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Stronger Together

Book of Abstracts

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Plenary Presentations

Sessions 1–6 · Monday 18 May – Wednesday 20 May 2026

Abstract #8

Augmenting Ocean Observatories with Environmental DNA: A Framework to Enhance Biodiversity Observations

Authors

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Presenting author

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Keywords

Augmented observatories, Biodiversity monitoring, Environmental DNA (eDNA), Ocean observatories

Abstract

Marine life worldwide is increasingly impacted by human-induced pressures on the oceans and seas. While ocean observatories are essential infrastructures for understanding marine ecosystems, they largely overlook biodiversity — a crucial component in tackling global biodiversity loss. Traditional observing systems focus primarily on physical and biogeochemical parameters, leaving biological diversity under-sampled and poorly integrated into long-term monitoring and forecasting frameworks. Environmental DNA (eDNA) analysis offers a scalable and sensitive approach to detect and quantify biodiversity directly from water samples. This talk presents a structured framework for integrating eDNA-based observations into existing ocean observatories — transforming them into Augmented Observatories (AOs). Building on discussions from the G7 Future of the Seas and Oceans Working Group (2017), we explore the design of AOs that (a) enhance biodiversity detection and monitoring across ecosystem levels, and (b) integrate biomolecular (eDNA metabarcoding), conventional (microscopy, flow-cytometry), optical (FlowCam imaging), acoustic, and remote-sensing observations to provide near real-time, comprehensive ecosystem insights. We outline design principles addressing purpose-driven observation, sampling strategies, institutional modalities, and data integration, with attention to FAIR principles, Essential Ocean and Biodiversity Variables (EOVs/EBVs), and international regulatory frameworks. Case studies from EMO BON and NEREA illustrate practical pathways for implementing eDNA-augmented observatories within existing monitoring infrastructures. By linking scientific, operational, and policy dimensions, this work provides actionable guidance for embedding molecular biodiversity data into global ocean observing systems — advancing our collective capacity to observe, forecast, and ultimately mitigate biodiversity loss.

Abstract #30

The European Digital Twin Ocean: Integrating Data, Models, and AI for Sustainable Ocean Management

Authors

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Presenting author

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Keywords

application, digital twin ocean, ocean ecosystem, what if scenario

Abstract

The European Digital Twin Ocean is a landmark initiative providing a comprehensive, multi-scale digital representation of the ocean to support scientific research, policy-making, and societal decision-making. At its core lies the EDITO platform, the foundational digital infrastructure that integrates heterogeneous ocean observations, models, and AI-based tools, harmonizing data from established European infrastructures such as EMODnet and the Copernicus Marine Service. Leveraging cloud and high-performance computing resources, EDITO enables “what-if” scenario simulations and transforms fragmented marine data into actionable knowledge. The platform also supports the development of regional and thematic “local twins” tailored to specific stakeholder needs. Pre-operationally unveiled in June 2024, EDITO is now entering its second development phase. This phase, through EDITO2, focuses on co-designing and co-developing advanced digital twin capabilities with European and international research initiatives to ensure interoperability, standardization, and broad accessibility. EDITO2 aims to integrate state-of-the-art ocean models, ecological monitoring, AI-based tools and models, and socio-economic analyses, fostering user-driven, fit-for-purpose applications and “what-if” scenario simulations. Key achievements include the demonstration of the next-generation European Digital Twin Ocean at the UN Ocean Conference 2025 (UNOC3), highlighting real-time data integration, scenario simulations, and applications spanning biodiversity protection, coastal risk management, and plastic pollution tracking. Looking forward, EDITO aims to expand the European Digital Twin Ocean ecosystem, strengthen long-term sustainability through open access, integrate complementary initiatives, and align with global efforts such as UN DITTO and the Ocean Prediction DCC. By combining technical innovation, collaborative governance, and cross-sectoral engagement, EDITO establishes a durable European Digital Twin Ocean framework that advances knowledge, supports informed decision-making, and promotes the sustainable

management of ocean ecosystems, servicing progress towards the societal objectives pursued by the EU Mission Restore our Ocean & Waters, the European Ocean Pact and the United Nations Decade of Ocean Science for Sustainable Development.

Abstract #34

Towards an Essential Ocean Variable Data Exchange

Authors

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Presenting author

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Keywords

Data Exchange, Essential Ocean Variable, Interoperability, Standardisation

Abstract

Essential Ocean Variables (EOVs), as defined by the Global Ocean Observing System (GOOS), represent a minimum set of key variables critical to understanding ocean change. EOVs provide a fundamental framework for ocean observations to capture dynamics and processes across physical, biogeochemical, biological and ecological ocean systems. EOV data has many applications and can be impactful at national, regional and global scales. The collection of EOV data is beneficial at a national and regional scale supporting ocean forecasts, early warning systems, climate projections and informing policy and industry. Furthermore, EOVs contribute to environmental assessments aimed at safeguarding ocean health whilst aligning with global initiatives such as Sustainable Development Goal 14 (Life Below Water) and the UN Decade of Ocean Science for Sustainable Development. EOVs are also closely linked to Essential Climate Variables, identified by the Global Climate Observing System, providing essential inputs for climate analysis and climate indicator development.

GOOS has identified 36 EOVs, based on impact and feasibility (of methodology and sustained observation at a global scale), each accompanied by a specification sheet developed by GOOS Expert Panels. Each specification sheet acts as a guide to collecting EOV data to contribute to the GOOS. These specification sheets outline recommended spatial and temporal resolution for data collection to observe processes of interest (phenomena), along with information on sensors, technologies and platforms, serving as a framework for standardising oceanographic data collection. However, assessing whether datasets comply with these standards is challenging. The sheets are not machine-readable and certain requirements are difficult to implement at regional and local scales, where EOV data are arguably most critical for policy, industry and early warning systems. Additionally,

the multitude of data portals without a unified source for EOV datasets can further complicate accessibility, interoperability and usability of EOV data.

We will present a use case demonstrating improved interoperability and standardisation of a selected EOV dataset by highlighting the minimum set of metadata needed to automatically assess if a long-term seawater temperature time series from the Marine Institute, Ireland meets the GOOS EOV specification. We will also provide recommendations to expand these practices across wider EOV data collections, with the goal of advancing toward an EOV Data Exchange.

Abstract #35

Downstream services for flooding risk reduction in the Western Mediterranean Sea

Authors

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Presenting author

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Keywords

Coastal flooding, early warning systems, high resolution modelling, proactive emergency management, wave-current coupled systems

Abstract

The Western Mediterranean coast, featured by a high population density, faces severe socio-economic and ecological risk from marine hazards. Coastal flooding in this region is driven by the joint action of extreme meteorological events, mainly wave storms, storm surges, and in-land flash floods. This situation will intensify due to rising coastal vulnerability, driven by anthropogenic pressure and erosion, and the increasing severity of climate drivers. Therefore, monitoring and reliable quantification of these impacts is fundamental to enable significant risk mitigation via proactive coastal management. Two Early Warning Systems (EWSs) are addressing this challenge: the e3HOPE (in operations since 2024) and ALISEO (expected operational release in early 2026). Both systems downstream regional Copernicus Marine predictions into targeted information for end-users. The e3HOPE service is implemented at the Ebro Delta in Spain, a low-lying, wave-dominated coast with high-value assets, including bivalve aquaculture, biodiversity protected areas, and a substantial tourism economy. The e3HOPE delivers daily predictions via the NAUI service platform to a growing community (more than 40 registered users, https://e3hope.naui.io/). This region is acutely sensitive to flooding and erosion, addressed with a coupled hydromorphodynamic model (XBEACH, Roelvink et al. 2009). The spatial resolution in specific transects of the Delta reaches 20 meters, providing the required fine resolution for local assessment. On the other hand, ALISEO is focused on the Genoa Gulf in Italy, a meteorological hotspot for explosive cyclogenesis. Its core objective is robust storm-surge forecasting to support operational safety, especially for maritime activities. Key stakeholders include harbor and marina operators, and the managing authorities of the Cinque Terre National Park. Thus, the

system’s primary targets are civil protection and nature conservation. This coastal forecast system reaches a spatial resolution of 70 meters on the National Park's vulnerable coastal fringe. ALISEO products will be disseminated via the SEAWETRA Platform (https://www.seawetra.org/). Despite their distinct zones, both ALISEO and e3HOPE share commonalities. Both EWSs downstream the Copernicus Marine Mediterranean MFC regional products. Predictions are generated daily, providing a 72-hour forecast horizon. These systems also add three advancements that increase their skill, especially for compound flooding events: (i) the implementation of a high-resolution, two-way coupled wave-current modeling system (COAWST, Warner et al. 2010); (ii) the use of high-resolution local atmospheric forcings to capture the spatial variability of extreme wind fields, precipitation and heat fluxes; and (iii) the incorporation of local river discharge monitoring and forecasting data, enhancing the coastal water budget. This contribution will present a validation of the two systems during a series of recent storm events. Local in-situ monitoring data and Copernicus Marine products (both in-situ and remote sensing data) will be used as reference. The analysis will not only demonstrate the systems' capability, but also it will highlight the prediction limits and the still-present sources of uncertainty in coastal EWSs. Ultimately, this initiative will show an example on how coastal prediction aligns with major European policy goals, including the EU Green Deal, the European Ocean Pact, and the Water Resilience Strategy.

Abstract #39

Trust in the Age of AI: Modernising the Ocean Data Publication Cookbook for the UN Decade of Ocean Science for Sustainable Development

Authors

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Presenting author

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Keywords

collaboration, data citation, digital ecosystem, persistent identification, trust

Abstract

In recent years there has been a disruptive force in the global data system as the private sector has become the largest aggregator of data through the likes of Anthropic, Alphabet, Meta and OpenAI as data are gathered to train Large Language Models (LLMs). Equally, the outputs of these LLMs are increasingly seen online in various forms. Ocean specific data aggregators such as Digital Twins of the Ocean are also emerging. This presents new challenges in the form of data provenance and trustworthiness.

The research data management community proposed in the early 2010s the idea of data citation as one avenue for identifying and crediting the sources or originators of datasets. The Intergovernmental Oceanographic Commission (IOC) of UNESCO published the most recent guidance for the marine data management community in its Ocean Data Publication Cookbook in 2013. This guideline presents a three-tier approach of data serving (making data available online); formal data publication (assigning a persistent identifier in the form of a digital object identifier to a static copy of the dataset made available online); to a gold standard of formal data publication with an associated data description paper in a data journal. However, as noted above, the wider landscape has significantly changed in the time since then and the use of data citations is not as widespread as hoped. This is still a barrier to the full adoption of open science principles, not assuring transparency and replicability of the scientific process, nor fairly rewarding professionals acting along the data life cycle. We

advocate a robust integration of Persistent Identifiers to ensure the longevity and visibility of digital resources while facilitating precise citation and collaboration.

As an implementing partner in the UN Decade of Ocean Science for Sustainable Development, EuroGOOS (through its Data Management, Exchange and Quality Working Group) has been collaborating with the Decade Coordination Office for Ocean Data Sharing to update the Ocean Data Publication Cookbook. These updates take into account the evolution in the data landscape including guidance such as dynamic dataset citation; persistent identification of researchers, projects and organisations; and the publication of both the FAIR and CARE principles. In addition, leveraging the new Complex Citation recommendations from the Research Data Alliance (RDA), will allow for a better recognition of data providers upstream for large data collections. By expanding and modernising the Ocean Data Publication Cookbook, marine data systems adopting the guidance will be in a better position to become trusted suppliers of data to the emerging global data infrastructure IOC is developing. These updates and use of the network of persistent identifiers empowers marine data aggregators such as EMODnet and Copernicus Marine to use trusted sources of data and allows data providers to gain more consistent credit for sharing their ocean data. This paves the way for digital certification of datasets by trusted research infrastructures or intergovernmental organisations.

In this presentation we will outline the updated guidance for formal data publication, and highlight the benefits of the new version of the Ocean Data Publication Cookbook.

Abstract #46

Blue-Cloud 2026 – establishing the Marine thematic EOSC node in the EOSC Federation and as component of the Digital Twin of the Ocean programme

Authors

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Presenting author

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Keywords

Datalakes, DTO, EOSC, Open Science, Virtual Research Environment

Abstract

Europe developed an impressive capability for marine observation, data-handling and sharing, modelling and forecasting, second to none in the world. This builds upon national observation and monitoring networks and programs, complemented with EU infrastructures such as the Copernicus satellite observation programme and related thematic services, EMODnet, European Research Infrastructures and major R&D projects. Since October 2019, the pilot Blue-Cloud project (https://blue-cloud.org) combined both the interests of the European Open Science Cloud (EOSC), and the blue research communities by developing a collaborative web-based environment for combining datasets from observations, analytical services, and computing facilities essential for blue science. The successor Blue-Cloud 2026 project is underway since January 2023 with a further evolution of this pilot ecosystem into a Federated European Ecosystem to deliver FAIR & Open data and analytical services, instrumental for deepening research of oceans, EU seas, coastal & inland waters. Key components of the Blue-Cloud are:

• Data Discovery & Access, reviewing and optimising FAIRness of web services of key European data management infrastructures, streamlining their abilities for federation in support of finding and retrieving multi-disciplinary datasets from multiple repositories

• DataLakes, establishing a set of datalakes for major marine data repositories providing fast performance for extracting, subsetting and harmonising big data and metadata

• Virtual Research Environment (VRE) providing a range of services and facilitating orchestration of computing and analytical services for constructing, hosting and operating Virtual Labs for dedicated applications

• Multi-disciplinary Virtual Labs (VLabs), configured with specific analytical workflows, targeting major scientific challenges, and which can be adopted and adapted for other inputs and analyses

• Analytical WorkBenches for EOVs, using datalakes and dedicated analyses software for generating harmonised and validated data collections of Essential Ocean Variables (EOVs) in physics, chemistry, and biology.

Blue-Cloud has evolved as a key component of Europe's FAIR marine digital knowledge ecosystem, providing a flagship community of practice and incubator for data analysis and modelling methods in support of applied research of the ocean, European seas, coastal and inland waters. As such it has become a major pillar under the EU Mission restore our ocean and waters by 2030. Recently, Blue-Cloud has successfully applied to become the Marine thematic EOSC node of the EOSC Federation. In agreement with EU DG RTD, EU DG MARE, and EU DG DEFIS it has been positioned next to the existing EU initiatives for EMODnet and Copernicus Marine, and under the umbrella of the European Digital Twin Ocean (DTO) programme. It has officially been named 'EOSC node / Digital Twin of the Ocean' and will focus on reaching out and engaging the wider European research community in support of the DTO and EOSC developments. For the implementation it will work closely with EMODnet, Copernicus Marine, marine Research Infrastructures, and the EDITO project, which develops and operates the European DTO backbone infrastructure, as well as with other nodes of the EOSC Federation. A 'smart' coupling of the EDITO and Blue-Cloud Virtual Research Environments (VRE's) is already underway while a closer cooperation for data access is aimed for.

Abstract #47

Argo-Yolo: AI-Powered Quality Control for Argo Data

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Presenting author

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Keywords

Argo, artificial intelligence, computer vision, salinity, temperature

Abstract

Quality control of oceanographic data from Argo floats traditionally relies on expert visual inspection — the trained "eye" of scientists capable of rapidly identifying anomalies in temperature-salinity profiles. Argo-YOLO introduces an innovative approach by applying computer vision techniques to replicate and scale this expertise. By treating oceanographic profiles as images, our system leverages deep learning algorithms to "see" data patterns and mimic expert visual assessment. This method automates anomaly detection while preserving the analytical nuance characteristic of human expertise, enabling faster and more systematic quality control across the millions of profiles collected by the Argo network.

We trained a YOLO-based model on 4,412 temperature-salinity profiles, each expert-labeled as "valid" (3,794 profiles) or "problematic" (618 profiles showing one or more data quality issues). The dataset was split 80/20 for training and validation, with model training performed on the Datarmor HPC facility. Initial results are highly promising, with the model achieving:
• 98% correct classification / 2% false positive rate
• 94% anomaly detection / 6% missed detections

Operational Performance: The trained model was deployed on one full year of Argo GDAC data (140 000 profiles). Quality control inference completed in 7 hours 45 minutes — approximately 0.2 seconds per profile — demonstrating the approach's scalability for operational near-real-time applications.

Future Developments Our roadmap addresses progressive integration into operational systems: Short-term: Real-time data validation, extension to additional oceanographic parameters, and decision threshold optimization. Medium-term: Integration into operational processing chains, hybridization with existing QC methods, and application to other in situ observations (Gliders, CTD, XBT). Long-term: Continuous learning with automated model adaptation and generalization across global marine observation datasets.

This proof-of-concept demonstrates that computer vision can effectively support operational quality control workflows. Argo-YOLO offers a scalable, augmentative solution that enhances — rather than replaces — human expertise, directly supporting EuroGOOS objectives of improved data quality assurance and operational efficiency in sustained ocean observing systems.

Abstract #54

Co-designing Real-Time Monitoring Services for Climate-Resilient Mussel Aquaculture

Authors

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Presenting author

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Keywords

Co-design / user-driven services, Mussel aquaculture resilience, Real Time Coastal observing systems

Abstract

The Coastal Observatory of the Xunta de Galicia (OCXG) has operated since 2008 as a local ocean monitoring and forecasting system supporting coastal management and maritime sectors in Galicia (NW Spain). Over the years, it has evolved from a provider of environmental information to a participatory model in which services are co-designed with stakeholders. This shift reflects the growing demand for ocean-data solutions that are scientifically robust but also operationally relevant to the needs, challenges and decision cycles of end users. The BATEAS project, implemented by CETMAR, funded by the Galician Ministry of the Sea and EMFAF, exemplifies this new approach in the context of mussel aquaculture. Galicia hosts the largest mussel aquaculture industry in Europe, sustaining thousands of coastal jobs and increasingly exposed to climate change. Extreme events, changes in precipitation or wind regimes, and shifts in oceanographic conditions are already affecting production cycles and increasing operational uncertainty. In this scenario, reliable Real-Time(RT) monitoring and early-warning capacities are becoming essential to maintain productivity and resilience. BATEAS responds to this challenge by directly involving mussel farmers in the design and deployment of new monitoring system and early warning services, ensuring that technological developments arise from practical priorities rather than solely from a research perspective. The core innovation of the project is the co-designed “sentinel mussel rafts”, located in the Ría de Arousa and equipped with an IoT monitoring system providing continuous environmental and production RT data. Farmers and technicians jointly defined measurement needs, optimized equipment placement to minimize interference and

improved operational solution maintenance. The system measures temperature and salinity at multiple depths, meteorological variables, fluorescence and variations in mussel rope weight, which act as a proxy for growth and condition. These automated observations are complemented by manual rope weighing during maintenance visits, generating a combined dataset that links environmental variability with biological response. Mussel farmers have also shaped data-access mechanisms. Most of the information collected by the system is openly and immediately provided through a web dashboard after quality control (https://apromex.gal/recursos-apromex/), enabling producers and technical staff to visualize and download data for further analysis. Beyond real-time access, producers and technicians developed a temperature-risk alert system for the mussel aquaculture. This tool combines in situ monitoring from the sentinel raft with ocean forecasts from OCXG and Copernicus, allowing early detection of potentially harmful high-temperature events. Developed within the Copernicus-supported MOLL-E MALLONE service, the system seeks to provide actionable warning indicators that anticipate heat-related stress on mussel stocks and reinforce climate resilience. The BATEAS workflow delivers three main outcomes:(1) strengthened marine observation capacity through high-resolution data collected directly from aquaculture structures; (2) long-term datasets that support trend analysis and the development of early-warning systems for climate-related stressors such as heat waves; (3) a co-design process that enhances usability and operational relevance, leading to a monitoring service firmly rooted in the realities of mussel farming. BATEAS demonstrates how co-design with end users drives a fully integrated transferable example of monitoring service, from sensor deployment to data access and early-warning system definition.

Abstract #59

Adaptive governance and ocean knowledge integration for emerging marine sectors: Insights from Ireland's seaweed industry

Authors

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Presenting author

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Keywords

adaptive governance, innovation policy, licensing, ocean knowledge systems, seaweed sector

Abstract

The expansion of the blue economy has brought new governance challenges for emerging marine sectors such as seaweed cultivation, which holds strong potential for sustainable food production, climate mitigation, and regional development. Realising this potential depends on governance systems to generate, coordinate, and apply robust ocean knowledge to support innovation and reduce uncertainty for early-stage sectors. This paper examines governance dynamics shaping Ireland's developing seaweed industry, focusing on how institutional arrangements, policy configurations, and knowledge infrastructures influence licensing processes, innovation pathways, and SME participation. It also evaluates how ocean observation and scientific evidence are integrated into policy instruments and identifies systemic constraints that hinder effective sector development. The analysis is anchored in three national strategies: Impact 2030, Ocean Knowledge 2030, and the BIM Irish Macro-Algal Cultivation Strategy 2030 which set Ireland's priorities for marine innovation, knowledge capacity, and regulatory direction. Together, these policies frame the structural environment within which seaweed enterprises operate and highlight the governance capabilities required to support a viable, knowledge-informed, and innovation-oriented sector. This study uses Resource-Based Theory (RBT) and adaptive governance principles to examine how firms in niche marine-food sectors navigate regulatory ambiguity, fragmented support systems, and uneven access to scientific and operational knowledge. RBT highlights the role of firm capabilities in innovation and competitiveness, while adaptive governance stresses flexibility, coordination, and continuous learning; qualities essential in emerging marine industries. Seaweed is a relevant case as it intersects marine spatial planning, environmental regulation, food safety, and rural development. The research employs a multi-method

qualitative design, including interviews with industry and policy actors, analysis of key marine and bioeconomy policies, and review of regulatory case files. This approach reveals institutional constraints, procedural dynamics, and the practical challenges faced by SMEs. Findings reveal a governance landscape characterised by fragmentation, limited coordination, and procedural opacity. Licensing emerges as a pivotal yet problematic policy instrument. Despite its importance for investment and innovation, the process is hindered by inconsistent application of environmental assessment requirements, limited regulatory capacity, and weak integration of scientific evidence into decision-making. These factors heighten uncertainty and delay sectoral development. The study further identifies a misalignment between national innovation ambitions and the realities faced by seaweed SMEs. While Impact 2030 and related strategies emphasise sustainability and bioeconomy growth, support instruments remain insufficiently tailored to small-scale marine innovators, often prioritising larger and more established maritime industries. Value-chain governance remains weak, with fragmented markets, low standardisation, and limited collective branding. The paper argues that strengthening Ireland's capacity for ocean knowledge requires better cross-agency coordination, a more transparent and well-resourced licensing system, and stronger integration of scientific evidence into policy tools. It highlights the need for collaborative platforms that enable adaptive learning, supporting a resilient and innovation-driven seaweed sector. By analysing how institutional arrangements and knowledge infrastructures shape sector development, the paper shows how ocean observation and knowledge systems can underpin adaptive governance for emerging marine industries, thus offering actionable insights for building robust, knowledge-driven governance frameworks aligned with the EuroGOOS 2026 theme on Governance and Capacity for Ocean Knowledge

Abstract #76

An extended NOOS view on modelling and observation requirements for the offshore renewable energy sector

Authors

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Keywords

Environmental Impacts, Offshore Renewable Energy, Optimisation of monitoring systems

Abstract

The unprecedented growth of offshore wind energy installations in the North Sea comes with a wide range of ecological, scientific, operational, economic and societal challenges. The increasing number of discussions about this topic in the NOOS community led to the formation of a respective offshore renewable energy (ORE) working group, with participants from research, operational forecast centers and agencies from all countries around the North Sea. The group aims to support the successful implementation of ORE installation targets at national and European levels with a number of specific objectives:

1) Collect and consolidate information about likely installation scenarios in the different countries 2) Collection of information about current procedures in spatial planning, bidding processes and legislation. 3) Survey of challenges faced in the evolution of the ORE sector in the different countries 4) Collection of requirements concerning earth system modelling and observation systems 5) Identification of potential synergies and cooperations in research, modelling and observation activities 6) Transnational aspects, e.g. cross-border environmental impacts or technology transfer and support 7) Providing ORE related input to the ongoing Integrated Ecosystem Assessments (IEA).

The NOOS ORE group reached out to colleagues from the Baltic Sea and Med Sea regions with involvement in ORE activities, who are facing very similar challenges to those

experienced in the North Sea. The view presented here reflects discussion results achieved in this extended work group.

The presentation will give a summary of the information collected by the extended NOOS ORE group. In addition, gaps that the group identified in the present modelling and observation activities will be presented. Topics of particular interest are:

1) simulation and observations of cumulative environmental impacts including impact cascades with physical, chemical and biological components. 2) simulation and observations of coupled impacts in the ocean and the atmosphere 3) standardization of ORE installation scenarios required for coherent transnational research on regional environmental impacts 4) modelling and observational challenges of floating offshore wind farm installations 5) advancing the definition of ORE impact metrics and indicators with particular focus on robust simulation and observation techniques. 6) inclusion of ORE impacts in operational forecast models and implications for data assimilation systems.

The presentation will conclude with some first recommendations developed in the ORE working group. The focus will be on the intensification of transnational cooperations in order to exploit synergies and to develop coordinated strategies in modelling and monitoring activities. In addition, the potential of joint efforts of the European modelling and observation community to create world leading cutting-edge technologies to support the international ORE sector will be outlined.

Abstract #91

From biogeochemistry to ecosystems: enhancing operational modelling in the Mediterranean Sea

Authors

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Keywords

biogeochemical model, data integration, ecosystem indicators

Abstract

The Mediterranean biogeochemical operational component (MedBGC) of the Copernicus Marine Service is the result of a 15-year-long history of advances in biogeochemical model development, data assimilation strategies, technological implementation, and the integration of diverse observational datasets for validation and uncertainty estimation. The current system combines a 3D variational assimilation scheme with a convolutional neural network approach (PPCON) to jointly assimilate satellite chlorophyll observations and BGC-Argo profiles of chlorophyll, nitrate, and oxygen. This hybrid assimilation framework significantly improves the system's ability to capture regional biogeochemical patterns. Recent evaluations highlight enhanced skill in reproducing the characteristic east–west gradient of primary productivity. Several major developments in recent years have further expanded the MedBGC model system's capabilities and the range of operational products. A new carbonate system module now enables the estimation of air–sea CO_2 fluxes; a multispectral optical component has been implemented to better represent primary producers, inherent optical properties, and the model's capacity to describe regional biodiversity patterns. These advances, combined with the systematic collection of validation datasets, have enabled the operational release of new biogeochemical variables such as optical properties and multiple classes of phytoplankton functional types. The modelling system is also evolving towards a more integrated ecosystem approach. Building on the 25-year physical and biogeochemical reanalysis, new synthetic ecosystem indicators have been developed to represent the spatial and temporal distribution of key seagrass species (Posidonia oceanica and Cymodocea nodosa) and marine exploited species (Merluccius merluccius, Aristeus antennatus, and Aristaeomorpha foliacea). These indicators are produced by linking environmental conditions simulated by the MedBGC modelling system with ecological niche distribution models. The successful integration of modelling systems and observational networks, as well as the good

performances of the predicted seagrass and marine exploited species, demonstrates the potential benefit of such validated and novel products for ecosystem assessment, marine spatial planning, monitoring and conservation.

Abstract #107

Global Ocean Observing System: To enable and evolve a globally integrated, responsive, and resilient ocean observing system for thriving communities and a healthy ocean

Authors

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Presenting author

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Keywords

co-design, data and metadata, GOOS, science-policy

Abstract

The Global Ocean Observing System (GOOS) provides leadership and coordination for a global system of sustained ocean observations, based on a set of Essential Ocean Variables. Through a globally integrated infrastructure of ocean observing networks, national and regional observing initiatives, and with the guidance of its expert panels, GOOS ensures the delivery of essential ocean information that supports ecosystems, economies, and communities worldwide. The GOOS Status Report 2025 shows advances in ocean observing for climate resilience, operational services, ocean health, and sustainable economies — yet warns that without stronger, coordinated investment and more diversified partnerships, this vital observing system and the services it underpins remain subcritical and at risk. We hereby highlight the recent updates from GOOS in supporting ocean observing system development and implementation, data and metadata flow and science-policy engagement. The GOOS cross-network data strategy setting the requirement real-time data, delayed mode data, metadata and best practices for GOOS networks. Meanwhile, by defining the minimum metadata required for unique ID (WIGOS ID), the metadata passport concept is under development by Ocean Coordination Group and OceanOPS to support user access and interoperability and enable tracking of the dataflow of GOOS global networks. The Expert Team on Operational Ocean Forecasting System (ETOOFS) contributes to the joint governance for the development and integration of the observing system (in-situ and satellite), data management, and ocean forecasting systems, ensuring that ocean observing and forecasting systems are connected towards the delivery of services. A landmark 10 000 Ships for the Ocean initiative was launched at the Third United Nations Ocean Conference, supported by the World Meteorological Organization (WMO), UNESCO-IOC, and the

International Maritime Organization (IMO). Through partnership with the shipping industry sector, the initiative aims to transform 10,000 commercial vessels into real-time meteorological and oceanographic observatories, equipping fleets with automated observing instruments and sensors. The GOOS UN Ocean Decade Programmes are key to bringing focus to advance and enhance regional observing and prediction system to meet key societal priorities. The CoastPredict Programme revolutionise global coastal observing and forecasting, supporting coastal communities for risk and adaptation. The OceanObserving Co-design programme transforms our ocean observing system to co-design with users and respond to their needs. The Global Ocean Indicators, marking pathways at the Science-Policy Nexus, are crucial for translating ocean science and data into practical metrics, guidance, and tools informing on the state and health of the ocean that can be directly applied by policymakers, practitioners, and the public. GOOS calls on governments, funders, and partners globally and in Europe to view ocean observing as critical infrastructure and work together in strengthening the backbone for met-ocean information needed for climate resilience, disaster risk reduction, ocean health, sustainable development, and economic stability.

Parallel Session A1

Innovation in Observations, Modelling, and Forecasting

Abstract #3

Development of Microsensors for Phosphate Detection in Aquatic Environments Using a Gold Electrode in Microfluidic System

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Presenting author

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Keywords

Electrochemical microsensors, microfluidic system, phosphate detection

Abstract

Phosphates play a critical role in aquatic ecosystems, but their excessive presence can lead to serious environmental issues such as eutrophication, which disrupts water quality and aquatic life. Effective monitoring of phosphate concentrations is therefore essential to ensure environmental sustainability and public health. In this context, the development of electrochemical micro-sensors is particularly significant. Integrated into microfluidic systems, these sensors enable rapid and precise detection of contaminants in aquatic environments. Detecting phosphates at low concentrations represents a major challenge in this field. Microfluidic systems combined with microelectrodes offer a promising solution due to their precision, low cost, and ability to operate in complex environments. In this work, phosphate detection and quantitation are achieved through voltammetry (cyclic voltammetry (CV), square wave voltammetry (SWV), and differential pulse voltammetry (DPV)). Two distinct strategies are employed. The first one utilizes gold electrodes modified with copper, where the electrochemical properties of copper enable direct and selective interaction with phosphate [1]. In this case, the detection process is based on monitoring the inhibition of the hydrogen evolution reaction (HER) caused by the addition of phosphate to the solution. This method achieves a limit of detection (LOD) of approximately 0.2 ppm. The second strategy employed molybdenum in solution, forming a specific colorimetric or electrochemical complex with phosphates [2],[3]. The limit of detection is 2 ppm using cyclic voltammetry (CV) and 1 ppm using differential pulse voltammetry (DPV). These complementary approaches maximize the sensitivity and reliability of measurements in microfluidic systems.

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Abstract #11

A method to estimate the representativeness of ship-based CTD profiles

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Keywords

CTD profile, representativeness, temperature, uncertainty

Abstract

Ship-based CTD profiles are used as reference in oceanography to qualify temperature and salinity data. They are generally considered as perfect or without uncertainty or with uncertainties close to the calibration uncertainty, in data assimilation and in the qualification per comparison of other instruments (XBT, Argo profiles, etc.). These temperature measurements are used to evaluate the oceans thermal heat content. The CTD profiles representativeness can be defined as the sum of the instrumental uncertainty and of the natural variability of the water masses crossed by the profiler fixed with other instruments, on a frame called carousel. However, in ocean areas with thermal gradients, the uncertainty of the temperature measured data is questionable due to the thermal inertia of sensors and the movements of the CTD in relation to the roll or pitch of the boat. To solve this question and quantifying the uncertainties and representativeness of CTD profiles, we developed a method based on: - using of a double C–T sensor configuration in order to be able to record downcast and upcast profiles and to calculate the deviations between the downcast and the upcast. - The numerical modelling of the temperature profile accounting for the movements induced by the boat. This modelling allows an assessment of the uncertainty related to the response time. - An uncertainty calculation that takes into account the depth positioning uncertainty related to the pressure measurement uncertainty. The exploitation of several campaigns at sea shows that the uncertainty on depth positioning dominates the others. It also shows that the contribution of natural variability is often much greater than the instrumental uncertainty in the first layers of water, and that the sea state must be taken into account when processing temperature profiles, as it can lead to significant measurement errors. In this case, it is difficult to distinguish between the part of the measurement uncertainty linked to the natural variability of the environment and the part linked to the mixing of the medium by the carousel. Data obtained during this exploitation have been used to create a database that can be used to quantify the representativeness of CTD profiles

carried out in areas close to the recorded profiles. Combined with a program based on artificial intelligence, it should make it possible to associate values of instrumental uncertainty and natural variability by water level with profiles obtained with a single pair of sensors.

Abstract #19

The Kerch Strait oil spill predictions in the Black Sea using SAR, CMEMS and CYCOFOS forecasts

Authors

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Presenting author

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Keywords

Black Sea, multi modelling approach, oil spill predictions

Abstract

Due to oil spills, it appears that the Black Sea is currently the most polluted marginal sea. Following the 4,000-ton of mazut leakage from the broken hull of the tanker Volgoneft 212, which then it was sunken at the south entrance of the Kerch Strait in December 2024, the well-established MEDSLIK and MEDSLIK-II oil spill models conducted multi-modelling oil spill predictions of the spill transport and fate in the Black Sea. The oil spill predictions examined in this work lasted from December 15 to December 25, 2024. The Kerch Strait oil spill was of the same magnitude in terms of spilled oil and similar source type as the one caused in the same area back in November 2007. The sea currents and sea surface temperature forecasting data from the Copernicus Marine Service BS MFC products were used together with ECMWF, the high-frequency SKIRON winds and the CYCOFOS (Cyprus Coastal Ocean Forecasting System) waves to initiate the predictions of the Kerch Strait oil spillage. Due to several uncertainties concerning the reported location and the time of the maritime incident, a stochastic approach was implemented. Initial spill locations were randomized between the two vessels' bunkering zones in the Black Sea where ships are waiting before entering the Kerch Strait. The Kerch Strait 2024 oil pollution crisis heavily impacted more than 60 km of the NE coastlines of the Black Sea. The multi-modelling oil spill response demonstrates a best practice within the broader context of the operational oceanography developments and the usefulness of the downstream applications at local and regional levels. To assess the oil spill predictions produced by the MEDSLIK, OpenDrift and MEDSLIK II Lagrangian particle-tracking models under various met-ocean forcings and configurations, and particularly to evaluate the two models' ability to adequately reproduce

the oil spill spreading and the impacted coastline, the limited available SAR imagery and local media reports were compared at first against the oil spill models results.

Abstract #23

Impact of Argo data assimilation on Mercator Ocean International 's global forecasting system

Authors

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Presenting author

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Keywords

Argo Data, Assimilation, Observing System Experiments

Abstract

Global Ocean real time forecasts and reanalysis highly rely on in situ observation of the ocean interior to deliver accurate estimate of the physical state of the ocean. A large variety of ocean observing platforms are assimilated in the real time 1/12° global ocean system. The impact of each type of in-situ observation on the analysis and forecasts of the global system will be highlighted. Argo floats are the major source of information at global scale allowing to constrain the water mass properties in real time analysis and reanalysis. We will review the impact of the present and future temperature and salinity profile observations in the global CMEMS system. Within Mercator-ocean, impact studies are carried out with the global system (1/12°) to highlight the impact of these data on the quality of the forecast and the analysis. From these OSEs (Observing System Experiments), we show the impact of Argo data (50% Argo, Without Argo and Only Argo) on the global forecasting system. A study on quality control was carried out during this OSE.

Abstract #25

Innovative Coastal Monitoring and Forecasting to Enable the Coastal Resilience of Tomorrow

Authors

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Presenting author

Joanna Staneva

Keywords

Climate change impacts, Coastal forecasting, Coastal management, Coastal monitoring, Coastal zones

Abstract

The Horizon Europe FOCCUS project (Forecasting and Observing the Open-to-Coastal Ocean for Copernicus Users, foccus-project.eu), brings together 19 partners from 11 countries in an effort to improve the existing capabilities of CMEMS and develop innovative coastal products in collaboration with 14 Member State Coastal Systems (MSCS) and their users that will contribute to resilience against coastal hazards and climate change. Recently endorsed by the UN Ocean Decade and part of the CoastPredict program (coastpredict.org), FOCCUS develops innovative coastal products through 3 key pillars: i) developing new coastal observations, ii) developing advanced hydrology and coastal models, and iii) establishing coastal applications for enhanced coastal risk management. FOCCUS develops novel high-resolution data products by integrating multi-platform coastal observations (in-situ coastal data and satellite and land-based remote sensing) with simulated data to enhance weather and marine services, and monitor ocean health, ecosystems and coastal changes. New coastal products are created by data fusion, merging diverse data sources, implementing new approaches with numerical models and Artificial Intelligence (AI) methods for image processing and data analysis. FOCCUS builds on existing pan-European hydrological models, E-HYPE and LISFLOOD, and develops a pan-European ensemble to provide improved river discharge (sediment, nutrients, water volume and active tracers) for ocean and coastal ocean models and their two-way feedbacks at the land-sea interface. New methodologies are being tested, taking advantage of stochastic simulation, ensemble approaches, and AI. Working to improve coastal management, FOCCUS will facilitate

advanced, seamless ocean monitoring and forecasting, from CMEMS global/regional systems to coastal systems, through demonstrations of new products and improved co-produced services. This includes focused coastal applications, co-designed with stakeholders, to address three areas of coastal risk: i) coastal management and protection (including the prediction of coastal erosion risk, marine pollution, and sediment tracking), ii) enhancement of the blue economy (including the co-use of wind and aquaculture resources), and iii) building resilience to coastal climate change (including tracking marine heatwaves, monitoring ecosystem degradation and harmful algae blooms, and predicting storm surge/waves). FOCCUS aims to provide the marine knowledge needed to support Marine Protected Areas, and address natural hazards and extreme events to protect coastal zones of tomorrow.

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Abstract #27

Holistic research for extreme events – A case study on Storm Babet

Authors

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Keywords

BOOS collaboration, fit-for-purpose monitoring and forecasting, holistic research for extremes, storm Babet, storm surge forecast error attribution

Abstract

With ongoing climate change, metocean extreme events (storms, storm surges, coastal flooding) are becoming more frequent and more severe. Societal response to such events is inherently multi-scale and multi-dimensional: early forecasting and warning before the event; emergency response during the event; post-event assessment and recovery; long-term climate attribution; and integration of lessons learned into future coastal planning. Citizens, governmental agencies, infrastructure operators and industry all have different requirements for these services, highlighting the need for holistic Earth-system approaches that combine multi-scale observations, models and forecasting tools. Storm Babet (October 2023) was a high-impact cross-domain event affecting large parts of Europe. The storm produced intense rainfall and flooding in Portugal, Ireland and the United Kingdom, and persistent strong easterlies over the North Sea and Baltic Sea triggered the highest storm surges in over a century along the German and Danish Baltic Sea coasts, causing severe coastal inundation, erosion and damage to houses, vessels and critical infrastructure. Using Babet as a case study, we explore a holistic framework that addresses a series of key scientific, technological and service-oriented questions: (i) Atmospheric drivers and climate context: What were the dynamical mechanisms behind this extreme event (e.g., blocking, jet interaction, moisture transport)? To what extent is Babet linked to climate variability and climate change, and how might similar events evolve in a warming climate? (ii) Monitoring and forecasting fitness-for-purpose: Do current observing networks and operational forecast systems adequately meet user needs before, during and after such extreme events? (iii) Cross-domain Earth-system interactions: What were the observed signatures in the atmosphere, ocean, waves, seabed and coastal zone, and how did these subsystems interact? (iv) Storm surge predictability: How well did existing storm-surge prediction systems perform, and how did controlling factors—atmospheric forcing, ocean preconditioning, topographic blocking, and wave–ocean

interaction—affect forecast errors? (v) Improving coastal forecasts: How can storm-surge skill be improved (e.g., through sea-level data assimilation, improved wind stress parametrization, optimized bathymetry or coupling strategies)? (vi) Coastal impacts: What were the impacts on morphology, dikes and seawalls, and to what extent were these impacts predictable? (vii) Wave–ocean–surge coupling: How did wave–current interaction and wave setup amplify local flooding risk? Over the past two years, a DMI-led research collaboration, together with BOOS partners, has developed new analyses and prototype tools to address these challenges. This presentation outlines the study's rationale, methodologies and key findings, and underscores the need for stronger cross-disciplinary collaboration with weather, hydrological and coastal-protection communities to better understand and anticipate compound extremes such as Babet, and opportunities for using recent advances in on-demand Digital Twin (DT) models for targeted what-if scenario experiments and mechanism analysis. The results also highlight priorities for optimizing current practices in operational oceanography: enhanced inter-comparison of high-impact event forecasts, more coastal data assimilation, more consistent atmosphere–wave–ocean coupling, and new rapid impact-assessment capacities for coastal erosion and infrastructure damage. These developments collectively point toward a more integrated, user-driven operational framework for analysing and predicting extreme events in a changing climate.

Parallel Session A2

Innovation in Observations, Modelling, and Forecasting

Abstract #33

UWC-West verification project and development of a North Sea storm surge community model

Authors

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Keywords

CMEMS in-situ data, NOOS community model, Storm surge forecasting and verification, UWC-WEST model HARMONIE

Abstract

In the United Weather Centres West (UWC-West) Ireland, Denmark, Iceland, and the Netherlands joined forces for the development and operation of the HARMONIE weather model. The first HARMONIE cycle on the new HPC facility in Iceland became operational in 2024 [1]; the next version is already expected in 2026. The parties that cooperate in UWC-West on numerical weather forecasting are also actively involved in storm surge forecasting around the North-West European Shelf; they are active members of NOOS. From the perspective of storm surge forecasting, it is challenging to keep up with the speed of developments in numerical weather forecasting and their effect on the quality of the tide and storm surge models that rely on the NWP forecasts. With a proposed 18-month HARMONIE update cycle, there simply is not enough time for traditional process schemes for verification on water levels and storm surges [2]. In 2025, we started a verification project with the aim of implementing a community hydrodynamic model at the UWC-West HPC facilities in Iceland and performing verification of storm surge model quality for upcoming cycles of HARMONIE. In the first year, we concentrated on the selection of the hydrodynamic model and the necessary developments in the model. The Dutch Continental Shelf Model (DCSM) was selected. This model is developed by Deltares and is used for Dutch operational storm surge forecasting [3]. For this project, the model domain is extended with the Baltic Sea to enable forecasting of water levels along the full Danish coastline. In Danish waters, seasonal baroclinic effects on water levels are more prominent than in the North Sea. A novel method is applied to parameterize these effects using a computationally efficient depth-averaged (2D) barotropic model. Furthermore, additional refinement of the model grid is applied around Ireland to improve quality in Irish waters. These developments turn a model originally focused on the Dutch coast into a true NOOS community model. In 2026, once the next cycle

of HARMONIE is released, a hindcast and reforecast study will be performed with the community model on the UWC-West HPC facilities in Iceland. For this analysis, shared verification metrics will be implemented in stand-alone validation tooling. We aim to obtain tide gauge data for the North West European Shelf through CMEMS In-Situ data products [4].

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Abstract #36

Addressing Observational Gaps in the Eastern Mediterranean with a High-Resolution NEMO Model

Authors

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Presenting author

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Keywords

Eastern Mediterranean, High-resolution Ocean Modeling, Levantine Intermediate Water, Mesoscale dynamics, NEMO

Abstract

Even though the scientific community recognizes the Mediterranean's key role in global circulation, researchers have devoted limited and largely separate attention to its two basins. This imbalance has left the eastern basin particularly understudied. To reduce this knowledge gap—especially in a region where long-term in-situ measurements are scarce—numerical modeling provides essential insight into the physical processes at work. In this study, we present a new three-dimensional high-resolution regional hydrodynamic model of the Nucleus for European Modelling of the Ocean (NEMO) 3.6, tailored specifically for the Levantine Sea. The model operates at a horizontal resolution of 2.2 km with 71 vertical levels, enabling it to resolve the fine-scale dynamics that shape this semi-enclosed basin. This configuration incorporates realistic atmospheric forcing, river inflows, and carefully tuned open-boundary conditions to maintain stable, physically consistent behavior throughout the 31-year hindcast (1992–2022). The model is numerically robust, offering an improved representation of intermediate-water dynamics—key processes that remain poorly constrained observationally. The model reproduces the broad seasonal and interannual patterns documented in previous studies. These include wintertime deepening of the mixed layer, long-term surface warming, and basin-scale circulation regimes associated with significant events such as the Eastern Mediterranean Transient. The explicit resolution of mesoscale structures—eddies, jets, filaments, and fronts—reveals the basin's dynamical richness. It provides a more precise depiction of regional variability than is typically attainable with coarser models. To evaluate the model's skill, we adopt a targeted case-study approach focused on the formation and export of Levantine Intermediate Water (LIW). By systematically identifying and tracking LIW throughout the simulation, we assess whether the model reproduces the known dynamical pathways of this water mass. The experiments successfully capture the classical formation center in the Rhodes Gyre and, crucially, also

reproduce the intermittent formation events in the Gulf of Antalya and the Cilician Basin—secondary sites that recent studies have shown to be episodic yet dynamically significant contributors to the LIW reservoir. This long-term case study further allows us to examine variability in LIW export from the region. Overall, this work introduces a reproducible model that significantly advances our capacity to investigate long-term physical variability in the Eastern Mediterranean. By combining high spatial resolution with three decades of continuous simulation, the configuration enables detailed examination of processes that have remained observationally elusive—mesoscale circulation features, episodic water-mass formation, and the evolving structure of intermediate layers. The model thus provides a robust foundation for future research on climate-driven changes, shifts in regional circulation, and potential biogeochemical applications. In doing so, it helps close long-standing observational gaps and offers a valuable new tool for understanding the dynamics of the Mediterranean Sea.

Abstract #40

Promoting Ocean Forecasting in the framework of the Decade

Authors

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Keywords

Community, Decade, Ocean Forecasting

Abstract

This paper outlines the progress and impact of the OceanPrediction Data Coordination Centre (DCC) in advancing Ocean forecasting under the framework of the Decade. The OceanPrediction DCC plays a central role in building a cohesive, international community of regional ocean forecasting teams, facilitating collaboration, and sharing knowledge and best practices. The first section of the paper focuses on the community aspect, highlighting the success of the Regional Teams that have come together to address specific forecasting needs and share knowledge for better ocean predictions. The second key contribution is the development of the Atlas of Ocean Forecasting Services, a comprehensive, online accessible Metadata repository of people, institutions, ocean forecasting models, and services. This is a matchmaking point and a tool to explore the present-day situation of the Digital Ocean Centers across the globe In addition, this paper details the technical advancements made by the OceanPrediction DCC, including the Architecture and the Operational Readiness Level (ORL) for Ocean Forecasting. The OceanPrediction DCC architecture is a guide on how to build an Ocean forecasting system, describing the required tools and data standards, and all the required “wiring” between the different components. The (ORL) is a tool designed to guide and promote the adoption of best practices by qualifying and quantifying the overall operational status of an ocean forecasting system. It supports system managers in understanding the operational capabilities and pinpointing gaps that should be addressed to further mature a system. Additionally, the ORL assists users in gaining a comprehensive understanding of the system's reliability, usability, and strengths. Improving the ORL qualification of a service is a means to identify and implement best practices and standards in ocean forecasting, enhancing the overall operability of the

system. Lastly, the paper examines two flagship projects—OPERA and OP4CR—which will serve as cornerstone initiatives driving the future of Oceanprediction DCC. The project OPERA - “Ocean Prediction Enhancement in Regions of Africa” will strengthen Ocean prediction capabilities and cooperation at national, regional, panAfrican levels in Sub-Saharan Africa. With 10 million euros of funding from the European Union, OPERA is the ocean component of the African Regional Centres of Excellence for the Green Transition (ArcX) programme. This overarching programme is dedicated to strengthening Digital and Science, Technology, and Innovation capacities in Sub-Saharan Africa, fostering scientific knowledge and innovation-driven sustainable development. Mercator Ocean International, through its coordinating role in the OceanPrediction Decade Collaborative Center and leveraging the African Regional team, has been entrusted with implementing OPERA. OP4CR is a two-year project aimed at strengthening Costa Rica’s capacity to access, use, and develop its own digital resources based on ocean forecasting and related operational services. This project is a collaborative effort between the European Union, Mercator Ocean International, and local Costa Rican partners. By showcasing the advancements made by the OceanPrediction DCC, this paper demonstrates how the Decade's framework is accelerating the development of ocean forecasting capabilities and fostering global collaboration for sustainable ocean management.

Abstract #41

Madeira Coastal Insight Service (MCIS): Advancing High-Resolution Coastal Observing and Forecasting in an EU Outermost Region

Authors

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Keywords

Biogeochemical modelling, Coastal observing, High-resolution modelling, Island oceanography, Lagrangian forecasting

Abstract

Oceanic islands in the European Union's outermost regions play a critical role in advancing ocean knowledge yet remain among the least resolved environments in operational oceanography. Madeira Island, located in the Northeast Atlantic Ocean, presents a highly dynamic coastal system shaped by steep topography, episodic island runoff events, and the limited capacity of several wastewater treatment plants, exacerbating water quality challenges. Monitoring these coastal waters is crucial, yet existing global and basin-scale forecast systems, such as those from the Copernicus Marine Service models (~3 km for the Atlantic Iberia-Biscay-Ireland region), lack the spatial resolution needed to represent small-island processes effectively (< 1km). This gap underscores the need for local operational services capable of delivering high-resolution, multi-source coastal information to support scientific innovation and EU environmental objectives. The Madeira Coastal Insight Service (MCIS; https://oom.arditi.pt/MCIS), coordinated by the Oceanic Observatory of Madeira (OOM; https://oom.arditi.pt/) within the Regional Agency for the Development of Research, Technology and Innovation (ARDITI; https://www.arditi.pt/en/) and funded through the Copernicus Marine Service National Collaboration Program, addresses these challenges by establishing a comprehensive coastal monitoring service by integrating advanced technologies and methodologies for real-time data collection, fully aligned with EU policies. The service's objectives include supporting the sustainable management and protection of Madeira's coastal waters, ensuring compliance with EU directives, and strengthening local

environmental management capacities. MCIS will combine local observations, remote sensing data, and high-resolution coupled ocean-atmosphere numerical models to provide both physical (blue ocean) and biogeochemical (green ocean) datasets. Within the MCIS framework, two Use Cases are being developed. Use Case 1 focuses on applying Lagrangian models to assess water quality, specifically targeting sanitary risks in areas crucial for tourism and aquaculture (https://marine.copernicus.eu/print/pdf/node/22523). This Use Case aims to improve existing pollution patch models by integrating WWTP discharge data and in-situ water quality measurements. Use Case 2 focuses on integrating biogeochemical models, remote sensing, and in-situ observations to evaluate nutrient budgets. The goal is to enhance understanding of nutrient sources, sinks, and cycling, and assess their impacts on marine ecosystems. Both Use Cases rely on numerical downscaling of CMEMS modeling products, which provide initial and boundary conditions for higher-resolution models around Madeira. To maximise usability and ensure that forecasting outputs directly support regional decision-making, MCIS includes the development of a user-friendly data-visualisation platform (https://geoportal.arditi.pt/plataforma_mcis/). Identified during the first stakeholder workshop as the region's top priority, this platform is being developed iteratively, incorporating feedback from stakeholders and end-users to guarantee intuitive access to real-time coastal information. It provides unified access to model forecasts, satellite products, in-situ observations, and risk indicators derived from both operational Use Cases, offering an integrated interface tailored to the needs of the Autonomous Region of Madeira. By leveraging a scalable, integrated digital architecture, MCIS strengthens the predictive capability and scientific understanding of Madeira's coastal environment while contributing directly to innovation in observations, modelling, and forecasting. The initiative provides a replicable and adaptable approach for advancing coastal operational oceanography in other outermost regions worldwide.

Abstract #48

High-resolution coastal forecasting — meeting user needs in complex environments

Authors

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Presenting author

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Keywords

archipelago, Baltic Sea, coastal, forecasting, maritime safety, waves

Abstract

Wave forecasting services in complex coastal regions, such as the Finnish coasts of the northern Baltic Sea, require significant improvement to better support maritime traffic and activities related to offshore wind energy and aquaculture. Regional forecasts often lack sufficient accuracy because their resolution is too coarse to capture the effects of complex bathymetry, irregular shorelines, and dense archipelagos on wave fields. Downscaled, high-resolution forecasts are therefore essential for representing local conditions and improving safety and operational planning for maritime and offshore sectors.

We present ongoing developments in wave forecasts and hindcasts for the Finnish coastal areas of the Baltic Sea. A key component is a high-resolution wave forecast tailored for maritime pilots, who often operate in fairways with challenging wave conditions. Although many fairways have nearby observations of weather conditions, measurements of surface waves are often lacking. High-resolution coastal wave forecasts can therefore improve situational awareness and support better monitoring of oceanographic conditions in these critical areas.

Because high-resolution modelling is computationally demanding, we are developing solutions to reduce computational requirements while still delivering valuable services to users. Wave hindcasts are readily available for the Baltic Sea, for example, from the Copernicus Marine Service. A better understanding of their accuracy and usability in near-coastal areas is essential for many users. To assess this, we ran a 10-year hindcast for a coastal area in the Bothnian Sea at a 0.25 nmi resolution. This region was selected because wave data from a measurement campaign conducted in 2020 were available. The evaluation focused on the usability of the 1 nmi resolution Baltic Sea hindcast in near-coastal areas. Naturally, the 0.25 nmi grid captured depth-induced variations in the wave field much better than the coarser grid. However, in some areas, the 1 nmi grid was able to describe wave

conditions fairly well. We present a detailed comparative analysis of the results and discuss the extent to which the coarser grid can adequately represent coastal wave dynamics.

For operational wave forecasts, we adopted an approach of running high-resolution coastal forecasts as an on-demand service. We developed an automated system to trigger these forecasts for specific coastal areas when potentially hazardous wave conditions are predicted. The evaluation uses an event-based method that estimates the exceedance of predefined thresholds based on regional wave forecasts. This method assesses the duration, magnitude, and location of the exceedance and automatically initiates a high-resolution forecast when conditions meet predefined criteria. We will describe the event-based method, provide a detailed overview of the forecasting system, and present insights from user feedback.

Abstract #52

Progress in the Baltic Sea Model Centre under EU's Copernicus Marine Service

Authors

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Presenting author

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Keywords

Baltic Sea, cooperative service, forecasts, operational oceanography, reanalysis products

Abstract

The five operational oceanographic institutes that have formed the Baltic Sea Monitoring and Forecasting Centre (BAL MFC) under the EU's Copernicus Marine Service for the past 10 years have been selected by Mercator Ocean International to continue providing the service for the next three years. The five institutes—the Danish Meteorological Institute, the Finnish Meteorological Institute, the German Federal Maritime and Hydrographic Agency, the Swedish Meteorological and Hydrological Institute, and Tallinn University of Technology in Estonia—deliver Baltic Sea model products through a coordinated approach involving both joint model development and joint operational production. The backbone in our production is a continues development of our Baltic Sea set up of this state-of-the-art model complex consisting of the ocean-ice NEMO-SI3 model, the biogeochemical ERGOM model, the data assimilation framework PDAF and the WAVEWATCH III wave model. Observations such as satellite derived surface temperature, in-situ temperature and salinity profile observations are all assimilated into the model products. Recently, the ocean model has been upgraded from NEMO4.0 to NEMO4.2 and satellite derived sea ice information has been included in the assimilation suite. Additionally, the ERGOM model has been upgraded and now includes a silicate cycle and dissolved iron. We will present a status of our Baltic Sea product portfolio and their quality, our recent production development as well as the planned product upgrades for the next years.

Parallel Session A3

Innovation in Observations, Modelling, and Forecasting

Abstract #61

UK Met Office future SMC multi-grid global wave forecasting model

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Keywords

hybrid parallelization, multi-resolution, unstructured grid

Abstract

Spherical Multiple-Cell (SMC) grid (Li, 2012) is an unstructured grid, supporting flexible domain shapes and multi-resolutions. It retains the quadrilateral cells as in the latitude-longitude grid so that simple finite-difference schemes can be used. Sub-timesteps are applied on refined cells for improved performance and grid cells are merged at high latitudes to relax the CFL restriction. A fixed reference direction is used in polar regions to solve vector polar problems so the whole Arctic Ocean could be included. The SMC grid was implemented in the WAVEWATCH III (WW3) wave model in 2012 and updated in the latest WW3 Version 7 with a multi-grid hybrid parallelization option (Li, 2022). The flexible domain shape of the SMC grid allows optimised domain splitting and minimised boundary exchanges. It also allows the sub-grid setup to be pre-calculated and tuned to save model run time. Timing results indicate that hybrid (MPI+OpenMP) parallelization may halve model runtimes in comparison with pure MPI runs and the multi-grid option may reduce the elapsed time further by 30%. Besides, the hybrid multi-grid method reduces memory demand on one computing node and allows model updates for higher spatial and spectral resolutions. Tool kits for generating SMC grid are available from GITHUB website at https://github.com/ww3-opentools/SMCGTools/.

The UK Met Office is planning to update its global wave forecasting model from the present 4-level (3-6-12-25 km) SMC grid to 3 SMC sub-grids at 5-level (1.25-2.5-5-10-20 km) spatial resolutions. It contains refined European waters at 4-level (1.25-2.5-5-10 km) resolution in the N Atlantic sub-grid and the rest of world oceans are resolved in 4-levels at 2.5-5-10-20 km. The total number of sea-points has nearly doubled from about 0.6 million for our present SMC 3-6-12-25 km grid wave forecasting model to over 1.2 million for this new model. The 1.25-20km 5-level 3 sub-grids model hybrid parallelization run takes only 50 s per model day on 90 nodes (11520 cores) with 1440 MPI ranks and 8 OpenMP threads per rank on our Cray EX supercomputer. Comparisons with spectral buoy observations indicate improved wave forecasting because of the increased spatial resolutions. One extra benefit of using the

multi-grid model is the possible speeding up of post-processing of the model output because most forecast products required by our UK and European customers could be produced with the N Atlantic sub-grid output, which is only 1/3 of the global model output in size. Sticking up the 3 sub-grids into a global grid is also straightforward, thanks to the flexible arrangement of unstructured SMC grid sea cells.

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Abstract #66

Miniaturised Drifting Buoys for a Comprehensive Upper Ocean Observation Network

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Keywords

drifting buoys, ocean observing network, operational oceanography, satellite validation, sea state measurements

Abstract

Ocean surface observations remain critically insufficient compared to land-based sensor networks. Most existing sensors are concentrated near the coasts of developed countries, with very few observations available in the centres of ocean basins and in the Southern Hemisphere. This observational gap significantly undermines our ability to validate numerical models and calibrate satellite remote sensing missions. In this work, we introduce the MELODI (Miniaturised Electronics Lagrangian Ocean Drifter) system as a cost-effective, scalable solution to address this critical shortage of upper-ocean layer observations. MELODI buoys are compact (240mm diameter, 10cm height, 1kg total weight), solar-powered drifters constructed from biodegradable materials. Multi-sensor configurations measure sea surface drift (GNSS positioning every 5-10 minutes with 5m precision), wave spectra (0.03-1 Hz), significant wave height, and sea surface temperature. The buoy's low-profile design significantly reduces direct wind impact, ensuring accurate Lagrangian tracking of upper ocean currents. Real-time satellite data transmission enables operational monitoring and data access via dedicated IT infrastructure (a web portal and data access APIs). The miniaturised design enables deployment from vessels of opportunity, small research boats, and ships with limited storage space—addressing a major operational constraint in expanding ocean observation networks. Large-scale deployment campaigns in 2025 demonstrate operational readiness, with 63 buoys deployed globally across the Mediterranean, Atlantic, Southern Ocean, and other ocean basins. Nearly half were deployed from small vessels, validating the practical advantages of the compact design. The ESA Ocean Training Course 2025 campaign (20 buoys, April-October 2025) collected over 300,000 positions and several thousand wave spectra with 99.8% data transmission completeness. The performance was also validated across a wide range of environmental conditions, including heavy storms with significant wave heights up to 7.8 m. The platform

delivers substantial value for satellite mission Cal/Val activities, with systematic satellite collocations supporting validation of Sentinel-1 (SAR imaging, wave fields), Sentinel-3 (SST, SRAL altimetry), SWOT (sea surface height, geostrophic currents), and CFOSAT (SWIM wave spectra). Validation data span diverse oceanographic regimes from Arctic to Mediterranean conditions, covering exceptional thermal gradients and multiple sea-state regimes. Ongoing developments include directional wave-spectrum capabilities via combined GNSS-IMU analysis and wind-speed retrieval from high-frequency spectral characteristics. The demonstrated technical maturity, ease of deployment across diverse platforms, operational infrastructure, and cost-effectiveness position MELODI as a viable building block for sustained, large-scale upper-ocean observation networks that address both operational oceanography and satellite mission requirements. We discuss pathways for transitioning from demonstration campaigns to coordinated operational network deployment, emphasising community coordination and sustained development of the observation framework.

Abstract #69

The ITINERIS' EYES cruise: an interdisciplinary cruise to foster technological synergies among European Research Infrastructures to investigate Mediterranean health

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Presenting author

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Keywords

ITINERIS, Mediterranean Sea, Research Infrastructures, Synergies, Technological Interoperability

Abstract

ITINERIS' EYES is an inter-disciplinary research cruise designed to investigate the health of Mediterranean planktonic ecosystems in open waters by filling spatial and temporal gaps in observations through multi-platform experiments acquiring several Ocean, Climate and Biodiversity Essential Variables (EOVs, ECVs and EBVs). To address multi-scale interactions that characterize the health and the biodiversity of planktonic ecosystems, ITINERIS' EYES leveraged on the technological readiness of 11 European and national Research Infrastructures (RIs). These RIs operate in the marine, atmospheric and biodiversity domains of the PNRR ITINERIS project, the Italian Integrated Environmental Research Infrastructures System (https://itineris.cnr.it/): EURO-ARGO, EMSO, ICOS, ACTRIS, DANUBIUS, EUROFLEETS, JERICO, eLTER, DISSCO, SIOS, and Laboratori Nazionali del Sud (LNS). The cruise was carried out on board the CNR's R/V Gaia Blu between 8th to 30th of July 2025, and encompassed the Western Mediterranean Sea, across the Tyrrhenian Sea, the Sardinia Channel, the Algero-Provençal basin and the Ligurian Sea. The sampling strategy was developed by combining discrete water sampling and cast-based sensor measurements at fixed stations, continuous measurements along the ship-track (Ferrybox, radiometry, Lidar), and deployment of more than 80 autonomous robotic platforms (BioGeoChemical and Deep-Argo floats, gliders and Lagrangian drifters). We built the sampling strategy on repeated deep stations distributed along transects defined by the MED-SHIP programme, enriched with stations to capture diversity in phytoplankton phenology and mesoscale dynamics. This coordinated approach allowed the exploitation of the complementary observing capabilities of the different platforms as well as the investigation of

the interoperability among sensors from various RIs that measured the same EV. For example, at five stations representative of various planktonic seascapes, after sampling from the ship and through continuous systems, we closely deployed eight autonomous platforms (Argo floats and Lagrangian drifters) based on a symmetric pattern along the ship's initial track in the following sequence: BGC-ARGO float, SVP drifter, CARTHE drifter, BGC-SVP drifter, CODE drifter, CARTHE drifter, SVP drifter, a second BGC- or Deep-ARGO float. In the Ligurian Sea, casts and deployments were performed around the EMSO/ICOS W1M3A mooring site and simultaneously with two gliders. Here, we will present the ITINERIS' EYES cruise and preliminary results on the comparisons of measured EVs across the technological diversity of used sensors and platforms. We will discuss the current interoperability between European Research Infrastructures operating in the ocean observing system.

Abstract #75

A 1-km Ocean Circulation Model of the Northeast Atlantic for Irish Maritime Users

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Keywords

Climate Services, CROCO, Ireland, Northeast Atlantic

Abstract

A high-resolution (1-km) simulation of the 3-dimensional regional ocean circulation of the Coastal and Regional Ocean COmmunity model (CROCO) for an area of the Northeast Atlantic, was successfully carried out from 1993 to 2024 (32 years). Outputs include physical ocean variables (e.g. temperature, salinity, water speed and directions and Mixed Layer Depth (MLD)). The hindcast simulation was validated with a variety of measured data sources. We evaluated the model skill by comparing with measured data and calculating statistics such as bias, mean error, root mean square error (RMSE), and correlation coefficient. The observations consist of satellite Sea Surface Temperature (SST), water level time series from the Irish and UK tide gauge networks, and Conductivity Temperature Depth (CTD) profiles. Output data from this model underpin downstream services to numerous stakeholders, e.g. the aquaculture industry, search and rescue services and oyster restoration efforts. This work forms part of the EMFAF-funded project “Climate projection and decision support tools”.

Abstract #84

Advancing Coastal Observation in Europe: The JERICO Research Infrastructure and Its Interfacing with EuroGOOS

Authors

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Keywords

Coastal, Interfacing, Multi-platforms, Observation, Services

Abstract

Improving and structuring the observation of the coastal marine environment in Europe is essential for addressing the societal challenges related to coastal ocean dynamics, environmental change and ecosystem health. Coordinated action across Member States and the European scientific community remains a strategic priority. Since 2011, the EU has funded four major projects in this regard, JERICO-FP7, JERICO-NEXT, JERICO-DS and JERICO-S3, which have built a strong community of 52 scientific institutions from 24 countries, all contributing to the JERICO application to the ESFRI 2026 Roadmap of European Research Infrastructures.

JERICO, the Joint European Research Infrastructure for Coastal Observation, has received political support from 14 nations, highlighting the shared European commitment to sustained and harmonised coastal monitoring. This distributed RI will support observations across all European coastal and regional seas, from the Norwegian and Baltic Seas to the North-West Atlantic shelf, the Mediterranean and Black Seas. Despite their diversity, these regions require coherent, long-term infrastructures capable of responding to environmental pressures.

JERICO's vision is to create a pan-European integrated gateway that delivers harmonised long-term observations and advanced services for coastal marine systems. This incorporates environmental sciences, technological development and modern data science, ensuring that high-quality observations are translated into FAIR, interoperable and policy-relevant information.

JERICO's mission is to reinforce and harmonise national coastal observation efforts to provide consistent regional and pan-European coverage. This will be achieved through complementary platforms and multidisciplinary observing systems, including ship-based measurements, fixed platforms, FerryBoxes, HF radars, gliders, while ensuring continued application and evolution of best practices in their integration. Through this integrated system, JERICO will offer open access to state-of-the-art facilities, innovative resources and tailored services, thereby facilitating strong international scientific collaboration.

JERICO will work closely with the EuroGOOS Regional Operational Oceanographic Systems (ROOSes), ensuring synergy between coastal observations and operational oceanography. This collaboration will rely on regional coordination, data sharing and modelling interfaces. In addition, JERICO will connect existing operational research infrastructures across Europe to strengthen the connection between terrestrial, transitional and marine observation systems, consolidating the land-sea and enabling more integrated environmental assessments.

JERICO's service offering is organised around three pillars, Access, Data & Products and Innovation, each aligned with its scientific strategy. The scientific strategy of JERICO addresses three major challenges: 1) Assessing and predicting changes in coastal marine systems influenced by global and local drivers; 2) Understanding and monitoring the impacts of rare or extreme events; 3) Distinguishing natural variability from human-driven changes in marine environments. Two thematic centres, one for Scientific Excellence and one for Regionalisation, will gather European leading experts to harmonise methods, ensure high-quality data and promote scientific integration from local to regional scales. Together, these elements position JERICO as a key actor in addressing coastal environmental challenges in Europe.

JERICO, at European level, will establish links, for example with EuroGOOS, between maritime or oceanic regions through harmonising methods, aligning priorities and enabling seamless data exchange. This coordination will strengthen coastal-to-regional integration, ensure coherent monitoring of the land–sea continuum and support unified services for European science, society and users.

Abstract #86

Augmented observation strategy to feed numerical twins of the ocean in river impacted coastal areas

Authors

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Keywords

augmented observation, Bay of Biscay, Gulf of Lions, rivers, smart observation

Abstract

Continental shelves are vulnerable coastal areas characterized by highly productive ecosystems that face a double constraint. On the one hand, the input of nutrients, particles and contaminants from rivers can cause eutrophication, hypoxia, toxic algal blooms, enhanced turbidity, and contamination in the coastal environment. On the other hand, climate change leads to an alteration of coastal circulation, changes in stratification, warming and acidification of the ocean, and an increase in the occurrence and intensity of extreme events such as storms, heat waves and floods. To deal with the future of these ecosystems and their medium- and long-term management (20 to 100 years), new insights in numerical tools and observations are required.

In the framework of the PPR RiOMar project, the building of future augmented observatories in river impacted areas along the French coast is foreseen to anticipate the future of coastal water quality (primary production, oxygenation, acidification, eutrophication, contamination, toxic algae). Augmented observatories will go beyond the existing observation networks within the french ILICO research infrastructure by densifying and spatializing data using autonomous and mobile devices (gliders, micro-AUVs), synoptic devices (satellites) or low-tech, moderate cost systems (Mastodon-2D lines). This new generation of connected observations will be oriented towards a "smart" data acquisition optimizing energy consumption and data storage, and allowing, in the long run, to interface measurements of all types through tools such as the Internet of Things (IoT).

First experiments were set up to deploy those systems together over the Gulf of Lions and in the Bay of Biscay. The systems deployed during the RIOMAR-RIGOL (R.V. Téthys II), RIOSB2 (R.V. Antedon 2) and RIOVILO (R.V. Côtes de la Manche) oceanographic campaigns will be presented, along with the data collected. In addition, a smart observation strategy designed to oversample during extreme events (such as storms and floods) at fixed COAST-HF network stations will also be introduced.

Parallel Session A4

Innovation in Observations, Modelling, and Forecasting

Abstract #89

The state of high frequency automated phytoplankton observations in European coastal seas based on optical imaging in flow methods

Authors

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Keywords

artificial intelligence, biodiversity, harmful algae, imaging, near real time, phytoplankton

Abstract

Phytoplankton are the dominant primary producers in our oceans, forming the base of the marine food web. They are highly diverse and can be divided into several functional groups, each with different ecological niches, including a subset of taxa that form harmful algal blooms. Our ability to observe phytoplankton, particularly at the short temporal and spatial scales characteristic of bloom formation and decline, has been hampered by traditional, labour-intensive methods such as microscope analysis which limits sample processing and therefore the frequency of sampling. Algal blooms, such as the spring bloom and some harmful algal blooms, typically last a few weeks and affect wide geographical areas making them difficult to study using low temporal resolution sampling. In recent years automated optical imaging in flow technologies have become viable methods for near real time observations of the distribution, biomass and composition of phytoplankton at high frequency. Such systems include examples like the McLane Imaging Flow Cytobot (IFCB), the CytoSense and the FlowCam, with some capable of being operated from different platforms such as shipboard Ferrybox systems, and moored on oceanographic buoys and piers. At present there are at least 18 IFCBs in operation in Europe, collecting observations in the Baltic Sea, the North Sea, the English Channel, the Bay of Biscay, Irish and Celtic Seas, the Atlantic and in the Mediterranean Sea. Their sampling frequency can reach up to ~25 minutes, thereby allowing for sample collection at < 10km resolution from a moving

vessel, with each sample comprising a collection of thousands of images of individual phytoplankton cells. A continuous deployment can generate millions of individual plankton species images. These images can then be automatically analyzed to identify and measure the organisms using AI-assisted supervised machine learning systems, trained on a subset of images labelled by expert taxonomists. The European IFCB user network was established in 2021 to facilitate cooperation, development of AI image classifiers and sharing of the valuable annotated image libraries used to train the AI models. Here we report on the activities of the European IFCB user network, highlighting recent results, advances in coordinating standard operating procedures, data pipelines and phytoplankton data shared in open access databases.

Abstract #92

Development of drift forecasting for the Gulf of Finland

Authors

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Keywords

drift modelling, Gulf of Finland, OpenDrift

Abstract

The Gulf of Finland in the Baltic Sea serves as transit route for the transport of goods and energy, and its coastal areas host a variety of urban infrastructure as well as unique ecosystems. Recent geopolitical tensions have made cooperation on environmental issues difficult, and the risk of hostile acts against marine and coastal infrastructure has increased. Developing coastal forecasting systems and impact assessment tools is essential for preventing and mitigating risks to the marine environment. We present ongoing advancements in drift forecasting services for this region, focusing on improving the ability to simulate the drift and fate of harmful substances in the marine system.

The Gulf of Finland presents several challenges for drift forecasting. As a long and narrow gulf, surface waves are primarily steered along its length, often creating significant differences between wind and wave directions. Additionally, its complex northern coastline, characterized by a dense archipelago, makes the representation of surface currents highly sensitive to model resolution. These factors make drift forecasting in this region both challenging and scientifically intriguing. The Gulf of Finland provides a unique environment to study wave-current interactions, the influence of coastal geometry on hydrodynamics, and the role of Stokes drift in transport processes, all of which are critical for improving drift modeling in complex coastal environments.

We use open-source drift model OpenDrift (opendrift.github.io) to develop drift forecasting system for the Gulf of Finland. We develop and optimize the system by testing different combinations of wind, wave, and current forcing. To calibrate and validate the drift forecasts, we incorporate data from drift experiments conducted in the Gulf of Finland. Additionally, we assess the system's performance through Use Cases related to drift and fate of harmful substances.

This work is supported by ongoing projects CoWup (Coastal waters under pressure – safeguarding a healthy Gulf of Finland in a changing political and environmental landscape), funded by the Strategic Research Council of Finland, (grant no. 365488) and DRIFTERI

(DRIFT Forecast for Environmental Rea-time Information) funded by the National Collaboration Programme of the EU Copernicus Marine Service.

Abstract #95

CoastPredict: Innovative, Cost-Effective Observing for Coastal Resilience

Authors

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Presenting author

Patrick Gorringe

Keywords

cloud-based data and computing, community resilience, Cost-effective coastal observations

Abstract

Coastal zones are increasingly exposed to intensifying pressures from human activities and climate change, including sea-level rise, extreme events, erosion, and ecosystem degradation. These accelerating risks threaten marine biodiversity, coastal infrastructures, and the well-being of communities. CoastPredict is a programme of the Global Ocean Observing System (GOOS) endorsed under the UN Decade of Ocean Science for Sustainable Development that aims to expand GOOS into the coast by co-designing and implementing an integrated coastal ocean observing and predicting system using a cloud-based platform for storage and computing. The vision is a responsive, fit-for-purpose system to deliver services to address coastal challenges such as storm surge, climate impacts, coastal erosion, hypoxia, marine heatwaves, carbon sequestration, etc.

Strengthening coastal resilience requires high-quality, sustained, and cost-effective observations capable of capturing the fast, multiscale dynamics of coastal systems. While global initiatives such as GOOS and EMODnet provide essential baselines, there is a critical gap in coastal ocean observations where acquiring observations to support trusted predictions is particularly challenging due to high variability in space and time. Existing observations must be complemented by innovative, affordable, and scalable observing solutions that increase spatio-temporal coverage of both abiotic and biotic processes. CoastPredict promotes innovative, cost-effective observing strategies that strengthen our capacity to monitor the dynamic and fragile coastal environment. Integrated monitoring platforms, low-cost and do-it-yourself technologies, autonomous systems, and community-driven Citizen Science initiatives can substantially expand observational capacity, support early-warning systems, and improve our ability to assess climate-driven impacts and ecosystem services.

The approach fosters multidisciplinary methods that merge in-situ and remote observations, numerical modelling, and marine citizen science to deliver comprehensive insights into the

effects of natural and anthropogenic stressors on coastal ecosystems. Furthermore, through initiatives like the Fishing Vessel Ocean Observing Network, FVON, relationships with citizen communities are established offering participation and benefit for end-users of observational data. These approaches facilitate long-term environmental assessments, support studies of physical and biological processes, and contribute to biodiversity monitoring, ecosystem restoration, and the sustainable use of marine resources.

A fundamental component of this effort is the development of robust data management practices that ensure the long-term usability, interoperability, and accessibility of coastal observations together with building trust in the data. By adopting internationally recognized FAIR principles, CoastPredict enhances transparency, maximizes the value of collected information, and supports effective data sharing across scientific, policy, and stakeholder communities. The cloud-based infrastructure enables standardized metadata practices, open access to data products, and seamless integration of heterogeneous data streams, thereby reinforcing the reliability and impact of coastal predictions.

By expanding observational capacity and promoting accessible monitoring solutions, and ensuring that data are managed according to FAIR and open-science standards, CoastPredict will provide essential knowledge for the economic valuation of natural capital and the development of resilient coastal management strategies.

Abstract #112

The European Best Practices Repository (EC-OBPSS) and its support of ocean practices for research and ocean information

Authors

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Presenting author

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Keywords

Metadata, Ocean Best Practices, Repository

Abstract

Ocean practices cover a wide spectrum of methodologies supporting ocean-related research, operations, and applications. These methodologies enable consistent and interoperable techniques, ultimately supporting informed decision-making. There have been challenges to make access to methods for ocean observations more comprehensive, coherent and available across Europe. Traditionally, methods access is fragmented across repositories and access to key practices may be lost when projects finish or web sites disappear. A decade ago, the need for a sustained, global system for best practices was identified and, in 2019, a framework for this was published (Pearlman, et al, 2019). As the use of best practices has increased and their importance and benefits are better understood, the benefits of a sustained repository has been widely recognized.

In 2024, the European Commission awarded a contract for a European repository of standards and best practices. The emphasis for the development was to have an open access digital collection of best practices which can support improved interoperability across Europe and support nations in guiding their ocean observation developments and operations. The repository focuses on practices for observations with an emphasis on more mature techniques which have been adopted by multiple institutions. The ocean practices maturity model developed under the European Horizon 2020 project, JERICO S3 (Mantovani et al, 2024), establishes the attributes of a better or best practice for acceptance in the repository. The repository includes the work of EuroGOOS teams supporting innovation and coordination of observations across Europe.

The new repository, named the European Ocean Best Practices and Standards System (EC-OBPSS), is built using a D-Space Framework for the back end and a customised front end to

enable users to easily find methods supporting their needs and interests. The platform is operating on a VLIZ server and supported by a team ETT, CTN and IEEE-France. Expansion of the repository content and upgrades are in process.

This presentation will provide an overview of the design, development and testing of the repository. It will also offer perspectives on the user experience and plans for evolution.

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Abstract #120

An innovative suite of multiple and diverse mobile sensor-platforms as ocean observation system for the blue economy

Authors

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Keywords

Autonomous uncrewed sensor platform, Blue Economy, Ocean Observing Systems

Abstract

For the last decade Akvaplan-niva, a non-profit research institute based in Tromsø, Norway, has developed an original and innovative concept for ocean data collection using a suite of multiple and diverse mobile sensor-platforms. These platforms include: 1) subsea gliders (Seaglider MK1 and two Slocum G3) rigged with advanced sensors (UVP an optical imagery sensor, the echo sounder EK80, the Observer Hydrophone from Jasco, an eDNA sampler from DoT); 2) Four USV Sailbuoys (Offshore Sensing) rigged with the echo sounder EK80, ADCP and a DoT eDNA sampler; an USV Otter (Maritime Robotics) rigged with echosounder EK80. Herein, we will demonstrate how we operate these platforms in environmental data collection through applications developed in support of the blue economy. Our concept allows the collection of biological information from phytoplankton, zooplankton, fish, sea mammals, biodiversity, and physical information such as temperature, salinity, ocean current, noise etc. For O&G industry, we studied the noise propagation across depth and distance during seismic shooting and its impact on zooplankton. Produced water discharges were mapped and impact on the zooplankton assessed. We looked at the reef effect of offshore renewable infrastructures. We developed a solution to detect in real time the salmon lice which threatens salmon aquaculture; last, we help detecting, characterizing and mapping Calanus finmarchicus a new resource for the fishery, with sub-sea, surface and satellite observations. Further, Akvaplan uses Blue Insight a cloud-based platform services to harvest, visualise and contextualise the data from our mobile assets and oversee their operations. Blue Insight is a product that Akvaplan and Kongsberg Discovery have initially co-developed through an industry project led by Akvaplan which allows sharing a common experience among data users. This highly flexible and performant ocean observing system can be adapted to many different contexts to collect marine data in support of the blue economy for a sustainable management.

Abstract #130

Hydro-Salinity Response of the coastal ocean to the October 2024 DANA event in Spain: Insights from a Numerical Model

Authors

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Presenting author

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Keywords

coastal salinity dynamics, DANA extreme event, freshwater plume, Mediterranean Sea, numerical modelling

Abstract

A severe DANA event leading to an extreme rainstorm generated by an isolated high-altitude low-pressure system, struck the Valencia region on October 29, 2024, producing one of the most extreme episodes recorded in the area. While its human, economic, and ecological impacts have been widely documented, scientific analyses remain largely focused on terrestrial and atmospheric processes or on restricted environments. Yet, sudden freshwater inflows into the Mediterranean can significantly modify coastal seawater properties, affecting benthic communities and water quality. In this study, we use a high-resolution numerical model to characterize the coastal ocean response to the 2024 DANA event. The model allows us to quantify the minimum salinity intensity associated with the freshwater input and to map the spatial extent of the resulting surface and bottom freshwater plume. We also assess how this anomalous water mass modifies coastal hydrodynamics, including circulation changes induced by the event. Furthermore, we compute the residence time of the freshwater mass and determine the lag between the atmospheric event and the oceanic response, providing new insight into the timing and persistence of such disturbances. This integrated modelling framework constitutes a first step toward future biological and biogeochemical impact studies, supporting improved risk assessment for similar extreme events.

Parallel Session B1

Digital Transformation, Integration, and Data Quality

Abstract #21

The Marine Autonomous Systems Digital Twin - Using AI to aid in the piloting of ocean gliders

Authors

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Keywords

AI, Digital Twin, Ocean glider

Abstract

Ocean gliders and Marine Autonomous Systems (MAS) have become a key tool used by the oceanographic community to observe the ocean. As this uptake of marine autonomous systems increases, key challenges have emerged including: • Enabling researchers to have more control of MAS operations on projects while retaining pilot accountably in vehicle operations. • Increasing the value of MAS observations to operational models. • Making the operation of increasingly complex MAS missions more efficient for MAS pilots.

To address these challenges the National Oceanography Centre and the Oxford Robotics Institute developed a digital twin of ocean glider operations that will use real time data sources including earth observation data, ocean currents from ocean models, and error estimates from an operational ocean model. The observations are combined with a user interface to generate mission objectives. A hydrodynamic glider model, combined with machine learning techniques, is then utilized to create mission plans for ocean gliders.

The project was ambitious with a 15-month duration and focused on 3 uses cases to deliver key functionality for users: 1. Autonomous waypoint navigation to optimize glider tracks for research applications in regions with complex currents. 2. Adaptive sensor sampling to maximize the value of real time decimated data to operational ocean models. 3. Glider mission planning to assess key mission parameters like energy budget and its impact on deployment duration.

The digital twin has been successfully used to aid in the operation of a the UK Met Office operating in the North Sea for a year. This paper will present key results from the project including developments on interoperable digital twin architectures.

Abstract #57

On technical standards of modelling platforms for Digital Twin of Ocean applications

Authors

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Presenting author

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Keywords

impact-resolving modelling, model reproducibility and relocatability, model stress tests, on-demand models, Technical standards of DTO models

Abstract

Digital Twins of Ocean (DTO) are a priority area of the UN Decade of Ocean Science. They provide cloud-based services that allow users to explore a “digital ocean” and apply models, either numerical or AI-based, and tools such as jupyter notebooks and dashboards to run virtual, on-demand ocean applications. especially what-if scenarios (WiS). A defining feature of DTO systems is the ability to execute what-if scenarios (WiS), where models simulate the impacts (the what) of hypothetical changes (the if). Such scenarios may include dike breaching, construction of new offshore infrastructure, altered land emission of nutrients, plastics and other pollutants, severe storms approaching from different directions and times, or observing system configurations. To simulate impacts across the ocean–wave–coastal continuum in the WiS, model configurations must be redefined dynamically – for example by adjusting focused model domains, coastlines, topography, grid resolution, atmospheric and riverine forcing, and even model parameters. DTO WiS therefore require the model systems can be automatically configured in the cloud and on the demands of users. Then the users should be able to run the new model configuration and generate required simulations in the cloud. This, in turn, imposes a set of technical requirements for DTO model design: relocatability, impact-resolvability, auto-configuration, reproducibility (binary-identical results), robustness under stress conditions, computational efficiency, and quality consistency. Despite several DTO initiatives in recent years, these technical standards remain largely unexplored. Over the past years, the DMI ocean team has developed seamless and impact-resolving modelling capacity for DMI operational two-way nested ocean model HBM in European projects such as CLAIM, FORCOAST, OLAMUR and FOCCUS. In the EU EDITO Model Lab, HBM has been further developed into an on-demand DTO model —HBMos. The HBMos has been extensively tested for quality assurance, relocatability, reproducibility, robustness (stress tests), HPC scalability, automatic workflows, and applied in WiS including

storm surge assessment, artificial infrastructure scenarios, offshore-wind-farm impacts, and microplastic remediation. Based on these developments, this presentation outlines the emerging scope, principles, and challenges in defining technical standards for DTO modelling platforms, and discusses how these standards can support the next generation of operational, user-driven digital twin systems.

Abstract #63

Building the foundations of a Digital Twin for a Marine Protected Area: Integrating Fine-Scale, High-resolution Data to enhance Coastal Observing Systems

Authors

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Presenting author

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Keywords

Biodiversity data, Cyprus, Eastern Mediterranean, Physicochemical data, SfM-photogrammetry

Abstract

High resolution, fine-scale ocean observations remain scarce across the eastern Mediterranean, particularly in coastal and nearshore ecosystems of Cyprus. Limited availability of long-term, high-frequency in-situ measurements of important parameters such as temperature, nutrients, sea-level rise, pH and biodiversity, restricts our ability to characterise the fine-scale physical and biogeochemical processes that underpin ecosystem resilience, pollutant behaviour, and climate vulnerability. Addressing this gap is a prerequisite for developing next generation observing systems and Digital Twin frameworks.

We present the first holistic, multi-disciplinary dataset assembled for 'Thalassines Spilies Ayia Napa' a small marine protected area (MPA) in Cyprus, hosting endangered species such as endemics Mediterranean Monk seal (Monachus monachus) and the pillow coral (Cladocora caespitosa). The dataset integrates complementary components such as: (i) high-resolution three-dimensional models produced through structure-from-motion photogrammetry (SfM); (ii) seasonal in-situ records of physicochemical parameters; (iii) pollutant and nutrient analyses; (iv) biological and ecological surveys of coral health, fish, benthic invertebrates, and planktonic organisms; (v) eDNA profiles; and (vi) paleo-environmental reconstructions from dated reef cores.

By consolidating these heterogeneous data streams into a coherent spatial framework, we establish the baseline architecture for a Digital Twin of the MPA. This foundational layer enables future data assimilation, model coupling, and scenario testing, such as projecting thermal stress, pollutant dispersion, or habitat shifts under different management and climate trajectories.

Our approach demonstrates how integrated, site-specific datasets can enhance coastal observing systems by filling critical fine-scale data gaps and providing the first step toward a holistic, decision-supporting digital twin. The framework developed here offers a replicable pathway for expanding Digital Twin applications across eastern Mediterranean MPAs and other data limited regions.

Abstract #68

Towards an optimal eDNA digital ecosystem: The eDNAqua-Plan project

Authors

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Keywords

Aquatic eDNA, Biodiversity, FAIR data, metadata, Reference library

Abstract

eDNA-based methods offer remarkable opportunities for effective marine and freshwater biodiversity observation, monitoring and conservation. However, the absence of agreed standards, formats, protocols and FAIR and open eDNA data infrastructure pose challenges that limit their routine application. The Horizon Europe-funded project eDNAqua-Plan is working to overcome these challenges by proposing solutions to meet the needs for a more harmonised and interoperable landscape for aquatic eDNA data across Europe and beyond.

Over the past two years, eDNAqua-Plan has been analysing the eDNA data landscape, particularly in Europe, from sample collection to application. By analysing (meta)data standards, (meta)data interoperability and reusability, and the harmonisation and interconnectivity of DNA barcode reference libraries, eDNA and biodiversity data portals, and biobanks, eDNAqua-Plan has identified gaps and bottlenecks in the system. It has connected with existing reference libraries, assessed existing standards, and identified key monitoring projects and programmes that the system needs to support.

Based on the mapping exercise and analysis, eDNAqua-Plan has proposed an ambitious vision with recommendations for a future eDNA digital landscape that is more efficient, sustainable and has FAIR data principles at its core. To advance this vision, eDNAqua-Plan members are co-creating a roadmap that sets the actions necessary to implement this vision together with key stakeholders, such as data providers, repositories, and end-users. This roadmap will also promote the identified good data practices and resources to enhance interoperability and standardisation of eDNA (meta)data. Through a collaborative effort, eDNAqua-Plan will continue to organise consultations and workshops that involve all actors who produce, use and/or manage eDNA data to facilitate the implementation of the roadmap.

The overall goal is to help unlock the long-promised potential of eDNA data to support future biodiversity monitoring and conservation initiatives in marine and freshwater ecosystems worldwide by making it easier for all stakeholders to find, access and (re)use eDNA data. In this presentation the outcomes of eDNAqua-Plan's stakeholder consultations and its recommendations for a future FAIRer eDNA digital ecosystem will be presented.

Abstract #73

Evaluating Ocean Model Quality via Material Transport: Connections to the Geometry of Dynamical Systems

Authors

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Keywords

Dynamical Systems, Ocean Model Quality, Transport

Abstract

Nowadays, there is a growing number of ocean data services offering operational information on the state of the ocean. Such data presents valuable opportunities for the management of environmental incidents [1,2], search and rescue operations, and other maritime applications. For these uses, the accuracy of the data is crucial. However, most available datasets provide limited information regarding their performance in terms of alignment with real-world observations. Some recent efforts [1,3,4] have explored the relationship between uncertainty and invariant dynamical structures in the ocean. In this presentation, building on those results, I introduce a methodology described in [5] to assess how well the material transport predicted by different ocean models matches observational data. This approach uses particle trajectories as the basis for comparison, and the connection between uncertainty and invariant dynamical structures is used to guide the implementation of statistical averaging strategies for systematically assessing the quality of ocean data.

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Parallel Session B2

Co-Design, Engagement, and Inclusivity

Abstract #15

CS-MACH1 – accelerating the use of Marine Citizen Science Data

Authors

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Presenting author

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Keywords

Citizen science, cost effective, marine data

Abstract

The CS-MACH1 (Marine Citizen science data Horizon) project, funded by Horizon Europe (GA 101214613), aims to establish a pan-European network for marine citizen science data. The project addresses current barriers limiting the full potential of marine citizen science initiatives, such as access, trust, recognition, and data sharing. By fostering collaboration among citizen science communities, developers of cost-effective technologies, data management experts, and researchers, CS-MACH1 develops FAIR data standards, best practices, observation protocols, and related training materials for citizen science coordinators. co-designed practical case studies, including existing citizen science initiatives and the deployment of new affordable sensors to collect coastal data, serve as the demonstration pillars of the project. In this paper, we present the project's procedures and workplan, and issue a call to action to stakeholders, including marine citizen science coordinators, data managers, research institutes, and cost-effective technology developers, to collaboratively bring marine citizen science closer to its full potential for widespread ocean observation data uptake.

Abstract #28

Integrated multi-scale co-design in operational oceanography

Authors

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Presenting author

Jun She

Keywords

co-design for coastal-shelf-deep sea continuum, Multi-scale co-design, public-private and public-public co-design, scientific-geographically coherent co-design, UNDOS Ocean Observing Co-Design

Abstract

Co-design has increasingly become one of the key components in optimizing modern operational oceanography, enabling the ocean observing and forecasting value chain to align scientific capability, technological innovation, and user needs. The field involves diverse actors—including observing networks, modelling and forecasting centres, marine data infrastructures, industry, policy bodies, and coastal communities—who increasingly require an operational oceanography system that is scientifically and geographically coherent, fit-for-purpose, and cost-effective. Co-design in operational oceanography includes both ocean observing co-design and service co-design. These processes occur at multiple scales—from global and inter-basin coordination to basin-scale observing systems and local service development—yet they remain insufficiently integrated. This work presents existing best practices across global, regional, and local scales and highlights the need to strengthen interactions among these levels to avoid fragmented or duplicated efforts. At the global level, the UN Decade Ocean Observing Co-Design Programme provides an ambitious framework for modernising observing strategies by integrating scientific requirements with user priorities. Its six Exemplar Projects—Ocean Boundary Currents, Marine Heatwaves, Tropical Cyclones, Storm Surge and Carbon Cycle, aim to co-design ocean observing in substantial thematic area. Connecting to the Exemplars, a scientific-geographically coherent co-design framework can be proposed for developing a global Coastal-Shelf-Deep Sea Continuum (CSDC) observing systems. The CSDC includes 13 subsystems, each comprising an ocean-boundary-current domain, a continental shelf, and a coastal/estuarine region. These areas exhibit strong natural variability and anthropogenic pressures, including sea-level rise, storm surges, marine heatwaves, acidification, and ecosystem degradation. A synthetic analysis shows that an integrated “network of networks” approach can meet common needs for seamless CSDC observations, while operational oceanography and emerging digital twin technologies offer pathways for delivering regular and on-demand fit-for-purpose products. At

the basin scale, the Baltic Sea offers a mature example of co-design. Here, data assimilation tools enable OSE/OSSE-based optimisation of observing networks—including Argo, gliders, moorings, and non-operational observations—by quantifying their impact on coupled physical–biogeochemical model systems. Public–private and public-public collaborations further illustrate basin-scale co-design in practice: BOOS partners cooperate with HELCOM to assess the fit-for-purposeness of CMEMS reanalysis for eutrophication monitoring, jointly develop Digital Twin Ocean services for offshore wind under DTO4OWE with wind industry, and validate citizen and commercial observations (VOTO, BDC) for operational forecasting. At the local scale, co-design directly links modelling to user-specific services. Examples include the development of fit-for-purpose model products for Limfjord oyster farming (FORCOAST) and aquaculture tools such as the Offshore Operation Planner and Early Warning Service (OLAMUR). Despite these advances, co-design efforts across local, basin, and global scales remain insufficiently harmonised. On the one hand Co-Design aims at meeting user/modelling needs for societal priority areas where we know observations will make a big difference (system and observing approach), and on the other a series of discrete co-designed elements at regional and local level aimed at enhancing services/service delivery, and it is still an open question for how these discrete examples fulfill prioritised system (regional and global) needs.

Abstract #31

A Future Ocean Data Paradigm: the FVON North Atlantic Arc Project

Authors

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Presenting author

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Keywords

co-design, Fishing vessels, global governance, ocean observing, stakeholder engagement

Abstract

Ocean observing is essential for informing short and long-term climate prediction, supporting ecosystem management, and a wide range of public and private ocean-based activities. However, current data collection efforts do not support the high level of benefits that could potentially be derived. The main barrier to achieving scale in ocean observing is limited and fragmented project-oriented funding that limits effective planning and the high cost of traditional observing methodologies. These factors limit the uptake of observing systems globally resulting in sub-optimal ocean and weather models; this may lead to reduced capability to accurately capture the behavior of fundamental ocean processes that determine how we design and deploy all ocean-based activities, and to identify extreme weather events such as hurricanes that are increasing in variability due to climate change.

To achieve ocean observing at scale new, cost-effective methodologies must be developed and supported by a more coordinated approach to funding observing systems to complement the existing systems. The Fishing Vessel Ocean Observing Network (FVON), an emerging network of the Global Ocean Observing System (GOOS), aims to facilitate partnerships with the fishing industry to collect high quality and trustworthy ocean data in areas of the ocean where the biggest data gaps exist and at a cost that permits widespread scaling. To achieve global scale, FVON is implementing a strategy centered around global coordination and inclusive partnerships, capacity building and citizen science, effective communications, rigorous data management, clear standards for technological innovation, and innovative market shaping. Over the past year, FVON's Steering Committee and working groups have made substantial progress in each of these areas, driving the delivery of data for a growing number of regions and use cases. And now, FVON is at the cusp of testing its blueprint for a new ocean data paradigm, with the North Atlantic Ocean as the testbed.

The “North Atlantic Arc” project is initially supported by philanthropic funding and an initial phase is aimed at establishing new networks of fishing vessels instrumented with oceanographic sensors across Iceland, the Faroe Islands, and the UK. However, FVON is inviting a broad range of stakeholders, both public and private, to co-design and co-implement an extended network that maximizes collective benefits across sectors. We aim to engage a public-private broad consortium—extending from the Caribbean to West Africa by way of the northern reaches of the Atlantic—to work together to demonstrate the value of ocean data and drive investment in sustained networks at scale. FVON will present progress on the strategic workstreams that have contributed to the success of the project as well as lessons learned for applying this approach to other regions within shifting international frameworks. We will present recent progress on this exciting project and witness the early stages of what may become a large component of the future of ocean observing.

Abstract #97

CoastPredict integrated services for risk assessment and management

Authors

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Presenting author

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Keywords

coastal resilience, Integrated coastal observing, prediction

Abstract

CoastPredict Programme and its GlobalCoast initiative aim to demonstrate the value of an integrated, fit-for-purpose coastal observing and prediction system that delivers innovative products and services for coastal resilience in collaboration with local partners and communities. A GlobalCoast Network of more than 135 Pilot Sites in 75 countries has been established to co-design and exchange knowledge for solutions, standards, and applications for risk assessment and management

The GlobalCoast concept was formulated from the realization that we can accelerate innovation for coastal resilience using Pilot Sites as testbeds in different coastal regions that have similarities and differences in characteristics. This innovation must be based on seamless integration from the open ocean to coasts and estuaries, encompassing both natural and built environments (including cities and ports). Expected outcomes include strengthened collaboration across different regions of the world, with methods and solutions that are developed globally and implemented locally, co-designed with appropriate stakeholders.

GlobalCoast provides partners - regardless of the current resource capacity - with opportunities to collaborate with leading international experts and benefit from cutting-edge science and technological advances in ocean observing, modeling, AI and end-user product development. The CoastPredict community focuses on transformational science and technology and a shared vision creates a remarkable international network devoted to exchanging ideas and advancing science.

A key element of GlobalCoast's resource sharing approach is the development of an innovative cloud-based infrastructure, a prototype for which has been developed called

‘ProtoCoast’, that makes data and information from all Pilot Sites openly accessible through a network system of interoperable regional clouds. This will enable synergy among sites and accelerate progress across regions by supporting intercomparison and the exchange of new insights, datasets, and approaches for strengthening resilience across coastal, marine, and urban environments worldwide.

Abstract #103

An operational framework for coastal risk assessment and environmental services co-designed with end-users in the Lisbon Metropolitan Area (Portugal)

Authors

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Presenting author

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Keywords

citizen science, co-design, Lisbon Metropolitan Area, low-cost sensors, operational modelling, remote sensing

Abstract

The Lisbon Metropolitan Area (AML) is the most populous metropolitan region in Portugal (NUTS III), with 2.8 million inhabitants. Its largest cities, Lisbon and Setúbal, are located on the banks of the Tagus and Sado estuaries, respectively. Coastal human activities in the AML include major port operations, leisure marinas, bivalve aquaculture (mainly in the Sado estuary), tourism, industrial hubs, and environmentally protected areas. However, the region also faces threats such as flooding, erosion, heatwaves, and risks associated with marine traffic. To address these challenges, initial steps are being taken to establish a coastal observatory that consolidates data from various sources along the water continuum and supports the sustainable development of the blue economy and related human activities. A key component of the observatory is the LisOcean numerical model, which represents the salinity continuum of the Tagus and Sado estuaries—from intertidal areas to the offshore Lisboa-Setúbal submarine canyon system. With a spatial resolution of 280 meters, the model downscales Copernicus Marine Global products at the ocean boundary and uses near-real-time river observations from EMODnet at the land boundary. Based on the MOHID circulation model, LisOcean provides daily 3D operational hydrodynamic forecasts, along with monthly updated 2D seasonal forecasts and total water levels using a SWAN-coupled version. This operational framework delivers freely accessible forecasts and outputs using community-recognized standards. This presentation showcases how the model supports oyster aquaculture, informs environmental agencies, and helps mitigate coastal risks from

compound flooding and marine heatwaves. It also highlights the integration of cost-effective technologies and citizen science to enhance monitoring and capture spatial variability within estuaries, in collaboration with local stakeholders such as Blue Schools, research centres, aquaculture producers and universities. These new observations contribute to product improvement and validation in under-monitored areas. To facilitate access to this variety of products, a one-stop-shop data visualization platform has been implemented, aggregating in-situ and remote observations, model results, and derived products.

Abstract #133

Co-designing a digital representation of the Estonian marine areas (Project "Merehunt")

Authors

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Presenting author

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Keywords

co-design, digital representation, smart buoy

Abstract

High-quality environmental and navigational information covering the entire marine area is an integral part of the modern maritime economy, sustainable management of the marine environment, and assurance of security and safety at sea. Estonia has thematic/sectoral monitoring programs, but the responsibilities, funding, and development of these programs are divided between sectors; information is mostly received in a delayed mode, and information exchange is insufficient both in Estonia and regionally (Baltic Sea region). There is a lack of operational, up-to-date information for effective pollution control (except for aerial surveys and remote sensing) and for protecting the marine environment. We lack infrastructure for automated/near real-time maritime surveillance, especially in offshore areas and subsurface layers. Data quality is uneven; different organizations handle data, and databases are not connected, making cross-use of data difficult. Driven by user needs and identified challenges, the Estonian government has decided to seek an efficient way to gather and interpret marine data to best serve as many users as possible. A consortium consisting of experts from Tallinn University of Technology, Flydog Solutions OÜ, and Nortal AS has been tasked with tackling this demanding goal. The launched project "Merehunt" aims to offer a monitoring network design, including descriptions of the platforms and sensors to be used, data management routines, and an IT platform with a database and fit-for-purpose user interfaces. An extensive user survey was conducted to gather information from governmental agencies and maritime companies, including wind park and aquaculture developers, environmental and rescue organizations, and the general public. A study of existing observational networks and available and emerging technologies has been accomplished. We present the design of the monitoring network, technical descriptions of observational platforms, including smart buoys, energy management and telecommunications systems, the architecture of the data management platform, connections

to regional and European systems, and user interfaces for acquiring, displaying, and visualizing data and data-driven products. The first phase of the project (2025-2027) aims to create working prototypes of innovative observational platforms and a prototype of the supporting data management platform. The long-term aim is to build a digital representation of Estonian marine areas to support a more efficient, data-driven decision-making system. We underscore that to be successful, a collaborative approach involving scientists, policymakers, businesses, and citizens must be pursued throughout the development process, from initial design and testing to implementation of the digital twin.

Parallel Session B3

Digital Transformation, Integration, and Data Quality

Abstract #90

Towards a Land–Sea Continuum Observing System: Innovation, Digital Integration, Network Governance and Foresight: the CNR-ISMAR contribution to the IT-IOOS Italian Integrated Ocean Observing System

Authors

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Presenting author

Angela Pomaro

Keywords

Autonomous Platforms, Data Management, Italian Integrated Ocean Observing System, Land–Sea Continuum, Marine Research Infrastructures

Abstract

The CNR-ISMAR Marine Observing System (SOM), which contributes to the IT-IOOS Italian Integrated Ocean Observing System, is undergoing a profound transformation also enabled by targeted Italy's National Recovery and Resilience Plan (PNRR) investments, marking a transition from a predominantly ocean-focused network to an integrated land–sea continuum observing framework. The recent upgrades significantly expand observational capability across rivers, lagoons, estuaries and deltas, coastal areas, and the open ocean. The network expansion, adding ten new observing sites across riverine, transition environments, and coastal ecosystems, substantially broadens both the disciplinary and spatial scope of marine and environmental observation. Combined with strengthened autonomous capabilities (ASVs, gliders, BGC-Argo, BGC-SVP drifters, smart imaging systems, wave buoys and HF-radar), SOM is increasingly aligned with foresight priorities for operational oceanography and observing systems of the future, enabling persistent, multi-sensor, multi-platform and intelligent high-frequency observation across tightly coupled land–sea domains.

These upgraded assets provide higher-resolution, more continuous observations across physical, biological, and biogeochemical domains, supporting enhanced modelling and forecasting capabilities. Future connections with strategic research initiatives and oceanographic campaigns will continue improving national and European capacity for deep-ocean studies, contributing to EuroGOOS priorities in Innovation in Observations, Modelling,

and Forecasting. Cross-platform complementarities already foster new scientific pathways, improve data readiness, and strengthen the integrative potential of the observing system.

Aligned with Digital Transformation, Integration, and Data Quality, SOM has reinforced its data-sharing infrastructure, increased the proportion of sensor-based variables, improved data-return efficiency, and advanced interoperability and standardisation across multiple ESFRI Research Infrastructures (EMSO, EURO-ARGO, ACTRIS, ICOS, DANUBIUS, eLTER). These upgrades enhance FAIR/TRUST-aligned metadata standards and support development of Digital Twins and virtual research environments by supplying high-density, cross-domain, and machine-readable datasets. This foundation also paves the way for forthcoming AI-based quality-control workflows, anomaly detection, and predictive maintenance. Complementary analyses under development will document improvements in time-series stability, data return efficiency, and identify remaining gaps in spatial and variable coverage relevant for contributing to the Essential Variables frameworks.

The ongoing redesign of SOM governance and access policies strengthens alignment with Co-Design, Engagement, and Inclusivity. Enhanced procedures for transnational and national access and clearer documentation of available resources and collaborations support broader community engagement. Recognition of human-resource effort across technical, scientific, and data-management roles reinforces European capacity building and highlights the essential contribution of early-career and non-permanent personnel.

Over the past years, SOM has been developing a comprehensive governance and management framework that includes a network-wide upgrade roadmap, long-term sustainability strategies (beyond PNRR), maintenance, risk and obsolescence planning, cost and human-resource assessments, and platform-specific failure and recovery metrics. This governance foundation has addressed long-recognised structural gaps and enabled strategic design and prioritisation of PNRR investments, ensuring upgrades respond to operational needs, interoperability targets, and European observing priorities, aligning SOM with international best practices for sustained ocean observing systems.

Finally, SOM’s multidisciplinary expansion enables integrated assessments of climate variability, biodiversity change, extreme events, pollution, and land–sea interactions. The upgraded network represents an open, advanced, interoperable, strategic national capability that supports scientific research, policy development, operational agencies, and society at large.

Abstract #104

Integrating AI in the value chain of the Mediterranean biogeochemical operational system

Authors

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Presenting author

Simone Spada

Keywords

Artificial intelligence, Biogeochemical modelling, Mediterranean Sea Operational Oceanography

Abstract

The Mediterranean biogeochemical operational model system of the Copernicus Marine Service combines advanced numerical modelling with an expanding portfolio of observational data. Alongside state-of-the-art data assimilation, novel artificial intelligence (AI) applications are being developed to modernize the entire value chain, from raw observations to high-quality products and ocean indicators. These AI-driven developments enhance forecast accuracy, increase computational efficiency, and expand the applicability of the operational system across spatial and temporal scales. To address the uneven temporal availability of biogeochemical observations, we integrate neural-network–reconstructed nitrate profiles into the BGC-Argo data assimilation workflow of the forecasting system. A 1D convolutional neural network trained on Argo profiles generates nitrate profiles based on temperature, salinity and oxygen profiles. When assimilated together with observations, AI-generated nitrate profiles contribute to improve the model's skill, reduce biases and better capture basin-scale processes such as nitracline variability, primary production, and oxygen vertical patterns. Gains in computational efficiency of the Mediterranean biogeochemical system are explored through AI-based emulation and downscaling. A two-phase deep-learning emulator reconstructs full 3D chlorophyll-a fields by blending process-based model outputs with in-situ BGC-Argo measurements. This approach delivers results orders of magnitude faster than full model runs while accurately reproducing spatial and temporal chlorophyll variability, including surface blooms and deep chlorophyll maxima and demonstrating an effective and efficient model–data fusion strategy. While the Mediterranean model system is evolving toward ensemble simulations which are essential for forecast uncertainty quantification, this is very computationally demanding. Thanks to the capability of a U-Net-based downscaling method to transform low-resolution ensemble members into high-resolution fields while retaining

essential fine-scale biogeochemical structures, computational costs can be substantially reduced without compromising the representation of small-scale features. AI also enables broader applicability of the operational system. While the Mediterranean model operates at 4.5 km resolution, many coastal applications require finer detail. A deep-learning downscaling technique has successfully enhanced the model outputs to higher-resolution coastal scales, capturing the influence of river discharges and local processes in a complex area such as the Adriatic Sea. The robustness of the proposed method suggests strong potential for transfer to other Mediterranean coastal regions. Overall, AI is proving instrumental in strengthening both our observational capabilities and our predictive skill. By integrating AI throughout its value chain, the Mediterranean biogeochemical operational system becomes more accurate, more efficient, and better equipped to support coastal and open-ocean applications.

Abstract #118

The Fr-OOS Dashboard: A strategic tool for coordinating french ocean observations and enhancing FAIR data interoperability

Authors

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Presenting author

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Keywords

dashboard, data interoperability, FAIR principles, FROOS, ocean observing system coordination, ODATIS, standardization

Abstract

Effective coordination of ocean observation systems requires transparent monitoring of operational status, spatial coverage, temporal continuity, and data flows across multiple networks and platforms. The French Ocean Observing System (Fr-OOS) Dashboard, developed in close coordination with ODATIS cluster (Ocean Data Information and Services), addresses this need by providing a comprehensive, interactive tool for strategic oversight and data-driven decision-making in French marine observation: https://www.froos.fr/Tableau-de-bord/Catalogue-de-donnees.

Established in 2023, Fr-OOS coordinates long-term ocean observation across French institutions, linking research infrastructures (Argo-France, EMSO-France, ILICO, and the future OHIS), operational networks and research vessels. Within the European Ocean Observing System (EOOS) framework, Fr-OOS serves as France's interface with EuroGOOS, EMODnet, Copernicus Marine Service, and the Global Ocean Observing System (GOOS). The Dashboard operationalizes this coordination by integrating distributed data sources into a unified monitoring and assessment platform.

Core Functionalities

The Fr-OOS Dashboard offers an interactive interface enabling users to: - Visualize measurement zones and sampling activities on dynamic maps with fluid rendering of millions of observations - Monitor operational status and temporal evolution of observation networks - Perform refined queries based on multiple criteria (time, space, networks, Essential Ocean Variables, observed parameters) with near real-time response - Generate dynamic indicators

for coordination and future planning - Analyze results through customizable graphics and automated reports - Contribute to European and international dashboards (EOOS, GOOS)

To handle the massive volume of ocean observations from multiple sources, the Dashboard leverages advanced Big Data technologies including Cassandra for distributed data storage and Elasticsearch for high-performance indexing and search capabilities. This architecture enables fluid visualization and analysis of millions of observations across decades of measurements, ensuring responsive user experience even with complex spatiotemporal queries spanning multiple networks and parameters.

The Dashboard's strength lies in its federated approach to data integration. Platform metadata is synchronized with OceanOPS, the WMO-IOC operational centre that monitors the global ocean observing network, ensuring consistent platform descriptions, deployment status, and technical specifications across national and international systems.

FAIR Principles Implementation and Interoperability

The Dashboard is built on FAIR data principles, ensuring that French ocean observations are Findable, Accessible, Interoperable, and Reusable. Integration with ODATIS, France's national marine data hub and part of DATA TERRA RI, guarantees compliance with international standards and supports EOSC (European Open Science Cloud) integration.

Metadata harmonization and adherence to controlled vocabularies (NERC, BODC) enable cross-network queries and facilitate data discovery across disciplines. The platform ensures traceability of data provenance and quality control processes, critical for maintaining TRUST principles (Transparency, Responsibility, User focus, Sustainability, Technology).

The Fr-OOS Dashboard strengthens France's contribution to global ocean knowledge by providing real-time visibility of national observation capacity, evidence-based support for infrastructure decisions, enhanced coordination between communities, and transparent reporting for international commitments.

Abstract #122

ODATIS: France's ocean data hub advancing FAIR principles and European integration through the DATA TERRA EOSC Node

Authors

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Presenting author

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Keywords

Copernicus, cross-domain workflows, DATA TERRA, EOSC Node, FAIR principles, interoperability, ocean data infrastructure, research infrastructure

Abstract

The ocean is the largest compartment on Earth, and the consequences of global changes require sustained, high-quality observations. Recent decades have witnessed a significant increase in marine and coastal observations from both in situ platforms and satellite missions. This exponential growth in data volume and variety necessitates effective infrastructures to make ocean data accessible, discoverable, and usable across the research community, operational agencies, and decision-makers.

ODATIS (Ocean Data Information and Services) is France's national ocean data cluster within DATA TERRA, the French Research e-Infrastructure for Earth system observation data. DATA TERRA organizes national resources through five thematic clusters: AERIS (Atmosphere), ODATIS (Ocean), THEIA (Continental Surfaces), Formaterre (Solid Earth), and PNDB (Biodiversity). As the entry point for all French marine data, ODATIS provides comprehensive access to observations spanning ocean physics, chemistry, biogeochemical cycles, and marine ecosystems, from coastline to open sea and from surface to seafloor.

Federated services and european integration

ODATIS operates through a network of specialized Data & Service Centers including Coriolis (operational oceanography), CERSAT (satellite ocean surface data), AVISO+ (altimetry) and others. These centers deliver quality-controlled datasets and contribute actively to European initiatives including Copernicus Marine Service, EMODnet, SeaDataNet and support European Research Infrastructures (Euro-Argo ERIC, JERICO-RI, EMSO ERIC).

EOSC Node: advancing multi-domain science

Since 2024, DATA TERRA operates as an official EOSC Node, positioning ODATIS at the forefront of European Open Science Cloud integration. This provides seamless access to high-quality, trusted, FAIR and AI-ready multi-domain data for Earth system sciences. The EOSC Node enables federated authentication (EduGain, ORCID, EOSC AAI), access to Virtual Research Environments (Galaxy, Jupyter), and cross-domain data analysis workflows connecting ocean observations with atmospheric, terrestrial, and biodiversity data.

FAIR principles implementation

ODATIS prioritizes FAIR principles (Findable, Accessible, Interoperable, Reusable) recognizing that ocean observations are non-reproducible and essential for characterizing long-term trends. The ODATIS portal (www.odatis-ocean.fr/en) provides catalog services with selection filters, data visualization, and multiple download options. Compliance with metadata standards and controlled vocabularies (NERC, BODC) ensures traceability, provenance information, and semantic interoperability across domains.

Community engagement and innovation

ODATIS supports the research community through annual technical workshops, training sessions on data processing and visualization, and Scientific Expertise Consortiums promoting innovation in ocean observation processing techniques. The EOSC integration expands these capabilities by providing researchers with scalable computing resources, facilitating interdisciplinary collaboration, and ensuring reproducibility through standardized tools and workflows shared via WorkflowHub.

By federating French capabilities and integrating with EOSC, ODATIS exemplifies how national coordination strengthens European-scale ocean observation, enabling transparent, interoperable access to marine data essential for climate monitoring and sustainable ocean management

Abstract #129

From Sustained Ocean Observations to Digital Services: A FAIR Framework for Monitoring and Modeling in the Iberian Atlantic

Authors

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Presenting author

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Keywords

Coastal ocean observing systems, FAIR data infrastructure, Individual-Based Models (IBMs)

Abstract

The Spanish Institute of Oceanography IEO operates sustained ocean observing systems in the Iberian Atlantic since the 1980s to characterise variability of different oceanographic phenomena like river plumes, upwelling, shelf and slope currents and its effect on the ecosystem. Recently, IEO has been developing data infrastructures and data services using open-source tools to ensure the datasets are FAIR (Findable, Accessible, Interoperable, Reusable). Workflows include quality control, transformation into SeaDataNet CDI formats, storage in PostgreSQL/PostGIS, and dissemination through OGC-compliant services (WFS, WMS, CSW) via GeoServer and GeoNetwork.

In this contribution, we will present how this development of standard catalogues and services enables us to organise and present a catalogue of oceanographic data but also to offer data services and products to support final users. We will show two examples of these digital services based on monitoring programs:

- The IEO observing system in the upwelling influenced shelf off A Coruña, Galicia, where IEO samples coastal sites and weekly different physical and biological variables with a coastal research vessel, and where there are monitoring programs from other institutions like the INTECMAR monitoring of HAB phytoplankton and environmental conditions and the Puertos del Estado buoys. Data services and portals allow us to distribute ocean data and present information and products for final users like aquaculture and the general public, but also for research users. Some examples will be presented on how combining in situ data with satellite data and hydrodynamical and particle tracking models can provide forecasts of transport of potential harmful species like HAB phytoplankton or Portuguese man o' war (Physalia physalis).

- The development and application of Individual-Based Models (IBMs) for early life stages of small pelagic fish. During the annual spring PELACUS surveys, data on anchovy and sardine egg concentrations are collected at the surface. Although PELACUS surveys focus on the acoustic assessment of small pelagic fish populations, they also gather extensive complementary information on the pelagic ecosystem, including physical and biogeochemical parameters and data on multiple trophic levels. The egg data produced are especially valuable for developing Individual-Based Models (IBMs) targeting the early life stages of small pelagic fish. After collection, the data are sent to the National Oceanographic Data Center (NODC), where they undergo quality control, secure storage, and formal curation. To comply with FAIR principles, they are converted into SeaDataNet CDI formats and enriched with standardized vocabularies. With storage in PostgreSQL and PostGIS, the data can be efficiently served through GeoServer using standard WFS and WMS services. Cataloging in GeoNetwork enhances discovery and visualization. The consistent application of standards enables automated systems to locate, interpret, and consume the data without custom coding. This greatly simplifies their integration into IBM workflows and supports the development of interannual IBM simulations to assess transport and survival of eggs and larvae of these small pelagic fish on the Galician NW Iberian shelf.

Parallel Session C1

Governance and Capacity for Ocean Knowledge

Abstract #7

Fr-OOS: Coordinating and Strengthening French Ocean Observing Efforts for Global Impact

Authors

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Presenting author

Fabrizio D'Ortenzio

Keywords

coordination, EOOS, EuroGOOS, GOOS, integrated ocean observing system

Abstract

The French Ocean Observing System (Fr-OOS) was established in 2023 to provide high-level coordination and strategic guidance for long-term ocean observation in France. It brings together the main French institutions involved in systematic marine observations from open sea to coastal areas, from the surface to the deep sea, and across disciplines ranging from physics to biology. Fr-OOS is built on a light governance structure composed of a Governing Board (GB), supported by an Executive Secretariat and the marine observation networks within the scope of Fr-OOS. The GB brings together the directors of the partner marine institutions and representatives from the relevant ministries (research, environment, and sea).

Fr-OOS objectives are to strengthen long-term ocean observation at global, regional, and coastal scales for research, climate and weather, sustainable ocean management, and operational oceanography, and to harmonize activities related to long-term ocean observation.

Fr-OOS organizes the interfaces between the national marine observation research infrastructures Argo-France (profiling floats), EMSO-France (deep-sea observation), ILICO (coastal observations), and a future open sea infrastructure (OHIS). It also interfaces with non-RI observation networks (e.g. meteorological, fisheries, and environmental monitoring), as well as with the French research vessel fleet, satellite observation programs, and ocean, weather, and climate modelling centers. Within the European Ocean Observing System (EOOS) framework, Fr-OOS serves as the national interface linking French initiatives with EuroGOOS, EMODnet, Copernicus Marine Service, EU-DTO, and the European Research Infrastructures landscape (ESFRI). Through these connections, Fr-OOS contributes to a coordinated European approach that ensures interoperability, data sharing, and sustained

operations. At the international level, Fr-OOS is fully aligned with the strategy and ocean observing coordination activities of the Global Ocean Observing System (GOOS).

This presentation will provide an updated overview of the French ocean observing landscape, highlighting how the national components contribute to the full value chain—from observation to modelling to applications and services—addressing both scientific and societal challenges. The Fr-OOS five-year strategy will also be outlined, emphasizing its role in reinforcing European integration, enhancing coordination between observation infrastructures, and promoting synergies with emerging technologies and data systems.

By fostering coherence between national, European, and international initiatives, Fr-OOS strengthens France’s contribution to global ocean knowledge, climate monitoring, and sustainable management of marine resources, contributing to the development of a fit-for-purpose and sustained ocean observing system.

Abstract #24

AQUARIUS: Strengthening Governance and Capacity for Ocean Knowledge through Integrated Research Infrastructure Access

Authors

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Presenting author

Aodhan Fitzgerald

Keywords

Capacity Building, Ocean Governance, Open Science, Research Infrastructures, Training Opportunities, Transnational Access

Abstract

AQUARIUS is a Horizon Europe-funded project (2024 – 2028) designed to transform ocean governance and knowledge capacity by providing transnational access to an unprecedented suite of 59 integrated research infrastructures. These include research vessels, mobile marine observation platforms, drones, satellites, fixed observatories, experimental facilities, and advanced data services. By connecting scientists and stakeholders across Europe, AQUARIUS supports the EU Mission “Restore Our Ocean and Waters by 2030”, the European Green Deal, the UN Decade of Ocean Science and contributes to the objectives of the Ocean Pact. AQUARIUS brings together 45 leading organisations from 18 countries, coordinated by the Marine Institute (Ireland). The consortium includes partners from major European Research Infrastructures such as EMSO ERIC, JERICO RI, EMBRC, Danubius-RI, EUFAR, Eurofleets and SeaDataNet as well as individual research organisations and universities. This diverse partnership ensures comprehensive expertise across marine and freshwater systems, enabling integrated approaches to research, governance, and innovation. The project addresses critical governance challenges by: • Launching two competitive Transnational Access Calls to foster collaborative research aligned with Mission Ocean objectives and Lighthouse Regions (Baltic/North Sea, Black Sea, Atlantic/Arctic, Mediterranean). • Facilitating Open Science and FAIR Data Practices to ensure transparent, interoperable knowledge systems. • Building capacity through targeted training for early-career researchers via internships, Floating Universities, and specialised courses on marine and freshwater themes. • Integrating diverse infrastructures to enable holistic approaches to ecosystem restoration, pollution reduction, and sustainable blue economy development. Expected Impacts: • Enhanced Governance and Policy Support: Better ocean knowledge

through harmonised data and integrated research infrastructure services resulting in improved decision-making. • Capacity Building: Strengthened skills and expertise among researchers and stakeholders, fostering a new generation of ocean professionals. • Accelerated Mission Ocean Goals: Direct contribution to pollution reduction, ecosystem restoration, and climate resilience in European waters. • Open Science Policy: Establishment of FAIR-compliant data management processes, promoting transparency and ensuring maximum benefit from acquired data. • Innovation for Blue Economy: Enabling research that supports sustainable marine industries and technological advancements. Upcoming Training Opportunities: AQUARIUS is committed to building capacity for ocean knowledge through a wide range of training programs for early-career scientists and technicians: • Marine & Freshwater Internships: Open to MSc, PhD students, post-docs, and technicians. Interns will gain hands-on experience working with international teams on AQUARIUS-funded projects and research infrastructures. • Floating Universities & Onboard Courses: Specialized training on research vessels and at partner facilities, focusing on marine observation technologies and data stewardship. • Summer Schools: Including the PLOCAN Glider Summer School, offering practical and theoretical training in marine glider technology. • Open Science & FAIR Data Training: Integrated into all programs to promote transparent and interoperable data practices. Applications for internships are accepted until February 2027, and training opportunities will run throughout the project timeline.

Abstract #58

Advancing Corporate Data Sharing for the European Leadership in Ocean Observing and Forecasting

Authors

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Presenting author

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Keywords

Blue Economy, Co-design, Data Sharing

Abstract

The Sustainable Blue Economy Partnership (SBEP) proposes an oral presentation to highlight the unified value of marine data sharing across science, policy and business. With the launch of the EU Ocean Pact at the 3rd UN Ocean Conference, the European Union has committed to ocean action. While ocean observation data builds the foundation of robust sciences and innovative solutions, surging amounts of data are currently being collected by marine-based industries in their pursuit of global competitiveness within the policy framework of climate neutrality, ocean health and biodiversity restoration.

To secure a decisive competitive advantage for the EU, mobilising corporate data wealth in conjunction with research and monitoring-driven collection will power the next generation of data-driven forecasting, modelling systems, and sustainable, profitable business solutions.

Despite apparent benefits for all stakeholders, corporate data sharing remains an exception. That is why “enhancing the integration and accessibility of priority datasets to inform sustainable and equitable economic decisions” with “the contribution of private sector entities to the data ecosystem” is a key milestone identified by the Ocean Decade for the achievement of a sustainable, resilient and equitable ocean economy. Furthermore, IOC Member States have committed to engage with the industry (IOC Decision A-33/3.4.2, July 2025) to unlock corporate data. Hurdles preventing the re-use of industry data range from data sensitivity, lack of standardization to limited awareness, and obstructing authorization processes.

As a contribution towards a coordinated, sustained and fit-for-purpose European Ocean Observing System under the EU Ocean Observation Initiative und the GOOS Vision 2030,

and in complementarity with the establishment of a European market for ocean observation technologies, SBEP aims at advancing corporate data sharing for sustainable communities across the European sea-basins and Atlantic front.

As a transboundary cooperation instrument between national ministries and research organisations, SBEP fosters the alignment of key ocean priorities to deliver impact-oriented R&I solutions. By mobilising its multi-stakeholder community of practice through this conference, SBEP aims 1) to engage the private sector with success stories, business incentives (e.g. optimization of operations, acceleration of permitting processes) and guidance on data-sharing; 2) to promote enabling frameworks and best practice (FAIR data, voluntary or mandatory sharing) 3) to explore innovative data-sharing models for a regenerative and sustainable blue economy. By building on existing mapping, co-design processes (e.g. Ocean Decade Corporate Data Group, Decade Coordination Office for Ocean Data Sharing, Regional Sea-Basin Organisations) and the implementation of a pilot in collaboration with EMODnet as an instrumental and trusted service for an operational marine knowledge value chain, SBEP aims at advancing corporate data sharing for sustainable ocean planning and management and towards the integration of public and private ocean observing systems.

Abstract #79

The Italian Integrated Ocean Observing System: Advancing a National System of Systems

Authors

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Keywords

governance, national system, observation

Abstract

A comprehensive understanding of the ocean—one of the Earth system's fundamental components—is essential for reducing human pressures on the environment and promoting the sustainable management of marine resources. Effective ocean governance relies on strong, coordinated observational capabilities able to deliver high-quality, interoperable, and openly accessible data. Over the past two decades, Italy has made significant investments in marine observing infrastructures, contributing to major European initiatives. However, the fragmentation of observational efforts and the absence of a unified national strategy have highlighted the need for coordinated action, a priority strongly emphasized by the Italian Oceanographic Commission, the national body of UNESCO's IOC. Responding to this need, in the framework of the National Recovery and Resilience Plan (PNRR), the ITINERIS project has supported Italy in promoting a comprehensive vision of the global ocean observing system as an interconnected network of research infrastructures, platforms, technologies, and data management systems. Within this framework, Italy has established the Italian Integrated Ocean Observing System (IT-IOOS), designed to provide data, tools, and expertise for environmental monitoring, operational activities and science studies. The IT-IOOS was developed by integrating, harmonizing, and strengthening research infrastructures, monitoring programs, and data services across the country. IT-IOOS brings together the Italian nodes of major European and national RIs—including EMSO, EuroArgo, DANUBIUS, ICOS, JERICO, eLTER, EUROFLEETS, and SIOS—along with nationally relevant facilities such as the Laboratori Nazionali del Sud, the research vessel R/V Laura Bassi, Gaia Blue, and the Italian environmental observing system GeoSciences-MER. Together, these infrastructures form the backbone of a unified national "system of systems" for marine observation and data access. A cornerstone of this integration is the National Marine Data store and portal, conceived as a federated system of geographically distributed Data Centres. Fully aligned with FAIR principles, the system ensures that marine data are

findable, accessible, interoperable, and reusable. It provides a seamless single-entry point to Italian marine data and supports pilot services tested in Virtual Research Environments to address emerging marine and environmental challenges. To reduce observational gaps, ITINERIS has expanded national monitoring capacity by improving the temporal and spatial coverage of Essential Ocean Variables, Essential Biodiversity Variables, and Essential Climate Variables. Observatory sites have been upgraded with innovative autonomous technologies—including drifters, gliders, and floats—while Italian research vessels have been equipped to collect near-real-time data along transects from coast to deep sea. The impact of the implementation of the IT-IOOS system was field-tested during ITINERIS' EYES an interdisciplinary research cruise, designed to investigate the health and predictability of Mediterranean planktonic ecosystems through multi-platform observations. Overall, IT-IOOS represents the first fully integrated national framework for ocean observation in Italy. By unifying data streams, enhancing observational capacities, and supporting cross-disciplinary cooperation. Through IT-IOOS, Italy will significantly enhance its long-term contribution to the Global Ocean Observing System (GOOS) and European Ocean Observing System other international initiatives.

Abstract #88

Towards educated probabilistic forecasting

Authors

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Presenting author

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Keywords

forecast-informed decision making, probabilistic forecasting, training forecasters

Abstract

In the Water Management Center of the Netherlands, forecasters operate daily to serve professionals and the public with high level information, including warning for storm surge at the Dutch coast. Decisions of crisis management authorities, such as whether or not to close a storm surge barrier, very much depend on these warnings. Forecasting surge or waterlevel is hardly ever taught at universities, and hydrologists need to establish their forecasting skills ‘on the job'. Using probabilistic model predictions requires even more knowledge. In addition to knowing your water system and your hydrological/ hydrodynamic model, you need to understand ensemble predictions and probabilistic reasoning. In recent years we investigated in procedures and tooling to bring the knowledge and expertise on ensemble predictions and forecast-informed decision making to a higher level: educating the knowledge base, train forecasting skills for extreme events and test their skills in forecasting tournaments. The first building block for a solid base are our masterclasses, given by senior experts on all relevant topics: • understanding the water system: tides, hydrodynamics, waves • understanding how it is modelled, and what are assumptions made in the modelling process • Understand the forecasting process and probabilistic forecasting • Understanding procedures and decision making based on probabilistic forecasts Of course, this is only useful if regularly trained and applied to real-time situations, and there we need to be creative as extreme events are rare, and it can take years until a forecaster can apply this knowledge. In 2025 we started a forecasting tournament, the WMCN-Open, to allow all forecasters to train their probabilistic forecasting skills. Firmly based on the “Superforecasting” approach forecasters make predictions about topics such as storm numbers, surge heights and timing of flood waves. In parallel, we are developing a tool to allow forecasters to make forecasts for storm surge events even if they are not on duty. This web-based tool will enable them to train their skills, also when not on duty, so that they can gain as much experience with extreme events as possible. Training our forecasters in dealing with probabilistic forecasts is essential to provide decision makers with high quality

information. It requires a fair bit of training and we are well on our way to design the required programme.

Parallel Session C2

Governance and Capacity for Ocean Knowledge

Abstract #99

The Synergy of Ocean Science and Global Ocean Governance: New Frontiers

Authors

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Keywords

BBNJ agreement, Ocean Decade, science-policy interface

Abstract

The dynamic interplay between ocean science and global ocean governance has never more critical. Recent transformative advancements in ocean science—such as the rise of digital twins, AI-powered biodiversity monitoring, autonomous observation systems and advanced remote sensing—and successful implementation of global ocean science initiatives fundamentally reshaping the mechanisms and ambitions of global governance paradigms by enabling more predictive and precise policies. Concurrently, the ambitious framework of the UN Decade of Ocean Science for Sustainable Development (2021-2030) has catalyzed the largest global coordination of ocean science efforts in history. The reverse is equally critical: evolving governance frameworks are now actively steering the direction and imperatives of scientific research.

A central pillar of this evolution is the deliberate strengthening of the science-policy interface. Ocean Decade-endorsed Actions are systematically generating essential public goods, including robust policy-support systems, standardized data frameworks, and innovative forecasting tools. These outputs empower policymakers with the evidence-based insights necessary for effective, adaptive, and transparent governance, from preventing and mitigating disaster, regulating deep-sea mining, facilitating sustainable fishing to designing Marine Protected Areas (MPAs), planning marine spaces and developing blue economy.

Furthermore, the Ocean Decade explicitly prioritizes equity and capacity building, with a strategic focus on Africa and Small Island Developing States (SIDS). By facilitating the transfer of low-cost technologies, enhancing local scientific capabilities, and co-designing solutions that address regional challenges like ocean acidification, extreme weather and sea-level rise, the initiative is ensuring that the benefits of advancing ocean science contribute to a more inclusive and equitable global ocean governance architecture. This synergy not only addresses current governance gaps but also paves the way for a sustainable and resilient future for the global ocean.

A prime example of governance driving science is the recent adoption of the agreement on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ Agreement). This landmark treaty, by establishing a legal framework for Marine Genetic Resources (MGRs) and mandating area-based management tools including Marine Protected Areas (MPAs) on the high seas, has created an urgent and unprecedented demand for new scientific knowledge. The BBNJ Agreement effectively mandates a new era of scientific exploration, compelling the global community to conduct baseline surveys in remote areas, assess the distribution and vulnerability of deep-sea ecosystems, and develop methodologies for environmental impact assessments in areas beyond national jurisdiction. It has transformed from a policy goal into a powerful catalyst for targeted, mission-driven ocean science.

Abstract #101

Advancing the Rolling Review of Requirements for ocean applications: Insights from a Structured Requirements Questionnaire

Authors

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Keywords

ocean applications, Requirements Questionnaire, Rolling Review of Requirements

Abstract

The ObsSea4Clim EU project aims to strengthen the Global Ocean Observing System (GOOS) and the Global Climate Observing System (GCOS) by developing guidelines for implementing the World Meteorological Organisations (WMO) Rolling Review of Requirements (RRR) process for emerging ocean and climate related Application Areas within ocean physics. In order to gather expert information from the ObsSea4Clim consortium, a dedicated Requirements Questionnaire has been designed considering guidance provided by both GOOS and the WMO, under whose authority the official RRR process is conducted. The RRR provides a systematic and transparent framework to support the design and evolution of the WMO Integrated Global Observing System (WIGOS) in alignment with its Vision for WIGOS in 2040. It compiles information on observational requirements, current observing system capabilities and key gaps in observing capacity by, and across, application areas, their cost-effectiveness, and draws on experts assessments and impact studies to identify priorities for closing gaps between requirements and capabilities, taking into account broader WMO priorities as well as those established by GOOS, GCOS and IOC. The Requirements Questionnaire developed in ObsSea4Clim supports the first step of the RRR process: the collection of user requirements in a technology-agnostic manner. It provides a standardized tool for identifying and defining observational requirements for different Application Areas. The concept of a WMO

Application Area describes a homogeneous activity for which it is possible to compile a consistent set of observational user requirements agreed upon by community experts working in this area. Within ObsSea4Clim, these “Application Areas” could be considered as Sub-Application Areas under the main WMO RRR Oceanic Climate Monitoring and Services Application Area (3.3), thereby enabling a more detailed specification of the observational requirements that support regional climate services, including those in Europe. ObsSea4Clim Sub-Application Areas also incorporate services that support the monitoring and analysis of extreme events. The questionnaire is organized into three components: (1) definition of the Sub-Application Area, (2) definition of the extent of the observational scope, and (3) formulation of the observational requirements through a structured Table of Requirements aligned with the WMO OSCAR requirements format. The questionnaire was answered by individual experts from the ObsSea4Clim consortium with the intention they may present a national perspective for the selection of subapplication areas worked up in the project. After internal development and testing within the project, the questionnaire will undergo external evaluation, with the longer-term objective of establishing it as a standardized tool for broader application of the RRR process to the ocean application area, including beyond the scope of ObsSea4Clim. By providing a clear, reproducible, and community-driven method for articulating user requirements, the ObsSea4Clim approach can directly support GOOS and WMO in strengthening the evidence base for future RRR cycles and in guiding the strategic evolution of the global ocean observing system.

Abstract #113

Brokering Industry–Science Partnerships for Transboundary Ocean Observing: Applications of the SO-SI Programme to Marine Spatial Planning

Authors

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Keywords

brokering, industry, marine spatial planning

Abstract

Marine Spatial Planning (MSP) relies on sustained access to high-quality, interoperable ocean data that can inform ecosystem-based management and cross-border coordination. Persistent gaps in in-situ meteorological, hydrographic, bathymetric and ocean health data continue to challenge the sustainable use of ocean resources, including MSP implementation, especially in regions where national monitoring capacities differ. The MEDSEAPLAN project , funded under the European Sustainable Blue Economy Partnership (SBEP) programme, offers a scalable model to close these gaps by engaging commercial vessels as data-collecting platforms.

The Smart Ocean – Smart Industries (SO-SI) programme of the World Ocean Council functions as a brokering system by aligning the interests and capabilities of diverse actors: shipping companies seeking operational efficiency and ESG compliance; marine technology providers developing automated observing systems; and research institutions requiring continuous, transboundary data flows to support ocean modelling and MSP evidence bases. Through coordinated brokerage, the programme facilitates the deployment of sensor packages, ferrybox systems, and opportunistic bathymetry instruments—producing datasets that inherently cross Exclusive Economic Zone (EEZ) boundaries and MSP regions.

This presentation demonstrates how brokering within SO-SI enhances transnational access to essential ocean variables and strengthens MSP processes across regional seas. Case studies include: (1) opportunistic bathymetry supporting seabed characterisation under the IHO S-100 framework; (2) surface-water quality observations from commercial vessels informing cumulative impact assessments; and (3) industry-collected MetOcean data improving maritime traffic planning and climate-resilience scenarios. These examples show

how coordinated brokerage reduces data inequality, harmonises standards across borders, and accelerates regional digital twin development.

SO-SI's brokered partnerships also integrate with European marine data infrastructures—including Copernicus Marine, EMODnet, and EuroGOOS ROOS networks—providing a pathway for industry-collected data to enter formal MSP and MSFD processes. By mediating technical, regulatory, and cybersecurity concerns, the programme creates a trusted environment for data sharing across sectors and jurisdictions.

Overall, coupling SO-SI's operational model with a brokering framework offers a powerful approach to strengthening transboundary cooperation in ocean observing and delivering the data required for adaptive, evidence-based Marine Spatial Planning.

Abstract #125

Towards a Co-Designed Inclusive Ocean Observing System across the Atlantic: The AtlantOS Vision

Authors

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Keywords

AMOC, Atlantic Ocean Observing System, Co-design, Data interoperability, ECOPs, Essential Ocean Variables, Inclusive ocean observation, Stakeholder engagement

Abstract

AtlantOS began as a European H2020 project aimed at enhancing coordination and integration in Atlantic Ocean observation. It has since evolved into a broader program, extending across the Atlantic basin and fostering international collaboration among observing networks, data systems, and diverse user communities. The initiative promotes a co-designed and inclusive approach, ensuring that observation strategies are scientifically robust, fit-for-purpose, and responsive to societal needs.

A core principle of AtlantOS is co-design, connecting experts in observing, modeling, and forecasting with key stakeholders and end-users. This approach fosters knowledge sharing, breaks down disciplinary silos, and enables the co-construction of tools, products, and services tailored to policy, climate adaptation, and ecosystem management. AtlantOS actively engages Early Career Ocean Professionals (ECOPs), ensuring that emerging scientists and practitioners contribute to the program's design, research activities, and stakeholder interactions, thereby strengthening capacity-building and fostering the next generation of ocean leaders. The program has recently achieved significant milestones, including significant contributions to AAORIA (All Atlantic Ocean Research and Innovation Alliance), strong engagement with industry partners, and the successful "AtlantOS Hour" webinar series, a widely attended forum for scientific exchange and stakeholder interaction. On the scientific front, AtlantOS' work on the Atlantic Meridional Overturning Circulation (AMOC) has provided new insights into large-scale ocean dynamics and climate variability.

This presentation will trace the different stages of AtlantOS' development, discuss the main challenges encountered, and highlight recent achievements and lessons learned.

AtlantOS also emphasizes FAIR data principles, interoperability, and digital infrastructures, supporting the development of a shared Atlantic Ocean Data Space and operational ocean

digital twins. Importantly, the program opens space for contributions from all Atlantic partners, promoting equitable participation and reflecting regional priorities.

By integrating scientific innovation, stakeholder engagement, early career involvement, and sustainable governance, AtlantOS provides a blueprint for a next-generation Atlantic Ocean observing system: co-designed, inclusive, interoperable, and capable of delivering actionable knowledge to support decision-making and long-term ocean sustainability.

Parallel Session C3

Monitoring & Understanding the Triple Planetary Crisis and Addressing Societal Needs

Abstract #5

Marine Geohazards and Blue Economy Resilience: Mapping and assessing submarine landslides, sediment instability, or seismic hazards to inform sustainable coastal infrastructure and ocean-based economic activities.

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Keywords

blue economy resilience., Marine geohazards, ocean observation, seabed instability, submarine landslides

Abstract

Marine geohazards, including submarine landslides, seabed instability, and earthquake-triggered ground movement, pose serious risks to coastal communities, infrastructure, and marine ecosystems. With growing investments in the blue economy such as offshore wind farms, oil and gas platforms, ports, and submarine cables, there is an increasing need to understand and manage these hazards. This study focuses on how geological investigations combined with ocean observation systems can help detect, map, and predict marine geohazards, reducing their impacts and supporting climate-resilient coastal development. The research integrates geological and geophysical methods, including bathymetric mapping, seismic reflection profiling, and sediment sampling, with ocean observation data such as currents, tides, temperature, and wave energy. By combining these datasets, it becomes possible to analyze how environmental and geological factors interact to influence seabed stability. For instance, changes in ocean currents or extreme weather events can increase sediment loading or trigger slope failures on the seabed. Understanding these processes helps identify vulnerable areas before major infrastructure is built or expanded. Preliminary findings show that regions with rapid sediment deposition, steep slopes, and active fault lines are particularly prone to submarine landslides. The interaction between sediment dynamics, ocean circulation, and tectonic forces often creates unstable seabed zones that can damage pipelines, disrupt seabed cables, and endanger marine habitats. These risks are expected to increase under climate change, as rising sea levels and stronger

storms intensify coastal erosion and sediment transport. Including marine geohazard assessments in coastal planning is therefore essential for safeguarding economic investments and ecosystems. Continuous ocean observing systems such as seabed sensors, autonomous underwater vehicles (AUVs), and satellite-based monitoring play a role in tracking environmental changes that may precede geohazard events. Real-time monitoring of oceanographic conditions and seabed deformation allows for early detection of instability, improving preparedness and response. Integrating these observations with geological models supports better forecasting and helps decision-makers adopt preventive measures, such as improved engineering designs or relocating vulnerable assets. This integrated approach bridges the gap between marine geology, oceanography, and socio-economic planning. It highlights the value of sustained ocean observations not only for science but also for public safety and economic resilience. By understanding the geological processes shaping the seafloor and their connection to ocean conditions, stakeholders can better plan and manage activities that depend on healthy and stable marine environments. The outcomes of this work support EuroGOOS's vision of strengthening the link between ocean observation and societal needs. It contributes to global efforts under the UN Decade of Ocean Science for Sustainable Development (2021–2030), promoting collaboration between scientists, policymakers, and industry. Ultimately, combining geological knowledge with advanced ocean observing technologies offers a path toward safer coastal zones, resilient infrastructure, and a sustainable blue economy that benefits both people and the planet.

Abstract #65

Enhancing Environmental Support Services for Aquaculture in Arousa Bay through Coastal Monitoring and Forecasting Solutions

Authors

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Presenting author

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Keywords

Co-designed services supporting aquaculture (mussel and cockles), Coastal Monitoring and forecasting, Early Warning Systems, Modelling, Operational oceanography

Abstract

Ria de Arousa (Galicia, Spain), is a hot spot in terms of aquaculture productivity, accounting for more than 2800 mussels' rafts (out of the 3600 Galician ones that accounts for 11% of world's production). Cockles are also harvested in shellfish banks in a semi-culture modality. Edible cockle (Cerastoderma edule) is both ecologically and economically important (harvests in the Ría reached in 2022 2,700 tons, generating revenues of €36 million). Furthermore, in the Ria, there are several environmentally protected areas (including National parks and EU Natura 2000 sites). The MOLL-e MALONE Service, developed by USC, CETMAR and NOW Systems, demonstrates how operational coastal monitoring and forecasting can support sustainable local aquaculture and protect coastal biodiversity. Through its User Service Platform, powered by NOW Systems' NAUI Aggregator Tool, it provides accessible met-ocean information and an Early Warning System for improved environmental management and data-driven decision making." Sedentary bivalves are highly vulnerable to abrupt shifts in water conditions—particularly to sudden extreme changes in salinity and temperature—often associated with severe weather events. Although cockles can tolerate brief periods of low salinity, prolonged exposure can induce physiological stress and even mortality. Heavy rainfall or sudden dam releases, when coinciding with certain tidal conditions, can significantly reduce salinity in the Ría, triggering mass mortality events. For mussels, water temperature is one of the primary factors governing both growth and mortality, being mussel mortality risks linked to marine heatwaves. To address these

challenges for local bivalve mariculture, and to support more resilient shellfish harvesting and aquaculture practices, two tailored MOLL-e modules were co-designed with Intecmar and CETMAR: i) a salinity-based indicator of cockle mortality risk for all the production zones, and ii) a module linking environmental variables—especially temperature—from forecasts and monitoring with near-real-time mussel growth data (provided by TransformAR Project), incorporating mussel welfare-based thresholds. These service tools enable data-driven decisions for shellfish gatherers and authorities, helping reduce potential economic losses. Additionally, research efforts are underway to improve coastal ocean models in the Ría. MeteGalicia is testing some downscaling updates that are expected to enhance their local forecasting system. Furthermore, within the framework of the AGORA Project, additional research on local coastal modelling is in progress, including the implementation of a new wave–current coupled system, with a wet–dry scheme, and the use as boundary condition of inputs from a new hydrological model for all the rivers discharging in the Ria. In the region, within the framework of the transboundary Galicia–Portugal WHISTLE Project, multiple model data sources—from Copernicus and national/regional forecasting services— have been integrated to support the Galician contingency plan (CAMGAL). To improve understanding of the performance and skill of these forecasts, a model intercomparison exercise has been carried out as a first step toward developing a new online, daily multi-model validation service. This service facilitates the assessment of ocean-model uncertainties in Galicia, particularly in the Ría de Arousa area.

Abstract #74

Test-casing the integration of plankton imaging and genomics data for biodiversity indicator assessments in the Southern North Sea

Authors

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Presenting author

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Keywords

eDNA, EOVs, MSFD, plankton indicators

Abstract

Planktonic organisms are the most abundant organisms in the oceans and are considered to be excellent indicators for environmental changes; they are the basis of the food web and, thus, ecosystem functioning. Changes in plankton diversity have been used extensively as an indicator of ecosystem health. Two of the Essential Ocean Variables (EOVs) (i.e., “Phytoplankton biomass and diversity” and “Zooplankton biomass and diversity”), as well as one Essential Climate Variable (ECV) (i.e., “Biological/Ecosystems: plankton”), are focusing on plankton. In addition, plankton is incorporated in the assessment of Marine Strategy Framework Directive (MSFD) Good Environmental Status (GES) (e.g. Descriptors 1, 2 and 5). Further, assessments of planktonic groups that perform similar functional roles, called “lifeforms”, are also used to evaluate GES under the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR). eDNA-based biodiversity observations are now being employed on a large scale, within coordinated networks at European level such as the European Marine Omics Biodiversity Observation Network (EMO BON). Despite eDNA-based observations currently not being used as data source for MSFD assessments, the coordinated nature of EMO BON offers great potential for their use for large-scale assessments. The aim of this study is to test-case EMO BON eDNA data against image-based observations to identify the similarities between the two methodological approaches and the potential for eDNA to serve as an input source for EOV assessments or MSFD indicators’ calculation. We used phyto- and zooplankton imaging data collected within

the scope of the VLIZ biodiversity observatory, which are already being used for MSFD reporting at national level. The considered time series consists of biodiversity data from seventeen stations which are monitored in the Belgian part of the North Sea (BPNS) on a monthly or seasonal basis (zooplankton: since 2014; phytoplankton: since 2017). Phytoplankton (55-300 um) was analysed with a FlowCAM, and zooplankton (>200 um) with a ZooScan. The identification of these images (zooplankton: order level; phytoplankton: genus level) was done using automatic image-recognition analysis, followed by manual validation. eDNA data was obtained from one EMO BON observatory in the BPNS where water samples are collected bi-monthly since 2021, filtered sequentially (0.2-3 um and 3-200 um) and sequenced using shotgun metagenomics. Part of the study's computational analyses will be conducted on the European Digital Twin Ocean (EDITO), and make use of tools (developed for the Demonstrator Use Cases of DTO-BioFlow project) facilitating the calculation of pelagic habitat indicators. This (proof of concept) study is a practical assessment of the suitability and validity of eDNA data for calculation of plankton based indicators and EOVs. It will provide insights on functional diversity in the Southern North Sea and showcase the potential of this approach to be replicated in other areas at European level, capitalising on the EMO BON network. The validity of the information deriving from both the eDNA and the imaging approaches will allow a better and holistic understanding of coastal biodiversity and its status.

Abstract #78

Past, present and future status of shallow reef ecosystems of Cyprus

Authors

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Keywords

biodiversity assessment, climate change, effective management, non-indigenous species, visual census

Abstract

Over the last decades the Eastern Mediterranean and Middle East have warmed significantly faster than other regions with the region's marine heatwaves (MHWs) increasing in duration and severity. Research on marine heat waves has shown that it is a driver for biodiversity loss, however they are not the only pressures. Bioinvasions, climate change, anthropogenic stressors, and marine pollutants like heavy metals and litter are amongst the threats. Understanding the impact on a local scale, effective management and policy are therefore required for the conservation of regional biota and its ecological functioning and services. PUREEF-Y project aims to assess the current status of shallow reef biodiversity, examine past status of intertidal reefs and through experiments study the effects of changing conditions on organisms to be used in forecasting the status of shallow reefs in this changing environment. Through the project, seasonal sampling of intertidal and subtidal communities at four sites (including 2 MPAs) will be carried out for two years. For the assessment of intertidal communities, abundance of macroalgae and benthic fauna species is quantified with a 50x50cm quadrat in-situ at both the edge and centre of vermetid reef. For the assessment of subtidal communities, visual census of fish abundances is performed and photoquadrats are collected for analysis of the benthic communities. Preliminary results for the intertidal macroalgae communities showed that there is a higher taxa diversity at the edge of the reef than the centre and higher diversity in the winter and spring seasons than in the summer. There is a strong presence of Non-Indigenous Species (NIS) in the intertidal zone, the most prominent being the dominance of Brachidontes pharaonis and, to a lesser extent, Isognomon bicolor species recognized as marine ecosystem engineers. In the subtidal communities, slightly higher species richness of native species was observed in the sites that were within MPAs. However, the ratio of native to non-native species doesn't appear to be affected between MPA or non-MPA areas between seasons. Overall, spatial and seasonal variation was present in the communities observed across our four sites.

Following the assessment of the current status of the shallow reef communities, incubation chamber experiments will be conducted to evaluate the metabolic rates of specific species and mesocosm experiments will be conducted to examine their response to different stressors. Data collected from these experiments will be used to forecast the responses and ecological state of shallow reef communities to changing environmental conditions and ultimately result in policy and effective management recommendations

Abstract #80

Advancing Microplastic Monitoring in Cyprus with Open-Access µFTIR Imaging

Authors

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Keywords

Eastern Mediterranean, Microplastics, Open-Access, µFTIR-FPA

Abstract

Microplastic (MP) pollution is increasingly recognised as a global environmental threat with major implications for aquatic ecosystems, food security, and human health. MPs, particles smaller than 5 mm, arise both from direct inputs (primary) and the fragmentation of larger debris (secondary), making them widespread and pervasive in marine systems. They can persist in the environment and accumulate across diverse habitats and matrices. Their long-term presence threatens organisms at multiple trophic levels, alters habitats, introduces physical hazards, and facilitates the transport of associated pollutants. The Mediterranean Sea, a semi-enclosed basin, subject to intense anthropogenic pressures, is particularly vulnerable to MP accumulation. Within this region, Cyprus constitutes a notable hotspot due to intensive tourism, rapid coastal development, limited water exchange and increasing UV radiation, all factors that favour microplastic accumulation and degradation posing increasing risks to marine ecosystems, fisheries, and the island's socioeconomic resilience. Despite rising concern, assessments of MP pollution in Cyprus remain limited. A central innovation to address the gap is the acquisition of the Bruker LUMOS II IMG µFTIR system equipped with a Focal Plane Array (FPA) detector. This advanced instrument enables full-filter imaging, high-resolution spectral mapping, and confident polymer identification, significantly enhancing analytical capabilities for MP research in Cyprus. Importantly, made possible through PLAST-IR project, the system will be made open-access, enabling broad collaboration across academic, industrial, and environmental stakeholders. Expressions of interest for the instrument reflect a diverse range of intended activities, including coastal and offshore environmental monitoring, validation of MP detection technologies, cross-method calibration, pollution mapping through geospatial analysis, environmental impact assessments, food-safety-related investigations, and experimental research on plastic degradation and bio-coatings. Additional proposed uses include professional and student training, demonstration projects, and the integration of µFTIR outputs into risk assessments and marine management frameworks. To launch the initiative, we aim to establish a robust

baseline of microplastic contamination in Cyprus' coastal environments through the PUREEF-Y project. Seasonal sampling has been undertaken during 2025 at four representative sites, including two Marine Protected Areas (Kryo Nero and Halavro). Sediment samples were collected using Van Veen grabs across three depth intervals (0-10, 10-20 and 20-30m), while Neuston nets was used for the collection of surface seawater. Laboratory preparation will include density separation, chemical digestion, and vacuum filtration onto aluminium oxide filters before analysis on the μFTIR. All performed under strict contamination-control procedures to ensure analytical reliability. The baseline dataset generated through PUREEF-Y, combined with the open-access capabilities of the LUMOS II μFTIR system, will strengthen marine pollution assessment in Cyprus and support evidence-based coastal management. Collectively, these activities demonstrate strong regional and international demand for an open-access μFTIR facility and highlight its potential as a shared scientific resource for Cyprus. This initiative will advance understanding of MP dynamics in semi-enclosed seas and promote informed environmental stewardship across the Mediterranean region and beyond.

Abstract #134

Bridging Gaps in Operational Oceanography: The SIPSEM Ecosystem and Innovation Through Neural Networks for Maritime Safety in Colombia

Authors

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Keywords

Operational Oceanography, Neural Networks, Hydrology, Maritime Safety, Information Systems.

Abstract

The Colombian General Maritime Directorate (Dimar), through the Caribbean Center for Oceanographic and Hydrographic Research (CIOH), has established the Integrated Forecasting System for Comprehensive Maritime Safety (SIPSEM). This operational ecosystem represents a structural advancement for the country, designed to close critical gaps in comprehensive maritime safety by integrating high-resolution numerical models and in-situ observational data.

SIPSEM integrates the latest-generation models, such as WRF for the atmospheric component, ROMS for the oceanic hydrodynamic component, and WAVEWATCH III/SWAN for ocean wave propagation. This architecture supports specialized products for Search and Rescue operations (Ocean Parcels) and oil spills (GNOME). However, the extreme variability in estuarine zones posed a challenge to traditional physical models, which cannot achieve the required accuracy for port efficiency.

As a success story and example of technical innovation, we present the development of a hydrological forecasting model for the access channel to the Port of Barranquilla (Bocas de Ceniza), at the mouth of the Magdalena River. Due to the complex nonlinear interaction between Andean River discharges, the Caribbean tidal regime, and density effects, an artificial intelligence-based solution was implemented using a Transformer-type neural network, which successfully captures hysteresis and seasonal fluctuations. It was trained and validated using historical river level series from upstream stations and local tide signals as input. The model demonstrates high predictive capability, with a correlation coefficient greater than 0.9, and enables a 12-day operational forecast horizon. Additionally, a current forecast is provided using the CROCO hydrodynamic model with a 3-day forecast horizon, capturing the dynamics relevant to maneuvering and navigation in the channel.

The combined availability of water level and current forecasts has a direct technical impact on decision-making, such as improving the estimation of hydraulic conditions in the channel, supporting the definition of safe navigation windows, and optimizing the management of operational draft in a port that handles 6.3% of the country's maritime cargo. This experience underscores the importance of moving toward hybrid operational services that integrate physical modeling with AI. These advances lay the technical groundwork for Colombia's future Integrated and Interoperable Ocean Information Ecosystem (EISOC) by 2042.

Parallel Session C4

Monitoring & Understanding the Triple Planetary Crisis and Addressing Societal Needs

Abstract #83

The Rolling Review of Requirements applied to Marine Heatwaves

Authors

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Keywords

capacity, marine heatwaves, requirements, uncertainty

Abstract

Prolonged periods of extreme warm ocean temperatures, known as marine heatwaves, cause wide-ranging impacts to ecosystems, ocean health and the Blue economy. In recent years, progress has been made in uncovering their characteristics, predictability and trends across the global ocean, with many operational monitoring and forecasting tools being developed based on this knowledge. However, our capacity to monitor and forecast these extreme events are still restricted by the availability of fit-for-purpose observations. To provide recommendations on how future integrated observing systems can fill these gaps, the Horizon Europe project “ObsSea4Clim” is applying the World Meteorological Organisation’s Rolling Review of Requirements (RRR) to new sub-application areas, including marine heatwaves. The RRR process compiles information about requirements for observations, the capabilities of the observing system, and their cost-effectiveness, drawing on experts and impact studies to guide the most important priorities for addressing the gaps between requirements and capabilities. Here, we present initial results and recommendations on many cutting-edge themes in marine heatwave monitoring addressed by the RRR: recommendations to EOV definitions and uncertainty requirements; the adequacy of monitoring in the coastal zone, where extremes are driven by complex and local-scale dynamics; progress in monitoring subsurface extremes; exploiting multiple observations to provide measures of uncertainty; and the provision of tools to provide user-relevant indicators.

Abstract #96

Rethinking marine temperature extremes under climate change: the CAREHeat project

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Keywords

impact studies, marine cold spells, marine heatwaves, satellite data

Abstract

Marine heatwaves (MHWs), periods of anomalous high seawater temperature, have been recognized in the last decade as one major threat to ecosystems and the associated services. These events are fuelled by the global warming trends, which makes them more frequent and intense, while, at the same time, marine cold spells (MCSs) are becoming rarer. Owing to the globally changing background, the definition of extreme becomes challenging, since most conceptual models assume stationarity and normality, conditions which do not necessarily verify in the real world. The objectives of the CAREHeat project, funded by the European Space Agency, are to advance our understanding of MHW detection and their impacts, by performing synergistic analysis of Earth observation data (satellite and in-situ), model-based outputs, and impact data (e.g., fisheries information) to increase our understanding of marine temperature extremes. In this contribution, we present our findings related to the sensitivity of MHW/MCS detection, illustrating how the choice of the dataset leads to major discrepancies in the early satellite era (the 1980s). This implies that the reference climatology, at least in observational studies, should be constructed by taking this into account. Furthermore, various detrending methods are inter-compared to better understand the ultimate effects on detection, with the result of an effective removal of the climate change signal, whose signature is uneven depending on the event severity. The availability of a vertically resolved dataset, obtained either from in situ or model data, also allows us to look into subsurface effects. Our discussion also touches upon the topic of compound events, whereby seawater anomalies occur together with other extreme conditions, such as high acidity events. We find that these events, albeit rarer, contribute to a substantial fraction of the air-sea carbon exchange, with strong modulation provided by tropical large-scale climate modes. Impact analysis carried out for the European seas are also presented, as we can demonstrate knock-on effects of MHWs on the ocean carbon cycle via the perturbation of the trophic chains, which can be quantified through robotic

platform biogeophysical measurements. On the other hand, confounding effects and lack of reliable data represents an obstacle towards the empirical assessment of the effects of seawater temperature extremes on fisheries.

Abstract #100

The Fantastic Baltic Four: A field sampling approach for four Biology and Ecosystem Essential Ocean Variables (EOVs)

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Keywords

3R principles, Essential Ocean Variables, FAIR data, integrative approach

Abstract

Environmental monitoring is, like ecosystems themselves, in change. The Baltic Sea Living Lab (BSLL), part of the EU Horizon project BioEcoOcean, develops integrated approaches for coastal monitoring to minimise the impacts on marine ecosystems, while ensuring scientifically robust ocean observations. The 3R principle (Replace, Reduce, Refine) guides these efforts, promoting methods that reduce disturbance, limit the number of organisms affected, and refine techniques for least-invasive monitoring. Around the island of Gotland, Sweden, the BSLL applies a multi-EOV (Essential Ocean Variable) framework to study biodiversity in a cost- and time-efficient manner. The BSLL focusses on four Biology and Ecosystem EOVs, referred to as the "Fantastic Baltic Four": 1) seagrass cover and composition, 2) macroalgal cover and composition, 3) fish abundance and distribution, and 4) benthic invertebrate abundance and distribution. Each EOV has a defined set of sub- and supporting variables with suggested observing approaches, platforms, and technologies, designed to capture status and trends of marine biodiversity in a standardised and comparable way. Our methodology prioritises least-invasive monitoring, including environmental DNA (eDNA), remote underwater video, drop cameras, surface observations, and Van Veen grabs. Standardised protocols are applied to maximise interoperability, and the resulting datasets will be shared through repositories such as the Ocean Biogeographic Information System (OBIS), in line with FAIR (Findable, Accessible, Interoperable, Reusable) principles. By combining multi-EOV observations with innovative technologies, the BSLL aims to support the production of species and habitat distribution maps, regional management, and contribute to global scientific assessments. By doing so, the BSLL contributes to international policy frameworks such as the UN Sustainable Development Goals (SDGs), with the larger goal to provide a comprehensive understanding of biodiversity patterns and their drivers in the central Baltic Sea.

Abstract #123

Prioritising Marine Debris Monitoring Using the Marine Plastics Debris Essential Ocean Variable

Authors

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Keywords

debris, integration, marine pollution, monitoring, plastics

Abstract

Anthropogenic marine debris, and particularly marine plastics, poses a growing threat to marine ecosystems, maritime activities, the well-being of ocean users, and to human health. Once at sea, these pollutants may persist and accumulate for decades and possibly centuries and be dispersed by physical processes such as ocean currents and winds, ultimately sinking to the seafloor or entering the food web. Achieving the ambitious SDG 14.1 goals of preventing and significantly reducing marine pollution critically requires harmonised global marine debris monitoring to obtain a better understanding of the sources, pathways, and fate of marine debris.

In this presentation we synthesise the global community efforts to prioritise marine debris monitoring using the newly developed Marine Plastics Debris Essential Ocean Variable (EOV) - the first in a new class of EOVs helping the Global Ocean Observing System (GOOS) address the need to monitor human impacts on the ocean. Furthermore, we invite feedback from the broad range of ocean observing and forecasting stakeholders to facilitate a fit-for-purpose delivery of information on marine debris and pollution.

The Marine Plastics Debris EOV specifies multi-scale measurements and recommended methods according to societal and scientific requirements. The proposed EOV sub-variables complement and expand the current set of global indicators of Sustainable Development Goals, in line with state-of-the-art guidelines for global monitoring of marine debris provided by the Group of Experts on Scientific Aspects of Marine Environmental Protection. Current observing capacity for measuring these variables as well as current multi-scale data management efforts are reviewed.

Development of Marine Plastics Debris EOV relies on the successful development of globally coordinated Integrated Marine Debris Observing System (IMDOS) which is being established

with support from GOOS, GEO Blue Planet and the UNEP Global Partnership on Plastic Pollution and Marine Litter, among others. IMDOS aims to support the building up, development and application of a globally, integrated observing system dedicated to marine debris with harmonised observing tools, approaches, and products that embracing the full complexity of marine litter composition, dynamics, distribution, and impacts. The synthesis of a variety of observations is thus required to provide long-term monitoring of anthropogenic marine debris and to support operational activities and strategic planning to mitigate impacts and to ensure the efficiency of policy implementation. IMDOS builds on the intelligent and dynamic integration of shoreline and at-sea in situ observations, remote sensing, and numerical modelling, thus further supporting gradual increase of readiness levels in Marine Plastics Debris EOV requirement setting, observing capacity and data management.

Abstract #131

Predicting the effects of climate change on a key sub-Arctic marine copepod across ecological and evolutionary timescales

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Keywords

arctic, climate change, zooplankton

Abstract

In the highly productive Lofoten-Vesterålen (LoVe) region of the Norwegian Sea, the herbivorous copepod Calanus finmarchicus forms a key link between primary producers and higher trophic levels. The ecological and socioeconomic values (e.g., harvesting of Calanus species for fish feed production) rendered by this species are sensitive to changes in the temperature, light, food and predation environments, which are shifting significantly due to anthropogenic climate change. To understand the cumulative impact of these environmental shifts on the behavior, life-history and population dynamics of C. finmarchicus, we developed a novel individual-based model with unprecedented biological detail – PASCal: Pan-Arctic Behavioral and Life-History Simulator for Calanus. PASCal has been executed on 3D environmental forcing extracted from a 30-year (1993-2023) Copernicus Ocean Physics and Biogeochemistry reanalysis timeseries. These simulations predict how the population size of C. finmarchicus in the LoVe region changed over time, and how these changes impact on the species' biomass and vertical carbon export, since the body size and generation time are sensitive to both bottom-up (food) and top-down (predation) environmental forcing. We emphasize the behavioral plasticity of C. finmarchicus in response to environmental shifts, such as the extent of diel vertical migrations and phenology of hibernation (diapause) and reproduction. Our findings broaden the understanding of the shorter- and longer-term adaptations of high-latitude copepods in rapidly changing environments. The ability of the model to forecast spatial distribution, abundance and biomass can facilitate and manage the ongoing Calanus harvesting operations in the LoVe region. Further, the spatio-temporal and taxonomic scalability of PASCal allows future eco-evolutionary predictions of lower trophic level organisms under scenarios like those from the IPCC Representative Concurrent Pathways throughout the Arctic.

Poster Presentations

Grouped by conference theme · ordered by abstract number within each theme

Theme 1: Innovation in Observations, Modelling, and Forecasting

Abstract #9

Micro-AUV Deployments in the Baltic Sea: Capabilities and Integration Into Coastal Observing Systems

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Presenting author

Taavi Liblik

Keywords

AUV, Baltic Sea, estuary, ocean front dynamics, ocean observing system, stratification, Submesoscale, upwelling

Abstract

Coastal areas of the Baltic Sea present observational challenges due to their strong spatial gradients, shallow depths, and rapidly changing conditions. To explore how a new platform might complement existing regional monitoring, we conducted the first multi-site evaluation of a micro-autonomous underwater vehicle (micro-AUV) in the eastern Baltic Sea. Eleven missions were carried out in 2025 in three contrasting settings — a shallow estuarine bay, a strait that acts as a meeting and modification zone for several water masses, and the coastal slope of the Baltic proper — covering depth ranges from roughly one meter to more than 100 m.

The vehicle performed reliably across these environments, collecting detailed profiles and transects that resolved fine-scale features, including a buoyant submesoscale intrusion, a dual upwelling structure along the coast, an estuarine frontal system, a high turbid benthic boundary layer, and other processes that are difficult to capture with traditional ship-based surveys or surface-only observing methods. Comparisons with independent reference measurements confirmed good accuracy for core hydrographic variables and consistent performance of the optical sensors. Its endurance and maneuverability supported efficient (sub)mesoscale mapping while enabling operations in shallow or constrained areas where gliders and profiling floats cannot be used.

These results indicate that micro-AUVs can usefully complement existing Baltic Sea observing components — such as research-vessel monitoring, moorings, floats, FerryBoxes, gliders, and remote sensing — by providing flexible, high-resolution water-column data in nearshore and transitional zones. While operational limits remain, particularly regarding endurance and communication range, the platform shows clear potential for targeted

surveys, adaptive sampling, and rapid deployments in support of integrated coastal observing systems.

Abstract #10

Ensemble forecasting for ocean physics and biogeochemistry in the North and Baltic Seas utilizing coupled data assimilation

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Keywords

biogeochemistry, data assimilation, ensemble forecasting

Abstract

An ensemble forecasting system for the ocean physics and biogeochemistry in the North Sea and Baltic Sea is developed based on the forecasting system of the CMEMS Monitoring and Forecasting Center for the Baltic Sea (BAL-MFC). The model system consists of the NEMO ocean model coupled to the biogeochemical model ERGOM including a carbonate module. The ensemble functionality is provided by the open-source Parallel Data Assimilation Framework (PDAF, https://pdaf.awi.de), which also provides data assimilation functionality to initialize the ensemble forecasts. Forecasts are calculated up to 21 days. We assess the influence of the application of ensemble Kalman filters on the model state with daily assimilation of satellite surface temperature and chlorophyll observations using an ensemble of 30 members. The data assimilation improves the forecasting skill with a stronger effect on the ocean physics than the biogeochemistry. In addition, the application of a nonlinear filter method is assessed. The nonlinear data assimilation yields improvements over the Kalman filter in the state estimates in particular for the simulated chlorophyll.

Abstract #12

The SeaCare Partnership Model for Advancing Research on Ocean and Human Health Using Ships of Opportunity

Authors

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Keywords

Ocean and Human Health, Partnership Model, Planetary Health, Sea Care Project, Ships of opportunity

Abstract

In the context of the United Nations Ocean Decade, it is imperative to collect a comprehensive array of oceanographic data, encompassing not only Essential Climate Variables (ECVs) but also chemical and biological contaminants. The process of ocean sampling is a complex undertaking that poses significant challenges. The necessity of an oceanographic vessel is an indispensable prerequisite for such endeavours; however, this also entails substantial financial costs. Moreover, the logistical intricacies inherent in each mission can be substantial. In a world where many vessels traverse the ocean daily, the utilisation of ships of opportunity as a way of mitigating costs while exploring even the most inaccessible regions is a compelling proposition. The concept of Health has evolved from the simple absence of disease in an individual, to the Health of an entire community (Public Health) and, more recently, has expanded to include animal and ecosystem health (One Health) and the concept of Planetary Health, a solutions-oriented, transdisciplinary field focused on analysing the impacts of human disruptions to Earth's natural systems on human health. This constitutes the foundation for the concept of Ocean and Human Health, a field of study that aims to examine the inextricable relationship between oceans and human health. This relationship extends from global climate regulation to the provision of water, oxygen, energy, and sustenance, as well as well-being. The Italian National Institute of Health (Istituto Superiore di Sanità, ISS) has entered into a memorandum of understanding with the Italian Navy (Marina Militare, MM) with the objective of exploiting Italian Navy vessels. These vessels are responsible for daily missions within the Mediterranean Sea and beyond, extending their reach to all the world's oceans from Cape Horn to the Arctic. This agreement is intended to serve as a model for institutional collaboration in accordance with UN SDG 17, which advocates pursuing other sustainable development goals, including 3, 6, 13, and 14. It

is evident that the utilisation of Navy vessels as ships of opportunity indubitably engenders logistical challenges. These ships vary considerably in their characteristics, ranging from sailing vessels to patrol vessels. The objective was to devise harmonised sampling protocols for the collection of surface and deep seawater samples, the measurement chemical-physical parameters using a multiparametric probe, and the execution of limited yet essential pre-treatment operations on board until the ship's return and the delivery of the samples to the laboratory. The Memorandum of Understanding permitted researchers from ISS and its scientific partners to be included on Navy ships for the purposes of conducting sampling missions, including long-term ones. The collaboration with the ship's crew, who provided technical expertise, was fundamental to the success of the activities. Seawater samples were collected for chemical and microbiological analysis to quantify pollutants and microbiological facies that could pose a threat to human health. The objective of this initiative is to propose a partnership model internationally to encourage other research institutes to seek collaborations with their national navies, which already possess fundamental resources needed to study the oceans

Abstract #14

Demonstration of Oil and Heavy metal sensors at the coast of Cyprus

Authors

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Keywords

Heavy metal sensor, Marine pollution, Monitoring technologies, Oil sensor

Abstract

The iMermaid project, Safeguarding the Mediterranean Sea from Contaminants of Emerging Concern, aims to advance innovative, smart solutions for the prevention, detection, and mitigation of emerging pollutants across the Mediterranean Sea basin. Contaminants of emerging concern (CoECs)—including pharmaceuticals, personal care products, industrial chemicals, and micro-pollutants—pose growing risks to marine ecosystems and human health, yet remain insufficiently monitored or regulated. Through a multi-country effort, iMermaid integrates advanced remediation and monitoring technologies tested across five representative use cases in Spain, Italy, Tunisia, Greece, and Cyprus. Each use case reflects distinct environmental pressures, enabling comprehensive assessment of technological performance and scalability. This collaborative framework strengthens regional capacity to safeguard marine resources and contributes to the development of sustainable, evidence-based environmental policies. The Cyprus use case constitutes a unique component of the project, as it is the only testbed implemented entirely in a marine environment. A metocean buoy, permanently stationed in the coastal zone of Limassol, provides an ideal setting to evaluate the resilience and functionality of the innovative monitoring systems under real marine conditions. Two advanced monitoring technologies were deployed, both requiring targeted adaptations to withstand salinity, instability caused by variable weather conditions and to integrate in the restricted area inside the buoy. Modifications included reinforced housing, anti-corrosion materials, and optimized power management to maintain stable performance during continuous exposure to sea elements. The oil-monitoring sensor was integrated into the buoy and subsequently also tested at two marinas (Larnaca Marina and St. Raphael Marina). The heavy-metal sensor, was similarly integrated in the buoy, requiring calibration adjustments to account for seawater conductivity that could interfere with measurements. These technologies can potentially allow continuous, real-time detection of contaminants that can act as an early warning system during acute pollution events and contribute to improved environmental management strategies. Both

monitoring systems achieved successful and sustained operation throughout their short deployment period, demonstrating the feasibility of real-time oil and heavy metal monitoring in dynamic marine environments. Detailed results—including sensor deployment, accuracy, stability, and long-term reliability will be presented. The outcomes of the Cyprus use case not only validate the technological adaptations implemented but also highlight the potential for broader deployment across the Mediterranean, reinforcing iMermaid's overarching mission to protect vulnerable marine ecosystems from contaminants of emerging concern.

Abstract #32

Portable Molecular Sensors as Proof-of-Concept for In Situ Biological Observations: Developments from the AquaBioSens Project

Authors

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Keywords

biological ocean observation, environmental RNA, molecular sensors

Abstract

The Horizon Europe AquaBioSens project develops portable devices to strengthen real-time biological observation across marine ecosystems. We present advances in eRNA-based quantification of microbial function in environmentally relevant and potentially hazardous species, and compact immunoassay platforms for rapid detection of biotoxins and organic contaminants. These technologies address key gaps in current observation systems by enabling rapid, sensitive, and field-deployable measurements that complement traditional sampling approaches. The prototype instruments are combined with a modular data pipeline that streams sensor outputs to a live visualization portal and supports integration with operational ocean observing frameworks. Together, these devices and the data pipeline serve as proof-of-concept for future fully in situ molecular sensing systems. Collectively, they demonstrate how molecular approaches can enrich biological data streams, improve temporal resolution, and pave the way for embedding molecular biology into next-generation ocean monitoring networks.

Abstract #37

Enhancing Operational Ocean Forecasting in the Rías Baixas Through a New Coupled Hydrodynamic–Biogeochemical MOHID System

Authors

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Keywords

biogeochemical modeling, coastal oceanography, MOHID, operational forecasting, Rías Baixas

Abstract

The Rías Baixas is a coastal region in northwestern Spain (Galicia), extending from Cape Fisterra to the Spain–Portugal border. From north to south, four main rías compose the system: Muros–Noia, Arousa, Pontevedra, and Vigo. Although each ría has its own characteristics, all are influenced by tidal forcing, wind dynamics, and river discharge. The region hosts valuable natural and economic resources, which are highly vulnerable to both natural and anthropogenic pressures. To support monitoring and operational forecasting, MeteoGalicia developed a high-resolution system based on the MOHID model more than a decade ago. The system provides daily forecasts of currents, temperature, and salinity for the Rías of Vigo, Arousa, and Muros–Noia, as well as the Ártabro region, with horizontal resolution of 300 m and between 25 and 34 vertical layers. MOHID is a three-dimensional numerical model based on a finite-volume, object-oriented architecture in FORTRAN, developed by MARETEC. It supports multi-scale and multi-system integration, allowing coupled simulations of estuaries, coastal zones, and watersheds, and has been widely used to simulate both physical and biogeochemical processes. Several studies have demonstrated MOHID's ability to reproduce the main observed circulation features in the Galician rías, including the Ría de Vigo (Taboada et al., 1998; Montero, 1999) the Ría de Pontevedra and other rías (Villareal et al., 2000). A new configuration has recently been implemented to simulate the entire Rías Baixas region within a single domain, enabling realistic interactions among the different rías. This domain has a 400 m horizontal resolution and 35 vertical layers. Additionally, a biogeochemical module has been incorporated to predict key variables affecting estuarine water quality. The first step was to calibrate this module. To accomplish

this, the model is forced at the open boundaries with biogeochemical fields from the Copernicus system, namely the concentrations of phytoplankton, oxygen, nutrients, fine sediments and dissolved and particulate organic matter. Calibration and validation were performed using satellite data, buoy time series from Observatorio Costeiro Xunta de Galicia, and Puertos del Estado, and CTD profiles collected by INTECMAR. The model runs in parallel mode (MPI) on the Galician Supercomputing Center (CESGA) using 64 processors. This work is part of a broader effort to strengthen a transboundary observation and prediction infrastructure for the western Iberian coast. Within this framework, an integrated ocean observatory has been established https://observatoriocosteiro.gal/.

Abstract #38

The Pasaia Ocean Autonomy Hub: Enhancing multiplatform approach through glider-based monitoring in the SE Bay of Biscay

Authors

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Keywords

acoustic data, Bay of Biscay, biogeochemical sensors, Glider-based monitoring, observational services, research infrastructure

Abstract

By incorporating two gliders and various marine autonomous systems (MAS) into the established EuskOOS-RI operational infrastructure, the Pasaia Ocean Autonomy (POA) hub is advancing the region's capacity for flexible and responsive data collection tailored to emerging research needs in the SE Bay of Biscay. Furthermore, POA is working towards providing external access to these advanced platforms and their associated services, facilitating collaborative opportunities for the wider European research community. In addition to physical and biogeochemical (BGC) sensors, echosounders installed on these autonomous platforms can complement the multidisciplinary observational efforts carried out in the area during yearly vessel-based traditional surveys. One of POA's first glider missions, conducted in November 2023, tracked the Adour River plume's westward spread over five days. BGC sensors revealed strong vertical gradients in key variables within the top 15 meters, highlighting the plume's impact. These observations, combined with HF radar and satellite data, provided valuable insights into the rapidly evolving plume dynamics and demonstrated the benefits of a multiplatform approach. Biogeochemical processes are fundamental to sustaining the marine trophic chain and the overall health of the ecosystem, making their monitoring a critical component of effective ocean management. Existing observatories in the Southeastern Bay of Biscay provide valuable long-term and high-frequency data on physical and BGC variables; however, gliders will help to fill significant observational and knowledge gaps, particularly in offshore and mesoscale environments. In addition, several missions using gliders equipped with echosounders have demonstrated the

added value of integrating acoustic data from autonomous platforms, as seen in the improved detection of juvenile European anchovy (Engraulis encrasicolus) and species such as mackerel (Scomber scombrus) during their migration. This offers a more detailed understanding of water column dynamics during key biological events. More specifically, the onshore movement detected by the echosounder during a storm event in the 2022 mission highlights the gliders' ability to capture fast and small-scale biological processes. Further evidence from a recent deployment, where a glider was equipped with an upward-facing echosounder for acoustic monitoring, revealed improved detection of juvenile European anchovy in the upper water column. Both examples illustrate how gliders can effectively overcome limitations associated with traditional vessel-based acoustic methods, enabling more accurate and timely observations of these vital biological components.

Abstract #43

The Italian Offshore Wave Buoy Network (ROCA): Advancing Marine Observation in the Mediterranean

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Keywords

climate change, wave buoys, wave measurements

Abstract

The Italian Offshore Wave Buoy Network, known as ROCA (Rete Ondametrica e Correndometrica d'Altura), represents a landmark in marine observation technology in the Mediterranean Sea. Established recently and detailed in this study, the network signifies a major progress in environmental monitoring capabilities, especially concerning climate change and marine ecosystem health. After seven months of continuous operation, preliminary data underscores the system's reliability and scientific importance. The ROCA system comprises eleven Fugro SEAWATCH® Wavescan® buoys, strategically deployed across Italian waters, from the Adriatic to the South Ionian, Tyrrhenian, and Ligurian Seas. Funded by the Marine Ecosystem Restoration (MER) project under the EU Next Generation initiative and overseen by ISPRA, the network aims to support ecological restoration, seabed mapping, and climate adaptation efforts. The buoys are equipped with advanced sensors capable of measuring a range of geophysical parameters: spectral significant wave height, peak period, and mean wave direction—crucial for understanding regional oceanographic conditions. They also record wave velocity profiles, air temperature, pressure, and wind speed, with real-time data transmitted via a redundant satellite communication system, ensuring continuous and secure data flow to a dedicated center. In addition to wave measurements, two buoys include seabed-mounted tsunami sensors installed solely for pioneering research purposes and not yet integrated into operational risk management systems, aiming to enhance scientific understanding and support future hazard monitoring in the Mediterranean. The data provided through these sensors and the ongoing geobathymetric mapping work under the MER project contribute to biodiversity preservation, marine habitat protection, and sustainable development activities like fishing and tourism. These efforts aim to foster a resilient "blue economy" aligned with global environmental goals. The network's strategic coverage addresses a critical gap in the understanding of Mediterranean currents and climate scenarios. The ROCA network enables detailed, reliable

data collection on the complex dynamics affecting Italian and Mediterranean waters—data that are invaluable for predictive models that currently lack precise current measurements. Validation against satellite and model data confirms the precision and operational robustness of the ROCA system. The integrated real-time geodata supports an array of applications, from climate research and habitat conservation to maritime safety and resource management. In conclusion, the Italian Offshore Wave Buoy Network embodies a significant technological and environmental achievement, exemplifying Italy's commitment to sustainable maritime development and climate resilience. It creates a comprehensive observation infrastructure capable of supporting foundational scientific research and informing policies to protect Italy's maritime and coastal ecosystems in the face of ongoing climate change. This innovative network not only enhances Italy's marine monitoring but also contributes significantly to the global efforts to monitor and adapt to marine environmental changes.

Abstract #44

An Innovative Autonomous Deep-Sea Observing Platform from Madeira Archipelago (Portugal): Local Research with Global Impact

Authors

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Presenting author

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Keywords

Autonomous platforms, AUVs/USVs, Deep-sea robotics, Ocean observing innovation, Operational oceanography

Abstract

The Madeira Archipelago remains one of the most observationally under-sampled regions of the Eastern North Atlantic Ocean, despite its ecological importance and strategic role within the European maritime space. To address longstanding gaps in deep-sea and coastal monitoring, the Oceanic Observatory of Madeira (OOM) — a research unit within the Regional Agency for the Development of Research, Technology and Innovation (ARDITI) — is leading a major regional investment in advanced ocean observing technologies. Supported by approximately €20 million in Recovery and Resilience Plan funding, OOM/ARDITI is implementing a modular ultra-deep ocean platform designed for research, monitoring, and technological validation across the full ocean depth, including operations beyond 6,000 metres. This new platform represents a significant step forward in deep-sea robotics, introducing a versatile architecture capable of integrating a wide range of autonomous systems. These include Autonomous Underwater Vehicles (AUVs) and Uncrewed Surface Vessels (USVs) equipped with multi-sensor payloads for bathymetric, acoustic, physical, and biogeochemical measurements. The system also incorporates Sub-Bottom Profilers (SBP), Side-Scan Sonars (SSS), and Ultra-HD imaging systems, enabling high-resolution mapping of seabed morphology, sub-surface structure, and habitat features. Additional tools, such as water-column samplers and environmental DNA (eDNA) technologies, enable detailed assessments of species composition and ecosystem dynamics across depth gradients. These assets, when combined, will provide a comprehensive, multi-platform approach to

deep-sea mapping and environmental monitoring, enabling data acquisition rates up to 50 times faster than those achieved by traditional survey methods. The platform will be deployed and tested within Madeira's Free Technology Zone, a dedicated maritime testbed. The infrastructure provides optimal conditions for validating new ocean technologies, supporting industrial prototypes, and enabling scientific missions. Its modular design promotes interoperability, scalability, and seamless integration with remote operations, enabling near real-time data transmission for scientific, environmental, and operational applications. To strengthen connectivity between coastal and deep-sea monitoring, OOM/ARDITI is integrating these new deep-sea assets with its existing coastal observations and regional forecasting tools (please consult "Products" section in the OOM website; https://oom.arditi.pt/). While not the main focus of this abstract, these established components provide valuable environmental context, support routine monitoring, and contribute to improved model-ready datasets across Madeira's marine domain. This initiative represents a significant advancement in deep-sea observing and multi-platform integration, enhancing Madeira's capacity to generate high-resolution environmental data across ocean domains that were previously inaccessible. The combination of autonomous platforms, multi-sensor payloads, and a modular deployment architecture strengthens the region's ability to characterise ocean processes, support model development, and validate forecasting tools in complex deep-sea environments. OOM/ARDITI's multidisciplinary team of oceanographers, engineers, data scientists, marine biologists and communication specialists ensures that the platform acts as a catalyst for regional innovation, fostering collaboration between research, industry, and policy sectors. By positioning Madeira as a testbed for next-generation ocean technologies, the initiative expands opportunities for international partnerships, technology validation, and capacity building across the Atlantic. This strategic investment strengthens Madeira's role within the European ocean observing community and accelerates the development of sustainable, technology-driven approaches to deep-sea exploration.

Abstract #45

A coastal monitoring and forecasting system for Galway Bay and Dublin Bay, Ireland – services for aquaculture, biodiversity restoration and environmental monitoring.

Authors

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Presenting author

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Keywords

aquaculture, biodiversity, downstream services, environmental monitoring., modelling, operational oceanography

Abstract

Ostrea edulis populations in Galway Bay have depleted significantly from their one-time substantial abundance due to a combination of factors. The episodes of low salinity or elevated water temperatures often lead to increased oyster mortality rates and subsequent economic loss for the farming sector. Dublin Bay, in turn, is adjacent to the biggest population agglomeration in Ireland, and is subjected to significant anthropogenic pressures. Access to real-time data and marine forecasts provided in an accessible, user-friendly and interactive way can be a significant aid to aquaculture farmers, environmentalists working on biodiversity restoration and institutions involved in water quality monitoring. This contribution will demonstrate a web service called NAUI, where real-time observational data, model forecasts and hindcasts and tailored products and services, co-developed with the end users, are provided. The modelling component of the service is based on very high-resolution coastal scale models based on ROMS, CROCO-PISCES and SWAN, downscaled sequentially from the global and regional models provided by the Copernicus Marine Service. The service includes marine conditions mapping, low salinity warnings, marine heatwaves monitoring and warning, and indicators of the rates of change of salinity during extreme events and offers a high degree of customization to the specific needs. This application constitutes an excellent example of the increasing efforts to extend the number of marine observations and forecasts available as actionable information to interested stakeholders. It is an innovative service co-developed with the stakeholders and paving the way for a highly impactful operational oceanographic services of tomorrow. We are planning an integration

with the European Digital Twin of the Ocean (DTO) since the service was selected as a coastal demonstrator in the Digital Ocean Forum 2024. Integrating into the European DTO would allow for a faster service and for an easy extension of the service to new geographical locations, enhancing its scalability and replicability.

Abstract #50

Atmospheric and oceanographic drivers in forecasting hotspots of Calanus patchiness – multi-year innovative and high-resolution approach

Authors

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Presenting author

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Keywords

Calanus patchiness, Meteorological forcing, Multi-year datasets

Abstract

Big data transforms ocean observing and forecasting systems by making ecological collections more comprehensive, analysis more powerful, and thus predictions more reliable. Mapping and forecasting the availability of Calanus spp. is particularly important because these copepods form an energetic foundation for higher trophic levels of many North Atlantic and Arctic planktivore animals. However, spatial distribution of zooplankton is highly patchy, with dense, short-lived aggregations that vary over hours and kilometers. To date, most studies have examined this patchiness primarily in relation to in situ hydrographic conditions including temperature, salinity, stratification, and chlorophyll a concentration. Yet for forecasting purposes it is important to consider all possible/available parameters including atmospheric forcing, because they can also rapidly alter the horizontal and vertical positioning of Calanus within the water column, thereby modulating its detectability and accessibility.

In this context, we analyse a unique, multi-year big data collection of high-resolution plankton and particles data obtained with Laser Optical Plankton Counter (LOPC) across repeated transects performed between 2010 and 2024 in the upper layer (0–50 m) of European Arctic waters. These observations were integrated with simultaneous CTD measurements as well as a comprehensive suite of meteorological variables, including wind speed and direction, wave height, atmospheric pressure, and solar radiation. Meteorological data were acquired from all available sources: i) the research vessel RV Oceania (IO PAN), which continuously records high-frequency atmospheric and sea-state parameters while crossing LOPC transects, ii) from coastal monitoring stations, and iii) from operational forecast products. Together, these complementary datasets allow for a detailed examination of how

atmospheric and oceanographic drivers interact to influence the structure and dynamics of zooplankton patches with a special focus on Calanus.

The primary objective of this work is to establish a methodological framework for evaluating how meteorological forcing shapes zooplankton patchiness across multiple spatial and temporal scales. To achieve this, all biological and physical datasets were harmonised, quality-controlled, and integrated into a R-based workflow, enabling consistent comparisons and robust analysis of driver-response relationships. This approach enables the identification of conditions under which aggregations are likely to intensify or weaken, providing insight into the physical mechanisms that structure surface zooplankton distribution patterns. Ultimately, our goal is to use these big datasets for predicting the occurrence, strength, and structure of Calanus patchiness under different weather conditions, supporting ecosystem monitoring, resource assessment, sustainable management, and thereby protection of valuable ocean resources.

Abstract #51

EasyOneArgo - delivering analysis-ready ocean data in the simplest way

Authors

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Keywords

ai ready, analysis ready, argo, quality control, salinity, temperature

Abstract

The Argo program delivers unprecedented global ocean observations, yet operational complexity — including multiple data modes, quality control flags, and metadata conventions — creates significant barriers to data uptake, particularly for non-specialist users and operational applications. The EasyOneArgo initiative transforms this paradigm by providing streamlined, analysis-ready Argo data products that eliminate technical overhead while preserving scientific rigor.

We present two operational products:
• EasyOneArgoTS delivers quality-filtered temperature-salinity profiles intelligently selected across real-time, adjusted, and delayed modes to maximize data quality and timeliness;
• EasyOneArgoTSLite provides vertically standardized profiles interpolated onto 102 pressure levels, enabling direct inter-profile comparison and statistical analysis. Each profile is distributed as a standalone CSV file with structured metadata and indexed for programmatic retrieval. Comparative analyses demonstrate substantial improvements in data accessibility and workflow efficiency compared to native Argo formats.

The methodology is actively being extended to biogeochemical variables through EasyOneArgoBGC and EasyOneArgoBGCLite products currently in development.

All EasyOneArgo datasets follow FAIR principles with monthly public releases on https://doi.org/10.17882/107233 and structured community feedback mechanisms.

EasyOneArgo represents a paradigmatic shift toward user-centric ocean data delivery: eliminating flags and documentation barriers to provide clean, structured datasets ready for immediate integration into research and AI workflows, operational systems, and uncertainty quantification frameworks.

This approach directly supports EuroGOOS objectives of enhancing ocean observation value chains and broadening the user base for sustained ocean observing systems.

Abstract #55

Novel Autonomous Lab-On-Chip Sensors for Monitoring the Ocean's Inorganic Carbon Cycle.

Authors

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Presenting author

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Keywords

autonomy, carbon, sensors

Abstract

High quality carbonate chemistry observations are essential to constrain oceanic carbon budgets and monitor ocean acidification and its consequences on marine organisms. Although efforts have been made to increase the availability of high-resolution carbonate chemistry measurements in the ocean, the lack of automated, high-performance low-cost carbonate sensors continues to hinder sustained and spatially extensive observations using autonomous platforms. Developing sensors capable of meeting future observing goals is therefore key for addressing knowledge gaps and uncertainties in our understanding of the global ocean carbon cycle and optimisation of global models of ocean acidification and its impacts. The capability of Lab-On-a-Chip (LOC)-based sensors has been demonstrated on moving and fixed observing platforms around the globe from surface to the deep ocean (6000 m). LOC technology enables miniaturization and automation of high-performance reagent-based analytical techniques offering high-quality autonomous observations even on small autonomous platforms. Here we present recent developments in autonomous LOC-based sensors for measurements of seawater pH, Total Alkalinity (TA) and Dissolved Inorganic Carbon (DIC), highlighting recent applications and offering a glimpse into the future of ocean carbon observing capabilities.

Abstract #56

Phytoplankton community diversity and Ecosystem function from Sentinels (Phytodiverse ESA project)

Authors

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Presenting author

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Keywords

Biodiversity indicators, Hyperspectral satellites, Phytoplankton, Remote sensing

Abstract

PHYTODIVERSE aims to develop an end-to-end workflow for producing phytoplankton indicators to support targets under the Convention on Biological Diversity (CBD). The project advances algorithms to derive phytoplankton community diversity using current satellite missions (Sentinel-2/3) and the upcoming hyperspectral NASA PACE and ESA CHIME missions. These algorithms, together with ecosystem-function Essential Biodiversity Variables (EBVs), will be used to investigate how phytoplankton communities respond to both gradual and extreme climate-driven processes across three science case studies: the North Atlantic, the Adriatic Sea, and the Arctic.

To support algorithm development and validation, PHYTODIVERSE is assembling the most comprehensive collated dataset of biological and hyperspectral bio-optical observations to date. New hyperspectral diversity algorithms will be tested and refined using these datasets, while ecosystem-level functional variables—such as phenology—will be applied to different phytoplankton groups. Additionally, species distribution models will complement satellite assessments, enabling evaluation of trends, extremes, and indicators of ecosystem sensitivity or resilience.

By integrating advanced remote-sensing capabilities with in situ observations and modelling, PHYTODIVERSE will deliver innovative biodiversity indicators and provide critical insights into phytoplankton dynamics under changing environmental conditions. Contributions of additional datasets are welcomed to enhance this growing resource.

Abstract #93

Development of a coupled hydrodynamic-biogeochemical model system for the Gulf of Finland

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Presenting author

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Keywords

Baltic Sea, biogeochemistry, coastal, ocean modelling

Abstract

Circulation plays a key role in shaping the marine environment in coastal areas, both by transporting nutrients and harmful substances and by regulating connectivity between regions. Accurate knowledge of these circulation patterns is therefore essential for assessing the impacts of human activities and climate change. Numerical models provide a powerful framework for simulating dynamics of complex coastal environments, enabling detailed analysis of hydrodynamic and biogeochemical processes across multiple spatial and temporal scales. However, in areas with dense archipelagos and irregular coastlines, such as the northern part of the Baltic Sea, capturing near-shore dynamics requires high-resolution models.

Our earlier work has demonstrated that the Nucleus for European Modelling of the Ocean (NEMO) ocean model is able to simulate circulation patterns and transport dynamics in complex coastal areas (Westerlund et al. 2019, doi.org/10.1080/16000870.2019.1627149; Miettunen et al. 2024, doi.org/10.5194/os-20-69-2024). Here we update our high-resolution NEMO setup covering the Gulf of Finland, and couple it to the Ecological Regional Ocean Model (ERGOM, Neumann et al. 2022, doi.org/10.5194/gmd-15-8473-2022), enabling us to simulate nutrient dynamics, pollutant dispersion, and ecosystem responses. Ultimately this will provide a more comprehensive representation of coastal processes, allowing us to support enhanced risk assessment and informed decision-making within complex coastal environments.

We will present the ongoing development of the model system and demonstrate its capabilities in simulating the biogeochemical processes in the Gulf of Finland. We will also discuss the challenges in implementing the model system for this coastal region and give an overview of our future plans.

This work is supported by CoWup project (Coastal waters under pressure – safeguarding a healthy Gulf of Finland in a changing political and environmental landscape), funded by the Strategic Research Council of Finland (grant no. 365488).

Abstract #94

Low-cost GNSS buoy makes ocean observation affordable

Authors

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Presenting author

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Keywords

buoy, GNSS, low-cost, observation

Abstract

Ocean wave observation is of vital significance in itself. With the great support of the UN Ocean Decade “Ocean to climate Seamless Forecasting system (OSF)” Programme, we have made key technical breakthroughs of buoy hardware design and data processing, including low-cost GNSS single-station real-time high-precision online speed measurement and positioning, real-time online inversion of multiple elements such as wave elements and water vapor content, wide-spectrum expansion and capture of wave spectrum, multi-element coding return and control integrated with Beidou Regional Short Message Communication (RSMC), optimization of low-power and high-performance algorithms, miniaturization of buoys and wave-following optimization, etc. The progress listed above has vastly improved the inversion accuracy, avoided the cost of precision differential correction services, and reduced the communication burden. With these progresses, we developed a new GNSS global ocean surface drifting buoy directly based on the free signals of GNSS satellites, which is able to accurately obtain 10 parameters, i.e., horizontal space position, time, wave height, period, wave direction, surface velocity, flow direction, surface sea temperature, surface sea salinity, atmospheric water vapor content. So far, more than ten field observation experiments have been carried out, and several comparisons have been implemented with current common observation equipment. The results show that the precision of this new buoy is on a par with that of the commonly-used wave-measuring equipment such as the "Waverider", with only cm-level difference, while the observation cost is reduced by leaps and bounds.

Abstract #108

Met-ocean Moored Data Buoy Network in Croatia, Achievements and Perspectives

Authors

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Presenting author

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Keywords

Adriatic Sea, climate monitoring, data buoy network, maritime traffic

Abstract

Croatian Meteorological and Hydrological Service (DHMZ) is the national marine meteorological authority. In 2022, DHMZ deployed a network of five met-ocean data buoys (DB) in the Adriatic Sea, positioned within Croatian territorial waters between the open sea and internal waters. The network provides real-time, high-precision measurements to support maritime safety and long-term monitoring of the Adriatic Sea climate. DHMZ has also established cooperation with the Marine Institute of Rovinj, and together they operate two additional met-ocean data buoys under the same program. All data buoys transmit their measurements in real time via GSM and IRIDIUM, and each buoy broadcasts AIS AtoN (Aids to Navigation) metro-hydrographic messages for nearby vessels. The buoys measure essential oceanographic variables (EOVs) relevant to meteorology, physical oceanography, and marine biochemistry. Where possible, they conduct vertical profiling of the water column down to 150 m. These observations support cross-disciplinary studies of the Adriatic Sea. Network data are used for observational comparisons in marine climate extremes monitoring, including analyses that compare coastal sea-surface temperatures (SST) with offshore met-ocean conditions. This approach helped diagnose marine heatwaves in July 2024. DHMZ is planning further cooperation with EUMETSAT to improve the calibration of satellite-derived products—such as sea surface brightness and chlorophyll-a concentration—using DHMZ's buoy measurements.

Abstract #110

Putting new wine into old wineskins: The Paradigm of the Seagider, UVP6, Continuous Plankton Recorder, and the satellite data that can connect them.

Authors

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Keywords

CPR, glider, zooplankton

Abstract

The ClinBlu-Feed project investigates the potential of low-trophic marine organisms as sustainable raw materials for aquafeed and other high-value bioproducts, while minimisng bycatch and increasing the availability of responsibly sourced blue food. Central to this effort is Calanus finmarchicus, a lipid-rich copepod of major ecological and commercial interest in the North Atlantic. Its seasonal dynamics, patchiness, and vertical behaviour require observational strategies capable of resolving fine-scale biological features across broad spatial and temporal scales. To address this challenge, the project integrates autonomous in-situ observation systems, space-borne ocean-colour remote sensing, and simulation modelling to detect and predict C. finmarchicus distribution patterns. Over the last decade, multiple studies have explored the feasibility of retrieving zooplankton information from satellite observations using water-colour products, machine-learning approaches, and empirical relationships with chlorophyll-a, temperature, and particulate backscatter. Recent efforts, including those by McCarry et al. (2023), demonstrate promising results by applying RGB-based classification metrics and time-series modelling to infer C. finmarchicus presence from satellite platforms s. However, the accuracy of such approaches remains constrained by the limited availability of high-resolution, co-located in-situ zooplankton observations. To overcome these limitations, we present the implementation of the Underwater Vision Profiler (UPV6-LP) integrated onto a Seaglider platform. This configuration enables continuous, non-invasive imaging of particles and mesozooplankton from the surface to 1,000 m depth, providing high-frequency measurements of organism size spectra, biovolume, and vertical distribution. The UPV6–Seaglider system generates detailed three-dimensional maps of C. finmarchicus layers, diel vertical migration, and aggregation patterns that cannot be resolved by ship-based sampling alone. These observations form a

critical component of algorithm training datasets for remote-sensing products. Complementary to this, Continuous Plankton Recorder (CPR) transects provide long-term, basin-scale information on C. finmarchicus abundance, phenology, and biogeographic shifts. CPR data serve as a robust validation and calibration resource, bridging the spatial scales between autonomous sampling and satellite imagery. By combining CPR time series with glider-borne UPV6 observations, we aim to refine satellite-derived proxies for zooplankton abundance, improve supervised learning models, and establish a pipeline for near-real-time estimation of C. finmarchicus distribution.

Abstract #117

MedJICARP – Initiative for a Joint Operational Oceanography Platform for Climate Resilience in the Eastern Mediterranean

Authors

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Presenting author

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Keywords

capacity building, climate change, data integration, forecasting, Mediterranean Sea, observational networks, operational oceanography

Abstract

The Mediterranean Sea is warming about 20% faster than the global average, with increasing sea-surface temperatures, marine heatwaves, shifts in biodiversity, and socio-economic pressure on coastal zones, already affecting sectors such as fisheries and tourism. The eastern Mediterranean in particular, is a hotspot of rising seawater temperatures, and therefore, countries in this region are in urgent need of increased climate resilience and adaptation capacity. As warming accelerates, it is expected that the frequency and intensity of extreme events, such as storm surges, erosion, and Mediterranean hurricanes ("Medicanes"), will increase. Furthermore, many coastal areas are vulnerable to maritime safety incidents and marine pollution.

To respond to scientific and societal challenges in the Mediterranean, effective and coordinated monitoring and forecasting systems are crucial for the region. The Mediterranean Joint Initiative for Climate Adaptation and Risk Prevention project (MedJICARP), funded under the Interreg NEXT MED programme, aims to address this need by establishing a cross-regional, multi-platform observing system that will include High-Frequency Radars (HFRs) and in-situ sensors such as FerryBox, buoys, drifters, tide gauges, and more. The need for setting-up cost-effective observing systems in the eastern Mediterranean is evident given the fact that there is a clear north-south and west-east unbalance of monitoring capabilities. Given that climate change adaptation is a key challenge for the area, a multi-level, multi-sector, participatory, and cross-border approach is urgently

needed, and it is expected to enhance the capacity of eastern Mediterranean countries to jointly deploy solutions and drive innovation for climate change adaptation, risk prevention, and disaster resilience.

MedJICARP brings together universities, research centres, governmental bodies and stakeholders, aiming to deliver a step-change in operational oceanographic services for the Eastern Mediterranean. Lead partner is the Oceanography Centre of the University of Cyprus, and partners include the Cyprus Marine and Maritime Institute (CMMI), the Hellenic Centre of Marine Research (HCMR), the University of Malta, ISPRA, University of Palermo, CNRS Lebanon, NIOF, and INSTM. Moreover, MedJICARP's stakeholder engagement, including governmental agencies and coastal communities, will ensure that the knowledge and services generated from the project respond to societal needs and policy frameworks. Through training workshops, summer schools, and overall dissemination activities, the project will strengthen regional capacity for climate adaptation and risk prevention across the region.

We will present the current status of the ocean observing system in the Eastern Mediterranean, and how this project has identified and begun addressing key needs to date. Progress on implementation and plans for the assessment phase will be described, as well as use cases and their impacts on society and policy for the system in the future.

By bridging operational oceanography and climate resilience under a shared regional framework, MedJICARP exemplifies a practical, collaborative approach to advancing the European ocean observing system and supporting societies facing the cumulative impacts of climate change.

Theme 2: Digital Transformation, Integration, and Data Quality

Abstract #16

EMODnet Physics state of art and future goals

Authors

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Presenting author

Antonio Novellino

Keywords

FAIR, marine data, operational oceanography

Abstract

The European Marine Observation and Data Network (EMODnet) is a long-term European Marine Knowledge initiative designed to enhance the discovery, accessibility, and usability of marine data and derived products and to play a central role in supporting the objectives of the European Green Deal and the development of the European Digital Twin Ocean. Its mission is rooted in providing free, harmonized, and interoperable marine data, ensuring robust support for environmental management, scientific research, and sustainable blue-economy growth across Europe. EMODnet Physics (www.emodnet-physics.eu) is one of the network's core thematic services. The project has matured through successive development phases, and continuously evaluates and enhances how its data services meet the needs of diverse user communities, including industry, public authorities, and the scientific sector. EMODnet Physics operates and maintains backend services enabling access to near real-time and historical time-series measurements of Europe's seas and oceans. Its data portfolio spans an extensive range of physical ocean parameters—temperature, salinity, currents, sea level, waves, wind, turbidity, underwater noise, river discharge, and sea-ice coverage—collected from a wide variety of fixed and mobile observing platforms. These include moorings, tide gauges, HF radars, ARGO floats, drifting buoys, gliders, ferryboxes, and repeated hydrographic surveys, resulting in a wealth of aggregated in situ datasets, reanalyses, and model-based products. Designed around a federated architecture, EMODnet Physics integrates data from major European and international marine observation infrastructures. It builds upon the heritage of the Global Ocean Observing System (GOOS) and EuroGOOS, embracing the principle of "collect once, use many times." Strong partnerships ensure streamlined operational data flows, particularly with the Copernicus Marine Environment Monitoring Service (CMEMS) In Situ Thematic Assembly Centre, SeaDataNet's network of National Oceanographic Data Centers, the International Council for the Exploration of the Sea (ICES), OceanOPS, and several specialized repositories. The platform now catalogs extensive holdings, including tens of thousands of ARGO and drifting-buoy records, thousands of moorings, tide gauges, river stations, unmanned vehicles, HF

radars, and millions of CTD profiles. Initial workflows for ingesting citizen-science contributions have also been established. This paper presents the state of the art of EMODnet Physics and its approach, reflecting the commitment of investigators, technicians, seafarers, and data managers whose contributions ensure the quality, continuity, and usability of marine observations. EMODnet serves as a showcase of Europe's capacity for ocean monitoring and knowledge generation, supporting both present and future societal needs.

Abstract #17

Deploying Beacon data lakes for high performance harmonised ocean data access - In Blue-Cloud and beyond

Authors

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Presenting author

Robin Kooyman

Keywords

data access, data lake, FAIR, software, technology

Abstract

In order to provide users and machines (models and applications) with fast and easy access to multidisciplinary data originating from large collections in Near Real Time and delayed mode, MARIS has developed a software system called Beacon that can, on the fly with high performance, extract specific data based on the user's request. This software has been customised and deployed in the Blue-Cloud2026 project and several other European and National projects and is designed to return one single harmonised file as output, regardless of whether the input contains different data types. In January 2025, Beacon 1.0.0 was made publicly available as an open-source software, allowing everyone to set-up their own Beacon 'node' to enhance the access to their data or use existing Beacon nodes from well-known data infrastructures such as Euro-Argo or the World Ocean Database for fast and easy access to harmonized data subsets. Recent updates include: The development of a "Beacon Studio" - a generic user interface on top of the API for less technical people; S3 Cloud Storage Support (AWS, MinIO, R2, etc…); Native Support for reading from ARCO formats (Parquet, Zarr, Beacon Binary Format); SQL query support; Even more performance improvements also supporting dynamic chunking of large files. More technical details, example applications, Github link, and general information on Beacon can be found on the website https://beacon.maris.nl/.

Within the context of Blue-Cloud2026, Beacon has been deployed to provide access to harmonised subsets from Blue Data Infrastructures for researcher groups that aim to generate harmonised and validated data collections of Essential Ocean Variables (EOVs). To this end a set of Infrastructure-specificBeacon nodes (monolithic) were set-up for relevant data collections such as the WOD, CMEMS Cora, Euro-Argo, SeaDataNet and more that are easily accessible via notebooks in a Virtual Research Environment.

Going one step further, the output from multiple monolithic Beacon instances are combined into one merged Beacon node for each research group demonstrating true data federation. Work is ongoing for a structural mapping from each monolithic Beacon to the target Common Metadata Profile as defined by the researchers. These mappings will be used in the Beacon queries to retrieve and load contents ‘as-is’ from monolithic Beacon instances into the merged Beacon instances, giving a common structure for variables, units, values, quality flags, and common metadata profile fields. The structured metadata and data will be supplemented by additional metadata data as available for each of the monolithic Beacon instances.

This presentation will cover an introduction of the Blue-Cloud 2026 project results, explaining how Beacon can practically serve as data lakes for many (VRE) applications and how it is extendable to other domains like the EuroGOOS NRT data domain. Also the latest improvements on the Beacon studio will be shared. By using examples from application cases, the reduction in time and effort spent for the data providers to publish, and researchers to collect the data, are highlighted.

Abstract #20

Framework for the assessment of evolving ocean forecasts

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Keywords

Assessment framework, Evolving forecasts, Ocean forecast verification

Abstract

The landscape of ocean forecasting is quickly changing with machine learning systems increasing in number and sophistication. These models are based on neural networks which minimize a loss function, typically the mean squared error between the prediction and the original target. Operational verification of ocean forecast has been heavily relying on error statistics estimated from matchup forecast and observations and are now being used for machine learning products. Unsurprisingly, the physic-based forecasts are outperformed by data-based models build on minimizing the metrics used for verification. Verification with metrics beyond error statistics between prediction and observations would make comparing data- and physics- based forecasts fairer. Beyond statistical comparison of ocean observations with their equivalent model fields, a large variety of assessment have been and can be considered. A classification of the different techniques and what aspect of the model performance they address is needed to guide the evaluation of how current and future ocean forecast perform and improve. This will help evolve operational assessments and will serve both ocean data producers and users. Planning the assessment of future ocean forecasting systems needs to consider ensemble forecasts. Ensembles are actively being developed for physic-based systems, and it is reasonable to think that in the future most types of forecasts will have an ensemble version. There are many metrics, variables, processes, visualisation that can be used to evaluate ocean forecasts. Here we organise and compare several assessments to build a framework of what we think the evaluation of future ocean forecast could look like.

Abstract #42

Utilising Deep Learning to Estimate the Abundance of Marine Debris

Authors

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Presenting author

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Keywords

AI, Marine debris, video footage

Abstract

Plastic debris in the marine environment constitutes one of the most severe environmental issues. Fathoming the scale and geographical distribution of marine plastic debris can help formulate more effective monitoring and mitigation strategies. Herein, we present smart image classifiers drawing on deep learning (DL) tools able to discern and count plastic marine litter and a fish species in still images and video footage. One of the smart methods, developed from using the YOLACT++ tool, when applied to images depicting plastic litter from 6 beaches in Cyprus predicted a plastic litter density of 0.035 items/m2. Scaled to the entire shorelines of the island, the intelligent method estimated about 66,000 plastic articles weighing a total of one metric tonne. Furthermore, the YOLO family of deep learning algorithms in conjunction with the region of interest line and the centroid tracking counting methods, were able to count marine litter and fish captured in video recordings. Results have showed that, with a counting accuracy of 79%, the centroid tracking method proved efficient thanks to its ability to trace the geometric centre of the bounding box of detected marine litter. Concluding, the YOLOv5 image classifier achieved a real-time object detection of 34 frames per second (FPS) when processing video footage, rendering it suitable for scanning large, littered areas in a short period of time.

Abstract #53

Automating the Ocean Data Processing Pipelines: A Modern Approach for Autonomous Platforms

Authors

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Presenting author

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Keywords

Argo, FAIR, machine-readable, metadata

Abstract

The rapid expansion of autonomous ocean observing platforms has created an urgent need for modern, scalable, and fully integrated data-processing systems. At the British Oceanographic Data Centre (BODC), significant progress has been made in modernising both data and metadata workflows, with the Argo programme serving as a benchmark for high-quality, interoperable ocean data management. Argo's long-standing commitment to robust quality control, standardisation, and technological innovation provides a powerful model that can be extended to other observational data systems and platforms such as gliders, moorings, and underway systems.

A key barrier to seamless data integration across autonomous platforms remains the inconsistent and non-standardised metadata delivered by manufacturers. Vendor metadata commonly varies in structure, terminology, and completeness—making manual validation at Data Assembly Centres (DAC) time-consuming, error-prone, and difficult to scale. In response, the Argo community has initiated a collaborative effort with manufacturers, data managers, and users to establish a standardised metadata framework in the form of a unified JSON schema for floats, platforms, and sensors.

Building on this community framework, BODC has developed the Argo Metadata Validator, an automated software tool designed to check the consistency and completeness of metadata against the NVS-based Argo JSON schema. This tool enables fully automated metadata validation and ingestion into DAC databases and processing pipelines. The result is an end-to-end improvement in data quality, workflow efficiency, and compliance with FAIR data principles. Automated validation reduces human errors, accelerates processing, and enhances traceability throughout the data lifecycle.

Crucially, the validator's modular and schema-driven design makes it adaptable beyond Argo. BODC is now extending this approach to additional autonomous platforms—including

gliders and other observational systems—supporting EuroGOOS priorities for digital transformation, cross-platform integration, and consistent, high-quality data delivery. This work demonstrates how collaborative standardisation efforts and modern software solutions can strengthen the interoperability and resilience of the European ocean observing system.

Abstract #67

Integrating Novel Sensors into Autonomous Platforms: Improving Automation, Interoperability, and FAIR Data Management

Authors

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Presenting author

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Keywords

automation, integration, Ocean gliders, sensors

Abstract

The use of autonomous platforms is drastically increasing as technologies advance and science works towards achieving Net Zero. Autonomous platforms are recognised as a key tool for achieving this goal and are now an established commodity in multidisciplinary oceanographic research. They are credited for their ability to access locations, inaccessible by large research vessels due to remoteness or seasonal constraints. We are now seeing an increase in the use of novel sensors, developed to collect data previously only available by traditional ship-based observations.

The British Oceanographic Data Centre (BODC), part of the Digital Science Division at the UK's National Oceanography Centre (NOC), provides data management services for autonomous platforms by supporting deployments in near-real time, recovery (i.e. full resolution), and delayed mode. Data processing has a strong focus on metadata, applying controlled vocabularies from the NERC Vocabulary Server, and utilising a Semantic Sensor Network (SSN) database to register sensors and platforms. There are multiple data dissemination pathways across the platforms with data contributing to the Global Ocean Observing System (GOOS).

The Accelerated Adoption of Sensor Innovation (AASI) integration programme comprises of three projects (SixSense, MASCOT and ASIMOV) which have each developed a new sensor for deployment on ocean glider and Autosub Long Range (ALR) platforms. BODC is working to adapt existing workflows to include data from these new sensors to ensure that we continue to provide resilient data management systems that are operational all year round.

To compliment this integration, new and existing tools are also being developed and extended across NOC under AASI to accommodate these new sensors and the increase in

autonomous platform deployments. This includes the development of a new Scientist Application which aims to provide scientists with a ‘one stop shop’ to track their deployments and help make operational decisions during missions, and the expansion of the BODC Metadata Portal to reduce duplication and further automation of end-to-end systems across NOC.

This poster will focus on the new workflows and tools BODC has developed under this project, demonstrating how we are integrating novel sensors into data management whilst ensuring that data are FAIR and working towards automated end-to-end systems.

Abstract #70

Activating Europe's Marine Biodiversity Data for the Digital Twin of the Ocean: The DTO-BioFlow Approach

Authors

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Presenting author

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Keywords

Biodiversity, data, digital twins

Abstract

The Ocean and its biodiversity are essential to life. Protecting and restoring biodiversity is one objective of the Horizon Europe Mission: Restore our Ocean and Waters, supporting the ambitions of the EU Green Deal, the EU Biodiversity 2030 Strategy and underpinning the objectives of the Ocean Pact. Identified as one of the Mission "enablers", the EU Digital Twin of the Ocean (DTO) will integrate observations, models and advanced digital infrastructures to explore "what-if" scenarios, inform evidence-based policy, and deliver societal benefits.

Central to this ambition is a functioning, robust biodiversity component that integrates sustained, quality biodiversity data streams. Despite myriad actors collecting biodiversity data and the development of novel cost-effective monitoring technologies, much marine biodiversity data remains inaccessible, unusable or effectively "dormant".

The Horizon Europe-funded DTO-BioFlow project is changing this. Since September 2023, DTO-BioFlow has been working to increase the volume, quality, and societal relevance of marine biodiversity data in European data and research infrastructures and the EU DTO through:

- Creating sustained data flows from existing monitoring networks to EMODnet and the EU DTO; - Building capacity among data providers through training, access to resources and financial support; - Developing Demonstrator Use-Cases (DUCs) that address real-world marine environmental management challenges; - Mobilising the community to share and use marine biodiversity data and digital resources through outreach and engagement;

To date, the project has conducted a landscape analysis, producing an inventory of unavailable data and prioritising them to identify initial targets for data mobilisation efforts, while evaluating the impact of the missing data. A first version of a “Barriers Playbook” is now available, identifying the most challenging barriers to enabling data to flow into the pathways developed within DTO-BioFlow. Two successful Data Calls to data holders were launched resulting in 18 projects awarded with grants. These enable the ingestion of previously inaccessible biodiversity data and the development of sustained flows into the EU DTO through data publication in EMODnet. A dataflow Blueprint was produced specifying data flows for several novel biodiversity data types, captured using different techniques and instruments, which do not yet have established dataflows to long-term data repositories; these include data from genomics observations, plankton imaging observations, fish, mammal and bird biologging, cetacean passive acoustic observations, and other relevant biodiversity data sources. Pipelines for data delivery to EMODnet are ongoing, with direct connections to the EU DTO underway for key European-level repositories to be completed by early 2027, including the European Tracking Network (ETN), Ocean Biodiversity Information System (OBIS), and EcoTaxa. These new data sources also contribute to the DUCs, which demonstrate how real-world marine challenges can be addressed in digital environments, with examples ranging from invasive species management to the impact of offshore renewable energy to food web modelling.

DTO-BioFlow is already generating valuable lessons and best practices for activating biodiversity data flows, fostering interoperability, and integrating biological information into digital twin frameworks. These insights - together with all project outputs, tools and resources - will be openly shared, ensuring long-term usability, transparency and impact.

Abstract #119

Standards and Practices for Digital Twins of the Ocean

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Presenting author

Sigmund Kluckner

Keywords

Digital Twins of the Ocean, Interoperability, Practices, Standards

Abstract

Digital Twins of the Ocean (DTOs) leverage advances in computing and data storage to improve ocean research and management through enhanced simulations, monitoring, and predictions. DTOs are an emerging field, with diverse approaches resulting in unique implementations.

Standardization and best practices enable interoperability and comparability across DTO systems, connecting data storage, models, simulation tools, and user interfaces from different domains. This enables the creation of a trusted ecosystem with consistency, accuracy, and reliability while still allowing proprietary innovation. Common data formats, protocols, metadata standards, and vocabularies reduce redundancy, minimize integration costs, and promote scalability. DTOs can then incorporate more variables or complex interactions without sacrificing quality, remain adaptable to new technologies, and support transparency and reproducibility.

Clear standards prevent fragmented efforts and accelerate global DTO adoption, improving decision-making for environmental and societal resilience. Defined practices streamline processes and ensure interoperability across technical and human layers, including:

• Architectures • Data storage and computing infrastructure • Sensor data • Syntactics and semantics • Legal and ethical considerations • User experience, design, and visualization

Defined or standardized frameworks shorten implementation timelines and improve communication among engineers and stakeholders. Shared taxonomies reduce misunderstandings and ensure comparable processes across projects.

The EU-funded Iliad project aimed to integrate localized DTOs for sectors like aquaculture, oil spill, offshore wind, or citizen science. Each pilot combines domain-specific engineering with digital systems practices (e.g., data lakes, OGC APIs). The Iliad Consortium documented these in a “compendium,” offering an overview of existing standards and practices. Newly developed practices and standards within Iliad and other DTO projects like

EDITO are encouraged to be documented and shared with the broader digital twin and ocean research communities, for example on the Ocean Best Practices System OBPS or in professional societies like IEEE Oceanic Engineering Society.

Mature practices, i.e. practices that have been well documented and widely used may evolve into formal standards through recognized organizations. The IEEE Working Group on “Recommended Practice for the Development of Digital Twins of the Earth” (P3501) aims to provide guidance for interoperable environmental digital twins, including DTOs. This includes reference architectures, subsystem interfaces, and related data and service models describing functions, outputs, and integration points.

Standards and best practices are essential for DTO development, ensuring interoperability, scalability, and trust. Initiatives like IEEE P3501 exemplify efforts to align practices globally, accelerating innovation and supporting resilient ocean management.

Abstract #124

ARCFISH – Digital Twin of the Ocean for Arctic Fisheries

Authors

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Keywords

Arctic fisheries, data products and services, Digital Twin of the Ocean

Abstract

ARCFISH (Digital Twin of the Ocean for Arctic Fisheries) is a project funded by the Sustainable Blue Economy Partnership (SBEP) program through five national funding agencies in Europe. ARCFISH develops a pilot Digital Twin of the Ocean (DTO) to support the Blue Economy by way of sustainable fisheries in the Arctic, focusing on two key regions: (1) Western Greenland, centred around Disko Bay, and (2) region around Iceland, northwards to the Svalbard archipelago and the Barents Sea. In the Arctic, sustainable fisheries are crucial for long-term ecosystem and community resilience. Traditional commercial activities have had negative impacts such as overfishing, pollution, habitat destruction, and climate change have adversely affected ocean health, resulting in declining fish stocks and loss of biodiversity. ARCFISH addresses these challenges by delivering new digital data products and services to support evidence-based fisheries management. These data products and services are co-designed with stakeholders in the fisheries sector and used to create products that can be applied in fisheries planning and management. The project will map available data sources, identify critical gaps, and ingest relevant datasets and derived products into the Blue Insight DTO platform developed by Kongsberg Discovery. Based on stakeholder needs, use cases for sustainable fisheries are implemented using the ingested data and tools for generating customised products. The use cases address two geographic regions, the west coast of Greenland centred around the rich fishing grounds surrounding Disko Bay, and the region around Iceland, northwards to the Svalbard archipelago and the Barents Sea. For example, in Disko Bay, ecosystem indices include spatial maps of zooplankton, benthos, shrimp biomass, and upwelling areas. Fisheries and fleet data from Iceland to the Barents Sea could be integrated into the DTO. Potential new services include advanced eLogbooks and spatiotemporal pattern detection and visualization, leveraging digital technologies for cost-efficiency. Using the compiled data and developed tools, a regional database of climate, environmental, and fisheries data will be

created and made available through an open data repository to support sustainable Arctic Fisheries. The Blue Insight Platform will be part of the Digital Twins of the Ocean (DITTO) program of the UN Decade of Ocean Science for Sustainable Development. As part of DITTO and through engagement with other running Digital Twin projects and initiatives, ARCFISH development will follow standards for data exchange and implementation of services and tools in the EU DTO. ARCFISH will also prepare training material for using the Blue Insight DTO and organise capacity building events for stakeholders and other users.

Theme 3: Co-Design, Engagement, and Inclusivity

Abstract #18

Cost-Effective Approaches to closing Coastal and Marine Observation Gaps

Authors

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Keywords

coastal, Cost-effective, FAIR, sensors

Abstract

Traditional coastal and marine monitoring methods are often costly and resource-intensive. To make observations more affordable and accessible, the global initiative 'Solutions for Cost-effective Ocean Observation Platform (SCOOP) was created. SCOOP connects developers of cost-effective devices with data managers, data collectors and users (scientists, researchers, citizen scientist) to foster collaboration and enhance the collection and sharing of marine data. SCOOP is an open-access web-platform that provides a comprehensive catalogue of low-cost sensors and emerging technologies, supported by documentation and expert guidance to help users optimize data collection and management. The initiative promotes FAIR (Findability, Accessibility, Interoperability, Reusability) principles to ensure seamless integration into global marine data infrastructures. SCOOP was endorsed by the UN Decade of Ocean Science for Sustainable Development in 2024 and is supported by developments in several European and global initiatives, including EMODnet, JERICO, GOOS, Synchro, CoastPredict, and the EU-funded LandSeaLot project (2024 – 2028). LandSeaLot aims to significantly reduce observation gaps in the land-sea interface, with a focus on river deltas. By integrating in situ, modelling, and Earth Observation data, the project connects key communities and initiatives such as Copernicus, ESA, EEA, GEOSS, EMODnet, and the European Digital Twin of the Ocean. Key activities include enhancing observation capabilities, reducing discrepancies between models and observations, and improving data integration across sensors, satellites, and models. A central element of LandSeaLot is the deployment of low-cost sensors guided by citizen scientists, including through the TransEurope Marinas network. These sensors are tested in LandSeaLot Integration Labs (LILs) located across diverse European coastal regions. The LILs support improved monitoring techniques that provide data relevant to societal challenges such as carbon fluxes, plastic transport, nutrient loading, eutrophication, biodiversity conservation, and climate adaptation. To ensure international data interoperability and FAIR compliance, LandSeaLot evaluates deployment protocols, as well as data and metadata models, working closely with developers for adjustments at the source. With input from cost-effective sensor

developers, users and data managers, and with LandSeaLot results, SCOOP will be further implemented to promote and democratize the use of cost-effective sensors and technologies in ocean observation and beyond.

Abstract #22

Collecting Practices and Methods in Marine Citizen Science for Increased, Shared Impact

Authors

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Presenting author

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Keywords

marine citizen science, methods, practices

Abstract

Marine Citizen Science (MCS) is a research approach which engages the public in the production of marine scientific knowledge. It supports the collection of valuable data through accessible ocean observing and monitoring methods for non-scientists, contributing to the better understanding of our ocean. However, the diversity and fragmentation of MCS methods and practices create a challenge for interoperability, scalability, and data uptake.

New global evidence from the marine citizen science initiatives (MARCSI) inventory documents 1,300 past and present marine citizen-science initiatives across all marine zones and scales, providing a robust baseline for practice design and uptake. This corpus counters persistent myths: more than half of initiatives run longer than five years, and 50 exceed three decades, with origins as early as 1876 (Wehn et al., 2025 [1]). The topical focus is led by single-species work (40%), followed by biodiversity (20%), pollution (14%), and ecology (11%). Almost half of the initiatives include an offshore component, challenging the idea that MCS is primarily onshore. The main bottleneck to integration in operational observing and modelling remains data management: among non-closed datasets, only 18% provide open raw data, 20% partial access, just 2% expose persistent identifiers, and only ten initiatives demonstrate transparent semantic interoperability, with two meeting strict FAIR compliance across all four principles. Practical implications are therefore explicit: plan for FAIR at design time; link observed properties to standard vocabularies; publish machine-readable metadata with persistent identifiers (PIDs); adopt clear open licences; and use existing inventories for discovery, benchmarking and to reduce duplication. These steps significantly enhance the reusability and acceptance of MCS streams in ocean observing and decision-support contexts.

The Ocean Best Practices System (OBPS) [2] comprises technological solutions and community approaches to enhance management of methods and support the development of best practices. The OBPS includes a persistent document repository, a peer-reviewed journal research topic, and training in the creation and use of practices. OBPS offers a space to MCS initiatives to collect and gather best practices, methods and guidelines through a dedicated community on the platform, jointly with the European Citizen Science Association, covering various themes and regions. OBPS also provides document templates for citizen science practice descriptions, to support format and content harmonization. To foster its role in MCS, the OBPS will host methods and practices collected in the framework of Horizon Europe project CS-MACH1 [3], which brings together MCS stakeholders, including practitioners, researchers, and technology developers, and supports them in mutual learning and information sharing.

This poster highlights successful examples of MCS practices in enhancing the effectiveness, replicability, and credibility of MCS to contribute to ocean observation. MCS has the potential to revolutionize ocean observations and maximize scientific, societal and policy impact. Embedding practices and methods into MCS projects early on is one of the keys to reach this potential.

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Abstract #29

Surfer Scientists: A Co-Designed, Community-Driven Model Democratising Nearshore Ocean Observations Across Portugal, France, Brazil, Sri Lanka and Indonesia.

Authors

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Presenting author

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Keywords

Citizen science, Co-design, Community dashboards, Nearshore observations, Ocean literacy, Youth empowerment

Abstract

Nearshore coastal zones—where people live, work, surf, and depend on marine resources—remain among the least observed environments worldwide. Yet coasts are changing faster than ever before in human history. This lack of high-resolution, accessible data constrains climate preparedness, ecosystem management, and coastal resilience, particularly in areas where traditional monitoring infrastructure is sparse or unevenly distributed. Surfer Scientists is an innovative, community-driven initiative that leverages surf culture, youth engagement, and low-barrier tools to democratise coastal observations across diverse socio-economic and geographical settings, including Portugal, France, Brazil, Sri Lanka, and Indonesia. What distinguishes Surfer Scientists is its transcontinental co-design process. Surfers, youth groups, tech designers, researchers, government representatives, and industry partners across multiple continents have contributed to shaping a model rooted in local needs, cultural relevance, and shared environmental purpose. This approach ensures that the programme is not "delivered to" communities, but created with them, strengthening trust, ownership, and long-term engagement. Surfer Scientists transforms surfers—often the first to observe changes in beach morphology, wave conditions, pollution, and coastal ecosystems—into trained citizen scientists generating nearshore data that are both locally meaningful and globally useful. Through hands-on coastal missions, participatory science activities, and skill-building modules, young people collect observations related to water quality, plastic debris, beach profiles, and shoreline change. The methodology emphasises scientific literacy, capacity development, and environmental agency, equipping youth to contribute

meaningfully to marine knowledge services. A key innovation is the Surfer Scientists Community Dashboard, a lightweight digital platform capable of operating in low-connectivity and resource-limited environments. The dashboard visualises community-generated data, surf club activity, and environmental change in near-real time, enabling local stakeholders—schools, NGOs, community leaders, and local governments—to understand coastal conditions and co-develop responses. By grounding environmental monitoring in passion, identity, and place, Surfer Scientists lowers barriers to participation and expands who contributes to ocean observing. The initiative has shown particular promise in communities with limited formal access to marine science, offering new pathways into ocean literacy, environmental stewardship, and local leadership. This presentation will share the co-design methodology, insights from pilots in Portugal, France, Brazil, Sri Lanka, and Indonesia, and early developments of the community dashboard. It will highlight how collaborative, culturally resonant approaches can expand the reach of ocean observing systems, enhance coastal resilience, and meaningfully involve youth and underrepresented communities in the future of marine knowledge services. Surfer Scientists demonstrates that democratising ocean observations is not only feasible, but joyful, scalable, and deeply human.

Abstract #49

Bridging Divers, Citizens and Science: A remote crowdsourcing platform for 3D reconstruction of underwater environments

Authors

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Keywords

3D reconstruction, crowdsourcing platform, photomosaics, Underwater Cultural and Natural Heritage (UCNH), underwater imaging, VR environment

Abstract

Documenting and understanding underwater environments are essential for marine ecosystem monitoring, ocean literacy and the preservation and protection of Underwater Cultural and Natural Heritage (UCNH). However, challenges such as limited accessibility, high operational costs, and the technical complexity of underwater imaging often prevent broad participation. This work presents i-ScubaDiving (www.i-scubadiving.iti.gr), a free remote crowdsourcing platform developed through a funded research project that has reached Technology Readiness Level (TRL) 7. This platform enables users to contribute visual data (videos and photos) captured with even action underwater cameras and support the creation of photomosaics, 3D representations of UCNH sites, also offering "dry" diving experiences in a virtual reality (VR) environment. The platform integrates advanced underwater image-processing pipelines, including feature-based stitching and quality enhancement, to overcome light absorption, scattering, and turbidity. These processed images or videos feed into a remote 3D reconstruction service that produces accurate digital models of underwater environments. Users can then view and explore these 3D models through an interactive GIS-based map, enabling site-specific visualization and facilitating wider access to underwater observations. They will further be able to work with this content through a dedicated self-service tool enabling them to create VR environments. A key innovation of the platform is its design, allowing users to upload imagery (videos and photos), receive feedback on data quality, and actively contribute to expanding the available visual record of UCNH sites. Early pilot deployments in Greece demonstrated high usability, strong user motivation, and the potential of the system to enhance community-driven ocean

engagement, scientific documentation, and awareness for UCNH protection and preservation. By combining technological innovation with inclusive, citizen-supported practices, the platform opens new pathways for democratizing ocean data collection, enhancing ocean literacy, and strengthening the connection between society and the underwater world.

Abstract #64

Co-designing a Resilient Coastal Future: The REDECOS Monitoring Network in Galicia (NW Spain).

Authors

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Presenting author

Pedro Montero

Keywords

Co-Designing, Coastal Monitoring, Operational Oceanography, Shellfish Management

Abstract

The artisanal shellfishing sector that operates in highly productive shallow intertidal zones is a key element in the economy, nearly 4000 people depends on it (https://www.pescadegalicia.gal/gl/publicacions) , and in the identity of Galicia culture (NW Spain). This important activity faces an uncertain future due to the increasing of events driven by climate change. To address these challenges, the Technological Institute for the Marine Environment of Galicia (INTECMAR) and the Galician Federation of Fishermen's Guilds collaborated to develop REDECOS (Modernization of the Coastal Monitoring Network) within the REDEMAR framework. REDEMAR aims to provide the Regional Administration with the best available information on the status of different resources for optimal fisheries management and planning to guarantee the future of the sea through responsible management. REDECOS aims to study the feasibility of continuously recording temperature and salinity in the shallow waters of Galician shellfish beds, due to the importance of understanding fluctuations in these parameters for the population dynamics of different bivalve species. These authors highlight the relevance of minimum salinity at high tide and the number of consecutive days below a specific salinity threshold to explain mortality in populations. In all cases, the thresholds refer to bottom salinity, specifically at a depth of 1 meter. For this reason, to improve the continuous monitoring of the most relevant environmental parameters for the survival of infaunal mollusk populations, it is considered essential to deploy the sensors obtained within the REDECOS project at 1 meter above the seabed." Currently, the project has moored 12 sensor that are measuring temperature and salinity every 10 minutes in shallow waters and plan to reach a total of 20. The location of these sensors was done in collaboration with the fishing sector and tacking into account the

economic value of the resource, historical susceptibility to salinity fluctuations, the logistical feasibility of maintenance Crucially, REDECOS has been established as a fully operational network integrated into the Coastal Observatory of the Xunta de Galicia (OCXG). This observatory, a collaborative consortium formed by Intecmar, the Marine Technology Centre (CETMAR), and the Galician Meteorological Agency (MeteoGalicia), unifies efforts to monitor ocean-meteorological conditions. The integration of REDECOS ensures that high-frequency data from shallow waters complements the OCXG's existing offshore observations, providing a comprehensive view of the coastal dynamic, moreover, the recorded data is collected by the fisheries association, saved in the OCXG databases and, after QC tests, shared to the public through the Observatory. The operational value of this network was demonstrated during the extreme precipitation events of autumn 2023. By recording the precise duration of lethal salinity levels in the shellfish beds—data often distinct from the stratified conditions recorded by deeper offshore platforms—REDECOS provided the irrefutable evidence required to administratively declare "Catastrophic Zones". This granular, in-situ information enabled the sector to access necessary financial aid, proving that co-designed, operational oceanography is a vital tool for the resilience of artisanal fisheries.

Abstract #81

Enhancing knowledge of flat oyster populations in the eastern Adriatic Sea through citizen science data collection

Authors

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Keywords

Citizen science, Data collection, Ostrea edulis

Abstract

Over 90% of oyster reefs have disappeared in many regions worldwide, and in the European ecoregion their status is considered poor or even functionally extinct. In the case of the European flat oyster Ostrea edulis, the decline results from the synergistic effect of high mortality caused by overfishing and the parasitic disease. Because oysters form biogenic reefs and play an important ecological role in ecosystem functioning, significant efforts have been made over the last two decades to restore native oyster populations and their habitats. Although O. edulis has completely vanished from some areas, it is still present in the Adriatic Sea; however, recent data show a significant decrease in its abundance in the northern Adriatic region over the last decade. Despite having an advantage over other regions due to the continued presence of natural populations, research on this species in the eastern Adriatic is still lacking. Research conducted within the POPOyster project – "Potential and Perspective of Native Oyster Restoration in the Adriatic Sea", has provided valuable information on the abundance of this species in areas where it is harvested with beam trawls, but these represent only a very small part of Croatian territorial waters. Considering the highly indented Croatian coastline and the patchy distribution of this species, more effort is needed to obtain a better insight into native oyster populations in the Croatian part of the Adriatic Sea. As one of the project objectives is to analyse the current status of oyster beds in the northern Adriatic, a simple citizen science project has been prepared to enable all sea users to contribute to research on O. edulis populations. The main idea is to collect data on presence and location, together with other important information such as assessments of abundance in specific areas, habitat descriptions, approximate size of individuals (e.g., newly settled small specimens versus larger and older ones), and, if possible, photographs of findings. An online site has been established for this purpose, providing a simple and user-friendly web portal that does not require installation of any additional applications. This initiative will be communicated to diving centres, nautical associations, marine protected

areas, high schools, and students. The campaign will begin at the beginning of 2026, with intensive activities organised in the months before summer when more people use the marine environment daily. The main aim of this action is to collect data that will support future scientific research. Based on the collected information, targeted scientific surveys will be carried out at selected locations to obtain quantitative data, using visual census methods conducted by scientific divers and/or ROV surveys. Citizen science engagement is crucial for collecting geographically broad information, and the accompanying educational activities will emphasise the ecological importance of this species as well as the value of restoring O. edulis in areas where it was once abundant. Therefore, in addition to its scientific goals, the project also includes a strong educational component aimed at empowering local communities and advancing ocean literacy in relation to native oyster importance and restoration.

Abstract #102

European Perspectives on Biology and Ecosystem Ocean Observing in a Global Context

Authors

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Keywords

coordination, data products, Essential Ocean Variables, FAIR data, interoperability

Abstract

Advancing biology and ecosystem (BioEco) knowledge to support the conservation and sustainable use of marine resources is pegged on streamlining both the existing and new ocean observation programs. Global frameworks such as the Global Ocean Observing System (GOOS) and its Essential Ocean Variables (EOVs) provide direction, yet regional capacities, priorities, and barriers vary widely. Understanding how European perspectives compare to those from non-European countries is crucial for ensuring that European Ocean Observing System (EOOS) developments are both regionally grounded and aligned with global ocean observing requirements. This study provides a comparative assessment of European and non-European stakeholder views on seven critical themes related to BioEco observations, revealing shared bottlenecks, unique regional challenges, and opportunities for reinforcing Europe's leadership in global ocean observing. A structured 5-point Likert-scale survey was distributed to stakeholders engaged in ocean observation. Respondents evaluated statements across seven key themes of the ocean observation system (1) Need for ocean studies, (2) FAIR (Findable Accessible Interoperable and Reusable) data, (3) Interoperability, (4) Interdisciplinarity and coordination, (5) Data and data products, (6) Services and technology, and (7) Familiarity with EOV standards. Responses were collected from European (n = 47) and non-European (n = 45) participants. Across all regions, stakeholders strongly emphasized the critical importance of global assessments, the urgent need for improved understanding of marine life and ecosystem change, and the need to normalize FAIR data principles. Both groups also identified persistent systemic barriers: incomplete metadata, difficulty discovering BioEco datasets, limited open access, challenging data integration across methods, underutilization of technological infrastructure, and insufficient verification of BioEco data products. Despite these shared barriers, notable regional differences emerged. European respondents showed greater uncertainty, with higher proportions of neutral responses across multiple themes, especially regarding the

accuracy and fit-for-purpose nature of existing BioEco products. Europe also demonstrated substantially higher familiarity with GOOS EOV standards, reflecting the continent's long-standing engagement with standardized observation frameworks. Conversely, non-European respondents showed stronger confidence in existing data products. Still, they reported more severe coordination barriers, lower awareness of data-sharing practices, and reduced access to service providers and digital infrastructure. The non-European respondents also expressed greater challenges in aligning local data collection efforts with global needs. In conclusion, European priorities include improving clarity and communication between data providers and users, enhancing accuracy, verification, and reporting uncertainty when developing data products and models, and integration of indigenous and traditional ecological knowledge in ocean observation. For the non-European respondents, targeted support is needed to strengthen coordination, improve metadata and data accessibility, and build capacity in FAIR data practices.

Abstract #105

The Copernicus Marine Product Quality Dashboard: a new end-user gateway to standardized product quality information

Authors

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Keywords

Model validation, Operational oceanography, Regional availability of satellite and insitu observations, User Service Application for Product Quality information

Abstract

Useful information on scientific quality of the Copernicus Marine Service products for ocean observations, or reliability of delivered forecast model products has to be provided to end-users in a consistent and effective way. The Copernicus Marine Product Quality Dashboard (PQ-D) is the reference online application to end-users that provides relevant indicators and skills score metrics for near-real-time (NRT) observations -both satellite and in-situ- as well as for model-based ocean products. It offers metrics for the Global Ocean and for the European Regional Seas, and for Blue, Green and White Essential Ocean Variables (EOV), computed according to standardized numerical methodologies as recommended by the GODAE/OceanPredict international community. From a technical standpoint, the PQ-D is the result of a collaborative co-designed framework within the Copernicus Marine Service, participated by the Thematic Assembly Centers (TAC) and Monitoring and Forecasting Centers (MFC), that has as final objective the monitoring of the quality of delivered products, performed on daily and monthly basis, thanks to operational Estimated Accuracy Numbers (EANs) and indicators of available valid observations. It ensures operational continuity with available scientific assessment provided during the pre-qualification of the NRT timeseries and fully described in the scientific documentation (i.e., Quality Information Document and Summary Quality Overview) delivered to users together with each Copernicus Marine Product. In this contribution, we present the last technical developments of the PQ-D application, whose architecture has been revised and simplified, strongly supported by a standardization process of delivered metrics datasets to fully exploit interoperability for improved user-experience. The PQ-D operational workflow guarantees flexibility in the ingestion of new metrics and indicators, following the validation plans proposed by Copernicus Marine producers, for more scalable metrics catalogue expansion and service

monitoring. Currently, more than 30 metrics datasets are integrated in the PQ-D application: the user can access product quality information by means of interactive tools such as charts and interactive maps, fully customizable and exportable. Metrics, that adopts data standards for easing correct processing and calculation of EANs at different time-space scale, are delivered and fully assessed by experts at production center level, leveraging the way Copernicus Marine Service delivers product quality information to its users.

Abstract #114

From fisheries to ocean science: blue technology as a tool for partnership

Authors

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Presenting author

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Keywords

collaboration, drifters, fishing industry, in-situ obervations

Abstract

The global ocean is a major value driver in today's society, and pivotal for the wellbeing of future generations. It is the main climate regulator, home of earth's largest ecosystem, and facilitates the Blue Economy, who's annual economic output is the equivalent of some of the largest economies of the world, providing livelihood and benefits for billions of people. However, less than 5% is comprehensively monitored. Ocean observations are increasingly recognized as essential for effective action regarding all aspects of this blue economy. On the interface between several economic sectors, industries, governments, scientific institutions and NGOs, there is massive potential for collaboration: data sharing and building trust across sectors is key to evidence-based policies, better conservation, and sustainable use of marine resources.

Against this background, fishers are vital for ocean observation: often equipped with modern gear like smart buoys and sensors, they collect valuable data in a sustained, reliable, and cost-efficient manner. While this technology is generally deployed alongside fishing gear, rather than with purpose-built drogues, it is of immense value for enhancing in-situ oceanographic observation networks such as the Global Drifter Program or European Marine Observation Data Network. In our study, we present how the drift patterns of tracking devices deployed by major fishing fleets that operate across all oceans, correlates with those of purpose-built drifting buoys. We further examine how industry-derived data can complement existing ocean observation networks, feeding into global ocean circulation models and improving forecasting capabilities for both scientists and decision-makers. Lastly, we illustrate the way forward for building a cross-sectoral ocean observing model where fishers are recognized not only as data collectors, but as essential partners in the ocean observation network.

Abstract #116

Containerized Cloud Services for Marine Data Management and Geospatial Forecasting in the Eastern Mediterranean Levantine Basin

Authors

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Keywords

cloud services, marine data management, ocean forecasting

Abstract

The current work presents cloud services that leverage Docker containerization to enhance operational efficiency in marine data management and ocean forecasting: the EMODnet-Cyprus Replication Manager (RM) and the well-established CYCOFOS-Cyprus coastal ocean forecasting and MEDSLIK-Mediterranean oil spill and trajectory prediction Forecaster Stack.

The Cyprus-EMODnet Replication Manager (RM) is a foundational Java (Tomcat) web application traditionally managed by SeaDataNet and EMODnet Ingestion-Chemistry consortium. The ORION Research team proposes running the Cyprus-EMODnet RM as a cloud Docker container to ensure fast and dependable operation across various environments (development, testing, production). The Cyprus-EMODnet RM service holds several thousand CDIs and ODVs containing hydrological and hydro chemical data, utilizing a MySQL DBMS that aggregates quality-controlled data from sources like SeaDataNet, EMODnet, Pangea, and Argo, focusing on the Eastern Mediterranean Levantine basin.

The containerized cloud environment approach provides significant operational benefits, including resource optimization by allowing a single system to host multiple RM instances for other data systems. It enables simplified deployment across Linux, MacOS X, and Windows, facilitates the easy upgrade of dependencies (running on Apache Tomcat v9 and JDK v11), and enhances security through process, storage, network, and container isolation, which can be further reinforced with WireGuard VPN. Management and monitoring are simplified via Web UI, CLI, and Portainer UI.

The CYCOFOS-MEDSLIK Forecaster Stack cloud service focuses on downscaling forecasting from CMEMS-Copernicus Marine Service, utilizing a three-part stack to create a highly automated, parametric system for publishing output forecast maps: - MEDSLIK, which runs on-demand as a cloud Docker container to predict the transport of oil spills affected by CMEMS- CYCOFOS sea currents and SST, SKIRON winds, and CYCOFOS waves; - PostGIS, an open-source geospatial RDBMS extension that converts MEDSLIK predictions output into geospatial objects; and - QGIS, which runs on-demand as a cloud Docker container to execute Python scripts for geospatial analysis and map generation.

These service implementations demonstrate the utility of cloud containerized stacks in creating robust, scalable, and secure data services for marine data management RM within the frame of EMODNet Ingestion and Chemistry, downscaling and down-streaming forecasting systems, such as CYCOFOS and MEDSLIK respectively.

Abstract #126

Co-Creating a Blueprint for Integrated Ocean Science: Advancing Ocean Observations for a Sustainable Future

Authors

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Keywords

Co-creation, Integration, Ocean observing, Stakeholder engagement, Support tool

Abstract

Understanding and managing the ocean requires coordinated, long-term biological and ecosystem observations. However, existing efforts are often fragmented across disciplines, sectors, and regions, limiting their effectiveness in addressing global challenges such as biodiversity loss, climate change, and ecosystem degradation. To address these issues, the EU-funded BioEcoOcean project is co-creating a Blueprint for Integrated Ocean Science. The Blueprint is under development and aims to bridge these gaps by providing a structured communication support tool to advance the ocean observing system.

A key feature of the Blueprint is its question-driven approach, which focuses on addressing critical knowledge gaps related to marine ecosystem dynamics, biodiversity shifts, and human-ocean interactions. By framing complex challenges through targeted questions, the Blueprint facilitates a systems-based approach to ocean science, enhancing our ability to detect trends, assess impacts, and develop predictive models. It also supports communication and thinking outside one's own field of expertise.

The overall aim of the co-creative process of developing the Blueprint is to bring together researchers, policymakers, and practitioners to identify fundamental questions that drive ocean observation and ensure alignment with societal needs. The Blueprint will serve as a support tool for designing and implementing observation strategies that are collaborative, open, and scalable, fostering interoperability across diverse data systems and stakeholders.

Abstract #127

TSG Gaillard: Towards a Citizen Oceanographic Fleet for Surface Ocean Observations

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Presenting author

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Keywords

Citizen Science, Cost-Efficient Technolgies, Sailing for Science, Surface ocean salinity and temperature

Abstract

The thermohaline circulation, also known as the global deep-ocean circulation, is driven by density differences in seawater, arising from variations in temperature and salinity. This circulation, together with surface currents, forms a vast thermohaline loop that redistributes heat around the globe and plays a crucial role in climate regulation. Despite its importance, the immense scale of this phenomenon makes it challenging to observe comprehensively.

Over the past fifty years, direct measurements have been carried out by academic networks such as the French National Service for Sea Surface Salinity Observation (SNO SSS), the oceanographic fleet, the international ARGO program, and satellite missions. However, coverage remains sparse due to the limited number of floats and vessels relative to the vast areas to be monitored. While numerical modeling helps interpolate surface salinity data, a denser observational network would significantly improve our understanding of the system.

Recent technological advances now enable the development of cost-efficient, high-precision instruments for oceanography. Although current devices are largely experimental, they could be adapted for large-scale use by citizen scientists. In particular, the population of offshore yachtsmen and yachtswomen—approximately 14,000 annually—offers an opportunity to expand observational coverage in regions rarely accessed by institutional vessels.

This project aims to establish the foundations of a citizen oceanographic fleet, equipped with lightweight, user-friendly sensors suitable for scientific projects not requiring heavy instrumentation. It aligns with the GOOS “10,000 for the Ocean” initiative, which seeks to engage tens of thousands of vessels in collecting reliable oceanographic data to support global monitoring. The system integrates high-precision temperature and salinity sensors with accuracies better than 0.02°C and 0.02 PSU, respectively, and optimizes the full data

cycle, including acquisition, pre-processing, near real-time IoT-based data transfer, and maintenance.

The first deployments of the TSG Gaillard system occurred during the Vendée Globe race aboard two offshore racing yachts (Romain Atanasio and Antoine Cornic), targeting specific regions of oceanographic interest. Preliminary results from this campaign will be available by Spring 2025, with full analysis expected in 2026. A second campaign is planned for late 2025.

This project demonstrates the potential of integrating citizen-based observations with institutional efforts, providing a scalable, complementary approach to global ocean monitoring.

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Theme 4: Governance and Capacity for Ocean Knowledge

Abstract #2

Review for an updated inventory of Mediterranean marine caves biota with a focus on stygofauna

Authors

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Keywords

diversity, inventory, marine caves, Mediterranean Sea, stygobiota, WoRCS, WoRMS

Abstract

Based on the review of 488 studies over a period of 299 years, 2,747 species were described inside Mediterranean marine caves (MedMC) with Animalia accounting for 78.52%, Chromista contributing for 11.97%, Plantae making for 7.64%, Bacteria standing for 1.67%, and other small kingdoms depicting less than 1% of reported species. Among the stygofauna, 19.52% of species were arthropods, 17.47% were sponges and 14.55% were molluscs. Despite their presence in MedMCs, 59 species were classified as non-marine by the WoRMS database. Fifteen of these non-marine species were considered eligible for inclusion in our inventory, based on their presence in brackish, freshwater, and terrestrial environments. As a result, the adjusted diversity of stygobiota was 2,705 species. Even though 85 species were missing from the present study (2024) when compared to the most recent and complete inventory (2021), the present study added 468 new species unreported from previous marine stygobiota's inventories. We extrapolated that the theorical adjusted diversity inside MedMCs could reach 2,790 species. Our updated inventory underlined the presence of Xenacoelomorpha phylum (unreported from previous assessments and under-reported in WoRCS) and of 50 additional microbial taxa. Our diversity assessment was deemed adequate due to the fact that more than 90% of our data had a GNR confidence score greater than 0.98. However, further studies with quantitative meta-analyses on the relationships between biocoenoses and biotopes are required to provide a fully comprehensive understanding of the marine stygobiota's bionomy within MedMCs.

Abstract #60

The Galicia Marine Observation Strategy: A Model for Strategic Coordination

Authors

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Keywords

Coastal monitoring strategy, Galician marine observation, Strategic governance

Abstract

Within the framework of the Marine Sciences Programme, a Marine and Coastal Observation Strategy has been developed with the aim of optimizing the public and private resources that support Galicia's marine observation network, in a region that is highly dependent on the services and opportunities provided by its maritime ecosystem. The strategy was designed through a structured, multi-stage process, beginning with an in-depth analysis of key information required to improve existing services and to define the need for new ones. This initial phase enabled a clear assessment of the baseline situation, including organizational capacities, human and technical resources, existing programmes, observation networks, alert systems, and other decision-support services. In parallel, needs and opportunities for improvement were identified through consultation processes and risk analyses, providing a solid foundation for the strategic diagnosis. This diagnosis was complemented by a detailed PESTEL analysis, offering insights into the political, economic, social, technological, ecological, and legal factors influencing marine observation. The study incorporated a review of legislative frameworks, sectoral policies, European and international initiatives, and comparable observatories in other regions, evaluating their operations, infrastructure, good practices, and funding mechanisms. The resulting information informed the development of an initial SWOT analysis, which was subsequently validated and enhanced through participatory workshops involving external stakeholders to ensure a shared and robust strategic outlook. Based on this process, the Strategy's Vision, Mission and Values were defined, together with the identification of major challenges and strategic objectives. Five key challenges were outlined: ensuring comprehensive and continuous observation; improving data accessibility and usability; establishing open and stable governance; securing long-term sustainable funding; and fostering a well-informed and engaged society. These challenges shaped 19 action lines and more than 70 actions, which will underpin future implementation plans for monitoring networks and services. The Strategic Plan also includes several essential support elements: a proposed governance structure, a communication plan, recommendations for data management plans, and the identification of financing

mechanisms. From a financial perspective, the analysis highlights the availability of opportunities at regional, national, and European levels, which will be leveraged through a Financial Action Plan, the creation of strategic consortia, public-private collaboration models, and a continuous monitoring system. The proposed governance structure is based on institutional coordination, multi-actor collaboration, transparency, sustainability, and shared responsibility. It is organized into three levels: a Governing Council providing strategic direction; a Coordination Committee responsible for operational planning; and a Technical Office offering methodological and documentation support. These are complemented by four technical commissions aligned with the strategic challenges: observation and technologies; data and services; governance and financing; and society and communication. Finally, the Strategic Plan incorporates a Communication Plan designed to highlight the importance of continuous marine monitoring for sustainability, innovation, and the blue economy. The plan is structured around five axes: institutional launch, digital strategy, media engagement, citizen participation, and educational and science-communication outreach. It also defines responsibilities, interinstitutional communication mechanisms, media planning, and monitoring and evaluation methods.

Abstract #98

The introduction of Coastal City Ocean-Based Solution Toolkit for Sustainable Development (COAST)

Authors

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Keywords

COAST toolkit, DCC-OCC, Ocean-Based Solution, UN Ocean Decade

Abstract

At present, the increasingly severe extreme Marine disasters caused by climate change, the destruction of the ecological environment by humans and the excessive exploitation of resources have seriously affected the sustainable development of the ocean and humanity. The United Nations Decade of Ocean Science for Sustainable Development (referred to as the "Ocean Decade") has transformed ocean science from scientific research to providing scientific solutions for governance. Against this backdrop, the "Coastal City Ocean-Based Solution Toolkit for Sustainable Development (COAST)", jointly developed by the UN Decade Collaboration Center for Ocean and Climate Nexus (DCC-OCC) and multiple research institutions from various countries, was officially released, providing the world's first comprehensive scientific tool for solving Marine governance challenges. The COAST toolkit is freely accessible to global users through a co-design - co-development - co-benefit approach. Its ultimate goal is to achieve rapid and seamless knowledge transfer of Marine scientific research results to the public and decision-makers, providing science-based solutions for Marine cities.

Abstract #106

Integrated multimodel forecasting for transnational environmental management on the Western Iberian Shelf

Authors

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Keywords

freshwater fluxes, numerical modelling, transboundary, West Iberian Buoyant Plume

Abstract

The WHISTLE project fosters transnational collaboration between Portugal and Galicia (Spain) to advance integrated multimodel forecasting for environmental management in the Western Iberian shelf. This region, part of the Euroregion Galicia–North Portugal, is environmentally and economically significant, supporting rich marine biodiversity, productive estuaries and wetlands, and vital fisheries and aquaculture industries. Its coastal waters are strongly influenced by upwelling and the Western Iberia Buoyant Plume (WIBP) a year-round, low-salinity water lens formed by overlapping river discharges (Douro, Minho, Mondego, and Galician Rias). The WIBP regulates coastal circulation, stratification, haline fronts, and nutrient distribution, shaping marine ecosystems, sustaining local economies, and influencing renewable energy development and marine spatial planning.

WHISTLE enhances operational modelling capacity by harmonizing meteorological and hydrological boundary conditions across both regions, downscaling Copernicus Marine global and regional models, and integrating land-based inputs. The project delivers a one-stop service platform that aggregates Copernicus Marine products, national forecasts, satellite data, and in-situ observations. Co-designed with stakeholders, this interface ensures actionable information for decision-makers, strengthening the value chain and boosting the use of Copernicus products.

Two case studies demonstrate applied benefits: (1) improving marine pollution response in Galicia through Plan Camgal, and (2) safeguarding water quality in Portugal's Northern Litoral Natural Park. Model outputs will be validated through traditional monitoring campaigns and Autonomous Underwater Vehicles (AUVs) missions. All data will follow FAIR principles

(Findable, Accessible, Interoperable, Reusable), ensuring accessibility to the wider research community.

WHISTLE establishes a pioneering transboundary marine coastal operational service. It strengthens environmental governance, fosters sustainable resource management, and contributes to regional cohesion and resilience in the Euroregion Galicia–North Portugal.

Abstract #115

The Ocean Practices Federated Network (OPFN): Transforming Ocean Methodology Sharing

Authors

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Keywords

Digital Repositories, Federation, Methodologies, Ocean Practices Federated Network (OPFN)

Abstract

Background. Observation and monitoring to understand ocean state and variability are critical for ocean management and governance, particularly for addressing the consequences of climate change and supporting sustainable development with a global perspective. However, the methodologies underpinning ocean observations and data management and modelling remain fragmented across institutions and regions, limiting interoperability and slowing scientific progress. To overcome these challenges, the Ocean Practices Federated Network (OPFN) is being developed as a transformative solution to unify methodological resources, link ocean practice repositories and thus enhance global collaboration in the journey toward interoperability.

The Ocean Practices Federated Network (OPFN). The OPFN is a federated system designed to provide single-point discovery of distributed methodological collections offering visibility while preserving organisational autonomy. Building on the decade-long success of the Ocean Best Practices System (OBPS), OPFN moves beyond a centralized repository model to interlink multiple repositories through common metadata standards and FAIR (Findable, Accessible, Interoperable, Reusable) and CARE (Collective Benefit, Authority to Control, Responsibility, Ethics) Principles. This approach ensures that organizations, programmes, and projects can preserve, organize, and share their practices to increase visibility, while maintaining ownership and control. The importance of OPFN lies in its ability to address critical gaps in methodological accessibility and interoperability. By enabling global standardized discovery and comparison of practices, OPFN supports consistent observational techniques, robust data management, and informed decision-making. It also

fosters cultural change toward global sharing of ocean practices, promoting transparency and trust across diverse ocean communities.

Co-design and establishment of a community of practice for OPFN. Current efforts focus on co-designing the OPFN architecture with initial global content providers, including IOC, FAO and ICES. Key technical features include agreed metadata pattern specifications, AI-enhanced search capabilities, multilingual support, and sustainability through cloud-based, portable designs. A Stakeholder survey including European repositories received 22 responses from data managers, scientists, and programme leaders which highlighted priorities such as quality assurance and long-term sustainability, and emphasized the need for comprehensive coverage of major European systems.

Current progress and pilot implementation of the OPFN. The European Horizon 2020 project ObsSea4Clim is supporting the development of the OPFN. The recently published conceptual design lays out a list of requirements, a framework and a roadmap for the implementation of the OPFN. The pilot use case for aquaculture has been developed and provides a use case for interoperability across digital repositories that manage and share methods across different thematic domains. The planned expansion of OPFN will include a focus on physical ocean variables.

This paper will address the design and current implementation status of the OPFN with emphasis on both the progress and the challenges for an operational OPFN.

Abstract #128

The Cyprus ocean forecasting system in operational service for more than two decades

Authors

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Keywords

currents and waves, Eastern Mediterranean Levantine Basin, operational forecast

Abstract

The CYCOFOS – Cyprus coastal ocean forecasting and observing system provides operational downscaling products in the Eastern Mediterranean since early 2002, initially within the framework of the legendary MFS projects, later within the MyOceans projects and since 2015 downscaling from the Copernicus Marine Service-CMEMS. The CYCOFOS forecasting system consists of hydrodynamical and wave models. Through the years the CYCOFOS forecasting models were improved, upgraded, validated, inter-compared, expanded from coastal to sub-regional and regional domains, including the Black Sea wave products, from low to high spatial and temporal resolution, operating from physical to cloud operational environments.

CYCOFOS is one of the downscaling forecasting systems of the MONGOOS network, the latter of which constitutes one of the EuroGOOS's ROOSes.

The CYCOFOS forecasting products were proven to assist the Cyprus national, sub-regional and regional response agencies during real major marine pollution incidents, Lebanon 2006, Israel 2021, Syria 2021, Kerch Strait 2024, risk assessment studies for coastal infrastructures, ports, fisheries, offshore platforms, SAR and training operations, both in the Mediterranean Sea and the Black Sea.

Abstract #132

IBIROOS: Strengthening Regional Collaboration for Sustainable Ocean Observing and Marine Services

Authors

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Presenting author

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Keywords

Marine Services, Regional Ocean Observing, Transboundary Cooperation

Abstract

IBIROOS is one of the EuroGOOS regional operational oceanography systems and involves partners from the five countries bordering the Iberian-Biscay-Irish (IBI) maritime area—France, Ireland, Portugal, Spain, and the UK. Its primary goal is to collaboratively develop and operate sustained ocean observing systems, delivering real-time operational data products and services to support environmental monitoring, climate studies, and maritime management. The network also includes archipelagos in the Macaronesia region, extending its observational and operational reach. IBIROOS exemplifies the value of regional and transboundary cooperation, in line with the EuroGOOS Strategy, by maintaining and enhancing marine observation infrastructure and operational products across the European Atlantic Area, from coastal zones to offshore waters. Since its establishment in 2004, IBIROOS has maintained strong partner collaboration and achieved significant scientific and operational progress. This poster summarizes 22 years of activity, highlighting the benefits of regional cooperation for sustainable ocean observing and the development of marine services. The IBIROOS observing network—including ship-based surveys, coastal and deep-water buoys and sampling sites, HF radars, tide gauges, ARGO floats, and gliders—has remained stable and reliable. Transboundary cooperation has been key to its establishment and maintenance, with the HF radar network as a notable example. Data acquisition and processing workflows have been increasingly automated, and new APIs and web interfaces have enhanced accessibility and user engagement. IBIROOS partners have actively participated in EU and INTERREG projects, fostering regional cooperation, co-development of marine services, and enhancement of observing and modelling systems. Marine services have been developed and demonstrated through strong member collaboration, supporting the observing system, data dissemination, and the joint development and validation of regional and coastal forecasts. Products range from traditional areas—such as harmful algal blooms, oil spills, chemical monitoring, and search and rescue—to emerging needs,

including marine litter, renewable energy, offshore aquaculture, and support for Marine Strategy Framework Directive implementation. Significant effort has been made to integrate observational and model data into Open Geospatial Consortium (OGC) standard services, facilitating the co-development of marine services applicable across the Atlantic Area. Key priorities moving forward include improving data accessibility and regional visibility, strengthening coordinated observation efforts and communities of practice, and securing targeted support for in situ data processing, dissemination, and marine service development throughout the IBIROOS region.

Theme 5: Monitoring & Understanding the Triple Planetary Crisis and Addressing Societal Needs

Abstract #6

Vulnerability of coastal biodiversity under future ocean conditions: a case study on shell loss in marine gastropod larvae under ocean acidification

Authors

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Keywords

Aplysia fasciata, Biogenic carbonate, Ocean Acidification, Tritia reticulata

Abstract

Ocean acidification (OA), driven by the ongoing rise in atmospheric CO_2, is altering seawater carbonate chemistry, with profound implications for marine calcifiers. The reduction in carbonate ion availability decreases the saturation state of calcium carbonate minerals, impairing shell formation and maintenance. These impacts are particularly critical during early ontogeny, when rapid calcification is essential for protection and developmental success. Larval stages of gastropods are, therefore, among the most sensitive biological indicators of ocean change, as even small decreases in pH can compromise morphogenesis, growth, and survival. To investigate the mechanisms underlying shell degradation and loss in the early life stages of gastropods under acidified conditions, controlled laboratory experiments were conducted in which larvae were exposed to a range of pCO_2 treatments representative of present-day and projected future oceanic scenarios. Larvae were monitored throughout ontogenetic development, and a suite of biological responses was assessed, including survival, growth, and shell integrity. In addition to evaluating structural alterations, complementary developmental endpoints were explored to support a mechanistic interpretation of the observed effects. Preliminary observations indicate that exposure to lowered pH can lead to increased larval mortality and pronounced shell deterioration, characterised by partial dissolution, thinning, and, in some cases, shedding of the carbonate shell. These alterations suggest that acidification alone can destabilise the delicate balance of biomineralisation and shell maintenance, ultimately leading to shell loss. Such phenomena, potentially resulting from impaired calcium uptake, disrupted organic matrix formation, or localised shell dissolution, collectively reduce larval fitness by compromising protection against predation and environmental stressors. The effects observed at the larval

level have cascading consequences that may impair population renewal and alter community structure over time. Understanding the processes driving shell degradation and loss in early life stages provides key insights into the resilience of marine calcifiers to ocean acidification and helps to anticipate broader ecosystem responses. Such knowledge is crucial for evaluating the vulnerability of coastal biodiversity to future ocean conditions.

Abstract #13

Marine chemical pollution under observation: preliminary results from the Sea Care project

Authors

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Keywords

Global Seawater Sampling, Interdisciplinary Partnership, Marine Pollution Monitoring, Ocean and Human Health, Persistent Organic Contaminants

Abstract

The monitoring and assessment activities stipulated in the Marine Strategy Framework Directive (2008/56/EC) represent the primary mechanism by which the European Union endeavors to protect the marine environment. A pivotal element of this directive is the identification and quantification of persistent and semi-volatile organic contaminants, including polycyclic aromatic hydrocarbons (PAHs), diethylhexyl phthalate (DEHP), and alkylphenols. These contaminants, widely used in industrial processes and consumer products, are recognized for their persistence, potential to bioaccumulate, and endocrine-disrupting effects. Despite its comprehensive scope, the Directive's application remains confined to the regional European level.

It is at this juncture that the SeA Care project becomes pertinent, as it seeks to extend the Marine Strategy paradigm to a global scale, employing a systemic approach to environmental assessment. The Sea Care project constitutes an Italian initiative coordinated by the National Institute of Health in collaboration with the Italian Navy and three research partners. From July 2023 to November 2024, a series of seawater samples were collected during the World Tour of the training ship Amerigo Vespucci. The extensive spatial coverage of this campaign (Atlantic, Pacific, and Indian Oceans as well as the Mediterranean Sea) underscores the project's systemic approach, which facilitates integrated and comprehensive marine observations with a view to enhancing understanding and management of the environment and human health. Sea Care collected surface and deep water samples from 31 sites to provide representative data on the presence and concentrations of key anthropogenic contaminants, such as PAHs, DEHP, and alkylphenols. A meticulous process was employed to collect seawater samples utilizing a Niskin bottle as the primary instrument

for this purpose. These samples were analyzed rigorously through gas chromatography–mass spectrometry techniques. The analytical approach allowed detection of PAHs in 53.2% of samples (48% of sites), with high concentration detected of 45 ng/L, DEHP was detected in eight sampling sites, with concentrations ranging from LOQ (0,2 µg/L) to 0.4 µg/L. Alkylphenols, specifically nonylphenol (NP) and octylphenol (OP), were detected with: NP found in 10 samples with concentrations up to 90 ng/L and OP has been identified in 14 sites with a maximum concentration of 28 ng/L. The integration of physico-chemical data measured in situ strengthens the contextual interpretation of chemical contamination patterns.

The Sea Care project strengthens collaboration among scientific, military, and public health sectors, providing a governance model focused on the establishment of sustainable marine observing systems. This project has the capacity to produce valuable datasets that have the potential to inform both marine ecosystems protection and public health safeguarding. The Sea Care project's contributions towards global chemical contaminant monitoring demonstrate the essential role of interdisciplinary and international cooperation in tackling marine pollution. These outcomes enable better understanding, forecasting, and management of marine environmental health risks, thereby supporting the development of evidence-based policies. Finally, the project aligns with the United Nations Sustainable Development Goals (SDGs), particularly SDG 17, SDG 14, and SDG 3, promoting sustainable ocean use, multi-sectoral global cooperation for environmental and public health protection.

Abstract #26

Ireland's Sentinel Coastal Monitoring Buoy Network: Enhancing Observations from Estuarine to Coastal Oceanic Environments for Climate and Ecosystem Prediction.

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Keywords

Coastal, high frequency, monitoring

Abstract

Estuarine to Coastal Oceanic Environments for Climate and Ecosystem Prediction. The Sentinel Sites programme, coordinated by the Marine Institute of Ireland, is developing a network of buoy-mounted coastal monitoring stations that transmit oceanographic and meteorological data to shore in Near Real Time (NRT). This European Maritime, Fisheries and Aquaculture Fund (EMFAF) supported project has begun to integrate multiple sites that vary in marine zone type, development stage, time-series maturity and sensor complexity. The sites, on the west coast include: a winched profiling system in a tidal lagoon prone to hypoxia, an aquaculture research site in a sheltered coastal bay and a high salinity site with strong oceanic influence. Together, these sites offer a comprehensive view of coastal environmental variability and change. Instrumentation varies by site, ranging from CTD and multiparameter sondes to high-accuracy sensors for pCO_2 and pH. Observations are complemented by in-person water sampling for plankton and geochemical analysis, alongside weather stations and wave buoys that provide atmospheric and physical context. Although relatively young, one of the Sentinel Sites, is already showing increasing trends in pCO_2, highlighting the importance of long-term monitoring to reveal ecosystem-scale changes. This site underscores the significance of maintaining and expanding coastal monitoring efforts and integrating their data with terrestrial, atmospheric, and offshore oceanographic monitoring programmes in relation to predicting ocean and climate. Expansion of the Sentinel Site network is already underway, to include ocean data from Met buoys, long-running climate stations, and new sites relevant to aquaculture, fisheries, and ocean climate research.

Abstract #82

Relative Contributions of Coastal Sediments to Anthropogenic Heavy Metal Enrichment in Recent Eastern Mediterranean Deep-Sea Deposits

Authors

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Keywords

Anthropogenic Enrichment, Coastal Sediment, Heavy Metal, Israel, Southern Cyprus

Abstract

Heavy metal pollution has become an increasingly prominent stressor in marine ecosystems, particularly in regions where natural circulation is limited and human pressures are intense. The eastern Mediterranean is one such environment as it is a semi-enclosed basin where restricted water exchange, coastal development and industrial activity combines to amplify the accumulation of metal contaminants. Metals are persistent, non-biodegradable, and capable of bioaccumulating within marine food webs, therefore understanding how they are mobilised, transported, and ultimately sequestered in sediments is critical for evaluating ecological risk and long-term environmental change. Coastal sediments play a central role in this process as they act as both sinks and secondary sources of trace metal contaminants, which can be redistributed offshore to deep-water sediments, where they have shown direct and indirect impacts on deep-water benthic and epibenthic habitats. Recent deep-water sediments in the eastern Mediterranean show significant anthropogenic enrichment of heavy metals, yet the relative contributions of different coastal sources remain poorly quantified. To address this, we characterised the metal signatures of the two potential end-member systems including Al, Fe, Mn, Cu, Zn, Pb, Cr, Ni and Cd in shelf sediments along the Israeli and south Cyprus coasts. In addition, we also take into consideration the atmospheric deposition end-member by using published values of measured atmospheric inputs from the region. Naturally weathered sediments from the Israeli coast, consist mainly of quartz sand from kurkar ridges, carbonate fragments from limestone and shells, and fine clays and silts from local streams, whereas the Cyprus end-member is represented by samples collected within the PUREEF-Y project, consisting predominantly of bioclastic carbonate sand and micritic carbonate mud from limestones, marls, and marine organisms, with only minor

siliciclastic volcanic grains from the nearby Troodos catchments. Both the Israeli and southern Cyprus continental shelves are influenced by inputs of industrial, urban, and agricultural pollution. Surface sediments from both regions were analysed by atomic absorption spectrometry (AAS), inductively coupled plasma mass spectrometry (ICP-MS), and atomic emission spectrometry (AES) for major and trace metals, with normalisation to conservative elements and grain size. Complementary deep-water sediments, collected midway between Israel and Cyprus, show elevated metal concentrations indicative of significant anthropogenic enrichment. Ongoing data analysis employs multivariate statistics, enrichment factors, and geochemical mixing models to quantify the relative contributions of the different end-members to the deep-water metal inventory. By integrating sediment composition, source-specific metal ratios, and end-member modelling, this study aims to determine the extent to which coastal anthropogenic signatures are exported offshore. The results will refine our understanding of pollutant dispersal, sediment transport pathways, and the growing human impact on the geochemical evolution of the eastern Mediterranean seafloor.

Abstract #85

Benthic Biodiversity Insights for Marine Spatial Planning: Assessing the Impact of Novel Nature-Based Solutions in Ultra-Oligotrophic Waters

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Keywords

benthos, biodiversity, macrofauna, monitoring, nature-based solutions

Abstract

The Levantine Basin is characterized by ultra-oligotrophic conditions, with extremely low nutrient availability that limits primary productivity and shapes unique marine ecosystems. Despite these nutrient constraints, the region supports a unique benthic biodiversity, including many endemic species adapted to warm, saline and nutrient-poor waters. In recent years, the EU has strongly promoted marine Nature-Based Solutions (NBS) as key tools for achieving climate resilience, improved biodiversity, and sustainable blue-economy growth. Through initiatives such as the EU Biodiversity Strategy 2030, the Green Deal, Mission Ocean, and Horizon Europe funding programmes, the EU encourages the deployment of nature-inclusive artificial reefs and other structures in ports and marinas. Marine NBS are increasingly integrated into Marine Spatial Planning frameworks and supported by dedicated research projects that demonstrate their ecological and socio-economic benefits, helping Member States adopt more holistic and ecosystem-based management approaches. There is a significant knowledge gap regarding the efficacy of novel marine NBS in the unique environment of the Levantine basin. This is more evident in the Case of Cyprus, an island with limited coastline characterised by increased anthropogenic activities. This study investigates the ecological performance of novel marine NBS tested in areas characterised by anthropogenic activities in coastal Cyprus, focusing specifically on benthic biodiversity responses across both hard-bottom and soft-bottom habitats. More specifically, nature-inclusive 3D-printed artificial structures have been deployed within one marina in Cyprus, and the response of benthic macrofauna has been investigated in treatment and control stations. The work combines quadrat-based biodiversity assessments, and soft-bottom macrobenthic community analyses to generate a comprehensive evidence base for Marine Spatial Planning (MSP). Biological monitoring of hard substrates was conducted seasonally

via scuba-based quadrat imaging. Quadrat images (n=3 per prototype) were analysed using PhotoQuad to quantify colonising assemblages through stratified point counts (n=100 points per image), enabling the calculation of Shannon diversity, Pielou's evenness, and other ecological metrics. To evaluate the broader ecological footprint of the proposed solution, sediment cores were collected annually using corer sampling to analyse the macrobenthic community structure. Resulting datasets were used to calculate relevant biotic and biodiversity metrics proposed under various EU legislations, followed by statistical comparisons to determine community-level differences. Preliminary patterns indicate that nature-inclusive artificial structures made from environmentally-friendly materials positively affect benthic diversity and structural complexity. These findings contribute valuable evidence for integrating biodiversity-enhancing NBS into future MSP strategies in data-poor, oligotrophic marine settings. This study presents an integrated environmental assessment of novel marine Nature-Based Solutions (NBS) with a focus on evaluating their capacity to enhance benthic biodiversity and improve ecological conditions in an ultra-oligotrophic and anthropogenically influenced coastal environment.

Abstract #109

A nested ocean climate model of the Northeast Atlantic

Authors

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Keywords

Biogeochemistry, Climate Projection, CROCO, Ireland's EEZ, Northeast Atlantic, PISCES

Abstract

The shelf seas of the Northeast Atlantic is a highly productive ecoregion. To better understand the potential impacts of climate change to the fishery productivity of the area, a nested CROCO-AGRIF ocean climate model was established encompassing the Irish EEZ, OSPAR Region III and ICES regions of national interest to Ireland. The nested grid was established with 9km resolution to oceanic depths and 3km resolution for shelf seas. This configuration yielded the speeds necessary to provide physics-only simulations in a very short timeframe and an ensemble of coupled physics-biogeochemistry projections in a way that is practicable from a project delivery point of view. From a range of CMIP6 Earth System Models (ESMs), two nominee lists were created of ESMs to downscale from such that a physics-only (CROCO) ensemble and a physics-biogeochemistry (CROCO-PISCES) ensemble would be possible.

A baseline hindcast was completed with two primary purposes in mind, (i) for historical fishery case studies and (ii) for bias-correction of climate projections from the same model system. To this end, climate projections were generated by downscaling from several CMIP6 Earth System Models covering a range of equilibrium climate sensitivities, timeframes and climate scenarios.

A summary of key findings from the ensemble simulations so far will be presented, such as climatological anomalies of key ocean climate variables.

Abstract #111

Subsurface Marine Heatwaves in the Levantine basin

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Keywords

climate change, gliders, Mediterranean, observational oceanography, subsurface marine heatwaves

Abstract

As a climate change "hotspot" area, the Mediterranean Sea has seen a rise in prolonged, extreme ocean temperatures events, known as marine heatwaves (MHWs), over the last few decades. While most studies have focused on surface events, MHWs can also occur in subsurface layers. However, little is known about the characteristics of subsurface events in the southeast Mediterranean Sea. Here we use a combination of ARGO float and high-resolution glider data collected between 1995-2015 to investigate the vertical propagation, seasonality, mean intensity and duration of subsurface MHWs around the Levantine basin. Given the critical role of the region as a formation site for Levantine Intermediate Waters, we further examine the influence of subsurface MHWs on water mass properties and regional ocean heat content, in the upper 1000m. Observational results are then compared against reanalysis product to assess model accuracy in capturing subsurface MHWs in the area. Our findings provide new insight into the properties of these events and guide efforts at estimating their effect on regional circulation, stratification, marine ecosystems and biogeochemistry in the Levantine basin.

Abstract #121

Environmental Impacts and Transition Challenges of Ocean Observation Systems: An Exploratory Study in France

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Keywords

Environmental footprint, Environmental impact assessment, Pressures-State-Responses, Research infrastructures (RIs)

Abstract

In the context of accelerating climate change and increasing anthropogenic pressures, the scientific observation of marine environments has become a strategic priority. In France, ocean observation research infrastructures (RIs) produce essential knowledge to understand environmental dynamics, anticipate risks, and inform public policies. However, these infrastructures also generate environmental impacts of their own — including energy consumption, reliance on research vessels, manufacturing and maintenance of instruments, waste production, large-scale data storage, and professional travel. This paradox — producing knowledge to protect the ocean while contributing to its degradation — lies at the heart of this research.

The work presented in this thesis was carried out during a 6-month professional internship in the field of ocean science and environmental transition. Its objective was to analyse the environmental footprint of French ocean observation RIs, identify the barriers hindering their ecological transition, and propose potential pathways for change. A qualitative methodology was employed, combining an extensive literature review with semi-structured interviews conducted across a variety of coastal and offshore infrastructures. The Pressures-State-Responses (PSR) framework was adapted to structure the analysis and examine existing mitigation strategies.

The findings reveal a growing awareness of environmental issues among RI stakeholders, although the level of engagement remains uneven. Several practical initiatives are emerging, including the mutualisation of sea campaigns, reuse and recovery of instruments, extension of sensor lifespan, reduction of energy consumption, and experimentation with low-tech approaches. At the institutional level, environmental labelling processes, monitoring tools, and professional networks are supporting gradual change. However, persistent challenges

include a strong attachment to conventional field practices, constraints linked to data production, fragmentation of the research system, a lack of dedicated resources, and the absence of shared methodological frameworks. A form of cognitive dissonance is also observed — environmental impacts are acknowledged but often justified in the name of scientific necessity.

This study suggests that the ecological transition within research must be approached not only as a technical challenge but also as a socio-organisational transformation. It requires rethinking professional identities, reassessing production models, and adapting governance structures. Several avenues for action are proposed: strengthening assessment tools, fostering training and collective reflection, developing shared standards, and promoting emerging practices such as low-tech solutions, participatory science, and digital sobriety. Collaboration, knowledge exchange, and co-construction of norms appear essential to achieving a coherent and collective transition.

Ultimately, oceanographic research infrastructures occupy a pivotal position: they produce indispensable knowledge while contributing to ecological pressures that now need to be addressed. The results of this internship indicate that transition is not only necessary but can serve as a lever for both scientific and societal innovation.

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