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Review of research into drifting FAD designs to reduce species of special interest bycatch entanglement and bigeye/yellowfin interactions

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Review of research into drifting FAD designs to reduce species of special interest bycatch entanglement and bigeye/yellowfin interactions

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Executive Summary

The FAD research plan adopted by WCPFC13 specified that a review be prepared for SC13 on the "design of non-entangling FADs [and designs that lead to] BET or YFT interaction reduction". This paper reviews available information with a focus on alternative man-made drifting FAD (dFAD) designs that reduce interactions, but minimise impacts on target catch levels.

Unintended mortality of sharks and turtles can occur with dFADs. Both taxa can become entangled on dFAD sub-surface netting, while turtles can also become entangled in netting on the dFAD surface structure. These events have been observed during WCPO purse seine fishing, but resulting numbers are likely underestimates, particularly for sub-surface entanglements which are only identified in the rare event that a dFAD is lifted from the water and the individual has not become detached post-mortem.

Trials of 'non-entangling' or 'reduced entanglement risk' dFAD designs have occurred in other tropical oceans, with no significant impact on the target tuna catch seen, and best practice guidelines developed (e.g. Figure 1). Trials have not been undertaken within the WCPO, but the effectiveness of designs across other oceans suggests similar performance can be expected. The precautionary approach would suggest the adoption of non-entangling dFAD designs (or at a minimum lower entanglement risk designs) should be considered within the WCPFC to minimise the impact of this mode of fishing on species of special interest and the WCPO ecosystem. Subsequent monitoring of target species catch rates and interaction rates should occur to ensure no unanticipated effects. Noting trials have concentrated on larger industrial fleets, the implications for smaller domestic PICT fleets should be considered.

Evaluation of dFAD designs for reducing juvenile bigeye and yellowfin catch rates is in its early stages. Given the potential impact of oceanographic influences on, for example, bigeye catches in the WCPO, the ability to infer performance of candidate designs from trials in other oceans may be limited. SC13 should consider the prioritisation of at-sea trials in the WCPO to pursue this area of work (see SC13-EB-WP-05).

Adoption of biodegradable dFAD designs would reduce marine debris and the impact of beaching events. However, the efficacy of alternative bio-degradable designs has not been confirmed, although trials of submerged structure material provide some information. To mitigate the risk on habitat of beaching in vulnerable areas (e.g. on coral reefs), dFAD retrieval programmes may be needed.

We invite WCPFC-SC13 to:

- Note available scientific information on alternative dFAD designs for reducing entanglement risk and provide scientific recommendations to the Commission on appropriate WCPO dFAD designs;
- Note the growing body of scientific information on alternative dFAD designs for reducing small bigeye and yellowfin catches and on biodegradable dFADs, in particular the findings for biodegradable submerged structures, but also the limitations of current information; and
- In conjunction with SC13-EB-WP-05, consider potential research activities on and at-sea trials of designs for reducing juvenile bigeye and yellowfin catch rates and trials of biodegradable design options in the WCPO to fill key knowledge gaps.

Introduction

Man-made drifting fish aggregating device (dFAD) designs have been developed with the aim of maximising the potential catch of purse seine target species (primarily skipjack). While enhancing the probability of catching tuna, the increased use of dFADs has had unintended consequences, including increased mortality of species of special interest (sharks, turtles, etc.; e.g. Filmalter et al., 2013) and ’undersized’ tunas (increased catches of small bigeye and yellowfin; Leroy et al., 2013).

dFADs have frequently been covered with netting to ensure both that the surface raft stays together, thereby ensuring it aggregates those species such as triggerfish that occupy space close to the dFAD and that are thought to increase its tuna-aggregative power, and to reduce the visibility of the dFAD to other vessels (Murua et al., 2016). Beneath the surface structure, dFADs generally have submerged ‘appendages’. The depth and extent of appendages are used to control the drifting speed of the dFAD, to provide bio-fouling opportunities, and shelter and shade for associated non-tuna finfish, all of which are felt to enhance tuna aggregation. The depth of those appendages can vary, from 10 to 120 m depth, depending on fleet, ocean and season, with a tendency for that depth to increase in recent years. Most tuna purse seine fishing companies world-wide have been using old tuna purse seine netting in dFAD construction, or recycled nets from other fisheries due to their low cost and ready availability. Tuna purse seine nets have relatively large mesh sizes (e.g. around 8-10 inch or 200-400 mm stretched mesh).

WCPFC13 adopted the revised draft of the FAD research plan prepared by the second WCPFC FAD Management Options Intersessional Working Group (WCPFC, 2016) with the note that the outcomes therein should be further considered at SC13 and TCC13 (paragraph 601 of the WCPFC13 meeting report).

The FAD IWG research plan requested that a “Review paper be prepared for SC13 on design of non-entangling FADs [and designs that lead to] BET or YFT interaction reduction”. To that end, this paper reviews the available information on studies relevant to these two goals, with a focus on alternative man-made dFAD designs that reduce interactions but minimise the impact on target catch levels, and provides some recommendations for SC13 consideration. In addition, given concerns over the potential for dFADs to contribute to marine debris, and the acknowledgement of trials being undertaken in other tRFMOs by the FAD IWG, it also reviews available research into biodegradable dFADs. The paper should be viewed in conjunction with the draft research proposals requested by the FAD IWG that have also been provided to SC13 (WCPFC-SC13-2017/EB-WP-05).

Definitions

We propose the following definitions for non-entangling and bio-degradable dFADs:

Non-entangling dFAD: dFAD designed to minimize ghost fishing (entanglement of fauna, primarily sharks and turtles). A non-entangling dFAD should preferably avoid the use of mesh material in the surface structure (raft) or in the submerged structure (tail). In the case of netting used for dFADs, it must have a mesh size of less than 7 cm or the net must be tied tightly in rolls (“sausages”).

Entangling dFAD: An entangling dFAD has components such as open nets with greater than 7 cm mesh size on the surface of the object (raft) and/or in the submerged part (tail), with the consequent potential of entanglement for species associated with the floating object and especially for vulnerable species, such as turtles and sharks.

Biodegradable dFAD: dFAD constructed with natural or biodegradable materials that reduce the impact of beaching and debris. The term biodegradable refers to a material or substance that is subject to a chemical process, during which microorganisms in the environment convert materials into natural substances such as water and carbon dioxide, and decompose organic matter. The time required for biodegradation of different materials varies. Its biodegradation should be as fast as possible after the desired life span for fishing, which is believed to be from 5 months to 1 year, depending on the ocean. Degradation products should not be pollutants to the ecosystem.

Non-Biodegradable dFAD: A dFAD that includes components of plastic origin, which requires hundreds of years to degrade.

The issue of entanglement

dFADs are known to be associated with unintentional entanglement of turtles and sharks in the materials used to construct those dFADs. Sharks, most probably as a result of chasing prey that hide around dFADs appendages, become entangled on dFAD sub-surface netting. Turtles, like sharks, can also become entangled in a dFAD´s submerged appendages, but in addition can become entangled in netting as they climb on top of the dFAD surface structure to breathe and rest.

Turtles

Studies have noted that, when compared to other fishing methods, the impact of purse seine fishing on marine turtles is relatively low (e.g. Bourjea et al., 2014). However, even low levels of mortality can contribute to the vulnerability of turtle populations to fishing pressure. A source of sea turtle mortalities associated with purse seine gear is through entanglement with dFADs, as noted both near the surface in the netting hanging in the water column, and on top of the floating structure of the dFAD.

In the WCPO, approximately 100 to 200 individuals per year have been observed interacting with purse seine gear in 2014 and 2015, with essentially 100% of captured individuals released, consistent with the requirements of CMM 2008-03. Where fate was noted in 2015, 88% of individuals were considered to be released alive and likely to live. Examining available detailed comments within observer GEN2 forms, in 2015 six interactions were specifically noted as entanglements with dFAD netting, and three of those were mortalities. These are likely to be underestimates, and need to be considered in the context of total fisheries impacts on turtle populations (e.g., longline captures; Common Oceans (ABNJ) Tuna Project, 2017).

Sharks

In recent years, it was believed that the majority of shark mortalities were caused directly through the purse seine fishing operations. Silky sharks (*Carcharhinus falciformis*) and to a lesser extent oceanic whitetip sharks (*C. longimanus*) were the most commonly affected shark species, with the former constituting over 95 per cent of all sharks observed at dFADs in the WCPO in 2015.

Specific visual studies in the Indian Ocean on 20 dFADs found that 40% had one or more entangled sharks (Chanrachkij and Loog-on, 2003) although this will be influenced by the particular design of dFAD encountered and local shark densities. Filmalter et al. (2013) estimated an annual dFAD entanglement mortality of half a million silky sharks in the Indian Ocean, which was almost an order of magnitude higher than that of the estimated catch of that species by purse seine gear.

The frequency of entanglement in the WCPO, as well as in the Atlantic and Eastern Pacific Oceans, is not clear. The identification of entanglement events is likely limited to those close to the surface or when the dFAD is lifted from the water. In 2015, WCPO observers noted 10 dead silky sharks entangled in netting under dFADs, which were observed only in the infrequent event that dFADs were lifted from the water. However, one of the key findings for sharks tagged at dFADs with archival tags in other oceans was that often dead entangled sharks would detach from the dFAD's appendages and sink to the seabed after just a few days (Filmalter et al., 2013). The result is that if the dFAD is not inspected during that time, a large proportion of the resulting mortality will be undetectable. That is why it is difficult to estimate the mortality of sharks (and other fauna) caused by dFADs that have netting or entangling structures; even if no entanglement is observed, a mortality event could have been caused previously by the gear (typically referred to as cryptic mortality). The fact that entanglements are rarely observable can make it difficult to convince fishers that they can occur.

Mitigation of shark and turtle entanglements

Entanglement mitigation approaches for these two taxa are similar. Some designs have been identified that reduce entanglement risk, which are dFADs that have either the netting tied in sausages or netting with a mesh size smaller than 7 cm (lower entanglement risk dFADs), while others essentially eliminate entanglement by using elements other than netting, such as ropes (non-entangling dFADs) (ISSF, 2015a; Figure 1):

- Reduce entanglement risk of both sharks and turtles by:
    - Reducing the amount of netting used on the surface 'raft' or submerged below;
    - Ensuring loose netting in the water column has a mesh size smaller than 7cm to reduce shark entanglement, although noting that after long periods at sea the netting may begin to break down, and as larger holes appear the risk of entanglement increases;
    - Tightly wrap/bundle netting in the water column, noting that such bundles can become untied over time and hence increase the risk of entanglement;
    - Reducing the raft surface area which may prevent turtles from attempting to climb onto the raft;
    - Covering the surface netting with canvas to reduce entanglement risk by turtles climbing onto the raft, but noting that when the fabric degrades the underlying netting is again exposed; and

    - Retrieving dFADs after a set and conducting any necessary repairs to ensure they will continue to be of reduced entanglement risk.
- Eliminate entanglement risk by:
    - Removing netting on the surface raft;
    - Using weighted panels or ropes as an alternative to underwater netting;
    - Eliminating netting within the construction, and use a subsurface structure of ropes, or non-entangling materials such as canvas or cloth sheets; and
    - Eliminating underwater appendages in dFADs.

It has been suggested that lower entanglement risk dFADs, particularly those that use ‘sausage nets’, may still pose an entanglement risk when they abrade through contact with coral reefs (Balderson and Martin, 2015).

Consequences for the economic performance of fleets

No publically-available trials of non-entangling or bio-degradable dFADs have been carried out in the WCPO to identify whether design changes will have negative impacts on tuna catches in this region. Hence inference must be drawn based upon trials undertaken in other oceans.

Trials of non-entangling dFADs have been conducted in the Indian and Atlantic Oceans (e.g. Delgado de Molina et al., 2005; see also Franco et al., 2009), but these trials were generally limited to small numbers of dFADs (e.g. less than 50 dFADs per trial). As a result of the low numbers and operational issues, the ability of those designs to aggregate tuna and reduce entanglement risk was not clear. Expanded trials undertaken by the French fleet operating in the Indian Ocean in 2010 deployed around 1000 lower entanglement risk dFADs. Those dFADs used small mesh net (e.g. < 2.5 inches or 70 mm) tightly strapped on the raft to reduce chances of turtle entanglement and submerged netting tied into bundles or sausages to reduce entanglement of both groups. Results indicated that tuna catches were comparable to those from traditional dFADs, while shark and turtle entanglement was greatly reduced (Goujon et al., 2012). Only in very limited instances (0.4% of dFADs tested) did sharks appear entangled when the twine used to tie the net into bundles had become undone. These positive results encouraged French purse seine companies to adopt these lower entanglement risk dFADs. Similarly, Spanish purse seine vessels from companies Opagac and Anabac agreed to adopt the use of either non-entangling dFADs or lower entanglement risk dFADs. These fleets currently deploy both these two types of dFADs and have experienced the same fishing efficiency as in previous years (when they were using entangling dFADs).

Feedback from skippers obtained through ISSF workshops further indicates that non-entangling dFADs did not reduce tuna catches. In turn, the materials used in the construction of non-entangling dFADs were not necessarily more expensive than those used to construct traditional ones (ISSF, 2015b). However, it takes more time per dFAD to tie the net into sausages and hence incurs a higher labour cost. There are FAD manufacturers on land that can provide this type of dFAD ready-made to purse seine companies, but smaller companies that cannot afford this service have to build them on board. Workshops also indicated that manufacturing dFADs on land was desirable to improve quality control and increase the uniformity in design, and that design could be more easily verified for non-entangling elements. However, at-sea inspection was also beneficial since the dFADs actually in operation were observed, including those that may not be owned by the vessel that sets on them.

Noting the above, the majority of trials have been performed within the large fleets of, for example, Europe or Ecuador. The implications of the necessary changes, including the availability of materials and the costs incurred etc., for smaller fully domestic fleets of Pacific Island Countries and Territories has not been examined. This should be considered when implementing these designs within the WCPO.

Designs to reduce catches of small bigeye and yellowfin

As described, considerable research has been focussed on modifying the design of dFADs to reduce bycatch of non-target species in particular species of special interest. However, less research has focussed on whether dFAD designs can be modified to reduce the catch of undesired tuna, in particular small bigeye and yellowfin tunas.

Gear characteristics may influence catch composition. Observations from the eastern Pacific Ocean suggest that different species of tuna typically inhabit different depths around dFADs (Schaefer and Fuller, 2002); bigeye tuna tend to be found deeper in the water column than skipjack tuna. Lennert-Cody et al. (2008) indicated that the depth of dFADs in the EPO was a significant factor in the likelihood of catching bigeye tuna, with shallow depth dFADs less likely to catch bigeye than those with deeper appendages in some areas. However, more research is needed to verify if the capability of the dFAD to aggregate bigeye tunas is related to the depth of the structure, or to the presence of bigeye in the area.

ISSF in collaboration with IATTC and industry (NIRSA from Ecuador) are further researching the level of bigeye catches through the manipulation of the depth of sub-surface dFAD structures. Over two years, a total of 150 shallow dFADs (5m depth appendages of 4 ropes of 1-2 inch diameter) and 150 deep dFADs (37m depth with two coils of twisted and tied netting, weighted with chain) have been deployed in pairs in the eastern Pacific Ocean and are being monitored through echo-sounder buoy signals and catches made while setting on those dFADs. Data from this project are still being collected (Restrepo et al., 2016).

For the WCPO, preliminary examination of available observer data (Abascal et al., 2014) demonstrated that while differences in the operational pattern of purse seine fleets cannot be ruled out, the available data on dFAD design were not adequate to identify dFAD characteristics that correlated with increased proportions of yellowfin and bigeye within dFAD sets. Recent analyses of available observer information on dFAD design and the level of bigeye catches suggest that the depth of sub-surface dFAD structures may be related to bigeye catches, in particular areas of the WCPO (SC13-MI-WP-07). However, the spatial variation in the influence of dFAD design on catch levels suggests some potential interactions with, for example, oceanographic features such as thermocline depth. This may imply that the behaviour of designs identified in the eastern Pacific Ocean may not necessarily work as expected in the central and/or western WCPO.

Developments towards the use of bio-degradable dFADs

Current dFAD designs commonly use petroleum products such as plastic, PVC, nylon nets, etc., as their main structural components. These elements bio-degrade slowly and the resulting components of the degradation process may be toxic for the ecosystem. Given the increased deployment of dFADs within oceans, there is growing concern over the issues of dFADs ghost fishing, creating marine debris, beaching in sensitive coastal habitats and on coral reefs, and/or of pollution when they sink (Maufroy et al., 2015; Moreno et al., 2016). The potential level of beaching impacts in the WCPO is currently being studied through the PNA FAD tracking programme. In the Indian Ocean, based upon the trajectories of the buoys used to geo-locate dFADs, around 10% of deployed dFADs ended up in stranding events (Maufroy et al., 2015).

As a result of those concerns, work on bio-degradable dFAD designs has been initiated. These designs use natural and/or biodegradable materials relevant to the region in question, such as palm leaves, coconut fibre, bamboo and sisal, to reduce their environmental impact upon beaching or sinking. These materials need to meet the general criteria to ensure dFADs maintain integrity for sufficient time to fulfil their primary aggregating role. An ISSF workshop on biodegradable dFADs suggests that for the Western Pacific, dFADs should maintain their integrity for fishing purposes for at least a year (Moreno et al., 2016; five months to a year in other oceans), but bio-degrade as fast as possible after this period.

Trials with biodegradable materials in controlled conditions

In 2015, ISSF in collaboration with ORTHONGEL (France) and the University of Hawaii, evaluated the degradation time of natural materials in tropical waters. Coir (coconut husk fiber) was tested at an anchored FAD offshore of Kaneohe, Oahu and in the lagoon at the University of Hawaii's Institute of Marine Biology. The material tested decomposed quite quickly, such that beaching impacts could be quite short-lived (Moreno et al., 2017). In turn, as low biofouling was observed, coir could be a suitable material for sub surface “tails” on dFADs if appropriate strand dimensions could be manufactured. The lack of biofouling would help maintain floatation of the structure through time. However, the rapid decline in tensile strength suggested coir would be sub-optimal for binding dFAD float components together, although increasing the strand diameter may increase its utility (Restrepo et al., 2016).

Further trials evaluating the bio-degradable properties of alternative ropes have been performed by ISSF in collaboration with the Marine Research Institute of the Maldives and International Pole and Line Foundation. Three different rope materials: (i) cotton, (ii) sisal and cotton and (iii) sisal, cotton and linen, in different configurations were trialled in both offshore waters attached to a mooring rope (simulating a dFAD in oceanic waters) and in a lagoon close to the reef in Maniyafushi island (simulating arrival of a dFAD to the coast). Preliminary results show higher resistance for cotton and sisal ropes followed by 100% cotton ropes and more degradation at the reef site compared to the oceanic site. Similar trials of alternative twine materials have been carried out off the coast of Spain in inshore aquaculture grounds (Lopez et al., 2016). These experiments, performed under controlled conditions, have identified materials suitable for testing under real fishing conditions as well as eliminating those materials that are too weak to be used in dFAD construction.

For sub-surface structures, the use of materials such as coco fibre and jute in fabric configuration has been rejected; fish feed upon the fabric, reducing their longevity below the 1 year mark. High resistance cotton canvas (in particular the thicker number 12 grade) has been identified as a good alternative for use as flags attached to the main structure of the dFAD, both to create more volume as a "drifting reef" as well as to use them as 'anchors' to make the dFAD drift more slowly. Cotton canvas has also been used as an alternative to cover the raft.

While biodegradable solutions exist to replace successfully the submerged appendages of dFADs, and to cover the dFAD´s raft, one of the challenges is to find a replacement material for the floatation of the dFAD. As a biodegradable alternative to current float materials (e.g. PVC pipes, purse seine net corks, plastic buoys, containers or drums), balsa wood has been suggested. However the effectiveness of this material to maintain floatation for a year has not yet been proven. Where readily available, bamboo canes, potentially treated with natural oils or waxes to increase their longevity and floatation, along with coconuts, may be appropriate.

Trials at sea in fishing conditions

A key practical difficulty encountered when testing biodegradable dFAD designs under real fishing conditions is that a high percentage of dFADs deployed by a given vessel are usually set on and repurposed by other vessels. The high turnover makes it difficult to return to individual dFADs and gather information on how the biodegradable structure evolves over time. It is therefore necessary to deploy a large number of dFADs to obtain the necessary information. ISSF in collaboration with INPESCA (EU-Spain) has initiated a small-scale pilot to identify the potential challenges in undertaking a large-scale experiment of biodegradable dFADs in the Indian Ocean. This pilot has been recently initiated and so far 85 biodegradable dFADs paired with 78 non-biodegradable dFADs have been deployed.

As one of the key issues for the lifetime of dFADs within the study was achieving the appropriate floatation period, the use of non-biodegradable buoys or purse seine corks was allowed during trials that tested biodegradable ropes and canvas both in the submerged structure and on top of the raft. In this way, the buoyancy of a given structure was ensured, and hence data could be gathered for that particular design, rather than it sinking and information being lost.

The use of a hydrostatic release unit for the buoy that is used to geo-locate dFADs, which would release the buoy before it sinks with the dFAD structure, has been suggested. This would require the buoy to be subsequently retrieved, as well as for its number to be reconciled in the Indian and Atlantic oceans where there is a limit on dFAD numbers allowed per vessel.

Best practice for adoption of new designs

At recent ISSF workshops (Moreno et al., 2016), seven biodegradable dFAD designs were developed. An appropriate selection of those designs could be used for trial within the WCPO.

At those workshops, suggestions were also made on the format of trials that can be applied to those on biodegradable and non-entangling dFADs, focussed on industry collaboration and sample numbers (Moreno et al., 2016; see Appendix 1). The workshop discussions and the adopted management requirements within other tRFMOs (see below), highlight an approach that provides a series of scientifically-based guidelines for dFAD designs, rather than providing a fixed design requirement. This allows industry to develop appropriate designs that meet those guidelines, while allowing them to use their technical knowledge to develop cost effective, efficient and safe-to-deploy dFADs that will be effective within the ocean in which they are used. For the WCPO, industry trials could, for example, be coordinated by SPC or be consistent with SPC-developed protocols (see SC13-EB-WP-05).

It is again noted that the majority of dFAD design trials have been performed with the collaboration of large DWFN fleets. Recommendations and guidelines must also be practical for smaller PICT fleets, whose access to materials (and their resulting expense) may vary.

Relevant conservation measures in other tRFMOs

Measures for a transition to the use of non-entangling and biodegradable dFADs by purse seine vessels have been developed and implemented in the three other tRFMOs covering tropical waters (IATTC: resolution C16-01; IOTC: resolution 17/08; ICCAT: Recommendation 16-01, and historically Recommendation 14-01, para 31 and Annex 6). As an example, given that similar language is used in each, the ICCAT recommendation 14-01 required that by 2016 all dFADs be replaced by non-entangling dFADs, with the following characteristics:

- The surface structure of the dFAD should not be covered, or only covered with material that has a minimum risk of entangling by-catch species;
- The sub-surface components should be exclusively composed of non-entangling material (e.g. ropes or canvas); and
- When designing dFADs the use of biodegradable materials should be prioritised.

A comparable CMM was proposed for WCPFC by the USA to the Tenth Regular Session of the WCPFC Commission, with a focus on the collection and analysis of data on fish aggregating devices (WCPFC10-2013-DP05; see also WCPFC11-2014-13_Attachment 2). The Commission was not able to agree to the adoption of the proposal at that time.

Summary and Recommendations

Trials of specific dFAD designs have not been undertaken within the WCPO, and hence inference must be drawn from those studies undertaken in other oceans. The precautionary approach would suggest the adoption of non-entangling dFAD designs (or as a minimum lower entanglement risk designs) should be considered within the WCPFC to minimise the impact of this largely unobservable mode of fishing on species of special interest and the WCPO ecosystem. These designs should be based on available 'best practice' guidelines developed and implemented in other oceans. Subsequent monitoring of catches and interaction rates should be prioritised to ensure no significant effects on target species catch rates and their success in minimising entanglements. In turn, given that the efficacy of these designs have to date only been studied in large industrial (e.g. European, Ecuadorean) purse seine fleets, the implications (practicalities and costs) of changes in designs for smaller domestic PICT fleets should be examined.

This review also suggests that:

- Evaluation of dFAD designs for reducing juvenile bigeye and yellowfin catch rates is in its early stages and further work is needed to identify the performance of candidate designs. Given the potential influence of local oceanographic conditions on the behaviour of species, it may be harder to draw inference from trials in other ocean areas, and hence trials should be considered specifically in the WCPO. SC13 should therefore consider the prioritisation of at-sea trials to pursue this area of work (see SC13-EB-WP-05).
- At present the efficacy of alternative bio-degradable designs (e.g., durability, water absorption, erosion by feeding fish) has not been confirmed, but work on submerged structure materials may be sufficient to provide recommendations. The potential to link the trials of designs for reducing juvenile bigeye and yellowfin catch rates to a trial of biodegradable design options in the WCPO is noted. However, there are concerns that the loss of, for example, key elements of the dFAD through early unanticipated bio-degrading will change their design and performance, and hence affect the ability to draw conclusions on the performance of designs to reduce juvenile bigeye and yellowfin interactions. Trialling bio-degradable elements directly on designs eliminating entanglement risk, or reducing juvenile bigeye and yellowfin tuna catches, is not therefore recommended.
- To mitigate the risk to habitat through beaching of dFADs and their potential contribution to marine debris, a programme of retrieving dFADs, particularly those that beach in critical ecosystems of high vulnerability (e.g. coral reefs) may be required.

We invite WCPFC-SC13 to:

- Note the available scientific information on alternative dFAD designs for reducing entanglement risk and provide scientific recommendations to the Commission on appropriate WCPO dFAD designs;
- Note the growing body of scientific information on alternative dFAD designs for reducing small bigeye and yellowfin catches and on biodegradable dFADs, in particular the findings for biodegradable submerged structures, but also the limitations of the current information; and
- In conjunction with SC13-EB-WP-05, consider potential research activities on and at-sea trials of designs for reducing juvenile bigeye and yellowfin catch rates and trials of biodegradable design options in the WCPO to fill key knowledge gaps.

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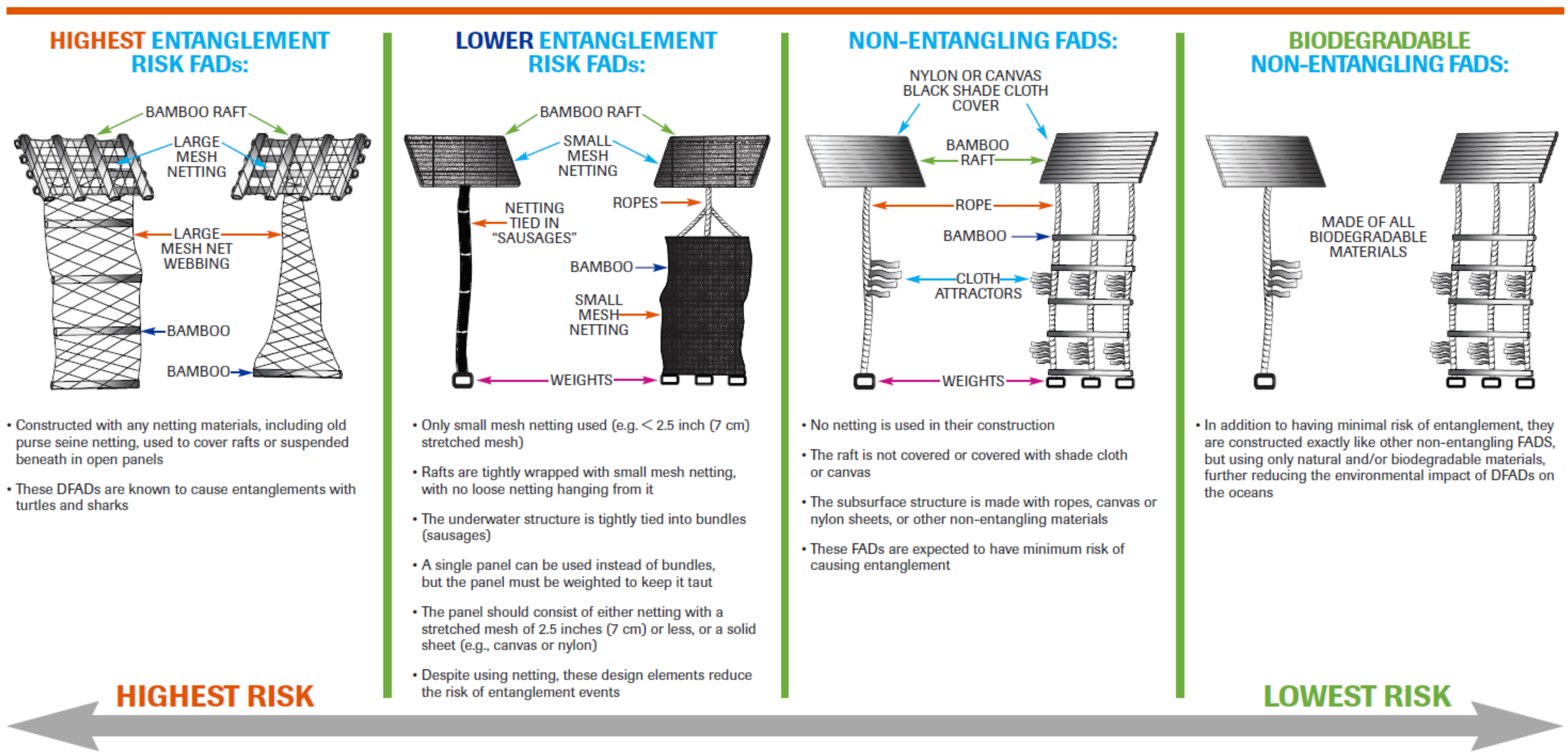

Figure 1. Expert ranking of FADs according to the risk of entanglement with four designs. Reproduced from ISSF (2015a).

Appendix 1. Moreno et al., 2016. Suggested protocol for biodegradable FAD trials.

- Fleets should collaborate by deploying FADs and providing information on the time evolution of biodegradable FADs encountered at sea.
- Fleets deploy a given number of biodegradable FADs per vessel (e.g. 10-20 FADs per vessel to reach a significant large number of FADs). These numbers should be determined during the meetings with the different fleets (fleet-owners and fishers).
- In order to get a meaningful result, 3 to 4 standardized designs maximum per ocean should be tested, so that enough data is retrieved per design type. Ideally experimental FADs should be built in port and deployed in the same area as traditional FADs, so their effectiveness could be compared with that of the traditional FADs for the same spatial and temporal strata.
- Since the objective is to monitor the time evolution of biodegradable materials and assess the buoyancy of the FAD, non-biodegradable floatation could be added at the beginning to guarantee that the FAD does not sink and that data will be collected.
- Deployment site, type of biodegradable design and the code of the geo-locating buoy should be registered. Every FAD should be well identified so that data can be retrieved and followed by the different owners.
- If a biodegradable FAD is encountered at sea, the following data should be registered: the catch (if any), the condition of the FAD and the new code for the buoy if the original has been replaced.
- Having access to the trajectories and sounder of the buoys attached to biodegradable FADs, would allow assessing the capability of biodegradable FADs to aggregate tunas even if they are not visited or fished by purse seiners, as well as following their lifetime if they are not retrieved.
- Data should not be collected in real time but with a given time delay and should be subject to a confidentiality agreement.
- An entity should be in charge of collecting and analyzing the data. It was suggested that ISSF could fulfil this role.