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Steps towards Non-entangling and Biodegradable dFADs:

from trials to the implementation in the EU fleet

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Steps towards Non-entangling and Biodegradable dFADs: from trials to the implementation in the EU fleet

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Abstract

The increasing use of drifting fish aggregating devices (dFADs) in tropical tuna fisheries and their potential negative impacts on marine species and ecosystems have moved scientists and the EU fleet to search for solutions in oceans where they operate. In the last decades, science-industry collaboration has resulted in different actions mainly to avoid entanglement and promote release of vulnerable species through voluntary adoption of a Code of Good Practices. More recently efforts are being focused on the use of natural origin materials for FAD construction to reduce marine litter and impacts when FAD beaching occurs in sensitive areas like coral reefs. This document summarizes three main actions put in place at global scale by the EU tropical tuna purse seine fishery: i) ISSF skippers workshops, ii) Code of Good Practices and iii) small and large-scale trials for biodegradable dFADs.

Introduction

The use of man-made drifting fish aggregating devices (dFADs) in tropical tuna purse seine (PS) fisheries has been constantly increasing since first used in the early 90s. Nowadays, about half of the tropical tuna caught worldwide is fished by PS with FADs (Lopez et al., 2017). The EU and associated tropical tuna PS fleet is responsible of around 10 % of the total annual catch of tropical tunas. Analyzing the data by oceans, around 80% of the catch of the EU PS and associated flag vessels corresponds to FADs in the Indian Ocean in 2014 (Chassot et al., 2015), around 60% in the Atlantic Ocean in 2017 (Pascual-Alayón et al., 2018) and in 2014 81% and 84% in the Eastern and Western Central Pacific Ocean, respectively (Ramos et al., 2017).

During these decades of dFAD use, associated monitoring equipment has developed together with available technology (e.g., radio beacons, satellite-linked GPS buoys or satellite-linked echo-sounder buoys) responding to PS fisheries requirements and improving fishing efficiency in terms of search time and successful catch rates (Dagorn et al., 2012; Lopez et al., 2014). dFADs construction materials have evolved, looking for higher resistance to increase dFAD durability, from natural origin components (e.g., bamboo canes) to synthetic materials, mainly petroleum derived products, such as plastic, PVC, nylon, etc. (Moreno et al 2017a). Moreover, to attain slower drifting and higher aggregation potential of the dFAD the tail configuration has been adapted and depth increased. Despite increasing fishing efficiency, the use of dFADs has been related to some negative effects such as increase of bycatch and catch of small individuals of some target-tuna species. Among fisheries, the bycatch rate of PS tropical tuna fishery is low

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(Kelleher 2005). However, floating objects sets, both natural logs and dFADs, are characterized by not only having target tuna species but a mixture of other bycatch species, averaging 2.2% of the catch (Justel-Rubio and Restrepo, 2015). Besides, FAD sets have been related to higher level catches of small sized juvenile bigeye and yellowfin tuna (e.g. 2-5 kg individuals). Some stocks of these larger tuna species taking longer to mature (e.g. 2-3 years), are under increasing pressure and have reached an overfished status in some regions (ISSF, 2018).

The type and configuration of dFAD synthetic components and the way of assembly during dFAD construction can generate other potential impacts like entanglement of sensitive species (Filmalter et al., 2013), marine litter increase (Dagorn et al., 2012) and FAD beaching (Maufroy et al., 2015). The use of potential entangling materials like nets with large mesh size (e.g. >7cm) and inadequate configuration of raft and underwater part of the FADs (e.g. open net panels) are responsible for most entanglement events of sensitive species like turtles and sharks (Lopez et al., 2017). Moreover, synthetic components such as netting made from nylon, net corks from Ethylene Vinyl Acetate (EVA), or pipes from polyvinyl chloride (PVC) are extremely durable. Therefore, when not retrieved, these stranded materials can accumulate year after year in sensible marine and coastal ecosystems. In addition, other synthetic long-lasting dFAD materials such as metallic raft frames with plastic containers for floatation have been introduced in the Indian and Atlantic Oceans in the last five years (ISSF, 2014). All these synthetic materials can contribute to the increasing problematic of marine litter and potential disruption to ecosystems like coral reefs, mangroves or beaches. A recent study has estimated that around 10% of dFAD deployed between 2007 and 2011 by French fleet in Atlantic and Indian Ocean ended beaching (Maufroy et al., 2015).

Considering all these potential impacts on the pelagic and coastal habitats and sensitive species interacting with the fishery, the t-RFMOs has adopted bycatch mitigation measures for the use of non-entangling dFADs and use of more sustainable materials in their construction. In recent years, specific guidelines have been gradually introduced in t-RFMOs worldwide: IATTC (C-13-04, C-16-01), ICCAT (14-01, superseded by 15-01, 16-01), IOTC (Res. 12-04; Res 13-08 superseded by Res. 15/08 and Res. 17/08), WCPFC (CMM-17-01). The designs of non-entangling raft and subsurface structures were set to reduce the entanglement of sharks, sea turtles or any other species. In addition, to diminish the amount of synthetic marine debris, t-RFMOs encouraged to use natural biodegradable materials (such as hessian canvas, hemp ropes, *etc.*) for dFAD construction. Except for the WCPFO, the principles across t-RFMOs are analogous and set as follows:

- The surface structure of the FAD should not be covered or only covered with material implying minimum risk of entangling by-catch species.
- The sub-surface components should be exclusively composed of non-entangling material (e.g. ropes or canvas).
- When designing FADs the use of biodegradable materials should be prioritized.

In line with the guidelines, ICCAT requires the replacement of existing FADs with non-entangling FADs by 2016 (Rec. 16-01) and the IATTC by 2019 including the use of biodegradable materials (C-17-02).

These measures have been implemented as sustainable fishing standards by tuna processors and retailers as well. For example, ISSF (International Seafood Sustainability Foundation) recently adopted a conservation measure for the use of non-entangling FADs (i.e. measure 3.5: Transactions with Vessels that Use Only Non-entangling FADs). This foundation also published an updated guide for non-entangling FADs classifying FADs according to the entanglement risk of each design. Risk categories were based on the materials used, mesh size and configuration when meshed material is present. In this risk category, non-entangling FADs are constructed without using net materials (ISSF, 2015). ISSF also conducts PS bycatch mitigation workshops, known as Skippers Workshops, to disseminate best FAD fishing practices (Murua et al., 2014; Murua et al., 2018). In addition, other standards such as the UNE 195006:2016 for Tuna from Responsible Fishing include the use of non-entangling FADs as a must.

In this scenario, the EU fleet, in collaboration with research institutes, is making significant efforts to improve dFAD designs to commit with RFMO requirements and the most demanding international sustainability standards; as follows:

1. ISSF Skippers workshops

Since 2009 ISSF has been organizing participative approach workshops between fishery scientists and fishers from tropical tuna purse seine fleets to discuss ways in which to reduce bycatch, principally in FAD sets. Key recent advances in bycatch mitigation like non-entangling FAD designs and the use of biodegradable materials for the construction are a direct outcome from the collaboration between scientists and fishers (Poisson et al., 2012; Murua et al., 2014). Best fishing practices, developed with direct input from fishers, has led to faster developments of efficient bycatch solutions and higher voluntary adoption by many fleets. From feedback by fishers in the workshops and analyzed observer collected data it is clear that the use of non-entangling FADs and lower entanglement risk FADs (e.g. using mesh but of small size or tied up to minimize entangling) has continued to increase in three out of the four oceanic regions. Practically all high-risk entanglement FADs (ISSF, 2015) have been replaced in the Indian and Atlantic Oceans where EU fleets mainly operate (Murua et al., 2018).

By 2016 the Skippers Workshops were reporting on the progress in advances towards biodegradable FADs, and the special Biodegradable FAD workshop organized by ISSF in San Sebastian between scientists and EU skippers (Moreno et al., 2016) was a precursor of further advances observed in 2017. Fishers understand that marine debris and ghost fishing produced by lost or abandoned dFADs is counterproductive for the public image of FAD fisheries and would like to solve this problem. Although alternative options to prevent dFAD beaching, such as having a dedicated boat to collect lost dFADs, have been discussed, the most widely accepted and practical option is the adoption of dFADs with biodegradable materials (Murua et al., 2018). Acceptance has been broad across fleets but raised some concerns regarding increased costs of buying and shipping biodegradable materials and decrease in durability (Murua et al., 2018).

Other mitigation activities, such as the use of short tail FADs to reduce bigeye tuna catches has been evaluated in these Skippers Workshops, with a low acceptance level in recent years (Murua et al., 2018). This could be related to the fact that depth of dFAD appendages by EU fleets and others has been increasing in recent times, according to fishers to maintain a slower drifting speeds and outcompete smaller floating objects for tuna attraction (Murua et al., 2018).

2. Code of Good Practices onboard purse seiners: use of non-entangling FADs and a verification system

To decrease potential impacts by purse seiners fishing on dFADs and improve the long-term sustainability of the tropical tuna fishery, the two Spanish tuna purse seiner associations, ANABAC and OPAGAC, established in 2012 a voluntary agreement known as the "Code of Good Practices" for responsible tuna fishing activities. The aim of this agreement is to use best fishing practices by reducing incidental mortality of sensitive species (sharks, rays, mantas, whale sharks, and sea turtles) and the obligatory use of non-entangling FADs. The good practices defined in this agreement also comprise: best releasing practices for vulnerable fauna, 100% observer coverage in PS and supply vessels, continued training of fishing crew and scientific observers, and the implementation of a FAD logbook (Lopez et al., 2017). Since 2015 monitoring is carried out by 100 % observers and the verification is carried out by AZTI. Nowadays, all ANABAC and OPAGAC vessels (69 purse seiners and 23 supply vessels), including Spanish and other flags, operating globally in 4 tuna RFMOs areas (ICCAT, IOTC, WCPFC and IATTC) are being monitored and evaluated for these practices. Monitoring is based on specifically designed forms for detailed data collection recorded by trained scientific observers, and more recently, also by electronic monitoring systems. Standard of fishing practices are assessed individually per vessel and results used to provide scientific advice and identify correction mechanisms if necessary. Specific data-collection forms recording details of design and construction materials for the raft and the underwater part of each dFAD have been developed and applied since 2015 by the program in the Atlantic and Indian Oceans (Annex 1). In order to better characterize the level of compliance of vessels with entanglement-minimizing designs, 6 categories are established for analysis, from lower to greater entangling potential based on ISSF guidelines (Lopez et al., 2017). Although trials were conducted to include Code of Good Practices specific observer forms in the Pacific Ocean, their use was not finally established in the region. However, successful collaboration with IATTC and WCFPC has enabled data collection of OPAGAC vessels operating under their observer programs, which included certain relevant information on FAD structure and materials.

To date, more than 900 PS and supply vessel fishing trips have been evaluated in the Indian and Atlantic Ocean. Since the implementation of the Code of Good Practices significant improvements have been observed in the compliance of best available bycatch mitigation practices. The degree of accidental entanglements has been significantly reduced and the majority of dFADs today are totally non-entangling, reaching the 90% (Lopez et al., 2017). For the Pacific Ocean, 117 trips have been analyzed. The data collected by observers in this region has no information on the mesh size used to construct the FAD's raft. This information is provided for the submerged structure, but the configuration is unknown, thus, the entangling potential can only be partially evaluated. However, from the information recorded it is observed that over 70% of the dFADs evaluated since 2015 have submerged structures that minimize entanglement and nowadays the non-entangling use is generalized (Lopez et al., 2017).

3. Biodegradable material testing for dFAD construction carried out by EU fleet in the Indian, Atlantic and Pacific oceans

In the last decade, public funded projects and private sector initiatives have been testing suitable natural materials and prototypes for biodegradable dFADs. Studies conducted by EU scientists and tropical tuna PS fishers to experiment on new FAD designs with ecological origin materials dates to the early 2000s (Delgado de Molina *et al.*, 2004; Delgado de Molina *et al.*, 2007). However, most at sea tests with biodegradable FADs have been very limited in scale, yielding inconclusive results and a slow rate of improvement. These first trials with non-entangling biodegradable dFADs were mainly looking for natural suitable materials testing an array of different options like jute, sisal and palm leaves (Molina et al., 2004). Further small plantations of experimental biodegradable dFADs were tested in the Indian and Atlantic Oceans, with bamboo rafts, sisal and jute ropes seeking to move towards ecological dFADs (Franco et al., 2009, 2012). Other biodegradable dFAD trials have originated from the private sector, with various PS companies from the EU testing them at sea during commercial fishing operations. These trials have experimented with ropes and canvas made from coconut fiber and high-resistance cotton. In addition, EU PS companies sponsored a study to evaluate best biodegradable twine materials and their structural configuration (e.g. twisted, braided and bulked) for use in dFAD appendages (Lopez et al., 2016). Several plant-origin fibres such as cotton, sisal, hemp and linen were analysed for the construction of ropes, and parameters like potential biodegradation, resistance, reproducibility, and availability in the market were assessed (Lopez et al., 2016). Similarly, natural origin biodegradable twines were also tested by ISSF in a year-long experiment in the Maldives, showing that mixed cotton and sisal ropes were the strongest (Moreno et al. 2017a).

These materials were trialed at sea by EU PS company in the Indian Ocean and despite the limitation derived from small-scale trials in which the high loss rate of dFADs to other vessels prevented obtaining statistically significant results (Moreno et al., 2017b), these studies have provided a foundation to develop recently launched larger-scale experiments in the Indian Ocean (Zudaire et al., 2017) and Pacific Ocean (TUNACONS 2017). The Indian Ocean project entitled "Testing designs and identify options to mitigate impacts of drifting fads on the ecosystem" is coordinated by a consortium of EU research centres (AZTI, IRD and IEO). This project funded by the European Union, in collaboration with ISSF, ABNJ Common Ocean project, and EU PS fleet, addresses the problems associated with the currently used synthetic materials and designs in dFAD construction. The project is strongly based on the active participation of 42 purse seine vessels (fleets associated to ANABAC, OPAGAC and ORTHONGEL) operating in the Indian Ocean, and has planned a large-scale experiment with the deployment of 1000 "BIOFADs" (i.e., non-entangling and biodegradable dFADs) built using natural origin materials like resistant cotton and bamboo canes (as of June 2018 24 BIOFADs has been deployed). Similarly, in the Eastern Pacific Ocean the project on biodegradable FAD, is funded by the European Union and the activities are coordinated by IATTC that counts with the collaboration of EU fleet grouped in the TUNACONS and OPAGAC FIPs. This project will also deploy around 1000 dFADs built by different biodegradable materials like hemp, cotton, balsa wood and bamboo canes. Both, Indian and Eastern Pacific Ocean projects aim to provide solutions that shall support the implementation in commercial fishing trips of dFADs built with natural origin materials in both regions. The results will also help both scientists and industry focus the discussion of suitable biodegradable materials and designs for dFADs addressing the problematic of marine litter, ghost fishing and dFAD beaching.

Conclusion

During the last decade, actions taken by the European tropical tuna purse seine fleet allowed addressing several of the potential impacts related to the increasing use of FADs in the Ocean. In this sense, the best scientific knowledge provided by research bodies collaborating with PS industry has facilitated moving from trials towards implementation in daily fishing operations. Skippers workshops have provided direct input from fishers and allowed scientist to work closely with them to foster advances in the development of feasible and efficient bycatch mitigation solutions and higher voluntary adoption by many fleets. In this line, EU PS fishers voluntarily adopted a Code of Good Practices providing the base for the long-term sustainability of the tuna fishery. The steps taken and increase in awareness by the tuna industry has greatly facilitated launching large-scale trials towards the implementation of biodegradable FADs built with natural origin materials.

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Annex I – Form to evaluate the use of dFAD in the frame of Best Practices code

Verification of Good Practices ANABAC/OPAGAC

Form D2 nº:

1 line by FAD if no modification, 2 lines by FAD if modification (state when arriving and state when leaving)

BOAT name:

Fishing trip start date:

OBSERVER:

Fishing trip code:

Nº Form D	when arriving	when leaving	own / else's	DATE	TIME	RAFT														SUBSURFACE STRUCTURE											OTHER COMPONENTS						
						Canes / Vegetal	Metallic or PVC	Superior					Inferior coverage					they modify it	they replace it	net in sausage		open net		single net pieces		rope / no mesh	not visible	no subs. struct.	they modify it	they replace it	plastic	Corks	Bags	Palms, canes…	Color belts	weights	entangled animal
								Net		cov. w/o net	non covered	not visible	Net		cov. w/o net	non covered	not visible																				
								≤ 7cm	> 7cm				≤ 7cm	> 7cm						≤ 7cm	> 7cm	≤ 7cm	> 7cm	≤ 7cm	> 7cm												
45	*X*			*14/03/2014*	*13:22*	*X*		*X*								*X*		*X*		*X*														*X*			
45		*X*		*14/03/2014*	*13:22*	*X*				*X*					*X*					*X*														*X*			