Guidelines to reduce the impact of drifting Fish Aggregating Devices on sea turtles

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Abstract

Scientific assessments of the impact of tropical tuna purse seine fishery on sea turtle populations indicate historically low turtle bycatch rates. This conception has been derived from direct capture or interaction of sea turtles with purse seine gear, where turtles have been hauled on board with targeted schools of tunas. However, the massive increase in the use of drifting Fish Aggregating Devices (FADs) by the tropical tuna purse seine fishery worldwide raises concerns about potential impacts on sea turtles. The two main concerns are related to the potential entanglement of sea turtles on FAD structures (i.e., ghost-fishing issues) and the potential impact of these structures when lost or abandoned on sea turtle essential habitats. Therefore, this document presents a series of guidelines to reduce the impact of FADs on sea turtles. These guidelines resulted from workshops between fishers and scientists conducted within a Pacific-wide project led by the International Seafood Sustainability Foundation in partnership with the Inter-American Tropical Tuna Commission, The Pacific Community, and Hawaii Pacific University.

1 Introduction

Despite being granted international protection and conservation status, sea turtles remain vulnerable to extinction due to their numerous threats, including climate change, illegal hunting, and incidental fisheries bycatch. Therefore, a holistic approach has been deemed necessary to enable sea turtle populations to recover in the long term. This approach involves (1) effective beach conservation to protect nesting females, eggs, and critical breeding habitats, (2) improving the survival of juveniles and adults at key developmental and large-scale migratory habitats, where they may interact with large-scale industrial fisheries (e.g. through avoidance and bycatch mitigation measures), and (3) decreasing mortality by small-scale artisanal coastal fisheries (Squires et al., 2021; Carpio et al., 2022).

Despite the fact that sea turtle bycatch from purse seine fishing gear (i.e., accidental catch in purse seine sets, also known as active catch) is known to be low (Table 1), the significant increase the use of Fish Aggregation Devices (FADs) require a reevaluation of their potential impacts. The massive use of FADs worldwide has raised concerns about their potential effects on sea turtle populations. Firstly, there is a possibility of sea turtles becoming entangled in the netting panels of FADs (i.e., ghost-fishing issues or passive catch). Secondly, lost or abandoned FADs could also impact the essential habitats of sea turtles (Franco et al., 2012; Escalle et al., 2019).

Fisheries need to adopt sustainable best practices over time to reduce their impact on the ecosystem. Bycatch mitigation measures must evolve and their efficacy assessed as fishing techniques and tactics continue to evolve. Given the increase in the use of FADs by tropical tuna purse seiners, which are traditionally built with netting materials and have a high risk of loss and abandonment, and the lack of dedicated research to estimate sea turtles' entanglement on FADs in the Pacific Ocean, we have defined a series of best practices and guidelines to minimize the impact of tuna purse seine fisheries on sea turtles.

Table 1 Active catch (bycatch in a set), passive catch (entanglement events) and fate of sea turtles in the tuna purse-seine fishery in the EPO for three different periods: 1994–1999, 2000–2014, and 2015–2020. These three periods were selected to demonstrate the early, mid, and current fishing practices.

	1994–1999		**2000–2014**		**2015–2020**	
Sea turtle fate	**Number**	**%**	**Number**	**%**	**Number**	**%**
Entangled alive	45	0.6	31	0.2	1	0.0
Released unharmed	6340	78.6	17163	88.4	4894	95.0
Light injuries	484	6.0	847	4.4	64	1.2
Grave injuries	372	4.6	234	1.2	15	0.3
Killed	175	2.2	87	0.4	5	0.1
Escaped/evaded net	340	4.2	874	4.5	160	3.1
Consumed	59	0.7	23	0.1	0	0.0
Other/Unknown	247	3.1	162	0.8	14	0.3
Total	8062		19421		5153	

2 Potential impacts of FADs on sea turtles

2.1 Entanglement issues

Based on observers' data, sea turtle entanglements in FAD structures in the eastern Pacific Ocean are relatively low. Between 1993 and 2020, 6,490 sea turtles were found entangled in FADs, of which 5,205 were sightings when visiting a FAD (without set), and the remaining 1,285 were seen entangled during one of the 180,538 FAD sets made during that period. In recent years (2014-2021), observers have registered an average of 108 sea turtle entanglements per year at FADs (min = 45, max = 169; Table 2), resulting in an annual average of 24 mortalities (min = 5 in 2020, max = 46 in 2015).

In summary, it is currently not possible to accurately assess the magnitude of the issue and determine the real impact of FADs entanglements on sea turtles.

However, despite 100% observer coverage on class-6 (>363 mt) purse seine vessels, the data collected by human observers may not be sufficient to fully support a low-impact scenario due to various logistical and practical reasons. For example, entangled animals may not be consistently detected while at sea because FADs remain at sea for several months to years, are only visited a limited number of times since deployment, and many are lost or abandoned without being visited again. Additionally, observers are restricted to work on the deck of the purse seine vessel, limiting their ability to detect sea turtle entanglements at FADs that may not be at a reasonable distance or depth (e.g. fishing vessels often remain several hundred meters away from the FAD before a set; and FADs submerged part could be 40-50 m depth). As a result, entanglements, which may only last a short time (Filmalter et al. 2013), may go mostly unobserved or unnoticed due to the operational characteristics of the FAD fishery. In summary, it is currently difficult to accurately assess the magnitude of the issue and determine the real impact of FAD entanglements on sea turtles using observer data.

Table 2. The number of turtles found entangled in a FAD, and their fate after being encountered in the EPO.

Year	Left entangled	Found dead	Released unharmed	Released light inj.	Released grave inj.	Other	Total
2014	0	34	97	18	5	3	157
2015	1	33	81	40	12	2	169
2016	2	24	100	28	5	4	163
2017	3	20	72	18	5	0	118
2018	0	14	51	16	3	0	84
2019	3	15	54	11	1	2	86
2020	1	3	31	7	1	4	47
2021	0	5	28	11	1	0	45
Total	10	148	514	149	33	15	869

Current conservation measures to address FAD entanglement issues

In the Pacific Ocean, Resolutions C-21-04 and C-19-01 (IATTC) and Conservation and Management Measure (CMM) 2021-01 (WCPFC) require CPCs (Members and Cooperating non-Members; IATTC) or CCMs (Members, Cooperating Non-Members and Participating Territories; WCPFC) to ensure that any FAD design and construction to be deployed in, or that drifts into, their Convention Areas comply with specific requirements starting in 2019 and 2020 for IATTC and WCPFC, respectively. These requirements aim to reduce the risk of entanglement of marine fauna (i.e., low entanglement risk FADs) and include the following:

- The floating or raft part (flat or rolled structure) of the FAD can be covered or not. To the extent possible the use of mesh nets should be avoided. If the FAD is covered with a mesh net, it must have a stretched mesh size of less than 7 cm (2.5 inches) and the mesh net must be well wrapped around the whole raft so that no loose netting is hanging below the FAD when it is deployed.
- The design of the underwater or hanging part (tail) of the FAD should avoid the use of a mesh net. If a mesh net is used, it must have a stretched mesh size of less than 7 cm (2.5 inches) or be tied as tightly as practicable in the form of bundles or "sausages" with enough weight at the end to keep the netting taut down in the water column. Alternatively, a single weighted panel (less than 7 cm, 2.5 inches, stretched mesh size net or solid sheets such as canvas or nylon) shall be used.

It is important to note that even if netting has a small mesh size or is tightly wrapped when newly built and still monitored by fishers, older netting in lost and abandoned FADs may end up untied and mesh breaking up to form larger holes. Due to the long life of plastic netting, these FADs will remain for prolonged periods at sea (i.e., years) and may eventually evolve into high entanglement risk FADs (ISSF, 2019). Therefore, WCPFC CMM 2021-01, has moved one step further and will prohibit the use of any mesh net in any part of a FAD, starting on January 1st, 2024.

2.2 Impact of lost and abandoned FADs on sea turtle´s essential habitats

Currently, it is difficult to provide accurate estimates of the number of lost and abandoned FADs in the purse seine fishery in the EPO. This is mainly due to two reasons: (i) the number of retrievals at sea and on land is largely unknown at local and regional scales, although observer data estimate that 5000-8000 retrievals occur in the EPO each year (Lopez et al., 2020), and (ii) vessels often remotely deactivate geolocating devices (satellite buoys) attached to FADs when they drift out of the fishing ground or are taken by other vessels.

Current conservation measures to reduce FAD loss and abandonment

Despite the lack of specific direct binding management measures related to FAD loss and abandonment in the EPO, there are a series of measures in place that indirectly address these issues. For instance, IATTC's Resolution C-21-04 requires large-scale purse seine vessels to recover a number of FADs equal to the number of FADs set within 15 days before the start of the closure period. The Resolution also prohibits remote deactivation and reactivation of satellite buoys, except in specific cases (e.g., out of the fishing ground, loss of signal, buoy

appropriated by another vessel), and mandates that vessels submit monthly reports of these activities to the Secretariat. In addition, vessels are required to submit high-resolution data of all satellite buoys used to monitor their FADs to the Secretariat. In the WCPO, CMM 2017-04 recommends the retrieval of any fishing gear to limit marine pollution from fishing vessels, and if retrieval is not possible, vessels are encouraged to report the coordinates and type of gear lost or abandoned. This measure also encourages parties to develop a data-sharing framework to reduce loss and facilitate recovery of lost and abandoned fishing gear, including FADs. Although developing such a system at the scale of the Pacific might be challenging, it could be led by regional bodies, such as the Parties to the Nauru Agreement or through national initiatives led by governments or NGOs (Zudaire et al., 2018).

Furthermore, the use of biodegradable materials for FAD construction, such as those made of organic materials like manila hemp or cotton, can reduce the lifetime of FADs as well as their impact when they strand. Consequently, IATTC's Resolution C-19-01 and WCPFC's CMM 2020-01 promote the use and investigation of natural or biodegradable materials for FAD construction.

3 Guidelines to reduce the impact of FADs on sea turtles

In the current situation, where the impact of FAD structures on sea turtles is uncertain and the conservation status of sea turtles is a priority, it is important to co-develop guidelines and best practices together with fishing fleets from the EPO and WCPO. Although FADs are managed separately by the WCPFC and IATTC, FADs freely drift from one convention area to the other. Therefore, harmonized best practices and conservation measures aligned with each other are necessary to reduce the potential impact of FADs on sea turtles in both regions.

To develop a series of guidelines and best practices, scientists worked with three tropical tuna purse seine fleets in the Pacific Ocean: the Ecuadorian fleet (diverse fishing companies mostly operating in the EPO), a fleet from the Federated States of Micronesia (Caroline Fisheries Corporation, fishing in the WCPO), and the Spanish fleet (Ugavi, Albacora and Atunera Dularra, fishing in both the EPO and the WCPO). A series of workshops were conducted to work with these fleets separately in Spain, Croatia (home town of Micronesian captains), and Ecuador.

Both fishers and scientists identified best practices following the chronology of the lifetime of a FAD, from its construction to the end of its lifetime. Fishers worked in small groups and each group presented its ideas. The criteria for grouping fishers were the degree of FAD use, the size of the vessels, and the fishing area/region. Scientists also gathered in one group and presented their ideas. Table 3 summarizes all practices mentioned and discussed during the workshops that could be implemented as best practices in the EPO and WCPO for the tropical tuna purse seine fisheries using FADs.

Several practices/actions were identified to help reduce the potential impacts of FADs on sea turtles, as shown in Table 3. These actions are detailed in the next section. Some can be implemented quickly and easily (i.e., short-term), while others would require more research and/or time to implement (i.e., long-term). Despite the diverse FAD use and fishing strategies of participating fishers, most fleets and participating groups came up with similar ideas. The actions described below are focused on what fishers could do to reduce the potential impacts of FADs on sea turtles. Fishers also identified actions for ship-owners, scientists, and other stakeholders to help reduce the impact of FADs on sea turtles. The complete list of these actions is shown on Tables I.1 and I.2 of Annex 1.

Table 3: Potential practices identified by fishers to reduce the impact of FAD structure on sea turtles.
Actions in bold were identified by all workshop participants in different countries.

FAD activity	Entanglement	Stranding
Construction	‣**Fully non-entangling FADs (NEFAD): FADs without netting in any of their components** ‣Non-entangling FADs provided by the fishing company to fishers ‣Built FADs on land with the required specifications to be NE	‣**Construct biodegradable FADs** that last 6 months ‣**Construct biodegradable FADs** that last one year and NEFAD to avoid entanglements in coastal habitats
Deployment	‣Limit more the active buoys per vessel	‣Avoid areas of deployment with high loss and abandonment risk ‣Limit more the active buoys per vessel
Monitoring		‣ Monitor/ track FADs more closely/strictly to avoid loss
Visit/Set	‣Routinely lift the FAD to observe any entanglement ‣**Release the species entangled if any**	‣**During visits/sets retrieve as much FADs as possible especially :** **(i) In areas close to the limit of the fishing ground, even if the dFAD is in good condition** (ii) Retrieve FADs without fish as much as possible ‣**Check FADs that are close* and repair or retrieve if damaged** ‣Routinely lift the dFAD to see if there is any damage that could lead to its loss ‣If the structure is damaged repair it or retrieve it
Deactivation	‣No deactivation of the FAD ‣Sell and share FADs before they are lost and when they drift to the western Pacific ‣Before FAD is deactivated see if there is any vessel close to retrieve it	
Retrieval	‣When someone elses FAD is encountered, retrieve everything buoy and FAD structure ‣Retrieve FADs on the way to port* ‣More communications among vessels to retrieve FADs at sea ‣Use one purse seine vessel to retrive FADs for a given time and shift among the entire fleet ‣Use FAD cleaning vessels paid by various companies to retrieve FADs and regulate their activity ‣Cleaning vessel paid by fishing associations ‣Cleaning vessel paid by the regional body	

3.1 FAD construction:

Fully Non-entangling and biodegradable FADs:
All groups identified this Best Practice as a crucial and high-priority element to minimize the potential impacts of FADs on sea turtles. To achieve this, fishers have requested the support of scientists and shipowners to conduct trials, receiving scientific assistance, and suitable biodegradable materials, while reducing the pressure by fishing companies to meet expected fishing performance. It is worth noting that while some fleets considered FADs need to last for a year, others considered six months enough for their fishing strategy.

FADs supplied by fishing companies:
Fishers suggested that fishing companies should provide FADs that meet the required specifications to be fully non-entangling (NE) and biodegradable. Some fishers construct FADs at sea, and this practice may make it more difficult to comply with the current resolutions.

FADs built on land:
Fishers recommended that FADs should be manufactured on land using non-entangling materials to standardize designs and meet the technical criteria. This approach would improve their monitoring and compliance if needed.

3.2 FAD deployment:

Further limit the number of FADs at sea:
A group of fishers proposed reducing the current limit on active FADs to reduce FADs at sea. Note that current resolutions in the Pacific Ocean are on active FADs which differs from the numbers deployed or real numbers at sea.

Avoid deployment areas of high risk of FAD loss:
All groups agreed that reducing deployments in areas with a high risk of FAD loss and stranding would reduce stranding events. If necessary, identification of these areas could be conducted through scientific studies with the collaboration of fishers.

3.3 FAD monitoring:

Closer monitoring of FAD tracks:
Fishers suggested that closer monitoring of FAD tracks would reduce FAD loss and abandonment events. This would allow for decisions in advance to retrieve or visit those FADs, both by the owner or in collaboration with other vessels.

3.4 Visits and sets

Routinely lift the FAD:
When visiting or setting on a FAD, fishers could lift the FAD to check for any interaction with an entangled animal and release it, and to repair/replace the structure, provided the structure if it is in bad condition or has entangling materials. Note that FADs in poor condition were identified as susceptible to higher probabilities of sinking or loss.

FAD retrieval during visits and sets:
Most fishers agreed that more FADs could be retrieved when visiting and setting on them, especially in these circumstances:

(i) In areas close to the edges of the fishing ground, even if the FAD is still in good condition.
(ii) When in doubt about leaving it at sea or retrieving it, favor the retrieval.
(iii) Retrieve FADs without associated tuna as much as possible.
(iv) Check FADs that are close to the one visited and if damaged, repair or retrieve them.

3.5 FAD tracking buoy deactivation

Actions before deactivation:

- Check if there is any vessel close to the FAD to help retrieve it.
- Sell and share FADs before they are lost or abandoned (some fleets from the EPO are already selling FADs that drift into the WCPO).

No deactivation of the buoy used to track FADs:
The satellite buoy used to track the FAD should not be deactivated until the end of its lifetime. A definition of the end of the lifetime of a FAD would be required for that.

Other marking systems:
Scientists proposed considering a marking system independent from fisher´s satellite buoy to track the FAD until the end of its lifetime. This could give information on the FAD, regardless of fisher´s tracking buoy status (i.e., active/deactivated).

3.6 Retrieval

Retrieval at sea by purse seine vessels:
When finding others´ FADs at sea, retrieve both the buoy and the structure. This could be improved by promoting communication among fleets to increase retrievals of lost or abandoned FADs or FADs that would be deactivated.

Retrieval at sea by other vessels:
Different options were proposed for FAD retrieval by a third party or vessel. The following options could be economically explored:

- Use of a purse seiner of the fleet that could be dedicated just to retrieve FADs for a limited time and shift among vessels.

- Use of a cleaning vessel paid among all fishing associations.
- Use of a cleaning vessel paid for by the fishing company.
- Use of a cleaning vessel paid for by a regional fishery management organization.

Participation in FAD retrieval programs:
Scientists suggested participation in a retrieval program, such as the "FAD watch" retrieval program in the Indian Ocean, the program in Palmyra atoll in the western Pacific Ocean and the one recently developed for Galapagos islands. For such a program to be effective, minimum standards should be developed.

4 Recommendations to reduce the potential impacts of FADs on sea turtles

Based on the guidelines and best practices to reduce the impact of FADs on sea turtles identified above, the following recommendations are made:

- *Adopt and effectively implement fully non-entangling FADs*: Only FADs without netting can eliminate the risk of sea turtles becoming entangled both at sea and when FADs become stranded in coastal habitats.
- *Adopt and effectively implement biodegradable FADs*: Biodegradable FADs can help reduce the persistence and degree of harm of stranded FADs in essential habitats for sea turtles by degrading much faster than current plastic-made FADs. They could even prevent FADs from arriving in coastal areas, provided that the materials degrade before reaching the coast.
- *Provide data on the entire trajectory of FADs*: Having the entire trajectory of FADs would allow for a better assessment and quantification of stranding events and their potential impacts and solutions.
- *Implement FAD marking:* Use an effective and unique FAD marking system, independent from that used by fishers (i.e., satellite buoys), that allows for monitoring and tracking of the FAD throughout its entire trajectory, even when fishers replace the tracking buoy when encountering other FADs.
- *Retrieve FAD at sea by purse seiners:* Put in place a set of best practices during visits/sets at FADs, such as routinely lifting the FAD at sea, repairing or retrieving it of damaged, retrieving FADs on the edge of fishing grounds, and communicating with other vessels to share/sell and retrieve FADs.
- *Participate in FAD retrieval programs*: Fishing companies should explore different options mentioned above to retrieve FADs in collaboration with third parties or other fishing companies. Scientists should help define standards for those programs to be effective.
- *Further limit the number of FADs at sea:* limiting the number of FADs at sea (e.g., limiting the deployment or reducing further active FAD limits) would reduce both entanglement events and damage to essential habitats.

5 Conclusion

This document presents a set of guidelines and best practices that have been identified by both scientists and fishers to reduce the impact of FADs on sea turtles. Most of these practices can be implemented in the short term, while others will require more research and regulations for their implementation. For instance, regulations would need to be developed to establish the activities and funding mechanisms for cleaning vessels that retrieve FADs.

FADs made of synthetic plastic fishing nets can stay at sea for years, potentially leading to ghost-fishing of sea turtles. Even Low Entanglement Risk FADs could eventually become High Entanglement Risk FADs as they deteriorate and netting opens, creating a larger mesh size (ISSF, 2019). Therefore, the use of fully non-entangling and biodegradable FADs was identified as a priority by all fishers and seems to be in line with the recommendations of tuna RFMOs. However, there are currently no definitive implementation plans for biodegradable FADs in the EPO, and most fishers acknowledge that greater support from scientists and shipowners will be necessary to move towards the full implementation of non-entangling and biodegradable FADs. Interestingly, fishers have identified best practices for visiting FADs at sea that can reduce the loss and abandonment of FADs. These practices can be complemented by routinely lifting and repairing the FAD.

Reconciling the recovery of critically endangered sea turtle populations in the Pacific Ocean with continued fisheries pressure is essential (Dutton and Squires 2008). Implementing guidelines and best practices for fishing, including FAD construction, is crucial for their recovery.

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ANNEX I

Table I.1. Practices identified by fishers and scientists for shipowners.

FAD activity	Entanglement	Stranding
Construction	Promote the use of fully non-entangling FADs	Searching for cost-effective biodegradable materials Investing in biodegradable material´s purchase Releave pressure and support fishers with biodegradable FAD trials Supply biodegradable materials to fishers More projects together with scientists to learn from the experiences at sea
Deployment		Reduce number of FADs deployed by their vessels
Visit/Set		Tolerate the loss of time to visit /retireve FADs
Deactivation		Keep buoys in their company activated until the end of their lifetime-no deactivation Sell and share FADs that will be lost
Retrieval		Participate in FAD recovery programs Consider the use of cleaning/supply vessels to retrieve FADs

Table I.2. Practices identified by fishers and scientists for other stakeholders.

	FAD construction/deployment	**FAD retrieval**
Buoy companies	Sensor to detach buoy if FAD is sinking	Low-cost mode to retrieve the FAD FAD with navigation capability Cover communication costs once FADs are deactivated
Port authorities		Facilities to store and recycle FADs
Scientists	Research on science based FAD limits Research on turtle behaviour around FADs Trials and workshops with fishers Research on alternative to plastic buoys Research on biodegradable materials	Provide information of areas of deployment with high risk of stranding Estimate stranding rates in sensitive areas Cost-benefit analysis of retrieval options Research spatial management of FADs to deploy and retrieve them
OROPS		Flexibility in understanding the constraints of fishing activity to put in practice new protocols