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Enhancing sustainable practices in the use of biodegradable Fish Aggregating Devices (FADs) in the EPO

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Jose Luis García, Juan Carlos Quiroz y Guillermo Morán V., and FUNDACION TUNACONS

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Abstract: This document discusses developing and deploying biodegradable Fish Aggregating Devices (eco-FADs) in the Eastern Pacific Ocean (EPO) to enhance sustainable fishing practices. It highlights using biodegradable materials, particularly Abaca fibre, in constructing eco-FADs to reduce environmental impacts. The research conducted by TUNACONS in Ecuador focuses on improving the durability and longevity of eco-FADs through fabric treatments and construction methods. The document also outlines the categorisation of eco-FADs based on biodegradability levels and the deployment timeline set by the Inter-American Tropical Tuna Commission (IATTC). The initiative aims to promote sustainable fishing practices, reduce the impact on marine ecosystems, and ensure the long-term health of tropical tuna populations in the EPO.

1. Introduction

Tuna Regional Fisheries Management Organizations (tuna-RFMOs) have been making significant strides in promoting sustainable fishing practices, particularly concerning using Fish Aggregating Devices (FADs). In recent years, there has been a growing emphasis on incorporating more biodegradable components into FAD constructions to reduce the environmental impact of these devices. This shift towards using biodegradable materials aligns with the RFMOs' goals of minimising the adverse effects of FADs on marine ecosystems and promoting the long-term health of tropical tuna populations.

Resolution C-23-04, adopted by the Inter-American Tropical Tuna Commission (IATTC), represents a promising outlook for sustainable purse seine fishing of tunas in the Eastern Pacific Ocean (EPO). The resolution scope covers two lines: 1) outlines the composition and degradability of Fish Aggregating Devices, and 2) provides FADs categories based on their biodegradability and non-entangling properties. It also lays out a strategy to decrease bycatch and improve sustainable fishing practices using non-entangling and Biodegradable FADs (hereafter referred to as eco-FADs), fostering hope for tuna harvesting in the EPO region.

The Ecuador fishing sector has been promoting environmentally friendly and sustainable fishing practices in the tuna industry. One key initiative is the creation of eco-FADs using materials of

plant origin that are completely biodegradable. This paper outlines Ecuador's efforts in implementing the deployment of eco-FADs and plans for future steps to reduce the impact of fishing in the EPO and promote sustainable fishing practices.

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2. Eco-FADs materials

TUNACONS, a non-profit organisation focused on supporting sustainable fishing harvests for tropical tuna species through scientific research, promoted the development of eco-FADs in Ecuador. Supported by the fishing sector, the eco-FAD building programs started at the beginning of 2017 and are currently promoting the use of at least 20% of all FADs deployed by the TUNACONS fishing fleets.

2.1. Fibre selection

The initial experiments in 2017 aimed to develop eco-FADs using biodegradable materials that could enhance their lifetime. After several trials with different materials, mechanical tests (e.g., density, tensile strength, elasticity, fracture elongation, humidity absorption) revealed that Abacá fibre (*Musa textilis*) exhibited advantageous properties such as high mechanical tensile strength associated with the biochemical architecture of its cell wall, low permeability due to its low moisture absorption, significant resistance to salinity, remarkable elongation and elasticity capacity, a reduced density that facilitates its buoyancy, and extensive fibres (up to 200 cm) that enable optimal cohesion attributes to achieve strong threads and fabrics. These properties were considered when selecting the Abaca fibre as the base material for advancing the development of eco-FADs for anchored and in-ocean trials.

2.2. Fabric treatments and construction

The duration in the ocean of an eco-FAD depends on many factors, such as degradation by microorganisms and alkalinity (pH 8.0 - 8.5) of the marine environment, destruction and drift caused by currents, waves, and extreme environmental conditions, and physicochemical changes generated by sea surface temperature, intensity of sunlight, and UV rays. In an eco-FAD, these stressors must be mitigated to maximise their lifetime.

Between 2018 and 2020, TUNACONS conducted multiple anchored scaled-FAD trials to assess the impact of Abacá fabric on the permeability, durability, and lifetime of eco-FADs. Various

treatments were applied to the fabrics using two different kinds of materials. The first kind used fats and oils to inhibit water permeability. This treatment combined palm oil and beef fat with antibacterial, binding, and repellent agents. The second kind included dragon's blood, natural rubber, and fish oil, all readily available in strategic locations in Ecuador.

Natural rubber is derived from a milky liquid known as latex, sourced from various tropical plants, such as *Hevea brasiliensis*, originating in the Amazon. On the other hand, Dragon's blood (*Croton lechleri*) is a tree belonging to the *Euphorbiaceae* family, and its latex is employed in homeopathic remedies for sealing skin injuries, preventing infections, and enhancing the healing process. Both natural latex varieties are semi-permeable, making them ideal for eco-FADs.

2.3. Anchored and in-ocean trials

Various segments of Abaca fabric underwent distinct treatments (as described in Section 2.2). All fabric samples were submerged throughout the trials to ensure uniform conditions in the experimental setup. The fabric's tear strength (measured in Newton, N) in different orientations was evaluated using a dynamometer in a controlled laboratory environment. The degradation percentage relative to the fabric left unsoaked for zero days was determined using a customised scale. Strength assessments were carried out per the ISO 13934-2:2014 standard at 20-day intervals.

The document FAD-06 INF-C summarises the construction of the eco-FAD prototype deployed by TUNACONS during the trials. After various trials on anchored eco-FADs, it was determined that treatment with natural rubber offers greater durability and resistance, which prolongs the useful lifetime.

3. Deployment of eco-FADs

From 2021 to 2023, trials performed by TUNACONS involving anchored eco-FADs were extended to encompass ocean deployment, thereby enriching experimental studies on durability, resilience, and permeability. Oceanic Eco-FADs were constructed under the specifications of Prototype #2 (Figure 1), utilised in the initial project in partnership with IATTC, albeit with certain modifications (see Documents SAC-11-11 and FAD-07-02).

Resolution C-23-04 regarding the design and biodegradability of FADs in the EPO stipulates that by 2026, vessels in the IATTC area must allow the deployment or redeployment of drifting FADs falling within biodegradability categories I, II, III, or IV (Table 1). By 2029, members of the IATTC

will gradually restrict the deployment or redeployment of drifting FADs of categories I or II. By 2030, the Commission will determine whether to mandate by 2031 that IATTC members only permit vessels to deploy or redeploy drifting FADs of Category I.

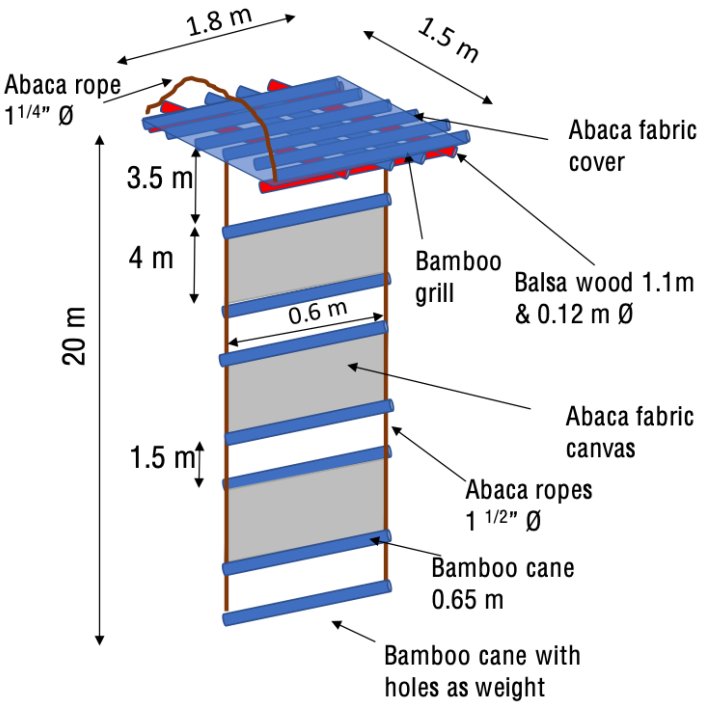

Figure 1: Design of eco-FAD assembled by TUNACONS in the IATTC framework, based on prototype #2.

Table 1: Eco-FAD specifications following categorisation stipulated in Resolution C-23-04. Five categories were identified based on their degree of biodegradability (from non-biodegradable to 100% biodegradable).

Category	Degree of biodegradability
I	The FAD is made of fully biodegradable materials.
II	The FAD is made of fully biodegradable materials except for plastic-based flotation components (e.g., plastic buoys, foam, purse-seine corks).
III	The subsurface part of the FAD is made of fully biodegradable materials, whereas the surface part and any flotation components contain non-biodegradable materials (e.g., synthetic raffia, metallic frame, plastic floats, nylon ropes).

IV	The subsurface part of the FAD contains non-biodegradable materials, whereas the surface part is made of fully biodegradable materials, except for, possibly, flotation components.
V	The surface and subsurface parts of the FAD contain non-biodegradable materials.

3.1. Last three years

Between 2021 and 2023, TUNACONS fishing fleets sowed 24,780 FADs. In December 2020, the member fishing companies collectively agreed to achieve a deployment of 20% eco-FADs, amounting to 4958 eco-FADs sowed (Figure 2).

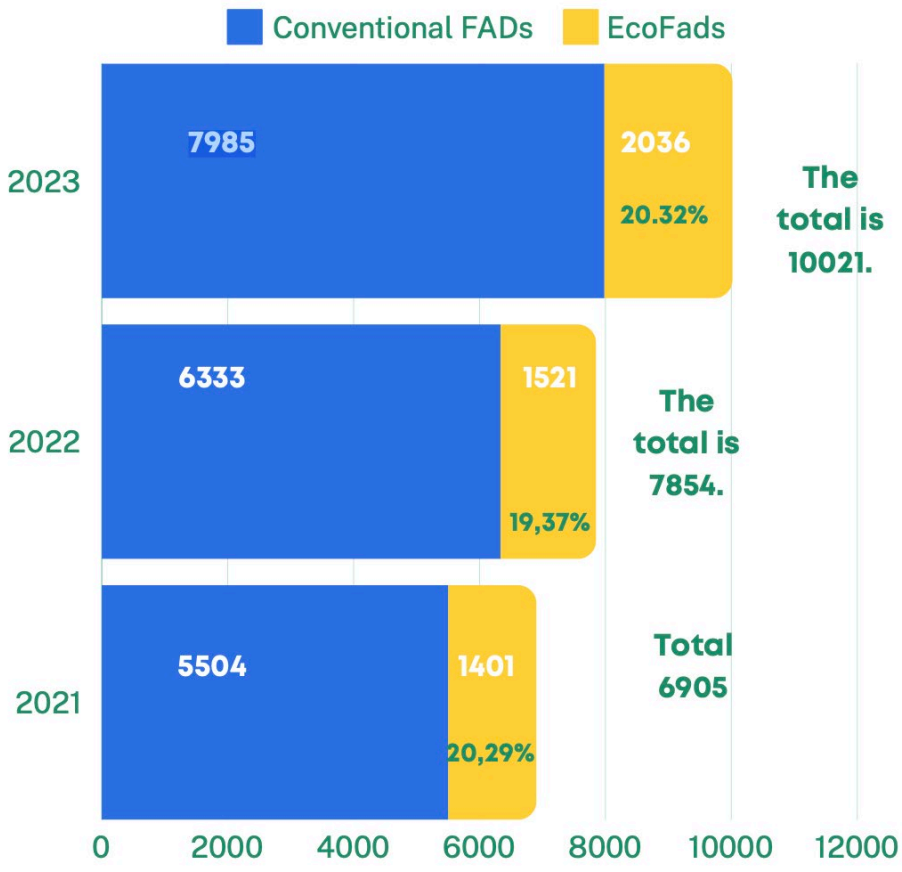

Figure 2: Deployment of conventional FADs and eco-FADs during the period 2021-2023.

These thousands of sowings were deployed under Category I of Resolution C-23-04, positioning Ecuador as the leading IATTC member in promoting eco-FAD use, minimising entanglement risks for vulnerable species, reducing pollution, and implementing regulations still under discussion in the IATTC framework.

All fishing logbooks containing the deployment of eco-FADs were created based on the ROF-C forms submitted by the observers from IATTC and TUNACONS, detailing the total number of vessels involved in the process.

3.2. Fishing operations

A total of 641 fishing sets were utilised to recover the eco-FADs deployed by the TUNACONS fleets during 2021 – 2023 (Figure 3). The fishing rate for 2023 stood at 25.3 tons/eco-FAD, mirroring the fishing rate achieved with traditional FADs.

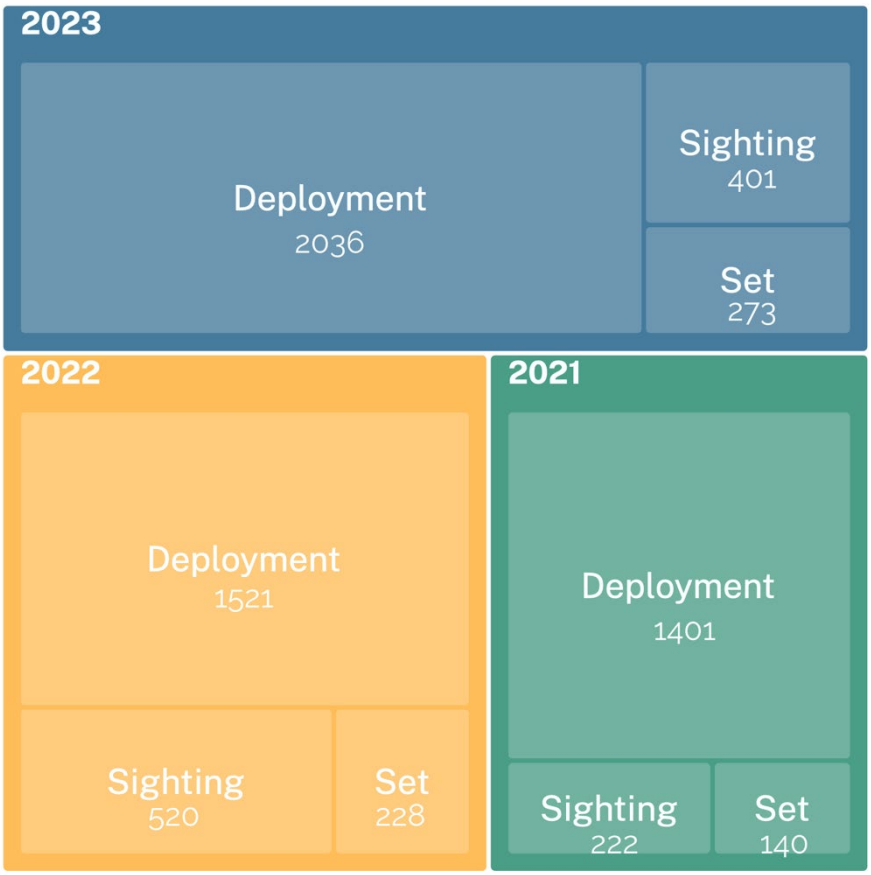

Figure 3: Summary of sowing, sighting, and fishing set for the total eco-FADs deployed by TUNACONS between 2021 and 2023.

The sighting rate, about total eco-FADs, has averaged 23% over the past three years. This level is very promising, indicating the significance of eco-Fads' recovery for the fleet and proposing a potential alteration in the fishing tactics or strategy of the vessels.

Table 2 summarises total fishing operations on eco-FADs. The outcome is 1143 eco-FADs visited, 722 fishing trips involved, and an average soak time of 46 days (up to 169 soak days).

Table 2: Summary of TUNACONS fleet operation between 2021 and 2023. Catch in tonnes, catch rate (tonnes), and time in days.

Year	Fishing Trips	eco-FAD Sighting	eco-FAD Sets	Total Catch	Catch By set	Soaking time
2021	179	222	140	3730	26,6	1-108
2022	271	520	228	3953	17,3	6-139
2023	272	401	273	6907	25,3	7-169
Total	**722**	**1143**	**641**	**14590**	**23,1**	**1-169**

3.3. eco_FADs condition

The recovery status of eco-FADs was classified according to a qualitative scale, as documented in SAC-11-11 and noted by observers in the ROF-C forms based on the condition of the abaca fabric of the upper structure of the floating part (grid), the fabric of the submerged part (tail), and the main tail rope. These structural parts of eco-FADs showed the highest level of biodegradation during soaking time.

Throughout 2021-2023, 48% of eco-FADs recovered were categorised as “Very Good”, while only 2.7% were classified as “Severely deteriorated” (Figure 4). The three main sections (cape, floating, and submerged) exhibited a comparable effect based on the duration of immersion.

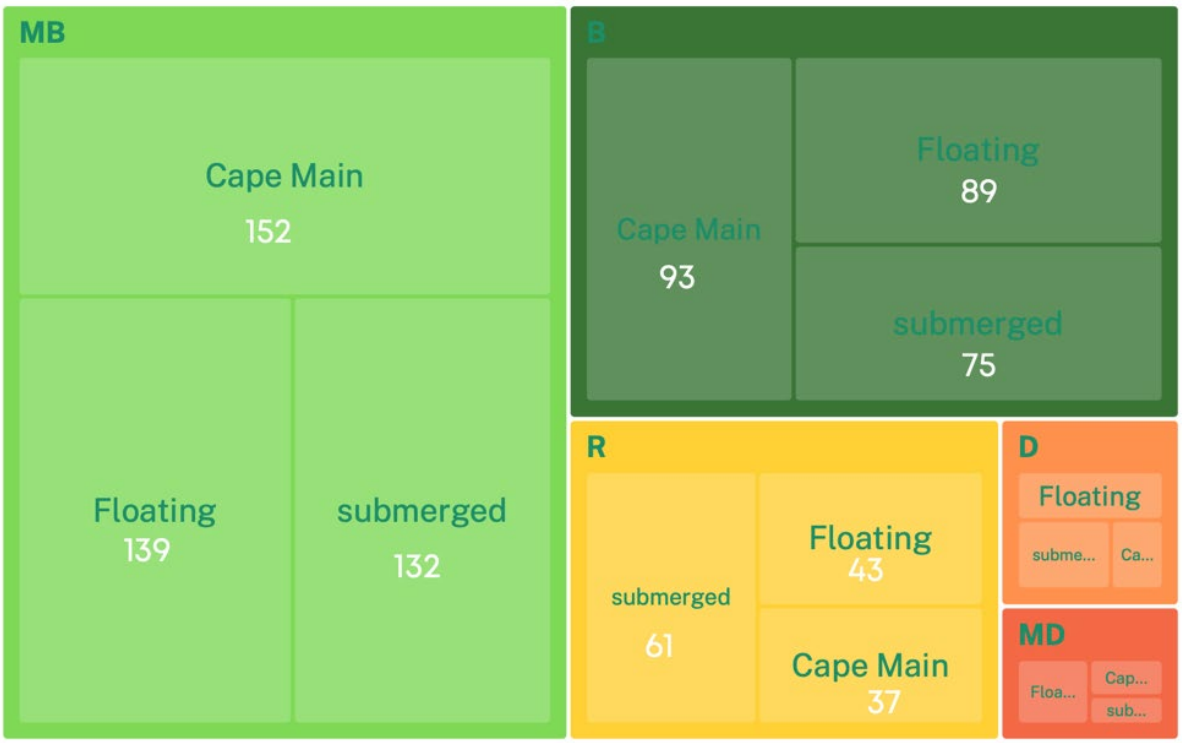

Figure 4: Frequency of biodegradation of the eco-FADs recovered by the TUNACONS fleet between 2021 and 2023

4. Discussion

The eco-FAD program implemented by TUNACONS has pinpointed several challenges that, when addressed, are expected to enhance advancements in purse seine fishing targeting tropical tunas in the EPO region.

Firstly, exploring the impact of communication between the fishing sector and fisheries scientists appears relevant. It is relevant to understand how fishermen often lack awareness of the environmental impacts of their fishing activities, such as by-catch mortality and effects on endangered species. The fishing sector focuses on maximising catches for income, overlooking sustainability concerns. Developing eco-friendly fishing practices aims to address these issues by promoting sustainable fishing practices and raising awareness among fishermen about the importance of conservation. Through interactions with scientists, the fishing sector gains insights

into the biology, ecology, and management of tuna and bycatch species, crucial for understanding marine ecosystems and conservation. Learning about the vulnerability of certain species due to their slow life histories, such as sharks and rays, helps the fishing sector to raise awareness about the importance of survival-enhancing practices. The proper use and setup of eco-FAD should increase fishers' environmental and market awareness, motivating them to voluntarily implement changes to minimise negative impacts and align with sustainable fishing practices. For the past 5 years, TUNACONS has been dedicated to improving the involvement of the fishing industry in these topics.

Secondly, it is known that attempts to conduct fisheries-independent research on large purse seines are deemed unsustainable due to high costs, and a shift towards conducting research on commercial vessels through cooperation with fishing companies should be a promissory approach. Implementing eco-FADs in the EPO region through regulations from IATTC may present challenges for some members, necessitating the establishment of a foundation for conducting intricate negotiations to promote best practices, including eco-FAD designs and the use of bycatch reduction devices. TUNACONS and the Ecuadorian government are prepared to facilitate these discussions, drawing on the expertise acquired through the eco-FAD program.

A key outcome of the TUNACONS eco-FAD program is identifying the fishing sector as a "Profile of a fisher-inventor"—fishing companies particularly interested in solving problems and experimenting with new ideas. TUNACONS should keep motivating the fishing sector to collaborate in developing selective fishing technologies and practices.

5. Conclusion

Conventional FADs made of non-biodegradable materials can contribute to marine pollution when they are lost, abandoned, or damaged. Since 2017, TUNACONS has promoted using 100% biodegradable materials derived from plants in FADs. These materials help to break down the FAD operation naturally over time, reducing the risk of harm to marine life and ecosystems.

Ecuador is focused on advancing sustainable fishing methods by utilising eco-FADs that comply with the objectives set by the IATTC commission for the upcoming five years, as outlined in Resolution C-23-04. This initiative aims to minimise environmental impact and support the preservation of robust tropical tuna populations.

The TUNACONS fleets have embraced the ecosystem objectives even though this shift required a slightly higher initial investment than conventional FADs. The long-term advantages of decreased environmental impact and enhanced sustainability can justify this initial cost.

The Ecuadorian government and fishing companies agree that implementing regulations or guidelines regarding eco-FADs, including requirements for biodegradable materials, is a promising way to ensure future social and economic well-being. Using biodegradable FADs can help fishing companies comply with these regulations and promote sustainable fishing practices.