

INSTRUMENTATION VIEWPOINT

NEWS BULLETIN FALL 2016

NUM. **19**

MARTECH 16

7TH INTERNATIONAL WORKSHOP
ON MARINE TECHNOLOGY

Head Office

SARTI Technological Development Centre of Remote Acquisition and Data processing Systems Universitat Politècnica de Catalunya (UPC)
Rambla Exposició, 24. 08800 Vilanova i la Geltrú (Barcelona, Spain)

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COVER: Underwater picture

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The acceptance of the articles presented depends on their scientific quality and their adaptation to magazine's editorial line.



EDITOR'S NOTE

Welcome to the 7th International Workshop on Marine Technology – Martech Workshop 2016. The main objective of this workshop is to present the state of the art in Marine Technologies development and to encourage knowledge sharing between engineers and scientists in an environmentally friendly use in marine research. MARTECH workshop congregates a broad research community dedicated to developing innovative equipment in the field of marine sciences and technology. The MARTECH lecture series began in 2005, and this year 2016 we are moving to Barcelona. This edition is co-organized by the Consejo Superior de Investigaciones Científicas (CSIC) and the Universitat Politècnica de Catalunya (UPC), and will be held between 26th and 28th October 2016 in the Instituto de Ciencias del Mar (CSIC). MARTECH 2016 workshop will gather more than 50 contributions, which will be presented in two parallel sessions covering different topics: Operational Oceanography; Seabed Observatories and sensor networking; Marine Robotics perspectives; Image and underwater communication; Instrumentation, Marine aquaculture Technology; Marine Geophysical technology solutions; Science application citizens and interfaces; Polar Research Infrastructure challenges, Metrology, Signal Processing; Remote sensing; Characterization of seabed and water column; Coastal, and regional research vessels and offshore platforms. Two stimulating plenary sessions will cover two extreme marine environments which require high complex technology, as deep sea floor and polar research. The tutorial sessions on the 26th October will be stimulated by well-known marine technology companies showing their cutting-edge instrumentation, hoping that the participation of these companies will help the transfer of knowledge in both directions: science and industry. In addition to the technical sessions, there will be an exhibitor area where companies will show their products, services and projects to the assistants.

I thank all the authors and companies for their contributions and the attending participants at MARTECH Workshop 2016 for their interest and collaboration. I am most grateful to the many contributors to the organising committee, especially those from the Unidad de Tecnología Marina and Instituto de Ciencias del Mar (CSIC), the SARTI Research group (UPC) and the Museu Marítim de Barcelona for their support and effort in the preparation and organization of this hopefully successful event. I hope you enjoy and find fruitful the meeting, and I wish all of you an enjoyable time in Barcelona. Finally, I want to give Special acknowledgment to my friend Dr. Antoni Mànuel who was the initiator of these successful meetings.
Yours sincerely

Juan Jose Dañobeitia,
Barcelona October 2016
Martech Workshop 2016 Chair

MARTECH 2016 TECHNICAL PROGRAM

TIME	WEDNESDAY 26/10/2016
14:00 h	Registration
15:00 - 15:45 h	Kongsberg Subsea Technology update. By Morten Bersten
15:45 - 16:30 h	Multibeam data. Beyond depth and backscatter information. By Matías Morales
16:30 - 17:00 h	Coffee Break
17:00 - 17:45 h	AUV - Latest Technology - Payload Sensors and Results".By Atle Gran
17:45 - 18:30 h	Phased array antennas MBR. Maritime Broadband Radio. New revolution in maritime communications. By Miguel A. Lleches

TIME	THURSDAY 27/10/2016		
08:00 h	Registration		
09:00 - 09:45 h	Chair welcome Prof. J.J. Dañobeitia Inaugural Session Prof. A. Palanques Invited Conference 1: Prof. Paolo Favali European Multidisciplinary and Water-Column Observatory -(EMSO ERIC):Challenges and opportunities for Strategic European Marine Sciences		
10:00 - 11:30 h	<table border="1"> <tr> <td>A1 (ROOM 1) Seafloor Observatories and sensor networks Chair Joaquin del Rio</td> <td>A2 (ROOM 2) Operational Oceanography and Technology for Marine Biology and Aquaculture Chair Jacopo Aguzzi</td> </tr> </table>	A1 (ROOM 1) Seafloor Observatories and sensor networks Chair Joaquin del Rio	A2 (ROOM 2) Operational Oceanography and Technology for Marine Biology and Aquaculture Chair Jacopo Aguzzi
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11:30 - 12:00 h	Coffee Break		
12:00 - 13:30 h	<table border="1"> <tr> <td>B1 (ROOM 1) European Multidisciplinary Seafloor & Water Column Developments (EMSODEV H2020 EU Project) Chair Jaume Piera</td> <td>B2 (ROOM 2) Marine Robotics perspectives: ROVs, AUVs, ASVs, Gliders, Crawlers Chair Marc Carreras</td> </tr> </table>	B1 (ROOM 1) European Multidisciplinary Seafloor & Water Column Developments (EMSODEV H2020 EU Project) Chair Jaume Piera	B2 (ROOM 2) Marine Robotics perspectives: ROVs, AUVs, ASVs, Gliders, Crawlers Chair Marc Carreras
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13:30 - 14:30 h	Lunch		
14:30 - 16:00 h	<table border="1"> <tr> <td>C1 (ROOM 1) Seafloor observatories and sensor networks Chair Ivan Rodero</td> <td>C2 (ROOM 2) Marine Robotics perspectives Chair Daniel Toma</td> </tr> </table>	C1 (ROOM 1) Seafloor observatories and sensor networks Chair Ivan Rodero	C2 (ROOM 2) Marine Robotics perspectives Chair Daniel Toma
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16:00 - 16:30 h	Coffee Break		
16:30 - 18:00 h	<table border="1"> <tr> <td>D1 (ROOM 1) Remote sensing, Seafloor observatories and sensor networks Chair Nuno Gracias</td> <td>D2 (ROOM 2) Marine Robotics perspectives Chair J Borges de Sousa</td> </tr> </table>	D1 (ROOM 1) Remote sensing, Seafloor observatories and sensor networks Chair Nuno Gracias	D2 (ROOM 2) Marine Robotics perspectives Chair J Borges de Sousa
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21:00 h	GALA DINNER		

Companies Exposition

TIME	FRIDAY 28/10/2016				
08:30 h	Registration				
09:00 - 10:30 h	<table border="1"> <tr> <td>E1 (ROOM 1) Marine geophysics technology and solutions and underwater imaging and communication Chair Rafael Bartolome</td> <td>E2 (ROOM 2) Instrumentation, Metrology, Signal processing Chair Jose Martin Davila</td> </tr> </table>	E1 (ROOM 1) Marine geophysics technology and solutions and underwater imaging and communication Chair Rafael Bartolome	E2 (ROOM 2) Instrumentation, Metrology, Signal processing Chair Jose Martin Davila		
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10:30 - 11:00 h	Coffee Break				
11:00 - 11:30 h	Some announcements Invited Conference 2: Dr. Nicole Biebow Towards a better use of Arctic marine infrastructure				
11:45 - 13:15 h	<table border="1"> <tr> <td>F1 (ROOM 1) Polar Research and Citizen Science applications interfaces Chair: Veronica Willmont</td> <td>F2 (ROOM 2) Instrumentation, Metrology, Signal processing and seafloor and water column characterization, costal regional and offshore research vessels and platforms Chair Daniel Rey</td> </tr> <tr> <td colspan="2">F3 (ROOM 3): Meeting Thematic Network. MarInTech Member's</td> </tr> </table>	F1 (ROOM 1) Polar Research and Citizen Science applications interfaces Chair: Veronica Willmont	F2 (ROOM 2) Instrumentation, Metrology, Signal processing and seafloor and water column characterization, costal regional and offshore research vessels and platforms Chair Daniel Rey	F3 (ROOM 3): Meeting Thematic Network. MarInTech Member's	
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F3 (ROOM 3): Meeting Thematic Network. MarInTech Member's					
13:15 - 13:30 h	Closing Session and Martech 2016 announcement				
13:30 h	Lunch				

Companies Exposition

INVITED SPEAKERS

TOPIC	ID	ABSTRACT TITLE	PG
Conference 1	34	European Multidisciplinary and Water-Column Observatory - European Research Infrastructure Consortium (EMSO ERIC): Challenges and opportunities for Strategic European Marine Sciences	78
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SESSION A1

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	26	Video monitoring of Sparidae temporal rhythms: Three-year study by OBSEA cabled observatory	61
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SESSION A2

TOPIC	ID	ABSTRACT TITLE	PG
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	20	Using ORB, BoW and SVM to identify and track tagged Norway lobster <i>Nephrops norvegicus</i> (L.)	50
	21	Integrating data from Vessel Monitoring System and fish landings in Mediterranean small fleets, using a PostgreSQL database with PostGIS extension.	53

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TOPIC	ID	ABSTRACT TITLE	PG
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	48	The EGIM, modular though generic addresses the requirements of the EMSO platforms	103
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TOPIC	ID	ABSTRACT TITLE	PG
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	6	Improving ocean-glider's payload with a new generation of spectrophotometric ph sensor	22
	8	Development of a ROV Titanium Manipulator for light work ROV vehicles	25
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TOPIC	ID	ABSTRACT TITLE	PG
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	41	SWE Bridge: Software Interface for Plug & Work Instrument Integration into Marine Observation Platforms	92
	45	Galway Bay Shallow-Water Observatory: Installation, Commissioning and Research Opportunities	97
	46	Architecting the Cyberinfrastructure for the National Science Foundation Ocean Observatories Initiative (OOI)	99

SESSION C2

TOPIC	ID	ABSTRACT TITLE	PG
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	24	AUV/ASC cooperative survey	58
	25	5 Year-long Monitoring of Barkley Canyon Cold-seeps with the Internet Operated Deep-sea Crawler "Wally"	60
	31	Review of lessons learned after five years of shallow water AUV operations	72

SESSION D1

TOPIC	ID	ABSTRACT TITLE	PG
Remote sensing and Seafloor observatories and sensor networks	2	Recent Technical Innovations around HF radar Technology and steps towards Integrated National HF radar Networks	14
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SESSION D2

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Marine Robotics perspectives: ROVs, AUVs, ASVs, Gliders, and Crawlers	28	Seabed monitoring with Girona 500 AUV working as HROV	65
	37	Range-only benthic Rover localization off the central California coast	86
	44	The LSTS open-source communication and autonomy software: enabling networked vehicle systems to find, track, and sample dynamic features of the ocean	97
	47	Obstacle detection algorithm of low computational cost for Guanay II AUV	101

SESSION E1

TOPIC	ID	ABSTRACT TITLE	PG
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	27	Technological and infrastructure collaborative seismic research in western Mexico	63
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	29	Development of a prototype for submarine communications in shallow waters	67

SESSION E2

TOPIC	ID	ABSTRACT TITLE	PG
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	15	iObserver: Species Recognition via Computer Vision	37
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SESSION F2

TOPIC	ID	ABSTRACT TITLE	PG
Instrumentation, Metrology, Signal processing and seafloor and water column characterization, coastal regional and offshroe research vessels and platforms	19	Bares 2.0 wave buoy and sustainable buoy network	47
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	18	Inndaga: An environmental data acquisition innovation platform	44

INVITED SPEAKERS

CONFERENCE 1 – 27TH THURSDAY, 9:15 – 9:45 (ROOM 1)

EUROPEAN MULTIDISCIPLINARY AND WATER-COLUMN OBSERVATORY - EUROPEAN RESEARCH INFRASTRUCTURE CONSORTIUM (EMSO ERIC): CHALLENGES AND OPPORTUNITIES FOR STRATEGIC EUROPEAN MARINE SCIENCES BY

PROF. PAOLO FAVALI, INGV, ROME, ITALY

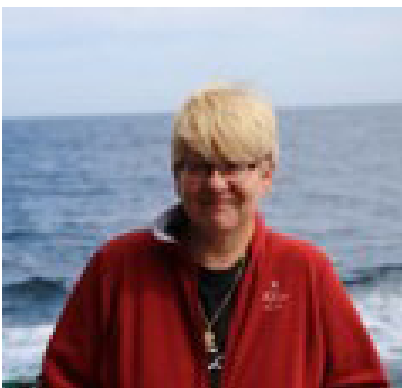


Professor Paolo Favali Research Director at INGV since 2000, he has about 40 years of experience especially in the fields of Natural Hazards (mainly Seismic), Seismotectonics, Geodynamics, Geophysics and Environmental Sciences. He published over 150 papers, including 3 books. He was in the Board of Directors member of the Istituto Nazionale di Geofisica from 1987 to 2000. Since 2000 acts an Expert Evaluator of EC projects. Head from 2001 to 2014 of the Marine Unit of INGV. He also was and is involved in many national and international projects. He has been teaching "Physics of Solid Earth" and "Earth Physics" in Italian Universities from 1994 to 2009. He worked in many research and technological projects with Italian/International Universities, Scientific Institutions and Industries, acting as coordinator in some of them. In these projects, complex underwater systems and sensor prototypes have been developed and validated not only for scientific uses with a complete interdisciplinary approach from shallow to deep waters. He has been coordinator of numerous European projects for the development and scientific use of multidisciplinary seafloor observatories and networks, and related infrastructures. Currently he is working as coordinator of the ESFRI Research Infrastructure EMSO (European Multidisciplinary Seafloor and Water-Column Observatory, <http://emso-eu.org>), included in the 1st ESFRI Roadmap (2006), and now "Landmarks" in the last ESFRI Roadmap (2016).

CONFERENCE 2 – 28TH THURSDAY, 11:00 – 11:30 (ROOM 1)

TOWARDS A BETTER USE OF ARCTIC MARINE INFRASTRUCTURE: EU- POLARNET, EUROFLEETS2 AND ARICE

BY DR. NICOLE BIEBOW, ALFRED WEGENER INSTITUTE, GERMANY



Dr. Nicole Biebow is the executive manager of the EU coordination and support action EU-PolarNet – Connecting Science with society and Head of International Cooperation Unit, Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung, Bremerhaven, Germany. She has long-standing experience in the management of international projects and coordination of international consortia. She received her PhD in Marine Geology at GEOMAR in Kiel in 1996. Since then she has worked as scientific coordinator or executive manager of international projects. From 1996 till 2004 she coordinated the large German - Russian Joint Project KOMEX (Kurile Okhotsk Sea Experiment) funded by the BMBF. In 2004 she moved to the Alfred-Wegener-Institute (AWI) and took over a position as the scientific assistant of the director and the scientific coordinator of the joint Russian – German Master Program for applied Polar and Marine Sciences, POMOR in St. Petersburg. Since 2010, she is heading the International Cooperation Unit. From 2009 – 2013 she additionally took care of the EU funding at the AWI.

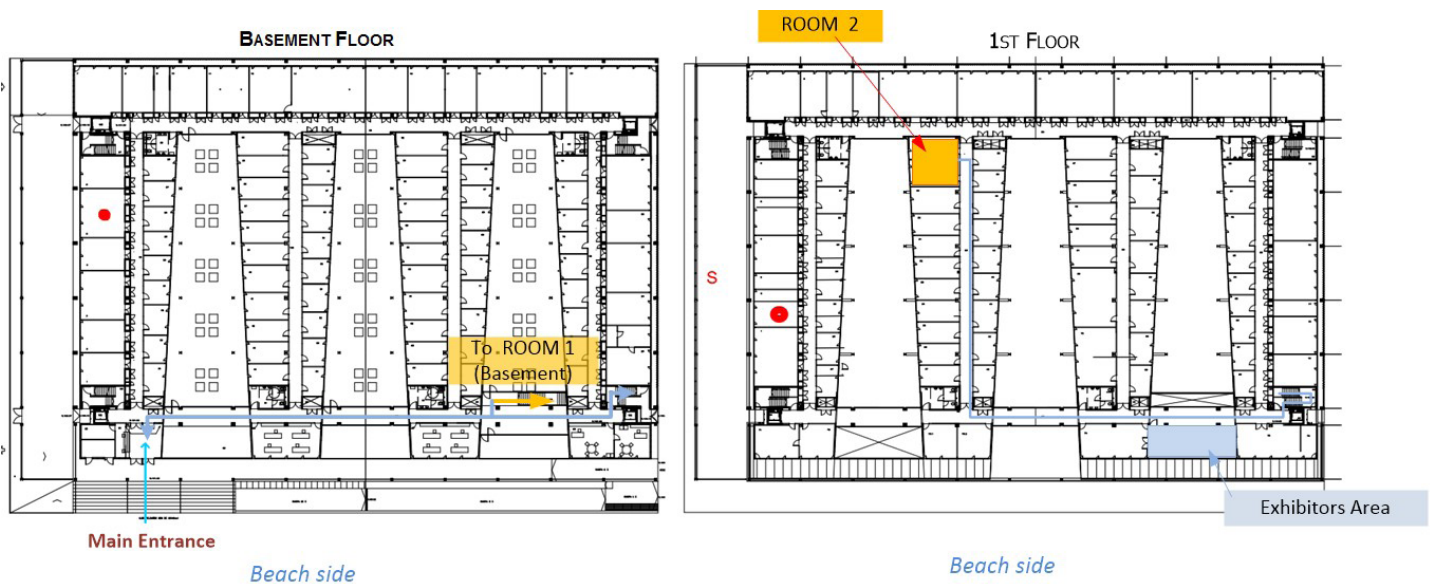
GENERAL INFORMATION

WHERE WILL THE CONFERENCE TAKE PLACE?

MARTECH 2016 will take place at the the Instituto de Ciencias del Mar - ICM- CMIMA (CSIC). The venue is located in Barcelona's Villa Olímpica District between Hospital del Mar and the Olympic Towers.
Location: Passeig Marítim, 08003 Barcelona



The conferences will take place in two different rooms: "Salón de actos" and "P31" theaters, located on the Basement and First floor.



REGISTRATION DESK

The registration desk will be open during the conference, and it will be located at the main door of the Instituto de Ciencias Del Mar. Your accreditation (badge, tickets and materials) should also be collected there, on the main entrance. WIFI connection is free and its password will be provided with your badge. Coffee breaks and lunches will be served in the Exhibition Area, in the hall of the Instituto de Ciencias Del Mar.

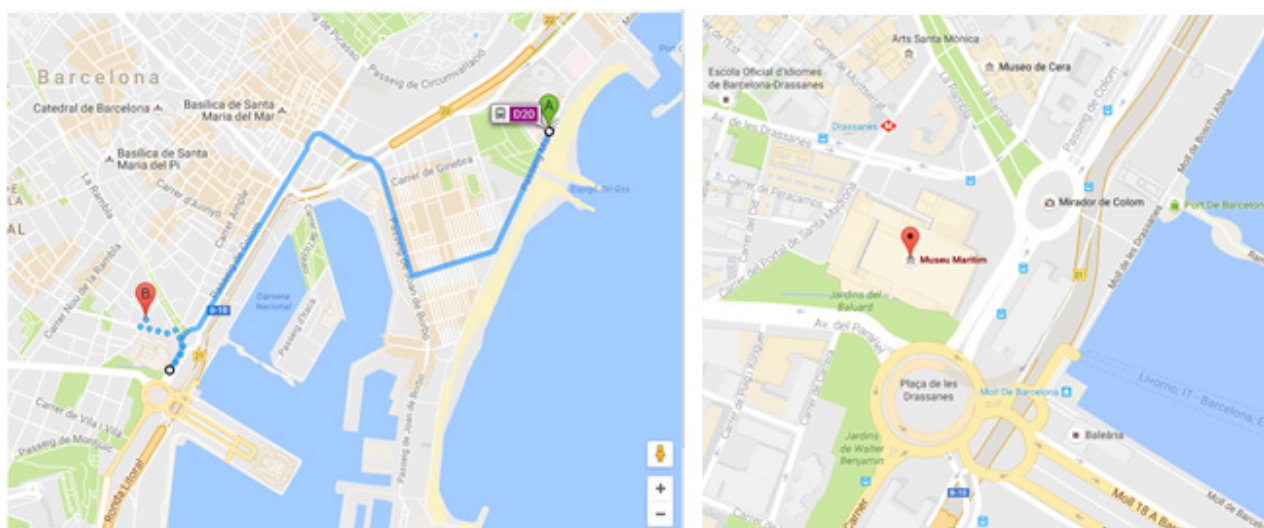
CONFERENCE DINNER



The Gala Dinner will take place in The Museu Marítim de Barcelona (Maritime Museum) a jewel of Catalan Gothic, which is in the building of the "Atarazanas Reales", it was a shipbuilding between the thirteenth and eighteenth centuries. The museum is located at the southern edge of the Old Town and at the end of the Rambla.

HOW TO GET HERE

Address: Av. de les Drassanes, s/n, 08001 Barcelona



COMMERCIAL EXHIBITION

EXHIBITION AREA

The exhibition area will be in the First Floor of the Instituto de Ciencias Del Mar, near the Cafetería.

EXHIBITOR LIST



Oceanografía, Tecnología en el fondo marino.

Álava Ingenieros potencia su línea de productos de Oceanografía e Hidrografía, incrementando sus acuerdos con socios tecnológicos líderes en el sector.

Los clientes tienen acceso a equipos que ofrecen diversas prestaciones, como ecosondas monohaz y multihaz, sistemas de posicionamiento, sondas multiparamétricas, perfiladores de la velocidad del sonido, software con sencilla interfaz,.... Desde Álava Ingenieros nos mantenemos en la vanguardia de todas estas tecnologías para ofrecer al cliente una solución flexible y completa, que incluye servicios de integración, instalación, puesta en marcha, soporte y mantenimiento del equipamiento suministrado.

Con oficinas en Madrid, Barcelona, Zaragoza y Lisboa, Quito, Lima y TEXAS el Grupo Álava comercializa sus soluciones con la experiencia de sus 40 años en el mercado de la instrumentación.



ACSM (Advanced Crew and Ship Management) provides global maritime services such as nautical management of vessels as well as complete services of submersible ROV vehicles for offshore projects with clients from all over the world. Established in 2001, ACSM key personnel have more than 15 years' experience in marine and subsea services for offshore operations.

ACSM has a wide experience in ship management with cable ships, special purpose offshore vessels, oceanographic/research vessels, and other types of vessels with Dynamic Positioning (DP) and/or Diesel- Electrical propulsion. The Marine Management service includes Human resources (MLC 2006 Certification), and full Technical Management in compliance with relevant IMO conventions and other applicable international and flag state regulations.



EMS offers a solid background in sensors, systems and vehicles, serving the oceanographic community and users of marine and underwater technology for more than 15 years with offices in Barcelona and Paris.

EMS represents leading manufacturers in the industry and offers advanced technical capabilities focused on system integration and data providing, as well as an own product line and associated technical services.

EMS sensors : Sea-Bird Electronics, WETLabs, Turner Designs, Teledyne RD Instruments, Biospherical Instrument, Sequoia Scientific, Paroscientific, Campbell Scientific, Ocean Waves, et al. EMS systems : Teledyne Blueview, ATLAS Hydrographic, MacArtney, Chelsea Technologies, Flotation Technologies, Deep Sea Power & Light, Technicap, Link-Quest, Falimat Cables, et al. EMS vehicles : Liquid Robotics, ATLAS SeaCat, Bluefin Robotics, International Submarine Engineering, Deep Ocean Engineering, VideoRay, et al.



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JAVAD GNSS Systems
IXBLUE Navigations Systems; Inertial INS for Aerial, Marine and Land applications; acoustic systems.
Wärtsilä ELAC Sistemas sonar y ecosondas multihaz
Roustescene Lidar system for UAV's integration.
Z+F Laser scanner 3D
ASV Unmanned Marine Surface Vehicles.
Alseamar Gliders, submarine profilers for oceanographic Data Acquisition.
Offshore Sensing Unmanned Surface Vehicle for ocean surface Data Acquisition
McLane Oceanographic Instrumentation
ASL Oceanographic Data profilers
Edgetech Side Scan Sonar; Multibeam Systems
BluePrint Surface and Underwater Navigation Aids.
Hypack. Aplicación lógica hidrográfica, Hidrografía
LinkQuest. Inc. Perfilador de corrientes Doppler
Dartcom Estaciones meteorológicas remotas, HRPT, CHRPT, SEAWIFS, AHRPT y DMSP, EUMET SAT, GMS, GOES, MTSAT.
Idronaut CTD, sensores.
General Oceanics Instrumentos oceanográficos. Analizadores de CO².
General Acoustics Instrumentos oceanográficos, Mareografos. Log_aLevel.

At the present time our company employs seven persons full time and two additional technicians on partial time. Half of them with technical or engineering degree.
All the personnel have ample experience in sales, training, after sales service and support.
We also maintain a workshop certified by the Spanish Institute of Metrology which provides technical assistance, maintenance and repair jobs as required.



- FURGO - WWW.FURGO.COM

The Fugro group of companies is an international consulting company that provides the people, equipment, expertise and technology that support the exploration, development, production and transportation of the world's natural resources. Fugro also provides its clients with the technical data and information required to design, construct and maintain structures and infrastructure in a safe, reliable and efficient manner.
Focusing on providing solutions to its client's requirements, the group was created by the merger of Fugro and McClelland groups of companies. Fugro operates on a world-wide scale. The group employs over 12,000 people in over 275 offices world-wide and is headquartered in the Netherlands.
Fugro provides a unique range of services and activities worldwide. These are organised in two divisions: Geotechnical and Survey.



- KONGSBERG MARITIME - WWW.KM.KONGSBERG.COM

KONGSBERG

Kongsberg Maritime is a wholly owned subsidiary of the Kongsberg Group. As a leading Norwegian technology company established on 20th March 1814, the Kongsberg Group can celebrate more than 200 years in business. The company can boast the longest industrial history in Norway, with continuous operations since its foundation.

Kongsberg Maritime provide innovative and reliable solutions for on- and offshore, merchant marine, subsea, navy, coastal marine, aquaculture, port & harbor surveillance, training services and more.



- QUALITAS REMOS - WWW.QUALITASREMOS.COM

QUALITAS Remos is a leading company in science and solutions for the operational oceanography, marine safety, offshore and marine renewables sector with international activity and business units in Spain, Portugal, UK, Colombia and Morocco.

The company vision is to provide innovative knowledge intensive solutions associated with technology and data to the marine community in cooperation with our clients and partners. The company has wide experience in the delivery of:

- Turnkey deployment, operation and maintenance of ocean observing systems with special focus on HF Radar.
- Innovative, powerful, reliable IT solutions and added value decision support software tools for marine information and marine risk management.
- Expert marine consultancy and testimony, spill trajectory and fate modelling, impact analysis as part of a marine pollution preparedness and response service.



- CASCO ANTIGUO OCEANOGRAFÍA - WWW.CASCOANTIGUOOCEANOGRAFIA.COM

In Casco Antiquo we are devoted to the manufacture, sale, distribution and commercialization of professional diving equipment, both technical and recreate, completing this extensive offer with a department of Search and Rescue, and another one of Oceanography.

Nowadays, Casco Antiquo is a leader in these areas in the Iberian Peninsula and Latin America, and in its product catalog you can find the most prestigious brands in each sector.

Casco Antiquo Oceanography is part of the Casco Antiquo Commercial Company, as a department specialized in products and equipment for the Oceanography, Hydrography and Underwater Technologies areas.



CLS

COLLECTE LOCALISATION SATELLITES

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CLS is a subsidiary of CNES, IFREMER and the investment company ARDIAN. It has been operating satellite systems and providing high value-added products and services since 1986.

CLS provides operational services for environmental monitoring, sustainable management of marine resources, and maritime security.

The company also provides services for telematics.

Through its range of products and services, CLS provides direct operational assistance to stakeholders in both the public and private sectors.

CLS operates over 80 instruments carried by 40 satellites and provides its expertise to a broad range of customers: governments, scientific organizations, non-governmental organizations, institutions, large industrial groups (maritime freight, oil and gas companies, commercial shipping, fisheries, etc.).

ID2- RECENT TECHNICAL INNOVATIONS AROUND HF RADAR TECHNOLOGY AND STEPS TOWARDS INTEGRATED NATIONAL HF RADAR NETWORKS

ISMAEL LOPEZ¹⁶⁷, ANDRÉS ALONSO-MARTIRENA¹⁶⁶, JORGE SÁNCHEZ¹⁶⁸, PEDRO AGOSTINHO¹⁶⁵, MARIA FERNANDES¹⁶⁴, ZOUHAIR BENMOUSSA¹⁶³, ABDERRAHIM OULHASSAN¹⁶²

Abstract – HF Radar is a proven technology for ocean observing that has at present more than 600 references in the world and which is since April 2016 in application on all continents for the purpose of 2D surface currents and waves monitoring. This has only been possible 44 years after its first implementation in 1972 in San Clemente Island in California, thanks to the permanent evolution of the radar technology with key achievements such as the present unique system compactness and its capability to make a very efficient use of the radio spectrum. This paper firstly presents some of the latest technical innovations around HF radar technology that are making the technology even more reliable, accurate and useful such as the new Automatic Antenna Pattern Generation solution based on AIS vessel positions and the implementation of new added value trajectory models forced by HF Radar surface currents able to accurately predict oil spill transport and movement of particles on the sea or persons adrift. Secondly, we present current plans existing in the Iberian Peninsula HF Radar network to integrate HF Radar technology as an operational component of a national tsunami early warning system. Finally, the advanced HF Radar system implemented by the Direction de la Météorologie Nationale du Royaume du Maroc is presented; one of the latest deployed systems and the first permanent system operating in Africa.

Keywords – Ocean observing, HF Radar, currents velocity, waves, tsunami detection

1. INTRODUCTION

HF Radar is today one essential component in many ocean observing systems of the most advanced institutions around the globe with more than 600 stations operating in 50 countries for the remote real-time surface current mapping and wave monitoring with ranges of up to 200 km from the coast. SeaSondes are operating now continuously on all continents; this milestone was reached in April 2016 when the Moroccan Met Office has started the operation of the first HF Radars in Africa. Before that, in January 2014 SeaSonde HF Radars were installed by Rutgers University and Alaska Fairbanks University in Antarctica to investigate the impact of local coastal physical processes and the impact of climate change in a highly under-sampled area.

2. ESSENTIAL FEATURES FOR THE EXPANSION OF HF RADAR INTO OCEAN OBSERVING NETWORKS

Since Dr. Donald Barrick established the theoretical basis of HF sea scatter back in 1968 on which both current extraction as well as waves monitoring is based, HF Radar technology has experienced a continuous evolution that has made its worldwide application possible. The current uniquely compact design of the SeaSonde HF radar and the patented SeaSonde synchronizing technology that allows multiple systems to operate at exactly the same frequency without interfering each other, are two of the most important breakthrough technological achievements.

2.1. System Compactness

One of the main difficulties in selecting feasible HF Radar sites is finding places where a) continuous power supply is guaranteed, b) there is a wide coast to coast view of the sea and c) there is enough space available for deploying all radar equipment (not only the electronics but also the HF radar antennas).

At first, HF Radar systems were designed as phased arrays with tens of separated antennas operating in Beam Forming mode, which were simple in concept but occupied several hundred meters of coast when deployed. In order to feasibly operate systems in areas with complex, urban or environmentally protected coastlines for continuous long-term monitoring, a new co-located cross-loop receive antenna design was developed for the SeaSonde® and the number of antennas was brought down to two: one transmit and one receive antenna. More recently, the compact cross-loop design has been further enhanced by combining transmit and receive antennas into a single mast. This latest single-mast design is currently available for all operating frequencies higher than 10 MHz. This design reduces the antenna footprint and visual impact that, in turn, increases the number of feasible sites for deployment (Fig. 1).



Fig. 1. Compact 2 x 13.5 SeaSonde HF Radar station. Livorno, Regione Toscana, SICOMAR, Italia.

2.2. Efficient Use of the Radio-Electric Spectrum

Frequency spectrum is a limited resource which needs to be shared among a wide number of applications. Thus the efficient use of it in agreement with The International Telecommunications Union recommendations is critical in order to make the implementation of wide scale HF Radar networks feasible. With this aim, CODAR invented and patented a methodology based on GPS timing along with FMCW (frequency-modulated continuous wave) gated signals to control the exact sweep time of multiple transmitters down to nanoseconds so all transmitters can occupy the exact same frequency channel without interfering each other. More precisely, each CODAR SeaSonde® system transmits a gated FMiCW (Frequency Modulated interrupted Continuous Wave) and the time difference between each system's sweep start is rigorously defined through GPS timing. This allows that, after complete demodulation, other HF Radar station signals and echoes are put in distant and unused range bins (Fig. 2).

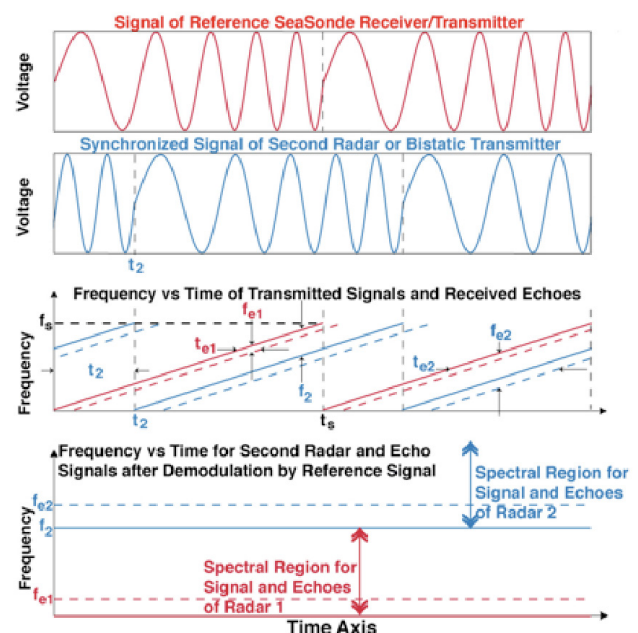


Fig. 2. Example on how GPS Modulation Multiplexing works. Toscana, SICOMAR, Italia.

3. RECENT ADVANCES AROUND HF RADAR

3.1. Better QA/QC of HF Radar Data by Means of a "New

Automatic Antenna Pattern Measurement Solution" HF Radars require calibration, which is something that is independent of the system design (arrays or compact single-antenna technology). The surrounding environment to an antenna affects its properties (namely the antenna response pattern - the directional dependence of the received signals used for bearing determination), so it is necessary to take this into account when processing the received electromagnetic backscatter - (Paduan et al, 2006), (Flores-Vidal et al, 2012). In general, for the area within one electromagnetic wavelength of the receive antenna, the presence of conductive or ferromagnetic material that scale one quarter wavelength or greater will affect the antenna response pattern. University of Santa Barbara together with CODAR Ocean Sensors have developed a procedure in order to automatically measure the antenna pattern (APM) using Doppler echoes from passing vessels as a signal source and their AIS transponder data for a reference bearing.

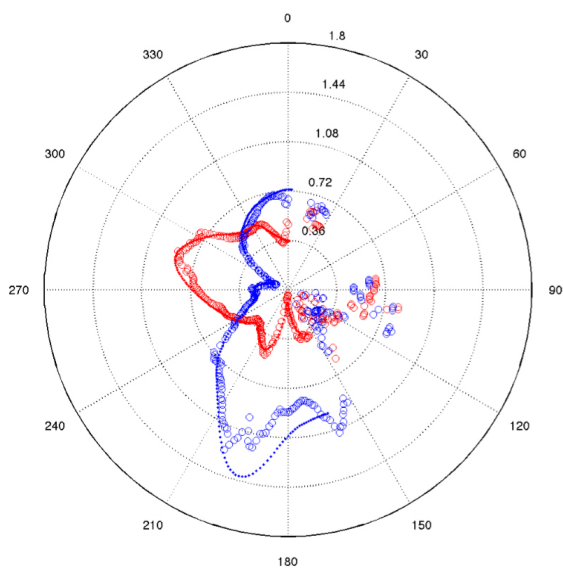


Fig. 3 - Loop patterns in the Espichel HF Radar station. Instituto Hidrografico of Portugal. Legend: red - Loop 1; blue - Loop 2; continuous line - boat pattern; circles - Auto-APM pattern. Toscana, SICOMAR, Italia.

Application experience of the technology over the first two years has proven that this new Quality Assurance/Quality Control (QA/QC) enhancing technology is useful for the following purposes without increasing the cost of system operation:

- a) to avoid unnecessary field antenna pattern measurements when this automatic procedure confirms the stability of the applied antenna pattern
- b) to improve the overall HF Radar output quality by reducing the bearing measurement uncertainty thanks to this automatic capability to detect changes to the antenna and the antenna environment at the very early stages

3.2. Enhancement of Oil Spill and Particle Trajectory Forecasts by use of HF Radar Data

The experience acquired in the past in management of crisis like the Prestige demonstrated the importance of operational forecasting systems for oil spill response (Montero et al., 2003; Castanedo et al., 2006; González et al., 2006). The accuracy of oil spill transport simulations highly depends on the quality of the met-ocean data used to force the oil spill transport models. Traditionally, these oil spill transport systems have been forced by atmospheric and oceanographic numerical models, which have their own errors that may affect the accuracy of the transport forecasts (Edwards et al., 2006; Price et al., 2006). The uncertainty becomes more important in the ocean circulation modelling of coastal areas, where the complex pattern that characterizes the slope currents complicates the forecasting of the current fields. In order to address this problem, high-frequency (HF) coastal radar observation systems have become an alternative to provide accurate current surface maps in near-real time and therefore suitable for oceanographic practical applications as forcing for Lagrangian trajectory models in an emergency response at sea (Abascal et al., 2009b). To take advantage of these data, an oil spill forecasting and backtracking system

has been developed by IHCantabria and Qualitas and validated by Marine Scotland in the Shetland-Orkney area as part of the Brahan Project to show the capabilities of HF radar systems for oil spill operations. The trajectory forecast system was operationally working during the period June 2014 - August 2014, in the framework of a project funded by the Spanish Ministry of Economy and Competitiveness (EEA Grants, IDI-20140011). The core of the system was the TESEO oil spill numerical model (Abascal et al., 2007), which was forced with ocean currents provided by the Brahan Long Range SeaSonde HF radar system and (2) wind forecast from the Global Forecast System model (NOAA) (Environmental Modeling Center, 2003). The main goal of the system was to provide short term oil spill trajectory forecasting and backtracking in the study area.

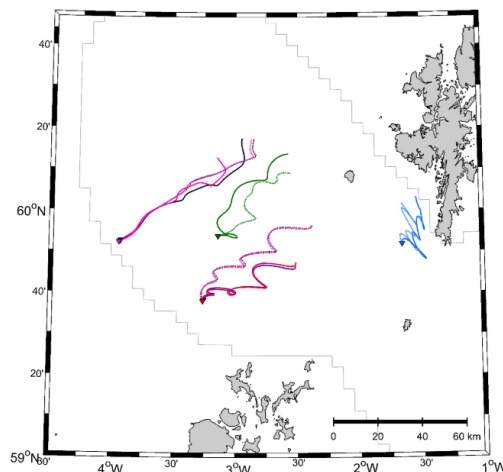


Fig. 4 Comparison between actual (continuous lines) and simulated trajectories (dashed lines). Gray line represents the HF radar system domain limit. Validation exercise carried out in October to December 2013 by Marine Scotland as part of the Brahan HF Radar project.

The oil spill transport forecast and backtracking system was calibrated by means of drifter buoys and its accuracy was successfully confirmed by comparing actual drifter trajectories and system's simulated trajectories (Oil spill trajectory modeling based on HF radar currents in the North Sea. AMOP 2015, Abascal et al.).

3.3. Plan Towards Integration of HF Radar Into Tsunami Early Warning Systems in the Iberian Peninsula

"Today there is no full proof of tsunami detection system operational with a significant warning capability in any part of the world. Most reliable detection is claimed with the help of buoy systems which are equipped with sea level and bottom pressure sensors together with data transmitting electronics. However, their capability is limited to the local area. Therefore very large numbers of such buoys would be required to cover a large ocean area. Tide-gauge sea levels at coastal positions provide useful quantitative information for locations further downstream. The sea state monitoring HF radars have a potential for observing couple of hundreds km which is promising to use in operational manner for detecting Tsunamis." (Assessment, Strategy and Risk Reduction for Tsunamis in Europe, 2015). Dr. Donald Barrick at the NOAA/ERL/Wave Propagation Laboratory in Colorado in 1979 developed the theory supporting the capability of HF Radar to detect tsunamis. First actual offline detection of a tsunami by HF Radar happened in 2011 and in the meantime 38 further detections by SeaSonde HF Radars have been reported. In 2016 US NOAA in cooperation with Rutgers University and CODAR Ocean Sensors have started a project to leverage the national state-of-the-art observational network of SeaSonde High-Frequency (HF) radars and the SWHFR tsunami detection algorithms already developed at CODAR to develop a new tsunami detection and observation capability for the Tsunami Warning Centers (TWCs), which focus is to develop an early warning capability for meteo tsunamis on the US East Coast. The Iberian Peninsula has implemented at present the widest HF Radar observing network in the EMEA region, operating a network of 22 SeaSonde HF Radar stations in a collaborative effort by 10 Spanish and Portuguese institutions (<http://www.iberoredhf.es/en/radarhf>). In this framework there is a plan by the Portuguese Instituto Hidrografico and the Spanish Puertos del Estado and Qualitas to validate the

capability of HF radars to measure the orbital velocity of long waves using the Sagres HF Radar station as a testbed. This station would be ideally located to detect a tsunami like the one that took place in Lisbon back in 1755. After this first validation, this same plan aims to develop and calibrate the models that would allow the integration of selected Iberian HF Radar sites into a European-African "Tsunami Warning Network" for the Southwest Atlantic and Alboran Sea. These activities shall start inside 2017 and are fully aligned with similar efforts taking place in the US East Coast.

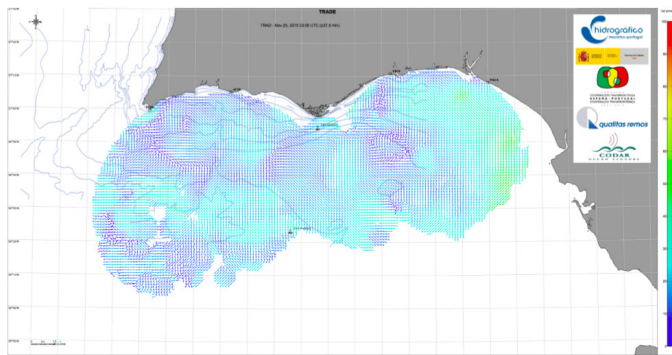


Fig. 5 Algarve and Gulf of Cadiz HF Radar network with 4 x 13.5 MHz SeaSonde stations including the Sagres site. (Operated by the Instituto Hidrográfico of Portugal and Puertos del Estado of Spain, TRADE). Toscana, SICOMAR, Italia.

4. MOROCCO DIRECTION DE LA MÉTÉOROLOGIE NATIONALE STARTS THE FIRST HF RADAR SYSTEM IN AFRICA

Morocco is known for its rich cultural heritage, its natural breath-taking landscapes and also for being a reference in science and technology in Africa. In line with this idea, the Direction de la Météorologie Nationale (DMN) (<http://www.marocmeteo.ma>), a public service that is part of the Ministry of Energy, Mines, Water and Environment of the Kingdom of Morocco and also a permanent member of the World Meteorological Organization, has done in April 2016 a relevant step to comply with its mandate of providing accurate and continuous marine weather and climate information, more specifically 2D surface currents maps and wave data, by starting the first operational coastal HF radar ocean observing system in Africa to monitor the marine conditions with a range of up to 200 km from the coast. The installation of this system has been carried out by the Moroccan firm Qualitas (<http://www.qualitasenv.com>).

The first HF radar station has been implemented in Casablanca Port, on top of the Met Office building having a spectacular view of the sea and of the Grande Mosquée Hassan II, which is the tallest and the second largest Mosque in the world. The second station is installed on the premises of the Civil Protection in Temara (close to Rabat) taking advantage of the uniquely compact design of the chosen SeaSonde HF radar technology. Special consideration has been paid by the Maritime Department of the Met Office at the time of choosing and implementing the new technology to all activities that influence the long-term sustainability and short-term utility of such a project such as:

- The highest quality, easiness of use and reliability of the chosen technology
- The implementation of the most advanced global QA/QC methods and system operation software tools (figure 4) implemented into a versatile redundant IT platform with an advanced architecture (2x1TB HD software [mirroring] and 3x1TB HD data [RAID5])
- The in depth training and education of the department staff to fully assimilate all capabilities that are needed to integrate the new observational component with the other technologies and resources that are at present in application at the Met Office

5. CONCLUSIONS

HF Radar has reached the reliability and the operational readiness which makes a wide scale application of this technology possible. These systems are already delivering benefits related to the protection of the marine and coastal environment, the increased safety of navigation, efficiency in search and rescue operations, better oil spill preparedness and response, the meteorological assistance for the better planning and conduct of port operations. Application of HF radar data can also provide a better understanding of the marine physical environment supporting fisheries management and also coastal engineering in general, as well as allow further improvement of the existing circulation



Fig. 6 Compact 2 x 4.5 MHz SeaSonde HF Radar system in Morocco and principal 2D deliverables, currents mapping and waves monitoring. (HF Radar system operated by the Direction de la Météorologie Nationale).

numerical models. New ideas to take the existing HF Radar networks to the next frontier are flourishing such as the ones that intend to integrate this kind of infrastructures into early tsunami detection networks and the studies to use the HF radar data to improve the intensity prediction of tropical storms and long-term climate change studies.

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ID3- DEVELOPMENT AND CALIBRATION OF A COST-EFFECTIVE TEMPERATURE SENSOR

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Abstract – Oceanographic sensors are accurate and reliable but very expensive. We have developed and calibrated a cheap temperature sensor with a good cost/accuracy ratio.

Keywords –Marine technology, Low cost temperature sensor, Calibration, Oceanographic sensors.

1. INTRODUCTION

Ocean temperature has been recorded for years with reversing thermometers, thermistors or some kind of instrument including a thermometer like a CTDs or thermosalinometers. Oceanographic instrumentation is commonly designed in different housings to allow deployment from 250 m to 10000 m. Some of them achieve an accuracy of ± 0.001 °C and a resolution of 0.0001 °C. After more than 6 years working on the metocean network of the RAIA Observatory (www.marnaraia.org), we have realized that in some applications there is no need to get such a high accuracy or resolution. Besides, it is most important to be able to obtain data at different depths without risk thousands of euros. Oceanographic thermometers that can be connected to a datalogger and send collected registers by any digital technology usually cost hundreds or thousands euros depending on quality of housing materials, accuracy, resolution, etc. Maintenance, spare parts and cables are usually expensive too. In this context, RAIA-TEC project has aimed to increase oceanographic instruments' reliability and availability. As part of this project, we have tested two digital thermometers, commonly used in industry, in an effort to reduce costs in oceanographic data collection. The DS18B20 sensor has a 1-wire interface and the TMP275 sensor uses I2C to send data. The obtained results are being used in the framework of SMARNET project, which tries to use cheap metocean sensors in fishing boats as a way to reinforce data collection from opportunity ships We decided to connect those devices to an Arduino because the datalogger in our stations is not compatible with them.

II. ELECTRONIC DESIGN.

The initial requirements were that the prototype must be as cheap as possible, must have Rs232 interface, low power consumption and be watertight. Size was not important but the smaller the better. Should be able to submerge at 20 m depth. An Arduino Nano was chosen because there are libraries that work with both DS18B20 and TMP275, its small size, price and our previous experienced in that platform. The Arduino Nano works as an interface adaptor, receiving data in I2C and 1-wire protocols and sending data in Rs232 9600 baud format. Our first electronic design was a compact shield to be connected to the Arduino NANO. See next figure.

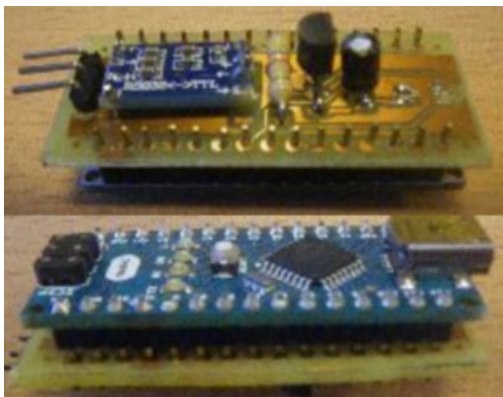


Fig 1 Arduino and sensors.

In previous images we can see the Arduino and the custom shield board including a DS18B20 and a TMP275 plus a small board that converts serial interface from TTL levels to Rs232 levels. That board is needed in order to allow our datalogger work with the prototype but could be discarded in other projects.

III. WATERTIGHT HOUSING.

We tried two different materials to protect the devices from water and pressure. We look for insulation kits and selected a 3M ScotchCast kit that provides an epoxy-like black mixture. After the mixture is done, it reaches a solid state in just 10 minutes. We used another product called Magic- Joint from Ray-Tech. This kit provides two liquids to be mixed and after some minutes stays as a transparent gel that allows us to reopen the device

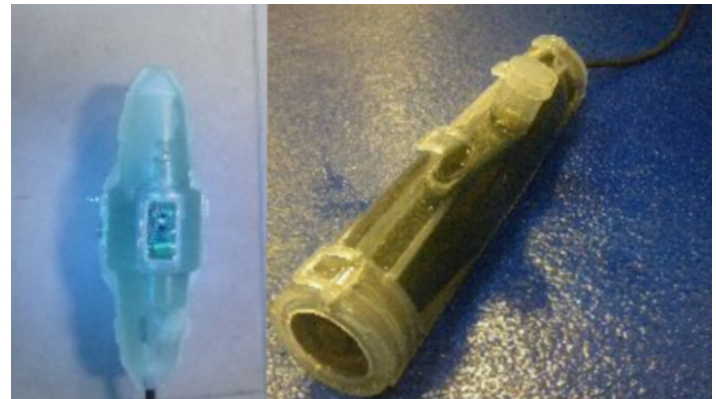


Fig 2 Magic-Joint kit and 3M ScotchCast kit assemblies.

The advantage of the transparent gel is that allows visual inspection and any failure of can be easily checked by eliminating the insulation. The 3M product can not be reopened but provides a capacity to deploy the device deeper than the Ray-Tech's. For tests, we made two prototypes, one insulated with epoxy and one with gel, each of them with a TMP275 and a DS18B20 inside.

III. CALIBRATION AND REBUILD.

In our calibration facilities we tested the two assembled prototypes and compared results against a Seabird SBE37- SIP CTD.

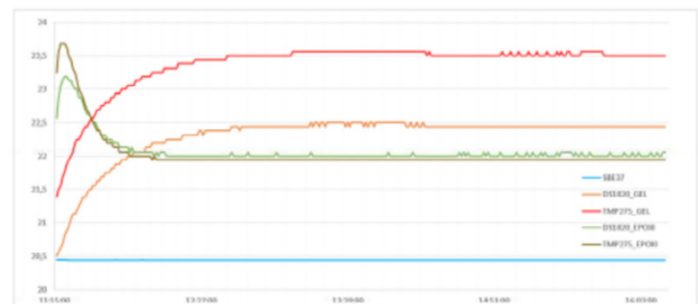


Fig 3 Data from test.

In previous capture, blue line represents data from SBE37 at 20.5oC, orange and red are DS18B20 and TMP275 insulated in gel and green and brown are DS18B20 and TMP275 insulated in epoxy. After some tests we realized two facts. Insulation materials produced different behaviours because of its different thermal conduction coefficients, and the second fact is that there was self-heating in the boards. Those two variables make the prototypes to have an offset and some delay to achieve the temperature set point. In view of these results, we verified that TMP275 and the DS18B20 digital thermometers behaviour and characteristics were very similar. We decided to rebuild the design. TMP275 sensor was discarded due to its similarity to DS18B20, chip format, price, interface, etc. DS18B20 sensor was set apart from Arduino and shield board so self-heating does not affect the thermometer. In this new assembly the electronic components are not insulated and a 20 m cable connects the DS18B20 to the Arduino.



Fig 4 View of final design.

In this design we have used a DS18B20 waterproof model. This version is made of stainless steel but we decide to cover the device with a thin epoxy insulation. As we previously described, electronic boards are going to be connected to a datalogger which is inside a watertight case so there is no need, in this design, to insulate them. Anyway some kind of protection is advised depending on user application.

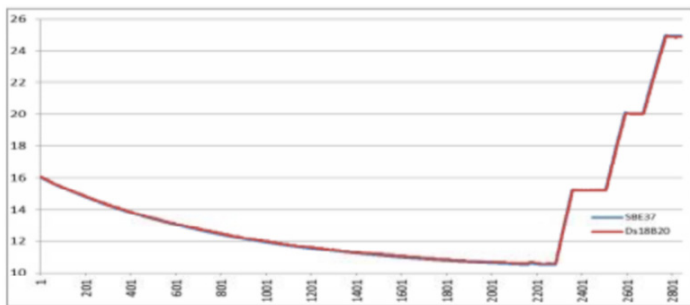


Fig 5 Final design test. Ds18B20 and SBE37 compared.

Manufacturer claims that sensor accuracy is ± 0.5 oC along the $- 10$ oC to $+ 85$ oC range. We selected this thermometer because after reading the specifications we expected to get an error of ± 0.2 oC or less in 10 oC to 30 oC range. In these new tests the sensor works better than we have expected and the accuracy is less than ± 0.1 oC

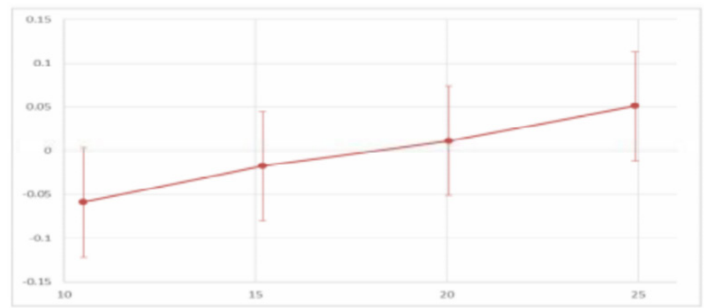


Fig 6 Residue vs temperature.

In previous graphic, residue (SBE37 measure – DS18B20 measure) is displayed in some set points. The sensor resolution of 0.0625 oC is displayed in each set point.

IV. CONCLUSIONS AND FURTHER WORK.

The designed device is a fully cost-effective way to monitoring temperature at different levels without putting in risk thousands of euros. Our tests have proved that DS18B20 sensor and our electronic interface provide a digital thermometer with a good ratio accuracy versus price, obtaining an accuracy of ± 0.1 oC or less. Future works will focus on evaluation of measure drift and uncertainty..

V. ACKNOWLEDGEMENTS

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ID4- SMART AND NETWORKING UNDERWATER ROBOTS IN COOPERATION MESHES - THE SWARMS ECSEL-H2020 PROJECT

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Abstract— The work presented on this paper is aimed to explain the role that unmanned underwater vehicles (AUVs/ROVs) plays in the ECSEL-H2020 SWARMS project. The main goal of the project is to reduce the operational cost and increase the safety of tasks assigned to divers in these operations. This will be achieved enabling the AUVs/ROVs to work in a cooperative mesh. The challenge is to design and develop an integrated platform (a set of Software/Hardware components), incorporated into the current generation of underwater vehicles in order to improve autonomy, cooperation, robustness, cost-effectiveness, and reliability of the offshore operations. The first demonstration of the project will be performed at PLOCAN (Oceanic Platform of the Canary Islands) where these technologies will be validated on its first stage.

Keywords— unmanned, marine, vehicle, AUV, robots.

1. INTRODUCTION

In the near future the oceans will supply a substantial part of human and industrial needs: the oil and gas industry will move to ever deeper waters and renewable energy will be harvested from the seas in offshore wind farms and with tidal, current and wave energy converters. Furthermore minerals such as cobalt, nickel, and copper, rare earths, silver and gold will be mined from the seafloor (deep sea mining). To this end, new offshore and port infrastructure will need to be built, maintained and repaired. The seas, including the oceans, cover approximately 72% of the surface of the earth. This unique habitat is home to almost 90% of all the life known to us. Given the magnitude of these figures, the importance of the seas is obvious from the perspective of both maintaining a healthy ecosystem and generating sustainable resources for the future. In the near future, these resources may cover a considerable part of human and industrial needs alike. New businesses founded on maritime economy, in e.g. food, energy, and transportation, will not only generate new jobs; they will probably enrich the world economy in a way that will facilitate emergence of disruptive innovations. The major part of marine offshore operations is done by divers. These missions often result risky and dangerous for them. Also, since their number is limited, the dependency on their work represents a real threat to the offshore industry. The extended use of unmanned underwater vehicles (AUVs/ROVs) could solve this problem but, even today, the Daniel A. Real-Arce, Tania Morales, C. Barrera, J. Hernández and O. Llinás are with the Oceanic Platform of the Canary Islands –PLOCAN Carretera de Taliarte s/n. 35214. Telde. Las Palmas. Spain (email: info@plocan.eu). commercial Autonomous Underwater Vehicles/Remotely Operated Vehicles (AUVs/ROVs) solutions are primarily ad-hoc, configured to address a specific need without any possibility to guarantee reuse. Consequently, cost-efficiency, from a broader perspective, is not possible to achieve. As in other complex technologies, robustness and reliability depend heavily on the budget.

II. THE SWARMS PROJECT

The ongoing H2020-ECSEL SWARMS project is aimed to expand the use of AUVs/ROVs and facilitate the creation, planning and execution of maritime and offshore operations. The main goal of the project is to reduce the operational cost and increase the safety of tasks assigned to divers in these operations. This will be achieved enabling the AUVs/ROVs to work in a cooperative mesh. This cooperation mode will enrich marine applications and will ensure re-usability as no specialized vehicles will be needed. Instead heterogeneous standard vehicles can combine their capabilities to achieve a global goal. This way the autonomy and usability of these marine robots will be also improved. In order to achieve the goals of the project, the approach is to design and develop an integrated platform (a set of Software/Hardware components), incorporated into the current generation of underwater vehicles in order to improve autonomy, cooperation, robustness, cost-effectiveness, and reliability

of the offshore operations. The SWARMS project aims to be able to coordinate a swarm of underwater vehicles (AUVs, ROVs) together with other support robots (USVs) and vessels to facilitate the creation, planning and execution of maritime and offshore operations (Fig. 1). Therefore, the expected elements involved in the SWARMS project are autonomous underwater vehicles (AUVs), remotely operated vehicle (ROVs), vessels, USVs and/or buoy and an ashore control station. One of the biggest challenges of the project is the design of a trustful software middleware that provides reliable control of the different vehicles. The communications between the vehicles are also a critical point that has to be well defined. In a swarm mesh of autonomous marine vehicles that have to coordinate themselves, the communication system is a key factor. During the first demonstration stage in PLOCAN the communication functionalities of all segments are going to be verified. An overlay network will be designed and developed for the exchange of information among cooperating networked Smart and Networking UnderWater Robots in Cooperation Meshes - The SWARMS ECSEL-H2020 Project Daniel A. Real-Arce, Tania Morales, C. Barrera, J. Hernández and O. Llinás SWARMS (AUVs/ROVs) and other network nodes such as base station. SWARMS is an industry-led project. Big technology companies collaborate with subsea specialized SMEs, robotics and communication companies, universities and research institutions. SWARMS' achievements will be demonstrated in three field tests carried out in different scenarios (Gran Canaria, Black Sea and Norway) along the lifetime of the project. The first of these demonstrations is going to be performed in PLOCAN Marine and Maritime Test Site in Gran Canaria. This will be a critical stage in order to test the developments made during this early stage of the project.

ACKNOWLEDGMENT

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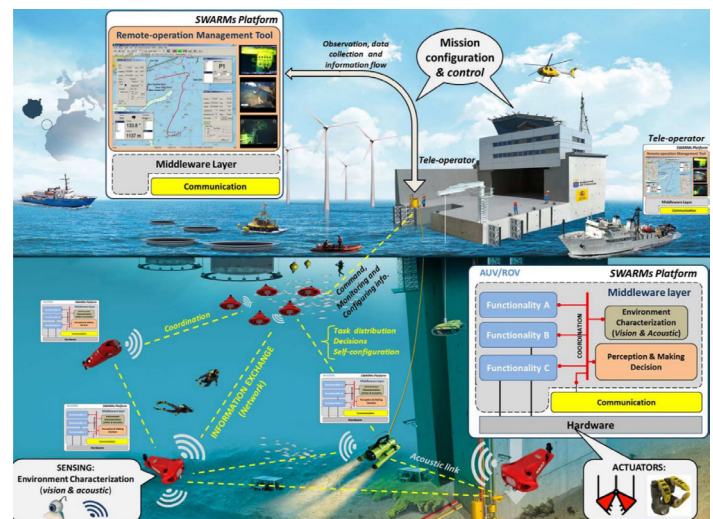


Fig. 1: The SWARMS concept

ID5- TOWARDS A BETTER USE OF ARCTIC MARINE INFRASTRUCTURE: EU-POLARNET, EUROFLEETS2 AND ARICE

NICOLE BIEBOW¹²² AND VERONICA WILLMOTT¹²³

Abstract –The Polar Regions may seem remote, but the observed rapid changes now affecting both the Arctic and Antarctic regions have resulted in significant consequences for the weather and climate in lower latitudes, including Europe. Environmental changes being observed, particularly in the Arctic, are a clear indication of the impending shifts that will increasingly affect European environment, society and industry. Changes in the Polar Regions present societal challenges, but also economic opportunities for Europe and the world. Science is a vital tool in understanding what is driving the rapid changes being observed at high latitudes. Research is also necessary to make our climate models and forecasting more realistic by identifying and reducing important sources of uncertainty that may impair reliable prediction. However the scale of many of the questions being posed is now recognised as being beyond the capabilities of individual nations and strong international cooperation is needed to overcome these challenges. There is often a need to obtain data from geographically widely separated areas of the Polar Regions and these need complementary observational schemes to be implemented for valid inter-comparisons. Similarly the costs of operating infrastructure in Polar Regions are becoming increasingly challenging and there is a need therefore to cooperate on infrastructure access and shared costs to optimise the support of larger research programmes.

The presentation will introduce three European projects: EU-PolarNet, EUROFLEETS2 and ARICE which actively work on improving infrastructure development and access in the Polar Regions in cooperation with international partners. The examples given are from the Arctic Ocean but similar models of transnational access and infrastructure sharing will apply for the Antarctic.

Keywords – Polar Research Infrastructures, Arctic, Antarctic,

1. INTRODUCTION

The melting of Arctic sea ice to record lows in recent years has prompted many nations, principally those with an Arctic coastline, to reassess their commitments and strategic interests in the Arctic Ocean. Climate change in the Arctic and its influence on global climate is one of the future grand challenges for European societies and the importance of studying the Arctic Ocean has been stressed repeatedly in official policy documents by the European Commission, the European Parliament, international organizations and national funding agencies.

European polar research has contributed critical knowledge to identifying the processes behind these rapid changes, but datasets from the Arctic Ocean are still insufficient to fully understand and more effectively predict the effects of climate change. The largest gaps in our knowledge and understanding of the Arctic system processes are outside the summer season, when the Arctic Ocean is logistically and technologically extremely difficult to reach.

The changing Arctic Ocean opens up economic opportunities, including exploitation of marine living and non-living resources and increase in marine traffic. Maritime transport in the Arctic has increased in recent years with the retreat of the summer sea-ice, closely linked to the development of economic activities within the Arctic and the export of raw materials such as petroleum and minerals. Arctic cruise tourism is also growing fast, and a few merchant ships have made transit voyages between Europe and Asia so far.

The industries operating in the Arctic Ocean include shipping (including for mining products), oil and gas, fisheries, cruise tourism and the submarine cable industry. They face significant challenges, including a lack of critical infrastructure (e.g. ports, navigation charts), lack of means of communications, and the need for essential search and rescue capabilities. Safety of navigation is a serious concern for ships operating in harsh conditions and remote areas. There is some concern about potential environmental damage to areas that so far have been effectively protected from human influence by sea-ice. There is also a need to better forecast future scenarios of Arctic sea ice variation and

ocean conditions, to better guide the future sustainable development of the Arctic economy. Thus, industry partners also have a critical need for better Arctic information to support safe, responsible, and effective industry operations in support of Blue Growth.

To answer questions of particular scientific, environmental and societal concern and to develop policy recommendations for a sustainable usage of the Arctic and its resources, the international polar science community must have access to world-class marine research infrastructure in the Arctic, able to operate in the Arctic Ocean outside the summer season.

II. EU-POLARNET “CONNECTING SCIENCE WITH SOCIETY”

The objectives of EU-PolarNet are to establish an on-going dialogue between policy-makers, business and industry leaders, local communities and scientists to increase mutual understanding and identify new ways of working that will deliver economic and societal benefits. The results of this dialogue will be brought together in an Integrated European Research Programme that will be co-designed with all relevant stakeholders and coordinated with the activities of polar research nations beyond Europe. This programme will be accompanied by a feasible implementation plan to provide Europe with the capability to define the nature of environmental risks so that governments can design policy measures to mitigate them and businesses and other stakeholders benefit from the opportunities that are opening up in the Polar Regions.

Polar research infrastructures represent significant investments made by individual nations, yet lack an overall co-ordinated framework for shared access and interoperability. EU-PolarNet therefore aims at initiating a European Network of Polar Operations that will develop a management system for transnational access to these infrastructures. These will thereby be made available to the whole European research community, their international partners and other users engaged in the Polar Regions to deliver the highest quality and relevant research. EU-PolarNet will also identify and incorporate information from industry, to determine how commercial polar infrastructures and facilities might contribute to the European Polar Research Programme (e.g. tourist ships in Antarctica ferrying scientists to research stations, ships of opportunity deploying observational floats or carrying Ferry-Box style instrumentation packages on transits).

Since satellite technologies are very efficient and practical tools to provide consistent, year-round observation in the Polar regions, as well as communication and navigation support in the harsh polar environment, EU-PolarNet collaborates and interact with relevant space organizations (e.g. European Space Agency (ESA), NASA, Canadian Space Agency) and operational services (e.g. Copernicus) to coordinate pertinent space activities in Polar Regions on European and wider international level.

III. EUROFLEETS 2 “New operational steps towards an alliance of European research fleets”

The EU funded project EUROFLEETS2 aims at consolidating the construction of a pan-European distributed research fleet infrastructure with common strategic vision and coordinated access to European marine research vessels and equipment. In this context, EUROFLEETS2 provides access to RVs for all European scientists and their industrial and international partners on the sole condition of scientific excellence covering all fields of marine science from environmental and biodiversity protection, to coastal zone management, geodynamics and climate change research. EUROFLEETS2 has provided for the first time access to six European Polar Research Vessels (PRV) and funded 49 days of research in both the Arctic and Antarctic regions.

The EUROFLEETS 2 work package “Flagship initiative for polar access” works on integrating the European PRV fleet and establishing models for implementing

a joint coordination of these vessels. It aims at optimizing the usage of the European Polar Research Fleet by determining the available capacities of Polar Research Vessels; comparing them with the scientific demand, and establishing models for optimization of this fleet by better coordination of the vessels' scheduling and by harmonizing the deployment of ice-strengthened research vessels with the heavy icebreakers.

IV. ARICE "Arctic Research Icebreaker Consortium: A strategy for meeting the needs for marine based research in the Arctic"

The project ARICE aims at providing Europe with better capacities for marine-based research in the ice-covered Arctic Ocean with the existing polar fleet by developing strategies to ensure the optimal use of the existing polar research vessels at a European and international level and by working towards an International Arctic Research Icebreaker Consortium which shares and jointly funds operational ship time on the available icebreakers.

It will provide trans-national access to a unique set of four key European and international icebreakers for European scientists based on scientific excellence:

- > PRV Polarstern, Germany
- > IB Oden, Sweden
- > PRV Kronprins Haakon, Norway (under construction, to be operative in 2017)
- > CCGS Amundsen, Canada

It also aims at improving the research icebreakers services by partnering with maritime industry on a "ship of opportunity" programme and by exploring into new key technologies that could lead to an improvement of ship-based and autonomous measurements in the Arctic Ocean, e.g. to install in existing RVs and ROVs or gliders. These could be advanced modulation techniques for the communication with autonomous devices and/or improved battery packs for usage in cold waters. ARICE will also work with Copernicus on data requirements for new Sentinel missions and better communication and data transfer in the Arctic Ocean. This collaboration on technology and innovation will lead to more efficient use of the research icebreakers and the growing number of commercial vessels in the Arctic, while reducing human impact on Arctic observation.

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MARTECH18

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ID6- IMPROVING OCEAN-GLIDER'S PAYLOAD WITH A NEW GENERATION OF SPECTROPHOTOMETRIC PH SENSOR

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Abstract- Ocean gliders have clearly become nowadays useful autonomous platforms addressed to measure a wide range of seawater parameters in a more sustainable and efficient way. This new ocean monitoring approach has implied the need to develop smaller, faster and more efficient sensors without reducing key features like accuracy, resolution, time-response, among others, in order to fit the glider operational capabilities. This work is aiming to present the latest development stages of a new spectrophotometric pH sensor, its integration process into a Wave Glider SV3 platform and the preliminary results derived from an offshore mission performed in subtropical waters between the Canary Islands and Cape Verde archipelagos

Keywords- Glider, ASV, sensor, ocean, marine.

1. INTRODUCTION

The overall goal of this challenging initiative is to improve ocean-observations capacity in the area of interest by using cutting-edge technologies in a cooperative and synergistic way between partners from different disciplines, by using new and existing resources provided by ongoing projects and initiatives at regional, national and international level, in order to cover the widest number of specific and common needs and requirements from each one of them, as well as additional stakeholders joining the initiative at a later stage. The work is done in the framework of H2020 AtlantOS EU- Project. It is a BG 8 (Developing in-situ Atlantic Ocean Observations for a better management and sustainable exploitation of the maritime resources) research and innovation project that proposes the integration of ocean observing activities across all disciplines for the Atlantic, considering European as well as non-European partners, such as The Oceanic Platform of the Canary Islands (PLOCAN) and the Center for Marine Environmental Sciences (MARUM). PLOCAN is a Research Infrastructure labelled by the ICTS (Unique Scientific and Technological Infrastructure) Spanish National Roadmap. It is a multi-purpose technical/scientific service infrastructure that provides support for research, technological development and innovation in the marine and maritime sectors, available to public and private users. The main purpose of MARUM is achieving a better understanding of key processes in the marine environment in order to provide information for sustainable use of the ocean. MARUM studies past and present environmental changes from coast to deep ocean at a global scale. Processes at and below the sea-floor are a special research focus.

II. MATERIALS AND METHODS

To achieve these objectives, PLOCAN and MARUM have explored the operational capabilities of the Wave Glider SV3 manufactured by the company Liquid Robotics to use the platform as a test-bed for new sensor developments, always in line with the end-user's goals for every single mission. These autonomous surface vehicles are the best option to perform this task, as base their propulsion on external factors such as wave motion, its real-time communication availability, it is always visible on the sea surface so always ready to transmit and receive satellite communications and it is equipped with solar panels, this way the vehicle can power all its systems and payloads by this mean [1]. The surface part (Fig. 1) is a versatile platform equipped with GPS, Iridium satellite communication systems and payloads with state-of-the-art ocean sensors to monitor the environment around it. On this occasion, the sensor installed in there is the Turner C3 fluorometer to measure chlorophyll, turbidity and oil data. The sub part of the glider is tethered under the sea by a 6 m umbilical cable. It has articulated wings that vary its position with the sea motion propelling the vehicle so it does not need refuelling and is fully free of emission, encouraging the use of sustainable energy [2] A submarine payload has been developed to integrate a set of brand new basic sensors. It is enclosed in a custom subsea housing physically attached to the Wave Glider sub part and is powered and communicates with the float through the Wave Glider umbilical



Fig. 1. Wave Glider SV3 around PLOCAN facilities.

cord. It has neutral buoyancy and has been designed to minimize drag (Fig. 2). The sensors integrated in this payload are, a Seabird GPCTD for measuring conductivity, temperature and pressure, Seabird 43F for dissolved oxygen and a new generation of spectrophotometric pH sensor design by SensorLab. The pH

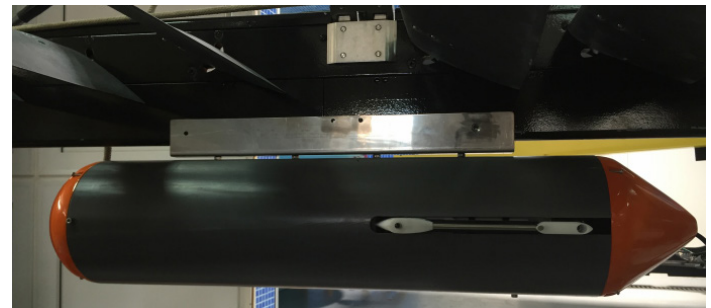


Fig. 2. Submarine payload design by SensorLab.

sensor is a SensorLab SP200-SM, a high accuracy and low drift sensor capable of very long deployments. All of this sensors will be connected through a parallel telemetry system, probably Iridium Rudics to a data logger with several web services to improve the data processing and storage. On the long run, it is expected the integration of further and innovative sensors, like an ADCP or a dust sampler developed by MARUM with the purpose of developing new lines of research.

III. EXPECTED RESULTS

PLOCAN and MARUM have been working on sensors integration into the Wave Glider during 2016 from January to March. In addition to the various laboratory tests that have been performed to verify the proper development of the whole process, couple of acceptance tests in saltwater have been conducted both in a confined tank located at PLOCAN land facilities and offshore in the test-site area placed in the East coast of Gran Canaria Island. Before long it is expected to carry out a biochemical science mission of several days in subtropical waters between Canary Islands and Cape Verde archipelagos in order to check the system in real conditions. Based on the results of this test mission, some other public and private stakeholders from marine and maritime sectors could be interested in joining further missions.

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ID7- SEVEN YEARS OF MARINE ENVIRONMENTAL CHANGES MONITORING AT COASTAL OPCS STATIONS (CATALAN SEA, NW MEDITERRANEAN)

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Abstract - Since March 2009 up to the present (more than 7 years now), the Operational Observatory of the Catalan Sea (OPCS; <http://www2.ceab.csic.es/oceans/>) remains a witness of persistent marine environmental changes. The OPCS has two fixed observation stations at the head of the Blanes Canyon (200 m depth, 41.66°N; 2.91°E) and at the Blanes bay (20 m depth, 41.67°N; 2.80°E) in the Catalan Sea, NW Mediterranean. At the canyon station, a multi-parametric buoy presently installed delivers high frequency (by 30 min) and multi-parametric oceanographic (i.e. salinity, temperature, chlorophyll, turbidity, as well as light intensity in the PAR range for the upper 50 m depth) and atmospheric (air temperature, relative humidity, wind speed and direction and PAR) data. Subsurface photos and videos by an IP high resolution fisheye camera attached to the buoy are also delivered at 4-hour basis. Data and multimedia are transmitted in near real time for public access, via combined GSM/GPRS and 3G connections. At both stations, CTD profiles and water samples (collected for nutrients and picoplankton analyses) are carried out on board a research vessel at fortnightly basis. Numerical simulations along with the time series of in-situ observations show inter-annual seasonality anomalies possibly linked to global environmental changes. The lower-atmosphere and upper-sea environmental time series data collected prove the occurrence of shifting patterns of heat and matter fluxes impacting pelagic and benthic organisms.

Keywords – Operational oceanography, oceanographic buoy, coastal monitoring, numerical modelling, long-term time-series.

1. INTRODUCTION

Long-term time series of marine environmental variables allow detecting anomalous trends and patterns impacting human activities and health and overall living organisms. Global warming, including the warming of the oceans [1], is perhaps the most widely known event.

One of the typical signals of global warming is the increasing occurrence of extreme seasons with a higher occurrence of warmer summers and less extreme cool weather [2]. A consequence of these changes has made temperature records to become nearly a rule. For example, the seven highest monthly global sea surface temperatures ever recorded has taken place within seven consecutive months from September 2015 to March 2016 [3, 4]. Though global warming was detected in the last decades, the recent records and reports suggest the Earth is facing an overall fast increasing temperature period irregularly evolving at diverse locations.

In-situ monitoring stations contribute to record environmental variability allowing the assessment of local anomalies potentially connected to global environmental changes. These stations, when integrated into marine observing networks, contribute to validate operational numerical ocean models and help improving marine weather forecasting. The Mediterranean Operational Oceanography Network for the Global Observing System (MONGOOS) contributes to that challenge.

Recent records show that Mediterranean Sea surface temperature [4, 5] and salinity [5] are increasing, though may not be increasing as fast as in areas of the Indian Ocean, Pacific, western and southern Atlantic, and the Arctic Seas [3]. Other areas have shown recent cooler-than-average records of temperatures such as the North Atlantic and the Southern Ocean near Antarctica [3]. Marine monitoring stations recording changes from daily to monthly time scales contribute to improve accuracy of reports and studies dealing with environmental changes. Warming of seawater is producing behavioural changes in a number of organisms, e.g. earlier spawning of fishes [6] or species assemblages moving from warmer to cooler areas [7]. Smaller organisms with shorter life times may be also altered particularly because of potential changes taking place at daily or hourly scales.

The Operational Observatory of the Catalan Sea (OPCS, <http://www2.ceab.csic.es/oceans/>) started operations in March 2009 [8] with a fixed observation station at the edge of the continental shelf, at 41.66°N, 2.91°E at the head of the

submarine Blanes canyon, in the Catalan Sea, NW Mediterranean.

Inter-annual, seasonal and daily environmental trends are measured, recorded and processed by the OPCS team. Two main time-scale data types are provided for public use in order to assess the effect of environmental conditions on living organisms with relatively short (e.g. hours, days) and long live (e.g. monthly, seasonal, inter-annual) cycles. Firstly, fortnightly sampling is performed collecting information of the biogeochemical and hydrological conditions at the observation stations. These data allow seasonal and inter-annual variability monitoring and are available to the public within days after collection. Secondly, 30-m time resolution information is provided of the lower atmosphere (i.e. 2 m above the sea level) and upper sea conditions (from surface to 50 m depth) by an oceanographic buoy. The data collected are available to the public in near-real time. The oceanographic buoy operates about six months per year, though full year coverage was achieved between June 2015 and May 2016.

The fixed observation stations maintained by the OPCS are expected to continue operating indefinitely to become a reference of long-term marine environmental time series acquisition and processing. In the present work, operational characteristic and milestones achieved by the OPCS are provided, for the seven years of continuous data recording of relevant environmental changes beyond sea surface temperature, including biogeochemical parameters [8] with potential impact on marine living organisms.

II. RELEVANT OBSERVATORY ACTIVITIES

A. Consolidation of long-term time series observations

As expected from its foundation, during seven years of operations, the OPCS has faced the basic challenge of consolidating long-term coastal monitoring [9]. This has implied, among other factors, getting over the budget cuts imposed by the economic crisis affecting Spain since 2007 up to the present. This was possible because of the persistent support from the CEAB to the relatively low-cost infrastructure, consisting of a small research boat (R/V "Dolores") with its instrumentation and instrumentation on the oceanographic buoy. Though initially expected to take to port once per year for maintenance, the oceanographic buoy has been taken to port and deployed twice the times expected i.e. 12 deployments have been made (see in Fig. 1). A number of situations dealing with quality of materials, galvanic corrosion and entanglements with longlines operating nearby, have caused the buoy to nearly stop operations, after rescuing it from mooring line detachments or after electronic failures or structure damages.

Coastal oceanography within the framework of the OPCS is possible with relatively low resources or with an efficient use of available resources. For example, the deployment of the 250 meters-long mooring line with a heavy weight required the use of an expensive research vessel only at the beginning of operations, in 2009. Subsequent operations were carried out with the in-house R/V "Dolores" trawling the line with the use of floating balloons. The CEAB facilities and the closeness of the Blanes port have also contributed to keep the observatory uninterruptedly running.

B. Two monitoring observation stations

Apart from the fixed original monitoring station set at the Blanes canyon head, visited twice per month on board the R/V "Dolores" and providing data on 30-minute basis from the probes and sensors on the buoy, a new observation station was added since March 2010 at the Blanes bay [see Fig. 1]. This station was added as a collaborative action with the Microbial Observatory group at Institute of marine Science (ICM-CSIC, <http://www.icm.csic.es/bio/projects/icmicrobis/>) in Barcelona. The station is moored at 20 m depth, contrasting with the 200 m depth mooring in the canyon. The Blanes bay station serves as a reference for comparing nearshore waters with those from the offshore station in the canyon. The two stations are sampled twice per month within the same cruise and have provided us with supporting data for explaining oligotrophic

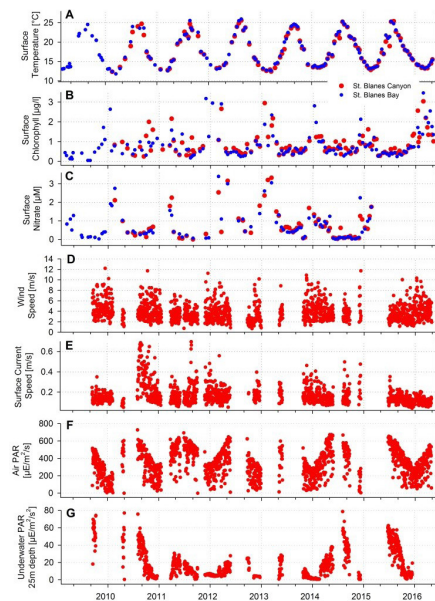


Fig. 1. Examples of available time series of marine environmental data collected at the OOCs fixed stations in the Blanes canyon head and in the Blanes bay. Some time series are created on a fortnightly basis on board R/V "Dolores with a CTD profiler (A, B) and from Niskin bottles samples (C) at both stations. Some other time series are created on a 30-minute basis by the oceanographic buoy at the Blanes canyon head, for segmented deployment periods. Daily averages from meteorological (D, F) and oceanographic (E, G) data collected by the buoy shown for reference.

conditions in the Blanes bay with supporting data showing oligotrophic conditions in the Blanes bay probably due to offshore water arriving from the Blanes canyon head.

C. Near real time data and media transmission

At the time the autonomous buoy was moored in September 2009, we weighted the possibility to add an underwater camera to the system for near-real monitoring of pelagic organisms (Fig. 2). In October 2012, a surveillance IP camera was adapted to operate underwater and attached facedown to the buoy. Images and short videos transmission is made taking advantage of the 3G coverage at the buoy location, 2.7 miles offshore. Therefore, apart from hourly data transmission via GPRS since March 2012, the video camera system provides image at 4-hour basis in summer time only, due to limited power energy resources [9].

D. Numerical modelling

Available climatic hourly data from the whole water column from surface to 200 m depth at the Blanes canyon station, allowed for the first time full validation of the 1DV model [9] operating at 1-hour time-step [10]. Following the IPCC scenarios, the model also tested the potential impact of longer summers on the CO₂ flux, suggesting that the Station can twist from yearly sink to source of CO₂. Also 3D numerical simulations were partially validated with the OOCs monitoring station data [5], allowing a better understanding of seasonal changes in the formation of gyres and meanders that impact local productivity. The same model was also used to track passive particle dispersion over the canyon area [3] (Fig. 3), showing a potential great impact of meanders on the dispersion of crustacean and fish eggs and larvae known to recruit and live in the area.

E. Outreach

A number of high school students and undergraduate and graduate students, as well as researchers, have made or are making use of data and OOCs facilities or have attended conferences and citizen science activities for learning about oceanography, marine observing systems and marine ecology. The evolution of the environmental conditions at the observation stations is communicated to public through Twitter (@ceab_oocs) and Facebook (www.facebook.com/ObservatorioMarino/) accounts. The social networks have been the way to inform the public on the inferred trends of water warming along the Catalan coast, in line with warming of the Mediterranean Sea in recent months and years. Since 2014, OOCs provides information to global marine networks such as MONGOOS (http://oceanobs.mongoos.eu/) fuelling operational models of the NW Mediterranean (e.g. IBI-ROOS) predictions. The Station is also a component

of the EMODNET (http://www.emodnet-physics.eu/portal/) and COPERNICUS (http://marine.copernicus.eu/). These networks are of public access and make available in-situ information for modelling hindcast and forecast providing a social service regarding e.g. the marine weather conditions or the expected circulation pathways in case of environmental emergencies, related to the field of operational oceanography.



Fig. 2. Pictures taken by the fisheye IP camera attached to the oceanographic buoy showing schools of rudderfish (*Centrolophus niger*, left and right) and pilot fishes (*Naucrates doctor*, center).

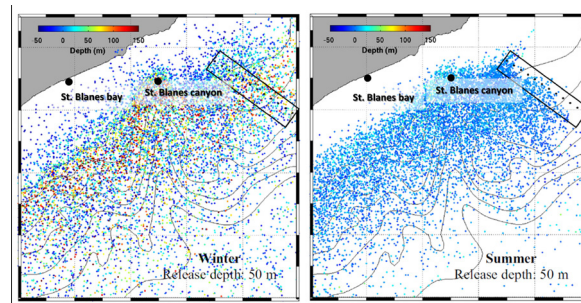


Fig. 3. Location of passive particles after 15-day tracking simulations around the OOCs observation stations (adapted with permission from Ahumada-Sempol et al., 2015). Rectangles show initial particles release positions.

III. FUTURE DIRECTIONS

Activities dealing with observation, analysis and numerical modelling remain the main target of the OOCs, in line with current international calls to gather information on the on-going changes in ocean physics, chemistry and biology in order to determine trends and variability, and assess their potential causes [6]. Analysis of the time series at the OOCs station may allow validating hypothesis regarding at which extent the local conditions reflect regional or global environmental changes. Finally, numerical modelling efforts at OOCs are currently addressed toward assessing the impact of local and remote circulation on the dispersion of organisms along the Golf of Lions, Catalan and Valencian coasts in order to investigate potential interconnections among pelagic and benthic populations.

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ID8- DEVELOPMENT OF A ROV TITANIUM MANIPULATOR FOR LIGHT WORK CLASS ROV VEHICLES

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ABSTRACT

This paper shows the development of a high technical equipment to be used as tooling of submersible ROV (Remote Operated Vehicles) for offshore operations, particularly the design and fabrication by Additive Manufacturing (AM) of a Titanium Manipulator for ROVs. From the initial concept and design until a new formed company "TITANROB"; this document shortly describes the fabrication of hydraulic titanium manipulators for mid size ROV vehicles, the TitanRob series M501, G500 and the M700.

KEYWORDS

ROV, SUBSEA, MANIPULATORS, TOOLS, OFFSHORE

MAIN TEXT

1. COMPANY PRESENTATION AND TRACK RECORD

ACSM (Advanced Crew and Ship Management) provides global maritime services such as nautical management of vessels as well as complete services of submersible ROV vehicles for offshore projects with clients from all over the world. Established in 2001, ACSM key personnel have more than 20 years of experience in marine and subsea services for offshore operations. ACSM has international clients from UK, USA, Italy, Norway, France, UAE and other countries. We operate worldwide, mainly at EU, Mediterranean, and Middle East; and currently we are increasing our presence in West Africa.

ACSM operates and also provides ROV submersible systems services supplying Work Class hydraulic ROV systems, inspection electric ROVs, and subsea Cable Ploughs, with high qualified technical personnel (Supervisors, Pilots and Technicians) for operation, maintenance and management. For over 15 years ACSM personnel have worked with submersible systems aboard many cable ships and offshore vessels with almost all type of ROV systems including Perry Slingsby, SMD, Schilling, Saab-Seaeye, and Sub-Atlantic among others, as well as with SMD and EB submersible cable ploughs.

2. ROV VEHICLES, EQUIPMENT AND TOOLING

The ROV vehicles are used in almost all type of offshore subsea works and operations, equipped with surveillance equipment as cameras, lighting and obstacle avoidance sonar, other survey equipment for data recording as Bathymetry, Side Scan Sonars, Profilers, Doppler DVL, etc. Also hydraulic tools for underwater intervention as cable cutters, torque tools, gripper, grinder, and the manipulators as the main ones.

New technology used to be slowly introduced in the maritime and offshore industry, many times with a significant delay, mainly due to the fact that any equipment must fulfill the harsh marine environment conditions and high standards and requirements from the Class Societies, Marine Administrations and other legal and safety requirements.

On 2014 ACSM supported by CIMA and Quantum, and investigation group and a spin off from the University of Vigo, started a project looking for some kind of equipment and technology not supported by any manufacturer or subsea equipment supplier. Our group founded that the hydraulic manipulators for ROV systems are supplied by only four companies, with just two of them servicing the 80/90 % of the market; Schilling for heavy WROV, and Hydrolek for light and small ROV system. There aren't standard electric systems or are not suitable enough.

There isn't any high quality equipment supply for small or mid size ROV vehicles, see above Fig. 1.

The titanRob series manipulators cover the gap of high quality manipulators for small and midsized ROV and WROVs

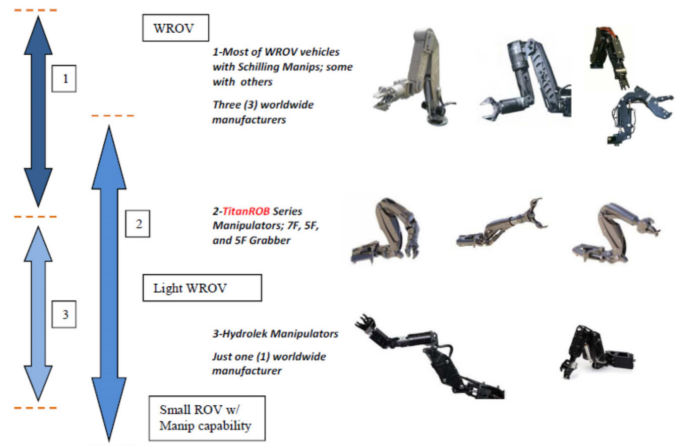


Fig. 1

3. DEVELOPMENT OF A TITANIUM MANIPULATOR

3.1 General and technical objectives

- Research and develop a new concept of anthropomorphic manipulator arm, developing and using optimized techniques for manufacturing titanium by additive technologies (AM)
- Achievement of an arm with an excellent weight to load capacity ratio, which improves weight specifications, movement (4-7 functions), scope and workload of current manipulators
- Analyze current technical solutions determining advantages and disadvantages
- Versatile designs to develop general subsea works, with variability of functions (4 to 7)
- Adapt the design to AM techniques
- Besides the design and manufacture of equipment, provide ancillary services such as maintenance, repair and commissioning

3.2 Engineering development

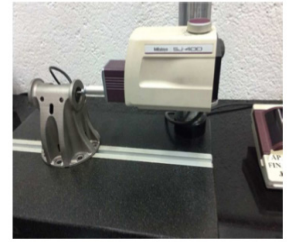
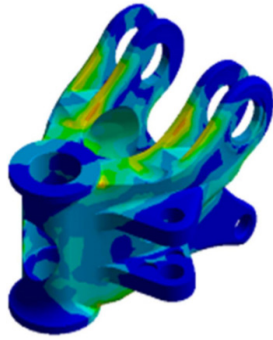
The design and preliminary specifications of the TitanRob manipulator arm has been thought to meet the following requirements: Good relationship between own weight and load capacity; full mobility to reach different working positions; low hydrodynamic coefficient shapes; easily exchangeable commercial components.



Then, a five "degrees of freedom" prototype was defined with an operating range of 1 meter. Based on the general parameters, a series of preliminary sketches that helped define the desired aesthetic and functional design of the manipulator were performed

Next engineering works were carried out as follows:

- Adaptation of the design to the mechanical arm mobility: Parameters to consider are specified to allow for expected mechanical mobility in the arm
- Definition of kinematic scheme of the arm (4, 5 and 7 functions)



- Defining tolerances of the various parts, especially those involved in arm mobility
- Definition and selection of elements to provide mobility to the different arms: shafts, joints, hydraulic cylinders, etc.
- Establishment of mobility range for the proposed arms
- Hydraulic system design: Definition of the appropriate hydraulic power needs for the manipulator, pressure and flow (1 kW HPU, 1.5 l/min, 140-200 bar), definition of the hydraulic circuit and its main components, and selection of all the materials as hydraulic hoses and fittings, cylinders, screws, etc.
- Mechanical Design & Optimization: 3D CAD to define the different parts that

make up the range of manipulator arms, and edition of first technical drawings

-Structures Optimization: The design of the system undertaken began with a preliminary model, which was subsequently modified to reach the final design or construction, then iterative process with structural FEA calculations in order to study the critical load conditions. Kinematic and dynamic simulations to determine if the parts withstand the operating conditions and to study possible interferences, FEA stress map.

Finally, the fabrication drawings were issued together with GA drawings, and revision of the final specifications.

3.3 Construction, Test, and Sea Trials

The fabrication of the arm itself is done by AM procedures: Selective Laser Sintering (SLS), Selective Laser Melting (SLM) and Electron Beam Melting (EBM) are the options, and finally it was decided to manufacture the set with EBM, as



the most suitable option due to the titanium elements design, with no need of any post-heating process.

Finishing where necessary with different procedures such as milling, lathe works, metal fabrication, machining and surface treatments for parts, followed by dimension and alignment checks.

The assembly of the various mechanical sub-assemblies was held, and the manipulator was integrated into one ACSM ROV vehicle for FAT and SAT test,

which were performed with excellent results.

A new company called "TITANROB" was created early 2016, with two sets of the M501 manip already sold, the G500 prototype built and tested, and the M700 prototype will be ready for test and trials by end of 2016. An electric manipulator is going to be develop in the near future.



ID9- SMARTBAY: THE DEVELOPMENT AND IMPLEMENTATION OF AN ADVANCED MARINE TECHNOLOGY PLATFORM ON THE WEST COAST OF IRELAND

ALAN BERRY¹⁵⁶, PAUL GAUGHAN¹⁵⁸, CAITRIONA NIC AONGHUSA¹⁵⁷

Abstract - This paper is about the development, implementation and operation of SmartBay - a subsea cabled observatory and supporting infrastructure to stimulate the development of marine technology in Ireland. Blue Growth is the long term strategy of the European Union to support sustainable growth in the marine sector and offers great potential for innovation.

The development of Ocean Technologies currently presents a number of challenges globally in terms of costs, reliability and longevity of infrastructure in the development of Renewable Energy, Blue Biotechnology, Water, and Environmental Monitoring & Management as well as more established markets such as Oil and Gas, Shipping and Security and Fishing and Aquaculture. We discuss the rationale behind the development of SmartBay in terms of addressing these challenges and focus particularly in the area of marine renewable energy technology development

The design and installation phases of SmartBay are discussed. Costs were minimised, whilst maximising the range of features and applications that the infrastructure can

provide to scientific and commercial users. The scientific subsea instrument node is also described in detail, along with the advanced supporting cyber-infrastructure that ensures the data is collected, processed archived and displayed as per end user requirements. The facility provides access to state of the art marine assets and resources for Researchers, Designers, Innovators and Entrepreneurs within Ireland and the EU and is a unique catalyst in the attraction of inward investment and venture capital investment.

The SmartBay infrastructure platform centres on a core technology or service, the provision of high quality, time-series marine data. This is essential for a broader, interdependent ecosystem of businesses to develop and supply complementary value-added products and applications to wide multidisciplinary set of users. SmartBay's role as a key technology node in broader European initiatives Ocean Observation initiatives like the European Multidisciplinary Seafloor and water column observatory (EMSO), which has been established as a European Research Infrastructure consortium (ERIC) is also discussed.



ID10- EMSO-AZORES: SIX YEARS OF CONTINUOUS MONITORING OF A DEEP SEA HYDROTHERMAL VENTS – TECHNICAL RESULTS

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Abstract - Since 2010, the EMSO Azores non-cabled deep sea observatory acquires scientific data on the Lucky Strike vent field on the mid Atlantic ridge. This paper presents the marine infrastructure of EMSO Azores observatory needed to acquire and transmit data in near real time 24/day during six years. It details technical results obtained during this period.

Keywords – non-cabled observatory, near real-time, COSTOF, EMSO, long-term subseamonitoring

I. INTRODUCTION

The MoMAR “Monitoring the Mid-Atlantic Ridge” project [1] was initiated by InterRidge in 1998 to study the environmental instability resulting from active mid-ocean ridge processes at hydrothermal vent fields south of the Azores. EMSO-Azores observatory is now a part of the European Research Infrastructure Consortium EMSO (European Multidisciplinary Seafloor and Water Column Observatory - <http://www.emso-eu.org>) European programs, which coordinates eulerian observatory initiatives in European seas. The non-cabled EMSO-Azores observatory, deployed in October 2010 on the Lucky Strike vent field at 1700 m depth, focuses on two main questions: what are the relations between volcanism, deformation, seismicity, and hydrothermalism at a slow spreading mid-ocean ridge and how does the hydrothermal ecosystem couple with these subseabed processes? The marine infrastructure consists of two Sea Monitoring Nodes (SEAMON) placed on the sea floor and fitted with the scientific sensors [2]. A surface buoy (BOREL) relays the acoustically received seafloor measurement data to the shore, via satellites.

An array of autonomous sensors (OBSs, pressure probes, temperature probes in selected smokers, current meters and temperature probes in the water column) and colonization devices complete the infrastructure. A site studies program contributes to increase the set of accessible parameters and to extend the spatial coverage of the study.

THE MOMAR INFRASTRUCTURE

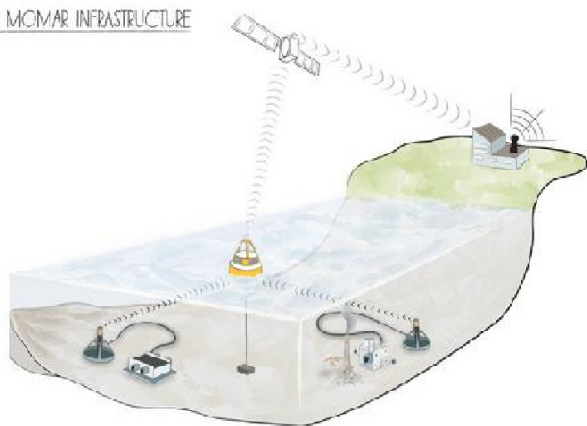


Fig.1. The EMSO Azores infrastructure is made up of two Sea monitoring nodes and a relay buoy

I. SEA MONITORING NODES

The two SEAMON nodes have the same architecture and include a set of components designed for long-term, non-cabled sub-sea monitoring, initially developed by Ifremer during the EU ASSEM project (2002-2004) and upgraded. The main components of SEAMON are:

A. COSTOF

The COSTOF (COmmunication and STORage Front-end) is the electronic unit serving a set of connected sensors by providing them with energy, sequencing, data storage, time stamping, local data transmission for the installation phase,

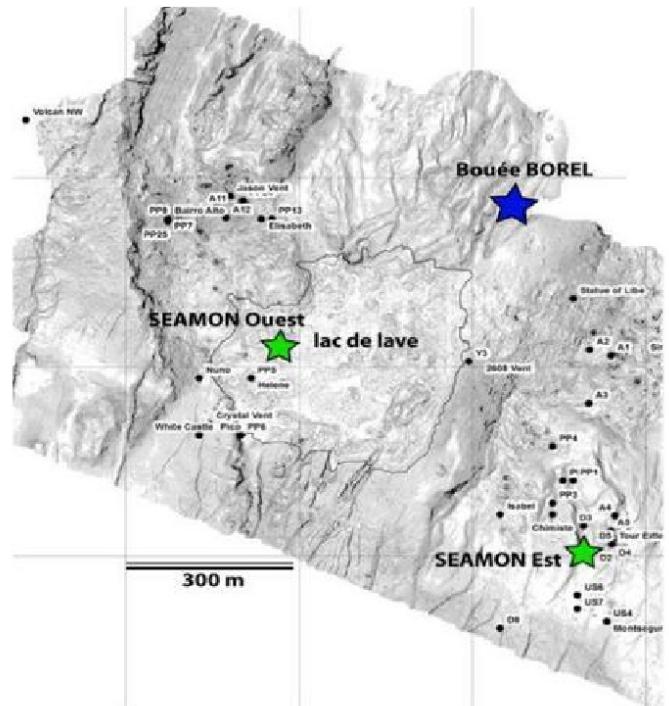


Fig.2. SEAMON and BOREL positions on the Lucky Strike vent field

remote data transmission, and active protection against biofouling. The COSTOF is designed with a distributed architecture including a series of simple, identical and low power electronic boards built around an 8-bits microcontroller (ATMEL® ATmega128), each dedicated to a specific function and communicating through a CAN (Controller Area Network) field bus, providing maximum modularity and reliability to the observatory. With this multi-master architecture, by running specific software based on a common kernel, each board is totally independent from the others and a failure on one of them does not have any effect on the others. Furthermore, this architecture facilitates the integration of a new sensor and avoids software interference. The choice of a CAN field bus has been motivated by its standardization level, its low power consumption, its multimaster capability and its wide use in the industry, especially in automotive, offering reliable service. Data, alarms and synchronization messages are sent through the CAN bus. Each board consumes 1.5mW in sleep mode and 860mW in active mode. A complete COSTOF consumes 12mW in sleep mode and 7W in active mode if all the boards awake synchronously. In addition to scientific data, COSTOF records and transmits technical data such as internal pressure, voltages, instantaneous current, remaining energy and water intrusion detection. Its titanium housing is 4000m deep rated. The COSTOF has proved its reliability during this six years period of experiment with a very good behavior. Only a harmless issue concerning energy measurement has been noticed.

B. COMMUNICATION LINKS

A local inductive serial modem allows an operator to configure the system before the deployment in air, and during the deployment in water, through the ROV, without any physical electrical connection, with a 57600 bits/sec maximum baud rate. Noise interference caused by the ROV hydraulic engine have been overcome by replacing the RS232 serial link by an RS422 (NKE® CLSI - ContactLess Serial Interface). A second type of modem developed by Ifremer is used to establish a local Ethernet link. This underwater 802.11g WiFi link allows

the user to stream HD video during the camera installation through an ROV without electrical connection, and to download files during the deployment. It is also very useful for configuration on deck to have a wireless remote access to the camera. The modem, switched on and off by the COSTOF, has a power consumption of 2.1W and provides a 10Mbits/sec bandwidth that will be improved by the use of a type 802.11n modem. Finally, an acoustic modem offers a near real time bidirectional link to the observatory. Four times a day, data collected by the COSTOF are transmitted through this acoustic link to the surface buoy connected to shore via IRIDIUM satellite communication. The acoustic modems have been chosen after short and long term trials (COMMODOC experiment, 2008-2010) confronting several manufacturers of the world market. The energy efficiency (number of correctly transmitted bits per joule) was a crucial factor for the choice. EvoLogics® S2CR12/24 underwater acoustic modems were selected as the most efficient and reliable solution. The bottom modems are composed with a 6000m rated titanium housing containing the electronics and a directional transducer with 60 degrees beam to optimize the efficiency/power level ratio. Daily transmitted data is around 100 kilo-bytes for the SEAMON East node (technical data, scientific data and a snapshot per day) and around 3.5 kilo-bytes for the SEAMON West node (technical and scientific data). Their mean consumption is 17mW. The mean bitrate observed on EMSO-Azores is around 1500 bits/sec depending of the sea state and the buoy position. The power efficiency is around 70 bits per joule. The source level used is 178dB re 1µPa corresponding to an electrical power of 15W (6000m range). During the six years, the four modems of the network have been very reliable. Indeed, only one issue has been encountered during the second deployment. It concerned wake-up difficulties, remotely corrected by the manufacturer during the 2011 cruise.

C. ACTIVE ANTI-FOULING PROTECTION

Biofouling is a major issue in the highly productive vent ecosystem environment. Biofilms form on every available surface and trap the mineral particles produced by the hot fluids. Localized micro-chlorination is used for preventing the portholes of the video camera, projectors and dissolved oxygen sensor from biofouling. A specific COSTOF board drives an electronic device generating a current between two electrodes. This allows sea water electrolysis generating hypochlorite on the surfaces. Programmed to run between two measurement periods, this system does not affect sensors data and the amount of chemicals released are negligible. The chlorination cyclic ratio, initially of 50%, has been lowered to 10% to save energy, without any difference.

D. ENERGY

SEAMON is powered by one or several energy containers composed with ten sets of twelve 3.6 V primary lithium thionyl chloride (Li-SOCI₂) cells, each container providing 4 kWh. Voltages and instantaneous consumed currents are monitored and transmitted with other technical data. Energy containers are 4000m rated aluminum housing fitted with a security overpressure valve.

E. CONNECTION/DISCONNECTION SYSTEM

A specific mechanical system has been developed by Ifremer to allow underwater connections and disconnections of sensors and batteries. The SEAMON can be fitted with several devices to allow the ROV to perform the installation of a new sensor or to change batteries without recovering the node. These devices have been used from 2010 to 2014 to install OBS and pressure gauges on SEAMON WEST.

F. SENSORS

SEAMON West is dedicated to geophysical monitoring. It serves two permanent pressure gauges as well as an ocean bottom seismometer (OBS), both provided by the Institut de Physique du Globe de Paris and installed on a solidified lava lake. SEAMON East is installed 600 m away from SEAMON West, at the base of the active Tour Eiffel edifice. It is dedicated to studying the links between faunal dynamics and physico-chemical factors. The node is composed with several elements such as an Ifremer SMOOVE (SMart Ocean Observatory Video Equipment) high definition video camera fitted with a solid-state drive and four pressure balanced-oil-filled LED lights, an Aanderaa® optode, a Wetlabs® turbidimeter, an Ifremer Chemini in situ iron analyser and since 2013 and an Ifremer CISICS (Cabled in situ Instrumented Colonizer System).



Fig.2. The SEAMON EAST node during deployment

II. RELAY BUOY

Moored within acoustic range of the two SEAMON nodes on the ocean surface, the BOREL relay buoy transfers every six hours, the received acoustic data flow on the satellite link to the shore server decoding and archiving data. Asynchronously, an operator can initiate a satellite session on shore and send remote configuration queries addressed to the buoy or a bottom station. The energy is provided by solar panels coupled with a regulator and lead-acid batteries. To increase available energy, especially during winter periods, additional panels have been installed and a sleep mode has been implemented on the acoustic modems by their manufacturer. The robustness of the buoy mooring is one of the technical challenges for the EMSO-Azores observatory. It is composed, from top to bottom, with 50m of steel cable (diameter 20mm), 700m of nylon cable (diameter 24mm) and 940m of polypropylene cable (diameter 28mm). Finally, a 1500kg steel ballast is connected to the line with a 10m chain (diameter 16mm) and an acoustic releaser for mooring recovery. The Electronic unit named UGB (Buoy Management Unit) includes an application board built around an 8 bits microcontroller (Atmel® ATmega128). This board manages the acoustic modem, the satellite modem and sensors (weather station, IPGP precision GPS). Two complete independent redundant transmission links are used on the buoy to optimize data transmission success rate. In case of a material failure, we can remotely switch from a link to the other one and reestablish the data transmission channel. A preventive reset is done daily on the UGB to prevent from any software issue blocking data transmission.

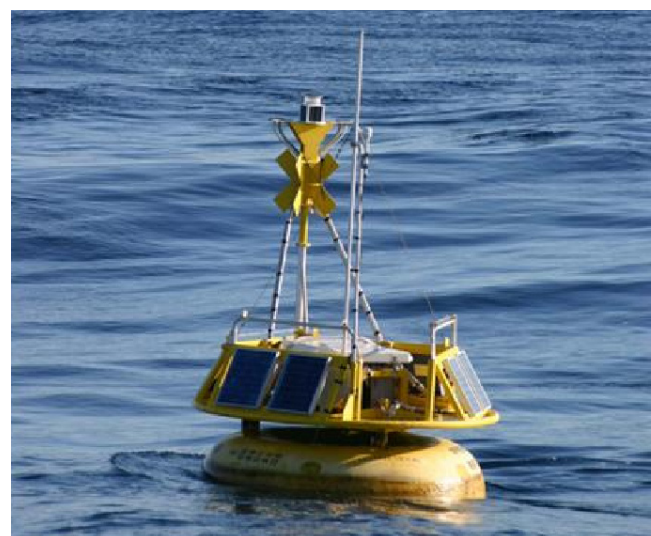


Fig.2. The SEAMON EAST node during deployment

The acoustic modems are identical to the SEAMON ones except the housing which is stainless steel 200m deep rated. They are installed on the buoy keel with a baffle to optimize the signal-to-noise ratio. The use of Iridium® RUDICS (Router-Based Unrestricted Digital Interworking Connectivity Solution) service on a Nal Research® A3LA-DG, associated to a specific data protocol allows efficient satellite transmission of a large amount of data. The effective bitrate

of the Iridium link is around 2000 bits/sec. Modem stability and reliability are considerable thanks to the RUDICS service having replaced the Direct Dial service. Connection time is around 15 seconds and cuts due to satellite connection loss are rare. Each BOREL independent link is powered with 4 solar panels associated to a regulator and to 2 lead acid batteries connected in series to deliver a 24V voltage to the UGB and to the modems. The average power consumption of each link is 3W, divided up almost fairly between UGB, Iridium modem and acoustic modem. The voltage varies from 25V to 28V, between days and nights, depending of the cloud cover and the season.

III. LOGISTICS

The observatory requires annual maintenance, carried out during a two week cruise from a research vessel equipped with a Remotely Operated Vehicle (ROV). During each maintenance cruise, each part of the observatory is recovered, reconditioned and re-installed. The BOREL buoy is recovered after releasing its ballast. The buoy requires a thorough cleaning of its submerged parts. Sacrificial anodes are replaced. After one year of service, it is frequent to find one or several solar panels damaged by strong waves. The acoustic modems are replaced every year and sent back to the manufacturer. A complete check of the electronics, batteries and external wiring is performed. Due to its critical role with regard to the whole observatory, a new mooring line is installed every year.



Fig. 4: cirripods on BOREL's keel after recovery in 2015

The two SEAMON seabed stations are recovered by lowering floatation devices, securing them to the stations with the ROV, then releasing a deadweight that triggers the ascent. Reconditioning consists in cleaning the stations, replacing the batteries and the acoustic modems, replacing the sacrificial anodes and upgrading the embedded software. The sensors are cleaned and calibrated or switched with lab calibrated units. Heavy data files that could not be sent to shore in real time (video footages and seismic data) are downloaded from the station. After a complete functional check, the stations are lowered to the seafloor with a cable. The final installation of the nodes and the precise installation of the sensors are performed by the ROV. The general functioning of the observatory, including acoustic and satellite data transmissions, is checked before leaving.

III. DATA MANAGEMENT

All the data acquired by the EMSO-Azores observatory are stored in the National data bases, CORIOLIS, SEXTANT, BGM and BIOCEAN managed by the

SISMER and RESIF. EMSO-Azores produces two flows of data. Data acquired by connected instruments are at least partially transmitted to the shore in near real time (every six hours) through acoustic and satellite link. They are decoded, stored and made available without quality check. They are attributed a DOI (Digital object identifier) updated on a daily basis and can be downloaded or plotted using the portal <http://www.emso-fr.org/EMSO-Azores>. The complete set of data is recovered annually during the maintenance cruises. This concerns the data for which the acoustic bandwidth is not sufficient for transmitting (video footages and seismic data for instance) and the data acquired by the autonomous instruments. These data are checked with respect to the quality process specified by EMODnet (European Marine Observation and Data Network). Each set of data acquired by each sensor during the deployment is also attributed a DOI and can be downloaded using the EMSO portal.

IV. CONCLUSION

After six years of operation, the EMSO Azores infrastructure shows a good level of reliability. We learned a lot from the different issues encountered during the first years of deployment, especially concerning underwater manipulations. Deployment and recovery procedures have been adapted and improved to try to minimize operation duration. ROV interventions are now optimized thanks to the pilots' experience and the Lucky Strike site knowledge. The COSTOF proved that its modular architecture was perfectly adapted to this kind of observatory, allowing easy sensor changes. Its low power consumption and its communication capability have been demonstrated. The data archiving and access step has been largely improved and standardized. The data can now be downloaded through a dedicated portal. Nevertheless, during this deployment period, we pointed out some limits to the COSTOF. As each sensor board is dedicated to one sensor, only six sensors can be connected. The lack of Ethernet connectivity is also a limitation, more and more sensors needing a 100BASE-T link to transmit their data. All these reasons convinced us to develop a new generation of electronic unit: the COSTOF2. The idea was to keep the COSTOF's benefits, improve some of its capabilities and add some new features. COSTOF2 has been developed around a similar distributed architecture based on a CAN bus and an Ethernet network has been added in parallel. This new front-end allows to connect up to 16 sensors with a fully configurable interface to choose voltage and data link for each sensor. Data storage capabilities, time stamping precision, user interface have also been considerably improved. A Sensor Development Kit has also been implemented to offer to any sensor provider a simple and convivial interface for coding each specific sensor driver. The COSTOF2 will be deployed on both SEAMON nodes on the EMSO Azores observatory during next maintenance cruise in August 2016 and will equip the buoy the year after. With this new innovative development, we start in 2016 a new period for the EMSO-Azores observatory with improved performances and new possibilities. Within the framework of the FixO3 Transnational access, the upgraded infrastructure will be able to welcome new sensors both on the SEAMON nodes and on BOREL buoy.

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ID11- A 3D MAPPING, OBSTACLE AVOIDANCE AND ACOUSTIC COMMUNICATION PAYLOAD FOR THE AUV SPARUS II

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Abstract— This paper presents the new payload for Turbot, the SPARUS II AUV unit, manufactured by the University of Girona and recently acquired by the Systems, Robotics and Vision Group of the University of the Balearic Islands. The new payload has been entirely designed and integrated to host all elements necessary to perform visual 2D/3D mapping, optical (visuallaser) object reconstruction, acoustic and visual obstacle avoidance, and acoustic localization and communication. Several experiments in shallow waters of Mallorca show the validity of the sensor integration and operation for all the required tasks.

Keywords — Autonomous Underwater Vehicle, Sonar, USBL, Stereo Vision, Laser.

I. INTRODUCTION

In the last years, there is an increasing scientific interest in the exploration of the underwater environment. As technology evolves, better quality 2D maps and underwater 3D dimensional reconstructions can be performed using up to date hardware. This three dimensional reconstructions and 2D maps will not only help scientists to recognize the environment, but they will also enhance the performance of the navigation modules installed in underwater vehicles and help the vehicle to better understand the medium in which it is moving. Autonomous navigation can be addressed with a well calibrated set of sensors and a navigation software able to interpret the incoming data, to guide the vehicle thrusters along a required path, whilst avoiding possible collisions. The navigation sensor suit can be formed, not only by inertial or dead-reckoning sensors, but also aided by absolute position sensors or visual SLAM (Simultaneous Localization and Mapping) [1] algorithms, which are used to correct periodically the odometry estimated by the former instruments. Concerning the tasks of 2D/3D mapping and object reconstruction, additional instrumentation is needed for video recording and 3D point cloud extraction. These two reasons have led us to design a new payload for Turbot, a SPARUS II AUV [2] unit acquired in December 2014. SPARUS II is a 1.6 m long torpedo-shaped vehicle with three thrusters, two horizontal for surge and heading, and one vertical to maintain its depth. This last thruster also allows the vehicle to remain static at a certain depth regardless of its surge speed. Its original sensor suite is formed by a DVL (Doppler Velocity Log), an IMU (Inertial Measurement Unit), a GPS (Global Positioning System), a pressure sensor and a Wi-Fi access point, as well as a 50 meter long Ethernet umbilical cable for wired connection if necessary. Its open-source software architecture COLA2 [3] is built on top of the ROS middleware. The new payload presented in this paper has been especially designed to host all the required instrumentation to perform autonomous navigation, 2D/3D mapping of the seafloor, object reconstruction, obstacle avoidance and acoustic localization/communication. The new equipment added to the payload are: a usb hub, an acoustic transducer linked to an USBL, a laser stripe, a Miniking sonar, and an ethernet stereo rig.

II. BACKGROUND

The Systems, Robotics and Vision group of the University of the Balearic Islands is currently involved in two Spanish research projects, ARSEA (TIN2014-58662-R) and MERBOTS (DPI201457746-C3) [4], which require an AUV capable of performing online robust three dimensional reconstruction of the underwater environment, autonomous navigation, object reconstruction and recognition, and underwater global positioning and communication. ARSEA is focused on surveying and controlling areas of special ecological, social or economical interest, for example, with very specialized tasks such as photo-mosaicking and building 3D models of seagrass meadows, and inspection of ship/aircraft wrecks or deteriorated infrastructures. These 2D and 3D models are inserted in an augmented reality integrated pilot console specially designed to command the vehicle in ROV mode, as the pilot was immersed in the aquatic environment. In the context of the aforementioned projects, neither

the available sensors nor the software architecture were enough to accomplish with their requirements. For example, there was no obstacle avoidance control or underwater cameras to perform visual exploration, mapping or aiding to the intervention. So the minimum needed payload has to include a stereoscopic system, lights for imaging at high depths, underwater communications (e.g. acoustic communications), a laser stripe to detect and build 3D objects in regions with very bad visibility, and an obstacle avoidance sensor

III. DESIGN

Turbot AUV is an open hardware and open source robot, based on the ROS middleware. The original software architecture, provided by the manufacturer is COLA2, a layered control architecture formed by a control layer, a navigation layer, a safety layer, and a teleoperation layer. This software is based on a single EKF (Extended Kalman Filter) to fuse all the inputs from the available sensors in the AUV to compute its dead reckoning. Its waypoint-based autonomous navigation allows the user to predefine a mission and send it to the robot. The vehicle has two physical spaces available for further improvements or hardware additions, one dry is located inside its hull towards the nose, and another wet which is the nose itself. The cap of the cylinder is already pre-drilled to fit up to eight M11 underwater rated connectors (such as Subconn). The next sections detail the designed expansion choices and their hardware implementation.

A. The Visual System

In order to solve all degrees of freedom of the resulting reconstructions, three dimensional mapping of the seafloor requires a stereoscopic system, if the visibility conditions are optimal, or a triangulation solution, such as using a laser projector, in case of poor visibility conditions. If only one camera was used, a bathymetry can complement the 3D model. However, the bathymetry would need an unknown scale factor. A stereo rig formed by two cameras Allied Vision Technologies G-283C, with a full resolution of 1936 x 1458 pixels at 35 frames per second were placed in the payload. These ethernet cameras are connected each to a different hardware interface and through dedicated underwater gigabit ethernet cable and connectors. The housing for the cameras had to be designed to withstand the same water pressure as the AUV, e.g. two hundred meters. The chosen material was aluminium, which was later anodized to endure on salt water. Artificial light is needed to record underwater scenes at more than ten meters or during the night. Two 4320 lumen LED lights from Mangrove AVS-6L were chosen. Each light head needs 40 W, so a relay board controlled by an Arduino was added to the dry payload system to manage the aforementioned lights. Apart from the lights, a slightly tilted laser stripe projector formed by a 532nm, 40 mW ZM18B green laser from Z-Laser was also added in our designed delrin housing and for the same water depth. With both systems, we are able to reconstruct underwater scenes even without features, thanks to the laser projector, and from altitudes up to three meters [5].

B. Obstacle avoidance system

Once the navigation system has been improved thanks to the USBL and a visual mapping system provided by the stereo rig, an obstacle avoidance system is desirable so that the vehicle does not hit an underwater structure, rock or wall. A Tritech Miniking imaging sonar has been mounted on the half bottom of the wet payload. This sonar has a vertical beam width of 40°, and a horizontal beam width of 3°. Although it can operate 360°, we only use the forward $\pm 45^\circ$ to look for obstacles. The CAD payload design can be seen in figure 1 and its complete integration in the vehicle is shown in figure 2.

C. Acoustic Communications System

Nowadays, most AUVs still rely on dead-reckoning systems (i.e. DVL, Visual Odometry, inertial sensors) which are subject to cumulative drift. Autonomous navigation and intervention underwater needs improved localization modules to withstand the increasing demand on mission duration and higher accuracy. Commonly used absolute

positioning devices such as GPS or LBL (Long Base Line) are available to the end users to localize the vehicle. However GPS does not work underwater due to the rapid energy absorption of the electromagnetic waves underwater, and an LBL system require a complex infrastructure deployment and calibration prior to use. On the other hand, USBL (Ultra Short Base Line) acoustic modem overcome these problems by simplifying the needed equipment and narrowing the distance between the acoustic transponders. AUSBL system is formed by a fixed USBL head that has four or five transceivers (hydrophones). This head is normally mounted on the hull of a vessel with known absolute position often provided by GPS (e.g. surface vehicles). Then, another mobile modem transceiver is installed on a vehicle which needs to be located and a permanent communication link with the base. A USBL is not only capable of the mobile modem localization from the USBL head, but also provides acoustic communication. A USBL modem 18/34 from Evologics was also installed in our payload. This unit can establish a communication link in a radius of 3500 m, and achieves a maximum throughput of 14 Kbps. The USBL head localizes the modem, and from the software, this position is send via the acoustic link to the vehicle, to be integrated in its own navigation filter. Apart from sending the localization, other service messages are send from the central laptop connected to the USBL head to the vehicle, such as, turn on/off the lights, turn on/off the laser, or safety recoveries in the case a mission has to be cancelled. The navigation data (position estimated by the vehicle EKF filter, battery status, depth, etc) are also sent from the vehicle to the USBL head.

IV. SOFTWARE ARCHITECTURE

The control architecture software of the AUV, based on COLA2[3], supplied with the vehicle, consists of a layered control structure with the following main layers: navigation, control, safety and guidance. Our new architecture complements and improves the original one in 3 main aspects: the navigation and localization modules, the safety layer, the Sensor aggregator (a new module that centralizes the reception of all the data given by all the sensors), and an obstacle detection module.

The new navigation solution simplifies the localization problem splitting it into

two EKF filters, to cope with different sensor update rates and the different nature of their provided data. Then, the system is easier to customize, debug, assess and evaluate.

In the first EKF, (called EKF odom), the predictions are computed using Newtonian mechanics and the updates are made with the dead-reckon information, such as the velocity updates from the DVL, a visual ORB tracker [6], the rotation rates provided by the IMU, plus the position updates in z from the depth sensor.

The second EKF (called EKF map) uses the same inputs of the EKF odom plus the GPS and the USBL position data received in the vehicle. These two additional sensors give absolute positions (with no orientation) with respect to a global coordinate frame (the map coordinate frame), and have an update frequency much lower than the other sensors listed in the previous paragraph. As mentioned in previous paragraphs, EKF odom is essential to correct the missynchronization of the last USBL position sample with the current EKF map update state, caused by the delays in the acoustic communications.

The position of the robot given by EKF odom responds to the sensors that emit at higher frequencies but it may drift. Whenever a new absolute measurement either from the GPS or from the USBL is available to the EKF map filter, the resulting robot global position is adjusted.

The sensor data is fed to the Sensor Aggregator, a module that checks that the sensor readings are well structured and input in the proper order at the boot of the vehicle. Filtering and data preprocessing is also handled here.

The safety layer has been reinforced with new and modular, value and frequency monitors. These monitors can be connected to any of the sensors to validate if the irreturned values are in between the established minimum or maximum, as well as the minimum frequency they should be working at. If the monitored device does not comply with the requirements, a recovery action is called. The recovery action is also user-configurable, and can range from a sensor reboot to an emergency surface of the vehicle.

Finally, the obstacle detection module uses the imaging sonar installed in the new payload. The echoes received from the sonar are parsed by our software and checked for possible obstacles. If there is any, the sonar software sends a message to the navigation layer to take the appropriate decisions.

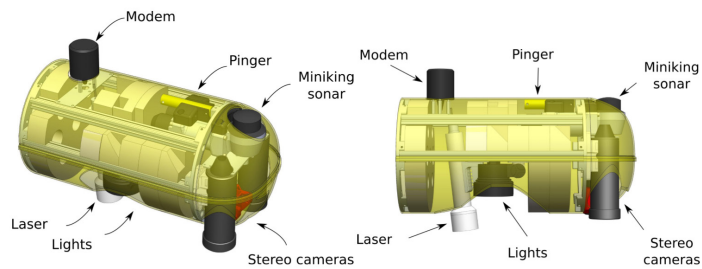


Fig. 1: Payload CAD design showing the location of the Laser, the lights, the cameras, the modem, the pinger and the sonar.

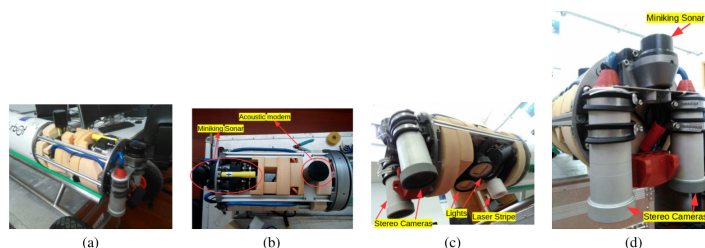


Fig. 2: (a) Finished payload integration. (b) Top view showing the Sonar and the acoustic transducer. (c) Bottom view showing the cameras, the lights and the laser stripe, all looking downwards. (d) Frontal view showing the cameras and the sonar.

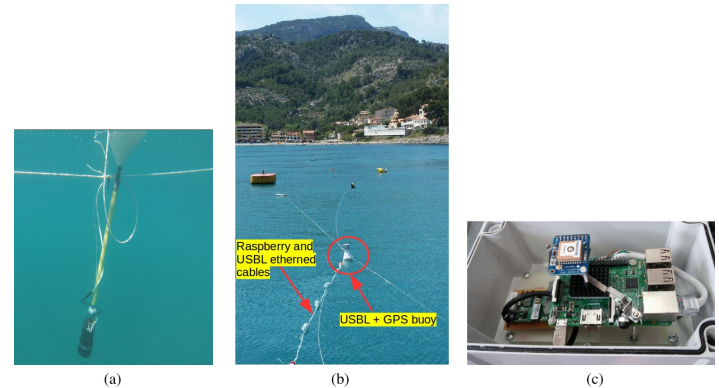


Fig. 3: (a) The USBL buoy photographed from the water. (b)-(c) Two different perspectives of the buoy and the AUV from the shore. (c) A photo of the Raspberry and GPS card mounted over the USBL buoy.

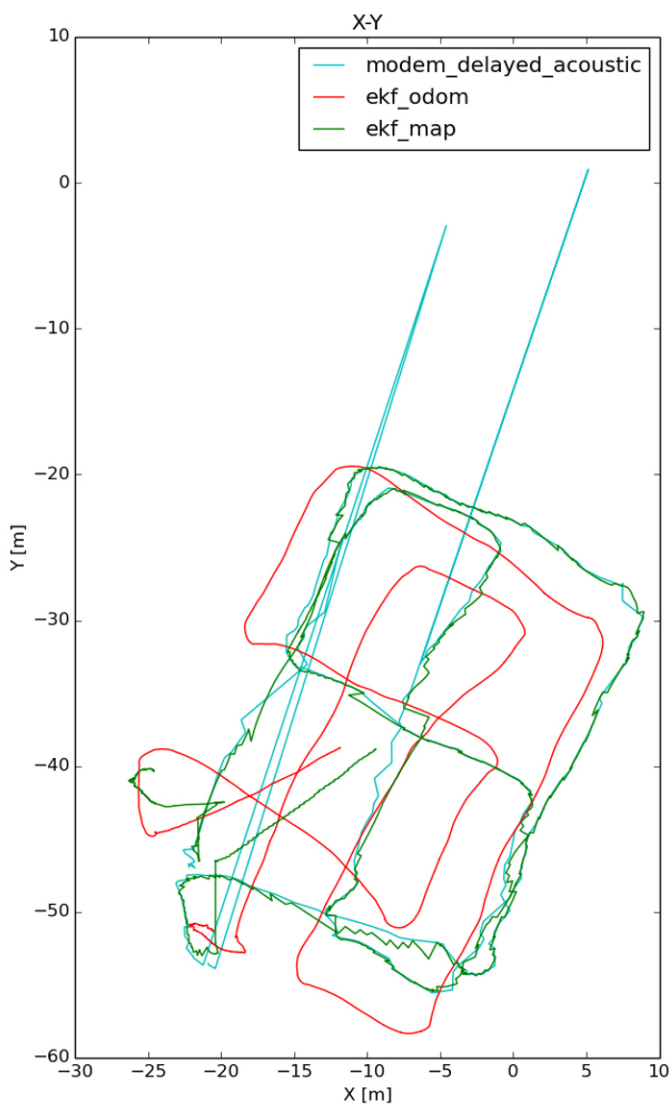


Fig. 4: The vehicle trajectory according to the USBL modem and the two EKF.

V. EXPERIMENTS

A wide range of tests have been carried out in the shoreline of Mallorca to prepare the upcoming experiments of the project MERBOTS, testing the new payload, the acoustic communications and the navigation/localization design. Forthcoming additional tests have been programmed to be conducted soon to verify the performance of the visual 3D mapping algorithms. In our real testing scenarios, the USBL head unit is hanged from a powered buoy, which has a GPS managed by a Raspberry Pi 3 unit, mounted in a sealed plastic box on the top of the buoy. The USBL and the Raspberry card are both connected to an ethernet switch located on the shore via a long cable, where a control laptop is also connected. Thanks to this switch, the USBL, the Raspberry card and the laptop are all connected at the same ethernet address range. This laptop is in charge to manage the USBL vehicle positions and to send them back to the robot transformed to the world coordinate frames system (e.g. in latitude, longitude, depth). Figure 3-(a) shows the USBL buoy fixed to a wire which is tied, in one end, to a big buoy delimiting the military harbour in Port de Soller, while the opposite end is tied to the harbour breakwater. This set up is shown in figure 3-(b). Figure 3-(c) shows the GPS and the Raspberry card mounted on the top of the buoy. Figure 4 shows the vehicle trajectory estimated by the USBL (modem delayed acoustic), the ekf odom and the ekf map, corresponding to one experiment in Port de Soller. Although the position estimates given by the USBL modem presents a couple of outliers, the EKF map has been able to eliminate them while it rectifies the odometric trajectory.

VI. ACKNOWLEDGEMENTS

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ID12- OPTICAL FIBERS TO MEASURE TEMPERATURE VERTICAL PROFILE AT SEA

ALBERT GARCIA-BENAD¹²²⁷, JOAQUIN DEL RIO FERNANDEZ¹⁸², MARC NOGUERAS-CERVERA²²², C. GARCÍA IZQUIERDO⁹, D. DEL CAMPO¹⁰, S. HERNANDEZ¹¹

Abstract- *The paper is focus in the use the optical fiber to measure the temperature in various heigh at the same time to get a temperature vertical variation. The temperature measurements are puntual while the Bragg gratings located in the fiber.*

Keywords- *Uncertainty, optical fibers, sea, calibration, Bragg gratins*

INTRODUCTION

In the framework of the EMRP project "ENV 58. Metrology for essential climate variables", a new technique to perform traceable temperature measurements

of the sea water profile and sea water surface will be designed, studied, developed and applied to a real situation. A thermometer, based on distributed temperature sensor, will be designed, paying special attention to the involved materials, in order to avoid the damages of such corrosive environment.

Nowadays, this techique is used in many infrastructures as bridge or airports by never has been used in sea, where the sea currents and biofouling are problems that will are wtudied at the project. However the optical fibers must been calibrated to know the uncertainty in temperature measure, and it is the purpose of the paper.

ID13- MULTIBEAM SYSTEMS FOR THE DETECTION OF GAS FLARES IN THE WATER COLUMN

CHRISTIAN ZWANZIG²³⁴

Wärtsilä ELAC Nautik is one major global player in the multibeam business. The multibeam systems are marketed under the well-known brand name SeaBeam, including systems for medium water depth and deep-water areas. The ELAC SeaBeam 3012/3020 deep-water systems operate in the 12 kHz and 20 kHz frequency bands, whereas the ELAC SeaBeam 3030/3050 medium-depth systems operate in the 30 kHz and 50 kHz frequency bands. While formerly only continuous wave (CW) pulses were applied, the new Mk II series of the ELAC SeaBeam 3030/3050 multibeam systems offer the possibility to apply frequencymodulated (FM) pulses for increased measurement ranges, improved range resolution and better data quality. FM pulses require a correlation of the beamformed data of all beam directions with pulse replica in order to obtain pulse compression. Additionally, Doppler shifts of the operating frequencies induced by the ship's movement have to be compensated. In order to obtain unrivalled data quality, the ELAC SeaBeam 3030 / 3050 multibeam systems apply Doppler compensation not only on the bathymetric depth data, but also on the water column imaging (WCI) data. In order to provide high data density, all ELAC SeaBeam MBES can transmit two quasisimultaneous swaths per ping cycle, which are frequency-separated. Compared to the singleping mode, the data density is doubled. The ELAC SeaBeam 3030/3050 multibeam systems include a functionality for to automatic cyclical steering of the transmitted swaths in the along-ship direction. Via this functionality, which is called "Advanced Transmission Beam Steering", an entire volume below the vessel can be insonified without requiring any movement of the vessel. The operator can specify an angle range and an angle increment, resulting in a periodic oscillation of the transmitted swaths from bow to aft and vice versa. This functionality is very helpful for the detection and analysis of gas flares, leakages or other objects in the water column during stationary vessel operation or on fixed platforms. Wärtsilä ELAC Nautik GmbH Page 2 of 3 31. May 2016

On order to provide highest operational flexibility, the ELAC SeaBeam 3050 and ELAC SeaBeam 3030 are available as mobile systems, providing the sonar electronics in flight cases and utilizing mobile transducer brackets for spatial resolutions of 1.5° x 2° for ELAC SeaBeam 3050 and 3° x 2° for ELAC SeaBeam 3030. Wärtsilä ELAC Nautik is the only supplier, offering a mobile 30 kHz multibeam

system with a depth performance of more than 6,000 meters. Wärtsilä ELAC Nautik is a main industrial partner within the German „Lighthouse“ Research Project SUGAR (Submarine Gas Hydrate Reservoirs) and cooperates with the GEOMAR Helmholtz Centre for Ocean Research Kiel. Wärtsilä ELAC Nautik participates in a SUGAR subproject, which is related to gas flare detection. Gas flares at the seabed are indicators for potential gas hydrate reservoirs and potential leakages of gas deposits. Therefore, gas flare detection is important for the exploration of submarine gas hydrates and for environmental monitoring. Driven by the SUGAR project, the ELAC SeaBeam multibeam systems store WCI data with very high resolution. For the online and offline visualization of high-resolution WCI data, the ELAC WCI Viewer is utilized, providing different window types for data visualization, different scaling and range options, forward and backward data playback as movies or single pictures, object and event functionalities and the display of external sensor data. These capabilities help to identify and analyze any kinds of objects in the water column or on the bottom (e.g. gas seeps).

Despite helpful aids for the online visualization of high-resolution WCI data, there is a need for an automatic processing of WCI data with respect to object detection. Such automatic processing will reduce the workload of survey operators significantly. Therefore, Wärtsilä ELAC Nautik has developed an automatic object detector (ELAC AOD) which is dedicated to gas flares in the water column. Due to the huge data volumes of high-resolution WCI data, the development of the ELAC AOD was ambitious and challenging. The ELAC AOD was implemented within the MATLAB development environment. The ELAC AOD is dedicated to WCI data from ELAC SeaBeam 3030 and 3050 medium-depth multibeam systems and stores all relevant information of detected objects in so-called object log files. It is possible to import such object log files into the ELAC WCI Viewer for visualization purposes. Due to the above-mentioned characteristics, multibeam systems from Wärtsilä ELAC Nautik are excellently applicable in order to detect and analyze gas flares in the water column. The presentation will provide detailed system information and important data examples.

ID14- ACOUSTIC SYSTEM FOR PHYSICAL OCEANOGRAPHY RESEARCH IN THE DEEP OCEAN

BERTA BIESCAS¹²⁷, VALENTÍ SALLARÈS¹⁰¹, JHON MOJICA¹⁰⁰ & SANDRO CARNIEL¹¹⁶

Abstract – Marine multichannel seismic (MCS) data, used to obtain structural reflection images of the Earth's subsurface, can also be used in physical oceanography exploration. This method provides vertical and lateral resolutions of 10 to 100 m, to full ocean depth, along profiles that can be hundreds of kms in length, covering the existing observational gap in oceanic exploration. All MCS data used so far in physical oceanography studies have been acquired using conventional seismic instrumentation originally designed for geological exploration. In this work we present the proof of concept of an alternative MCS system that is better adapted to physical oceanography and has two goals: (1) to have an environmentally low impact acoustic source to minimize any potential disturbance to marine life, and (2) to be light and portable. The synthetic experiments simulate the main variables of the source, shooting and streamer that compose the proposed MCS system. The proposed system utilizes a 5 s long exponential chirp source of 208 dB re 1 micro Pa @ 1m with a frequency content of 20-100 Hz, and a relatively short 500-m long streamer with 100 channels. We exemplify through numerical simulations that the 5 s long chirp source can reduce the peak of the pressure signal by 26 dB with respect to equivalent airgun-based sources by spreading the energy in time, greatly reducing the impact to marine life. Additionally, the proposed system could be transported and installed in mid-size oceanographic vessel, opening new horizons in acoustic oceanography research.

Keywords - Acoustic exploration, acoustic source, multichannel seismic reflection technology, chirp source, coherent source.

I. INTRODUCTION

The main physical parameters of the ocean (temperature, salinity, pressure and density) are commonly measured using vertical profiles as conductivity-temperature-depth (CTD) casts or expendable bathythermographs (XBT). These instruments sample the ocean at vertical resolution of 0.1 -1 m that allows to analyse processes generated within the submeso-and-fine scales. However, this method of exploration does not observe lateral structure at these scales because lateral spacing between vertical casts are rarely shorter than 1000 m. This observational gap is becoming increasingly relevant as numerical models increase in resolution. Physical oceanographers demand empirical data with lateral resolution of 10-100 m to incorporate submesoscale and finescale processes and calibrate and validate new models and theory. Marine multichannel seismic reflection (MCS) data, collected and used to obtain structural images of the Earth's subsurface, also display coherent reflections from within the water layer. A partial list of features observed via MCS data includes internal waves, thermohaline staircases and intrusions, density and turbidity currents and submesoscale coherent vortices, which are key ocean mixing processes [1,2,3]. Because of signal redundancy provided by the multiple illumination of a single reflector point, MCS systems enhance coherent signals over noise, resulting in clear acoustic images of the oceanic thermohaline structure with lateral and vertical resolutions of 1-100 m. Furthermore, inversion methods applied to acoustic images provide 2D temperature and salinity maps, which may cover the current observational gap in physical oceanography exploration [4,5]. Most of the MCS surveys carried out so far for oceanic research have used conventional seismic instrumentation (airgun sources and hydrophone streamers) and standard acquisition parameters (shot spacing, distance between channels, source power, etc) that were conceived for geological exploration. However, oceanic targets are shallower, typically from the sea surface to 4 km deep, and their exploration does not require the same source characteristics as for geological exploration. This work presents an alternative MCS system specifically conceived for physical oceanography exploration using a methodology for generating synthetic MCS experiments in the ocean. The goal is to have an environmentally low impact system with the weakest possible source in order to minimize any potential disturbance to marine life which, in turn, could be installed in mid-size oceanographic vessels.

The proposed system is simulated using a numerical solver of the acoustic wave equation, realistic acoustic ambient noise in the ocean and a realistic model of the water layer. The system is based on chirp signals, which are commonly used to examine the sediments on and below the sea floor. Impulsive sources such as airguns emit high peak pressures in a very short time (10-3s); on the contrary, chirp signals spread the source energy out over time, reducing the peak sound levels.

II. METHODOLOGY

The methodology used to generate the synthetic experiments consists of the following main steps: first, the Martech 2016. Marine Technology Workshop 26,28th October. Barcelona, Spain shot gathers are generated using a 2D finite difference algorithm that solves the acoustic wave equation within a grid that represents the oceanic properties. The grid representing the ocean corresponds to a model of properties that was obtained by inversion of real MCS data along profile GO-LR-01 of the GO experiment [5] and contains sound speed values with vertical and lateral resolution of 10 m and 100 m, respectively. The location of the source moves along the top of the grid in accordance to the shot spacing. For each shot gather, the acoustic wavefield is recorded and saved at the position of each channel of the streamer. Once shot gathers for the whole line are generated, background oceanic noise is added to the synthetic shot gathers. The simulated noisy synthetic shot gathers are then processed using standard MCS functions to obtain the stacked section. Finally, the quality of the tested MCS system is quantified by measuring the spectral signal to noise (S/N) ratio in the stack section.

Two different wavelets are used in the simulations presented in this work: i) a Ricker wavelet of 234 Db re 1 microPa @ 1m with frequency content within the range of 10-100 Hz, which is similar to the source wavelet used in the GO-LR-01 profile of the GO survey and is used to calibrate the synthetic simulations; and a 5 s long exponential chirp wavelet of 208 dB re 1 microPa @ 1m amplitude, a Gaussian taper and frequency content of 20100 Hz. The Ricker and the chirp wavelets are described by the following equations, respectively:

$$\text{RickerSource}(t) = A (1 - 2 \pi f_0(t-t_0))^2 \exp(-\pi f_0(t-t_0)^2) \quad (1)$$

where $A=500000$ is the maximum amplitude of the wavelet, $f_0=45 \text{ Hz}$ and $t_0=0.33 \text{ s}$.

$$\text{ChirpSource}(t) = A \exp(-((t-t_0)/2)^2) \sin(\phi + (2 \pi f_1 ((kt-1)/(\ln k)))) \quad (2)$$

where $A=25000$ is the maximum amplitude of the wavelet, $\exp(-((t-t_0)/2)^2)$ with $t_0=2.5 \text{ s}$ corresponds to a 5 s wide Gaussian taper, $k=(f_2/f_1)^{(1/t_{\max})}$, $t_{\max}=5 \text{ s}$, $\phi=0$, $f_1=20 \text{ Hz}$ and $f_2=100 \text{ Hz}$. The wavelets, frequency content and frequency change in time are shown in Figure 1. III. RESULTS Data computed for the first experiment presented were produced using parameters (source frequency content and peak-to-peak amplitude, distances between shots and receivers, number of channels, first offset and fold) similar to those used in the GO-LR-01 profile acquired in the Gulf of Cadiz (NE Atlantic Ocean). The acoustic synthetic source consists of a Ricker wavelet of 234 dB re 1 microPa @1m (500000 Pa peak signal), with a frequency content in the range of 10-100 Hz (Figure 1). In order to compare the synthetic and real data, we propagated the synthetic data through the sound speed model that was obtained by inverting the MCS data recorded along this line [5]. In particular, the section that we used is 5 km long and images the right edge of a meddy, which is a typical structure detected in this area that consists of a warm and salty rotating lens. Comparison between the real (Figure 2a) and synthetic experiments (Figure 2b) shows remarkable similarity, with both displaying the same reflectors that correspond to the oceanic fine structure. The spectra of a part of the seismic section containing mainly reflected signal (S) and mostly noise (N) are calculated for both sections and the corresponding S/N ratio is shown in the upper right insets of Figures 2a and 2b. The S/N ratio of the real data is slightly lower than the one calculated from the synthetic experiment (peak at 1.5 vs peak at 2.2),

probably due to additional noise in the real experiment related to electronic effects in the hydrophones and the oscillations of the streamer and source near the sea surface. Overall, this comparison validates our methodology for generating realistic synthetic MCS experiments in the ocean and testing the effect of the involved variables.

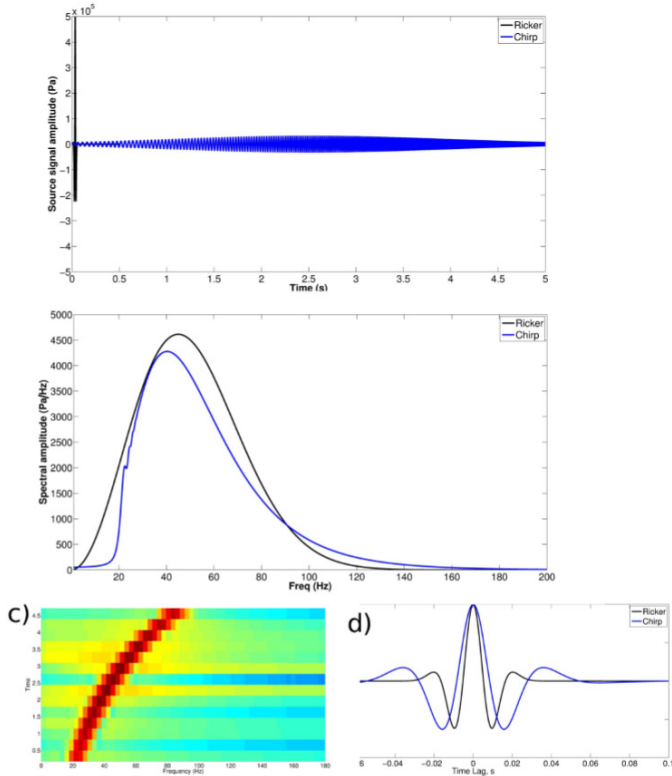


Fig 1. 234 dB re 1 microPa @ 1m\$ Ricker wavelet (black) and 5 s exponential chirp of 208 dB re 1 microPa @ 1m with a Gaussian taper (blue) displayed as: a) time domain, b) frequency domain, c) chirp spectrogram and d) Klaunder wavelets.

The second synthetic experiment (Figure 2c) simulates data that would be collected with the portable MCS system suggested in this work and characterized by a significantly lighter and shorter streamer. The source wavelet used in this experiment is a 5 s long exponential chirp wavelet of 208 dB re 1 microPa @ 1m (25000 Pa peak signal) with a Gaussian taper, which minimizes the side lobes of the autocorrelation function of the chirp, and a frequency content of 20-100 Hz (Figure 1). The stacked section from these synthetic data (Figure 2c) shows the meddy finestructure well and the S/N ratio is equivalent to that obtained using the impulsive source's system. The Ricker source is a signal 20 times stronger in amplitude than the chirp wavelet. However, as the chirp wavelet has a 5 s duration, the level of the total energy is similar to the one emitted by the Ricker pulse, resulting in similar levels of effectiveness in oceanic exploration.

IV. CONCLUSIONS

We exemplify through numerical simulations that oceanic thermohaline structure can be detected with similar S/N ratio using an impulsive source of 234 dB re 1 micro Pa @ 1m (500000 Pa peak signal) or equivalently, a 5 s chirp source of 208 dB re 1 micro Pa @ 1m (25000 Pa peak signal). The chirp source can reduce the peak of the pressure signal 20 times by spreading the energy in time. There is evidence that a swept signal with lower peak amplitude may have less impact on marine animals than a higher peak impulsive signal [6]. For example, considering the Ricker source, the radius of the exclusion zone for most cetaceans (area affected by more than 160 dB re 1 micro Pa) would be 5000 m. That means that, if these species were observed or detected with passive acoustic monitoring, closer than 5000 m to the airguns, these had to be immediately shut down. Since the energy of the source decreases with the square of the distance, and since the energy is proportional to the square of the amplitude of the emitted signal, then the exclusion zone for the proposed

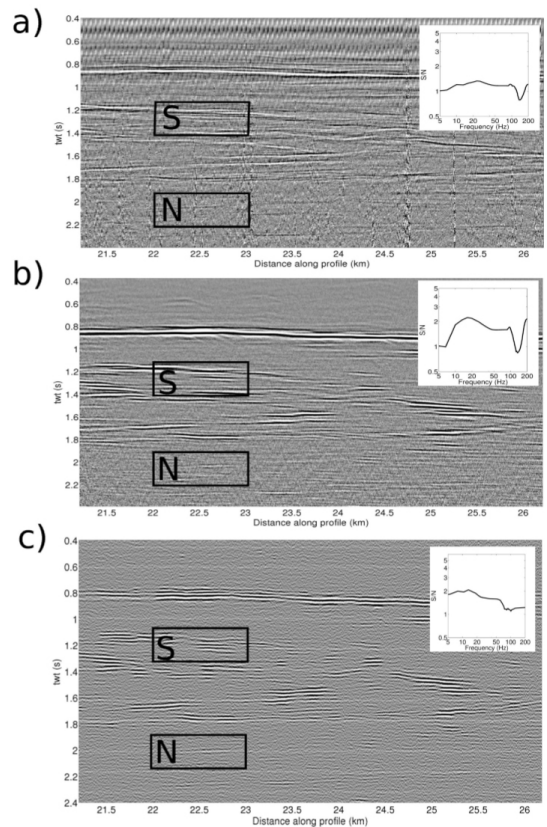


Fig 2. a) Stack section of 5 km long of the GO-LR-01 profile acquired in the GO Survey (Gulf of Cadiz, NE Atlantic Ocean, April-May 2006). b) Stack section of the synthetic data generated with the 234 dB re 1 microPa @ 1m Ricker wavelet. c) Stack section of the synthetic data generated with the 208 dB re 1 microPa @ 1m 5 s exponential chirp wavelet. The right upper white insets correspond to the S/N ratio of the data within the two corresponding rectangles.

system would be 250 m; thus 20 times smaller than with the impulsive signal. In summary, the system that we propose in this work, compensates for a shorter streamer and relatively low chirp source amplitude with a longer time duration. It would provide thermohaline information of full-depth water column and along lateral distances of hundreds of kilometers in the ocean, with lateral and vertical resolutions of the order of 10 m. This proposed system could be the starting point for the development of an ocean-specific low-frequency acoustic projection system for physical oceanography.

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ID15- IOBSERVER: SPECIES RECOGNITION VIA COMPUTER VISION

FERNANDO MARTÍN-RODRÍGUEZ⁴¹, MÓNICA BARRAL-MARTÍNEZ⁴², ÁNGEL BESTEIRO-FERNÁNDEZ²⁰, JOSÉ ANTONIO VILÁN-VILÁN²¹

Abstract- This paper is about the design of an automated computer vision system that is able to recognize the species of fish individuals that are classified into a fishing vessel and produces a report file with that information. This system is called iObserver and it is a part of project Life-iSEAS (Life program). A very first version of the system has been tested at the oceanographic vessel "Miguel Oliver". At the time of writing a more advanced prototype is being tested onboard other oceanographic vessel: "Vizconde de Eza". We will describe the hardware design and the algorithms used by the computer vision software.

Keywords: fishing boat, oceanographic vessel, computer vision, object recognition, C++/OpenCV.

I. INTRODUCTION

As stated in the abstract, iObserver is part of a larger project called iSEAS (<http://lifeiseas.eu/el-proyecto/>). iSEAS project is about appropriate management and reduction of discarded fish. iSEAS is funded by Life program. iObserver is part of iSEAS and tries to develop and test various technologies that can be installed on-board fishing (or oceanographic) vessels in order to collect useful data from fishing campaigns.

Particularly, this paper is about the part of iObserver that obtains a report on the number and species of captured fish, both useful captures and discards. For us, iObserver will be a computer vision system, installed over a conveyor belt inside a fishing or oceanographic vessel. This space is called the "processing room" and it is used to manually classify fish that is afterwards put into stowage facilities or discarded and thrown again to sea.

Nowadays, European authorities want to reduce (and even eliminate) discards as they can cause problems to ecosystems. iObserver is seen as a help in this process because it will be able to measure the amount of each species that enters the vessel (useful or not).

iObserver consists of an industrial (computer vision) camera and a processing unit (industrial PC) equipped with our self-developed computer vision software. Normally, it will be placed over the conveyor belt at its same beginning. Software is designed to need almost no user interaction. User only starts the capturing process and stops it when fish classification work has ended. At end of each capturing burst, system generates a report file (ascii-csv format) containing recognition results.

II. HARDWARE DESIGN

The first prototype installed in the "Miguel Oliver" ship in March 2015, was designed trying to hold camera and lighting in the same box. This idea yielded an enormous, heavy and not very practical design. A second, more practical, prototype was designed for the second campaign (travel of "Vizconde de Eza" vessel to NAFO fish area). This new prototype is described below.

A. Main Box

Main system box is a steel waterproof box that contains the key elements of the system: processing unit (industrial PC), industrial camera, touchscreen and an auxiliary system to avoid water condensation (based on a peltier cell).

We have tested two different cameras: Basler ACE acA2040-25gc (GigEthernet interface) [1] and JAI GO- 5000C (USB3.0) [2]. Both of them have a big image sensor: 1" and C-mount for optics, resolution is above 5 Mpixels in both cases. Both are possible elections. Quality of optics and lighting is more important than camera for this system. Although we have performed tests with fixed focal length lenses, varifocal lenses are more practical here because belt width can be very variable from one ship to another (and also are environmental conditions like roof height that can make us to install camera nearer or further).

Industrial PC is a fanless model with solid state disk. The first prototypes are also

equipped with an external disk to save captured images (to save disk space the system automatically discards void and/or repeated images, repeated images are frequent because of moments when belt is stopped). These images will be used later in refining the computer vision software.

Nowadays it is still pending the design of an auxiliary system that can measure belt speed generating a synchronization signal for capturing images at constant belt advances (just now, captures are launched at constant time intervals).

B. Lighting

Lighting is designed to provide a constant soft light rectangle on the belt. For that issue, we use a pair of LED strip lights at both sides of the belt (figure 1). Height and angle of these lights can be modified to minimize shadows and light variations.

Lights are embedded in steel waterproof boxes and are electrically fed from a power source inside the main box.



Fig. 1. Main Box and external lighting as they were mounted in the oceanographic vessel: Vizconde de Eza.

III. COMPUTER VISION SOFTWARE

Computer vision software was designed starting from test images captured at IEO (Instituto Español de Oceanografía: <http://www.vi.ieo.es/>) where we installed a conveyor belt and a camera. Software development is performed in two parallel stages: algorithms are tested and simulated (prototyped) using at-lab [3], definite methods are then implemented using C++ [4] and OpenCV [5].

A. Initial Calibration

Calibration is mainly about finding out color characteristics of belt (we can find blue belts, but with different hues and also white ones). We also want to determine the expectable maximum and minimum brightness values to perform color enhancing (basically white balance). Other important issue in calibration is establishing a relationship between pixel coordinates and real distances (millimeter per pixel in our images).

See that lighting conditions and camera position will be always constant, so that this process may be performed only one time (offline, with an auxiliary software

application) and we can rely on user's manual help.

To calibrate, basically, user must put some object on the belt and run the calibration application. We have designed a calibration card (figure 2) that can be easily printed any time (the higher printing quality the better calibration).

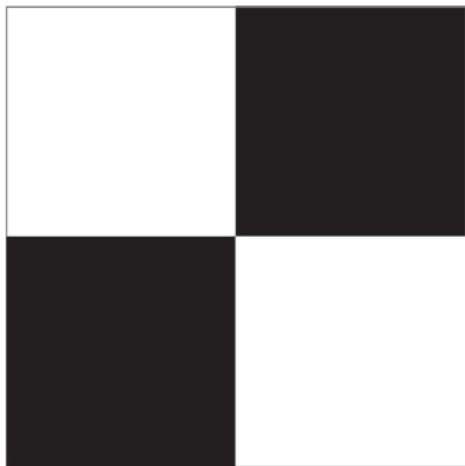


Fig. 2. Calibration card.

Calibration card has absolute white (brightness=1) and absolute black (brightness=0) inside so that calibration program can find out them. In fact, our application searches for the value that only has 1% of image pixels above (in brightness) \blacktriangle white and the value that has 1% pixels below \blacktriangledown black.

After we know these two values, we can stretch color histograms [6] to lie always between both values, this is the color enhancement process that we will apply to all captured images.

After that, user is required to manually select background areas so that the application can compute the interesting parameters: mean values of R, G and B and mean value of Hue (the H of the HSV color space [7]). User selects a rectangle on captured image. As background portion can be small if photographing the calibration card, user can remove it and capture an additional "background only" image. This process can be repeated so many times as convenient.

Size calibration (millimeter per pixel computation) is also done using the calibration card. Resolution of the TIFF file (CalibrationCard.tif) is fitted to get exactly a 10 inches card (254 mm), obviously each of the four squares has 5 inches per side (127 m).

B. Conveyor Belt Removing

To remove background we use the mean values computed by the calibration application. Now we are in the main application and calibration values have been saved in a configuration file.

Other configuration file value that we must establish first is ROI. ROI in computer vision means "Region of Interest" and it is the part of the image where we are going to work. In this case ROI is constant because camera position also is. In figure 3 (from tests at IEO), we see that we capture more than the desired belt and its contents. We define a central ROI to avoid dealing with irrelevant and possibly problematic objects.



Fig. 3. Image background (conveyor belt) removing.

To remove background, application computes four masks. A mask is a selection image that has zero value for nonselected points (background) and value one for selected "active" points. Masks are computed by mean Hue, mean R, mean G and mean B. A tolerance of 0.1 is used (in a scale from 0 to 1, a point is considered to be background if its value is between "mean - tolerance" and "mean+tolerance"). Masks are combined with this equation:

$$M = [M_H]^{c_H} [M_R]^{c_R} [M_G]^{c_G} [M_B]^{c_B}$$

So basically masks are multiplied but using some coefficients (ci's) that may be zero or one (activating or deactivating that criterion). This is so because we did not find a unique formula that could fit all the conveyor belt color/fish combinations. User must see the masks and decide which the best segmentations are, assigning to the corresponding (ci's) the active value. This is the last "manual calibration" that the system requires. Software can be optimized so that masks with a zero coefficient don't need to be computed.

Resulting mask M is refined using mathematical morphology operations [8] that are useful to remove salt and pepper noise (black points in white background or vice versa).

Background removing is also used to compute the percentage of active (non-background pixels) permitting to remove empty images. Previously, capture function has removed images that are equal to the previous one (previous image, empty or not is stored in memory for this task). These two simple operations allow avoiding many unnecessary computations.

C. Object Segmentation

In this problem, object segmentation (Id EST: distinguishing between different overlapping fishes) is very difficult. Traditional methods based on derivatives or other kind of gradient operators do not work well. We have the help of having detected the background but still any derivative is likely fooled by the local variations in fish skin (squama, dots...).

We have implemented an approximate method based on gray regions and in the watershed transform.

Method (explanation of stages):

- Compute the corresponding grayscale image (we tested also with the "value" or V component of HSV space).
- Apply two morphological operations [8]: first, open by reconstruction; second closing by reconstruction. This, basically, will erase strong local variations.
- Search for local peaks in gray level histogram. A peak is defined as a value higher than three times the mean histogram value. This will detect possible different objects.

Applying region growing [8] to the selected objects: this will make greater these objects and will possibly merge similar and near ones.

- Compute a gradient operator for the original graylevelimage. Add to the detected gradient points, those belonging to the boundaries of background detection (frontiers between black and object in figure 3, right).
- Using the detected objects as seeds and the complete gradient of above, apply the watershed algorithm [6,8].

In figure 4, we can see the segmentation result for image of figure 3. We can see that it is not exact but it is mainly correct giving us big portions of fish to be classified.

D. Species Classification

As we have just seen in the previous section, objects (fish specimens) will overlap and will occlude each other, making almost impossible using contour or morphology descriptors. For this reason we have centered in using "skin" descriptors: color and texture.

For a proper classification, user has to manage a "Fish Alphabet". To add a species to the alphabet, user has to put specimens on the conveyor belt and use an "Add Fish Sample" application. The more samples we have, the better this species will be represented in the alphabet.

The "add-sample" application only removes background; it does not execute the object segmentation, assuming all active points come from true skin of the declared species. User is responsible not to fool the application.

Once background pixels are removed, some characteristics about color and texture must be computed. At the time of writing, we only compute a 2D (10x10 intervals) color histogram of the "a" & "b" color components (from Lab color space [7]).

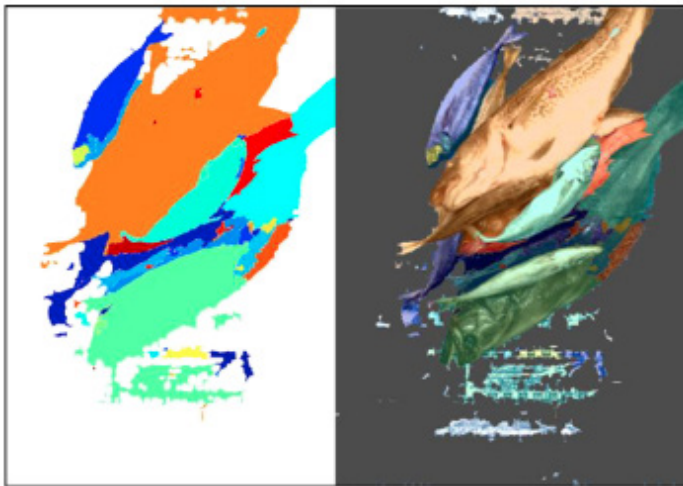


Fig. 4. Object segmentation: label image (left), combined representation (right).

At recognition time, the same characteristics (again only color histogram) are computed from the segmented objects. Then these values (in fact, matrixes) are compared through Euclidean distance with the alphabet yielding a recognized species.

Our system also computes a self-confidence value for each segmented (and recognized) object. Self-confidence tries to determine how sure an automatic recognizer is of its own decision. It is computed using the minimum distance value (the lesser, the more confident), the relation between minimum distance and second best (the greater, the better) and object area (very small objects are typically segmentation errors and are not well classified). Combining all these values empirically we get a number between 0 and 100 (intuitively like a percentage) that measures recognizer self-confidence. Empirically we deduced that confidences less than 10 are not reliable and these recognitions are removed from final report.

In figure 5, we see two recognition examples where recognized objects are converted into color blobs. Color is assigned according to the recognized species. Low confidence blobs are removed. In the upper example, there are no errors: "Atlantic halibut" (*Hippoglossus hippoglossus*) gets red, species 2 gets green and "mackerel" (*Trachurus trachurus*) goes yellow. The image below is not so well recognized, the big fish above should get blue and it is misclassified as a mackerel.

Recognition stage still needs improving, adding texture descriptors (like, perhaps, Gabor filters [9]) to the extracted feature vector (nowadays, this vector is only the "ab" matrix histogram). We must also test other classification methods because only Euclidean distance is very basic.

IV. CONCLUSIONS AND FUTURE LINES

We have designed a system for solving the problem of species classification. Development is still incomplete although we are already getting promising results. Important conclusions are: the difficulty of overlapping objects segmentation, solved only approximately and the need to implement a "fish skin" recognizer that works based on color and texture. Perhaps objects get broken or merged in segmentation but the species percentage can still be computed correctly.

Main future lines are:

- Adding a speed sensor to the conveyor belt to fire an image when belt has moved a predefined length.
- Adding new, texture, features to the recognition stage.
- Testing new classification schemes that could be less prone to errors.

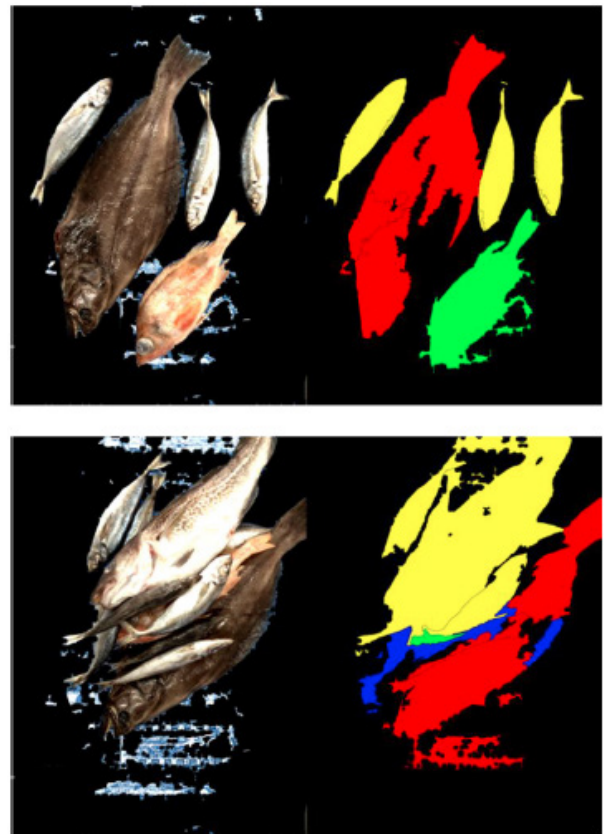


Fig. 5. Classification.

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ID16- MEASUREMENT ERRORS WITH LOW-COST CITIZEN SCIENCE RADIOMETERS

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Abstract— The KdUINO is a Do-It-Yourself buoy with low-cost radiometers that measure a parameter related to water transparency, the diffuse attenuation coefficient integrated into all the photosynthetically active radiation. In this contribution, we analyze the measurement errors of a novel low-cost multispectral radiometer that is used with the KdUINO.

Keywords— Diffuse attenuation coefficient; low-cost; citizen science; radiometer and Arduino.

INTRODUCTION

A widely adopted, scientific approach to assess the environmental status of water bodies consist in measuring their optical properties, such as color and transparency. The transparency of natural waters is affected by the presence of dissolved organic matter, sediment load and gross biological activity, which are considered water quality indicators.

The KdUINO is a DIY (Do-It-Yourself) moored system, based on the open hardware platform Arduino [1] and quasi-digital sensors that measure light irradiance in the photosynthetically active radiation (PAR) at different depths. The buoy is very easy to build and to use. Its cost is less than 100 \$. This type of devices increments the marine citizen science community and crowdsourcing capabilities, allowing a much larger spatial and temporal monitoring of parameters related to water quality. A detailed description of the system components is in [2].

The irradiance measurements allow calculating the diffuse attenuation coefficient parameter (Kd), a parameter related to water transparency. Kd in the PAR is used in some biological studies. However, the value of Kd in multiple wavelength regions could be very useful for more precise biological studies and remote sensing calibration of satellites.

In this contribution, we will analyze the measurements and results of the KdUINO with a new “homemade” multispectral sensor. Its cost is less than 5 \$. We will validate the sensors and estimate the measurement errors. We will demonstrate we can obtain a multispectral Kd parameter whose value is similar to the Kd calculated with expensive high precision instruments.

DISCUSSION

The new version of the KdUINO contains several multispectral optical sensors. The sensors [3], placed at different depths in a water column, convert the multispectral irradiance measurements into frequency. By counting the number of cycles over large periods of time (several minutes), it is possible to obtain a time-integrated measurement of irradiance values near the water surface, reducing the measurement variability derived from the significant light fluctuations caused by focusing of sunlight by surface waves [4].

The sensors measurements are subject to some errors, both electronic and mechanic:

Sensor tolerance: Sensors are available with an absolute output frequency tolerance. However, the sensor tolerance is not specificity in the technical specifications.

Changes in wavelength illumination: The technical specifications of the sensor contain imprecise information on the outcome variation as a function of wavelength. This imprecise information induces some errors in the calculation of Kd.

Encapsulation: The response of the sensors depends on the form and material of the capsule. The capsules are “homemade” and the irradiance measurement can change depending on the how you made them.

METHODOLOGY AND RESULTS

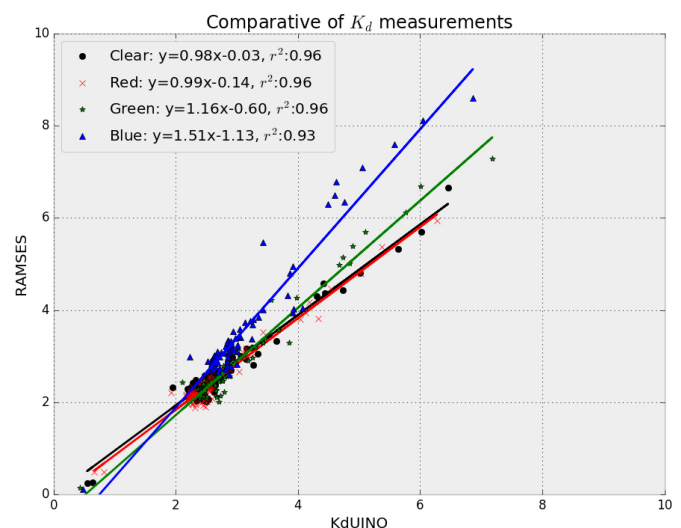
We compared more 100 estimations of Kd in the wavelength ranges of the reds, blues, greens and visible (clear) obtained from data from the KdUINO with the novel sensors and another common-used oceanographic instrument, the RAMSES [5] (the cost of the scientific instrument is higher than 10000 Euros). Laboratory results indicate a substantial similarity between the two sets of values (see Figure 1) as noted in the concluding section.

CONCLUSION

According to our preliminary results, with the KdUINO measurements and a post-processing data analysis, it is possible to obtain the Kd parameter with an error of around 10%.

Fig. 1. Comparison of Kd results in four wavelength ranges (red, blue, green and visible) with two different instruments. They are highly linearly correlated.

We conclude that the KdUINO with the multispectral sensors is a very useful and inexpensive tool to study the variability of the Kd. Many KdUINOs can be deployed and placed in a wide sea area where, for the same price, just one of any other oceanographic instrument could be used. According to the price and the easy development of the device, we consider that the KdUINO could be an excellent citizen science tool.



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ID17- REAL-TIME LOSSLESS COMPRESSION OF MULTIBEAM ECHOSOUNDER WATER COLUMN DATA

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Abstract - Multibeam echosounders can generate vast amounts of data when recording the complete water column, which poses logistic, economic and technical challenges. Lossy data compression can reduce data size up to one or two orders of magnitude, but often at the expense of significant image distortion. Lossless compression ratios tend to be modest and at a high computing cost. In this work we test a high-performance data compression algorithm, FAPEC, initially developed for Space data communications with low computing requirements. FAPEC provides good compression ratios and supports tailored pre-processing stages. Here we show its advantages over standard and high-end lossless compression solutions currently available, both in terms of ratios and speed.

Keywords - Water column, multibeam, lossless, compression, FAPEC.

I. INTRODUCTION

In the last years remarkable advances in sonar technology, spatial positioning and computation power have led to significant improvements in mapping, imaging and monitoring of the oceans. Multibeam echosounders are now capable of collecting backscatter data for the whole water column, in addition to the traditional measures of bathymetry and seafloor reflectivity. These new data sets open up a new range of applications for multibeam sonars, including direct imaging of fish and marine mammals, mapping of suspensate plumes, location of mid-water targets, proper determination of sunken structures such as shipwrecks and investigating a wide range of physical oceanographic processes [1]. Despite the potential value of water column reflectivity measurements, the enormous increase in data collection often makes the media storage requirements prohibitive, which forces many users to opt for not recording systematically water column information. The volume of data generated in multibeam water column surveys can easily be one order of magnitude larger than in conventional bottom detection assessments, especially in shallow water where the higher ping rates lead to data rates of several gigabytes per hour [2]. This complicates the efficient browsing, querying, sharing and transfer of data. It also limits the design of Autonomous Underwater Vehicles (AUVs) equipped with multibeam echosounders and remote assistance during sea works by technical support teams, which often rely on expensive satellite links.

Data compression provides a potential solution to this challenging issue. However, few published studies face this question, and most of them use lossy methods involving a certain degree of signal distortion and water column imagery degradation [2,3,4]. Even fewer sonar-dedicated lossless compression algorithms have been proposed [5,6], and commonly used lossless techniques, such as ZIP, RAR or 7z, yield only modest compression rates at very slow speeds. Here we evaluate these data compression tools and their performance on multibeam water column data. We also provide the results obtained with a lossless compression algorithm called FAPEC (Fully Adapted Prediction Error Coder) [7], initially designed to meet the tight requirements of satellite payloads and deep space communications. More precisely, it is inherited from a Technology Research Programme of the European Space Agency for Gaia, an ambitious space astrometry mission which aims at measuring the position, distances and motions of more than one billion stars with unprecedented accuracy [8]. The large amount of data and its complex data model required a tailored and extremely optimized solution. In [9], an initial solution based on stream partitioning and standard compressors was proposed, but finally a solution based on Rice-Golomb codes [10] was adopted and improved with an outlier-resilient algorithm, which is at the core of FAPEC [11]. In this work we take advantage of the lessons learned in Space research to adapt the FAPEC algorithm to multibeam water column data.

II. WATER COLUMN DATA

Multibeam echosounder raw records are usually logged as binary files using signed or unsigned integer numbers. Each sonar manufacturer has a specific file format, which in turn can vary depending on the particular sonar model, the survey purpose, its configuration and the external sensors included such as CTD probe, GPS, Compass and Gyro. Each file usually contains time-stamped information about beam geometry, sonar configuration, navigation, attitude, sound speed, bathymetry and water column backscatter measurements. Most of the data volume comes from backscatter raw samples, composing the image as a two-dimensional array (number of beams times the number of samples for that beam). Each element is typically an 8, 16 or 32 bit integer value. In our case we have signed 8-bit samples. Note that array dimensions are not necessarily uniform throughout the data file, which complicates its handling by image compression algorithms.

In this study we analyse water column data acquired with a Kongsberg EM710 multibeam echosounder. The EM710 operates at sonar frequencies in the 70-100 kHz range with a maximum ping rate of 30 Hz, up to 400 soundings per swath and a coverage that can reach 140°.

III. THE FAPEC DATA COMPRESSOR

FAPEC is a highly-optimized entropy coding algorithm which offers outstanding resiliency in front of outliers in the data [7,11]. That is, FAPEC reaches good compression ratios even on data severely contaminated by noise and values outside the typical statistics. In general, its compression efficiency is typically above 90%, which means that it barely introduces any redundancy with respect to the actual data entropy.

This highly configurable system follows a typical two-stage approach. The first stage, or decorrelator, reduces the original entropy of the data by applying a reversible (lossless) or partially-reversible (lossy) algorithm. It can be as simple as a delta stage, outputting differences between consecutive samples. Linear filters can also be used, as well as interleaving for samples following some given patterns. Elaborated stages are also available, such as pattern recognition, multi-band prediction, or image compression algorithms. Some of these stages support lossy compression, but in this work we focus on the lossless case. If needed, a tailored pre-processing stage can be implemented and easily integrated into FAPEC.

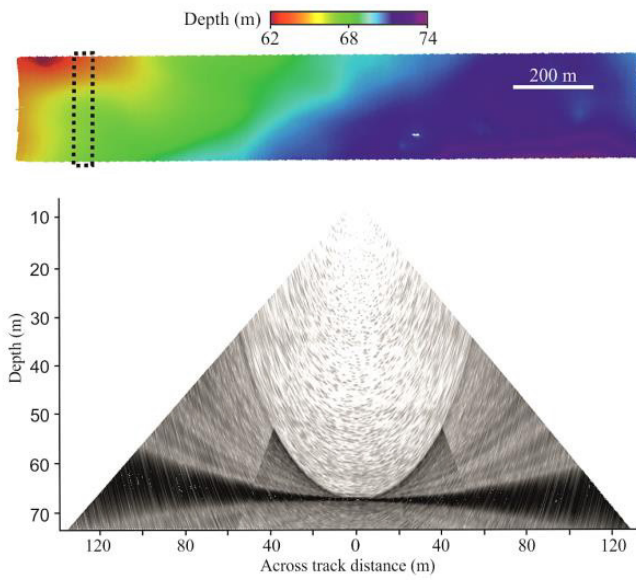
The output of the first stage is a sequence of signed integers (the prediction errors). The second stage (the entropy coder in itself) generates short binary codes for more frequent values, and slightly longer codes for less frequent values. It includes mechanisms for the efficient compression of sequences with repeated values, thus going beyond the simple entropy coding.

FAPEC, implemented in highly optimized ANSI C, is available as an executable program for Linux, Windows or Mac, and as a dynamic library with a simple Application Process Interface (API) for better integration with data handling systems. A hardware prototype in VHDL language is also available for programmable electronic chips (FPGAs). FAPEC can natively handle sample sizes of 8 to 24 bits, and arbitrarily large samples by means of interleaving. Its compression performance is excellent especially on samples of 16, 32 or 64 bits. FAPEC also enforces data integrity, minimizing data loss in case of file or data transfer corruption.

IV. TEST SETUP

The two data sets used to test the lossless compression algorithms were acquired with a Kongsberg EM710 multibeam survey in the outer continental shelf southeast of Spain. Both datasets correspond to a relatively smooth and homogeneous bathymetry, the second one including a shipwreck (Fig. 1). Table 1 summarizes the data files used for these tests and their main characteristics.

A. Smooth seafloor



B. Shipwreck

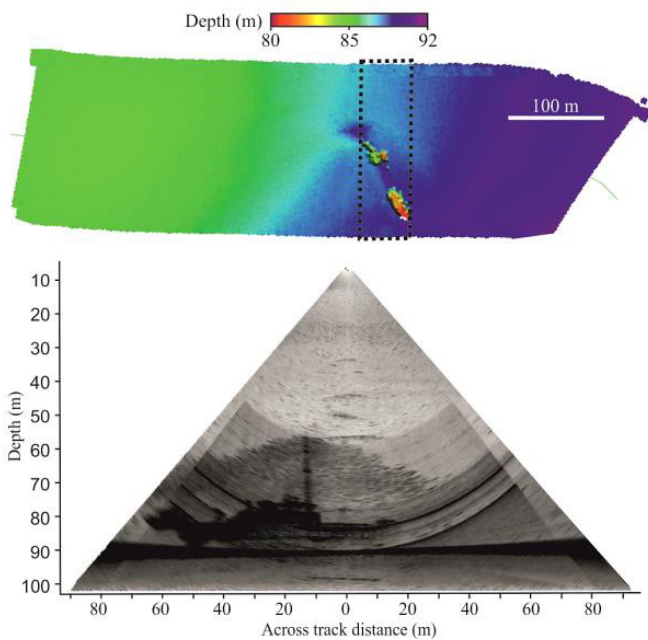


Fig. 1. Swath bathymetry and water column data of the two test sites. The black dashed frame shows the water column corridor displayed.

File	0001_20160519_193149_AA.wcd	0044_20140814_213726_AA.wcd
Size	339.5MB	149.3MB
Acquisition time	5 min	2 min 38 s
Acquisition rate	1.33MB/s	0.95 MB/s
Case	Smooth seafloor	Shipwreck
Depth range (m)	62-74	80-92

Table 1: Water column data files used in the tests.

For the data compression tests we selected the well-known gzip, bzip2, rar and 7z programs, testing the fast and best options for each of them. We forced a single-thread operation in rar to obtain better comparable results. In the case of FAPEC, we used release 2016.0 Core with an automatic configuration, leading to an 8-bit delta pre-processing, as otherwise expected for our case. We have forced a single-thread operation as well, as FAPEC also supports multi-threaded compression. All tests were run on a laptop with Intel Core i7 2640M 2.8GHz processor running 64-bit Gentoo Linux. Only the User time (that is, the CPU time) has been taken into account to ignore the effect of disk I/O, and to account the actual time accumulated by all threads in the 7z case.

Tests were done directly on the Kongsberg wcd file (water column datagram). In order to evaluate a potential improvement, we did a test with FAPEC using a prototype pre-processing stage tailored for this kind of files. Specifically, we “transposed” most of the raw samples in order to enhance their correlation. Also, samples were compressed separately from ancillary information and attributes (such as time stamping and beam information). This approach is very similar to the one initially proposed for the Gaia space mission [9].

V. TEST RESULTS

Table 2 shows the lossless compression ratios obtained with these tests (that is, the original file size divided by the compressed file size). As predicted by the Information Theory, the shipwreck file is more difficult to compress because it contains more information, that is, the intrinsic entropy of its raw samples is higher. The best “standard” compressor regarding ratios is 7z with its ultra configuration, although bzip2 offers similar results. FAPEC, in its standard and automatic configuration, offers modest ratios of 1.43 and 1.30 for the two tested files, which is anyway better than what gzip can offer, and very similar to what rar can achieve. However, when combined with a simple pre-processing stage tailored for this kind of files, the overall compression ratios boost to 1.8 and 1.65 respectively (12% and 17% better than 7z in its ultra configuration). Specifically, 7z reduces the file sizes down to 248MB and 106MB respectively, whereas our tailored FAPEC reduces them to 221MB and 90MB. It is worth noting that the FAPEC tailoring is just a prototype. Further improvements should lead to even better ratios.

Regarding compression times, Table 3 shows the throughputs (or speeds) achieved during these tests, calculated as the original file size divided by the CPU time, shown in megabytes per second. Depending on the disk access times, the actual speeds may decrease very slightly. Here differences between the tested compressors become evident. Both gzip and rar, in their fast configuration, provide reasonably good speeds around 30MB/s, but performance drastically decreases when setting them to best. Bzip2 offers a quite uniform and reasonable performance. When considering both the ratio and speed, bzip2 appears as an interesting solution. On the other hand, 7z is quite slow even in its fast configuration, but its ultra option is even slower than the actual data acquisition rate, which is about 1.0MB/s to 1.3MB/s (Table 1). Finally, FAPEC clearly provides the fastest solution, with the tailored version slightly faster than the standard one. This is one of the features of FAPEC, namely, its compression speed is better when data is more compressible. To better illustrate overall performances, Figs. 2 and 3 plot the ratios and throughputs, respectively.

File		Smooth seafloor	Shipwreck
Gzip	--fast	1.37	1.24
	--best	1.39	1.25
Bzip2	--fast	1.55	1.38
	--best	1.58	1.40
Rar	-m1	1.38	1.25
	-m5	1.44	1.35
7z	-mx1	1.52	1.34
	-mx9	1.61	1.41
FAPEC	Standard	1.43	1.30
	Tailored	1.80	1.65

Table 2: Compression ratios obtained on the test files

File		Smooth seafloor	Shipwreck
Gzip	--fast	34.7	31.1
	--best	5.9	16.8
Bzip2	--fast	11.9	10.7
	--best	11.1	9.9
Rar	-m1	29.6	26.2
	-m5	5.4	10.6
7z	-mx1	9.7	9.0
	-mx9	1.1	1.2
FAPEC	Standard	71.3	67.9
	Tailored	79.9	74.6

Table 3: Compression throughputs (MB/s) obtained on the test files

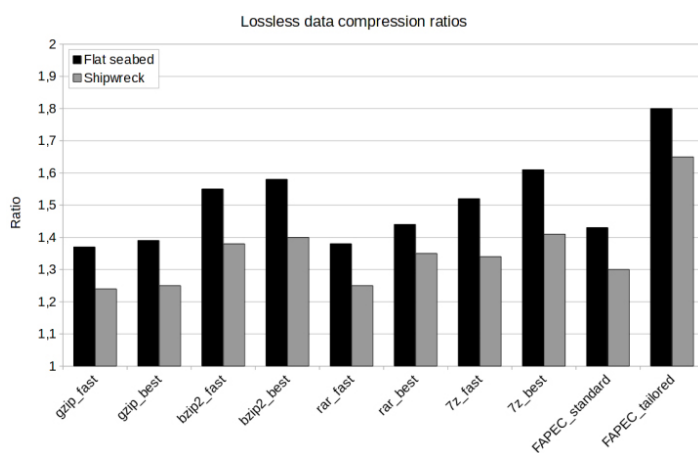


Fig. 2. Lossless compression ratios obtained in the tests.

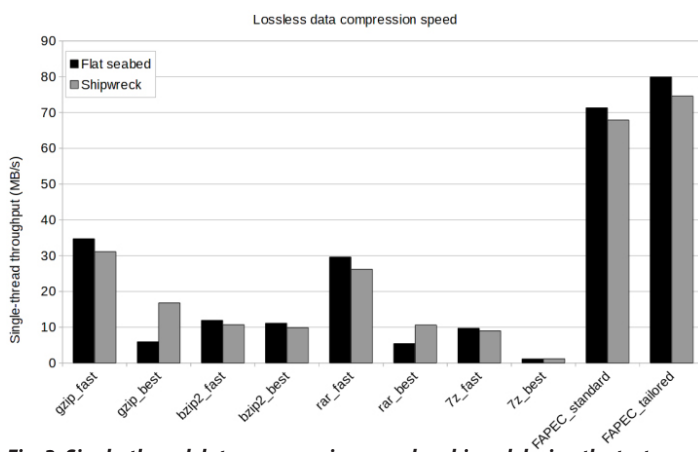


Fig. 3. Single-thread data compression speeds achieved during the tests.

Besides compression speeds, the memory requirements of the several compressors are also relevant. Both gzip and bzip2 have very modest requirements (4MB to 11MB). FAPEC needs also are about 8MB of RAM. Nevertheless, rar raises this requirement to 68MB or 97MB, depending on its configuration. The worst case is 7z, which uses just 27MB in its fast configuration, but its ultra configuration raises this requirement up to 700MB.

VI. CONCLUSIONS AND FORTHCOMING WORK

In this preliminary study we have evaluated the lossless data compression performance of a variety of algorithms on multibeam echosounder water column

data. One of these solutions, FAPEC, is a high-performance algorithm initially devised for satellite payloads, which makes it very lightweight and therefore applicable to compression of large datasets or massive data handling systems. Lossless compression tests on two water column data files have assessed the very high speed of FAPEC, making it suitable for real-time compression and decompression. For example, it could be applied as a transparent compression and decompression system, allowing directly processing and handling compressed datasets on-the-fly instead of having to decompress them beforehand. Regarding compression ratios, the default (differential) pre-processing stage of FAPEC is able to provide competitive results, and when tailoring it with an adequate pre-processing algorithm the ratios become better than any other solution tested here. Therefore, this is a lossless data compressor with the highest ratios and speeds on water column data. This is an especially remarkable result considering that compression is done on relatively small chunks of data. Specifically, each datagram is handled independently, and compression in itself is done in chunks of just 1MB. Therefore, in case of file corruption, most of the original file can still be recovered. This error resilience is one of the features inherited from the Space data communications field.

While excellent by themselves, these FAPEC results should be considered preliminary. We are working on further improvements of the tailored pre-processing stage to take better advantage of the intrinsic data redundancy, not only within a beam or between adjacent beams in a datagram, but also between adjacent swaths. It should also be noted that the ratios obtained here are relatively low because of the 8-bit sample format. FAPEC performs even better (both in ratios and speeds) when dealing with samples of 16 bits or more. If necessary, FAPEC allows introducing some level of losses to reduce further the compressed files, which may be interesting in some scenarios. Finally, further tests will be done to include analysis in different depth settings and seafloor characteristics, and using different echosounder models.

ACKNOWLEDGEMENTS

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ID18- INNDAGA: AN ENVIRONMENTAL DATA ACQUISITION INNOVATION PLATFORM

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Abstract – INNDAGA is a multipurpose platform for conducting oceanographic surveys in coastal areas developed on an 8.5 m long inflatable boat. This concept allows the vessel to operate safely and with great manoeuvring flexibility in areas where larger research vessels cannot access (rocky areas, port ...) at low operational cost. Is fully integrated in an information management system to providing efficiency and effectiveness of strategic decision making

Keywords – INNDAGA, ENVIRONMENTAL MAGNAGEMENT TOOLS, ITCZ, COASTAL RESEARCH VESSEL

I. INTRODUCTION

Half the world's population lives within 200 km of the coast. This densely populated strip represents 15% of the Earth's surface, and concentrates many rich and productive, but also vulnerable, areas. The concentration of human activities on the coast dedicated to the legitimate enterprise of increasing the level of life of its inhabitants, cause important environmental problems.

In this way, the convergence of social, economic and environmental interests in this small strip of the Earth have cause such an immense anthropic pressure through the centuries to the point of threatening their own existence and becoming the source of human health issues.

Therefore, in recent decades it has been identified the need for careful planning coastal protection, that allows of a rational development of the ever increasing needs for subsistence of the population.

Integrated coastal zone management (ICZM) has become one of the biggest environmental challenges for mankind today, being the target of numerous international programs. ICZM requires an understanding of the major interactions in coastal ecosystems. Understanding the interactions between all the elements that compose these systems at the short, middle and long term is a very fundamental objective for scientists and managers, if the sustainability of these areas are to be guaranteed. Informed decision-making requires understanding both the environmental and socioeconomic aspects of the coastal areas, something that can be best achieved by the use and further development of advance tools based on the most advanced scanning and data acquisition techniques.

II. INNDAGA

In this context, Inndaga (acronym for environmental data acquisition innovation platform) was initially developed under the INNODRAVAL Project (IPT-310000-2010-17) of the National Plan for Scientific Research, Development and Technological Innovation. Our main aim was to pursue innovation in the environmental restoration operations of coastal areas by developing an integrated platform for characterization of the marine environment including, geophysical surveying, and water and sediment sampling. The main goal was to develop an integrated tool that implemented the best available techniques of characterization and monitoring of the environmental condition in port areas; and that at the same time time met the necessary responsive and operationally inexpensiveness to work in such a environment.

Originally conceived to serve the operations of dredging, treatment and recovery of sludge and sediments with organic and inorganic contaminants in port areas, its range of use has now been widely extended to any applied and research activity in coastal areas

III. WHAT IS INNDAGA

INNDAGA is a multipurpose platform for conducting oceanographic surveys in coastal areas developed on an 8.5 m long inflatable boat. The boat hull combines a shallow draft rigid submerged structure with a high strength pneumatic float. This concept allows the vessel to operate safely and with great manoeuvring flexibility in areas where larger research vessels cannot access (rocky areas, harbours, etc.).

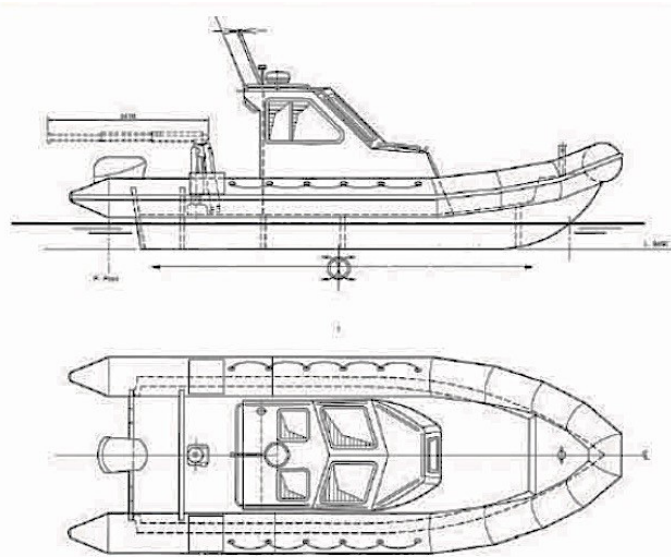


Fig 1. Inndaga blueprints

The vessel includes a closed cabin that houses the scientific instrumentation consoles, allowing for normal operation of the more sensitive equipment even in adverse environmental conditions. The implementation of a Honda 3KVA generator grants electric autonomy (220/12V) to the entire platform. INNDAGA also integrates a small crane with a capacity load of up to 200 kg, which facilitates the operation of small scientific instrumental.



Fig 2. General view of the vessel showing the cabin and the crane.

IV. SCIENTIFIC EQUIPMENT

INN-DAGA is equipped with scientific instrumentation of the highest performance in the market such as advanced DGPS and RTK Positioning; Systems (Trimble SPS), geophysical and hydrographic survey systems such as Side Scan Sonar (Klein 3900), Multibeam Sonar (Kongsberg GS+) and Parametric Sounder (Innomar 2000Compact Sounder); and sampling and parameter acquisition tools such as a 120 cm long Piston corer (UWITEC), a 500 ml grabber (Van Veen, Niskin bottles, CTDs (XRX- 620 and SBE 37-SMP MicroCAT), Portable Multiparameter probe (YSI) and current meters (Aandera RCM9/Seaguard). All the equipments can operate between 1 – 60 m of depth.



Fig. 3. Detail of the installation of the operating unit within the cabin under the folding table and the top right are seen the GPS in yellow. The solution adopted is also shown for output cables to the transceiver unit in the two photographs bottom of the figure.

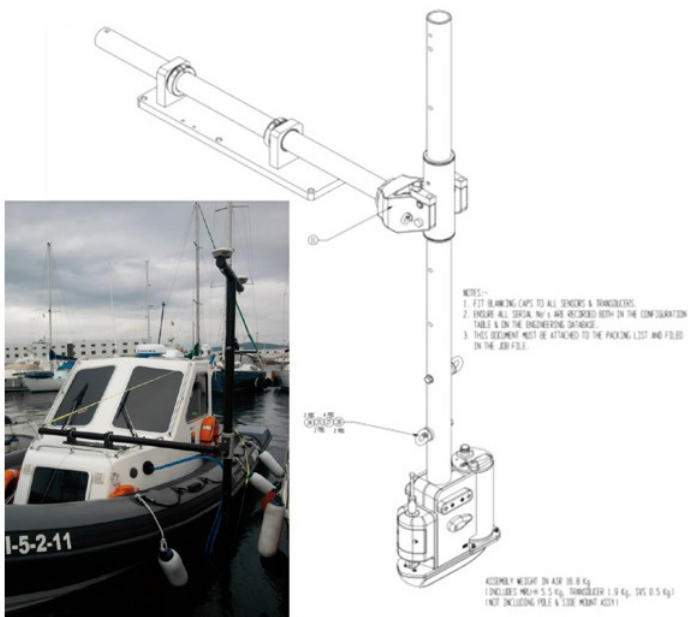


Fig. 4. Blue print and view of the structure in full swing pole, installed in the INN-DAGA boat to anchor the multibeam system plus GeoSwath of Geoacustics and GPS antennas on line.

V. APPLICATIONS

- Sea bed quality determination
- Shallow water high resolution bathymetry
- Determination of sediment units thickness
- Subtidal area characterization of oceanographic conditions in subtidal areas.
- Monitoring and quality control in dredging operations.
- Assessment of maritime construction works.
- Location and positioning of underwater structures and salvage operations.



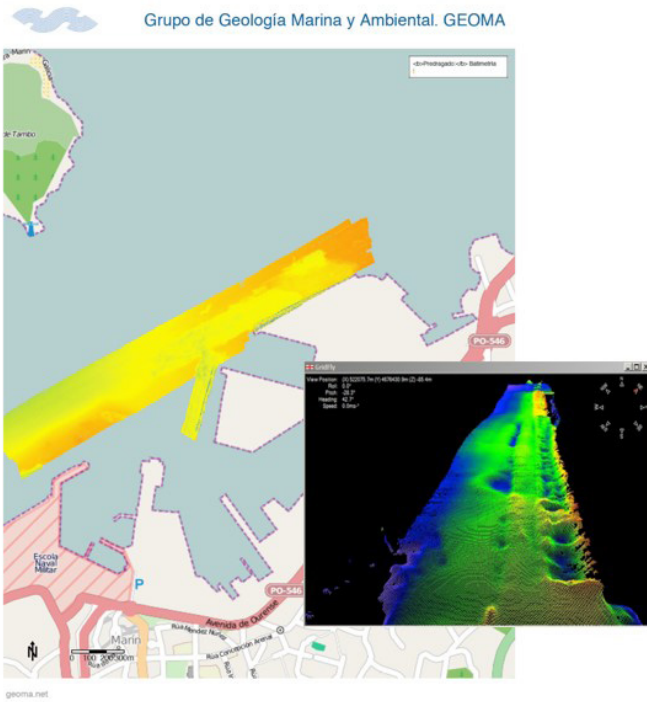
Fig 5. Piston corer and van Veen grabber being deployed.

VI. INN-DAGA AND ICZM

Inndaga is very flexible and has a very wide range of applications. In ports, it becomes an ideal platform to develop site-specific technologies and methodologies for accurate inspection and monitoring of port elements and piers, hydrographical conditions, and to improve their maintenance and operation in compliance of current EU directives (ie DMEM) and UN descriptors.

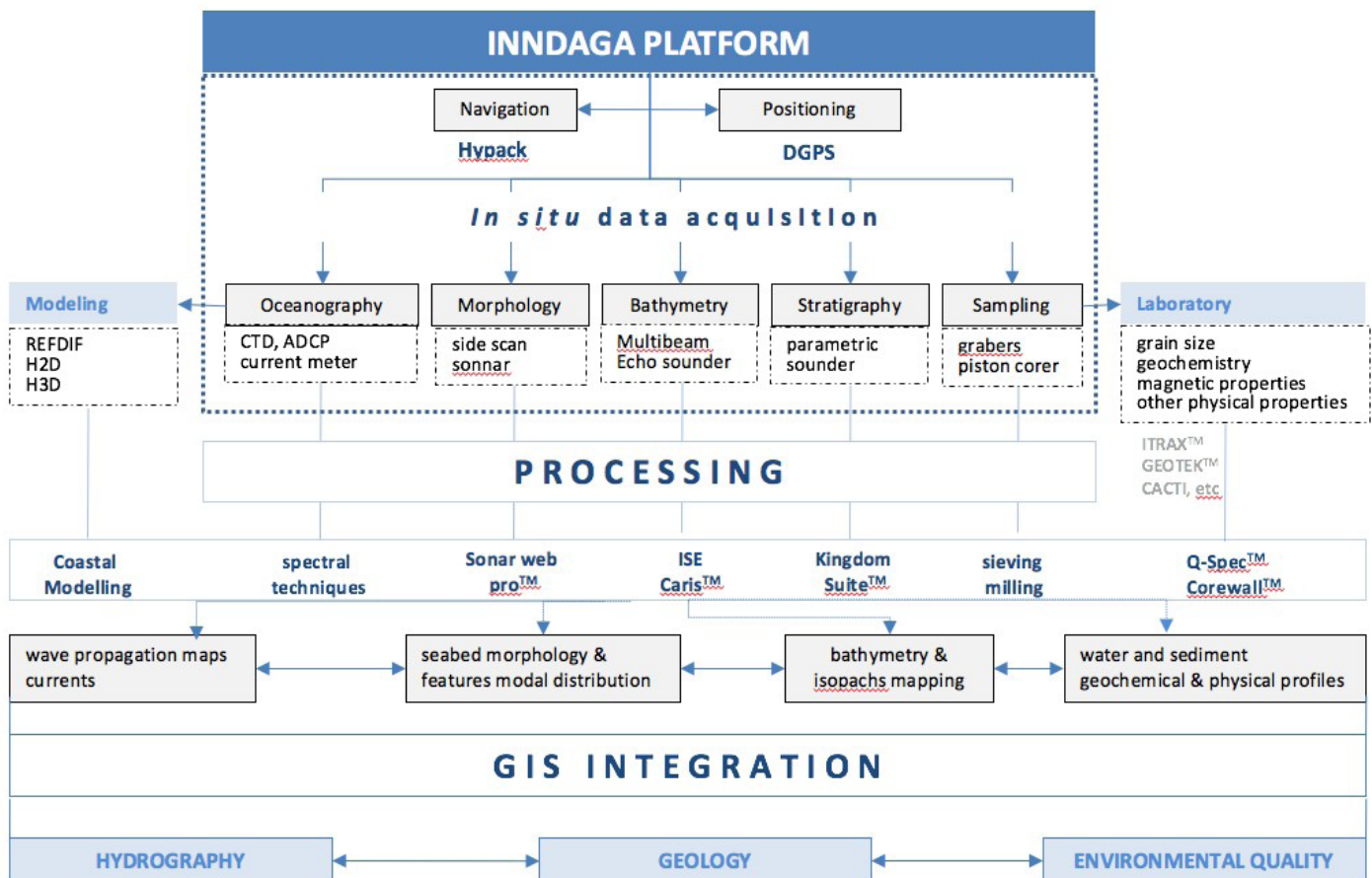
This concept allows for acquisition of high-resolution data necessary to improve hydrodynamic models, important to predict the possible effects of dredging, to analyse the behaviour of a structure, or to design strategies to combat and management potential spills.

A fully developed postsurvey scheme allows for quick data processing and water and sediment sample analysis. These results are integrated in a Georeferenced Information System (GIS) allowing the display of all the relevant for the environmental management of coastal areas information, providing efficiency and effectiveness of strategic decision-making. This allow to develop practices that integrate morphodynamic numerical models habitat mapping techniques, including geological observations, bathymetric, Biological and Physical Properties acquired able to predict, monitor and mitigate the impacts of human activity in coastal areas where larger research vessels cannot access (rocky areas, beaches, small estuaries, ports, etc.).



(left) Fig 5. Typical INDDAGA automated quick report output produced from the integrated WebGIS at <http://geoma.net/geomapas.html>.

(below) Fig 6. Flow diagram showing INDDAGA capacities and work-flow to aid informed decision making in common coastal management situations.



ID19- BARES 2.0 WAVE BUOY AND SUSTAINABLE BUOY NETWORK

P. GONZÁLEZ⁷³ X. FERNÁNDEZ⁷⁴

Abstract – The aim of this article is to show the operation of the Bares 2.0 wave buoy and the Bares network developed by HCTech. In the marine sector it is highly important to know the state of the sea for applications such as the construction of ports, the study of the impact of waves in coastal areas, the development and calibration of forecasting wave models, the knowledge of the state of the maritime navigation channels, etc. Some of the great difficulties that exist in order to obtain the information of ocean waves is the high cost of the buoys, installation and maintenance. The Bares network aims to cover areas of high oceanographic interest, the target is a sustainable network of buoys that facilitate the access to wave data. The features of this network are the optimized cost, high reliability and reduced maintenance.

Keywords - buoy, waves, network, swell, Bares, Triaxys, oceanography, comparative.

1 INTRODUCTION

The Bares 2.0 wave buoy and the Bares network allow analyzing the behavior of the sea at an optimal cost, with high precision and high robustness in order to obtain long temporal series with high quality. In the following sections the most important aspects of hardware and software are explained, we talk about the Bares network project and finally we will see a brief comparative between the Bares 2.0 and the Triaxys sensors.

2 HARDWARE AND SOFTWARE

2.1 Energy Module

The buoy includes three rechargeable batteries and four solar panels, this elements provide an autonomous operation for a long time. Thanks to the optimal consumption of electronics it is possible to guarantee the operation in adverse conditions, that is, with very low solar energy. This buoy has different states of operation, if the available energy is too low the buoy works in a low consumption state in order to ensure the operation of the system.

2.2 Inertial Sensors

The buoy has a cutting-edge and cost-effective IMU/AHRS (Inertial Measurement Unit/Attitude Heading Reference System) based in MEMS (Micro Electro Mechanical System) technology. This unit has a three axis accelerometer, a three axis gyroscope, a three axis magnetometer and a temperature sensor. The most relevant characteristics of the IMU/AHRS are:

- MEMS sensors with high linearity and low noise.
- Sensors calibrated and tested in the range of -40 to 85 ° C.
- Efficient microprocessor running the Kalman [1] algorithm at 1KHz. This algorithm implements the sensor fusion and rejects spurious vibrations.
- 0.2° pitch and roll accuracy.
- 0.8° heading accuracy.
- Very low consumption.

2.3 Control Module

This module controls, synchronizes and monitors all subsystems in the buoy. For guarantee a robust and an efficient operation, we made a great effort in the development of both software and hardware. The control module software is based on the state machine concept, the most relevant characteristics are:

- In function of battery charge it automatically adjusts the operation mode. If it is too low for the processing, the software stores raw data and only processes when the battery charge has the correct level. The system has FIFO queues for the pending raw data, thus this data will be processed in the same order that they were stored.
- In the case of critical errors in the processing and communication module, the system stores the raw data. Thus raw data can be recovered and processed later.
- A solid state memory to store the raw data for more than two years. The raw data that were processed and transmitted are removed.

- In the case of critical errors as errors in the inertial sensors, the system will send alert messages to the servers.
- In the case of GPS errors due to malfunction or buoy drifting, the system will send alert messages to the servers.

2.4 Processing and Communication Module

The processing of raw data and the communications with the servers are performed in this module. The more relevant characteristics are:

- Powerful and efficient ARM microprocessor that runs the C++ applications.
- GPRS/3G modem. Due to modular design it is also possible to use other interface types as satellite communication.
- The integration of the communication module in the Bares 2.0 sensor allows increasing energy efficiency and reliability.
- A solid state memory allows storing the processed data for more than seven years. This memory is independent of control module memory and when the communication interface is broken or when there are not enough battery for transmit the processed data it stores the processed data. The system has FIFO queues for the pending processed data, thus this data will be sent in the same order that they were stored.
- The wave processing software was completely developed by HCTech. This software was validated comparing our sensor with Triaxys and Datawell sensors.
- The communication software was completely developed by HCTech. This software is highly reliable and efficient and is based on the AMQP protocol described in [2]. The integrity and the confidentiality of the data in the transmission toward our servers is ensured by our software.

The wave processing software is an improvement of the Bares 1.0 software. Initially the software was developed in Matlab platform and in order to validate the correct operation of the mathematical model we develop a wave simulator based on Simulink. Then in order to perform an on-board processing in the ARM microprocessor all the software was implemented in C++.

As can be seen in the comparative section of this paper, we show the comparison of both Bares 2.0 and Triaxys sensors, but previously a comparison between the Bares 1.0 and the Triaxys was made. In this we saw that non directional parameters of the Bares 1.0 are comparable with the Triaxys parameters, however due to the noise and the nonlinearity of the IMU/AHRS we saw that the directional parameters were not accurate enough. For this reason Bares 2.0 includes a cutting-edge and cost-effective IMU/AHRS for assuring the accuracy.

Generally, the operating of the software is the following:

1. Transformation of accelerations in to a fixed coordinate system.
2. Digital integration and high pass filtering of accelerations in order to obtain velocities and displacements according to [3].
3. Non directional processing as shown by Earle [4]: statistical-temporal processing and spectral processing of vertical displacement.
4. Directional processing as shown by Benoit [5]: spectral processing of vertical and horizontal displacements.

An advanced protocol between the buoy and the servers is performed by the communication software. This is based on AMQP protocol which allows sending a very high quantity of messages, always ensuring the integrity and confidentiality of the data. The main advantages of this protocol are:

- Message-oriented protocol.
- Redundancy and availability. If the application of the server fails on processing the messages, these are not lost because the protocol insists until they are fully processed.
- Asynchronous communication that allows processing the messages one by one or for groups.
- Delivery guarantee of messages in the order in that they were sent.

- Scalability.
- Multicasting between the server and the buoys with the possibility of actualizations of the wave processing software.
- Remote configuration of the buoys.

3 THE BARES NETWORK

The knowledge of the sea state is highly important for applications such as the port construction, the study of wave impact in coastal areas, the development and calibration of forecasting wave models, the knowledge of the state of the marine navigation channels, the recreational navigation, the aquatic sports, the study of the climate change, etc.

At present it is difficult to obtain a quality ocean wave data because the buoys are expensive and difficult to install and to maintain. This implies that the number of ocean wave buoys is small and that in order to cover an extensive marine area it is very frequent to install only one wave buoy.

The Bares network aims to contribute to reduce these lacks in the oceanographic physics. The main objective is to promote in the creation of a stable and sustainable coastal wave buoy network that allow increasing the number of sample points. In fact this is the principal philosophy of the project, because increasing the number of sample points provides the next advantages:

- Allows increasing the accuracy in the characterization of ocean waves and allows improving the forecasting models.
- Allows ensuring the wave data of the marine area because there are not a single point of failure.
- Allows installing wave buoys near the coastal area. Thus it is possible to study in great detail the waves affected by the underwater topography.

This is possible because the Bares 2.0 is a cost-effective buoy with low maintenance requirements and highly robust.

HCTech will contribute to generating the wave buoy network in places where interest for the ocean wave data is high. Interested entities will be able to access the data contractually. Betting for this sustainable solution, you do not need to make large investments for buying buoys and neither no need to worry about maintenance.

4 COMPARATIVE

The next figures show real data from the Bares 2.0 and the Triaxys, both sensors in the same buoy during ten days in June 2016. Figures 1, 3 and 5 are comparative plots, upper subplots show the Bares signal under the Triaxys signal and lower subplots show the Bares signal above the the Triaxys signal. Figures 2, 4 and 6 are scatter plots.

In figures 1 and 2 we can see the significant wave height, in figures 3 and 4 the mean spectral period and finally in figures 5 and 6 the average mean direction of the ocean waves. For define these parameters, previously we need to know the next concepts and equations:

- Spectral moments where $S(f)$ is the spectrum of the vertical displacement and f is the frequency:

$$m_k = \int_0^{\infty} f^k S(f) df$$

- Directional spreading function that models the directional spreading of the wave energy at each frequency:

$$\int_0^{2\pi} D(f,\theta) d\theta = 1; D(f,\theta) \geq 0$$

- Directional spectrum:

$$S(f,\theta) = S(f)D(f,\theta)$$

- Fourier coefficients a_0, a_1, b_1, a_2 and b_2 that are determined from the cross-spectral data. With this we can obtain the wave direction and directional spreading function as showed in [4].

Thus the parameters in the comparison are defined as follows:

- Significant wave height:

$$H_{m0} = 4\sqrt{m_0}$$

- Mean spectral period:

$$T_z = \sqrt{m_0/m_2}$$

- Mean wave direction:

$$\theta_0 = \text{Arg}(a_1 + ib_1)$$

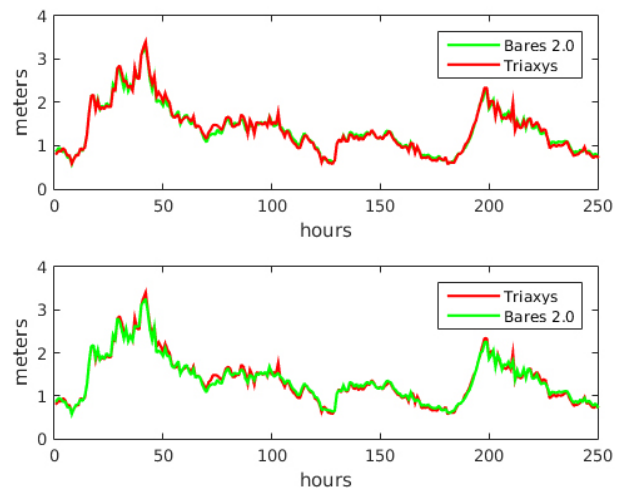


Fig. 1 Comparative plot of significant wave height (spectral), H_{m0} .

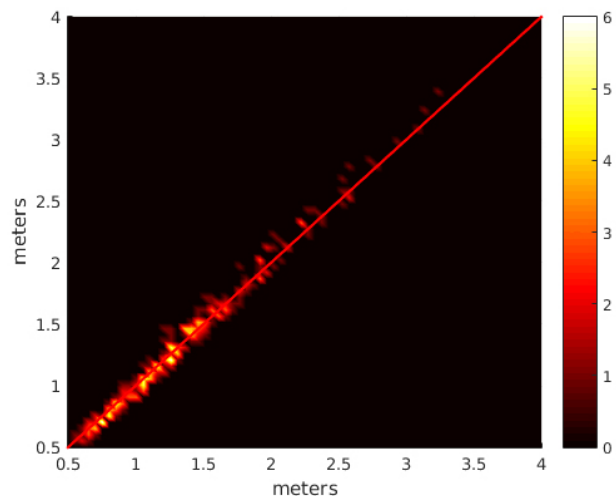


Fig. 2 Scatter plot of significant wave height (spectral), H_{m0} .

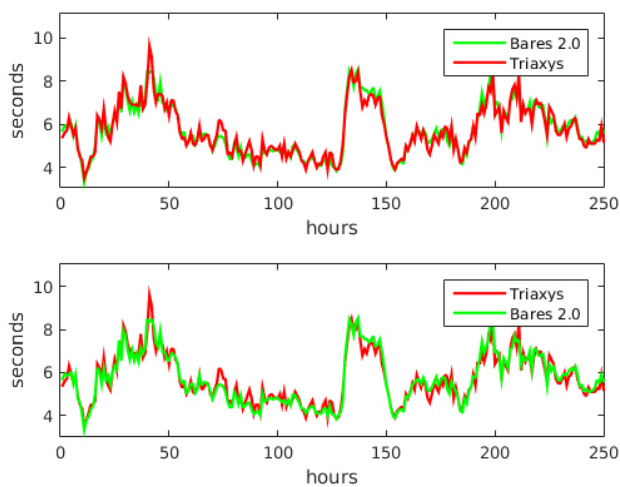


Fig. 3 Comparative plot of mean spectral period, T_z .

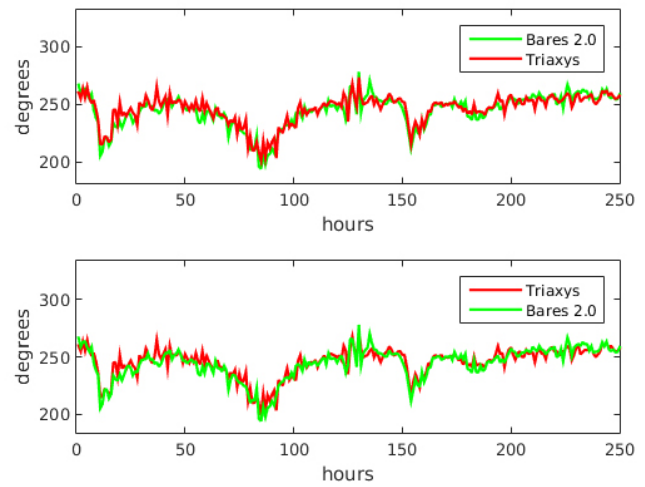


Fig. 5 Comparative plot of mean wave direction, θ .

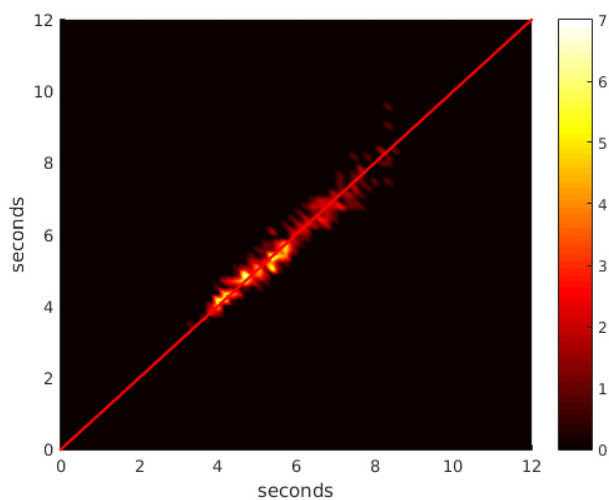


Fig. 4 Scatter plot of mean spectral period, T_z

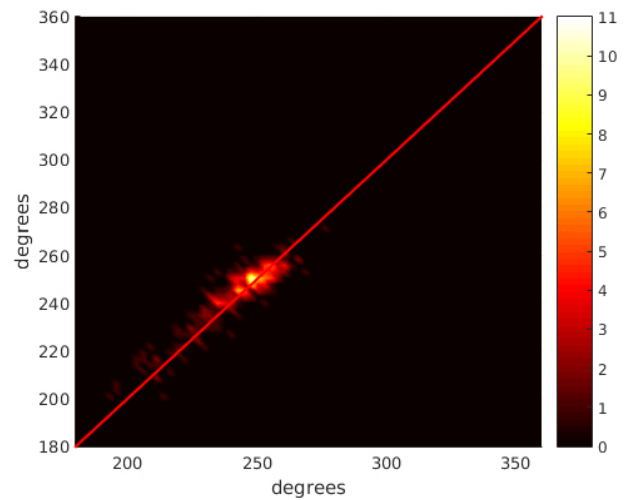


Fig. 6 Scatter plot of mean wave direction, θ .

5 CONCLUSIONS

In the previous section can be seen the good performance of the Bares 2.0 directional wave sensor. In the comparative plots (figures 1, 3 and 5) and in the scatter plots (figures 2, 4 and 6) the high similarity and correlation between the sensors can be seen.

The most critical parameter is the mean wave direction because the noise and nonlinearity of the IMU/AHRS should be optimal, if both are high it is not possible to obtain an accurate wave direction. Bares 2.0 has a cutting-edge and cost-effective IMU/AHRS that allows to obtain an accurate wave direction.

These results and the characteristics of the wave buoy allow us to ensure that the Bares 2.0 will contribute to create a permanent and sustainable buoy network that will provide high quality wave data.

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ID20- USING ORB, BOW AND SVM TO IDENTIFY AND TRACK TAGGED NORWAY LOBSTER NEPHROPS NORVEGICUS (L.)

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Abstract – Sustainable capture policies of many species strongly depend on the understanding of their social behaviour. Nevertheless, the analysis of emergent behaviour in marine species poses several challenges. Usually animals are captured and observed in tanks, and their behaviour is inferred from their dynamics and interactions. Therefore, researchers must deal with thousands of hours of video data. Without loss of generality, this paper proposes a computer vision approach to identify and track specific species, the Norway lobster, *Nephrops norvegicus*. We propose an identification scheme where animals are marked using black and white tags with a geometric shape in the center (holed triangle, filled triangle, holed circle and filled circle). Using a massive labelled dataset; we extract local features based on the ORB descriptor. These features are a posteriori clustered, and we construct a Bag of Visual Words feature vector per animal. This approximation yields us invariance to rotation and translation. A SVM classifier achieves generalization results above 99%. In a second contribution, we will make the code and training data publically available.

Keywords - Computer vision, object identification, video analysis, object tracking, ORB, SVM, BoW, behaviour, *Nephrops norvegicus*

I. INTRODUCTION

The Norway lobster, *Nephrops norvegicus* is a burrowing decapod representing a major target in crustacean European fishery [1]. The animals are caught by trawl nets only during burrow emergence, the timing of which is set upon the day-night cycle. Emergence is also modulated by social interaction in a fashion that is to date not clarified. Doubts on real stock size are reported by comparing field sampling data from trawling with more direct observations on individual behaviour in the laboratory [2]. Under isolating controlled conditions each individual expresses neat locomotor activity. Anyway, the analysis of catch samples by sex and size during different periods of the year suggests a modification of emergence during different stages of the growth or the reproductive cycle. Emergence is also apparently modulated by the close proximity of other co-specifics (as presence-absence close to the burrow), being this specie territorial [3], [4].

Behavioural animal video recording generates a huge number of videos with a large quantity of recorded hours. The human annotation of these videos requires trained people that cost large amounts of time and economical resources. Video-image analysis can be an efficient tool for microcosm experiments portraying the modulation of individual behaviour based on social interactions. Videoimage analysis is increasing its applicability to the biological research, both in the laboratory and in the field, due to the progress in frame processing for object recognition [5]. Differently from actography, hardware settings are easier, since they do not require the use of infrared barriers [6] or wheels[7], and it's not orientated to analyse social behaviour.

The analysis of social behaviour presents major limitations in the discrimination and tracking of the movement of single individuals within a group. This can be overcome with the design of particular individual tags [8], [9] to make possible the differentiation among individuals. Also it is possible to mark individuals using electronic devices like RFID chip [10] applied to Norway lobsters, or a combination of both technologies [11] (in this particular case applied to house mice). When using Computer Vision methods, the tag geometry or image quality become the central issues that condition the performance of video-image analysis and tracking with multiple individuals. In [12], authors used background subtraction techniques with flight path characteristics to identify up to 40 fruit fly (*Drosophila melanogaster*) individuals.

In this paper, we present a computer vision method for feature extraction and object recognition, in the context of an application to marine animal tracking. This study is a prerequisite to the posterior automated behaviour analysis, which is based on the location and recognition of the tags with different shapes placed on the top of animal's cephalothoraxes.

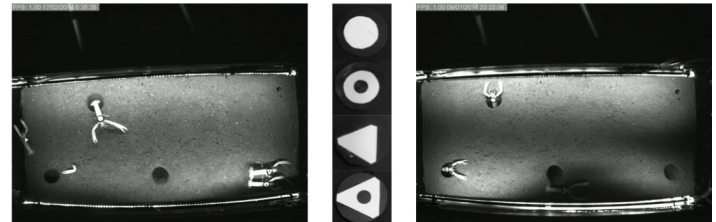


Fig 1. Two different frames of distinct experiments. Notice the high variability in the illumination and the appearance of one claw on the bottom of the tank (left frame), which is a result of a fight between two animals. In the middle of the figure we depict the designed tags photographed out of sea water (in perfectly controlled conditions).

II. MATERIAL AND METHODS

In order to track individual animals, we designed four different tags in the experimental recordings. Tags are composed of a circle of black colour, and a white figure in centre of the circle with an approximate diameter of 45 mm. Figures are circle, holed circle, triangle and holed triangle and then are glued on the cephalothorax top. Figure 1 shows original form examples and animals with glued tag.

A fiberglass social tank of 150cmx70cmx30cm was constructed in order to simulate selected environmental features of *N. norvegicus* habitat (see an example in Figure 1), and include: the presence of four burrows (entrance and tunnel diameters of 10 and 7 cm, respectively; tunnel length of 25 cm; angular inclination of burrow entrance of 20°) and substratum simulating the sediment (made by synthetic acrylic glued to the tank base).

An USB 2.0 monochrome high-quality CMOS sensors digital camera (UI-1545LE-M, IDS) of 1280x1024 pixels resolution (SXGA/1.3 MP) took a frame each 1s. during 15 days through a software application (i.e. iSpy an open source surveillance software). That application stored each 24 hours a video record, naming it with the progressing date and time of acquisition. The video camera was endowed with a wide-angular objective of 6.0 mm and F1.4 screw C 1/2 (IDS) and it was placed in zenith position.

The illumination of the experiments was made with LED tubes of blue light (472 nm) and infrared (IR) light (860 nm), located in longitudinal position along the tank. We used blue light to simulate light conditions at deep sea [13], and IR light to allow recording the animals in darkness conditions. Finally all recordings were made in grayscale, given that the illumination light spectrum is not suitable for colour recordings.

The proposed benchmark dataset consists of four video extracted from distinct experimental trials. A total of 17 biological experiments were conducted, lasting 15 days each, and recorded at 24 fps during 60 minutes per day (approximately 500Gb of disk space). Figure 1 shows some examples of the tank and the prototypical examples of the tags.

Depending on exact time, some of the animals are partially/globally occluded in the burrows. In a preprocessing step, we took benefit of the static tank's position and we computed the bounding box of each animal using a simple background subtraction algorithm. From each detected bounding box, we found the central region of the animal, and obtained the candidate tag image. A human annotator manually labelled each image (32x32 pixels), and erroneous detections were discarded. The final tag database contains 46027 images, and it consists of: 15212 images from circles, 13451 images from holed circle, 6369 images from triangles, and 10995 images from holed triangle. Notice that the database is not fully balanced, given that some animals remain occluded longer periods of time. Figure 2 illustrates some of the segmented tags under different acquisition conditions.

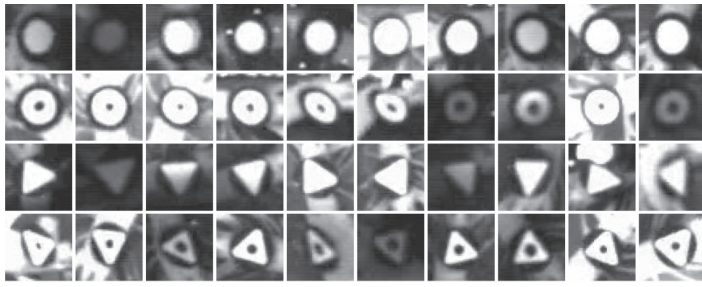


Fig 2. Examples of several tags in a real situation, extracted from the same video recording. Notice differences in position, rotation and illumination.

Once the image has been segmented and the subject is located, we used only the bounding box of the tag location from the fixed position in the subject's back. The tag can appear to the classifier in any orientation, being the rotation invariant property critical for a successful classification process. Depending on the subject's position, we usually find slight variations in the scale and relevant out of plane rotations.

To classify the images, we used The Oriented, Fast and Rotated Brief (ORB) algorithm [14] for image feature extraction, and we used as a classification rules the Support Vector Machines classifiers [15].

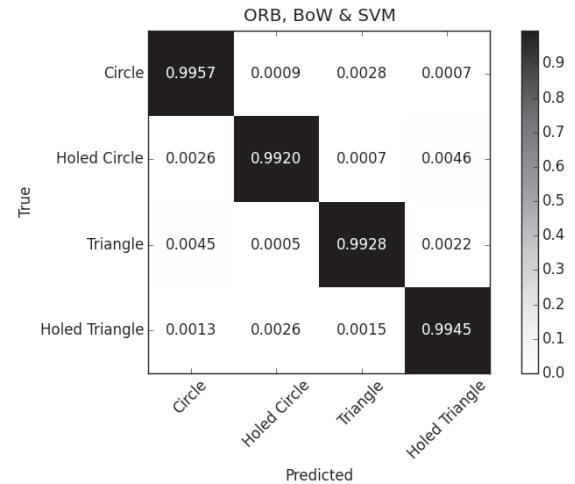
The ORB algorithm is a fast visual descriptor based on the BRIEF (Binary Robust Independent Elementary Features) method [16]. BRIEF descriptors are a string of bits obtained performing simple random binary tests on the neighbourhood of each key point. In order to improve its robustness to in-plane rotation, ORB steers the key point neighbourhood with respect to its dominant orientation. In addition, the ORB algorithm improves BRIEF in the computation of the location of the binary tests. Instead of sampling random positions from a Gaussian distribution, ORB learns the best set of tests according to a training set, in a Greedy search for the tests with higher variance. In this paper we used the OpenCV implementation from [14], which has been successfully been applied to object detection and tracking.

In addition, we also implemented the Bag of Words model [17], given its strong success in the content based image retrieval literature [18]. Essentially we located relevant keypoints and computed the ORB local invariant features. Then, the obtained samples are clustered in 4096 bags, using the k-means algorithm. Per each image we construct a histogram according to the presence of the features with respect to the components of the bags. This histogram acts as a rotation invariant feature vector focused on the main features of each class. Finally, a SVM (RBF) is trained on these features as in [17]. The parameters from the SVM have been set automatically cross validating the training set.

The algorithm have been implemented using the out-of-the- box code from the OpenCV library, and tests have been performed using the Python version of the OpenCV [19] and the Scikit-learn library [20].

III. RESULTS

We followed a 10-fold cross validation protocol. We randomly split the database in ten folds, and nine of them were used for training and one for testing. The experiments were repeated ten times, each time with a different testing fold. Table 1, summarizes the mean accuracies along the ten iterations and the 95% confidence interval and CPU time consumed to classify one shape.



(page before) Fig 3. Normalized confusion matrix of the implemented algorithm.

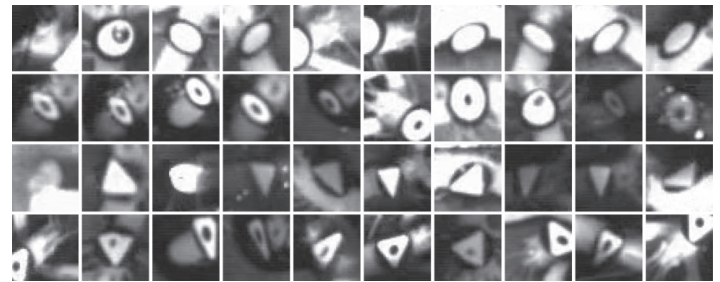


Fig 4. Examples of misclassified shapes in multiple situations. Accuracy CPU TIME ORB, BoW & SVM 99.39 ± 0.06 0.02960849 s.

	Accuracy	CPU TIME
ORB, BoW & SVM	99.39 ± 0.06	0.02960849 s.

Table 1. Mean accuracy and 95% confidence intervals of the proposed algorithm.

IV. DISCUSSION

The ORB features are computed using specifically designed tests to differentiate the classes from the training set. This approximation obtains robust features with a strong degree of invariance to tags rotation. The algorithm's performance is similar across classes as shown in the normalized confusion matrix from Figure 3 Only residual confusions are found. In a qualitative analysis, Figure 4 illustrates several misclassified samples. Notice the strong out-of-plane rotations, deformations due to water flowing, and the extreme illumination conditions present in the images.

V. CONCLUSIONS

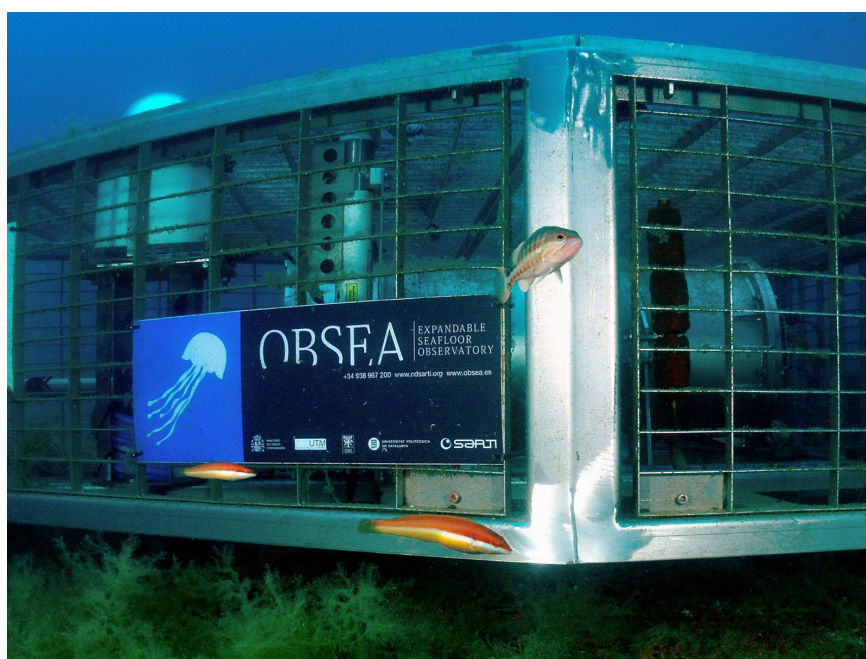
In this paper we introduce the use of a local descriptor in the automated monitoring of *Nephrops norvegicus* behaviour. We propose a complete set up to record and extract infrared images from an experimental set up. Our proposal evaluates the application of a computer vision method to the detection of especially designed tags placed in the animal's cephalothoraxes. The use of discriminant local descriptors (ORB) allows a real time detection of the tags with accuracy close to the human performance (above 99%). We plan as a future work to use more complex deep learning techniques to further improve the accuracies

on the tag detection, and extend the work to the detection of the position of the animal's limbs and head, as a previous stage to animal's interaction and behaviour modelling. In addition, we propose the possibility of changing tags shape and colours order, using the white colour to background and the black colour to the shape, given that the animal colour in IR light is white. We think that this fact could increase the visual differences between tags and it will make possible to increase their number to identify more than four individuals. The proposed code and database will be made publicly available.

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ID21- INTEGRATING DATA FROM VESSEL MONITORING SYSTEM AND FISH LANDINGS IN MEDITERRANEAN SMALL FLEETS, USING A POSTGRESQL DATABASE WITH POSTGIS EXTENSION.

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Abstract – Geospatial technologies represent an advance in knowledge of marine ecosystems, allowing approach the study of the potential effect of world fishing fleets and their dynamics. Nevertheless, their application to fisheries biology is very recent and its use is generalizing when the ICES (International Council for the Exploration of the Sea) proposed one methodology to study fisheries and their impact in Atlantic Ocean ecosystems in the 2008 year. This procedure is based on the use of position data from the "blue boxes" (VMS-Vessel Monitoring System), mandatory since 2006 due to a European regulation, and it's present in most fishing boats. The junction of the VMS, fishing logbooks and landings data enables us to obtain among others results, maps of fishing effort, behaviour of fishing fleet and precise

location of fishing grounds at the European waters. However, its design is made for large trawlers and longliners, and extensive Atlantic areas. This fact makes impossible its application for the study of the fleet and fisheries in Mediterranean waters. Because, the boats are much smaller, have lower mobility and they work in small fishing areas. The aim of this work has been to develop and apply a methodology (ICES based) to study fishing effort on species of commercial interest in Catalan coast, using scripting PL/SQL procedures of PostgreSQL system database with PostGIS extension.

Keywords – Geospatial, PostgreSQL, PostGIS, Vessel Monitoring System, landings, fishing effort, Mediterranean Sea.

ID22- FIRST AUV AND ROV INVESTIGATION OF SEISMOGENIC FAULTS IN THE ALBORAN SEA (WESTERN MEDITERRANEAN)

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Abstract – In May-June 2015 we carried out the SHAKE cruise on board the RV "Sarmiento de Gamboa" the first in situ investigation using state-of-the-art underwater vehicles, the AUVs "AsterX" and "IdefX" (IFREMER, France) and the ROV "Max Rover" (HCMR, Greece). Here we present how these vehicles helped us to achieve our main goals to survey active seismogenic faults and associated structures of the Eastern Alboran Sea (Western Mediterranean).

Keywords – micro-bathymetry, AUV sub-bottom profiles, ROV high-resolution video-imaging, ROV sampling.

I. INTRODUCTION

The SHAKE cruise consisted in a 30-day investigation using state-of-the-art underwater vehicles (AUV and ROV) to survey active seismogenic faults of the Eastern Alboran Sea. These fault systems have been well characterized during previous national and European projects. In the frame of the Spanish project SHAKE we had shiptime on the RV "Sarmiento de Gamboa" to carry out an ultra-high resolution marine geophysical investigation of active faults and associated processes.

The first part of the cruise (Leg 1: 23 April-13 May 2015) was devoted to acoustic seafloor investigation (i.e. micro-bathymetry, sub-bottom profiler) to search for surface ruptures and on-fault / near-fault co-seismic seafloor deformation using the AUVs "AsterX" and "IdefX" (IFREMER, France) (Fig. 1) obtained in the frame of an OFEG exchange. The second part of the cruise (Leg 2: 16 May to 22 May), was focused to a direct visual seafloor exploration and sampling of selected sites (i.e. scarps related to earthquake ruptures, fluid venting and associated habitats) using the ROV "Max Rover" (HCMR, Greece) (Fig. 2) in the frame of the IRIS project granted within EuroFleets-2.

II. OBJECTIVES

The main objective of the SHAKE project was the in situ characterization of the following fault systems: the Carboneras Fault, North-South Faults, Djibouti Fault, Al-Idrissi Fault and Yusuf Fault [1, 2]. Additional surveys were dedicated to spe-

cific studies on seamounts, such as Cabliers Bank [3], to investigate deep-sea habitats associated to the active structures. To achieve such a high-degree of resolution we used cutting-edge techniques that allow a cm-resolution in surface mapping and profiling, and high-resolution video imaging.

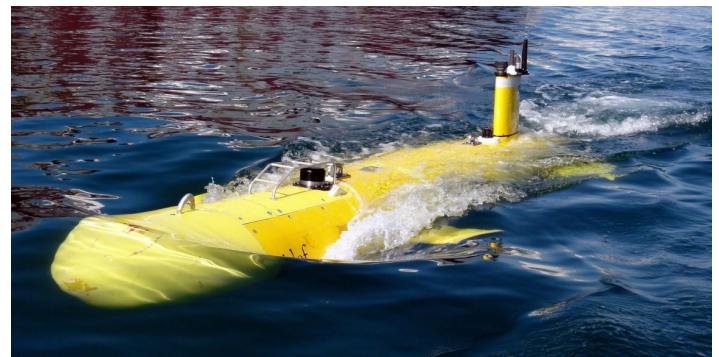


Fig 1. AUV IdefX (IFREMER, France) navigating at sea surface.

The specific objectives were threefold: 1) Obtaining fault offsets using the AUVs AsterX and IdefX. The goal is to carry out a fault-scarp profiling and surface mapping of co-seismic scarps and seafloor ruptures associated to recent earthquakes; 2) Identification and dating of earthquake seafloor ruptures using the ROV Max Rover. The aim is to identify recent earthquake ruptures associated to the active faults, and to obtain single event co-seismic slip; and 3) Evaluation of fluid circulation and characterization of associated benthic habitats. Using the AUV and ROV we also investigated the occurrence of fluid flow escape processes and associated habitats.

III. METHODS

The following methodologies were used during the SHAKE cruise:

a) Autonomous underwater vehicles (AUVs) survey: The AsterX and IdefX (Fig. 1) AUVs missions were devoted to study the seabed and water column with multiple objectives through various payloads: Multibeam echosounder (2 EM2040 Kongsberg Maritime), Sediment Sub-bottom profiler (Echoes 10000 Ixe), CTD (Seabird SBE49) and current profiler (ADCP300k and 1200k). The payload capacity of the AUVs is characterized by a weight in water of 100 kg and a maximum power consumption of 500 W for 8 hours. The vehicle needs a minimum speed to manoeuvre (1 to 4 knots). The system has on board control and navigation system and includes means for mission implementation composed by the Caliste deployment and recovery cage, rigging, battery chargers, transport and maintenance support and on board equipment installation.

b) Remote operated vehicle (ROV) survey: Max-Rover is an underwater, remote-controlled system to perform high-quality optical imaging, with a maximum operating depth of 2000 m (Fig. 2). It has 6 electric motors x 2.0 hp for a resulting underwater speed of approximately 2.5 knots. Average transect speed on the seabed would be approximately 800 m/hour. The ROV has several cameras, with a main HDTV full frame colour camera with zoom lens. Lights are 2 x 100 W HID and 4 x 150 W Quartz. The manipulators are 2 Hydrolek electro-hydraulic 5 function manipulators. Main sensors are pressure depth-meter, altimeter and digital compass. The positioning system is a Linkquest Tracklink USBL, georeferenced through Max-Sea software.

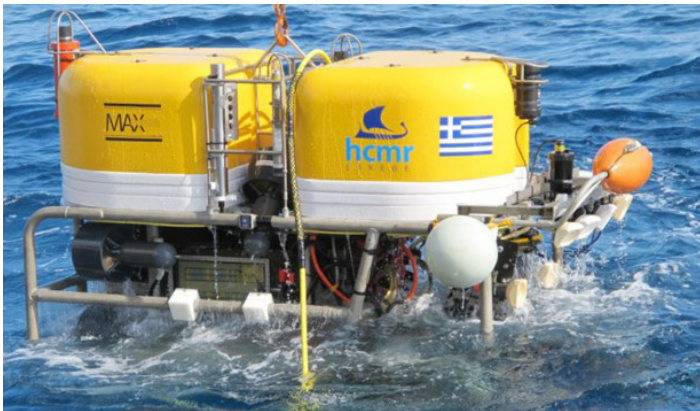


Fig 2. Recovering the ROV Max Rover (HCMR, Greece).

c) High-resolution Sparker seismic survey: We used Geo-Spark 16 kJ (Geo-Marine Survey Systems) pulse power supply that allows survey from 2 to 2500 m depth, with a vertical penetration < 750 m and vertical resolution < 30 cm. The streamer was a Geo-Sense 250 m long, 48 channels separated 3.125 m. Seismic signals were recorded by the Geo-Suite software.

d) Underway geophysical survey: During transits and simultaneously to seismics, we used the ATLAS Hydrosweep DS multibeam echosounder (14.5 to 16 kHz) and the Parasound P35 narrowbeam parametric sub-bottom profiler. It uses a primary frequency of 18-39 kHz, and a secondary frequency of 0.5 to 6 kHz, yielding a theoretical maximum bottom penetration of > 150 m.

e) Sediment sampling: A 3 m and 5 m long gravity corer was used to collect sediment samples in selected sites.

IV. RESULTS

During the SHAKE cruise a total of 26 AUV dives and 10 ROV dives were done, and 34 high-resolution MCS Sparker profiles, 23 gravity cores, swath-bathymetry and sub-bottom profiler data were acquired (Fig. 3)

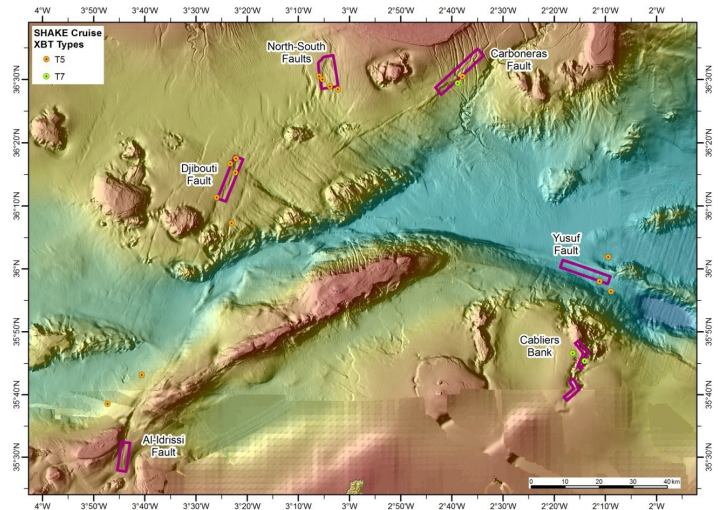


Fig 3. Map of the Alboran Sea with the location of the AUV dives and XBT probes.

In Leg 1, a total of 26 AUV dives were acquired along and across the main faults and prominent structures and basins of the Alboran Sea. The new high-resolution bathymetry covers 222 km² and the high-resolution sub-bottom profiles totalize 77.5 km of new data acquired across different active faults as well as the Cabliers Bank.

During Leg 2 ("IRIS"), despite serious problems with the ROV positioning and navigation at the start of the leg, we have been able to perform direct visual seafloor exploration and sampling of selected sites. A total of 10 ROV dives were done and 34 high-resolution MCS Sparker profiles (274 km of new seismic data), bathymetry, parametric echosounder and ADCP data, and gravity cores were acquired along and across the main faults and prominent structures and basins of the Alboran Sea. Outstanding results were obtained at the shallowest sites of the Cabliers Bank.

V. CONCLUSIONS

In conclusion, we have obtained ultra-high resolution mapping and profiling of the main active strike-slip and normal faults of the Alboran Sea (Carboneras, N-S, Djibouti, Al-Idrissi and Yusuf) and Cabliers Bank (Fig. 3). We have also explored numerous circular seafloor depressions related to gas escapes, referred to as "pockmarks", and discovered, imaged and sampled a deep sea coral site with great detail. With no doubt, we can affirm that SHAKE has been a marine paleoseismology expedition with no precedents.

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ID23- AUTOMATIC FISH COUNTING FROM UNDERWATER VIDEO IMAGES: PERFORMANCE ESTIMATION AND EVALUATION

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Abstract – Cabled observatories offer new opportunities to monitor species abundances at frequencies and durations never attained before. When nodes bear cameras, these may be transformed into the first sensor capable of quantifying biological activities at individual, populational, species, and community levels, if automation image processing can be sufficiently implemented. Here, we developed a binary classifier for the fish automated recognition based on Genetic Programming tested on the images provided by OBSEA EMSO testing site platform located at 20 m of depth off Vilanova i la Gertrú (Spain). The performance evaluation of the automatic classifier resulted in a 78% of accuracy compared with the manual counting. Considering the huge dimension of data provided by cabled observatories and the difficulty of manual processing, we consider this result highly promising also in view of future implementation of the methodology to increase the accuracy.

Keywords –Cabled observatories; manual fish counts; automated fish counts; pattern recognition

I. INTRODUCTION

Persistent climatic or human-induced environmental changes can produce long-lasting modifications in species behavior, with pervasive effects on population distributions and abundances [1]. These effects can be particularly apparent in fish, due to their high mobility, which can allow entire populations to respond rapidly to environmental changes [2].

Tracking these changes at the fine temporal scale is today a need of community studies, with clear implications for fisheries and, in a broader sense, for ecosystem management. Yet, the cabled seafloor video-observatory technology offers new opportunities to monitor species abundances at frequencies and durations never attained before [3]. The largest existing networks, are to date the European Multidisciplinary Seafloor and water column Observations unit (EMSO; www.emso-eu.org), the Ocean Network Canada unit (ONC; www.oceannetworks.ca/), and the Japanese Dense Oceanfloor Network System for Earthquakes and Tsunamis (DONET; <http://www.jamstec.go.jp/donet/e/>). When nodes bear cameras, video-counted individuals can be used as indicator of population rhythms and then related to surrounding habitat conditioning in terms of cause-effect principles, by measuring at the same time different oceanographic, chemical, and geologic parameters.

Video cameras may be transformed into the first sensor capable of quantifying biological activities at individual, populational, species, and community levels, if automation image processing can be sufficiently implemented [4,5]. A consolidated scientific literature exist in computer vision and pattern recognition [6,7] and rapid progresses have been made in implementing automatic counting and classification. These technological advances, combined with the continuous improvement of the hardware performances provide a valid support for investigating the big amount of data provided by the cabled observatories and for understanding the complex dynamics of the underwater ecosystems;

Actually, within the Pattern Recognition literature, very few journal papers propose methodologies for recognizing fishes, and all of them are based on small datasets where the images of the fishes are really easy to be processed (e.g. no turbidity, no fouling, shape and texture of the fishes are clearly visible, etc.). Conversely, there are abundant conference-papers proposing different Martech 2016. recognition approaches, but also with very simple data sets (few images processed, few days analysed, single species approach, etc.).

Here, we studied and developed a binary classifier for the fish automated recognition based on a Genetic Programming supervised machine learning approach. The classifier has been trained on the images acquired by the OBSEA EMSO testing site platform (www.obsea.es) located at 20 m of depth off Vilanova i la Gertrú (Spain).

The high variability of environmental conditions in coastal

environments, especially related to turbidity, hydrodynamics, light and fouling, makes it challenging the study of the habitats and actually automatic counting has been never tested in these variable environments. Moreover the Marine Strategy Framework directive (MSFD, 2008/56/EC) through the technical guidance for monitoring (JCR 2014, Report EUR 26499 EN) identified in high-definition cameras promising approaches for biodiversity monitoring (Descriptor 1), which could have implications also for other descriptors, such as 2 (alien species), 3 (commercially exploited fish and shellfish) and 10 (marine litter). Thus the implementation of an automation protocol could have several important consequences for monitoring programs at a European or ider scale. Within this context, the aims of this work are to:1) estimate and compare the performance of the method here tested by contrasting automatic vs. manually-recorded data; 2) to assess the performance of this methods in different environmental conditions/constrains (i.e., clean vs. turbid water; clean vs. dirty camera, daytime vs. nighttime)

II. MATERIALS AND METHODS

The Observatory of the Sea (OBSEA) is represents one of the few coastal multi-parametric observatories currently active. OBSEA was launched in 2009 off the Catalan Coast in Spain (western Mediterranean: 41°10'54.87" N and 1°45'8.43" E) and deployed at a depth of 20 m within a marine reserve (Colls Miralpeix Marine Reserve) for details on the platform, instruments and sensors see [4].

A time-series consisting of about 12,900 images, collected every 30 minutes by the OBSEA observatory in the 2012, has been visually inspected by expert biologists in order to estimate the number of fishes captured by the images. The camera was oriented in front of an artificial reef, composed by concrete blocks. Additionally, the formation of fouling on the camera protecting dome preventing from the acquisition of good images.

The data resulted from the visual inspection of the OBSEA time-series has been used as training and validation set for learning an automatic image classifier capable to automatically recognise the fishes present in the images;

Every image has been processed in order to extract the image-features used by the automatic image classifier to discriminate fishes from other floating objects and from the seabed and from the fouling.

In order to extract the image-features, a pre-processing step is needed to identify the the image Region of Interest (Rol) potentially containing fishes. Histogram adjustment based on the Contrast Limited Adaptive Histogram Equalization (CLAHE) algorithm [8] is performed, for improving contrast between background and foreground items. The foreground is then segmented from the background using an adaptive thresholding. The foreground binary map is post-processed by opening/closing morphology operators to remove small dots and fill small gaps. Edge detection is performed with a filtering process based on the Sobel operator [9]. The segmentation process is tuned in order to maximize the probability to identify the Rols potentially containing fishes, allowing for an unavoidable incidence of false alarms.

The image-features extracted form the Rols belong to two groups: geometrical, based on the shape of the blob; textural, based on the grey levels distribution inside (and outside) the Rol. The geometrical features are: length of the minor semiaxis (sAxm), bounding box minor dimension (axm), bounding box major dimension (axM), eccentricity related to the semiaxis ratio (ecc). Other geometrical features, are the Rol solidity defined as the area ratio between the Rol and its convex hull (sol), area (areap), perimeter (per), radius histogram shape index defined as the ratio between the standard deviation and the mean value of the boundary (hstl), entropy (ent). The textural features, are: exterior-interior contrast defined as absolute difference between the averaged grey levels inside/outside the Rol (ctrs), grays level standard deviation (stdg1), contrast index defined as the ratio between standard deviation and mean of the grey levels (stdg), gray levels entropy (entg).

The machine learning methodology used in this work is based on Genetic Pro-

gramming (GP).

GP is an evolutionary computation methodology capable of learning how to accomplish a given task. GP generates the task solutions starting from an initial population of randomly generated functions, based on a set of mathematical primitives, constants and variables. The initial solutions are improved by miming the selection processes that occur naturally in biological systems through the Selection, Crossover and Mutation genetic operators [10]. In the proposed work, the set of mathematical operators S is used to generate binary classifiers expressed as mathematical functions, whose variables correspond to the image-features discussed above. Details on this method can be found in [11]. The training experiments have been performed within a Kfold cross-validation (CV) framework [12] in order to estimate the generalization performance of the automatic image classifier.

III. RESULTS AND DISCUSSION

The image classifier has been trained on 700 randomly sampled images, corresponding to the 5.4% of all the images acquired in 2012. The remaining 11600 images have been used for testing the learnt classifier.

The training and validation performance of the image classifier have been estimated by computing the average and standard deviation of Accuracy:

$ACC = (TP + TN) / (TP + FN + FP + TN)$, the True

Positive Rate $TPR = TP / (TP + FN)$ and False Positive

Rate $FPR = FP / (FP + TN)$, where TP, FP and TN

represent True Positive, False Positive and True Negative recognitions respectively (Table 1).

	Mean	SD
ACC	0.78	0.02
TPR	0.62	0.08
FPR	0.13	0.04

Table 1. Mean and standard deviations (SD) of performance indicators. ACC=accuracy; TPR= true positive rate; FPR= false positive rate.

If we train the classifier to capture fishes that vanish into the background, we increase the risk to mistake the fouling as fishes (false positives), while if the camera is clean some false positives occur, without affecting the performance. Generally the classifier was effective in fish identification in reduced fouling conditions (Figure 1).



Fig 1. An example of image captured with the camera without fouling

If the scene is crowded the classifier identifies group of fishes as they were just one fish (Figure 2). That is why in the time series corresponding to crowded periods, the number of recognized fishes is smaller than the number of observed fishes. Nevertheless the trend of the fishes is still coherent.



Fig 2. An example of an image inaccurate identification by the classifier of a group of fish as one fish.

Overall, the performance evaluation of the automatic classifier resulted in a 78% of accuracy compared with the manual counting (Figure 3).

IV. CONCLUSIONS

The OBSEA time-series are very relevant because only few observatories in the Mediterranean Sea provide so much information (AcquaAlta, <http://www.ismar.cnr.it/infrastructures/piattaforma-acquaalta/>) and because the acquisition conditions are highly variable and make these time-series a real dataset and not a toy example, as in similar works using this methodology.

The automatic recognition of fishes provides good results especially when fouling on the camera is limited, while improvements are needed in order to reduce the false positives caused by fouling and for managing large school of fishes that make the scene crowded. The classifier learnt from the images acquired in 2012 will be also validated on the images acquired from 2013 to 2016. Finally, the methodology proposed in this work for learning the automatic classifier will be also applied on the image timeseries acquired by other observatories (e.g. the Acqua Alta platform).

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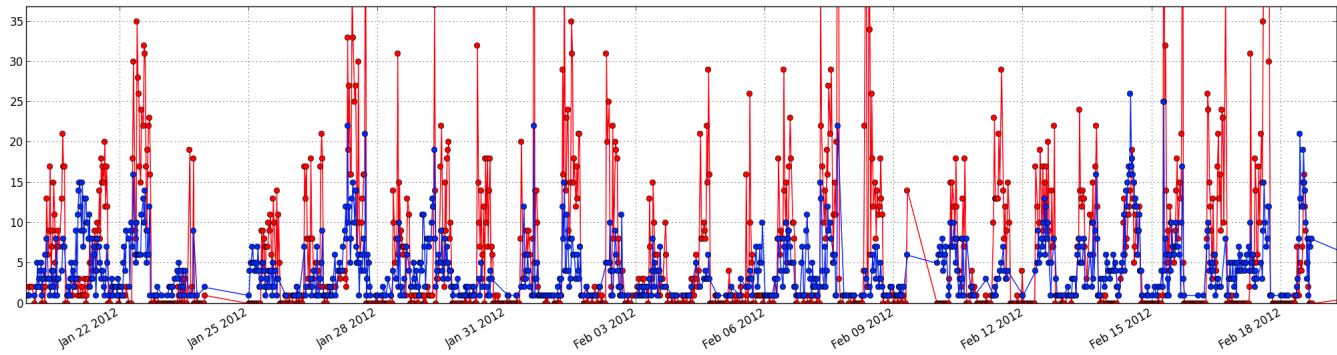
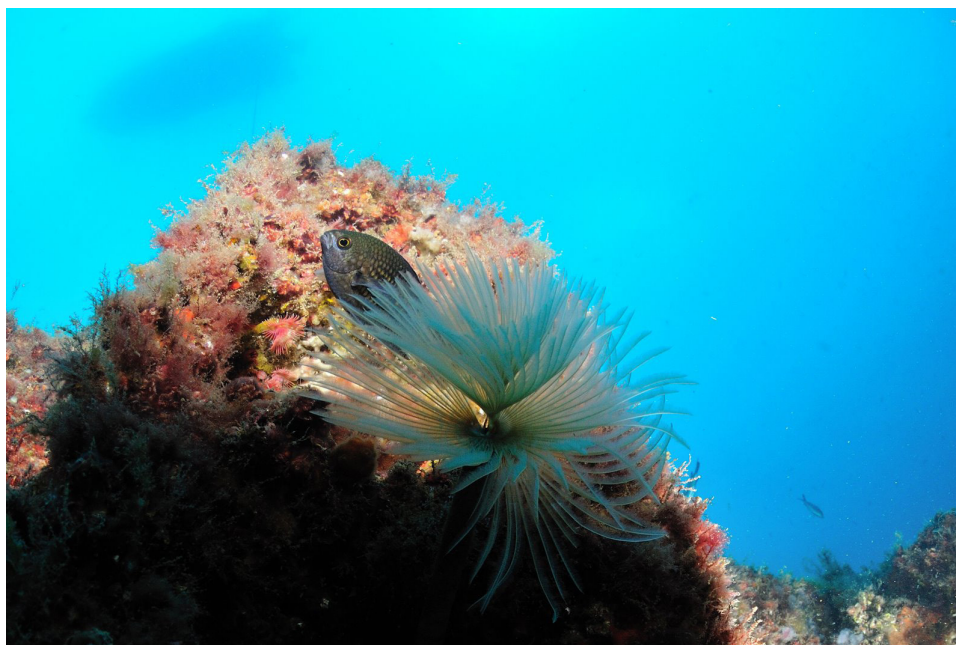


Fig 4. a) Bathymetry generated from the multibeam data gathered by Sparus II data while navigating



ID24- AUV/ASC COOPERATIVE SURVEY

NARCÍS PALOMERAS²⁰³, NATALIA HURTÓS²⁰⁴, MARC CARRERAS²⁰²

Abstract – In this paper we describe a solution to perform autonomous surveys taking advantage of a cooperative multivehicle setup. In the proposed configuration, an ASC provides –through an USBL– absolute positioning and communications to an AUV. Thus, by following the AUV with the surface vehicle we facilitate the reception of USBL measurements in the AUV regardless of the extent of the mission. This turns into an improved navigation on the AUV's side, with the drift bounded thanks to the absolute measurements. Experimental results show that the proposed algorithm is able to maintain the ASC at a close distance and improve the navigation of the AUV. Moreover, the bathymetric maps built from the AUV data are consistent enough to enable the automatic detection of present targets and program further localized missions in the area.

Keywords – cooperative navigation, autonomous survey, multiple vehicles, localization.

I. INTRODUCTION

The Spanish funded project MERBOTS [1] aims to push forward the development of underwater intervention systems. To that end, it involves the use of multi-robot cooperation and multimodal perception systems in the context of archaeological missions. The project divides underwater interventions in two main stages. The first stage is implemented with an autonomous underwater vehicle (AUV) equipped with acoustic and optical sensors and an autonomous surface craft (ASC) whose goal is to localize the AUV acoustically and enable its communication with a remote base. This configuration is used to produce an acoustic map on which a set of targets can be automatically detected and then, generate and execute a second survey, at a closer range using optical sensors. The second stage consists in the actual intervention operation, which is carried out by a hybrid remotely operated vehicle (H-ROV) with an electric manipulator and an AUV equipped with cameras that support the HROV operation providing images from an external viewpoint. This paper focuses on the first stage, more specifically, on the cooperative survey where the AUV performs a pre-planned trajectory underwater while the ASC is following it at surface.

Standard navigation sensors for underwater vehicles include Doppler velocity log (DVL) to measure linear velocities, attitude heading reference system (AHRS) to measure orientations and angular velocities and pressure sensors to measure depth. The lack of absolute measurements to estimate the AUV north-east position causes the vehicle to drift over time. To avoid this problem several techniques can be used: surface the vehicle regularly to obtain GPS updates, install several long baseline (LBL) buoys or use a USBL system are amongst the most popular. While the first one is the most affordable it is clearly the less convenient. The LBL system is expensive and difficult to install. On the other hand, the USBL main drawback is that, in order to obtain accurate measures, the AUV has to navigate inside the cone described by the USBL transceiver, which can become a problem if the survey area is shallow or relatively large. To solve this problem and allow real-time communication between a remote base and the submerged AUV we propose a cooperative AUV/ASC setup. Instead of the typical USBL installation in a buoy, an ASC will be used to follow the AUV without any a priori knowledge of the trajectory to be performed. Section II describes the navigation filter implemented in both the AUV and the ASC. The tracking algorithm executed by the ASC is detailed in Section III. Section IV reports the experiments performed in a harbour environment to test the proposed approach and Section V summarizes the main conclusions.

II. NAVIGATION

Both vehicles use the same extended Kalman filter (EKF) for navigation. The proposed state vector is $x_k=[x, y, z, u, v, w]^T$ where $[x, y, z]$ is the vehicle position (in world coordinates) and $[u, v, w]$ are the linear velocities (with respect to the vehicle's frame). Vehicle orientation is not estimated by the filter, however, it is used as an input in the EKF. The filter uses a constant velocity model and it is able to receive four different measurement updates: velocities $[u, v, w]$, depth $[z]$,

position $[x, y]$ and delayed position $[x, y]$. It is important to differentiate between delayed (USBL) and not delayed (GPS) position updates. While GPS measures are introduced in the filter on-time, the USBL measures are gathered by the ASC through the USBL and sent to the AUV using the acoustic modem thus adding a significant delay (i.e., between 2 to 10 seconds). Therefore, the filter must be able to deal with these delayed positions. Figure 1 shows the measurement updates available in each vehicle. Notice that, although the filter is the same, the updates are significantly different. While the AUV has DVL, GPS, depth sensor, AHRS and USBL updates, the ASC only has GPS and AHRS. However, the revolutions per minute (RPM) that the controller sends to the thrusters are used to estimate its velocity.

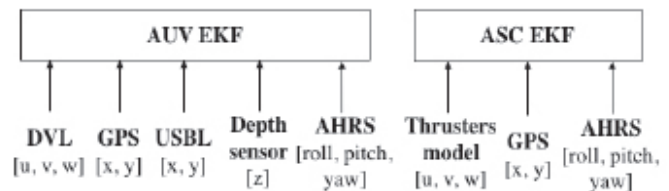


Fig 1. AUV and ASC navigation sensors and EKF

III. ASC TRACKING ALGORITHM

In the proposed cooperative survey scenario, the AUV starts following a pre-defined trajectory at a certain altitude and the ASC must follow it automatically. In order to provide the maximum number of USBL updates to the AUV navigation filter, the ASC must be located as close as possible to the AUV vertical. Besides, due to the limited acoustic modem bandwidth, the tracking algorithm must be able to work with restricted communications between the ASC and the AUV. In view of these requirements, the following procedure has been implemented:

- When the ASC detects the AUV position with the USBL, it navigates towards this position and sends this information to the AUV using the modem.
- Every time that the AUV receives a USBL update it updates its filter and replies the ASC with the current goal position.
- If the ASC receives the goal position where the AUV is navigating to, it computes how to intercept the AUV knowing its own position, the last AUV position obtained with the USBL and the goal position (see Algorithm 1).
- If the AUV is already over the ASC and it knows where the AUV is going it sets the same goal position but in surface.

Algorithm 1 shows how to compute the interception point knowing the AUV and ASC positions, the average velocities of both vehicles and the position where the AUV is navigating to (goal).

```
function intercept(AUV, ASC, goal)
    angle = atan2(goal.x - AUV.x, goal.y - AUV.y)
    v.x = cos(angle)*AUV.surge
    v.y = sin(angle)*AUV.surge
    t.x = AUV.x - ASC.x
    t.y = AUV.y - ASC.y
    a = v.x2 + v.y2 - ASC.surge2
    b = 2*(v.x*t.x + v.y*t.y)
    c = (t.x)2 + (t.y)2
    ti = (-b - sqrt(b2-4*a*c)) or (-b + sqrt(b2+4*a*c))
    return [ASC.x + v.x*ti, ASC.y + v.y*ti]
```

Algorithm 1. Compute interception point

IV. RESULTS

The proposed cooperative survey mission has been tested in Sant Feliu harbour (Spain). The AUV vehicle has been a Sparus II AUV [2] equipped with an Imagenex multibeam sonar, an optical camera and an Evologics modem as well as an AHRS, a DVL, a depth sensor and a GPS to initialize the filter. The ASC role has been played by a Girona 500 AUV [3] equipped only with an AHRS, a GPS and an Evologics USBL.

Sparus II AUV has been commanded to follow a lawnmower trajectory. Figure 2 shows the trajectory performed by both vehicles. It can be seen how not all the USBL measurements are correctly transmitted to the AUV due to modem communication failures. Figure 3, shows the distance between both vehicles over time. Notice that this distance is in average below 5 meters in the north-east plane except between seconds 400-500 where several outlier USBL measurements have moved the ASC incorrectly (position 20, 0 in Fig. 2).

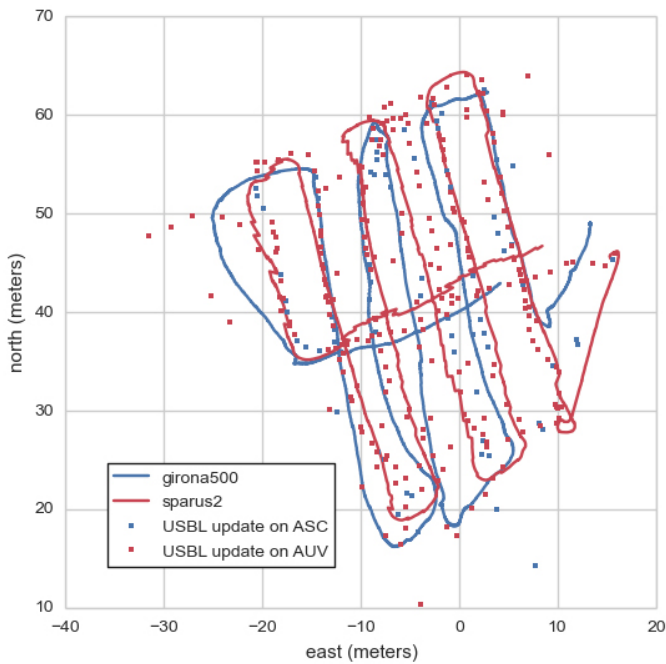


Fig 2. AUV and ASC autonomous trajectories

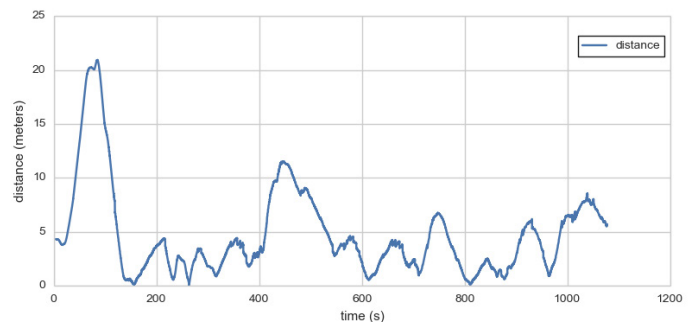


Fig 3. Euclidean distance between AUV and ASC over the whole mission

It is possible to check that, thanks to the USBL updates, the AUV navigation presents almost no drift. We have built the bathymetry of the multibeam data gathered along the lawnmower trajectory (see Fig. 4a) and we can observe how the resulting map is consistent (i.e., the objects that are visible in more than one transect are consistently mapped). Furthermore, we can see how the resulting bathymetry matches almost perfectly a previous bathymetry obtained with an RTK GPS (Fig. 4b).

V. CONCLUSIONS

This paper has presented a cooperative setup in which an ASC provides absolute localization and communications to an AUV while performing an autonomous mission. Using a minimal sensor suite, the AUV has been capable to perform a trajectory keeping its drift bounded. This improvement in the navigation enables the generation of consistent maps and will enable the AUV to accurately revisit detected targets in an automated way. As a future work we are working to filter the USBL data in the interception algorithm to avoid outlier measurements as well as to complete the automatic target detection and inspection.

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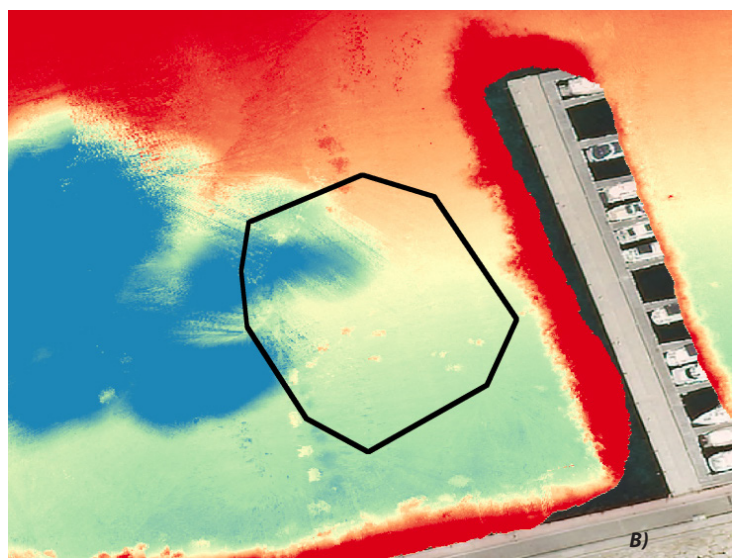
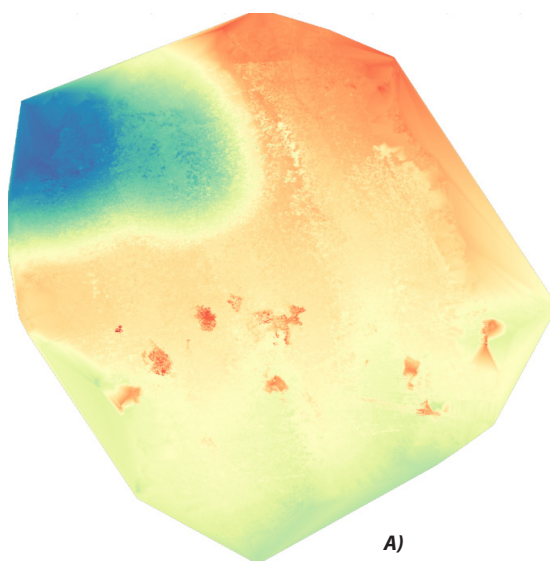


Fig 4. a) Bathymetry generated from the multibeam data gathered by Sparus II data while navigating

ID25- 5 YEAR-LONG MONITORING OF BARKLEY CANYON COLD-SEEPS WITH THE INTERNET OPERATED DEEP-SEA CRAWLER “WALLY”

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Abstract

Despite the technological advances of the last decades (e.g. ROVs, AUVs, cabled observatories), our knowledge of most deep-sea environments is still strongly limited by spatio-temporal sampling and observational capabilities. The novel Internet Operated Deep-Sea Crawler technology can provide high-frequency, multi-sensor data, during long-term deployments, 24/7 communication with researchers and broader spatial coverage (i.e. mobile platform) than fixed instrument installations. The crawler “Wally” is deployed at the Barkley Canyon methane hydrates site (NE Pacific, Canada; ~890 m depth) and connected to the Ocean Networks Canada NEPTUNE cabled observatory network (ONC; www.oceannetworks.ca). Here we present the environmental and biological datasets obtained from Wally instruments and cameras, during the first deployment phase (September 2010 to January 2015), as well as new features and preliminary results obtained since it was re-deployed (May 2016 – present). In addition to data provided by the standard payload of the crawler (i.e. ADCP, CTD, methane sensor, turbidity sensor and fluorometer), the hydrates community was video-monitored at different frequencies and timespans. Photomosaics were generated at two distinct locations, in order to map chemosynthetic bacterial mats and vesicomyid clam

colonies covering the ~2-3 m high hydrate mounds, and document their temporal dynamics. The crawler followed the development of a deep-sea shell taphonomic experiment aiming to quantify biogenic carbon fluxes at the hydrates environment. The composition and diel activity patterns of the hydrates megafaunal community were studied with the use of linear video-transects conducted from February 2013 to April 2014. Since the summer of 2016, video-frames recorded at different locations of the site are analyzed for a biodiversity study and photomosaicing of the hydrate mounds continues, with 3D modelling of the mound structures also available as a new feature of the crawler deployed in May 2016. All data are archived in real-time and can be accessed online on the Ocean Networks Canada database. As deep-sea crawler technology and similar mobile, benthic platform technologies progress towards full operational autonomy, they will provide an even greater capacity for future monitoring and understanding of dynamic, extreme environments such as methane hydrate fields.

Keywords: Internet Operated Deep-Sea Crawler Wally, Ocean Networks Canada, Barkley Canyon hydrates, Multi-sensor data, Video-monitoring



ID26- VIDEO MONITORING OF SPARIDAE TEMPORAL RHYTHMS: THREE-YEAR STUDY BY OBSEA CABLED OBSERVATORY

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Abstract - The abundance and composition of fish assemblages varies at different temporal scales as a product of diel and annual rhythms. In this study, we used a video-wired observatory (OBSEA, www.obsea.es) to monitor annual rhythms in a coastal fish assemblage with a 3-year data set (2012-2014). The photographs were acquired at 30 min frequency. Five species of the family Sparidae were studied (i.e. *Dentex dentex*, *Diplodus sargus*, *Diplodus vulgaris*, *Diplodus annularis* and *Diplodus puntazzo*) together with water temperature and daylength. The results of the annual rhythmicity analysis indicated that most of the peaks of abundance occurred in the autumn months. Results suggest differentially temporal use of the reproductive or trophic niche.

Keywords: OBSEA, cabled observatory, long-term monitoring, annual rhythms, temporal niche, Sparidae.

INTRODUCTION

The abundance and composition of fish assemblages varies at different temporal scales as a product of diel (i.e. 24-h based) and annual rhythms. In this context, the development of a suitable technology for the continuous and long-term monitoring in situ, allows grasping those changes otherwise impossible to describe with other types of sampling [1]. Fishes can be considered good biological indicators because they modify their behavior and physiology within certain ranges of temperature [2]. Furthermore, fishes are mostly visual feeders and light thresholds also play a paramount role in controlling seasonal changes in behavior [3]. Here, we used a video-wired coastal observatory (OBSEA, www.obsea.es) to monitor annual rhythms in a coastal fish assemblage in the vicinity of an artificial reef with a 3-year data set (2012-2014).

MATERIALS AND METHODS

Photographs were acquired at 30 min frequency over a constant field of view [4]. Two important environmental factors were also measured: water temperature and daylength. During the night hours, two spotlights were used to illuminate the area for few seconds only during image acquisition to avoid constant light contamination.

The photographs were manually processed to determine the number of fish individuals at species level. Then, we defined "abundance" as the total number of counted individuals divided by the number of photographs used for the counting. This type of normalization is needed because the number of the photographs available was variable.

Five model species (representing the family Sparidae) were chosen given their abundance and phylogenetic proximity: common dentex (*Dentex dentex*), white seabream (*Diplodus sargus*), common two-banded seabream (*Diplodus vulgaris*), sharpsnout seabream (*Diplodus puntazzo*), and the annular seabream (*Diplodus annularis*). We calculated the total monthly abundance for each species (36 time points), while the environmental factors were averaged at a monthly basis.

The rhythmicity of the time series has been studied with a non-parametric analysis using the computational language R (www.r-project.org) through one of its add-on packages: Rain (Rhythmicity Analysis Incorporating Non-Parametric Methods) [5].

RESULTS

The number of pictures taken was 52609, while the actual number of used photos is 40989 (78%). The total abundance of the selected species during were: *D. dentex* (1359); *D. sargus* (11420); *D. vulgaris* (89767); *D. puntazzo* (997); *D. annularis* (20577). These 5 species together represent 58% of the counts recorded in the dataset. The results of the annual rhythmicity analysis indicated that most of the peaks of abundance occurred in the autumn months (Fig. 1, Table 1). *Dentex dentex* showed a significant ($p < 0.001$) annual rhythmicity and a peak of abundance in August (8). The abundances of *Diplodus sargus*, *D.*

	<i>p</i> value	Phase	Period
<i>D. dentex</i>	< 0.001	Aug	12
<i>D. sargus</i>	< 0.001	Oct	12
<i>D. vulgaris</i>	< 0.001	Oct	12
<i>D. annularis</i>	< 0.001	Dec	12
<i>D. puntazzo</i>	0.766	-	-
Temperature	< 0.001	Aug	12
DayLength	< 0.001	Jun	12

Table 1. The results of the statistical test (rain) on time series of species and environmental variables. The *p* value is reported together with the peak (indicating by the month) and period of the oscillation.

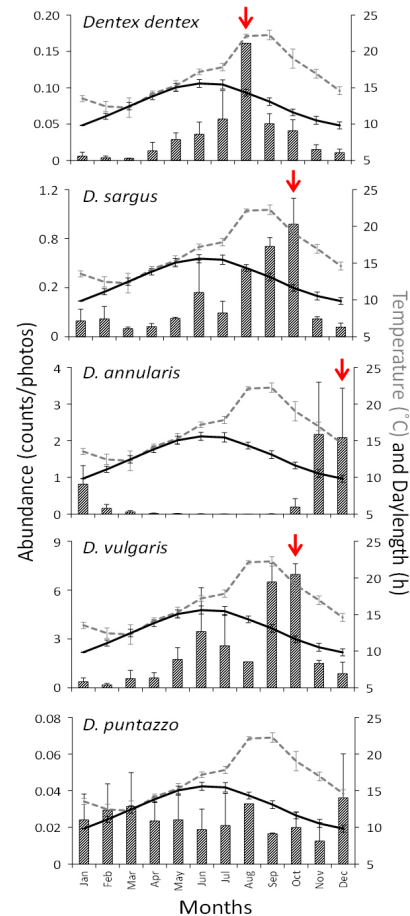


Fig. 1 The figure shows the trend of abundance of the species compared to the performance of the two environmental variables: temperature and daylength. The bars represent the monthly abundance of the selected five species. The grey dashed line represents the average monthly water temperature. The dark continuous line represents the daylength. Arrows indicate the significant peak (see Table 1)..

vulgaris and *D. annularis* indicated a significant ($p < 0.001$) annual rhythmicity but with a peak respectively in October the former two and in December the latter. Differently, the abundance of *D. puntazzo* did not show significant ($p = 0.766$) rhythmicity. Finally, as expected, the temperature of water and daylength showed a significant ($p < 0.001$) annual oscillation with a peak in the month of August and June, respectively.

DISCUSSION

The three-years data set showed to be promising to detect temporal rhythms of fishes at the annual scale. In the next future, the analysis will be implemented at the daily basis and statistical modelling (GAMLLS; [6]) will be used to describe the correlations of fish abundance with other environmental parameters. Results are promising to reveal novel feature on the temporal use of ecological niche of Sparidae. In fact, preliminary interpretation suggests that the family evolved differentially annual pattern in the use of the niche, probably related to reproductive or feeding constrains.

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MARTECH18

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ID27-TECHNOLOGICAL AND INFRASTRUCTURE COLLABORATIVE SEISMIC RESEARCH IN WESTERN MEXICO

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Abstract – In February and March 2014, Spanish, Mexican and British scientists and technicians explored the western margin of Mexico, a region with a high occurrence of large earthquakes ($M_w > 7.5$) and tsunami generation, on board the British Royal Research Ship James Cook. This successful joint cruise, named TSUJAL, was made possible thanks to a cooperative agreement between NERC and CSIC as part of the Ocean Facilities Exchange Group (OFEG), a major forum of European oceanographic institutions for the exchange of ship time, equipment and personnel. A dense geophysical data set was acquired using for the first time 6 km length seismic streamer facilities from Spain's Consejo Superior de Investigaciones Científicas (CSIC), usually operating in the Spanish RV Sarmiento de Gamboa, onboard the British RRS James Cook by solving all mechanical, electrical and electronic problems. The RRS James Cook in turn provides the seismic source and the acoustic, hullmounted echosounder operated by the British Natural Environment Research Council (NERC). Multiscale seismic and echosounder images unravel the subduction geometry, nature of the crust, and evidence faults and mass wasting processes. The data are crucial to estimating fault seismic parameters, and these parameters are critical to carrying out seismic hazard in Mexico, especially when considering large-magnitude earthquakes ($M_w 8.0$), and to constrain tsunami models.

Keywords – Seismic and tsunami hazards, Collaborative research, OFEG, multichannel seismic, Rivera Plate, technology, Mexico

I. INTRODUCTION

The Rivera plate is particularly a region where large earthquakes have occurred with very destructive consequences, including the generation of big tsunamis, e.g. the $M_w > 8.0$ 1932 and 1995, demonstrating that the Jalisco Block is a zone of high seismic potential as a consequence of the subduction dynamics. Research in subduction zones includes several geophysical techniques such as multichannel reflection seismic and high resolution bathymetry. To understand the processes involved in the subduction of the Rivera Plate and to solve the lack of seismic imaging and bathymetry information in the area, a multidisciplinary geophysical approach has been performed to characterize the area from the surface, to the deep zones. These data, of unprecedented quality, were recently acquired in the framework of the TSUJAL (TSU-nami and JAL-isco) project [1,2]. The unprecedented quality of the data provides a brand new seismic image of the internal structure of the Rivera Subduction Zone beneath the North American plate from which the geodynamic context can be inferred. Furthermore, the characteristics of the interaction between the Jalisco Block and the sediments thickness of the trench clearly indicate the probability of the occurrence of large earthquake. This information will be of paramount importance for future seismic hazard assessment.

II. EARTHQUAKE HISTORY OF THE JALISCO REGION

The macroseismic history of the Jalisco region dates back to the year 1544. In the last 120 years, 10 major earthquakes were reported with magnitude of $M_s \geq 7.5$, including those occurring on June 3 and 18, 1932 in Jalisco with $M_s = 8.2$ and 7.8, respectively, and having maximum tsunami run-up height of 3 m, causing 400 casualties. The recurrence time estimated for earthquakes similar to the 1932 event on the coast of Jalisco is 77 years. Considering that the earthquake of 1995 was generated with the rupture of only the southern half of the rupture area in 1932, the likelihood of an event occurring similar to 1995 is very high in the northern coast of Jalisco. This means an area of high potential seismic hazard, also known as the Vallarta Gap, which includes Bahía de Banderas, where the tourist city of Puerto Vallarta is located

III. OFEG: EUROPEAN MARINE ALLIANCE

The TSUJAL project was originally scheduled to use the Spanish RV Sarmiento de Gamboa, which was 6,000 naut. mi. from the work site. It was rescheduled to

use the English ship RSS James Cook instead, already conveniently located in the Caribbean Sea. The data gathering was successfully accomplished between February 17 and March 19, 2014, led by Dr. Rafael Bartolome (CSIC) under a barter agreement between NERC and CSIC.

This project was conducted under the auspices of OFEG, a forum of Europe's leading oceanographic research organizations for a global- and ocean-class research fleet aiming to maximize overall scientific output using state-of-the-art marine facilities in support of the European oceanographic community. The main aim of OFEG is to reduce the operating costs of marine vessels, maintaining or even improving the quality of scientific work in ocean matters, giving scientists the opportunity to use the most appropriate and advanced oceanographic research equipment. The use of large offshore installations requires a fluid exchange of information on scenarios and geographical areas of work among members, who meet twice a year to plan future exchanges. These include joint cruises, exchange of existing instrumentation and ship time, and exchange of engineers and technicians. No money changes hands, and the arrangements do not provide extra "free" ship time for any country/institution. Members, as per 2014, are: France (Ifremer), Germany (University of Hamburg, GEOMAR and Alfred Wegener Institute), Netherlands (NIOZ), Norway (Institute of Marine Research-IMR), Spain (CSIC), and the U.K. (NERC).

The OFEG fleet includes 21 research vessels from six countries and marine facilities include ROVs, AUVs, submersibles, and large multichannel seismic and mobile compressors. To arrange specific barter, interested marine scientists should contact the representatives in their own country, who will act on behalf of the marine community to negotiate barter as required.

IV. METHODS: A COLLABORATIVE CHALLENGE WELL RESOLVED

The integration of different types of multiscale acoustic and high-resolution data allows detailed mapping of active faults and submarine landslides to assess potential earthquake (and tsunamigenic) hazard and risk by constraining seismic parameters, such as geometry, slip rate, frequency, maximum magnitude, recurrence period, etc. These parameters are critical for assessing seismic hazard models, especially when considering large-magnitude earthquakes, and for constraining tsunami models.

seismic (WA) data between 18° N and $22^\circ 30' \text{ N}$, and $103^\circ 30' \text{ W}$ and $107^\circ 30' \text{ W}$, mainly at the Rivera Plate. The MCS experiment used, for the first time, the 6-km-long digital seismic streamer of the Spanish RV Sarmiento de Gamboa aboard the RSS James Cook, acquiring a total of 1,524 km of deep multichannel seismic data. The resulting 15 MCS profiles show the structure of the Rivera Plate with unprecedented resolution and penetration, from the oceanic domain up to the Continental Shelf.

For MCS data acquisition, we used an airgun array as a seismic source, with a four-airgun string, totaling 12 BOLT guns towed at 8-m depth, recorded with a 5.85 km streamer at 12.5-m group distance (468 channels) towed at 10-m depth. We completed 27,000 airgun shots, one every 50 m. Seismic source ranges from 5800 c.i. to 3540 c.i. depending on the profile. Nine profiles of wide angle seismic have been acquired as well, coincident with MCS data, in order to investigate the structure and nature of the lithosphere. A total of 970 km have been sounded at sea with the help of 16 OBS from the UTM-CSIC pool deployed two times during the survey, and 100 land stations. Wide angle seismic source ranges from 11 to 14 airguns BOLT ranging between 6800-8000 c.i., rich in low frequency, working at 15 m depth and fired every 120 s. Concurrently with the seismic survey, approximately 5,438-km swath bathymetry, acoustic backscatter, subbottom profiler, gravity and magnetics data were collected, providing complementary information of the seafloor morphology, subseafloor deformation and crustal structure. To accurately measure water velocity, one XBT (expendable bathythermograph) per day was launched during the survey, whose values were integrated into the echosounder acquisition program.

V. RESULTS

Processed seismic data obtained during this geophysical survey show images of the Rivera and Cocos Plates crustal structure subducting beneath the North American (NA) Plate, where the active subduction can trigger significant earthquakes and tsunamis. Data illustrate an oceanic domain dominated by subduction-accretion processes along the lower slope of the Jalisco margin (20°N, 106°W) with a subparallel sediment thickness of up to (approx.) 2 km in the Middle American Trench. Further, from these data the region appears to be prone to giant earthquake production. The top of the oceanic crust (intraplate reflector) is very well imaged almost continuous with a gentle dip (<10°); however, it is disrupted by normal faulting resulting from the bending of the plate during subduction [3]. The continental crust presents a welldeveloped accretionary prism consisting of highly deformed sediments with prominent slumping towards the trench that may be the result of past tsunamis (Figure 1)

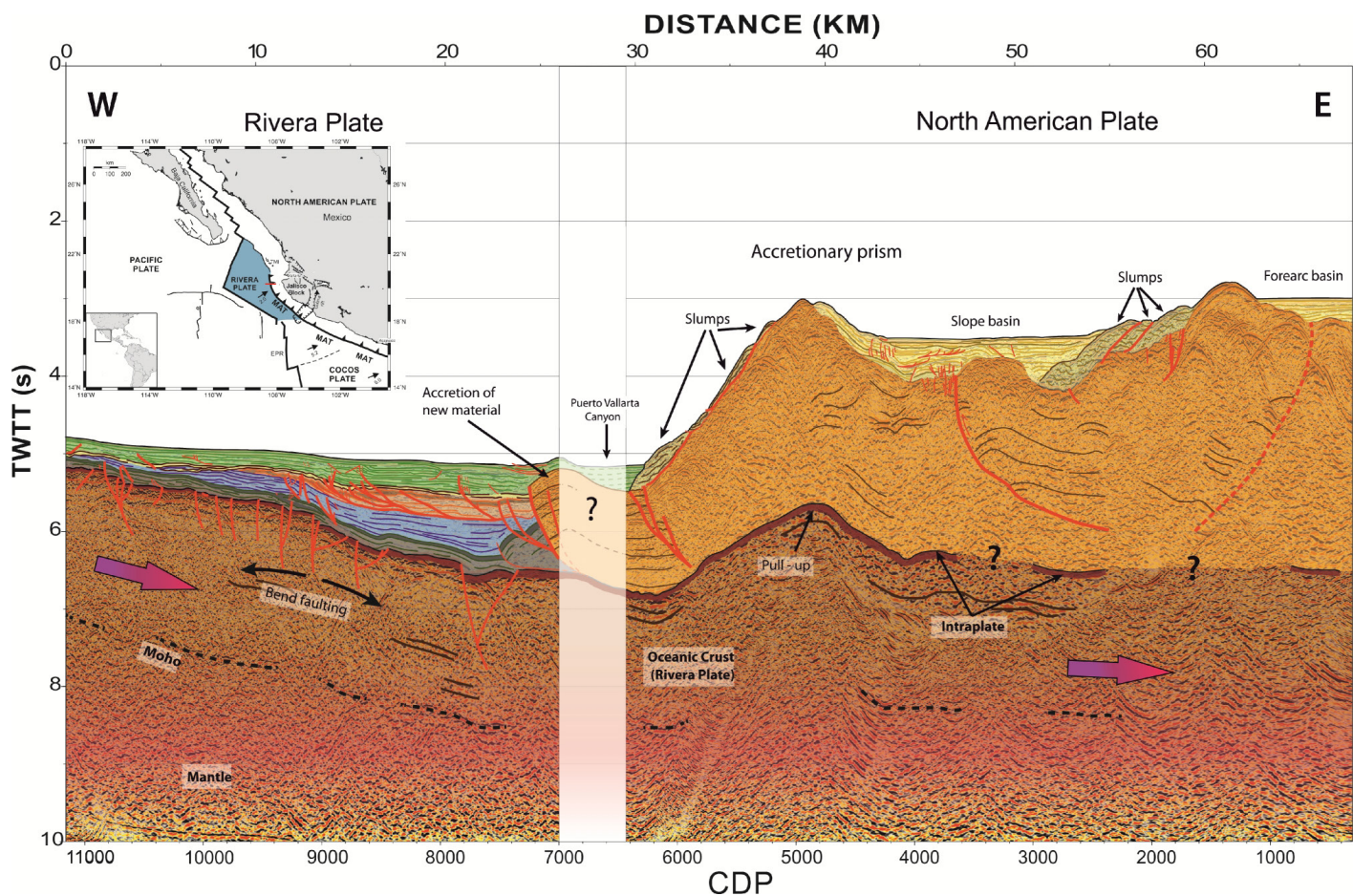
VI. CONCLUSIONS

The TSUJAL project was conducted as a result of the fruitful collaboration between NERC and CSIC, leading to the acquisition of new geophysical data. By using bartering, the geographical location of OFEG ships can be linked to science requirements, thus increasing research efficiency and saving time and money for the whole OFEG fleet. The exchange involves solving a set of technical issues that must be resolved for the perfect equipment integration between infrastructures. This open exchange provides scientists with the opportunity to access larger geographical areas and state-of-the-art equipment, thus improving the quality of science.

Although TSUJAL data processing is ongoing, first MCS processed data defines the structure of the crust in different areas of the Mexican margin. In addition to MCS data, seafloor and subseafloor information from multibeam and parametric echosounder images allow identifying and characterizing mass transport deposits and submarine landslides associated with active faults, emphasizing the ones that can generate earthquakes and tsunamis. Future analysis, modeling and interpretation of seismic data provided by wide-angle data at sea (via 16 OBS) and onshore (via 100 portable seismic stations) will allow resolving the velocity/depth structure and geometry of the Rivera oceanic crust subducting beneath the NA Plate along the active margin of Mexico at various locations.

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ID28- SEABED MONITORING WITH GIRONA 500 AUV WORKING AS HROV

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Abstract – This paper presents the use of Girona 500 AUV as a Hybrid ROV (HROV) to inspect underwater habitats by combining basic teleoperation and automatic way-point following. This duality allows safe movements, when inspecting visually the seabed, together with precise way-point movements, when mapping or reaching the area. Also, the use of a HROV containing its own energy simplifies the management of the umbilical cable, which can be smaller, and integrates all safety measures of an AUV. The Girona 500 AUV has been tested acting as HROV during 3 campaigns at 80 metres depth in a project for evaluating the state of transplanted gorgonians.

Keywords – Autonomous Underwater Vehicle, Hybrid Remotely Operated Vehicle, Seabed Monitoring

I. INTRODUCTION

This paper presents a research collaboration to use the Girona 500 AUV [1] (see Fig. 1) for monitoring transplanted gorgonians in the north of Cap de Creus (Spain) at 85 m depth. In the context of the ShelfReCover project [2], gorgonians were transplanted on three artificial lander structures (see Fig. 1), which were deployed on the continental shelf. The AUV Girona 500 was used during 3 campaigns (July 2015, December 2015 and September 2016) to locate the 3 landers, to acquire images of the gorgonians and to map visually and acoustically the area in which the landers were deployed.

Girona 500 was acting as a Hybrid Remotely Operated Vehicle (HROV), being physically connected to a surface boat with an Ethernet connection, but having its own batteries to power all systems, and its software architecture for controlling the robot. The surface boat was also carrying an USBL positioning system, which estimated the position of the vehicle and sent position updates to it (see Fig.2). The HROV was able to follow the commands from the surface boat while transmitting real-time images. Commands varied from simple teleoperation set-points, to high-level commands such as: keep depth, keep altitude, keep heading, keep position, go to waypoint, execute coverage trajectory. The HROV was also running all basic AUV systems, such as the navigation filter and the safety behaviours to avoid minimum altitude and maximum depth, and to abort the mission and emerge in case of failure, such as a loss of communication due to a cut in the umbilical cable.

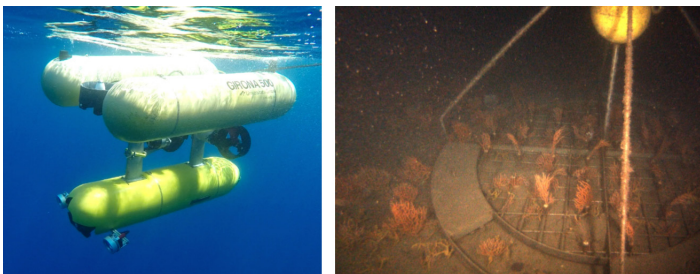


Figure 1. Girona 500 HROV before the seabed monitoring (left). Image of a lander after 6 months of deployment in Cap de Creus at 85 m depth, with transplanted gorgonians next to natural ones (right).



Fig 2. Girona 500 HROV ready for the experiment on top of a 7 meters boat having the USBL positioning system and the electrical winch for the umbilical communications (top). The HROV has a light 30 meter umbilical cable, which allows a free movement of the vehicle, connected to a vertical 200 meter metallic cable which is provided by the winch. The boat maintains its position on top of the HROV by using the estimates of the USBL.

II. RESULTS

The Girona 500 AUV was equipped with a HD stereo camera system, 2 led lights, a scanning imaging sonar, a multibeam profiler and the umbilical cable, together with the standard equipment: USBL positioning and modem, DVL, IMU, pressure sensor, GPS, sound velocity sensor and 5 thrusters (for surge, sway, heave and yaw degrees of freedom). The 230 meters of umbilical were passing a DSL connection encoding the standard Ethernet network of the AUV, from which all the sensors can be monitored and all levels of control can be managed. During the 3 campaigns of the ShelfReCover project, the HROV was manually teleoperated as a ROV, but also automatically guided as an AUV, all the time with the human supervision. This combination allowed an easy search of the 3 landers, by using the imaging sonar, a teleoperated inspection of the gorgonians (see Fig.3), and some automated movements once the environment was known: keeping altitude, heading or position; travelling from point to point; and way-point following for covering the area (see Fig.4).

The Girona 500 AUV allowed the supervision of the transplanted gorgonian in the 3 landers during the 15 months between their release and the third campaign, showing a very good survival rate of the specie (see Fig. 5). The approach was successful and opened the door to future developments to improve the performance of the HROV concept.

Fig 5. Images of the landers at different moments of the project (from top left to down right): releasing day; after 1 month; after 6 months, after 15 months. It can be appreciated the survivancy of the transplanted gorgonian and, also, the evolution of the marine growth.



Fig 3. Images of the 3 landers in the second campaign, in December 2015.

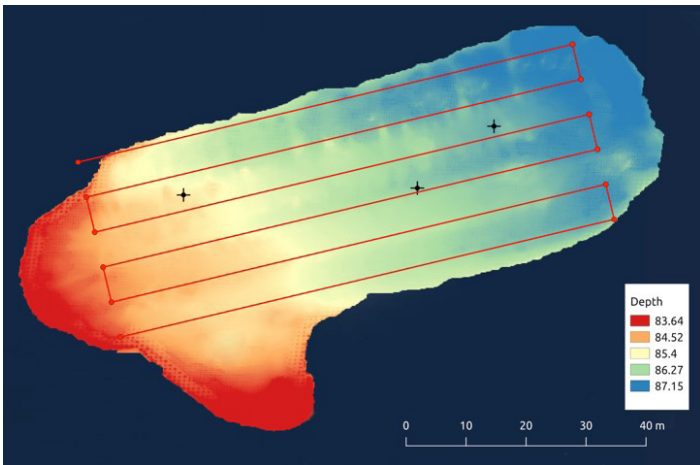


Fig 4. Coverage trajectory for creating the bathymetry of the area including the 3 landers. It can be appreciated the slope of the seabed. Also, the white rectangle shows the point-cloud of one lander (seen laterally) detected by the multibeam.

III. CONCLUSIONS

The three campaigns carried out at more than 80 meters in the waters of Cap de Creus showed the feasibility and advantages of using Girona 500 AUV, a hovering vehicle, as an HROV. Its autonomous behaviours combined with the human supervision and teleoperation, offered a very effective and powerful combination to explore the seabed for scientific purposes. Automatic movements are better when a precise trajectory is desired, while manual movements are better when image interpretation is required.

ACKNOWLEDGEMENTS

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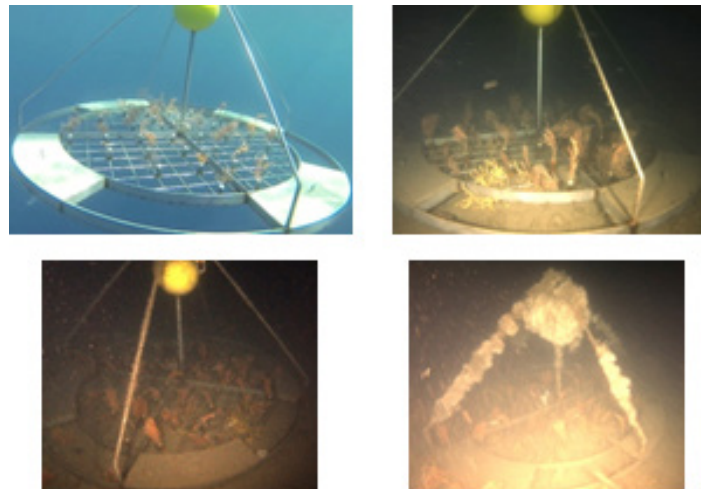


Fig 5. Images of the landers at different moments of the project (from top left to down right): releasing day; after 1 month; after 6 months, after 15 months. It can be appreciated the survivancy of the transplanted gorgonian and, also, the evolution of the marine growth.

ID29- DEVELOPMENT OF A PROTOTYPE FOR SUBMARINE COMMUNICATIONS IN SHALLOW WATERS

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Abstract – The Telecommunications Marine Laboratory (TML) of the University of Cádiz takes part in a research project to study the intertidal sediments of the Bay of Cádiz. The collection of samples from the seabed and the transmission of data to the surface are performed by a Mini Profiler with four channels (MP4), which is supplied by UNISENSE. Each channel processes the samples collected by a single sensor. For power, control, and data transmission, a special wiring that connects the submerged subsystem with the surface subsystem is used. The tension transmitted by the cable to the MP4 structure makes its handling and positioning under water more difficult. This article explains the technological solution developed by the TML to replace some wiring from the MP4. For the prototype, two underwater acoustic modems have been used and an electronic system has been developed based on the Arduino platform, in order to multiplex, digitize, and transmit the data collected by the MP4 sensors, eliminating the need to use wiring. The submerged subsystem has an autonomous power supply by a battery.

Keywords – modem, DAC, ADC, sensor, propagation.

I. INTRODUCTION

The MP4, which is distributed by UNISENSE, consists of two subsystems. One is composed of the elements found on the surface and the other consists of those immersed. The Fig. 1 describes the data flow from the sensors to the computer system.

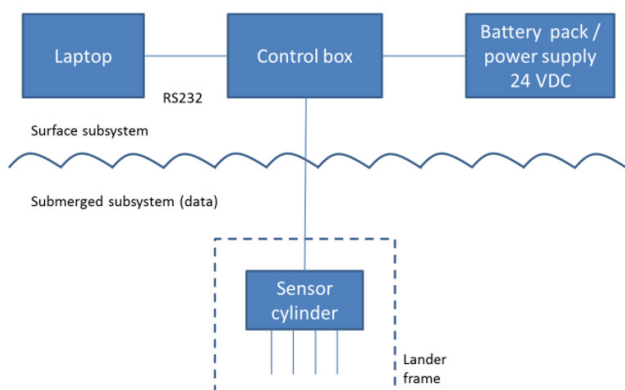


Fig. 1. Block diagram of the Mini Profiler's data subsystem

Currently, the umbilical cable connecting the control box to the cylinder containing the sensors and analog amplifiers supports the transmission of a set of signals. On the one hand, the power down signal (two wires); and on the other hand, the upstream data signals (four wires, one per channel). The data signal generated by a sensor (electrical current or voltage) has a very small value. Due to this fact, it is necessary to amplify said signal before sending it to the surface. The sensor group cylinder container has a channel amplifier that amplifies the signal corresponding to about 60 dB before injecting it into the umbilical cable. The signals from the cylinder are digitized on the surface in the control box by an analog-digital converter (ADC) of 15 bits, and sent to a computer via RS232 for further processing. Two improvements were identified in the MP4 for further operation of the system. Firstly, the elimination of the umbilical cable and, second, the scanning data signal near the source. The TML has made and validated a prototype to assess the technological solution that allows us to obtain the proposed improvements.

II. SYSTEM DESCRIPTION

To implement the aforementioned improvements, it is necessary to consider which part of the surface subsystem in charge of data transmission should be

transferred to the dipped subsystem. In Fig. 2 the chosen solution can be seen, which replaces the umbilical cable by the wireless link between the acoustic modems, and moves the data processing system -made in the box control- and battery to the submerged part.

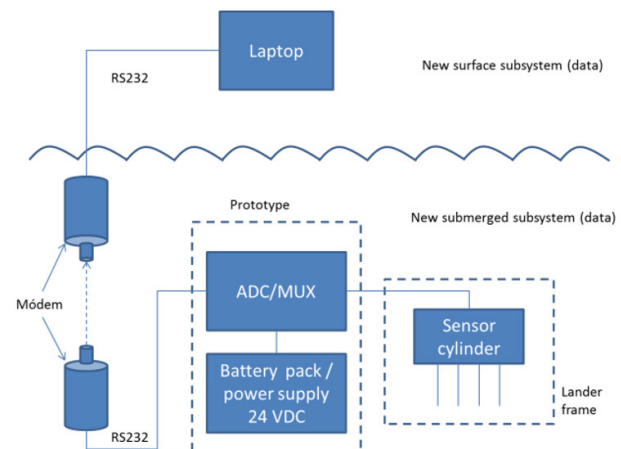


Fig. 2. Block diagram of the modified data subsystem

The new data processing system consists of an ADC per data channel and a multiplexer (MUX) to go from four channels to one. The system connects to the submerged modem via RS232. Data from the sensors are passed through an amplifier before entering each ADC to ensure an appropriate range of input amplitudes. The ARDUINO

UNO platform [1] was selected for the interconnection of all the elements that form the data processor. A set of voltage regulators provides power to the various elements of the submerged subsystem, including modem and cylinder sensors. On the surface, the modem is connected to the computer system via RS232. The received signal is processed by a Python program that performs channel demultiplexing and digital-analog conversion (DAC) of their output signal. Finally, the program transforms the processed data to recover their initial range of values. The program allows for a pre-calibration of each data channel.

II. ADC / MUX DESIGN

To adjust the amplitudes of the output signals of the sensor cylinder, a circuit based on an operational amplifier has been designed. The cylinder contains four sensors with their corresponding signal amplifiers. Each sensor responds with a peak current or voltage whose values are proportional to the measured value (e.g., pH) physicochemical variable. These values are in the range of ± 0.5 mV. The channel amplifier applies a gain of 60 dB to the signal generated by the sensor. Thus, the range of amplitude values of the output signals of the cylinder becomes ± 0.5 V. The ADC used is ADS1115 [2], which is configured for an input

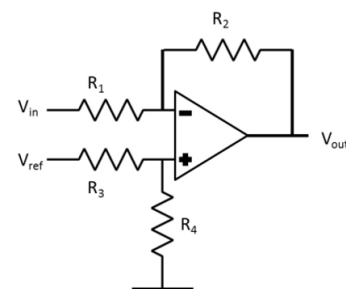


Fig. 3. Amplifier with setting output medium level.

range of 0 to 4.096 V, so it is necessary to insert an amplifier to the input of each channel to adapt the signal levels before the corresponding ADC. The Fig.

$$V_{out} = -V_{in}(R_2/R_1) + V_{ref}(1 + R_2/R_1)/(1 + R_3/R_4) \quad (1)$$

3 illustrates the circuit described.

The resistor values are calculated to have an output range, in each case, included in the input range of the ADC, by (1)

The reference voltage V_{ref} allows focusing the output voltage V_{out} within the range of the ADC. Due to the tolerances of the resistors, the nominal output amplitude range of each amplifier has been reduced, to avoid saturation in the ADCs. Specifically, the calculations are performed following the same method for each amplifier, to achieve an output range of 0.3 to 3.7V. The LM324 [3] circuit, which consists of four operational amplifiers, has been selected for the purpose. The circuit ADS1115 includes four 16-bits ADCs -a sign bit and 15 magnitude bits. With the configuration noted above, it has up to 32 768 quantization levels, which provides a sampling resolution of 125 microvolts. The ADS1115 also provides multiplexing of four data channels, which optimizes the number of system components. The multiplexed data are given to ARDUINO for transmission by the modem. Since the modem has an RS232 connection for data input and output, an interface between ARDUINO and the modem is inserted to adapt the output and input formats of the signals. After several tests, the MAX232 circuit [4] was selected.

III. MODEM AND BATTERY

The modems used for system validation are the S2CR 18/34 model by EVO LOGICS [5]. This is a type of acoustic modem with an omnidirectional broadcast pattern and data transfer capacity of up to 13.9 Kbits/s. The maximum working depth is limited to about 200 m (housing made of delrin). Once the actual consumption at full load is measured, the submerged subsystem capacity necessary to provide the system with a range of several hours of battery power was calculated. Finally, a LI-ION 24V 2.6Ah battery was selected.

IV. SYSTEM APPLICATION

The modem connected to the surface subsystem delivers the data received from the submerged modem to the computer. To manage the flow of incoming data, a code in the Python programming language has been developed. The code demultiplexes the four channels and converts the encoded data into voltage values. That is, through this program the inverse ADC / MUX submerged subsystem functions are performed. Finally, the voltage values obtained are processed to calculate actual values of voltage, delivered by the cylinder sensors to ADC / MUX, considering amplification and translation by these values. The tolerances of the components are compensated by the calibration process and the necessary information is obtained to reset the parameters entered in the program. Thus, the calibration is performed by the program rather than physically adjusting the value of any component of the ADC / MUX. The program is set up so it can access the serial port to which the modem is connected to and read the received data. Once the port is accessed, the program generates an Excel file where modem data are kept indicating the date and time of receipt.

V. EXPERIMENTAL RESULTS

For prototype testing, the water tank facilities from the TML (Fig. 4) were used. The tank is 4 m long, 2.5 m wide and 1.5 m high. Because of the echoes of the signals from the sides and the bottom of the tank we had to bring the modem to a distance for which the multipath effect was negligible. Battery and ADC / MUX were kept out of water for this test, as in the current development phase the objective is to validate the link point to point.

The result obtained in the calibration of one channel sensor cylinder is presented; more specifically, the one corresponding to the oxygen sensor. This channel presents a range of voltages to the amplifier output of 0 to 0.5 V. The sensor signal is simulated by a precision power supply available in the LTM. The source was connected to the ADC input of the corresponding channel ADC / MUX.



Fig. 4. Experimentation tank (CACYTMAR)

A range of input voltages to compare with readings PYTHON program was selected. The results are shown in Table 1.

Table 1. Results for Oxygen channel (values in volts)

v_{in}	v_{python}	$v_{python}-v_{in}$
0.000	-0.0001	-0.0001
0.050	0.0500	0.0000
0.100	0.1001	0.0001
0.150	0.1501	0.0001
0.200	0.2000	-0.0000
0.250	0.2501	0.0001
0.300	0.2999	-0.0001
0.350	0.3500	-0.0000
0.400	0.4001	0.0001
0.450	0.4498	-0.0002
0.500	0.5001	0.0001

As can be seen, the differences between the pattern signal (v_{in}) at the input of the ADC / MUX and the detected and processed signal in the computer area (v_{python}) are in the order of hundreds of microvolts (decimal places). The error can be justified by the quantization process of the signal, because the sampling interval is 125 microvolts. The results obtained in the other channels are similar, which validates the technological improvement proposal for the MP4.

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ID30- PRECISE OBS LOCATION AT THE SEA BOTTOM IN ACTIVE SEISMIC PROFILES USING THE AIR GUN SHOT RECORDS.

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Abstract – The Norcaribe campaign, in November – December 2013, funded by Spanish Ministry of Innovation and Science (Norcaribe Project CGL2010-17715), was performed on board of the Spanish research vessel “Sarmiento de Gamba” around the Hispaniola island, also with the participation of the Dominican Republic Navy patrol vessels and several Haiti and Dominican Republic institutions. During the campaign, a 200 km long, wide-angle refraction seismic profile was carried out crossing the Beata ridge. The air gun signal (5100 ci) was recorded by 15 OBSs deployed along the seismic line in water depths between 2.300 meters and 4.320 meters. To obtain the section records, the OBS position is needed, usually the deployment location is used, but the OBS can drift while is sinking due to the deep oceanic currents. The recovery locations at surface could provide information about the drift, assuming a constant sea current since the deployment to the recovery, but it is imprecise. In this work we show a method to obtain a precise location of the OBS at the sea bottom using a high-resolution bathymetry and the OBS record of the closest air gun shots of the profile. Also, the preliminary results for the Norcaribe campaign (Beata ridge profile) are shown.

Keywords – OBS, sea bottom location, seismic profile, shots.

I. INTRODUCTION

The Caribbean Plate arouses much interest in the geoscientist community for many reasons. Some of them are the amalgam and interaction of distinct tectonic terrains and the complex tectonic history. In addition, this densely populated region is exposed to significant geological risks as it was recorded in the geological record. The Spanish NORCARIBE project (Geodynamics Northern Caribbean: Dominican Republic – Haiti Sector) was funded, in 2010, by the Spanish Ministry of Science and Innovation, and it aimed to study the tectonics and its seismic hazard and tsunamigenic potential in the Hispaniola region.

The NORCARIBE project [1,2] was led by the department of Geodynamics of the Complutense University of Madrid (UCM) with the participation of the Royal Spanish Navy Institute and Observatory (ROA). Also, the Spanish Institute of Oceanography, the “U. S. Geological Survey” and local institutions, as the National Authority of Maritime Affairs and the Geological Survey of the Dominican Republic, were involved in the project. In addition, the Dominican Republic Navy supported the project providing three patrol vessels for deploying and recovering the OBS’s and as chase boats for seismic experiments. Previously, the UCM and ROA led others Spanish projects in the northern Caribbean area. In 2005, GEOPRICO-DO campaign (“Structure and Geodynamics of the Caribbean plate: Puerto Rico microplate”) was carried out on board of the Spanish R/V “Hesperides”. In this project participated the Puerto Rico Seismic Network and the University of Mayaguez and the Dominican Republic Navy and the Autonomous University of Santo Domingo. In 2009, CARIBENORTE campaign (Analysis of Contact between the Caribbean plate and North America from the Beata Ridge to Anegada Passage), also on board of the R/V “Hesperides” and with the collaboration of the several Dominican Republic institutions and navy.

The NORCARIBE geophysical marine campaign (16th November – 17th December 2013) was carried out on board of the Spanish oceanographic research vessel “Sarmiento de Gamba” around the Hispaniola island. During this cruise were recorded systematic swath bathymetry data, gravity and magnetics data, high-resolution seismic, multichannel seismic reflection and wide-angle seismic data (figure 1).

The present work is focused in the problem of the location of the OBS at the sea bottom. For making the section records and the 2-D seismic modeling is necessary the accurate OBS location. Generally, the the coordinates of deployment location at the sea surface are used, but the OBS can drift while is sinking due to the deep ocean currents. Note the OBS sinking velocity rounds 60 meters per minute, it means that takes about 1 hour to reach the sea bottom for a depth of 4.000 meters.

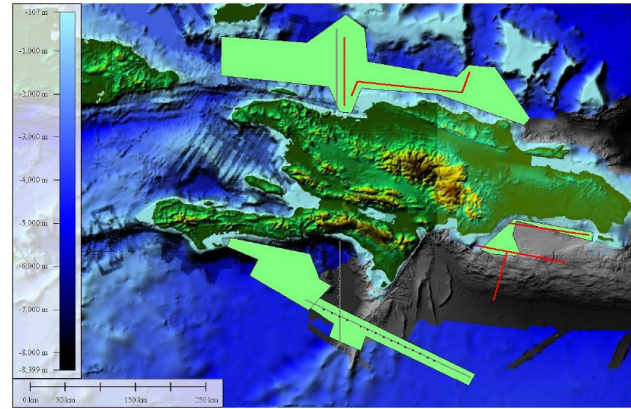


Fig 1. NORCARIBE campaign. Green areas: systematic surveys (bathymetry, gravity and magnetic). Red lines: multichannel reflection profiles (6 km streamer). Grey lines: wide-angle refraction profiles. Black dots: OBS.

II. THE PROBLEM

The OBS are deployed at the selected sites along the planned seismic profile (or in a grid points for 3-D seismic studies), although the location has a good precision (GPS) at surface where the ship is placed, as it was previously mentioned, the OBS drifts due to the deep ocean currents, that varies along the sinking path. This drift can reach even several hundreds or thousands meters. An estimation of the OBS position, at the sea bottom, could be done comparing the deploying location and the recovery location of the OBS, but a constant current during the deployment and the recovery times should be assumed. It means that the OBS should be located at the sea bottom just in the middle point. But the recovery location is not well determined due

	Deployment		Recovery		Diff. (m)
	Lat.	Long.	Lat.	Long.	
OBCB 14	16° 35'.963 N	70° 52'.738 W	16° 36'.069 N	70° 52'.670 W	230
OBCB 13	16° 38'.377 N	70° 57'.682 W	16° 38'.546 N	70° 57'.982 W	617
OBCB 12	16° 41'.250 N	71° 03'.384 W	16° 41'.323 N	71° 03'.534 W	298
OBCB 11	16° 43'.913 N	71° 08'.867 W	16° 43'.720 N	71° 09'.510 W	1195
OBCB 10	16° 46'.462 N	71° 14'.491 W	16° 45'.717 N	71° 13'.850 W	1788
OBCB 09	16° 49'.293 N	71° 20'.532 W	16° 49'.325 N	71° 20'.573 W	93
OBCB 08	16° 51'.392 N	71° 25'.349 W	16° 51'.437 N	71° 25'.393 W	114
OBCB 07	16° 54'.230 N	71° 31'.277 W	16° 54'.208 N	71° 31'.396 W	214
OBCB 06	16° 57'.207 N	71° 37'.533 W	16° 57'.016 N	71° 37'.598 W	372
OBCB 05	16° 59'.825 N	71° 43'.620 W	17° 00'.103 N	71° 43'.946 W	773
OBCB 04	17° 02'.370 N	71° 49'.054 W	17° 02'.056 N	71° 53'.085 W	7161
OBCB 01	17° 12'.632 N	72° 10'.977 W	17° 12'.535 N	72° 11'.462 W	876
OBCB 15	17° 15'.312 N	72° 17'.107 W	17° 15'.277 N	72° 17'.686 W	1026

Table 1. Differences between the deployment and recovery location for the OBS in the Norcaribe campaign.

It must be mentioned that, during the Norcaribe cruise, there was a bad general weather during the recovery for all OBSs, so it took (in general) over half an hour to recovery some of them.

Therefore, a precise location of the OBS at the sea bottom can not be determined only by estimating the middle point between the deployment and the recovery locations.

III. A THEORETICAL SOLUTION

A theoretical and more precise location can be obtained using the travel times of the direct wave of the shots arriving to the OBS. Multiplying the travel time for the wave velocity in the water (1500 m/s), the range between the air guns and the OBS is obtained.

The OBS location is over a down semi-sphere of radius equal to the obtained distance and a center located in the position of the shot (with a known depth below the surface). The location is the common point of at least three of these semi-spheres. This is, the solution of the a system composed by "n" equations (one for each used air-gun shot) as the following one:

where the subscript "i" means the shot position for each equation, "zo" is the depth of the air guns, and "di" is the distance (radius) for each shot. The solution is the exact location of the OBS laying over the sea floor.

$$(x+x_i)^2+(y+y_i)^2+(z-z_o)^2=d_i^2 \quad (1)$$

In figure 2 an schematic diagram of this solution, for a 3 spheres, is shown. But, unfortunately, there are several uncertainties:

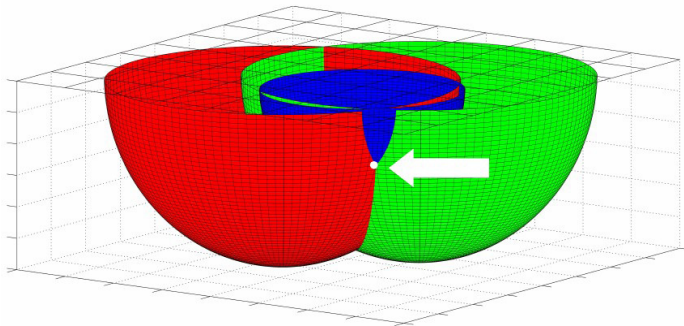


Fig 2. An schema of the solution of equations (1) for three shots.

- Shot location error. The location of the shot is obtained translating the vessel GPS antenna (precise) to the shot generation point, some meters at the stern of the ship (figure 3). Although the estimation is quite precise, the GPS error remains.
- Direct wave travel time error. Although the direct wave can be picked with precision using the shot records, there are always some error, at least one period between samples.

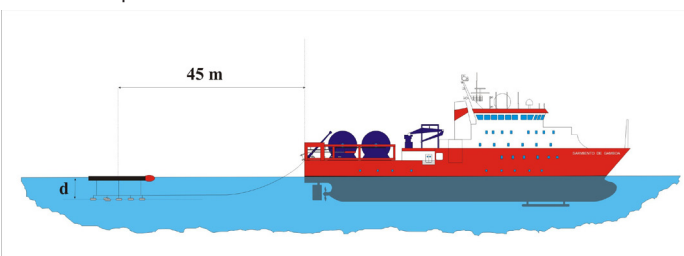


Fig 3. An schema of the location of the shot point and the vessel "Sarmiento de Gamboa" during the NORCARIBE campaign. In the schema, "zo" represents the shot depth. The distance between the GPS antenna and the stern of the vessel is well known.

- The shot time has a small error. The shot is produced with the selected GPS pps pulse (one each 90 seconds) and there are some delays due to the system and the GPS receiver. This error is usually less than a microsecond and can be negligible.
- Finally, the shot wave velocity in the water is assumed as 1500 m/s, but it is not exact neither constant along the path.

All these uncertainties made the equation system has not a unique solution, not all semi-spheres has a common point. Therefore any algorithm to minimize errors could be used to obtain the most probable solution (for example, the

classical minimum square mean error [3], or minimizing any behavior index as in [4]).

As the OBS is placed at the sea bottom, the bathymetry surface could be used to constrain the problem. So, only those solution places over the sea bed should be considered.

IV. THE NUMERICAL PROPOSED METHOD

The proposed method is based on the numerical minimum square mean error. The accuracy will depend of the resolution of the used bathymetry. Nevertheless, due to the OBS deployments are selected where the sea bed is quite flat, to avoid the OBS could move down along the slope of the sea floor, a grid interpolation could be done to improve the resolution of the final position.

The method was programmed in MATLAB script. The stages of the method are as follow:

- Obtain the bathymetry file (xyz) and if it necessary interpolate to get a regular grid (latitude and longitude in degrees and the depth in meters) of several km around of the OBS location. A matrix "D", with the depth in each grid point, of X rows and Y columns is obtained. Rows correspond to the latitude and the columns to the longitude.
- For each point of the matrix "D" the theoretical travel time is determined. This is, first the distance between the shot point and each grid point of the bathymetric surface is calculated, and then, dividing by the velocity in the water the travel time is obtained (matrix "M" of size XY).
- Select the shots. Several shots (N) close to the OBS deployment position should be selected. The first arrival to the OBS will correspond to the direct wave for the closest ones. If some selected shot is some faraway from the OBS the direct wave arrival must be identify carefully. In figure 4 a piece of a section record is show, where the direct wave can be observed as the first arrivals for the closest shots, but arrivals from other phases come first as we move away from the OBS position.

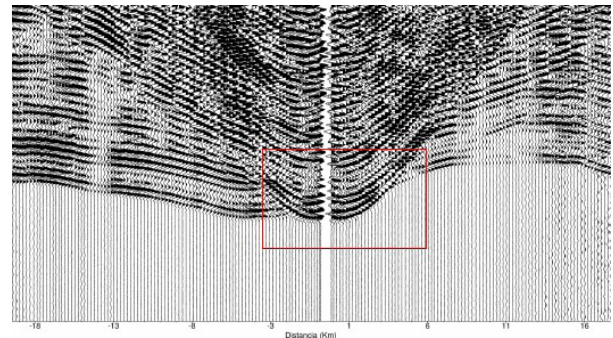


Fig 4. A piece of a section record. In the center part of the red box the first arrival correspond to the direct wave.

- Pick the onset direct wave arrival from the shot record (the vertical component or the hydrophone is generally selected). In figure 5, an air-gun shot record of the vertical component of an OBS is shown.

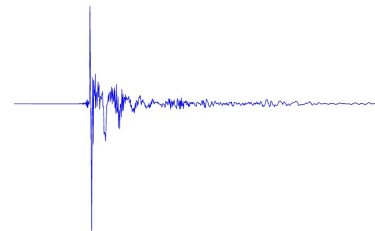


Fig 5. A shot record for the OBCB15 (vertical component).

- Calculated the travel time ("ti"). For each shot the travel time is calculated by subtracting the shot time to onset arrival time (picked), obtaining a vector of size "N".
- Calculate the mean square error matrix (E):

$$E_{i,j}^2 = \frac{1}{N} \sum_{i=1}^N (M_{i,j} - t_i)^2 \quad (2)$$

• Finally, the best OBS position is the grid point with the minimum mean square error (equation 3). To estimate the OBS position error, is only necessary to multiply this minimum error (seconds) for the wave velocity in the water.

$$E_p = v_w * \min(\sqrt{E_{ij}^2})$$

where E_p is the rms position error and v_s is the wave velocity in the water. The latitude and longitude is the corresponding to the minimum value.

V. RESULTS

The described method has been applied to the OBS from the Beata ridge profile made during the NORCARIBE campaign.

In the table 2 the obtained positions and their rms errors in meters are shown.

	Lat.	Long.	Rms error (m)
OBCB 14	16° 36'.1131 N	70° 52'.6096 W	88.57
OBCB 13	16° 38'.4579 N	70° 57'.5725 W	01.13
OBCB 12	16° 41'.1421 N	71° 03'.4315 W	24.21
OBCB 11	16° 43'.7309 N	71° 08'.8737 W	98.59
OBCB 10	16° 46'.3168 N	71° 14'.5044 W	93.42
OBCB 09	16° 49'.2886 N	71° 20'.5132 W	08.00
OBCB 08	16° 51'.3788 N	71° 25'.3249 W	64.97
OBCB 07	16° 54'.0092 N	71° 31'.3863 W	25.46
OBCB 06	16° 57'.1038 N	71° 37'.5800 W	47.48
OBCB 05	16° 59'.9101 N	71° 43'.6596 W	29.24
OBCB 04	17° 02'.3843 N	71° 49'.0367 W	40.00
OBCB 01	17° 12'.6007 N	72° 10'.9627 W	85.00
OBCB 15	17° 15'.4229 N	72° 17'.0621 W	86.16

Table 2. Best OBS positions and their rms errors.

The results show a rms error less than 100 meters in all cases and much less than the differences between the deployment and recovery positions. In figure 6, the rms error grid for the OBCB05 is shown.

VI. CONCLUSIONS

The problem of the location of the OBS at the sea floor has been described and a numerical method, based on the minimum square mean error, using the shot records of a seismic refraction profile, has been shown.

The results show the goodness of the proposed method. The results of the method for the Beata ridge profile of the NORCARIBE campaign show an error less than 100 meters.

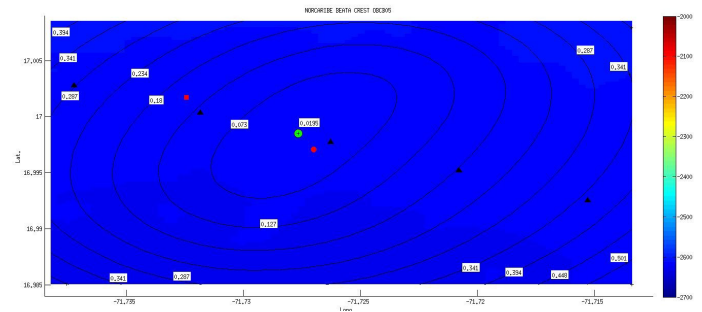


Fig 6. Result of the method for the OBCB05. Green dot: best position. Red dot: deployment position. Red square: Recovery position. Black triangles: selected shots. Labels indicate the rms errors

ACKNOWLEDGMENT

This work was partially funded by the Spanish Ministry of Innovation and Science (Norcaribe Project CGL2010-17715) and also for the Spanish ALERTES-RIM project (CGL2013-45724-C03-03-R).

Also we thanks to the Norcaribe campaign team for their help and well done.

We are indebted to the crew and technicians of the R/V Sarmiento de Gamboa and the Dominican patrol vessel Orion for their professional help at sea. The professional work of the technicians of the Unidad de Tecnología Marina is greatly appreciated.

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ID31- REVIEW OF LESSONS LEARNED AFTER FIVE YEARS OF SHALLOW WATER AUTONOMOUS UNDERWATER VEHICLES (AUV) OPERATIONS

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Abstract – The Unidad de Tecnología Marina (UTM) acquired in 2010, due to the wide scientific requirement to obtain high quality images of the seafloor, a couple of AUV's for shallow waters applications with the aim to support marine research operations in coastal waters. The vehicles has been used as a routine science vehicle but also for technical development. During these years a valuable experience has been gained for future operation on either, coastal and open waters with new and more performant platforms.

Keywords - AUV, marine research

I. INTRODUCTION

The Unidad de Tecnología Marina (UTM. CSIC) after listening to the scientific requirements, decided to set up a department devoted to the newest imaging sea technology concerning the Autonomous Platforms with several objectives. • First the acquisition of two generic well proven AUV's for shallow waters operations mostly at coastal areas. • Gather technical and operational experience with issues related with the submarine vehicles and to study the feasibility of using them on board the vessels managed by UTM. • Provide support to scientific research using the vehicles as sensor platform, integrating new sensors if needed. During these years these technical objectives are somehow fulfilled, and additionally valuable lessons learned on operations and sensor were accomplished to build a long term strategy for future operations.

II. REVIEW OF OPERATIONAL ISSUES.

The natural operational environment for our vehicles is shallow waters, i.e. ports or coastal areas. These coastal environments involve certain operational risks, therefore we have developed a specific protocol to minimize risks, although risk zero doesn't exist, and by applying these procedures we have been able to recover our vehicles every time we have had a high-risk situation.

This protocol encompasses three phases:

- Information. Study of potential risks and adaptation of the mitigation protocol to the mission
- Planning and execution of the mission applying the risk mitigation protocol
- Analysis of the mission and update of the mitigation protocol if needed.



Fig 1.- Ecomapper grounded after an emergency mission was started. Alfacs, 2012.

Our experience with this simple protocol works correctly, and all the parties involved on our AUV operations have been satisfied with the implementation. However, this is a dynamic process and continuous adjustments are necessary in every new survey to improve it.

In addition to our experience in coastal waters with AUV's, our normal operational environment is on board oceanic and global research vessels. Thus,

in recent years, several cruises with Deep Remoted Operated Vehicles (ROV's) and AUV's have been done on board vessels BIO Hesperides and BO Sarmiento de Gamboa and a considerable experience has been gained on the setup and operation of such platforms. So the UTM already has the technical and operational expertise to take the full responsibility for the integration of sensor in whatever operations using Deep sea vehicles.

The main reason that UTM has been unable to operational respond to the scientific demands is the substantial reduction in R&D funding scientific projects and investment in new marine platforms. Therefore, we have opted for small UAVs that are more suitable for low-cost science on coastal waters but this advantage is slight when the number of projects (specially the small / cheap ones) drops by the lack of funding.

An extra effort on outreach and information had to be done to make the platforms and its potentialities known. Thus only few research groups had been actively interested on the use of the vehicles for the active projects and certainly more can be done on this area.

However, there are positive signs: an increasing number of research projects (presented at National and European level) which demands the use of AUV's and / or ROV's and it seems that a confidence build up is starting inside the scientific community. .

III. DEVELOPMENT

Development has been another of our main targets; in this case, focus has been put on the operational aspect of the AUV. Our main concern is related with safety, mission control and sensor integration and these has been the main zones where we start working on hardware and software solutions. Given the costs and time constraints on sensor development, we have focused on hardware development in small sensors integration, adding commercial sensors (Ecopuck, radio-modems) to the original vehicle frame, either, inside or outside the vehicle's setting.

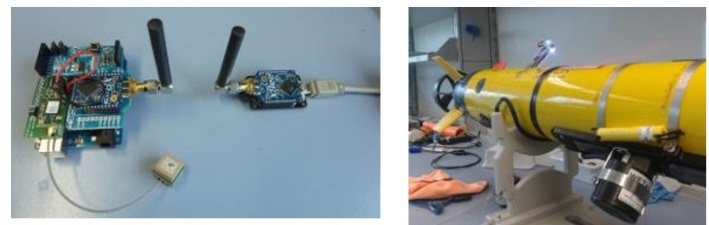


Fig. 2. Xbee (left) and Ecopuck (Right) sets installed on Iver2 vehicles

GPS-trackers have been valuable assets for safe recovery of stranded vehicles when an emergency arise, we have developed different Delrin/ABS containers to install such devices on top of our vehicles, although outside GPRS range these devices doesn't work. For this reason we have started the development of radio-modem, based on XBee®, which, besides knowing the location of the vehicle, will allow us to have fully control of vehicle status and main functions.

Once implemented we will be able to monitor the vehicle status, download data during the mission to make a quasi-real time assessment of a particular process and modify and upload a new mission if necessary. We also have successfully integrated an Ecopuck Triplet on our vehicle, demonstrating the feasibility to integrate small sensors thanks to the vehicle's Open Architecture; the sensor was installed at the bottom of the vehicle and connected to the auxiliary CPU via serial line.

Our vehicles have installed a Nortek 1 Mhz DVL with profiling option and we are investing some effort to gather useful current data with this sensor

Averaged water currents direction occurrence [%] @ 10.5 m depth

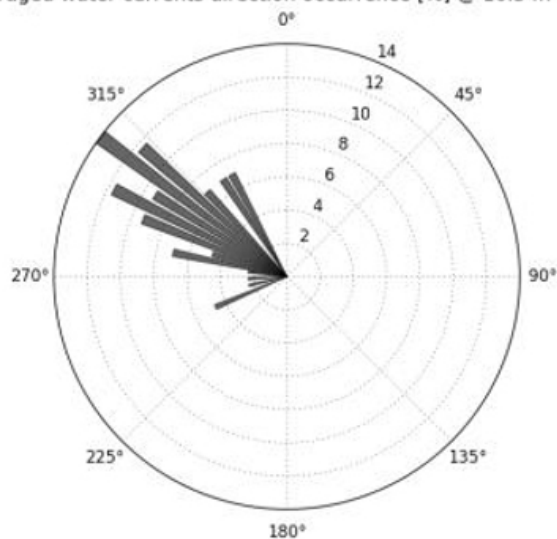


Fig. 3. ADCP Current polar plot of a transect.

For all our developments Python has been the standard programming language, we have used it to program different scripts (automatic report generation, navigation processing, ADCP, data comparison, etc.) for either, real time applications or processing.

IV. CONCLUSIONS

The economic crisis has put serious constraints to the Spanish scientific research in most fields, marine research operations and investments on new technologies have been affected as well, but the relative small operational cost of the vehicles has allowed us to continue operating at small scale and gather experience on a field that should represent an key part of future our marine research operations in all kind of platforms (regional or global) as it is now in other agencies. Despite the work done, additional effort is needed to integrate AUV's and ROV's as regular scientific platforms, integral part of bigger assets which will contribute to enhance our knowledge and supporting of the marine environment research.

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ID32- NEAR REAL TIME SEISMIC DATA FROM THE COASTAL OCEAN

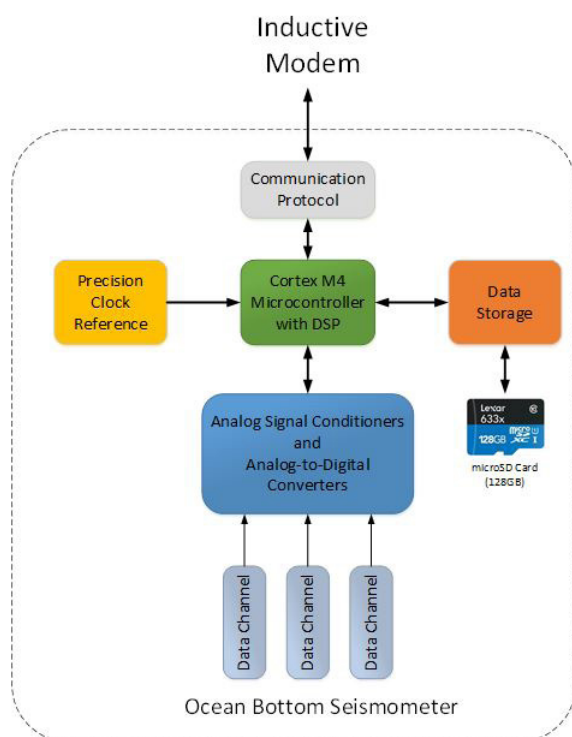
DANIEL M. TOMA¹⁸¹, XAVIER ROSET²²⁶, XAVI ALONSO²²⁵, CARLA ARTERO-DELGADO²²⁴, JOAQUÍN DEL-RÍO-FERNÁNDEZ¹⁸²

Abstract – A moored-buoy system for collecting near real-time seismic data from the coastal ocean has been developed and will be deployed for its initial field trial in the fall of 2016. The technology that makes possible the near real time telemetry of seismic data is the inductive modem technology. This type of data telemetry provides a solution that is convenient, economical, reliable, and flexible. We present results of a prototype system that demonstrate the feasibility of this concept. It will transmit continuous data at a rate of about 1000 bps to a radio link in the surface buoy. A GPS receiver on the surface buoy will be configured to perform accurate and synchronized timestamps on the seismic data on the sea surface, which will make it possible to include data from these undersea systems in the existing seismic data network. Power to operate the system will be supplied by solar panels and rechargeable batteries on the surface buoy and batteries on OBS.

Keywords -Marine Seismometers, Data Transmission and Management Systems, Inductive Communications, Marine and Environmental Observatories.

I. INTRODUCTION

The study of seismic activity has played a key role in increasing the understanding of the dynamics of the Earth and its internal structure. Variations in real time seismicity provides knowledge of the state of local and regional stresses in the short and medium term, essential information to study the potential seismic risk that may affect infrastructures and population located in the area. Recent seismic activity, possibly induced, in the Gulf of Valencia or the intense underwater seismic activity associated with the eruption of El Hierro (2011-2012) shows the importance of controlling the seismicity located in the sea that is not covered by the terrestrial monitoring networks. The integration of real time data generated by marine seismometers will be possible thanks to the development of inductive communication systems, the increasing potential for miniaturization of sensors, storage devices and data processing, which have opened the door to a new generation of distributed intelligent sensor networks that are connected by communication networks.



II. THE OCEAN BOTTOM PACKAGE DESIGN

The prototype ocean bottom package is a modification of the Ocean Bottom Seismometer (OBS) developed in 2012 [1] with the addition of an inductive modem and its associated interface processor as depicted in Figure 1.

The sensors are a geophone that has three perpendicular components; it has been designed from small, robust and high sensitivity magnetic velocity sensors (SM-6 with 28.8 V/m/s from Input-Output Inc. Stafford, TX, USA. and GS-11 with 85 V/m/s from OYO GeoSpace Technologies, Houston, Texas, USA). Two Cirrus Logic CS5372 24 bit chip sets digitize the sensor voltages sampling at 125 samples per second (SPS). The data are arranged in fixed-length packets with time stamps and archived on a microSD card. The data packet of one channel (vertical component of the geophone) is also sent via a serial link to the inductive modem interface, which buffers them for transmission via the inductive modem to the buoy. On demand, the user can also request the data packet of all three channels if an event occurs.

III. THE COMMUNICATIONS SYSTEMS

There are two separate communications systems; one satellite/GSM links between the buoy and shore and one inductive link between the buoy and the OBS.

A pair of Sea-Bird Electronics, Inc. inductive modems [2] was used for the inductive telemetry between the OBS and the surface buoy. The OBS modem receives commands from and transmits data to the buoy modem. The modems support data rates of up to 1200 bps. For 125 SPS sensor data a block is generated for each channel every second. The vertical channels is transferred, repacks to avoid the transmission of the special characters, to the communication protocol controller. These packets are then passed to the inductive modem for transmission to the buoy modem.

On arrival, the gateway computer of the buoy timestamps the packets received from the inductive modem. Next, the satellite/GSM link connects the gateway computer of the buoy with shore. The gateway computer's primary task is to buffer and reformat messages connecting the satellite/GSM and inductive communications channels.

IV. CONCLUSIONS

The tests of a prototype of an OBS with inductive telemetry have demonstrated that the concept is viable for long-term deployment. The longevity of the OBS will be limited by its energy supply but at least 6 months is feasible.

V. ACKNOWLEDGMENT

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(left) Figure 1 Block diagram of OBS electronics. The Inductive modem interface connects to the OBS via a serial line.

ID33- OMNIDIRECTIONAL UNDERWATER SURVEYING AND TELEPRESENCE

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Abstract – Exploratory dives are traditionally the first step for marine scientists to acquire information on a previously unknown area of scientific interest. Manned submersibles have been the platform of choice for such exploration, as they allow a high level of environmental perception by the scientist on-board, and the ability to take informed decisions on what to explore next. However, manned submersibles have extremely high operation costs and provide very limited bottom time. Remotely operated vehicles (ROVs) can partially address these two issues, but have operational and cost constraints that restrict their usage.

This paper discusses new capabilities to assist scientists operating lightweight hybrid remotely operated vehicles (HROV) in exploratory missions of mapping and surveying. The new capabilities, under development within the Spanish National project OMNIUS, provide a new layer of autonomy for HROVs by exploring three key concepts: Omni-directional optical sensing for collaborative immersive exploration, Proximity safety awareness and Online mapping during mission time.

Keywords - HROVs, telepresence, collaborative underwater exploration, advanced assisted 2D/3D mapping, autonomous safety awareness, mapping of challenging environments, mapping quality control.

I. CONCEPT

The study of marine habitats is a key component for understanding and managing ocean resources. In addition to their scientific and economical interest, underwater studies can be used for assessing sites that are important from a conservation point of view, determining areas sensitive to disturbance and pollution, development of coastal and marine protected areas management plans. Currently, such studies face serious challenges, mainly resulting from the harshness and the hazard of the underwater environment. The use of divers drastically limits the depth range and the duration of the studies, while the use of manned submersibles involves high operational costs.

Within the Spanish national project OMNIUS, a new paradigm is being pursued which provides the basis for more direct, interactive and efficient underwater studies, while reducing the associated costs.

From the hardware point of view, the proposal has three main elements (Fig. 1): (i) an intelligent ROV that will be used to acquire and transmit data such as: panoramic visual data, acoustic imaging, and other mission-specific data; (ii) a data processing unit that will process the data acquired by the ROV, creating 2D/3D multimodal representations of the environment; and (iii) a telepresence environment, in which the scientists will have a 360 degrees panoramic real-time view of the area currently surveyed by the ROV, complemented with other navigation sensor information.

The starting hypothesis is that lightweight hybrid remotely operated vehicles (HROV), similarly to the Girona500 [1], can be used by a much wider group of marine scientists without requiring specialized personnel, if such platforms are endowed with suitable mapping and navigation capabilities.

The goal of this effort is to develop new capabilities to assist scientists operating a lightweight hybrid remotely operated vehicle in exploratory missions of mapping and surveying, to ensure the creation of high quality map products at the end. The new capabilities provide a new layer of autonomy for HROVs that will assist scientists in using the platform as an exploratory tool.

Regarding research and innovation, the general objectives are to devise and validate experimentally three new capabilities of high operational impact: (1) advanced assisted mapping, (2) spatial awareness and safety, and (3) user immersion/telepresence.

1 - Advanced assisted mapping - It addresses the need to provide the scientists with high-level information on the mapping data that is being acquired, during exploratory and mapping surveys. This high-level information addresses two common concerns – what areas in the surrounding regions contain interesting features to be mapped, and once the scientist has decided to start mapping, if

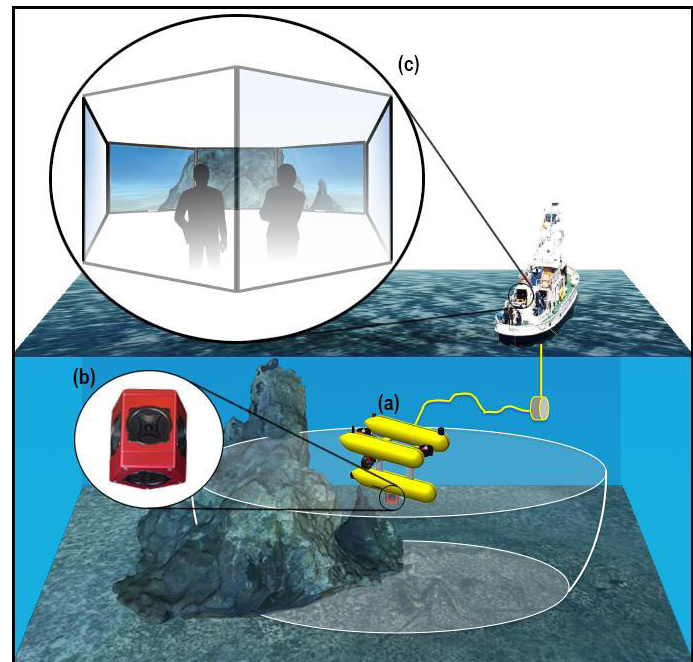


Figure 1 - Concept of the OMNIUS acquisition system. A tethered HROV (a) performs data acquisition using an omnidirectional camera (b) that provide the scientists with 360 degrees of visual feedback (c). This feedback is used to control and drive the acquisition

that area is being properly mapped. This information will assist the scientist in taking informed decisions on what to map and inspect, while taking full control of the exploration process.

2 - Spatial awareness and safety - It aims at providing the vehicle with proximity awareness capabilities when navigating in complex 3D and unstructured environments. Examples of such environments are confined spaces or very steep slopes. The aim is to release human operators from the pressing need to monitor vehicle safety when operating in very close proximity to obstacles in the surroundings. The vehicle will know when it is unsafe to navigate, and override or correct human control input if needed. This will allow the inspection and mapping of difficult areas that, otherwise would not be reachable due to the risk of damaging or entangling the vehicle.

3 - Immersion and Telepresence - aims at validating and demonstrating the expected impact of using an omnidirectional optical sensor as part of a collaborative visualization and exploration tool. This effort addresses the following question: Can a low-cost, customized Hybrid ROV/AUV be used to replicate the experience of a group of scientists on a manned submersible for purely interactive (and reactive) surveying?

II. ONGOING WORK AND ACHIEVEMENTS

Several technical advances are being pursuit within the project.

Among others, underwater omnidirectional imaging is a key sensing technology. An Omnidirectional Multi-camera System (OMS), based on a commercially available 6-camera system, was adapted for underwater use (Fig. 2). A custom-made compact housing inspired the development of a new 3-stage calibration procedure due to its non-conventional geometry [6]. This camera system was used at sea with the Girona500 AUV (Fig. 3) for tracking a formation of AUVs navigating at both close distance to each other and to the benthos [4], and also

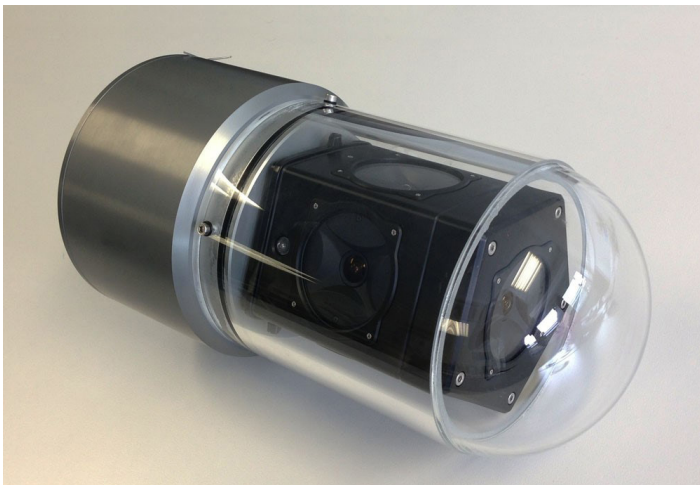


Figure 2 - Omnidirectional sensor based on a 6-camera system. A custom housing was designed and built, comprising a cylindrical viewport with a hemispherical cap, and a metal container for a small form factor pc.

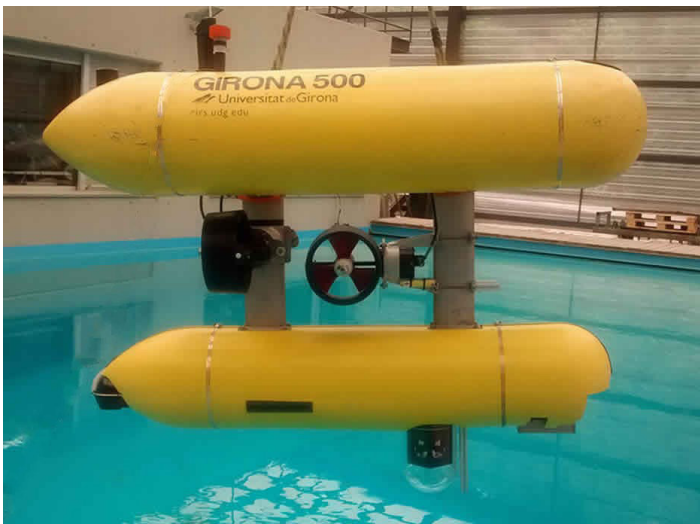


Figure 3 - Side view of the Girona 500 AUV/HROV with the omnidirectional camera installed.

to create virtual panoramic tours for public outreach, in a similar concept to Google StreetView [5,3] (Figs. 4 and 5).

An important aspect in exploratory missions is the ability by the scientists to adequately perceive the visual information from the surroundings, since they have to decide on-the-fly where to navigate next. As such it become important to improve the live imagery in real-time, to counteract part of the image degradation that the underwater medium creates. Towards this goal a new method for color correction of underwater images was proposed [7], using the Lab color space and having a low computational cost suitable for on-line operation.

Another key aspect is the ability to build optical maps during mission. Several steps have been taken to perform optical mapping using computationally efficient approaches, towards the goal of on-line operation [8]. The case of multi-camera mapping has been addressed in the context of habitat mapping in the Azores [9], along with the problem of creating high quality 3D surfaces from noisy point data [2].

An important operational concern relates with the quality of the navigation data that is used in the mapping process. While altitude, depth and heading can be assumed to be highly reliable in most conditions, the same is not necessary true for latitude and longitude, which depend on the quality of inertial systems and/or on the presence of an acoustic positioning infrastructure. In this sense effort was devoted for the creation of optical maps when only the image measurements are assumed to be reliable (i.e. in absence of navigation data). These methods make use of graph theory to devise efficient approaches for image overlap prediction and joint optimization of the image registration, on large images sets [10,11,12]

III. FUTURE DIRECTIONS

The technologies developed within the OMNIUS paradigm aim at the study of the benthos immersively and

in real time, and at the remote interaction with the vehicle in a safe and intuitive manner. Within this paradigm, several future directions can be identified as being of high potential impact for marine science. Two new integrated capabilities are pointed out due to their high operational relevance.

The first one is the ability to identify benthic structures of interest automatically and during mission time. An example of such is the detection of a particular invasive species, such as the *Caulerpa webbiana* in the Azores, or small man-made objects such as marine munitions or accident debris. Such detection is particularly well suited for the large field of view of the omnidirectional camera, and will serve to complement (and improve upon) the visual detection conducted by the scientist piloting the vehicle.

The second is the automated detection and characterization of temporal changes, for areas that are visited repeatedly over time. This ability is central to a number of ecology studies, and traditionally involves extensive manual work. The automated change detection and interpretation underwater requires techniques, such as pre-processing, registration and classification, that have not yet reached the required maturity and performance level.

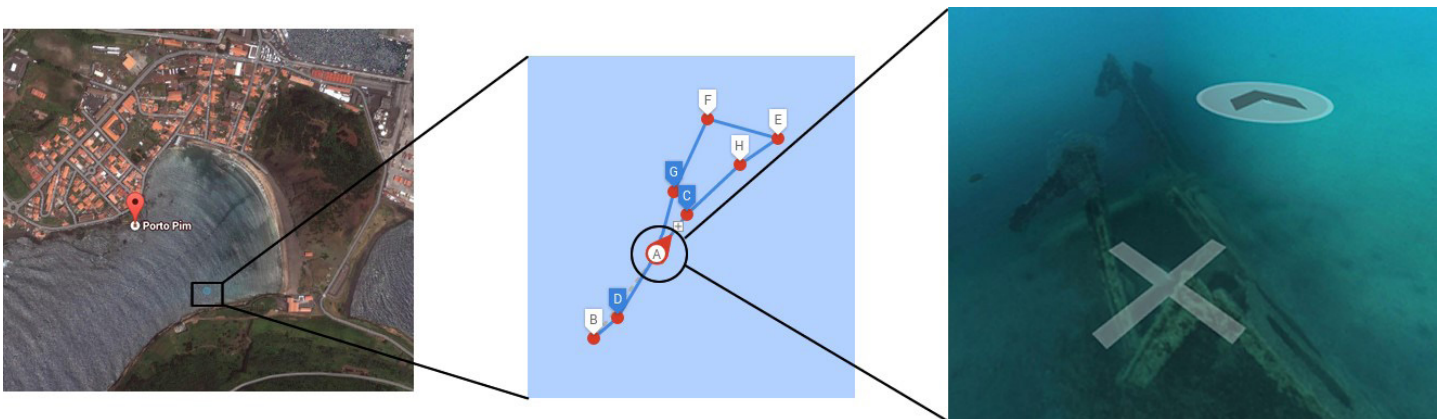


Figure 4 - Location and sample image of a shipwreck virtual tour in Google Maps

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Figure 5 – Panoramic image using the equirectangular projection of a shipwreck survey in Horta, Azores Islands in September 2014.

ID34- EUROPEAN MULTIDISCIPLINARY AND WATER-COLUMN OBSERVATORY - EUROPEAN RESEARCH INFRASTRUCTURE CONSORTIUM (EMSO ERIC): CHALLENGES AND OPPORTUNITIES FOR STRATEGIC EUROPEAN MARINE SCIENCES

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Abstract – EMSO (European Multidisciplinary Seafloor and water-column Observatory, www.emso-eu.org) is a large-scale European Research Infrastructure I. It is a distributed infrastructure of strategically placed, deep-sea seafloor and water column observatory nodes with the essential scientific objective of real-time, long-term observation of environmental processes related to the interaction between the geosphere, biosphere, and hydrosphere. The geographic locations of the EMSO observatory nodes represent key sites in European waters, from the Arctic, through the Atlantic and Mediterranean, to the Black Sea (Figure 1), as defined through previous studies performed in FP6 and FP7 EC projects such as ESONET-CA, ESONET-NoE, EMSO-PP (Person et al., 2015).

Keywords - Seafloor and water-column, Research Infrastructure, environmental processes

I. INTRODUCTION

Through the EMSO-Preparatory Phase project, funded by the EC FP7, the governance and management structure of EMSO RI was agreed among the participant countries interested in supporting the infrastructure (Italy, France, United Kingdom, Germany, The Netherlands, Ireland, Norway, Sweden, Portugal, Spain, Greece, and Turkey). EMSO RI has then entered in the final phase to establish the EMSO ERIC (European Research Infrastructure Consortium), the legal body that will be in charge of running EMSO observatory nodes as a unique integrated marine infrastructure. The process towards the foundation of EMSO ERIC is close to completion, with the EMSO ERIC. The EMSO ERIC will be hosted by Italy with participation of Italy, France, The United Kingdom, Greece, Spain, Ireland, The Netherlands, Germany, Portugal and Romania. Other countries such as Norway, Sweden, Turkey, and Malta have expressed their interests.

II. THE STRATEGIC SCOPE

The oceans cover 70% of the Earth's surface and contain roughly 97% of the Earth's water supply; Oceans dynamics drive most of the ecosystems on Earth, representing the largest most complex Biome on Earth, and control on the Climate at global scale. 70% of volcanism on Earth occurs underwater, being the source of hazards often unpredictable. Thus, the oceans are the very foundation of human life, and the suitable place to study the interactions between the physical, chemical, and biological components of the environment, including their effects on all types of organisms.

The fundamental challenge is to build the foundation for an innovative approach to ocean observation long-term fixed-point observatories provides continuity, vigilance and high time-resolution data in a broad time scale (milliseconds to years). Continuous observation allows the detection of unpredictable events such as earthquakes, tsunamis, dense water cascades, plankton blooms, water mass movements, and influence of eddies, which cannot be detected by intermittent, short-term ship expeditions. Furthermore by monitoring the water column from the surface to the seafloor, phenomena can be investigated that are beyond the capacity of remote sensing approach (Best et al., 2014).

III. TECHNOLOGICAL DEVELOPMENT

To understand the expected changes in the coming decades, it requires a significant technological effort in the field of marine sensors that allow us a continuous and interactive recording of a variety of parameters that make feasible a complete observation of the oceans based on the following approach:

a) Research Infrastructure Technology:

The aim is through EMSODEV EU funded project to provide the basis to equip EMSO sites with a standardised tool for ocean parameter measurements by developing a multidisciplinary sensor system called EGIM (EMSO Generic Instrument Module). More specifically the objective is to offer features beyond the state of the art using a comprehensive set of sensors and devices that meet particular technology readiness thresholds to collect observations including

temperature, pressure, salinity, dissolved oxygen, turbidity, chlorophyll fluorescence, currents, and passive acoustics. Relatively novel sensors will also be considered including those for pH, pCO₂, and nutrients (Figure 2). These generic variables can be used to directly address a wide range scientific topic:

- Global change (e.g., temperature, conductivity).
- Ocean circulation (e.g., currents, conductivity and temperature).
- Benthic biologic processes (e.g., turbidity, oxygen).
- Large impact geo-hazard (e.g., pressure).
- Acidification (e.g., dissolved carbon dioxide and pH measurements).
- Underwater natural and man-induced noise (e.g., ground motion, sound propagation).

b) Reliable Ocean Science Measurements

Standardization in measuring physical and chemical parameters in the ocean increases the potential scientific impact of the collected data. The long-term recorded data or in situ ocean measurements are critical issues not yet resolved, since the sensors suffer extreme ambient conditions, corrosion, mechanical stress, sudden changes in temperature and their electronic components supports a remarkable wear. By implementing the EGIM, composed of the sensors required to acquire short-term as well as long-term variations and changes in the ocean facilitating regional predictions applications such as regional scale monitoring and modelling for climate change predictions; figure 2 Illustration of the main processes in the marine environment showing main interactions between atmosphere, surface ocean, biology, deep ocean, and solid earth after Ruhl et al., 2011

c) Big Ocean Data

The data management system will establish an infrastructure to support the massive volume of data produced by individual, geographically distributed ocean sensors, acquiring time series describing phenomena involving different temporal scales. This platform will be serving scientists and other 3rd party data users all over the world, and delivering data products for a wide and heterogeneous group of stakeholders.

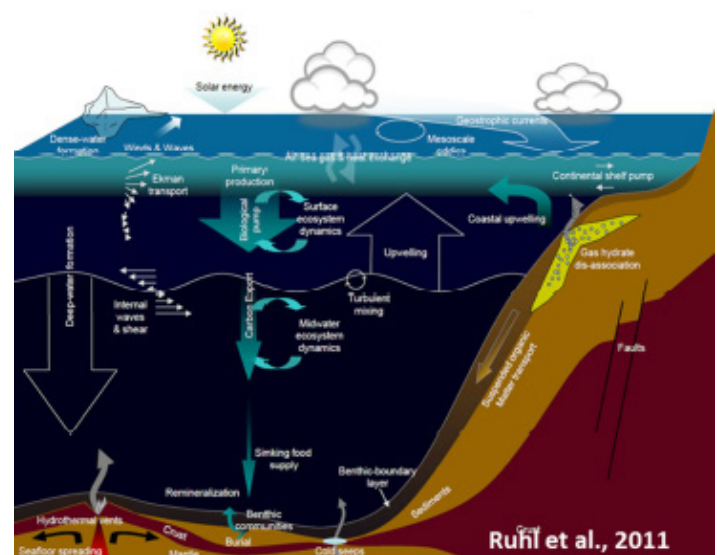


Figure 2 Illustration of the main processes in the marine environment showing main interactions between atmosphere, surface ocean, biology, deep ocean, and solid earth after Ruhl et al., 2011

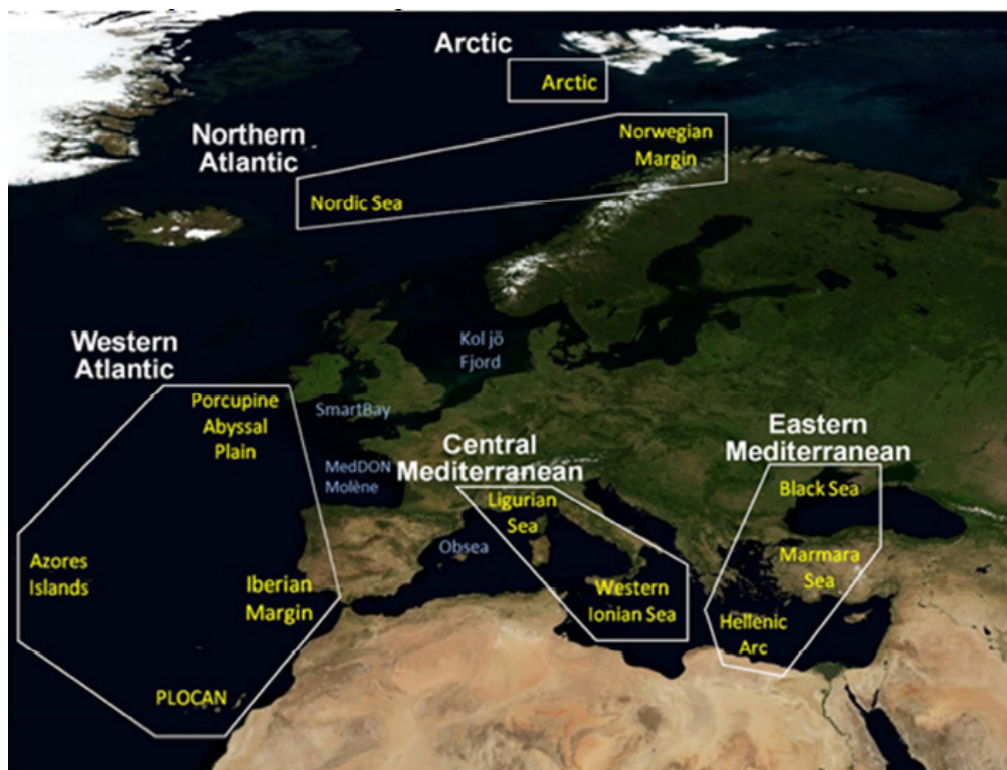


Figure 1. Map of EMSO nodes (yellow) and shallow-water test sites (blue)

IV. SCIENTIFIC & SOCIETAL IMPACT OF EMSO RI

EMSO RI, with an extremely broad-ranging extension in term of environmental conditions, covers a relevant part of the Northern hemisphere from subtropical regions to the Arctic. Homogeneous Essential Climate Variables produced by EMSO RI are thus central to addressing the environmental challenges by delivering knowledge and tools to enable Europe to prepare for, and adapt to these changes. National and regional decision and policy makers are major users of EMSO ERIC data that must be shown the major advantages of having standardized information that may help the development of Regional intervention plans. By the use of standardized services new and innovative solutions can be drawn in order to address the major Societal Challenges.

Industrial interests can be illustrated according to the economic sectors:

- Requirement for impact assessment for marine renewable energy concepts (all EGIM parameters) and resource evaluation for marine turbines (underwater current variability is a direct input to the business plan);
- requirement for stand-alone observatories to monitor oil/gas spills either around large shipwrecks or oil/gas production leakages or gas storage leakages;
- requirement for impact assessment of marine mineral resources extraction fields (all EGIM parameters) and more precisely permanent monitoring of sub-sea particle clouds of dust (current and turbidity);
- requirement for geo-hazard monitoring around some oil & gas production fields, impact assessment of most oil & gas fields;
- requirement for monitoring fish behaviour at some key areas (conflict of fisheries with other marine uses, implementation of Ecosystem Approach to Fisheries (FAO 2003) replacing trawling by fixed gears);
- requirement for civil protection towards geo-hazard mitigation measures.

V. CONCLUSIONS

EMSO is one of the environmental RIs included on the roadmap of ESFRI (European Strategic Forum on Research Infrastructures) since 2006, and it is included as Landmark in the last ESFRI roadmap 2016 (www.esfri.eu/roadmap-2016). It provides a new kind of large-scale infrastructure for multidisciplinary and interdisciplinary investigation of deep ocean processes related to Marine Ecosystems, Climate Change and Marine Geohazard. This distributed ocean observatory significantly improve marine research capacity of EU Member States and increases the ability to respond to the major challenges related to environmental changes. EMSO contributes to the Global Monitoring for Environment and Security initiative (now renamed COPERNICUS programme, www.copernicus.eu).

The present operational status of EMSO in terms of the number of operating

nodes (eight nodes running out of twelve expected), and data acquisition and dissemination, has been reached over ten years of research, development and coordination activities responding to local and regional requests, funded by the individual countries and by the EC through projects with different time-lines and budgets; enhancements to these nodes are ongoing on the same basis. An open data policy has already been adopted in compliance with the recommendations being developed within the GEOSS initiative (Global Earth Observation System of Systems, www.earthobservations.org/geoss.php) to allow for the shared use of the data infrastructure and the free exchange of scientific information and knowledge.

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ID35- EUROPEAN POLAR RESEARCH: STATUS AND CHALLENGES OF EUROPEAN POLAR FLEET FOR ENHANCING STRATEGIC COLLABORATION

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Abstract – Polar Regions are the most vulnerable world areas to any climate change, and therefore can be considered drivers of global climate change, so small and systematic changes in the Polar Regions affect critically the global environment. This is particularly worrying for Europe and the Arctic due to ocean circulation interaction between the North Atlantic and the Arctic Oceans whose outcome is already producing significant climate anomalies in the Northern Hemisphere. Many European countries support polar research, not only in the Arctic but also in Antarctica, and in fact many European polar research programs have a two-pole perspective. However Europe lacks sufficient marine technological platforms to meet the challenges posed today in marine polar research.

Keywords – Polar Research Infrastructures, Arctic, Antarctic, Global change.

I. INTRODUCTION

During the 70s, the opinion of scientists was increasingly in favor of the views of global warming. In the early 90s, the improvements and reliability of computer models, together with an extensive observational work confirming the Milankovitch theory of ice ages, allowed for a broad consensus in the scientific community on the role of the greenhouse effect on most climate change and that anthropogenic emissions favored global warming. Since then the polar scientific community has persistently warned about the urgent need to investigate the Polar Regions in order to respond adequately to the growing societal concerns about how to respond to these significant global changes. In 1988, the Intergovernmental Panel on Climate Change (IPCC) was set up by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP). The IPCC is the international body for assessing the science related to climate change with regular reviews of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation. Polar-related issues have been growing in the political agenda across Europe over the past last decade. The increasing level of investment now being made by governments is a clear demonstration of how critical polar research outcomes are for informing policy objectives, including those relating to climate change, energy security, global food security, innovation and economic growth. This situation can be substantially improved by an overall integrated scientific approach, increasing the level of coordination of polar research and promoting cooperation with all relevant European and international actors.

II. THE POLAR FLEET STATUS.

In recent years the European Commission has promoted through different coordinated actions and/or funded projects (including Eurofleets2, EU-PolarNet, ARICE), an analysis of the European status of the large scale infrastructures (i.e., Polar Research Vessels (PRVs), Polar Stations, etc.) which is a fundamental step to organize a pan-European polar approach.

Here we summarize the studies on the large scale facilities after assembling information on PRVs operating at both poles (Arctic and Antarctica).

In a first approach, we have distributed the PRV's in accordance with the new International Maritime Organization (IMO) Polar Code (PC) classification (Fig 1): Category A, B and C. Most of the information has been assimilated from the EU-project Eurofleets2 and information by EurOcean, Council of Managers National Arctic Program (COMNAP), International Research Ship Operators (IRSO), European Research Vessel Operators (ERVO), etc.

a) Heavy Icebreakers

We have identified worldwide 13 operational Category A vessels (Fig 2) potentially empowered to accomplish research in the Polar Oceans, operating at least in first-year sea-ice (according to the new Polar Code classification, between PC1-PC5). The heavy icebreakers are generally long vessels (95-167 m) with large draft and well prepared for long endurance voyages. The crew ranges mostly from 25-45 members, except for the Swedish PRV "Oden" which reports only 23

POLAR RESEARCH VESSELS		IACS	
World	Europe		
Healy, Polar Sea, L. S. St. Laurent, Amundsen, Shirase II	Polarstern, Oden,	PC1 PC2 PC3	Year-Round navigation in Polar Waters
N. B. Palmer, Araon, Agulhas II, Al. Irizar, Sikuliaq	Akademik Tryoshnikov	PC4 PC5	
Winter navigation in Sub-Polar waters	IA Super	PC6 PC7	Summer Navigation in Polar waters
	IA		
	IB		
	FSICR Ice Class Rules		

Fig 1. Equivalence between new IMO Polar Code (PC) and the previous ice classification for PRVs

crew members. However, these ships show great variability with reference to capacities, equipment, schedules, access, etc. All of these Research Vessels also have capacities to support polar stations within the Antarctic or Arctic areas, and a few of them are fully equipped for multidisciplinary science. Regarding vessels with full capacity of year-round operations, Europe is currently limited to two PRVs, the German "Polarstern", and the Swedish "Oden". Worldwide only a few more are available, such as the USA "Healy" and USA "Polar Sea" ("Polar Sea" has been out of service since 2010 due to engine failure and a decision is pending as to whether it will be scrapped or repaired) the Canadian "Louis S. St. Laurent" and "Amundsen" and the Japanese "Shirase II".

Among these PRVs, only the "Polarstern" is exclusively dedicated to research. When restricted to European PRV's, the list includes the Russian "Akademik Tryoshnikov" in addition to "Polarstern" and "Oden". Worldwide the list is extended with "Sikuliaq" and "Nathaniel B. Palmer" (both USA), "Agulhas II" (South Africa), "Araon" (Republic of Korea), and "Almirante Irizar" (Argentina). This justifies that, to provide a response to societal demands it is necessary to increase the international cooperation for the use of these expensive platforms. Most of these PRVs are operated by National Science Agencies; exceptions' being those operated by the USA and Canada Coast Guards. The heavy icebreakers are generally old ships and only three of the ships (Fig. 2), are less than 5 years old. The remainder each have more than twenty years of service. We have identified only the "Araon", "Amundsen" and the "Polarstern" as capable of working with deep sea Remotely Operated Vehicles (ROVs). The PRVs "Polarstern", "Healy", "Louis S. St Laurent" also have Automated Underwater Vehicles (AUV) capacities. The worldwide scenario for heavy icebreakers is a little bit more optimistic due to recent constructions. The continuation of operations at least in Antarctic waters is almost guaranteed by the three PRVs recently built; "Araon" (2009), "Akademik Tryoshnikov" (2011) and "Agulhas II" (2012), although these vessels – with the exception of the "Araon" – are more specifically commissioned to logistical support to polar stations than to perform marine research. In addition, USA extended its PRV fleet in 2014 with "Sikuliaq" - the first vessel built for the US National Science Foundation in more than three decades. "Sikuliaq" is an almost 80m length, well equipped research platform operated by the University of Alaska Fairbanks School of Fisheries and Ocean Sciences. Furthermore, the Australian Government has signed a




Region	Polar Code Category	IACS Class	Ship Name	Picture	Country	Length (m)	Built year	Operator	Ice Class NEW POLAR CODE	Research Equipment	Operating area	Major Refit	Supply Station
EUROPE	A	PC1 to PC3	Polarstern		Germany	118	1982	AWI	PC2/PC3	100/100	Antarctic Arctic	2002	Yes
			Oden		Sweden	108	1988	SMA	PC2/PC3	60/100	Antarctic Arctic		Yes
WORLDWIDE	A	PC1 to PC3	Healy		USA	128	1997	USACGC	PC2	60/100	Antarctic Arctic		Yes
			Polar Sea		USA	122	1978	USACGC	PC2	25/100	Antarctic Arctic		Yes
			L. S. St-Laurent		Canada	120	1969	CCG	PC2	60/100	Arctic	decom. 2017	No
			Amundsen		Canada	98	1979	CCG	PC3	50/100	Arctic	2003	No
			Shirase II		Japan	138	2008	Ministry of Defence & JARE	PC3	50/100	Antarctic Arctic		Yes
EUROPE	A	PC4 to PC5	Ak. Tryoshnikov		Russia	134	2011	AARI	PC4-PC5	50/100	Antarctic Arctic		Yes
WORLDWIDE	A	PC4 to PC5	N.I.B. Palmer		USA	94	1992	USAP	PC4/PC5	100/100	Antarctic		Yes
			Almirante Irizar		Argentina	121	1978	Argentina Navy	PC5	60/100	Antarctic	ongoing	Yes
			Agulhas II,		South Africa	134	2012	SANAP	PC5	60/100	Antarctic		Yes
			Araon		South Korea	110	2009	KOPRI	PC5	100/100	Antarctic Arctic		Yes
			Sikuliaq		USA	80	2014	U. of Alaska UNOLS	PC5	100/100	Arctic		No

Fig 2. Summary of Heavy PRV Ice-Classes for year-round polar operations modified from EUROFLEETS2

contract for a new icebreaker with the Australian company DMS Maritime Pty Ltd. They will be responsible for both the overall design and build of the ship, and the operation and maintenance of the ship over its expected 30 year life, starting in 2020. China has recently (April 2016) published a public tender for a new PRV icebreaker which is expected to be in service around 2019. In the beginning of 2016, Chile announced a contract for the design of a new icebreaker for the Chilean Navy as replacement for the "Oscar Viel" in 2021. The contract, with Chile's ASMAR Shipbuilding & Ship Repair Company, will be for a 400-foot icebreaker of 13,000 tons displacement, rated for one meter of ice. She will carry a complement of 150 and will serve throughout the Southern Ocean for purposes including research, Search and Rescue (SAR), logistics support and resupply for Chile's bases in Antarctica. In Peru, the PRV "BAP Carrasco" of 97m length, polar class PC7, was launched in May 2016 at "Construcciones Navales P. Freire"

shipyard in Vigo, Spain. The PRV belongs to the Peruvian Navy Hydrographic Service to carry out research and support to the Peruvian Antarctic stations and perform research in Peru's exclusive economic zone. The vessel is equipped with the latest technology and will be the platform for Peruvian Navy to conduct investigations in hydrography, oceanography, geology, biology and geophysics.

b) Ice classified Icebreakers

The Ice Class B and C (PC 6-8) PRVs in Fig 3 are mostly designed for science purposes, except the PRV "Oscar Viel" which is principally a station logistical support vessel.

Most of the ships have underwater vehicle capacity for both AUVs and ROVs. Most vessels (with the exception of some naval ships) have ample space for scientists and technicians due to a reduced crew. There is also a reasonably good balance between vessels operating at either pole.










Region	Polar Code Category	IACS Class	Ship Name	Picture	Country	Length (m)	Built year	Operator	Ice Class NEW POLAR CODE	Research Equipment	Operating area	Major Refit	Supply Station
EUROPE	B	PC6 to PC7	Aranda		Finland	59,2	1989	Finnish Env. Inst.	PC-6	100/100	Arctic		No
			Astrolabe		France	65	1986	IPEV/P&O Maritime	PC 6	40/100	Antarctic		Yes
			Akad. Federov		Russia	141	1987	AARI	PC 6	50/100	Antarctic Arctic		Yes
			James C. Ross		UK	99	1990	BAS	PC 6	100/100	Antarctic Arctic		No
			Maria S Merian		Germany	95	2005	IOW_Warnermunde	PC 7	100/100	Arctic		No
			Sanna		Greenland	32,3	2012	GINR	PC 7	100/100	Arctic		No
			Italica		Italy	130	1981	DIAMAR	PC 7	/100	Antarctic		Yes
			Helmer Hanssen		Norway	64	1988	University of Tromso	PC 7	100/100	Arctic	1992	No
			Lance		Norway	61	1978	Norwegian Polar Ins.	PC 7	100/100	Antarctic Arctic		No
WORLDWIDE	B	PC 6 to PC 7	Aurora Australis		Australia	95	1989	P & O / ADD	PC6	60/100	Antarctic	2013	Yes
			L. M. Gould		USA	70,2	1997	USAP	PC 6	50/100	Antarctic		Yes
			Xue Long		China	167	1993	CAI	PC6-PC7	50/100	Antarctic Arctic	2013	Yes
EUROPE	C	PC7 to PC8	G.O. Sars		Norway	77,5	2003	UiB	PC 7	100/100	Antarctic Arctic		No
			Hesperides		Spain	82,5	1991	Spanish Navy CSIC-UTM	PC 7	100/100	Antarctic Arctic		Yes
			E. Shackleton		UK	80	1995	BAS	PC 7	25/100	Antarctic	2001	Yes
			Dana		Denmark	78	1981	DTU Aqua	PC 8	100/100	Arctic	1992	No
			A. Fridriksson		Iceland	69,9	2000	MRI	PC 8	100/100	Arctic		No
			OGS-Explora		Italy	73	1973	OGS-Trieste	PC 8	100/100	Antarctic Arctic		No
WORLDWIDE	C	PC7 to PC8	BAP Carrasco		Peru	95	2016	Peru Navy	PC 7	100/100	Antarctic		Yes
			Al Maximiliano		Brasil	93,4	1974	Brasil Navy	PC 8	100/100	Antarctic		Yes
			Oscar Viel		Chile	90	1969	Chile Navy	PC 8	25/100	Antarctic		Yes
			Tangaroa		New Zealand	70	1991	NIWA	PC 8	100/100	Antarctic		Yes
			Sagar Kanya		India	100	1983	NACAOR		100/100	Antarctic Arctic		Yes

Fig 3. Summary of Ice-Class PRVs for winter navigation in subpolar operations, modified from EUROFLEETS2

III. SCIENCE REQUIREMENTS REGARDING EQUIPMENT AND PRV CAPABILITIES

a) Future equipment needs

Due to the constant increase in costs for the deployment of these ships, and increasing needs for transdisciplinary research, the next generation of PRVs must be multifunctional, and comprise modular components that are easily interchanged, mobilized and demobilized depending on the type of research scheduled for an upcoming cruise. The ship should have the capacity to operate in winter ice with pressure ridges and multi-year ice. The ship should be equipped with a centreline moon pool to facilitate sampling of the water column under extreme conditions and to enable also e.g. the deployment of AUVs and ROVs through this access point. As the Antarctic Research Vessel Oversight Committee (ARVOC, USA) suggests, new technological capabilities are expected to support the investigation of atmospheric sciences using remote sensing instruments based on laser and microwave technologies. This also includes unmanned aerial drones for research in the atmosphere and studies of sea ice and glacier ice in areas where polar research vessels will be required to serve as the main base, and also in SAR operations. Acoustic instruments are crucial to both physical and biological marine research. This includes multibeam echosounders, subbottom profilers, acoustic current meters, fisheries acoustics, and acoustic underwater positioning and navigation systems. An optimized hull design is therefore required to achieve a certain acoustic noise reduction level (ringing, reverberation, background noise, acoustic blocking, etc.) as well as for transit in open water (benign in heavy seas, resistance, energy efficiency etc.). Powerful and versatile winch and crane arrangements are key elements.

b) Predictable evolution of the Polar Research fleet

We consider here the perspective of the European Polar Research fleet (Fig. 2) based on the forecast at the beginning of 2014. From the point of view of the heavy icebreakers, Europe has two operative vessels, the "Oden" which is dedicated exclusively for Arctic research since 2011, and the "Polarstern" which mostly spends her time in Antarctic waters. "Polarstern" is reaching the end of its life time, after 30 years of continuous operation, while "Oden" has an estimated 15 years to go without a major refit.

There are some progressing projects such as the Norwegian 100 m length PRV "Kronprins Haakon", polar class PC 3, under construction and to be operational in early 2018. With deep sea ROV and AUV operations capacity, together with a moonpool and a hangar for sampling at low temperatures, this vessel is carrying state of the art equipment to support the highest standards in Polar science, targeting areas mostly in the Arctic region, but also on a regular basis in the Antarctic.

Another ongoing project is the "Polarstern" replacement by "Polarstern II". This is a 140m length PRV with polar classification PC2-PC3 and designed with an optimized hull to reduce noise and vibration, high level energy efficiency- and environmental standards, a moonpool, and a hangar for sampling at low temperatures. "Polarstern II" is planned to be arranged and equipped with state of the art scientific technology that will support high class research standards and with a significant cargo capacity to supply the German Antarctic station Neumayer III. It is estimated to be operational in 2019.

In the UK, "James Clark Ross" will be replaced by the new 125m length "Sir David Attenborough" which will enter in to service in 2019. It will be used for both marine research and logistics support to British Antarctic research stations. The vessel will have a number of marine research instruments and systems on board, including multiple hydro acoustics systems for bathymetry, oceanography and biology and a moonpool for launch and recovery of underwater vehicles. The Swedish government has given the Polar Research Secretariat the task to do a pre-study on how Sweden should plan long-term for a polar research vessel after that Oden has been decommissioned.

c) Status of the Polar Research fleet front of H-2020

When estimating an average vessel lifespan of 30 years and correcting where midlife refit is reported, the life-time termination of the fleet will be about year 2025. This scenario predicts that few of the current European heavy icebreakers will be operating beyond the 2020 horizon (Fig. 4), and as well predicts higher global reduction when considering vessels fully equipped for high standard quality science. The current heavy icebreaker fleet analysed here show signs of aging as a whole (Figure 4), hopefully the Norwegian and German ongoing projects improves the outlook, but requires thorough reflection by funding agencies and research agencies.

The other ice classified PRV's, the UK "James Clark Ross" (to be replaced by the new "Sir David Attenborough") and the Spanish "Hespérides" will continue in op-

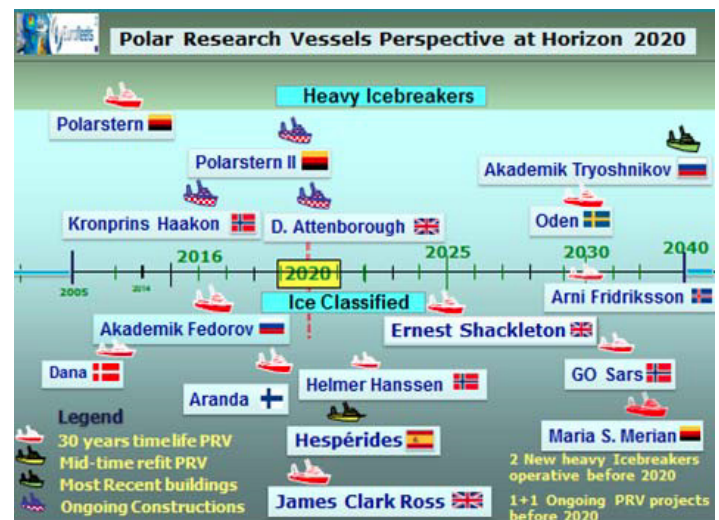


Fig 4. H-2020 perspectives of EUROPEAN PRV's

eration until 2020, while the "Ernest Shackleton" will reach 30 years of polar service by 2025. A few of the ice strengthened PRV's, i.e. "Arni Fridriksson" "Aranda" (is currently going through a midlife update), and the "Maria S. Merian", mostly operating in Arctic waters, will remain in operation well beyond year 2020. This scenario points to where efforts should be made to maintain the competitiveness of European polar research, through more and better cooperation within the European Union. A line of action already initiated by Norway and Germany is the planned construction of highly interoperable medium-size ships with research and cargo capacities, and finding mechanisms to share them. In this respect, the lesson learned from the grounded "Aurora Borealis" project, possibly as consequence of the enormous building costs and essentially the huge operating cost, has to be taken into account. Furthermore, due the low possibility of new PRV's constructions, strategies for sharing existing European PRV capacities, as intended by the Arctic Research Icebreaker Consortium for Europe (ARICE) initiative, should be supported by the European Union, since in the horizon 2020 only three heavy icebreakers will be available and most PRV's will be at the tail end of their lifetime.

IV. SEA-ICE VARIABILITY IN THE POLAR REGIONS

a) Arctic

After a study over 32 years (1979-2010) of Arctic sea ice using microwave radiometers satellite data (Parkinson & Cavalieri, 2012), concluded that the sea-ice extent (the outer edge of the area covered with ice) and area trends vary widely by month depending on the region and season. The results of these three decades of observations show a remarkable decrease in the sea-ice area and the amount of multiyear ice (perennial) as illustrated in Figure 5.

In terms of areas for year-round research, the thicker/older sea ice is located north-north east of Greenland and Canada as shown in this recent ice extension image from NSDC (Figure 6).

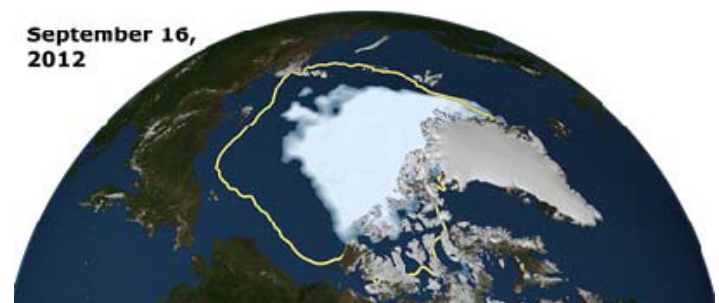


Fig 5. Minimum sea-ice extent, the yellow line indicates the average of the minimum sea-ice extent over last 30 years compared with the minimum sea-ice extent on September 16th 2012

b) Antarctic

In contrast with the dramatic decreasing sea-ice extent in the Arctic area, something more complex is happening in Antarctica (Fig. 7). A NASA study shows that from 1978 to 2010 (Parkinson, C. L. and Cavalieri, D. J., 2012) the total extent of sea ice in the Southern Ocean surrounding Antarctica grew at an average rate by roughly $17.000 \text{ km}^2 \pm 15\%$ every year, with some indications that this rate of increase has recently accelerated.

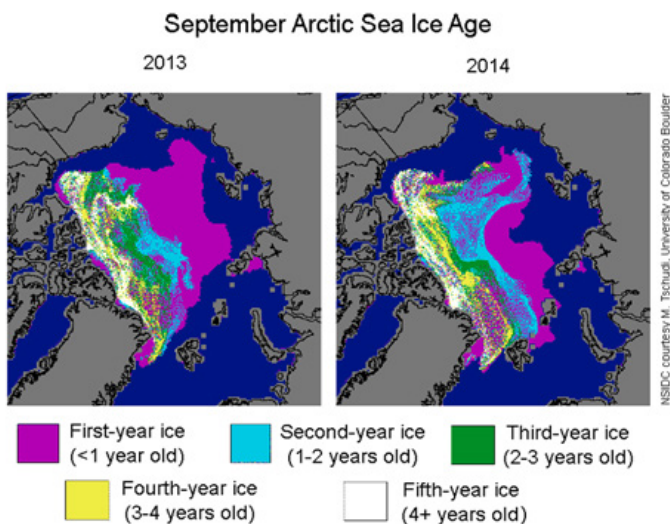


Fig 6. Variability of sea-ice ages between September 2013 and 2014 (after NSDC, 2015)

The European polar research fleet with ice classification able to work in thin to medium ice sheet shows a good coverage, mostly in autumn and summer time, at both poles in terms of both research and cargo capacities. These are vessels within the new polar categories B and C. Research has mostly been limited to the marginal sea ice zone areas that are accessible with the current icebreaking/icegoing capabilities.

However, the situation is quite different in terms of year-round European polar operations capacity, with only two PRV's ("Polarstern" and "Oden"); an analogue scenario applies for worldwide PRVs, even though it is more extensive in the Arctic because of the greater ice breaking capability of the Polar Class icebreakers such as USCG "Healy". Therefore, under these conditions, little research can be done during the polar winter or in areas with thick ice cover year-round, especially in Antarctica.

V. CONCLUSIONS

The capacity and infrastructure of the European Polar fleet does not reach the level that is needed by the European Polar Research Community, even when considering the ongoing construction projects of "Kronprins Haakon" and "Polarstern II", to support the societal demands and needs for multifaceted polar research targeting critical thematic issues such as climate change impacts at large, e.g. ocean circulation patterns, and sustainability in exploitation of natural resources addressing e.g. environmental issues, biodiversity, and systems ecology. There is, beyond doubt, an increased interest within the European society for Polar Research involving both an Arctic and an Antarctic dimension in support of a number of research and policy issues.

EU-PolarNet intends to establish an ongoing dialogue between policymakers, business and industry leaders, local communities and scientists to increase mutual understanding and identify new ways of working that will deliver economic and societal benefits. This consortium brings together science, business and policy teams with recognised expertise in the field of stakeholder and public engagement.

The Antarctic scenario is somewhat different, as a natural reserve, devoted to peace and science, due to the Antarctic Treaty System and the number of countries that have agreed to be bound by that system. However, in both regions the study of recent and past climate processes, ocean circulation and other topics,

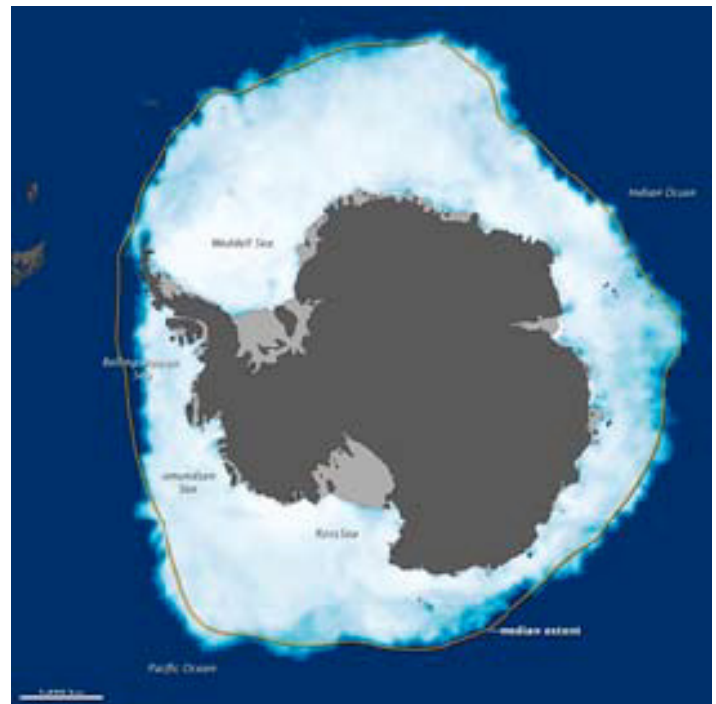


Fig 7. The average sea-ice extent in September from 1979 to 2010 is marked by the yellow line (after NASA/Goddard Space Flight Centre Scientific Visualization Studio)

require a complex and expensive scientific infrastructure, as well as significant continuing international cooperation. This paper benefited from EUROFLEETS2 Grant Agreement No. 312762 FP7-INFRA-0098, and EUPolarNet funded network Horizon 2020 Programme Grant Agreement No. 652641.

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ID36- DATA ACQUISITION SYSTEM DEVELOPMENT FOR EGIM ON EMSODEV EU PROJECT

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Abstract – The EMSODEV1 (European Multidisciplinary Seafloor and water-column Observatory DEVELOPMENT) is a UE project whose general objective is to set up the full implementation and operation of the EMSO distributed Research Infrastructure (RI), through the development, testing and deployment of an EMSO Generic Instrument Module (EGIM). The EGIM module will measure various ocean parameters in a long-term consistent, accurate and comparable manner. These measurements are critical to respond accurately to the social and scientific challenges such as climate change, changes in marine ecosystems, and marine hazards. Here we present the current status of the EGIM data acquisition system development

Keywords – EMSO, data acquisition, EMSODEV, EGIM, OGC, SOS, SES, SWE, 52 North, SensorML, Zabbix.

I. INTRODUCTION

The general objective of the EMSODEV project is to implement a Generic Sensor Module (EGIM) within the EMSO ERIC distributed marine research infrastructure. Our contribution in the implementation of the EGIM data acquisition system module (WP4 of the EMSODEV project) focusses on developing standard-compliant generic software for Sensor Web Enablement. The main objective of this development is to allow the registration and data acquisition of a new EGIM system and all sensors connected to it, to a centralised SOS server and to a laboratory monitor system (LabMonitor) for recording events and alarms. The primary aim is to validate the EGIM prototype system in shallow-water conditions. The acquisition layer is located in the structure of the system between the data source (EGIM) and the data management. Thus, two main interfaces are implemented. On one side, they should guarantee that the data has been recorded from the EGIM hardware and for the other side, it must implement a standardize OGC-SWE compliant SOS2 Gateway to allow polling data from data-management layer.

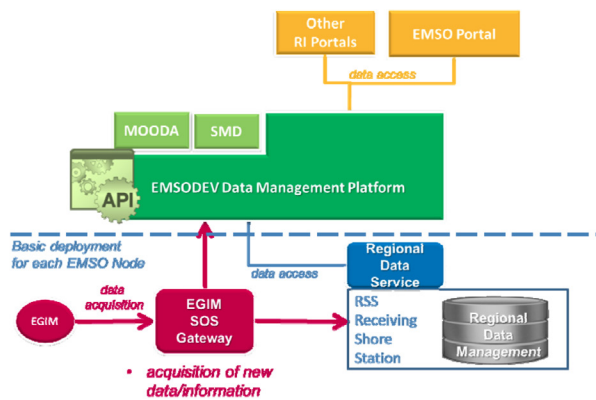


Figure 1 EGIM diagram showing SOS Gateway relations

II. SYSTEM OVERVIEW

In order to get all the hardware required by each components of this system we use a virtualization service, that virtualizes the hardware for each separate roll on the whole system generating three virtual machines ('Mussel', 'SeaShell' and 'Donax').

We have made three virtual machines; one for acquisition, another for SOS server and a third one for laboratory monitoring. Each one has been configured with the necessary resources (database container, web server, VPN client ...) provided with the necessary interfaces to communicate with the others hosts.

III. SOS GATEWAY INTERFACE

To accomplish the SOS Gateway requirement, and once we have analysed the

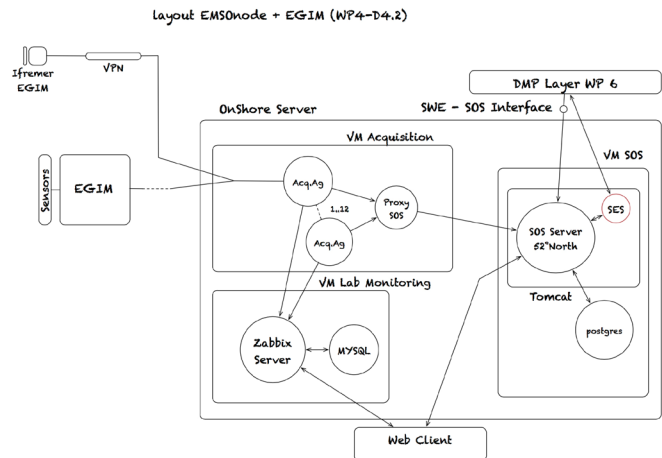


Figure 2 General Server and Services Layout

actual state of the art on SOS implementations, we have decided to use the 52 North SOS 2.0 implementation. This SOS implementation aggregates readings from live, in-situ and remote sensors. The service provides an interface to make sensors and sensor data archives both accessible through an interoperable web-based interface, using SensorML and Observation and Measurements (O&M). The main SOS 2.0 interfaces offered with this implementation are:

Core Extension

- GetCapabilities, for requesting a self-description of the service
- GetObservation, for requesting the pure sensor data encoded in Observations & Measurements 2.0 (O&M)
- DescribeSensor for requesting information about a certain sensor, encoded in a Sensor Model Language 1.0.1 (SensorML) instance document.

Enhanced Extension

- GetFeatureOfInterest, for requesting the GML 3.2.1 encoded representation of the feature that is the target of the observation.
- GetObservationById, for requesting the pure sensor data for a specific observation identifier

Transactional Extension

- InsertSensor, for publishing new sensors
- UpdateSensorDescription, for updating the description of a sensor
- DeleteSensor, for deleting a sensor
- InsertObservation, for publishing observations for registered sensors

Result Handling Extension

- InsertResultTemplate, for inserting a result template into a SOS server that describes the structure of the values of a InsertResult of GetResult request.
- InsertResult, for uploading raw values accordingly to the structure and encoding defined in the InsertResultTemplate request
- GetResultTemplate, for getting the result structure and encoding for specific parameter constellations
- GetResult, for getting the raw data for specific parameter constellations

For this deployment we use the 'Mussel virtual machine'. Therefore we deployed the 52 North web applications over a Tomcat web server container version 7, configured with a Postgres database container. Some other small configurations have been implemented for conditioning the application in our domain. For attending client requests, we have installed the JavaScript web client application from 52 North, which allows, in a lightweight manner, real time and historical data visualization using the SOS gateway. This web application has been opened to be accessed from outside the local network.

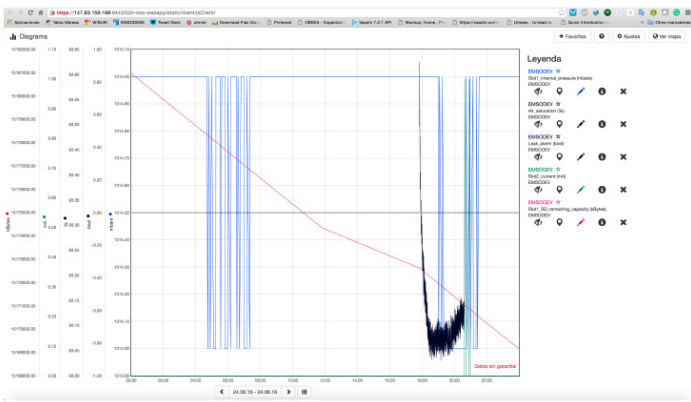


Figure 3 Visualization of EGIM status data on 52 North JavaScript web client

IV. ACQUISITION SERVICES

The acquisition environment has been deployed on the 'Seashell' virtual machine. On this server all the elements are configured to accomplish the acquisition requirements. This requirements includes the processes to acquire the data from the connected sensors to EGIM, we call this the acquisition agent, and to send the observations to SOS Gateway and to Lab Monitor systems.

To acquire data from EGIM system, we need to distinguish two kinds of reading procedures. First, there is a reading procedure for the external sensors connected to EGIM system at channels 1 to 12. This is done based on TCP Sockets connections. Second, there is a reading procedure of the internal sensors of EGIM, which is done based on readings of UDP packets to a specific port. Once the agent read this two kind of data, we use a 'proxy SOS' implemented tool, which is doing automatically all the write operation between the acquisition agent and the SOS Server. Hence, this tool is registering any new sensors connected to EGIM and send the InsertResult queries for each new data acquired from EGIM. Moreover, the acquisition agent is generating also JSON requests to Zabbix server, in order to add these values to the database of the Lab Monitor.

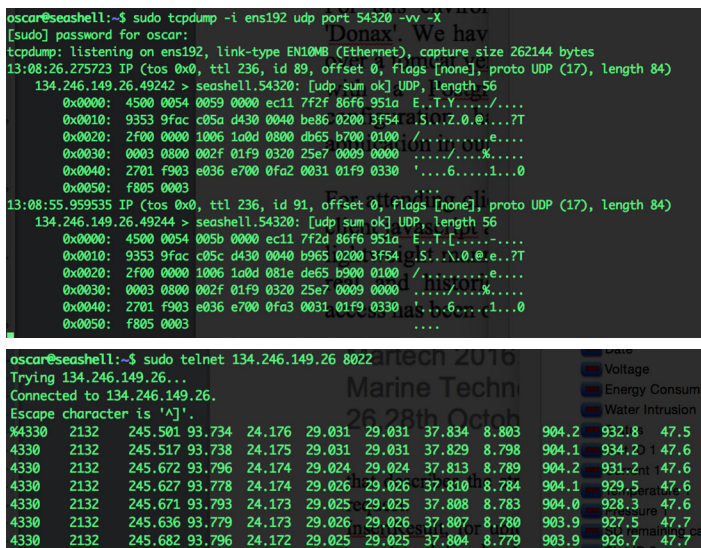


Figure 4 UDP and TCP data from EGIM

V. MONITOR LAB

To perform the benchmark test as well as for production processes, it is necessary to visualize some real data and historical trend data from sensors, with the objective to control some critical information by arranging some triggers. In the same manner, we need to monitor the correct behaviour of the whole system (EGIM Status data). For accomplishing this requirement, we have built a Lab-Monitor system, using the Zabbix4 open source application.

Zabbix is designed for monitoring availability and performance of IT infrastructure components. It works like a centralised monitoring system using active or passive agents for requesting or receiving from hosts. The system can use many protocols. In our scenario we use Zabbix agents to retrieve information about each virtual machine, and the observations from EGIM system retrieved by the acquisition agents..

For this purpose, we have created the 'Donax' virtual machine, which uses MySQL database as a data container and an apache web container for attending web client requests. In each server, it has been installed a binary Zabbix agent that is reporting all the information about the host to the Zabbix server. This functionality has been added also inside the acquisition software, to send all the data acquired from the EGIM system. The acquisition agent, gets the data received from EGIM sensors, and send it to the Zabbix server using a formatted JSON request. Then, the server informs to the client if the data has been created successfully or it sends a report in case of any problem arise. Once the data has been received on LabMonitor, the data is written to the database, and can be visualised on the web application. If a trigger has been configured for this data, the system will check the rule configuration and informs of any status change. We can also check the state of the EGIM equipment monitoring all the status values that come from EGIM status packed. We have configured alarms for critical data as the internal temperature, internal humidity, power consumption and water leak. In case of any reporting alarm occurs, we arranged a email account to receive a message every time the trigger switch on or off in the system, informing the sensor data involved and some more detailed information. Finally, we set up a public access for remote monitoring purposes, which only require a web client for real time system data access. Moreover, it is also feasible to request historical data, which could be really useful for analysing the events processes and crossing data.

VI. CONCLUSIONS

At the time of writing this document, we are in development phase and compiling all the necessary components for the final production environment (estimated to October 2016). For this reason, it may happen the data will have no much meaning or eventually some gaps on historical trends could appear. In the following months new development may introduce changes, such IP's, ports etc...

For the development phase, the connection to EGIM equipment is virtually implemented through VPN connection, and this kind of communication is not as stable as we would like. In a short time, estimated by September 2016 the system will work in real conditions. From then, the whole configuration will be the same, and we will only need to change the network interface configuration on the Acquisition Server Virtual Machine.

We are trying to improve the system complementing the way that Data Management Platform should get the data. Initially, this configuration requires a connection polling to request data from DMP to SOS Server. This implies two operations for each request data. We have installed the Sensor Event Service in SOS server, with the objective that, users with a publish/subscribe-based interface, could access to sensor data and measurements located at SOS server. Basically, SES produces notifications and provides methods to subscribe for notifications and retrieve the latest notification. Meanwhile, users can also register new sensors dynamically and send notifications to the service.

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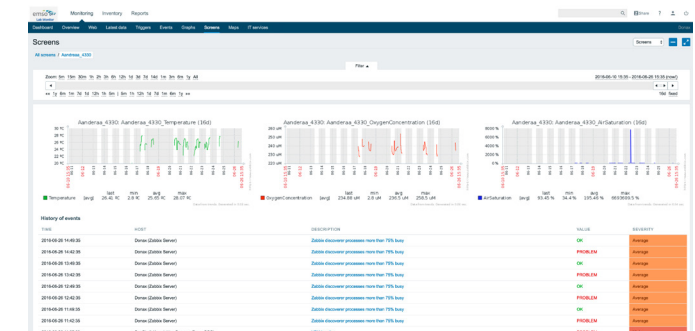


Figure 5 Zabbix Screen with Graphs and events

ID37- RANGE-ONLY BENTHIC ROVER LOCALIZATION OFF THE CENTRAL CALIFORNIA COAST

I. MASMITJA¹⁷⁴, S. GOMARIZ¹⁷⁵, J. DEL RIO¹⁸², B. KIEFT¹⁴⁷, T. O'REILLY¹⁴⁸

Abstract— Nowadays, the use of autonomous vehicles for ocean research has increased, since these vehicles have a better cost/performance ratio than crewed vessels or oceanographic ships. For example, autonomous surface vehicles can be used to localize underwater targets. This paper describes a mission to find a crawling robot - Benthic Rover - on the abyssal plain in the north eastern Pacific, using single-beacon localization from onboard a Wave Glider autonomous surface vehicle. While the Wave Glider is moving around the surface in the target zone, it takes ranges between the target and itself using acoustic modems. With these ranges it can compute the target location, as a Long Baseline (LBL) system. The benefit of this approach is the reduction of cost and complexity relative to deployment of a traditional shipboard LBL system. Additionally, this is a mobile system, and can cover long distances, and can geolocate multiple targets over a large area.

Keywords— target localization, underwater, vehicle, acoustic, benthic rover

I. INTRODUCTION

One of the main challenges in oceanographic research is that of underwater positioning. It is well known that GPS signals suffer a large attenuation underwater. Therefore different methods and architectures have been developed using acoustic signals, which have better underwater performance.

This paper presents a range-only target localization method, using a Wave Glider autonomous surface vehicle [1] that acoustically ranges to an underwater target while moving on the surface, using the ranges to compute target position. Therefore, we can consider this method as an LBL system with only one moving transponder on the sea surface.

The method presented in this paper can be used in a wide range of applications using the long-duration, autonomous navigation and computational characteristics of the Wave Glider, to locate stationary or slowly moving targets on the seabed or in the water column. In this work we present results of a mission to find a slowly moving crawling robot on the abyssal plain off the central California coast.

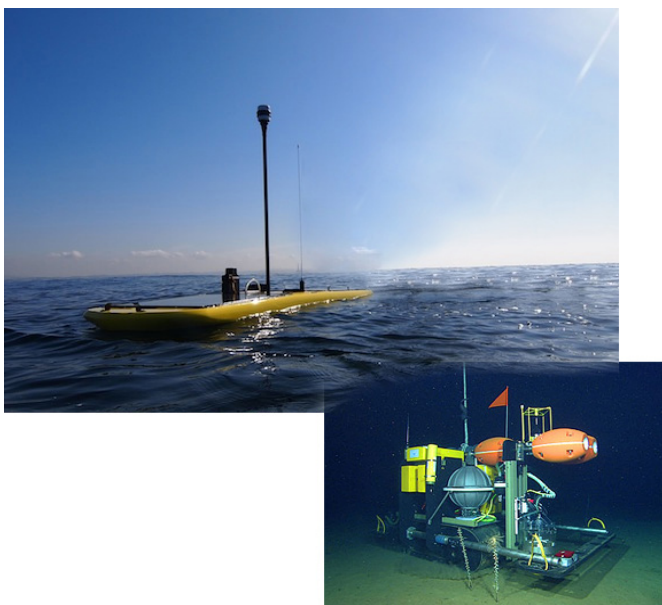


Fig. 1 Mission carried out in Monterey Bay, California, to localize a benthic Rover (down-right picture) using a Wave Glider (up-left picture) as a moving LBL.

II. MISSION CHARACTERISTICS

The benthic Rover (fig. 1) is a mobile physiology laboratory designed by Dr. Ken Smith at MBARI, which slowly crawls along the seafloor [2]. Typically, it moves about 5 m, stops to take a set of measurements for 3 days, then it moves another 5 meters to the next location. It can stay underwater for six to nine months, therefore it can travel hundreds of meters during this period. Therefore it is necessary to periodically determine its position in order to map the location of the measurement sites, and to eventually recover the vehicle. The Rover is equipped with an acoustic modem, to enable data and command exchange and ranging with a surface vehicle.

The most recent Rover deployment is at "Station M" in the north eastern Pacific, at 34° 50'N, 123° 00'W, 4000 meters depth, 220 km west of the central California coast. This location is approximately known from previous shipboard acoustic measurements.

The Wave Glider is equipped with an acoustic modem compatible with the one installed on the Rover. On April 14, 2016, we sent the Wave Glider to the Rover target zone to test our auto-localization algorithm. In our algorithm, the Wave Glider autonomously swims in a circle of specified radius, centered near the estimated target location. While swimming in the circle, the Wave Glider's onboard acoustic modem periodically measures the range to the target's acoustic modem.

Fig. 1 Mission carried out in Monterey Bay, California, to localize a benthic Rover (down-right picture) using a Wave Glider (up-left picture) as a moving LBL.

With these ranges and the GPS position of the Wave Glider, our software computes the target location using least squares or iterative minimization algorithms.

Detailed descriptions of the algorithm, mission characteristics such as mission time, maneuvers, initial deployment and Rover movements will be shown in the extended version of this paper.

III. RESULTS

The results obtained are shown in fig. 2, in which the circular path executed by the Wave Glider (round dots) and the computed Rover position (triangle) are shown. Furthermore, we can see range obtained for each Wave Glider position on the color bar. The UTM position for benthic Rover obtained with this algorithm is (500523.820928, 3888509.15227, 3977.3), which is x, y and z in meters.

Figure 2. Target localization results. In this picture we can see the circular path executed by the Wave Glider in order to localize a benthic Rover.

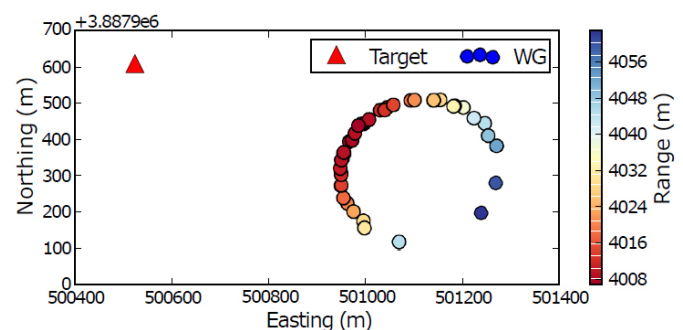


Figure 2. Target localization results. In this picture we can see the circular path executed by the Wave Glider in order to localize a benthic Rover.

IV. CONCLUSIONS

This work describes a field test conducted to acoustically localize a benthic Rover deployed at 4000 m depth from an autonomous surface vehicle. For this purpose a new application using a Wave Glider as a single-beacon LBL has been developed. The work presented in this paper proves the good performance of this method.

ACKNOWLEDGMENT

This work was partially supported by the project NeXOS from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No 614102. We also had financial support from Spanish Ministerio de Economía y Competitividad under contract CGL2013- 42557-R (Interoperabilidad e instrumentacion de plataformas au-

tonomas marinas para la monitorizacion sismica, INTMARSIS). The main author of this work have a grant (FPI-UPC) from UPC for his PhD research. We gratefully acknowledge the support of MBARI and the David and Lucile Packard foundation.

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ID38- DATA COMPARISON BETWEEN THREE ACOUSTIC DOPPLER CURRENT PROFILERS DEPLOYED IN OBSEA PLATFORM IN NORTH-WESTERN MEDITERRANEAN

MATIAS CARANDELL WIDMER²²³, MARC NOGUERAS CERVERA²²²

Abstract – Three different Acoustic Doppler Current Profilers (ADCP) have been deployed in OBSEA platform, a 20 meters depth underwater observatory cabled with a 4 km mixt cable to Vilanova i la Geltru's coast. Two months of continuous data have been collected in order to confirm their proper operation and long term North current characteristic from the area.

Keywords – ADCP, Doppler Effect, North current

I. INTRODUCTION TO THE DOPPLER EFFECT

The Doppler effect is the difference in frequency that can be appreciate in a wave when the observer is moving in different directions. In example, an observer walking into the waves will see more waves in a given interval than someone standing still, and this will see even more than an observer moving away [1]. ADCPs use the Doppler effect by transmitting sound at a fixed frequency and listening to echoes returning from scatterers in the water. These scatterers are everywhere in the ocean and they float in the water moving on average at the same horizontal velocity as the water. So ADCP receives sound echoed from the scatterers and Doppler-shifted to a different frequency proportional to their

movement. The angular motion causes no Doppler shift, only the radial one. ADCPs use multiple beams pointed in different directions in order to calculate different velocity components. With three beams, east, north and up velocity can be calculated and there's an extra one to estimate the validity of the sensor data.

II. OBSEA PLATFORM

OBSEA is an underwater observatory connected to the coast with a 4 km mixt cable that provides power and data. It is placed at a depth of 20 meters in a fishing protected area near the coast of Vilanova i la Geltru'. The main advantage of the cable observatory is the capacity to feed the station from the land up to 3.6 kW and the high bandwidth communication link of 1 Gbps. This gives the opportunity of observe in real-time multiple marine environment parameters. The main objective of OBSEA is to have a test bed for the development of oceanographic instrumentation while providing real time data to the scientific community.

This platform counts on two subsea nodes in series and one Buoy connected to the first one. Further, there's a secondary buoy connected to the first recently

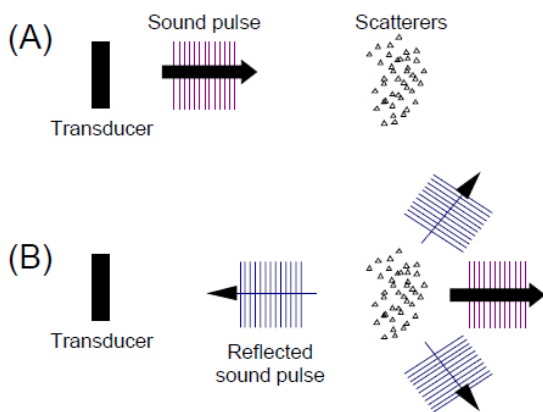


Fig 1. Backscattered sound. (A) Transmitted pulse; (B) A small amount of the sound energy is reflected back (and Doppler shifted), most of the energy goes forward.

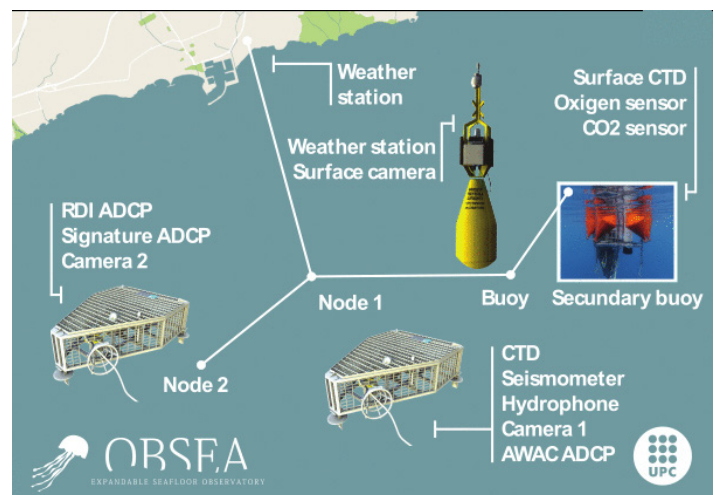


Fig 2. OBSEA platform distribution

installed. Each has its own instruments such as ADCPs, CTDs cameras or a seismometer. The actual distribution of OBSEAs platform can be seen in figure 2.

III. ADCPS CHARACTERISTICS AND SET UP

Three ADCPs have been deployed, two of them are Nortek technology and the third is from RD Instruments. The ones build by Nortek are able to measure current profile and waves height and direction while the RDI ADCP only provides the current profile. In this paper only the current profile data would be considered.

The three ADCPs include the follow sensors: tilt, pressure and temperature. All can be powered by batteries but are cabled to OBSEA nodes to provide real time data. This communication is through RS232 or RS422 in all cases. Each one has its personal software for communication.

The first that had been installed was the AWAC ADCP from Nortek (figure 3). It was first deployed in March of 2013 and it works at 1 kHz. It is connected at OB-



Fig 3. AWAC [Nortek] ADCP

SEA node 1, supported with a tripod at 10 meters and powered at 12 V. As it can be seen in figure number 3, it has 4 beams, 1 vertical and 3 at 25°.

It was bought by CSIC (Consejo Superior de Investigaciones Científicas) for OBSEAs usage. In April 2016 it was deployed the Sentinel ADCP in OBSEAs node 2. It is fixed to the cage of node 2 with brackets. In this case, it is powered at 48 V and works at



Fig 4. Sentinel [RD Instruments] ADCP

600 Hz. It can be appreciated from figure 4 that it has 4 beams symmetrically distributed in angle. It is property from SmartBay and deployed under the funding of SMARTSEA project of FixO3. The objective of this project is to test SmartBay equipment in a real scenario (OBSEA) before the deployment in Galway. Further, to train SmartBay personnel on operational procedures and, finally, to compare data and exchange know-how.

The last ADCP deployed has been the Signature from Nortek (figure 5). It works at 1 kHz and it's powered at 12 V. As the AWAC, it is supported with a tripod at 10 meters from node 2. This ADCP belongs to Nortek and it's in OBSEA under CISWE project funding from FixO3. The aim of CISWE is to execute a comparison of data between two Nortek currentmeters during a long period of time in order to perform the following: evaluation of the current speed estimations, evaluation of the current direction estimations and, evaluation of the power consumption.



Fig 5. Signature [Nortek] ADCP

Differences between both instruments.

It is important to avoid interferences between instruments. For this reason, no ADCP has been deployed nearby with the same frequency. AWAC (1 kHz) is at node 1 and Sentinel (600 Hz) and Signature (1 kHz) had been deployed at node 2. Additionally, magnetic interferences should be avoided to prevent errors in the compass side. It has been considered not to deploy instruments with magnetic materials in their supports. Both node cages are built with Stainless Steel. All ADCPs have been set up with the same configuration so data comparison could be done. Taking care OBSEA is 20 meters depth, 20 beams have been established, each one 1-meter height. In Sentinel ADCP only 19 cells were configured. ADCP measures the velocity at different distances from the transducer by measuring the Doppler shift of the returning signal at different times. No measurements are made immediately in front of the transducer in what is referred to as the blanking region. This allows time for the transducers and electronics to recover from the transmit pulse. The blanking region had been used to place the beginning of the first cell in each ADCP at the same position. Considering that the height of tripods and node cages are different, different blanking height were set up in order to align cells between ADCPs.

Finally, the sampling interval should be determined. It is not mandatory but setting the same in all ADCP is recommended.

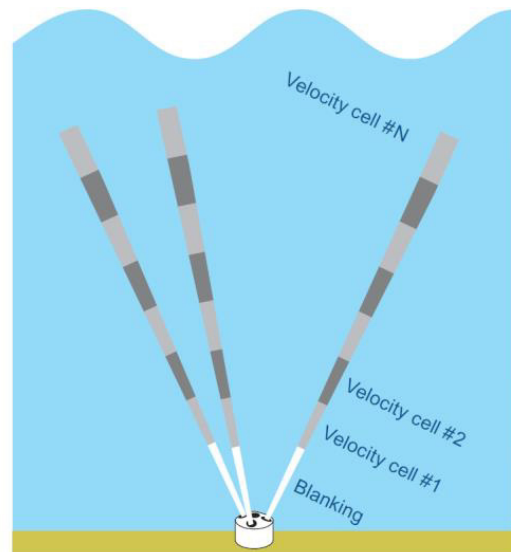


Fig 6. ADCP set up, Cells and Blanking

600 Hz. It can be appreciated from figure 4 that it has 4 beams symmetrically distributed in angle. It is property from SmartBay and deployed under the funding of SMARTSEA project of FixO3. The objective of this project is to test SmartBay equipment in a real scenario (OBSEA) before the deployment in Galway. Further, to train SmartBay personnel on operational procedures and, finally, to compare data and exchange know-how.

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Finally, the sampling interval should be determined. It is not mandatory but setting the same in all ADCP is recommended.

IV. DATA TREATMENT

To validate the correct functionality of all ADCP two months of data have been

collected. In each sampling moment, data of velocity in east, north and up components are collected for each cell in all current meters.

Getting data in a sample rate of 10 seconds, an hour average has been calculated for each velocity component (east, north, up). Multiplying this data per time we obtain the accumulated displacement of current for each cell and ADCP for an interval of time.

This can be plotted as it's done in figure number 7 and 8 where displacement of water can be appreciated for an interval of time.

V. CONCLUSIONS

Figures 7 shows the displacement of water between 18-04 and 09-05 in 2016 in AWAC. As it can be seen water has moved about 30 km south and 120 km west (depending on the cell position). Although there are some days of turbulent movement, generally it has a south-west direction, parallel to the coast and following the North Current direction that describes the zone of north-western Mediterranean.

Figures 8 shows the displacement of water between 18-04 and 09-05 in 2016 in RDIs ADCP. The plot shows that water displacement components were 45 km south and 120 km west. In this plot can be seen, again, the characteristic North current because it has generally a south-west component, parallel to the coast.

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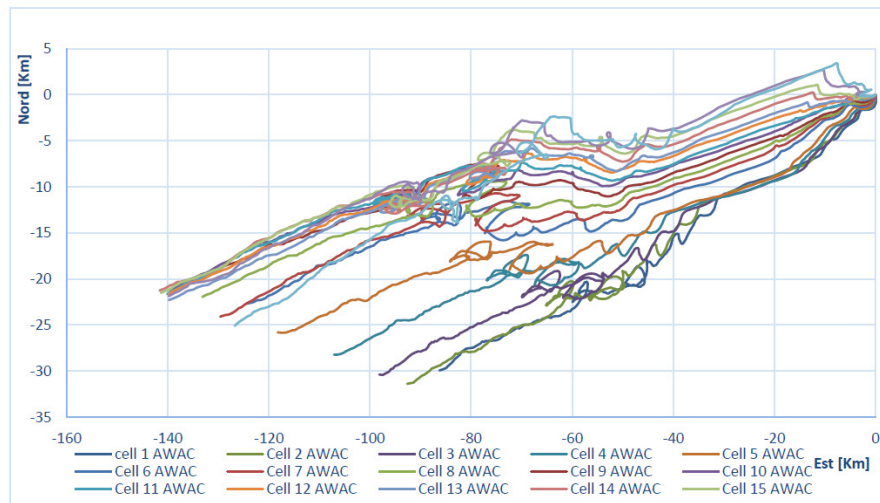


Fig 7. AWAC horizontal displacement of water

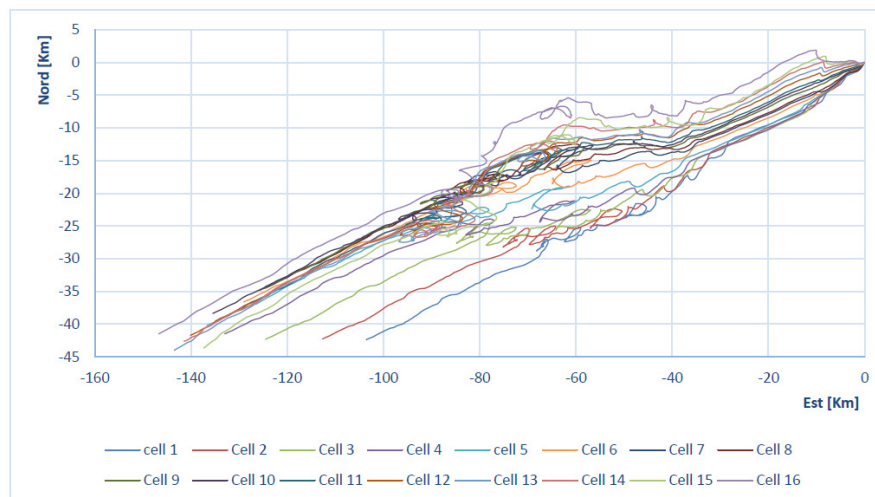


Fig 8. RDI horizontal displacement of water

ID39- HIGH FREQUENCY PCO2 MONITORING IN THE MEDITERRANEAN COASTAL WATERS.

MAITE BÁEZ-HERNÁNDEZ¹⁷⁰, MELCHOR GONZÁLEZ-DÁVILA¹⁷¹, J. MAGDALENA SANTANA-CASIANO¹⁶⁹, MARC NOGUERAS²²², JOAQUÍN DEL RÍO¹⁸²

Abstract –Monitoring the Air-Sea pCO₂ variability in the coastal areas is a priority due to the effect of the biological and biogeochemistry process on this process. The Northwestern Mediterranean Sea is an oligotrophic area in a semi-closed basin, therefore the changes on the surface waters properties take place faster than in other seas. This work focuses in the establishment of a pCO₂ monitor system and other related sensors at the OBSEA surface buoy.

Keywords –Air-Sea pCO₂, Development, OBSEA, Surface buoy, pCO₂.

I. INTRODUCTION

The ocean waters had absorbed approximately 30% of anthropogenic CO₂ emissions [1]. This processes contributed to the global carbon cycle, changing the ocean chemistry. The coastal areas play an important role on this system due to the physics and biogeochemistry processes can resist or amplify the effect of the increased CO₂ partial pressure.

The Mediterranean Sea is a semi-closed basin [2] with a surface ocean circulation of Atlantic water which produce baroclinic instability and eddies. The biogeochemistry studies shown high variations on distribution and concentrations of nutrient in surface waters, even so is generally considered an oligotrophic area [3].

Due to its structure, processes occurring on a global scale can be approximated to smaller time and space scales. The aims of this study are:

1. Characterizing the carbon system in the Northwestern Mediterranean Sea and the Temporal evolution of the Air-Sea fluxes
2. Evaluate the effects of nearness coast areas on the Air-Sea pCO₂.
3. Estimate the inter-annual, seasonal and diary variations on the partial pressure of CO₂ and the processed that control it.

II. METHODOLOGY

The OBSEA seafloor observatory was selected for deployment the Battelle pCO₂ sensors in order to monitorize this area. A coastal site has been selected in order to consider the advantages of the remote and real time control.

Connected to the main buoy of the OBSEA platform, a structured with the 3 systems was installed (FIG. 1).

1. Autonomous Battelle Seaology pCO₂ Monitoring System. Provides time series measurements of ocean and atmospheric carbon dioxide and air-sea exchange. This equipment is set to provide values each 3 hours (00, 03, 06...) (Fig.2).
2. Oxygen Optode 4835, measuring the oxygen concentration and air saturation each 30 seconds (Fig.3).
3. Sea-Bird Microcat to determinate the sea surface temperature and salinity with a 10 seconds interval measure (Fig.4).

The data for all the equipment is receive in real time and every last data is pub-



Figure 1. OBSEA buoy and the Systems Structure after the deployment on 28th of June 2016.

lished at the OBSEA web (<http://www.upc.edu/cdsarti/OBSEA/data/co2.php>). In order to study the carbonate system variables, discrete samples for total Alkalinity and total dissolved inorganic carbon measurements will be collected.

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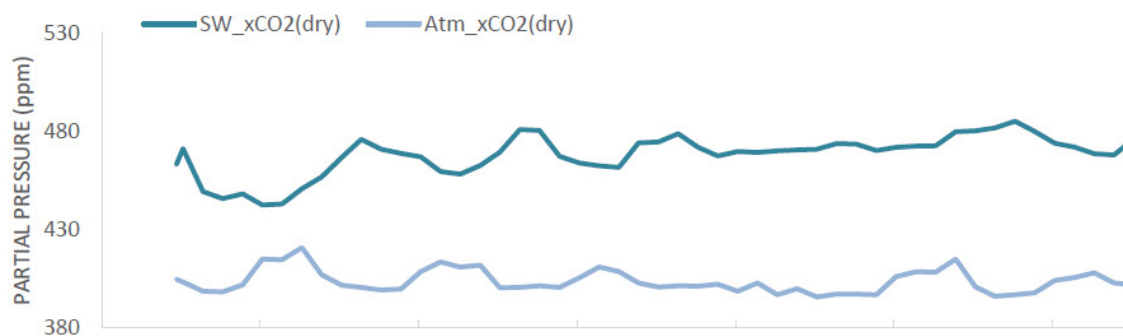


Figure 2. Data collected from the CO₂ Monitor System 29/06 - 5/07

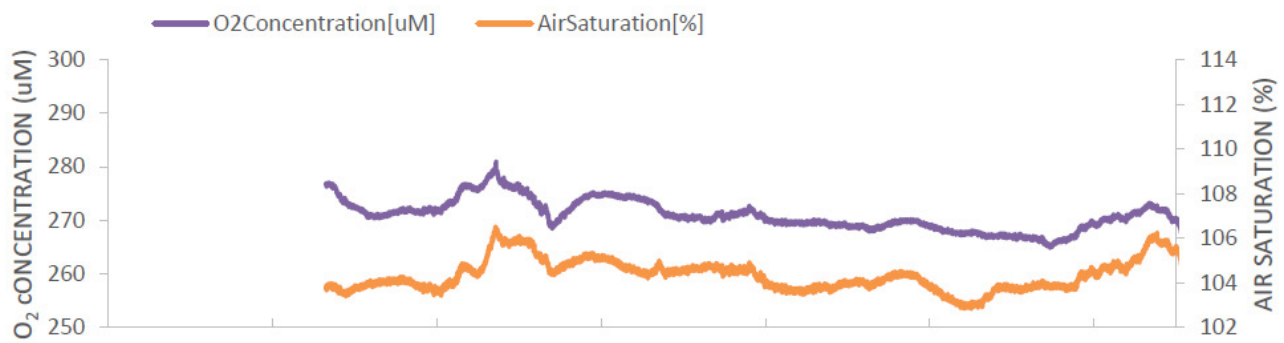


Figure 3. Data collected from the Oxygen Optode 30/06 – 5/07

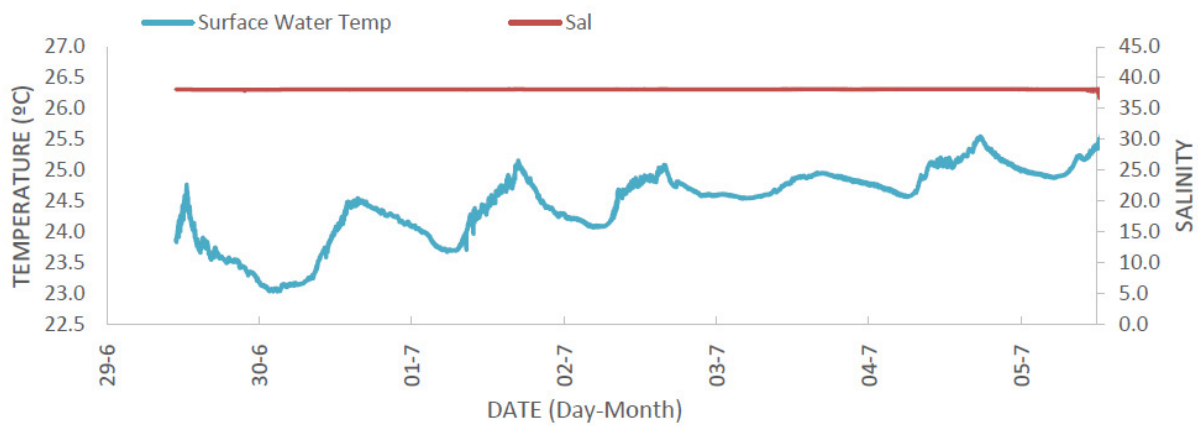


Figure 4. Data collected from the Microcat 29/06 – 5/07

ID40- NOISE AND BIOLOGICAL SOUNDS: ARCTIC SOUNDSCAPES DURING THE 2013 AND 2014 SEASONS

MIKE VAN DER SCHAAR¹³⁴, ANJA JOHANSEN HAUGERUD¹⁸⁹, JÜRGEN WEISSENBERGER¹⁹⁰, MICHEL ANDRE¹³³

Statoil deployed three acoustic recorders from fall 2013 to fall 2014 in the Arctic region as part of a broad scientific campaign. One recorder was installed in the Barents Sea southeast of Spitsbergen. Two other recorders were installed in the Greenland Sea north-east of Greenland. All recorders were operating at a duty cycle of 2 minutes on and 30 minutes off, sampling at 39062 Hz and recording in 24 bits. This presentation will report the acoustic analysis done on the data using SONS-DCL, comparing the results between the different locations and putting emphasis on the differences in received sound levels mostly due to ice movement, anthropogenic sources and the presence of cetaceans in the different seasons. For the Greenland Sea data, an overview will be presented of the relationship between received levels and distance of a detected seismic survey. As

for the animal presence it was found to be minimal during the summer months, although sperm whales were present all year round and some fin whale calls were received in early summer as well. Bearded seal presence was very seasonal from around April to June both at Spitsbergen and Greenland. Bowhead whale presence at Greenland was especially strong during the winter, with possible humpback presence at Spitsbergen. But no attempt was made to distinguish humpback and bowhead whale calls. At Spitsbergen belugas or narwhals were present; at the Greenland recorders there were fewer dolphin signals, and those found were most likely from white beaked dolphins. A number of unidentified acoustic events were detected as well. These data will be shown here, but are also available for playback from a dedicated website.

ID41- SWE BRIDGE: SOFTWARE INTERFACE FOR PLUG & WORK INSTRUMENT INTEGRATION INTO MARINE OBSERVATION PLATFORMS

ENOC MARTÍNEZ¹⁷⁸, DANIEL M. TOMA¹⁸¹, JOAQUÍN DEL RÍO¹⁸², ÓSCAR GARCÍA²¹⁰, IKRAM BGHIEL¹⁷⁹

Abstract – The integration of sensor systems into marine observation platforms such as gliders, cabled observatories and smart buoys requires a great deal of effort due to the diversity of architectures present in the marine acquisition systems. In the past years important steps have been taken in order to improve both standardization and interoperability, i.e. the Open Geospatial Consortium's Sensor Web Enablement. This set of standards and protocols provide a well-defined framework to achieve standardized data chains. However a significant gap is still present in the lower-end of the data chain, between the sensor systems and the acquisition platforms. In this work a standards-based architecture to bridge this gap is proposed in order to achieve plug & work, standardized and interoperable acquisition systems.

Keywords – Platform integration, interoperability, standards, sensor web enablement.

I. INTRODUCTION

Marine sensor systems and marine observation platforms are generally developed by relatively small and medium sized companies and research institutions, resulting in a vast variety of architectures and implementations, usually custom-made and, in many cases, using proprietary communication protocols. Moreover, a given kind of sensor may be deployed into different platforms such as gliders, cabled observatories and smart buoys, to name a few.

Due to the large variety of sensor protocols and sensor interfaces, most applications integrate sensor resources through proprietary mechanisms, instead of using a well-defined integration layer. This manual bridging between sensors and applications requires an in-depth knowledge of the platform's hardware and software architecture, as well as knowledge of proprietary protocols implemented by the sensor [1]. In order to address this issue the Open Geospatial Consortium (OGC) has defined a set of standards that conform the Sensor Web Enablement (SWE).

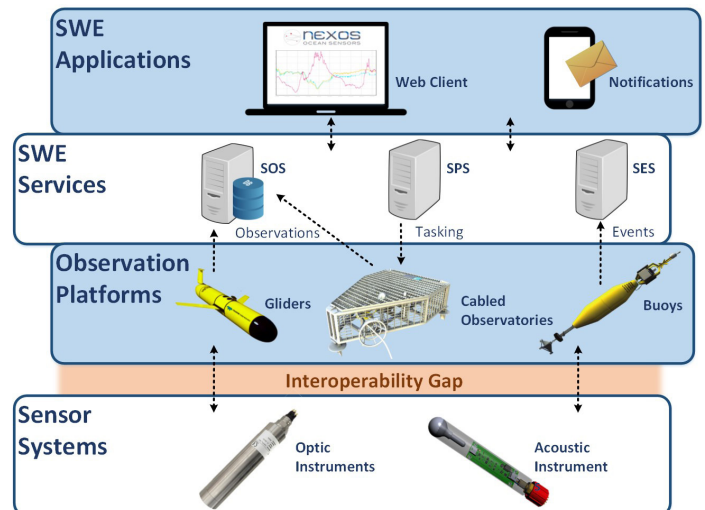
The SWE framework has been progressively adopted by the ocean community as a standard approach to manage data in an interoperable way. Within this framework the Sensor Web is defined as "Web accessible sensor networks and archived sensor data that can be discovered and accessed using standard protocols and application programming interfaces" [2]. To achieve this objective a coherent and modular approach needs to be taken when treating both instrument data and metadata. Metadata is indispensable, as it may contain information about the validity of the acquired data, such as calibration coefficients, instrument identifier's, absolute errors, etc.

There are several implementation of SWE services and SWE applications that have been developed and presented to the community the past years. However, there is not any standardized mechanism to integrate a new sensor to an existing SWE infrastructure. Thus, the development of a specific driver to convert the sensor system proprietary output to standard SWE format is still required.

II. SWE BRIDGE OVERVIEW

The Sensor Web Enablement Bridge (SWE Bridge) aims to bridge the gap between sensor systems and observation platforms. It is an auto-configurable acquisition software meant to be deployed in any kind of observation platforms, fixed or mobile, whose main objective is to provide plug & work capabilities to any instrument, whether it is SWE-compliant or not.

Regarding its implementation, the SWE Bridge is a modular, light-weight and resource-efficient software component written in ANSI C in order to improve portability across platforms. Special attention has been paid in creating a hardware abstraction layer, which permits the use of different communications interfaces (i.e. RS-232, TCP/IP, UDP, etc.), operating systems (UNIX, Windows, etc.) and even different file systems. This design permits the deployment in a wide variety of observation platforms, with or without operating system.



III. SWE BRIDGE STANDARDS AND SERVICES

In order to provide plug & work capabilities to an acquisition system, four operations are required: instrument detection, description, configuration and data retrieval. The SWE framework provides a set of standards that can fulfil these requirements, i.e. PUCK protocol and SensorML standard.

The OGC PUCK protocol addresses installation and configuration challenges for sensors by defining a standard protocol to store and automatically retrieve metadata and other information from the instrument device itself. This protocol provides auto-identification and auto-definition capabilities to an instrument [3].

The Sensor Model Language (SensorML) provides a robust and semantically-tied means of defining processes and processing components associated with the measurement and post-measurement transformation of observations. This includes sensors and actuators as well as computational processes applied pre- and post-measurement. SensorML can provide an exhaustive definition of a sensor, instrument or even observation platform in structured format such as XML, providing a complete description of an instrument metadata [4].

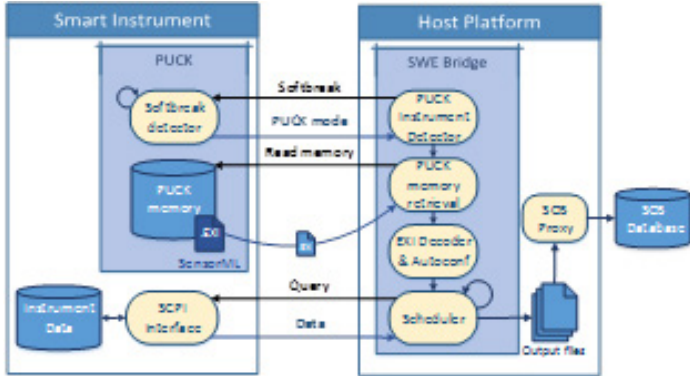
Nonetheless, the acquisition chain does not end at the observation platform, but the data has to flow from the instrument to the acquisition server where it will be stored. To continue the data chain a standard output compatible with the Sensor Observation Service (SOS) has to be provided [1].

IV. ARCHITECTURE

The SWE Bridge takes a SensorML description file as input, which describes a specific instrument: name, manufacturer, unique identifiers, communication interface, commands, etc. Thus, the whole communications layer and the instrument information are described within this file.

In the case of PUCK-enabled instruments, the SensorML file is stored within the instrument PUCK memory. This file can be automatically retrieved by the SWE Bridge, without previous knowledge of the instrument. Otherwise if the instrument does not have this protocol implemented, the file can be stored locally in the Observation Platform. In this case the auto-detection capability is lost, while the auto-description and auto-configuration capabilities are maintained. The SWE Bridge reads and decodes this file, auto-configuring itself with the retrieved information, establishing a communication link according to the instru-

ment description. Afterwards, it starts getting data from the instrument in push or pull mode, using the instrument's proprietary communication protocol. The data retrieved from the instrument is stored in SWE-compliant XML files that can be directly injected in the SOS database.



V. CONCLUSIONS

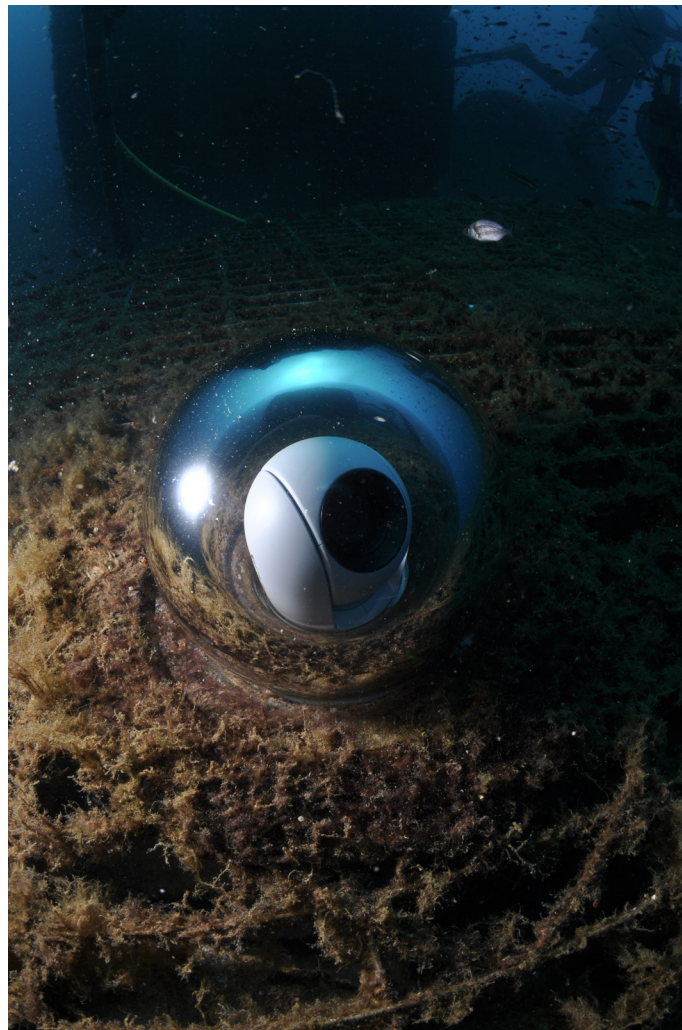
The Sensor Web Enablement Bridge provides a powerful way to minimize the efforts for integrating an instrument into different platforms due to the capability of auto-detection and auto-configuration. Only a minimal effort is needed to generate a SensorML description file to integrate new sensors. Once the instrument is plugged to any Sensor Web Enabled platform data flows from the sensor to the SOS database automatically.

ACKNOWLEDGMENT

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ID42- FIRSTS UNDERWATER POTENTIOSTAT SEA-TESTS IN THE OBSEA

I. MASMITJA¹⁷⁴, J. J. DE DAMBORENEA¹³, A. CONDE¹², P. DAPONTE⁴⁹, S. RAPUANO⁵⁰, J. DEL RIO¹⁸²

Abstract—Corrosion due to seawater studies are urgently required for a safe technology development. Some studies demonstrated that the corrosion rates for most alloys could be four times less than surface corrosion rates. A device for continuous electrochemical measuring of corrosion in real time and underwater has been designed. Therefore, this equipment allows improving the knowledge about long-term materials behavior in this aggressive environment for the scientific community. Also, it has been designed to allow the connection to underwater observatories such as OBSEA. In this paper we expose the first tests have been conducted in a real environment such as OBSEA.

Keywords— Potentiostat; corrosion; electrochemical; real-time; sea-tests;

I. INTRODUCTION

Corrosion studies due to seawater are very interesting for the scientific community to develop a safe technology. It is well known that the corrosion rate is influenced by the amount of dissolved oxygen in seawater, since oxygen is an active cathode depolariser. Also there are more factors, such as temperature, salinity, current velocity, wave action, biofouling, and so on [1] [2]. However, there is no electrochemical data in situ and in real time about it. The possibility to measure corrosion potential, polarization curves or others parameters open new possibilities for electrochemical measurements under the sea that never before have been done.

For this purpose a new concept of potentiostat has been developed with capabilities to allow connection to an underwater observatory such as OBSEA. It can be seen in our previous work [3]. In this paper we presented the first sea-tests carried out in the OBSEA.

This paper is organized as follows. Section II and III describes the potentiostat and electrodes cells. Section IV reports the device deployment. Finally the sea-tests are shown in section V.

II. POTENTIOSTAT

The block diagram of the potentiostat system connected to the underwater observatory OBSEA is shown in figure 1. The basis of the implemented system is formed by the Potentiostat and the Electrode under test, the OBSEA infrastructure and the PC with a specific software to control and acquire measurements from the potentiostat in real-time.

On other hand, in the OBSEA we have different instruments to monitoring the environment. Therefore, we can use these instruments to observe, compare and correlate the evolution of the electrodes under test with different parameters such as temperature, pressure, salinity and currents. Also we can observe the degradation and the effect of biofouling thanks to an underwater web cam connected permanently to the observatory (see chapter IV).

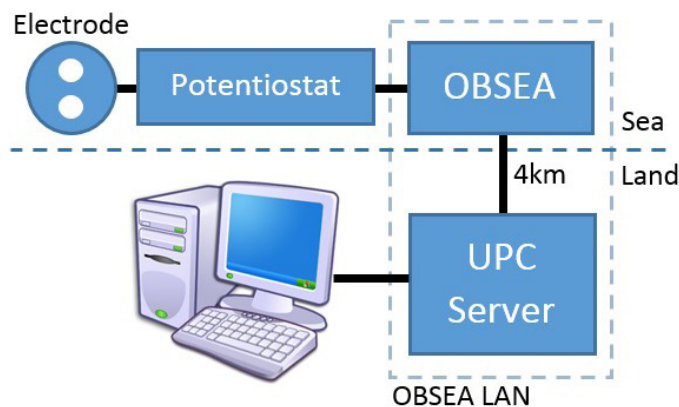


Figure 2 (A) shows the potentiostat device in his standard box. This box is not waterproof and is only designed to work in a laboratory. Otherwise, figure 2 (B) shows a specific cylinder with a capability to support depths down to 200m where the potentiostat have been introduced to deploy it in the OBSEA. Also, in this picture the hyperbaric chamber and others electronics components to perform both pressure and communication final tests are shown.

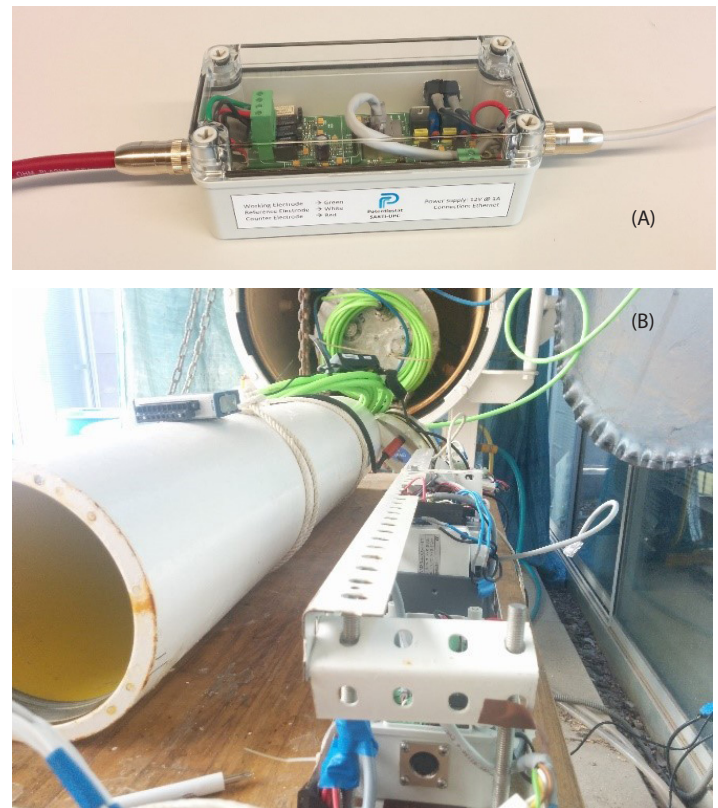


Fig. 2. (A) Potentiostat with standard box. (B) It shows the potentiostat with waterproof cylinder and a hyperbaric chamber for tests.

III. ELECTRODES

In this first deployment we used a three electrodes cell made with two identical stain steel electrodes (as counter and working) with 0.3cm² and one platinum electrode (as reference). Figure 3 shows these electrodes, picture (A) is the cell for laboratory purposes and picture (B) is the cell designed to deploy it with the potentiostat in the OBSEA.

IV. POTENTIOSTAT DEPLOYMENT

The OBSEA underwater observatory (www.obsea.es) is connected with 4 km of cable to the coast of Vilanova i la Geltrú (Barcelona, Spain) and placed at a depth of 20 meters.

Figure 4 shows the first deployment of the potentiostat in the OBSEA. In the center of the picture is an artificial biotope on the top is the observatory and on the bottom is the potentiostat connected with a yellow cable.

(left) Fig. 1. It shows the block diagram of potentiostat system connected to the OBSEA LAN.

V. SEA TESTS

First's tests have been carried out with potentiostat in the OBSEA. In these tests we carried out measurements of noise, acquiring the voltage and the current between counter and working electrode.

During first test have been obtained 90 days of information. These data has compared with the information of the environment (temperature, salinity, etc.). Figure 5 (A) shows one of these comparisons, in this case between current and temperature during the test. Figure 5 (B) shows a consecutive images of the electrodes cell obtained with the web cam of the OBSEA. These images will help to correlate the electric information obtained with some biofouling or others oceanographic phenomena.

VI. CONCLUSIONS

These initial tests demonstrate the good behavior of the potentiostat system designed and his capability to do electrochemical measurements in-situ for a long period of time. In future work, we will carried out more long term studies with this new instrument.

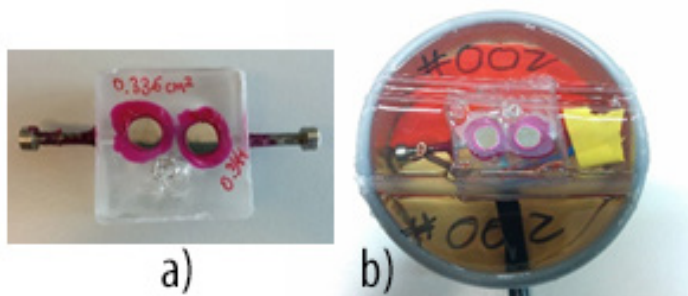


Fig. 3. (A) Three Electrode Cell. (B) Three Electrode Cell with waterproof enclosure.

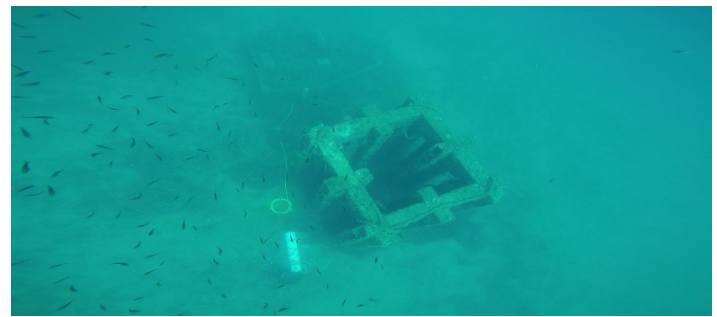


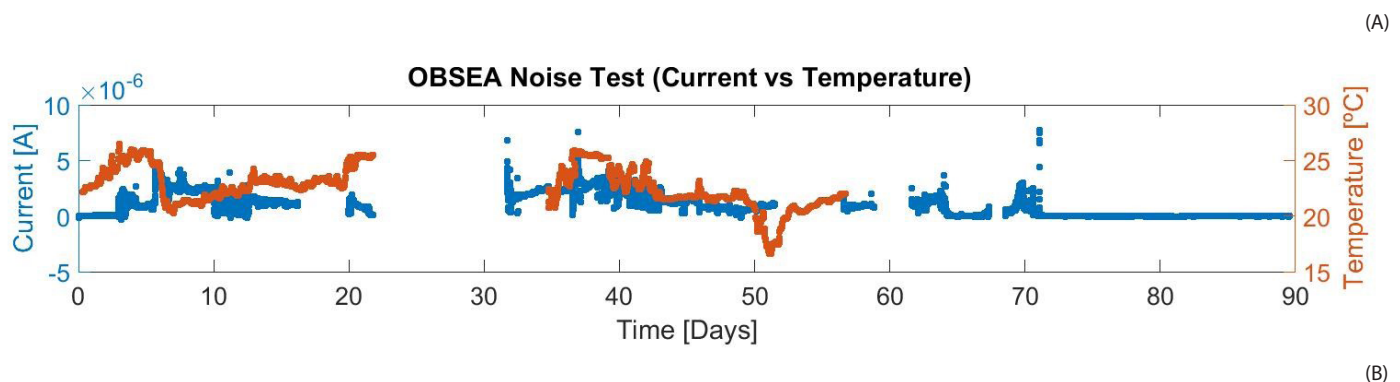
Fig. 4. Potentiostat deployment in the OBSEA.

ACKNOWLEDGMENT

This work was partially supported by the projects NeXOS and FixO3 from the European Union's Seventh Programme for research, technological development and demonstration under grants agreement No 614102 and No 312463 respectively.

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(A)

(B)

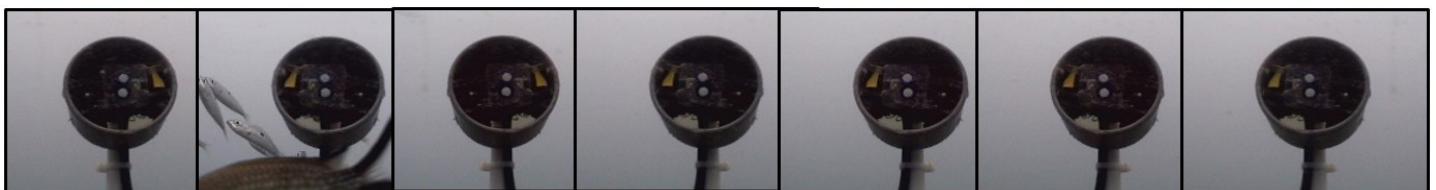


Fig. 5. (A) It shows a comparison between current of working electrode with the temperature of the water. (B) It shows a consecutive images of the electrodes cell (7 minutes between images)

ID43- A BIG DATA ARCHITECTURE DESIGNED FOR OCEAN OBSERVATION DATA MANAGEMENT

PASQUALE ANDRIANI⁶⁷, MASSIMILIANO NIGRELLI⁶⁸, DARIO PELLEGRINO²³⁷, LEANDRO LOMBARDO²⁴², LUCIO BADIALI⁹⁴

The focus of this paper is on the architecture and the early-stage prototyping of a data management platform which is able to collect oceanographic measurements coming from both sensors deployed in different ocean observatories located in European waters (through EGIMs - EMSO Generic Instrument Module) and existing EMSO regional nodes (a European-scale research infrastructure of seafloor observatories).

The EMSODEV project (funded under the Horizon 2020 Programme, H2020-INFRADEV-1-2015-1, Grant Agreement n°676555) will include a Data Management Platform which will simultaneously collect, analyse and make a number of chemical and physical ocean parameters available, addressing needs from a very large scientific user community including biologists, geoscientists, chemists, and engineers.

The platform enables the exploitation of e-Infrastructures capabilities with the final goal of developing flexible and scalable data management services for long-term, high-resolution, (near)-real-time monitoring of environmental processes (e.g. natural hazards, climate change and marine ecosystems)

A big data architecture is a key requirement to guarantee availability, scalability and fault-tolerance for a state-of-the-art data management platform that is able to ensure flexible processing capabilities, pluggable data analysis services and a homogenised data access.

The early-stage data management platform prototype is based on the open source Hortonworks distribution of the Hadoop platform and includes a set of common services, compliant to the ENVRI reference model through the RM-ODP reference model:

- data acquisition and transformation services;
- data curation services (including data storage and partitioning, data quality checking and cataloguing services);
- data processing services (real time and/or batch processing computing capabilities);
- community support services (platform authentication and authorization);
- data access services (APIs for external access).

Sensors data will be coming both in asynchronous/batch and real-time mode, from two different data sources: a Sensor Observation Service (SOS) deployed close to each EGIM and the EMSO regional nodes. Both historical time series and real time data will be accessible and searchable via Application Programming Interfaces (APIs) built on top of NoSQL databases (e.g., HBase, OpenTSDB).

Two main processes happen during the data acquisition and transformation phase:

- Data Scraping extracting parts of a corpus of a sea observation coming/retrieved from the SOS (Sensor Observation Service) server;

- Data Munging/Wrangling converting data from a "raw" format of the observation coming/retrieved from the SOS server into another one that allows data to be more conveniently consumed later on in the data chain.

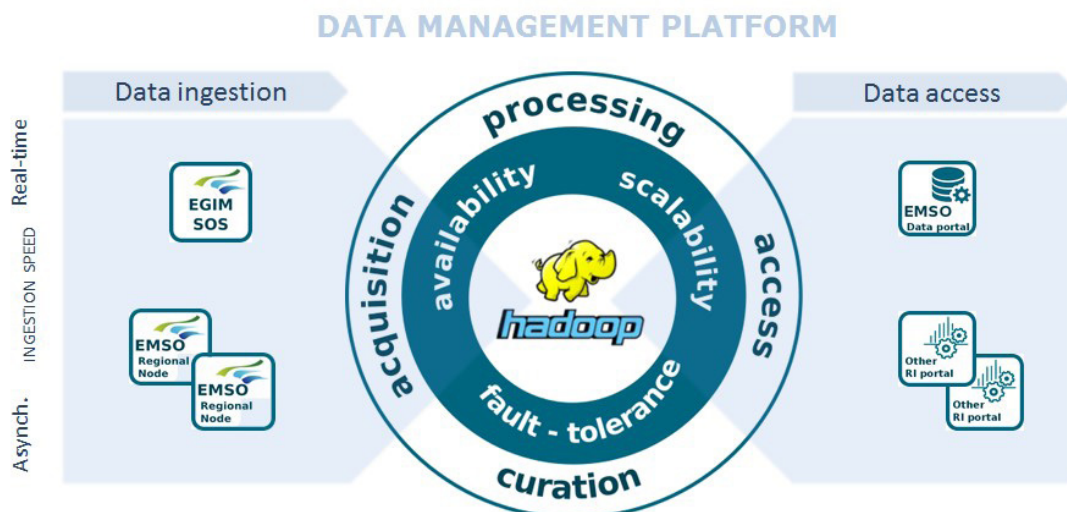
The data acquisition and transformation phase is implemented with the aid of Apache Nifi. Sensor data can be either retrieved via API exposed by an SOS server ("PULL" mode) or sent to the data management platform before being consolidated on the SOS server itself ("PUSH" mode).

Formatted details are then sent to different systems (an HDFS distributed file system, two different NoSQL databases, a Time series database, a Publish/Subscribe component) via specialised NIFI components performing HTTP POST/PUT submits against those systems. The distributed file system represents the way to store (and make available) long series of historical data. The data flowed into the Time Series DB are stored for further analysis and real time visualisation by customisable dashboards. The data flowed into NoSQL databases are used to feed the data management platform APIs which allow interested scientific communities to access various oceanographic parameters in different time ranges (e.g. the sea water temperature in a specific observatory within a certain time range).

Accurate, consistent, comparable, long-term measurements of ocean parameters are key to address urgent societal and scientific challenges such as climate change, ocean ecosystem disturbance, and marine hazards. Collecting ocean data and analysing them on a day-to-day basis are two big challenges to face in order to continuously monitor environmental processes including natural hazards, climate change, and marine ecosystems.

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- EMSODEV - European Multidisciplinary Seafloor and water-column Observatory DEVELOPMENT - <http://www.emsodev.eu>
- OGC (Open Geospatial Consortium) - <http://www.opengeospatial.org/>
- ENVRI Reference Model - <https://confluence.egi.eu/display/EC/ENVRI+collaboration+and+documentation+space+Home>
- RM-ODP - Reference Model of Open Distributed Processing - <http://www.rm-odp.net/>
- Hortonworks - <http://hortonworks.com/>
- Apache Hadoop - <http://hadoop.apache.org/>
- Sensor Observation Service - <http://www.opengeospatial.org/standards/sos>
- Apache Nifi - <https://nifi.apache.org/>



ID44- THE LSTS OPEN-SOURCE COMMUNICATION AND AUTONOMY SOFTWARE: ENABLING NETWORKED VEHICLE SYSTEMS TO FIND, TRACK, AND SAMPLE DYNAMIC FEATURES OF THE OCEAN

J. BORGES DE SOUSA¹³⁶, J. PEREIRA¹³⁷, A. SÉRGIO FERREIRA¹³⁵, M. RIBEIRO¹⁴¹, J. PINTO¹³⁸, P. DIAS¹⁴², M. COSTA¹⁴⁰ AND K. RAJAN¹³⁹

This paper discusses how the LSTS open-source communication and autonomy software (<http://www.lsts.pt/toolchain>) will enable networked vehicle systems to find, track, and sample dynamic features of the ocean. The software toolchain includes the following components:

- Ripples – Web application including a communications hub and tools for remote visualization, tasking, and supervision enabling remote collaborative planning and execution control, as well as outreach and education activities.
- Neptus – Distributed off-board command and control framework supporting planning, execution control, and post-mission analysis for networked vehicle systems.
- IMC – Protocol for networked vehicle systems operating in communications challenged environments. There is a discovery mechanism using different broadcasting mechanisms to identify end-points exposed in the network (over UDP, TCP, HTTP, acoustic modem, Iridium, etc.) The links among devices are dynamically created during execution.
- Dune – Onboard software framework providing logging, communications, navigation, and control functions for all supported vehicles, with a small memory and computational footprint to run virtually on any POSIX-compliant system.
- TREX – Onboard deliberative planning software enabling autonomous decision-making without human intervention integrated with the LSTS-UP tool chain.
- EUROPTus – Shipboard mixed-initiative planning and execution controller for

multi-vehicle oceanographic field experiments and Neptus front-end.

These components endow a dynamic set of physical assets with system level properties targeted at adaptive volume observation and sampling of interacting ocean processes. The approach builds on experience in large ocean experiments with multi-vehicle systems and on advances in: 1) standardized vehicle onboard software, including autonomy software; 2) delay and disruptive tolerant networking communications; 3) adaptive sampling of ocean features; 4) mixed initiative planning and execution control; 5) inter-operability protocols for heterogeneous vehicles; and, 8) visualization software for integrated situational awareness and planning and control.

The LSTS vehicles and software toolchain will, for the first time, allow effective inter-disciplinary study of fronts and other oceanographic features of high mobility at fine spatial and temporal scales. Field trials are being performed with the LSTS unmanned vehicle systems (<http://www.lsts.pt/vehicles/>): AUVs in several configurations equipped with several types of sensors (CTD, fluorometer, holographic camera, turbidity, O₂, cameras, and micro-turbulence), WiFi and satellite communications, acoustic modems, and battery packs enabling up to 36h endurance; fixed-wing UAVs capable of up to 1h of flight time equipped with several types of video cameras (including IR), WiFi, and capable of bent Line of Sight (LOS) communications; and, multi-copters/vertical takeoff and landing (VTOL) equipped with WiFi communications and cameras, and capable of bent LOS, of deploying drifters, and of collecting water samples.

ID45- GALWAY BAY SHALLOW-WATER OBSERVATORY: INSTALLATION, COMMISSIONING AND RESEARCH OPPORTUNITIES

DIARMUID GEARÓID Ó CONCHUBHAIR¹⁴³, DR ELEANOR O ROURKE¹⁴⁴

Abstract – The Galway Bay shallow-water observatory was installed in August 2015 and officially launched in July 2016. The observatory is located within the Galway Bay Marine and Renewable Energy Test Site at a depth of around 23m. The infrastructure has a core suite of scientific sensors monitoring a variety of marine parameters as well as providing dedicated scientific ports (sockets) for marine research projects.

Keywords – ‘Marine’ ‘Research’ ‘Science’ ‘R&D’ ‘Technology’ ‘Subsea’ ‘Observatory’ ‘Galway’ ‘Ireland’ ‘EMSO’

I. CONTEXT AND OVERVIEW

The Galway Bay shallow-water observatory is part of a collaborative project between the Sustainable Energy Authority of Ireland (SEAI), the Marine Institute (MI), University College Cork (Marine Renewable Energy Ireland - MaREI), Smart-Bay Ireland and Dublin City University (DCU) to upgrade existing facilities at the Galway Bay marine and renewable test site. The overall project was funded by Science Foundation Ireland (SFI)*.

The Marine Institute had 4 main objectives to ensure a successful installation and completion of an operational marine observatory; 1) To procure and install main system components, 2) To apply for all relevant permissions (foreshore, planning, road-opening licence), 3) To procure and commission all onshore infrastructure (ductwork and shore station) and 4) to ensure integration of the entire system.

The culmination of the above steps led to the deployment of the Cable End Equipment (CEE) in August 2015 (fig. 2). The CEE is constructed of titanium housing (fig. 1) and is 1.78m in length and has a diameter of 0.48m. It contains 17 science ports, 4 fibre ports and 1 video port (a full list of CEE port functions can be viewed in Table 1).

The installation of the observatory also required terrestrial works (mainly civil) and included the cable landing site at a local pier, terrestrial duct work taking the cable ~1k underground to a specialised and fully equipped shore station. The shore station is located at a local second-level school and represents a successful partnership between the MI and the school. The dedicated shore facility was completely renovated and fitted out with a climate controlled server room. The shallow-water observatory has a core suite of environmental monitoring

sensors for provision of long-term marine data at the site. The sensor and instrumentation payload includes a CTD (salinity and temperature), ADCP (water current velocities throughout the water column), Hydrophone (underwater noise monitoring), Fluorometer (measuring the intensity of fluorescence, used chiefly in biochemical analysis), HDTV (HD video footage), Lights, Turbidity sensor, Nutrient Monitoring sensor, Dissolved O₂ & CO₂ sensor, pH sensor as well as dedicated ports for scientific research projects (see table 1).

In 2016 the Marine Institute launched a SmartBay National Infrastructure Access Programme (NIAP)⁶. The goal of NIAP is to continue the expansion of the observatory user base to encompass research teams, Small & Medium Enterprises (SME's) and Multinational Companies (MNC's), nationally and internationally, and demonstrate significant socio-economic impact through the growth of an associated industry base that commercialises research outputs, or uses the technologies to enhance productivity. This fund provides awards up to a maximum of €25K per application to research teams through a national competitive process, which is open to all higher education institutions on the island of Ireland.

II. FIGURES AND TABLES



Fig 1. Above: Construction of the Cable End Equipment (CEE).

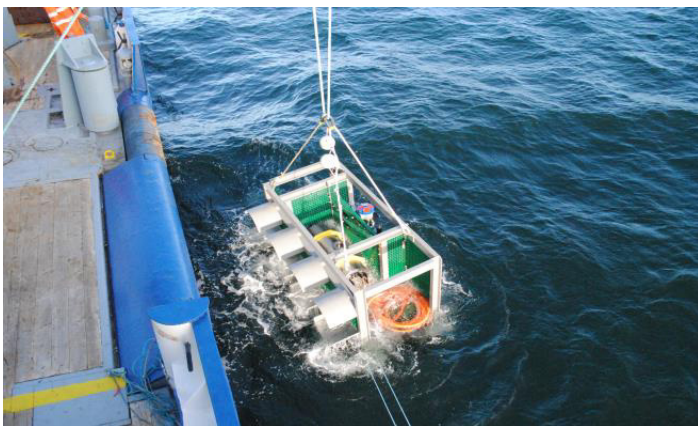


Fig 2. Above: Deployment of the CEE, installed horizontally in the centre of the observatory frame on which the sensors and instrumentation are also housed (note attached ADCP on centre right of frame)

III. CONCLUSIONS

In 2012 Harnessing Our Ocean Wealth (HOOW)⁵ set out the Irish Government's Vision, high-level goals, and key 'Enabling' actions to put in place the appropriate policy, governance and business climate to enable Ireland's marine potential to be realised. HOOW states that creating an infrastructure to support the blue economy is critical to the success of Ireland's integrated marine plan; Galway Bay's shallow-water observatory is a prime example of how this can be achieved. The observatory infrastructure has placed Ireland in a position where it can be one of the founding member countries of the EMSO-ERIC (European Multidisciplinary Seafloor and Water Column Observatory – European Research Infrastructure Consortium)³. This will be the legal entity charged with the coordination of open ocean fixed-point observatory infrastructures in Europe¹.

CEE Port #	Communications	Function
EX1	CWDM	Sea Station
EX2	CWDM	Acoustic Array
EX3	CWDM	Science Port
EX4	CWDM	Science Port
S1	Ethernet	Hydrophone
S2	Ethernet	Science Port
S3	Ethernet	Science Port
S4	Ethernet	Science Port
S5	Ethernet	Science Port
S6	Serial	CTD/DO ₂
S7	Serial	Turb/Fluor
S8	Serial	Science Port
S9	Serial	Science Port
S10	Serial	Vemco
S11	Serial	Science Port
S12	Serial	ADCP
S13	Serial	Science Port
S14	Serial	Lights
S15	Serial	Lights
S16	Serial	Science Port
S17	Serial	Science Port
V1	Coaxial+ Serial	HDTV
SR	-	Ground Reference
U	-	Uplink

Table 1. Above: List of observatory ports, communication type and their function

The MI has also been successful in a number of European proposals associated with the shallow-water observatory, including EMSODEV2, which is in the process of designing a state-of-the-art, standardized multidisciplinary EMSO Generic Instrument Module (EGIM), a harmonized observation system which will align and standardise data from all European observatories. H2020 observatory involvement also extends to JERICOnext4 whose objectives include; supporting European coastal research communities, enabling free and open access to data, enhance the readiness of new observing platform networks by increasing the performance of sensors, and to showcase the adequacy of developed observing technologies.

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*The cable project is funded in part by SFI under its Research Infrastructure Call 2012 which contributed €2.2m to the project. The Department of Agriculture Food and the Marine (DAFM) contributed an additional €600,000 to the project in 2014.

ID46- ARCHITECTING THE CYBERINFRASTRUCTURE FOR THE NATIONAL SCIENCE FOUNDATION OCEAN OBSERVATORIES INITIATIVE (OOI)

IVAN RODERO¹⁷² AND MANISH PARASHAR¹⁷³

Abstract – The NSF Ocean Observatories Initiative (OOI) is a networked ocean research observatory with arrays of instrumented water column moorings and buoys, profilers, gliders and autonomous underwater vehicles (AUV) within different open ocean and coastal regions. OOI infrastructure also includes a cabled array of instrumented seafloor platforms and water column moorings on the Juan de Fuca tectonic plate. This networked system of instruments, moored and mobile platforms, and arrays will provide ocean scientists, educators and the public the means to collect sustained, time-series data sets that will enable examination of complex, interlinked physical, chemical, biological, and geological processes operating throughout the coastal regions and open ocean. The seven arrays built and deployed during construction support the core set of OOI multidisciplinary scientific instruments that are integrated into a networked software system that will process, distribute, and store all acquired data. The OOI has been built with an expectation of operation for 25 years.

Keywords – Research Infrastructure, Cyber-Infrastructure.

I. INTRODUCTION

The National Science Foundation-funded Ocean Observatories Initiative (OOI) is an integrated infrastructure project composed of sciencedriven platforms and sensor systems that measure physical, chemical, geological and biological properties and processes from the seafloor to the air-sea interface. The OOI network was designed to address critical sciencedriven questions that will lead to a better understanding and management of our oceans, enhancing our capabilities to address critical issues such as climate change, ecosystem variability, ocean acidification, and carbon cycling.

The OOI has transformed research of the oceans by integrating multiple scales of globally distributed marine observations into one observing system and allowing for that data to be freely downloaded over the internet in nearreal time. The OOI will continue to deliver data and data products for a 25-year-plus time period within an expandable architecture that can meet emerging technical advances in ocean science.

Building on last century's era of ship-based expeditions, recent technological leaps have brought us to the brink of a sweeping transformation in our approach to ocean research – the focus on expeditionary science is shifting to a permanent presence in the ocean. As technological advances continue over the lifetime of the OOI, developments in sensors, computational speed, communication bandwidth, Internet resources, miniaturization, genomic analyses, high-definition imaging, robotics, and data assimilation, modeling, and visualization techniques will continue to open new possibilities for remote scientific inquiry and discovery.

The OOI is funded by the National Science Foundation and is managed and coordinated by the OOI Program Office at the Consortium for Ocean Leadership (COL), in Washington, D.C. COL is leader, owner, and operator of the OOI and its infrastructure. Implementing Organizations (IOs), subcontractors to COL, are responsible for construction and development of the different components of the program. Woods Hole Oceanographic Institution is responsible for the Coastal Pioneer Array and the four Global Arrays, including all associated vehicles. Oregon State University is responsible for the Coastal Endurance Array. The University of Washington is responsible for cabled seafloor systems and moorings. Rutgers, The State University of New Jersey, is implementing the Cyberinfrastructure component. The OOI Data Management and education and public engagement team is co-located with the Cyberinfrastructure group at Rutgers University [1].

II. OBSERVATORY COMPONENTS

The design of the OOI enables multiple scales of marine observations integrated

into one observing system via common design elements and overarching, interactive Cyberinfrastructure Technology. The coastal assets of the OOI expand existing observations off both U.S. coasts, creating focused, configurable observing regions. Cabled observing platforms 'wire' a single region in the Northeast Pacific Ocean with a high speed optical and high power grid. And the global component addresses planetary-scale changes via moored open-ocean buoys linked to shore via satellite.

This unprecedented and diverse data flow is coming from 89 platforms carrying over 830 instruments which provide over 100,000 scientific and engineering data products. Design, construction, and full deployment of these systems was completed late last year. This infrastructure includes 12 surface moorings, 8 subsurface flanking moorings, 22 profiler moorings, 20 cabled seafloor packages, 32 gliders, and 2 Autonomous Underwater Vehicles (AUVs). Some of this cutting edge instrumentation had never been fielded in an operational format before and are now in the water and actively collecting data, including the in situ massspectrometer, particulate DNA sampler, and other vent chemistry sensors [1]. The map with the location of the seven OOI arrays is shown in Figure 1.

III. OOI CYBER-INFRASTRUCTURE SERVICES

The primary functions of the OOI Cyber-Infrastructure are data acquisition/col-lection, storage, processing and delivery.

(a) Data Collection and Transmission to the OOI Cyberinfrastructure:

Data is gathered by both cabled and un-cabled (wireless) instruments located across multiple research stations in the Pacific and Atlantic oceans. Once acquired, the raw data (consisting mostly of tables of raw instrument values – counts, volts, etc.) are transmitted to one of three operations centers: Pacific City, directly connected via fiber optic cable to all cabled instruments in the Cabled Array; Oregon State University (OSU), an OperationalManagement Center (OMC) responsible for all un-cabled instrument data on the Pacific coast; and Woods Hole Oceanographic Institute (WHOI), the OMC for Atlantic coast-based un-cabled instrument data. The data from the operations centers is transferred to the OOI Cyberinfrastructure for processing, storage and dissemination.

(b) Data Management, Storage, and Processing:

Two primary cyber-infrastructure (CI) centers operated by the Rutgers Discovery Informatics Institute (RD12) are dedicated to OOI data management: the West Coast CI in Portland, Oregon, and the East Coast CI, at Rutgers University. While data from the Cabled Array components are initially received at the Shore Station in Washington, it is the East Coast CI that houses the primary computing servers, data storage and backup, and front-facing CI portal access point, all of which are then mirrored to the West Coast CI over a high-bandwidth Internet2 network link provisioned by MAGPI (Mid-Atlantic GigaPOP in Philadelphia) on the east coast and PNWGP (Pacific- Northwest GigaPOP) on the west coast. The data stores at the OMCs at OSU and WHOI are continuously synchronized with the data repositories located at the East and West Coast CI sites.

(c) Data Safety & Integrity:

Data safety and protection is ensured in two ways: data security and data integrity. Data security is addressed through the use of a robust and resilient network architecture that employs redundant, highly available nextgeneration firewalls along with secure virtual private networks (VPN). Data integrity is managed through a robust and resilient Information Life-cycle Management (ILM) architecture.

(d) Public Data Access:

The OOI CI software ecosystem (OOINet) employs the uFrame software framework that processes the raw data and presents it in visually meaningful and comprehensible ways in response to user queries, which is accessible over the



Internet through the CI web-based portal access point [2]. The OOI CI portal also delivers command and control functionality. In addition to the portal, OOI CI provides the following data delivery methods:

- THREDDS Data Server: delivers any data and associated metadata that have passed the evaluation process are accessible as individual and aggregated datasets, via OPeNDAP and NetCDF Subset Services. It includes pre-calculated preliminary data sets for platforms identified by the OOI Science Oversight Committee and data products requested through the CI portal (i.e., generated asynchronously).
- Raw Data Archive: delivers data as they are received directly from the instrument, in instrument-specific format.
- Alfresco Server: provide cruise data, including shipboard observations.
- Other methods for data delivery will be available such as a machine-to-machine interface and an ERDDAP server.

OOI CI software ecosystem permits 24/7 connectivity to bring sustained ocean observing data to a user any time, any place. Anyone with an Internet connection can create an account or use CILogon (Federated Authentication) [3] and access OOI data.

IV. DESIGN AND IMPLEMENTATION ISSUES

The OOI CI design and implementation principles are based on industry best practices for the different aspects of the CI. The approach is based on a decentralized but coordinated architecture, which is driven by requirements, e.g., data storage capabilities, system and load stability, security, etc.

(a) Redundancy and resiliency:

The OOI CI is a mirrored infrastructure for high availability, disaster recovery and business continuity. It implements a resilient Information Life-cycle Manage-

ment (ILM) architecture that integrates redundant enterprise storage area network (SAN) (disk-based) and a robotic library (tape-based). Redundancy is implemented at different layers, for example, an enterprise-level storage network of multiple hard drives managed by an intelligent device manager, reduces the data footprint by reducing data duplication while maintaining data integrity and access performance through storage redundancy, and tape storage, a “last tier” storage that is not dependent on power or cooling, supports longer-term backup and archiving, disaster recovery, and data transport.

(c) Service-oriented Architecture:

The core of the OOI CI software ecosystem (Uframebased OOINet) is based on a Service Oriented Architecture (SOA), a set of data dataset/instrument/ platform drivers and data product algorithms, which plug in to the uFrame framework. Uframe-based OOINet uses latest generation technologies for big management data such as Apache Cassandra, which is a state-of-the-art, scalable and highly available distributed database management system designed to handle large amounts of data. Uframe-based OOINet services are exposed through a web-services API and will be available as the machine-to-machine interface for external access. The use of a well defined API based on standard protocols will enable other systems to interface and interact with OOI CI.

(c) Cyber-security:

The system is based on a multi-tier security approach with dedicated and redundant (highly available) appliances at the CI perimeter. The OOI CI implementation supports encryption of traffic, network traffic segregation, multilayer traffic filtering, multi-layer access control and comprehensive monitoring. Further, data delivery to external users is implemented through dedicated and distinct storage appliances (i.e., physical and logical isolation from core storage infrastructure) In addition to implementing industry best practices, the OOI CI cyber-security effort includes a comprehensive cyber-security program based on

engagement with the NSF Center for Trustworthy Scientific Cyber Infrastructure (CTSC) [4]. This program encompasses a set of policies and procedures as listed below:

- Master Information Security Policy & Procedures: represents the core information security policies and procedures, including information security-related roles and responsibilities; references to other, special purpose policies; and the core procedures for developing, implementing, and maintaining the information security program.
 - Acceptable Use Policy: set of rules that a user must agree to follow in order to be provided with access to a network and/or resources. Used to reduce liability and act as a reference for enforcement of policy.
 - Access Control Policy: defines the resources being protected and the rules that control access to them.
 - Asset Management Policy: requirements for managing capital equipment including: inventory, licensing information, maintenance, and protection of hardware and software assets
 - Information Classification Policy: used to ensure consistency in classification and protection of data.
 - Disaster Recovery Policy: contains policies and procedures for dealing with various types of disasters that can affect the organization.
 - Personnel Exit Checklist: form to be completed at the end of employment that addresses revoking access to resources, physical space and the return of organizational assets.
 - Incident Response Procedures: a pre-defined organized approach to addressing and managing a security incident.
 - Password Policy: a set of rules designed to establish security requirements for passwords and password management.
 - Physical [and Environmental] Security Policy: details measures taken to protect systems, buildings, and related supporting infrastructure against threats associated with their physical environment.
 - Training and Awareness Policy: outlines an organization's strategy for educating employees and communicating policies and procedures for working with information technology (IT).
- Regular vulnerability scans/audits (both internally and externally) are also performed to the OOI CI.

V. CONCLUSION

The OOI network was designed to support of the needs of users to conduct research across a wide range of science themes, within an expandable observing infrastructure that spans widely differing ocean domains. The network is designed to provide observations of processes at multiple oceanographic scales, from ocean basin to continental shelf, over time scales from, short-term episodic events to decadal cycles.

OOI CI has initiated its operational phase and data (including science, engineering and data products) flowing from those instruments is freely available to users. The OOI CI portal provides all data, metadata and data processed via conventional algorithms or direct retrieval from OOI storage or data archives. Data quality and data management will utilize generally accepted protocols, factory calibrations and at sea calibration procedures.

During the first months of its operation, OOI community has been growing every day and is made up of a diverse set of users from 180 different organizations from around the world. At least 500 people has already registered on the OOI Data Portal, it has 3,000 unique visitors to the OOI website each month. In June alone, users downloaded over 6TB of data.

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ID47- OBSTACLE DETECTION ALGORITHM OF LOW COMPUTATIONAL COST FOR GUANAY II AUV

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Abstract – Obstacle detection is one of the most important stages in the obstacle avoidance system. This work is focused to explain the operation of a designed and implemented for the overall detection of objects with low computational cost strategy. This strategy of low computational cost is based on performing a spatial segmentation of the information obtained by the SONAR and determine the minimum distance between the SONAR (AUV) and the obstacle.

Keywords – Obstacle Detection, Real Time, Low Computational cost.

I. INTRODUCTION

The obstacle avoidance system for AUVs are divided into two phases: the first obstacle detection and the second consisting of a strategy of evasion. At work

[1], an obstacle avoidance system was designed for the vehicle Guanay II. In this work, the phase of obstacle detection is subdivided into three general stages. The first stage corresponds to the configuration of SONAR and communication with the control unit. The second stage is related to the configuration of the operating parameters of obstacle detection system [2]; these parameters affect the execution time of the algorithm. Finally, we have in the third stage the strategy of obstacle detection, from the data provided by the SONAR.

Initially in previous work [3], we have designed and implemented a detection strategy, based on the identification of objects automatically on an image, constructed from data provided by the SONAR.

The measured time of execution of this strategy is 22.7s. At that time, it includes the time for the acquisition of measurements (10.89s), the time used to process the image and perform the obstacle detection (11.89s).

According to the exposed in [1], if the AUV is moving at a speed of 1 m/s, the distance traveled by the AUV before the system can take a decision that will avoid a collision is 23 m, which generates a high risk of collision with sudden obstacles. To avoid this problem, this paper proposes to reduce the execution time of the step of the algorithm that is responsible for processing information and perform the object detection. We have designed and implemented an algorithm of low computational cost, which is explained in the next section.

II. ALGORITHM FOR OBSTACLE DETECTION OF LOW COMPUTATIONAL COST

The global strategy of obstacle detection of low computational cost that is proposed uses the same acquisition stage that the algorithm presented in [3]

The new stage is responsible for processing information and detect obstacles, this stage is divided into two blocks, the first the segmentation of data and the second analysis of each sector and determining the value of interest.

The first block, divided into three sectors of 30° the area scanned by the SONAR (see Fig. 1). In previous work [2], the operating parameters of the SONAR were defined. We have contemplated a scan area of 90°, with a step of between beams of 0.9° and 400 samples per beam.

Each sector consists of 33 beams, which generates 33 data vectors. In this case we obtain a matrix of 400 (samples) X 99 (vectors).

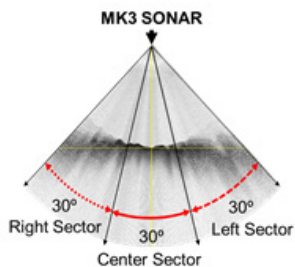


Fig 1. Sectorization of the scanned area

In the second block, it is analyzed in real time, each of the 33 vectors corresponding to the sector in the which the beam is located. Each vector is analyzed, and the minimum distance between SONAR and the obstacle is calculated for each vector. Finally, a global minimum distance is determined for the sector.

The beam goes through the different sectors until completing the area of 90°, at each point the process is repeated and the minimum distance (SONAR - obstacle) is calculated for each sector.

Finally, as a result of this strategy to overall detection of the obstacle, we obtain the minimum distance between the SONAR to obstacle for each of one of three sectors, allowing us to determine the globally location of the obstacle.

These 3 values are used as input variables in obstacle avoidance algorithm exposed in [1].

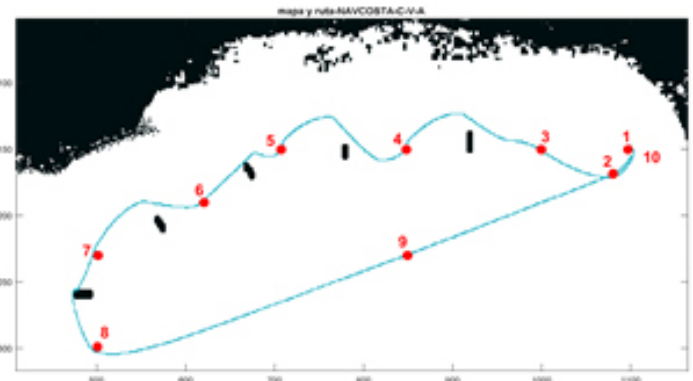


Fig 2. Simulation result

III. RESULTS

In experimental tests, the measured time of the execution of this strategy of obstacle detection algorithm is 0.198s. By contrast, for the algorithm used in [3], which does not divide the image and processes the full image, the runtime measured is 11.89s. Therefore, we have achieved a reduction of 51.2%.

The total execution time of the algorithm, considering the different stages is now the 11.08s, the which allows to obtain a distance traveled by the AUV of 11.08m at a speed 1m/s, this decreasing the risk of collision with sudden obstacles.

Using the new strategy to overall detection of the obstacle and obstacle avoidance algorithm presented in previous work [1], we obtain the simulation result shown in Fig.2.

IV. CONCLUSIONS

We have designed and implemented a new strategy of obstacle detection, which has a lower computational cost reducing the initial cost in 51.2%. Reducing the risk of collision with sudden obstacles.

This reduction is a consequence of that the new algorithm uses an array of less dimensions, and that the processing and data analysis is performed directly on the vectors and not on a pre constructed image.

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ID48- THE EGIM, MODULAR THOUGH GENERIC ADDRESSES THE REQUIREMENTS OF THE EMSO PLATFORMS

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The EGIM (EMSO Generic Instrument Module) is designed to consistently and continuously measure parameters of interest for most major science areas covered by EMSO. This research infrastructure provides accurate records on marine environmental changes from distributed regional nodes around Europe. The system can deliver data that can support the Global Ocean Observing System – Essential Ocean Variables concept, as well as the Marine Strategy Framework Directive towards evaluating environmental status.

The EGIM is flexible for adaptation according to site and discipline specific requirements. Inter-operability and capacity of future evolution of the system are key aspects of the modularity.

The EGIM is able to operate on any EMSO node type: mooring line, sea bed station, cabled or non-cabled and surface buoy to monitor environmental parameters over a wide depth range. Operating modes, power requirements, mechanical design can adapt to the various EMSO node configurations.

In addition to sensors already included in the EGIM prototype (temperature, conductivity, pressure, dissolved Oxygen, Turbidity, currents and passive acoustics) the EGIM can host up to five additional sensors such as chl-a, pCO₂, pH, seismic and photographic/video images or new sensors. The EGIM provides all the sensor hosting services required, for instance power distribution, positioning, and protection against bio-fouling.

Within EMSO, the EGIM aims to have a number of ocean locations where the same set of core variables are measured homogeneously: using the same hardware, same sensor references, same qualification methods, same calibration methods, same data format and access and the same maintenance procedures.

Its compact and modular nature allows for flexible deployment scenarios that include being able to accommodate new instruments such for Essential Ocean Variables and other needs as their technology readiness levels improve.



ID49- ELECTRONIC SYSTEM FOR DRIFT CLOCK CALCULATION AND SYNCHRONIZATION FOR SEAFLOOR OBSERVATORY

UMBERTO APPONI¹⁸⁷, DAVIDE EMBRIACO¹³⁰, GIUDITTA MARINARO¹²⁹, VINCENZO ROMANO¹²⁸

Abstract –The paper describes a new electronic device that allows an easily measurement of the drift between a reference time source (usually GPS) and an atomic rubidium clock which is normally used in seafloor observatories. The Rubidium clock is used in autonomous seafloor observatories to supply reference time for data acquisition with the precision of milliseconds. During the deployment of seafloor observatory the clock is synchronized with GPS. It is critical to evaluate the time drift between the clock and the GPS, when the observatory is recovered. In fact, thanks to an accurate drift measurement it's possible to have a correct timestamp for data series collected by seafloor observatory's instruments. The device described in this paper is composed by an Arduino mega shield integrated with other electronic circuits. The device is easily customizable for different clocks in fact Arduino IDE allows development of the desired features for the rubidium clock used in the specific application.

Keywords: clock drift, Arduino, GPS, seafloor observatory

I. INTRODUCTION

The device described in this paper has been realized in the framework of the EU project EMSODEV [1] (EMSO implementation and operation: DEvelopment of instrument module) whose objective is to catalyse the full implementation and operation of the EMSO (European Multidisciplinary Seafloor & water-column Observatory) distributed Research Infrastructure (RI), through the development, testing and deployment of an EMSO Generic Instrument Module (EGIM). The stand-alone prototype of EGIM will host a precise internal clock to synchronize all the data acquired by the observatory. Usually the clock is synchronized with a GPS before the deployment and immediately after the recovery of the seafloor observatory it is necessary to measure the clock drift.

The device was developed to measure the clock drift between the GPS and an atomic clock. It is designed for seafloor stand-alone observatory, that requires a precise time synchronization between GPS and observatory's clock. This goal is obtained measuring the drift between these signals, that are synchronized before the observatory deployment. After the recovery it's important to evaluate this measure to have a precise timestamp for instrument's data. The device is fully customized as the firmware is written in C code with Arduino IDE. So, it's possible to modify the code to adapt it to a different clock. Also, it's possible to modify the baud rate and serial protocol for serial GPS and clock.

II. ELECTRONICS

A device block diagrams is represented in Figure 1

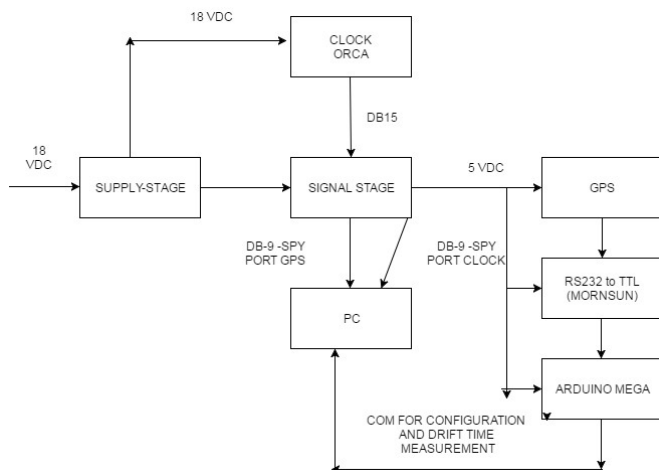


Fig. 1: Block diagram

In this figure you can identify the following blocks:

- GPS: It generates NMEA strings[2] on RS-232 serial port with DB9 connector (9600-8N1). PPS signal output on a BNC connector will be generated only if there is an identification of the position.
- ORCA Clock[3]: The rubidium clock provides the time. It has a DB15 connector that is connected to an external device called SIGNAL STAGE (Figure 1), which is responsible for distributing the TOP SEC signal (clock PPS) to a microcontroller and a BNC. This stage also allows you to bring the signals to a DB-9 (RS-232 serial port in configuration 7N1), connected to the microcontroller.
- Arduino Mega 2560 board[4]: This is the heart of the implemented device. It allows you to configure the serial (one for GPS and the other for ORCA clock), measure the time drift between the PPS[5] of the GPS signal and TOP-SEC ORCA signal, sending this to devices.
- Power Stage: This provides power to the various elements of the circuit. In particular, supply voltage of 18 VDC is sent directly to the ORCA input and, with a series of voltage regulators, it splits the power on each regulator to generate the following voltages 15VDC, 12VDC, 8VDC and 5 VDC, which powers the GPS.

III. DEVICES OPERATIONS

In order to make the measurement of clock drift and verify the calibration of the rubidium clock with GPS time the following steps are performed by device:

- Check GPS NMEA output string.
- Measure time drift between Pulse per second (PPS) GPS signal with PPS clock ORCA (TOP_SEC signal).
- Control if GPS PPS signal and TOP_SEC signal are referred to the same temporal instant.

All the operation are managed by mega microcontroller. In fact, it performs the following operations:

- Configure the BAUD RATE and serial transmission protocol. The command that it implements is:
ABCDE

Where ABCDE is a string of 5 character that the user passes to Arduino Mega serial 0 (9600 8N1).

A: ascii character that identifies the transmission rate in baud (from 300 to 115200) of the first serial (Serial 1) between 0 and 9

B: ascii character that identifies transmission protocol used the first serial.

C: ascii character that identifies the transmission rate in baud of the second serial (Serial 2).

D: ascii character that identifies the transmission protocol for the second serial

E: ascii character that identifies the selected function for the operation of the clock . If it is 1 ORCA clock function can be used, if 2 another user defined function will be used.

· Wait until the GPS is connected correctly. The microcontroller wait until GPS is locked, when NMEA string is so similar to:

```
$GPRMC,045200.000,A,3014.3820,N,09748.9514,W,36.88,65.02,030913,,,A*77\r\n
```

· Measure the clock drift between the PPS signals and TOP_SEC. To do this, the Arduino uses interrupts (Figure 2): one on the rising edge (GPS_PPS signal) and one on the falling edge (TOP_SEC signal).

· Start ORCA clock, sending correct address to it, reading the resulting time to check if this is referred to the same instant time of GPS, using this formula (Figure 3)

$$T_{pps} = (T@-1000000us - t_2) + (t_2 - State) < 1000000 us$$

Where the time correspond to:

Tint: enabling of the interrupts for signals with frequency of 1 Hz (GPS and TOP_SEC).

State: rising front of the GPS PPS.

State2: falling edge of the clock signal TOP_SEC of ORCA.

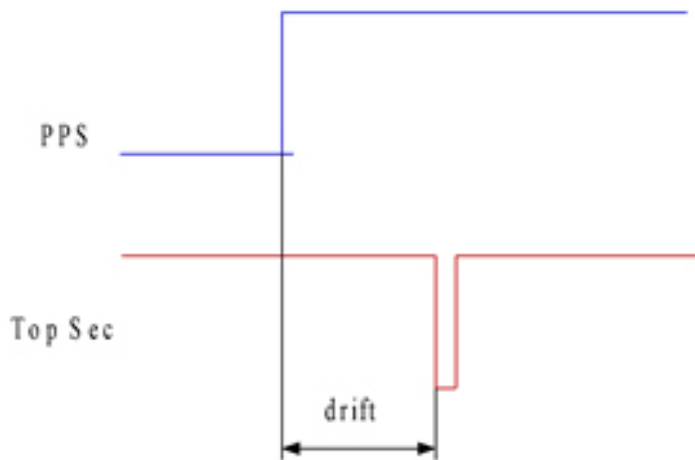


Fig 2. Drift between PPS and clock signal

$T_2 = T_{int} + 1s$
 State and State2 are always between T_{int} and T_2 .
 Time clock: time instant when the clock gives to Arduino the time.
 $T@$: Time clock + 1 second when the "@" ascii character is send to Arduino from Clock ORCA.

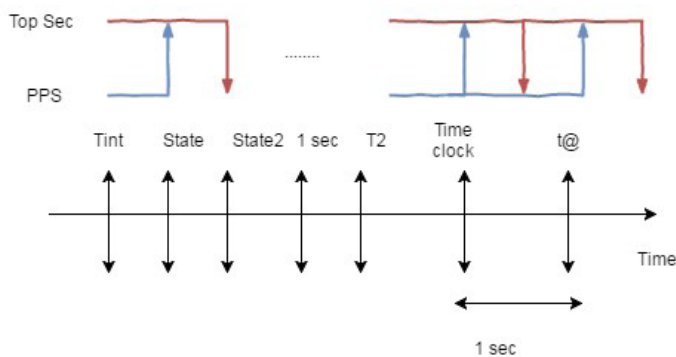


Fig 3. Time manage by Arduino mega microcontroller

IV. VALIDATION AND TESTS

The testing procedure for the device has requested these connections:

- Power for the device to 18 VDC
- Receiver antenna to GPS
- DB15 for electronic device and clock ORCA
- BNC PPS with oscilloscope CH1
- BNC oscilloscope CH2 to TOP SEC signal
- Spy -port DB9 LPHR to the PC terminal (9600,7,1)
- Spy -port DB9 GPS to the PC terminal (9600,8,1)
- USB Arduino port onto PC

Two tests are made: the first with an oscilloscope, that gives us a "qualitative" result (Figure 4); the second in order to measure the crystal oscillator accuracy mounted on microcontroller shield. With oscilloscope, we measure the temporal drift as $550000 \pm 50000 \text{ us}$. With the implemented procedure, using Arduino, the obtained drift is $546524 \pm 2 \text{ us}$ (Figure 4). The resolution time for Arduino is 1 us.

The second test shows that the device is almost insensitive to the accuracy of crystal oscillator mounted on the microcontroller, as we implemented a special function that allow the accurate measure of the period of the internal clock of Arduino with the GPS PPS signal. The reference period of PPS is 1 second and the Arduino result is 999928 us with a standard deviation of 1.24us on 150 samples.

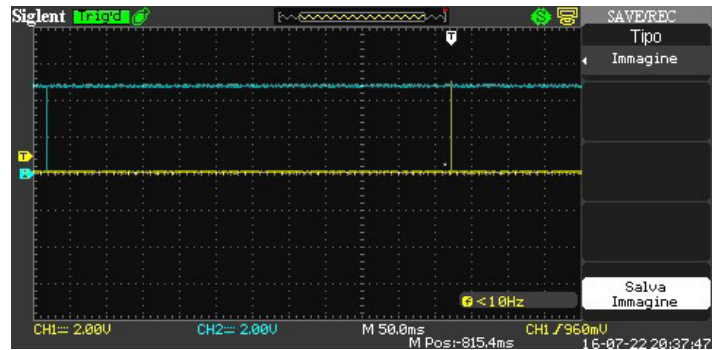


Fig 4. Drift between GPS PPS and clock signal TOP_SEC



Fig 5. The Electronic system

V. CONCLUSIONS

The device presented in this paper allows the time drift measurement between the PPS GPS signal and the 1 Hz output of seafloor observatory rubidium clock. The device has a time resolution of 1 us. Such result is innovative because the obtained resolution is four time improved respect to the one obtained by Arduino Mega standard shield. Moreover the firmware code can be implemented using Arduino IDE making the electronics easy customizable. It allows to write in C language a management function for every rubidium clock used in the seafloor observatory. The device also evaluates the time drift between GPS signal and Arduino internal clock, in order to be insensitive to the accuracy of the crystal oscillator mounted with microcontroller.

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