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IMPLEMENTATION OF BIODEGRADABLE FADS IN THE EASTERN PACIFIC OCEAN

TUNA CONSERVATION GROUP

NGO FOR TUNA CONSERVATION

Implementation of biodegradable FADs in the Eastern Pacific Ocean

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1. Context

Traditional Fish Aggregating devices, FADs, made of synthetic materials that do not biodegrade in the marine environment, have been severely criticized for their impacts on the ocean environment (e.g., marine pollution), population dynamics (e.g., fish behavioral changes), and pelagic fisheries management (e.g., difficulty in controlling unregulated fishing, increased mortality of juvenile fish). Considering the urgency to address and minimize these impacts in the Eastern Pacific Ocean (EPO), the member companies of the Tuna Conservation Group, TUNACONS Foundation, are seeking eco-friendly alternatives to improve the ecological and fishing efficiency of FADs through biodegradable construction. The collaboration of these companies is part of the actions for the sustainability of the FAD fishery in EPO areas.

FADs built with biodegradable materials are expected to significantly minimize the negative impact on the marine environment, mainly in two ways: (i) reducing marine debris and consequently pollution in the ocean, and (ii) facilitating fishery management and management, as a consequence of changes in fishing strategies.

2. Search for optimal biodegradable materials for FADs

In 2016, TUNACONS began a research program aimed at finding natural fiber materials to replace the synthetic materials of traditional FADs. The challenge of the program was to find sufficiently resistant materials to build an Ecological FAD (Eco-FAD) that would have the same functional characteristics of a synthetic FAD (i.e., operationally viable to add fish), but conditional on the construction materials coming from a sustainable market, are highly biodegradable in the marine environment and safe for the target species of the fishery. The search extended to a significant number of fibers of plant origin, finally focusing on three species: jute[1], cabuya[2] y abaca[3].

3. Pilot Phase

During the pilot phase that began in January 2017, experimental and field tests were carried out under standard fishing conditions.

In the case of the experimental tests, three Eco-FADs were built using the fibers with the best properties identified during the material search process. The Eco-FADs were deployed and anchored 9 miles off the coast of Jaramijó – Ecuador. After continuous monitoring to inspect the

[1] Jute is the plant fiber extracted from the stem and bark of the Corchorus capsularis plant. Its cultivation hardly uses fertilizers and pesticides, and it is friendly to the environment by absorbing up to 15 tons of carbon dioxide and releasing 11 tons of oxygen during the growing season.
[2] Its fiber that is extracted from the Agave sisal plant, used for the manufacture of high resistance threads. This plant is very abundant in the central region of Ecuador, with a total life of approximately twenty-five years, of which 18 to 20 are used for production.
[3] The Musa Textiles plant produces abaca fiber, also known as Manila hemp. Its main characteristic is resistance and durability.

level of biodegradation, it was observed that the Eco-FADs built with jute, cabuya and abaca became not functional at 25, 35 and 67 days, respectively. The level of biodegradation (Figure 1), which reduces its efficiency to non-functional levels to add fish, was visually confirmed under expert judgment, making sure that under minimal longitudinal pressure the fiber showed ruptures (floating part and tail). In the case of the Eco-FADs built with abaca fibers, which showed the best performance and duration during the experimental tests, additional resistance verifications were carried out under laboratory conditions, which confirmed that after 67 days under marine conditions, the loss resistance was 94%[4].

During the tests at sea, a group of shipowners from the TUNACONS Foundation participated in an experiment in order to verify the efficiency of Eco-FADs built with cabuya and abaca fiber. In the case of the Eco-FADs built with rope, a total of 66 FADs were deployed during the months of April to September 2017 under standard fishing conditions, of which only 8 were possible to visit, without observing fish aggregation. Similar tests at sea were carried out between February 2018 and May 2019, using Eco-FADs built with abaca fiber. The construction was carried out using similar dimensions to the traditional FADs. During these tests, 426 Eco-FADs were deployed, on which 22 fishing sets were made and a catch of 611 tons was obtained.

[4] Strength reduction from 251.6 kgF (day 1) to 13.8 kgF (day 67).

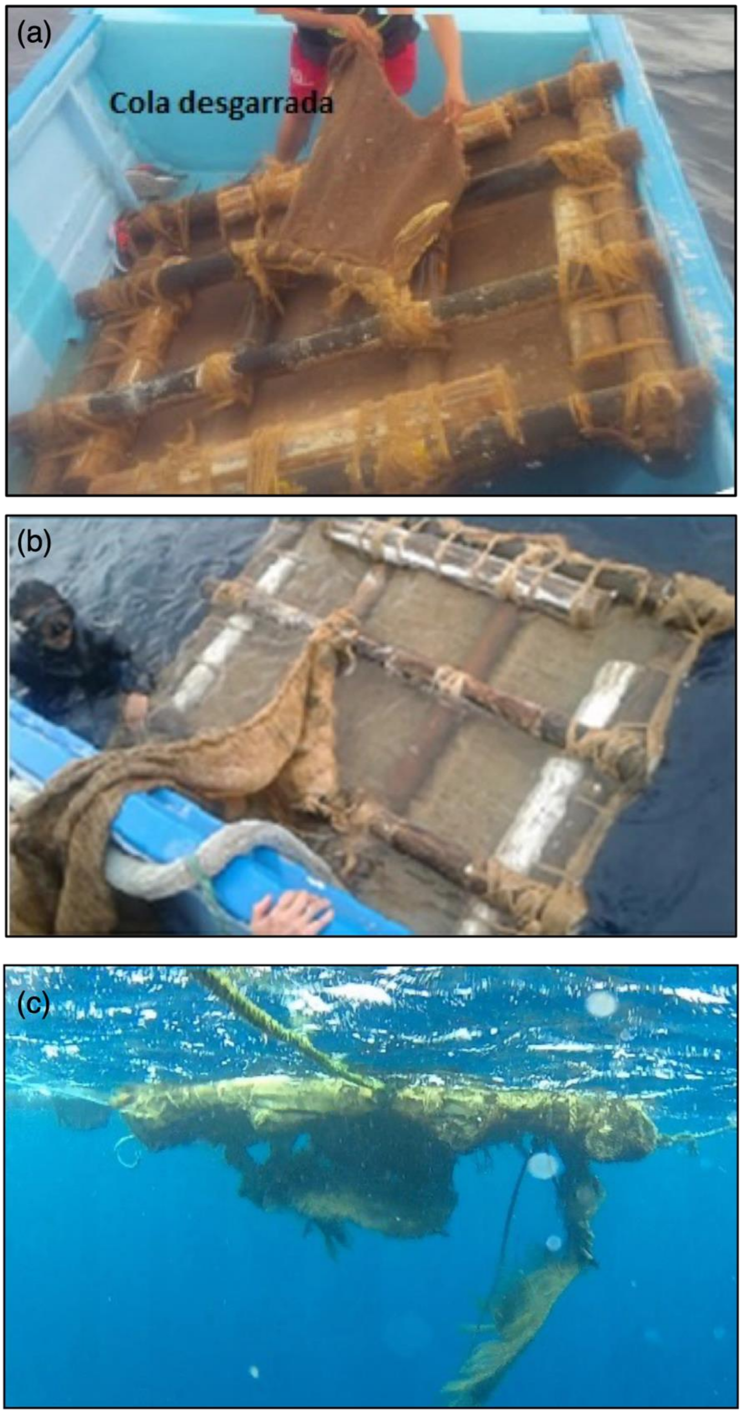

Figure 1: Biodegradation level of Eco-FADs constructed using jute (a), cabuya (b) and abaca (c) fibers

4. Functional Phase

The results of the sea trials, obtained during the pilot phase (see Section 3) motivated the captains to carry out fishing operations using Eco-FADs made of abaca fibers. This promoted a functional phase that required the improvement of this type of Eco-FADs, thereby providing security to shipowners that the construction of new FADs would be viable and comparable to standard fishing activities.

This improvement involved treatments in the abaca fiber that allow a greater level of impermeability and resistance, therefore, a longer period of functional duration of the Eco-FADs under marine conditions. For this, several treatments were carried out with natural and totally biodegradable products such as animal fat, organic palm oil, fish oil, *sangre de drago* and natural rubber or latex.

After the application of the different treatments and the results of physical stress tests under laboratory conditions[5], it was determined that the abaca fiber treated with natural rubber increased durability, resistance and impermeability in the ocean environment. Less satisfactory results, but equally candidates for fiber treatments were animal fat (cow), followed by palm oil.

4.1 Implementation of *Eco-FADs* by the TUNACONS fleet

In December 2020, the member companies of the TUNACONS Foundation voluntarily decided to reach 20% of Eco-FADs deployments with respect to the total FADs deployed[6] during the 2021 fishing season. The Eco-FADs were built (fabrics and ropes) with Abaca fibers treated with natural rubber, thus ensuring the highest experimental level of durability, resistance and impermeability. The construction of the Eco-FADs was based on the standards of prototype #2 with which they participated in the project with the IATTC[7], although certain improvements[8] were inserted (Figure 2).

Compliance with measure C-21-04

At the end of 2020, the fleet represented by the TUNACONS foundation began deploying the Eco-FADs, reaching a coverage of 20.3% during the fishing season in 2021 (Table 1). The data was obtained by comparing the records in the IATTC ROF + ROF-C forms and those obtained by TUNACONS from the observers of the smaller fleet.

It should be noted that the 20.3% coverage was based on the number of traditional FADs vs. Eco-FADs deployed, traditional FADs that vessels have installed a satellite buoy were not considered.

[5] under a technical cooperation with Textile Engineering professionals from the Universidad del Norte de Ibarra – Ecuador
[6] according to art. 17 of conservation measure C-21-04 on fish aggregating devices
[7] Partial results reported in document SAC-11-11-MTG, entitled: Test of biodegradable materials and prototypes for the tropical tuna fishery in FADs
[8] Addition of two sections of balsa stick of 1.10 m, Ø 10 or 12 cm for greater flotation; In addition, 3 sections of guadúa cane of 0.65 m injected with animal fat were added, to serve as an attractant, the ropes and fabric treated with natural rubber.

Table 1: Participation of the fleet represented by the TUNACONS foundation with respect to the total allocated FADs for the 2021 fishing season

	FADs deployed according to C-20-06	deployment of traditional FADs	deployment of Eco-FADs	Proportion of Eco-FADs
TUNACONS Fleet	6905	5504	1401	20,3%

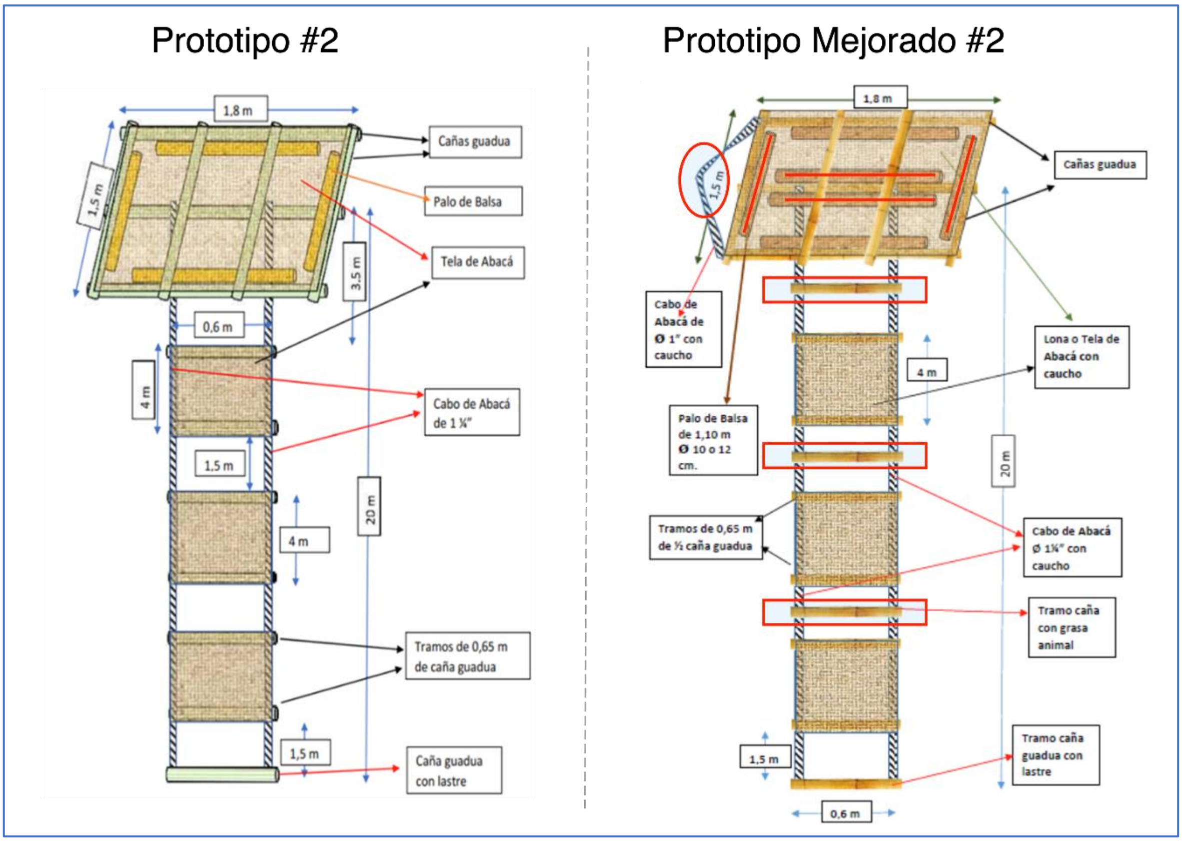

Figure 2: Design of Eco-FADs used in the framework of the CIAT project (left) and during the functionalimplementation period by the TUNACONS Foundation member companies (right)

4.2 Fishing activities during the 2021 fishing season

Functional phase methods

From the ROF-C forms provided by the IATTC and TUNACONS observers, a summary of the fishing operations was made for the total number of vessels participating in the functional phase (see Section 4, opening paragraph).

The soaking time was defined as the operation time of the Eco-FADs from the day of sowing until the fishing set. This time was classified into 4 categories (<30, 31-60, 61-90, >91 days), with which the level of biodegradation of the Eco-FADs was summarized. The summary by category represents the average biodegradation for the group of sets (i.e., data with information) on Eco-FADs.

The level of biodegradation was made based on a qualitative scale (see Table 3), recorded by the observers in the ROF-C forms based on the condition of the abaca fabric (excluding ropes or cords) of the floating structure (grid) as submerged (tail), because these pieces of the Eco-FADs are the ones that showed the highest level of biodegradation during the experimental tests (Section 3). The removal of the Eco-FADs was decided by the ship's captain based on the level of biodegradation.

Functional phase results

Of the total number of deployed Eco-FADs (1,401, see Table 1), a total of 222 were visited over the course of 188 fishing trips (cruises), reaching a visit rate of 15.8%. The soaking range was between 1 and 100 days. The total catch on Eco-FADs reached 3,964 tons and was obtained in 148 fishing sets, summarized in an average catch per set of 26.8 tons (Table 2).

The level of biodegradation shows that in 46% of the Eco-FADs that were the target of fishing sets, the floating structure was in very good condition; while 7% of these Eco-FADs were in conditions (<Bad, Table 3 for scale) to be surveyed. Similar percentages were observed in the level of biodegradation of the submerged structure of the Eco-FADs, finding that 43% were in very good condition and 8% in non-functional conditions (Table 2).

Table 2: Summary of the fishing activities of the fleet represented by the TUNACONS foundation on Eco-FADs for the 2021 fishing season

	fishing cruises	visits Eco-FADs	Sets on Eco-FADs	catches in Eco-FADs	Catch per set	soaking period	biodegradation floating part	biodegradation submerged
TUNACONS Fleet	188	222	148	3964	26,8	1 – 100	46% MB 25% B 20%R 7%M	43%MB 14%B 28%R 8%M

Table 3 shows the biodegradation status of the Eco-FADs for the 4 soaking period categories. It is notable to observe that, between 61 and 90 days, the floating structure of the Eco-FADs was in a good-fair level, while the submerged structure showed greater deterioration. For Eco-FADs with a soaking time of less than 60 days, both the surface and submerged sections of the Eco-FADs are expected to be in good to very good condition.

soaking period	Sets	floating structure	Sets on Eco-FADs
< 30	29	1,9	2,1
31 - 60	44	2,8	3,2
61 - 90	19	3,7	4,7
> 91	2	4,0	4,0

N obs	0
Excelente	1
Muy Bueno	2
Bueno	3
Regular	4
Malo	5
Muy Malo	6
Sin Rabo	7

Table 3: Level of biodegradation of the Eco-FADs seeded by the fleet represented by the TUNACONS foundation during the 2021 fishing season

5. Discussion

The use of Eco-FADs in the EPO is a promising solution to: (i) mitigate the negative impacts linked to marine pollution; (ii) promote the structure and adoption of management plans for Eco-FADs, addressing their management.

The greatest concern of the fishing companies and shipowners represented by the TUNACONS Foundation, regarding the implementation of Eco-FADs through the TUNACONS research program, lay in the operability and efficiency of these new fish aggregating devices.

Regarding operability, the experimental and sea tests of the pilot phase (Sections 2 and 3) have shown that it is feasible to identify a biodegradable plant material for the construction of Eco-FADs. Laboratory tests and the expert judgment of researchers have shown that abaca fibers and their treatment with natural rubber make it possible to build strong and durable Eco-FADs to withstand EPO fishing conditions. Indeed, during the functional phase (see Table 3) the application of treatments to increase the impermeability of the abaca fiber, showed that the Eco-FADs manage to increase their duration by an average of 30-45 days compared to fibers without treatment, reaching durations up to 100 days (see Table 2). However, the 100 days is still less than the duration of traditional FADs which reach around 240 days at sea. In addition, these plant-based materials are friendly to the environment and also come from local producers and sustainable use.

The research program has also shown that the efficiency of Eco-FADs based fishing operations is similar to traditional FADs. First, the field tests of the pilot phase (Section 3) showed that the 426 Eco-FADs planted by the fleet represented by TUNACONS, facilitated a catch rate of 27.8 tons/set, while the functional phase (Section 4.2) implemented in 2021 reported a catch rate of 26.8 tons/set (see Table 2). These rates are similar to the average catch rate of 26.9 tons/set, contained in the recent report on the status of fisheries in the EPO (SAC-13-03, based on Table A7).

6. Conclusions

The results of the TUNACONS research program for the development and implementation of Eco-FADs in the EPO suggest paying attention to the following points:

- Promote the continuity of research work on Eco-FADs, which makes it possible to standardize the use of plant fibers and protection treatments with organic materials.
- Eco-FADs prototypes require investment to optimize their production. Within the framework of the research program, the tests of the pilot phase (section 3) used manual labor and artisanal methodology. However, the implementation of the functional phase (Section 4) required investments in machinery and dependence to carry out the efficiency tests of the materials used for the construction of the Eco-FADs. In this way:
    - A process of improvement of the Eco-FADs is expected when the biodegradable materials are built with specialized machinery.

- Binding conservation measures with the use of fish aggregating devices should promote the implementation of Eco-FADs in the entire EPO purse-seine fleet. For this, the creation of incentives is important and reasonable, for example:
    - Set a limit on active Eco-FADs per ship class greater than traditional FADs, and/or,
    - Use a minimum annual percentage limit of Eco-FADs with respect to fish aggregating devices defined by resolution, for example, 20%.

- The Eco-FADs are viable devices to replace the traditional traditional FADs, however, some operative variables such as the duration and operational time of fishing could potentially modify the current fishing strategies of the purse-seine fleet. For this reason, recognizing the differences between traditional FADs and Eco-FADs in future zoning resolutions is crucial to avoid restrictions that prevent the development and implementation of the latter.