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Marine Litter from Fisheries in the Gulf of Mannar and Palk Strait

KNOWLEDGE BASIS AND
RECOMMENDED AVENUES FOR CHANGE

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About the project partners:

SALT is a Norwegian private advisory and research enterprise based in Norway. SALT specializes in services related to enabling sustainable marine environments and coastal communities.

Lanka Environment Fund (LEF) is a not-for-profit organization established in 2019 in Sri Lanka. The aim of the Fund is to support existing conservation and environmental initiatives with their work and to foster a sense of stewardship of the island's exceptional beauty and natural value.

International Union for Conservation of Nature (IUCN) Sri Lanka is a membership union uniquely composed of both Government and Civil Society organizations serving in Sri Lanka for more than 30 years. IUCN is an organization dedicated towards safeguarding the environment by supporting sustainable natural resource management initiatives covering conservation and management of critical habitats, policy/legal and institutional support and environmental education and awareness.

Suganthi Devadason Marine Research Institute (SDMRI) is a research and higher education organization, based in Tamil Nadu, India. Research is focused on the needs of marine and coastal ecosystems in India; to promote higher education in marine science; and to enhance societal involvement in marine resource conservation and to assist the coastal folk in the improvement of socio-economic conditions.

Marine Litter from Fisheries in the Gulf of Mannar and Palk Strait

Knowledge Basis and Recommended Avenues for Change

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Photo: © Dinithi Samarathunga

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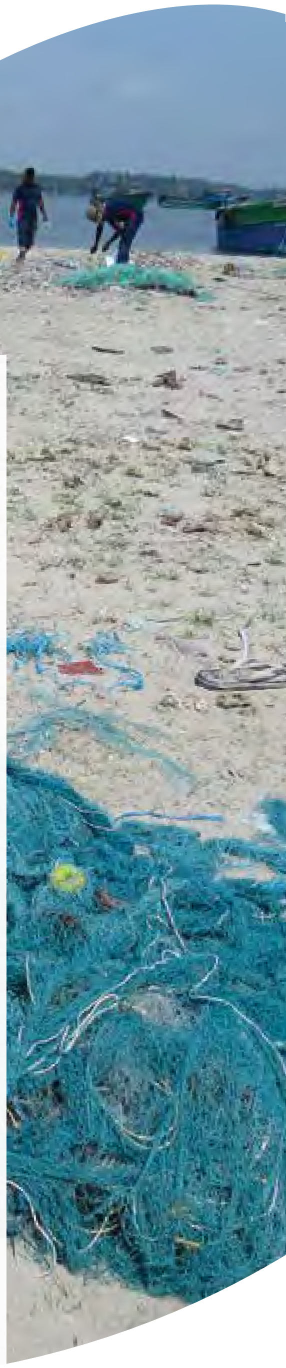

ALDFG	Abandoned, Lost or otherwise Discarded Fishing Gear
ANOVA	Analysis of Variance
APEC	Asia-Pacific Economic Cooperation Council
EEZ	Exclusive Economic Zone
EOLFG	End-of-Life-Fishing-Gear
EPR	Extended Producer Responsibility
FAD, dFAD	Fish Aggregating Device, Drifting Fish Aggregating Device
FAO	Food and Agriculture Organization of the United Nations
FTIR-ATR	Fourier-Transform Infrared Spectroscopy - Attenuated Total Reflection
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GGGI	Global Ghost Gear Initiative
GLMM	Generalized Linear Mixed Models
HDP	High-Density Polyethylene
IMO	International Maritime Organization
IOTC	Indian Ocean Tuna Commission
IUU	Illegal, Unreported and Unregulated fishing
LKR	Sri Lankan Rupee
MARPOL	International Convention for the Prevention of Pollution from Ships
MEPC	Marine Environment Protection Committee
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
RFMO	Regional Fisheries Management Organization
TNAFCFL	Tamil Nadu State Apex Fisheries Co-operative Federation Limited
UNCLOS	United Nations Convention on the law of the sea
UNEA	United Nations Environment Assembly
UNFSA	United Nations Fish Stocks Agreementb
WWF	World Wildlife Fund

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Executive Summary

The Gulf of Mannar and Palk Bay are areas of high biodiversity and sensitive marine ecosystems, located between the Northwestern and Northern coasts of Sri Lanka and the Southeastern coast of India. These marine areas are under increasing pressure due to high resource exploitation, the use of destructive fishing methods, and pollution—not least plastic pollution stemming from fisheries. This report builds on new data and knowledge and draws upon existing literature to describe both the challenges and potential solutions to marine litter from fisheries.

This report provides the reader with a holistic picture of the issue with marine litter from fisheries in the region, including:

- the natural values of the geographical region,
- an overview of the fisheries industry and fishing gear production,
- the concentration and composition of marine litter in the region stemming from fisheries,
- governance and policy on marine litter from fisheries,
- case examples of good practices from around the world to prevent and manage marine litter from fisheries,
- recommendations to prevent and mitigate marine litter from fisheries.

KEY FINDINGS:

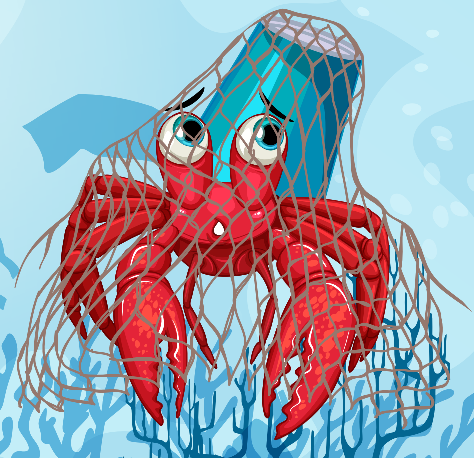
Marine litter from fisheries is a major threat to the Gulf of Mannar and Palk Strait marine environments. The situation is already concerning and is expected to grow in severity.

Marine litter is one of several human-induced stressors, which put pressure on the sensitive marine habitats of the Gulf of Mannar. The region is an important breeding and fishing ground for commercial marine species in India and Sri Lanka—making the issue precarious and critical for both livelihoods along the coasts and the marine environment.

Active involvement and regulatory intervention by public authorities in India and Sri Lanka are critical to successfully tackle marine litter from fisheries in the region.

Developing solutions require cross-sectoral approaches involving close dialogues with the fishing industry (gear suppliers and the fishing community), the waste management sector, and relevant representatives from civil society interest groups.

These marine areas are under increasing pressure due to **high resource exploitation, the use of destructive fishing methods, and pollution—not least plastic pollution stemming from fisheries.**



Executive Summary

New policies need to be developed covering comprehensive rules, guidelines, and action plans to improve waste management from fisheries, prevent ALDFG, and clean up items already lost. Recommended focus policy areas are gear marking, mandatory gear loss reporting, extended producer responsibility for fishing gear, gear design, and litter removal incentive schemes.

Marine National Parks, Biosphere Reserves, and Sanctuaries with eco-sensitive habitats (coral reefs, seagrass beds, mangroves, etc.) shall be a high priority in controlling and managing ALDFG with relevant departments like Forest and Environment.

Stranded marine litter in the Gulf of Mannar

- Abandoned or otherwise discarded fishing gear (ALDFG) made up a significant share of stranded macrodebris in the Gulf of Mannar: 50% of litter items and 74% of total litter weight on Indians shores, and 41% of items and 40% of the weight on Sri Lankan shores.
- ALDFG items play a dominant role in the presence of microplastic found on beaches.
- Larger plastic items and fragments in the natural environment is a major contributor to the accumulation of micro plastic.

Fisher folks' views on marine litter and waste from fisheries

- Bottom-set gillnets, followed by gillnets, were regarded as having the most negative impacts on the marine environment by fisherfolk in both countries. At the same time, both countries' fishers considered gillnets the gear type most frequently lost at sea during fishing.
- Designated locations to dispose of used gear are lacking, according to Indian and Sri Lankan fisher folk. At the same time, fishers in both countries are largely positive about supporting a system that would collect old fishing gear.

This report has identified some of the most pressing issues in the Mannar region that cause fisheries related littering to occur. A comprehensive list of countermeasures is provided in the chapter "Recommendations and avenues towards systemic solutions", including:

- Regulation, policy and fisheries management, involving measures related to the enforcement of fisheries in MPAs and addressing conflicts of interest, regulation of gear design and gear marking, extended producer responsibility.
- Waste management, involving take-back systems and waste reception in harbours, waste management onboard and building resilience amongst fisheries communities for alternative livelihoods.
- Litter removal, recommending potential litter removal programs with reference to successful international examples.
- Further research and building evidence, including expanded monitoring efforts of ALDFG, analysis of material flows and value chains for discarded fishing gear, further assessments of environmental impacts of ALDFG, assess carrying capacity of fisheries to prevent habitat damage.
- Awareness, education and community solutions, including relevant educational campaigns to support new policy and regulation.

Chapter Summaries


Photo: © Chanaka Sooriyabandara

GOVERNANCE AND REGULATION OF MARINE LITTER FROM FISHERIES

Sri Lanka and India have both ratified the UN Convention on the Law of the Sea (UNCLOS), the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex V, and the UN Fish Stock Agreement (UNFSA), which imply that the countries shall develop and implement regulations for the conservation and utilization of the living resources in their respective exclusive economic zones – including harvest practices and gear use (and gear design) that do not threaten resources, for example, ghost-fishing (UNCLOS Part V). The countries are also to minimize waste, discards, and catch by lost and abandoned gear and to protect biodiversity in the marine environment (UNFSA). The Action Plan to Address Marine Plastic Litter from Ships (2018) under MARPOL Annex V includes nine initiatives to minimize marine litter caused by fishing activities. Regarding port reception facilities for waste generated at sea, both India and Sri Lanka are obliged to international pollution prevention regulations as set out in the MARPOL.

The current management of ecosystems and habitats regarding the fisheries sector suffers from overlapping responsibilities and the lack of cooperation and coordination among various government organisations. In Sri Lanka, no legislation specifically targets ALDFG, although many laws are meant to prevent pollution and destruction of the environment and ensure sustainability. Reporting lost gear is also not mandatory. However, DFAR (Sri Lanka) has planned to introduce a regulation for fishers to report lost gear.

The government of India has no national legislation on plastic waste from fisheries.

The Action Plan to Address Marine Plastic Litter from Ships (2018) under MARPOL Annex V includes **nine initiatives specifically aimed at minimising marine litter caused by fishing activities.**

Fishing gear and boat types allowances are regulated in each state. There is a guideline for sustainable small-scale marine gillnet fishing, including recommendations on reducing gear loss and incentives for bringing damaged and retrieved debris to shore. The Department of Fisheries also implements various free training programmes for the benefit of the fisherman community in Tamil Nadu. There are, at present, no effective regulations, guidelines, or common systems for marking gear in India.

FISHERIES AND FISHING GEAR IN MANNAR

In the state of Tamil Nadu, information from producers indicate an approximate total of 750-950 tonnes of fishing nets supplied to the Ramanathapuram and Tuticorin districts annually. There are over 65 fishing net production enterprises. According to the manufacturers, 90% of fishing net supplies to the Gulf of Mannar fishers are from the Kanyakumari District. In the Gulf of Mannar region, the use of Monofilament

Chapter Summaries

Photos: © IUCN

nets is the most dominant (55%), followed by Multifilament (30%) and HDP (15%).

In terms of quantity, Sri Lanka imported more fishing gear than was exported each year, 2018-2022. However, concerning monetary value, Sri Lanka's total fishing gear export values exceed those of total imports in the same period, largely because the export values of fish hooks grossly exceed the imported values. It is worth noticing that imports of monofilament nets stopped in 2022, although they had been prohibited from use since 2016.

Approximate total of **750-950 TONNES** of fishing nets supplied to the Ramanathapuram and Tuticorin districts annually. There are **OVER 65 FISHING NET PRODUCTION ENTERPRISES.** According to the manufacturers, **90%** of fishing net supplies to Gulf of Mannar fishers are from the Kanyakumari District. In the Gulf of Mannar region, the use of Monofilament nets is the most dominant **(55%)**, followed by Multifilament **(30%)** and HDP **(15%)**.

FISHERIES-RELATED LITTER ON THE SHORES OF THE GULF OF MANNAR

Based on sampled data, abandoned or otherwise discarded fishing gear (ALDFG) made up 50% of stranded macrodebris along the Indian shores of the Gulf of Mannar and 41% of debris on the Sri Lankan shores by item counts. By weight, ALDFG comprised 74% of debris on the Indian shore and 40% on the Sri Lankan shore. Although the evidence is partly inconclusive, this study also indicates that the ratio of ALDFG to total macrodebris may be lower along the Sri Lankan coast than the Indian coast of the Gulf of Mannar (based on both counted and weighed samples during the Northeast Monsoon).

Rope was the most abundant ALDFG-related item in Sri Lanka (Count: 15%, Weight: 16%) and India (Count: 28%, Weight: 23%). In Sri Lanka, the rope was also the most abundant item overall. Other common items were parts of nets, styrofoam, boat pieces, traps, floats, buoys, etc.

Based on the project's field samples, average litter concentrations in the Gulf of Mannar are in the same order of magnitude as found in reviewed literature on beach litter in Sri Lanka and India (see chapter "Marine litter in India and Sri Lanka"), spanning roughly around less than one to just a few items per square meter. No significant difference in macrolitter concentration was detected between the Indian and the Sri Lankan side of the Gulf of Mannar during the Northeast Monsoon.

Ocean surface currents suggest that floating debris will get transported from the Bay of Bengal through Palk Strait into the Gulf of Mannar during the Northeast Monsoon (November to January). During the Southwest Monsoon (May to September), onshore winds are typical for the season, potentially transporting floating debris to shore in the Gulf of Mannar. However, no statistically significant effect of season was found on the relative prevalence of ALDFG along the Indian coast of the Gulf of Mannar. Along the Sri Lankan shores of the Gulf of Mannar, ALDFG was more prevalent during the Southwest Monsoon than during the Northeast Monsoon.

A positive correlation exists between how much fishing-related litter (and macroplastics in general) was found on the beach in India and Sri Lanka and how much microplastics the beach sediments contained. This conclusion implies that larger plastic items and fragments in the natural environment are major contributors to the accumulation of microplastics. Hence, preventing as well as cleaning up larger plastics will likely reduce microplastics in the environment. It also suggests that ALDFG items play a dominant role in the presence of microplastic found on beaches.

Photo: © Dinithi Samarathunga

About the Report

Photo: © Dinithi Samarathunga

This report is part of the project 'Mannar Region Systemic Solutions (MARESSOL)', an international partnership between SALT (Norway), Suganthi Devadason Marine Research Institute (SDMRI) in India, Lanka Environment Fund and International Union for Conservation of Nature (IUCN) in Sri Lanka. The project started in 2021 and lasts until 2024, funded by the Norwegian Retailers' Environment Fund, the project is cross-disciplinary, containing research, awareness building and policy advisory aspects to enable a structured, and targeted approach to limit marine plastic pollution from fisheries in the region of the Gulf of Mannar and Palk Strait.

The overall goal of this project is to reduce the amount of marine litter deriving from the fishing industry within the Gulf of Mannar and the southern section of the Palk Bay.

Who	*Partnership structure:* **- SALT, research and advisory, Norway** **- Suganthi Devadason Marine Research Institute, India** **- The International Union for Conservation of Nature, Sri Lanka** **- Lanka Environmental Fund, Sri Lanka** **- Norwegian Retailers Environment Fund, Norway**
What	*What do we aim to accomplish?* **Sustainable, clean and nutritious oceans for the future, with focus on solutions found both with support in theory for policy and practical intervention tests with fisheries and fishery gear producers**
Why	*Why the focus on upstream solutions for marine litter from fisheries and ocean related industries?* **The fisheries and ocean based industries in the region is responsible for a great portion of the plastic pollution by volume and weight. However, the responsibility goes beyond the users; the quality of gear, options for handling of waste in the harbour, ability to sort and recycle, regulation of the production and choice of gear in the industry are all considered parts of the problem.**
How	*How do we envision targeting upstream marine litter through policy programmes?* **By sharing best practices for research, to develop a common scientific ground, that can aid a streamlined program for dialogue, awareness and advisory targeted to public and private sector, as well as local communities and NGO sector initiatives.**

Latter parts of the project outline comprise "Policy Orientation and Dialogue" and facilitating "Pilot Projects" in India and Sri Lanka. In its final step, systemic solutions will be advocated to policymakers and key stakeholders.

Project outline and timeline

This report summarizes work and findings carried out during the project's initial stage to create a shared knowledge platform. The Research Group of MARESSOL has identified the following research areas as relevant to focus on to create a valuable basis of knowledge for the remainder of the project:

- Describe the structure and composition of the fishing fleet in the study region to better understand the potential sources of marine litter, i.e., what gear types are in use, where and to what extent, and how the labour is organized.
- Investigate the inflow of fishing gear used in the study region to fill knowledge gaps with regards to understanding the relationship between what is being put to market, what is in use, and what ends up as ALDFG, as well as shed light on required monitoring and policy development.
- Acquire more and better data to understand the composition and relative quantity of ALDFG in the study region. The research will aim to uncover what types of fishing gear end up in the marine environment as a knowledge basis to prioritize mitigation measures in line with the order of problematic gear types.
- Acquire a better understanding of the most important reasons or causes for abandoning, losing, or otherwise discarding fishing gear for the different segments of the fleet as a knowledge basis for exploring preventative measures against the most common types of ALDFG.

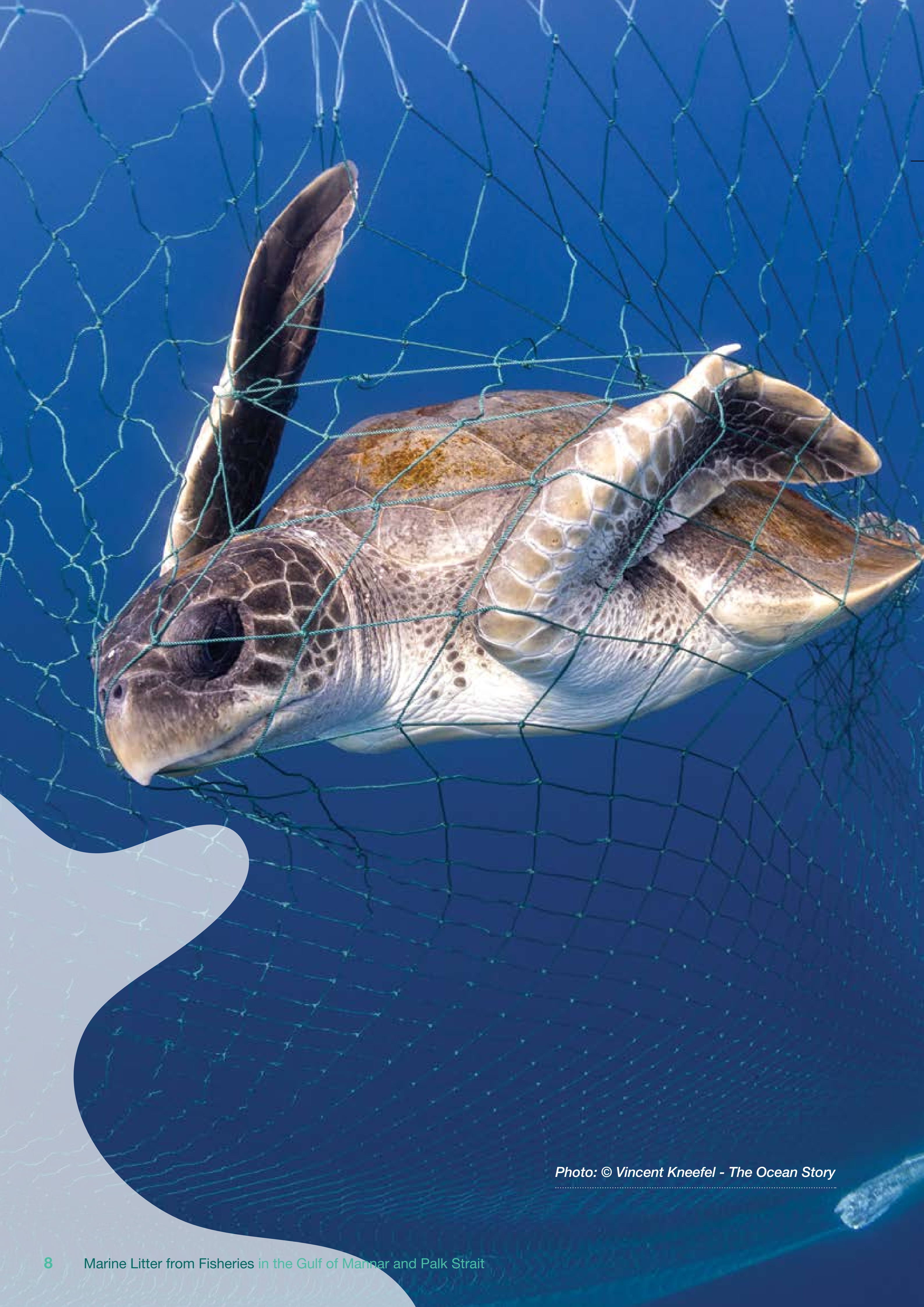


Photo: © Vincent Kneefel - The Ocean Story

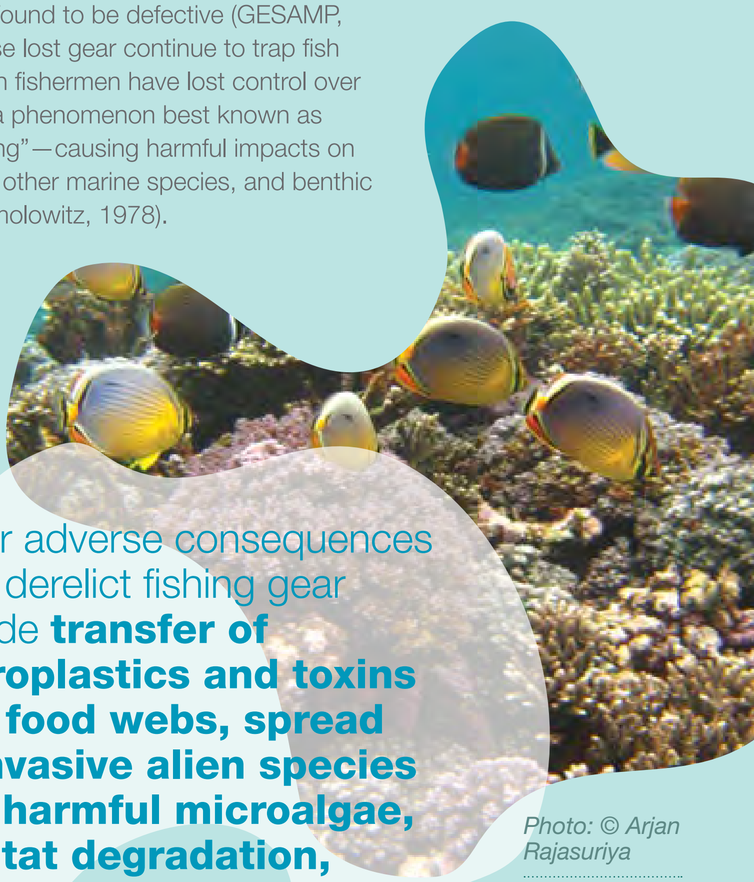
Introduction

1.1. Marine Litter from Fisheries: A Global Outlook

Plastic pollution in the oceans is expected to triple by 2040 if drastic measures are not taken to control it (UNEP, 2021). Efforts to reduce inputs of marine litter from all sources are urgently required (GESAMP, 2021). Sea-based sources of marine litter (including from fisheries) may not only be significant but may also have greater impacts on marine biota and habitats than on other forms of marine litter (ibid). Ocean and coastal-based sources of marine litter are largely from activities related to fishing and shipping (Galgani et al., 2015), and discarded fishing gear constitutes a high percentage of the total marine litter globally (Richardson et al., 2019). An estimated 2% of all fishing gear[1] used globally is lost to the ocean annually (Richardson et al., 2022), and the amount of *abandoned, lost, or otherwise discarded fishing gear* (ALDFG) entering the ocean now has implications for managers and policy makers as they work to tailor solutions at scale (Richardson et al., 2021).[2]

An estimated 4.6 million marine fishing vessels were in operation globally in 2018 (FAO, 2020), with Asia having the largest fleet. Based on FAO's long-term monitoring of assessed marine fish stocks, the proportion of fish stocks within biologically sustainable levels decreased from 90% in 1974 to 66% in 2017 (ibid). In parallel, fisheries today have transitioned to using synthetic, less-expensive, more durable, and buoyant materials than what was the case just decades ago (Kroodsma et al., 2018), which has introduced new challenges in regard to the usage patterns and impacts on the natural environment. This rapid expansion and transition of fishing efforts in recent decades imply increasingly concerning impacts of ALDFG on the natural environment.

Fishing gear may get lost in the seas due to rough weather conditions, gear damage, entanglement with bottom obstructions like wrecks and reefs, or sometimes dragged away by other fishing gear/boats. Also, fishermen may intentionally discard gear into the seas if the gear is found to be defective (GESAMP, 2021). These lost gear continue to trap fish even though fishermen have lost control over their use—a phenomenon best known as "ghost fishing"—causing harmful impacts on fish stocks, other marine species, and benthic habitats (Smolowitz, 1978).



Other adverse consequences from derelict fishing gear include **transfer of microplastics and toxins into food webs, spread of invasive alien species and harmful microalgae, habitat degradation, obstruction of navigation** and in-use fishing gear, and coastal socioeconomic impacts.

Photo: © Arjan Rajasuriya

[1] Based on interviews with 451 fishers from Iceland, USA, Belize, Peru, Morocco, Indonesia and New Zealand. Gear types represented: gillnets, purse seines, longlines, pots/traps, trawls

[2] While scientists have worked since the 1970s to develop quantitatively rigorous estimates for ALDFG, the estimate that 640,000 tons of ALDFG enters the ocean annually has been repeatedly and erroneously cited for over a decade. They trace the history of this misinformation and discuss the implications of the perpetuation of this estimate, and present opportunities to refine and improve estimates of lost fishing gear. Industry", 2016.

Other adverse consequences of derelict fishing gear include the transfer of microplastics and toxins into food webs, the spreading of invasive alien species and harmful microalgae, habitat degradation, obstruction of navigation and in-use fishing gear, and coastal socioeconomic impacts (Gilman et al., 2021). Stelfox et al. (2016) conducted a review work on the effect of ghost gear entanglement on marine megafauna. Interestingly, there appears to be a deficit of research in the Indian, Southern, and Arctic Oceans, and as such, they recommend that future study efforts should focus on these areas.

Efforts have been made to quantify gear-specific relative risk from ALDFG. A recent publication ranks "set and fixed gillnet, trammel net and drift gillnet" as posing the highest risk of all gear types on a global basis, followed by tuna purse seine with drifting FADs (Fish Aggregating Device) and bottom trawling (Gilman et al., 2021), recommending that the specific context dictate local management interventions.

The complex economic impacts of ALDFG have not yet been estimated systematically but include incremental costs associated with fishing operations, compliance, accidents at sea, search and rescue, and recovery (Kershaw, 2016). Likewise, the impacts on biodiversity have not been addressed systematically (ibid.).

However, as an example, a study by Jain and Raes (2021) has estimated that a stock of approx. 1.6 million tons of marine macro plastics could have incurred a revenue loss of USD 23 million in 2019 for Thai fisheries operating in the Gulf of Thailand.[3] This figure equals a decrease in Thai fisheries' net value of 1.88%, with the most impact stemming from time lost clearing nets, net repairs, dumped catch, and fouling incidents. In addition, ALDFG in the Gulf of Thailand is estimated to have incurred an estimated 1% loss of fish catch due to ghost fishing, equalling a value of USD 12.5 million in 2019.

Numerous policies, programmes, and guidelines are in place at all levels of geographic scale to prevent ALDFG, some of which will be further described in this report. On a global scale, the United Nations has a clear agenda to combat plastic pollution in general, with UNEP currently negotiating a legally binding treaty against plastic pollution, aimed to take effect in 2024.[4] This aligns with Sustainable Development Goal 14.1: "By 2025, prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution."[5] However, how plastic litter from fisheries is to be integrated into a global treaty is yet too early to tell.

1.2. Marine Litter in India and Sri Lanka

This chapter compiles brief summaries of existing literature known to the authors relating to marine litter in general in India and Sri Lanka. The literature selection is not systematic but is instead a reflection of the most prominent recent publications known to the authors of this report.

India and Sri Lanka were ranked 12th and 5th, respectively, among 20 countries assessed for mismanaging[6] plastic waste globally (Jambeck et al., 2015), with 85% and 82% mismanaged in each country. Plastic composed 3% and 7% of all waste in India and Sri Lanka, respectively. This translates to an estimated 2.9 and 1.9 million metric tonnes of mismanaged plastic waste per year in 2025 in India and Sri Lanka.[7]

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[3] The Thai study is based on rough assumptions, and although similar figures have not been estimated for Sri Lanka or India it indicates the scale of the economic impact of marine litter on the primary fisheries sector in an economy (Thailand) not too distant to India or Sri Lanka. Economic impacts to supporting industries in the value chain, such as fish processing, were not calculated, but should be considered in a wider scope.

[4] UNEP, 2022: https://www.unep.org/news-and-stories/story/what-you-need-know-about-plastic-pollution-resolution

[5] The UN Agenda 2030: https://sdgs.un.org/2030agenda

[6] "Mismanaged" defined by Jambeck as "material that is either littered or inadequately disposed. Inadequately disposed waste is not formally managed and includes disposal in dumps or open, uncontrolled landfills, where it is not fully contained. Mismanaged waste could eventuall y enter the ocean via inland waterways, wastewater outflows, and transport by wind or tides."

[7] The referred study does not include waste from sea-based activities, such as fisheries, as well as random events, such as flooding. Hence, the total amount of waste generated and leaked is likely underestimated.

Land-based sources of marine litter include improperly disposed garbage in urban areas, material from landfills and recreation areas, garbage swept into the ocean through floodwaters, and garbage in coastal lagoons, canals, and wetlands. Beach litter may accumulate on the backshore or get buried, depending on wave action, beach characteristics, and beach substrate (Williams & Tudor, 2001). The fate of the plastic in the ocean is determined by various factors, including oceanographic processes, plastic degradation depending on the material's characteristics, and the plastic pieces' surface area. The plastic's buoyancy also matters. The heavier material will sink to the bottom while the lighter component will float and be distributed over large areas by ocean currents. Some will accumulate in ocean gyres as floating garbage patches (Sivadas et al., 2021). The monsoonal currents that reverse in directions during the southwest and Northeast Monsoons and the lack of a sub-tropical gyre in the North Indian Ocean results in much of the floating debris accumulating on the coastlines of the countries that border the North Indian Ocean (Pattiaratchi et al., 2022; Sivadas et al., 2021). The presence of plastic litter in the Gulf of Mannar originating from countries other than India and Sri Lanka indicates that ocean currents transport floating debris over long distances (Sivadas et al., 2021). Therefore, the origin of marine and beach litter in the study area includes non-biodegradable matter from several countries in the region.

1.2.1. Coastal Litter in India and Sri Lanka

Numerous scientific papers have been published regarding beach litter on Indian coasts. Beach litter on 254 beaches of Peninsular India and Andaman and Lakshadweep Islands were studied between 2013 and 2014. The coast of Odisha, in Eastern India, has the lowest quantity of beach debris (0.31 g/m^2), while the coast of Goa, Western India, has the highest amount (205.75 g/m^2). Samples of debris collected from beaches revealed that all the items were domestic and anthropogenic discards (Kaladharan et al., 2020). Studying 33 Indian beaches, (Mishra et al., 2023) recorded an average beach litter of 0.48-0.51 items/m^2 (in 2019) and 0.3-0.4 items/m^2 (in 2021).

Reddy et al. (2006) reported 81.43 mg of plastics per kg in the intertidal sediments of the Alang-Sosiya Ship-Breaking Yard (Gujarat). The urban Mumbai beaches (Maharashtra) had a plastic litter level of 11.67 items/m^2, whereas Mumbai's recreational beaches had 68.83 items/m^2 (Jayasiri et al., 2013a, 2013b). Two sandy beaches of Mumbai recorded a total of 618 ± 271.82 items/50 m weighing 2,616.77 ± 989.19 g/50 m (Ashokan et al., 2023). The main factors contributing to the abundance of beach litter in India were identified as sand depositions from the sea and the use of beaches for recreation, tourism, and religious activities.

Three main beaches in Mangaluru (Karnataka) reported fishing activities as the major contributor (369 items/m^{-2}) to the total amount of litter (32.41–59.0%) in 2011-2016 (Sulochanan et al., 2019), with the maximum abundance found during the Southwest Monsoon. Daniel et al. (2019) reported an average of 14.4 ± 12 fishing-related items/100 m^2, corresponding to a mean weight of 0.55 ± 0.7 kg/100 m^2 in six beaches on the Kerala coast, with fishing ropes being the dominant composition (38%), higher in the post-monsoon season than the Monsoon.

According to Kaviarasan et al. (2020), the beaches of the Lakshadweep Islands had a total of 1,231 marine litter items with the highest average abundance of 193 ± 97 items/400 m^2, the primary contributing sources being fishing (45%) and the public (34%). A study by Mugilarasan et al. (2021) regarding marine litter on 17 beaches along the Hooghly Estuary, a part of the Gangetic Delta (West Bengal), reported abundances ranging from 0.54 and 2.01 items/m^2 and weight ranging from 0.23 and 0.60 g/m^2. Litter abundance was higher during Monsoon than post-monsoon, and fishing-related litter accounted for 29.1% of the total number and 17.67% of the total weight of marine litter.

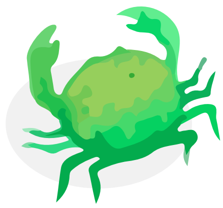
Marine debris on Marina Beach in Chennai (Tamil Nadu) was reported as a total of 6.87 items (171.8 counts/100m) of 46 different categories, weighing a total of 129.67 kg (3.24 kg/100 m) during March and April 2015 (Kumar et al., 2016).

Sri Lanka only has a few studies on marine litter compared to India. Various types of marine litter are found on the coast of Sri Lanka, including polystyrene, rubber, wood, metals, discarded medical and sanitary equipment, sewage-related debris, household plastic items, plastic drinking water bottles, paper and cardboard, household waste, tetra packs, ceramics, and batteries. Pollution related to the fishery sector includes polystyrene fish boxes, ropes, discarded buoys, and fibre glass pieces from boats (BOBLME, 2013).

1.2.2. Marine Litter in the Gulf of Mannar and Palk Bay

Marine debris has affected an area of 1,152 m^2 of coral reefs in the Gulf of Mannar (Patterson Edward et al., 2020). Abandoned fishing nets formed 43.17% of the total debris. In Rameswaram Island in the Gulf of Mannar, the range of microplastic abundance was 24 ± 9 to 96 ± 57 items/L in water and 55 ± 21 to 259 ± 88 items/kg in sediment. The coral reef site had a higher abundance than the seagrass and near-shore sites, with polyethylene being the predominant polymer (K. I. Jeyasanta et al., 2020). Studying eleven fishing beach sites in Palk Bay (Southeast India), Priyanka et al. (2022) recorded a total of 4,227 items of marine litter with an average density of 0.70 items/m^2. Most of the plastic marine debris (84.54%) came from fishing activities. The most common items included ropes, strings, fishing lines, equipment, floats, and buoys.

The studies on marine debris in Nallathanni Island in the Gulf of Mannar (Tamil Nadu) by Krishnakumar et al. (2018) reported a maximum of 82 items/m^2 on the coast's seaward side with nylon and polystyrene being the dominant polymers. I. Jeyasanta et al. (2020) reported mean concentrations of macroplastics (1.38 ± 78 to 6.16 ± 94 items/m^2), mesoplastics (2 ± 0.8 to 17 ± 0.11 items/m^2), and microplastics (25 ± 1.58 to 83 ± 49 items/m^2) in eight beaches of Tuticorin (Tamil Nadu) with polyethylene and polypropylene being the dominant polymers.



1.2.3. Microplastics in the Coastal Zones of India and Sri Lanka

Studying microplastics in 19 islands of GoM, Patterson et al. (2020) reported microplastic (MPs) abundance ranging from 28.4 to 126.6 items/L in water and 31.4 to 137.6 items/kg in sediment. Polyethylene (PE) and polypropylene (PP) were the most common polymers in both matrices. Sambandam et al. (2022) reported the mean abundance of MPs in the shelf region of India's central east coast to be 5.3×104 particles/km^2 in water and 209±99 particles/kg sediment. Riverine influx and fishing-related activities were the primary sources of MPs, and polyethylene and polypropylene were the predominant polymers. Perumal et al. (2023) collected 11,439 items of marine debris on seven beaches of Kanyakumari,Southern India. According to their findings, plastics were the most prevalent material (65.08%), and land-based sources the chief contributors (96.87%) of marine litter.

Dharmadasa et al. (2021) reported on the abundance of microplastics in the coastal waters and lagoon sediments in two marine protected areas in Sri Lanka; Bundala National Park (BNP) and Hikkaduwa Marine National Park (HMNP). The results of this study revealed that the abundance of microplastics was generally higher in coastal sediments and waters in HMNP (111±29 items/m^2 for sediments and 0.52±0.05 items/m^3 for water) than in the BNP (102±16 items/m^2 for sediments and 0.28±0.08 items/m^3 for water). The common microplastics were fragments of plastic material and polyethylene.

Another study on the abundance of microplastics in surface waters and beach sediment covering a distance of 91 km along the southern coast of Sri Lanka revealed that the beach sand contained 60% of microplastics while the surface waters contained 70%. The majority of the plastics were polyethylene and polypropylene, two of the most common synthetic material used for manufacturing fishing nets and ropes. Some sampling sites also contained polystyrene (Bimali Koongolla et al., 2018).

1.2.4. Fishing Gear Losses and Retrieval

India has 174,000 units of fishing gear in operation, of which 154,008 are gillnets/drift nets and 7,285 are traps (CMFRI, 2012). Research on ghost fishing was initiated in the country by ICAR-CIFT, Kochi, in 2018. Ghost gear retrieval attempts on the Enayam Coast (Tamil Nadu) were reported in March 2019. Scuba divers retrieved about 33 kg of ghost gear from 700 m^2 of the sea bottom. The lost gear recovered were polyamide (PA) monofilament gillnet panels (47.5 m^2), pieces of trawl cod ends (2.8 m^2), PA monofilament long lines (15.6 m), polypropylene ropes (8.3 m), damaged traps (fish and lobster traps), and squid jigs (3nos) (Thomas et al., 2019).

In a survey done with fisherfolk representing 325 vessels in Sri Lanka, in 2022, the respondents admitted that an average of 116 kg of ALDFG per vessel (Gallagher et al., 2023) with an estimated 22.6 tonnes of plastic fishing gear were lost to the marine environment during the previous year. The amount of ALDFG per year was recorded to be almost twice the amount of gear that was disposed of as waste. Gillnet fishing was recorded to have a high frequency of gear loss. The main drivers of these losses were oceanic and meteorological conditions, a lack of education and awareness amongst fishers, and poor waste management facilities both onboard and ashore. Additionally, gear conflict between Sri Lankan fishers and Indian bottom trawlers was highlighted by respondents in the northern parts of the country.

A study by Edwin et al. (2020) assessed the extent of gear lost in different sectors and ascertained the presence of any indigenous or institutional mechanism for gear marking prevalence. The survey conducted in Kerala's three major trawl fishing centers showed that no marking system was followed in trawl fisheries. However, colours or special knotting were used on the webbing part to identify the nets to conveniently sort and select gear among fisher groups. Fishers estimated an average loss of 500-1,200 kg of webbing for each vessel per year. In addition, accessories like floats, sinkers, iron chains, and otter boards were also abandoned in emergencies, such as rough weather. It was reported that 25% of fishers are forced to abandon gillnets yearly. The main parts abandoned included webbing, floats, and sinkers. Webbing caught in underwater obstacles such as shipwrecks, sunken fishing boats, rocks, wartime wreckage debris, etc., were usually abandoned. An average of 500-900 kg of webbing is discarded per vessel per year. All gillnetters surveyed in the study area reported a 38% loss in parts of gillnets per year. Fishers also reported that 37% of webbing was discarded in the sea.

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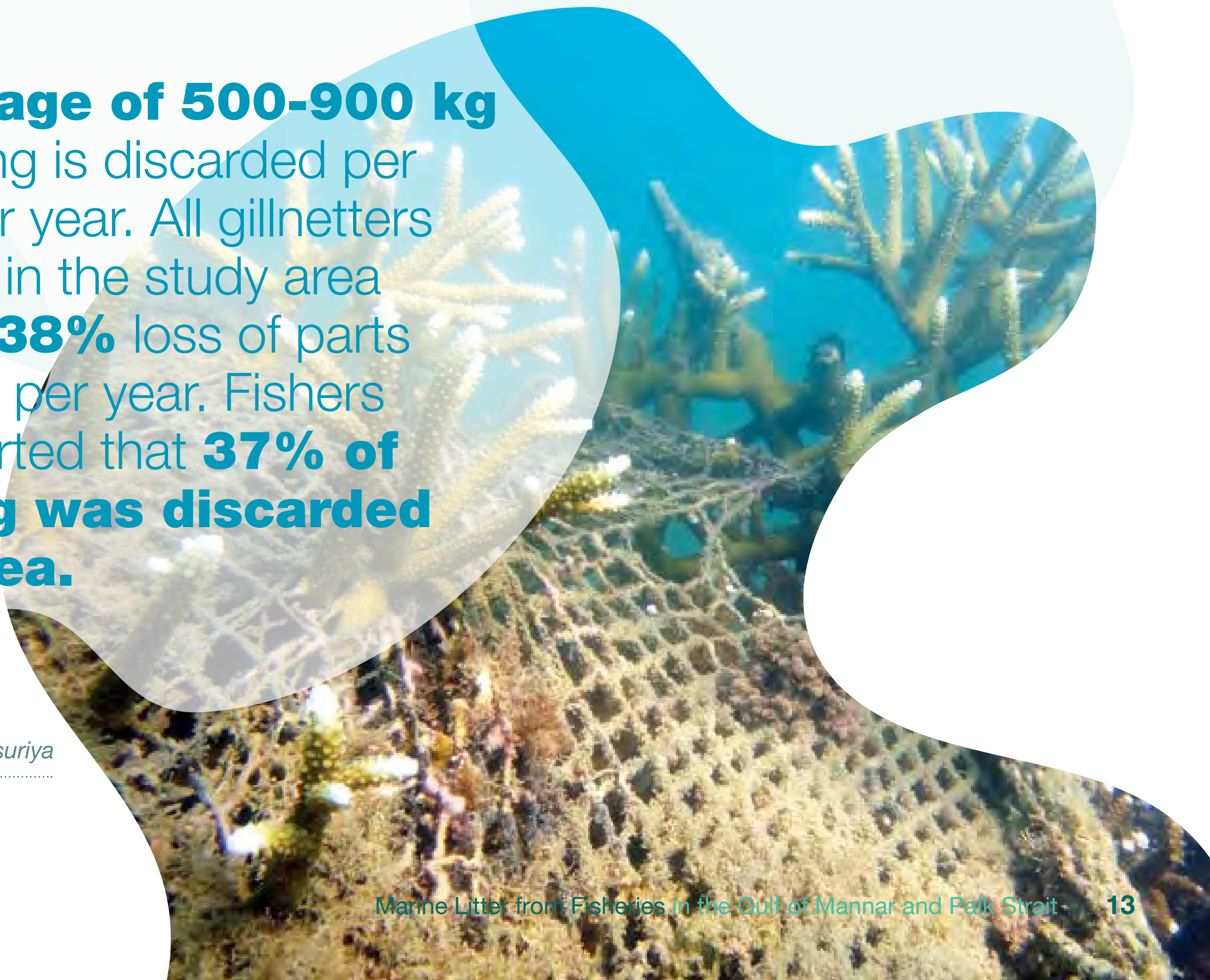

Photo: © Arjan Rajasuriya

Photo: © Dinithi Samarathunga

1.3. Value of Marine Resources in the Gulf of Mannar, Palk Bay and Palk Strait

The Gulf of Mannar and Palk Bay is located between the northwestern and northern coasts of Sri Lanka and the southeastern coast of India. The Gulf of Mannar has a shallow continental shelf and a deep-water area in the middle of the Gulf. Palk Bay and Palk Strait are very shallow, and the maximum depth in this area is about 15 m. The Gulf of Mannar and Palk Strait are separated by a series of small sand islands called the Adam's Bridge. The climate and ecology of this area are governed by the Northeast and Southwest Monsoons. The monsoons in the Northern Indian Ocean and the boundary currents, the East Indian coastal currents, and the West Indian coastal currents reverse seasonally due to the Southwest and Northeast Monsoons. Some of the strongest currents exceeding 1 ms^{-1} occur across the Adam's Bridge during the Northeast Monsoon (Swan, 1983). The Gulf of Mannar and the Palk Strait are high-biodiversity marine areas. Many sensitive marine ecosystems support extensive fisheries, including export-oriented fisheries such as shrimp, chanks, lobsters, and sea cucumbers. The maritime boundary between the two countries divides the Gulf of Mannar, Palk Bay, and Palk Strait. However, living marine resources are distributed on both sides, and larval distribution and recruitment originate from both ecosystems. The living resources in the Gulf of Mannar, Palk Bay, and Palk Strait are under increasing pressure due to the high degree of resource exploitation, destructive fishing methods, pollution, and climate change implications.

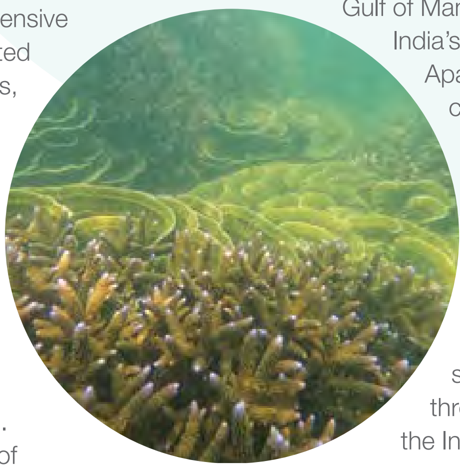

Photo: © Terney Pradeep

1.3.1. Ecology

The Gulf of Mannar is an ecologically important region that India and Sri Lanka share. The monsoons in the Northern Indian Ocean and the reversal of the boundary currents, the East Indian coastal current, and the West Indian coastal current have a direct bearing on species distribution in the Gulf of Mannar and Palk Bay and Palk Strait.

The shallow marine areas on both sides of the Gulf support important sensitive habitats: coral reefs, seagrass meadows, and mangroves. In both countries, coastal lagoons and extensive areas of salt marshes and mudflats are present. The shallow Palk Bay and Palk Strait contain extensive seagrass meadows, fringing coral reefs, and relatively large patches of mangroves.

The Indian part of the Gulf of Mannar, encompassing 10,500 sq.km, has been declared a marine biosphere reserve. The 21 uninhabited islands and surrounding fringing reefs have legal status as a marine national park (Kannaiyan & Venkataraman, 2008). The Indian part of the Gulf of Mannar is considered one of India's four major coral reef areas. Apart from the island reefs, patch coral reefs are widespread between Rameswaram and Kanyakumari in the Indian part and also in the coastal waters of Sri Lanka. Similarly, resources such as seagrass beds, mangroves, oyster beds, seaweed stretches, etc., are available throughout the Gulf of Mannar in the Indian and Sri Lankan parts.

The coastal waters on the Sri Lankan side contain the largest shallow-water coral reefs in the country, surrounded by extensive seagrass meadows (Dayaratne et al., 1997; Weerakoon et al., 2020; Weerakoon et al., 2018). The salt marshes and mudflats surrounding the Gulf of Mannar and Palk Bay are important feeding grounds for avifauna. This area is one of two major flyways for migratory birds from the Asian landmass to Sri Lanka during the winter period of the Northern Hemisphere (Weerakoon et al., 2020).


Photo: © Dinithi Samarathunga

Certain fishing methods such as trap fishing, shore seine, mechanized trawling, spearfishing, and purse seine **endanger the biological resources in the Indian side of the Gulf of Mannar**.


Photo: © Chanaka Sooriyabandara

1.3.2. Biodiversity

The entire Gulf of Mannar should be considered a single ecosystem due to the connectivity of ecosystems across the Gulf. Similarly, the Palk Bay and Palk Strait also have high connectivity, and many species are shared as there is larval dispersal on both sides of the Gulf of Mannar and a high exchange of larvae from the Gulf of Mannar to the Palk Bay during the Southwest Monsoon and a reversal of this exchange during the Northeast Monsoon. Comparatively, the marine biodiversity in the Gulf of Mannar is richer than in the Palk Bay and Palk Strait. A total of 4,223 species have been reported so far in the Indian part of the Gulf of Mannar, which include 15 species of seagrasses, 181 species of seaweeds, 11 species of mangroves, 117 species of hard corals, 856 species of molluscs, and 1,147 species of finfish (Balaji et al., 2012). The availability of important marine habitats supports the survival of endangered animals, such as marine mammals and sea turtles, in the Gulf of Mannar and Palk Bay.

Compared to the number of scientific studies done on the Indian side of the Gulf, the number of similar studies done about the Gulf of Mannar on the Sri Lankan side is very low. However, the biodiversity on the Sri Lankan side is also high. Among the major categories are 11 species of seagrasses, 86 species of hard corals, 172 species of reef fish, six species of sea cucumbers, and five species of seaweeds (Weerakoon et al., 2020). A total of 8,041 ha of mangroves are present in the four districts of Puttalam, Mannar, Kilinochchi, and Jaffna that border the Gulf of Mannar, Palk Bay, and Palk Strait (Edirisinghe et al., 2012). Thirteen true mangrove species and 18 mangrove associates have been reported from the Puttalam Lagoon and islands bordering the Gulf of Mannar alone (IUCN, 2012). Eleven species have been recorded from the Vidattaltivu Mangrove Stand in Palk Bay (Cooray & Marynathan, 2018). These mangrove areas, together with the connected ecosystems of seagrass meadows and coral reefs, are critically important for the productivity of coastal fisheries.

On the Sri Lankan side, the diversity of corals and reef fishes increases southwards in the Gulf of Mannar. Studies conducted in the Bar Reef Sanctuary in the mid-1990s recorded more than 120 species of corals and over 200 species of reef fishes, excluding the semi-pelagic and pelagic species (Dayaratne et al., 1997). Similar to the Indian side, the dominant species of hard corals on the Sri Lankan side in the Gulf of Mannar belong to the families of Acroporidae, Faviidae, and Poritidae (Patterson et al., 2008; Rajasuriya A, 1998; Weerakoon et al., 2020).

Pearl banks occur on both sides of the Gulf of Mannar. Pearl oysters were harvested heavily in the 1920s and were a major source of income for local governments. Pearl fishery was famous until the mid-20th Century, but they are not harvested anymore. The Pearl banks of Sri Lanka were last surveyed in the 1980s. Pearl fishery on the Indian side of the Gulf of Mannar was discontinued in the 1960s due to the lack of commercially available quantities of pearl oysters (Pragasam & Sudhendradev, 1988). However, the sacred chank *Turbinella pyrum* is collected on the Indian side using the surface-supplied diving technique (Raj, 2015).

There are several species of marine mammals in the Gulf of Mannar and Palk Bay. However, the Gulf of Mannar has a higher diversity of marine mammals, including large whales, which are extremely rare or absent in the Palk Bay and Palk Strait, though occasional strandings have been recorded in the Palk Strait (De Silva, 1987).

Seasonally migrating marine mammals and the five species of sea turtles are present in the Indian waters of the Gulf of Mannar (ENVIS, 2015). The birds, sea turtles, and marine mammals are migratory, and hence the diversity of these animals is similar in the Indian and Sri Lankan sides of the Gulf of Mannar and Palk Bay. Several species of marine mammals have been reported on the Sri Lankan side, including the Blue whale (*Balaenoptera musculus*), Sperm whale (*Physeter macrocephalus*), Humpback whale (*Megaptera novaeangliae*), Minke whale (*Balaenoptera acutorostrata*), Bryde's whale (*Balaenoptera edeni*) and a number of dolphins including the Orca (*Orcinus orca*), Spinner dolphin (*Stenella longirostris*), and Bottlenose dolphin (*Tursiops truncatus*). In addition, there are coastal dolphin species, especially those that enter coastal lagoons. Resident pods of the Indo-Pacific Humpback dolphin (*Sousa chinensis*) are present in the Puttalam Lagoon bordering the Gulf of Mannar. Due to recent taxonomic revisions, this species may be considered the Indian Ocean Humpback dolphin (*Sousa plumbea*). Nanayakkara et al. (2017) recorded the Finless porpoise (*Neophocaena phocaenoides*) in the Adam's Bridge area. The Dugong (D*ugong dugon*) is present on both sides of the Gulf of Mannar and Palk Bay due to extensive seagrass meadows. As this is a transboundary species, the population is shared by both countries. Its global status is 'vulnerable to extinction' according to the IUCN Red List of Threatened Species, and it is highly threatened in this region (Worldfish, 2018). To conserve the critically endangered marine mammal *Dugong dugon* on the Indian side of Palk Bay, a dugong conservation reserve was recently established. (Meyyanathan, 2022).

1.3.3. Human Impacts and Other Threats to Living Resources in the Gulf of Mannar

The Indian side of the Gulf of Mannar is heavily fished by artisanal fishers, commercial trawlers, and other fisheries that use a variety of fishing gear, including gill nets and bottom-set. The main threat to biodiversity is the overexploitation of resources over the past two to three decades (ENVIS, 2015). Certain fishing methods, such as trap fishing, shore seine, mechanized trawling, spearfishing, and purse seine, endanger the biological resources on the Indian side of the Gulf of Mannar (Patterson et al., 2012; Raj, 2015; Raj et al., 2017). After the discontinuation of pearl fishing, chank collection is carried out by about 2,000 people in the Tuticorin region of the Gulf of Mannar on the Indian side using surface-supplied diving (Raj, 2015). Similar overexploitation occurs on the Sri Lankan coastal waters, too, with many small-scale fishermen using fiberglass boats with outboard motors.

Photo: © Fergus Kennedy

Photo: © Vincent Kneefel - The Ocean Story

In addition to overexploitation, fishers use destructive fishing methods, including blast fishing. Using destructive fishing gear, especially bottom-set gill nets for rays and sharks seriously threatens the Dugong (Weerakoon et al., 2020). Dugongs are hunted on both sides of the Gulf. According to Jones (2007), there were many individuals in large groups of Dugongs in the early 20th Century, but hunting decimated these populations. Today, the Dugong is highly threatened in the Gulf of Mannar region (IUCN, 2018; Jones, 2007). Furthermore, it is to be noted that sea cucumbers are not allowed to be collected on the Indian side, whereas it is allowed on the Sri Lankan side.

Mangroves are being damaged and destroyed due to development activities, especially shrimp farming. The main types of destructive fishing methods include blast fishing, netting on reefs, bottom trawling, push and pull nets on seagrass meadows, trammel nets, and bottom-set gillnets (ENVIS, 2015; Weerakoon et al., 2020).

Coral reefs in the Gulf of Mannar, Palk Bay, and Palk Strait have been severely damaged due to repeated coral bleaching events since 1998 (Patterson et al., 2018; Raj et al., 2021; Rajasuriya et al., 2002; Tamelander, 2008) (Edward et al., 2015). Severe coral mortalities were recorded in the summers of 2010 and 2016, which reduced the coral cover significantly on the Indian side (Patterson et al., 2012; Raj et al., 2021). Space competition, algal blooms, and invasion of exotic algal used for commercial purposes have also been reported to cause damage to the coral reefs on the Indian side (Arasamuthu et al., 2023; Patterson et al., 2018; Patterson et al., 2012; Raj et al., 2021; Raj et al., 2020) (Edward et al. 2009, 2015).

The recovery of corals has been variable, and it continues to be affected by severe fishing pressure and destructive fishing practices.

Water pollution due to sewage and industrial discharge, along with the shipping and fisheries industries, is a concern on the Indian side (Patterson Edward et al., 2021). The threat posed by non-biodegradable materials, especially plastic items, including fishing gear, is serious. Discarded nets and other items used by the fisheries industry significantly threaten marine biodiversity (Patterson Edward et al., 2020). In addition to ALDFG, the Northern Indian Ocean receives large amounts of plastic from several rivers. The Northern Indian Ocean lacks a subtropical offshore gyre. Therefore, most of the floating plastic debris may end up on the coasts of the countries bordering the Northern Indian Ocean (Pattiaratchi et al., 2022).

1.3.4. Protected Areas in the Gulf of Mannar and Palk Bay

The Gulf of Mannar drew the attention of scientists, conservationists, and authorities concerned about its rich biodiversity and the threats posed by increasing resource exploitation. Recognizing the threats faced by the valuable resources, the Government of India declared an area of 10,500 sq.km as a Marine Biosphere Reserve in 1989, and the Man and Biosphere (MAB) programme of UNESCO recognized this declaration in 2001. In order to protect the biodiversity hotspot around the 21 uninhabited

Photos: © Terney Pradeep Kumara

Coral reefs in the Gulf of Mannar, Palk Bay and Palk Strait **have been severely damaged due to repeated coral bleaching events since 1998**

Photo: © Arjan Rajasuriya

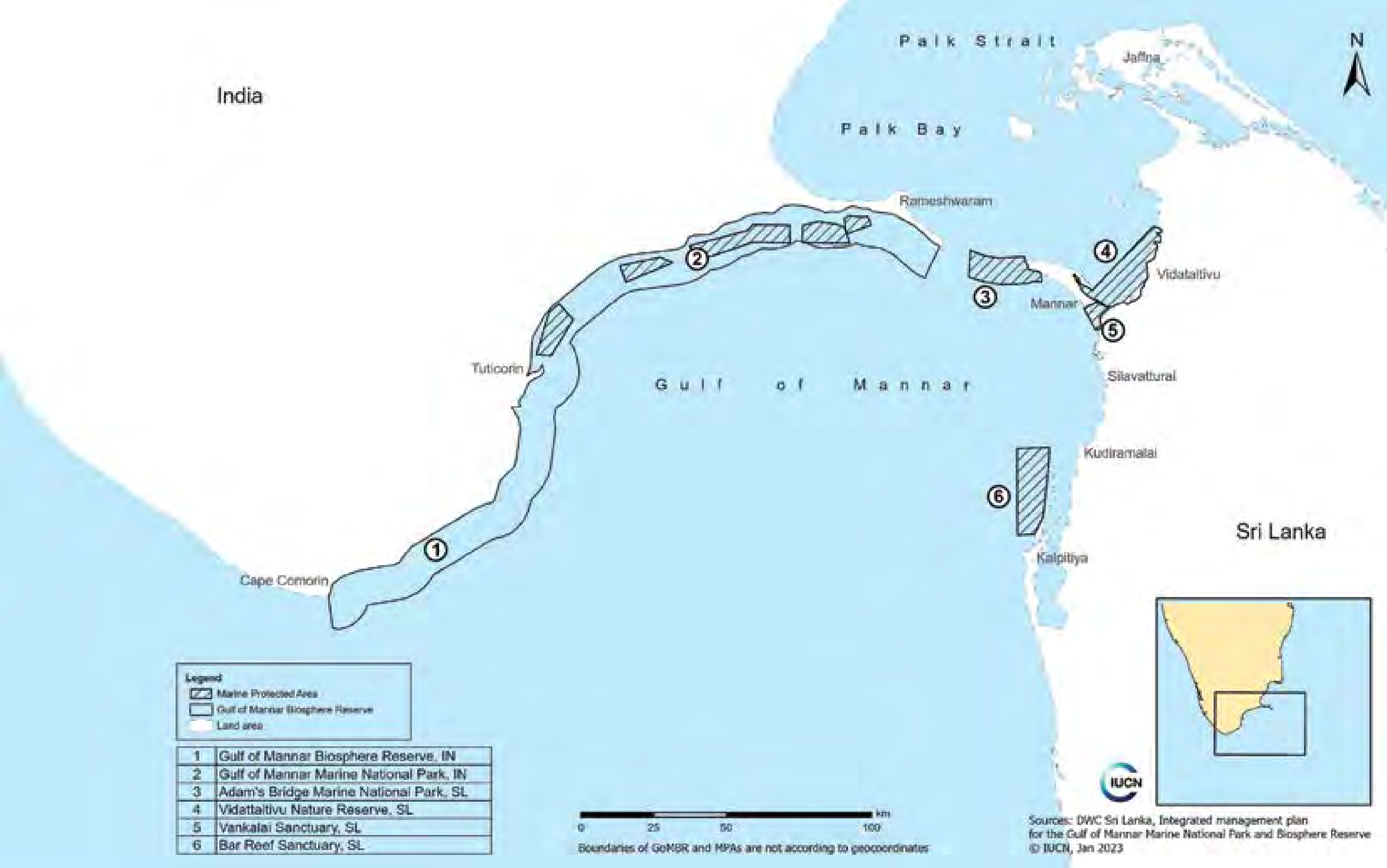

Figure 1. *Marine protected areas (MPAs) in the Gulf of Mannar and Palk Strait and the Gulf of Mannar Biosphere Reserve (GoMBR). Source: IUCN, Jan 2023.*

islands, a 560 sq.km core area was declared as a Marine National Park in 1986 by the Government of Tamil Nadu. The coastal waters of Thanjavur and Pudukkotai districts in Palk Bay, covering 448.34 sq.km, were declared in 2022 as India's first dedicated Dugong Conservation Reserve.

There are three marine protected areas within the Gulf of Mannar and Palk Bay on the Sri Lankan Side. They are the Bar Reef Sanctuary (306.7 sq.km), Vidattaltivu Nature Reserve (291.8 sq.km), and the Adam's Bridge Marine National Park (189.9 sq.km). Three additional protected areas have been identified to protect the Dugong, both in the Gulf of Mannar and Palk Bay. All marine protected areas are declared under the Fauna and Flora Protection Ordinance of the Department of Wildlife Conservation.

1.3.5. Protected Species

On the Indian side, several marine species have been brought under the Wildlife Protection Act 1972 to stop commercial trade. All marine mammals, five species of turtles, scleractinian corals, gorgonians, and several species of sponges, molluscs, and fishes, are protected under this Act. All marine mammals and sea turtles are protected in India and Sri Lanka, covering both sides of the Gulf of Mannar, Palk Bay, and Palk Strait. However, Dugongs are killed occasionally by fishers of both countries. In addition, dolphins are occasionally trapped in purse seines in Sri Lanka. Sri Lanka has protected all hard and soft corals as well as several species of molluscs under the Fauna and Flora Protection Ordinance. Three species of Thresher sharks, the Whale shark and the Oceanic Whitetip shark, have been protected under the Fisheries Act.

1.4. Regulation and Governance of Fisheries and Pollution

Photo: © Dinithi Samarathunga

1.4.1. International and Regional Governance

This section briefly outlines the main international instruments addressing marine pollution and abandoned, lost, or otherwise discarded fishing gear (ALDFG) from fisheries (Hodgson, 2022; Raubenheimer et al., 2017).[8] The UN Convention on the Law of the Sea (UNCLOS) is the public international law instrument that sets out the *basic rules and principles* that bind States in their international relations concerning ocean governance.[9] UNCLOS is, therefore, the general legal framework within which *all activities* at sea must be carried out. Sri Lanka and India have both ratified UNCLOS. One key element of the UNCLOS framework is the establishment of maritime borders by coastal states, including exclusive economic zones (EEZs). Ocean spaces are therefore divided into areas under *national jurisdiction* and beyond national jurisdiction, also called the *high seas*. UNCLOS sets out numerous rights and duties of the parties to the Convention in areas under national jurisdiction and the high seas. There are, for example, general obligations to *protect and preserve* the marine environment in Part XII, Section 5 of UNCLOS; see especially article 211 concerning pollution from vessels at a general level.

1.4.1.1. Pollution-Oriented Global Instruments

There are numerous pollution-oriented global instruments adopted under the UNCLOS framework.[10] The International Convention for the Prevention of Pollution from Ships (MARPOL) Annex V can be highlighted as both Sri Lanka and India have ratified it. MARPOL is the principal convention of the International Maritime Organization (IMO), the specialized UN agency for international shipping. Annex V contains complex regulations (including prohibitions and exceptions) to prevent pollution from ships. Hodgson (2022) underlines that Annex V is an important step forward in preventing ALDFG as it is the only binding legal instrument of the general application under international law that addresses the issues. However, it is of limited scope in relation to fishing vessels as it does not provide a realistic enforcement mechanism (Hodgson, 2022). In 2018, the IMO Marine Environment Protection Committee (MEPC) adopted a global action plan that further specified regulations under Annex V and introduced new supporting measures to reduce marine plastic litter from ships, including promoting the reporting of the loss of fishing gear, considering making the marking of fishing gear mandatory, facilitating the delivery of retrieved fishing gear to shore facilities and strengthening international cooperation.[11]

[8] Important instruments not addressed in this section are the Convention of Biological Diversity (CBD), the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (the London Convention/London Protocol) and regional frameworks such as for example the OSPAR Convention.

[9] See more in Churchill, R. R., & Lowe, A. V. (1999). The Law of the Sea (3 ed.). Juris Publishing, Manchester University Press. https://doi.org/10.1017/S1355770X02230120

[10] See the doctoral dissertation Confronting the Global Plastics Problem Threatening the Marine Environment – A Framework and Elements for an International Legal Response, by Linda Finska at the UiT The Arctic University of Tromsø (2021), for a through and recent study of the legal responses to the global plastics problem and relevant literature in that regard. https://munin.uit.no/bitstream/handle/10037/23741/thesis.pdf?sequence=2&isAllowed=y

[11] Resolution MEPC.310(73) adopted on 26. October 2018: https://wwwcdn.imo.org/localresources/en/MediaCentre/HotTopics/Documents/IMO%20marine%20litter%20action%20plan%20MEPC%2073-19-Add-1.pdf

Looking ahead, developments in international regulation of marine litter, in general, will likely be further established. In March 2022, the United Nations Environment Assembly (UNEA) signed a resolution to adopt a legally binding treaty against plastic pollution by 2024.[12] The inclusion of plastic pollution from sea-based sources is likely, from the authors' perspective, deeming the large volume of scientific evidence pointing to its significance.

1.4.1.2. Extended Producer Responsibility Schemes for Fishing Gear and Port Reception Facilities

Extended Producer Responsibility (EPR) is a concept already implemented on a range of other products, such as electronics (e.g. European WEEE Directive 2002/96/EU), batteries (European Battery Directive 2006/66/EC), packaging (European packaging Directive 94/62/EC),[13] and more, in a variety of national states world-wide. The general concept of EPR makes the producer of the targeted product responsible for financing the end-of-life-cost, while providing incentives to prevent waste at the source and to design products that are recyclable or reusable. EPR schemes commonly include take-back and recycling of the targeted product, with producers covering the costs of collection, transport, treatment, as well as awareness raising preventative measures. Common mechanisms of EPR schemes include regular reporting of product volumes put on market, financial guarantees and registration mechanisms. Product design to facilitate dismantling, re-use and recycling is often built into EPR regulations, as well as product marking and standardizing information to end-users and treatment facilities.

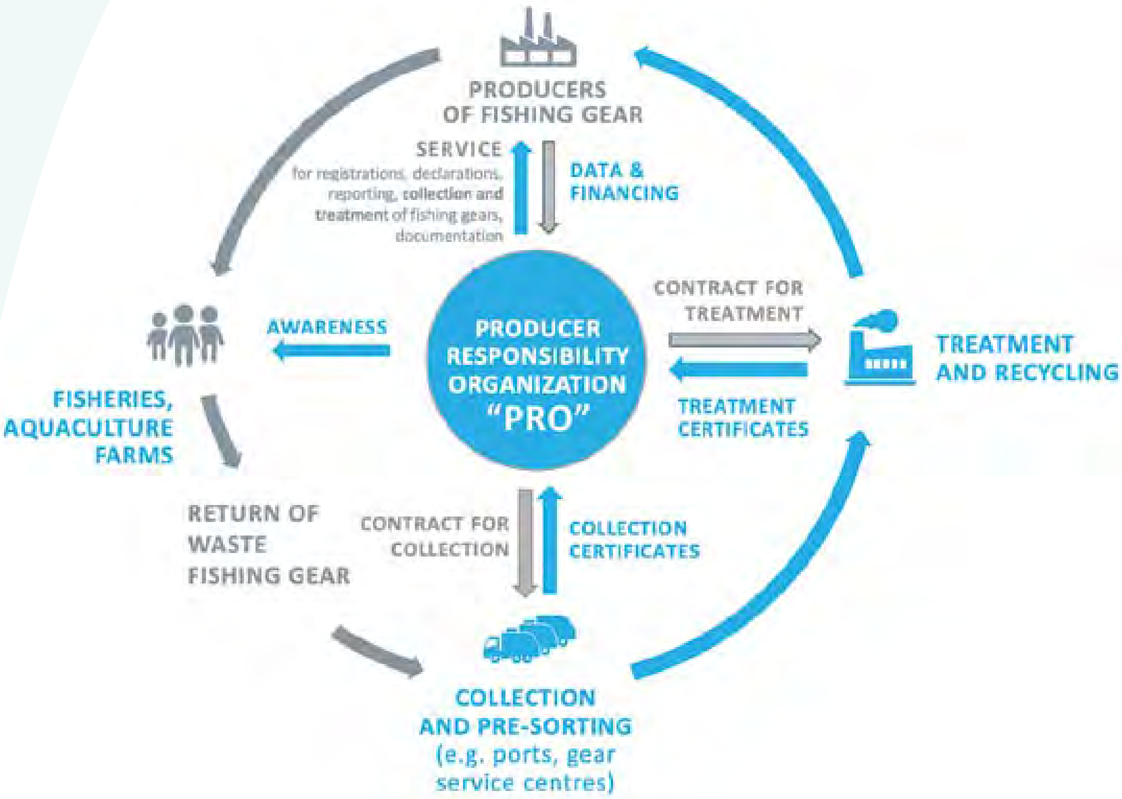

Figure 2. *A conceptual visualization of an EPR scheme for fishing gear. Source: Landbell Group*[14]

[12] UNEP, 2022: https://www.unep.org/news-and-stories/story/what-you-need-know-about-plastic-pollution-resolution

[13] E.g., European WEEE Directive 2002/96/EU for electronics, European Battery Directive 2006/66/EC, European packaging Directive 94/62/EC

[14] Presentation by Aneta Zych, global take-back solitions manager, Lanbell Group. Available from: https://webgate.ec.europa.eu/maritimeforum/en/system/files/landbell_aneta_zych_epr_schemes.pdf

The EU's Single Use Plastic Directive came into effect in 2019, which requires EU member states to launch EPR schemes for plastic waste from fishing and aquaculture by January 1, 2025, including national collection targets. Sweden, Austria, and Estonia were among the first EU countries to transpose the EU directive into their national legislation. The effect of such a scheme with regards to preventing ALDFG is currently not proven, and there is currently no (EPR) scheme in any other state outside of the EU that covers plastic waste from fisheries.

As a complement to the SUP Directive, the EU Port Reception Facilities Directive of 2019[15] sets out additional requirements for ships to report on waste storage and production and for ports to provide sufficient waste reception facilities. This updated directive is intended to be harmonized with the MARPOL convention on pollution from ships. The legislation is to be implemented by 2023 in the national jurisdictions of the EU member states. The directive is of relevance as an important reference for legislators in India and Sri Lanka in terms of its scope and intended purpose of improved waste management from ships and in ports.

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1.4.1.3. Regulation of Marine Resources and Ghost Fishing

For the conservation and management of *wild-living marine resources* by a coastal state in its EEZ and fishing by states in the EEZ of another coastal state, UNCLOS Part V is paramount. A coastal state has several sovereign rights in its EEZ, including the right to explore, exploit, conserve, and manage natural resources; see more in article 56. On the other hand, articles 61 and 62 set out duties for the conservation and utilization of the living resources in the EEZ, including determining allowable catches, building on the best scientific evidence, and establishing conservation and management measures so that the living resources are not endangered by over-exploitation. Although the obligations are generally articulated, they imply that consideration to harvest practices and gear use (and design) that do not threaten resources, for example ghost-fishing, must be given due consideration when developing and implementing regulations at the national level.

More specific rules on environmentally sustainable fishing practices are found in *non-binding* instruments developed by the Food and Agricultural Organization (FAO), including the FAO Code of Conduct for Responsible Fisheries (the Code). FAO is a specialized UN agency that leads international efforts to defeat hunger. Explicit references to ALDFG are set out in sections 7.2.2. and 7.2.6 of the Code that encourage states to take "appropriate measures to minimize waste, discards, catch by lost or abandoned gear." Other relevant guidelines from FAO are found in the International Guidelines on Bycatch Management and Reduction of Discards from 2011 and the Voluntary Guidelines on the Marking of Fishing Gear (VGMFG) from 2018.[16]

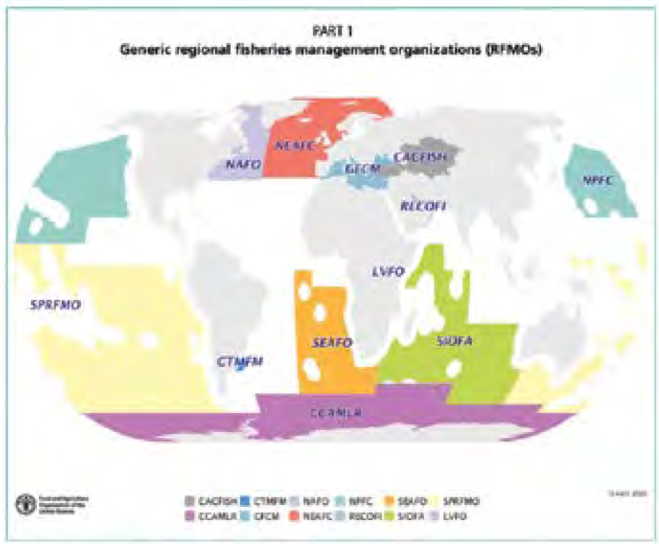
For the conservation and management of wild-living resources on the *high seas*, UNCLOS Part VII, Section 2, sets out the rights and duties of the parties to the Convention. More specific rules for international co-operation on the high seas, *cross-jurisdictionally* and to some extent in areas under national jurisdiction, including management of *straddling stocks* and *highly migratory species*, are laid down in the UN Fish Stock Agreement

[15] Directive (EU) 2019/883
[16] See more on the FAO instruments in FAO (2022) chapter 3.2.

(UNFSA) from 1995. Sri Lanka and India have both ratified UNFSA. Several general principles for the conservation of straddling fish stocks and highly migratory fish stocks are set out in Article 5, including a duty to minimize waste, discards, and catch by *lost and abandoned gear* (d) and to protect biodiversity in the marine environment (g).

Although states can cooperate directly (bi- or multilaterally), an essential mechanism for regional cooperation under UNFSA Part III is the establishment of the Regional Fisheries Management Organization (RFMOs). There are two types of RFMOs. The first is "General RFMOs," which have a broad mandate to adopt legally binding conservation and management measures to all fishery resources that are not explicitly excluded from their jurisdiction. The other is "Species-Specific RFMOs," established to explicitly manage fisheries for specific species (like tuna and tuna-like species), which have a distinct nature that makes it more appropriate to manage them through separate organizations.

Sri Lanka and India are parties to the Indian Ocean Tuna Commission (IOTC); see the geographical area of IOTC in Figure 3 b. There is no general RFMO that is competent to regulate living marine resources in the Northern Indian Ocean.[17] IOTC has adopted some measures to address ALDFG for the species under its jurisdiction,[18] including improving the design of drifting fish aggregating devices (dFADs) to reduce the incidences of entanglement of marine turtles, promoting the use of biodegradable materials (Resolution 12/04 adopted in 2012), and annual limits of dFADs (Resolution 15/08, superseded by Resolution 19/02).[19] Adopted measures in RFMOs must be implemented and translated into appropriate actions at the country and regional levels. Lastly, UNFSA Part VII sets out and recognizes the special requirements of developing states in relation to the dependency on living marine resources concerning subsistence, small-scale and artisanal fisheries, women fisher workers, and indigenous people.



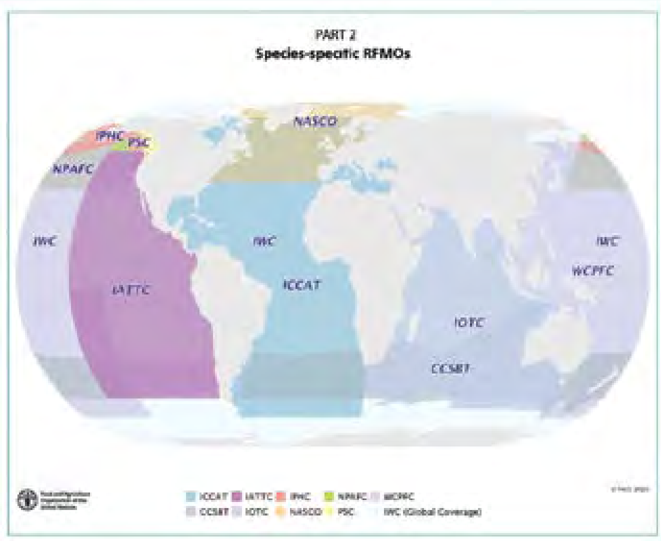


Figure 3: a & b. General and Tuna (Species-specific) RFMOS. Source: Løbach et al. (2020)

[17] There is at the same time regional cooperation on fisheries management in the Bay of Bengal Programme (https://bobpigo.org/html_site/aboutbobp.htm), which is a regional fishery advisory body (inter-governmental organization), and in the inter-governmental organization Indian Ocean Rim Association (IORA - https://www.iora.int/en). Sri Lanka and India are both members of these organizations.

[18] Species under the management mandate of IOTC are listed here: https://www.iotc.org/about-iotc/competence

[19] See more on the measures in an IOTC information paper from 2021 (IOTC-2021-WGFAD02-INF12): https://www.iotc.org/documents/ghost-fishing-mortality-and-habitat-damage-ald-drifting-fads

* CCAMLR is a conservation organization with a mandate to manage fisheries within its area of competence.

** NPFC: North Pacific Fisheries Commission; SPRFMO: South Pacific Regional Fisheries Management Organisation; NAFO: Northwest Atlantic Fisheries Organization; NEAFC: North East Atlantic Fisheries Commission; GFCM: General Fisheries Commission for the Mediterranean; SEAFO: South East Atlantic Fisheries Organisation; SIOFA: Southern Indian Ocean Fisheries Agreement; and CCAMLR: Commission for the Conservation of Antarctic Marine Living Resources. WECAFC (Western Central Atlantic Fishery Commission) and CECAF (Fishery Committee for the Eastern Central Atlantic) are regional advisory bodies that cover fishery resources in the ABNJ.

Figure 4. *General RFMOs, areas under national jurisdiction (white) and high seas not under jurisdiction (blue areas). Source: Løbach et al (2020)*

1.4.2. Governance in India and Sri Lanka

India and Sri Lanka have several laws and regulations to protect the marine environment and species from harmful human activities. They are mainly coastal development, fisheries, and land-based pollution. However, both countries lack adequate laws or regulations regarding ALDFG and plastic waste from fisheries. Sri Lanka recently introduced a mechanism on plastic water bottles used in multi-day fishing craft.

Laws and regulations regarding fisheries and marine pollution in India may vary among different states. In Sri Lanka, they are under the central government and there are no variations among different districts. However, all the laws and regulations in both countries focus on protecting the environment and safeguarding living marine resources. Implementation of laws and regulations remains challenging in both countries due to the large number of fishermen involved in multispecies, multi-gear tropical fisheries, and the dearth of resources for effective management.

1.4.2.1. Fishing Gear

The Government of India has legislation on marine fisheries in the different states of India, with Tamil Nadu being subject to regulation of areas permitted to different types of boats and fisheries.[20] There are specific regulations on deep sea fishing.[21] Guidelines for sustainable small-

[20] The Indian Fisheries Act, No. IV of 1897, Government of India

[21] New Deep Sea Fishing Policy, 1991; The Marine Fishing Policy, 2004

scale marine gillnet fishing are published by the Central Institute of Fisheries Technology (CIFT), including descriptions of minimum mesh size and maximum gear dimensions per specific fishery type. The guidelines also cover measures of rigging gear to reduce incidental and non-targeted catches, as well as recommendations on how to reduce the risk of losing gear, and incentives for bringing damaged and retrieved debris to shore. There are various free training programmes launched by the central and state governments and implemented by the Department of Fisheries for the benefit of the fisher community of Tamil Nadu. The Government of India and Government of Tamil Nadu provide all the necessary support to the trainees, who can benefit from these programmes.[22]

Sri Lanka does not differentiate the operation of various fishing gear among types of fishing craft. As in India, Sri Lanka has regulations for different gear types, their mesh sizes, and the fishing operations such as purse seine regulations (DFAR 2015). The regulations do not cover guidelines on gear rigging to reduce bycatch, and no incentives are offered for bringing discarded gear and other debris to shore. There are no training programmes for fishermen on responsible use of fishing gear and their operations.

1.4.2.2. Fishing Gear Marking

Fishing gear marking is an important mechanism for regulating legal and illegal fisheries. If a gear is well-marked and has sufficient identification, it can be linked to vessel or gear registers. This is a useful tool for enforcement agencies checking on gear sets in certain areas (FAO, 2016). The basic purpose of gear marking is to determine ownership and to trace back information regarding the gear. It also enables the state to take effective action against defaulters in case of Abandoned, Lost, and Discarded Fishing Gear (ALDFG). Presently there are regulations for marking gear in India and Sri Lanka. However, a clear-cut policy on gear marking in India is lacking. Due to the vast diversity of the gear used in India, there are several challenges with regard to gear marking (Edwin et al., 2020). Some reasons for the less priority accorded to this issue so far may be due to India having characteristic multi-species, multi-gear tropical fisheries and a long coastline with a multiplicity of harbours/ landing centers (>1500). It has been estimated that 0.5-0.6 million fishing gear are operated in the marine sector (Edwin et al., 2020). Fabrication of gear is done by artisans locally, and there is no system of registration of locally constructed gear.

Photos: © IUCN

[22] Department of Fisheries, India: https://www.fisheries.tn.gov.in/includes/assets/pdf/Start-A-Business/Free_Training.pdf

Like in India, Sri Lanka has multi-species and multi-gear fishing operations. All fishers must apply for an annual license for fishing, listing the type of fishing craft, gear, and other details such as types of targeted species. Although this information must be listed when applying for fishing permits, there is no monitoring in the field to ensure that individual fishers adhere to these conditions listed in their license.

Should gear marking be introduced in India, Edwin et al. (2020) suggest a Unique Identification Code that can be machine read for each gear that is being operated from registered fishing vessels, marking the gear while providing encrypted information on the gear used. The implementation in India would require

- awareness creation among fishermen on the international requirements and the use of gear marking system;
- providing gear manufacturers with clear guidelines on marking gear;
- making it mandatory that all registered fishing vessels should operate only marked gear;
- documenting the specification details of each gear available onboard a vessel; and
- details of the operation.

At the same time, considering the large section of artisanal fishers in India, factoring marking costs into the gear cost will be difficult for the fishers to bear. It would be difficult to prevent defaulters without stringent monitoring. However, in contrast to India, the Department of Fisheries and Aquatic Resources in Sri Lanka has introduced a regulation to mark fishing gear (GoSL, 2015).

1.4.2.3. Fisheries Management

The fisheries departments of the various states in India have multiple functions, from registering vessels to implementing social schemes, and the manpower is relatively stretched with work to be given additional responsibilities (Edwin et al. 2020).

Each coastal district in Sri Lanka has a Department of Fisheries and Aquatic Resources (DFAR) branch and is staffed by an Assistant Director of Fisheries along with several Fisheries Officers. Responsibilities include registering fishing operations, including craft and gear, and implementing welfare schemes for fishermen (GoSL, 2005; DFAR, 2011). As in India, inadequacies in staff and facilities, including patrol craft and trained manpower, affect the effectiveness of the implementation of fisheries regulations in Sri Lanka.

There is a lack of information related to ALDFG in Sri Lanka compared to India. Fishing nets entangled on shipwrecks and dive sites are removed occasionally by the sport diving community. The Department of Fisheries and Aquatic Resources and the Ministry of Fisheries and Aquatic Resources Development has conducted several clean-up operations at several fishery harbours in the country to remove discarded fishing gear and other plastic items, including fiberglass pieces, from damaged boats.

Photo: © R. L. Laju

The Ministry of Fisheries and Aquatic Resources Development (MFARD) in Sri Lanka introduced a regulation in 2006 prohibiting the import, distribution, and use of monofilament nets for fishing activities under the Gazette No. 1454/33. This was done based on scientific reports that monofilament nets have a high catching efficiency, which is detrimental to the health of fish stocks (GoSL, 2006). Other reasons are entanglement on a substrate such as coral and trapping and killing endangered species, including sea turtles and the Dugong. In addition, the MFARD has prohibited the use of large-scale gillnets in the Indian Ocean since March 2021 by Sri Lankan fishers considering the negative impacts on the environment. Following the Indian Ocean Tuna Commission (IOTC) regulations, a circular has been issued by DFAR to limit the length of gillnets to 2.5 km from January 1, 2022 (DFAR Circular, 2021). Discussions are being held to explore the possibility of reducing gillnets' use and gradually replacing them with longlines.

Managing multispecies fisheries in extensive marine areas is a major challenge for both countries. Violations of fisheries laws and regulations are occuring regularly due to inadequate management by the authorities and lack of compliance by the fishers. Due to this situation, there is Illegal, Unreported, and Unregulated (IUU) fishing in the Gulf of Mannar, Palk Bay, and Palk Strait (Kavindra & Kularatne, 2020; Scholtens et al., 2012; Sosai, 2015). Richardson (2021) reports that IUU fishing contributes significantly to ALDFG.

1.4.2.4. Marine Pollution Prevention

India and Sri Lanka have laws to prevent pollution in terrestrial and aquatic environments. Regarding port reception facilities for waste generated at sea, the Government of India (GoI) applies Section 356 of the Merchant Shipping Act (1958) to fulfill its obligations to international regulations on pollution prevention as set out in the MARPOL. Further, as a mandatory requirement of the IMO III Code (Implementation of IMO Instruments), the Indian Maritime Administration should be audited by auditors from the IMO for the year 2021-2022. The audit is to determine the extent to which India has given its fullest cooperation to fulfill the obligations and responsibilities contained in all International Conventions of IMO, to which the country is a signatory. Availability and adequacy of Port Reception Facilities under MARPOL is a key area of concern for IMO, as seen from the III audit reports of other Maritime Administrations. In order to fulfill the responsibility for effective supervision and control of the provisions of MARPOL, it was decided that all major and non-major ports shall be assessed every year with effect from April 1, 2018, for the availability and adequacy of port reception facilities, including the methodology on the verification of onshore treatment, storage and disposal management of waste received from ships in compliance with the provisions of the Water (Prevention and Control of Pollution) Act, 1974 and the Air (Prevention and Control of Pollution) Act, 1981 and rules made thereunder and as amended from time to time including the "Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016," framed under Environment (Protection) Act, 1986, published by the Ministry of Environment, Forest and Climate Change.[23]

Both India and Sri Lanka have regulations on the use of plastic packaging. India has regulations under the Extended Producer Responsibility,[24] along with targets and minimum levels of recycling of plastic packaging waste.[25] Amendments to rules on plastic waste management were also implemented in 2021 covering a list of single-use plastic articles and commodities.[26]

Based on this regulation, the Tamil Nadu Government has banned single-use plastic (SUP). The Ministry of Environment in Sri Lanka has taken measures to reduce the use of SUP polythene or polythene products of less than 20 microns in thickness (EFL, 2020).

[23] Government of India: Standard Operating Procedure for Assessment of Adequacy of a Port Reception Facility (file nr ENG/PORT-28(1)/2016): https://www.dgshipping.gov.in/WriteReadData/UserFiles/file/SOP_Port_reception_eng_branch.pdf

[24] CG-DL-E-17022022-233568 DT: 16.2.2022

[25] CG-DL-E-071102021-230228 DT: 07.10.2021

[26] CG-DL-E-071102021-230228 DT: 07.10.2021

Ministry of Environment promotes the repair and reuse of plastic goods in the automobile and construction industries and to increase the present level of recycling, which is 4% of waste, to 15% by 2025. Presently 27% of PET bottles are recycled, and the target has been set for 100% by 2025 (Ministry of Environment, 2021). Following the Ministry of Environment guidelines, the DFAR has taken measures to limit single-use plastic bags (SUP) in the fishing industry.

Fishers in multi-day fishing craft in Sri Lanka use five-liter plastic water bottles on fishing trips and dump empty bottles at sea (BSL, 2017). In order to reduce marine pollution, the DFAR introduced a rule in 2019 prohibiting the use of plastic drinking water bottles of less than five liters in offshore fishing craft. It is also mandatory for fishers to inform the fishery harbour officials of the number of plastic bottles onboard and to bring back the same number of empty bottles after each trip (DFAR circular 2019). Presently, this rule is only applied to multi-day fishing craft operating through fishery harbours. However, there are large numbers of smaller craft operating from fish landing centers located around the country.

Marine pollution and microplastics are two of the main issues identified among a number of issues related to environmental pollution in Sri Lanka's National Action Plan on Plastic Waste Management (2021) as primary threats to human health and the environment; however, plastic pollution due to fishing activities has not been specifically addressed. A report by the Commonwealth Litter Programme (2021) has identified that manpower, technical capacity, and the necessary skills are lacking in the country and recommends bilateral and regional cooperation to manage marine litter (CLIP, 2021; Gallagher, 2022).

1.4.2.5. Community Participation

For the effective conservation and management of resources in the Gulf of Mannar, community participation has been encouraged since the establishment of the Marine National Park in 1986. All stakeholders, including research institutions and non-governmental organizations, have participated in implementing various projects funded by Union and State Governments and International agencies. The launching of the collaborative initiative of the Government of India, the Government of Tamil Nadu and the Global Environment Facility (GEF)-United Nations Development Programme (UNDP) on "*Conservation and Sustainable Utilization of Gulf of Mannar Biosphere Reserve's Coastal Biodiversity*" in 2002, brought the community together to take part in the conservation and management along with the authorities of the Gulf of Mannar Marine National Park (GOMMNP). The Gulf of Mannar Biosphere Reserve Trust (GoMBRT), a registered Trust of the Government of Tamil Nadu under the Chairmanship of the Chief Secretary to the Government of Tamil Nadu, was formed to ensure effective inter-sectoral coordination and mainstreaming of biodiversity conservation issues into the productive sector and policy development.

Photo: © SDMRI

Marine pollution and microplastics are two of the main issues identified among a number of issues related to environmental pollution in Sri Lanka's National Action Plan on Plastic Waste Management (2021) **as primary threats to human health and the environment; however, plastic pollution due to fishing activities has not been specifically addressed.**

Grass-root level community organizations like Village Marine Conservation and Eco-Development Committees (VMC and EDCs) with a mandate for linking conservation with livelihood improvements have been established in 252 villages/hamlets along the 160-km long coastal stretch from Rameswaram (Ramanathapuram District) to Periathalai (Tuticorin District). About 2,400 Self Help Groups (SHGs), mainly with women members, are functioning in the area in association with VMC and EDCs. The SHGs have been trained and supported with varying amounts of funds to start various alternate and income-generating livelihood activities, and the repayment of credits has been prompt. Various groups are pursuing as many as 52 types of activities (Melkani, 2012). The VMCs and EDCs continue to actively participate in the conservation and management activities with support from the Government of Tamil Nadu to date.

Several community participatory programmes have been held in Sri Lanka under different projects in the past to engage the coastal communities in resource management (Chandrasekara, 1996; Hikkaduwa SAMP 1996; CCD 2005a & b.). Co-management was introduced to selected fisheries communities in a project implemented by the National Aquatic Resources Research and Development Agency (NARA) (Long et al., 2010). However, community participation in fisheries co-management in Sri Lanka remains weak; furthermore, translating policy into practical fisheries management plans and their effective implementation have been major challenges to the DFAR, NARA, and the Ministry of Fisheries and Aquatic Resources Development (MFARD) (World Bank 2021).

1.4.2.6. Marine Protected Areas and Fisheries Management Areas

Considering the importance of coastal habitats like coral reefs, seagrass beds, mangroves, and associated biodiversity, the Government of Tamil Nadu established the Gulf of Mannar Marine National Park (GOMMNP) in 1986 under the provision of the Indian Wildlife (Protection) Act, 1972. The Park encompasses the 21 off-shore islands and the surrounding coral reef systems, covering an area of 560 sq.km and bordering the coastal districts of Ramanathapuram and Tuticorin. The GOMMNP is located within the Biosphere Reserve and forms the Core Zone of the Reserve, and the remaining 9,960 sq.km area makes the Buffer Zone. GOMMNP is a 'no go' and 'no take' zone, where fishing, tourism, and all other commercial activities are prohibited. The Chief Wildlife Warden, Tamil Nadu Forest Department, Government of Tamil Nadu, is responsible for the Gulf of Mannar Marine National Park's conservation, management, and enforcement.

The Gulf of Mannar Biosphere Reserve (GOMBR) was established in 1989 by the Government of India. It covers the entire 10,500 sq.km. The Indian part of the Gulf of Mannar area spreads along the 364.9 km coastline between Rameswaram Island and Kanyakumari, bordering the districts of Ramanathapuram, Tuticorin, Tirunelveli, and Kanyakumari. The Reserve's management activities involve the coastal villages within 10 km of the coastline. GOMBR obtained the recognition of UNESCO's (United Nations Educational, Scientific and Cultural Organization) MAB (Man and the Biosphere) Programme in 2001. The Director of GOMBR is responsible for the conservation and management of the Biosphere Reserve.

In Sri Lanka, all marine protected areas are established under the Fauna and Flora Protection Ordinance and are managed by the Department of Wildlife Conservation (DWC). Presently the DWC applies the same laws and regulations for terrestrial and marine protected areas leading to several problems in managing MPAs. There are three categories of MPAs, namely Marine National Parks, Nature Reserves, and Sanctuaries. Three marine protected areas (Bar Reef Sanctuary, Adam's Bridge National Park, and Vidattaltivu Nature Reserve) and one salt marsh protected area (Vankalai Sanctuary) are present in the Gulf of Mannar and Palk Bay, respectively (Figure 1).

In addition, Sri Lanka has three fisheries management areas (Northwestern, Southern, and Eastern). The Northwestern Fisheries Management Area includes the Gulf of Mannar of Sri Lanka from the Kalpitiya Peninsula to Talaimannar in Mannar Island (Weerakoon et al., 2018).

Photo: © Dinithi Samarathunga

2 The Fishing Fleet and Gear Used in the Study Area

In India and Sri Lanka, respectively, a number of authorities are responsible for matters relating to fisheries, as summarized in the table given below.

Table 1: Main government organizations involved in fisheries management and research.

India	Sri Lanka
Ministry of Fisheries, Animal Husbandry and Dairying	Ministry of Fisheries and Aquatic Resources Development (MFARD)
National Fisheries Development Board, Ministry of Agriculture, Planning commission of India	Department of Fisheries and Aquatic Resources (DFAR)
Coast Guard, Ministry of Defence	National Aquatic Resources Research and Development Agency (NARA)
Ministry of Environment and Forests	National Aquaculture Development Authority
Earth Commission, Ministry of Earth Sciences	

Different fishing gear types are used in the Gulf of Mannar and Palk Bay. Fishing gear and methods of use vary among coastal, lagoon, and offshore fisheries. The coastal fisheries target demersal and semi-pelagic species strongly associated with the bottom habitats, including coral reefs, seagrass meadows, and soft bottoms (sand and mud). The offshore fishery is mainly for pelagic species. The general types of fisheries, their gear usage, and details on typical fishing grounds have been summarized in Table 2.

Marine fisheries play an important role in the economies of India and Sri Lanka. There are eight coastal districts in India, from Kanyakumari to Nagapattinam and four coastal districts in Sri Lanka from Puttalam to Jaffna bordering the Gulf of Mannar and Palk Strait. Three hundred ninety-five (395) fishing villages were present in 2016 (CMFRI-DoF, 2020). The total fisher population in the eight districts were 609,674 within 150,241 families. The total number of active and part time fishers were 163,681 in 2016. A total of 28,070 motorised and non-motorized boats operates on the Indian side of the Gulf of Mannar and Palk Strait of which 4,682 conduct mechanized fishing operations while the rest consist of non-mechanized motorised boats and non-motorised boats. According to the fisheries census of 2016 there were 275,137 members in the fisheries cooperatives in the eight coastal districts (CMFRI-DoF, 2020).

There were 54,990 fishing households in the four coastal districts from Puttalam to Jaffna with a total fishing household population of 239,520 individuals in 2019. The total number of active fishermen stood at 65,400. There were 13,794 fishing crafts in six categories of which the majority (13,687) belong to the fiber reinforced plastic type (FRP boats). The total fish productivity was 117,630 Mt in 2019. The highest productivity was from Jaffna District (44,250 Mt) followed by districts of Puttalam (36,440 Mt), Mannar (25,270 Mt) and Kilinochchi (11,670 Mt). There are 370 fisheries community organisations with a total membership of 29,392 individuals in the four coastal districts (MFARD 2020).

Photo: © Dinithi Samarathunga

There are many types of fisheries that we need to consider, which all add ALDFG to the environment:

1. Large pelagic fisheries, mainly offshore in the seaward areas of Territorial waters and beyond;
2. Small pelagic fisheries, mainly within the Territorial waters;
3. Demersal and Lagoon fisheries, mainly in the Puttalam Lagoon and Palk Bay.

Table 2: Types of fishing gear used in the Gulf of Mannar and Palk Bay for edible fish and other marine species excluding the marine ornamental fish (Sources: (DFAR, 1995; Patterson Edward et al., 2020; Raj et al., 2015; Raj et al., 2017; Raj, P A, et al., 2021; Raju, 2000).

Types of fisheries	Types of gear	Fishing areas and other details	Target species and impacts on other species/habitats
Drift gillnet fishery	Large mesh drift gill nets	Coastal inshore and coastal offshore	Large demersal and semi-pelagic fish including rays, skates, and sharks. Also traps dugongs and sea turtles.
	Large mesh drift gill nets	Offshore	Pelagic species.
	Small mesh drift gill nets	Coastal inshore and coastal offshore	Anchovies, sardines, flying fish, Indian mackerels, frigate tuna and other small pelagic species.
Bottom-set gillnet fishery	Large mesh gillnets set on the bottom	Coastal inshore and coastal offshore	Large demersal rays, shovel nose rays, saw fish. This type of net traps and kill dugongs and sea turtles.
Longline fishery	Tuna longlines	Offshore (edge of continental shelf)	Pelagic species.
	Shark longline	Offshore	Pelagic and demersal.
	Oceanic/Deep water tuna longline	Offshore in the EEZ and high sea	Pelagic.
	Drift longline for billfish	Offshore in the EEZ and beyond	Pelagic.
	Bottom-set longline for large demersal fish	Coastal and offshore	Large demersal fish (sharks, groupers, etc.).
Handline fishery	Handline for large pelagic species	Offshore	Tuna, billfish, sharks, and other large pelagic species.
	Drift handline with live and dead bait	Coastal inshore and coastal offshore	Large and medium pelagic species.
	Handline for demersal fish	Coastal inshore and coastal offshore	Reef and reef associated fish species.
Pole and line fishery	Pole and line fishery	Coastal inshore and coastal offshore	Mainly targets skipjack tuna.
Trolling	Trolling with artificial / dead bait	Coastal inshore and coastal offshore	Pelagic and semi pelagic species.
Sport fishing (rarely practiced in the Gulf of Mannar and Palk Bay)	Angling / trolling with rod and reel or with palm tree branch rod. Operated from a boat or from the coast. Artificial or live bait	Coastal inshore and coastal offshore	Pelagic, semi-pelagic and demersal finfish.
Purse seine fishery	Purse seine	Coastal offshore and offshore	Legally to be operated from 7 miles (11 km) and beyond. (as per purse seine regulations of the Fisheries Act).
		Coastal inshore and coastal offshore	Mainly targeting semi pelagic and demersal fish. This is an extremely harmful net. It is operated with scuba diving.
	Legally to be operated from 7 miles (11 km) and beyond. (As per purse seine regulations under the Fisheries and Aquatic Resources Act 1996 of Sri Lanka)	Small and medium size pelagic and semi-pelagic species of fin fish	Used for small pelagic species, such as bonito, kawakawa, mackerel and other shoaling species.

Types of fisheries	Types of gear	Fishing areas and other details	Target species and impacts on other species/habitats
Beach Seine fishery	Large net used from the coast	Coastal inshore, operated where rocks and reefs are not present	Small semi-pelagic coastal finfish.
Shore seine	Large type of nets operated from inland shore and Island shores	Inshore areas in coastal and island beach	Demersal and semi-pelagic species. High physical damages to seagrasses and coral reef ecosystems. Over exploitation of benthic organisms.
Surrounding net fishery	Net similar to a gill net (small mesh) with two poles and dragged along the water's edge.	Coastal inshore	Operated from the beach by two fishermen.
Push net fishery	Triangle shaped net pushed along the seagrass meadows	Lagoons only	Mainly for shrimp in the lagoons. This fishing method is prohibited in Sri Lanka as it causes uprooting of seagrasses.
Cast net fishery	Cone shaped net operated by one person	Coastal inshore and lagoons.	Targets small shoals of inshore species such as mullets.
Fish trap (fish kraal) fishery	Large and medium fish	Coastal inshore. The trap is fixed to the seabed with poles and long guiding arm (leader) is present to guide the fish into the trap	The trap is a passive nonselective fishing gear that guide fish into the trap using the leader (also called the guide arm). This gear uses nets for the trap as well as the leader.
Fish trap	Large nylon fish traps	Operated mainly in the coral reef areas in shallow water to offshore waters in India	Severe live coral damage and high removal of parrot fishes. Abandoned plastic traps affects the benthic communities.
Fish aggregation device fishery	Tree branches and old pieces of fishing net tied into a bundle. Used primarily to attract squid and cuttlefish to lay eggs	Coastal inshore	Used primarily for squid and cuttlefish. Caught with hooks at night with the aid of a light.
Net fishery for edible molluscs	Net laid over seagrass and coral rubble areas to entangle carnivorous molluscs.	Coastal inshore	Highly damaging to the seagrasses and habitat. Very high bycatch of various species of invertebrates (starfish, molluscs and rare fish such as Cowfish).
Chank fishery	Skin-diving and Scuba diving in Sri Lanka and India. Surface air supplied diving in India	Inshore and offshore	High collection of gastropods and bivalves for ornamental purposes.
Spear fishing	Surface air supplied diving in India. Scuba and skin diving in Sri Lanka	Inshore and offshore	Threat to endangered fishes and commercially important fin fishes. Spearfishing is banned in Sri Lanka under the Fisheries and Aquatic Resources Act.
Bottom trawl net fishery	Bottom trawl nets used with mechanized craft	Coastal inshore and coastal offshore. In the coastal waters trawling is used mainly over sand/mud banks.	Main target species include shrimp and demersal fin fish. Trawling has been prohibited in Sri Lanka since 2017 under the Fisheries and Aquatic Resources Act.
Mid-water trawl fishery	Trawl nets used with mechanized craft	Coastal offshore	Pelagic and semi-pelagic species.
Pair trawl fishery	Small mesh size net operated for prawn, sea cucumber and fishes	Inshore and offshore	Physical damages observed on seagrass and reef habitats in India.

Photos: © IUCN





2.1. Marine Fisheries in Tamil Nadu

The marine fisheries sector in Tamil Nadu plays a crucial role in the overall economic development of the state. There are 591 marine fishing villages and 363 marine fish landing centres in Tamil Nadu (CMFRI, 2010). About 10,692 mechanized units and 24,942 motorized and non-mechanized units are engaged in marine fishing activities in the state. Trawlers (54%) and gillnetters (38%) are the main craft types in the mechanized sector. The human resource potential of the marine fisheries sector includes 192,697 families with a total fisher population of 802,912. The marine fish production in Tamil Nadu during 2011-2012 was estimated at 6.30 lakh (CMFRI, 2012), contributing 10-12% to the total marine fish production in the country. The mechanized and motorized sectors contributed 75% and 24% of the total landings, respectively, while the non-mechanized sector contributed only 1%.

Photo: © Carl Höjman

Photos: © R. L. Laju

Table 3: Marine Fisheries in Tamil Nadu based on fishing methods

	Mechanized								Mortarized				
State	Trawlers	Gilinetters	Dolnetters/ Bagnetters	Liners	Ring seiners	Purse-seiners	Others	Total Mechanized	Inboard	Outboard	Total Mechanized	Non-Mortarized	Total
West Bengal	2,004	1,764	191	31	0	0	24	4,014	6,564	0	6,564	476	11,054
Odisha	1,390	358	0	0	0	0	0	1,748	2,443	3235	5,678	1,256	8,862
Andhra Pradesh	1176	0	0	0	0	0	0	1176	3,146	8,932	12078	6965	20,219
Tamil Nadu	5278	441	0	16	219	0	7	5,961	8945	22334	31279	6115	43,355
Puducherry	223	0	0	0	78	0	0	301	387	975	1,362	656	2,319
Kerala	2654	417	0	2	646	81	0	3800	0	13,868	13,868	4,016	21,684
Karnataka	3,071	40	0	0	0	669	0	3,780	304	5,575	5,879	2225	11,884
Goa	600	0	0	0	0	209	49	858	5	937	942	182	1,984
Maharashtra	3408	584	1,637	0	0	230	8	5,867	5979	809	6,788	2865	15,520
Gujarat	9905	2602	1554	0	0	0	0	14061	3541	9284	12825	756	27,642
Daman & Diu	1,063	342	14	0	0	0	0	1,419	95	301	396	177	1,992
Total	**30,772**	**6,548**	**3,396**	**49**	**943**	**1,189**	**88**	**42,985**	**31,409**	**66,250**	**97,659**	**25689**	**166,333**

Table 4: Marine Fisheries in Tamil Nadu based on involvement of fishing communities

	Actual fishing		Fish seed collection				
	Full time	Part time	Full time		Part time		
State			Male	Female	Male	Female	Total
West Bengal	50,662	32859	1,040	1,765	1,499	4,516	**92,341**
Odisha	80,350	31,019	2,126	2,041	1,220	2,197	**118,953**
Andhra Pradesh	120,005	14,712	438	290	216	417	**136,078**
Tamil Nadu	200690	17661	55	26	60	202	**218,694**
Puducherry	11501	974	6	2	8	2	**12,493**
Kerala	120706	15264	549	126	96	507	**137,248**
Karnataka	32222	3,057	66	26	85	46	**35,502**
Goa	1,778	933	22	12	6	7	**2,758**
Maharashtra	60,258	15515	365	301	117	372	**76,928**
Gujarat	59,616	15,918	796	568	593	452	**77,943**
Daman & Diu	3,683	95	81	1	5	2	**3,867**
Lakshadweep	2415	3983	47	0	25	18	**6,488**
Andaman & Nicobar	4593	1,978	472	120	305	320	**7,788**
Total	**748,479**	**153,968**	**6,063**	**5,278**	**4,235**	**9,058**	**927,081**

At the state level, a cabinet minister is responsible for the sector. He is assisted by a Secretary to the Government, who is the administrative head of the Department of Fisheries and Fishermen Welfare and Commissioner/Director of Fisheries. The Commissioner/ Director of Fisheries is also the Managing Director of Tamil Nadu Fisheries Development Corporation Limited (TNFDC Ltd.), the Functional Registrar of all Fishermen Cooperative Societies, including Tamil Nadu State Apex Fisheries Cooperative Federation Ltd. (TAFCOFED), and the Member Secretary of Tamil Nadu Fishermen Welfare Board (TNFWB).

The Department has survey stations along the coast to provide information to fishermen with regard to fishing grounds and types of suitable fishing gear.

2.1.1. Industry Organizations

FISHERIES CORPORATIONS

The Tamil Nadu Fisheries Development Corporation Ltd. (TNFDC) was set up as a commercial organization. The Director of Fisheries is also the Managing Director of TNFDC. The Department took over all industrial activities, assets, and functions for which the Fisheries Directorate was earlier responsible for.

FISHERIES COOPERATIVE SOCIETIES

The Fisheries Cooperative Societies of Tamil Nadu are under the administrative control of the Director of Fisheries and provide financial assistance and relief to member fishermen. The Fisheries Cooperative Societies play a pivotal role in uplifting fishermen and fisherwomen in the State. The Department executes various welfare schemes for fishermen/fisherwomen through Fisheries Cooperative Societies.

GOVERNMENT POLICY

The Government of Tamil Nadu framed the Tamil Nadu Marine Fishing Regulation Rules, 1983, which regulate fishing activities. As per Rule 3 (2) of the said Regulation, certain prohibitions are imposed. They are, (i) Mechanized fishing vessels shall not be used for fishing within five nautical miles from the shore; (ii) Deep-sea fishing vessels shall not be used for fishing within territorial waters; and (iii) Any deep-sea fishing vessels operating from the State shall leave from and return to the notified place for berthing or anchoring during the day between 8.00 hours and 18.00 hours.

Further, Rule 17(7) of the Tamil Nadu Marine Fishing Regulation Rules regulates the use of specified nets for fishing. As per Rule 17(7), (i) No fishing gear or less than 10 mm mesh from knot to knot in respect of nets other than trawl nets shall be used; (ii) Bottom trawling operations shall not be conducted within three nautical miles from the coastline; (iii) The authorized officer shall have the right of prohibiting the catching of any particular species of fish, during any particular season as may be notified; (iv) The non-mechanized fishing vessel shall be used for fishing within three nautical miles from the shore and shall go for hook and line fishing and boat seine; (v) Fishing within 100 m below a river mouth is prohibited; (vi) The owner of a non-mechanized fishing vessel shall not use his gill net in the channel earmarked as the passage for mechanized fishing vessels; (vii) The number of mechanized fishing vessels, which may be used for fishing in any specified area shall be decided by the authorized officer having jurisdiction over that area (Tamil Nadu Marine Fishing Regulation Rules, 1983).

Photo: © Dinithi Samarathunga

2.2. Fishing Gear Production Flows

2.2.1. Fishing Gear Imports to Sri Lanka

Sri Lanka has a well-established fisheries industry consisting of sub-sectors: offshore, deep-sea, coastal fishery, and inland fishery and aquaculture. Sri Lanka is endowed with a number of coastal habitats such as coral reefs, large extents of beaches and dunes, and multi-species. The marine fish production was 415,490 Mt in 2019 (EDB, Sri Lanka, 2022), an increase of 3.2% compared to the average between 1999-2019 but a decrease of 8.2% compared to 2009-2019 (Amarasinghe, 2014; Edirisinghe et al., 2018; NARA, 2018).

The coastal fishery includes demersal and pelagic species, while the offshore fisheries mainly target pelagic species such as billfish, tuna, sharks, and rays. Fishermen use several types of gear, including nets, fishing lines, hooks, artificial lures, fishing rods, floats, and scuba gear. Also, some fishermen construct their own gear using some of the items mentioned above and use them according to their needs, primarily based on the target species and their habitats.

The Gulf of Mannar region, along with Sri Lankan waters, is rich in offshore (large pelagic and small pelagic fisheries) and inshore (lagoon and estuarine fisheries) finfish and shellfish harvest. A significant portion of fisheries harvest in the Gulf of Mannar is export-oriented (Davies, 2019). Specifically, in Sri Lanka, during the early and mid-20th century, pearl fishing was confined to the Gulf of Mannar (Katupotha, 2019). Sri Lankans and Indians have used the Gulf of Mannar waters for centuries for fisheries and commercial trading purposes. Thus, the Gulf of Mannar and Palk Strait are impacted by fishing activities on both Sri Lankan and Indian sides as it is situated between the two countries (Ilangakoon et al., 2008). The use of active and passive fishing gear has been a severe issue in these waters, considered a biodiversity hotspot (Marirajan et al., 2012). One of the key challenges noted is the accumulation of ALDFG in the Gulf of Manner region with the expanding human population (Patterson Edward et al., 2020). However, coastal fisheries provide a living for

The use of active and passive fishing gear has been a **severe issue in these waters, considered a biodiversity hotspot (Marirajan et al., 2012).** One of the key challenges noted is the accumulation of ALDFG in the Gulf of Manner region with the expanding human population (Patterson Edward et al., 2020).

millions of people in India and Sri Lanka (Jinadasa et al., 2020; Pouw & Baud, 2011). Therefore, India and Sri Lanka should urgently consider developing a common framework in relation to policies and supporting livelihoods while mainstreaming coastal and marine biodiversity. Both countries have a comprehensive set of laws and regulations governing the use of fishing gear. These laws and regulations are enforced in Sri Lanka by the Department of Fisheries and Aquatic Resources with the support of Sri Lanka Navy and Sri Lanka Coast Guard.

Sri Lankan customs have recorded information on export and import values and quantities of fishing gear. However, the fishing gear consumption and distribution-related information is not available, which highlights the importance of having a properly managed database along with a centralized system to track and monitor the use and distribution of fishing gear (Management Effectiveness Tracking System) under relevant governmental authorities to understand the consumption pattern versus imports/exports. Further, it is recommended to introduce a geo-tagging system for distributed equipment to keep track of discarded fishing gear and to avoid environmental impacts caused due to mismanagement of gear.

As per the Sri Lanka Customs classification, there are more than 30 fishing gear importers, distributors, and supply companies in Sri Lanka. Out of these, about ten and three fishing gear suppliers are registered with the Department of Fisheries and Aquatic Resources. Apart from this, about 72 boat manufacturing companies in Sri Lanka are registered with the Department of Fisheries.

Sri Lanka has imported a wide range of fisheries industry-related equipment over a significant period. In order to interpret the latest fishing gear-related imports, the imports from 2018 to 2022 were analyzed and obtained from the Sri Lankan Customs (see Figure 5), including materials for fiberglass fishing boats, fish hooks (whether or not snelled), fishing reels, fishing rods, fishing vessels, multi-day deep sea operating vessels (MDOVs), beach seines, OFRP, log rafts, and artisanal fishing vessels, man-made textile materials for the manufacturing of fishing nets (textile material manufacturing of organic polyamides such as silk threads, etc.), man-made textile materials and other synthetic fibers (artificial polyamides and derivatives such as nylon), and other material imported for the manufacture of fishing nets.

The HS code category definitions seem to be undefined; however, as per the Sri Lanka context, although factory ships were mentioned in the list of items given by the Customs Department, they are neither traded nor operated in Sri Lanka. However, the dataset's section for fishing vessels includes beach seines. Likewise, low-stretch nylon thread is used recorded as a man-made monofilament textile material to make fishing nets, and environmentally friendly biodegradable material used for net manufacturing is recorded as a man-made other textile material for making fishing nets.

According to customs data, fish hooks constitute the largest imported values and quantities of fishing gear to Sri Lanka, followed by other synthetic fibers for manufacturing fishing nets. A total value of LKR 2.34 billion were imported during 2018-2022, with the highest imported values recorded in 2018 and 2022 (around LKR 610 million). Also, the import trend of fishing gear indicates a lower growth rate during the years 2020 and 2021 while highlighting that the pandemic situation and country policies on imports have affected it to a certain extent. However, in 2022, a perceivable growth could be expected when compared to 2020 and 2021.

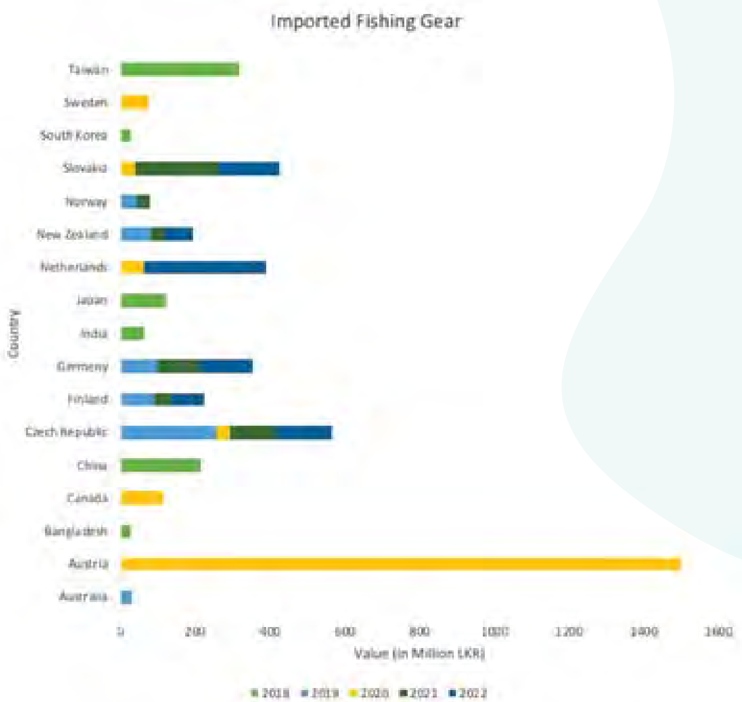


Figure 5. *Import values of fishing gear to Sri Lanka*

Figure 5 highlights 2020's highest expenditure cost for importing fishing gear during 2018-2022, where 82% of the funds were used to import fishing gear from Austria. This mainly included raw materials used to manufacture the fiberglass boats. Notably, 2020 is the only time Sri Lanka imported gear from Austria in the period between 2018 to 2022. Although Sri Lanka imported fishing gear from Austria only in 2020, it was recorded as the highest expenditure that Sri Lanka spent on importing fishing gear from all the countries during the considered period. The second highest expenditure was importing fishing gear from the Czech Republic over the considered time. Also, the Czech Republic maintained a consistent flow in importing fishing gear to Sri Lanka.

Even though the import, transport, purchase, sale, and use of monofilaments fishing nets for catching fish within Sri Lankan waters has been prohibited since 2006 (GoSL, 2006), the import statistics indicate imports of monofilaments until 2021. However, imports of monofilaments were null in 2022, indicating that this legislation has been enforced. However, further studies are needed to understand the link between imports and the use of monofilaments.

2.2.2. Fishing Gear Exports from Sri Lanka

Several companies in Sri Lanka manufacture and export fishing gear, including fishing vessels, fishing rods, fish hooks, made-up fishing nets, etc. Sri Lankan customs data indicate that these products are exported to several countries. Even though some export items have dropped in 2022, the total value of exports was the highest compared to the past four years starting from 2018. Figure 6 highlights that Sri Lanka earned the highest export revenue in relation to fishing gear by exporting fishing gear to China between 2018 to 2022.

Photo: © Dinithi Samarathunga

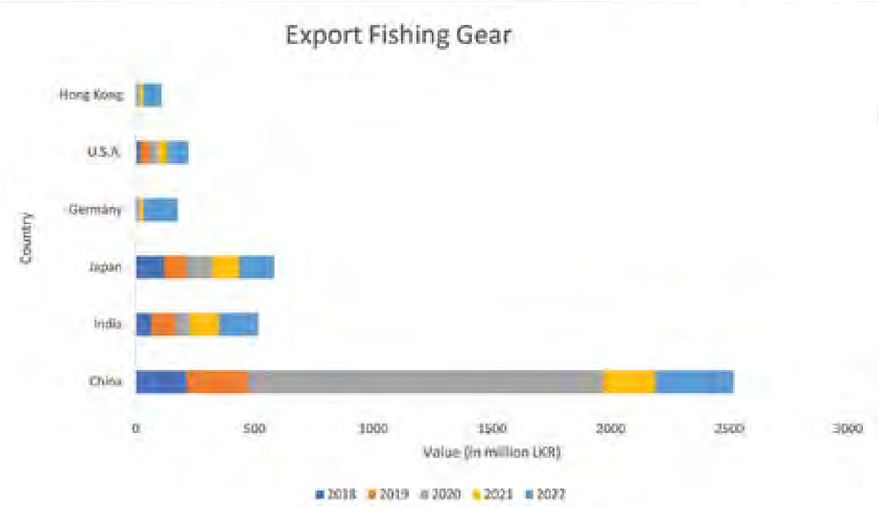


***Figure 6.** Export values of Fishing Gear from Sri Lanka.*

Concerning the trade balance related to fishing gear in Sri Lanka, the country maintained a trade surplus/positive trade balance during the last five years. The highest trade balance, LKR 309,070,442, was recorded in 2022, and the lowest trade balance, LKR 175,794,681, was recorded in 2020 in the international fishing gear trade in Sri Lanka. However, in terms of quantity, Sri Lanka exported far less than it imported during the last five years. That is because Sri Lanka mostly imports fishing rods, fishing hooks, and man-made fishing nets, while it exports mostly fishing vessels. Over the previous five years, the quantity-related trade balance (imports vs. exports) peaked in 2018 at 457,735 and fell to 103,395 in 2020. From the Sri Lankan context, the trade balance for each of the main groups of fishing gear is recorded as positive for all fishing gear and vessels and fish hooks (whether or not snelled). The trade balance is negative for the categories of others (for the manufacturers of fiberglass fishing boats), such as fishing reels, fishing rods, man-made textile materials (made up of fishing nets of monofilament), man-made textile materials (made up of fishing nets of other synthetic fibers: imported for the manufacture of fishing nets and other (imported for the manufacture of fishing nets).

Photo: © Dinithi Samarathunga

2.2.3. Composition of Netting Materials

Monofilament, multifilament, and HDP-high-density polyethylene nets are the three primary types of fishing nets produced in India. The main ingredients that India uses to manufacture fishing nets have been identified as Nylon-6 (Polyamide -6), Caprolactam, and Benzene. When taken into account, 15% of the total fishing nets used in India are imported, most of which are used in the Indian inland fisheries sector. In Sri Lanka, man-made textile materials (monofilament and multifilament) and synthetic netting materials such as polyamide (PA or nylon), multifilament, polyethylene, and polypropylene are utilized in the manufacture of fishing nets. However, a progressive trend in Sri Lanka has lately been toward creating fishing nets from natural fibers (FAO.,1990). Furthermore, according to Sri Lanka Custom statistics, Sri Lanka did not import monofilament textile material lately.

2.2.4. Identified Gaps

Although factory ships are referenced in the Sri Lankan customs dataset, factory ships are neither traded nor operated in Sri Lanka. However, the dataset's section for fishing vessels includes multi-day deep sea operating vessels (MDOVs), beach seines, OFRP, log rafts, and artisanal fishing vessels. Likewise, tangus thread is used as the man-made monofilament textile material to make fishing nets in Sri Lanka. As a man-made other textile material for making fishing nets, environment-friendly biodegradable material is used in Sri Lanka.

SOME RECOMMENDATIONS TO OVERCOME THESE GAPS INCLUDE:

1. Strengthen Marine spatial planning (MSP) practices for both Sri Lankan and Indian regions (Karnad, 2017).
2. Sri Lanka does not have a fishing gear manufacturer's directory. It would benefit numerous industries if their data were publicized and openly accessible.
3. To minimize the amount of abandoned fishing gear in the Gulf of Mannar region, both Sri Lanka and India must take action to lessen fishing pressure.
4. Sri Lankan custom data descriptions for HS codes for fishing equipment and related products are not properly defined, and inventories are in different categories. Therefore, it is recommended to separate the various fishing-related items and update the HS code description for fishing gear and other categories such as boats, boat-building items, accessories, etc.
5. Conduct training programs for SL Customs Department officials to properly identify and inventorizing imported and exported fishing gear and related items.
6. Establish a national database for fisheries-related items, including manufacture, import, and export of all fishing gear and related items, fishing boats, etc., at the DFAR with a link to the database at the SL Custom Department.

2.2.5. Fishing Gear Production in Tamil Nadu, India

Tamil Nadu has over 65 fishing net production enterprises—about 60 of them in the Kanyakumari district, four in Chennai, and one in Coimbatore. According to the manufacturers, 90% of fishing net supplies (tons per year) to the Gulf of Mannar fishers are from the Kanyakumari District, which includes Asia's second-largest fishing net producer. About 15% of fishing nets used in the state, mainly freshwater fishing nets, are imported from countries like Russia, China, and Thailand.

The fishers in the region of the Gulf of Mannar acquire their fishing nets directly from the producers or via retailers. Eligible fishermen receive a fishing net subsidy along with a boat and icebox from Tamil Nadu State Apex Fisheries Co-operative Federation Limited (TNAFCFL). There is no subsidy for fishing nets alone.

Approximately 250 to 450 tons of nets are supplied from net producers to the Ramanathapuram district and 500 tons to the Tuticorin District annually. Together, these two districts make up the Indian side of the Gulf of Mannar region, where the use of monofilament nets is the most dominant (55%), followed by multifilament (30%) and HDP (15%). Raw materials used in the production of these materials are Nylon-6 (Polyamide -6), Caprolactam, and Benzene, which the net producers mainly buy from Gujarat State Fertilizers & Chemicals Ltd. About 20% of chips are imported from countries like Russia, China, and Thailand.

ACCORDING TO THE MANUFACTURERS, **90%** OF FISHING NET SUPPLIES (TONS PER YEAR) TO THE GULF OF MANNAR FISHERS ARE FROM THE KANYAKUMARI DISTRICT, WHICH INCLUDES **ASIA'S SECOND-LARGEST FISHING NET PRODUCER.**

Photos: © Anja Stokkan

Photos: © Anja Stokkan

Table 5: List of net manufacturers[27]

State	District	Number of factories	% of nets supplied to Gulf of Mannar
Tamil Nadu	Kanyakumari	60	Above 90% (≈(1000 tons/year)
		Offshore	Pelagic species
	Coimbatore	1	
Kerala	Kochi and Kollam	3	
Pondicherry	Union Territory	2	
Karaikal	Union Territory	1	
	Oceanic/Deep water tuna longline	Offshore in the EEZ and high sea	

MAJOR MANUFACTURING UNITS IN KANYAKUMARI

1. Kumaran Fishnets Pvt Ltd.
2. Sreema Filaments Pvt Ltd.
3. Vee Fishnets.
4. Vasantham Nets.
5. Indo Nets.
6. Abirami Fishnets.
7. Annam Fishnets
8. Adam Polymers
9. Derik Monofilament Pvt Ltd.
10. Agni Nets.
11. RBR Monofilament Pvt Ltd
12. Super Fill Pvt Ltd.
13. Fida Monofilament Pvt Ltd.
14. Global Monofilament Pvt Ltd.
15. Glofil Fibres and Plastics
16. ET Perumal Fishnet

[27] Based on written and spoken correspondence between SDMRI and manufacturers in 2021-2022.

Photo: © Dinithi Samarathunga

Project-Specific Research Results in the Gulf of Mannar

As part of the MARESSOL project, quantitative and qualitative assessments were conducted to improve the understanding of concentrations and composition of ALDFG at 17 locations along the Gulf of Mannar coastline, 12 in India and 5 in Sri Lanka (see Figure 7).

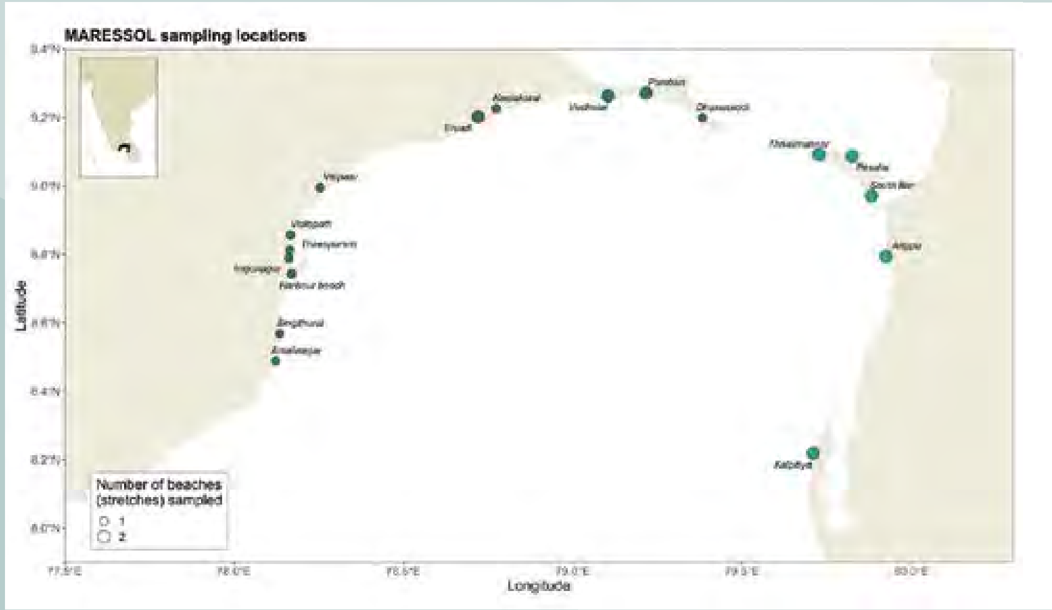


Figure 7. *Map showing the sampling locations along the Indian and Sri Lankan coastlines of the Gulf of Mannar (Gulf of Mannar).*

Briefly about study methods and data acquisition

Quantitative data on the ALDFG found on shorelines were recorded by counts, weights, and relative abundance (%) to total amounts of litter. Qualitative information on the coastal ALDFG is based on the polymer composition identified using FTIR-ATR following by standard protocols. The study identified the number of solid waste dumping sites near the shore, measured the deposit area, and evaluated the dominant macro debris (> 2.5 cm to < 50 cm size of the debris) and its chemical compositions. Beach sediment litter was collected for microplastic analysis and their chemical compositions were assessed. ALDFG was also characterized based on land disposal. Production, import and export of fishing gear was also assessed through interventions with the producer organizations as well as public trade records in Sri Lanka and India.

Photo: © IUCN

A detailed description of methodology used for data acquisition and analysis can be found in the Appendix section of this report.

3.1. Concentration of Stranded Macrodebris

Some **general conclusions** on the concentration of macrodebris stranded on the shoreline can be drawn from the data collected in this study.

- On the Indian side of the Gulf of Mannar, slightly less litter (items per square meter) was found ashore during the Northeast Monsoon than during the Inter-monsoonal period.
- On the Sri Lankan side, less litter was found during the Southwest Monsoon than the northeast.
- Based on the project's field samples, average litter concentrations in the Gulf of Mannar are in the same order of magnitude as found in reviewed literature on beach litter in India and Sri Lanka (see chapter "Marine Litter in India and Sri Lanka"), spanning roughly around less than one to just a few items per square meter.
- No significant difference in litter concentration was detected between the Indian and the Sri Lankan side of the Gulf of Mannar during the Northeast Monsoon.

The conclusions are drawn based on the outcomes of the analyses, shown in Figure 8. Box plots of the raw data (Figure 8a) show high variability among (and within) sites, and the fitted estimates (+/- 95% confidence intervals) for the models are shown as well. Individual model outputs follow below (Figure 8 b-d).

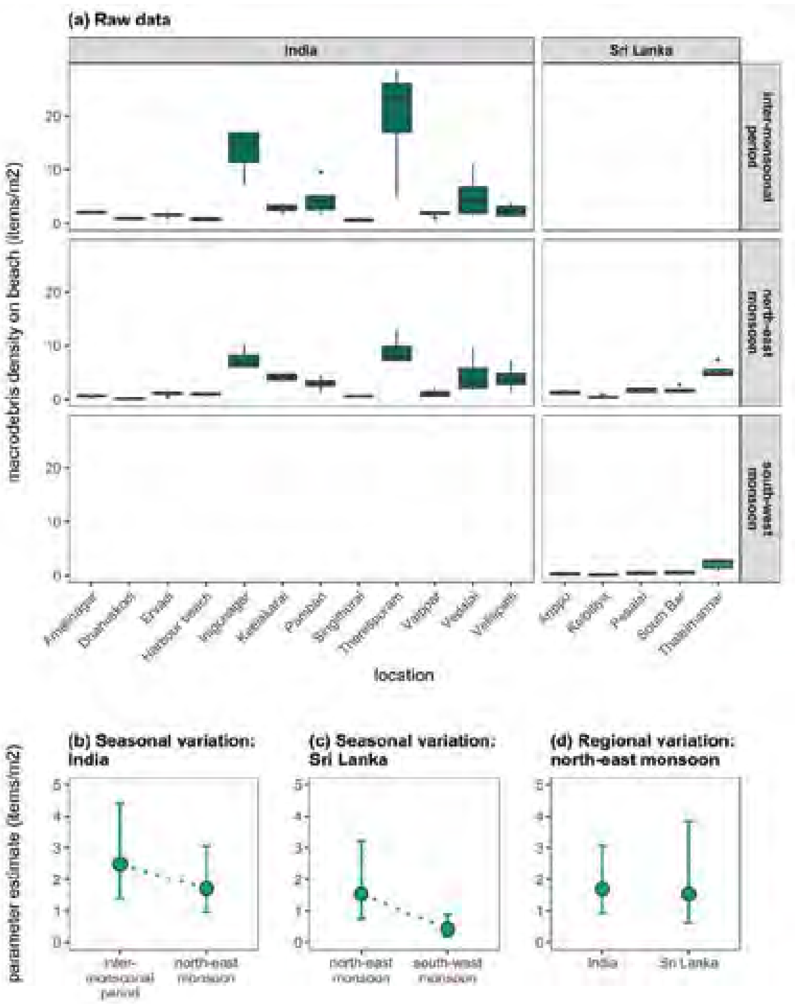


Figure 8. *An abundance of beach-cast macrodebris.*

(a) Box plots showing the distribution of densities recorded in the transects surveyed at each location by Gulf of Mannar shore and season.

(b) Average densities (i.e., exponentiated fitted model parameters) by season on the Indian Gulf of Mannar shore. Macrodebris density was significantly lower during the Northeast Monsoon than during the Inter-monsoonal period ($p = .0001$).

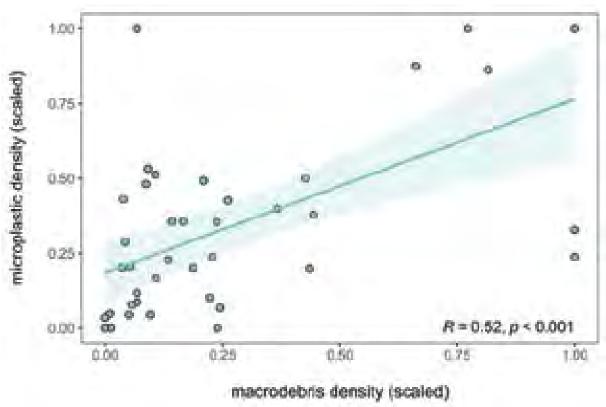
(c) Average densities (i.e., exponentiated fitted model parameters) by season on the Sri Lankan Gulf of Mannar shore. Macrodebris density was significantly lower during the Southwest Monsoon than during the Northeast Monsoon ($p < .0001$).

(d) Average densities (i.e., exponentiated fitted model parameters) by shoreline during the Northeast Monsoon; there was no significant difference between the two ($p = .858$). Error bars show 95% confidence intervals.

3.2. Correlation between Beach-Cast Macrodebris and Microplastics

A positive correlation exists between how much macrodebris was found on the beach in India and Sri Lanka and how much microplastics the beach sediments contained (Figure 9a).There is also a positive correlation between how much fisheries-related litter was found on beaches versus how much microplastic was found (Figure 9b). This conclusion implies that larger plastic items and fragments in the natural environment are major contributors to the accumulation of microplastics. Hence, preventing and cleaning up larger plastics will likely reduce microplastics in the environment. It also suggests that ALDFG items play a dominant role in the presence of microplastics found on beaches.

Approximately half the spatial variability observed in the mean microplastic density in beach sediments can be explained by spatial variability in the mean density of beach-cast macrodebris (Figure 9a). Slightly more than half the spatial variability observed in the mean microplastic density in beach sediments can be explained by spatial variability in the mean density of beach cast ALDFG (Figure 9b).



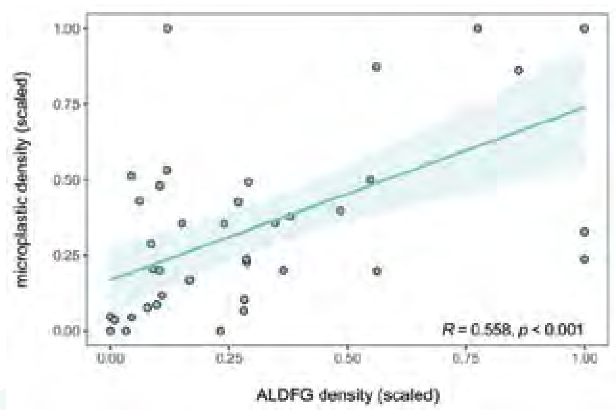


Figure 9. (a) *Correlation between the average densities of beach cast macrodebris and microplastic density in the beach sediment for each site (i.e., not aggregated by location). Both variables are scaled so that the average density among sites each season and on both shores ranges from 0-1. The Spearman correlation is significant (p < .001, confirmed by 95% confidence intervals following 10,000 non-parametric bootstraps not including zero).*

(b) *Correlation between the average densities of beach cast ALDFG and microplastic density in the beach sediment for each site (i.e., not aggregated by location). Both variables are scaled so that the average density among sites each season and on both shores ranges from 0-1. The Spearman correlation is significant (p < .001, confirmed by 95% confidence intervals following 10,000 non-parametric bootstraps not including zero).*

This conclusion implies that larger plastic items and fragments in the natural environment **is a major contributor to the accumulation of microplastics.**

Photo: © Dinithi Samarathunga

3.3. Microplastics in the Water and on Beaches

Photo: © Soren Funk/ Unsplash

This study provides documentation of the presence and abundance of microplastics on beaches and in surface waters of the Gulf of Mannar Region of India and Sri Lanka.

On the Indian side of the Gulf, 3.54 to 85.94 microplastic items per kilogram of sand were recorded in the surface sediment at 12 selected beach locations during the Northeast Monsoon. During the Inter-monsoonal period, the range was 5.00 to 89.67 items/kg. In water samples, abundance ranged from 8.22 to 106.85 items per liter.

On the Sri Lankan side of the Gulf, 32 to 57 microplastic items per kilogram sand were recorded in the surface sediment at five selected beach locations during the Southwest Monsoon period, and 380 to 800 items per m^{-3} in surface waters.

The most common shapes of microplastics identified were fibers (e.g. filaments) and fragments in both India and Sri Lanka. The predominant polymers on both sides of the Gulf (i.e. India and Sri Lanka) were Polyethylene (PE) and Polypropylene (PP), in water and beach samples.

The correlation between microplastics in water samples versus in beach sediment was not possible to assess due to insufficient replication and temporal match of data. There was insufficient sample size with adequate temporal overlap to include water samples in such a correlation given that in India, the water samples were taken at a completely different time of year than the macrodebris samples. This could be done for the Sri Lankan data alone but given there are only five locations and no replication within them, this would not be a meaningful analysis (i.e., power is very low).

Photo: © IUCN

3.4. Fisheries Related Litter in Stranded Macrodebris

Abandoned or otherwise discarded fishing gear (ALDFG) made up a significant share of stranded macrodebris, both in terms of counted items (50% on the Indian shores of the Gulf of Mannar, 41% on the Sri Lankan shores) (Figure 9a) as well as by share of the total weight of marine litter (74% on the Indian shores, 40% on the Sri Lankan shores[28]). Other studies conducted in Sri Lanka and India report similar findings, as described in the chapter "Marine Litter in India and Sri Lanka."

No effect of season on the relative prevalence of ALDFG along the Indian coast of the Gulf of Mannar was found (Figure 10b). However, along the Sri Lankan shores of the Gulf of Mannar, ALDFG was more prevalent during the Southwest Monsoon than during the Northeast Monsoon (Figure 10c).

The data sampled for this study indicate that the ratio of ALDFG to the total macrodebris may be slightly lower along the Sri Lankan coast than the Indian coast of the Gulf of Mannar during the Northeast Monsoon. However, the evidence is inconclusive[29] (Figure 10d). Measured by weight (instead of count), ALDFG was more prevalent along the Indian shore of the Gulf of Mannar during the Northeast Monsoon (Figure 10f).

By weight (not count), ALDFG was somewhat more prevalent during the Northeast Monsoon along the Indian coast of the Gulf of Mannar (Figure 10e). As there was no seasonal effect of ALDFG prevalence by abundance, this suggests not more, but heavier, ALDFG items during the Northeast Monsoon than during the Inter-monsoonal period.[30]

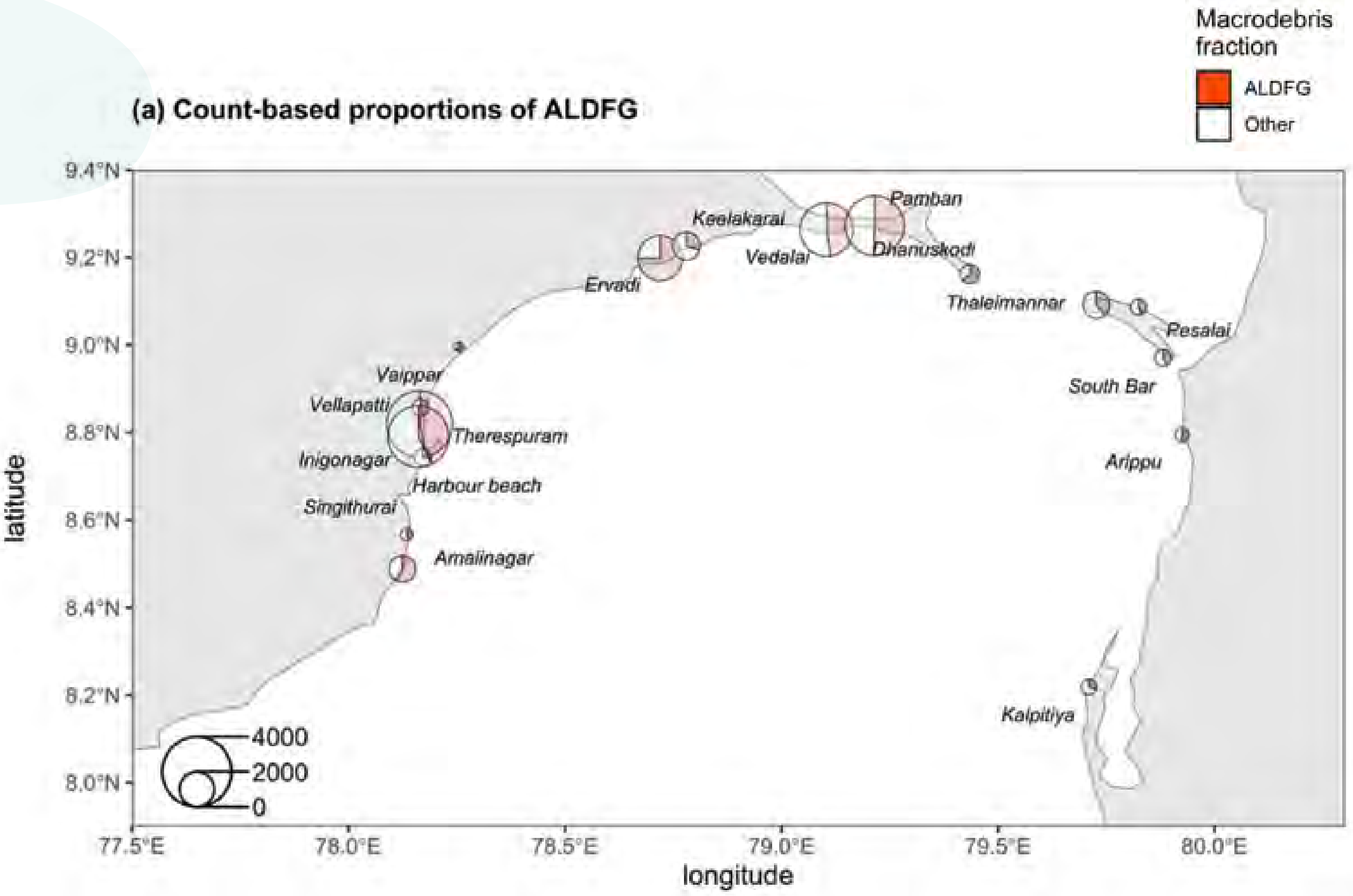


Figure 10. *The relative abundance of ALDFG.*

(a) Based on item counts, the proportion of beach-cast macrodebris consisting of ALDFG versus other litter types. The size of the pie is proportional to the total amount of litter used to calculate the proportions.

[28] Note that for Sri Lanka this result is from the first sampling during the Northeast Monsoon only as non-ALDFG debris was not weighed during the second sampling during the Southwest Monsoon; hence the sample is relatively small.

[29] The results are marginally non-significant, but given the low sample size and consequently lower power (one assumes, power analysis not performed) there is potential for erroneous conclusions and here the probability of a difference (i.e., the p-value) is in a bit of a grey zone.

[30] Note, however, that this must be interpreted with considerable caution as it is not unlikely that larger items which had been present on the beach for some time (and which could have been deposited there during any season) were removed during the first standing stock survey.

Photo: © IUCN

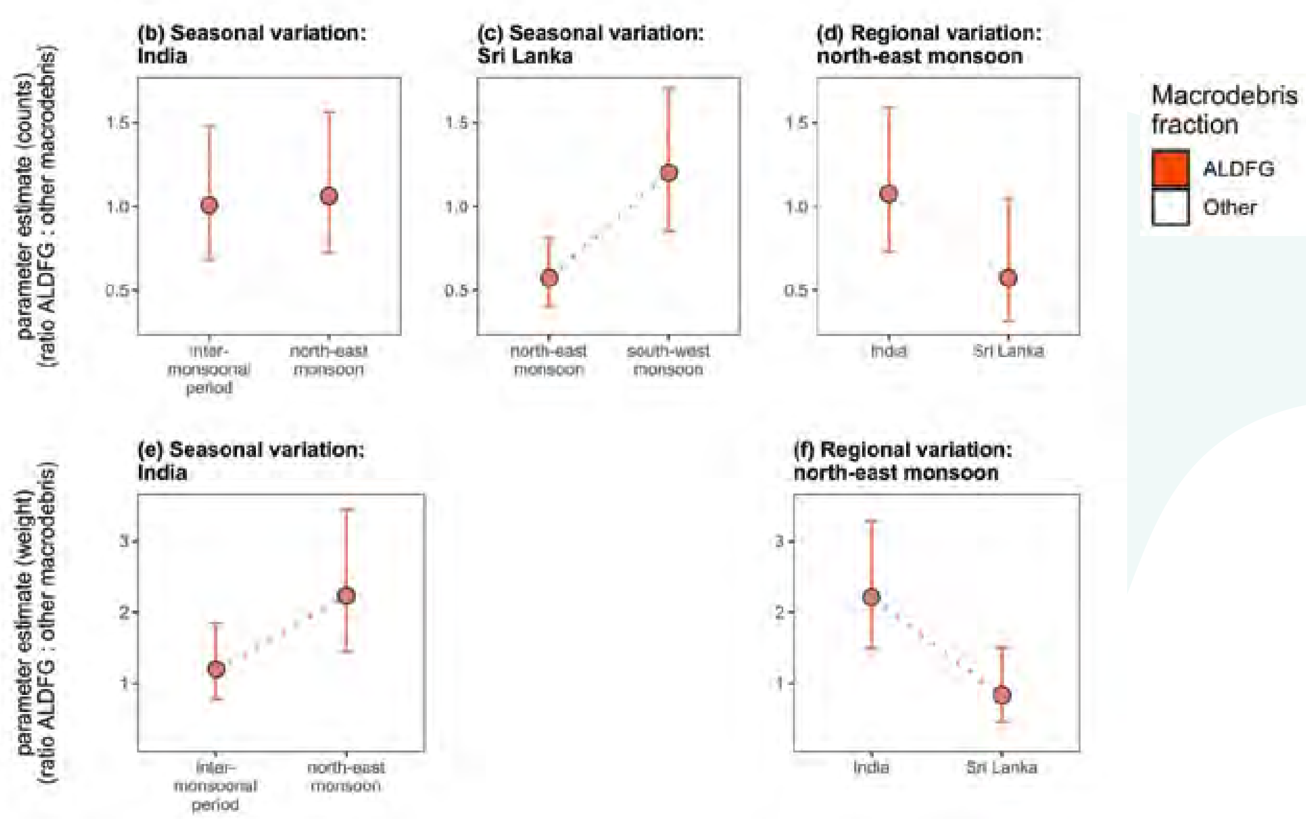


Figure 10. *The relative abundance of ALDFG.*

(b) The average ratio of ALDFG to other debris (i.e., fitted model parameters) by season on the Indian Gulf of Mannar shore. There was no significant difference between the seasons (p = .579).

(c) The average ratio of ALDFG to other debris (i.e., fitted model parameters) by season on the Sri Lankan Gulf of Mannar shore. ALDFG was more prevalent during the Southwest Monsoon than during the Northeast Monsoon (p < .0001).

(d) The average ratio of ALDFG to other debris (i.e., fitted model parameters) by shoreline during the Northeast Monsoon. The two had a marginally non-significant difference (p = .079). Panels b-d show results based on item counts.

(e) The ratio of ALDFG to other macrodebris was significantly higher during the Northeast Monsoon along the Indian shoreline based on weight (p = .003).

(f) During the Northeast Monsoon, the ratio of ALDFG to other macrodebris was significantly higher along the Indian shoreline based on weight (p = .006). A ratio of 1 indicates equal amounts of ALDFG and other macrodebris; a ratio <1 indicates that ALDFG was less prevalent than other macrodebris, while a ratio >1 indicates ALDFG was more prevalent than other macrodebris.

3.5. General Composition of Stranded Macrodebris

Below is a series of graphs showing different aspects of litter composition. For the Indian data, this comprises only the ALDFG portion of litter, as other debris was not categorized. For the Sri Lankan data, both ALDFG and other debris were analysed.

While several different items were recorded, most of the debris comprised a smaller selection of more abundant items. Along the Sri Lankan coast (59 different items were recorded), the five most abundant items comprised 50% of the total beach litter. The nine most abundant items comprised 75% of the total, and the 21 most abundant items comprised 98% of the total (Figure 8).

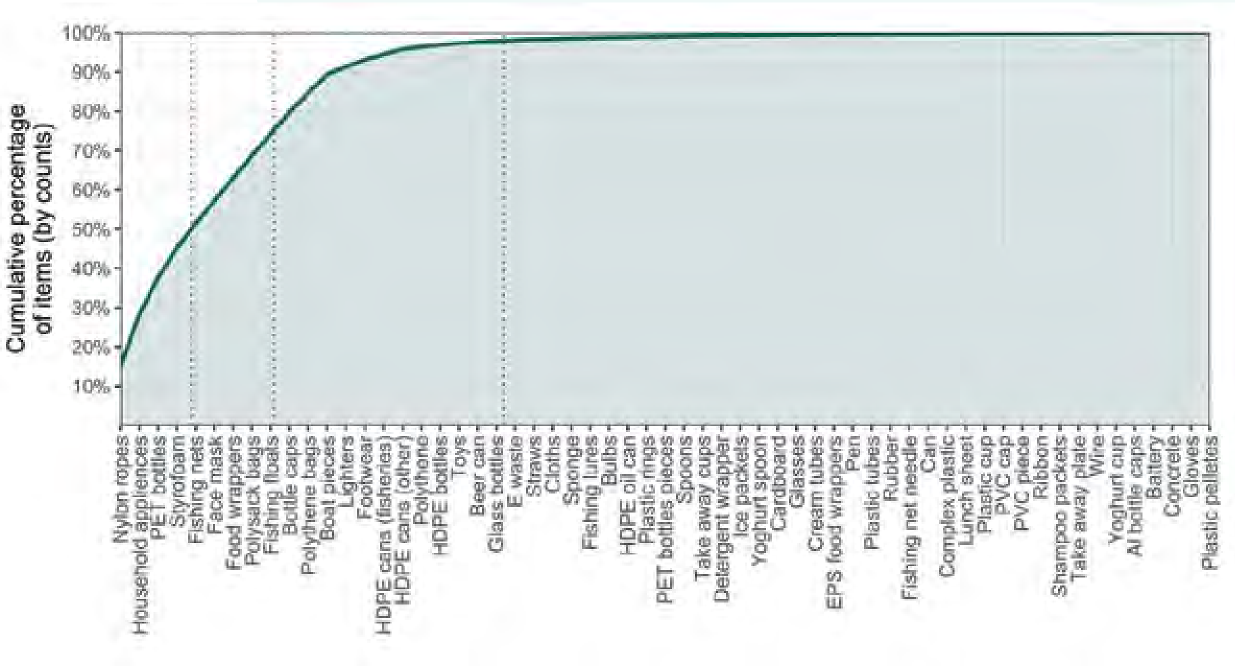


Figure 11. *The cumulative proportion (by counts) of different litter items recorded along the Sri Lankan coast (all data aggregated across sites and seasons). The items are ordered according to descending abundance from left to right (i.e., nylon ropes were the most frequently recorded litter item and plastic pellets the least). The three stippled vertical lines shows when the cumulative percentage reached 50%, 75%, and 98%, from left to right, respectively.*

Ropes were the most abundant ALDFG-related item in both Sri Lanka and India. In Sri Lanka, the rope was also the most abundant item overall (in India, this could not be assessed as all non-ALDFG debris was pooled and not further categorized). Figure 9 shows the variability in the prevalence of different types of ALDFG vs. other macrodebris, sampled in Sri Lanka and India, respectively, in different seasons.

Figure 10 shows the composition of all ALDFG item categories at locations in India and Sri Lanka during the different seasons. Figure 11 shows the share of ALDFG to total macrodebris per sampling location in India and Sri Lanka, at different sampling seasons, and the proportion of ALDFG constituted by ropes (the most commonly found item).

[31] Conducting chi-square analyses for data in Figure 10 is not possible without first eliminating the categories which do not occur in both countries, therefore there are no associated statistics.

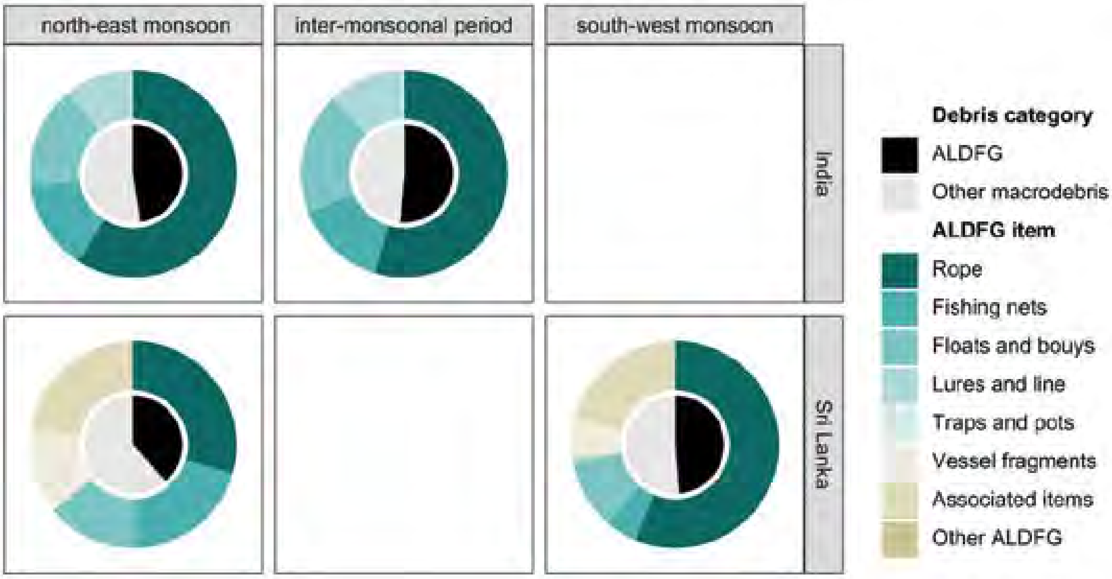


Figure 12. The proportions of ALDFG to other macrodebris (inner pies) and of different types of ALDFG items harmonized across datasets (outer donuts) by abundance (i.e., item counts). All debris sampled has been aggregated across the country and season.

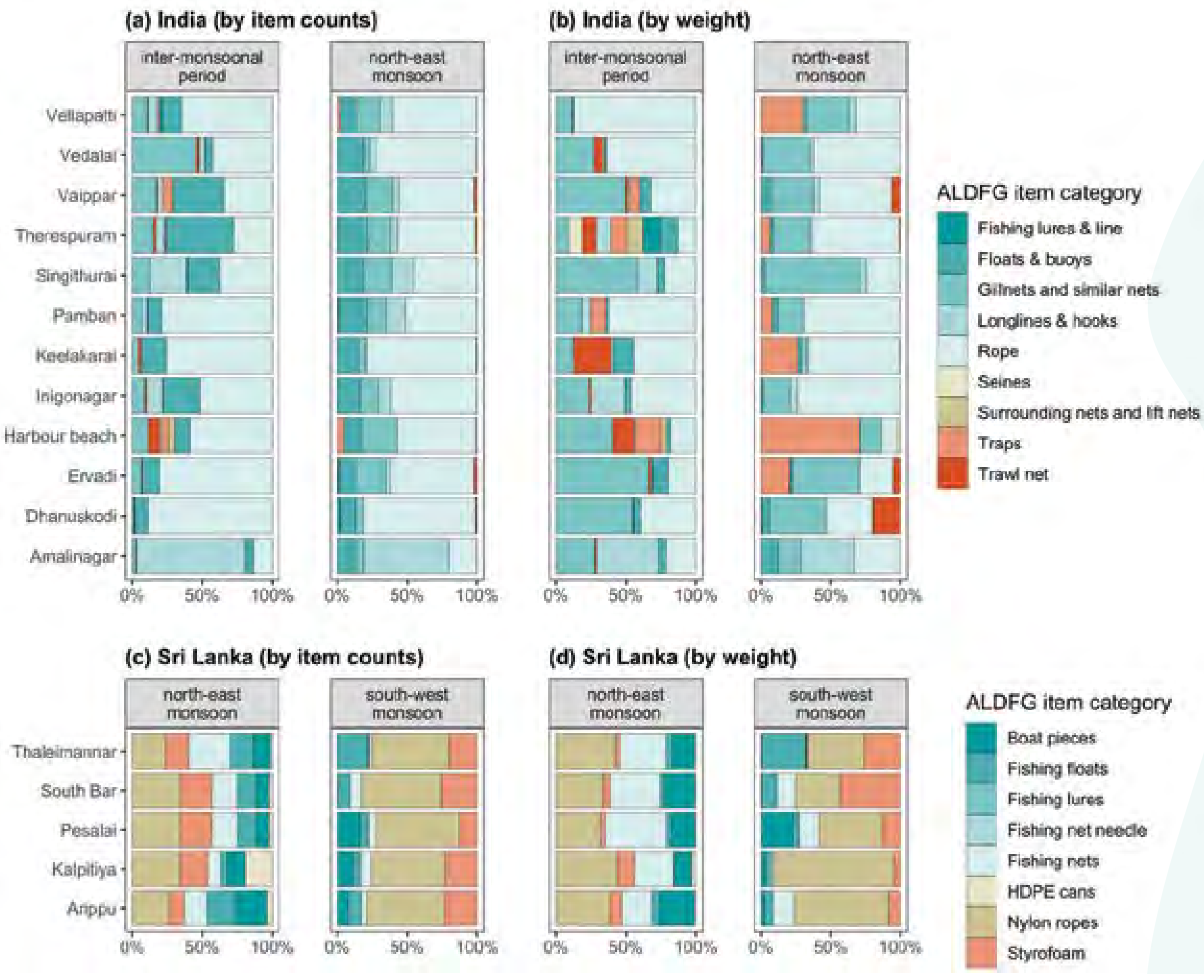


Figure 13. Composition of ALDFG at locations in India and Sri Lanka during the different seasons. All data collected at each location have been aggregated.

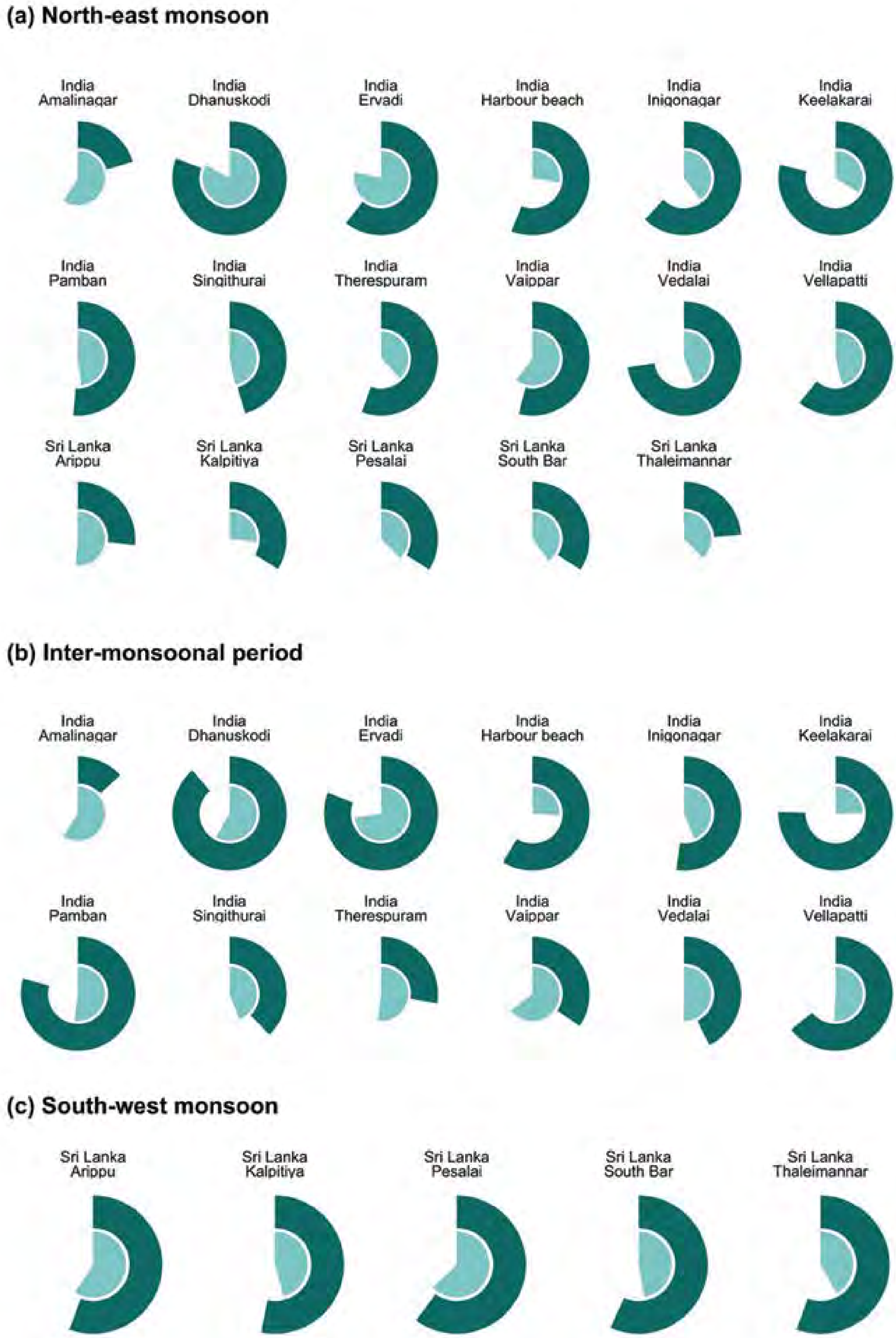


Figure 14. *The central pie charts show the proportion of ALDFG by abundance (item counts), and the outer donut shows the proportion of this ALDFG which was constituted by ropes. Litter from all the transects within a location has been aggregated.*

There was a significant association between the season and the prevalence of ropes both in India (chi-square test, $p < .0001$) and Sri Lanka (chi-square test, $p < .0001$), as well as a significant association between the country and the prevalence of ropes during the Northeast Monsoon (chi-square test, $p < .0001$). For the Sri Lankan shore, the significant association between season and rope abundance is likely due to a greater proportion of ALDFG being ropes during the Southwest Monsoon than during the Northeast Monsoon (56% versus 30%, respectively). As there was no detectable difference in litter density between the seasons, the proportion of all ropes collected and sampled during each season was fairly similar (53% during the Northeast Monsoon and 47% during the Southwest Monsoon). Along the Indian shore, however, the association is more likely due to a greater proportion of the total number of ropes observed being found during the Inter-monsoonal period (60% of ropes registered were found during this sampling round) rather than a large difference in the proportion of ALDFG constituted by ropes each season, which varied much less (59% during the Northeast Monsoon and 55% during the Inter-monsoonal period). Consequently, this significant association is likely driven by the higher litter density during the Inter-monsoonal period than by a seasonal difference in the relative prevalence of ropes. The significant association between shore/country and rope abundance during the Northeast Monsoon is the result of both greater litter abundance along the Indian shore and a greater prevalence of ropes among ALDFG there (86% of all rope registered during the Northeast Monsoon were done so in India, and the prevalence of rope among ALDFG was 59% in India at the time, compared to only 30% along the Sri Lankan shore).

3.6. Fisherfolk Perceptions and Waste Practices: An Interview Study

Photo: © IUCN

To gain insights into the fisherfolks' perceptions of marine litter, a survey questionnaire was conducted in 2022. Three hundred and forty-three fisherfolk and 125 individuals were interviewed in India and Sri Lanka, respectively. The participants included individuals from the fishing communities in the study area along the coast of the Gulf of Mannar.

Some **general conclusions** from the survey are summarized below:

- The fisherfolks in India and Sri Lanka lack designated locations to dispose of used gear. At the same time, fishers in both countries are largely positive about supporting a system that would collect old fishing gear.
- Lost gear, to some extent, is attempted to be both prevented and retrieved when lost by fishers, but to unknown success rate.
- In Sri Lanka, fishers blame "bad weather" as the main cause for gear loss, whereas "bottom snagging" is regarded as the main cause by Indian fishers.
- The issue of "ghost fishing" and its impacts was largely regarded as a serious problem by Sri Lankan fisherfolk.
- Bottom-set gillnets, followed by gillnets, were regarded as having the most negative impacts on the marine environment by fisherfolk in both countries. At the same time, fishers in both countries regarded gillnets as the gear type most frequently lost at sea during fishing. Bottom-set gillnets were also commonly lost by Sri Lankan fishers.
- Discussions about abandoned, lost, or otherwise discarded fishing gear is not commonly discussed amongst fisherfolk or between fisherfolk and the authorities.

Photo: © SDMRI

In both countries, the fisherfolk interviewed in the survey were of varying ages and had varying experiences in terms of years engaged in fishing. The majority of respondents in both countries used fiberglass reinforced fishing craft (Sri Lanka: 61 %, India: 78 %), vallams (Sri Lanka: 32%, India: 3%), and trawlers (Sri Lanka: 5%, India: 15%) along with other types of craft. Indian respondents fished mostly around coral reefs (30%), seagrass bottoms (25%), or sand bottoms (32%), while 8% fished in mangroves, 5% on open waters, and 1% on paar. According to Sri Lankan respondents, 14% fished around coral reefs, 35% around seagrass bottoms, 39% around sand bottoms, and 11% on open waters. The most commonly used fishing gear were gillnets and bottom-set gillnets in both countries, and surface long lines (Sri Lanka) and bottom long lines (Sri Lanka and India were well represented too (Figure 15). Around 69% of Indian and 36% of Sri Lankan fishers responded that they actively fished for more than 180 days per year.

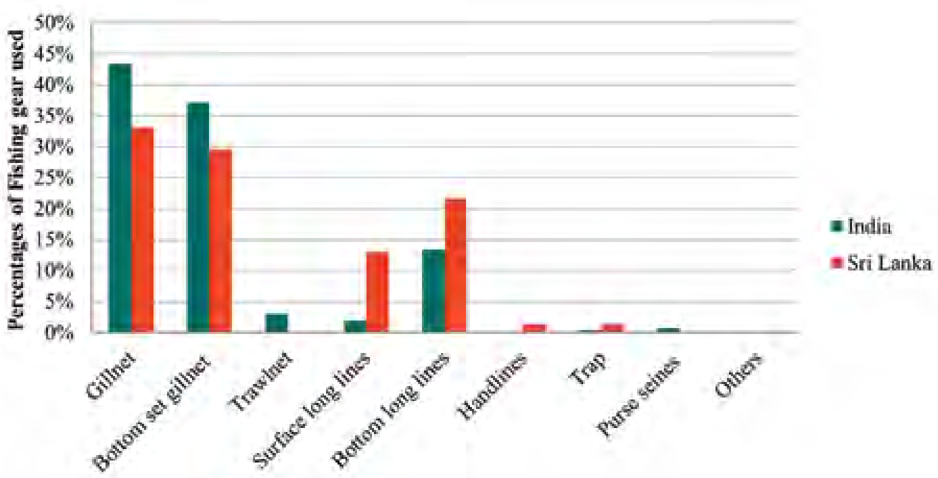


***Figure 15.** Percentages of gear used by fisherfolk interviewed in the survey, in India and Sri Lanka respectively.*

When asked if the fishers had designated locations to dispose of the used gear, all Indian respondents and 92% of the Sri Lankan respondents answered that they did not have. Hence, as a result, gear must be disposed of at random along the shoreline or into the sea. The study could not obtain responses to the allocation between the two options (disposed along the shoreline or into the sea).

When asking the fishers whether they tried to retrieve lost gear, 46% of Indian fishers and 18% of Sri Lankan fishers answered that they did. The retrieval success rate was not quantifiable based on the responses collected. Ghost fishing was more commonly recognized as a “serious problem” by Sri Lankan fishers (42%), while most (69%) of Indian fishers regarded ghost fishing as an “insignificant problem” (Figure 16).

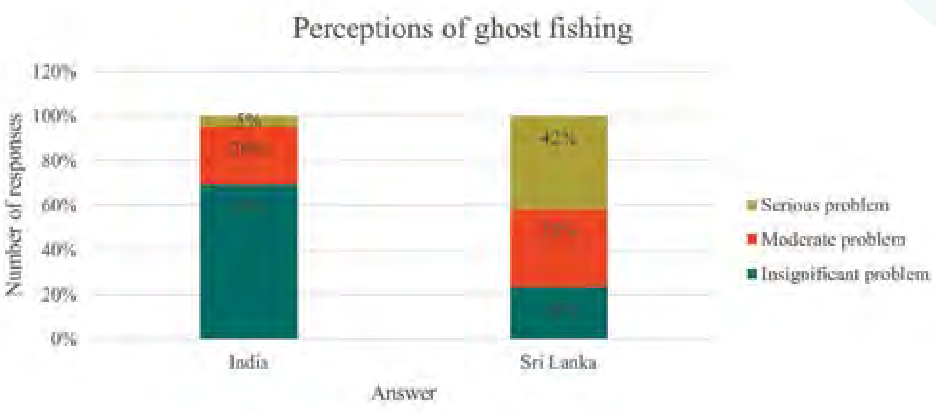


Figure 16. *The fisherfolk were asked if they regard ghost fishing as a serious, moderate or insignificant problem.*

When asked to specify which fishing gear has the most negative impact on the marine environment when lost at sea, most responded as bottom-set gillnets in both countries, followed by gillnets (Figure 17).

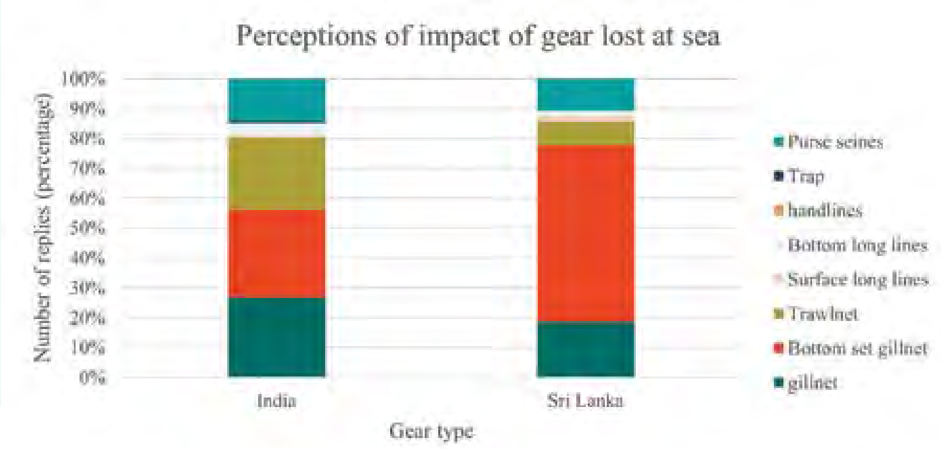


Figure 17. *Percentage of fishers responding to which type of fishing gear has the most impact when lost at sea.*

Gillnets were regarded as commonly lost annually by fishers in India (70%) and Sri Lanka (38%). Bottom-set gillnets also stood out as a commonly lost item by the Sri Lankan fishers (38%) (Figure 17). Areas at sea where discarded nets accumulate were observed by 12% of Indian fishers and 27% of Sri Lankan fishers.

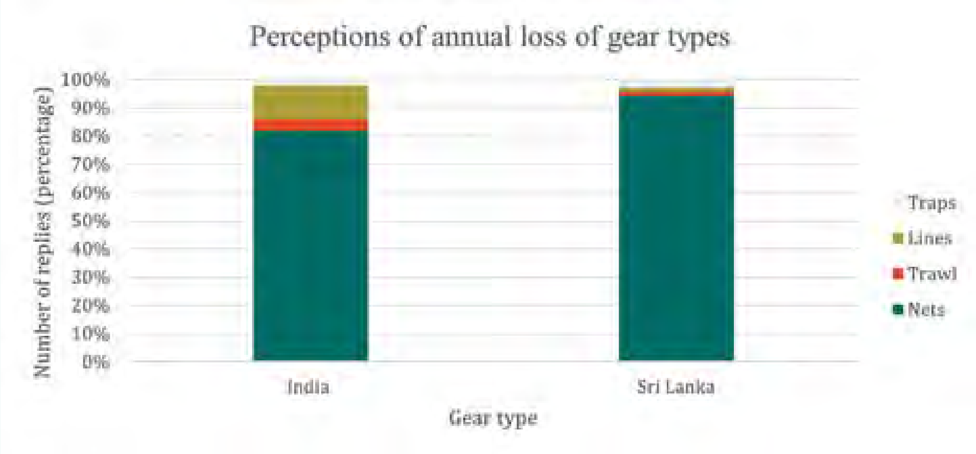


Figure 18. *Percentage share of respondents stating that they lose different types of fishing gear annually.*

When fishers were asked if they understood that improperly dumped fishing gear can cause damage to fishing grounds and species, 38% and 98% of Indian and Sri Lankan fishers, respectively, answered “Yes” (Figure 19, Question nr. 1). Forty five percent and 40% of Indian and Sri Lankan fishers, respectively, had made attempts to reduce the dumping of old fishing gear at sea or on the beach (Figure 19, Question .nr. 2). Discussions about abandoned, lost or otherwise discarded fishing gear (ALDFG) had taken place in the area according to 28% and 11% of Indian and Sri Lankan fishers, respectively (Figure 19, Question nr. 3), while 27% and 10% had the experience of discussing the issue with a public authority (Figure 19, Question nr. 4). Fishers in both countries were very positive to support a system that would collect old fishing gear by handing in old gear (84% and 97% in India and Sri Lanka respectively) (Figure 19, Question no. 5). When asked if the fishers try to retrieve fishing gear (e.g., nets) when the gear gets entangled on shipwrecks and reefs, 46% and 72% of Indian and Sri Lankan fishers, respectively, responded that they do so.

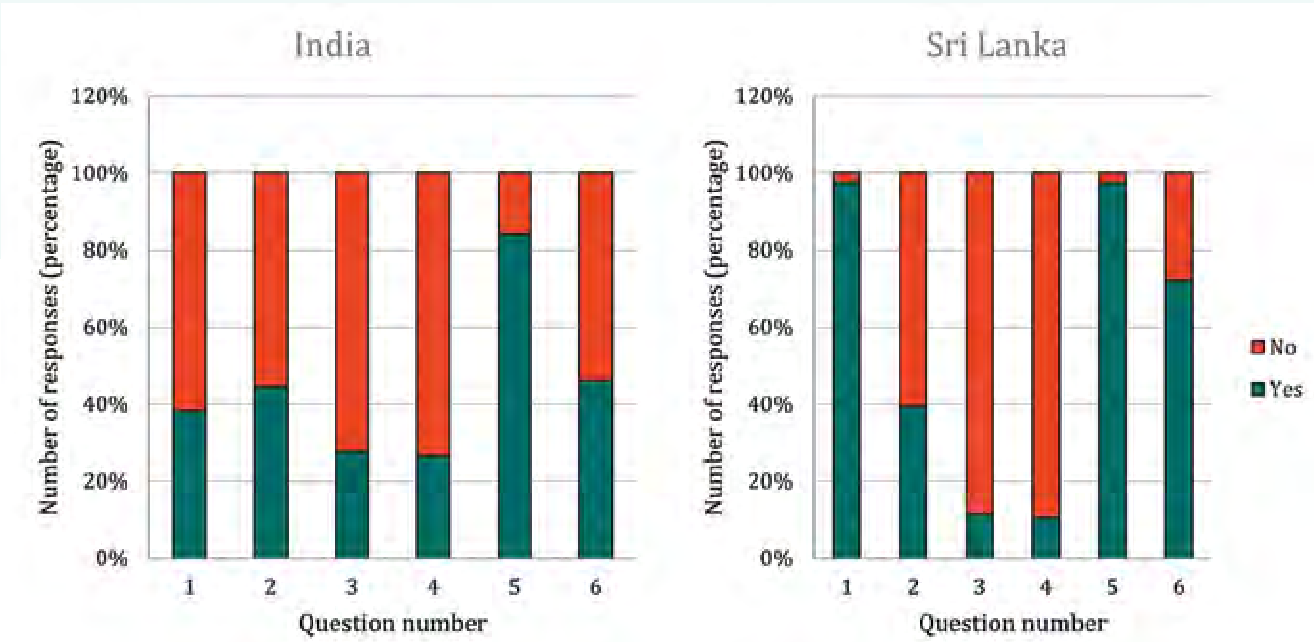


Figure 19. *Answers “Yes/No” from Indian and Sri Lankan fishers respectively. Six questions were posed to fishers:*
1. Do you understand that improperly dumped fishing gear can cause damage to fishing grounds and species?
2. If you understand that discarded fishing gear could cause damage to fishing grounds and fish stocks, have you made any attempts to reduce dumping of old fishing gear (at sea or on the beach)?
3. Has there been any discussions on ALDFG in your area?
4. Has the Department of Fisheries and Aquatic Resources (DFAR) discussed this issue with you?
5. Will you support a system that will collect old fishing gear by handing in your old gear?
6. Do you try to retrieve gear (nets) when the gear gets entangled on shipwrecks and reefs?

To understand what causes the gear to get lost at sea, the fishermen were asked to name the reasons for the loss freely. Answers were grouped arbitrarily into the categories in Figure 20. Responses show that a multitude of important causes for gear loss exists. In Sri Lanka, "bad weather" is perceived as the most common cause. In India, "bottom snagging" of gear is regarded as the most common cause of gear loss.

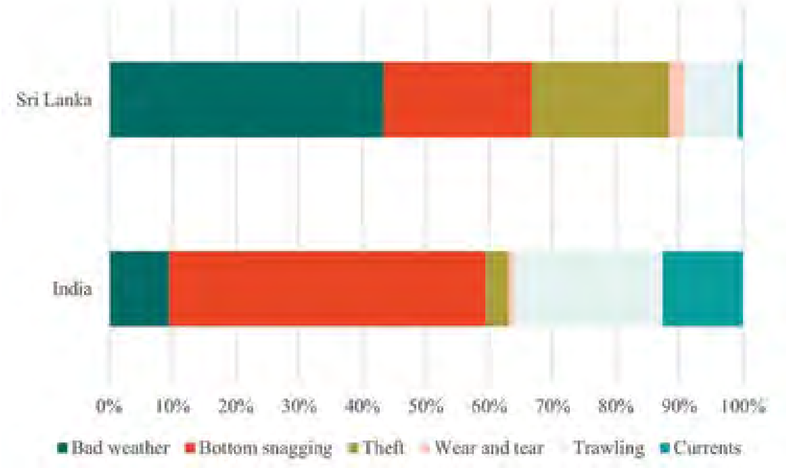


Figure 20. *Relative distribution of the fishers' responses: reasons that cause the loss of fishing gear at sea.*

3.7. Summary of Solid Waste Dumping Areas

According to the study and the interviews conducted with fisherfolk in the region, the Indian fisherfolk indicated that there is no relevant infrastructure to dispose the derelict fishing gear in their area. Most forms of fishing gear have a finite life span, after which time they can no longer be used and must be disposed of. Therefore, the cost and lack of suitable shore-side collection facilities for unwanted or old gear are critical issues that drive the fishers' disposal of unwanted gear. The adequacy of facilities for the safe disposal of unwanted fishing gear ashore and any related disposal costs when facilities are available may be an important determinant in reducing the problem of ALDFG, both at sea and on shores. Among the 12 study sites, notable solid waste sites near the shore were observed in only two locations (Pamban and Vedalai) in the Ramanathapuram District. The area coverage of the solid waste dump site is 192 m^2 in Pamban, while Vedalai has an area of 321 m^2 in site 1, 180 m^2 in site 2, and 111 m^2 in site 3. About 65% of this litter is mainly plastics, aluminium, and glass. The remaining 35% of litter are fishery bycatches. The fishing gear consists of various synthetic polymers, including polyamide (nylon), polyethylene, and polypropylene, contributing significantly to plastic waste. The polymers on the solid waste deposits near the beaches could be transported via ocean currents or tides and may accumulate with sedimentation.

Table 6: Assessment of solid waste dumping areas for marine debris and ALDFG at 12 study sites in India. Dumping sites were found only in Pampan and Vedalai. No dumping sites were found in Dhanuskodi, Keelakarai, Ervadi, Vaipaar, Vellapatti, Thirespuram, Inigonagar, Harbour beach, Singithurai, Amalinagar

Sampling sites	No. of dumping sites	Solid waste dumping area (m2)	Waste composition
Pamban	1	192	Domestic waste (100%) (plasticbottles, covers, clothes)
Vedalai	site (1)	321	Fishing nets (25%), buoys (25%), ropes (20%), and domestic waste (30%)
	site (2)	180	Fishing nets (50%), buoys (25%), and domestic waste (25%)
	site (3)	111	Fishing ropes (30%), nets (25%), traps (10%), buoys (15%), and domestic waste (20%)

Photo: © SDMRI

Photos: © Anja Støkkan

Good Practices to Reduce Litter from Fisheries in the Region

To find good practices, we have scanned available literature and contacted relevant regional stakeholders to collect information on tried and tested practices that have been proven successful in preventing, mitigating, or remediating marine litter from fisheries. The recent publication from FAO (Giskes, 2022) has has gathered precisely this, which is worth highlighting.

Challenges and mistakes in case implementations are generally less documented and harder to identify in literature; however, just as important is to acknowledge success factors. Dialogues with some of the mentioned case examples are recommended when moving forward in the MARESSOL project to build a deeper understanding of project implementations and lessons learned from other projects.

Identified good practices can cover the prevention, mitigation, or remediation of ALDFG and its impacts. Solutions often imply close involvement of several sectors, including government agencies, private organizations, and NGOs/civil societies. In general, creating successful management solutions against ghost gear tend to follow a consistent path, as depicted in Figure 21. Different solutions can be directed toward different parts along the seafood value chain. Hence, solutions must identify and handle key stakeholders along that value chain for the specific geography and local context.

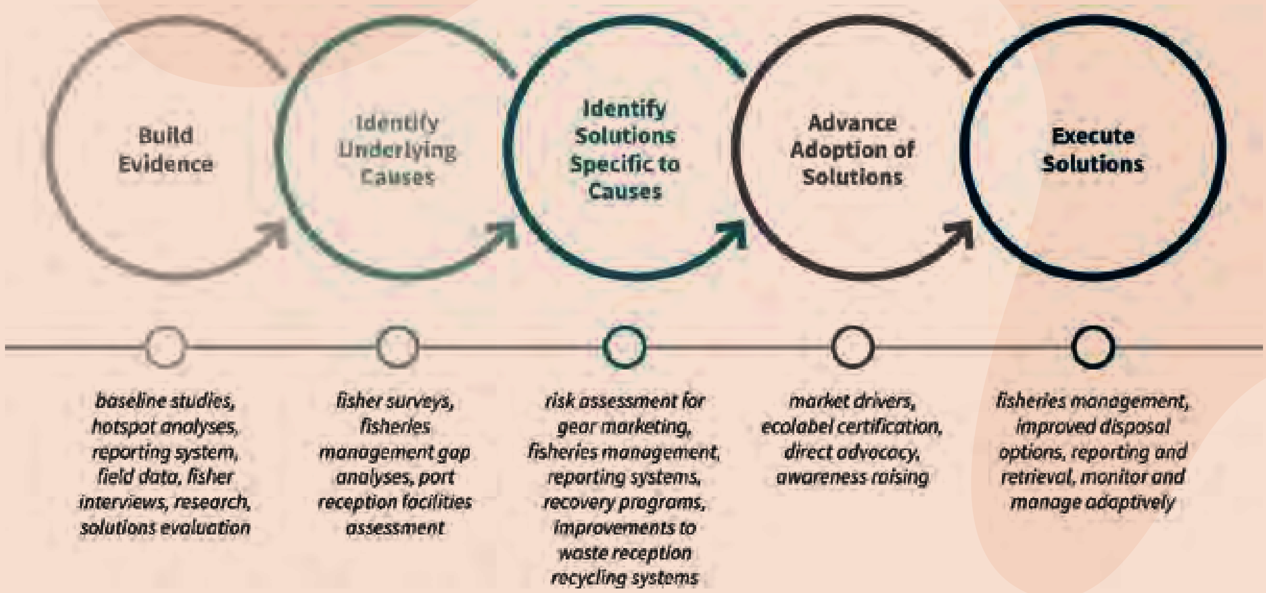


Figure 21. Pathway to ghost gear management solutions. Source: (Global Ghost Gear Initiative, Unknown year)

On a general level, recommendations from the Global Ghost Gear Initiative (Unknown year) point to five pillars around which to build solutions to prevent ALDFG:

1. Research and building evidence
2. Policy and advocacy
3. Fisheries management
4. Market-based solutions
5. Community-based solutions

Solutions to reduce litter from fisheries can be developed based on a combination of these five pillars, e.g., take-back waste management schemes can result from evidence, policy programmes, community engagement initiatives, and market-based solutions. Below is a non-exhaustive list of common and ubiquitous types of solutions, which will have to be tailored to the specific type of fishery and local context (Global Ghost Gear Initiative, Unknown year).

Table 7: List of common and ubiquitous types of solutions to prevent and remedy marine litter from fisheries. Inspired by contents from Global Ghost Gear Initiative's report Effective Ghost Gear Solutions

Fishing practices	Gear design	Reporting and retrieval programmes	Collection systems	Waste management and recycling	Education and awareness
Decrease gear conflict	Product quality and fitness	Mandatory loss reporting	Accessible waste reception facilities for fisheries	Re-use and Upcycling initiatives for ALDFG	Awareness and knowledge through fisheries students' programs
Seasonal restrictions	Ease of use	Removal and clean-up programmes	Buyback programmes and sound pricing system for ALDFG	Financially viable recycling systems for ALDFG	Programs directed towards professional fishermen
Gear marking	Biodegradability				
Adequate space for onboard waste storage					
Retrieval of lost equipment on board					

In the following sections, a number of good practice case examples are briefly described. It is not an exhaustive list, but rather a selection of relevant cases that could be considered and entered into dialogues with the aim to develop and promote prevention, mitigation and remediation measures in Sri Lanka and India, respectively, to arrest marine litter in the om fisheries sector. The cases have been categorized in the below matrix to give an overview of the different types of solutions described.

Table 8: Overview of good practice case examples described in this report

	Fishing practices	Gear design	Reporting & retrieval programmes	Disposal systems	Upcycling & recycling systems	Education & awareness
Research & building evidence		8	8, 15	13, 14		
Policy & regulation		1			6	
Market-based solutions				5, 7, 10, 11	3, 4, 5, 7, 10, 11, 12, 14	
Community-based solutions			2, 9, 15	4, 7, 9, 11	4, 7, 14	4, 7, 9

Case 1: Development of a Best Practice Framework in APEC to Address ALDFG

In brief: Capacity building amongst member countries in the APEC to combat ALDFG and IUU.

Project organization: Funded by the APEC and member countries.

Scope and extent: 2020-2022.

Through regional cooperation, led by the Asia-Pacific Economic Cooperation (APEC), the project[32] aims to build member economies' capacity (mainly Thailand, Malaysia, and the USA) to manage the challenges with ALDFG through policymaking and encouraging fieldwork to find local solutions. Workshops and collaborative efforts will share best practices and lessons learned from the involved countries. The project is based on the principles outlined in FAO's Voluntary Guidelines on the Marking of Fishing Gear, and the Global Ghost Gear Initiative's (GGGI) Best Practice Framework for the Management of Fishing Gear for Wild Capture Fisheries. The project is structured around three core outputs: 1) ALDFG Best Practices Guide for the APEC region, 2) APEC Regional Compendium of Gear-Marking Schemes, and 3) Regional stakeholder workshop on ALDFG.

Case 2: Buyback of Litter Caught by Fishermen in South Korea

In brief: Buyback programme of litter caught by Korean fishermen.

Project organization: Funded by the Central Government of Korea and local governments. Operationalized through the Fisheries Cooperative Union.

Scope and extent: In operation in major ports of Korea since 2003. 29,472 tons collected between 2003-2008 at a cost of USD 19,417 (Morishige, 2010).

A successful buyback programme has been in operation in major ports in Korea since 2003 (MERRAC, 2015; Morishige, 2010). Based on the National Basic Plan of Marine Litter Management (2009), the Central Government of Korea and the local governments provide funds for the programme, purchasing marine litter voluntarily brought to shore by fishermen at the designated ports. The programme does not include end-of-life gear but only marine litter caught by the fishermen. The Fisheries Cooperative Union distributes the sacks to fishermen as they leave port, and fishermen deliver filled sacks labelled with their vessel name, fishing type, and contact details back to the Cooperative. Morishige (2010) reports that the buyback programme is a cost-effective way to remove seabed litter by utilizing the efforts of fishermen already at sea and providing an extra source of income for fishermen while making them more aware of the problems with ALDFG.

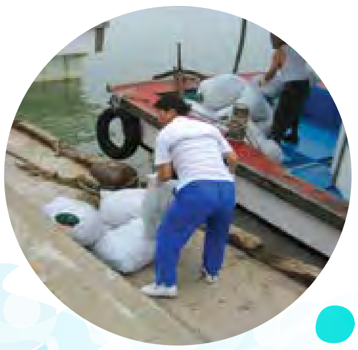


Photo: © Morishige, 2010

[32] https://aimp2.apec.org/sites/PDB/Lists/Proposals/DispForm.aspx?ID=2665

Case 3: Aquafil – Industrial Scale Nylon Recycling for Fishing Gear

In brief: A global leader in recycling of nylon filaments.

Project organization: : The company Aquafil has headquarters in Italy where it was founded in 1965. Now Aquafill has 20 factories globally. The closest factory to India and Sri Lanka being located in Thailand.

Scope and extent: Aquafil has a global sourcing network of nylon fibers from discarded fishing gear textiles and carpets. They produce nylon yarn for carpets, textiles and polymers as well as being invested in plant engineering for the design of industrial plants for chemical and polymer industries.

Aquafil's factory in Thailand. Photo: © Aquafil.com

Aquafil is a well-known recycling agent for discarded fishing gear made of nylon. Their processing technology involves “depolymerization” to achieve high-grade new materials, with the most renown product being “ECONYL®”.

Screen shot of Aquafil's landing webpage, aquafil.com. Here, the main product Econyl is showcased, which is a yarn fabric made from recycled nylon waste, such as fishing nets.

Case 4: Net Free Seas in Thailand

In brief: Through a value chain approach, Net Free Seas provides fishermen with alternative ways of disposing used nets, rather than burning them on site or sending them to landfills (Giskes et al., 2022).

Project organization: Launched in early 2020 by the Environmental Justice Foundation. The project is funded by the Norwegian Retailers' Environment Fund and Rufford Foundation and supported by the Department of Fisheries in Thailand, the Department of Marine and Coastal Resources, and the Department of National Parks, Wildlife and Plant Conservation. The project covers both the Gulf of Thailand and the Andaman Sea. Involved collaborative stakeholders are Ranong Recycle for Environment (operated by the Jan & Oscar Foundation), NatureMind-ED, Qualy (a Thai recycling and end-user product company), Teamplas and Micro Precision (recycling and manufacturing companies), and local NGOs and associations for artisanal fishermen. Thai research institutions are involved in conducting plastic material quality tests.

Scope and extent: Giskes et al. (2022) report that the project had collected 16 tons of fishing nets through clean-ups from 76 communities, or 1,500 fishers, across Thailand as of August 2021.

The project has introduced a value chain for used nylon (PA6) fishing gear, educated local coastal communities on marine litter, and helped them make waste management part of their daily practices. The company Qualy purchases discarded nets from communities participating in the project. The money goes to the community as direct payments or a community fund. Qualy brings collected nets to a factory, where they are cleaned, shredded, and melted into pellets. The pellets are then sold to companies producing high-quality consumer goods, such as water sports equipment, household wares, face masks, and carpets.

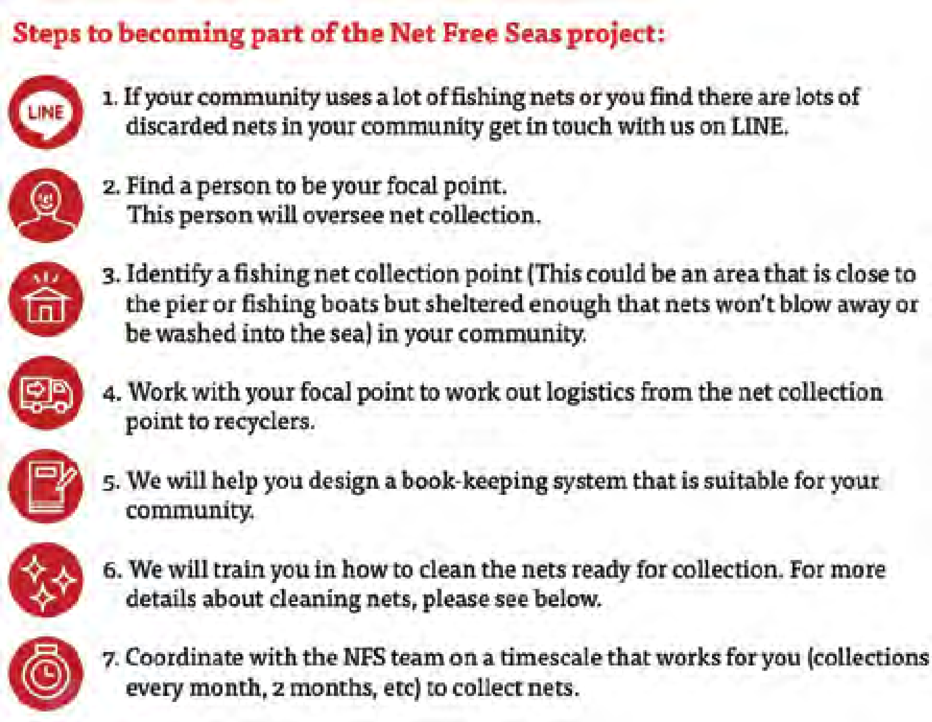
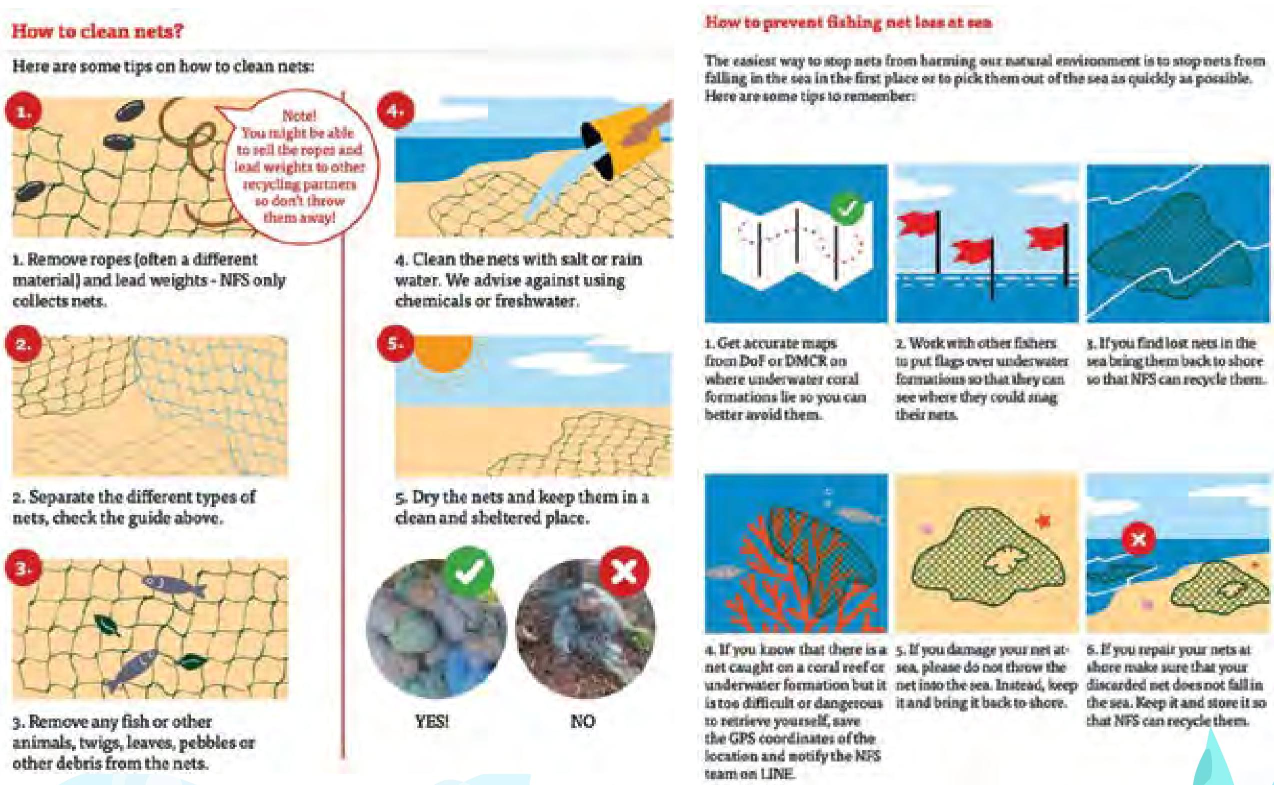


***Figure 22.** Step-by-step guide for fishers on how to become a part of the Net Free Seas project. **Source:** EJF (2021)*

The project has released a "*Net Free Handbook for Fishers*" (EJF, 2021), including several step-by-step guides directed towards easy communication with fishers on:

- How to become a part of the project, see Figure 22.
- A simple and illustrated guide on what types of gear and material types are accepted by the collection scheme, which currently only includes monofilament nylon.
- Simple tips on how to prevent net losses, see Figure 22 below.
- A simple and illustrated guide on cleaning and preparing nets for collection, see Figure 22 below.



Case 5: Ocean Plastics Scheme for Artisanal Fishers in Thailand

In brief: Plastics collected by artisanal fishermen are collected and sorted by local minority groups.

Project organization: Implemented by the Jan and Oscar Foundation as part of the IUCN MARPLASTICC's initiative.

Scope and extent: In operation since 2019, a small-scale initiative in the Andaman Sea.

The project 'Moken Guardians of the Sea: Safeguarding the Ocean from Plastics' in Southern Thailand[33] buys plastic from artisanal fishers to develop new products. Since April 2019, the Foundation has managed a plastic sorting facility with direct access to the sea in Ranong. It allows fishermen to bring and sell plastic with their long tail boats directly at the pier. The project provides education and housing for young students, as well as employment and income opportunities for women and precarious local minorities, including the Moken, an ethnic group of semi-nomadic fishing people who live on several islands in the Andaman Sea. According to Jain and Raes (2021), it will be difficult to scale up the initiative or similar ones, providing an additional source of income for small-scale fishers, if not recycling incentives, and the demand for recyclable plastic is strengthened.

Case 6: Circular Economy Solutions Preventing Marine Litter in Ecosystems in India

In brief: Development of extended producer responsibility schemes in India.

Project organization: Funded with EUR 5,000,000 by the German Society for International Cooperation (GIZ).[34]

Scope and extent: Duration from 2020-2023, India.

The project "Circular Economy Solutions Preventing Marine Litter in Ecosystems" (CES) is an ongoing project aiming to develop ways to implement EPR schemes with the involvement of private-sector actors, such as recycling agents, the packaging industry and informal workers in the waste sector. The project also works with the Indian Ministry of Environment, Forest and Climate Change to demonstrate technological approaches for tracking and monitoring waste in marine ecosystems. The project is not specifically targeting litter from fisheries but plastic litter in general.

[33] The project is part of the IUCN Marine Plastics and Coastal Communities initiative (MARPLASTICCs)

[34] CES project: https://www.z-u-g.org/en/responsibilities-and-tasks/grant-programme-against-marine-litter/project-overview/india-ces/

One key prevention strategy identified was to build **end-of-life gear disposal**, which was then implemented by constructing a "hubnet" of collection sites consisting of semi-permanent structures where **fishers can dispose of either old or damaged gear. The handed-in gear is then recrafted to new products.**

Case 7: Fishing Net Gains Project in Nigeria

Photo: SOFER Initiative

Project organization: Run by the SOFER[35] Initiative. The project is supported by the Ocean Conservancy's Trash Free Seas® programme, the Global Ghost Gear Initiative®. (GGGI), PADI, Fisheries & Oceans Canada, and the World Animal Protection. The project has received funding from the Joanna Toole Ghost Gear Solutions Award.

Scope and extent: Started in 2019, ongoing primarily in the Nigeria and West Africa regions.

The SOFER's Fishing Net Gains programme, initiated in Nigeria, addresses ghost fishing and other related threats to marine life by creating economic opportunities for coastal communities—especially women and youth. In the project's initial stage, SOFER conducted interviews and surveys with 100+ stakeholders in Nigeria (later also in Cameron and Ghana), including community leaders, ministry officials, and fishers, to understand the problem with ALDFG. Later, a multi-stakeholder workshop was held to share information, raise awareness and build capacity. A nine-part action plan was then shaped for combatting ghost gear in Akwa Ibom coastal communities, based on the GGGI (Global Green Growth Institute) Best Practice Framework for the Management of Fishing Gear. One key prevention strategy identified was to build end-of-life gear disposal, which was then implemented by constructing a "hubnet" of collection sites consisting of semi-permanent structures where fishers can dispose of either old or damaged gear. The handed-in gear is then recrafted to new products. The project is scaling up in West Africa, trains volunteer dive corps, and conducts underwater surveys and removals.

[35] https://soferinitiative.org/project/fishing-net-gains/

Photo: © Dinithi Samarathunga

Case 8: Gear Marking in Indonesian Small-Scale Fisheries

In brief: Piloting of fishing gear marking for small-scale fisheries to assess its practical and economical feasibility, with aims to reduce illegal, unreported, and unregulated fishing (IUU) in Indonesia.

Project organization: Partnered by the Indonesian Ministry of Marine Affairs and Fisheries, World Animal Protection, and the FAO.

Scope and extent: Pilots conducted in 2017, Indonesia.

The Indonesian Government supported the FAO in conducting a pilot project on marking fishing gear to address the country's high abundance of ALDFG and the increasing threat of IUU fishing. The project's key aims were to assess the practical and economical feasibility of various gillnet gear marking options for small-scale and artisanal fisheries and to prove gear marking as a management system to help reduce ALDFG and IUU in a developing country. The project was carried out also to underpin the recommendations of the draft FAO Guidelines on the Marking of Fishing Gear[36] and to scope the viability of a net recovery and/or recycling project (Dixon et al., 2018).

Photo: FAO (2018)

Two pilot sites were selected in Java: 1) in "Pkalongan," where low rates of gear loss were reported due to both favourable weather and sandy, muddy sea-bottoms (reducing the risk of nets snagging); 2) in "Sading,k," where fisheries operated in deeper waters in less favourable weather and with higher rates of gear loss.

Low-cost tags of different types were tested in trials and assessed based on criteria for pollution risk; safety; ease for fishermen in operation; cost; lifespan; ease of monitoring; and material availability.

A list of recommendations was compiled, indicating a need to build greater understanding and acceptance amongst fishermen of the benefits of gear marking, the ability to retrieve the gear when lost and the need for environmentally-friendly tags. Gillnets were of low value in Indonesia due to government subsidy programmes; hence, there was a limited incentive to retrieve lost nets, although repair and reuse of damaged gear were common. The extra cost induced on small-scale fisheries by technical marking may apply a challenge, which is recommended to be addressed by marking during manufacturing and adding value to the gear's end-of-life. Gear marking for small-scale fisheries in Indonesia is deemed not a solution on its own. However, it must be combined with other management approaches to effectively combat ALDFG, such as fisher education and awareness raising, spatial management of fishing efforts, and a circular economy approach to managing end-of-life gear.

GEAR MARKING FOR SMALL-SCALE FISHERIES IN INDONESIA IS DEEMED **NOT A SOLUTION ON ITS OWN.**

[36] FAO Guidelines on the Marking of Fishing Gear: https://www.fao.org/fileadmin/user_upload/COFI/COFI33Documents/MX136_COFI_2018_Inf30en.pdf

Case 9: Fishing for Litter in Europe

In brief: Marine litter caught by fishermen delivered free of charge at port reception facilities sorted for recycling.

Project organization: National authorities funding collection and waste management.

Scope and extent: Started in 2004 by KIMO[37], now active in 10 European countries.

'Fishing for Litter' is a state-financed programme where associated fishing boats are given big bags to collect litter and ghost gear caught in their nets during normal fishing operations. The programme collaborates with selected ports to make available port waste reception facilities, which are free of charge for fishing boats. Waste is sorted and sent to recycling facilities to as much as possible. Fishermen receive information on programme updates, waste amounts collected and recycled, and diplomas from the administrative bodies of the programme, providing an important feedback mechanism to fishermen.

The programme not only enables and encourages the volunteering fishermen to remove litter from the ocean, but also raises awareness of the impact of marine litter and has a documented effect on changing the fishers' behaviour while at sea.

The programme, endorsed by the OSPAR Commission, encourages its 15 member countries to adopt Fishing for Litter programmes as part of its Regional Action Plan against marine litter. The European Commission also recognizes FFL as a best practice; it is part of the United Nations Environment Programme Mediterranean Action Plan (for the Barcelona Regional Sea Convention).

Photo: © Carl Höjman

Fishing Gear Return Schemes in Northern Europe

Several well-established industrial value chains collect, sort, clean, and recycle discarded fishing gear. As summarized in a report by the Norwegian Center Against Marine Litter (Höjman et al., 2022), a multitude of projects are ongoing or in development in Northern Europe to inform policy-making, education, and awareness initiatives to prevent ALDFG, research, and development on the design of fishing gear to prevent loss and impacts. Below, a few examples have been described in brief.

- Nofir is a Norwegian company that, since 2011, has collected over 54,000 tons of discarded fishing and fish farming equipment.[38] Nofir collects large container batches at local deposits in Europe, e.g., from ports, net lofts, waste facilities, washing facilities, or aquaculture sites. Nofir then transports the feedstock (e.g., purse seine nets, trawl nets, gill nets, ropes, and plastic aquaculture gear) to factories in Lithuania or Turkey, where the gear is dismantled and prepared for recycling. Nofir has partnered with Aquafil in Slovenia to turn the discarded gear into ECONYL filaments from nylon yarns through chemical recycling. Other recyclable fractions are made into pellets by partner recycling agents. End products are automotive parts, garden furniture, carpets, and textiles.
- In Sweden, a national collection scheme ("Fiskereturen"), financed by the central authorities and small collection fees, is operated by a national fisheries association. Collected ALDFG and EOLFG are then sent to a manual disassembly and sorting facility (Marin återvinningscentral Sotenäs) owned by a municipality. Sorted fractions (recyclable plastic fractions; PE, PP, PA, PET; and metals) are then sold to recycling agents. Hundreds of tons of gear are treated annually. The value chain is also the basis for a policy and research project run by

[37] https://www.kimointernational.org/
[38] Nofir: https://nofir.no/en/sustainability/

Swedish national authorities to implement EPR on plastic fisheries equipment according to the EU's SUP Directive.

- An estimated 80% of nets are recycled in Iceland, where the "Fisheries Iceland[39] Return Scheme" allows for free-of-charge delivery by fishermen to waste reception facilities of certain gear types. The setup stimulates gear users and producers by allowing free-of-charge delivery of certain plastic materials that are easy to recycle. The scheme is financed by the Icelandic Recycling Fund, established by Icelandic authorities to enact producer liability. Fisheries Iceland operates the scheme in collaboration with the fishing industry and foreign recycling agents.
- Aion[40] is a Norwegian company delivering "Circulariy as a Service" by implementing a digital platform for end-customers to source recycled plastics and feed them back into closed material loops after use, recording a digital trail of information about the material's origin and environmental footprint. They source feedstock from companies like Oceanize[41] while partnering with plastic product manufacturers to produce plastic food trays, transportation pallets, shopping baskets, and more.

Case 10: Net+Positiva in Chile and Peru

In brief: Value chain for collection and recycling of end-of-life fishing gear.

Project organization: Commercial value chain.

Scope and extent: 600 tons recovered from 50 fisheries in South America since 2013. Only in 2022, 400 tons were recycled.[42]

Net+Positiva began in Chile in 2013 and was replicated in 2019 in Peru.[43] It is an ongoing collaboration between GGGI, Bureo,[44] and the World Wildlife Fund (WWF), creating a circular value chain for ALDFG by providing the fishing industry an alternative to discarding nets into the marine environment. Just as with the MARESSOL project, an assessment of the impacts of ALDFG was initially conducted in Peru. WWF and Bureo set out to better understand the challenges fishers face with disposing end-of-life fishing gear, motivating factors to improve practices, and what capacities and resources will be needed to create a systematic collection and recycling system for ALDFG.

Photo: Bureo: Net Positiva

When establishing the business in Peru, three fishing ports were selected as collection points based on their importance regarding gillnet fisheries and purse seining for anchovy. The three main anchoveta fishing companies were asked to donate discarded purse seine nets to finance the engagement of artisanal gillnet fishing communities. The fish producers are motivated to reduce their impacts on the marine environment and contribute to the artisanal fisheries communities. The collector covers transportation costs of EOLFG from fisheries communities (i.e., the fishers can hand it over for free). The operator on the ground, Bureo, works with well-known retail brands to create private consumer goods made from recovered nets, where the share of recycled material in products is communicated to consumers. The goal is to reach a capacity of 1,000 tons of recycled nets per year. According to the Bureo webpage,[45] the company has recovered 600 tons from 50 fisheries in South America since 2013. Only in 2022, 400 tons were recycled.[46]

[39] Fisheries Iceland: https://csr.sfs.is/fishing-gear/

[40] Aion: https://www.aion.eco/

[41] Oceanize is a Norwegian recycling agent, providing mechanical recycling of PE/PP hard plastics, ropes, nets and floats: https://oceanize.no/en/

[42] Verbal reference from Andrea Stolte (WWF Germany) at FAO webinar 10.10.2022

[43] www.ghostgear.org/projects/2018/11/21/qf8ta90ssp85rbkpd6cqhls0w2mnfi

[44] https://bureo.co/pages/netpositiva

[45] https://bureo.co/pages/netplus

[46] Verbal reference from Andrea Stolte (WWF Germany) at FAO webinar 10.10.2022

Case 11: Fishing Gear Collection and Recycling in Sri Lanka

In brief: Small-scale collection of discarded fishing gear in Sri Lanka for international export.

Project organization: Operated by a local private actor, the intial funding was provided by the MAS Foundation and USAID, while additional funding was provided from the plastic credits allowed by Empower.

Scope and extent: Started operations in 2021, collecting from nine areas in Sri Lanka.

Local waste collectors associated with the private initiative Lanka Upcycles collect discarded fishing gear from fisheries communities.[47] Between the period of February 2021 to August 2022 a total of 2.27 MT was collected. The collected feedstock was sent to the private plastic recycling operator EcoSpindles[48] in Sri Lanka. An unknown fraction is exported to Aquafil[49] for processing abroad.

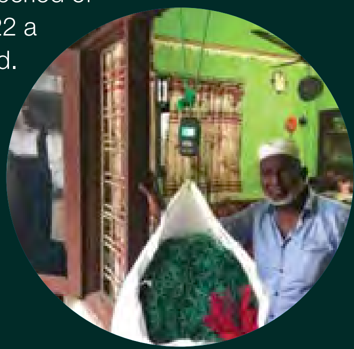


Photo: Lanka Upcycles

Case 12: Upcycling of Waste at Rice & Carry in Sri Lanka

In brief: Upcycling of used plastic products.

Project organization: Operated by the private social enterprise Rice & Carry[50] in Eastern Sri Lanka.

Scope and extent: In operation since 2012.

The social enterprise Rice & Carry staff employs over 40 women to produce new consumer goods from used plastic products. Over 60,000 rice and jute bags and 120,000 plastic bottles are collected annually. Their enterprise is registered as a World Fair Trade Organization. Rice & Carry is an inspiring case of local employment following high ethical standards for creating new value from plastic waste.

Photo: Lanka Upcycles

[47] https://www.lankaupcycles.com/
[48] https://www.ecospindles.com/
[49] https://www.aquafil.com/
[50] https://www.riceandcarry.eu/en/

Case 13: Fishing Net Collection and Recycling Pilot in Sri Lanka

In brief: Pilot establishing a financing scheme for the collection and recycling of discarded plastic fishnets in Galle, Sri Lanka.

Project organization: Funded by Norad, as part of the project 'Marine Litter and Microplastics: Promoting the Environmentally Sound Management of Plastic Waste and Achieving the Prevention and Minimization of the Generation of Plastic Waste', and implemented by the BRS Secretariat and the Ministry of Environment of Sri Lanka. Cooperating partners include the Institute for Global Environmental Studies and, for the pilot, the local NGO Help-O. A steering committee composed of relevant government stakeholders and fishermen representatives oversees the implementation of the pilot. Data gathering, planning, and consultations took place in 2022, and the pilot will be implemented in 2024.

Scope and extent: Started in 2022 and planned to last until 2024. Implemented in Galle; plans for future replication/scale-up beyond the project duration across the country are being explored.

Photo: BRS Secretariat

The project is investigating establishing a sustainable value chain for recycling plastic fish nets in Sri Lanka, starting with a pilot project in Galle. Initially, several consultations were held with fishing communities around Galle. Fishers have so far shown strong interest in participating. It is estimated that there are approx. 310 fishing boats in the area around Galle, discarding approx. 15 tons of fishing nets of nylon per year, while tenfold (150 t/y) for the whole of Sri Lanka. Currenlty collected fish nets need to be exported for recycling since no recycling facility in Sri Lanka has the required technical capacity. Exports are deemed costly, so developing a a domestic value chain for recycling is being explored. The Sri Lankan Ministry of Environment is engaged and supports the project proceedings.

IT IS ESTIMATED THAT THERE ARE **APPROX. 310 FISHING BOATS** IN THE AREA AROUND GALLE, **DISCARDING APPROX. 15 TONS OF FISHING NETS OF NYLON PER YEAR, WHILE TENFOLD (150 T/Y) FOR THE WHOLE OF SRI LANKA.**

Case 14: Net Collection Pilot in Ghana

Inspection of nets during the pilot testing of a collection scheme for waste fishing nets in Ghana 2021. Photo: © Öko-Institut e.V.

In brief: Pilot project focusing on establishing a value chain for discarded fishnets in Jamestown, Accra, Ghana.

Project organization: Implemented by SCYCLES[51] (a local NGO), the Öko-Institut e.V.[52], the Ministry of Environment, Science, Technology & Innovation (MESTI[53]) of Ghana, and the BRS Secretariat[54], with funding from Norad.[55]

Scope and extent: 2019-2022.

The pilot project in Accra was implemented in the context of the project 'Marine Litter And Microplastics: Promoting The Environmentally Sound Management of Plastic Waste and Achieving the Prevention and Minimization of the Generation of Plastic Waste', funded by Norad and in parallel implemented in Sri Lanka (see "Case 14").

Documentation[56] of the pilot project was made public during a workshop on March 31, 2021, which intended to inform and involve government officials, the private sector, and civil society about the long-term potential of the concept following the pilot. The pilot launched an incentive-based collection system for plastic waste fishing nets in Jamestown, Accra. More than 700 kg of discarded plastic fishing nets were collected biweekly with high support from the local fishing community. A survey was conducted with fishers and sellers of discarded nets as part of the project (in 2020 with 35 respondents), indicating that fishers largely disagree with dumping fishing gear in the sea and that marine litter is a problem and a challenge for fisheries. Ninety-one percent agree that discarded fishing gear lacks a proper waste management system, with waste management agencies regarded as having the biggest responsibility to manage marine litter. At present, 57% sell out discarded fishing gear, while 37% burn it. Only 3% leave it on the shore. The respondents were interested (86%) in participating in nets collection should there be a functional system.

Pricing of discarded nylon and cotton nets were respectively considered and tested. The cost structure for different recycling options downstream was evaluated (export sales to Sea2See for the manufacture of sunglasses in Spain or export to Aquafil for recycling). Assembly/collection points for discarded nets were identified. The collection was done every second week with a monetary incentive. The encouraged payment method was using mobile money. Replication and scale-up of the pilot are currently ongoing.

[51] https://mountainresearchinstitute.com/Scycles.html
[52] https://www.oeko.de/en/
[53] https://mesti.gov.gh/
[54] http://www.brsmeas.org/
[55] https://www.norad.no/en/front/
[56] http://www.basel.int/Implementation/Plasticwaste/Technicalassistance/Workshops/GhanaWorkshopOnlineMay2021/tabid/8884/Default.aspx

Photo: © Christine Fagerbakke / Norwegian Institute of Marine Research

Case 15: Diver-Based Cleanup of Raet National Park in Norway

In brief: The project's ambition is zero ghost fishing in the national park, to be realized by systematically removing lost fishing gear by trained divers and using underwater technology for mapping and removal. Research and insights from the project are disseminated to similar cleanup projects in Norway.[57]

Project organization: Led by the Norwegian "Institute of Marine Research,"[58] Green Bay,[59] and voluntary organizations involved in the cleanup and removal actions.

Scope and extent: 2020-2021.

Through close collaboration between the Norwegian Institute of Marine Research and municipalities, diver organizations, and local volunteer organizations, a good overview of the types of lost gear and its distribution in the national park of "Raet" have been gathered.

The project's first stage tested different methods for cleaning up the sea bottom to find best practices, as well as researching what measures could help prevent fishing gear from getting lost in the first place. The project's second stage involved systematic cleanup actions in the year 2021.

[57] https://handelensmiljofond.no/prosjekter/raet-nasjonalpark - Page only in Norwegian

[58] https://hi.no/hi/en

[59] https://green-bay.no/

Photo: © Chanaka Sooriyabandara

5 Recommendations and Avenues Towards Systemic Solutions

The main avenues to curtail ALDFG and ghost fishing can be categorized as Regulation & Policy, Waste Management, Litter Removal, Further Research, and Awareness & Education. This chapter gathers recommendations for each of these themes based on findings in this report.

Public authorities, such as the State Fisheries Department, will be key in implementing many of the recommendations and action plans below. Wherever required, other relevant enforcement and conservation departments like Forest Department, Environment Department, Marine Police, and Coast Guard may be actively involved.

Marine National Parks, Biosphere Reserves, and Sanctuaries with eco-sensitive habitats (coral reefs, seagrass beds, mangroves, etc.) shall be a high priority in controlling and managing ALDFG with relevant Departments like Forest and Environment.

This report has identified some of the most pressing issues and causes for fisheries-related litter in nature as ALDFG. These are summarized in Table 9 below. An associated brief description of potential measures and target stakeholders is also included in the table. In the following sub-sections of this chapter, the same issues and related measures are described in more detail, categorized by theme (e.g., "Regulation & Policy").

MARINE NATIONAL PARKS, BIOSPHERE RESERVES, AND SANCTUARIES WITH ECO-SENSITIVE HABITATS (CORAL REEFS, SEAGRASS BEDS, MANGROVES, ETC.) SHALL BE A **HIGH PRIORITY IN CONTROLLING AND MANAGING ALDFG WITH RELEVANT DEPARTMENTS LIKE FOREST AND ENVIRONMENT.**

Photo: © Terney Pradeep

Immediate action (<1 yr)	
Medium-term action (1-3 yrs)	
Long-term action (3+ yrs)	

Table 9: A summary of identified issues related to ALDFG in the Gulf of Mannar and Palk Strait. Corresponding measures for each issue are proposed and potential stakeholder groups for realization of measures are suggested.

Identified issues	Related theme	Potential measures	Intended stakeholders
Lack of awareness and knowledge amongst fishers about losses of fishing gear, its impacts, and possible mitigation measures	Awareness & Education	Information posters at fish landing sites, adapted to local conditions.	Fishers, authorities
		Strengthening citizen science approaches by engaging fishers in surveys and cleanup programmes.	
		Improved waste management onboard and improved routines for gear maintenance according to the international standard on "Waste reduction and treatment on fishing vessels" (ISO 5020:2022).	
		Efforts to educate fishers through established programmes or digital channels.	
Lack of alternative livelihood options to supplement the income of fishers	Building Resilience	Establishing Public-Private-People Partnerships (PPPPs) to setup Environmental, Social and Governance (ESG) programmes such as alternative livelihood training courses and insurance schemes.	Intended stakeholders
Lack of incentives to reuse, recycle or recover fishing gear and fishers' waste	Regulation & Policy: Waste Management	Legislate extended producer responsibility for fishing gear. Follow the implementation examples in the EU.	Authorities, producers, importers
		Test take-back solutions for used fishing gear and waste, involving economic incentives along the value chain and technical solutions downstream for material recycling.	Authorities, producers, retailers, waste collectors, waste recycling agents, fishers
		Developing recyclable fishing gear with a focus on material composition.	Authorities, producers
Gear conflict and lack of easily available statistics on losses of fishing gear	Regulation & Policy: Awareness & Education	Develop and test new reporting systems for gear placement, marking, and loss: e.g., GPS trackers and digital platforms. This could be initiated with multi-day vessels that already have Vessel Monitoring Systems (VMS).	Authorities
		Implement new legislation to make loss and retrieval reporting mandatory for all fishers.	
		Information campaigns and training programmes to roll out reporting systems.	
		Strengthening regional governments' capacities to maintain records on the regional level inflow of gear and use of gear.	
		Creating a database to regulate the import and export of gear by including more information such as clear categorization of HS codes, materials used, etc.	

Identified issues	Related theme	Potential measures	Intended stakeholders
Cleanup of lost fishing gear and waste	Regulation & Policy: Litter Removal Waste Management Awareness & Education	Local adoption of the Fishing for Litter concept that has been in operation in several countries for years by incentivizing fishers to bring back ALDFG caught in their gear during normal fishing operations. There is a strong willingness to participate in such a programme amongst fishermen in the Gulf of Mannar, according to MARESSOL's survey study. Possible financing through the sale of fishing licenses.	Authorities, fishers
		Reef cleanups by divers funded by public authorities, possibly based on gear collection funding or the sale of fishing licenses.	
		Introducing stewardship approach as a new legislation by promoting locally managed areas to provide ownership for fishers to protect marine ecosystems due to ALDFGs.	
Bottom snagging leading to gear loss and ghost fishing	Regulation & Policy	Enforcement of the ban on using nets on reef habitats.	Authorities
Fishing in marine protected areas	Regulation & Policy	Increasing the enforcement of existing fishing bans in MPAs to prevent gear loss and ghost fishing in sensitive habitats. Challenging conflicts of economic interests between the livelihoods of fishers, the seafood industry, and marine environmental protection.	Authorities
		Introducing spatial management systems and additional regulations to strengthen the protection of MPAs.	
		Addressing the challenging conflicts of economic interests between the livelihoods of fishers, the seafood industry, and marine environmental protection.	
Ghost fishing and gear design	Regulation & Policy	Legislate gear design requirements covering biodegradable components to enable release mechanisms to stop the fishing ability of, e.g., traps and pots when lost.	Authorities, academia and research organisations
		Follow international research developments and assess whether biodegradable plastics should be used with a special focus on environmental impacts.	Authorities, academia and research organisations
		Introducing a fishing gear certification mechanism to ensure the quality of fishing gear.	Authorities
		Introducing and promoting regulations for the usage of alternative materials for fishing gear (for e.g., instead of using styrofoam pieces/PET as floaters).	Authorities

Identified issues	Related theme	Potential measures	Intended stakeholders
Knowledge gaps	Further Research	Further research on: - Density and distribution of ALDFG on sea-floor habitats. - Impacts of ghost fishing on the marine environment of the Gulf of Mannar. - Material flow analysis of sold discarded fishing gear: uncover the formal and informal waste collectors and waste facilities. Map the financial structure of the value chain for different gear types and materials. - Technical capacity for material recycling of used fishing gear in Tamil Nadu: Identify capacity, gaps, and weaknesses with installed waste treatment facilities and assess technology demands. - Improved gear quality considering a multi-criteria analysis of economic, social, and environmental factors from a lifecycle perspective. - Warning systems in areas with a high risk of gear conflict to reduce the losses due to bottom tangling. - Tools such as Natural Capital Accounting and Assessment and System of Environmental-Economic Accounting to assess the environmental impact of ALDFGs, e.g., social costs due to ghost fishing through lost incomes. - The carrying capacity of fisheries in each area to prevent overfishing that leads to habitat damage. - Identifying gaps in fisheries management, regulations, and policies and mapping out stakeholders and their mandates. - How spatial mapping and machine learning technologies can help in identifying lost gear.	Academia and research organisations
Lack of a unified monitoring body and system to address, enforce and strengthen decision-making on environmental impacts	Regulation and Policy	Introducing a centralized monitoring and operationalizing body for the GoM for UNCLOS, MARPOL, Oil spills, and harvesting densities (UNFSA) as an extension of IMO.	Authorities
		Promoting a dashboard system with continuous monitoring covering ALDFG, harvesting, and other issues and engaging citizen (fisherman) participation for monitoring.	Authorities
		Strengthening guidelines for regional fisheries, harbours, and ports at different scales to reduce environment impact due to ALDFGs.	Authorities

Photo: © SDMRI

5.1. Regulation, Policy and Fisheries Management

Photos: © Dinithi Samarathunga

There is an urgent need to frame policy on marine litter at the national and state levels. Preventing litter from entering the marine environment is key to effective management. The Policy should contain explicitly stated and comprehensive rules, guidelines, and action plans with a clear focus on waste from fisheries and ALDFG.

Recovery and disposal of ALDFG and recycling are curative measures. Critical analysis of Indian gillnet fisheries shows that the gillnet sector is rapidly moving from small-scale to large-scale, at least in the mechanized sub-sector, targeting tuna and other large pelagics with the nets extending to more than 15 km, weighing up to 3,000 kg. Besides, with almost 100% adoption of nylon monofilament in small-mesh and large-mesh gillnets operated from non-motorized and motorized sub-sectors, ALDFG and ghost fishing will be a critical problem in the coming years. Therefore, future policies and regulations of fishing practices and gear design are recommended to keep marine litter and ghost fishing well in mind.

5.1.1. Gear Conflict and Gear Marking

To prevent gear conflict and subsequente gear loss, all fishing gear should be appropriately and uniquely marked to identify the ownership and location of placed or drifting gear. To make the gear marking system more effective, identification should be made an intrinsic feature of gear at the manufacturing point and recorded at the most appropriate level in the supply chain. There should also be a system for mandatory reporting of the loss of gear to the authorities (e.g., Fisheries Department). Reports should contain details such as gear identification number, date and the lost location. The manufacturing industry and government should consider efforts and means to recover ghost-fishing gear.

The Department of Fisheries and Aquatic Resources in Sri Lanka introduced a gear marking system by Gazette no. 1904/10 of March 3, 2015. The regulations stipulate that buoys and long lines should be either marked or tagged for recognition by the owners, and similar marking is mandatory for gillnets. However, in practice, fishers may not always adhere to this regulation, and the lack of offshore policing makes it difficult to enforce it. Furthermore, there are a large number of small-scale fishing craft operating off the coast, and there is no enforcement of the regulation on the small-scale fishers. Currently, this regulation is enforced only on craft operating from the fishery harbours. However, there are no statistics on reports of lost gear.

5.1.2. Extended Producer Responsibility

The design and implementation of an Extended Producer Responsibility (EPR) legislation for fisheries gear is a general recommendation for governments to consider. Such schemes are currently being implemented in the EU for plastic equipment for fisheries and aquaculture, which could be utilized for knowledge sharing and inspiration for Indian and Sri Lankan governments. EPR is already in place for plastic packaging in Tamil Nadu since 2016, which speaks in favour of utilizing the state government's accumulated experience with the scheme to expand and adapt its frame to cover fisheries related plastic products as well.

5.1.3. Fishing in Marine Protected Areas and Bottom Snagging

Fishing in sensitive habitats and protected areas is a critical concern for marine management of commercial and non-commercial species, as well as for preventing gear loss and ghost fishing. Often, fish dwell in reef habitats, making such habitats more attractive to fishers. Several regulative measures are needed to enforce bans on using nets on reef habitats and enforce existing bans on fishing in MPAs to prevent gear loss and ghost fishing in sensitive habitats. This is a sensitive issue that poses challenges with regards to conflicts on economic interests between the livelihoods of fishers and the seafood industry and marine environmental protection.

5.1.4. Gear Design

Loss of fishing gear is sometimes due to bad luck and can be more or less inevitable in fishing. Therefore, using biodegradable and less durable gear components is a potential curative measure to limit the amount of marine life that gets trapped and killed after the fishers lose the gear (i.e., "ghost fishing"). As an example, pots and traps can be built with a biodegradable component to be activated as a release mechanism after a certain amount of soaking time (i.e., the time it takes for example a wood fiber rope to degrade and snatch open a hatch to release trapped marine life) to stop the fishing ability of lost gear such as gillnets and traps once they are lost. This concept has been thoroughly tested in some locations, e.g., for crab fishing in Chesapeake Bay (the USA), without showing any negative impact on catches (Bilkovic et al., 2012).[61]

The biodegradability of plastics indented for use in fishing gear is a relatively young field of research and development. Hence, it should be treated with some caution before being implemented as regulative measures. Although several projects globally are currently in progress or completed (e.g., DSolve,[62] BIOFAD,[63] INdIGO[64]), challenges remain with regard to the completeness of material degradation (some materials only partly decompose into smaller fragments and microplastics) in different marine environments, potential chemical side effects, and the assessment of life-cycle environmental impacts. In addition, these biodegradable plastics are generally priced significantly higher than conventional plastics in the current markets, and field studies indicate varying and sometimes less catch efficiency.

Photo: © IUCN

Recommendations to implement the above are:

- Fishing gear marking, with consideration of FAO's "Voluntary Guidelines on the Marking of Fishing Gear", including mandatory gear loss reporting by law.
- GPS enabled operation of fishing gear placement and attaching radar reflectors and radio buoys to fishing gear to prevent gear conflict.
- Strengthen governmental enforcement of the prohibition of fishing in marine protected areas.
- Conduct investigations on the potential of EPR schemes for fisheries related equipment in Sri Lanka and India, respectively.

[61] Read some general findings from the Chesapeake Bay project here: https://www.vims.edu/ccrm/research/marine_debris/solutions/panels/index.php

[62] https://uit.no/research/dsolve-en

[63] http://hdl.handle.net/10508/14203

[64] https://indigo-interregproject.eu/en/

5.2. Waste Management

Provision of appropriate waste collection and management can have a significant role to play in preventing ALDFG from ending up in the environment by reducing the likelihood of haphazard dumping of unwanted gear at sea or along the coastline.

To date, there is a general lack of waste reception facilities for discarded fishing gear in the Gulf of Mannar, while fishing related litter now impose a significant share of the marine litter in the region.

Governmental authorities, such as the State Fisheries Department, should ensure that fishing villages are provided adequate, accessible and affordable reception facilities for old and unserviceable fishing gear. Where cost recovery is necessary, it may be included in harbour charges rather than as a stand-alone fee. Women Self Help Groups (SHGs) are to be encouraged with financial support.

Waste reception facilities need to become an integrated part of the waste value chain to function. Here, incentive schemes can play a critical role in the success of establishing such value chains, beginning with the fishers, through collection facilities, collectors and middle-men, and waste treatment facilities. Incentive schemes may include:

- Buyback.
- Deposit-refund.
- Rewarding fishing vessels for returning used gear and retrieving lost gear.
- Subsidies or tax breaks for collecting, cleaning, and recycling systems at small-scale fisheries or ports.
- Financial support for transitioning to alternative gear types and presenting a lower likelihood of loss or causing environmental damage.

Improved routines and standard procedures for waste management aboard fishing vessels through regular inspections are also important.

Recommendations to implement the above are:

- Launch a pilot take-back system for used fishing gear and waste, involving economic incentives along the value chain as well as technical solutions downstream for material recycling. Conclusions from the evaluation of the pilot system can be utilized for rolling out full-scale systems as a second step.
- Improved waste management onboard and improved routines for gear maintenance according to the international standard on “Waste Reduction and Treatment on Fishing Vessels” (ISO 5020:2022).
- This report has described a multitude of case examples from around the world where discarded fishing gear is collected and treated systematically. Relevant and appealing cases should be utilized as role-models to be adapted to the local conditions in Sri Lanka and India.
- Establish Public-Private-People Partnerships and integration of ongoing programmes of government and Non-government and development partners to establish sustainable and collective waste management approaches to reduce the impact of ALDFGs and other plastics on the marine and coastal environment.

Photo: © SDMRI

5.3. Litter Removal

Ghost fishing from gear that is already lost is, unfortunately, a fact we have to face. In addition, future fishing operations inevitably lead to further loss of fishing gear that can only be prevented to a certain extent, even with measures in place. Losses are often unintentional and more or less an integral aspect of fishing operations. Hence, litter and lost gear removal need to be considered as a remedy to lessen the impacts of ALDFG.

As gear recovery helps reduce the impact of ALDFG on the marine environment, recovery by individual actions (e.g., retaining onboard any marine debris, including ALDFG collected while at sea) should also be encouraged as a matter of good practice.

Further, support should be given to developing affordable transponders and supporting equipment to aid in finding the location of drifting or lost gear, making retrieval possible before gear gets permanently lost. In addition, GPS technology and assistance in its use should be directed at small-scale fishers so that they can identify the position of static gear. Such gear marking is subject to preceding public regulation, discussed in the recommendation section above.

Photo: © Dinithi Samarathunga

Recommendations to implement the above are:

- A local adoption of the Fishing for Litter concept that has been in operation in a number of countries for years by incentivizing fishers to bring back ALDFG caught in their gear during normal fishing operations. There is a strong willingness to participate in such a programme amongst fishermen in the Gulf of Mannar, according to MARESSOL's survey study.
- Diver or ROV cleanups of selected hotspots for lost gear can be conducted by funding from e.g. EPR schemes or allocated public funds. Sensitive bottom habitats, such as coral reefs and marine protected areas are to be prioritized. Diver or ROV surveys can be used to identify ALDFG in seabed habitats. Divers involved in gear recovery should have the necessary up-to-date qualifications by undergoing proper training. The authorities and stakeholders should devise a training system for divers.
- As an inspiration: The Norwegian Directorate of Fisheries has conducted annual clean-up missions along the Norwegian coast since the early 1980s. Since then, more than 1,000 tons of lost fishing equipment have been removed from the seabed. Norwegian fishers must report to the Norwegian coastguard the type, quantity and location of where lost equipment was last seen. Reports are received in a digital database which informs where cleanup missions are to be focused, leading to 70-80% of all equipment that is reported as lost been recovered again and either returned to the owner or delivered for waste treatment.
- There are numerous effective cleanup initiatives of ghost gear described from around the globe, some of which are described in the "Good Practices" chapter of this report.
- Encouraging citizen science, stewardship programmes and partnership approaches to remove litter to protect marine and coastal resources.

Photo: © SDMRI

5.4. Further Research and Building Evidence

To continue building a better understanding of the causes and effects of marine litter, specifically ALDFG from fisheries, a number of different areas of further research can be prioritized. The efficiency of various mitigating measures should also be evaluated through periodic monitoring and evaluation.

Focused research on the quality, trade, utilization, and impact of gear should be carried out involving reputed research organizations that are actively and closely associated with the coast and the community.

Some of the most relevant areas requiring further research are listed below:

- Density and distribution of ALDFG on sea-floor habitats, including the quantity, distribution, and impact of ALDFG.
- Material flow analysis of sold discarded fishing gear – uncover the formal and informal waste collectors and waste facilities. Map the financial structure of the value chain for different gear types and materials.
- Technical capacity for material recycling of used fishing gear in Tamil Nadu and Sri Lanka: Identify capacity, gaps, and weaknesses with installed waste treatment facilities and assess technology demands.
- Technology can be used to reduce the impacts of ALDFG, particularly through alterations to the gear itself (e.g., the use of biodegradable nets) to minimize the risk of ghost fishing. Further research and development are required by academia as well as producers of gear to enable efficient, biodegradable gear that does not cause secondary environmental impacts. Governmental fisheries regulations on using biodegradable gear and gear design have to follow technical developments in this area.
- Assessing the environmental impact of ALDFG using tools such as Natural Capital Accounting and Assessment and System of Environmental-Economic Accounting, e.g., social costs due to ghost fishing through lost incomes.

FURTHER RESEARCH AND DEVELOPMENT ARE REQUIRED BY ACADEMIA AS WELL AS PRODUCERS OF GEAR TO **ENABLE EFFICIENT, BIODEGRADABLE GEAR THAT DOES NOT CAUSE SECONDARY ENVIRONMENTAL IMPACTS.**

5.5. Awareness, Education and Community Solutions

Awareness and education about the problems with waste and litter from fisheries will only be meaningful and effective if coupled with solutions. Hence, development and dissemination of awareness and education programmes must be coupled with recommendations on curative measures described in the above sections. An important example is making accurate weather forecasts available to fishers and providing education on how to interpret weather forecasts in relation to decision-making on when to fish, where to fish, and with what gear. This could potentially help avoid gear loss due to bad weather, which was highlighted as one of the leading causes for gear loss both in the survey conducted in this project and by Gallagher et al. (2023).

Measures to reduce ALDFG should be developed and implemented in close consultation with relevant stakeholders in a coordinated and integrated manner. In this context, there is a need to impart awareness about ALDFG to all stakeholders, including fisherfolks, port operators, marine users, and the general public, for which campaigns may be conducted at local, national, regional or international levels.

Fishermen should be educated on the impacts of plastics on the marine environment, and beach clean-up campaigns should be organized to mitigate the magnitude of plastic pollution. In addition, the awareness of fishermen's associations on the impact of debris related to fishing activities in the marine ecosystem and on the marine fauna is also necessary. Graphic images of entangled marine species are often used to publicize the dangers of ALDFG, which is one example of a striking awareness-raising measure.

Several types of awareness and educational programmes could become relevant to prevent marine litter and to proper waste management among fisher folk:

- Information campaigns on waste collection pilot projects
- Information and educational programmes about new regulations on gear marking and bans
- Discouraging the use of damaged or old gear

Information campaigns need to be tailored to reach intended target groups. Hence, both on-site manned efforts as well as digital advertising or other formats will have to be considered.

"Our actions over the next 10 years will determine the state of the ocean for the next 10,000 years"

– Sylvia Earle

Photo: © Dinithi Samarathunga

Appendices

Appendix A: Research Methodology

A range of different datasets were collected as a basis for this study. As a general principle, sampling and analysis methods in India and Sri Lanka have strived to be as similar as possible to accommodate for comparing results between the countries. Due to the different prerequisites of the research organizations in each country (SDMRI in India, IUCN in Sri Lanka), some divergence and modifications of methods were, however, necessary. The implications of these disparities have been highlighted in the below section.

India: Quantitative Data Methods

Sampling Locations and Seasons

Both sides of the Gulf of Mannar were sampled during the Northeast Monsoon; India in November 2021 and Sri Lanka in December 2021. For the 2022 sampling, however, the Indian shore was sampled during the Inter-monsoonal period in April and the Sri Lankan shores during the Southwest Monsoon in June. Water samples for microplastics in India were sampled during the Inter-monsoonal period in August 2022.

On the Indian side of the study region, 12 locations were selected for sampling (Figure 23). The number of locations was selected as result of the capacity of the available project resources. A justification for the selection of each location is given in Table 10 below. In general, locations were selected based on the following three criteria:

- Earlier observations of debris accumulated along the shorelines.
- The coast witnessed discarded nets and other fishing gear.
- Shoreline dumped with solid wastes and sewage outlets.

In Sri Lanka, five locations were selected for sampling for litter along the shoreline (Figure 23). The number of locations was selected s a result of available project resources and the capacity to carry out fieldwork.Sampling locations were selected based on two criteria:

1. Past observations where debris floating in the sea accumulates due to longshore current patterns.
2. Locations with fishing communities where discarded gear and related items are present.

THE NUMBER OF LOCATIONS IS A RESULT OF THE **CAPACITY OF THE PROJECT RESOURCES AVAILABLE.**

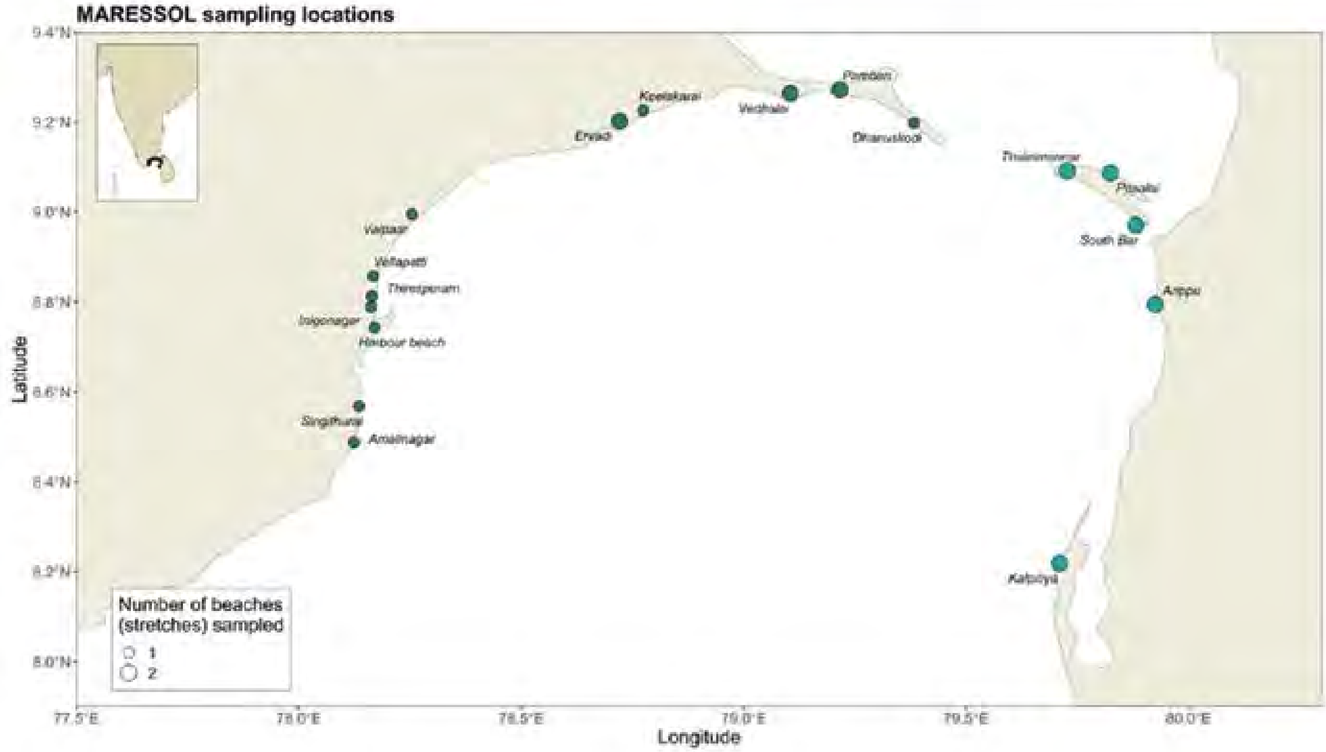


Figure 23. Map showing sampling locations. Within each location 1-2 beaches were sampled. On each beach, 3-4 transects were sampled for macrodebris, 3-9 quadrats sampled for microplastics in sediment, and 1-3 water samples to test microplastic concentrations. Sampling was repeated during different seasons. See text for details.

The justification for selecting each location is detailed in Table 10 below. The islands north of the Kalpitiya Peninsula have not been included, as it was necessary to travel by boat.

Table 10: Sample locations and justifications for location selection in the Sri Lanka sampling program (5 locations) and the India sampling program (12 locations).

Country	Locations	Justification
Sri Lanka	Kandakuliya	• A lot of floating debris accumulates in the Kandakuliya area as the northerly coastal current dumps float debris onto the beach. • A large fishing community is present. The Bar Reef Marine Sanctuary is located about 20 km north of Kandakuliya.
	Arippu	• Fishing community present • Fishing gear and other floating debris have been observed
	South Bar - Mannar	• Fishing community present. • Fishing gear and other floating debris have been observed.
	Thalaimannar	• Floating debris accumulates in this area due to longshore currents. • A relatively small fishing community is present.
	Pesalai - Mannar	• Fishing community present. • Much debris on the beach.

Country	Locations	Justification
India	Dhanuskodi (Ramanathapuram district)	• Fishing coast. • Discarded fishing nets and bycatches are present along the coast.
	Pamban (Ramanathapuram district)	• Intense fishing activity area with floating debris. • Solid wastes are dumped near shore. • Influenced by the Gulf of Mannar and Palk Bay current pattern. • Coral reefs and seagrass meadows are present in the offshore.
	Vedhalai (Ramanathapuram district)	• Large fishing communities are present along the coast. • Discarded fishing nets and bycatches are present along the coast. • Solid wastes are dumped near the shore. • Coral reefs and seagrass meadows are present in the offshore.
	Keelakarai (Ramanathapuram district)	• Fishing activities take place. • Sewage outfall is present. • Discarded fishing nets and bycatch are present along the coast. • Solid wastes are dumped near the shore. • Coral reefs and seagrass meadows are present in the offshore.
	Ervadi (Ramanathapuram district)	• Fishing activities take place. • Coral reefs and seagrass meadows are present in the offshore.
	Vaippar (Tuticorin district)	• Fishing activities take place. • River inflow occurs • Discarded fishing nets and bycatch are present along the coast. • Coral reefs and seagrass meadows are present in the offshore.
	Vellapatti (Tuticorin district)	• Fishing activities take place. • Discarded fishing nets and bycatch are present along the coast. • Coral reefs and seagrass meadows are present in the offshore.
	Thirespuram (Tuticorin district)	• Fishing activities take place. • Sewage outfall is present. • Solid wastes are dumped near shore. • Discarded fishing nets and bycatch are present along the coast. • Coral reefs and seagrass meadows are present in the offshore.
	Inigonagar (Tuticorin district)	• Fishing activities take place. • Floating debris occurs near the coast • Solid wastes are dumped along the coast • Discarded fishing nets and bycatch are present along the coast. • Mangroves are seen along the coast.
	Harbour Beach (Tuticorin district)	• Fishing activities take place. • A lot of floating debris is seen. • Discarded fishing nets and bycatch are present along the coast. • Coral reefs and seagrass meadows are seen offshore.
	Singithurai (Tuticorin district)	• Fishing activities take place • Discarded fishing nets and bycatch are present along the coast.
	Amalinagar (Tuticorin district)	• Fishing activities take place • Discarded fishing nets and bycatch are present along the coast.

India: Quantitative Litter Sampling

At each sampling location in India, a haphazardly determined number of 100-meter "sites" were selected for laying out sampling transects perpendicular to the shoreline. Transects were laid randomly based on a random table provided by NOAA[65]. In general, four transects were laid per 100m of coastal length. However, the number of transects varied depending on the occurrence of the debris. The width (from the waterline to the back of the shore boundary) of the transect depended on the width of the shore boundary. The accuracy of the GPS used to mark each transect (India) was 5-10 m.

Quantitative data on the ALDFG found on shorelines were recorded according to a slightly modified version of the "NOAA Shoreline Debris Data Sheet" (2013) by adding a table named "Fishing-related debris" with nine categories of ALDFG items according to UNEP/MAP, 2015, to acquire more details on ALDFG items. Also, registration of weights was added to the registration protocol for all item categories, in addition to only registering counts. Four transects of 5 m width were randomly selected on a 100 m stretch of each shoreline parallel to the water line (Figure 24). Along each transect, all anthropogenic surface debris items measuring > 2.5 cm were collected by walking along the width of the selected transect, and then the debris was sorted, counted, and weighed. ALDFG items measuring >2.5 cm were sorted for polymer composition analysis using FTIR-ATR.

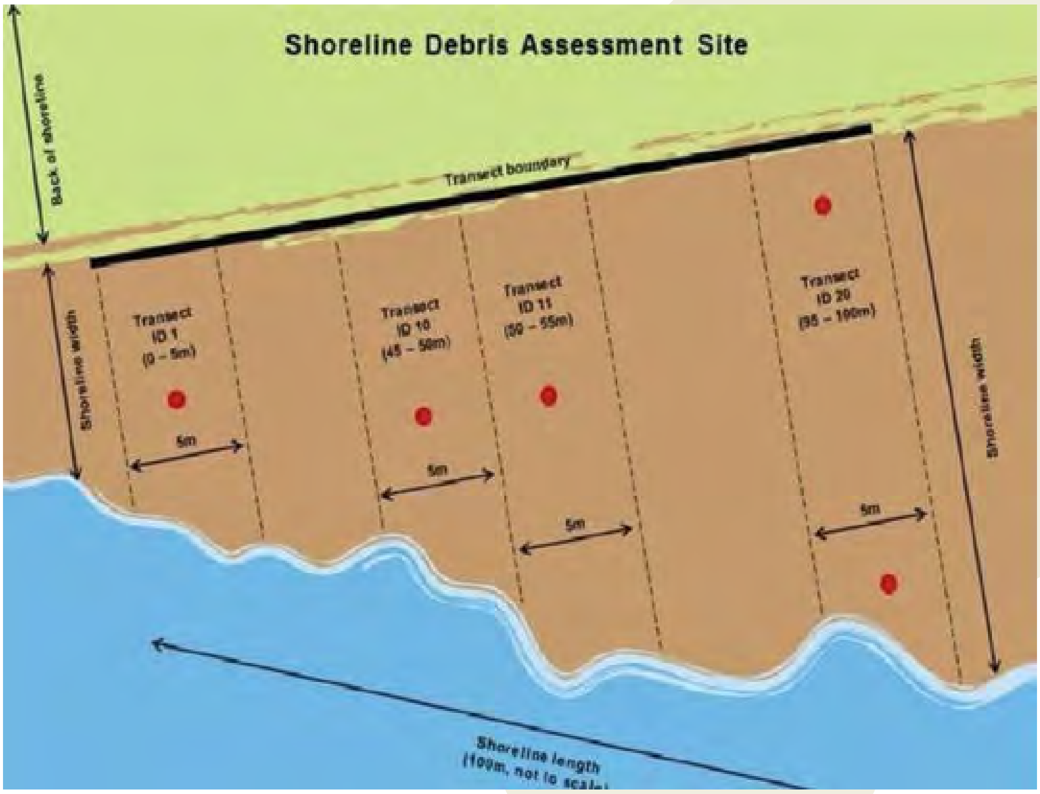


Figure 24. *Sampling design of shoreline debris assessment site*

ALDFG was recorded as a number of items/m^2 and their weight as kg/m^2. ALDFG items concentration (number of debris items/m^2) per transect was then calculated as follows: C= n / (w × l), where w = width (m) of shoreline section recorded during sampling (i.e., transect width), l = length (m) of shoreline sampled.

[65] https://pub-data.diver.orr.noaa.gov/marine-debris/pacificislands/Lippiatt%20et%20al.%202013

The polymer composition of ALDFG was identified using ATR-FTIR analysis (Thermo Nicolet model iS5, USA). The MP composition was identified using a readily available Spectral Library with an instrument setup (Nelms et al., 2021). A background scan was carried out before running each batch of samples. FTIR absorption spectra were recorded as an average of 32 scans in the mid-infrared range 400–4000 cm^{-1} at the resolution of 16 cm^{-1}. An acceptance threshold of 80% was set, and matches were accepted if their confidence levels equalized or surpassed 80%. The different polymers were identified through compositional assessment, and their relative abundance at each sampling site was estimated.

Figure 25. chemical analysis (Photo: SDMRI)

Figure 26. Collection of beach sediment samples. (Photo: SDMRI)

Assessment of Solid Waste Dumping Area for Marine Litter

To count the number of solid-waste dumping sites near the shore (both household and fishing gear), a handheld GPS was used to track and measure the area of solid waste deposits (Patterson et al., 2022). Visual observation of macro debris composition was done, and the sites were photographed with GPS tags. Also, we collected some samples (> 2.5 cm to < 50 cm size of the debris) for chemical analysis (Figure 25).

Beach Sediment Sampling for Microplastic Analysis

Quantitative study of MPs in beach sediment

Samples of beach sediments were collected from low tide waterline along the 100m shoreline in the 12 designated locations of the Gulf of Mannar. One sediment sample was collected from a 50×50 cm random quadrat on the shore from a depth of approximately 5 cm using pre-cleaned stainless-steel tweezers. Thus, 12 samples were collected as triplicate from the 12 sites and were air-dried at room temperature for further analysis.

Microplastics extraction

From the triplicate sediment samples, microplastics were extracted by digestion and density separation following the method of Masura et al. (2015). The collected sediment samples were placed in an oven and dried to a constant weight at 50oc for 48 h, then passed through 5 mm mesh to remove large debris and retain particles of <5 mm size. The dried sediment samples were treated with 30% H2O2 for 72 h at room temperature to remove organic materials. After digestion, density separation was performed by a fully-saturated salt solution (dissolving 358.9 g of NaCl in 1 L of demineralized water, water density of 9043 kg/m^3 at 20°C). This solution was stirred for 48 h at 600 rpm at 60 °C. The salt solution was left to cool down and then filtered to remove impurities using 47 mm Millipore 0.45 µm filter papers. Dry sediment was combined with saturated salt solution (ratio of 100 g dried sand in 400 mL of salt solution) and stirred with a magnetic stirrer for 2 min at 600 rpm). The mixture was stirred for 2 min and allowed to settle to enable the MPs to float on the supernatant fraction for 24 hours.

After 24 h of flotation, the supernatant solution of water and sediment samples was filtered with a vacuum pump using 0.8 µm nitrocellulose membranes. The filtration procedure was repeated three times for better extraction results. The beaker was rinsed 2-3 times with Milli-Q water to ensure the complete removal of microplastics. The

filter paper was immediately kept in a clean petri dish and dried at room temperature for further examination.

Microplastics identification

Filter papers from all sampling separations underwent visual sorting using a stereomicroscope (Olympus, Japan). A lower size limit of 50µm was fixed for this study, as it is not possible to physically handle MPs below this size. MPs were visually identified and measured according to their physical characteristics. Based on shapes, the particles were classified (Free et al., 2014) as fibre (thin or fibrous, straight particle), pellet/bead (hard, rounded particle), fragment (hard, jagged particle), foam (spongy substance) and film (a thin plane of the flimsy particle).

The size of the MP particles was determined by measuring the longest dimension, and based on size, the particles were placed under six classes: < 0.5 mm, 0.5-1 mm, 1-2 mm, 2-3 mm, 3-4 mm, and 4-5 mm. The dominant surface color was noted. The number of MPs was recorded separately for each filter and then summed for total MPs in each individual. The filter papers were then kept at room temperature for further confirmation and identification of polymer type using FTIR spectroscopic analysis.

Polymer composition of microplastics

The MP particles of > 0.5 mm were selected from each site and analyzed by the attenuated total reflectance-Fourier transform infrared spectroscopy (ATR-FTIR; Thermo Nicolet model iS5) to characterize the sorted MPs based on polymer type. The spectra were observed in the range of 4000 cm^{-1} to 750 cm^{-1} at a rate of 32 scans per analysis. All spectra were compared with a database (OMNIC polymers library) to verify the identity of the polymer. The MP abundance in sediment was recorded as a number of items/kg.

Photo: © SDMRI

SEM-EDAX analysis of samples

A selection of MPs in different samples (macro debris and microplastics) was examined under a scanning electron microscope (SEM; Carl Zeiss EVO 18) to produce high-resolution surface morphology images. During the SEM observation, the qualitative elemental composition of particles was confirmed using an energy-dispersive X-ray spectroscopy (EDAX; X-Act, Oxford).

Quality assurance and quality control

During each step of the sampling and sample-handling procedures, precautions were taken to minimize background contamination. The highest risk is associated with airborne contamination, such as synthetic fibers from clothing, equipment, and general atmospheric deposition. Therefore, strict control measures were implemented during the laboratory analyses to avoid airborne and laboratory contamination. Sources of contamination were reduced by cleaning all equipment prior to sampling. Non-plastic materials were used wherever possible, and all glassware was cleaned using ultra-pure water before use. Samples were covered as soon as and whenever possible. Contamination from research personnel was minimized by wearing polymer-free (cotton) clothing and gloves. The stereomicroscope area was cleaned prior to sample analysis. Once the filtration was performed, the filters were kept in Petri dishes made of glass until the FTIR analysis. The movement of people was minimized in the laboratory, and the lab windows were kept closed throughout the experiments.

Fishing Intensity Index: India

The fishing intensity was selected as a criterion to correlate with the prevalence of plastic (Dowarah and Devipriya, 2019). The number of boats active on each site was used to estimate the fishing intensity index in Sites 1 to 12. This score was used as an indicator of the intensity of fishing. Based on this, we classified beaches as having high fishing intensity (with more than 500 fishing vessels), medium fishing intensity (with the number of fishing vessels between 150 and 500), and low fishing intensity (with less than 100 fishing vessels).

Sri Lanka: Quantitative Sampling Methods

Sampling Beach Litter

Two sampling sites on a 100m coastline were haphazardly selected at each location based on where the field staff identified fishing activities (fish landing, net transfers, boat anchoring). In Kandakuliya and Talaimannar, the selection process also took into account plastics coming to the shore through natural processes. At each sampling site, three 5 m wide transects were placed randomly at low tide, perpendicular to the waterline up to the hightide waterline, where debris has pushed up the coast, as depicted in Figure 27.

Macroplastics were collected along the full length of the 5 m transect. All samples were counted and weighted per item category.

For microplastics, two 100m stretches were randomly marked for sampling. Then the three 5m transects were marked within the 100m stretch, and microplastic samples were collected from a randomly placed quadrat at high, mid, and low tide levels inside the transect. A known volume of sand from the surface layer was collected from each quadrat to sample for microplastics, and a 5 cm layer of the top sand layer was collected per quadrat to sample for microplastics. Samples were then sieved on site to remove the sand and the samples were stored for analysis in the laboratory. The microplastic quantities were standardized for one kilogramme after analysis. A photo was taken of each quadrant before collecting the samples.

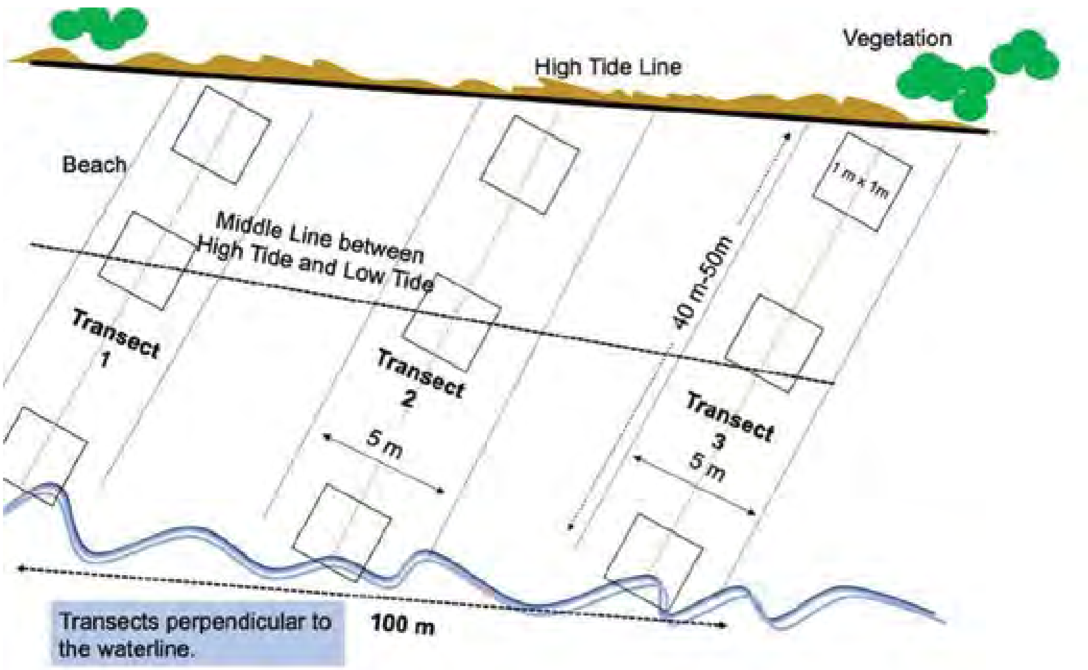


Figure 27. *Depiction of a sample site, consisting of #3 transects for sampling macroplastics. Each transect contains #3 quadrats for sampling of mesoplastics and microplastics.*

Coastal Water Sampling

Triplicate water samples were collected from each of the 5 locations (see details on locations above), within 3-5 m of each other, using the Albatross sampler (Abeynayaka et al., 2020). Samples were analyzed through microscopic analysis. FTIR analysis was conducted for the five composite water samples (compositing all three samples of each five locations) to identify polymer types of microplastics. Dates of water samples do not match those of macroplastics and microplastics.

Sampling Dumps and Discarded Gear and Plastics

Dump sites in the selected beach stretches were selected to record the macroplastics. Digital photos of dump sites of discarded fishing gear and plastic litter were taken. Photos were later analysed visually to register the number of different types of objects. The method was chosen since field staff were not able to dig into the dump. Identifiable objects of plastics were registered into categories.

Qualitative Data Sampling Methods

Interview Study with Fishermen

Qualitative data on estimates of types and amounts of fishing gear used, disposed and lost throughout the year (length, m) will be based on interviews with fishermen (N=343 in India, N=125 in Sri Lanka), using a semi-structured form based on Albuquerque et al. (2010), which contains questions related to: location, type of fishing gear, target species, causes (sea condition/accidental removal/unskilled fisher/debris/disappearance), season and methods of prevention (enforcement/equipment/training/weather forecast) of ALDFG. The full questionnaire is attached in Appendix B.

Statistical Test Methods

Density of Beach Cast Macrodebris

Data were analysed using generalized linear mixed models (GLMM) with country and season as fixed factors and location as a random factor. All transects were pooled within a region (i.e., no consideration of site/stretch). This had to be done as the site level of the hierarchal nested design was insufficiently replicated (i.e., it is not mathematically possible to compute the variance for a sample of $n < 3$). Therefore, one of the levels of spatial nesting (location or site) had to be ignored in analyses. This is not ideal, given there may be spatial autocorrelation among transects on a site and inter-site differences/patterns within a region, thus resulting in a certain level of pseudo-replication. Still, it was the only available option for analyses. The distance between locations and between sites within locations was highly variable, but in general, the distances between locations were considerably greater than the distance among sites within locations. As such, the location was chosen as the spatial grouping to retain in analyses. In future studies, it is recommended that either the site-level replication within locations be increased or, if the effort cannot be increased, to increase the size of the single site within locations (i.e., allow random selection of transects from a larger area rather than grouping them into two sites).

GLMMs were explored as the assumptions of a standard analysis of variance (ANOVA) (normality of residuals and homogeneity of variances) were violated. However, this could not be rectified by assuming an underlying Poisson or negative binomial distribution (as opposed to a Gaussian/normal distribution). Log-transforming the density data ensured model assumptions were met. However, we therefore, returned to a standard least squares regression (assuming a Gaussian distribution) on the log-transformed data. For this analysis, litter densities were standardized by area (item counts divided by transect length * transect width).

Note that the analyses were completed through three independent models:

1. Comparison of density during the Northeast Monsoon and the Inter-monsoonal period in India
2. Comparison of density during the Northeast Monsoon and Southwest Monsoon in Sri Lanka
3. Comparison of density in India and Sri Lanka during the Northeast Monsoon

This was necessary as sampling only occurred during two of the three seasons in each country (i.e., it is not possible to compare density during the Southwestern Monsoon or Inter-monsoonal periods between countries). Thus a single combined model with both country and season as fixed factors is not possible. Given the prevalent wind during the Southwestern Monsoon and the much calmer conditions during the Inter-monsoonal period, it does not make sense to group these two periods as a single “dry season”.

A major weakness of the study when comparing seasons is that the first sampling event during the Northeast Monsoon was effectively a standing stock survey, while the second sampling event was an accumulation survey as the same transects were sampled twice. If returning to the same locations, a pre-sampling cleanup should have been done at a given interval (e.g., two weeks) before the actual sampling took place to generate estimates of accumulation (litter items per area per day) during each season. Or even better, an initial cleanup followed by multiple repeated accumulation surveys within each season (e.g., daily sampling for one week) as recommended by the GESAMP monitoring guidelines. Alternately, a randomized site (transect) selection procedure could have been carried out within each defined location independently for each sampling to conduct two standing stock surveys. However, this latter option would likely result in higher variance and less power, thus requiring greater replication to detect any trends. Knowing when (or if) each location may have been cleaned previously (independent of the study) would be useful.

Beach Cast Macrodebris and Microplastics in Beach Sediment

When looking for a correlation between macrobedris on the beach and microplastics in beach sediment, for the Sri Lankan data, this was done at the transect level as the microplastic quadrats were sampled within the transects sampled for macrodebris. In India, however, the microplastic samples were not within the macrodebris transects. Consequently, the only correlation possible is at the location level. Ideally, this would mean aggregating data across transects and quadrats. However, this was impossible because raw data were not provided for microplastic samples (all counts were already standardized by kg sediment, and there were no raw counts per quadrant). Thus, densities were averaged across transects and across quadrats for each site/stretch (the highest available resolution), and these averages correlated against each other.

Prior to the correlation analysis, the three variables (total macrodebris and ALDFG density on the beach and microplastics density in the beach sediment) were scaled within each coast/country and season (e.g., Northeast Monsoon samples in India). Scaling was done following the standard formula (xi – xmin) / (xmax – xmin). This alters the range of all values to between 0 and 1, and doing so for each group (country x season) eliminates seasonal and geographic variation driving a potential correlation. This way, the correlation tests purely whether there was a spatial correlation among sites each season and on both shores between when microplastic density in the sediment was high or low and when macrodebris densities on the beach were high or low. Scaling the densities also at least partially mitigates the issue that the minimum detectable size of microplastics was different between the two countries (50 vs. 100 microns).

Data are non-normally distributed (H0 of not different from normal rejected). Thus, a non-parametric Spearman correlation was carried out instead of calculating the parametric Pearson correlation coefficient (parametric methods make assumptions regarding the underlying distribution of the data while non-parametric methods do not; the former are generally more powerful, but the latter adaptable to more types of data).

Composition of Beach Cast Macrodebris

The ratio of ALDFG to other litter was analysed using GLMMs the same way macrodebris density was, using the same three models separating season and country/coastline as necessary. The ratios were log-transformed to improve model residuals and ensure the analysis outcome does not depend on which litter fraction is set as the denominator in the calculation (see Hedges et al. 1999; DOI: 10.2307/177062). As the dependent variable is log-transformed, a simple Gaussian distribution and identify link functions were used in the GLMMs (i.e., equivalent to a normal linear model with identical outcomes).

Note that the model has the same issue with heterogenous variances as the same comparison for macrodebris density.

Following the analysis of item counts, the same tests were repeated for item weights, except for a seasonal comparison in Sri Lanka, as non-ALDFG debris was not weighed during the Southwest Monsoon sampling.

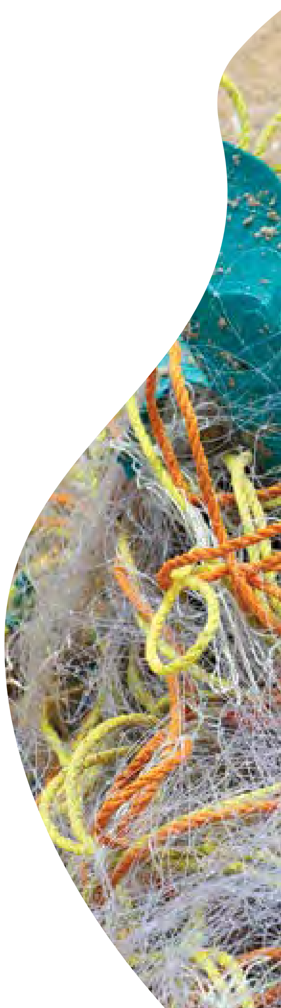


Table 11: The harmonization of ALDFG categories in each country used to generate Figure 12.

Country	Item	Harmonised
Sri Lanka	Boat pieces	Vessel fragments
Sri Lanka	Fishing floats	Floats and bouys
Sri Lanka	Fishing lures	Lures and line
Sri Lanka	Fishing net needle	Other ALDFG
Sri Lanka	Fishing nets	Fishing nets
Sri Lanka	Nylon ropes	Rope
Sri Lanka	Styrofoam	Associated items
Sri Lanka	HDPE cans	Associated items
India	Traps	Traps and pots
India	Fishing lures & line	Lures and line
India	Floats & buoys	Floats and bouys
India	Gillnets and similar nets	Fishing nets
India	Longlines & hooks	Lures and line
India	Rope	Rope
India	Seines	Fishing nets
India	Surrounding nets and lift nets	Fishing nets
India	Trawl net	Fishing nets

Photo: © IUCN

Appendix B: Fisherman Survey Questionnaire

Ref No:	**Date:**
1.0 Information about the village (from AD/DFAR)	
Name of village:	Divisional Secretary Division (DSD):
No of active fishermen:	No of fisheries societies:

1.1 How many fishing craft are available in the village (from AD/DFAR)			
No. OFRP boats	**No. Trawler**	**No. Canoe (vallam)**	**Other: Log craft**

2.0 Individual fisherman's details		
Personal details were removed to make the survey completely impartial and to alleviate any concerns that the fishers may have regarding the information they provide.	Male/female	

Village / location	
No of years engaged in fishing:	Are you a fisherman/boat owner/helper:
Are you a diver/snorkeler:	What do you dive for? / type of catch
Name of Fisheries Society:	Are you a member: Yes/No No of years of membership:
Are you a migratory fisherman and what is your home town/village:	Where do you migrate to fish during the off season? Location details:

3.0 What is the type of craft you use and how many do you own			
OFRP boats	**Trawler**	**Canoe (vallam)**	**No craft / Log craft**

4.0 Types of gear used by the fisherman (indicate by X)		
Gill nets	Offshore Purse seines	Beach seines
Bottom set gill nets	Bottom set nets for shells	Angling from shore/boat
Surface Longlines	Bottom longlines	Fish Kraals (large stake nets)
Scuba (sea cucumber, chanks and lobsters)	Scuba (aquarium fish)	Crab net
Trawl net		

5.0 Information about fishing grounds
Location of your main fishing grounds: (show on a map). List geo-coordinates if available

5.1 Fishing ground topology (habitat types) (Mark X and include comments below each)					
Coral reef	**Seagrass**	**Mangrove**	**Sand bottom**	**Lagoon/Estuary**	**Open water**

6.0 Main target species			
Species (common name/scientific name)	**Habitat type**	**Gear type**	**App. Weight (kg)**

7 (This the same as No 4. Therefore no 7.0 was deleted)		

7.0 Fishing gear usage (select from 7.0 and add as required)		
Types of fishing gear used annually	**Nos.**	**Size (length in meters)** **Sizes (floats, hooks etc)**
Gill nets		
Bottom set gill nets		
Scuba diving		
Trawl net		
Purse seines (surrounding)		
Surface Longlines		
Beach seines		
Bottom longlines		
Fish Kraals (large stake nets)		
Hooks and lines		
Floats and other items		

8.0 Number of fishing days per year (mark X)			
< 60:	**60 - 80:**	**80 - 100:**	**100 – 120:**
120 – 140:	**140 – 160:**	**160 – 180:**	**180 – 200:**
>200:			

9.0 Fishing gear lost at sea (annually)			
Types of fishing gear lost at sea **(Note: This might vary depending on the type of gear and fishing operations).** **Lost (due to "bottom snagging" "bad weather" "mishandling" "wear and tear", "Deliberately dumped", and other reasons**	**Reason for losing**	**Nos.**	**Size (length in meters)** **Sizes (floats, hooks etc)**
Gill nets or similar nets			
Trawl nets			
Purse seines (surrounding nets)			
Hooks and lines			
Floats and other items			

9.1 Do you try to retrieve lost gear? Yes/No
9.2. How often do you succeed to retrieve lost gear (0-100 %)?

10.0 Disposing fishing gear (land / sea)
10.1 Is there a designated location to dispose gear: (list the location if present)

10.2 Is the fishing gear disposed at sea or thrown on the beach:

(1). Dumped at sea (%) :

(2). Dumped on beach (%) :

(3). Disposed in designated waste site on land (%) :

11.0 Types of disposed fishing gear (annually)

Types of fishing gear (add to list as required)	Where was it disposed (land/sea)	Nos.	Size (length in meters) Sizes of floats etc.
Gill nets or similar nets			
Trawl nets			
Purse seines (surrounding nets)			
Hooks and lines			
Floats and other items			

12.0 Reusing items from the fishing gear (floats, lines, hooks, weights etc)

Items	Nos.
Floats (buoys)	
Hooks	
Lines	

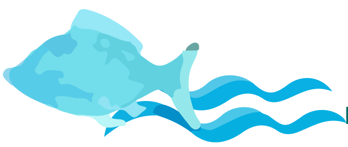
13.0 Impact of ALDFG

13.1 Ghost fishing

Insignificant problem	Moderate problem	Serious problem

13.2 Which type of fishing gear do you lose (annually, bi-annually)

Gill nets	Purse seines (surrounding)	Beach seines
Bottom set gill nets	Surface Longlines	Bottom longlines
Fish Kraals (large stake nets)	handlines	Trawl net



13.3 Have you observed any areas where more discarded nets / gear accumulates

13.4 Which fishing gear has the most impact when lost at sea		
Gill nets	Purse seines (surrounding)	Beach seines
Bottom set gill nets	Surface Longlines	Bottom longlines
Fish Kraals (large stake nets)	Handlines	Trawl net

13.5 What are your recommendations to prevent the loss of fishing gear (list recommendations according to each type of gear)
Gill nets
Purse seines
Bottom set nets
Longlines
Handlines
Trawl net

13.6 Do you experience debris getting entangled in your nets

13.7 Impact of ALDFG (testing the understanding)	
Do you understand that improperly dumped fishing gear can cause damage to fishing grounds and species	
If you understand that discarded fishing gear could cause damage to fishing grounds and fish stocks, have you made any attempts to reduce dumping of old fishing gear (at sea or on the beach)?	
Has there been any discussions on ALDFG in your area?	
Has the Department of Fisheries and Aquatic Resources (DFAR) discussed this issue with you?	
Will you support a system that will collect old fishing gear by handing in your old gear?	Would you expect a payment for this?
Do you try to retrieve gear (nets) when the gear gets entangled on shipwrecks and reefs?	

14.0 Purchase of fishing gear

Where do you purchase the gear? (Please list the sellers – wholesale? Or retail?

Gear type	Supplier

15.0 Questions for divers

Do you see a lot of ALDFG underwater	Location	Type of gear

Name of Interviewer	Signature:
	Date:

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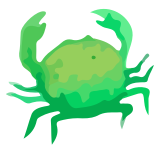

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