

ESONET- European Sea Floor Observatory Network.

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Abstract - ESONET is a proposed sub sea component of the European GMES (Global Monitoring for Environment and Security) to provide strategic long term monitoring capability in geophysics, geotechnics, chemistry, biochemistry, oceanography, biology and fisheries. To provide representative sampling around Europe 10 nodes are proposed in contrasting oceanographic regions:

1-Arctic, 2-Norwegian margin, 3-Nordic Seas, 4-Porcupine/Celtic, 5-Azores, 6-Iberian, 7-Ligurian, 8-East Sicily, 9-Hellenic, 10-Black Sea. In addition, a mobile response observatory will be available for rapid deployment in areas of anthropogenic or natural disasters to provide data for environment management and government agencies.

I. INTRODUCTION

The European GMES programme for Global Monitoring for Environment and Security has identified a need for a subsea component of a proposed surveillance system. This will be directed to monitor the solid earth beneath the sea, processes at the interface between the solid earth and sea and processes in the water column.

ESONET was set up as a concerted action (EVK3-CT-2002-80008) sponsored by the European commission to consider the feasibility of such a system. ESONET is directed to monitoring the submarine terrain around Europe from the continental shelves to the abyss, an area of ca. 3 million km². This is comparable in size with the total land mass of Europe and is increasingly important for resources, such as minerals, hydrocarbons and fisheries. Only a small fraction of this realm has been explored and new features, and communities of animals (e.g. cold water corals and mud volcanoes) are discovered every year. The biodiversity probably exceeds that of the European land mass. There are natural hazards such as submarine slides and earthquakes with associated tsunamis. Human impacts on this zone are poorly understood. A prerequisite for management, conservation and protection from hazards of this zone is the establishment of a long-term monitoring capability. ESONET through a co-ordinated approach will provide data to users on time scales from instantaneous real-time hazard warning to long term archiving of data for tracking of global change around Europe.

II. COVERAGE

The aim of ESONET is to provide representative monitoring around Europe. Seismic activity in Europe is generally along the southern margin of the continent associated with collision with the African Plate beneath the Mediterranean Sea. Plate boundaries extend into the Atlantic Ocean at the Straits of Gibraltar and to the Mid-Atlantic Ridge. Seismicity is evident throughout the length of the Mid-Atlantic ridge from the Azores to Iceland (Fig. 1)



Fig 1. Locations of Earthquakes around Europe

There is therefore a clear need for stations at strategic locations along these plate boundaries to monitor events in the earth's crust.

Superimposed on this pattern within the solid earth are contrasting environments associated with the water column. Longhurst [1] has divided the world's oceans in to biogeographic zones based to a large extent on sea surface chlorophyll distribution as measured using the Coastal Zone Color Scanner carried on board US NIMBUS remote sensing satellites [2]. Around Europe 5 such deep water biogeographic provinces are recognised (Fig. 2). ARCT- Atlantic Arctic Province. This is the part of the Arctic Ocean with non-permanent ice cover and is characterised by strongly seasonal plankton production in surface layers.

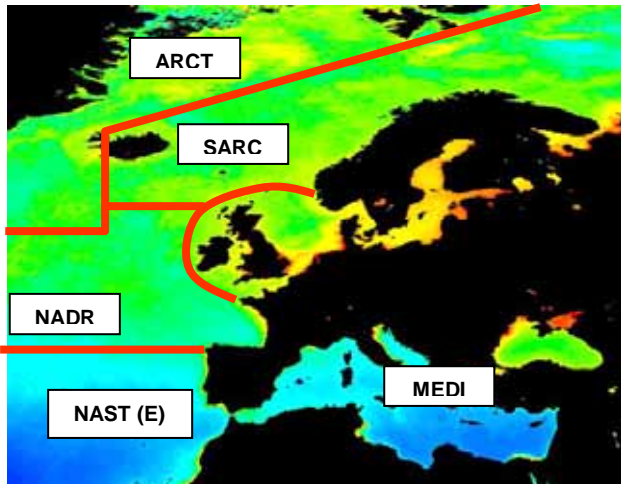


Fig 2. Biogeographic provinces around Europe. ARCT- Atlantic Arctic Province, SARC- Atlantic Subarctic province, NADR – North Atlantic Drift Province, NAST – North Atlantic Subtropical Gyre Province, MEDI – Mediterranean Sea/Black Sea province. Ocean colours represent chlorophyll concentration in summer, blue low red high.

SARC- Atlantic Subarctic province is influenced by surface warm water from the Atlantic and shows seasonal production that is distinct from that of true arctic waters further north. This region includes the highly productive Barents sea fishery area.

'NADR – North Atlantic Drift Province, This area has the biggest seasonal change in chlorophyll concentration anywhere in the world's oceans and has a dominant effect on the environment of western Europe.

NAST – North Atlantic Subtropical Gyre Province has lower productivity than the regions to the north and shows minimal primary production in later summer. Production increases in late autumn and reaches a peak in late spring. MEDI – The Mediterranean Sea resembles the subtropical Atlantic in its pattern of productivity but there are special features of an enclosed sea. The Mediterranean deep water is warm (ca. 12°C) to the bottom at over 4000m and highly oxygenated. The Black sea is strongly influenced by freshwater inflow from continental rivers producing a strong density gradient and a boundary at 80-200m depth below which oxygen is absent and hydrogen sulphide concentrations increase with depth.

Life in the deep sea is almost entirely dependent on fall out of organic matter from the surface layers. Therefore the abundance, biomass and composition of deep sea life is influenced by the patterns of surface productivity. The abundance of deep sea fishes is clearly influenced by surface production [3]. Furthermore flux from the surface varies both seasonally and from year to year. In the NADR province on the Porcupine Abyssal Plain a strong seasonal deposition of phytoplankton detritus has been observed in late summer at 4800m depth [4]. Over time the composition of the deep sea fauna has changed possibly associated with change in fluxes to the deep sea influenced by the North Atlantic Oscillation. During 1997-2000 and infestation of the North east Atlantic Ocean abyssal plain by sea cucumbers *Amperima rosea* (6457 ha⁻¹) and brittle stars *Ophiosten hastatum* (54,000 ha⁻¹) was detected [5]. If such events had occurred following some human intervention, such as deep sea waste disposal, it is likely that that the anthropogenic effect would have been held

responsible. It is evident that the deep waters around Europe function as coupled systems and it cannot be assumed that the deep sea is uniform and stable. Large scale changes occur that are very poorly understood. The central Porcupine Abyssal Plain location (PAP) in NADR is the best monitored deep sea abyssal location in the world. However monitoring only began in 1989 and a number of years are missing from the time series. There is an urgent need to establish continuous monitoring at this and other sites in order to track changes over time in the Oceans around Europe. Simple exploration during single visits to locations is no longer adequate.

An additional driver for development of ESONET is the development of underwater telescope arrays for detecting high energy neutrinos passing through the earth [6]. Three such systems are at various stages of development in the Mediterranean sea which has been chosen for its relatively sheltered location and low productivity resulting in low level of natural bioluminescence in the water column. The neutrinos are detected by an array of photosensors that identify Cerenkov radiation stimulated by interactions with water molecules. The aim is to implement an array up to 1km³ in dimension at a depths greater than 2km. Such an infrastructure with extensive cabling systems on the sea floor would provide considerable opportunities for synergistic development of ESONET observatories.

ESONET proposes a network of 10 regional observatories as shown in fig 3. ESONET will be a federation of these regional observatories each with its own lead institution and implementation committee. ESONET will provide standardisation, co-ordination and data interchange.

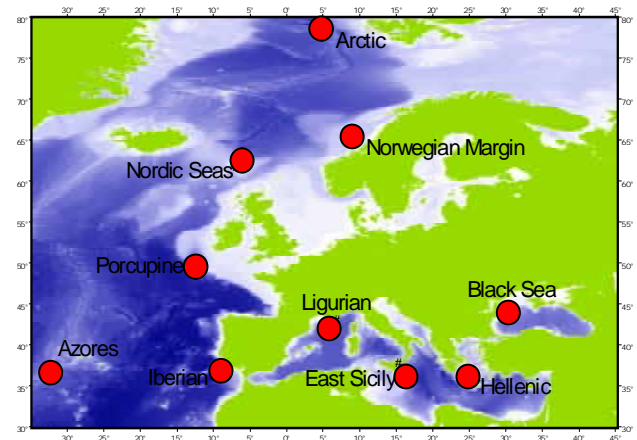


Fig. 3 The ten proposed ESONET regional nodes

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III. DESCRIPTION OF THE REGIONAL OBSERVATORY NODES

A - Arctic

The polar regions play an important role within the earth's climate system. Both regions, at high northern and southern latitudes, are characterised by low temperatures, distinct seasonality, huge areas of seasonal and permanent ice coverage. Massive and deep reaching permafrost layers cover large areas of the Arctic coasts. In particular, the Arctic is of outstanding relevance in respect to the development of the climate in Europe

Arctic water exiting into the Atlantic ocean between Europe and Greenland is an important component of the global deep water circulation of the planet and its heat budget. Establishment of a long term station here is important for tracking global change as ice cover decreases but there are also important deep sea habitats such as mud volcanoes in the 'Hausgarten' region, off Svalbard.

Polar regions are very sensitive to climate change. At the same time, they govern global climate evolution, directly influencing global sea level changes and, hence, the impact on coastal regions. Due to extremely long recovery cycles polar ecosystems are highly susceptible to perturbations. These sensitivities and properties make polar regions pertinent for long-term observations. Enabling the detection of any expected changes in abiotic and biotic parameters in the transition zone between the northern North Atlantic and the central Arctic Ocean, and contributing to a better understanding of deep-sea biodiversity, the German Alfred Wegener Institute for Polar and Marine Research (AWI) established a long-term deep-sea observatory (AWI-"Hausgarten") in 1999. This observatory, comprising 15 long-term stations covering a depth range of 1000 to 5500 m water depth, is situated west of Svålbard (see Figure).

Repeated sampling and the deployment of moorings and different long-term lander systems which act as observation platforms has taken place since the beginning of the station. A Remotely Operated Vehicle has been used for targeted sampling, the positioning and servicing of autonomous measuring instruments and the performance of in situ experiments.

Seasonal ice cover at "Hausgarten" hampers direct access to data and samples obtained by moorings and free-falling observation platforms. Permanent subsea stations and a cable connection to "Hausgarten" will help to overcome these logistic problems. The development of new long-term sensors and sampling devices operating autonomously over long time scales (e.g. an autonomous sediment sampler) are scheduled for the near future in close cooperation with SMEs.

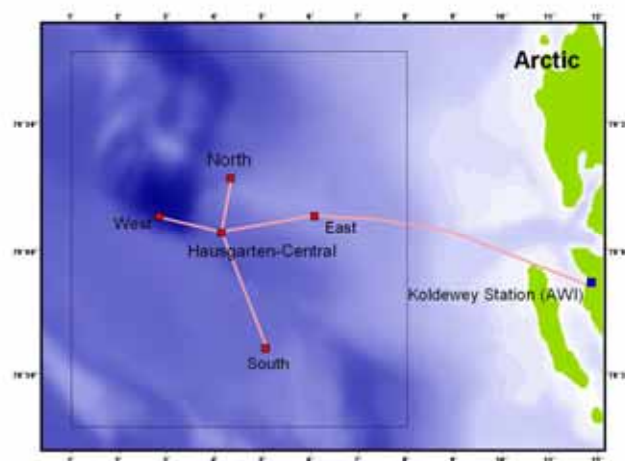


Fig.4 The proposed ARCTIC node west of Svalbard

B - Norwegian margin

This is a region that has shown slope instability with evidence of major submarine slides which if repeated could result in catastrophic damage to offshore oil and gas installations as well as indirect effects of tsunamis striking the coasts of the British Isles and elsewhere. Special deep water habitats, such as coral reefs, are also an issue.

Although there is a wide range of evidence indicating that global warming is taking place we are not well prepared to detect rapid as well as long term thermohaline circulation changes on a human time scale. Permanent stations are needed to monitor these changes.

Fluid flow from gas hydrates and geohazards may be a significant process within continental margins. The flow and gas emission at the seabed system that operates within them is not understood, even at the most fundamental level. Fluid flow is also potentially an important influence on the local distribution of benthic biota on continental margins and on biota in the sediments beneath them. We need to understand flow systems at a range of time and scales from that operating through the whole margin to those acting through a single seep. Do potential areas of deep-sea methane release have impacts on geohazards or climate? What are fluid flow episodes and how do they relate to ocean temperature changes?

The seabed of the ocean margins functions like a great bioreactor which harbours a vast diversity of microorganisms. There is ample evidence indicating that gas production, degradation of hydrocarbons, precipitation

of minerals, transformation of metals and much more are all microbial processes shaping ocean margin ecosystems. However, we are only at the beginning to identify the key microorganisms in these processes.

Sites of significance

Two sites of major interest relate to both the very important northern high latitude thermohaline circulation loop and gas hydrates. The thermohaline circulation to the Norwegian Sea manifested in the northward directed warm-water flow of the Norwegian current determines climate and living conditions above the Arctic Circle. Its warm water masses reach down approx. 700m, bathing the upper slope of the Norwegian continental margin. It is known that "switched on/off" scenarios existed for the Norwegian current and that such changes occurred during global climate change. It is deemed important to understand its short and long term development for predicting rapid and/or drastic changes which may, in turn, influence resources such as fish stocks in the ocean or societal living conditions on land.

Second, gas hydrates consist of ice-like crystals and store huge amount of methane, which is a potent green house gas. Gas hydrate melting and methane release may have elevated the planet out of ice ages, but they also may contribute to a future increase in global warming. The stability of this cold ice stored in sediments of the continental margins depends on both temperature and pressure. Thus the ocean bottom temperature are to be monitored in order to decipher potential environmental impacts. Two observatory stations with cable transects, one on the Mid-Norwegian margin close to one of the largest deep-water gas fields in Europe (Ormen Lange at Storegga), and one on the Barents Sea continental margin at a submarine mud volcano (HMMV), are envisioned. The sites range from approximately 900 and 1200 m water depth to the shallow water depth of the Norwegian current.



Fig.5 The proposed Norwegian margin node

C - Nordic Seas

The existing MOEN (Meridional Overturning Exchange with the Nordic Seas) station uses the Faroes branch of the CANTAT-3 cable for measuring water column induced voltage. The recorded voltage is strongly influenced by the inflow of the North Atlantic Current. Long term monitoring of this current is of paramount importance in the understanding oceanic fluxes of heat, salt and freshwater at

high northern latitudes and their effect on global ocean circulation and climate change in the arctic region.

The pleasant and stable weather situation of the northern Europe is largely a result of a heat and salt transport from lower to higher latitudes by the Gulf Stream. The actual Gulf Stream turns south at lower latitudes, but a persistent branch continues northwards. Eventually this current flows from the North Atlantic into the Nordic Seas, where it gradually loses its heat. The once warm and saline water becomes cold and heavy and as a result sinks and refills the Nordic Seas basin with dense saline bottom water. The continuous refilling of dense water results in an overflow of bottom water into the Atlantic over the deepest exit in the submarine ridge. This takes place in the Faroe Bank Channel. Hence, the warm surface stream has returned into the Atlantic as cold bottom water. This flip-over of water is named 'the thermohaline circulation' by oceanographers. A not insignificant side-effect of the heat loss is that living conditions of northern Europe become endurable.

There is no doubt that a slight change in the heat transport will alter the European climate and indirectly put a large strain on the social-economical status of the modern European society. The last ice age was associated with large changes in the thermohaline flow pattern, leading among others to the extinction of Neanderthals. Hence a long-term monitoring of the heat-flux into and out of the Nordic Seas is an important task to achieve. A highly providential circumstance is the fact that the Faroes are situated in the centre of the flows. This makes the Faroes a natural node of the Nordic Seas.

A full coverage of the flows requires three cabled branches, all of them commencing from the Faroes. The northern branch should be laid so to make measurement of the major inflow route possible. Likewise should the southern branch, monitor the warm surface water entering the Nordic Seas east of the Faroes. The western branch is laid with the purpose to facilitate measurement of the outflow into the Atlantic of dense cold bottom water. The work-horse will be the acoustical-doppler-current-profilers, but electromagnetic methods, current meters,

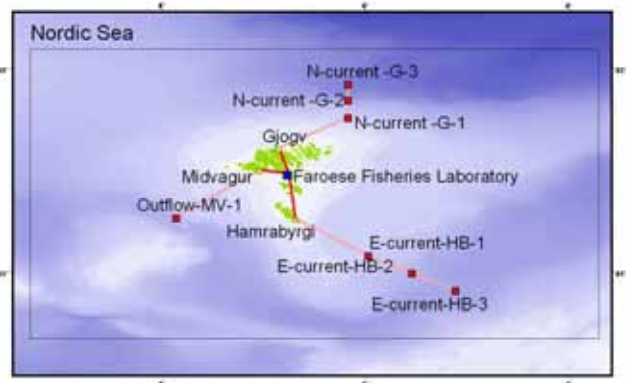


Fig.6 The proposed Nordic Seas node

temperature and salinity rigs will also be used. The locations of sensors are dictated by the position of the flow. All three branches have to make measurements possible over a transect-line covering meanderings of the flows. Each branch should, therefore, be equipped with junction boxes, to which the observatories will be connected

D - Porcupine/Celtic

This area has been an important area for bio-geochemical flux studies in the past but is also a very productive fisheries and oil-gas exploration area. It is a stable margin with little evidence of seismicity, but does have important deep water habitats.

The 'Atlantic Frontier', to the west of Ireland, is endowed with a diverse and rich assemblage of marine environments and associated habitats and fauna. At the European continental margin, water depth increases over a relatively short distance from about 150m to 4500m. Ireland's extensive offshore territory is considered one of the most promising for petroleum hydrocarbons (i.e. crude oil and natural gas). The Porcupine area forms a focal point of European deep sea fisheries and is closely located at one of the main arteries of global shipping. The continental margin features a high geomorphological variety with abundant canyons, broad- and narrow banded slopes, a vast intersection into the margin (Porcupine Seabight, PSB), in combination with a variety of smaller mesoscale geomorphological structures such as carbonate mounds. This large geomorphological variability provides the basis for a multifaceted habitat- and species diversity. Consequently, the area represents a major genetic and biochemical reserve of the European continental margin. One of the most spectacular ecosystems of the Irish EEZ are aphotic coral ecosystems, widely distributed along the NW-European continental margin. In the North Atlantic the major reef constructing coral is the colonial azooxanthellate *Lophelia pertusa* that has the potential to build substantial reefs in the aphotic zone.

Adjacent to the Irish continental margin lies the Porcupine Abyssal Plain (PAP). Surface water layers during winter form a mixed layer as deep as 800m driven by thermally convective overturning and wind forcing. With warming and reduced storm frequencies in spring, the water column becomes more stable and an upper mixed layer of about 50m thickness is established, leading to a major phytoplankton bloom. PAP lies south of the main stream of the North Atlantic Current and is subject to return flows from this coming from the West and Northwest. Processes at the seabed are dynamically coupled to upper mixed layer processes geared by atmospheric forcing. The downward

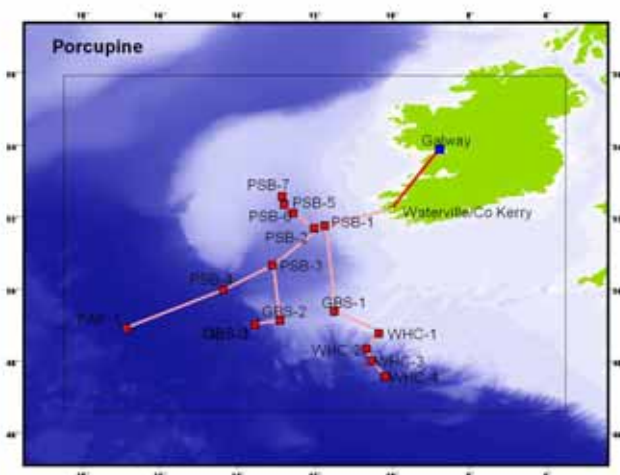


Fig.7 The proposed Porcupine node

flux of particulate matter from the upper part of the water column has a profound effect on ocean biogeochemistry and hence on the global climate; export below the winter mixed layer may isolate it from the upper ocean for

decades or centuries. Over the last decade, a dramatic change has occurred in the abundance of megafauna living over a vast expanse of the PAP. Many taxa, particularly sea cucumbers, on the abyssal seafloor at a depth of about 4850m have all increased significantly in abundance. Sites of significance encompass a main cable route from the shelf through the Porcupine Seabight into the Porcupine Abyssal Plain focussing on a carbonate mound/coral reef ecosystem (Belgica Mounds), a vast sponge ecosystem (Phaeronema Belt), a mid Bight station, the mouth of the PSB and the BENGAL Station on the PAP. Branches are proposed to the Hovland Carbonate Mound province, to the Goban Spur and to a canyon system, the later acting as a rapid conduit between shelf and deep sea.

E - Azores

This area has special habitats associated with hydrothermal vents and sea floor morphology is distinct with recent crust spreading from the mid ocean ridge axis. Several international meetings promoted by the InterRidge community concluded that the Azores is the key area of the North Atlantic for continuous monitoring. This area extends over the Azores Islands and along the Mid-Atlantic Ridge and

offers a unique opportunity to monitor:

- biodiversity of marine ecosystems
- life in extreme environments,
- the Mid-Atlantic Ridge
- volcanic seamounts
- response to environmental change
- sustainable management of fishing resources/ biodiversity
- chemical, geological, and geophysical processes
- interactions over inter-annual to decadal scales of the air-sea interface, water column, seafloor and mantle

A regional seafloor system will be an important European contribution to the global network of seismic and magnetic Observatories, currently implemented to study the Earth's deep interior. The MAR near the Azores is ideally located for this marine multidisciplinary observatory project: it is near port, allowing for short transit times for the deployment and retrieval of tools, and for cable deployment. It has been the focus of a great number of cruises in the past few years, as part of FARA (French-American Ridge Atlantic), the MARFLUX (MAST II, EC), AMORES and ASIMOV (MAST III, EC) and VENTOX (Framework V) European projects. The geological-geophysical background of this region is well constrained, as are the general characteristics of the known hydrothermal vents and the broad diversity of the associated ecosystems. From an oceanographic and climatic standpoint, an opportunity for remote observation of basin scale ocean circulation and its effect on long-term climate changes is possible.

The processes of interest are multi-scaled in space and time, requiring both fine and broad scale spatial sampling (cm to km), frequent temporal sampling, and sustained observation (inter-annual to decadal). Long time-series measurements of critical biological, geological, chemical and physical parameters are needed; addressed only by establishing continuous long-term observing capabilities

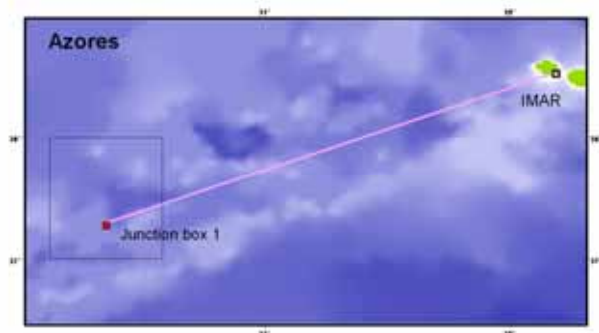


Fig.8 The proposed Azores node

F - Iberian

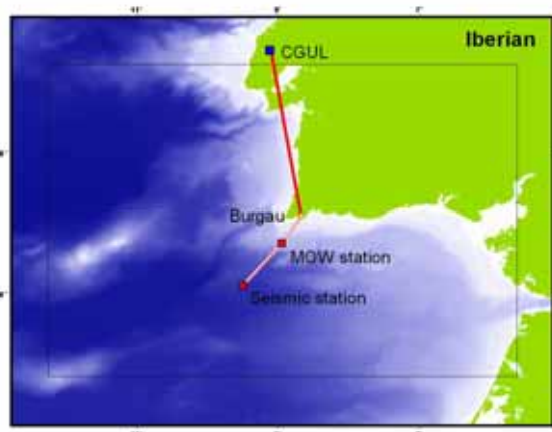
This is a region of complexity with the junction of the Eurasian and African plates resulting in doming of the sea floor, mud volcanoes and other complex features. The interaction of the Mediterranean outflow with Atlantic waters is significant.

Southwest Portugal, the Gulf of Cadiz and Morocco are prone to earthquake and tsunami as testified by the great 1755 Lisbon earthquake and tsunami. This event was the most catastrophic earthquake that ever occurred in historical times, Western Europe. With an estimated magnitude 8.5-9.0, this event generated anomalous sea waves that struck the coast of Portugal, Spain and Morocco and were observed all over the North Atlantic, as far as Great Britain, Finland and the Caribbean Sea. It caused severe destruction in Lisbon, Tanger and Casablanca. Most of the seismic activity is due to Europe - Africa plate convergence and it occurs at sea, along the continental margin of SW Iberia and in the Gulf of Cadiz. Due to lack of permanent seismic stations at sea the seismic activity is not properly monitored. This fact prevents either the early detection of the eventual tsunamis waves, either the precise location of low magnitude earthquakes, which are key data to understand the present stress behaviour of the margin.

Extensive mud volcanism, pockmarks, mud diapirism and carbonate chimneys related to hydrocarbon rich fluid venting are been recently observed throughout the Gulf of Cadiz. The Gulf of Cadiz is also the site to investigate of the Mediterranean Outflow Water (MOW) because it affects the deep-water circulation on global scale.

The main objective for the Iberian region is to realise a seismic monitoring network in the Gulf of Cadiz, thereby providing an in-depth knowledge of the seismic activity of the area and a capability in early detection of tsunami. From an oceanographic point of view the Gulf of Cadiz is of great importance for the study of the Mediterranean Outflow Water (MOW), which affects global deep-water circulation. An additional objective in this region is to monitor the temporal variation of the warm (13°) and saline (>37 g/l) MOW. The MOW flows out from the strait of Gibraltar and spreads in the Gulf of Cadiz at depth of 800-1200 m with two main branches. One branch diverge northward, toward the Bay of Biscay, the other crosses the North Atlantic reaching the Labrador and Norwegian - Greenland seas after 20-30 years. The station will allow, through continuous measurements over the years, the correct assessment of the salinification and warming of

MOW and the study of its inter and intra-annual variability in relation to atmospheric forcing. Measurements of MOW in the Gulf of Cadiz may anticipate climate change at the scale of tens of years. The location for the main deep-sea long-term observatory is at about 100 Km SW of Cape San



Vicente at water depth of 3000-4000m.

Fig.9 The proposed Iberian node

G -Ligurian Sea

Existing cables installed for the ANTARES neutrino detector experiment and long term data for the nearby Banyuls Sola site (SOMLIT network) make this a practical early site for development.

The Ligurian sea is a large multidisciplinary area of interest with many technical advantages for a demonstration observatory. It would play in ESONET a similar role to the Monterey Accelerated Research System (MARS) in the American NEPTUNE development. Many subsystems are already available such as the land fall station, the cable landing and one junction box from the Antares neutrino observatory project. All the technology and subsea intervention know-how is mastered by the partners. Moreover, the site is in deep water not far from important harbours and seastate conditions are well known and favourable for tests and sea operations.

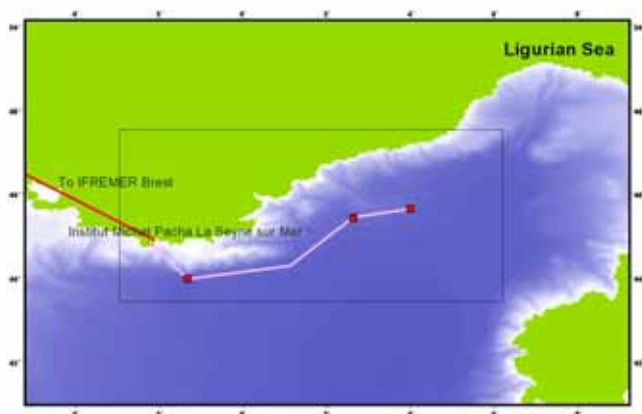
Almost all scientific packages within ESONET will have a scientific interest at the Ligurian region. Long term series of data exist in many fields and scientists now require real time high frequency sampling rates to understand processes and develop predictive modelling.

Positive features of the Ligurian region are:

- It is a seismic area not far from an inhabited region. The active fault in deep water cannot be monitored from shore due to propagation anomalies induced by the geologic structure. An instrumented ODP borehole will complement seismometer measurements in the future.
- Slope instabilities are located on the continental slope. The last catastrophic event occurred at Nice airport, in October 1979. One effect of this land slide was the rupture of telecommunication cables 110km from Nice in 2500m water depth. It would be dangerous to land the cable in this area; it is better to use the Antares installation in Toulon.
- Hyperpycnal and turbidity currents appear at the Var river mouth during overflow events and their effect is propagated down the Var canyon. The same phenomena at larger scale appear in major river systems like the Zaïre. The site is convenient to develop scientific knowledge on this process.

- In the Ligurian Sea, the offshore area is completely isolated from coastal influence by the Liguro-Provençal current. It is representative of large areas of the world ocean. Dynamics of Fluxes in this region have been monitored since 1988, participating to the JGOFS program.
- More than 20 parameters are collected on a monthly basis. Since 2003, the area is used as a calibration point (BOUSSOLE buoy) for water colour satellite sensors.
- Dynamics of oceanographic processes: wind driven coastal upwelling, particle plumes, nutrient benthic exchange, bottom boundary layer processes, mesoscale variabilities.
- The site is an international sanctuary for marine mammals. The observatory will allow an understanding of their behaviour in relation with oceanic processes.

It is proposed that the Ligurian Sea node will comprise:
-three stations with at least broadband seismometers,



biogeochemical sensors and physical sensors;
-a local array with acoustic networking will monitor slope stability (piezometer, geodesic and turbidity –current sensors, turbidimeter, ...);
-- moorings on DYFAMED area will monitor the dynamic flux studies (particle samplers, fluorimeter, chemical analysers, ...).

Fig.10 The proposed Ligurian Sea node

H -East Sicily

This is located at an important offshore site close to Mount Etna, where the Italian SN-1 multidisciplinary observatory has been established. The existing cable for NEMO neutrino experiment provides a focus for real-time data transfer and the integration of the seafloor observatory into land-based networks.

Eastern Sicily has experienced disastrous seismic events, some of them accompanied by tsunamis, mostly generated by seismogenic structures lying at sea. The 1693 and 1908 earthquakes, both reaching an intensity of XI on the MCS scale, completely destroyed the cities of Catania and Messina. A large area, from the southern Calabria to Malta, was devastated. Both shocks were followed by a large tsunamis along the whole eastern Sicily coast, the Messina Straits and, probably, the Aeolian Islands.

In recent times Eastern Sicily has experienced events of minor intensity, many of which originated from off-shore tectonic structures, causing serious coastal damage. In December, 1990 an earthquake (intensity VIII MCS) caused severe damage in Augusta, south of Catania and numerous fatalities in the small town of Carlentini (Catania).

This earthquake was accompanied by anomalous sea behaviour along the Augusta coast.

The Mediterranean basin is characterised by the collision processes between the African and the European plates; Sicily represents the natural connection between the Apennine and the North-African chains. The region is characterised by intense volcanic basaltic activity, probably connected to extensional tectonics responsible for the Iblean volcanism and the formation of the Etna edifice, or by frequent and strong seismic events. The adjacent Ionian region is characterised by the presence of a large submerged structure, the Malta escarpment. The existence of other important submerged seismic structures is confirmed by off-shore bathymetric and seismic prospecting; however, medium-low magnitude marine seismicity, which could provide useful information on the characteristics of the area, is neither well detected nor localised.

The Eastern Sicily node will be based on SN-1, a deep seafloor multi-parametric cabled to shore observatory. SN-1 mainly focuses on geophysical, oceanographic and environmental data that are uniquely time referenced. A modular design allows additional sensors to be added as required.

SN-1 was developed in the framework of an Italian national project co-ordinated by INGV, and was validated during a long-term mission (7 months) in the period Autumn 2002-Spring 2003 in the Ionian sea, 25 km off the city of Catania at a depth of 2000m at the foot of the Malta escarpment. SN-1 is a spin-offs of the GEOSTAR projects (GEophysical and Oceanographic Station for abyssal research), which led to the development and successful operation of the first European seafloor observatory.

The underwater electro-optical cable for the connection of the observatory to on-shore, already deployed, is property of the Italian Istituto Nazionale di Fisica Nucleare (INFN) and will also supply a pilot experiment for the submarine detection of neutrinos (NEutrino Monitoring Observatory, NEMO). SN-1 is already equipped with a junction box for the connection to the cabled interface-device.

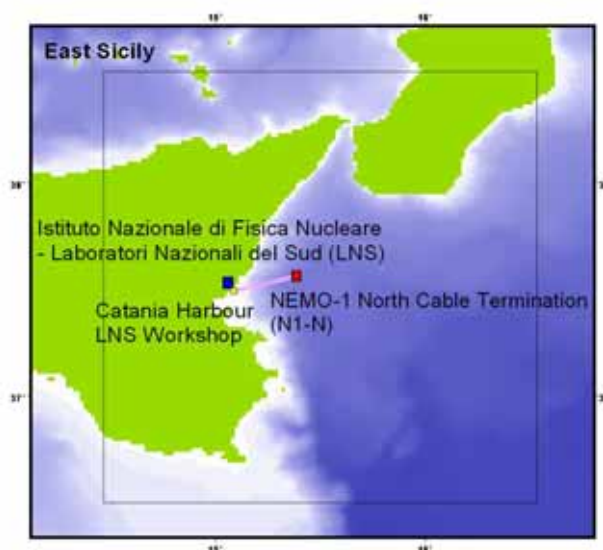


Fig.11 The East Sicily node

I -Hellenic

The eastern Mediterranean is characterized by significant seismicity, special habitats in deep basins and a very steep drop off in depth from the coastlines

The Hellenic region comprises of four distinct networks:

1. NESTOR (existing neutrino observatory cable),
2. BUTT-1 (IODP – site of proposed deep borehole),
3. Cretan basin
4. Rhodos basin.

The overall aim of these stations is for the long term investigation of seafloor processes.

- to quantify slow versus fast fluid flow and carbon/methane fluxes
- to develop long term monitoring observatories for oil/gas industry
- to create a science platform capable of offering a totally new approach to public outreach and awareness of ocean processes.
- to develop an enhanced 3D visualization of multi parameter datasets
- to carry out hydroacoustic studies on fluid flow pathways and mineral crusts in upper sediment layers
- to link fluid, methane flow with tectonic movement and seismic activity
- monitor the biology and ecology of these deep area

An internet operated vehicle (IOV) has been built with the capability to move along the seafloor by video control and to carry out detailed investigations on fluid and particle fluxes in the benthic boundary layer.

For the NESTOR-ESONET deep sea observatory three crawlers will be built, each equipped with different sensor systems. All crawlers will be connected to one central instrument system (lander), which is located up to 100 m away from the node, carries additional sensors and transfers the data of the IOVs to the land based data centre or offshore installation.

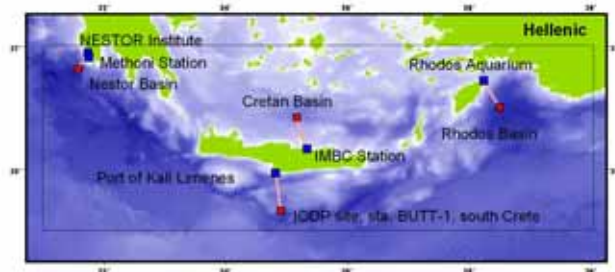


Fig.12 The Hellenic Regional node

J -Black Sea

With anoxic conditions in the deep, problems with invasive species and high sediment loads delivered to the system, this area has unique problems requiring long term stations.

The Black Sea represents an almost landlocked basin and the largest anoxic water mass on earth. It is a key region for the south European climate as it is the source for the south European rain fall. The coastal zone is densely populated with approximately 16 million inhabitants and an annual 4 million tourists visiting the sea coast. Since the early 70s, there has been a rapid rise in nutrients, organic eutrophication and chemical pollution due to transportation, construction, tourism and the use of pesticides and fertilizers. In addition, high intensity gas seeps, gas hydrates, mud volcanoes and earth quakes are frequent. Both in turn affect the Black Sea biota and biological

resources. The intense marine traffic and offshore exploration of oil and gas constitute additional sources of marine pollution.

The biological components of the Black Sea ecosystem are strongly dependent on its geographical position and morphology. The upper water layer, supporting a unique biodiversity of species is so thin and fragile that the effects of pollution, unsustainable fishing or destruction of habitats and landscape result in dramatic ecological changes which have knock-on socio-economic impacts. In deeper anoxic waters, unique microbial ecosystems form reef-like structures above methane seeps. However, knowledge about life in the deep layer is still very limited. The disturbance of the natural balance between the two water layers could trigger irreversible damage to the ecosystem and people of the Black Sea.

Sites of significance are:

- Zernov's Phylophora fields (unique ecosystem endangered by hypoxia since the 1960s)
- Dnjepr paleo-delta at the shelf margin (shallow, above gas hydrate stability zone, gas plumes cross anoxic/oxic interface and may reach the sea surface)
- Dvurechenskiy mud volcano area at the Sorokin Trough (deep, below gas hydrate stability zone, 1000m high gas flare detected 2002)
- Danube Delta (major river discharge)
- Dniestr and Dniepr River mouths
- Varna & Bosphorus (earth quake occurrence)



Fig.13 The Black Sea node

The long-term cabled observatory will provide continuous data on high intensity gas flares and environmental control parameters of gas and fluid discharge (e.g. bottom currents, microseismicity, earthquakes, gas hydrate stability, role of mud volcanoes)

IV. MOBILE OBSERVATORY

Many ocean sensors (e.g. optical imaging, chemical sensors) have a limited field of detection so that a sea floor observatory can only sample a small fraction of submarine domain. The aim of the ESONET system is to achieve representative temporal and spatial sampling. However from time to time emergencies may arise and it is important to be able to respond by deployment of observing capacity in the region of interest. A mobile element is therefore proposed within ESONET to monitor unforeseen natural or anthropogenic disasters, wherever they may take place, in order to mitigate any negative impacts on ocean resources and guarantee future environmental security.

Catastrophic maritime events often happen in very bad weather conditions and in areas where environmental

conditions are not very well known. Crisis management and safety advice can only be based on available data. Mobilisation of resources from within the ESONET network would provide a hitherto unseen capacity to respond and tackle such issues rapidly and efficiently, while providing vital information in a timely and coordinated way. This could be achieved using ships of opportunity, military aircraft or civilian chartered helicopters. Equipment flown from a centrally located environmental security centre could arrive anywhere within Europe in less than 24 hours, providing environmental managers with a critical and distinct advantage.

ESONET proposes to deploy an local acoustic networked observatory system around the wrecked ship or within the geohazard event area. Operations will be conducted in two steps:

1 - Deployment of bottom stations, by opportunity ships or helicopters, performing standard environmental measurements (temperature, salinity, current profile, oxygen, methane,...). These stations will be flown from a security centre to achieve a rapid response time. An acoustic local network, will be used to communicate between stations and between stations and a surface receiver, on a ship or on a helicopter during the first step.

2 - Additional dedicated nodes equipped with sensors appropriate to the cargo of the wrecked ship or geohazard will be deployed after the initial response phase. Sites of data collection will be refined and specific monitoring infrastructure will be relocated by submersible or ROV: e.g. cameras for monitoring continuing seepage, fluorimeters, spectrometers, chromatographs etc. A buoy will be also moored to assume permanent communications with a remote control centre.

V. CONCLUSIONS

The ESONET plan has been developed under a concerted action sponsored by the European Commission. A partnership with over 300 members world-wide has been established. Parts of ESONET build on existing cable infrastructure. Other parts operate with non-real time data acquisition using autonomous observatories (e.g. landers). ESONET will be gradually developed as a federal system using appropriate technologies, funding and management regimes in different regions.

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