JERICO-S3 DELIVERABLE

Joint European Research Infrastructure for Coastal Observatories

Science, Services, Sustainability

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APPROVALS

	Name	Organisation	Date	Visa
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WP Leaders	Alan Berry	Marine Institute		

Diffusion list

Consortium beneficiaries	Third parties	Associated Partners	other
X	X		

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1. EXECUTIVE SUMMARY

JERICO-S3 has offered researchers free of charge access to the coastal observatories listed in D8.1 Description of Facilities in Transnational Access Provision (Gaughan and Berry, 2021) through the Transnational Access programme. There were four calls conducted where users applied for access to facilitate their proposed research project. Projects were reviewed by the external panel for scientific integrity, logistical work plans, and seeding links to industry.

Detail on the procedures and implementation of the transnational access calls are described in D13.3 TA: Policies and Procedures Document (Gaughan et al. 2021), with subsequent deliverables 13.4 (Loughlin and Gaughan, 2021) and 13.5 (Loughlin and Gaughan, 2022) outlining any changes to the policies and procedures after each call. The selected projects and the completed final project report results are included in this report.

2. INTRODUCTION

JERICO-S3 facilitated four Transnational Access (TA) calls, summarised in Table 1, to provide free of charge access to high quality coastal observation infrastructures. One of the main features of the JERICO-S3 TA programme is the multidisciplinary facilities offered, with a range of infrastructures including gliders, cabled observatories, fixed platforms, ferryboxes, and calibration laboratories.

All calls were announced on the JERICO-RI website and the application and guidance notes attached to the press release. The overall review process for the calls remained the same throughout all four calls.See Deliverable 13.3 (Gaughan, et al., 2021) for a detailed outline on the policies and procedures for the JERICO-S3 calls. All user groups were encouraged to contact the facility operators before applying in order to ensure the project is viable and agree upon a time frame for access.

Proposal applications were first reviewed and sanity checked by the JERICO internal panel, of which remained the same throughout the JERICO-S3 lifetime. The internal panel assessed in particular basic eligibility, the T&S budget request, the validity of the work schedule, and soundness of the contingency plan. Once reviewed, the panel provided initial feedback to applicants and offered them a short timeframe to return a final application that would be presented to the external panel.

The internal selection panel consisted of:

- Paul Gaughan (Marine Institute, JERICO-S3 WP8/TA Coordinator),
- Christine Loughlin (Marine Institute, JERICO S3 WP8/TA Coordinator)
- Lea Godiveau (Ifremer - Jerico S3 Coordination)
- Laurent Delauney (Ifremer)
- Melanie Juza (SOCIB)
- Jukka Seppälä (SYKE)
- Laurent Coppolla (CNRS)
- Luis Felipe Artigas (ULCO)

The external panel reviews the proposal applications for scientific integrity, seeding links to industry, work schedule and contingency plans. Each project was reviewed by at least three reviewers and final scores were either an average of individual scores or a consensus score agreed upon by the panel after a discussion during the meeting.

The external selection panel consisted of:

- Janet Newton (University of Washington)
- Henry Ruhl (CENCOOS) Central and Northern California Ocean Observing System
- Rogerio Chumbinho (Bluewise Marine)
- Steve Hall Pembrokeshire Coastal Forum (PCF)
- Clarissa Anderson, Ph.D. (SCCOOS) Southern California Coastal Ocean Observing System

Table 1: Summary of the JERICO-S3 four calls.

	Call 1	**Call 2**	**Call 3**	**Call 4**	
Call Opening	2 June 2020	29 March 2021	1 March 2023	20 October 2024	
Call Closed	16 November 2020	31 May 2021	3 May 2023	21 November 2024	
Proposals Submitted	20	12	12	5	**Total Proposals Submitted**
Proposals Selected	19	11	12	5	**Total Proposals Selected**

3.First Call

The first TA call was implemented in Task 8.8. The call was announced on 2 June 2020 until 16 November 2020. The call was kept open longer due to COVID delays. It was published to the JERICO-RI website as per the means of verification requirement and promoted across the various social media outlets. Deliverable 13.4 provides more details about call 1 and any changes to the policies after the call (Loughlin and Gaughan, 2022a).

Twenty project applications were received and reviewed by an internal JERICO-S3 panel with suggested revisions being sent to applicants for a re-submission. The final submitted applications were then reviewed by an external panel for scientific excellence and integrity. The selection panel scored the applications and passed on comments to the steering committee to base their decisions on funding the projects.

As a result, nineteen projects were accepted for funding. TA End User agreements were signed by the end user, facility operator, and coordinator IFREMER.

4.Second Call

The second TA call was open from 29 March 2021 to 31 May 2021, see Deliverable D13.5 (Loughlin and Gaughan, 2023) for more details on call 2. The call was promoted on the JERICO-RI website with a press release, application and guidance notes. To promote this call further, a month-long "Facility of the Week" was featured on the website to highlight facilities that were not as popular in the first call and to increase the social media awareness of the second call. 4 host facilities and infrastructures that are offered in the TA call were highlighted in a blog post and shared on JERICO-RI twitter feed.

At the close of the call, the 12 submitted applications were reviewed by an internal JERICO-S3 panel with suggested revisions being sent to applicants for a re-submission. The final 12 submitted applications were then reviewed by an external panel for scientific excellence and integrity. The panel recommended to approve 10 applications and advised 2 of the applications to be approved but contingent upon further clarifications from the applicant.

The steering committee approved 10 projects for funding with the guidance of the external panel's comments. One outstanding project provided additional clarifications, and was approved by the steering committee, while the second project (Mimetic) opted not to submit comments and, therefore, was not funded. The successful applicants were informed and sent granting letters to start the contract process.

5.Third Call

The call was announced on 1st March to 3rd May 2022, see Milestone MS44 for a more detailed description of Call 3 (Loughlin and Gaughan, 2022b). The call was promoted on the JERICO-RI website and JERICO-RI social media channels. JERICO-RI TA coordination team celebrated Women In Science Day on 11 February 2022 with blog posts on 3 women PI users for projects funded in the last two TA calls. During this campaign the upcoming third call was promoted with encouragement for female applicants as the representation of female user group members was a concern in the first periodic review. Additionally, a facility highlight blog post was written for the JERICO-RI website to promote facilities that were not as requested for in the previous two calls.

Applications were received for 12 projects and all were ultimately funded after the external panel's review. In advance of the 3rd call meetings were held with the Aquacosm-RI TA TA coordinator and Work package leaders to promote and facilitate collaboration via the TA process between the two RI's.

6.Fourth Call

A shorter, additional fourth TA call was agreed by the Steering Committee and was opened from 20 October 2022 to 21 November 2022, more details were provided in the second Periodic Report. The call was open for a period of 1 month as there was a tight schedule for finalising the call procedures before the end of the year so projects would have an opportunity to start at the beginning of 2023. The 4th call's review process was similar to all previous calls, with a virtual internal meeting held on 24 November 2022 and the external consensus meeting held virtually on 9 December 2022. Five applications were submitted with all being funded after the review process.

7.Overview of Selected Projects

Over the course of four calls, JERICO-S3 selected to support 47 projects. Table 2 is a complete table of all selected projects including the external panel's consensus scores.

Table 2: A complete table of all selected calls with evaluation scores.

Submission Number	User project Acronym	Title	User Group PI	Host Infrastructure(s)	Facility Type	Score
4018	V-RUNAS	Validation of a Real-time Underwater Noise Acquisition System	Ehsan Abdi Cyprus Subsea Consulting and Services, Cyprus	UPC OBSEA, Spain	Cabled Observatory	18.6
4019	FRONTIERS	Fault detection, isolation and Recovery fOr uNderwaTer glIdERS	Enrico Anderlini University College London, UK	SOCIB Glider, Spain	Gliders and AUV	21.7
4020	FRIPP-Spring	Frontal dynamics influencing Primary Production: investigating the onset of the spring bloom mechanism through gliders	Antonio Olita ISAC Institute of Atmospheric Sciences and Climate, Italy	SOCIB Glider, Spain	Gliders and AUV	18
4021	MultiNuD	In-situ parallel nutrient sensor deployments	Matthew Patey National Oceanography Centre, UK	UPC OBSEA, Spain	Cabled Observatory	23.4
4022	CONAN	Cabled Observatory Network for the Advanced monitoring of ecosystems and their Natural resources	Jacopo Aguzzi Instituto de Ciencias del Mar (ICM) Institute of Marine Sciences, Italy	MI SmartBay Observatory, Ireland	Cabled Observatory	21
4023	ATLAS	Advanced ecosysTem monitoring in ecoLogicAl obServatory	Sergio Stefanni Stazione Zoologica Anton Dohrn, Italy	UPC OBSEA, Spain	Cabled Observatory	21.3

Submission Number	User project Acronym	Title	User Group PI	Host Infrastructure(s)	Facility Type	Score
4024	FISHES (A) FISHES (B) FISHES (C)	Fibre-optic Intelligent Submarine High-Fidelity Environmental Sensing	Mohammad Belal National Oceanography Centre, UK	● UPC OBSEA, Spain ● MI SmartBay Observatory, Ireland ● PLOCAN, Spain	● Cabled Observatory ● Cabled Observatory ● Multi platform	20.7
4025	DeepDeg (A) DeepDeg (B)	Development of a reliable system to assess biodegradation of different materials in the European deep sea	Christian Lott HYDRA Marine Sciences GmbH, Germany	● CNR CoCM, Italy ● CNR SICO, Italy	● Fixed Platform ● Fixed Platform	20
4030	ABACUS 2021	ABACUS 2021: Algerian Basin Circulation Unmanned Survey 2021	Yuri Cotroneo University Parthenope, Italy	SOCIB Glider, Spain	Gliders and AUV	20.3
4031	YUCO-CTD	Validation of an innovative easy-to-use affordable micro-AUV platform, embedding an high accuracy and resolution CTD sensor.	Quentin Peyregne Seaber, France	MI SmartBay Observatory	Cabled Observatory	22
4032	S100-Bio	ANB Sensors S Series: Longterm Biofouling Deployment	Nathan Lawrence ANB Sensors Ltd, UK	UPC OBSEA, Spain	Cabled Observatory	21.6
4033	AMBO	AMBO: Autonomous Multiplatform Biophysical Observations	Maristella Berta CNR-ISMR, Italy	CNRS GNF DT_INSU, France	Gliders and AUV	19.3
4034	EMPORIA	EMPORIA: Exploring the mesoscale processes in the area of freshwater influence	Māris Skudra Latvian Institute of Aquatic Ecology, Latvia	Taltech Glider Mia + Profiler, Estonia	Gliders and AUV	19

Submission Number	User project Acronym	Title	User Group PI	Host Infrastructure(s)	Facility Type	Score
		(Gulf of Riga)				
4036	EuroFluoro (A) EuroFluoro (B) EuroFluoro (C)	EuroFluoro	Sam Kirby and Kevin Oxborough Chelsea Technologies, UK	● SYKE MRC Lab, Finland ● MI SmartBay Observatory, Ireland ● HCMR Poseidon, Greece	● Supporting Facility ● Cabled Observatory ● Multi platform	20.3
4037	APHYMOSO	Automated phytoplankton monitoring at ship of opportunity	Machteld Rijkeboer Rijkswaterstaat, Netherland	NIVA Ferryboxes, Norway	Ferrybox	19
4038	AQUA-Action-1	AQUACOSM-JERICO pilot supersite action @ SYKYE	Dr. Stella Berger Leibniz Institute of Freshwater Ecology and Inland fisheries, Germany	SYKE Marine Research Centre Lab, Finland	Supporting Facility	21.3
4039	AQUA-Action-2	AQUACOSM-JERICO pilot supersite action @ Utö	Dr. Stella Berger Leibniz Institute of Freshwater Ecology and Inland fisheries, Germany	Uto Atmospheric and Marine Research Station, Finland	Cabled Observatory	20.3
4040	IMAPOCEAN	Integrated Multilevel Active Passive Ocean Current Education Advancement Network	Ariadne Dimoula Paramount Planet Product, Okeanolog Maine USA	HCMR Buoy & HCMR POSEIDON calibration Lab, Greece	● Multi platform ● Supporting facility	18.7
4041	Jive	JERICO-DANUBIUS-RI Observation initiatiVE	Dr Evangelos Spyrakos University of Stirling, UK	CNR-ISMR S1-GB, Italy	Fixed platform	20.2
4042	LASE-NOPAH	Levels and air-sea exchange of nitrated and oxygenated	Gerhard Lammel RECETOX, Masaryk University,	HCMR Buoy & HCMR POSEIDON	● Multi platform ● Supporting facility	16

Submission Number	User project Acronym	Title	User Group PI	Host Infrastructure(s)	Facility Type	Score
		polycyclic aromatic hydrocarons in the marginal sea of Europe	Brno, Czech Republic	calibration Lab, Greece		
4043	OpenLevo	Enhancing Wave Measurement with energy autonomous Wave Sensing Buob	Georgios Koutras Openichnos, Greece	MI SmartBay Buoy	Fixed platform	19
4044	S1100-HTHSal	ANB Sensors S Series: High temperature and high salinity	Nathan Lawrence ANB Sensors Ltd., UK	HCMR Buoy & HCMR POSEIDON calibration Lab, Greece	● Multi platform ● Supporting facility	21.3
4045	CTDEmEx	CTD inter-comparison: existing and emerging sensors	Glenn Nolan Marine Institute, Ireland	HCMR Buoy & HCMR POSEIDON calibration Lab, Greece	● Multi platform ● Supporting facility	19
4046	RADCONNECT	Underwater radioactivity measurements	Christos Tsabaris HCMR, Greece	COSYNA Underwater Node Helgoland (UNH), Germany	Cabled Observatory	19.3
4048	CBONDEX	Coastal BOuNDary Exchages	Joao Vitorino Instituto Hidrografico, Portugal	Plocan, Spain	Multi platform	20
4049	ABACUS 2023	Algerian Basin Circulation Unmanned Survey 2023	Yuri Cotroneo University Parthenope, Italy	SOCIB Glider, Spain	Gliders and AUV	19.5
4050	BalHObEx	Baltic Sea Heat Waves: Observation and Experimentation	Iordanis Magiopoulos HCMR, Greece	SYKE-ALG@LINE, SYKE Marine Research Centre Lab, Finland	● Ferrybox ● Supporting Facility	20.8
4051	CABS	Capacity Building for	Dimitar Berov	COSYNA Stationary	Ferrybox	19

Submission Number	User project Acronym	Title	User Group PI	Host Infrastructure(s)	Facility Type	Score
		Autonomous Biogeochemical Sensing in the Southwest Black Sea	Institute for Biodiversity and Ecosystem Research, Bulgaria	FerryBox system, Germany		
4052	FRESNEL	Field expeRiments for modEling, aSsimilatioN and adaptive sampLing	Ajit Subramaniam Columbia University, New York, USA	IH MONIZEE, Portugal	Fixed platform	20.3
4053	FRIPP-CEE	Frontal dynamics influencing Primary Production: Carbon Export Experiment	Antonio Olita ISAC Institute of Atmospheric Sciences and Climate, Italy	SOCIB Glider, Spain	Gliders and AUV	17.7
4054	GliderBloom	Use of FMI glider during the EMB-cruise GER – FIN -GER 2023/07	Dr. Henry Bittig Leibniz Institute for Baltic Sea Research Warnemünde (IOW), Germany	FMI Baltic Sea Glider, Finland	Gliders and AUV	21.3
4055	GOOM	Glider Cooperation Mission in Eastern Gotland Basin	Lars Arneborg SMHI, Sweden	FMI Baltic Sea Glider, Finland	Gliders and AUV	17
4056	IMAPOCEAN	Integrated Multilevel Active Passive Ocean Current Education Advancement Network	Ariadne Dimoula Paramount Planet Product, Okeanolog Maine USA	MI SmartBay Observatory	Cabled Observatory	15
4057	OBS-EXP-Bridge	Bridge between OBServation and EXPerimentation communities of JERICO and AQUACOSM	Dr. Francesca Vidussi CNRS-MARBEC, France	SYKE Marine Research Centre Lab, Finland	Supporting Facility	17
4058	OC300-LTLSal	ANB Sensors OC range: Low temperature and low salinity	Nathan Lawrence ANB Sensors Ltd., UK	SYKE-ALG@LINE, SYKE Marine Research Centre	• Ferrybox • Supporting Facility	22.7

Submission Number	User project Acronym	Title	User Group PI	Host Infrastructure(s)	Facility Type	Score
				Lab, Finland		
4059	PoGo	Po delta to Gulf of Trieste: Microbiological connectivity study and field testing of a Video-CTD probe prototype	Martin Vodopivec National Institute of Biology, Slovenia	CNR S1-GB, Italy	Fixed Platform	15
4060	SEASAM	Simulating an automated environmental DNA sampler/analyser for in situ metabarcoding	Maddalena Tibone Atlantic Technological University, Ireland	CNR-ISMAR Venezia- Acqua Alta Platform, Italy	Fixed Platform	21.5
4061	ACMaREMAS	Acoustic Characterisation of a Marine Renewable Energy test site using Marine Authonomous Systems	Ivia Closset Finnish Meteorological Institute, Finland	• MI SmartBay Observatory • MI SmartBay Glider	• Cabled Observatory • Gliders and AUV	19.8
4062	GLOBE	Glider Observations of the Black sea Environment	Nikolay Valchev Institute of oceanology-bulgarian academy of sciences, Bulgaria	SOCIB Glider, Spain	Gliders and AUV	19.5
4063	MultiNuD2	In-situ parallel nutrient sensor deployments	Matthew Patey National Oceanography Centre, UK	UPC OBSEA, Spain	Cabled Observatory	22
4064	SMART	SMART: Sardinia-Mallorca Repeated Transect	Jacopo Chiggiato Consiglio Nazionale delle Ricerche, Italy	SOCIB Glider, Spain	Gliders and AUV	19
4065	LISTEN	Glider Mission to Resolve Mixing in the Southern Baltic	Anna Bulczak Institute of Oceanology Polish Academy of Sciences, Poland	Taltech Glider Mia + Profiler, Estonia	Gliders and AUV	20

8.User Project Reports

8.1.First TA Call

8.1.1. V-RUNAS

Project Information

Proposal reference number	21/1001596
Project Acronym (ID)	V-RUNAS
Title of the project	Validation of a Real-time Underwater Noise Acquisition System
Host Research Infrastructure	OBSEA (UPC)
Starting date - End date	20/09/2021 – 23/02/2022
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Ehsan Abdi Cyprus Subsea, 34A Paragogikotitas, 2326, Lakatamia, Cyprus e.abdi@cyprus-subsea.com +35797817638

Project Objectives

The main objective of this project is the technical and scientific validation of the Real-time Underwater Noise Acquisition System (RUNAS) in coastal waters. This system aims to provide real-time underwater noise measurements compliant with the Marine Strategy Framework Directive (MSFD) indicator 11.2.1. The scientific and technical validation of the system has three main objectives:

Objective 1: "Robustness and Readiness": Assess the proper functionality of the equipment and monitor its stability and performance, including mechanical components, internal electronics and software.

Objective 2: "In-situ underwater noise algorithms": Validate the real-time underwater noise algorithms embedded within RUNAS and compare them with the Sound Pressure Level dataset produced by the reference hydrophones at OBSEA.

Objective 3: "FAIR cyber-infrastructure": Setup and test a data management cyber-infrastructure following the FAIR principles (findable, accessible, interoperable and re-usable). Standard protocols and interfaces will be used to encourage the scientific use of the acquired data (e.g. calibration of underwater noise models, underwater noise impact on local fauna). This objective will be achieved by using Open Geospatial Consortium's standards for data and metadata archival and access (Sensor Observation Service, Sensor Modelling Language, Observations & Measurements) and combine them with tools that have a broad acceptance within the ocean observing community (e.g. ERDDAP).

Main achievements and difficulties encountered

The main outcome of this project was that for the first time, a system using off-the-shelf products and a commercially available hydrophone (namely icListen Kayak) were integrated and using the SWE Bridge interoperability framework. Furthermore, data acquired by the system has been successfully integrated in real-time in state-of-the art data services such as ERDDAP. Data has been processed according to the MSFD directive and is shared following the FAIR principles.

The system worked flawlessly during the whole deployment period: from 13th December 2021 until 3rd February 2022. The only difficulty was experimented during a communications outage at OBSEA, where the RUNAS system continued acquiring internally until the hard drive was full. This extreme and uncommon situation lead to some data loss. However, this situation can be easily solved in future deployments by placing a larger SD card on the junction box.

In the data analysis, data from both datasets (RUNAS dataset and a reference hydrophone at OBSEA) the 1/3 octave bands centered at 63 Hz and 125 Hz have a good correlation (98.18% and 96.69% respectively). However, the correlation at the 2000Hz 1/3 octave band is significantly lower: 78.96%. It is believed that the progressively decrease on the correlation is related to the higher self-noise of the OBSEA hydrophone, which leads to an artificial increment of the measured background noise as the 1/3 center frequency is incremented .

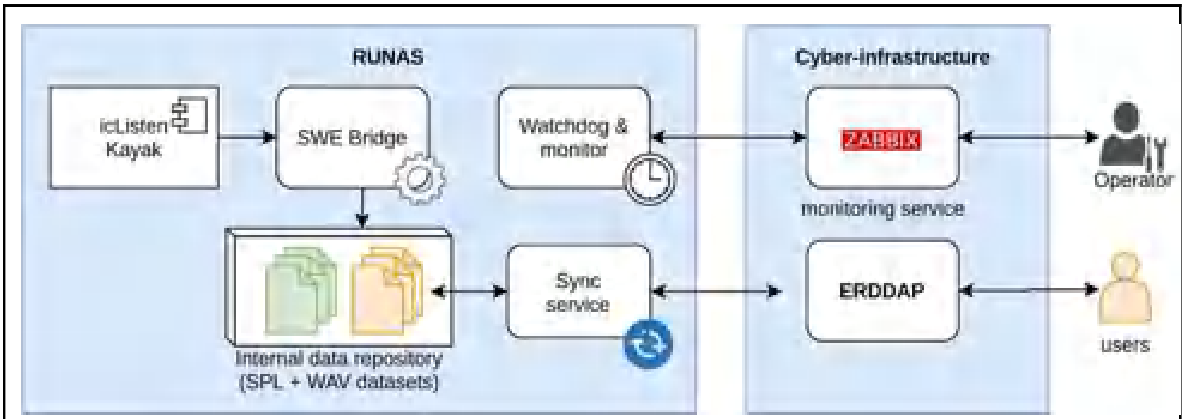
Dissemination of the results

Acoustic and processed Sound Pressure Levels (SPL) data from the experiment can be publicly access using the below links:
SPL:
https://erddap.obsea.emso.eu/erddap/tabledap/OBSEA_kayak_hydrophone_spl_levels.html
WAVS:
https://erddap.obsea.emso.eu/erddap/tabledap/OBSEA_kayak_hydrophone_wavs.html
It is planned to disseminate the results of the deployment and the data analysis in an upcoming conference paper.

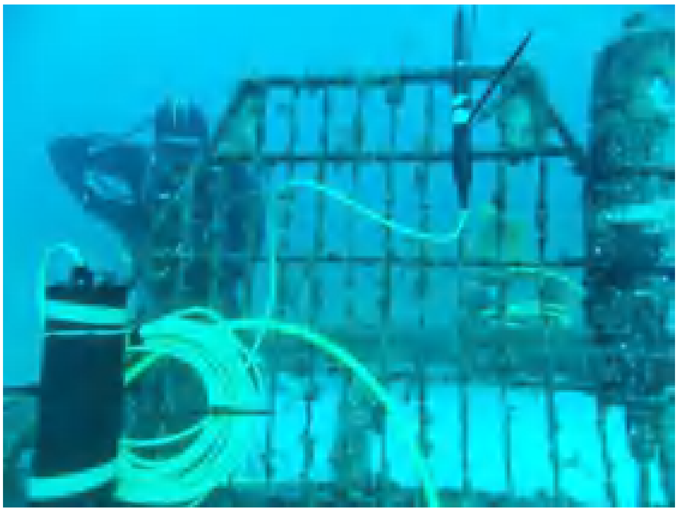
Technical and Scientific preliminary Outcomes

RUNAS System Development: The first step to achieve the above, was to decode the proprietary streaming protocol of the Kayak hydrophone. Then, a machine-actionable description of the hydrophone was created using the SensorML metadata standard (part of the OGC's Sensor Web Enablement framework). The open-source software SWE Bridge takes this information and interfaces the icListen accordingly, processing the acoustic data in real-time, generating a SPL dataset and acoustic recordings.

Using this framework SPL data were reporting an MSFD compliant stream of data straight into ERDDAP, making it accessible to everyone in real-time. Additionally, a monitoring system (Zabbix) was setup to monitor the system, providing technical feedback to the operators to ensure the correct operation of the system. The overview of the RUNAS system and its associated cyberinfrastructure is shown in the following diagram:



Deployment & recovery: The system was deployed on December 14th 2021 and recovered on 3rd Februrary 2022. In the following picture shows the RUNAS System deployed at OBSEA, including the Kayak hydrophone (center top) and the junction box (bottom left).

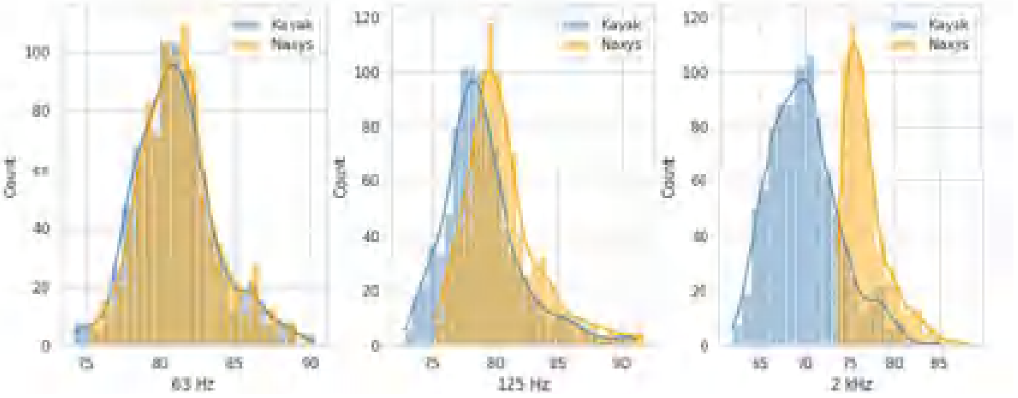


The Kayak hydrophone was situated approximately at 1.5 meters from the NAXYS hydrophone. The latter is the hydrophone permanently deployed at OBSEA, which will be used to validate the results from the RUNAS system.

The system proved reliable throughout the whole deployment, acquiring data continuously. The only data gap was during a communications outage at OBSEA, where data was logged internally until the RUNAS hard drive was full. For future deployments an increase of the internal space is recommended to extend the acquisition time during communications outages (although these events are quite uncommon).

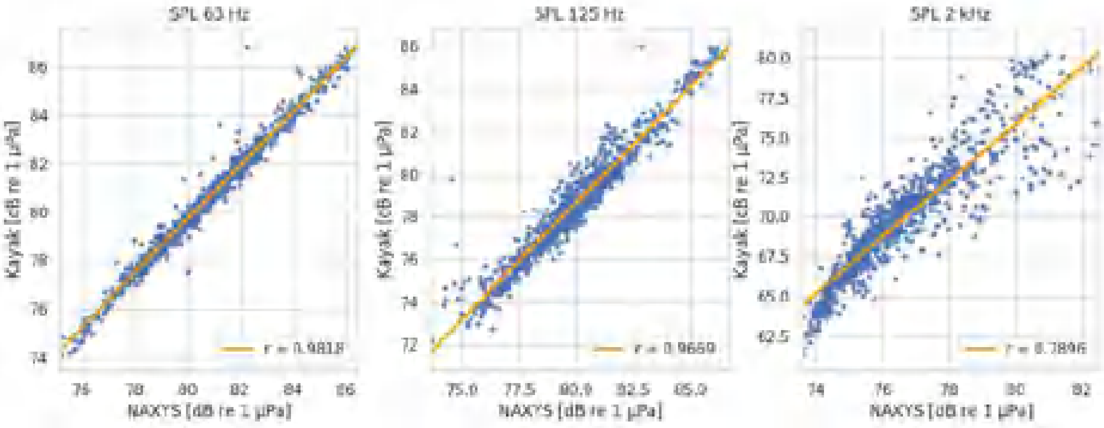
Data analysis: It has been detected that the self-noise of NAXYS hydrophone is significantly higher than the icListen kayak, leading to an artificial increase of the perceived background noise. The noise floor from the kayak dataset and the Naxys dataset increases as the ⅓ octave band center frequency. However, this effect is less apparent in the icListen kayak, due to its better self-noise characteristics.

The following plot shows the histogram and kernel density estimation (KDE) of the SPL measurements from both hydrophones at 1/3 octave bands centered at 63, 125 and 2000 Hz. It is possible to appreciate how the distance between the peaks of the different hydrophone distributions becomes greater as the frequency band center frequency increases. This phenomenon is believed to be associated with the increase of the bandwidth of the 1/3 octave band, thus introducing more self-noise power to the SPL calculation.



A part from the visual coherence between the histograms a correlation analysis has been performed using both datasets. However, in both datasets there are some outliers that do not have temporal coherence between datasets. Although it is difficult to assign a clear cause for these outliers, a hypothesis is the influence of biodiversity, such as fish and algae in the transducer proximity, producing air bubbles and impacts. These phenomena can produce locally significant changes in pressure, but they are rapidly attenuated as the distance increases. So, due to the distance between transducers these outliers are not captured in both datasets.

To minimize the influence of these outliers, the top 5% values from the distribution have been ignored in the correlation analysis (i.e. the values that conform the L95 percentile). Then, the correlation of SPL levels of both datasets can be observed in the following figure:



At the 63 and 125 Hz centered 1/3 octave bands the correlation is quite good (98.18 and 96.69% respectively). However, at 2kHz the correlation drops significantly until 78.96%, probably due to the different self-noise characteristics of both hydrophones.

8.1.2. FRONTIERS

Project Information

Proposal reference number	21/1001599
Project Acronym (ID)	FRONTIERS
Title of the project	Fault detection, isolation and Recovery fOr uNderwaTer glIdERS
Host Research Infrastructure	SOCIB, ES
Starting date - End date	02/07/2021 - 19/07/2021
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Enrico Anderlini, Marine Research Group, Department of Mechanical Engineering, University College London Roberts Engineering Building, London, WC1E 7JE, UK E.Anderlini@ucl.ac.uk +44 7450272675

Project Objectives

The updated aim of the project is to validate methods for the smart anomaly detection and fault diagnostics for underwater gliders. The project outcomes will help increase the reliability of these platforms and help over-the-horizon pilots to monitor the conditions of these systems.

The project aim will be achieved through the following updated objectives:

O1 Introduction of data-driven methods for the anomaly detection and fault diagnostics of MAS (as part of project ALADDIN funded by the Assuring Autonomy International Programme, a partnership of Lloyds' Register Foundation and the University of York);
O2 Validation of the tools with the actual field test of an underwater glider for the following case studies:

- suddenly wing loss;
- incorrect ballasting and trimming.

Main achievements and difficulties encountered

The project has successfully validated the introduced anomaly detection and fault diagnostics methods. The glider has been deployed, recovered and redeployed multiple times to simulate the loss of either wing, incorrect ballasting (through the addition or removal of weight pills) and incorrect trimming (through the addition or removal of the weight pills along the length of the vehicle as well as different settings of the internal battery position). Furthermore, the glider had additional intrinsic anomalies: slow leak in the thermal valve of the variable buoyancy device, a small offset in the CTD sensor readings and high energy consumption levels.

The simulated faults were correctly detected and identified, whilst the intrinsic smaller faults will provide additional training data to expand the system in the future. Validation of the diagnostics of these anomalies could be not completed as the training data available before the test from many other glider deployments did not present the same failures.

The main difficulties encountered concerned the global pandemic, which prevented the UCL team to travel to Mallorca due to the constantly changing travel rules. However, this problem was solved thanks to the professionalism of the SOCIB team, their user-friendly data exchange portal and regular email exchanges or calls. Bad weather before the project start meant that the project actually began a few days later than expected.

Dissemination of the results

The project has been advertised on LinkedIn with two posts with 1,749 total views on 23/07/2021 and to the AAIP.
Further planned dissemination activities involve:

- Open-access publication of the collected data on the SOCIB data portal https://www.socib.eu/?seccion=observingFacilities&facility=glider, https://thredds.socib.es/thredds/dodsC/auv/glider/sdeep01-scb_sldeep001/L0/2021/dep0036_sdeep01_scb-sldeep001_L0_2021-07-02_data_dt.nc.html,
- Publication of one collaborative journal article in the Journal of Field Robotics or IEEE Journal of Oceanic Engineering,
- Use of the results in up to three additional journal article publications as part of project ALADDAIN, https://www.york.ac.uk/assuring-autonomy/projects/unmanned-marine-systems-safety/,
- Inclusion of the project outcomes within the AAIP's Body of Knowledge entries 2.2.4.1 – Verification of sensing requirements, 2.2.4.2 – Verification of understanding requirements, https://www.york.ac.uk/assuring-autonomy/body-of-knowledge/,
- Advertisement on SOCIB's twitter account, https://twitter.com/socib_icts/status/1417784285264760833,
- Further advertisement on the principal investigator's LinkedIn account once the results are postprocessed.

Technical and Scientific preliminary Outcomes

Figure 1. Summary of the glider deployment for the FRONTIERS project.

The project mission is summarised in Figure 1, which shows the GPS coordinates of the glider during the deployment, the number of days spent at sea, the number of profiles undertaken, the distance covered, the maximum depth reached and the average surge speed.

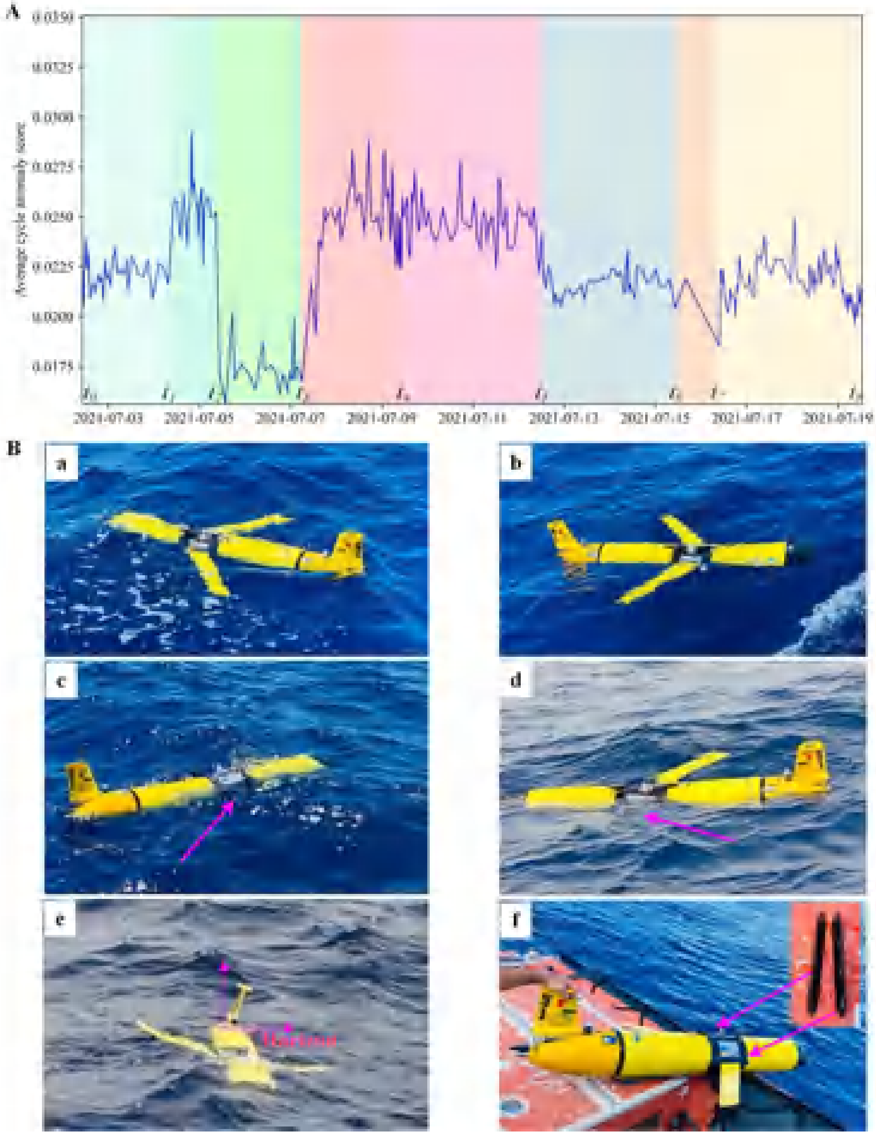


Figure 2. (A) anomaly scores over the test. (B) a: the glider at the beginning of the test, b: the glider before recovery at the end of the test, c: the glider with its starboard wing removed, d: the glider with its port wing removed, e: incorrectly ballasted glider, f: the balancing weight setting for the simulated trimming fault.

As shown in Figure 2A, the test started at t_0 (Figure 2B-a) and ended at t_8 (Figure 2B-b). The anomaly detection system based upon Bidirectional Generative Adversarial Networks (BiGAN) has successfully output anomaly scores over the test. The pitch angles for t_0-t_1, t_1-t_2, and t_2-t_3 were set as 30°, 18°, and 26°, respectively. The glider's starboard wing was removed at t_3 (see Figure 2B-c). At t_4, the starboard wing was restored while the port wing was removed (see Figure 2B-d). At t_5, the port wing was restored while the balancing weight setting in the wing rails was adjusted from left-2 & right-5 to left-5 & right-2 (each pill is 15.5 g) (see the vehicle status in Figure 2B-e). At t_6, the wrong battery position was applied. At t_7, the battery position servo mode was set, and the balancing weight setting was changed to left-0 & right-3 (2 extra pills removed along the length of the vehicle in each wing rail, see Figure 2B-f). The glider was recovered at t_8.

A data-driven anomaly detection system based on a BiGAN architecture with added hints was trained with data from deployments from the British Oceanographic Data Centre and the SOCIB portal. The system uses the decimated semi-real-time data signals from each dive of the glider sent ashore to calculate an anomaly score that can be used to determine whether anomalies are present on board the vehicle. Once trained, the system was validated using the data stream from the JERICO deployment. As can be seen in Figure 2A, as the 30° and 18° pitch settings were not included in the training dataset, high anomaly scores have been incorrectly returned at the start of the deployment for normal behaviour. However, the system was able to clearly detect the loss of wing, as removing the starboard and port wings resulted in high anomaly scores of similar magnitudes. Additionally, relatively high anomaly scores can be observed from t_5 to t_8 for the incorrect ballasting and trimming. In conclusion, the simulated faults were correctly detected, validating the proposed anomaly detection solution, although further work is needed to address the false positive at the start of the deployment. This will be tackled through data augmentation.

Additionally, the BiGAN architecture is used as the first layers of a classification-based, data-driven fault diagnostics system currently being actively developed. Correctly labelling the individual faults is particularly challenging due to the sever class imbalance towards healthy baseline glider behaviour. The data collected during project JERICO will be critical to develop and demonstrate this system. Work is currently being undertaken to validate this fault diagnostics method.

8.1.3. FRIPP-Spring

Project Information

Proposal reference number	21/1001600
Project Acronym (ID)	FRIPP-Spring
Title of the project	Frontal dynamics influencing Primary Production: investigating the onset of the spring bloom mechanism through gliders
Host Research Infrastructure	SOCIB
Starting date - End date	1 March - 30 April 2021
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	**ANTONIO OLITA** **ISAC - Institute of Atmospheric sciences and Climate, Cagliari section, Italy,** % Dipartimento di FIsica - Università degli studi di Cagliari, CIttadella Universitaria di Monserrato antonio.olita@cnr.it +39 328 532 11 16

Project Objectives

The project aims to study, through a multisensor sea-glider mission supported by modeled and remotely-sensed data, the impact of frontal dynamics on the Phytoplankton production and distribution as inferred from fluorometric measurements.

The specific objectives are the following:

1) Observe the dynamics of the front in terms of: horizontal and vertical velocities; instabilities; mixing and enhanced dynamical stratification
2) Study the impact of such frontal dynamics on new production and on displacement of phytoplanktonic biomass in a well mixed regime, during the first onset of the early spring bloom, *and characterize phytoplankton community composition through an Optical Community Index*

Main achievements and difficulties encountered

No particular technical difficulties have been encountered. The sampling was postponed of some week because of logistic issues. The glider started sampling the area on April 5. The mission ended on May 3, 2021. The main technical difficulties were due to strong currents encountered that obliged to correct the trajectory of the glider twice. Postponing the glider mission allowed to observe already structured DCM instead of the intiation of the Bloom along the front. Anyway interesting features have been matched.

Dissemination of the results

Dissemination by preparation of abstract for congresses was stopped because of COVID-19 pandemic that didn't allow people to attend conferences . Anyway I'm working on a paper based on the results of the sampling. Compatible with pandemic dynamic, I will also attend congresses (e.g. next EGU in WIEN) in 2022 to disseminate results.

Data are available here:
https://thredds.socib.es/thredds/catalog/auv/glider/sdeep06-scb_sldeep006/L0/2021/catalog.html?dataset=auv/glider/sdeep06-scb_sldeep006/L0/2021/dep0003_sdeep06_scb-sldeep006_L0_2021-03-30_data_dt.nc

https://thredds.socib.es/thredds/catalog/auv/glider/sdeep06-scb_sldeep006/L1/2021/catalog.html?dataset=auv/glider/sdeep06-scb_sldeep006/L1/2021/dep0003_sdeep06_scb-sldeep006_L1_2021-03-30_data_dt.nc

https://thredds.socib.es/thredds/catalog/auv/glider/sdeep06-scb_sldeep006/L2/2021/catalog.html?dataset=auv/glider/sdeep06-scb_sldeep006/L2/2021/dep0003_sdeep06_scb-sldeep006_L2_2021-03-30_data_dt.nc

Technical and Scientific preliminary Outcomes

The sampling was conducted as planned. A "butterfly" sampling was designed and conducted as represented in figure 1, where the planned track it is also shown.

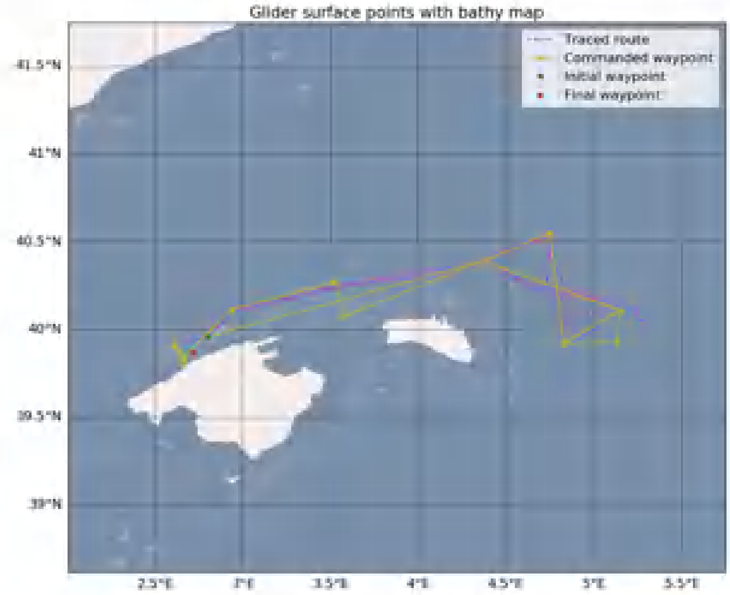


Fig.1 - Planned vs actual tracks of the glider flight.

As above mentioned, a structured Deep Chlorophyll Maximum was already onset on the area and period sampled, as a consequence of the dynamical and thermal stratification.

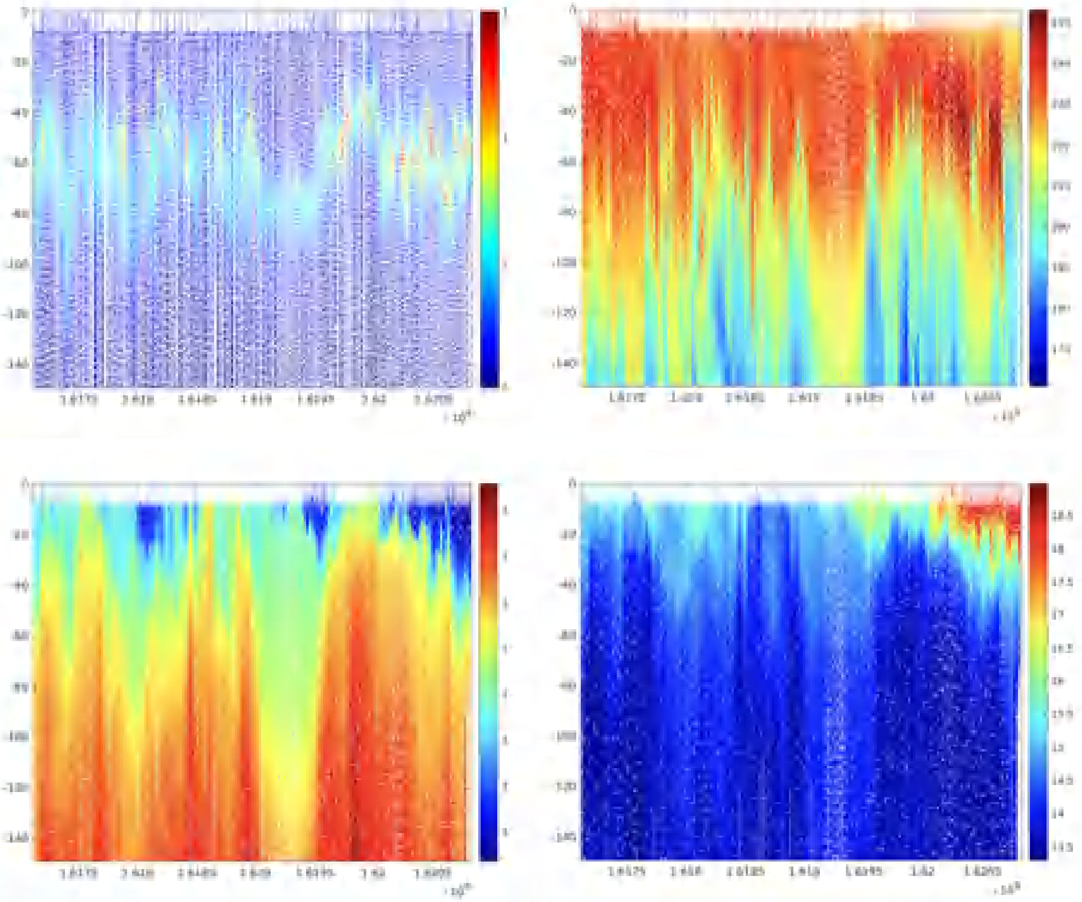


Fig.2 - From top left, clockwise: Chlorophyll, Oxygen concentration, Temperature and Salinity

sections.

In figure 2 the modulation of biological features (namely CHl concentration and Oxygen distribution) operated by physical features (the salinity front) are evident in the section. In particular the shallowing of the DCM depth in correspondence of the salinity front and the larger Chl concentration are probably linked to an enhanced production (as testified by the exceeding Oxygen concentration just above the production area).

The preliminary results are very promising and further analysis will be conduced to assess the role of the front in the increased DCM production.

8.1.4. MultiNuD

Project Information

Proposal reference number	21/1001601
Project Acronym (ID)	MultiNuD
Title of the project	In-situ parallel nutrient sensor deployments
Host Research Infrastructure	OBSEA
Starting date - End date	2021-07-22 - 2023-08-01
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Matthew Patey National Oceanography Centre, European Way, Southampton, SO14 3ZH mpatey@noc.ac.uk +44 (0)23 8059 6622

Project Objectives

In this project, we aimed to deploy lab-on-chip phosphate, silicate and nitrate in-situ sensors at the OBSEA coastal Observatory. We would collect a suite of laboratory-quality nutrient measurements over an extended period to produce a nutrient dataset with a temporal resolution that is unprecedented in the surface ocean.

While these prototype sensors had been deployed previously (e.g. in estuaries, rivers and low temperature (polar) waters, the coastal waters of the observatory offer environmental conditions that offer new challenges to the sensors. Specifically, we want to test three aspects that limit the capacity to deploy in-situ sensors in long-term moorings: reagent stability, biofouling, and low level performance.

Main achievements and difficulties encountered

The start of the project was delayed due to working restrictions at NOC and a large number of other delayed projects preventing work on this one. We sent the sensors to OBSEA in March2022 and they began work on integrating them into the observatory. OBSEA personnel created custom cables and a mounting bracket and wrote software to operate the sensors and retrieve results. This work was completed in June 2022 and two deployments were made in this month.

Unfortunately, changes to import and export procedures between the UK and Spain following Brexit resulted in large unforeseen costs to the project and €12 000 in VAT charges were paid when importing the sensors to Spain. This resulted in a large overspend on this project and we were unable to travel to oversee the deployments or repair or replace the sensors when they broke. OBSEA personnel were trained via video conference and successfully carried out two deployments. Unfortunately all the sensors failed on 6th July 2022 and no further data was collected.

Follow on funding was successfully requested from Jerico-S3 in the form of a follow on project (MultiNud 2), which has allowed us to send further sensors and personnel in 2023 in order to complete the planned work.

Dissemination of the results

Once the follow on project has been completed we hope to include data from the deployments in a published article. We will acknowledge Jerico-S3 in any publication that includes the data.

DOI: https://doi.org/10.17882/98662

Technical and Scientific preliminary Outcomes

- OBSEA have physically integrated NOC sensors with the OBSEA platform and are able to operate the sensors remotely and retrieve data from them in near real time.
- Despite NOC personnel not being able to attend in person, OBSEA personnel were trained remotely to operate the sensors.

Chronologically, the main activities at the facility were:

18/3/2022	sensors reception
10-16/6/2022	building cables and tests in lab
16/6/22	1st deployment Obsea
22/6/2022	recovery from Obsea
29/6/2022	2nd deployment
06/07/2022	recovery from Obsea
2/8/2022	3rd deployment
07/09/2022	recovery from Obsea

Figure 1. Integration of NOC sensors with OBSEA infrastructure.

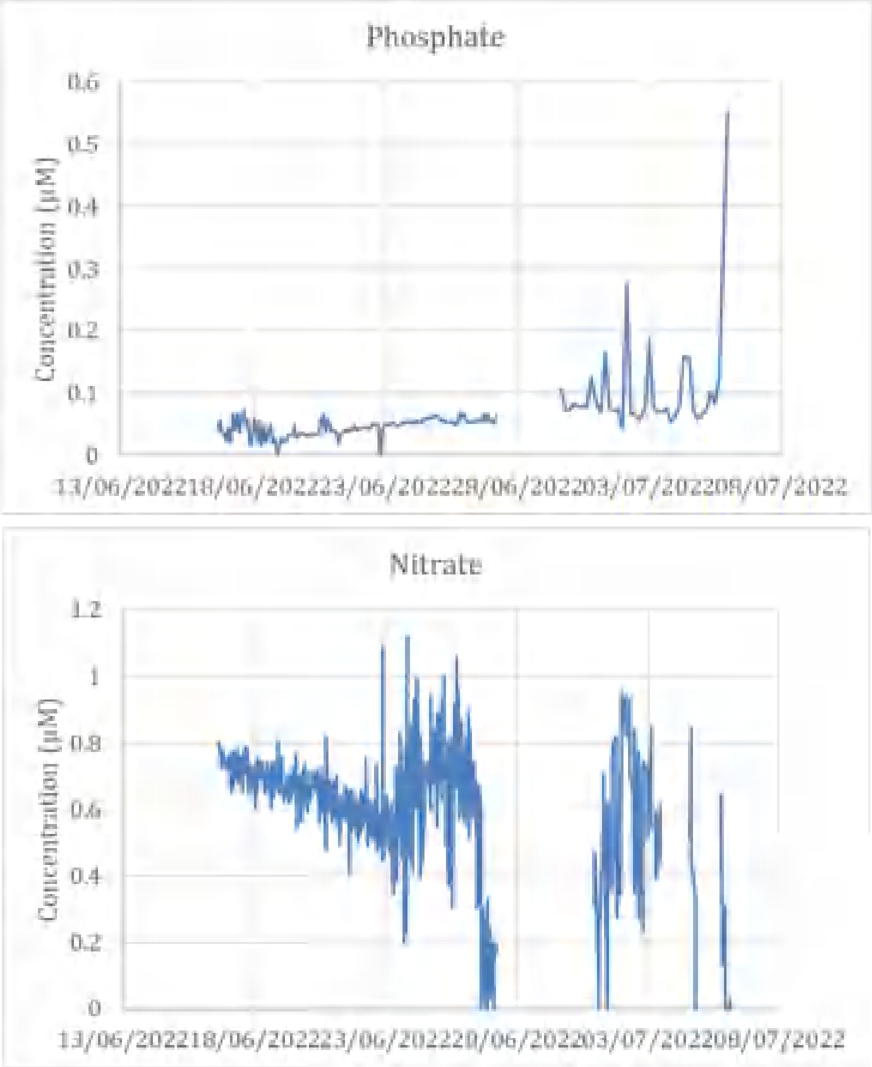


Figure 2. Preliminary data for nitrate and phosphate sensor showing about 2 weeks' data. A diurnal signal is apparent in the phosphate data during the last days of the second deployment.

8.1.5. ATLAS

Project Information

Proposal reference number	JS3_CALL_1_REF_4023
Project Acronym (ID)	ATLAS
Title of the project	Advanced ecosysTem monitoring in ecoLogicAl obServatory
Host Research Infrastructure	OBSEA
Starting date - End date	Images: 06/09/2021 – 19/09/2021 eDNA Sampling: 14/09/2021 - 17/09/2021
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Sergio Stefanni Stazione Zoologica A. Dohrn, Villa Comunale, 80121 Naples (ITALY) sergio.stefanni@szn.it +39 081 5833228

Project Objectives

This pilot project aims at setting a baseline of eDNA integration with other techniques/end users communities, that can be applied on fixed monitoring points such as cabled observatories. It comprises several aspects:

A- monitoring capability aspects on the integration of multiple independent datasets (images, sounds, environmental parameters with molecular genetics approaches), methodological for eDNA (time point sampling using Niskin bottles + filtration vs. autonomous sampler over 24 hours' period) and use of time-series as benchmark for comparison.

B- methodological aspects to expand the use of eDNA to evaluate the biodiversity monitoring efficiency in a coastal technological hub. The use of different primers combinations would provide feedbacks on hidden biodiversity components never measured with present sensor assets.

C- Validation aspects on the pathway or the creation of in-situ operating eco-genomic sensors: Automated eDNA sampler coupled with time point sampling could be redefined in terms of number (more sampling throughout the day) or filtering larger amount of water. Comparisons in monitoring capabilities by manual sampling and remotely scheduled filtering to be used as benchmark to set optimum volumes and frequency of filtering.

D- Data processing and statistic elaboration aspects: extract (prior) information from the long time series of OBSEA images , abiotic measurements and how eDNA can complement the monitoring process, to test hypotheses and cause/effect relationships associated to in situ manipulations.

Main achievements and difficulties encountered

The OBSEA (www.obsea.es) (Fig. 1) is equipped with Ocean Optics camera (360 dg. rotation capability) in the main node, movable tripod AXIS P1346 camera with 800 m cable length, and Imaging from a crawler (with 80 m tether). All cameras are equipped with lights. Underwater sensors include Temperature and Salinity (CTD), Chlorophyll and Turbidity (AWAC) (Fluorescence), Passive Acoustic Monitoring (PAM; Hydrophone). OBSEA has also a large database with information stored since 01 January 2012.

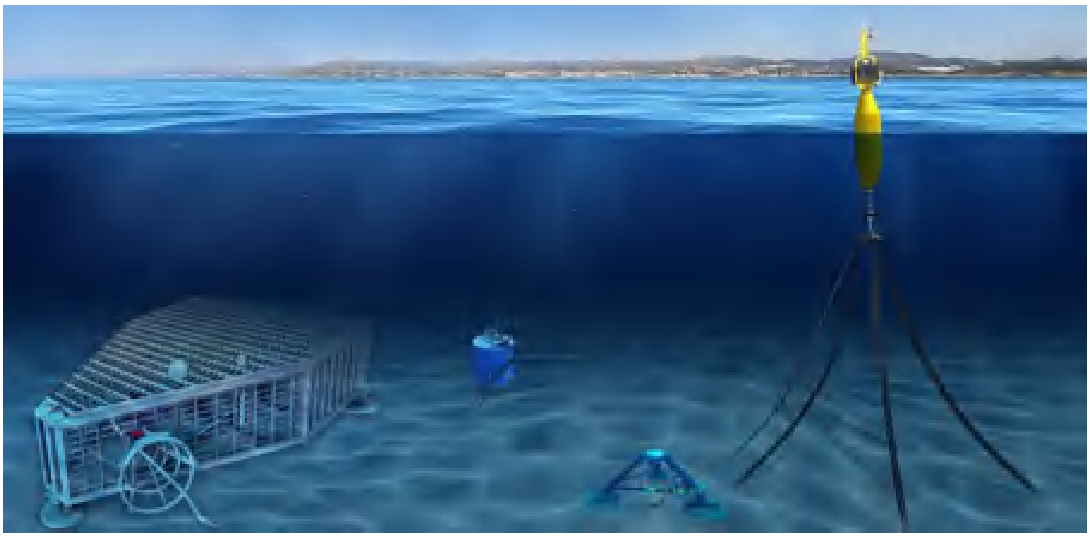


Figure 1. Schematic representation of OBSEA Observatory

The testing period for ATLAS had to be compacted in a single slot of time between 07-19/09/2021 for the imaging while the sampling for eDNA was concentrated in 3 days (14-17/09/2021). The main camera collected images from the water column (Fig. 2A), while the tripod camera was positioned and set to have in the field of view part of the artificial reef and part of the sandy bottom. Within the field of view of the cameras, the 2 autonomous samplers (Fig. 2B) trapped eDNA in time laps filtering up to 50L seawater, within a 24 hours' period, and deployed/retrieved at 20:00 of every day of the experiment. For the same days, and the same site, at 8:00 and at 20:00 respectively, an operator collected water using a Niskin bottle (3 independent replicates) and filtered 1L at the time on sterile Sterivex using a syringe (Fig. 2C).

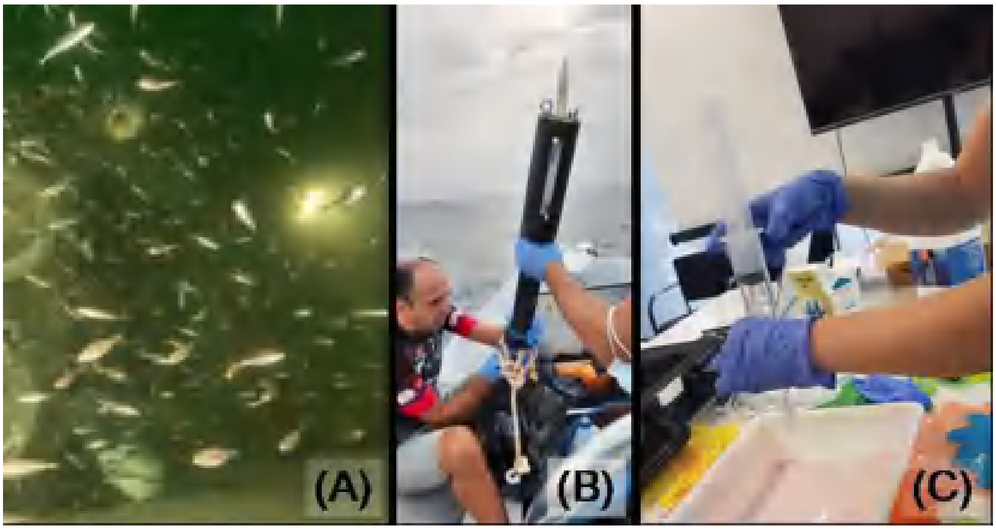


Figure 2. Image from the main camera (A), autonomous sampler (B) and syringe with sterivex filter ©

Capitalising from the 3 days experiment allowed us to explore more in details the methodological aspects of the efficiency in retrieving biodiversity using eDNA data comparing large volumes of seawater filtered every 24 hours (in duplicate) versus small volumes of water filtered in 2 time points a day (in triplicates)(Fig. 3). All filters were sent to Applied Genomics (UK) for eDNA extractions, amplifications (using 2 sets of primers targeting fishes), HT sequencing and bioinformatic analysis. Taxonomic association was compared to the list of species identified by image analysis.

Dissemination of the results

All work carried out in ATLAS, will be disseminated through scientific conferences and scientific articles in peer-reviewed journals. The methodological output will work as reference base-line for further monitoring programmes in OBSEA as well as other ecological observatories.

Most of the original data will be closed for usage by our team until the complete dataset is analysed and published in peer-reviewed journal and become publicly available.

However, we have no problems in sharing the original data prior to publication to other user of OBSEA.

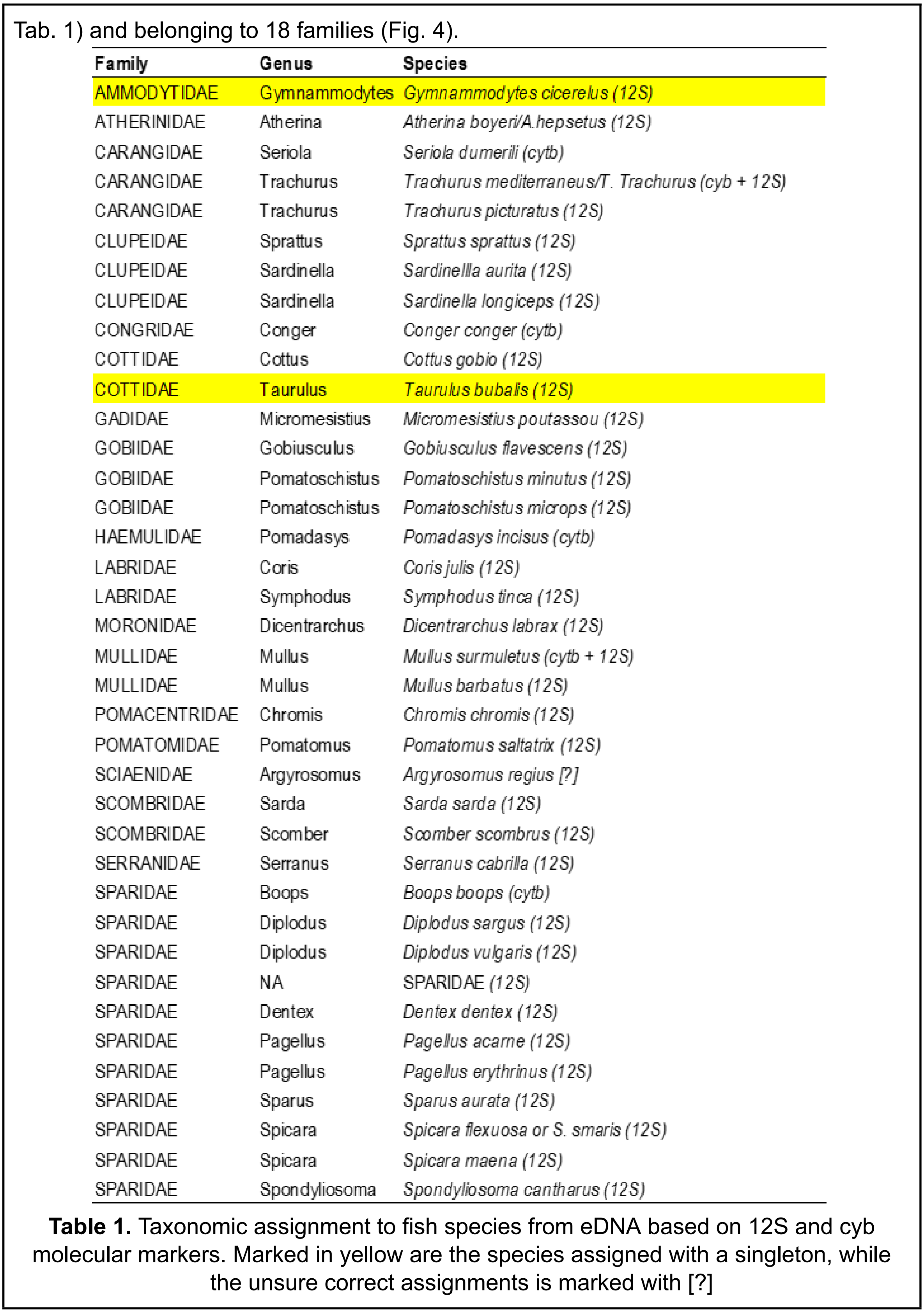
Data: https://www.seanoe.org/data/00848/95952/

Technical and Scientific preliminary Outcomes

Sequence analysis of eDNA was carried out at Applied Genomics (UK). All samples were processed using specific primers (12S and cytb) targeting fish assemblages. The number of reads assigned to fish varies across replicates and samples, either using small (sterivex) or large volumes (autonomous samplers) (Fig. 3). All samples collected with strerivex filtration provided larger amount of sequence reads attributed to fish.

Figure 3. Distribution of reads among sterivex and autonomous samplers. The contribute of 12S (in orange) and cyb (in green) are grouped in replicates (R1-3 and S1-2)) for sterivex and autonomous samplers, respectively. On top, it is shown how the data derived from large volume sampling and sterivex in the 3 days experiment were compared.

In total, combining all the sampling methods, the eDNA approach detected the presence of 38 species of fish (34 only by 12S and 4 only by cytb, 2 of which by both markers,



Tab. 1) and belonging to 18 families (Fig. 4).

Family	Genus	Species
AMMODYTIDAE	Gymnammodytes	*Gymnammodytes cicerelus (12S)*
ATHERINIDAE	Atherina	*Atherina boyeri/A.hepsetus (12S)*
CARANGIDAE	Seriola	*Seriola dumerili (cytb)*
CARANGIDAE	Trachurus	*Trachurus mediterraneus/T. Trachurus (cyb + 12S)*
CARANGIDAE	Trachurus	*Trachurus picturatus (12S)*
CLUPEIDAE	Sprattus	*Sprattus sprattus (12S)*
CLUPEIDAE	Sardinella	*Sardinella aurita (12S)*
CLUPEIDAE	Sardinella	*Sardinella longiceps (12S)*
CONGRIDAE	Conger	*Conger conger (cytb)*
COTTIDAE	Cottus	*Cottus gobio (12S)*
COTTIDAE	Taurulus	*Taurulus bubalis (12S)*
GADIDAE	Micromesistius	*Micromesistius poutassou (12S)*
GOBIIDAE	Gobiusculus	*Gobiusculus flavescens (12S)*
GOBIIDAE	Pomatoschistus	*Pomatoschistus minutus (12S)*
GOBIIDAE	Pomatoschistus	*Pomatoschistus microps (12S)*
HAEMULIDAE	Pomadasys	*Pomadasys incisus (cytb)*
LABRIDAE	Coris	*Coris julis (12S)*
LABRIDAE	Symphodus	*Symphodus tinca (12S)*
MORONIDAE	Dicentrarchus	*Dicentrarchus labrax (12S)*
MULLIDAE	Mullus	*Mullus surmuletus (cytb + 12S)*
MULLIDAE	Mullus	*Mullus barbatus (12S)*
POMACENTRIDAE	Chromis	*Chromis chromis (12S)*
POMATOMIDAE	Pomatomus	*Pomatomus saltatrix (12S)*
SCIAENIDAE	Argyrosomus	*Argyrosomus regius [?]*
SCOMBRIDAE	Sarda	*Sarda sarda (12S)*
SCOMBRIDAE	Scomber	*Scomber scombrus (12S)*
SERRANIDAE	Serranus	*Serranus cabrilla (12S)*
SPARIDAE	Boops	*Boops boops (cytb)*
SPARIDAE	Diplodus	*Diplodus sargus (12S)*
SPARIDAE	Diplodus	*Diplodus vulgaris (12S)*
SPARIDAE	NA	SPARIDAE *(12S)*
SPARIDAE	Dentex	*Dentex dentex (12S)*
SPARIDAE	Pagellus	*Pagellus acarne (12S)*
SPARIDAE	Pagellus	*Pagellus erythrinus (12S)*
SPARIDAE	Sparus	*Sparus aurata (12S)*
SPARIDAE	Spicara	*Spicara flexuosa or S. smaris (12S)*
SPARIDAE	Spicara	*Spicara maena (12S)*
SPARIDAE	Spondyliosoma	*Spondyliosoma cantharus (12S)*

Table 1. Taxonomic assignment to fish species from eDNA based on 12S and cyb molecular markers. Marked in yellow are the species assigned with a singleton, while the unsure correct assignments is marked with [?]

Figure 4. Proportion of specie of fish, grouped by the respective families, retrieved by eDNA approach combining sterivex and autonomous samplers.

The small volume sampling (sterivex, 1L each with 3 replicates at every morning and evenings) performed more efficiently than the large filters mounted on the autonomous samplers (50L each) in retrieving eDNA to trace fish at OBSEA (Fig. 5A). And while the autonomous sampler collected eDNA in time-laps over 24 hours, the sampling with the sterivex allowed to analyse separately the detection of fish species in the morning and evenings separately (Fig. 5B).

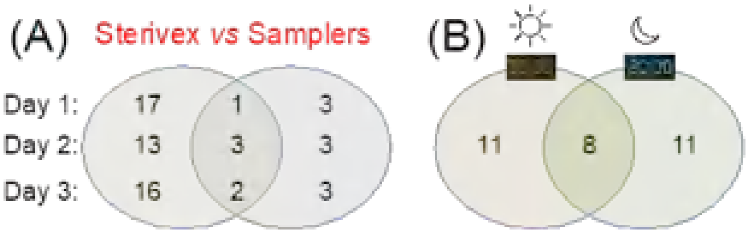


Figure 5. Proportion of species of fish retrieved by eDNA approach by: (A) the two sampling methods (sterivex vs autonomous samplers) and (B) sterivex sampling in the mornings vs evenings.

8.1.6. FISHES a

Project Information

Proposal reference number	Ref.21_1605-JS3_CALL_1_REF_4024a_FISHES
Project Acronym (ID)	FISHES (A)
Title of the project	FISHES@OBSEA: Fibre-optic Intelligent Submarine High-Fidelity Environmental Sensing at OBSEA
Host Research Infrastructure	OBSEA
Starting date - End date	9/12/21-14/2/22
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Dr M. Belal National Oceanography Centre European Way, Southampton SO14 3ZH, UK mob@noc.ac.uk 0771962585

Project Objectives

Key objective is to demonstrate our Distributed Acoustic Sensing (DAS) capability, i.e., ability to measure close to shot-noise broadband spatially resolved distributed measurements on the existing seafloor cable, in three different environmental conditions. This application covers access to one of three observatory access requests for this investigation. The tests conducted on the sea-floor cable will demonstrate monitoring-coverage of the multiparameter marine environmental variables space without affecting the fundamental electrical operability and connectivity purpose of the cable. The aim of this test would be to capture several marine processes, namely:

1. Tracking: anthropogenic activity and/or structural health of the cable, albeit because of the active noise sources, e.g., scuba divers, vessel/ship traffic activity, water flow structure etc.

2. Wind/waves/currents: such events in shallower waters impact the seafloor and hence the cable more directly. Distributed strain profiling over well separated time events will help capture these signatures.

Main achievements and difficulties encountered

We have successfully managed to pick anthropogenic activities, e.g., diver motion and their underwater actions. Additionally, we have also been successful in identifying contributions from dynamic changes in physical oceanographic features, e.g., wave changes due to surface winds etc, to the ambient noise variability observed over the duration of tests.

Harsh weather enabled insights into the dynamics of the physical oceanographic features (surface wind related wave characteristics etc.), and how they contribute to significant background noise which compromises the SNR (Signal to Noise Ratio) of an event of interest. For example, when tracking anthropogenic activity across different sections of the cable, which due to its variable orientation relative to the seabed, experiences varied dynamic loading from the consequently varied physical oceanographic effects, it inadvertently suffers from deteriorating SNR. However, the ability to leverage the characteristically distinct frequency of an event and its unique temporal evolution is what helped disentangle the diver actions, despite poor SNR on occasions.

The staff/members at the facility in OBSEA were supportive and incredibly flexible. For instance, the recording of events during the test plan could not be in strict accord with the plan directives. This was largely due to the lack of controllability (orientation etc.) of the UW speaker system. Despite these logistical challenges thrown at us during the execution of the desired test plan, impromptu decisions were welcomed and incorporated by the in-field staff at OBSEA. This led to a professional execution despite immense variability in sea state and hence speaker orientation.

Dissemination of the results

Results from the experiment will be published in high-impact journals.

Data in Seanoe: Belal Mohammad (2022). Jerico-S3 TNA access data- Fibre-optic Intelligent Submarine High-Fidelity Environmental Sensing at OBSEA. SEANOE. https://doi.org/10.17882/88395

Technical and Scientific preliminary Outcomes

Several TBs of data has been generated which will be analysed in detail over time. However, early analysis reveals that anthropogenic cable ambient activity (as shown in figure 1), is successfully picked and identified together with other natural sources of noise, e.g., surface generated turbulence due to wind forcing etc., visible in the same figure, albeit over 200 – 300 m section, all throughout the time series. Figure 1 shows the last 700 m of interrogated cable section.

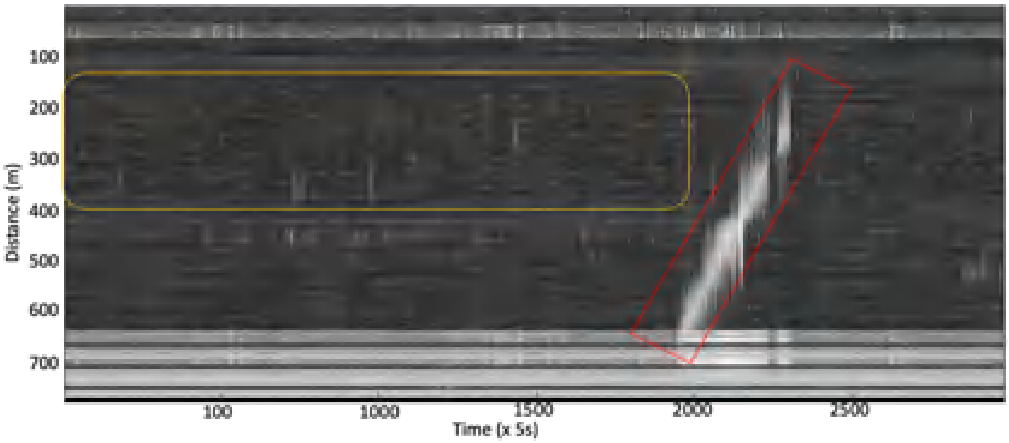


Figure 1: Shows ambient anthropogenic activities captured as a function of offshore distance and time during interrogation of the last 700 m of the seafloor cable at OBSEA, with 0 – 5kHz bandwidth. The red and orange box regions highlight the simultaneous identification of the constituent signals (diver activity and wave motion, respectively) contributing to the ambient marine noise.

Figure 2, which focuses over 0.5 - 1 kHz bandwidth, enables better appreciation of the features in the data, belonging to the region inside the orange box, shown in figure 1.

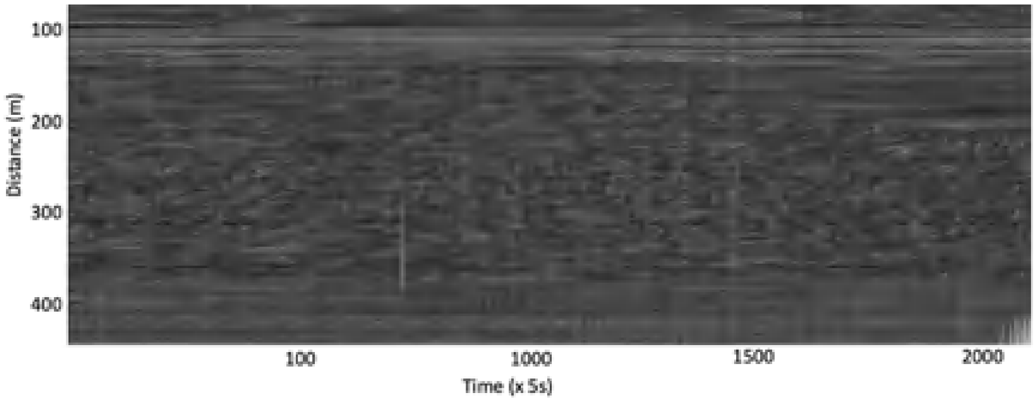


Figure 2: Shows the zoomed in version of the data from figure 1, albeit belonging to the space-time region within the orange box, analysed with frequency band energies corresponding

to the 200 – 500 Hz.

Figure 3 shows ambient noise (together with identification of some of the contributing signal fields to the noise) over 4 kms of cable length and 0 – 1kHz bandwidth.

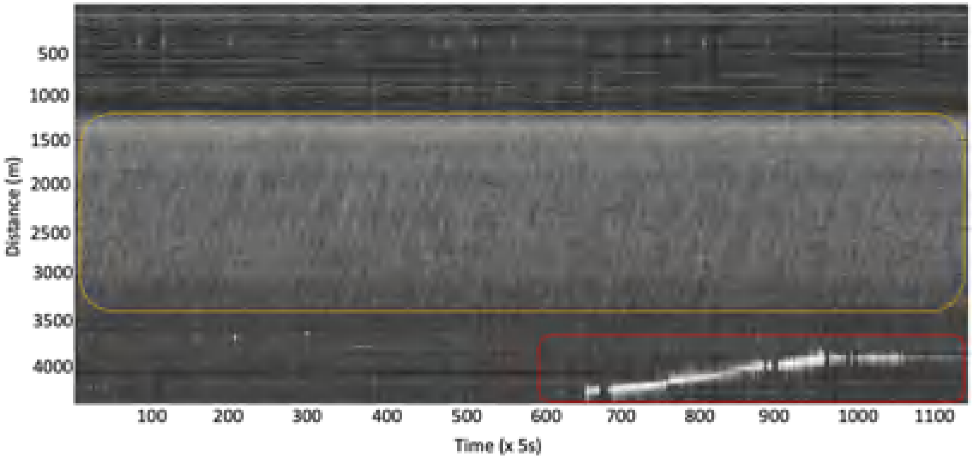


Figure 3: Shows ambient anthropogenic activities captured as a function of offshore distance and time during interrogation of much longer length of seafloor cable at OBSEA, with 0 – 1kHz bandwidth. The red and orange box regions highlight the simultaneous identification of the constituent signals (diver with ongoing repair activities and physical oceanographic motions corresponding to a buried section of the cable, respectively) contributing to the ambient marine noise.

The findings and their ongoing analysis bring us a step closer to realising some of the machine learning approaches which will enable localisation and tracking attributes to be realised, albeit of both natural and anthropogenic activities. The comparative analysis between ambient noise (especially natural noise fields) signatures between exposed (figure 2)and buried (figure 3, orange box section) cable sections should provide insights into the nature of noise coupling and open prospects to examining seafloor too.

Additionally, the variability in the weather pattern, had been found to contribute to the variability in the ambient marine noise content and distribution. This renders the prospects of disentangling several of its attributes through detailed statistical modelling, which is an ongoing investigation, that should ensure tremendous opportunities for enabling development and realisation of novel learning algorithms.

8.1.7. FISHES b

Project Information

Proposal reference number	Ref.21_1631-JS3_CALL_1_REF_4024b_FISHES
Project Acronym (ID)	FISHES (B)
Title of the project	FISHES@SMARTBAY: Fibre-optic Intelligent Submarine High-Fidelity Environmental Sensing at SMARTBAY
Host Research Infrastructure	SmartBay
Starting date - End date	19/11/2021-3/12/21

Name of Principal Investigator	Dr M. Belal
Home Laboratory Address	National Oceanography Centre European Way, Southampton SO14 3ZH, UK
E-mail address	mob@noc.ac.uk
Telephone	0771962585

Project Objectives

Key objective is to demonstrate our Distributed Acoustic Sensing (DAS) capability, i.e., ability to measure close to shot-noise broadband spatially resolved distributed measurements on the existing seafloor cable, in three different environmental conditions. This application covers access to one of three observatory access requests for this investigation. The tests conducted on the sea-floor cable will demonstrate monitoring-coverage of the multiparameter marine environmental variables space without affecting the fundamental electrical operability and connectivity purpose of the cable. The aim of this test would be to capture several marine processes, namely:

1. Wind/waves/currents: such events in shallower waters impact the seafloor and hence the cable more directly. Distributed strain profiling over well separated time events will help capture these signatures.

2. High-resolution temperature changes (~ 0.001 °C) enabling insight into differential thermal loading effects

3. Ambient marine noise (passive) variability

4. Tracking: aquatic mammals, structural health of the cable, scuba divers, vessel/ship traffic activity, water flow structure, e.g., surface generated turbulence due to wind forcing, etc.

Main achievements and difficulties encountered

We have successfully managed to pick anthropogenic activities both in the marine as well as terrestrial environments, e.g., vessel motion, road traffic etc. Additionally, we have also been successful in identifying contributions from dynamic changes in physical oceanographic features, e.g., wave changes due to surface winds etc, to the ambient noise variability observed over the duration of tests.

Whilst harsh weather enabled insights into the dynamics of the physical oceanographic features (surface wind related wave characteristics etc.), it contributed to significant background noise which compromises the SNR (Signal to Noise Ratio), especially when tracking anthropogenic activity across different sections of the cable, which due to its variable orientation relative to the seabed, experiences varied dynamic loading from the consequently varied physical oceanographic effects.

The support extended from the staff/members at the facility in SMARTBAY was incredible. The recording of events during the test plan in accordance with the plan directives and execution of tests, yet again in line with the plan details was not only done professionally, but with apt scientific rigor.

Dissemination of the results

Promotional Article for Trials at SmartBay: *The UK's National Oceanography Centre to trial Artificial Intelligence at the SmartBay Observatory through the JERICO-S3 project*. Date TBC

Results from the experiment will be publish in high-impact journals

Belal Mohammad (2022). Jerico-S3 TNA access data- Fibre-optic Intelligent Submarine High-Fidelity Environmental Sensing at Smartbay. SEANOE. https://doi.org/10.17882/86453

Technical and Scientific preliminary Outcomes

Several TBs of data has been generated which will be analysed in detail in time. However, early analysis reveals that anthropogenic activity, both marine and terrestrial (as shown in figure 1), is successfully identified together with other natural sources of noise, e.g., wave swells (as shown in figure 2) etc., whilst being agnostic to the cable type, orientation, and location.

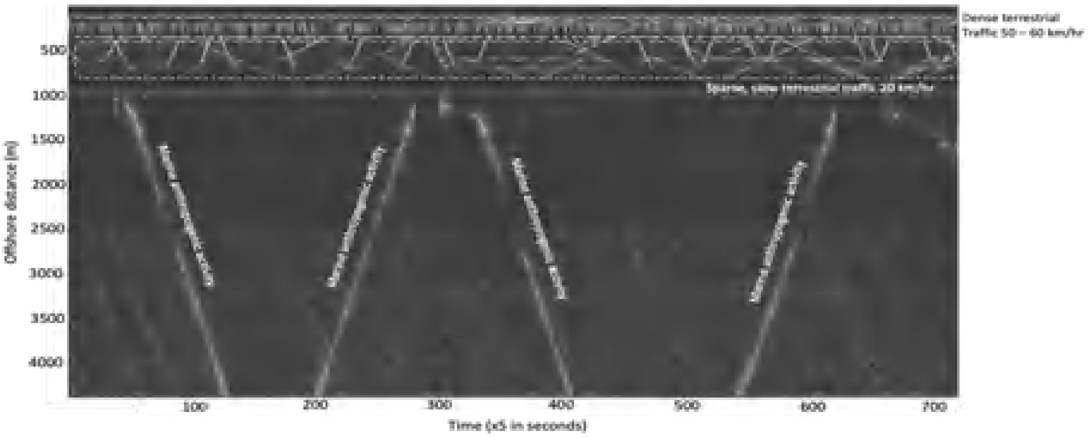


Figure 1: Shows marine and terrestrial anthropogenic activities captured as a function of offshore distance and time during interrogation of the seafloor cable at SMARTBAY

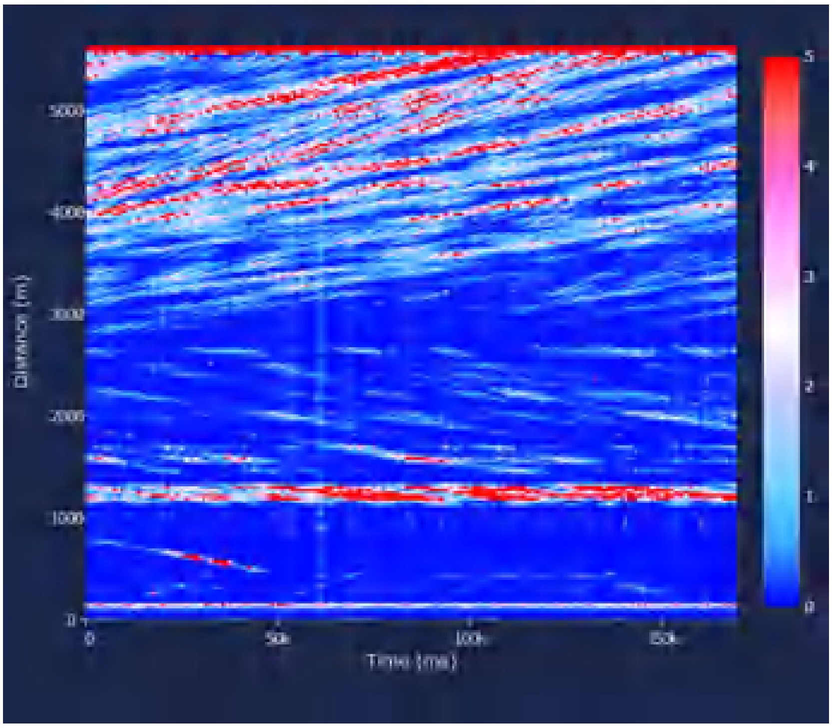


Figure 2: Shows the wave swells captured as high energy exhibits during interrogation of the seafloor cable. The change in directionality of the energy expressions from the wave swells beyond 2500 m offshore is attributed to the change in the cable direction beyond 2500 m offshore (cable makes a right angle turn after first 2500 m offshore)

The findings and their ongoing analysis bring us a step closer to realising some of the machine learning approaches which will enable localisation and tracking attributes to be realised.

Additionally, the variability in the weather pattern, had been found to contribute to the variability in the ambient marine noise content and distribution. This renders the prospects of disentangling several of its attributes through detailed statistical modelling, which is an ongoing investigation, that should ensue tremendous opportunities for enabling realisation of novel self-learning algorithms.

8.1.8. DEEPDEG (SICO)

Project Information

Proposal reference number	21/1001606 Sicily Channel Observatory (SiCO)
Project Acronym (ID)	DeepDeg
Title of the project	Development of a reliable system to assess biodegradation of different materials in the European deep sea (DeepDeg)
Host Research Infrastructure	CNR ISMAR
Starting date - End date	10/02/2021 - 12/31/2023

Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Andreas Eich, Christian Lott, Miriam Weber HYDRA Marine Sciences GmbH Steinfeldweg 15 77815 Bühl Germany m.weber@hydramarinesciences.com +491624354131

Project Objectives

- To conduct a pilot experiment to demonstrate the feasibility of using the exposure method adapted from shallow water systems for repeated deployments and retrievals of samples in deep sea environments.
- To analyze and compare the specific degradation time of different materials in the deep sea by measuring material loss.
- To collect sufficient data to apply statistical modeling on the degradation data set and calculate material- and site-specific half-life for plastic films, fibrous materials, and fabric materials.
- To compare degradation speed under environmental settings of the Sicily Channel.
- To obtain the baseline to plan then additional experiments to compare degradation rates of different materials in various ocean basins, depths, and habitats.

Main achievements and difficulties encountered

The main achievements of the project include the successful demonstration of the feasibility of using the adapted method from shallow water systems for repeated deployments and retrievals of samples in deep sea environments. This has provided valuable insights into the specific disintegration time of different materials in the deep sea, shedding light on material loss. Additionally, a comparison of disintegration under environmental settings in the Sicily Channel has yielded valuable information on the reduction of pollution and environmental impact. Furthermore, these achievements have laid a good baseline for planning further experiments in various ocean basins, depths, and habitats, contributing to a comprehensive understanding of material residence time in marine environments. However, one of the main difficulties encountered was the collection of sufficient data to apply statistical modelling on the disintegration data set, particularly for fast disintegrating materials and small or thin items from which several data points are needed for subsequent modelling and calculation of material- and site-specific half-life for plastic films, fibrous materials, and fabric materials. The proposed solution is to either deploy only minimum 2mm thick demonstrators or sample more frequently than every 6 months.

Dissemination of the results

The results of the JERICO -S3 project will now be analysed and published in a scientific publication in the near future.

Technical and Scientific preliminary Outcomes

1. Custom-built metal frames have been successfully tested for holding the samples, demonstrating readiness for deep-sea deployment (Fig. 1 and 2).
2. The frames were successfully used repeatedly in the Sicily Channel (SICO) (Fig. 1,

2).
3. Due to the pandemic a HYDRA scientist did not participate in cruises to deploy and retrieve the samples. Ensuring accurate documentation and sampling was achieved through training of CNR-ISMAR colleagues (Dr. Giuseppe Suaria). After deployment, the samples were retrieved by the facility operator and shipped back to HYDRA for further analysis.
4. 343 samples were deployed during the experiments. No sample was lost. Documentation at each retrieval (Fig. 3).
5. Most of the samples which were expected to disintegrate were disintegrated to 100% or nearly 100% (Tab. 1).
6. As expected, the negative control, LDPE film, showed no disintegration. It also showed no signs that the downward and upward application caused mechanical changes to the samples. Similarly, as expected, no degradation was observed in 3 of the TexDeg samples because these fabrics are non-biodegradable.
7. The filter paper, the positive control, was already 100% disintegration after 612 days in the SICO. We can only estimate how quickly it effectively disintegrated 12 and 18 months, as it is not possible to analyze the samples in between.
8. The natural material wood was, as expected, the slowest to disintegrate. In SICO no disintegration could be recorded (0%) after 612 days, however at CoCM after 1249 days.
9. The exposed cotton T-shirt, the MaterBi shopping bag, the Profissimo organic waste collection bag, the PHB Mirel film, and the disintegrading TexDeg samples showed 100% or close to 100% disintegration. The cigarette filters were not disintegrated after 612 days, and the biodegradable labeled cigarette filters had disintegrated by 80±26% (smoked) or 67±40% (non-smoked).
10. The disintegration of the samples was more advanced in the CoCM site than in the SICO. This is primarily due to the exposure time of 1060 and 612 days respectively. The TexDeg fabrics were exposed for 707 (CoCM) and 612 (SICO) days respectively. Here too, the disintegration in the CoCM was further than in the SICO. The 3 months longer exposure time could be the reason, and/or also better conditions for degradation. Metadata collected during the cruises, such as the nutrient concentration of the surrounding water, the microbial community in the environment, temperature, oxygen, salinity, etc. will be used for further interpretation of the disintegration data.

These outcomes demonstrate the successful development and testing of the custom-built frames, as well as the planned deployment and retrieval process, which will contribute to the accurate measurement and analysis of material degradation in marine deep-sea environments.

Figure 1: PHB film sample prior and post assembling in protection frames and mesh. Mounted onto steel frame ready for deployment at Sicily channel (SICO).

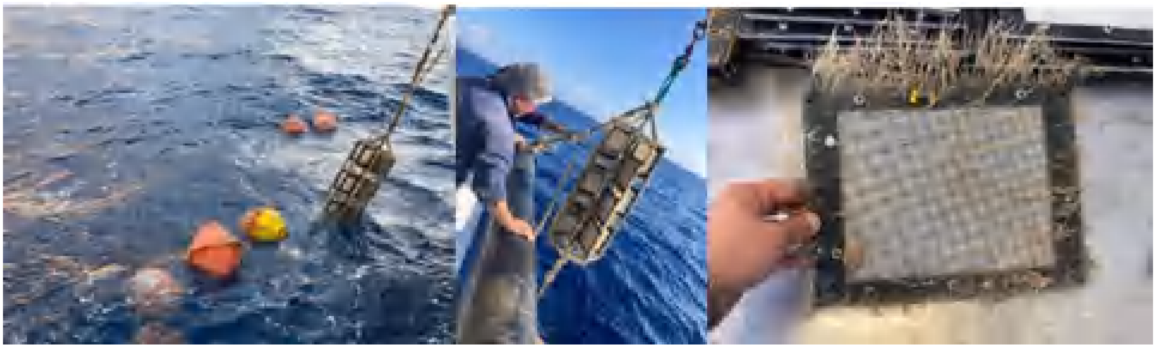


Figure 2: Retrieval of the steel frame with mounted samples at Sicily Channel (SICO) in October 2022, and documentation of fouling. All pictures are representative for the deployment at the Corsica Channel (CoM).

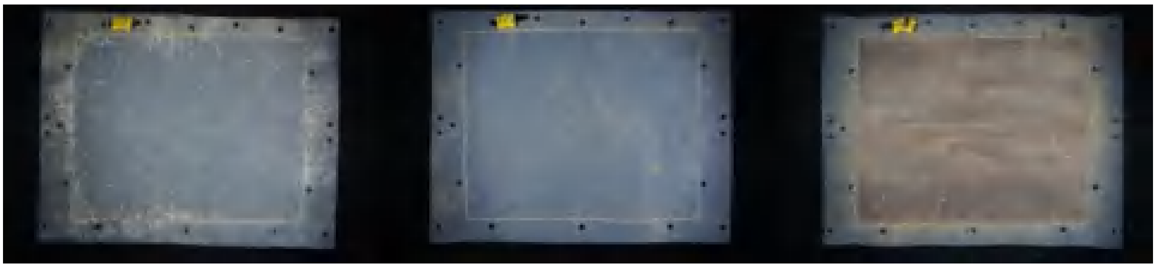
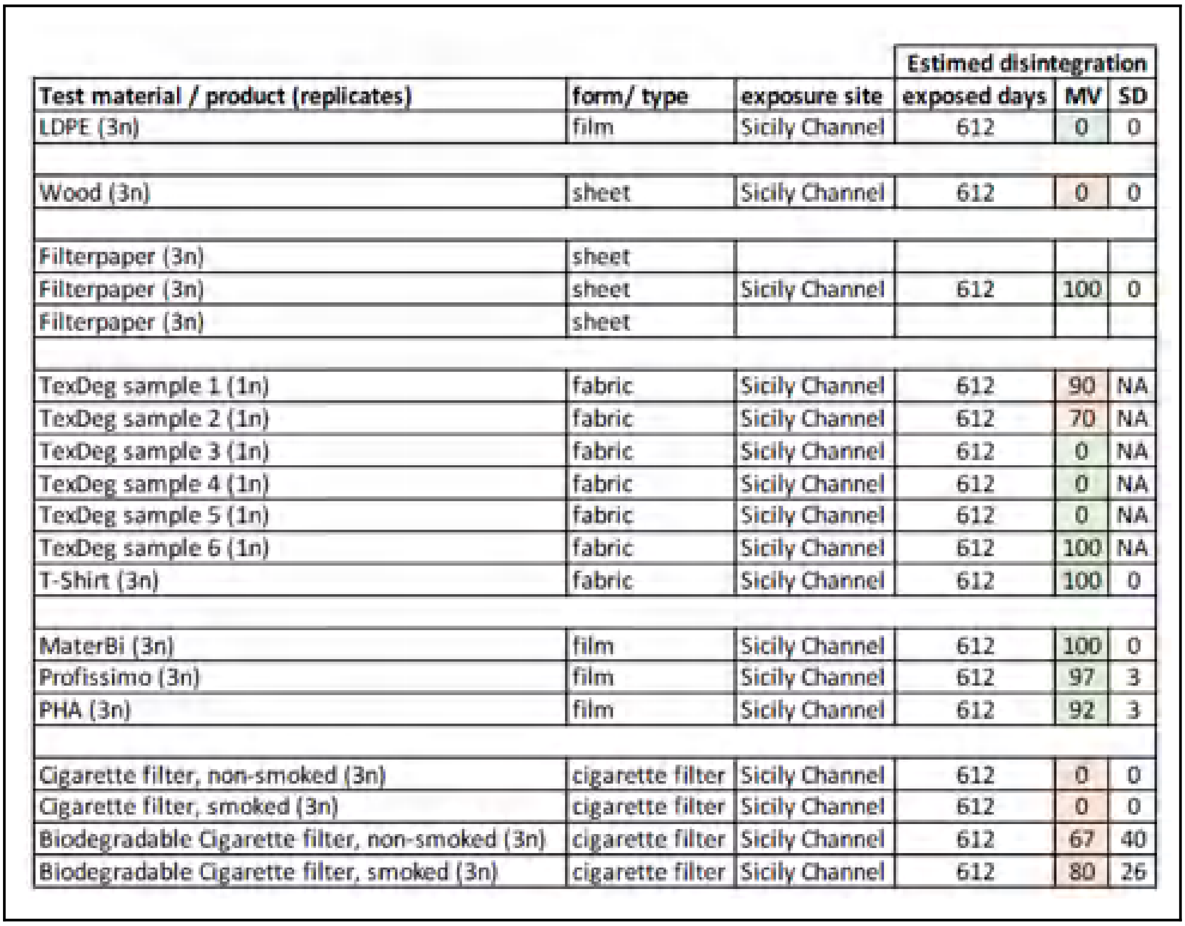


Figure 3: Documentation of samples after dismantling from protective mesh and frame. Photo documentation with the fine protective mesh: 3E1: white PHB film (100%), 3F1: white Cellulose filter paper (100%); 3W1: thin brown wood plate (0%=intact), exposed at Sicily channel (SICO).

Table 1: Estimated disintegration (mean value and standard deviation) of LDPE shopping bag, thin wood plate, cellulose filterpaper, 7 textiles samples, MaterBi shopping bag, Profissimo compost collection bag, PHA film, and 2 types of cigarette filters (smokes, and non-smoked), after exposure of 612 days at 532 m depth in the channel of Sicily (SICO), respectively. Green colour indicates similar results between Corsica and Sicily channel, red colour not.



			Estimed disintegration		
Test material / product (replicates)	form/ type	exposure site	exposed days	MV	SD
LDPE (3n)	film	Sicily Channel	612	0	0
Wood (3n)	sheet	Sicily Channel	612	0	0
Filterpaper (3n)	sheet				
Filterpaper (3n)	sheet	Sicily Channel	612	100	0
Filterpaper (3n)	sheet				
TexDeg sample 1 (1n)	fabric	Sicily Channel	612	90	NA
TexDeg sample 2 (1n)	fabric	Sicily Channel	612	70	NA
TexDeg sample 3 (1n)	fabric	Sicily Channel	612	0	NA
TexDeg sample 4 (1n)	fabric	Sicily Channel	612	0	NA
TexDeg sample 5 (1n)	fabric	Sicily Channel	612	0	NA
TexDeg sample 6 (1n)	fabric	Sicily Channel	612	100	NA
T-Shirt (3n)	fabric	Sicily Channel	612	100	0
MaterBi (3n)	film	Sicily Channel	612	100	0
Profissimo (3n)	film	Sicily Channel	612	97	3
PHA (3n)	film	Sicily Channel	612	92	3
Cigarette filter, non-smoked (3n)	cigarette filter	Sicily Channel	612	0	0
Cigarette filter, smoked (3n)	cigarette filter	Sicily Channel	612	0	0
Biodegradable Cigarette filter, non-smoked (3n)	cigarette filter	Sicily Channel	612	67	40
Biodegradable Cigarette filter, smoked (3n)	cigarette filter	Sicily Channel	612	80	26

8.1.9. DEEPDEG (CoCM)

Project Information

Proposal reference number	21/1001635 (Corsica Channel Mooring (CoCM)
Project Acronym (ID)	DeepDeg
Title of the project	Development of a reliable system to assess biodegradation of different materials in the European deep sea (DeepDeg)
Host Research Infrastructure	CNR ISMAR
Starting date - End date	10/02/2021 - 12/31/2023
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Andreas Eich, Christian Lott, Miriam Weber HYDRA Marine Sciences GmbH Steinfeldweg 15 77815 Bühl Germany m.weber@hydramarinesciences.com +491624354131

Project Objectives

- To conduct a pilot experiment to demonstrate the feasibility of using the exposure method adapted from shallow water systems for repeated deployments and retrievals of samples in deep sea environments.
- To analyze and compare the specific degradation time of different materials in the deep sea by measuring material loss.
- To collect sufficient data to apply statistical modeling on the degradation data set and calculate material- and site-specific half-life for plastic films, fibrous materials, and fabric materials.
- To compare degradation speed under environmental settings of the Corsica Channel.
- To obtain the baseline to plan then additional experiments to compare degradation rates of different materials in various ocean basins, depths, and habitats.

Main achievements and difficulties encountered

The main achievements of the project include the successful demonstration of the feasibility of using the adapted method from shallow water systems for repeated deployments and retrievals of samples in deep sea environments. This has provided valuable insights into the specific disintegration time of different materials in the deep sea, shedding light on material loss. Additionally, a comparison of disintegration under environmental settings in the Corsica Channel has yielded valuable information on the reduction of pollution and environmental impact. Furthermore, these achievements have laid a good baseline for planning further experiments in various ocean basins, depths, and habitats, contributing to a comprehensive understanding of material residence time in marine environments. However, one of the main difficulties encountered was the collection of sufficient data to apply statistical modelling on the disintegration data set, particularly for fast disintegrating materials and small or thin items from which several data points are needed for subsequent modelling and calculation of material- and site-specific half-life for plastic films, fibrous materials, and fabric materials. The proposed solution is to either deploy only minimum 2mm thick demonstrators or sample more frequently than every 6 months.

Dissemination of the results

The results of the JERICO -S3 project will now be analysed and published in a scientific publication in the near future.

Technical and Scientific preliminary Outcomes

1. Custom-built metal frames have been successfully tested for holding the samples, demonstrating readiness for deep-sea deployment (Fig. 1 and 2).
2. The frames were successfully used repeatedly in the Corsica Channel (CoCM) similar as shown in fig. 1, 2 where the samples were deployed at Sicily Channel (SICO).
3. Due to the pandemic a HYDRA scientist did not participate in cruises to deploy and retrieve the samples. Ensuring accurate documentation and sampling was achieved through training of CNR-ISMAR colleagues (Dr. Giuseppe Suaria). After deployment, the samples were retrieved by the facility operator and shipped back to HYDRA for further analysis.
4. 343 samples were deployed during the experiments. No sample was lost. Documentation at each retrieval (Fig. 3).
5. Most of the samples which were expected to disintegrate were disintegrated to 100%

or nearly 100% (Tab. 1).
6. As expected, the negative control, LDPE film, showed no disintegration. It also showed no signs that the downward and upward application caused mechanical changes to the samples. Similarly, as expected, no degradation was observed in 3 of the TexDeg samples because these fabrics are non-biodegradable.
7. The filter paper, the positive control, was already 100% disintegration after 392 days in the CoCM. We can only estimate how quickly it effectively disintegrated between 6 and 12 months, as it is not possible to analyze the samples in between.
8. The natural material wood was, as expected, the slowest to disintegrate (22±9% after 1249 days).
9. The exposed cotton T-shirt, the MaterBi shopping bag, the Profissimo organic waste collection bag, the PHB Mirel film, the disintegrading TexDeg samples and the cigarette filters from the CoCM showed 100% or close to 100% disintegration.
10. The disintegration of the samples was more advanced in the CoCM site than in the SICO. This is primarily due to the exposure time of 1060 and 612 days respectively. The TexDeg fabrics were exposed for 707 (CoCM) and 612 (SICO) days respectively. Here too, the disintegration in the CoCM was further than in the SICO. The 3 months longer exposure time could be the reason, and/or also better conditions for degradation. Metadata collected during the cruises, such as the nutrient concentration of the surrounding water, the microbial community in the environment, temperature, oxygen, salinity, etc. will be used for further interpretation of the disintegration data.

These outcomes demonstrate the successful development and testing of the custom-built frames, as well as the planned deployment and retrieval process, which will contribute to the accurate measurement and analysis of material degradation in marine deep-sea environments.

Figure 1: PHB film sample prior and post assembling in protection frames and mesh. Mounted onto steel frame ready for deployment at Sicily channel (SICO). All pictures are representative for the deployment at the Corsica Channel (CoM).

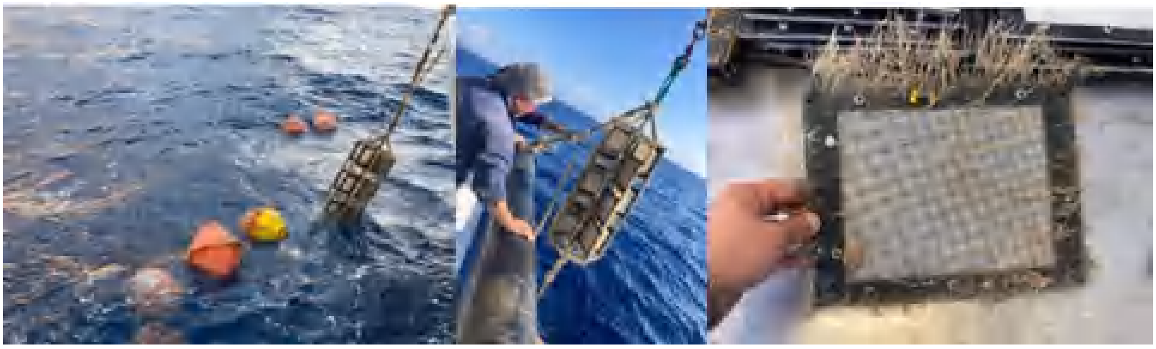


Figure 2: Retrieval of the steel frame with mounted samples at Sicily Channel (SICO) in October 2022, and documentation of fouling. All pictures are representative for the

deployment at the Corsica Channel (CoM).

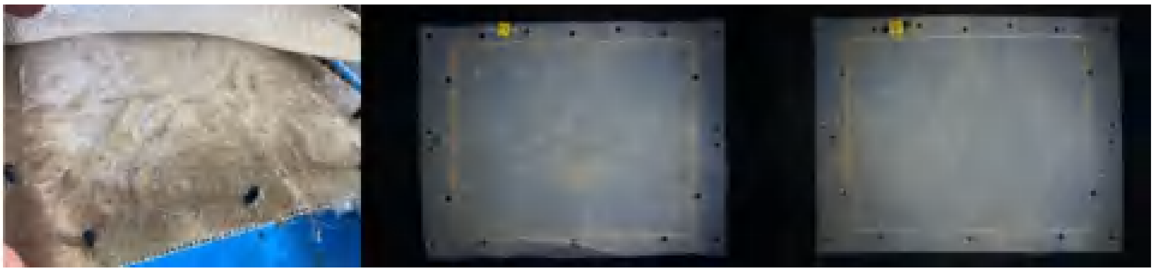
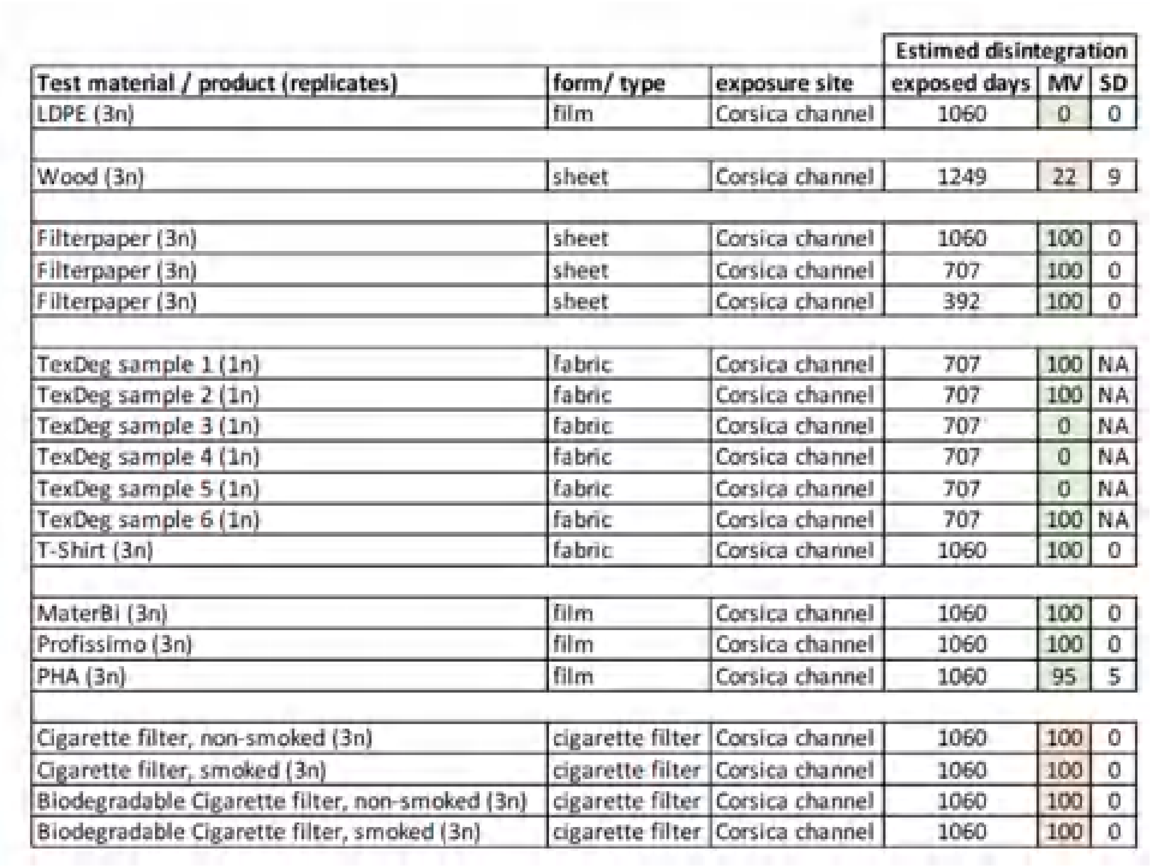


Figure 3: Documentation of samples after dismantling from protective mesh and frame. Photo documentation with the fine protective mesh: A1: white T-Shirt fabric (100% disintegrated), D1: green Profissimo compost collection bag film (100%), exposed at Corsica channel (CoCM).

Table 1: Estimated disintegration (mean value and standard deviation) of LDPE shopping bag, thin wood plate, cellulose filter paper, 7 textiles samples, MaterBi shopping bag, Profissimo compost collection bag, PHA film, and 2 types of cigarette filters (smokes, and non-smoked), after exposure of 392-1249 days at 400 m depth in the channel of Corsica (CoCM). Green colour indicates similar results between Corsica and Sicily channel, red colour not.



			Estimed disintegration		
Test material / product (replicates)	**form/ type**	**exposure site**	**exposed days**	**MV**	**SD**
LDPE (3n)	film	Corsica channel	1060	0	0
Wood (3n)	sheet	Corsica channel	1249	22	9
Filterpaper (3n)	sheet	Corsica channel	1060	100	0
Filterpaper (3n)	sheet	Corsica channel	707	100	0
Filterpaper (3n)	sheet	Corsica channel	392	100	0
TexDeg sample 1 (1n)	fabric	Corsica channel	707	100	NA
TexDeg sample 2 (1n)	fabric	Corsica channel	707	100	NA
TexDeg sample 3 (1n)	fabric	Corsica channel	707	0	NA
TexDeg sample 4 (1n)	fabric	Corsica channel	707	0	NA
TexDeg sample 5 (1n)	fabric	Corsica channel	707	0	NA
TexDeg sample 6 (1n)	fabric	Corsica channel	707	100	NA
T-Shirt (3n)	fabric	Corsica channel	1060	100	0
MaterBi (3n)	film	Corsica channel	1060	100	0
Profissimo (3n)	film	Corsica channel	1060	100	0
PHA (3n)	film	Corsica channel	1060	95	5
Cigarette filter, non-smoked (3n)	cigarette filter	Corsica channel	1060	100	0
Cigarette filter, smoked (3n)	cigarette filter	Corsica channel	1060	100	0
Biodegradable Cigarette filter, non-smoked (3n)	cigarette filter	Corsica channel	1060	100	0
Biodegradable Cigarette filter, smoked (3n)	cigarette filter	Corsica channel	1060	100	0

8.1.10. ABACUS 2021

Project Information

Proposal reference number	JS3_CALL_1_REF_4030_ABACUS 2021
Project Acronym (ID)	ABACUS 2021
Title of the project	Algerian Basin Circulation Unmanned Survey 2021
Host Research Infrastructure	SOCIB - Balearic Islands Coastal Ocean Observing and Forecasting System GLIDER SOCIB Glider Facility
Starting date - End date	**Total project duration:** 01 December 2021 – 30 July 2023 **Glider Mission:** ABACUS 2021 LEG 1 01/12/2021–23/12/2021 FALL 1 ABACUS 2021 LEG 2 18/05/22 – 10/06/22 SPRING ABACUS 2021 LEG 3 26/09/22 – 24/10/22 FALL 2
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Yuri Cotroneo Università degli Studi di Napoli "Parthenope" Centro Direzionale Isola C4 – Napoli, Italy yuri.cotroneo@uniparthenope.it

Project Objectives

ABACUS focuses on the physical and biochemical characteristics of the Algerian Basin (AB) circulation. The AB is dominated by the presence of energetic mesoscale structures that usually develop from meanders of the Algerian Current to isolated cyclonic and anti-cyclonic eddies. The project aims at confirming the importance of the ABACUS monitoring line across the AB between Palma de Mallorca and the southern part of the Algerian basin.
Main objectives are:

- To continue the time series of oceanographic data collected in the AB along the endurance line between Mallorca and Algeria;
- To identify the physical and biochemical variability of the different water masses that are present between Balearic Islands and Algerian coasts at surface and intermediate depth;
- To collect in-situ observations in the late spring where mesoscale high mesoscale activity take place.
- To collect high resolution data able to describe the sub-basins dynamics;
- To assess the ocean description capabilities of several satellite products when approaching coastal areas, also comparing them to glider in situ data;
- To validate the new along-track (L3) and gridded interpolated maps (L4) altimetry products provided by the Sentinel-3 altimetry mission and other satellites overflying the western Mediterranean Sea;
- To contribute at the creation of a composite dataset to be used for the SWOT satellite mission preparation and calibration;
- To acquire ground truth for satellite retrievals of particulate backscattering (bbp) which are widely used in studies of ocean ecology and biogeochemistry, but have been historically difficult to validate due to the paucity of available comparative field measurements;
- To explore the potential of glider measurements for ecosystem monitoring (fish stocks to cetaceans).

Main achievements and difficulties encountered

After the deployment of the ABACUS2021 glider in May 2021, some issues in navigation and data collection were encountered, probably due to a shark attack to the glider. The latter, led to the recovery of the glider and to revise our sampling strategy and glider mission planning with the SOCIB glider team for the ABACUS 2021.

Sea activities were re-scheduled over three glider missions of the approximate duration of 20 days each to navigate the monitoring line during two different years, including both spring and fall season, as follows:
ABACUS 2021 LEG 1 December 2021
ABACUS 2021 LEG 2 May/June 2022
ABACUS 2021 LEG 3 September/October 2022

Data collected during the ABACUS 2021 allowed:

- The monitoring of the main physical and biochemical properties of the water column;
- To extent the glider datasets in the AB;
- The collection for the first time of acoustic data across the AB to identify wind and rain patterns, as well as the presence of marine mammals

From a more technical point of view, the glider mission has covered the following for each leg:

- spent 23 days in water for ABACUS 2021 LEG 1 – collecting 199 profiles along the transect
- spent 24 days in water for ABACUS 2021 LEG 2 – collecting 162 profiles along the transect
- spent 29 days in water for ABACUS 2021 LEG 3 – collecting 173 profiles along the transect

During each leg the glider realized 2 complete transects across the AB and was overflown by the Sentinel 3 satellite. A total of about 530 complete profiles were collected along the 6 planned transects;

Dissemination of the results

1) Data collected during ABACUS 2021 can be downloaded through the SOCIB DAPP.
2) Data collected during all the ABACUS missions since 2014, can be downloaded from the webpage http://apps.socib.es/data-catalog/#/data-products/abacus that is regularly Updated

A DOI was assigned to this dataset that can be cited as
Miralles, A., Rubio, M., Rivera, P., Zarokanellos, N., Charcos, M., Férnandez, J. G., Budillon, G., Cotroneo, Y., Aulicino, G., Balager, P., Wirth, N., Casas, B., Baeza, J., Calafat, N., Juza, M., Notario, X., Heslop, E., Ruiz, S., Muñoz, C., … Tintoré, J. (2018).SOCIB TNA Abacus (Version 1.0) [Data set]. Balearic Islands Coastal Observing and Forecasting System, SOCIB. https://doi.org/10.25704/B200-3VF5

3) The results achieved during this and the previous ABACUS glider missions have been presented at international conferences, e.g., the EGU general assembly 2023 (Vienna, April 2023): Cotroneo, Y., Aulicino, G., Fusco, G., Ruiz, S., Pascual, A., Testor, P.,

Cauchy, P., Zarokanellos, N.,Miralles, A., Zerrouki, M., Tintoré, J., and Budillon, G.: ABACUS – a repeated glider monitoring line across the western Mediterranean Sea , EGU General Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-6024, https://doi.org/10.5194/egusphere-egu23-6024 , 2023"
4) We realized seminars for graduate and post-graduate students, at Università degli studi di Napoli "Parthenope"
5) Three master degree students did their intership using and analysing the ABACUS data in the framework of their course.

Technical and Scientific preliminary Outcomes

ABACUS 2021 project contributed to data collection in the Southern European Seas, one of the main EU maritime policy objectives, as outlined in the Marine Strategy Framework Directive (MSFD). In particular, the high resolution of glider data and the efforts to get simultaneous satellite altimetry data along the same groundtrack, allowed us to observe and describe the oceanographic characteristics of the area at several time and spatial scales.

Additionally, the innovative use of a passive acoustic recorder allowed us to analyse the sounds associated to wind, rain, and marine mammals in the study area. ABACUS 2021 allowed us to realize a glider mission in the Algerian Basin organized into 3 legs during autumn 2, spring 2021 and autumn 2022 sampling the water column up to 1000 m depth with the spatial resolution of about 2 Km.

In the framework of the project, during last in person access (July 2023) a productive discussion amongthe partners led to a definition of a new shared quality control protocol. It can be summarized as follows: After the mission, data are transferred from the internal glider memory to the SOCIB Data Center where pre-processing, quality control and validation are carried out and production of level 1 and level 2 data occurred. Then at University Parthenope a second quality control process is applied to identify any persistent spike in the data and reduce the possible noise of the signal. A final visual check is performed on the single profiles and on the θ/S diagram. In a next future, glider data will be compared with the available Argo floats for cross calibrations.

The ABACUS 2021 quality-controlled datasets are then used to realize a preliminary analysis focused on the identification of the different water masses characteristics and on their location along depth and latitude.

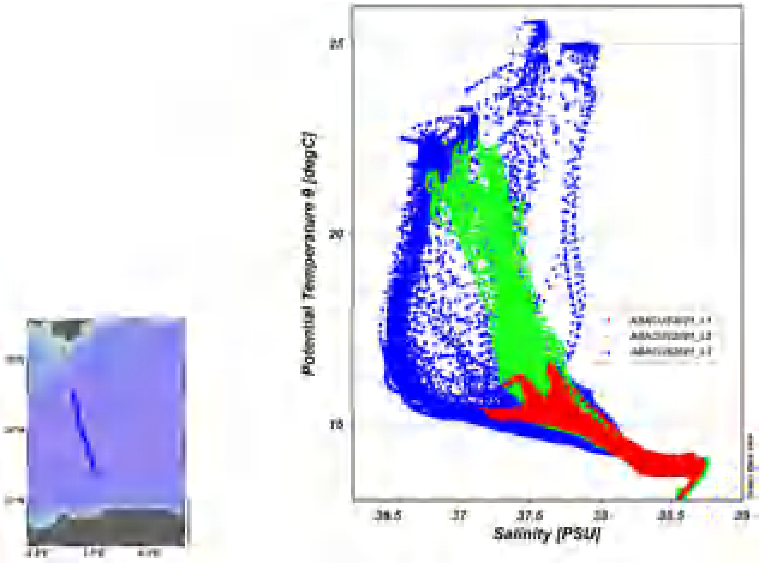


Figure 1 shows the map of ABACUS2021 glider mission and the associated Theta/S diagram color coded for each leg.

It is evident from this diagram the existence of a strong seasonal variability during the three legs repeated along the same Sentinel 3 groundtrack. ABACUS 2021 observations are characterized by high spatial and temporal resolution, which is allows us to identify the different physical and biochemical processes.

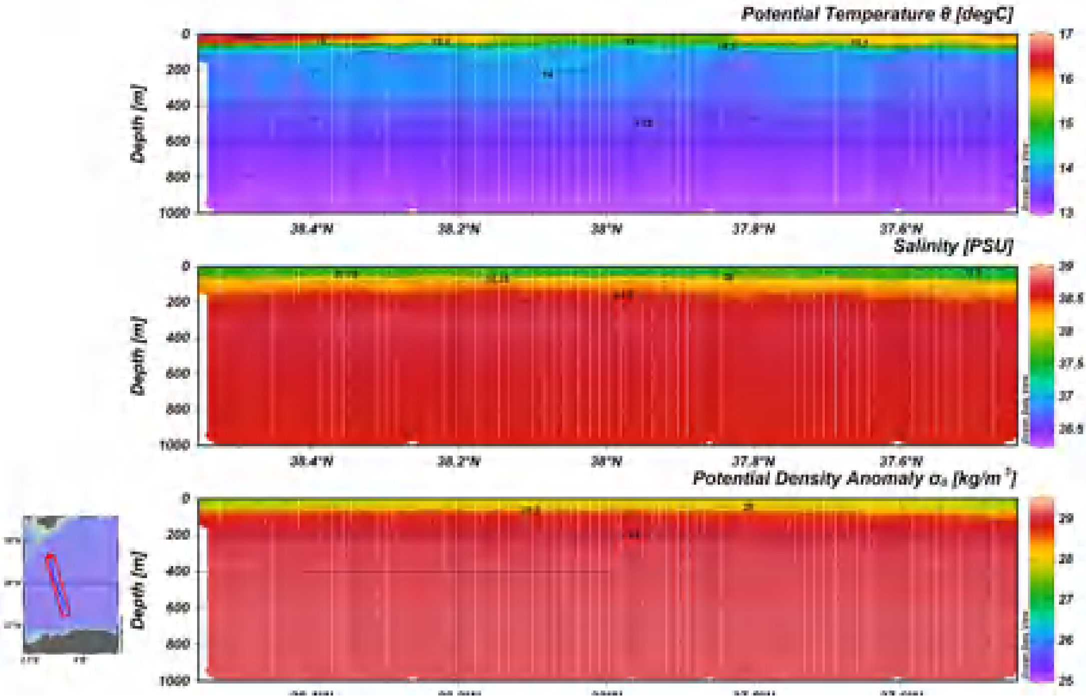
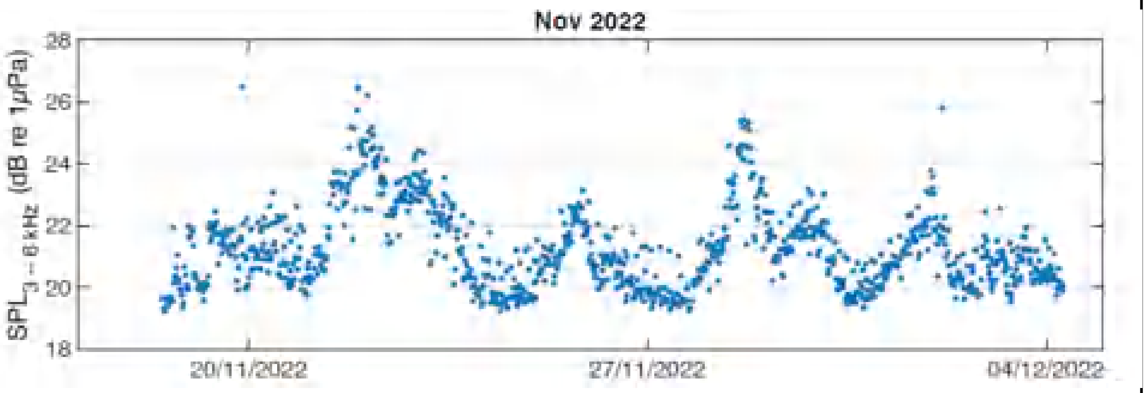


Figure 2 shows the vertical transect along the monitoring line of early December 2021 for Potential temperature, Salinity, Potential Density anomaly. Analogous figures have been realized for the other 5 transects realized and for the Chlorophyll concentration, turbidity and Oxygen concentration data collected by the glider.

One of the most innovative aspects of the ABACUS 2021 project consists in the use of

an
ACOUSONDE passive acoustic recorder installed on the glider.



Figures 3 and 4 show some preliminary results of the acoustic data analysis.
The analysis of the acoustic data requested an additional effort. This is mainly due to the large amount of data collected and to the different analyses that need to be performed to identify the sound originated by the different sources.

The first figure shows the signal associated to wind noise during the November 2022 leg, while figure 4 shows the noise associated to Sperm whale echolocation sounds, characterized by very regular trains of clicks at about~ 10 kHz, 2 clicks/s. Similar analysis highlighted the presence of Dolphin echolocation clicks as rapid and variable click patterns ~ 30 kHz, 10 – 20 clicks/s.

8.1.11. YUCO-CTD

Project Information

Proposal reference number	JS3_Call_1_REF 4031
Project Acronym (ID)	YUCO-CTD micro-AUV
Title of the project	Validation of an innovative easy-to-use affordable micro-AUV platform , embedding an high accuracy and resolution CTD sensor.

Host Research Infrastructure	SmartBay
Starting date - End date	1st February 2021 – 30th November 2021
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Thomas LAMSON SEABER 31 rue des Fontaines 56100 LORIENT thomas@seaber.fr +33 (0) 972354338

Project Objectives

The main objective of the Yuco-CTD micro-AUV project is to perform quantitative and georeferenced salinity and temperature profiles in coastal areas using an easy-to-use affordable fully autonomous micro-AUV platform embedding an Argo referenced, high accuracy and resolution CTD sensor.
The project's secondary objectives are the following:

- Demonstrate the accessibility, ease-of-use and reliability of this AUV technology to oceanographers such as ocean physicists, who are not necessarily trained in underwater robotics.
- Demonstrate that this micro-AUV technology is able to perform accessible, swift and reliable CTD measurements in challenging coastal environments.
- Prove that micro-AUVs embedded with CTD sensors can be used to complement the existing methodologies for CTD measurement.
- Provide a use case to show that more distributed, repeated and scientifically reliable CTD measurements can be made in coastal areas using Yuco-CTD micro-AUV.
- Demonstrate the capability of Yuco-CTD micro-AUV to perform almost vertical profiles with various "sawtooth" navigation modes in coastal waters.
- Prove the capability of Yuco-AUV to navigate accurately in unsheltered coastal area with tidal currents such as those present in Galway bay thanks to INX © navigation.
- Perform high sampling, high resolution and high accuracy temperature and salinity measurement on the Yuco micro-AUV moving platform based on CTD RBR Argo referenced sensor.
- Demonstrate the great autonomy and useability of Yuco-CTD micro-AUV platform combining AUV own performance and low-power CTD.
- Analyse variation and measurement of temperature stratification and correlate Yuco-CTD measurements with data from the SmartBay cabled observatory and glider reference platforms.

Main achievements and difficulties encountered

Most of the objectives were completed.
YUCO micro-AUV from SEABER was successfully deployed 3 days in a row and properly measuring during missions.

Day one and day two – 01/11/2021 & 02/11/2021 – were used to perform various types of profile patterns with the YUCO micro-AUV, next to a reference CTD cast made from the deployment vessel.

On day three 03/11/2021 one YUCO micro-AUV performed a long mission of approximately 3 hours long and about 15km distance with 2,5 knots average speed. The mission consisted in a back and forth travel from both sides of Galway Bay while performing sawtooth CTD profile all along the water column.

The YUCO micro-AUV being totally autonomous, both Marine Institute and SEABER crew had the opportunity to stay at shore during the 3 hours mission and come back to pick it up at expected end mission position and time. At the end of the mission, YUCO was about 200m from expected recovery point. This is an estimated error of navigation of about 1%, which is better than the initial target of 2%.

The main issue encountered is the unavailability of Marine Institute Glider that didn't allow us to perform following:

- Analyse variation and measurement of temperature stratification and correlate Yuco-CTD measurements with data from the SmartBay cabled observatory and glider reference platforms.

As deployment took place in autumn, deploying a glider in Galway Bay at this period of the year is very complex. In a way, this issue showed the interest of using micro-AUV technology in this type of complex area where other vehicles main not be that easy to deploy.

Dissemination of the results

Analysis of the data is still in progress but it is clear that results shall be published soon especially when automated compensation algorithm of temperature convergence delay will be implemented.

Once published data will be disseminated with public access.
https://smartbay.marine.ie/data/jerico-S3/YUCO-CTD/

Technical and Scientific preliminary Outcomes

The YUCO-CTD micro-AUV experiment took place in SmartBay area and allowed to perform a great number of autonomous missions to measure water temperature and conductivity.

Various types of patterns were tried – sawtooth, diving-screws, vertical profiling (popping-up).

Some missions happened along a CTD cast reference at some key positions, which provided a correlation information. Finally, Smart Bay fixed station provided a reference CT measure at fixed positions. Data from the RBR Legato3 was acquired at high sample rate, 2Hz.

The great variety of performed patterns showed interesting impacts on the measurement value depending of horizontal and vertical speed of the micro-AUV. Especially, the exact depth of the thermocline base (~12.7°C) was measured at different values depending on the vertical speed of the AUV.

The RBRLegato3 used for this trial is a standard thermistor with an estimated time response of about ~1s. Therefore, depending on whether the micro-AUV is diving down or rising, and depending on its exact vertical speed, temperature measurements are shifted in depth and that must be accounted for. On the other hand, the time response of conductivity sensor is shorter but still non-zero, meaning that it must also be shifted and synchronized with temperature measurements to have an accurate correlation of both C, T and D parameters.

High repetitiveness of the measurement time shift shows that it can be easily corrected with automated algorithms. Indeed, once temperature measurement delay is corrected data comparison between YUCO-CTD micro-AUV and CTD cast seems to be well in line.
Even if data requires deeper analysis, it appeared that the less adapted pattern for such configuration is the saw-tooth where a low inclination spiral and a vertical surfacing – profiler like – showed less deviation. However, we can suppose that combining high-acquisition rate CTD and embedded algorithm can lead to very high data standard and totally comparable to a cast of a reference CTD.

Also, for such application of profile it may be interesting to consider the "high-speed" CTD version of the RBRLegato3 with 16Hz and fast response thermistor. In general, this project led to a real proof of interest of using YUCO micro-AUV solution in coastal environment to perform CTD measurements all along the year and showed the possibility to extract scientifically exploitable data.

The great coverage in 3D at low-effort and low-cost opens the way to regular and more spatialized measurement approach for coastal monitoring.

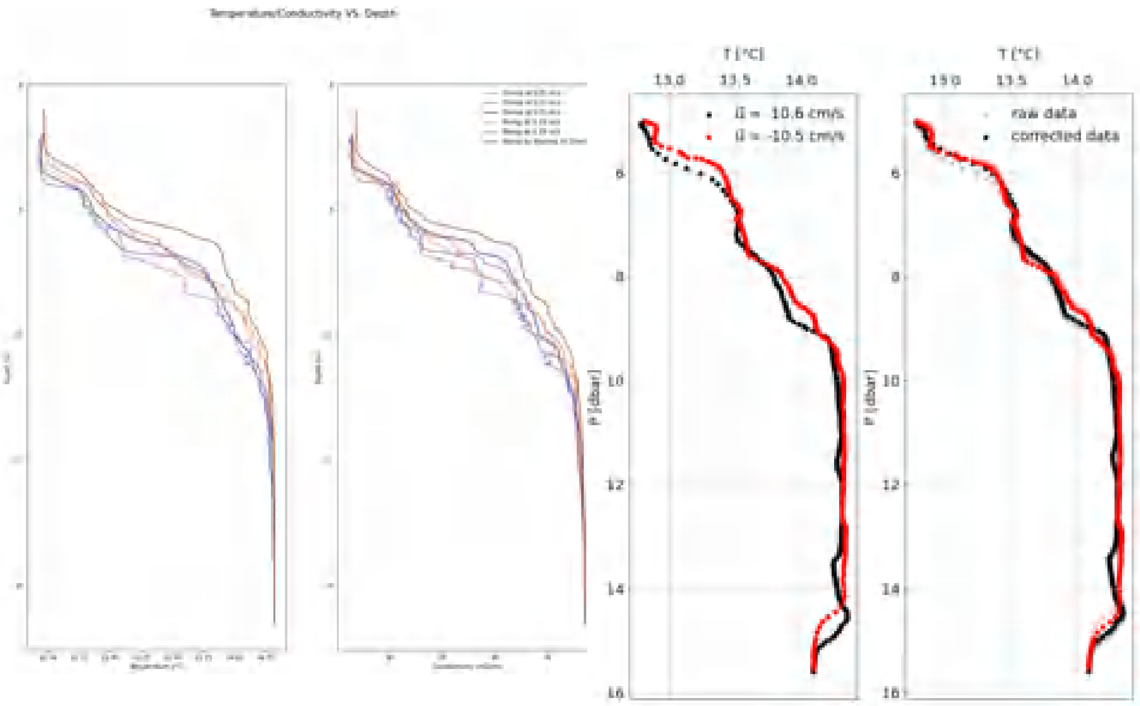


Figure 1: CTD casts taken at various vertical speeds in the same location (total duration

: ~30min).
Left: Orange/Brown profiles are taken by YUCO-CTD while rising up to the surface ; Purple profiles are taken while diving. Graph shows an hysteresis particularly visible at the thermocline base due to vertical speed.
Right: Down profile (black) and up profile (red) at 10cm/s vertically, uncorrected on the left, time-shifted on the right. Graph shows that after correction, CTD casts are very well correlated.

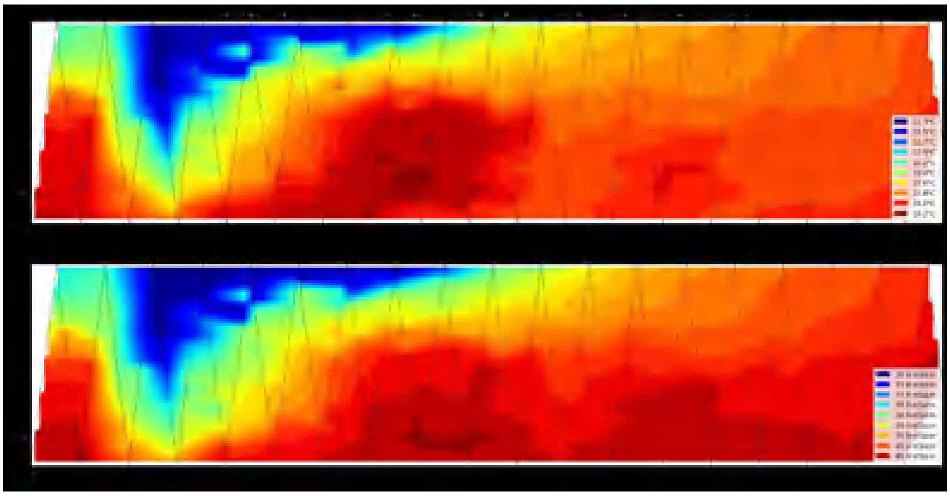


Figure 2: Temperature transects on 03/09/2021 sawtooth pattern uncorrected

Figure 3: 2D map of travelled distance during transect on 03/09/2021 Blue : underwater trajectory, Orange : surface trajectory (with GPS signal)

Figure 4: 2D map trajectory on 02/11/2021, where six vertical profiles were realised in a single mission. Blue : underwater trajectory, Orange : surface trajectory (with GPS signal)

8.1.12. S1100-Bio

Project Information

Proposal reference number	S3_CALL_1_REF_4032_S1100-Bio
Project Acronym (ID)	S1100-Bio
Title of the project	ANB Sensors S Series: Long term Biofouling Deployment
Host Research Infrastructure	OBSEA underwater observatory (UPC)
Starting date - End date	20/09/2021 – 24/10/22
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Dr. Nathan Lawrence ANB Sensors 6 Old Farm Business Centre, Toft, CB23 2RF, UK nlawrence@anbsensors.com 01223 263545

Project Objectives

ANB Sensors was trialling its S1100 with a TRL of 8/9. Previous prototypes of the sensor have been tested on short deployments at SYKE through Jerico S3 funding. The key objectives for the Jerico-Next project in collaboration with UPC were to:

1. Deploy the S1100 on a coastal observing station at 20m depth for 3-4 months.
2. Deploy a second S1100 alongside the first to provide inter validation between the two sensors.

3. Provide feedback on the sensors ease of use, ease of deployment and data retieval features.
4. Evaluate the performance of the S1100 over a prolonged period of time, observing seasonal changes in weather and biodiversity.
5. Study the biofouling resistance of the sensor.
6. Validate the sensors response against independent measurements in real time deployment.
7. Allow ANB Sensors to understand the issues associated with oceanography and sensor deployment for other analytes – providing scope for future collaborations.

Main achievements and difficulties encountered

One of the main achievements was proving the performance of the S1100 in a lab, as well as the verification from the end user that the sensor was indeed easy-to-use. Maintenance of the transducer was carried out successfully and in-situ underwater, realising the goal of this sensor being the preferable option for long term deployments as it doesn't need to be recovered for maintenance. Finally, although the body of the sensor was covered in bio growth by the end of the 8 week deployment, the transducer surface was clean, proving the biofouling resistance claim of the sensor.

The main difficulty encountered was the ability of the sensor to perform for a longer time, due to the deployment issues highlighted. Although the interferences between the sensors connected to the same power supply was a big obstacle, the power isolation board developed by ANB overcame this issue. The leakage of the sensors was a big adversity too but provided very useful information for the next design.

Dissemination of the results

Utilizing the data and results gathered throughout this Jerico S3 project, in conjunction with our in-situ lab-based research, an academic peer-reviewed article detailing the measurement technique and the performance of the sensor in seasonal changes in weather and biodiversity will be published. In addition, the data will be communicated through conference/meeting presentations in order to demonstrate the validity of our system, and for the public, through social media like Twitter. Finally, the results and data will be gathered to procure intellectual property on the technologies directly resulting from this research project.

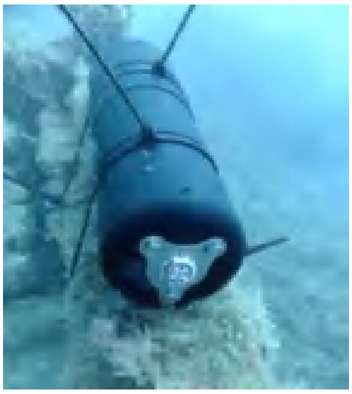
No public link to data at the time of the writing of this report.

Technical and Scientific preliminary Outcomes

The experimentation for this project was conducted in the OBSEA underwater observatory in Barcelona, Spain, in collaboration with Universitat Politecnica de Catalunya (UPC).

The sensors were first tested in the lab at UPC to ensure a good performance before deployment. The tests were performed in a bucket with seawater and were powered simulating the OBSEA connection, which was a 12V power supply connecting the two sensors. It was seen that testing two sensors in the same tank with the same power supply induced noise in the response due to electrical interferences between the sensors. This effect was confirmed by testing those two sensors using the same power supply but in different tanks, which resulted in a correct behaviour, demonstrating the performance of the sensors themselves, and highlighting the electrical interferences issue when testing more than one system in the same tank.

Following these lab tests, the two sensors were deployed at OBSEA. At this time the firmware on the sensor was upgraded and tested by the staff at UPC. Excellent feedback was given on the ease of use of the sensor in terms of both the firmware configuration of the sensor prior to deployment and the low amount of handling required for the sensor to be deployed. However, on this initial deployment electrical interference cross talk was observed across the sensors. To alleviate this in the short term one of the sensors was put in sleep mode, and the second sensor ran. However, the initial impact of this electrical cross-talk meant the response of the sensor was already effected for the longer term measurements.



Despite the electrical cross talk meaning that the sensors response was not optimal, they were left at the OBSEA to study the impact of biofouling on the transducer head. After 4 weeks, the sensor in sleep mode was recovered, while the other one was left in the OBSEA for a longer study of the biofouling. The sensor recovered showed a white layer deposited on the head (see image on the left). This was caused by electrolysis, as the electrodes on the surface of the head are polarized to induce salt deposition, as the difference voltage between the negative pole of the power supply induced current between the OBSEA chassis (it is connected to earth) and the sensor head, producing that salt deposition on the transducer head. The second sensor was recovered from the OBSEA 4 weeks later. After a total of 8 weeks under the water, no biofouling was found. Nevertheless, as predicted from the previous sensor deployed, salt deposition was found (see image on the right) on the surface of the counter electrodes, where the current flows. These results highlighted the importance of these tests to understand the performance of the sensor under different conditions, and the urgent need of an isolation system for the sensor.

During this deployment a power isolation board was developed by ANB to avoid the electrical interferences between the sensors. In order to install the isolation boards in the sensors, they were opened by the staff from UPC. The feedback on this process was provided to ANB, the learnings of which were used for the development of the next version of the sensor. Upon opening of the sensors both sensors showed rust inside,

indicating some leakage, especially where the transducer was placed.
The emergence of rust within the sensors suggests that the transducer had leaked during deployment and the poor responses were obtained in the lab due to the corrosion in the socket board produced by the leakage. After both sensors were cleaned, isolation boards were incorporated, and the transducers were replaced, both sensors showed correct measurement for pH in the lab trials. However, when downloading the data, it was seen that the SD card in one of the sensors was corrupted. The sensor was then opened to access to the SD card, and the files were removed, to ensure smooth performance. All this real field trial feedback was very useful to ANB, as it is difficult to replicate this in-house.

The sensors were then redeployed in the OBSEA, and no further electrical interferences were found between the sensors, indicating the effectiveness of the isolation boards. Unfortunately, one of the sensors showed a quick decay in the electrode's response, very possibly due to the socket board being damaged after the leakage. On the other hand, the data collected in the other sensor showed different responses between the electrodes, corroborating the heterogeneity between the electrodes after its previous issues. The transducers needed abrasion, but due to bad weather, the next diving operation, and therefore the next abrasion, was done after 6 weeks. The sensors response to biofouling in this time was very pleasing. No bio growth or salt deposits were seen on the transducer surface after 6 weeks deployment (see image), confirming the biocide formation and the effectiveness of the isolation boards. Both transducers were successfully abraded underwater, giving good responses after. This results highlights that remediation of the sensor surface can be achieved in-situ without the need to bring them to surface. However, the after abrasion the signals that the sensors measure were too large for the sensor to interpret, achieving the maximum limit set by the firmware at that time. These results were very useful to ANB to improve the firmware settings for future deployments. Furthermore, the importance of knowing when the transducer required abrasion was flagged by UPC so ANB developed a colour code firmware update instructing the end user when to perform maintenance.

After further tests, it was seen that the reference sensing part was damaged in both sensors, which in turn led to corruption of the SD card. All these issues were taken into consideration for the development of the next version of the sensor. The sensors were recovered 3 weeks later, again showing no bio growth on the transducers. They were both opened to understand why the reference system failed. Water leakage was found inside of one of them, which irreparably damaged that sensor, however, the other was still functioning, so it's transducer was replaced, checked in the lab, and deployed in the OBSEA. After showing no biofouling within 4 weeks, the communication between the OBSEA and the sensor was lost due to a problem inside the OBSEA node. The sensor was then recovered and deployed again with a battery pack for two weeks, but unfortunately the data showed inconsistences between the pH sensing electrodes, which was found to be due to a leakage in the battery cylinder, where one O-ring was compromised, so no discernible data resulted.

The data retrieval unit (DRU) provided by ANB was not used in the OBSEA deployment, but it was tested in the lab and found to suffer with some random communication issues. These observations helped ANB for the development of the new power source unit for the new version of the sensor.
In conclusion, all the tests performed allowed ANB to highlight some key issues, such as interferences between sensors, leakage, and the need for more accurate QA/QC limits after abrading the transducer underwater. None of these development issues could be unearthed in laboratory tests, so these field trials were invaluable. All the feedback gathered from UPC, positive and negative, has been vital for further sensor development.
The other big win from these tests was the positive biofouling results achieved. This differentiates ANB's sensor from all other ocean sensors and will make it the go-to sensor for long term oceanographic monitoring of pH.

8.1.13. AMBO

Project Information

Proposal reference number	Ref.21_1613-JS3_CALL_1_REF_4033_AMBO
Project Acronym (ID)	AMBO
Title of the project	Autonomous Multiplatform Biophysical Observations
Host Research Infrastructure	ALSEAMAR glider (in collab. with CNRS)
Starting date - End date	April 14 - April 28, 2022
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Maristella BertaCNR-ISMAR Forte Santa Teresa s.n.c. 19032 Pozzuolo di Lerici (SP) Italy maristella.berta@sp.ismar.cnr.it +393391251613

Project Objectives

AMBO is a transnational collaborative effort involving Italian partners (CNR-ISMAR and ENEA) and French partners (CNRS and ALSEAMAR) providing the use of the glider infrastructure. The aim of AMBO is to carry out a comprehensive study of the water masses exchange and overall dynamics through a multi-platform and multidisciplinary approach, focusing on the inter-comparison and combination of essential physical variables measured through different observing systems, as well on the link between circulation patterns and biochemistry, in the North-Eastern Ligurian waters. Therefore, the period chosen for the AMBO experiment is spring, season typically associated with higher biological and frontal activity. AMBO focuses on the development of methodologies to combine surface and water columns observations, the development of metrics to study vertical transport associated with frontal structures, as well as on the investigation of submesoscale frontal dynamics and associated vertical processes, which play a key role in the transport of nutrients and biological particles with significant consequences on the marine ecosystem. AMBO relies on the collection of independent and complementary in-situ and remote observations of the physical and biochemical components using coastal HF radars continuously measuring high resolution surface currents, glider transects highly resolving physical and biochemical variability along the water column, drifters observations to track surface currents passive transport, water column CTD casts, oxygen, turbidity and chlorophyll samplings, as well as very surface physical observations from Ferrybox.

Main achievements and difficulties encountered

AMBO represented a unique opportunity to explore new international collaborations that put into system complementary sea technologies and expertise from the partners involved. It was a very positive collaboration from the planning of the activity to the actual experiment that covered a wide sea area nearby the Cinque Terre Marine Protected Area, providing an unprecedented collection of coordinated biophysical measurements. Difficulties encountered fall within the usual range of logistical issues of a sea experimental activity, nothing related to our specific collaboration, on the other hand the cooperative attitude of the group allowed to run smoothly the whole experiment made of multiple phases and including remote coordination among partners for autonomous platforms management.

Dissemination of the results

So far, a general account of the experimental activity has been disseminated through some interviews to newspapers and TV channels. During 2023, we plan to submit a high-impact publication informative on the experimental strategy and another peer-reviewed paper focusing on the data analysis and the overall description of the local dynamics captured by the combined multidisciplinary and multiplatform observations.

A public data link has not been made available yet at the time of the writing of this report.

Technical and Scientific preliminary Outcomes

The AMBO experiment took place in the Eastern Ligurian Sea (Mediterranean Sea), an area encompassing the Cinque Terre Marine Protected Area and located within the marine mammals Pelagos Sanctuary. This fragile natural environment coexists with intense anthropogenic activities (as marine traffic, nearby ports, fisheries and tourism) and such conditions motivate the interest for monitoring the local sea state and for investigating its dynamics and variability. In fact, the area is already monitored by specific remote and autonomous systems, such as the CNR-ISMAR HF radar network providing hourly surface current maps with a resolution of 1.5km and covering a sea area up to approximately 40km from the coast. In the same area, the LABMARE mooring, made available from the collaboration among many Italian institutions and entities (DLTM, CNR-ISMAR, ENEA, INGV, IIM), monitors the water column physical properties (mainly temperature, salinity, currents) down to 600m depth. The availability of these background measurements and knowledge, together with satellite observations of the sea surface temperature and surface chlorophyll distribution in the area gave strategic guidance for the AMBO planning and for the definition of the activity location and timing. These complementary observations are also fundamental for the interpretation of the data collected during the AMBO activity itself, that will be resumed in the following.

The AMBO experiment took place in spring, from April 14 to April 28, 2022, a period characterized by enhanced sea biological activity and intensified water column dynamics variability. The transnational collaboration involves the deployment of a glider, provided by CNRS and ALSEAMAR, equipped with physical and biogeochemical sensors, plus an ADCP, to monitor water column properties at very high resolution along a 500m-depth transect across the HF radar coverage continuously repeated for the whole duration of the experiment. The activity was organized with three boat surveys of the area at different days, on board of the M/B Santa Teresa, provided by ENEA.

During the first site visit, the ALSEAMAR glider was deployed in front of Levanto and concurrent water column measurements were performed by ENEA with CTD casts, ADCP, oxygen and turbidity samplings. Along the boat track, sea surface water observations of temperature, salinity, oxygen, turbidity and chlorophyll were collected through a Ferrybox system provided by ENEA. During the first site survey, 20 CARTHE drifters (gps-tracked buoys spanning the first 60cm water layer) were deployed by CNR-ISMAR to monitor the surface currents pattern and variability across the HF radar field coverage. The observations made available in near-real time by the glider, HF radars and drifters evidenced the presence of a front associated with a mesoscale anticyclone (visible from satellite images). On April 14, both HF radars and drifters showed a surface divergence pattern at the edge of the anticyclone, indication of frontal activity and enhanced vertical dynamics, that is as well confirmed by the glider survey in the following days (April 15-21) showing the presence of a subducting water filament, down to 250m depth, associated with the surface signature of the front.

The second boat site visit, in April 19, was dedicated to further water column measurements in order to cover the area with CTDs, ADCP, oxygen and turbidity samplings at different depths. During boat transit Ferrybox measurements were taken, analogously to the first visit, and 12 more CARTHE drifters were deployed up-wind with respect to the glider transect location. In the next two days, the drifter trajectories crossed the glider transect location, complementing the water column picture with surface currents passive transport information. Around April 21-23 the drifters sampled a cyclone within the HF radar coverage and in the same area of the glider transect. The cyclonic feature was also evident from chlorophyll satellite observations.

The third and last boat visit was dedicated to the ALSEAMAR glider recovery coordinated with CTDs, ADCP, water samplings of oxygen, chlorophyll and turbidity in the same location of the glider for intercomparison purposes. All along the boat path, continuous Ferrybox observations were collected as well. The overall glider transect timeseries evidenced high-resolution variability of surface features but as well an interesting warming process of the whole water column down to 500m depth.

The targeted observations collected in the Eastern Ligurian Sea during AMBO represented an unprecedented opportunity for biophysical monitoring, with the added value of the international cooperation among many Italian and French partners. The multiplatform and multidisciplinary set of measurements will be deeply analysed and discussed through a joint effort of the partners involved and published in dedicated peer-reviewed journals.

8.1.14. EMPORIA

Project Information

Proposal reference number	JS3_CALL_1_REF_4034
Project Acronym (ID)	EMPORIA
Title of the project	Exploring the mesoscale processes in the area of freshwater influence (Gulf of Riga)
Host Research Infrastructure	Taltech Glider Mia + Profiler
Starting date - End date	26.09.2021 – 04.08.2022
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Māris Skudra Latvian Institute of Aquatic Ecology (LIAE) Voleru street 4, LV-1007, Riga maris.skudra@lhei.lv +371 28740641

Project Objectives

The project's scientific objective was to research the dynamic processes (vertical features, movement of water masses, upwellings/downwellings, coastal gradients, etc.) occurring in the northeastern (NE) part of the Gulf of Riga (GoR), describe their characteristics and possible impact on the GoR environment by conducting high-resolution glider survey perpendicular to the E coast complemented with CTD profiling. Likewise, an autonomous profiler was deployed in the central part of the GoR.

A glider survey was the first such application carried out in the GoR water basin, thus, it allowed to obtain important information about the glider operability and functioning in shallower water basins (e.g. GoR) as opposed to deeper basins where a glider has been used till now.

Novel data acquisition using glider surveys in combination with an autonomous profiler and with already known and used methods (e.g. ship-based monitoring) will allow more detailed view about the environment in the GoR – a target which is important for the national level (e.g. marine monitoring program, environmental assessment improvements, setting up indicator values for specific parameters) as well as European level (assessment reports to EU authorities, policymaking etc.).

Finally, such research would improve the international cooperation between scientific organizations (in this case with TALTECH) and personnel involved which might be useful in further scientific projects and/or research.

Main achievements and difficulties encountered

Main achievements:
1) Successfully conducted glider survey in 2022 and data obtained for the period 04.07-31.07.2022

2) Basic knowledge gained on how to practically operate and set-up the glider survey onboard the ship
3) Data obtained from the autonomous profiler for the period 04.07 to 12.07. The profiler data were complemented by the measurements in the fixed depths in the water column until end of the glider survey.

Difficulties encountered:
1) Malfunction of the glider in the first planned deployment survey during September 2021 and subsequent delay of the project till 2022 in order to obtain data during the summer which was the initial aim of the project
2) An autonomous profiler was deployed but its measurements did not cover the full period of the glider mission due to technical issues. The missing profiler data were complemented by the measurements in the fixed depths in the water column.
3) Nobody from the user group was able to join the glider deployment cruise in July 2022. However, user group participated in planning of the glider path and in real time piloting of the glider.

Dissemination of the results

The results produced from the data obtained within the framework of the EMPORIA project are planned to be published as scientific articles touching such topics as coastal processes (e.g. upwellings/downwellings) and water exchange/renewal in the GoR. Outcomes might be presented in international scientific conferences.

A public link to the data is not available at the time of the writing of this report.

Technical and Scientific preliminary Outcomes

Overall, the glider followed the route of specific coordinates in the GoR and gathered data from July 4-31, 2022. Three coordinate pairs were as follows (red triangle in the figure 1):
23deg39'0000 57deg 36'0000
24deg13'0000 57deg 36'0000
23deg33'4000 57deg 43'4000

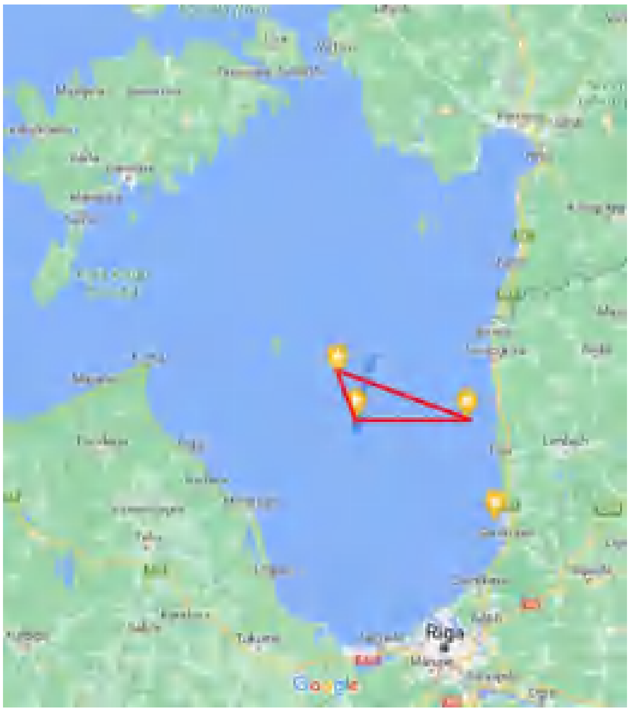


Figure 1. Glider route represented by the red triangle.

One of the aspects was to find out if current setting of glider route would allow to detect upwelling events and their created temperature gradients (lower temperature signal further offshore) in the coastal area. During July 12-14 there was rather short but strong upwelling event in the E part of the GoR (Figure 2). Nevertheless, the lower temperature signal does not seem to appear very clearly in the glider data (Figure 3) which might mean that the closest glider route point to the shore was still too far for the signal to reach it. However, the glider data allows to detect the origin of the upwelled water. Likewise, elevation of the thermocline were measured by glider on July 14-15 (Figure 3). We can also notice from the glider data slightly lower oxygen concentrations and slightly higher turbidity, which might also hint that these waters come from or are related to the aforementioned upwelling event. Thus, glider observations well complemented our coastal time-series at Skulte

Figure 2. Sea surface temperature (1h temporal resolution) at the Skulte coastal station in the eastern part of the GoR.

This might indicate, after all, that it is possible to detect such events further away from the coast or their influence using high resolution equipment. Further details will be explored in the future.

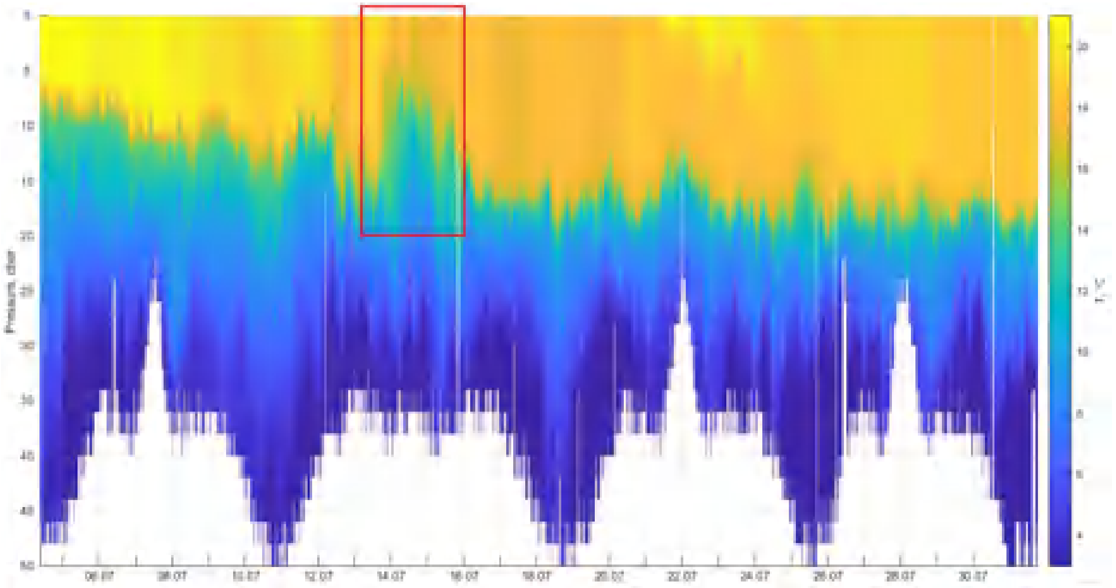


Figure 3. Temperature distribution from the obtained glider data. Red rectangle represents the lower temperatures in the upper layer which might be the indication of the upwelling event which occurred in the eastern part of the GoR couple days before.

Remaining ongoing work. The obtained glider data will be used as an additional data source to explore and research the coastal processes as well as to analyse water exchange/renewal in the GoR deep part. More detailed data analyse is yet to be performed. Currently, it is planned that the results obtained within framework of EMPORIA project would contribute to at least 2 scientific publications.

8.1.15. EuroFluoro b

Project Information

Proposal reference number	JS3_CALL_1_REF_4036b_EuroFluoro
Project Acronym (ID)	EuroFluoro II
Title of the project	Field testing and validation of a new multiparameter sensor in European Coastal waters 2
Host Research Infrastructure	Marine Institute
Starting date - End date	26-08-2021 - 20-12-2021
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Dr James Kirkbride Chelsea Technologies 55 Central Avenue West Molesey Surry, KT8 2QZ, UK jkirkbride@chelsea.co.uk +44 (0)20 8481 9000

Project Objectives

Chelsea Technologies Group has developed its new VLux miniature multi-parameter fluorometer configured to provide high quality in situ detection of either Algae, Aromatic Hydrocarbons or Tryptophan-like fluorescence. Fluorescence is automatically corrected for turbidity, absorbance and temperature to provide robust data collection over extended deployments. The instrument has several monitoring applications. EuroFluoro will test the usability of the VLux AlgaePro fluorometer, having 4 excitation bands and one emission band, in optically complex coastal waters.

The main objectives of project EuroFluoro were:

- Follow development of a spring bloom and demonstrate the added value of having several wavebands to identify different algal classes.
- Monitor the biofouling accumulation on the sensor, measuring the effectiveness of the antibiofouling inbuilt UV LED light in the sensor. - Compare against a VLux casing with no anti-biofouling LED.
- Compare readings with another commercially available algae sensor (ECO FLNTU).
- Compare environmentally corrected readings with ECO FLNTU which lacks the corrections.

Main achievements and difficulties encountered

The project encountered several problems. In the first place, COVID restrictions and procurement issues delayed the build of the sensors, delaying the deployment until the end of the summer (August 2021) rather than spring as intended. Following on from this, travel restrictions, both government imposed and company policy concerning COVID prevented anyone from Chelsea Technologies from visiting the host at any stage in the process.

The second problem was only realised towards the end of the deployment. The sensor stopped responding at the end of November. The next available window to raise the subsea frame coincided with the end of the deployment so it was not possible to fix or replace the sensor. On raising the sensor and the control housing it became apparent that significant corrosion had occurred around the windows, raising severe doubts about the validity of the collected data. This will be more fully explored in section 5. When the sensor was dismantled, the electronics showed rust and residue showing that a leak had occurred.

Dissemination of the results

Results will be used to inform further internal development work.
Data: https://doi.org/10.17882/86790

Technical and Scientific preliminary Outcomes

The VLux was installed on the subsea observatory with the data being transmitted in the form of csv files sent by email once per hour. As this soon constituted several hundred file attachments, the emails were automatically placed into a separate folder from which an automated process downloaded the data to OneDrive. The VLux provides data with an interval of 1 second so a Python script was used to average the data over a 5-minute period to reduce the number of data points and smooth out measurement noise. Some periods of missed data occurred, though it is not apparent whether this was due to the sensor or to data transmission issues. The first data was collected on 26/08/2021 and the sensor failed on 25/11/2021, having run for three months. The sensor frame was raised at the next scheduled maintenance period prior to Christmas so in total the sensor and control housing were underwater for four months.

Upon raising the sensor, severe corrosion of the copper bezels surrounding the windows was observed. The sensor housing is made of titanium and the copper bezels surrounding the windows are incorporated for the anti-biofouling properties of copper. The experiment was intended to look at the effectiveness of the inclusion of a UV light source for anti-biofouling above that of the copper bezels alone. In actuality, the corrosion of the copper has resulted in the deposition of chemical contaminants on the windows. This occurred on both the complete sensor and on the control housing which contained no electronics.

Galvanic corrosion of dissimilar metals is of course a common problem. Nevertheless, the scale of the corrosion seen here in just four months was a surprise. VLuxs have been deployed in freshwater with no sign of any corrosion and while saltwater is obviously a much more corrosive environment than fresh, this was not expected to be an issue over the length of the deployment. A VLux has previously been deployed on a FerryBox system in the Baltic sea without showing this type of corrosion, although that system was not fully submerged and was subject to regular cleaning.

The anodic indices of titanium and copper differ by just 0.05 V, a value generally considered suitable even for harsh environments. Moreover, copper generally corrodes to form basic copper carbonate which forms a layer that protects the remaining copper underneath (as on copper roofs or the Statue of Liberty). The exact chemical makeup of this copper patina depends on the environment. In this instance the corrosion has not simply formed a protecting layer but spread to cover the sapphire windows and some of the titanium housing adjacent. This coating raises significant doubts over the validity of the acquired data.

The leak which caused the failure of the sensor appears to have been from the connector end of the instrument so is not thought to have been due to the corrosion of the window bezels. There is no evidence of a leak on the control housing, so it is suspected that this was due to a failure of the seal around the top of the instrument. Further investigation will be necessary to determine the exact cause. With seawater ingress, the optics are likely to have been damaged to some extent which raises further doubts over the validity of the data. There is no indication as to whether the leak was a sudden failure or a slow accumulation so it is difficult to say at what point the data may have been affected. Similarly, it is not known over what time scale the corrosion occurred, so it is difficult to say to what extent the data is affected at any time during the deployment.

As an example of the effect the chemical fouling has had on the data, below is shown the VLux turbidity response over the course of the deployment:

The turbidity rises sharply shortly after deployment then begins to fall. It eventually plateaus at a negative reading. This is because there is normally a small amount of scatter that is measured in zero turbidity water which produces an offset in the readings. With the windows clouded over, both the IR light emitted and the scattering is blocked and the offset applied to the calibration causes a negative value to be output. We cannot assume that the data preceding the negative values is valid since build-up of fouling must have occurred during this period and affected the data. It is possible that initial build-up may have caused an increase in scatter, but this is conjecture and would require specific investigation to understand.

Due to the problems of corrosion and leaking, we do not have confidence in the validity of the acquired data. For this reason, we are not able to comment on the efficacity of the UV illumination for biofouling prevention. We will further investigate the corrosion issue to try to better understand the problem and see whether there is a way the copper bezels can be used in marine environments.

8.1.16. EuroFluoro c

Project Information

Proposal reference number	21/1001637
Project Acronym (ID)	OligoSTAF
Title of the project	Field testing and validation of a new STAF sensor in oligotrophic Mediterranean waters
Host Research Infrastructure	HCMR

Starting date - End date	17th to 28th October 2021
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Kevin Oxborough Chelsea Technologies Ltd. 55 Central Avenue, KT8 2QZ, UK koxborough@chelsea.co.uk +44 2084819002

Project Objectives

Photosynthetron-based measurements of ^{14}C assimilation can provide accurate estimates of net primary productivity over a long time period. However, this method cannot provide information on dynamic processes or downregulation during the incubation, which is typically two hours or more. Furthermore, long incubation times, expensive reagents, and a complex experimental protocol mean that only a few ^{14}C data sets can be acquired per day. In contrast, Fluorescence light curves (FLCs) provide detailed dynamic data over a 20 minutes measurement cycle (typical). The main issue with comparing ^{14}C and STAF data is that the STAF measurements quantify PSII photochemical (electron) flux, rather than carbon uptake. This study was conducted to investigate the quantitative relationship between ^{14}C fixation and STAF-derived PSII electron flux in oligotrophic waters.

The overall goal of the work was to determine whether LabSTAF could be used to monitor primary productivity in oligotrophic waters. While the methodology for STAF-based measurements of PSII electron flux on a volume basis was published ten years ago (Oxborough et al. 2012), previous generations of fluorometers have lacked the required level of sensitivity.

There were three additional aims of the experiments: 1) to assess the level of variability in primary productivity estimates between the ^{14}C and STAF-based methods; 2) to determine how primary productivity changes during the long incubation times used in a photosynthetron, particularly at the high light levels; 3) to determine the electron per carbon ratio ($F_{e,C}$) for carbon assimilation by comparing the primary productivity estimations from ^{14}C uptake and LabSTAF.

Main achievements and difficulties encountered

LabSTAF was able to acquire high-quality data from 2 m, 20 m and 60 m seawater samples. Continuous FLC analysis showed that LabSTAF had the sensitivity to identify diurnal trends in oligotrophic water, at much higher temporal resolution than ^{14}C-uptake experiments.

Detailed experiments were conducted on the 20 m samples, to compare FLC-derived measurements of PSII electron flux (JV_{PII}) with ^{14}C-based estimates of primary productivity. The range of electron per carbon ratios ($F_{e,C}$) derived from these measurements were within the expected range, at approximately 8 to 40. A strong positive correlation was observed with the photosynthetron actinic light level. In all samples, the JV_{PII} and $F_{e,C}$ values were significantly lower after 120 minutes of incubation relative to 20 minutes of incubation.

One practical consideration with these measurements was the need to apply spectral matching between the photosynthetron-derived ^{14}C-fixation data and LabSTAF-derived FLC data. This was complicated by a significant spectral change in the photosynthetron actinic light experienced by the samples going from front to back (highest to lowest actinic light levels). The correction method applied within this study is detailed within the report. Since this analysis was carried out, a number of new functions have been added to the RunSTAF software used to control the LabSTAF system which make it much easier to apply spectral matching between the light source used to drive photosynthetron-based ^{14}C-fixation and the integrated LabSTAF light source used to generate FLC data.

Dissemination of the results

The data presented within this report are extracted from a more extensive document.

Public data link is not available yet at the time of the writing of this report.

Technical and Scientific preliminary Outcomes

Sample collection

Carboys of seawater were collected on 18/10/2021 from depths of 20 m and on 22/10/2021 from depths of 2, 10, 20, and 60m. The sample from 18/10/2021 was only used for experiment prototyping and initial tests (not included within this report). The sample from 22/10/2021 at 20 m was used to compare LabSTAF-based and photosynthetron-based measurements.

Experimental setup

Samples were incubated in a photosynthetron incorporating a uniform radiance PAR lamp (Photon Systems Instruments SL3500-W-C white lamp running at 70-90% full intensity). The light levels in the incubation bottles were controlled by distance from the lamp and strategically placed 30% neutral density (ND) filters. The entire photosynthetron area was surrounded by black sheeting to exclude external light sources, and the temperature of the photosynthetron was maintained at 23°C using an air conditioning unit connected through the black sheeting.

Two parallel rows of incubation bottles were run with matched light intensities and temperatures to provide replicate datapoints for each condition (Figure 1). The two rows were labelled as A and B, and the bottles were labelled 1 to 7. The temperature was monitored in bottle 3B and 7B. Incubations were run for between 2 h 5 mins and 2 h 25 mins.

Two Chelsea Technologies LabSTAF systems (004 and 008) were installed in the lab next to the photosynthetron (Figure 1). While ^{14}C incubations were ongoing, seawater from the same Carboy was analysed in the LabSTAF units using the 'Repeat FLC' protocol to acquire parallel estimates of PSII electron flux (JV_{PII}). Table 1 summarises all measurements made during this study.

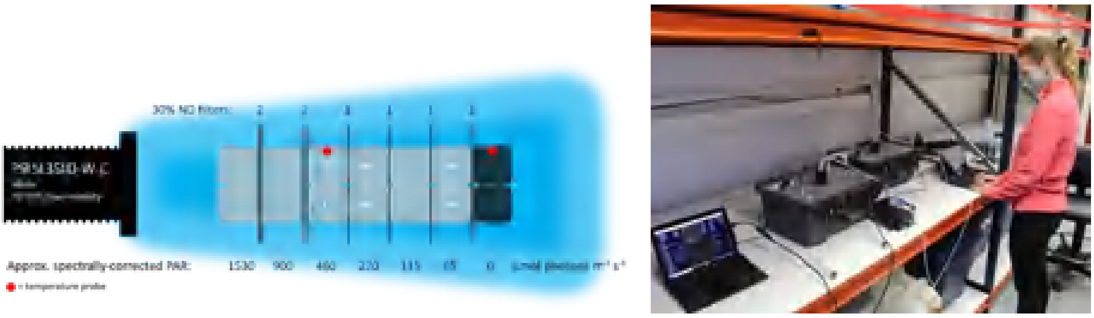


Figure 1: The setup for the photosynthetron (left) and the LabSTAF units (right).

Expt.	Date	14C experiments	004 FLCs	008 FLCs
LS0	19/10/2021	Trial light curve, 125 minute incubation	No data	No data
LS1	21/10/2021	Trial light curve, 132 minute incubation	Continuous from Carboy	Discrete from photosynthetron
LS2	22/10/2021	Trial light curve, 127 minute photosynthetron incubation	Discrete from photosynthetron	No data
LS3	25/10/2021	Light curve, 130 minute photosynthetron incubation	Discrete from photosynthetron	Discrete from photosynthetron
LS4	26/10/2021	Light curve, 145 minute photosynthetron incubation	Discrete from photosynthetron	Discrete from photosynthetron

Table 1: Overview of experiments. Where 'Discrete from photosynthetron' is used to describe the protocol used, measurements were at 20 and 120 minutes.

LS0 and LS1 were used to optimise the experimental protocol and timings for the ^{14}C assimilation and LabSTAF procedures.

LS2 was used to trial the final experimental procedure. Only one FLC measurement was acquired for each light level at each timepoint with this series.

LS3 and LS4 followed the same experimental protocol as LS2, except two complete FLC measurements were acquired for each light level at each time point. Timing issues experienced in LS2 were improved for LS3 and resolved for LS4.

Summary of results

The photosynthetron-based measurements provided ^{14}C-fixation rates within units of µmol C m^{-3} s^{-1}. The STAF Fluorescence Light Curves (FLC) measurements provided PSII electron flux with units of µmol electrons m^{-3} s^{-1} from. Points along the FLCs were matched to the light intensity within each of the photosynthetron sample bottles. These primary data allowed for calculation of electron per carbon ratios ($F_{e,C}$). The $F_{e,C}$ values within Table 2 are within the expected range for oligotrophic conditions (Lawrenz et al. 2013).

	LS2 (minutes)		LS3 (minutes)		LS4 (minutes)	
	20	120	20	120	20	120
Matched $\Phi_{e,C}$	18.1±4.5	13.2±4.2	14.1±2.2	12.2±1.8	22.8±8.6	19.2±4.6
Maximum $\Phi_{e,C}$	23.2±5.8	15.6±5.8	16.1±2.9	14.5±2.0	24.6±8.6	20.4±4.0

Table 2: The 'matched' $F_{e,C}$ values shows the average with each ^{14}C-fixation rate coupled to the

FLC step at the same actinic light intensity. The 'maximum' $F_{e,C}$ values from each experiment is also shown. All values are corrected for differences in the spectral output of the actinic light sources used.

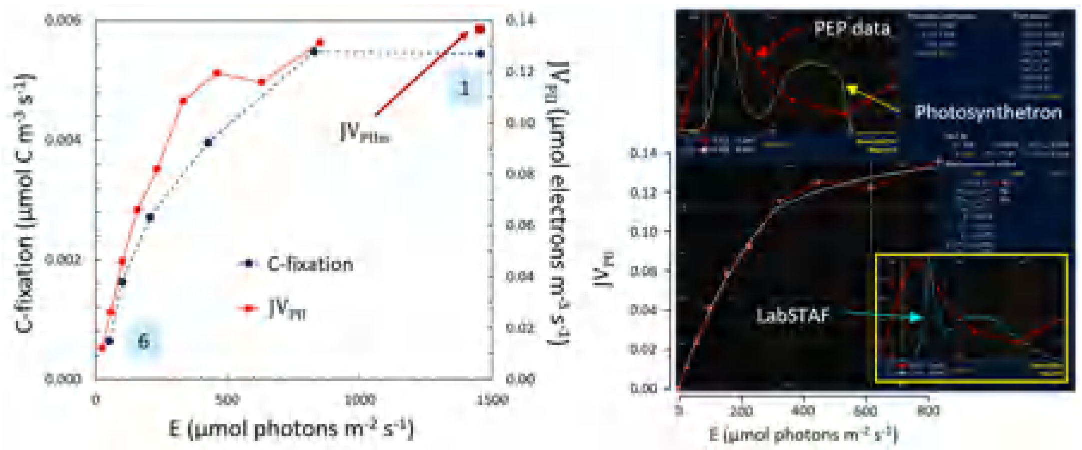


Figure 2: Sample data comparing photosynthetron-derived ^{14}C-fixation and LabSTAF-derived PSII electron flux. The blue labels **1** and **6** in the left plot indicate the bottle locations within Figure 1. The right plot is a crop from the RunSTAF screen and includes the Photochemical Excitation Profile (**PEP data**). The **Photosynthetron** line is the spectral output from the actinic light measured within the sample vessel. The **LabSTAF** line within the inset is the spectral output from the LabSTAF actinic light. Automated spectral correction between the two is now possible within RunSTAF.

Additional technical information plus cited and other relevant references can be found within the LabSTAF and RunSTAF Handbook: http://dx.doi.org/10.25607/OBP-1029.4.

8.2.Second TA Call

8.2.1. APHYMOSO

Project Information

Proposal reference number	JS3_CALL_2_4037_APHYMOSO
Project Acronym (ID)	APHYMOSO
Title of the project	Automated phytoplankton monitoring at ship of opportunity
Host Research Infrastructure	NIVA NorFerry Ferrybox: MS Fantasy
Starting date - End date	02/05/2022 – 10/05/2022
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Machteld Rijkeboer Rijkswaterstaat-CIV-Laboratory for Hydrobiological Analyses Zuiderwagenplein 2 8224AD Lelystad, the Netherlands machteld.rijkeboer@rws.nl +31 620407667

Project Objectives

Explore the feasibility of unattended and continuous monitoring of phytoplankton species composition and primary production with underway flow cytometric and fast repetition rate fluorometer on board a ship with FerryBox system

Questions to answer:

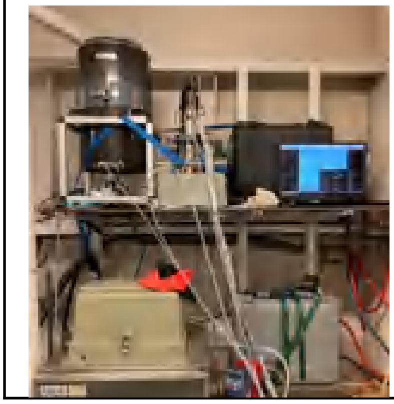
- Can these delicate instruments (FCM, FRRf) work in an unattended, noisy and warm environment like the engine room of cruise ferry or a bulk container
- Is the temperature control in the engine room stable enough to enable reliable observations
- Can the instruments perform the measurements fully automatically
- Can we automatically upload our data to the internet, allowing the operator and stakeholders to follow online measures and results online and near-real time
- Can additional observations (with FRRf) help to correct for non-photochemical quenching effects in fluorescence observations that are commonly made from Ferrybox systems

The obtained results will be helpful to define the conditions needed for installation on Ships of Opportunity (SOP) like the cs. Connector, which has a Ferrybox system run by NIVA and RWS since 2021.

Long-term these results and technologies will be used for the optimalization of the monitoring of Rijkswaterstaat (and other partners) on the North Sea. This will change the common monthly, discrete sampling strategy with a RWS vessel into a fully automatic monitoring using High Frequency sampling and integrating diverse instruments. In a similar way, automated monitoring platforms can be developed near windfarms to generate near-real time results, which are available for third parties and can act as early warning systems.

Main achievements and difficulties encountered

During the first round trip (Oslo-Kiel-Oslo) installation of FCM and FRRf in the engine room was achieved smoothly. FCM (every 30 min) and FRRf (every 20 min) automatically ran their measurement protocols and data of FCM were near-real time available on a website by using EasyClusLIVE software. A IT infrastructure with internet is required. The FRRf data can also be sent to the website, but needs some extra environmental input to calculate primary production from the raw data. This input (i.e. total irradiance) was not available on the ms Fantasy. The FCM is an optical instrument with lenses and light sensitive detectors, which are influenced by temperature to a certain degree. The focusing optics showed a stable alignment although environmental temperature conditions were not optimal. The FCM was placed in an airflow with a slightly lower temperature. The special temperature box, we intended to test could not be brought on board due to a communication mistake. Also the images made by the FCM are temperature sensitive, the focal quality could have been much better. The opening of the instrument in the engine room to adjust the system to the local temperature was not



performed due to the risk of getting dirt inside the system. Recent FCM instruments have automated adjustable translators (of the injector) to solve realign the system without opening it. The FRRf has its own temperature control unit and had no temperature issues.

Water inflow towards the instruments was regulated via a sampling chamber, but the flow-through rate had to be set much lower than preferred, because of a reduced waste water remove opportunity. Impact was not observed in the results, but this can be optimized in future.

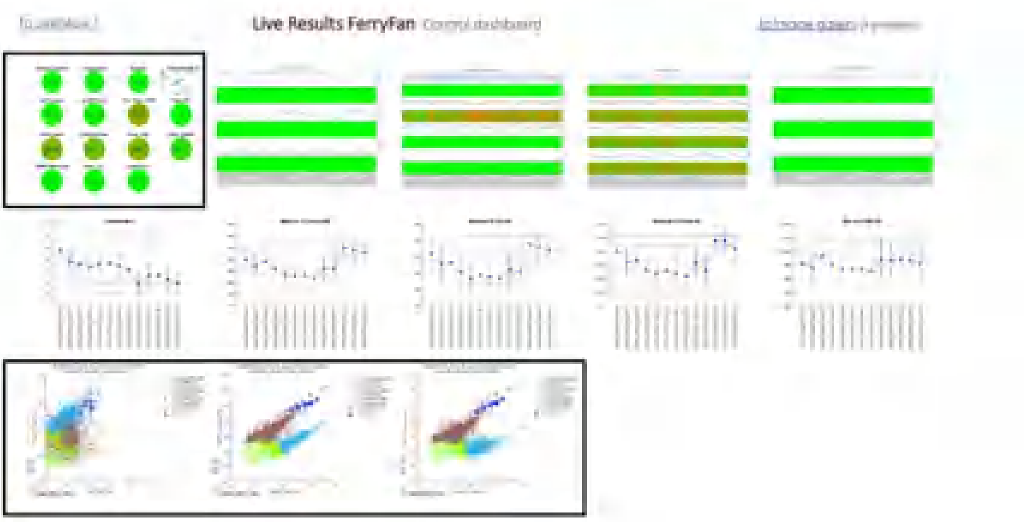
The overall conclusion is that the instruments worked stable and fully automated in this environment. No serious problems were encountered, which opens the way for further implementation on other non-manned platforms or SOP's.

Dissemination of the results

The prime and overall results will be published in a working report which will be shared with RWS and the Jerico-community and can be used as a guideline for installing High Frequency instruments (like the FCM and the FRRF) at SOP's. The raw data are kept at RWS server (not public at this moment). The results of analyzed flow cytometer data are available via www.phytoplanktonlive.com. A PowerPoint presentation was held for the own organization department CIV-Laboratory for Hydrobiological Analyses (in Dutch). A short new item was written for the newsletter of IGA-CIV (in Dutch).

Technical and Scientific preliminary Outcomes

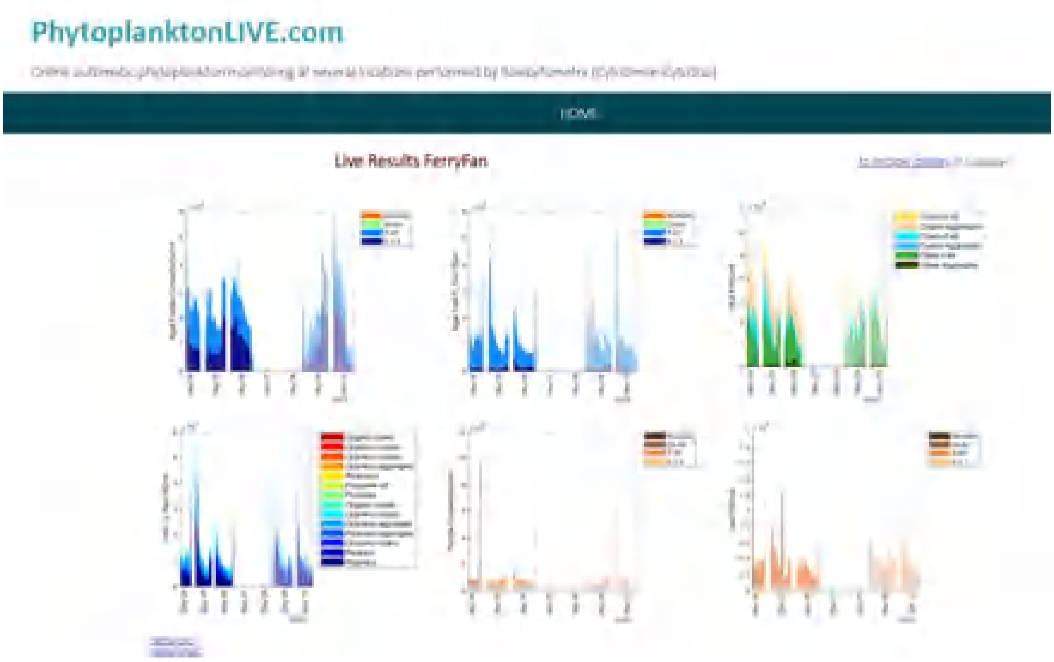
In principle both CytoSense flow cytometer and FRRF worked fully automated in the unmanned environment. The measurements started and stopped automatically. The data for the flow cytometer were automatically analyzed with EasyClusLIVE software and uploaded to the internet.



The above figure is automatically generated information for the operator, which can be accessed remotely. The overview in time of the most important parameters, like number of particles and used analysis volume, alignment of the FCM, fluidics pressure, temperature in the FCM and some scatter plots of the clustered data. The encircled data are referring to the last measurement done. The (green) traffic light panels indicate if measurements are correct.

The information in the panel below is for scientific and management activities. The concentration and discrimination of the size based and optical (phytoplankton) groups may be followed during the transect of measurement or in time. Variables such as chlorophyll, turbidity, counts, biovolume, particles sizes, cyanobacteria and other phytoplankton groups are measured by FCM.

Chlorophyll, light curves, Fmax/Fo, primary production related variables are measured by FRRf.



PhytoplanktonLIVE.com

Live Results FerryFan

Important lessons learned during this TNA

Vibrations:

Extra vibrations or oscillations were expected in the engine room at the lowest part of the ship. Although some vibration could be felt during the first cruise on board, this did not pose any problems with the instruments. Specifically no changes were detected in data or alignment of the FCM on a time-scale that could be related to vibrations. Similar observations (i.e. no effect of severe ship movements on the FCM) have been made in the past during other cruises with stormy weather at research vessels.

Water-in and outflow

Seawater has to be transported towards the instruments. The shorter the route, the less changes in the phytoplankton community and primary production can be expected. At the ms. Fantasy the sample water from the Ferrybox-pipeline was divided between the Ferrybox and two separate tap points. One was used for the automated sampler and one for the inlet of the flow-through sample chamber, from which both the FCM and the FRRf pump their water. The flow rate through the sample chamber had to be set lower than the desirable rate, due to a limit in output possibility of the waste water. Therefore, there was some concern about the residence time of water in the sample chamber. A faster refreshment rate of the sample chamber will reduce temperature increase due to the high temperature in the engine room.

For applying these instrument in a permanent setup in a ship, it is recommended not to use a separate sample chamber, but use the fixed pipeline of the ship from which the instruments immediately can get their input water.

Temperature conditions in the working space
The instruments involved and usual all optical instruments are temperature sensitive. For the FCM the environmental air is used to cool the internal instrument temperature, which increases by the electronics and lasers. This is done by a blower on top, but this is only efficient when the external temperature is lower than the internal. Most ideally the FCM is place in a temperature controlled room. Constant temperature conditions are necessary for maintaining stable alignment (the position of the sample core *vs*. the laser beam) and for images in focus, but also to reduce detector (noise) effects.

During this cruise some cooling airflow was used, which was just enough for keeping the alignment at an acceptable level, but this may not be the case later in the season. For applying the FCM at a SOP, there has to be an adequate temperature control system be installed. For the FRRf, the cooling was realised by connecting the water jacket around the measuring cuvette to a cryostat, which worked adequately.

Data infrastructure
Real-time data must be available for implementation in smart monitoring platforms and also when the data are used in predictive modelling. A reliable data infrastructure is needed for analysing the data, as well as for real-time access of the data for third parties. The FCM data was fully automatically analysed and this data and results were automatically uploaded to a server and the website. In future this can be done in a similar way for the FRRf data.
The development of the data infrastructure will be ship and/or transect dependent and must be organised before applying the instruments.

8.2.2. AQUA-Action-1

Project Information

Proposal reference number	JS3_CALL_2_4038_AQUA-Action-1
Project Acronym (ID)	AQUA-Action-1
Title of the project	AQUACOSM-JERICO Pilot Supersite Action @ SYKE
Host Research Infrastructure	SYKE-MRC (Marine Research Centre) Mesocosm Facility
Starting date - End date	18.8.2022 - 3.9.2022
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Dr. Stella A. Berger Department of Plankton and Microbial Ecology, Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB), Zur alten Fischerhuette 2, 16775 Stechlin

	stella.berger@igb-berlin.de +49 151 40092826 (mobile)

Project Objectives

Our project AQUA-ACTION-1 aimed at relating two overarching objectives:
1. Scientifically, we took the opportunity to study how the Baltic Sea plankton community is responding to extreme events such as sudden shifts in temperature, by mimicking a heat wave in the SYKE-MRC Indoor Mesocosm Facility. The experimental set-up was based on observations by continuous long time series recorded by the facility owner. As the IGB-team has recently studied effects of extreme events on lake ecosystems, we specifically wanted to compare our results in freshwater plankton systems with similar pressures on coastal plankton.
2. The second objective was to take this opportunity for knowledge transfer and harmonisation of competences between European Research infrastructures i.e. AQUACOSM-plus partner IGB (hosting the LakeLab facility, Germany) and JERICO-S3 partner SYKE (hosting the SYKE-MRC Indoor Mesocosm Facility, Finland) by collaboratively foster further development and best practices of technology solutions especially for mesocosm research and plankton imaging. We specifically aimed to initiate
RI-RI collaboration at using Artificial Intelligence for high-throughput analysis of plankton images on several instrument platforms i.e. two Imaging Flow CytoBots (IFCB), a CytoSense and a FlowCam. With the support of the scientific team at SYKE, we intended to use complimentary instrument parks, and exchange experience and knowledge in the application of the different imagers. Finally, both IGB and SYKE groups share a strong incentive to develop open-source programs that are independent of instruments.

We expect that this exchange will benefit these overall objectives, and the wider plankton
community by supporting the development of platform-agnostic and open-source approaches for
plankton analyses.

Main achievements and difficulties encountered

Both scientific teams at IGB and SYKE successfully shared knowledge and harmonised competences for plankton imaging technologies during the time course of the indoor mesocosm experiment. In particular, the SYKE-team helped the IGB-team to set up the Imaging Flow CytoBot (IFCB) in the AQUABOX for benchmark comparison of taxa identification and abundance measurements with the convolutional neural network (CNN) developed by SYKE (Kraft et al. 2022). Parallel measurements of phyto- and microplankton species with the FlowCam performed by the IGB-team during the mesocosm experiment allowed to compare measurements between the IFCB imaging flow cytometers and the FlowCam including different properties such as phytoplankton abundance and biomass estimations by FlowCam and IFCB associated with pigment group-dependent abundance measured in the CytoSense.

This knowledge transfer permitted to create a valuable and rich data-set in terms of annotated images from all the imaging platforms that will be further used in the image library for CNN improvements. These annotated images will then be further used to test and compare the results of the different automated approaches developed at the host institution SYKE and at IGB. The IGBteam will use these results to further develop the "LabelChecker" software currently version 2 based on open-source algorithms, and strengthen our open-source program initiative that are independent of instruments (Bochinski et al. 2018). Finally, IGB expects after thorough interpretation of the experimental results to be able to infer the effects of heat waves on plankton systems from bulk phytoplankton measurements and imaging data.

Unfortunately, the S::SCAN spectro::lyser underwater spectrophotometer could not be setup due to instrument failure and limited manpower for repair.

Dissemination of the results

- JRA-TA activity was presented in the media on the JERICO-RI webpage: (https://www.jerico-ri.eu/2022/09/06/joint-jerico-s3-and-aquacosm-plus-study-on-balticsea-heatwaves/)
- And on the AQUACOSM-plus web page: https://www.aquacosm.eu/news/article/jointaquacosm-plus-and-jerico-s3-study-on-baltic-sea-heatwaves, https://www.aquacosm.eu/news/article/participation-in-a-mesocosm-experiment-at-sykehelsinki-hcmr-team-and-little-maria
- Raw data obtained during the mesocosm experiment by the instruments run by the IGB team , i.e. IGB-IFCB and the FlowCam, will be available on open source after quality checking and will be part of an open access paper describing the effect of a simulated heat-wave on the plankton community and size distribution. QC data described above will be available on open source (by CC) in an open source publisher (for example Pangaea https://pangaea.de) and on the scientific journal site (if available).
- Results from the method developments and the mesocosm experiment will be presented in scientific meetings in collaboration with SYKE and the other teams on location.
- Results from the method developments and the mesocosm experiment will be published in scientific peer-reviewed journals in collaboration with SYKE and the other teams on location.
- Publication of next version of the Label Checker software on open source (e.g. GitHub) is planned. So far, AI tools developed at IGB have been shared with SYKE to collaborate on future software developments for AI-supported automatised plankton classification.

AQUA-ACTION-1-2022 (FlowCam data – IGB-team)
Link to metadata
https://data.aquacosm.eu/geonetwork/srv/eng/catalog.search#/metadata/9f89f26f-bd77-440c-b1ff-5b9195dbd457
Link to Raw data
https://nimbus.igb-berlin.de/index.php/s/M8Sfw3Piey3CnP2

AQUA-ACTION-1-2022 (IFCB data – IGB-team)
Link to metadata
https://data.aquacosm.eu/geonetwork/srv/eng/catalog.search#/metadata/0673f86e-5d38-4db4-95ec-9fb323a81c26

Technical and Scientific preliminary Outcomes

5.1) Set-up and installation of the IGB-IFCB

Both teams IGB and SYKE successfully shared their knowledge and expertise to harmonise competences for plankton imaging technologies. In particular, IGB'S IFCB has been set up (mounted, aligned, filled with fluids) with the support of Kaisa Kraft (Figure 1), a PhD student at SYKE specialized in automated identification and detection of plankton by combining IFCB and CNN technologies (Kraft et al. 2021, 2022). IGB's

IFCB has been calibrated under the same conditions as SYKE's IFCB. After a row of difficulties, in particular pump dysfunctions and lasers alignment issues, the team effort was successful and we could finally install the IGB-IFCB in the AQUABOX system which is connected to the experimental mesocosm tanks and to run plankton samples in parallel with the SYKE-IFCB (Figure 2).

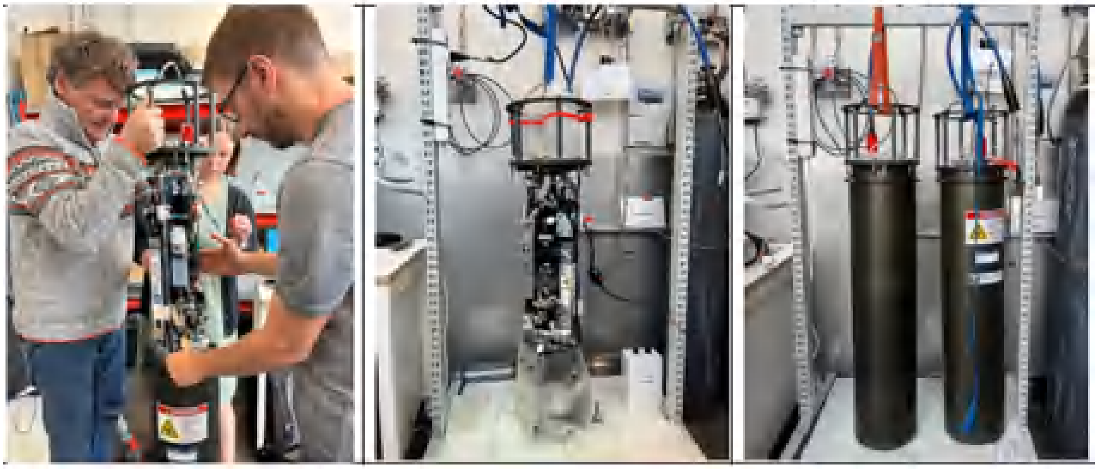


Figure 1. Setting up the IGB-IFCB (left, Jens Nejstgaard, Kaisa Kraft, Christian Dilewski); Naked hanged up IGBIFCB filled with fluids and ready to measure (mid); IGB-IFCB (135) and SYKE-IFCB (114) ready be installed in the AQUABOX (right); (Photos: Stella A. Berger, IGB).

Figure 2. From left to right: Christian Dilewski trouble shooting the night measurement routine in the IFCB software; Installation of the IGB-IFCB in the AQUABOX system to run plankton samples in parallel with the SYKEIFCB (Photos: Stella A. Berger, IGB).

5.2) Comparison of measurements between both IFCBs

In both IFCBs, image-specific biovolumes were computed and the biovolumes were converted to biomass (µg L-1) assuming a plasma density of 1 g cm-3 (CEN 2015; see Kraft et al. 2022). We compared IFCB-specific phytoplankton biomass estimates at four different equivalent spherical diameter (ESD) ranges (ESD = 6*biovolume/PI^(1/3)).

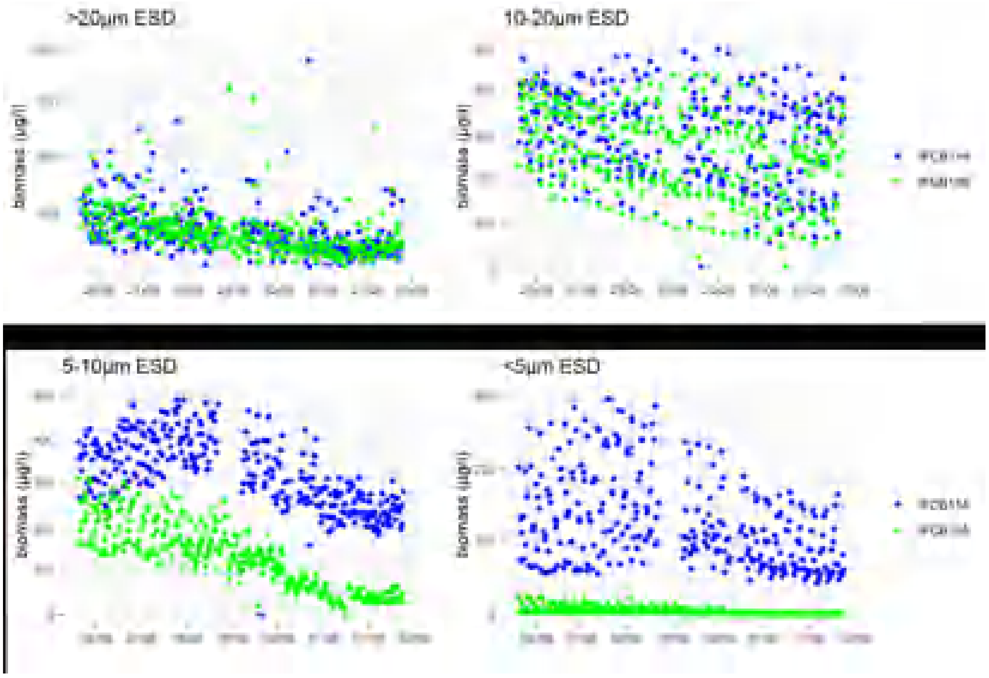


Figure 3. Comparison of IFCB-specific biomass estimates at four different equivalent spherical diameter (ESD) ranges (preliminary results provided by Kaisa Kraft, SYKE).

Preliminary results look very promising and the phytoplankton biomass estimates were very similar between both IFCBs at ESD above 10 µm (size groups 10-20 µm ESD and >20 µm ESD). However, the biomass estimates differed between the IFCBs at ESD below 10 µm (size groups < 5 µm ESD and 5-10 µm ESD). Overall, differences in biomass estimates between both flow cytometers decreased as particle size increased. Currently, the IFCB provides best quantitative observations at a ESD > 10 µm. Despite our effort, some differences in the instrument settings in recognizing small-sized cells still remained and need to be improved in future. For instance, the pixel to µm calibration has not been done for the IFCB 135 (IGB), and we used the conversion of the IFCB 114 (SYKE). Finally, we compared only single small samples volumes (< 5mL). Consequently, larger sample volumes have to be tested to get a better comparison of IFCB-specific results.

5.3) FlowCam measurements during the mesocosm experiment and response of plankton size

Phytoplankton cell size is a key functional trait that often governs resource acquisition, growth, reproduction or interactions with consumers. Temperature changes affect the metabolic rates of phytoplankton that are allometrically scaled with cell size. It is thus expected to observe higher proportion of small species with fast metabolism during heat waves, as compared to larger species with slower metabolism. The IGB team ran samples from each mesocosm every day (or second day) in a FlowCam equipped with a 100 µm flow cell and 10x objective to obtain plankton images in the size range between 3 and 100 µm (Figure 4 and 5).

Figure 4. Sampling of the mesocosms (left, IGB-team and Sami) and run of plankton samples in the FlowCam (Alexis Guislain, right) during the SYKE mesocosm experiment at temperature setting of 16, 18, 20, 22°C 4x replicated (Photos: Stella A. Berger, IGB).

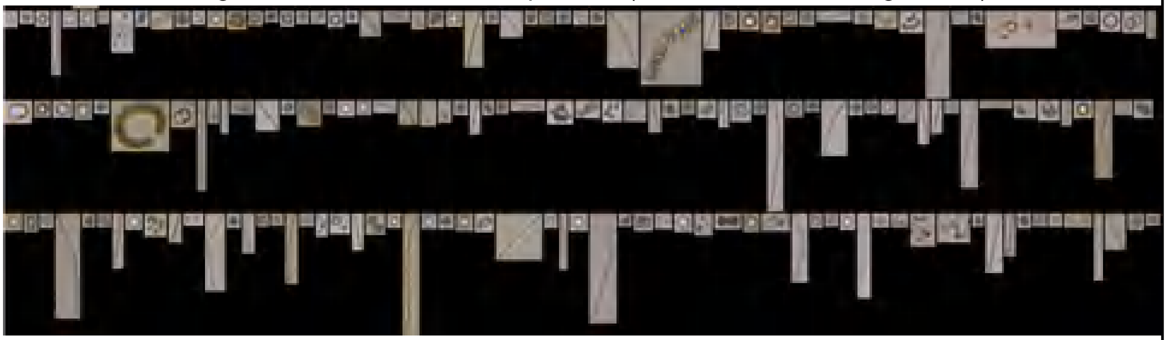


Figure 5. Example of collage images obtained with the FlowCam on August 30th 2022 from the community incubated at 16°C (Photo, IGB).

Preliminary results supported the introductory rationale (Figure 6). Particles (algae plus detritus) below ESD of 20 µm accounted for 90% of the total community biovolume when incubated at 22°C. In contrast, the ESD range had to be twice as large for the community incubated at 16°C to reach 90% of the community biomass. These differences in size distribution during heat waves are expected to have severe consequences on carbon cycling or size-dependent predation for instance.

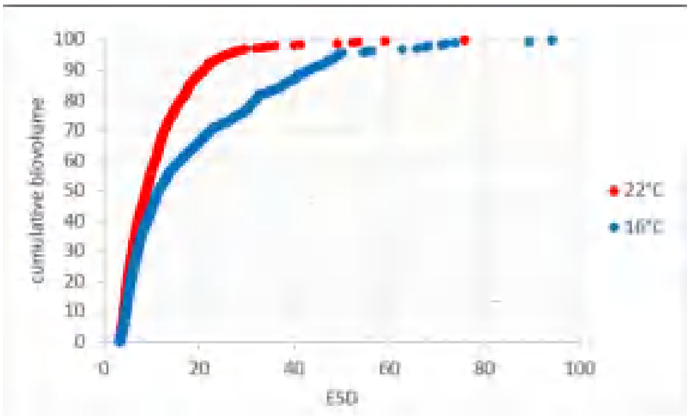


Figure 6. Size distribution (ESD) of the community biomass (expressed as biovolume = ESD*pi^(1/3)* 1/6) in the communities incubated at 22°C and 16°C. The contribution of smaller organisms to the total community biovolume increased as temperature increased (Graphic, Alexis Guislain).

5.4) Use of IFCBs and FlowCam image data to assess the effects of heat wave on plankton

The mesocosm experiment gave us the opportunity to further develop a calibrated suite of flow cytometers with different properties and to create a valuable and rich data-set in terms of annotated images that will be used to further develop the "LabelChecker" (Bochinski et al. 2018). The primary ambition for the IFCB was to be installed as a long-term monitoring instrument in situ. The FlowCam however, was dedicated to laboratory measurements. Both IFCB and FlowCam have now the possibility of being calibrated and complement each another (Figure 3). The FlowCam software has been updated by IGB to Visual Spreadsheet 4.19 to improve volume estimation of plankton particles. FlowCam includes all particles also those without fluorescence signal such as heterotrophic microzooplankton, flagellates and detritus, thus, comparison with IFCB needs classification and sorting of particles, which will be supported by LabelChecker 2.0. After thorough interpretation, our results should enable us to infer to some extent the effects of heat waves on plankton systems from imaging data.

Thanks for the great team at SYKE and specifically Kaisa, Katri, Jukka, Maiju, Pasi, Sami, Timo, Otso, Teresa, Noora, Mari, Joanna, Christian, Anne-Mari and more as well as the opportunity for fruitful collaboration with all other research teams visiting SYKE.

8.2.3. AQUA-Action-2

Project Information

Proposal reference number	JS3_CALL_2_4039_AQUA-Action-2
Project Acronym (ID)	AQUA-Action-2
Title of the project	AQUACOSM-JERICO Pilot Supersite Action @ Utö
Host Research Infrastructure	Utö marine station
Starting date - End date	3.9.2022 - 5.9.2022 (hosts continued the observations until 7.9.2022 – Remote Access for two days)
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Dr. Stella A. Berger Department of Plankton and Microbial Ecology, Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB), Zur alten Fischerhuette 2, 16775 Stechlin stella.berger@igb-berlin.de +49 151 40092826 (mobile)

Project Objectives

Our project AQUA-ACTION-2 aimed at relating two overarching objectives:
1. Scientifically, the tests conducted at Utö marine station should assist our experimental work at SYKE MRC-lab, by providing a comparison of different imaging instruments (IFCBs, CytoSense, other sensors) installed in an AQUABOX system monitoring the Baltic Sea plankton at Utö, and especially improving our understanding of sensor and instrument specific uncertainties in abundance and biomass estimation of natural plankton communities.
2. Our second objective was to utilize this opportunity for knowledge transfer and harmonisation of competence between European Research infrastructures, by collaboratively developing best practices and technology solutions for plankton imaging. We specifically aimed to initiate RI-RI collaboration in using Artficial Intelligence (AI) for high-throughput analysis of plankton image on several instrument platforms. Our aim during the Utö visit was to exchange experiences and discuss best approaches for integration of IFCB instruments in operational multi-sampling platforms. This includes automated and remote maintenance practices, physical, fluidical and electronic integration, and practices in data transfer. We expect that this knowledge exchange and harmonisation approach will benefit the wider plankton community by supporting the development of platform-agnostic and open-source approaches for plankton analyses.

Main achievements and difficulties encountered

The scientific teams involved in this activity from IGB (TA users), FMI (operator) and SYKE (operator) successfully shared their expertise and knowledge, harmonised competences for plankton imaging technologies and during the stay at Utö marine station located (UMS) on Utö Island (59º 46'50N, 21º 22'23E) at the outer edge of the Archipelago Sea (Baltic Sea) https://en.ilmatieteenlaitos.fi/uto . Long-term measurements of physico-chemical parameters are in line with image-based data acquisition of Baltic Sea phytoplankton by using the permanently running IFCB installed in the AQUABOX (Kraft et al. 2021, 2022). During the visit of the IGB team at Utö, the SYKE-team helped the IGB-team to set up the IGB-Imaging Flow CytoBot (IFCB) and connected it to the AQUABOX installed at Utö marine station. The IFCB at Utö got maintenance and parallel measurements of algae cultures were performed to confirm that they measured similar values (which they did, within ca 5-10% from each other each run), before attaching both to the water intake for the AQUABOX. Parallel measurements of phyto- and microplankton species with both IFCB imaging flow cytometers (from IGB and SYKE) were then used to compare measurements between both instruments including different properties. We achieved benchmark comparison of taxa identification, abundance measurements and biomass estimations with both IFCB instruments supported by the convolutional neural network (CNN) analyses developed by SYKE (Kraft et al. 2022). These measurements will also be compared with pigment group-dependent abundance analyses in the CytoSense performed by Lumi Haraguchi (SYKE).

This knowledge transfer permitted to create a valuable and rich data-set in terms of annotatedimages from all the imaging platforms that will be further used in the image library for CNN improvements. The annotated images will then be further used to test and compare the results of the different automated approaches developed at the host institution SYKE and at IGB. The IGBteam will use these results to further develop the "LabelChecker" software currently version 2 (based on open-source algorithms and Bochinski et al. 2019), and strengthen our open-source program initiatives at both involved institutions, e.g. to develop approaches more independent of instrument platforms preferably across the involved institutions, and beyond. This collaboration will also support planned collaboration in the new HORIZON Europe project Aqua-INFRA, where both IGB and SYKE are partners with focus on plankton imaging.

This project has a strong relevance at the European level, through the collaboration between key persons and institutions in both JERICO-S3 and AQUACOSM-plus RIs forming a direct RI-RI collaboration to enable transfer of knowledge, harmonisation of competence, develop best practices and technology solutions between European Research infrastructures.

Dissemination of the results

- Raw data obtained by the instrument IGB-IFCB during the access to Utö, will be available on open source after quality control and will be part of an open access paper comparing the IFCB instruments used for analysing the Baltic Sea plankton community and size distribution.
- QC data described above will be available on open source (by CC) in an open source publisher (for example Pangaea https://pangaea.de) and on the scientific journal site (if available).
- Results from the method developments and short-term comparison of IFCB instrumental set-up and data acquisition of the Baltic Sea phytoplankton monitoring data will be published in scientific peer-reviewed journals in collaboration with SYKE and FMI/UMS teams on location.
- Results from the measurements and method developments achieved at the Utö station and the mesocosm experiment will be presented in scientific meetings in collaboration with SYKE, FMI/UMS and the other teams on location.
- Publication of next version of Label Checker (GitHub) or similar is under planning; AI tools developed at IGB were shared with SYKE to collaborate on developments.
- Results and benefits of the RI-RI collaboration will be disseminated through the channels of the EU-networks - JERICO-S3, AQUACOSM-plus and the Aqua-INFRA projects.

AQUA-ACTION-2-2022 (IFCB metadata – IGB-team)
Link to metadata
https://data.aquacosm.eu/geonetwork/srv/eng/catalog.search#/metadata/a03462ff-56b3-4d2c-92da-ba17000f5559

Technical and Scientific preliminary Outcomes

1) Monitoring infrastructure and plankton analyses at Utö
The scientific teams involved in this activity from IGB, FMI and SYKE successfully shared their expertise and knowledge, harmonised competences for plankton imaging technologies and during the stay at Utö Marine Research Station (Laakso et al. 2018). The Utö Atmospheric and Marine Research Station of Finnish Meteorological Institute is located on Utö Island (59º 46'50N, 21º 22'23E) at the outer
edge of the Archipelago Sea, Baltic Sea (Figure 1). Marine observations are lead by the Head of Group, Lauri Laakso (FMI) and biological observations are lead by the Head of laboratory, Jukka Seppälä (SYKE). The Finnish Meteorological Institute started meteorological observations on the island in 1881, marine observations in 1900 and atmospheric trace gas and aerosol measurements in 1980. Utö Atmospheric and Marine Research Station is part of the HELCOM marine monitoring network, European Monitoring and Evaluation Programme EMEP, Integrated Carbon Observing System ICOS, The Aerosol, Clouds and Trace Gases Research Infrastructure ACTRIS and Coastal research infrastructure network Jerico-RI. Currently, it is developed to become a national ACTRIS site. Real-time observations from the station available at https://en.ilmatieteenlaitos.fi/uto .

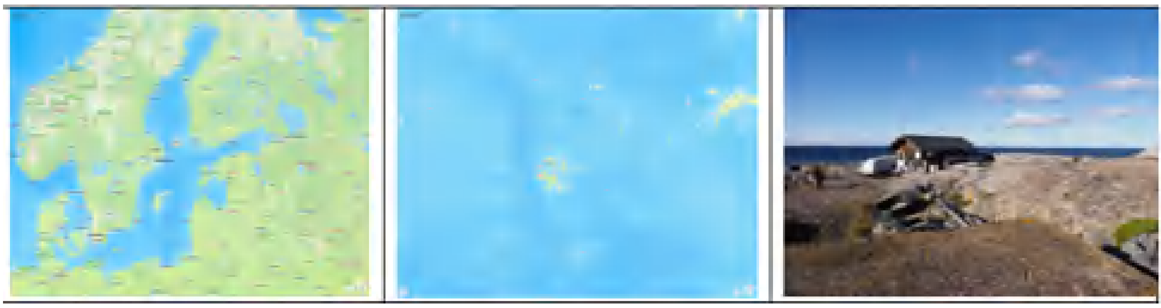


Figure 1. Location and photo of Utö Marine Station on the island Utö, Baltic Sea (Photo: Jens Nejstgaard).

The TNA activity by the IGB team enabled a collaboration between FMI, SYKE and AQUACOSM-plus, including the set-up and field-testing of the IGB-IFCB in parallel with the SYKE-IFCB at Utö. Long-term measurements of physico-chemical parameters of the Baltic Sea at Utö are combined with image based data acquisition of phytoplankton by using the permanently running IFCB installed in the AQUABOX (Kraft et al. 2021, 2022). We compared the results of both IFCB instruments measuring the Baltic Sea phytoplankton community by a continuous flow-through setup and collected image data with both IFCBs in September 2022. As only a stay between 3-5 September was possible for some of the participants, including the IGB team, the rest of the running of the IFCB had to be conducted as Remote Access until the local team took the instrument back from Utö to Helsinki, after the mission was completed on 7 September 2022. The IFCBs capture images of planktonic cells and processed a 5-mL sample every 20 minutes. Both instruments were operated with chlorophyll a trigger to capture images of chlorophyll-containing cells and to prevent detritus and other non-living material to be
imaged. The size of the imaged particles ranged from 5 µm nanoplankton to large colonies or filaments such as cyanobacteria with a length of ~300 µm. A 150 µm mesh was used at the instrument inlet to prevent the instrument from clogging.

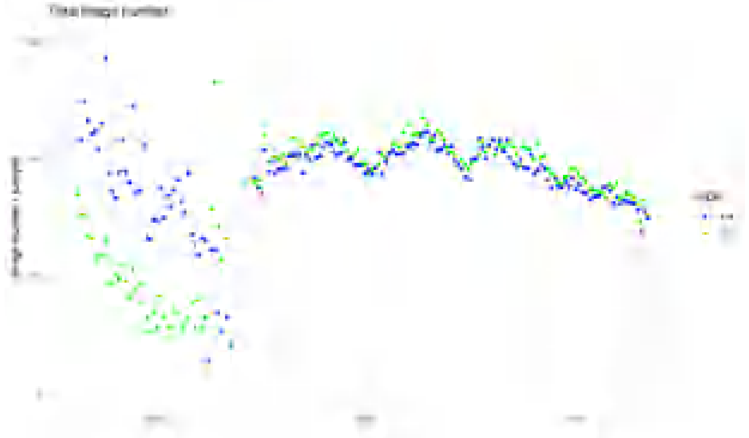
2) Set-up and installation of the IGB-IFCB at Utö

The research teams from IGB, SYKE and IMF successfully shared their knowledge and expertise to harmonise competences for plankton imaging technologies. In particular, IGB strongly benefitted from this TNA, as IGB's IFCB has been set up (mounted, aligned, filled with fluids) with the critical support of Kaisa Kraft (Figure 1), a PhD student at SYKE specialized in automated identification and detection of plankton by combining IFCB and CNN technologies (Kraft et al. 2021, 2022). IGB's IFCB has been calibrated under the same conditions as SYKE's IFCB. The team effort was successful and we could finally install the IGB-IFCB in the AQUABOX system at Utö which is connected to the Baltic Sea water inlet and to run plankton samples in parallel with the SYKE-IFCB (Figure 2).

Figure 1. Top row, from left to right: Kaisa Kraft and Jens Nejstgaard, setting up the IGB-IFCB attaching the fluid pouches to prepare for operation; Jens Nejstgaard working on the IGB-IFCB with Lumi Haraguchi working on the CytoSense and Jukka Seppälä working on the AQUABOX in the background; Lumi Haraguchi setting up the CytoSense; Lower row, from left to right: The water intake tubing for the AQUABOX; comparing the IGB and SYKE-IFCBs before closing the instruments; both IFCBs connected to the AQUABOX water intake system (Photos: Stella A. Berger, IGB).

3) Comparison of measurements between both IFCBs

In both IFCBs, the total number of images per sample and image numbers of IFCB-specific estimates at four different equivalent spherical diameter (ESD) ranges were compared.



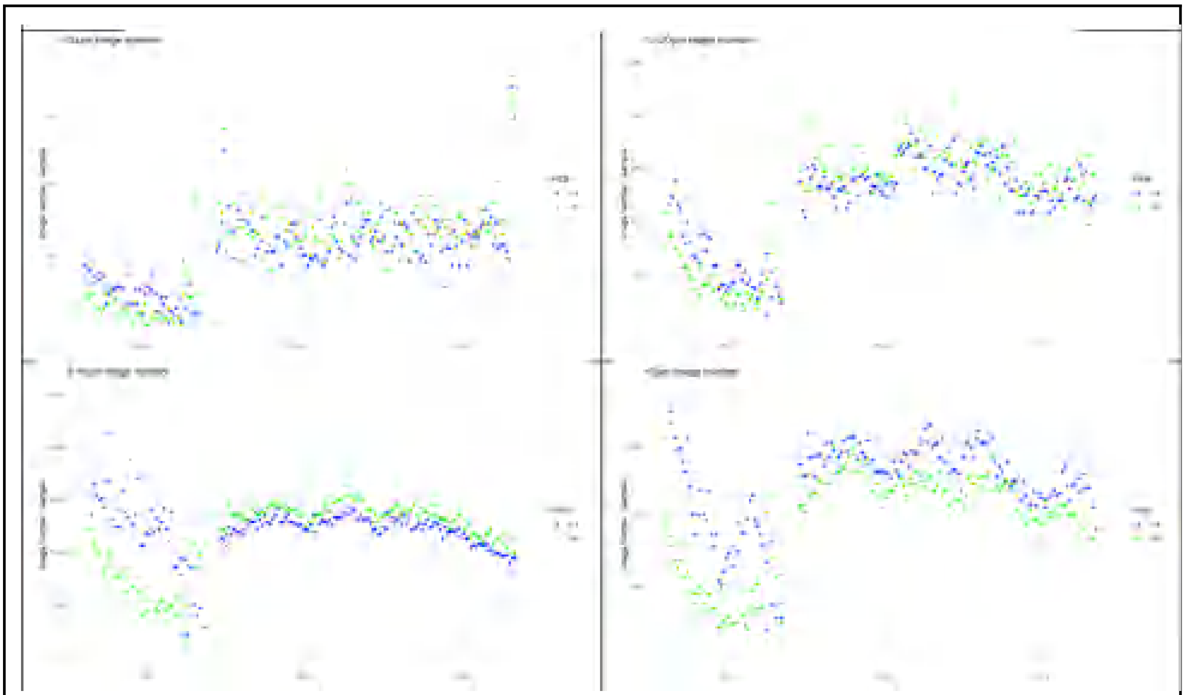


Figure 3. Comparison of IFCB instruments (SYKE-IFCB 114 in blue and IGB-IFCB 135 in green) measuring Baltic Sea water samples including natural phytoplankton. Total image numbers (upper large graph) and different equivalent spherical diameter (ESD) ranges > 20 µm, 10-20 µm, 5-10 µm, < 5 µm (lower graphs). Preliminary data kindly provided by Kaisa Kraft, SYKE.

Despite that the biomass estimates have been very similar between the two IFCBs tested at SYKE in the previous project AQUA-ACTION-1, the total numbers per sample and the size-specific numbers at first appeared to be very different between the two IFCBs compared at Utö (Figure 3). This can be seen in the left part of all panels of Figure 3 where systematically higher numbers were detected in the SYKE-IFCB. We discovered that this was related to which of the water intakes that was used for the respective IFCB instrument. The error could be found in the intake system i.e. the intake micro tube was pressed against the side of the intake tube in one of the two hose connections (Figure 4). The problem could be solved during the period of Remote Access, and after this, both instruments gave very similar results as indicated in the right part of all panels in Figure 3. Total image numbers were very similar between both IFCBs as well as image numbers in the size groups 10-20 µm ESD and >20 µm ESD. Image numbers slightly differed between both IFCBs in the size groups <5µm ESD and 5-10 µm ESD (Figure 3). Overall, differences in image numbers between both flow cytometers decreased as particle size increased because the IFCB provides better quantitative observations at a

ESD ranging between 10 and 80 µm. Despite our effort, minor differences in the instrument settings in recognizing small-sized cells still remained. For instance, the pixel to µm calibration has not been done to IFCB 135 (IGB), instead we used the conversion factor from IFCB 114 (SYKE), which may affect in which size class the images go (i.g. data from IFCB 135 showed less images in 5-10 µm and more in < 5µm size class).

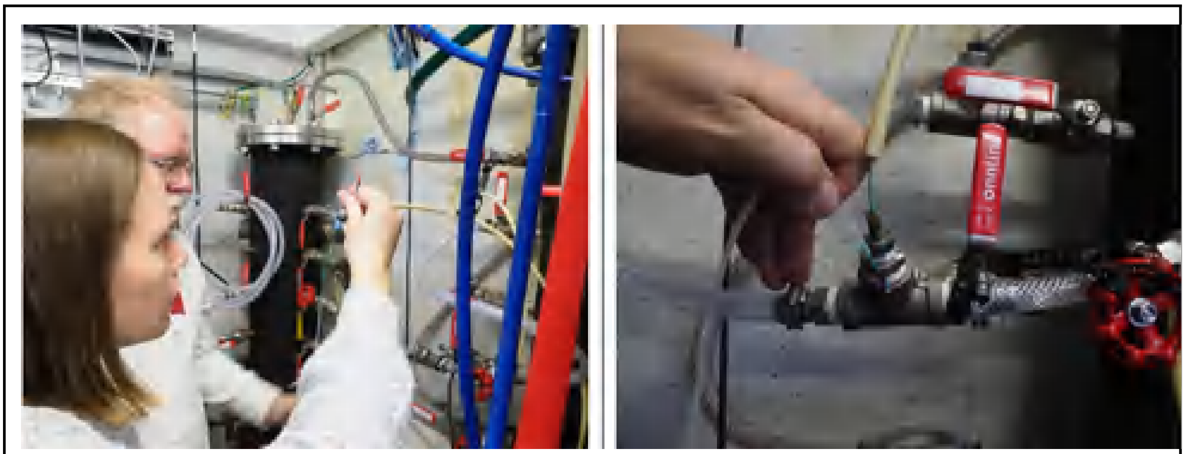


Figure 4. Critical control, and reinstallation of the hose connection to the AQUABOX system.

4) Use of IFCB image data to assess plankton dynamics in pelagic aquatic ecosystems

The visit to Utö measurement station and the SYKE mesocosm experiment gave us the opportunity to further develop a calibrated suite of flow cytometers with different properties and to create a valuable and rich data-set in terms of annotated images that will be used to further develop the "LabelChecker" (Boschinki et al. 2019). The primary ambition for the IFCB was to be installed as a long-term monitoring instrument in situ. After thorough interpretation, our results should enable us to infer to some extent the effects seasonal developments in plankton communities from imaging data. The exercise at Utö helped us to define i) how to best install IFCB for continuous operations on
location and when getting back to IGB to install the IFCB at Lake Stechlin and ii) estimate instrument specific uncertainties for imaging by comparing the the images quired in both IFCBs and technical connections to the AQUABOX.

The collaborative study between FMI, SYKE and AQUACOSM-plus, including the set-up and fieldtesting of the IGB-IFCB in parallel with the SYKE-IFCB supported by long-term observational physical and chemical data at Utö and the experimental data at SYKE, will contribute to better understanding of how phytoplankton communities are affected by extreme climatic forcing. Several aspects of interests for the research community studying pelagic plankton system can be achieved i.e. to enhance spatio-temporal analyses of plankton samples and support time-consuming microscopic analyses. Thus, this activity contributed to the tools needed to cope with Grand Challenges for aquatic ecosystems connected with global climate change. The knowledge-transfer during this activity enabled future phytoplankton data collection also at the freshwater LakeLab platform in Lake Stechlin, North Germany, upon return of the IGB-team.

Thanks to the great team at Utö marine station and specifically to Lauri, Kaisa, Jukka, Otso, and Lumi for the collaborative experience, super teamwork and wonderful impressions of the island and engaged and informative guidance by Lauri on the Utö island, Jens and Stella

5) References

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Kraft K, Seppälä J, Hällfors H, Suikkanen S, Ylöstalo P, Anglès S, Kielosto S, Kuosa H, Laakso L, Honkanen M, Lehtinen S, Oja J and Tamminen T (2021) First Application of IFCB High-Frequency Imaging-in-Flow Cytometry to Investigate Bloom-Forming Filamentous Cyanobacteria in the Baltic Sea. Front. Mar. Sci. 8:594144. doi:10.3389/fmars.2021.594144

Kraft K, Velhonoja O, Eerola T, Suikkanen S, Tamminen T, Haraguchi L, Ylöstalo P, Kielosto S, Johansson M, Lensu L, Kälviäinen H, Haario H and Seppälä J (2022) Towards operational phytoplankton recognition with automated high- throughput imaging, near-real-time data processing, and convolutional neural networks. Front. Mar. Sci. 9:867695. doi: 10.3389/fmars.2022.867695

Laakso, L., Mikkonen, S., Drebs, A., Karjalainen, A., Pirinen, P., and Alenius, P. (2018) 100 years of atmospheric and marine observations at the Finnish Utö Island in the Baltic Sea, Ocean Sci., 14, 617-632, https://doi.org/10.5194/os-14-617-2018

8.2.4. IMAPOCEAN

Project Information

Proposal reference number	JS3_CALL_2_4040_IMAPOCEAN
Project Acronym (ID)	IMAPOCEAN
Title of the project	Integrated Multilevel Active Passive Ocean Current Education Advancement Network
Host Research Infrastructure	HCMR POSEIDON and PCL
Starting date - End date	June 2022 - May 2023
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Ariadne Dimoula Paramount Planet Product 42 Mill St. Orono Maine 04473 ariadne@p3rd.earth (207)307-9393

Project Objectives

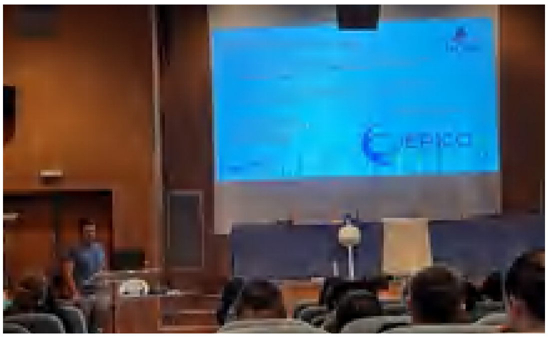
- Quantify the transport of intermediate and deep waters.
- Monitor ocean surface flow through active drifting ocean drones.
- Engage the public in ocean current research through building and deploying Drifters.
- Guide and lead students to reach their own conclusions about our impact on the Earth.
- Activate and connect schools and communities across the Globe, creating a web of oceanographic data and increasing global connectedness and climate awareness.

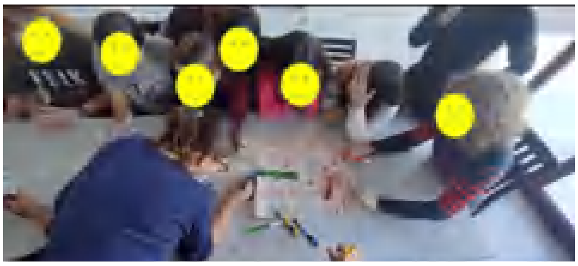
Scientific and technical objectives are over a 1 year time period to execute a multilevel study of the water column using both active and passive monitoring tools. These tools are Sea Horse Tilt Current Meter, and student-built biodegradable oceanographic drones called "Drifters" which use GPS to monitor ocean surface currents. This is a continuation from EMSO-Link Transnational Access (TNA) 2020 and the POSEIDON coastal . Our instruments will be deployed on a mooring and will collect additional measurements of currents and waves at different depths, which will provide data for comparison and cross calibration of the instruments performance.

Main achievements and difficulties encountered

Integrated Multilevel Active Passive Ocean Current Education Advancement Network (I.M.A.P.O.C.E.A.N) experiment successfully started on the 30th of August 2020 at 08:50 am, UTC in the South East Ionian Sea, offshore Pylos (Peloponnese), Greece (36º84'N, 21º61'E). The main achievement of IMAPOCEAN was the launch and recapturing of a Sea Horse Tilt Current Meter. On 08/09/2021 The Philos our vessel was able to retrieve the mooring line, which was delivered to our base in Crete. One of four sensors deployed made it to the surface. The two hobos (alternative sensors for Lowell Tilt Meters, still structured as a seahorse tilt meter) and one of the current meters were lost at sea and the mooring line attachment points surfaced empty in the 3 depths, only the deepest one surveyed. With its recapture, one year's worth of data from 2020-2021 was retrieved. A computing program such as python or R was used in order to understand the movement of ocean currents at different levels. A difficulty that was encountered directly stemmed from the Corona Virus Pandemic. Unfortunately, COVID-19 halted countries' sea-going research activities worldwide, as well as travel restrictions and long periods of lockdowns. Due to the pandemic, IMAPOCEAN had to alter its experiment timeline in order to contribute to the slow Corona Virus. Schools limited all outside parties from in-school interaction to prevent the spread of the Corona Virus.

In November 2023 IMAPOCEAN citizen science research component was brought to students for them to understand and participate in Ocean research data exploration.





Dissemination of the results

Data can be displayed on web portals (eg Poseidon webpage). To ensure the output from our research informs research facilities and educational institutions we will be using The Sea Horse Tilt Current Meter, and student-built biodegradable oceanographic drones called "Drifters" which use GPS to monitor surface ocean current flow. Sea Horse Tilt Current Meter is a novel instrument developed recently by CoPI(Sheremet) for US National Oceanic Atmospheric Administration (NOAA) to be used during fishy surveys. Our instruments will be deployed on the existing mooring and will collect additional measurements of currents and waves at different depths, which will provide data for comparison and cross-calibration of the instruments performance. Ocean Drifters provide valuable real-time data for scientists as well as stakeholders and engages students in citizen science.

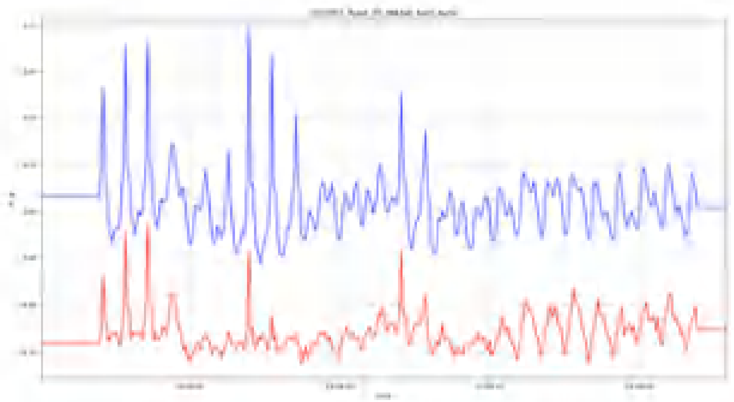
The students will follow their student drifters on this website
https://studentdrifters.org/tracks/
As the data set of both tools grows, additional scientific reporting opportunities can be identified.

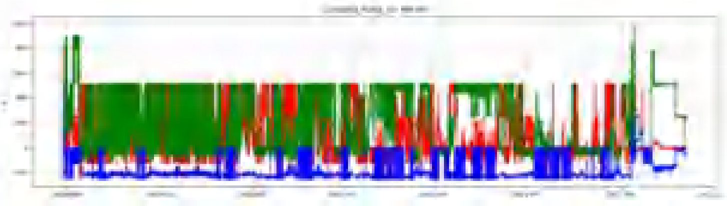
This data was collected during the 2020-2021 season off of Pylos Greece, Demonstrating the seahorse current tilt meter.

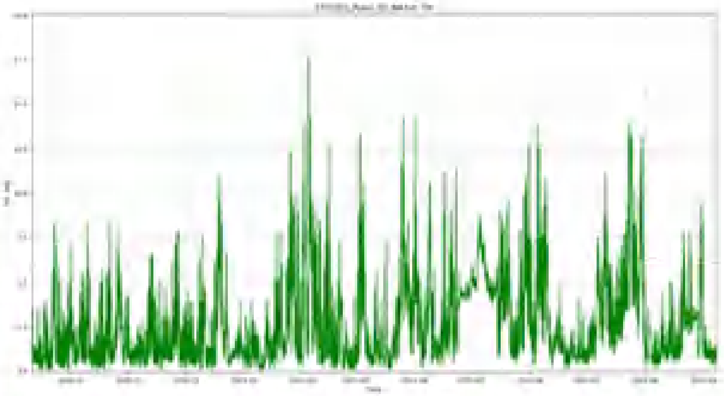
1. Basically, only one current meter (out of 4) was recovered.
2. When reprogramming the logger, Manolis specified very sparse sampling rate once an hour for 20sec - should be about every 5 min or so.
3. Magnetometer on the current meter has failed - the readings are weird (Figure M.png). Maybe it was next to a magnet at some point during the transit or storage.
4. Accelerometer and Temperature channels worked well. I am able to derive the tilt of the instrument. See attached plot (Tilt.png).

Axy_zoom1.png shows detailed behavior during a burst (20s long) sampling. This data is from an early stage of the research, the first deployment. This data allows us to analyze the performance of the instrument. Basically, the range of tilt angles shows that the instrument can work in relatively high current regimes. It will be helpful to compare the tilts with some other current measurements from the same mooring and plot a correlation diagram.

Also, we can plot Tilt vs Wind when we get meteo data from that area. The sampling rate during bursts was adequate to get estimates of velocity, but the burst samplings need to be set to something faster than once an hour in order to collect more data and resolve higher frequencies.







As of July 2024, the Mediterranean drifter is still active, meaning it has been collecting ocean surface data for over 3 months. You can see the Poseidon informational IMAPOCEAN drifter page here:

https://poseidon.hcmr.gr/news/students-construct-and-deploy-drifters-current-data-acquisition
As well as the active tracks here:
https://studentdrifters.org/tracks/drift_imapocean_2024_1.html

Technical and Scientific preliminary Outcomes

I.M.A.P.O.C.E.A.N is an international multilevel -ocean depth of 1590m to ocean surface 1m depth – an ocean current research experiment. With capabilities to expand around the globe. Scientific and technical objectives are to execute a multilevel study of the water column using "Active" meaning Lagrangian (moving) and "Passive" meaning Eulerian (moored) monitoring tools. The moored monitoring tool is the "Sea Horse Tilt Current Meter" stationed at different depths on Hellenic Marine Research Center (HMCR) Deep-Sea Research Buoy in Pylos, Greece. These oceanographic tools, designed by scientists at Okeanolog, Lowell Instruments, and University of Rhode Island (URI) are suited for measuring waves and currents. The Sea Horse Tilt Meter used in this experiment is also known as the MAT-1 Data Logger™. This device is capable of recording absolute orientation (tilt), acceleration (including vibration), and temperature. The logger contains three sensors: a 3-axis magnetometer, a 3-axis accelerometer, and a thermistor. The system, packaged in a tough, waterproof PVC (300m depth) or titanium (4500m depth) case, is suitable for continuous use in a wide variety of demanding applications, including underwater. The moving monitoring tool is the student-built oceanographic "Drifter" which uses Global Positioning System (GPS) to monitor the top 1m surface ocean currents. Such Drifters are utilized by U.S.A's National Oceanographic Atmospheric Administration (NOAA)'s Northeast Fisheries Science Center (NEFSC) to estimate fish larvae transport. Drifters can record and telemeter latitude and longitude position data in real-time via GLOBALSTAR satellite multiple times a day. New designs incorporate biodegradable materials such as wood, aluminum, bamboo, canvas, rocks for ballast. The GPS unit is attached to the top and foam buoys keep the electronic unit above the waterline. Underwater canvas sails catch the ocean current. Drifters can be built in any classroom and provide valuable real-time data for scientists as well as stakeholders while engaging students in citizen science.

In September 2023 project PI presented IMAPOCEAN to HCMR Crete employee during a summer seminar session.

The Education Team of HCMR, Crete, and the POSEIDON team hosted students and teachers from the Heraklion School of Arts and Music School of Heraklion at Thalassocosmos (HCMR, Crete) for the JERICO S3 IMAPOCEAN TNA initiative. Under the coordination of Mrs. Ariadne Dimoulas and funded by JERICO S3 (HCMR PI: Dr George Petihakis), the IMAPOCEAN project (Integrated Multilevel Active Passive Ocean Current Education Advancement Network) seeks to actively involve young students in hands-on ocean current data collection by constructing and deploying Drifters. These Drifters, sourced from the USA's NOAA and the Northeast Fishery Science Center (NEFSC), were initially designed for recording flow data related to fish larva movement. Constructed from materials like aluminum or bamboo, canvas, rocks for ballast, and a foam buoy with a GPS unit above the waterline, these Drifters can be assembled in a classroom setting with minimal experience. The Drifters play a crucial role in recording meaningful sub-surface data by telemetrically reporting their movement using GPS at regular intervals. Beyond the educational aspect, this student-built oceanographic tool has the added benefit of actively involving students and their communities in ocean research through the entire process, from building to launching and monitoring the Drifters. During their visit to HCMR, the students participated in a presentation on ocean currents and scientific monitoring tools. Following the presentation, they engaged in the hands-on experience of building and decorating their Drifters. This initiative not only provides valuable insights into ocean science but also fosters a sense of participation and community engagement in ocean research among the students.

8.2.5. LASE-NOPAH

Project Information

Proposal reference number	JS3_CALL_2_4042_LASE_NOPAH
Project Acronym (ID)	LASE-NOPAH
Title of the project	Levels and air-sea exchange of nitrated and oxygenated polycyclic aromatic hydrocarbons in the marginal sea of Europe
Host Research Infrastructure	HCMR
Starting date - End date	1 January 2022 - 31 December 2022

Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Gerhard Lammel RECETOX, Masaryk University Kamenice 5 /D29, 62500 Brno, Czech Republic gerhard.lammel@recetox.muni.cz +420-54949-4106

Project Objectives

Determination of levels of nitrated and oxygenated polycyclic aromatic hydrocarbons in surface waters of the Mediterranean and in the atmosphere, and determination of the direction of diffusive air-sea exchange and related fluxes.

This research is part of a study on sources and atmospheric fate of NPAHs and OPAHs in the source region Europe and the background marine atmosphere.

Main achievements and difficulties encountered

Deployments of passive air and water samplers was done at 2 JERICO stations during 3 seasons, (in total 2x3x2 months) as planned. The sampling periods covered fall and winter 2021/22 and spring 2022. The samples were collected along with field blanks, and shipped within a few days to the trace laboratory.

Dissemination of the results

Results will be included in a project report to a national funding agency (Czech Science Foundation) and are planned to be published in the scientific literature together with other data sets from other marine or continental background sites. The data is publicly available through the GENASIS environmental data repository (https://data.genasis.cz/#/outdoor/spatial-distribution#project@216).

Technical and Scientific preliminary Outcomes

Elevated levels of polycyclic aromatic compounds were confirmed in surface seawater and surface air above (0.3-0.6 and 0.2-0.4 ng/m^3, respectively) in summer and fall at the moderately polluted marine site POSEIDON HCB and the remote marine background site POSEIDON E1-M3A, both in the Aegean Sea. At these off-shore sites, water pollution by the polycyclic aromatic compounds is understood to be dominated by atmospheric depositions, which are probably strongest during summer. A water pollution gradient between these two sites was found in fall (no direct comparison in summer), with contaminants concentrations typically a factor of 2 (but for some substances up to a factor of 10) higher at HCB. The directions of diffusive air-sea mass exchange of 18 nitrated and 13 oxygenated PAHs were determined. The results indicate that several 3-4 ring compounds have been approaching phase equilibrium, and several 2-3 ring compounds, namely the nitronaphthalenes, 5-nitroacenaphthene and 9-fluorenone, were net volatilisational during the measurement period i.e., were returned to the atmosphere from the surface seawater.

These results are preliminary. Seasonal variation can only be assessed once the results of chemical analysis of samples collected in winter and spring will be accomplished.

8.2.6. OpenLevo

Project Information

Proposal reference number	JS3_CALL_2_4043_OpenLevo
Project Acronym (ID)	OpenLevo
Title of the project	Enhancing Wave Measurement with energy autonomous Wave Sensing Buoy
Host Research Infrastructure	Marine Institute (MI) SmartBay (SMARTBUOY)
Starting date - End date	01st Dec 2021 – 30th Nov 2022
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Georgios Koutras Openichnos Hellas Private Company An. Papandreou 57, 71305, Heraklion Crete koutras@openichnos.com +306976791019

Project Objectives

OpenLevo is a wave measuring system that consists of a small buoy with a solar panel and a communication module. The project submitted for Jerico TA aimed at deploying this system in SmartBay for data comparisons and validation and to further develop the system. The deployment made use of the facilities and services in SmartBay.

A major objective of that development was to have a cost-efficient buoy for wave measurements producing different parameters associated with wave motion such as Heave, Direction, Period and Water Temperature. Moreover, it provided us a real time wave analysis transmitting the collected data via satellite. Additionally, the applicability of OpenLevo solution was tested in a maritime environment with long term field exposure under harsh sea conditions.

- Energy autonomy of the device was tested.
- Weather proofing of the device was long term tested under extreme environmental conditions (heat, wave energy, salt).
- Total endurance in real maritime conditions was tested.

SmartBay facility covered all the range of our objectives as it allowed us to verify all those measurements.

Main achievements and difficulties encountered

The installation of OpenLevo in oceanographic observing platforms provides us significant added value as a) it increases the efficient transmission of Wave data in 100% global range, b) it leads to future research in developing cost efficient Wave Sense buoys with low energy requirements and state of the art communication capability.

The proposed SmartBay facility offered us a unique opportunity for the testing of OpenLevo in a whole new market, that of the marine observing platforms. The installation and testing of the device in a wide range of environmental conditions gave us the possibility to fully exploit and test the operational capabilities of the product. Moreover, the SmartBay facility is located in areas which were ideal for satellite tracking solutions.

Dissemination of the results

The outcomes of this activity will be presented by the Openichnos in industry and operational oceanography meetings and workshops. When the experiment started Openichnos announced this activity in the Greek Press.

(1) Live wave data from the wave rider can be downloaded over a given timeseries from the following web portal: https://www.digitalocean.ie/Dashboard/Galway Select: SmartBay WaveBuoy and download data.
(2) OpenLevo measurement data throughout Galway Bay deployment
https://www.dropbox.com/sh/elwaxs08gbq6j33/AACyTishY1CE4yigReSL4I17a?dl=0
https://smartbay.marine.ie/data/jerico-S3/OpenLevo/

Technical and Scientific preliminary Outcomes

This project's primary goal was to test the OpenLevo Wave Buoy in Galway Bay. This region's varied sea states provide an ideal testing environment. Galway Bay has a depth of roughly 20 meters and generally calm sea conditions.

In addition, Galway Bay is home to a WAVERIDER (1) buoy, a standard for measuring waves that enables us to use the data as a benchmark. Galway Bay saw the deployment of the OpenLevo from July till August of 2022. Marine Institute was in charge of the installation. The device installed in the JERICO S3 infrastructure operated continuously for this period of exposed to the marine environment without any maintenance or servicing procedures. The deployment period and the challenging climatic conditions at the deployment site demonstrated the OpenLevo device's reliability.

A ship of Marine Institute made the installation for OpenLevo. Deployment was made according to the following guidelines: there is a specific way of deploying the buoy in order to record the wave parameters. The buoy has to move freely and not be interrupted by any rope pulling it down.

1. Assistant buoy anchor
2. Assistant buoy rope
3. Assistant buoy with light indicator
4. Rope connecting the OpenLevo to the assistant buoy

5. OpenLevo Chain
6. Wave characterization buoy OpenLevo

Figure 1: OpenLevo deployment diagram

In order to freely move and capture the wave data, the OpenLevo buoy needs to be deployed with a second buoy as an assistant in a 4 to 5 meters radius. After the deployment in Galway Bay, OpenLevo began to collect sea measurements, which were then sent over GSM or over Iridium Satellite. Along with wave data, the buoy also communicated its GPS location and its battery status so that it can be verified that it is in the right place and its communication parts are active. The following table presents the minimum and maximum measurements for values for the significant air wave, peak wave period and mean wave period in the deployment site whereas a more detailed report is also available. (2)

	Significant Wave Height - hm0 (m) (min-max)	Peak Wave Period - Tp (s) (min-max)	Mean Wave Period - Tm01 (s) (min-max)
SmartBay	0 – 1.6	1.70 – 10.31	1.54 – 7.11

Table 1: Minimum and maximum values for the significant air wave, peak wave period and mean wave period in the deployment site

Preliminary outcomes

OpenLevo is a smart buoy that utilises the latest advancements in the MEMS-based sensors and IMU-Fusion algorithms to measure directional waves. The device can capture significant wave height, wave period and wave direction precisely, without any maintenance, sensing the 3D motion. Using power-efficient sensors, solar energy and satellite coverage. OpenLevo can be deployed in the sea or lakes and report meaningful wave characteristics around the world 24/7. Wave sensing buoys can improve sea forecasting models, have an important role in research programs and act as a valuable source of information for emergency situations. Galway Bay deployment gave significant insights and proper testing environment, proving our data measurement consistency. Moreover, the OpenLevo buoy is constructed in such a way that the center of gravity combined with the chain protects it from going upside down, and in the meanwhile being a lightweight system with a high frequency response. This had been also successfully checked through the period of testing.

A more detailed study of the results for the comparison of wave date, the geolocation information, the efficiency of transmission and their consistency will be carried out at a future period which will come as a result of OpenLevo final calibration.

References:

(1) Live wave data from the wave rider can be downloaded over a given timeseries from the following web portal: https://www.digitalocean.ie/Dashboard/Galway Select: SmartBay WaveBuoy and download data.
(2) OpenLevo measurement data throughout Galway Bay deployment https://www.dropbox.com/sh/elwaxs08gbq6j33/AACyTishY1CE4yigReSL4I17a?dl=0

8.2.7. S1100-HTHSal

Project Information

Proposal reference number	S3_CALL_2_4044_S1100-HTHSal
Project Acronym (ID)	S1100-HTHSal
Title of the project	ANB Sensors S Series: High temperature and high salinity
Host Research Infrastructure	POSEIDON Calibration Lab (PCL) and FerryBox (PFB)
Starting date - End date	01/10/2021 – 01/10/23
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Dr. Nathan Lawrence ANB Sensors 6 Old Farm Business Centre, Toft, CB23 2RF, UK nlawrence@anbsensors.com 01223 263545

Project Objectives

The aim here being to test the S1100 performance as the conditions transcend the season when biofouling is and isn't prevalent. In addition to the long term and bio-fouling evaluation, testing of the sensor in waters that have a higher salinity and higher temperature are extremely valuable, and the lessons learnt from these tests will be incorporated into ANB Sensors next revision. Most importantly the impact of temperature and salinity on the sensitivity of the response will be key to ensuring the sensor can work across the entire oceanographic range.

The principle objectives for the project are:

1. Deploy the S1100 on a costal observing multiplatform system in elevated temperatures and salinities.
2. Deploy a second sensor on one of a field profiler or a surface vehicle equipped with a FerryBox system to understand the impact of lateral flow accross the sensor surface and the impact of temperature sensitivity on the sensors response.
3. Provide feedback on the sensors ease of use, ease of deployment and data retieval features.
4. Validate the sensors response against independent measurements in real time deployment.

5. Allow ANB Sensors to understand the issues associated with oceanography and sensor deployment for other analytes – providing scope for future collaborations.

Main achievements and difficulties encountered

One of the main achievements was proving the performance of the S1100 in a lab, as well as the verification from the end user that the sensor was indeed easy-to-use. Maintenance of the transducer was carried out successfully both in the lab and on deployment onboard the ferry, realising the goal of this sensor being the preferable option for long term deployments as it doesn't need to be recovered for maintenance. The tests at the lab were conducted in higher saline waters and showed the sensor responded well in these conditions with no detrimental impact on the sensors transducer.

There were two main difficulties, the first was with access to the facilities due to hardware malfunctions which were rectified by HCMR and the second was with longterm data collection on the sensor. The sensor in deployment failed to save data after some time of monitoring due to issues with the internal memory. This is discussed below.

Dissemination of the results

Utilizing the data and results gathered throughout this Jerico S3 project, in conjunction with our in-situ lab-based research, an academic peer-reviewed article detailing the measurement technique and the performance of the sensor in HTHP. In addition, the data will be communicated through conference/meeting presentations in order to demonstrate the validity of our system, and for the public, through social media.

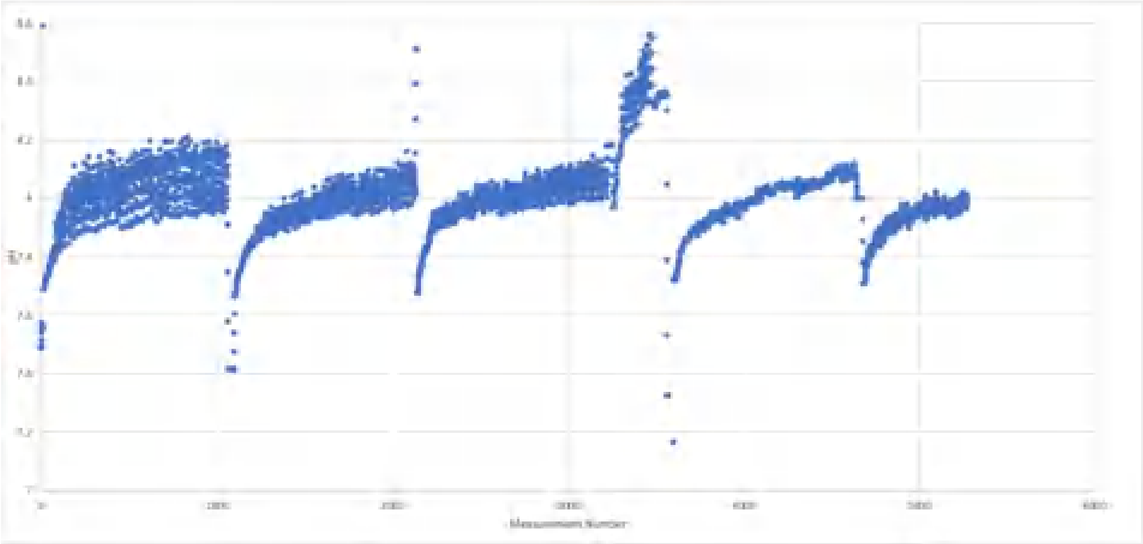
A public link to the data has not been made available yet at the time of the writing of this report.

Technical and Scientific preliminary Outcomes

The experimentation for this project was conducted at the PCL (Poseidon calibration) laboratory in HCMR and on the PFB (Poseidon ferry box) mounting.

The sensors were first tested in the lab at HCMR to ensure a good performance before deployment. The tests were performed in a high salinity seawater solution and were powered simulating the Ferry Box connection. The sensors were run over a period of hours and data was retrieved from each showing consistency of pH measurements between the two. At this point we asked for operational feedback of the sensor, the USP's of easy to use, and set-up were confirmed. However, on discussions it was thought the size of the sensor maybe an issue for AUV monitoring.

Due to technical issues with the Ferrybox there was a delay in getting the sensor onboard the vehicle. Once operational a bespoke flow chamber was constructed by the team at HCMR which was capable of being attached to the main FB flow circuit. In operation solution was passed by the sensor and the sensor monitored the pH of the solution continuously. The sensor was powered using the FB power channels and the data logged in the FB windows PC through terminal software. The first device was installed at 22/07/23 and operation started to operate on the 25/07/23. However, there was an issue found with the sensor, it was stalling and no data was obtained. This sensor was operational in the previous laboratory trials. This sensor was then replaced with the second device on the 15/08/23 in accordance with ship maintenance schedule. The second sensor collected data for a period of time however, failures were then seen with the health number of the transducer rising and the data showing error messages. The collected data is shown in the figure below:



It can be clearly seen that there is periodic trend in the data, which is not from the solution it is immersed and it appears to be the sensor repowering after a power cycle and restabilising after this power cycle. Analysis of the average of the all the data provides a pH of 7.952 and a standard deviation of 0.23. Removing the data associated with the stabilisation data pH <7.8 provides an average pH of 7.99 and a standard deviation of 0.11. the normalized (25deg C) pH values in the Cretan sea annual variation is 7.99-8.05 based on a full year sensor deployment in one of the HCMR buoys in 2020-21.

The work and data obtained has been extremely useful in improving the operational performance of the sensor. The data and understanding from these trials has been fed into the development of our next generation sensor range, the most notable impacts are:

Smaller size: the new range is 10 times smaller per unit volume than the S Series.

Improved sealing: issues around transducer sealing from solution contact to the internals of the sensor were seen to be an issue and has been completely redesigned to ensure pressure integrity. Measures are now in place to pressure test all sensors.

Improved transducer performance: Due to the sealing issues failures of the transducers occurred quicker than expected. New manufacturing methods have been implemented to improve the structural rigidity of the sensing elements and thus significantly improve mean time to failure.

Improved data saving: Data saving was an issue observed in these trials, the firmware around the data saving has been re written with a significant reduction in failures.

8.2.8. RADCONNECT

Project Information

Proposal reference number	N°21/1002072
Project Acronym (ID)	RADCONNECT
Title of the project	Underwater radioactivity measurements
Host Research Infrastructure	Helmholtz-Zentrum Geesthacht (HZG) & Alfred-Wegener-Institut (AWI)
Starting date - End date	13/4/2022 – 30/6/2024
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Christos Tsabaris 46.7 Km Athens-Sounio Ave, 19013 Anavyssos, Attica, Greece tsabaris@hcmr.gr +302291076410

Project Objectives

- Deploy and operate on a continuous basis an innovative underwater radioactivity device on a cabled observatory.
- To study the environmental total gamma ray intensity anomalies due to high precipitation events and correlating the activity concentration of radon daughters with precipitation rates as calculated with other methods.
- To study potential anthropogenic pollutants.

Main achievements and difficulties encountered

Efficient integration of GeoMAREA underwater sensor.
Continuous data in two areas (one close to seabed and another one in seawater).
Surveillance of marine environment in terms of radioactive contamination and potential development of decision making system support.

Dissemination of the results

A paper will be published in Journal of Marine Science and Engineering (Sep 24).
Presentation of results in the Hellenic Nuclear Physics Society Symposium (Thessaloniki, Greece, 2024).

Technical and Scientific preliminary Outcomes

Understanding the distribution and change of oceanic rainfall patterns is a major component of global/regional water cycle and climate change. The most common instruments used to measure rainfall are rain gauges, which however represent a point measurement. A lot of effort is given the last year to monitor radioactivity in the sea as well as in the air for studying air-sea interactions. As concerns the radioactivity measurement in the sea, radon progenies can be observed after and during a rainfall event. Radon progenies in the atmosphere are transported to the sea surface by the scavenging effects of rainfall. Radon can be detected via its daughters (214Bi and 214Pb) which are gamma-ray emitters. The continuous monitoring of gamma radiation in the marine environment provides significant information on various environmental processes where radon (and/or thoron) can be applied as a tracers. 222Rn (half life 3.825 d) is a noble gas and is found in aerosol particles in accumulation-mode. It has been observed qualitatively after rainfall from the short-lived radon daughters (214Bi and 214Pb). However, the variation of radon activity is not constant mainly due to rainfall intensity, rainfall type and humidity. It has been measured (using the lab-based method) that the volumetric activity of radon decay products in rainwater amounts up to 105 Bq/l. This phenomenon causes the environmental gamma ray intensity at the sea to increase significantly during the rainfall, anywhere from several to tens of percentage points of intensity compared to dry conditions. The study of radon progenies is necessary in order to correctly assess rates of precipitation and fallout issues and processes (after an accident). Furthermore, the radon progenies in rainwater are useful when studying the atmospheric scavenging of harmful substances and aerosols because these progenies behave as tracers that reveal the dynamics of the process.

The vision of the proposed technology gave an effective autonomous, robust, low power consumption and cost-effective in-situ radioactivity system that provided real-time measurements of gamma-ray intensity as well as of all gamma-ray emitters present in the seabed and in the seawater. Furthermore, the data analysis did not exhibit potential contaminants originated from anthropogenic activities. This complementary information will dramatically support existing actions for assessing the state of the sea in the future.

A. Seawater Monitoring Data

The experimental set up for the integration of GeoMAREA system in the COSYNA cabled observatory is shown in Figure 1. The GeoMAREA system was deployed in a distance of around 2m below sea surface and 9m from the seabed. This set up was decided to avoid contribution of gamma-rays produced in the atmosphere as well as from the sediment of the seabed.

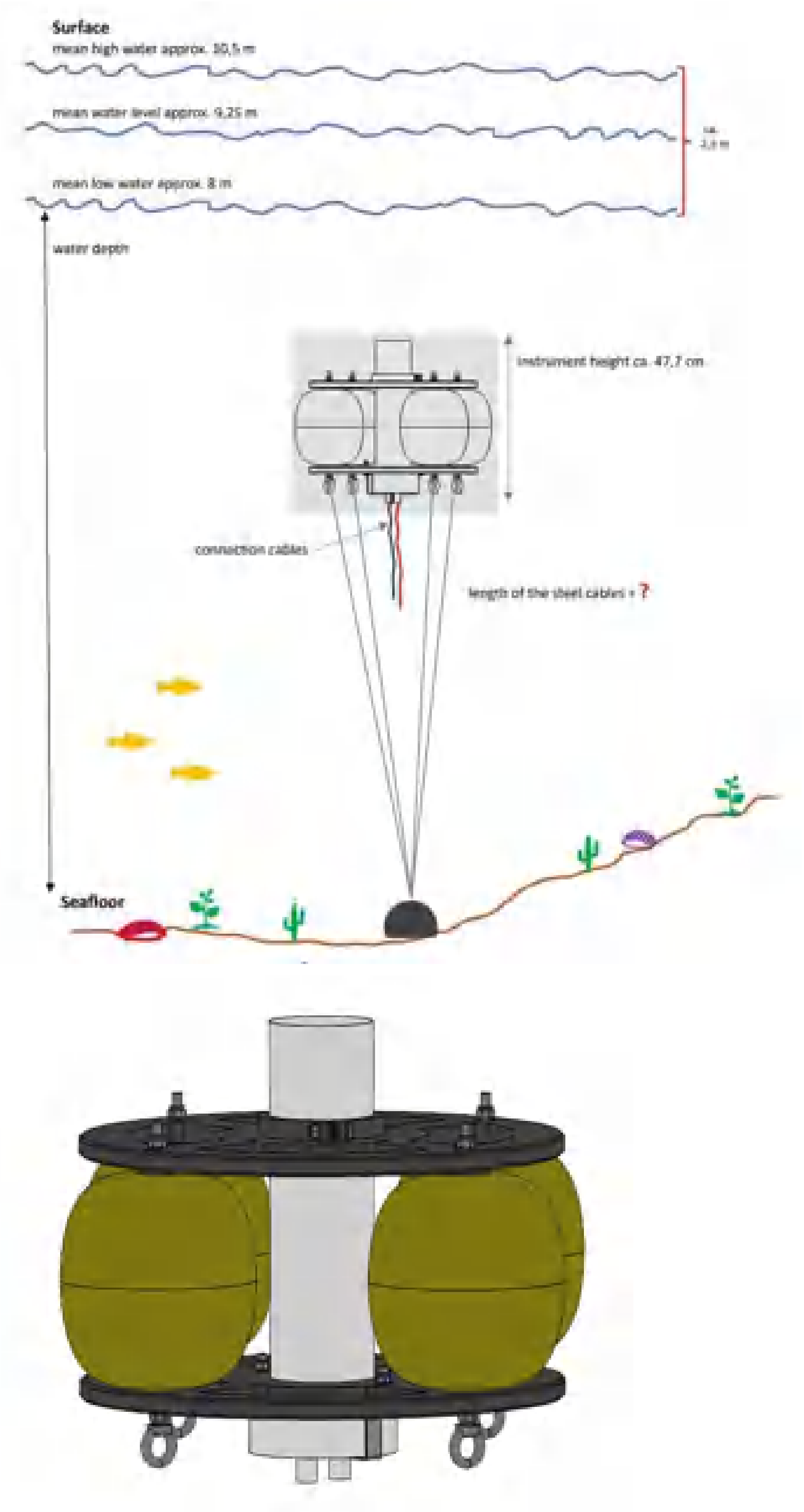


Figure 1. Experimental set up of GeoMAREA integration into the COSYNA network for the deployment in the seawater environment in Helgoland.

In the Figure 2, we show the time series of the observed values in terms of gamma-ray per second (or total counting rate-TCR). In literature this is called a gamma-ray intensity rate parameter. The TCR is a key factor to assess any potential parameter. There are two main phenomena when there is such gradient of TCR. The first one is to check the natural gradient of radon progenies due to rainfall and the second one has anthropogenic origin and may be due to a nuclear incidence (e.g. an identification of a radioactive plume due to a nuclear accident or nuclear blast). The key anthropogenic tracer that it is easily detected after a nuclear accident of nuclear blast is Cs since it has high production fission yield and it is soluble in the seawater. The observed data are analysed appropriately for this period of measurements and show that the gradients of TCR is due to rainfalls and not to any anthropogenic reason. The level of Cs-137 (as the most adequate radionuclide exhibited an average value of (8 ± 2) Bq/m3.

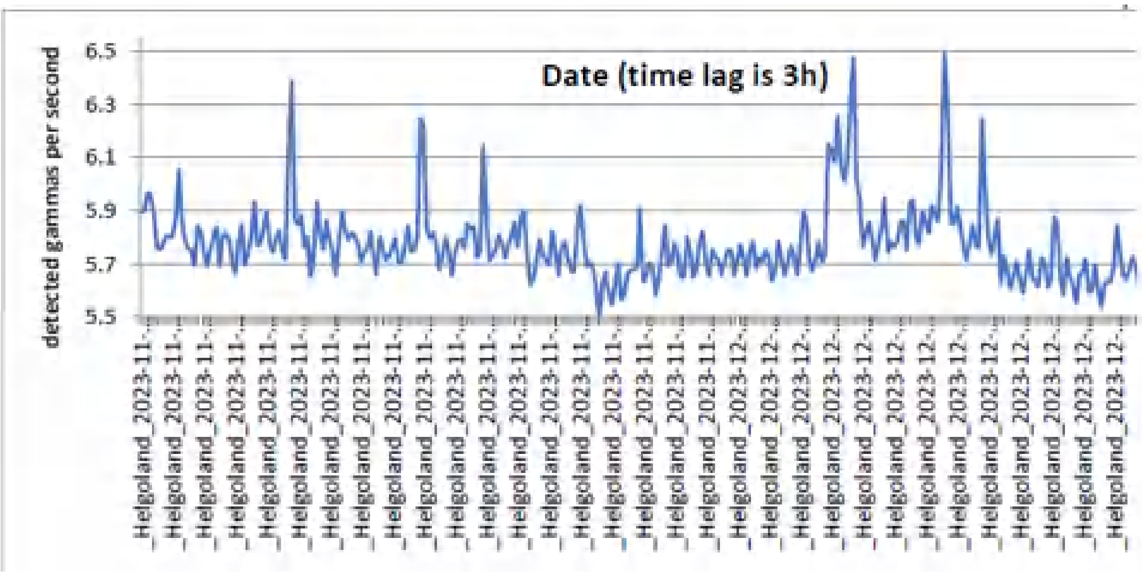


Figure 2. The time series of gamma-ray intensity rate during the period of monitoring.

8.2.9. CBONDEX

Project Information

Proposal reference number	21/1002073
Project Acronym (ID)	CBONDEX
Title of the project	Coastal BOuNDary EXchanges
Host Research Infrastructure	PLOCAN
Starting date - End date	April 2022 - April 2024
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Joao Vitorino Instituto Hidrografico Rua das Trinas, 49 - 1249-093 Lisboa-Portugal joao.vitorino@hidrografico.pt (351) 210943043

Project Objectives

CBONDEX aimed to improve the present understanding on the processes of interaction between the deep ocean and coastal ocean areas along the western Portuguese margin. These include the development of the Iberian poleward slope current (which can transport southward influences by thousands of kilometres along the slope, impacting the conditions in the Bay of Biscay and French margin), the shedding of mesoscale eddies as a consequence of interactions of the slope/outer shelf circulation with the shelf/slope topography or the impacting of large upwelling filaments from the W Iberian upwelling system. To fulfil this objective, the project proposed to articulate glider observations from the PLOCAN glider facility, with Instituto Hidrográfico (IH) own systems in operation along the coastal ocean area of W Portugal. Two missions were initially planned, with glider observations extending from the area of Nazaré (39.5ºN) to the southward extreme (about 36.5ºN, southwest of Cape St. Vicente). Due to the different problems that occurred from 2022 to beginning of 2024 (described below), this objective was only partially accomplished.

A second major objective of CBONDEX was the transfer of knowledge in the operation of gliders, with IH team profiting from the direct contact with PLOCAN team during the different phases of the CBONDEX operations to expand their own capacities. While not including the visits of one IH team to PLOCAN (as initially planned), this objective was largely accomplished.

Main achievements and difficulties encountered

CBONDEX was affected by several factors. The difficulty of purchasing batteries for gliders (due to COVID19 crisis) delayed to December 2022 the first deployment, which occurred offshore Nazaré. Once in the water, the glider presented several technical problems and was recovered. During 2023, the PLOCAN and IH teams worked together to try to solve the technical problems. In October 2023 the teams were finally able to conduct the second deployment operation. Again, the glider was affected by technical problems when in the water. In November 2023 it was decided to send the glider back to PLOCAN. In February 2024, a new glider (SeaExplorer) was sent to IH. The deployment operation was conducted on the 5th April 2024, in an area offshore Sesimbra (south of Lisbon). The glider was successfully deployed and initiated the planned track. On the 14th April, however, the glider surfaced reporting technical problems and the mission was aborted. The glider was recovered on the 22 April by a vessel from the Portuguese Navy. CBONDEX profited from the fact that in April, IH also deployed for the first time one of the two first gliders (SeaExplorer) received at this institute. The two sets of simultaneous glider observations combine to provide a comprehensive view of the covered geographical area. The intense collaboration between IH and PLOCAN, from 2022 to 2024, provided a robust training of the IH team in the challenges of glider operation. This is now being used in the operation of the institute's own gliders.

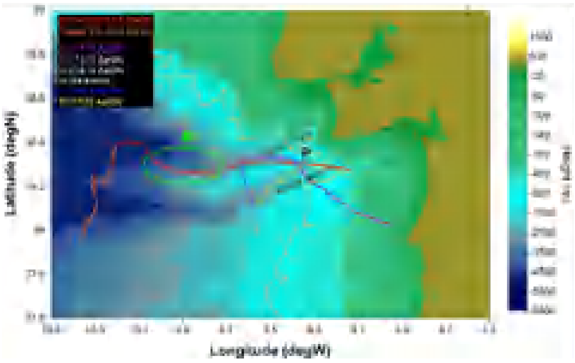
Dissemination of the results

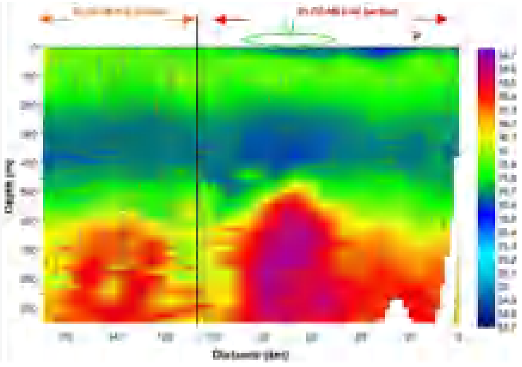
CBONDEX data from the PLOCAN glider, once processed and converted to NetCDF, will be available at the PLOCAN threeds server: http://data.plocan.eu/thredds/catalog.html . Even before completed the processing stage, the data can be requested by general public through PLOCAN access https://plocan.eu/en/access. Complementary data collected by IH systems integrating the MONIZEE infrastruture are publically available at the Hidrográfico+ webportal: https://geomar.hidrografico.pt/ .

The processing and analysis of the glider data as well as the integration with other available data collected by IH own systems (HF radar, multiparametric buoys) or with complementary information (remote sensing, numerical model results) will continue in 2024. A publication synthesizing the observation program and main results is planned to be submitted in early 2025 to a peer review journal.

Technical and Scientific preliminary Outcomes

The observations collected in the framework of CBONDEX focussed on the area offshore the Setubal Bay area. Located in the central part of the W Portuguese continental margin (figure1), this area is impacted by the presence of large coastal population centres such as Lisbon (about 50 kilometres to the north) and Setubal (about 50 km to the east). The topography of the area is characterised by the large inflexion of the shelf/slope from the region south of 38.3ºN (where the bathymetric contours have a meridional alignment and the shelf presents a width of about 25 km) to the area north of 38.3ºN (where the shelf projects offshore, forming the large Estremadura Plateau with a width of about 100 km). A second major characteristic of this area is the presence of important submarine canyons – such as the Lisbon Canyon and the Setubal Canyon- that can potentiate the interactions between the deep ocean and the shelf environment. The study area is under the influence of seasonal forcing conditions. A well-defined upwelling season occurs during the summer months, promoted by persistent northerlies, leading to the development of large upwelling filaments (particularly in Cape da Roca, which extend to the area). Energetic conditions, which frequently are associated with downwelling, are typical of the winter months. During winter and spring the area can also be under the influence of the Tagus river plume (river mouth just north of the study area) and, in less degree, of the Sado river plume (river mouth just east of the study area).





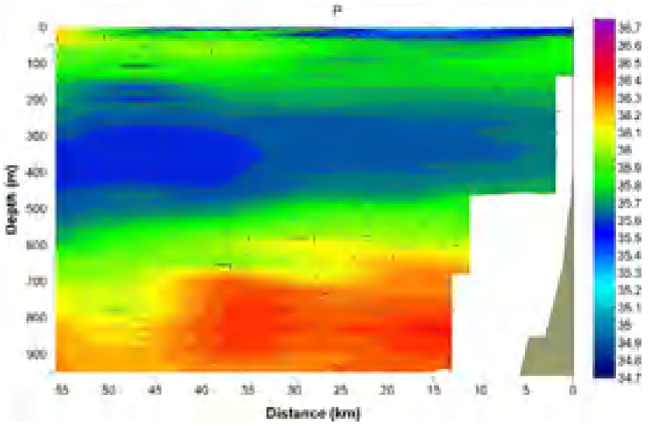


Figure 1 (top left). Tracks of the PLOCAN and IH gliders contributing to CBONDEX over the bathymetry of the Setubal Bay and adjacent areas. For comparison with figures 2, point P and region M are indicated. The 1000m isobaths is coloured in thick gold for reference.

Figure 2a (top right) Salinity section collected by the PLOCAN glider during CBONDEX. Profiles where MW salinity maximum was observed indicated as region M. For comparison with figure 2b, point P is also indicated.

Figure 2b (bottom right)) Salinity section collected by the IH glider from 19 to 22 April (yellow track in figure 1). For comparison with figure 2a, point P is also indicated.

The CBONDEX glider section conducted by PLOCAN (figure 2a) started in a position over the Setubal Canyon, inside the Setubal Bay, and progressed from there to the Lisbon Canyon. This segment of the track was particularly prone to allow to detect, in the upper layers, the influences from the shelf located to the north. Lower salinity waters are found in the upper 30-50m, particularly between 9.3ºW and 9.7ºW, perhaps more indicative of upwelling conditions developing on the coast to the north (and of Cape da Roca filament) rather than associated to Tagus river outflow. The glider then progressed offshore (westward), covering the complete coastal transition zone (CTZ) from the surface to about 950m depth. This provided a comprehensive view of the main water masses influencing the outer boundary of the coastal ocean in this region. To about 200m depth a relatively saltier and warm water mass corresponds to the influence of the subtropical component of the Eastern North Atlantic Central Water ($ENAW_{st}$) which carries to this region influence from the open ocean regions SW of the Portuguese coast. Below, the progressive influence of the subpolar component of the Eastern North Atlantic Central Water ($ENAW_{sp}$) is expressed by the decreasing of salinity until the salinity minimum observed at about 400m. Below 500m depth the salinity significantly increases as the glider entered in the layer of influence of the Mediterranean Water (MW), which extends from about 500m to 1500m depth. An interesting aspect was the maximum salinities observed between 600 and 800m, in the region indicated as M in both figure 1 and 2a, which seems to correspond to the expression of the Mediterranean Water upper core in this area. A more detailed analysis (to be followed) would help to clarify why this signature is presented in this area with such high values of salinity. After reaching about 10.2ºW the PLOCAN glider then head southward, starting the N-S section along the outer part of the SW Portuguese CTZ, showing the continued presence of the different waters masses described below. The fact one of the two IH gliders (the first of these systems acquired by IH) was available to be deployed, for a test period, at the time of the deployment of the PLOCAN glider, provided a supplementary source of observations in this area that could be integrated in the CBONDEX project. By navigating in the closer area of the continental slope that is cut by the Lisbon and Setubal canyons, IH glider could provide a more detailed view of the conditions promoted by the deep ocean forcing measured by PLOCAN glider. IH glider was only deployed on the 14 April, so about 10 days after the start of the PLOCAN glider observations. Since the planned track for this glider had segments that corresponded to the tracks followed by the PLOCAN glider, this opened the opportunity to integrate both data sets in the detection of adjustments of the coastal ocean conditions in response to rapid changes in the forcing conditions (e.g. wind forcing, riverine input). This seems to be the case of the low salinity layer that appears in the upper 30m of IH glider observations, to about 9.3ºW (to point P), which seems to express the influence of the Tagus plume transported to south under northerly (upwelling) wind conditions. This aspect needs to be confirmed by integrating complementary observations. The ongoing work comprises the processing of the different data sets. This will be followed by the integration of complementary data from IH (such as surface currents from HF radar stations or from multi parametric buoys) as well as remote sensing and numerical model results.

8.3. Third TA Call

8.3.1. ABACUS 2023

Project Information

Proposal reference number	JS3_CALL_3_4049_ABACUS2023
Project Acronym (ID)	ABACUS 2023
Title of the project	Algerian Basin Circulation Unmanned Survey 2023
Host Research Infrastructure	SOCIB - Balearic Islands Coastal Ocean Observing and Forecasting System GLIDER SOCIB Glider Facility
Starting date - End date	**Total project duration:** 18 November 2022 – 30 July 2023 **Glider Mission:** ABACUS 2023 LEG 1 18/11/2022 – 12/12/2022 WINTER ABACUS 2023 LEG 2 01/06/2023 – 20/06/2023 SPRING ABACUS 2023 LEG 3 19/07/2023 – 10/08/2023 SUMMER
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Yuri Cotroneo Università degli Studi di Napoli "Parthenope" Centro Direzionale Isola C4 – Napoli, Italy yuri.cotroneo@uniparthenope.it

Project Objectives

ABACUS focuses on the physical and biochemical characteristics of the Algerian Basin (AB) circulation. The AB is dominated by the presence of energetic mesoscale structures that usually develop from meanders of the Algerian Current to isolated cyclonic and anti-cyclonic eddies. The project aims at confirming the importance of the ABACUS monitoring line across the AB between Palma de Mallorca and the southern part of the Algerian basin.

Main objectives are:

- To continue the time series of oceanographic data collected in the AB along the endurance line between Mallorca and Algeria;
- To identify the physical and biochemical variability of the different water masses that are present between Balearic Islands and Algerian coasts at surface and intermediate depth;
- To collect in-situ observations in the late spring where mesoscale high mesoscale activity take place.
- To collect high resolution data able to describe the sub-basins dynamics;
- To assess the ocean description capabilities of several satellite products when approaching coastal areas, also comparing them to glider in situ data;
- To validate the new along-track (L3) and gridded interpolated maps (L4) altimetry products provided by the Sentinel-3 altimetry mission and other satellites overflying the western Mediterranean Sea;
- To contribute at the creation of a composite dataset to be used for the SWOT satellite mission preparation and calibration;
- To acquire ground truth for satellite retrievals of particulate backscattering (bbp) which are widely used in studies of ocean ecology and biogeochemistry, but have been historically difficult to validate due to the paucity of available comparative field measurements;

- To explore the potential of glider measurements for ecosystem monitoring (fish stocks to cetaceans).

Main achievements and difficulties encountered

Sea activities during ABACUS 2023 were scheduled over three glider missions of the approximate duration of 20 days each to navigate the monitoring line during different seasons namely summer and fall, as follows:
ABACUS 2023 LEG 1 Nov/Dec 2022
ABACUS 2023 LEG 2 June 2023
ABACUS 2023 LEG 3 Jul/Aug 2023

Data collected during the ABACUS 2023 allowed:

- The monitoring of the main physical and biochemical properties of the water column;
- To extent the glider datasets in the AB;
- The collection of acoustic data across the AB to identify wind and rain patterns, as well as the presence of marine mammals.

From a more technical point of view, the glider mission has covered the following for each leg:

- spent 25 days in water for ABACUS 2023 LEG 1 – collecting 284 profiles along the transect
- spent 20 days in water for ABACUS 2023 LEG 2 – collecting 128 profiles along the transect
- spent 22 days in water for ABACUS 2023 LEG 3 – collecting 157 profiles along the transect

During each leg the glider realized 2 complete transects across the AB and was overflown by the Sentinel 3 satellite. A total of about 569 complete profiles were collected along the 6 planned transects.

Dissemination of the results

1) Data collected during ABACUS 2023 can be downloaded through the SOCIB DAPP.
2) Data collected during all the ABACUS missions since 2014, can be downloaded from the webpage http://apps.socib.es/data-catalog/#/data-products/abacus that is regularly updated

A DOI was assigned to this dataset that can be cited as Miralles, A., Rubio, M., Rivera, P., Zarokanellos, N., Charcos, M., Férnandez, J. G., Budillon, G., Cotroneo, Y., Aulicino, G., Balager, P., Wirth, N., Casas, B., Baeza, J., Calafat, N., Juza, M., Notario, X., Heslop, E., Ruiz, S., Muñoz, C., … Tintoré, J. (2018). SOCIB TNA Abacus (Version 1.0) [Data set]. Balearic Islands Coastal Observing and Forecasting System, SOCIB. https://doi.org/10.25704/B200-3VF5

3) The results achieved during the previous ABACUS glider missions have been presented at international conferences, e.g., the EGU general assembly 2023 (Vienna, April 2023):

Cotroneo, Y., Aulicino, G., Fusco, G., Ruiz, S., Pascual, A., Testor, P., Cauchy, P., Zarokanellos, N., Miralles, A., Zerrouki, M., Tintoré, J., and Budillon, G.:"ABACUS – a repeated glider monitoring line across the western Mediterranean Sea", EGU General

Assembly 2023, Vienna, Austria, 24–28 Apr 2023, EGU23-6024, https://doi.org/10.5194/egusphere-egu23-6024 , 2023". We expect to present the ABACUS 2023 results at international conferences planned in 2024.

4) ABACUS results are usually presented in seminars for graduate and post-graduate students, at Università degli studi di Napoli "Parthenope"
5) Three master degree students did their internship using and analysing the ABACUS 2023 data in the framework of their course.

Technical and Scientific preliminary Outcomes

ABACUS 2023 project contributed to data collection in the Southern European Seas, one of the main EU maritime policy objectives, as outlined in the Marine Strategy Framework Directive (MSFD). In particular, the high resolution of glider data and the efforts to get simultaneous satellite altimetry data along the same groundtrack, allowed us to observe and describe the oceanographic characteristics of the area at several time and spatial scales.

Additionally, the use of a passive acoustic recorder allowed us to analyse the sounds associated to wind, rain, and marine mammals in the study area. ABACUS 2023 allowed us to realize a glider mission in the Algerian Basin organized into 3 legs during winter 2022, spring 2023 and summer 2023 sampling the water column up to 1000 m depth with the spatial resolution of about 2 Km.

The ABACUS 2023 quality-controlled datasets are then used to realize a preliminary analysis focused on the identification of the different water masses characteristics and on their location along depth and latitude.

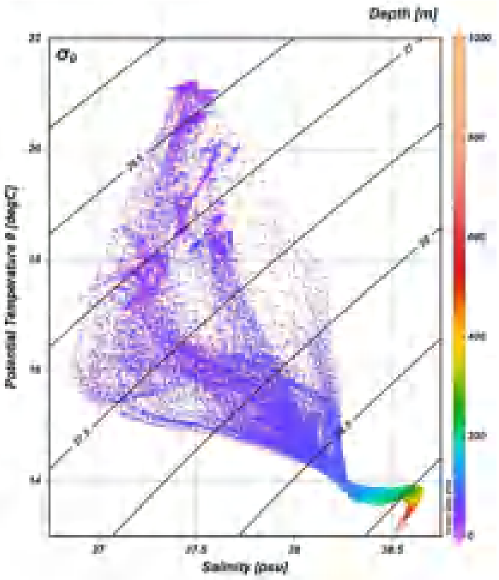
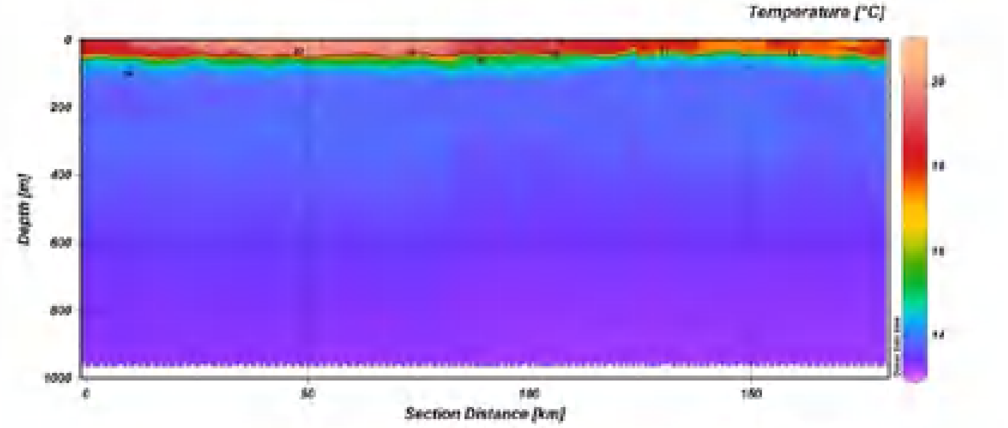
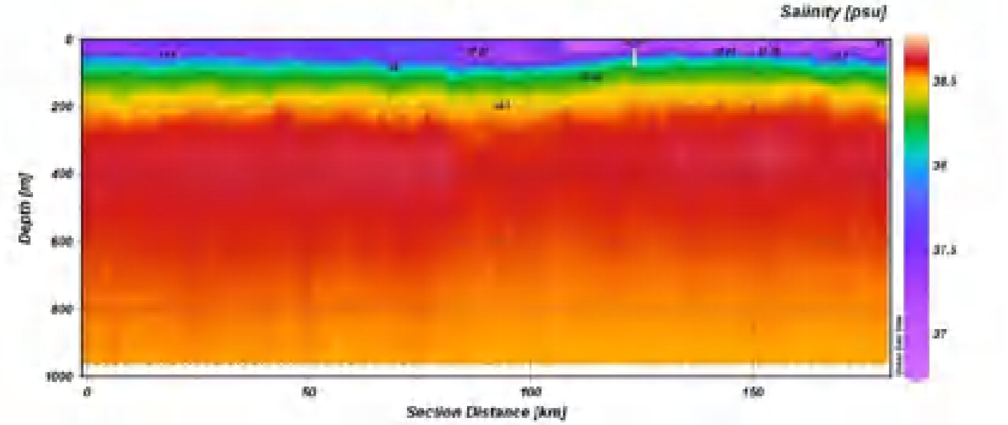


Figure 1 shows the map of ABACUS2023 glider mission and the associated Theta/S diagram.

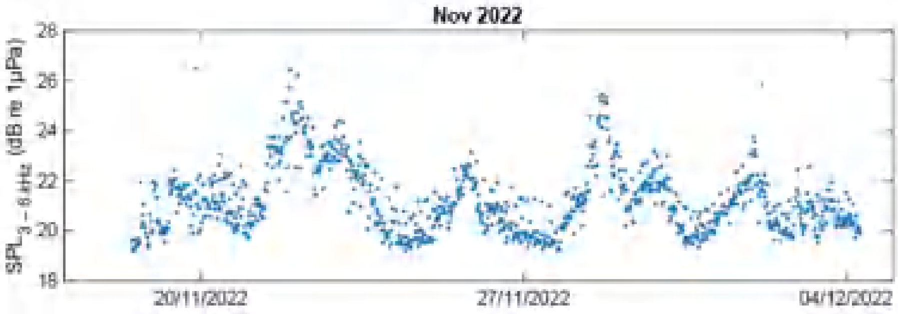
ABACUS 2023 observations are characterized by high spatial and temporal resolution, which is allows us to identify the different physical and biochemical processes. **Figure 2** shows the vertical transect along the monitoring line of late November 2022 for Potential temperature and Salinity. Analogous figures have been realized for the other 5 transects realized and for the Potential Density anomaly, Chlorophyll concentration, turbidity and Oxygen concentration data collected by the glider.





One of the most innovative aspects of the ABACUS 2023 project consists in the use of the passive acoustic recorder installed on the glider (ACOUSONDE). Some of these data already available, were also included in the ABACUS 2021 finale report.

Acoustic data requires long elaboration time and have not been analysed at the moment. This is mainly due to the large amount of data collected and to the different analyses that need to be performed to identify the sound originated by the different sources.
Nevertheless, data acquisition during the 4 transects of AbACUS 2023 (i.e, on November/December 2022 and July/August 2023) is confirmed. Unfortunately, the hydrophone did not record anything on the June 2023 mission.



Figures 3 and 4 show some preliminary results of the acoustic data analysis. The analysis of the acoustic data requested an additional effort. The first figure shows the signal associated to wind noise during the November 2022 leg, while figure 4 shows the noise associated to Sperm whale echolocation sounds, characterized by very regular trains of clicks at about~ 10 kHz, 2 clicks/s. Similar analysis highlighted the presence of Dolphin echolocation clicks as rapid and variable click patterns ~ 30 kHz, 10 – 20 clicks/s.

8.3.2. BalHObEx

Project Information

Proposal reference number	22/1002919
Project Acronym (ID)	BalHObEx
Title of the project	Baltic Sea Heat Waves: Observation and Experimentation
Host Research Infrastructure	SYKE MRC-lab and Alg@line
Starting date - End date	SYKE MRC-lab 19/8/2022 to 4/9/2022 Algaline 29/6/2022 to 21/9/2022 (8 sampling dates)
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Iordanis MagiopoulosInstitute of Oceanography, Hellenic Centre for Marine ResearchEx-American Base iordanis@hcmr.gr +30 6988 55 22 25

Project Objectives

BalHObEx project followed a holistic approach to study the effects of extreme heat waves on the planktonic food web of the Baltic Sea.

More specifically:

1. **Investigate the effects of extreme heat waves on the marine plankton food web via a mesocosm experiment.** Mesocosms allow experimentation on whole plankton food webs in close to real-life conditions and they are considered the most reliable way to test hypotheses and predict effects of environmental pressures on the complex marine ecosystems. Therefore, the participation of the BalHObEx research team to the already planned mesocosm experiment at the SYKE mesocosm facility allowed the study of the effects of the elevated temperature (from 16℃ up to 22℃) on the microbial community under controlled environmental conditions and in combination with a number of various other analytical tools and real-time data from sensors, collected by other participating researchers.

2. **Compare and combine the results from the above mentioned mesocosm experiment with findings in the natural environment** in order to get a more complete view on the effects of the heat waves on natural plankton communities of the Baltic Sea.

Main achievements and difficulties encountered

Both the participation in the mesocosm experiment and the in-situ samplings using the FerryBox facility of SYKE went according to the plan.

The BalHObEx team and the scientists and technicians from the SYKE facility had an excellent collaboration from the planning of both the experiment and Ferrybox samplings to the shipping of the samples back to HCMR.

The samples collected during the mesocosm experiment were analysed at HCMR in Crete, Greece and the data collected will be combined with data generated by other teams, such as the pigment content (by the CNRS-MARBEC team) and bacterial production (by the SYKE team), to produce concrete conclusions on the responses of marine microbes to sudden temperature increases.

The only difficulty encountered was the shipment of samples from Helsinki, FI to Heraklion, GR, due to their nature (chemically fixed samples in dry ice) and the consequently high shipping cost.

Dissemination of the results

The activity was presented on the JERICO-RI web page (https://www.jericori.eu/2022/09/06/joint-jerico-s3-and-aquacosm-plus-study-on-baltic-sea-heatwaves/) and on the AQUACOSM-plus web page (https://www.aquacosm.eu/news/article/joint-aquacosm-plusand-jerico-s3-study-on-baltic-sea-heatwaves). In addition, a news article with a more "personal" and "family" perspective was published in the AQUACOSM website, showing the challenges faced by a scientist that wants to take part in a TA activity but is also a parent of a very young kid (https://www.aquacosm.eu/news/article/participation-in-a-mesocosm-experiment-at-sykehelsinki-hcmr-team-and-little-maria). All articles were promoted through AQUACOSM-plus social media.

The results from both the experiment and the field sampling will be presented in scientific
meetings and will be published in scientific peer-reviewed journals in collaboration with SYKE and the other teams on location.

A public link to the data was not available yet at the time of the writing of this report.

Technical and Scientific preliminary Outcomes

During the mesocosm experiment, samples for the analysis of the microbial community were collected from the beginning (Day 0 – just before the temperature increase) until the end (Day 9) of the experiment. The temperature treatments were 16℃, 18℃, 20℃

and 22°C.

For the field samplings, samples were collected from 4 stations (St 19, 21, 22 and 24 where St 24 was just outside the port of Helsinki, St19 was a relatively open water station - N.B. the water for the mesocosm experiment was collected in the area between St 21 ad St 22) at 8 time points. The first sampling was conducted on the 29th of June and the last on the 21st of September. During that period, in-situ surface water temperature ranged from approx. 15-16.5°C (June 26th) to 21.5°C (August 19th) and went back to 15°C (September 21st).

The BalHObEx team collected samples for the analyses of viruses (abundance and cytometric groups) and viral production, heterotrophic and autotrophic bacteria (abundance, cytometric groups, pigments per cell, relative size), autotrophic nano-flagellates (abundance, pigments per cell, relative size) and microplankton (abundance and diversity) from both the mesocosm experiment and the FerryBox samplings (apart from viral production in the field samplings as it was not technically possible).

All samples were shipped to HCMR, Crete Greece and were analyzed by means of flow cytometry (using a BD FACSCalibur and a Life Technologies Attune NxT flow cytometer) and inverted microscopy (using an Olympus IX70 inverted microscope).

Bellow some of the above mentioned data will be presented briefly. More data analysis will follow, in close collaboration with the teams that participated in the mesocosm experiment as well as with the SYKE team that operates the FerryBox.

Heterotrophic Bacterial abundance (Figure 1) didn't change significantly between treatments at the beginning of the experiment, with only a significant increase at the +2°C treatment (18°C) on Day 3. By the end of the experiment, bacterial abundance was higher at the 20°C treatment.

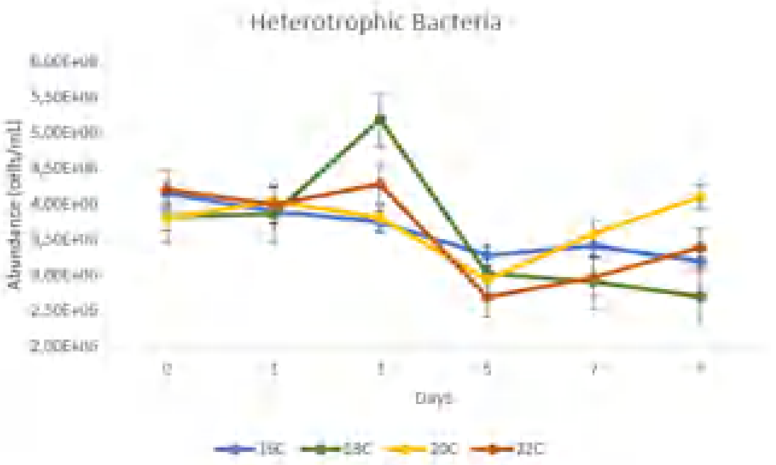


Figure 1. Abundance of heterotrophic bacteria (in cells/mL) during the mesocosm experiment.

Also, the abundance of autotrophic bacteria (Figure 2), which were mainly belonging to the Synechococcus genus, was higher in the 20 and 22°C treatments at the end of the experiment.

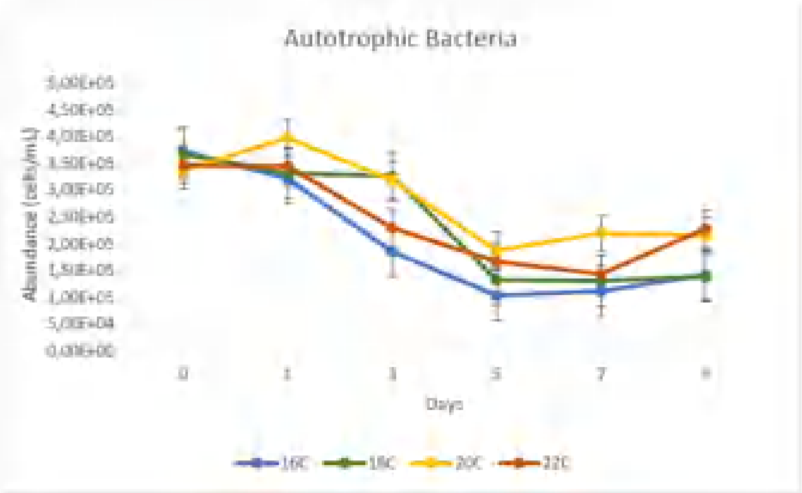


Figure 2. Abundance of autotrophic bacteria (in cells/mL) during the mesocosm experiment.

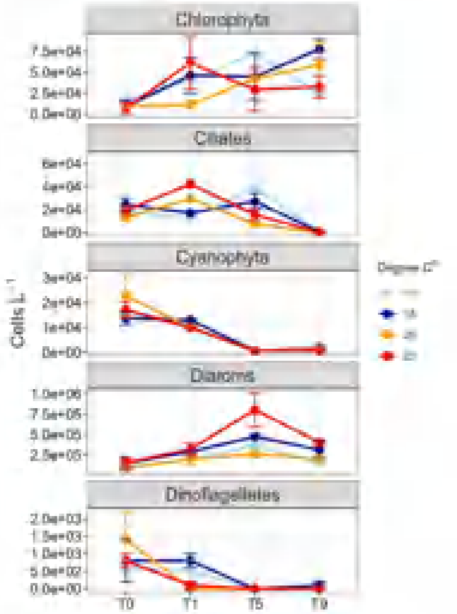


Figure 3. Abundance of the main microplankton groups (in cells/L) during the mesocosm experiment.

From the analysis of the microplankton community (Figure 3), it was found that Chlorophyta responded negatively at 20℃ in the beginning of the experiment while Ciliate abundance increased at the two higher temperature treatments in the same time point. From the middle of the experiment until the end, no statistically significant changes were found, regarding the microplankton abundance.

The results of the field samplings showed that Heterotrophic Bacterial abundance, from all stations, (Figure 4) increased along with the temperature increase (from June 26th to August 19th when the maximum temperature was recorded); however, it was not significantly different after August 31st and onwards (when temperature decreased to 18 and 15℃), while during the same period, the contribution of the High Nucleic Acid (HNA) bacteria to the total bacterial community decreased from approximately 35-45%, between the end of June to mid-August, to 25-30%, between the end- August and the end-of September.

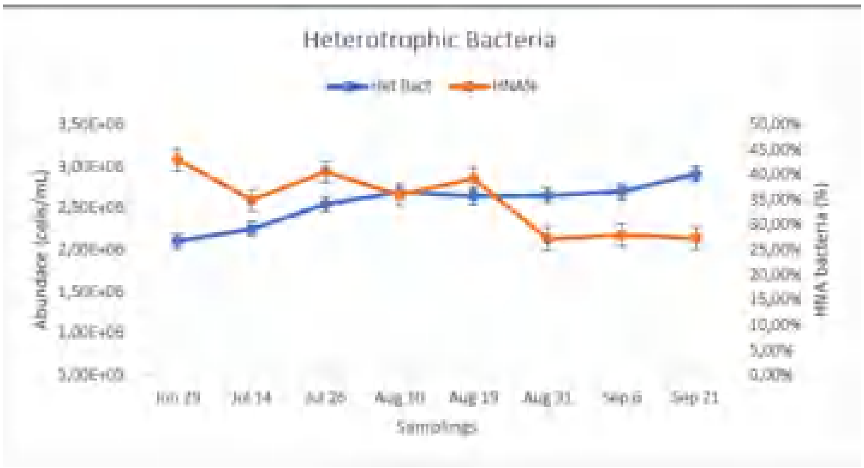
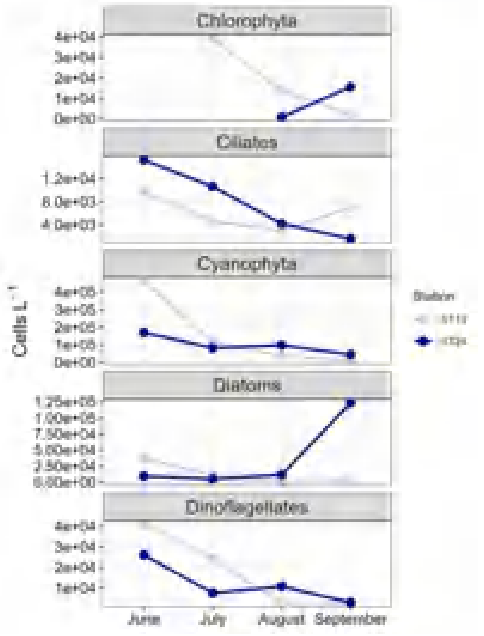


Figure 4. Heterotrophic Bacterial (Het Bact) Abundance (in cells/mL) and High Nucleic Acid (HNA) bacterial relative abundance (in %) to the total bacterial community from the field samplings. Data presented here are the average of all 4 sampling stations.



The analysis of the microplankton community showed a decrease in abundance of most microplankton groups (mainly Ciliates and Dinoflagellates) from June to September, with the exception of Diatoms and Chlorophyta at the stations next to the Helsinki Harbor during the last sampling mission.

Figure 5. Abundance (in cells/L) from the main microplankton groups from Stations 19 (open water) and 24 (Helsinki port) during the field samplings

The Raw data that were obtained after the mesocosm experiment, by analysing the samples using the flow cytometers and microscopes at HCMR-Crete, will be available on open source after quality checking and cross checking with another lab at HCMR-Athens and will be part of an open access paper describing the effect of a simulated heat-wave on the plankton community and size distribution. The Metadata and Data will be available on open source in an open source publisher (for example Pangaea https://pangaea.de and/or the AQUACOSM Data/Metadata Portal https://www.aquacosm.eu/metadata-and-data) and on the scientific journal site (if it is available such option).

8.3.3. CABS

Project Information

Proposal reference number	22/1002926
Project Acronym (ID)	CABS
Title of the project	Capacity Building for Autonomous Biogeochemical Sensing in the Southwest Black Sea
Host Research Infrastructure	Helmholtz-Zentrum hereon GmbH

Starting date - End date	1.11.2023 - 11.11.2023
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Dimitar Berov Institute of Biodiversity and Ecosystem Research 2 Juri Gagarin Street, Sofia, Bulgaria Dimitar.berov@gmail.com +359885112171

Project Objectives

Our project aims at the eventual integration of automated FerryBox type monitoring of water quality in the work of the partner laboratory (LME-IBER-BAS), as a continuation of the ongoing water quality monitoring campaigns of the research institute.One goal of this project is to apply current autonomous methods of EOV observations to a Jerico-S3 FerryBox station, with the intention of using such methods at oceanographic facilities at the Black Sea coast. In particular, we are interested in applying for the use of automated nutrient sensors and automated carbonate system sensors, as well as FerryBoxes. The primary goal is to study the effect of eutrophication on sea grass beds and biodiversity along the southern Black Sea Coast. In particular, we are interested in applying for the use of automated nutrient sensors and automated carbonate system sensors, as well as FerryBoxes. Automated measurements of inorganic nutrients can significantly enhance our understanding of the state of eutrophication beyond the monthly surveys currently in place. Another goal is to enhance our understanding of the effect of seagrass beds, mussel beds and macroalgal 'forests' on the carbonate system along the southern Black Sea coast. We intend to use this collaboration with Hereon, to further enhance our observational capabilities in these EOVs, but also to further our collaboration with our German partners. Hereon's long-term experience in coastal ecosystems monitoring, and the use of automated systems will help us achieve these goals.

Main achievements and difficulties encountered

Main achievements:

1. Our team received a thorough demonstration and initial training on procedures of use of automated ferry box –type systems, including maintenance of the system, calibration procedures- discrete samples collection and subsequent lab analysis, data management systems and data processing procedures
2. We've evaluated the pros and cons of the use of the different automated systems at Heren, as well as got familia with the technical, and financial challenges of adopting an autonomous monitoring system with optote sensors for physical and biological parameters (temperature, pH, pCO2, turbidity, salinity, chl-a), as well as automated nutrient analyzer use.
3. We've discussed in details and made concrete plans for actual sites of deployment of such instruments at suitable locations in the area currently monitored in IBER-BAS water monitoring program (Sozopol, Burgas Bay).

Main identified difficulties:

1. The adoption of such system requires the employment of a highly trained technical personnel that can maintain and calibrate the system
2. We've identified possible difficulties in installing the system at a suitable location that is in close proximity to the water bodies that we are monitoring, that has access to electricity, and that is secure enough for the equipment to be left unattended for long periods of time.

Dissemination of the results

A link to the data that was acquired was not available at the time of the writing of this report.

Technical and Scientific preliminary Outcomes

1. Goal of work

The primary goal of the work was to receive demonstration of the use of autonomous measurement systems for investigating essential ocean variables, and determine how these can be applied for oceanographic measurements in the Black Sea. In particular, the CABS project focused on the use of a FerryBox system, as well as the autonomous measurements of pCO2 using membrane-based sensors, and automated nutrient analyzers. In addition, information was provided on the applications of using the high-frequency dataset these systems generate, with presentations of recent work by PhD student Louise Rewrie (time series analysis, and the carbonate system of the Elbe estuary), Postdoc David Kaiser (Influence of heat waves on the biogeochemistry of the German Bight adjacent to Cuxhaven station), and an introduction by Yoana Voynova of the Cuxhaven station, relevant biogeochemical characteristics and recent results, including summary recent projects, like JERICO-S3.

In addition, the laboratory in Sozopol, western Black Sea coast, Burgas Bay, was presented by Dimitar Berov, Nikola Bobchev and Stefania Klayn. They introduced the site, and related projects, and specifically ones connected to coastal benthic ecosystems studies, and pollution impacts. Emphasis was placed on the regular (weekly) monitoring in place, which could then benefit from applications of more automated observation systems, to collect data in between the existing monthly sampling.

2. Cuxhaven site

The Cuxhaven FerryBox Station was established in 2010, at the mouth of the Elbe Estuary. It hosts a large FerryBox system, designed by 4H-Jena Engineering (Jena, Germany), which measures a number of parameters (Table 1). Most parameters were already available in the summer of 2010, or by the start of 2011. Water is pumped into the station using a ground-water scale pump, with a flow of at least 80 L/min. The pump is located at a depth of about 5 m. The station is located on a pier close to the main channel of the Elbe discharging into the German Bight (Figure1). This location has restricted access, and is therefore secure.

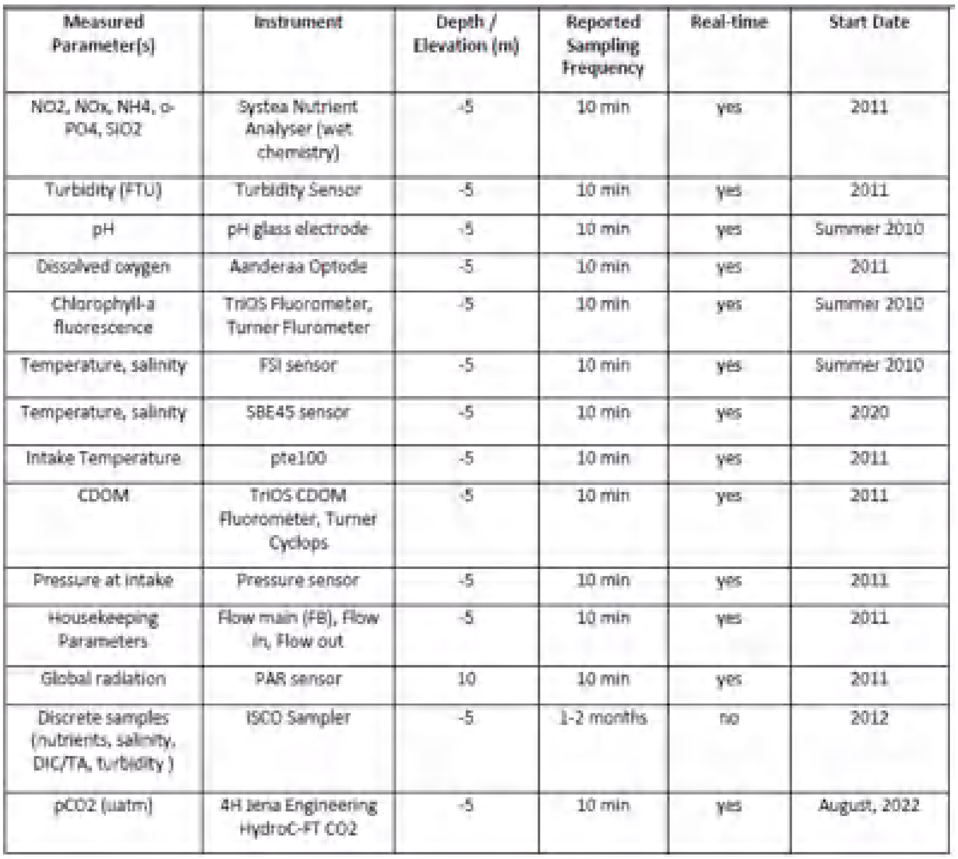
The HydroC-FT CO2 sensor (4H Jena Engineering) was installed in 2022 at the Cuxhaven station in order to address the aim of the CABS proposal. This new installation is now planned to contribute measurements to ICOS-D, after Cuxhaven became a pilot estuarine ICOS station in 2023.

A nutrient wet chemistry autoanalyzer provided by Systea was re-installed at Cuxhaven prior to the visit during CABS (spring 2023), after a break of about 1-1.5 years in measurements. Automated measurements (about every hour) for nitrate, nitrite and phosphate from a Systea Micromac analyzer were available during the CABS visit, and additional nutrient samples were collected for comparison. Unfortunately, during the CABS visit, the SEAL-500 nutrient autoanalyzer at Hereon was not working, and the samples had to be analyzed at a later stage.

Figure 1. Location of Cuxhaven Station (source: Google and HCDC, Hereon).

During the visit at Cuxhaven, Hendrik Rust and PhD student Louise Rewrie demonstrated the maintenance and sample collection procedure adopted by Hereon for operating a time-series station like Cuxhaven. As a result, this training allowed to experience the automated measurements onsite, including for pCO2, nutrients, dissolved oxygen, and turbidity. Additional samples were collected on site, and the importance of discrete samples for quality control of these parameters were discussed. In addition, samples for dissolved inorganic carbon (DIC) were collected, as part of the routine sampling of the carbonate system at Cuxhaven, with the goal to demonstrate the method of DIC measurement in the lab by the end of the visit.

Table 1. Measured parameters available at Cuxhaven Stationary FerryBox



Measured Parameter(s)	Instrument	Depth / Elevation (m)	Reported Sampling Frequency	Real-time	Start Date
NO2, NOx, NH4, o-PO4, SIO2	Systea Nutrient Analyser (wet chemistry)	-5	10 min	yes	2011
Turbidity (FTU)	Turbidity Sensor	-5	10 min	yes	2011
pH	pH glass electrode	-5	10 min	yes	Summer 2010
Dissolved oxygen	Aanderaa Optode	-5	10 min	yes	2011
Chlorophyll-a fluorescence	TriOS Fluorometer, Turner Flurometer	-5	10 min	yes	Summer 2010
Temperature, salinity	FSI sensor	-5	10 min	yes	Summer 2010
Temperature, salinity	SBE45 sensor	-5	10 min	yes	2020
Intake Temperature	pte100	-5	10 min	yes	2011
CDOM	TriOS CDOM Fluorometer, Turner Cyclops	-5	10 min	yes	2011
Pressure at intake	Pressure sensor	-5	10 min	yes	2011
Housekeeping Parameters	Flow main (FB), Flow in, Flow out	-5	10 min	yes	2011
Global radiation	PAR sensor	10	10 min	yes	2011
Discrete samples (nutrients, salinity, DIC/TA, turbidity)	ISCO Sampler	-5	1-2 months	no	2012
pCO2 (uatm)	4H Jena Engineering HydroC-FT CO2	-5	10 min	yes	August, 2022

3. Results - time series

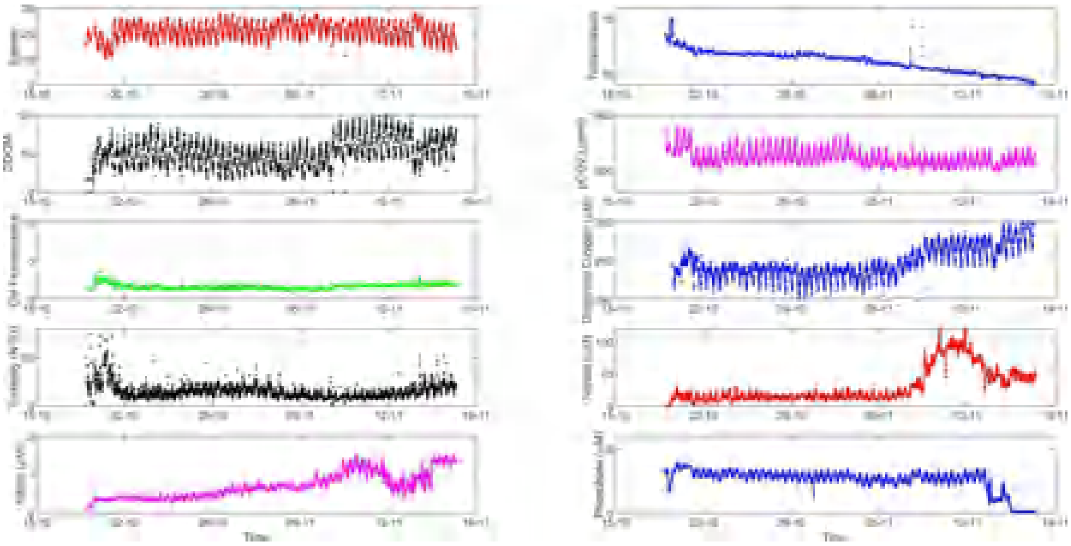


Figure 2. Measured parameters before, during and after the CABS on site participation and sample collection (15.10-19.11, 2023). Parameters shown include salinity, water temperature, CDOM fluorescence, pCO2 (µatm), chlorophyll a fluorescence, dissolved oxygen (µM), turbidity (NTU), and nutrients measured via Systea nutrient analyser (nitrate, nitrite and phosphate in uM).

The measured parameters at Cuxhaven station shown in Fig. 2 were downloaded within the CABS project participants, as a result of the collaboration. In order to get a better idea of the local variability, data for about 1 month of deployment at Cuxhaven was selected. Compared to the western Black Sea, Cuxhaven station results show large tidal variability dominating the signal of all parameters in Fig. 2. In addition, we can observe temperature decrease, and concomitant increase in dissolved oxygen concentration, likely driven by the temperature change. During the Cuxhaven visit (6-7 November, 2023), the optical sensors were also cleaned, which raised slightly the chlorophyll a fluorescence and CDOM fluorescence signals as a result. The trends in the rest of the parameters in Fig. 2 did not change during and after the Cuxhaven visit and service. Nitrogen (nitrate and nitrate in uM) increased after the visit, but this signal should be further investigated when comparing these measurements to the discrete samples. Respectively, phosphate did not increase, but instead, the phosphate signal seems to have been affected at the end of the period after 13. November. This is most likely due to a technical problem with the phosphate measurements, since the tidal variation also disappears. Based on these measurements however, it seems that this site in late fall has relatively high nutrients, but lower seasonal chlorophyll content. Most likely, this could be associated with the high turbidity, and low daylight available during this time. In comparison, our site at the western Black Sea - a nontidal sea , and an area with no direct influence from river waters inflows, is significantly less turbid, so light limitation from turbidity in the water column is not limiting the phytoplankton development. Rather, the seasonal variations in phytoplankton is driven by changes in inputs of nitrates and phosphates, with well pronounced early spring and summer peaks, and low concentrations in autumn and winter. Nitrate and phosphate concentrations at Sozopol are an order of magnitude lower than those at the Cuxhaven site. Nitrates vary in the range between 0.1 and 4.5 uM.l-1 , while phosphates are usually between 0.1 and 1.0 uM.l-1.

The comparison of the discrete samples processed in the lab and the FerryBox data in Fig. 2 will take place at a later stage, due to the short CABS visit, which did not allow for all samples to be processed during this project.

4. Calibration procedures

Discrete samples for dissolved oxygen, DIC, nutrients, temperature and salinity were collected at Cuxhaven station during the CABS project, using the available ISCO sampler. The samples were brought back to the laboratory, and the lab-based measurements were demonstrated on site. Due to the limited time available, and the unavailability of the SEAL nutrient autoanalyzer, only samples for DIC (6), dissolved oxygen (3) and salinity and turbidity were analyzed. Nevertheless, the methods for these discrete sampling used for quality control were explained, and the training was useful to help understand the effort required for the external quality control of the autonomous methods discussed in the CABS project. As a comparison, the weekly sampling in Sozopol and surrounding area for nutrients uses manual wet chemistry methods, which limits the amount of samples that can be analyzed in the laboratory.

At the end of the visit at Cuxhaven, Hereon Postdoctoral Researcher Vlad Macovei presented data management approaches for quality controlling the autonomous high-frequency data obtained from the FerryBox, and from the pCO2 membrane-based systems. This was of great interest due to the approach used and considerations for proper quality control of such systems, as well as the needed information regarding the effort required for quality controlling similar large datasets. This knowledge is important when considering the personnel effort needed to generate quality controlled datasets when applying for autonomous systems such as the FerryBox.

5. Discussion of feasibility of application of Ferrybox in Sozopol monitoring

a. Land-based monitoring

Based on the practical experiences and discussions during our visit to Hereon, we identified a number of practical criteria and issues for the selection of possible sites for a coastal 'FerryBox'-type of monitoring station. The coastal site needs to have direct access to the marine waters of interest, possibly away from local point sources of influence (e.g. sewage or rain water discharge points, port activities). The site where the instrumentation will be mounted needs to be easily accessible, preferably with road access. It also needs to have access to the electrical grid and possibly good coverage by mobile networks. Security should also be taken into account - preferably the site should have limited access from both land and sea, and be under some surveillance, which would minimize the risks of equipment damage by people.

Taking into account all these practicalities, we identified two possible options for possible future installation of a monitoring station in the vicinity of the Laboratory of Marine Ecology-Sozopol, as a possible upgrade of the current water quality monitoring program.

Option 1: The ferrybox station can be installed in the building of LME- Sozopol.
Pros: water sampling will be carried out in the same location where the currently ongoing monitoring program is taking place. The servicing and maintenance of the installed equipment will be done in the lab without any logistical difficulties. There will be no issues with security.
Cons: The lab is located on a rocky shore some 20 meters above the sea level. The pumping of water would require the construction of a pump system that can bring water from the sea-level to the lab, which might be difficult in terms of acquiring the necessary permits from the local authorities. Also, during severe sea weather, the site is heavily impacted by storm waves, which could result in possible damage to the pumps and pipe systems.
Option 2: The ferrybox station can be installed in the vicinity of the Border Police harbor in the port of Sozopol.
Pros: The site provides easy access to the sea, the harbor area is just 1-2 m above sea-level, which would make water pumping quite easy and straight forward. The site is secure, it also has access to the electrical grid system and has good mobile network coverage.
Cons: Water sampling will be done in a different location about 1 km away from the current location of water sampling for our monitoring program. Also, the site is possibly under the influence of local waste water discharges from the harbor. Special permits will be needed for the installment of the monitoring station in the area. Additional costs for container installation will be needed too.

Fig. 2 Possible locations for the positioning of a future monitoring station in Sozopol, Bulgaria.

b. Ship-based seasonal sampling with Mini FerryBox system

An alternative to the stationary sampling program is the possible use of the Pocket FerryBox system onboard the small research vessel of LME-Sozopol during the monthly monitoring activities of the lab in the wider Burgas Bay (see https://csr.seadatanet.org/report/21031599). The introduction of the system to our regular monitoring activities would greatly improve the quality and spatial resolution of our monitoring of the eutrophication gradient in the coastal zone of the Burgas Bay. As a first step in this possible future application of the system, we are discussing possible test runs with our partners from Hereon in the framework of other future projects.

8.3.4. FRIPP-CEE

Project Information

Proposal reference number	22/1002928
Project Acronym (ID)	FRIPP-CEE
Title of the project	Frontal dynamics Influencing Primary Production – Carbon Export Experiment
Host Research Infrastructure	SOCIB
Starting date - End date	31-05-2023 - 20-06-2023
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Antonio Olita CNR-ISAC, Cagliari, Italy Antonio.olita@cnr.it +393285321116

Project Objectives

The project was aiming to study the impact of frontal dynamics on the Phytoplankton production and distribution as inferred from fluorometric measurements during the Deep Chlorophyll maximum (DCM) stage. Observed variations in the DCM can indicate the role
of the Mesoscale and submesoscale features on Carbon export. This is the main aim of the present project.

The specific objectives were:

1) Observe the dynamics of the front in terms of: horizontal and vertical velocities; instabilities; mixing and enhanced dynamical stratification
2) Study the impact of such frontal dynamics on production in a DCM condition as in Olita et al 2017.
3) 3) Estimate Carbon export from DCM to deeper layers (>200 m) promoted by vertical submesoscale and mesoscale dynamics.

Main achievements and difficulties encountered

The sampling was successfully performed as planned. No major difficulties have been encountered during the glider mission. The glider dived down to 300 m, a depth that was considered a good compromise to have both high temporal and spatial resolution observations below the euphotic layer and maintain the actual glider path (low horizontal currents) to resolve fine structures.

Dissemination of the results

We are preparing a contribution for Ocean Science Meeting 2024 will be held in New Orleans, US. Then we will consider the opportunity of submitting a full paper once the results will be analysed in depth.

Data:
https://thredds.socib.es/thredds/catalog/auv/glider/sdeep09-scb_sldeep009/L2/2023/catalog.html

Technical and Scientific preliminary Outcomes

Glider sampled the area indicated in Fig. 1 from 31 May to 20 June 2023.

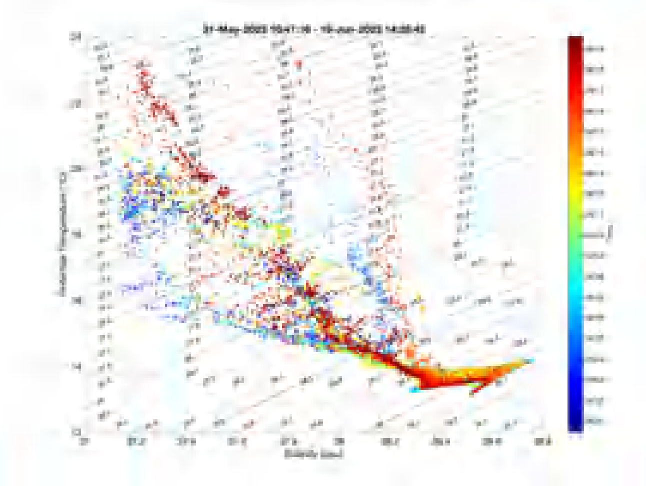


Fig.1 Glider Track of the experiment FRIPP-CEE
Fig.2 T-S Diagram for the whole dataset collected by the glider flight.

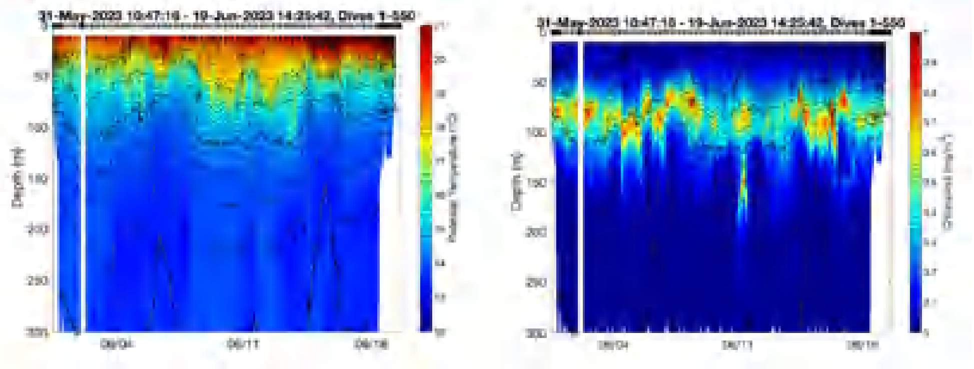


Fig.3 Potential Temperature (left) and chlorophyll (right) sections.

Temperature section (as well as density, not shown) shows that during the cruise the thermal stratification was already formed, although signature of intensification of the stratification as the sampling proceeds is also evident. DCM, deep chlorophyll maximum, was already present at the bottom of the stratified layer, ranging 60 to about 100 m depth.

An interesting feature, in terms of Chlorophyll appears around June 11, with a chlorophyll patch centered at about 160 m suggesting a subduction of water which footprint can be recognised (in Chl and other bio-optical variables) till 200 m.

High oxygen concentrations were observed in the DCM where the productivity enhanced and associated with areas where enhancement of CHL observed. In addition, relative high oxygen below 100 m observed in patches linked with the observed patchiness of the WIW water in the region.

Oxygen maxima are just above the DCM area. This could suggest a diffusion of Oxygen from production areas, an effect that should deserve further investigation, by analyzing the production of the different patches, a synoptic view that would also encompass the PAR analysis. Within DCM large number of cells would determine production of O2 but also its consumption during night (respiration).

We will analyze the export of organic carbon from production areas mediated by the subduction filament we observed to act in the middle of the "transect".

8.3.5. GliderBloom

Project Information

Proposal reference number	22/1002929
Project Acronym (ID)	GliderBloom
Title of the project	Use of FMI glider during the EMB-cruise GER – Fin – GER 2023/07
Host Research Infrastructure	Finnish Meteorological Institute - FMI Baltic Sea Glider
Starting date - End date	01/07/2023 – 15/09/2023
Name of Principal Investigator **Home Laboratory Address**	Henry Bittig

E-mail address **Telephone**	Leibniz-Institute for Baltic Sea Research Warnemünde IOW, Seestraße 15, 18119 Rostock, Germany henry.bittig@io-warnemuende.de

Project Objectives

The objective of this project was to use a FMI's Baltic Glider to support a field campaign consisting of a combination of two observing vessels (the VOS Finnmaid and the RV Elisabeth Mann Borgese) focusing on nitrogen dynamics and its relationship to cyanobacterial bloom in the Baltic Sea by increasing the vertical and temporal coverage of the planned research.

FMI's new G3 glider "Koskelo" in the area N-NW off Hiiumaa island inside Estonian EEZ. The planned mission of the glider was a 5nm virtual mooring section between lanes of the traffic separation zone. The path crossed the deepest part of the mouth of the Gulf of Finland. We planned to run the mission in Finnish EEZ waters SW off the Hanko peninsula as a secondary option.

The vessels FINNMAID and EMB, which were involved in the study, passed the line at a distance of about 2-3 nm. FINNMAID passed the area every few days, and EMB twice during its cruise.

"Koskelo" glider has a varied sensor set consisting of a SBE CTD, an Aanderaa oxygen optode, a SBE SeaOWL fluorometer, and, as new sensors, Sequoia's Glider-LISST particle analyzer and Tau transmissometer.

Main achievements and difficulties encountered

We aimed to run the missions with the Slocum G3 glider "Koskelo" inside the Estonian EEZ. After getting permission to enter Estonian waters, we had to state that this time, the permission conditions were too demanding for us to implement the original plan. Thus, we had to change to our backup plan to operate in the Finnish EEZ waters instead.
There were also problems with the sensors of the new glider, so we carried out the study with FMI's Slocum G2 glider "Uivelo". This device just came back from service and calibration. "Uivelo" has the same set of sensors as "Koskelo" (SBE CTD, Aanderaa oxygen optode, and SBE SeaOWL fluorometer) except Sequoia sensors.
For Uivelo, the shallower section on the Finnish side was more suitable, because its buoyancy adjustment margin would not have been enough in the deeper and saltier (more dense) conditions of the Estonian side.

From 11th July to 1st August "Uivelo" made 20 back and forth segments between two waypoints (59°29.7456'N 022°43.323'E) and (59° 28.2186'N 022° 34.833'E). It measured 3030 profiles with maximum depths of ca. 70 m. "Uivelo" was recovered by the Finnish Coastal Guard on 2nd August East of the research area. "Uivelo" managed to follow the mid-line of the safety area quite well.

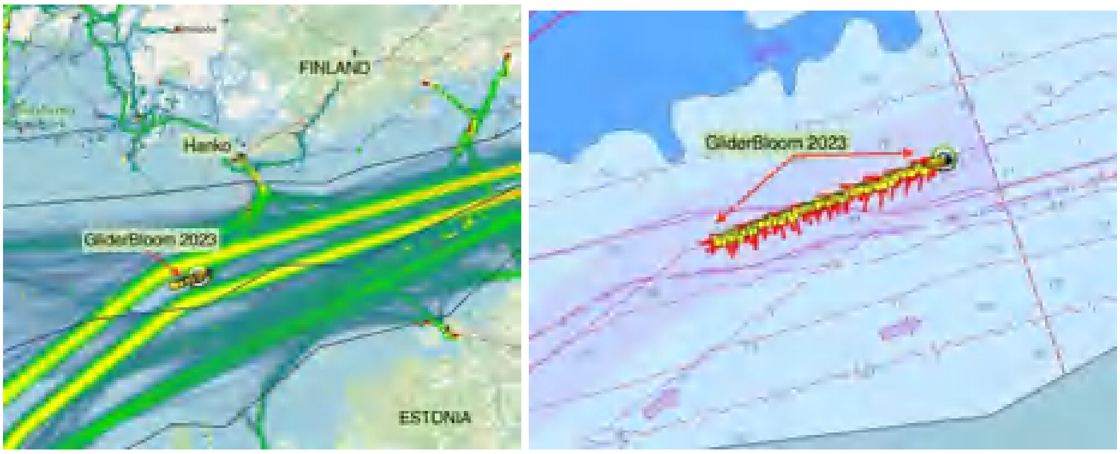


Fig 1. GliderBloom missions was the first mission "Uivelo" had after factory maintenance and calibration in Spring 2023.

Dissemination of the results

The data measured by "Uivelo" will be openly available in the FMI ERDDAP service (https://ocean-erddap.fmi.fi/erddap/).

Technical and Scientific preliminary Outcomes

The aim of the supporting observations performed by the Baltic glider is to provide vertical information on water column properties before, during and after the research cruise. The main benefit of this dataset relies in its high spatial and temporal resolution that provide valuable information on the physical and biogeochemical context where the detailed observation will be carried out by the two first observing platforms.

1) Hydrological context

The vertical structure of the water column in the area was stable during the glider mission with a relatively strong pycnocline centered around 20m that separate the warm surface mixed layer from the deeper cold and more saline waters. As seen in figure 2, both the thermocline and halocline progressively deepen from around 15m early July to 30m at the end of July. At depth, an intrusion of a saline water mass (more than 9 psu) occurred at depth mid-July, disrupting the stability of the deep water. The density of the water masses seems to be mainly controlled by temperature variations in surface water, while it is clearly controlled by variations of salinity deeper than 50 m (cf. TS diagram in figure 2).

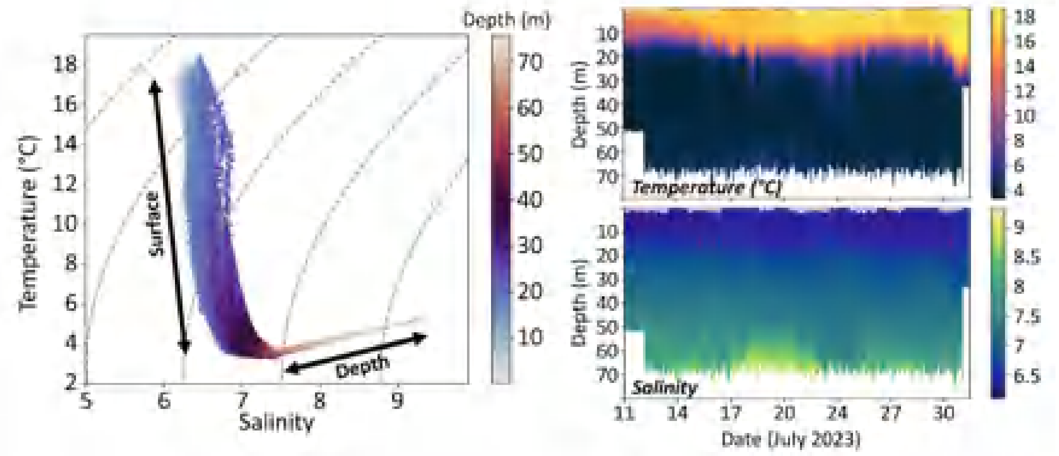


Figure 2: Temperature vs. salinity diagram of all the profiles sampled by the glider as well as variation of temperature and salinity during the GliderBloom mission.

2) Biogeochemical processes

*Phytoplankton activity: The fluorescence of chlorophyll measured by the glider is a good proxy of autotrophic activity and primary production, although this parameter can be potentially subject to attenuation when light is too intense close to the surface of the water column and need to be corrected from this effect. Backscattering fluorescence on the other hand, could be considered as a proxy of particles suspended (living cells as well as detritus) in the water column.

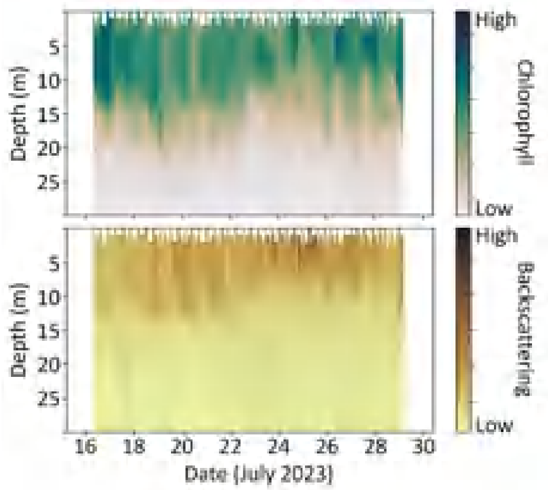


Figure 3: Temporal and spatial variations of the chlorophyll fluorescence and backscattering measured by the SeaOWL fluorometer carried by the glider during the GliderBloom mission.

As expected, these two parameters seem to be strongly correlated, with higher magnitude measured in the mixed layer (figure 3). Interestingly, chlorophyll fluorescence exhibits clear periodic oscillations at the end of the glider mission, which can be likely associated with diurnal migration of phytoplankton in the mixed layer (between 10 and 20 m), benefiting from light near the surface and accessing nutrients concentrated at the vicinity of the thermocline.

*Respiration and remineralization: Dissolved oxygen displays a distribution that is characteristic for the Baltic Sea with decreasing concentrations towards deeper water (figure 4).

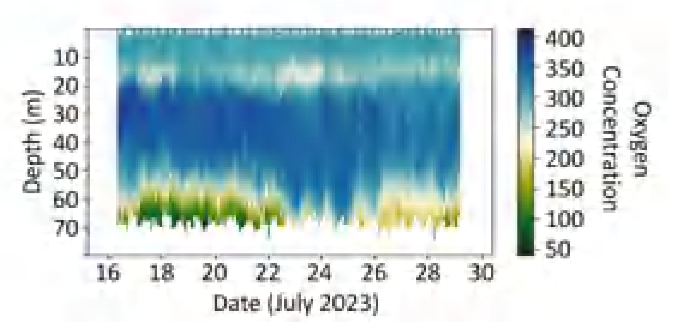


Figure 4 Temporal and spatial variations of the oxygen concentration measured by the Aanderaa optode mounted on the glider during the GliderBloom mission.

We did not observe any deep anoxic layer along the glider path and an intrusion of more oxygenated waters, perhaps associated with some mixing event, occurred between July 23rd and 25th. The water column displayed a subsurface minimum in oxygen concentration centered between 15-20 m during the whole glider mission. This could be associated with zooplankton respiration grazing on phytoplankton or bacterial remineralization of organic matter. However, this hypothesis needs to be supported by data collected from the ships (phytoplankton and zooplankton community inventories and/or bacterial production experiments).

3) Next steps and other outcomes

Data analysis is still in progress, FMI team still need to finalize the numerical tools that will be used to calibrate and control the quality of the biogeochemical parameters measured by the glider. This involved comparison with data collected from the ships during the cruise as well as other internal standardized methods.

On a different aspect, this TNA project highlighted the fact that the use of gliders often has legal restrictions when operated in different territorial waters (EEZ), i.e. cross-border use of gliders in territorial waters is not automatically granted. An application to obtain a permit to deploy the glider in Estonian water was made and supported by a document describing how the glider operations are conducted the safety regarding other pleasure and fishing boats during the glider mission is monitored and ensured. Permit was eventually granted but with high constraints regarding the glider mission leading FMI team to change the location of measurements back to Finnish water. This pointed out the need of designing a more official document demonstrating the strength and reliability of glider operating at sea that can be used by the community and will satisfy the authorities.

8.3.6. GOOM

Project Information

Proposal reference number	22/1002923
Project Acronym (ID)	GOOM
Title of the project	Glider Cooperation Mission in Eastern Gotland Basin
Host Research Infrastructure	Finnish Meteorological Institute - FMI Baltic Sea Glider
Starting date - End date	2022-07-01 - 2022-11-30

Name of Principal Investigator	Lars Arneborg
Home Laboratory Address	SMHI Sven Källfeltsgata 15, 42671 Västra Frölunda, Sweden
E-mail address	lars.arneborg@smhi.se
Telephone	0046 31-751 8982

Project Objectives

The main objectives of this glider mission are related to the central Baltic Sea water exchange and circulation. The main reason for using the glider is to obtain three-dimensional data on circulation and vertical structure of the sea. The period of the observations is selected so that it will support the fixed ADCP-mooring observations carried out in the Estonian EUROFLEETS study, CABLE.

Specific scientific objectives related to circulation and water exchange in the Central Baltic Sea:

a) What are the horizontal current patterns at the selected cross-section? What are the mean meridional transports through this cross section during the experiment? What is the quantified contribution of forcing factors (particularly wind) in driving the sub-surface currents?
b) What is the spatial variability of the temperature and salinity structure?

Main achievements and difficulties encountered

The aim of our glider project, GOOM, is to get a broad spatial coverage of the water masses east of Gotska Sandön.

One of the difficulties was to get permission for the Finnish Glider to enter into Swedish territorial waters. FMI applied for a permit to access the waters close to Gotska Sandön, in order to be able to measure the transect all the way into shallower waters.
The Swedish Coastguards granted access for the Finnish glider within the Swedish EEZ but not on territorial waters (<12 nm from Gotska Sandön).

The Glider deployment period was successful with a total number of 1948 dives during the whole period of 20 days and 330 km. The mission started on September 22th with the vessel "Ocean Poet" of VOTO (Voice of the Ocean, Swedish Foundation) and the glider was recovered with the same vessel on October 12th.

Reference CTD casts were made on RV Aranda at the end of the mission on October 10th on the station NBP2.

Dissemination of the results

- Raw data from the project will be available on open source after quality control.
- Data obtained during the project will be part of an open access paper comparing data from different projects in the area within the same time frame.
- Results and processed data will be part of an open access paper by the project partners SMHI and FMI.
- Results and data will be discussed together with scientists participating in the Cable project and employees from the organisation VOTO. Both Cable project

and VOTO have done measurements in the project area during the project period.

Technical and Scientific preliminary Outcomes

Mission planning, glider preparation and piloting

We got permission to run a glider mission in Swedish EEZ east of of Gotska Sandö on between August 15. and end of October. We planned the mission to use two waypoints 19°41.76E 58°24.60N (Western) and 20°24.60E 58°24.60N (Eastern).

Figure 1. Uivelo's GOOM mission path 2022-09-22 - 2022-10-12, map. EMODNet Bathymetry.

The mission started late September, when the surface water had cooled enough. Otherwise, the difference in water density would have exceeded the adjustment possibilities of the buoyancy engine of the "Slocum G2 200m" glider. In the first section we limited the diving depth to about 80 meters. After that, we increased the maximum depth of the dives to about 120 meters. In deeper dives, the vertical speed decreased slightly. At the end of the mission, we had to reduce energy consumption, at first, by regulating buoyance engine movements, and finally also measurements with the optode and the fluorometer.

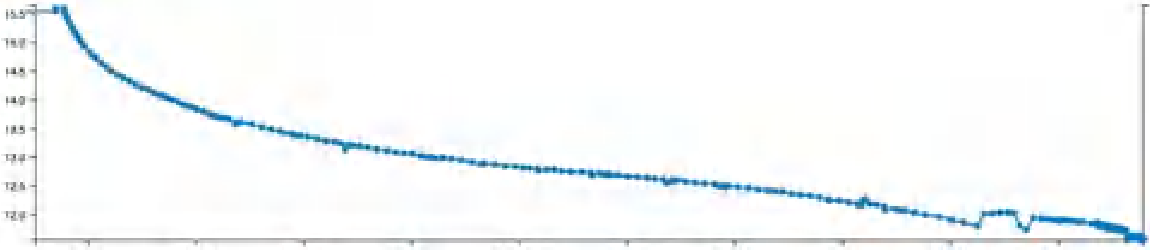


Figure 2. Voltage drop [V] of Uivelo during the GOOM mission.

The deployment and the recovery of the mission

We deployed Uivelo in cooperation with VOTO on September 22, 2022. Uivelo was recovered by VOTO researchers with their vessel on October 12 2022, with FMI researchers controlling the glider via satellite. The operations ran quite smoothly, although, both had to be postponed from planned until the weather conditions were sufficiently favourable. The final length of the mission was 20 days and 330 km with a total number of 1948 dives. Uivelo managed to reach the Eastern waypoint 3 times and measure the ca. 41km section 6 times.

Scientific data

The glider was equipped with the sensors: SBE's glider CTD, Aanderaa's oxygen optode and SBE's SeaOWL fluorometer with channels for chlorophyll, backscatter and fDOM. We made a comparison to T & S climatologies, which were mean September-October values of CMEMS reanalysis of 1995-2020.

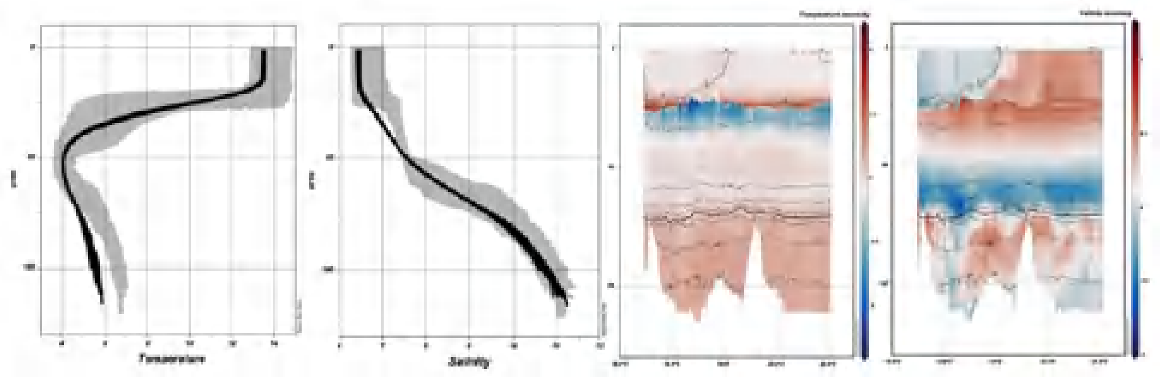


Figure 3. Salinity and temperature of Uivelo's measurements (gray) and CMEMS climatology (black) and anomalies along the path.

As expected, the climatology does not describe the sharper thermocline. Data from deeper waters, below halocline, are warmer than in climatology. In the western part of the transect surface waters were fresher than in the climatology. In the area, waters are hypoxic below the halocline at ca. 75 m depth. Uivelo's fluorometer measured a spike just above and in the oxycline around 75 to 85 meters depth. The thickness of the maximum layer varied being thickest in the western end of the transect. This maximum may either be due to a bacterial decomposition processes or resuspended matter that interleaves the water column due to mixing and resuspension at the sloping bottoms. This needs to be investigated further.

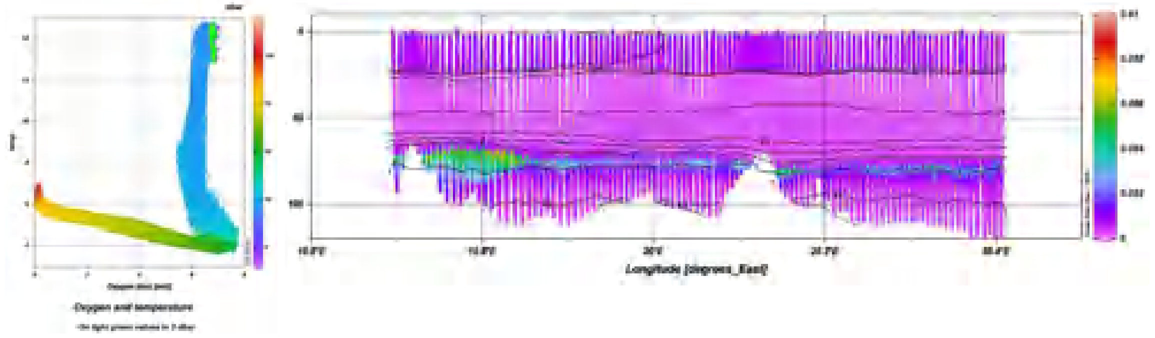


Figure 4. Oxygen concentration and backscattering (700 nm) along the 5th section (E-W) with isobar lines.

8.3.7. IMAPOCEAN

Project Information

Proposal reference number	JS3_CALL_3_4056_IMAPOCEAN
Project Acronym (ID)	IMAPOCEAN
Title of the project	Integrated Multilevel Active Passive Ocean Current Education Advancement Network
Host Research Infrastructure	Marine institute SmartBay Observatory
Starting date - End date	2/12/2023 - 5/12/2023

Name of Principal Investigator	Ariadne Dimoula
Home Laboratory Address	Paramount Planet Product 42 Mill St. Orono Maine 04473
E-mail address	ariadne@p3rd.earth
Telephone	(207)307-9393

Project Objectives

- Quantify the transport of intermediate and deep waters.
- Monitor ocean surface flow through active drifting ocean drones.
- Engage the public in ocean current research through building and deploying Drifters.
- Guide and lead students to reach their own conclusions about our impact on the Earth.
- Activate and connect schools and communities across the Globe, creating a web of oceanographic data and increasing global connectedness and climate awareness.

Our scientific and technical objectives are to execute a multilevel study of the water column using both active and passive monitoring tools. These tools are Sea Horse Tilt Current Meter, and student-built oceanographic drones called “Drifters” which use GPS to monitor surface ocean current flow. These Drifters can be built in any classroom with relatively little experience. They record meaningful sea surface data through telemetrically reporting drifter movement every few minutes using GPS. This tool has the added benefit of engaging students’ and their communities in ocean research through building, launching, and monitoring their Drifter. Drifters rescue and re-launch collaborations allow for additional people and communities to be engaged in a single project. This research project is designed in such a way that it can be carried out in multiple locations in order to understand changes in surface to bottom current patterns as well as the interconnectedness of ocean systems. By continuing this research in Ireland we are creating a robust dataset contributing knowledge of current movement throughout the water column, including understanding any changes occurring because of climate change.

Main achievements and difficulties encountered

The presence and widespread outbreak of Covid-19 has slowed down school interactions but now that the world is starting to heal and reopen, it is more possible to connect. However, for areas still at risk, this is where the benefit of remote education comes in, as well as social distancing.

Coordinating with schools and this research funding timeline can be challenging as both can occur on different programs, where schools can require flexibility and extra support in the preplanning of the research conduction. A major outcome of this program is a curriculum centered on oceanographic research and the roll of oceanographers for Irish Transitional Year Students.

However, exposing early school students to pursue careers in the physical ocean and natural science through demonstrating impact through their first-hand gathered research is an important achievement. It demonstrates a creativity that takes people or ideas to the next level and raises the awareness of today’s natural systems. We hope to set an example for students of how it is possible to collect data on ocean systems, and use climate data to inform decisions. For those of us coordinating IMAPOCEAN, this project demonstrates a larger driving passion for the Earth and ocean circulation system, combined with a passion for educating and transforming the brains and hearts of students and their communities to see the ocean as a global network.

In August 2023 the smart bay subsea observatory developed a fault and needs to be recovered. This means there will be no ocean current/ tidal data available at the time of this project as the observatory will likely not be redeployed for a couple of months. Discussion with the JERICO team decided to proceed with launching our research tools even though there may not be comparison data. Our subsea surface data will become more reliable the more data we are able to collect over time, so starting now in effort to build valuable data.

In January 2024 the tilt meters did not make it to Ireland because of mailing failures. The tilt meters arrived late to project PI Ariadne in Maine, they arrived over a week late in the US mail, while she was already in Ireland. Then when Ariadne mailed the tilt meters to Ireland they were stuck in customs and were never delivered to the Marine Institute. We are unsure of why they were not mailed to the Marine Institute.

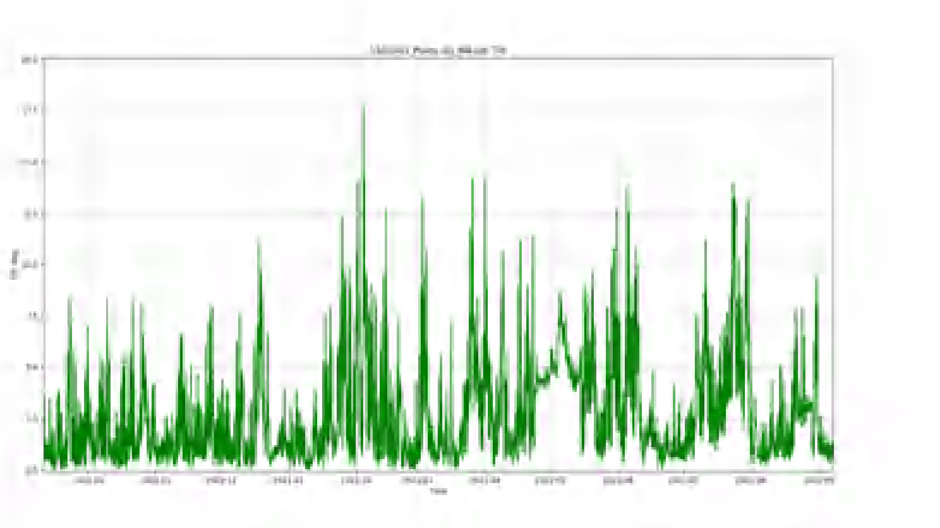
Dissemination of the results

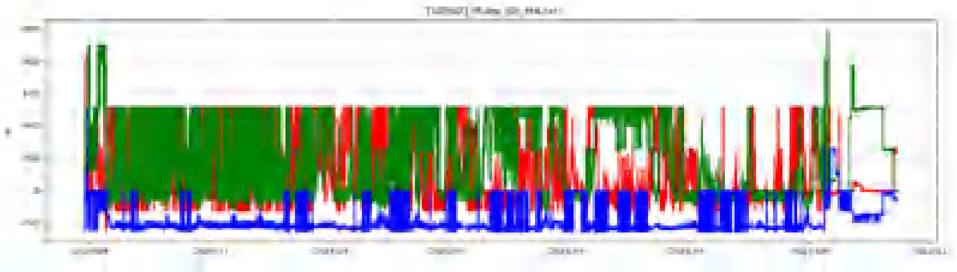
To display the data collected by the tilt current meters while at the same time coordinating workforce development by orientating the students to where the data is stored, the Smart Bay web developer team will work to display the Tilt Meter data once collected on their web portal. To make sure only the highest quality of data is displayed throughout the JERICO network and on the Smart Bay site, the tilt meter data will need to be verified by comparing to previous current records or the Smart Bay instruments if repaired in time. The data package will be sent via email to team which worked to prepare and launch the Tilt Meters

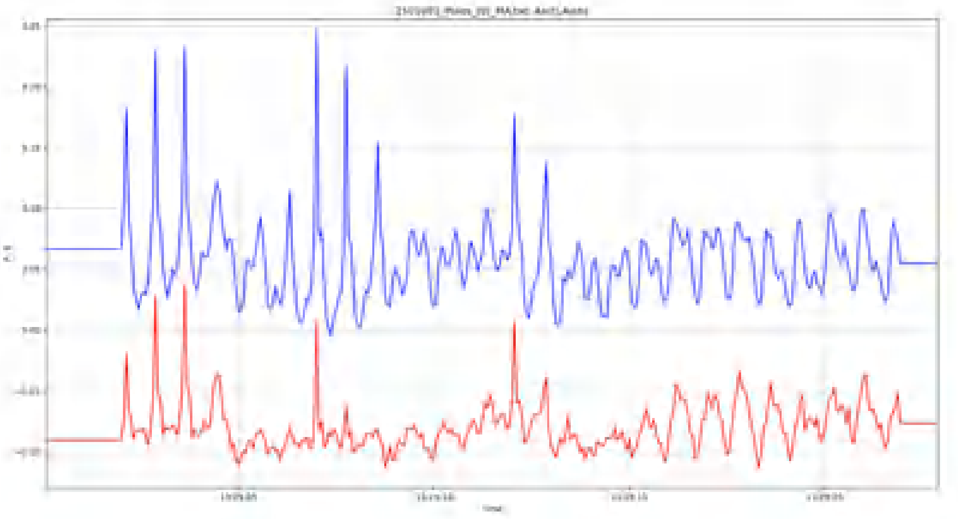
The students will follow their student drifters on this website https://studentdrifters.org/tracks/
As the data set of both tools grows, additional scientific reporting opportunities can be identified.

Technical and Scientific preliminary Outcomes

Ariadne worked with Nóirín from Galway Atlantiquria to create a lesson plan for IMAPOCEAN targeting transition year students. Ariadne networked with her connections in education to translate the lesson plan to Irish and Greek. Ariadne worked with Conall and his team on creating the drifter. Conall and his team created a highly fortified drifter as they plan to release from the bow of a large ship and we look to see how this handles.







This data was collected during the 2021 season off of Pylos Greece, Demonstrating the seahorse current tilt meter.

1. Basically, only one current meter (out of 4) was recovered.

2. When reprogramming the logger, Manolis specified very sparse sampling rate once an hour for 20sec - should be about every 5 min or so.

3. Magnetometer on the current meter has failed - the readings are weird (Figure M.png). Maybe it was next to a magnet at some point during the transit or storage.

4. Accelerometer and Temperature channels worked well. I am able to derive the tilt of the instrument. See attached plot (Tilt.png).

Axy_zoom1.png shows detailed behavior during a burst (20s long) sampling.

This data is from an early stage of the research, the first deployment. This data allows us to analyze the performance of the instrument. Basically, the range of tilt angles shows that the instrument can work in relatively high current regimes. It will be helpful to compare the tilts with some other current measurements from the same mooring and plot a correlation diagram.

Also, we can plot Tilt vs Wind when we get meteo data from that area.

The sampling rate during bursts was adequate to get estimates of velocity, but the burst samplings need to be set to something faster than once an hour in order to collect more data and resolve higher frequencies.

8.3.8. OBS-EXP-Bridge

Project Information

Proposal reference number	JS3_CALL_3_4057_OBS-EXP Bridge
Project Acronym (ID)	OBS-EXP Bridge
Title of the project	Bridge between OBServation and EXPerimentation communities of JERICO and AQUACOSM
Host Research Infrastructure	SYKE MRC-lab Facility
Starting date - End date	08/19/2022 to 09/03/2022
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	VIDUSSI Francesca MARBEC CNRSPlace E. Bataillon, CC 093 34095 Montpellier Francesca.vidussi@cnrs.fr +33 631395499

Project Objectives

The main objectives of the OBS-EXP Bridge project were:

1) Study the metabolic and structural responses of plankton communities of the Baltic Sea to a simulates heatwave using high-frequency sensors of LAMP-Sensor-System and Low-Cost-Sensor System that we have developed, and deployed in the inland mesocosms at the host SYKE laboratory,
2) Compare our high-frequency data obtained by LAMP-Sensor-System and Low-Cost-Sensor System with those acquired by host SYKE laboratory using the AQUABOX-device during this heat wave experiment, and
3) Compare the responses of the Baltic Sea communities to heat wave obtained by LAMP-Sensor- System which those obtained previously in the NW-Med Sea during in situ mesocosm experimentations that we have realised in the frame of Transnational Access of AQUACOSMplus between April 25 and May 25 2022. This last project called "Effects of consecutive heat waves on the resistance, resilience and recovery of marine plankton communities (Heat Waves)"(https://ta.aquacosm.eu/facility-call/61af9b474b6b59001e3f7ffa). Finally, by intermediate of this project we would like to bring together the EU communities studying the marine ecosystems using observational infrastructures (JERICO S3) with those using experimental ones (AQUACOSM-PLUS).

Main achievements and difficulties encountered

Seawater was collected at 5 m depth in the Baltic Sea (August 19 2022), screened at 100 µm to remove large particles and nutrients were added to simulate an upwelling and to avoid nutrientlimitation. Then water was preserved in tanks at controlled light and temperature (16°C) at the SYKE laboratory until filling the twelve inland mesocosms

(August 22 2022). The set-up of the LAMP and the Low-Coast Sensor Systems, which have been sent before to SYKE, was achieved between August 20 and 22. All sensors were installed at mid-depth of four mesocosms using a support in plexiglass. Each of four Lamp-Sensor-System comprised sensors of light (Li-Cor), temperature and conductivity (Aanderaa), oxygen (Aanderaa), and Chlorophyll *a* (Chl *a*) fluorescence (Wetlabs) and a data acquisition and storage system. Each of four Low-Cost-Sensor-System included a fluorescence of Chl *a* sensor (two home-made versions), oxygen sensors (Aqualabo), and a data acquisition and storage system. Sensor frequency measurements were set at every minute and sensor data were checked daily or two time daily. Water temperature was increased using heating systems installed in the mesocosms to obtain four temperature level treatments: 16°C that was the natural temperature of the seawater and maintained with the cooling system of the mesocosm's room , 18°C, 20°C and 22°C. Daily manual sampling started the day after filling the twelve mesocosms. (August 23) and included samples for phytoplankton pigment analysis (HPLC), and two size-fractions (< 2 and < 20 µm) for particulate organic carbon, nitrogen, phosphorous and chlorophyll *a*.

Dissemination of the results

Raw data obtained using the LAMP sensor system will be available on open source as soon as quality cheking will be done. As raw data of the Low-Cost-Sensor-System need additional treatments, they will be available as the additional treatements , notably post-calibration and quality cheking will be done. These sensor data and the accessory data on pigments and those on size-fractionated (< 2 µm and < 20 µm) particulate organic carbon, nitrogen, phosphorous and chlorophyll a would be part of an open access paper describing the effect of a simulated heat-wave on the plankton community metabolism. All the data will be available on open source (by CC) in an open source publisher (as for example Seanoe https://www.seanoe.org) and on the journal site (if available). Two technical papers in open access journals are also planned: one comparing the LAMP and Low-Cost-Sensor- System and one comparing the data obtained by the LAMP-System-System and the AQUABOX system. So all the data obtained during this project will be available on open access. In addition, we plan to communicate these results in scientific conferences and meetings.

Technical and Scientific preliminary Outcomes

All the sensors were previously calibrated with the procedure described in Soulié et al. 2020 thus the data shown hereafter are data accounting this calibration. LAMP temperature sensor system showed that the desired target water temperatures simulated different heat-wave intensities of 18, 20 and 22°C above natural water temperature (16°C) were well obtained in the mesocosms and maintained stable until the end of the experiment (Figure 1). The slight decrease observed at regular intervals (every 6 hours) in the 22°C mesocosm and at lower level in the 20°C mesocosm were due to the automated sampling of the AQUABOX-device. The 16°C mesocosm (simulating natural temperatures) showed a more fluctuating temperatures than the heated ones even if these fluctuations were very low. This fluctuation that reveals day-night cycles with temperatures slightly higher (around 0.1°C) during day than during the night was due to the fact that the 16°C mesocosm was at room temperature and that that manual sampling activities during the days including the opening/closing door slightly influenced the maintenance of a constant 16°C temperature in the room. Salinity (figure 1B) showed constant values around 5.67 in all mesocosms.

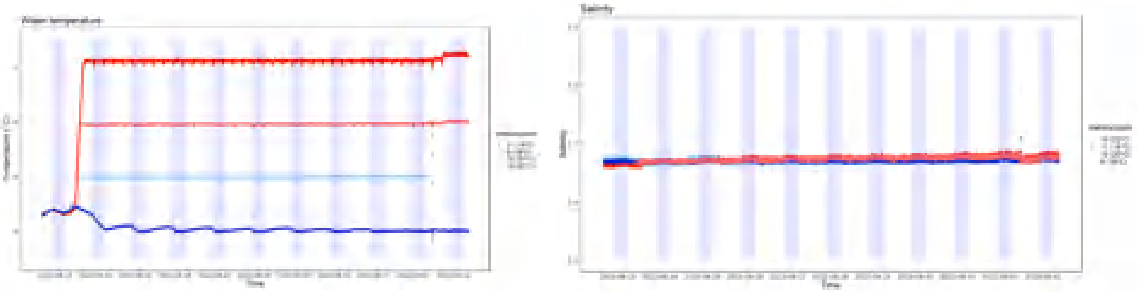


Figure 1: LAMP-Sensor System water temperature (A) and salinity (B) measurements in the 16, 18, 20 and 22°C mesocosms during the simulated heat-wave experiment. Light blue bands indicate dark periods (simulating night), while white ones designate light periods (simulating day).

The oxygen concentration measured by the LAMP-SensorSystem showed that initial values before the increase of temperature were around 316 µmol L-1. To note that in the 18°C and the 22°C heated mescosms the data of the first day of the experiment were missed due to a cable disconnection of the data storage system. The oxygen concentrations in the mesocosms follow the water temperature gradient with higher oxygen concentrations at 16°C and lower and lower in the 18, 20, 22 °C mesocosms (Figure 2, A). This is what is expected as temperature reduce the water oxygen concentration due to less gas solubility in warmer water compared to colder ones. Interestingly a clear marked day-night cycles of oxygen concentrations with values increasing during the day and decreasing during the night were observed in all mesocosms. This is due to the biological metabolism showing oxygen production by phytoplankton encompassing consumption during the day and only oxygen consumption by plankton during the night. To note also the decrease trend in oxygen concentrations along the experiment notably in the 20 and 22°C mesocosms, probably due to the plankton activity in these mesocosms leading to minimum values at the end of the experiment of about 10-15% less than those observed at the beginning of the experiment. The oxygen concentration daily cycles will be used to estimate oxygen net and gross production, and oxygen respiration (Soulié et al. 2020) and thus evaluate the effect of the simulated heat-wave on the plankton oxygen metabolism.

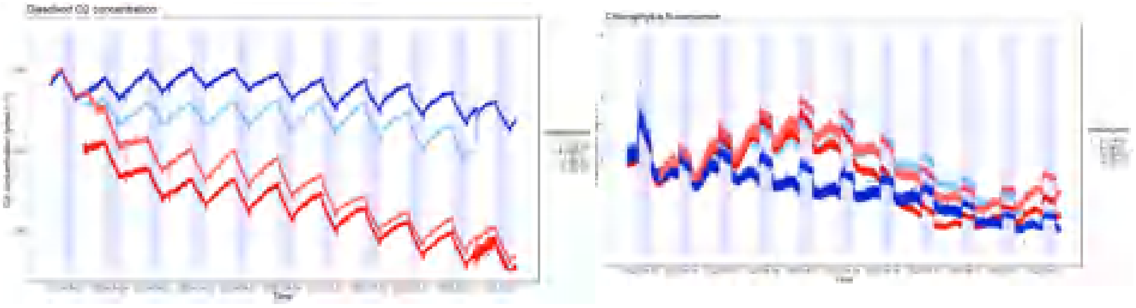


Figure 2: LAMP-Sensor System oxygen (A) and fluorescence of chlorophyll a measurements (B) in the 16, 18, 20 and 22°C mesocosms during the simulated heat-wave experiment. Light blue bands are dark periods (simulating night), while white ones are light periods (simulating day).

The chl *a* measured using sensor fluorescence showed initially values around 2 µg L-1 in all mesocosms. As for the oxygen a day-night cycle was also observed with chl *a* production and loss during the days and only chl *a* losses during the nights. However, this daily cycle is partially masked by the nonphotochemical quenching occurring during the light period that depress fluorescence. However, due to the extremely controlled system used in this experiment and the huge amount of data we will be able to precisely estimate this depression due to photochemical quenching and deriving the chl *a* concentration values during the day. This chl *a* daily cycle will allow to evaluate how heat-wave affect chl *a* production and losses (including those due to grazing, viral lysis and phytoplankton sedimentation). In this sense, chl *a* derived from fluorescence sensors clearly showed an increase in chl *a* in the heated mesocosms (18, 20 and 22°C) compared to the non-heated one (16°C) indicating the occurrence of a moderate phytoplankton bloom under heating. This bloom attained chl *a* maximum values around 3 µg L-1 four days after heating in the heated mesocosms, while chl *a* concentrations in the unheated mesocosm (16°C) showed a decreasing trend with values around or <2 µg L-1. To note that maxim chl *a* values were observed in the 20°C mesocosm, while the 18 and the 22°C showed lower values. This observation could potentially indicate that 20°C is an optimum temperature for this planktonic system. Chl *a* derived by fluorescence measurements showed a sudden decrease in the heated mesocosm indicating the phytoplankton bloom declined at the last days of the experiment and interestingly, this decrease was more sudden in the most heated mesocosm (22° C). At the end of the experiment, chl *a* concentrations in all the mesocosm attained similar values. As mentioned before, raw data of the Low-Cost-Sensor-System need more time to be treated and they will not be shown in this report however, they will be presented later together with those of Lamp-Sensor-System on the same site. These sensor data will be completed by the accessory data on phytoplankton pigments and size-fractionated (< 2 µm and < 20 µm) particulate organic carbon, nitrogen, phosphorous and chlorophyll *a*. which are actually under analysis in the laboratory. The obtained chl *a* data will be used to validate chl *a* fluorescence measured by sensors. The pigments data will be used to evaluate the effect of the heat-wave on the major phytoplankton groups inferred using taxonomic pigments and it will help also to interpret the oxygen metabolism response and the phytoplankton biomass productions and losses under warming inferred using chl *a* fluorescence data. Finally, the size-fractioned particulate organic carbon, nitrogen phosphorous and chl *a* will allow to evaluate the effect of heat waves on the partitioning in different size classes as increase of temperature can change this portioning with consequences on biogeochemical cycles.

8.3.9. PoGo

Project Information

Proposal reference number	22/1002932
Project Acronym (ID)	PoGo
Title of the project	Po delta to Gulf of Trieste: Microbiological connectivity study and field testing of a Video-CTD probe prototype
Host Research Infrastructure	CNR ISMAR S1-GB
Starting date - End date	3 May 2023 – 31 October 2023
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Dr. Martin Vodopivec National Institute of Biology, Marine Biology Station Fornače 41, 6330 Piran, Slovenija martin.vodopivec@nib.si

	+386 59 232905

Project Objectives

The first objective of the PoGo project was to compare ADCP (acoustic doppler current profiler) and microbial ecology data at two different North Adriatic areas, Po Delta – site S1-GB and Gulf of Trieste – site Vida, characterized with different degree of anthropogenic pressure and riverine water discharges. Besides understanding how the differences in physio-chemical and biological parameters affect microbial community dynamics, our aim is to provide the first insights on ecological connectivity between sites by coupling microbial analysis with oceanographic observations and numerical modelling.

The second objective of the PoGo proposal was to test a Mini Video-CTD probe (V-CTD) prototype developed by the National Institute of Biology in waters with high salinity variations. The probe prototype has already been tested in Slovenian national waters and additional testing would be required in a different location. The waters at S1-GB feature high salinity differences and present a perfect testing site for such a device.

Main achievements and difficulties encountered

The S1-GB is an elastic beacon equipped with meteo-oceanographic sensors, located 4 nautical miles south of the mouth of Po di Goro (Po River Delta-Northern Adriatic). The station consists of an aerial platform at 6.5 m above sea level, a steel pipe structure, a submerged float and an elastic joint for mooring to the sinker. The beacon is located at a key monitoring point for the study of interactions between the Upper Adriatic and the Po River, experiencing a wide range of oceanographic conditions.

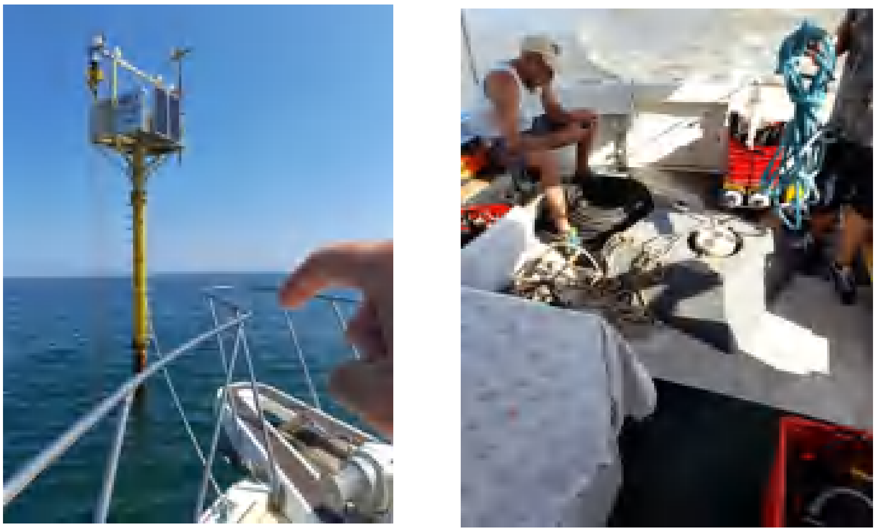


Figure 1: S1-GB beacon and the recovered ADCP still in the housing (Foto: Francesco Riminucci).

The project faced extreme difficulties in securing a suitable time window for site access. This was mainly due to many extreme weather events and frequent wind during the duration of the project. Despite these, we were able to perform four field campaigns, two of these as a joint team from both institutions and two additional campaigns by the host institution.

We successfully deployed an acoustic doppler current profiler (ADCP; Nortek AWAC - 1 MHz) which continuously measured currents at the location from 19 July 2023 to 29 September 2023. We performed two samplings for microbiological analysis. Several casts with the V-CTD prototype were performed on one of the campaigns.

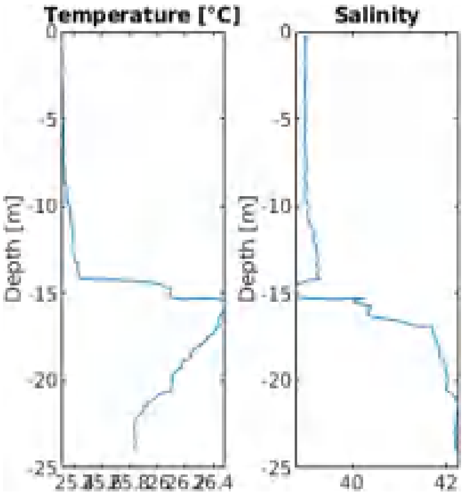
The ADCP has been positioned at the soft bottom near the station and secured by a rope which was fixed at the S1-GB pylon. Unknown perpetrators have cut the rope and the ADCP was considered lost for some time, only to be later recovered by two additional campaigns by the host institution with specialized team of professional divers.

Dissemination of the results

All work carried out in PoGo, will be disseminated through scientific conferences and scientific articles in peer-reviewed journals. The ADCP and V-CTD raw data are already made publicly available in Zenodo repository dedicated to this project (DOI: 10.5281/zenodo.10123570; https://zenodo.org/records/10123570). Other obtained data will be added to the repository later, after analysis and inspection of results. All the emerging omics data will be deposited at publicly available databases (i.e.European Nucleotide Archive).

The work done in the scope of PoGo project matches well with Biodiversa PETRIMED project. Further field campaigns are planned in the scope of PETRIMED, and the data obtained during PoGo will be used in PETRIMED as well.

Technical and Scientific preliminary Outcomes



The V-CTD was deployed three times on 17 October 2023. The interface between fresher and colder water (Po outflow) and saltier and warmer water can be observed at around 15 m depth. Salinity and temperature profiles were obtained with a calibrated SeaBird CTD (operated by the host institution) as well. These will be compared with prototype measurements. The accompanying video, recorder with the camera, which is part of the V-CTD prototype, shows a school of small fish at 15 m depth and a ctenophore at about 5 m depth. A recalibration of the prototype V-CTD will be performed in the following months and recalibrated values will be again compared with the SeaBird CTD measurements.

Figure 2: Temperature and salinity profiles as measured by the mini-CTD prototype.

The ADCP was mounted to a custom-made housing. The bottom of the housing was blocked with a wooden plate to reduce sinking into the mud that covers the bottom at the site. The method proved successful as the ADCP recorded the currents throughout the deployment period. The tidal signal can be observed in the pressure sensor data and in currents as well. As expected, there are several instances with pronounced currents in the northward or eastward directions which could contribute to water transport towards the Gulf of Trieste. These measurements will be related with the microbial analysis and circulation models to indicate whether such transport did indeed

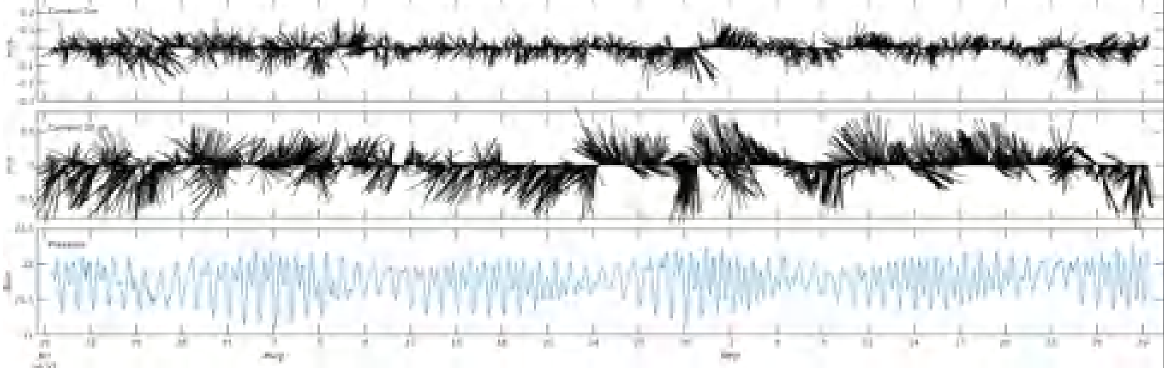


Figure 3: Currents measured 1 m (top) and 20 m (middle) above the ADCP, and pressure (bottom) as recorded by the ADCP current sensor.

The abundance, diversity and functional potential of microbial communities occupying surface layer of water column will be analyzed. For microbial abundance we sampled in triplicates bulk seawater and fixed samples with glutaraldehyde immediately after sampling. Samples are flash-frozen in liquid nitrogen and will be kept at -80C until processed. For HPLC-based analysis of phytoplankton community composition 1L of bulk seawater samples was collected onto GF/F filters (glass fiber, Whatman), in triplicate, and flash-frozen in liquid nitrogen and will be kept at -80C until further processed. For analysis of microbial community composition and function bulk seawater samples were collected onto 0.2 um polyether sulfonic filters. We collected several replicates of 500mL samples, flash-frozen collected filters in liquid nitrogen, which will be kept at -80C until further processed.

Microbial abundance will be determined using flow cytometry (as described elsewhere, Orel et al., 2022), diversity of phytoplankton community will be determined via HPLC-based analysis of phaeopigments (as described elsewhere, Flander-Putrle et al., 2022) and via metabarcoding (i.e., targeting 18S rRNA genes, as described in Turk Dermastia et al., 2023). The composition of bacterial community will be determined via 16S rRNA bacterial genes using next-generation sequencing platforms (as described in Orel et al., 2022). The insights into the functional potential of microbial community will be provided by applying metagenomic approach (as described in Tinta et al., 2023). All constructed datasets will be analyzed using state-of-the-art bioinformatics and statistics tools.

8.3.10. SEASAM

Project Information

Proposal reference number	JS3_CALL_3_4060_SEASAM
Project Acronym (ID)	SEASAM
Title of the project	Simulating an automated environmental DNA sampler/analyser for *in-situ* metabarcoding
Host Research Infrastructure	ISMAR- Venezia

Starting date - End date	21/05/2023 - 17/06/2023
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Maddalena Tibone Atlantic Technological University, Old Dublin Road, galway, Ireland maddalena.tibone@research.atu.ie +39 3459684975

Project Objectives

The objectives stated in the project proposal were to (i) simulate an automated environmental DNA (eDNA) sampler/analyser and (ii) cross-reference of eDNA with imaging data. However, during the project planning, these objectives were modified to accommodate field and laboratory logistic possibilities. The focus was shifted towards comparing active and passive eDNA sampling methods to compare their effectiveness in capturing fish DNA from the environment.

Short-term objectives were identified as active sample collection through filtration of seawater, and passive sample collection through deployment and retrieval of passive samplers, both published and “home-made” devices. To compare the methodologies, eDNA was extracted from the samples and amplified using a real-time quantitative PCR (qPCR) assay to verify the presence and quantity of fish DNA.

The medium and long-term objectives of the project include the definition of an effective sampling protocol for both active and passive eDNA sampling, and the provision of recommendations on which sampling method is more effective in describing the local species richness/biodiversity. These objectives will allow a better understanding of the ideal sampling methodology to be applied in the context of an automated sampler/analyser. Lastly, the data collected from eDNA samples will be compared to the data obtained through analysis of the underwater camera images. This will help to further validate the eDNA workflow by providing evidence in support to methodological recommendations.

Main achievements and difficulties encountered

The main goal of this project (i.e. targeted field sampling and processing of eDNA at the Acqua Alta oceanographic platform) was achieved.

Regarding field work, due to technical/logistic constraints it was not possible to remain overnight aboard the Aqua Alta platform (as previously envisaged), thus the sampling design had to be adapted to regular daily visits, although adverse weather conditions prevented access to the platform on multiple occasions. Nonetheless, sampling took place over the four weeks of access, with a total of 8 daily missions to the infrastructure. During this process, samples were collected with one active technique and with two or more passive methods. Secondly, a subset of the samples collected (50% of the active samples and 20% of the passive samples) was processed in the molecular laboratory at ISMAR. Processing included eDNA extraction and amplification by means of qPCR with a universal assay targeting fish. Results were collected and analysed on site, and protocol optimization was successfully carried out when necessary. This included resolving issues related to presence of PCR inhibitors in the samples, which resulted in false negatives in early qPCR trials. This issue was successfully tackled with strategies to reduce inhibition.

Dissemination of the results

The dissemination of the results obtained will be carried out after further analysis of the samples, as some of the issues with the amplification output still need to be clarified. Dissemination of results will include the present report, and the presentation of the project at internal ATU seminars and international conferences, as well as the data set publication in peer reviewed ISI Journals as part of the PhD thesis work in which the present activities are framed. In addition, the protocols and methodological developments defined during the project will be shared with the scientific community through online platforms (e.g. protocol.io).

The metadata of the samples collected, and the qPCR output data are available upon request. Any further data produced from these samples will be made openly available as soon as possible. Data: https://www.seanoe.org/data/00846/95815/

Technical and Scientific preliminary Outcomes

Sampling was carried out successfully at the Acqua Alta platform, using both active and passive sampling techniques. Active filtration samples (hereinafter CN) were collected on Cellulose-Nitrate membranes (0.45 µM porosity, 47 mm diameter). Passive samples were collected on different substrates: (i) glass fibre filters (1.2 µM porosity, 47 mm diameter) tied to a grid (hereinafter GF/C), (ii) rolls of gauze inside a Metaprobe support (Maiello et al. 2022) (hereinafter M) and (iii) Free Gauze spread out on a grid to maximise the sampling surface (hereinafter FG). CN samples were collected each day of platform access collecting water with a Niskin bottle at -13 m of depth. GF/C and M samples were collected after 3 hours, 24 hours, 48 hours, 1 week and 2 weeks of deployment under the platform at -13 m. The time of deployment was variable, depending on the possibility to access the platform (see section 3). For each timepoint, three replicate samples were collected, for a total of 36 CN samples, 42 GF/C samples and 42 M samples. Only 5 FG samples were collected in total, after 3 hours, 24 hours, 48 hours, 72 hours and 1 week of deployment at -13 m. In addition, negative samples were collected from both the Niskin and the pumping system, after decontaminating them, by filtering 2 L of milliQ water on cellulose nitrate filters. Negatives were collected only on 5 of the 8 days on the platform, due to logistic/timing difficulties.

A subset of the samples (50% of CN, 20% of GF/C, 20% of M and 80% of FG) were processed with eDNA extraction and qPCR amplification in the laboratories at ISMAR. A universal qPCR assay targeting fish was used to verify the presence of fish DNA. As many amplifications were unsuccessful on first try, the presence of PCR inhibitors was hypothesized, and a 5-fold dilution was applied to the extracts to reduce inhibition. Figure 1 shows an overview of the preliminary outcomes of the project. Firstly, the success rate of amplification increased for all sampling methods, when the raw extracts were diluted 1:5 in water. This confirms the presence of PCR inhibitors in the samples. Overall, the active filtration method was more successful than the passive methods. Among the latter, the free gauze showed 100% amplification after dilution, while no amplification with the raw extracts. The amplification success of both GF/C and M samples increased after dilution but did not reach 100%. This indicates that both substrates capture very low quantities of eDNA.

All the negative control samples (both from the Niskin and the pump system) amplified after the 5-fold dilution. Although most samples showed very late amplification, indicating only traces amounts of fish DNA in the negative controls, the decontamination process should be reviewed and improved.

When analysing the qPCR results, a puzzling aspect was the presence of multiple peaks in the melt curve profiles. For positive amplification of genomic fish DNA (from a tissue sample) an individual peak would be expected. Instead, the presence of multiple peaks could suggest non-specific amplification of DNA from other organisms present in the sample, such as bacteria. When separating the PCR products by means of gel electrophoresis, two bands were present (when only one band would have been expected) further confirming the possibility that, after over 30 PCR cycles the selected primers may produce non-specific amplification with microbial DNA fragments.

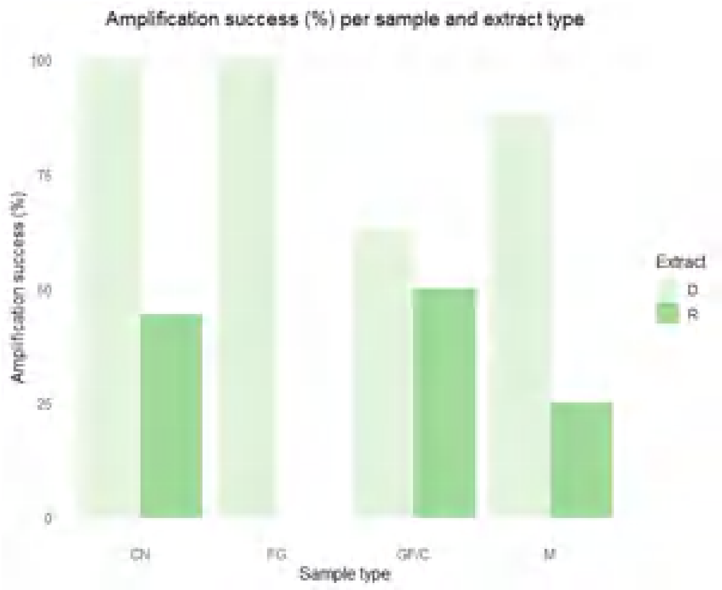


Figure 1. Bar plot indicating the amplification success (shown as a percentage) divided by sample type (CN for active sampling; FG, GF/C and M for passive sampling) and type of extract used for the amplifications (D = diluted 1:5 in water, R = raw extract).

Overall, over the course of this project we carried out successful sampling, extractions, amplifications and troubleshooting. Considering the results obtained up to now, the active sampling method is the most effective one in terms of amplification success. Of the passive methods, the FG samples were the most effective after extract dilution, indicating that gauze is a better substrate than glass fibre filters and that a higher sampling surface is an advantage.

Further work on these samples will include metabarcoding analysis to identify the composition of the local fish community. This profile will be compared with the imaging data from the underwater cameras to verify the effectiveness of eDNA sampling as a biodiversity monitoring tool. In addition, further tests will be run to explain the presence of multiple peaks in the melt curves.

References

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enhances ocean monitoring. Fisheries Research, 249(July 2021), 106259. https://doi.org/10.1016/j.fishres.2022.106259

8.4.Fourth TA Call

8.4.1. ACMaREMAS

Project Information

Proposal reference number	23/1003404
Project Acronym (ID)	ACMaREMAS
Title of the project	Acoustic Characterisation of a Marine Renewable Energy test site using Marine Autonomous Systems
Host Research Infrastructure	Marine Institute, SmartBay and glider
Starting date - End date	13/02/2023 - 07/03/2023
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Ivia Closset Finnish Meteorological Institute Erik Palménin Aukio 1, FI-00560, Helsinki ; postal: PO BOX 503, 00101 Helsinki, Finland ivia.closset@fmi.fi +35850 4421329

Project Objectives

This project aimed to study the applications and advantages of using Marine Autonomous Systems to characterise the underwater soundscape at a Marine Renewable Energy Test Site in Galway Bay, Ireland. It benefited from the unique SmartBay facility that is designed to undertake low-cost sea trials and validation of devices and components at various technology readiness levels. The unique co-location of glider deployment and the SmartBay facility allowed us to address the following objectives:

1. At a short term, configure and deploy a Slocum S3 glider with an attached hydrophone to determine the acoustic characteristics of the renewable energy test site.
2. At a medium term, analyse and compare acoustic data from an existing fixed point acoustic sensor lander that provides an acoustically quiet and stable monitoring station with the Glider acoustic dataset to investigate noise propagation in the test site area.
3. At a longer term, determine the sound propagation of noise generated on the site by a test renewable energy device and a sound projector device generating noise of known frequency and intensity, and validate the use of gliders as a suitable platform for future acoustic monitoring studies.

Additional objectives are:

4. Transfer knowledge and technical expertise on glider operations, best practices and mission strategy planning between Smartbay Glider Team and FMI project team to enable similar glider acoustic monitoring missions in the future.

Main achievements and difficulties encountered

Despite some technical difficulties encountered regarding the synchronization of the hydrophone recording and the sound projector, the project successfully fulfilled most of the objectives.

The glider and hydrophone were successfully configured (see figure 1) and deployed in the vicinity of the SmartBay Test site with both FMI and MI teams operating together (Objective 1). This effort led to the successful implementation of a comparable device at FMI with the ambition of similarly monitoring the acoustic landscape in the Baltic Sea (Objective 4).

Figure 1: The soundtrap pointing forward and attached under the hull of the G3 Slocum glider.

The early termination of the mission by the glider itself due to a technical problem with the engine led to the unanticipated recovery of the device after only five days and therefore had strongly narrowed down our sampling strategy. Our ability to fully investigate sound propagation at the Test site has been seriously limited since we were not able to perform the second round of tests with the sound projector planned later during the glider mission. However, preliminary results from the shortened mission show a good coherence when comparing recordings between both hydrophones (Objective 2).

With regards to data analysis, noises produced by the glider seemed to be easily identified from the hydrophone dataset and FMI team is currently working on developing a statistical method that will filter out glider's noise and allow better analysis of the underwater soundscape and sound propagation at the Test site (Objective 3).

Dissemination of the results

Data analysis is still in progress, FMI team will present the main results of this project during the International Underwater Glider Conference (part of the 9th EGO meeting supported by OceanGlider and the EuroGOOS Glider Task Team) scheduled from June 10th to June 14th, 2024, in Gothenburg (Sweden).

After the completion of further hydrophone testing in the Baltic Sea area, datasets from the ACMaREMAS project and from the Baltic Sea will be combined and compared with the ambition of being published in a scientific paper investigating the sound propagation in shallow coastal waters (estimated submission by the end of 2024-early 2025).

Data: https://smartbay.marine.ie/data/jerico-S3/ACMAREMAS_data/

Technical and Scientific preliminary Outcomes

One of the main purposes of the project was to investigate the characteristics of the self-noise produced by the glider and to preliminary verify the ability of the glider to serve as a platform to study underwater noise using a set of tests performing with a sound-projector and by comparing acoustic data collected from the glider with those collected from a fixed point (broadband 0-200 KHz) iClisten hydrophone. Despite the shorter than expected observation period and the mismatch between the glider-mounted hydrophone and the sound-projector system used at the Test site, several interesting preliminary findings have emerged from this project.

1) Identification of glider self-noise

Before studying the underwater ambient noise and signal detection capability, the self-noise of the glider needs to be analysed. The self-noise of a SLOCUM G3 glider is expected to come mainly from the piston and the pitch-battery motors which controls the buoyancy and barycentre of the glider respectively. The SLOCUM G3 glider is also equipped with a rudder which will steer the platform during the dive when it deviates from the preset heading. These self-noises can be easily identified on the spectrogram (figure 2).

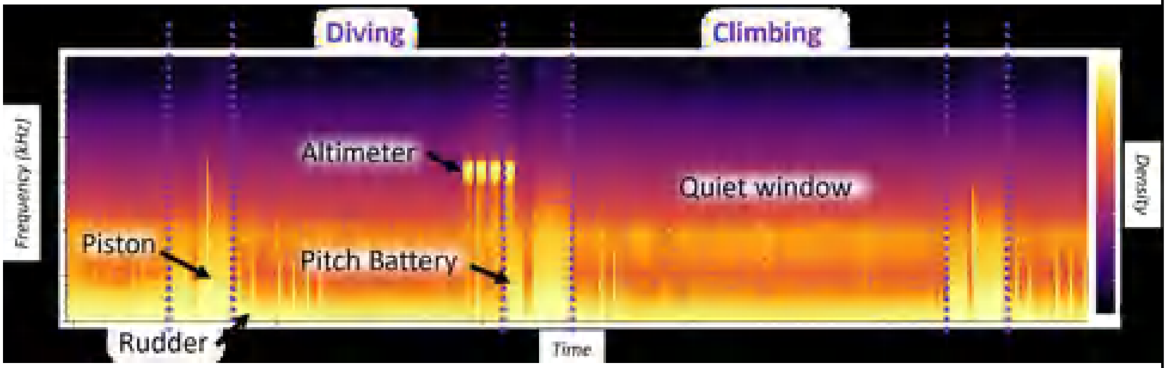


Figure 2: Spectrogram of the glider self-noises during and full yo (diving and climbing phases).

The piston-motor and pitch-battery have the highest noise level and the main energy of the noise is concentrated below 5000Hz. The rudder noise can happen randomly during the dive but seems to occur mostly right after the turning phase (both at depth and on surface). A feature that is different from deep gliders operating in open ocean is the altimeter that has a clear signature (centred around 16kHz) at the end of the diving phase and that is triggering the turning. All those noises will interfere with the acoustic environment acquisition and signal detection ability of the glider. However, in between these periods, the self-noise of the glider is negligible, validating its use as a recording platform.

2) Intercomparison between the glider Soundtrap and Smartbay iCListen datasets

Shortly after the glider deployment, an acoustic source was deployed at the SmartBay Test site and three sets of acoustic signals were transmitted corresponding to the low, medium, and high frequency range of the sound-projector. Unfortunately, a mismatch between the sampling window of the glider hydrophone and the time of emission from the sound-projector prevented us to examine the low and medium sets.

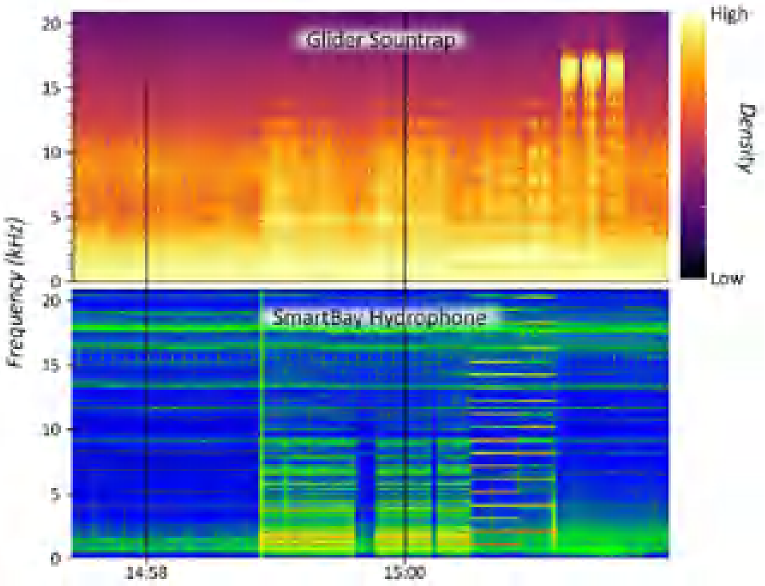


Figure 3: Spectrograms showing the acoustic signals emitted by the sound-projector (from 2 to 10 KHz) recorded simultaneously by the glider Soundtrap (top panel) and SmartBay hydrophone (bottom panel).

The raw spectrograms of the high frequency set recorded by the glider Soundtrap and the SmartBay iCListen presented in figure 3 show similar patterns between 2 and 10 KHz (the sound-projector ran out of power after 10KHz), confirming that both hydrophones recorded the acoustic signals. As anticipated, the intensity of the signal recorded by the glider is lower and partly diluted in background noises. Surprisingly, the signal recorded by both hydrophone display several "bands" distributed over different frequencies, although the sound-projector should have emitted sequentially at a single known frequency from 2 to 10 KHz. This observation requires further analysis but might result from the reverberation or echo associated with shallow bathymetry that would affect signal propagation and would be missing from deep environment datasets.

3) Next steps and other outcomes

The project has served to train staff from FMI in the use of a glider as a passive acoustic platform in a shallow environment. The experience acquired during the project has been essential to understand how the sensor is implemented on the glider as well as how acoustic data is managed, quality controlled and analysed. A substantial effort is ongoing at FMI to translate this effort into a comprehensive glider acoustic data processing interface which will serve to generate visualization plots and quality controlled acoustic datasets. For example, glider acoustic data acquired during this project is currently quality controlled and will be compared to data collected from a similar testing experiment performed in the Baltic Sea in September 2023. Preliminary results from the latter reveal a good consistency of self-noise between the SmartBay and Baltic gliders and proved the ability of the system to track nearby environmental sound source such as those produced by surface vessels.

8.4.2. MultiNuD2

Project Information

Proposal reference number	23/1003407

Project Acronym (ID)	MultiNuD2
Title of the project	In-situ parallel nutrient sensor deployments
Host Research Infrastructure	OBSEA
Starting date - End date	2023-07-06 - 2023-11-21
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Matthew Patey National Oceanography Centre, European Way, Southampton, SO14 3ZH mpatey@noc.ac.uk +44 (0)23 8059 6622

Project Objectives

In this project, we aimed to deploy lab-on-chip phosphate, silicate and nitrate in-situ sensors at the OBSEA coastal Observatory. We would collect a suite of laboratory-quality nutrient measurements over an extended period to produce a nutrient dataset with a temporal resolution that is unprecedented in the surface ocean. We have little experience of testing the nutrient sensors with the more challenging conditions of warm temperatures and low nutrient concentrations found in OBSEA, especially during the summer months.

While these prototype sensors had been deployed previously (e.g. in estuaries, rivers and cold (including polar) waters, the coastal waters of the observatory offer environmental conditions that offer new challenges to the nutrient sensors. Specifically, we wanted to test three aspects that limit the capacity to deploy in-situ sensors in long-term moorings: reagent stability, biofouling, and low-level performance.

Main achievements and difficulties encountered

Main achievements:

- We have had a successful collaboration with our colleagues at OBSEA, who helped us to overcome the shipping problems previously encountered.
- The observatory proved to be an excellent location to test sensors and we hope to use their facilities in the future for tests of lab on chip and other technology.
- We did not manage the 6-month deployment originally envisioned. However, a short deployment during July and August was successful, with all three sensors working well, despite very warm conditions and nutrient concentrations at levels that are challenging even for established laboratory techniques.
- Significant biofouling of the sensors occurred during the short summer deployment (see photo below). But the inlet filters appeared to be good enough to protect the sensors and no clear biofouling signal (such as a diurnal cycle) could be detected in the data.

Figure 1. Nutrient sensors deployed at OBSEA in July 2023

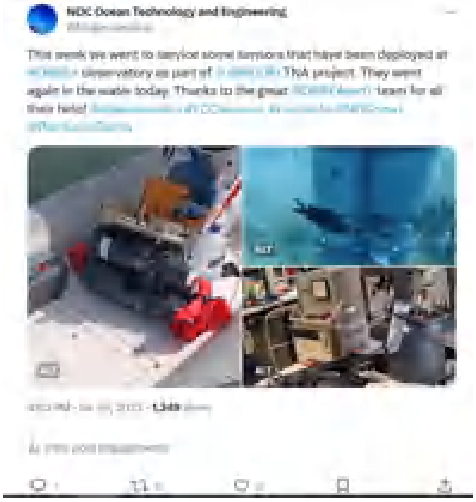
Difficulties encountered:

- Due to transport delays the sensors were deployed in summer when the water temperatures are higher than 25C and sensors reagents do not normally last more than a few weeks. Future deployments and studies will include improvements of the longevity of the reagents.
- During summer, the water at OBSEA is very oligotrophic, this didn't allow us to record any value above detection limit for the N sensor. For Si and P sensors, values were below detection limit in 5% and 60% of the samples, respectively. In this case, we are sure that the sensors were working properly since they measured Kanso CRMs during the visit in July 23 and values agreed with those reported for the standard. For future deployments we will aim to cover other seasons such as early spring when higher values can be measured.

Dissemination of the results

The data from the deployments DOI https://doi.org/10.17882/98662 .
NOC personnel visit to OBSEA in July 23 was publicised in our group Twitter channel, see link to the news:

- https://twitter.com/biogeosensing/status/1682043228554694665



NOC Ocean Technology and Engineering
[illegible]

This week we went to service some sensors that have been deployed at [illegible] observatory as part of [illegible] TNA project. They went again in the water today. Thanks to the great [illegible] team for all their help! [illegible]

NOC Ocean Technology and Engineering [illegible]

We would also like to thank colleagues from the Chemistry Department at [illegible] for providing some reagents at a very short notice. This enabled one of the sensors keep on measuring.

NOC Ocean Technology and Engineering [illegible]

If you want to see our sensors in real time, take a look at the #OBSEA Camera

[illegible]
OBSEA Camera
OBSEA Camera

Technical and Scientific preliminary Outcomes

OBSEA have physically integrated NOC sensors with the OBSEA platform and are able to operate the sensors remotely and retrieve data from them in near real time.

Despite NOC personnel not being able to attend in person for much of the project, OBSEA personnel were trained remotely to operate the sensors.

OBSEA personnel took water samples every time they visited the observatory which will be used to validate the sensor measurements. These samples will be measured in early 2024 following gold standard protocols.

NOC personnel visited twice the facilities at OBSEA, first visit was between 17-19/07/23 and main objective was to service the sensors (repair P and Si sensors, prepare new reagents and measure some Kanso CRMs to check sensor performance). The second visit was between 20-21/11/23 and the main objectives were to prepare the sensors for shipping and collect data.

Two deployments were carried out before the sensors failed:

- The first deployment took place between 29/6/23 until 03/07/23, only the N sensor worked since P and Si sensors due to a problem with the reagent bags. Values for the NO3+NO2 were below detection limit of the sensor (80 nM).
- The second deployment took place between 20/07/23 until 31/08/23. All 3 sensors worked well. Again, N sensor values were below LD, P sensor worked during the whole period, values were close to the detection limit of the sensor (0.06 µM average) see Figure 2. Si sensor worked only until the 12/08/23, we suspect that the reagents went bad due to the warm water temperatures, values were very low (0.4 µM average) see Figure 3.

Figure 2. Concentration of dissolved phosphate in µmol/L, as measured by the LOC sensor at OBSEA between late July / early September 2023.

Figure 3. Concentration of dissolved silica in µmol/L, as measured by the LOC sensor at OBSEA during late July / early August 2023.

8.4.3. SMART

Project Information

Proposal reference number	23/1003408
Project Acronym (ID)	SMART
Title of the project	Sardinia-Mallorca Repeated Transect
Host Research Infrastructure	SOCIB glider facility (SOCIB-GF)
Starting date - End date	12/02/23 to 18/02/23 (preparatory phase) 03/07/23 to 10/07/23 (preparatory phase) 11/07/23 to 22/08/23 glider mission 18/09/23 to 22/09/23 (post-mission phase)
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Jacopo Chiggiato, Ph.D. Istituto di Scienze Marine (CNR-ISMAR) Consiglio Nazionale delle Ricerche Arsenale - Tesa 104 Castello 2737/F 30122 Venezia - Italy jacopo.chiggiato@cnr.it (+39) 041.2407.945

Project Objectives

The project aims to enhance the monitoring coverage across the Algerian Basin spanning from Palma de Mallorca to Sardinia. Executing this glider mission is intended to extend the dataset previously gathered in the region since 2017, contributing valuable information for inter-annual comparisons and long-term monitoring.

The key objectives of the SMART project include:

- Continuing the collection of oceanographic data along the endurance line between Mallorca and Sardinia, augmenting the dataset acquired through external access SOCIB calls in 2017, 2018, 2020, and 2022.
- Identifying the physical and biological characteristics of surface and intermediate water masses in the region between the Balearic Islands and Sardinia.
- Understanding the dynamics of sub-basins and the intricate interactions arising from eddies.

- Studying the mixing of water masses through microstructure measurements.
- Monitoring trends in oxygen levels.

Main achievements and difficulties encountered

Data collected during the SMART mission allowed:

- A real time monitoring of the main physical and biochemical properties of the water column;
- The extension of the glider high resolution dataset;
- Research activities connected to microscale turbulence regimes

From a technical perspective, the glider:

- spent 42 days in water;
- navigated 860 Km (464 Nm);

No particular difficulties were encountered

Dissemination of the results

The observations supported by the TNA activity will be published in a peer-reviewed journal and be part of a PhD internship. At the moment the data are still under preliminary scientific processing and not yet completed quality-control procedure (only L0 and L1 available at the moment).
L0 and L1 Data in NETCDF are freely available via THREDDS at:
https://thredds.socib.es/thredds/catalog/auv/glider/teresa-cnr_teresa/L0/2023/catalog.html
and
https://thredds.socib.es/thredds/catalog/auv/glider/teresa-cnr_teresa/L1/2023/catalog.html
L2 data will be available soon at
https://thredds.socib.es/thredds/catalog/auv/glider/teresa-cnr_teresa/L2/2023/catalog.html

Technical and Scientific preliminary Outcomes

The mission successfully covered the Mallorca-Sardinia transect two way, with deployment and recovery in Spanish waters, south of Palma. The figure below show the actual path of the glider, with color code associated to days after the deployment. It can be seen as each 1-way path took 21 days to complete.

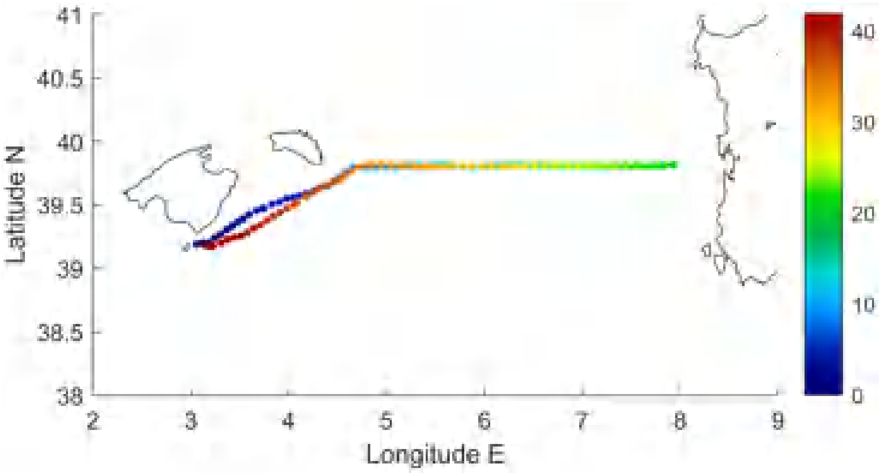


Figure 1: the transect.

Scientific data are still under quality control analysis, so at the moment only raw data are available, thus limiting any scientific interpretation in depth, left after the QC. Based on these preliminary dataset, temperature and salinity data show a seasonal thermocline due to summer heating (see temperature plot below) and the Atlantic Water – Intermediate Water interface marked by salinity change at some 100-150 m depth. Below, it is clear the core of the Intermediate Water of eastern mediterranean origin (38.7+ salinity core) that is at the centre of the salinity plot, that means it is found along the Sardinia boundary (as the plot covers the full 2-way track), where the Intermediate Waters travel north and are relatively less diluted than in the western part of the transect. There is no sign of intermediate water of Western Mediterranean origin (WIW), probably as by the summer it already moved away from the area. Small scale tiltings of the pycnocline are associated to dynamical structures that are under investigation.

Soon the data will be confronted with previous dataset, outlining recent trends in tracers and differences of dynamical behaviour at the mesoscale.

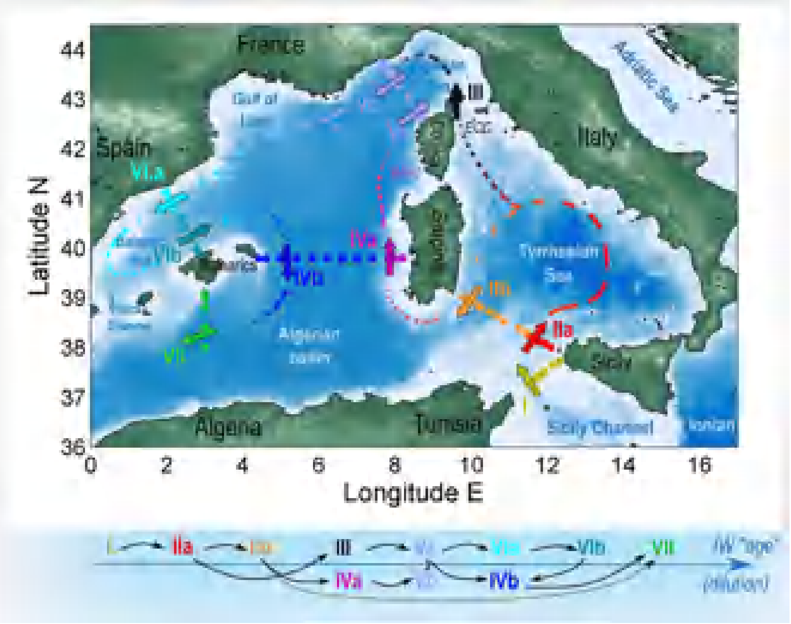


Figure 2: path of the intermediate water as from Schroeder et al., 2020 FMARS

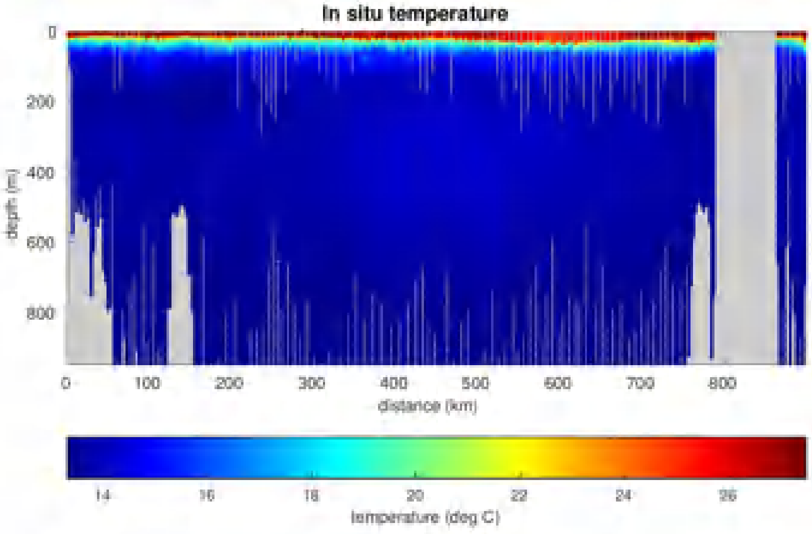


Figure 3: temperature data from the glider (raw data)

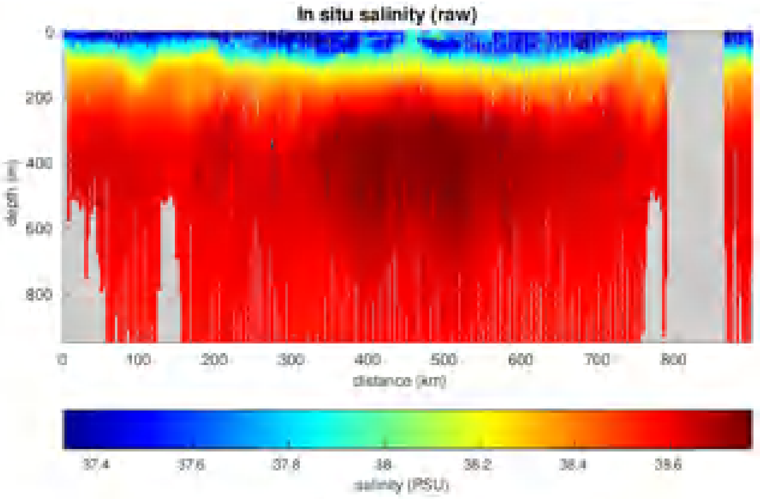


Figure 4: temperature data from the glider (raw data)

8.4.4. LISTEN

Project Information

Proposal reference number	JS3_CALL_4_ 4065_LISTEN
Project Acronym (ID)	LISTEN
Title of the project	Glider Mission to Resolve Mixing in the Southern Baltic
Host Research Infrastructure	Taltech Glider Mia + Profiler
Starting date - End date	24.04.2023 - 10.10.2023
Name of Principal Investigator **Home Laboratory Address** **E-mail address** **Telephone**	Anna Bulczak Ul. Powstańców Warszawy 55, 81- 712 , Sopot, Poland abulczak@iopan.pl

Project Objectives

The main aim of the project is to perform high-resolution CTD, oxygen and chlorophyl A transect along and across the Slupsk Furrow in the Southern Baltic Sea using an ocean glider to complement and enhance the IO PAN standard ship-borne measurements. The goal is to study water mass structure, stratification and mixing processes in the Slupsk Furrow, which is a key area for the transport and mixing of highly saline and oxygen-rich inflow waters originating from the Major Baltic Inflows towards the central and eastern Baltic.

The secondary objective of the project is focused on field testing of the system for acoustic data transfer between the glider and a sub-surface mooring, developed during a BIOGLIDER project. This is a step towards application of gliders as data messengers for harvesting measurements records from underwater platforms in the future ocean observing systems.

Main achievements and difficulties encountered

The glider successfully collected oceanographic data (temperature, salinity, chlorophyll a, turbidity, and partially dissolved oxygen) during 10 days from 8-18 May 2023 along the section in the Slupsk Furrow in the Southern Baltic Sea. However, the oxygen sensor stopped working and after some time, which later caused a failure of all sensors. Therefore, much shorter data set was collected than initially planned (Fig.1 black lines) covering only part of the long transect along the Slupsk Furrow (Fig. 1, yellow line). The glider was successfully recovered on May 30.

For the acoustic experiment, the mooring equipped with hydroacoustic modem was deployed and the glider was equipped with GAN (Glider Acoustic Node). The glider was deployed to perform predefined flights in vicinity of the mooring. Due to technical problem with buoyancy package and very strong current at the location, it was not possible to fly the glider along the required path. Acoustic communication was achieved only for modem technical commands without transferring data packages. The main achievement of the acoustic experiment was to prove a concept of the external GAN setup on a glider for acoustic communication and to gather technical data for improving the GAN design and future integration.

Dissemination of the results

The plan is to present the results of the LISTEN project at the national and international conferences and/or workshops in 2024, particularly at "IV Polish Conference of marine research" and the 5th Baltic Earth Conference, which will be held between 13. May 2024 and 17. May 2024 in Jūrmala, Latvia.

One publication in scientific international journal is also planned, to be submitted in 2024.
Information about the acoustic communication experiment was included in the presentation 'Bioglider: an integrated glider solution for enhancing environmental knowledge' during the OCEANS 2023 Gulf Coast conference, IEEE Oceanic engineering society, Sep 2023, Biloxi, US.

Bulczak, A., & Liblik, T. (2023). Glider measurements of temperature, salinity, dissolved oxygen, Chlorophyl-A, turbidity collected in the Slupsk Furrow in 8-18 May 2023 during LISTEN project (Version 1.0) [Data set]. Institute of Oceanology, Polish Academy of Sciences (IOPAN). https://doi.org/10.48457/IOPAN-01DB2B

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Technical and Scientific preliminary Outcomes

The CTD , dissolved oxygen measurements and ocean currents were conducted from the research vessel RV Oceania within the Slupsk Furrow on May 9, 2023, at stations spaced at 5 nautical-mile intervals, one day prior to the commencement of glider profiling operations (see Figure 1). Subsequently, the vessel assumed a position approximately 3 kilometers behind the glider to preclude any potential collision, adopting a westerly drift with a velocity of 1 kilometer per hour, mirroring the glider's course.

Continuous ocean current measurements were performed using 150 kHz vessel mounted
ADCP. The Microstructure measurements were undertaken at hourly intervals, corresponding to 1 kilometer separation, using a Vertical Microstructure Profiler (VMP250) ofRockland Scientific. This VMP data collection transpired approximately 3 hours to the east of the glider, spanning from 10:00 AM on May 10, 2023, to 10:00 PM on May 11, 2023, and from 12:30 PM on May 12, 2023, to 4:00 AM on May 15, 2023.

In total, the VMP recorded 294 profiles, distributed across 98 stations, each separated by 1 km, with a minimum of 3 profiles performed at each station. The VMP measurements were constrained by temporal and logistical limitations, necessitating their cessation on May 15, 2023, after covering the deepest segment of the basin. Owing to complications with the oxygen sensor, the glider was only able to profile a single extended section along the Slupsk Furrow, as indicated by the yellow trajectory in Figure 1, spanning from May 10, 2023, to May 18, 2023. The subsequent recovery and retrieval of the glider occurred on May 30, 2023.

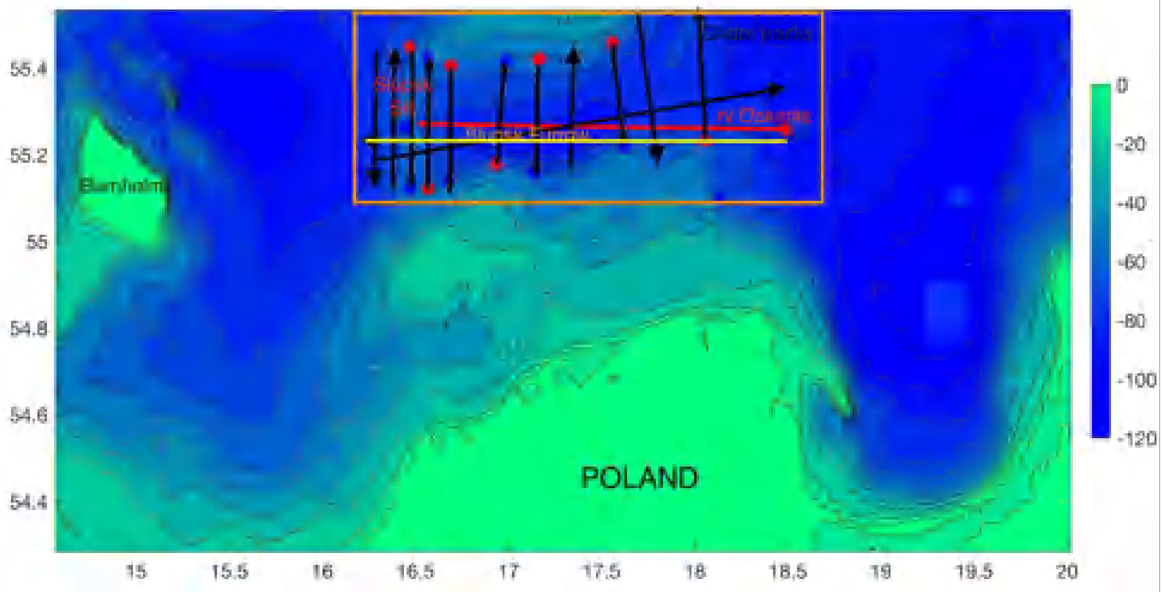


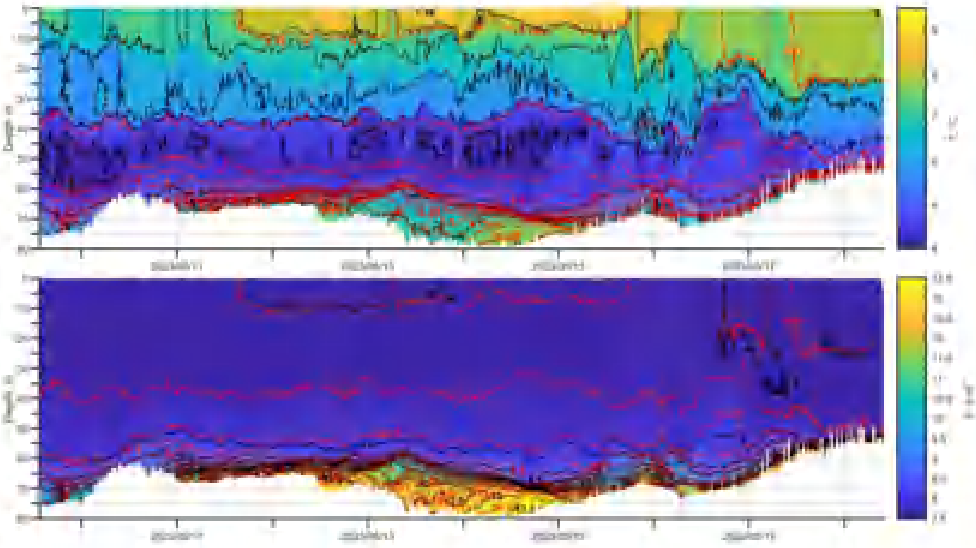
Figure 1. Map of the study. The initial mission plan is shown in black, the actually measured track is shown in yellow and the rv Oceania ship track is shown in red. Colours represent bathymetry [m].

The preliminary glider-derived data underwent a post-processing procedure. The data quality assessment adhered to established best practices as stated in the: Argo Quality Control Manual, the Real Time Quality Control of biogeochemical measurements (2011) MyOcean, and the Delayed Mode QA/QC Best Practice Manual (2021), in alignment with the standards set forth by IMOS Ocean Gliders.

Prior to binning, science variables, with the exception of oxygen, were subjected to filtration using a single-pole filter method as proposed by Fofonoff et al. (1974). Evaluation of sensor response was accomplished by comparing consecutive profiles. Time coefficients spanning the range from 0 s to 2 s in 0.1 s increments were employed, with the mean area determined using the trapezoidal method and root mean square error (RMSE) computed between profiles. Subsequently, median values for each time coefficient were compared. The implementation of response time during post-processing served to diminish disparities between successive temperature and conductivity profiles.

However, the glider-derived oxygen concentration data was omitted due to the distinct response times of the oxygen and temperature sensors, which approximate ~25-30 s and ~10 s, respectively. To approximate true oxygen values, oxygen saturation was re-calculated to its phase, following the methodology outlined by Bittig et al. (2014, 2017). This approach facilitated the estimation of sensor response and the filtering of phases that could subsequently be utilized to recompute oxygen saturation using CTD temperature data. The outcomes of this post-processing are visually depicted in Figure 2, portraying 3D fields encompassing temperature, salinity, chlorophyll-A, turbidity, oxygen saturation, and oxygen concentration.

The results show that chlorophyll-A data notably exhibits diurnal variability, with elevated concentrations near the surface during daylight hours and decreased concentrations during the night. This diurnal variation is indicative of vertical phytoplankton migrations (such as dinoflagellates, chlorophytes etc.), which are particularly pronounced in the western Słupsk Furrow, possibly influenced by an increase in solar radiation over deployment time. The water temperature data manifest substantial spatial and temporal fluctuations, characteristic of the region in May. The presence of internal waves or sub-mesoscale eddies is discernible in the temperature and salinity/density data, particularly in the vicinity of the Słupsk Sill. Conversely, turbidity exhibits limited variability along the transect, with minor changes near the seabed attributed to heightened sediment transport and slight surface variations, likely a consequence of plankton activity, as a similar pattern is evident in the chlorophyll-A data and surface temperature measurements.



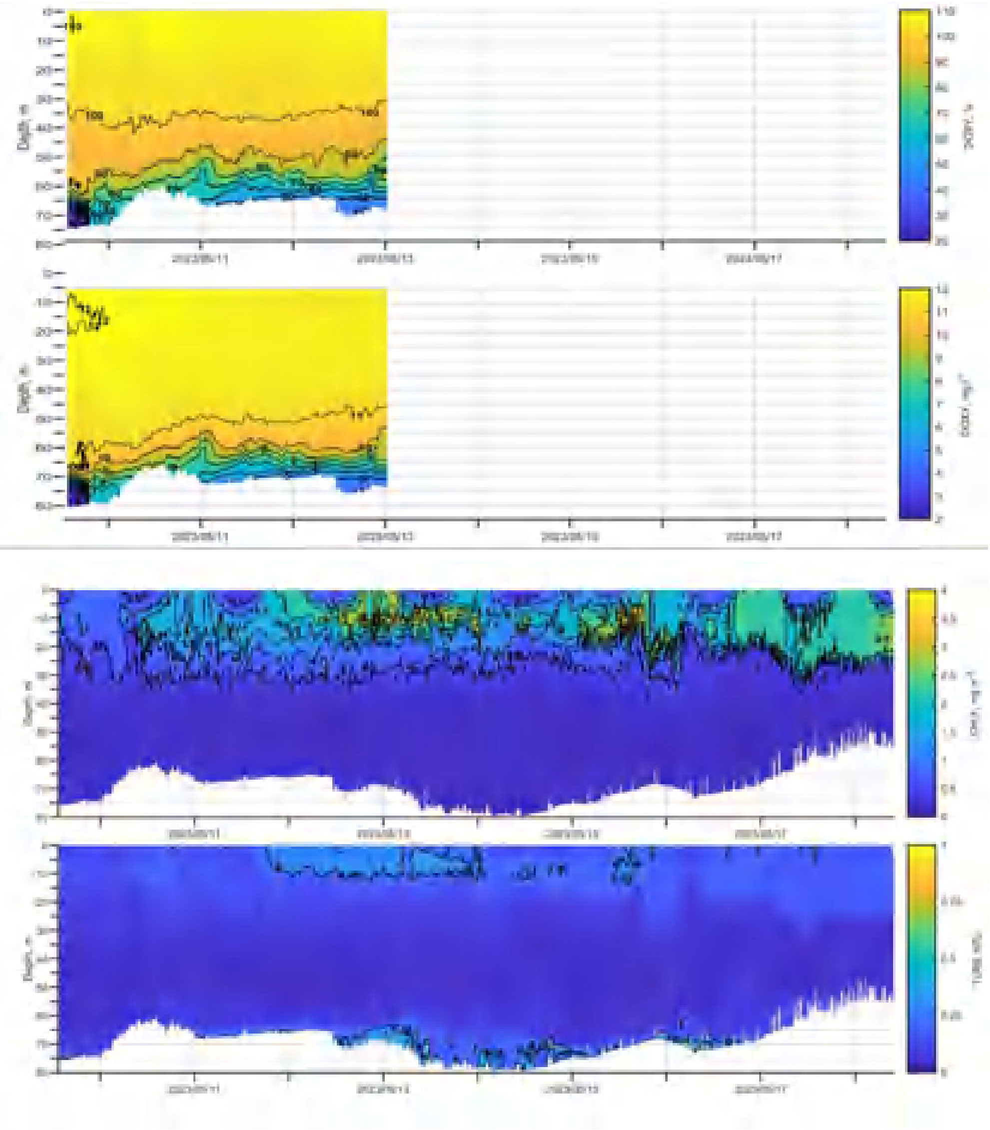


Figure 2. From the top: temperature, salinity with potential density contours overplotted in red, oxygen saturation, dissolved oxygen concentration, chlorophyl-A and turbidity, along the transect in the Slupsk Furrow.

For the acoustic experiment, the mooring equipped with hydroacoustic modem was deployed and the glider was equipped with GAN (Glider Acoustic Node consisting of the acoustic modem, data integrator and buoyancy package). The glider was deployed and performed predefined flights in vicinity of the mooring. The GAN setup was tuned during the experiment but due to technical problem with buoyancy package and very strong current at the location, it was not possible to fly the glider along the required path. In result, only technical part of acoustic communication was achieved without transferring any data packages. However, the main achievement of the acoustic experiment proving a concept of the external GAN setup on a glider for acoustic communication and gathering technical data for improving the GAN design and future integration. Due to the limited time of acoustic experiment (most of TA time was devoted to the main experiment) it was not possible to repeat glider deployment with the improved GAN setup, but it is foreseen in the future projects.

9.CONTRACT AND FACILITY MANAGEMENT

The TA coordination team at IFREMER issued contracts to be signed by the host facility and end user, with the IFREMER legal team signing as the last signature. The contract signing process ran smoothly for some projects; however, many projects were held up in the contract signing stage due to the multiple back and forth between entities before agreements were settled. For more information on policies and procedures in regards to contracts and management, see Deliverables D13.3 (Gaughan, et al., 2021), 13.4 (Loughlin and Gaughan, 2021) and 13.5 (Loughlin and Gaughan, 2022) .

During JERICO-S3, there were 8 cancelled projects, these are all listed in Table 3. Majority of the cancellations were due to scientific and technical reasons. Many accepted projects successfully worked with the host facility and TA team to adjust the work plan set out in the application to suit any issues encountered. However, the below projects ran into issues that were unable to be solved, many being problems with shipping or instrument failures.

Table 3: The list of cancelled projects and reasonings.

Project Acronym	**Project Title**	**Lead Organisation**	**Facility**	**TA Call**	**Date Cancelled**	**Reasoning**
CONAN	Cabled Observatory Network for the Advanced monitoring of ecosystems and their Natural resources	Instituto de Ciencias del Mar (ICM) Institute of Marine Sciences, Spain	MI SmartBay Observatory	1	08/08/2023	Unavailability of the Underwater Legged Robot SILVER2 due to changes in affiliation of the researchers involved in the action which have dramatically slowed down the maintenance and development on the robot.
FISHES c	Fibre-optic Intelligent Submarine High-Fidelity Environmental Sensing	National Oceanogaphic centre, UK	Plocan	1	08/11/2023	Instruments were lost in shipment to Plocan (summer 2021), issues with Brexit arose for reshipment which caused the cost to exceed the grant budget.
Eurofluoro a	Eurofluoro	Chelsea Teach, UK	SYKE MRC LAB	1	17/07/2023	Unforeseen technical issues in manufacturing the sensors to be tested
JIVE	JERICO-DANUBIUS-RI Observation initiatiVE	University of Stirling, Uk	CNR-ISMAR (S1-GB)	2	04/04/2024	The proposed project must be cancelled due to unforeseen technical issues with the sensors.
CTDEmEx	CTD inter-comparison: existing and emerging sensors	Marine Institute, Ireland	HCMR - Poseideon; HCMR cal lab	2	09/12/2022	The timeline for obtaining the instruments and the deadline for project reports to be completed meant the project was not feasible.
FRESNEL	Field expeRiments for modEling, aSsimilatioN and adaptive sampLing	Columbia University, USA	INSTITUTO HIDROGRAFICO, Portugal-Monizee (IH)	3	23/01/2024	Unforeseen length of time to negotiate agreement which has ultimately reduced the available project time making it impossible to meet the proposed tasks.
OC300-LTLSal	ANB Sensors OC range: Low temperature and low salinity	ANB Sensors Ltd., UK	SYKE-ALGALINE; SILJA SERENADE; SYKE	3	08/11/2023	Unforeseen technical issues in manufacturing the sensors to be tested.

			MRC-Lab			
GLOBE	Glider Observations of the Black sea Environment	Institute of oceanology-bulgarian academy of sciences, Bulgaria	SOCIB	4	18/07/2023	The 40 day glider mission would incur Bulgarian customs issues on importing the glider. Taxes on the value of the glider would need to be paid which is not feasible for the project to continue.

10.OUTREACH, DISSEMINATION AND COMMUNICATION ACTIVITIES

All four calls were announced on www.jerico-ri.eu website and promoted on all social media outlets. The application and guidance notes (see Deliverable 13.3, Gaughan et al, 2021) were uploaded onto the website and tweets were used to promote the call opening and draw attention to closing dates. Outside of these main communication activities, some alternative campaigns were used in promoting calls two and three.

During the second call, a "facility of the week" campaign was run where, for four weeks, one facility was featured each week in a blog post and associated tweet on Twitter, now known as X. An example of a blog post can be found here https://www.jerico-ri.eu/2021/04/20/jerico-s3-ta-facility-of-the-week/. The four facilities featured were one of each main type of facility (cabled observatory, ferrybox, glider, fixed platform) and ones that were not selected in the first call in an attempt to draw attention to them. The four highlighted were PLOCAN, NIVA research station and ferryboxes, COSYNA Slocum 2 glider, and E1-M3A station at POSEIDON. These posts were fun from 20 April 2021 - 19 May 2021, coinciding with the last month of the call being open to promote the call and raise awareness of the closing date.

In the lead up to the third call, blog posts and tweets were used to promote and raise awareness of the upcoming third call. To celebrate International Women and Girls in Science day on 8 February 2022, 3 women PI's in the TA programme were featured in blog posts. The aim was to promote women in science, encourage other women users to apply, and to announce in advance the upcoming springtime launch of the 3rd call. One blog post was published to introduce the Women in Science Day https://www.jerico-ri.eu/2022/02/10/jerico-ri-celebrating-women-in-science-empowering-women-leaders/, with 3 subsequent posts on each woman PI describing their scientific background and the Jerico TA project they are leading.

On 14 April 2022, a blog post on the JERICO-RI website was posted https://www.jerico-ri.eu/2022/04/14/jerico-ta-facility-highlight/ to highlight four different types of facilities, especially those that were not used in the first & second call. This post was shared on the Twitter account too to increase the social media awareness of the third call. The four facilities highlighted were COAST-HR SMILE buoy, COSYNA Underwater Node Helgoland (UNH), SmartBay Glider, and CEFAS FerryBox.

Throughout the JERICO-S3 lifecycle, blog posts were published on the website about different projects as they finished. These articles were written under the direction of the facility operator and were also promoted on social media. An example of a TA project blog post, the project is DEEPDEG:

https://www.jerico-ri.eu/2023/01/12/jerico-s3-transnational-access-scientific-cruise-in-the-mediterranean/ .

Finally, the TA coordination team conducted two surveys for feedback from users and facility operators. See Deliverable 8.3 for analysis and conclusions from the responses (Loughlin, et al., 2024). Additionally, the TA coordination team held feedback interviews with users to present a short testimonial video at the Final General Assembly for the JERICO-S3 partners. The interviews with users were extremely beneficial to hear more about their experience from the JERICO-S3 TA. They gave feedback on the benefits and challenges they faced, and also about the longer term benefits the JERICO-S3 funded project they conducted had on their research and future collaborations on other projects.

User feedback video:
https://drive.google.com/file/d/1WVwq0HZZiOA_f-AavH7kCzT0VbMnTXIN/view?resourcekey

11. CONCLUSIONS

One of JERICO-RI's major strengths is in its Transnational Access service, providing free of charge access to high-quality coastal observation infrastructures. The TA provides marine researchers access to facilities such as cabled observatories, gliders and AUVs, ferryboxes, fixed platforms, and calibration laboratories to carry out experiments for technology development and scientific research.

A total of 39 projects were successfully supported throughout four TA calls in JERICO-S3. Refer to D8.3 (Loughlin, et al., 2024) for more detailed conclusions on user statistics and feedback survey results. All project reports attached to this deliverable provide information on each specific project's objectives and preliminary results. The TA was successful in connecting researchers to high-quality coastal research facilities to facilitate innovation and the furthering of marine research.

12. ANNEXES AND REFERENCES

Gaughan, P., Berry, A., 2021. JERICO-S3 D8.1 Description of Facilities in Transnational Access provision.

Gaughan, P., Godiveau, L., Berry A., 2021. JERICO-S3-WP13-D13.3 Transnational Access: Policies and Procedures document -28.01.2021-V2.0, 28/01/2021.

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