

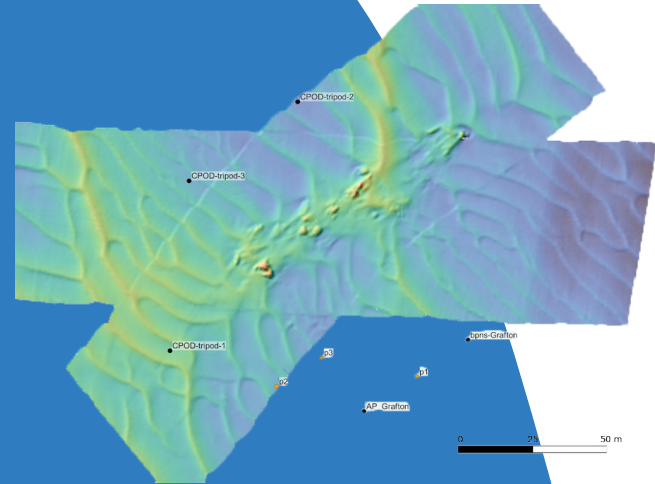


Advancing Integrated Marine & Coastal Biodiversity Observations for the European Ocean Pact

Demand for marine and coastal biodiversity knowledge is growing, driven by EU and global ocean policy, the Blue Economy and societal needs. This MARCO-BOLO knowledge transfer brochure showcases project field trials and innovative integrated sensor and platform approaches that deliver new tools for biodiversity monitoring towards holistic ecosystem assessments

Testing in the field

MARCO-BOLO conducted a number of field trials across European regional seas. This included a pilot study in May 2025 in the Belgian part of the North Sea. Led by project partners, VLIZ, NOC and DTU-Aqua, the trial tested new innovations by deploying multiple sensors and technologies simultaneously on fixed seabed observatories and mobile platforms. This concerted, multi-sensor deployment complemented existing long-term monitoring and enabled direct comparison of multi-parametric observations, assessing sensor performance, limitations, effectiveness and complementarities. Field activities were complemented by a parallel trial in UK waters, of a multi-sensor autonomous surface vehicle to support the same objectives.

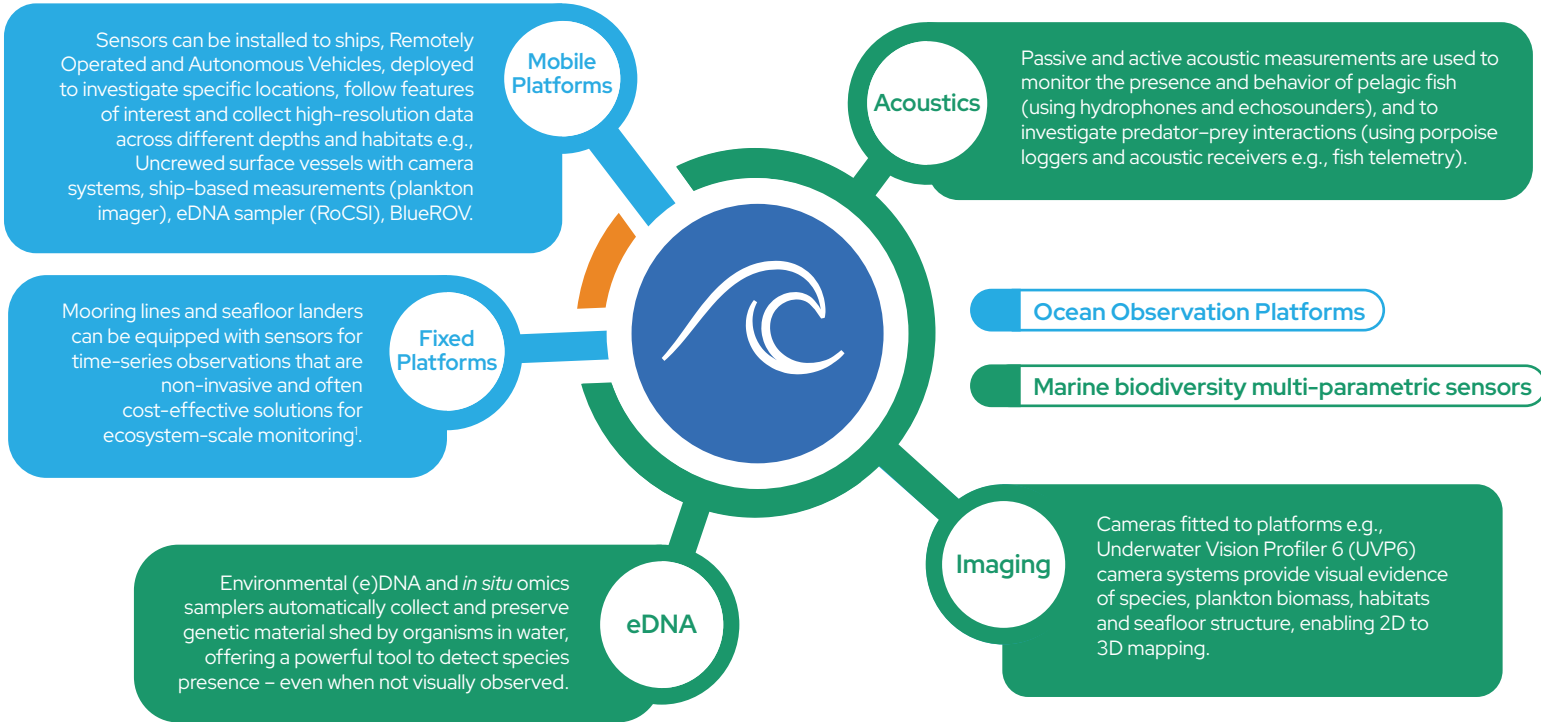


MARCO-BOLO sensor field trials, Grafton study site positions.



From Surface to Seafloor: MARCO-BOLO's Marine Biodiversity Observing Toolbox

Illustrating the diversity of *in situ* platforms and sensors used in MARCO-BOLO*



* Satellite and earth observations are not addressed here, as the focus is on *in situ* observations

OceanEye and the European Ocean Pact

Biodiversity observations are a critical part of the marine knowledge base underpinning EU ocean policies, such as the Marine Strategy

Framework Directive, Habitats Directive, Nature Restoration Law, and international commitments, including Biodiversity Beyond National Jurisdiction. Yet, despite growing demand for marine biodiversity monitoring, the European market for marine biodiversity observation technologies remains limited, with challenges including perceived high risk and often high investment required to bring these sensors and samplers to market.

The Business Case for marine biodiversity monitoring

Ocean observation is a growing Blue Economy sector³, with automation and technology integration as emerging trends⁴. Through innovative sensor field trials, MARCO-BOLO strengthens European marine biodiversity observation capabilities, a core component of Europe's OceanEye⁵ and Ocean Pact. Expanding business opportunities, linked to applications like blue carbon mapping, are accelerating public-private partnerships to observe and assess Europe's seas and coasts, e.g., Fugro geo-data solutions company (EMODnet Associated Partner and UN Ocean Decade Corporate Data Group co-chair).

What does the private sector say?

“With decades of experience in marine environmental services for infrastructure development, Fugro is well aligned with the growing focus on marine biodiversity monitoring. European legislation now requires countries, investors, companies and projects to report on both their impacts on biodiversity and the impacts of biodiversity loss on them. This is driving strong demand for marine biodiversity monitoring data at all scales, and we are excited to be investing in solutions that will enable this.”

Daniel Smith, Offshore Wind Biodiversity Solution Owner at Fugro

Integrated sensor approaches to Marine Biodiversity Monitoring

Georeferenced and Automatically Sampled Genomics Data

Value

Integrating genomics and precise location data provides a **reliable “fingerprint” of local biodiversity**, supporting high-resolution ecosystem assessments and long-term monitoring.

Technology

Robotic Cartridge Sampling Instrument (RoCSI)

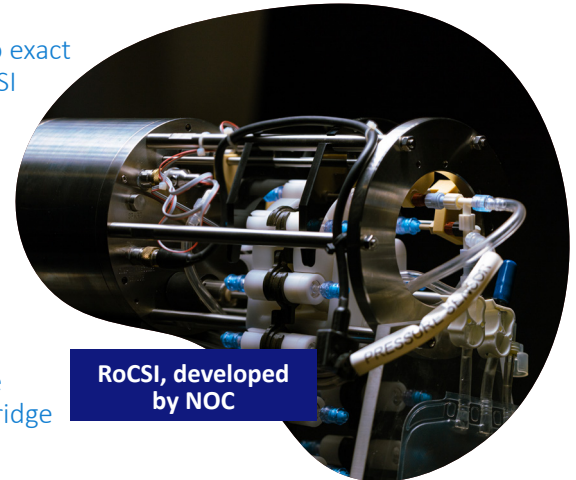
An automated, programmable **in situ omics and eDNA sampler** that preserves samples with a chosen fixative. Once processed in the lab, RoCSI samples reveal detailed genetic signatures of the species present.

Challenge

Linking RoCSI’s sampling events to exact locations is **time-consuming**. RoCSI timestamps have to be merged manually with the ship or vehicle’s GPS records. Syncing two separate sources of location data complicates reporting and reduces efficiency.

Innovative Solution

Geolocation data from the vehicle and RoCSI’s metadata (Time, Cartridge ID, Sampling Duration, Treatment, Stop Reason, Volume Seawater Pumped, Maximum Pressure) are bundled into one unified .csv output. This streamlined file can be transmitted via radio or infrared from a mobile platform, **enabling accurate, ready-to-use genomic sampling locations**.



RoCSI, developed by NOC

Onboard Image Processing for Near-Real-Time Particulate & Plankton Classification

Value

Integrating a state-of-the-art *in situ* camera system for plankton and particle images on an autonomous platform with georeferencing and AI-based classification.

Technology

Underwater Vision Profiler 6 (UVP6)

fitted to AutoNaut Uncrewed Surface Vessel for **on-board classification** with an automated, programmable camera

system targeting the 0.2 – 50 mm size range. Collects *in situ* images, which are then classified to reveal plankton and particle abundance and community structure. **Novel AI classifier architecture** was developed, providing superior recognition.

Challenge

Fitting UVP6 on AutoNaut that enables high-quality images and linked with GPS for digital sample processing.

On-board compute requires resources; the platform has tight latency and power budgets. Site-to-site differences can change the classification accuracy.

Innovative Solution

Geolocation data from the vehicle and UVP6 metadata are unified post deployment. Classification is carried out post deployment and quick re-calibration on new data is developing.

Integrating Multiple Acoustic Sensors for Long-Term, Holistic Monitoring

Value

Combining acoustics, together with other technologies, reveals how multiple species use an area over time, enabling continuous, non-invasive monitoring of marine mammals and tagged fish.

Technology

Passive Acoustic Devices (PODs)

attached to seafloor lander platforms/ moored lines record echolocation clicks from marine mammals, enabling

population-level monitoring without disturbance.

Challenge

PODs detect animals but cannot identify individuals. Acoustic receivers, by contrast, track tagged fish with high specificity but is limited by how many animals are tagged. **Each method offers only a partial view.**

Innovative Solution

A multi-sensor mooring integrates:

RoCSI, echosounders, a **broadband hydrophone, cetacean logger** and acoustic fish telemetry receiver.

This combination enables simultaneous monitoring of marine mammals and tagged fish, **capturing species co-occurrence across time and space**[®]. A structured dataflow ensures high-resolution results ready for publication into public repositories such as EMODnet Biology and EurOBIS, **amplifying their scientific and operational value.**



Mapping Seafloor and Pelagic ecosystems

Value

High-resolution seafloor 3D mosaics provide detailed **insights into benthic habitats, species distribution and ecosystem health**. They support long-term monitoring, habitat assessment and effective marine management.

Technology

BlueROV2 by Blue Robotics

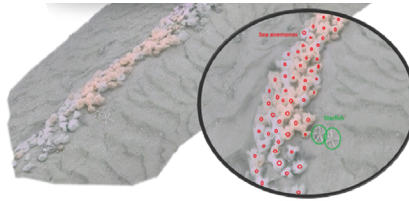
An affordable, modular remotely operated vehicle (ROV) equipped with detachable payloads for multi-camera imaging, enabling **robust and flexible pelagic and benthic surveys**.



BlueROV2, customised by DTU-Aqua

Challenge

Assessing benthic biodiversity in shallow waters with complex seafloor structures and limited visibility is an ongoing challenge, together with producing efficient workflows.



Section of the 3D model of the Grafton Shipwreck, Ostend, Belgium with starfish and sea anemones quantification and biovolume measurement

Innovative Solution

BlueROV2 integrated with a Multi-Camera System, for detailed seafloor and structure mapping, and a Ultra Short Baseline (USBL) enabling georeferenced video and acoustic data. A custom-calibrated multi-camera rig and a preprocessing Graphical User Interface for frame extraction and preprocessing support accurate 3D reconstructions. Future innovation is set to offer functionalities including **automatically identifying and quantifying benthic species, producing large-scale seafloor images and annotated biodiversity maps**.



Through its field trials, **MARCO-BOLO** shows the huge potential for multi-parametric 3D biodiversity sampling, imaging and mapping and its value for assessing Good Environmental Status, reversing biodiversity loss and restoring marine ecosystems. Biodiversity observations are an essential component of the OceanEye and now Europe should promote technology transfer to ensure this can scale.

Acknowledgements

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Content draws on MARCO-BOLO deliverables and relevant peer-reviewed publications (see list below)



This brochure is part of a MARCO-BOLO knowledge transfer series.

See the project website for more information:

[MARCOWOLO-PROJECT.EU/KNOWLEDGE-TRANSFER-SERIES](https://marcobolo-project.eu/knowledge-transfer-series)

About

MARCO-BOLO addresses key challenges in coastal and marine biodiversity observation by advancing how biodiversity data are collected, integrated, shared and used. The Horizon Europe project connects existing initiatives and capabilities, unifies data collection practices and drives innovation across the full marine biodiversity pipeline – from observation and data acquisition to data management, services and uptake – ensuring that data are analysis-ready and reusable in public services like OBIS and EMODnet.

1. Calonge, A., et al. (2026). Scalable low-cost seabed landers: The missing link for sustained, integrated, long-term observations in dynamic shallow seas. *Remote Sensing in Ecology and Conservation Online first*: 1-9. <https://dx.doi.org/10.1002/rse2.70072>
2. European Commission. (2025). The European Ocean Pact. https://oceans-and-fisheries.ec.europa.eu/european-ocean-pact_en
3. European Commission. (2025). EU Blue Economy Report 2025. https://blue-economy-observatory.ec.europa.eu/news/eu-blue-economy-report-2025-2025-05-22_en
4. Farinha, J., et al. (2026). Observing the Future- Horizon scanning for emerging technologies and breakthrough innovations in the field of ocean observation, Publications Office of the European Union, Luxembourg. <https://data.europa.eu/doi/10.2760/3939356, JRC144401>.
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6. Calonge, A.; Goossens, J.; Muñiz, C.; Reubens, J.; Debusschere, E. (2024). Importance of multi-sensor observations to advance species co-occurrence knowledge: A demonstration of two acoustic technologies. *Mar. Ecol. Prog. Ser.* 727: 49-65. <https://dx.doi.org/10.3354/meps14496>