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EDITOR'S NOTE

First of all, we want to thank the academic, scientific and industrial community for their collaboration and presence in this tenth edition of the International Workshop on MARine TECHnology - MARTECH2023.

This edition is being organized by the Jaume I University of Castellón and the Polytechnic University of Catalonia, specifically by the CIRTESU-IRSLab (Research Center for Robotics and Underwater Technology - Interactive Robotic Systems Lab) and SARTI (Development Center of Remote Acquisition and Information Processing Systems) research centers. We also thank all the colleagues and collaborators of these two institutions for the work they are doing, in many aspects such as the preparation of the proceedings, reviews, logistics, secretariat, website, demos, etc.

MARTECH2023 is focused on the presentation and joint study of new and future marine technologies at the service of science and society. Technological advances are important in applications such as aquaculture, oceanography, archaeology, water treatment, and many others of great importance. Moreover, a special session dedicated to renewable marine energies has been added, considering its great importance towards the energy transition. Also, some papers are dedicated to technological advances in the field of underwater robots, including artificial intelligence techniques, communication systems, computer technology, underwater sensors, and their applications. In this area, as relevant works, we would like to thank the plenary conferences of professors Pere Ridao, Matilde Santos and Giovanni Indiveri.

Considering the importance of education for new researchers in this field, we want to thank the institutions that facilitated the joint activities of MARTECH2023 and the (MIR) Erasmus Mundus Marine

and Maritime Intelligent Robotics Master Annual Event and Championship (<https://www.master-mir.eu/>).

We wish all those attending MARTECH2023 that this workshop be beneficial, both in a scientific, professional, and personal sense, and that it also serves to better understand the culture of Castellón, so rich in gastronomy, history, architecture, and art.

DR. RAÚL MARÍN PRADES (RMARIN@UJI.ES)

DR. JOAQUIN DEL RIO FERNÁNDEZ (JOAQUIN.DEL.RIO@UPC.EDU)

8:00 - 9:00	Reception and Registration (Hall Building TD ESTCE)
9:00 - 9:15	Opening of the Conference (Building TD 3rd Floor, TD0301CC Salón de Actos)
Plenary 9:15 - 10:15	Advances in Underwater Robotics Operations Prof. Dr. Pere Ridao, Universitat de Girona, Spain
10:15 - 10:45	Coffee break (Hall Building TD ESTCE)

Session 1.1 Special Session on Marine Technology Applications 10:45 - 12:00 (TD0301CC Salón de Actos)	ID16 New advances in AI-based electronic monitoring (EM) technologies for automatic, real-time catch data collection: the iObserver2.0 Luis T. Antelo, Instituto de Investigaciones Marinas (IIM-CSIC), Spain
	ID21 Arduino controlled valvometry equipment for mussel raft monitoring Miguel Gilcoto, Instituto de Investigaciones Marinas (IIM-CSIC), Spain
	ID22 Model type II regression for lagrangian validation of HF Radar velocities in the NW Iberian Peninsula Adrián Martínez Fernández, Instituto de Investigaciones Marinas (IIM-CSIC), Spain
	ID23 A window to the sea: RAIA Observatory tool for assessing environmental risks in the NW Iberian coastal upwelling system Paula C. Pardo, Instituto de Investigaciones Marinas (IIM-CSIC), Spain
	ID44 The BlueNetCat - The Catalan reference network for the knowledge transfer in Blue Economy Pablo Bou, BlueNetCat - UPC, Spain

Session 1.2 Special Session on Marine Technology Applications 10:45 - 12:00 (Sala de Grados TD0112FR)	ID07 Modular acoustic platform to develop underwater bidirectional tags Gerard Batet, SARTI - Universitat Politecnica de Catalunya, Spain
	ID14 Development of an autonomous submersible profiler with the ability to stop at specific depths for measurement of marine parameters Isabel Pilar Morales Aragón, Technical University of Cartagena, Spain
	ID20 KOSTASystem, a multipurpose coastal videometry system Asier Nieto, AZTI, Spain
	ID24 Pathways of economically relevant demersal species in the Ibiza Channel from a Lagrangian backtracking approach Juan Manuel Sayol, University of Alicante, Spain
	ID27 Operational oceanography applied to the management of offshore aquaculture on the Basque coast (SE Bay of Biscay) Luis Ferrer, AZTI, Spain

Session 2.1 Special Session on Marine Technology Applications 12:00 - 13:30 (TD0301CC Salón de Actos)	ID29 Enhancing Marine Ecosystem Monitoring through the Integration of Pop-up Buoys with Wireless Communication and Satellite Connectivity Marc Nogueras, SARTI - Universitat Politecnica de Catalunya, Spain
	ID31 CIM-UVIGO mesocosms facilities: a realistic experimental approach for grand challenges in oceanography Jose González, CIM - Universidade de Vigo, Spain
	ID39 Low Cost Greenhouse gas sensor: GIDA-GEI Iván Ibáñez Felip, Universitat Jaume I, Spain
	ID41 A Data Management e-Infrastructure for the OBSEA Cabled Observatory Enoc Martínez, SARTI - Universitat Politecnica de Catalunya, Spain
	ID42 Low cost USV development to study spring ponds José Enrique Tent-Manclús, Universidad de Alicante, Spain

Session 2.2 Special Session on Marine Technology Applications 12:00 – 13:30 (Sala de Grados TD0112FR)	ID02 Validating combined navigational sensor packages for small vehicle platforms Cristobal Molina, Nortek AS, Norway
	ID08 BenthosSearcher: A Machine Learning Based Tool to Ultra-Fast, Automatic Characterization of Vulnerable Marine Ecosystems Luis T. Antelo, Instituto de Investigaciones Marinas (IIM-CSIC), Spain
	ID13 The video-based EGIM development Marco Francescangeli, SARTI - Universitat Politecnica de Catalunya, Spain
	ID38 Towards sampling of the circalittoral benthos for monitoring impacts on marine communities limitations and next steps Victor Tena-Gascó, IMEDMAR-UCV, Spain

13:30 - 15:00	Lunch break (Cafetería Facultad Jurídicas y Económicas, Floor 0)
Plenary 15:00 – 16:00 (TD0301CC Salón de Actos)	Marine Technology in the field of Energy Matilde Santos, Universidad Complutense de Madrid, Spain María Tomás-Rodríguez, City University of London, United Kingdom

Session 3.1 Special Session Renewable Marine Energy 16:00– 17:30 (TD0301CC Salón de Actos)	ID03 Optimization of a Small-Scale, N-Pendulum, Wave Energy Converter for Drifter Applications based on OrcaFlex Simulation Joaquín del Río, SARTI - Universitat Politecnica de Catalunya, Spain
	ID06 Fuel consumption reduction in tuna purse seiners using oceanographic data and genetic algorithms Fernando Gonda, Marine Instruments, Spain
	ID09 Consumption Evaluation of a Relaxation Oscillator as a Control Sampling Circuit for Fast-Tracking FOCV-MPPT Circuits in Wave Energy Converters Joaquín del Río, SARTI - Universitat Politecnica de Catalunya, Spain
	ID10 Tuning structural control devices with Genetic Algorithms for a floating wind turbine Matilde Santos, Universidad Complutense de Madrid, Spain
	ID11 Frequencies Identification of NREL 5MW ITI Barge Wind Turbine: First Approach Jesús Enrique Sierra-García, Universidad de Burgos, Spain
	ID30 The CIM UVIGO Plug-in Hybrid Propulsion Vessel for Coastal Oceanographic Research: A tool for the ecological transition Daniel Rey, Centro de Investigación Mariña, Universidade de Vigo, Spain

Session 3.2 Special Session Renewable Marine Energy 16:00– 17:30 (Sala de Grados TD0112FR)	ID28 Uncrewed Surface Vehicles Network in support to EOOS: The EuroSea project Carlos Barrera, PLOCAN Spain
	ID32 An approach to the application of additive manufacturing for water environments: A case study to measure dissolved carbon dioxide Iván Ibáñez Felip, Universitat Jaume I, Spain
	ID33 Long Baseline (LBL) Positioning System for the Crawler Tele-operated Underwater Vehicle in OBSEA Observatory Ainhoa Idiondo Molina, SARTI - Universitat Politecnica de Catalunya, Spain
	ID34 Automatic System for 3D Photogrammetry of Small Artificial Biotopes Using the Crawler Remote Operating Vehicle at OBSEA Observatory María Meishan Oliver De Urmeneta, SARTI - Universitat Politecnica de Catalunya, Spain
	ID35 Experiments on zebrafish using mini robot fish prototypes to identify stressors Andrea Pino Jarque, Universidad Jaume I, Spain
	ID43 On the development and application of intrusive sensors for two-phase flows characterization in complex environments Guillem Monrós Andreu, Universidad Jaume I, Spain

Cultural Visit 19:00 – 20:00	Guided Visit to Castellón City Center
Gala Dinner 20:00	Real Casino Antiguo de Castellón (Plaza Puerta del Sol, 1, 12001 Castellón de la Plana, Castellón)

8:15 - 9:00	Reception and Registration
9:00 - 9:15	Welcome Reception of the students and professors of the Erasmus Mundus Master MIR (TD0301CC Salón de Actos)
Plenary 9:15 - 10:15	Marine Robotics to serve society Giovanni Indiveri, Genoa University, Italy
10:15 - 10:45	Coffee break (Hall Building TD ESTCE)

Session 4.1 Special Session on Robotics, Artificial Intelligence, Sensors and Communications 10:45 - 11:45 (TD0301CC Salón de Actos)	ID37 Further Teleoperated Experiments with an Underwater Mobile Manipulator via Acoustic Modem: Modem Characterization Joaquín González, Universidad Jaume I, Spain
	ID15 Modelling and Identification of an Autonomous Surface Vehicle Thalia A. Morel, Universidad Loyola Andalucía, Spain
	ID18 Underwater Autonomous Event-Driven Profiler and Data Retrieval System João Pereira, LSTS - Universidade do Porto, Portugal
	ID45 Marine Ecosystems Observation by a cooperative AUV in the PLOME project Marc Carreras, Universitat de Girona, Spain
	ID46 Shared Autonomy for Mapping and Exploration of underwater environments using an HROV Sebastian Realpe, Universitat de Girona, Spain

Session 4.2 Special Session on Robotics, Artificial Intelligence, Sensors and Communications 10:45 - 11:45 (Sala de Grados TD0112FR)	ID40 Towards Automatic Hole Detection of a Net for Fish Farms by means of Robotic Intelligence Salvador López-Barajas, Tecnológico de Monterrey, Escuela de Ingeniería y Ciencias, Mexico
	ID04 Towards Hash Similarity and Geometric-based Image Filtering to Lighten Underwater Photo-Mosaicing Pol Baños Castelló, University of the Balearic Islands, Spain
	ID05 Mesopelagic Crustacean Habitat Identification and Analysis Using Deep Learning Francisco Jesús Bonin Font, University of the Balearic Islands, Spain
	ID25 Calibrating the Movement of an Underwater Crawler Using Pulse Width Modulation (PWM) Ahmad Falahzadeh, SARTI - Universitat Politècnica de Catalunya, Spain
	ID26 Multisensor Acoustic Tracking Benthic Landers to Evaluate Connectivity of Fishes in Marine Protected Areas Daniel Mihai Toma, SARTI - Universitat Politècnica de Catalunya, Spain

Session 5 Special Session on Robotics, Artificial Intelligence, Sensors and Communications 11:45 - 12:45 (TD0301CC Salón de Actos)	ID17 Bridging heterogeneous networks in challenging and disruptive maritime environments Manuel Ribeiro, LSTS - Universidade do Porto, Portugal
	ID19 A novel and multi-purpose ASV for the Basque Coast: design, experimental testing, and main challenges Irene Ruiz, AZTI, Spain
	ID36 Processing acoustic images for the exploitation of fish farms Fernando Gómez-Bravo, Universidad de Huelva, Spain
	Seaber's YUCO-SCAN first trials at Graó de Castelló. Oswaldo López(INNOVA oceanografía litoral) and Alejandro Palmeiro (Nautilus Oceánica), Spain
	Seaber's YUCO-SCAN first results at Graó de Castelló. Alejandro Palmeiro (Nautilus Oceánica) and Oswaldo López(INNOVA oceanografía litoral), Spain

12:45 - 13:15	Closing Ceremony and Best Papers' Awards
13:30 - 15:00	Lunch
15:00 - 17:00	Visiting CIRTESU (Research Center on Robotics and Underwater Technology) Pere Ridao, Universitat de Girona Alejandro Solis, Universidad Jaume I de Castellón
Tutorial 15:00 - 16:00 (TD0301CC Salón de Actos)	Programming Artificial Intelligence Algorithms in Underwater Robots (Recommended for MIR students participating in Competition) Salvador López, Instituto Tecnológico de Monterrey Raúl Marín, Universidad Jaume I de Castellón

CONTENTS

ORGANISING COMMITTEE	3
INTERNATIONAL SCIENTIFIC COMMITTEE	3
EDITOR'S NOTE	4
ID02 Validating combined navigational sensor packages for small vehicle platforms	11
ID03 Optimization of a Small-Scale, N-Pendulum, Wave Energy Converter for Drifter Applications based on OrcaFlex Simulation	11
ID04 Towards Hash Similarity and Geometric-based Image Filtering to Lighten Underwater Photo-Mosaicing	13
ID05 Mesopelagic Crustacean Habitat Identification and Analysis Using Deep Learning	15
ID06 Fuel consumption reduction in tuna purse seiners using oceanographic data and genetic algorithms	17
ID07 Modular acoustic platform to develop underwater bidirectional tags	19
ID08 Benthosearcher: A Machine Learning Based Tool to Ultra-Fast, Automatic Characterization of Vulnerable Marine Ecosystems	21
ID09 Consumption Evaluation of a Relaxation Oscillator as a Control Sampling Circuit for Fast-Tracking FOCV-MPPT Circuits in Wave Energy Converters	23
ID10 Tuning structural control devices with Genetic Algorithms for a floating wind turbine	25
ID11 Frequencies Identification of NREL 5MW ITI Barge Wind Turbine: First Approach	27
ID13 The video-based EGIM development	29
ID14 Development of an Autonomous Submersible Profiler with the Ability to Stop at Specific Depths for Measurement of Marine Parameters	30
ID15 Modelling and Identification of an Autonomous Surface Vehicle	32
ID16 New advances in AI-based electronic monitoring (EM) technologies for automatic, real-time catch data collection: the iObserver2.0	34
ID17 Bridging heterogeneous networks in challenging and disruptive maritime environments	36

ID18	Underwater Autonomous Event-Driven Profiler and Data Retrieval System	38
ID19	A novel and multi-purpose ASV for the Basque Coast: design, experimental testing, and main challenges	40
ID20	KOSTASystem, a multipurpose coastal videometry system	41
ID21	Arduino controlled valvometry equipment for mussel raft monitoring	43
ID22	Model type II regression for lagrangian validation of HF Radar velocities in the NW Iberian Peninsula.	45
ID23	A window to the sea: RAIA Observatory tool for assessing environmental risks in the NW Iberian coastal upwelling system.	47
ID24	Pathways of economically relevant demersal species in the Ibiza Channel from a Lagrangian backtracking approach	49
ID25	Calibrating the Movement of an Underwater Crawler Using Pulse Width Modulation (PWM)	51
ID26	Multisensor Acoustic Tracking Benthic Landers to Evaluate Connectivity of Fishes in Marine Protected Areas	53
ID27	Operational oceanography applied to the management of offshore aquaculture on the Basque coast (SE Bay of Biscay)	55
ID28	Uncrewed Surface Vehicles Network in support to EOOS: The EuroSea project	57
ID29	Enhancing Marine Ecosystem Monitoring through the Integration of Pop-up Buoys with Wireless Communication and Satellite Connectivity	59
ID30	THE CIM-UVIGO PLUG-IN HYBRID PROPULSION VESSEL FOR COASTAL OCEANOGRAPHIC RESEARCH: A TOOL FOR THE ECOLOGICAL TRANSITION	61
ID31	CIM-UVIGO mesocosms facilities: a realistic experimental approach for grand challenges in oceanography	62
ID32	An approach to the application of additive manufacturing for water environments: A case study to measure dissolved carbon dioxide	63
ID33	Long Baseline (LBL) Positioning System for the Crawler Tele-operated Underwater Vehicle in OBSEA Observatory	64
ID34	Automatic System for 3D Photogrammetry of Small Artificial Biotopes Using the Crawler Remote Operating Vehicle at OBSEA Observatory	66

ID35	Experiments on zebrafish using mini robot fish prototypes to identify stressors	67
ID36	Processing acoustic images for the exploitation of fish farms	69
ID37	Further Teleoperated Experiments with an Underwater Mobile Manipulator via Acoustic Modem: Modem Characterization	71
ID38	Towards sampling of the circalittoral benthos for monitoring impacts on marine communities: limitations and next steps.	73
ID39	LOW COST GREENHOUSE GAS SENSOR: GIDA-GEI	74
ID40	Towards Automatic Hole Detection of a Net for Fish Farms by means of Robotic Intelligence	76
ID41	A Data Management e-Infrastructure for the OBSEA Cabled Observatory	77
ID42	Low cost USV development to study spring ponds	79
ID43	On the development and application of intrusive sensors for two-phase flows characterization in complex environments	80
ID44	The BlueNetCat – The Catalan reference network for the knowledge transfer in Blue Economy	82
ID45	Marine Ecosystems Observation by a cooperative AUV in the PLOME project	84
ID46	Shared Autonomy for Mapping and Exploration of underwater environments using an HROV	85
AUTHOR'S DATABASE		87

IDO2 VALIDATING COMBINED NAVIGATIONAL SENSOR PACKAGES FOR SMALL VEHICLE PLATFORMS

RORY FINDLAY¹, CRISTOBAL MOLINA²

Abstract

Introduction of new sensor packages for marine autonomous applications is invariably a learning process for both the developer and the user. As the field of marine autonomy continues to accelerate into new technical realms, sensor manufacturers need to ensure that products are fit for contemporary and future applications. Technical capability is only part of the solution. The proliferation of advanced autonomous control and navigation is accompanied by a drive to provide such capabilities across a wider range of price and payload brackets – in other words, democratising autonomous control and navigation in addition to advancing it. In order to balance technical capability with commercial needs, Nortek have combined acoustic and inertial sensor capabilities in a compact navigation package designed exclusively to extend the capabilities of smaller vehicles.

Following two years of internal development and external collaborative testing, Nortek present use cases that demonstrate technical improvements resulting from an iterative process of user informed development. This presentation will focus on case studies covering multiple vehicle domains, and addresses the specific technical requirements associated with various vehicle applications. Use cases include: Fully autonomous navigation and combined oceanographic data collection from Micro-AUVs. Intelligent control and pilot aiding onboard inspection class ROVs. Simplifying underwater navigation for divers using a combined inertial and acoustic navigation package.

Keywords – ROV, AUV, ASV, Underwater navigation, DVL

IDO3 OPTIMIZATION OF A SMALL-SCALE, N-PENDULUM, WAVE ENERGY CONVERTER FOR DRIFTER APPLICATIONS BASED ON ORCAFLEX SIMULATION

REGINA FLIX³, MATIAS CARANDELL⁴ AND MONTSERRAT CARBONELL⁵

Keywords - Lagrangian Drifter, Energy Harvesting (EH), Wave Energy Converter (WEC), OrcaFlex, N-Pendulum, Parametric Pendulum

Abstract

Lagrangian Drifters are small oceanic instrumentation devices that provide oceanographic surface data for use in climate research, oil spill tracking and rescue operations. These autonomous passive floating devices are low-cost, versatile and easily deployable. Drifter deployments can last for years and cover large oceanic regions, so autonomy is one of the main challenges related to their design. To reduce maintenance costs for battery replacement, several energy harvesting (EH) sources are being explored such as the kinetic oscillatory movement of the waves [1]-[2].

Several studies report the parametric pendulum as a wave energy converter (WEC) system to harvest energy from the sea surface [3]. The main concept is that by exciting the pendulum's pivot point with the vertical oscillation of the waves ($z(t)$ in Fig. 1) and using the specific constructive parameters, complete rotations can be obtained (in Fig. 1). However, this is not possible for all the combinations of excitation parameters. To obtain parametric oscillation in a pendulum WEC resulting in complete rotations, at least a pendulum's natural frequency of twice the excitation fre-

quency is required. This leads to pendulum lengths of hundreds of meters, which is not realistic for drifter applications. To mitigate this issue, two solutions have been suggested. First, a N-pendulum is proposed in [4] which it can achieve low natural frequencies by adding multiple masses (m_i) distributed around an array of pendulum arms (l_i). This allows to keep the size of the device small. Second, the concept of reduced gravity is proposed in [5]. By tilting the vertical axis of the pendulum (α in Fig. 1), the effect of the gravity is reduced according to the inclination of the pendulum's axis.

The objective of this work was to optimize the WEC concept by using OrcaFlex dynamic simulations. An oceanic drifter as the one shown in Fig. 1 was modelled with an embedded N-pendulum with 4 arms placed on a plane tilted α from the vertical. By tuning α , the relative rotation θ between the drifter and the pendulum arm was optimized under wave excitation. Table 1 reports the drifter, pendulum and environmental parameters used for this work.

Fig. 2 shows the accumulated θ between the pendulum swing and the drifter in a 180 seconds simulation with a δt of 20 ms for different α inclinations. The accumulated θ gives an idea of how many turns the N-pendulum has made during the simulated period. The environmental conditions were maintained fixed for all simulations, where m_3 and l_3 differ from the other pendulum's lengths and masses.

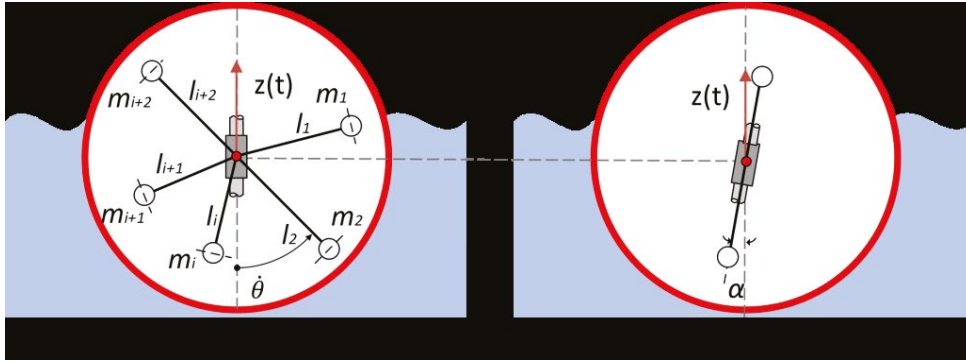


Fig. 1. N-pendulum Wave Energy Converter embedded on an oceanic drifter with the plane of the arms titled α from the vertical.

Environmental parameters		Drifter parameters		Pendulum parameters	
Depth	20 m	Diameter	0.2 m	m1,2,4	0.032 kg
Water density	1027 kg/m ³	Total mass	3.5 kg	m3	0.029 kg
Temperature	17°	Center of mass*	0.05 m	l1,2,4	0.02 m
Wave height	5.1 m	Horizontal inertia	0.0095 kg·m ²	l3	0.01 m
Wave period	10 s	Vertical inertia	0.0065 kg·m ²	α	Variable

Table 1. Environmental, Drifter and pendulum parameters used in OrcaFlex. *Distance taken from the center of the drifter.

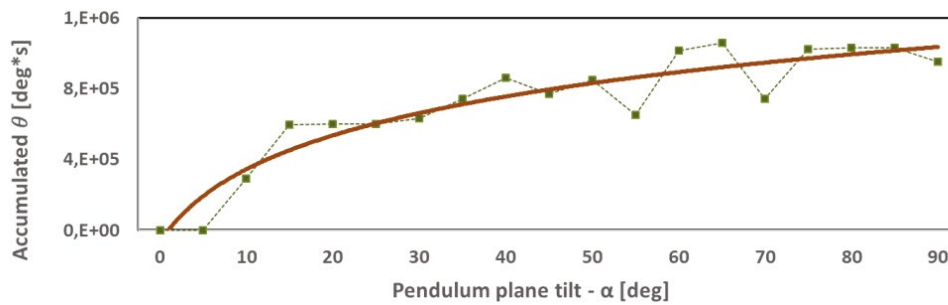


Fig. 2. Accumulated θ in a 180 seconds simulation for different α inclinations. The dashed green line represents the simulated data and the solid brown line is a logarithmic trendline.

Observing the results, an increase in α influences the rotation of the pendulum relative to the drifter positively. In fact, for small alphas (pendulum plane orientated vertically) no appreciable rotation is detected, and for large alphas (pendulum plane orientated horizontally), the rotation achieved during 180 seconds of simulation reaches 34 complete turns.

ACKNOWLEDGEMENT

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IDO4 TOWARDS HASH SIMILARITY AND GEOMETRIC-BASED IMAGE FILTERING TO LIGHTEN UNDERWATER PHOTO-MOSAICING

POL BAÑOS CASTELLÓ⁶, FRANCISCO BONIN-FONT⁷

ABSTRACT

This paper presents a novel strategy to filter out images that contain redundant information when building photomosaics from the sea bottom. The goal is to alleviate computational resources and processing time in their construction. The algorithm operates in a set of sequential steps, extracting images from video sequences following camera translation and rotation pre-defined constraints and removing redundant data using hash similarity and SIFT feature matching techniques.

Keywords – Photo-Mosaicing, Image Hash, SIFT features.

MOTIVATION, TECHNICAL BACKGROUND AND EXPERIMENTAL RESULTS.

The interest in exploring the sea bottom with advanced technology, such as, towed UWTV systems, ROVs or AUV equipped with cameras, combined with image post-processing techniques, has been growing in the last years since it permits to extend underwater observation missions in depth, space and time, without risks on humans. Photo-mosaics offer a unique, colored and detailed view of the recorded seabed area, as a single big spot, and they can be build either from just visual information [1] or combining it with the camera localization estimated by means of navigation instruments resident on the carrying vehicles [2]. However, a specific criteria to select the images for the mosaic that includes a trade off between complete informativeness of the whole recorded area with a minimum of redundant information remains still unformalized, leaving a wide open field for further improvements: a) How many images shall be added to the mosaic to cover the whole area minimizing the gaps, b) The acceptable percentage of overlap between images that view partially the same area, and c) How many overlapping images can be accepted to avoid areas with repeated views or unrealistic or distorted textures due to color blendings on zones where various images overlap. This paper presents a novel strategy to select images from a dataset that will be used to form a mosaic. The process has been designed to run on the ROS platform [3] because this is the middleware that has major impact on field robotics nowadays. The successive steps work and have been tested as follows: 1) Mosaics are build from images grabbed in situ by a moving platform, and stored in ROS bag files [3] that also contain the platform navigation data (global pose, velocity, altitude, depth, etc.); the platform needs to have a reliable self-localization module based on its navigation instruments to provide the camera pose and velocity, 2) consecutive images contained in the bag file are decimated by either 2 or 4 and stored in the hard disk together with their corresponding localization, at a maximum rate of 2.5 fps, considering a maximum overlap of 75%, and a minimum platform velocity, 3) besides, the image storage is also constricted to a minimum and a maximum altitude to guarantee that images grabbed during the platform immersion and emersion are rejected, and a minimum variation in yaw in consecutive frames to avoid including many images of the same position when the camera turns essentially in yaw with no traslation, 4) for each stored image, SIFT keypoints and descriptors [4] and the HALOC [5] im-

age hash are also computed and stored for further comparison and filtering, 5) each individual image, called from now on a query, is related with all images (from now on called candidates) already stored and that were grabbed inside a circular Region of Interest (ROI), centered in the query global pose and with a radius parametrized between 2.5 and 3 meters, 6) afterwards, a double layer filter is applied, namely, a first coarse one, to select candidates inside the ROI with a difference (L1-norm) between their hash and the hash of the query (so called hash similarity) lower than a certain threshold, and a second and fine, to keep only those pre-filtered candidates that match with the query a number of features (rejecting outliers with RANSAC) higher than another predefined threshold; filtering first by hash similarity permits to select candidates that potentially and most likely overlap with the query saving time and computer resources [5], while requiring a minimum robust feature matchings confirms solidly that the query and the finally selected candidates overlap (the greater the number of matchings, the higher should be the overlap), and, finally, 7) for each query, the algorithm discards for the mosaic all candidates that survived the second filter, that is, those that presumably view an area most in common with the query, and, in consequence, those that represent redundant information that can be omitted; since this process is applied continuously, while the bag file is running, discarded images are not taken again as possible candidates, been removed from the whole process. Finally, the mosaic is constructed placing the remaining images in the mosaic frame according to the camera global pose (in horizontal coordinates [x,y] with respect to the origin of the mission) converted from meters to pixels thanks to the known calibrated focal length and the vehicle navigation altitude observed at each frame timestamp. Thresholds have to be adjusted depending on the site, the texture of the sea bottom and a relation between overlap and number of matchings observed in each different type of environment. Test include, for a certain dataset, checking how many images are discarded changing the radius of the ROI, the hash similarity and the feature matching thresholds, evidence visually that the discarded Martech 2023. candidates have indeed an important overlap with the query, and verify the quality, coherency and reliability of the resulting mosaic. Some datasets used to assess the procedure are lawn-mower shaped surveys conducted in the south coast of Mallorca with an AUV model SPARUS II [6] equipped with an IMU, a DVL and a stereo rig, at depths between 9 and 15 meters, and tentative navigation altitudes between 3 and 4 meters, at constant lineal speed between 0.5 and 1 knots, mostly is areas where the sea bottom was densely colonized with sea grass. Table 1 shows some results of one mission: a relation of number of discarded images over the total number of images that would have been stored for the mosaic in case the double layer filter had not been applied, depending on the radius of the ROI, the hash similarity and the features matching mask. Ongoing work includes to verify the adequacy of the discarded frames and to generate sets of true and false positives and negatives that will be used to calculate the quality metrics of the process. Figure 1 shows the mosaic corresponding to combination 6 (left), which is not the one with more discards, but it turns out to be the most reliable in terms of minimum repeated structures and maximum similarity with the real environment. Figure 1 also shows two images that overlap (one discarded) nearly the 70%, with a hash similarity of 35.54 and 200 feature matchings.

Combination	Radius (m)	Hash similarity threshold	Feature matchings threshold	Total Nbr of images	Nbr of Discarded images
1	2.5	60	50	1265	664
2	2.5	60	60	1265	490
3	2.5	50	50	1265	543
4	2.5	50	60	1265	430
5	3	60	50	1265	709
6	3	60	60	1265	560
7	3	50	50	1265	622
8	3	50	60	1265	464

Tab 1. Discard metrics

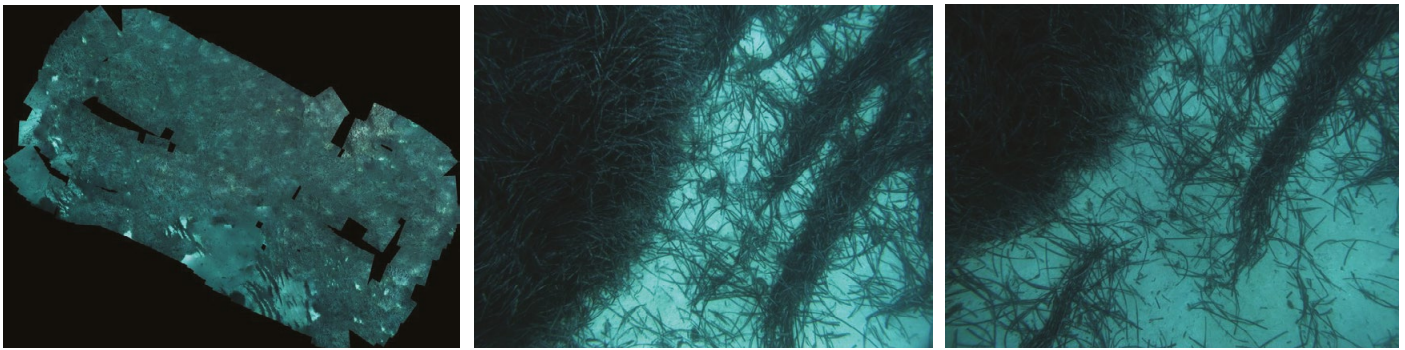


Fig 1. Best mosaic for the sample dataset and two images that overlap nearly a 70%

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IDO5 MESOPELAGIC CRUSTACEAN HABITAT IDENTIFICATION AND ANALYSIS USING DEEP LEARNING

ANTONI BURGUERA⁸, FRANCISCO BONIN-FONT⁷, DAMIANOS CHATZIEVANGELOU⁹

ABSTRACT

This paper presents a software infrastructure based on Deep Learning aimed at identifying habitats of certain species of crustacean that colonize areas of the marine Mesopelagic zone. Determining their presence is done, in this case, from the detection of holes in the sand that form sets of burrow structures. Preliminary inferencing models are obtained from images captured in the North Sea by trawled UWTV (underwater TV) stations, offering quite significant detection success ratios.

Keywords – Deep Learning, Species Identification, Image Processing.

The growing interest in capturing species that inhabit the Mesopelagic zone of the sea has forced accurate studies and analysis of their habitats and habits in order to design sustainable plans of exploitation that include adequate fishing gears [1] that do not destroy the entire environment and benthos, and, in parallel, efficient preservation actions for the species with highest commercial interest. *Nephrops norvegicus* is a crustacean very valued in the fish markets, and a trade off between the desire of stakeholders to satisfy the continuous demand and the protection of this particular species is mandatory. Nowadays, traditional studies of *Nephrops norvegicus* habitats and rhythms based on trawling [2] are highly invasive. Some alternatives include the video recording, day and night, from a grid of UWTV stations mounted on sledges towed by boats, and focus their estimations in counting for burrows, either manually [3] or with Deep Learning [4]. Burrows save individuals from the trawl tow capture, and, well identified, are a clear sign of a colony. The ongoing Spanish project PLOME [5] goes one step forward in the study of the *Nephrops norvegicus*, grabbing video sequences in situ with underwater vehicles, and applying CNN to automatically detect burrows and animals to estimate their density.

Object Detection (OD) is a computer vision technique aimed at identifying and locating objects in images. In the recent years, Deep Learning (DL) has shown outstanding capabilities to perform OD, clearly surpassing traditional methods. One of the most prominent DL-OD approaches is You Only Look Once (YOLO). The aim of this work is to advance in the automatic detection of *Nephrops norvegicus* burrows in the context of the PLOME project, experimentally evaluating the ability of YOLOv5 [6] to perform it in underwater imagery grabbed in marine environments densely

colonized with this species. This work focuses on YOLOv5, though other YOLO versions could be tested. Training DL-OD systems requires large amounts of labeled data. In general this can be problematic because data labeling is a tedious and time consuming task. When it comes to underwater imagery, specially in deep sea, the problem is magnified since the data itself is scarce and difficult to obtain. Data augmentation alleviates this problem but it can lead the DL-OD to overfit. Our novel proposal is to generate DL-OD training data in the form of image sub-samples extracted arbitrarily from photo-mosaics which were built from actual underwater images, instead of using the individual images to perform the YOLOv5 training. This approach has several advantages. On the one hand, it is less tedious and error prone for a human to tag a single large image rather than hundreds or thousands of smaller images. On the other hand, each object in the mosaic is labeled only once whereas, if the individual images are used, it has to be labeled at every single image where it appears. Our approach, thus, avoids inconsistent labels among images and generates more training data than the actual input images since viewpoints that did not exist in the images can be realistically extracted from the mosaic. This approach has also two main drawbacks. First, the mosaic has to be constructed and, second, some underwater artifacts, such as vignetting or changes in illumination, are removed by the mosaic building tools. Our proposal to solve this latter problem is to artificially add these artifacts when creating the labeled data. The fully documented source code of the proposed dataset generator is publicly available at <https://github.com/aburguera/MOSAICDATASET>.

EXPERIMENTAL RESULTS

A total of 1810 burrows were hand labeled in five different underwater mosaics of sizes ranging from 1900x39603 pixels to 1900x50615 pixels. The photo-mosaics were supplied by the Functioning and Vulnerability of Marine Resources research group of the ICM (Institut de Ciències del Mar-Barcelona) and images used to form them were originally grabbed from a UWTV system formed by sledges equipped with cameras, and towed at a constant speed from a vessel in the confluence of the Baltic and the Scandinavian north sea. All mosaics represent rectilinear transects approximately 20 meters long. Four of them have been used to build the train (4000 images) and validation (500 images) datasets using our proposal whilst the fifth mosaic was solely used to construct the test dataset (500 images). All the generated images have a resolution of 640x480 pixels and were grayscaled.

YOLOv5 MODEL	INF. TIME	mAP@0.5	mAP@0.5:0.95
YOLOv5s	11.571 ms	0.797	0.422
YOLOv5m	28.181 ms	0.755	0.401
YOLOv5l	51.253 ms	0.792	0.427

Tab 1. Quality metrics

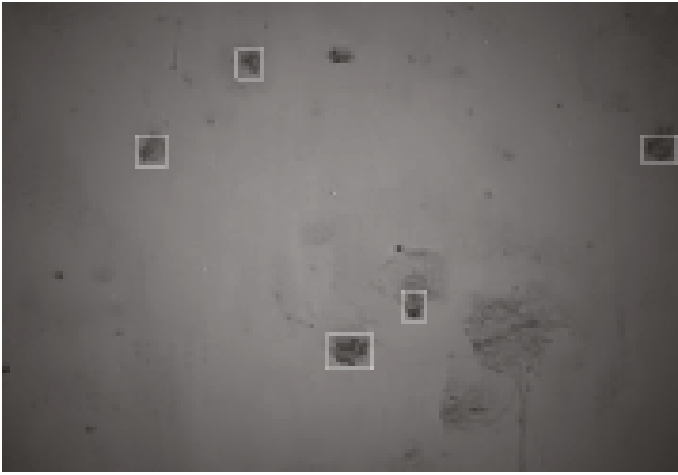


Fig 1. Image showing the inferred burrows.

Afterwards, small, medium and large YOLOv5 architectures (YOLOv5s, YOLOv5m and YOLOv5l) were trained with the train dataset fine tuning the hyper-parameters with the validation dataset. Then, the quality of each model was assessed on the test dataset. The evaluation was performed on a standard laptop computer (i7 CPU at 2.9 GHz) equipped with a NVIDIA GeForce GTX 1650 and using torch-1.11.0+cu113 over Ubuntu 20.03. Table 1 summarizes the results. Even though the larger the model the slower the inference, the resulting quality is almost identical, being close to a mean Average Precisions (mAP)@0.5 of 0.8 and a mAP@0.5:0.95 of 0.4 in all cases. Figure 1 shows a sample image where inferred burrows appear in squared bounding boxes.

Since results suggest no major differences in mAP between models, we decided to focus on YOLOv5s because it shows a reasonably stable detection rate of 86.423 fps. Figure 2 shows, in the left, the Recall-Precision curves for different level combinations of Intersection over Union (IoU) and Average Precisions (AP), and, on the right, the F1-Score changes depending on the IoU and the confidence score thresholds used. This allowed us to determine the optimal thresholds, which are 0.1 for the IoU and 0.5 for the confidence score. Using this optimal configuration we reached not only a precision close to 0.8 but also a recall of 0.74 and an F1-Score of 0.77.

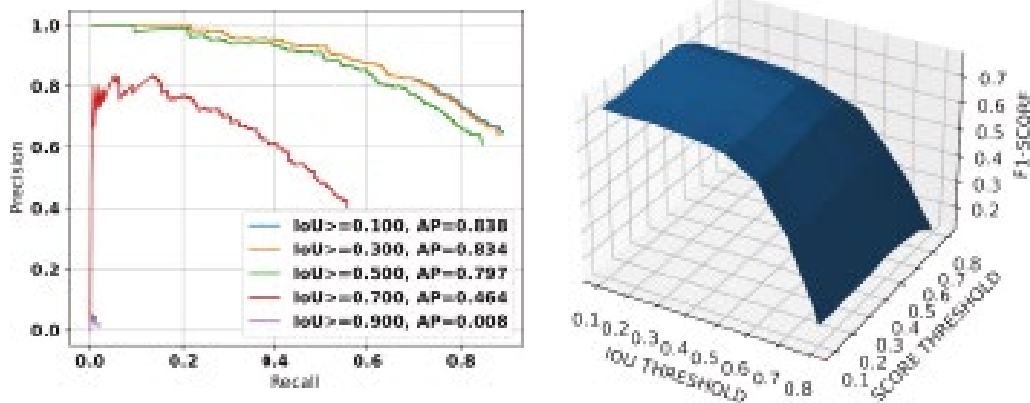


Fig 2. Recall-Precision (left) and F1-Score (right) curves for the trained YOLOv5s.

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IDO6 FUEL CONSUMPTION REDUCTION IN TUNA PURSE SEINERS USING OCEANOGRAPHIC DATA AND GENETIC ALGORITHMS

FERNANDO GONDA¹⁰, FELIPE GIL¹¹, CARLOS GROBA¹², DANIEL LOWE¹³, BEGOÑA VILA¹⁴

ABSTRACT

Between 30% and 75% of the total operational costs of tuna vessels are fuel-related [1]. Both these costs, with their effect on fish prices and food security [2], and the impact on climate change of the greenhouse gases emitted during the vessels' activity [3], make it necessary to find ways to increase fuel efficiency.

The European Union's Horizon 2020 SusTunTech project was born with the following goals in mind: to reduce the greenhouse gases emitted by the fishing vessels between 20% and 25%, to diminish the time they spend at sea and their fuel costs, and to increment their revenues and improve the economic and environmental sustainability of the tuna fishing industry, one of the most important in that sector. One way to reach these objectives is by providing skippers with an optimal fishing route planner which includes fuel oil consumption prediction. These routes are obtained combining different methodologies, such as machine learning, big data, artificial intelligence and –as outlined in this article– genetic algorithms, together with datasets collected from two tuna fishing vessels (by using sensors installed on them) and oceanographic data from Copernicus and EMODnet.

Keywords – Greenhouse gas emissions, Genetic Algorithms (GA), FOC (Fuel Oil Consumption) prediction, Oceanographic data, Optimal route

INTRODUCTION

Among other techniques, tuna vessels use the echo soundings received from the satellite buoys at sea to estimate where and how large the fish schools are. The order in which these constantly drifting buoys are visited depends on how close they are to the vessel and the size of the schools beneath them. Although there are exact algorithms that provide a solution to this travelling salesman optimization problem, the total number of possible routes increases exponentially with $N!$, being N the number of reachable buoys within the set duration.

A more computationally efficient way to determine the optimal route is using genetic algorithms (GA), which are evolutionary, show statistical convergence and tend to a global optimum with considerable robustness, making them the appropriate choice to obtain an optimal solution for this problem [4], in which the fuel consumption is the parameter to minimize.

METHODOLOGY

The steps followed to implement a typical GA are as follows (right-hand side of Fig. 1): They start with a set of randomly generated solutions called population. Each individual belonging to this population, called chromosome, represents a possible solution to the given problem. The algorithm attempts to find the best solution –or, at least, a very good approach– to the problem evolving the population through multiple generations by using mutation and crossover in the chromosomes. The fitness function is calculated for each population, which provides a value that determines how good the solution is for every chromosome until the stop criterium is reached (i.e., a fixed number of generations without improvement in the value returned by the fitness function).

In our specific case, we want to maximize the tons of fish underneath each buoy (ton) and minimize the fuel consumed (oil) to reach each of them along the route, which yields the following fitness function:

$$F(\text{ton}, \text{oil}) = \sum_{x=0}^f \frac{\text{ton}_x}{\sum_{y=0}^x \text{oil}_y} \quad (1)$$

To obtain the value of oil we need to consider both the speed over ground (SOG) the vessel is moving at and the most significant environmental factors –determined beforehand– affecting the vessel's performance

and fuel consumption. The analysed environmental data have been collected from Copernicus' Marine Environment Monitoring Service (CMEMS) [5] and NOAA's Global Forecast System (GFS) model [6]. The combination of these data and the real consumption data collected from onboard two tuna fishing vessels has made it possible, through machine learning methods, to determine both which environmental variables have a greater influence on the fuel oil consumption, and to create a model using this information and the vessel's speed to return a fuel oil consumption value.

The application of the obtained fuel oil consumption model in the GA follows this path: When one route is created by the algorithm, the first stage of the model, which is a Random Forest classifier, combines SOG with the relevant environmental variables at the times and positions along the route to obtain the speed through water (STW) values, while the second stage of the model, which is a polynomial model, returns the route's fuel oil consumption values from the STW values and the engine operating mode of the vessel. These values can be introduced in the fitness function to maximize the tons of captured fish while minimizing the fuel consumed. Fig. 1 shows the schematic of the integration of the fuel oil consumption model with the genetic algorithm.

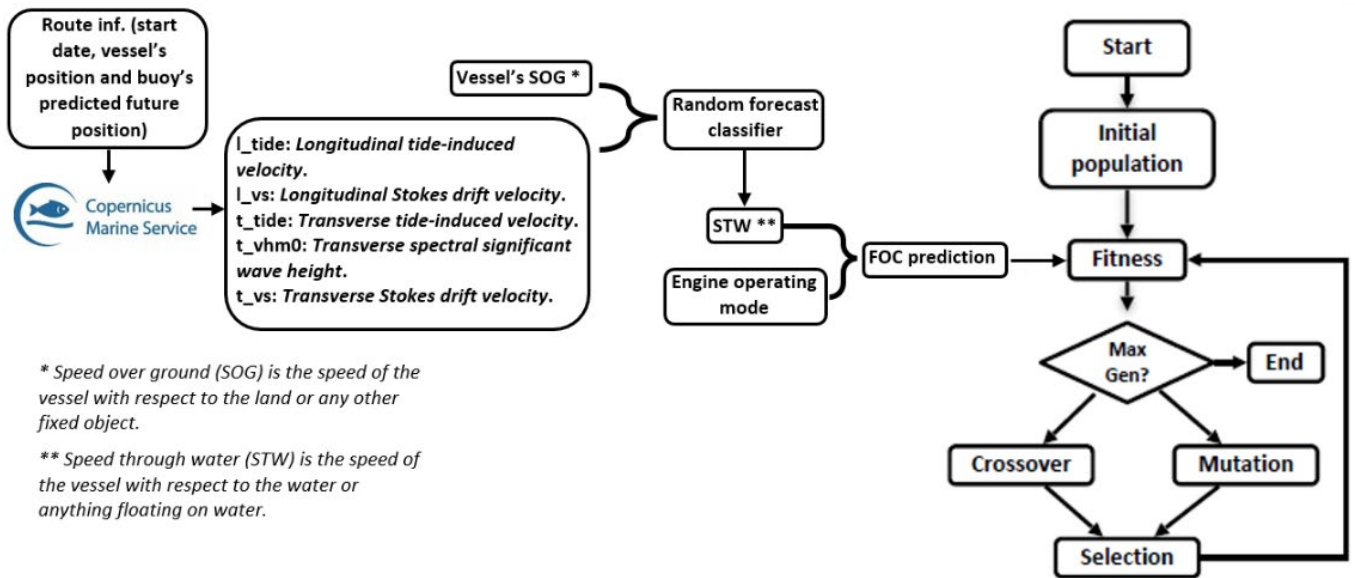


Fig. 1. Integration of the fuel consumption model with the genetic algorithm

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IDO7 MODULAR ACOUSTIC PLATFORM TO DEVELOP UNDERWATER BIDIRECTIONAL TAGS

G. BATET¹⁵, D. SARRIÀ¹⁶, M. NOGUERAS¹⁷, S. GOMARIZ¹⁸, J. DEL RIO¹⁹, I. MASMITJA²⁰

ABSTRACT

Miniaturised acoustic tags are key to conducting spatial behaviour studies on marine organisms (e.g., Norwegian Lobster). Nonetheless, the current technology has its limitations, specifically in acquiring high-resolution 3D movements. Engineering and developing new bidirectional acoustic tags will help improve the tracking and monitoring capabilities of the tagged species. To accomplish this milestone, a testbed needs to be established to validate and iterate over every tag's system. In this paper, the construction and capabilities of the first testbed's keystone tool are presented, and results from laboratory and field tests are discussed.

Keywords – Acoustic, Tags, Miniaturized, Tracking, Modularity.

INTRODUCTION

The development of a bidirectional acoustic tag implies a significant advancement in the field of fish and underwater species tracking and monitoring (e.g., Single base transceiver point range calculation), improving knowledge on the movements and spatial behaviours of these organisms, and thus helping better protect them from overfishing and another human-caused endangerment. This work aims to provide a highly modular and flexible platform to develop and implement new communication algorithms and protocols. Additionally, the platform has the capability to be connected and configured remotely, which allows us to connect it to the OBSEA underwater cabled observatory [1]. This study is a continuation of the first design and proof of concept presented previously [2].

THE PLATFORM

ELECTRONICS

This first encapsulated version consists of a basic functioning acoustic transmitter with reprogrammable firmware. This follows the process flow diagram shown in Fig.1, with three main blocks: (A) communications and power supply; (B) data processing and I/O; and (C) signal conditioning, amplification with a ceramic piezoelectric element tuned at 69 kHz.

COMMUNICATION PROTOCOL AND FUNCTIONING

For communications and power supply, a plug-and-play module has been designed based on the Lantronix Xport and a Direct Current (DC) power supply converter (DC to DC) isolated brick from TracoPower (model TEL 8-1210), switching the 9-18 V from the base station to the 3.3 V used in the tag's systems. A custom communication commands protocol over Ethernet has been implemented, this enables remote automation, control, and configuration with the LabVIEW application designed. Communication is divided into two phases. First, after powering on the system, the microcontroller expects, during 30 seconds, a go or no-go from the user to launch a tailor-made specific bootloader, for new firmware uploading. And if those 30 seconds have passed, the second phase starts with the routine program loading pre-set values and waits for a start command to begin a continuous 69 kHz emission. If necessary, the user can configure, via established commands, one of the other modes. The three modes available in the current firmware version are the following: (i) Continuous Emitting Mode at a given Frequency; (ii) Single Shot with a user-choice number of pulses (e.g., 50 pulses at 69 kHz with a 3/3 power level); and (iii) Pulse Position Modulation (PPM) with configurable pulses and stop time.

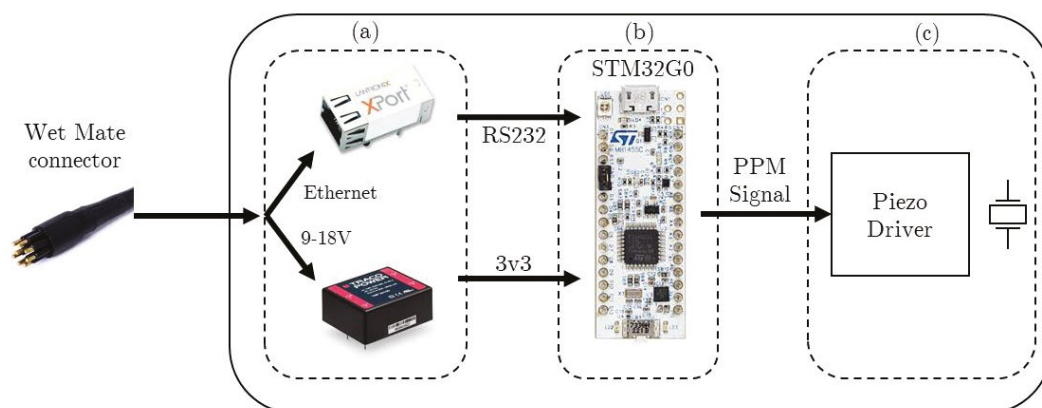


Fig.1. Systems' Process Flow Diagram. Three main blocks: A) Communication and Power, B) Microcontroller and C) Piezoelectric element and its driver

ASSEMBLY AND ENCAPSULATION

The board containing all three blocks has been assembled in a longitudinal stick form factor, this facilitates the encapsulating process. The electronics are connected to Subconn (McCartney Underwater Technology Group, Denmark) connector cable through a wire to an Ethernet connector (see Fig 2.). A rigid plastic material strip is added on both sides to reduce bending and torsion actions, an epoxy-based resin is poured in heat shrink tubing, serving as a mould and final outer mechanical protection. The piezoelectric element has its own encapsulation in a more rigid resin to enhance acoustic performance [3].

RESULTS

The tests done in the Laboratori d'Aplicacions Bioacústiques (LAB) research group pool facility from the Universitat Politècnica de Catalunya (UPC) revealed a transmitting power of 145 dB re 1 uPa at 3/3 power driver level. This test also validates the operability of having a bootloader to change the firmware. Field tests regarding range have been conducted in the OBSEA's region at 4 km off the Vilanova i la Geltrú coast. Up to 220 m the signal could be received by a commercial unit and 340 m with the installed Hydrophone

on the observatory at the seafloor (Fig. 2 Showing the last 255 m approximation to the hydrophone position).

CONCLUSIONS

This newly developed platform served as a baseline to test the first capabilities of the transmitting system composed of the piezoelectric and the driver, this is the first step in developing a major testbed system to test the designs and new systems to develop a bidirectional acoustic tag.

ACKNOWLEDGEMENTS

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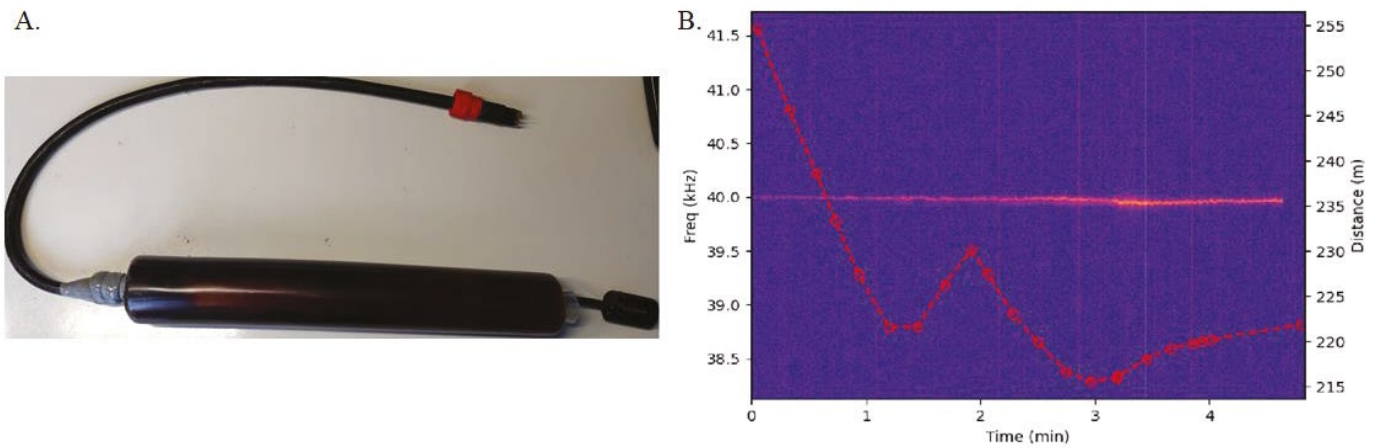


Fig 2. (A) The System fully encapsulated and (B) the first emitting test spectrogram with the varying range from the tag to the OBSEA's Hydrophone (Bjorge ASA NAXYS-Ethernet-02345)

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IDO8 BENTHOSearcher: A MACHINE LEARNING BASED TOOL TO ULTRA-FAST, AUTOMATIC CHARACTERIZATION OF VULNERABLE MARINE ECOSYSTEMS

VICENTE DOMÍNGUEZ-ARCA²¹, JUAN CARLOS OVALLE²², LUIS T. ANTELO²³

ABSTRACT

The degradation and impoverishment of the seabed that has been detected during last decades is the result of numerous variables, among which are uncontrolled exploitation of the seabed concerning its vulnerability, based on trawling gear. Intending to bring the situation under control, European fishing authorities have concluded a series of proposals to promote, define and defend Marine Vulnerable Ecosystems (VMEs), among which one of the most controversial and with the greatest social and economic impact is the veto of trawling in numerous fishing areas/grounds that currently are exploited by a large number of vessels from many countries of the EU, which see their livelihood in danger. In the process of proposing an alternative that is attractive to both parts, we propose an automatic, real-time tool (BentoSearcher) based on artificial intelligence so that trawlers will have the autonomy to decide whether or not to cast the net on the seabed in which the vessel is operating based on the data of benthic species detected in previous fishing hauls or trips that characterize and allow to identify vulnerable seabeds.

Keywords – Machine Learning, Vulnerable Marine Ecosystems, iObserver, Trawling Gear.

INTRODUCTION

From the point of view of ecology, there is no longer any doubt that there are several significant challenges that humanity currently faces, one of them being sustainable fishing to achieving development that safeguards food security, livelihoods, human dignity and natural resources. In recent years, different regulations have been implemented to solve the problem but not without facing numerous controversies. So, sustainability is a basic premise and a key pillar of the economic and social future of European fisheries, and the main objective of the Common Fisheries Policy (CFP) of the EU [1] that incorporated a ban of fish discards, i.e., the volume of unwanted captures returned to the sea for different reasons, by introducing the so-called Landing Obligation (Article 15 of the CFP). This states that all catches of regulated species (species under Total Allowable Catches - TAC, or Minimum Conservation Reference Size - MCRS) must be kept on-board, landed, and counted against quotas. From our scientific activity, we have designed, and implemented an automatic electronic monitoring (EM) system based on artificial intelligence and ultra-fast image detection to identify and quantify in real time total catches (retained + discards + by-catch) in the fishing park called iObserver [2]. It has shown good results on-board trawlers even in a problem as complex as the detection of fishing haul images in a trawler's fishing park, in which overlapping and wide species diversity are major challenges that have been faced.

In this work, we take advantage of the strategy and the concept followed by iObserver to develop an ultra-fast detection and identification tool for benthic species caught during trawling as a non-invasive monitoring tool to characterize VMEs called BentoSearcher. To this aim, we have created a strategy based on the iObserver hardware and a convolutional neural network that uses transfer learning. The developed U-Net is based on the success of this type of configuration in semantic image segmentation tasks [3]. The input to the convolutional network is an image. The output is a semantic segmentation of the input image, in which the masks attributed to each class to be identified can be located. Initially, a training of the neural network will be configured based on the selection, and manual segmentation, of images of characteristic species of vulnerable seabeds that are obtained from the set of iObserver images obtained during a research campaign (Flemish Cap 2022) carried out in collaboration with the Spanish Institute of Oceanography (IEO) in the NAFO fishing ground - Division 3M in July and August 2022. To help in the validation stage, the detection performance has been tested in artificial images built as a mosaic with original iObserver images. Finally, the detection capacity of 12 species has been verified, including 8 vulnerable benthic species and 4 actinia species characteristic of vulnerable seabeds.

METHODOLOGY AND RESULTS

As a starting point, 12 target species have been selected, among which are 8 that are classified as vulnerable due to their slow growth or low reproductive capacity, and another 4 among which are several actinia species characteristic of vulnerable seabeds:

Group 1: *Stauropathes arctica*; *Flabellum alabastrum*; *Anthoptilum grandiflorum*; *Funiculin quadrangularis*; *Halipteris finmarchica*; *Heteropolypus* sp.; *Polymastia* sp.; *Histodermella* sp.

Group 2: *Ceramaster granularis*; *Hippasteria phrygiana*; *Stephanauge nexilis*; *Didemnidae*

Once the images of interest for training were selected, first filtering was done using a Python routine to clarify the images. This task facilitates the manual segmentation that is accomplished by using LabelMe. This segmentation is based on the elaboration, using polygons, of a mask for each species detected in a selected image. Thus, each species has a mask colour associated with it. The images, and their respective masks, are subjected to an image augmentation process using the Python *Imgaug* library. Finally, 1,995 images and their corresponding masks for the 12 target species are set.

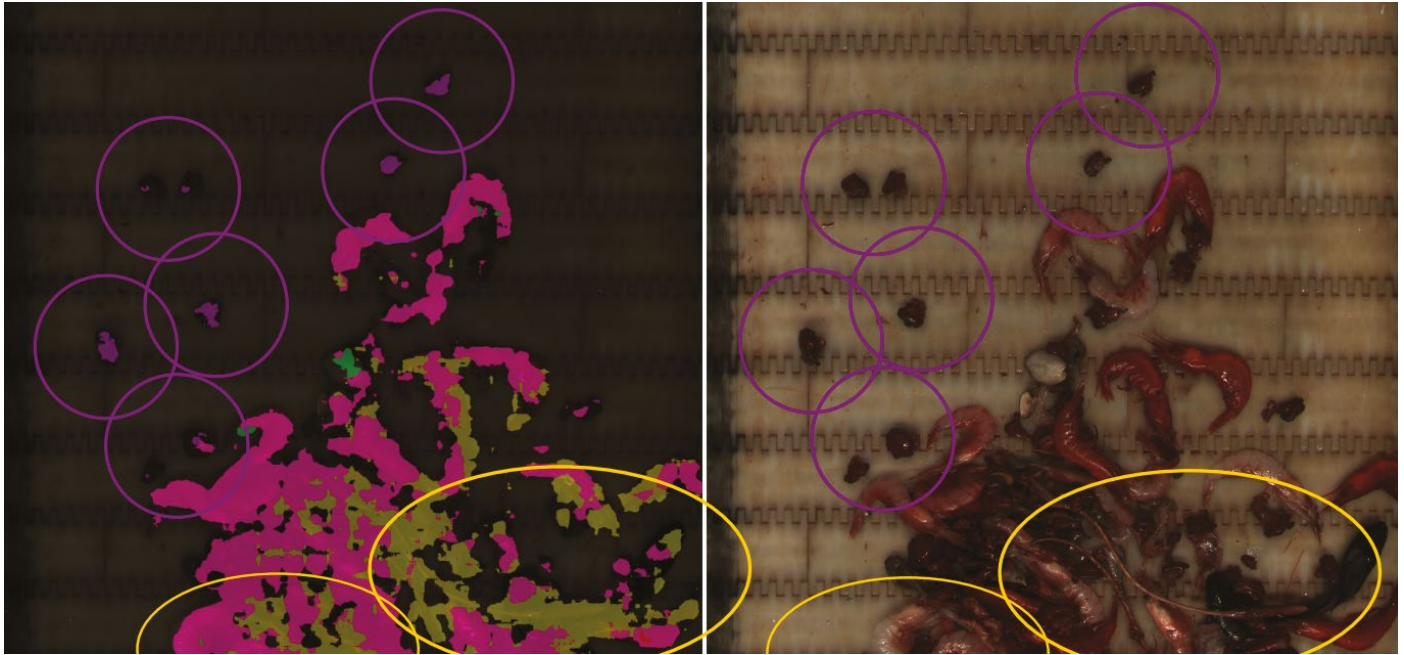


Fig 1. Real application of the BentoSearcher trained for 300 epochs to an image of high heterogeneity in species present. Anthoptilum (yellow) and heteropolypus (purple) masks have been successfully detected. The magenta mask segments all species listed in others.

The generated set of images and masks were used for training a U-Net. The configuration of the U-Net is based on the use of MobileNetV2 for the encoding part and a set of concatenation layers in the decoding part. The training was carried out for 300 epochs using 64 cores of 2 NVIDIA a-100 GPUs provided by Galician Supercomputing Centre (CESGA). The test of the predictive capacity for the semantic segmentation of images has been put to the test with different original campaign images in Flemish Cap. Figure 1 presents the masks generated by the trained neural network of an image with high heterogeneity in species. We visually identified with the presented first version of the BentoSearcher the two target species, anthoptilum (yellow) and heteropolypus (purple) present in the haul image taken by the iObserver. The pink masks would belong to the “others” group, including everything that is not a target species.

CONCLUSIONS

An automatic, real-time artificial intelligence-based tool called BentoSearcher for the ultra-fast monitoring and detection of characteristic species of vulnerable seabeds and VMEs has been presented. The trained neural network has shown high efficiency in detecting species, even in highly heterogeneous images. The system should be subjected to more intensive training regarding the species in the “others” group. In the same way, it is necessary to establish a correlation between the number of pixels detected for each species and a threshold value from which the seabed on which work is being done must be characterized as vulnerable.

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IDO9 CONSUMPTION EVALUATION OF A RELAXATION OSCILLATOR AS A CONTROL SAMPLING CIRCUIT FOR FAST-TRACKING FOCV-MPPT CIRCUITS IN WAVE ENERGY CONVERTERS

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ABSTRACT

Energy harvesting (EH) sources require a power management unit (PMU) with maximum power point tracking (MPPT) functionalities to maximize the energy generation. One simple MPPT approach, widely used in low-power EH applications and thoroughly explained in [1], is the fractional open circuit voltage (FOCV) method. In this method, maximum energy is harvested by fixing the output voltage of the EH source to the maximum power point (MPP) voltage (V_{MPP}), which is a percentage of its open circuit voltage (V_{OC}). Typically, V_{OC} is periodically measured (at a sampling period of T_{MPPT}) by momentarily disconnecting the EH source from the PMU during a sampling time (t_{SAMP}) and storing the V_{OC} corresponding to the new environmental conditions. Some sources, such as wave energy converters (WEC), require fast tracking of the MPP because

V_{OC} shows relatively rapid variations. For example, [2] presents a WEC with V_{OC} oscillating at around 1.8 Hz, which is fast-varying compared to other types of EH sources, e.g. solar and thermal. However, commercial PMUs fail to provide these fast-tracking methods.

In [3] we designed a custom, fast-tracking FOCV-MPPT circuit, and demonstrated that by sampling 15 times higher than the EH source's frequency (f_{EH}), 99% of the maximum energy can be harvested. The circuit was based on a commercial MPPT, the ADP5092 IC, with additional low-power circuitry to greatly reduce t_{SAMP} and T_{MPPT} . Later, in [4] we presented a low-power relaxation oscillator (RO) that generates the pulse signal (V_{PULSE}) to control the sampling process of V_{OC} . Fig. 1 shows the RO circuit with a qualitative representation of V_{PULSE} .

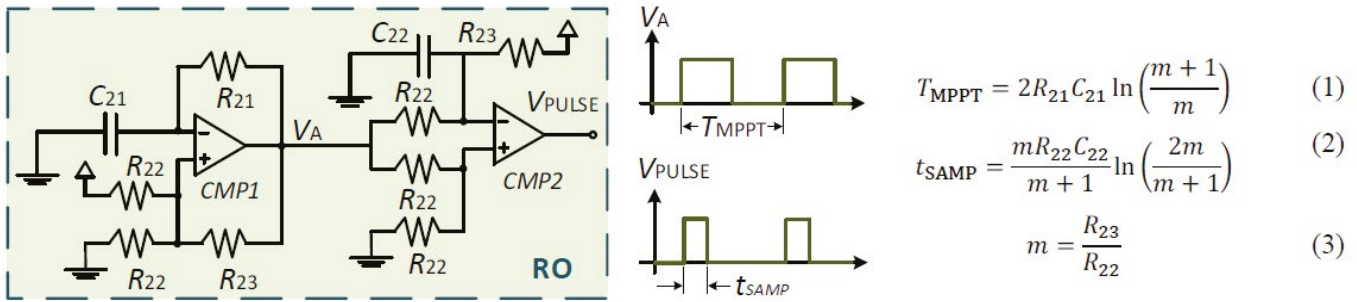


Fig. 1. Relaxation oscillator (RO) for the generation of V_{PULSE} .

The power consumption of the RO must be lower than the power gain achieved by speeding up the sampling rate ($f_{MPPT} = 1/T_{MPPT}$) of the MPPT. Therefore, the power consumption of the RO was assessed with the following values; $R_{22} = 1 \text{ M}\Omega$, $R_{23} = 5 \text{ M}\Omega$, $C_{21} = 33 \text{ nF}$ and $C_{22} = 1.2 \text{ nF}$. The two comparators (CMP1 and CMP2) were implemented with the MCP6542 IC. Six different values for R_{21} were used to evaluate its consumption at different sampling conditions, as a change in this resistor modify T_{MPPT} according to the equations (1) - (3) presented in [4]. Resulting nominal values of T_{MPPT} and f_{MPPT} are reported in Table 1, with t_{SAMP} fixed to 0.5 ms according to (2). A 10 k Ω shunt resistor of 0.1% tolerance was used to measure the current consumption of the RO circuit, which was supplied at 3.8 V.

R_{21}	1	2	5.1	10	14.8	29.8
$T_{MPPT} [\text{ms}]$	12.0	24.1	61.4	120.3	178.1	358.6
$f_{MPPT} [\text{Hz}]$	83.3	41.5	16.3	8.3	5.6	2.8

Table 1. Nominal values for R_{21} , T_{MPPT} and f_{MPPT} on the consumption test of the sampling circuitry.

Fig. 2 (top) shows the current consumption profile of the RO at $T_{MPPT} = 61.4 \text{ ms}$ ($R_{21} = 5.1 \text{ M}\Omega$) with an average value of 4.31 μA (16.3 μW). As can be seen, there are three different levels. When V_A is high and V_{PULSE} is low, current consumption is around 5 μA . When both V_A and V_{PULSE} are low, it is around 3 μA . Finally, a 10 μA current peak is found when V_A and V_{PULSE} are high, corresponding to the sampling time of V_{OC} (t_{SAMP}). By increasing f_{MPPT} , T_{MPPT} decreases whereas t_{SAMP} is kept fix. This leads to a percentual time increase of the current peaks and thus to an increase of the average current consumption. This is shown in Fig. 2 (bottom), where the average power consumption is represented as a function of f_{MPPT} . As can be seen, power consumption linearly increases with f_{MPPT} varying from 15 to 20 μW .

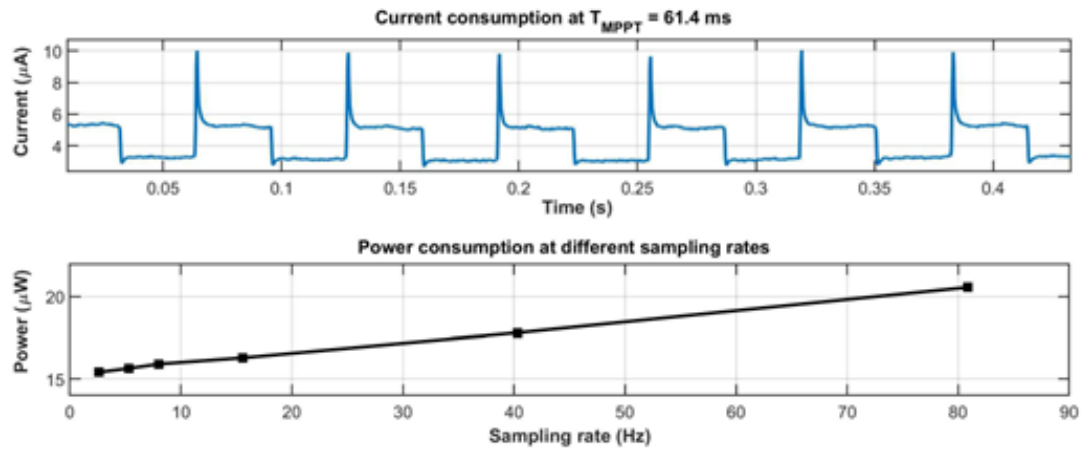


Fig. 2. Consumption of the RO. Top: current consumption at $T_{MPPT} = 61.4$ ms. Bottom, average power consumption at different sampling rates.

Results in [3] show a small-size WEC excited in a linear-shaker and report that a fast-sampling circuit ($f_{MPPT} = 60$ Hz) provided a useful power of 7.68 mW whereas a low-sampling circuit ($T_{MPPT} = 16$ s) just 6.1 mW; thus, a power gain of 1.57 mW was achieved. The same WEC was deployed at the sea in [4]. In that case, the

fast sampling-circuit ($f_{MPPT} = 21$ Hz), which included the power waste of the RO, provided 218 μW whereas the low-sampling circuit just 80 μW . Given the consumption of the RO at the tested sampling rates is below 20 μW , its use is worthwhile.

ACKNOWLEDGEMENT

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ID10 TUNING STRUCTURAL CONTROL DEVICES WITH GENETIC ALGORITHMS FOR A FLOATING WIND TURBINE

ALEJANDRO RAMÍREZ-QUESADA²⁸, MATILDE SANTOS²⁹, MARÍA TOMÁS-RODRÍGUEZ³⁰

ABSTRACT

Floating offshore wind turbines present several advantages over land-based and bottom-fixed offshore wind turbines, but they are also exposed to strong environmental loads, especially wind and waves, which generate vibrations in the structure and compromise their efficiency and useful life. In this paper, a simplified theoretical model of a barge-type 5MW floating offshore wind turbine is developed and validated with reference software FAST, and used to study the effects of structural control. A tuned mass damper (TMD) is tuned using genetic algorithms for free decay different pitch angles of the platform, which could simulate different heights of waves impacting the turbine, with the goal of reducing the fore-aft tower top displacement. The proposed structural control improves the dynamic response of the system, with a vibration suppression rate of 34.9%.

Keywords - floating offshore wind turbine, structural control, tuned mass damper, genetic algorithms, suppression rate

INTRODUCTION

Although with some clear advantages over onshore and bottom-fixed offshore wind turbines (WT), floating offshore wind turbines still pose significant challenges from the control and stability point of view [1]. Nevertheless, they are subjected to undesirable vibrations caused by strong wind, waves, and tidal loads, and these vibrations must be minimized to increase efficiency and useful life [2, 3].

In this paper, the authors work with a wind turbine model simulated in both, FAST and Matlab/Simulink software, specifically the NREL 5MW WT (three blades, rotor diameter of 12 m and a nacelle height of 90 m) [4]. The floating foundation is the ITI Energy Barge (40 m x 40 m x 10 m and eight mooring lines). The structural control that is applied to the turbine is a TMD (Tuned Mass Damper), installed in the nacelle. This system absorbs energy from the tower's pitch rotation, reducing vibrations and the displacement of the WT tower top [5, 6]. TMD devices have been proved efficient in reducing the vibrations if the parameters of the TMD are tuned properly, which may be a tedious and difficult task [7]. Because of that, heuristic techniques, including evolutive algorithms, have been used [8,9].

WIND TURBINE MODEL AND VALIDATION

In this work, a simplified model of a FOWT is used, with the degrees of freedom limited to the pitching motion plane of the tower in the

downwind (fore-aft) direction. It consists of a system of masses that represent the platform, the tower and the tuned mass damper. It does not consider any other structural components such as blades or mooring lines. With this model, three equations of motions are used, each of them corresponding to one of the three degrees of freedom. All equations are linearized for small angles. From the characteristic equations of the theoretical model, a state space model is built. The spring, damping, and inertia constants can be identified by comparing the outputs of the state space model with the outputs of the high-fidelity FAST model using identical inputs. This process is carried out by means of identification algorithms, the results of which may vary depending on the algorithm, the initial conditions and the simulation time [10].

In this work, the parameters of the model have been identified by the Levenberg-Marquardt algorithm, with different initial inclination of the platform. That is, the different platform pitch angles that are set for the free decay simulation experiments represent the different heights of the waves. The rest of the parameters are known and have been taken from [11]. The model has been identified without TMD. For the validation of the theoretical model, the results obtained by FAST and the previously identified simplified model are compared for a simulation of 100 s, with an initial platform pitch of 5° and including the TMD, with a mass of 20000 kg, damping coefficient 9000 Ns/m and a spring stiffness of 5000 N/m. TMD configuration is the one used by [12]. The mean of the absolute error of the displacement of the tower top (TTDspFA) is 0.042, being considered acceptable.

TMD TUNED BY GENETIC ALGORITHMS AND RESULTS

Genetic algorithms are applied to optimize the stiffness and damping constant of the TMD. To compare the results obtained with previous works, the size of the mass has been set to 20,000 kg [12]. The fitness function is the Fore-Aft Tower Top Displacement, σ TTDFA. Simulations of 100 s have been carried out, starting from a platform pitch of 5° and a null displacement, both of the tower top and of the TMD mass. The genetic algorithm has been configured using an initial population of 75 individuals with two chromosomes (spring constant kTMD and damping coefficient dTMD), with a crossover probability of 0.05*Population, and a mutation probability of 0.01. The generations stop when the average change of the value of the cost function is less than 10⁻⁶ during 15 generations.

The kTMD and dTMD values obtained as a result of the optimization are 4868 N/m and 2419 Ns/m, respectively. The responses of the system with the optimized TMD, without TMD and with the reference TMD [12] are compared. The tower top displacement standard deviation (σ TTDFA) value is reduced from 0.487 without TMD to 0.317 with the optimized parameters, that is, 35% reduction. The vibrations suppression rate is 28.6% respect to the reference TMD and 34.9% with the optimized TMD (Fig. 1).

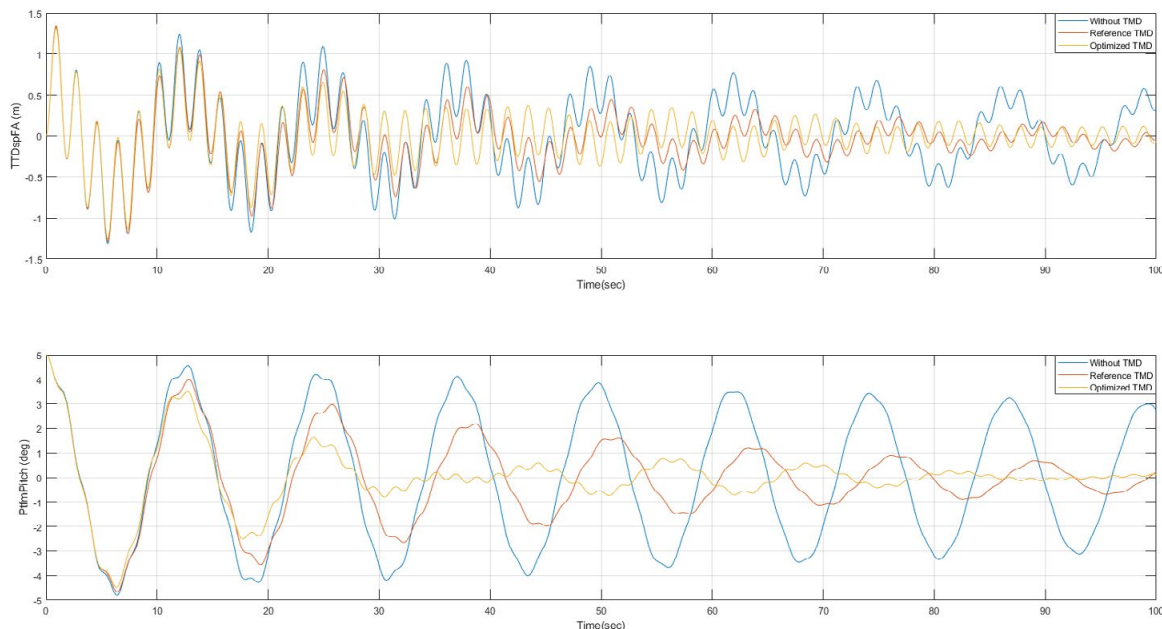


Fig 1. Example of the response of the WT without TMD and with the reference TMD y optimized TMD (platform pitch = 5°). Upper graph: fore-aft tower top displacement; bottom graph: platform pitch angle

CONCLUSIONS AND FUTURE WORKS

The application of a TMD located in the nacelle of a floating wind turbine has a decisive effect in mitigating the vibrations of the tower. The optimal parameters of the TMD must be obtained for different angles of the platform pitch so as to improve the stability of the structure for different initial conditions of this angle, which can simulate different wave heights. This control presents improvements in vibration attenuation compared to other TMDs tuned for fixed initial conditions. The results obtained invite us to study the application of a semi-active control according to the

amplitude of the vibrations and consider the non-linearities of the TMD [13] to incorporate external forces, such as the action of waves.

ACKNOWLEDGEMENTS

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ID11 FREQUENCIES IDENTIFICATION OF NREL 5MW ITI BARGE WIND TURBINE: FIRST APPROACH

MIKEL SERRANO ANTOÑANZAS³¹, JESÚS ENRIQUE SIERRA-GARCIA³² AND MATILDE SANTOS³³

ABSTRACT

In this work we present a process to identify the main frequencies that affects a floating offshore wind turbine (FOWT), specifically, the NREL 5MW ITI Barge Wind Turbine. This floating platform is highly affected by surge and sway translational movements due to the strong winds and mainly the waver it is subjected to. However, one of the most important modes is the 1st tower fore-aft bending mode, whose frequency has the same value than the forced 3P component, provoking these frequencies to be highly excited. In this work this effect is observed in the power spectrum of the tower top acceleration signal along the nacelle "x" axis.

Keywords - floating wind turbine, barge, frequency identification, surge, sway, 3P, 1st tower fore-aft bending mode, FFT.

WIND TURBINE VIBRATION MODES IDENTIFICATION

Besides reducing carbon print, meeting the increasing demand of renewable energies, mainly wind based, requires their installation in more challenging and harsh environments [1]. However, as these new and larger wind turbines are installed offshore in deep water, the strong winds, waves and currents they are subjected to may cause significant damage to the entire structural system [2, 3].

Considering the fact of time-varying process of offshore structures, it is often necessary to understand the variation of frequencies with time by employing time-frequency analysis methods, which can describe the frequency energy intensity of a signal at different times [4]. The well-known Fast Fourier Transform (FFT) can be used to analyse the power spectrum of the time window.

In the case of a Spar-Buoy Floating Wind Turbine, there are two main modes, the Platform Pitch and 1st Tower Fore-Aft FA bending [5]. In this paper, the authors check how modes are modified by enabling and disabling different degrees of freedom (DOF). In [6], load evaluation was performed according to time series and FFT results. The main findings of this study related to the problem here addressed are: first, in the correlation analysis, the tower-top deflection had the highest correlation, and this further affects nacelle acceleration. Second, the tower-base pitch moment increased with the significant wave height. In [7], the effect of load (wave, wind and dynamic bending moment) on the first natural frequency is investigated using different analysis techniques in the frequency domain and time domain for a monopile offshore wind turbine. A clear correlation between load level and first natural frequency is demonstrated.

However, in this paper frequency modification is not the target of the analysis, but the gain variation based on the deactivation, one by one, of a specific DOF in simulation. This way, a DOF is deactivated each time and then the FFT of the tower top acceleration signal along "x" and "y" nacelle axes are checked to see which peak has been damped. This process is repeated for each of the following DOF:

FlapDOF1, FlapDOF2, EdgeDOF, DrTrDOF, GenDOF, YawDOF, TwFADOF1, TwFADOF2, TwSSDOF1, TwSSDOF2, PtfmSgDOF, PtfmSwDOF, PtfmHvDOF, PtfmRDOF, PtfmPDOF and PtfmYDOF.

To do so, different test with a 5MW NREL Floating ITI Barge Wind Turbine [8] were carried out using OpenFAST, an aero-hydro-sero-elastic fully coupled analysis tool, with Matlab/Simulink software. All DOFs were considered in the simulations, except the one deactivated in each simulation, including the blades, tower, and platform, together.

The environment conditions to identify the main frequencies are:

- Wind speed: 13m/s. This ensure that the turbine is operating at rated power and generator speed.
- Wind turbulence: Steady, no turbulence. This allows the frequencies to be shown with no wind perturbations.
- Wave mode: none, still water. This allows the frequencies to be shown with no wave perturbations.

The OpenFAST variables analysed are:

- YawBrTAXp [m/s²]: Tower-top / yaw bearing fore-aft (translational) acceleration (absolute). Directed along the xp-axis.
- YawBrTAYp [m/s²]: Tower-top / yaw bearing side-to-side (translational) acceleration (absolute). Directed along the yp-axis.

Fig 1 represents the simulations results obtained and shows different frequencies that affect the nacelle acceleration. The FFT has been obtained from a simulation of 4500 s to ensure a good resolution. First 1500 s has been discarded to allow the platform to be stabilized from the initialization. Resolution used is 27307 points.

As a summary, the main natural identified modes are the following:

- Platform horizontal surge translation (PtfmSgDOF): 0.0097 Hz.
- Platform horizontal sway translation (PtfmSwDOF): 0.085 Hz.
- First fore-aft tower bending-mode (TwFADOF1): between 0.55 and 0.6 Hz.
- First side-to-side tower bending-mode (TwSSDOF1): 0.6 Hz.
- First edgewise blade mode (EdgeDOF): 1.28 Hz.
- Second fore-aft tower bending-mode (TwFADOF2): 3 Hz.
- Second side-to-side tower bending-mode (TwSSDOF2): 3 Hz.

Nonetheless, it is important to highlight the effect of the forced 3P frequency, which coincides with the 1st tower fore-aft mode at 0.6 Hz, very different from non-floating turbines [9, 10]. This is a forced frequency due to the wind shear effect, which causes that the higher the height, the higher the wind speed. Therefore, the blade in the top is receiving more wind than the others and the thrust is higher for this blade, pushing back the nacelle. This phenomenon happens every time that one blade is at the top. Tower shadow also affects this mode.

The 3P frequency value is calculated in equation (1), where rated rotor speed is 12.1 rpm and there are three blades. Therefore, at rated operation point 3P frequency is 0.605 Hz. It is possible to see how this value matches the results shown in Fig. 1.

$$3P [Hz] = n^{\circ} \text{ of blades} \cdot \frac{\text{RotorSpeed_Rated [rpm]}}{60 [s/min]} \quad (1)$$

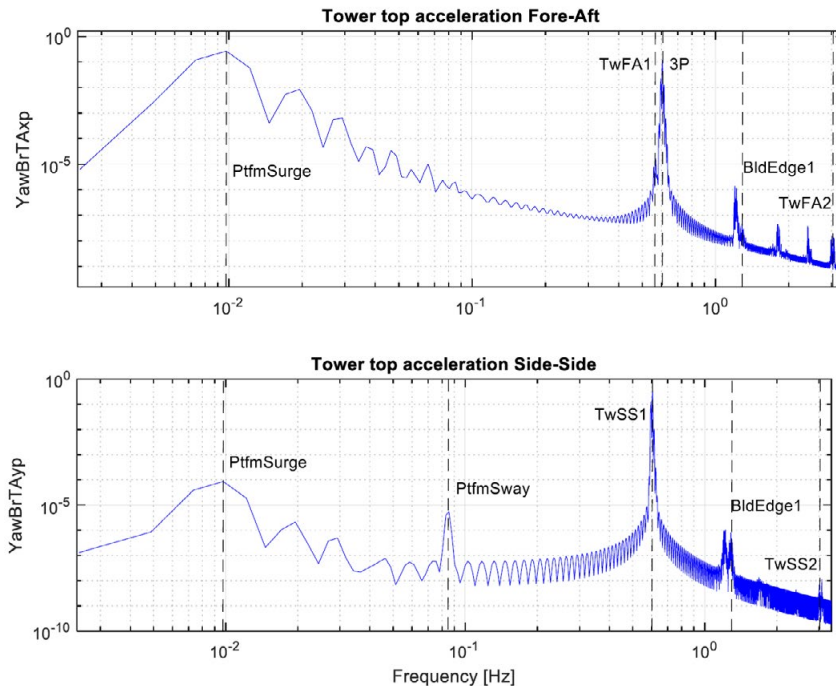


Fig 1. Wind Turbine Vibration Modes in tower top fore-aft and side-side direction.

CONCLUSIONS AND FUTURE WORKS

Floating ITI Barge wind turbine is mainly affected by platform translation movements, such as surge along “x” axis and sway along “y” axis, as well as the 1st tower fore-aft and side-side bending modes. Moreover, 3P forced component at rated generator speed has the same value than 1st tower modes. This coincidence should be avoided by all means because it generates a high frequency peak visible in Fig 1, which will be then transferred to tower base loads, reducing the useful life of the turbine.

As further works, tower stiffness could be modified to move tower modes. Another possibility is to change gear box ratio, keeping the same rated generator speed, so that rotor speed can be different and hence 3P value does not match with 1st tower modes.

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ID13 THE VIDEO-BASED EGIM DEVELOPMENT

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Keywords – *Rhythmic behaviour, environmental cycles, cabled seafloor observatories, climate change, biodiversity indicators, environmental drivers, fish community.*

ABSTRACT

The use of technology as a low-impacting monitoring method is becoming widespread across the oceans. Furthermore, the declared United Nation (UN) Decade of Ocean Science for Sustainable Development highlighted the importance of the technological development for the protection and sustainable use of marine resources. In particular, the use of seafloor cabled observatories in an integrated way, with a multitude of sensors and cameras, will be fundamental in the future management decisions of marine resources. Cameras in such infrastructures could be used as biological sensors extracting meaningful information on number of individuals per marine species. In this context, the Observatory of the Sea (OBSEA, www.obsea.es) [1] was deployed in 2009 at 4 km off the Vilanova i la Geltrú harbour (Barcelona, Spain), at a depth of 20 m. The OBSEA seafloor platform is a testing site of the European Multidisciplinary Seafloor and water column Observatory (EMSO, www.emso.eu) [2] where an EMSO Generic Instrument Module (EGIM) was tested, as multi-sensor probe, from 1st December of 2016 to 31st March 2017 (Fig. 1). This new instrumentation hosted a Seabird SBE37 CTD to measure Salinity (PSU), Temperature (°C), and Water Depth (m) (calculated in shifts of water pressure), and an AADI DW4831 Oxygen Optode to measure Dissolved Oxygen ($\mu\text{mol/l}$). This new set of sensors expanded the previous payload of the OBSEA adding information on the concentration of oxygen in the water, as important Essential Oceanic Variable (EOV) to determine the environmental status. In addition, relevant information on the local fish community was captured by two time-lapse cameras, located about 5 m apart from each other and equipped with artificial lights for night photos, focussing the EGIM structure. Each photo captured from the two cameras was manually ana-

lyzed by trained operators (e.g.; [3]) and had a time-stamp code to match each detected faunal entry to the concomitant acquired environmental data. The visual census by cameras was performed in a high-frequency (one photo each 30 min.) and continuous (i.e.; day and night) fashion, giving information on count fluctuations of 17 bony fish taxa. With this test we aim to present the results obtained from a new set of sensors at the OBSEA with future perspectives to improve the ecological monitoring with cabled seafloor observatories. The concomitant acquisition of environmental and relevant biological data allowed us to obtain information on changes in species composition (i.e. richness) and relative species abundance (i.e. evenness), as well as ecosystem functioning (e.g. food-web structure, carbon and energy fluxes etc.), and possible cause-and-effects principles between environmental and biological variables. The results from waveform analysis showed a general diurnal behaviour of the different fish species (Figure 2), with only *Apogon* sp. genus and *Sciaena umbra* detected as nocturnal species, and *Scorpaena* sp. genus and unclassified fishes as nocturnal/crepuscular species. The difficulty to classify fish species with artificial lights could have determined the nocturnal/crepuscular detected rhythm of the unclassified fish category. Nevertheless, the same analysis pointed out the cyclic pattern of the environmental variables with little variations in salinity and depth, and right shifts from the photoperiod for temperature and dissolved oxygen concentration (Fig. 2). The peaks in fluctuations of the fish counts and the environmental variables were determined with the Midline Estimated Statistic of Rhythm (MESOR) method by re-averaging all the mean values of each 30 min. of the day. These results highlighted that the fish species which do not follow the general behavioral pattern in relation to the photoperiod, likewise do not follow the general environmental ranges. However, longer experiments with the same instrumental setting covering the whole seasonal cycle are required to have more reliable data. Furthermore, additional environmental sensors for new EOVs, such as chlorophyll concentration, could add information on the ecological niche of the detected fish species.

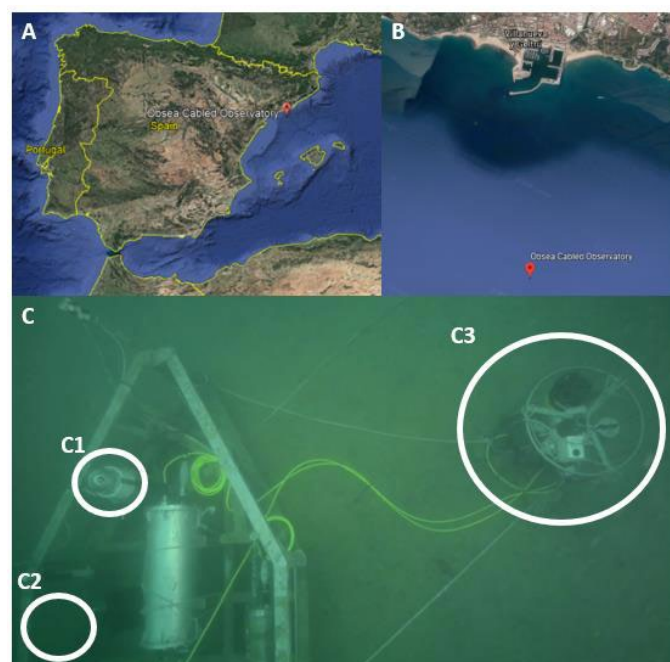


Fig. 1. The location of the OBSEA seafloor cabled observatory in the western Mediterranean Seas (A), with details of its location off the Catalan coast (B). A detailed above view of the platform (C), showing the position the CAM 1 (C1), the CAM 2 (C2) and the EGIM infrastructure (C3) with white circles.



Fig. 2. Integrated chart of significant daily increases in measured values for the 5 biologically relevant oceanographic variables, and visual counts of the 17 taxa, unclassified and total fishes obtained from 1st of December 2016 to 31st March 2017 of continuous measurement by the EGIM sensor infrastructure in front of the OBSEA (dark gray horizontal bars report values above the MESOR for the oceanographic measures, while black horizontal are used for visual counts). With light gray boxes in background is showed the duration of the night hours.

ACKNOWLEDGEMENTS

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"Sistemas de Adquisición Remota de datos y Tratamiento de la Información en el Medio Marino (SARTI-MAR)" 2017 SGR 371. Researchers want to acknowledge the support of the Associated Unit Tecnoterra composed by members of Universidad Politécnica de Cataluña (UPC) and the Consejo Superior de Investigaciones Científicas (CSIC). This work used the EGI infrastructure with the dedicated support of INFN-CATANIA-STACK and data derived from "estacions meteorològiques automàtiques de la xarxa d'estacions de Catalunya (XEMA), Meteocat".

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ID14 DEVELOPMENT OF AN AUTONOMOUS SUBMERSIBLE PROFILER WITH THE ABILITY TO STOP AT SPECIFIC DEPTHS FOR MEASUREMENT OF MARINE PARAMETERS

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ABSTRACT

Understanding marine pollution problems is a complex topic that has led to a wide range of research over the last decades. In this research, an autonomous submersible profiler with controlled depth detention for the measurement of parameters of interest in shallow marine environments -is presented. The device has been designed to carry on several sensors including dissolved oxygen, chlorophyll, electrical conductivity and temperature among others. The profiler includes the performance for sampling, collecting and wireless sending reliable real-time data in marine environments. In addition, its ability to stop at a given depth allows

for more accurate and stable measurement of marine parameters at different depth levels. This research describes the design of the profiler as well as the different control assumptions made to achieve zero buoyancy at a given depth. The results show that the submersible profiler is a valuable tool for continuous monitoring of marine parameters relevant to study the causes leading to critical environmental situations.

Keywords – sensor carrier platform, submarine profiler, WSN, depth control, process simulation.

INTRODUCTION

Coastal marine ecosystems, especially coastal lagoons, are natural spaces with high ecological value that provide goods and services to society, but at the same time they are extremely vulnerable to environmental pressures derived from the exploitation of their resources. The socio-ecological system of the Mar Menor [1], unique in Europe and emblematic in the Region of Murcia, has suffered its greatest environmental crisis in recent years, which has compromised its identity and caused economic losses and loss of natural values [2]. The different scientific groups, governments and associations with scientific competence in the biological behaviour of these vulnerable ecosystems, have highlighted the need for continuous monitoring of relevant marine parameters to study the causes that lead to these critical situations and determine the effectiveness of the actions undertaken for their recovery.

This research presents a portable and autonomous underwater profiler made of low-cost materials, capable of submerging, surfacing and serving as a multi-sensor carrier platform, offering the possibility of measuring at different depths and sending real-time data to a web server.

MATERIALS AND METHODS

a. Mechanical design

The mechanical and electronic design has been developed with the objective of achieving a flexible monitoring without the need of infrastructure for its installation. A low economic cost to have enough measurement points that, on the one hand, minimize spatial variability and, on the other hand, allow the instrumentation of different areas and model the hydrodynamic characteristics of the lagoon. In addition, it has been designed with the aim of instrumenting the parameters at different depths. The sampling time is adjustable to allow an adequate balance between the energy consumption and the measurement time of the several sensors. The system is fully autonomous, designed to allow to know the state of the lagoon several times a day, as well as to send the information obtained to a web server in real time using IoT technologies, such as Sigfox.+

b. Control design

This research proposes two types of depth control that differ in the actuators used and their dynamic response. One case is based on achieving static equilibrium using thrusters for high speed actuation but is only suitable for short time lapses due to energy consumption and the fouling issues. In the second case, zero buoyancy is achieved by adjusting the weight of the profiler by

means of ballast tanks, which allows longer tracking at the cost of slower actuation speed.

c. Field testing

In order to check the validity of the profiler's depth control operation, several tests have been carried out in different environments: In a two meter high tank installed at the Polytechnic University of Cartagena for the preliminary test, at the "Real Club de Regatas de Cartagena" for real depth operation and at different sea points of the Mar Menor to check the control management in response to disturbances caused by sea conditions.

RESULTS

In order to optimise the use of energy, it is necessary to balance the operation of thrusters and ballast, which requires the use of different control strategies. Thruster control is based on a conventional PID controller. However, when using ballast tanks, due to their operating principle it was necessary to use a fuzzy control. After experimental tests, both scenarios showed satisfactory control and a steady-state error of less than 10 cm and tunability. By using thrusters, a higher response speed is obtained to reach the setpoint and to act on disturbances. The settling time obtained for control with thrusters and ballast tanks is 30 and 50 seconds, respectively. On the other hand, ballast tanks allow to stay at the desired setpoint with minimum consumption. However, thrusters must always be in motion to stay at a certain depth in addition to being affected by fouling. Therefore, the decision on the optimal control will depend on the specific application for which it is to be used.

In addition, it should be noted that, in parallel to the control study, several profilers were installed in the Mar Menor to test their behaviour in a real environment. In this way, it was possible to conclude that the mechanical and electronic design of the profiler was correctly carried out and that, in the absence of depth control, the autonomy of the profiler reached 2 months. However, due to fouling in the Mar Menor, the profiler must be maintained every 3 weeks to ensure reliable measurements.

CONCLUSIONS

This research presents a profiler with the ability to stabilise at a given depth. In this way, it allows the built-in sensors to provide more stable and accurate measurements for each desired depth. Therefore, this type of profiler could be used as a tool capable of obtaining the state of the physico-chemical alterations and fluctuations in the Mar Menor or any type of shallow water in real time.

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ID15 MODELLING AND IDENTIFICATION OF AN AUTONOMOUS SURFACE VEHICLE

THALIA A. MOREL⁴⁰, LUIS ORIHUELA⁴¹, GUILLERMO BEJARANO⁴²

ABSTRACT

This work aims to provide technical information regarding the identification and modelling of the Yellowfish Autonomous Surface Vehicle (ASV) developed at Universidad Loyola Andalucía. The goal is to have a simple model of the vehicle that can be later ex-

ploited for estimation and control, either as an individual vessel, or as part of a coordinated fleet.

Keywords – Autonomous surface vehicles, identification, marine robotics, modelling.

INTRODUCTION

Identifying a system, such as an autonomous surface vehicle, is of paramount importance as it allows us to understand its characteristics, capabilities, and limitations. System identification also provides critical information about its behaviour and optimisation of different situations, which is essential for safe and efficient operation [1].

In the specific case of an autonomous surface vehicle, system identification is crucial to ensure its proper functioning in different environmental conditions and avoid potential risks and accidents [2]. Furthermore, system identification is also necessary for optimising and maintaining the vehicle, improving its performance, and extending its lifespan.

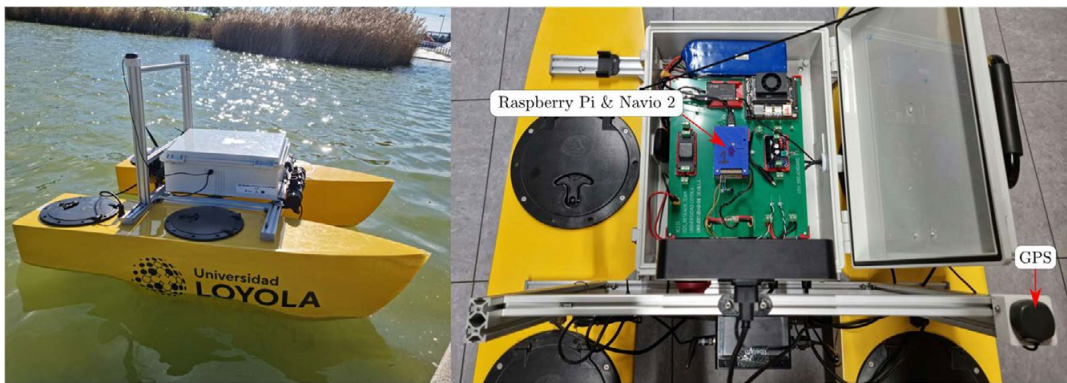


Fig 1. The Yellowfish ASV and the on-board sensors

THE YELLOWFISH ASV: TECHNICAL DESCRIPTION AND ON-BOARD ELECTRONICS

The Yellowfish ASV is shown in Fig. 1. This catamaran-like vessel is used for different purposes, such as monitoring water masses. This abstract focuses only on the elements with a role in the motion and control, independently from the application. The ASV is equipped with two propellers, thus giving the three-degree-of-freedom ASV two control actions, making it underactuated.

A Raspberry Pi 4 model B and Navio2 handle commands and drive actuators (see Fig. 1). The Raspberry supports system telemetry, communicates drone data, and enables settings changes. Navio2 has enough sensors (GPS, IMUs, UART, Radio, and PWM) to operate this low-cost ASV remotely and autonomously. However,

the Yellowfish incorporates a GNSS RTK with a ground station for more reliable position measurements. The gyrocompass in Navio2 board measures the orientation of the vehicle. Finally, the control software that is implemented in Navio2 is called Ardupilot. All the telemetry data can be remotely accessed, so the ASV can be tracked in a software called Mission Planner.

MODELLING AND IDENTIFICATION OF THE YELLOWFISH ASV

The rigid-body kinematics and kinetics of an ASV moving in the horizontal plane under the maneuvering theory can be expressed in vectorial form according to:

$$\begin{cases} \dot{\eta} = \mathbf{R}(\psi)\mathbf{v}, \\ \dot{\mathbf{v}} = \mathbf{M}^{-1}\boldsymbol{\tau} + \boldsymbol{\sigma}, \end{cases} \quad \text{with } \mathbf{M} = \begin{bmatrix} m - X_{\dot{u}} & 0 & 0 \\ 0 & m - Y_{\dot{v}} & mx_g - Y_{\dot{r}} \\ 0 & mx_g - N_{\dot{v}} & I_z - N_{\dot{r}} \end{bmatrix}, \quad \text{and } \mathbf{R}(\psi) = \begin{bmatrix} \cos(\psi) & -\sin(\psi) & 0 \\ \sin(\psi) & \cos(\psi) & 0 \\ 0 & 0 & 1 \end{bmatrix},$$

where $\eta = [x, y, \psi]^T$ denotes the position and orientation vector expressed in the earth-fixed frame $\{n\}$, $v = [u, v, r]^T$ denotes the linear and angular velocity vector expressed in the body-fixed frame $\{b\}$, and $\tau = [F_u, 0, T_r]^T$ describes the force and torque acting on the vehicle in the body-fixed frame $\{b\}$. Matrix $R(\psi)$ represents the rotation matrix between the body-fixed frame $\{b\}$ and the earth-fixed inertial frame $\{n\}$ [3]. This formulation groups most nonlinear terms (Coriolis, buoyancy, and damping) into the lumped generalized disturbances σ , so only the inertia matrix M , consisting of the rigid-body inertia and the added mass, is required. For matrix M , m is the total mass of the vessel, X_g is the vector from the centre of origin of $\{b\}$ to the centre of gravity [3], I_z is the moment of inertia about the Z_b axis, and $X_{(ij)}$, $Y_{(ij)}$ and $N_{(ij)}$ are the added mass hydrodynamic parameters according to standard notation [4].

Table 1 lists all identified values within a range for the inertia matrix and control system of the Yellowfish ASV. Each main component of the ASV is weighted to determine its mass. Steiner's Theorem was used to calculate the centre of gravity and moment of inertia, considering both the hulls and the electronics box to have uniformly distributed mass. The added mass is estimated with the heuristic method in [5], considering the hull as an ellipsoid submerged in a fluid.

Parameter	Minimum	Nominal	Maximum	Units
m	23.73	24.39	25.73	kg
X_g	-18.7	-19.6	-20.5	mm
I_z	1.07	1.81	2.81	kg m ²
X_u	-2.15	-1.00	-0.27	kg
Y_v	-22.59	-10.92	-3.59	kg
N_r	-4.35	-3.95	-3.74	kg m ²
Y_r	-	0	-	kg m
N_v	-	0	-	kg m

Table 1. Parameters of the Yellowfish ASV

CONCLUSIONS

This report gathers different sorts of information required to automatically control the Yellowfish ASV, a surface vessel designed by Universidad Loyola Andalucía. It covers transversal topics, such as vessel equipment, modelling, and identification.

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Due to the particular geometry of the vessel, control forces are given by $F_u = T_R + T_L$, $\tau_r = \frac{d}{r}(T_L - T_R)$, where d is the distance between propellers, and T_L, T_R are the thrusts of left and right propeller, respectively. The thrusts depend on the

PWM signals. However, due to their highly non-linear internal dynamics, the propeller thrust is tough to calculate [5]. The Yellowfish ASV considers a second-order static model with identified dead-zone:

$$T_i(N) = \begin{cases} 15.7454\tilde{\delta}_i^2 + 15.8080\tilde{\delta}_i - 1.3197, & \tilde{\delta}_i \geq \tilde{\delta}_f \\ 0, & \tilde{\delta}_r < \tilde{\delta}_i < \tilde{\delta}_f \\ -12.3884\tilde{\delta}_i^2 + 12.4403\tilde{\delta}_i + 1.2567, & \tilde{\delta}_i \leq \tilde{\delta}_r \end{cases}$$

where $i \in L, R$. The PWM input signal δ_i is scaled to the range $[-1, 1]$. Lastly, $\tilde{\delta}_f$ and $\tilde{\delta}_r$ are the experimentally obtained dead-zone values for forward and reverse movement of the propellers, being $\tilde{\delta}_f = 0.0775$ and $\tilde{\delta}_r = -0.0925$.

ID16 NEW ADVANCES IN AI-BASED ELECTRONIC MONITORING (EM) TECHNOLOGIES FOR AUTOMATIC, REAL-TIME CATCH DATA COLLECTION: THE IOBSERVER2.0

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ABSTRACT

The implementation and fully compliance of the Common Fisheries Policy (CFP) of the EU depends largely on the ability to quantify total catches on board commercial fishing vessels. To this aim, the use of electronic devices is gaining relevance and vision-based electronic monitoring technologies have emerged as a more cost-effective and efficient way to monitor fishing activity. In this work, we present the iObserver 2.0, a device that uses Deep Learning image recognition to automatically identify and quantify in real time the entire catch on board fishing vessels. It builds upon two previous prototypes, improving image quality by using line scan technology. Two neural networks are used for fish species segmentation, identification, and length regression tasks. As main results of this disruptive technology, the iObserver 2.0 distinguishes more than twice the number of species than previous version, works with area scan and line scan camera images, and it is evaluated with a test set incorporating more complex images. An experimental fishing survey has been conducted to assess the system's performance in real-life conditions, showing promising results in terms of total catch registration of target and discard fish species.

Keywords - Electronic monitoring, deep learning, image recognition, fish species identification, fish length regression, line scan.

INTRODUCTION

Catch registration and reporting, as well as monitoring, control and surveillance (MCS) are extremely challenging in wild capture fisheries. Insufficient reporting and MCS have contributed to unsustainable fishing practices, caused data limitations in stock assessments and created opacity and unfair competitive advantage for those disobeying the rules. It is a fact that the successful implementation of the Common Fisheries Policy (CFP) (with an increasing level of compliance with the Landing Obligation) depends, to a large extent, on the ability to quantify total catches on board commercial vessels. So, major expenses and efforts are awarded to MCS, but effectiveness and coverage is generally limited. However, as improved technological solutions are fast emerging, the potential to significantly improve data collection, information accuracy and verification, automatic catch registration, reporting and MCS, while also reducing costs, is on the horizon. These solutions include Electronic Monitoring (EM), satellite detection, Vessel Monitoring Systems (VMS), Automatic Identification Systems (AIS), video monitoring (CCTV), computer vision, artificial intelligence (AI), and application of various sensors. Authorities, fishing companies and enterprises are already experimenting with these solutions, with some having implemented elements of these new techniques, with the aim of reaching Fully Documented Fisheries (FDF) towards sustainability of fishing activity.

In this work, we present the iObserver 2.0, an EM device that uses Deep Learning image recognition algorithms to automatically identify and quantify (fish ID) total catches on board fishing vessels. Located over the conveyor belt of catch processing deck (Fig. 1), it takes pictures of entire catch during fish sorting, and each picture is analysed to identify the species and length of each individual, from which weight is estimated, and then combined to generate a catch report for the entire haul. We present next the main characteristics of this new concept of automatic, AI-based EM system.



Fig 1. iObservers 2.0 installed on board R/V Miguel Oliver

HARDWARE

The iObserver 2.0 builds upon two previous prototypes: the first one used classic Computer Vision algorithms [1] and, the second one incorporated Convolutional Neural Network based recognition algorithms that greatly improved the fish ID results [2]. In this work, we present a new version of AI-based EM system where the size of the image capture unit over the conveyor belt is reduced by moving the processing hardware to an external computer, achieving increased power and flexibility. Image quality is also improved by replacing the area scan camera system with a line scan system. To this aim, two different versions of the iObserver 2.0 were developed: one based on the use of line scan cameras and the other one based on area scan cameras that work in linear mode aided by an optical flow analysis algorithm created ad hoc. The use of line scan technology allows to avoid the problems of image stitching of individual photos while providing a continuous capture of entire hauls. Moreover, it uses more focused light sources so the number of light bars is reduced and brightness is increased, allowing to reduce exposure time to just 1 ms, solving motion blur issues and reducing noise.

ALGORITHMS

The iObserver is based on two neural networks; i) for the fish species segmentation and identification task, the Mask R-CNN algorithm was adapted to the problem at hand and; ii) for the fish length regression task, a modified MobileNet Convolutional Neural Network was developed. Since both neural networks only work with single images, for the iObserver 2.0, a Multi-Object Tracking and Segmentation inspired algorithm was developed to provide a solution for the continuous identification and quantification of the fishing hauls. Moreover, to the catalogue of 14 target species recognized by the iObserver (corresponding to targets of Spanish trawlers operating in ICES areas 8c and 9a), 16 non-target species were added in the iObserver 2.0. Additionally, the new images obtained with the line scan version of iObserver 2.0 and over 3,000 new annotations were added to retrain the neural networks.

RESULTS

As main results for the detection task, a precision of 96% (percentage of correct identifications) and a recall of 92% (percentage of correct identifications among positives) was obtained for images that were not used to train the algorithms (test set). Regarding the length regression algorithm, the mean absolute percentage error was 3.1%, and the mean absolute error was 9 mm. Although these results are quantitatively similar to those obtained in the previous version of iObserver, qualitatively they represent a great improvement, since now the iObserver 2.0: i) distinguishes more than twice the number of species; ii) works both with area scan camera images and line scan camera images and; iii) it is evaluated with a test set that incorporates more complex images with multiple fish and overlap. The iObserver 2.0 was tested (on the framework of TIPES project) on the DESCARSEL0921 research campaign to assess its performance under close-to-real fishing conditions (Figure 1). Such research campaign was carried out by our colleagues of the Oceanographic Center of Vigo of the Spanish Institute of Oceanography on board the R/V Miguel Oliver, of the General Secretary of Fisheries of the Spanish Government. The fishing hauls were carried out under ordinary conditions simulating the activity of a commercial trawler. The fishery is a mixed bottom fishery, targeting different species, with various colours, sizes and shapes (rounded, plane or laterally compressed bodies). During the trials, the discharge of the fish from the hopper to the belt was controlled by the crew to avoid excessive fish clumps on the belt and occlusions whenever possible. Obtained results are very promising (Fig. 2). When calculating the catch weight by species, the Weighted Average Percentage Error (WAPE) for the target species was 49%. However, when grouping similar species such as gurnards and megrims, as in commercial classification, the value dropped to 20%. The model had some difficulty with species with few individuals or very similar appearance. When calculating WAPE per haul, it was 18%, dropping to 16% when grouping similar species. In this case, the weighted effect of the most abundant species improved the final result. For non-target species, weight was not estimated, so calculations were based on the number of individuals, resulting in a WAPE of 381%. In this case, the reduced

number of annotations used in training was noticeable, although we expect to greatly improve these values for the most abundant species or by grouping the two species of flying squid.

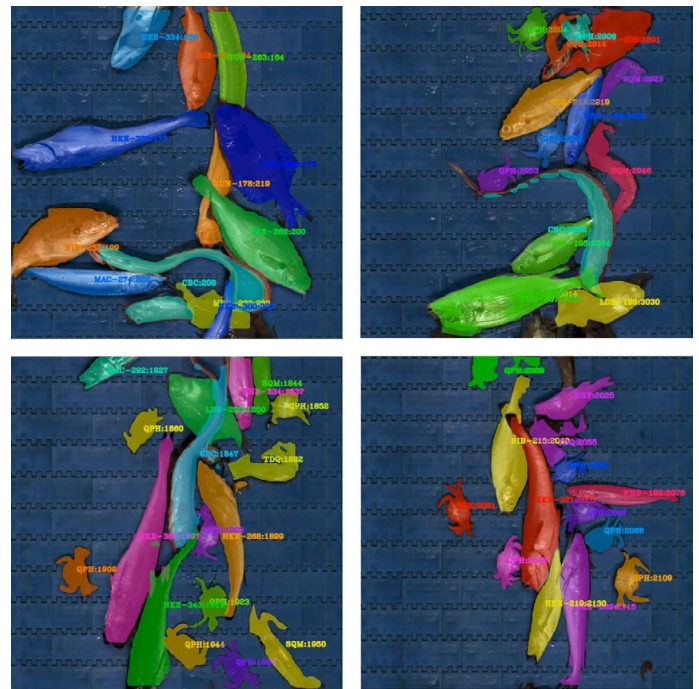


Fig 2. Example output of the algorithms for one haul of DESCARSEL0921. For each detection species FAO code, length in mm for target species and track-id are shown.

CONCLUSIONS

The trial results obtained when using the iObserver 2.0 for providing total catch estimates are promising, but further research is still needed, and research groups involved in this work are currently conducting it. The main obstacle lies in hauls with a high overlap of fish. To solve this, it will be necessary to install a mechanical fish separation system in the fishing parks (physical barriers, vibrating devices, conveyor belts with different speeds, etc.). In addition, and from the point of view of the software/algorithm, many of the observed problems could be alleviated by improving the annotation catalogue by incorporating specimens with a complete and balanced distribution by species and size. The implementation of recognition algorithms has considerable room for improvement, and new advances are published daily. Finally, more tests on commercial ships will be necessary to produce a device that can be used systematically for the entire fleet.

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ID17 BRIDGING HETEROGENEOUS NETWORKS IN CHALLENGING AND DISRUPTIVE MARITIME ENVIRONMENTS

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ABSTRACT

In this work, we describe the development of a system that aims to deal with different communication means when operating in a network of heterogeneous systems with ad-hoc behaviour that has proved helpful in real-life scenarios. Using the LSTS toolchain, we can support the deployment of ocean, surface and air vehicles, providing transparent communication between them in a fashion way.

Keywords – autonomous; systems; networks; bridging; toolchain.

INTRODUCTION

Recent advancements in autonomous vehicles, such as underwater (AUVs), surface (ASVs), and aerial vehicles (UASs), have led to an increasing use in a wide range of civil and military applications. With their increased capabilities, either as single units or as a team, they are being used for surveillance, search and rescue, oceanographic and atmospheric studies and infrastructure inspection, to name a few. This diversity, both at the level of scenarios and type of vehicles, leads to increased difficulty in guaranteed interoperability concerning communication between them and between different means.

This paper outlines the development and testing of a communication gateway – Manta, as a centralized communication hub for maritime assets, which provides support to different communication means for heterogeneous systems, using the LSTS software toolchain [1] in a real environment where oceanographic studies can take place.

CONTEXT & MOTIVATION

The pursuit of science is crucial in advancing our understanding of the world around us, including the complex ecosystems of the oceans. By studying the effects of pollution, climate change, and other stressors on marine life, we can develop strategies to protect and preserve these fragile environments. This is where the importance of scientific pursuit comes into play. It enables us to improve our ability to explore and study the oceans, leading to the development of new technologies that can enhance our understanding and allow us to take action to protect and maintain the maritime environment. With this pursuit in mind, over the past decade, at Laboratório de Sistemas e Tecnologias Subaquáticas (LSTS) based at the University of Porto [2], we have been designing, building and deploying AUVs, ASVs and UASs [3][4], as well as buoys and communication gateways, along with a powerful software toolchain, capable of integrating not only in-house built heterogeneous systems but also systems from other manufacturers.

In order to abstract the complexity of interacting with multiple and heterogeneous systems that can enter and exit the network in an ad-hoc way, there was a need for a hub that could act as an intermediary between these different systems, allowing them to communicate with each other even if they are using different communication protocols or frequencies. This can help to ensure that all systems in a multi-vehicle network are on the same page and that information is being shared effectively between them.

DEVELOPED WORK

To address this, we created a portable communication hub – The Manta gateway (Fig 1), which is essentially a rugged, waterproof enclosure with in-house developed electronics to support off-the-shelf communication modules, designed and built to allow multiple operators to control and monitor multiple vehicles in a networked environment over distinct platforms, running the LSTS toolchain on a single-board computer. The device is battery-powered for full autonomy and portability, capable of providing between a minimum of 8-hour uninterrupted operation, composed of different radio modules such as Wi-Fi (typically 2.4GHz), Iridium, GPS, GSM/4G, RFD868, and acoustic modems (compatible with SeaTrac[5], Evologics[6], uModem[7])



Fig 1. Manta gateway with two distinct acoustic modems



Fig 2. Manta main carrier board for V2

CONCLUSIONS AND FUTURE WORK

In conclusion, the Manta has emerged as a valuable tool for bridging communication between diverse assets and operators, using the LSTS toolchain to interface several different protocols. This technology has been used in various real-life scenarios, and its usefulness has been demonstrated in several exercises in recent years [8][9].

With the clear intention of further pursuing this topic, we also started working on a more modular and improved version (Fig 2) of the Manta that features a 'carrier' board concept, simplifying development and debugging for different modules that can be attached or removed as needed, also supporting latest 5G technology, and with an increased battery capacity to extend operation time further.

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ID18 UNDERWATER AUTONOMOUS EVENT-DRIVEN PROFILER AND DATA RETRIEVAL SYSTEM

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ABSTRACT

Understanding Ocean variability, particularly in the productive upper water column, requires understanding ocean processes. Numerous physical and bio-geochemical processes in the water column must be studied at different spatial and temporal scales that still need to be fully understood. Current fixed-point observatory structures are one of the principal methods to collect data from the Oceans due to their endurance and capability to observe oceanic phenomena at a high rate. In this work, we present a new conceptual approach and design for an oceanic profiler which intends to overcome the most common logistical hurdle when deploying those kinds of platforms at sea.

Keywords – Ocean; Observatory; Autonomous; Profiler.

INTRODUCTION

Current fixed-point observatory structures are one of the principal methods to collect ocean data due to their endurance and capability to observe phenomena. That potential capability is especially true for oceanic phenomena that suffer rapid modifications in time and must be monitored at high-rate frequency. Complementary means such as Biogeochemical-Argo (BGC-Argo) floats, profilers like the Wirewalker, and robots such as Gliders and AUVs are now one of the main tools in the observational capacity of the ocean on a global scale [1]. State-of-the-art Autonomous vehicles can play a crucial role in data collection for newly envisioned concepts of underwater observatories by adding portability, economic sustainability and the capability to operate as a node in a network [2]. The prime objective of this work was to create a new concept of autonomous profiler to overcome the logistical hurdle of deploying equipment to sample the water column.

APPROACH AND IMPLEMENTATION

The system in development had to be simple and lightweight enough to be deployable and recoverable by a single person. The water column sampling characteristics required the system to be somehow “stationary” concerning the X and Y axis (considering cartesian coordinates) but moving along the Z axis. The system had to endure between one and four days comprising a minimum set of sensors mandatory for oceanographic studies, such as Conductivity, Temperature and Depth. The system development targeted sampling the top 200-meter depth water column, which corresponds roughly to the limit of the continental shelves. To fit within the project budget, it had to be designed to be low-cost (less than 10k€ without payload) without compromising the data collection quality. Finally, it needed to be compatible with the LSTS toolchain [3] to enable direct interaction with other systems qualifying to be part of a heterogeneous network and discard the need to develop more software to be commanded and controlled.

To be able to vertically profile the water column, the system (APDR) needs to either have buoyancy variation or have vertical thrusters to navigate along the Z axis. Taking advantage of developed technology for the LAUV in terms of drag efficiency and the existing propulsion system, it was decided to use the same tail as in the LAUVs which has proved to be robust and proficient in controlling cylindrical format underwater vehicles. This choice conditioned thus the system shape, payload capacity and components selection and placement inside the system. Since it had a similar shape and shared the same hotel and payload as in the LAUV, the battery design had as a reference the LAUV used in the River Plume Front experiments [4]. That specific configuration figures a power consumption of less than 90Wh and is equipped with batteries totalling 2.5kWh capable of operating (at 1m/s) for roughly 24 hours. To keep a slightly buoyant cylinder vertical in the water, most of the mass had to be distributed at the bottom of the cylinder. The top of the system was populated with the computational system and the payload. The APDR can rely on a GPS device installed to provide global position at the surface. The interaction with the APDR can be done either wirelessly or acoustically.

A customized Globalstar satellite SPOT device is used to ascertain the current position of the vehicle at the surface, aiding in the recovery of the system. A standalone acoustic pinger marker will help locate the system if trapped underwater.

RESULTS

Figure 1 displays the subsystems inline before and from assembly perspective. As can be realized, there is a huge space between the batteries and the computational subsystem purposely designed to keep the APDR in a vertical position. The APDR propulsion operation principles allow for three different types of operation: It can lock a position and keep profiling the water column vertically at that very same position; it can be released at a location and perform vertical profiles without locking an X and Y coordinates (thus drifting); or it can work as a data carrier by downloading data from a moored underwater observatory and uploading it once at the surface.

CONCLUSIONS

An Underwater Autonomous Event-Driven Profiler and Data Retrieval system was projected, considering the specific requirements of fast and easy profiling of the underwater column. The prototype is assembled and currently in technology readiness level 4. Water trials will ultimately validate the platform reliability when profiling the water column up to 200m and assess its usefulness in real conditions.

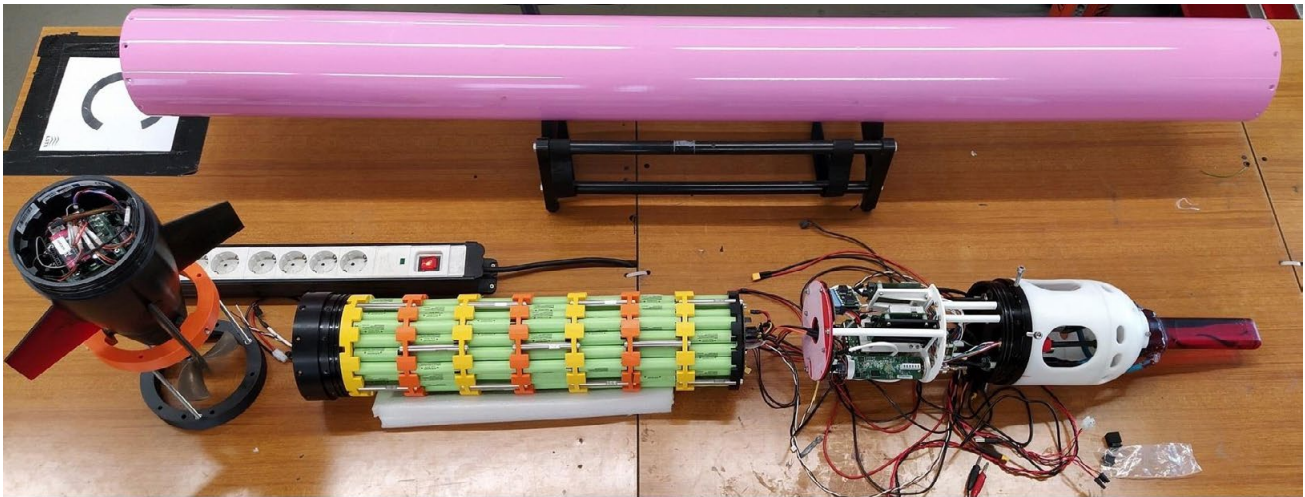


Figure 1 - Preassembled subsystems on the top and projected assembly on the bottom

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ID19 A NOVEL AND MULTI-PURPOSE ASV FOR THE BASQUE COAST: DESIGN, EXPERIMENTAL TESTING, AND MAIN CHALLENGES

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ABSTRACT

Autonomous Surface Vehicles (ASVs) have become a powerful tool for marine research due to their capability to make observations over a wide range of temporal and spatial scales. ASVs provide accurate, high-resolution, continuous data, benefiting environmental monitoring by decreasing the costs when compared to fully manned vessels. In the framework of Oarsoaldea Blue Hub project, a 6 m length electrical ASV equipped with acoustic sensors for measuring water currents and fish biomass has been designed and developed as a solution for more efficient oceanographic observations in the coastal area.

Keywords - Autonomous surface vehicles, marine monitoring, Basque Coast

MOTIVATION

Oarsoaldea Blue Hub project seeks the development of an observatory in the Port of Pasaia (Spain), which will provide Marine Ecosystem Data (both historical and in real time) to tackle the needs associated with integrated coastal management. The adoption of new technologies is changing the way ports operate, driving new efficiencies and creating an advanced ecosystem that will eventually span the entire supply chain. For this reason, the Oarsoaldea Blue Hub project is firmly committed to promote the blue economy in the area, betting on the development of information and

services oceanographic observation based on autonomous observing technologies, including autonomous underwater vehicles and autonomous surface vehicles (AUVs and ASVs, respectively). The data for the Oarsoaldea Blue Hub should be used to respond to needs in the areas of fishing activity management, the conservation and recovery of Biodiversity and Habitats, the challenges faced by Climate Change and Global Change, the implementation of Policies and Directives on the management of the marine environment, in particular, the European Marine Strategy Directive (DEME) and, in general, the integrated management of coastal zones.

RANGER PROTOTYPE DEVELOPMENT AND FIELD TESTS

Despite the benefits and capabilities of ASVs, their uptake for research purposes is still limited due low consumer confidence and barriers from legal and regulatory frameworks. There remain also complex challenges from a technical perspective. In terms of navigation, experimental field testing has been identified as a prerequisite and crucial step to ensure a safety performance of ASVs. In this work, we present the design and testing process of the RANGER, a novel and multi-purpose ASV, with a modular sensor payload devoted to marine environmental monitoring. Two field testing campaigns in the Basque Coast are planned to assess the feasibility of the RANGER and its performances in terms of operation, scientific equipment, and communications. Aspects related with the compliance with the regulatory guidelines for operating autonomous platforms particularly in coastal areas are also discussed.

ID20 KOSTASYSTEM, A MULTIPURPOSE COASTAL VIDEOMETRY SYSTEM

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ABSTRACT

This contribution presents the KOSTASystem technology, a multi-purpose coastal videometry system. It is implemented in 20 operational stations distributed along the Basque Coast (Spain), covering urban and natural beaches, port protection structures and natural coastal stretches. The purpose of this technology is to provide basic quantitative and qualitative data for coastal management applications. The most representative advances are related to the hardware, with the development of autonomous photovoltaic stations, and to the software, developing several tools for the calibration and restitution of the images and for the extraction of the information used in the different applications. In the long-term, within a climate change context, the most essential results have been obtained in the monitoring of beach morphology. In the short-term, the camera network works under extreme wave conditions, monitoring wave overtopping and flooding. Apart from this, it is also used for the daily management of the beaches in the summer season, improving the safety by detecting and predicting rip currents and providing information about beach user density (BUD). Finally, the constant improvement of this technology and its applications help to grow and collaborate within the European framework of the coastal observation network.

Keywords – Coastal videometry, Observing network, Beach morphology, Wave impact, Rip currents, Beach occupancy, Image processing.

INTRODUCTION

The coastal systems play an essential role for human life. The variety and uniqueness of the ecosystems that come together in this area encompass landscape, socio-economic, cultural, and educational values of great importance. The coastal zone is in constant change, and Basque Coast, which is highly populated, anthropized, and very exposed to energetic wave action, there is the need to highlight its vulnerability. Adding the perspectives associated to climate change, it demands special attention.

As such, video remote sensing techniques represent an efficient monitoring tool as they can provide useful data with high spatial and temporal resolution and coverage. In this line AZTI has developed the KOSTASystem technology and works in the generation of different products that transform the images in effective coastal zone management information. The first KOSTASystem station located in Mundaka has been capturing images of the Oka estuary mouth since 2007. Since then, over 20 stations have been installed and put into operation along the Basque Coast covering different coastal systems and key infrastructures.



Fig 1. Map of the coastal videometry stations operating in the Basque Country, Spain

HARDWARE AND SOFTWARE

The most important advance has been the design and implementation of photovoltaic autonomous stations. Simplifying installation, reducing costs and the administrative procedures for installation. Another breakthrough has been the installation of intelligent controllers, which allow access to the control of certain parts of the station.

For camera calibration and orthorectification the methodology is based on a two-step calibration [1]: intrinsic and extrinsic. This allows the orthorectification of the images on a uniform z plane or in a predefined digital terrain model grid.

The most used products in coastal videometry are those derived from the temporal processing of images. For this purpose, the open-source SIRENA software is used [2]. SIRENA creates 4 different types of images: snap (instantaneous images), timex (average images), var (variance images) and timestack images (defined profile images).

COASTAL SERVICES

In long-term and climate change context, monthly representative timex images of mean low tide and high tide are selected. The coastline detection is carried out from these images, and two indicators are derived: i) the beach width at low and high tide and, ii) the intertidal and supralittoral beach areas. These indicators are related with the incident wave energy on the beaches and used to describe the morphological evolution of the beaches and for validation of morphological models that can be used to analyse the future scenarios and associated evolution of the beaches in response to sea level rise [3].

In NRT and wave overtopping and flooding monitoring, timestack and infrared images are used to monitor the wave run up and overtopping along different transects with an automatic overtopping detection tool. Very useful for the Directorate of Emergencies of the Basque Government (EU Interreg POCTEFA Marlit project).

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In NRT rip current detection and forecast, a rip current risk assessment tool has been developed. The orthorectified timex images of the beach are sent to an app called BEACHGUARD that is operated by the lifeguards, to have a better monitoring of the breaking zone and associated sandbar morphology. These images are also used to obtain the bathymetry of the shallow areas of the beach which is used to forecast the circulation patterns using numerical models.

In NRT user density monitoring, a beach user density (BUD) tool has been developed using machine learning, providing information about beach users attendance to see indicators that affect tourism. For the COVID-19 context, the network has been adapted to provide real time information about beach occupation to ensure complying with the recommended social distancing [4] and displays the information through a mobile app (Nik Hondartzak).

CONCLUSIONS

Azti is coordinating further developments on hardware and software to improve the capabilities and efficiency of the KOSTASystem technology. Also, other applications as the use of InfraRed cameras and specific algorithms to detect river floating litters will be adapted to be compatible with the hardware of the stations.

AZTI is also working on obtaining hydrodynamic data from timestack images (wave height and flow information). The first version of the algorithm has been developed. The results are promising but further work is needed to get an operational tool and generate another reliable source of data.

All the ongoing works and the integration of the videometry data with modelling tools are opening new forecasting capacities both with long term and short-term applications. A good practice in the implementation of videometry opens up perspectives for European collaboration and integration in the coastal observing network.

ID21 ARDUINO CONTROLLED VALVOMETRY EQUIPMENT FOR MUSSEL RAFT MONITORING

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ABSTRACT

High-Frequency Non-Invasive (HFNI) instruments are currently used in bivalve mollusks in order to use them as bio-indicators of the local conditions of the environment. Under the STRAUSS project an Arduino controlled equipment has been developed to log the valve movements activity of mussels (*Mytilus galloprovincialis*) using Hall-effect sensors. The equipment is able to record at 10Hz the signals of 27 Hall-sensors, temperature, fluorescence and , to store the records in internal microSD cards and to send the stream of data to in premisses data servers for storing and plotting them.

Keywords – HFNI, Arduino, Hall-effect, bio-sensor.

MOTIVATION

There is an increasing demand, when socioeconomic implications exist (e.g. shellfisheries), to understand the impacts of coastal environments variability on marine fauna. The use of biosensors is playing an key role on exploring natural environmental variability and a number of natural and anthropogenic stressors. Emerging monitoring systems and technologies, as High-Frequency Non-Invasive (HFNI) instruments, are also being very useful [1]. Since they

are bio-indicators of the local conditions, bivalve mollusks are target organisms for this type of studies combining biosensors and HFNI. Several devices have been implemented for both laboratory and field experiments and used as early warning alerts in environmental monitoring through changes in animal's behaviour (e.g. MolluSCAN eye; [1]). In fact, from valve's movements of these organisms it is possible to infer individuals' health or status [2]. The amplitude and frequency of valve opening would be an indication of stress, modulations in these variables may offer signalling of environmental change. The use of these bio-sensors includes the gluing a Hall-effect sensor in one valve and a magnet in the other valve (Fig 1c), the intensity of the magnetic field felt by the sensor will change with the distance between the two valves.

HFNI valvometry has been already successfully applied to mussels in Galician waters and laboratory studies, under natural variability rhythms of mussels attached to cultivation system (rafts [3]) and under toxic *Alexandrium minutum* exposure in experimental tanks [4], respectively. Recently, the impact of ocean acidification and seawater warming on populations of the Mediterranean mussel *Mytilus galloprovincialis* were also explored using this technology [5,6]. In these cases, very expensive devices were used though cheaper options are available [7]. Trying to reduce costs, we have developed an Arduino controlled equipment (Figure 1a). 9,20th June. Castellón de la Plana, València, Spain

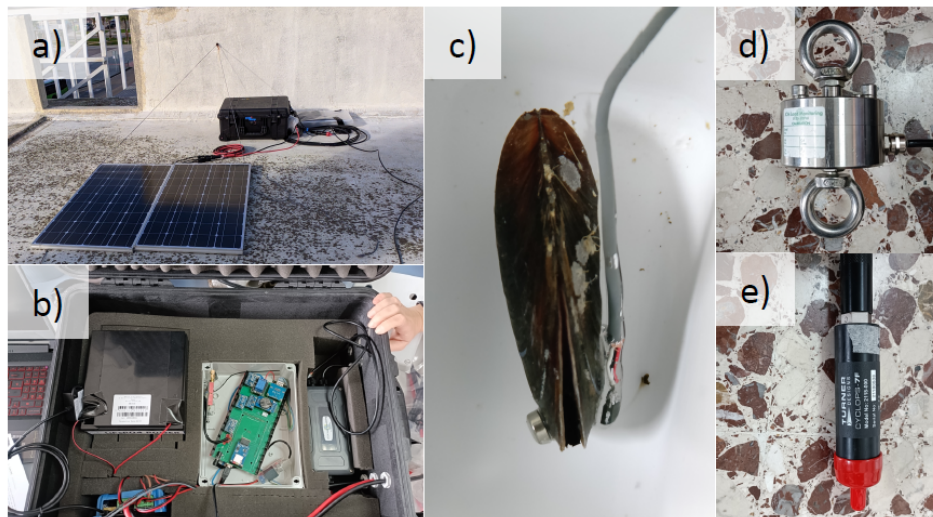


Fig 1. a) Equipment on the IIM terrace, b) case with electronics and battery, c) mussel with magnet and hall sensor, d) load cell, and e) fluorometer.

EQUIPMENT DESCRIPTION

The hardware components of the equipment were integrated in a Mega2560 R3 Arduino board (Table 1) through a custom-made PCB (Fig. 1b) designed by Javier Vila (<https://vilabesada.com>). The final global design was polished by SC Robotics (<https://scrobotics.com>). Several sensors have been added to monitor other interesting variables: a load cell unit (Fig. 1d) to record the weight change in the mussel ropes of the raft, a fluorometer sensor (Fig. 1e) to estimate chlorophyll water content, an Inertial Movement Unit to

monitor the mussel raft movements under ocean waves, and a temperature sensor. The equipment has been designed to operate as an autonomous instrument with solar panels, batteries and GPRS communication with the data servers at IIM premises. A microSD card adapter serves main storage system, and a real time clock (RTC) is used to timestamp each record stored in the SD card. The data stream arriving at the data servers is stored in a InfluxDB database. The InfluxDB database is connected to a Grafana visualization platform that, in turn, can plot the data through dashboards in any Internet browser.

Component description	Model/Version
Hall-effect Sensor	49E
Cable from sensor to AD converter	MOGAMI AWG33 -3C
Real Time Clock Module	Adafruit DS3231
MicroSD Card Adapter Module	HW-115
Analog-to-Digital Converter Module	Adafruit ADS1115
Power Supply Unit	Mean Well 5V-5A
Arduino board	Elegoo Mega2560 R3
Temperature sensor	DS18B20
Fluorometer	Turner Cyclops - 7F
Load Cell	JCM Load Monitoring, TNC600
IMU	MPU9250
Communications (GPRS)	SIM900
Solar Panels	2x100W
Solar Charge Controller	Victron MPPT 75 10
Battery	LiFePO4, 12.8V 26.6Ah
PCB	Custom-made
Database Software	InfluxDB
Visualization	Grafana 7.3.6 and FireFox/Chrome/Safari

Table 1. System/Equipment components

CONCLUSIONS

In the context of STRAUSS project, a real-time monitoring system has been developed, using an Aduino controlled equipment with 27 Hall-effect sensors sampled at 10Hz, to log the valvometry activity on clams *Mytilus galloprovincialis* plus a load cell, a fluorometer, an IMU and a temperature sensor in order assess the effects of waves in mussel dislodgments.

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ID22 MODEL TYPE II REGRESSION FOR LAGRANGIAN VALIDATION OF HF RADAR VELOCITIES IN THE NW IBERIAN PENINSULA.

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ABSTRACT

Two designs of lagrangian low-cost drifting buoys have been developed in order to monitor the ocean surface dynamics in the North-west Iberian Peninsula and provide ground-truth observations that can be used to assess the performance of High Frequency (HF) Radars of RAI A observatory from 2020 to 2022. Since regression model type I, which is typically used in buoy-HF radar antennas validations, does not consider the presence of errors in the observations from both instruments, regression model type II was proposed to instrument intercomparison. Furthermore, a new metric was developed to better assess both model types regressions in lagrangian validations.

Keywords - Drifting Buoy, HF Radar, Observing System, Lagrangian validations.

The antennas of the HF Radar systems are routinely calibrated through transponders to obtain the Antenna Pattern Measurement (APM), which allows correcting the signals received by the antenna [1]. However, this type of remote-sensing technology

is subject to various sources of uncertainty, some arising from space-time scale limitations and others intrinsic to the antenna technology itself. For this reason, regular validation exercises against independent surface velocity data from in situ instruments is highly recommended to ensure the quality of HF radar-derived observations. Within this context, drifting buoys are very useful tools to conduct lagrangian validations [2].

LOW COST LAGRANGIAN BUOYS.

Two models of drifting buoys, named SPOT and GPRS, were developed at IIM-CSIC [3] based on specific communication capabilities (satellite/Iridium or cellular/GPRS) and height of the water column, were probed by the different antennas of the HF radar system of RAI A observatory. To minimize wind-drag, both models have a low aerial to underwater surface ratio (lower than 1:45). The buoys were constructed using standard PVC materials and off-the-shelf GPS/communication electronics to keep costs at a minimum.

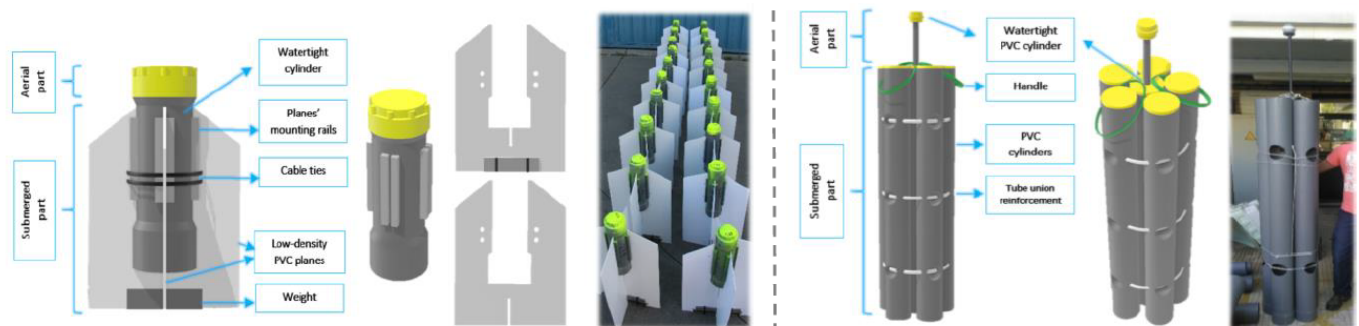


Fig 1. GPRS (left) and SPOT (right) buoys.

VALIDATION METRICS

To validate the data obtained by the antennas, the velocities of the surface currents given by the radial and total vectors of the HF radar were compared with current velocities provided by drifting buoys as they pass through the radar cells. In the comparisons, the standard deviations (variances) of both the data from the buoys and the HF radar were taken into account to reject or include the observations into the comparisons, i.e. to filter out mean values with associated standard deviations above a established threshold.

Traditionally, these comparisons are based on metrics such as the root mean square error (RMSE) and the statistics derived from the linear regressions type I (slope, intercept, coefficient of determination and probability of rejection). In type I regression models, the data from one of the instruments works as a predictor variable (X, generally observations from buoys or other instrument) while those from the other work as a predicted variable (Y, generally the

HF radar velocities), where only the predicted variable contains error. This does not suit to reality since both instrument measurements have uncertainties associated to intrinsic errors (from the corresponding device electronics) and to natural variability (the currents). Therefore, regression model type II was proposed to do the comparisons, since it includes errors in both, predictor and predicted, variables [4][5].

Starting with two sets of paired (buoy-HF radar) mean values, one set unfiltered and other filtered, and applying two different regression models to them, four sets of regression results were obtained, each with its own statistics and adjustment coefficients. Since both regression models are linear and single-variable, the regression coefficients are the intercept (a) and the slope (b). The statistics metrics used were the correlation coefficient (R), the variance ($Var(Y)$) of the estimate (Y) generated by the regression, and the root mean squared error (RMSE) or root mean square deviation (RMSD).

Usually, the RMSD is used as one of the most important criteria to compare linear regression models, the lower RMSD value the better model adjustment. Using this criterion, the selected regression model, out of 4 possible, for most of the HF antennas was the "filtered model type I". However, this criterion also came with a collateral, nearly always the selected regression also had a much lower variance of the estimate ($Var(\hat{Y})$) than the variance of the original observed data ($Var(Y)$). That is, the regression model selected produced estimates with too low variance, which is unrealistic.

To solve this issue, a new metric was developed to select the best model, the Root Weighted Square Difference (RWSD), which considers the original standard deviation ($SD(Y)$) of the original data and the standard deviation of the regression estimate ($SD(\hat{Y})$).

$$RWSD^2 = \frac{(SD(\hat{Y}) - SD(Y))^2 \cdot w_\sigma + RMSD^2 \cdot w_R}{w_\sigma + w_R = 1}$$

Using this new metric, with $w_\sigma=0.75$ for ensuring that the standard deviation of the estimated values is equal or greater than original data, the selected models for most of the cases were the "filtered model type II".

ACKNOWLEDGMENTS

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ID23 A WINDOW TO THE SEA: RAI A OBSERVATORY TOOL FOR ASSESSING ENVIRONMENTAL RISKS IN THE NW IBERIAN COASTAL UPWELLING SYSTEM.

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ABSTRACT

The international RAI A Observatory serves the main maritime activities of the NW Iberian coastal upwelling system. Over the last few years, the partners of the observatory have identified at least 12 key environmental risks that can potentially affect the ecosystem services of this coastal area. In order to evaluate these risks, different environmental indicators are used, which are developed and optimized according to the specifications provided by international environmental agencies. A Window to the Sea is the publicly-accessible web-service created to present and share the results from this evaluation. So far, current results have allowed to establish risk assessment protocols for the coastal region, and identify critical observational gaps. The web-is user-friendly with the intention to achieve as many end-users as possible, not only from academia, but also from other governmental institutions, fisheries, enterprises and the general public.

Keywords – Environmental Risk, Environmental Indicators, Global Change, Web-Service, RAI A Observatory, NW Iberian Peninsula.

THE RAI A OBSERVATORY

The RAI A Observatory resulted from the effort of 12 research and academic institutions and public agencies (Spanish and Portuguese) developing meteorological and oceanographic studies along the shelf and coastal region of the NW Iberian upwelling system, and it is the first transnational observatory in Europe.

The observatory (www.marnaraia.org) is organized on the bases of an observational network, numerical models and services. The observational system includes data from a wide variety of instruments (buoys, tide gauges, meteorological stations, radars...) and from cruise repeats. The high-resolution regional models (meteorological and hydrodynamic) offer information on dynamics and biogeochemistry of the coastal region, including 72-hour predictions. Since the beginning, the RAI A Observatory provides data, information and services to the main maritime activities of the NW Iberian coastal area (fisheries, maritime transport, marine renew-

al energies...) and specific tools have also been developed for certain users (recreational divers, sea-shell gatherers).

ENVIRONMENTAL RISKS AND INDICATORS

Coastal ecosystems and their services are the most at threat from the impacts of global change and the increasing of human population [1]. Considering this and that recent international efforts (i.e., the Sustainable Development Goals and the COP21 Paris agreement) are calling for progress towards a more resilient and sustainable future, the different partners of the RAI A Observatory have worked to identify potential environmental risks, and their correspondent environmental indicators, affecting the NW Iberian coastal upwelling system. An environmental indicator is a measure, generally quantitative, that illustrates and communicates complex environmental phenomena simply, providing insight into the state of the environment, and are fundamental tools for the evaluation and mitigation of environmental risks. [2]

In 2019, the partnership under the RAI A Observatory developed the web-service presented here, A Window to the Sea (Fig.1), (<https://marrisk.inesctec.pt/public/#/indicators>) that allows users to get information on the current environmental state and evolution of the NW Iberian coastal upwelling ecosystem.

MATERIAL AND METHODS

Data was analyzed and compiled by the various partners of the RAI A Observatory. The development and optimization of the environmental indicators has been done according to the specifications provided by the European Environmental Agency (EEA) and the International Panel for Climate Change (IPCC).

RESULTS AND CONCLUSIONS

Current data analysis showed that the Euroregion's ecosystems are in good health, but a follow-up of the time evolution of the indicators is key to detect future changes on them that can be use as early detectors of the vulnerability to specific environmental risks.

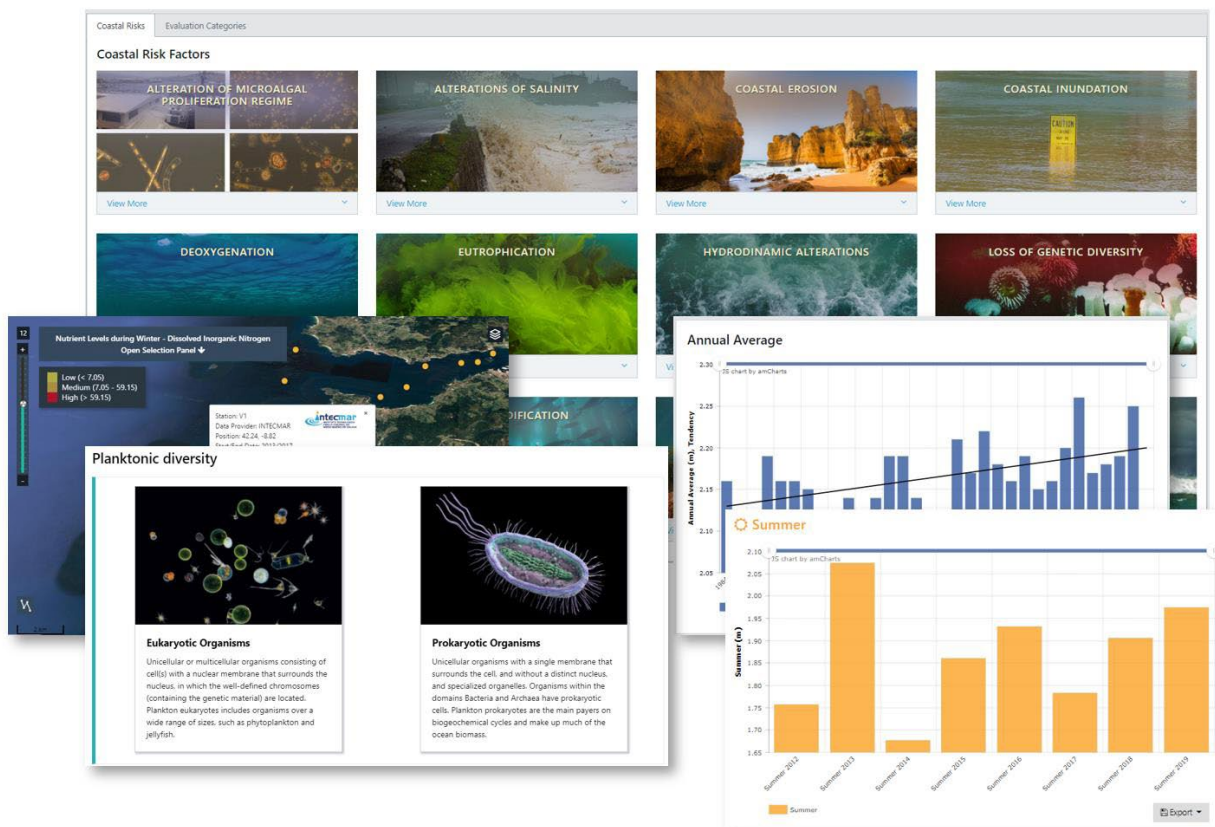


Fig 1. Background: A Window to the Sea, web-service of the RIA Observatory. Images at front are examples of indicators, from back to front: Left) Levels of Dissolved Inorganic Nitrogen (risk of Eutrophication) and Plankton diversity (risk of Loss of Genetic Diversity), Right) Mean Sea Level's annual tendency (risk of Coastal Inundation) and Seasonal mean Significant Wave Height (risks of Coastal Erosion, Coastal Inundation and Overwash).

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ID24 PATHWAYS OF ECONOMICALLY RELEVANT DEMERSAL SPECIES IN THE IBIZA CHANNEL FROM A LAGRANGIAN BACKTRACKING APPROACH

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ABSTRACT

This work studies the most probable spatial origin of demersal species that eventually reach the Ibiza Channel after a dispersion stage, a region where water masses with different characteristics choke. Demersal species are assumed to be in a planktonic stage in which they behave as passive particles, being only advected by the dominant ocean currents. To find the origin we have performed a set of backward Lagrangian simulations using a high-resolution model of currents. As a result, we obtain the preferred pathways of dispersion for demersal species. A careful analysis of pathways provides useful information on the spatiotemporal variability of demersal and their origin weeks ago before they reach the Ibiza Channel. This information is very valuable from a conservation standpoint to determine the key regions that should be protected as eggs and larvae exportation areas.

Keywords – Ibiza Channel, Mediterranean Sea, Lagrangian simulations, demersal, fishing

INTRODUCTION

Among the most interesting demersal species fished in the Ibiza Channel we can find the red shrimp (*Aristeus antennatus*), the white shrimp (*Parapenaeus longirostris*), and the hake (*Merluccius merluccius*). These three species are economically the ones that contribute the most to a fishing port like Denia (Alicante, Spain). As a consequence, it is critical to identify the preferred pathways of those species, and their temporal variability, in order to ensure future recruits and sustainable fishing in the region. Trajectories are obtained through a Lagrangian backtracking approach in which passive particles are advected using daily outputs of a high resolution numerical model of ocean currents, which allows us to obtain their favorite water mass conditions (temperature, salinity) and their potential spatial origin [1-3]. To conclude, the final aim of this research would be to identify those regions that should become marine reserves because of their importance in the propagule supply of the studied area in order to preserve both, biodiversity and fishing activity.

METHODS

Virtual particles simulating the horizontal passive advection of planktonic stages of demersal species following the main currents have been launched every day for 1 year, from 2023-02-28 to 2022-03-01, and then tracked backwards in time. Three different depths are considered for the simulations: surface, ~50 m and ~110 m, thus covering the whole range of depths in which species of interest could be found. Once deployed, particles are horizontally advected using an output velocity field from IBI-MFC model, provided by Copernicus with a spatial resolution of 1/36° [4]. Forecasting fields include zonal and meridional velocity components, as well as salinity and potential temperature for the 50 vertical layers. About 12000 particles are launched every day in the Ibiza Channel at each depth. A diffusive term modelled by a random walk approach is applied to reduce the number of particles that get stuck in land. Lagrangian simulations have been performed with Ocean Parcels, a freely available package developed in Python language [5-6].

RESULTS

The initial distribution of launched particles in the Ibiza Channel are shown in Figure 1 (left panel). As seen, particles are located between Denia and Ibiza, off the coastal shelf, in a region with bottom depths between 300 and 1000 m.

With the daily maps of the final position of particles, we calculate the percentage of particles within squares of 0.25° x 0.25° for each of the three depths of study. As a result, daily maps of probability are obtained for 1 year and for the selected time horizon of simulations (90 days). The annual mean percentage of particles launched at a depth of 110 m are displayed in Figure 1 (right panel). Interestingly, 90 days before reaching the Ibiza Channel most of particles originate from the North, being mainly distributed off the Gulf of Valencia, the Catalan shelf and around Ibiza Island. One reason to further explore is the semipermanent location of a gyre at the southern side of Ibiza Channel, which can be delaying several weeks particles from the Alboran Sea to reach the North. In contrast, many more particles come from the south when they are deployed at the surface (not shown).

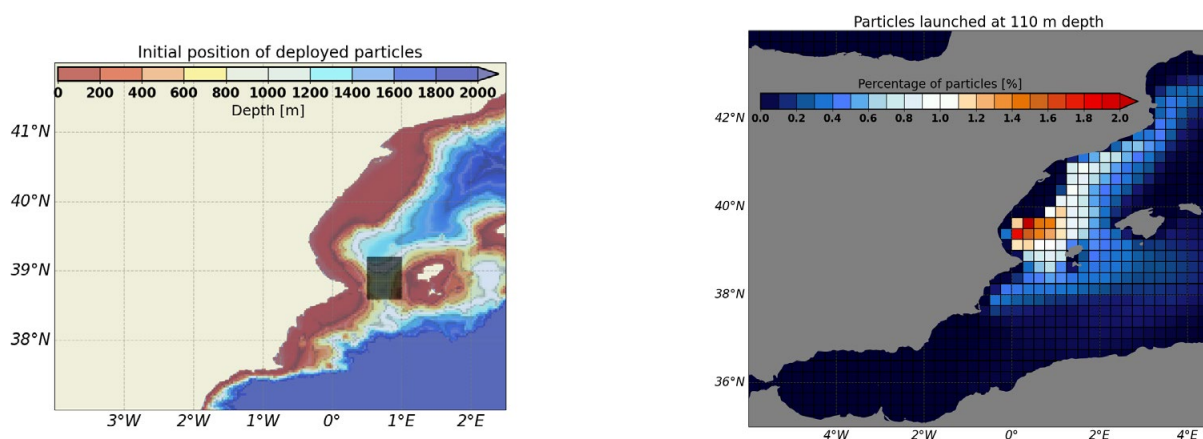


Fig 1. (Left) Map showing the initial location of deployed particles in the Ibiza Channel (black dots). Bottom depth is displayed in colour (unit in m). (Right) Annual mean of the percentage of particles according to their location 90 days before reaching the Ibiza Channel.

CONCLUSIONS

Preliminary conclusions suggest the relevance of oceanic structures in modulating the geographical origin of recruits of demersal species that may eventually reach the Ibiza Channel, a region with an intense fishing activity. As these structures vary throughout the year, a spatiotemporal analysis is required. Therefore, we plan to decompose the variability of the spatial distribution of the percentage of particles using an EOF analysis. With this approach

we will be able to detect the moment of the year in which particles come from a certain region for each depth. This will provide information on those regions from which planktonic stages come from, and consequently, which areas should be prioritised to preserve in order to boost bigger sizes of individuals and thus a much higher number of eggs and help to preserve both biodiversity and fishing productivity.

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ID25 CALIBRATING THE MOVEMENT OF AN UNDERWATER CRAWLER USING PULSE WIDTH MODULATION (PWM)

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Keywords – Underwater crawler, cabled seafloor observatories, PWM pulse, ecological monitoring.

ABSTRACT

The development of monitoring protocols based on cabled marine observatories is becoming strategic to acquire real-time multiparametric biological and environmental data. Unfortunately, most cabled observatories depend on fixed cameras to perform video-based ecological monitoring. Therefore, docked mobile platforms are useful, to extend underwater observatories surveil-

lance radius and improve their performance and functionality [1]. In this study we present an underwater crawler [2] connected to the OBSEA (www.obsea.es) [3] as European Multidisciplinary water column and Seafloor Observatory EMSO Testing-Site [4].

The crawler in [2] moves by sending Pulse Width Modulation (PWM) signals from the ODROID C4 controller board [5] to the motor controllers (Faulhaber SC5008S), which provide then power to the motors (Faulhaber 3564K 048B). The asymmetrical behaviour of the motor controllers, the motors, and the tracks, in forward and backward directions, cause the deviation of the crawler from a straight trajectory (Figure 1) [6].

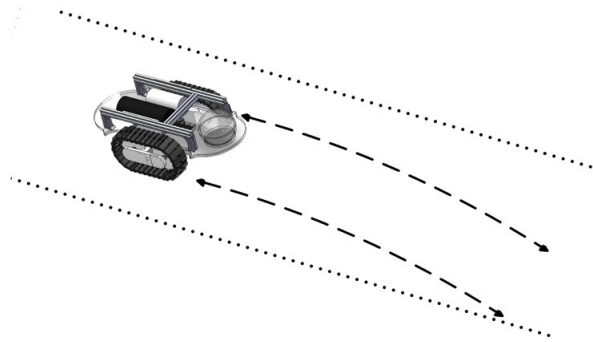


Figure.1 Deviation movement of the crawler in forward direction

To tackle this issue and compensate for the speed discrepancy between the two motors, the PWM signals applied to each motor were calibrated. For this purpose, the PWM applied to one of the motors was considered as a reference (in our case, right motor

and PWM1). The PWM applied to the other motor (left motor and PWM2) was consequently calibrated in both forward and backward direction (Figure 2).

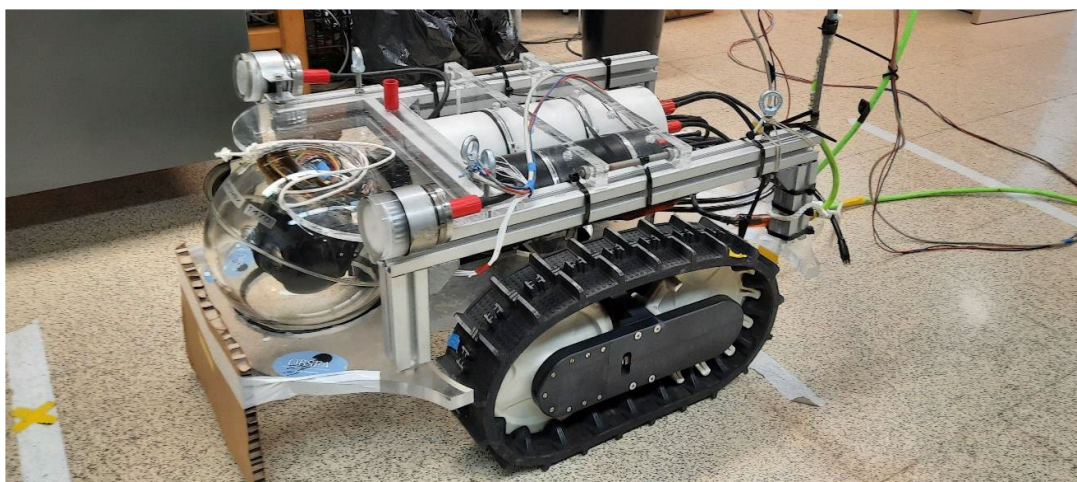


Figure 2 Crawler and measuring marks (white tape) on the floor

The speed of motors for the PWM signals and the results of this calibration process are shown in Figure 3. In particular, the measurement results illustrated in Figure 3A shows that applying an equal amount of PWM, motor 2 moves faster than motor 1. There-

fore, in order to compensate for this difference and reduce the speed of motor 2, the PWM2 was decreased, accordingly to the PWM1 (Figure 3B).

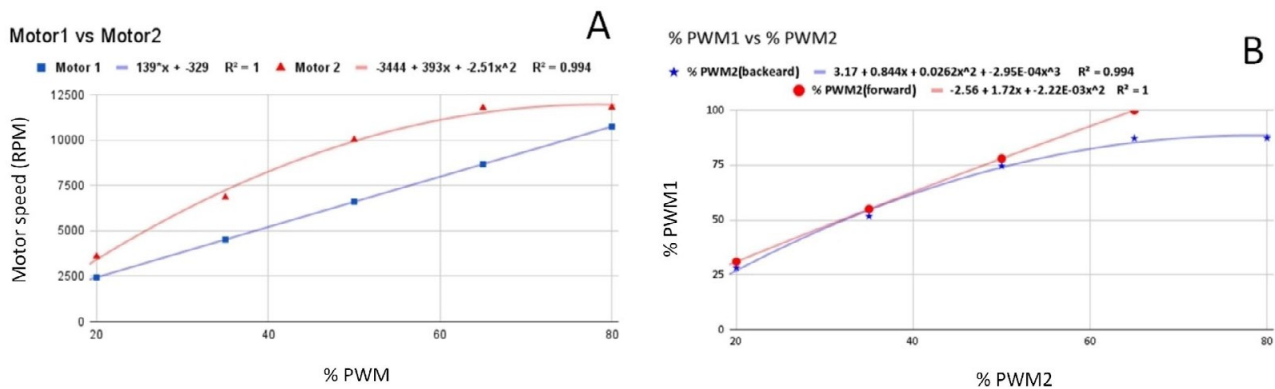


Figure 3 PWM pulses and speed of motors (A) and calibrated PWM2 based on PWM1 for the forward and backward movements (B).

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ID26 MULTISENSOR ACOUSTIC TRACKING BENTHIC LANDERS TO EVALUATE CONNECTIVITY OF FISHES IN MARINE PROTECTED AREAS

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ABSTRACT

Deep-sea fishing has been carried out on an industrial scale since the 1950s, and this has had a variety of effects on the environment and its biota. Most benthic species experience a decline in abundance or a constant decline in abundance as a result of direct disturbance of the seafloor, such as its plowing and scraping by hauled nets, with overall impacts on regional biodiversity [1]. Sediment has lost some of its biogenic habitat complexity, and sessile epifauna-provided microhabitat has been destroyed or disrupted [2] and marine protected areas (MPAs) have been widely implemented to address this decline. Marine fish mobility, which is crucial for ecosystem function and is increasingly being researched with acoustic telemetry, has an impact on how well no-take MPAs (i.e., marine reserves) work in terms of protecting and repopulating fish populations [3], [4]. Therefore, it is necessary to continuously monitor periodic changes in commercially exploited deep-sea ecosystems in order to gather baseline information, give accurate environmental impact assessments, and derive sound biological indicators for restoration. Using a fixed acoustic ultra-short baseline (USBL) receiver on benthic lander and miniature bidirectional acoustic tags [5], we address three key questions: How far can fish move? Does connectivity exist between adjacent MPAs? Does existing MPA size match the spatial scale of fish movements?

Keywords - Seafloor Ecosystem Monitoring; Acoustic Tracking; Bidirectional Acoustic Tag; Tagged Animals; Benthic Lander; Marine Technology; Marine Instrumentation; Environmental Protection.

INTRODUCTION

Species richness and biodiversity have been monitored using stand-alone devices (i.e., landers) susceptible to temporal intermittent deployments. Examples include the EMSO Generic Instrument Module (EGIM), which was created for stand-alone applications [6] or the installation of moored instruments to track animals that have tags [7]. However, in several cases, underwater acoustic arrays are sizeable, and may require complex handling for deployment at sea. In recent years, benthic landers of various forms have been developed for a number of purposes. Their technological features and models have drawn a lot of interest [8]–[10]. Additionally, to the acoustic tracking, remote underwater video landers are an innovative, non-intrusive way to provide ecological indicators for a variety of marine species, such as time series of counts, local lists, and evenness [11]. Multisensor marine

fixed observatories (multiparametric benthic landers) should be arranged into integrated spatial networks for the autonomous monitoring of fishing-impacted deep-sea ecosystems in order to effectively monitor targeted species of fishery interest [12] through optical and acoustic means. Distance can be calculated by using an acoustic signal's time of flight (TOF) and slant range in conjunction with the bidirectional communications capabilities of bidirectional acoustic tags. The tracking precision of species with bidirectional tags is improved by the addition of the bearing information computed by ultrashort baseline (USBL) devices. In addition, the benthic lander could cooperate with Autonomous Underwater Vehicles (AUVs), permanently allocated into mobile Docking Stations (DSs), that can be equipped with acoustic receivers, which act as a virtual LBL and use acoustic modems to measure the target's range [13], and expand the range of autonomous monitoring of fishing-impacted deep-sea ecosystems. In this framework, the developments in BITER will be centered on a fleet of inter-communicating multisensor landers with acoustic tracking capabilities.

BENTHIC LANDER PLATFORM

The BITER lander is a low-cost modular system, weighing about 200 kg in air, with a large payload capacity, designed to hold autonomous video systems and USBL devices as well as other oceanographic sensors, and equipped with an acoustically triggered sacrificial drop-weight release mechanism that enables resurfacing (see Figure 1). A stainless-steel frame and a specially created buoyancy module made of synthetic foam make up the bulk of the lander. The acquisition module(s) are carried by the frame, a versatile mechanism that can be quickly switched out as needed. The lander's architecture is intended to support multiple deployment scenarios, including: (1) a free-fall mode, where precise landing position control is constrained due to operation with Vessels of Opportunity (VOO) or without ROVs; and (2) a controlled mode.

ACOUSTIC TRACKING SYSTEM

The USBL device from EvoLogics, model S2C R 48/78 USBL [14], is installed on the top of the lander and is oriented at 90 degrees upwards; it is the acoustic array that is taken into consideration in our experiment. At the bottom two cylinders, house control hardware and batteries to operate the platform. The USBL device includes a modem-capable, software-defined ultra-short baseline (SDM-USBL). The external sync-in signals and SDM-USBL option, both introduced by EvoLogics in the context of BITER, make it feasible to gather acoustic samples simultaneously from all channels without disabling the USBL firmware. Finally, we take into account the creation of useful algorithms to obtain precise detections, estimates of the direction of arrival (DoA), and estimations of the positions of bidirectional acoustic tags employing wideband arrays.



Figure 1 Multisensor benthic lander deployed during the summer of 2022 at OBSEA observatory (www.obsea.es)

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ID27 OPERATIONAL OCEANOGRAPHY APPLIED TO THE MANAGEMENT OF OFFSHORE AQUACULTURE ON THE BASQUE COAST (SE BAY OF BISCAY)

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ABSTRACT

With the support of the Basque Government, offshore longlines have been used for mussel production in Mendexa (“Bivalve Mollusc Production Area”) since 2019. This area is located about 2 nautical miles from the Basque coast (SE Bay of Biscay). Here, an Integrated Marine Observing System (IMOS) has been established to identify toxic HABs. This system includes in situ data, sampling activity, satellite images, numerical models and other external sources of information.

Keywords – Aquaculture, Bay of Biscay, longline, Mendexa, mussel

INTRODUCTION

Offshore aquaculture, and in particular the production of bivalve molluscs, has increasingly attracted the attention of researchers, industry and policy makers as a promising opportunity to diversify marine aquaculture production. Technological advances in this type of farming systems have succeeded in extending aquaculture production to more oceanographically exposed areas, minimising coastal environmental impacts and avoiding conflicts with other marine uses. In 2016, the Basque Government legally declared a “Bivalve Mollusc Production Area” in Mendexa (SE Bay of Biscay), where production of mussels (*Mytilus galloprovincialis* Lmk.) has been carried out on offshore longlines since 2019. These longlines are located about 2 nautical miles offshore, at a depth of approxi-

mately 45 m, where they can withstand waves of up to 9 m in significant height (Fig. 1). However, mussel farming is encountering some difficulties, such as the increasing occurrence of different harmful algal blooms (HABs), that compromise the economic benefit of the activity. Most systems for predicting the occurrence of HABs have been developed for estuaries and bays, while systems for open waters are scarce. Here we describe the prediction system developed for the Basque coast to support the management of the emerging offshore mussel aquaculture sector in Mendexa.

MATERIALS AND METHODS

In April 2016, an Integrated Marine Observing System (IMOS) started to be established for HABs in the Mendexa production area (Fig. 2). At present, this system includes analysis of biotoxins in shellfish by chemical methods (okadaic acid group toxins, azaspiracids, yessotoxins, domoic acid and “Paralytic Shellfish Poisoning” (PSP) toxins), identification of potentially toxic phytoplankton species in water samples, in situ hydrographic measurements with CTD, fluorescence and temperature sensors measuring continuously, a 3D coastal hydrodynamic model (CROCO), a Lagrangian particle tracking model (SOFT), high- and mid-resolution satellite imagery (MODIS-AQUA, MODIS-TERRA, VIIRS, Sentinel-2 and Sentinel-3), and ancillary meteorological (wind, precipitation and solar radiation) and river input observations (flow and nutrients) from nearby meteorological and hydrological stations. Sampling of mussels and water for biotoxins and potentially toxic phytoplankton determination has been carried out at least monthly, but the sampling frequency has increased during high-risk periods.



Fig 1. Map of the Basque coast (SE Bay of Biscay) showing the location of the offshore longlines in Mendexa

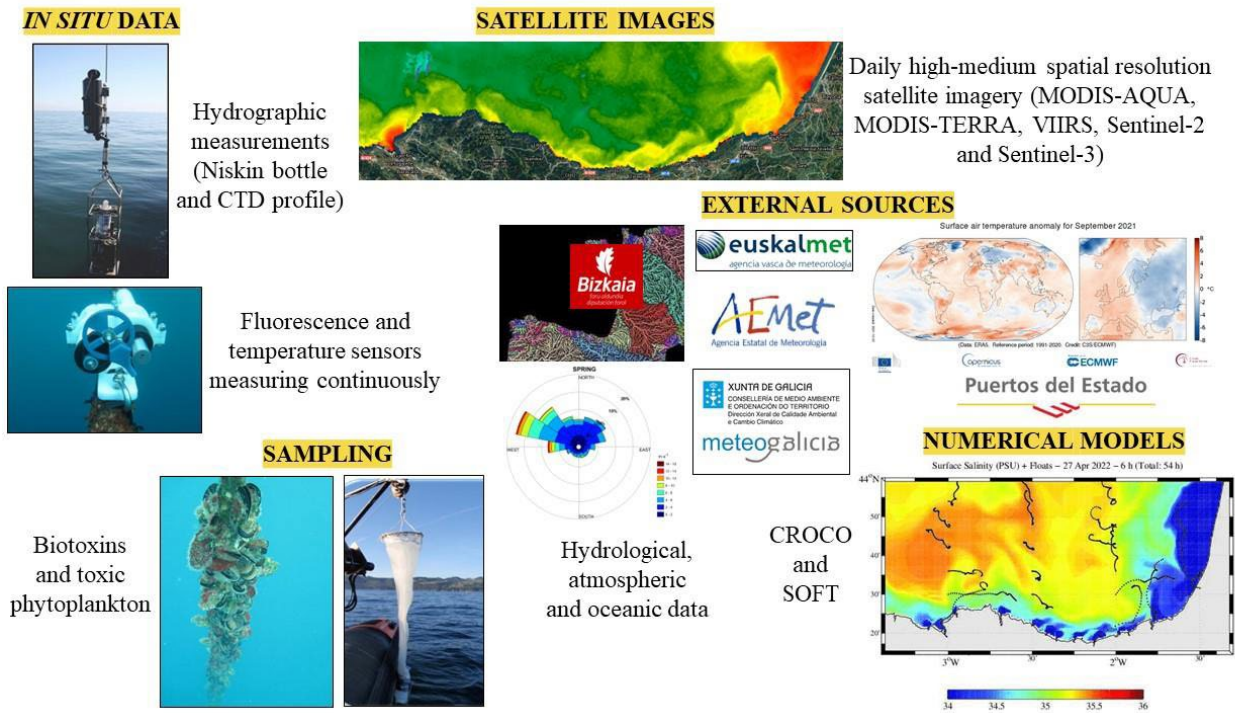


Fig 2. Integrated Marine Observing System established in Mendexa

RESULTS AND CONCLUSIONS

The okadaic acid, a “Diarrhetic Shellfish Poisoning” toxin produced by the dinoflagellate *Dinophysis acuminata* in this area, exceeded its regulatory limit every year in spring. Other dinoflagellates caused the banning of the production on some occasions due to yessotoxins (at the end of spring and autumn) and PSP toxins (in autumn and winter). However, the domoic acid, an “Amnesic Shellfish Poisoning” toxin which is produced by some *Pseudo-nitzschia* species, was rarely detected, and never the azaspiracids. Spring and autumn were the most affected seasons and, consequently, with the highest risk of closure of the Bivalve Mollusc Production Area. During some toxic episodes, the most likely trajectories of the responsible species were determined in the surrounding area. On the one hand, *D. acuminata* peaked during the conditions of thermal homogeneity and haline stratification that are typical of the late-winter and spring blooms in the Bay of Biscay. This dinoflagellate appeared in cell densities above an alert threshold of 100 cells L⁻¹ in association with anomalous colder waters and the predominance of northerly winds. The advection induced by these northerly winds could have favoured the transport of *D.*

acuminata from the open sea to the coastal zone. On the other hand, the PSP toxins were close to the banning limit on 18 January 2022. This event coincided with a fluorescence peak and was preceded by conditions of high rainfall and temperatures 10 days before. *Centrodinium punctatum* and *Alexandrium cf. ostenfeldii* (potential PSP species) were observed in autumn and could have been the responsible species of this event, in which GTX1,4 accounted for 71% of the toxicity and GTX2,3 for the rest. For this specific event, two possible geographical origins were identified using the SOFT model: (i) the coastal zone near the Ondarroa estuary, if the bloom started 84 hours before the peak measured in Mendexa, and (ii) the northwest offshore area of Mendexa, if the bloom started earlier.

ACKNOWLEDGEMENTS

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ID28 UNCREWED SURFACE VEHICLES NETWORK IN SUPPORT TO EOOS: THE EUROSEA PROJECT

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ABSTRACT

A wide range of platforms and systems constitute the current Global Ocean Observing System (GOOS) including satellites, research vessels, floats, underwater gliders, fixed-point observatories, sea level stations, high frequency radar and uncrewed surface vehicles. The European Ocean Observing System (EOOS) is designed to align and integrate Europe's ocean observing capacity, promote a systematic and collaborative approach to collecting information on the state and variability of our seas, and underpin sustainable management of the marine environment and its resources. EOOS attempts to link the currently disparate observing system components and promote novel technology and infrastructure development, standardization, open access to data, and capacity building. Within the framework of EOOS is the EU-funded EuroSea project, with the overall goal to consolidate an integrated interdisciplinary ocean-observing-system to deliver essential information for the wellbeing, blue growth and sustainable management of the ocean, based on the implementation and coordination of the different observing networks above-mentioned, being the Uncrewed Surface Vehicles (USV) technology one of the novelties in terms of network initiative attempting to engage existing and forthcoming actors from public and private sectors, to consolidate an international USV network under common standard operational procedures and regulatory framework in support to EOOS strategy.

Keywords – USV, ASV, network, EOOS, ocean, EuroSea.

THE EOOS FRAMEWORK

The Ocean Observing System includes different networks, integrating their data output in assimilation centers that feeds into the assimilation and forecast systems. A wide range of platforms and systems constitute the current global ocean observing infrastructure, including satellite observations, research vessels, autonomous floats, underwater gliders, fixed-point observatories, sea level stations, high frequency radar and autonomous surface vehicles [1]. Currently the ocean observing system remain largely immature and is composed of a large and diverse set of actors, such as research institutes, governmental agencies and the private sector [2]. The European Ocean Observing System (EOOS) is a coordinating framework designed to align and integrate Europe's ocean-observing capacity, promote a systematic and collaborative approach to collecting information on the state and variability of our seas, and underpin sustainable management of the marine environment and its resources. An overarching strategy across all measurement platforms is required to ensure that best use is made of limited resources in Member States and at European level [3]. EOOS attempts to link the currently disparate components of the observing system in Europe and promote novel technology and infrastructure development, standardization, open access to data, and capacity building.

Within the framework of EOOS is the EU-funded EuroSea project, with an overall goal about to consolidate a more integrated interdisciplinary ocean observing system able to deliver essential information for the wellbeing, blue growth and sustainable management of the ocean, based on the implementation and coordination of the different observing networks above-mentioned. The USV technology is one of the main novelties in terms of network initiative that attempts to engage existing and forthcoming actors from public and private sectors, to set and coordinate current and upcoming efforts in order to establish and consolidate a recognized international network under common Best Practices and Standard Procedures in support to EOOS strategy.

USV TECHNOLOGY

Transition from research concept to commercial product and related services has not always been easy in most cases due to technology, business and policy framework constrains. Unmanned Surface Vehicles (USV) is one of the right domains to illustrate this evolution [4] [5]. Starting as small custom-prototypes operating near shore for survey and research applications to evolve a more complex and capable platforms able to operate also in highly demanding specific-scenarios or open-ocean areas for long periods in routine-fully-autonomous mode as single unit or fleet configuration [6] [7] [8]. This has enabled to pave the way to release a first approach on small and large-scale autonomous ships implementation as ultimate step in maritime autonomy. Technology developments enabling USV include a multidisciplinary set of cutting-edge sensors and systems for guidance, navigation, control, telemetry, propulsion, path planning, as well as specific tools for oversight operations and situational awareness, being key the inclusion of machine/deep learning and artificial intelligence techniques. USV capabilities and applications include nowadays a wide range of operations and services addressed to cover specific needs from marine and maritime sectors. The policy and regulatory environment of USV is being developed at high and global level by IMO for MASS implementation [9] [10]. We are nowadays facing a step further towards a new paradigm associated with cyber-physical systems, big data and autonomy as part of Shipping 4.0 and Digital Ocean international trends and strategies. Efforts in transport cost reduction, the global need of minimize emissions and the demand for improving safety at sea are three base reasons on why autonomous shipping is under consideration and early stages of implementation. The development and future implementation of vessels as MASS (Maritime Autonomous Surface Ship) will represent an inflexion point for the paradigm shift in the industry and maritime shipping system as a whole. Industries related to high specialized technology base sectors such autonomy and automation, unmanned operations, big data, artificial intelligence, machine learning, enterprise-grade connectivity and analytics will be essential. As ultimate regulator responsible for the COLREGs, the International Maritime Organization (IMO) in 2017 agreed to include marine autonomous surface ships (MASS) in agenda and started with a scoping exercise to determine how the safe, secure and environmentally sound operation of MASS might be introduced in IMO policies and rules.

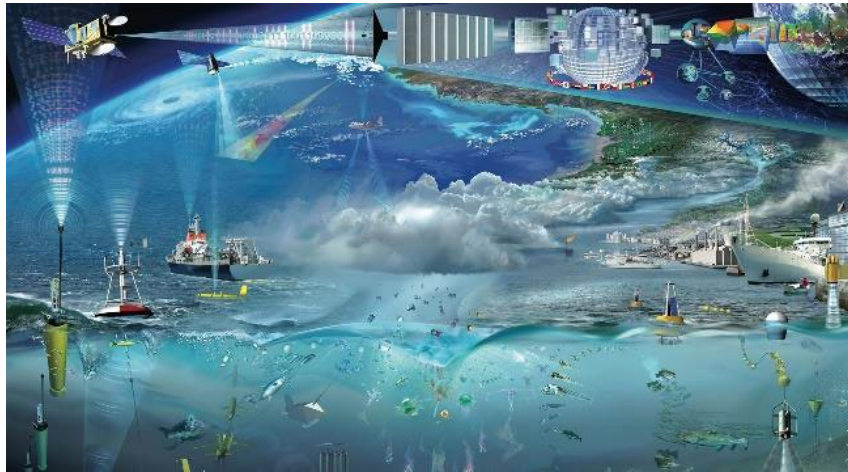


Fig. 1. Conceptual approach of the Global Ocean Observing System based on existing monitoring technologies.



Fig 2. Some of the USV technologies currently available for ocean-observing

ACKNOWLEDGEMENTS

The authors want to acknowledge the EuroSea project coordination board as well as the EuroGOOS Secretariat for their support to this initiative. Special mention also to all the companies, institutions and stakeholders already engaged and committed to make the USV network real and useful for the EOOS community in benefit to society.

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ID29 ENHANCING MARINE ECOSYSTEM MONITORING THROUGH THE INTEGRATION OF POP-UP BUOYS WITH WIRELESS COMMUNICATION AND SATELLITE CONNECTIVITY

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ABSTRACT

Upgrading underwater communication capabilities for seafloor monitoring: The PLOME project's innovative pop-up buoy concept for near-real-time data collection and transmission.

Keywords - Stand-Alone Oceanographic Platform, Seafloor Ecosystem Monitoring and Pop-Up Buoys.

INTRODUCTION

The rise in the ocean temperature caused by industrial and transport pollution has forced marine species to migrate to other habitats in search of suitable environmental conditions [1]. Additionally, overfishing has severely depleted the stock of some species, such as tuna [2]. Policymakers have implemented marine protection policies to mitigate these effects in response to global awareness. However, there is an urgent need to improve our understanding of marine ecosystem to quantify the effectiveness of such policies. This improvement relies on adequate spatiotemporal multiparametric monitoring procedures that require technology to play a central role.

Underwater-cabled observatories with video capabilities, such as those presented in [3], are essential for acquiring multidisciplinary oceanographic and biogeochemical data for monitoring marine ecosystems and their species. These observatories provide knowledge on different ecological indicators such as species richness and biodiversity. However, their high deployment and maintenance costs, as reported in [4], have led to the increased use of standalone platforms for ecosystem monitoring in temporary deployments. Articles [5] and [6] reported other stand-alone seafloor ecosystem monitoring platforms, including video acquisition. However, access to data in these examples is only possible after the recovery of the platform, making new real-time and in-situ communication strategies necessary to monitor the data acquisition status.

METHODOLOGY, RESULTS and DISCUSSION

The PLOME (Platform for Long-lasting Observation of Marine Ecosystems) project, funded by the Spanish Ministry of Science and Innovation, aims to improve the communication capabilities of standalone seafloor platforms. By integrating several remote stations with Autonomous Underwater Vehicles (AUVs) and Unmanned Surface Vehicles (USVs), data can be collected and transmitted in near real-time. This project included the use of pop-up buoys to expand communication capabilities. These buoys, upgraded with sensing, processing, and communication capabilities, are released periodically to transmit stored data and positions

through a satellite link, providing scientists with access to data before the station is recovered, and ensuring proper experimental functioning.

As shown in the schematic (Fig. 1) the pop-up buoy must have a microcontroller, Wi-Fi, logging, communication, GNSS modules, and an autonomous power system. However, the development of pop-up buoys poses technological challenges. One challenge is to include a wireless link to transmit oceanographic data to the internal storage of the buoy [7]. Wi-Fi is the selected technology due to its low-power capabilities [8].

Another challenge is to develop an automated release mechanism that can maintain the positive buoyancy of a buoy. As a preliminary mechanism, Nd magnets driven by a motor equipped with an endless screw were tested [9].

The pop-up buoy must have a reliable satellite communication unit to transmit data during the drift phase. The Kinéis system, which uses Argos-4 network nanosatellites, is a cost-effective and low-power solution to achieve global coverage. This technology has already been used for drifters as stated in [10]. A test proved its effectiveness in pop-up buoys [11]. Additionally, the buoy must have a battery pack to power all modules before and during release, which requires low power consumption and a well-designed sleep-wake cycle.

CONCLUSION

This work aims to address the challenges faced in marine ecosystem monitoring by developing an innovative solution that integrates seafloor stand-alone remote stations with pop-up buoys to transmit data in near-real time through a satellite link. The use of pop-up buoys with sensing, processing, and communication capabilities enables the collection of scientific and engineering data, without the need to recover the station. Although there are technological challenges related to the development of pop-up buoys, including wireless communication, automated release mechanisms, reliable satellite communication, and battery power, our work aims to develop a proof-of-concept design to demonstrate the feasibility of transmitting data from stand-alone platforms in near-real time to validate its correct operation without the need to recover it.

ACKNOWLEDGMENT

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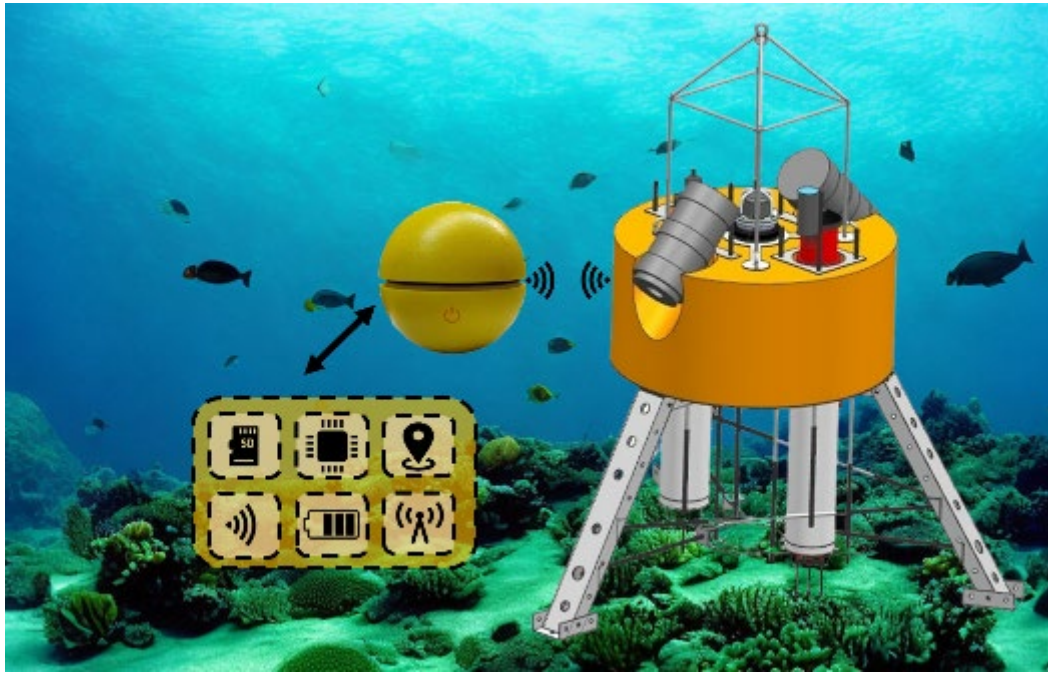


Fig. 1. Seafloor ecosystem monitoring platform from PLOME, with the under design pop-up buoy and its main functionalities.

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ID30 THE CIM-UVIGO PLUG-IN HYBRID PROPULSION VESSEL FOR COASTAL OCEANOGRAPHIC RESEARCH: A TOOL FOR THE ECOLOGICAL TRANSITION

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We present an oceanographic research fiberglass reinforced polyester vessel of medium size (19.5 m length x 5.4 m beam) and plug-in hybrid propulsion complemented by a power generation system based on solar panels with polycrystalline cells connected to a charger and two wind turbines connected to their control systems. The vessel will be equipped for scientific research tasks in seas and coastal waters, with an operating cost that makes it viable in the long term, that is environmentally friendly, with an efficient management model, and that facilitates the collection of oceanographic data of high technical quality.

The construction is promoted by the Centro de Investigación Mariña de la Universidade de Vigo (CIM) and commissioned to Rodman Polyships. The vessel's 3-day autonomy will facilitate oceanic observation, the study and monitoring of the effects of climate change on the marine-coastal ecosystem, marine ecotoxicology, sustainable exploitation of marine resources (living and non-living) and integrated management of the coastal zone. It

aims to strengthen the center's capabilities to address with greater assurance and competence some of the most critical societal challenges related to climate and environmental change, for which the generation of ocean data is a crucial element to provide adequate information to support the development of the sustainable blue economy.

The infrastructure will be managed as a general service provided by the Marine Environment Unit of the Estación de Ciencias Mariñas de Toralla (ECIMAT), a Research Support Center (CAI) organically dependent on the CIM, with the capacity to invoice and provide the necessary technical assistance. It will be made available to the international community through the European Marine Living Resources Research Infrastructure (EMBRC-ERIC) to which ECIMAT belongs, and through the participation of CIM research groups in other European infrastructure networks such as EMSO or EPOS.

ID31 CIM-UVIGO MESOCOSMS FACILITIES: A REALISTIC EXPERIMENTAL APPROACH FOR GRAND CHALLENGES IN OCEANOGRAPHY

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ABSTRACT

Marine mesocosms, the closest experimental approach to the marine ecosystems, are a powerful tool to study ecosystems functioning, to address those problems derived from global change and to test mitigation strategies. During the last years the CIM-UVIGO has worked to create a highly automated mesocosm facility able to address a wide range of studies, from benthos to pelagic communities, simulating different environmental conditions and future scenarios.

Keywords – Mesocosms, global change, oceanography, grand challenges

INTRODUCTION

Mesocosms are experimental water enclosures close to natural conditions, in which environmental conditions can be manipulated in a realistic way. They represent the closest experimental approach to the natural environment, with greater volumes than laboratory experiments, including different trophic levels. They represent a powerful tool to study the real world but also to simulate future scenarios and to address grand challenges [1] (acidification, brownification, warming, eutrophication, pollution, etc.) and to test possible remediation approaches for those problems derived from global change, as ocean alkalization, artificial upwelling, etc.

CIM-UVIGO MESOCOSMS FACILITIES

Mesocosms facility of the Centro de Investigación Mariña de la Universidade de Vigo (CIM) has capacity to allocate different experimental designs, including benthic, pelagic and benthopelagic experiments (Fig.1). This highly automated system includes real-time monitoring of the experimental tanks and the environmental conditions, measuring the main variables with a 10 minutes frequency (temperature, conductivity, dissolved oxygen, pH, irradiance, etc.). A tide-simulation system is also installed in the tanks, in which the range of the tide can be defined by the user and both temperature and salinity can be set-up to vary with the tide, simulating the changes observed at the inner part of the estuaries during the tidal cycle. This facility is able to provide 30 m³/h of natural or filtered seawater at environmental temperature, cooled up to 12°C or warmed up to 25°C. Water can be UV disinfected and the experimental tanks include air and gasses supply (O₂ and CO₂) as well as fresh water. All the processes to control the water supply are also automated, with real-time monitoring and control of pumps, heating and cooling systems and alarms set to send a notification in case of deviation from the set-up values.

This infrastructure is managed as a general service provided by the Oceanography Unit of the Estación de Ciencias Mariñas de Toralla (ECIMAT), a Research Support Center (CAI) organically dependent on the CIM, with the capacity to invoice and provide the necessary technical assistance. It is available to the international community through the European Marine Living Resources Research Infrastructure (EMBRIC-ERIC) to which ECIMAT belongs, through the European mesocosms network (AQUACOSM-plus H2020 project) and through the participation of CIM research groups in other European infrastructure networks such as EMSO or EPOS.



Fig 1. Experimental tanks for pelagic, benthopelagic and benthic mesocosms experiments

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ID32 AN APPROACH TO THE APPLICATION OF ADDITIVE MANUFACTURING FOR WATER ENVIRONMENTS: A CASE STUDY TO MEASURE DISSOLVED CARBON DIOXIDE

IVÁN IBÁÑEZ-FELIP¹²⁶, ROSARIO VIDAL¹²⁷

ABSTRACT

This paper describes the design of a case for the grouping and protection of the elements required for the quantification of dissolved carbon dioxide, allowing measurements to a depth of 10 meters. The possibility of implementing additive manufacturing (AM) technologies to reduce the production cost and design capabilities of the system is studied.

Keywords - Additive manufacturing, Product design, Carbon dioxide, Low-cost, Dissolved

INTRODUCTION

To understand the variability of carbon dioxide concentrations in different terrestrial systems, field measurements are necessary and require high quality equipment which must be used in large quantities and over long periods of time. However, the existing products on the market are excessively expensive.

This situation has led to the proliferation of projects for the adaptation and implementation of Non-dispersive Infrared sensor

(NDIR) technology [1,2,3]. NDIR sensors offer good performance at low cost and minimal maintenance and infrastructure requirements [4,5]. By contrast, there are few case studies with the purpose of forming a container/enclosure that protects the different electronic equipment from the aqueous environment, being mainly studied in this field the surface measurement equipment [3,6,7].

This work focuses on the creation of a housing for the grouping of the elements necessary for the quantification of carbon dioxide dissolved in water, allowing measurements to be taken at a depth of 10 meters. The ability to implement additive manufacturing technologies in order to reduce the production cost of devices is also studied.

THE APPLICATION OF ADDITIVE MANUFACTURING

Two additive manufacturing techniques were studied, Fused Deposition Modeling (FDM) and Stereolithography (SLA) for their technical capabilities and market presence. Thus, two prototypes of similar shape and purpose were manufactured with both techniques. PET-G was used for FDM while ELEGOO ABS-like photopolymer resin was used for SLA. The different casings were immersed in water to a depth of 5 meters to observe the particularities of the technique and possible complexities, Figure 1.



Fig 1. A: FDM prototype immersed in water. B: SLA prototype open.

RESULTS

Limitations of the FDM technique due to the presence of defects/holes in parts resulted in low watertightness, although, surface finishes of two coats of polyester resin were applied by brush.

On the other hand, SLA offers better performance together with the use of surface finishes, making it possible to obtain watertight housings. However, the use of photopolymer resin presents problems of embrittlement and deformation when exposed to prolonged periods of time, these facts should be studied in greater depth.

CONCLUSIONS

Through the different prototypes it has been possible to conclude the capabilities and methods for the use of additive manufacturing in the conformation of parts/devices for aqueous environments. Likewise, a functional prototype of a probe for the measurement of dissolved carbon dioxide case to measure dissolved carbon dioxide has been generated, which can be used in future research.

ACKNOWLEDGEMENT

This study forms part of the projects GEIROV, funded by Universitat Jaume I (UJI-B2021-61, and JELLYFISH-towards a sustainable precision aquaculture based on robotics, AI and low-cost sensors”,

included in the Aquaculture programme supported by MICINN with funding from European Union NextGenerationEU (PRTR-C17.11) and by Generalitat Valenciana (ThinkInAzul/2021/037, 2021-25).

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ID33 LONG BASELINE (LBL) POSITIONING SYSTEM FOR THE CRAWLER TELE-OPERATED UNDERWATER VEHICLE IN OBSEA OBSERVATORY

AINHOA IDIONDO MOLINA¹²⁸, DANIEL M. TOMA²⁴

Keywords: *Tele-operated Underwater Vehicle; Acoustic Communications; Hydrophone Array; Long Baseline (LBL) Positioning*

ABSTRACT

Due to the increased interest in maritime exploration, underwater robots, or remotely operated underwater vehicles, are essential to marine research projects like monitoring ocean pollution. [1], marine biology exploration [2], [3], and industry applications [4], [5]. Reliable navigation data is necessary for effective navigation and control of the tele-operated underwater vehicle, and precise placement is required. [6]. A long-baseline system (LBL) is an acoustic positioning technology for underwater vehicles, affording high accuracy and a broad operational spectrum [7], [8]. But in a low signal-to-noise ratio (SNR) and reverberation environment, biological noise, multipath fading channels, and other environmental noise commonly affect an LBL positioning system, reducing the underwater vehicle distance measurement accuracy and

ultimately affecting the vehicle positioning accuracy.

Designing a special configuration of an LBL system in the OBSEA cabled observatory[9] environment, we will be able to detect with more precision the objects that are under the water and incorporate them to improve the navigation and, therefore, the mapping of the robots. This work is based on the OBSEA cabled observatory, which is part of the EMSO (European Multidisciplinary Seafloor and water column Observatory), and the underwater Crawler [10], a Remote Observation Vehicle (ROV), which is a modified version of the “Wally” platform series. The Crawler is easily deployable for monitoring to depths up to 50 m. In this work we use an acoustic system of uWave modems [11] with the NeXOS hydrophones [12] for getting a LBL position system. Later, we used this system to determine the position of the Crawler using triangulation around the OBSEA platform.

As it is illustrated in the Figure 1 we position the four hydrophones and a modem on the top of the artificial reef, at 3 meters high from the seafloor, close to the OBSEA, in order to avoid interferences in

the acoustic link between the modem from LBL assembly and the crawler. The modem sends a ping request that is received by the modem that is located in the Crawler, and responds with a ping. During this time, each hydrophone is recording the acoustic communication in wav format. When we have the audio file, we start processing it and after denoising we extract the transmission and reception time, by detecting the exact time between the transmission and reception of the two modems in each hydrophone. With

this information we determine the time difference between the four hydrophones and we triangulate and obtain the angle with respect to the modem located on the Crawler. The distance is given by the modem and the time difference of arrival (TDOA) give us the direction. With this information we can know the position of the Crawler around the OBSEA. Moreover, we detail the results obtained for the acoustic acquisition system calibration test done in air, small aquarium, pool and sea scenarios.

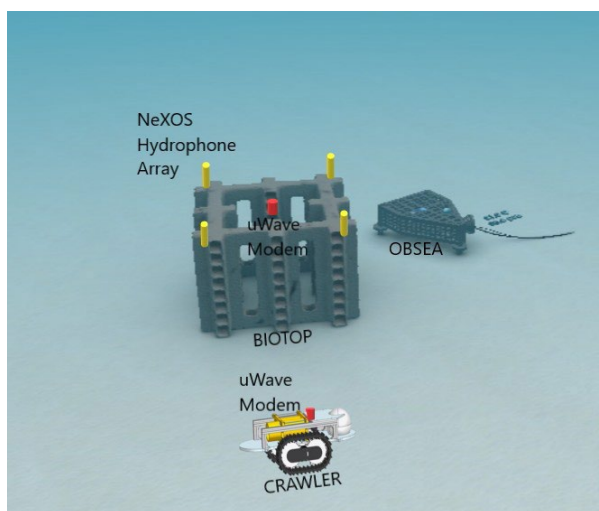


Figure 1 Architecture of Crawler LBL at OBSEA observatory

ACKNOWLEDGEMENT

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ID34 AUTOMATIC SYSTEM FOR 3D PHOTOGRAMMETRY OF SMALL ARTIFICIAL BIOTOPES USING THE CRAWLER REMOTE OPERATING VEHICLE AT OBSEA OBSERVATORY

MEISHAN OLIVER¹²⁹, DANIEL M. TOMA²⁴

Keywords: *Tele-operated Underwater Vehicle; 3D Photogrammetry; Underwater Photogrammetry*

ABSTRACT

Nowadays, the need to save the sea is getting more recognized, which is why marine technologies are so important. These can perform different functions complicated by people or help in science studies. 3D photogrammetry can help with different seabed studies, such as marine biology [1] or visualizing the evolution of a marine artificial biotope [2]. Getting the evolution of a marine artificial biotope can help with different issues investigations such as the ecological niche, the functional relationship between biodiversity and ecosystem processes such as production, and the applied problems of nature conservation such as designing nature reserve systems or networks.

This work is based on the OBSEA cabled observatory [3], that is part of the European Multidisciplinary Seafloor and water column Observatory (EMSO), and Remote Observation Vehicle (ROV), the underwater Crawler [4], a modified version of the “Wally” platform series. The new ROV is easily deployable for monitoring benthic

communities, such as biotopes. The Crawler has an 360° HD camera with a 180° tilt embedded in a glass sphere on the front of the vehicle, allowing a panoramic view (FOV). The control of the Crawler camera has been enhanced with a semiautomatic underwater 3D photogrammetry. Semiautomatic, because the Crawler control and the image taking was automatic, but the photogrammetry part, was manual. For the 3D photogrammetry we have tested different opensource programs, such as Agisoft Metashape, Meshroom, Regard3D and COLMAP.

All these programs generate a 3D model through imported images. Images must be taken along the entire surface of the desired object, using different angles and directions, to obtain more or less detail with more or fewer images. We have done a review to choose the best option, and in our case, it was Agisoft Metashape, using the demo version.

In this work we present the results obtained through a circular circuit around the biotope, as shown in Figure 1, stopping at different point to take photos at three different angles, close enough to detect details. And, as the photos are taken, the Crawler processes and calibrates them, to create the photogrammetry more easily later.

Agisoft Metashape	Stand-alone software product that performs photogrammetric processing of digital images and generates 3D spatial data. Agisoft PhotoScan Standard (Version 2.0.0) (Software). (2022*). Retrieved from http://www.agisoft.com/downloads/installer/
Meshroom	Free, open-source 3D Reconstruction Software based on the AliceVision framework. Meshroom (Version 2023.1.0) (Software). (2023*). Retrieved from https://alicevision.org/#meshroom
Regard3D	Regard3D contains many third-party libraries and programs. All of them are published under an open-source license. Regard3D (Version 1.0.0) (Software). (2023*). Retrieved from https://www.regard3d.org/index.php/download
COLMAP	COLMAP is a general-purpose Structure-from-Motion (SfM) and Multi-View Stereo (MVS) pipeline with a graphical and command-line interface. It offers a wide range of features for reconstruction of ordered and unordered image collections. COLMAP (Version 8.3) (Software). (2023*). Retrieved from https://github.com/colmap/colmap/releases

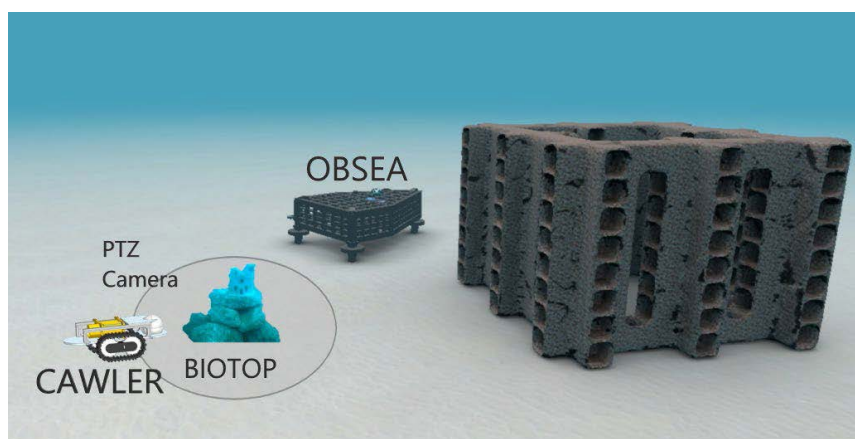


Figure 1 3D photogrammetry of small biotopes with Crawler

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ID35 EXPERIMENTS ON ZEBRAFISH USING MINI ROBOT FISH PROTOTYPES TO IDENTIFY STRESSORS

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ABSTRACT

This paper describes the behavioural tests carried out with real fish to study their behaviour and stress against the different prototypes of mini-robot fish with the aim of identifying stressors and reducing them when designing future robots for aquaculture.

Keywords - Aquaculture, fish behaviour, robot-fish, stress factors, robot biomimicry

INTRODUCTION

Certain research papers provide detailed reviews of the main characteristics of fish [1][2], on how changes in morphological structure, patterning, coloration or movement of fish affect how they relate to other fish of the same species [3], and also on the behavior of fish schools when interacting with robotic fish-like systems [4][5][6]. Based on this information, different prototypes of small free-swimming robotic fish are developed in this project, with relative similarity to zebrafish (*Danio Rerio*), with the objective of determining and reducing the stressors introduced by a robot in aquaculture applications.

Three robotic fish prototypes have been developed: two based on the redesign of a commercial robotic fish driven by electromagnetic actuators, focused on imitate the zebra fish shape, and one prototype based on an original design driven by a servo motor

and controlled remotely via Bluetooth, focused on testing different tail beat frequencies.

EXPERIMENTAL SETUP

For the behavioural tests, planning has been carried out, developing a matrix of factors that allows all aspects to be tested on different versions of the prototype, by the colours used, the pattern of the lines on the back, the shape of the body, the size or the beat of the tail, among other possible stress factors.

For these analyses, different tests have been performed, using different sized tanks since the space available to the fish to face the threat may influence their response. Firstly, first contact tests (Fig.1) have been carried out, analysed in a preliminary way by ocular inspection and time measurement, until the fish no longer feels threatened. This helps us to get information that can be useful in planning and guiding the subsequent detailed experiments. These first contact tests were carried out with isolated individuals, to study their response to the robot individually, and then with more than one individual to study the change in behaviour when the situation is faced as a group.

Secondly, behavioural tests were performed with isolated individuals in narrow tanks for 2d image processing analysis. The image software allows statistically to determine the significance of the studied variables and their potential stressor degree.

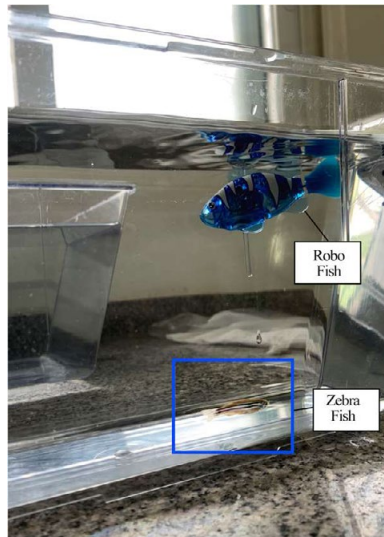


Fig 1. Preliminary test with robotic fish

CONCLUSIONS

Through the different prototypes of mini-robot fish and thanks to the different stress tests carried out with real fish, it has been possible to determine the factors present in the robots that can cause greater stress in the fish, in order to modify or avoid them in future prototypes and obtain less stressful robotic fish.

For these behavioural tests with zebrafish, the stress response of the fish when faced with a robot that could be interpreted as a stranger or a threat was studied. As a part of the future work of this research line these results can be applied in the design of a more robust and technologically capable prototype that can be tested in tanks with larger fish or directly as a part of an inspection system in fish farms.

ACKNOWLEDGMENT

This study forms part of the projects GEIROV, funded by Universitat Jaume I (UJI-B2021-61), and "JELLYFISH-towards a sustainable precision aquaculture based on robotics, AI and low-cost sensors", included in the Aquaculture programme supported by MICINN with funding from European Union NextGenerationEU (PRTR-C17.11) and by Generalitat Valenciana (ThinkInAzul/2021/037, 2021-25).

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ID36 PROCESSING ACOUSTIC IMAGES FOR THE EXPLOITATION OF FISH FARMS

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ABSTRACT

This work presents a processing methodology that uses data from a SONAR sensor located on a HROV to support the exploitation and management of fish farms.

Keywords - Sustainable aquaculture, underwater Remotely Operated Vehicles, underwater acoustic imaging

INTRODUCTION

The European Union's Blue Growth Plan [1] proposes that the future of fishery resources lies in smart, sustainable, and inclusive aquaculture production, which will play an essential role in providing food for the European population. To achieve this, it is crucial to use different technological solutions that support the sustainable exploitation of aquaculture farms and ensure their viability [2].

In recent years, modernization efforts in aquaculture have focused on estimating growth, biomass [3], and physical-chemical parameters [4]. Additionally, underwater vehicles equipped with special sensors are being used to provide information on the state of the ponds of the farms [5].

This work illustrates a processing methodology that allows extracting adequate information from the data provided by a MSIS (Mechanical Scanned Imaging Sonar) sensor that performs a 360° scan by using an acoustic beam, which has a wide vertical aperture and a narrow horizontal opening and generate acoustic cross sections of the environment [5].

The proposed methodology has been used within the framework of the KTTSeaDrones Project, funded by the European Union, and lead by the University of Huelva. In this project, two Hybrid Remotely Operated Underwater Vehicles (HROVs) [5] have been used to support the exploitation and management of fish farms, where the turbidity of the water is so high that it is impossible to use traditional optical sensors to visualize the objects in the environment of the vehicle (see Fig 1 a) and Fig 2 a).

Particularly, the objective consists in using acoustic images for locating the elements that are around the HROV and that may be

of interest for the exploitation of the installation. To this end, the proposed procedure makes it possible to locate the objects relative to the HROV and globally in order to create a geographic coordinates map of the bottom of the pond.

ACOUSTIC IMAGE PROCESSING

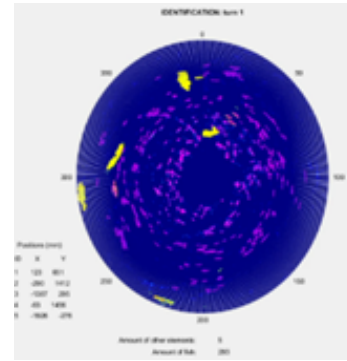
The data acquired by the Ping360 sonar provides information about the environment of the HROV. However, this information includes redundant data and noise that needs to be filtered to identify potential targets of interest for the farm's operators. Therefore, a processing mechanism with a series of stages has been implemented:

- Filtering of the bordering areas with the limit of the pond. At the edges of the pond, there are bounces and reflections of the signal that can lead to the identification of false objects. For this reason, a mechanism has been developed to exclude the bordering areas with the edges of the pond.
- Threshold filtering. This mechanism discards data that are the result of bounces with an intensity less than or similar to that of the signal returned by the water.
- Proximity noise filtering. Data close to the location of the HROV are discarded due to the appearance of false bounces of stochastic nature.
- Identification of elements according to the intensity of the returned echo and classified by proximity and connectivity. The data resulting from filtering represent physical elements that provide an echo signal with similar intensity and compact spatial distribution. Therefore, a processing technique based on clustering has been applied to group these elements based on their proximity and connectivity, as well as the homogeneity of the intensity of the received signal. As a result, a matrix of elements is obtained, characterized by the position of the groups' centroids, their size, and the intensity of the echo signal.

Once the processing is complete, the distances between the HROV and the centroid of each element are known, as well as the sectors where the elements are located. This information can be used to obtain the position of any of them referred to the local system of the HROV, giving the user a representation of the solid elements that surround the vehicle (see Fig 1 b).



a)

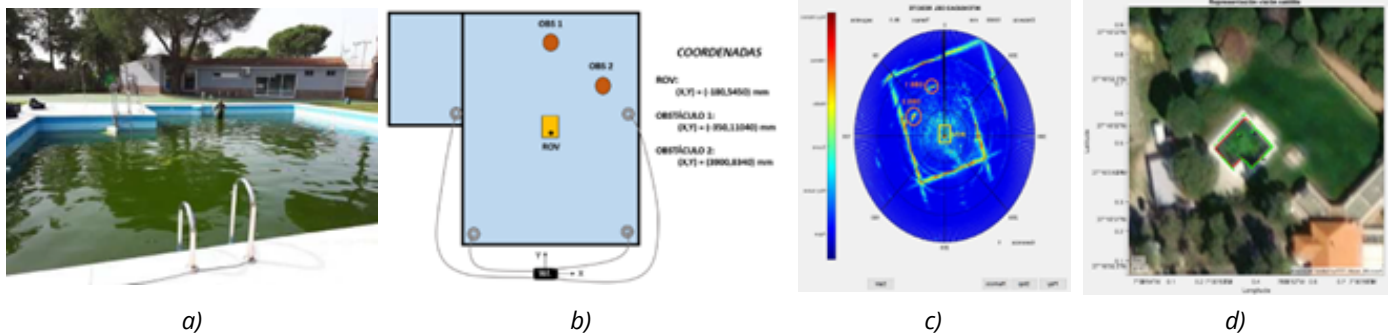


b)

Fig 1. a) Natural fish farm; b) Local Map

Additionally, by incorporating a global location system into the vehicle, it is possible to carry out a geographic mapping of each of the identified elements. Fig 2 illustrates an outdoor experiment, where several objects were located in a pool Fig 2 a). Fig 2 b) rep-

resents the setting of the experiment; Fig 2 c) shows the local map, and Fig 2 d) presents the objects represented in a geographic coordinates map.



CONCLUSIONS

This article illustrates a methodology for processing the information provided by a MSIS sensor in order to develop local and global maps of the bottom of a pond in a fish farm. The proposed approach has been tested in real scenarios in the context

of the KTTSeaDrones Project ('Conocimiento y transferencia de tecnología sobre vehículos aéreos y acuáticos para el desarrollo transfronterizo de ciencias marinas y pesqueras 0622-KTTSEADRONES-5-E') founded by the European Regional Development Fund (FEDER) through the Interreg Program V-A España-Portugal (POCTEP) 2014-2020.

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ID37 FURTHER TELEOPERATED EXPERIMENTS WITH AN UNDERWATER MOBILE MANIPULATOR VIA ACOUSTIC MODEM: MODEM CHARACTERIZATION

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ABSTRACT

In this study, we conducted preliminary experiments to characterize an acoustic sonar [1][2] for underwater communication. We carried on image transmission experiments and attempted to reduce reflections using insulating cork. Moving the buoy along the surface revealed the central area of the tank to have the best communication with Girona. We plan to conduct further experiments with the acoustic modem in a realistic environment. In addition, we are also testing Visible Light Communication (VLC) [3] optical

modems, which yielded better results than the acoustic modem. We aim to develop a multimodal system for improved communication under different environmental conditions.

Keywords - Underwater Communications, Robot Networks, Simulation, Remote Control, Hardware In the Loop, Optical Modem

SUMMARY OF EXPERIMENTS

We are following up with the acoustic sonar characterization experiments at CIRTESU. Firstly, we repeated the image transmission experiments previously conducted and explained in the Oceans article.

Nevertheless, due to problems with reflections caused by the tank walls, we attempted to reduce the reflections by using insulating cork. However, this did not improve communication. We also per-

formed various tests by moving the buoy along the surface to identify areas with better communication with Girona, and the best results were obtained in the central area of the tank, as we can see in figure 1.

Our next test with the acoustic modem will be carried out at the Port of Castellón, as we believe it to be a more realistic environment.

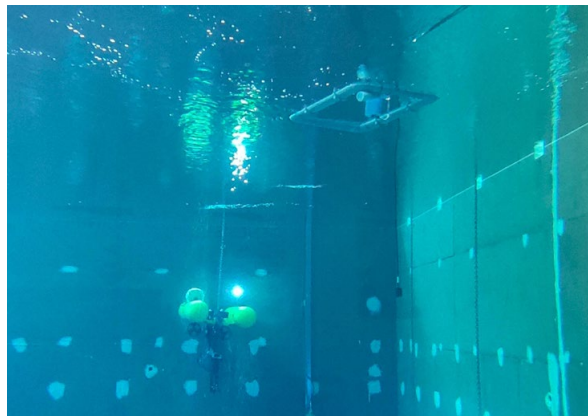


Fig 1. Cirtesu stage with the buoy located in the middle of the tank

Meanwhile, we are conducting experiments at CIRTESU using Visible Light Communication (VLC) optical modems (reference) to improve communication and develop a multimodal system with two communication modes to obtain the best communication conditions regardless of the environment. We can see in figure 2 a scheme of the scenario.

Preliminary tests with the optical modem yielded much better results than those conducted with the acoustic modem. However, the major disadvantage of the optical modem compared to the acoustic modem is the range, which is limited in theory to 50 meters. Therefore, we aim to develop a multimodal system that will allow us to communicate using the optical modem and switch to the acoustic modem in case of loss of communication. Although

the acoustic modem has a lower bandwidth, it has a much greater range. Moreover, we can use both modems simultaneously, allowing us to take advantage of the acoustic modem to obtain location information, operation and supervision commands. Furthermore, with the optical modem, we can obtain images in real time and there is even the possibility of connecting several robots to each other to carry out cooperative tasks.

With the acoustic modem, we can also calculate the distance between the buoy and Girona, which will help us determine when to switch between communication modes. Furthermore, by knowing the depth of Girona and its relative distance to the buoy, we can orient the optical modem using a servo motor.

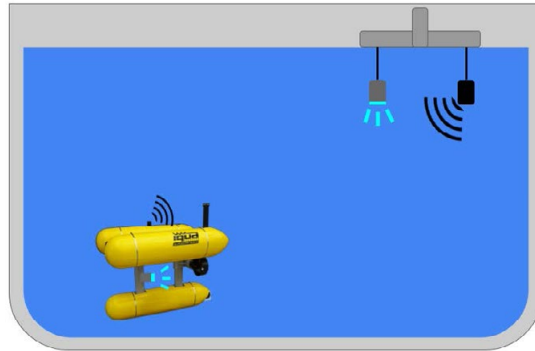


Fig 2. Diagram of the tank with the two modems

CONCLUSIONS

In conclusion, our preliminary experiments with both acoustic and optical modems have shown promising results for underwater communication. While the acoustic modem has a greater range, the optical modem has higher bandwidth and performs better in terms of communication quality. Developing a multimodal communication system that incorporates both modems could provide the best of both worlds, allowing for improved communication

under various environmental conditions. Future studies will focus on refining the multimodal system and conducting more experiments in realistic underwater environments.

ACKNOWLEDGMENT

This contribution has been partially funded by Spanish MICINN under PID2020-115332RB-C31 grant (COOPERAMOS Project)

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ID38 TOWARDS SAMPLING OF THE CIRCALITTORAL BENTHOS FOR MONITORING IMPACTS ON MARINE COMMUNITIES: LIMITATIONS AND NEXT STEPS.

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Keywords – ROV, circalittoral floor sampling, circalittoral monitoring, monitoring impacts tool.

Direct sampling in marine research refers to sample collection in which the scientist observes the sampling process at any moment (Eleftheriou, 2013). This category includes, among others: scientific scuba diving, the use of ROV (Remotely Operated Vehicle) or tripped submarines such as the bathyscaphe. Autonomous diving or any other type of diving technique has several limitations in the collection of samples in deep areas, since physically and physiologically the human being is not adapted to withstand the environmental characteristics in these areas. Therefore, scientific work at depths below 30 m is not a highly recommended option. Consequently, the monitoring of the marine communities of the circalittoral bottom requires advanced robotic techniques focused on sampling specific species, avoiding the risk for the scientist. One of the biological communities of greatest interest for monitoring the impacts of human activities such as aquaculture or fishing is the biocenosis of Coralligenous habitats, where the gorgonian facies stands out due to the high presence of filtering organisms. The main Mediterranean gorgonian species are located in mesophotic or subcoastal benthic zones (30 to 150 meters deep) (Coma et al., 1994), being the study of these populations of interest for the monitoring of the seabed as contemplated in the framework of the OCECOSVAL project of the ThinkinAzul program in the Valencian Community (Spain). To study the evolution of these organisms we use a Bluerov2-VP-300M equipped with 4 LED lights (Lumen Subsea Light), a 150 m umbilical cable, two LASER pointers and a manipulator arm with clamp. However, the possibilities offered by commercial models do not solve some key problems such as the collection of several independent samples in one dive, which would be of great interest for population genetics studies to understand the differential population dynamics of species such as *Paramuricea clavata* (Risso, 1827) classified as vulnerable (IUCN, 2021). Thus, these studies will contribute to the improvement of the conservation status of vulnerable circalittoral species of the deep infralittoral where it is very relevant to track large areas of the bottom to locate specimens of *Pinna nobilis* (Linnaeus, 1758) in critical status of extinction (García-March et al., 2020; IUCN, 2021). In the context of this workshop meeting, we propose the adaptation of this device with new functional tools that even make possible the translocation of specimens to more favorable areas for the development of the population, thus avoiding its disappearance (Chiappone et al., 2003). In conclusion, increasing and enhancing the usefulness of ROVs for sampling and scientific work at depths not recommended for divers, would facilitate the study and knowledge of many species that a priori

are inaccessible to humans.

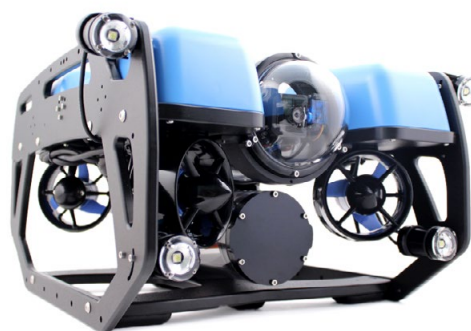


Fig 1. Remotely Operated Vehicle Bluerov2-VP-300M [Source: Qstar ROV & sub-sea solutions, 2023].

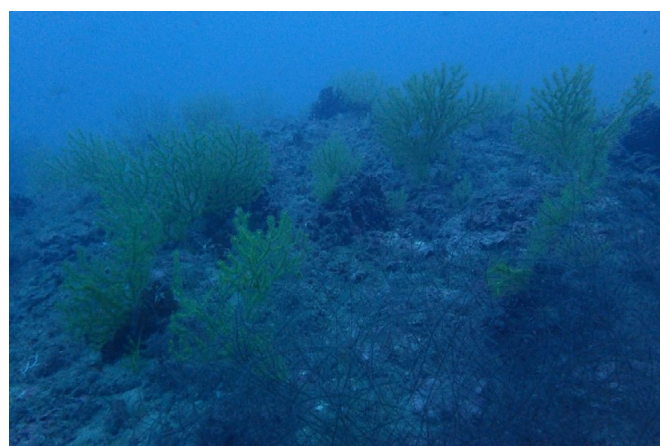


Fig 2. Gorgonian specimen of *Paramuricea clavata* [Source: IMEDMAR-UCV, 2022].

ACKNOWLEDGMENTS

This study forms part of the ThinkInAzul programme and was supported by MCIN with funding from European Union NextGenerationEU (PRTR-C17.11) and by Generalitat Valenciana.

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ID39 LOW COST GREENHOUSE GAS SENSOR: GIDA-GEI

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ABSTRACT

This paper presents a low-cost compact Bluetooth sensor designed to periodically measure both in and out of water the concentration of greenhouse gases such as CO₂, CH₄ and N₂O. For this purpose, it has several sensors and modules connected and controlled by an Arduino Nano Every.

Keywords – Greenhouse, Low-Cost, Arduino, Underwater, Wireless

LOW COST GREENHOUSE GAS SENSOR

GIDA-GEI is a low-cost compact Bluetooth sensor designed to periodically measure both in and out of water the concentration of greenhouse gases such as CO₂, CH₄ and N₂O. For this purpose, it has several sensors and modules connected and controlled by an Arduino Nano Every.

Once the system is turned on, it can be operated completely wirelessly from any device capable of running a Bluetooth serial. It does not require constant communication, only the connection is necessary to start and stop the value recording process.

All readings from the gas, pressure, temperature and global positioning sensors are transmitted via Bluetooth and recorded in the system's internal memory. The values can be tracked during the measurement process or downloaded after the end of the sampling period.

The system uses a 3000 mAh battery at 7.4V, which provides a life service of 10 hours with periodic recordings of all sensors every minute. However, the battery life can be extended depending on the application in which GIDA-GEI will be used, for example, underwater surveys where the GPS signal will not be recorded and constant Bluetooth communication is not feasible, the use of these modules can be turned off or reduced. Another option to extend the operating time of the sensor is to mount a larger battery, the system can support up to 12.6V batteries.

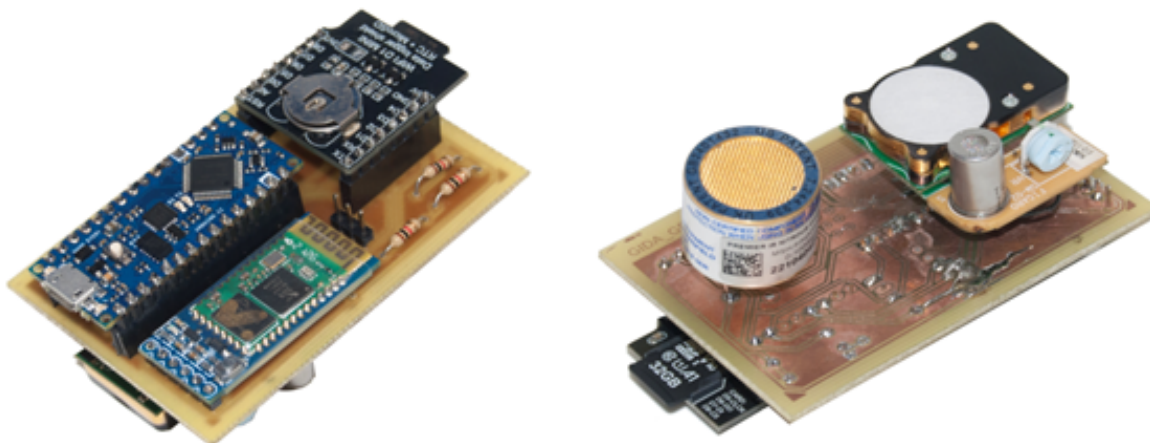


Figure 1: GIDA-GEI front and rear

COMPONENTS

The GIDA-GEI system is composed of seven electronic modules connected to an Arduino Nano Every through a printed circuit board. Four of them are sensors to record different properties of the environment, while the other three are a RTC - Micro SD module (Wemos d1 mini data logger shield), in charge of keeping the date and storing the values recorded by the sensors, a Bluetooth module (HC-05) that allows wireless communication with the system and a GPS module (Air 530). With all these components GIDA-GEI dimensions are 8 x 4 x 3 cm, figure 1.

These are the sensors incorporated in GIDA-GEI:

- Figaro NGM2611-E13 is a pre-calibrated module for natural gas, in this case it is used to measure the CH₄ concentration.

The module uses TGS2611-E00 which incorporates a filter to eliminate the influence of interference gases. The measurement range of the sensor is 300 - 10000 ppm.

- COZIR-LP 500 is a low power NDIR CO₂ sensor that uses a solid-state LED optical technology. The measurement range of the sensor is 0 - 5000 ppm.
- DYNAMENT N₂O is an infrared gas sensor for Nitrous Oxide gas over the range 0 - 1000 ppm.
- BMP 280 is a low power environmental sensor with thermometer and barometer.

Figure 2 shows the electrical connection of the modules with the Arduino.

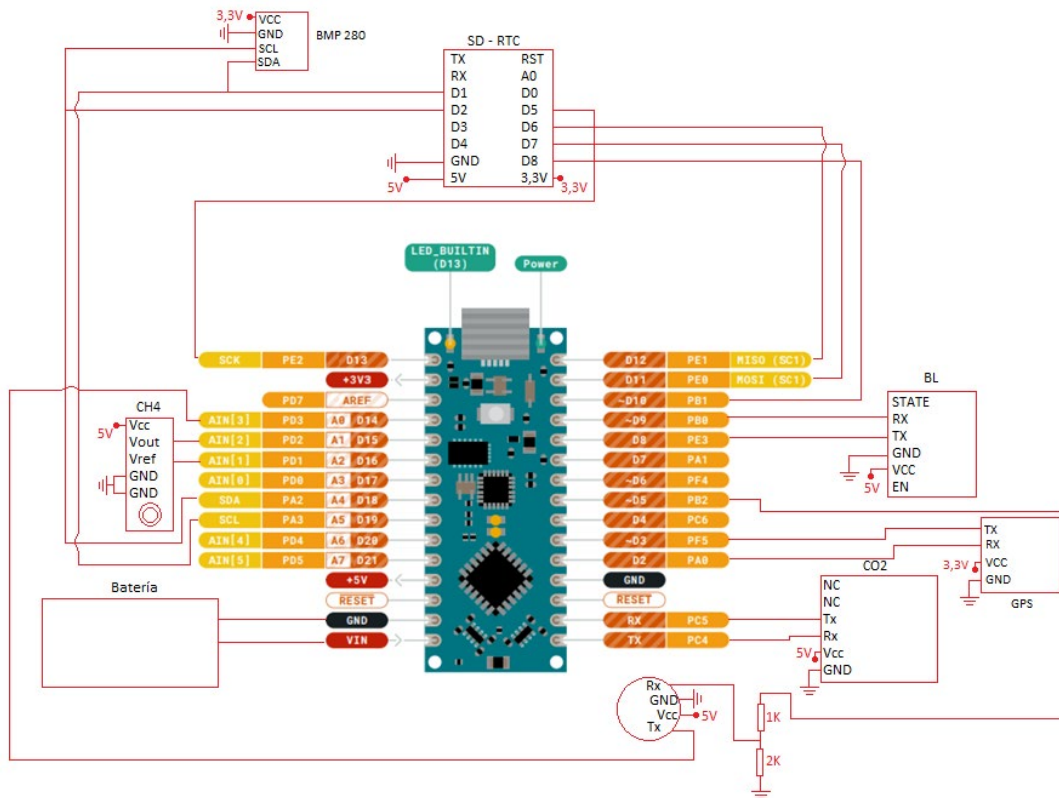


Figure 2: Electric scheme.

CONCLUSIONS

GIDA-GEI is a prototype for the underwater measurement of greenhouse gases with great potential and very low cost. Future work will proceed to design the printed wiring board with the aim of reducing power consumption and dimensions, resulting in greater sampling autonomy.

ACKNOWLEDGEMENT

This study forms part of the projects GEIROV, funded by Universitat Jaume I (UJI-B2021-61, and JELLYFISH-towards a sustainable precision aquaculture based on robotics, AI and low-cost sensors", included in the Aquaculture programme supported by MICINN with funding from European Union NextGenerationEU (PRTR-C17.11) and by Generalitat Valenciana (ThinkInAzul/2021/037, 2021-25).

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ID40 TOWARDS AUTOMATIC HOLE DETECTION OF A NET FOR FISH FARMS BY MEANS OF ROBOTIC INTELLIGENCE

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ABSTRACT

In the last decades fish farms became one of the most important sources of seafood. This industry is facing complex and costly problems like net holes, especially due to unexpected situations, such as depredators and storm effects. This is a complex problem because fishes can escape from the fish farms containers or a depredator can enter in the container. To solve this problem divers are needed, but this solution is difficult and sometimes can be dangerous for the diver. The main objective of this work is to present the current state of a system where an underwater robot can detect holes in the net of a fish farm. Once the robot detects the hole it will proceed to manipulate it. This task is bordered using convolutional neural networks and the BlueROV2 platform with the Newton Gripper from BlueRobotics, which will be upgraded in a second stage to perform preliminary net repairs. This work contributes in the area of aquaculture, computer vision, underwater inspection and manipulation.

Keywords - Underwater Robots, Computer Vision, Underwater Manipulation, Aquaculture

INTRODUCTION

In the literature there are some works that have tried to solve the net holes problem. Most of them are able to solve the inspection. One example is the article of Lee, H et. al. [1], that proposes an autonomous set point distance between the net and the ROV. Other works like the gripper of the kraken ROV from Tech Stream [2], offer a solution to fix a net hole, while following a manual teleoperation with the help of an expert operator that controls the robot in every kind of movement. In this work a human-supervised autonomous inspection is presented, to be enhanced in a second stage also for repairs.

NET HOLE DETECTION

At the moment of writing, the net hole detection algorithm uses transfer learning from YOLO, and is being trained using a dataset with images of the real net installed at CIRTESU, in Universitat Jaume Primer. Figure 1 shows the labeling of the image and the test scenario. This net has been selected to simplify the image recognition, while a more realistic scenario will be used in a second stage.



Fig 1. At the left the net hole labeling and at the right the BlueROV2 inspecting the net

NET MANIPULATION

The current results demonstrate that the robot is able to approach the newton gripper to the autonomous recognized hole, under certain conditions. For fixing the net holes the solution will be to patch them temporarily, so that the diver can perform a more robust patch in a second stage. Figure 2 shows an image of the newton gripper facing the net hole.

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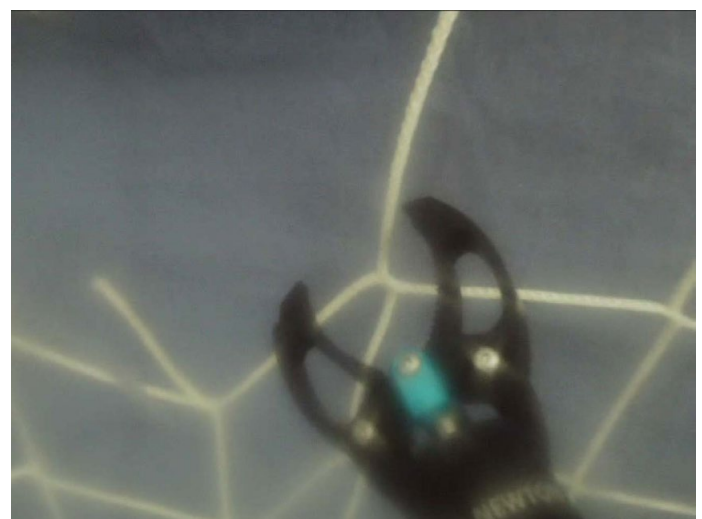


Fig 2. Net manipulation using the Newton Gripper

ID41 A DATA MANAGEMENT E-INFRASTRUCTURE FOR THE OBSEA CABLED OBSERVATORY

ENOC MARTÍNEZ²⁶, ALBERT GARCÍA-BENADÍ¹⁵⁵, DANIEL M. TOMA²⁴, MATÍAS CARANDELL⁴, MARC NOGUERAS¹⁷, JOQUÍN DEL RÍO¹⁹

ABSTRACT

Underwater cabled observatories are a key assets to monitor the oceans, providing high-resolution multi-parametric data from a wide variety of sensor systems. Their outstanding observational capabilities lead to significant amounts of data that need to be properly acquired, archived, curated and distributed. This paper presents the OBSEA e-Infrastructure, a modular data infrastructure to manage and distribute data from the OBSEA underwater observatory in a Findable, Accessible, Interoperable and Re-usable manner.

Keywords - Data Management, FAIR principles, Open Geospatial Consortium, SensorThings API, Cabled Observatories

INTRODUCTION

Underwater observatories are becoming a mature technology in the past decades, providing massive amounts of multiparametric data over large periods of time. Their ability to measure biogeochemical and physical parameters make them a valuable asset to understand the oceans. However, the management of such volumes of information proves a real challenge for small and medium-sized institutions. In addition to sensor data, activities such as maintenance, calibrations and deployment operations also need to be properly documented and archived. Applying the FAIR guidelines to this multidisciplinary and dynamic (meta)data is therefore a complex task [1].

An example of such installations is OBSEA, a cabled underwater observatory, located off-the-coast of Vilanova i la Geltrú (Spain) [2]. Since its deployment in 2009 it has been continuously acquiring heterogeneous environmental data such conductivity, temperature, depth, currents, waves, video, underwater sound, seismic activity physicochemical data among others. With more than 10 years of archived data, a modular and scalable e-infrastructure was required to manage both historical and real-time data. Furthermore, since OBSEA is part of several European initiatives such as EMSO, the integration of OBSEA's data services with further research infrastructures and data aggregators is required.

Different software tools and strategies have been proposed to address many of the data management, reducing the need of developing ad-hoc solutions. However, most of these tools address partially the requirements of data infrastructures such as data storage, access, visualization, alarming, etc. Therefore, data managers and sensor operators rely on several systems for their daily operations. This work proposes an e-infrastructure that leverages existing open-source and community-accepted tools into a coherent and organized (meta)data workflow.

OBSEA E-INFRASTRUCTURE

This e-infrastructure, depicted in Fig. 1, aims to reconcile two different aspects: support the daily activities of sensor operators and provide access to high-quality (meta)data. The former includes the management of operations (sensor calibrations, deployments, maintenance operations, etc.) while the latter provides (meta) data access following the FAIR guidelines to both human and machines. Since all the data acquired are usually sent to shore in real-time, all the elements in the data pipeline (acquisition, quality control, processing and storing) are automated. Human intervention is only needed to register new equipment or operations (deployment, calibration, etc.).

When sensor data comes into the e-infrastructure it is processed by a set of data acquisition scripts. These are in parse the data and performs some preliminary checks. Several tools are used, such as the SWE Bridge universal driver. The acquired data is then passed to the Real-Time Quality Control System (real-time QC in Figure 1), which adds quality information based on the QARTOD guidelines [3].

Once flagged, data is sent to OBSEA's e-infrastructure central component: the FROST Server (Fraunhofer Open-Source SensorThings Server), an implementation of the OGC SensorThings API (STA)[4], [5]. This standard from the Open Geospatial Consortium (OGC) defines a geospatial-enabled and unified way to interconnect the Internet of Things (IoT) devices, data and applications over the Web. Its flexible and powerful data model provides an ideal framework to encode all (meta)data components from complex sensor systems.

The e-infrastructure takes advantage of the expandable nature of the STA data model, encoding both contextual and operational metadata. Contextual metadata includes descriptive information about sensors and measuring stations: e.g. serial number, deployment information, contact person or sensor history. All this metadata is semantically enhanced by the use of controlled vocabularies from the NERC Vocabulary Service and provides machine-understandable context and meaning [6].

In addition to contextual metadata, operational metadata includes all the information required to automatize the workflow, such as quality control thresholds, instructions to integrate variables into datasets, scheduled tasks to be performed to a data streams (e.g. averaging), etc. Therefore, both (meta)data and configuration parameters are accessible through the SensorThings API, enhancing the traceability and data provenance.

The data ingested at the SensorThings API is periodically exported into ERDDAP and CKAN services [7], [8]. ERDDAP is a de-facto standard in the ocean observing community which provides standardized access to subsets of data in multiple formats. This service is used to ingest OBSEA's data into European research infrastructures such as EMSO and as a gateway for aggregators (MonGOOS, EMODnet, Copernicus, etc.).

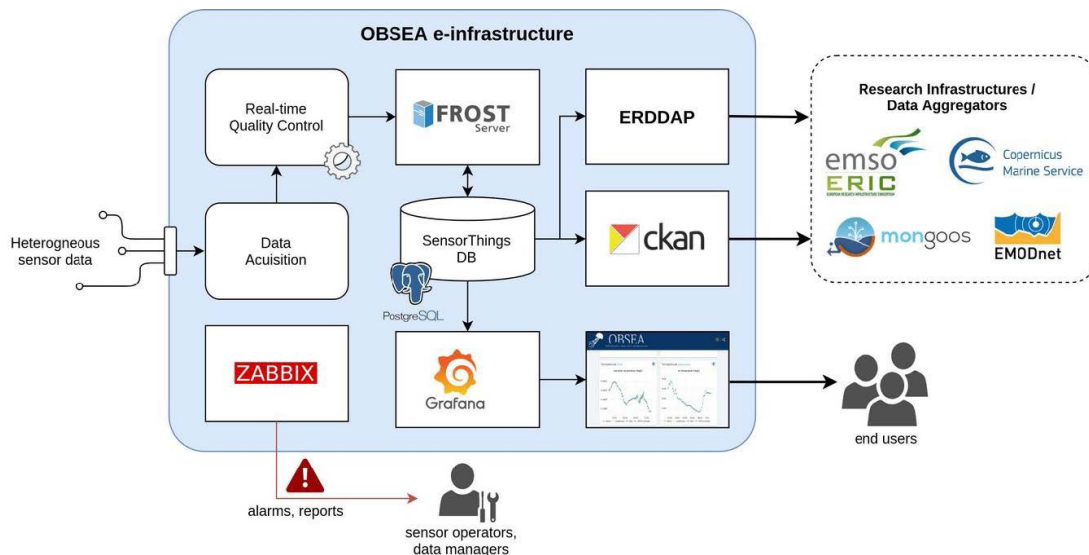


Fig 1. OBSEA e-Infrastructure dataflow and services. The incoming data from the sensors is parsed, quality-controlled in real-time and stored into a PostgreSQL database through a SensorThings API. Data is periodically exported to data services such as ERDDAP and CKAN, which are used as a gateway to data aggregators. For visualization purposes data a grafana service is deployed and connected with OBSEA web page. A zabbix service monitors the e-Infrastructure health and the data dataflow.

CKAN (comprehensive knowledge archive network) is an open-source data management system that includes a powerful data catalog system. Within OBSEA's e-infrastructure, CKAN is the final storage of the produced datasets, where DOIs are assigned and maintained. In addition to CKAN's web interface, it also provides a powerful API, granting access to its data and metadata to both humans and machines.

For visualization purposes, OBSEA's data is also connected to a Grafana service, where dashboards are generated for both

end-users and operators to internally assess the performance of the system [9]. Finally, the whole system health is monitored by a Zabbix alarming system, sending alarms and reports to the operators to quickly address any unforeseen situations [10].

CONCLUSIONS

In summary, the proposed e-infrastructure leverages existing software tools in order to achieve a complete FAIR data manage-

ment system. Its data is findable since each dataset in CKAN has an assigned DOI and integrated to other research infrastructures such as MonGOOS, EMODnet, Copernicus and EMSO. Its variety of data access interfaces (OGC SensorThing, ERDDAP and CKAN) make (meta)data accessible to both human and machines. It is interoperable, since it is semantically enhanced by controlled vocabularies using common formats. Finally, it is reusable due to the open licenses used, (cc-by) and thanks to the extensive metadata on data provenance provided.

ACKNOWLEDGEMENTS

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ID42 LOW COST USV DEVELOPMENT TO STUDY SPRING PONDS

JUAN LEANDRO RONDA¹⁵⁶, BOUALEM YOUCEF NASSIM BENABDELOUED¹⁵⁷, JOSÉ ENRIQUE TENT-MANCLÚS¹⁵⁸

ABSTRACT

Current practices in bathymetry survey in lakes (available method) are indeed having some limitations. As for instance the size of the equipment that has to be transported and then deployed in the lake. New technologies such as using USV (Uncrewed Surface Vessel or Unmanned Surface Vehicle) start to be common. As they are easy to transport, high manoeuvrability and permit to work in less than 1-m-deep water masses. A quite wide commercial offer has been developed for many uses but as this equipment do not have a high demand, it has a high cost. The USV uses in harbours and open marine waters is quite straightforward because the good visibility and easy access permit rescues of the USV in case of malfunction. Lake surveys have the problem of the densely vegetated margins, riparian vegetation, and sometimes also with floating natural/or rubbish elements. Commonly the survey is tracked away from the margins to avoid the possible problems, that in case of occur are major issues (rescue this non-cheap equipment). In these scenarios it is needed to establish some rescue protocols as, for instance a rope to the USV to pull, or transport a rescue boat to be sure to recover the equipment.

One of the most common problems is the underwater vegetation entangle in the propellers as normally is not seen by the observers or pilot. Overestimate the power thrust of the propellers can be a solution but commonly the unseen vegetation is more than the expected and the USV ends trapped.

Keeping all the previous in mind, and after the experience developing cheap, and easy-to-replace equipment as the Geophonino-W [1, 2], a wireless multichannel seismic noise recorder system which is suitable for array measurements (Geophysics), or seismic record station for earthquakes, it was developed our low cost USV.

Keywords – Spring Ponds, USV, bathymetry.

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It has a modular design first the floating part, as an aluminium structure with 125mm-diameter PVC-tube floats filled by polystyrene to prevent any accidental sinking. Then a control unit and the battery pack inside a plastic waterproof box, and finally the propellers jailed by a 1mm-light metal grid to prevent its obstruction. The USV can be held many devices as single beam Sonar, side scan sonar, multibeam, CTD-probes, cameras, etc...

The control unit is an Arduino microcontroller ATmega328g, with microSD, GPS NEO-M8N and Bluetooth HC-05 module. It is powered by a 12,6 V Li-ion battery that with a Furuno FCV-600L (50-200 kHz) single beam sonar installed allows a more than 4 hours autonomy. A green-light flash when the microSD card is recording data, and the Bluetooth is used to connect the cellular phone to the test the NMEA-183 string of the Furuno sonar being recorded.

The main advantage of this development respect to the commercial ones is that we can fixed and upgraded without limits. We can have a set many of different USV adapted to more or less vegetated lakes for the less price of one commercial one. Any loss of equipment is a problem but in this case is less a matter than when a high cost, inventoried, high technology piece of equipment is lost, and it has to be justified.

This work has been financed by the project PID2020-114381GB-I00 of the State Research Agency of the Ministry of Science and Innovation, funds from the thinkinazul NextGenerationEU program (PRTR-C17.11) of the European Union, project of the Generalitat Valenciana GVA -THINKINAZUL/2021/039 and the Institut Cartogràfic Valencià. It is a contribution of the research group of the VIGROB21-053 (University of Alicante).

ID43 ON THE DEVELOPMENT AND APPLICATION OF INTRUSIVE SENSORS FOR TWO-PHASE FLOWS CHARACTERIZATION IN COMPLEX ENVIRONMENTS

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ABSTRACT

Intrusive sensors are widely employed in numerous industrial applications to determine the phase fraction in gas-liquid two-phase flows. Such applications include those in the chemical, nuclear, and oil industries. This study aims to investigate the use of three distinct intrusive sensor topologies, specifically intended for underwater applications, wherein the detailed characterization of the disperse phase is the primary objective. Examples of such applications include aeration diffusers in wastewater treatment plants (WWTPs) and fish farming facilities.

Keywords – Two-phase flow, intrusive sensors, signal processing, aeration processes

INTRODUCTION

Two-phase flows occur in a multitude of scenarios, including both industrial and natural processes. In past decades, their study has primarily focused on topics related to the chemical, nuclear, and petroleum industries. Recently, their use has extended to other areas such as wastewater treatment, aquaculture, and natural water sources regeneration. In all of these cases, detailed characterization of aeration systems is of great utility. Such knowledge allows for the optimization of processes, from both energy efficiency and economic perspectives.

For example, in WWTPs, aeration processes typically require a significant amount of electricity to power the equipment used to generate and distribute air to the biological reactor. Therefore, the energy impact of aeration processes can be substantial, particularly in medium to large WWTPs. However, some aeration processes, such as diffused aeration, can be more energy-efficient than others, such as surface aeration. In the case of intensive marine aquaculture, the correct distribution of dissolved oxygen is one of the most important factors for ensuring the proper growth of fish. When the availability of food and dissolved oxygen is limited, the optimal temperature for fish growth is lower than when feeding and oxygen availability are not limited.

Therefore, monitoring and controlling the level of dissolved oxygen (DO) is necessary but complex in both WWTPs and marine aquaculture facilities, as it depends on multiple factors, including the physical and chemical properties of the water, available transfer area, turbulence of the continuous phase, etc. Having an accurate model of the behavior of gas-phase aeration systems (number and size of generated bubbles, distribution of void fraction, available interfacial area, etc.) is essential for optimizing and controlling these systems.

AVAILABLE INSTRUMENTATION

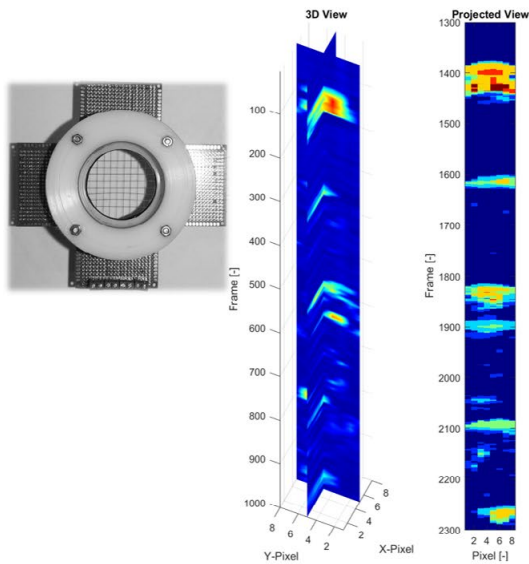
Instrumentation for measuring gas phase parameters includes local intrusive sensors. These sensors allow the complete characterization of any aeration system throughout local measurements, with high temporal and/or spatial resolution, of the main two-phase flow parameters: void fraction, bubble frequency, local velocity, and available interfacial area, etc. Basically, they identify the present phase in their measurement volume based on differentiating physical characteristics of the present fluids, such as conductivity (resistive or conductive sensors), permittivity (capacitive or impedance sensors), or optical properties (optical sensors). Among the different types, the following stand out:

- Conductivity sensors [1]: These sensors are composed of two or more sensitive tips. Phase discrimination is based on whether or not current passes between the sensitive tips. They allow for obtaining all local flow parameters. However, they require that bubbles pass through the sensor, so there are limitations regarding the minimum size of the bubble and the surface tension of the measured medium. They are widely used in water-air flows.
- Capacitive sensors: Phase discrimination is based on the difference in electrical permittivity of the fluid between electrodes (Figure 1). They allow measurements between non-conductive fluids and have no limitations in terms of detectable bubble size. Although similar to conductivity sensors, the signal processing of capacitive sensors is more complex, but their construction can be much more robust.
- Wire-mesh sensors: Unlike the previous sensors, measurements are not local but rather taken in a measurement plane (Figure 1). They allow for high-resolution temporal and spatial measurements. However, since it is a multiplexed system, they do not reach the temporal resolution of the previous sensors. Depending on the measurement circuit, they allow for measurements based on both conductivity [2] and permittivity [3]. The signal processing and electronics are more complex compared to the previous sensors.

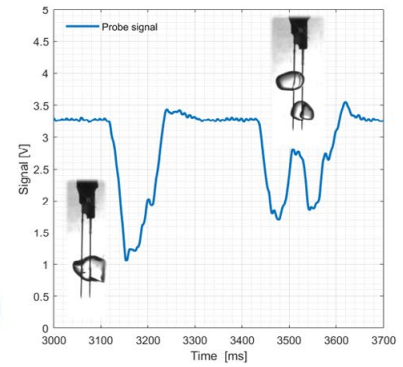
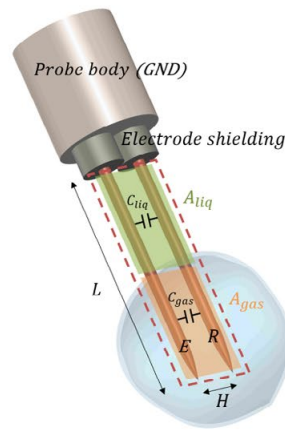
The choice of sensor type depends on the measurement conditions and the required data resolution, including the properties of the medium (maximum conductivity, minimum difference in permittivity between phases, viscosity, etc.) and the required sensor robustness.

CONCLUSIONS

Three types of intrusive sensors have been presented that allow for detailed characterization of the dispersed phase behavior in aeration systems. Due to their characteristics, these sensors can be widely applied in various complex environments, such as marine environments or biological reactors in wastewater treatment plants. Furthermore, these sensors can be used for inspection and maintenance activities, such as assessing the state of aeration diffusers.



Wire-mesh 8x8 sensor



Two-needle capacitance probe

Fig 1. Example of a wire-mesh with 8 sensing lines and an example of slug bubble measured passing through the sensor (left). Detail of two-needle capacitance sensor and isolated bubbles measurement example signals (right).

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ID44 THE BLUENETCAT – THE CATALAN REFERENCE NETWORK FOR THE KNOWLEDGE TRANSFER IN BLUE ECONOMY

PABLO BOU¹⁶⁴, LOURDES REIG¹⁶⁵

ABSTRACT

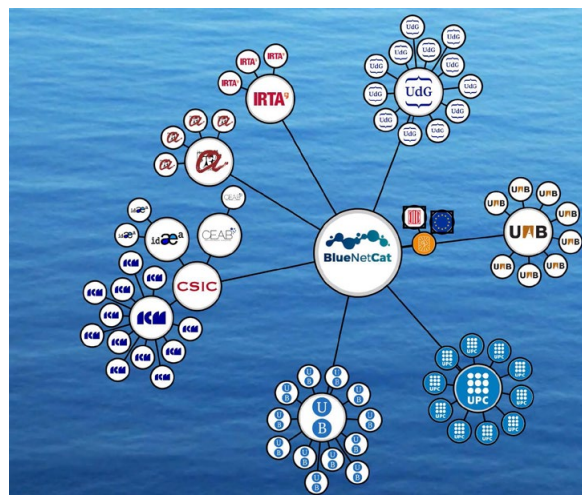
The blue economy is an essential sector to accelerate the green transition and to comply with the most important European and international regulations (e.g., the Blue Growth Strategy and the European Green Deal, and the UN Sustainable Development Goals).

In Catalonia, the blue economy accounts for about 5.8% of total employment and 3.4% of GVA. Due to the crucial location of the region within the Mediterranean Basin, and its scientific and technological capacity, Catalonia may be among the leaders in terms of innovation in blue economy, with huge potential to export innovation and to provide the whole society with huge benefits and positive impacts.

In 2018, Catalonia was among the first regions in Europe to adopt a maritime strategy according to the EU directives and regula-

tions. Within the Catalan Maritime Strategy, the technological transfer of innovation in blue economy plays a key role. Thus, the BlueNetCat (“Xarxa d’R+D+I Marítima de Catalunya” in Catalan, www.bluenetcat.eu) was designed as a tool to foster the technological transfer - in all the disciplines affecting the blue economy sectors - from the Catalan universities and research centers toward the market and the society.

Nowadays, the BlueNetCat (“Xarxa d’R+D+I Marítima de Catalunya” in Catalan) is an open innovation multidisciplinary community, accounting for more than 700 researchers, trainees, and technicians. The network is constantly growing and currently is composed by 67 research groups belonging to 5 Catalan universities (University of Barcelona, Autonomous University of Barcelona, Universitat Politècnica de Catalunya, University of Girona, Rovira i Virgili University) and 2 research institutions (the Spanish National Research Council, CSIC, with three different research centers, and the Institute of Agrifood Research and Technology, IRTA).



The BlueNetCat is constantly working to create a bridge with the quadruple helix by acting as a single innovation hub to link up the technological offer of the Catalan researcher with the market. The BlueNetCat has also a privileged situation in Catalonia, being part of the Catalan Maritime Co-ordination Council (CCCM) and at national level, being part of the Knowledge Space in Blue Economy of the Spanish Ministry for Agriculture, Fish and Food.

The BlueNetCat has also positioned itself at international level, collaborating and interacting with the most relevant initiatives and organizations (e.g. the Vanguard and the WestMED Initiatives, The European Regions Research and Innovation Network, the World Ocean Council).

In the past three years the BlueNetCat assisted 32 research groups with specific actions designed to bring their technology closer to the market or the society:

- 1 team was supported in the study of the commercial viability of the innovation.
- 1 team received help in the assessment of the economic viability of the technology.

- 6 groups were assisted in the definition of the market study and the business model.
- 7 research teams received support and assistance in elaborating their roadmap to the market.
- 8 teams were supported in the study for the protection of their intellectual property.
- 9 teams received assistance in the improvement of the Technology Readiness Level (TRL) or the Societal Readiness Level (SRL) of their innovation.

Among other projects, the BlueNetCat fostered different technological projects like, for example, an Integrated Geographic System for responsible anchoring, an Intelligent buoy for coastal management, an IoT tracking system for buoys and small vessels, and a PET-recycling system with engineered marine enzymes.

In the next three years, the BlueNetCat will continue to consolidate its integrative governance structure, also incorporating diversity and the participation of social agents active in the blue economy, to continue defining a co-responsible, participative, and transparent structure to make a positive impact in society.

In particular, the four main objectives for the period 2023-2025 are the followings:

(1) Consolidate the community as a structure for innovation transfer. This objective will encompass in particular:

- a. leverage the extensive and multidisciplinary expertise (Blue Skills) in thematic working groups, also open to stakeholders of the quadruple helix, organized to solve relevant Maritime Challenges.
- b. Grow up the portfolio of technologies and services the members of the network can provide.
- c. Empower the BlueNetCat members and relevant stakeholders with ah-hoc training sessions
- d. Foster the technological transfer by empowering the members of the network through and entrepreneurship program.

(2) create and identify open innovation environments to solve societal problems and needs. By proactively searching and detecting potential opportunities (including funding) and partners at Catalan and national and international level, the BlueNetCat aims at detecting the more relevant blue economy needs and opportunity for the society, while also positioning itself as an international reference in open innovation.

(3) Help the BlueNetCat members to exploit their knowledge and bring their technology closer to the market, in co-creation with the quadruple helix. This objective will be achieved by:

- a. Mentoring and supporting the members through strategic actions (e.g., studies and documents) that may help them along the process.

b. Fostering the internationalization of the technology through the BlueNetCat extensive networking.

c. Creating specific working sessions and events (e.g. the annual Maritime Hub) to foster the networking and interaction among the BlueNetCat members and relevant stakeholders of the quadruple helix.

d. Setting up a talent training incubation and acceleration service and a specific programme (BlueNetVal) to further develop the technical and entrepreneurial skills of the BlueNetCat members.

(4) Communicate and disseminate as key action to generate social impact. The BlueNetCat wants to promote Ocean Literacy, defined by UNESCO as understanding the influence of the ocean on you and your influence on the ocean, a fundamental step to act sustainably.

In the next three year, the BlueNetCat also aim at identifying more than 100 new technologies and to detect more than 30 new blue economy international challenges for the society, to increase the Readiness Level of at least 30 technologies and to provide assistance to at least 20 research groups.

Through its actions, BlueNetCat will generate a positive social impact, by providing key tools to pour the knowledge generated in the Catalan research ecosystem towards the most relevant stakeholders, thus allowing the sustainable creation of wealth and progress in the blue economy sector. Last but not least, by involving citizens and increasing their awareness about the marine environment, the BlueNetCat will contribute to making them co-protagonists in the protection and the sustainable use of marine resources.

Keywords – Technological transfer, knowledge transfer, Blue Economy, Entrepreneurship, Blue Skill, quadruple helix.

ID45 MARINE ECOSYSTEMS OBSERVATION BY A COOPERATIVE AUV IN THE PLOME PROJECT

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Keywords - Ecosystem monitoring, platform for observing, remote observation, AUV, underwater communications, underwater localisation, path planning, deep learning, image processing, optical and acoustic seabed mapping.

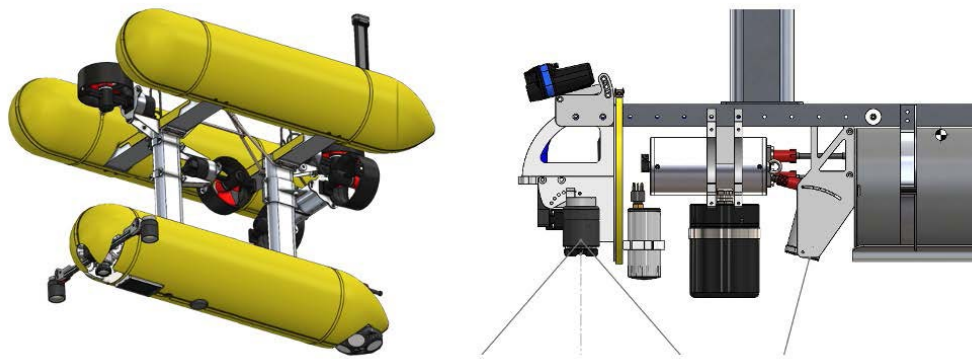


Figure 1. Girona 1000 AUV and its payload for the PLOME project.

ABSTRACT

To improve our understanding of how marine ecosystems function, it is crucial to quantify their processes using proper spatio-temporal multiparametric monitoring techniques. Science and innovative technologies must play a central role in developing the Blue Growth in a sustainable manner, where advances in enabling technologies such as remote sensing, modelling, AI and autonomous systems, will enhance our capacity to monitor and predict, assess and manage ecosystems. The PLOME project proposes a spatially adaptive, non-invasive, modular platform of independent and wirelessly connected benthic stations and AUVs to intelligently observe, monitor and map marine ecosystems, during long-lasting periods with real-time supervision. The monitoring solution has a simple deployment and is easy-to-move from an experimental site to another, without any cable installation, for coastal and deep water environments. Stations provide continuous and intensive temporal observation, while AUVs can provide such intensive measurement at spatial level, when they undock for a mission from a station in which they previously recharged batteries and transmitted information.

The PLOME project will demonstrate the proposed concept in two scenarios. The first one, involves testing independent capabilities in a real deep-sea scenario, while the second one entails a one-

week demonstration in shallow water, where an AUV will be operated from a docking station. This paper describes the Girona 1000 AUV from the Universitat de Girona that will be used for the deep tests, conducted at depths ranging from 200 to 400 meters. The AUV will be used in cooperation with two fixed stations developed by the Universitat Politècnica de Catalunya. Acoustic communications and ranges between the AUV and the stations will be used to coordinate the AUV's work and to improve its navigation. Optical communications will be used to transmit data to the stations gathered from the AUV observations. The AUV will integrate a multimodal sensor payload, including an optical camera and LED lighting system, a laser for microbathymetry and a forward-looking sonar for acoustic mapping. The AUV will also be able to process some of the data to transmit relevant information to the stations. Deep learning techniques will be used in real-time to detect species on the optical camera images, 3D point-clouds will be generated to describe the seabed's profile, and onboard acoustic mosaicking will generate an acoustic map of the seabed.

ACKNOWLEDGEMENTS

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ID46 SHARED AUTONOMY FOR MAPPING AND EXPLORATION OF UNDERWATER ENVIRONMENTS USING AN HROV

SEBASTIAN REALPE¹⁷³, NARCIS PALOMERAS¹⁶⁶, PERE RIDAO¹⁶⁹

ABSTRACT

One of the main goals in robotics is to achieve full autonomy. However, for certain tasks, robots still lack the level of abstract reasoning that gives the ability to make decisions, plan ahead, and change actions during the execution of a process, these abilities are acquired at its best degree only by humans. In terms of unknown underwater environments, the combination of specialized robotics that can withstand harsh environments and the reasoning of a human operator can give effective results on exploration, inspection, and subsequent tasks. Standard solutions propose to use fully teleoperated Remotely Operated Vehicles (ROVs) or fully Autonomous Underwater Vehicles (AUV). Still, both solutions have their drawbacks: high operation costs and limitations due to the need of a physical connection in the case of ROVs, and limitations in the communications or problems while facing complex decision making in case of AUVs. These limitations can be overcome with the concept of shared autonomy applied to a Hybrid ROV (HROV). In this new paradigm, an operator leads the mission by selecting objectives at a high level, and a HROV executes them taking all the low level decisions. This paper explores the shared autonomy concept applied to an underwater exploration task, leading the first steps towards intervention missions.

Keywords – Exploration, Frontier, Shared Autonomy, HROV, Clustering.

INTRODUCTION

Technology has always helped us tackle challenging tasks, from complex calculations to working in hard-to-reach places like underwater environments. Diving into this context, underwater robotics, such as Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs), have emerged as a solution for exploring these harsh environments. Both of these offer good results depending on the task to achieve, but also account for different challenges. While ROVs provide continuous control and

real-time feedback to operators, they need to be tethered to expensive vessels to achieve these capabilities. In contrast, AUVs can operate autonomously without constant supervision, but their level of autonomy is limited, normally, to basic survey tasks.

Joining both approaches (ROVs and AUVs), can settle a middle ground solution to ease these challenges. This can be established with the concept of Shared autonomy [1], where the high level thinking of a human operator can be combined with the autonomous execution of low level tasks by an HROV to achieve a complex goal.

METHODOLOGY

Although our end goal is to perform partially supervised intervention in underwater scenarios, the first task to achieve is to understand the environment by means of exploring it, to generate a map that can be used to navigate and perform further tasks. The approach in this paper is covered in three main pivots: the gathering of mapping data with on-board sensors, propose new locations to be mapped to an user using an utility metric, and then navigate to them using motion planning techniques. While basic tasks will be directly carried out by the robot, others will be validated by a human operator in the shared autonomy strategy trying to maximize safety and effectiveness.

This proposal uses the Octomap [2] framework as a mapping tool. From a point cloud obtained by a 3D laser sensor [3] or a stereo camera placed in the robot, an occupancy grid map is generated, giving a three dimensional representation of the environment using voxels. The map is structured as an octree, which is processed to locate frontier voxels, found on the boundaries between free space, and unknown space [4].

The frontier voxels are grouped by means of a clustering algorithm [5], which takes the position of said voxels as an input, and outputs a centroid position for each cluster of voxels in close proximity. These centroids are marked as suggested points to the user, allowing them to choose the next position of interest.

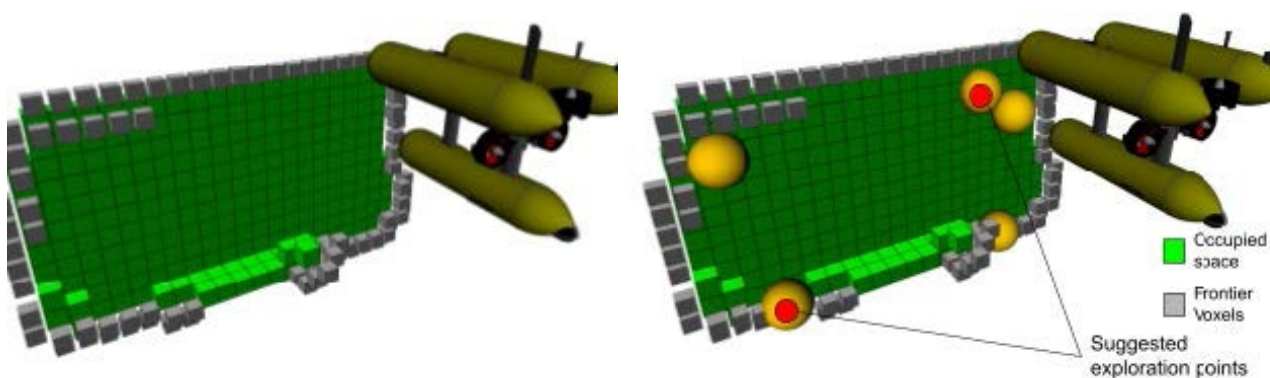


Fig 1. Suggested exploration points obtained by clustering frontier regions.

Once a suggested point is selected by the user, the robot will employ a motion planning algorithm to suggest a path, which the

user can also validate, or, request another path to be proposed.

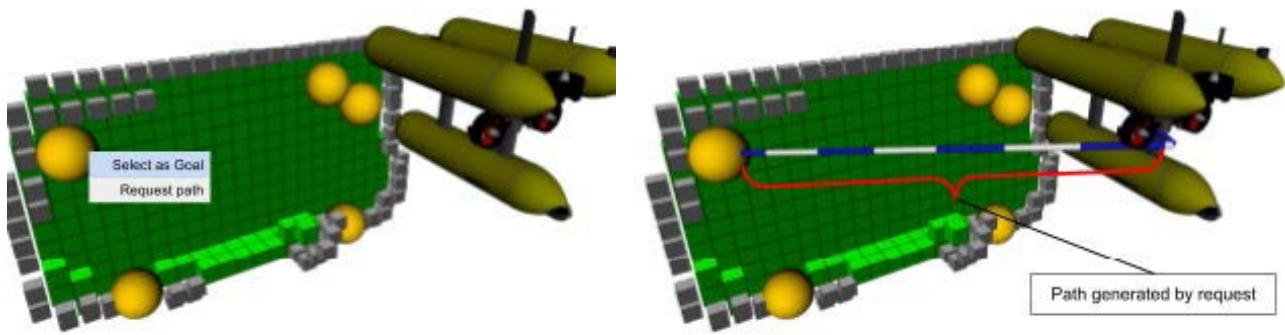


Fig 2. Path generation to selected cluster centroid as a goal.

As the robot navigates to these points, the map will keep growing, accomplishing the exploration task around the area of interest to the user through the shared autonomy technique. The robot will check that the path the robot is following is still valid, and in case it is no longer valid prompts the user how to proceed.

Communication between the HROV and the user can be performed over a low bandwidth channel and withstand significant

delays as the robot performs all low-level actions. For the proposed application, we propose to use an optical modem with a velocity of about 10 Mb/s but with a limited field of view that introduces additional constraints to both the exploration and the motion planning.

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