Marine plastics, fisheries and livelihoods in Mozambique

Leander Raes,
Carlos Litulo,
Marcos A. M. Pereira,
Peter Manyara

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Authors: Leander Raes (IUCN), Carlos Litulo (Consultant), Marcos A. M. Pereira (Consultant), Peter Manyara (IUCN)

Editors: Jennifer Ross-Jones, Lynn Sorrentino (Publication Coordinator)

Reviewers IUCN: Janaka de Silva, Peter Manyara

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Global Marine and Polar Programme (GMPP)
Rue Mauverney 28
1196 Gland
Switzerland
Tel +41 22 999 0000
Fax +41 22 999 0002
www.iucn.org/theme/marine-and-polar/our-work/close-plastic-tap-programme/reports

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1. Introduction

Marine and coastal ecosystems are severely impacted by litter on a global level. Approximately 60 to 80% of this littler consists of plastics that end up in the oceans and seas (Barboza et al., 2019; Galgani et al., 2019). Plastics come from both land and sea-based sources, and their continuous accumulation in aquatic ecosystems causes both economic and ecological impacts (Thushari and Senevirathna, 2020; UNEP, 2014). These impacts include: entanglement of marine wildlife, toxicological effects via ingestion of plastics, and the introduction of invasive species, which causes significant ecological damage. The degradation and modification of marine and coastal systems causes socio-economic effects by negatively affecting tourism, fisheries, shipping, and human health (Thushari and Senevirathna, 2020). Other important negative impacts that have received less attention include the damage to subsistence fisheries and the impacts of plastics on soft sediments, reefs and rocky substrata (Gregory, 2009; Nash, 1992; Uneputty and Evansh, 1997).

The environmental, social, and economic impacts of marine plastic pollution are significant. Using a natural capital lens – keeping in mind ecosystem service values and the amount of stock of marine plastic – it is estimated that the cost per tonne of marine plastic pollution is between USD 3,000 and USD 33,000 per year (Beaumont et al., 2019). This economic cost represents a lower bound of the full economic costs incurred by marine plastic pollution (Beaumont et al, 2019).

One of the many sectors that is heavily impacted by marine plastic pollution is the fisheries sector. Given fisheries' reliance on marine ecosystems and the services they provide, marine plastic pollution can affect the productivity, viability, profitability and safety of fisheries, as well as aquaculture (Beaumont et al., 2019). These impacts can be caused by marine litter and plastics caught in nets, physical entanglement, damage to boats and fishing gear (Mouat et al., 2010), and can also directly impact fish stock. For example, marine litter can destroy marine habitats (Mouat et al., 2010) and can decrease fisheries' resources as a result of entanglement or ingestion of plastics by a wide range of marine species (Lusher et al., 2013; Rochman et al., 2015; Steer et al., 2017). These impacts make the fishing sector particularly vulnerable, especially when combined with other factors such as climate change and overfishing (Beaumont et al., 2019). Beyond these financial impacts are the negative effects on human health and well-being. Given that significant populations, particularly coastal communities, are highly dependent on seafood for nutrition, their health and well-being is highly vulnerable to changes in the quantity, quality, and safety of this food source (Golden et al., 2016).

The fisheries sector is also a generator of plastic waste. Plastic is a material frequently used in shipbuilding, ship maintenance, in a wide variety of fishing gear, and for seafood preservation (FAO, 2017). Specifically, a type of debris from the fishing industry that has caused great concern is abandoned, lost or otherwise discarded fishing gear (ALDFG) (Macfadyen et al., 2009), also known as 'ghost gear' (Link et al., 2019). ALDFG is recognised as a severe threat to marine life, vessels, and marine ecosystems such as coral reefs (Macfadyen et al., 2009; Pichel et al., 2012).

2. Mozambique

2.1 General information

Mozambique is located on the east coast of Southern Africa and has a total population of about 31 million people as of 2021 (INE, 2021). Mozambique is considered a Least Developed Country (World Bank, 2017). The current GDP is estimated to be close to USD 15.3 billion with a GDP per capita of USD 504 (World Bank, 2021).

Mozambique has one of the longest coastlines in Africa, about 2,700 km (Benkenstein, 2013a; Souto, 2014). The country has a land area of 786,380 square kilometres and an exclusive economic zone of 567,883 square kilometres (FAO, 2019) (Figure 1). Mozambique possesses abundant marine fishery resources that support the livelihoods of coastal communities (UNCTAD, 2017; World Bank, 2018).

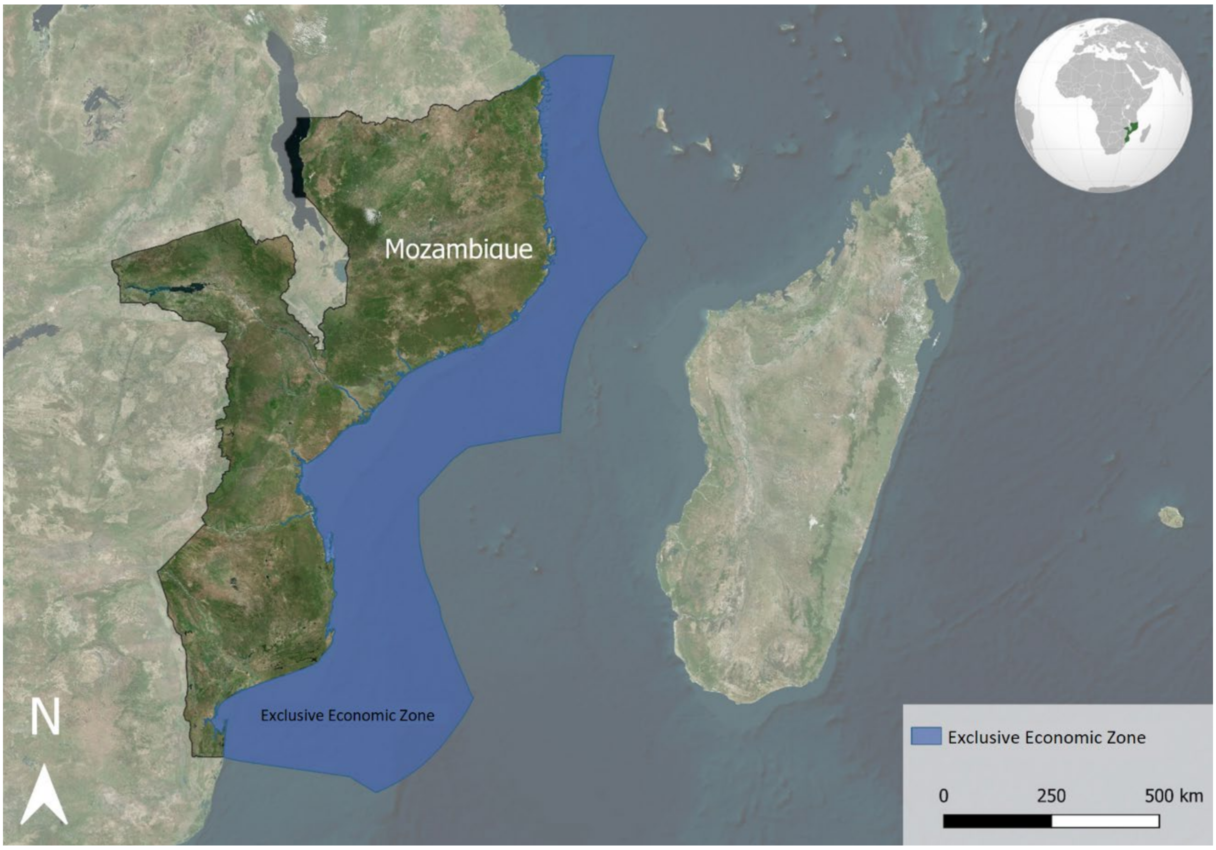


Figure 1: Mozambique (Source: www.marineregions.org/gazetteer.php?p=details&id=8347 marineregions.org, accessed 3 June 2021)

2.2 Plastic leakage in Mozambique

In Mozambique, all plastics that are consumed are imported. According to the 2020 *UNEP/IUCN National Guidance for Plastic Pollution Hotspotting and Shaping Action* National Report for Mozambique, of the 179,000 tonnes of domestically generated waste, less than one percent of the plastic is recycled, while around 17,000 tonnes of plastic waste leaks into the marine environment. This is equivalent to an individual leakage of 0.6 kg/capita/year and is due to significant mismanagement of solid waste. Macro-leakage contributes to 95% of the country's overall leakage (UNEP and IUCN, 2020).

In the *UNEP/IUCN National Guidance for Plastic Pollution Hotspotting and Shaping Action* National Report for Mozambique, the fisheries sector has the highest relative leakage rate of plastics (20%), per tonne leaked by any sector, though contributes very minimally in absolute terms (UNEP and IUCN, 2020). The fisheries sector contributes less than 2% of Mozambique's total leakage, with the packaging sector dominating at 76%. Leakage from the fisheries sector includes gear loss at sea, leakage from overboard littering of packaging materials, and leakage from fishing gear that is mismanaged on land. The high plastic leakage rate from the fisheries sector is important, as an increase in fishing effort increases the quantities of plastics leaked at a faster rate than from other sectors.

Plastic waste on the beach in Mozambique (Photo by WWF Mozambique, World Ocean Day, 2018)

2.3 Fisheries in Mozambique

Fisheries in Mozambique are conducted in two distinct zones: coastal and offshore. The coastal zones are where all artisanal and subsistence fisheries are located, along with semi-industrial and industrial fisheries for shrimp and other primarily demersal resources (Machava et al., 2014, Benkenstein, 2013b). Mozambique's offshore fisheries target highly migratory species, such as tuna and swordfish. These fisheries activities are conducted in deeper waters up to the extent of the Exclusive Economic Zone (EEZ). These offshore fisheries are mostly exploited through joint ventures between the Mozambican government and foreign fishing vessels (Tenreiro de Almeida, 2005, Palha de Sousa et al., 2015). In 2017, there were 94 licenced, national, industrial fishing boats, 31 licenced, foreign vessels, and 341 licenced, semi-industrial, boats. In addition, there were also 18,197 artisanal fishing licences as well as 6,221 licences for sport or recreation fishing (Ministério do Mar, Águas Interiores e Pescas, MIMAIP, n.d).

Industrial fisheries typically use large vessels of more than 20m, equipped with autonomous freezing facilities on board (Williams et al., 2018).

The main commercial catches are *Penaeid* shrimp, lobster, crabs, crayfish, deep sea shrimp (*Haloporoides triathurus*, *Aristeomorpha foliacea*), tuna (*Thunnus albacares, Thunnus obesus*, *Thunnus alalunga*), and swordfish (*Xiphias gladius)* (Chacate and Mutombene, 2019). The artisanal fisheries normally use non-motorised boats 3-8m long, hand or wind propelled, and use beach seines, gillnets, and lines to catch fish (Doherty et al., 2015). The catches are mostly composed of small pelagic and demersal fish. The small-scale fishers are primarily targeting near-shore fish stocks such as pelagic species, demersal line fish and crustaceans such as shrimp and crab (Benkenstein, 2013b).

The total capture production in 2019 was around 392,221 tonnes, with about 274,791 tonnes derived from marine fisheries and the rest from inland captures (FAO, 2019). In addition to the economic value, the social value of fisheries is considerable (World Bank, 2018). For Mozambique, artisanal fisheries are of particular importance to the country's national food security (Chacate and Mutombene, 2019).

Fisherfolk fishing along the shores on a Mozambique Coast (credit: IUCN Eastern and Southern Africa Regional Office (ESARO))

Small boats used by artisanal fisherfolk (credit: IUCN ESARO)

3. Impact of plastics

3.1 Direct impact on fisheries

Fisheries suffer direct economic impact from marine plastic pollution. The economic losses for marine fisheries include aspects such as the value of dumped catch, the costs to repair fishing gear and nets, the overall costs of fouling incidents, and lost earnings as a result of reduced fishing time due to clearing litter from nets (Mouat et al., 2010). Several attempts have been made globally to estimate the impact of marine plastics on fisheries' revenue. For example, Takehama (1990) estimated the cost of damage on Japanese fishing vessels caused by marine debris based on statistics from the insurance system. The study considered accidents, collisions with debris, obstruction of water systems, and entanglement of debris with the engine. Mouat et al., (2010) estimated the costs caused by marine litter in the Scottish fisher fleet, which showed that the main cost resulted from the loss of fishing time, which is a consequence of the time required to clean marine litter from the nets. Another major impact is the overall cost to repair the nets and fishing gear.

Takehama (1990) estimated the impact on fisheries' revenue at 0.3% of gross annual value. This estimate is also used by McIlgorm et al. (2011, 2009) to estimate the economic cost and control of marine debris damage in the Asia-Pacific region. Mouat et al., (2010) estimated that marine litter reduces the revenue generated by affected fisheries by up to 5% per year. This estimate is used in other studies. For example, Arcadis (2014) estimated and adjusted the impact of marine litter on EU fisheries at 0.9% of the revenue. UNEP (2014) calculated that marine plastics cause an annual global revenue loss of 2% in marine fisheries. As no studies exist specifically on the impact of marine plastics on the fisheries of Mozambique, these impact estimates can be used to illustrate the potential impact of marine plastics on the fisheries of Mozambique.

The most recent data available for the value of fisheries in Mozambique (for the year 2017) are shown in Table 1. The total Gross Domestic Product (GDP) of Mozambique in 2017 was MZN[1] 638.488 billion.

The potential annual cost of marine plastics on marine fisheries in Mozambique is estimated at MZN 347 million or 0.05 percent

Table 1: Fishery statistics Mozambique 2017 (Source: MIMAIP, n.d)

Fishery type	Quantity marine capture (Tonnes)	Gross Annual Value (MZN)
Industrial	11,622[a]	1,413,345,000[b]
Semi-industrial	8,806	389,983,000
Artisanal	224,418[c]	15,131,573,000[d]
Total	**244,846**	**16,934,901,000**
% GDP		*2.7*

[a] Excludes 3,478 tonnes caught by foreign vessels in 2017
[b] Excludes the value of 2017 catch by foreign vessels of MZN 232,138,000
[c] Excludes 90,052 tonnes of inland capture
[d] Excludes the value of 2017 inland capture of MZN 6,010,962,000

1 MZN = Mozamb ique Metical

Table 2: Potential cost of marine plastics to Mozambican national marine fisheries

Impact estimate (%)	Source estimate	Impact revenue Mozambican marine fisheries (MZN/year)
0.3	Takehama (1990), McIlgorm et al. (2011, 2009)	50,804,703
0.9	Arcadis (2014)	152,414,109
2.0	UNEP (2014)	338,698,020
5.0	Mouat et al. (2010)	846,745,050
Average		**347,165,471**

of GDP, based on 2017 values. However, costs and revenue losses could potentially be higher due to an underestimation of the value of fisheries, but also due to aspects not included, such as the costs resulting from the impact of ghost fishing. Ghost fishing contributes to the reduction of available species that can be caught by fishing vessels, resulting in a loss of revenue for fisheries (Macfadyen et al., 2009).

Furthermore, marine plastics can also result in revenue losses for marine aquaculture due to water quality degradation (UNEP et al., 2014; Viool et al., 2019). However, this is less applicable for Mozambique, as most, if not all aquaculture, is produced inland (focused on tilapia production), and is not marine aquaculture (MIMAIP, n.d.; FAO, 2019).

3.2. Broader economic impacts

Lastly, there are additional potential broader economic impacts of plastic pollution that must be considered, including its impacts on export revenue, employment, food security, marine ecosystems, and marine biodiversity.

3.2.1. Impact on export revenue

Mozambique exports fish, such as tuna, as well as lobster and crab among other species (Table 3). A negative impact of marine plastics on the total capture by national fisheries in the longer term could translate into fewer exports. This, in turn, could negatively impact the balance of trade. Decreased domestic fish production could also translate into increased fish importation. Mozambique already imports a large volume of fish, particularly horse mackerel, which makes up 94.5 percent of the total imported volume (MIMAIP, n.d.). According to FAO (2019), in 2017, imports of fish and fishery products were valued at USD 74 million and exports at USD 42.2 million.

Table 3: Potential revenue losses for Mozambican national marine fisheries (Source: MIMAIP, n.d.)

	Fishery type	Quantity (Tonnes)	Value of annual loss (USD)
Export[a]	Industrial	9,073	
	Semi-industrial	1,667	
	Artisanal	3,994	
	Total	**14,735**	**88,892,000**
Import		79,999	n.a.

[a] Includes both freshwater and marine species

3.2.2. Impact on employment

Marine plastic pollution creates a direct cost for fisheries. This can impact the number of people employed in the sector. According to the FAO (2019), in 2016, an estimated 65,600 people were engaged in fisheries. In 2017, there were eight frozen fish factories (MIMAIP, 2018), while an estimated 42,473 people were employed in fish processing (Ministério das Pescas, 2007; FAO, 2014; Ministério do Mar, Águas Interiores e Pescas, MMAIP, personal communication with Masquine, Z., 2020). In total, the overall fishing sector provided employment to 202,000 people in 2013 (FAO, 2019). Other sources indicate the number of commercial fishing crew is 4,512 people (Tenreiro de Almeida, 2005; USAID, 2010; Eide, 2004) and the number of artisanal fishers is 284,071 (Instituto de Desenvolvimento de Pescas de Pequena Escala, IDPPE, 2013; Ministério das Pescas, 2019; Jacquet et al. 2010).

Of the people employed in the fishing sector, women make up approximately half of the work force; they are involved in fishing with small seines, on foot, picking of seafood, gleaning, and marketing and processing (FAO, 2020; FAO, 2019; World Bank, 2018). Lastly, fisheries are an important source of cash income for many households (World Bank, 2018). Approximately 850,000 families, approximately 20% of the population, depend on fishing for part of their income (UNCTAD, 2017). Fishing is an important income supplement, with people turning to fishing when other income generation activities fall short (World Bank, 2018).

3.3. Impact on food security

Fishing is not only an important source of income and employment, but also a vital source of food. Fish provide vital nutrition and a source of protein essential to the diet of many coastal communities, especially impoverished communities (FAO, 2020). In Mozambique, chronic malnutrition rates are high, particularly among children; and are higher in rural areas than urban areas (Carrilho et al., 2015; INE, 2008). Around 80% of the people cannot afford an adequate diet (World Food Programme (WFP), 2021), and 9.6 million people are undernourished (FAOSTAT, 2021). The impact of marine plastics on fish stocks and on the fisheries sector can also negatively impact Mozambique's food security (Benkenstein, 2013a, World Bank, 2018). A large proportion of the population relies on the fisheries sector for subsistence. It is estimated that this sector contributes 50% of the total animal protein consumed nationally (Souto, 2014). Fish is sometimes the only accessible source of protein for rural communities (Brugere and Maal, 2014). Per capita consumption of fish products was estimated to be about 14 kg in 2017 (MIMAIP, n.d.).

Small-scale fisheries are especially important for food security. Evidence is scarce, but the impacts of marine plastics specifically on small-scale fisheries have been reported, including propeller entanglement, damage to fishing gear and even injuries (Nash, 1992). Any impact on coastal and marine resources not only has an impact the economy and income generation for coastal communities but can also directly impact the available sources of food and nutrition for the country's population. Moreover, marine plastics can potentially have negative health impacts, for example when ingested through the consumption of seafood. Specifically, microplastics are a concern regarding their physical and chemical toxicity (Smith et al., 2018).

In summary, by directly impacting fishing and fish stocks, marine plastic pollution can have a negative impact on the economy, as well as the livelihoods and food security of the people of Mozambique.

3.4. Impact on marine ecosystems

Beyond economic impacts, marine plastic pollution negatively impacts the marine ecosystems that provide the habitats for fish species caught and consumed in Mozambique. Key habitats for fish and fish nurseries are mangroves and coral reefs. Mozambique has approximately 264,000 hectares of mangroves (Shapiro, 2018), an estimated 186,000 hectares of coral reefs (Spalding et al., 2001), and 43,900 hectares of seagrass beds (Marzoli, 2007). The existence of these very productive habitats make Mozambique one of the countries with the highest biodiversity richness in the East African region (Pereira et al., 2014). Of the 1,425 of marine finfish species known to be found within the Mozambique's EEZ, nearly 300 are species of commercial importance (Doherty et al., 2015).

Marine debris, including plastics, causes degradation of oceanic and coastal ecosystems (NOAA Marine Debris Program, 2016), such as coral reefs, mangroves and seagrass beds (Cordeiro and Costa, 2010; Shester and Micheli, 2011; Yoshikawa and Asoh, 2004). For example, plastic debris interferes directly with the ecological role of mangrove forests (Ivar do Sul et al., 2014) or blocks mangrove tidal channels (UNEP, 2009). Abandoned fishing gear damages seagrass beds by re-suspending sediments, disturbing rhizomes, and impacting the root structure of seagrasses (Barnette, 2001). In addition, mangrove forests and seagrass beds act as both traps and filters for marine plastics, including microplastics (Debrot et al., 2013; Sanchez-Vidal et al., 2021). Coral reefs also suffer

School of Lunar-tailed Bigeyes (*Priacanthus hamrur*), Tofo, Mozambique (Shutterstock, Daniel Lamborn)

A couple of anemone fish playing around, Mozambique (Shutterstock, RMFerreira)

Plastic material stranded on a mangrove tree (credit: IUCN ESARO)

Ocean trash washing out on the beach after a storm off the coast of Mozambique (Shutterstock, Jax137) impacts, including mechanical impacts such as the damage to branching corals caused by derelict fishing gear (Beneli et al., 2020) or through the promotion of colonisation by pathogens that cause disease outbreaks (Lamb et al., 2018). Lamb et al., (2018) found that the likelihood of diseases occurring in corals increases from 4% to 89% when they are in contact with plastic.

The ecosystem degradation caused by plastic pollution in marine and coastal habitats will impact fish stocks that depend on these habitats as well as also marine wildlife in general. Marine biodiversity that is not directly targeted by fisheries – such as seabirds and marine mammals – are not only impacted through habitat degradation, but also suffer directly by debris entanglement and drowning, for example.

3.5. Impact on marine biodiversity

According to the Convention on Biodiversity (CBD) Report, *Marine Debris: Understanding, Preventing and Mitigating the Significant Adverse Impacts on Marine and Coastal Biodiversity*, the total number of species known to be affected globally by marine debris (mainly plastics) is around 800, whereas the proportion of cetacean and seabird species affected by marine debris ingestion is 40% and 44%, respectively (CBD, 2016). These impacts can occur through different routes, primarily through ingestion, entanglement and through the toxic effects of chemical additives.

Solid plastic particles in the marine environment are ingested by fauna. Although most of these particles will be excreted, some may remain in the stomach undigested (Rochman et al., 2015). Certain marine animal populations especially those that feed exclusively at sea, such as seabirds[2] and sea turtles present plastic debris in their stomachs (Hammer et al., 2012; Wilcox et al., 2015). Sea turtles can, while feeding, ingest plastic debris at all stages of their lifecycle (Mascarenhas et al., 2004). This can potentially have lethal consequences. For example, Wilcox et al., (2018) found a 50% probability of mortality once the sea turtles they analysed had 14 pieces of plastic in its gut. Discarded and semi-inflated, floating bags are of particular hazard as they are often mistaken for jellyfish, and can block the oesophagus once ingested (Gregory, 2009).

Entanglement in plastic debris is another manner in which animals are impacted (Galgani et al., 2019). Marine mammals are among those species that are most affected by entanglement (Hammer et al., 2012). ALDFG poses special risks for large, air-breathing marine animals, such as whales, dolphins, seals, sea lions, manatees and dugongs, as they can become entangled in the nets and drown (Laist, 1997; Lusher et al., 2018).

Marine plastic can also be a source of chemical additives (Hermabessiere et al., 2017). Marine plastics, specifically those with a lifetime of hundreds of years, tend to degrade into micro- and nanoplastics over time. The smaller particle size facilitates the uptake of plastics by marine biota. These plastics may contain chemical additives and contaminants, some of them with suspected endocrine disrupting action that may be harmful for marine animals when ingested (Gallo et al., 2018). In addition to the direct ingestion of plastic debris, plastic is also ingested by larger animals higher on the food chain. Microplastics are easily ingested by small organisms, such as plankton. Contaminants leached from plastics tend to bioaccumulate in those organisms that ingest them; the higher the trophic level, the higher the chemical concentrations (Hammer et al., 2012).

Marine plastics can further affect marine biodiversity and ecosystems by facilitating the introduction of alien species. Aggressive invasive species can be dispersed by free-floating marine plastics. The introduction of new species could endanger sensitive, or at-risk coastal environments (Gregory, 2009).

2 For example: albatrosses, petrels, shearwaters, skuas, gulls and auks (Laist, 1997).

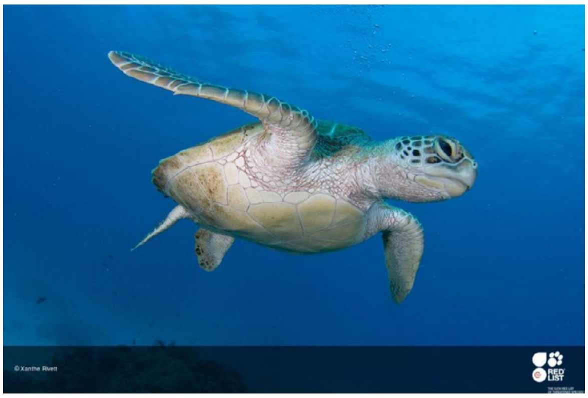
In addition, there is growing concern for the potential for microplastic debris to act as vectors, transporting viral and bacterial pathogens (harmful to both humans and animals), potentially spreading them to new areas (Bowley et al., 2021). For example, *Vibrio* spp. bacteria have been found in abundance on plastic debris as compared to non-plastic, natural particles, and can lead to increased outbreaks of disease (Bowley et al., 2021).

Mozambique has a high level of marine biodiversity (Pereira et al., 2014). Not only are the marine ecosystems (e.g. coral reefs or mangroves) under threat, but several marine species such as sharks and rays, bony fish, sea turtles and marine mammal species, are also threatened. Although biodiversity is under threat from a range of different activities such as exploitation of oil and gas reserves, overfishing, and illegal fishing (UNCTAD, 2017), marine plastic pollution is an additional pressure on many species. Table 4 provides an overview of the sea turtle and marine mammal species in Mozambique and their current status on the IUCN Red List.[3] These species are also impacted through ingestion of plastics, entanglement, or bioaccumulation of contaminants.

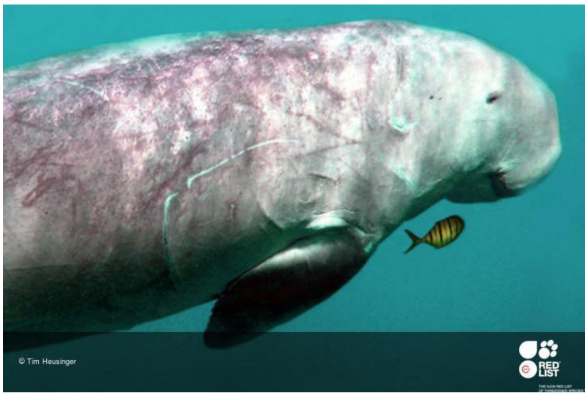
Table 4: Red List status sea turtles and marine mammals of Mozambique

Turtles		
Green Turtle	*Chelonia mydas*	Endangered
Hawksbill Turtle	*Eretmochelys imbricate*	Critically endangered
Leatherback Turtle	*Dermochelys coriacea*	Vulnerable
Loggerhead Turtle	*Caretta caretta*	Vulnerable
Olive Ridley Turtle	*Lepidochelys olivacea*	Vulnerable
Mammals		
Blue Whale	*Balaenoptera musculus*	Endangered
Dugong	*Dugong dugon*	Vulnerable
Fin Whale	*Balaenoptera physalus*	Vulnerable
Sperm Whale	*Physeter macrocephalus*	Vulnerable

Source: IUCN Red List of Threatened Species (accessed 7 June, 2021)



Green turtle (credit: Xanthe Rivett, IUCN Red List)



Dugong (credit: Tim Heusigner, IUCN Red List)

3 IUCN Red List, www.iucnredlist.org

Marine plastic pollution leaked from terrestrial sources, plastic debris from fisheries and other marine activities, and plastics entering Mozambique's waters through ocean currents negatively impact the country's fisheries sector and livelihoods, as well as local marine ecosystems and marine biodiversity. It is imperative that strategies aiming to conserve Mozambique's marine biodiversity consider the reduction of plastic leakage and the stock of plastics present in the marine environment as one of their threat reduction objectives.

4. Reducing plastic leakage and its impact

The results shared in the *UNEP/IUCN National Guidance for Plastic Pollution Hotspotting and Shaping Action* (UNEP and IUCN, 2020) National Report for Mozambique provide a list of potential actions that are recommended to be undertaken to reduce plastic leakage. Some of these actions focus on improving waste collection and increasing recycling, some of which are already in place in Mozambique.

For example, 3R[4], a national private waste company based in the capital, Maputo, works on establishing value chains for plastic waste across different cities and towns, with the ultimate aim of reducing plastic leakage to the environment, while turning a profit. It has already established a value chain for different plastic streams, namely polypropylene (PP), high density polyethylene (HDPE), and polyethylene terephthalate (PET) in Vilanculos, and prevented 32.8 tonnes from reaching local dumpsites. Although the focus has been to divert waste from going to local dumpsites, the process reduces the overall plastic leakage from the dumpsite itself, prevents recyclable waste from being abandoned in the environment, and improves overall waste collection.

In the short term, these types of actions can provide new livelihood opportunities for coastal communities. However, in the longer term, an improvement of the waste management sector and an overall transition towards a circular economy model will be necessary. This includes the integration of artisanal fishers in marine clean ups and waste entrepreneurship, which could potentially provide an additional source of income and contribute to reducing the different impacts of marine plastics on fisheries and marine biodiversity.

According to the results of the *UNEP/IUCN National Guidance for Plastic Pollution Hotspotting and Shaping Action* National Report for Mozambique, the fishing sector has the highest relative leakage of plastics, including leakage from gear loss at sea and leakage from overboard littering of packaging (UNEP and IUCN, 2020). Based on some key characteristics of the different types of fisheries in Mozambique (Table 5), a distinction can be made between specific actions where artisanal, or semi-industrial and industrial fisheries could support a reduction in marine plastics by: (1) reducing their own marine plastic waste production, and (2) collecting marine plastics including ALDFG and other plastics found while fishing.

For example, programmes where fishing boats receive incentives to bring back marine plastics collected have already been implemented in countries such as South Korea[5] and Thailand,[6] and have been proposed for implementation in Viet Nam.[7] This type of scheme could potentially be replicated. In the case of semi-industrial and industrial fisheries - which fish in the open sea and for longer periods of time - the development of such a scheme should include consideration of available storage, and could focus on plastics already floating in the open ocean. Such incentive schemes should also

4 Read more about the IUCN-supported circular economy project of 3R here: https://www.iucn.org/news/eastern-and-southern-africa/202102/marplasticcs-video-series-3r-ecopoint-network-a-circular-economy-initiative-3r-mozambique

5 https://g20mpl.org/partners/republicofkorea (accessed 15 April, 2021)

6 https://www.fondationjan-oscar.ch/en/training-project-for-the-moken-people/ (accessed 24 June, 2021)

7 Included in the Viet Nam Action Plan: Marine Plastic Waste Management in the Fisheries Sector, period 2020-2030 https://www.iucn.org/news/viet-nam/202103/viet-nam-develops-action-plan-reducing-plastic-waste-fisheries-sector

Table 5. Summary of select characteristics of artisanal and commercial fisheries in Mozambique

Parameter	Artisanal	Semi-industrial	Industrial
Work force	Familiar, or involving community fishers	Employed, generation of local and indirect employments	Employed, generation of indirect employment, more jobs, including outside the country
Social organisation	Individual, familiar	Ship owners are individuals/small businesses	Ship-owners are important enterprises
Fishing campaign	Daily	Up to 10 days	More than 30 days
Fishing days per year	Not more than 100	200 to 250 days	More than 250 days
Fishing zone	Local, in estuaries, bays, coastal up to 5-6 km from the coast.	Coastal, and marine areas up to 55 km from the coast.	Coastal, and marine areas up to the limit of the EEZ

Source: adapted from Chacate and Mutombene (2019); and Williams et al. (2018)

focus on the reduction of marine plastic waste from the fishing sector itself. This can include improved on-board waste collection systems or the use of location devices to reduce the loss of fishing gear (He and Suuronen, 2018).

Given that the majority of people involved in the fishing sector in Mozambique are part of the artisanal fishing sector, any scheme considering the inclusion of fishers in the collection of marine plastic should focus on artisanal fisheries. Artisanal fishers can collect plastic on a daily basis and catch plastic from terrestrial sources and beaches before it enters the ocean. Additionally, incentives to collect plastic in this sector could have direct, positive livelihood impacts by providing an additional source of income for coastal communities.

Artisanal fisheries fish from the coast and use different types of boats (Table 6) to fish in marine coastal areas. Some of the gear used by artisanal fishers (beach seines, gillnets, and purse seines, see Table 6) can also catch plastics and marine debris when used. Considering this 'by-catch' as raw material for recycling and the development of new products could provide a new source of revenue.

This type of collaboration with small-scale fishers already exists in some countries. For example, in Thailand, the 'Moken Guardians of the Sea: Safeguarding the Ocean from Plastics' project implemented by the Jan and Oscar Foundation[8] buys plastic from artisanal fishers for the development of new products. The project aims to reduce marine plastic pollution by collecting Ocean Bound Plastic (OBP) in southern Thailand in a circular economy approach and supporting the local community.

Table 6: Summary of fishing licences per gear type issued for artisanal fisheries in Mozambique

Type of boat	Number
Canoa	26,924
Chata	2,938
Canoa, Moma type	7,740
Lanchas	1,086
Type of gears	**Number**
Beach seines	**9,916**
Hand lines	13,853
Gillnets	**20,396**
Longlines	1,077
Purse seines	**563**

Source: IDPPE (2012) and updated from Chacate and Mutombene (2019)

8 Read more here: MARPLASTICCs video series: Moken Guardians of the Sea: Safeguarding the Ocean from Plastics, a Circular Economy initiative by the Jan & Oscar Foundation in Thailand | IUCN

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 local precarious minorities, including the Moken, an ethnic group of semi-nomadic fishing people who live on several islands in the Andaman Sea. This project, as well as the 3R project mentioned above, are part of the IUCN Marine Plastics and Coastal Communities (MARPLASTICCs) initiative.[9]

Including artisanal fishers in the collection of marine plastics could potentially recover 440 kg of leaked plastic per boat per year or 4.4 kg per day of fishing; 561 kg per net per year or 5.6 per net per day of fishing; between 283 and 60 kg of leaked plastic collected per artisanal fisher per year or between 2.8 and 0.6 kg per day of fishing. These illustrative estimates are based on linking the total amount of plastic leakage of Mozambique (17,000 tonnes) with the total number of artisanal boats (estimated at 38,688), the number of nets (estimated at 30,312 seine and gillnets), and the total number of artisanal fishers (between around 60,000 and 280,000[10]).

Some artisanal fishers in Mozambique have already expressed interest in participating in such schemes. A brief survey carried out on 13 December 2020 by two of the authors of this brief of a group of 10 women involved in the fishing sector (boat owners, traders, and invertebrate collectors) in the Costa do Sol fishing centre showed an interest in engaging in plastic collection. On average, the people surveyed estimated that they would be able and willing to collect around 20 kg of plastics per person per day, in addition to the fishing activities they are already involved in.

As previously mentioned, the above calculations are used for illustrative purposes only, and represent a simplification of the realistic situation on the ground. The estimated leakage for Mozambique is based on national modelling from the *UNEP/IUCN National Guidance for Plastic Pollution Hotspotting and Shaping Action* National Report for Mozambique. Local ground-truthing of flows and leakages, including from street littering, illegal dumping near the coastline, and gear losses of the fishing fleet, could yield more accurate figures, so the actual leakage could be higher or lower. In addition, the estimates on plastic collection presented here imply that all plastic leaked on an annual basis can and will be collected. Furthermore, plastics in the marine environment can also enter national waters through the currents from sources outside of Mozambique, increasing the amount of plastics in the coastal areas and the ocean. Conversely, some plastic leaked will flow out of the area. Not only could the actual amount of leakage be different from the model results, but not all plastic is easy to collect, and not all plastic that can be collected can be recycled. To date, the leaked materials that can be recycled include: plastic bags (approximately 4,900 tonnes leaked); plastic bottles (approximately 1,500 tonnes leaked); PET, PP and low-density polyethylene (LDPE), which are leaked at an annual rate of 5,700, 3,200 and 3,000 tonnes, respectively (UNEP and IUCN, 2020).

Lastly, the largest challenge associated with including artisanal fishers in Mozambique in the collection of marine plastic debris is the size and volatility of the recycling markets. The 3R company in Maputo sends most of its materials to South Africa for recycling, as there is little demand for these materials domestically; Mozambique also imports all plastics. If recycling incentives are not strengthened, and if the demand for recyclable plastic material is not increased, it will be difficult to scale circular economy initiatives to provide an additional source of income for small-scale fishers.

9 See the MARPLASTICCs page https://www.iucn.org/theme/marine-and-polar/our-work/close-plastic-tap-programme/marplasticcs

10 See Section '3.2.2. Impact on employment'.

5. Summary and recommendations

Plastics affect Mozambique's fisheries directly through damage to ships, plastic in fishnets and the impact of ALDFG. Direct and indirect impacts on marine ecosystems and marine biodiversity further increase the negative effects of plastic pollution. This not only negatively affects the economy, but also impacts individual households' livelihoods and food security, especially in coastal communities.

Marine plastic pollution however, is not the only threat damaging Mozambique's fishing sector. The latter also suffers from a declining fish catch due to overfishing and illegal fishing, marine pollution from a range of sources, and the impacts of climate change (Hussein et al., 2020; UNCTAD, 2017). In addition, small-scale fisheries face many challenges including weak infrastructure affecting processing, trade, and commercialisation of small-scale fisheries products. Credit and financial services are also weak, which disrupts or prevents many potential innovations of the sector. Similarly, inadequate fisheries administration capacity at both national and local levels has been contributing to a reduction in surveillance, regulation, and data collection in the sector (Agulhas and Somali Current Large Marine Ecosystems Project, ASCLME, 2012).

Overall, marine plastic pollution plays a crucial role in marine ecosystem degradation and the services these ecosystems provide. This is not only a problem for the fisheries sector, but can also impact other sectors of the economy, such as potential losses in the tourism sector or increased costs of beach clean-ups to avoid these losses (Galgani et al., 2019), and increases in the costs of marine transport (McIlgorm et al., 2011).

Reducing plastic leakage and plastic stocks in the environment can thus create positive outcomes that are beneficial not only for the environment, but for the fisheries sector, and other sectors of the economy that directly depend on the marine environment. There are a broad range of potential interventions and solutions for consideration, such as improved waste management infrastructure and the inclusion of coastal communities in circular economy initiatives. The improved management of plastic waste and the reduction of plastics flowing into the marine environment should be an integral part of any strategy that attempts to strengthen the economic sectors that depend on the marine environment, or when reviewing support to the blue economy of Mozambique.

Small-scale circular economy projects specifically targeting coastal communities and assuring the inclusion of women can play a key role in these interventions. The projects could be linked with some of the ongoing decentralisation and co-management of marine resources. For example, the issuing and charging of licenses, as well as enforcement of fisheries regulations and collection of fines are now starting to be managed by district administrators (ASCLME, 2011). Likewise, co-management committees have been integrating local chiefs from fishing villages into the administrative process as a means of sustaining traditional management techniques (Samoiylis et al., 2017). Thus, the inclusion of small-scale fishers in the management of marine resources, including waste management, can support further development of the fisheries sector and the blue economy, while assuring that Mozambique's marine biodiversity is conserved.

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FOR CONSERVATION OF NATURE

WORLD HEADQUARTERS
Rue Mauverney 28
1196 Gland
Switzerland
Tel +41 22 999 0000
Fax +41 22 999 0002
www.iucn.org