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Next generation multiplatform ocean observing technologies for research infrastructures

22.10.2024

Next-generation Technologies for Ocean Observations

On behalf of all authors: GEORGE partners,
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GEORGE project received funding from European Union's Horizon Europe programme under grant agreement no. 101094716

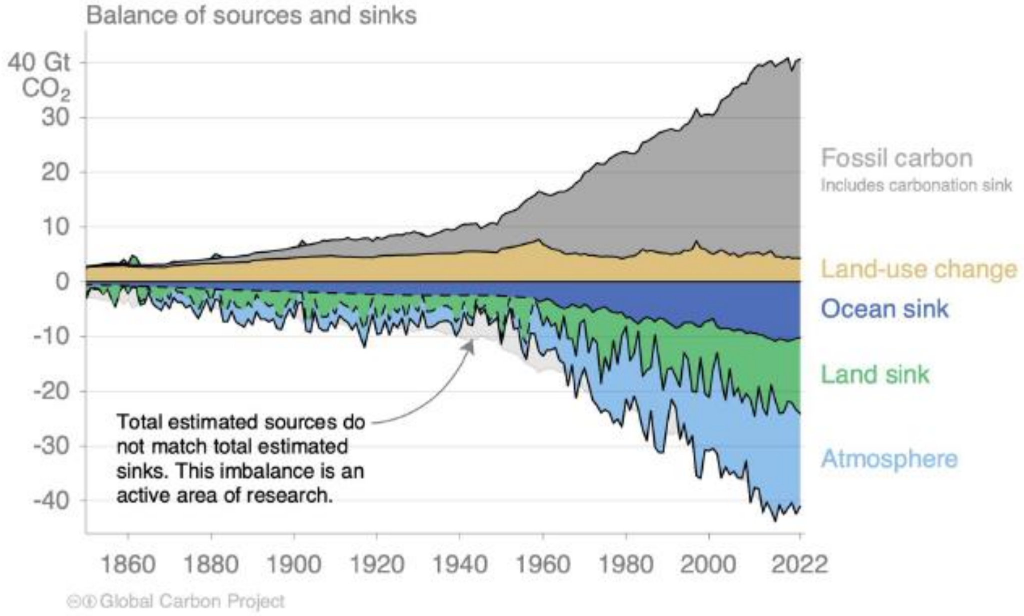
george-project.eu

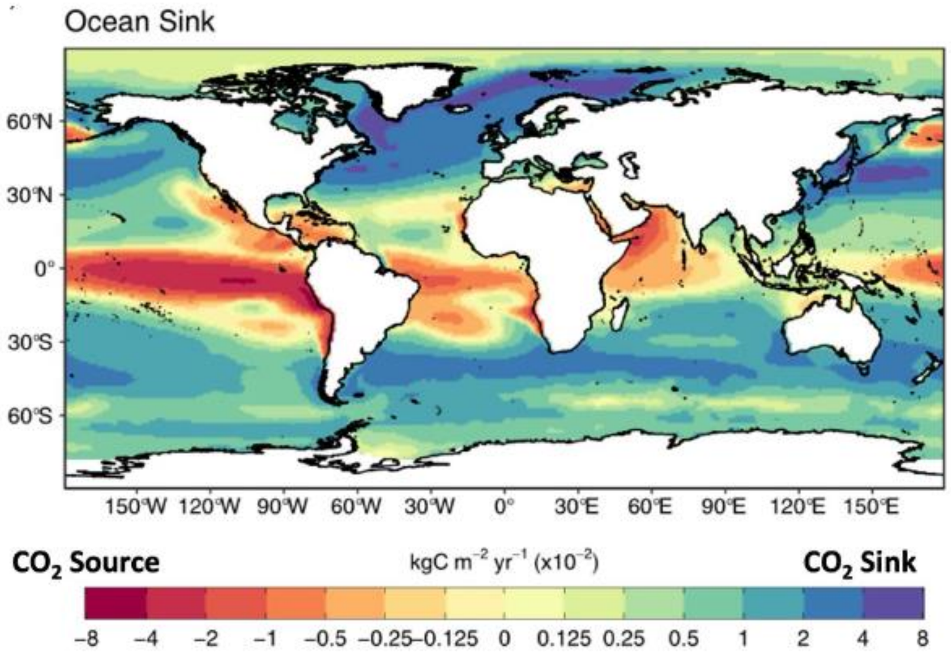
The ocean is a major sink of anthropogenic CO_2

Ocean as a Major Carbon Sink
The ocean absorbs approximately 27% of atmospheric CO2 emissions annually, acting as a crucial natural sink to mitigate climate change.

Challenges in CO2 Flux Estimation
Rising global temperatures reduce the ocean's CO2 absorption capacity, complicating efforts to accurately estimate CO2 flux.

Need for Advanced Technologies
Accurate CO2 flux estimation requires new observation technologies and methodologies to overcome current limitations.





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Source: *Friedlingstein et al 2023*; *Global Carbon Project 2023*

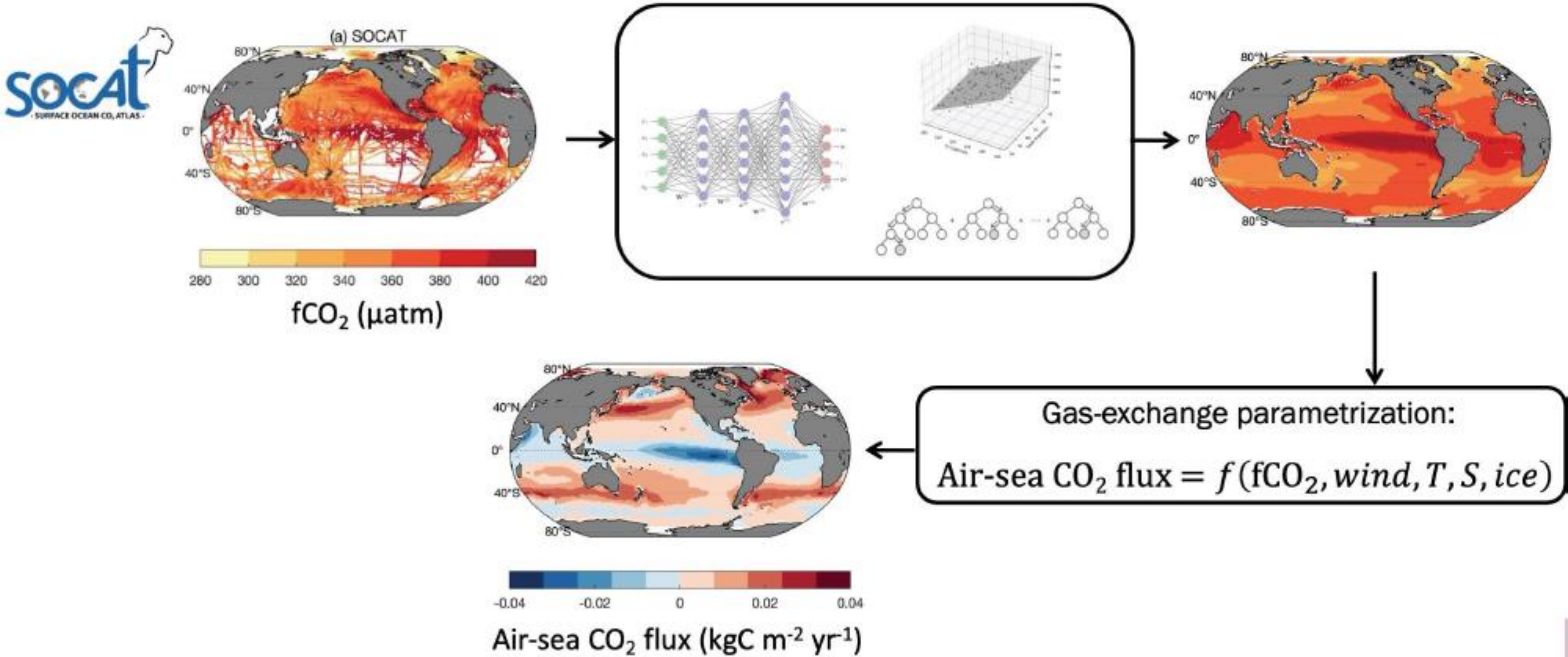
Current methods and limitations in CO_2 flux estimation

SOCAT's Role in CO2 Monitoring
The Surface Ocean CO2 Atlas (SOCAT) relies on ship-based observations, but these have significantly declined, leading to data gaps.

Impact of Climate Change
Warmer oceans dissolve less CO2, reducing the effectiveness of traditional observation methods.

Need for Continuous Observation
Gaps in seasonal data highlight the need for advanced, continuous monitoring systems.

Observation-based products (fCO_2-products):



New Innovations needed for Ocean Observations

- The ocean plays a vital role in mitigating the effects of climate change, but not enough is known about its condition and responses to the rising temperatures
- Sustained, long-term in situ observations are crucial to better understand and predict the impact of climate change on ocean ecosystems, increase resilience and develop better mitigation and adaptation strategies.
- Novel sensing technologies can dramatically enhance the quality, coverage and resolution of ocean observations

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About GEORGE

- GEORGE is a Horizon Europe-funded project that develops novel technologies to improve ocean observations.
- Collaboration with 28 industrial and academic partners, including three ocean research infrastructures: ICOS ERIC, EMSO ERIC and Euro-Argo ERIC.
- The project started in Jan 2023
- The project ends in June 2027.

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The Main Objectives

1. To enable high-quality ocean carbon observations, from the surface to the seafloor
2. To facilitate enhanced resolution, coverage and continuity of marine observations
3. To integrate and streamline ocean carbon observations across European marine RIs
4. To train professionals engaging in marine observation
5. To engage with European SMEs through co-development and evaluation of technologies
6. To demonstrate an integrated observing system at sea operated by the three ERICs
7. To incorporate the project results in the international ocean observing systems, databases and initiatives.

Novel Technologies

Operational models for high-precision sensors and platform technology for monitoring the ocean carbon system.

Integrated Ocean data

Fully integrated carbon observing systems across European marine research infrastructures.

Training and Education

Easy-to-use online training platform, offering training on technologies and data management for technical staff.

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Work Packages

- WP1 Project Management (lead: ICOS ERIC)
- WP2 Innovations in autonomous sensor and sampler technologies (lead: NOC)
- WP3 Innovation on Ocean Platform Technologies (lead: Sorbonne University)
- WP4 Integration and Interoperability (lead: University of Exeter)
- WP5 Implementation and Demonstration (lead: EMSO ERIC)
- WP6 Training and Education (lead: University of Helsinki)
- WP7 Exploitation, Communication, Sustainability and Impact (lead: ICOS ERIC)

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What does GEORGE offer to scientists, industry and the society?

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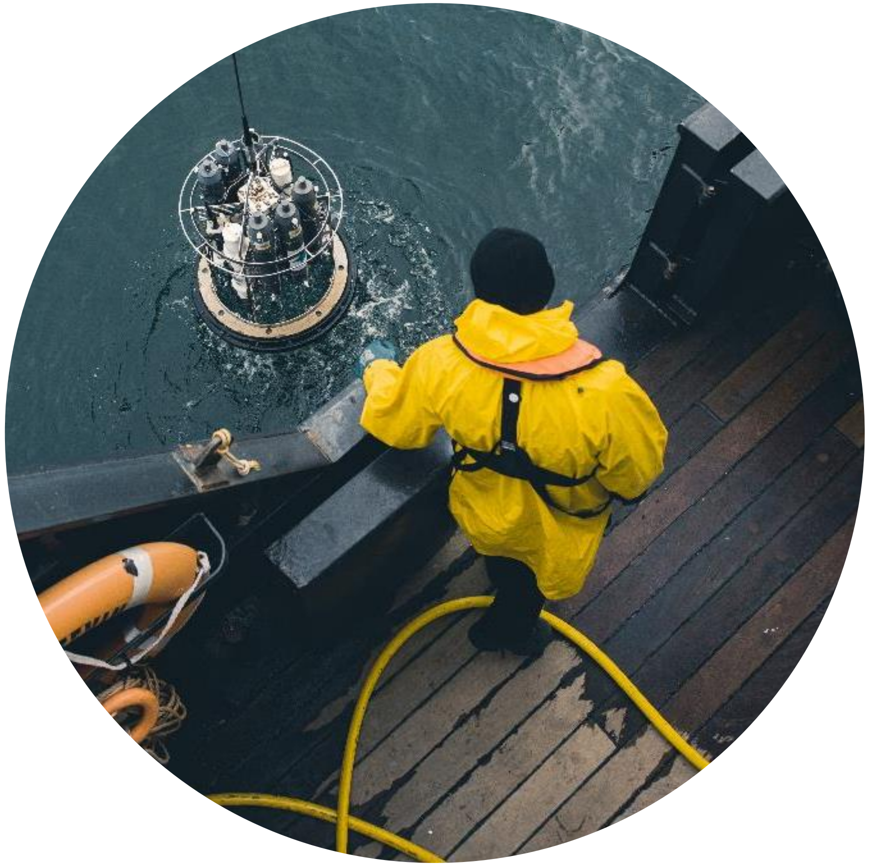

For Scientists

- The new technology will enable better measurements and consequent models
- New instruments may be able to reach parts of the ocean that are currently inaccessible
- Sensors can be used on floats, moorings and ships and integrated into the Argo float and EMSO Instrument Module (EGIM).
- Full integration of carbon observing systems across marine RIs in Europe
- Training opportunities available both on-site and online

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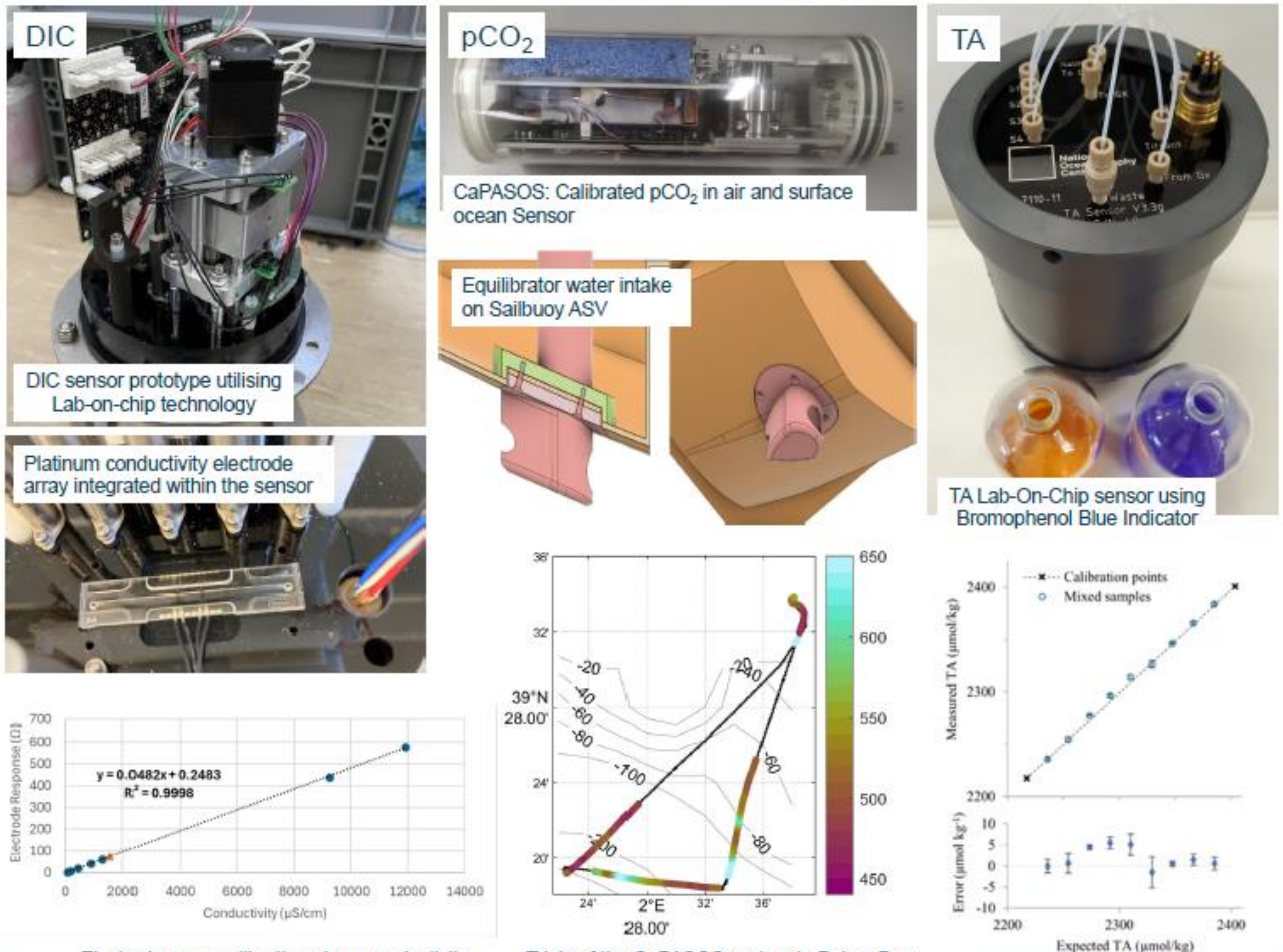
© Innovations of sensor developments: ICOS SC2024
Presentation by Socratis Loucaides and A. Lucio, P. Trucco Pignata, M. Arundell, A. Schaap, S. Castle, U. Schuster, W. Tatkiewicz, K Seelmann, M. Mowlem, P. Simpson, M. González Dávila, I. Alonso, M. Chalopin and N. Lanteri

Novel sensors for ocean carbon observations



DIC sensor prototype utilising Lab-on-chip technology

Platinum conductivity electrode array integrated within the sensor

CaPASOS: Calibrated pCO_2 in air and surface ocean Sensor

Equilibrator water intake on Sailbuoy ASV

TA Lab-On-Chip sensor using Bromophenol Blue Indicator

Electrode array calibration along conductivity range relevant to seawater DIC concentrations

Trials of the CaPASOS system in Palma Bay

Laboratory TA validation measurements

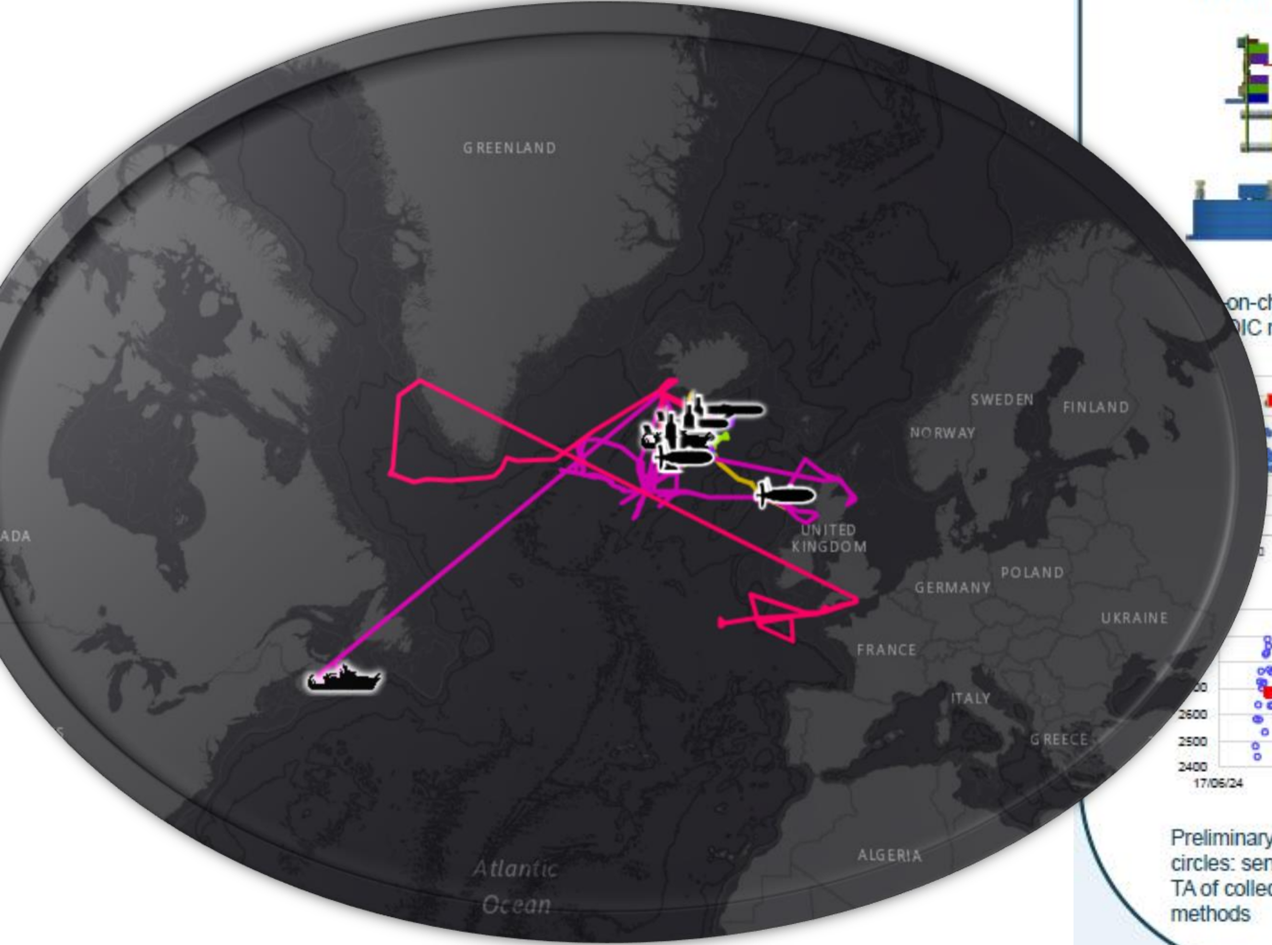
National Oceanography Centre · Ifremer · University of Exeter · ULPGC · OCEAN ICE / ocean mic · ClearWater SENSORS · 4H JENA ENGINEERING

Pls see Collision testing video

https://youtu.be/kKEmJCZLDY4

 Innovations of sensor developments: ICOS SC2024

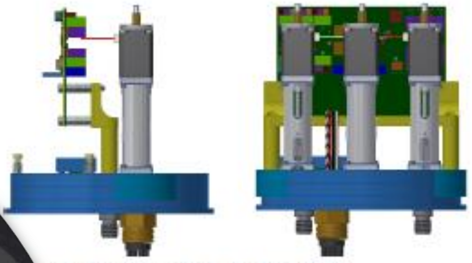
Presentation by Socratis Loucaides and A. Lucio, P. Trucco Pignata, M. Arundell, A. Schaap, S. Castle, U. Schuster, W. Tatkiewicz, K Seelmann, M. Mowlem, P. Simpson, M. González Dávila, I. Alonso, M. Chalopin and N. Lanteri



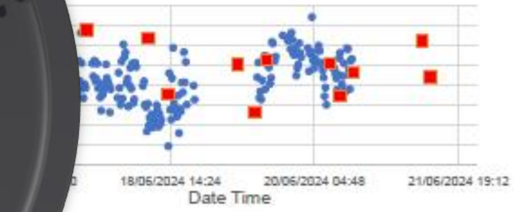
First field tests successfully carried out in between Iceland and UK. Instruments reached UK in August

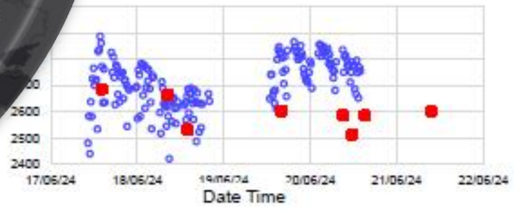
Multi-parameter sensor development

TA/DIC



Lab-on-chip sensor for combined TA and DIC measurements



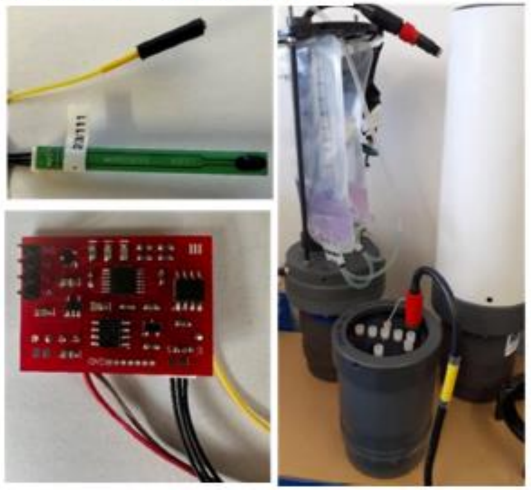


Preliminary testing in Southampton water (2024). Blue circles: sensor measurements, Red circles: measured TA of collected samples using laboratory standard methods

CO_2/CH_4

HydroC® CO2/CH4 Combi FT connected to the calibration unit

pH x 2



Lab-on-chip pH sensor combined with an electrochemical ISFET-type pH sensor enabling fast, high-accuracy measurements on fast-moving platforms such as gliders.

National Oceanography Centre | Ifremer | University of Exeter | ULPGC | OCEANMIC | ClearWater Sensors | 4H Jena Engineering

Gliders objectives and applications

OceanGliders

- Maneuverable: horizontal speed ~ 25km/day

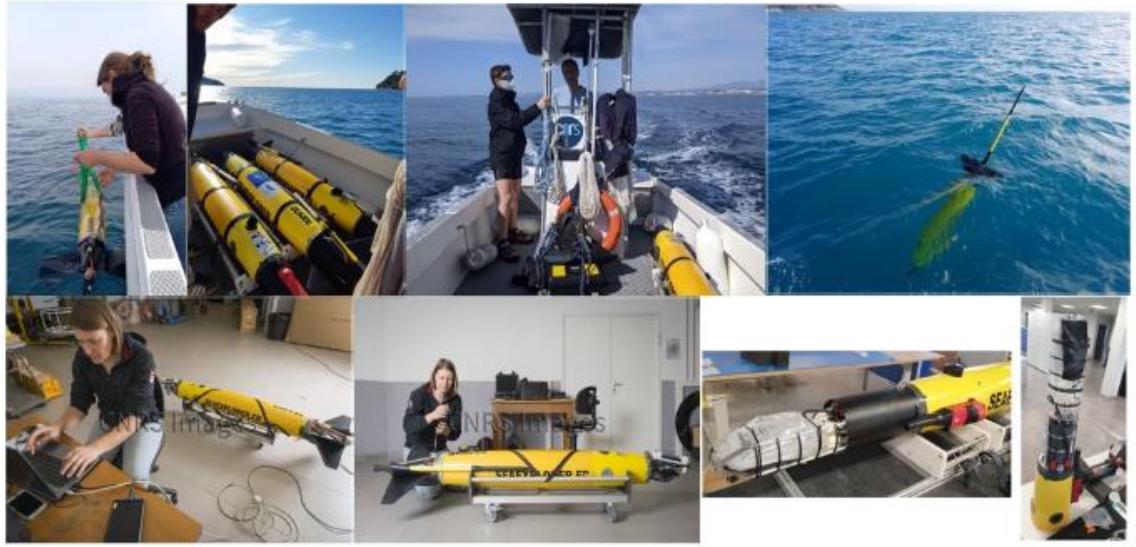
one dive ~0.5 - 5h (‘vertical’ profiles spaced ~0.5 - 5km a part) 300km in 10 days (~ 250-300 profiles)

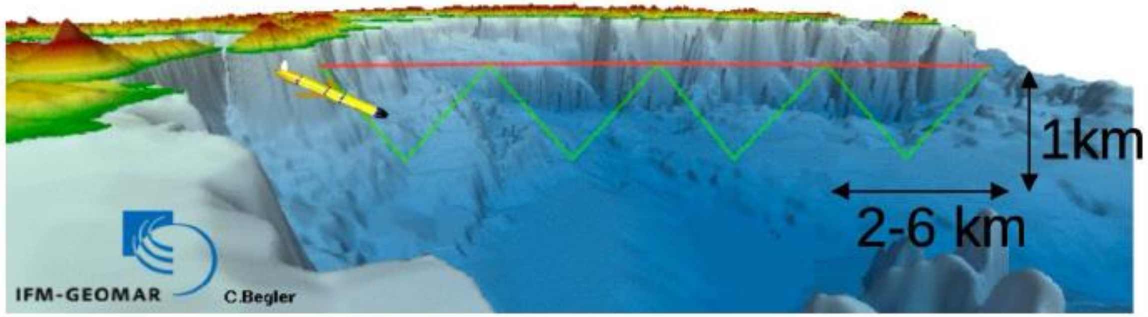
- Multi-tasking and re-deployable
- On-board physical and biogeochemical sensors

ECVs/EOVs: T, S, O2, fluorescence (Chl-a), nitrate

Other variables: Optical backscatter, CDOM, PAR, ADCP (current), hydrophones, zooplankton imagery (UVP6), …

Particularly well-suited to the study of regional oceanic processes over the long term





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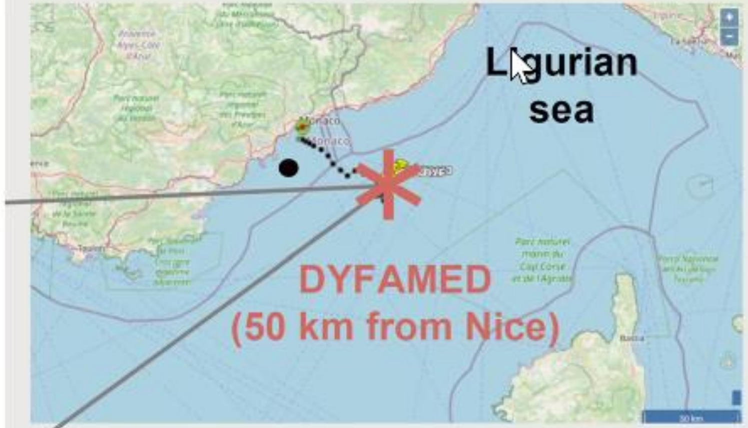
LOV

SORBONNE UNIVERSITÉ

Task 3.1 : Novel sensors integration (SU)

➢ **Measuring carbonate variables and wind speed on ocean gliders: integrate LOC and ACOUSTIC sensors on SEA-EXPLORER Glider (SU)**

- For Acoustic, we decided to use COST sensors (Mini-Pro CO_2 and PORPOISE). The glider piloting and behavior of sensors will be tested during the first mission planned in April/May 2024 in Villefranche/Mer.



Glider **virtual mooring** at Dyfamed
16 to 30 May 2024

Raw data

Figure 2). Time evolution of vertical profiles of xCO_2 (ppmv) in may 2024 at DYFAMED

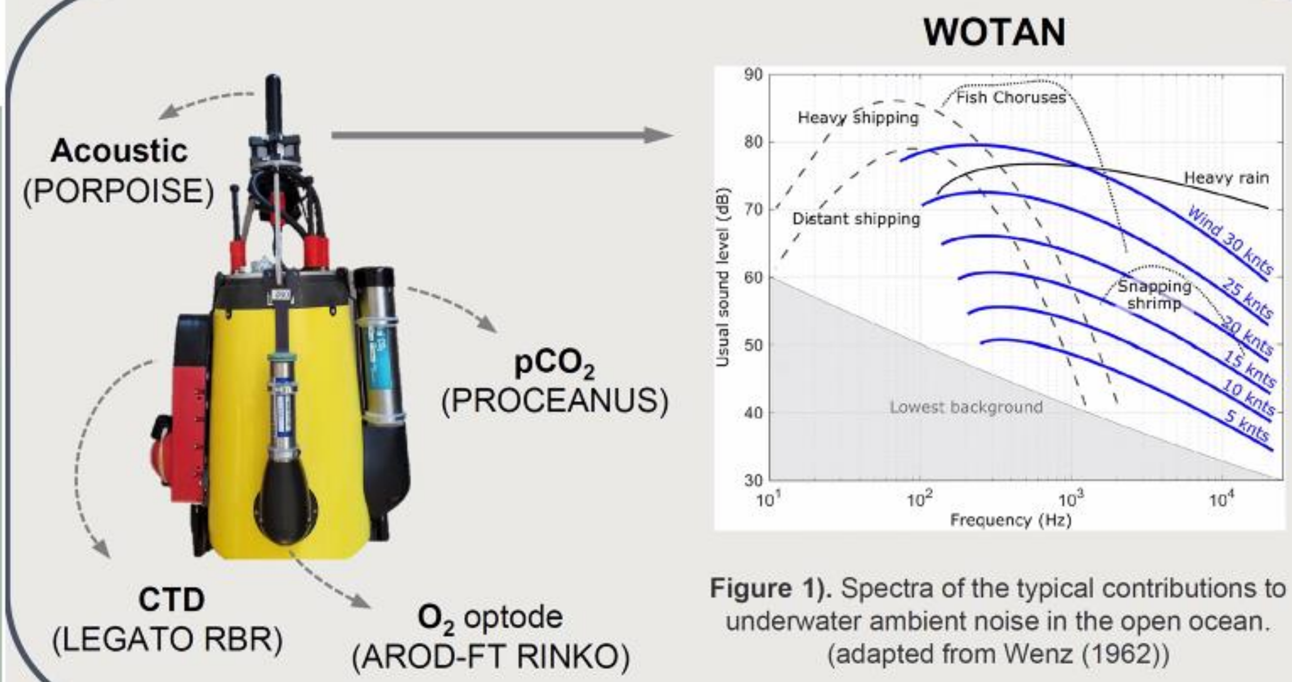


Figure 1). Spectra of the typical contributions to underwater ambient noise in the open ocean. (adapted from Wenz (1962))

Task 3.1 : Novel sensors integration (SU)

➢ **integrate low-power COTS acoustic sensors on Argo Float (NKE, SU)**

Objective : Acoustic wind measurement to refine CO_2 flux estimation

Third octave bands transmission:

- Reduced 9 bands : traffic Noise : 63, 125 Hz + Weather : 400 Hz, 1, 2, 5, 8, 12.5 and 20 kHz
- Option for Full 23 bands : 63, 100, 125, 160, 400, 500, 630, 800 Hz, 1, 1.25, 1.6, 2, 2.5, 3.15, 4, 5, 6.3, 8, 10, 12.5, 16, 20 and 25 kHz

✓ **May : Tested in Ifremer pool**
- July : Test by nke at sea (shallow depth)
- September : Test at LOV at full depth

nke INSTRUMENTATION

ABYSsens

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innovation & services at sea

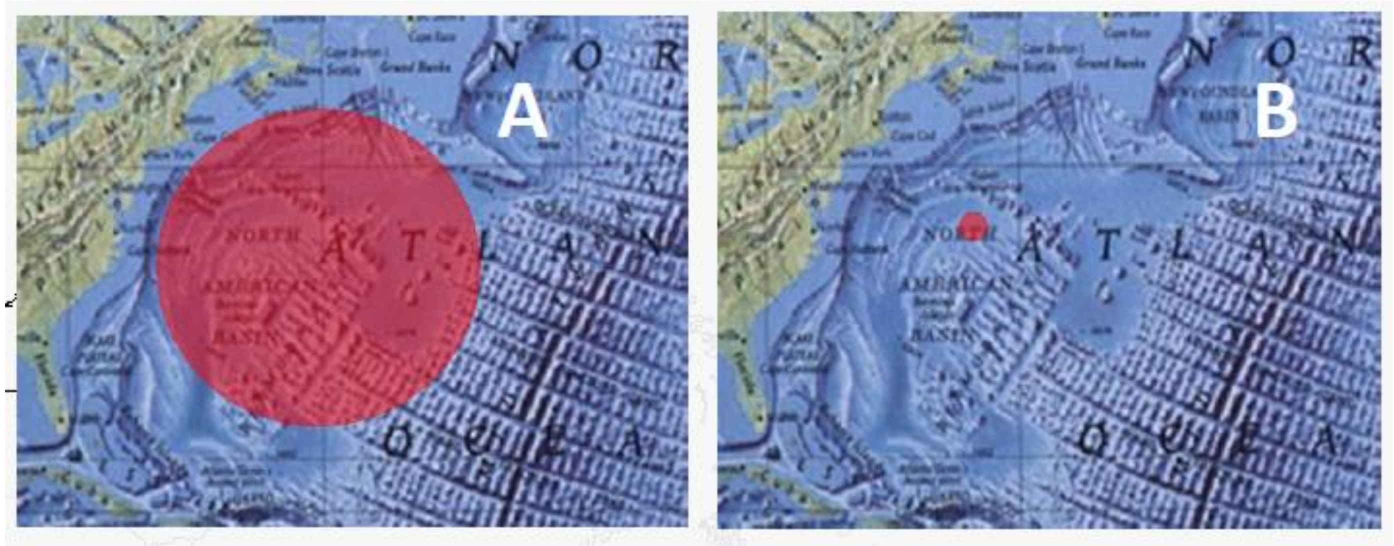
Acoustics for whale monitoring

Example of biological oceanography
Slides from Felix Margirier

GEORGE Technical Forum, May 2024 Villefranche sur Mer.

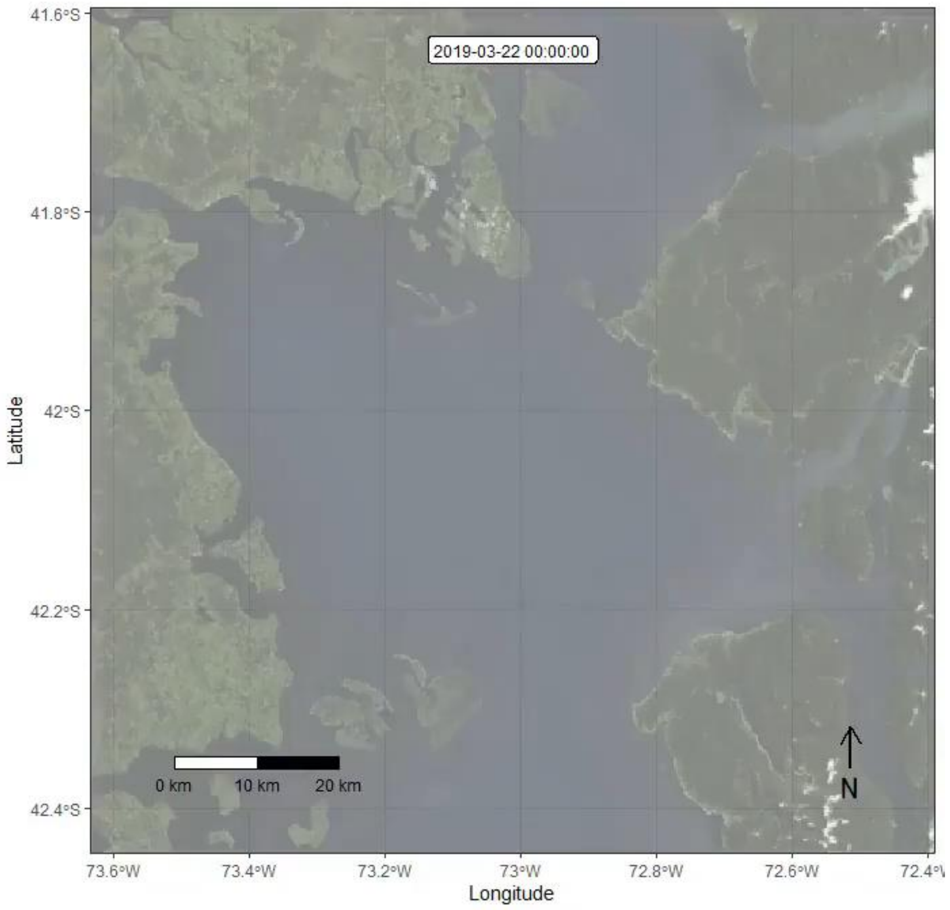
Shipping noise

Noise impacts from shipping **reduces communication and detection ranges**. This leads to increased **stress** and increasing difficulties for **mating, catching praises**, and **territory defense**.



Communication range of whales with and without maritime traffic.

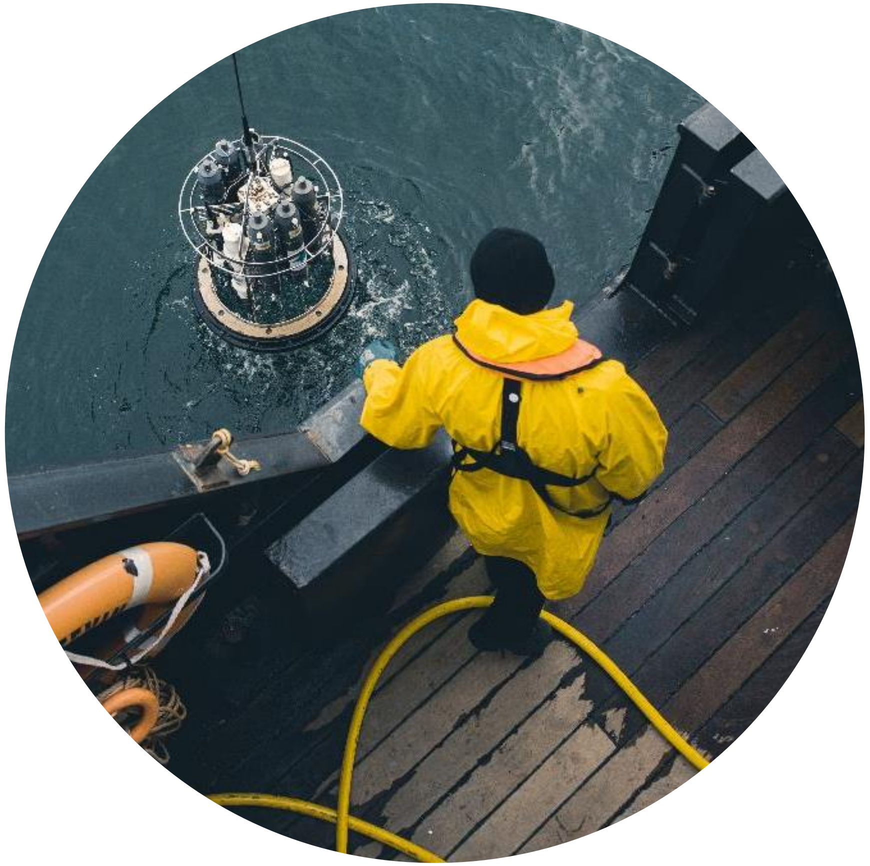
Source : Okeanos Foundation 2008



A week in the life of a blue whale in the eastern South Pacific (north Patagonia).

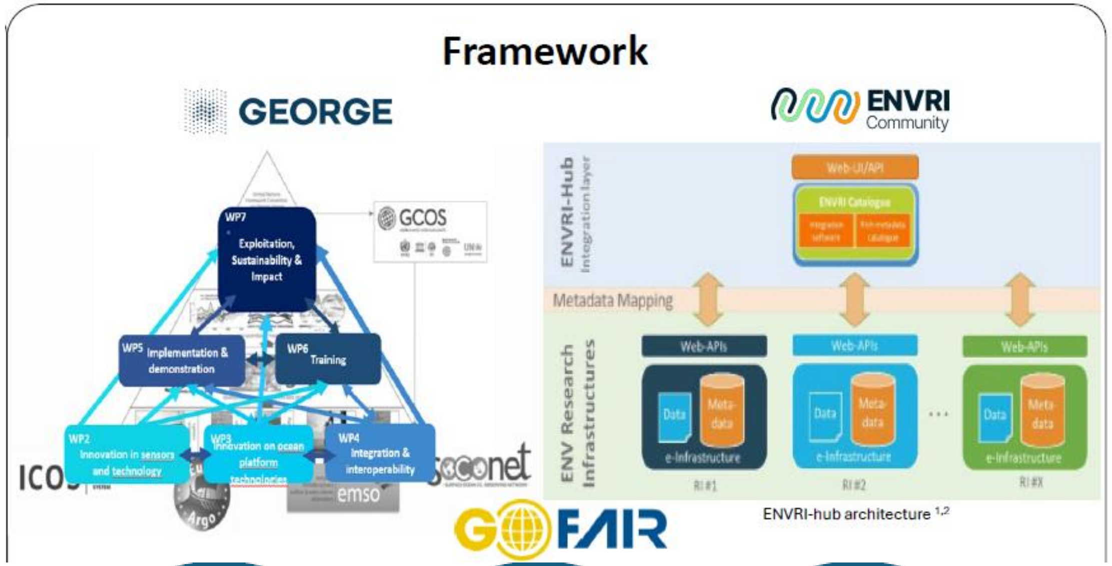
Image credit : Luis Bedriñana-Romano, Universidad Austral de Chile

More information contact: seaexplorer@alseamar-alcen.com



Roadmap towards marine data interoperability of 3 ERICs (EMSO – Euro-Argo – ICOS).

Technical Objectives



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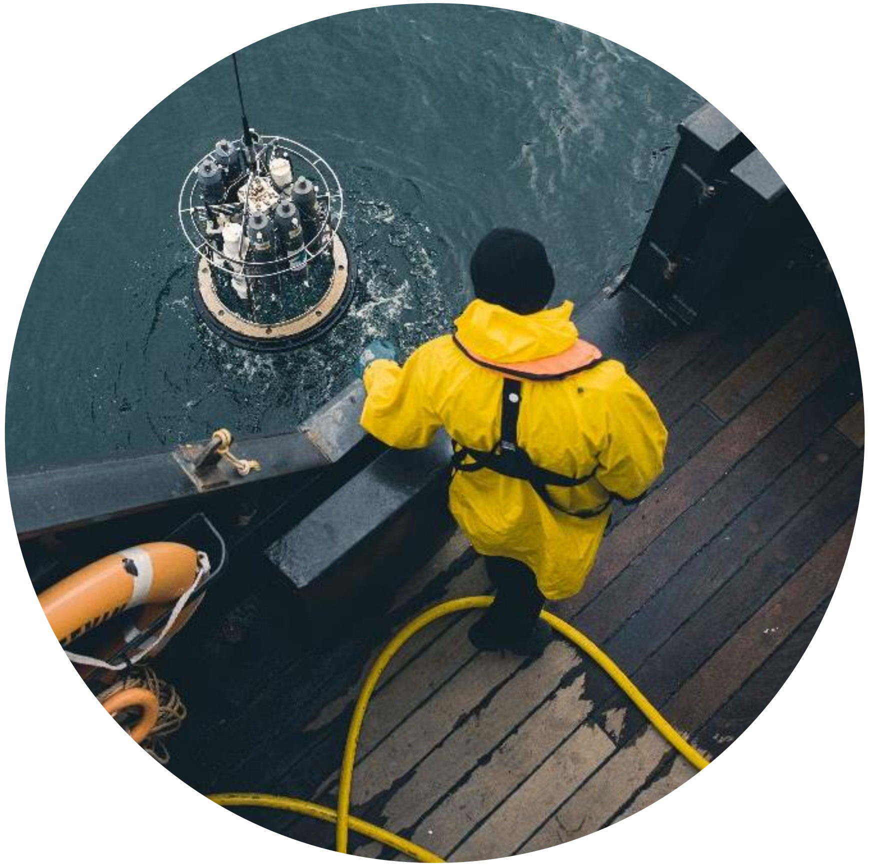
1. Examine Data Services for each RI
2. Identify data storage/catalogue endpoints
3. Harvest endpoints
4. Interoperability analysis
5. Reporting
6. Roadmap

Deep Sea Trials at 4000m in PAP optimization using hindcast data for 2026



MyOCEAN Resources Ltd. is helping to support improved integrated multi-RI information and data value chain through deployment of its FleetBot objective optimisation algorithms and procedures. FleetBot was a development of Operational Oceanography, where optimal observational capability was required within available, often minimal, resources and time.

Forecast modelling, combined with Near-Real Time data constraint and assimilation is central to the FleetBot processes and drives adaptive sampling, data processing and management strategies. Under GEORGE, cosmopolitan sampling will not be limited to multiple platform types, it will also extend to Research Infrastructures (RIs) flexible sampling programmes and regional ranges; to provide optimised network capacity and programme modification (within permissible ranges/parameters) for sea trials with novel instruments for observation of components of marine carbon pathways.

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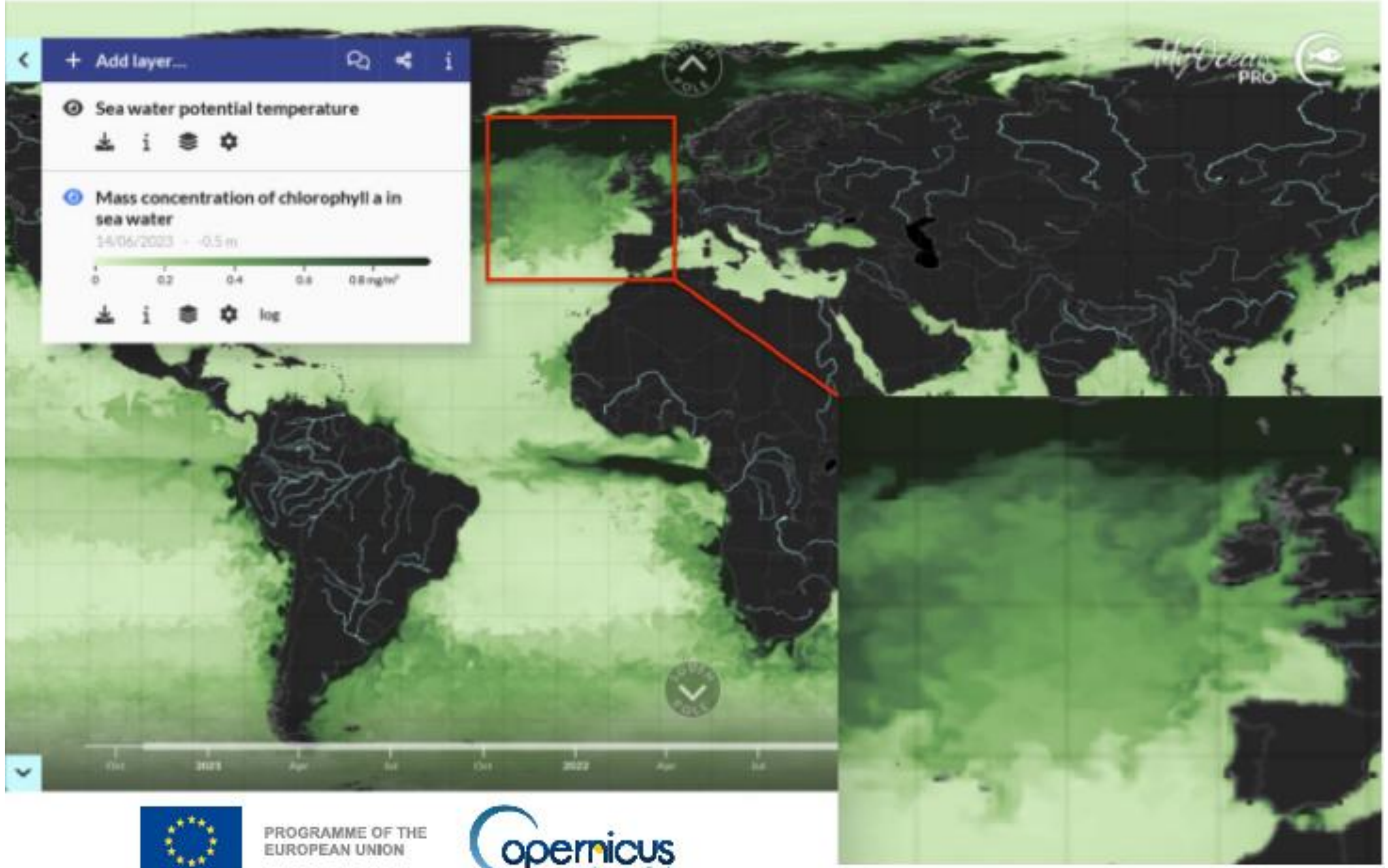
Fleetbot myocean resources

FleetBot processes optimisation of cosmopolitan sampling using Copernicus hindcasts



PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

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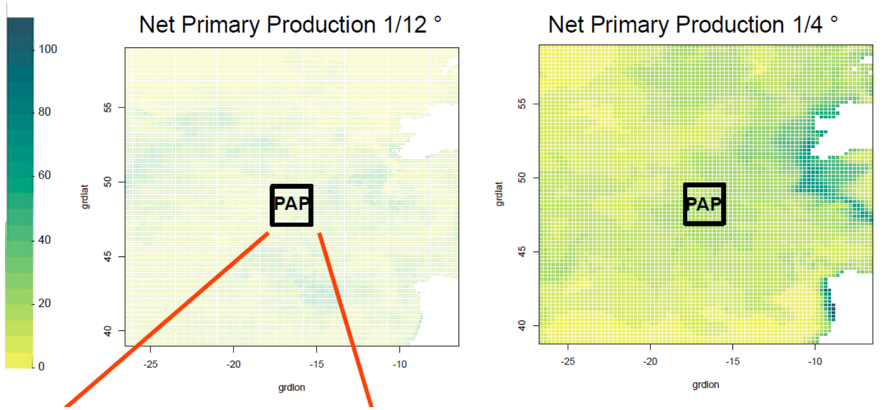
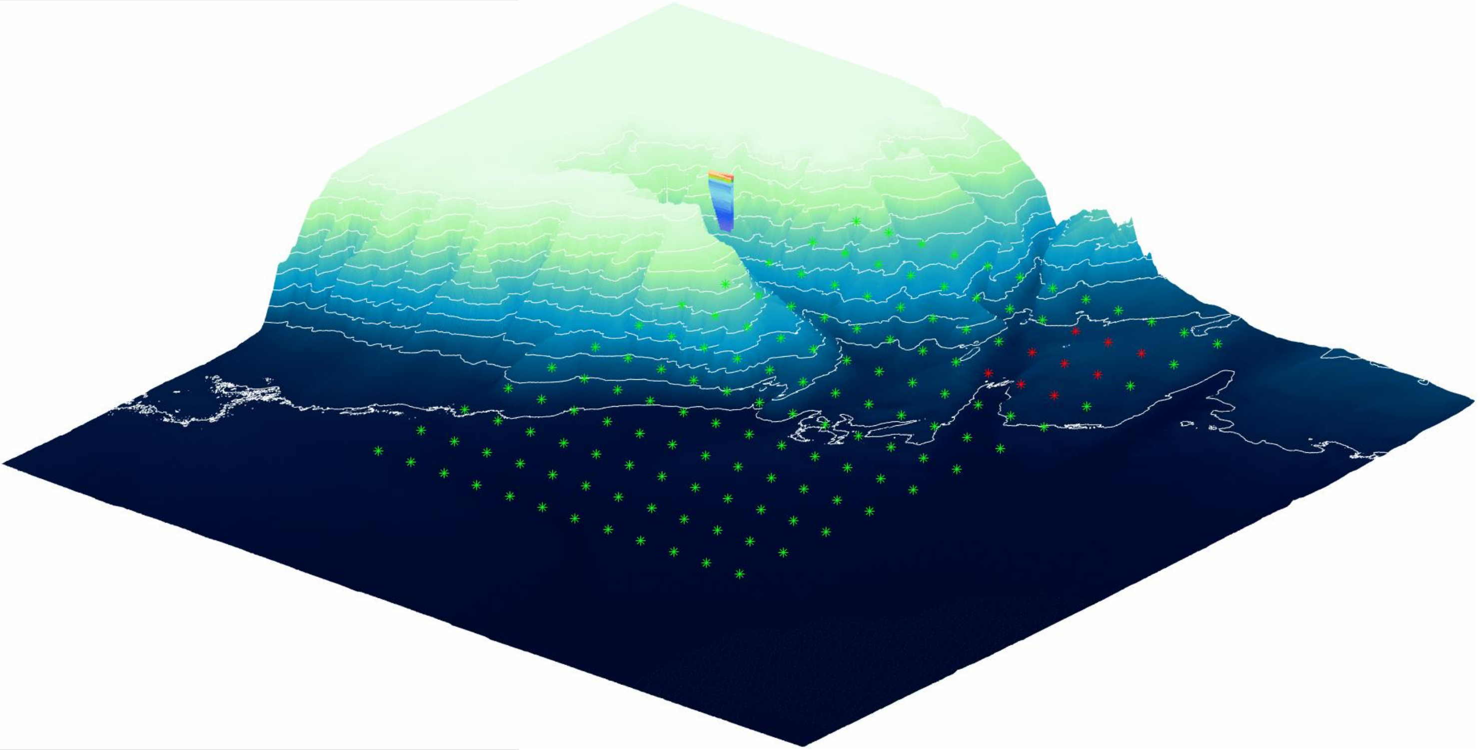
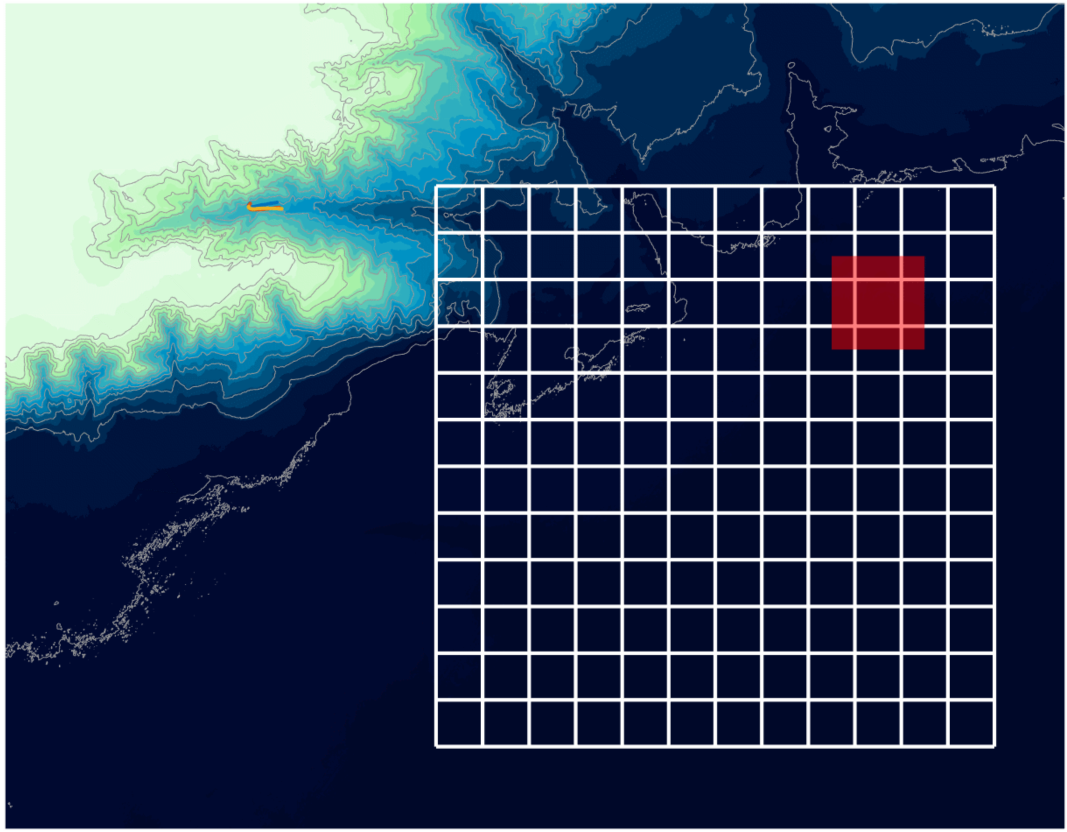
We use Copernicus hindcasts to demonstrate the FleetBot processes, in a deep sea region around the Porcupine Abyssal Plain (PAP) site, at both 1/4 and 1/12 degree resolutions. Advising and informing research programmes of their optimal potential and how to attain it, FleetBot monitors 'past' ability/skill to predict and correct future sampling/observing. Under GEORGE, FleetBot expands its use ofgenetic algorithm approaches to advise and inform research infrastructures of their optimal co-operative potential.



Glider Fleet navigation





Slide from Felix Margirier - Alseamar
Presented at GEORGE Technical Forum I,
May 2024 Villefranche sur Mer.

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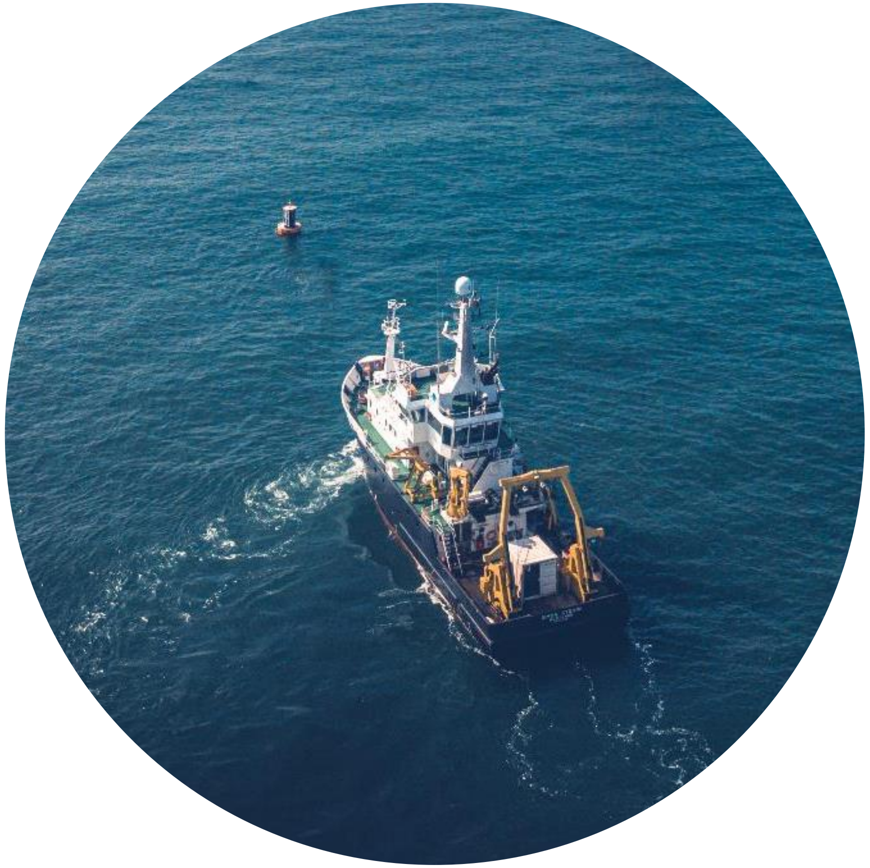

For Policymakers

- The project aims to provide policymakers with reliable scientific data on the ocean’s condition to support informed decision-making
- The new sensor and platform technology will significantly improve our understanding of the ocean carbon cycle and spark new research
- By collaborating actively with industry, the project will also enhance the competitiveness of the European industries that produce and supply ocean observation equipment and technology

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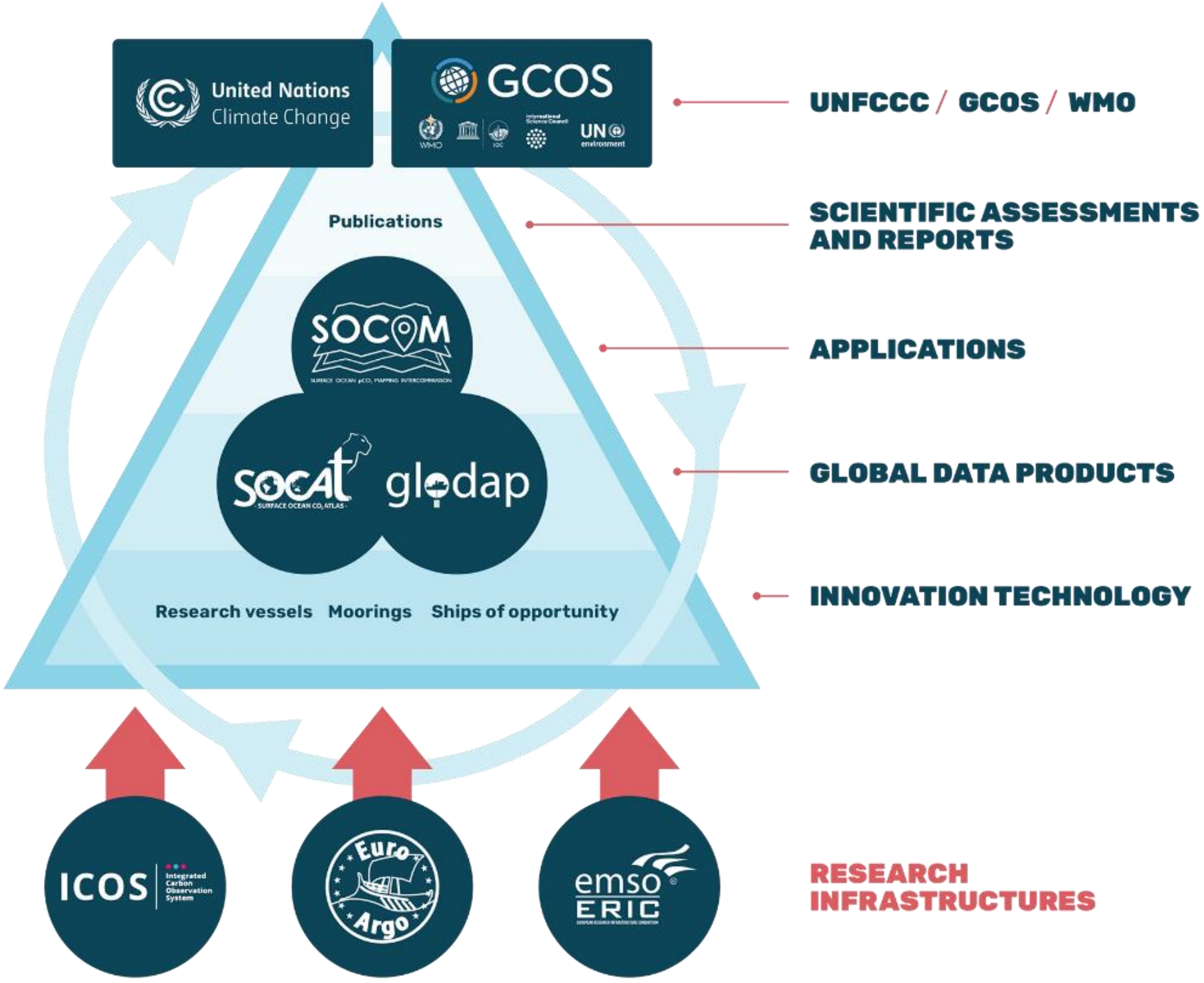
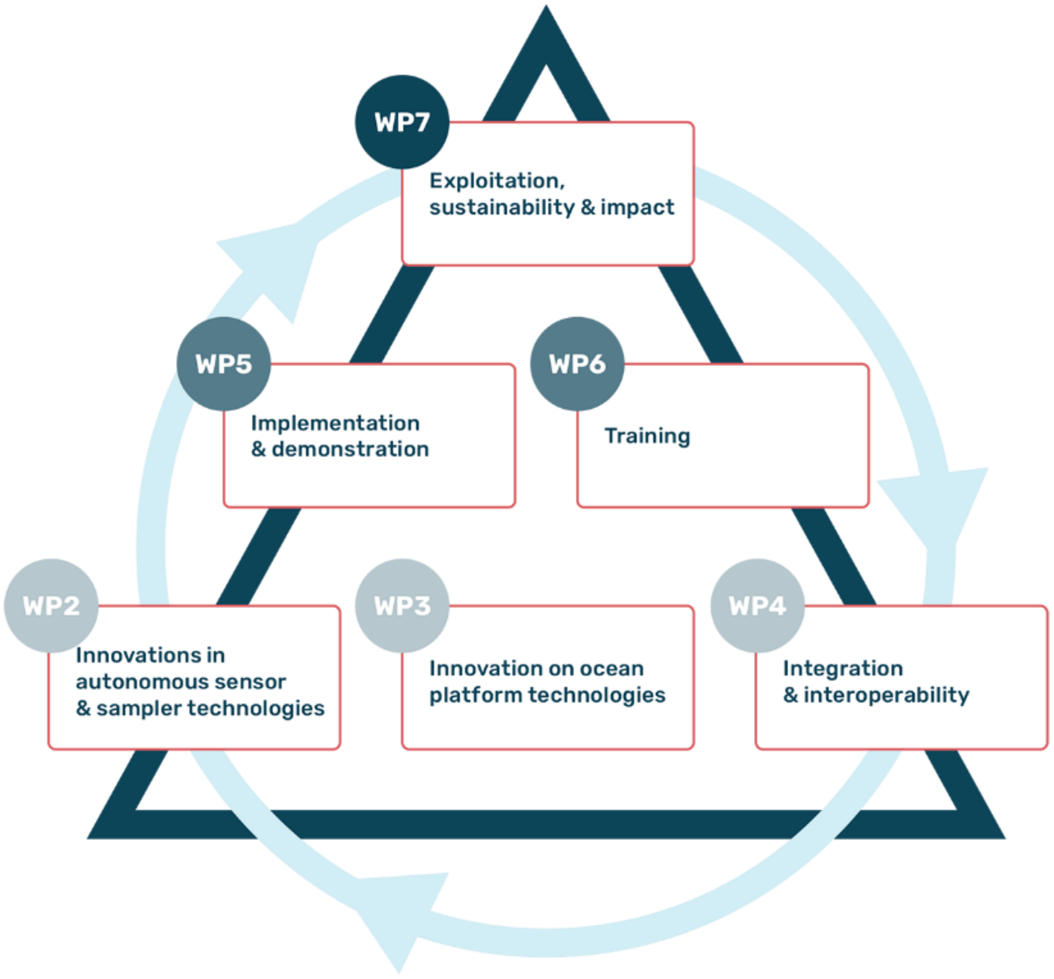
GEORGE & Ocean Biochemical Data Value Chain



Redrawn from Guidi et al. (2020) Big Data in Marine Science. EMB Future Science Brief 6. Doi:10.5821/zenodo.3755793. https://creativecommons.org/licenses/by/4.0/

GEORGE & Ocean Biochemical Data Value Chain



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For Industry

- GEORGE is a novel collaborative project bringing together academic and industry partners
- The project aims to develop new sensors beyond the technology readiness level to be commercially produced by industry partners
- The low-cost, energy-efficient technology can be seamlessly integrated into existing platforms
- The project will also provide training on the new technologies, enabling new users to operate the instruments seamlessly

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ERICs (European Research Infrastructure Consortiums)

ICOS
Integrated
Carbon
Observation
System

emso ®
ERIC
EUROPEAN RESEARCH INFRASTRUCTURE CONSORTIUM

Euro
Argo

Universities

SORBONNE UNIVERSITÉ

University of Exeter

UNIVERSITY OF BERGEN

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

ULPGC Universidad de Las Palmas de Gran Canaria

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

GEORGE

Research Institutes

National Oceanography Centre

VLIZ

NORCE

GEOMAR
Helmholtz-Zentrum für Ozeanforschung Kiel

PLOCAN Plataforma Oceánica de Canarias

Ifremer

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Research Institutes cont.

SOCIB Balearic Islands Coastal Observing and Forecasting System

cnrs

Leibniz Institute for Baltic Sea Research Warnemünde
IOW

Istituto Nazionale di Geofisica e Vulcanologia

Foras na Mara
Marine Institute

Industry

4H JENA ENGINEERING

OCEAMIC
MARINE BIO AND TECHNOLOGY

ClearWater SENSORS

nke INSTRUMENTATION

POKaPOK

W • SENSE
INTEGRATED CABLELESS SOLUTIONS

Offshore Sensing

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Fleetbot myOcean resources

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Next generation multiplatform
ocean observing technologies
for research infrastructures

Thank you!

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