

Monterey Bay Aquarium Seafood Watch®

Blue swimming crab

Portunus pelagicus



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Sri Lanka

Set gillnets

December 19, 2018

Seafood Watch Consulting Researcher

Disclaimer

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

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About Seafood Watch

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

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

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

Guiding Principles

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

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

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

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

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

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

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

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

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

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

Summary

This report includes recommendations for Blue swimming crab (BSC; *Portunus pelagicus*), a large-bodied, benthic crustacean caught by bottom-set crab net. The fisheries occur in Sri Lanka (SL), specifically in the north, referred to as the Palk Bay fishery (Bay of Bengal/Northern Province, Districts of Jaffna, Kilinochchi, Mannar [north coast]) and the northwest, referred to as the Gulf of Mannar fishery (Northwestern Province, Districts of Puttalam and Mannar [south coast]).

Recent stock assessments for the Palk Bay and Gulf of Mannar fisheries suggest that the SLBSC in all fisheries are above the recommended Limit Reference Point (SPR 20%) and, in Palk Bay, above the upper Target Reference Point (SPR 40%). In the Palk Bay fishery, the majority of the catch is mature, suggesting that crabs are able to spawn at least once before being caught. Since BSC has low inherent vulnerability and there are two positive data-limited indicators, abundance was deemed a "low" concern. For the Gulf of Mannar fishery, there are conflicting data-limited indicators (SPR [positive indicator] and percent maturity [negative indicator, since the percentage of catch that is mature should be above 90%]), so a score of "moderate" concern was given. Overfishing does not appear to be occurring; data suggests that fishing mortality is generally targeting larger, older crabs in the fishery, which somewhat protects the spawning potential of the stock; for these reasons, fishing mortality is scored as "moderate" concern.

The SLBSC bottom-set crab net fisheries typically have high levels of bycatch (30 to 55%) and interact with some species of concern (e.g., sharks, rays, sea turtles, dugongs, and grouper). Sharks and rays limit the Criterion 2 score for the bottom-set crab net fishery due to their high inherent vulnerability and their high likelihood of interacting with this fishery.

There are recently implemented formal procedures, measures, or regulations in place to specifically manage the SLBSC fishery. There are also informal or indirect measures that regulate the fishery, as a result of external issues, such as fishing effort being restricted to three days per week, due to the illegal fishing activities of Indian and Sri Lankan trawlers in SLBSC fishing grounds. In addition to the harvest control rules and tools, there is a "Voluntary Code of Conduct" (CoC), which was developed to ensure the sustainable use of resources by applying good management measures in maintaining the status of BSC stocks at healthy limits, and to minimize the impact on the marine environment and the associated species. Because management measures have not been in place long enough to evaluate their effectiveness, management is deemed "moderately effective."

The SLBSC fishery has an overall moderate impact on ocean habitats and ecosystems. Although there are no gear-specific modifications to reduce impacts to the seafloor, SLBSC fishermen switch gears and fisheries throughout the year, depending on the availability and wholesale value of different fisheries, giving the BSC stocks and their habitat a "break."

Overall, the bottom-set crab net fisheries in Sri Lanka are rated "yellow" or "Good Alternative."

Final Seafood Recommendations

SPECIES/FISHERY	CRITERION 1: IMPACTS ON THE SPECIES	CRITERION 2: IMPACTS ON OTHER SPECIES	CRITERION 3: MANAGEMENT EFFECTIVENESS	CRITERION 4: HABITAT AND ECOSYSTEM	OVERALL RECOMMENDATION
Blue swimming crab Sri Lanka Eastern Indian Ocean, Gillnets and entangling nets (unspecified), Sri Lanka, Gulf of Mannar	Yellow (2.644)	Red (1.000)	Yellow (3.000)	Yellow (3.000)	Good Alternative (2.208)
Blue swimming crab Sri Lanka Eastern Indian Ocean, Gillnets and entangling nets (unspecified), Sri Lanka, Palk Bay	Green (3.318)	Red (1.000)	Yellow (3.000)	Yellow (3.000)	Good Alternative (2.337)

Summary

Fisheries for blue swimming crab in Sri Lanka are considered a "Good Alternative" by Seafood Watch. Stock abundance is healthy and there is a new management system in place that is expected to effectively protect the crab stocks. There is some uncertainty regarding the impact of the fishery on other species.

Eco-Certification Information

There is a fishery improvement project (FIP) in place in each fishery. The FIPs were launched in 2103 and are currently completing their fifth year of operation. The FIPs are tripartite initiatives that ring together fishing communities, government authorities, and seafood processors to improve the biological and ecological status of each fishery and 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 crab net. The fisheries occur in Sri Lanka, specifically in the north, referred to as the Palk Bay fishery (Bay of Bengal/Northern Province, Districts of Jaffna, Kilinochchi, Mannar [north coast]) and the northwest, referred to as the Gulf of Mannar fishery (Northwestern Province, Districts of Puttalam and Mannar [South Coast]).

Species Overview

Species overview

Blue swimming crabs (BSC) are brachyuran crabs that belong to 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 (aka. horns) along their carapace, on either side of their eyes (GWA DOF 2011). Males are bright blue in color with white spots and with characteristically long chelipeds; the females are a duller green/brown, with a more rounded carapace (BFAR 2013). Spawning occurs year-round: March to June in Kalpitiya (Puttalam Lagoon, Gulf of Mannar fishery), January to April in Jaffna (Palk Bay), and November to February in Mannar (Palk Bay), with the end of the northeast monsoon and commencement of the second inter-monsoonal rains (Creech 2013). Female blue crabs mate only during molting, with the male crabs carrying and protecting them until molting and mating occurs. BSC are common throughout the Indo-Pacific in inshore and continental shelf habitats including sand, mud, algae and seagrass near reefs and mangrove areas, and are found from the intertidal up to depths of 70 m (Ingles, 1988) (Germano et al. 2006). BSC are a focal point of fishery industries in the region, such as in Indonesia, Philippines, Vietnam, Cambodia, Malaysia, Thailand, India, and Sri Lanka (Germano et al. 2006) (Creech et al. 2016); see first figure). They mature quickly (about one year), have short lifespans (about three years), and are partial brooders (Josileen and Menon 2007) (Kangas 2000).

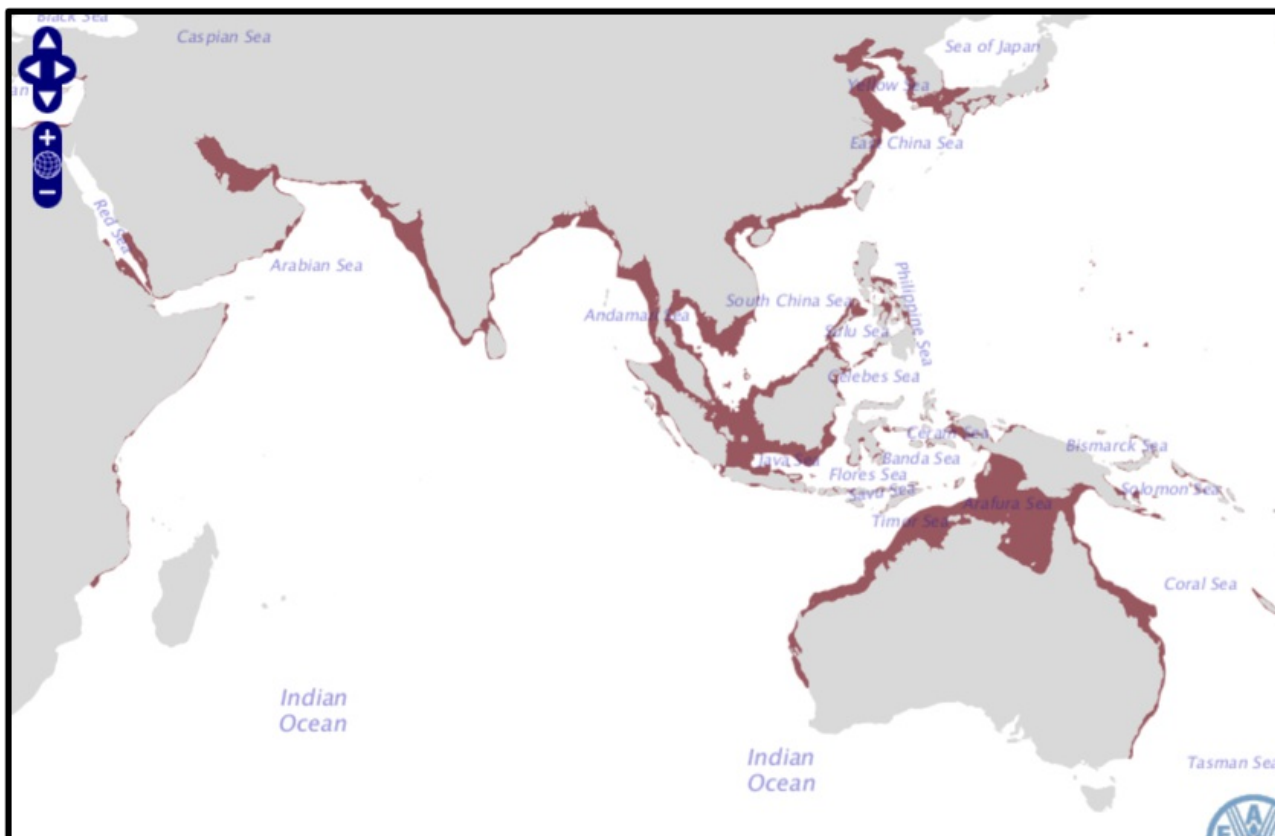


Figure 1 BSC distribution map (FAO 2016a).

SLSBC fishery locations and gear

The main area of the Sri Lankan Blue Swimming Crab (SLBSC) fishery (in terms of effort, production, purchasing, processing, and export) is located in the districts of Mannar, Kilinochchi, and Jaffna on the Sri Lankan side of the Palk Bay (Palk Bay fishery; (Creech 2013)). The Gulf of Mannar fishery, including the Gulf of Mannar and the Puttalam estuary complex, comprises Portugal Bay, Dutch Bay and Puttalam Lagoon (see figures; (Wetland Conservation Project 1994)).

SLBSC is caught using bottom-set crab nets, which are nylon half pieces of net, set three feet in height off the bottom. Mesh sizes range from 3.5 to 6 inches and each crab net contains between 8 and 20 net pieces (Creech 2013; see figure). Each boat may set up to 5 nets per trip, at depths of 3 to 5 fathoms, and at distances of 2 to 15 km from shore. Crab nets are set in the evening and hauled within 10 to 12 hours (Creech 2013). Most of the catch is not sorted at sea, with the exception of a very few species such as weaver fish and jellyfish (both venomous). Because all other catch is tangled in the net, which requires quite a bit of time to untangle, it gets hauled into the boat and brought back to the landing (pers. comm., S. Creech, 10 May 2016; see figures).

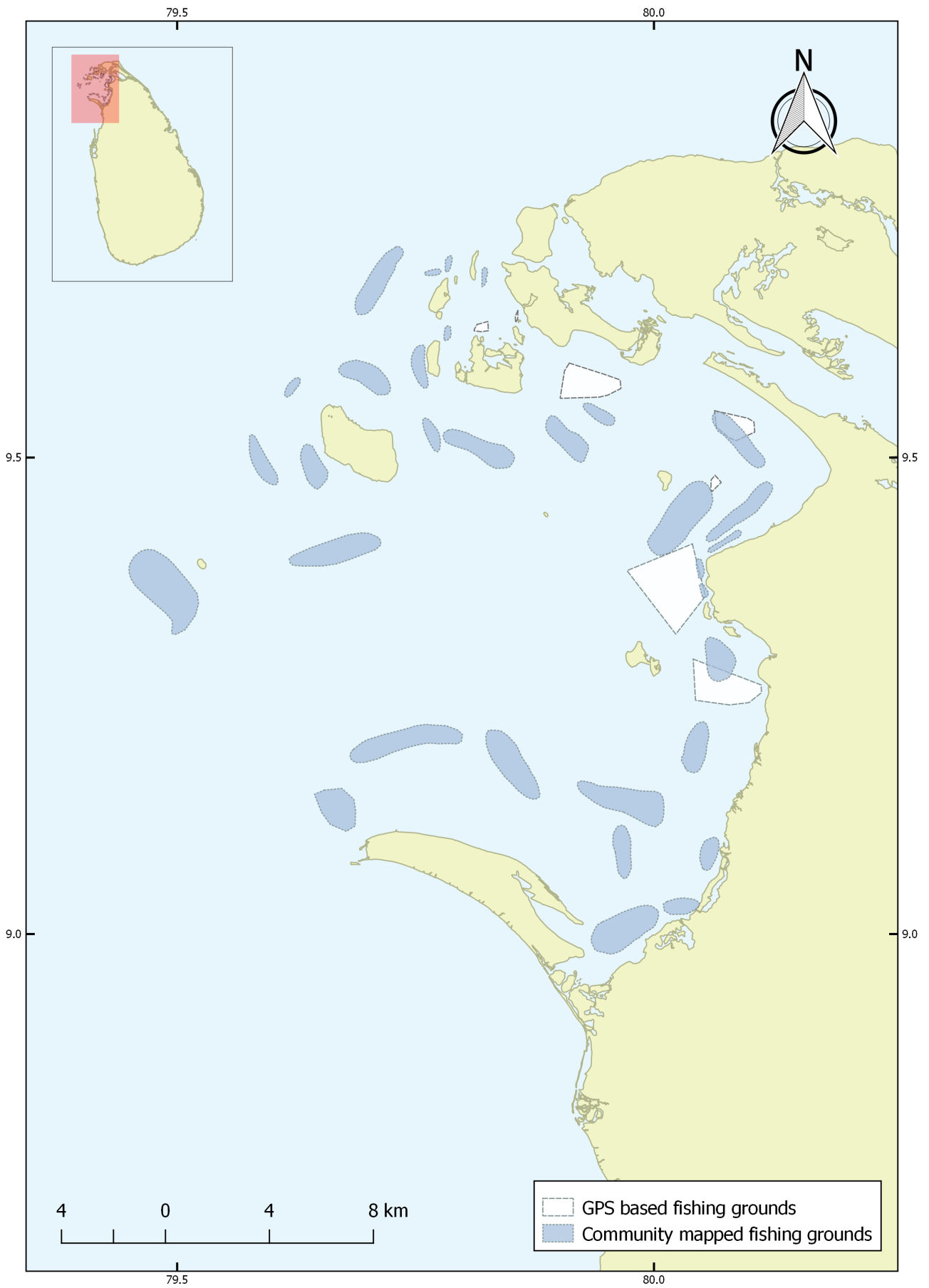


Figure 2 Fishing grounds in the Palk Bay blue swimming crab fishery as identified through GPS and community mapping studies.

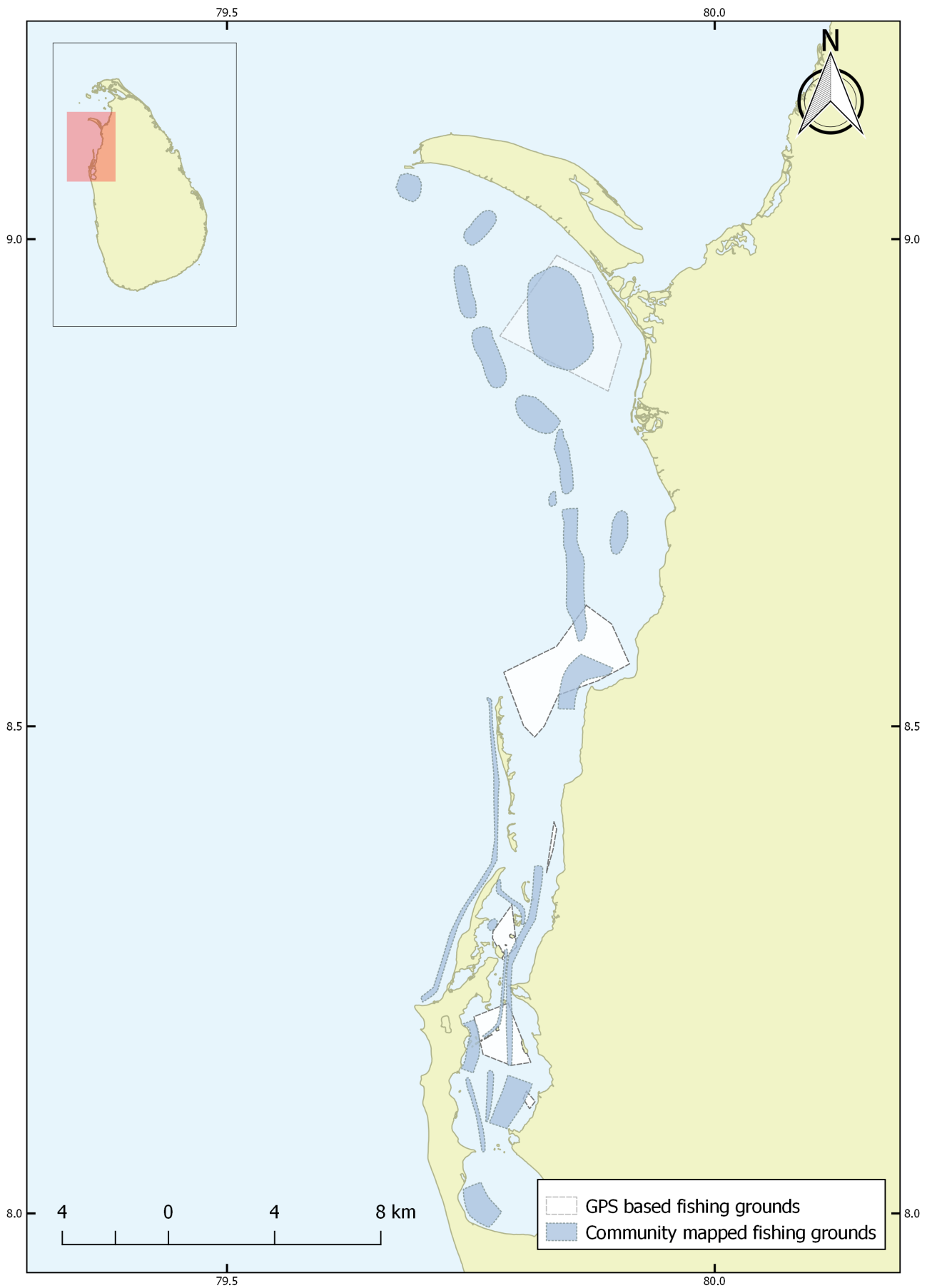


Figure 3 Fishing grounds in the Gulf of Mannar blue swimming crab fishery as identified through GPS and community mapping studies.



Figure 4 Photo of BSC fishermen from Baththalangunduwa hauling bottom-set crab nets in the Gulf of Mannar fishery (photo courtesy of Steve Creech).



Figure 5 Photo of BSC bottom-set crab nets with catch entangled (photo courtesy of Steve Creech).



Figure 6 Fibre-Reinforced Plastic (FRP) crab fishing boat and outboard engine loading a crab net at the landing centre at Soththupitiyawadiya, Puttalam District, Gulf of Mannar Fishery in 2014 (photo courtesy of Steve Creech).

History of SLBSC fishery

SLBSC is a new (and comparatively small) fishery in Sri Lanka (Creech 2013). Fishers in the north did not target SLBSC until very recently; they were considered an annoyance when entangled in fishers' nets. The growth of the SLBSC fishery is a result of a strong international demand for SLBSC product coupled with the end of the 30-year civil conflict in Sri Lanka, where fisherman were only allowed to fish between the hours of 6 a.m. and 6 p.m. daily. After the conflict ended, these fishing restrictions were lifted, and there was increased access for seafood companies to northern seafood resources (Creech 2013).

Management

In Sri Lanka, the chief authority for the regulation and management of all coastal and offshore fisheries is the MFAR, or the Honorable Minister of Fisheries and Aquatic Resource, with the legislative framework embodied in the Fisheries and Aquatic Resource Act of 1996 (to which new regulations and amendments have been added (Creech 2013). The Director General and staff of the Department of Fisheries and Aquatic Resources (DFAR), which is comprised of six divisions, undertakes the task of implementing the regulations and managing the exploitation of fisheries and aquatic resource in Sri Lanka.

Along with the DFAR, there are 15 District Fisheries Offices (DFOs) located at each of the 14 coastal districts (2 for Puttalam District), which comprise numerous Fisheries Inspectorate Divisions, run by an Assistant Director. These Fisheries Inspectors (FIs) enforce the fishery regulations and implementations of the government's policies for the sector's management and development (Creech 2013).

FIP

The SLBSC FIP was initiated by the Seafood Exporters' Association of Sri Lanka (SEASL) in May 2013, with the support of the National Fisheries Institute Crab Council, after receiving a request from representatives of SL seafood companies, government authorities, researchers, and civil society organizations associated with the north SLBSC fishery (SEASL and NFICC 2013). SEASL acts as an essential focal point for engagement between

seafood companies and the Government of Sri Lanka. The aim of the FIP is to gather all those associated with the SLBSC fishery to create and implement a local plan that will improve the economic, social, and ecological sustainability of the fishery. The FIP was officially launched by the MFAR in November 2013 (Creech et al. 2016).

Production Statistics

The increasing global demand for the BSC and their wide distribution throughout the Indo-Pacific make them an important species for a number of countries (Creech 2013) (FAO 2016a), and there has been a steady increase in global supply since the 1960s (see figure).

In 2014, the total global production of BSC was 212,571 tons (t), of which Asia contributed 208,816 t. Specifically, China contributed 83,877 t, Indonesia 52,437 t, Philippines 27,570 t, Thailand 26,635 t, Taiwan 7,084 t, and Australia 3,755 t (FAO 2016b). India, Vietnam, and Sri Lankan catches are not accounted for in this data (no values were given).

The SL crab fishery increased by 180% in the three years following the end of the 30-year civil conflict. The total catch of crabs* in the five coastal districts (full geographical range of SLBSC) was 10,620 t in 2012, compared to 3,780 t in 2009 (MFAR 2016). In 2014, total catch of crabs was 6,450 t (MFAR 2016).

*The monthly Customs Reports compiled by the Department of Customs make no distinction between crab species. The mud crab, *Scylla serrata*, and the three-spot swimming crab, *Portunus sanguinolentus*, are the other two main crab species caught/exported in Sri Lanka.

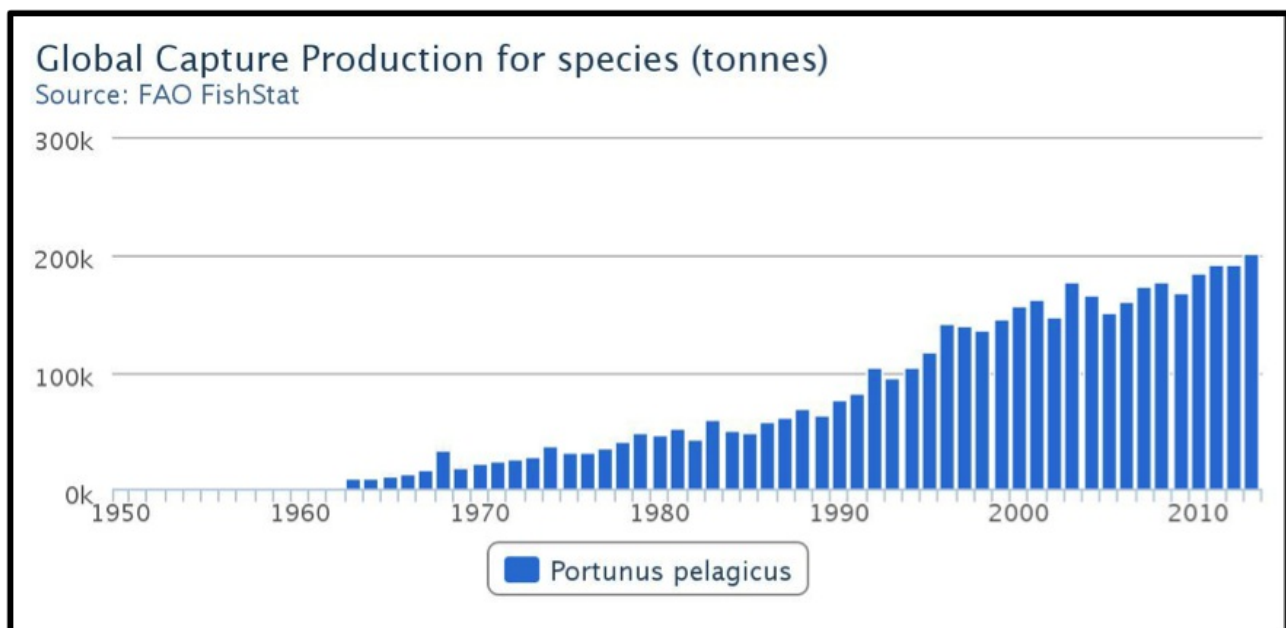


Figure 7 BSC global catch (FAO 2016a).

Importance to the US/North American market.

Sri Lankan crab products exported to the US accounted for 40% of the total annual export earnings from Sri Lankan crab products in 2011, worth around USD 6 million (SEASL 2016). BSC accounted for the majority of Sri Lankan crab exports, both in terms of volume and value in 2011 (ibid). In 2015, 191.02 t of portunid crabs (species not identified) were imported into the US from Sri Lanka, with a value of ~USD 4.2 million (NMFS 2016; see figures).

The value of crabs exported from SL increased from roughly LKR 1,000 million (USD 7.75 million) in 2009 (during the civil conflict) to LKR 1,560 million (USD 12.09 million) in 2011 (after the civil conflict ended; (MMAF 2011). In 2014, crab was valued at LKR 2,617 million (USD 17.8 million; (MFAR 2016). The increase in value of crab exported from SL is largely attributed to the increased catch and export of SLBSC.

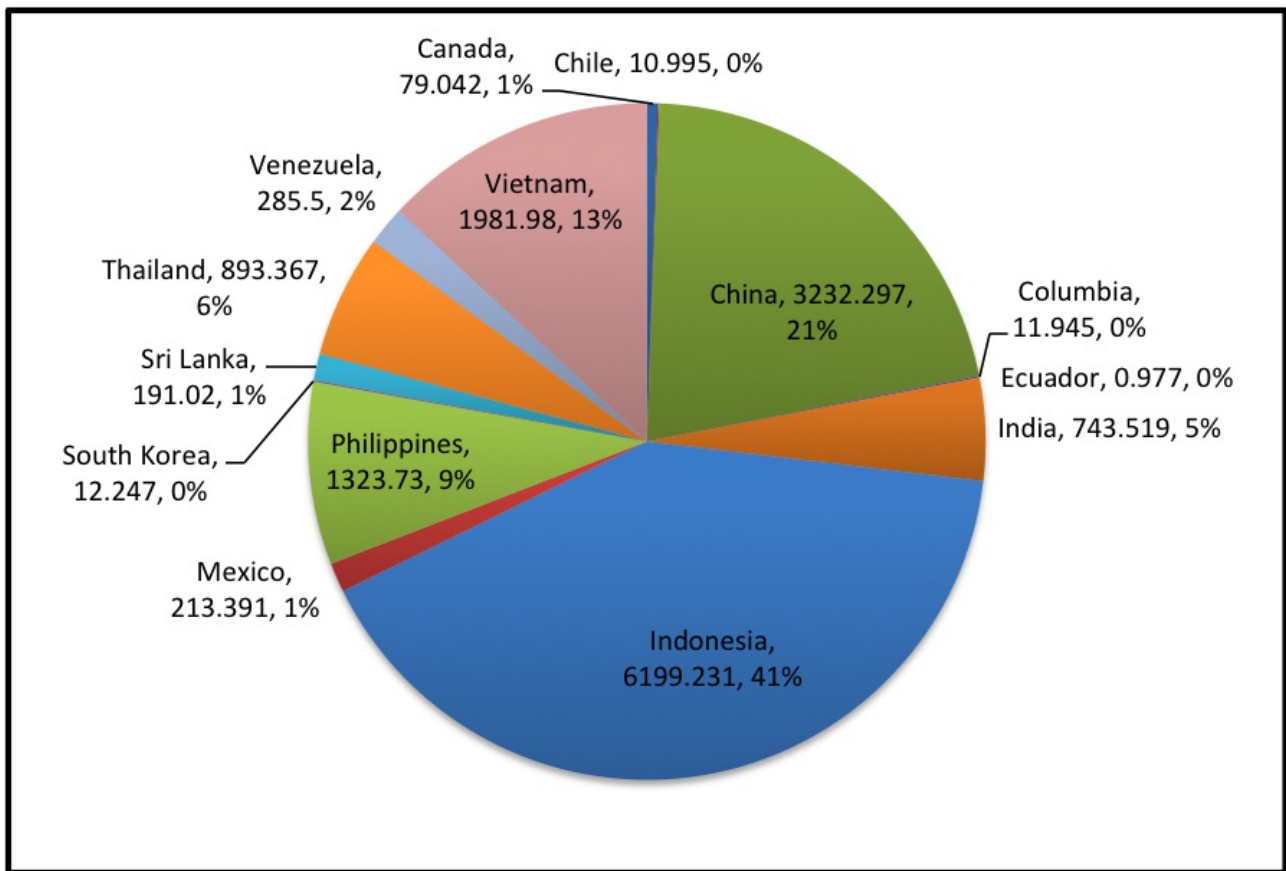


Figure 8 Portunid crab imports into the U.S. (by tons) in 2015 (data from NMFS 2016).

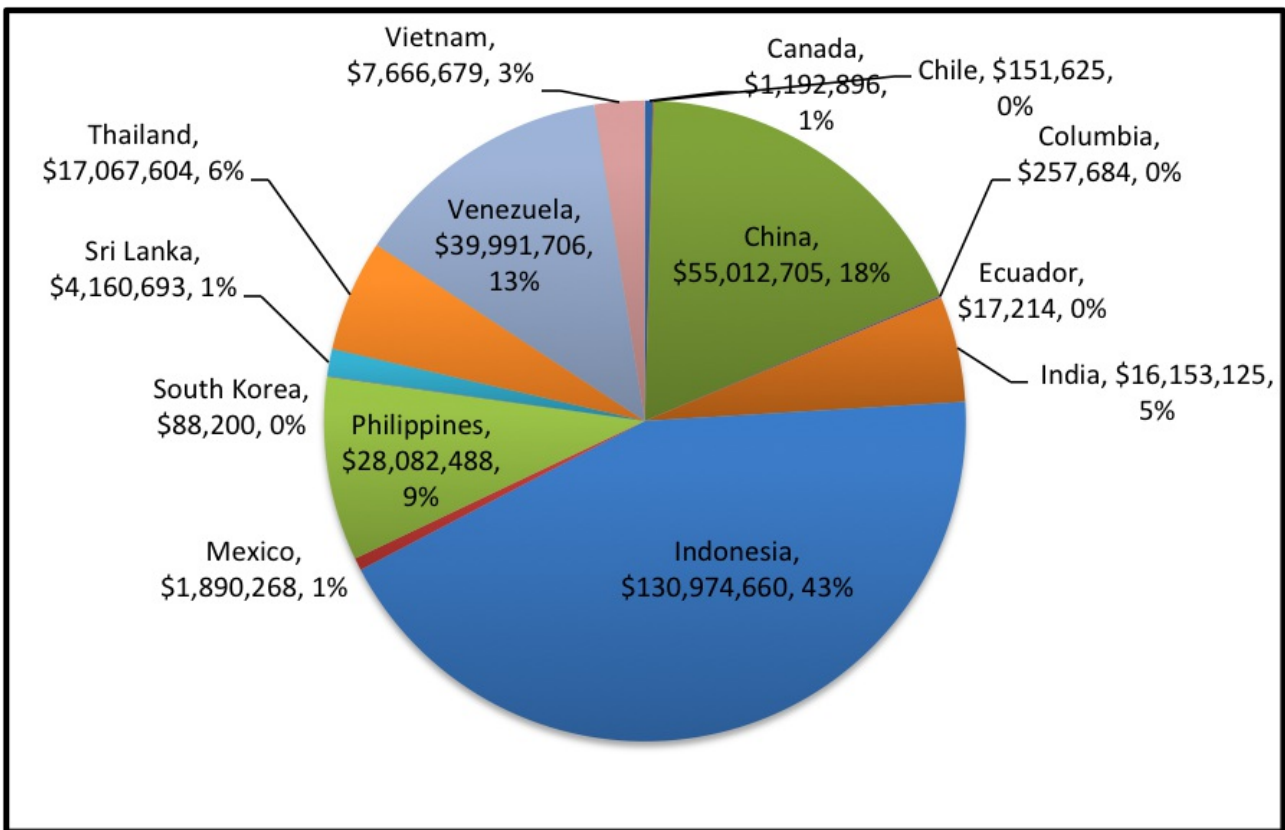


Figure 9 Portunid crab imports into the U.S. (by value) in 2015 (data from NMFS 2016).

Common and market names.

Blue swimming crab is also known as flower crab, blue crab, blue swimmer crab, blue manna crab, horse crab, sand crab, and swimming crab (GWA DOF 2011) (FDA 2016) (Fishsource 2016).

Primary product forms

Portunid crabs are sold interchangeably and these species can include RSC, BSC, and others, like *Portunis sanguinolentus* and *P. trituberculatus* (Lai et al. 2010) (Sea Fare Group 2011). SLBSC are exported by seafood companies as fresh, frozen and canned products. Fresh crab is either exported as "head on" or "cut crab" products. Cut crabs are processed by removing the top shell, guts and gills, and then brushed clean and cut into two sections. Canned crab is a pasteurized product that involves picking the meat from boiled crabs. Crab meat is graded according to type and size. Grades include colossal, jumbo, B jumbo, flower, lump, special, claw, B claw and finger. Canned crab products include "fancy," "special," "jumbo lump," "back fin," "lump," "white," and "claw" (Creech 2013).

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
Sri Lanka/Eastern Indian Ocean Gillnets and entangling nets (unspecified) Sri Lanka Gulf of Mannar	2.33: Moderate Concern	3.00: Moderate Concern	Yellow (2.644)
Sri Lanka/Eastern Indian Ocean Gillnets and entangling nets (unspecified) Sri Lanka Palk Bay	3.67: Low Concern	3.00: Moderate Concern	Green (3.318)

Criterion 1 Assessment

SCORING GUIDELINES

Factor 1.1 - Abundance

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

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

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

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

Factor 1.2 - Fishing Mortality

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

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

BLUE SWIMMING CRAB

Factor 1.1 - Abundance

SRI LANKA/EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

Moderate Concern

The 2018 stock assessment of Gulf of Mannar included data from eight landing sites in the Mannar and Puttalam districts and used the Length-Based Spawning Potential Ratio (LB SPR) approach (Pelagikos Pvt. Ltd. 2018b). The estimated residual spawning potential (SP) of the SLBSC stock in Gulf of Mannar was 37% (Mannar 61%, Puttalam 33%; *ibid.*), which is above the recommended Limit Reference Point (SPR 20%), but below the upper Target Reference Point (SPR 40%) (Prince et al. 2014). Therefore, the results of the LB SPR assessment indicate that abundance is within the range of what could be considered a sustainably managed fishery. In addition, 84% of female BSC sampled in the Gulf of Mannar fishery were mature, ranging from 99.5% in the Mannar District, to 83% in the Puttalam District (*ibid.*). This shows that both fisheries enable most BSC to mature (and potentially spawn) before entering the fishery; however, it is below the general target of 90% provided in the scientific literature (Seafood Watch 2016).

BSC also has low inherent vulnerability according to the Productivity Susceptibility Analysis (PSA = 2.16; see detailed scoring below). Nevertheless, because there are conflicting data-limited indicators (SPR [positive indicator] and percent maturity [negative indicator, since the percentage of catch that is mature should be above 90%]), a score of "moderate" concern is awarded.

Justification:

The selectivity curve for the SLBSC fishery in the Gulf of Mannar was positioned well to the right of the generic maturity curve produced from the studies of the BSC population in the Asian region and observations from the SLBSC fishery (Pelagikos Pvt. Ltd. 2018b). The stock assessment results over the past four years (2018: 37% SPR; 2017: 41% SPR; 2016: 46% SPR; 2015: 31% SPR) indicate that current fishery management measures are maintaining the fishery at a level equivalent to a sustainably managed fishery (*ibid.*). However, there are some concerns related to using the generic Asian BSC values for SL50 and SL95, as opposed to the values

that are now being collected by stock assessments and the National Aquatic Resources Research and Development Agency (NARA; which also has its concerns, mainly underrepresentation of age/maturity classes) (Pelagikos Pvt. Ltd. 2016b).

Productivity-Susceptibility Analysis (if Applicable):

Scoring Guidelines

1.) Productivity score (P) = average of the productivity attribute scores (p1, p2, p3, p4 (finfish only), p5 (finfish only), p6, p7, and p8 (invertebrates only))

2.) Susceptibility score (S) = product of the susceptibility attribute scores (s1, s2, s3, s4), rescaled as follows: $S = [(s1 * s2 * s3 * s4) - 1/40] + 1$.

3.) Vulnerability score (V) = the Euclidean distance of P and S using the following formula: $V = \sqrt{(P - S)^2}$

Productivity Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	Approx. 1 year (Josileen and Menon 2007; Kangas 2000)	1
Average maximum age	Approx. 3 years (Josileen and Menon 2007) (Kangas 2000)	1
Fecundity	229,468 to 2,236,355 eggs/batch (Zairon et al. 2015)	1
Average maximum size (fish only)	-	-
Average size at maturity (fish only)	-	-
Reproductive strategy	Brooder	2
Trophic level	2.5 to 3.2 (first level carnivore; (de Lestang et al. 2000)	2
Density dependence (invertebrates only)	-	-

Total Productivity (average)		1.4
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Susceptibility Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	High areal overlap (Creech 2013)	3
Vertical overlap (Considers all fisheries)	Target species (Creech 2013)	3
Selectivity of fishery (Specific to fishery under assessment)	Individuals < size at maturity are rarely caught (Creech 2013)	1
Post-capture mortality (Specific to fishery under assessment)	Target species	3
Total Susceptibility (multiplicative)		1.65

PSA score for BSC in Sri Lankan gillnet fisheries is calculated as follows:

$$\text{Vulnerability (V)} = \sqrt{(P2 + S)^2}$$

$$V = \sqrt{(1.4 + 1.65)^2}$$

$$V = 2.16$$

Factor 1.2 - Fishing Mortality

SRI LANKA/EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

Moderate Concern

The ratio of fishing mortality to natural mortality (F/M) for the Gulf of Mannar fishery (Puttalam Lagoon) was 1.6 (Pelagikos Pvt. Ltd. 2018b), which is higher than the generally accepted target value for F/M for a sustainable fishery (< 1). Although the estimate of F/M ratio was a little higher than the generally accepted target F/M value for sustainable fisheries, other data suggests that fishing mortality (F) was generally targeting larger, older crabs in the fishery, which somewhat protects the spawning potential of the stock. F relative to F_{MSY} is unknown, but overfishing does not appear to be occurring. For this reason, SLBSC fishing mortality for the Gulf of Mannar is deemed "moderate" concern.

BLUE SWIMMING CRAB

Factor 1.1 - Abundance

SRI LANKA/EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Low Concern

The 2018 stock assessment of Palk Bay included data from nine landing sites in the Jaffna, Kilinochchi, and Mannar districts and used the Length-Based Spawning Potential Ratio (LB SPR) approach (Pelagikos Pvt. Ltd. 2018a). The estimated residual spawning potential (SP) of the SLBSC stock in Palk Bay was 45% (Jaffna 54%, Kilinochchi 38%, Mannar 44%; *ibid*), which is above both the recommended Limit Reference Point (SPR 20%) and the upper Target Reference Point (SPR 40%; (Prince et al. 2014). Therefore, the results of the LB SPR assessment indicate that abundance is above a level consistent with a sustainably managed fishery. In addition, only 6.5% of female BSC sampled in the Palk Bay fishery were immature, ranging from 0.7% in Jaffna District to 12% in Mannar District (*ibid*). This shows that both fisheries enable almost all BSC to mature (and potentially spawn) before entering the fishery.

BSC also has low inherent vulnerability according to the Productivity Susceptibility Analysis (PSA = 2.16; see detailed scoring below). Although the SPR and percent maturity indicators are similar and are from the same study, the SPR in particular shows such conclusive results that a score of "low" concern is deemed appropriate.

Justification:

The selectivity curve for the SLBSC fishery in both Palk Bay and the Gulf of Mannar was positioned well to the right of the generic maturity curve produced from the studies of the BSC population in the Asian region and observations from the SLBSC fishery (Pelagikos Pvt Ltd. 2018a). The stock assessment results over the past four years (2018: 45% SPR; 2017: 47% SPR; 2016: 44% SPR; 2015: 32% SPR) indicate that current fishery management measures are maintaining the fishery at a level equivalent to a sustainably managed fishery (*ibid*). However, there are some concerns related to the use of generic Asian BSC values for SL50 and SL95, as opposed to the values that are now being collected by stock assessments and National Aquatic Resources Research and Development Agency (NARA; which also has its concerns, mainly underrepresentation of age/maturity classes) (Pelagikos Pvt. Ltd. 2016b).

Productivity-Susceptibility Analysis (if Applicable):

Scoring Guidelines

1.) Productivity score (P) = average of the productivity attribute scores (p1, p2, p3, p4 (finfish only), p5 (finfish only), p6, p7, and p8 (invertebrates only))

2.) Susceptibility score (S) = product of the susceptibility attribute scores (s1, s2, s3, s4), rescaled as follows: $SS = [(SS1 * SS2 * SS3 * SS4) - 1/40] + 1$.

3.) Vulnerability score (V) = the Euclidean distance of P and S using the following formula: $VS = \sqrt{(P^2 + S)^2}$

Productivity Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
------------------------	----------------------	--

Average age at maturity	Approx. 1 year (Josileen and Menon 2007; Kangas 2000)	1
Average maximum age	Approx. 3 years (Josileen and Menon 2007) (Kangas 2000)	1
Fecundity	229,468 to 2,236,355 eggs/batch (Zairon et al. 2015)	1
Average maximum size (fish only)	-	-
Average size at maturity (fish only)	-	-
Reproductive strategy	Brooder	2
Trophic level	2.5-3.2 (first level carnivore; (de Lestang et al. 2000)	2
Density dependence (invertebrates only)	-	-
Total Productivity (average)		1.4

Susceptibility Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	High areal overlap (Creech 2013)	3
Vertical overlap (Considers all fisheries)	Target species (Creech 2013)	3
Selectivity of fishery (Specific to fishery under assessment)	Individuals < size at maturity are rarely caught (Creech 2013)	1

Post-capture mortality (Specific to fishery under assessment)	Target species	3
Total Susceptibility (multiplicative)		1.65

PSA score for BSC in Sri Lankan gillnet fisheries is calculated as follows:

$$\text{Vulnerability (V)} = \sqrt{(P^2 + S)^2}$$

$$V = \sqrt{(1.4 + 1.65)^2}$$

$$V = 2.16$$

Factor 1.2 - Fishing Mortality

SRI LANKA/EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Moderate Concern

In 2018, the ratio of fishing mortality to natural mortality (F/M) for the Palk Bay fishery (Jaffna, Kilinochchi, and Mannar districts) was 1.77 (1.39, 3.46, 1.14; respectively) (Pelagikos Pvt Ltd. 2018), which is higher than the generally accepted target value for F/M for a sustainably fishery (< 1). Although the estimate of F/M ratio was a little higher than the generally accepted target F/M value for sustainable fisheries, other data suggests that fishing mortality (F) is generally targeting larger, older crabs in the fishery, which somewhat protects the spawning potential of the stock. F relative to F_{MSY} is unknown, but overfishing does not appear to be occurring, therefore SLBSC fishing mortality for Palk Bay is deemed "moderate" concern.

Criterion 2: Impacts on Other Species

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

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

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

Guiding Principles

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

Criterion 2 Summary

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

BLUE SWIMMING CRAB - SRI LANKA/EASTERN INDIAN OCEAN - GILLNETS AND ENTANGLING NETS (UNSPECIFIED) - SRI LANKA - GULF OF MANNAR					
Subscore:	1.000	Discard Rate:	1.00	C2 Rate:	1.000
Species	Abundance	Fishing Mortality	Subscore		
Rays	1.00:High Concern	1.00:High Concern	Red (1.000)		
Sharks	1.00:High Concern	1.00:High Concern	Red (1.000)		
Sea turtles	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		
Pale-edged stingray	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		
Echinoderms	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		
Orange-spotted grouper	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		
Dugong	1.00:High Concern	5.00:Low Concern	Yellow (2.236)		
Blue-spotted stingray	2.33:Moderate Concern	3.00:Moderate Concern	Yellow (2.644)		
Snails	2.33:Moderate Concern	3.00:Moderate Concern	Yellow (2.644)		
Spotted catfish	2.33:Moderate Concern	3.00:Moderate Concern	Yellow (2.644)		

BLUE SWIMMING CRAB - SRI LANKA/EASTERN INDIAN OCEAN - GILLNETS AND ENTANGLING NETS
(UNSPECIFIED) - SRI LANKA - PALK BAY

Subscore:	1.000	Discard Rate:	1.00	C2 Rate:	1.000
Species	Abundance	Fishing Mortality	Subscore		
Rays	1.00:High Concern	1.00:High Concern	Red (1.000)		
Sharks	1.00:High Concern	1.00:High Concern	Red (1.000)		
Sea turtles	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		
Pale-edged stingray	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		
Echinoderms	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		
Orange-spotted grouper	1.00:High Concern	3.00:Moderate Concern	Red (1.732)		
Dugong	1.00:High Concern	5.00:Low Concern	Yellow (2.236)		
Snails	2.33:Moderate Concern	3.00:Moderate Concern	Yellow (2.644)		
Pharaoh cuttlefish	2.33:Moderate Concern	3.00:Moderate Concern	Yellow (2.644)		

Net fisheries targeting blue swimming crab in Sri Lanka typically land all species caught for sorting on shore, enabling monitoring studies to identify the species caught. A number of such studies have been conducted in recent years and are summarized below to identify the main species discussed in this assessment. There are limitations to these bycatch studies because some species may not always be landed if they are encountered. To assess the risk to species identified using the Unknown Bycatch Matrix we reviewed a recent study that uses a novel approach to determine the risk to megafauna (Hines et al. 2018).

A study conducted on the SLBSC fishery in Pesalai (Palk Bay fishery) found larger quantities of bycatch consisted of pharaoh cuttlefish (*Sepia pharaonis*), adusta murex (*Chicoreus brunneus*) and Bleeker's whipray (*Himantura bleekeri*), representing 15.6%, 5.23% and 4.38% of the total catch, respectively (Dolawaththage 2015). Of the 45% bycatch, 30% is retained and 15% is discarded (Dolawaththage 2015). *Himantura bleekeri* and other rays (Butterfly ray (1.04%), sharpnose stingray (0.68%), honeycomb ray (0.32%), blue-spotted stingray (0.25%), pale-edged stingray (0.21%) caught as minor bycatch in the SLBSC fishery are vulnerable species. There are ray fisheries in Sri Lanka, although more research needs to be done to determine which species are targeted (pers. comm., S. Creech, 6 June 2016).

Another study, conducted on the SLBSC fishery in the Puttalam District (Gulf of Mannar), reported that species that consisted of >5% of the catch were spiral melongena (*Pugilina cochlidium*: 19.19%) and spotted sea catfish (*Arius maculatus*: 5.5%; (Gunasekera and Fairoz 2015). There are commercial fisheries in Sri Lanka for two of the prominent (>5%) bycatch species from the two studies—catfish and cuttlefish—so the BSC fishery is not believed to be a major cause of fishing mortality (pers. comm., S. Creech, 6 June 2016). Both of the above studies were conducted during the BSC off-season, which is thought to contribute to the large amount of bycatch relative to target species. In addition, the northeast monsoons were active, and BSC are sensitive to low salinity levels, which would also contribute to smaller amounts of target species in the usual fishing areas (Gunasekera 2016).

The November 2016 bycatch assessment indicated that pale-edged stingrays, *Telatrygon (Dasyatis) zugei*, were caught in both the Palk Bay and Gulf of Mannar BSC fishing areas in Sri Lanka and represented 14.7% of the total catch in the Gulf of Mannar fishery (Pelagikos Pvt. Ltd. 2017). Pale-edged stingrays are classified as "Near Threatened" (NT) on the IUCN Red List (White 2016) and have therefore been included as a Criterion 2 species.

Blue-spotted stingrays, *Neotrygon kuhlii*, were also recorded as 15.8% of the total catch in the Gulf of Mannar fishery, and like pale-edged stingrays, are seasonally targeted by BSC fishers.

The most recent bycatch assessment for the Gulf of Mannar fishery (Feb 2017) stated that approximately 44.2% of the total catch consisted of targeted species and 55.8% of NTS species, of which 85.7% was retained (sold or consumed), and 14.3% was discarded. For the Palk Bay fishery, approximately 68.9% of the total catch was comprised of BSC, and 31.1% of NTS species, of which 45.5% were retained and 54.5% were discarded. To date (average), BSC comprised ~53.2% of the catch (9.87 t) from both fisheries, although 35.2% (6.56 t) of NTS were retained (sold or consumed) by BSC fishers, and the balance 11.6% (2.17 t) was discarded (Pelagikos Pvt. Ltd. 2017).

Sea turtles and dugongs are known to reside within Palk Bay and the Gulf of Mannar (DSCP 2016). In a 2008 study where gillnet fishers in Sri Lanka were interviewed about the incidental bycatch of dugongs in fishing nets, all fishers responded that dugongs are incidentally caught and likely killed for their meat (despite the fact that they are a protected species; (Ilangakoon et al. 2008). However, it appears that shark/ray nets are the gear capturing most dugongs, and not crab nets; therefore, dugongs are scored as "low" concern for fishing mortality. Incidental capture of sea turtles in crab nets does occur often (released alive when possible), and because they are thought to be overfished, they are scored as "moderate" concern for fishing mortality. Long-tail butterfly rays (*Gymnura poecilura*; NT), spotted eagle rays (*Aetobatus narinari*; NT), sharpnose stingrays (*Himantura gerrardi*; NT), honeycomb stingrays (*Himantura uarnak*; NT), orange-spotted groupers (*Epinephelus coioides*; NT), blacktip reef sharks (*Carcharhinus melanopterus*; NT), grey bamboo sharks (*Chiloscyllium griseum*; NT), great hammerhead (*Sphyrna mokarran*; "Endangered") and the surf redfish sea cucumber (*Actinopyga mauritiana*; "Vulnerable") have also been included (in broad groupings) because Criterion 2 species, due to their high vulnerability, unknown stock status, and high potential to interact with this gear type. Species that did not constitute more than 5% of the catch have been grouped into broad taxonomic groups to streamline the assessment.

For bottom-set crab nets in both the Palk Bay and Gulf of Mannar SLBSC fisheries, sharks and rays limit the score for Criterion 2.

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)

RAYS

Factor 2.1 - Abundance

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

High Concern

According to the SFW Unknown Bycatch Matrices, rays have a high stock status concern for bottom-set gillnet

fisheries. Rays also have high inherent vulnerability according to the SFW criteria, and many of the rays caught in the SLBSC fishery are listed as "Near Threatened" (IUCN 2016). For these reasons, their abundance is ranked as "high" concern.

Justification:

Long-tail butterfly rays (*Gymnura poecilura*), spotted eagle rays (*Aetobatus narinari*), sharpnose stingrays (*Himantura gerrardi*), and soneycomb stingrays (*H. uarnak*) have been caught (but comprised <0.06% of total catch in the Palk Bay fishery, and <0.31% of total catch in the Gulf of Mannar fishery) and recorded in the SLBSC fishery (Pelagikos Pvt. Ltd. 2017).

Factor 2.2 - Fishing Mortality

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR
 SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

High Concern

For bottom gillnet fisheries in Southeast Asia, ray fishing mortality is scored a 2 out of 5, or high concern, using the SFW unknown bycatch matrix.

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

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR
 SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

< 100%

Discards from the two SLBSC fisheries studied appear to be around 26% of the total catch. We assume that dead discards landings are less than 100% of the retained catch, and therefore assume a multiplying factor of 1.

SHARKS

Factor 2.1 - Abundance

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR
SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

High Concern

Sharks have high inherent vulnerability according to the SFW criteria and many sharks caught in the SLBSC fishery are listed as either "Near Threatened" or "Endangered" according to the IUCN (IUCN 2016). As a result, their abundance is ranked as a "high" concern.

Justification:

Blacktip reef sharks (*Carcharhinus melanopterus*; "Near Threatened"), grey bamboo sharks (*Chiloscyllium griseum*; "Near Threatened"), great hammerheads (*Sphyrna mokarran*; "Endangered") and bignose sharks (*Carcharhinus altimus*) have been caught (but comprised <0.08% of total catch) and recorded in the SLBSC fishery (Pelagikos Pvt. Ltd. 2017).

Factor 2.2 - Fishing Mortality

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR
SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

High Concern

The number of sharks being caught in the SL non-target species studies are low; however, it is unknown what the cumulative take is or what level of take is appropriate, and as such, scoring is based on the SFW unknown bycatch matrix. For bottom gillnet fisheries in Southeast Asia, shark fishing mortality is scored a 2 out of 5, or high concern.

Factor 2.3 - Modifying Factor: Discards and Bait Use

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

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

RATIO OF BAIT + DISCARDS/LANDINGS	FACTOR 2.3 SCORE
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<100%	1
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>=100	0.75
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SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR
SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

< 100%

Discards from the two SLBSC fisheries studied appear to be around 26% of the total catch. We assume that dead discards landings are less than 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.

Criterion 3 Summary

Fishery	Management Strategy	Bycatch Strategy	Research and Monitoring	Enforcement	Stakeholder Inclusion	Score
Fishery 1: Sri Lanka / Eastern Indian Ocean Gillnets and entangling nets (unspecified) Sri Lanka Gulf of Mannar	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Highly Effective	Yellow (3.000)
Fishery 2: Sri Lanka / Eastern Indian Ocean Gillnets and entangling nets (unspecified) Sri Lanka Palk Bay	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective	Highly Effective	Yellow (3.000)

Criterion 3 Assessment

Factor 3.1 - Management Strategy and Implementation

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

based on scientific advice, and evidence that the measures in place have been successful at maintaining/rebuilding species.

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Moderately Effective

Sri Lanka has a comprehensive set of acts and regulations for all fisheries. The acts and regulations provide for the demarcation of FMAs (several have already been declared), and the membership of the committees is stipulated and includes fisher's representatives (PDSRSL 2013). All vessels and engines are numbered and registered, and all fishers and fishing gears are licensed annually. A Fishing Operating License (FOL) entitles a fisher to harvest a number of different species, including SLBSC, using the licensed gear (Creech 2013). FOLs are issued based on mesh size of the gear, rather than on the fishery in which the gear is supposed to be used (ibid). Overall fishery policy in SL is committed to sustainable fishery management as a goal (DFAR 2016).

For each of the five districts in Palk Bay (Jaffna, Kilinochchi, and Mannar districts) and Gulf of Mannar (Puttalam and Mannar districts) fisheries, there is a detailed Fishery Management Plan (FMP). The harvest control strategies used to manage the efficiency of the fishery include specifying the type of fishing gear, the number of net pieces, fishing hours, and days. These are as follows: 1) Fishers are required to use only polyfilament, bottom-set crab nets with a mesh of greater than 4.5" (114.3 mm) to harvest BSC for export; 2) No person who intends to supply BSC for export shall use any other gears such as traps, trawls, or fixed nets, other than the bottom-set crab net prescribed in #1 above; 3) Fishers shall not set more than 35 net-pieces per fisher, per day to harvest BSC for export; 4) Fishers shall not harvest BSC for more than 6 days/nights per week; and 5) Fishers shall not set bottom-set nets for more than one night (DFAR 2017) (DFAR 2018).

Fishing pressure on SLBSC is limited by the nationwide ban on the use of monofilament nets by reducing fishing efficiency, or escapability, during the 3–4 months throughout the year when the ocean is calm and there is a decrease in turbidity/increase in visibility (Creech 2013). The prohibition of monofilament nets also aids in the creation of an "offseason," when nylon crab nets are more visible and more easily avoided, and fishers tend to target other commercial species. However, the regulation prohibiting the use of monofilament nets in the SLBSC is not fully enforced (ibid).

Stock assessments (SAs) are conducted annually before 30 January, with the assistance of BSC fishing communities and manufacturers/exporters of BSC products. Representatives of the regulatory authorities (DFAR or NARA) participate in the annual stock assessment and the results are made available (published) to the regulatory authorities, BSC fishing communities and manufacturers/exporters of BSC products, on or before 28 February, or within three months of completing the stock assessment (in the Palk Bay fishery) (ibid). Stock assessments use the Length-Based Spawning Potential Ratio (LB SPR) approach, with the following reference points (RPs): 1) Upper Target Reference Point (Upper TRP) = Spawning Potential >40%; 2) Lower Target Reference Point (Lower TRP)= Spawning Potential ≥30%; 3) Limit Reference Point (LRP) = Spawning Potential <20%. Stock assessments in both fisheries have been above the LRP and the Lower TRP for the last four years, which shows that the fisheries are being sustainably managed (ibid). Four harvest control rules have been put into place and may be implemented in response to SA results. In addition, there is an appropriate bycatch management strategy in place (pale-edged stingrays ("Near Threatened") and blue-spotted stingrays are targeted by BSC fisherman for part of the year in Sri Lanka), as well as monitoring and surveillance, and dispute resolution (ibid).

Since 2013, Sri Lankan fishers in the north have campaigned and lobbied for the government to take action to end IUU fishing by Tamil Nadu trawlers in Sri Lankan waters, including filing legal action in the court of appeal and supreme court (pers. comm., S. Creech 1 October 2018). An amendment to the Fisheries (Regulation of Foreign Fishing Boats) Act 1979 was published in November 2017 and became law in January of 2018 (Parliament of the Democratic Socialist Republic of Sri Lanka 2017). Since then, the government has taken steps to arrest and prosecute Tamil Nadu boat owners under the amended act. As a result, the incidence of IUU fishing by Tamil Nadu trawlers in Sri Lankan waters had decreased by as much as 90%, compared to the situation prevailing at the start of the FIP in 2013, according to local fishers' leaders (pers. comm., S. Creech, 1 October 2018).

In addition, to the harvest control rules and tools above, there is a "Voluntary Code of Conduct" (CoC). The CoC was developed to ensure the sustainable use of resources by applying good management measures in maintaining the status of BSC stocks at healthy limits, and to minimize the impact on the marine environment and the associated species (see "Justification" section below) (DFAR 2017).

However, because measures have not been in place long enough to evaluate their success, we have deemed this factor as "moderately" effective.

Justification:

Some of the input controls agreed by stakeholders that cannot be easily incorporated into the legislation are included in a "Voluntary Code of Conduct" (see below), to be agreed upon by the Fisheries Committees and other groups and associations representing fishers and other stakeholders. This pledges voluntary compliance by fishers to do the right thing with no sanctions, except social and moral obligations (DFAR 2013). As of May and July 2018, 97% of BSC fishers have endorsed the voluntary CoC for BSC fishing in the Palk Bay fishery, and 94% have endorsed the voluntary CoC in the Gulf of Mannar fishery (Gunasekera 2018a) (Gunasekera 2018b).

The voluntary CoC includes that: **Rule 1.** BSC fishers will operate in compliance with the Fisheries and Aquatic Resources Act No. 2 of 1996 (amendments and regulations); **Rule 2.** BSC shall only be harvested using 4-ply or 6-ply bottom-set crab nets with a minimum mesh size of 4.5" (114.3 mm); **Rule 3.** The maximum height of a bottom-set crab net shall be 15 eyes and the maximum length of shall be 1,500 eyes per piece; **Rule 4.** An individual fisher can use/set a maximum number of 35 net-pieces/panels in a single day; **Rule 5.** The set time (soakage time) of a bottom-set crab net for catching of BSC shall be not more than 12 hours: 6.00 p.m. to 6.00 a.m.; **Rule 6.** An individual fisher will not deliberately place or set bottom-crab nets on coral reefs, rocky reefs, or seagrass beds; **Rule 7.** BSC fishing will be limited to six nights per week, commencing Sunday evening and ending on Saturday morning; **Rule 8.** Any person who intends to supply BSC for export shall not use any other gears such as traps, trawls, fixed nets, other than the bottom-set crab net prescribed above; **Rule 9.** BSC fishers will dispose of all used, damaged, discarded crab nets on land, in an environmentally safe manner to avoid "ghost fishing"; **Rule 10.** Any person who engages in fishing for BSC in compliance with this code and/or purchases, sells or processes BSC harvested using bottom-set crab nets shall assist the DFAR in the collection of catch, effort data, and production data as and when requested by staff and officers of the respective District Fisheries Extension Offices and or the Fishery Management Division in Colombo (DFAR 2017).

A new regulation for BSC fisheries was written in 2016 and was submitted to the Director General, DFAR in June 2017 (pers. comm., S. Creech, 8 June 2017). The final draft is currently at the Attorney General's office. Once approved, it will be sent to the legal officer at the ministry who prepares it for parliament, where the act will be presented/read three times before it is approved (pers. comm., S. Creech, 10 June 2018). It will stipulate the following:

- 1) No person shall harvest BSC using bottom-set nets with a mesh size of less than 114.3 millimetres (4.5") or

a yarn of more than 6-ply.

2) No person shall use rigid or collapsible baited traps to harvest BSC.

3) All persons shall dispose of used, damaged, or discarded bottom-set crab nets on land, in an environmentally safe manner.

Another rule, relating to BSC minimum size for export, was removed from the regulation and put into a new schedule for the export of BSC under the Import and Export Act, which already provides the legal framework for exporting seafood (includes obtaining a license; *ibid*). One of the conditions for obtaining/maintaining an export license for exporting BSC in the future will be not to purchase or process blue swimming crabs weighing less than 100 g. The minimum size has been set based on feedback and discussions with fishers, the seafood industry, and an analysis of the SoM data collected by the FIP; the data suggests that at 100 g (carapace width 120 mm) around 95% of SLBSC are mature (*ibid*).

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.

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Moderately Effective

The SLBSC fishery recently implemented a FMP for all five districts in the Park Bay and Gulf of Mannar fisheries. In these FMPs, an explicit bycatch management strategy is laid out. The following measures will be implemented by the regulatory authority and representatives of the BSC fishing communities in the respective districts, to minimize the impact of the bottom-set BSC net fishery on other species, particularly species of national and international concern.

These are: 1) Use of low net height: the maximum net height of bottom-set BSC nets shall be ≤ 15 eyes in all landing centers (except Thooraiyoor (Jaffna), which requires a maximum net height of 12 eyes); 2) Use of weak (breakable) nets: the maximum thread used for bottom-set crab nets shall be 4 to 4.5-ply (6-ply in Jaffna); 3) Avoiding critical marine habitats: fishers shall not set crab nets on coral reefs, rocky reefs, or seagrass beds (frequented by dugongs and turtles); 4) Safe disposal of old nets: fishers shall dispose of all used, damaged, discarded crab nets on land, in an environmentally-safe manner; 5) Measures taken to reduce the fishery's impact on pale-edged stingray: fishers targeting both BSC and pale-edged stingray shall use bottom-set nets with a mesh of $\geq 5.5''$ (139.7 mm), to avoid catching immature pale-edged stingrays; and 6) Supporting scientific research and implementing the findings: the regulatory authority and representatives of the BSC fishing communities will promote, encourage and support further research about impact of the BSC fishery on other species including pale-edged stingrays, turtles and dugongs. If any negative impacts are demonstrated, measures to mitigate these impacts will be formulated and implemented under the next annual DFMP (DFAR 2017) (DFAR 2018).

Because some species of concern are targeted, as well as caught as bycatch, and management has not been in place long enough to evaluate its effectiveness, this factor is scored as "moderately effective."

Justification:

Other legislation that applies to ETP species and species of concern, such as dugongs and sea turtles, is the Fauna and Flora Protection Ordinance. This protective legislation exists on paper; however, implementation is very weak, resulting in illegal take and illegal commercial use of bycatch (pers. comm., A. Langakoon, 27 September 2018).

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.

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SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Moderately Effective

At the commencement of the FIP in 2013, there were no published scientific studies on the population biology of SLBSC. To address this issue, the FIP commissioned NARA to undertake the first scientific study of SLBSC population biology (results published in 2016). Since then, the FIP has also had help from the Bay of Bengal Large Marine Ecosystem (BOBLME) Project, which conducted a survey of fishing effort for SLBSC, and had numerous undergraduate students from Uva Wellassa University, Ocean University and the University of Colombo to conduct their bachelor's theses on all aspects of the SLBSC fishery; four stock assessments have been conducted in each of the fisheries (Palk Bay and Gulf of Mannar) using Dr. Prince's LB SPR approach. An assessment has also been proposed to determine the impact of the prawn stake net fishery on immature and juvenile SLBSC in Puttalam Lagoon.

The FIP is working with local institutions to ensure ongoing research into the impacts of the fishery, stock assessments are conducted annually, and are peer-reviewed, but do not include fishery-independent data. Bycatch is regularly monitored, but there is no data on lost gear/effects of ghost fishing. For these reasons, this factor is rated "moderately effective."

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.

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SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Moderately Effective

Most of the SLBSC fishers comply with the regulations that currently govern the exploitation and management of the SLBSC fishery (Creech 2013). Monitoring, control, and surveillance mechanisms for vessel and gear licenses (by DFAR) and the prohibition of illegal fishing gears (e.g., monofilament nets and trawlers) are implemented systematically across the entire fishery and are satisfactory (ibid). As laid out in the FMP, any

person who engages BSC fishing in compliance with the FMP and/or purchases, sells, or processes BSC harvested using bottom-set crab nets shall assist the DFAR in the collection of catch, effort data, and production data when requested by DFAR and/or the Fishery Management Division in Colombo. Monitoring of the implementation of the FMP is undertaken every three months by the Fishery Inspector in collaboration with BSC fishing communities in each FID (every six months in the Palk Bay fishery) (DFAR 2017) (DFAR 2018). Compliance with the provisions set out in the FMP and/or the voluntary CoC for BSC will be monitored annually by the Assistant Director, DFO (ibid).

In May and June 2018, DFAR conducted follow-up compliance surveys of the BSC fishery against the CoC. The surveys were conducted by fishery inspectors in their respective fishery inspector divisions, with representatives of fisher's cooperatives whose members engage in BSC fishing. Overall compliance is up in both fisheries; in Palk Bay (97%), Jaffna 98%, Kilinochchi 98%, Mannar North 95%, in Gulf of Mannar (94%), Puttalam 92%, Mannar South 99% (Gunasekera 2018a) (Gunasekera 2018b). The largest increases in compliance were due to: 1) efforts by DFAR officers and BSC fishers to register their boats and engines and obtain operating licenses for BSC fishing (Rule 1); 2) more than 95% of BSC in the Gulf of Mannar fishery now using no more than 35 net pieces to harvest BSC (Rule 5); and 3) the considerable decrease in use of monofilament nets in Jaffna District (Palk Bay; ibid).

The regulatory authority will take immediate action against any fisher or seafood company found to be in contravention of the provisions set out in the FMP and or the voluntary CoC for BSC fishing (DFAR 2017). IUU fishing has been a cause for concern for the overarching effectiveness of fisheries management in Sri Lanka, but the Sri Lankan parliament passed a bill in July 2017, banning the destructive fishing practice of bottom-trawling in the island waters, and imposing heavy fines on the violators (ColomboPage 2017). Since then, incursions by Indian trawlers have been reduced by 50% due to illegal fishers/boats being taken into custody (Parliament newspaper article: "Fish Exports Will Reach 44% by End of Year: Amaraweera"), and the new amendment, which fishers lobbied for in the supreme court, will further increase the deterrent (pers. comm., S. Creech, 20 December 2017).

Enforcement and/or monitoring are in place to ensure goals are successfully met, although effectiveness of enforcement/monitoring may be uncertain; hence, a score of "moderately effective" is given.

Justification:

Monofilament net use is prohibited under the Fisheries & Aquatic Resources Act in Sri Lanka, but they are still thought to be used, mostly in Puttalam Lagoon and in the Jaffna District. Previously, as much as 75% of the catch was landed using monofilament nets (Creech 2013). Monofilament net use is thought to be a remnant of the 30-year civil conflict, where fishing was only allowed between 6 a.m. and 6 p.m. each day and fisherman needed to be more efficient. They are used because they are cheaper than nylon, harder to see in turbid water, are more efficient and catch fewer non-targeted species (ibid).

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.

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SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Highly Effective

Stakeholders literally form the very basis of the SLBSC FIP, which was initiated when SEASL received a request from representatives of SL seafood companies, government authorities, researchers, and civil society organizations associated with the north SLBSC fishery. The aim of the FIP is to gather all those associated with the SLBSC fishery to create and implement a local plan that will improve the economic, social, and ecological sustainability of the fishery.

In particular, the scoping document was based on comments and suggestions by fishing communities. The initial fishery preliminary assessment included interviews with fishers in all four districts (Creech 2013). Fishing cooperatives have endorsed the FIP, with letters of commitment. Producers, processors, regulators are all participants in the annual meetings. The Harvest Control Strategy and Harvest Control Rules and Tools were translated into the local language (Sinhala and Tamil) and stakeholders were asked for their comments, feedback, and opinions. The district assistant directors endorsed and agreed to implement the FIP. The BSC fisheries have become key fisheries and the fishers are very committed to sustainably managing the stock (pers. comm., S. Creech, 1 July 2018). The FIP also aims to get cooperatives registered as FT producers to further build decision-making about the SLBSC fishery (pers. comm., S. Creech, 5 June 2016).

Any disputes arising in connection with the provisions set out in the BSC FMP and/or the voluntary CoC will be resolved either by: 1) The Fisheries Inspector, with representatives of BSC fishing communities and/or seafood exporters at the FID level; 2) The Assistant Director, with representatives of BSC fishing communities and/or seafood exporters at the DFO level; or 3) The Director General, with representatives of BSC communities and/or seafood exporters at the DFAR (DFAR 2017) (DFAR 2018).

The management process is transparent, high participation by all stakeholders is encouraged, and there is a mechanism in place to effectively address user conflicts, so this factor is rated "highly effective."

Criterion 4: Impacts on the Habitat and Ecosystem

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

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

GUIDING PRINCIPLES

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

Rating cannot be Critical for Criterion 4.

Criterion 4 Summary

Region / Method	Gear Type and Substrate	Mitigation of Gear Impacts	EBFM	Score
Sri Lanka / Eastern Indian Ocean / Gillnets and entangling nets (unspecified) / Sri Lanka / Gulf of Mannar	3	0	Moderate Concern	Yellow (3.000)
Sri Lanka / Eastern Indian Ocean / Gillnets and entangling nets (unspecified) / Sri Lanka / Palk Bay	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

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3

Palk Bay, specifically, has a number of marine habitats of high importance, including coral reefs, rocky (limestone) reefs, seagrass beds, fringing mangroves, mudflats and open marine environment (Creech 2013). Using the community-based data, which is more accurate than the GPS data, the BSC fishery in Palk Bay recorded an observed potential overlap of 10,947 hectares (ha) with seagrass beds (6,378 ha from the Kilinochchi District alone), out of the total fishing ground area (26,679 ha) (Bandara 2018a) (pers. comm., J. Bandara, 17 July 2018), or 41%. Overall, BSC fishing area in Palk Bay potentially overlaps with 10,962 ha of seagrass beds, 68.8 ha of coral reefs, 1.2 ha of mangroves, and 0 ha of limestone reefs (ibid.; see first figure), totaling 41% of potential overlap of fishing grounds with sensitive habitats.

Community-based data for BSC fishing grounds in the Gulf of Mannar recorded an observed potential overlap of 9,365 ha with seagrass beds (9,277 ha from the Mannar District alone), out of the total fishing ground area (40,444 ha) (Bandara 2018b) (pers. comm., J. Bandara, 17 July 2018), or 23%. Overall, BSC fishing area in the Gulf of Mannar potentially overlaps with 9,365 ha of seagrass beds, 190 ha of coral reefs, 0 ha of mangroves, and 181 ha of limestone reefs (ibid.; see second figure), totaling 24% of potential overlap of fishing grounds with sensitive habitats.

According to the Seafood Watch criteria, bottom-set nets that come into contact with substrates other than boulders/coral reef (e.g., mud, sand and other non-sensitive/resilient substrates) are scored a 3 out of 5.

Justification:

In Puttalam District, bottom-set crab nets used in the fishery are mainly set within the Puttalam Estuary (inner/middle Puttalam Lagoon, Dutch Bay, and Portugal Bay); the majority of coral/rocky reefs in the district are located outside the estuary. Bottom-set nets are also not set close to the shore, in very shallow (<2 m), where mangroves are ubiquitous (ibid).

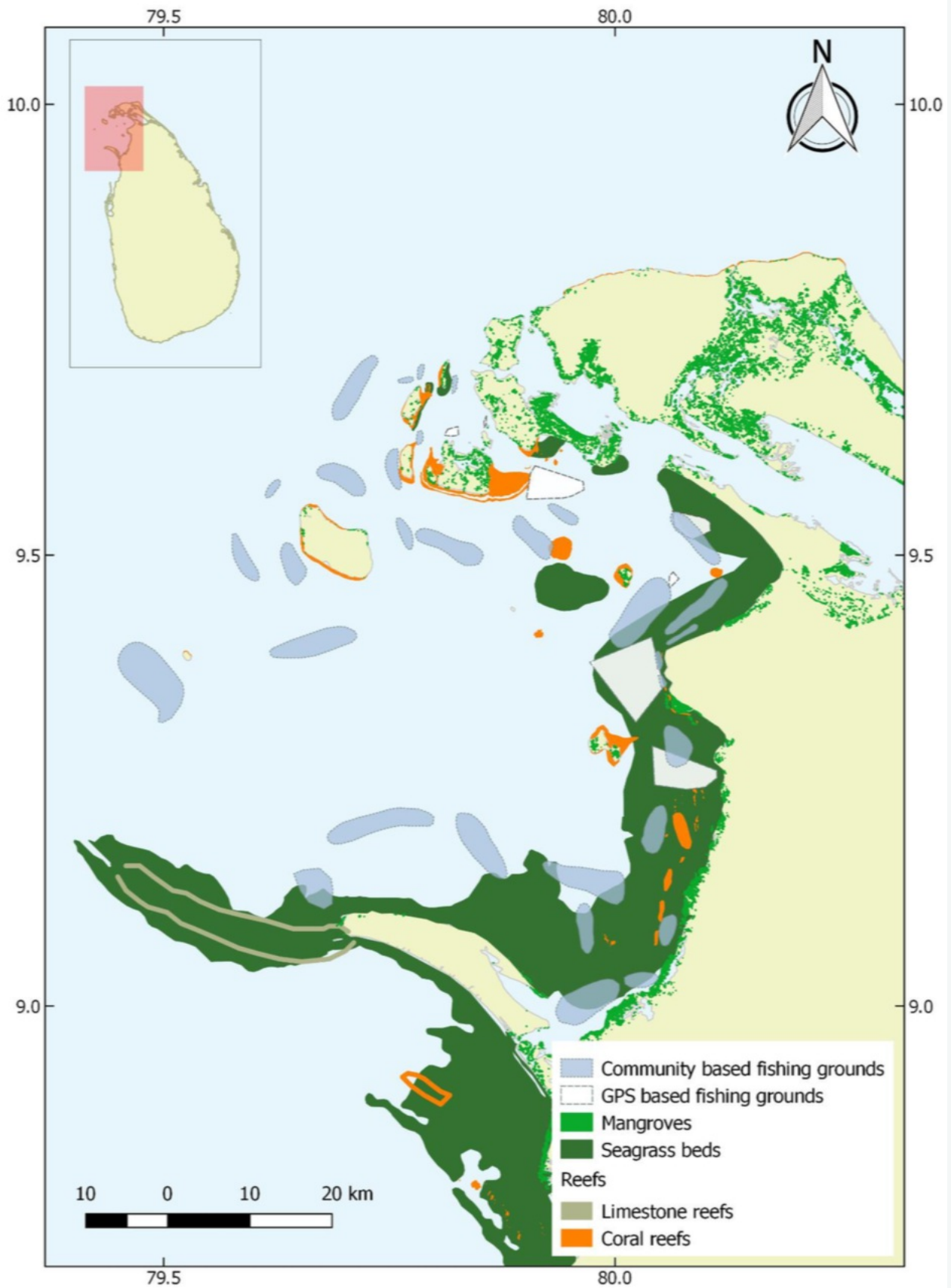


Figure 11 Potential overlap of BSC fishing grounds and marine habitats in Palk Bay (Bandara 2018a).

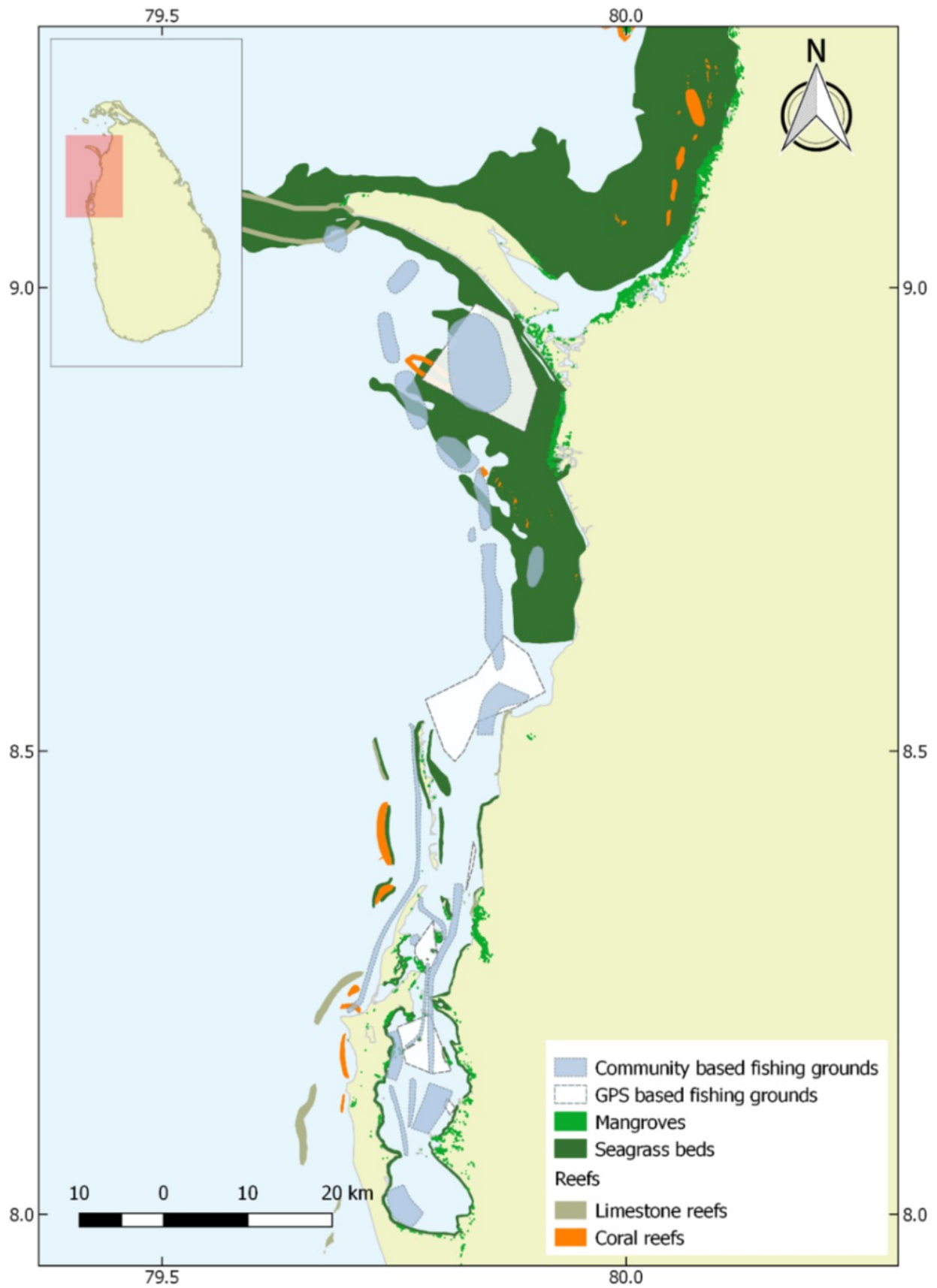


Figure 12 Potential overlap of BSC fishing grounds and marine habitats in the Gulf of Mannar fishery (Bandara 2018b).

Factor 4.2 - Modifying Factor: Mitigation of Gear Impacts

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

0

It has been observed that the bottom-set crab nets used for SLBSC are not associated with any damage of critical marine habitat in the fished areas of Sri Lanka (Creech 2013). Percentage of overlap between the BSC fishery and sensitive habitats was low when compared to the percent habitats in Sri Lanka as a whole. For example, the Palk Bay fishery overlapped with 10,947 ha of seagrass beds, which represents 12.7% of seagrass found in the Palk Bay (88,524 ha) and only 3.2% of seagrass found in Sri Lanka (Bandara 2018a). The Gulf of Mannar fishery overlapped with 9,365 ha of seagrass beds, which represents 13.7% of seagrass found in the Gulf of Mannar (68,452 ha) and only 2.7% of seagrass found in Sri Lanka (Bandara 2018a). Aside from these potentially fished sensitive habitats, BSC is fished over mud/sand.

The Gulf of Mannar has five Marine Protected Areas (MPAs), two national parks, two sanctuaries, and one nature reserve (see figure) (Bandara 2018b). Fishing and agriculture cannot be carried out inside a national park, whereas sanctuaries have some restrictions on fishing, though they are not clearly mentioned in the legislature, and nature reserves have no restrictions on fishing (ibid). Total closure of those areas to fishing that overlaps with the Gulf of Mannar is roughly 47,504 ha (ibid); however, some BSC fishing still occurs in these areas (Bandara 2018b).

Since there are no gear modifications in place to protect the marine habitat from BSC fishing activity, and closures are not always abided by, Seafood Watch considers there to be "no effective mitigation."

Justification:

The community mapped fishing grounds data suggests that a single fishing ground was located along the border of the buffer zone of the Bar Reef marine sanctuary (ibid). There was no overlap of these fishing grounds with the core zone of the sanctuary. The GPS tracking data, on the other hand, suggests that the BSC crab fishery does not interact with MPAs in the Gulf of Mannar; however, the community-based data of BSC fishing grounds in Puttalam District showed an overlap of 530 ha (2.07%) with the buffer zone of the Bar Reef Marine Sanctuary (where there are restrictions on fishing, but fishing is not prohibited). One fishing ground from South Mannar showed an overlap of 691 ha (3.88%) with the Adam's Bridge National Park (which has shifting sand bars that are used by marine birds to nest and lay eggs; the fishing ground was located well away from these sand bars; ibid). The overlap between MPAs and fishing grounds identified by community-based surveys was low, less than 5% in both Puttalam and Mannar Districts and for the fishery overall (ibid).

It is important to note that SLBSC fishers switch gears and fisheries throughout the year, depending on the availability and wholesale value of different fisheries (Creech 2013). There are always alternatives to BSC when the catch is low, like when crabs move offshore due to unusual weather (too rough, too wet, too hot; ibid). Additionally, when other species are more abundant than BSC (e.g., carangids, scombrids, prawns, cuttlefish, etc.), BSC fisherman target those species instead, giving the BSC stocks and their habitat a "break" (pers. comm., S. Creech, 10 May 2016).

Protected Area	Type	Total designated area (ha)	Area that overlaps with Gulf of Mannar (ha)
Bar Reef Marine Sanctuary Core Zone	Sanctuary	6,750	6,750 (100%)
Bar Reef Marine Sanctuary Buffer Zone	Sanctuary	25,657	25,657 (100%)
Vidaththaltivu Nature Reserve	Nature Reserve	28,923	3,009 (10%)
Adams Bridge National Park	National Park	19,024	17,819 (93%)
Wilpaththu National Park	National Park	131,347	29,685 (22%)

Figure 13 Marine protected areas (MPAs) found in the Gulf of Mannar (Bandara 2018b).

Factor 4.3 - Ecosystem-Based Fisheries Management

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Moderate Concern

BSC are often considered opportunistic, bottom-feeding carnivores and scavengers. They primarily consume various sessile and slow-moving prey such as, worms, mollusks and crustaceans (Batoy et al. 1987), as well as smaller fish, but not much is known about the role of BSC as prey in Sri Lankan waters. In Australia, BSC are prey to turtles, sharks, rays, large fish, birds and other BSC (GWA DOF 2011). Intense fishing pressure on BSC could alter the trophic structure and species composition by reducing predation on crab prey, and/or by reducing food for higher-level predators.

There is a proposed EAFM (Ecosystem Approach to Fisheries Management) plan written for SLBSC (BOBLME 2015), and a "report on inputs" to the proposed plan (Jayakody 2015), which aims to offer a "practical and effective means to manage fisheries, representing a move away from traditional fisheries management that focuses on target species, towards systems and decision-making processes that balance environmental, human, and social well-being within improved governance frameworks" (BOBLME 2015). Since the goal is to run the SLBSC fisheries using EBFM, and progress is being made towards this, we have scored this factor "moderately effective."

Acknowledgements

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

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

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Appendix A: Extra By Catch Species

SEA TURTLES

Factor 2.1 - Abundance

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

High Concern

Sea turtles are listed as Endangered or Threatened throughout the world (NOAA 2016), and are therefore scored as "high" concern using the SFW criteria.

Justification:

Five of the world's seven sea turtle species including green turtles, leatherbacks, olive ridleys, hawksbills, and loggerheads come to nest on Sri Lankan beaches (Deraniyagala 1953). However, the concern is with the two species that migrate through the waters around the northwest of Sri Lanka (olive ridley and green turtles), rather than those that are nesting in the south of Sri Lanka.

Factor 2.2 - Fishing Mortality

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Moderate Concern

For bottom gillnet fisheries in Southeast Asia, sea turtle fishing mortality is scored as 1 out of 5, or "high" concern, using the SFW unknown bycatch matrix. There is no clear evidence that the crab fishery does not interact with turtles ("low" concern or removal); however, expert opinion suggests that while gillnets are a threat, it is flying fish and ray nets that are a greater threat in the region (pers. comm., R. Nanayakkara and T. Kapurusinghe, 20 February 2017).

This information was corroborated by a recent bycatch study of megafauna in northwestern Sri Lanka, where researchers found that marine turtles were mentioned on a number of occasions as being present in the study areas and are commonly caught in nets in unsustainable numbers. It was reported that olive ridley (*Lepidochelys olivacea*) and leatherback (*Dermochelys coriacea*) turtles stay closer to shore, so bycatch risk is higher along the shore, and also in swimming crab nets throughout Palk Bay (Hines et al. 2018). For green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles, who stay closest to seagrass beds and coral reefs, nearshore shark/ ray, swimming crab, and trawler fisheries showed the most risk throughout the study area (ibid). Because there are reports of capture in the swimming crab fishery, and an overall indication of overfishing across fisheries, we have rated fishing mortality as "moderate" concern.

Justification:

The incidental capture of sea turtles in certain fisheries along the northwestern (one area where BSC is fished), western and southwestern coast of SL has been reported (Kapurusinghe and Saman 2001) and is thought to be the leading cause of sea turtle mortality in Sri Lanka (Jones and Fernando 1968) (Jinadasa 1984). In particular, it has been reported that Kandakuliya, a remote village in the Gulf of Mannar on the

northwestern coast of Sri Lanka, has a high incidence of turtle (olive ridley) bycatch (Kapurusinghe and Cooray 2002) (Shanker and Choudhury 2006), but no nesting (Rajakaruna et al. 2009). From the northwestern to the southern coast of Sri Lanka, an annual catch of more than 5000 turtles has been reported (Kapurusinghe and Cooray 2002), both from incidental takes and targeted catch of turtles, despite their protected status (Frazier 1980) (Hewavisenthi 1990). It is thought that these turtles are predominantly entangled in nets from the seasonal flying fish fishery, which uses 5/8 inch mesh nets. These nets are used both along the coast and offshore, along the western coast of Puttalam District, but are not used in Puttalam Lagoon or in BSC fishing grounds (pers. comm., S. Creech, 27 February 2017; as per conversation with SL sea turtle expert Dr. Lailith Ekanayake). The Gulf of Mannar (and Palk Bay) is part of the olive ridley turtle's migration route to nesting sites off the eastern coast of India (ibid).

Factor 2.3 - Discard Rate

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

< 100%

Discards from the two SLBSC fisheries studied appear to be around 26% of the total catch. We assume that dead discards landings are less than 100% of the retained catch, and therefore assume a multiplying factor of 1.

DUGONG

Factor 2.1 - Abundance

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

High Concern

Dugongs are listed by the IUCN as "Vulnerable," with a decreasing population trend (Marsh and Sobotzick 2015). In particular, the dugong population in the Gulf of Mannar, Palk Bay region is highly depleted (Anand et al. 2015) and continues to be threatened due to multiple anthropogenic factors, including direct illegal hunting, despite being legally protected (pers. comm., A. Langakoon, 27 September 2018). Therefore, abundance is scored as "high" concern using the SFW criteria.

Factor 2.2 - Fishing Mortality

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Low Concern

Between 1988 and 2017, there were a total of 33 known dugong deaths in the Puttalam District, Gulf of Mannar, with approximately one death by drowning per year due to fishing nets (Creech and Bandara 2018). However, the probable cause of these deaths are ray/shark/sea bass nets, not BSC crab gillnets (ibid; see

figure). Ray and sea bass nets, which have the same specifications as shark nets, are stitched with 18-ply up to 36-ply (ray nets); easily strong enough to hold, restrain, and tangle a 400 kg dugong. Crab nets, on the other hand, are usually 4-ply, which is not strong enough to be a risk to dugongs (pers. comm., S. Creech, 20 December 2017). This information was corroborated by a recent bycatch study of megafauna in northwestern Sri Lanka. It was reported that, for dugongs, most of the bycatch risk is in the Gulf of Mannar, from trawlers and shark/ray nets; dugong exposure to crab nets is low (Hines et al. 2018). Because of this, we have rated fishing mortality as "low" concern.

Justification:

SL fishers have been interviewed regarding the capture of dugongs, and most have stated that they have never experienced interactions with dugongs, claiming mesh size and twine thickness as possible reasons why dugongs are not caught in the crab nets (pers. comm., S. Creech, 17 February 2017). There are concerns, however, that if dugongs did encounter the crab nets, they would remain entangled because they tend to panic when they encounter nets, which leads to them becoming wrapped up in the nets (pers. comm., Ellen Hines, 31 August 2017).

IUCN Sri Lanka (IUCNSL) is taking part in an ongoing project to map seagrass beds in the Gulf of Mannar and to track and study dugongs (pers. comm., S. Creech, 27 February 2017, as per conversation with Arjan Rajasuriya, Coordinator of Marine and Coastal Thematic Areas for IUCNSL re: dugong). Arjan believes that entanglement in bottom-set nets are a potential risk to dugongs, and that the level of risk depends on the height of the net, mesh size, ply, and the extent to which the net billows out (the deeper the curve of the net, the more of a risk of entanglement; *ibid*).

There are currently numerous proposals to reduce the accidental death of dugongs in Puttalam District (see (Creech and Bandara 2018)).

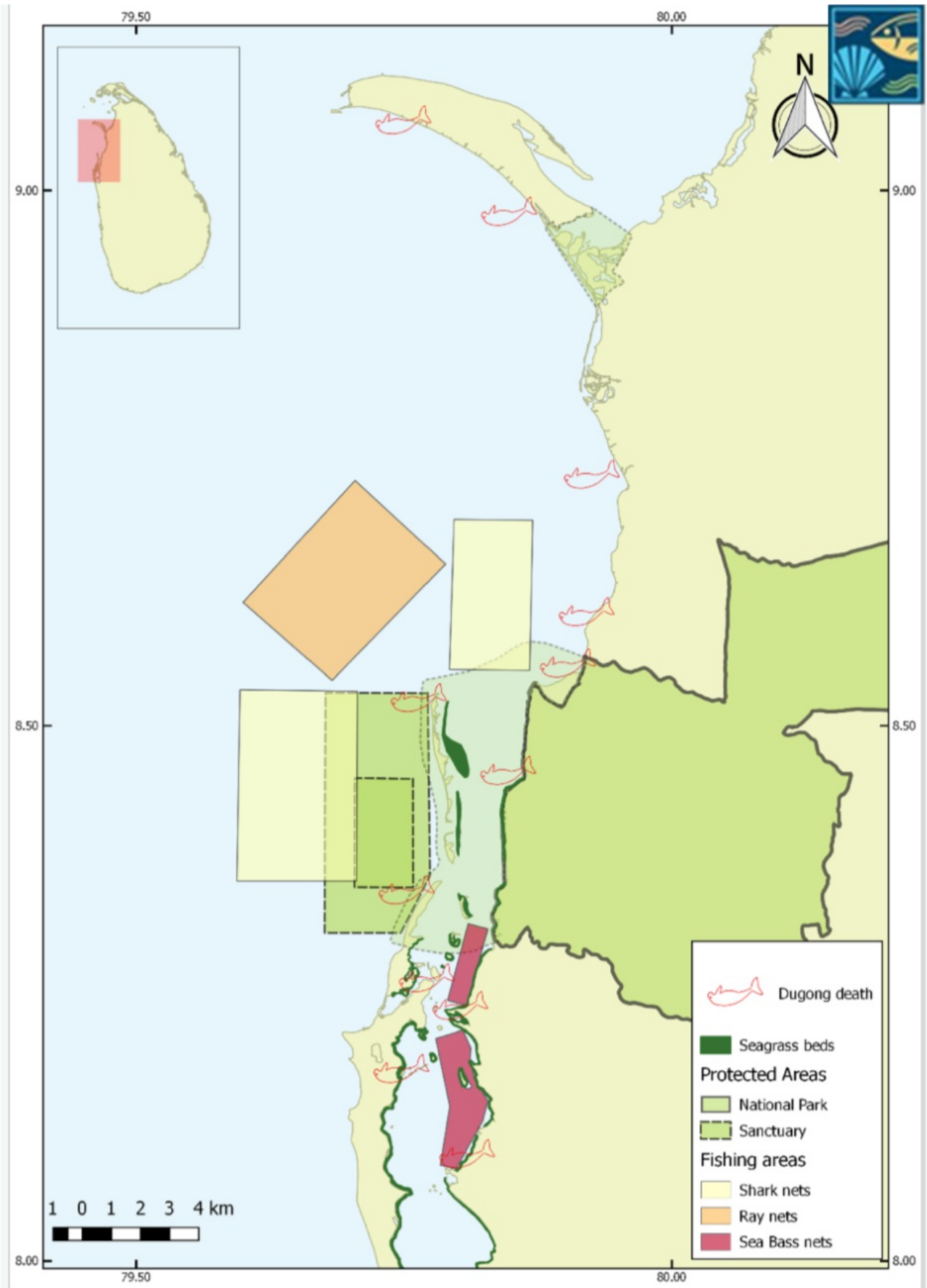


Figure 10 Known dugong deaths in relation to ray/shark/sea bass fishing areas, seagrass beds, and protected areas (Creech and Bandara 2018).

Factor 2.3 - Discard Rate

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

< 100%

Discards from the two SLBSC fisheries studied appear to be around 26% of the total catch. We assume that dead discards landings are less than 100% of the retained catch, and therefore assume a multiplying factor of 1.

PALE-EDGED STINGRAY

Factor 2.1 - Abundance

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

High Concern

The pale-edged stingray, *Telatrygon (Dasyatis) zugei*, is listed as "Near Threatened" on the IUCN Red List (White 2016); therefore, abundance is considered "high" concern.

Factor 2.2 - Fishing Mortality

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Moderate Concern

The impact of the SLBSC fishery on the pale-edge stingray stock is unclear; therefore, fishing mortality is scored as "moderate" concern.

Justification:

Pale-edged stingrays were a common (>5%) component of the BSC catch in three of the seven surveys conducted at landing centers in both the Gulf of Mannar (Anawasala and Baththalangunduwa) and Palk Bay (Delft Island) fisheries, and a common component of the Gulf of Mannar fishery non-target study (14.77%). They are targeted alongside BSC at certain landing centers (pers. comm., S. Creech, 13 January 2017).

Factor 2.3 - Discard Rate

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

< 100%

Discards from the two SLBSC fisheries studied appear to be around 26% of the total catch. We assume that dead discards landings are less than 100% of the retained catch, and therefore assume a multiplying factor of 1.

BLUE-SPOTTED STINGRAY

Factor 2.1 - Abundance

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

Moderate Concern

There is no stock assessment for blue-spotted stingrays, *Neotrygon (Dasyatis) kuhlii*, in Sri Lankan waters. However, according to the SFW Productivity-Susceptibility analysis (PSA score = 3.07), blue-spotted stingray is deemed moderately inherently vulnerable. Because there is no stock information for this species and they are considered moderately inherently vulnerable, we have scored their abundance as "moderate" concern.

Justification:

Productivity-Susceptibility Analysis:

Scoring Guidelines

1.) Productivity score (P) = average of the productivity attribute scores (p1, p2, p3, p4 (finfish only), p5 (finfish only), p6, p7, and p8 (invertebrates only))

2.) Susceptibility score (S) = product of the susceptibility attribute scores (s1, s2, s3, s4), rescaled as follows:

$$SS = [(S1 * S2 * S3 * S4) - 1 / 40] + 1.$$

3.) Vulnerability score (V) = the Euclidean distance of P and S using the following formula: $V = \sqrt{(P^2 + S)^2}$

Productivity Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	3 to 6 years (Jacobsen and Bennett 2010)	1
Average maximum age	10 to 13 years (Pierce and Bennett 2009)	2

Fecundity	1 to 3 pups (Froese and Pauly 2016)	3
Average maximum size (fish only)	<70cm (Froese and Pauly 2016)	1
Average size at maturity (fish only)	12 to 46.5 cm (Froese and Pauly 2016)	1
Reproductive strategy	Live bearer (ovoviviparous; Froese and Pauly 2016)	3
Trophic level	3.3 (Froese and Pauly 2016)	3
Density dependence (invertebrates only)	-	-
Total Productivity (average)		2

Susceptibility Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	Present in 7 of 8 BSC landing centers sampled to date (Pelagikos Pvt. Ltd. 2017)	3
Vertical overlap (Considers all fisheries)	High overlap w/fishing gear (Pelagikos Pvt. Ltd. 2017)	3
Selectivity of fishery (Specific to fishery under assessment)	Individuals < size at maturity are regularly caught (Pelagikos Pvt. Ltd. 2017)	2
Post-capture mortality (Specific to fishery under assessment)	Retained species (Pelagikos Pvt. Ltd. 2017)	3
Total Susceptibility (multiplicative)		2.33

PSA score for Blue-spotted stingrays in SL crab net fisheries is calculated as follows:

$$\text{Vulnerability (V)} = \sqrt{(P^2 + S)^2}$$

$$V = \sqrt{(2^2 + 2 \cdot 33)^2}$$

$$V = 3.07$$

Factor 2.2 - Fishing Mortality

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

Moderate Concern

The impact of the SLBSC fishery on the Blue-spotted stingray stock is unclear; therefore fishing mortality is scored as "moderate" concern.

Justification:

Blue-spotted stingrays were a common (>5%) component of the BSC catch in the Gulf of Mannar fishery (Pelagikos Pvt. Ltd. 2016d). They are targeted alongside BSC at certain landing centers (ibid; pers. comm., S. Creech, 13 January 2017).

Factor 2.3 - Discard Rate

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

< 100%

Discards from the two SLBSC fisheries studied appear to be around 26% of the total catch. We assume that dead discards landings are less than 100% of the retained catch, and therefore assume a multiplying factor of 1.

ECHINODERMS

Factor 2.1 - Abundance

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

High Concern

Echinoderms (benthic invertebrates) are ranked as "moderate" concern for abundance based on SFW criteria; however since the IUCN lists Surf redfish sea cucumber (*Actinopyga mauritiana*) as "Vulnerable," with a decreasing population trend (Con et al. 2013), abundance is scored as "high" concern.

Justification:

Surf redfish sea cucumber (*Actinopyga mauritiana*) and chocolate chip sea stars (*Protoreaster nodosus*) have been caught and recorded in the SLBSC fishery (but, comprised <4% of the total catch in the Palk Bay fishery and <1% in the Gulf of Mannar fishery) (Pelagikos Pvt. Ltd. 2017). No information is available on the status of surf redfish stocks in SL waters.

Factor 2.2 - Fishing Mortality

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Moderate Concern

In the SFW Unknown Bycatch Matrix, benthic invertebrates caught as bycatch in a bottom gillnet fishery are scored a 3 out of 5, or "moderate" concern.

Factor 2.3 - Discard Rate

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

< 100%

Discards from the two SLBSC fisheries studied appear to be around 26% of the total catch. We assume that dead discards landings are less than 100% of the retained catch, and therefore assume a multiplying factor of 1.

SNAILS

Factor 2.1 - Abundance

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Moderate Concern

Benthic invertebrates such as gastropods are ranked as "moderate" concern for abundance, based on the SFW criteria.

Justification:

Adusta murex (*Chicoreus brunneus*), spiral melongena (*Pugilina cochlidium*) and spider conch (*Lambis lambis*) are commonly caught (>5%) and retained in the SLBSC fishery (Pelagikos Pvt. Ltd. 2017). No information is available on the status these species' stocks in Sri Lankan waters.

Factor 2.2 - Fishing Mortality

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Moderate Concern

In the SFW Unknown Bycatch Matrix, benthic invertebrates caught as bycatch in a bottom gillnet fishery are scored a 3 out of 5, or "moderate" concern.

Factor 2.3 - Discard Rate

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

< 100%

Discards from the two SLBSC fisheries studied appear to be around 26% of the total catch. We assume that dead discards landings are less than 100% of the retained catch, and therefore assume a multiplying factor of 1.

SPOTTED CATFISH

Factor 2.1 - Abundance

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

Moderate Concern

There is little information available on the stock status of spotted catfish in Sri Lankan waters. A Productivity-Susceptibility Analysis (PSA) was performed to determine the vulnerability of spotted catfish to fishing activities; a vulnerability score of 2.77 suggests a medium vulnerability. With an absence of information on stock status and medium vulnerability, a score of "moderate" concern is given.

Justification:

Productivity Attribute	Relevant Information	Score
Average age at maturity	1.6 (modeled) (Froese 2016)	1
Average maximum age	7 (modeled) (Froese 2016)	1
Average maximum size	80 cm (Froese 2016)	1
Average size at maturity	38 cm (Froese 2016)	1
Reproductive Strategy	Brooder	2
Trophic level	3.4	3
Productivity Score		1.5

Susceptibility Attribute	Relevant Information	Score
Areal Overlap	Unknown	3
Vertical Overlap	Bottom feeder caught in bottom-set net	3
Selectivity	Unknown	2
Post capture mortality	Retained species	3

Susceptibility Score	3.235
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Factor 2.2 - Fishing Mortality

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

Moderate Concern

There is little information to determine whether the current impact of the blue crab fishery is at a sustainable level; therefore, a score of "moderate" conservation concern is given.

Factor 2.3 - Discard Rate

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

< 100%

Discards from the two SLBSC fisheries studied appear to be around 26% of the total catch. We assume that dead discards landings are less than 100% of the retained catch, and therefore assume a multiplying factor of 1.

ORANGE-SPOTTED GROUPE

Factor 2.1 - Abundance

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

High Concern

There is no local stock assessment or estimate of abundance for orange-spotted grouper in Sri Lanka. An IUCN assessment of orange-spotted grouper globally resulted in a listing of "Near Threatened" with a declining trend in abundance (Cornish and Harmelin-Vivien 2004). Due to the concern associated with orange-spotted grouper globally, a score of "high" conservation concern is given.

Justification:

Orange-spotted grouper consisted of 0.07% of the total catch, with the majority in the Gulf of Mannar fishery. It was caught in 4 of the 8 NTS surveys (1 in the Palk Bay fishery, 3 in the Gulf of Mannar fishery), with a total of 29 individuals caught overall (Pelagikos Pvt. Ltd. 2017). No information is available on the status of orange-spotted grouper stocks in Sri Lankan waters.

Factor 2.2 - Fishing Mortality

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Moderate Concern

There is little information to identify the impact of Sri Lankan fisheries on orange-spotted grouper. The species makes up a minor proportion of catch in the Sri Lankan blue swimming crab fishery, which suggests that overfishing is unlikely; therefore, a score of "moderate" conservation concern is given.

Factor 2.3 - Discard Rate

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, GULF OF MANNAR

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

< 100%

Discards from the two SLBSC fisheries studied appear to be around 26% of the total catch. We assume that dead discards landings are less than 100% of the retained catch, and therefore assume a multiplying factor of 1.

PHARAOH CUTTLEFISH

Factor 2.1 - Abundance

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Moderate Concern

There are no local stock assessments for pharaoh cuttlefish in Sri Lanka or the wider Bay of Bengal. In order to determine their vulnerability to fishing activity, a Productivity-Susceptibility Analysis (PSA) has been conducted (see Justification section for details). The vulnerability score for pharaoh cuttlefish = 2.19, resulting in a low vulnerability. Since there is no indication whether pharaoh cuttlefish abundance is at an appropriate level, the low vulnerability leads to a score of "moderate" concern.

Justification:

Productivity Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Average age at maturity	<5 years (Mehanna et al. 2014)	1
Average maximum age	<10 years (Mehanna et al. 2014)	1
Fecundity	100–20,000 eggs/year (Chembian and Mathew 2011)	2

Average maximum size (fish only)	-	-
Average size at maturity (fish only)	-	-
Reproductive strategy	Demersal egg layer (Chembian and Mathew 2011)	2
Trophic level	<2.75 (Dolawaththage 2015)	1
Density dependence (invertebrates only)	Depensatory dynamics at low population size (Allee effects) demonstrated or likely (Dolawaththage 2015)	3
Total Productivity (average)		1.67

Susceptibility Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	<10% overlap (Dolawaththage 2015)	1
Vertical overlap (Considers all fisheries)	Medium overlap with fishing gear (Dolawaththage 2015)	2
Selectivity of fishery (Specific to fishery under assessment)	Individuals < size at maturity are frequently caught (Dolawaththage 2015)	3
Post-capture mortality (Specific to fishery under assessment)	Retained species or majority dead when released (Dolawaththage 2015)	3
Total Susceptibility (multiplicative)		1.43

Factor 2.2 - Fishing Mortality

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

Moderate Concern

There is no information regarding the impact of Sri Lankan fisheries on pharaoh cuttlefish, resulting in a "moderate" conservation concern.

Factor 2.3 - Discard Rate

SRI LANKA / EASTERN INDIAN OCEAN, GILLNETS AND ENTANGLING NETS (UNSPECIFIED), SRI LANKA, PALK BAY

< 100%

Discards from the two SLBSC fisheries studied appear to be around 26% of the total catch. We assume that dead discards landings are less than 100% of the retained catch, and therefore assume a multiplying factor of 1.

Appendix B: C3.3-3.5

C 3.3 Scientific Research and Monitoring

Palk Bay and Gulf of Mannar, Bottom-set crab net

Moderately effective

Key relevant information:

At the commencement of the FIP in 2013, there were no published scientific studies on the population biology of SLBSC. To address this issue, the FIP commissioned NARA to undertake the first scientific study of SLBSC population biology (results published in 2016). Since then, the FIP has also had help from the Bay of Bengal Large Marine Ecosystem (BOBLME) Project, which conducted a survey of fishing effort for SLBSC, and had numerous undergraduate students from Uva Wellassa University to conduct their bachelor's theses on SLBSC reproductive biology and non-target species (bycatch). There have been four stock assessments conducted in each of the fisheries with the help of Dr. Prince's LB SPR approach. An assessment has also been proposed to determine the impact of the prawn stake net fishery on immature and juvenile SLBSC in Puttalam Lagoon.

However, because the stock assessments do not appear to be peer-reviewed, or contain fishery-independent data, and there is a lack of regular bycatch monitoring and data on lost gear/effects of ghost fishing, this factor is rated "moderately effective."

C 3.4 Enforcement of Management Regulations

Palk Bay and Gulf of Mannar, Bottom-set crab net

Ineffective

Key relevant information:

Most of the SLBSC fishers comply with the regulations that currently govern the exploitation and management of the SLBSC fishery (Creech 2013). Monitoring, control, and surveillance mechanisms for vessel and gear licenses (by DFAR) and the prohibition of illegal fishing gears (e.g., monofilament nets and trawlers) are implemented systematically across the entire fishery and are satisfactory (ibid). However, with specific regards to the SLBSC fishery, the monitoring, control, and surveillance mechanisms are not comprehensive or consistently applied across the fishery (ibid).

Because the regulation prohibiting the use of monofilament nets in the SLBSC is incompletely enforced (ibid.), the FIP is working with cooperatives to enforce this measure. IUU fishing by Tamil Nadu and SL trawlers, however, is an external obstacle that also needs to be addressed/enforced (pers. comm., S. Creech, 5 June 2016). In order to see if there is even an institutional capacity and the intention to implement BSC-specific regulation once written, DFAR has been asked to prepare a list of enforcement cases of the Fisheries Act (pers. comm., S. Creech, 5 June 2016).

Due to the above, a score of "ineffective" is given for this factor. IUU fishing is a cause for concern for the overarching effectiveness of fisheries management in SL.

Justification:

Monofilament net use is prohibited under the Fisheries & Aquatic Resources Act in Sri Lanka, but they are still thought to be used, mostly in Puttalam Lagoon and in the Jaffna District. Previously, as much as 75% of the catch was landed using monofilament nets (Creech 2013). Monofilament net use is thought to be a remnant of the 30-year civil conflict, where fishing was only allowed between 6 a.m. and 6 p.m. each day and fishers

needed to be more efficient. They are used because they are cheaper than nylon, harder to see in turbid water, are more efficient, and catch fewer non-targeted species (ibid).

C 3.5 Stakeholder Inclusion

Palk Bay and Gulf of Mannar, Bottom-set crab net

Moderately effective

Key relevant information:

Stakeholders literally form the very basis of the SLBSC FIP, which was initiated when SEASL received a request from representatives of SL seafood companies, government authorities, researchers, and civil society organizations associated with the Palk Bay SLBSC fishery. The aim of the FIP is to gather all those associated with the SLBSC fishery to create and implement a local plan that will improve the economic, social, and ecological sustainability of the fishery.

In particular, the scoping document was based on comments and suggestions by fishing communities. The initial fishery preliminary assessment included interviews with fishers in all four districts (Creech 2013). Fishing cooperatives have endorsed the FIP, with letters of commitment. Producers, processors, regulators are all participants in the annual meetings. Eventually, the aim is to get each village society to endorse the FIP by the end of 2017 (pers. comm., S. Creech, 5 June 2016). The Harvest Control Strategy and Harvest Control Rules and Tools will be translated into the local language (Sinhala and Tamil) and stakeholders will be asked for their comments, feedback, and opinions. If issues arise, the HCS and HCR&T will be amended. The FIP also aims to get cooperatives registered as FT producers to further build decision-making about the SLBSC fishery (pers. comm., S. Creech, 5 June 2016).

The management process is transparent and high participation by all stakeholders is encouraged; however, there is no mechanism in place to effectively address user conflicts, so this factor is rated "moderately effective."