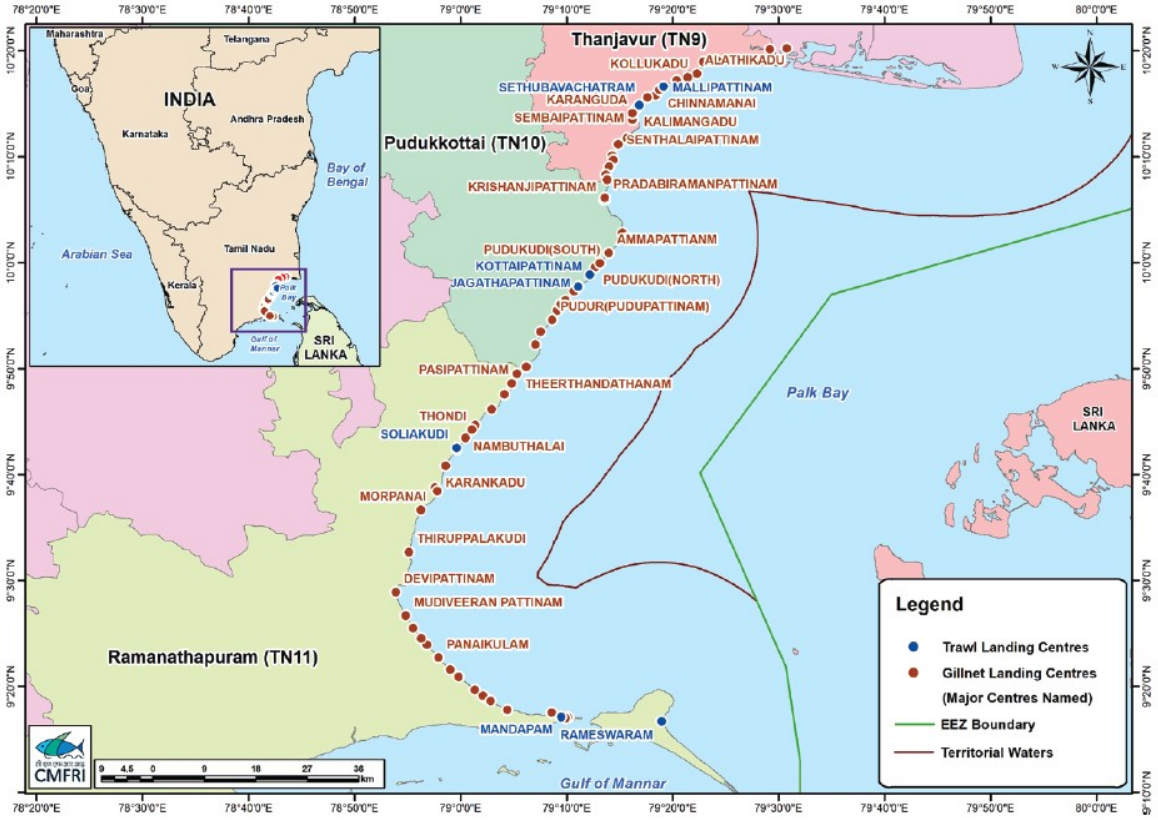

Figure 4. Map of BSC landing centers in Palk Bay. Taken from (Jose et al. 2019).

Historically, the gillnet fishery in Tamil Nadu was smaller scale, where fishers used dugout canoes of 3–7 m and two or three crew members (Jose et al. 2019). More recently, fishing of BSC has intensified, and fishers have started using fiberglass boats of 7.5–10 m length, with 30–35 nets onboard (Jose et al. 2019). Each gillnet is 60–100 m long and 90–120 cm in height, and sections of the net may be tied together so the entire net is 1,000–1,200 m long (Jose et al. 2019). The net is made of high-density monofilament nylon, and the head rope is made of nylon and is 1.5 cm thick (Jose et al. 2019). Small floats are attached to the net, 1.5 ft apart, and small sinkers are attached to the footrope, helping the net to rest on the seabed or just above it (Figure 5) {Jose, J & N. G. Menon 2007}(Jose et al. 2019).

Trawls operate throughout the year in Palk Bay and land BSC along with other species (Jose et al. 2019). Trawls usually operate at a depth of 10 m; the average length of the trawl vessel is 15–20 m, and the engine is between 110 and 400 HP (Jose et al. 2019). Between 2007 and 2017, an average of 1,756

tonnes of BSC was caught using trawls from the Palk Bay region (Jose et al. 2019).

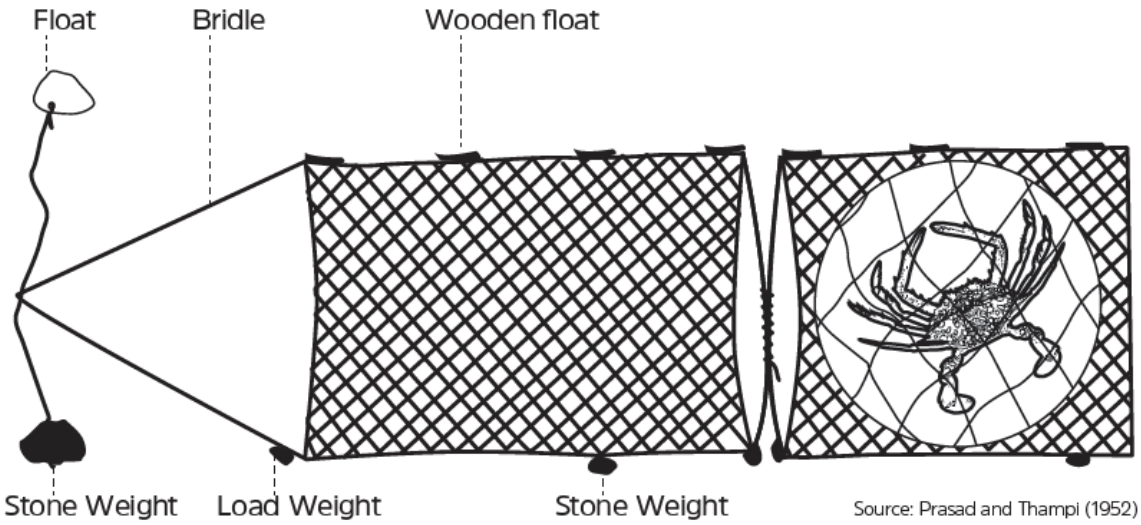

Figure 5. Traditional gillnet known as *nanduvalai*, which is used to target BSC in Palk Bay, Tamil Nadu. Taken from (Jose et al. 2019).

Figure 6. Crab fisher in Palk Bay with a gillnet or *nanduvalai.* Taken from (Jose et al. 2019).

Figure 7. Gillnet BSC landing center at Palk Bay. Taken from (Jose et al. 2019).

Other nets are also used elsewhere in India to catch BSC; these include gillnets such as *aedi bale*, *beenibale*, and *jeppubale* in Karnataka on the west coast, and *peethu valai* in Kakinada, Andhra Pradesh on the east coast {Jose, J & N. G. Menon 2007}(Dineshbabu A. P. et al. 2008). Off the coast of Mangalore in Karnataka, BSC is also caught as by-catch in trawl nets and mini trawl nets {Jose, J & N. G. Menon 2007}. To a lesser extent, other small-scale fishing gears are used to catch BSC; these include seine nets known as *matabale* and *kairampani*, cast nets in Karnataka (Dineshbabu A. P. et al. 2008), and baited lines in the creeks and lagoonal areas of Kakinada, Andhra Pradesh, and the Suderbans of West Bengal (Jose et al. 2019). Landings of BSC have also been reported from the Gulf of Kuchchh in Gujarat along India's west coast, during 8 months of the year {Pathak, N. et al. 2019}.

A recent stock assessment of BSC in the Palk Bay fishery of Tamil Nadu was conducted in 2019, using data from 2007 to 2017 (Jose et al. 2019). These data indicate that BSC in Tamil Nadu is overfished, but the stock is in the rebuilding stage, and is not currently being overfished (Jose et al. 2019). No other stock assessments of BSC have been conducted from Karnataka or other locations in India in the last 10 years.

Importance to the US/North American market.

BSC has been exported from India since 2001 (Jose et al. 2019). The United States is the biggest market for BSC from India, and 99% of the Indian BSC is exported to the United States (Jose et al. 2019). U.S. businesses that import BSC from India include Phillips Foods Inc. (Baltimore, Maryland), Chicken of the Sea Frozen Foods, Handy Seafood Incorporated, Newport International, Trans-Global Inc, and Harbor Seafood (Jose et al. 2019). In terms of volume, in 2021, 6% of BSC imported into the United States was from India (Figure 8). The value of the BSC imported to the United States from India in 2021 was USD 49,406,727 (NOAA Fisheries 2022).

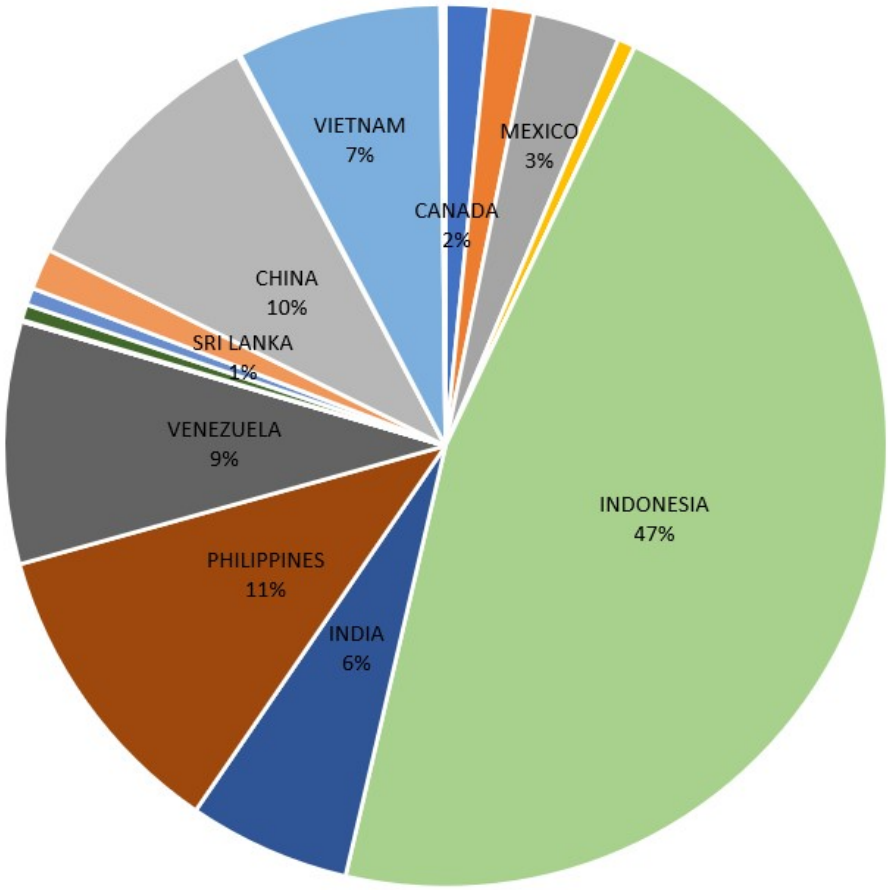

Figure 8. Percentage of BSC imports to the U.S. market in 2021. Data obtained from (NOAA Fisheries 2022).

Common and market names.

Blue swimming crab is also known as blue swimmer crab, blue manna crab, sand crab, blue crab, and flower crab (Kangas, M. I. 2000)(FishSource 2021b). Local names used in India include *chitra kankda*, *gelaipeeta*, *kavalan njandu*, *khekhada*, *naksa kankra*, and *olakkal nandu* (FishSource 2021b).

Primary product forms

The various grades of processed BSC meat that is packed into pasteurized cans or plastic containers for export include (a) Jumbo, (b) Super lump, (c) Lump, (d) Special, (e) Claw meat, and (f) Claw finger, as shown in Figure 9 (Jose et al. 2019).

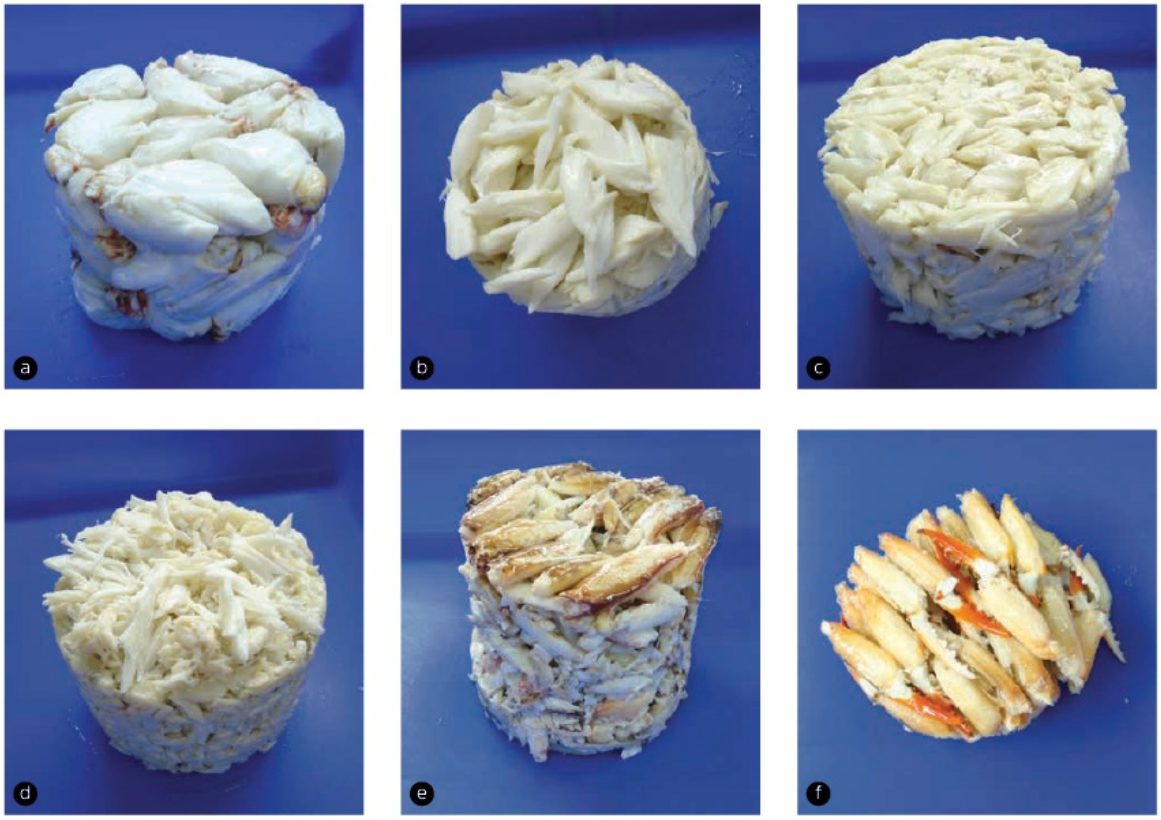

Figure 9. Grades of pasteurized BSC crab meat from India. Taken from (Jose et al. 2019).

Assessment

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

Criterion 1: Impacts on the species under assessment

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

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

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

Guiding principles

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

Criterion 1 Summary

BLUE SWIMMING CRAB			
REGION / METHOD	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

Criterion 1 Assessments

SCORING GUIDELINES

Factor 1.1 - Abundance

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

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

Factor 1.2 - Fishing Mortality

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

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

Blue swimming crab

Factor 1.1 - Abundance

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra

Moderate Concern

Because there has been no stock assessment of blue swimming crab from the west coast of India within the past 10 years, a productivity-susceptibility analysis (PSA) was conducted to determine the vulnerability score of the species. The PSA generated a score of 3.10, indicating that BSC has medium vulnerability. For this reason, abundance of BSC has been rated a moderate concern.

Justification:

Productivity Attribute	Relevant information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	<1 year (Dineshbabu A. P. et al. 2008)	1
Average maximum age	Up to 3 years (Dineshbabu A. P. et al. 2008)	1
Von Bertalanffy (Brody) Growth Coefficient (K)	1.2 per year (Dineshbabu A. P. et al. 2008)	1
Fecundity	Between 60,000 and 1,9763,98 in crabs with carapace widths of 100 to 190 mm. Average fecundity is 830,000. (Jose, J. 2013) (Jose et al. 2019){Wardiatno, Z. Y. et al. 2015}	1
Reproductive strategy	Females are ovigerous and partial brooders (Kangas, M. I. 2000)	2
Density dependence	No compensatory or depensatory dynamics known	2
Productivity score		1.33

Susceptibility Attribute	Relevant information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	>30% of the species concentration is fished Previous studies have shown that BSC is fished in all the states along the west coast of India (pers. comm., Mohamed) and particularly along the coast of Karnataka (Dineshbabu A. P. et al. 2008) and the Gulf of Kuchchh in Gujarat {Pathak, N. et al. 2019}.	3
Vertical overlap (Considers all fisheries)	BSC is found in inshore and continental shelf regions from the intertidal zone to depths of 50 m (Kangas, M. I. 2000). In India, it is fished using bottom set gillnets at depths to 15 m, and with bottom trawls at depths to 50 m {Jose, J & N. G. Menon 2007}; hence there is a high degree of overlap between fishing depths and depth range of the species.	3
Seasonal Availability (Considers all fisheries; score using the most conservative option)	Along the coast of Karnataka, the peak fishing season extends for about 7 months, from December to June (Dineshbabu A. P. et al. 2008); in Gujarat, in the Gulf of Kuchchh, the fishery extends for about 8 months {Pathak, N. et al. 2019}.	3
Selectivity of fishery (Specific to fishery under assessment)	The species is targeted or incidentally encountered, and is unlikely to escape the gear {Jose, J & N. G. Menon 2007} (Dineshbabu A. P. et al. 2008) {Pathak, N. et al. 2019}, but conditions of "high risk" do not apply	2
Post-capture mortality (Specific to fishery under assessment)	Unknown, default score used	3
Susceptibility score		2.8

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

Moderate Concern

Because there has been no stock assessment of blue swimming crab from the east coast of India, north of Tamil Nadu, a productivity-susceptibility analysis (PSA) was conducted to determine the vulnerability score of the species. The PSA generated a score of 3.10, indicating that BSC has medium vulnerability. For this reason, abundance of BSC has been rated a moderate concern.

Justification:

Productivity Attribute	Relevant information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	<1 year (Dineshbabu A. P. et al. 2008)	1
Average maximum age	Up to 3 years (Dineshbabu A. P. et al. 2008)	1
Von Bertalanffy (Brody) Growth Coefficient (K)	1.2 per year (Dineshbabu A. P. et al. 2008)	1
Fecundity	Between 60,000 and 1,976,398 in crabs with carapace widths of 100 to 190 mm. Average fecundity is 830,000. (Jose, J. 2013) (Jose et al. 2019)	1
Reproductive strategy	Fertilization is internal; berried females release fertilized eggs {Wardiatno, Z. Y. et al. 2015} {de Lestang, S. et al. 2003}	2
Density dependence	No compensatory or depensatory dynamics known	2
Productivity score		1.33

Susceptibility Attribute	Relevant information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	Unknown, default score used	3
Vertical overlap	Unknown, default score used	3

(Considers all fisheries)		
Seasonal Availability (Considers all fisheries; score using the most conservative option)	Unknown, default score used	3
Selectivity of fishery (Specific to fishery under assessment)	Default score used, conditions of "high risk" do not apply	2
Post-capture mortality (Specific to fishery under assessment)	Unknown, default score used	3
Susceptibility score		2.8

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern

According to the 2019 stock assessment of blue swimming crab (BSC) (*Portunus pelagicus*) from Tamil Nadu, India, B/B_{MSY} in 2017 was 0.833 (Jose et al. 2019). Thus, although landings show a declining trend in recent years (Figure 10), the stock appears to be >75% of B_{MSY} (Figure 11) and is currently being rebuilt (Jose et al. 2019). Nevertheless, there are gaps in the level of accuracy and coverage of the abundance data collected, fishery-independent data are not collected, and the BSC stock assessment has not been peer reviewed {Fernandez & Ganapathiraju 2019}, leading to significant uncertainty in the results. For these reasons, abundance has been rated a moderate concern.

Justification:

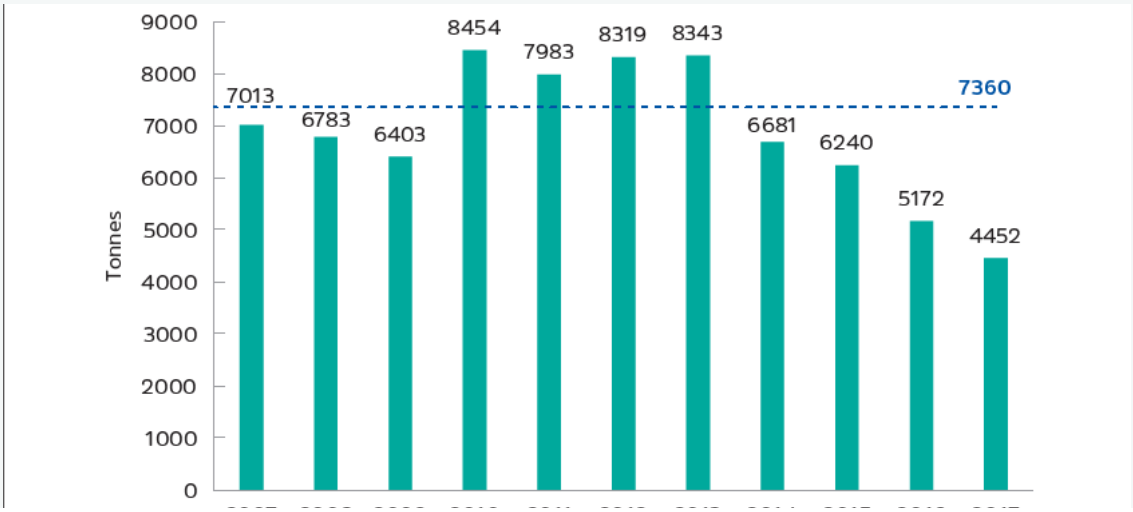

Figure 10. Total BSC landings in Palk Bay from 2007–2017 showing MSY. Taken from (Jose et al. 2019).

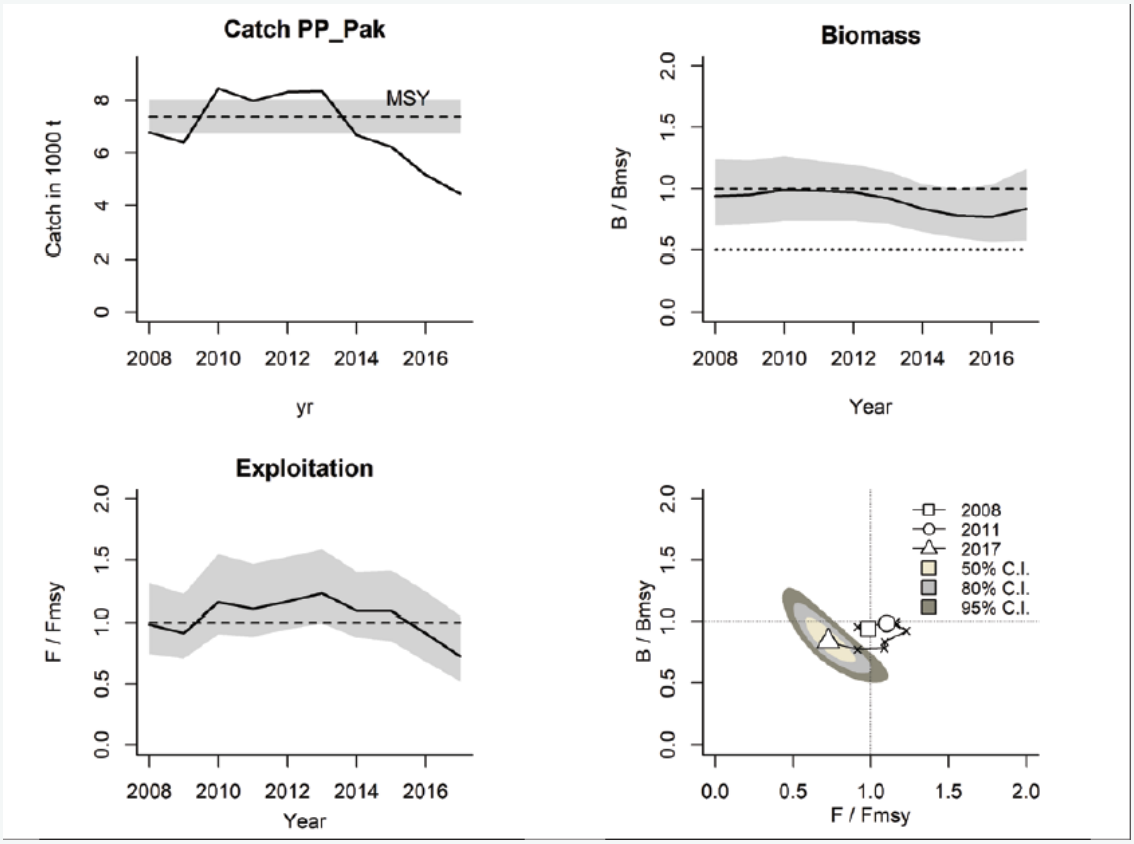

Figure 11. Summary of stock assessment analysis of BSC for Palk Bay, Tamil Nadu, from 2007–2017. Taken from (Jose et al. 2019).

Factor 1.2 - Fishing Mortality

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra

Moderate Concern
Because there has been no stock assessment conducted on BSC from the west coast of India within the last 10 years, fishing mortality is unknown. For this reason, this factor has been rated a moderate concern.

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls |

Andhra Pradesh | Odisha | West Bengal
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

Moderate Concern
Because there has been no stock assessment conducted on BSC from the East coast of India, north of Tamil Nadu, fishing mortality is unknown. For this reason, this factor has been rated a moderate concern.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Low Concern
Per the 2019 stock assessment of BSC in Tamil Nadu, exploitation of the crab F/F_{MSY} in 2017 was 0.726, indicating that overfishing was not occurring (Figure 12) (Jose et al. 2019). For this reason, fishing mortality for BSC in Tamil Nadu has been rated a low concern.
Justification:

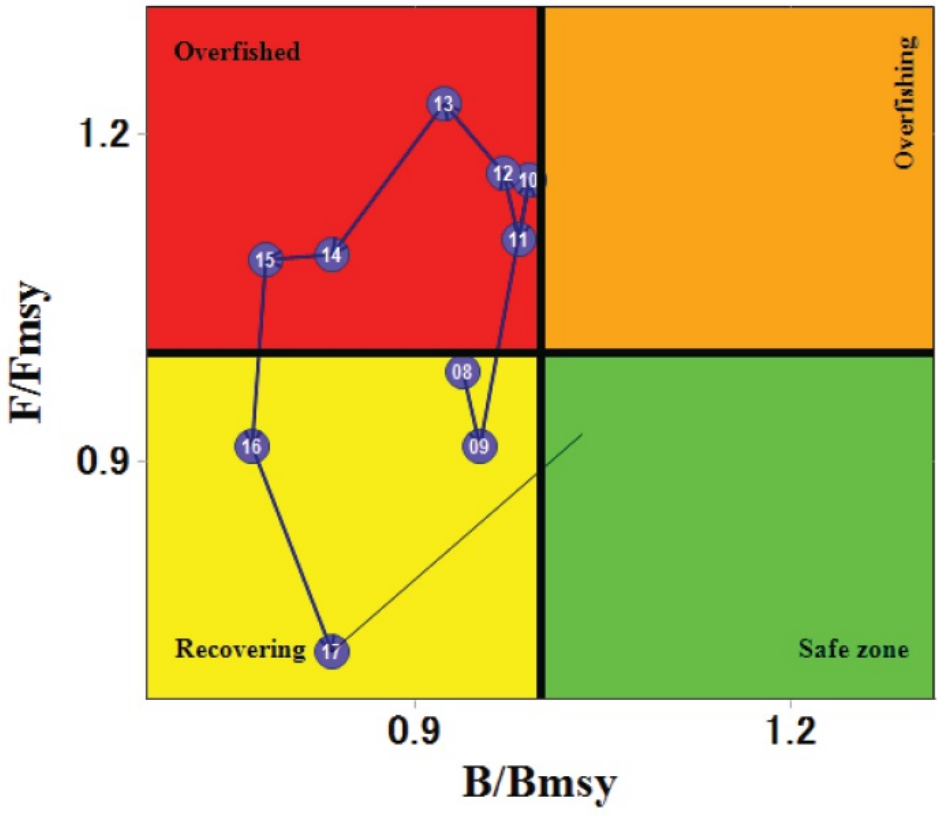

Figure 12. Stock status of the BSC fishery in Palk Bay, Tamil Nadu from 2007–2017. Taken from (Jose et al. 2019).

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.

BLUE SWIMMING CRAB			
REGION / METHOD	**SUB SCORE**	**DISCARD RATE/LANDINGS**	**SCORE**
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra	1.000	1.000: < 100%	Red (1.000)
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal	1.000	1.000: < 100%	Red (1.000)
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu	1.000	1.000: < 100%	Red (1.000)
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra	1.000	1.000: < 100%	Red (1.000)
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal	1.000	1.000: < 100%	Red (1.000)
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu	1.000	1.000: < 100%	Red (1.000)

Criterion 2 main assessed species/stocks table(s)

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

ARABIAN SEA | INDIAN OCEAN, WESTERN | INDIAN OCEAN, WEST / 51.4 | BOTTOM TRAWLS | GOA | GUJARAT | KARNATAKA | KERALA | MAHARASHTRA

SUB SCORE: 1.000 | DISCARD RATE: 1.000 | **SCORE: 1.000**

SPECIES	ABUNDANCE	FISHING MORTALITY	SCORE
Benthic inverts	1.000: High Concern	1.000: High Concern	Red (1.000)
Corals and other biogenic habitats	1.000: High Concern	1.000: High Concern	Red (1.000)
Dugong	1.000: High Concern	1.000: High Concern	Red (1.000)
Sea cucumber	1.000: High Concern	1.000: High Concern	Red (1.000)
Sea turtle (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Seahorses	1.000: High Concern	1.000: High Concern	Red (1.000)
Sharks	1.000: High Concern	1.000: High Concern	Red (1.000)
stingrays (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Finfish	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Marine mammals	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Seabirds	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Blue swimming crab	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Forage fish	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)

ARABIAN SEA | INDIAN OCEAN, WESTERN | INDIAN OCEAN, WEST / 51.4 | GILLNETS AND ENTANGLING NETS | GOA | GUJARAT | KARNATAKA | KERALA | MAHARASHTRA

SUB SCORE: 1.000 | DISCARD RATE: 1.000 | **SCORE: 1.000**

SPECIES	ABUNDANCE	FISHING MORTALITY	SCORE
Corals and other biogenic habitats	1.000: High Concern	1.000: High Concern	Red (1.000)
Dugong	1.000: High Concern	1.000: High Concern	Red (1.000)
Marine mammals	1.000: High Concern	1.000: High Concern	Red (1.000)
Sea turtle (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Seabirds	1.000: High Concern	1.000: High Concern	Red (1.000)
Seahorses	1.000: High Concern	1.000: High Concern	Red (1.000)
Sharks	1.000: High Concern	1.000: High Concern	Red (1.000)
stingrays (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Finfish	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Forage fish	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Benthic inverts	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Sea cucumber	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Blue swimming crab	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)

BAY OF BENGAL | INDIAN OCEAN, EASTERN | INDIAN OCEAN, EAST / 57.1 | BOTTOM TRAWLS | ANDHRA PRADESH | ODISHA | WEST BENGAL

SUB SCORE: 1.000 | DISCARD RATE: 1.000 | **SCORE: 1.000**

SPECIES	ABUNDANCE	FISHING MORTALITY	SCORE
Benthic inverts	1.000: High Concern	1.000: High Concern	Red (1.000)
Marine mammals	1.000: High Concern	1.000: High Concern	Red (1.000)
Sea cucumber	1.000: High Concern	1.000: High Concern	Red (1.000)
Sea turtle (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Seahorses	1.000: High Concern	1.000: High Concern	Red (1.000)
Sharks	1.000: High Concern	1.000: High Concern	Red (1.000)
stingrays (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Finfish	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Blue swimming crab	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Forage fish	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)

BAY OF BENGAL | INDIAN OCEAN, EASTERN | INDIAN OCEAN, EAST / 57.1 | GILLNETS AND ENTANGLING NETS | ANDHRA PRADESH | ODISHA | WEST BENGAL

SUB SCORE: 1.000 | DISCARD RATE: 1.000 | **SCORE: 1.000**

SPECIES	ABUNDANCE	FISHING MORTALITY	SCORE
Corals and other biogenic habitats	1.000: High Concern	1.000: High Concern	Red (1.000)
Marine mammals	1.000: High Concern	1.000: High Concern	Red (1.000)
Sea turtle (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Seahorses	1.000: High Concern	1.000: High Concern	Red (1.000)
Sharks	1.000: High Concern	1.000: High Concern	Red (1.000)
stingrays (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Finfish	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Forage fish	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Benthic inverts	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Sea cucumber	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Seabirds	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Blue swimming crab	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)

PALK STRAIT AND PALK BAY | INDIAN OCEAN, EASTERN | INDIAN OCEAN, EAST / 57.1 | BOTTOM TRAWLS | TAMIL NADU

SUB SCORE: 1.000 | DISCARD RATE: 1.000 | **SCORE: 1.000**

SPECIES	ABUNDANCE	FISHING MORTALITY	SCORE
Benthic inverts	1.000: High Concern	1.000: High Concern	Red (1.000)
Corals and other biogenic habitats	1.000: High Concern	1.000: High Concern	Red (1.000)
Marine mammals	1.000: High Concern	1.000: High Concern	Red (1.000)
Sea cucumber	1.000: High Concern	1.000: High Concern	Red (1.000)
Sea turtle (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Seahorses	1.000: High Concern	1.000: High Concern	Red (1.000)
Sharks	1.000: High Concern	1.000: High Concern	Red (1.000)
stingrays (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Finfish	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Dugong	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Forage fish	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Blue swimming crab	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

PALK STRAIT AND PALK BAY | INDIAN OCEAN, EASTERN | INDIAN OCEAN, EAST / 57.1 | GILLNETS AND ENTANGLING NETS | TAMIL NADU			
SUB SCORE: 1.000	DISCARD RATE: 1.000		**SCORE: 1.000**
SPECIES	**ABUNDANCE**	**FISHING MORTALITY**	**SCORE**
stingrays (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Seahorses	1.000: High Concern	1.000: High Concern	Red (1.000)
Sea turtle (unspecified)	1.000: High Concern	1.000: High Concern	Red (1.000)
Finfish	1.000: High Concern	1.000: High Concern	Red (1.000)
Sharks	1.000: High Concern	1.000: High Concern	Red (1.000)
Marine mammals	1.000: High Concern	1.000: High Concern	Red (1.000)
Mullet spp.	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Mojarra spp.	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Forage fish	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Catfish spp.	2.330: Moderate Concern	1.000: High Concern	Red (1.526)
Dugong	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Sea cucumber	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	1.000: High Concern	3.000: Moderate Concern	Red (1.732)
Oil sardine	3.670: Low Concern	1.000: High Concern	Red (1.916)
Goatfish	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Perforated-scale sardine	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Goldstripe sardine	2.330: Moderate Concern	3.000: Moderate Concern	Yellow (2.644)
Blue swimming crab	2.330: Moderate Concern	5.000: Low Concern	Green (3.413)

For bottom-set gillnets and entangling nets in the Palk Bay region, catch composition data were provided in the CMFRI Fishery Management Plan for blue swimming crab in Palk Bay (Jose et al. 2019). Species were evaluated, and those making up more than 5% of the catch were included in this assessment. Further, any endangered, threatened, or protected (ETP) species listed by the International Union for the Conservation of Nature (IUCN) or the Indian Wildlife Protection Act (1972) among the catch composition data were included in this assessment. Also from the catch composition data, for species that were overfished or being overfished, if by-catch in the BSC gillnet fishery amounted to >5% of the species' F_{MSY}, it was included in this assessment.

The SFW Unknown By-catch Matrix was used to identify by-catch species that were included in Criterion 2 of this assessment, caught using bottom-set gillnets and entangling nets along the west coast of India and in Andhra Pradesh, Odisha, and West Bengal along the east coast, and caught using trawl nets along the east and west coasts. Because of uncertainly in the existing catch composition data, for certain categories of species such as sea turtles, syngnathids, benthic invertebrates, dugongs, whales and dolphins, seabirds, and corals and other biogenic habitats, the Unknown By-catch Matrix was also used to identify Criterion 2 species potentially caught using bottom-set gillnets and entangling nets in Palk Bay.

For bottom-set gillnets and entangling nets in the Palk Bay region: sea turtles, syngnathids, benthic invertebrates, dugongs, other marine mammals, and sea cucumbers limit the score due to their protected status under the Indian WPA; finfish, sharks, and stingrays limit the score due to their status on the IUCN Red List; the Indian oil sardine limits the score because the BSC gillnet fishery is a substantial contributor to the total fishing mortality of the species in Tamil Nadu; and catfish species, forage fish, mojarra species, mullet species, and seabirds limit the score per the Unknown By-catch Matrix.

For trawl nets in the Palk Bay region: sea turtles, syngnathids, benthic invertebrates, dugongs, marine mammals, sea cucumbers, and corals limit the score due to their protected status under the Indian WPA; finfish, sharks, and stingrays limit the score per the Unknown By-catch Matrix.

For bottom-set gillnets and entangling nets along the west coast: sea turtles, syngnathids, benthic invertebrates, dugongs, marine mammals, sea cucumbers, and corals limit the score due to their protected status under the Indian WPA; finfish, forage fish, sharks, seabirds, and stingrays limit the score per the Unknown By-catch Matrix.

For trawl nets along the west coast: sea turtles, syngnathids, benthic invertebrates, dugongs, marine mammals, sea cucumbers, and corals limit the score due to their protected status under the Indian WPA; finfish, sharks, seabirds, and stingrays limit the score per the Unknown By-catch Matrix.

For bottom-set gillnets and entangling nets in Andhra Pradesh, Odisha, and West Bengal along the east coast: sea turtles, syngnathids, benthic invertebrates, marine mammals, sea cucumbers, and seagrasses limit the score due to their protected status under the Indian WPA; finfish, forage fish, sharks, seabirds, and stingrays limit the score per the Unknown By-catch Matrix.

For trawl nets in Andhra Pradesh, Odisha, and West Bengal along the east coast: sea turtles, syngnathids, benthic invertebrates, marine mammals, and sea cucumbers limit the score due to their protected status under the Indian WPA; finfish, sharks, and stingrays limit the score per the Unknown By-catch Matrix.

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

Benthic inverts

Factor 2.1 - Abundance

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra

High Concern
Along the west coast of India, benthic invertebrates such as mollusks have been listed on the Indian WPA (1972), specifically because of the existing illegal harvest and trade in shells of these species. Hence, abundance of these mollusks is rated a high concern.
Justification:
Mollusks that are found along the west coast of India and are protected because they are listed on the Indian WPA (1972) include:

Species name	Status per the Indian WPA (1972)	State/region where found
Placuna placenta	Schedule IV (MoEF 2001b) {ENVIS Centre on Wildlife & Protected Areas 2011}	Gujarat, Maharashtra, Goa, Karnataka (Das, R. R. et al. 2019)
Murex spp.	Could include *M. ramosus*, *M. haustellum*, *M. palmorosae*, which are Schedule I (MoEF 2001)	West Coast {Mohamed K. S. & V. Venkatesan 2017}
Conus sp.	Could include *C. malneedwardsi*, which is Schedule I {ENVIS Centre on Wildlife & Protected Areas 2011}	West Coast {Mohamed K. S. & V. Venkatesan 2017}

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

High Concern
The windowpane oyster is a benthic invertebrate found along the east coast of India, in the states of Karnataka, Odisha, and West Bengal. The species has been listed on Schedule IV of the Indian WPA (1972) (Das, R. R. et al. 2019){Laxmilatha, P. 2015}{ENVIS Centre on Wildlife & Protected Areas 2011}, specifically because of the existing illegal harvest and trade in shells of this species. Because of the protected status of windowpane oyster, abundance is rated a high concern.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets

and entangling nets | Tamil Nadu

High Concern

There are many benthic invertebrates along the Tamil Nadu coast {Lakshmanan, R. et al. 2021}, including a few species of mollusks, which have been listed on the Indian WPA (1972), specifically because of the existing illegal trade in shells of these species. Hence, abundance of these mollusks is rated a high concern.

Justification:

The following mollusk species are found along the coast of Palk Bay, Tamil Nadu {Fernandez & Ganapathiraju 2019}; their status according to the Indian WPA is listed in the table:

Species name	**Status per the Indian WPA, 1972**
Charonia tritonis	Schedule I (MoEF 2001b)
Lambis truncata	Schedule IV (MoEF 2001b)
Lambis chiragra	Schedule IV (MoEF 2001b)
Lambis chiragra arthritica	Schedule IV (MoEF 2001b)
Lambis millepeda	Schedule IV (MoEF 2001b)
Lambis scorpius	Schedule IV (MoEF 2001b)
Conus bengalensis	Schedule I (MoEF 2001)
Conus milneedwardsi	Schedule I (MoEF 2001b)
Conus textile	Schedule I (MoEF 2001)
Conus nobilis	Schedule I (MoEF 2001)
Conus geographus	Schedule I (MoEF 2001)
Conus marmoreus	Schedule I (MoEF 2001)
Cypraea lamacina (also known as *Staphylaea limacina*)	Schedule IV (MoEF 2001b)
Cypraea cribraria	Schedule I (MoEF 2001)
Cypraea tigris	Schedule I (MoEF 2001)
Cypraea mappa	Schedule IV (MoEF 2001b)
Cypraea talpa	Schedule IV (MoEF 2001b)
Cypraea carneola	Schedule I (MoEF 2001)
Cypraea mauritiana	Schedule I (MoEF 2001)
Cypraea onyx	Schedule I (MoEF 2001)
Cypraea argus	Schedule I (MoEF 2001)
Trochus niloticus	Schedule IV (MoEF 2001b)
Xancus pyrum	Schedule I (MoEF 2001)
Cassis cornuta	Schedule I (MoEF 2001b)
Nautilus pompilius	Schedule I (MoEF 2001b)
Murex palmorosae (also known as *Chicoreus palmarosae*)	Schedule I (MoEF 2001)
Murex haustellum	Schedule I (MoEF 2001)
Murex ramosus	Schedule I (MoEF 2001)
Strombus plicatus sibbaldi (also known as *Canarium labiatum*)	Schedule IV (MoEF 2001b)
Strombus listeris (also known as *Mirabilistrombus listeri*)	Schedule I (MoEF 2001)
Fasciolaria trapazium (also known as *Pleuroploca trapezium*)	Schedule IV (MoEF 2001b)
Fusinus longicaudus (also known as *Fusinus colus*)	Schedule I (MoEF 2001)
Mitra mitra	Schedule I (MoEF 2001)

Mitra papalis	Schedule I (MoEF 2001)
Cymatium pileare	Schedule I (MoEF 2001)
Tridacna maxima	Schedule I (MoEF 2001b)
Tridacna squamosa	Schedule I (MoEF 2001b)
Hippopus hippopus	Schedule I (MoEF 2001b)
Pteria brevilata (also known as *Pteria heteroptera*)	Schedule I (MoEF 2001)
Placuna placenta	Schedule IV (MoEF 2001b)
Paphia alapapilionis	Schedule I (MoEF 2001)

Factor 2.2 - Fishing Mortality

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu

High Concern
According to the SFW Unknown By-catch Matrix, benthic invertebrates caught as by-catch in bottom trawl nets are scored 2 out of 5, so fishing mortality is considered a high concern.

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern
According to the SFW Unknown By-catch Matrix, benthic invertebrates caught as by-catch in bottom set gillnets nets are scored 3 out of 5, so fishing mortality is considered a moderate concern.

Catfish spp.

Factor 2.1 - Abundance

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern
According to the SFW Unknown By-catch Matrix, unknown fish species such as *Arius* spp. are rated a moderate concern for abundance.

Factor 2.2 - Fishing Mortality

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern
According to the SFW Unknown By-catch Matrix, finfish caught as by-catch in bottom set gillnets are scored 2 out of 5, so fishing mortality is considered a high concern.

Corals and other biogenic habitats

Factor 2.1 - Abundance

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra

High Concern
The west coast of India, the Gulf of Kutch, and the coastal regions of Malvan in Maharashtra, Goa, and Karnataka states have fringing coral reefs (Venkataraman K. 2011) (Figure 13). The Gulf of Kutch also has seagrass meadows. Both coral reefs and seagrasses form biogenic habitats in these regions. All corals are listed as Schedule I species on the Indian WPA (1972) {ENVIS Centre on Wildlife & Protected Areas 2011}. Therefore, abundance for coral reefs is scored a high concern.
Justification:

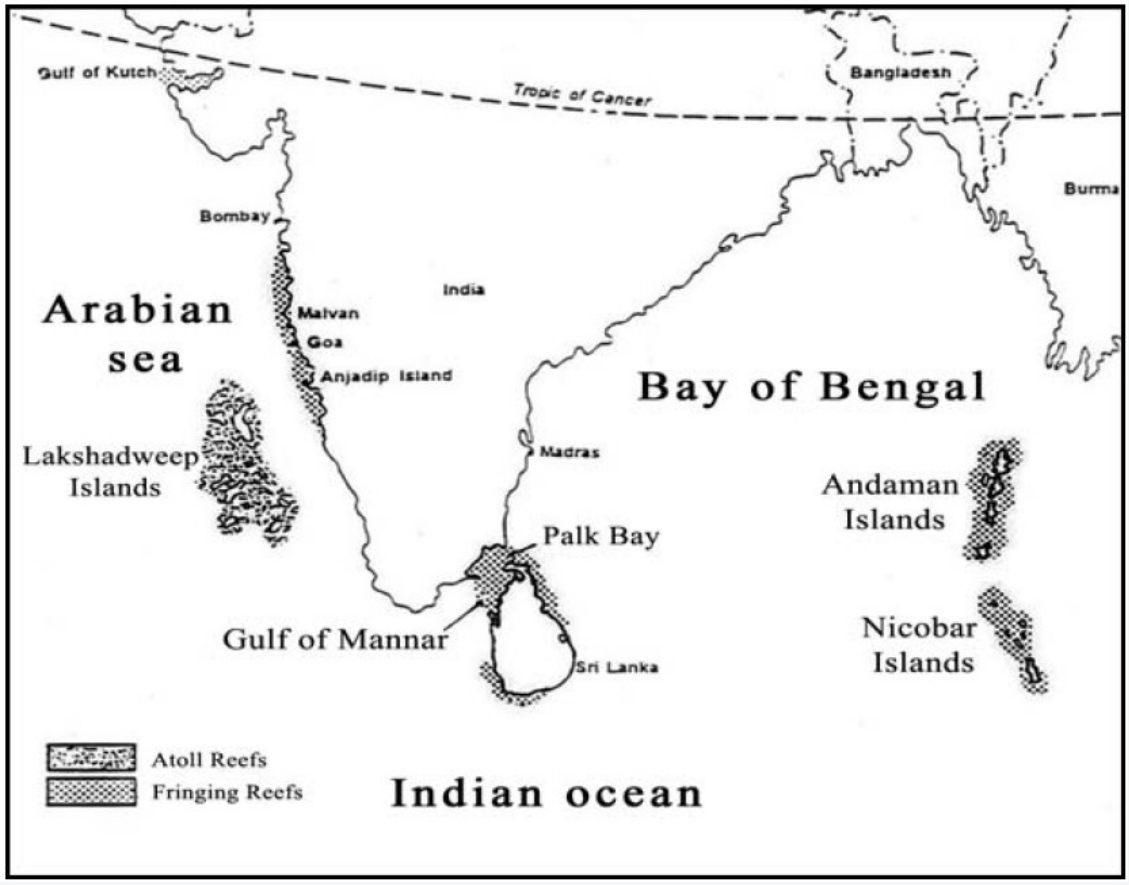

Figure 1: Major coral reef regions in India. Taken from [Venkataraman K. 2011}.

The status of specific corals according to the Indian WPA (1972) and the IUCN Red List are given in the table below:

Species name/group	Status per the Indian WPA {ENVIS Centre on Wildlife & Protected Areas 2011}	Status per the IUCN Red List
Reef-building corals (all Scleractinians)	Schedule I	-
Black corals (all Antipatharians)	Schedule I	-
Organ pipe coral (*Tubipora musica*)	Schedule I	Near Threatened (Obura, D. 2008)
Fire coral (all *millipora* spp.)	Schedule I	-
Sea fan (all *gorgonian* spp.)	Schedule I	-

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

High Concern

North of Tamil Nadu along the east coast of India, there are seagrass meadows in Chilika lagoon in Odisha state {Geevarghese, G. A. et al. 2018}. According to the SFW Unknown By-catch Matrix, seagrasses have high inherent vulnerability, and therefore are scored a high concern for abundance.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu

High Concern

Palk Bay and the Gulf of Mannar have corals and seagrasses, both of which form biogenic habitats in these regions; all corals are listed as Schedule I species on the Indian WPA (1972) {ENVIS Centre on Wildlife & Protected Areas 2011}. Therefore, this factor is scored a high concern.

Justification:

The status of specific corals according to the Indian WPA (1972) and the IUCN Red List are given in the table below:

Species name/group	Status per the Indian WPA {ENVIS Centre on Wildlife & Protected Areas 2011}	Status per the IUCN Red List
Reef-building corals (all Scleractinians)	Schedule I	-
Black corals (all Antipatharians)	Schedule I	-
Organ pipe coral (*Tubipora musica*)	Schedule I	Near Threatened (Obura, D. 2008)
Fire coral (all *millipora* spp.)	Schedule I	-
Sea fan (all *gorgonian* spp.)	Schedule I	-

Factor 2.2 - Fishing Mortality

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra

High Concern
Corals and seagrass meadows have a high susceptibility to bottom trawls and bottom set gillnets. According to the SFW Unknown By-catch Matrix, corals and other biogenic habitats are scored 1 out of 5 for bottom trawl nets and 2 out of 5 for bottom set gillnets, so fishing mortality is considered a high concern.

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

High Concern
Seagrass meadows have a high susceptibility to bottom set gillnets. According to the SFW Unknown By-catch Matrix, seagrasses are biogenic habitats and are impacted by bottom set gillnets, so seagrasses are scored 2 out of 5. Thus, fishing mortality is considered a high concern.

Dugong

Factor 2.1 - Abundance

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern
Dugong is listed as "Vulnerable" with a decreasing population trend by the IUCN {Marsh, H. & Sobtzick, S. 2019}, is a Schedule I species on the Indian WPA {ENVIS Centre on Wildlife & Protected Areas 2011}, and is on Appendix I of CITES (UNEP-WCMC 2021). In particular, the dugong population in the Gulf of Mannar and Palk Bay region, although the largest in India, is currently much lower than historical numbers {Sivakumar, K. & K. Nair 2013}{Anand Y. et al. 2015}. The population of dugong on the west coast of India in the Gulf of Kutch is currently the smallest in India, and it is isolated from other dugong populations (Anand, Y. A. et al. 2017)(Apte, D. et al. 2019). Therefore, collectively, dugong abundance is scored a high concern.
Justification:
Dugong is considered to be one of eight critically endangered species in India {Sivakumar, K. & K. Nair 2013}; thus, its conservation is a priority of the Ministry of Environment, Forests and Climate Change through the centrally sponsored species recovery component of the Integrated Development of Wildlife Habitats scheme {Sivakumar, K. & K. Nair 2013}. Also, a Task Force was established to conserve dugong, to implement the UNEP/CMS dugong MoU in India, and to create an action plan to increase the number of dugong in the country {Sivakumar, K. & K. Nair 2013} (Sivakumar, K. 2013).

Factor 2.2 - Fishing Mortality

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra

High Concern

Fishing mortality in gillnets has been cited as one of the most likely fishery-related threats to dugong in India (Eros C. et al. 2002). But, a perception survey among fishers in India in 2013 indicated that only 9% of fishers believed that trawling (both through habitat destruction of seagrass beds and directly) was a cause of dugong mortality, and only 4% believed that gillnets were {Sivakumar, K. & K. Nair 2013}. In the Gulf of Kuchchh (the only dugong habitat along the west coast of India), fisher perceptions indicated that trawling was believed to be the major fishery-related threat to dugong in the region (Anand, Y. A. et al. 2017). The population of dugong in the Gulf of Kuchchh is known to be quite small (10–15 individuals), is isolated, and fishing-related mortality is known to occur {Sivakumar, K. & K. Nair 2013}(Anand, Y. A. et al. 2017). Therefore, any fishing mortality on a dugong population of that size would be unsustainable. Because the extent of dugong mortality caused by various fishing gears in the Gulf of Kuchchh is unknown, and fishery-related mortality of dugong in the region is likely unsustainable, fishing mortality in both gillnets and trawl nets is rated a high concern.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern

Fishing mortality in gillnets has been cited as one of the most likely fishery-related threats to dugong in India, and particularly so in the Gulf of Mannar and Palk Bay (Eros C. et al. 2002). But, a perception survey among fishers in India in 2013 indicated that only 9% of fishers believed that trawling (both through habitat destruction of seagrass beds and directly) was a cause of dugong mortality, and only 4% believed that gillnets were {Sivakumar, K. & K. Nair 2013}. Database records indicate that dugong strandings still occur in Tamil Nadu (Marine Mammal Research and Conservation network of India 2021). In particular, 19 dugongs appear to have been stranded in Palk Bay from 2009 to 2020 {Balaji, V. & V. Sekar 2021}. Of the stranded dugongs that were recorded, 13 were fishing-related strandings, of which 6 were due to shore seine nets and 1 was caused by a gillnet; the specific gear that caused the remaining strandings was not confirmed {Balaji, V. & V. Sekar 2021}. Further discussions with local experts working in the region confirmed that shore seine nets are a significant threat to dugong in Palk Bay (pers comm., Sekar, R., Prem Jothi, P. V. R., & Madhu Magesh, K.). Although it is possible that gillnets and trawl nets also pose a threat to dugong in the region, there is little firsthand confirmation (pers comm., Sekar, R., Prem Jothi, P. V. R., & Madhu Magesh, K.). Because it cannot be confirmed whether fishing due to trawl and gillnets substantially contributes to dugong mortality in the region, but these gears are not considered to be the major contributor to fishing mortality in Palk Bay, this factor is rated a moderate concern.

Finfish

Factor 2.1 - Abundance

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

Moderate Concern
According to the SFW Unknown By-catch Matrix, unknown finfish species are rated a moderate concern for abundance.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern
A number of species are caught in the Palk Bay gillnet fishery (Jose et al. 2019) that do not have stock assessments, and are grouped here. This includes narrow-barred Spanish mackerel, which is listed as "Near Threatened" on the IUCN Red List (Collette, B. et al. 2011). For this reason, abundance for the group finfish is rated a high concern.

Justification:
The finfish by-catch species caught in gillnets in Palk Bay (Jose et al. 2019) and their IUCN status is given in the table below:

Species name	IUCN Red List status
Lethrinus spp.	Could include *Lethrinus mahsena*, which is "Endangered" (Al Abdali, F.S.H. et al. 2019)
Narrow-barred Spanish mackerel (*Scomberomorus commerson*)	Near Threatened (Collette, B. et al. 2011)

Factor 2.2 - Fishing Mortality

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa

| Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern
According to the SFW Unknown Bycatch Matrix, finfish caught as by-catch in bottom set gillnets and trawl nets are scored 2 out of 5, so fishing mortality is considered a high concern.

Forage fish

Factor 2.1 - Abundance

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

Moderate Concern
According to the SFW Unknown By-catch Matrix, unknown teleost species are rated a moderate concern for abundance.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern
According to the SFW Unknown By-catch Matrix, unknown finfish and invertebrate species such as *Sardinella* spp., *Thryssa* spp., and *Uroteuthis* spp. are rated a moderate concern for abundance.

Factor 2.2 - Fishing Mortality

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu

Moderate Concern
According to the SFW Unknown By-catch Matrix, forage fish caught as by-catch in bottom trawl nets are scored 3 out of 5, so fishing mortality is considered a moderate concern.

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern
According to the SFW Unknown By-catch Matrix, forage fish caught as by-catch in bottom set gillnets are scored 2 out of 5, so fishing mortality is considered a high concern.

Goatfish

Factor 2.1 - Abundance

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern
According to the SFW Unknown By-catch Matrix, unknown fish species such as *Upeneus* spp. are rated a moderate concern for abundance.

Factor 2.2 - Fishing Mortality

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern
According to the SFW Unknown By-catch Matrix, finfish caught as by-catch in bottom set gillnets are scored 2 out of 5, so fishing mortality would rate a high concern. But, *Upeneus* spp. is likely caught in other gear in the region as well, yet the extent is unknown, so fishing mortality is rated a moderate concern.

Goldstripe sardine

Factor 2.1 - Abundance

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern

There has been no stock assessment of *Sardinella gibbosa* from India within the past 10 years, so a productivity-susceptibility analysis (PSA) was conducted to determine the vulnerability score of the species. The PSA generated a score of 2.97, indicating that *S. gibbosa* has medium vulnerability. Thus, abundance of *S. gibbosa* is rated a moderate concern.

Justification:

Productivity Attribute	Relevant information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	Reaches maturity after 1 year {Dayaratne & Gjøsaeter 1986}	1
Von Bertalanffy (Brody) Growth Coefficient (K)	K = 0.32–1.8 (FishBase 2021)	1
Fecundity	Up to 68,377 eggs (Ghosh S. et al. 2013)	1
Average maximum size	Max length = 29.6 cm TL (FishBase 2021)	1
Average size at maturity	L_M = 12.8 cm (FishBase 2021)	1
Reproductive strategy	Broadcast spawner (Hunnam, K. 2021)	1
Productivity score		1

Susceptibility Attribute	Relevant information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap	Unknown, default score used	3

(Considers all fisheries)		
Vertical overlap (Considers all fisheries)	Unknown, default score used	3
Seasonal availability (Considers all fisheries; score using the most conservative option)	Unknown, default score used	3
Selectivity of fishery (Specific to fishery under assessment)	Default score used, conditions of "high risk" do not apply	2
Post-capture mortality (Specific to fishery under assessment)	Unknown, but species likely retained	3
Susceptibility score		2.8

Factor 2.2 - Fishing Mortality

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern

There has been no stock assessment conducted on *S. gibbosa* from India within the last 10 years, so fishing mortality is unknown. Thus, this factor is rated a moderate concern.

Marine mammals

Factor 2.1 - Abundance

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern
There are several species of marine mammals (in this case, whales and dolphins) that are found along the Indian coast and are potentially at risk of interacting with fishing gear. Marine mammal strandings may sometimes be associated with fishing gear in the region, although confirmation often needs to be made by a necropsy of the stranded carcass. All the species of marine mammals that were found stranded or sighted on the east and west coasts of India are listed as Schedule I on the Indian WPA, so abundance is rated a high concern. (See Figures 14, 15, and 16 and the table in Justification).

Justification:
A number of whale and dolphin species have been stranded or sighted in the coastal waters of India; database records from (1) the state of Tamil Nadu; (2) the west coast of India; and (3) the eastern states of Andhra Pradesh, Odisha, and West Bengal from 2000 to 2021 are presented in Figures 14, 15, and 16, respectively (Marine Mammal Research and Conservation network of India 2021).

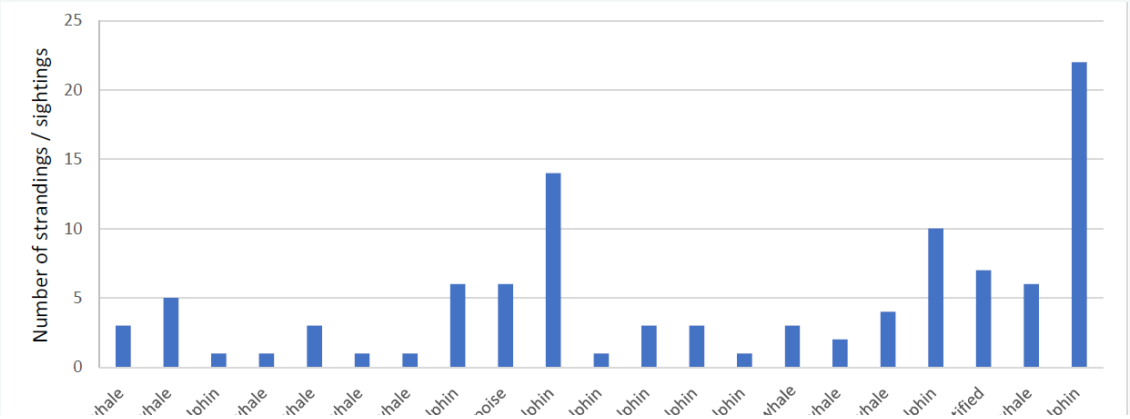

Figure 14. Sightings and strandings of whales and dolphins from Tamil Nadu waters from 2000 to 2021 (Marine Mammal Research and Conservation network of India 2021).

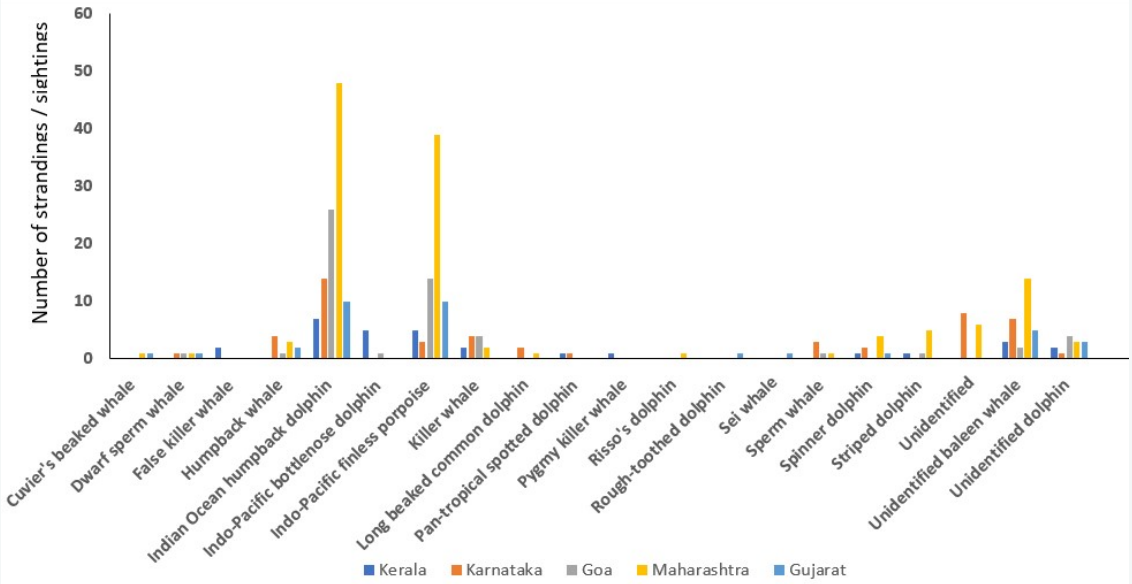

Figure 15. Sightings and strandings of whales and dolphins along the west coast of India waters from 2000 to 2021 (Marine Mammal Research and Conservation network of India 2021).

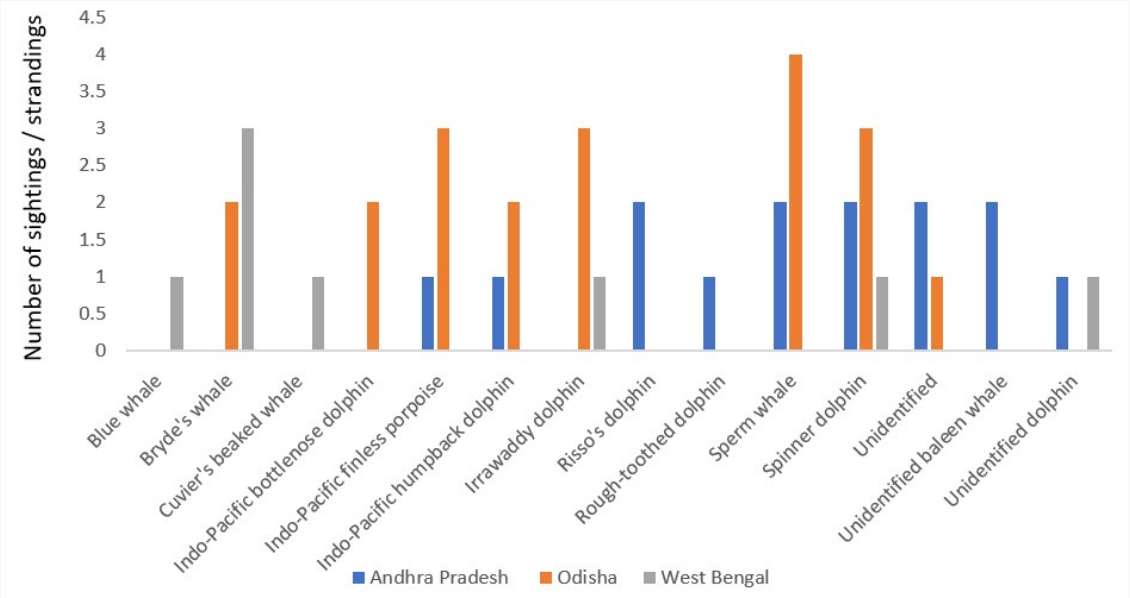

Figure 16. Sightings and strandings of whales and dolphins along the coastal states of Andhra Pradesh, Odisha, and West Bengal from 2000 to 2021 (Marine Mammal Research and Conservation network of India 2021).

The whale and dolphin species sighted or stranded along the east and west coasts of India, along with their status under the India WPA, are listed in the following table:

Marine mammal species that were sighted/stranded along the east and west coasts of India	Status under the Indian WPA {ENVIS Centre on Wildlife & Protected Areas 2011}
Blue whale	Schedule I
Bryde's whale	Schedule I
Common bottlenose dolphin	Schedule I
Cuvier's beaked whale	Schedule I
Dwarf sperm whale	Schedule I
False killer whale	Schedule I
Humpback whale	Schedule I
Indo-Pacific bottlenose dolphin	Schedule I
Indo-Pacific finless porpoise	Schedule I
Indo-Pacific humpback dolphin/Indian ocean humpback dolphin	Schedule I
Long-beaked common dolphin	Schedule I
Pan-tropical spotted dolphin	Schedule I
Risso's dolphin	Schedule I
Rough-toothed dolphin	Schedule I
Sei whale	Schedule I
Short-finned pilot whale	Schedule I
Sperm whale	Schedule I
Spinner dolphin	Schedule I
Irrawaddy dolphin	Schedule I
Killer whale	Schedule I
Pygmy killer whale	Schedule I
Striped dolphin	Schedule I

Factor 2.2 - Fishing Mortality

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra

Moderate Concern

According the SFW Unknown By-catch Matrix, marine mammals caught as by-catch in trawl nets in the Western Indian Ocean are scored 3 out of 5, so fishing mortality is rated a moderate concern.

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern

According the SFW Unknown By-catch Matrix, marine mammals caught as by-catch in gillnets and trawl nets in the Eastern Indian Ocean and in gillnets in the Western Indian Ocean are scored 1 out of 5, so fishing mortality is rated a high concern.

Mojarra spp.

Factor 2.1 - Abundance

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern
According to the SFW Unknown By-catch Matrix, unknown fish species such as *Gerres* spp. are rated a moderate concern for abundance.

Factor 2.2 - Fishing Mortality

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern
According to the SFW Unknown By-catch Matrix, finfish caught as by-catch in bottom set gillnets are scored 2 out of 5, so fishing mortality is considered a high concern.

Mullet spp.

Factor 2.1 - Abundance

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern
According to the SFW Unknown By-catch Matrix, unknown fish species such as *Mullet* spp. are rated a moderate concern for abundance.

Factor 2.2 - Fishing Mortality

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern
According to the SFW Unknown By-catch Matrix, finfish caught as by-catch in bottom set gillnets are scored 2 out of 5, so fishing mortality is considered a high concern.

Oil sardine

Factor 2.1 - Abundance

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Low Concern

Along the coast of Tamil Nadu, on the east coast of India, B_{CURR}/B_{MSY} of the Indian oil sardine (*Sardinella longiceps*) is 0.825 (Rohit, P. et al. 2018). The stock is slightly overfished in Tamil Nadu, because it appears to be >75% of B_{MSY} (Figure 17); however, abundance is rated a low concern.

Justification:

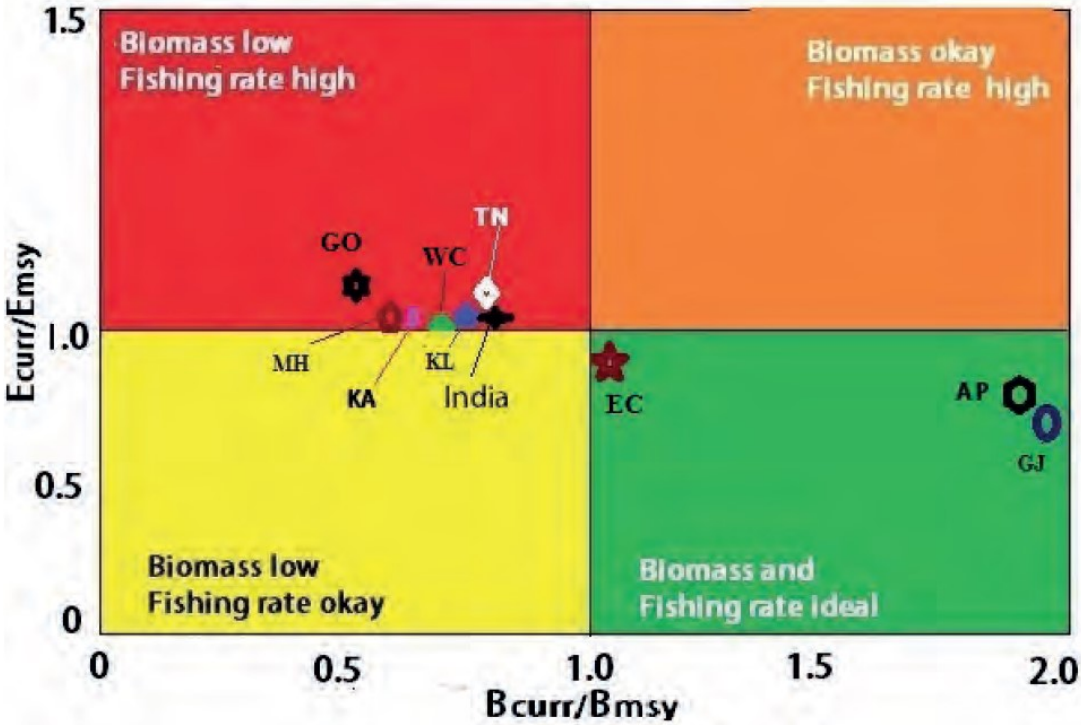

Figure 17. Stock status of Indian oil sardine showing biomass and exploitation. TN indicates stock status in the state of Tamil Nadu. Taken from (Rohit, P. et al. 2018).

Factor 2.2 - Fishing Mortality

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern

The exploitation of the Indian oil sardine from all sources (Figure 18) is high, because $E_{CURRENT}/E_{MSY}$ is 1.04, indicating that the stock is experiencing overfishing (see Figure 17 in Criterion 1_1-35) (Rohit, P. et al. 2018). In addition, fishing mortality of the Indian oil sardine caught in the blue swimming crab gillnet fishery amounts to >5% of the total fishing mortality of Indian oil sardine in Tamil Nadu from all sources, so the fishery is a substantial contributor to the total fishing mortality of the species (Jose et al. 2019)(Rohit, P. et al. 2018). Thus, fishing mortality is rated a high concern.

Justification:

The contribution of various gears to the fishing of the Indian oil sardine is shown below:

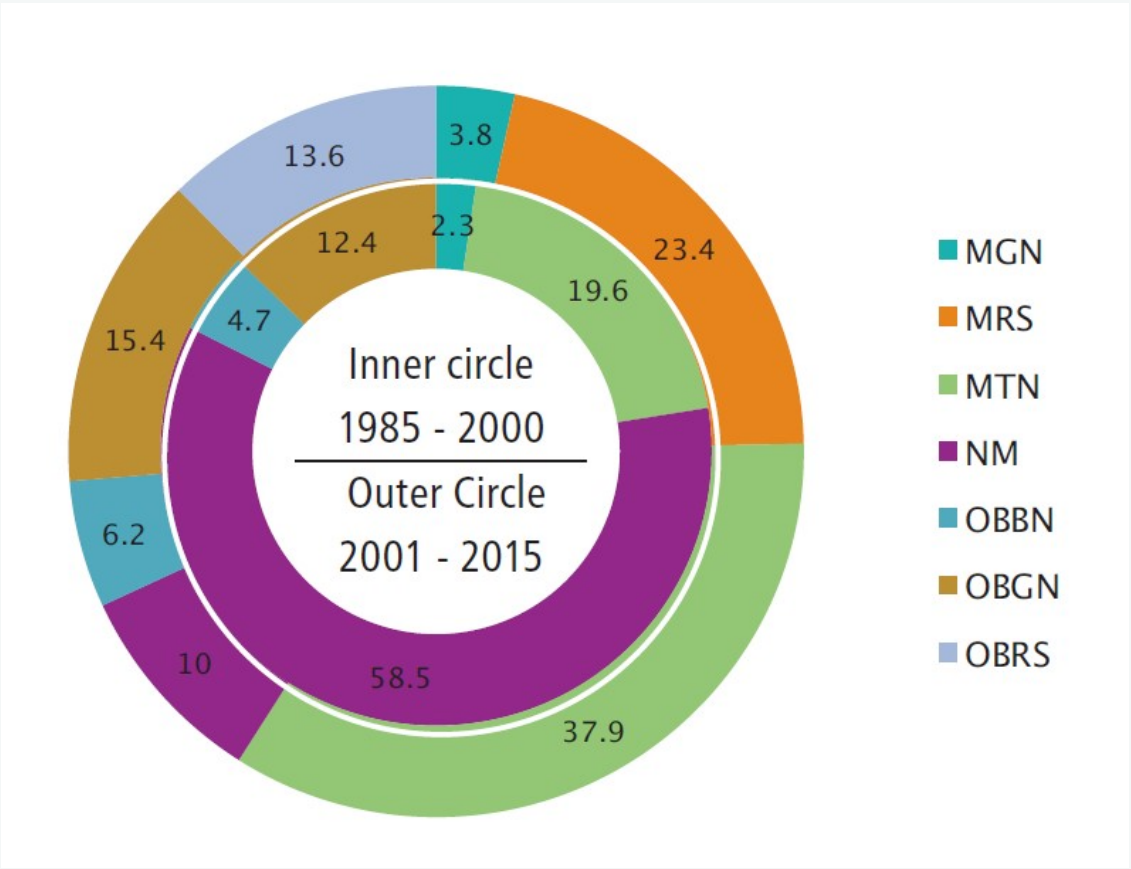

Figure 2: Gear-wise contribution to the Indian oil sardine fishery in Tamil Nadu from 2001–2015. MGN = mechanized gillnet, MRS = mechanized ring seine, MTN = mechanized trawl net, NM = nonmechanized, OBBN = outboard bagnet, OBGN = outboard gillnet, OBRS = outboard ring seine. Taken from (Rohit, P. et al. 2018).

Perforated-scale sardine

Factor 2.1 - Abundance

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern

There has been no stock assessment of *Sardinella albella* from India within the past 10 years, so a productivity-susceptibility analysis (PSA) was conducted to determine the vulnerability score of the species. The PSA generated a score of 3.033, indicating that *S. albella* has medium vulnerability. For this reason, abundance of *S. albella* is rated a moderate concern.

Justification:

Productivity Attribute	Relevant information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	Reach maturity after 1 year {Dayaratne & Gjøsaeter 1986}	1
Von Bertalanffy (Brody) Growth Coefficient (K)	K = 1.10–2.03 (FishBase 2021b)	1
Fecundity	10,000 to 13,500 eggs for fish of lengths from 14.6 to 15.5 cm (Bennet, P. S. et al. 1986)	2
Average maximum size	Average maximum length = 14 cm SL (FishBase 2021b)	1
Average size at maturity	L_M = 9 cm (FishBase 2021b)	1
Reproductive strategy	Broadcast spawner (Hunnam, K. 2021)	1
Productivity score		1.167

Susceptibility Attribute	Relevant information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	Unknown, default score used	3
Vertical overlap (Considers all fisheries)	Unknown, default score used	3

(Considers all fisheries)		
Seasonal availability (Considers all fisheries; score using the most conservative option)	Unknown, default score used	3
Selectivity of fishery (Specific to fishery under assessment)	Default score used, conditions of "high risk" do not apply	2
Post-capture mortality (Specific to fishery under assessment)	Unknown, but species likely retained	3
Susceptibility score		2.80

Factor 2.2 - Fishing Mortality

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern

There has been no stock assessment conducted on *S. albella* from India within the last 10 years, so fishing mortality is unknown. Thus, this factor is rated a moderate concern.

Sea cucumber

Factor 2.1 - Abundance

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

High Concern
Because sea cucumbers are listed as Schedule I on the Indian Wildlife (Protection) Act, 1972 {ENVIS Centre on Wildlife & Protected Areas 2011}, abundance has collectively been ranked a high concern.
Justification:
The list of Holothuroids reported from the west and east coasts of India (Raghunathan, C. et al. 2016) is given in the table below:

Genus name	Found along the west coast of India	Found along the east coast of India
Bohadschia		X
Holothuria	X	X
Stichopus	X	X
Bathyplotes	X	X
Benthothuria	X	
Mesothuria	X	X
Paelopatides	X	X
Synallactes		X
Psolidium	X	
Psolus	X	X
Actinocucumis	X	X
Oshimella	X	
Phyllophorus	X	X
Pseudocucumis		X
Althyone	X	
Cucumaria	X	X
Havelockia		X
Hemithyone		X
Leptopentacta	X	X
Pantacta		X
Pseudocnus		X
Pseudocolochirus	X	X
Stolus	X	X
Thorsonia		X

Thorsonia		X
Thyone	X	X
Oneiriphanta	X	
Orphnurgus		X
Benthogone		X
Laetmogone	X	
Benthodytes		X
Anapta		X
Chondrocolea	X	
Labidoplax		X
Opheodesoma		X
Protankyra	X	X
Psamothuria	X	X
Synapta		X
Synaptula	X	X
Ankyloderma		X
Trochostoma	X	X
Acaudina	X	X
Paracaudina		X
Bathyzona	X	
Benthophyces	X	
Eupyrgus	X	
Perizona	X	
Psuedothuria	X	
Molpadia		X

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern

Because sea cucumbers such as *Holothuria scabra* are listed as "Endangered" on the IUCN Red List (Hamel, J.-F. et al. 2013) and as Schedule I on the Indian Wildlife (Protection) Act, 1972 {ENVIS Centre on Wildlife & Protected Areas 2011}, abundance of sea cucumbers collectively is ranked a high concern.

Justification:

Historically, up to 39 species of sea cucumber were found in the Palk Bay and Gulf of Mannar region {Asha P.S. et al. 2017}. Although *Holothuria scabra* has been listed as the only sea cucumber species caught as by-catch in gillnets in the Palk Bay region (Jose et al. 2019), other species of sea cucumber have also been found in these regions, including *H. spinifera*, *H. atra*, *H. leocospilota*, *Stichopus horrens*, *Bohadschia marmorata*, *H. edulis*, *Bohadschia* spp., and *Colochirus quadrangularis* (CMFRI 2015){Asha P.S. et al. 2017}. All these species could potentially be found as by-catch in gillnets and trawl nets in this region (CMFRI 2015), and they are listed as Schedule I on the Indian Wildlife (Protection) Act, 1972 (henceforth Indian WPA) {ENVIS Centre on Wildlife & Protected Areas 2011} (see table below). Although the statuses of these sea cucumber populations are unknown, surveys conducted between 2014 and 2015 by the Central Marine Fisheries Research Institute show that the density of sea cucumbers is not low in all cases, which could indicate that abundance of some of these species may have increased since they were listed on the Indian WPA in 2001 (see table below) (CMFRI 2015){Asha P.S. et al. 2017}. But, these sea cucumber species have not been removed from the Indian WPA, so for the purpose of this report, they are still considered a high concern.

Species	**IUCN status**	**WPA status** {ENVIS Centre on Wildlife & Protected Areas 2011}	**Mean density (±SE) in Palk Bay in nos/ha**	**Mean density (±SE) in Gulf of Mannar in nos/ha**
Holothuria scabra	Endangered (Hamel, J.-F. et al. 2013)	Schedule I	2,352.6±546.7	178.94±110.2
H. spinifera	Data Deficient (Samyn, Y. 2013)	Schedule I	75.5±57.7	69.14±33.02
H. atra	Least Concern (Conand, C. et al. 2013)	Schedule I	190.3±101.9	767.7±177.01
H. leucospilota	Least Concern {Conand, C. et al. 2013b}	Schedule I	5.21±5.21	987.4±362.5
H. edulis	Least Concern	Schedule I	-	11.4±11.4
Stichopus horrens	Data Deficient (Conand, C. et al. 2013c)	Schedule I	6.8±6.8	1,599.8±619.2
Bohadschia marmorata	Data Deficient {Conand, C. & Purcell, S. 2013}	Schedule I	10.9±10.9	192.9±89.1
Bohadschia spp.	Includes ETP species	Schedule I	-	11.36±11.4
Colochirus quadrangularis	-	Schedule I	-	34.4±34.4

Factor 2.2 - Fishing Mortality

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal

High Concern
According to the SFW Unknown By-catch Matrix, benthic invertebrates such as sea cucumber that are caught in bottom trawls as by-catch score 2 out of 5, so fishing mortality is rated a high concern.

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

Moderate Concern
According to the SFW Unknown By-catch Matrix, benthic invertebrates such as sea cucumber caught in gillnets as by-catch score a 3 out of 5, so fishing mortality is rated a moderate concern.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu

High Concern
Although harvesting of sea cucumbers has been banned in India since they were included under the Indian WPA in 2001, they are still illegally harvested in the Palk Bay region (CMFRI 2015){Asha P.S. et al. 2017}. Sea cucumbers are caught to a larger extent as by-catch in trawl nets in the Palk Bay region (CMFRI 2015){Asha P.S. et al. 2017}. Because fishing of sea cucumbers from the Palk Bay region is very likely unsustainable (CMFRI 2015){Asha P.S. et al. 2017} and fishing mortality due to trawl nets is likely to be significant, yet is unknown, this factor is scored a high concern.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern
Although harvesting of sea cucumbers has been banned in India since they were included under the Indian WPA in 2001, they are still illegally harvested in the Palk Bay region (CMFRI 2015){Asha P.S. et al. 2017}. Nevertheless, only a small proportion of sea cucumbers are caught as by-catch in gill nets in the Palk Bay region (CMFRI 2015). Because the fishing mortality of sea cucumbers caught in gillnets in Palk Bay is unknown, this factor is scored a moderate concern.

Sea turtle (unspecified)

Factor 2.1 - Abundance

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra

High Concern
All four species of sea turtles found along the west coast of India are listed on the Indian WPA {ENVIS Centre on Wildlife & Protected Areas 2011}, so sea turtles are rated a high concern for abundance.
Justification:
Along the west coast of India, four species of sea turtles were historically recorded (Dileepkumar, N. and C. Jayakumar 2006)(Sharath, B. K. 2006)(Giri, V. and N. Chaturvedi 2006)(Sunderraj, S. F. W. et al. 2006), as shown in the table below. In 2006, nesting of olive ridley turtle was observed in all five western states, whereas green sea turtle was seen nesting in Maharashtra and Gujarat, leatherback turtle was noted nesting in Maharashtra and Goa, and hawksbill turtle was observed nesting in Maharashtra (Dileepkumar, N. and C. Jayakumar 2006)(Sharath, B. K. 2006)(Giri, V. and N. Chaturvedi 2006)(Sunderraj, S. F. W. et al. 2006). Currently, olive ridley turtle is the most abundant species in the region and is observed nesting along the west coast.

Species name	State of historical presence	IUCN Red List status	Indian WPA status {ENVIS Centre on Wildlife & Protected Areas 2011}
Olive ridley turtle (*Lepidochelys olivacea*)	Kerala, Karnataka, Goa, Maharashtra, Gujarat	Vulnerable {Abreu-Grobois, A. & Plotkin, P. 2008}	Schedule I
Hawksbill turtle (*Eretmochelys imbricata*)	Kerala, Maharashtra, Gujarat	Critically Endangered {Mortimer, J.A. & Donnelly, M. 2008}	Schedule I
Green sea turtle (*Chelonia mydas*)	Kerala, Goa, Maharashtra, Gujarat	Endangered (Seminoff, J.A. 2004)	Schedule I
Leatherback turtle (*Dermochelys coriacea*)	Kerala, Goa, Maharashtra, Gujarat	Vulnerable {Wallace, B.P. et al. 2013}	Schedule I

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

High Concern

All five species of sea turtle found along the east coast of India are listed on the Indian WPA {ENVIS Centre on Wildlife & Protected Areas 2011}, so sea turtles are rated a high concern for abundance.

Justification:

Although four or five sea turtle species have historically been reported in the state waters of Andhra Pradesh, Odisha, and West Bengal, olive ridley turtle has more recently been reported as the most common and abundant species, with nesting observed in all three states (Tripathy, B. et al. 2006)(Pandav, B. et al. 2006)(Chowdhury, B. R et al. 2006). This species migrates from the coastal waters of Tamil Nadu to mass-nest on the beaches in Odisha (Pandav, B. et al. 2006). Sporadic nesting of this species also occurs on the northern beaches of Andhra Pradesh, in Odisha, and in West Bengal (Tripathy, B. et al. 2006)(Chowdhury, B. R et al. 2006)(Pandav, B. et al. 2006).

The status and historical record of all five species of turtles along the east coast of India are given in the table below:

Species name	Historical distribution by state	IUCN Red List status	Indian WPA status {ENVIS Centre on Wildlife & Protected Areas 2011}
Olive ridley turtle (*Lepidochelys olivacea*)	Andhra Pradesh, Odisha, West Bengal	Vulnerable {Abreu-Grobois, A. & Plotkin, P. 2008}	Schedule I
Loggerhead turtle (*Caretta caretta*)	Andhra Pradesh, West Bengal	Vulnerable {Casale, P. & Tucker, A.D. 2017}	Schedule I
Hawksbill turtle (*Eretmochelys imbricata*)	Andhra Pradesh, Odisha, West Bengal	Critically Endangered {Mortimer, J.A. & Donnelly, M. 2008}	Schedule I
Green sea turtle (*Chelonia mydas*)	Andhra Pradesh, Odisha, West Bengal	Endangered (Seminoff, J.A. 2004)	Schedule I
Leatherback turtle (*Dermochelys coriacea*)	Andhra Pradesh, Odisha	Vulnerable {Wallace, B.P. et al. 2013}	Schedule I

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern

All five species of sea turtles found along the east coast of India are listed on the Indian WPA {ENVIS Centre on Wildlife & Protected Areas 2011}, so sea turtles are rated a high concern for abundance.

Justification:

Five species of sea turtles are found in Tamil Nadu waters, including olive ridley turtle (*Lepidochelys olivacea*), loggerhead turtle (*Caretta caretta*), hawksbill turtle (*Eretmochelys imbricata*), green sea turtle (*Chelonia mydas*), and leatherback turtle (*Dermochelys coriacea*) {Bhupathy & Saravanan 2006}(WWF-India 2013). Of these, four species—olive ridley, green sea, hawksbill, and leatherback—are more commonly sighted {Shanker, K. & Choudhury, B. C. 2006} and were historically known to nest on the beaches of Tamil Nadu; however, more recent surveys indicate that only olive ridley turtle nests in the state (WWF-India 2013). The status on the IUCN Red List and the Indian WPA of each of these five species of sea turtle is listed in the table below.

Species name	IUCN Red List status	Indian WPA status {ENVIS Centre on Wildlife & Protected Areas 2011}
Olive ridley turtle (*Lepidochelys olivacea*)	Vulnerable {Abreu-Grobois, A. & Plotkin, P. 2008}	Schedule I
Loggerhead turtle (*Caretta caretta*)	Vulnerable {Casale, P. & Tucker, A.D. 2017}	Schedule I
Hawksbill turtle (*Eretmochelys imbricata*)	Critically Endangered {Mortimer, J.A. & Donnelly, M. 2008}	Schedule I
Green sea turtle (*Chelonia mydas*)	Endangered (Seminoff, J.A. 2004)	Schedule I
Leatherback turtle (*Dermochelys coriacea*)	Vulnerable {Wallace, B.P. et al. 2013}	Schedule I

Factor 2.2 - Fishing Mortality

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra

High Concern

Gillnets and trawl nets are a threat to sea turtles along the entire Indian coast (Rajagopalan, M. et al. 1996). Overall, trawl nets account for less than 20% of the incidental turtle mortality, whereas gillnets account for more than 60% (Rajagopalan, M. et al. 2006). Although fishing mortality is unknown, these gears likely pose a significant threat to turtle populations, so this factor is rated a high concern.

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

High Concern

Fishery-related incidental mortality is a known threat to olive ridley sea turtle, because it encounters a high density of gillnets and trawl nets along the coasts of Andhra Pradesh, Odisha, and West Bengal (Rajagopalan, M. et al. 1996)(Rajagopalan, M. et al. 2006) on the migratory route to its mass nesting grounds in Odisha {Shanker, K. & Choudhury, B. C. 2006}(WWF-India 2013). In Odisha in particular, up to 20,000 turtles are known to have died annually due to fishery-related mortality {Behera, C. R. 2006}. Along the Indian coast overall, trawl nets account for less than 20% of the incidental turtle mortality, whereas gillnets account for more than 60% (Rajagopalan, M. et al. 2006). Although fishing mortality of turtles in this region is unknown, it is very likely unsustainable, and gillnets and trawl nets are expected to be substantial contributors to total fishing mortality in this region. Because of these reasons, this factor is rated a high concern.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern

Gillnets and trawl nets are a threat to sea turtles along the entire Indian coast (Rajagopalan, M. et al. 1996). Overall, trawl nets account for less than 20% of the incidental turtle mortality, whereas gillnets account for more than 60% (Rajagopalan, M. et al. 2006). Although fishing mortality is unknown, these gears likely pose a significant threat to turtle populations, so this factor is rated a high concern.

Justification:

The coast of Tamil Nadu forms part of the migratory corridor of olive ridley turtle en route to its mass nesting grounds in Odisha along the east coast of India {Bhupathy & Saravanan 2006}(WWF-India 2013). In particular, the incidental catch of turtles in gillnets and trawl nets in Tamil Nadu has been previously documented (Rajagopalan, M. et al. 1996){Bhupathy & Saravanan 2006} (Rajagopalan, M. et al. 2006). The recently amended Tamil Nadu Marine Fishing Regulation Rules, 2020 include a rule mandating the use of turtle excluder devices (TED) in trawl nets (Government of Tamil Nadu 2020); once implemented, this regulation is expected to decrease the threat of trawl nets to the fishing mortality of turtles in Tamil Nadu waters.

Seabirds

Factor 2.1 - Abundance

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern
According to the SFW Unknown By-catch Matrix, seabirds have high inherent vulnerability and therefore are scored a high concern for abundance.

Factor 2.2 - Fishing Mortality

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra

Moderate Concern
According to the SFW Unknown By-catch Matrix, seabirds caught as by-catch in bottom trawl nets in the Western Indian Ocean are scored 3 out of 5, so fishing mortality is considered a moderate concern.

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra

High Concern
According to the SFW Unknown By-catch Matrix, seabirds caught as by-catch in gillnets in the Western Indian Ocean are scored 1 out of 5, so fishing mortality is considered a high concern.

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern

According to the SFW Unknown By-catch Matrix, seabirds caught as by-catch in gillnets in the Eastern Indian Ocean are scored 3 out of 5, so fishing mortality is considered a moderate concern.

Seahorses

Factor 2.1 - Abundance

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

High Concern

Seven species of seahorses are found in India (see Figure 19 in criterion 1_1-22), of which one (*H. kelloggi*) is found along the coast of Andhra Pradesh; one (*H. kuda*) is found along the coasts of Odisha and West Bengal; three (*H. trimaculatus*, *H. kuda*, and *H. kelloggi*) are found along the coast of Kerala; one (*H. kuda*) is found in the waters of Karnataka, Goa, and Maharashtra; and one (*H. camelopardalis*) is found in Gujarat {Vinod, K. et al. 2018}. All these species of seahorses are listed on the Indian WPA (1972) {ENVIS Centre on Wildlife & Protected Areas 2011}, CITES (UNEP-WCMC 2021), and the IUCN Red List. For these reasons, abundance of seahorses has been rated a high concern.

Justification:

The statuses of seahorses according to the Indian WPA (1972), CITES (UNEP-WCMC 2021), and the IUCN Red List in the eastern states of Andhra Pradesh, Odisha, and West Bengal, and along the west coast in the states of Kerala, Karnataka, Goa, Maharashtra, and Gujarat, are given in the table below:

Species name	Status per the Indian WPA (1972) {ENVIS Centre on Wildlife & Protected Areas 2011}	CITES status (UNEP-WCMC 2021)	IUCN Red List status
H. trimaculatus	Schedule I	Appendix II	Vulnerable (Wiswedel, S. 2015)
H. kuda	Schedule I	Appendix II	Vulnerable (Aylesworth, L. 2014)
H. kelloggi	Schedule I	Appendix II	Vulnerable (Pollom, R. 2017b)
H. camelopardalis	Schedule I	Appendix II	Data Deficient (Pollom, R. 2017d)

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern

Seven species of seahorses are found in India, of which six are specifically found along the Tamil Nadu coast (Figure 19): *Hippocampus trimaculatus*, *H. kuda*, *H. spinosissimus*, *H. kelloggi*, *H. histrix*, and *H. mohnikei* {Vinod, K. et al. 2018}. In addition, one species of pipefish —*Syngnathoides biaculeateus*—has been reported from the Palk Bay region (Fisheryprogress.org 2020). All these species of syngnathids are listed on the Indian WPA (1972) {ENVIS Centre on Wildlife & Protected Areas 2011} and CITES (UNEP-WCMC 2021), and all the seahorses are on the IUCN Red List. Further, evidence suggests that, since the harvesting of seahorses was banned in 2001 when they were added to the Indian WPA (1972), an illegal trade emerged in seahorses caught as by-catch in gear from the Palk Bay and Gulf of Mannar regions in Tamil Nadu; this illegal trade subsequently exacerbated the decline of seahorses in the region {Vinod, K. et al. 2018} {Vaidyanathan et al. 2021}{Vaidyanathan, T. & A.C. J. Vincent 2021}. For these reasons, abundance of seahorses has been rated a high concern.

Justification:

The distribution of seahorses in India are shown in Figure 19 below:

Figure 19. Distribution of seahorses in Indian waters. Taken from {Vinod et al. 2018}.

The status of seahorses in Tamil Nadu waters according to the Indian WPA (1972), CITES (UNEP-WCMC 2021), and the IUCN Red List are given in the table below:

Species name	Status per the Indian WPA (1972) {ENVIS Centre on Wildlife & Protected Areas 2011}	CITES status (UNEP-WCMC 2021)	IUCN Red List status
Hippocampus trimaculatus	Schedule I	Appendix II	Vulnerable (Wiswedel, S. 2015)
H. kuda	Schedule I	Appendix II	Vulnerable (Aylesworth, L. 2014)
H. spinosissimus	Schedule I	Appendix II	Vulnerable (Pollom, R. 2017)
H. kelloggi	Schedule I	Appendix II	Vulnerable (Pollom, R. 2017b)
H. histrix	Schedule I	Appendix II	Vulnerable (Pollom, R. 2017c)
H. mohnikei	Schedule I	Appendix II	Vulnerable (Pollom, R. 2017d)
Syngnathoides biaculeateus	Schedule I	-	-

Factor 2.2 - Fishing Mortality

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

High Concern
According to the SFW Unknown By-catch Matrix, unknown finfish caught as by-catch in gillnets and trawl nets are scored 2 out of 5, and are rated as high concern for fishing mortality.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern

By-catch due to various fishing gears poses a significant threat to seahorses in the Palk Bay and Gulf of Mannar regions of Tamil Nadu {Vinod, K. et al. 2018}{Vaidyanathan et al. 2021} {Vaidyanathan, T. & A.C. J. Vincent 2021}. Of the gears used, the catch per unit effort (CPUE) of seahorses in both trawl nets and gillnets is relatively high (Figure 20) {Vaidyanathan et al. 2021}. Because these gears are quite likely substantial contributors to the fishing mortality of seahorses in the region, this factor is scored a high concern.

Justification:

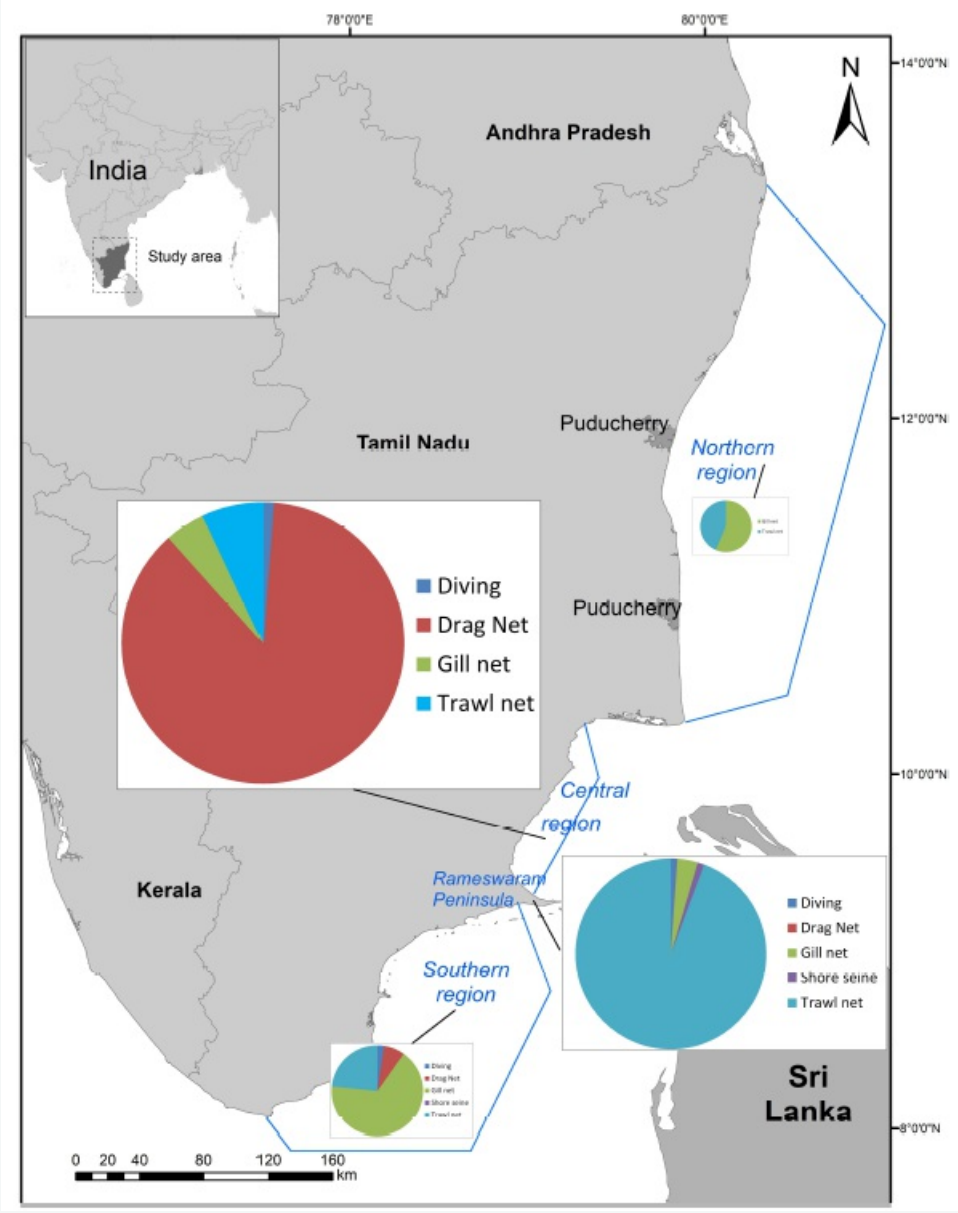

Figure 20. Seahorse catches by location and gear type along the coast of Palk Bay and Gulf of Mannar in Tamil Nadu. Taken from {Vaidyanathan et al. 2021}.

Sharks

Factor 2.1 - Abundance

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

High Concern
According to the Seafood Watch standard, all sharks are considered highly vulnerable and are rated a high concern for abundance.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern

The slender bamboo shark (*Chiloscyllium indicum*), which is found as by-catch in bottom set gillnets in Palk Bay, Tamil Nadu, is listed as "Vulnerable" on the IUCN Red List (VanderWright, W.J. et al. 2020); therefore, abundance of sharks has collectively been rated a high concern.

Justification:

The statuses of sharks that were reported as by-catch in blue swimming crab gillnets in the Palk Bay region (Jose et al. 2019) on the IUCN Red List and the Indian WPA are listed in the table below:

Species name	IUCN Red List status	Indian WPA status {ENVIS Centre on Wildlife & Protected Areas 2011}
Spottail shark (*Carcharhinus sorrah*)	Near Threatened (Simpfendorfer, C. et al. 2021)	-
Carcharhinus spp.	Many species of this genus are endangered, threatened, or protected (ETP) and found in the region	*Carcharhinus hemiodon* is listed as Schedule I
Slender bamboo shark (*Chiloscyllium indicum*)	Vulnerable (VanderWright, W.J. et al. 2020)	-
Chiloscyllium spp.	Many species of this genus are endangered, threatened, or protected (ETP) and found in the region	-
Spadenose shark (*Scoliodon laticaudus*)	Near Threatened (Dulvy, N.K. et al. 2021)	-

Factor 2.2 - Fishing Mortality

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra

High Concern

According to the SFW Unknown By-catch Matrix, sharks caught as by-catch in trawl nets in the Western Indian Ocean are scored 2 out of 5, whereas those caught in gillnets are scored 1 out of 5; therefore, fishing mortality is considered a high concern.

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu

High Concern
According to the SFW Unknown By-catch Matrix, sharks caught as by-catch in trawl nets in the Eastern Indian Ocean are scored 1 out of 5, so fishing mortality is considered a high concern.

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern
According to the SFW Unknown By-catch Matrix, sharks caught as by-catch in gillnets in the Eastern Indian Ocean are scored 2 out of 5, so fishing mortality is considered a high concern.

stingrays (unspecified)

Factor 2.1 - Abundance

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

High Concern
According to the SFW standard, all rays, being elasmobranchs, are considered highly vulnerable and are rated a high concern for abundance.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern
Coach whipray (*Himantura uarnak*) and Bleeker's whipray (*Pateobatis bleekeri*), which are found as by-catch species in the blue swimming crab gillnet fishery, are listed as "Endangered" on the IUCN Red List (Sherman, C.S. et al. 2021)(Sherman, C.S. et al. 2020), so abundance is rated a high concern.

Justification:
The statuses of rays that were reported as by-catch in blue swimming crab gillnets in the Palk Bay region (Jose et al. 2019) on the IUCN Red List are listed in the table below:

Species name	IUCN Red List status
Coach whipray (*Himantura uarnak*)	Endangered (Sherman, C.S. et al. 2021)
Himantura spp.	Includes endangered, threatened, and protected (ETP) species
Cowtail ray (*Pastinachus sephen*)	Near Threatened (Kyne, P.M. et al. 2017)
Bleeker's whipray (*Pateobatis bleekeri*)	Endangered (Sherman, C.S. et al. 2020)
Dasyatis spp.	Includes endangered, threatened, and protected (ETP) species

Factor 2.2 - Fishing Mortality

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra

High Concern
According to the SFW Unknown By-catch Matrix, rays caught as by-catch in trawl nets in the Western Indian Ocean are scored 2 out of 5, whereas those caught as by-catch in gillnets are scored 1 out of 5; therefore, fishing mortality is considered a high concern.

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

High Concern
According to the SFW Unknown By-catch Matrix, rays caught as by-catch in trawl nets in the Eastern Indian Ocean are scored 1 out of 5, whereas those caught as by-catch in gillnets are scored 2 out of 5; therefore, fishing mortality is considered a high concern.

Factor 2.3 - Discard Rate/Landings

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal

< 100%
In general, trawl discards along the east and west coasts of India have decreased, and the landings of low-value by-catch have increased, due to the high demand for trash fish for the production of fish meal, fertilizer (Dineshbabu, A. P. et al. 2013), and poultry feed {Lobo. A. et. al. 2010}. We assume that the discard rate for this gear type is <100% of the retained catch, and therefore assume a multiplying factor of 1.

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

< 100%
Discards in crab bottom-set gillnets from the Gulf of Mannar region have been found to be 23.1% of the total catch (Harsha, K. et al. 2017). We assume that the discard rate for similar gillnets along the east and west coasts of India is <100% of the retained catch, and therefore assume a multiplying factor of 1.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu

< 100%
Although there are no estimates of discards from trawl fisheries in Palk Bay, the literature suggests that, in Tamil Nadu, landings of by-catch both for human consumption and as raw material for poultry and fishmeal industries have increased drastically since the late 1980s, because it makes trawling more profitable than relying on target species alone {Lobo. A. et. al. 2010}. We assume that the discard rate for this gear type is <100% of the retained catch, and therefore assume a multiplying factor of 1.

Criterion 3: Management Effectiveness

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

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

The Criterion 3 rating is determined as follows:

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

Rating is Critical if Management Strategy and Implementation is Critical.

Guiding principle

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

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

Criterion 3 Summary

FISHERY	MANAGEMENT STRATEGY	BYCATCH STRATEGY	DATA COLLECTION AND ANALYSIS	ENFORCEMENT	INCLUSION	SCORE
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra	Critical	Ineffective	Ineffective	Ineffective	Ineffective	**Black (0.000)**

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra	Critical	Ineffective	Ineffective	Ineffective	Ineffective	**Black (0.000)**
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal	Critical	Ineffective	Ineffective	Ineffective	Ineffective	**Black (0.000)**
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal	Critical	Ineffective	Ineffective	Ineffective	Ineffective	**Black (0.000)**
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu	Ineffective	Ineffective	Ineffective	Moderately Effective	Moderately Effective	**Red (1.000)**
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu	Ineffective	Ineffective	Moderately Effective	Moderately Effective	Moderately Effective	**Red (1.000)**

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.

Factor 3.1 - Management Strategy And Implementation

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

Critical

At the federal level, the newly formed Department of Fisheries, under the Ministry of Fisheries, Animal Husbandry and Dairying, develops overarching marine fisheries policies in India (Government of India 2021). At present, the Indian Marine Fisheries Act of 2021 is in draft form (Government of India 2021b); this policy addresses areas of the ocean up to 200 nm from sore, which forms the exclusive economic zone (EEZ) of India.

Broadly, regulations that are currently outlined by the State Fisheries Departments along the west coast of India, and in Andhra Pradesh, Odisha, and West Bengal along the east coast of India (GoK 1980)(GoK 2018)(GoK 1986)(GoG 1980)(GoM 1981)(GoG 2003)(GoA 1994)(GoO 1981)(GoO 1983)(GoWB 1993), include:

1. An annual seasonal fishing ban, which is imposed on mechanized trawlers. In Kerala, this ban is for 52 days, whereas in the rest of the states, it is for 61 days.
2. Ensuring that all fishing vessels are registered and licensed.
3. Restrictions on movement of fishing vessels.
4. In Kerala, vessels must follow a length-to-horsepower ratio, trawlers must be equipped with a vessel monitoring system (VMS) or an automatic identification system, nets have a minimum mesh size, and there is a three-tier system of fisheries management at the village, district, and state level.
5. On the east coast, there is a zoning of fishing grounds, such that traditional and motorized vessels can access regions closer to the shore within a specified distance, and trawlers must use zones farther from the shore.
6. State Fisheries Departments may regulate and restrict fishing, fishing gear, fishing vessels, and/or restrict fishing of specific species for specified periods of time in any specific area through an official notification.

Nevertheless, fisheries-specific harvest control rules are currently not mandatory under the regulatory framework in India (Jose et al. 2019), so there are no specific management regulations for blue swimming crab fisheries along the west coast of India and in Andhra Pradesh, Odisha, and West Bengal along the east coast. Therefore, at present, there appears to be no management strategy in place where it is clearly needed. As a result, the management strategy of the BSC fishery along the west coast of India and in Andhra Pradesh, Odisha, and West Bengal is rated critical.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Ineffective

At the federal level, the newly formed Department of Fisheries, which operates under the Ministry of Fisheries, Animal Husbandry and Dairying, is responsible for developing overarching marine fisheries policies in India (Government of India 2021). At present, the Indian Marine Fisheries Act

fisheries policies in India (Government of India 2021). At present, the Indian Marine Fisheries Act of 2021 is in draft form (Government of India 2021b); this policy addresses areas of the ocean up to 200 nm from the shore, which forms the exclusive economic zone (EEZ) of India.

Each coastal state in India is also responsible for managing the marine fisheries resources within the 12 nm of its territorial waters, and has been tasked with updating its marine fisheries policies. Because the outer limits of the Palk Bay lie within the territorial waters of Tamil Nadu, and for its proximity to the International Maritime Boundary line with Sri Lanka, management of the blue swimming crab fishery in the Palk Bay region falls primarily under the jurisdiction of the Tamil Nadu State Fisheries Department.

In the Palk Bay ecosystem, historically, there has also been a prevalence of legal pluralism that affects fisheries in the region (Jentoft, S. et al. 2009)(Salagrama, V. 2014). For instance, in addition to the existing government ministries at the central and state levels, locally elected community-based institutions such as *meenavar uur panchayats*, modern institutions (such as *gram panchayats*, fishers' cooperative societies, and other self-help groups), and stakeholder group-based institutions (such as boat owners' associations) play a role in fisheries governance (Salagrama, V. 2014). The more recent emergence of the state institutions has somewhat undermined the power of the traditional institutions, but the latter still play an important role in fishing community actions and fisheries governance (Salagrama, V. 2014). An important function of these traditional institutions is their capacity to enforce rules effectively (Salagrama, V. 2014).

Restrictions that are currently imposed by the Tamil Nadu State Fisheries Department in the Palk Bay that affect the blue swimming crab fishery include:

1. A 61-day fishing ban, which is imposed on mechanized trawlers (from 14 April to 14 June) along the Tamil Nadu coast each year. These restrictions are not followed by the gillnet fishers of blue swimming crab, who mostly fish using fiberglass-reinforced plastic (FRP) motorized boats, using engines of up to 25 HP {Fernandez & Ganapathiraju 2019}.
2. A token system, implemented for the past 30 years through the 3:4 day rule, by which mechanized trawl fishing vessels are allowed to fish for 3 days in the week (i.e., Monday, Wednesday, Friday), whereas small-scale fishing boats using gillnets are expected to fish on the remaining 4 days (i.e., Tuesday, Thursday, Saturday, Sunday). Compliance with this rule is inconsistent (Salagrama, V. 2014){Fernandez & Ganapathiraju 2019}, and may depend on how strongly local fisher institutions enforce it (pers. comm., Malayilethu).
3. Ensuring that all fishing vessels are registered and carry an appropriate registration mark assigned to them by the authorized officer. All vessels in the Palk Bay that target blue swimming crab are required to clearly display registration numbers provided by the Tamil Nadu State Fisheries Department {Fernandez & Ganapathiraju 2019}.
4. Limiting movement of boats between fish landing villages in the Palk Bay (all fishing boats also need a permit to anchor). Fishers who intend to shift operations from one landing port to another must notify and seek approval from the Tamil Nadu State Fisheries Department (Muralidharan 2009) {Fernandez & Ganapathiraju 2019}.

The recent Fishery Management Plan for blue swimming crab, released in 2019 (Jose et al. 2019) and developed by the Central Marine Fisheries Research Institute (henceforth CMFRI), has

suggested implementing the following science-based recommendations to ensure that the blue swimming crab stock in the Palk Bay remains within sustainable limits. These include:

1. A total ban on the landing of blue swimming crab berried females caught by all gear in Palk Bay (Jose et al. 2019).
2. Reducing the total number of days that gillnetters are allowed to fish for blue swimming crab (Jose et al. 2019).
3. Implementation of a minimum landing size of 90 mm carapace width (CW) (Jose, J. 2018).
4. Effort limitations if yields in the fishery increase or decrease, to ensure that the stock remains at a sustainable level, and closing the fishery if yields increase by 50% (Jose et al. 2019).

The Tamil Nadu Marine Fishing Regulation Act of 1983 is currently in the process of being amended, to formulate the Tamil Nadu Marine Fishing Regulation Rules, 2020 (henceforth TNMFRR, 2020) (Government of Tamil Nadu 2020); these rules build the framework for monitoring and control of fishing activities within the territorial waters of Tamil Nadu, for mechanized and nonmechanized fishing vessels. The following rules of the TNMFRR (2020), once implemented, could potentially be useful to improve the management of the blue swimming crab fishery in Palk Bay:

1. Mechanized vessels and trawling are not allowed to operate within 5 nm of the coast.
2. Caps on the number of fishing vessels in an area can be implemented by the authorizing officer who has jurisdiction over the area.
3. Following the science-based recommendations of the CMFRI, the minimum landing size of blue swimming crab and a ban on landing berried females could be declared through a notification, to ensure that smaller-sized individuals, juvenile crabs, and berried females are not harvested. Following this notification, the authorizing officer has the authority to seize and impound fishing vessels that land the illegal catch, if the vessels are appropriately identified.
4. All gillnets used must have a minimum stretched mesh size of 25 mm.
5. Trawl nets must have a minimum stretched mesh size of 40 mm at the cod end.
6. Through a notification, the Tamil Nadu State Department of Fisheries could potentially declare a "closed season" in the blue swimming crab fishery, to regulate, restrict, or prohibit the catching of the species by classes of fishing vessels.

Nevertheless, the TNMFRR (2020) have not yet been implemented. Currently, fisheries-specific harvest control rules are not mandatory under the regulatory framework in India (Jose et al. 2019). No closures or restrictions exist on small-scale fishers deploying gillnets of huge lengths (often combining 10-15 nets of various lengths deployed by each fishing boat) {Fernandez & Ganapathiraju 2019}. Even if policies at the federal and state level were already amended, there currently is no mechanism to verify effective implementation of federal laws (e.g., Indian Fisheries Act, 1897; Draft Indian Marine Fisheries Bill, 2021) and state laws (e.g., Tamil Nadu Marine Fishing Regulation Act 1983, Tamil Nadu Marine Fishing Regulation Rules, 2020) in the Palk Bay. There also appears to be no coherent strategy between institutions to implement various federal and state regulations to manage the fishery {Fernandez & Ganapathiraju 2019}. Once the TNMFRR (2020) has been implemented, the basic regulatory framework and science to manage the blue swimming crab fishery would exist in Palk Bay, Tamil Nadu, provided that specific rules pertaining to the

crab fishery would exist in Palk Bay, Tamil Nadu, provided that specific rules pertaining to the fishery in the Palk Bay are notified by the Tamil Nadu State Department of Fisheries. But, the TNMFRR (2020) has not yet been implemented and, of the rules that are currently being implemented, the effectiveness of implementation is unknown.

Despite these limitations, there has been recent progress in managing the blue swimming crab fishery. In 2019, the Tamil Nadu Fisheries Department passed an order to establish a four-tier system of fisheries co-management, designed to work at the village, district, zonal, and state levels (GoTN 2019). Subsequently, to address management in the blue swimming crab gillnet fishery in Palk Bay, the Palk Bay Fishing Management Council (PBFMC) was set up in 2020, and they have had one meeting in 2021 since then (Fisheryprogress.org 2022). Because the four-tier system of fishery management and the PBFMC have only recently been introduced and implemented, their effectiveness in improving management in the fishery is yet unknown.

Further, in 2020, the Crab Meat Processors Association (CMPA) took the initiative to distribute 750 crab gauges among the blue swimming crab gillnet fishers, to encourage fishers not to harvest juveniles (Fisheryprogress.org 2022b). The CMPA has also taken a decision not to buy berried females, and has devised a raw material procurement format to ensure that crabs below minimum landing size (MLS) and berried crabs are not purchased (Philips Foods India Pvt Ltd 2020). As a consequence, the percentage of berried crabs reported in the catch in 2020 and 2021 was 9.46% and 7.71%, respectively (Fisheryprogress.org 2022b); similarly, the percentage of crabs landed below MLS in 2020 and 2021 was 5.64% and 6.32%, respectively (Fisheryprogress.org 2022b).

Although there has been recent progress—particularly in the blue swimming crab gillnet fishery in Palk Bay on account of the existing fishery improvement plan (FIP)—in implementing the four-tier management structure, and due to the recent initiative taken by the CMPA to control the harvesting of juveniles and berried females, the effectiveness of the four-tier system in managing the fishery is yet unknown; and, though the actions of the CMPA are commendable, they lack the legitimacy of a management authority (such as the Tamil Nadu Fisheries Department) or a group of local stakeholders officially appointed to make science-based and knowledge-based management decisions (such as the PBFMC). Further, and importantly, the existing management of the blue swimming crab fishery is not responsive to changes in stock productivity and/or biomass. Therefore, management strategy and implementation is rated ineffective.

Factor 3.2 - Bycatch Strategy

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

Ineffective

Currently, there is no unified by-catch reduction strategy specifically to address monitoring, assessment, and regulation of fisheries by-catch or by-catch of endangered, threatened, or protected (ETP) species caught by trawl nets or gillnets along the west coast of India, or in Andhra Pradesh, Odisha, and West Bengal along the east coast.

The State Forest Departments, which operate under the MoEFCC, Government of India, are responsible for enforcing the Indian WPA (Government of India 1972). This Act establishes a list of Schedule species, creating a blanket ban to prohibit the hunting and harvesting of all protected species in India, from Schedule I to Schedule IV. Because nontarget species caught in gillnets and trawl nets in the blue swimming crab fishery may be Schedule species, by-catch of these species is illegal under the WPA. Nevertheless, the lack of effectiveness of a blanket ban on harvesting Schedule species has been discussed in the literature (CMFRI 2015){Asha P.S. et al. 2017}{Vinod, K. et al. 2018}{Vaidyanathan et al. 2021}{Vaidyanathan, T. & A.C. J. Vincent 2021}.

In addition to the WPA, to address the decline in the population of dugong, a task force was established by the government of India to formulate an action plan for the conservation of dugong (Sivakumar, K. 2013). The task force addresses threats to dugong from all sources, including by-catch. In 2007, the MoEFCC established the WCCB, through amendments to the WPA, 1972 (Government of India 1972), for the protection of megafauna including the dugong and to enforce the trade ban on ETP species such as seahorses.

Despite the lack of a strategy and measures specifically to address by-catch in trawl nets, the states of Kerala along the west coast and Andhra Pradesh, Odisha, and West Bengal along the east coast have passed legislation mandating the use of turtle excluder devices (TED) in trawl nets (GoWB 2000)(GoO 2001)(MPEDA 2022). In the state of Odisha, there is a notification banning the use of trawl fishing within 10 km of the shore, from November to March, during the turtle breeding season (GoO 1981). But, there is no compliance with these regulations.

Because trawl nets and gillnets are generally highly unselective and result in a large amount of by-catch, a unified by-catch strategy is lacking, and compliance with by-catch reduction regulations is lacking where they exist, the by-catch strategy for trawl nets is rated as ineffective.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu

Ineffective

Currently, there is no unified by-catch reduction strategy specifically to address monitoring, assessment, and regulation of fisheries by-catch or by-catch of endangered, threatened, or protected (ETP) species caught by trawl nets in India.

The State Forest Department of Tamil Nadu, which operates under the Ministry of Environment, Forests and Climate Change (henceforth MoEFCC), Government of India, is responsible for enforcing the Indian Wildlife Protection Act, 1972 (henceforth WPA) (Government of India 1972). This Act establishes a list of Schedule species, creating a blanket ban to prohibit the hunting and harvesting of all protected species in India, from Schedule I to Schedule IV. Because nontarget species caught in trawl nets in the blue swimming crab fishery may be Schedule species, by-catch of these species is illegal under the WPA. Nevertheless, there has been a large amount of published discussion on the lack of effectiveness of a blanket ban on harvesting Schedule species, and in some instances, this ban has exacerbated the illegal trade in species caught as fisheries by-catch, such as seahorses, sea cucumbers, and mollusks in Palk Bay and the Gulf of Mannar region (CMFRI 2015){Asha P.S. et al. 2017}{Vinod, K. et al. 2018}{Vaidyanathan et al. 2021}{Vaidyanathan, T. & A.C. J. Vincent 2021}.

In addition to the WPA, to address the decline in the population of dugong, a task force was established by the government of India to formulate an action plan for the conservation of dugong (Sivakumar, K. 2013). The task force addresses threats to dugong from all sources, including by-catch. In 2007, the MoEFCC established the Wildlife Crime Control Bureau (WCCB), through amendments to the Wildlife Protection Act, 1972 (Government of India 1972), for protection of megafauna including the dugong and to enforce the trade ban on ETP species such as seahorses.

Despite the lack of a strategy and measures specifically to address by-catch in trawl nets, the recently amended Tamil Nadu Marine Fishing Regulation Rules (TNMFRR 2020) includes clauses that, if implemented appropriately, would help reduce the extent of by-catch in the blue swimming crab fishery (Government of Tamil Nadu 2020). These include:

(1) A minimum landing size of blue swimming crab and other species, which could be declared through a notification, to ensure that smaller sized individuals and juveniles are not harvested. Following this notification, the authorizing fisheries officer may seize and impound fishing vessels that land the illegal catch, if the vessels are appropriately identified.

(2) Trawl nets must have a minimum stretched mesh size of 40 mm at the cod end.

(3) Trawl nets need to use a turtle excluder device (TED) at the cod end during specified periods, as may be notified by the authorized officer.

(4) Fishing vessels are not allowed to fish species declared as protected fish species or living organisms under the WPA.

(5) A ban on the use of highly nonselective and potentially destructive fishing gear, such as pair trawling using any fishing vessel or craft, along the entire coast of Tamil Nadu.

Given that the TNMFRR have not yet been implemented, trawl nets are generally highly unselective and result in high levels of by-catch, and ETP species are known to be caught as by-catch in Tamil Nadu trawlers (resulting in an illegal trade of certain species), the by-catch strategy for trawl nets is rated ineffective.

rated Ineffective.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Ineffective

As mentioned in the blue swimming crab fishery management plan (FMP), the Central Marine Fisheries Research Institute (CMFRI) collects and monitors data on by-catch of species caught in blue swimming crab gillnets in the Palk Bay (Jose et al. 2019). But, there appears to be no regulation of fisheries by-catch or by-catch of endangered, threatened, or protected (ETP) species caught in blue swimming crab gillnets in the region.

The State Forest Department of Tamil Nadu, which operates under the Ministry of Environment, Forests and Climate Change (henceforth MoEFCC), Government of India, is responsible for enforcing the Indian Wildlife Protection Act, 1972 (henceforth WPA) (Government of India 1972). This Act establishes a list of Schedule species, creating a blanket ban to prohibit the hunting and harvesting of all protected species in India, from Schedule I to Schedule IV. Because nontarget species caught in gillnets in the BSC fishery may be Schedule species, the by-catch of these species is illegal under the WPA. Nevertheless, there has been much published discussion on the lack of effectiveness of having a blanket ban on harvesting Scheduled species, and in some instances, this ban has exacerbated the illegal trade in species caught as fisheries by-catch, such as seahorses, sea cucumbers, and mollusks in Palk Bay and the Gulf of Mannar region (CMFRI 2015){Asha P.S. et al. 2017}{Vinod, K. et al. 2018}{Vaidyanathan et al. 2021}{Vaidyanathan, T. & A.C. J. Vincent 2021}.

In addition to the WPA, a task force was established by the government of India to address the decline in the population of dugong, and to formulate an action plan for the conservation of dugong (Sivakumar, K. 2013). The task force addresses threats to dugong from all sources, including by-catch. In 2007, the MoEFCC established the Wildlife Crime Control Bureau (WCCB), through amendments to the Wildlife Protection Act, 1972 (Government of India 1972), for the protection of megafauna including the dugong and to enforce the trade ban on ETP species such as seahorses.

The recently amended Tamil Nadu Marine Fishing Regulation Rules (TNMFRR 2020) includes clauses that, if implemented appropriately, would help reduce the extent of gillnet by-catch in the blue swimming crab fishery (Government of Tamil Nadu 2020). These include:

(1) A minimum landing size of blue swimming crab and other species, which could be declared through a notification, to ensure that smaller-sized individuals and juveniles are not harvested. Following this notification, the authorizing fisheries officer may seize and impound fishing vessels that land the illegal catch, if the vessels are appropriately identified.

(2) All gillnets used must have a minimum stretched mesh size of 25 mm.

(3) Fishing vessels are not allowed to fish species that are declared as protected fish species or living organisms under the WPA.

Although the gillnets used to harvest blue swimming crab in Palk Bay are considered a more selective gear type, and data on by-catch is being collected and monitored by the CMFRI (Jose et al. 2019), there are no measures in place to regulate gillnet fisheries by-catch, some ETP species are still caught as by-catch in these nets, and the TNMFRR have not yet been implemented. As a result, the by-catch strategy for gillnets is rated ineffective.

Factor 3.3 - Scientific Data Collection and Analysis

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

Ineffective
Data on the blue swimming crab fishery in India are collected by the National Marine Fisheries Data Centre (NMFRC) of ICAR-CMFRI. The fishery is annually monitored by collecting fishery-dependent data (catch and catch per unit effort [CPUE]) (Jose et al. 2019)(SCS Global Services 2019). There is also adequate literature on the general biology of the blue swimming crab, including the life cycle, growth and development, food and feeding, and fecundity {Jose, J & N. G. Menon 2007}(Jose, J. 2011)(Jose, J. 2011b)(Jose, J. 2013). Data are typically collected following a stratified multistage random sampling design, developed to collect species and gear-wise data on fishery landings and fishing effort, collected every month by trained observers at fish landing sites (Sathianandan, T. V. et al 2021). But, these data were not available for the blue swimming crab stock status from other regions of India, apart from Tamil Nadu. Similarly, no data on by-catch of species caught in blue swimming crab fisheries in other parts of India were available. Because data on stock status and by-catch from other parts of India are unavailable, scientific data collection and analysis from these regions is rated ineffective.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu

Ineffective

Data on the blue swimming crab fishery in Tamil Nadu are collected by the National Marine Fisheries Data Centre (NMFRC) of CMFRI. The fishery is annually monitored by collecting fishery-dependent data (catch and catch per unit effort [CPUE]) (Jose et al. 2019)(SCS Global Services 2019). There is also adequate literature on the general biology of the blue swimming crab, including the life cycle, growth and development, food and feeding, and fecundity {Jose, J & N. G. Menon 2007}(Jose, J. 2011)(Jose, J. 2011b)(Jose, J. 2013). Stock abundance is monitored annually using standardized commercial CPUE as an index (Jose et al. 2019); however, annual CPUE estimates with confidence intervals are not provided {Fernandez & Ganapathiraju 2019}. There are also gaps in the level of accuracy and coverage of these collected data, and fishery-independent data are not collected {Fernandez & Ganapathiraju 2019}. Further, the stock assessment conducted is not peer reviewed {Fernandez & Ganapathiraju 2019}. In the case of blue swimming crab caught in trawl nets, no by-catch data are collected and there is no observer coverage, so an accurate estimation of discard or effort data would not be possible. Because some data on stock abundance exist, but there are no by-catch and discard data available, and there is no observer coverage for a highly unselective gear type such as trawl nets, scientific data collection and analysis is rated ineffective.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderately Effective

Data on the blue swimming crab fishery in Tamil Nadu are collected by the National Marine Fisheries Data Centre (NMFRC) of ICAR-CMFRI. As part of the ongoing blue swimming crab fishery improvement plan (FIP), data on the presence of berried females in the catch, carapace width, and wet weight are collected from nine blue swimming crab landing centers in the region (Fisheryprogress.org 2022b). There is also adequate literature on the general biology of the blue swimming crab, including the life cycle, growth and development, food and feeding, and fecundity {Jose, J & N. G. Menon 2007}(Jose, J. 2011)(Jose, J. 2011b)(Jose, J. 2013). The fishery is annually monitored by collecting fishery-dependent data (catch and catch per unit effort [CPUE]) (Jose et al. 2019)(SCS Global Services 2019). Stock abundance is monitored annually using standardized commercial CPUE as an index (Jose et al. 2019); however, annual CPUE estimates with confidence intervals are not provided {Fernandez & Ganapathiraju 2019}. Data are collected following a stratified multistage random sampling design, developed to collect species and gear-wise data on fishery landings and fishing effort, collected every month by trained observers at fish landing sites (Sathianandan, T. V. et al 2021). Nevertheless, there are gaps in the level of accuracy and coverage of collected data, and fishery-independent data are not collected {Fernandez & Ganapathiraju 2019}. Further, the stock assessment conducted is not peer-reviewed {Fernandez & Ganapathiraju 2019}. Although by-catch data for blue swimming crab gillnets are collected, data on discards are not collected. Because some data related to stock abundance are collected, with gaps in the data collection and analysis, this factor is rated moderately effective.

Factor 3.4 - Enforcement of and Compliance with Management Regulations

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

Ineffective

Several government institutions assume official responsibility for enforcement of fisheries management and regulations in India. For all fishing activity within 12 nm of the coast, enforcement is primarily the mandate of the State Fisheries Departments (GoK 1980)(GoK 2018)(GoK 1986)(GoG 1980)(GoM 1981)(GoG 2003)(GoA 1994)(GoO 1981)(GoO 1983)(GoWB 1993) and the State Marine Police. These organizations are responsible for implementing articles under the State Marine Fishing Regulation Acts, which includes implementing fishing rules and regulations. The State Forest Departments enforce bans on harvesting and illegal trade of Schedule species, per the Indian WPA 1972; many of these species are potentially caught as by-catch in blue swimming crab fisheries along the Indian coast. The Wildlife Crime Control Bureau (WCCB), which comprises officers from several government agencies such as the State Forest Departments, Customs, Marine Police, and the State Fisheries Departments, coordinates enforcement to prevent the illegal harvesting and trade of endangered, threatened, and protected (ETP) species (Government of India 2021c). Surveillance is mandated by the State Fisheries Departments in Kerala and Maharashtra.

Even though there are several organizations responsible for fisheries enforcement, there is a lack of coordination among various institutions, and limited enforcement and compliance to fisheries regulations on the ground. Overall, because enforcement and surveillance are lacking and compliance is known to be poor, this factor is rated ineffective.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderately Effective

Several government institutions assume official responsibility for enforcement of fisheries management and regulations in Tamil Nadu. Because all fishing activity in the Palk Bay occurs within 12 nm of the coast of Tamil Nadu, enforcement is primarily the mandate of the Tamil Nadu State Fisheries Department (Government of Tamil Nadu 2021) and the Tamil Nadu Marine Police. These organizations are responsible for implementing articles under the Tamil Nadu Marine Fishing Regulation Act (1983), which includes implementing fishing rules and regulations and preventing trade in banned species. The Tamil Nadu State Forest Department enforces the ban on harvesting and illegal trade of Schedule species, per the Indian WPA (Government of Tamil Nadu 2021b); many of these species are potentially caught as by-catch in fisheries in the Palk Bay. The Wildlife Crime Control Bureau (WCCB), which comprises officers from several government agencies such as the Tamil Nadu State Forest Department, Customs, Marine Police, and the Tamil Nadu State Fisheries Department, coordinates enforcement to prevent the illegal harvesting and trade of endangered, threatened, and protected (ETP) species (Government of India 2021c). Traditional, locally elected, community-based institutions such as the *meenavar uur panchayats* also take on the responsibility of enforcing fisheries regulations at a local level (Jentoft, S. et al. 2009)(Salagrama, V. 2014). The Tamil Nadu State Fisheries Department has recently passed an order to introduce a four-tier system of co-management, with the intention of sharing the responsibility of enforcement with local communities (GoTN 2019). In addition, in an attempt to step up enforcement, the Tamil Nadu Government has appointed police officers as part of the fisheries enforcement wing (GoTN 2022); this increased enforcement has resulted in a number of penalties for fisheries infractions (GoTN 2018)

Nevertheless, some issues with enforcement persist. Even though there are several organizations responsible for fisheries enforcement, there is a lack of coordination among various institutions, which limits effective enforcement and compliance to fisheries regulations on the ground {Fernandez & Ganapathiraju 2019}. Generally, compliance tends to be inconsistent across the Palk Bay, and may depend on how strongly local fisher institutions enforce regulations (pers. comm., Malayilethu). Furthermore, although the Tamil Nadu Marine Fishing Regulation Rules, 2020 clearly stipulate that surveillance systems are required onboard fishing vessels (Government of Tamil Nadu 2020), these rules have not yet been implemented. Overall, although enforcement exists, the effectiveness of enforcement and the extent of compliance are unknown, so this factor is rated moderately effective.

Factor 3.5 - Stakeholder Inclusion

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and

entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

Ineffective
In general, of all the coastal Indian states under consideration (including the western states and the eastern states of Andhra Pradesh, Odisha, and West Bengal), only Kerala has effective inclusion and co-management (Jentoft, S. et al. 2009), with a three-tier system of fisheries management at the village, district, and state level, and effective local representation at all these levels (GoK 2018). But overall, stakeholder inclusion in fisheries management is lacking within the specified region, so this factor is rated ineffective.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderately Effective
For the blue swimming crab fishery in Palk Bay, the Crab Meat Processors Association (CMPA) conducts regular community awareness programs at small-scale fishing landing centers about the importance of releasing juveniles and berried crabs {Fernandez & Ganapathiraju 2019}. Further, the CMPA has initiated stakeholder consultation meetings among some fishers, village councils, and government institutions, to exchange information and campaigns to enable improvement of the fishery {Fernandez & Ganapathiraju 2019}. Nevertheless, not all stakeholders have been included in this process. Also, the process of consultation has been occasional and not systematic {Fernandez & Ganapathiraju 2019}. Because the consultation process has been initiated by the CMPA, it lacks legitimacy {Fernandez & Ganapathiraju 2019}.

In general, small disputes in the Palk Bay region are resolved by local traditional institutions such as the *uur-panchayats* {Fernandez & Ganapathiraju 2019}; larger disputes (for instance, between gill netters and trawlers) are resolved by the District Collector and the Tamil Nadu Fisheries Department through Dispute Resolution Meetings {Fernandez & Ganapathiraju 2019}. Before 2019, fishers may have been informally involved by state agencies in the fishery management decision-making process, but there was no formal inclusion, and co-management was weak despite the presence of legal pluralism (Jentoft, S. et al. 2009). In 2019, the Tamil Nadu Fisheries Department passed an order to establish a four-tier system of fisheries co-management, designed to work at the village, district, zonal, and state levels (GoTN 2019). This system proposes to include local stakeholders in fisheries management, decision-making, and enforcement. Subsequently, to address management in the blue swimming crab gillnet fishery in Palk Bay, the Palk Bay Fishing Management Council (PBFMC) was set up in 2020, and they have had one meeting in 2021 since (Fisheryprogress.org 2022). The four-tier system of fishery management and the PBFMC have only recently been introduced and implemented, and their effectiveness in terms of inclusion and addressing user conflicts is unknown, so stakeholder inclusion is rated moderately effective.

Criterion 4: Impacts on the Habitat and Ecosystem

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

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

Guiding principles

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

Rating cannot be Critical for Criterion 4.

Criterion 4 Summary

FISHERY	FISHING GEAR ON THE SUBSTRATE	MITIGATION OF GEAR IMPACTS	ECOSYSTEM-BASED FISHERIES MGMT	FORAGE SPECIES?	SCORE
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra	0	0	High Concern		**Red (0.000)**
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra	2	0	Moderate Concern		**Yellow (2.449)**
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal	2	0	High Concern		**Red (2.000)**
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal	3	0	Moderate Concern		**Yellow (3.000)**
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu	1	0	High Concern		**Red (1.414)**
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu	3	0	Moderate Concern		**Yellow (3.000)**

Criterion 4 Assessment

SCORING GUIDELINES

Factor 4.1 - Physical Impact of Fishing Gear on the Habitat/Substrate
Goal: The fishery does not adversely impact the physical structure of the ocean habitat, seafloor or associated biological communities.

- *5 - Fishing gear does not contact the bottom*
- *4 - Vertical line gear*
- *3 - Gears that contacts the bottom, but is not dragged along the bottom (e.g. gillnet, bottom longline, trap) and is not fished on sensitive habitats. Or bottom seine on resilient mud/sand habitats. Or midwater trawl that is known to contact bottom occasionally. Or purse seine known to commonly contact the bottom.*
- *2 - Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Or gillnet, trap, or bottom longline fished on sensitive boulder or coral reef habitat. Or bottom seine except on mud/sand. Or there is known trampling of coral reef habitat.*
- *1 - Hydraulic clam dredge. Or dredge or trawl gear fished on moderately sensitive habitats (e.g., cobble or boulder)*
- *0 - Dredge or trawl fished on biogenic habitat, (e.g., deep-sea corals, eelgrass and maerl)*
  Note: When multiple habitat types are commonly encountered, and/or the habitat classification is uncertain, the score will be based on the most sensitive, plausible habitat type.

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts
Goal: Damage to the seafloor is mitigated through protection of sensitive or vulnerable seafloor habitats, and limits on the spatial footprint of fishing on fishing effort.

- *+1 —>50% of the habitat is protected from fishing with the gear type. Or fishing intensity is very low/limited and for trawled fisheries, expansion of fishery's footprint is prohibited. Or gear is specifically modified to reduce damage to seafloor and modifications have been shown to be effective at reducing damage. Or there is an effective combination of 'moderate' mitigation measures.*
- *+0.5 —At least 20% of all representative habitats are protected from fishing with the gear type and for trawl fisheries, expansion of the fishery's footprint is prohibited. Or gear modification measures or other measures are in place to limit fishing effort, fishing intensity, and spatial footprint of damage caused from fishing that are expected to be effective.*
- *0 —No effective measures are in place to limit gear impacts on habitats or not applicable because gear used is benign and received a score of 5 in factor 4.1*

Factor 4.3 - Ecosystem-Based Fisheries Management
Goal: All stocks are maintained at levels that allow them to fulfill their ecological role and to maintain a functioning ecosystem and food web. Fishing activities should not seriously reduce ecosystem services provided by any retained species or result in harmful changes such as trophic cascades, phase shifts or reduction of genetic diversity. Even non-native species should be considered with respect to ecosystem impacts. If a fishery is managed in order to eradicate a non-native, the potential impacts of that strategy on native species in the ecosystem should be considered and rated below.

- *5 — Policies that have been shown to be effective are in place to protect species' ecological roles and ecosystem functioning (e.g. catch limits that ensure species' abundance is maintained at sufficient levels to provide food to predators) and effective spatial management is used to protect spawning and foraging areas, and prevent localized depletion. Or it has been scientifically demonstrated that fishing practices do not have negative ecological effects.*
- *4 — Policies are in place to protect species' ecological roles and ecosystem functioning but have not proven to be effective and at least some spatial management is used.*
- *3 — Policies are not in place to protect species' ecological roles and ecosystem functioning but detrimental food web impacts are not likely or policies in place may not be sufficient to protect species' ecological roles and ecosystem functioning.*
- *2 — Policies are not in place to protect species' ecological roles and ecosystem functioning and the likelihood of detrimental food impacts are likely (e.g. trophic cascades, alternate stable states, etc.), but conclusive scientific evidence is not available for this fishery.*
- *1 — Scientifically demonstrated trophic cascades, alternate stable states or other detrimental food web impact are resulting from this fishery.*

Factor 4.1 - Physical Impact of Fishing Gear on the Habitat/Substrate

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra

0

Along the west coast of India, in coastal regions such as Karnataka, the trawl fishery that catches blue swimming crab operates at depths of around 100 m on muddy and loamy sea bottoms (Dineshbabu A. P. et al. 2008). But, in the Gulf of Kuchchh in Gujarat, also on the west coast, where the blue swimming crab fishery operates for 8 months in a year {Pathak, N. et al. 2019}, trawl nets most likely operate over sensitive habitats such as seagrasses and coral reefs. Following the SFW criteria, bottom trawls that operate on sensitive habitat such as coral reefs and seagrasses are scored a 0 out of 5.

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra

2

In general, along the west coast of India, in regions such as the coast of Karnataka (between Mangalore and Malpe), where blue swimming crab is caught using gillnets, fishing occurs at depths of approximately 15 m on muddy or loamy sea bottoms (Dineshbabu A. P. et al. 2008). But, in the Gulf of Kuchchh in Gujarat, it is likely that blue swimming crab is caught in gillnets set in coral reefs. According to the SFW criteria, bottom-set gillnets on habitats such as coral reefs are scored a 2 out of 5.

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal

2

Along the east coast of India, in Kakinada, Andhra Pradesh, where there is a reported blue swimming crab fishery (Jose et al. 2019), the sediment is sandy and muddy {Raut, D. et al. 2005}. According to the SFW standard, bottom trawl nets set on sandy and muddy sea bottoms are rated a 2 out of 5 for physical impact on habitat structure.

Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

3

Along the east coast of India, in Kakinada, Andhra Pradesh, where there is a reported blue swimming crab fishery (Jose et al. 2019), the sediment is sandy and muddy {Raut, D. et al. 2005}. According to the SFW standard, bottom-set gillnets set on all sea bottoms except boulders and coral reefs are rated a 3 out of 5 for physical impact on habitat structure.

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu

1

The Palk Bay is known to be a quite shallow flat basin with a maximum depth of 15 m and an average depth of 9 m {Kasim, H. M. 2015}. These shallow waters are the reason for its high primary productivity, as well as its ability to support marine resources and, consequently, the human livelihoods that depend on these resources {Kasim, H. M. 2015}(SCS Global Services 2019). Palk Bay thus comprises many diverse and productive ecosystems, including seagrass meadows, mangroves, estuaries, salt marshes, and fringing coral reefs (SCS Global Services 2019); underwater surveys conducted in the Palk Bay by the Central Marine Fisheries Research Institute (CMFRI) showed that the seabottom in this region comprises sandy silty bottoms, seagrass ecosystems, mudflat ecosystems, sandy ecosystems, and rocky ecosystems (Figures 21 and 22) (Jose et al. 2019).

Nevertheless, sea grasses represent one of the largest ecosystems in the Palk Bay region, and these meadows are also the most widespread in India {Geevarghese, G. A. et al. 2018}. In fact, seagrass patches are found along the entire stretch of Palk Bay from Adiramapattinam in the north to Rameshwaram in the south, and in most areas, they exist within a width of about 300 m from the coast {Geevarghese, G. A. et al. 2018}. Although a small fringing coral reef extends across 25–30 km^2 of the southern part of Palk Bay {Kasim, H. M. 2015} from Mandapam to Rameshwaram {Azeez, P. A. et al. 2016}, the northern region of Palk Bay has only a few patches of bleached or degraded corals {Azeez, P. A. et al. 2016}.

Because trawlers in the Palk Bay region mostly operate at 3 nm from the shore, they likely encounter mostly sandy, silty sea bottoms; however, there is a possibility that trawl nets also

encounter mostly sandy, silty sea bottoms, however, there is a possibility that trawl nets also operate over seagrasses, which are extensive in this region. Following the SFW criteria, bottom trawls that operate mainly on sandy and silty sea bottoms and have the potential of coming into contact with sensitive habitat such as seagrasses are rated a 1 out of 5.

Justification:

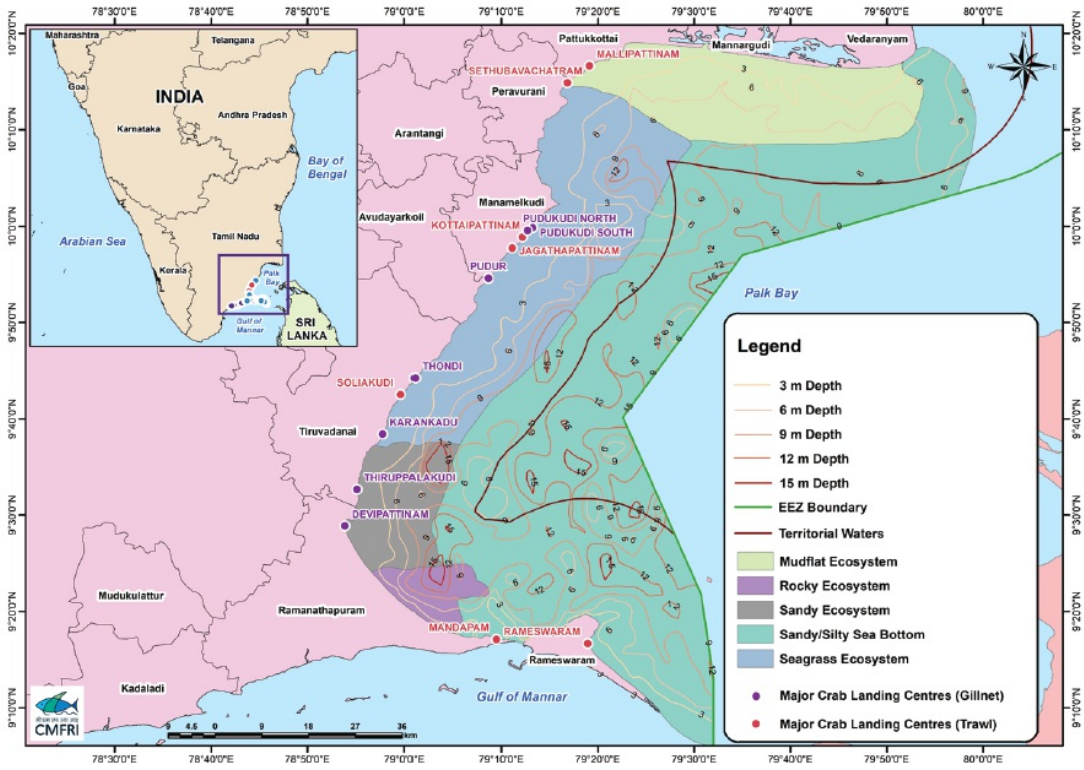

Figure 21. Map showing different ecosystem types and sea bottoms in the Palk Bay. Taken from (Jose et al. 2019).

Ecosystem	Area (Sq.km)	Area (%)
Sandy silty sea bottom	4069	58
Seagrass ecosystem	1430	20
Mudflat ecosystem	933	13
Sandy ecosystem	392	6
Rocky ecosystem	167	2
Total	**6991**	**100**

Figure 22. Table showing different ecosystem types and sea bottoms in the Palk Bay with area covered. Taken from (Jose et al. 2019).

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

3

The Palk Bay is known to be a quite shallow flat basin with a maximum depth of 15 m and an average depth of 9 m {Kasim, H. M. 2015}. These shallow waters are the reason for its high primary productivity, as well as its ability to support marine resources and, consequently, the human livelihoods that depend on these resources {Kasim, H. M. 2015}(SCS Global Services 2019). Palk Bay thus comprises many diverse and productive ecosystems, including seagrass meadows, mangroves, estuaries, salt marshes, and fringing coral reefs (SCS Global Services 2019); underwater surveys conducted in the Palk Bay by the Central Marine Fisheries Research Institute (CMFRI) showed that the sea bottom in this region comprises sandy silty bottoms, seagrass ecosystems, mudflat ecosystems, sandy ecosystems, and rocky ecosystems (see Figures 21 and 22 in criterion 4_1-1) (Jose et al. 2019).

Nevertheless, seagrasses represent one of the largest ecosystems in the Palk Bay region, and these meadows are also the most widespread in India {Geevarghese, G. A. et al. 2018}. In fact, seagrass patches are found along the entire stretch of Palk Bay from Adiramapattinam in the north to Rameshwaram in the south, and in most areas, they exist within a width of about 300 m from the coast {Geevarghese, G. A. et al. 2018}. Although a small fringing coral reef extends across 25–30 km^2 of the southern part of Palk Bay {Kasim, H. M. 2015} from Mandapam to Rameshwaram {Azeez, P. A. et al. 2016}, the northern region of Palk Bay has only a few patches of bleached or degraded corals {Azeez, P. A. et al. 2016}.

According to the SFW criteria, bottom-set gillnets that come into contact with substrates other than boulders/coral reefs (e.g., seagrasses, mud, silt, sand, and other nonsensitive/resilient substrates) are scored a 3 out of 5.

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal

0

The peninsula of India has 24 marine protected areas (MPA) that cover an area of 8,214 km^2 (Figures 24 and 25) (Sivakumar, K. et al. 2013b). Trawling is normally banned in these protected areas, whereas gillnetting may be allowed to operate. But, enforcement of bans on trawling within the MPAs is often lacking.

In general, there are no modifications on gillnets that can mitigate their impact on the seafloor. Along the west and east coasts of India, there are currently no modifications implemented on trawl nets that could mitigate their impact on the seafloor. Because the effectiveness of the existing MPAs is questionable and there are no gear modifications that could reduce the impact of gillnets and trawl nets on the seafloor, this factor is rated a 0.

Justification:

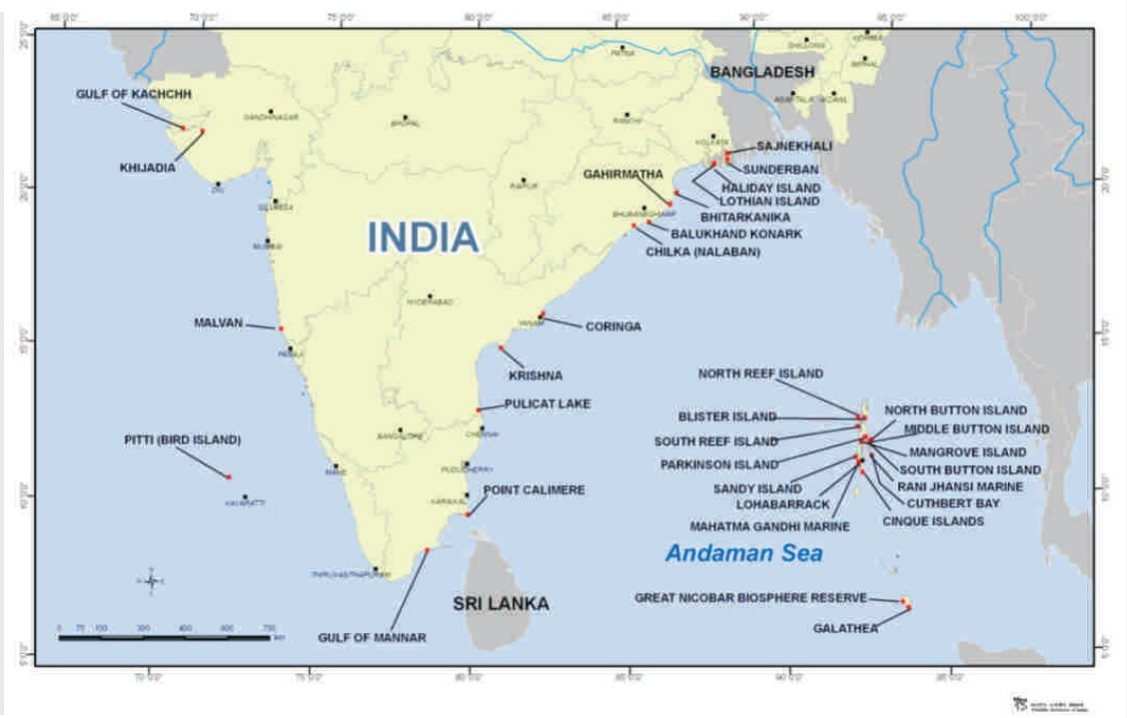

Figure 24. Important coastal and marine protected areas in India. Taken from (Sivakumar, K. et al. 2013b).

Sl. No.	Name of MPA	State	Category	IUCN category	Area (km^2)	Year of establishment
1.	Coringa	Andhra Pradesh	Sanctuary	IV	235.7	1978
2.	Krishna	Andhra Pradesh	Sanctuary	IV	194.81	1989
3.	Pulicat Lake	Andhra Pradesh	Sanctuary	IV	500	1980
4.	Dadra & Nagar Haveli	Dadra & Nagar Haveli	Sanctuary	IV	92.16	2000
5.	Fudam	Daman & Diu	Sanctuary	IV	2.18	1991
6.	Chorao Island	Goa	Sanctuary	IV	1.78	1988
7.	Marine (Gulf of Kachchh)	Gujarat	National park	II	162.89	1995
8.	Khijadia	Gujarat	Sanctuary	IV	6.05	1981
9.	Marine (Gulf of Kachchh)	Gujarat	Sanctuary	IV	295.03	1980
10.	Kadalundi Vallikkunnu Community Reserve	Kerala	Community reserve	NA	1.50	2007
11.	Malvan Marine	Maharashtra	Sanctuary	IV	29.12	1987
12.	Bhitarkanika	Odisha	National park	II	145	1998
13.	Bhitarkanika	Odisha	Sanctuary	IV	672	1975
14.	Chilika (Nalaban)	Odisha	Sanctuary	IV	15.53	1987
15.	Balukhand Konark	Odisha	Sanctuary	IV	71.72	1984

16.	Gahirmatha	Odisha	Sanctuary	IV	1435	1997
17.	Gulf of Mannar Marine	Tamil Nadu	National park	II	6.23	1980
18.	Point Calimere	Tamil Nadu	Sanctuary	IV	172.6	1967
19.	Pulicat Lake	Tamil Nadu	Sanctuary	IV	153.67	1980
20.	Sundarbans	West Bengal	National park	II	1330.1	1984
21.	Haliday Island	West Bengal	Sanctuary	IV	5.95	1976
22.	Sajnakhali	West Bengal	Sanctuary	IV	2091.12	1976
23.	Lothian Island	West Bengal	Sanctuary	IV	38	1976
24.	West Sundarban	West Bengal	Sanctuary	IV	556.45	2013

Figure 25. List of marine protected areas (MPA) in India. Taken from (Sivakumar, K. et al. 2013b).

Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

0

The state government of Tamil Nadu has recently declared 500 km^2 of area along the northern part of Palk Bay, from Adiramapattinam to Amapattinam, as a dugong conservation reserve (Figure 23) {Krishna Chaitanya, S. V. 2021}. At the moment, detailed studies and stakeholder meetings are being conducted, to determine the actual size of the conservation reserve when it is officially notified {Krishna Chaitanya, S. V. 2021}. Although no information is currently available on whether blue swimming crab gillnetting will be allowed within the conservation reserve after it is notified, trawl fishing will be banned within this area afterward {Krishna Chaitanya, S. V. 2021}.

In general, there are no modifications on gillnets that can mitigate their impact on the seafloor. In Tamil Nadu, there are currently no modifications implemented on trawl nets that could mitigate their impact on the seafloor. Because the conservation reserve in Palk Bay has not yet been notified, and there are no gear modifications that could mitigate the impact of trawl nets on the seafloor, this factor is rated a 0.

Justification:

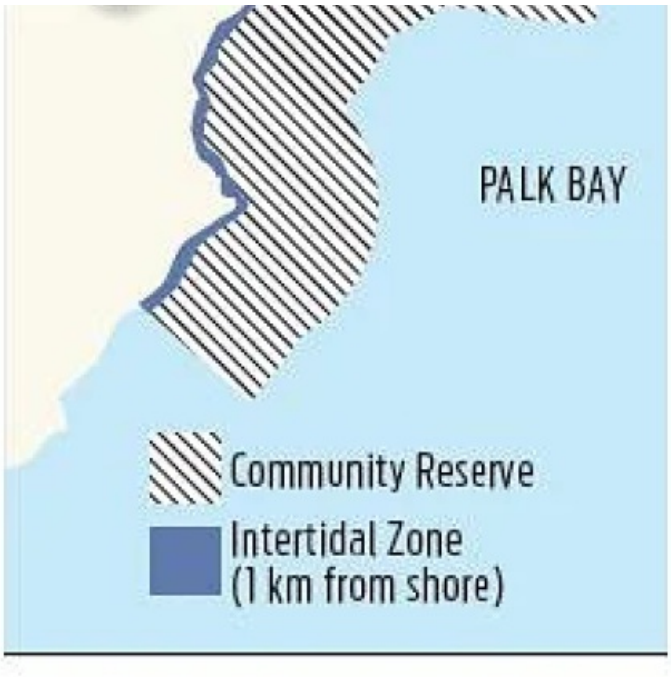

Figure 23. Proposed area for the dugong conservation reserve in Palk Bay, Tamil Nadu. Taken from {Krishna Chaitanya, S. V. 2021}.

Factor 4.3 - Ecosystem-based Fisheries Management

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Bottom trawls | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Bottom trawls | Tamil Nadu

High Concern

Blue swimming crab is an opportunistic scavenger and bottom-feeding carnivore (Kangas, M. I. 2000). In Palk Bay, India, the species is known to consume crustaceans, mollusks, fishes, and debris, with a clear preference for crustaceans (Jose, J. 2011b). Although its predators are unknown in India, in Australia they include sea jellies, fishes, other crabs, rays, sharks, and birds (Kangas, M. I. 2000)(Government of Western Australia, Department of Fisheries 2011). Intense fishing pressure the species could therefore alter the trophic structure and species composition, by reducing predation on crab prey and/or by reducing food for higher-level predators.

The importance of adopting an ecosystem-based approach in fisheries management in India has been acknowledged as an effective tool to move beyond traditional management methods, "ensuring that fishery management decisions do not adversely affect the ecosystem function and productivity, so that harvesting of stocks is sustainable in the long-term" (Vivekanandan, E. 2005). Following this thought process, Article 7.2.3 of the Indian Marine Fisheries Code, developed by the Central Marine Fisheries Research Institute (CMFRI), provides guidance on how an ecosystem-based approach could be incorporated into fisheries management in India (Mohamed, K.S. et al. 2017). Nevertheless, with respect to the blue swimming crab trawl net fishery, there are no policies in place to protect ecosystem functioning and account for the capture species' ecological role. Further, detrimental food web impacts from this fishery are likely, although specific scientific evidence of them are lacking. In general, in India, it is well-established that trawling has had both short-term and long-term impacts on the ecosystem (Dineshbabu A. P. 2016). Thus, ecosystem-based fisheries management is scored a high concern for the blue swimming crab trawl net fishery.

Arabian Sea | Indian Ocean, Western | Indian Ocean, West / 51.4 | Gillnets and entangling nets | Goa | Gujarat | Karnataka | Kerala | Maharashtra
Bay of Bengal | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Andhra Pradesh | Odisha | West Bengal
Palk Strait and Palk Bay | Indian Ocean, Eastern | Indian Ocean, East / 57.1 | Gillnets and entangling nets | Tamil Nadu

Moderate Concern

Blue swimming crab is an opportunistic scavenger and bottom-feeding carnivore (Kangas, M. I. 2000). In Palk Bay, India, the species is known to consume crustaceans, mollusks, fishes, and debris, with a clear preference for crustaceans (Jose, J. 2011b). Although its predators are unknown in India, in Australia they include sea jellies, fishes, other crabs, rays, sharks, and birds (Kangas, M. I. 2000)(Government of Western Australia, Department of Fisheries 2011). Intense fishing pressure on the species could therefore alter the trophic structure and species composition, by reducing predation on crab prey and/or by reducing food for higher-level predators.

The importance of adopting an ecosystem-based approach in fisheries management in India has been acknowledged as an effective tool to move beyond traditional management methods, "ensuring that fishery management decisions do not adversely affect the ecosystem function and productivity, so that harvesting of stocks is sustainable in the long-term" (Vivekanandan, E. 2005). Following this thought process, Article 7.2.3 of the Indian Marine Fisheries Code, developed by the Central Marine Fisheries Research Institute (CMFRI), provides guidance on how an ecosystem-based approach could be incorporated into fisheries management in India (Mohamed, K.S. et al. 2017). Nevertheless, with respect to the blue swimming crab gillnet fishery, there are no policies in place to protect ecosystem functioning and account for the capture species' ecological role, but detrimental food web impacts from this fishery are unknown. Thus, ecosystem-based fisheries management is scored a moderate concern for the blue swimming crab gillnet fishery.

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

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