Innovative and cost-effective tools for ocean monitoring, fisheries resource management, and the assessment of climate-related challenges

Dr. Michela Martinelli

CNR
IRBIM
ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

FishMed-PhD Teaching week 2026
23 February 2026

michela.martinelli@cnr.it

Course Outline

- Icebreaker
- **Module 1** Setting the Stage: Climate Change Science and Global Policy Frameworks
- **Module 2** Observing the ocean: Ecosystem Value, Blue Growth, Data Stewardship and Observational Platforms
- **Module 3** Enabling Solutions: Sensor-Platform Integration and Innovative Technologies
- **Module 4** Monitoring in Action: Case Studies and Future Challenges

My Background & Expertise

CNR IRBIM
ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

CENTERS NEWS CONTACTS MARINE RESEARCH CNR EN

MENU

HOME / PEOPLE / MICHELA MARTINELLI

BACK TO HOME

Michela Martinelli
Senior Technologist

BACK TO INDEX

M.Sc. (2004) in Marine and Oceanographic Biology, Ph.D. (2010) in Marine Biology and Ecology, since 2006 she has collaborated and since 2009 she has been Technologist at CNR Ancona. She deals with the development of innovative monitoring tools (e.g., Fisheries and Oceanography Observing Systems), fishery resource assessment, GIS, and databases (e.g., surveys, biological sampling of commercial catches, etc.). From 2010 to 2019, she was in charge for the UnderWater TeleVision program for monitoring Norway lobster in the central Adriatic (carried out in collaboration with IZOR Split and FAO AdriaMed, and sponsored by RITMARE from 2012 to 2015), and from 2016 to 2023, she also led a monitoring program for the Pomo Fishery Restricted Area (sponsored by MIPAAF). Since 2013, she is responsible for the AdriFOOS infrastructure and related activities in EU projects (e.g., FP7 JERICO, FP7 NEXOS, H2020 JERICO NEXT, H2020 NAUTILOS). She participates in numerous national and international working groups (for example, she is part of the Steering Committee of the Fishing Vessel Ocean Observing Network).

IRBIM
INSTITUTE FOR MARINE BIOLOGICAL RESOURCES AND BIOTECHNOLOGY

The Institute for Marine Biological Resources and Biotechnology of the National Research Council (IRBIM CNR) is dedicated to advancing scientific research on life, ecosystems and biodiversity in seas and oceans.

FIND OUT MORE

https://www.irbim.cnr.it/en/

https://orcid.org/0000-0003-1231-2346

michela.martinelli@cnr.it


LET'S
BREAK
THE ICE

Esegui la scansione del codice a matrice o usa il collegamento per partecipare

https://forms.office.com/e/G6DEuSZJ2D

Copia collegament

3 risposte inviate

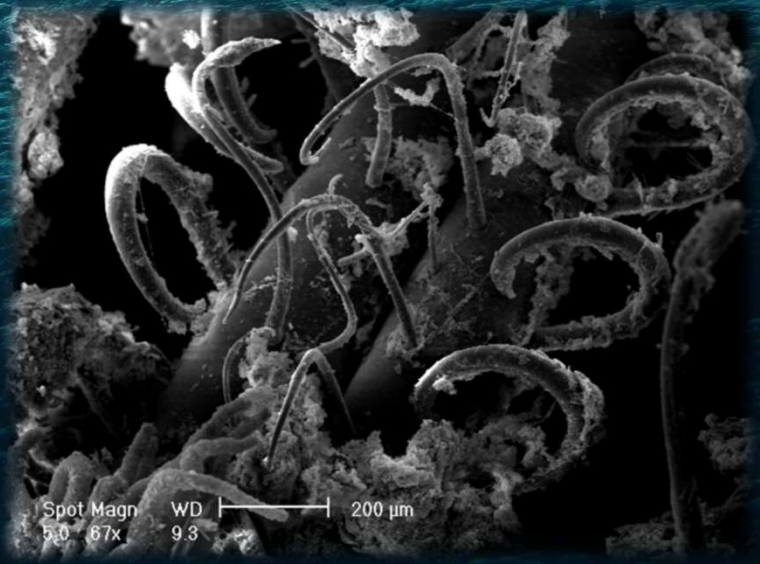
What is your background?

Wordcloud | Tutte le risposte

1 di 1

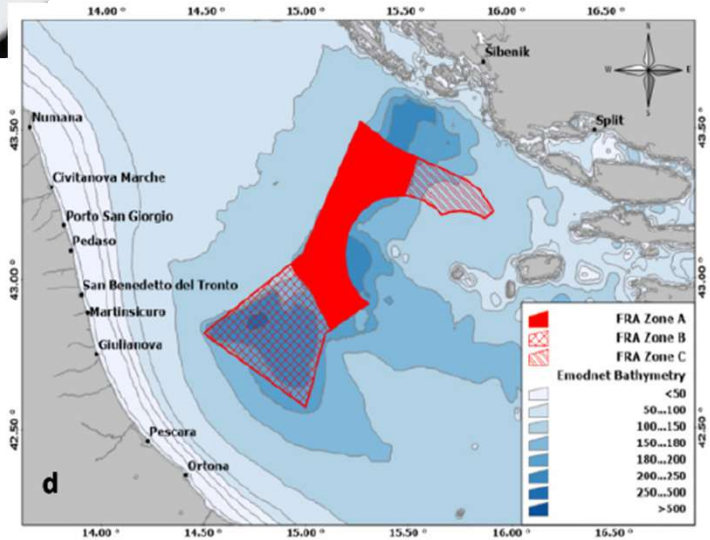
Early Career

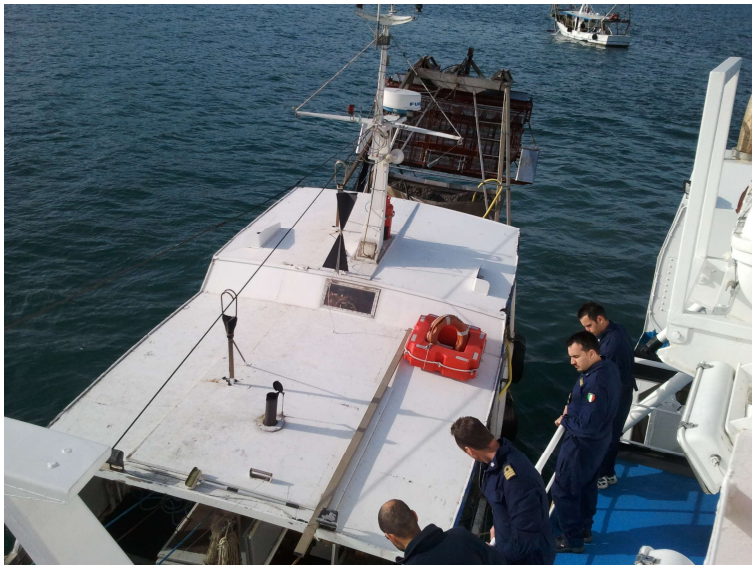
Doctoral thesis:
Masking behaviour, morphological adaptations and epibiosis in brachyuran crabs



Professional Trajectory:

- Biology of commercial species (focus on decapod crustaceans)
- Sustainable exploitation of fishery resources
- Oceanography
- Vulnerable Marine Ecosystems
- …..





Technical skills:

- Knowledge of fishing techniques and environmental regulations,
- Planning and coordination of surveys at sea,
- Geographic Information System, development and management of databases
- …..

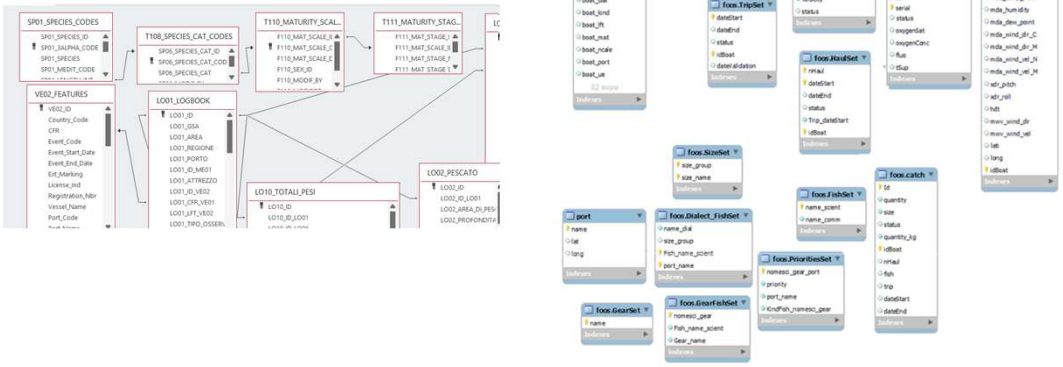
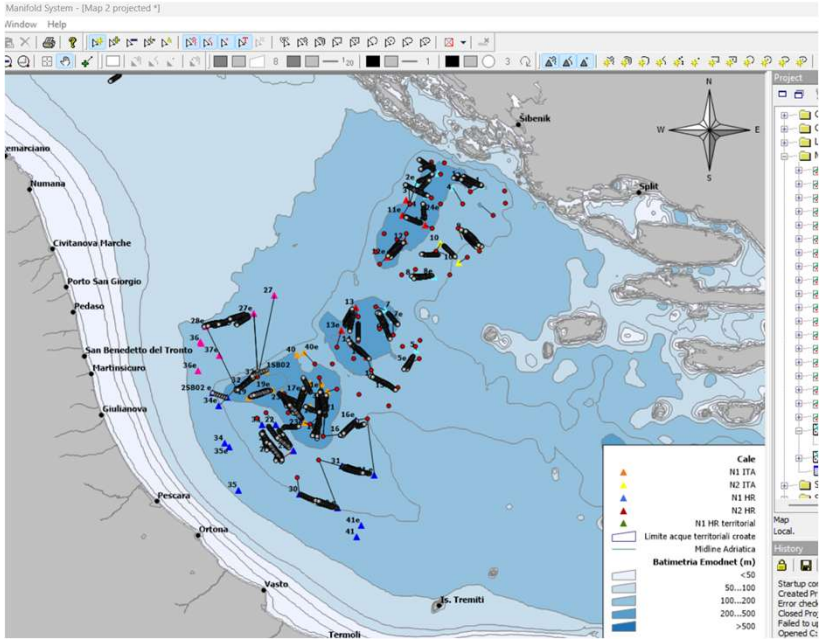
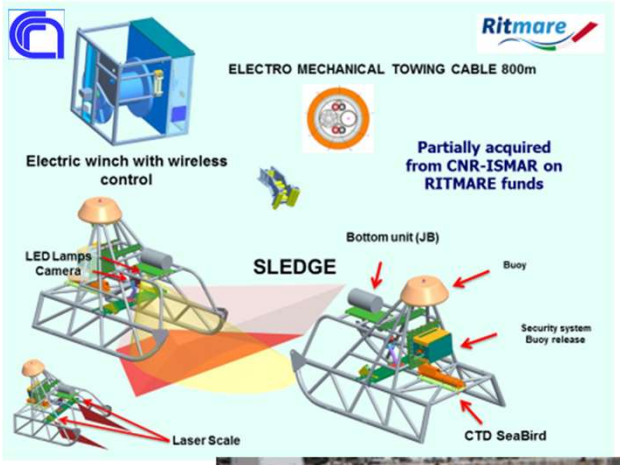
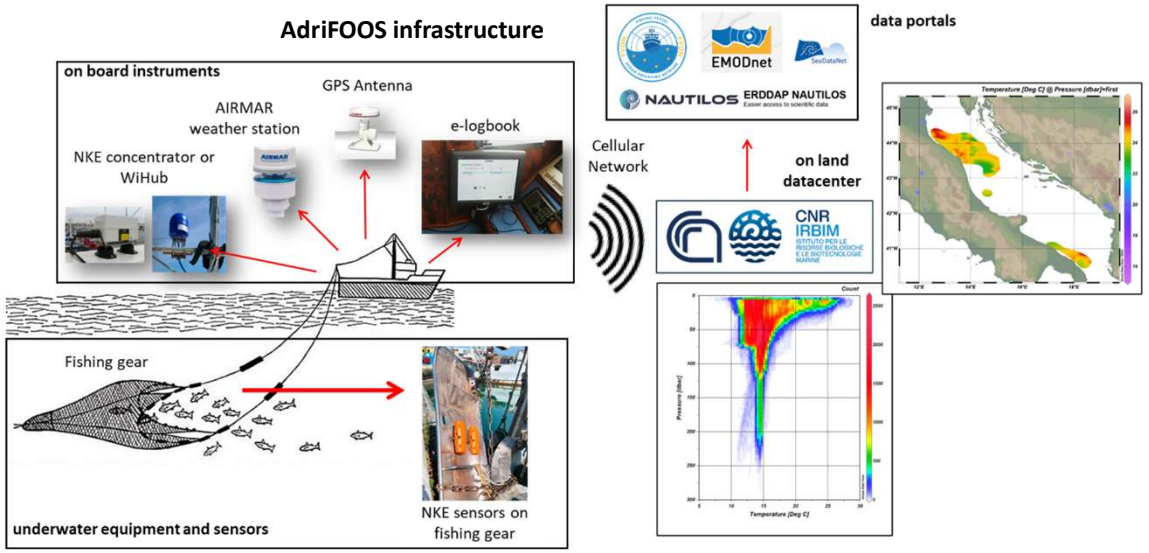


Figure S1. Schema of the relational database embedded in the AdriFOOS on land datacenter (diagram made by means of MySQL Workbench 8.0).





UWTV equipment



Innovative monitoring technologies

michela.martinelli@cnr.it

Esegui la scansione del codice a matrice o usa il collegamento per partecipare

https://forms.office.com/e/G6DEuSZJ2D

Copia collegamento

24 risposte inviate

What is your background?

Wordcloud | Tutte le risposte

1 di 1

Module 1
Setting the Stage: Climate Change Science and Global Policy Frameworks

Content:

Climate Change Definitions
Key Institutions
Data Sources

International Olympic Committee

For more than a century, the Olympic Winter Games have helped winter sport develop and deliver lasting benefits for their host regions. Climate change is now reshaping sport as we know it, requiring the Games to evolve responsibly.

Milano Cortina 2026 reflects this evolution through a more flexible, regionally distributed model that maximises existing venues, reduces environmental impact and strengthens community resilience. Innovation in snow-making technologies, clean energy and low-carbon mobility is helping ensure safe, fair and reliable competition while supporting host regions in adapting to a changing climate.

WORLD ECONOMIC FORUM

Join us Sign in

CLIMATE ACTION AND WASTE REDUCTION

The Winter Olympics aren't immune to climate change. Here's how the Games could change

Published Feb 16, 2026 · Updated Feb 13, 2026

The Policy Lens:

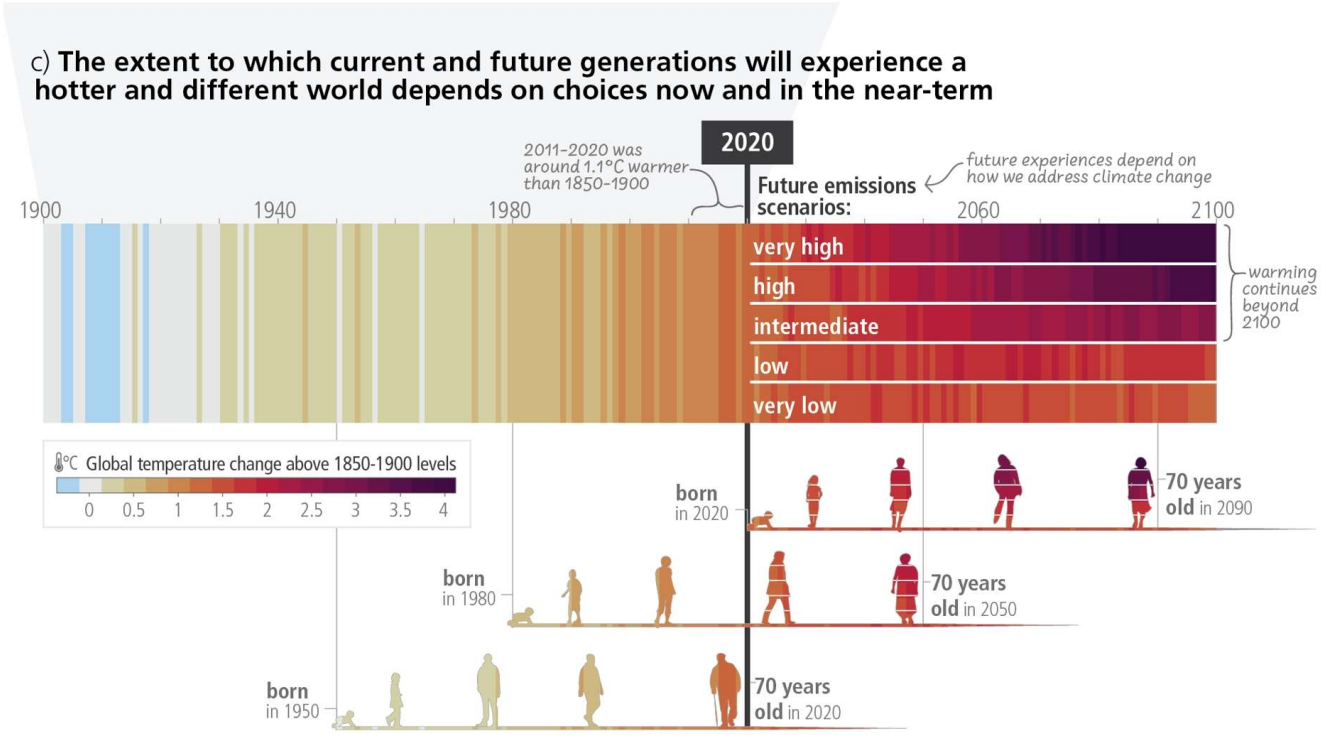
United Nations Framework Convention on Climate Change (UNFCCC) & the Conference of the Parties (COP)

- Founded in 1992, the UNFCCC provides the international foundation for multilateral action against climate change and its impacts on humanity and ecosystems.
- The 1997 Kyoto Protocol and the 2015 Paris Agreement were negotiated under the UNFCCC framework.
- Annual Meetings: COP is the supreme decision-making body of the UNFCCC, meeting annually to review progress.

https://unfccc.int/resource/bigpicture/

UNFCCC defines "**climate change**" in Article 1 as:

"a change of climate which is **attributed directly or indirectly to human activity** that alters the composition of the global atmosphere."



IPCC. (2023). Summary for Policymakers. In: *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 1-34.

Policy Implication:
This specific definition establishes the legal basis for responsibility and mitigation under international law, focusing exclusively on human-induced change.

The Scientific Lens:
Intergovernmental Panel on Climate Change (IPCC)

- UNFCCC encourages research, systematic observation, and cooperation with international programmes.
- **Science** provides the foundation for understanding climate change and informing policy under the UNFCCC.
- **Role:** The IPCC is the UN body for assessing the science related to climate change.
- **Purpose:** Created to provide policymakers with regular scientific assessments on the implications, risks, and mitigation options.
- **Outputs:** assesses global research and compiles methodologies, comprehensive assessment reports, special reports.
- **Info:** https://www.ipcc.ch/

What is climate change according to IPCC?

A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/ or the variability of its properties and that persists for an extended period, typically decades or longer.

What causes climate change?

It is due to **natural internal processes or external forcings** such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use.

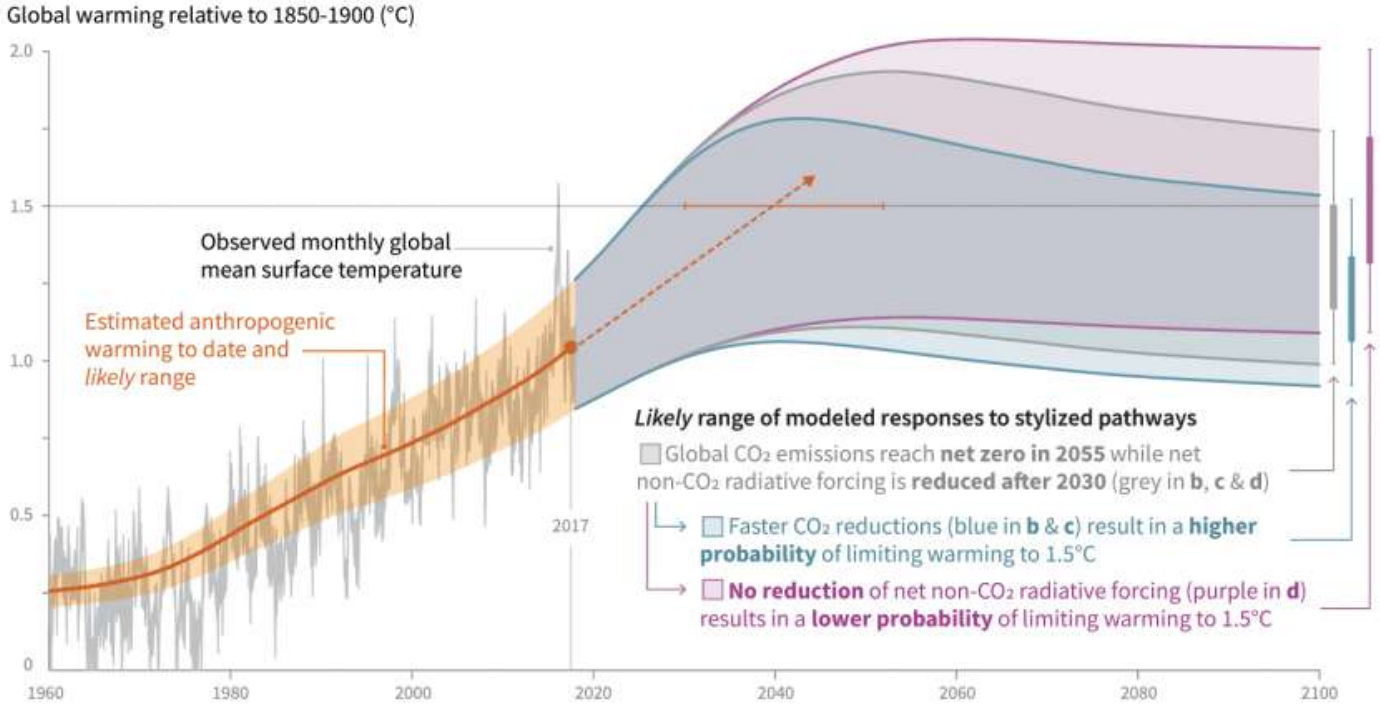
What is global warming?

Global surface temperature increase relative to a baseline, averaged over 20-30 years to filter out year-to-year fluctuations.

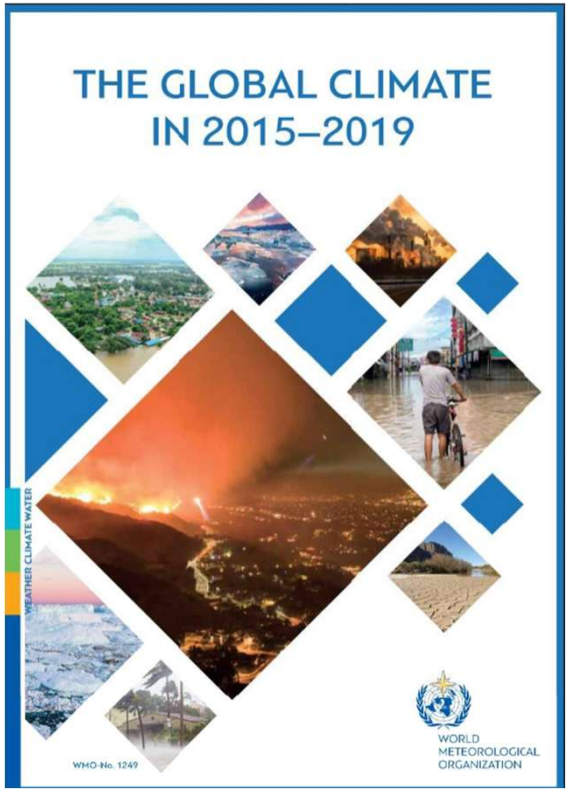
A common baseline is the period 1850 -1900, as it represents the earliest timeframe with reliable observations and adequate geographic coverage.
More contemporary baselines may be used depending on the specific application.

a) Observed global temperature change and modeled responses to stylized anthropogenic emission and forcing pathways

IPCC, 2018: Summary for Policymakers. 10.1017/9781009157940.001.



IPCC, 2021 Climate Change 2021: The Physical Science Basis doi:10.1017/9781009157896.022. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_6_WGI_AnnexVII.pdf



The **World Meteorological Organization (WMO)** publishes annual "State of the Global Climate" reports, providing updates on trends and impacts.

https://library.wmo.int/records/item/57035-global-climate-in-2015-2019

Scientific Visualization Studio

Galleries Help Search...

Climate Essentials

Released Wednesday, November 10th, 2021

Updated Friday, January 24th, 2025 at 12:00AM

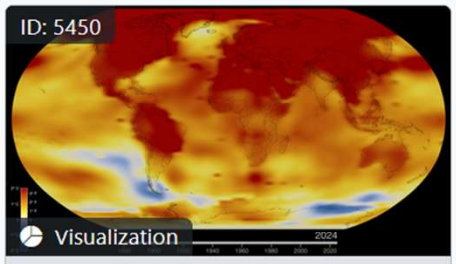
ID: 40016

Contents

Overview

This Climate Essentials multimedia gallery brings together the latest and most popular climate-related images, data visualizations and video features from Goddard Space Flight Center. For more multimedia resources on climate and other topics, search the Scientific Visualization Studio. To learn more about NASA's contribution to understanding Earth's climate, visit the Global Climate Change site.

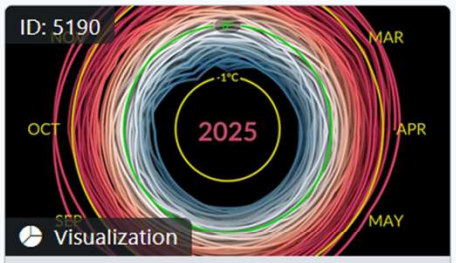
Temperature Visualizations



Global Temperature Anomalies from 1880 to 2024

January 10, 2025

This color-coded map in Robinson projection displays a progression of changing global surface temperature anomalies. Normal temperatures are

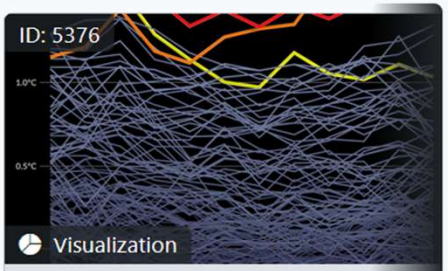


NASA Climate Spiral 1880-Present

November 15, 2023

(updated January 14, 2026 at 2:39 PM EST)

The NASA climate spiral visualization of the GISTEMP global temperature record.



Record Temperature Years: 2024, 2023, and 2016

January 10, 2025

A visualization of global temperature anomalies highlighting the record years of 2024, 2023, and 2016. The visualizations morphs between a data grid showing

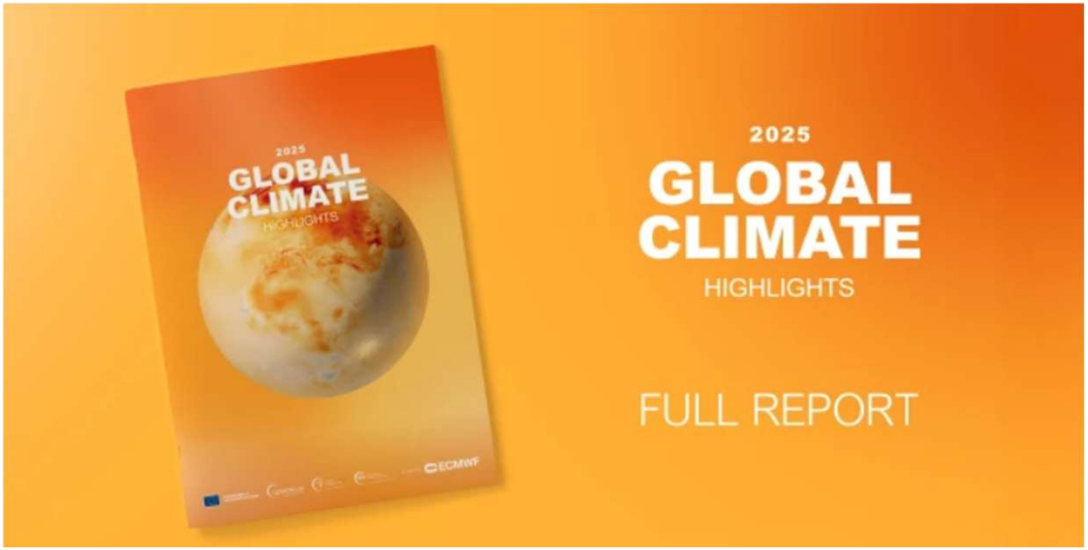
https://svs.gsfc.nasa.gov/gallery/climate-essentials/

Copernicus

the Earth observation component of the European Union's Space programme

Climate Change

We provide authoritative information about the past, present and future climate, as well as tools to enable climate change mitigation and adaptation strategies by policy makers and businesses.



https://climate.copernicus.eu/sites/default/files/custom-uploads/GCH-2025/GCH2025-full-report.pdf

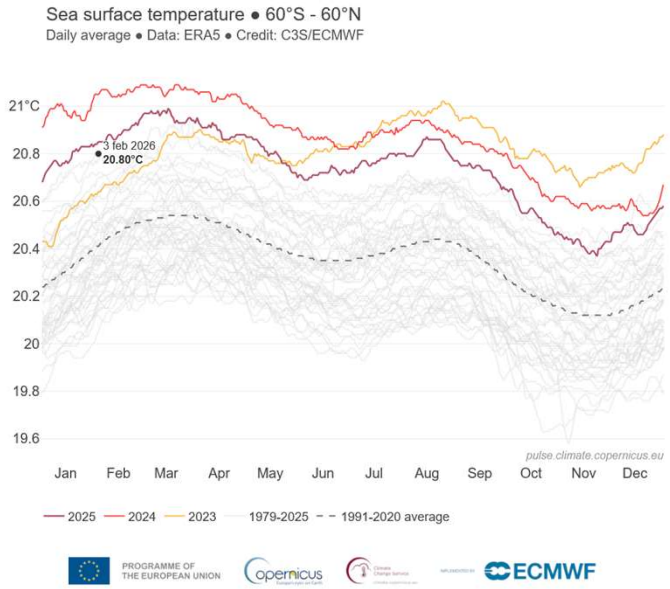
PROGRAMME OF THE EUROPEAN UNION

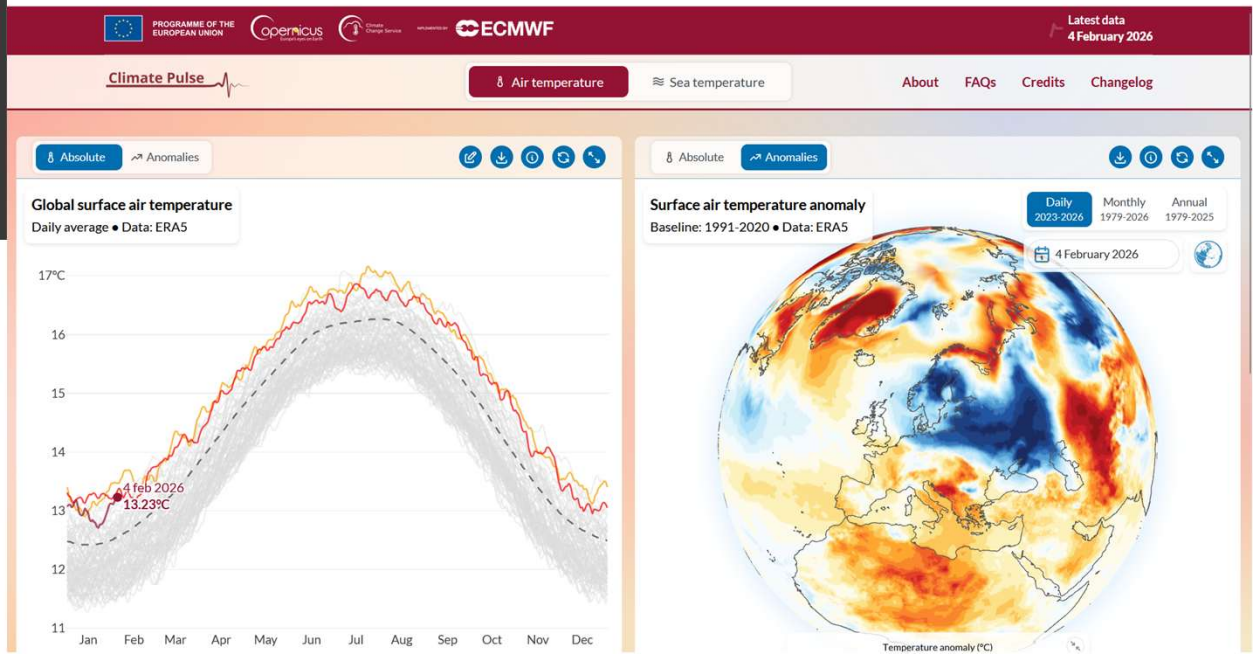
Copernicus
Europe's eyes on Earth

Climate Pulse

Climate Pulse provides near real-time updates of key global climate variables from the Copernicus Climate Change Service (C3S).

C3S is implemented by the European Centre for Medium-Range Weather Forecasts (ECMWF) on behalf of the European Commission as part of the European Union's space programme.



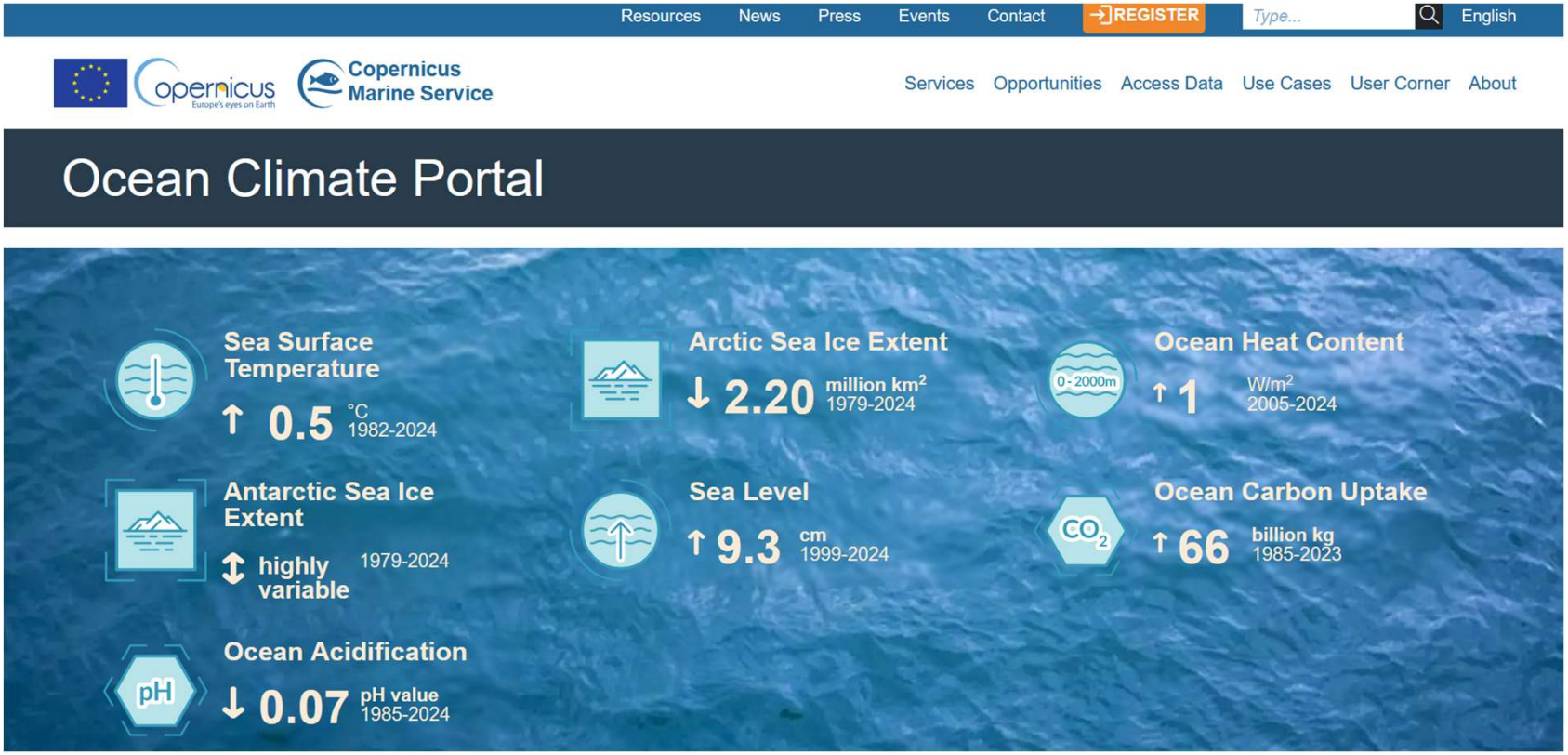


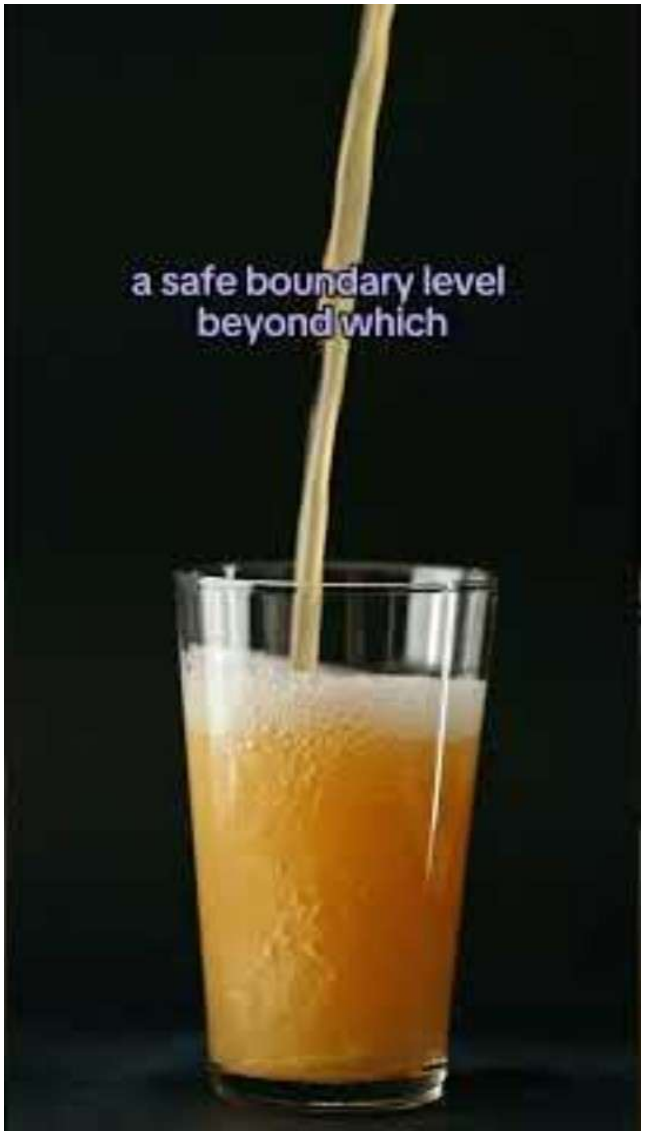
https://pulse.climate.copernicus.eu/

Copernicus Marine Service

Providing free and open marine data and services to enable marine policy implementation, support Blue growth and scientific innovation.

https://marine.copernicus.eu/ocean-climate-portal





https://www.youtube.com/shorts/M-xktkH_6j0?feature=share

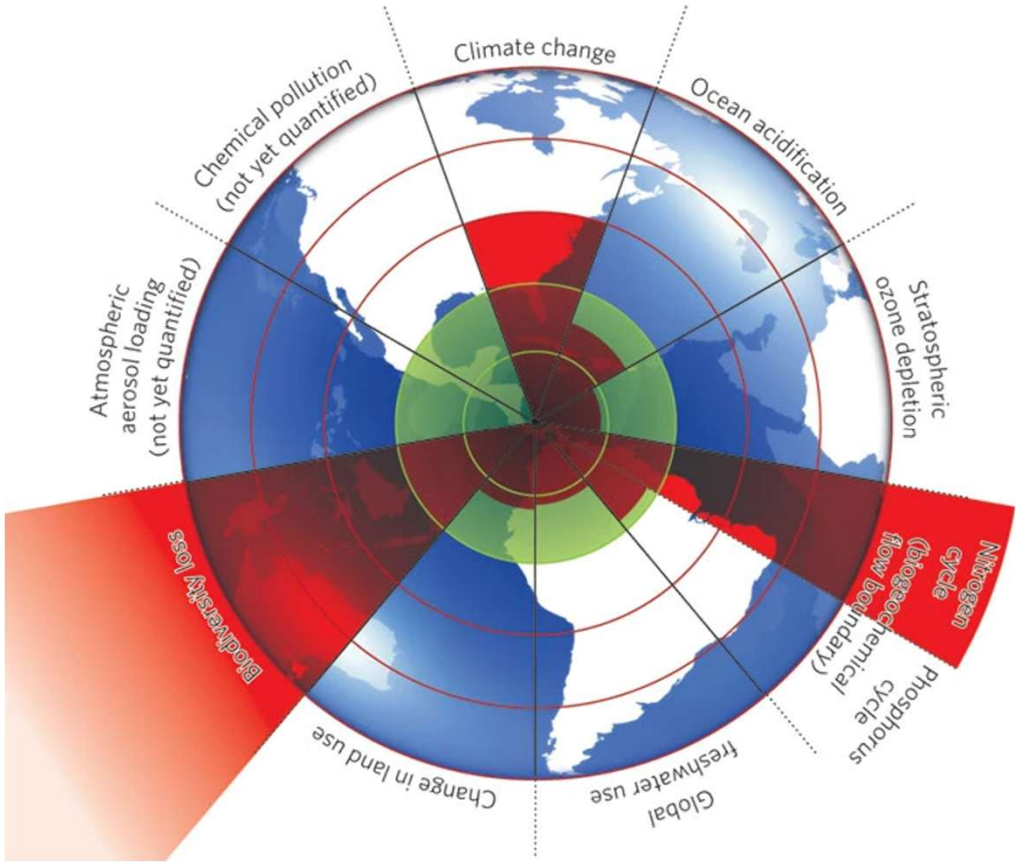
nature

Explore content | About the journal | Publish with us

nature > features > article

Feature | Published: 23 September 2009

A safe operating space for humanity



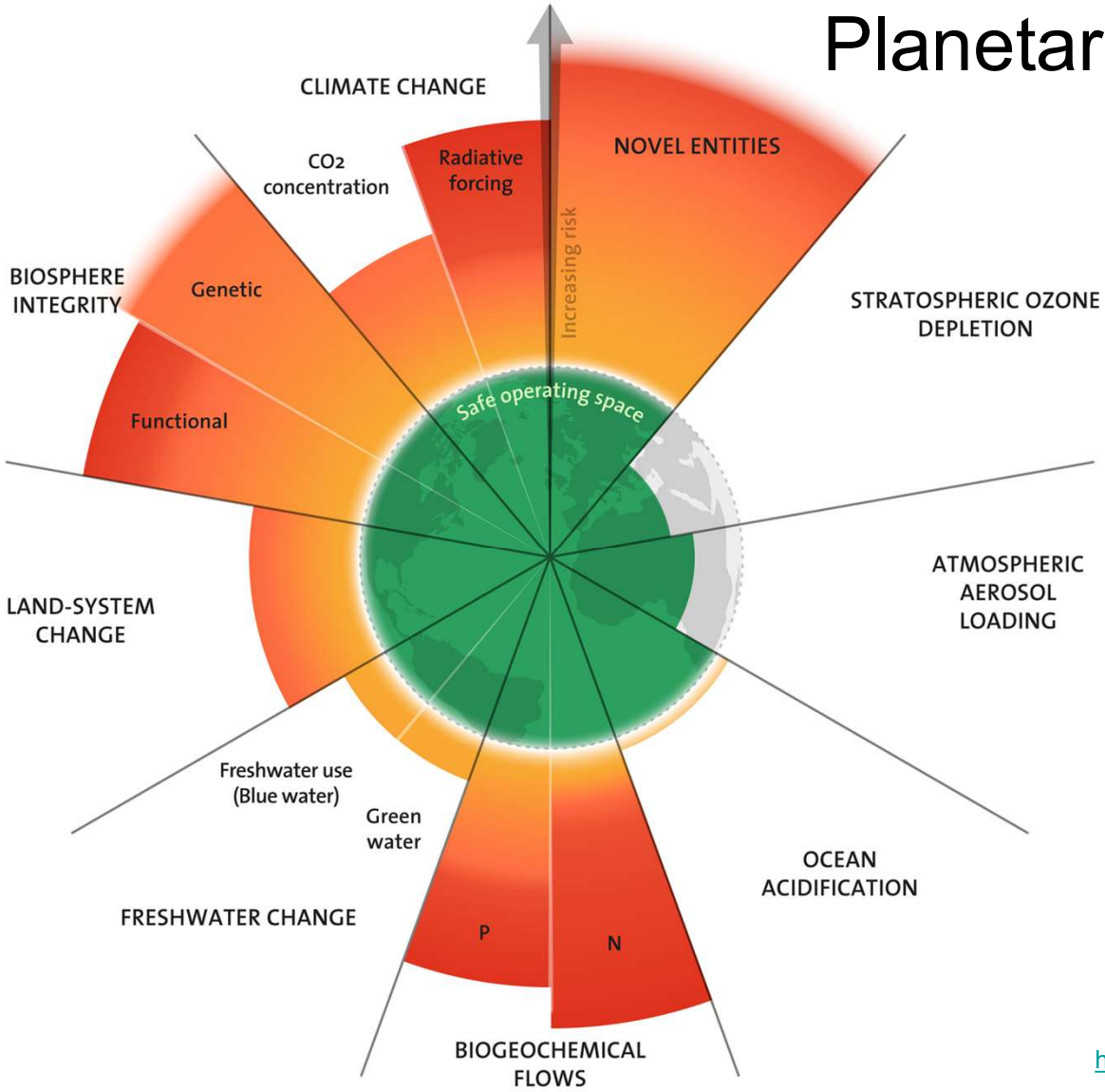
Rockström et al. 2009
https://doi.org/10.1038/461472a

Green shading: proposed **safe operating space** for nine planetary systems.

Red wedges: **estimate** of 2009 position for each variable.

Boundaries in rate of **biodiversity loss**, **climate change** and human interference with **nitrogen cycle** had already been exceeded.

Planetary Boundaries Approach



Proposed in 2009 by The Stockholm Resilience Centre defines a "safe operating space for humanity".

Concept: Identifies nine critical Earth system processes essential for maintaining global stability and resilience.

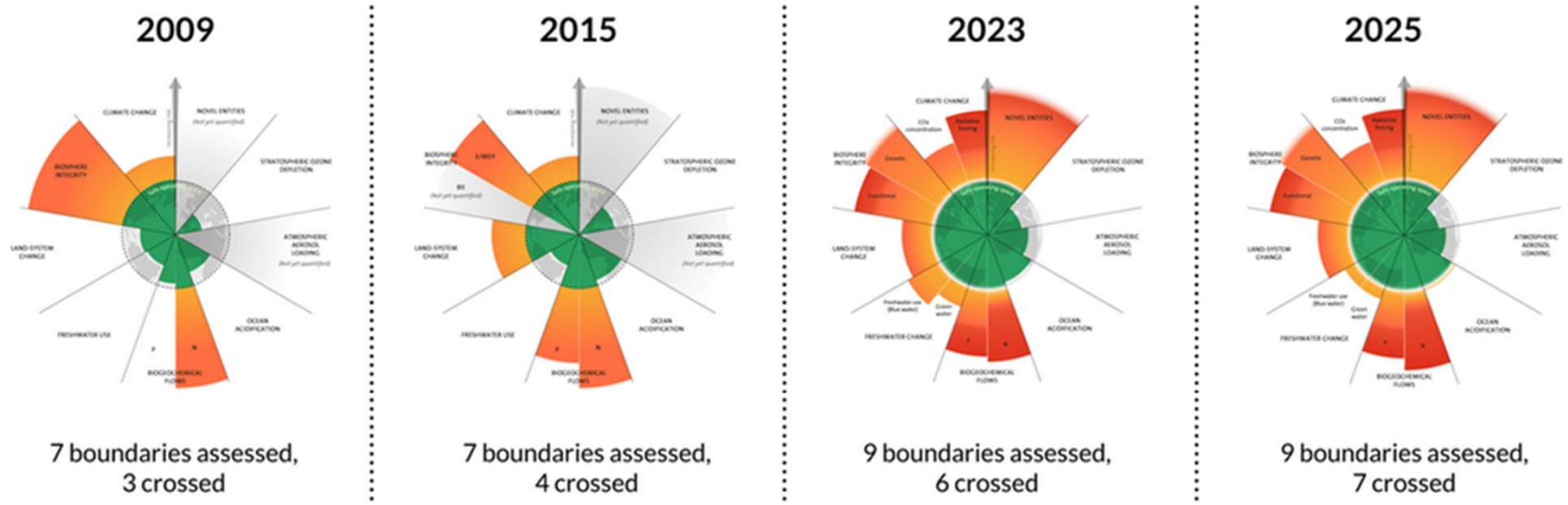
Thresholds: Transgressing these boundaries increases the risk of losing life support stability and nature's ability to absorb shocks.

The 2025 update to the Planetary boundaries. Licensed under CC BY-NC-ND 3.0. Credit: "Azote for Stockholm Resilience Centre, based on analysis in Sakschewski and Caesar et al. 2025".

https://www.stockholmresilience.org/research/planetary-boundaries.html

Stockholm Resilience Centre | Stockholm University

Planetary boundaries



The evolution of the planetary boundaries framework. Licenced under CC BY-NC-ND 3.0 (Credit: Azote for Stockholm Resilience Centre, Stockholm University. Based on Sakschewski and Caesar et al. 2025, Richardson et al. 2023, Steffen et al. 2015, and Rockström et al. 2009).

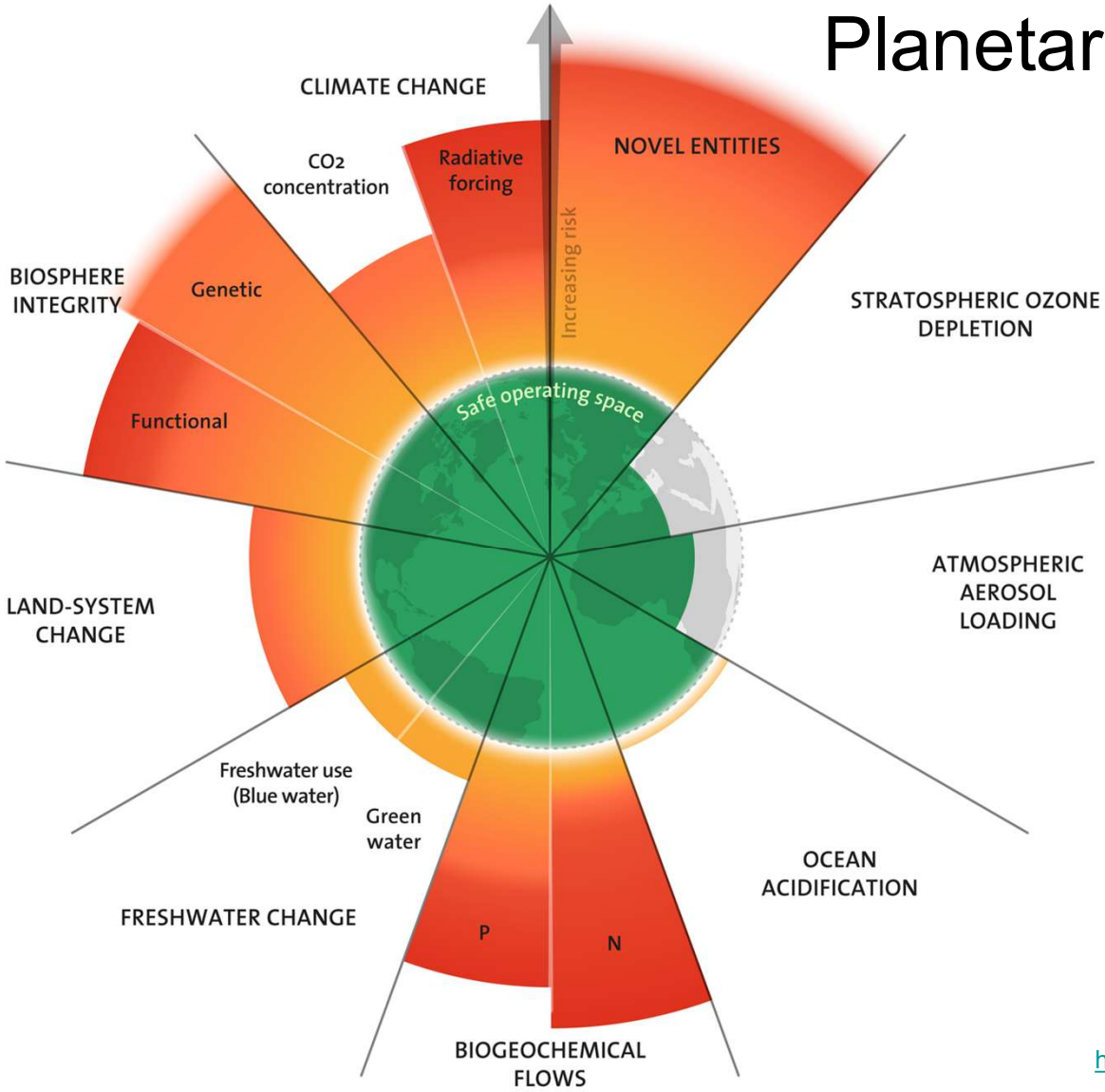
Status of the Nine Boundaries

https://youtu.be/ndPVcg6uSZc

- Recent analysis indicates that **seven of the nine boundaries are now transgressed** (outside the green zone).
- **Climate Change:** Transgressed, CO2 concentrations rising above safe levels.
- **Novel Entities:** In high-risk zone due to synthetic substances released without adequate testing.
- **Ocean Acidification:** Breached for the first time as of the 2025 assessment.

https://www.planetaryhealthcheck.org

Planetary Boundaries Approach



Proposed in 2009 by The Stockholm Resilience Centre defines a "safe operating space for humanity".

Concept: Identifies nine critical Earth system processes essential for maintaining global stability and resilience.

Thresholds: Transgressing these boundaries increases the risk of losing life support stability and nature's ability to absorb shocks.

The 2025 update to the Planetary boundaries. Licensed under CC BY-NC-ND 3.0. Credit: "Azote for Stockholm Resilience Centre, based on analysis in Sakschewski and Caesar et al. 2025".

https://www.stockholmresilience.org/research/planetary-boundaries.html

The Threshold of Irreversibility: Global Tipping Points

Definition:
A tipping point is a **"critical threshold that, when crossed, leads to large, accelerating and often irreversible changes in the climate system."**

Risk:
Harmful tipping points threaten humanity by disrupting life support systems and societal stability globally.

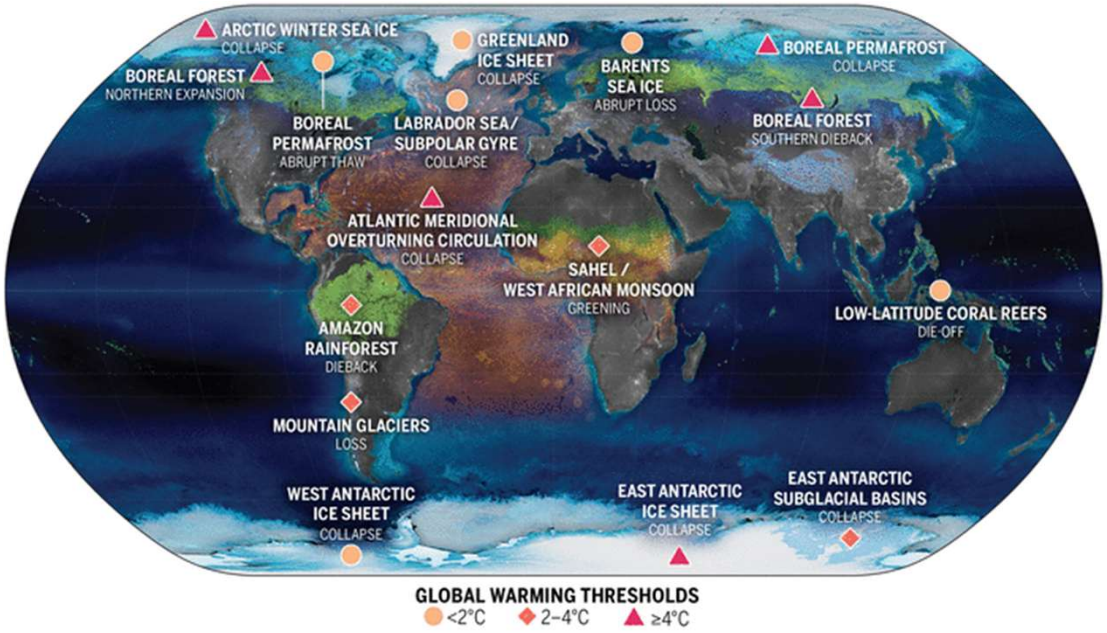
Mitigation:
Positive tipping points are opportunities where beneficial changes become self-sustaining.

Global Tipping Points Report 2025 prepared for COP30.

https://global-tipping-points.org/

- Tipping events possess "catastrophic potential" not always represented in traditional climate models.
- The system is interconnected: crossing one point can accelerate others.

Exceeding 1.5°C global warming could trigger multiple climate tipping points.



Examples of Major Tipping Points

Cryosphere (Ice): Greenland & West Antarctic Ice Sheets collapse; Arctic summer sea ice disappearance; Permafrost thaw (methane release).

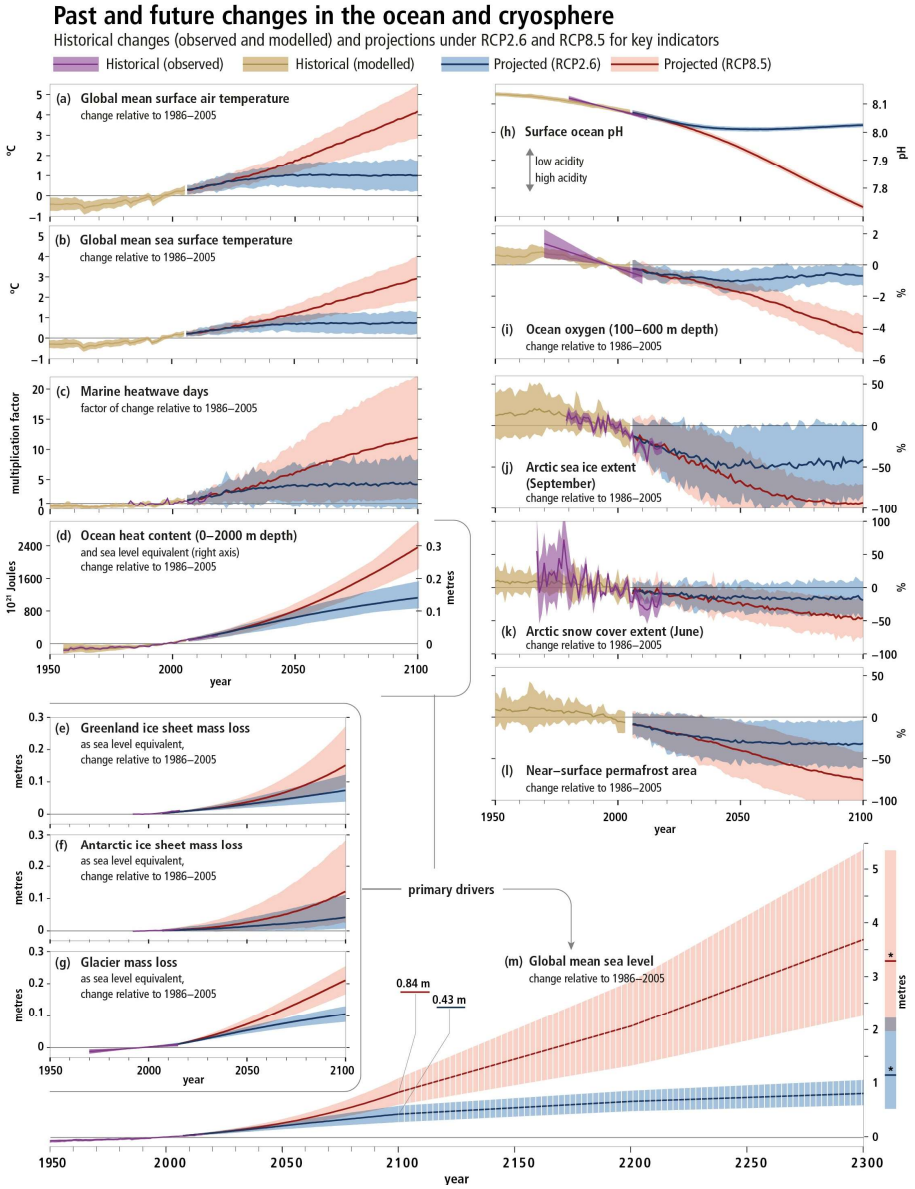
Ocean Circulation: AMOC (Atlantic Meridional Overturning Circulation) slowdown or collapse.

Biosphere: Amazon rainforest dieback; Mass coral reef bleaching and death.

Armstrong McKay et al 2022. Science
https://www.science.org/doi/10.1126/science.abn7950

IPCC SROCC Framework

- **IPCC's Mission**: provide policymakers with periodic scientific assessments on climate change, projected future risks, and viable adaptation and mitigation strategies.
- **SROCC Report**: Special Report on the Ocean and Cryosphere in a Changing Climate, September 2019, https://doi.org/10.1017/9781009157964
- **Key Contribution**: SROCC offers an exhaustive **risk assessment of historical and projected changes across the ocean and cryosphere**, detailing their interconnections within the Earth system through the global cycling of heat, water, and carbon.



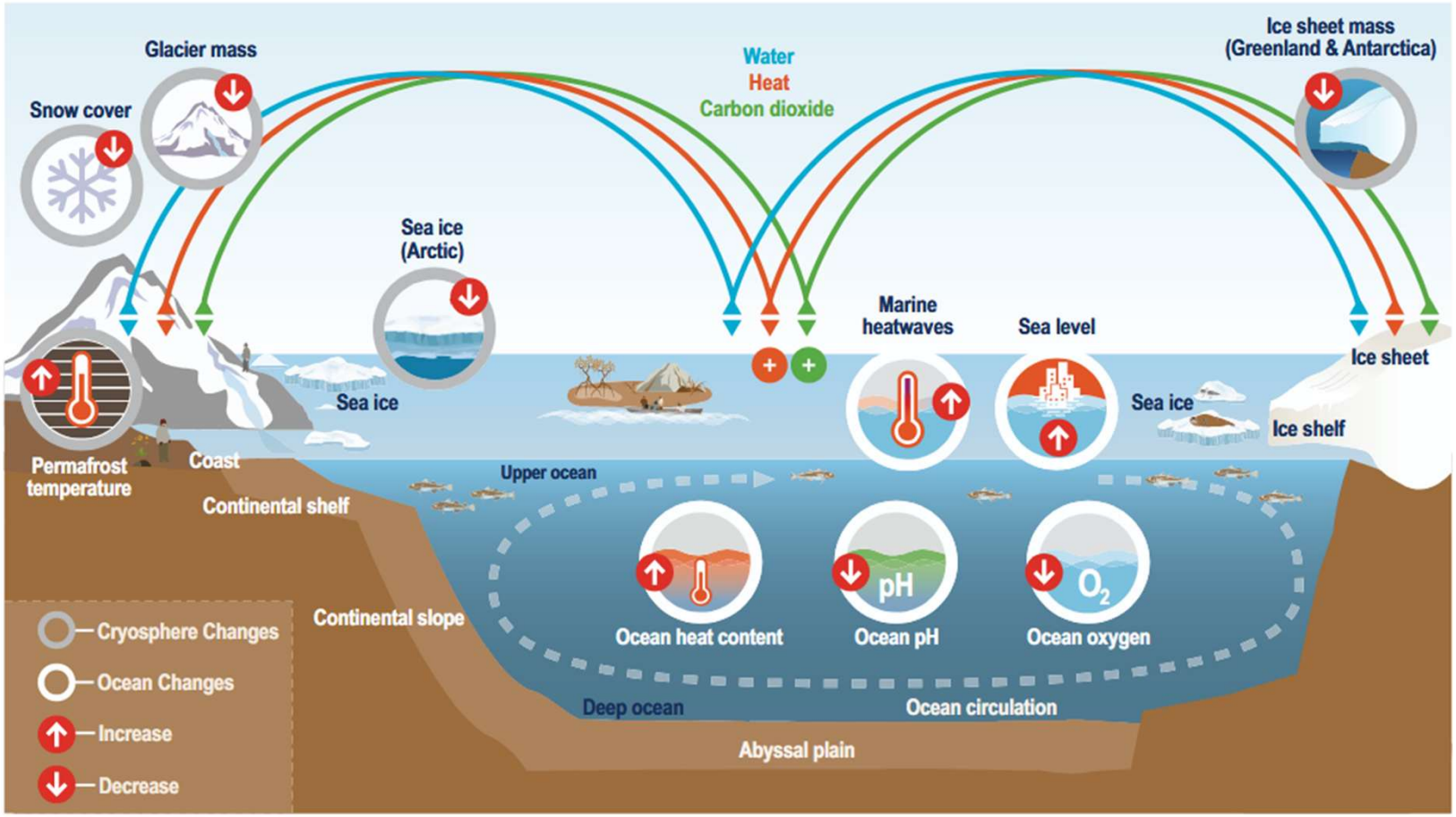


Figure TS.2 | Schematic illustration of key components and changes of the ocean and cryosphere, and their linkages in the Earth system through the global exchange of heat, water, and carbon (Section 1.2). Climate change-related effects (increase/decrease indicated by arrows in pictograms) in the ocean include sea level rise, increasing ocean heat content and marine heat waves, increasing ocean oxygen loss and ocean acidification (Section 1.4.1). Changes in the cryosphere include the decline of Arctic sea ice extent, Antarctic and Greenland ice sheet mass loss, glacier mass loss, permafrost thaw, and decreasing snow cover extent (Section 1.4.2). For illustration purposes, a few examples of where humans directly interact with ocean and cryosphere are shown (for more details see Box 1.1).

Observed regional impacts from changes in the ocean and the cryosphere

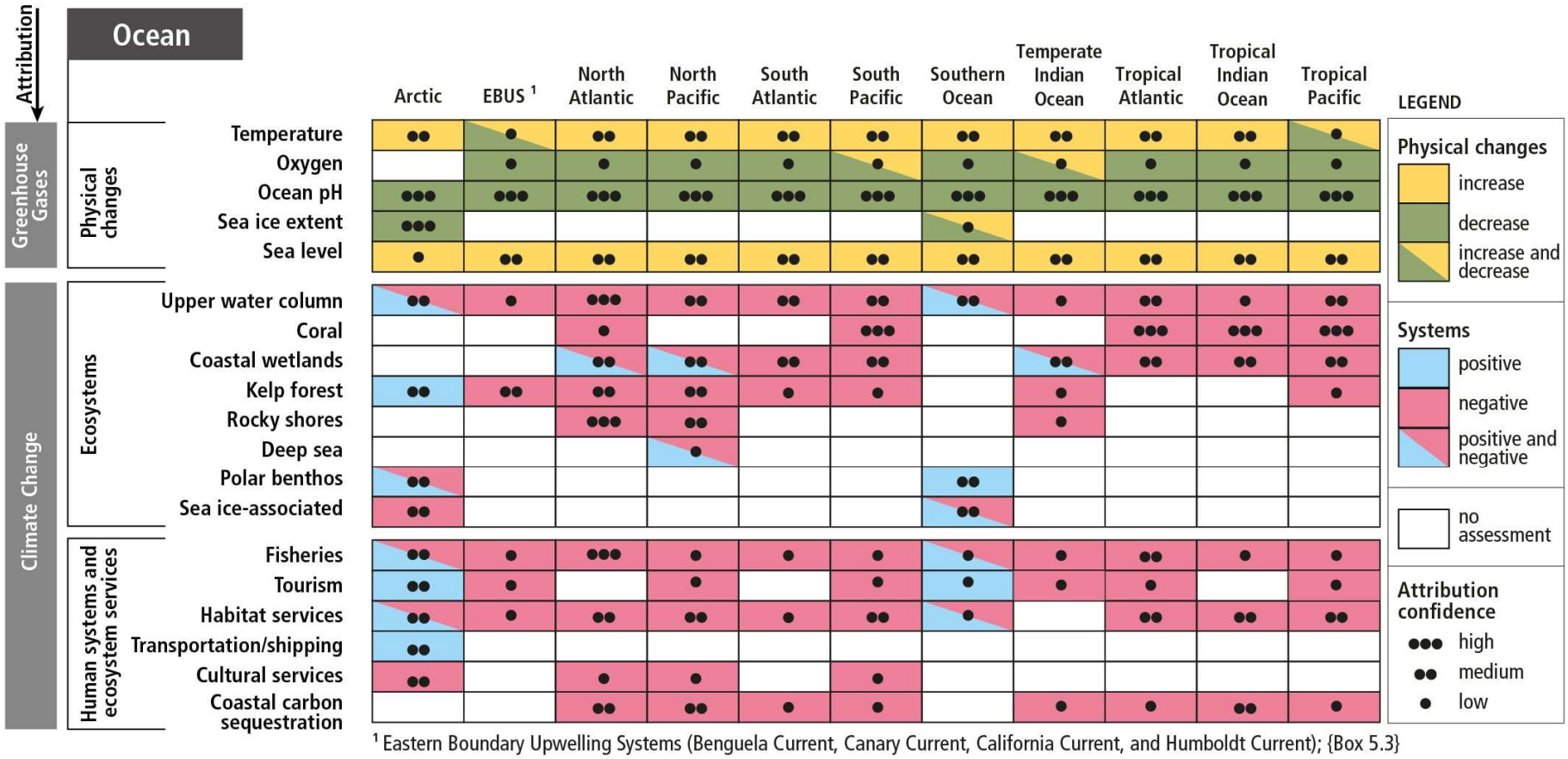
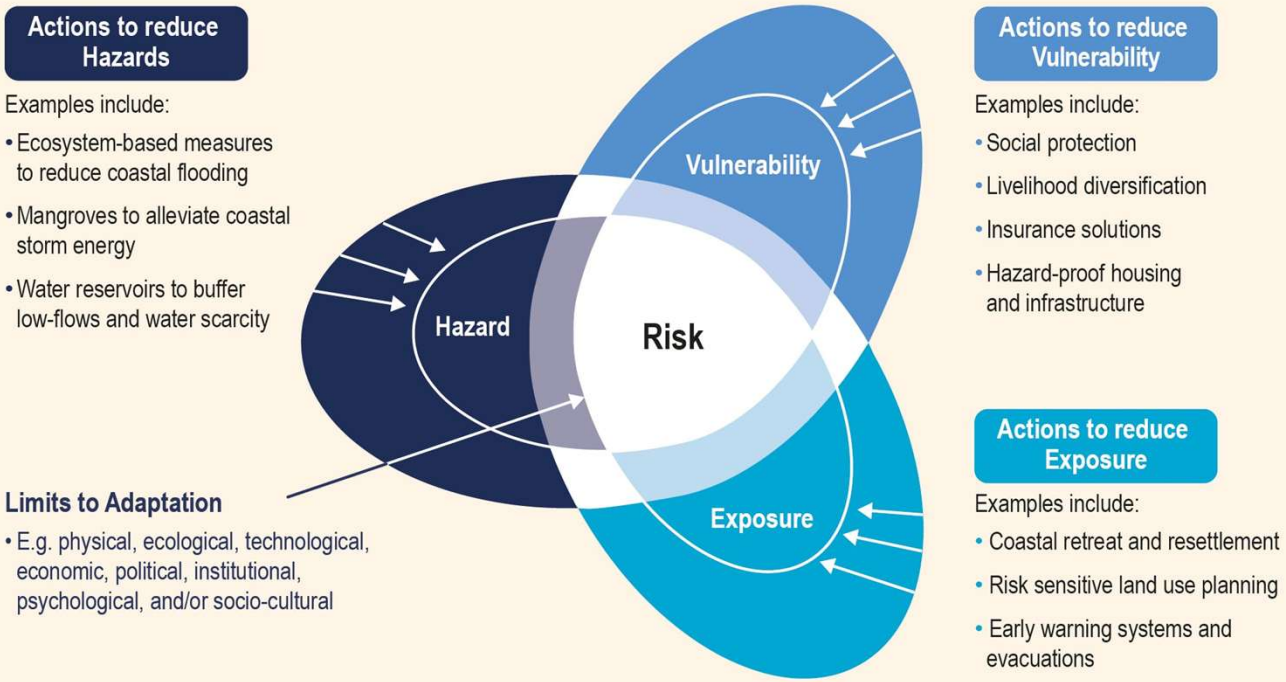


Figure SPM.2 | Synthesis of observed regional hazards and impacts in ocean assessed in SROCC.

Coffee Break

Food for thought: Risk reduction through Adaptation



The reduction of vulnerability, exposure, and/or hazard potential can be achieved through different **policy and action** choices over time until limits to adaptation might be reached.

https://www.ipcc.ch/srocc/chapter/technical-summary/ts-0-introduction/ipcc-srocc-ts_4/

Positive Message:

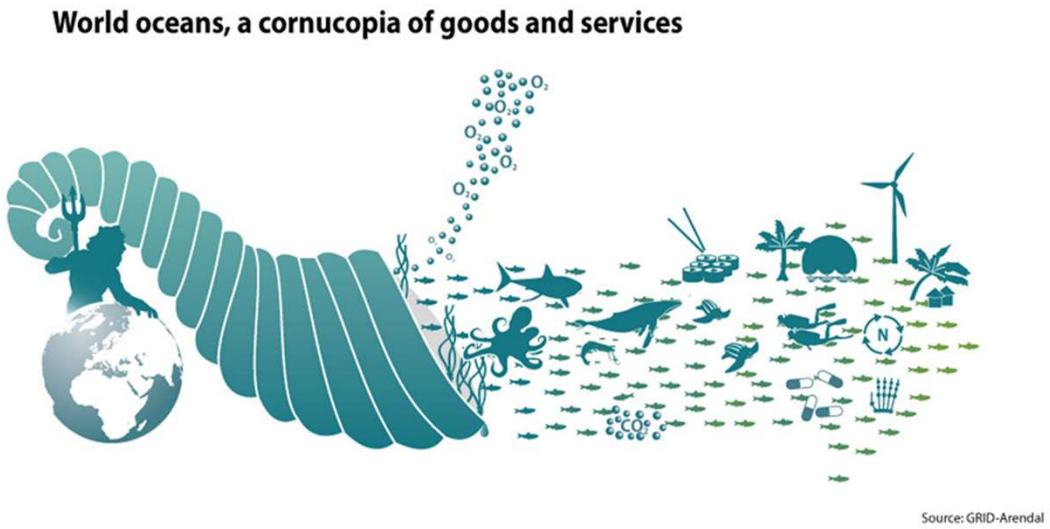
Adaptation can reduce risk by addressing **risk factors: vulnerability, exposure, and/or hazard**.

Question:

What are the essential requirements for developing effective 'Early Warning Systems' and 'Nature-based Solutions'?

Up next:
Module 2 – Observing the ocean: Ecosystem Value, Blue Growth, and Data Stewardship.

MODULE 2 Observing the ocean: Ecosystem Value, Blue Growth, Data Stewardship and Observational Platforms



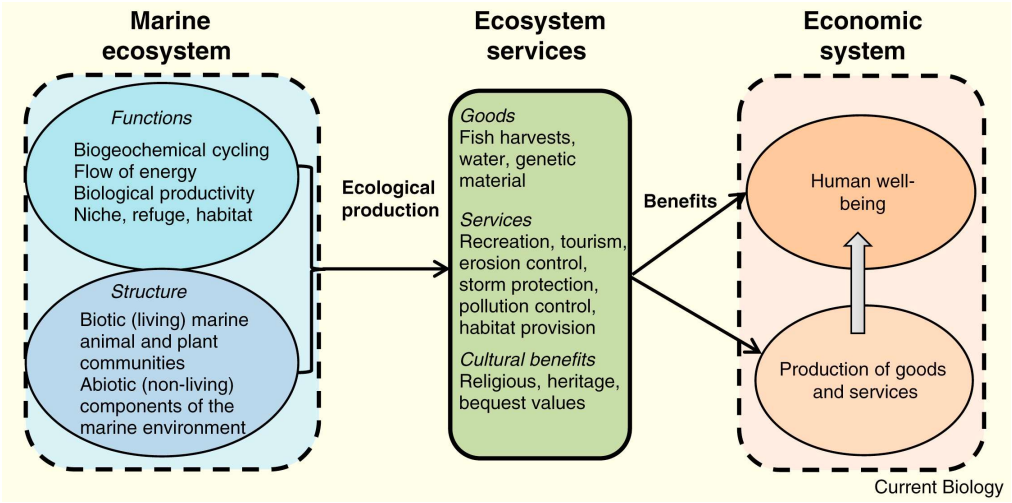
Natural Capital and Marine/Coastal ecosystem services

Example of benefits provided to humans by marine ecosystems:

Goods	Services	Cultural benefits
• Fish harvests	• Recreation and tourism	• Carbon sequestration
• Wild plant and animal resources	• Transportation	• Bequest for future generations
• Raw materials	• Scientific and educational opportunities	• Religious significance
• Genetic material	• Flood control	
• Water	• Storm protection	
	• Pollution control	
	• Breeding and nursery habitats	
	• Shoreline stabilization and erosion control	
	• Carbon sequestration	

Barbier 2017
https://doi.org/10.1016/j.cub.2017.03.020

How marine ecosystems generate economic benefits?



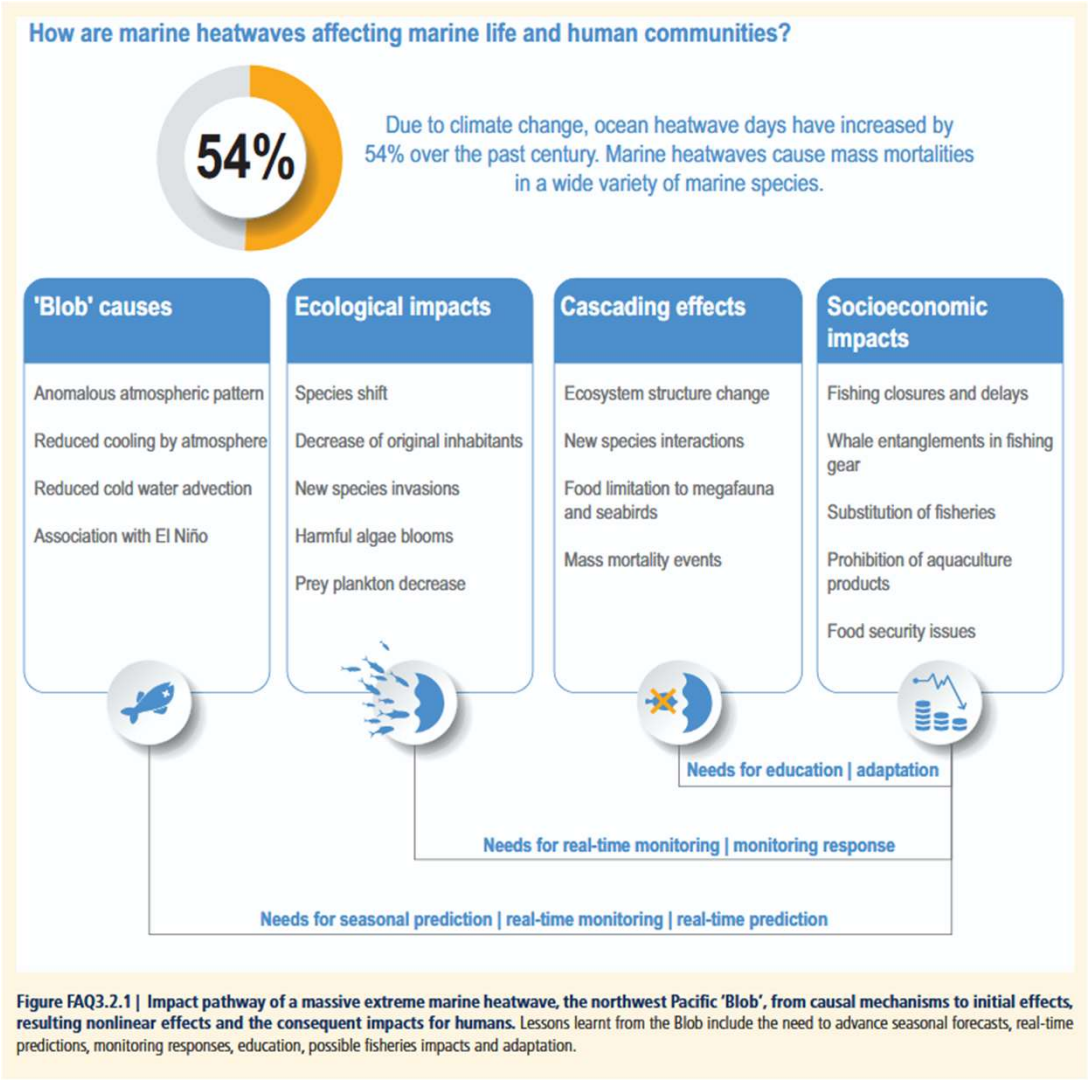
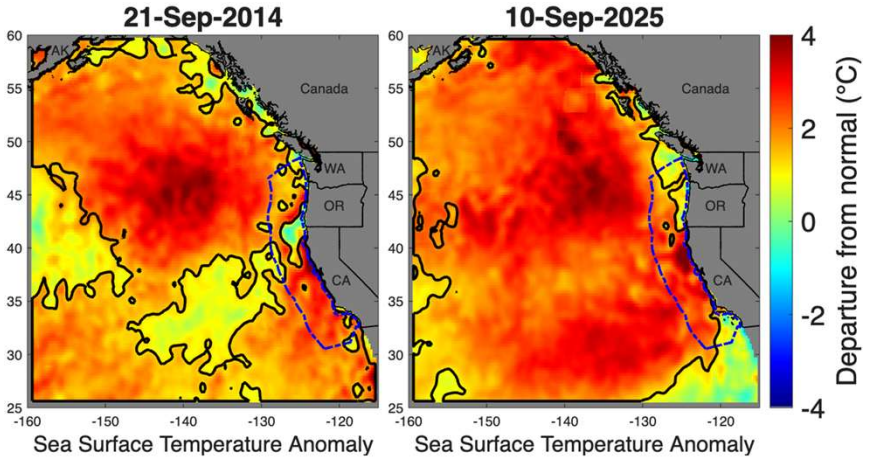


Figure FAQ3.2.1 | Impact pathway of a massive extreme marine heatwave, the northwest Pacific 'Blob', from causal mechanisms to initial effects, resulting nonlinear effects and the consequent impacts for humans. Lessons learnt from the Blob include the need to advance seasonal forecasts, real-time predictions, monitoring responses, education, possible fisheries impacts and adaptation.

Cooley and Schoeman 2023 in https://doi.org/10.1017/9781009325844.005

- **Event :** A major MHW known as **'The Blob'** occurred in the northeast Pacific in 2014, lasting until mid-2016.
- **Ecological Effects**: it triggered widespread ecological shifts, such as record-breaking harmful algal blooms and food web disruptions.
- **Frequency:** The phenomenon has been observed repeatedly since 2019.



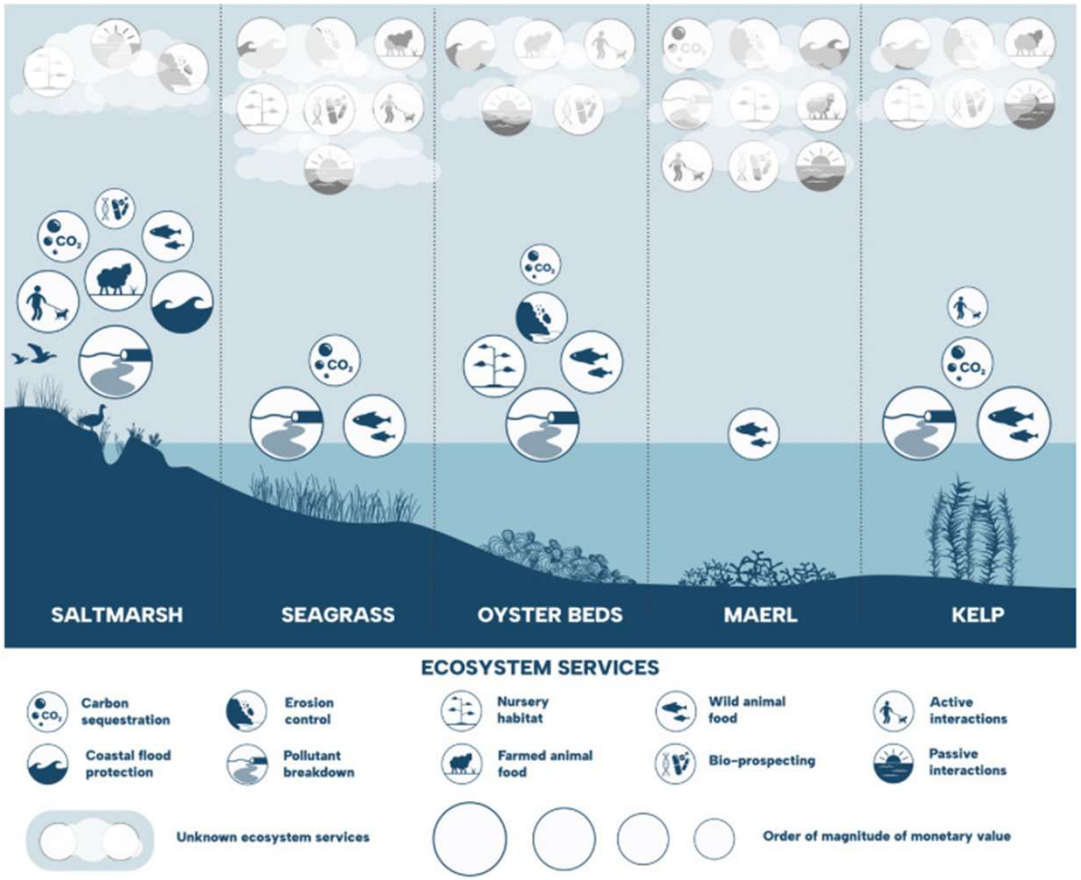
The "blob" at its near maximum areal extent in September 2014 and the 2025 MHW (NEP25A) at its near maximum areal extent in Sept 2025. ***Source: NOAA***

https://www.integratedecosystemassessment.noaa.gov/regions/california-current/california-current-marine-heatwave-tracker-blobtracker

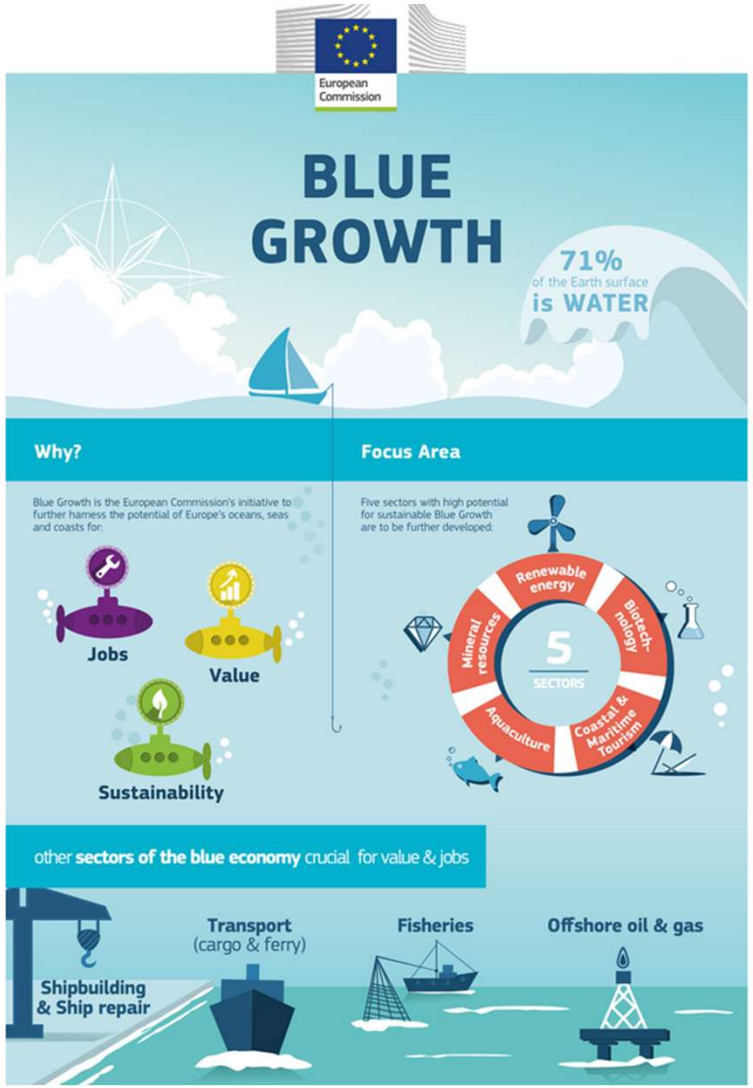
Ecosystem Services and Ocean economy

Blue economy meaning coincides nowadays with that of a ‘sustainable ocean economy’.

Mulazzani and Malorgio 2017
https://doi.org/10.1016/j.marpol.2017.08.006



Summary of available ES monetary values and evidence gaps for blue ecosystems.
Rendon et al. 2025 https://doi.org/10.1016/j.crsus.2025.100582



https://webgate.ec.europa.eu/maritimeforum/en/node/3551

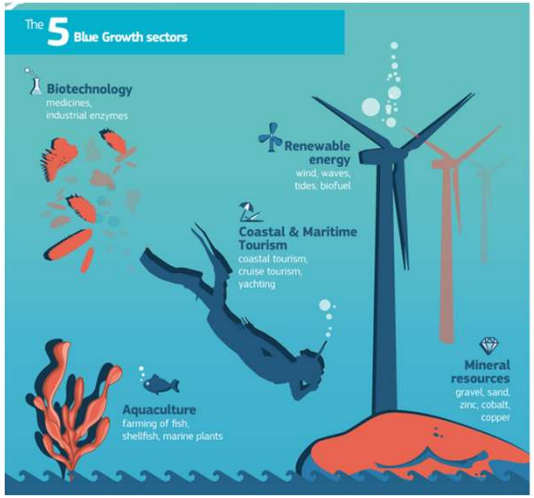
Blue Growth:
The EU's strategy for sustainable marine and maritime growth

Blue Economy Impact: Marine and maritime activities employ 5.4 million people across the EU, generating an annual Gross Value Added of nearly EUR 500 billion.

Strategic Framework: In 2012, the EU launched a long-term strategy to harness the full potential of its oceans and seas.

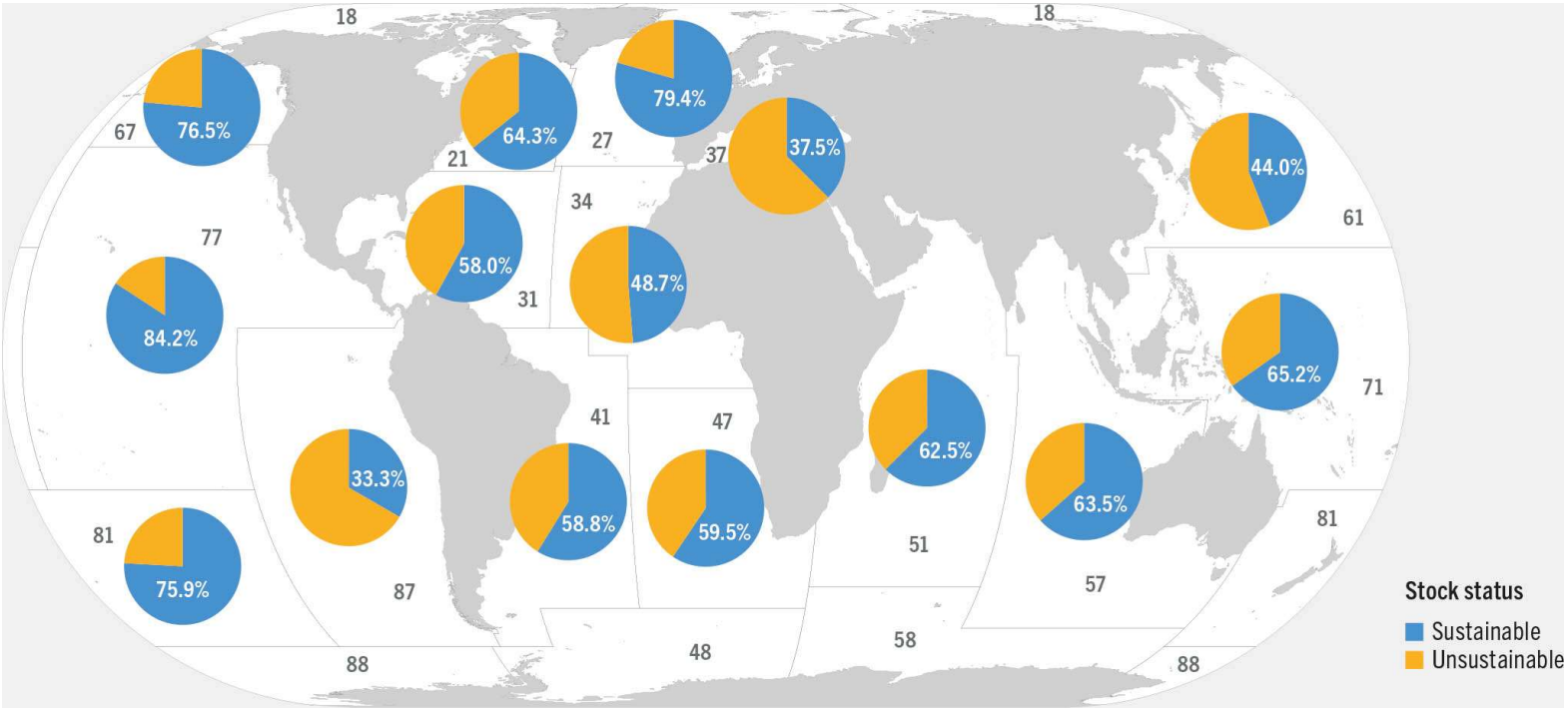
The Blue Growth Strategy: it targets the marine and maritime sectors to drive sustainable economic recovery; the core objectives are job creation, fostering innovation, and promoting long-term sustainable growth.

https://eur-lex.europa.eu/EN/legal-content/summary/the-eu-s-strategy-for-sustainable-marine-and-maritime-growth-blue-growth.html



PERCENTAGES OF BIOLOGICALLY SUSTAINABLE AND UNSUSTAINABLE FISHERY STOCKS BY FAO MAJOR FISHING AREA, 2021

FAO The State of World Fisheries and Aquaculture 2024
https://doi.org/10.4060/cd0683en



- **Fisheries and Marine Ecosystem Model Intercomparison Project**:
  Climate change is significantly altering the distribution and productivity of marine organisms and fisheries resources on a global scale.

- **Strategy:** Robust scientific knowledge and model-based projections of fish biomass fluctuations are essential for developing climate-resilient fisheries management and effective adaptation strategies.

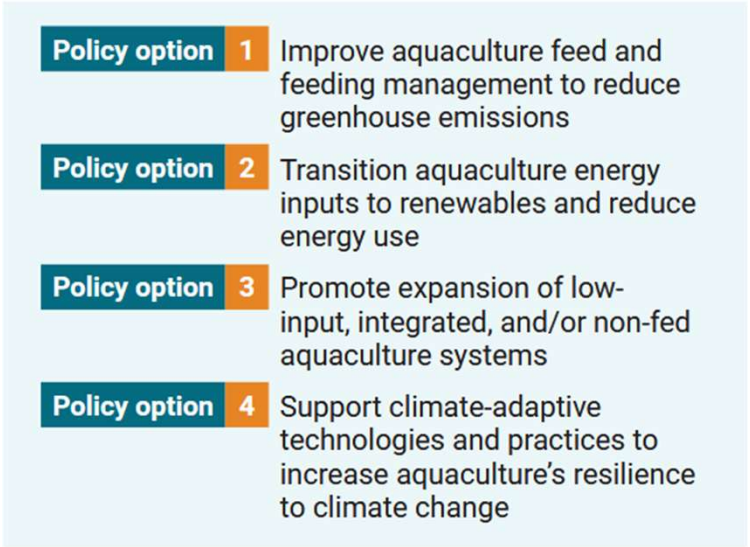
Blanchard & Novaglio 2024
https://doi.org/10.4060/cd1379en

Climate change risks to marine ecosystems and fisheries

- **FAO** developed the **Climate Change Strategy 2022–2031**, built upon cutting-edge science and innovation, promoting **evidence-based solutions** to address global climate challenges.
- **FAO Blue Transformation Strategic Framework** agenda for fisheries and aquaculture prioritizes the implementation of **sustainable practices**.
- By leveraging **innovative data and scientific insights**, aiming to support ecosystem restoration and enhance the resilience of fish stocks against the escalating impacts of climate change.

Capture fisheries production

Aquaculture production



Integrating Blue Foods into National Climate Strategies 2024. https://doi.org/10.25740/Cq607gn4098

Food and Agriculture Organization of the United Nations

Ecosystem Approach to Fisheries (EAF) is a risk-based management planning process encompassing the principles of Sustainable Development.
It integrates human and social dimensions alongside ecological and environmental components.
It facilitates optimal decision-making based on available information, adopting precautionary and adaptive approaches to management actions.
To support this, various models—including multispecies, whole-ecosystem, and environmental forcing models—serve as essential tools.
FAO 2008 https://openknowledge.fao.org/handle/20.500.14283/i0151e

NOAA FISHERIES

Ecosystem-based fisheries management (EBFM) is a holistic approach to managing fisheries and marine resources by considering the entire ecosystem of the target species.
Its primary objective is to maintain ecosystems in a healthy, productive, and resilient state, ensuring they continue to provide the essential services that humans rely on.
NOAA 2016 https://www.fisheries.noaa.gov/s3/2024-02/Revised-EBFM-Policy-FINAL-2.12.24-508-signed-JC.pdf

United Nations Decade of Ocean Science for Sustainable Development (2021-2030)
coordinate by Intergovernmental Oceanographic Commission (IOC) of UNESCO

Throughout the Ocean Decade, partners will generate the data, information and knowledge needed for more robust science-informed policies and stronger science-policy interfaces at global, regional, national and even local levels.

https://oceandecade.org/

OCEAN DECADE MISSION

'Transformative ocean science solutions for sustainable development, connecting people and our ocean.'

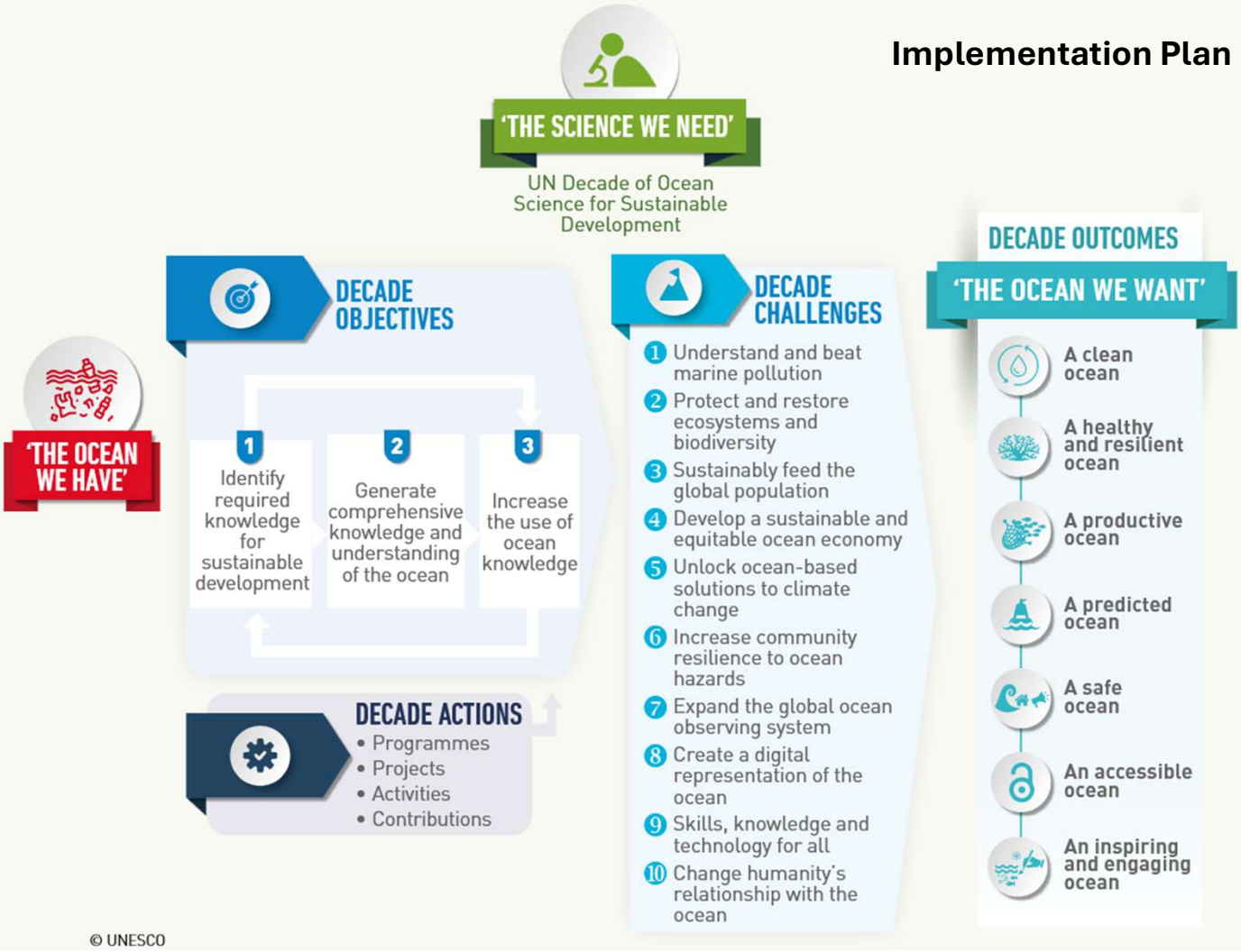
10 Ocean Decade Challenges on the road to 2030:

1. Understand and beat marine pollution
2. Protect and restore ecosystems and biodiversity
3. Sustainably nourish the global population
4. Develop a sustainable, resilient and equitable ocean economy
5. Unlock ocean-based solutions to climate change
6. Increase community resilience to ocean and coastal risks
7. Sustainably expand the Global Ocean Observing System
8. Create a digital representation of the ocean
9. Skills, knowledge, technology and participation for all
10. Restore humanity's relationship with the ocean

UNESCO-IOC 2021
https://unesdoc.unesco.org/ark:/48223/pf0000377082

Figure 3. Moving from the ocean we have to the ocean we want.

Implementation Plan



Global Ocean Observing System

an Intergovernmental Oceanographic Commission (IOC)-led programme

Principle: Ocean observing essential for **better understanding** of how life on earth is affected by climate change.

Role:

- lead and **support a community** of international, regional and national ocean observing programmes, governments, UN agencies, research organizations and individual scientists
- help **develop observing tools and technology**, information systems, scientific analysis and forecasts to leverage global community investment

3 focus areas:

Climate/Ocean Change
Accurate modelling, mitigation and adaptation require long-term, in-depth observations.

Forecasts and warnings
Effective data flow enables businesses and individuals to make more informed and better decisions.

Ocean health
Scientific evidence shows that marine ecosystem health is impacted by and can impact human activities.

Goal by 2030:
a global ocean observing system truly responsive to the needs of end users, able to mitigate mounting pressures on the ocean and enable resilient and sustainable blue economies

Sponsored by

unesco Intergovernmental Oceanographic Commission

WORLD METEOROLOGICAL ORGANIZATION

UN environment programme

International Science Council

https://goosocean.org/

Essential Ocean Variables (EOVs)

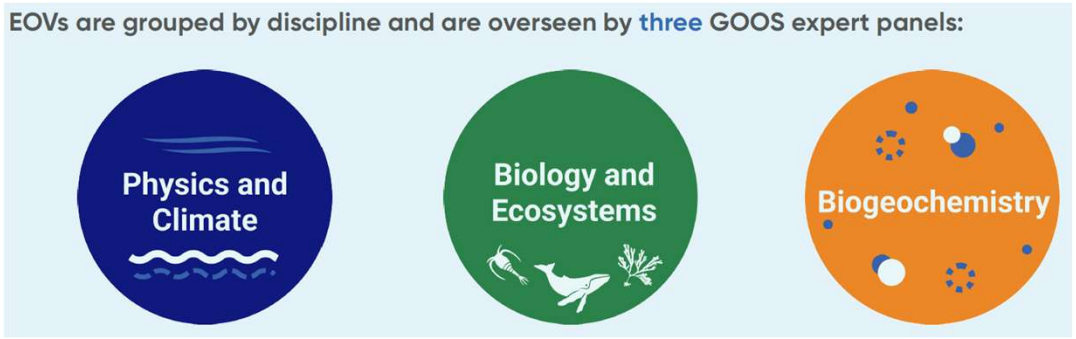
Monitoring the state and health of the ocean

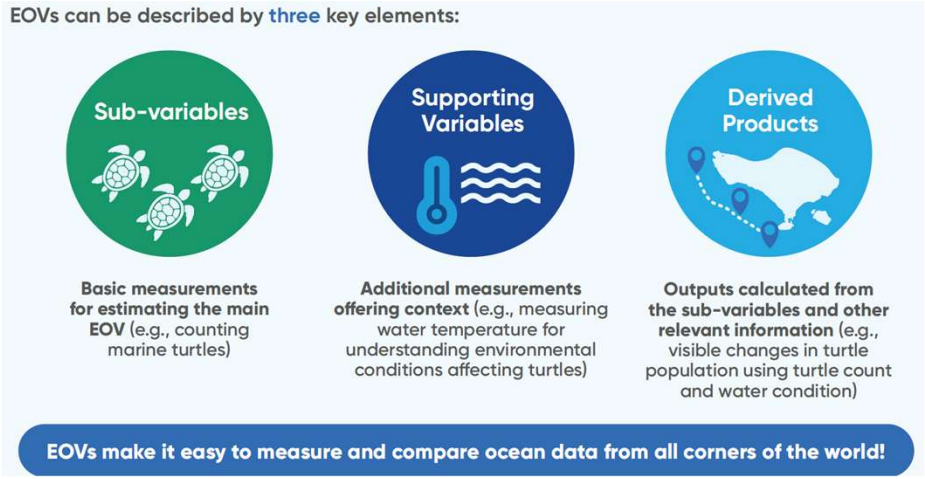
EOVs are the **minimum set of ocean variables** needed to understand the state of the ocean and the variability of important oceanic processes.

They provide information to manage activities that benefit society.

EOVs are **defined and standardised** by GOOS.

Global Ocean Observing System



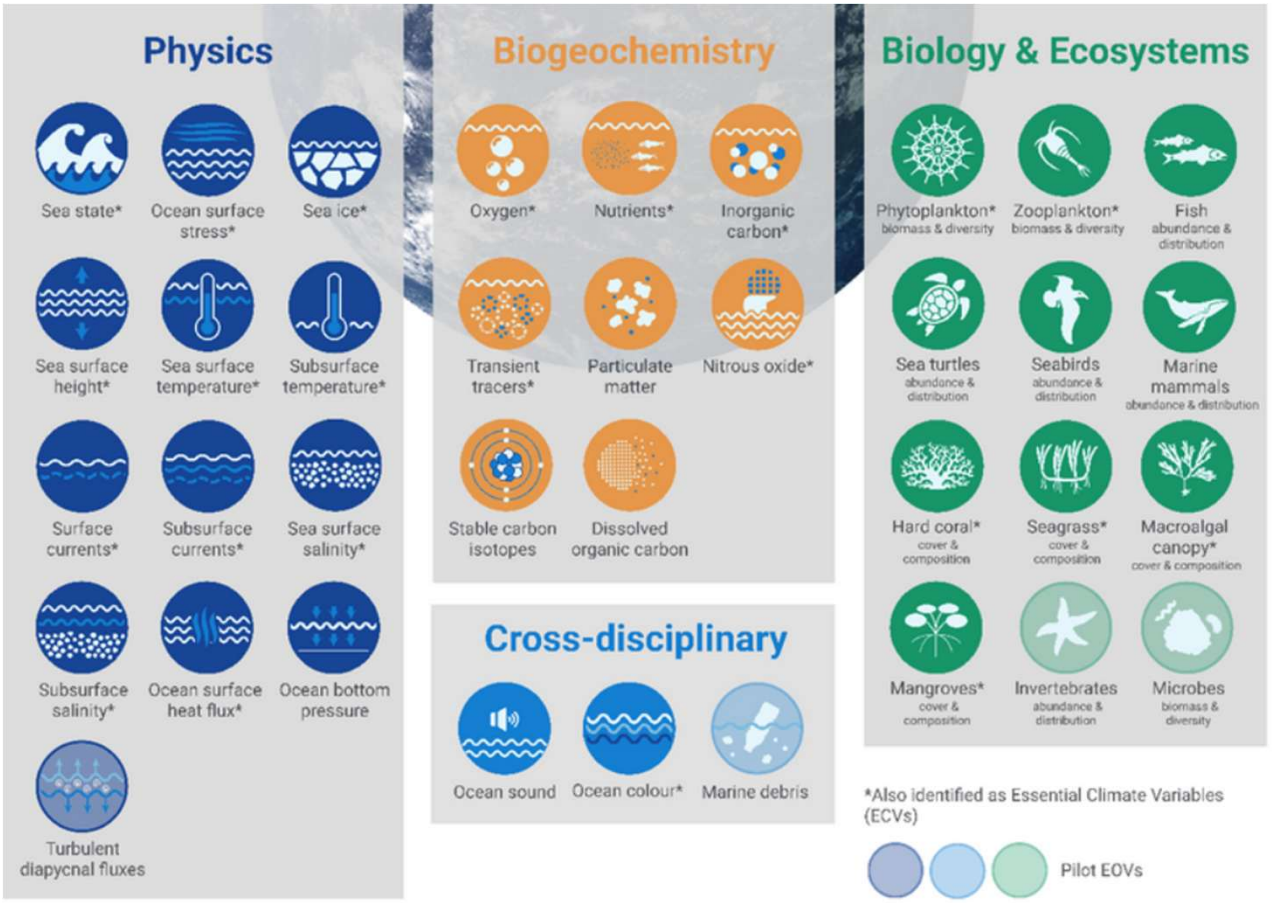


The majority of EOVs are also Essential Climate Variables (ECVs) defined by the Global Climate Observing System. ECVs cover atmospheric, oceanic, and terrestrial domains.

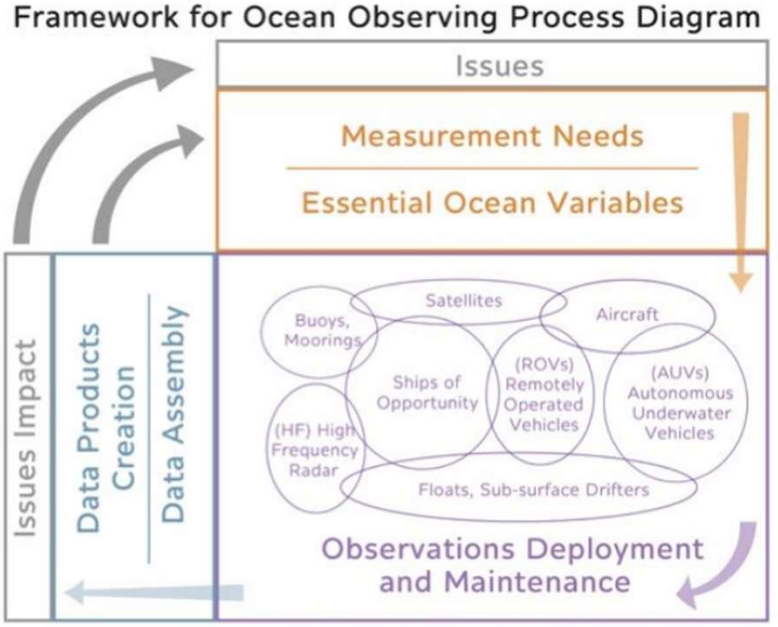
A number of GOOS ocean observing networks measure atmospheric and oceanic ECVs.

https://goosocean.org/document/36676

https://goosocean.org/what-we-do/framework/essential-ocean-variables/



The aim of this framework is to address the variables to be measured, the approach to measuring them, and how data and products should be managed and made widely available to modelling efforts and a wide range of users.



https://goosocean.org/what-we-do/framework/

EuroGOOS

European Global Ocean Observing System

The constants throughout the EuroGOOS history have been its collaborative, bottom-up structure, and a drive for sustained observation capacities making full and economic use of all available resources.

PAN-EUROPEAN AND GLOBAL COOPERATION

1991 Establishment of GOOS

1994 Establishment of EuroGOOS with headquarters in UK supported by NERC, NOC, Ifremer, and BSH

1996 1st EuroGOOS International Conference

Soon after Establishment of EuroGOOS Regional Systems, ROOS

2002 Headquarters move from UK to Sweden hosted by SMHI

2006 EuroGOOS Data Working Group established (in addition to existing Science Advisory & Coastal Modelling WGs)

2008 EuroGOOS and EMB joint vision to define Framework for European Ocean Observing System

2010 Development of core marine service, later Copernicus Marine Service

2013 EuroGOOS incorporated as a legal entity headquartered in Brussels

2015 EuroGOOS Task Teams - networks of in situ observing platforms

2019 EuroGOOS Ocean Literacy Network

2023 EuroGOOS reaches 46 Member Organizations from 19 countries

2023 10th EuroGOOS International Conference

2023 EuroGOOS Members, ROOS, WGs and Task Teams bring together 140 organizations in 30 countries

EuroGOOS Task Teams:

The extent of European economic investment in the maritime sector required a cohesive observation system to attend to the needs of the continent as one of the world's most prominent blue economies, and to maintain its competitive ability.

Leading the development and implementation of sustained and coordinated operational oceanography across Europe.

www.eurogoos.eu

GOOS Dialogues with Industry Initiative

Key topics

- Instrument provision: Supply and development of sensors and platforms
- Multi-sectoral ocean architecture: Integrating new observing networks and business models
- User driven ocean information services: Core and downstream services
- Looking ahead: New technology for the Ocean Decade

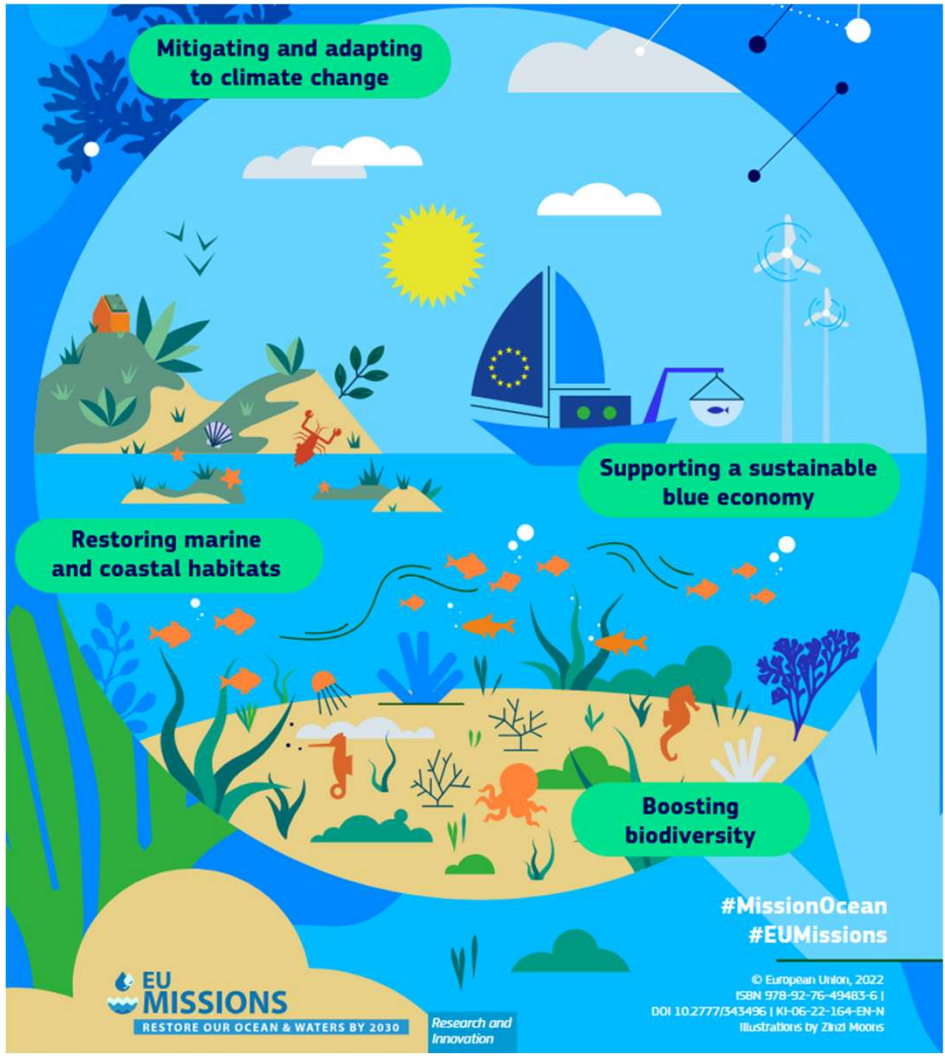
https://goosocean.org/our-work/dialogues-with-industry/

European Policies demanding for ocean data:

- **Marine Strategy Framework Directive** aims to protect marine ecosystems and biodiversity, crucial for human health and socio-economic activities; outlines 11 qualitative descriptors to help EU countries achieve Good Environmental Status (GES) https://environment.ec.europa.eu/topics/marine-environment_en
- Data Collection Framework under the **Common Fishery Policy** to support scientific advice on resources management https://dcf.ec.europa.eu/general-information_en
- Maritime spatial planning under the **Integrated Maritime Policy** aiming to reduce conflicts and creating synergies between different activities https://oceans-and-fisheries.ec.europa.eu/ocean/blue-economy/maritime-spatial-planning_en
- Etc. etc….

EU funding to science and cooperation with industries and society

https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/restore-our-ocean-and-waters_en



Better understand for a better decision-making.

- **Strategic Driver:** Sustainable, multidisciplinary ocean observation is the essential for achieving global research, political, and societal goals concerning climate and blue economy challenges.
- **Core Roles of Observation:** Sustained observations provide the necessary basis for assessing trends, planning environmental management, and monitoring the effectiveness of mitigation and adaptation strategies.
- **Requirements:** The international community demands systematic ocean observations across all marine environments, ranging from the open and deep ocean to coastal and shelf seas.
- **Obstacles:** The vast and harsh nature of the marine environment remains a significant barrier, making data collection logistically complex and costly.
- **Data Resolution Gap:** The primary challenge lies in obtaining high-resolution (spatial and temporal) and long-term measurements for complex processes in a cost-effective manner.
- **Critical Knowledge Gaps:** There is an urgent need for data on ocean biogeochemistry, biology, and ecosystems to accurately track rapid environmental shifts.
- **Operational Benefits:** Increasing spatio-temporal resolution and filling data gaps will lead to new operational products, enhanced forecasting, and a deeper understanding of marine processes.

Sparnocchia et al. 2021 NAUTILOS D2.1 - A review and prospectus of the mandate for marine environmental monitoring systems: technology challenges and opportunities. Zenodo. https://doi.org/10.5281/zenodo.7163906

THE DATA CHALLENGE

Technological Necessity: As data collection initiatives expand in intensity, connectivity, and scope, **robust technological support** becomes essential to guarantee data availability, accuracy, and interoperability.

Democratic Access: European data initiatives are increasingly prioritizing democratic access to information and the development of user-centric solutions.

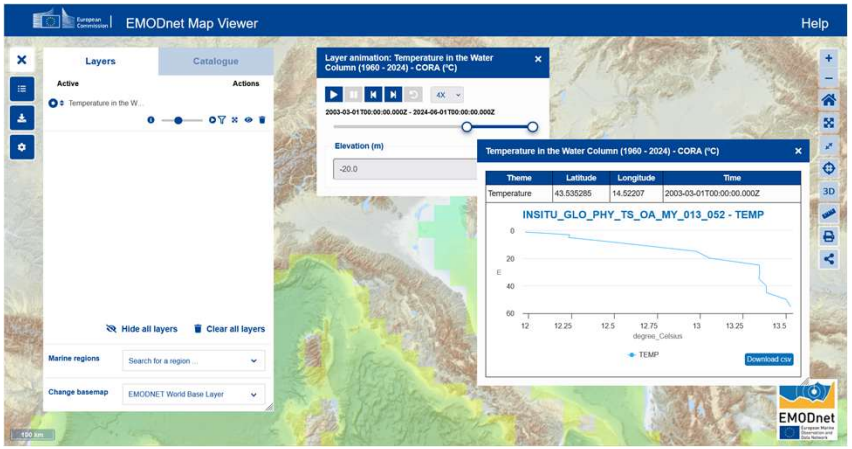
Standardization Challenge: A primary challenge involves adopting common standards for data collection and dissemination to maximize utility, while strictly adhering to the **FAIR principles** (Findability, Accessibility, Interoperability, and Reusability; Wilkinson et al., 2016; https://doi.org/10.1038/sdata.2016.18)

EMODnet Foundation and Core Principle: Launched in 2010, the European Marine Observation and Data Network is a long-term initiative founded on the principle of "collect once, use many times." (https://emodnet.ec.europa.eu/)

Data Integration: EMODnet aggregates information into FAIR-compliant, pan-European layers, harmonizing data and metadata in accordance with EU and international standards.

Accessibility: The network provides free and open access to marine data, metadata, and specialized products and services across seven diverse disciplinary themes.

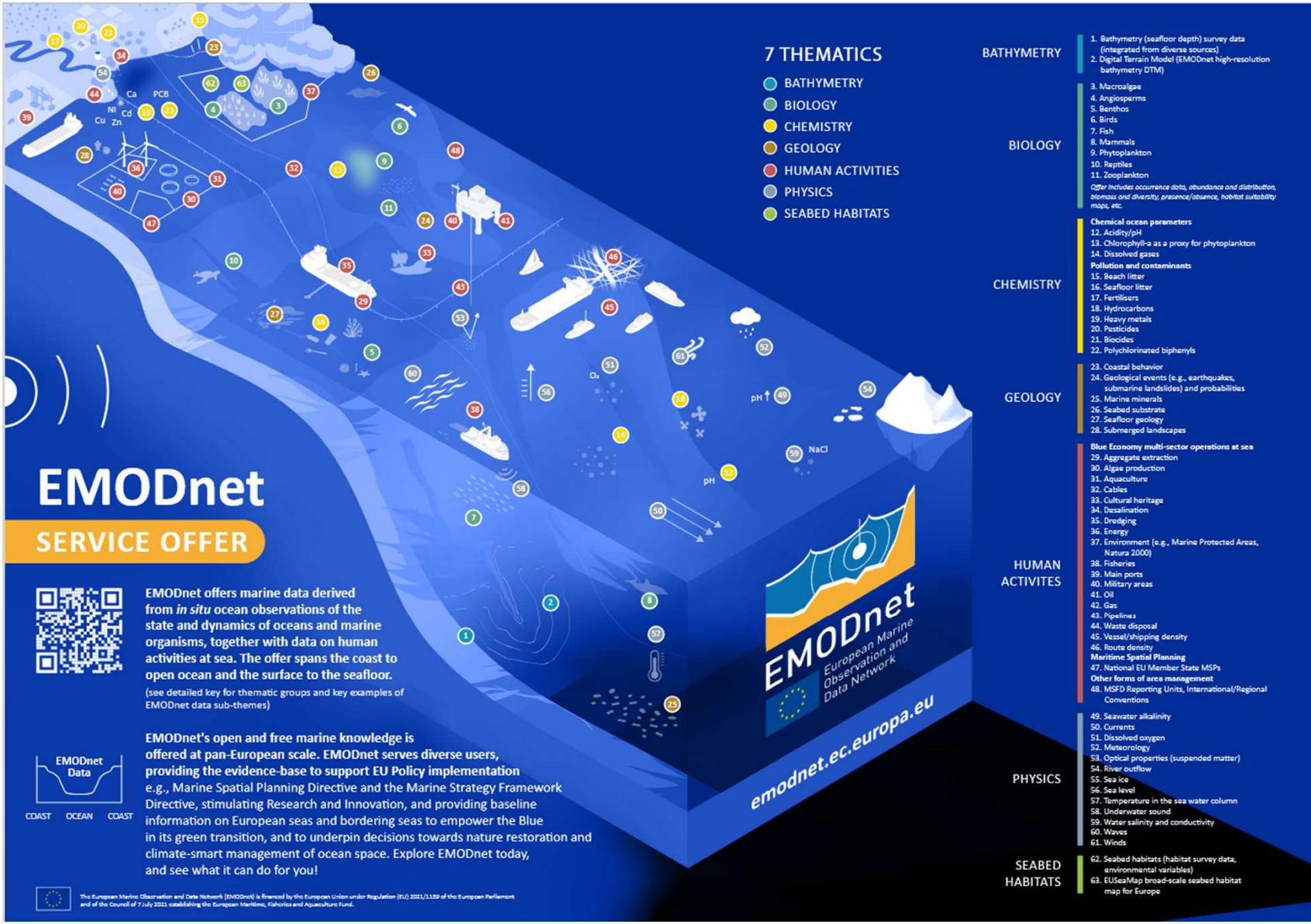
https://youtu.be/P1k-GwU4WmM



European Marine Observation and Data Network (EMODnet)

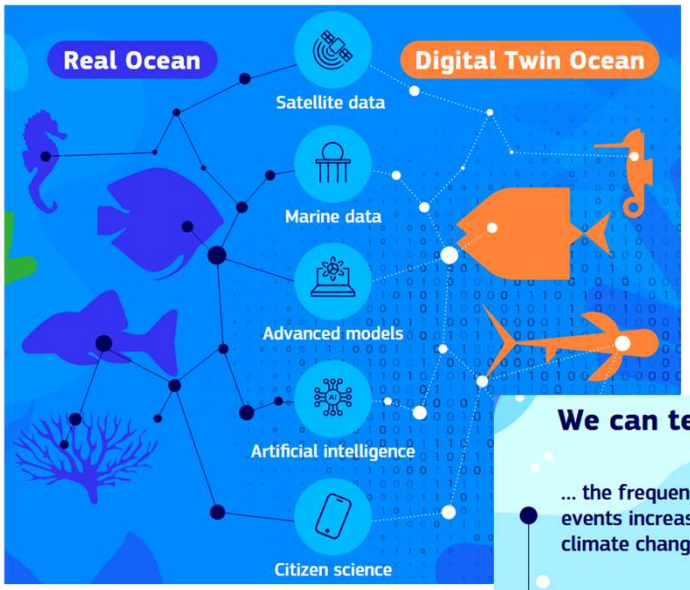
is the European Commission *in situ* marine data service

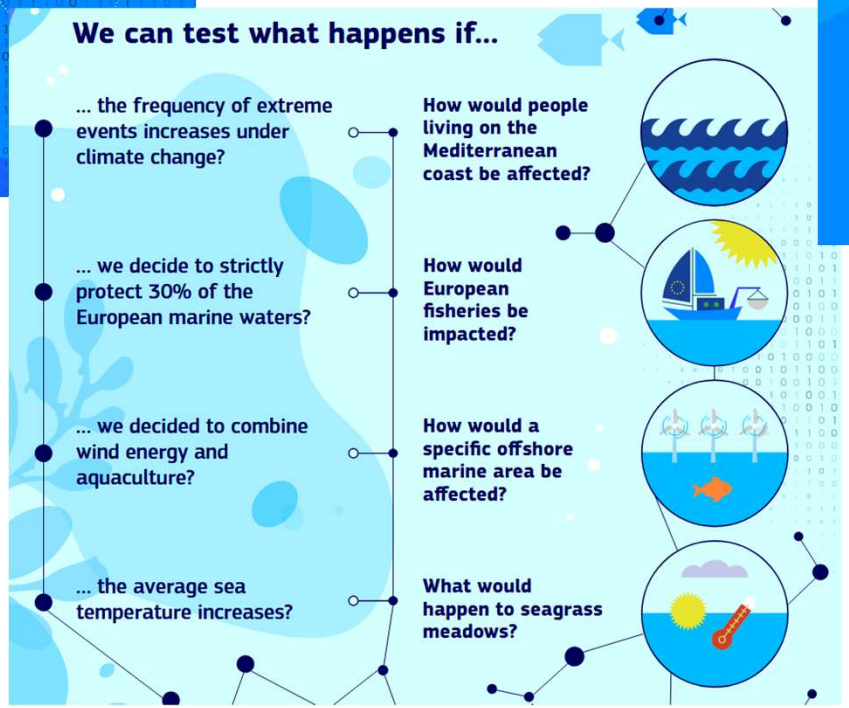
EMODnet serves users in policy, research, industry, and society, the EU Digital Twin Ocean and global ocean data initiatives

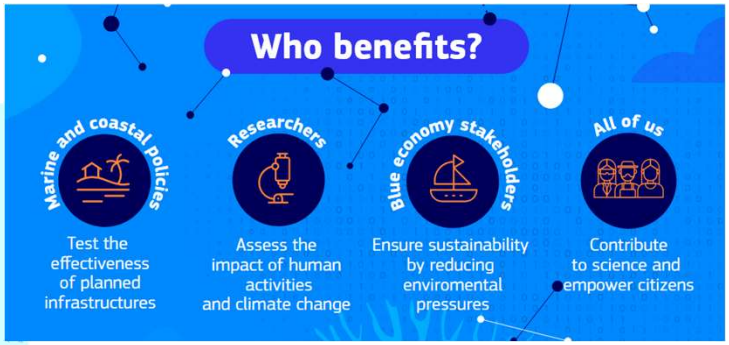


DIGITAL TWIN of the OCEAN

A **digital space** providing access to **vast amounts of data**, **models**, **artificial intelligence** and other tools, to allow the replication of the **properties and behaviours of marine systems**, including ocean currents and waves, marine life and human activities, and their interactions, in and near the sea.



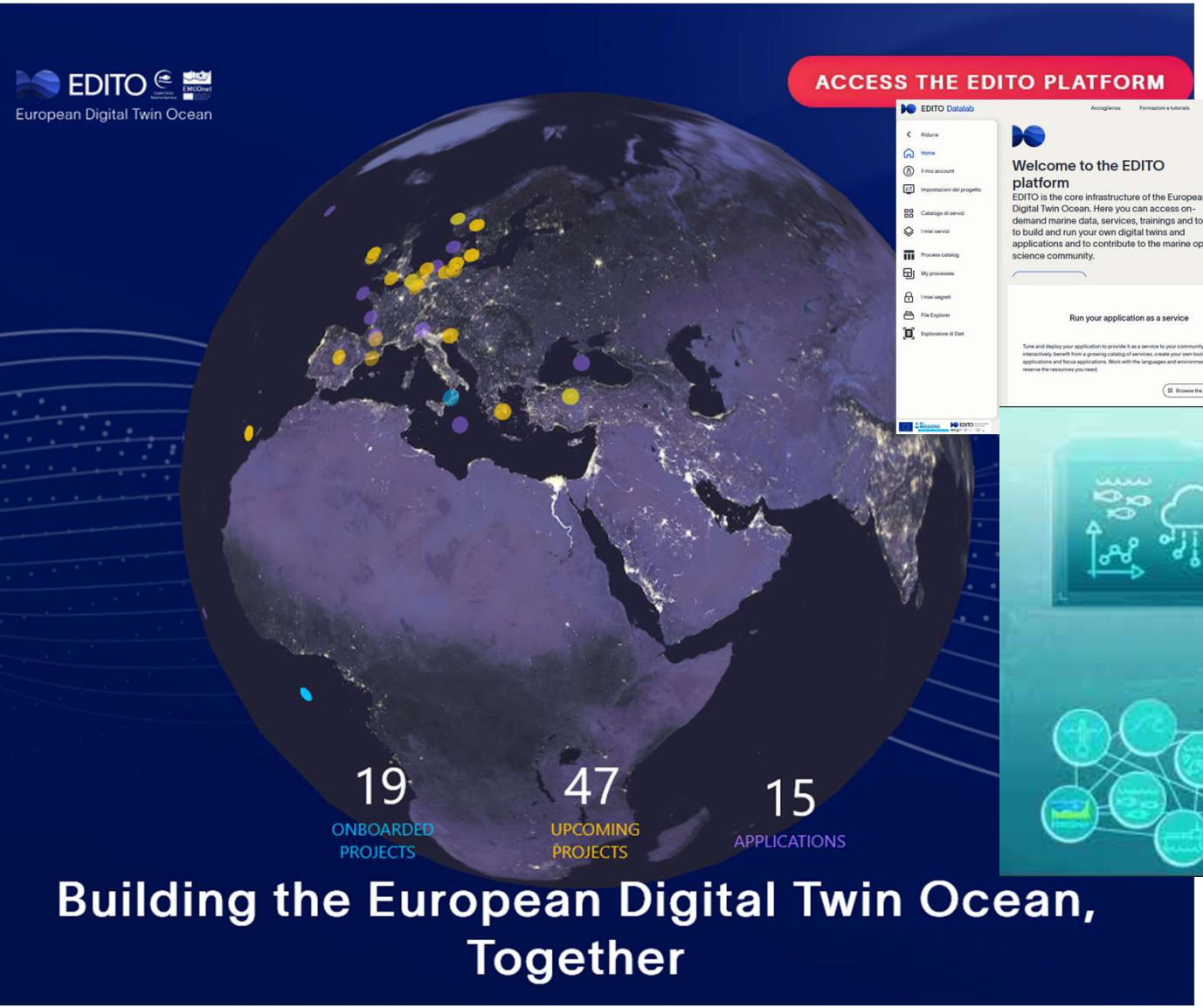


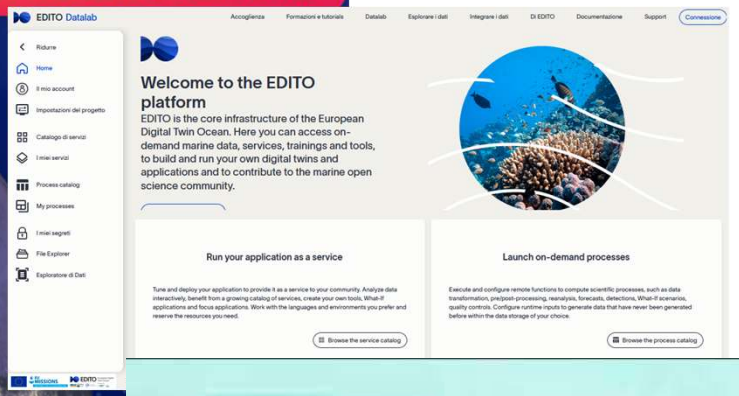


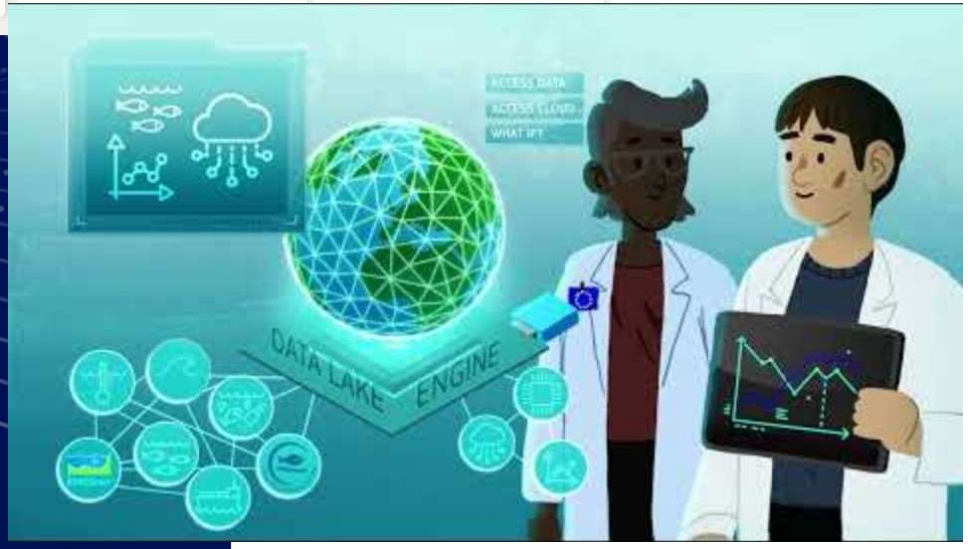
By connecting data and models through tailor-made applications, scientists, marine experts, policymakers, entrepreneurs and user-driven applications can **test different specific scenarios**.

DTO aims to **integrate** a wide range of existing and new **data sources**, to transform data into knowledge and to connect, engage, and empower citizens, governments and industries by providing them with the capacity to **inform their decisions.**

EC 2022 https://data.europa.eu/doi/10.2777/343496

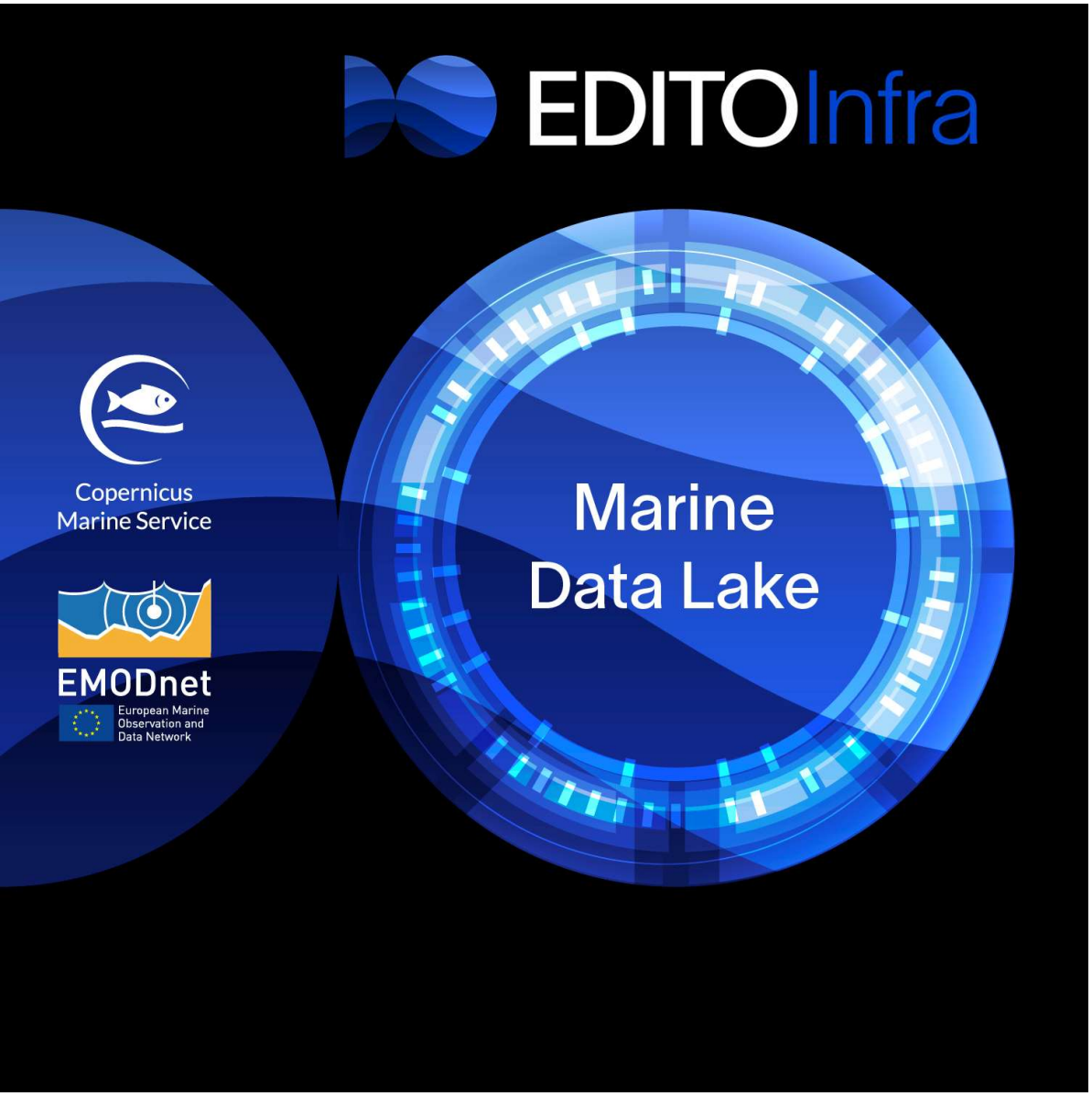






https://www.edito.eu/

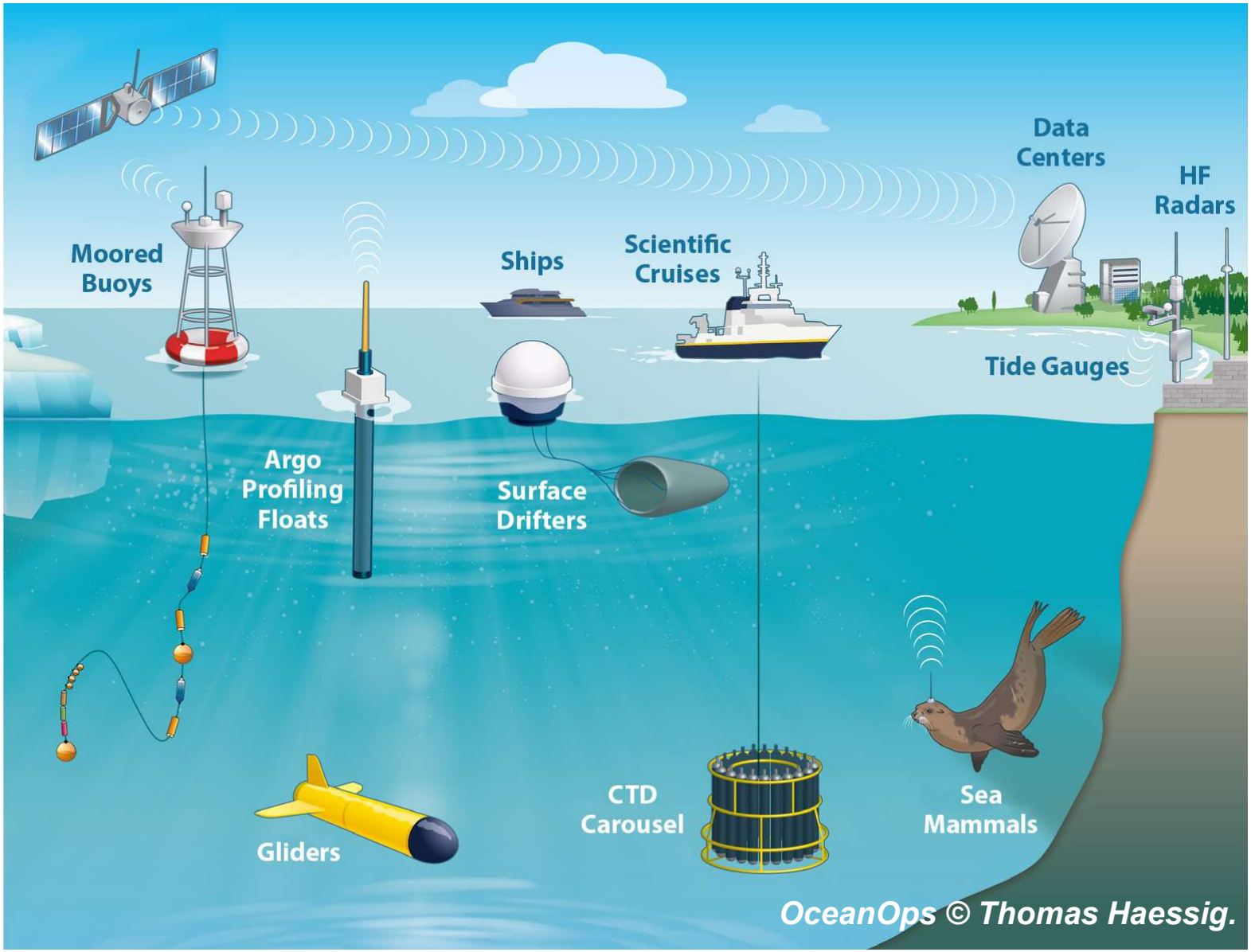
https://youtu.be/SgnaEoYS8Fo



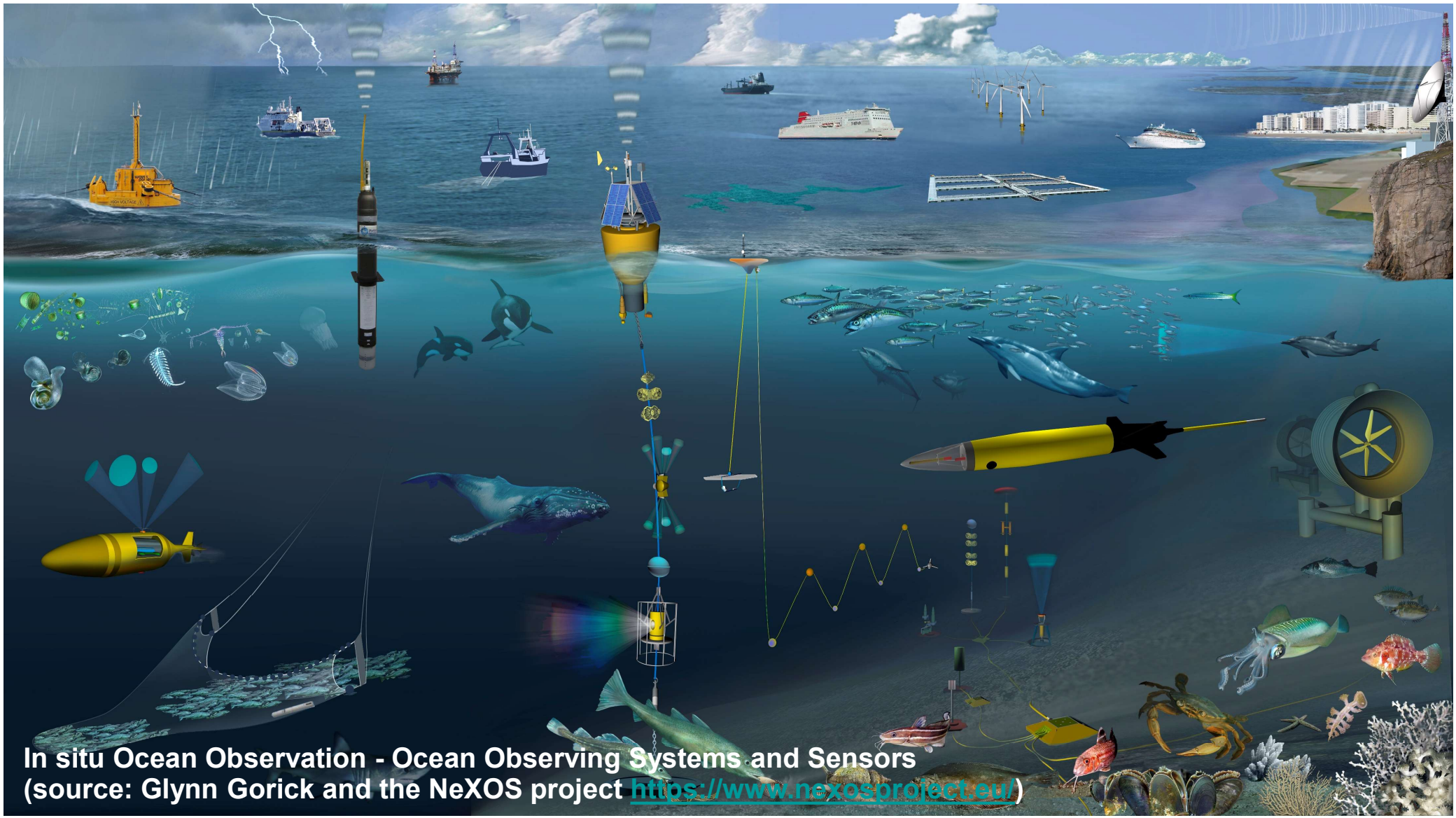
The Infrastructure Backbone

- **The Modern Challenge:**
  Beyond simple data collection, the current priority is the **efficient management and high-speed analysis** of massive marine datasets.
- **The Power of Data Lakes:**
  By leveraging cloud-native technologies, these systems provide the scalable architecture essential for advanced **big data analytics and machine learning**.
- **Integration:** EDITO-Infra establishes a unified Data Lake for EMODnet and CMEMS, offering "cloud-ready" data that **eliminates the need for format conversion.**
- **Expanded Scope:** The platform has recently integrated new biological data streams, such as eDNA and tracking data.

https://edito-infra.eu/news/what-is-a-data-lake/



Example of a coastal **ocean observing network** comprising multiple **platforms and infrastructure** equipped with **data-gathering technologies.**



In situ Ocean Observation - Ocean Observing Systems and Sensors
(source: Glynn Gorick and the NeXOS project https://www.nexosproject.eu/)

Examples of observational platforms

Remote Sensing & Aerial Platforms

- **Environmental Satellites:** Space-based platforms measuring SST, ocean color, ice cover, and sea level.
- **Unmanned Aerial Vehicles (UAVs) / Drones:** High-resolution aerial monitoring for coastal areas, marine life, and surface pollutants.
- **HF Radars:** Land-based stations for mapping surface currents and wave heights.

Autonomous & Mobile Platforms

- **Argo Floats:** Robotic floats for vertical profiling of physical and biogeochemical data.
- **Underwater Gliders:** Buoyancy-driven vehicles for long-range subsurface data collection.
- **Surface Drifters:** Buoys tracking surface currents and meteorological data.
- **Unmanned Surface Vehicles (USVs):** Surface drones (e.g., Saildrones) for air-sea interaction and weather data.
- **Remotely Operated Vehicles (ROVs):** Tethered robotic platforms equipped with sensors and manipulators for real-time sampling and visual inspection in diverse underwater environments.

Fixed & Coastal Platforms

- **Moored Buoys:** Anchored stations for long-term weather and sea-state monitoring.
- **Fixed Pylons:** Rigid coastal structures anchored to the seabed, providing a stable platform for long-term monitoring of sea level, water quality, and air-sea interaction
- **Tide Gauges:** Instruments for measuring sea-level changes and tides.
- **Cabled Observatories:** Permanent seafloor stations with real-time power and data links.
- **Landers:** Autonomous seafloor frames for benthic and deep-sea research.

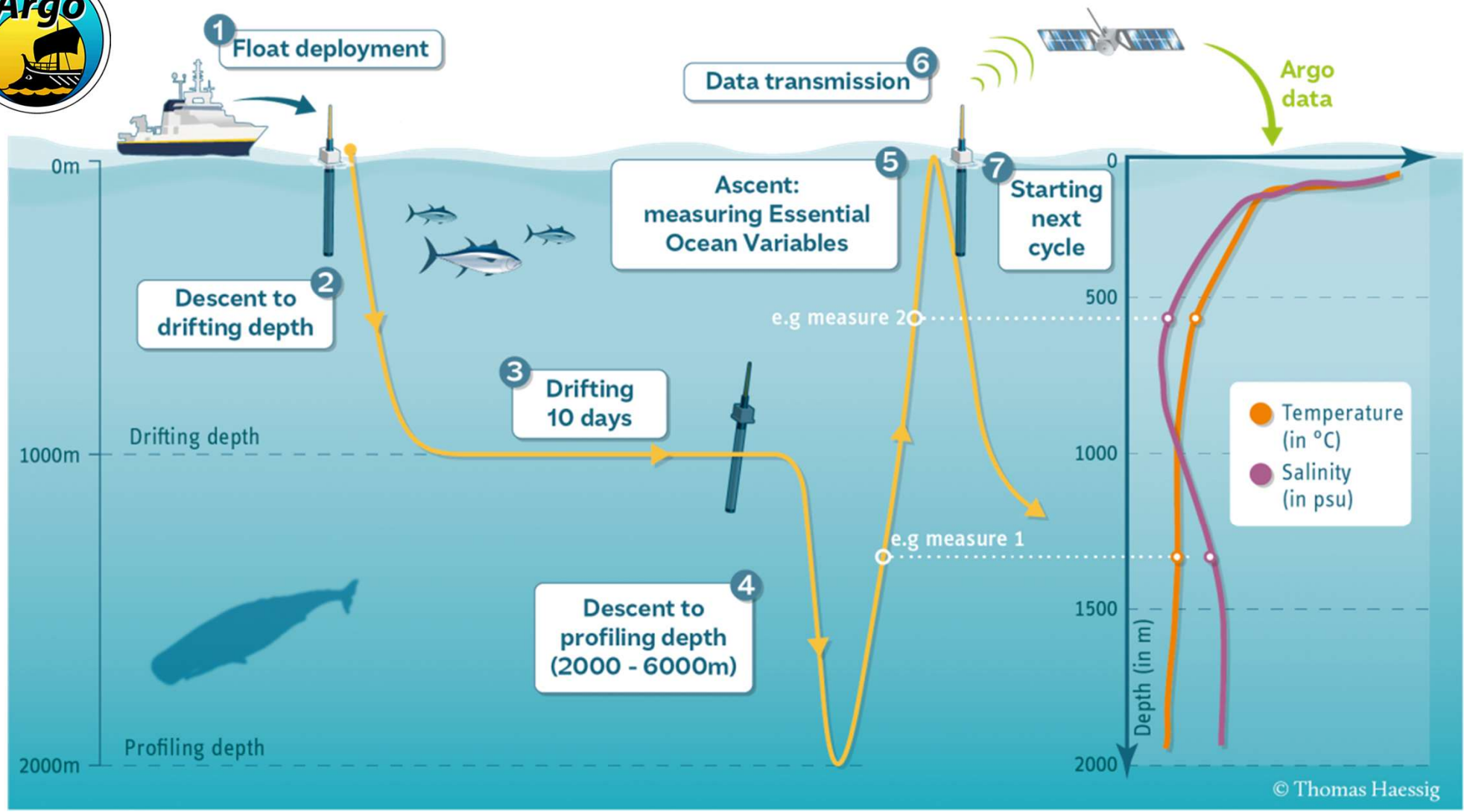
Ship-Based Platforms

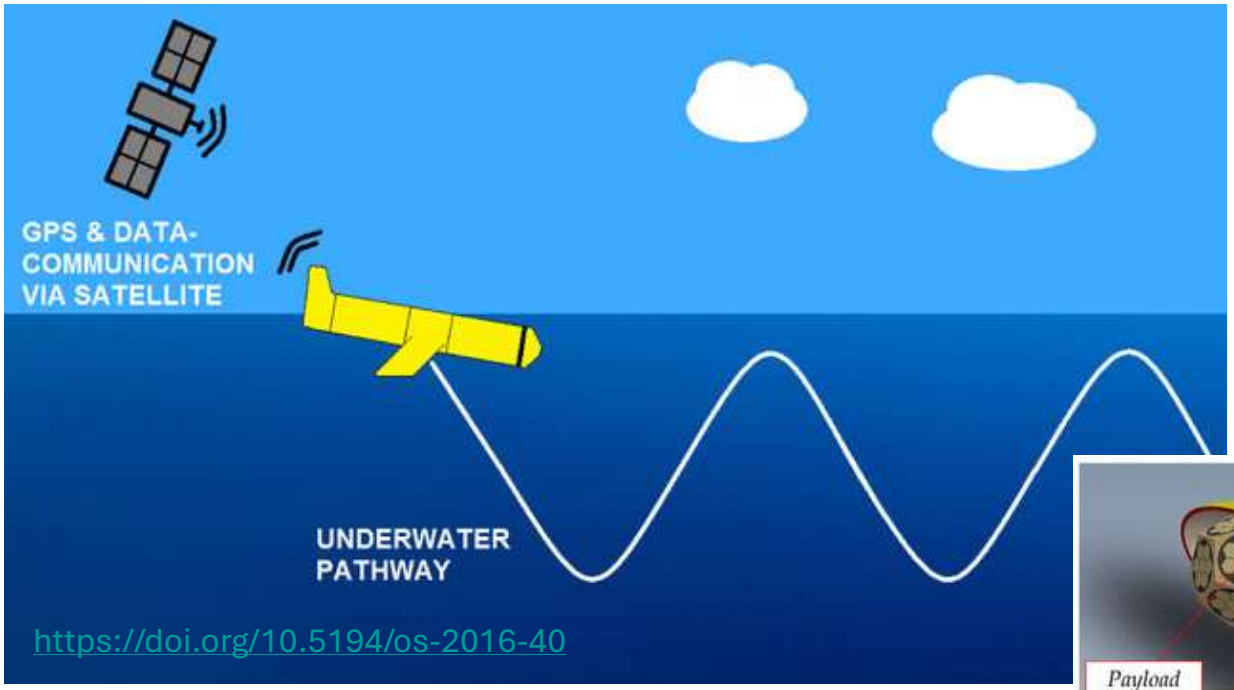
- **Research Vessels (RVs):** mobile laboratories designed to deploy oceanographic instrumentation and conduct multidisciplinary scientific sampling at sea.
- **Ships of Opportunity (SOOs):** Commercial vessels equipped with automated sensors like FerryBoxes.

Biological Platforms

- **Animal-Borne Platforms:** animals equipped with tags to collect data in remote or deep environments.

https://argo.ucsd.edu/how-do-floats-work/

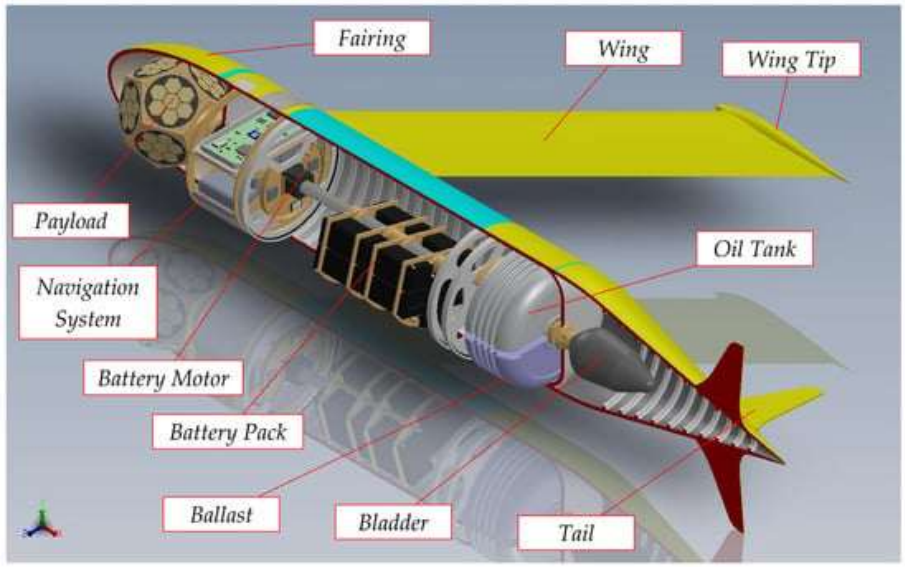




Autonomous Underwater Glider:

A Comprehensive Review

https://doi.org/10.3390/drones9010021



- Propel themselves with changes in buoyancy, ascending and descending through the water column.
- Reusable, remotely controlled
- Cost-effective method for collecting repeat subsurface ocean observations

Break Time

Think about your data: Are they Findable, Accessible, Interoperable, and Reusable?

The FAIR Guiding Principles

To be Findable:
F1. (meta)data are assigned a globally unique and persistent identifier
F2. data are described with rich metadata (defined by R1 below)
F3. metadata clearly and explicitly include the identifier of the data it describes
F4. (meta)data are registered or indexed in a searchable resource

To be Accessible:
A1. (meta)data are retrievable by their identifier using a standardized communications protocol
A1.1 the protocol is open, free, and universally implementable
A1.2 the protocol allows for an authentication and authorization procedure, where necessary
A2. metadata are accessible, even when the data are no longer available

To be Interoperable:
I1. (meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation.
I2. (meta)data use vocabularies that follow FAIR principles
I3. (meta)data include qualified references to other (meta)data

To be Reusable:
R1. meta(data) are richly described with a plurality of accurate and relevant attributes
R1.1. (meta)data are released with a clear and accessible data usage license
R1.2. (meta)data are associated with detailed provenance
R1.3. (meta)data meet domain-relevant community standards

Wilkinson et al. 2016 https://doi.org/10.1038/sdata.2016.18

MODULE 3
Enabling Solutions: Sensor-Platform Integration and Innovative Technologies

Technological Evolution

1. Strategic Vision: Closing the Data Gap

•**Objective:** Expanding the monitoring of under-sampled variables to ensure comprehensive spatio-temporal coverage in strategic maritime areas.

•**Operational Foundation:** Leveraging established **Research Infrastructures (RIs)** to provide specialized facilities and services for both academia and industry.

2. Technological Drivers of Innovation

•**The Shift to Autonomy:** A fundamental transition toward the widespread adoption of **autonomous, real-time *in situ* sensing**.

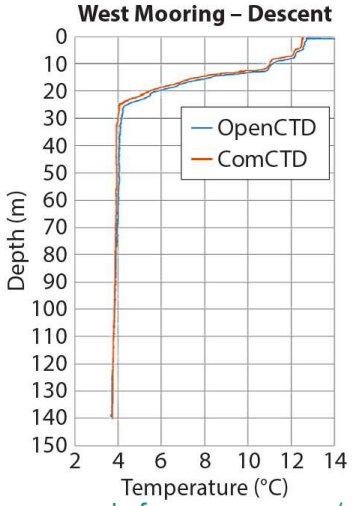
•**Advanced Hardware:** Progress fueled by **sensor innovation** and the continuous **miniaturization** of electronic components.

•**Economic Sustainability:** A critical focus on cost-effective solutions to minimize acquisition, deployment, and long-term maintenance costs.

3. Expected Outcomes & Benefits

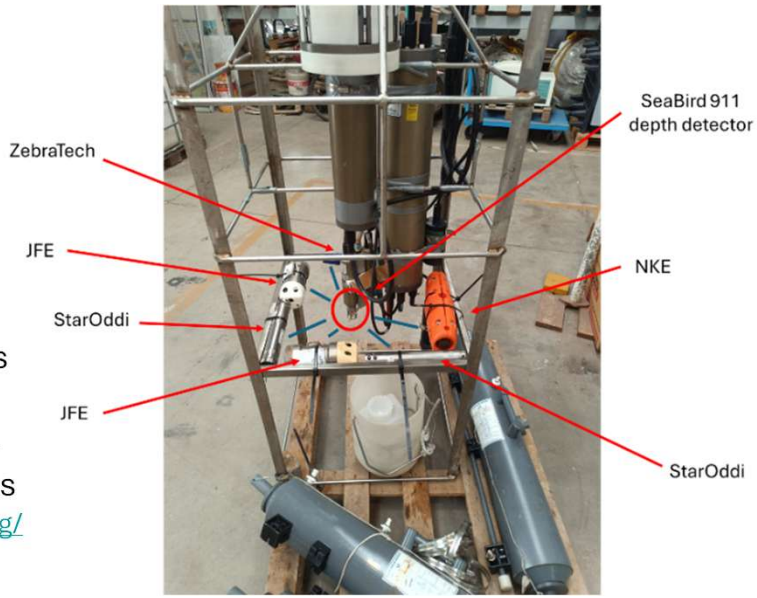
•**Enhanced Understanding:** Greater spatial resolution and temporal continuity, enabling a deeper analysis of complex ocean processes.

•**Next-Gen Services:** High-quality data streams that drive **precise marine forecasting** and the creation of innovative operational products.



https://oceanographyforeveryone.com/

Compact Cost-Effective sensors compared with oceanographic-class instruments
https://www.fvon.org/



	Low-Cost	Cost-Effective
Primary Focus	Minimizing initial purchase **price** and lowering entry barriers.	Maximizing the **Value of Information** and Return on Investment.
Hardware & Software	Often uses off-the-shelf components and open-source hardware and programming; compact; low power consumption.	High-precision, certified instrumentation; typically proprietary hardware/software.
Main Advantage	**Democratization of data**; allows for large-scale spatial deployment.	**Long-term reliability** and high data fidelity/stability.
Data Quality	Basic functionality; prone to **sensor drift** and high noise-to-signal ratio; accuracy depends on external validation.	Prioritizes **metrological traceability**; high native precision and stable measurements over time.
Calibration	Primarily factory-calibrated with limited or no user-controlled options.	Factory-calibrated with user-performed options for optimal in-situ performance.
Key Use Cases	**Citizen Science**; crowdsourced coastal networks; education; prototyping.	**High-level research**; regulatory decision-making; long-term deployment in extreme/remote environments.
Constraints	**High failure rates**; significant "hidden costs" in data processing and validation.	**Higher upfront cost**; optimized cost per valid data point produced over time

Esegui la scansione del codice a matrice o usa il collegamento per partecipare

https://forms.office.com/e/fC89RXFNAm

Copia collegamento

15 risposte inviate

What do you think could be innovative tools for ocean monitoring?

Wordcloud | Tutte le risposte

1 di 1

Expert Consultation:
Horizon scanning for **emerging technologies and breakthrough innovations** in the field of **ocean observation** to support European Innovation Council Strategic Intelligence

https://publications.jrc.ec.europa.eu/repository/handle/JRC144401

https://knowledge4policy.ec.europa.eu/projects-activities/futurinnov_en

Ocean Observation: Strategic Technology List (not exhaustive)

Autonomous Systems

- **Enhanced Argo Floats and Autonomous Platforms for Biogeochemical Parameters**
- **Autonomous Robot Samplers (Biodiversity focus)**
- Robotic Networks
- Autonomous Microbial Analyzers

Molecular & In Situ Sensing

- eDNA & Next-gen RNA Monitoring
- Lab-on-a-Chip (LOC) Systems

Subsurface Observation

- Enhanced Acoustic Monitoring
- Fiber-optic Distributed Acoustic Sensing
- Real-time Observation Networks

Data Intelligence

- **Machine Learning & Automated Image Analysis**
- Satellite & In Situ Data Integration

Scalable Solutions

- **Low-cost Sensors (Citizen Science enablers)**
- Modular Sensor Platforms

New Approach to Underwater Technologies for Innovative, Low-cost Ocean obServation

NAUTILOS

http://www.nautilos-h2020.eu/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101000825 (NAUTILOS). This output reflects only the author's view and the European Union cannot be held responsible for any use that may be made of the information contained therein.

NAUTILOS

Project Information

NAUTILOS

Grant agreement ID: 101000825

Project website

DOI

10.3030/101000825

Project closed

EC signature date

4 September 2020

Start date

1 October 2020

End date

30 June 2025

Funded under

SOCIETAL CHALLENGES - Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy

EU contribution

€ 9 048 349,10

PROJECT ACTIVITIES

NAUTILOS developed, integrated, validated and demonstrated new cutting-edge marine observation and monitoring technologies.

PROJECT PARTNERS

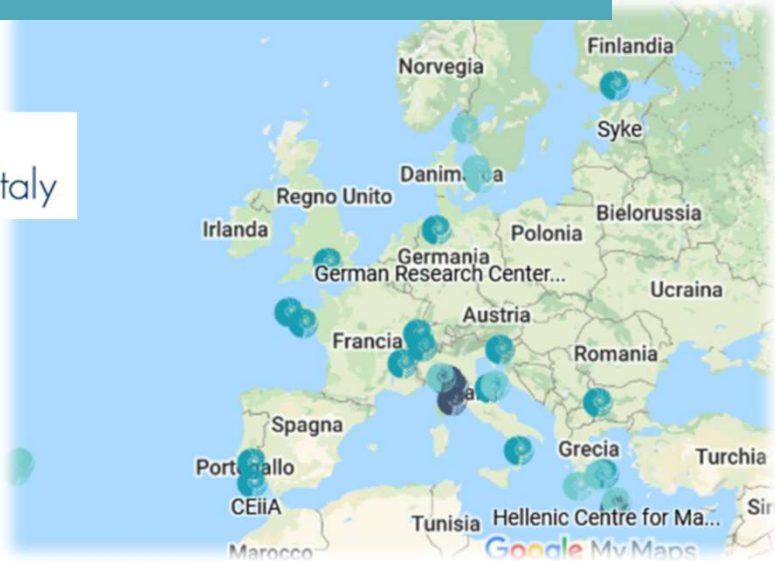
NAUTILOS was coordinated by the ***National Research Council of Italy (CNR)*** and brought together a multidisciplinary group of 21 entities from 11 European countries.

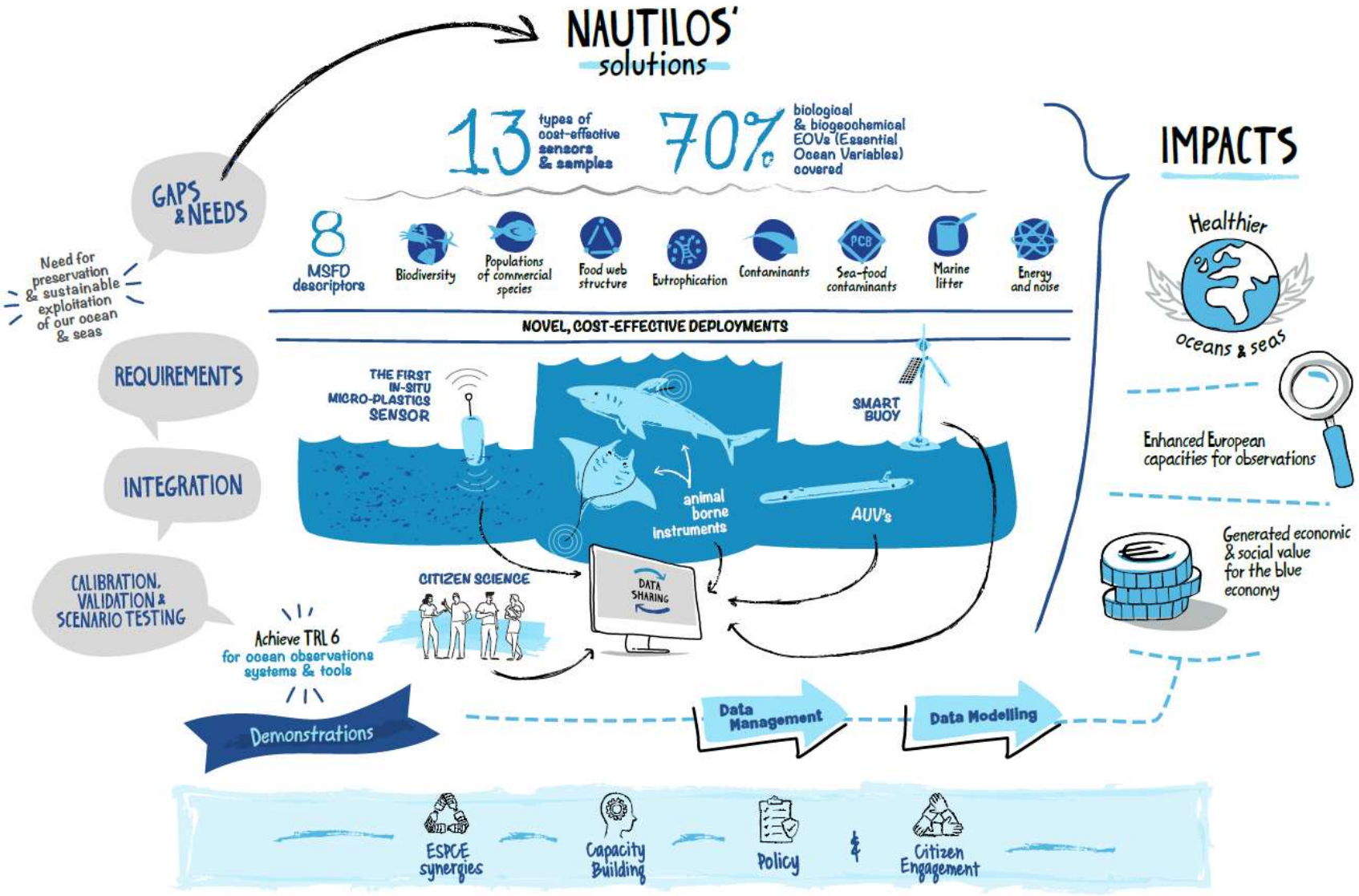
National Research Council of Italy

ISTITUTO DI SCIENZA E TECNOLOGIE DELL'INFORMAZIONE "A. FAEDO"

CNR IRBIM ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

CNR ISMAR ISTITUTO DI SCIENZE MARINE



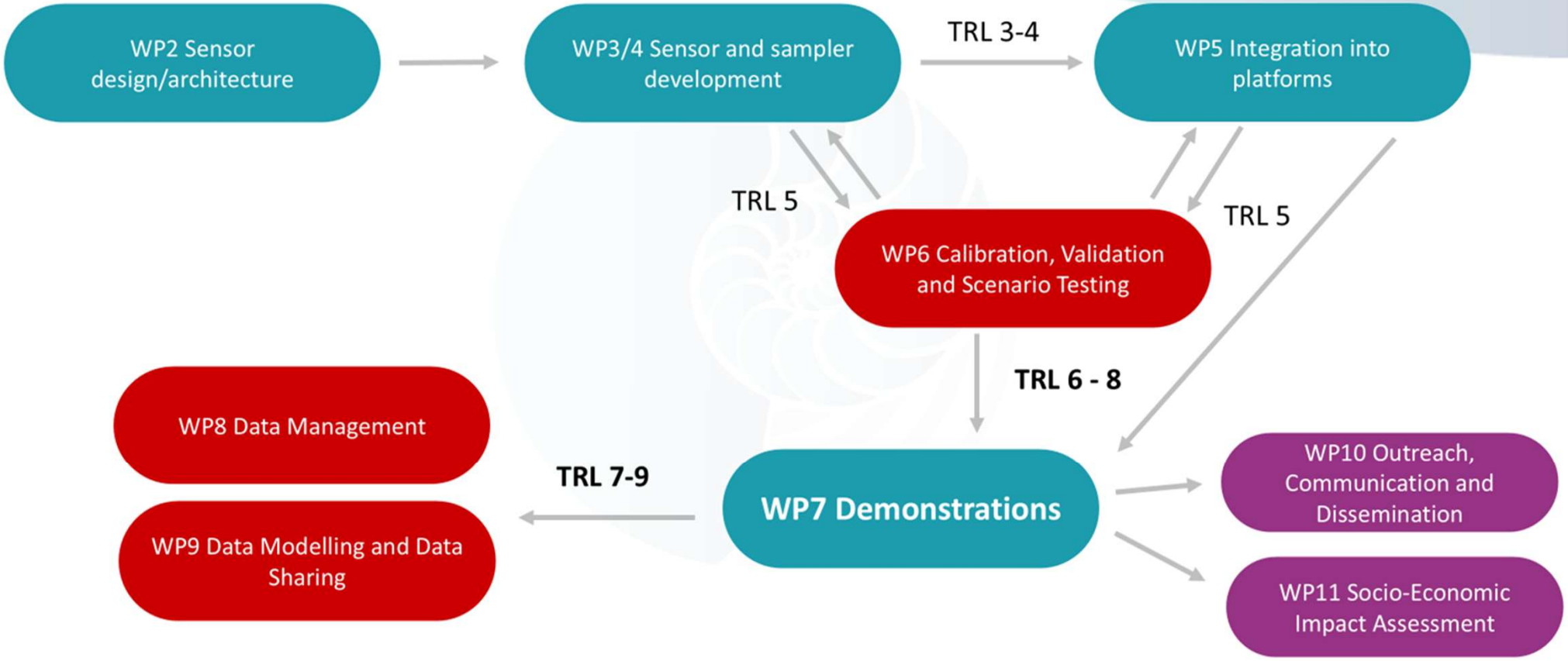

NAUTILOS' solutions
GAPS & NEEDS
Need for preservation & sustainable exploitation of our ocean & seas
REQUIREMENTS
INTEGRATION
CALIBRATION, VALIDATION & SCENARIO TESTING
Achieve TRL 6 for ocean observations systems & tools
Demonstrations
13 types of cost-effective sensors & samples
70% biological & biogeochemical EOVs (Essential Ocean Variables) covered
8 MSFD descriptors
Biodiversity
Populations of commercial species
Food web structure
Eutrophication
Contaminants
PCB
Sea-food contaminants
Marine litter
Energy and noise
NOVEL, COST-EFFECTIVE DEPLOYMENTS
THE FIRST IN-SITU MICRO-PLASTICS SENSOR
SMART BUOY
animal borne instruments
AUV's
CITIZEN SCIENCE
DATA SHARING
Data Management
Data Modelling
ESPACE synergies
Capacity Building
Policy
&
Citizen Engagement
IMPACTS
Healthier oceans & seas
Enhanced European capacities for observations
Generated economic & social value for the blue economy

Technology Readiness Level (TRL):
a scale for measuring or indicating the maturity of a given technology, from a paper sketch to its entry into the market.

What is your solution?	TRL 3	TRL 4	TRL 5	TRL 6	TRL 7	TRL 8	TRL 9
A Product that is manufactured	Analytical studies on separate elements of the technology. Laboratory based trials that show the feasibility of the predictions.	Basic technological components integrated together to show that they work together. At this point, durability is not yet important.	Basic technological components integrated within realistic context under a fully controlled environment in or outside the lab.	A functional version of the product working on a realistic environment able to draw conclusions on the technical and operational capabilities of the product.	A manufacturable version of the product working on an environment which addresses all the operational requirements for the product.	Product in its final form working in full mode under expected conditions and periods.	Product in its final form under full commercial deployment.

https://horizoneuropencpportal.eu/sites/default/files/2022-12/trl-assessment-tool-guide-final.pdf

Work plan – Work Packages interactions



WP7 Objectives

Fully operational field demonstrations of NAUTILOS-developed sensors, samplers and systems in a broad range of key environmental settings (from shore to deep sea deployments) and EU policy-relevant applications.

- **Instruments integrated to already operational platforms** such as ships of opportunity, research vessels, surface, aerial and underwater autonomous vehicles, landers, fixed observatories, Argo floats and animal-borne instrumentation modules.
- **New technological components and novel approaches** in marine environment observation combined and cross platform evaluation of the measurements performed.
- Demonstration activities in both swallow water and deep sea missions.

WP 7 Demonstrations M6 – M57

WP lead: Hellenic Centre for Marine Research (HCMR) – Manolis Ntoumas
Co lead: CONSIGLIO NAZIONALE DELLE RICERCHE (CNR) – Michela Martinelli

Fisheries Observing Systems
Adriatic Sea: Fishery and Oceanography Observing System (FOOS) device/platform on commercial fishing vessels;
French waters: on commercial fishing vessels

Aquaculture Observing Systems
Coastal Norway and Greece: FerryBox facilities, Fishery Research Vessels

Marine Mammal Monitoring Systems
Swedish Sound/Kullaberg/Lysekil waters: Commercial Fisheries;
Italy: Portofino MPA cetaceans' sanctuary

Platforms of Opportunity
Coastal Norway: NorSOOP FerryBoxes on M/S Trollfjord;
Gulf of Finland: Ferryboxes cruising across Gulf of Finland;
Eastern Mediterranean (Cretan Sea): Poseidon FerryBox

Augmented Shelf-Seas, Open Sea and Deep-sea Observing Systems
Shelf sea - POSEIDON Heraklion Coastal Buoy (HCB) Open sea - E1M3A station
Deep sea experiment - Aegean sea

Argo Platform
Mediterranean Sea, up to 2000 m

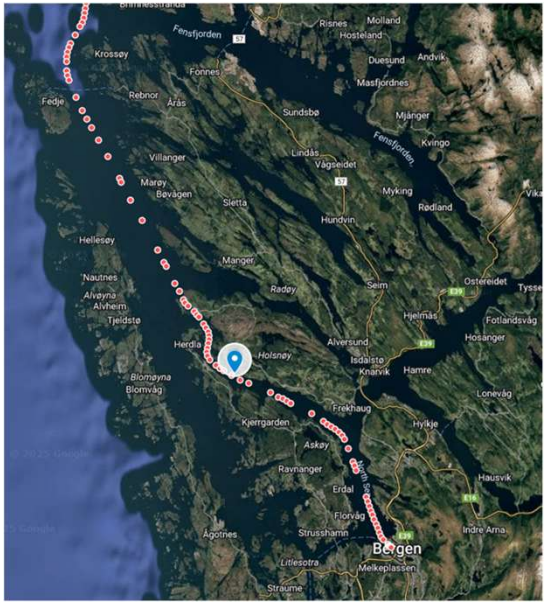
Animal-borne Instruments
Azores islands: combination of long and short duration deployments
Valdes Peninsula, Argentina: deployment from October to December on Elephant seal females, 10 deployments over 2-year

Sub-task 7.1.2: Novel approach to Aquaculture Observing Systems [Leader: NIVA]

DO, Chl-*a*, **pH** and **pCO2** low-cost sensors demonstrated from 14 May 2025 to 17 June 2025 at the aquaculture site in **Norway**.

Sensors installed at the **fish farm and NIVA FerryBoxes** measuring simultaneously.

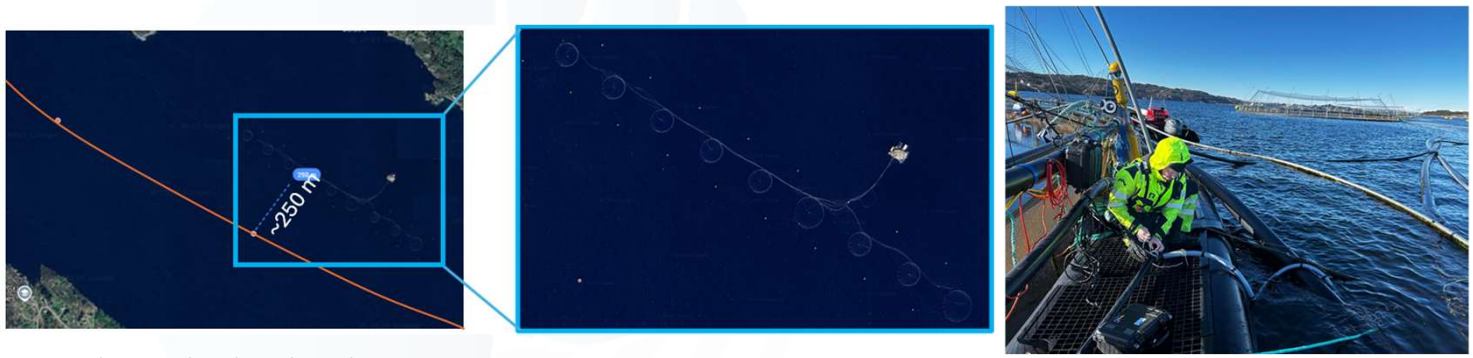
Collected datasets are available through NAUTILOS portals, changes to the initial plan, technical issues and recommendation for future actions are reported in D7.2.



Motor Ships Richard With and Trollfjord route in red.

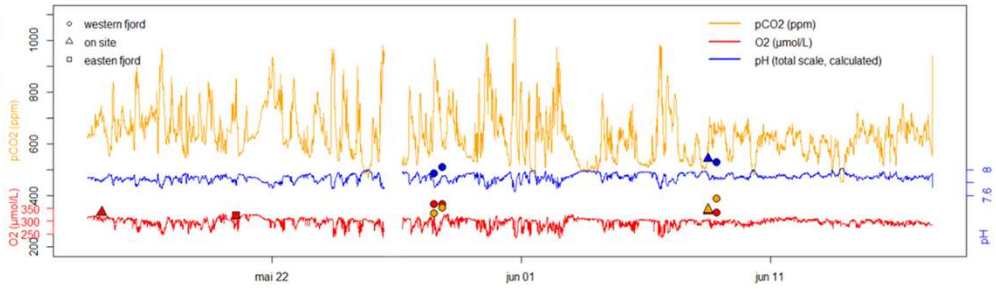
Salmon aquaculture is a major industry in Norway and **algal blooms** can cause significant losses.

Sensors deployed on a frame off the side of the fish cage at ~2 m depth.



March 2025, **2023-2025 time series from 3 FerryBoxes annotated** by NIVA's experts for **phytoplankton blooms** through Grafana interface.

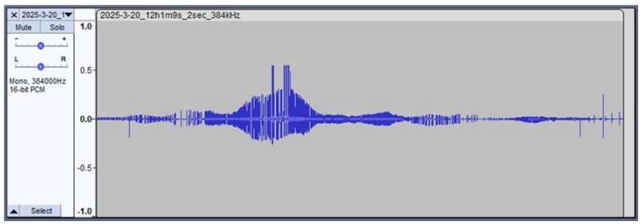
Annotated dataset containing 51 events transferred to **DFKI** for **algal bloom event detection algorithm** training. Methods described in D 7.2 and D7.3.



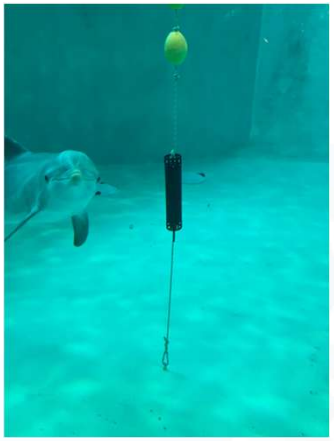
Sub-task 7.1.3: Demonstration of Acoustic Marine Mammal Monitoring System [AQUATEC]

To demonstrate efficiency and effectiveness of the standalone **AQUAclick Sound Passive Acoustic Sensor (PAS),** developed by **AQUATEC** under ST 3.3.2, in detecting and identifying marine mammals in their natural habitats:

- **April 2024-April 2025** sensors **deployed by AQUATEC under controlled conditions** at Kolmården Dolphinarium to optimize broadband audio recording triggered by dolphin clicks

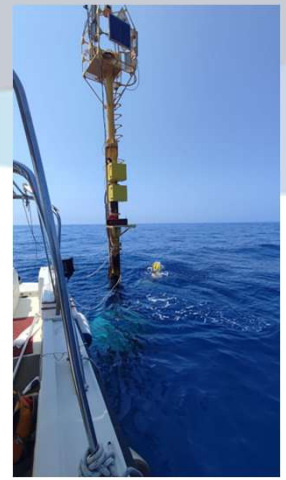


Dolphin clicks audio sample



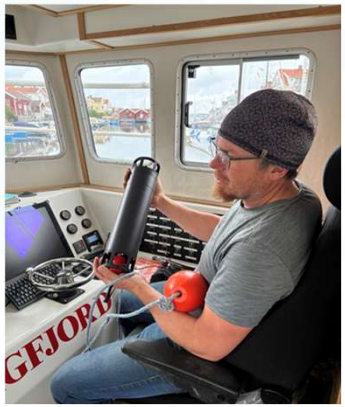
- **August 2024** and **May-June 2025, ETT demo** in the **Pelagos Sanctuary for Mediterranean Marine Mammals (Portofino)** to further evaluate efficiency and effectiveness in **detecting and identifying marine mammals in field**

PAS sensor installed at 2.2 meters depth on a pylon



- **mid-June 2025** successful **open-water deployment** in the Lysekil area of **Swedish waters** (collaboration with **SLU Aqua)** to showcase PAS performance in a **natural marine environment** and demonstrate potential to support **sustainable fishing practices** (help to reduce bycatch)

Swedish coastal fishermen involved in the PAS deployment.



- **TRL advancement** thanks to mechanical and software improvements → **Final TRL= 7**
- issues, battery performance, firmware and software updates, overall sensor functionality, deployment and post-analysis of recorded audio data reported in **D7.2**
- Acoustic recordings available through **NAUTILOS data portals** (e.g. ERDDAP™ server)
- ETT developed a **Google Colab notebook** to facilitate data discovery and harvesting

Task 7.2: Demonstration on platforms of opportunity (M34->) [Leader: SYKE]

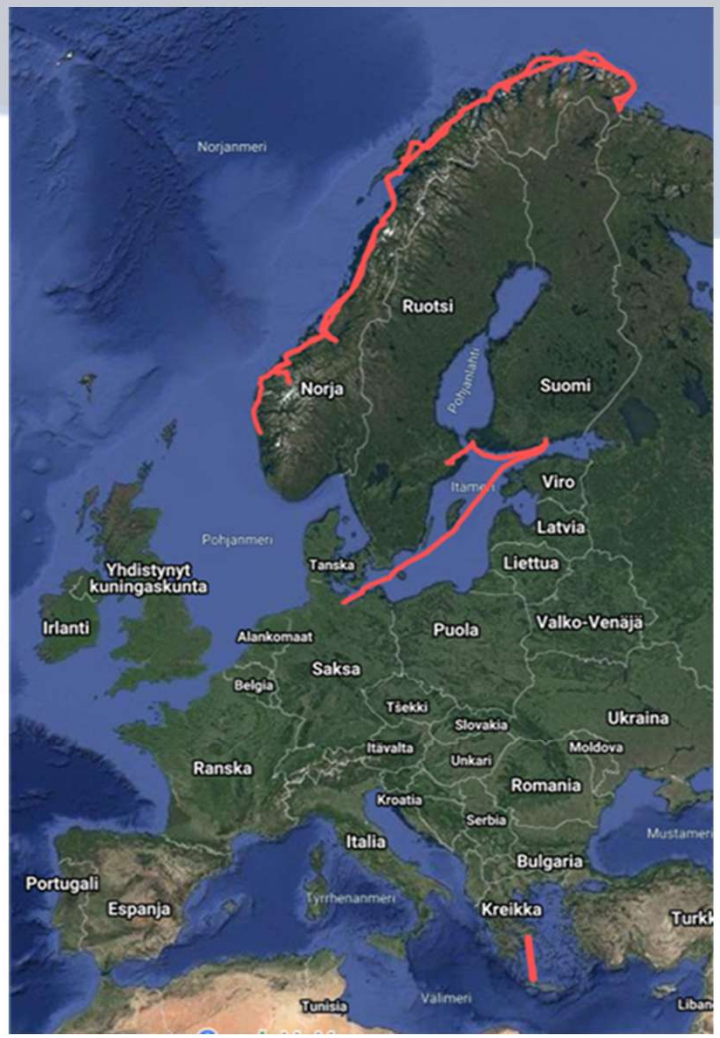
Objectives

Demonstration of the operational use of sensors in FerryBox infrastructures

Where; overview

<u>Platforms of Opportunity</u>

- Coastal Norway: NorSOOP FerryBoxes on M/S Trollfjord, M/S Color Fantasy, ASV and aerial drones
- Baltic Sea: Ferryboxes cruising across Baltic Sea;
- Eastern Mediterranean (Cretan Sea): (Poseidon FerryBox) / R/V Philia

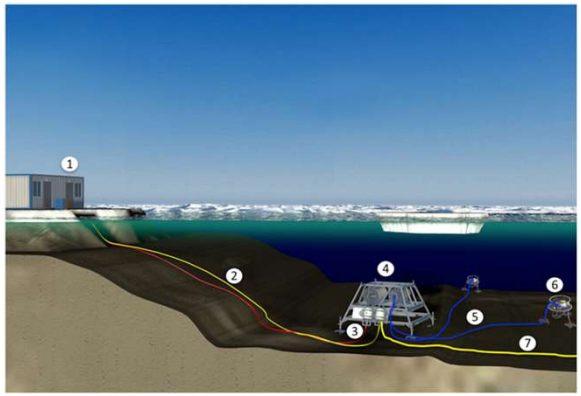


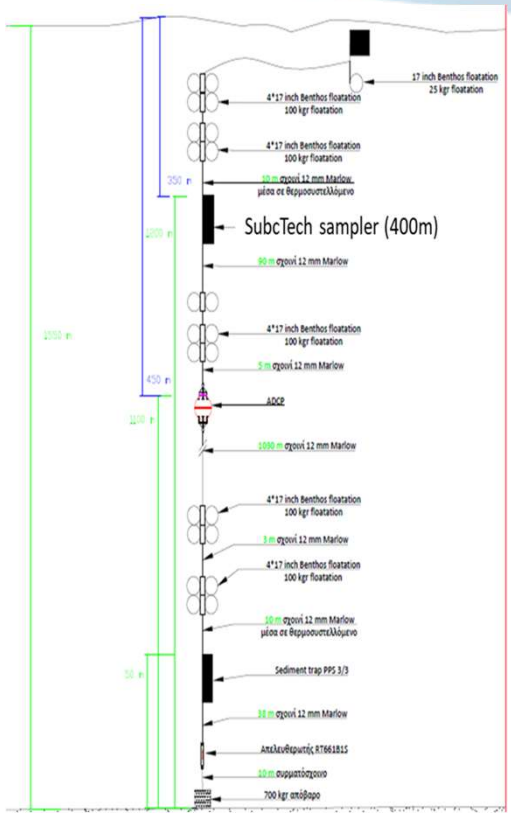
Sensors included in the demo

- The IR temperature sensor
- Drones with multi and hyperspectral cameras; LIF LIDAR
- Sampler for phytoplankton and other suspended matter.
- Micro plastic sampler
- Carbonate system/ocean acidification sensors
- Ferry Box Stream Data Analysis

Task 7.3: Demonstrations on Augmented Observing Systems [HCMR,CEiiA, EDGELAB]

- Different locations of demo (Germany, Greece,Portugal,Italy)= 3 different “subtasks” = 5 different ocean platforms (R/Vs, cabled obs, ocean buoys, AUV, mooring lines)





Task 7.4 Demonstration on ARGO platform [Leader: NKE]

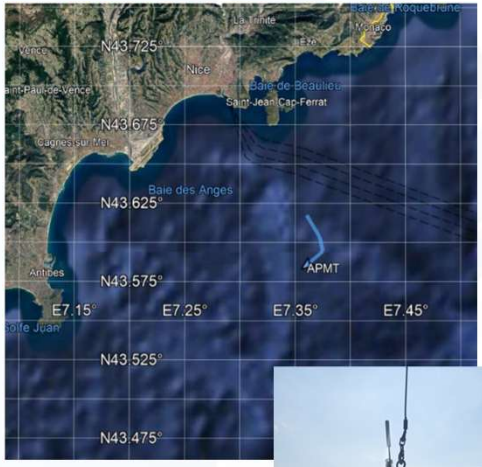
NAUTILOS **silicate sensor,** developed by **NKE** in task 4.2, laboratory calibrated in ST6, integrated on a new generation of **ARGO float** (CTS5) and field validated in ST5.4 was demonstrated:

- In May 2025 on ARGO float in the **Mediterranean Sea** by **CNRS-LGC** up to >500m to allow verification of robustness, acquisition measurement in real environment, communication and transmission protocol and showcase data collected in near real-time on NAUTILOS data portals.

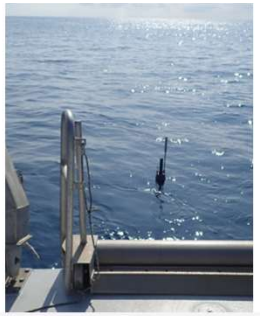
- Silicate float deployed with success in the Mediterranean Sea to enhance understanding of major **biogeochemical cycles and their impact on climate**

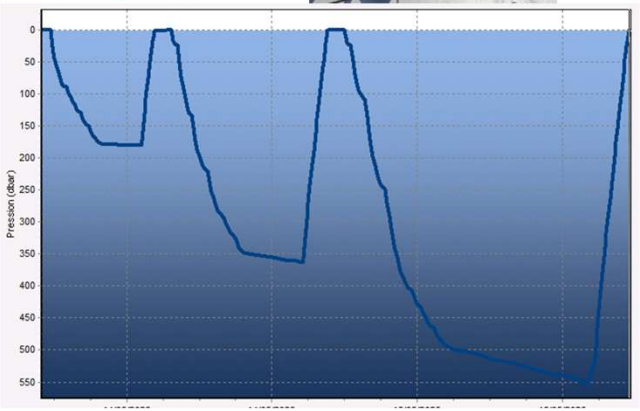
- **Low concentration of silicate measured in the Mediterranean Sea**

➔ **Final TRL = 8**



Trajectory of the float



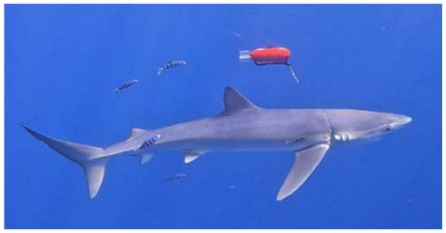


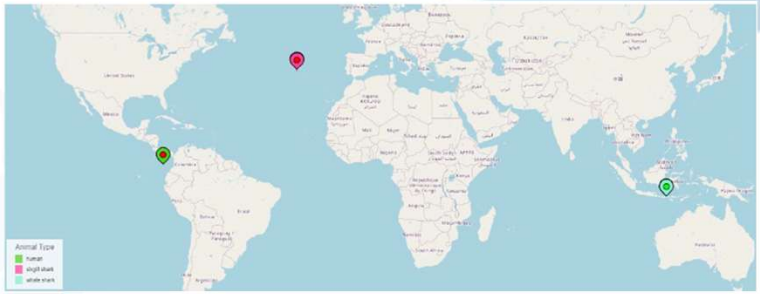
Deployment configurations, issues occurred before and during the deployment, actions taken, data retrieval, results, etc. are described in **D7.5**

Task 7.5: Animal-borne instruments demonstrations [Leader: CEiiA]

Information collected is relevant not only for understanding ecology and ethology of the species, but the animals themselves can serve as platforms for EOV sensors useful for understanding the marine environment and its changes, especially in areas not frequently explored with conventional methods.

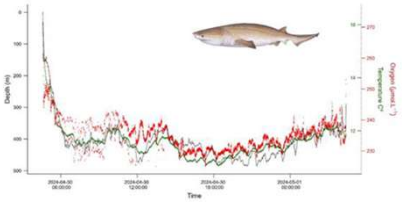
MAANTA tagging device with integrated **dissolved oxygen sensor** was designed by **CEiiA** for depths up to **2000m.**
Actual deployments exceeded original plan expectations (3 species representing contrasting ecologies, behaviors, and habitat use in the Atlantic Ocean)

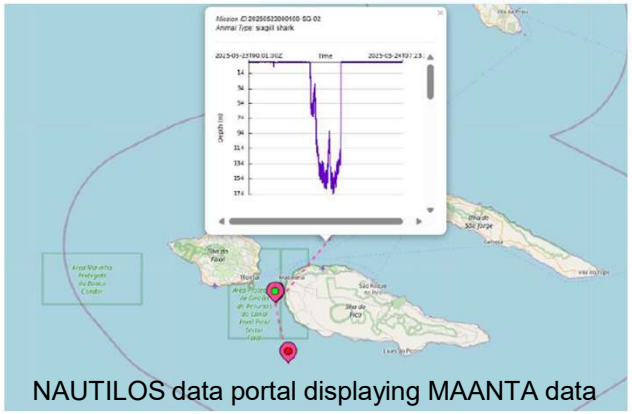




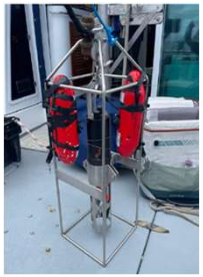
April 2024-June 2025 **IMAR** tagged 19 individuals of **Bluntnose sixgill shark, Blue shark, Chilean devil ray, Shortfin mako shark and Whale shark** in various geographical areas and depths (up to 1240m) in the **Atlantic Ocean.**

1 human deployment in March 2025 in the **Pacific Ocean** (up to 65m) + 4 **Whale sharks** tagged in the **Indian Ocean** (up to 226m) in June 2025.





NAUTILOS data portal displaying MAANTA data



\+ 11 test drops deployments in Matosinhos & Azores

➔ Final TRL = 8

Deployment details, issues occurred, actions taken, testing and improvements, data retrieval, results and suggested next steps for TRL advancement described in D7.6

Task 7.5: Animal-borne instruments demonstrations

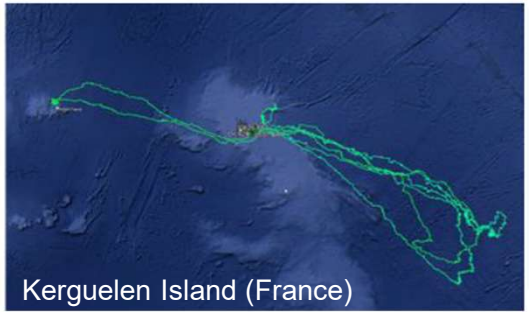
Southern elephant seals contribute to the collection of **80 % of the temperature and salinity profiles** south of 60°S and 98% of the profiles associated with the Antarctic sea-ice. **Oxygen Minimum Zone is expanding**, animal-borne oxygen tags can provide extremely valuable information in poorly sampled areas such as the Southern Ocean.

CNRS integrated Argos CTD-SRDL tags from the Sea Mammal Research Unit with **low cost optical dissolved oxygen sensor**.

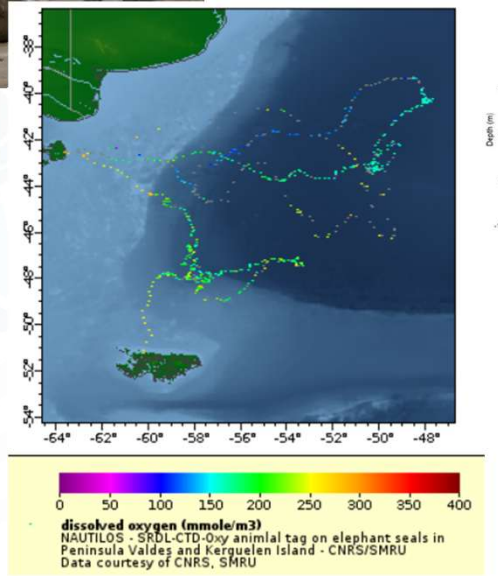
+ Zooplankton and micronekton are crucial link between phytoplankton and upper predators.

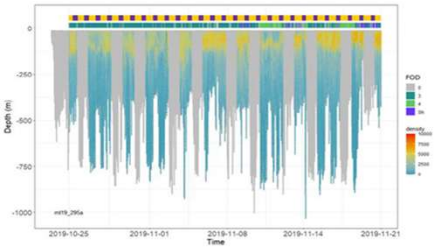
5 **SRDL-CTD-Oxy** deployed in **2021** on post-breeding southern elephant seal females in **Valdes Peninsula** and 5 in **2023-2024** in Kerguelen Island (1 lost).

➔ **Final TRL = 8**



Data made available through NAUTILOS portals



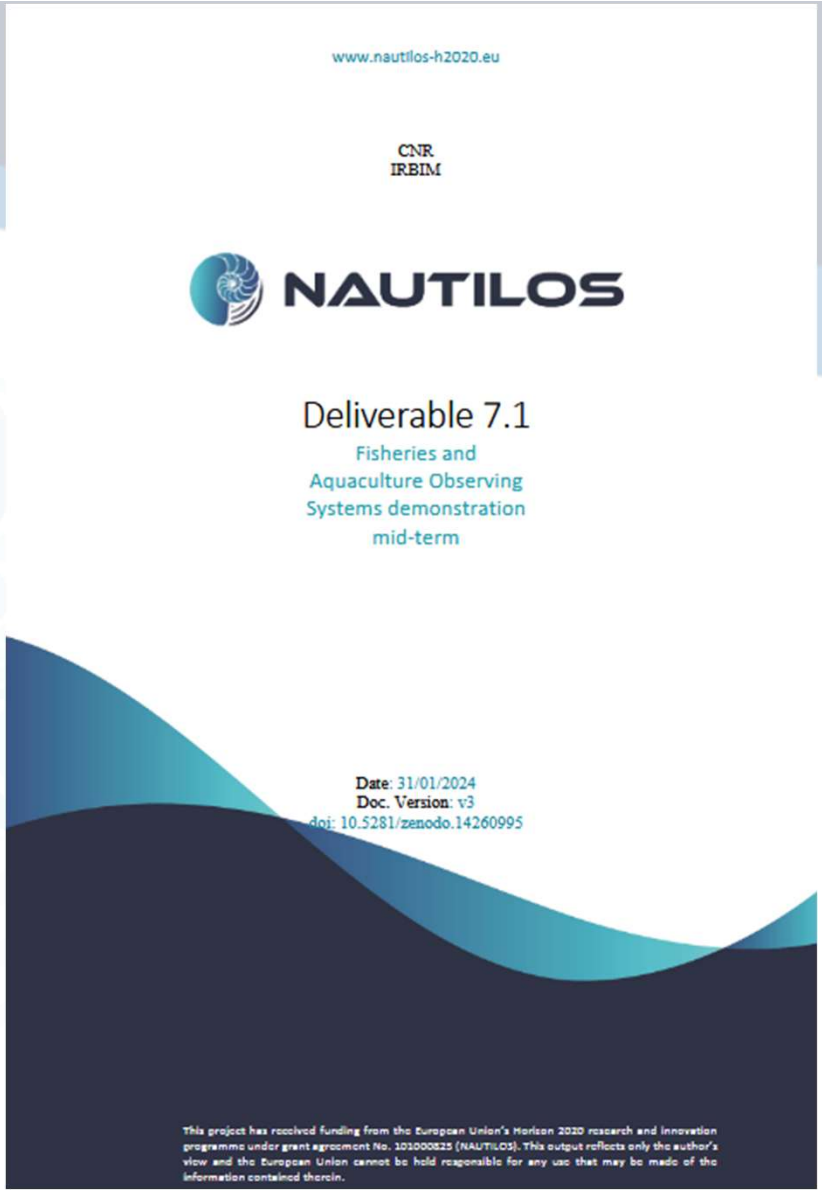


4 active micro sonar tag integrating a high sensitivity high-frequency light sensor to assess bioluminescence was also deployed.

Technical details, issues occurred and actions taken, data analysis and quality assessment, suggested next steps for TRL advancement described in D7.6

ETHICAL ASPECTS

1. DATA PROTECTION
2. ENVIRONMENTAL PROTECTION
3. HEALTH AND SAFETY
4. PROTECTION OF MARINE LIFE
5. DUAL USE POTENTIAL



Martinelli et al 2024.
https://doi.org/10.5281/zenodo.14260995

Lessons learnt after meeting realistic sea conditions

•**Field Demonstrations:** allowed testing sensors under real conditions, identifying **weak points** (mechanical or software) that were promptly improved thanks to the collaboration between the partners
•**Optimization:** While some deployments encountered challenges—such as biofouling—these instances were critical in defining **optimal operational conditions**

Emerging Risks

•**Stakeholder Engagement:** Challenges in obtaining consistent feedback e.g. from aquaculture operators.
•**Infrastructure Constraints:** Limited availability of facilities compared to initial project plan.
•**Operational Delays:** Cumulative setbacks caused by sensor failures, adverse weather, and regulatory shifts.
•**Logistics:** Significant budgetary and temporal pressures related to transportation.

Strategic Actions

•**Adaptive Demo Planning:** Developed a flexible demonstration strategy incorporating diverse regions and optimized platform-sensor configurations, executed necessary deviations from original plans to ensure project viability.

Long-Term Impact & Scalability

•**System Integration:** Advancing ocean observing systems through the introduction of next-generation instrumentation and expanded measurement parameters.
•**Scalable Methodologies:** Establishing a proven, modular approach ready for large-scale deployment and broader geographical reach.
•**Enhanced Data Solutions:** Delivering high-value data products to support informed maritime decision-making and scientific research.

Lessons learnt and Best practices for the community

- ***Best practice #1:*** *Involve both scientists and technology manufacturers in the early stages of design.*
- ***Best practice #2:*** *Make use of already existing research infrastructures like laboratories and coastal marine observatories as evaluators and testing fields for technology.*
- ***Best practice #3:*** *Build demonstration scenarios based on already existing scientific activities to expand apart from the technical criteria of the testing.*
- ***Best practice #4:*** *Build realistic scenarios for duration and location including risk assessments and alternative planning of activities*
- ***Best practice #5:*** *Build demonstrations taking into account that some procedures and tests must be repeated.*
- ***Best practice #6:*** *Marine instrumentation needs robust design and dedicated antifouling techniques. This should be considered in the original design of the technology.*
- ***Best practice #7:*** *More than one prototype of a technology should be available for cross-platform validation in several sites with different environmental conditions.*

Ntoumas et al. 2025 https://doi.org/10.5281/zenodo.18244791

AdriFOOS

UWTV

Last break
Next 'Monitoring in Action'

michela.martinelli@cnr.it

MODULE 4
Monitoring in Action: Case Studies and Future Challenges

- Section 4.1 - Progress and opportunities in using fishing vessels as a platform for widespread coastal DO monitoring

- Section 4.2 - *Nephrops norvegicus* UWTV surveys in Pomo Pits (Adriatic Sea)

Section 4.1

Progress and opportunities in using fishing vessels as a platform for widespread coastal DO monitoring

Michela Martinelli

Institute for Marine Biological Resources and Biotechnology,

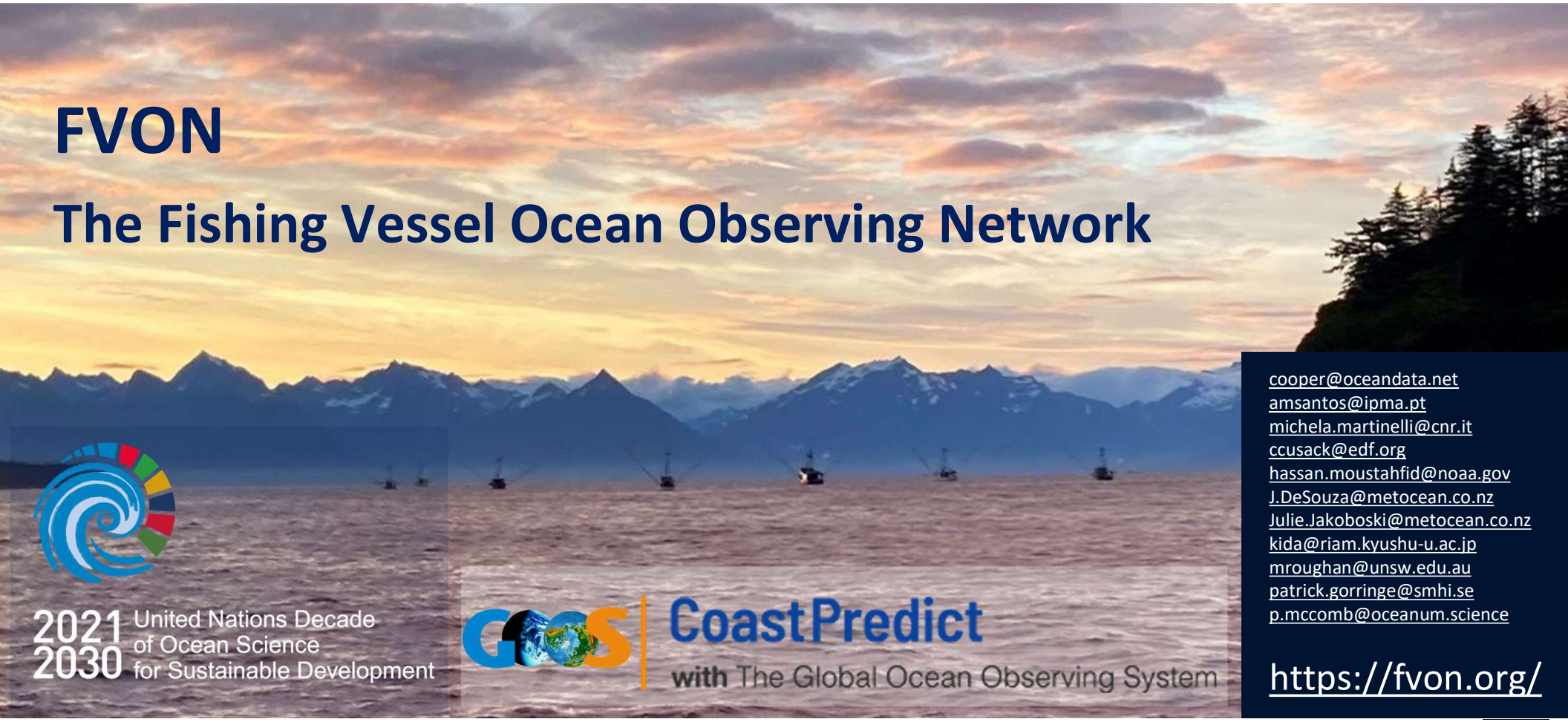
National Research Council, Italy

CNR IRBIM ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

michela.martinelli@cnr.it

FVON

The Fishing Vessel Ocean Observing Network



2021 2030 United Nations Decade of Ocean Science for Sustainable Development

GOOS | CoastPredict with The Global Ocean Observing System

cooper@oceandata.net
amsantos@ipma.pt
michela.martinelli@cnr.it
ccusack@edf.org
hassan.moustahfid@noaa.gov
J.DeSouza@metocean.co.nz
Julie.Jakoboski@metocean.co.nz
kida@riam.kyushu-u.ac.jp
mroughan@unsw.edu.au
patrick.gorringe@smhi.se
p.mccomb@oceanum.science

https://fvon.org/

OCEAN DATA NETWORK

EMODnet European Marine Observation and Data Network

CNR IRBIM Istituto per le Risorse Biologiche e le Biotecnologie Marine

MetService Te Ratonga Tirorangi

IPMA Instituto Português do Mar e da Atmosfera

Integrated Ocean Observing System

NOAA

Environmental Defense Fund

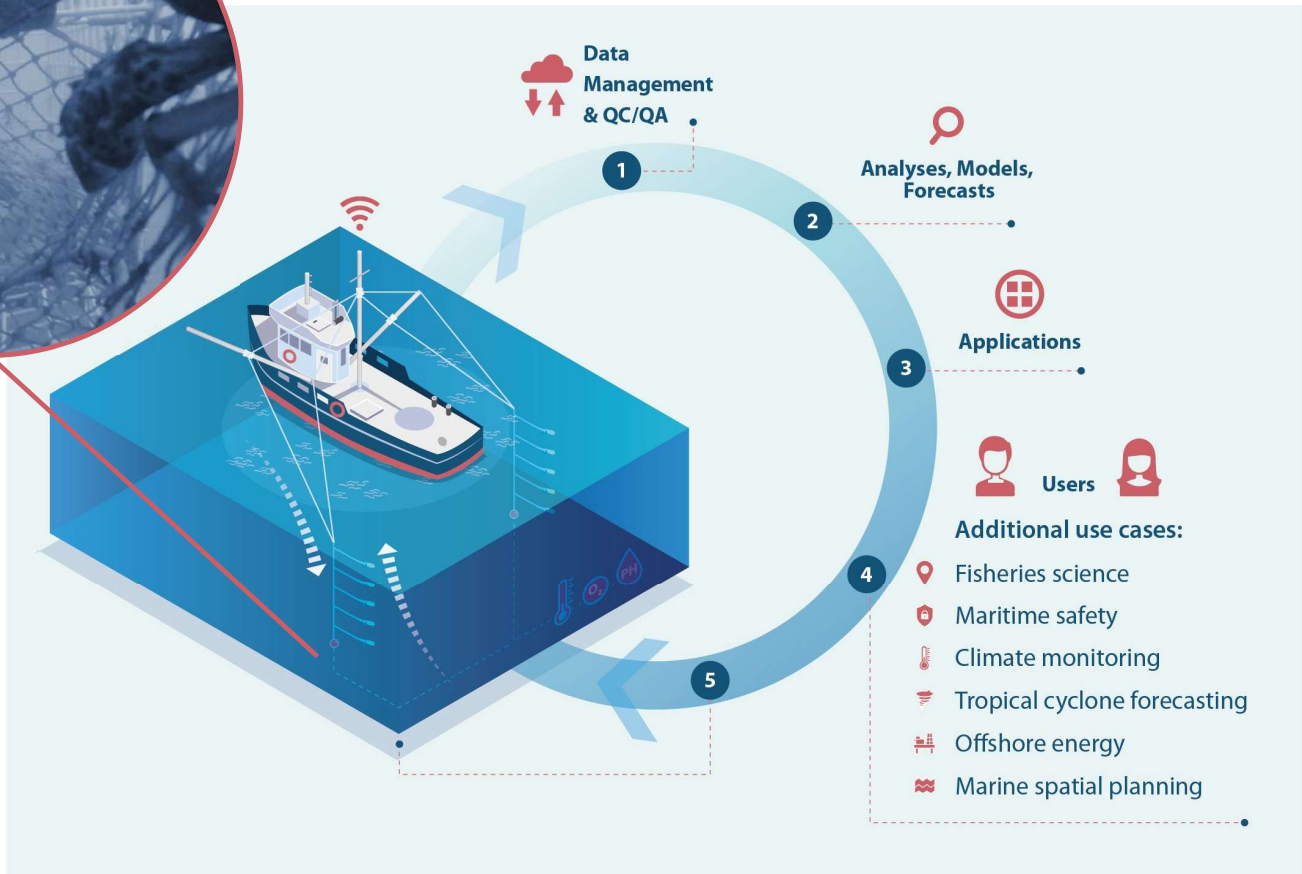
UNSW Sydney

Applied Mechanics

Concept

Fishing for data

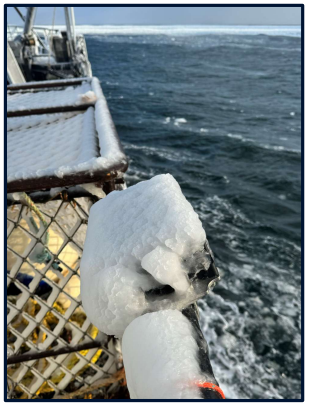
- Unique subsurface data collection capability at relatively low costs
- Sensors go along for the ride catching water column profiles
- Fully automatic: as soon as the gear & sensor surface, data is telemetered via deck hub
- Starting with temp profiles, opportunities for co-located surface met, sea surface, & additional subsurface

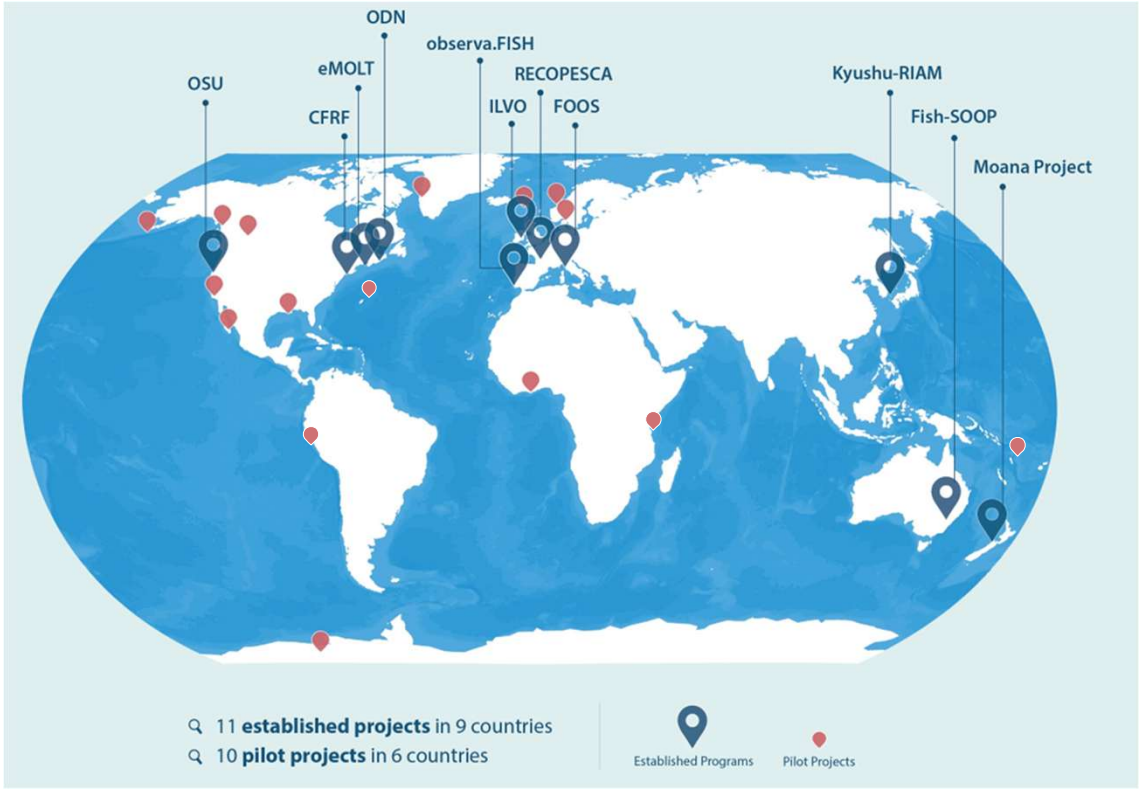


Coordination

FVON

- Interdisciplinary Group: Oceanography, Fisheries science, NGOs, Start-ups
- Harmonizing data collection, promoting data sharing, defining best practices
- Do things at scale and meet the needs of data users and society
- Work with thousands of vessels spreading the approach globally
- Endorsed as Decade Action No.46.5 under the Coastpredict Programme (February 2024)
- GOOS emerging network (announced August 2024)



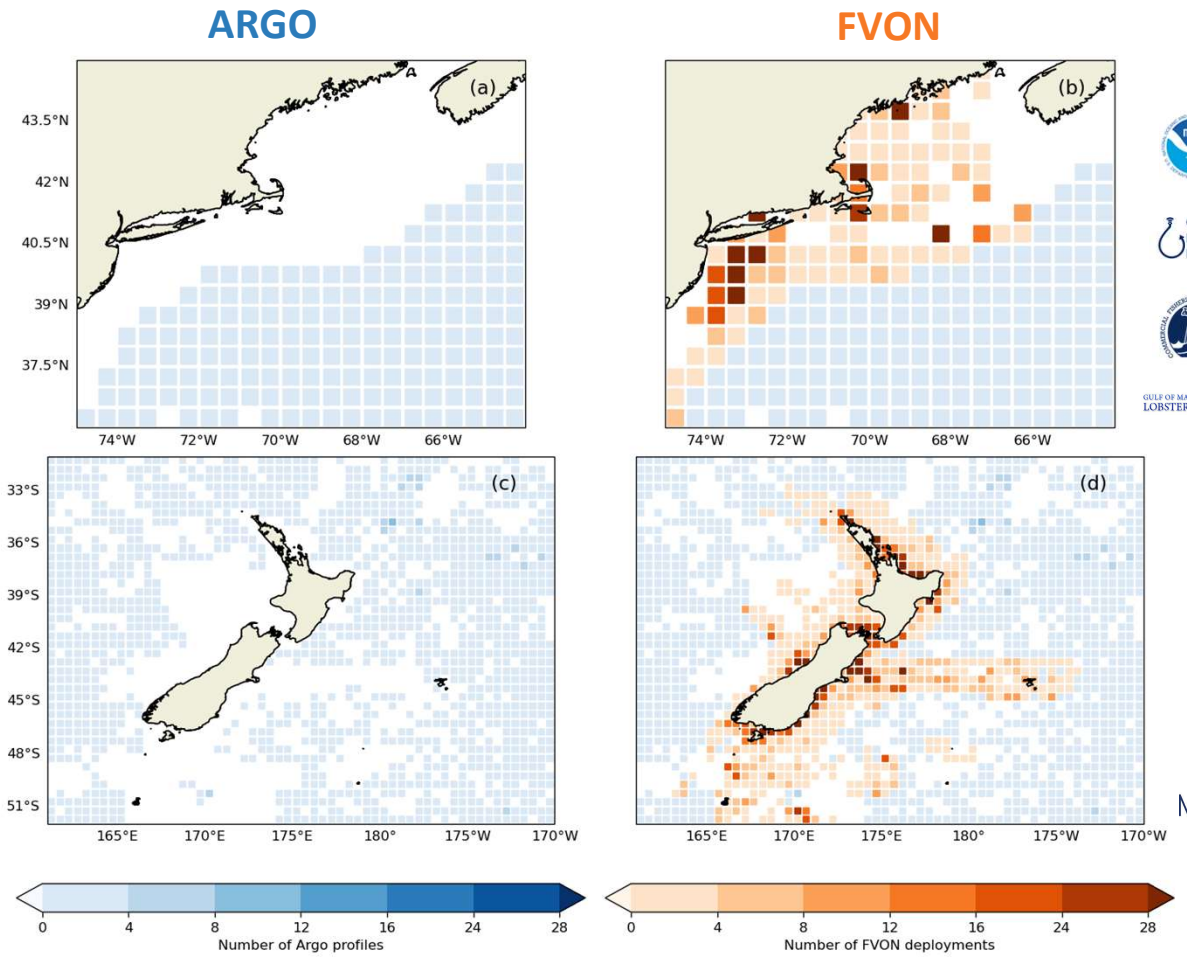


Van Vranken, C. H., Jakoboski, J., Carroll J. W., Cusack, C., Gorringe, P., Hirose, N., Manning, J. P., Martinelli, M., Penna, P., Pickering, M., Santos, A. M., Roughan, M., De Souza, J., & Moustahfid, H. (2024).
Towards a global Fishing Vessel Ocean Observing Network (FVON): State of the art and future directions.
https://www.frontiersin.org/articles/10.3389/fmars.2024.1176814/

Mission

Complement existing ocean observing systems

- Fishing operations primarily take place in the coastal zone
- Fill Spatial and Temporal Gaps in oceanographic observations
- Biodiversity and socio-economic hotspots



Van Vranken, C., Vastenhoud, B. M. J., Manning, J. P., Plet-Hansen, K. S., Jakoboski, J., Gorringe, P., & Martinelli, M. (2020). **Fishing Gear as a Data Collection Platform: Opportunities to Fill Spatial and Temporal Gaps in Operational Sub-Surface Observation Networks**. Frontiers in Marine Science, 7. https://doi.org/10.3389/fmars.2020.485512

2003-2013:
FISHERY OBSERVING SYSTEM (FOS)

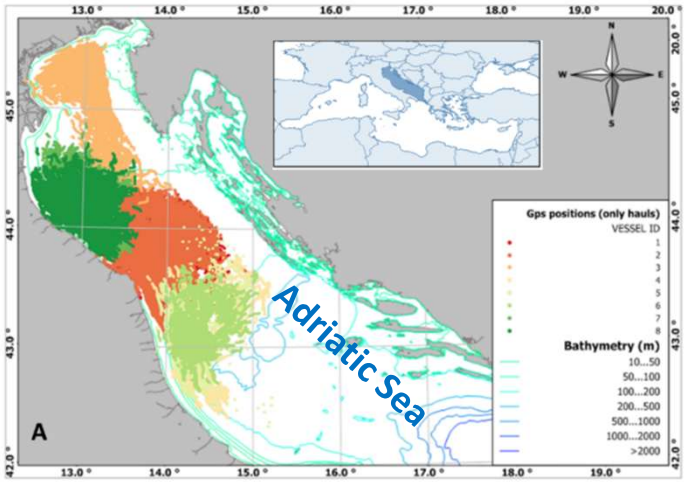
Mediterranean Forecasting System: Toward Environmental Predictions

FOS components

- ***e-logbook*** *with integrated user-friendly software (A)*
- *touch screen and* ***GPS antenna*** *(B)*
- ***T/P sensors*** *mounted on the fishing gear (C)*

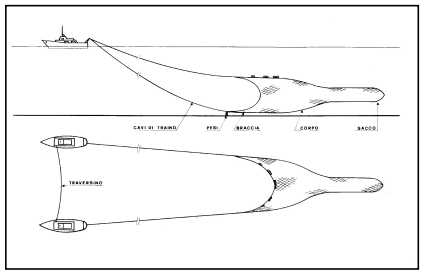
Collected information

- ***catches*** *and sizes of the target species*
- *GPS* ***positions***
- *water* ***temperature*** *and fishing* ***depth***

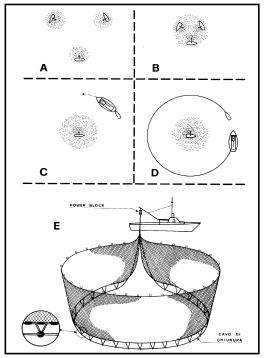


Positions (1 per minute) of monitored vessels recorded only during fishing operations.

Fishing gear

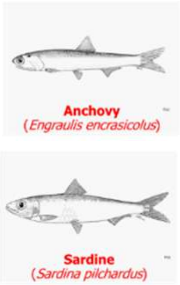


n. 6 pelagic pair trawlers



n.1 purse seiner

Target species: Small pelagics



Ocean Sci., 3, 189–203, 2007
www.ocean-sci.net/3/189/2007/

Ocean Science

An observing system for the collection of fishery and oceanographic data

P. Falco[1], A. Belardinelli[1], A. Santojanni[1], N. Cingolani[1], A. Russo[2], and E. Arneri[1]

https://doi.org/10.5194/os-3-189-2007

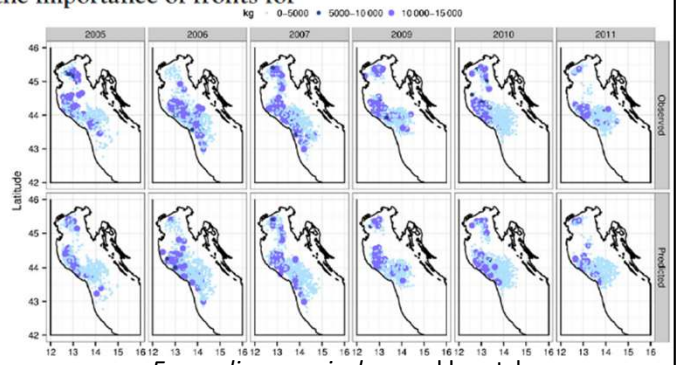
2003-2013: FISHERY OBSERVING SYSTEM (FOS)

FISHERIES OCEANOGRAPHY
FISHERIES OCEANOGRAPHY Fish. Oceanogr. 24:6, 521–532, 2015

Coupling an oceanographic model to a Fishery Observing System through mixed models: the importance of fronts for anchovy in the Adriatic Sea

PIERA CARPI,[1]* MICHELA MARTINELLI,[1] ANDREA BELARDINELLI,[1] ANIELLO RUSSO,[1,2,3] ENRICO ARNERI,[1,3] ALESSANDRO COLUCCELLI[2] AND ALBERTO SANTOJANNI[1]

Carpi et al. 2015
https://doi.org/10.1111/fog.12126

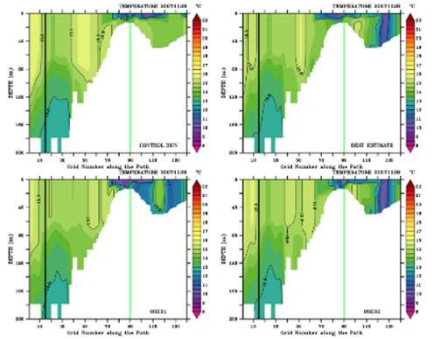


Engraulis encrasicolus weekly catches

ELSEVIER
Journal of Marine Systems
journal homepage: www.elsevier.com/locate/jmarsys

Assimilation experiments for the Fishery Observing System in the Adriatic Sea

Ali Aydoğdu [a,b,*], Nadia Pinardi [a,c], Jenny Pistoia [d], Michela Martinelli [e], Andrea Belardinelli [e], Stefania Sparnocchia [f]



Root mean square of **temperature errors reduced** up to 44%; similar impact with reduced number of vessels if spatial coverage does not change significantly.

Aydoğdu et al. 2016
http://dx.doi.org/10.1016/j.jmarsys.2016.03.002

ELSEVIER
Ecological Modelling
journal homepage: www.elsevier.com/locate/ecolmodel

Modelling the strategy of mid-water trawlers targeting small pelagic fish in the Adriatic Sea and its drivers

Tommaso Russo[a,*], Jacopo Pulcinella[a], Antonio Parisi[b], Michela Martinelli[c], Andrea Belardinelli[c], Alberto Santojanni[c], Stefano Cataudella[a], Sabrina Colella[c], Luca Anderlini[d]

Russo et al. 2015
https://dx.doi.org/10.1016/j.ecolmodel.2014.12.001

ELSEVIER
Ecological Indicators
journal homepage: www.elsevier.com/locate/ecolind

Assessing the fishing footprint using data integrated from different tracking devices: Issues and opportunities

T. Russo[a,*,1], L. D'Andrea[a,1], A. Parisi[b,1], M. Martinelli[c], A. Belardinelli[c], F. Boccoli[d], I. Cignini[d], M. Tordoni[d], S. Cataudella[a]

Russo et al. 2016 http://dx.doi.org/10.1016/j.ecolind.2016.04.043

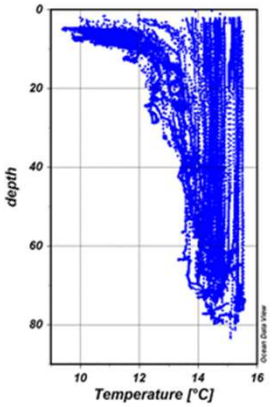
ELSEVIER
Marine Policy
journal homepage: www.elsevier.com/locate/marpol

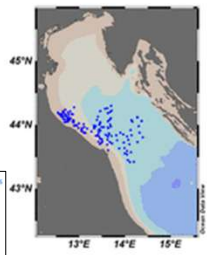
Small pelagic purse seines in the Adriatic Sea: A spatial analysis and technical overview in relation to Mediterranean Regulation provisions

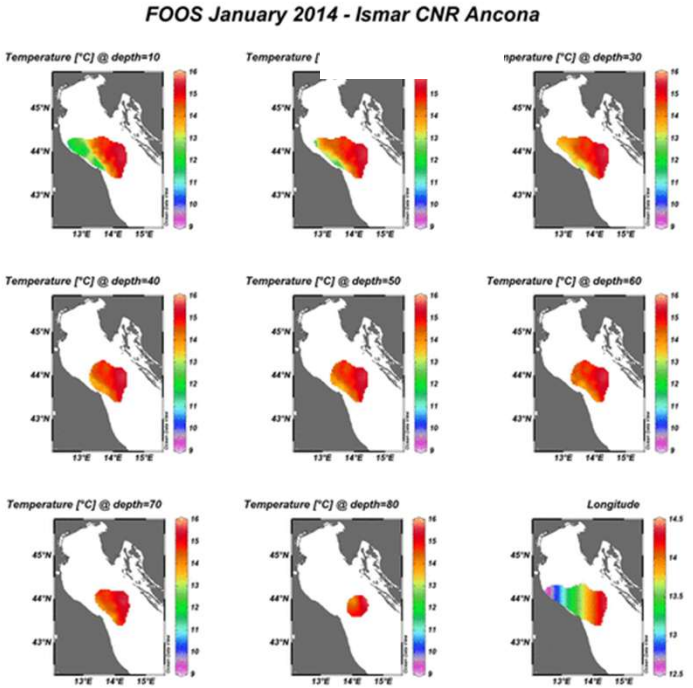
Alessandro Lucchetti[a,*], Andrea Belardinelli[a], Lorenzo D'Andrea[b], Bojan Marčeta[c], Michela Martinelli[a], Tommaso Russo[b], Vanja Čikeš Keč[d], Barbara Zorica[d], Massimo Virgili[a]

Lucchetti et al. 2018 https://doi.org/10.1016/j.marpol.2018.09.031

2012-2026: Fishery and Oceanography Observing System (FOOS)







Journal of Operational Oceanography

ISSN: 1755-876X (Print) 1755-8778 (Online) Journal homepage: http://www.tandfonline.com/loi/tjoo20

The Fishery and Oceanography Observing System (FOOS): a tool for oceanography and fisheries science

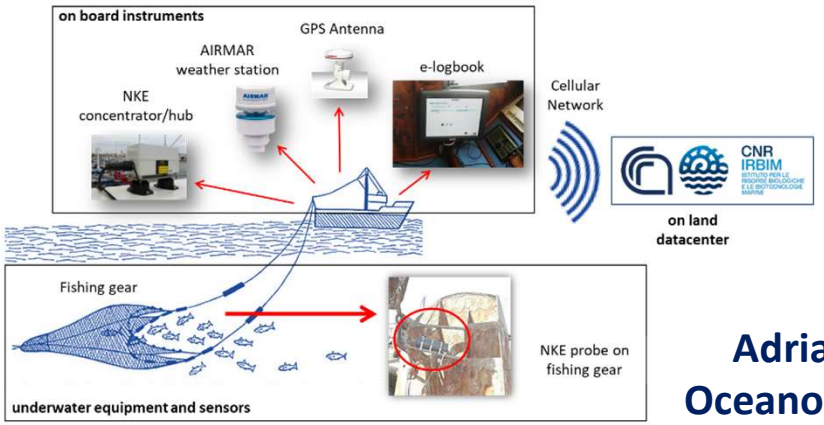
B. Patti, M. Martinelli, S. Aronica, A. Belardinelli, P. Penna, A. Bonanno, G. Basilone, I. Fontana, G. Giacalone, N. Gabriele Galli, R. Sorgente, I.V.M. Angileri, C. Croci, F. Domenichetti, D. Bonura, A. Santojanni, S. Sparnocchia, R. D'Adamo, M. Marini, F. Fiorentino & S. Mazzola

http://dx.doi.org/10.1080/1755876X.2015.1120961

Best Practices, 2019
http://dx.doi.org/10.25607/OBP-898

JRAP Synthesis and **contribution to the strategy for the future**, 2019.
https://doi.org/10.13155/68871

AdriFOOS



Adriatic Fishery and Oceanography Observing Systems infrastructure

https://doi.org/10.5194/essd-15-3513-2023
https://doi.org/10.17882/73008

http://foosweb.irbim.cnr.it/
username: foosample
pwd: fsA@23.mp

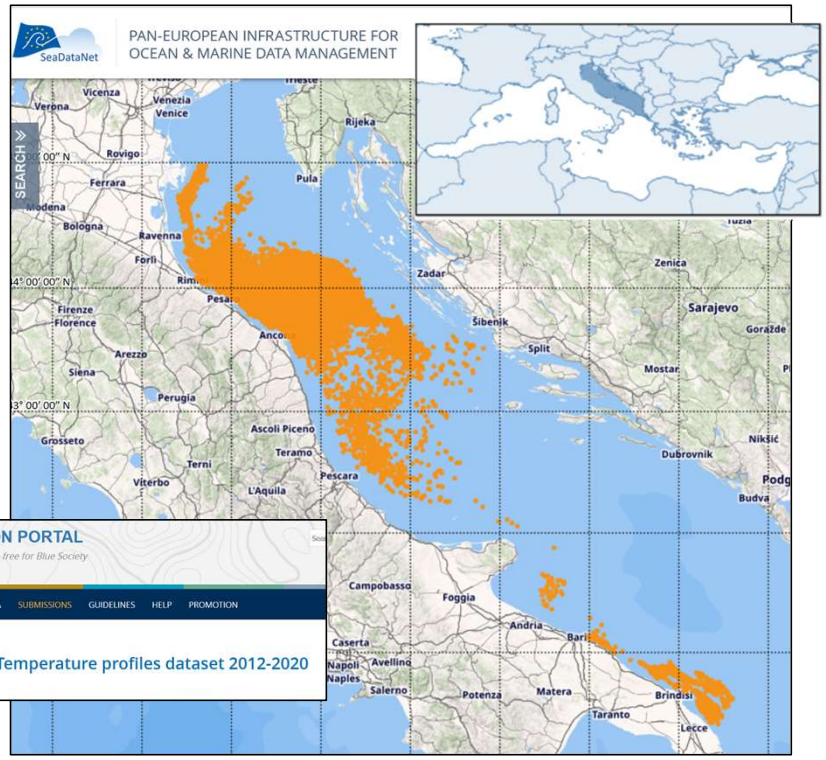
Dataset of depth and temperature profiles obtained from 2012 to 2020 using commercial fishing vessels of the AdriFOOS fleet in the Adriatic Sea

Pierluigi Penna, Filippo Domenichetti, Andrea Belardinelli, and Michela Martinelli

Open Access Earth System Science Data

SEANOE SEA SCIENTIFIC OPEN DATA PUBLICATION

14811 depth/temperature profiles collected by **10 vessels**



AdriFOOS as **testing platform** for sensors

Pressure, Temperature, Salinity

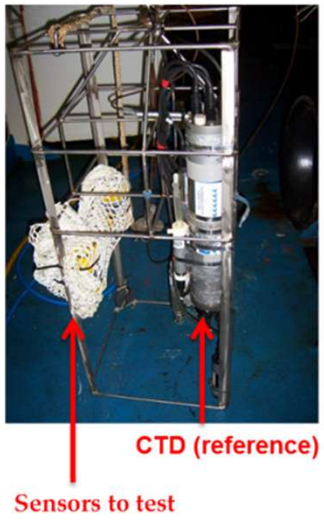
To compare datasets produced by sensors on fishing gears to traditional oceanographic ones (e.g. CTD transects):

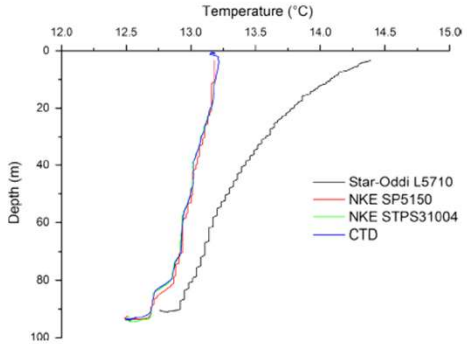
i) sensors need to be tested to determine the **accuracy of the produced datasets**;

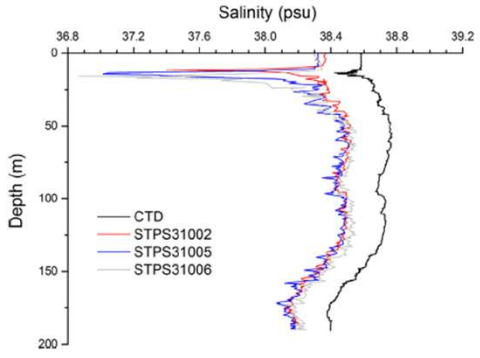
ii) the **optimal operational conditions** should be defined.

After evaluating the accuracy of the sensors, further refinements can be achieved by **correcting the raw data with the calculated offsets**.

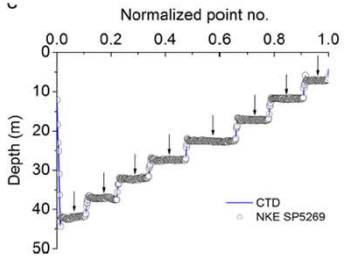
Simultaneous profiling

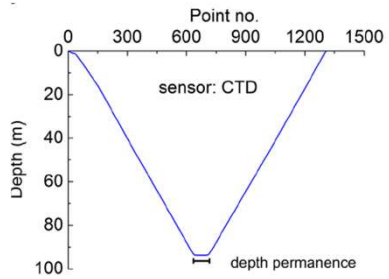






Simulations of data collection during fishing activity





Ocean Engineering
journal homepage: www.elsevier.com/locate/oceaneng

Evaluation of the oceanographic measurement accuracy of different commercial sensors to be used on fishing gears

M. Martinelli [a,*], S. Guicciardi [a], P. Penna [a], A. Belardinelli [a], C. Croci [a], F. Domenichetti [a], A. Santojanni [a], S. Sparnocchia [b]

http://dx.doi.org/10.1016/j.oceaneng.2015.10.037

NEXOS
2013-2017

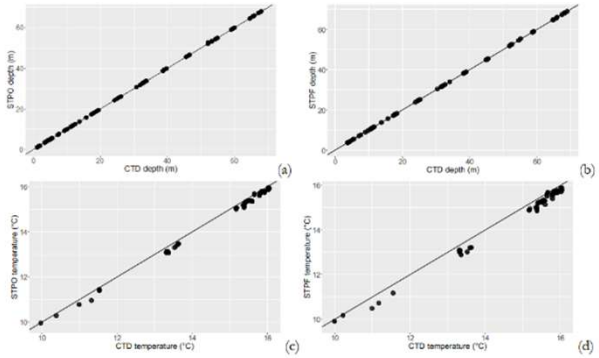
Oxygen, Fluorescence

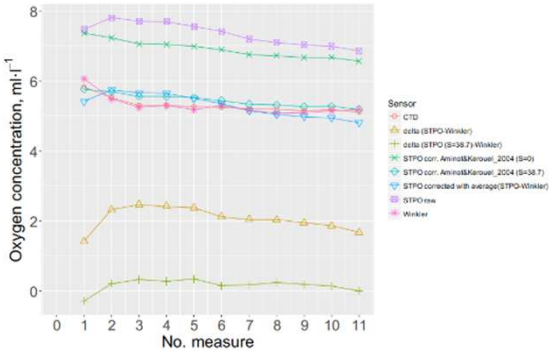
Optimisation and Calibration of nke INSTRUMENTATION prototypes

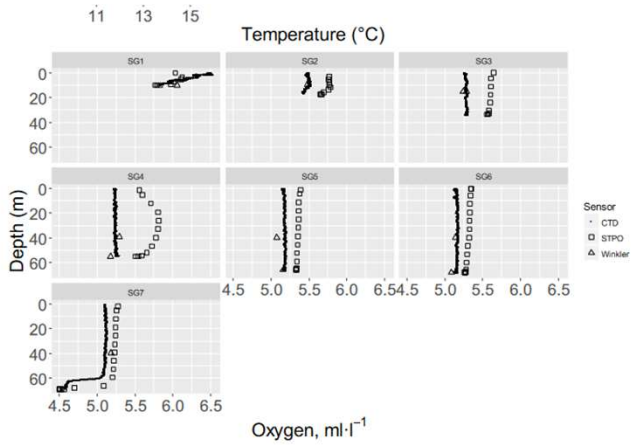
(1) Water sampling and comparison with lab tests

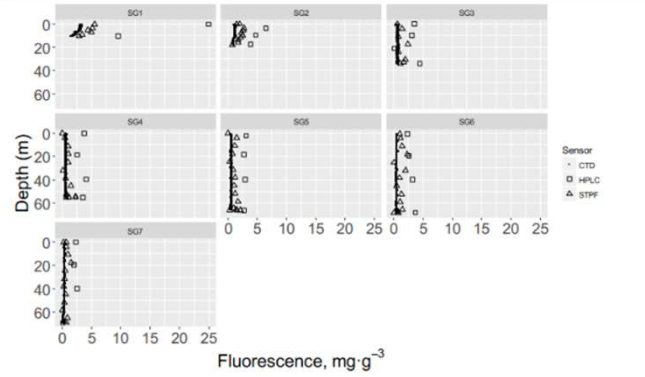
(2) Simultaneous profiling with CTD

(3) Trials with sensors mounted on fishing gears









Deliverable 8.2 – Validation report
https://archimer.ifremer.fr/doc/00630/74255/73886.pdf

New Approach To Underwater Technologies For Innovative, Low-Cost Ocean Observation

NAUTILOS

Oct 2020 - Jun 2025

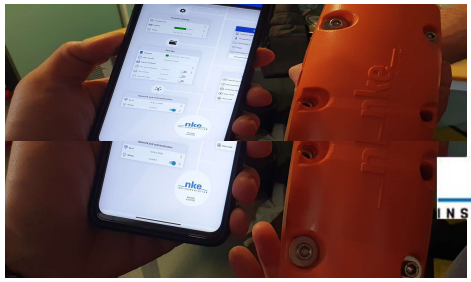
New generation of **Dissolved Oxygen** and **Chlorophyll-*a*** sensors + receiver **WiHub**

Sub-task 6.1.1: Dissolved Oxygen and fluorescence sensors for fishing vessels calibration [**IFREMER,** CNR, SYKE]

Sub-task 5.3.1: Integration of DO and Chl-a sensor and Hub system on fishing vessels [**CNR,** IFREMER, NKE, SYKE]

Sub-task 7.1.1: Demonstrations on Fisheries Observing Systems [**CNR,** IFREMER, NKE, SYKE]

Sub-task 7.1.2: Novel approach to Aquaculture Observing Systems [**NIVA**, HCMR, DFKI]



nke INSTRUMENTATION

contact:
dmalarde@nke.fr

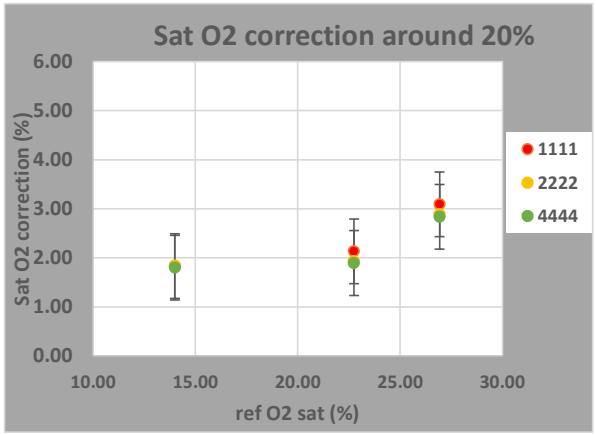
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101000825 (NAUTILOS). This output reflects only the author's view and the European Union cannot be held responsible for any use that may be made of the information contained therein.

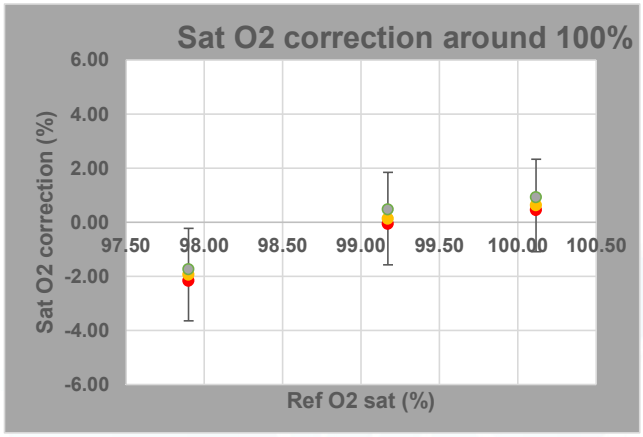
https://nautilos-h2020.eu/

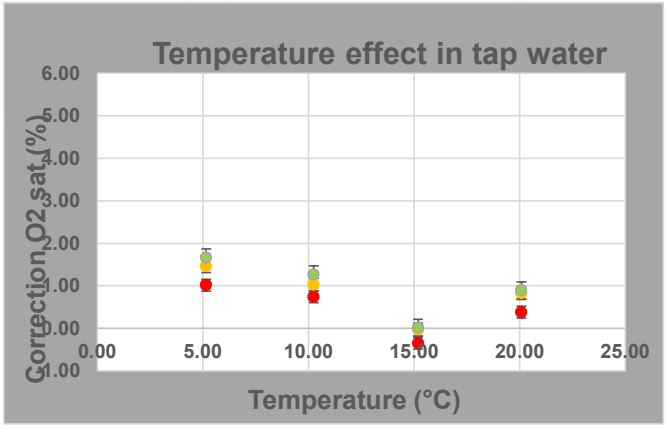
Dissolved Oxygen sensors for fishing vessels *lab calibration*

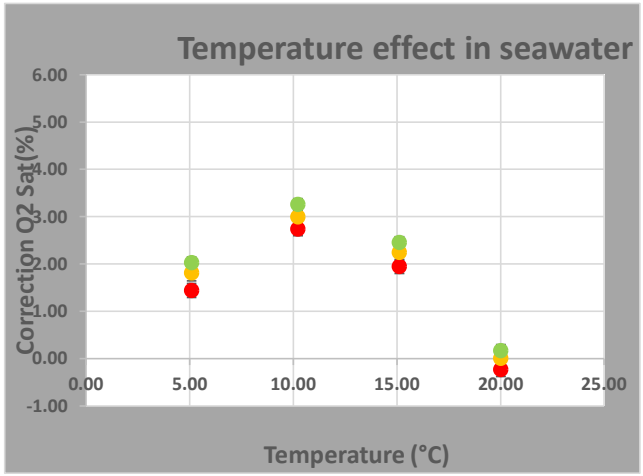
Tests on 3 sensor prototypes carried out jointly by Ifremer and CNR at Ifremer facilities:

- Repetability, accuracy, linearity
- Temperature effect







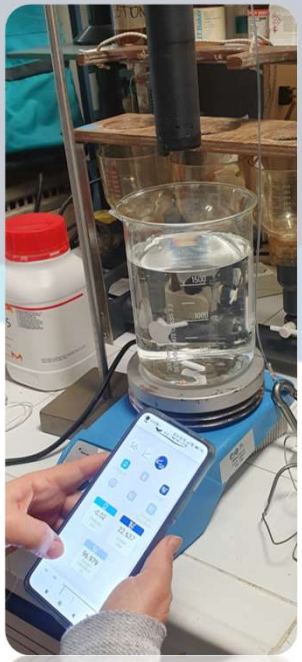


Similar response for the 3 prototypes

Complementary tests at CNR

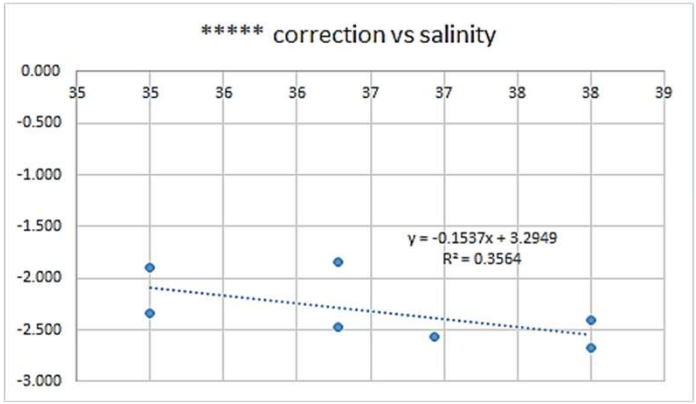
Tests on internal salinity set (in total 33 tests) main results:

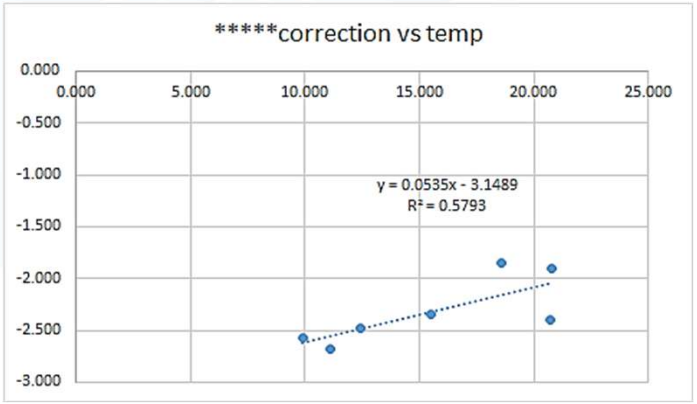
avg correction Winkler-sensor (+/-100%sat)	mg/L	st.dev.
H2O Salinity=35 and setting=0	-2.121	0.309
H2O Salinity=36.6 and setting=0	-2.298	0.392
H2O Salinity=38 and setting=0	-2.538	0.195

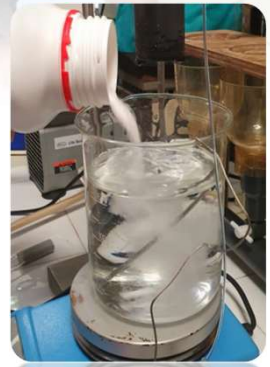


internal salinity set = salinity solution (0-100%sat)

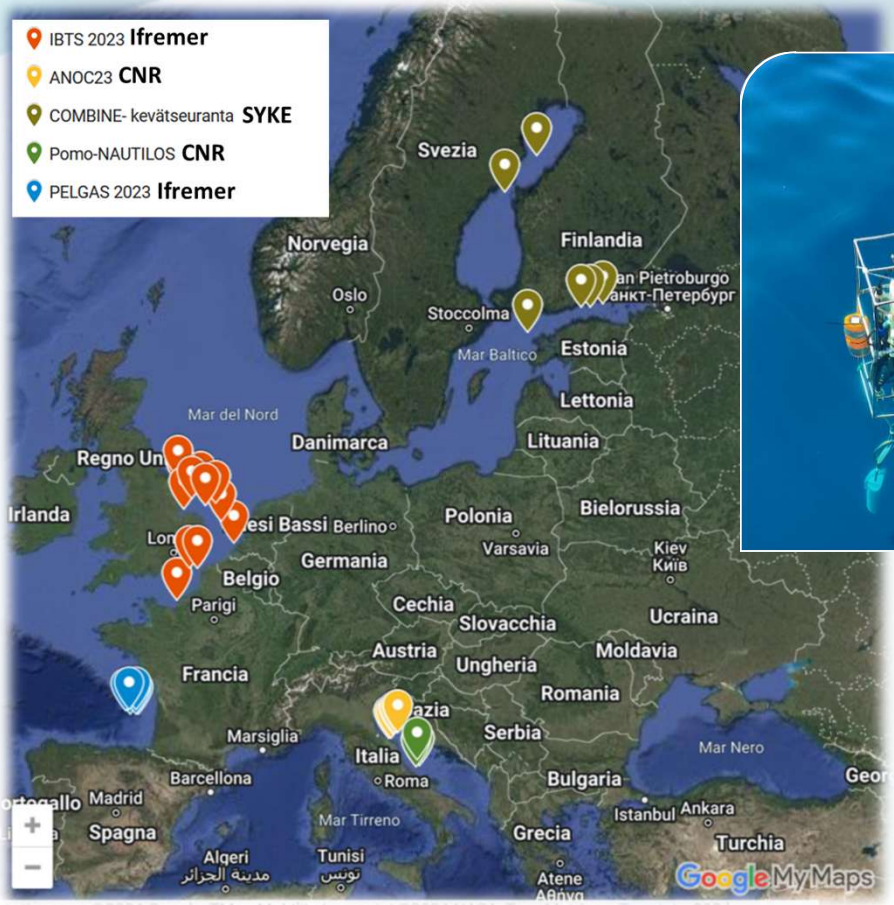
average difference with Winkler in mg/L = - 0.271 (st.dev. 0.349)

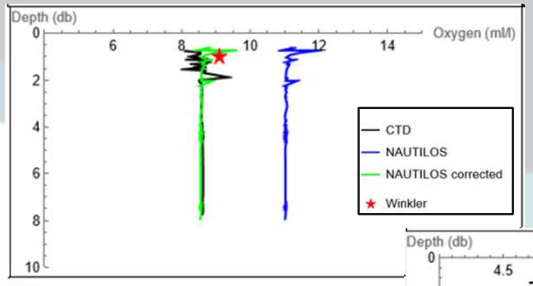




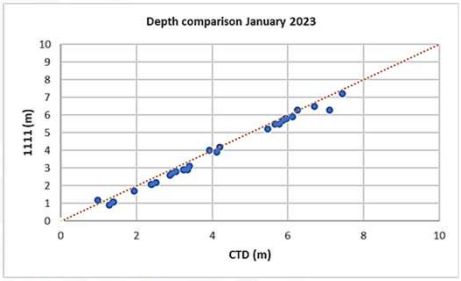


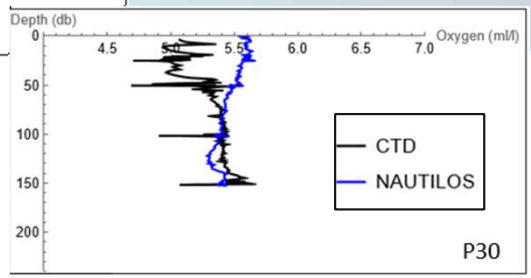
Field validation of Dissolved Oxygen (DO) and Fluorescence (Chl-*a*) prototypes

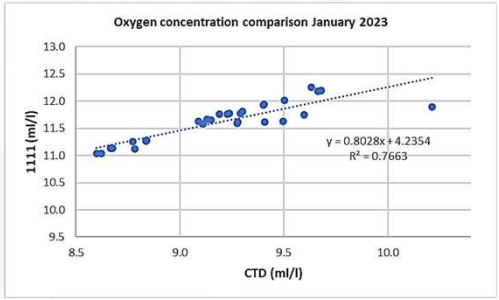


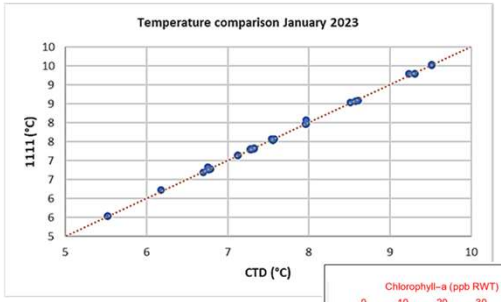


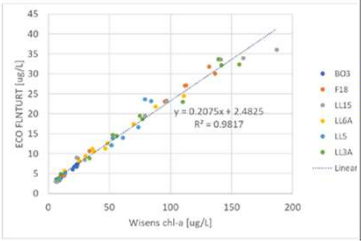
Simultaneous profiling and water samples

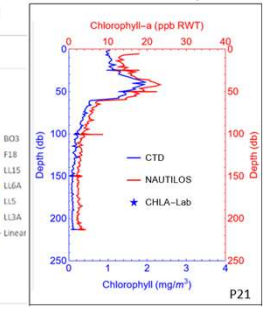












Field validation **cruises** carried out by partners Jan-May 2023

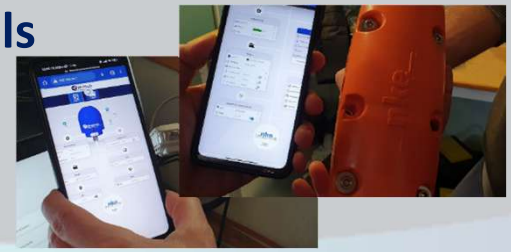
Common ***field protocols*** simulating operational conditions on fishing vessels

Deliverable 5.6

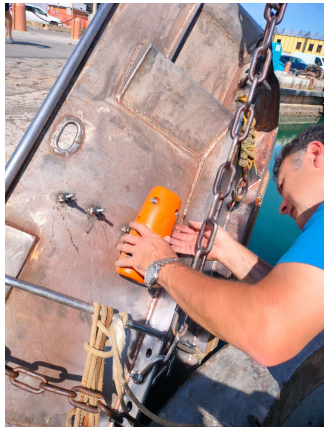
Validation and integration report on ships of opportunity

https://doi.org/10.5281/zenodo.10909202

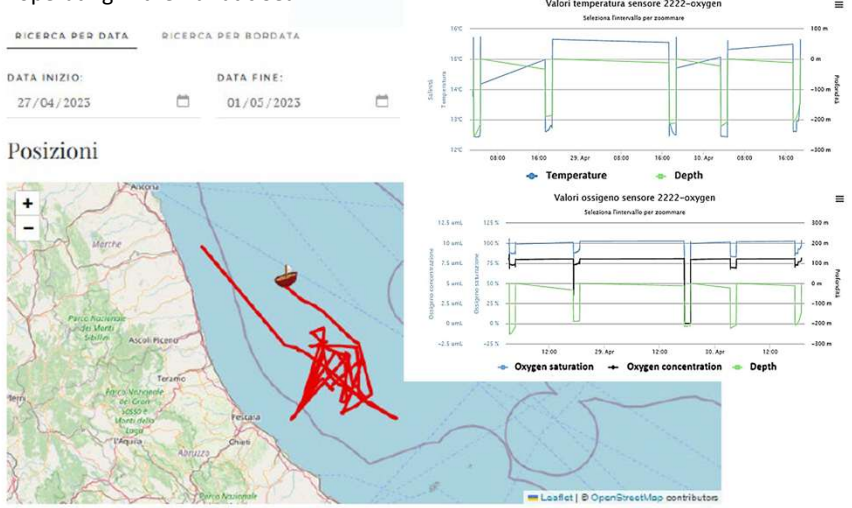
Integration of DO and Chl-*a* sensor and WiHub system on fishing vessels



April 2023 experimental fishing cruise in the Adriatic Sea on board R/V



Sensors mounted on the otter door of a commercial bottom trawler operating in the Adriatic Sea

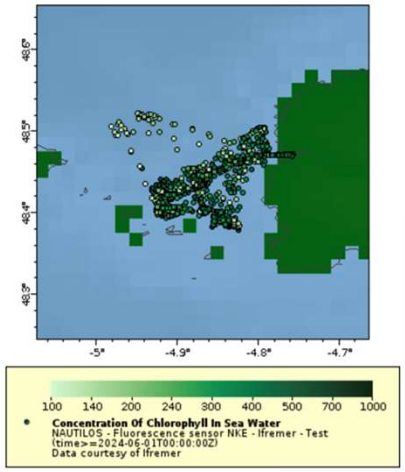


July 2023
installation on a commercial bottom trawler belonging to the CNR **AdriFOOS** fleet
and on a vessel using traps in the **Bay of Biscay** by IFREMER

Vessel using traps in the Bay of Biscay

Sub-task 7.1.1: Fisheries Observing Systems [Leader: CNR]

DO and Chl-*a* sensors (developed by **NKE** in ST3.1.2, lab calibrated in ST6.1.1, field validated and integrated in ST5.3.1) and WiHub were demonstrated on **commercial fishing vessels:**



- by **CNR** in the **Adriatic Sea** on otter doors of bottom trawlers

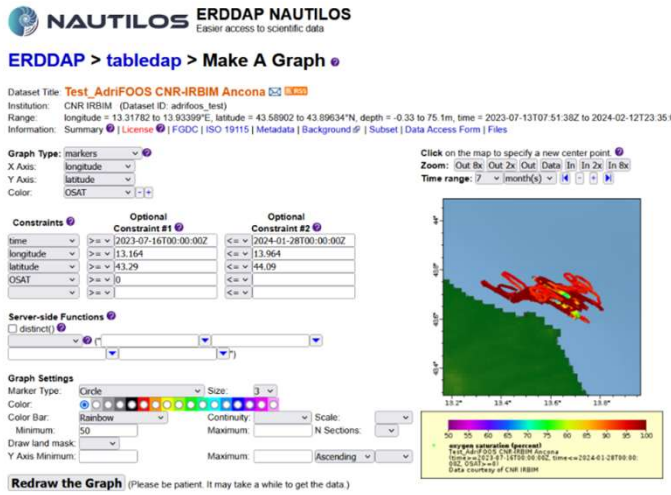
  September 2023-January 2025 first pair of sensors, January-**February 2025** sensors previously used by Ifremer,

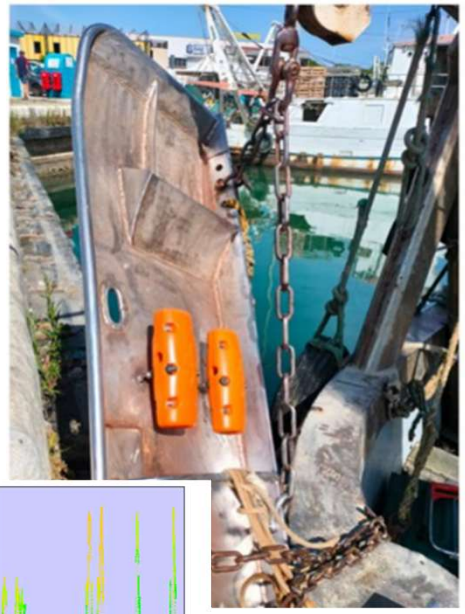
  to allow **robustness** verification, **battery** life, **communication** protocols
  and to showcase data collected in **NRT**:

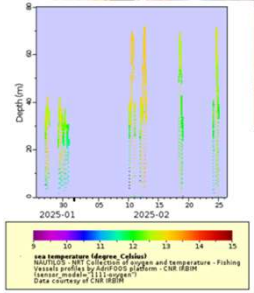
  regular data flow and battery level check, sensors maintenance and TRL upgrades

- by **Ifremer** in the **Bay of Biscay** on fishing traps
  October 2023-August 2024,
  to quantify prototypes' **drift** and evaluate **measurement cycles**:

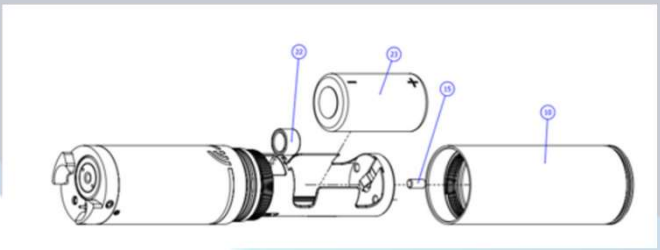
  technical and biofouling issues reported in D7.1 and D7.2, data delivered to NAUTILOS portals,
  sensors returned to NKE for inspection and repair.







Sub-task 7.1.1: Fisheries Observing Systems



- **Recommendation** for sensor use and definition of **best practices** (e.g. best deployment conditions, length of deployments, settings to be used, battery usage programming, etc. reported in D7.2)

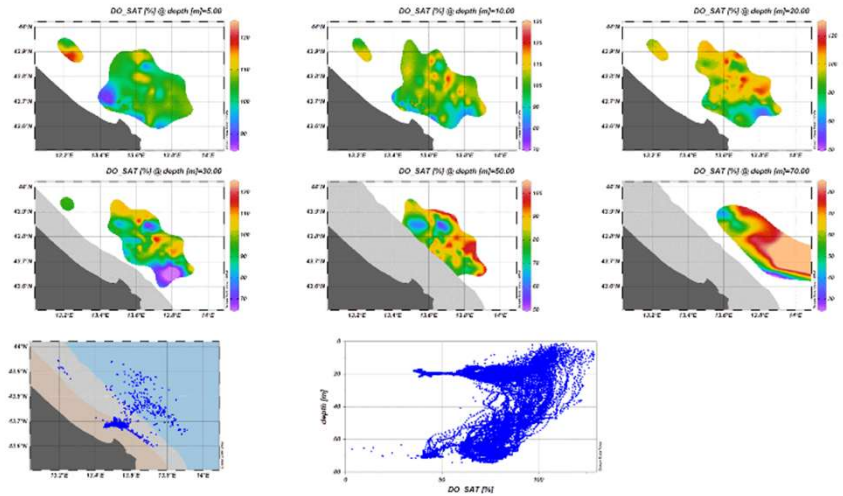


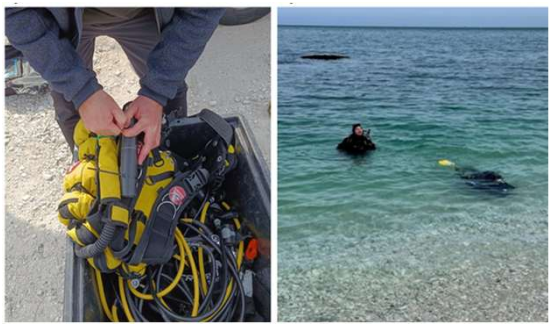
Figure 10A2: Dissolved oxygen saturation (%) maps at depths of 5, 10, 20, 30, 50 and 70 m, related to the fishing area exploited by the vessel monitored through CNR AdriFOOS and the NKE DO sensor, generated from the validated dataset for the period from April to June 2024.

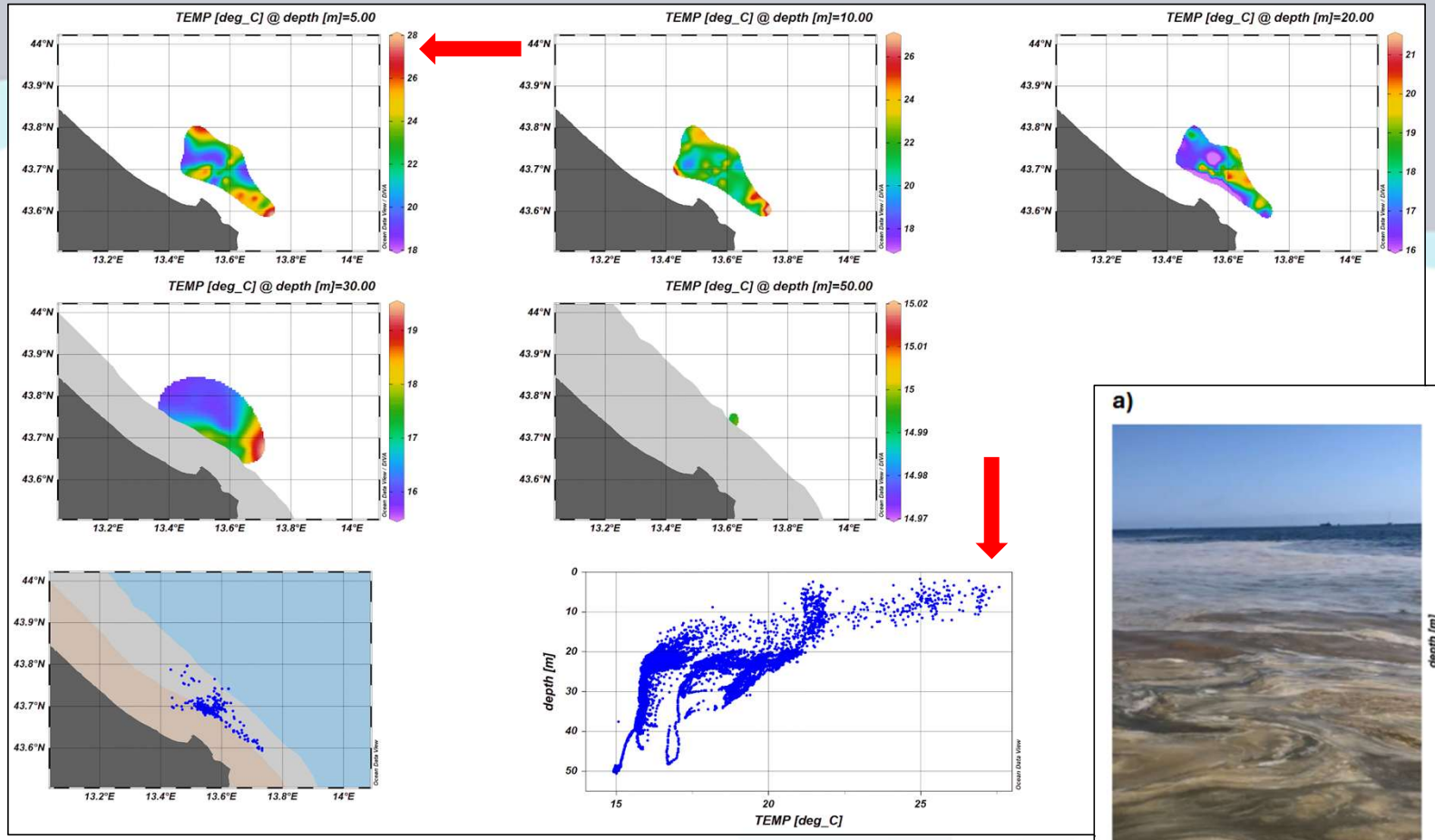
- Depth, Temperature, Dissolved Oxygen and Chlorophyll-*a* time series available on NAUTILOS portals and QCed Adriatic Sea **dataset published** (i.e. 504190 measurement points; https://doi.org/10.5281/zenodo.15397169)
- DO and Chl-*a* sensors **increase observational capacity** of well established Fisheries Observing Systems
- Collected **data showed to be useful** to detect transitory and exceptional events occurred in the Adriatic Sea (e.g. extreme temperatures and mucilage)

➔ Final TRL = 7 for the Chl-a sensor and 9 for the DO sensor

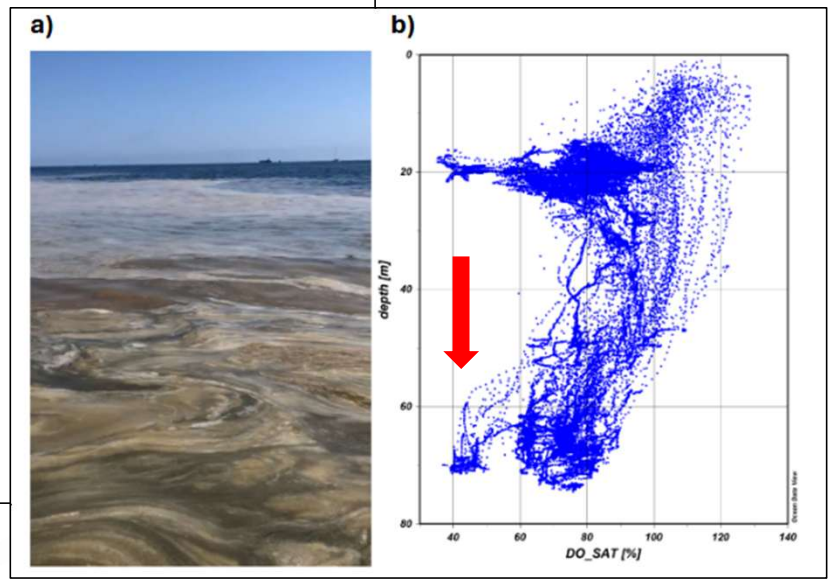
Martinelli et al. 2025 https://doi.org/10.5281/zenodo.18243127

Link to WP10: Additional citizen science activity in March 2025





Temperature (°C) maps *at depths of 5, 10, 20, 30, 50 and 70 m, related to the fishing area exploited by the vessel monitored through CNR AdriFOOS and the NKE DO and Chl-a sensors, generated from the validated dataset for the period from* ***July to September 2024****.*



Mucilage event *documented in the monitored area, picture taken on* ***21 July 2024*** *(a); Scatter plot of dissolved oxygen saturation (%) at depth (m) data recorded by the NKE DO 2222 sensor in the fishing area exploited by the vessel monitored through CNR AdriFOOS for the period May to July 2024 (b).*

Martinelli et al. 2025 https://doi.org/10.5281/zenodo.18243127

PLOS ONE

CNR IRBIM ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

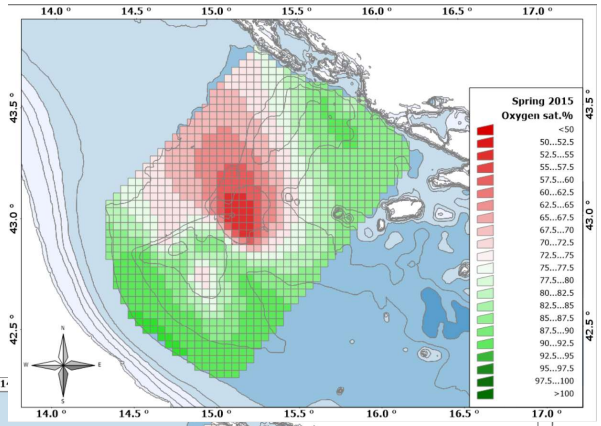
INSTITUT ZA OCEANOGRAFIJU I RIBARSTVO SPLIT

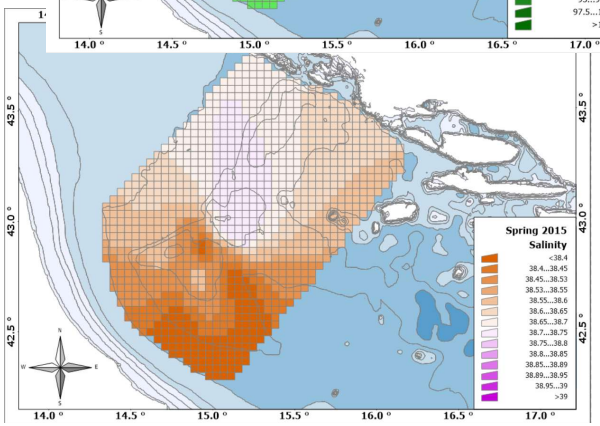
mipaaf ministero delle politiche agricole alimentari e forestali

Accounting for environmental and fishery management factors when standardizing CPUE data from a scientific survey: A case study for *Nephrops norvegicus* in the Pomo Pits area (Central Adriatic Sea)

Matteo Chiarini, Stefano Guicciardi, Silvia Angelini, Ian D. Tuck, Federica Grilli, Pierluigi Penna, Filippo Domenichetti, Giovanni Canduci, Andrea Belardinelli, Alberto Santojanni, Enrico Arneri, Nicoletta Milone, Damir Medvešek, Igor Isajlović, Nedo Vrgoč, Michela Martinelli https://doi.org/10.1371/journal.pone.0270703

2012-2019
spring/autumn
CTD + bottom trawling





Final selected Generalized Additive Model (GAM):

$$CPUE = \beta^0 + s_1(Y) + s_2(D) + s_4(Oxy) + s_5(Sal) + s_7(Yr, by = Fishery) + f_1(Fishery) + f_2(ToD) + \varepsilon$$

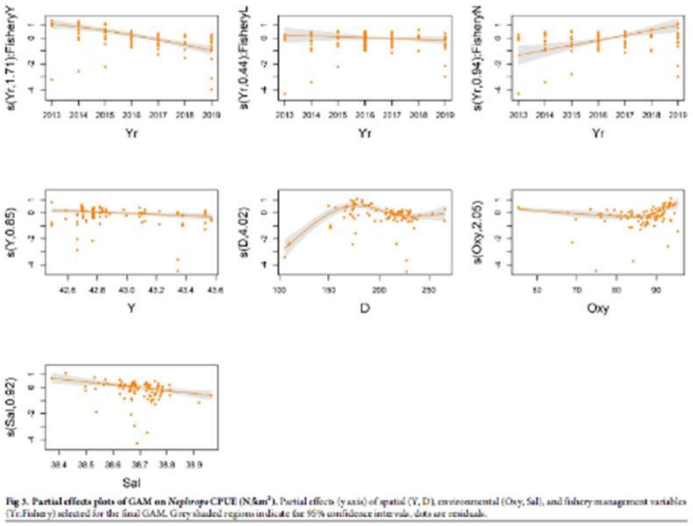


Fig 3. Partial effects plots of GAM on *Nephrops* CPUE (N/km²). Partial effects (y axis) of spatial (Y, D), environmental (Oxy, Sal), and fishery management variables (Yr:Fishery) selected for the final GAM. Grey shaded regions indicate the 95% confidence interval, dots are residuals.

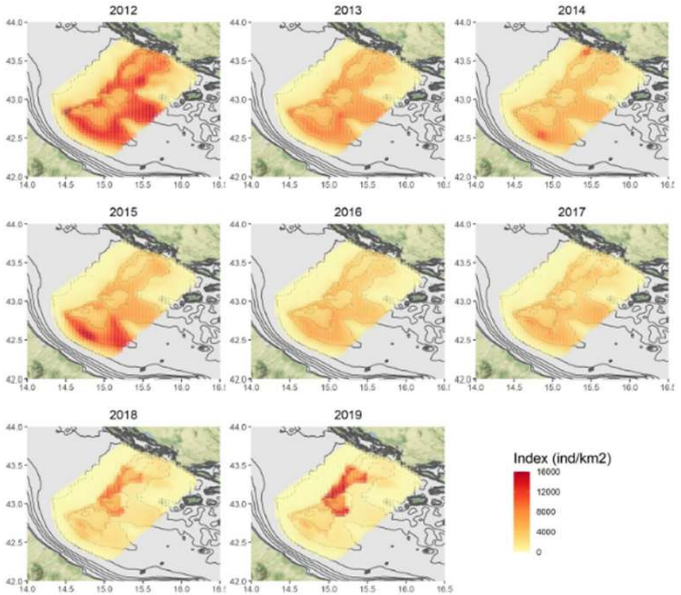


Fig 6. Predicted spatial distributions of *Nephrops* density index (N/km²) for the spring time series. Maps were made using the ggmap package [108] for R. Bathymetry layer source: [75]. Map tiles by Stamen Design, under CC BY Data by OpenStreetMap, under ODbL.

CNR
IRBIM
ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

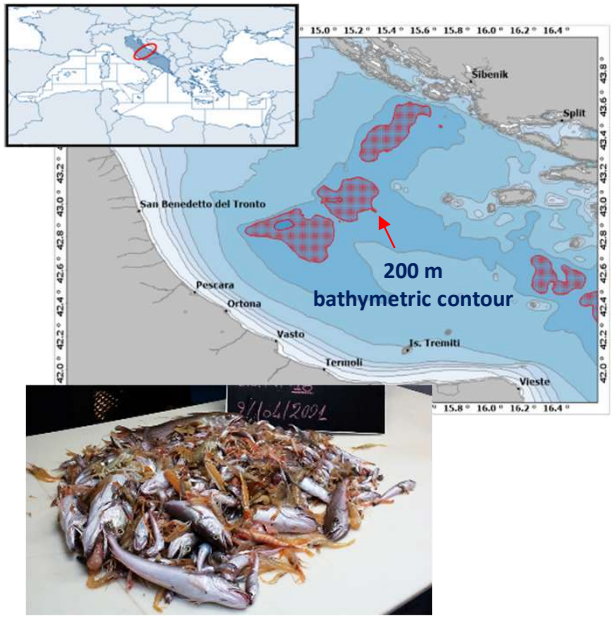
Section 4.2
Nephrops norvegicus
UWTV surveys
in Pomo Pits (Adriatic Sea)

Photo: Paolo Scarpini

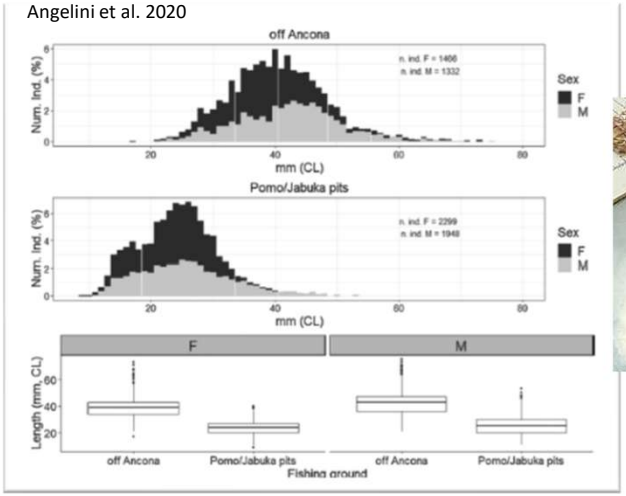
michela.martinelli@cnr.it

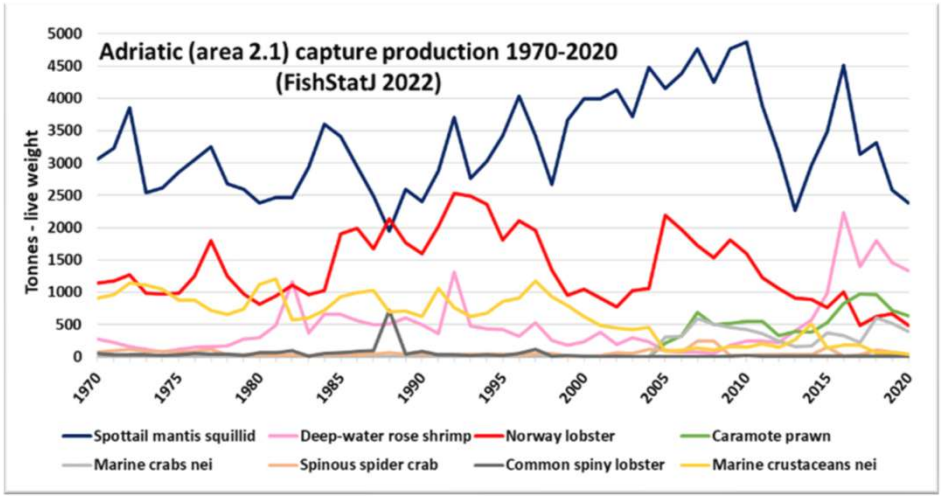
Jabuka/Pomo Pits (Central Adriatic Sea, GSA 17)

- Area with **peculiar oceanographic conditions** (periodical water mass renewal impact on the status of local benthonic communities; Marini et al., 2016; Taviani et al., 2016)
- **Fishing ground historically shared** by Italian and Croatian fleets (Russo et al., 2018)
- Main nursery in the Adriatic Sea for the European Hake ***Merluccius merluccius*** (Druon et al., 2015)
- Muddy bottoms ideal habitat for Norway Lobster ***Nephrops norvegicus*** (Martinelli et al., 2013)
- Main **spawning area** for *N. norvegicus*, that sustains itself and the areas south-west of it (Melaku Canu et al. 2021)
- Biological evidence of the presence of **different subpopulations** of Norway lobster in the Adriatic sea based on size at the onset of first maturity (SOM) estimation (Angelini et al. 2020)
- Pink shrimp ***Parapenaeus longirostris*** abundance peak in 2017 (Martinelli et al., 2020)
- Presence of **Vulnerable Marine Ecosystems indicators** (Martinelli et al., 2013, 2023)
- Presence of other **rare and ecologically relevant species** (Froglia et al. 2017, Kousteni et al. 2022, Cappuccinelli et al. 2023)



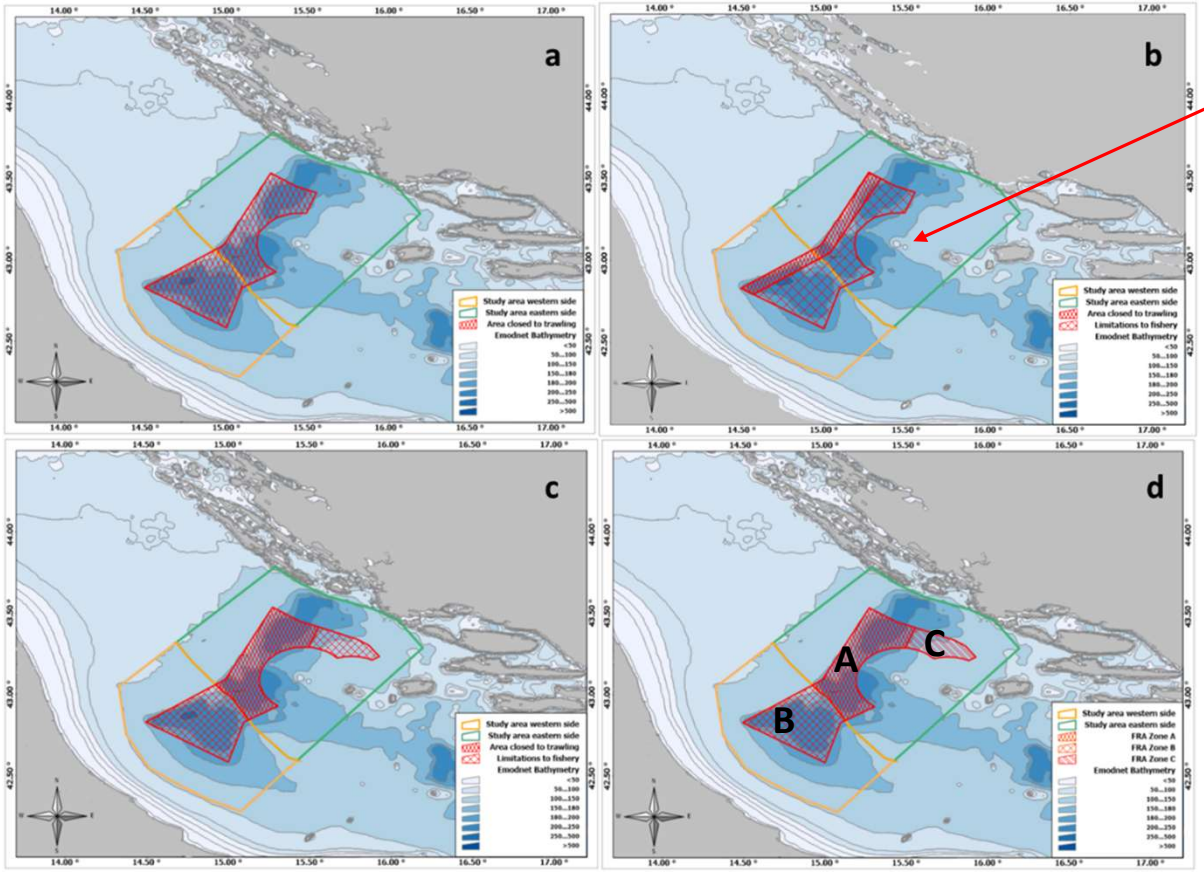
Angelini et al. 2020





Management of the Pomo/Jabuka pits

Measures implemented since 2015, changing until 2017…



… then:

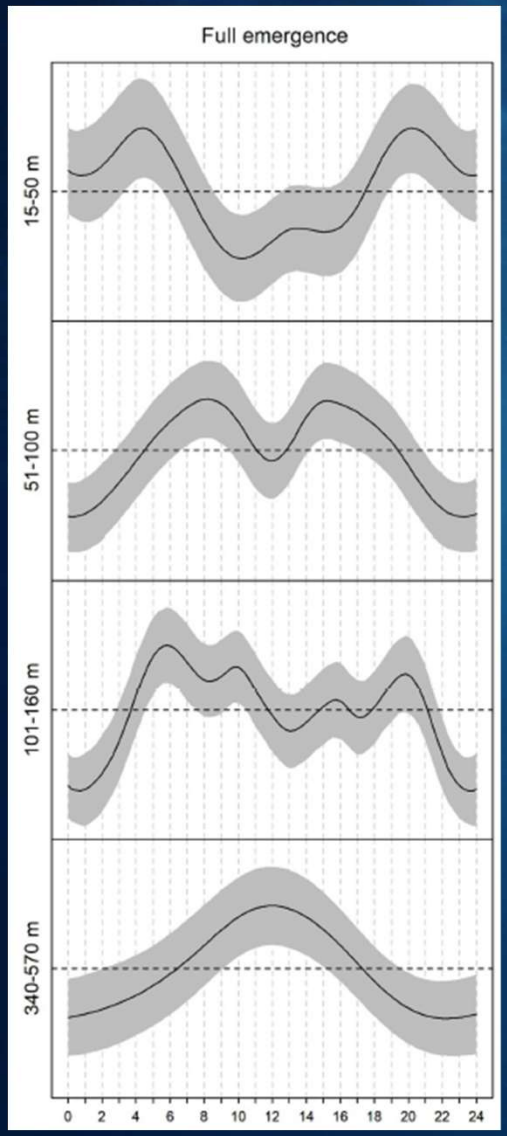
Recommendation GFCM/41/2017/3 on the establishment of a fisheries restricted area in the Jabuka/Pomo Pit in the Adriatic Sea

Ratified by the EU Regulation 2019/982 which modifies that n.1343 / 2011

SAC 2021 advice on positive contribution of the Jabuka/Pomo Pits FRA for protection of juveniles and biomass of demersal species

Recommendation GFCM/44/2021/2 establishes the FRA as permanent

(divided in zones A, B, C) to contribute to the protection of vulnerable marine ecosystems (**VME**) and essential fish habitats (**EFH**) for demersal stocks such as European hake and Norway lobster and for small pelagic stocks such as anchovy and sardine

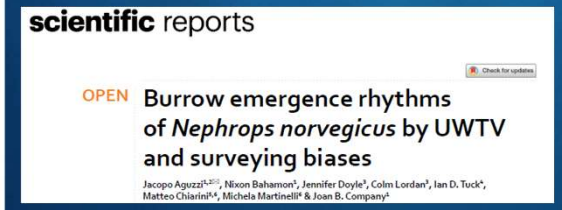


NORWAY LOBSTER's emergence from burrows depends on:

CNR IRBIM
ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

- depth
- time of day
- season
- animal size
- sex
- reproductive status


Photo: Jim Atkinson


scientific reports

OPEN Burrow emergence rhythms of *Nephrops norvegicus* by UWTV and surveying biases

Jacopo Aguzzi[1,2✉], Nixon Bahamon[1], Jennifer Doyle[3], Colm Lordan[3], Ian D. Tuck[4], Matteo Chiarini[4,4], Michela Martinelli[4] & Joan B. Company[1]

Nephrops norvegicus STOCK ASSESSMENT

- The species is caught in commercial gear only when it emerges from burrows, thus the fishery samples the population very selectively and in a different manner according to sex and season

- Fishery-dependent techniques yield an incomplete prospection when used for *Nephrops*

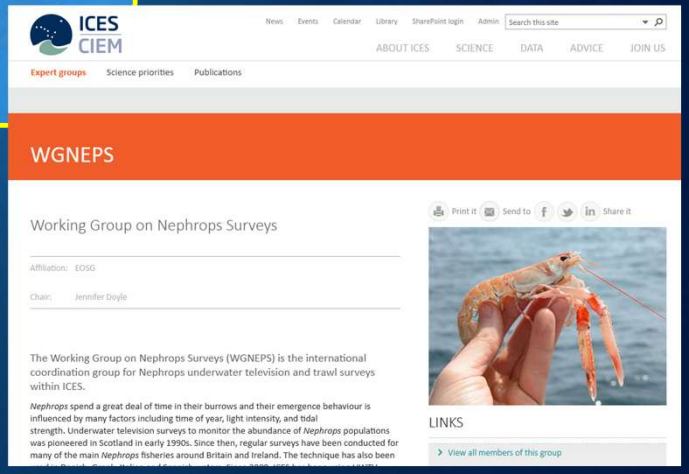
- **Thus other fishery-independent methods are of particular importance for this species**

- The most practical method uses burrow densities as an index of stock abundance (appropriately integrated with otter trawl hauls, burrow densities can be converted into biomass estimates)

michela.martinelli@cnr.it

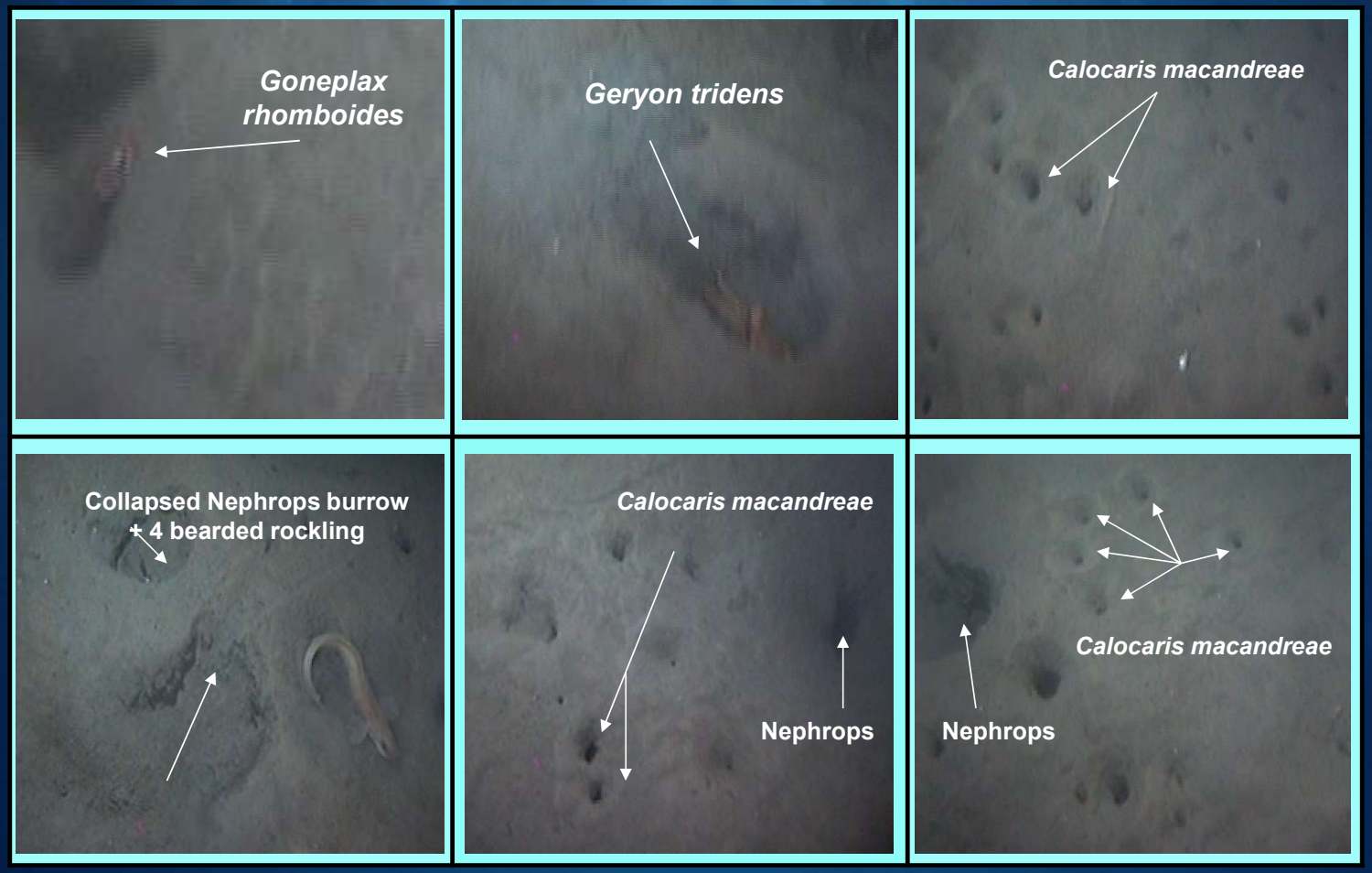
CNR
IRBIM
ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

UWTV METHODOLOGY



michela.martinelli@cnr.it

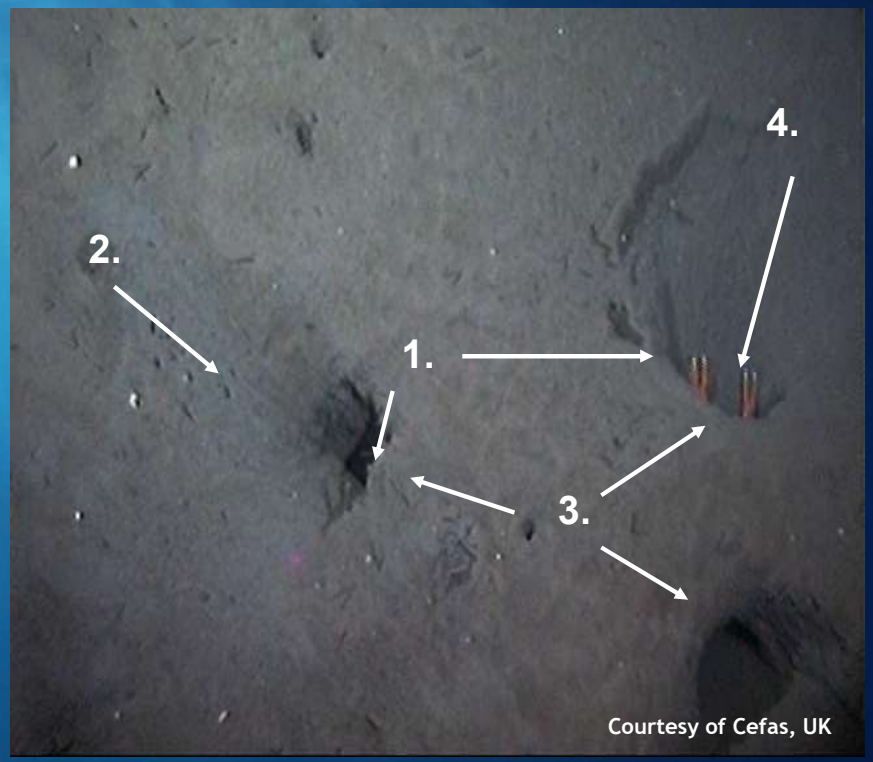
OTHER SPECIES



Courtesy of Cefas, UK

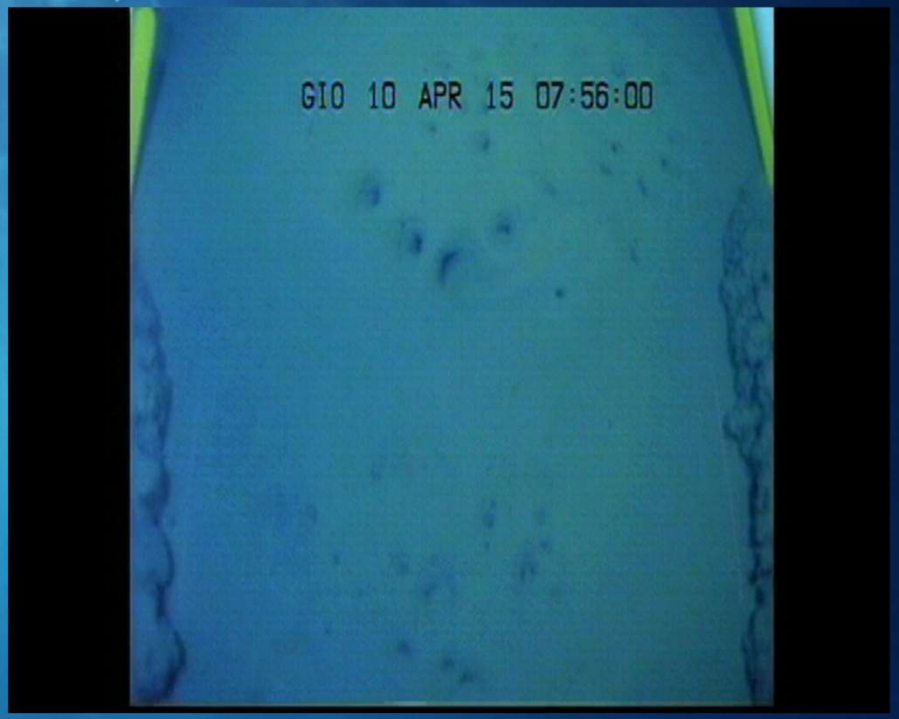
N. norvegicus BURROW 'SIGNATURES'

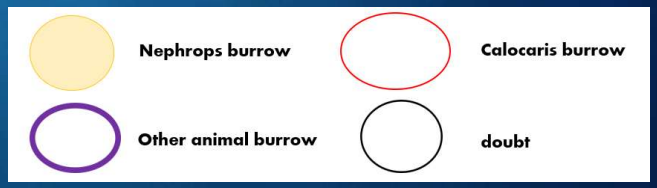
1. Crescentiform entrance
2. Sediment ejecta and radial scrapings around entrance. Claw or perieopod indents. 'Drive-way'
3. Single to multiple entrances, focussing on an apparent 'raised' centrum
4. *Nephrops*



- *Nephrops vs Calocaris macandreae*

Photos: Jim Atkinson





michela.martinelli@cnr.it

CNR IRBIM
ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

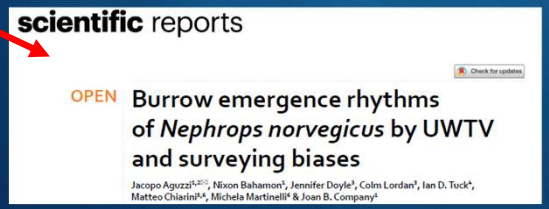
BURROW IDENTIFICATION

Main features:

- Shape of burrow opening(s)
- Presence of tracks and trails
- Presence of characteristic clusters
- Diameter of burrow opening(s)
- Distance between openings of a given burrow
- Orientation of burrow
- Presence of the occupant

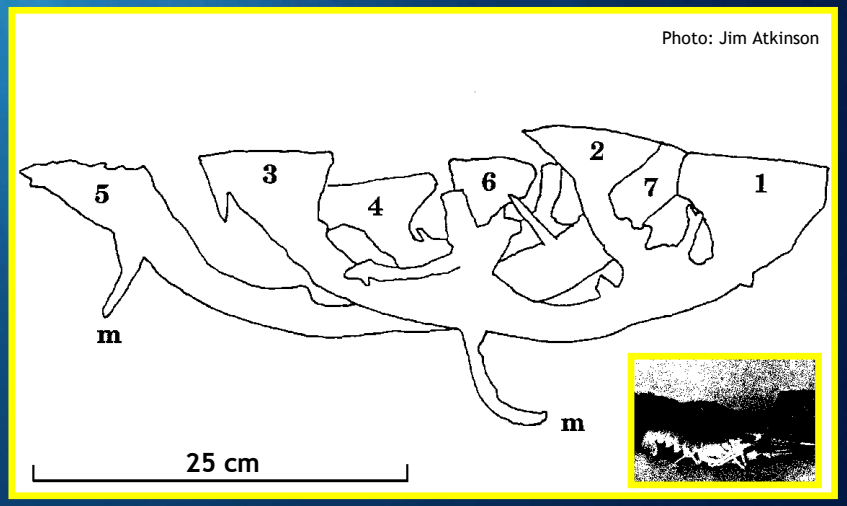
ASSUMPTIONS

1. ACCURATE BURROW IDENTIFICATION
2. RELATED CLUSTERS CONSIDERED AS 1 SYSTEM
3. 100% OCCUPANCY
4. SINGLE OCCUPANCY


scientific reports

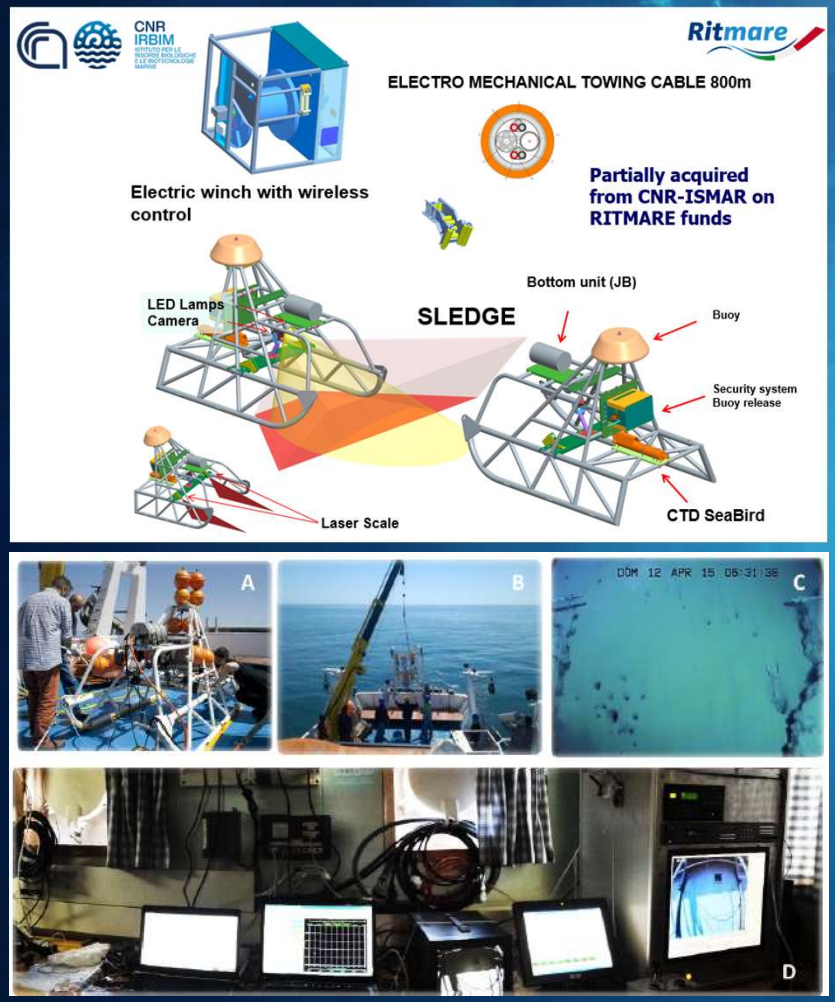
OPEN Burrow emergence rhythms of *Nephrops norvegicus* by UWTV and surveying biases

Jacopo Aguzzi[1,2✉], Nixon Bahamon[2], Jennifer Doyle[3], Colm Lordan[3], Ian D. Tuck[4], Matteo Chiarini[3,4], Michela Martinelli[4] & Joan B. Company[1]

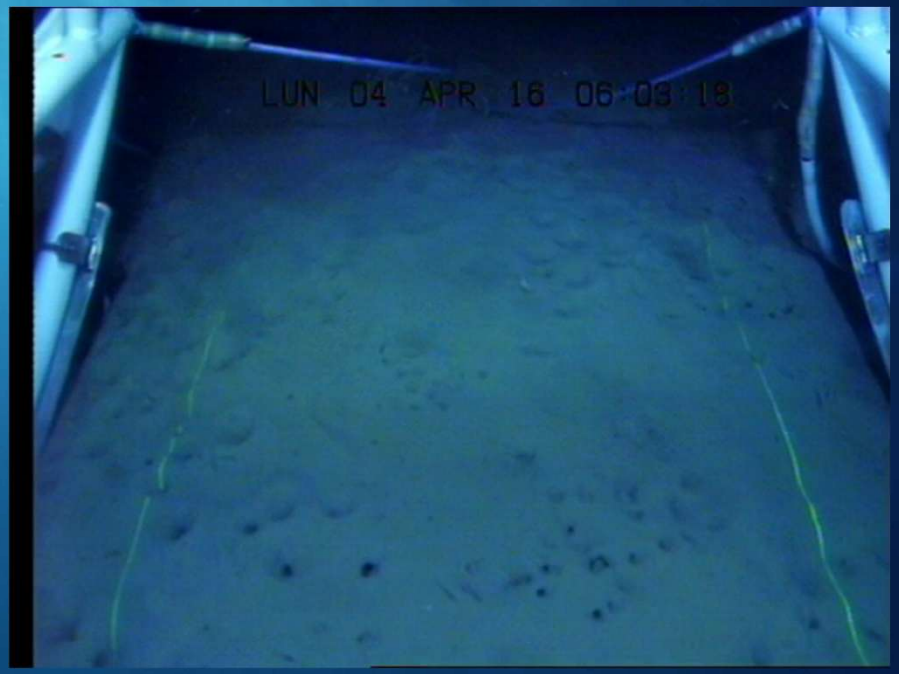


THE UWTV METHODOLOGY

ADRIATIC I-UWTV SURVEY



A) configuration of the sledge used during the I-UWTV survey 2015, 2016 and 2017; B) sledge deployment; C) image of the sea bed; D) work station in the dry lab of the R/V Dallaporta, from left to right: laptop used for the navigation software, laptop used for CTD data acquisition, control monitor receiving images in real time from the camera on the sledge, touch screen for the direct control of the instruments, digital recording and backup system.



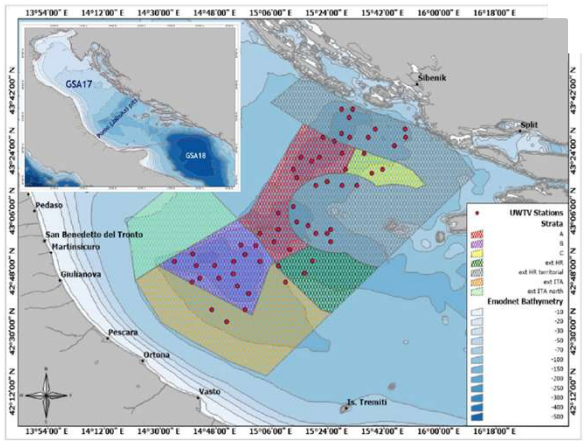
michela.martinelli@cnr.it

CNR IRBIM
ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

ADRIAMED

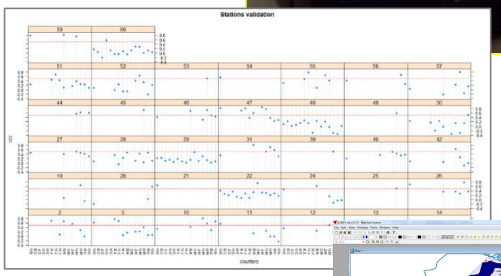
INSTITUT ZA OCEANOGRAFIJU I RIBARSTVO SPLIT

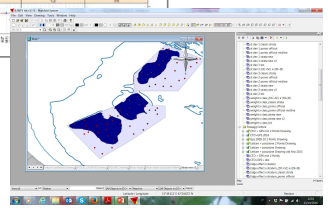
Adriatic I-UWTV SURVEYS 2009-2019



Training and readings protocols + Analysis of collected footage:

- Training with ICES materials + reference videos for Adriatic (generated from previous years footage) + Lin's CCC test on readers performances
- Joint readings in lab after the cruise during a dedicated session
- Minutes or stations with turbidity > 3 NTU and / or speed> 1.3885 knots are discarded
- Independent readings on a minimum of 7 min, final counts = average of 3 readers (consensus readings only when variability among readers is high)
- Lin's CCC procedure for validation of stations
- Application of biases (edge effect, fixed etc…)





michela.martinelli@cnr.it

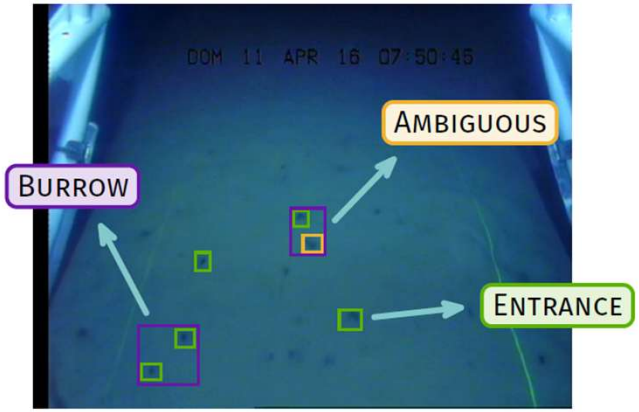
T8.5: Automatic Image Analysis

NAUTILOS

Objective: Develop an automatic tool that is able to count *Nephrops norvegicus* burrows in underwater television footage.

Deep learning models have proven fruitful in recent years in a variety of contexts in computer vision tasks.
However, they need a lot of data for training.

Annotation



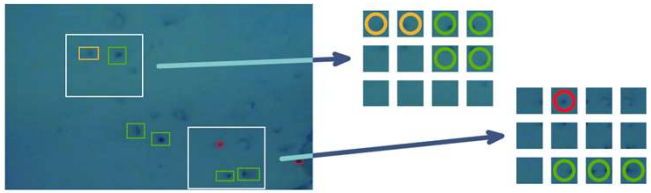
Annotation guidelines:
https://doi.org/10.5281/zenodo.14973160

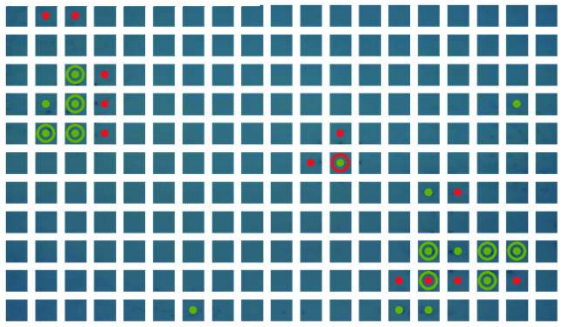
Home > Pattern Recognition and Image Analysis > Article

Advancing Automated Detection of *Nephrops norvegicus* Burrows in Underwater Television Surveys through Machine Learning

PROCEEDINGS OF THE 9TH INTERNATIONAL WORKSHOP "IMAGE MINING: THEORY AND APPLICATIONS" (IMTA-IX-2024) / Session Papers

Published: 06 April 2025 **Papini et al. 2025** https://doi.org/10.1134/S1054661824701062





Papini et al.
Results presented at
ICES WGNEPS
November, 2025

T8.5: Automatic Image Analysis

NAUTILOS

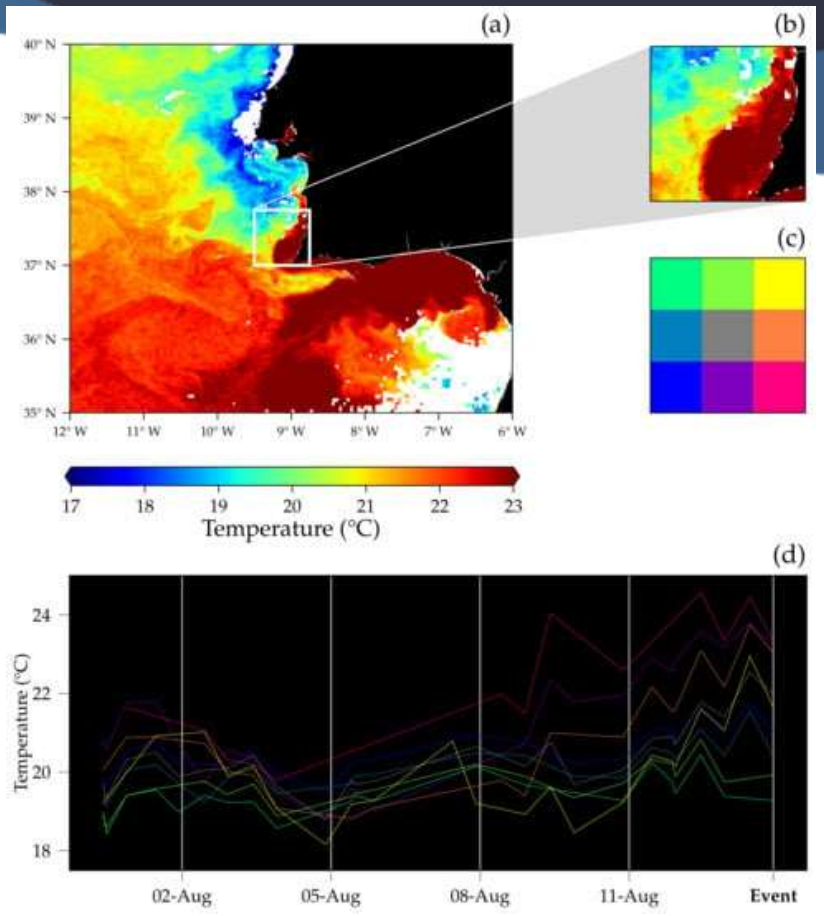
Automated image processing to classify upwelling events based on the analysis of Sea Surface Temperature time series from remote sensing

The impact of climate change on marine ecosystems is often expressed by simplified warming trends.

Near the coast, global drivers are modified by topography and by local atmospheric and oceanographic circulation patterns, including upwelling.

Remote sensing images are usually classified into specific **categories**, employed in natural hazards detection, environment monitoring etc.

Manual detection and identification of events remains a significant **challenge** due to manual effort involved.



Example of SST map related to an event on 13 August 2016

Reggianini et al. 2023 https://doi.org/10.1007/978-3-031-37742-6_43
Pieri et al. 2023 https://doi.org/10.3390/app13031565

frontiers | Frontiers in Marine Science

TYPE Review
PUBLISHED 09 September 2022
DOI 10.3389/fmars.2022.969071

https://doi.org/10.3389/fmars.2022.969071

OPEN ACCESS

EDITED BY
Daphne Cuvelier,
University of the Azores, Portugal

REVIEWED BY
Simon De Lestang,
Department of Primary Industries and Regional Development of Western Australia (DPIRD), Australia
Ian David Tuck,
Ministry for Primary Industries, New Zealand
Nick Caputi,
Department of Primary Industries and Regional Development of Western Australia (DPIRD), Australia

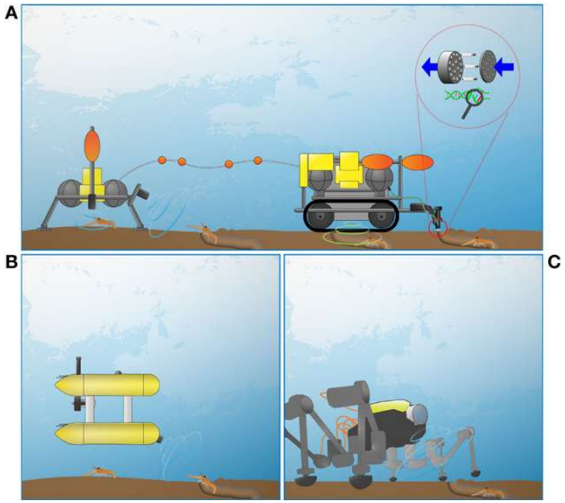
*CORRESPONDENCE
Jacopo Aguzzi
jaguzzi@icm.csic.es
Jennifer Doyle
jennifer.Doyle@marine.ie

SPECIALTY SECTION
This article was submitted to Deep-Sea Environments and Ecology, a section of the journal Frontiers in Marine Science

RECEIVED 14 June 2022

Advancing fishery-independent stock assessments for the Norway lobster (*Nephrops norvegicus*) with new monitoring technologies

Jacopo Aguzzi[1,2*], Damianos Chatzievangelou[1], Nathan J. Robinson[1], Nixon Bahamon[1], Alan Berry[3], Marc Carreras[4], Joan Batista Company[1], Corrado Costa[5], Joaquin del Rio Fernandez[6], Ahmad Falahzadeh[6], Spyros Fifas[7], Sascha Flögel[8], Jordi Grinyó[1,9], Jonas Pall Jónasson[10], Patrik Jonsson[11], Colm Lordan[3], Mathieu Lundy[12], Simone Marini[13], Michela Martinelli[14], Ivan Masmitja[1], Luca Mirimin[15,16], Atif Naseer[17,18], Joan Navarro[1], Narcis Palomeras[4], Giacomo Picardi[19], Cristina Silva[20], Sergio Stefanni[2], Maria Vigo[1], Yolanda Vila[21], Adrian Weetman[22] and Jennifer Doyle[3*]



Robotic & Observational Platforms

ROVs (Remotely Operated Vehicles)
AUVs (Autonomous Underwater Vehicles)
Tethered and Untethered Crawlers
Biomimicking Platforms
Cabled Seafloor Observatories
Biogeochemical Landers
Low-cost camera platforms (Action cameras)

Imaging & Sensing Hardware

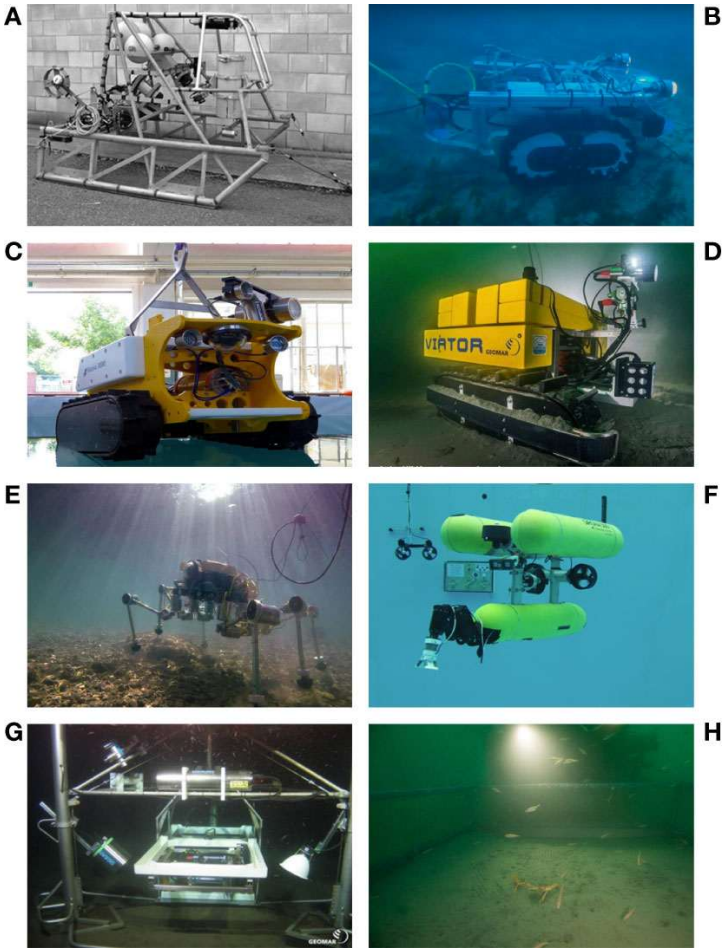
HD and 4K Cameras
Stereo-camera systems
Optoacoustic imaging
Laser line-scanners
Multibeam Echosounders
Multiparametric sensors

AI & Data Analysis Software

Artificial Intelligence (AI)
Machine Learning (ML)
Deep Learning (DL)
Computer Vision algorithms
BIIGLE (Image annotation software)
Cloud Computing
Digital Twin strategies

Molecular & Tracking Technologies

eDNA metabarcoding (Environmental DNA)
Acoustic Telemetry (Acoustic tracking & tags)



Key Takeaways

From Policy to Action: While climate change is the primary driver, **International Policy Frameworks** provide the legal and scientific mandates that make monitoring not just beneficial, but mandatory. The path from **Risk to Resilience** is built upon reliable, high-resolution, and open-access data.

The Importance of Data Stewardship: Ocean observation goes beyond data collection; applying **FAIR principles** ensures long-term research impact and fosters a sustainable **Blue Economy**.

Technology as an Enabler: The shift toward **Innovative Sensing** (e.g., autonomous platforms, low-cost sensors) is closing spatio-temporal gaps, making ocean monitoring more pervasive and cost-effective.

Monitoring in Practice: Real-world case studies demonstrate that **Integrated Systems** are essential to addressing future challenges.

The future of ocean health depends on the data we collect today.

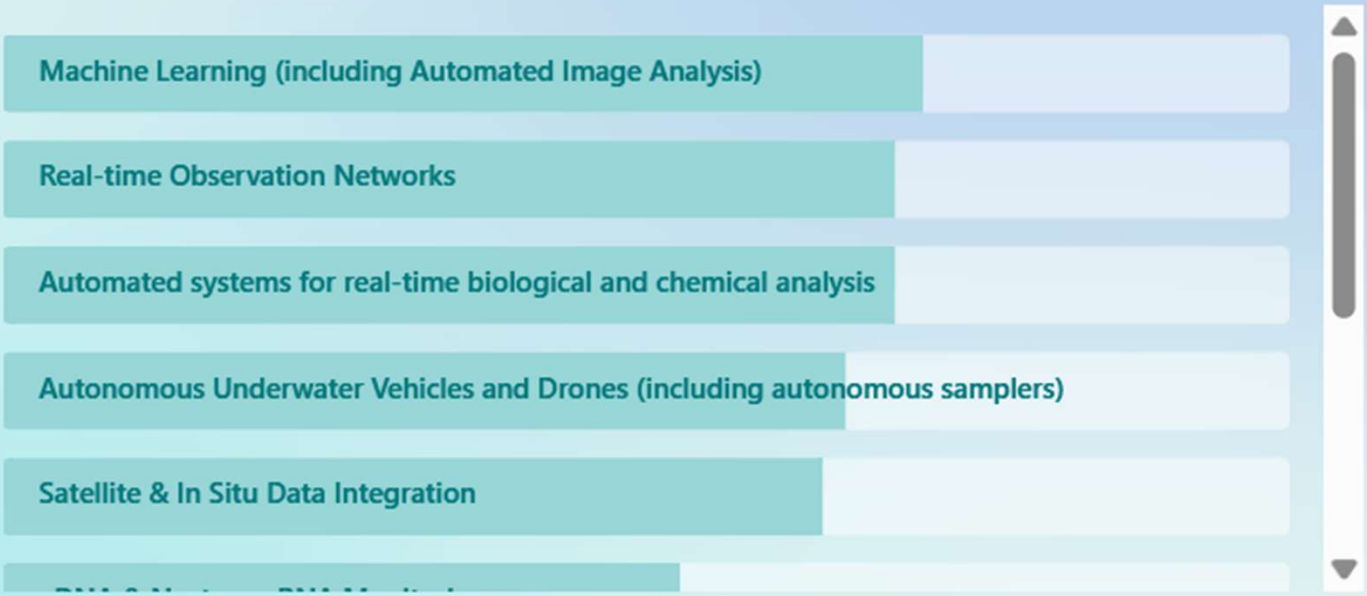
Esegui la scansione del codice a matrice o usa il collegamento per partecipare

https://forms.office.com/e/MHmJsb7DbE

Copia collegamento

18 risposte inviate

How would you rank these tools in terms of strategic importance?



Assignment:
Create a conceptual proposal bridging climate/policy mandates and technical sensing solutions.

Structure:
1.Framework: Identify which scientific challenge (e.g., Ocean Acidification), policy or scientific mandate your project supports (e.g., MSFD, CFP, EU Green Deal, IPCC targets).

2.Sensing Strategy: Select and describe specific **innovative sensors** and **platforms** to fill the identified data gaps.

3.Data Stewardship: Briefly describe how you will ensure data quality and accessibility (e.g., following FAIR principles).

4.Operational Feasibility - *Analyze the "Real-World" implementation of your project:*

- **Logistics & Replicability:** How will you deploy and maintain the system in the field (consider the harshness of the marine environment)? Would that be replicable across different regions through standardized protocols?
- **Cost-Effectiveness, Sustainability & Scalability:** Discuss the balance between technology costs and the need for long-term, sustained monitoring. Would that be scalable from a pilot site to a large-scale network?
- **Risk Management:** Identify the main technical or logistical obstacles (e.g. biofouling, power supply, data transmission) and propose a practical mitigation strategy.

Output: A 1-page proposal + figures or diagrams where necessary

Submission Deadline: 12/06/2026