SAFE WAVE

STREAMLINING THE ASSESSMENT OF ENVIRONMENTAL EFFECTS OF WAVE ENERGY

DELIVERABLE 2.5
Monitoring fish communities

Co-funded by the EMFF programme of the European Union

WP 2

Deliverable 2.5 Monitoring fish communities

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1. SafeWAVE project synopsis

The European Atlantic Ocean offers a high potential for marine renewable energy (MRE), which is targeted to be at least 32% of the EU's gross final consumption by 2030 (European Commission, 2020). The European Commission is supporting the development of the ocean energy sector through an array of activities and policies: the Green Deal, the Energy Union, the Strategic Energy Technology Plan (SET-Plan) and the Sustainable Blue Economy Strategy. As part of the Green Deal, the Commission adopted the EU Offshore Renewable Energy Strategy (European Commission, 2020) which estimates to have an installed capacity of at least 60 GW of offshore wind and at least 1 GW of ocean energy by 2030, reaching 300 GW and 40 GW of installed capacity, respectively, moving the EU towards climate neutrality by 2050.

Another important policy initiative is the REPowerEU plan (European Commission, 2022) which the European Commission launched in response to Russia's invasion of Ukraine. REPowerEU plan aims to reduce the European dependence amongst Member States on Russian energy sources, substituting fossil fuels by accelerating Europe's clean energy transition to a more resilient energy system and a true Energy Union. In this context, higher renewable energy targets and additional investment, as well as introducing mechanisms to shorten and simplify the consenting processes (i.e., 'go-to' areas or suitable areas designated by a Member State for renewable energy production) will enable the EU to fully meet the REPowerEU objectives.

The nascent status of the Marine Renewable Energy (MRE) sector and Wave Energy (WE) in particular, yields many unknowns about its potential environmental pressures and impacts, some of them still far from being completely understood. Wave Energy Converters' (WECs) operation in the marine environment is still perceived by regulators and stakeholders as a risky activity, particularly for some groups of species and habitats.

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The complexity of MRE licensing processes is also indicated as one of the main barriers to the sector development. The lack of clarity of procedures (arising from the lack of specific laws for this type of projects), the varied number of authorities to be consulted and the early stage of Marine Spatial Planning (MSP) implementation are examples of the issues identified to delay projects' permitting.

Finally, there is also a need to provide more information on the sector not only to regulators, developers and other stakeholders but also to the general public. Information should be provided focusing on the ocean energy sector technical aspects, effects on the marine environment, role on local and regional socio-economic aspects and effects in a global scale as a sector producing clean energy and thus having a role in contributing to decarbonise human activities. Only with an informed society would be possible to carry out fruitful public debates on MRE implementation at the local level.

These non-technological barriers that could hinder the future development of WE in EU, were addressed by the WESE project funded by European Maritime and Fisheries Fund (EMFF) in 2018. The present project builds on the results of the WESE project and aims to move forward through the following specific objectives:

1. Development of an **Environmental Research Demonstration Strategy** based on the collection, processing, modelling, analysis and sharing of environmental data collected in WE sites from different European countries where WECs are currently operating (Mutriku power plant and BIMEP in Spain, Aguçadoura in Portugal and SEMREV in France); the SafeWAVE project aims to enhance the understanding of the negative, positive and negligible effects of WE projects. The SafeWAVE project will continue previous work, carried out under the WESE project, to increase the knowledge on priority research areas, enlarging the analysis to other types of sites, technologies and countries. This will

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increase information robustness to better inform decision-makers and managers on real environmental risks, broad the engagement with relevant stakeholders, related sectors and the public at large and reduce environmental uncertainties in consenting of WE deployments across Europe;

2. Development of a **Consenting and Planning Strategy** through providing guidance to ocean energy developers and to public authorities tasked with consenting and licensing of WE projects in France and Ireland; this strategy will build on country-specific licensing guidance and on the application of the MSP decision support tools (i.e. WEC-ERA[1] by Galparsoro et al., 2021[2] and VAPEM[3] tools) developed for Spain and Portugal in the framework of the WESE project; the results will complete guidance to ocean energy developers and public authorities for most of the EU countries in the Atlantic Arch.
3. Development of a **Public Education and Engagement Strategy** to work collaboratively with coastal communities in France, Ireland, Portugal and Spain, to co-develop and demonstrate a framework for education and public engagement (EPE) of MRE enhancing ocean literacy and improving the quality of public debates.

[1] https://aztidata.es/wec-era/;
[2] Galparsoro, I., M. Korta, I. Subirana, Á. Borja, I. Menchaca, O. Solaun, I. Muxika, G. Iglesias, J. Bald, 2021. A new framework and tool for ecological risk assessment of wave energy converters projects. Renewable and Sustainable Energy Reviews, 151: 111539
[3] https://aztidata.es/vapem/

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2. Glossary

ASV	Autonomous Surface Vehicle
AUV	Autonomous Underwater Vehicle
BiMEP	Biscay Marine Energy Platform
EMFF	European Maritime and Fisheries Fund
EMODnet	European Marine Observation and Data Network
EVE	Ente Vasco de la Energía
FWT	Floating Wind Turbines
GB	Gigabyte(s)
GPS	Global Positioning System
Hz	Hertz
kHz	Kilohertz
Km	Kilometre(s)
m	Metre(s)
m/s	Metre(s) per second
mm	Millimetre(s)
MRE	Marine Renewable Energy
MRED	Marine Renewable Energy Device
MSFD	Marine Strategy Framework Directive
N	North
NASC	Nautical Area Scattering Coefficient (m2nmi−2)
NE	Northeast
nm	Nautical mile(s)
S	South

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SafeWAVE	Streamlining the assessment of environmental effects of Wave Energy
SONAR	Sound Navigation and Ranging
t	Tonne(s)
UTC	Coordinated Universal Time
W	West
WE	Wave Energy
WEC	Wave Energy Converter
WESE	Wave Energy in Southern Europe
WGS	World Geodetic System

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3. Executive summary

The ocean energy development is one of the main pillars of the EU Blue Growth strategy. However, while the technological development of devices is growing fast, their potential environmental effects are not well-known.

The SafeWAVE project aims to improve the knowledge on the potential environmental impacts from Wave Energy projects. In the project scope, Work Package 2 aims to collect, process, analyse, and share environmental data related to four priority areas of research: i) Electromagnetic Fields, ii) Acoustics (noise), iii) Seafloor integrity, and iv) Fish communities. Four sites where Wave Energy Converters are operating in Portuguese, Spanish and French coastal waters will be monitored, representing different types of technology, different types of locations (onshore, nearshore, and offshore), and different types of project scales (single devices and arrays of devices), hence, different types and/or magnitudes of environmental impacts.

The aim of the present report (Deliverable 2.5) is to present the work done related to the conditioning and tunning activities of ITSASDRONE (an autonomous marine surface drone), test and check its operational procedure and navigation system and, finally, explore the association between Wave Energy Converters and fish aggregations around the Penguin WEC-2 of WELLO Oy which was deployed off the coast Armintza, Basque Country, Spain in August 2021. On 19th of December 2021 the WEC was towed to harbour for inspection, maintenance, and repairs due to the detection on the 28th of November an alarm of leakage. Although the plan was to repair Penguin WEC-2 and bring it back to its localization in BiMEP area, after more than 10 months, the penguin is still in the port of Bilbao. We, therefore, decided to carry out the monitoring work around the HarshLab floating laboratory device of Tecnalia.

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Even if HarshLab could be considered as a good model of the possible reef or fish attraction effect due to its similar dimensions with the WECs, it does not have specific elements of the WECs that can intervene or affect this potential effect. Underwater noise generated by the moving parts of the harnessing machine inside the WEC, and the electromagnetic fields of the exporting electrical cables could generate an avoidance effect and compensate the attraction of the floating structures of the devices.

According to the results of the project, the ITSASDRONE proved to be a viable autonomous vehicle for fish school monitoring under the conditions of this study. It still needs some technological improvement related to navigation system, but in general, the ITSADRONE meets the objectives for which it was conceived and could be an excellent monitoring technique due to its capacity to work remotely and in near shore areas.

Schools of unidentified small pelagic fish were observed distributed throughout the water column, predominantly near the bottom in the device area. The acoustic sensors showed a relatively high abundance in the BiMEP area, in general as high or higher than in the access route from Armintza harbour. However, those results are preliminary result, and they should be considered as baseline information. Future studies are needed to further explore the association between WECs and fish aggregations.

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4. Introduction

Artificial structures deployed in the sea (e.g., sea cages, oil rigs, offshore platforms) and coastal infrastructures are nowadays considered as pollutant due to their association with the discharge of toxins and nutrients, noise and light pollution increment, the establishment and spread of non-native species and also, because frequently destroy and fragment natural habitats (Strain *et al.*, 2022). A very significant increase in the installation of Marine Energy Devices is foreseen, thus Public Administrations, regulators, Marine Energy industrial developers, scientists and citizen in general are concerned about the possible impacts generated by those devices on sea fauna, flora and habitats. Galparsoro *et al.* (2022) have develop a conceptual framework, considering technical, environmental and conflicts for space aspects that play a role on the development of those projects.

Generally speaking, any artefact located in the sea may cause an attraction effect on fish communities, especially if it is floating. Similar effects have been observed by Morrisey et al. (2006) in relation to floating structures for aquaculture (fish cages, mussel mesh, etc.). Such attraction can favour changes in species composition in the study area and alter the relation predator-prey (Boehlert, 2008). In the case of Marine Renewable Energy Devices, during the operation phase, in general, the placement of any artefact in the sea can result in an attracting effect on fish communities, especially if it is floating (Langhamer, 2012; Langhamer, 2016; Hemery, 2020). However, noise and vibrations from the devices' operation could compensate this attraction effect (Bald *et al.*, 2010).

In the offshore wind energy sector it has been observed that the increase of epibiont fauna on wind turbine piles favours the creation of habitat and the presence of species that can be food sources for ichthyofauna (Dong-Energy and Vattenfall-a/S, 2006). A study carried out by Wilhelmsson *et al.* (2006) in the Baltic found a higher abundance of fish in the vicinity of the

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turbines, but similar richness and diversity to control areas. Bender et al. (2020) detected an increment in biodiversity richness and abundance of reef species compared to surrounding sand bottom areas in the vicinity of offshore renewable energy foundations localized in cold temperate areas. However, at present there are no evidence to indicate that large energy farms address fish aggregation below devices.

In general, the association between Marine Energy Devices and fish aggregations can be studied using a wide range of methods and techniques. Traditional monitoring methodologies (Underwater Visual Census by divers, line or encircling fishing techniques, etc.) are being complemented by new technological developments (Underwater Autonomous Video Cameras, ROVs, hydroacoustic devices). Even more recently, the technological development of autonomous marine drones is allowing us to access to open ocean, work remotely and present the advantage that it is not dependent on the weather, the seasons or the time of the day. At the same time, engineering solutions relate to sensor manufacturing is being remarkable, designing and producing more sensitive and accurate sensors.

Data collection procedure and further data processing and interpretation analysis can be also done according to several techniques and methodologies, but in recent years, machine learning techniques are becoming more important. Those new techniques are expected to analyse huge quantity of data, reduce process time and identify patterns and make more timely and accurate predictions.

This Deliverable shows the result obtained around the Harslab, the *Advanced floating laboratory,* localized in BiMEP test site (Lemoiz, North of Spain) with the ITSASDRONE surface drone. The ITSASDRONE incorporates an echosounder and has been designed for a long-term missions.

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5. Objectives

The main objective of the present work was to develop the monitoring of fish communities around the Penguin WEC-2 Wave Energy Converter in BiMEP test site with the ITSASDRONE surface drone of AZTI.

The following were set as operational objectives:

1. Conditioning and tuning of the ITSASDRONE.
2. Once the ITSASDRONE was set up and ready to operate, first fish monitoring trials were done in BiMEP.
3. Explore the association between WECs and fish aggregations.

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6. Material and Methods

6.1 ITSASDRONE tunning and aconditioning

The ITSASDRONE is an autonomous marine surface drone for long term missions (3 months or more), capable of carrying out different tasks operating autonomously (Figure 1) by means of an automated remote control with radio or satellite communication (Figure 2). This catamaran (designed and constructed by BRANKA Solutions Inc[4].) has been used to perform fish monitoring surveys in BiMEP test site.

It is operating 100% on renewable energy in the marine environment and with a zero-emission propulsion system. The system has a length of 145 cm, 207 cm beam, 50 cm draft and 50 kg of weight. With 2 electric thrusters and two solar panels, it can reach 3-4 knots. The applications of the drone may range from oceanographic, meteorological, or biological research to control by marine authorities, including target monitoring.

Figure 1. ITSASDRONE, an autonomous marine surface drone (Source: AZTI).

[4] https://www.brankasolutions.com/en

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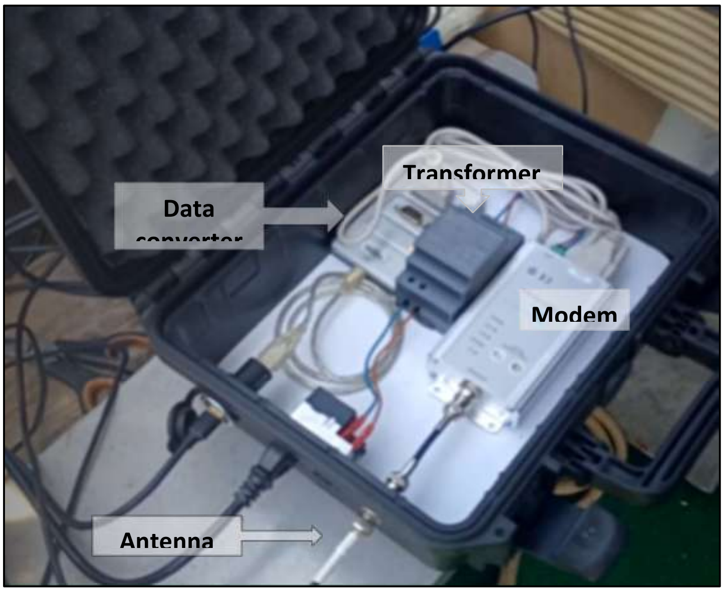

Figure 2. Communication Ground Control Station system (Source: AZTI).

The navigation system of ITSASDRONE has been developed by Dynautics Ltd.[5]. The software designed allows an operator to monitor and control a vehicle from a remote location, or indeed from on board the vehicle itself. Thus, it is possible to connect via analogue signals to various thrusters and, as well as, to on-board sensors as GPS, MEMS motion sensors, compasses, speed logs. Thus, the track or trajectory can be programmed by designing a sequence of "waypoints" (Figure 3).

The main panel of the software provides real-time indications of demanded and achieved machinery settings, water- and ground- speeds in two axes, yaw rate, heading, wind and tide. The recorded data is logged to file for later analysis.

Once these first trials where done, a Wideband Autonomous Transceiver Mini (WBAT mini) echo-sounder developed by SIMRAD was integrated in the ITSASDRONE (Figure 4).

[5] https://www.dynautics.com/

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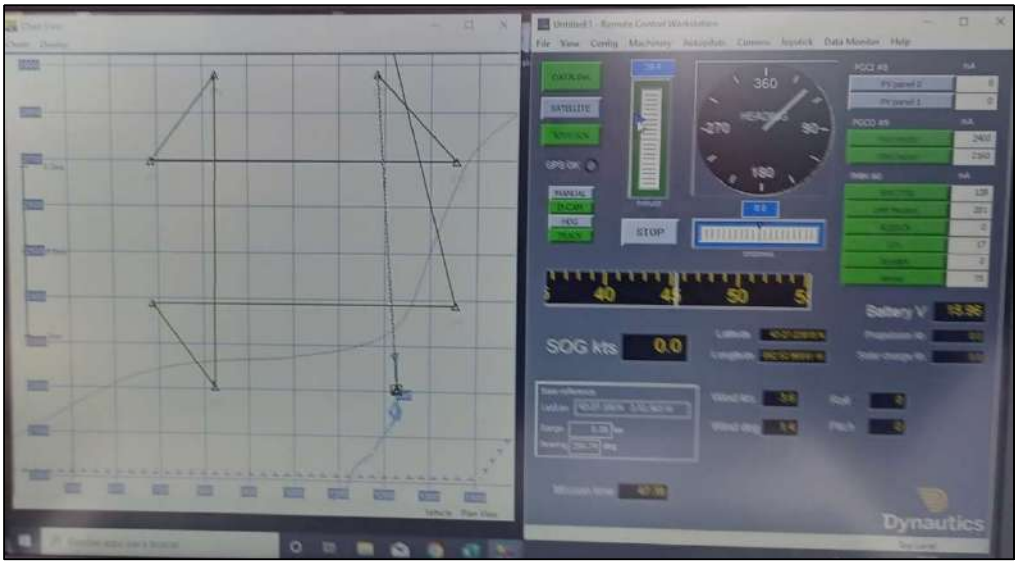

Figure 3. Main panel of Dynautic's Navigation System of ITSASDRONE. Left side, programmed track; right side, main panel of navigation indicators (Source: AZTI).

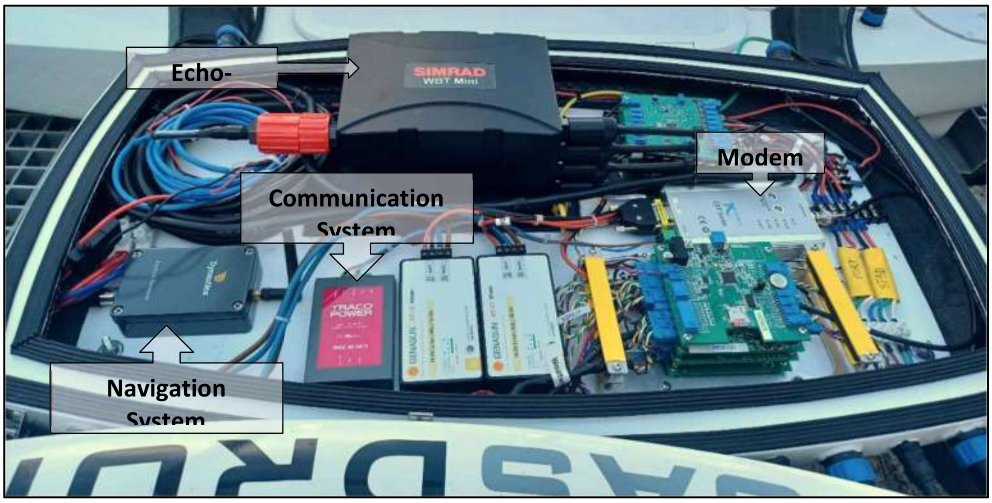

Figure 4. Marine Station System (Source: AZTI).

The WBT mini is a Simrad EK80 programmable, stand-alone split-beam acoustic echo sounder. In this scenario, it was operated at a narrowband frequency of 200 kHz, at which precise acoustic backscatter data were collected, stored and then post-processed and replayed (Figure 5) in

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order to identify significant fish schools to assess the possible aggregation effect of the device.

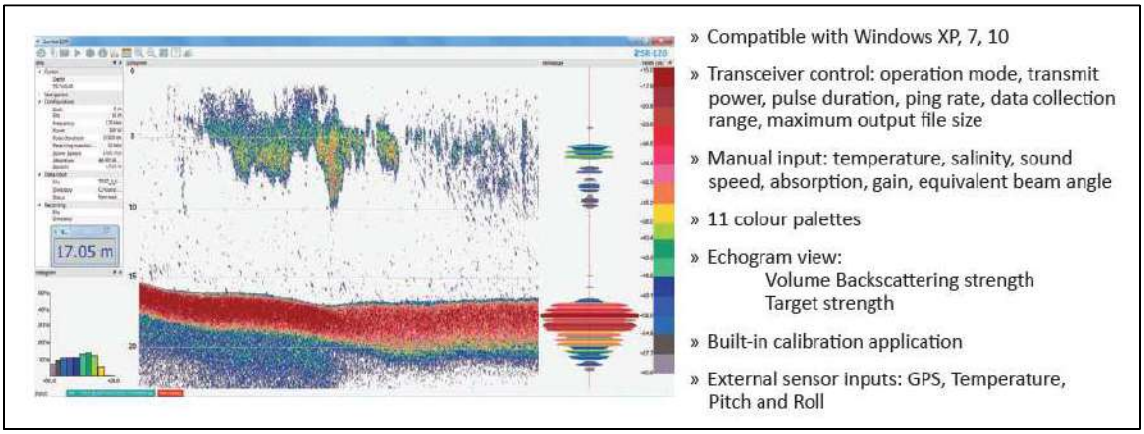

Figure 5. Backscattering data of WBAT echo sounder integrated in the ITSASDRONE (source: AZTI).

The acoustic data processing follows a pre-established sequence of steps:

- Firstly, the acoustic signal should be pre-processed by: i) detecting and excluding the seabed echo; ii) applying spike filters for interference removal; and (iii) applying a minimum threshold of -60 dB.
- Secondly, the acoustic signal is processed by means an acoustic echo-integration. In this case, an integrated acoustic energy value is obtained from 500 pings x 10 m depth cells.

Finally, the mapping of the acoustic energy around each structure and the plotting of the relative abundance as a function of the distance of each cell to the centre of each of the installations, allows to assess the effect generated by the presence of structures on the fauna in the area.

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6.2 Survey

The work that should have been done in response to the objectives of the Task 2.5 focused on the monitoring of fish communities around the Penguin WEC-2 Wave Energy Converter in BiMEP (a detailed description of BiMEP test site and the Penguin device is provided at the Deliverable 2.1). The Penguin WEC-2 was deployed off the coast Armintza, Basque Country, Spain in August 2021. On 19th of December 2021 the WEC was towed to harbor for inspection, maintenance, and repairs due to the detection on the 28th of November an alarm of leakage. Although the plan was to repair Penguin WEC-2 and bring it back to its localization in BiMEP area, after more than 10 months, the penguin is still in the port of Bilbao.

We, therefore, decided to carry out the monitoring work around the HarshLab floating laboratory device of Tecnalia. Although the floating laboratory is not a WEC, it is very similar to it, and it can be used as a good model in terms of the potential reef effect due to the presence of structures on the water surface. The dimensions are close to a WEC, the device is a floating and mooring and mooring lines are similar to those employed for the installation of some WECs. During the operation phase, in general, the placement of any artefact in the sea can result in an attracting effect on fish communities, especially if it is floating (Langhamer, 2012; Langhamer, 2016; Hemery, 2020). Thus, this option has been considered as a mitigation strategy to the fact that Penguin WEC-2 is no longer operational in BiMEP.

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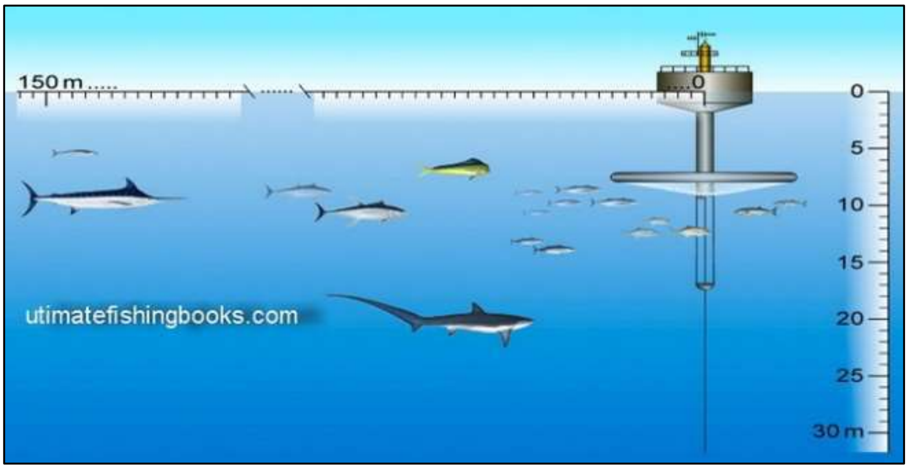

Figure 6. Possible effect produced by WEC (source: Ultimate Fishing News[6]).

6.2.1 HarshLab

HarshLab[7] is an *Advanced floating laboratory for the validation and experimentation of materials, components and equipment in real offshore environment* developed and operated by Tecnalia Research (Figure 7).

[6] https://ultimatefishingnews.com/en/25-fish-aggregating-devices-off-somalia-to-tackle-piracy/
[7] https://harshlab.eu/en/

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Figure 7. HarshLab 2.0 (Source: https://harshlab.eu/en/).

The installation of the first HarshLab version (HarshLab 1.0) in the BIMEP area took place in September of 2018. It was moored at 65 m of depth and 1.8 nautical miles out. The second version (HarshLab 2.0) was moored three years later, in June of 2021, in the same location (Figure 8). According to Tecnalia, this location ensures 100% offshore trial conditions, perfect for assessing new materials and solutions against corrosion, ageing and fouling.

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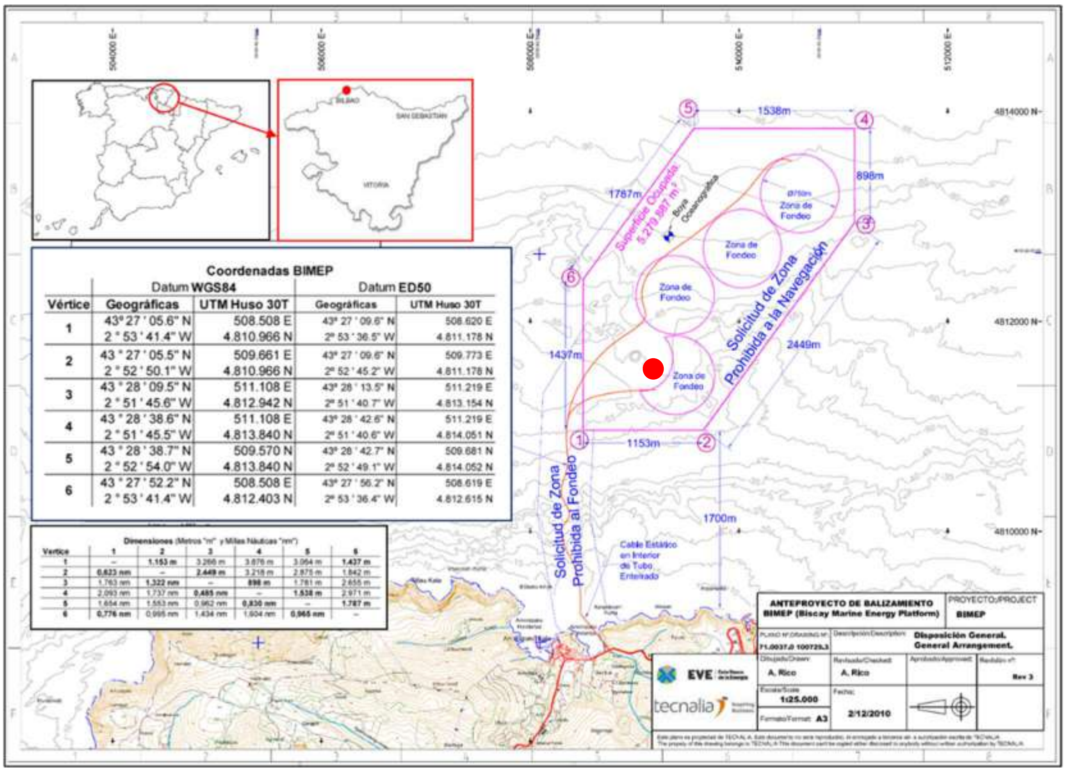

Figure 8. HarsLab 2.0 position (red dot) in BIMEP area.

The HarsLab 2.0 has been deployed with 3-legged mooring system specifically designed for BiMEP's conditions (Figure 9). The coordinates of each leg are presented in Table 1. Each mooring line presents:

- Steel wire
  - Steel Wire DN = 90 mm
  - Total length = 70 + 70 + 24.5 + 36.7 = 201.2 m
- Chain
  - Studless R4S, DN = 70 mm
  - Total length = 332 + 436 + 172 + 8.7 = 948.7 m
- Chain
  - Studlink R4, DN = 76 mm
  - 100 m for each line (100 + 3 = 300 m in total)

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- Drag Embedment Anchors (STEVSHARK ©REX from VRYHOF)
  - Mass = 4.5 + 2.4(R) - 3.5(FR) – 3.5(FL)

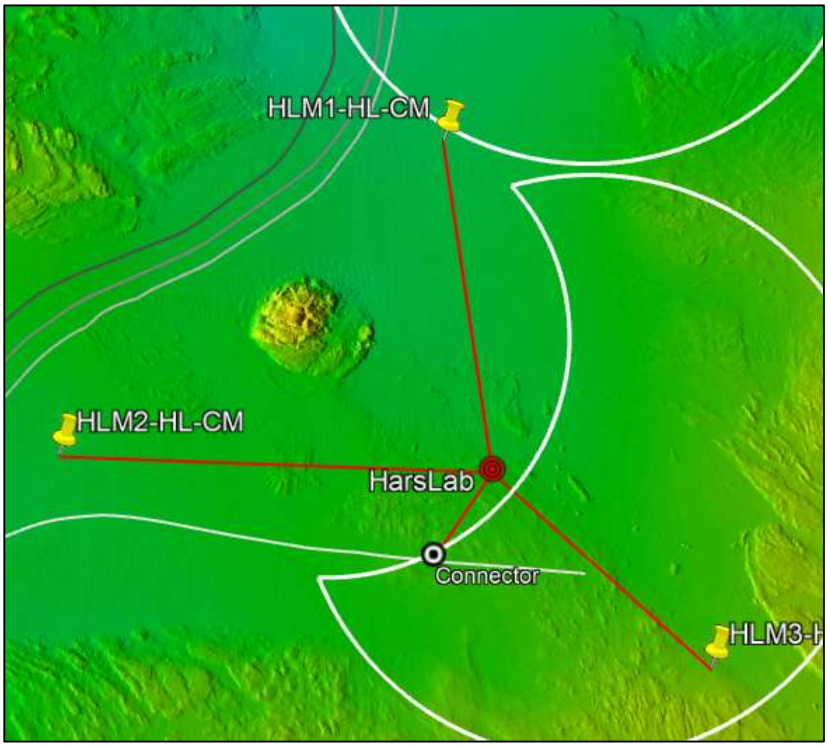

Figure 9. Schematic view of positioning of the mooring system (Source: BiMEP/AZTI).

Figure 10. Drag Embedment Vryhof anchors utilized (Source: Tecnalia).

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Table 1. HarsLab 2.0 mooring and connector coordinates (WGS 84; Degrees, Decimal Minutes) (Source: Tecnalia&BiMEP). Lineal distance (approximation) between HarsLab and mooring points & connector (Source: AZTI).

Point	Longitude	Latitude	Lineal distance
HML1-HL-CM	43° 27.232'N	2° 53.919'W	~445 m
HML2-HL-CM	43° 27.376'N	2° 53.540'W	~560 m
HML3-HL-CM	43° 27.232'N	2° 52.919'W	~375 m
Connector	43° 27.307'N	2° 53.179'W	~130 m

The laboratory reaches 8.5 m of diameter and height of 7 m, presents a 60 m^2 outdoor deck space and 57 m^2 of indoor space. It is ready to carry out tests in atmospheric zone, splash zone, immersion zone, seabed area and also is prepared to testing antifouling solutions in Dynamic conditions (Figure 11).

In 2023 it will be connected to the BiMEP submarine network that will provide electricity and optic fiber communication. Until then it is powered by a renewable electricity generation system that allows to obtain data from the installed equipment and transmit them from sea to land in real time.

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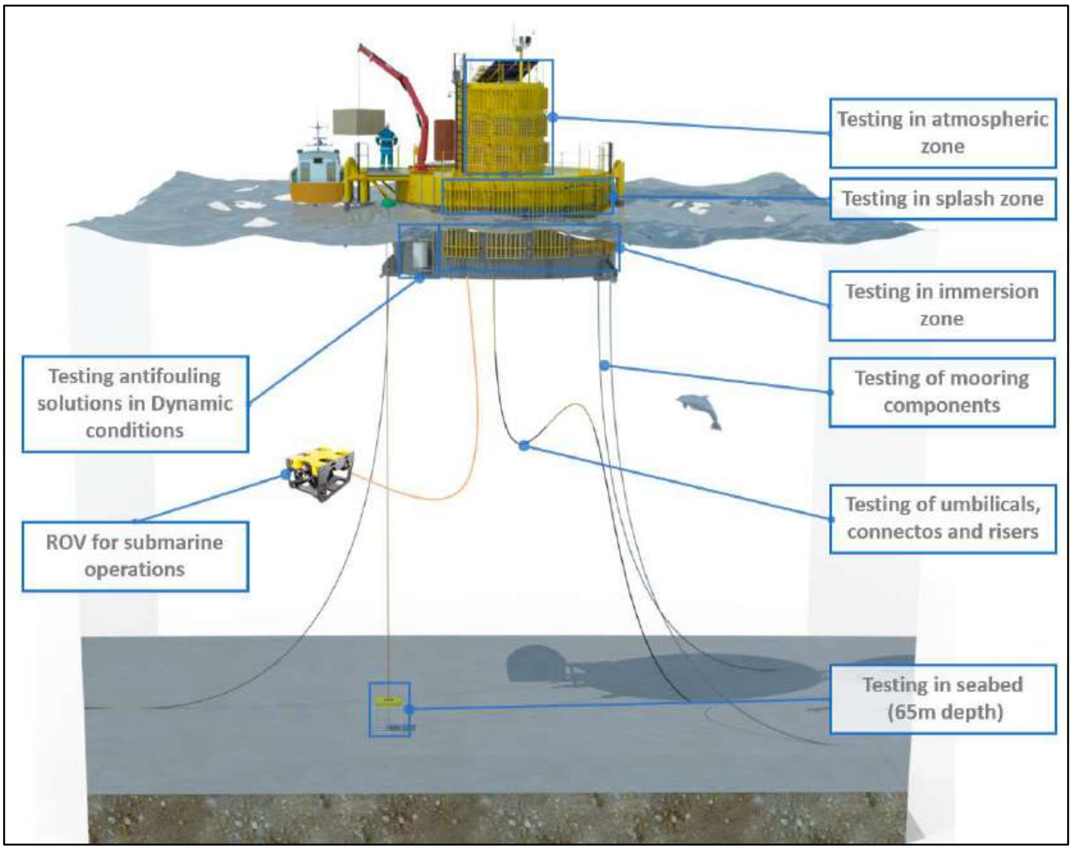

Figure 11. Schematic view of positioning of the mooring system (Source: Tecnalia).

6.2.2 Monitoring methodology

After the final fine-tuning process between January and July of 2022, the fish monitoring survey took place on 30th of August 2022[8] between 12:00 – 15:00 GMT in the BiMEP area (detailed data in Annex 1). A summary can be seen in a video of the survey in the YouTube channel of AZTI: https://youtu.be/iUQyxb-cw4g

As supporting vessel, the OLATU, a 6.0 m long and 3.0 m wide yacht was employed (Figure 12). The mobilization took place in Armintza harbour (Basque Country, Spain). The ITSASDRONE was deployed and retrieved by

[8] https://youtu.be/iUQyxb-cw4g

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a docking station (Figure 13, a) in the harbour. The ITSASDRONE was towed by OLATU from the harbour to the initial point of the survey and, also, from the last point of the survey to the harbour (Figure 13, b). ITSASDRONE navigated "over" the predefined transects by means of an automated remote control.

Figure 12. OLATU yacht (source: AZTI).

Figure 13. a) ITSASDRONE inside the docking station, b) ITSASDRONE towed by OLATU yacht (source: AZTI).

The survey design was defined following a star pattern shape, similarly to other studies for assessing biomass of fish aggregations around fixed positions (Doray et al., 2008). This types of non-parallel designs allow

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estimation of biomass as a function of distance to the fixed position and are widely applied in acoustic fisheries studies (Tugores *et al.*, 2016; Gastauer *et al.*, 2017; Uranga *et al.*, 2019). As showed in Table 2 and Figure 14, several transects were established relative to three predefined waypoints:

1. 4 transects around the HarshLab device (denoted as H).
2. 2 transects around "A" point located in the third berth position of BiMEP.
3. *Control site,* far enough from HarsLab device.

Table 2. Selected waypoints coordinates (WGS 84; Decimal Degrees) and consecutive distance between waypoints in meters (Source: AZTI).

Waypoint	Transect	Latitude	Longitude	Distance (m)	Cumulative Distance (m)
P1	VE	43.4541	-2.8863	0	0
P2	VE	43.4586	-2.8863	500.04	500.04
P3	HS	43.4554	-2.8881	380.51	880.55
P4	HS	43.4554	-2.8819	500.11	1380.66
P5	VW	43.4541	-2.8838	211.60	1592.26
P6	VW	43.4586	-2.8838	500.04	2092.30
P7	HN	43.4572	-2.8881	381.59	2473.89
P8	HN	43.4572	-2.8819	500.10	2973.99
A1	A1A2	43.4682	-2.87486	1479.33	4453.32
A2	A1A2	43.4381	-2.88584	1226.48	5679.8
A3	A3A4	43.4721	-2.88029	745.41	6425.21
A4	A3A4	43.4646	-2.88030	839.10	7264.31

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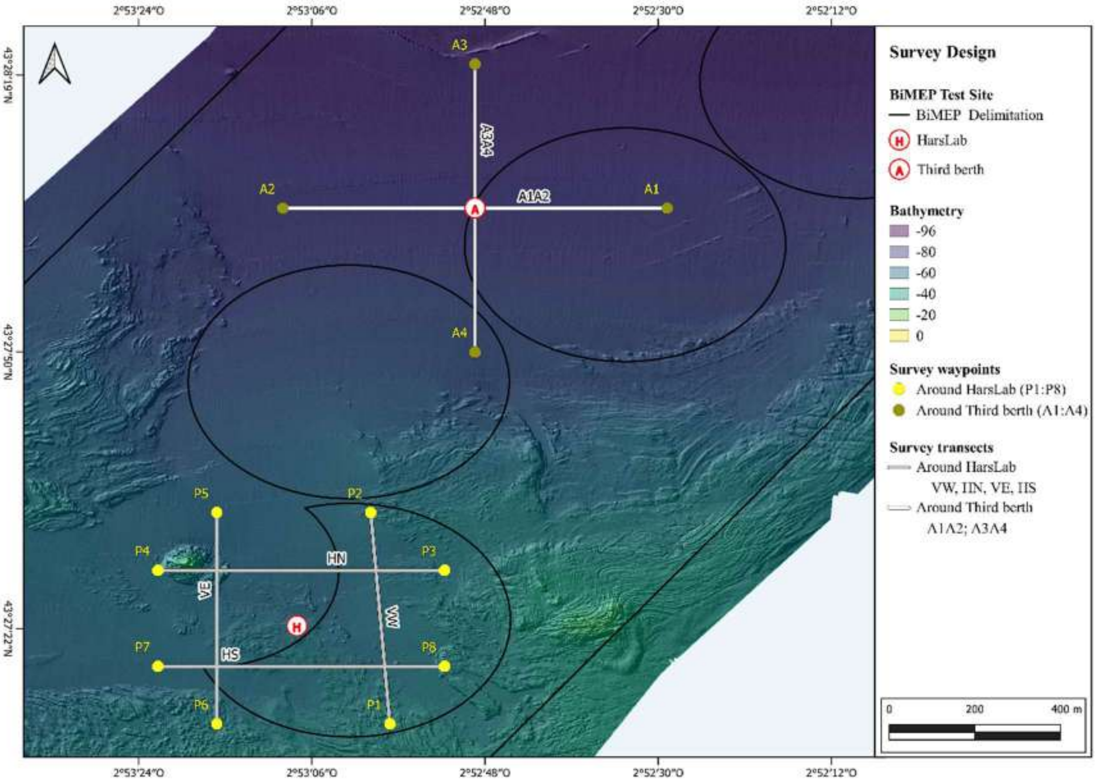

Figure 14. Survey designed around HarsLab and Third berth area (source: AZTI).

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7. Results

7.1 Conditioning and tuning of the ITSASDRONE

As explained in Section 6.1, the ITSASDRONE was designed and constructed by BRANKA Solutions Inc. in collaboration with AZTI in 2019-2020. The project was concluded in 2020 as scheduled, but the ITSASDRONE was not finalized so, the first conditioning and tuning of the ITSASDRONE has been run over 2021.

The first conditioning and tuning activities included several physical modifications and, a better communication and navigation system development. Below are detailed those main modifications:

- Physical modifications:
  - Broken-propellers replacement.
  - Installation of strut to deploy and retrieval the ITSASDRONE by vessel. It was not feasible, so the strut was removed.
  - Design and construction of docking-station.
- Communication and navigation system:
  - Complete the integration of communication and navigation system in the catamaran.
  - Online training-course with Dynautics.
  - Establish a communication between catamaran and land station.
  - During summer 2021, the first trials of *ITSASDRONE* were done in Urdaibai estuary (Bizkaia, north of Spain).

During summer 2021, the first trials of *ITSASDRONE* were done in Urdaibai estuary (Bizkaia, north of Spain). After checked and adapted the

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communication system between ITSASDRONE and Ground Control Station (a datalink, transmitting information from one point to another), the navigation system was checked, updated, and customized. These can be seen in the YouTube channel of AZTI: https://youtu.be/12XZhNtiFmA.

7.2 Operational Procedure

The deployment and retrieval of ITSASDRONE was successfully performed using the docking station. The docking station (with composite structure) is light so, it can be moved and put in the water by only two people (Figure 15). Similarly, towing the ITSASDRONE between harbour and BIMEP area by the Olatu yacht was also achieved adequately (Figure 13b).

From an operational perspective, the survey demonstrated that the deployment, towing and retrieval procedure of ITSASDRONE is feasible and straightforward. On this basis, we can conclude that the use of this autonomous marine surface drone with small vessels has been a success.

Figure 15. Retrieval of docking station in Armintza's harbour (source: AZTI).

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7.3 Navigation

The interface of Dynautics's navigation system is not smart neither intuitive. Its appearance is sometime confusing and requires from the user to have a good knowledge of the abundant options provided by the software configuration menus.

The Dynautics's navigation system of the ITSASDRONE was successfully configured according to predefined waypoints and transects around HarsLab, third berth position of BiMEP (denoted as "A") and, surrounding areas far enough from HarsLab device (denoted as "Control Site"). The ITSASDRONE should have navigated over these predefined transects, however, the ITSASDRONE skipped two of the pre-defined waypoints of the transects (Figure 16). The exact cause of this error is unknown, but it is likely due to a technical aspect of the Dynautics navigation software related to configuration parameters of the diameter of the confusion zones defined around the waypoints.

An automated remote-control communication system works correctly both in open sea and in tacking and lowering operations with the docking-station.

The sea state, with 0.5 m wave height and about 8 knots of wind, was enough for the correct navigation of the ITSASDRONE. The navigation speed of the autonomous vehicle varied between 2 and 4 knots.

In short, in order to provide a useful navigation system for the Itsasdrone, the Dynautics navigation system should perform changes and improvements related to technical specifications, design, and appearance of the software.

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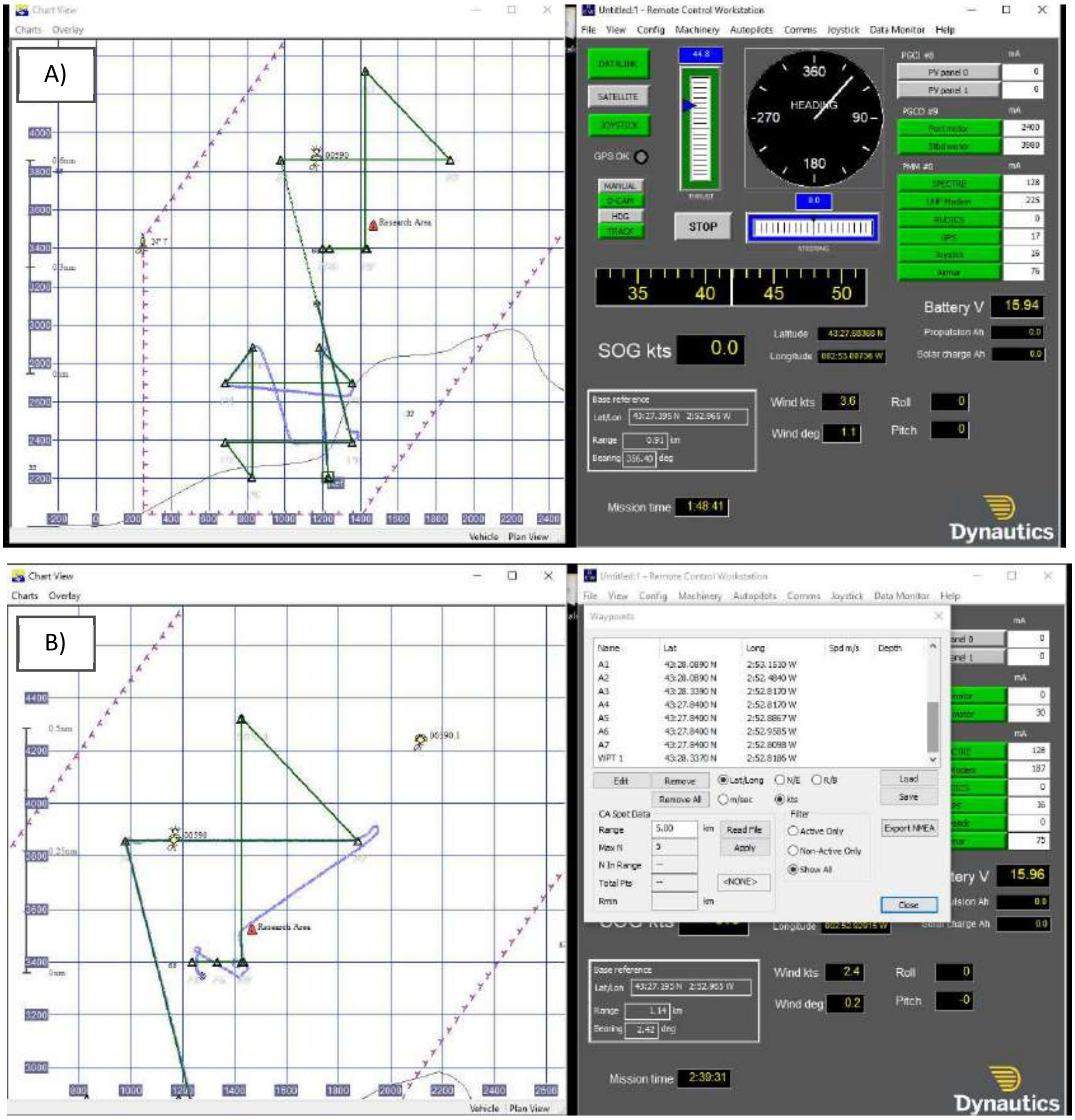

Figure 16. Acoustic sampling design around the HarsLab and 3rd berth position (green lines) and real path of the ITSASDRONE (blue lines) during the BIMEP acoustic survey on 30 August 2022. The left panels show the route maps, and the right panels show the ITSASDRONE path configuration window provided by Dynautics. The upper panel (A) shows the sampling design performed around the HarsLab, and the lower panel (B) shows only the third berth area (Source: AZTI).

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7.4 Fish Monitoring

The fish monitoring was successfully performed by the WBT mini echo-sounder integrated in the ITSASDRONE. Data registered by the echo sounder was used for identification of fish shoals and to evaluate the possible aggregation effect of the HarshLab.

The initial data analysis generated two echograms (Figure 17). These echograms show the vertical distribution of acoustic backscattering energy along the entire acoustic track, from and to the harbour of Armintza. Raw acoustic data are shown in the upper echogram (Figure 17 A), where pings are plotted in the horizontal axis and depth in the vertical. The red line marks the bottom, and the color scale represents the acoustic energy (proportional to fish density) ranging from -60 dB (low fish density) to -24 dB (high fish density).

The echogram below (Figure 17 B) was obtained after data processing, mainly: bottom detection (green line) and removal of the bottom echo, acoustic interferences and other noise sources (by means of filters and threshold values). The orange regions were defined to identify the two main surveyed areas: HarshLab (H, left region) and the third berth (A, right area). The violet line across the echogram is the integration line and represents the cumulative relative acoustic abundance of fish along the entire acoustic track. Each vertical step in the line is proportional to the increase in the amount of energy detected (and, hence, fish density).

As a result, it can be stated that schools of unidentified small pelagic fish were observed distributed throughout the water column, predominantly near the bottom in the HarshLab area. In the third berth area (A point) unidentified small fish schools appeared in the water column.

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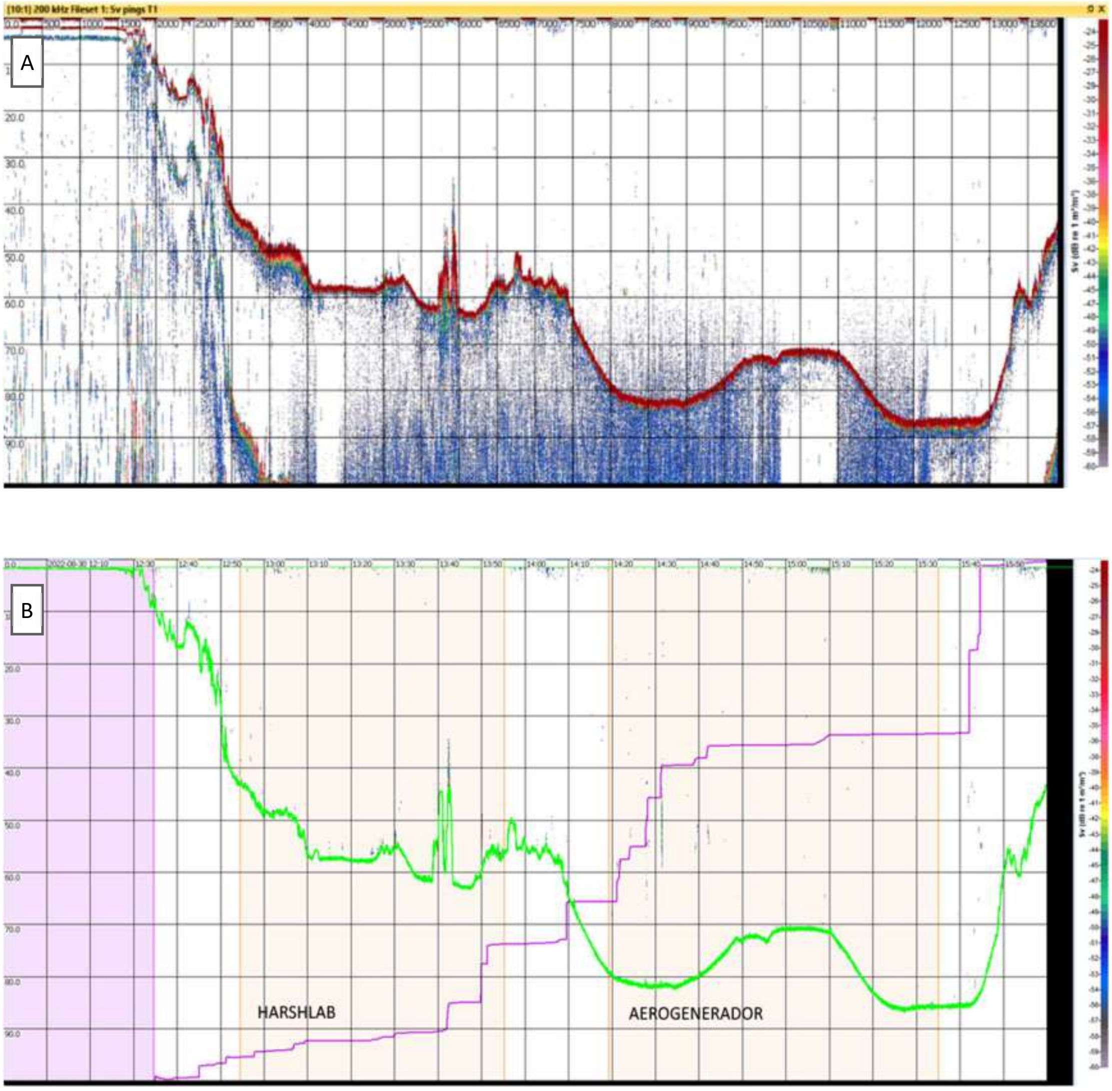

Figure 17. Echograms showing an acoustic energy distribution along the entire acoustic survey. A) echogram showing the distribution of raw acoustic energy during the entire BiMEP acoustic survey run, from the departure of the Itsasdrone from Armintza harbour to its return to port. The grid shows the 500 ping x 10 meter cells set up for echo integration. B) The same echogram is shown after preprocessing that removes interference and noise before echo integration. The green line indicates the bottom detection, and the violet line shows the cumulative relative acoustic abundance. The orange regions illustrate the two surveyed areas of analysis: HarshLab (H, left area) and third berth (A, right area). The color scale represents the acoustic energy and ranges from –60 dB to –24 dB.

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The evaluation of the effects generated by the presence of structures in areas of fish presence was done by determining relative abundance as a function of the distance from each cell to the centre of each of the devices. The result of the analysis revealed a similar (non-significantly different $p > 0.1$) abundance in the BIMEP areas as in the access route from the port of Armintza (Figure 18).

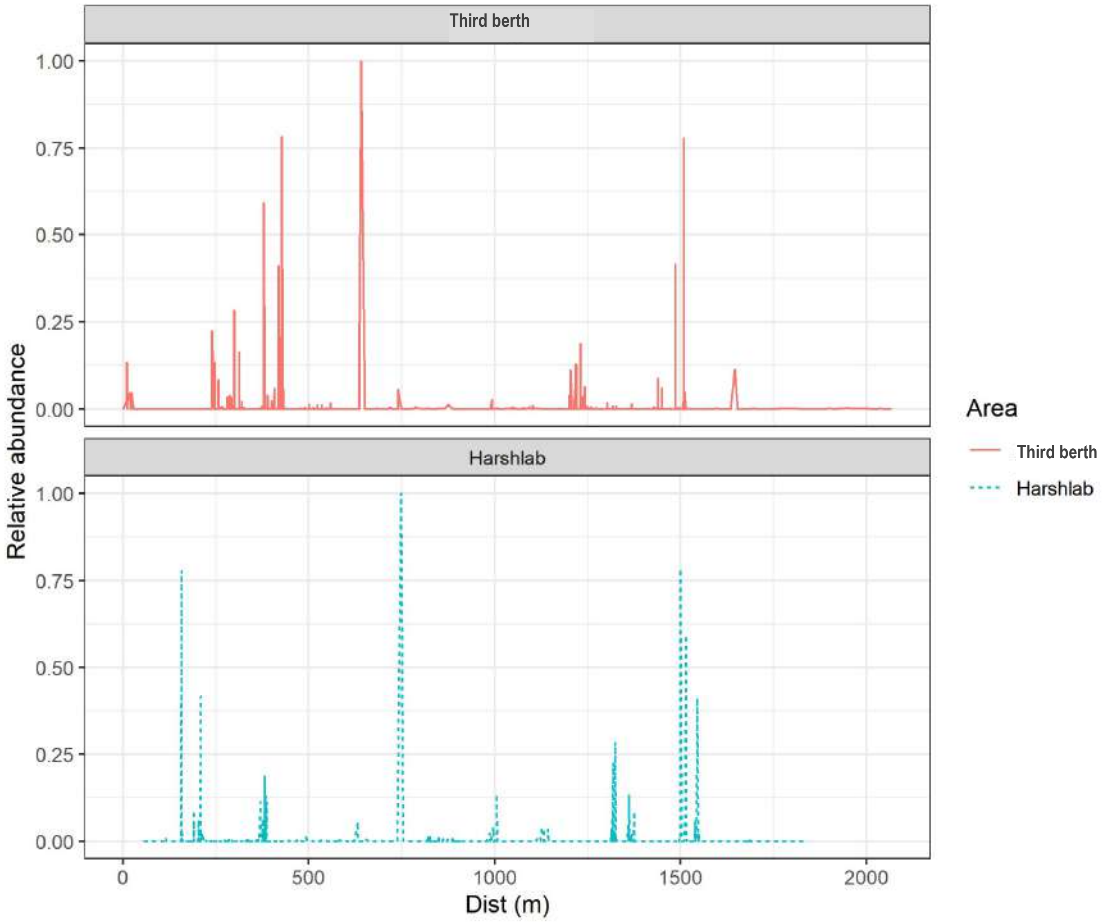

Figure 18. Biomass relative abundance as a function of the distance from third berth and HarsLab in the surveyed area.

Next, we focussed on estimating that the horizontal distribution of fish density along the whole surveyed area. Thus, plotting echointegration

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results and quantifying the energy distribution over the transect navigated by ITSASDRONE over the whole surveyed area, a graph as shown in Figure 19 is obtained Figure 19. The integrated acoustical data were expressed in Nautical Area Scattering Coefficient (NASC). The results of the analysis are the following:

- No patterns or spatial trends were observed in the horizontal distribution.
- The acoustic sensors showed similar abundance in the BIMEP area, as in the access route from the port of Armintza.
- Similar fish density was found also around the HarsLab, as outside its area of influence.

Those results are considered as baseline information. Future studies are needed to further explore the association between WECs and fish aggregations.

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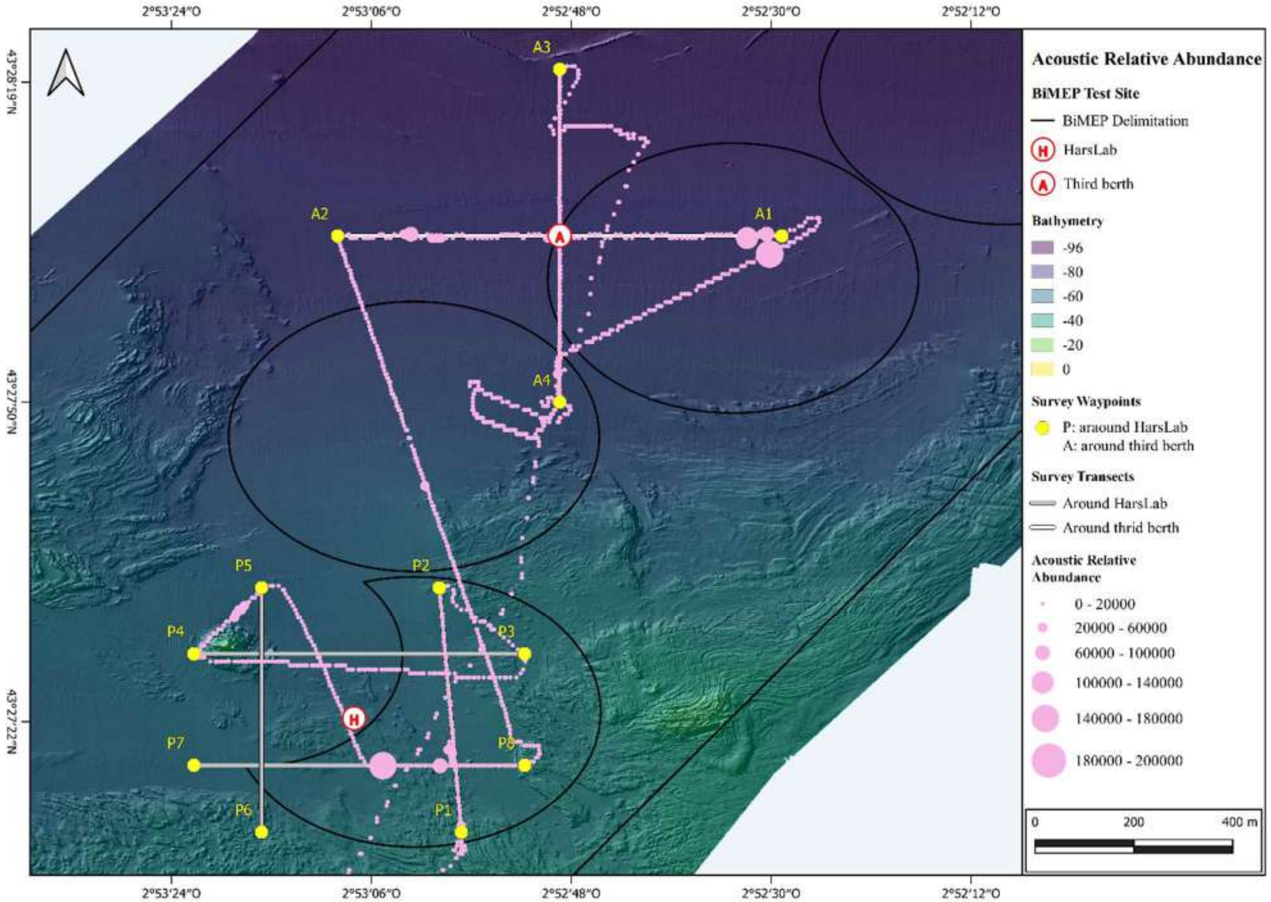

Figure 19. Chart of the acoustic sampling carried out by the ITSASDRONE at BIMEP area. The diameter of the circles represents the acoustic abundance (NASC, mn2m-2) along the path navigated by the ITSASDRONE.

8. Conclusions

The removal of the Wello Penguin WEC-2 from BiMEP area was initially a setback for the team. As a mitigation strategy, the project team decided to carry out the monitoring work around the HarshLab floating laboratory device of Tecnalia. Although the floating laboratory is not a WEC, it is very similar to it, and it can be used as a good model in terms of the potential reef effect due to the presence of structures on the water surface. In general, the placement of any artefact in the sea can result in an attracting effect on fish communities, especially if it is floating. The objective of the project was to monitor this possible effect thanks to the deployment of the ITSASDRONE device which is equipped with a Simrad EK80 programmable stand-alone split-beam acoustic echo sounder.

The first conclusion of the project is focused on the use of ITSASDRONE for fish monitoring. According to the project results, the ITSASDRONE is a good kind of autonomous marine surface drone for monitoring fish. It can be used with small vessels successfully. The main failure of the ITSASDRONE ASVs is related to the navigation system. The Dynautics navigation system needs to be updated and improved technically to avoid overshootings. It is necessary also necessary a more "user-friendly" and simplified navigation system. The interface of Dynautics's navigation system is not smart neither intuitive.

Regarding the possible reef or fish aggregating effect, it can be stated that schools of unidentified small pelagic fish were observed distributed throughout the water column, predominantly near the bottom in the HarshLab area, and more detached from the bottom in the deeper third berth position. The acoustic sensors showed a relatively high abundance in the BiMEP area, in general as high as in the access route from Armintza harbour.

Although HarshLab could be considered as a good model of the possible reef or fish attraction effect due to its similar dimensions with the WECs, it´s true that it does not have specific elements of the WECs that can intervene or affect this potential effect. These are the underwater noise generated by the moving parts of the harnessing machine inside the WEC and the electromagnetic fields of the exporting electrical cables which could generate an avoidance effect and compensate the attraction of the floating structures of the devices.

Consequently, these results are considered as baseline information. Future studies and more trials with the ITSASDRONE device are needed to further explore the association between WECs and fish aggregations.

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10. Annex 1. Recording sheet for fish monitoring

Location:	Armintza – BIMEP	**Survey start date:** 24 Ago 2022	**Survey end date:** 30 Ago 2022
Device:	HARSLAB	**Team:** Jon / Unai (Olatu SL) Jon Lasa (Branka Solutions) Guillermo Boyra (AZTI) Bea Sobradillo (AZTI) Ainhize Uriarte (AZTI)	

Equipment:	ItsasDrone:
	• Recording status:
	  o programmed track
	  o manual
	  o Heading
	• Trust: several
	• Communication:
	  o Antenna
	  o
	• Ancillary sensors: temperature and salinity
		Sensor: Simrad WBT Mini (Miniature wideband echo sounder transceiver)
		
		Operating Mode: Autonomous mode:
		• Transducer: 200 kHz – 7C.
		• Ping Group:
		  o CW
		  o Ping interval = 512 us
		  o Range = 100 m
		  o Ping interval = 1 s
		  o Number of pings = 100
		• Ensemble:
		  o Loop: 60 min
		• Duration: 6 h
			Boat:
			
			Olatu
			
			Length: ~ 6 m.
			Width: ~3 m.

	24 Ago 2021	**25 Ago 2021**	**31 Ago 2021**
Sea State	Harbour; tuning	Harbour; tuning	Wave height: ~ 0.5 m Wave direction: ~350° Wind: 1- 2 knots T_p: 8.0 s
Other Comments	The time in the sensor and navigation system was Local time. We have to check datalogger and extract GPS data from RCW Chart (navigation program) according to Dynautics notes. We have to solve why the navigation system skips planning-tracks points, "waypoints overshooting" and, also, why GPS on in the interface is not activated (green colour (next telco with Henry/Allison). Increase Itsasdrone SOG and redesign Trust (smart).		

WPT	Hora local	Long	Lat	Trust	Notes
Harbour	14:20	2° 53.88 W	43° 25.98 N	Towed	Check and change data Base Reference data Load Track Mission Time: 0:00
P1	14:58			30% - 50% - 35%	15:17:00 On rising to 50% the engines stop. Down to zero and back up to 35%. 15:19 recovers track
P2	15:26			40% - 45%	Overshooting
P3	15:30			"	Overshooting; recover track
P4	15:41			"	Everything ok
P5	15:45			"	Overshooting; track lost
P6	----			---	missing point
P7	----			---	missing point
P8	15:56				Turn North, towards A1 Energy comsuption: 15.94 V
A1	16:21			cte	Everything ok 16:27 Device position point SOG: cte.
A2	16:33			!	Overshooting; track lost (goes to A6) Energy comsuption: 15.81 V Overshoot in the middle poit towards A4
A3	----			---	missing point
A4	16:48			!	Turn 360° Energy comsuption: 15.80 V STOP. Trust 0. New Track ==> Not respond. STOP. Click Dcam + Heading 360° ==> Not respond. STOP.
	17:00			----	Draw new track again: A3 to A4. Energy comsuption: 15.87 V
A4	17:12			40%	Middle point: 17:19
A3	17:26			----	Stop. Mission Time: 3:29 Planning END
	17:27				Manual control.
TESTS	17:28			29.4%; 35.8% 46.1% 52.1% 60% ¿40%?	Heading 185° At 60% the truster crashes ==> Limit between 50% - 60%. The system stops.
	17:29			40%	Controlled by joystick. Stop. Fin.
Navigation	17:43			Towed	Energy comsuption: 15.96 V Mission Time: 3:22

Harbour	18:09			Docking Station	Mission Time: 3:49