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A novel FAD tracking device tested in the Pacific Ocean

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Summary

The objective of this project was to conduct field tests using NAOS beacons, designed at CLS, to track drifting Fishing Aggregating Devices (dFADs) under real fishing conditions. A total of 20 NAOS beacons were deployed and tested for a period of one year, from October 2021 to October 2022, in the Pacific Ocean, in collaboration with the Atunera Dularra fleet.The project focused on evaluating the usability, transmission quality, durability, and autonomy of the NAOS beacons. The results indicated that both the NAOS beacons and fishers' tracking buoys provided similar trajectory information. Fishers successfully monitored and tracked the dFADs for an average of 4.5 months, after which the dFADs were either stolen or drifted out of the fishing grounds. An interesting finding was that the NAOS beacon continued to track the trajectory of the dFAD even when it changed ownership (i.e., when the buoy was replaced), for a maximum duration of 11 months. This demonstrates the capability of the NAOS beacon to persistently monitor dFADs, even in the hands of different owners.To enhance the effectiveness of these beacons and gain a better understanding of the technical and logistical requirements for tracking drifting FADs, it is recommended to conduct further tests with a larger number of FADs. These additional tests would provide valuable insights and contribute to the overall improvement of these tracking beacons.

1 Context

1.1 FAD marking requirements

NAOS was designed by CLS to meet the recommendations of the Fisheries Committee of the FAO (Voluntary Guidelines of July 2018 referenced COFI/2018/Inf.30) which recommends the marking of fishing gear.

Regarding WCPFC FAD marking requirements (WCPFC, 2016b), the Thirteenth Regular Session of the Scientific Committee recommended: "*as a first step the Commission should consider introducing a buoy ID scheme which requires the registration of all buoys attached to FADs deployed. Field tests in conjunction with industry and observers should be undertaken to determine the optimal configuration of future developments of a fully marking system that also includes the FADs themselves."*

While due to its simplicity and cheapness using existing fishers´ tracking buoy satellite data, when provided, has been the preferred method by WCPFC and IATTC for marking and monitoring dFADs (WCPFC, 2016b), this does not favor the monitoring of the dFAD structure itself. Alternative marking systems, such as physical marking on the dFAD's raft, or electronic marking with a device remaining actively attached to the dFAD's structure throughout its lifetime, should be considered (WCPFC, 2016a)

Regarding IATTC´s FAD marking requirements, Resolution C-19-01 (Annex I) indicates that:

CPCs shall obtain unique alphanumeric codes from the IATTC staff on a periodic basis and distribute those numbers to the vessels in their fleets for FADs that may be deployed or modified, or in the alternative, if there is already a unique FAD identifier associated with the FAD (e.g., the manufacturer identification code for the attached buoy), the vessel owner or operator may instead use that identifier as the unique code for each FAD that may be deployed or modified. The alphanumeric code shall be clearly painted in characters at least 5 cm in height. The characters shall be painted on the upper portion of the attached radio or satellite buoy in a location that does not cover the solar cells used to power the equipment. For FADs without attached radio or satellite buoys, the characters shall be painted on the uppermost or emergent top portion of the FAD. The vessel owner or operator shall ensure the marking is durable (for example, use epoxy-based paint or an equivalent in terms of lasting ability) and visible at all times during daylight. In circumstances where the observer is unable to view the code, the captain or crew shall assist the observer (e.g. by providing the FAD identification code to the observer).

Nowadays in IATTC the buoys used by fishers to monitor their FADs are the principal FAD marking system. In recent years, IATTC scientific staff presented during the *Ad Hoc* working group on FADs the difficulty to follow the track of a given FAD from its deployment to the end of its lifetime. This is due to (i) fishers' appropriation of other´s FADs and thus, exchanging the tracking buoys, and (ii) the deactivation of tracking buoys once FADs drift out of the fishing ground. The need for a marking system that allows monitoring the entire trajectory of the FAD from its deployment is necessary to better understand the dynamics of FAD tracking and tuna along the lifetime of a FAD and to monitor the fate of FADs until the end of their lifetime, allowing their potential retrieval (both at sea or on land).

1.2 NAOS buoy system overview

NAOS is an affordable, low-power satellite buoy for fishing gears´ monitoring. The Argos-GNSS beacon, allows easy track and marking of fishing gears (Figure 1). It can be easily deployed:

- It is robust and small (280mm x 160mm and 1.23kg),
- it floats by itself,
- it is attached thanks to 3 hooks, and
- it is activated just by removing a magnet.

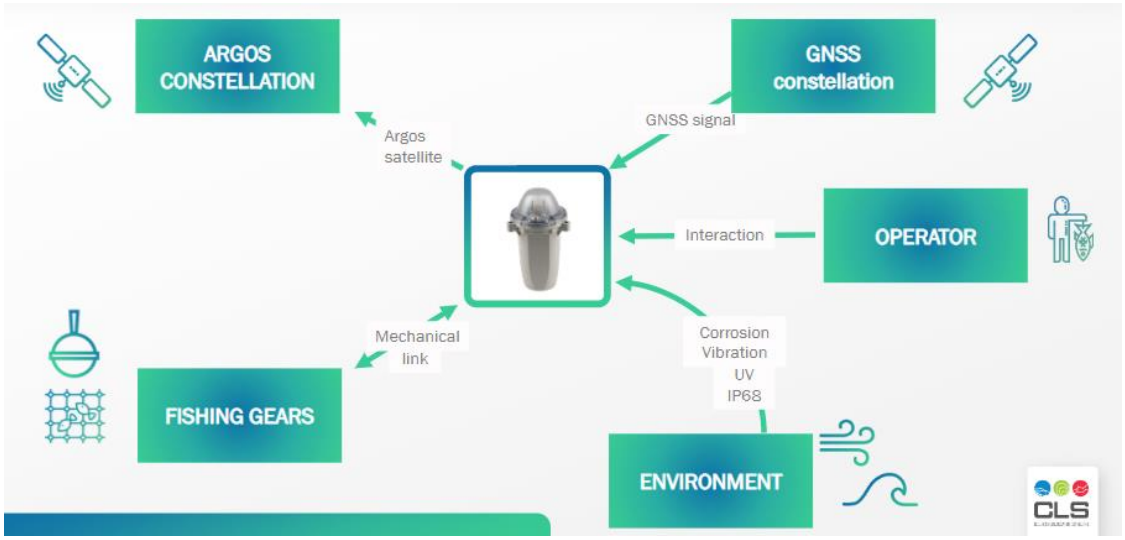

Figure 1 – NAOS system overview

As of today, this beacon is not rechargeable, and its autonomy will depend on the number of positions provided by day (Table 1).

Table 1. Autonomy table for 2 cells NAOS beacons (function of the number of positions per day and satellite transmission strategy)

Number of location per day	Days of autonomy
1	560
2	340
4	150
12	120
24	110
96	90

The NAOS uses a monitoring platform (CLS view or Fishweb). Users can monitor their fishing gears, display corresponding data on the cartographic interface and consult information (Figure 2). Functions include:

- Map customisation,
- Gears trajectories in near-real-time & animate tracks,
- Manage and display information about each gear,
- Add and manage zones for geofencing,
- Draw polygons, lines and points,
- Configure alerts,
- Filter and export data in tabular format,
- Measure distances and calculate Estimate Time of Arrival (ETAs).

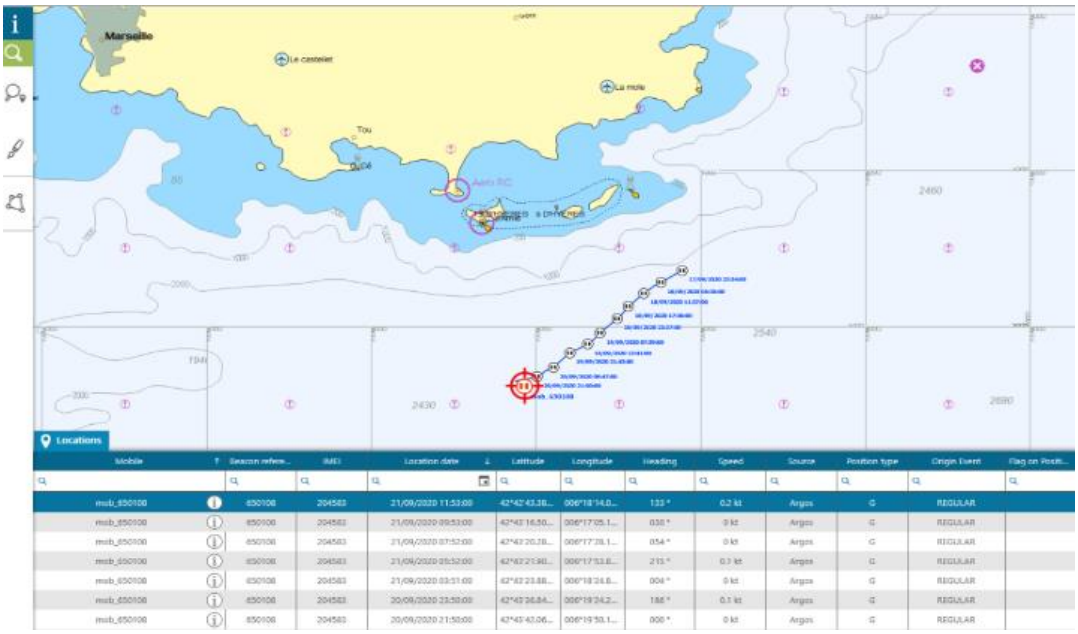

Figure 2 - Fishweb interface

2 Project description

First experiments consisted in testing 3 NAOS prototypes in the Mediterranean Sea. Once those experiments in semi-controlled conditions were finished, tests in real fishing conditions were conducted in the EPO. The objective was to study the technical feasibility and the operational interest of beacons for marking FADs by satellite.

2.1 Installation and activation

Twenty NAOS were tested in real fishing conditions during one year (October 2021 to October 2022). Those beacons were attached to drifting FADs and trajectories of the NAOS beacon compared to those of fisher´s tracking system i.e., echo-sounder buoys.

The project began in November 2021. Fifteen NAOS were configured to transmit two positions a day while five transmitted one position. Two types of NAOS were also tested: one with two batteries or two cells and one other with one battery or one cell (Table 1).

Table 2 - NAOS types tested

ID	TID	Activation date	Type	Emission
1	650359	06/11/2021	2 cells	2 positions per day
2	650364	06/11/2021	2 cells	2 positions per day
3	650368	06/11/2021	2 cells	2 positions per day
4	650383	06/11/2021	2 cells	2 positions per day
5	650388	06/11/2021	2 cells	2 positions per day
6	650389	08/11/2021	2 cells	2 positions per day
7	650393	08/11/2021	2 cells	2 positions per day
8	650398	06/11/2021	2 cells	2 positions per day
9	650402	07/11/2021	2 cells	2 positions per day
10	650434	08/11/2021	2 cells	2 positions per day
11	650266	07/11/2021	1 cell	2 positions per day
12	650270	08/11/2021	1 cell	2 positions per day
13	650271	07/11/2021	1 cell	2 positions per day
14	650280	07/11/2021	1 cell	2 positions per day
15	650281	06/11/2021	1 cell	2 positions per day
16	650295	07/11/2021	1 cell	1 position per day
17	650301	06/11/2021	1 cell	1 position per day
18	650302	06/11/2021	1 cell	1 position per day
19	650307	07/11/2021	1 cell	1 position per day
20	650327	07/11/2021	1 cell	1 position per day

Figure 3 - NAOS beacons being prepared on a purse seiner's deck

NAOS beacons were tested onboard Atunera Dularra fleet (Bolton foods) (Figure 3). Some were directly attached to the FADs' rafts while some others were attached with a rope (Figure 4).

Figure 4 – Fixation systems: (left) directly to the FAD and (right) attached to the FAD with a rope.

2.2 FAD marking system monitoring

To monitor NAOS beacons, a Fishweb account was created. The following screenshots are two examples (Figure 5 and 6). Fishers deployed the beacons but had no access to the data, which was monitored by scientists.

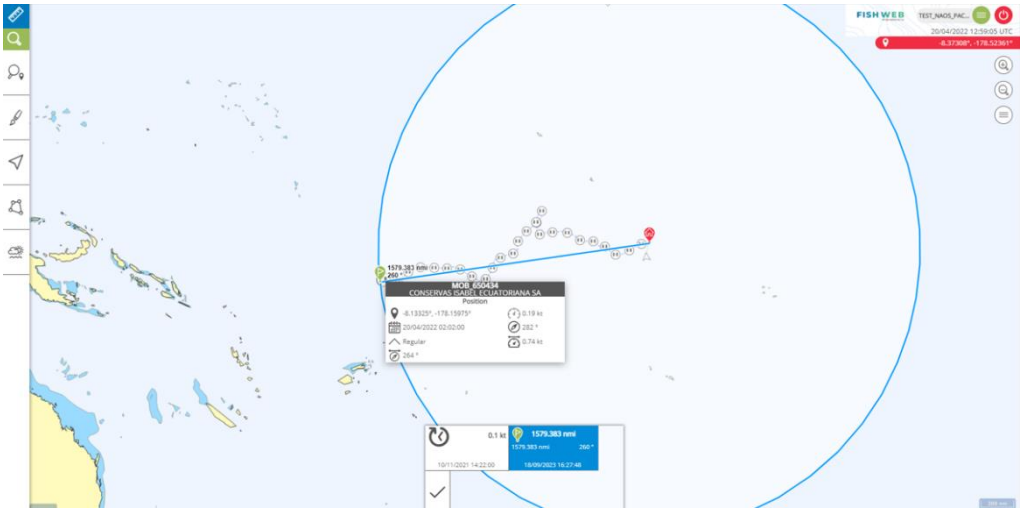

Figure 5 – A NAOS monitored on Fishweb

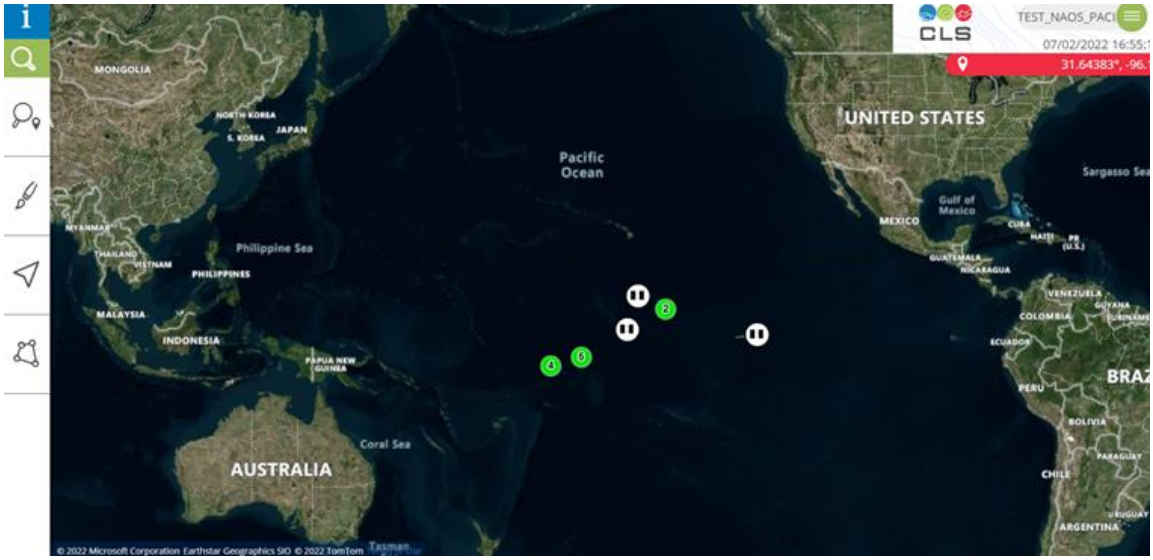

Figure 6 - 14 NAOS beacons transmitting

3 Results

3.1 Comparison with fisher´s echosounder buoys

The study compared the trajectories of fisher´s echosounder buoys with that of NAOS beacons. Figures 7 and 8 are examples of the comparison of the two trajectories: dots in black are NAOS positions and in orange tracks of fisher´s buoys. Although fisher´s buoys used Iridium system, and NAOS used Argos, both trajectories were almost identical.

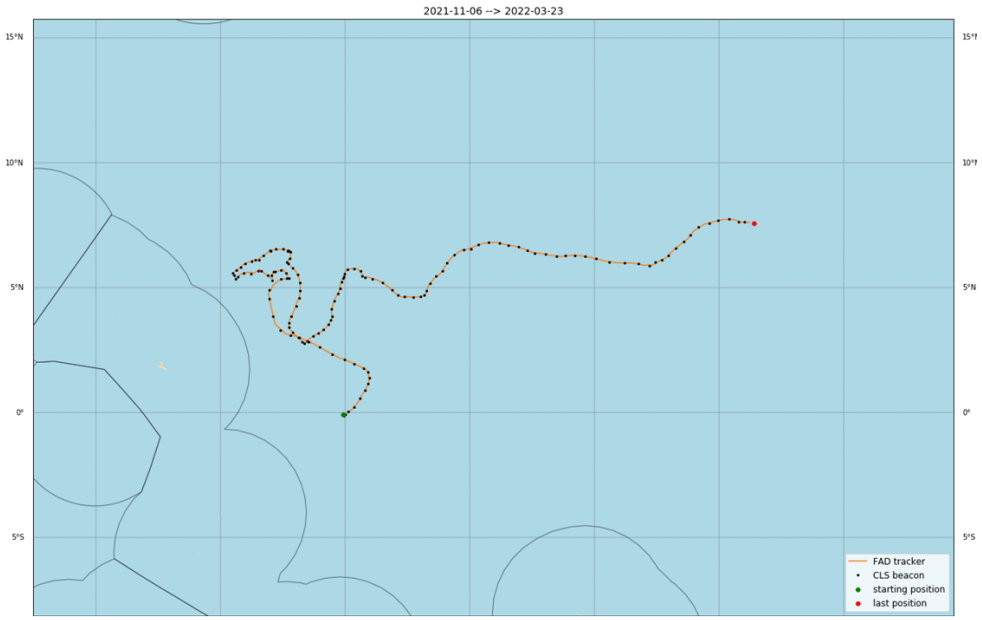

Figure 7 - NAOS trajectory compared to another FAD tracker

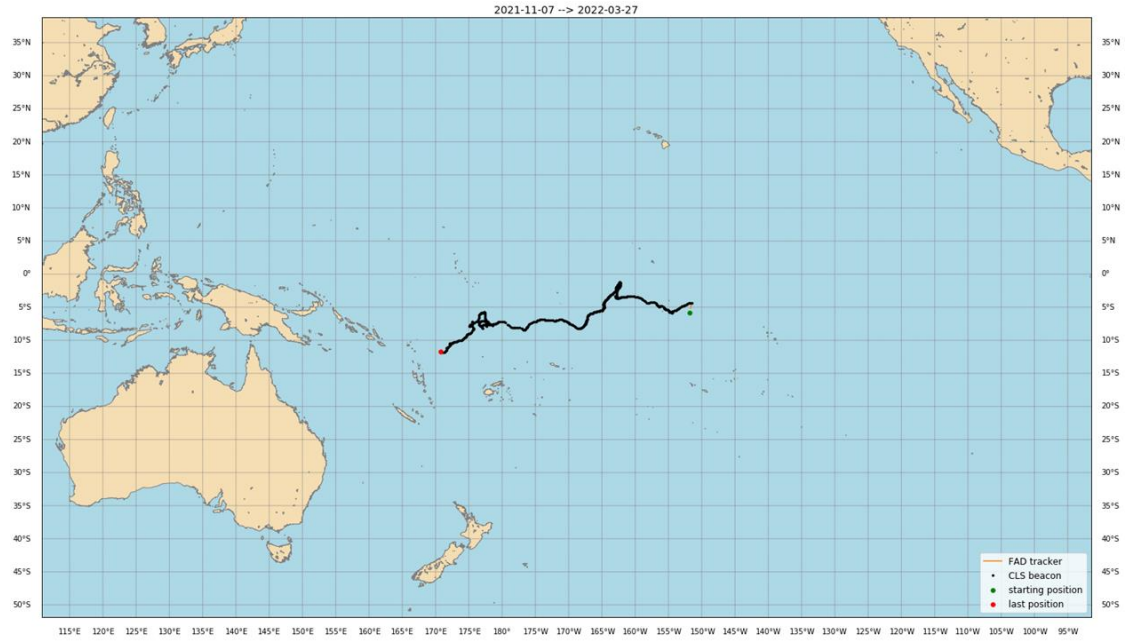

Figure 8 - NAOS trajectory compared to another FAD tracker

Table 3 summarises the fate of each NAOS tracked. By month 7, most of the NAOS were not transmitting and after 11 months only one beacon was still transmitting. 35% (n=7)) of the drifting FADs tested together with the NAOS beacon were appropriated by other vessels between 3 and 5 months after FAD deployment, 30% (n=6) of the FADs and NAOS beacons were out of the fishing ground around by the end of Q1 2022, 15% (n=3) of tested FADs were sold to another company operating in the western Pacific Ocean, and another 20% (n=4) had an unknown fate, which could end up sinking, stranded or stolen by other vessels.

One of the beacon that stopped reporting was retrieved by Atunera Dularra fleet and sent to CLS in France. It appeared that the casing was not robust enough and water filtered inside and it is very likely that other beacons that stopped reporting had the same problem.

Some FADs (IDs 1, 11 and 14, in Table 3) were stolen and NAOS beacon continued providing position so the trajectory of the FAD was monitored even when fishers changed their tracking buoys. Likewise, some of the FADs that were sold (ID 10, Table 3), were tracked after the owner changed.

The NAOS beacon that reported longer, ID 14, was a 1 cell (battery) beacon programmed to report 2 positions per day. So, it seems the lack of data from other beacons may not be related to the lack of battery, as this beacon was able to report twice per day with one cell.

Table 3. NAOS activation date, last position and fate of the FAD

ID	TID	Deployement & Activation date	Last location NAOS	FAD´s fate from fishers	Months monitored by the fisher that deployed it
1	650359	06/11/2021	Mid-May 2022	Stolen 23/02/2022	4
2	650364	06/11/2021	08/04/2022	Stolen 22/04/2022	6
3	650368	06/11/2021	End of January 2022	Stolen 17/03/2022	5
4	650383	06/11/2021	19/03/2022	Out of fishning ground 30/04/2022	6
5	650388	06/11/2021	Begining of March 2022	Out of fishing ground 22/03/2022	5
6	650389	08/11/2021	Mid February 2022	Stolen 27/02/2022	3.5
7	650393	08/11/2021	Mid March 2022	N/A	-
8	650398	06/11/2021	Begining of March 2022	Sold 30/03/2022	5
9	650402	07/11/2021	Mid March 2022	Stolen 23/01/2022	3
10	650434	08/11/2021	Mid July 2022	Sold 30/03/2022	5
11	650266	07/11/2021	Mid April 2022	Stolen 27/02/2022	4
12	650270	08/11/2021	Begining of April 2022	N/A	-
13	650271	07/11/2021	Begining of February 2022	Sold 27/03/2022	5
14	650280	07/11/2021	Mid September 2022	Stolen 20/05/2022	7
15	650281	06/11/2021	Mid February 2022	Out of fishing ground 12/02/2022	4
16	650295	07/11/2021	Begining of April 2022	N/A	-
17	650301	06/11/2021	Mid March 2022	Out of fishing ground 23/05/2022	7
18	650302	06/11/2021	Mid March 2022	N/A	-
19	650307	07/11/2021	Mid January 2022	Out of fishing ground 23/02/2022	4
20	650327	07/11/2021	Begining of February 2022	Out of fishing ground 29/01/2022	3

4 Discussion/conclusion

The results of this experiment, with 20 beacons in real fishing conditions, show that FADs remained less than a year in the hands of the fisher that deployed them. Average monitoring period was 4.5 months, with a minimum and maximum of 3 and 7 months of monitoring respectively (Table 3). Those FADs could remain in the fishing ground on the hands of other fishers or drift out of the fishing ground and end up lost, stranded or sunk. In both cases monitoring the track until the end of their lifetime would be necessary for efficient FAD monitoring purposes.

In this project, two types of NAOS were tested: first type with one battery and the second type with two batteries, with different autonomies and reporting frequency. It would be necessary further tests to find a compromise between the number of positions needed per day to efficiently track the FAD and the total monitoring period needed for a given FAD.

NAOS with four batteries will be soon available to double the autonomy of the beacon: 680 days (almost 2 years) with two positions per day and 1100 days (3 years) with one position per day. And rechargeable beacons will also be available soon.

Apart from the batteries, the following improvements will be made to the beacon and tracking software:

- The casing will be ruggedized to improve watertightness and avoid water leaking.
- In addition to Argos, NAOS will be able to share its data to the future KINEIS constellation in 2024.
- Geofencing up to 100 zones with 100 points each.
- Argos messages will be optimised (duty cycle mode, legacy mode, etc), which will also improve autonomy.
- GPS accuracy will be improved.
- Autonomy will be provided in each message.
- Beacon will send a specific message when the battery runs out.

One of the desired functions of this beacon would be the ability to communicate with fishers´ echosounder buoys so that NAOS can register fisher´s buoys IDs attached to the FAD and the number of fishers´s buoy exchanges.

From this positive experience, in which both, NAOS beacon and fisher´s buoys track provided similar data, we would recommend further tests, with a large number of beacons and FADs monitored, to test and propose technology improvements, beacon´s attachment options to FAD structure, etc. to meet FAD marking requirements and better understand the fate and casuistic when monitoring a larger number of FADs.

Finally, a parallel discussion would be needed to define the potential use of this beacon and other FAD marking systems in the future.

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