

# ESONET NoE : Status of the project

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## Abstract:

*A deep sea observatory is a station linking marine sensors to the shore by acoustic or cable connection in real or near-real time. These observatories enable data acquisition on ocean and climatic phenomena at relative high frequency. They allow to monitor a large area of phenomena.*

*Observatories are a complementary tool to usual practices such as satellite images and data, oceanographic cruises, moorings... The goal of the ESONET NOE is the lasting integration of European research on these deep sea multidisciplinary observatories. ESONET is funding demonstration actions to bring at high level of excellence in the technology at different development phases and implementing the standardisation and interoperability of the different platforms from the consortium. Demonstration missions are acquiring scientifically relevant time-series data. They are an input for integrated studies, common workshops and a raw material to demonstrate the integration of data management.*

## Keywords –

*Observatory, smart sensors, standardization,*

## Introduction

The intention of ESONET NoE is not to cable connect regional European observatories between themselves but to network activities in order to build up on existing facilities in the most efficient and cheap ways, by uniting scientist, engineers, and users of different European nations around a common aim. This is why ESONET is a Network of Excellence according to the European Commission which co funds the activity during 4 years starting from March 2007. This network gathers 50 partners (Universities, research centers, Industrials and SMEs) of 14 countries, meaning ~300 scientists, engineers and Technicians. The scientific questions concerns processes of the seafloor and of the water column as well for Marine Hydrodynamics, Geohazards, Climate changes, Ecosystem life and Evolution... More information can be found on the website: [www.esonet-emso.org](http://www.esonet-emso.org).

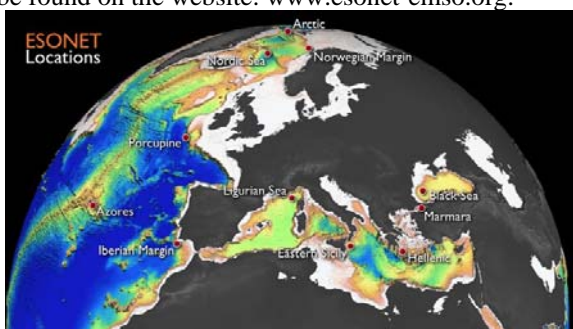


Fig. 1 : ESONET/EMSO nodes

ESONET will not fund observatory infrastructure and implementation directly but will chose how they will be implemented by considering marine intervention, infrastructures, sharing facilities, interoperability and where fund would be found. EMSO preparatory phase project is a complementary infrastructure initiative. The EMSO

infrastructure is included in the ESFRI Roadmap (European Strategy Forum on Research Infrastructures) (ESFRI). ESONET/EMSO nodes are placed in specific marine sites on the European Continental Margin from the Arctic to the Black Sea through the Mediterranean Basin.

## Standardization in ESONET

A major objective of ESONET is to facilitate the transition from conventional, stand-alone mono-disciplinary instrumented ocean observations into a complex network of observatories with commonly usable data services. The heterogeneity of organizational and technical approaches, equipment and methods used in the observing stations as well as the dynamics of scientific and technical developments requires common agreements. Standardization covered different aspects: interfacing, underwater intervention, data management, scientific demands and existing infrastructure issues. The idea is to make efficient use of existing knowledge and come up with concepts that are sustainable within future observatory infrastructures (Puillat I. & al. 2009).

### Plug'n work instruments

An important issue in regard to the technical implementation of ocean observatories is to have a clear definition of the interfaces between the basic building blocks. This is an indispensable step in the design of an interoperable system on the device level. Within ESONET it is planned to make use of the IEEE 1451 standard which allows for the envisioned plug and work functionality. Another possibility is the implementation of Smart Sensor Interface that provides network infrastructures services at different levels:

- compatible with a cable network, tethered buoy or autonomous observatories, with Serial and Ethernet instrument interface, it works as a Plug and play interface.
- provide an electronic biofouling interface,

This interface can be implemented at different places: as a bridge between the IP network and the instrument, or it can be integrated inside a network infrastructure (junction box ...) or inside a new instrument.

### Esonet Sensor registry

The sensor registry concept as conceived within the ESONET project will form the nucleus around which the basic functional blocks of an interoperable observatory system will be grouped. In its simplest form it will consist of a web interface that allows a user of an observatory to insert all necessary metadata to describe the sensor function. It is necessary that the registry will act as a dynamic registry for identifying the current status and whereabouts of a given sensor. It will be implemented to define and include descriptive metadata to the data stream coming from the individual sensor system.

### Data management in Esonet

The data and information management plan is lead by our partner KDM/Bremen university. A first version is edited as a generic and dynamic document meeting today's

requirements. In its chosen form as a wiki-based structure the plan is open for the incorporation of further development in the context of data capture, data flow, and data migration and will be available at any time in its respectively updated form (*PANGAEA*). With increasing integration of observatories over time, in particular through the demonstration cases, specifications can be added and the document can be adapted to the evolutionary design of the ESONET observatories network. The fundamental underlying principle for this plan is the full and open exchange of data and information for scientific and educational purposes (GEOSS data sharing principles). After the Best Practices workshop the plan has been detailed according to figure 2.

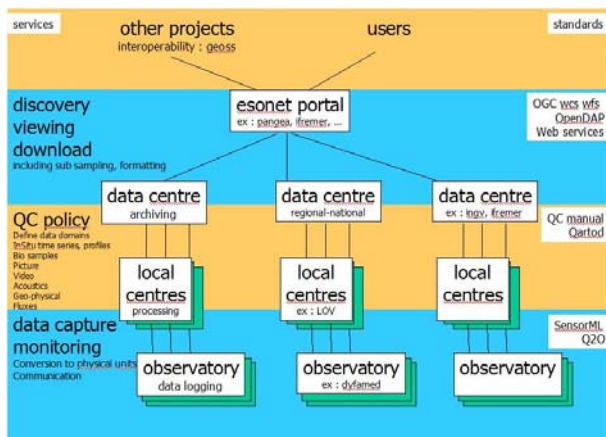


Fig. 2: ESONET data management

A complement to the data management system and part of the data and information management plan is the creation of an interactive topology of existing regional observatories, which itself brings a complete state of the knowledge on the sites and will eventually impart among regional observatories through a common data infrastructure based on global standards. The ESONET interactive topology is publicly available via the internet at:

<http://features.pangaea.de/map.php>.

#### Underwater intervention

It is more than obvious that the existing intervention equipment (Submarines, ROVs, AUVs) available within the scientific community will govern the early days of intervention procedures on underwater observatories.

A direct transfer of the offshore philosophy to the installation of underwater scientific modules could be detrimental to the scientific community in terms of equipment availability and installation costs. As opposed to the offshore philosophy which offers no compromise to equipment performance, a more flexible approach should be taken by the scientific community by evaluating performances of alternative methods such as smart rigging and lower cost of the support ships, versus sea state capability and global cost.

Concerning the main cable for cabled observatories, it is more than likely that planning, installation, and future maintenance will be committed to commercial submarine telecommunications systems and specialized survey

companies that make use of existing and proven commercial hardware, jointing, methods and techniques. So the project cycle for a scientific system will largely follow the standards of these companies and the steps of commercial undersea cable systems.

However, scientific submarine cable systems impose different requirements for route survey data. Moreover due to the smaller size of the modules to deploy in scientific missions compared to offshore industry, and the deliberate choice to do the operation by good sea conditions with stand by acceptance, lifting operations are generally conducted with no highly specialized ship, even sometimes with small oceanographic vessels.

## ESONET Demonstration missions

Demonstration missions have been planned at sites where existing infrastructures or/and facilities such as service with research vessels and ROVs allow for time and cost effective implementation and where demonstration missions can benefit of the synergy with other endorsed and funded initiatives. Tests of cabled observatory designs are carried out at sites that have an existing cable connection to shore.

Demonstration missions typically involve a pre-cruise phase of scientific and technological design and engineering (including equipment testing), a few days ship time for deployment of seafloor and/or water column observatory packages and devices recording of a set of time-series data over some months (typically 6 months) (via cable or acoustic transmission), recovery of the systems, followed by a post-cruise phase of data analysis, assessment of the technological aspects of the mission, design improvement, and reporting. Six Demonstration missions are running.

### LiDO

LIDO (Listening to the Deep Ocean environment) is establishing a first nucleus of a regional network of multidisciplinary seafloor observatories contributing to the coordination of high quality research in the ESONET NoE by allowing the long-term monitoring of Geohazards and Marine Ambient Noise in the Mediterranean Sea and the adjacent Atlantic waters. Specific activities are addressed to a long-term monitoring of earthquakes and tsunamis and the characterisation of ambient noise induced by marine mammals (Bioacoustics) and anthropogenic noise. The objective of the project were achieved through the extension of the present capabilities of the observatories working in the ESONET key-sites of Eastern Sicily(NEMO-SN1) and of the Gulf of Cadiz by installing not-already-included sensor equipments related to Bioacoustics and Geohazards.

LIDO is improving the real-time and near-real-time detection of signals by a multiparameter seafloor observatory network at regional scale for the characterisation of potential tsunamigenic sources. Its methodological approach is based on the cross-checking of geophysical, oceanographic and environmental time series acquired on the seafloor and in the water column. LIDO provides real-time and near to- real-time seismological and water-pressure comparative time series from near-shore sources and operational tools (e.g., prototype of tsunameters) integrated in seafloor observation systems, and in the terrestrial networks.

On the bioacoustics aspect, LIDO is evaluating the human and natural contributions to marine ambient noise and for the first time describes the long-term trends in ambient noise levels, especially from human activities (influenced for example by increasing shipping) and in marine mammals populations (migration patterns, presence, and habitat use of key species, like sperm -, fin - and beaked whales).

Partners are UPC, UB/MARUM, FFCUL/CGUL, INGV, ISMAR, INFN, CSIC, Dbscale, CIBRA, TFH, Tecnomare  
**LOOME**

LOOME DM is a networking action for the long-term observation of a major site of methane emission from the deep European margin, the Håkon Mosby mud volcano (HMMV). A good understanding of spatial scales of geological, hydrographical, chemical and biological parameters of this exemplary mud volcano ecosystem has been acquired, so that results from the first observation of temporal variation and eruption events will immediately lead to important findings. The HMMV is a cold seep ecosystem located at a water depth of 1250 m on the SW Barents Sea slope off Norway, in an area with a history of seabed slides and tsunamis, and under exploitation for hydrocarbon resources and fisheries. Previous work of the partners at HMMV yielded evidence of several eruptive events, indicated by strong gas bubble emission and abrupt temperature changes of almost 10°C within a few days. High resolution bathymetric maps and video observations of the seafloor before and after this event clearly showed changes in the morphology of HMMV. Only continuous observations, recording a wide variety of parameters, can give learning about the mechanics of such eruptions and their early signals, estimating the amount of gas released and the consequences for geochemistry and local communities as well as for seafloor stability, which are main scientific objectives.

The HMMV is a key site of the EU projects HERMES, MARBEF as well as the ESF EuroDeep program CHEMECO. LOOME DM has proposed for the first time a detailed investigation of the temporal variability at an active gas emitting mud volcano covering the sequence of events before, during, and after an eruption, and to analyse their effects on gas hydrate stability, seafloor morphology and the distribution and colonization patterns of benthic communities. A main goal of the project is the integration of existing technology to establish in a first phase an autonomous non-cabled observatory for seafloor seismic, temperature and pore pressure, chemical profiling, sonar detection of gas flares, methane measurements of bottom water, together with the study of colonization patterns, community structure and biodiversity. The sensor systems and biological experiments will be integrated around a combination of deeply penetrating in situ temperature and geo-acoustic recording units, which will give an early warning of eruptive events, and which are relevant for mobile response observatory platforms.

Partners are KDM, Ifremer, UiT, NGI, UPMC, TMBL  
**MARMARA DM**

The goal of the MARMARA-DM demonstration mission is to contribute to the establishment of optimised permanent seafloor observatory stations for earthquake monitoring in the Marmara Sea. The Marmara Sea (MS) offers the ideal

location for seafloor seismogenic observations directed towards risk assessment, because of the following reasons: 1) the deformation rates (20 mm/y) are very high compared to any other marine sites in Europe, resulting in active submarine processes that are measurable on short time scales; 2) more than 15 millions people are under the threat of seismogenic hazard in the whole Marmara Region. Hence, the continuous seafloor monitoring would have high societal impact; 3) numerous fluid vents and related features have been discovered along the MS fault system. The MS is thus a unique area to test hypothesis on the relations between strike-slip deformation, seismic activity, fluid flow and gas expulsion within the active fault zone; 4) logistics are favoured by the proximity to the coastlines (only 5 to 30 km), which makes cost-effective and realistic the establishment of permanent seafloor observatories.

The specific objectives of the present demonstration mission are: 1) To characterize the temporal and spatial relations between fluid expulsion, fluid chemistry and seismic activity in the MS; 2) To test the relevance of permanent seafloor observatories for an innovative monitoring of earthquake related hazards, appropriate to the Marmara Sea specific environment; 3) To conduct a feasibility study to optimise the submarine infrastructure options (fibre optic cable, buoys with a wireless meshed network, autonomous mobile stations with wireless messenger). This study will also ensure standardization and integration with other initiatives world wide (Europe through Esonet, but also with Neptune); 4) To ensure the sustainability by involving the national and local authorities, and coordinate national (Turkish) and international efforts towards a optimised, permanent seafloor monitoring for the geohazard risk assessment and mitigation in the MS.

Partners are ITU, IFREMER, ISMAR, INGV, CNRS/Cerege, DEU/IMST  
**MOMAR DM**

The MoMAR (“Monitoring the Mid-Atlantic Ridge”) project is a component of the work planned at the Azores ESONET node, which focuses on active processes at ridge hydrothermal systems. Hydrothermal circulation at mid-ocean ridges impacts the transfer of energy and matter from the interior of the Earth to the crust, hydrosphere and biosphere. Seawater circulates through the permeable oceanic crust, exchanges chemicals with the surrounding rocks, and is heated to temperatures reaching 400°C. This hot fluid flows up and is expelled at hydrothermal vents, forming emissions of different physico-chemical properties (from black smokers to diffuse venting). The unique faunal communities that develop near these vents are sustained by chemo synthetic micro organisms that use reduced chemicals presents in the hot fluids as energy sources.

The MoMAR-D proposal contributes to the implementation of the Azores node through a 1 year deployment of an acoustically-linked multidisciplinary observing system at the Lucky Strike vent field, with satellite connection to shore. The SEAMON technology developed during the ASSEM project has been used, with two nodes acoustically linked to a surface buoy that ensured satellite communication to a land base station. This observatory infrastructure acquires a synchronized multidisciplinary data

set, test solutions for sensor interoperability, shore-sensor interactive communication, data management and dissemination. MoMAR-D will also develop a public outreach strategy.

Partners are Uaç, Univ. Lisbon ,IPGP, NOC, OMP-LMTG, UB/MARUM, UPMC-LOCEAN, Ifremer, UBO/TUEM,

#### **MODOO**

This project is demonstrating the functioning of a MODular and mobile Deep Ocean Observatory (MODOO) with real-time data access. The MODOO concept is linking and operating existing stand-alone observatories as such that they merge into a single observatory. MODOO is mobile (or re-locatable) as it can be moved to regions where it is required, MODOO is modular as its architecture allows other stand-alone systems to connect to MODOO. For the Demo-Mission MODOO is operating at the Porcupine Abyssal Plain (PAP), 350 nm off southwest Ireland, one of the ESONET NoE's key sites. At the PAP site exists the longest running multidisciplinary open ocean time-series in Europe. Short-term variability of the oceans is examined, including physical mixing, ecosystem dynamics and nutrient cycling. Also longer-term trends in the Earth's climate are investigated. MODOO will make use of the existing water column mooring infrastructure at PAP, which forms part of the EuroSITES network of European Eulerian ocean observatories and develop this within the objectives of ESONET beyond the current state-of-the-art. MODOO will demonstrate (as MOMAR DM) one of the deepest acoustic links from the deep seafloor to the surface integrating the existing water column observatory with a benthic lander observatory into a single, real time accessible observatory.

Partners are IFM-GEOMAR, NERC-NOCS, IMI, NIOZ, UNIABDN, AWI.

#### **AOEM**

The Arctic Ocean will be the site of the most significant and probably irreversible environmental change as climate warming proceeds through the 21st century. Sustained ocean observing of key sites and / or processes will be crucial to understand the "trajectory" of climate change including whether it will be progressive or a series of tipping points, and what are the consequential feedbacks to earth system processes and ecosystems. Fram Strait and western Svalbard shelf are key sites to undertake sustained seafloor / ocean observing to understand this Arctic climate change and are already the sites of long-term observing with the HAUSGARTEN, Kongsfjord, and KONGHAU projects. The new MASOX (Monitoring Arctic Seafloor – Ocean Exchange) and ARCOONE (Arctic Operational Oceanography Network in ESONET), sub-projects of the Arctic Ocean ESONET Mission (**AOEM**), address important facets of developing science understanding, technology, and real-time environmental data streams to enhance monitoring of Arctic Ocean climate change.

The Arctic ESONET / EMSO site is where methane hydrate is actively dissociating. Monitoring this methane dissociation is imperative because release of methane from gas hydrate has been proposed as a key causative process for climate change and catastrophic continental margin collapse. The central science objective of MASOX is to determine

whether there is a causative effect of warming shallow Arctic seas conducting heat into the seafloor and subseafloor sediments that will further perturb the thermodynamic stability zone of methane hydrate, increasing the release of free and dissolved methane gas (and CO<sub>2</sub> via redox reactions) into the ocean and atmosphere, with consequences for benthic ecology and biogeochemical cycles.

Integration of Fram Strait and HAUSGARTEN ocean water column observations towards an ESONET multidisciplinary cabled observatory must be considered by designing, testing and implementing infrastructure and technological solutions, as a case study for Arctic Ocean Observing Systems providing operational data for physical parameters.

Both MASOX and ARCOONE sub-projects will be deployed at the designated Arctic ESONET / EMSO site, which currently comprises the HAUSGARTEN, Kongsfjord, and KONGHAU projects presently monitor biological oceanography across the western Svalbard continental slope and shelf. The addition of the ARCOONE project across Fram Strait linking with the HAUSGARTEN project and MASOX on the upper western Svalbard shelf now provides "critical scientific mass" for a cabled observatory at the Arctic ESONET / EMSO site. Indeed the new Norwegian SIOS (Svalbard Integrated Arctic Earth Observing System) provides a crucial impetus to developing the Arctic ESONET / EMSO site.

Partners are NOC, AWI, IFM-GEOMAR, FORTH, UiT.

#### **CONCLUSIONS**

After two years of Esonet activity, some technical solutions and methodologies have been selected and implemented on demonstration missions. These solution are often developed with international cooperation with other sea observatory operators. The next step will be to decide at international level of some rules to ensure that the shared observations and data products from deep sea observatories are accessible, comparable, and comprehensive.

#### **Acknowledgements**

Esonet activity is a collaborative work involving Esonet partners by different ways, so acknowledgment are first dedicated to all participating partners, specially work packages leaders. This work is undertaken in the framework of the FP6 European Commission program under the contract GOCE 036851, consequently we also acknowledge the European Commission for its support.

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