

EMSO ERIC

Development of a Strategic
Plan for a pan-European
Distributed Research
Infrastructure

OBSERVING THE OCEAN TO SAVE THE EARTH

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REGIONAL FACILITIES AND TEST SITES

8 Regional Facilities and 3 Test sites located at strategic sites from the North Atlantic through the Mediterranean, to the Black Sea

2nd ERIC Forum

EMSO (European Multidisciplinary Seafloor and Water-column Observatory) is a strategic Marine European Research Infrastructure Consortium (ERIC), with the capacity to collect high quality environmental parameters

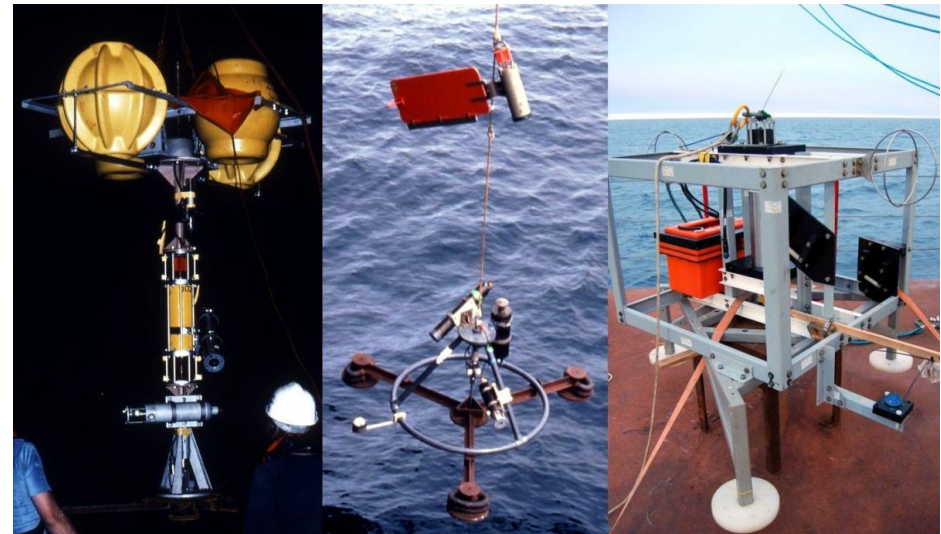


EMSO RF: Porcupine Abyssal Plain (PAP)

The Porcupine Abyssal Plain Sustained Observatory (PAP-SO) is a **sustained, multidisciplinary observatory** in the **North Atlantic**

Distance from land: 300 miles
Max water depth: 4850 m
Date 1st deployment:
Supported by: United Kingdom

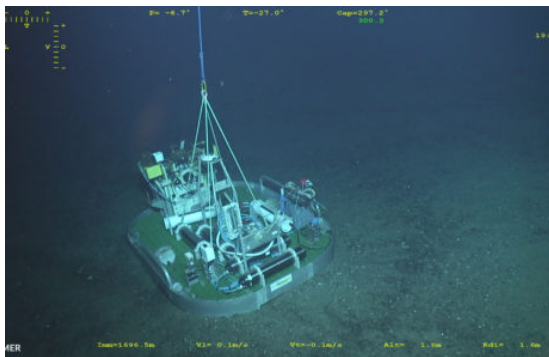
This site has been studied for over 30 years. It is positioned between the North Atlantic current and the Azores Currents and it is crossed by clockwise and anticlockwise swirls and eddies. Its seabed hosts a rich living community, that is sampled and photographed.



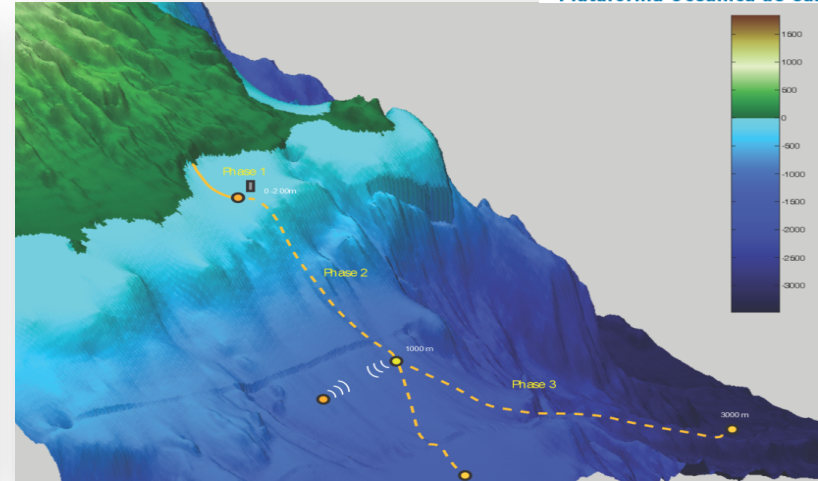
EMSO RF: Azores

Set atop an active volcano, **the Lucky Strike**, and its hydrothermal field, EMSO-Azores observatory gives unique research opportunities. The hydrothermal vent, which is a fissure in Earth's surface from which hot water come out, can be investigated with a multidisciplinary approach. The **hosted peculiar fauna and microbial communities**, the water composition and circulation are studied. Being at the Mid-Atlantic ridge, where tectonic plates diverge, the site allow to study closely tectonic and volcanic activities.

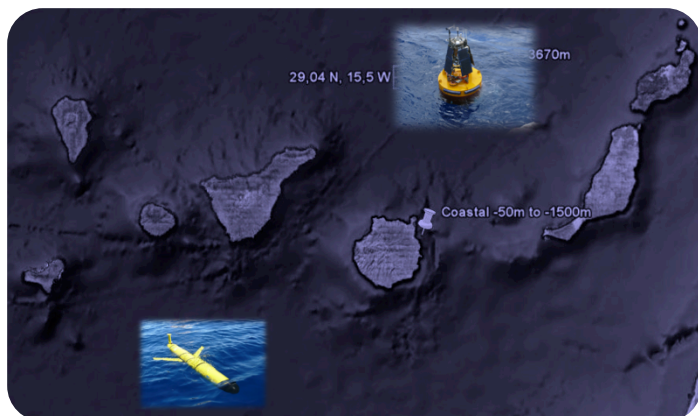
Location: Mid-Atlantic ridge near Azores
Distance from land: 200 NM
Max water depth: 1700 m
Date 1st deployment: October 2010
Supported by: France



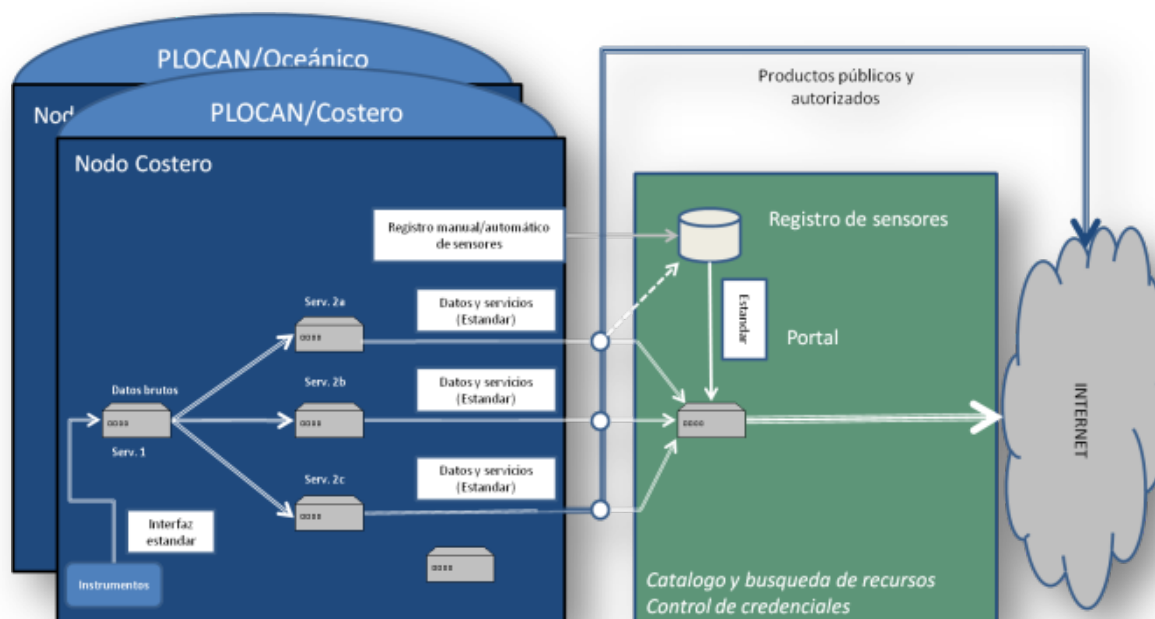
EMSO RF: Canary Islands.-PLOCAN



ESTOC-PLOCAN Open-ocean surface, within an Intraplate active volcanism
Coastal Observatory (optical fiber cable down to 100 m, 4km offshore, for deeper water is planned)
Mobile Observatory (3 gliders operating around regional station, down to 1500 m depth)



Canary Is.-PLOCAN



PLOCAN OBSERVATORY CSIC- Infrastructure support

A RV Sarmiento de Gamboa well equipped and experienced in seafloor operations with deep-sea ROVS, cable deployment, and other tools and equipment.

A pool of up to 17 OBS for acoustic/seismic surveillance, volcanic instabilities or massive slides (geo-hazards)

CI: Service Oriented, **INSPIRE Directive** and **GEOSS Guidelines**



EMSO RF: Iberian Margin

The area of Cadiz is very important for geo-hazards. It was the site where one of the worst earthquakes that hit Europe occurred in 1755, coupled with a destructive tsunami. Here African and European tectonic plates converge. It is a seismic a volcanic region. It is also the site to investigate the flow that from Mediterranean move into the Atlantic and affects the deep-water circulation on global scale. The geologic and oceanographic features of this region favour the presence of highly diverse benthic communities and have also a central role in the distribution of several marine mammals and fish species.

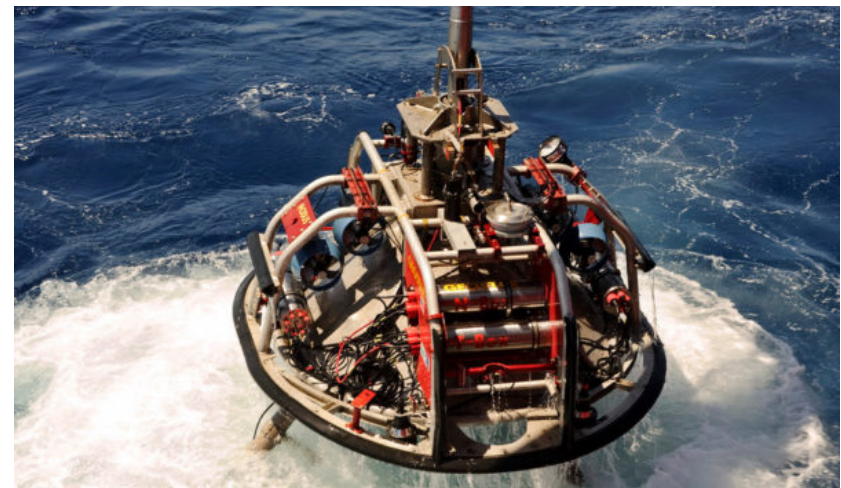
Location: Gulf of Cadiz

Distance from land: 60 NM

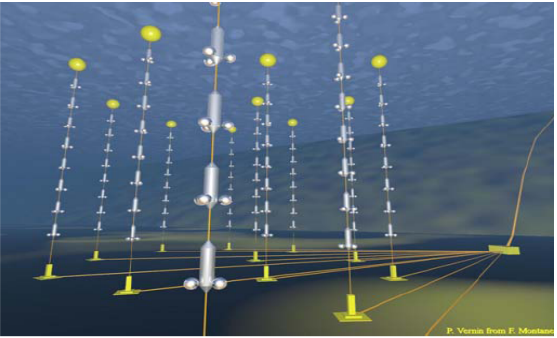
Max water depth: 3200 m

Date 1st deployment: October 2010

Supported by: Portugal2008



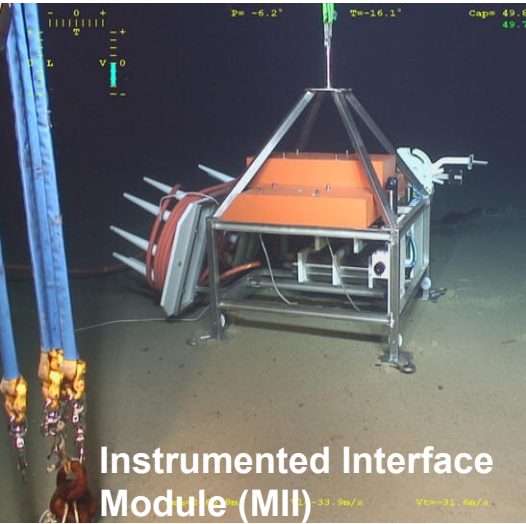
EMSO RF: Ligurian Sea



ANTARES



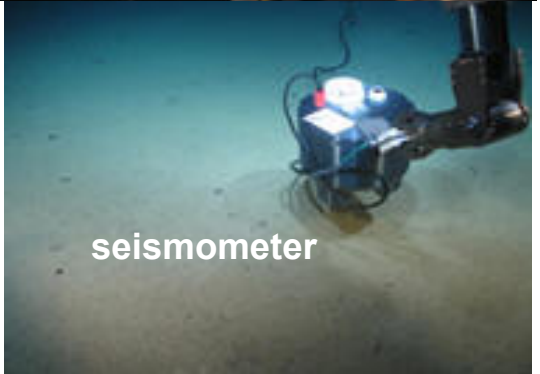
ANTARES
Astronomy Neutrino Telescope Abyss RESEARCH
infrastructure



Instrumented Interface Module (IMI)



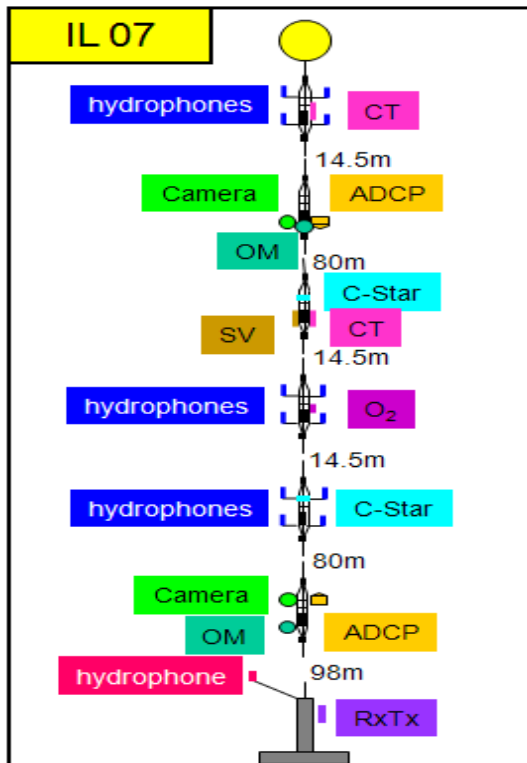
secondary junction box (SJB)



seismometer

- Seismology module
- CTD
- Oxygen sensor
- Turbidity sensor
- ADCP
- Absolute pressure sensor
- Optical camera

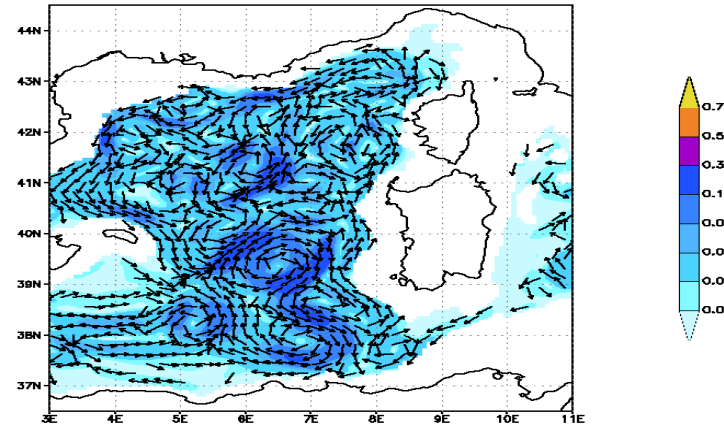
EMSO RF Ligurian Sea



-  **Bioluminescence**
-  **Environmental Monitoring**
-  **Seismology**
-  **Oceanography (Med Sea Circulation)**



velocity [m/s] - date 070129 depth 1000 m



The deepest Infra-red camera in the sea



EMSO nodes: Western Ionian Sea

INFRASTRUCTURE NEMO-SN1 seafloor observatory, cabled to laboratory in the harbour of Catania by electro-optical cable

OPERATING IN REAL TIME SINCE 2005 Integrated with land-based networks by transmitting real-time data to National Seismological Service Centre in Rome; Test site for realisation of the underwater neutrino telescope

RESEARCH Geohazards, tsunami, climate change, bioacoustics and ambient noise.

PREVIOUS/RECENT ACTIVITIES LAMS and SIRENA FESR projects (national). GNDT-SN1 (national). PEGASO project (Structural funds). ESONET demo missions (LIDO, Listening to the Deep Ocean environment). GENESI-DEC, SCIDIP-ES (FP7 infrastructures), KM3NET, TRANSFER

Stand-alone 2002-2003 - Cabled 2005-2008 & 2012-2013 real-time data

WESTERN IONIAN SEA

Geo-hazards

(earthquakes, tsunamis, volcanic activity)

Bio-acoustics

(mammal tracking)

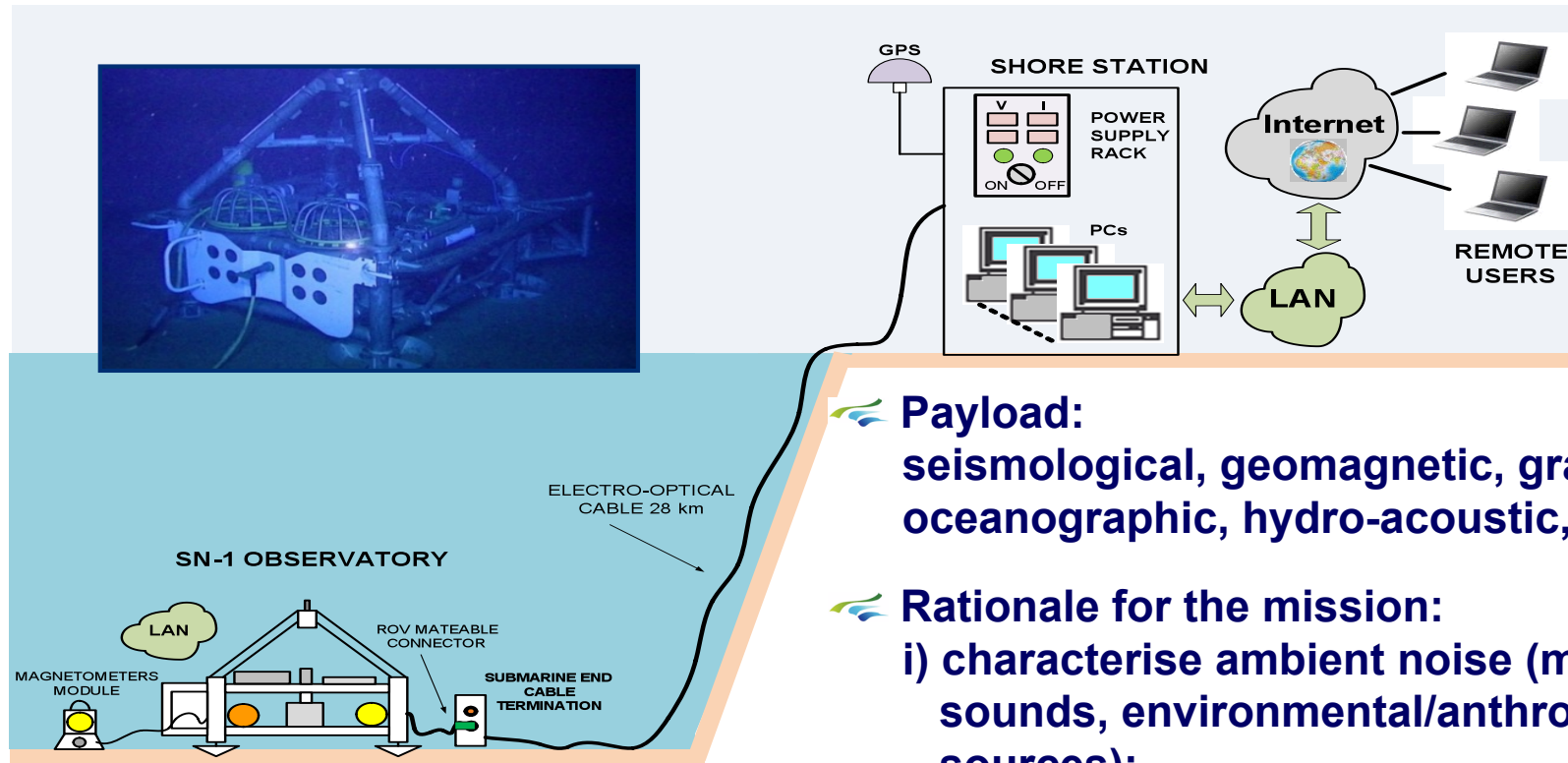
Oceanography

(e.g., deep water circulation, current intensity and direction, temperature, salinity)



NEMO-SN1 concept

Western Ionian Sea



➤ **Payload:**
seismological, geomagnetic, gravimetric,
oceanographic, hydro-acoustic, bio-acoustic

➤ **Rationale for the mission:**
i) characterise ambient noise (marine mammal sounds, environmental/anthropogenic sources);
ii) study earthquake and tsunami generation in Western Ionian Sea

➤ **Detection algorithm runs in the Shore Station**

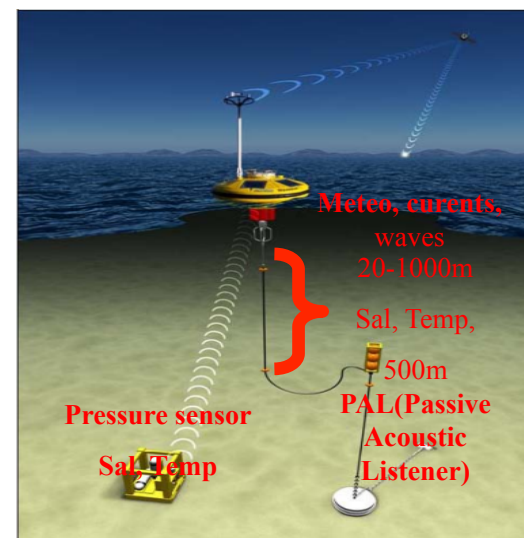
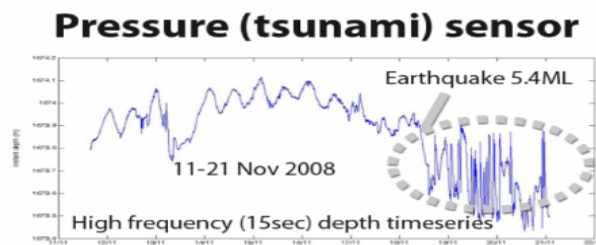
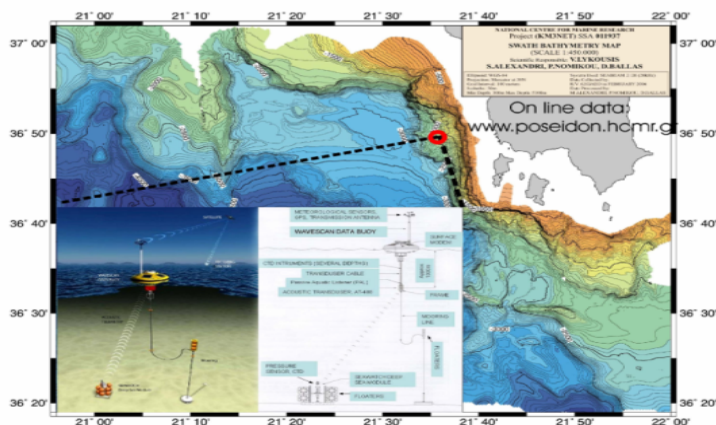


Istituto Nazionale di
Geofisica e Vulcanologia



tecnomare

EMSO nodes: Hellenic Arc



- 1650m depth
- 15 km fiber optic Cable connection to Methoni town
- Real-time data transmission
- Implementation 2012-15
- Initial budget for construction 3.7 M€

INFRASTRUCTURE Cabled system **NESTOR**, Stand alone **Poseidon Pylos** and **Poseidon E1-M3A** (35°06'N, 24°09'E), Proposed drilled observatory **BUTT**

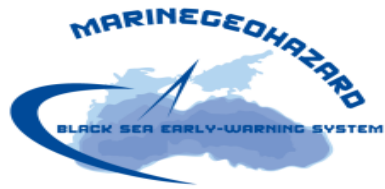
RESEARCH Geohazards, tsunami, climate change, bioacoustics and ambient noise, biogeochemical fluxes, benthic-pelagic interactions; benthic respiration; biogeochemical fluxes; photography-based ecology; seabed methane fluxes; oil and gas industry activities

PREVIOUS/RECENT ACTIVITIES EuroSITES, IODP, HERMES-HERMIONE, SEAHELLARC, TRANSFER, KM3NET
Continuity of stand-alone observatory over to 2014.

FUTURE ACTIVITIES Implementation of a new cabled observatory within the frame of EMSO (EMSO-Hellenic) near Poseidon-Pylos site (about 15km from shore and in 1600m depth) with equipment according to ESONET standards. Project funded by the Greek government (EMSO contribution).
Estimated budget 3.7MEuro (2012-2015).

HELLENIC ARC

EMSO nodes: Black Sea



Images from shallow-waters tests – Courtesy by INGV



alization, and
Phys. Geogr.,

DISTRIBUTED ORGANISATION MODE

EMSO ERIC provides harmonized integration, operation and development of Regional Facilities



It will increase visibility, capacity and research, supported by a distributed strategy, offering integrated services to a broad range of users

The logo graphic consists of three stylized, overlapping wave-like shapes. The top shape is green, the middle one is light blue, and the bottom one is a darker blue. They are positioned to the right of the 'emso' text.

emso

ERIC

EUROPEAN RESEARCH INFRASTRUCTURE CONSORTIUM

Observing the ocean to save the earth

Juanjo Dañobeitia ^(1,2), Paolo Favali ^(1,3), Laura Beranzoli ^(1,3), Mairi Best ^(3,4), Jérôme Blandin ⁽⁵⁾, Joaquin Hernandez-Brito ⁽⁶⁾, Mathilde Cannat ⁽⁷⁾, Andrew Gates ⁽⁸⁾, Maria I. Fredella ⁽¹⁾, Aleardo Furlani ⁽¹⁾, Paola Materia ^(1,3), George Petihakis ⁽⁹⁾, Henry Ruhl ⁽⁸⁾, and EMSO ERIC CMO Team cmo@emso-eu.org

MISSION



To establish a comprehensive and smart sensor system in water column, seafloor, and sub-seafloor environments as part of the integrated and sustainable organization EMSO ERIC

This distributed infrastructure provides HQ data and knowledge to illuminate major environmental processes to understand the complex interactions among the geosphere, biosphere and hydrosphere



RESEARCH CONSORTIUM

COUNTRY	REPRESENTING ENTITY
FRANCE	Ifremer L'Institut Français de Recherche pour l'Exploitation de la Mer CNRS Centre National de la Recherche Scientifique
GREECE	HCMR Hellenic Centre for Marine Research
IRELAND	MI Marine Institute
ITALY Host Country	INGV Istituto Nazionale di Geofisica e Vulcanologia
PORTUGAL	FCT Fundação para a Ciência e a Tecnologia
ROMANIA	GeoEcoMar National Research and Development Institute for Marine Geology and Geoecology
SPAIN	PLOCAN Plataforma Oceánica de Canarias
UK	NOC National Oceanography Centre





Landscape of the European Research Infrastructures in the Environmental sector

EMSO ERIC essential scientific objectives are to observe, in real time and in the long term, key environmental processes related to the interaction between the geosphere, the biosphere and the hydrosphere.

EMSO facilities require, in the medium and long term, constant technological interventions and enhancement; EMSO members are committed to ensure the assistance of European oceanographic vessels.

GLOBAL LANDSCAPE





Socioeconomic benefit of the Ocean Observatories

EMSO represents capacity to address Societal Benefits of Ocean observatories



Scope

Increasing demand of HQ data due improvements in technology, communications data storage, online information, etc.

Ocean data are valued

Science

- Constant Improving scientific understanding of the oceans;
- A Better understanding of the ecosystem benefits of the oceans;
- A better understanding of the role of the oceans in the overall earth system

Environmental policies

- Formulation of policies
- monitoring of policy compliance and effectiveness
- regulate ocean uses

Technology

- Testing and demonstration marine operations
- Sensor and platform development
- Massive data storage

Industry & Innovation

- support operational needs
- Consultancy & management, commercialization, partnerships, technology transfer
- met ocean information needs of commercial maritime activities and operations.

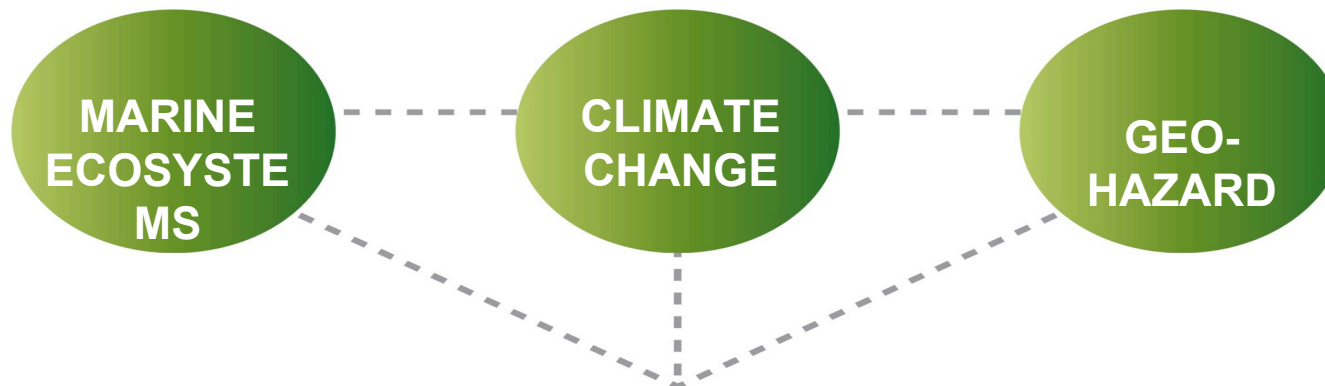
**WHY
OBSERVE
THE DEEP
SEA?**

Oceans play a crucial role in human wellbeing

- Degradation and loss of biodiversity impacts marine resource exploitation
- Ocean circulation affects climate change
- Natural hazards such as tsunamis from earthquakes and volcanic eruptions impacts human life

EMSO ERIC MISSION

Support investigations in:



TO ACHIEVE

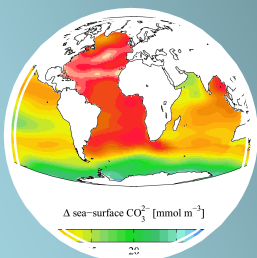
sustainable management and protection of marine resources

TO REACH

an efficient and reliable service of geo-hazard warning

Research Infrastructure Challenges

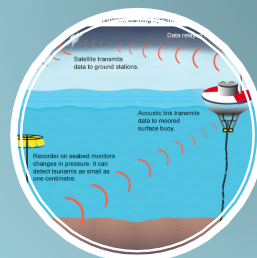
To fulfil European societal scientific demands targeted in the EU's H2020 Blue Growth Strategy



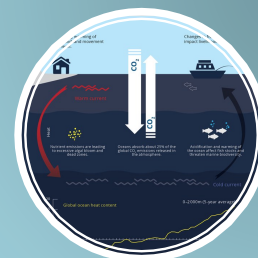
Global ocean warming and acidification



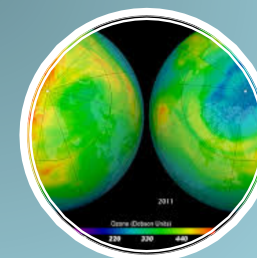
Impact and sustainability of Marine Resources exploitation



Real-time observations and early warning systems for earthquakes & tsunamis



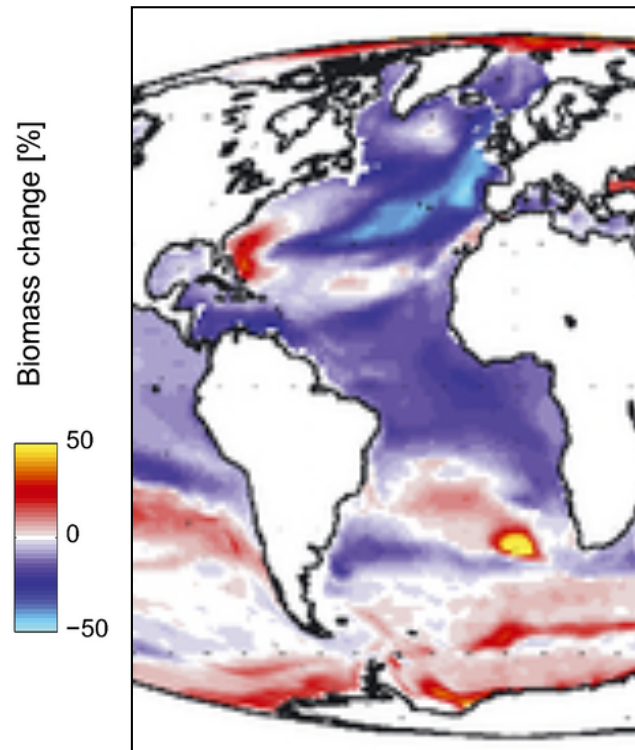
Marine Ecosystems and Climate Change mitigation



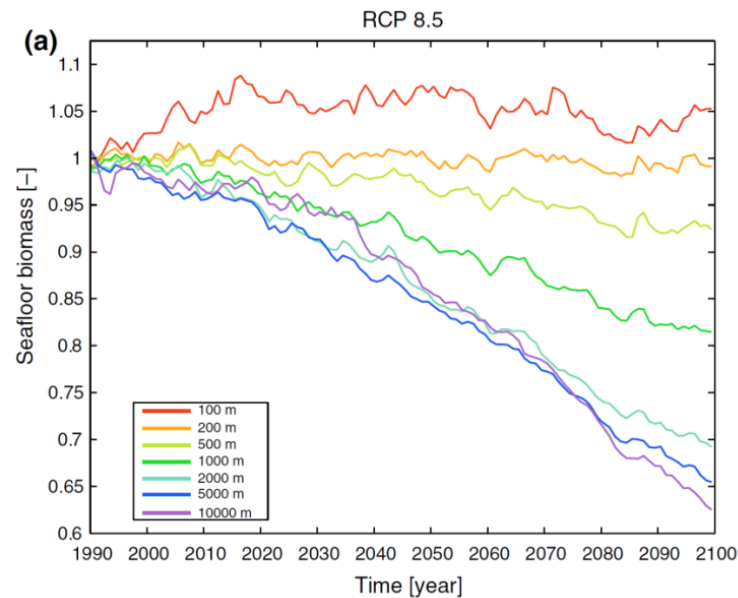
Earth interactions hydrosphere, biosphere, lithosphere, atmosphere

Access HIGH QUALITY MARINE ENVIRONMENTAL DATA

ECOSYSTEMS AND CLIMATE



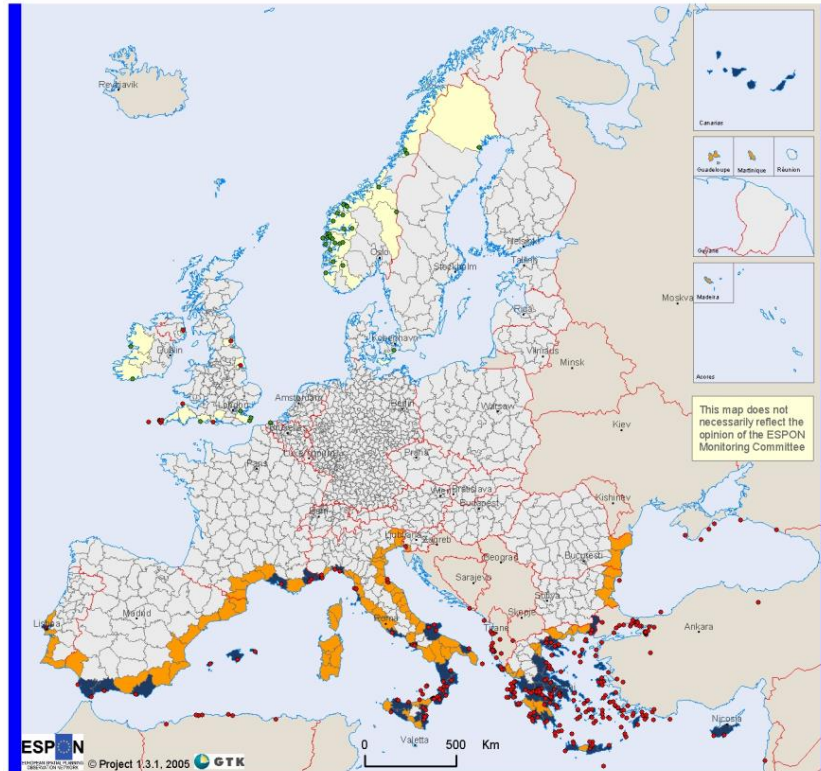
Jones et al. 2014 *Global Change Biology*



Yool et al. 2017, *Global Change Biology*

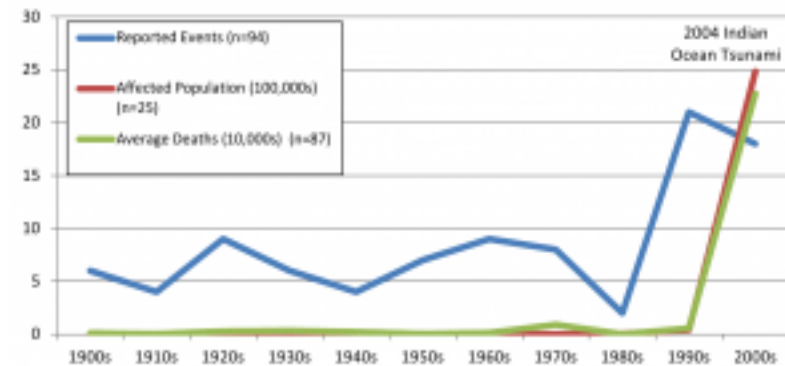
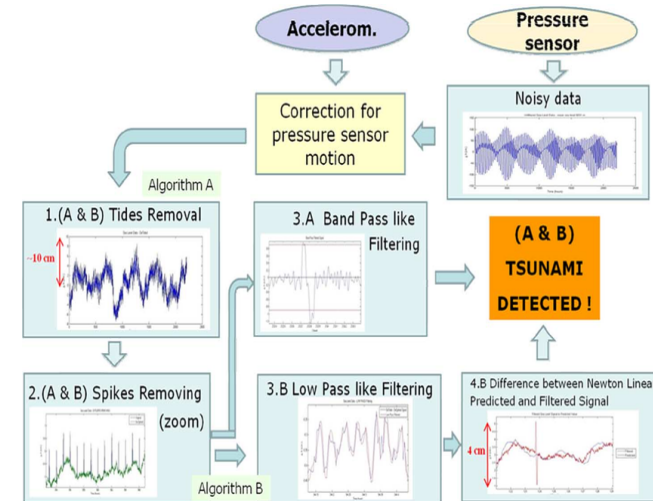
- Global warming is not just an environmental disaster but an economic one as well. “If we do nothing, if we do business as usual, by 2100 the median low income country will lose **9 per cent of its GDP**. (IMF Chief Economist [Maurice Obstfeld](#))
- Ocean acidification will cost the world economy more than \$1 trillion annually by 2100, according to the [U. Nations Convention on Biological Diversity](#)

GEO-HAZARDS

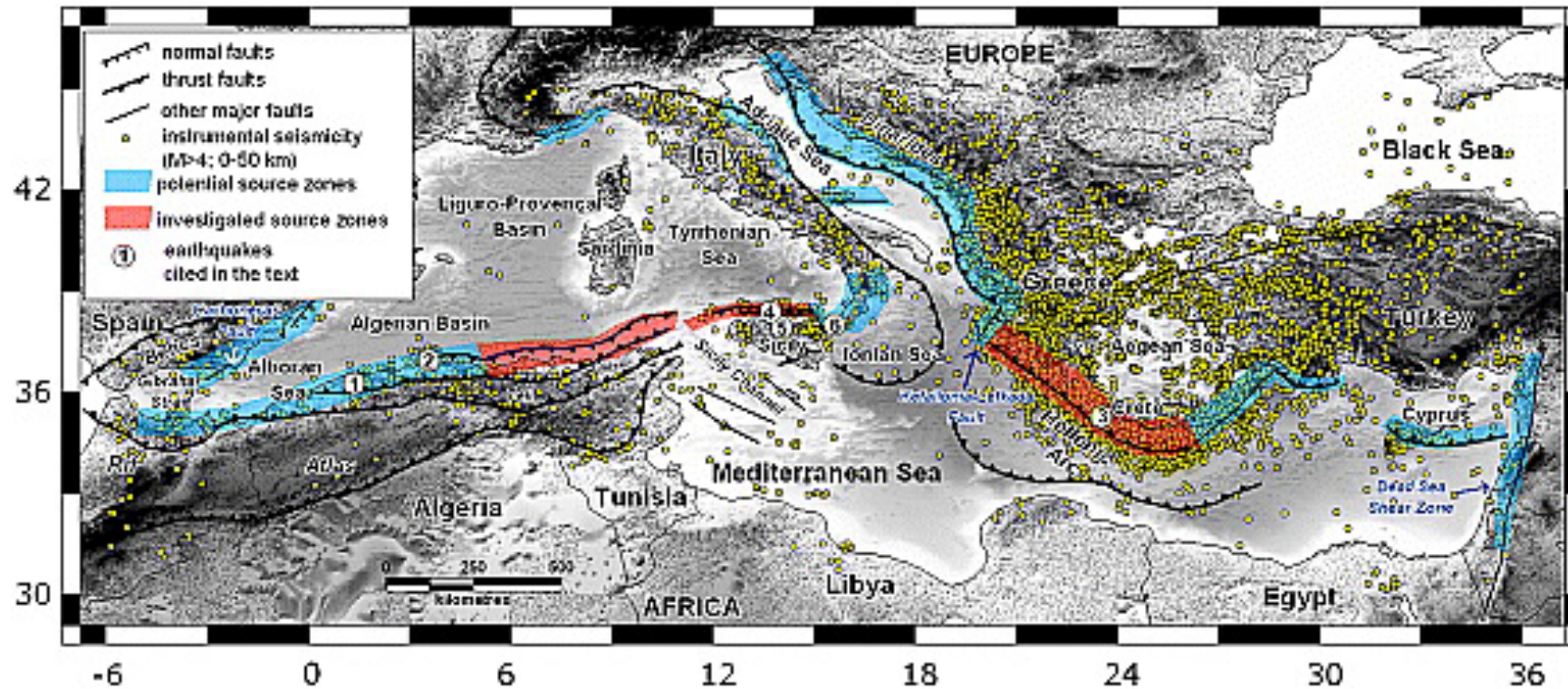


Historically recorded tsunami runups

- Terrestrial landslide associated/ unknown cause
 - Earthquake/volcano/submarine landslide associated
- Espon space
 ■ Regions that experienced landslide associated tsunami
 ■ Tsunami potential in coastal areas close to tectonically active zones
 ■ Regions that lie in vicinity to tectonically active zones and have experienced earthquake/volcano/landslide associated tsunami
 ■ Non ESPON space
- Origin of the data: © EuroGeographics Association for the administrative boundaries
 Northern coast of Africa and Spain: Hébert, 2003
 Greece: Institute of Geodynamics, National Observatory of Athens
 Spain: Instituto Geográfico Nacional
 Italy: Istituto Nazionale di Geofisica e Vulcanologia, Roma
 World Tsunami data: National Geophysical Data Center (NGDC)
 World Map of Natural Hazards: Munich Reinsurance Company
 Source: ESPON Data Base

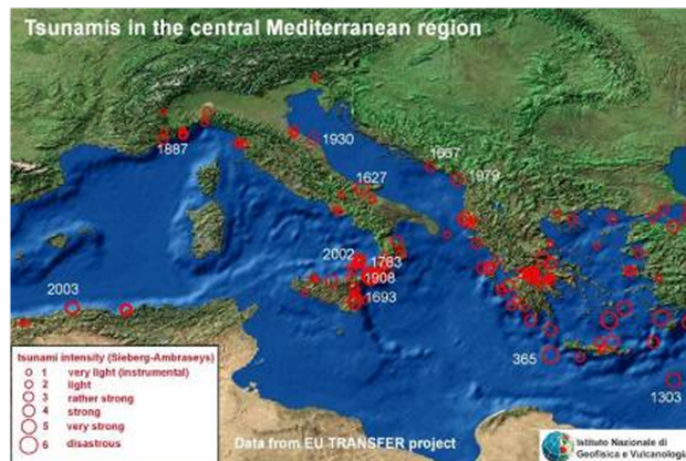
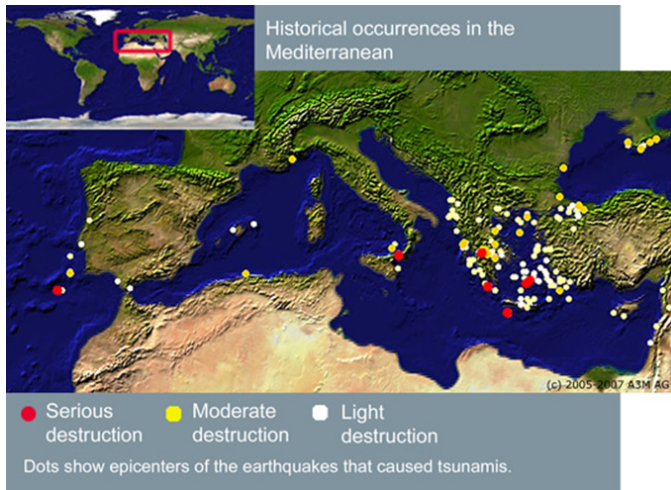


Tsunami events affecting human populations by decade



Tectonic sketch of the Mediterranean basin, after Papadoupoulus, 2001

HISTORICAL TSUNAMIS IN THE MEDITERRANEAN BASIN

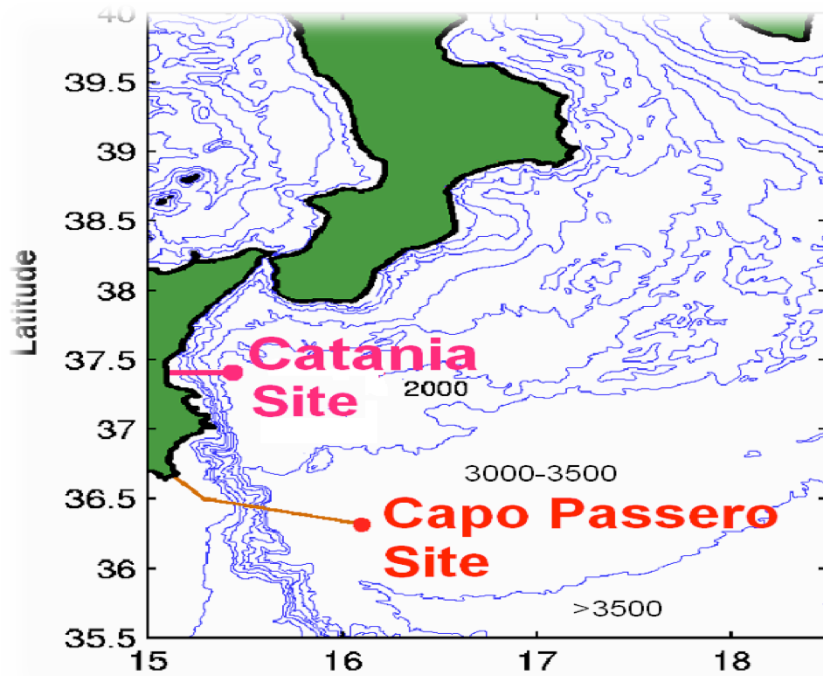


YEAR	LOCATION	CASUALTIES	SOURCE	K (max 12)	RUN UP Height (cm)	SHORT DESCRIPTION
1410 BC	Santorini	Unknown	Volcanic			devasted Santorini & Coast of Crete
426 BC	Maliakus Gulf	Unknown	Earthquake	8		devastated Malian coasts and Euboean Gulfs
226 BC	Rhodes	Unknown	Earthquake			Destroyed Colossus of Rhodes.
79 AD	Bay of Naples	> 10,000	Volcanic			destroyed Pompeii & Herculaneum
1169	Strait of Messina	Unknown	Earthquake	8		
1303	Crete	thousands	Earthquake	10		
1343	Tyrrhenian Sea		Earthquake			destroyed Amalfi Coast
1343	Maramara Sea	Unknown	Earthquake	8	200	
1650	Santorini	Unknown	Volcanic	10	2000	
1680	Alboran Sea	70	Earthquake			severely affected the city of Málaga,
1693	Catania	60000	Earthquake	7		destroying at least 70 towns and citie
1748	V. Gulf of Corinth	Unknown	Earthquake	9	1000	
1755	Lisboa	> 50000	Earth 8,5 Mw	>10	5000	
1783	Calabria	50000	Earthquake	9	900	
1817	Gulf of Corinth,	Unknown	Earthquake	9	500	
1908	Strait of Messina	> 100,000	Earthquake	10	1300	
1956	Cyclades	few 3	Earthquake	9	1500	
1990	Eastern Sicily	18	Earthquake			
2002	Stromboly	0	Volcanic/Landslide	7	900	
2003	Balearic island	0	Earthquake			

References; Ambraseys (1962), P = Papadopoulos (2001), TM = Tinti and Maramai (1996) and Tinti et al. (2004).

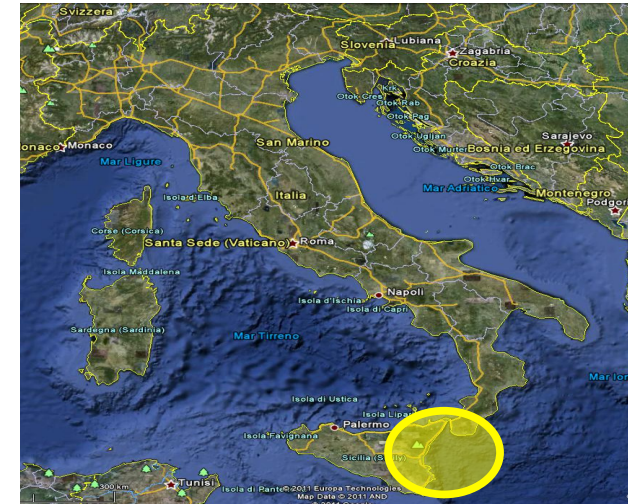
EMSO nodes: Western Ionian Sea

Cabled observatories



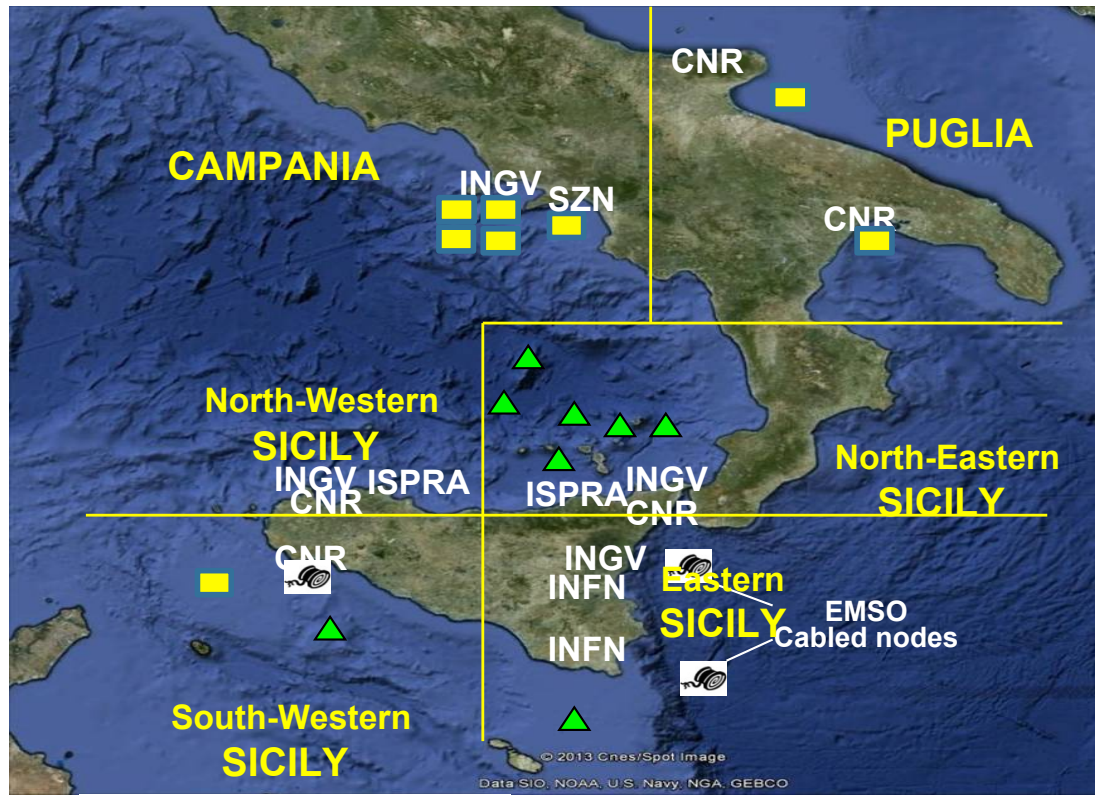
North-eastern
Sicily (2100m bsl)

South-eastern
Sicily (3500m bsl)



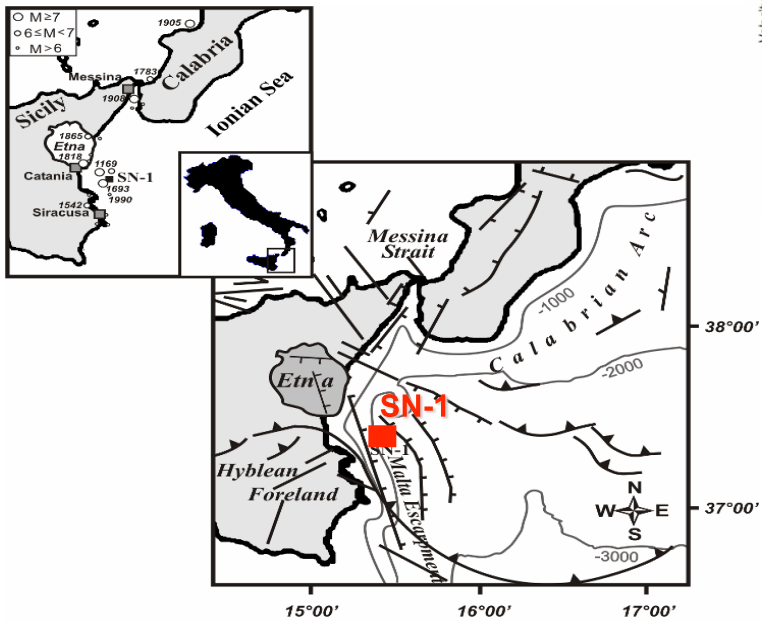


EMSO-MedIT in the context of EMSO and EMSO-Italy

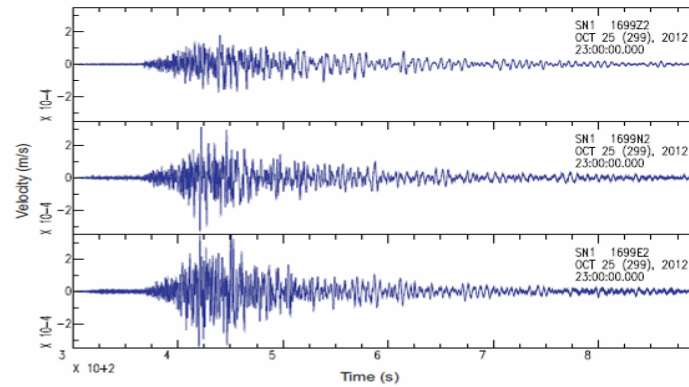


EMSO seismic data records

Geo-hazards:

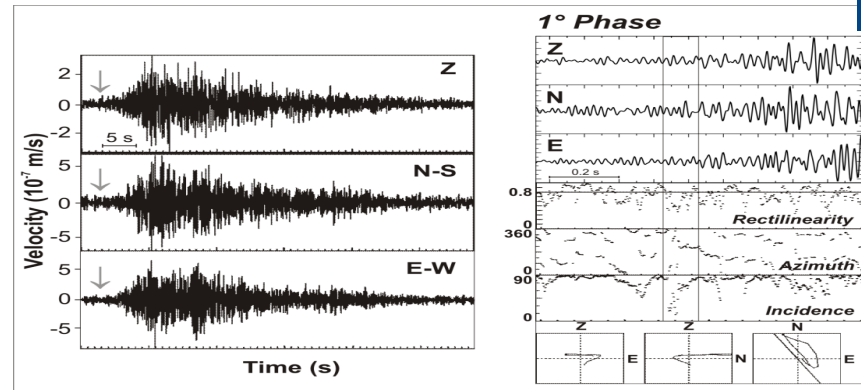


Pollino Event (M_w 5.0) 6.3 km depth
25/10/2012 (23:05:24 UTC)



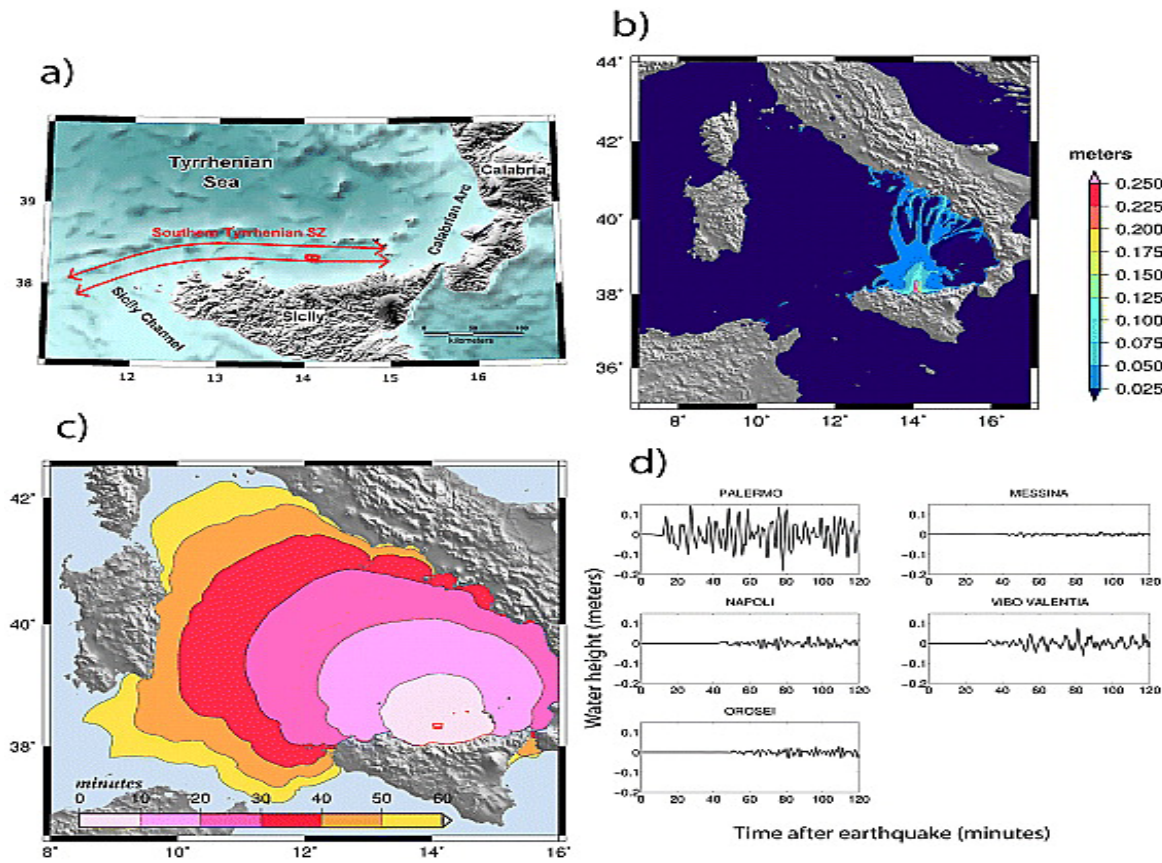
earthquakes

submarine
landslides



Western Ionian Sea

Earthquake-generated tsunamis in the Mediterranean Sea: Scenarios of potential threats to Southern Italy

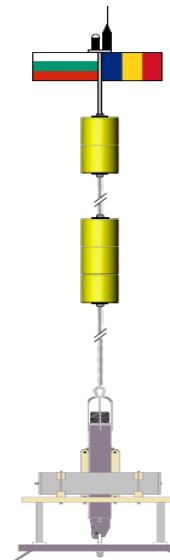
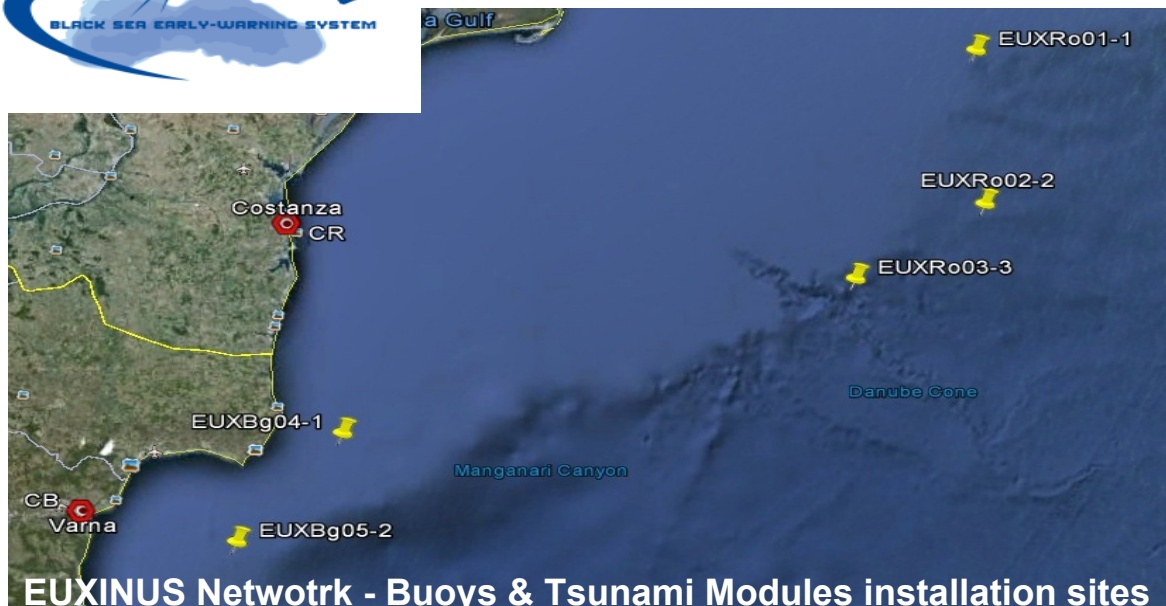


Earthquake-generated tsunamis in the Mediterranean Sea: Scenarios of potential threats to Southern Italy, Volume: 113, Issue: B1, First published: 09 January 2008, DOI: (10.1029/2007JB004943)

EMSO nodes: Black Sea



Romanian-Black Sea coastal area



Geo-hazards

(earthquakes, tsunamis)

Oceanography

(e.g., deep water circulation, current intensity and direction, temperature, salinity)

Structural funds:

**CBC Romania-Bulgaria
2007-2013 Programme**

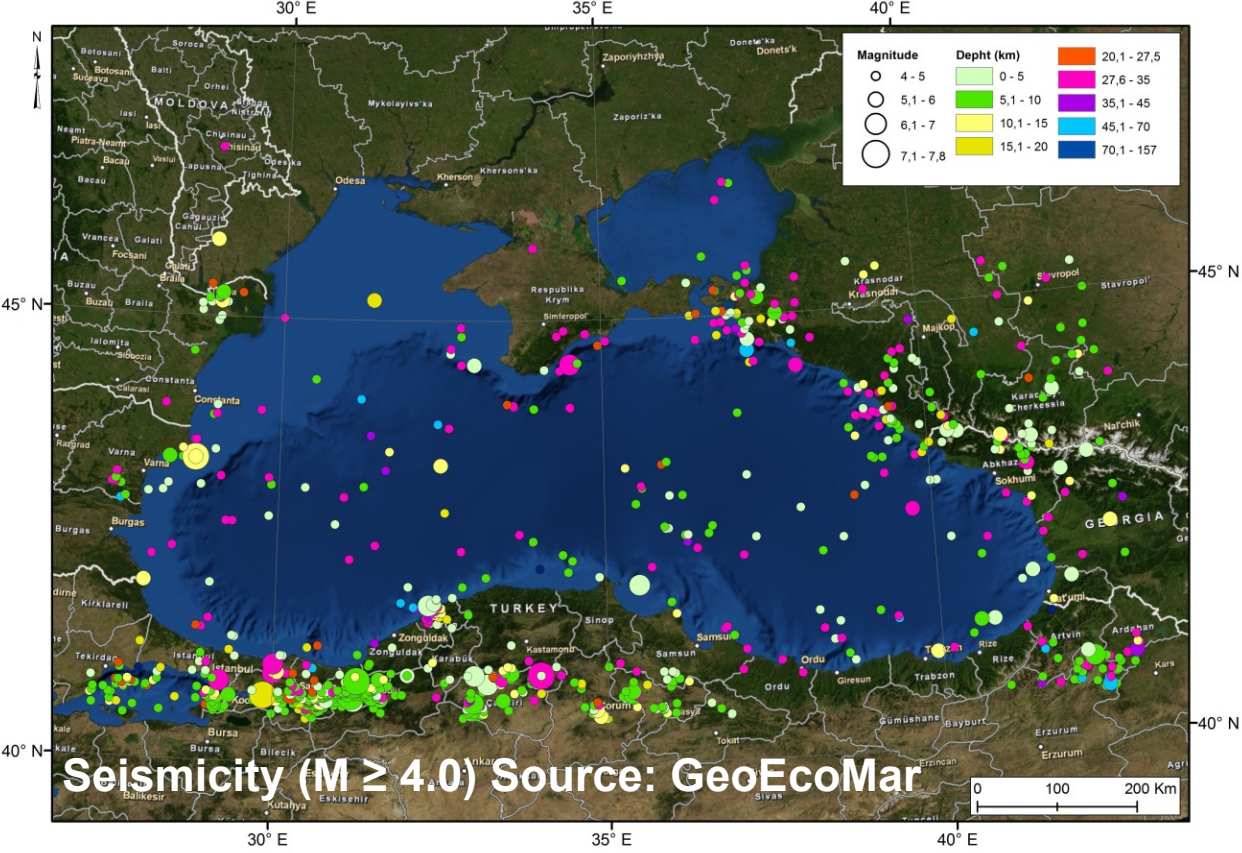
Period of implementation:

**December, 2010 - June,
2013**

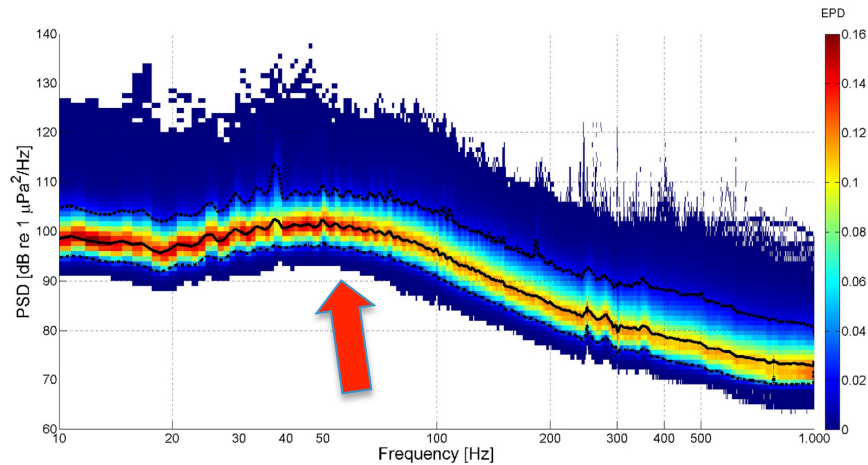
Total value: 6,5 M€

Joint regional early-warning system for protection of local communities, environment and assets within the cross-border area, from consequences of natural marine geo-hazards

EMSO RF: Black Sea seismicity



Marine traffic monitoring



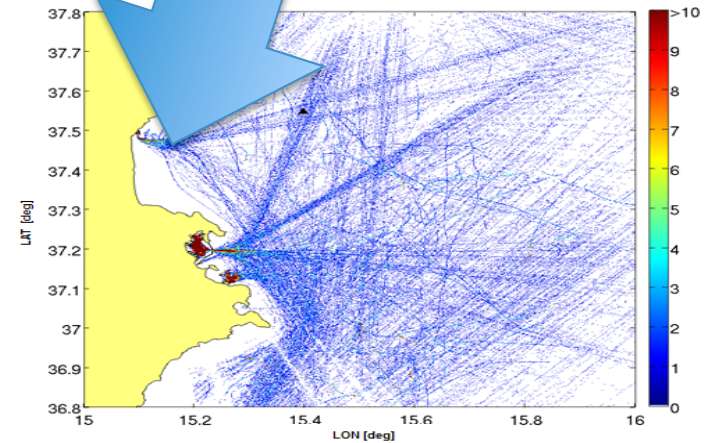
Noise distribution showing average PSD (power Spectral Density) Up to about 70 Hz, the median of the average PSD often > 100 dB re 1 $\mu\text{Pa}^2/\text{Hz}$.

European Marine Strategy

Acoustic noise and correlation with AIS data



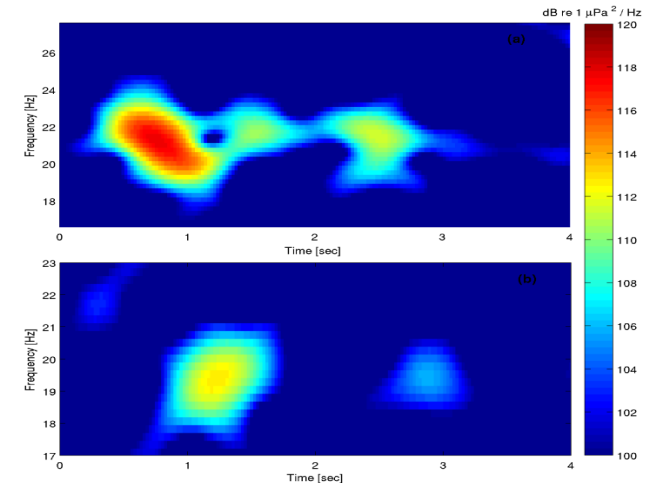
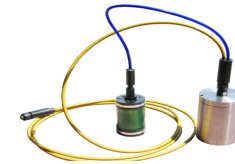
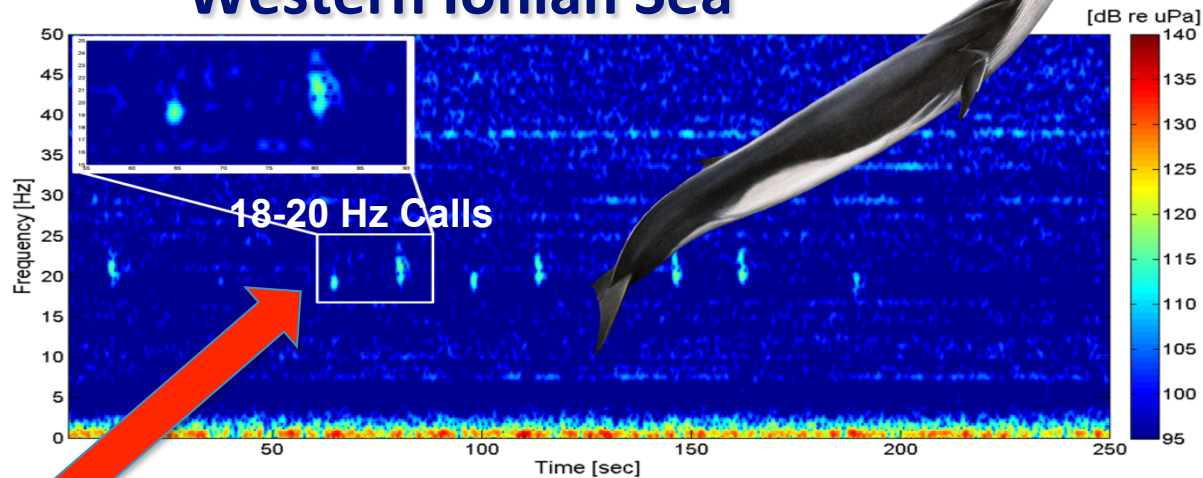
Proprietary AIS data in real time on Google map web page (custom app)



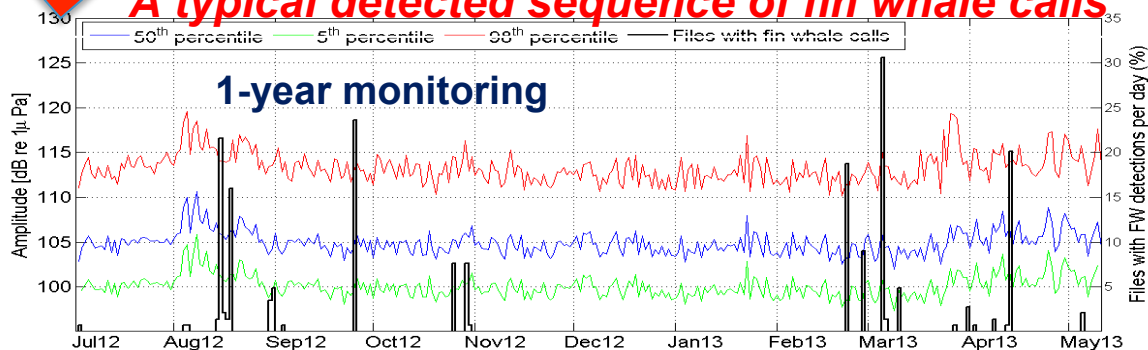
Western Ionian Sea

Marine mammals acoustic detection

Western Ionian Sea



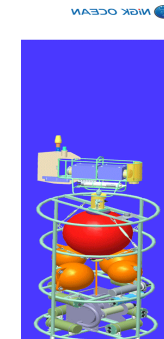
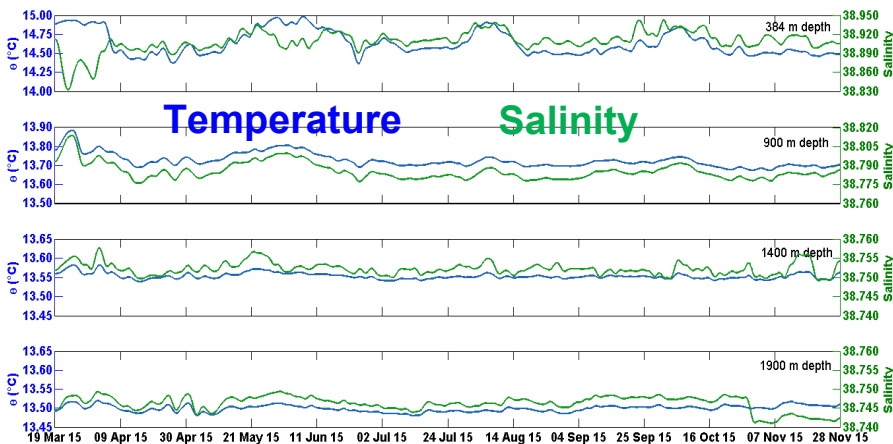
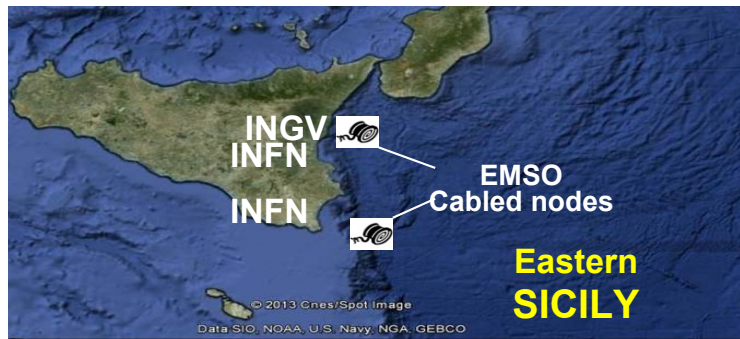
A typical detected sequence of fin whale calls



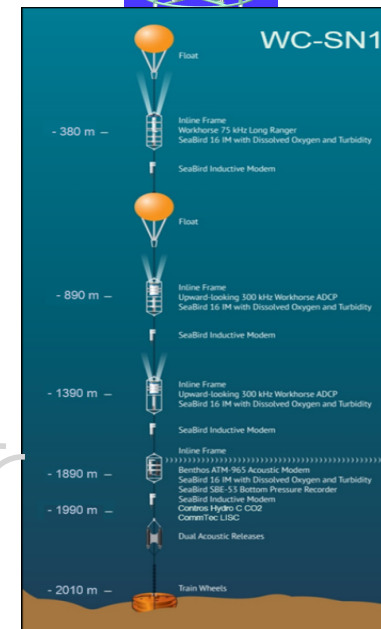
Fin whale detection using data from hydrophone installed on NEMO-SN1. (a) type A or “classic pulse” and (b) type B or “back-beat” are here showed in detail. [picture from Sciacca et al. (2015) Annual Acoustic

Global change and Ocean circulation

Water Column (mooring) - WC-SN1 Physical and biogeochemical parameters



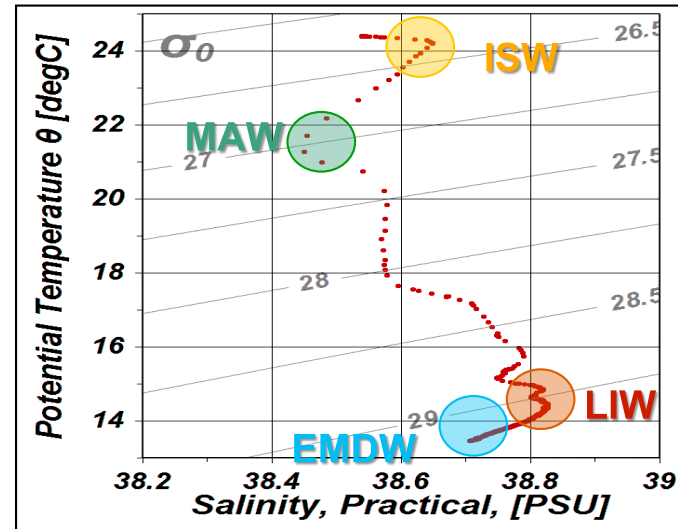
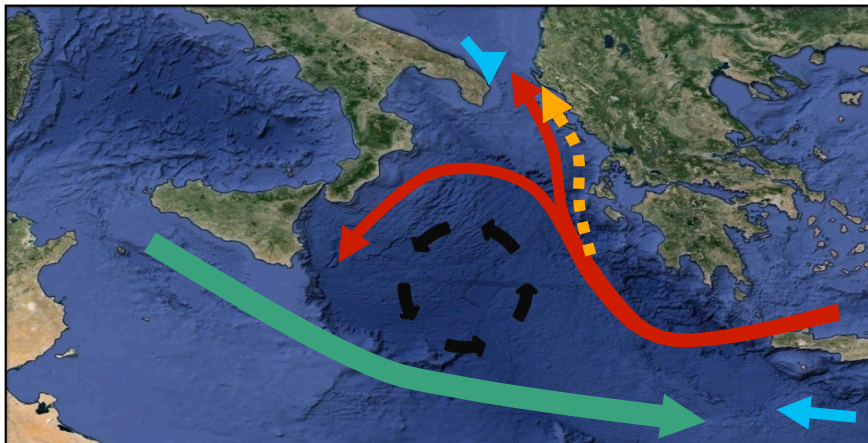
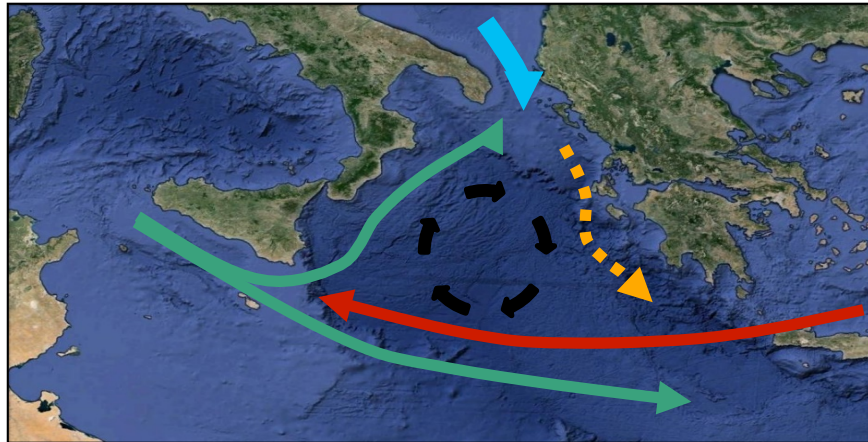
Phase 2
implemented
March 2016



Phase 1
implemented
March 2015



Global change and Ocean circulation



Modified Atlantic Water (MAW)

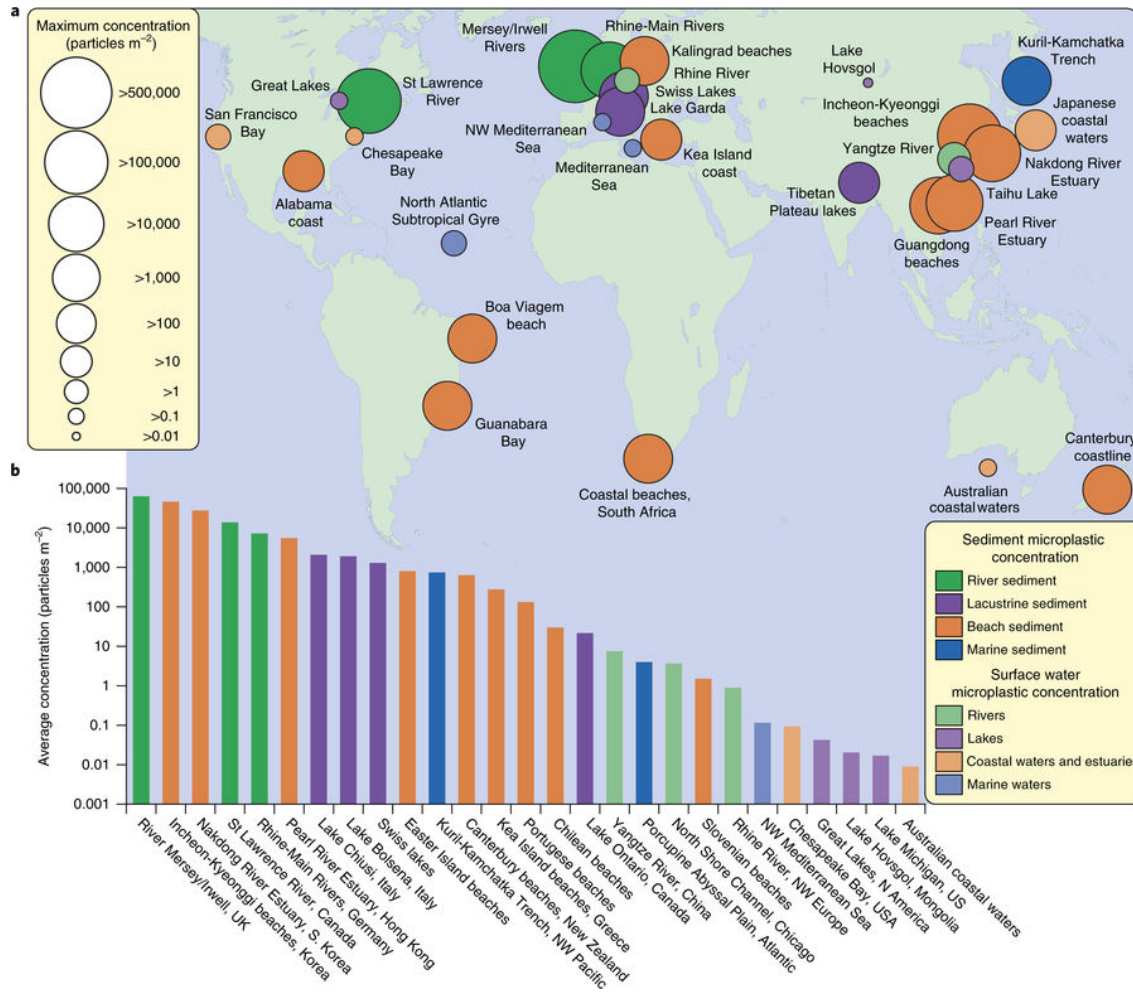
Levantine Intermediate Water (LIW)

Eastern Mediterranean Deep Water (EMDW)

Ionian Surface Water (ISW)

Bios decadal inversion

PLASTICS



‘current estimate for the number of particles in the ocean – is a major underestimate.’

Hurley et al. 2018, *Nature Geoscience*

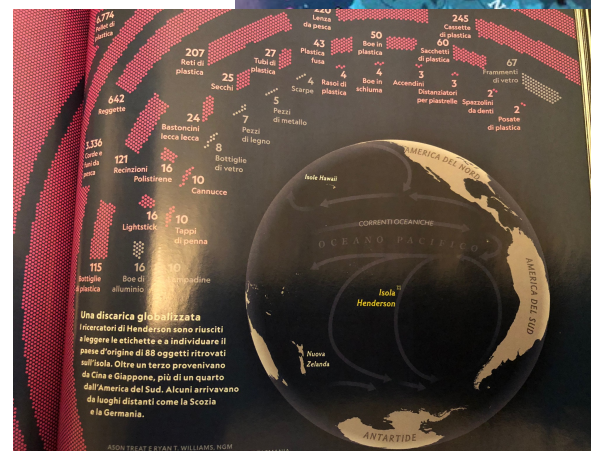
Micro plastics are highly bioavailable to marine organisms, either through direct ingestion, or indirectly by trophic transfer from contaminated prey (Sarah E.Nelms et al., 2018, *Environ. Pollut.*)

PLASTICS

we are dumping around 10 tons of plastic to the oceans every year, ESA is already indirectly capable of measuring the large distribution of plastic, we are in the way to implement smart sensors capable to detect the "in situ" the volume of **microplastics** in the ocean

Henderson Island is a tiny, uninhabited island in the middle of the Pacific Ocean, 4,000 km from major population centers. It is half the size of Manhattan, more than 19 tons of garbage pollute its white sand beaches.

From Laura Parker & Randy Olson, National Geographic, June 2018



SUSTAINABLE DEVELOPMENT GOALS



UN Decade of Ocean Science for Sustainable Development (2021-2030)



SDG 14

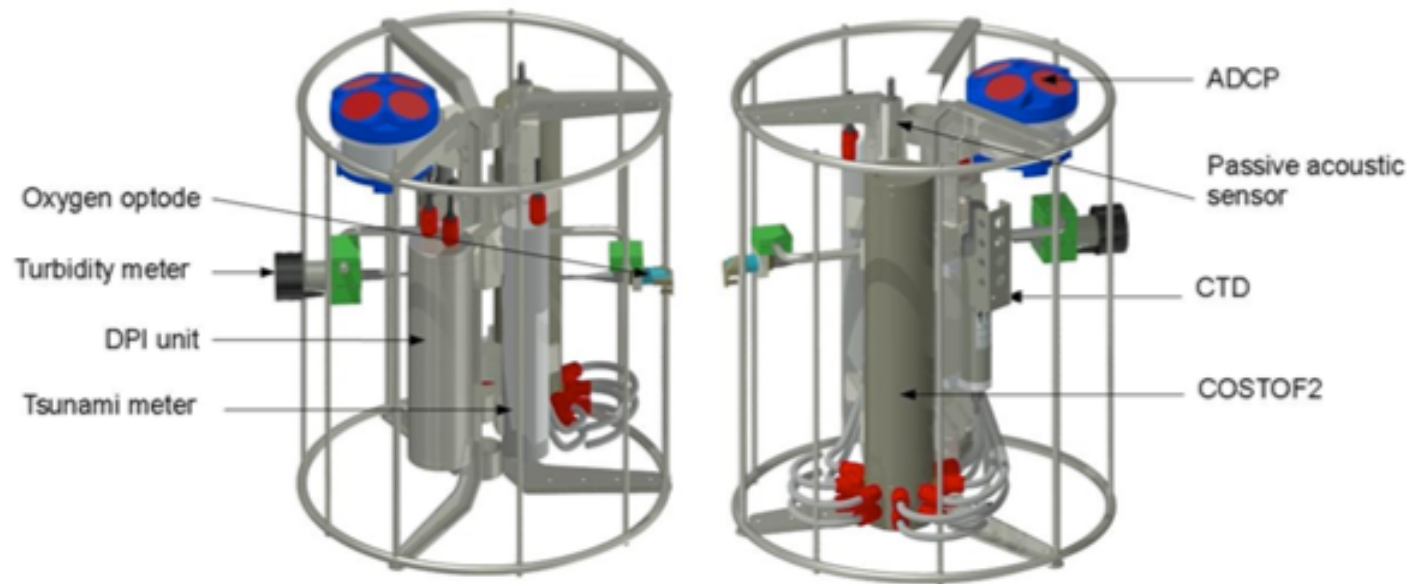
	Targets
14.1	Reduce marine pollution
14.2	Protect marine and coastal ecosystems
14.3	Address ocean acidification
14.4	Address overfishing
14.5	Conserve at least 10 per cent of coastal and marine areas
14.6	Prohibit certain forms of fisheries subsidies
14.7	Increase economic benefits to Small Island developing States
14.a	Increase scientific knowledge
14.b	Access for small-scale artisanal fishers to marine resources and markets
	Enhance the conservation and sustainable use of oceans and their resources



ENGINEERING & LOGISTICS

EGIM measurements:

- Temperature
- Conductivity
- Pressure
- Dissolved O₂
- Turbidity
- Ocean currents
- Passive acoustics



The development of EGIM is an example of the engineering services that EMSO can provide.

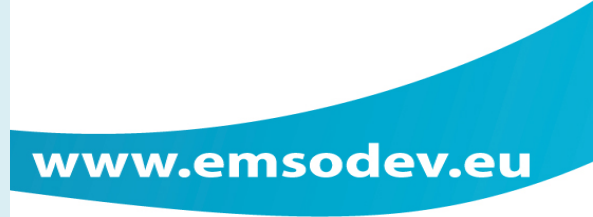
EMSO implementation and operation: DEvelopment of instrument module



EGIM
EMSO Generic Instrument Module
 is envisioned to ensure increased
 coordination, integration,
 interoperability and standardisation
 across sites and disciplines

Core variables captured by the EGIM and their cross-disciplinary application

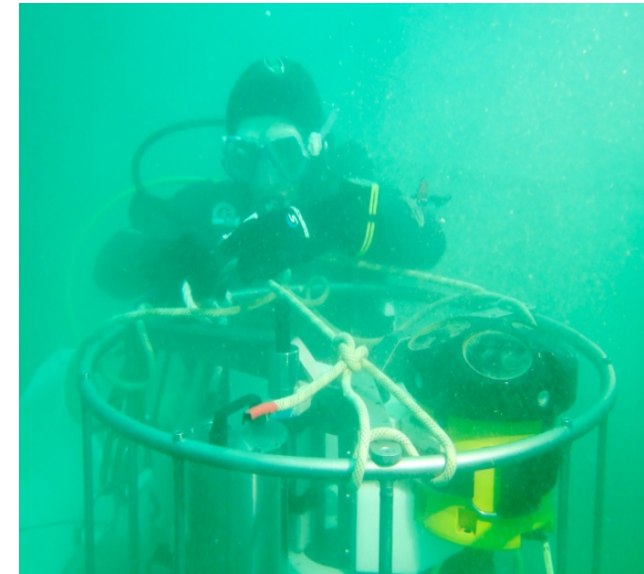
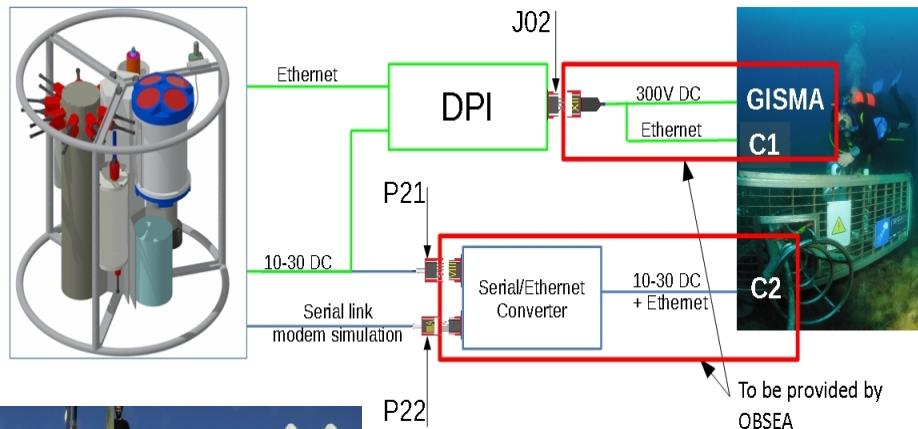
Variable	Geosciences	Physical Oceanography	Biogeochemistry	Marine Ecology
Temperature	X	X	X	X
Conductivity	X	X	X	X
Pressure	X	X	X	X
Dissolved O ₂	X	X	X	X
Turbidity	X	X	X	X
Ocean currents	X	X	X	X
Passive acoustics	X			X



EGIM tests at OBSEA

european
multidisciplinary
seafloor and water-column
observatory development

emsodev
EGIM connection
to OBSEA



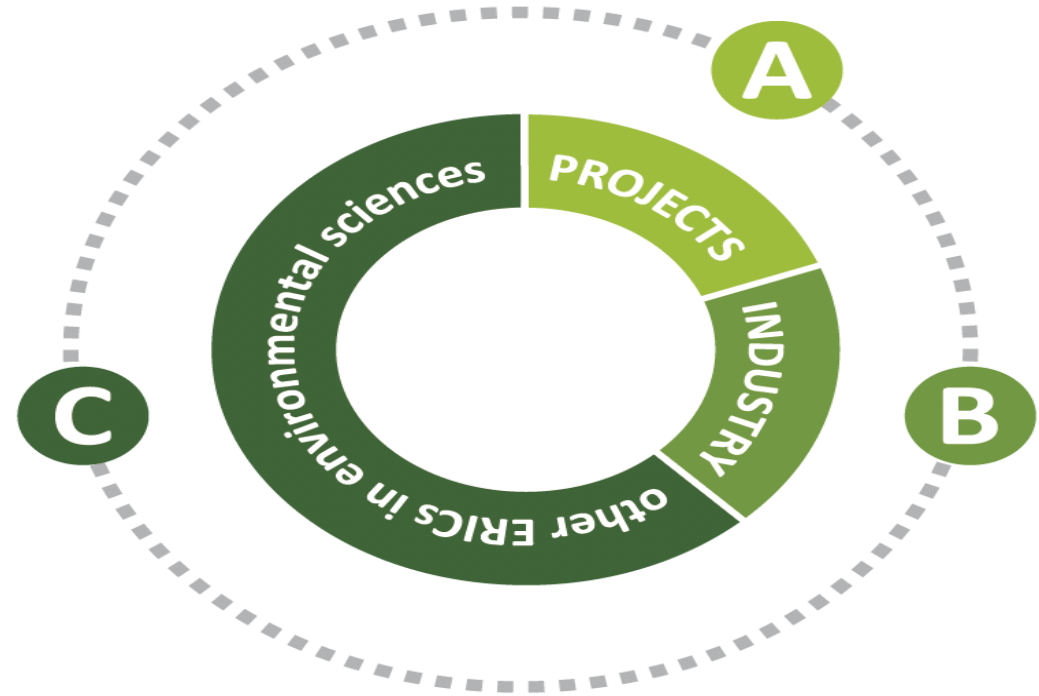
www.emsodev.eu

EGIM prototype was deployed on October 24, 2016
and recovered on April 24, 2017 (6 months)

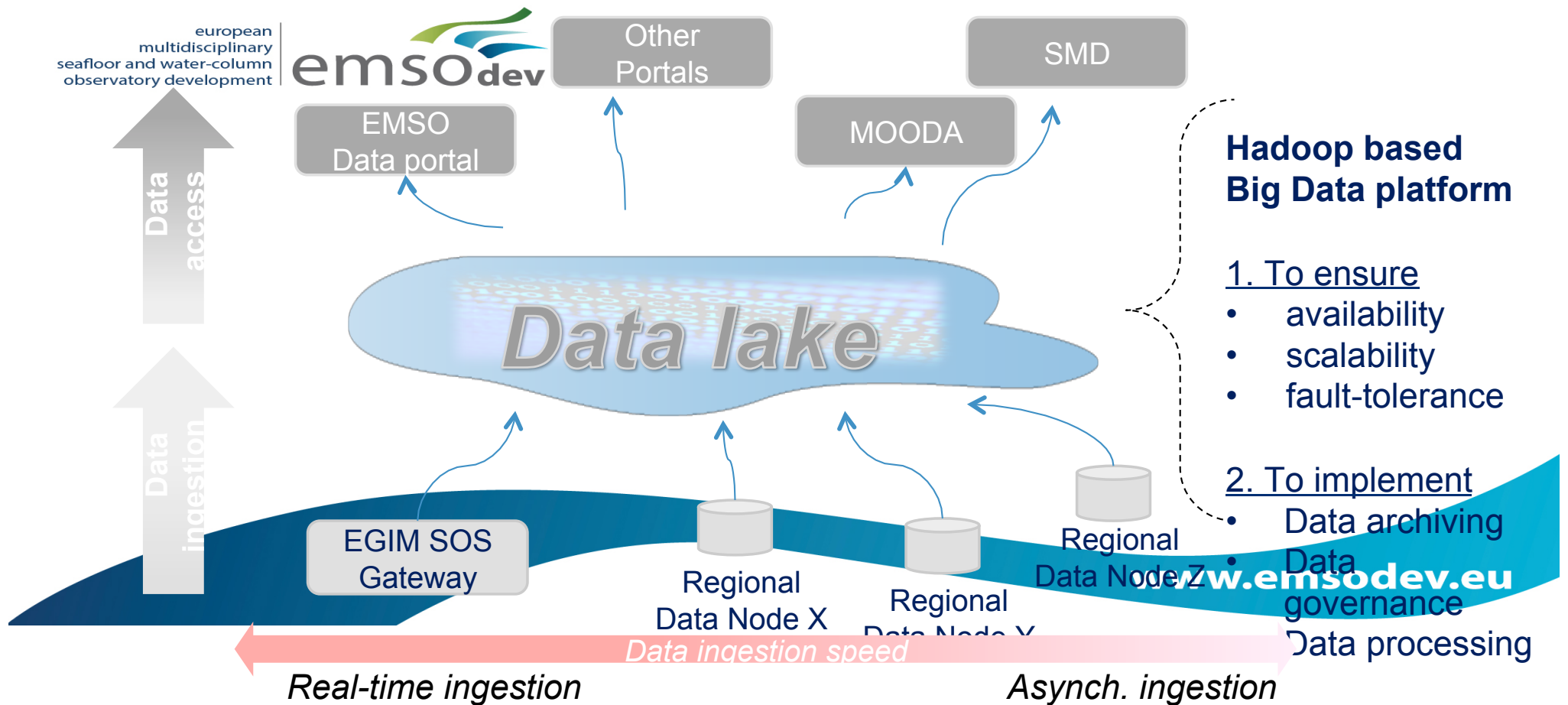
emso
ERIC
EUROPEAN RESEARCH INFRASTRUCTURE CONSORTIUM

EMSO ERIC LINKS WITH

- A** **PROJECTS** such as EMSODEV, COOP+, AtlantOS, NeXOS and JERICONEXT to exchange information and develop synergies on common issues (common forum for marine technology; metrology for marine sensors; carbon flux and climate change).
- B** **INDUSTRY** to improve/develop the technology behind EMSO ERIC and to proffer the possibilities offered by the network. (use of EMSO ERIC nodes as test beds for industrial equipment, methods or services)
- C** **INFRASTRUCTURES** such as ENVIRONMENTAL ERICs in environmental sciences (e.g., ICOS, EURO-ARGO, LIFEWATCH,) and other world wide infrastructures (e.g., OOI, ONC, IMOS) to reach a global monitoring for marine environment.

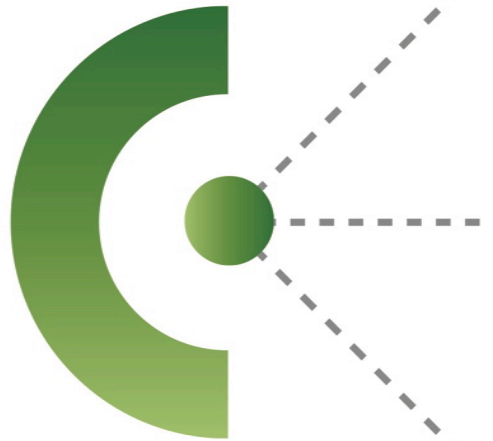


DMP-Data Management Platform





SHARING EMSO ACHIEVEMENTS WITH



**SCIENTIFIC
COMMUNITY**


**POLICY
MAKERS**

**SOCIETY
WIDER
PUBLIC**

To make **world-class science** with a new multi-inter-disciplinary approaches supported by the infrastructure. To offer **HQ data products and opportunities** for collaboration.

To make aware on the need of **increasing the synoptic/aggregated information on marine health** and for an **efficient exploitation of marine resources** through long-term observations.
To make aware of the international cooperation guaranteeing a support for a **sustainable Blue Growth**.

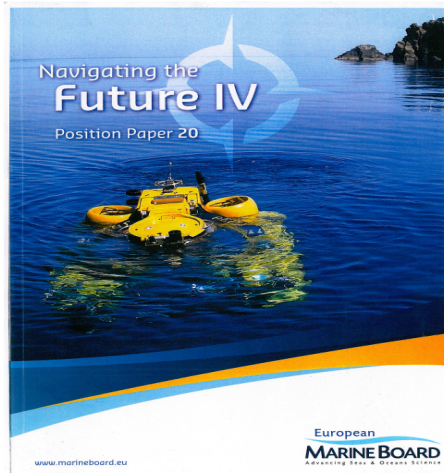
To increase the awareness of the marine domain on Earth good health and global processes (such as Climate Change).
To attract the youngest generation to a scientific carrier for their future. To highlight the importance of European Union funds to finance the marine research in order to help a sustainable future.



What's the Future ?

An Integrated and Sustained European Ocean Observing System (EOOS)

2013



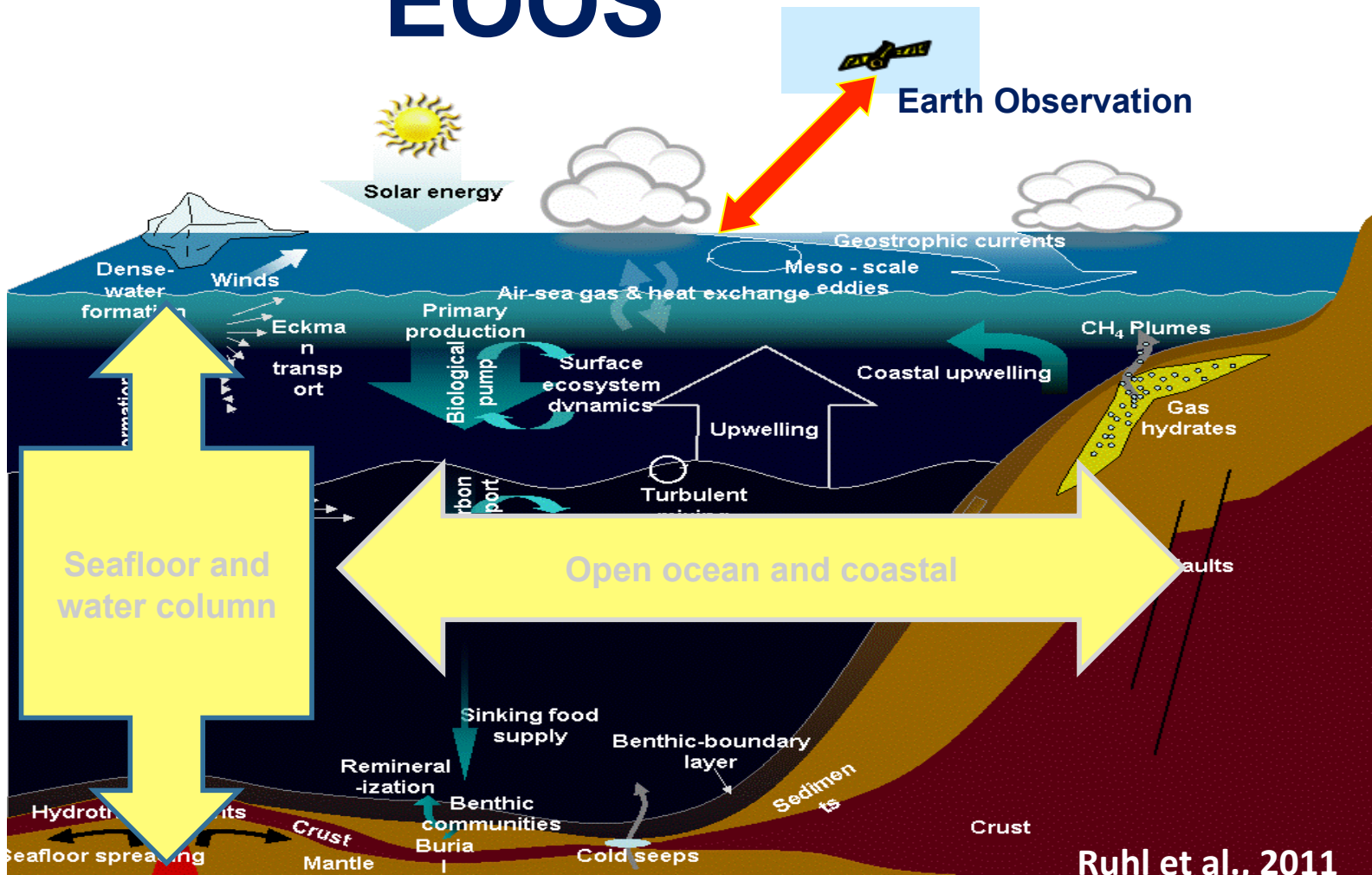
European
MARINE BOARD
Advancing Seas & Oceans Science



EuroGOOS
European Global Ocean
Observing System



EOOS



In line with:
“Support the development of a truly integrated and sustainably funded European Ocean Observing System...”

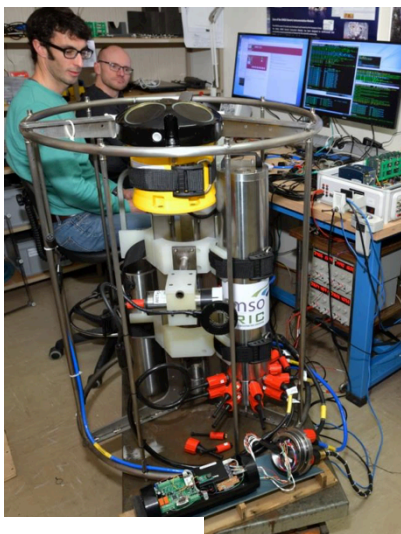
Ostend Declaration
2010

Ruhl et al., 2011

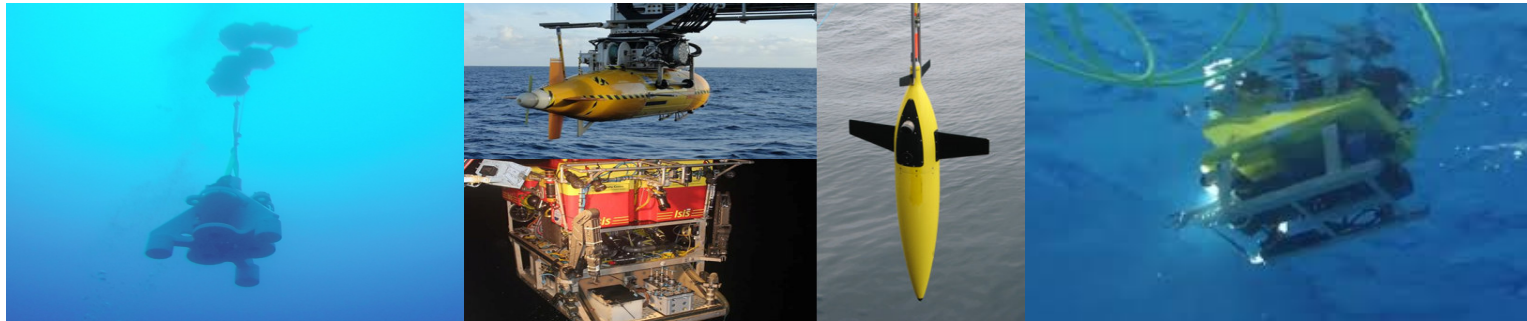
SUMMARY



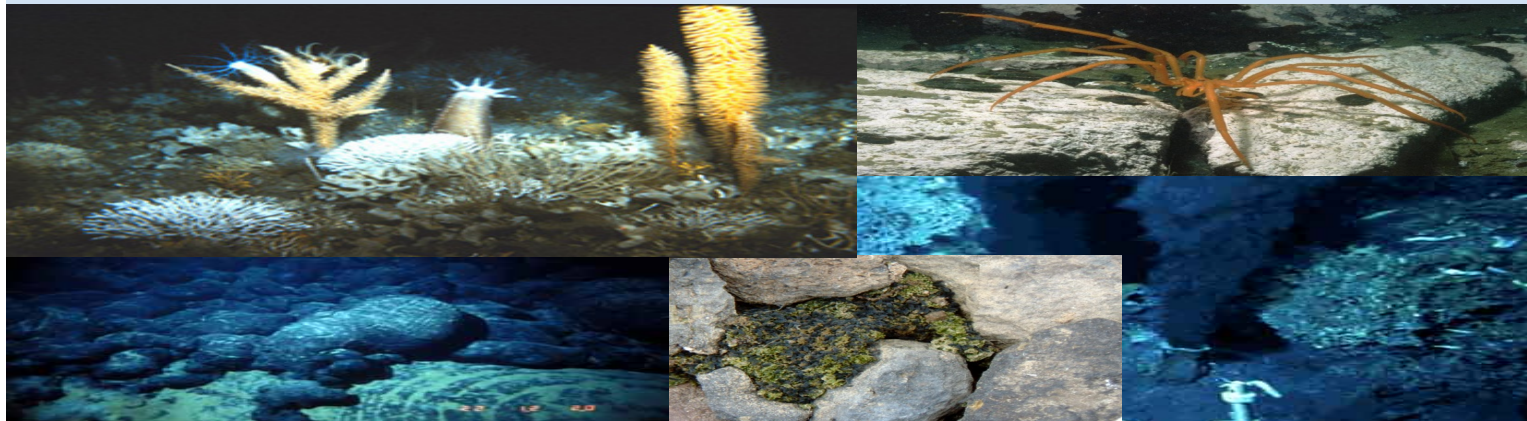
- The development of Distributed RI at seafloor and water column of EMSO nodes (cabled or stand alone) provides a unique European operational capacity in collecting scientifically relevant datasets
- The use EGIM sensor developed within EMSO implements, common, standardized technologies based on architectures and interoperability, enabling EMSO observatories to serve the science community, industry and governmental organizations as well as other key stakeholders and even similar infrastructures



- **EMSO ERIC will provide** information and knowledge impact
- Climate Change & Ocean acidification
- How warming seas are forcing fish to seek new waters
- Appraisal of Economic Impact of Algae Blooms
- Mitigation of Natural disasters (i.e., submarine volcanoes, submarine landslides, earthquakes, tsunamis)
- Copernicus services, marine safety, marine resources, climate forecasting, etc.



OBSERVING THE OCEAN TO SAVE THE EARTH



The EMSO-Link project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements N° 731036.

Thank you for your attention

www.emso-eu.org

