IEEE SA STANDARDS ASSOCIATION

INNOVATIONS FOR SUSTAINABLE OCEANS

Importance of sensing technology for understanding the condition of the ocean

July 22, 2025

HIGH-LEVEL POLITICAL FORUM ON SUSTAINABLE DEVELOPMENT

IEEE

IEEE SA STANDARDS ASSOCIATION

HIGH-LEVEL POLITICAL FORUM ON SUSTAINABLE DEVELOPMENT

Agenda

Welcome	Karen Mulberry
Setting the Stage and Speaker Introductions	Christopher Whitt
Sensing the Sea by AI and Robotics	Giulia De Masi
Accessible Ocean Technology	Patrick Gorringe
Building Trust in Environmental Data Through Standards	Christoph Waldmann
Policy and Technology	Laura Meyer
Roundtable discussion and Q&A	Moderator Christopher Whitt
Closing Summary	Karen Mulberry

HIGH-LEVEL POLITICAL FORUM
ON SUSTAINABLE DEVELOPMENT

The Ocean is Critically Important

The ocean plays a crucial role in the achievement of the Sustainable Development Goals and the livelihoods of billions of people. We urgently need to change how we interact with it.

—United Nations Secretary General António Guterres

IEEE Oceanic Engineering Society

The OCEAN is vitally important – WHY?

- Jobs
- Primary production
- Carbon storage
- Storm Protection
- Food Security
- Energy Production
- Transport
- Tourism and Recreation

Presenters

Christopher Whitt
IEEE Oceanic Engineering Society

Giulia De Masi
Associate Professor and Principal Investigator, Sorbonne University Abu Dhabi

Patrick Gorringe
Swedish Meteorological and Hydrological Institute

Christoph Waldmann
IEEE Oceanic Engineering Society

Laura Meyer
Decade Coordination Unit, UNESCO-IOC

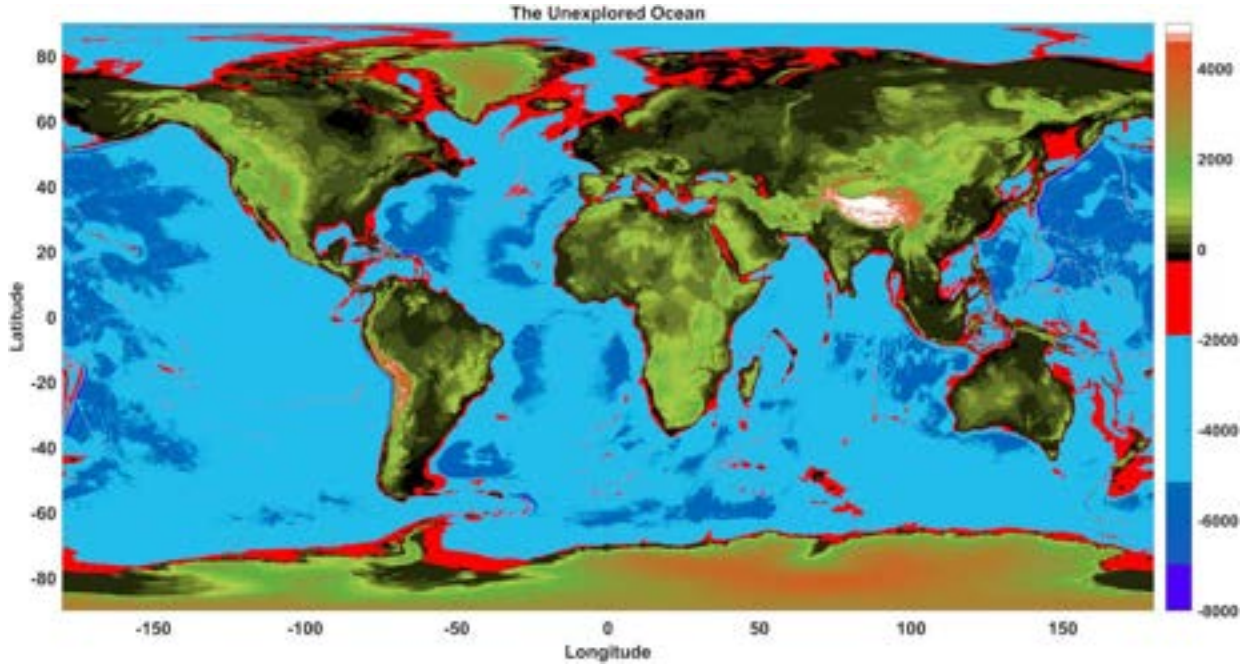
SENSING THE SEA BY AI AND ROBOTICS

Prof. Giulia De Masi
Sorbonne University Abu Dhabi

IEEE Oceanic Engineering Society

SORBONNE UNIVERSITY ABU DHABI

WHY WE NEED TO KNOW MORE THE OCEAN



The average depth of the world's oceans is 3,790 meters, or 12,400 feet, or 2 ⅓ miles. There is no light, and the pressure is 370 atmospheres

Ocean is covering 70% of Earth surface

We have only explored five percent of our world ocean. That means that 95 percent of our ocean is unknown (NOAA).

Ocean impact our survival. Still it is poorly understood.

We need to know to understand the impact of human activities of marine biosystem.

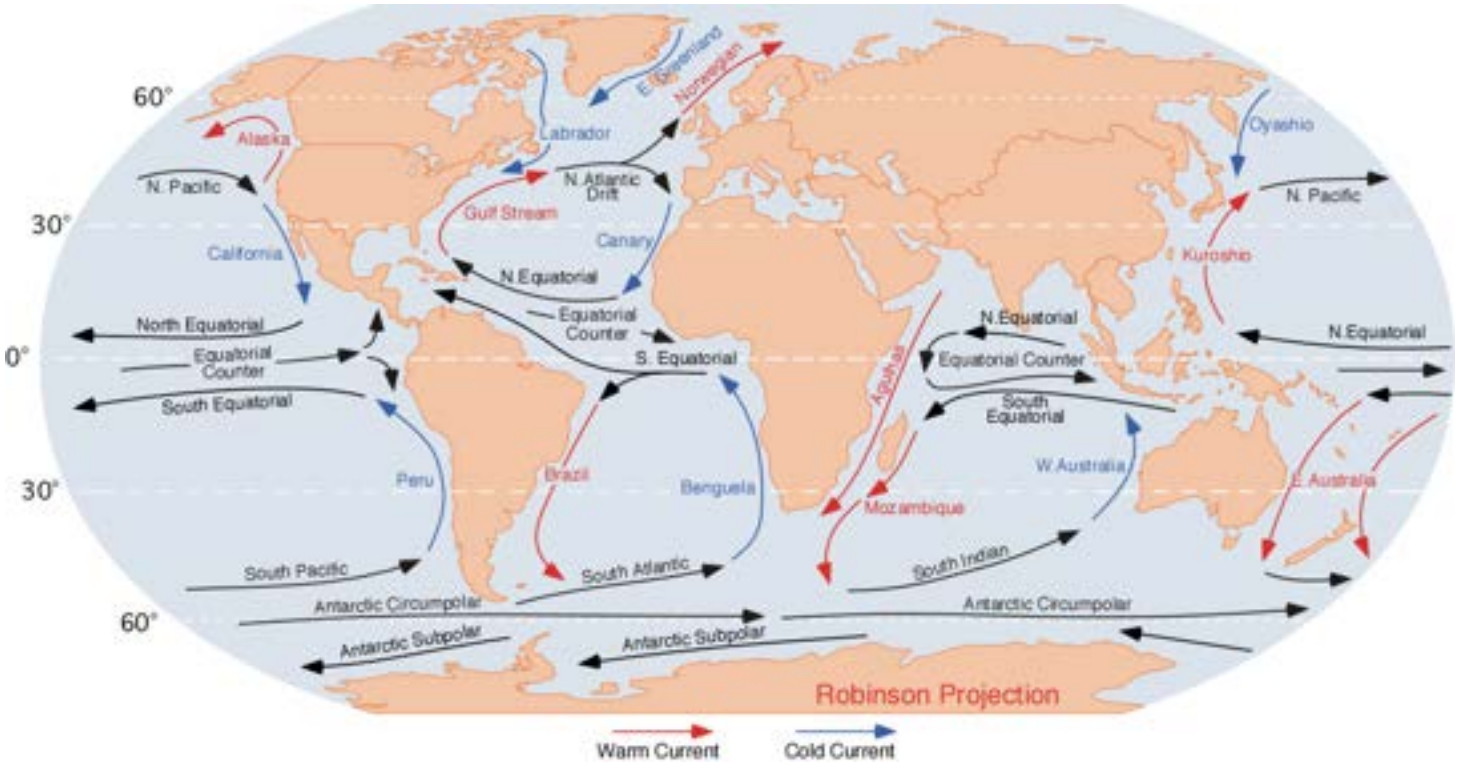
SHARED OCEAN - SHARED KNOWLEDGE

Ocean phenomena are on global scale. For this reason a global action is needed.

Data are collected by many different stakeholders.

Data should be:

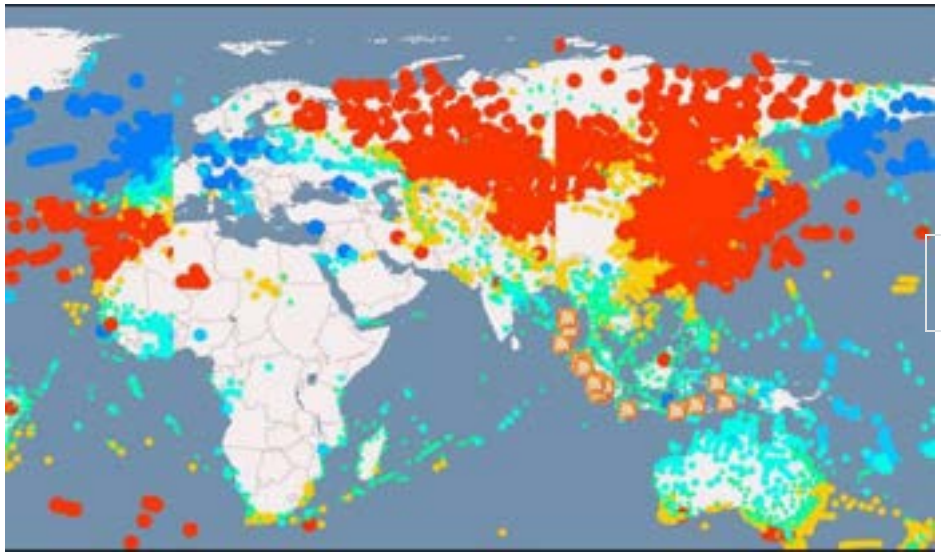
- Interroperale
- Findable
- Accessible
- Reusable



TECHNOLOGY FOR NATURE PRESERVATION AND RESTORATION

- Incredible advances in Autonomous systems (robots) and Artificial Intelligence
- This can serve the nature for
  1. Monitoring the current health status of ecosystems
  2. Inspect human made structures to prevent and mnimize environmental disasters
  3. Predict environmental hazards and climate impact

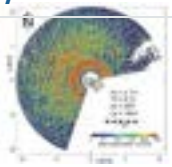
ANALYSIS OF ENVIRONMENTAL DATA

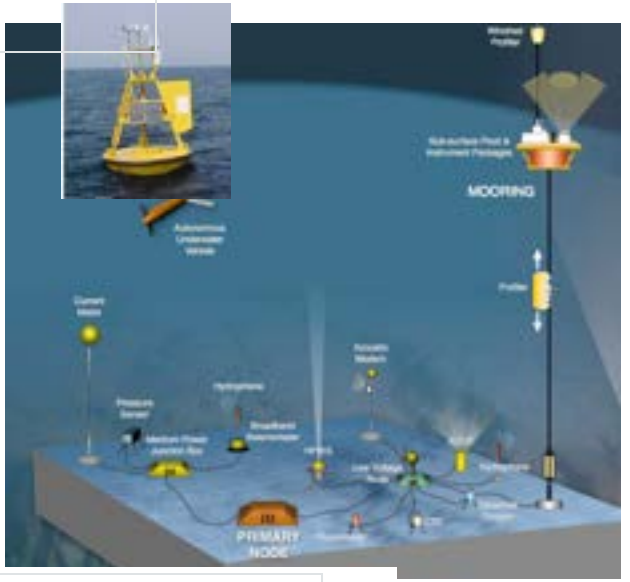


Large scale measurements: weather satellite

Drones

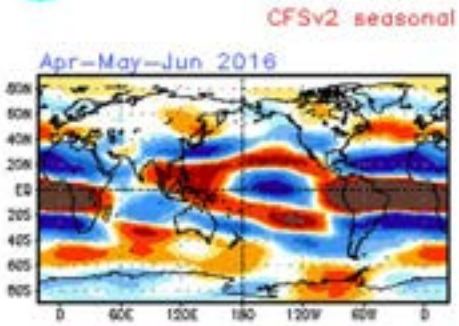
Local measurements: wave radar and buoy



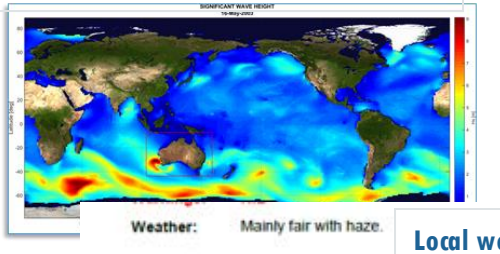


Nowadays several environmental large databases are increasingly available.

Climate forecast



Weather hindcasting



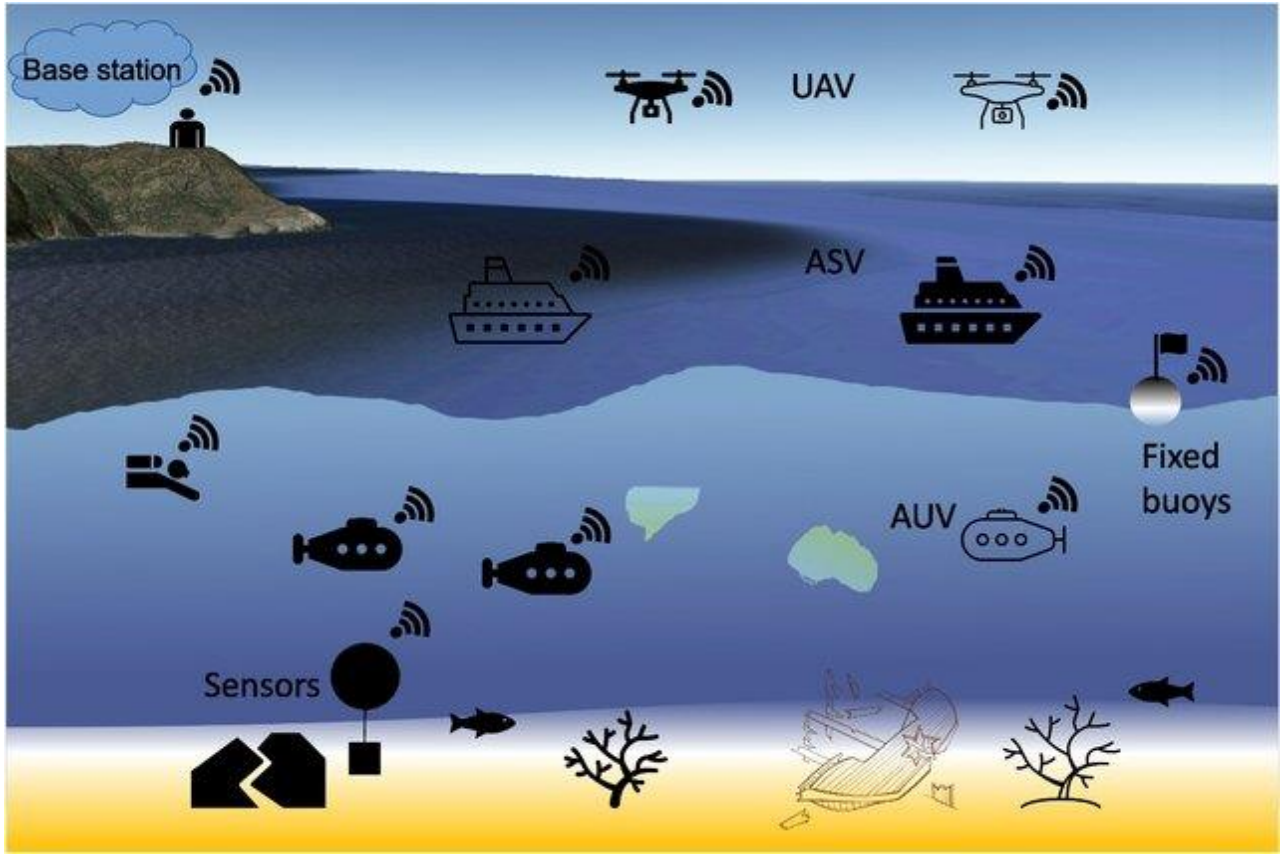
Weather: Mainly fair with haze.

Local weather bulletin

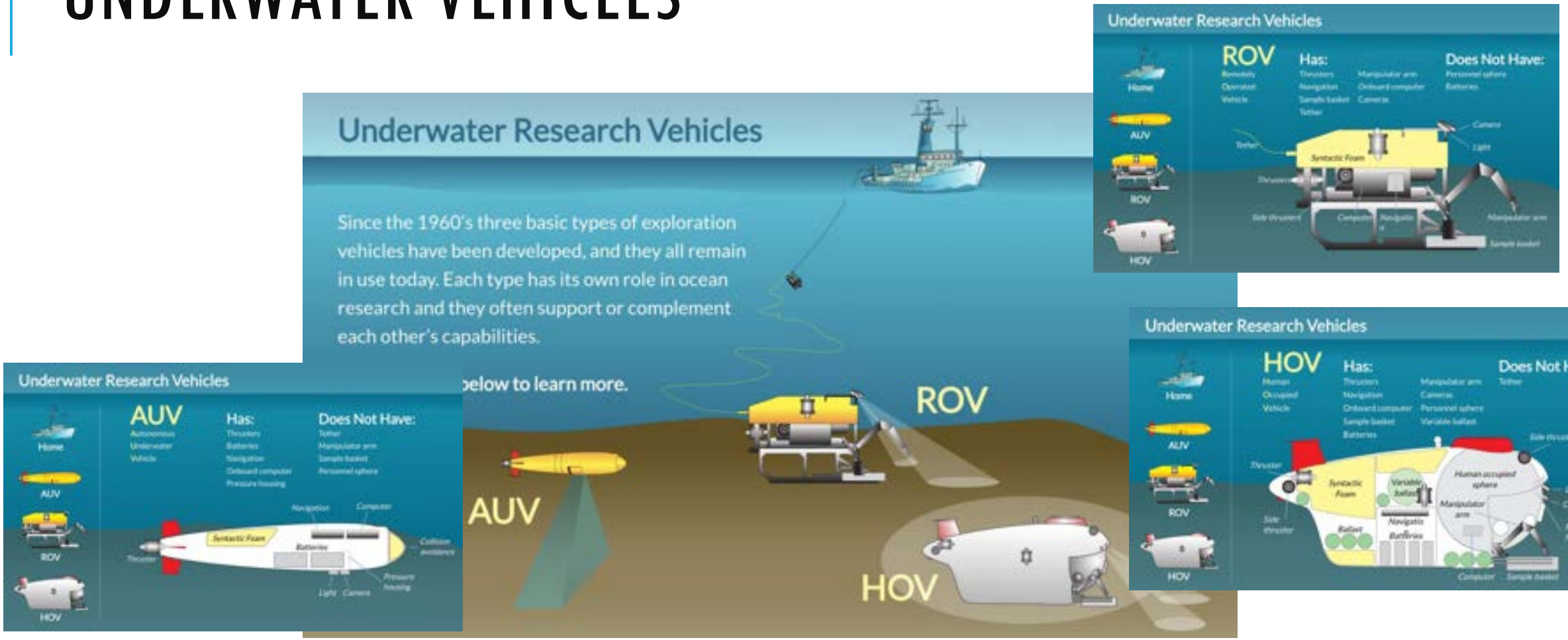
Time	10m wind Dir	10m wind Spd [kts]	10m wind Gust [kts]	50m Spd [kts]	Sea Hgt [m]	Swell Dir	Swell Hgt [m]	Swell Per [s]	Total Sea Sig [m]	Total Sea Max [m]	Tmp [°C]	RH [%]	Rain [mm]	Cloud [%]	Vis [km]
Limits															
06	N	15	20	19	0.3	-	-	-	0.3	0.5	24.7	50	0.0	0	10.0
07	N	16	21	21	0.4	-	-	-	0.4	0.7	25.6	42	0.0	0	10.0
08	N	17	21	21	0.4	-	-	-	0.4	0.7	28.2	35	0.0	0	10.0
09	N	18	23	22	0.4	-	-	-	0.4	0.7	30.7	30	0.0	0	10.0
10	N	18	23	22	0.4	-	-	-	0.4	0.7	32.1	29	0.0	0	10.0

COLLABORATIVE 3D ASSESSMENT AND MONITORING

- Underwater measures can be taken from FIXED stations and MOVING stations (ROVs or AUVs)
- Combing all the data sources, 3D distribution of environmental parameters can be obtained:
  - Temperature, Pressure, Conductivity (salinity)
  - pH
  - Dissolved oxygen
  - pCO2
  - Water Quality Indicators: turbidity, nutrients (nitrogen, phosphorus), heavy metals, hydrocarbons, and microplastics
  - Pictures/videos of sea-grass/corals and benthic habitat
- Relevant for both monitoring and restoration purpose



UNDERWATER VEHICLES



Courtesy Woods Hole Oceanographic

FROM SINGLE TO MANY: SWARM OF AUVS

An artificial swarm of AUVs is realized, imitating natural school of fishes. In real schools, a group of fishes shows a coordinated motion, generated by local interactions only.

Similarly, artificial fishes can communicate each other using long and short-range communications.

They can communicate if they found an interesting object or acoustic signal, in a way to attract other fishes to improve monitoring or mapping.

Their concept is tailored to robots' swarm operations, with several sensorial and communication tools, such as long-range communications (acoustic way) or short range (electric sense, blue light).

H-SURF: Heterogeneous Swarm of Underwater Robotic Fish, Saverio Iacoponi, Godfried Jansenvanvuuren, Gaspare Santaera, Nikita Mankovskii, Igor Zhilin, Federico Renda, Cesare Stefanini, Giulia **De Masi**, Proceedings OCEANS2022, IEEExplore

MONITORING FROM THE SURFACE

Some sensing can be done also from the sea surface (fixed buoys or autonomous boats) or even from the sky (drones)

Autonomous or telecontrolled surface vehicles are useful for sensing of specific chemical/physical/biological parameters of the sea water.

Detection of **dolphins,** of **algal bloom,** or drifting **oil patches** can be done from drones.

In all these cases, AI offer suitable methods for identification of objects and tracking

THE ROLE OF ARTIFICIAL INTELLIGENCE

GIULIA DE MASI - JULY 2025

AI FOR ENVIRONMENTAL METOCEAN DATA

Applications of Machine Learning for:
1) Nowcasting based on local measurements
2) Improving bulletin forecasting based on local measurements
3) Energy efficient schedule optimization of operations in the sea

Weather: Mainly fair with haze.

Local weather bulletin

		10m wind			50m	Sea	Swell			Total Sea						
	Time	Dir	Spd [kts]	Gust [kts]	Spd [kts]	Hgt [m]	Dir	Hgt [m]	Per [s]	Sig [m]	Max [m]	Tmp [°C]	RH [%]	Rain [mm]	Cloud [%]	Vis [km]
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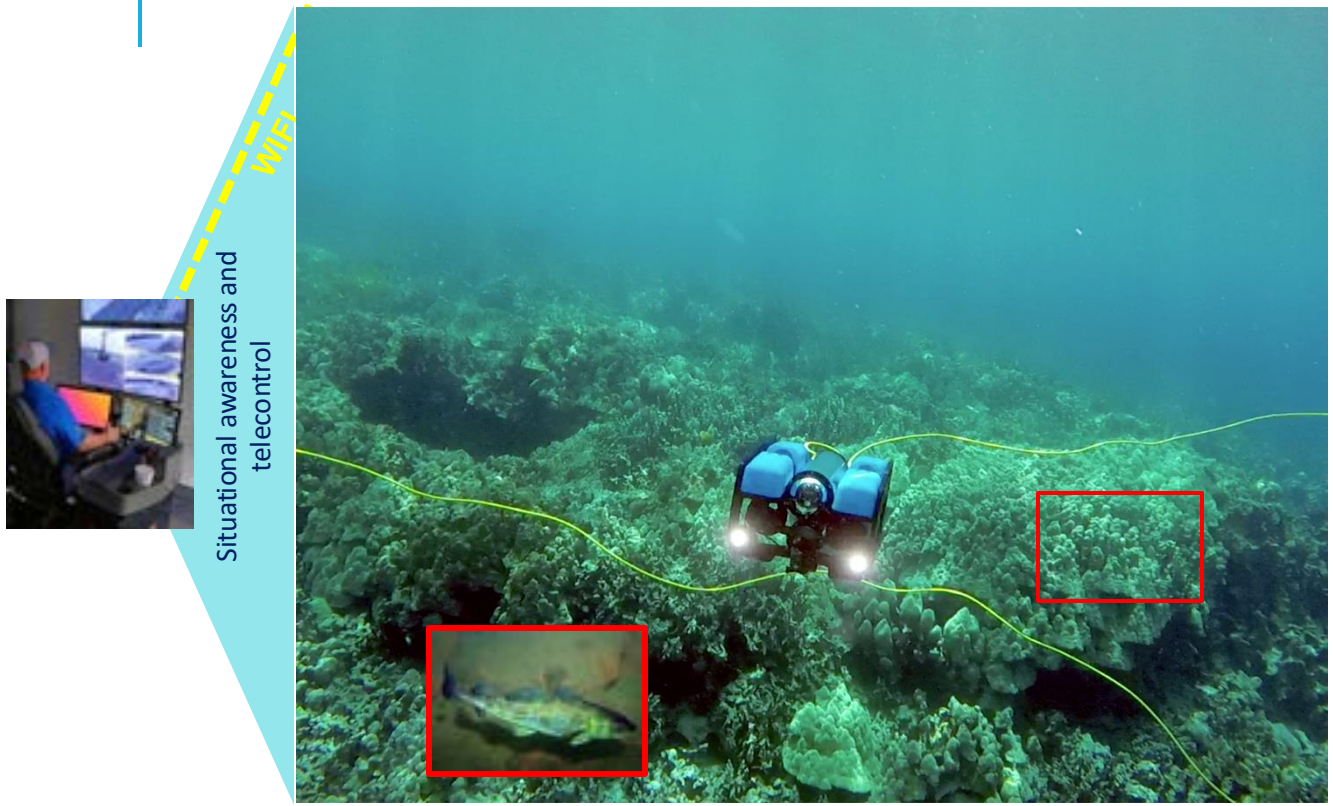
	10	N	18	23	22	0.4	-	-	-	0.4	0.7	32.1	29	0.0	0	10.0

1. *Analysis of opportunity windows for weather sensitive operations,* Y.P. Foo, K. Gan, D. Giudice, **G. De Masi,** OTCA2014
2. *Optimization of critical wave forecasting by Artificial Intelligence*, **G. De Masi**, F. Gianfelici, Y.P. Foo, OCEANS2013, IEEE Proceedings (2013)

MARINE ECOSYSTEMS REAL-TIME MONITORING



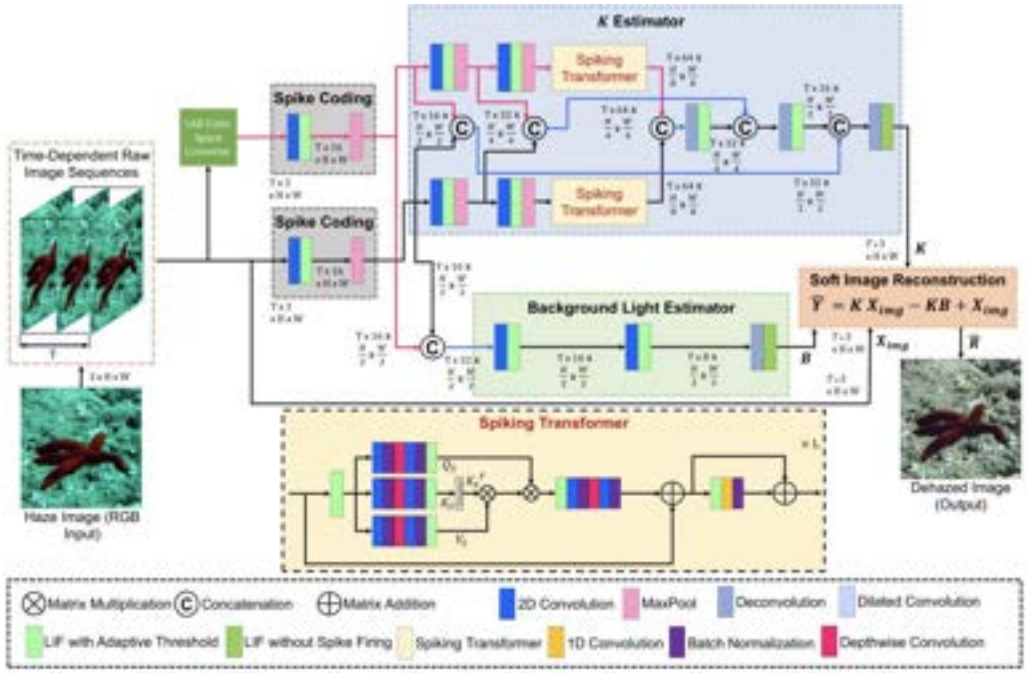
- ROVs inspect the coral reefs/sea grass meadows
- Detailed images are recorded
- Images can also be transmitted from the ROV to surface via ethernet cable and to the base station by radiofrequency in quasi real time
- Environmental parameters are also measured (PH, turbidity; salinity to monitor the full health status also of the water)

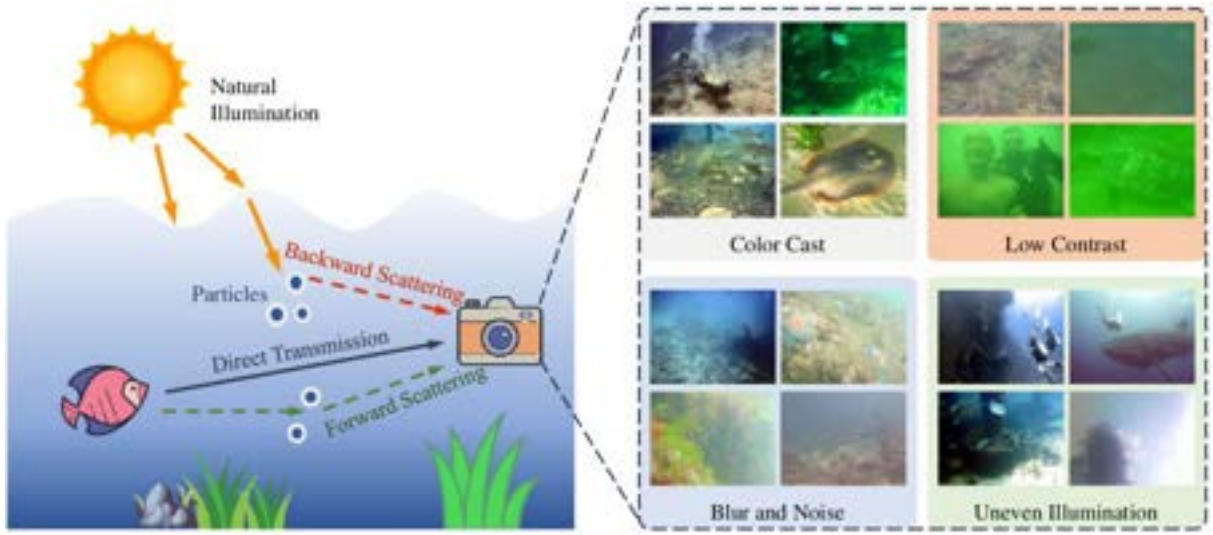
AI for :

- Autonomous detection of marine species (corals/animals)
- Study of correlation between environmental parameters and ecosystem health-status
- Autonomous monitoring of evolution of the environment
- Image and video understanding

Wireless teleoperation of HSURF artificial fish in complex paths, S. Iacoponi, S. Alhajeri, M. Hanbaly, F. Renda, C. Stefanini, G. **De Masi**, OCEANS 2023 - Limerick, Ireland, 2023, pp. 1-5, doi: 10.1109/OCEANSLimerick52467.2023.10244729.

IMAGE PROCESSING





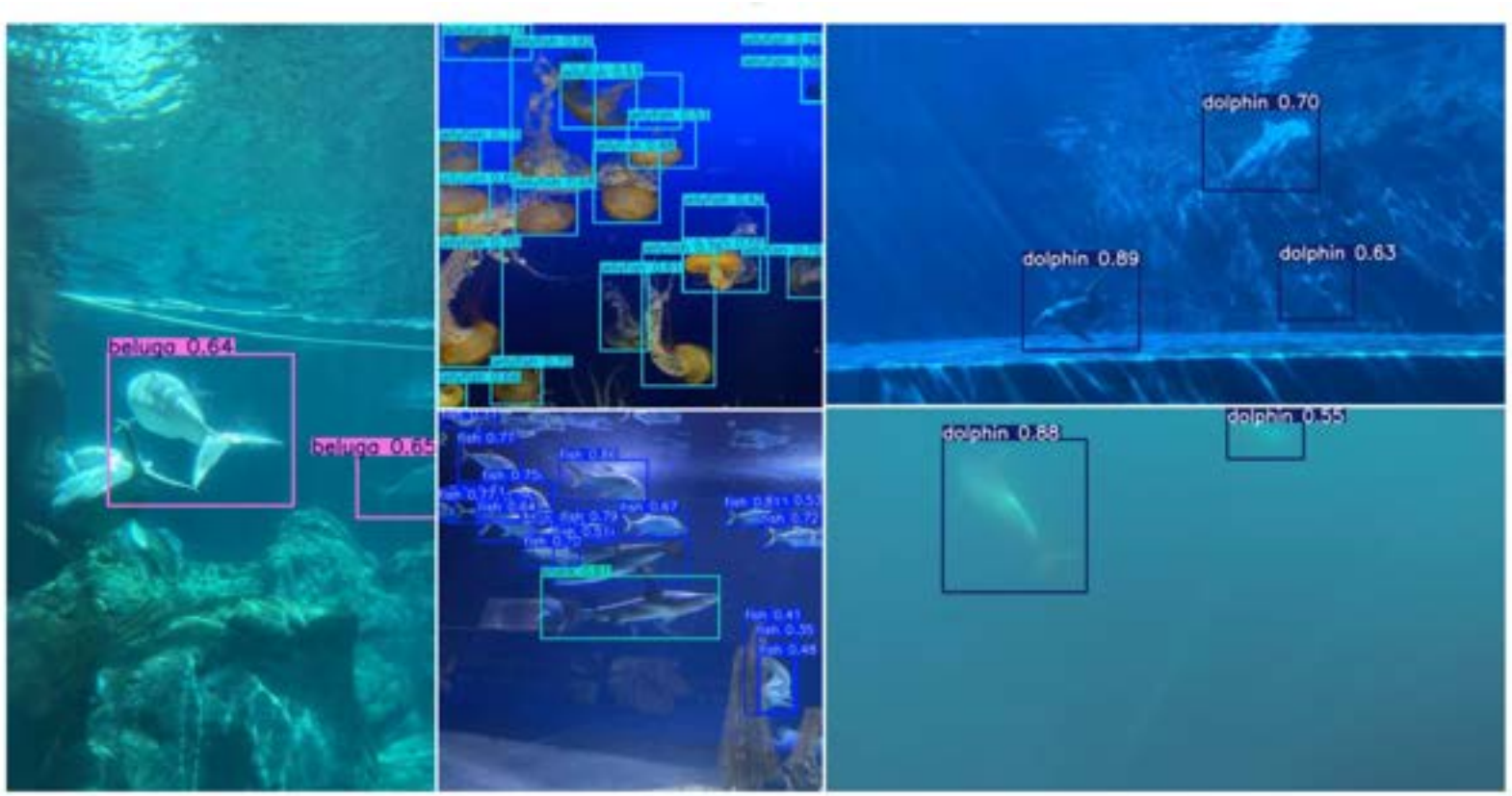
Main issues underwater:

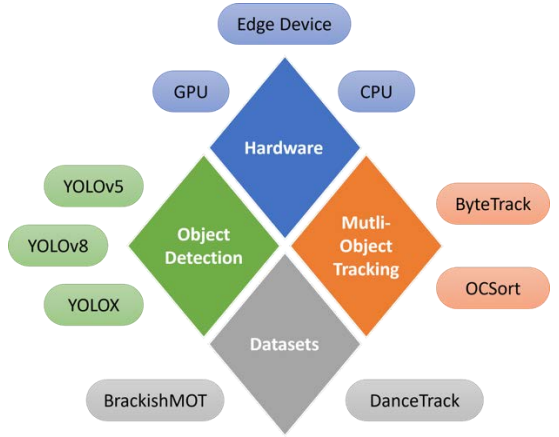
1. Forward and backward Scattering
2. Absorption

Dehazing and Visibility enhancement are vital to conduct any vision-based tasks under extreme conditions
Minimize energy consumption is crucial in Deep neural Networks: neuromorphic approach

snnTrans-DHZ: A Lightweight Spiking Neural Network Architecture for Underwater Image Dehazing
Vidya Sudevan, Fakhreddine Zayer, Rizwana Kausar, Sajid Javed, Hamad Karki, Giulia De Masi, Jorge Dias, arXiv:2504.11482

UNDERWATER VISUAL DETECTION AND TRACKING





Underwater Inspection Platform for Vision-Based Biodiversity Identification, Gianluca Manduca, Gaspare Santaera, Ada Natoli, Giulia De Masi, Cesare Stefanini, Donato Romano, 2025 IEEE International Workshop on Metrology for the Sea (MetroSea)

ACOUSTIC MONITORING

- ROVs/AUVs ca be equipped with many sensors including acoustic transceiver
- Using many AUVs allow to patrol extended areas, detecting acoustic signals' like those emitted by ships
- Leveraging AI, they can be used to detect autonomously acoustic signals in presence of cetaceans in order to understand their behavior and preserve their communities
- They can also be used for preventing collisions of ships with big mammals

HIGH-LEVEL POLITICAL FORUM
ON SUSTAINABLE DEVELOPMENT

PERSPECTIVES

- Increased Autonomy and AI Decision-Making
- Swarm Robotics and Collaborative Systems
- Integration with Satellite Imaging and IoT
- Advanced Navigation and Energy Efficiency
- Applications in Marine Conservation and Sustainability
- Bio-Inspired and Soft Robotics

PATRICK GORRINGE

ACCESSIBLE OCEAN TECHNOLOGY

HIGH-LEVEL POLITICAL FORUM ON SUSTAINABLE DEVELOPMENT

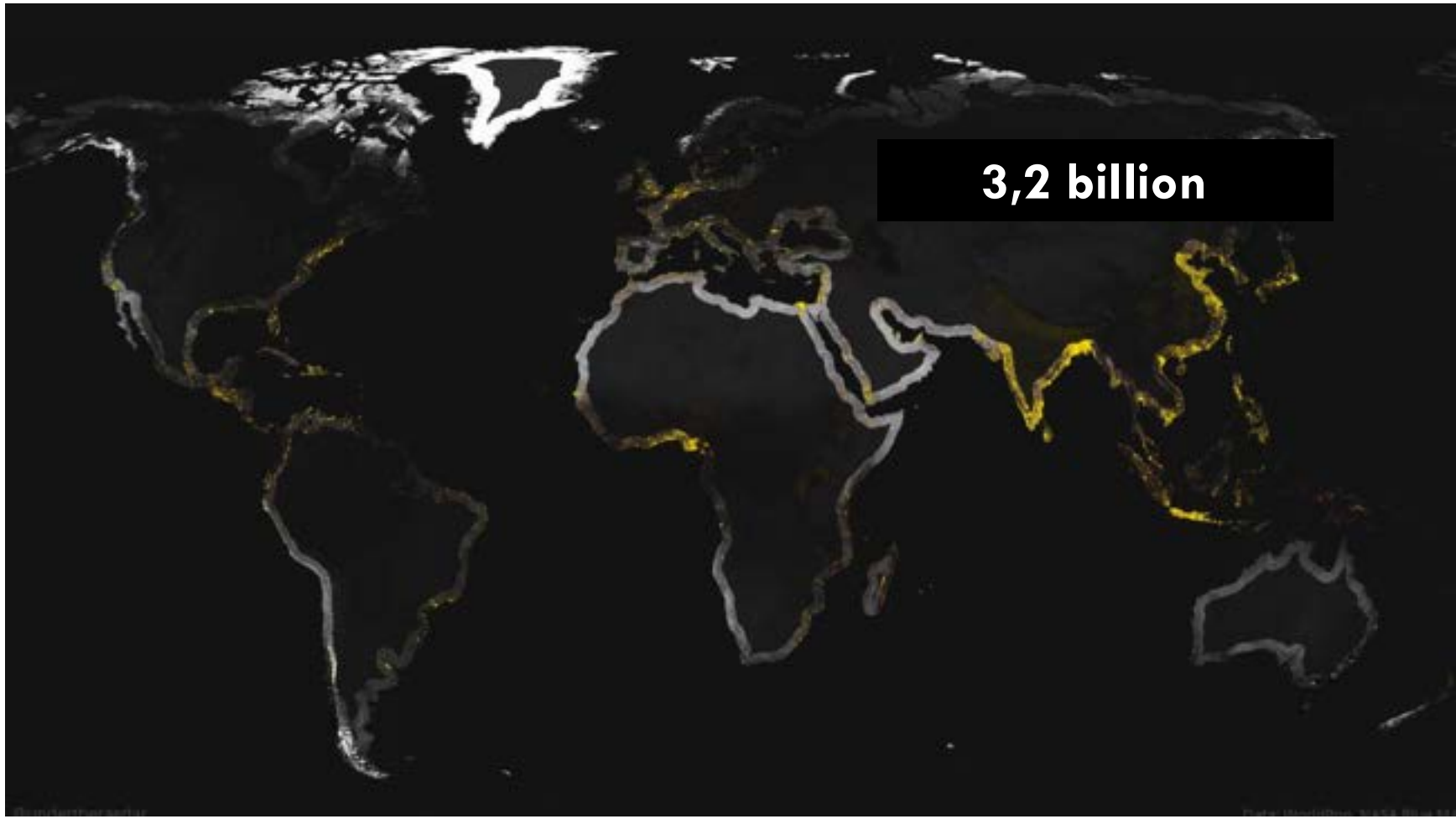
Innovations for sustainable Oceans - Importance of sensing technology for understanding the condition of the ocean

Global Ocean Observing System

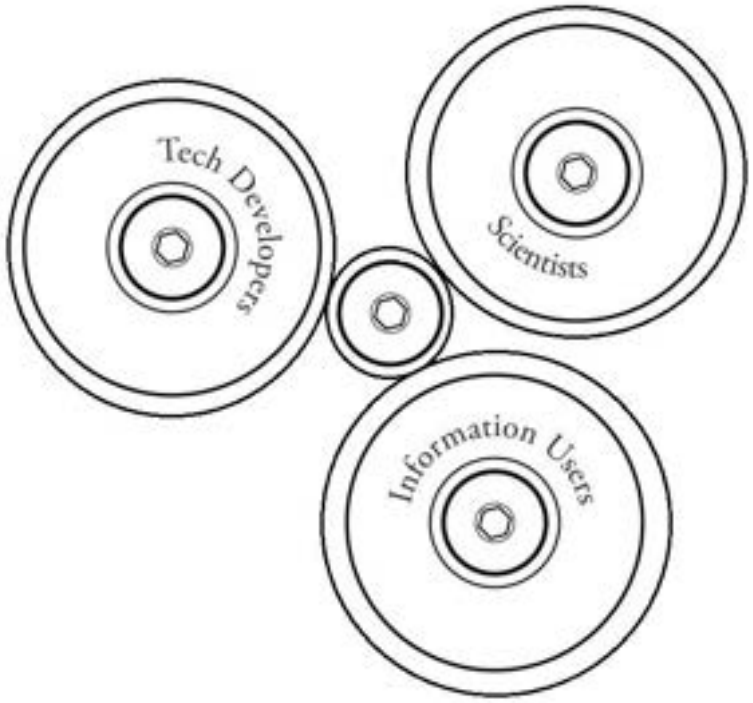
IEEE

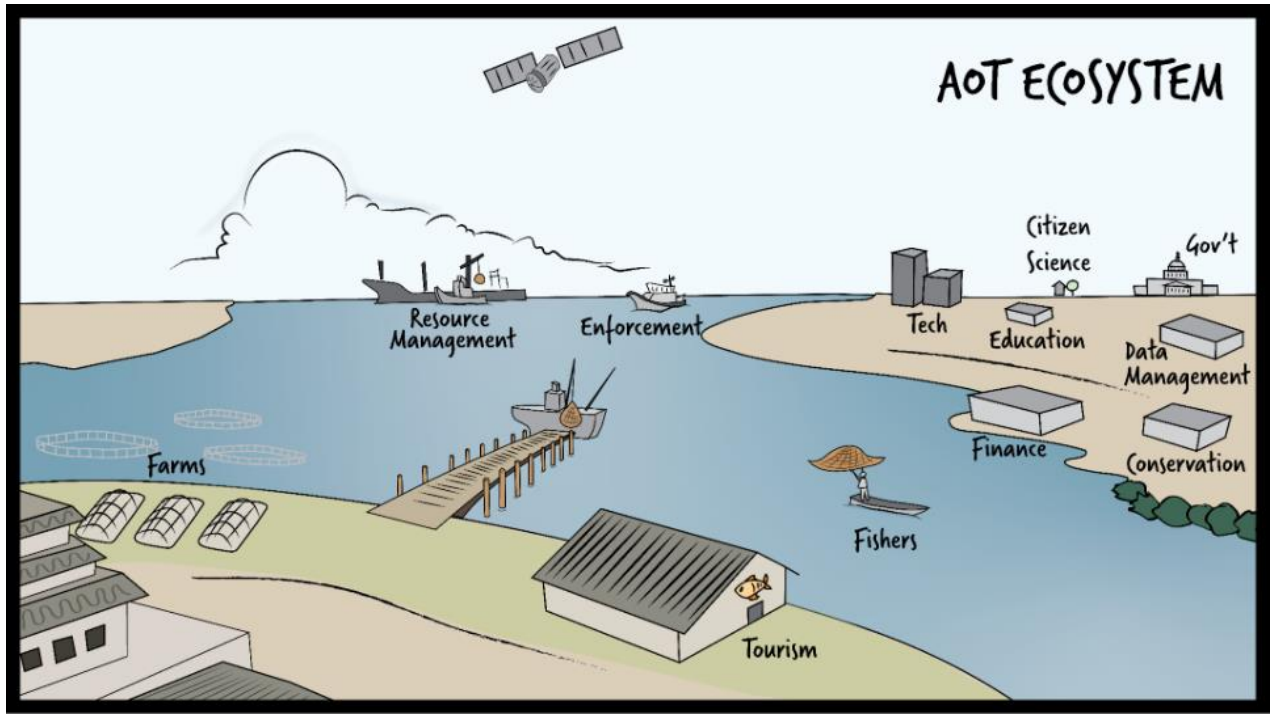
GOOS
Global Ocean Observing System

- About **40%** of the world's population lives within 200 km from the coast.
- Ocean is a source for
  - **food** - Fish accounts for about 17% of the animal protein consumed globally
  - **employment** - Only in the European Union, blue sector employs almost three and a half million workers
  - **transportation** - 50.000 ships trade internationally
  - **tourism, energy, …**
- Ocean regulates **short- and long-term climate.**



AOT, Key Question: How can we ensure coastal communities benefit from ocean technology that's practical, affordable, and built for real-world use?

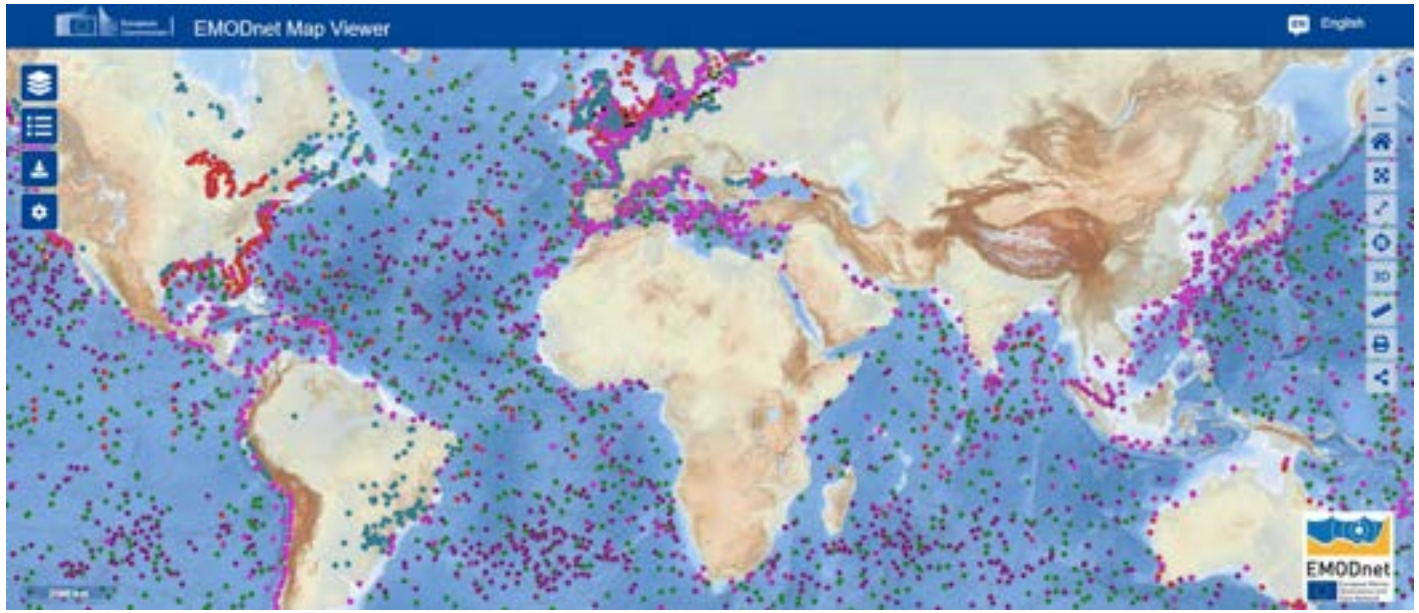




Accessible Ocean Technology (AOT) lowers the financial, logistical, technical and resource restrictions of ocean observation while broadening access. This approach promotes sustainable ocean monitoring while building capacity in communities of ocean stakeholders






EMODnet Map Viewer
English
EMODnet

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

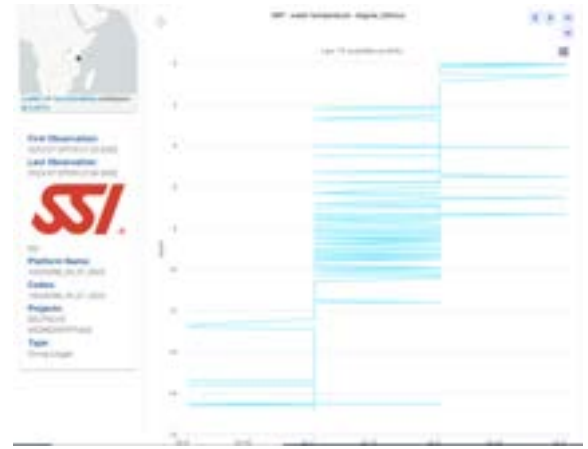
THE FVON APPROACH

FVON FISHING VESSEL OCEAN OBSERVING NETWORK

FISHING FOR DATA.

- Millions of fishers already operate in shelf and coastal regions
- Sensors *go along for the ride* on nets, traps, etc., catching water column profiles
- Co-located surface met, sea surface, & subsurface data – powerful!
- Fully automatic: as soon as the sensor surfaces data is automatically transmitted

GOOS Global Ocean Observing System



Deutsche Meeresstiftung
German Ocean Foundation

SSI
SCUBA SCHOOLS INTERNATIONAL

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

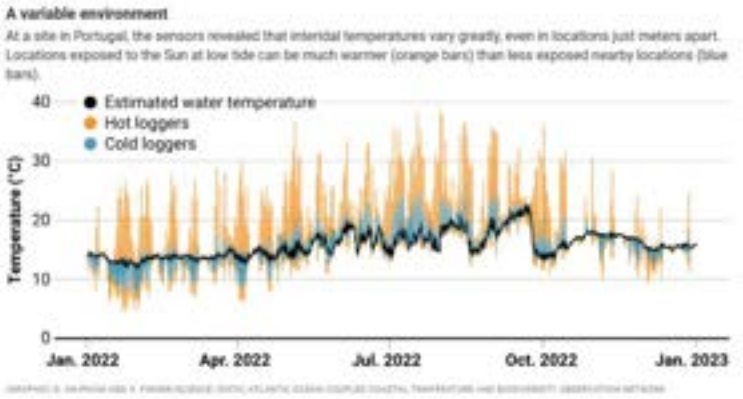
EMODnet
European Marine Observation and Data Network

IEEE

GOOS
Global Ocean Observing System

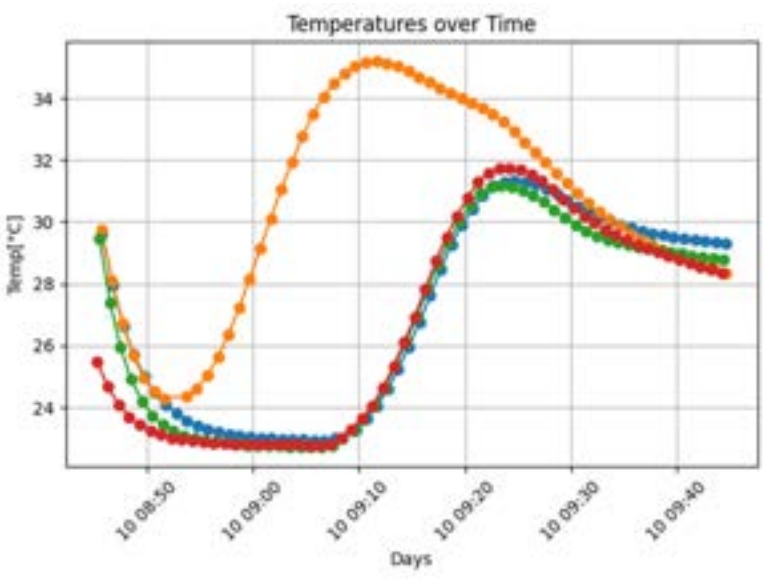
Coupled Coastal Temperature and Biodiversity Observation Network

- Largest of its type on Earth
- Hourly temperature data
- Yearly biodiversity surveys
- Infrastructure running for > 1 decade
- Citizen Science
- Open, FAIR, data



TRANSFORMING SURFING PASSION INTO SUSTAINABLE IMPACT

- Protection of marine ecosystems across remote surfing communities worldwide
- Surfing is the fastest growing water sport in the world, 25-30 million surfers globally
- Using the passion people have for surfing as a platform from which to collaborate and bring innovation.



CoastPredict
with The Global Ocean Observing System

COAST PREDICT PROGRAMME

Fragmentation of knowledge & efforts

- Establish international network for Global Coastal Ocean innovation and solutions

Large data gaps: coastal zone & Global South

- Equitable & free access
- Development & sharing of knowledge, resources & services

Technology gaps

- Coastal & urban models for the future
- Accessible observing technologies
- Delivery of services & big data

Objective

Provide decision-makers and coastal communities with integrated observing and predicting systems

to identify solutions for managing risk (short-term) and planning for mitigation and adaptation (long-term)

context of future climate and ocean change

https://www.fvon.org https://emodnet.ec.europa.eu/en https://aliquidfuture.org https://www.coastpredict.org

patrick.gorringe@smhi.se

HIGH-LEVEL POLITICAL FORUM
ON SUSTAINABLE DEVELOPMENT

Building Trust in Environmental Data Through Standards

Dr. Christoph Waldmann

Chair of the

IEEE Oceanic Engineering Society Standards Committee

HIGH-LEVEL POLITICAL FORUM
ON SUSTAINABLE DEVELOPMENT

IEEE Oceanic Engineering Society

Agenda

- Understanding Standards
- Ocean Sensing Technologies and Platforms
- The Technology Life Cycle
- Way Forward

Standards

Think of them as a **formula** that describes the best way of doing something -

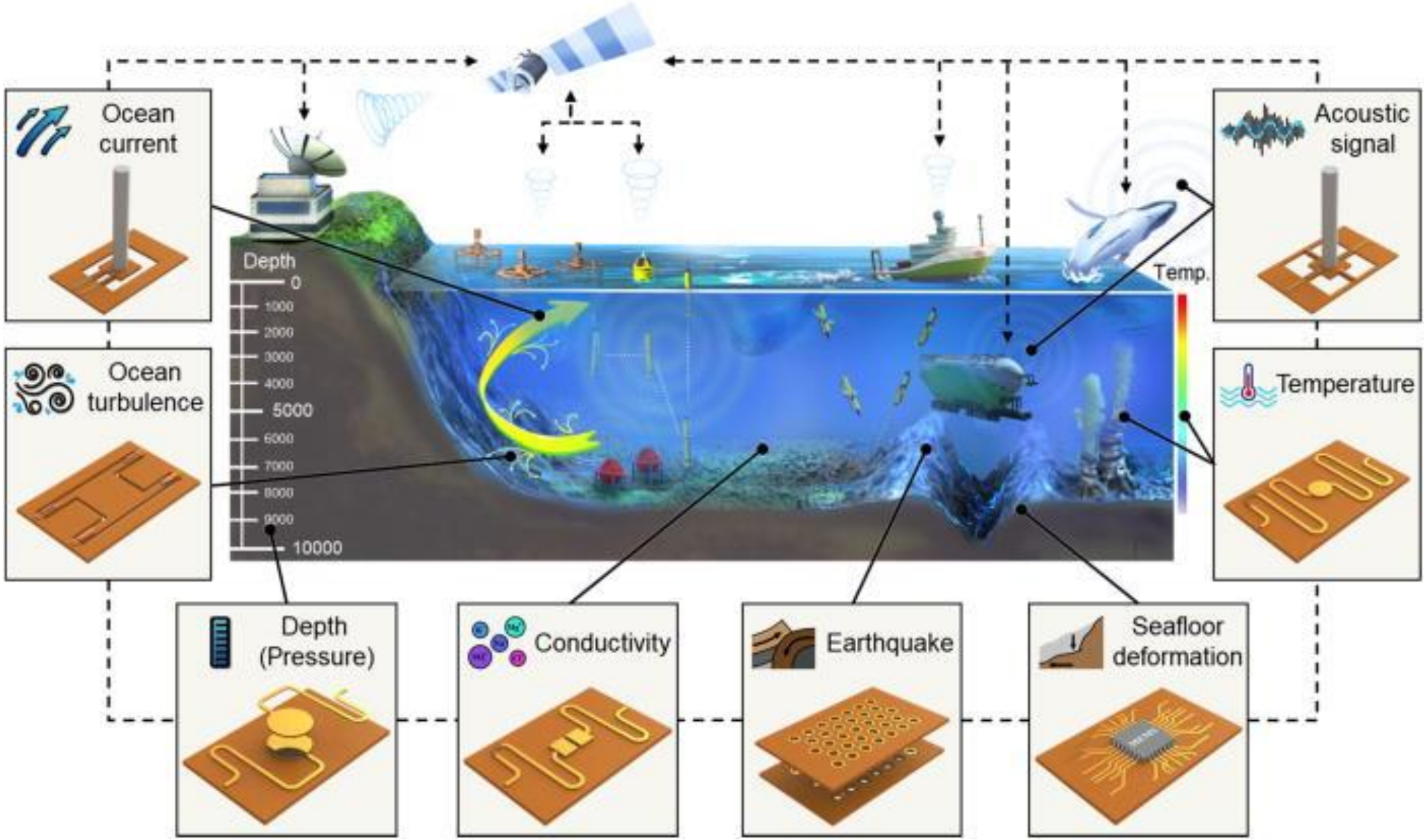
- Making a product
- Managing a process
- Delivering a service
- Supplying materials

Standards are the **distilled wisdom** of people

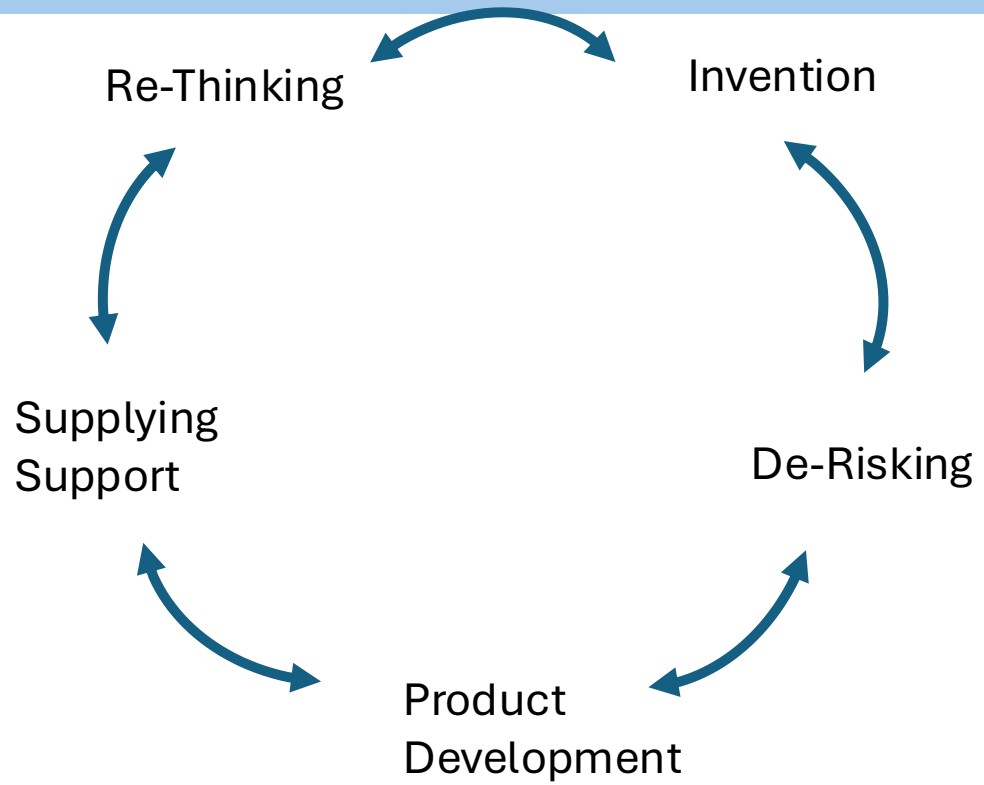
https://www.iso.org/standards.html

How to get from distilled wisdom to a cooking recipe?

- NEEDS AND REQUIREMENTS HAVE TO BE IDENTIFIED
- AN AGREEMENT BETWEEN ALL INVOLVED EXPERTS MUST BE ACHIEVED



The Technology Life Cycle



- Standards support every step of that process
- It is never to early to develop terminology standards are needed
- Trustworthiness evolves from mutual understanding

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Standards fuel the Technology Life Cycle

Scientific revolutions do not require standards industraal revolutions do!

- Standards are not just physical standards but there are also documentary standards
- Going from De-Risking to Product Development calls for use cases
- Identify markets and boost consumer confidence
- Learning from field deployments to further improve the product

Way Forward

- The OES Standing Committee on Standards is defining its role in this framework as a **coordinating body to bring the different stakeholders** together and motivate the development of standards

- Standards help for a better understanding between communities

- As part of the discussion on the impact of climate variability and changes standards appears to be a necessary step towards achieving **trustworthy information** on the condition of the world oceans

Policy powered by technology: advancing governance through science-based solutions

In the context of the United Nations Decade of Ocean Science for Sustainable Development

unesco
Intergovernmental Oceanographic Commission

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Laura Meyer
Stakeholder Coordination Officer, Decade Coordination Unit,
Intergovernmental Oceanographic Commission of UNESCO

22.07.2025

The Ocean as an ally in climate protection

"People protect what they love. We need to help them fall in love with the ocean." - Jacques Cousteau

WHAT IS THE OCEAN DECADE

Vision: *'The science we need for the ocean we want.'*

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

Launched in **January 2021**, the **Ocean Decade** provides a global framework to advance ocean science and collaboration.

It fosters partnerships across diverse sectors to **revolutionize ocean science**, ensuring it drives policy, innovation, and sustainability.

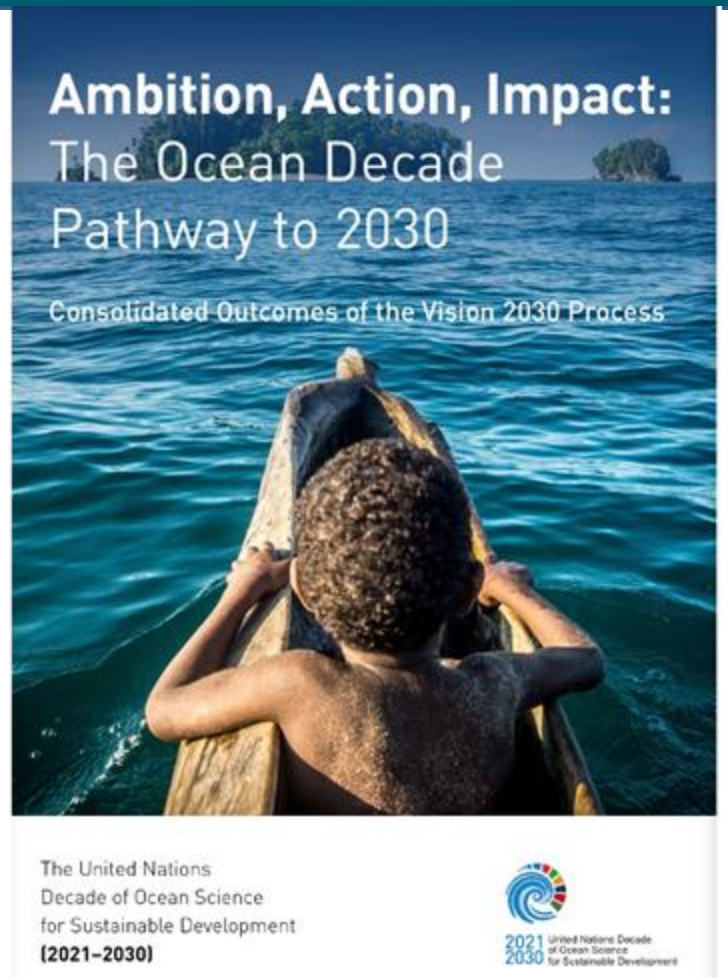
The Ocean Decade aligns research, investments, and initiatives to create a **productive, resilient, and sustainable ocean.**

unesco
Intergovernmental Oceanographic Commission

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

IMPLEMENTATION OF THE OCEAN DECADE

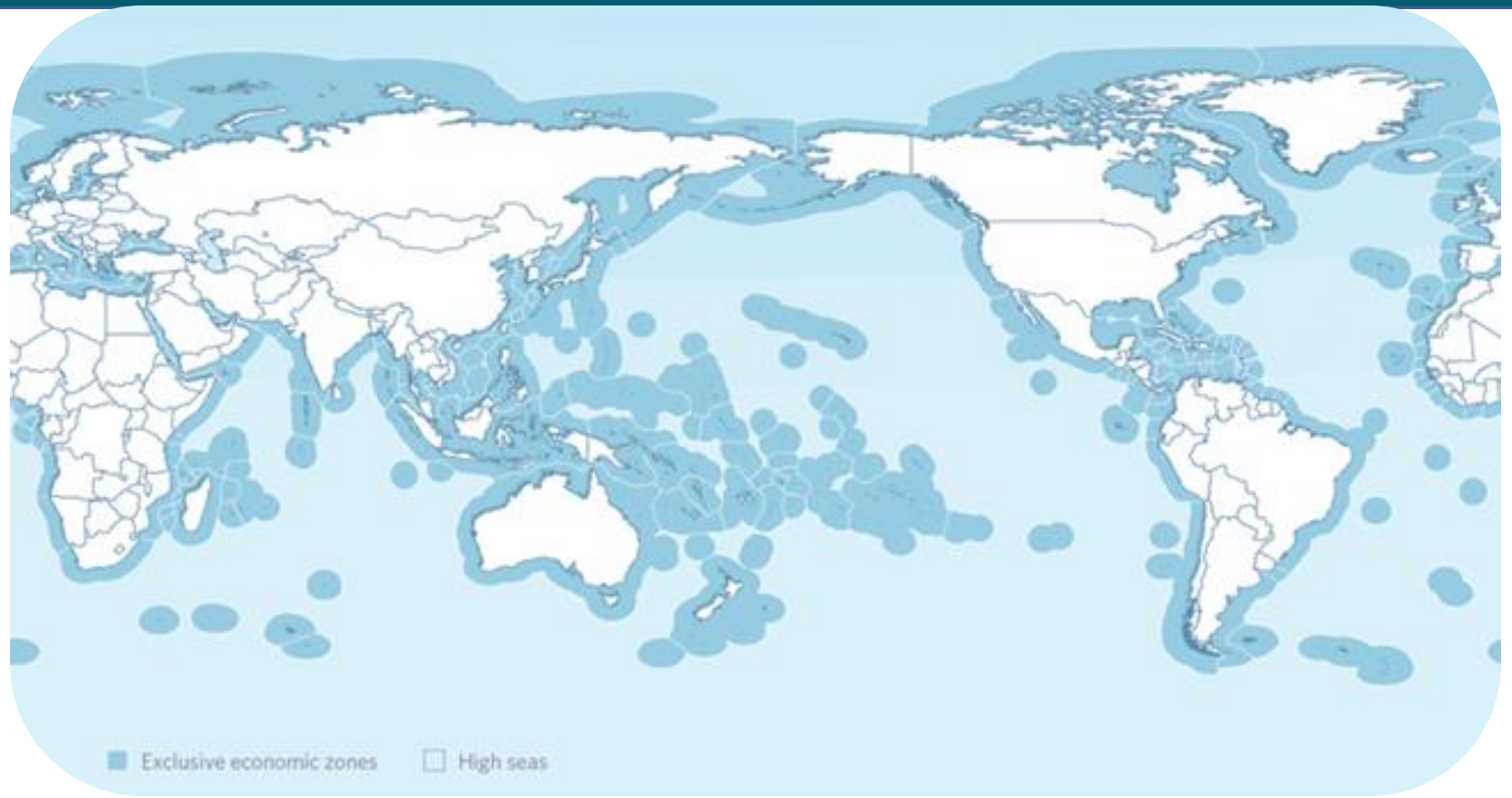
- The Ocean Decade builds on existing ocean science achievements and catalyzes transformation across geographies, genders, sectors, and generations.
- **Ocean Decade Actions:** Initiatives led by research institutes, governments, UN entities, NGOs, businesses, educators, and community groups worldwide.
- Decade Actions are aligned with **10 Decade Challenges**.
- **The Ocean Decade Alliance**: 11 Patrons and 19 institutional members, with the aim to leverage and multiply financial and in-kind resource commitments.


Ambition, Action, Impact:
The Ocean Decade
Pathway to 2030
Consolidated Outcomes of the Vision 2030 Process
The United Nations
Decade of Ocean Science
for Sustainable Development
(2021–2030)
2021 United Nations Decade of Ocean Science for Sustainable Development
2030

IMPLEMENTATION OF THE OCEAN DECADE

Countries marked with an asterisk (*) are Ocean Decade Liaisons.

Jurisdiction in the ocean



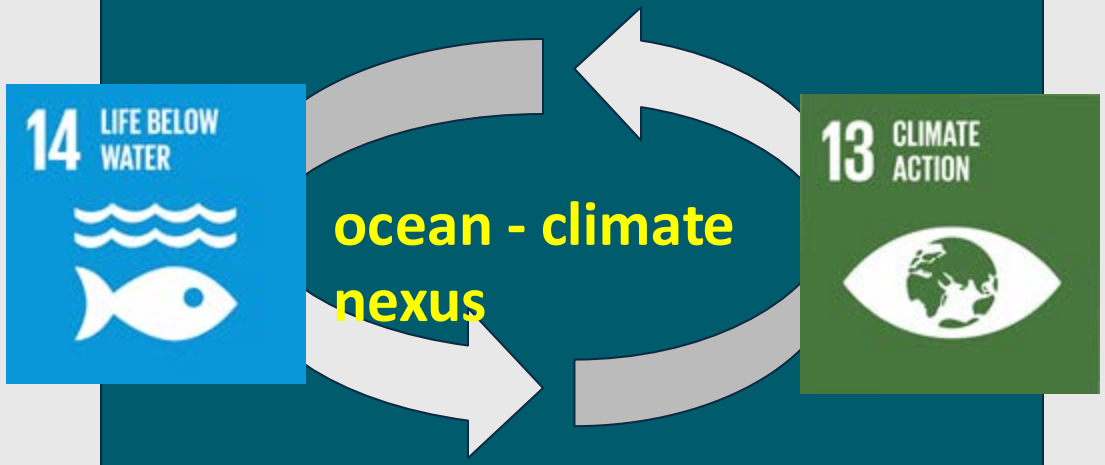
https://www.pewtrusts.org/en/research-and-analysis/articles/2018/06/07/5-surprising-stats-show-why-high-seas-need-protection

The light blue waters in this map represent all of the high seas.
This vast ocean area performs many functions that, together, are vital to most life on Earth.

Existing Treaties and Legal Frameworks

Marine environment:

- **UNCLOS** (United Nations Convention for the Law of the Sea)
- **London Convention** with **London Protocol**
- **CBD** (Convention on Biological Diversity)



Climate Change:

- **UNFCCC (United Nations Framework Convention on Climate Change)**
- **Paris Agreement**

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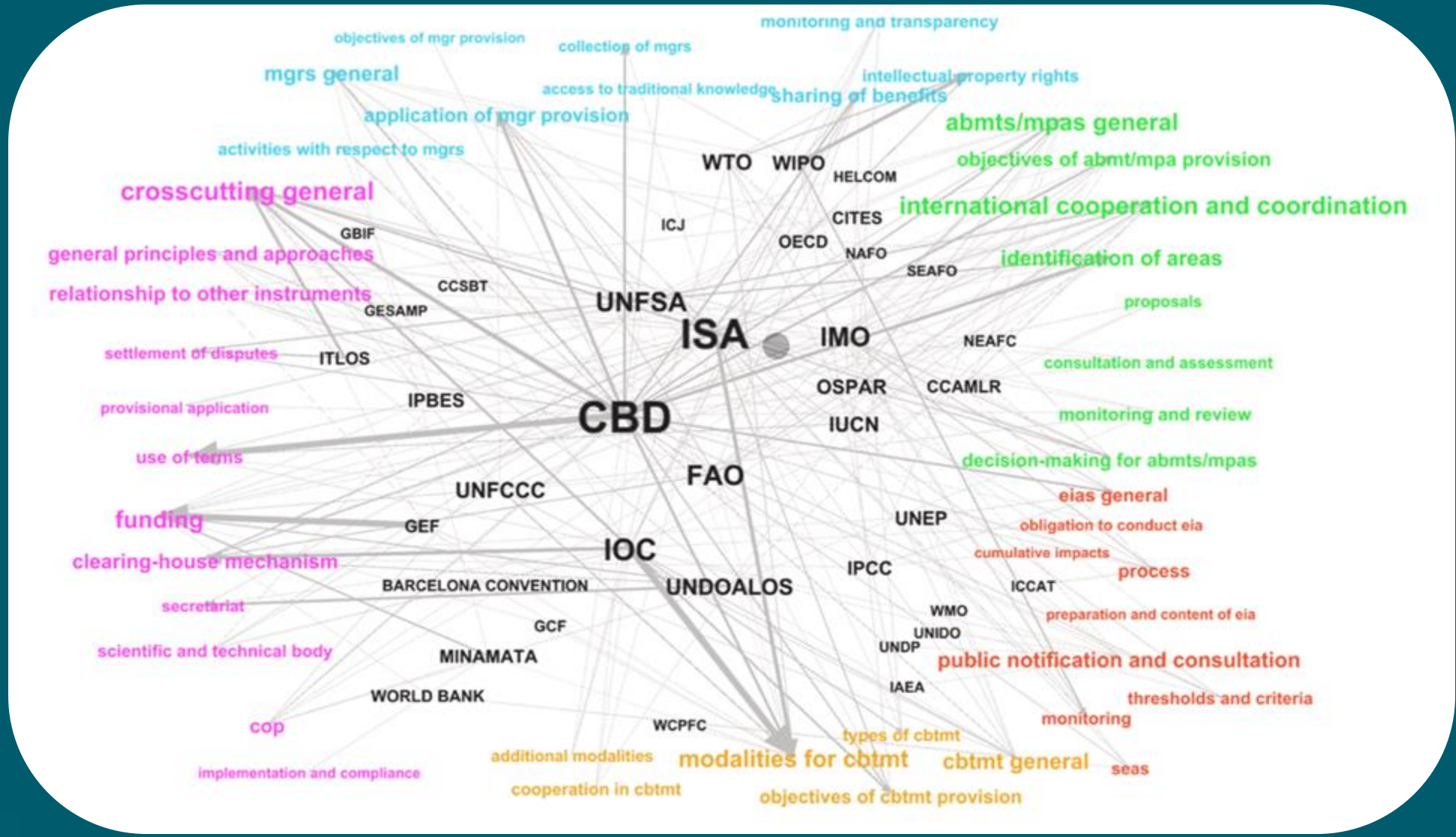
Concept of Regime Interaction



Arne Langlet, Alice B.M. Vadrot, Not 'undermining' who? Unpacking the emerging BBNJ regime complex, 147 Marine Policy 105372 (2023)

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BBNJ AGREEMENT:
Four key 'packages' that will contribute to the conservation and sustainable use

Marine genetic resources (MGRs)

Area-based management tools (ABMTs)

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Capacity-building and the transfer of marine technology (CBTMT)

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Capacity-building and the transfer of marine technology (CBTMT)

Equity:
Helps developing countries participate meaningfully in ocean science and decision-making.

Enabling science-based policy:
Countries need **tools, infrastructure, data access**, and **training** to translate science into policy.

Technology as a connector:
From satellite monitoring to deep-sea sensors and ocean data platforms—**technology transforms marine observations into actionable governance tools.**

Join the wave

Laura Meyer, Stakeholder Coordination Officer,

l.meyer@unesco.org

There are many ways to get involved in the Ocean Decade, visit www.oceandecade.org to learn more

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Roundtable Discussion and Q&A

Christopher Whitt, Moderator

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