Towards improvement in monitoring, reporting and management of Fish Aggregating Devices in the Indian Ocean Purse Seine Tuna Fishery

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ABSTRACT

The Sustainable Indian Ocean Tuna Initiative (SIOTI) has been established in a collaborative effort by key governments in the Indian Ocean, fishing companies, tuna processors and WWF. They have launched a Fisheries Improvement Project (FIP) to support improvements towards the sustainable management of purse seine tuna fishing, with the ultimate goal of certification by the highest standards for sustainable fishing, the Marine Stewardship Certification (MSC) standard. SIOTI commissioned a pre-assessment of the fishery as part of its FIP, which has identified several areas where action should be taken in order to achieve MSC certification, i.e., their Improved Performance Goals (IPGs). Among these, are IPGs related to the impacts of Fish Aggregating Devices (FADs) in habitat outcomes, management strategies, and information. The objective throughout this study is to identify deficiencies in the FAD data collection, reporting, and transmission process and provide recommendations that would enhance transparency and compliance with FAD Management Plans and IOTC resolutions, with the ultimate goal of achieving MSC certification for the SIOTI Indian Ocean purse seine tuna fishery. Here, we review the recent conservation measures adopted at the 23rd IOTC Commission meeting in Jun 2019 and identify areas where further advances can be made towards the sustainability of the Indian Ocean purse seine tuna fishery.

KEYWORDS: Fish Aggregating Devices, FAD, purse seine fishing, tuna, yellowfin, *Thunnus albacares*, bigeye, *Thunnus obesus*, skipjack, *Katsuwonus pelamis*, Marine Stewardship Council certification, Sustainable Indian Ocean Tuna Initiative, Fisheries Improvement Project, Echebastar, Indian Ocean, the Code of Good Practice, OPAGAC, ANABAC, ORTHONGEL, SAPMER, tRFMOs, FAD Management Plans, FAD Watch, Seychelles.

1 INTRODUCTION

FADs are human-made floating structures that are used to attract and concentrate fish, particularly tuna. These devices are equipped with satellite-tracked buoys such that they can be followed by fishing vessels. From the 1990s, many industrial tuna purse seine fisheries in the Indian Ocean have increasingly used FADs to facilitate fishing and increase catch. These buoys are now often equipped with echosounders that can estimate the level of biomass under the FAD and aid fishers in targeting the FADs that have high concentrations of fish, thereby increasing fishing efficiency.

Fishing and the increased use of FADs has led to serious concerns about the impact on fish stocks and the marine ecosystem. Young fish tend to concentrate around FADs, which when fished in high proportions, can have long-term effects on the status of the stock. Ecosystem impacts are also a concern for FAD fishing as bycatch and discards of non-target and vulnerable marine species occur 90% more often when setting around a FAD than when setting on a free-school (Sánchez et al. 2007, Amandè et al. 2010). In addition, non-target species can become entangled in the FAD structure (e.g., Filmalter et al. 2013). The FADs that drift out of the fishing zone and whose satellite buoys are deactivated, are abandoned at sea to sink, drift as marine debris, or beach in coastal habitat. Impacts to sensitive coastal environments (e.g., coral reefs) by discarded or beached FADs are beginning to be documented (Balderson and Martin 2015, Zudaire et al. 2018a).

Several initiatives by the industries and others have begun to address the threats imposed by FADs to vulnerable ecosystems, including initiatives promote new designs to reduce entangling risk, a switch to constructing FADs using biodegradable materials to reduce marine pollution, and development of autonomous FADs to prevent beaching and reduce the number of FADs deployed. Furthermore, a recent Seychelles-based project, FAD Watch, is currently assessing and attempting to mitigate the impact of FADs on coral reef habitats, through monitoring, interception and clean up efforts of derelict FADs.

The Sustainable Indian Ocean Tuna Initiative (SIOTI) has been established in a collaborative effort by key governments in the Indian Ocean, fishing companies, tuna processors and WWF, and currently represents 42 vessels (Appendix 1). SIOTI has launched a Fisheries Improvement Project (FIP) to support improvements towards the sustainable management of tuna fishing, with the ultimate goal of certification by the highest standards for sustainable fishing, the Marine Stewardship Certification (MSC) standard. Based on pre-assessments of the fishery, several Improved Performance Goals (IPG) were identified to which SIOTI should demonstrate progress towards MSC standards for responsible fisheries. To attain MSC certification, these IPGs specifically recommend that SIOTI demonstrate that FAD use in their fishery is highly unlikely to have serious or irreversible impacts on vulnerable marine environments (VMEs) (IPG 12 Habitat outcome). In order to demonstrate this, management measures should be implemented (IPG 13 Habitat management strategies), and there should be enough data to determine the main impacts of FADs on the habitat (IPG 14 Habitat information).

A SIOTI partner fleet, Echebastar, was recently (November 2018) certified by MSC with eight conditions for its skipjack fishery (DeAlteris et al. 2018). The strengths of the Echebastar fishery were that the skipjack stock is well-monitored and in good condition, there are adequate data to monitor ecosystem impacts due to 100% observer coverage, and there is relatively little bycatch, with the exception of silky sharks. In addition, Echebastar took several steps to strengthen its sustainability credentials, including 1) 100% observer coverage to provide assurance of the compliance of the fishery and the quality of the data generated; 2) implementing non-entangling FAD designs within its

fleet to minimise the likelihood of endangered, threatened, or protected (ETP) species bycatch, and 3) introducing a second conveyor belt on three of five of its vessels to aid in the rapid release of bycatch.

In order to improve scoring against certain Performance Indicators (PIs), and therefore keep its certification, specific conditions were imposed on the Echebastar fleet that require progress over the next five years. These include ensuring there are sufficient information to measure trends by collecting data and conducting research to improve understanding of the fishery's impacts on ETP species. The information must be sufficient to support a management strategy that can demonstrate that FADs that become lost and stranded on coral reefs are highly unlikely to reduce coral reef structure and function to a point where there would be serious or irreversible harm.

In a recent study, using the IPGs outlined in the SIOTI FIP pre-assessment and the Echebastar MSC certification report as a guideline, we reviewed the monitoring, reporting, and management of FADs within the SIOTI fleet. Furthermore, we reviewed the IOTC resolutions relating to FAD data and reporting, and the management measures included in the new Resolution 19/02 adopted at the 23rd Commission of the IOTC. Building on these, we identify where further advancement could be made to improve the monitoring, reporting, and management of FADs in the Indian Ocean purse seine tuna fishery, with the goal to achieve MSC Certification of the SIOTI fleet. Here, we present the main recommendations resulting from the larger study.

IOTC FAD data and reporting requirements and management measures

The 23rd meeting of the IOTC Commission recently adopted Resolution 19/02: Procedures on a Fish Aggregating Devices (FADs) Management Plan. This and other IOTC resolutions that outline the data and reporting requirements related to FADs are reviewed briefly.

IOTC FAD data collection requirements

Resolution 15/02 specifies the catch and effort data elements required for all different types of fisheries, and specifies that surface fisheries (including purse seine) stratify their reporting by fishing mode (i.e. free-swimming or sets on floating objects), giving information on FAD identifier, FAD type, the FAD design characteristics of each FAD.

Resolution 19/02, which supersedes Resolution 18/08, requires that any encounter with a FAD should be recorded in a FAD logbooks to be submitted to the Secretariat and following the minimum data requirements from Annex III of Resolution 19/02 and form 3FA (Appendix 3). These observations should include information on the type of FAD, the activities relating to the FAD, the FAD ID and buoy ID, ownership, design, position, area, data, number of sets made and the catch, bycatch and effort if a set is made.

IOTC FAD management measures

Resolution 19/02 sets the maximum number of instrumented buoys active and followed by any purse seine vessels to 300 instrumented buoys at any one time, the active number being calculated as the number of active buoys operated by a purse seine vessel. The number of instrumented buoys that shall be acquired annually for each purse seine vessel is set at no more than 500. The IOTC Secretariat will send an annual report to the Compliance Committee to report the level of compliance of each CPC with operational buoy limits, annual limits of instrumented buoys purchased.

This resolution states that all FADs must be equipped with an instrumented buoy and that only purse seiners and their support or supply vessels can deploy a FAD in the IOTC area of competence.

Buoys can only be made operational when physically onboard the vessel to which it belongs or its support or supply vessel and that the activitation should be appropriately recorded in the correct logbook. The entry should specify the unique buoy ID number, date, time, and geographical coordinates of deployment. Reactivation can only be possible once a buoy is brought back to port.

CPCs can set lower limits to the number of buoys deployed in their EEZ, and they are required to monitor the compliance of vessels operating under their flag to buoy limits. Vessels are required to declare to their CPC the number of buoys onboard and their unique ID before and after every fishing trip.

CPCs must submit an annual FAD Management Plan, following the guidelines outlined (Annex I (Appendix 2)). These plans are to be analysed by the compliance committee and should include statement requiring the vessels to compl with this resolution.

FADs are to be non-entangling (Annex V), and the use of natural or biodegradable material is promoted and trials of FADs using biodegradable material are encouraged. Furthermore, vessels are encouraged to remove traditional (entangling) FADs from the water to be disposed of in port.

A unique identifier is required for each instrumented buoy, and a marking scheme shall by developed by 2020.

A FAD tracking and recovery policy will be established in 2021, and will define FAD tracking, reporting of lost DFADs, arrangements to alert coastal States of derelict/lost DFADs at risk of beaching in near real-time, how and who recovers the DFADs, how the recovery costs are collected and shared.

IOTC Reporting requirements

Resolution 12/02 requires that the tuna purse seine fishery report their catch data stratified by FAD association to the IOTC as 1° longitude by 1° latitude by month in an annual report.

Resolution 19/02 requires that buoy activity reports are to be submitted to the Secretariat in monthly reports either directly from the buoy provider or by the vessel and should include daily information on date, instrumented buoy ID, assigned vessel and daily position for all active FADs submitted within 60 days, and no longer than 90 days.

CPCs shall require their vessels to send annual reports on the number of operational, lost, and transferred buoys followed by each vessel at a resolution of 1° x 1° per month. The new resolution is unclear, but it is interpreted that these data be sent to the IOTC Secretariat.

Whilst the new resolution 19/02 has made significant progress towards improving the monitoring, reporting, and management of FADs in the Indian Ocean, we find that further improvements can be made. Here, we present further suggestions that could be considered by the IOTC community, but particularly the SIOTI fleet to aid in the MSC certification of the Indian Ocean purse seine fishery.

2 FAD DATA REPORTING

2.1 Submission of the proof of buoy purchase

Resolution 18/08 made a clear statement requiring that proof of buoy purchase be provided to the CPC to monitor the number of buoy purchases for the current year. Resolution 19/02 mentions that the IOTC Secretariat shall submit a report, on an annual basis, to the IOTC Compliance Committee on the level of compliance of each CPC with annual limits of instrumented buoys purchased. However, it does not clearly state how the Secretariat will receive this information. It is recommend that the Commission require annual reports of the number of buoys purchased per vessel should be submitted directly from the buoy provider to the IOTC Secretariat in an annual report by 1 January of each year.

Table 2.1 Priority recommendations to improve the quality of FAD data reporting.

Recommended to submit to the IOTC directly	Submitted by	Spatio-temporal resolution of data	Frequency of submission	Submission option from IOTC Resolution 19/02
Purchase orders of buoys	Buoy provider	1/year/vessel	Annual	Unclear
Number of activated, deactivated, active, and lost/stolen FADs	Buoy provider/ Independent agency	1°/month/vessel	60-90 days	Required

2.2 Harmonising terminology of the IOTC data forms

FAD logbooks are required and should record information from any encounter with a FAD taken following the minimum data requirements from Annex III of Resolution 19/02 and and form 3FA (Appendix 4) and including information on the type of FAD, the activities relating to the FAD, the FAD ID and buoy ID, ownership, design, position, area, data, number of sets made and the catch, bycatch and effort if a set is made.

Ramos et al. 2017 notes that the standardization of templates, tools and guidelines for FAD data reporting at the RFMO level and, if possible, among t-RFMOs, would be highly desirable, and would no doubt improve data usability, and would also enhance data reporting compliance. They also note that there is little information that supports the collection of many of the current fields and that attention should be given to fine-tune the trade-offs between the efforts and benefits in the acquisition of FAD-related information.

Several works have been conducted recently to analyze data collection- and submission-related problems and have proposed potential solutions. Here are reviewed the suggestions made by Báez et al. 2017a and Grande et al. 2018. Continued efforts to harmonise Form 3FA and FAD logbooks would greatly aid consistency and quality of data reporting throughout the SIOTI fleet. These subjects have already been significantly invested in and are not far from being finalised.

Form 3 FA

Báez et al. (2017a) made specific suggestions relating to form 3FA, i.e. the IOTC FAD logbook form. Their suggestions are based on the results of the CECOFAD project, and interpretations of the IOTC data and reporting requirements. Báez et al. (2017a) suggests that CECOFAD terminology should be

adopted for both FAD and FAD activity data categories. They also suggest that FAD ownership, vessel type and the number of vessels and days at sea should be recorded in a per grid cell per month.

These suggestions were presented to the IOTC, who reviewed and replied to their proposals (IOTC 2017a) and discussed them within the context of the Working Party for Data Collection and Statistics (IOTC 2017b). The most recent version of form 3FA available on the IOTC website has been updated to include the specific requests that were agreed upon at the WPDCS, and includes the updated fields type of FOB, and type of activity (Appendix 2). The IOTC Secretariat is waiting on feedback from the parties interested in modifying the FAD terminology, they note that changes to terms will not be difficult for data management, and it has already been stated that intersessional discussions are welcome. Therefore, specific recommendations to Baez et al. 2017a's requests are outlined in Table 2.2.

Table 2.2 The specific requests by Báez et al. (2017a), the IOTC Secretariat's response (IOTC 2017b), and the recommendations from this report. Green = request accepted; orange = discussion required; blue = IOTC suggestion to be confirmed; red = currently a negative response by IOTC to request.

Request 1	**Modify the title from "Catch and Effort" to "Catch and Effort on FOBs"**
Response	Minor request, agreed
Request 2	**Delete the field "Target species" since it is unnecessary**
Response	Metadata at form level; currently optional; can be provided by fleets that are recording this data. Suggested to keep it as it is (optional)
Recommend	Agree with IOTC to keep the field as it does not significantly simplify the forms to delete this field relative to the Secretariat's response.
Request 3a	**Rename column "Type of FAD" as "Type of FOB"**
Response	Minor request, agreed
Request 3b	**Consider FOB types based on CECOFAD definitions**
Response	See the differences between CECOFAD and IOTC FOB / FAD types then take an informed decision
Recommend	In terms of monitoring FADs: It is recommended to keep the information about whether the buoy is tracked, as in current IOTC codes for FAD type. These data are used often (for example tracking investigating a procedure to split effort between tracked and untracked FOBs (Kaplan 2018). In terms of assessing the impacts of FADs to bycatch and ecosystems: CECOFAD recommendations to include the inherent environmental impacts of FADs are also highly important for many studies looking into ecosystem impacts.
Request 4a	**Rename column "Type of visit" as "Type of activity"**
Response	Minor request, agreed
Request 4b	**Consider activity types on FOBs using CECOFAD definitions**
Response	See the differences between CECOFAD activity and IOTC visit types then take an informed decision
Recommend	In terms of enhancing the clarity, improving data and reporting :

	Any FAD definition must be mutually exclusive from all other definitions to avoid any confusion or misreporting, e.g., the IOTC FAD activities are often overlapping, for example DH, DI, and DR all have 'retrieval' as part of their activity.
Request 5	**Add column defining FOB ownership as table 4 in doc. 27 ("Owned" / "Not owned")**
Response	Not owned = "not equipped with a buoy or equipped with a buoy not owned by the vessel" might be ambiguous. Suggest to add "Not equipped with buoy" as further classification to table 4
Recommend	Ownership of the FADs allows for the life cycle of the FAD to be better tracked, enhances accountability of the fate of FADs, and is important for compliance. Thus, accept the suggestion of the IOTC that a third field be added : "Not equipped with buoy".
Request 6	**Rename column "Effort" as "No. of activities" for more clarity**
Response	Currently, "Effort" is expected to record the number of FOBs subject to the activity. With the proposed changes, how can multiple visits (n > 1) to the same FOB (n = 1) be recorded?
Recommend	Clarify that "Effort" relates to the number of FOBs subject to the activity.
Request 7	**Add a column specifying the type of vessel among those in table 5 in doc. 27 ("PSEU" / "SUPP" / "OTH")**
Response	Currently, form 3_FA contains the type of fishery as a metadata (i.e. same for all activities recorded in the form). If type of vessel is added as a new column / data, then there shall be no restriction (proposed classification in table 5 is too coarse)
Recommend	If the field leads to duplications, do not include.
Request 8	Add a column on the total number of days at sea spent in each grid cell
Response	Could be added, although for supply vessels it will be redundant considering also what should be reported through form 3_SU
Recommend	If the field leads to duplications, do not include.
Request 9	Add a column on the total number of vessels considered in each grid cell
Response	Could be added, if Request 8 is also positively considered
Request 10	Delete column "NO. SET ON FAD" as sets are already included in the activity types of Table 3
Response	Could work if we assume that each FF / FR / FT activity corresponds to one fishing set
Recommend	Continue discussion with the IOTC to identify the intention behind this request. Identify whether the proposed field will correspond to one fishing set.
Request 11	Harmonize required information and codes between different t-RFMOs
Response	Need to involve other t-RFMOs as well: IOTC adopting CECOFAD classifications is not an automated guarantee of harmonization
Recommend	At the next opportunity, either at the next tRFMO meeting or call a dedicated meeting, discuss possibilities for harmonising FAD data collection between tRFMOs.

2.3 SIOTI CPC FAD management plans

IOTC Resolution 19/02 mandates that CPCs with vessels that fish on FADs shall submit an annual FAD Management Plan to the Commission defining FAD use on each of their purse seine vessels and the minimum guidelines for which each CPC should follow. All SIOTI-CPC FAD management plans

are only partially compliant according to IOTC guidelines. Each SIOTI-CPC should annually update their FAD management plans and include all aspects of the IOTC guidelines for its preparation, including at least the minimum IOTC requirements and all updates from new resolutions, including changes to limits in the number of buoys.

Furthermore, here are presented some recommendations to clarify the data and reporting requirements within the FAD management plans so that CPCs can better comply with the demands of the IOTC.

Tabular formatting for data and reporting requirements

The FAD management plans of SIOTI partner CPCs outline the data and reporting standards of their vessels, which should include in a standard format the data to be reported, the minimum resolution of the data, who they should be reported by and to, at what timeline, and whether the reporting is required, recommended or needs to be requested. Furthermore, these plans should ensure that the provision of data for scientific purposes is clearly outlined (below). Currently, this information requires detailed reading and misinterpretation of requirements is possible. However, reporting these requirements in a tabular format (e.g. Table 2.3) would allow all users to clearly understand the recommendations and obligations of each FAD management plan.

Table 2.3 The data and reporting requirements as defined in the FAD management plan as outlined in a tabular format. EU-France and EU-Italy FAD management plan is taken to give an example. Reporting stratifications refers to the frequency and timing of data submission and for which level of data. Reporting options indicate whether the data are required or recommended to be reported, or whether they are available upon request.

Data	Reporting stratification	Reported by	Reported to	Reporting option (Required, recommended, available on request)
Buoy record and monitoring				
Buoy serial number;	Quarterly/vessel	Operators	Flag state	Required
Vessel(s) receiving location reports from the buoy;	Quarterly/vessel	Operators	Flag state	Required
Buoy brand and type.	Quarterly/vessel	Operators	Flag state	Required
Number of active buoys	Quarterly/vessel	unspecified	Flag state	Required
Number of de/activated buoys	Quarterly/vessel	unspecified	Flag state	Required
number of transmitting buoys	Quarterly/vessel	unspecified	Flag state	Required
Location reports	Quarterly/vessel	unspecified	Scientific body	Required
Echo-sounder data	Quarterly/vessel	unspecified	Scientific body	Required
FAD logbook data				
Deployed/released FAD or marking of a FAD with a buoy	Immediately/trip/ vessel	Operators	Flag state/scientific body	Required
Removal of any FAD or buoy	Immediately/trip/ vessel	Operators	Flag state/scientific body	Required
Visit or fishing with or without any action on the FAD (maintenance/exchange)	Immediately/trip/ vessel	Operators	Flag state/scientific body	Required
Discontinued buoys (lost	Immediately/trip/	Operators	Flag state/scientific	Required

FAD)	vessel		body	
FAD and buoy details (type, ownership, serial number)	Immediately/trip/ vessel	Operators	Flag state/scientific body	Required
Set details (date, time, position)	Immediately/trip/ vessel	Operators	Flag state/scientific body	Required
Observer logbook data				
Deployed/released FAD or marking of a FAD with a buoy	After validation/trip/vessel	Validation agency	Flag state/scientific body	Required
Removal of any FAD or buoy	After validation/trip/vessel	Validation agency	Flag state/scientific body	Required
Visit or fishing with or without any action on the FAD (maintenance/exchange)	After validation/trip/vessel	Validation agency	Flag state/scientific body	Required
Discontinued buoys (lost FAD)	After validation/trip/vessel	Validation agency	Flag state/scientific body	Required
FAD and buoy details (type, ownership, serial number)	After validation/trip/vessel	Validation agency	Flag state/scientific body	Required
Set details (date, time, position)	After validation/trip/vessel	Validation agency	Flag state/scientific body	Required
Catch (tons)	After validation/trip/vessel	Validation agency	Flag state/scientific body	Required
Bycatch (tons)	After validation/trip/vessel	Validation agency	Flag state/scientific body	Required
Discards	After validation/trip/vessel	Validation agency	Flag state/scientific body	Required
FAD design	After validation/trip/vessel	Validation agency	Flag state/scientific body	Required

Streamlining data reporting

Where possible, catch and FAD logbooks should be recorded via an electronic reporting system (ERS) to streamline data collection and reporting between the vessel and the CPC, which is already the case with some parts of the SIOTI fleet. It should be possible to link the catch logbook directly with the FAD activity. This will ensure that investigations between catch and FADs can be made directly upon delivery of data to scientific body. Catch and FAD logbooks should be provided by the vessel owner directly to the CPC and the verification body of the CPC immediately upon upload where recording by ERS is possible; otherwise, at the end of each fishing trip.

Specific guidelines for data provision for scientific purposes

Furthermore, these FAD management plans should ensure that the provision of data to the scientific body is clearly outlined, including specific guidelines of data provision for buoy GPS and acoustic data and FAD and observer logbooks, including Electronic Monitoring System data, noting that many of these data are shared with the scientific body voluntarily by the operators. It is recommended that the following data be shared for scientific purposes:

1) Annual reports of buoy purchases per vessel provided by the buoy manufacturer to the scientific body.
2) Following Resolution 19/02, monthly reports of the daily positions (or more) of active buoys should be shared with the scientific body with a lag of 60 to 90 days. Information on the activity state (activated, deactivated, or loss) can be calculated from these data.

3) Acoustic data of each buoy at the highest resolution possible in terms of storage and cost (to be defined clearly by each CPC) should be reported to the scientific body of the relevant CPC.
4) Catch and FAD logbooks should be provided by the vessel owner directly to the scientific body of the CPC as soon as possible to allow for the fullest range of scientific questions to be addressed.
5) Observer data at the maximum coverage rate available.

Independent third-party reporting

Where analyses are required for control purposes (e.g. observer lobbook verification), all SIOTI-CPC FAD management reports should clearly state that analyses are to be undertaken by an independent third-party agency, thereby minimising any potential bias in data reporting.

3 FAD MONITORING

3.1 Observer programs

Observer data collected during fishing operations are commonly used to complement other data sources as they are independent and are often the best or only source of information for some types of data, for example, bycatch and discards as well as FAD design. The fundamental purpose of the observer scheme is to collect data directly from the fishery that cannot be obtained in port or at the landing site.

There is increasing pressure on fishing companies to achieve 100% observer coverage (e.g., by the MSC and the International Seafood Sustainability Foundation (ISSF), and a recent call by 13 different non-governmental organisations). The fishing companies have financially supported the extension of the observers to address some of the requirements of the MSC standard for responsible fisheries, and to comply with the ISSF eco-label certification for vessels with 100% observer coverage (including EMS in this case). The collection of data that provides information on the impact of FAD fishing on marine ecosystems, including endangered, threatened and protected (ETP) species, constitutes a major component of the MSC certification (DeAlteris et al. 2018) and thus is an important component of the SIOTI action plan (Lucas et al. 2017).

There are many different observer programs operating in the Indian Ocean tuna purse seine fishery. These include the European Union Data Collection Framework observer program with an objective of 10% effort coverage, though coverage requirements may increase to 20% in the near future; the IOTC regional observer scheme (Resolution 11/04), which requires requires 5% observer coverage, ORTHONGEL's OCUP, ANABAC and OPAGAC's good practice observer guide, the Seychelles observer program and Electronic Monitoring Systems (EMS) used as a complement to human observers. From 2014, private contracts between industry and scientific partnerships significantly increased observer coverage from that of the EU-DCF. In addition to increased human observer coverage, an increasing number of trips is being covered through EMS since 2016. Between these different programs, observer coverage is currently close to 100% for the SIOTI fleet (Ruiz et al. 2017).

Improvements to data reporting

Both human and EMS observer data, including all data on bycatch, FAD type, FAD design, FAD activities, and sensitive species handling and release strategies should be shared with the IOTC, flag

state and the scientific body to the maximum rate of observer coverage. This will enable better analysis of potential ecosystem impacts of FAD fishing. The availability of these data are an important step to achieving sufficient habitat information, as required by the MSC.

Improvements to IOTC observer coverage

At the next opportunity, SIOTI members should push for the IOTC to increase the required human observer coverage rates to at least 20% over the next two years, and incorporate EMS on 100% of supply vessels. EMS cannot collect biological samples, its estimates of target species composition is variable and many of the observations required for FAD monitoring are specific to camera placement (Ruiz et al. 2017). Whilst they are consider a good complement, human observers should be used when possible and EMS should be used when necessary to maintain 100% observer coverage in the SIOTI fleet.

Improvements to data quality control via capacity building

In 2013, the Republic of Seychelles implemented a National Scientific Observer Programme, carried out by the SFA and following the DCF observer data and reporting requirements (above). Since its inception, a large amount of data have been collected and human observer coverage rates have increased significantly from 7% in 2014 to more than 50% in 2015, with a decrease in coverage to about 25% in 2016 (Lucas et al. 2017). However, due to the limited training of the observers and limited human resources at SFA devoted to the data management, some variability in data quality has been observed. AZTI recently deployed a staff member to SFA to aid in quality-control to develop a robust procedure for validation and control of future data (Lucas et al. 2017).

All future third-country observer programs should ensure that enough staff can be funded to support high quality training and debriefing of observers, data quality controls and proper database management.

3.2 Common SIOTI Code of Good Practice

MSC certification requires that robust fisheries management measures are in place and credible and effective methods to implement these measures can be verified. These standards can be met by developing a robust Code of Good Practice. In February 2019, ISSF released a Collective Best Practices for Well-Managed FAD Fisheries (ISSF 2019). This was developed in collaboration between several NGOs and gives brief, non-exhaustive recommendations for best practices to be used to ensure that FAD fishing is well-managed and transparent.

The Code of Good Practices for Responsible Tuna Purse Seining (2017), developed and agreed to by OPAGAC and ANABAC was originally developed in 2012, and has been updated following scientific findings, with the most recent version released in 2017. This Code of Good Practice is an initiative whose effectiveness can be quantifiably demonstrated (e.g. Goñi et al. 2017 and Lopez et al. 2017b), which is a key component to address MSC requirements showing that management strategies are in place and their effect can be tracked.

There is no current FAD code of practice for SIOTI, nor a code that applies to all SIOTI partners. Many of the partners comply with aspects of a code of good practice, but SIOTI would benefit from a shared code with mimimum standards that are agreed to by all members, and verified by a third party. As a basis for minimum standards, we reviewed guidelines recently recommended by ISSF Code of

Good Practices, and those developed and currently followed by OPAGAC and ANABAC fleets (Table 3.1) that could be incorporated into a common Code of Good Practice.

Table 3.1 Comparison between the Code of Good Practice recommended by ISSF, OPAGAC/ANABAC, and this study.

Theme	Guideline	ISSF	OPAGAC/ANABAC	Recommendations
Data and reporting	Electronic data (GPS, echosounder, biomass estimates)	Sent to RFMOs, flag states	Currently defined by MOUsA	Send to scientific bodies, third-country
	FAD type	Set by free school or FAD type	Collect required minimum based on relevant FAD MP	Follow ISSF, specify definitions of FAD type
	Support vessels	Send RFMO the number and activity of support vessels	Not specified	Follow ISSF, specify definitions of SV activities
	flag state and RFMO data and reporting requirements	Full compliance	Full compliance with RFMO/FAD MP	Follow OPAGAC/ANABAC
	Pilot study reports	Should be reported to science bodies and RFMOs	Ad hoc	Follow ISSF
	FAD activities	Not specified	Collect required minimum based on relevant FAD MP	Full compliance with RFMO/FAD MP, specify definitions of FAD activities
Bycatch	Non-entangling FAD	Non-entangling FAD	Non-entangling	Non-entangling, i.e. no netting on surface or subsurface (IOTC Resolution 19/02)
	Non-entangling FAD raft	Not specified	Not covered, mesh <7cm, or non-entangling material	No netting
	Non-entangling FAD subsurface	Not specified	Simple rope, mesh <7cm, sausage net, non-entangling material	No netting
	Biodegradable	Participate in pilot studies	Ad hoc	(IOTC Resolution 19/02)
	Biodegradable	Require biodegradable materials for FADs	Not specified	Follow ISSF
	Safe handling	Safe handling of sharks and rays	Detailed handling and release methods of sharks, skates, rays, turtles, and whale sharks	Follow OPAGAC/ANABAC
	Shark finning	Not specified	Strictly prohibited	Follow OPAGAC/ANABAC
	Silky shark bycatch mitigation	Target FADs with large tuna aggregations (>10t)	Not specified	Study the effects of targeting large school for bycatch and for juvenile target species
	Silky shark bycatch mitigation	Avoid silky shark hotspots	Not specified	Follow ISSF
	Whale shark/ cetaceans	Prohibit intentional setting	Prohibit intentional setting	Prohibit intentional setting
	Whale shark/ cetaceans release	Not specified	Detailed release methods	Follow OPAGAC/ANABAC
Monitoring	Observer coverage	100%	100%, at least 10% human observers	100%; specify how EMS data are

				processed and shared.
Management	FAD numbers	Follow RFMO and science-based advice	Full compliance with relevant MP	Follow RFMO, FAD-MP and science-based advice
	Retention of bycatch	Examine kept/landed to reduce waste	Not specified	Follow ISSF
	FAD recovery	FAD recovery policy for lost or derelict FADs	Not specified	Specify policy for lost or derelict FADs; investigate FAD Watch for coastal beachings; investigate innovative FAD designs to control FAD trajectories
	Support vessel regulations	Require support vessels to comply with all regulations	Not specified	Follow ISSF
	Support vessel activities	Register with RFMO	Not specified	Follow ISSF; clearly define activities
	Management plan	Not specified	Full compliance with relevant MP	Follow OPAGAC/ANABAC
Training	Handling/ release	Not specified	Crew and observers	Follow OPAGAC/ANABAC
	Data collection	Not specified	Observers	Follow OPAGAC/ANABAC
	Data management	Not specified	Not specified	Local and third-country capacity building of data management and validation
Verification	Compliance	Not specified	6-monthly reports by independent scientific body	Follow OPAGAC/ANABAC, should include flag-state/ third-country fishing authority where applicable.
Updates	Updates to code	Not specified	Steering committee advised by scientific board updates on science-based advice.	Steering committee should involve all stakeholders, including flag-states and third-country fishing authorities

Data and reporting

- Data collected on FAD type and activity should follow clearly defined codes that are standardised between the Code of Good Practice program, the relevant FAD management plans, and the RFMO data collection guidelines. To achieve this, SIOTI should push CPCs to have the same regulations in terms of data and reporting requirements in their FAD management plans, specifically in terms of the definitions of FAD types and activities, which evolve in relation to scientific needs. This would ensure standardised compliance to FAD management plans.
- Electronic buoy and observer data should be shared with scientific bodies and flag states as outlined above (Section 2.3). Delivery of the data can be delayed by several months.
- Results of pilot studies with aims to enhance the sustainability of FAD fishing should be shared with scientific bodies, flag-states, third-country fishing authorities, and the RFMO.

Bycatch mitigation

- The new IOTC Resolution 19/02 states that biodegradable materials should be encouraged with the aim to transition to these materials by 2022. The SIOTI code of good practce should require the maximum use of biodegradable materials for FAD structures.
- Silky shark mitigation should be specifically addressed to avoid silky shark hotspots. ISSF recommends that sets on FADs with < 10 tonnes of fish should be avoided. Studies should be funded to determine the relationship between set size and bycatch, using data that is already available, and then targets should be adjusted based on those findings.
- The processing of EMS observer data should be specified. Data sharing protocols should follow those of human observer data.
- The effect of the use of heavy equipment (e.g. an extra conveyor belt) to aid in the release of sensitive species bycatch should be examined relative to the impacts on survival rates, using data from the vessels that already have this equipment installed. This sort of equipment at a proportion of 3 out of 5 vessels in the fleet was an important point in favor of the Echebastar MSC certification decision.
- Minor equipment such as chutes on the fishing deck, stretchers and brailers should be required for all fishing vessels.

Management

- It should be specified in the code that buoy numbers are limited based on RFMO and FAD MP resolutions.
- A FAD recovery policy should be specified. Recommendations should be made to participate in pilot studies for regional FAD Watch programs, to test innovative FAD designs (e.g., to control FAD trajectories), or to employ cost-effective recovery-at-sea programs.
- Daily active buoy data as required to be reported to the IOTC in Resolution 19/02, should be compiled into a common database to be made available for modeling or scientific studies, as recommended by the MSC. A standard algorithm, such as that in Goni et al. 2015, should be applied to identify activated and deactivated states and lost buoys.

Training

- Training programs for observers should have quantitative results to prove their efficacy (i.e. testing after training), and annual review periods where knowledge of protocol is quantitatively evaluated by an independent body. Likewise, trainers should be similarly evaluated in their knowledge of the Code.
- Capacity building training should be given to third-countries to aid in data management and validation of observer data.

Compliance

- The body that verifies compliance (‘verification body’) should be independent and results should be shared with the flag state or third-country fishing authority where applicable.
- Where possible, multiple sources of data should be used to verify that practices are being complied with, e.g. compare between EMS and human observer data for handling and release compliance, or between ICS FAD Watch observer data and onboard observer data (human and EMS) for FAD design compliance.
- Half-yearly reports should be made by verification bodies and sent to scientific bodies, flag-states, and third-country fishing authorities to aid in compliance monitoring.
- Steering committee should involve all stakeholders, including flag-states, scientific bodies, and third-country fishing authorities.

Implementation of a SIOTI Code of Good Practice

Between SIOTI members, agree upon minimum standards for a common Code of Good Practice, following the recommendations as above. The agreed-upon code should be incorporated as an Annex to the FAD management plan. A statement should be made in the management plan that purse seine and supply vessels will comply with this Code.

4. FAD MANAGEMENT

4.1 Limiting FAD numbers

One of the most effective and simple measures for limiting the effects of FADs on vulnerable marine environments is to limit the number of FADs in the environment. Resolution 19/02 reduced the number of active buoys allowed to be followed at any one time to 300 per vessel and the number of instrumented buoys that shall be acquired annually for each purse seine vessel has been set at no more than 500 per year per vessel. This is a reduction from 350 at any one time and 700 purchasd annually. While this can certainly be seen as progress, investments should be made in studies that identify a science-based number of buoys that can be used to maintain sustainable fishing for target species and bycatch. Once identified, a potential strategy to ensure that only a sustainable number of FADs are deployed is to set a maximum number of buoys for the IOTC convention area, to be allocated per vessel relative to size, as is the case in the WCPFC.

4.2 Identifying high-risk deployment zones

Buoy data should be analysed and used to inform modelling studies to further determine FAD hotspots and high-risk deployment regions. Using buoy trajectory data to identify deployment zones that lead to FADs having a high risk of entering a VME or beaching would allow recommendations or best practices to be given in terms of which deployment zones to avoid and when. These studies could also enable more efficient use of FADs by identifying deployment zones that lead to FADs drifting quickly out of the fishing area (see Imzilen et al. 2019). Furthermore, this work could be used towards feasibility studies of time/area closures, as is recommended in the IOTC Resolution 19/02.

In addition, recent research has noted that target and non-target species show minor differences in their spatio-temporal aggregation patterns around FADs (Orue et al. 2019). These relationships were weak, and further work could be conducted to investigate where and when FADs could be deployed to better avoid aggregations of non-target species.

4.3 FAD Watch and its potential expansion

Resolution 19/02 states that a FAD tracking and recovery policy will be established in 2021, and will define FAD tracking, reporting of lost DFADs, arrangements to alert coastal States of derelict/lost DFADs at risk of beaching in near real-time, how and who recovers the DFADs, how the recovery costs are collected and shared.

A major project that incorporates many aspects of this part of the resolution, as well as many aspects of IPG12 Habitat Outcome is FAD Watch. In recent years, a multi-partner initiative, FAD Watch (OPAGAC, the Island Conservation Society (ICS), the Islands Development Company (IDC) and SFA), has begun monitoring derelict FADs that are in danger of beaching in sensitive habitat. The objectives of FAD Watch are to monitor and mitigate the effects of beached FADs. This program appears to directly address several of the IPGs as detailed in the SIOTI FIP Action Plan (Appendix

B), thus this section evaluates how FAD Watch addresses the specific actions recommended in the plan.

Final results of the project are not currently available, but Zudaire et al. 2018a presented the progress on the ongoing FAD-Watch programme. It is estimated that of the FADs that were detected during this program <1% were intercepted at sea. Of those that were detected, about 90% were recovered, but not before beaching. The rest (<10%) were lost or were unable to be recovered due to inaccessibility (*pers comm* P-A Adams). One of the main results from Zudaire et al. 2018a, was to note that 69% of the FADs that beached during the study period were from non-OPAGAC vessels, indicating that in order for FAD Watch to significantly contribute to IPGs 12, 13, and 14 of the SIOTI FIP, the program should be expanded to all SIOTI vessels. Extending this agreement should entail investment in project costs of other fishing associations, which should increase the rate of FAD interception in sensitive marine habitats. Zudaire et al. 2018a end their summary by suggesting that this project could also be extended to other islands and regions. However, the efficacy of this program is likely highly linked to cost, accessibility of the seascape in terms of geography as well as political agreements and the availability of human resources and equipment.

Prior to expanding this program further, a cost/benefit analysis should identify to partners the economic strengths and weaknesses of FAD Watch, and produce a provisional budget to ensure that the program can continue. Furthermore, this study should weigh the risks and difficulties of expanding the program against the decreased potential impact on marine habitat. This would require a quantification of the timeline over which habitat damage is made by FADs and the severity of the damage. FAD watch is currently collecting data that could aid in this analysis (e.g., surface area impacted by FAD, type of habitat, entanglements, time stamps of alerts and interceptions).

Another major consideration is to weigh the cost of the project (US$ 105,000) against the value of the buoys that are recovered (US$ 750 - US$ 1,000 each). In this light, the cost of the project is more than covered by the cost benefit of recovering the 335 buoys (US$251,250 - US$335,000), though it should be noted that not all recovered buoys can necessarily be reused.

A related issue is to identify what equipment and resources are necessary to expand the study to include 1) more FAD interceptions at sea and 2) greater geographical scope. Both would likely require more than the one boat that is available to FAD-Watch at the moment. In addition, accessibility and access rights of these additional vessels to remote and vulnerable areas should be ensured.

Zudaire et al. (2018a) note that further trials are required to assess how this program could work in different geographical locations and more effort should be made in developing protocols to provide to the CPCs for the implementation of FAD-Watch program in different countries (e.g. Herrera et al. 2019). Pilot studies, similar to the work of Balderson and Martin (2015) could be undertaken in different countries as a preliminary step of assessing the effect of FADs. Furthermore, Zudaire (*pers comm*) notes that CPCs should standardise their definitions of FAD activities and data and a system to assess buoy deactivation or loss.

Expanding this initiative to other countries would require involvement from many different stakeholders including conservation NGOs (e.g. WWF, scuba federations), foreign scientists and government officials. Hotspots of beaching (e.g. Maufroy et al. 2015, above) should be analysed to indicate which countries to target. Current suggestions include Maldives, Madagascar, Kenya, and Sri Lanka.

It is therefore recommended that a cost/benefit analysis be conducted to determine whether the FAD Watch program is viable to continue and expand. If so, investment should first be placed in expanding the project to include the entire SIOTI fleet prior to expanding to other countries, as this step will be the most logistically feasible and will contribute significantly to IPGs 12 to 14. In terms of proposing appropriate mechanisms for CPCs to mitigate FAD loss and beaching, incorporating FAD watch into their management plans could be an effective future strategy. The IOTC includes the monitoring and retrieval of lost DFADs as part of its guidelines for developing national FAD management plans. The EU-France and EU-Italy FAD management plan already includes a provision on including FAD Watch pending the results of the 2016-2017 pilot study (Article 12).

CONCLUSIONS

This report focused on improving the data and reporting requirements to improve monitoring and reporting of FAD use in the Indian Ocean purse seine tuna fishery for the SIOTI fleet and to identify measures that could be implemented to mitigate the negative ecosystem effects of FADs. Many recommendations have been given to improve the data collection, data harmonisation, and data flow between tRFMOs, CPCs, and SIOTI partners. Implementation of the specific activities related to these recommendations will work towards addressing the adequacy of habitat information (IPG 14). Recommendations have also been given to improve the current Code of Good Practice to further address the requirements of the MSC standards and that of ISSF. Implementation of this code would contribute significantly to strengthening the sustainability credentials of the SIOTI fleet. Finally, a range of potential mitigation measures are described, including discussions on the expansion of the FAD Watch project. A range of these measures tailored to the particular needs of each fleet could be implemented, allowing management strategies to be implemented more effectively by allowing for differences between fleets. Implementation of these specific activities could contribute significantly to IPGs 12 and 13, and will aid towards the final goal of MSC certification.

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Appendix 1 Vessels in the SIOTI fleet.

Owner country	Flag	Association	Owner/Operator	Vessel
Spain	Spain	OPAGAC	Albacora Group	Albacan
Spain	Spain	OPAGAC	Albacora Group	Albatun Dos
Spain	Spain	OPAGAC	Albacora Group	Albacora Uno
Spain	Spain	OPAGAC	Albacora Group	Albatun Tres
Spain	Spain	OPAGAC	Inpesca	Txori Zuri
Spain	Spain	OPAGAC	Inpesca	Txori Argi
Spain	Spain	OPAGAC	Inpesca	Txori Gorri
Spain	Spain	OPAGAC	Inpesca	Itxas Txori
Spain	Spain	OPAGAC	Europea de Tunidos (OPAGAC)	Albacora Cuatro
Spain	Spain	ANABAC	Pevasa	Playa de Aritzatxu
Spain	Spain	ANABAC	Atunsa	Izurdia
Spain	Spain	ANABAC	Atunsa	Doniene
Spain	Spain	ANABAC	Echebastar	Alakrana
Spain	Spain	ANABAC	Echebastar	Elai Elai
Spain	Seychelles	OPAGAC	Albacora Group	Draco
Spain	Seychelles	OPAGAC	Albacora Group	Intertuna Tres
Spain	Seychelles	OPAGAC	Albacora Group	Galerna Dos
Spain	Seychelles	OPAGAC	Albacora Group	Galerna Tres
Spain	Seychelles	OPAGAC	Inpesca	Txori Toki
Spain	Seychelles	OPAGAC	Inpesca	Txori Aundi
Spain	Seychelles	ANABAC	Pevasa	Playa de Anzoras
Spain	Seychelles	ANABAC	Atunsa	Artza
Spain	Seychelles	ANABAC	Echebastar	Izaro
Spain	Seychelles	ANABAC	Echebastar	Jai Alai
Spain	Seychelles	ANABAC	Echebastar	Euskadi Alai
France	France	ORTHONGEL	Compagnie Française de Thon Océanique (CFTO)	Avel Vad
France	France	ORTHONGEL	Compagnie Française de Thon Océanique (CFTO)	Cap Saint Vincent
France	France	ORTHONGEL	Compagnie Française de Thon Océanique (CFTO)	Cap Sainte Marie
France	France	ORTHONGEL	Compagnie Française de Thon Océanique (CFTO)	Glenan
France	France	ORTHONGEL	Compagnie Française de Thon Océanique (CFTO)	Talenduic
France	France	ORTHONGEL	Compagnie Française de Thon Océanique (CFTO)	Drennec
France	France	ORTHONGEL	Compagnie Française de Thon Océanique (CFTO)	Trevignon
France	France	ORTHONGEL	SAPMER	Dolomieu
France	France	ORTHONGEL	SAPMER	Franche Terre
France	France	ORTHONGEL	SAPMER	Manapany
France	France	ORTHONGEL	SAPMER	Bernica
France	Mauritius	ORTHONGEL	SAPMER	Belouve
France	Mauritius	ORTHONGEL	SAPMER	Belle Isle
France	Mauritius	ORTHONGEL	SAPMER	Belle Rive
France	Seychelles	ORTHONGEL	SAPMER	Morne Blanc
France	Seychelles	ORTHONGEL	SAPMER	Morne Seselwa
Italy	Italy	ORTHONGEL	Industria Armatoriale Tonniera (IAT)	Torre Giulia

Appendix 2 Annex I of the IOTC Resolution 19/02 : GUIDELINES FOR PREPARATION OF DRIFTING FISH AGGREGATING DEVICE (DFAD) MANAGEMENT PLANS

To support obligations in respect of the DFAD Management Plan (DFAD–MP) to be submitted to the IOTC Secretariat by CPCs with fleets fishing in the IOTC area of competence, associated to DFADs, DFAD–MP should include:

1. An objective
2. Scope

Description of its application with respect to:
- vessel-types and support and tender vessels
- DFAD numbers and DFADs beacon numbers to be deployed
- reporting procedures for DFAD deployment
- incidental bycatch reduction and utilisation policy
- consideration of interaction with other gear types
- plans for monitoring and retrieval of lost DFADs
- statement or policy on “DFAD ownership”

3. Institutional arrangements for management of the DFAD Management Plans:
- institutional responsibilities
- application processes for DFAD and /or DFAD beacons deployment approval
- obligations of vessel owners and masters in respect of DFAD and /or DFAD beacons deployment and use
- DFAD and/or DFADs beacons replacement policy
- reporting obligations

4. DFAD construction specifications and requirements:
- DFAD design characteristics (a description)
- DFAD markings and identifiers, including DFADs beacons
- lighting requirements
- radar reflectors
- visible distance
- radio buoys (requirement for serial numbers)
- satellite transceivers (requirement for serial numbers)

5. Applicable areas:
- Details of any closed areas or periods e.g. territorial waters, shipping lanes, proximity to artisanal fisheries, etc.

6. Applicable period for the DFAD–MP.
7. Means for monitoring and reviewing implementation of the DFAD–MP.
8. DFAD logbook template (data to be collected specified in Annex IV).

Appendix 3. ANNEX III of Resolution 19/02 : DATA COLLECTION FOR DFADS

a) For each activity on a DFAD, whether followed by a set or not, each fishing, support and supply vessel to report the following information:

i. Vessel (name and registration number of the fishing, support or supply vessel)

ii. Position (as the geographic location of the event (Latitude and Longitude) in degrees and minutes)

iii. Date (as DD/MM/YYYY, day/month/year)

iv. DFAD identifier (DFAD or beacon ID)

v. DFAD type (drifting natural FAD, drifting artificial FAD),

vi. DFAD design characteristics

• Dimension and material of the floating part and of the underwater hanging structure

vii. Type of the activity, (visit deployment, hauling, retrieving, loss, intervention to service electronic equipment).

b) If the visit is followed by a set, the results of the set in terms of catch and bycatch, whether retained or discarded dead or alive. CPCs to report this data aggregated per vessel at 1*1 degree (where applicable) and monthly to the Secretariat.

Appendix 4. Headers of the current IOTC form 3FA, FAD logbook.

month	grid				area	estimation	type of FOB	type of activity	FOB ownership	no. set on FOB	effort	species
	size	quadrant	latitude	longi-tude								catch units