



The Contribution of Italian Research Infrastructures towards a Coordinated Observation of Essential Variables in the Mediterranean

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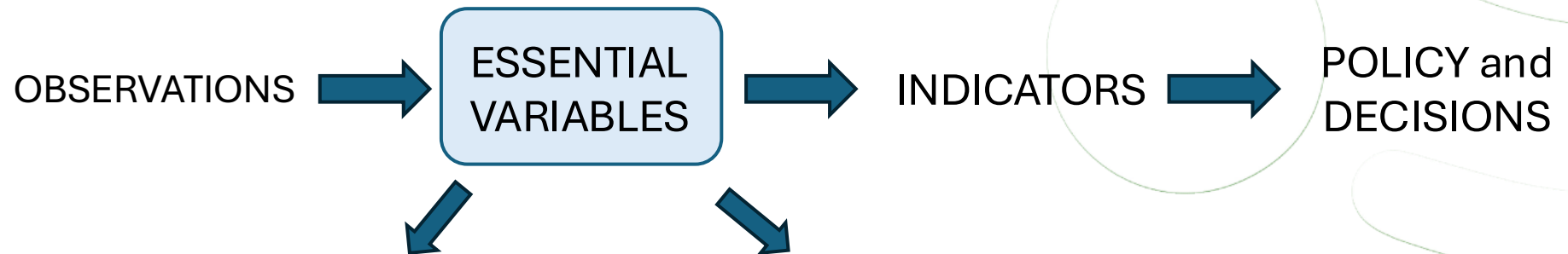
EMB Science Webinar, 16 July 2026

IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System
(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-
Mission 4 "Education and Research" - Component 2: "From research to business" - Investment
3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures"



What Are Essential Variables (EVs)?

Essential Variables are a common language that link **observations**, **science** and **policy** by translating diverse measurements into a standardized set of variables, suitable for informing indicators and decisions.



✓ *Relevance* ✓ *Sensitivity to change*
✓ *Feasibility* ✓ *Policy usefulness*
✓ *Scalability* ✓ *Harmonization*

- **ECV** - Essential **C**limate **V**ariables
- **EOVS** - Essential **O**cean **V**ariables
- **EBVS** - Essential **B**iodiversity **V**ariables

Essential Climate Variables (**ECV**)

- a physical, chemical, or biological variable or a group of linked variables that contributes to the characterization of **Earth's climate**.
- defined by the Global Climate Observing System (**GCOS**) program in **2003**



Global Climate Observing System (GCOS)



55 **ECVs**

Key document:
GCOS Report-245
The 2022 GCOS ECVs Requirements
2022 edition – Updated in 2025

The **Global Climate Observing System (GCOS)** is co-sponsored by WMO, IOC-UNESCO, UNEP, and ISC. GCOS is supported by the European Union.



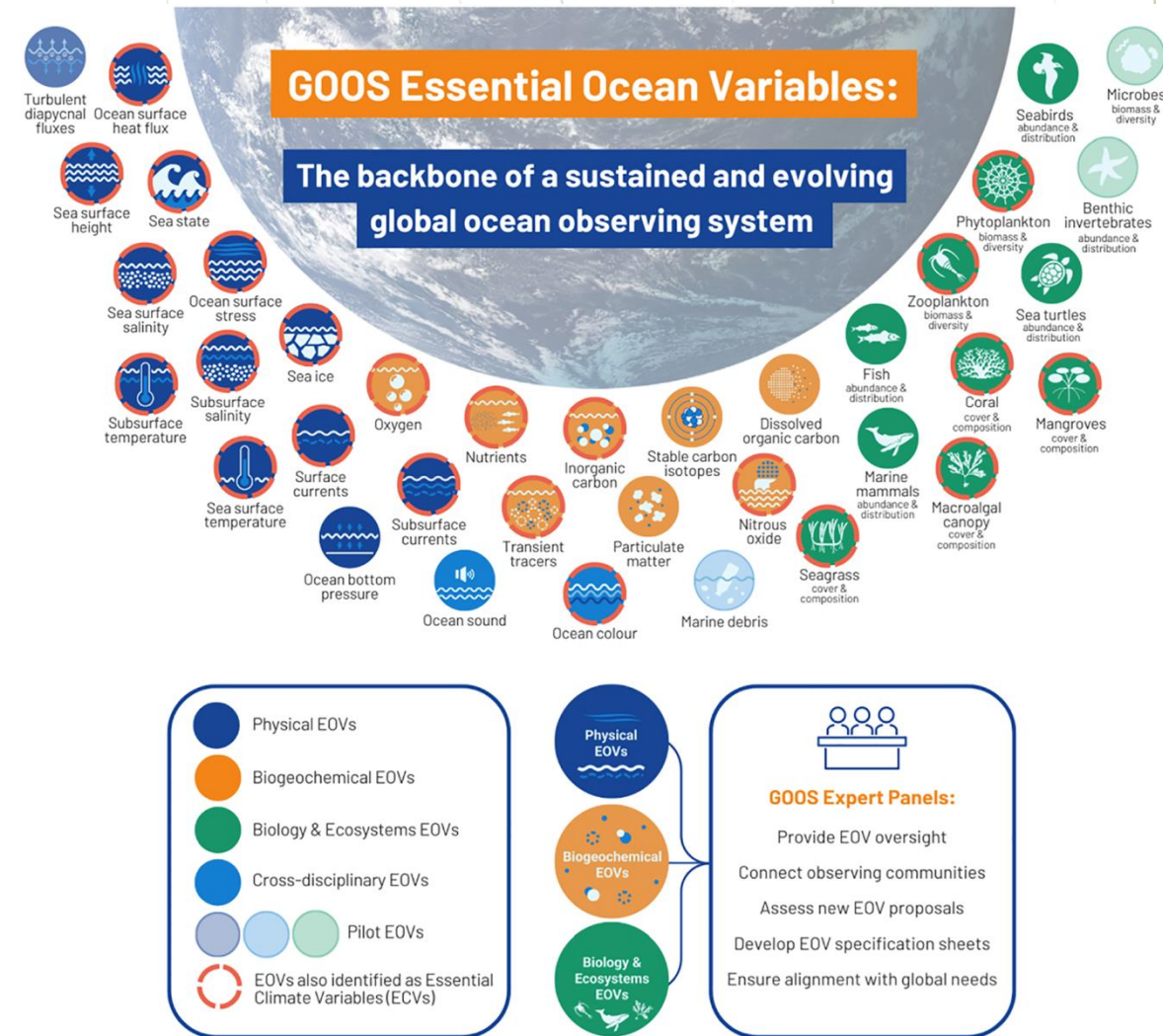
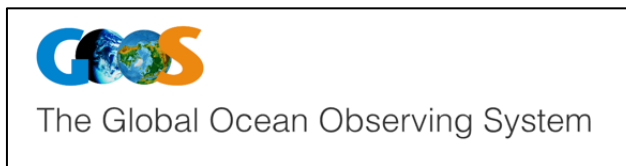
Atmosphere	Land	Ocean
Surface - Precipitation - Surface Pressure - Surface Radiation Budget - Surface Temperature - Surface Water Vapour - Surface Wind Speed and Direction - Upper-air Temperature	Hydrology - Groundwater - Lakes - River Discharge - Terrestrial Water Storage (TWS) - Evaporation from Land - Soil Moisture Cryosphere - Glaciers - Ice Sheets and Ice Shelves - Permafrost - Snow Biology - Above-ground Biomass - Albedo - Fire - Fraction of Absorbed Photosynthetically Active... - Land Cover - Land Surface Temperature - Leaf Area Index - Soil Carbon Human Use of Natural Resources - Anthropogenic Greenhouse Gas Emissions - Anthropogenic Water Use	Physical - Ocean Surface Heat Flux - Sea Ice - Sea Level - Sea State - Surface Currents - Sea Surface Salinity - Surface Stress - Sea Surface Temperature - Subsurface Currents - Subsurface Salinity - Subsurface Temperature Biogeochemical - Inorganic Carbon - Nitrous Oxide - Nutrients - Ocean Colour - Oxygen - Transient Tracers Biological/Ecosystems - Marine Habitats - Plankton

Essential Ocean Variables (EOV)

- essential ocean variables for monitoring ocean state and change, supporting science, services, and policy
- defined by the Global Ocean Observing System (GOOS) starting in 2010



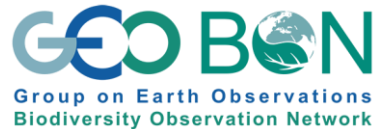
36 EOVs



Martín Míguez & Heslop et al., 2026

Essential Biodiversity Variables (**EBV**)

- a standardized biological metric for monitoring biodiversity across time, space, and biological levels
- introduced by **GEO BON** in **2013**, the EBV framework proposed **21 candidate variables** grouped into **6 classes**
- **EBVs** bridge primary biodiversity observations and policy-relevant indicators, supporting conservation and sustainable management

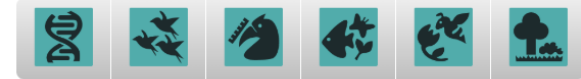


21 **EBVs**

H. M. Pereira et al., 2013
M. Lumbierres et al., 2025

EBV classes and names

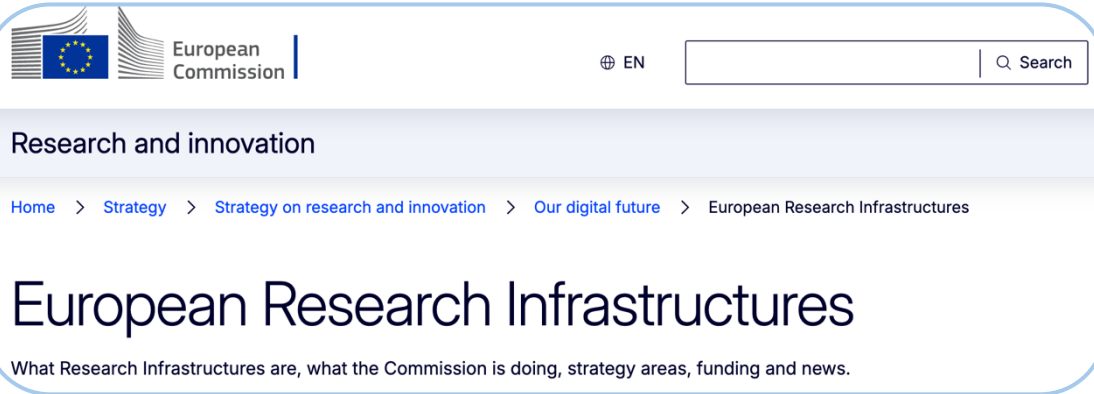
There are 6 EBV classes and 21 EBV names. By clicking on the icon you will get more detailed information.



[SHOW ALL EBVs](#)

EBV class	EBV name
Genetic composition	Genetic diversity (richness and heterozygosity)
	Genetic differentiation (number of genetic units and genetic distance)
	Effective population size
	Inbreeding
Species populations	Species distributions
	Species abundances
Species traits	Morphology
	Physiology
	Phenology
	Movement
	Reproduction
Community composition	Community abundance
	Taxonomic/phylogenetic diversity
	Trait diversity
	Interaction diversity
Ecosystem functioning	Primary productivity
	Ecosystem phenology
	Ecosystem disturbances
Ecosystem structure	Live cover fraction
	Ecosystem distribution
	Ecosystem Vertical Profile

What Are European Research Infrastructures (RIs)?



RIs provide the sustained capacity to observe EVs

RESEARCH INFRASTRUCTURES

- Facilities
- Data systems
- Instruments
- Networks
- Expertise
- Services



modified Zhao and Jeffery 2020



Strategy Report on Research Infrastructures
ROADMAP 2026

EUROPEAN RESEARCH INFRASTRUCTURE CONSORTIUM

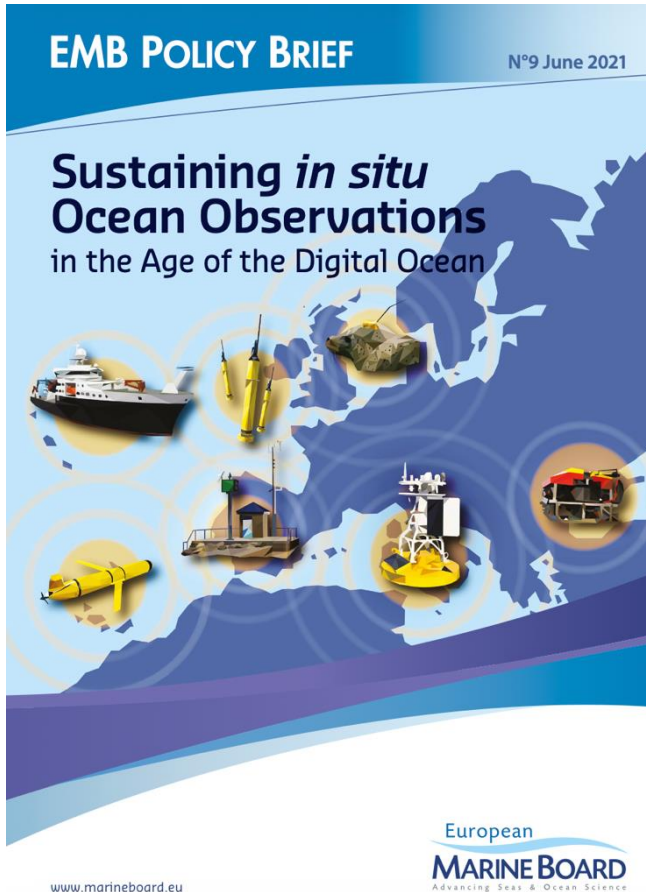
the legal framework designed to establish and operate research infrastructures

ERIC

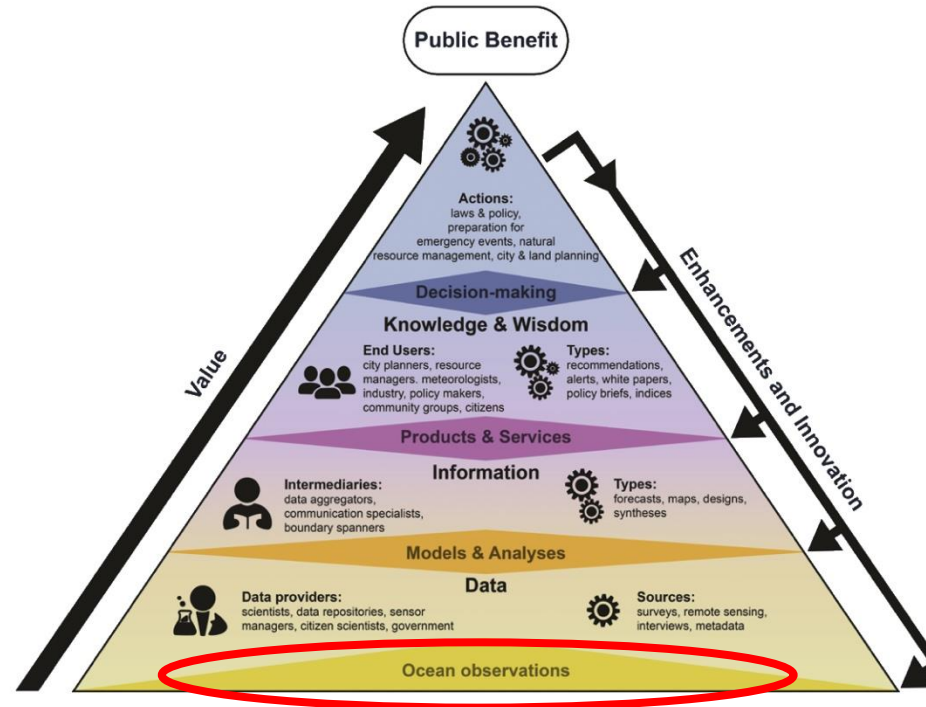
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NATIONAL INFRASTRUCTURES

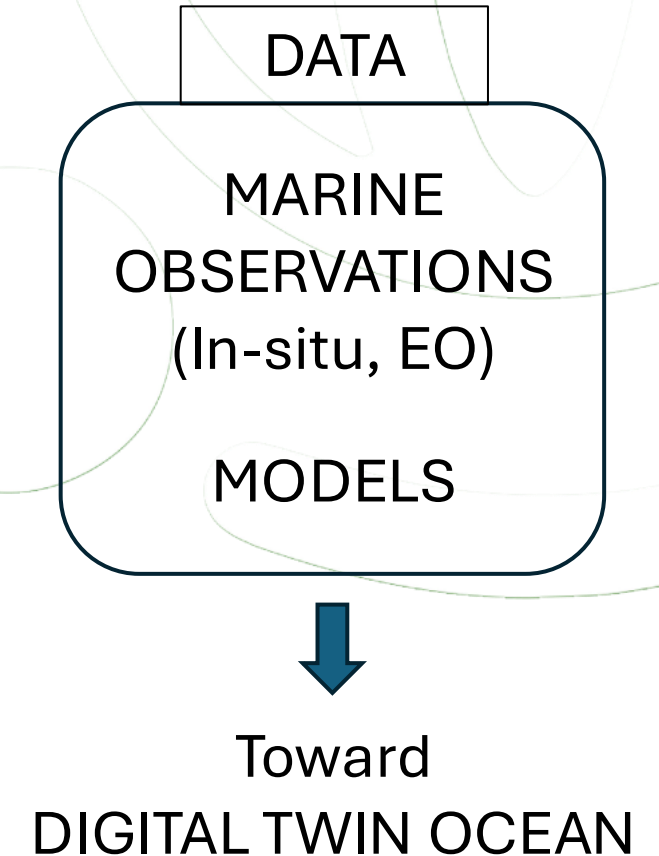
European Marine Board Policy Brief



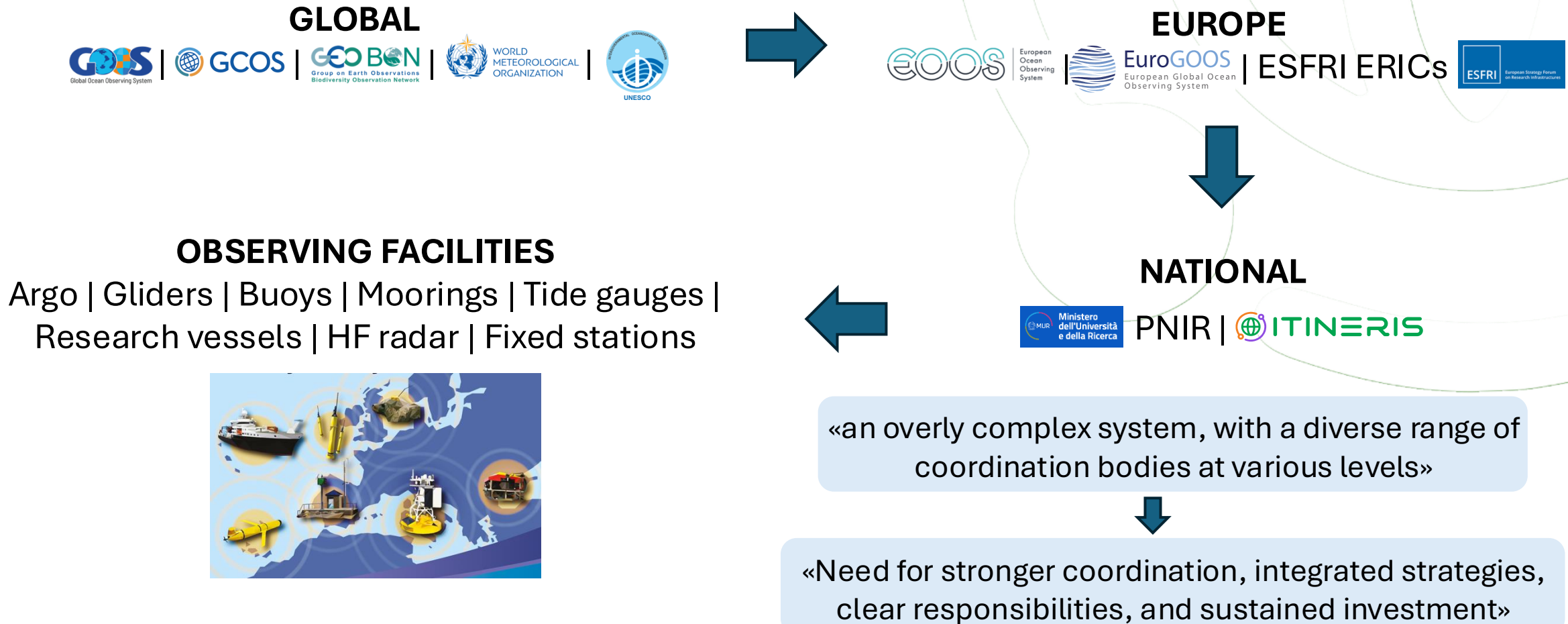
The Ocean Observation value chain



Adapted from Virapongse, et al., 2020



European Marine Board Policy Brief



ITINERIS: a contribution to an integrated Environmental Research Infrastructure system

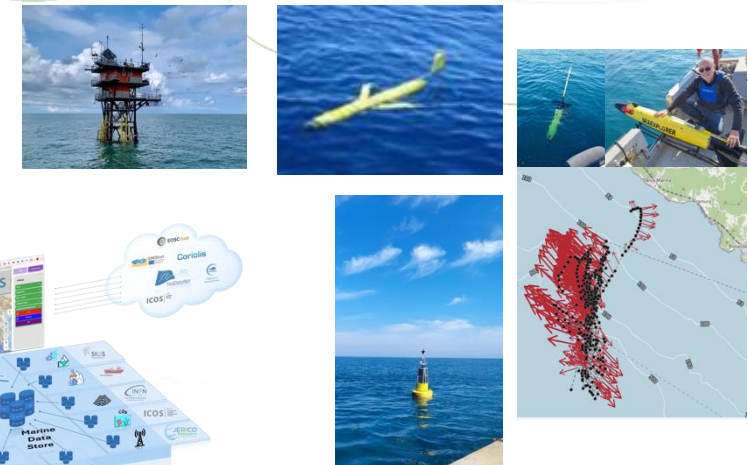
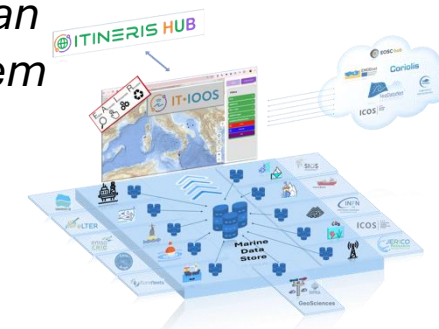
- **22** Research Infrastructures (ESFRI or National RIs within PNIR)
- **€ 155M** total budget → including **€ 50M** for the Marine Domain
- Funded by National Recovery Plan - MUR
- Project duration: 1 Nov 2022-30 Jun 2026
- Planned operation: at least 10 years



ITINERIS aims to enhance digital automation of Italian research vessels and improve sensors, infrastructures, data flows, data storage and FAIR data availability

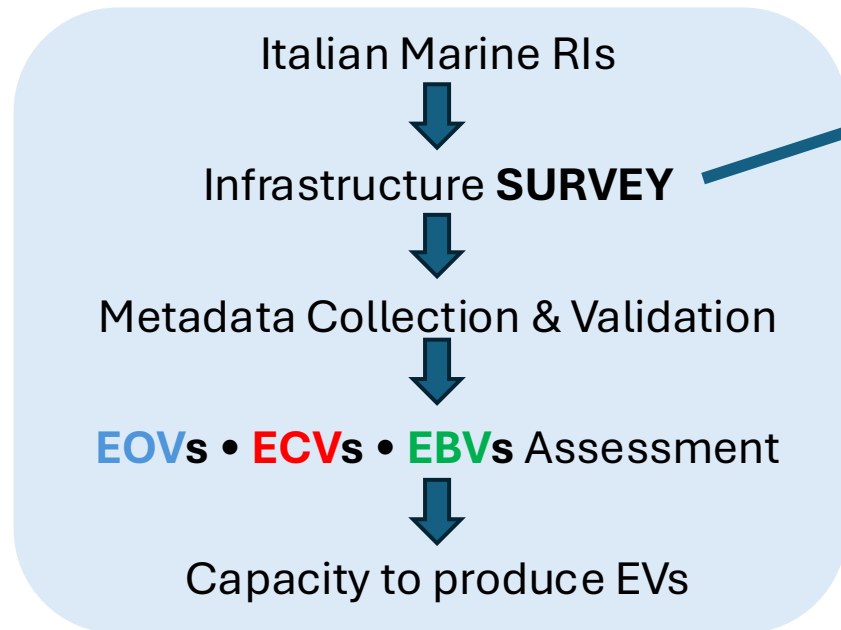


IT-IOOS the *Italian Integrated Ocean Observing System*



Essential Variables Already Observed?

- What is already being observed?
- Which Essential Variables can be produced?
- How mature is the observing system?



METHOD

2023 survey of marine RI facility managers

- Metadata collected on:
 - Observed variables
 - Instruments and sensors characteristics
 - Measurement quality
 - Spatial and temporal coverage
 - Observation continuity
- Validation against EV frameworks



Considered RIs and EVs

The analysis focused only on **EVs** potentially produced by ITINERIS marine **RIs** and observing facilities, rather than all RIs/EVs defined by **ECV**, **EOV** and **EBV** frameworks



54 EVs



8 RIs



Research infrastructure (RI)	Type of RI	Scope	Number of facilities	Type of facilities involved in this study	Contribution
DANUBIUS-ERIC	ESFRI Project	River-Sea Systems of major European rivers	10	Multidisciplinary observatories on rivers, deltas and coasts	Understanding of River-Sea interactions and processes
EMSO ERIC	ESFRI Landmark	Deep sea and water column	15	Multidisciplinary seafloor cabled observatories, moorings and buoys	Bio-geophysical, oceanographic and chemical data to monitor climate change on the ocean system
Euro-Argo ERIC	ESFRI Landmark	Open Ocean profiling	44	Autonomous Argo floats	Profiles for climate and oceanographic research
ICOS ERIC	ESFRI Landmark	Greenhouse gases and carbon cycle	5	Atmospheric, ecosystemic, and oceanic stations	High-quality carbon and greenhouse gases data for climate change
eLTER RI	ESFRI Project	Ecosystem and Socio- Ecological Long-Term Research	16	Coastal and transitional research sites	Long-term ecological monitoring of transitional and coastal ecosystems
JERICO	Applied to the 2026 ESFRI Roadmap	Costal Marine Systems	25	Fixed platforms, Lagrangian buoys and drifters, HF radars, gliders, multiparametric buoys, tide gauges, ferry boxes, coastal benthic observations, calibration facilities for coastal observations	Multiplatform approach for high-resolution coastal oceanography
GeoSciences Project	National Research Infrastructure	Earth systems and coastal dynamics	51	Tide gauges, wave buoys, meteorological sensors, research vessels	Observational networks for oceanographic, atmospheric, and seismic data
LNS Italian National Facility	National Research Infrastructure	Deep-sea physics, acoustic and astrophysics	6	Cabled observatories, acoustic and optical sensors	Provide accesses to advanced research laboratories and seafloor observatories

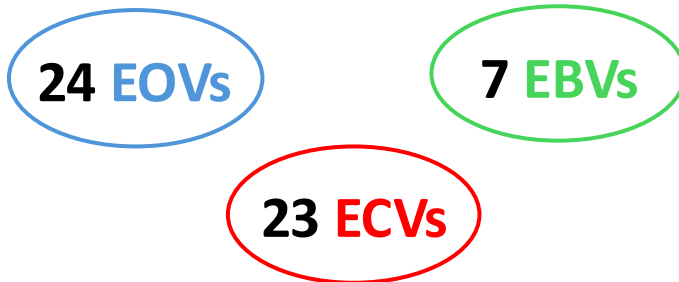
EV	GROUP/CLASS	SUBGROUP/SUBCLASS	VARIABLE
EOV - Essential Ocean Variables	Physics	Physics	Ocean bottom pressure
			Ocean surface heat flux
			Ocean surface stress
			Sea state
			Sea surface salinity
			Sea surface temperature
			Subsurface currents
			Subsurface salinity
			Subsurface temperature
			Surface currents
	Biology and Ecosystems	Biology and Ecosystems	Fish Abundance and Distribution
			Invertebrate Abundance and Distribution (*emerging)
			Macroalgal Canopy Cover and Composition
			Microbe Biomass and Diversity (*emerging)
			Phytoplankton Biomass and Diversity
ECV - Essential Climate Variables	Biochemistry	Biochemistry	Zooplankton Biomass and Diversity
			Nitrous oxide
			Oxygen
			Transient tracers
			Inorganic carbon
	Cross-Disciplinary	Cross-Disciplinary	Dissolved Organic Carbon
			Particulate Matter
			Ocean colour
			Ocean Sound
			Air Pressure (near surface)
	Atmosphere	Atmosphere Surface	Air Temperature (near surface)
			Precipitation
			Surface Radiation Budget
			Surface Water Vapour
			Surface Wind Speed and Direction
EBV - Essential Biodiversity Variables	Atmospheric Composition	Atmospheric Composition	Carbon Dioxide, Methane & Other Greenhouse Gases
			Inorganic Carbon
	Biogeochemical	Biogeochemical	Nutrients
			Oxygen
			Transient Tracers
	Biological/Ecosystems	Biological/Ecosystems	Ocean Colour
			Marine Habitats
	Ocean	Physical	Ocean Surface Heat Flux
			Sea Level
			Sea State
			Sea Surface Currents
			Sea Surface Salinity
			Sea Surface Stress
			Sea Surface Temperature
			Subsurface Currents
			Subsurface Salinity
			Subsurface Temperature
EBV - Essential Biodiversity Variables	Species Populations	Species Populations	Species distributions of benthic marine invertebrates
			Species distributions of invasive alien marine taxa of European concern
			Species distributions of marine fishes
	Ecosystem Function/Structure	Ecosystem Function	Marine primary productivity
			Phenology of marine spring phytoplankton bloom
EBV - Essential Biodiversity Variables	Community Composition	Community Composition	Ecosystem distribution of marine macroalgae canopy cover
			Functional diversity of marine phyto/zooplankton (based on traits)

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These EVs are those actually reported as produced by the participating facilities:



54 EVs

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≠ SCOPE AND CONTRIBUTIONS

≠ FACILITIES OBSERVATIONS PARAMETERS

Facilities Map

**155
FACILITIES**

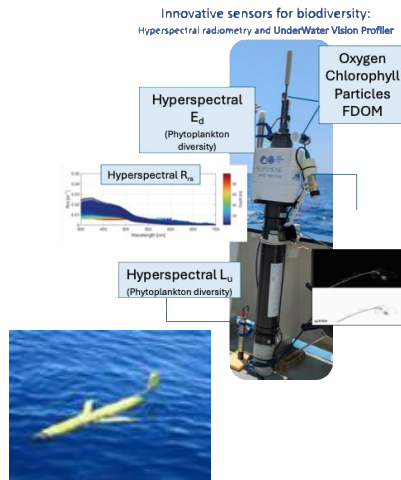
≈ 70%

**108
FIXED
PLATFORMS**



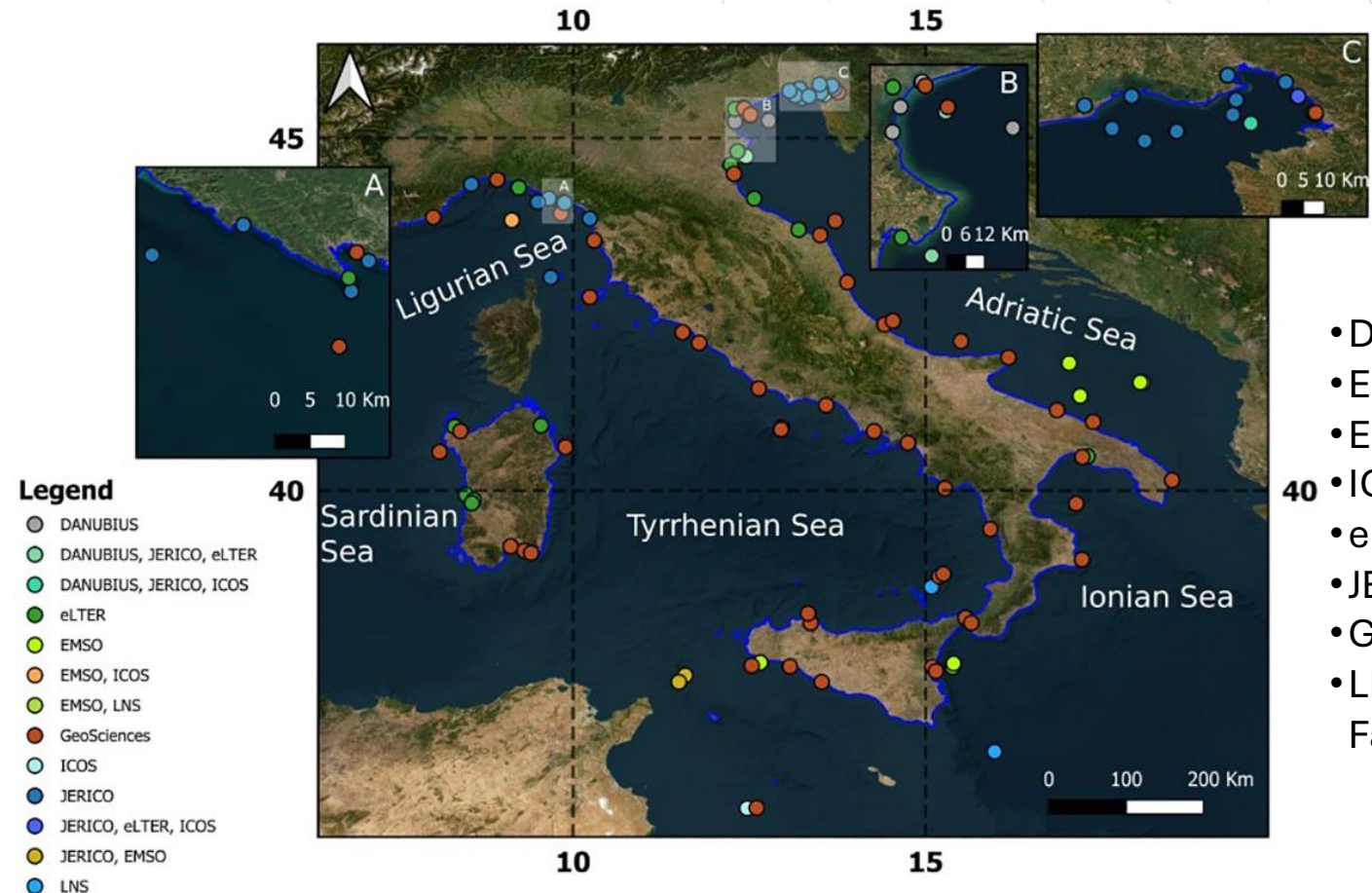
≈ 30%

**47
MOBILE
PLATFORMS**



GEOGRAPHIC DISTRIBUTION OF FACILITIES

(fixed stations, platforms, moorings, etc.)



8 RIs

- DANUBIUS-ERIC
- EMSO ERIC
- Euro-Argo ERIC
- ICOS ERIC
- eLTER RI
- JERICO
- GeoSciences
- LNS National Facility

Quantification of Observational Effort

EVs PER FACILITY

→ each EV counted once per facility

1299 EVs 510 EOVS 753 ECVs 36 EBVs

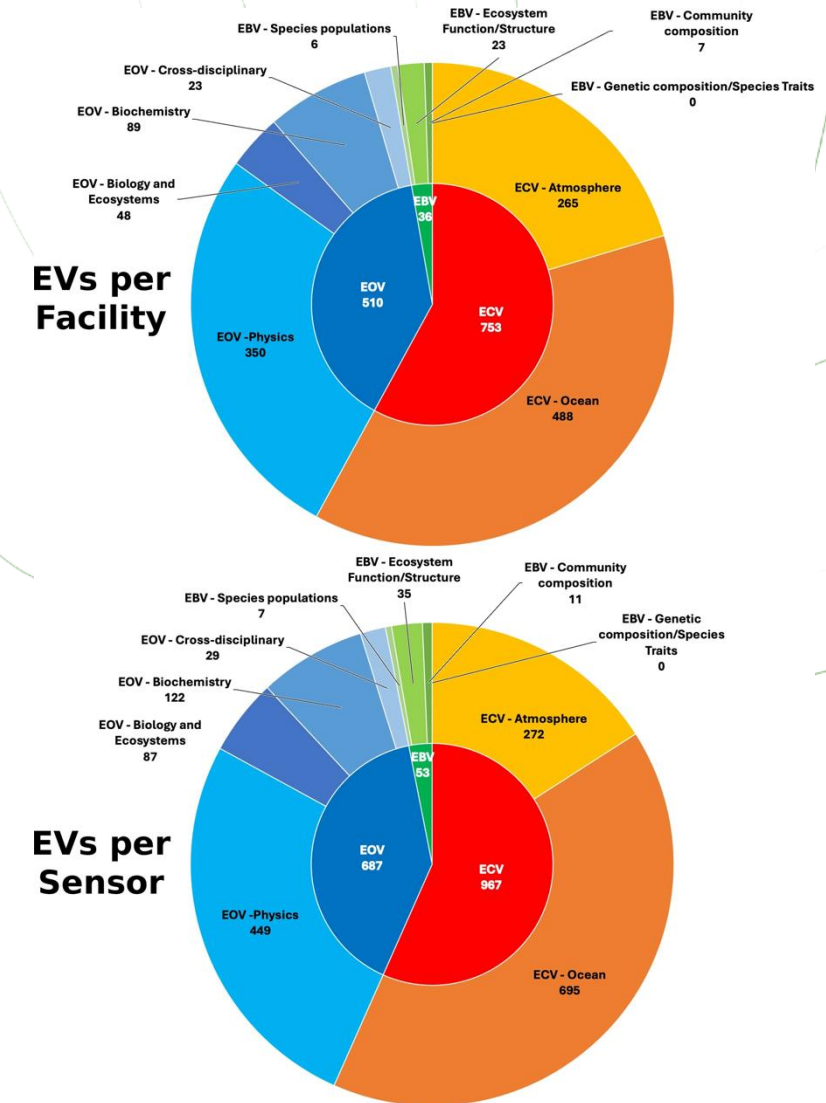
EVs PER SENSOR

→ multiple observations counted when measured at different depths or by different sensors

1707 EVs 687 EOVS 967 ECVs 53 EBVs

“Per facility tells us breadth. Per sensor tells us intensity.”

→ >90% of entries were classified as CORE: 1550 out of 1707



Quantification of Observational Effort

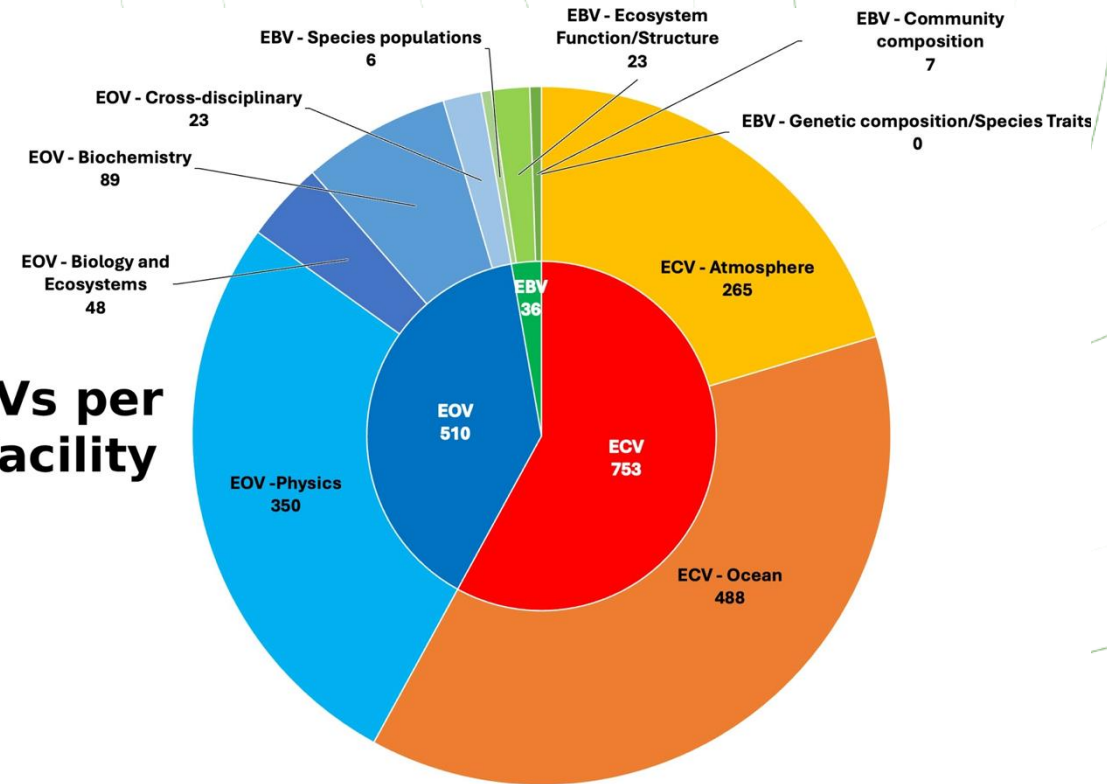
STRONG OCEAN AND CLIMATE MONITORING CAPACITY

- **EOVs** / **ECVs** dominate the observing system
- Key variables: temperature, salinity, oxygen, sea level
- Reflects long-term investment in operational oceanography and climate monitoring

BIODIVERSITY IS A GAP

- **EBVs** are a small fraction of observations
- Biological monitoring is less standardized/automated
- Many observations rely on field sampling and lab analyses

EVs per Facility



Physical variables → Automated sensors → Continuous observation → many EVs

Biological variables → Manual analyses → lower frequency observations → fewer EVs

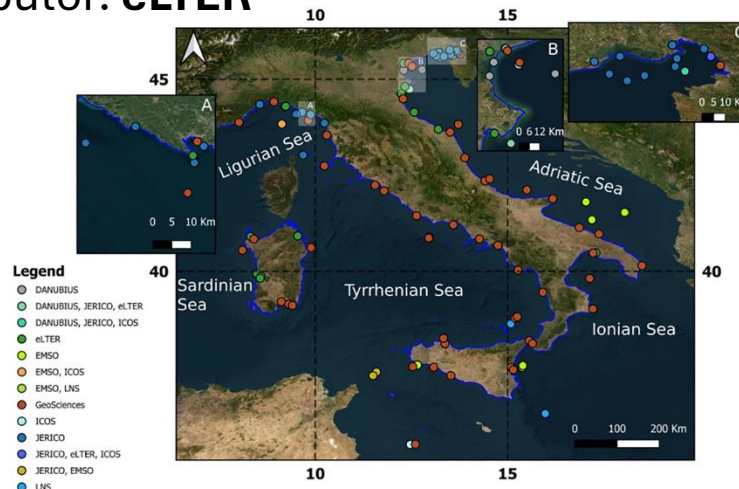
Marine EVs across RIs: who produces what?

MARINE OBSERVING SYSTEM

→ NOT a single homogeneous network

→ BUT a complementary ecosystem of RIs with distinct observational roles

- Largest **EOV** contributions: **Euro-Argo**, **eLTER**, **JERICO**
- Largest **ECV** contributions: **GeoSciences**
- Key biogeochemical and carbon-cycle observations: **EMSO**, **DANUBIUS**, **ICOS**
- Main **EBV** contributor: **eLTER**



EVs	DANUBIUS (10)	EMSO (15)	Euro-Argo (44)	ICOS (5)	eLTER (16)	JERICO (25)	GeoSciences (51)	LNS (6)	Total
EOV - Physics	15	32	145	12	44	52	50	0	350
EOV - Biology and Ecosystems	6	2	11	2	22	5	0	0	48
EOV - Biochemistry/ Biogeochemistry	7	9	26	6	28	13	0	0	89
EOV - Cross-disciplinary	3	6	4	1	3	0	0	6	23
ECV - Atmosphere	14	10	0	12	26	34	169	0	265
ECV - Ocean	26	36	166	20	73	72	86	0	479
ECV - Cross-disciplinary	2	0	4	1	2	0	0	0	9
EBV - Species populations	1	0	0	0	5	0	0	0	6
EBV - Ecosystem Function/ Structure	5	1	2	1	9	5	0	0	23
EBV - Community composition	2	0	1	0	3	1	0	0	7
EOV	31	49	186	21	97	70	50	6	510
ECV	42	46	170	33	101	106	255	0	753
EBV	8	1	3	1	17	6	0	0	36
Total	81	96	359	55	215	182	305	6	1.299

1299 EVS PER FACILITY:

- Euro-Argo: 359
- eLTER: 215
- GeoSciences: 305
- JERICO: 182

Marine EVs across RIs

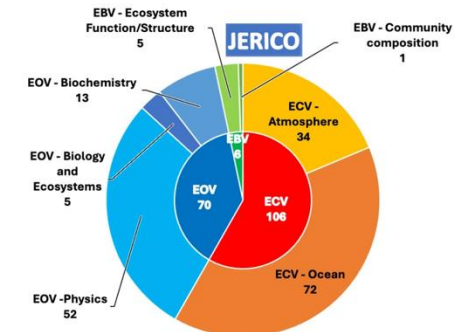
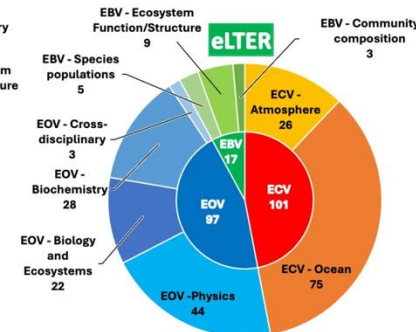
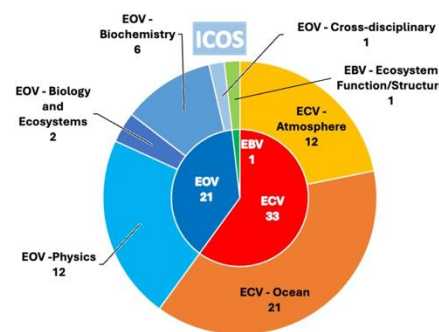
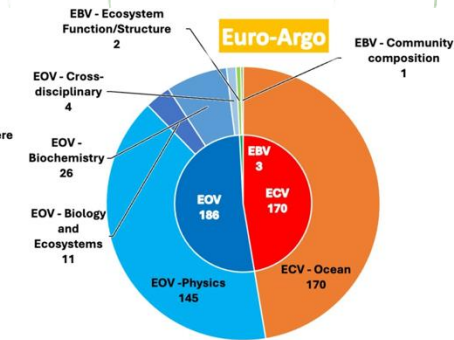
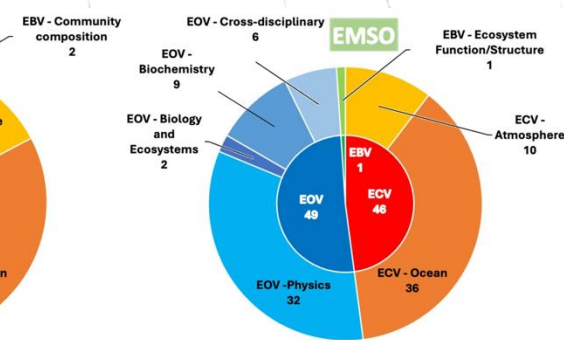
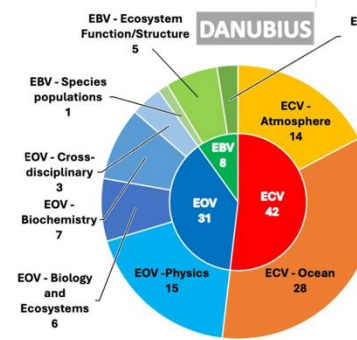
Specialized and multidisciplinary RIs together
provide an integrated observing capacity

SPECIALIZED RIs

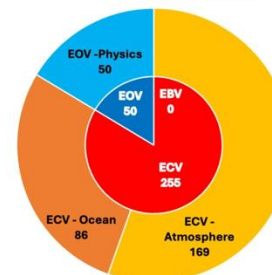
- **Euro-Argo** → open-ocean physical and biogeochemical profiles
- **EMSO** → deep-sea and water-column observations
- **ICOS** → greenhouse gases and air-sea carbon fluxes
 - **GeoSciences** → national sea-level, wave and atmospheric coverage
- **LNS** → focused on cross-disciplinary deep-sea observations

MULTIDISCIPLINARY RIs

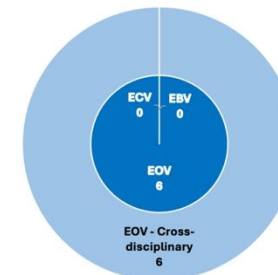
- **eLTER** → ecological and biodiversity monitoring
- **JERICO** → coastal ocean observing systems
- **DANUBIUS** → river-sea and transitional environments



GeoSciences



LNS



Depth through
specialization,
integration through
multidisciplinary

From measured parameters to EVs: CORE vs SUPPORTING

Survey metadata from RI/facility managers

- Observed variable
- Instrument / sensor characteristics
- Accuracy and resolution
- Depth range and spatial-temporal coverage
- Continuity of observations
- Data information

Checked against EV framework requirements

GOOS → **EOVs**
GCOS → **ECVs**
GEO BON → **EBVs**



e.g. **EOV**

2022 GCOS ECVs Requirements, updated in 2025

4. PHYSICS

4.1 ECV: Sea-Surface Temperature

4.1.1 ECV Product: Sea-Surface Temperature

e.g. ECV

Name	Sea surface temperature				
Definition	Radiative skin sea surface temperature, or Bulk sea surface temperature at stated depth				
Unit	Kelvin (K)				
Note	The "bulk" temperature refers to the depth of typically 2 m, the "skin" temperature refers to within the upper 1 mm.				
Requirements					
Item needed	Unit	Metric	[1]	Value	Notes
Horizontal Resolution	km	length	G	5	
			B	100	
			T		
Vertical Resolution			G	-	N/A
			B	-	
			T	-	
Temporal Resolution	d	time	G	1/24	In situ measurements, daily in the case of satellite measurements
			B		
			T	7	
Timeliness	h	time	G	3	
			B		
			T	24	
Required Measurement Uncertainty (2-sigma)	K		G	0.05	Over 100 km scale
			B		
			T	0.3	Over 100 km scale
Stability	K/decade		G	0.01	Over 100 km scale
			B		
			T	0.1	Over 100 km scale
Standards and References	Johnson et al (2015): Informing Deep Argo Array Design Using Argo and Full-Depth Hydrographic Section Data; https://journals.ametsoc.org/doi/full/10.1175/JTECH-D-15-0139.1 ; 5 x 5 degree array proposed with 15-day repeat cycle. Estimated reduction of sub-2000 m OHC error in decadal trends from +/- 17 TW to +/- 3TW. Desbruyeres et al (2017): Global and Full-Depth Ocean Temperature Trends during the Early Twenty-First Century from Argo and Repeat Hydrography; https://journals.ametsoc.org/doi/full/10.1175/JCLI-D-16-0396.1 ; "Estimate of global ocean heat uptake of 0.71 ± 0.09 W m–2 during 2006-2014 with < 2000m layer accounting for 90% of the observed change." Rayner (2017) User Requirements Document, SST_CCI-URD-UKMO-201, ESA. 2 https://climate.esa.int/media/documents/SST_CCI-URD-UKMO-201-Issue_2.1-signed.pdf Merchant, C.J., Embury, O., Bulgin, C.E. et al. Satellite-based time-series of sea- surface temperature since 1981 for climate applications. Sci Data 6, 223 (2019). https://doi.org/10.1038/s41597-019-0236-x				

Meets EV requirements?



Yes



CORE



No



SUPPORTING

Requirements Settings				
Responsible GCOS/GOOS Panel Reporting Mechanism	OOPC Reporting through GCOS to UNFCCC Technical Reporting through CEOS SST-VC, GHRST and ICOADS			
Readiness Level ⁵	Mature			
Phenomena to capture.	Air-Sea Fluxes	Fronts and eddies	Coastal Shelf Exchange Processes	Upwelling
Temporal Scales of the Phenomena	daily	weekly	> hourly	weekly
Spatial Scales of the Phenomena (order)	100km	10km	1km	10km
Magnitudes/range of the signal, thresholds to capture for the				

Gaps in EV production: CORE vs SUPPORTING

CORE vs SUPPORTING highlights quality gaps

CORE vs SUPPORTING reveals maturity differences:

- **Strong maturity**

>90% **CORE** observations mature physical and climate monitoring

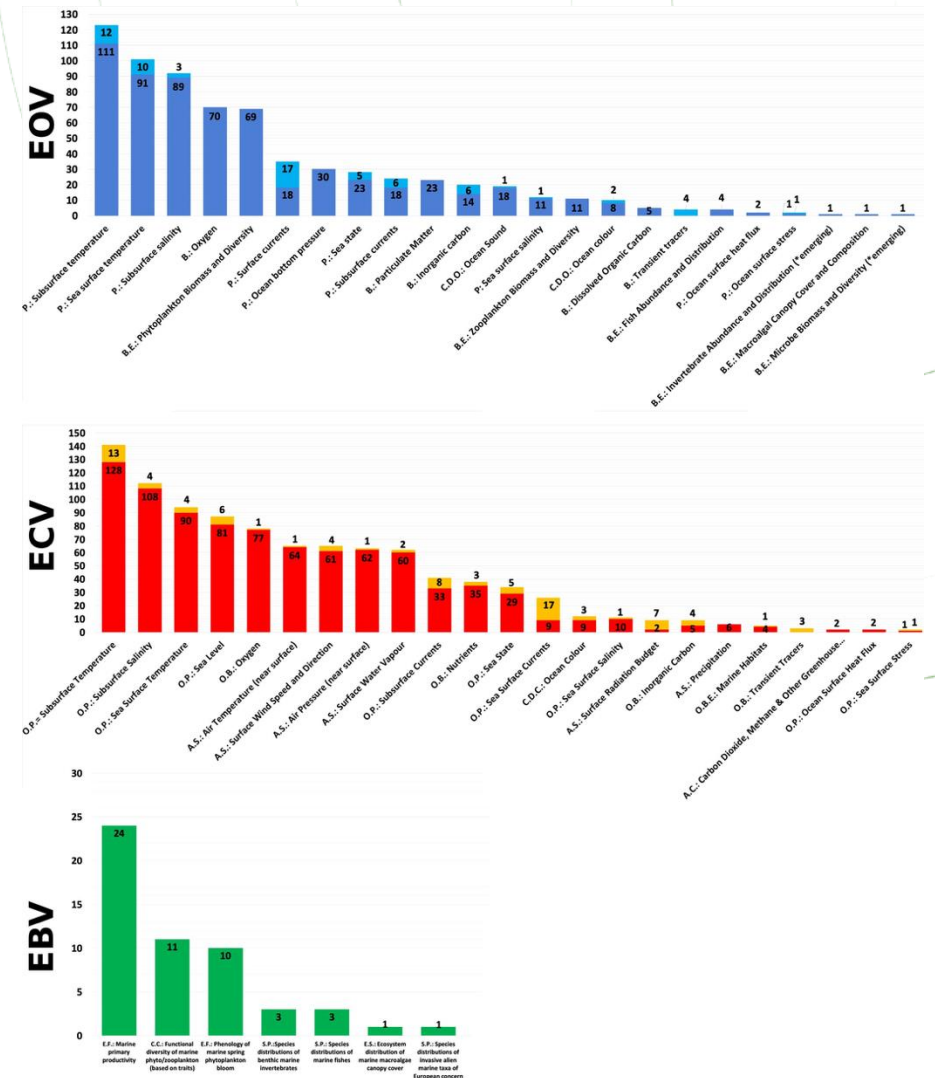
- **Hidden quality gaps**

SUPPORTING values reveal limits in:
accuracy - time resolution

- **Uneven maturity across domains**

EOVs / ECVs → abundant and mature

EBVs → compliant but few and less diverse



ITINERIS impact on the observatory

2023 Baseline

Existing observing capacity



ITINERIS implementation

- New instruments, sensors and upgraded observing facilities
- Improved data flows and FAIR data availability
 - RI integration through IT-IOOS
 - EV baseline and quality assessment



2026 Expected Capacity

Higher EV production and improved interoperability

Expected increase in EV production

 +38–40% overall

Preliminary estimates*:

+30% **EOV** data streams

+50% **ECV** data streams

+40% **EBV** data streams

*not yet fully validated

ITINERIS moves the system from “many observations” to a more interoperable observing portfolio

Fixed stations + Moorings + Argo floats +

Gliders + Research vessels + Coastal

platforms + Tide gauges

=

**INTEGRATED OBSERVING
PORTFOLIO**

Conclusions

EMB Policy Brief challenge

- ✓ European ocean observing remains fragmented across: funding, mandates, platforms and data flows
- ✓ Stronger coordination, clearer responsibilities and sustained investment are needed

ITINERIS long-term challenge

- From project
- to infrastructure
 - to sustained national observing governance

KEY MESSAGES

- Italy already has a strong marine observing capacity, especially for physical and climate variables (and >90% observations satisfy EV requirements)
- The main challenge is not infrastructure, but **coordination**, interoperability and long-term sustainability
- Biodiversity and ecosystem observations remain major gap and require innovation and automation
- **Essential Variables** provide a common framework linking observations, data quality and policy needs
- **IT-IOOS** should act as the long-term national coordination and Single Access Point for high-quality, FAIR marine datasets



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e di Geofisica
Sperimentale



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Istituto Superiore per la Protezione
e la Ricerca Ambientale



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3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures"



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