IN SUPPORT OF THE IOTC ECOSYSTEM REPORT CARD: INDICATORS FOR MARINE DEBRIS

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SUMMARY

This document addresses the “marine debris” ecosystem component to support the development of an indicator-based ecosystem report card at the IOTC. The goal of the document is to point out the importance of identifying the marine debris produced by the fishing activities of the major IOTC fisheries and its potential impact on the marine ecosystem in the Indian Ocean. With this objective the following points have been developed: (1) We describe the “marine debris” ecosystem component, highlight its importance and the need of monitoring it. We also make a proposal of a conceptual and an operational objective to measure progress towards the management of this component. (2) We propose candidate indicators, which are shared by all fishing gears, that could be measured to monitor the extend of marine debris both on the open ocean and coastal ecosystems produced by IOTC fisheries.(3) We chose to initiate our work by identifying the potential sources of the different fishery activities to marine debris and examine data availability and sources to support indicators development, and (4) Finally, a draft work plan to guide the future work is defined. If interested, contact the corresponding authors to find out how you can contribute to this initiative.

KEYWORDS

Marine debris, Fish Aggregating Devices, Abandoned Lost Discarded Fishing Gear

1. Introduction

To facilitate the implementation of an Ecosystem-Based Fisheries Management (EBFM) in the IOTC Convention Area, the Working Party on Ecosystems and Bycatch (WPEB) recommended in 2018 the development of an indicator-based ecosystem report card (Juan-Jordá et al., 2018). Its goal is to provide stronger links between ecosystem science and fisheries management and to increase the awareness, communication and reporting of the state of different Indian Ocean ecosystem components to the IOTC Commission (Juan-Jordá et al., 2018). To achieve this objective the WPEB identified different ecosystem components as key areas that would be required for monitoring the overall health of the ecosystem of the IOTC species.

The overall objective of the present document is to point out the importance of identifying marine debris as one of the ecosystem components covered in the IOTC ecosystem report card. To reach this goal this document identifies the marine debris produced by the fishing activities of the major IOTC fisheries and its potential impact on the marine ecosystem in the Indian Ocean. When assessing this component, it is important to examine the contribution of marine debris across the multiple gear types and their relative contributions.

This document addresses the “marine debris” ecosystem component and specifically it contributes towards developing the following elements:

1. We describe the “marine debris” ecosystem component, highlight its importance and the need of monitoring it. We also make a proposal of a conceptual and an operational objective to measure progress towards the management of this component.

2. We propose candidate indicators, which are shared by all fishing gears, that could be measured to monitor the extend of marine debris both on the open ocean and coastal ecosystems produced by IOTC fisheries.

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3. We chose to initiate our work by identifying the potential sources of the different fishery activities to marine debris and examine data availability and sources to support indicators development.

4. Finally, a draft work plan to guide the future work is defined.

2. The "marine debris" component and objectives to towards the management of this component.

Marine debris, according to UNEP and NOAA (2012) is "any anthropogenic, manufactured, or processed solid material (regardless of size) discarded, disposed of, or abandoned in the environment, including all materials discarded into the sea, on the shore, or brought indirectly to the sea by rivers, sewage, storm water, waves, or winds". It is long-recognized the indiscriminate disposal of plastic and other synthetic materials into the ocean as an international problem (Gregory, 2009). Recently, it was estimated that between 4.8 and 12.7 million tonnes of plastic enter the marine environment every year, and according to Jambeck et al. (2015), this problem could increase in the coming year without appropriate waste management strategies. Plastic are the major source of marine debris with approximately 60 to 90% of litter made up of one or a combination of plastic polymers, while the other 10 to 40% of the litter could be paper, wood, textiles, metal, glass, ceramics, and rubber (Butterworth et al., 2012; UNEP and GRID-Arendal, 2016).

There are two main sources of marine debris to the ocean i) land-based inputs and ii) sea-based inputs. It is widely assumed that land-based sources contributes with approximately 80% to the total marine debris and rivers seem to represent a key entry point to the ocean (González et al., 2016). Sea-based inputs can contribute approximately with 20% but existing reports show strong fluctuations at regional level in the seas and oceans around the world, so more consistently studies are still needed (EEA 2015, UNEP 2016). The origin of latter source could be classified in three main groups i) *fishery activity*, mainly by garbage generation and Abandoned Lost or Discarded Fishing Gears (ALDFG), ii) *shipping activities*, litter derived for example from cargos and iii) other vessels activity, for example litter derived from recreational activities. These three groups also contribute to marine debris with unmanaged disposal of garbage generated onboard. In particular, ALDFG has become a serious concern as fishing effort in the world's ocean and the durability of fishing gears increased (Macfadyen et al., 2009; Bilkovic et al., 2014). ALDFG can cause ecological problems for marine species when floating gears continue catching and killing organisms (known as ghost fishing). It can also have an impact on sensitive habitats (e.g. coral reefs) when stranded offshore as well as cause socio-economic problems for the fishing fleets by increasing costs when lost unintentionally. The replacement of the gear lost at sea and the reduction of the potential harvestable catch are two of the key economic effects of lost or abandoned fishing gear (Butler et al. 2013; Arthur et al. 2014; Bilkovic 2014). In addition, due to the breakdown of plastic materials, microplastics are generated and the toxics substances contained are introduced throughout the food chain supposing a threat to the human health and the ecosystem (Rochman, 2015). In respond of theses impacts research has been conducted around the world on ALDFG, particularly in the last year, however, there are still significant data gaps mainly because fishing gears are diverse and specific of the target species and region, and research actions has been focalized in localized regions (Richardson et al., 2019). Indeed, based on the data collected in the Global Ghost Gear Initiative[4] the Indian Ocean is a poor data region.

In the IOTC Convention Area the fishing activity is conducted by different fisheries, such as purse seine, drifting longlines, pole and line, trollers, and drifting gillnets. Trawlers and squid jigger also operate in the Indian Ocean but do not target tuna species. In this region there is also a significant artisanal fishery component, corresponding approximately 40% in respect of fishery targeting tuna. All of them contribute to the increase of marine debris mainly through a poor management of garbage generated onboard and ALDFG. In the last decades, the IOTC has related ALDFG impacts with increase mortality of sensitive non-target species such as seabirds, turtles and shark, through the entanglement of these species on ALDFG (known as ghost fishing) and by ingest of litter (IOTC Resolution 12/04; Ryan et al., 2016). However, the rate and magnitude of ALDFG in the Indian Ocean, like other regions in other oceans, is still largely unknown (Macfadyen et al., 2009). It is well documented that ALDFG as part of the marine debris, like other pollutants, can also affect sensitive habitats, the ecological function and the health of organisms of the ecosystems where is accumulated (UNEP and GRID-Arendal, 2016). This indicates a direct impact for the welfare of sensitive species routinely entangled in or by species ingesting lost or discarded fishing gear's components (Butterworth et al., 2012). However, it is still unknown how this litter could affect other large pelagic species under IOTC management responsibility (Romeo et al., 2015).

[4] https://www.ghostgear.org/

The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international instrument covering prevention of pollution of the marine environment by ships from operational or accidental causes, which includes a specific Annex V for the prevention of pollution by garbage from ships (IMO, 1973). This convention stablishes the manner at which different types of garbage need to be managed specifying the distances from land and how they may be disposed. The Annex V also includes a complete ban imposed on the disposal into the sea of all forms of plastics. For vessels ≥400 GT or scertified to carry ≥15 persons, the convention includes the obligation to provide a Garbage Record Book (GRB), and the provision of adequate reception facilities at ports without causing undue delay to ships. The GRB includes the record of each discharge made at sea or a reception facility, or a completed incineration, including date, time, ship position, category of the garbage (i.e. plastics, food waste, domestic wastes, cooking oil, incinerator ashes, operational wastes, animal carcasses, fishing gear, e-wate) and the estimated amount (i.e. cubic meters) discharged or incinerated. The implementation of Annex V has been recently reinforced by the new action plan adopted for ships but also for vessels including measures as the reporting of the loss of fishing gear and facilitating the delivery of retrieved fishing gear to shore facilities (IMO, 2018). Additionally, regional instruments as EU Marine Strategy Framework Directive (EU-MSFD) also addressed marine debris prevention as an integral policy instrument for the protection of the marine environment for the European Community, following an ecosystem-based approach (EU 2008). In the EU-MSFD, EU Member State should achieve or maintained the Good Environmental Status including the marine litter as one of the descriptors (i.e. descriptor 10). In this framework, the indicators define to monitor the marine litter, are trends in the amount, distribution and composition of marine litter in beaches, in the water column and on seafloor, including microplastics (Galgani et al., 2015). Additional criteria are the impact on the marine fauna and includes as indicators the rate of entangled fauna and the amount of debris in gut contents (EU 2010). Other instruments at international and regional level and guidelines has been elaborated for managing and monitoring of marine litter which can be found in Chen (2015).

At t-RFMOs level, specific forms were adopted to collect information on marine debris thought the observer programs as is the case for the SPC/FFA (i.e. Form GEN-6 designated in 2000 to Monitor violations of MARPOL annex I and annex V) which record quantity by type of the waste dumped to the sea (Richardson et al., 2016). At IATTC the Resolution C-04-05 REV 2[5], prohibits vessels from disposing of plastic containers and other debris at sea, and instructs the Director to study and formulate recommendations regarding the design of FADs, particularly the use of netting attached underwater to FADs. The IOTC have also been working on to minimize impacts generated by fisheries activity specially those related with ALDFG in the ecosystem. For example, IOTC resolution 12/12 prohibits the use of large-scale driftnets on the high seas to prevent detrimental effects these nets, if lost or discarded (e.g., ghost fishing), may cause on species of concern and the marine environment. Similarly, IOTC Resolution 19/02 defines the procedures on FADs management plans, prohibiting the deployment of FADs without operational buoys, use of netting material in FAD construction and promoting the use of biodegradable materials to phase synthetic material out. In the same resolution (Res 19/02, para. 19) it is also noted the obligation to remove from the water, retain onboard and only dispose in port, all traditional FADs encountered from 2022 on.

The “marine debris” ecosystem component of the IOTC ecosystem report card focuses on examining the magnitude and extent of the ALDFG and addresses contribution of garbage discharged from vessels generated by the fishery activity of the IOTC fleets in the Indian ocean. Currently the magnitude and extends of the impacts of the marine debris derived by IOTC fleets are unknown or poorly known, and the actual data gap prevents the quantification, monitoring and assessment of this ecosystem component. Not accounting for the mortality due to entanglement with ALDFG and ingestion of debris in population and stock assessment models has the potential to make less effective the harvest strategies of managed species. It is also a threat for the most vulnerable species populations (e.g. sea turtles, marine mammals, seabirds and some sharks and bony fishes) which can impact on the status (Coggins et al., 2007; Gilman et al., 2013). Accumulation of marine debris produced by fisheries along the coast can also impacts the health of coastal ecosystems and their utilizations by coastal communities.

In order to measure progress towards managing the “marine debris” ecosystem component of the IOTC ecosystem report card, we propose the following conceptual and operational objective:

Conceptual objective: “Monitor, prevent, and reduce marine debris generated by IOTC fisheries”

Operational objective: “Determine the extent of marine debris and its trend over time generated by IOTC fisheries”

[5] https://www.iattc.org/PDFFiles/Resolutions/IATTC/_Spanish/C-04-05-REV-Jun-2006-Active_Resolucion%20consolidada%20sobre%20captura%20incidental.pdf

3. A proposal of candidate ecological indicators to monitor the "marine debris" component of the IOTC ecosystem report card

Marine debris are a global threat to marine life and it has been documented to disrupt breeding cycle, compromise foraging habitats, increase mortality of turtles, sharks, coral and seabirds by entanglement and/or ingestion of litter (UNEP, 2016). While improved management on marine debris are becoming an urgent need, limitations on the management instruments, poor cooperation and coordination and insufficient data prevent from an appropriate quantification and assessment. In the case of the Indian Ocean, the trend and quantification on marine debris in the IOTC are limited, and this lack of information does not allow the assessment of the contribution of each fishing gears under the management of IOTC.

To better understand fisheries activity contribution to marine debris and impacts on species and broader ecosystem, it is necessary a quantitative and qualitative information of the source and amount of marine debris. This requires to quantitatively estimate the magnitude of the inputs, i.e., number of items, size and weight of introduced debris by fishing gear, and to qualitatively characterize the type of materials disposed into the sea. The estimation of these parameters is critical as a baseline for management decisions and to inform those decisions required to prevent, reduce, and control the impacts caused by marine debris. Thus, this document proposes three potential indicators for all fisheries operating in the IOTC Convention Area:

1. **Number of debris item** disposed and/or discharge events into the ocean.

2. **Weight and volume of debris item** disposed into the ocean, provided in kilograms and cubic meter, respectively (if possible).

3. **Type of debris item** description; when item is composed by different components/parts specify each component material.

These three indicators should be estimated for all fisheries operating in IOTC Area. Each fishery should be considered separately to identify the source of debris generated by each of them and properly estimate relative contribution to the total input. This will also allow to assess fishery-specific input's impact for the ecosystem and inhabiting species. Temporal and spatial scale information should be also provided to improve our understanding of marine debris pathways and its spatial temporal variability within the IOTC convention area.

Presence of microplastic (particles < 5 mm in diameter) in different ecosystem habitats, both primary microplastics (i.e., purposefully manufactured to carry out a specific function) and secondary microplastics (i.e., resulting from wear and tear or fragmentation of larger objects), is also an important aspect to consider as potential indicator for monitoring the overall health of the ecosystem (GESAMP, 2019). It has been documented that microplastic can be ingested by biota, such as marine mammals, seafood, birds, turtles and several commercial fish species (UNEP, 2016). Consumption of microplastic has associated physical and chemical impacts that potentially affect the health and biological traits of these species (UNEP, 2016) and potentially the whole food chain. However, according to UNEP (2016) little is known about the impact of their consumption and the possible transfer of chemicals associated with microplastics into organisms' tissues, which could end transferring these contaminants to the fish flesh, and hence be made available to predators, including humans. Monitoring of microplastic requires specific sampling protocols to ensure correct measurement in different ecosystem habitats (JRC, 2013; GESAMP, 2019). Similarly, it is widely recommended the need of harmonization of sampling methods and data collection protocols to facilitate comparations between regions and the observation of trends that allow decision-makers the adoption of corrective management measurements, if necessary. Nowadays, the contribution of IOTC fisheries to the production of part of the secondary microplastics generated from marine debris disposed to the ocean could be hardly estimated and future works should be devoted to exploring monitoring options for this component of the Marine Debris.

4. Indicator development

We conducted a preliminary revision on how marine debris indicators could be estimated on various fishing gears catching tropical tunas in the western Indian Ocean, including the revision of the data source, available data (e.g. collected by observers and CPCs:, FAD logbooks; and submitted by CPCs to the IOTC: 3FA), and data gaps. It will allow to determine the data requirements by fishery to assess the potential contribution of each fishery to marine debris and monitor its trend. This exercise provides us perspective about the feasibility to develop proposed indicators supported by the available data.

Table 1. Description of fishery contribution to marine debris, data available, existing data sources, data gaps and future data collection requirements to assess proposed indicators candidates. The FAD information is analyzed in a specific section as specific data collection protocols are already in place for the assessment of the number of FADs and activities, which could be potentially used for accounting of marine debris in the future.

Contribution to marine debris	Candidate Indicators	Data Source	Data available	Data Gaps and requirements
Abandoned and Lost FADs	Number of debris items	- FAD logbook - 3FA - Buoy transmission on FADs**** - Observer Data (100% coverage)	- FAD Abandoned and lost by vessel*	- Number of FAD abandoned or lost and never recovered**.
	Weight and size of debris items	- FAD logbook - Observer Data (100% coverage)	- Depth of the submerged structure and size of the floating structure	
	Type of debris items	- FAD logbook - Observer Data (100% coverage)	- Entangling character and nature of materials	
Abandoned Lost or Discarded Fishing Gears ALDFG for other fisheries at IOTC area	Number of debris items	-RGB of MARPOL***	- Gear lost - Nº of abandoned and lost by vessel if recorded in RGB of MARPOL	- Number of Fishing Gear abandoned or lost
	Weight and size of debris items	- RGB of MARPOL***	- size of abandoned and lost gear by vessel if recorded in RGB of MARPOL	- Gear weight and size for vessels without RGB.
	Type of debris items			- Type of gear and its component
Discharge of garbage from vessel	Number of debris items or discharge events	- RGB of MARPOL	- N of events if recorded in RGB of MARPOL	- N of events for vessels without RGB
	Weight and size of debris items	- RGB of MARPOL	- Weigh and volume by garbage type for each discharge if recorded in RGB of MARPOL	- Weigh and volume of by garbage type for vessel without RGB of MARPOL
	Type of debris items	- RGB of MARPOL	- Type of garbage as defined in MARPOL if recorded in RGB of MARPOL	- Type of garbage for vessel without RGB of MARPOL

*The individual contribution of each case is not available

**The specific strategy of FAD fishery tent to recover and reuse FADs found at sea (any FAD abandoned or lost by any purse seiner). Therefore, the specific component of those FADs that are lost or abandoned and never reuse is unknown

***For vessels ≥400 GT or certified to carry ≥15 persons

****Since 1st of January to 2020 to evaluate the commitment with buoy limitations in force (Res 19/02), with future potential use for marine debris

We highlight that fishery impacts need to be investigated by major fisheries and gears as well as their cumulative impacts on a regional basis, since cumulative impacts can only provide a true understanding of the extent of the fishing impacts on species, communities and the broader marine ecosystems including sensitive habitats. This first preliminary assessment shows that purse seiner fishery could be a data reach fishery which has adopted a 100% observer coverage (Goujon et al. 2018; Lopez et al., 2017) and collects and provides information on activities with FADs and specific data for FAD tracking (i.e. buoy transmission data), in this last case shared to conduct specific research actions (Katara et al., 2018; Zudaire et al., 2018) and since 1st of January to 2020 to evaluate the commitment with buoy limitations in force (Res 19/02). This information could be potentially used in the future to estimate FAD beaching events or proportion of FAD lost and abandoned (Maufroy et al., 2015; Zudaire et al., 2019). In addition, the vessels, should all record all garbage discharge in RGB following requirements of MARPOL. However, concerning to IOTC fisheries and in support of MARPOL data collection on ALDFG and garbage discharge, substantial effort should be done for quantifying the amount of marine debris on IOTC area of competence. Complementing the data collection mechanism stablished by MARPOL specific guidelines and protocols should be defined for developing standardized data collection and transmission mechanism.

5. Discussion and Future work

The main challenge of marine debris monitoring through the development of proposed indicators for all fisheries operating in the IOTC convention area is the availability and access to the data. This will require the engagement and cooperation of the industry. The development of specific guidelines, and data collection form following the recommendation posed by international organism expert in the field will also be necessary. This will entail the establishment of a standardized methodology for data collection and exchange to ensure harmonization with existing programs allowing comparison of datasets and thus detect significant changes in the spatial or temporal distributions (JRC, 2013).

Below we summarize some recommendation for future works to advance towards monitoring the “marine debris” ecosystem component of the IOTC ecosystem report card. This document should be considered as the first step towards addressing this component, and it will be in progress with the aim to be updated annually at the WPEB meetings. To ensure the correct identification and estimation of indicators for monitoring marine debris it is necessary the collaboration of multiple experts with experience in the multiple gears operating in the IOTC convention area and the marine debris problematic. We invite the IOTC community to contribute towards the development of the “marine debris” component to support the IOTC ecosystem report card.

Recommendation for future work:

- In order to improve knowledge on this ecosystem component, the exchange of data collection protocols and of already available data is promoted as first important step towards the monitoring of marine debris.
- The review of specific protocols in place and available data will allow to further identifying gaps in data and knowledge and design the methodological approach to quantity and monitor trends in marine debris.
- Marine Debris monitoring protocols to collect data for the assessment of marine debris indicators, should be defined considering existing master list of categories of litter items (for example Annex 8.1 at JRC, 2013; Annex V of MARPOL, the Global Ghost Gear Initiative) to ensure harmonization between programs.
- Data on marine debris disposal should include temporal and spatial scale information to enable mapping of occurring events and to improve our understanding of marine debris pathways and variability in litter transport, and final fate within the IOTC convention area.
- Data collection on Marine Debris could be supported by Observer Programs, either human observers or by electronic monitoring system.
- Development of risk matrix, considering the category of probability or likelihood of an item disposal against the category of consequence severity of that disposal, can be promoted as future work. This will allow WPEB to assess all fishing gear jointly by a simple mechanism and increase visibility of each gear risks and assist management by proposing best approaches according to the risk levels.

All those points would allow the WPEB to better understand the impact of marine debris in the overall health of the ecosystem of IOTC species.

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