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REPORT TO EMSO ON IMPLEMENTATION MODEL

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Organization name of lead contractor for this deliverable: **IMI**
Lead Authors for this deliverable: **Mick Gillooly, Nick O'Neil, Paolo Favali, Jean-François Rolin, Henry Ruhl**

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RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	X

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1.0 EXECUTIVE SUMMARY

The scientific, political and socio-economic drivers for deep-ocean observation have increased as societies depend more and more on information about the ocean and its hazards and functions. The European Union (EU) has invested in deep-ocean research for many years. However it has been recognized for more than a decade that current observation and research efforts are not capturing the detailed information we now know is needed about the ocean. Consecutive EU Framework Programs have since invested in the successful integration of the geoscience, physical oceanography, biogeochemistry, and marine ecology research communities in order to reduce fragmentation and increase the effectiveness of research investments. The formation of an open-access European ocean observatory research infrastructure is a key solution to fostering further integration of stakeholders, technology and standardisation, quality control, and ultimately needed data, thus maximising research investment. Long-term fixed-point observatory systems in the deep ocean with sensor-to-shore telemetry comprise a key contribution to worldwide earth observing systems. By connecting processes from the surface to below the seafloor over a range of scales these observatories will provide critical data for evaluating the potential impacts of climate change and other human impacts, as well as information for maritime industries and improving geo-hazard early warning.

The importance for sustained integrated global ocean observations is becoming well known because of the contribution of ocean observations to improved weather forecasts, climate projections, natural resource management, tsunami warning and earthquake awareness. The cost of disasters in social and economic terms continues to rise. The European ocean multidisciplinary observatory network will not only provide key scientific research data, but it will be capable of providing deep-ocean data to the Global Monitoring of Environment and Security (GMES) and Global Earth Observation System of Systems (GEOSS) programmes, which will improve longer-term forecasting. As a matter of fact, the development of models will be fostered thanks to the calibration by in-situ data immediately available. Ocean observatories will ultimately benefit all maritime activities in Europe, which are considerable. The open-access policy for collected data will also increase access for women and young researchers and those areas where access to high-quality data is relatively rare, enlarge the access to deep-sea research for a wider pan-European community and attract world wide research cooperation.

Eleven sites have been identified by the European Seas Observatory NETwork Network of Excellence (ESONET NoE) as potential nodes of underwater infrastructure for scientific, technological, and socio-economic interests. Some of these sites are cabled and already have some operations ongoing; others are stand-alone sites with moorings and benthic instruments communicating in real time or delayed mode; while others are at earlier stages.

The EMSO (European Multidisciplinary Seafloor Observatory) Preparatory Phase programme endorses the new EU framework called European Research Infrastructure Consortium (ERIC), for creating a formal organization to operate ocean observatory infrastructures in Europe in cooperation with the ESONET NoE and observatory users worldwide. A roadmap and business plan for staged implementation has been developed, with key phases to be completed between 2010 and 2020. There are a number of decision and cost points to allow timely progress. The structure of financing is flexible with grant funds by member states, bank loans including EIB Risk-Sharing Finance Facility, and possibly revenue re-investment, and private sector equity all having roles over the project lifetime. The adoption of the plan will require a commitment from at least three member states, represented by their national funding agency to set up the ocean observatory ERIC. The phased development of the network will occur in sequence dictated by the scientific and socio-economic needs of national and intergovernmental marine agencies and industry and the level of funding offered by member states, private sector, and EC.

2.0 INTRODUCTION

The EMSO research infrastructure preparatory phase[1] is underway. It will meet the needs of a wide networked community built around ESONET Network of Excellence[2]. The interests for this field of subsea observatories have been shown by a large group of stakeholders as demonstrated by a recent workshop for organising a Virtual Institute of Scientific users of deep-Sea Observatories (VISO) in Tromsø, Norway [3].

It is likely that the EMSO observatory infrastructure will be among the first marine environment research infrastructures in Europe meeting the criteria of an open access long-term operation.

As planned in the Description of Work of both projects, the Network of Excellence (ESONET WP5) reports to EMSO Preparatory Phase in order to support this implementation process. This report is also a basis of discussion for the strategic committees.

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[1] Funded according to the ESFRI roadmap by the European Commission –FP7-INFRASTRUCTURE-2007-Project 211816

[2] Esonet NoE (European Seas Observatory Network) is a Network of Excellence funded by EC under FP6 – Global change and Ecosystems – Contract 036851

[3] Virtual Institute of scientific users of deep Sea Observatories
http://www.esonet-noe.org/news_and_events/esonet_workshops_and_meetings/
viso_workshop_11_12_june_2009_in_tromso_norway

3.0 THE OCEAN AROUND US

Ocean research has identified a great number of processes that have mechanistic links to societally important functions like climate regulation, carbon dioxide uptake, and natural resource production and safety of coastal population, which occur over a wide range of scales. The importance of these processes to society has driven the need for further research into how these processes operate and interact to become a major international science priority. These processes operate in and among the fields of geoscience, physical oceanography, biogeochemistry, and marine ecology (Figure 1). Integrating research in these fields using ocean observatories will advance innovation in ocean and Earth science in Europe and inform future European policy and increase European competitiveness. Several important themes persist including:

- Natural and anthropogenic change
- Interactions between ecosystem services, biodiversity, biogeochemistry, physics and climate
- Impacts of habitat destruction and pollution on ecosystems and their services
- Impacts of exploration and extraction of energy, minerals, and living resources
- Geo-hazard early warning capability (e.g. for earthquakes, tsunamis, and CH_4 release)
- Connecting scientific outcomes to stakeholders and policy makers

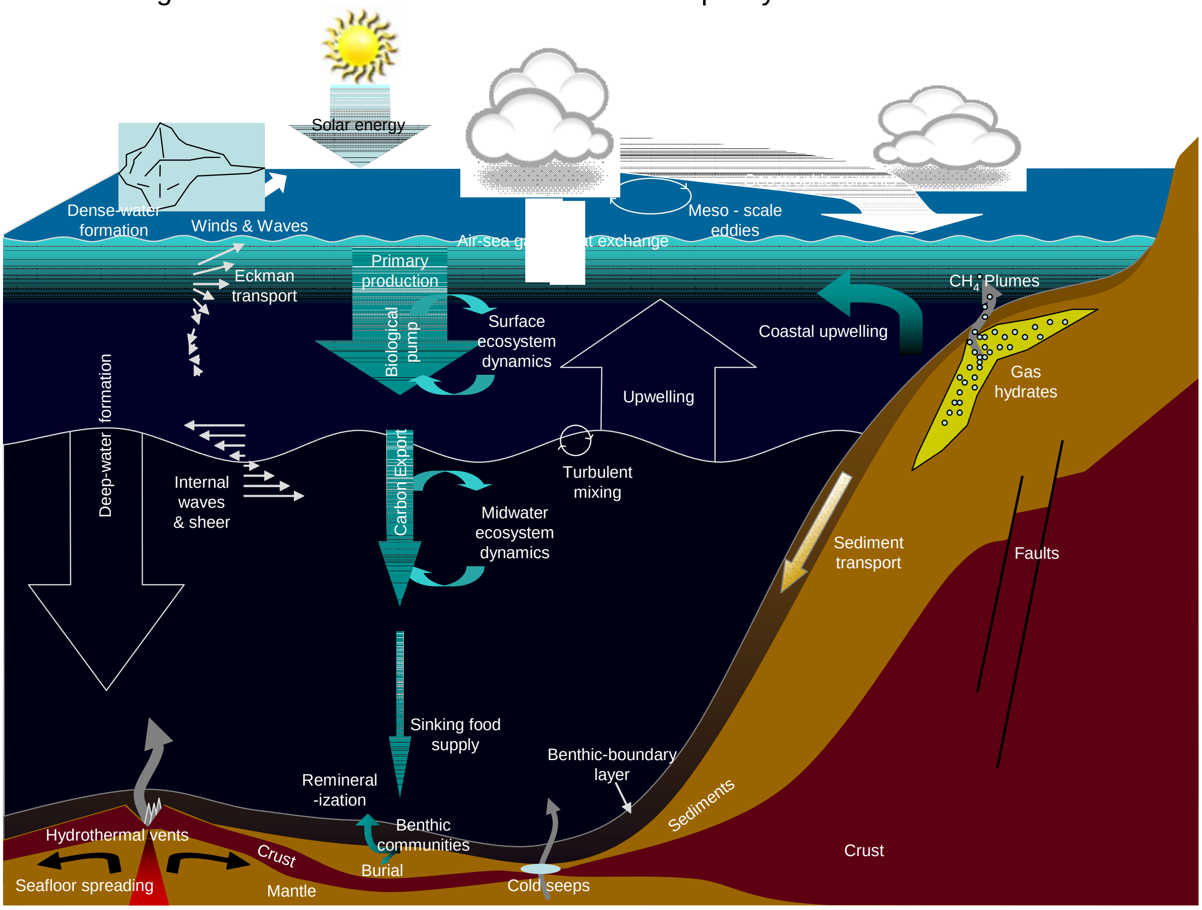

Figure 1 Illustration of major processes in the marine environment indicating the interconnectedness of atmospheric, surface ocean, biological pump, deep-sea, and solid-Earth dynamics. This figure is from Ruhl et al. (submitted) and is based on other similar figures prepared by P. Cochonat, C. Berndt, the US Ocean Observatories Initiative (OOI), and ESONET-NoE.

Geoscience

The solid earth holds many natural resources and its dynamics release massive amounts of energy in relatively unpredictable ways. The majority of Earth, however, is covered by water several thousand meters deep. Efforts to more effectively collect solid earth data must include substantial amounts of information from deep-sea sites. Seismic activity in particular is related to tectonic motion, fault rupture, magma flow, volcanism, hydrothermal venting, ridge and seamount formation, slope stability, and can cause the formation of tsunamis. Intense geologic activity can result in damage to offshore industry infrastructure, ecosystem perturbations, and catastrophic impacts on citizens. Seepage of fluids (cold seeps, hydrothermal activity, hydrate melting, etc) have a strong influence that can only be evaluated from the seafloor over a long observation times. High-resolution measurements substantially aid the deciphering of factors that lead to earth motions and control geologic processes, as well as improving theoretical frameworks. These measurements need to be of long enough duration to pick up sufficient numbers of episodic events to differentiate them from trends or shorter period variations, have enough dispersed measurements to capture important signals, and convey them to stakeholders in a timely manner.

Physical Oceanography

Ocean circulation transports heat and entrained chemical and biological essentials through lateral and vertical motions, and therefore has a tremendous impact on processes that relate to all other marine disciplines. Physical processes in the ocean range from sub-millimetre to basin scale. Thus detailed knowledge about ocean transport is mandatory when it comes to assessing the role of the ocean in the climate system or understanding the oceans ecosystem function. The major forces that govern physical processes in the ocean include buoyancy changes, horizontal pressure gradients, friction at the oceans surface and the sea-floor, gravity, and earth rotation (Coriolis force). Interaction of the forces creates complex transport patterns such as surface and internal waves, tides, fronts, ocean currents, and eddies, which all feedback on other ocean marine processes. One of the most pressing issues in ocean science today is the need to understand the impacts of global climate change on the marine environment, which will likely be long lasting. Understanding ocean circulation is a fundamental part of evaluating ocean-climate feedbacks and how climate change could influence biogeochemistry and marine ecology. There is a need of deep-sea reference data for the establishment and assimilation inside physical oceanography models and their operational application.

Biogeochemistry

Ocean biogeochemical dynamics describe the ways in which the geophysical and chemical attributes of the ocean interact with marine biology and ecology. For instance up to one third of the anthropogenic carbon dioxide being produced today is being taken up by the oceans through two processes widely known as the solubility and biological pumps. Traditional oceanographic methods have not been able to effectively quantify the efficiency of these processes. Fisheries management depends on informed estimates of the dynamics of the biological pump, as does understanding variation in the efficiency with which surface production is transferred to support deep-sea life.

The ability of the ocean to store excess carbon related to climate change is not well constrained. Declining uptake of anthropogenic carbon dioxide by the ocean could increase the proportion that accumulates in the atmosphere. Integrated research has so far found that impacts from climate change include ocean warming and acidification, which are anticipated to have important impacts on ocean circulation and global biogeochemical cycles. Further integration of research is needed to understand what ocean processes and feedbacks will be most critical during climate change.

Marine Ecology

Marine life is widely regarded for its diverse array of form, splendour, and renewable food resources, but marine organisms also have critical biogeochemical and ecosystem functions. Marine ecosystem function maintains key services like primary production, climate regulation, carbon sequestration and storage, and living resources like fisheries and natural molecular products. Specimens collected from marine habitats during observatory operation in deep-sea and extreme environments could have potential for cancer, antibacterial, extreme environment enzymes, and other beneficial molecular products.

The oceans are filled with natural and biological sounds, although many artificial sources have contributed increasingly to its overall noise budget. How these anthropogenic sources are affecting marine life constitutes an issue of considerable interest both to the scientific and public community. The design and implementation of research on the effects and control of man-made noise in the marine environment will be interdisciplinary and will use information provided by existing and future underwater observatories.

The pace and scale of anthropogenic changes occurring in the oceans and the impact of these changes on marine biodiversity and ecosystems are cause for serious concern. Ocean observatory research efforts to better understand marine biodiversity will provide the knowledge necessary to inform an adaptive management process by linking variations in biodiversity, its function, and the ecological and environmental forcing that drive change in a comprehensive way.

The persistent discovery of life in environments that were previously thought to be relatively devoid of life continues to redefine the fundamental abundance, distribution, and function of life on earth. (Figure 1) The discovery of microbial life in hypersaline brine in sediments several hundred meters below the seafloor and chemosynthesis-based communities at the seafloor continue to redefine understanding of life and ecosystem tolerances. While chemosynthetic systems are spatially isolated compared to photosynthetically-driven systems, they provide excellent opportunities to study systems which are partly independent from solar energy. Quantifying the diversity of form and metabolic function in these extraordinary communities continues to be a major research focus with direct links to geoscience (see also Deliverable 11 of ESONET NoE).

The Vision for Transformation

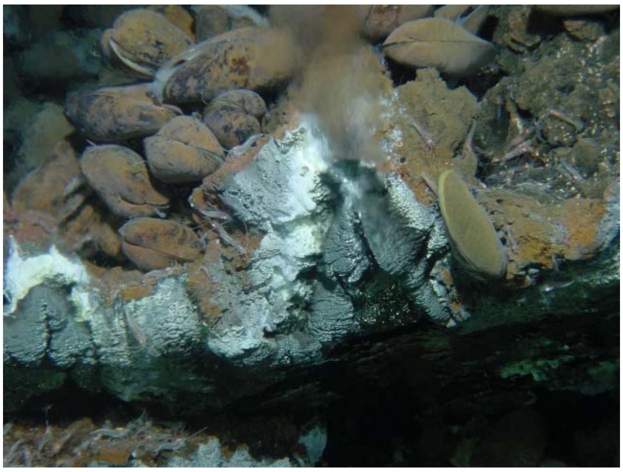

Figure 2 Sulphide structure colonized by the mussel (adults and juveniles) Bathymodiolus azoricus, with the fish Gaidropsaurus mauli on the fissure. © Missão Seahma. 2002 FCT/PCDTM 1999MAR/15281)

The combination of data from ocean observatories with other data from seismic, climatic and other data centres has great potential to change the way in which researchers cross research disciplines and reduce uncertainty in issues of great societal importance like climate change, natural resource utilisation, and increased understanding and monitoring of environmental geo-hazards. A better understanding of global change, human impact reduction, mitigation and geo-engineering methods will result in socio-economic benefit. Therefore ocean observing efforts have and will attract public and private financing to continue to build, expand and integrate the European ocean observatory network.

A durable European research network and infrastructure of ocean observatories to simultaneously collect interdisciplinary data will transform the ability of science to inform European government policy and business strategy with a certainty and efficiency which has not yet been possible. Furthermore, European research will become more integrated through open access to the ocean observatory infrastructure. Open access boosts the scientific and technological return from the large investment in observatory infrastructure; it enables scientists from less-favoured countries to perform top-level research without migration of skilled workers and enhances the research opportunities for women and young researchers.

4.0 SOCIO-ECONOMIC DRIVERS

There is a growing awareness of the impact of the open-ocean and deep-sea environments on human society. People are witnessing a decline of the ocean's vast resources and their ability to use those resources. Pollution, habitat destruction, over fishing, climate change, and invasive species emerge repeatedly as the major causes. These threats interact with each other to damage natural ecosystems, reduce biological and economic diversity and productivity. Human societies now depend on accurate and timely information on climate, weather, water, ecosystems, biodiversity, energy resources, and natural disasters. It is the societal need to understand and mitigate against the negative effects of these matters that drives the majority of earth and ocean science.

The United Nations Environment Programme and the Center for Ocean Solutions have highlighted oceanic and deep-sea ecosystem functions and the goods and services and socio-economic benefits they provide (Table 1).

Forcing factor	Supporting services	Socio-economic services	Socio-economic impacts
Natural disasters	Photosynthetic production	Provisioning services	Increased geohazard risk
Climate change	Chemosynthetic production	Food resources	Reduced biogeochemical pump efficiency
Ocean warming	Nutrient cycling	Hydrocarbon energy	Respiratory stress
Ocean acidification	Carbon sequestration & storage	Minerals	Altered heat and nutrient transport
Storm intensity	Biodiversity resilience	Genetic resources	Heath risks from toxic compounds
Seafloor stability	Habitat	Chemical recourses	Food web destabilization
Sea-level rise	Sediment transport	Waste disposal sites	Habitat loss
Overfishing	Organic matter transport	Regulating services	Human and animal migration
Pollution	Geomorphology	Water circulation & exchange	Reduced tourism, recreation, aesthetics
Habitat destruction		Climate & weather regulation	Food security
Acoustic noise		Carbon sequestration & storage	Marine-related industry activity
		Waste absorption & detoxification	
		Biological control of harmful species	
		Geoengineering	
		Cultural services	
		Employment	
		Education	
		Scientific advancement	
		Quality of life	
		Recreation	
Science & Policy	Science	Science & Policy	Policy

Table 1 Connections between forcing factors, supporting and utilized services, and socioeconomic impacts, as well as how these relate to policy and ocean observatory science which describes links between forcing and services and thereby informs societal policy. This table was adapted from the similar relationships outlined by the United Nations Environment Programme (UNEP), HERMES, and the Center for Ocean Solutions (Table 1, Ruhl et al. (submitted), UNEP 2007, Center for Ocean Solutions 2009, Grehan et al. 2009).

Services provided by oceanic and deep-sea ecosystems can be broken down into upstream supporting services, and provisioning, regulating and cultural services that rely on the supporting services. In the ocean these range from nutrient cycling and biodiversity resilience in the upstream to food resources, climate regulation, weather stabilisation and quality of life. The connections between forcing factors, supporting services, and services and their socio-economic impacts are often undefined. It is the societal need to understand these connections that drives ocean observatory science today. Results from observatory science will feed into GEO, as well as other organizations like the Intergovernmental Panel on Climate Change (IPCC), UNEP, and OSPAR, (the Convention for the Protection of the Marine Environment of the North-East Atlantic) to form and revise policy and legislation. The strategy of the European Union provides a major driver for EMSO and a schedule of implementation. EMSO open seas and margins seafloor data are needed to build the program of the Marine Strategy Framework Directive [4] before 2014 and operate the prescribed monitoring to ascertain a good environmental status from 2014 over to 2020.

The case for sustained integrated observations for the atmosphere is direct and easy to make. Everyone has an understanding of the value of weather and climate information. The case for sustained integrated global ocean observations, including the tremendous and poorly known deep seas, is much less obvious to decision makers and to the public, in spite of the indirect contribution of ocean observations to improved weather forecasts and climate projections. According to the insurance company Swiss Re in 2008 natural catastrophes, such as tropical cyclones, typhoons and earthquakes caused 234,842 fatalities and lead to economic losses of USD 269bn. The cost to property insurers was USD 52.5bn making 2008 one of the costliest catastrophe years in history. Despite improved understanding of the hazard phenomena involved, the cost of disasters in social and economic terms continues to rise. The disproportionate vulnerability and impact of disasters on developing countries is a cause for concern in the developed world: methodologies of permanent observation experimented nearby Europe seas will have to be disseminated . The need for improved prediction and early warning that integrates measurements from deep-ocean and land-based observations is needed particularly in the Mediterranean, Arctic and NE Atlantic regions. European observatory infrastructure is providing the capacity to synergise with the US, Canada and Japan to provide these services.

The socio-economic interest in marine safety in relation to transportation, pollution, search and rescue, and minimizing consequences of natural hazards all require specific observations of ocean physics. The European subsea observatory network will not only provide key scientific data, but it will be capable of providing fixed point deep-ocean data to GMES and GEOSS which will improve longer-term forecasting. These data will be especially important for geo-hazard monitoring (e.g. Mediterranean from Atlantic to Black Sea) and for monitoring of the pollution in areas of dense maritime traffic (e.g. in the Sea of Marmara) where accidents and resulting pollution of oil and hazardous substances do occur. In such cases observatory time-series data will inform ship owners, port authorities, local authorities and insurance companies about the source and migration of pollutants. Prominent examples of observational networks that have already revolutionized understanding of ocean physics are the Tropical Atmosphere Ocean (TAO) array in the equatorial Pacific Ocean and the global set of upper water column (first 2000m) profiling drifters as part of the international Argo initiative. EMSO, working together with the physical oceanographic community including EuroSITES, collaborates for the deeper seas and Eulerian (fixed) water column

[4] European Parliament and Council - 17 June 2008 - DIRECTIVE 2008/56/EC Official Journal of the EU - L 164/19 and following.

observatory infrastructure with the Euro Argo research infrastructure[5] which contributes to Argo.

The KM3NeT project is also under Preparatory Phase within the ESFRI Roadmap. It aims at designing and building a neutrino telescope in the deep Mediterranean Sea, constituted by thousands of photomultipliers over a large volume of 1 km3, interlinked and cabled to shore. One conclusion of the KM3NeT Design Study (report to be issued beginning of 2010) is that KM3NeT will share one to three junction boxes to deploy instruments of EMSO. The two communities, high energy physicists and marine scientists, are cooperating since the late nineties in different research & technology activities. This cooperation is currently formalised through MoUs. The EMSO and KM3NeT infrastructures will continue to have fruitful synergies and will share facilities and logistics; extension and instruments as well as data processing and management onshore will be entirely EMSO infrastructure components.

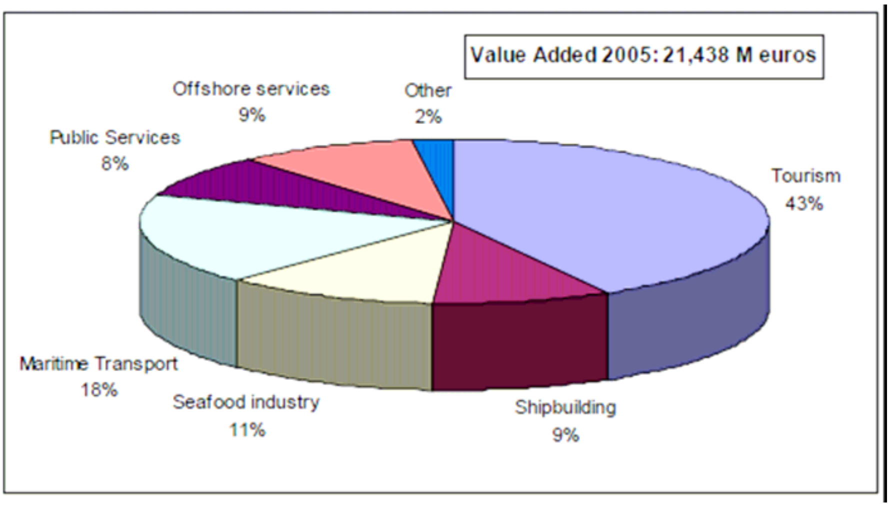

Figure 3 : Figures on French maritime economy 2005

The socio-economic gains that are possible through increased understanding of ocean science by using real-time observatories are considerable. EMSO will be a pioneer to providing multidisciplinary real-time data from the sea. Its focus on key areas stimulates similar deployments in more coastal zones[6]. These initiatives are associated with EMSO and part of the scope of VISO. There are specific benefits for local maritime activities such as improving fishing effectiveness, predicting coastal erosion, containing oil pollution and closing public beaches in advance of harmful algal blooms (HABs). However, the benefits of ocean observation have a much larger impact on all marine activities. A study by the United Kingdom estimates that the GDP attributed to marine-related activities is approximately £46 billion with £19 billion in oil and gas, £3.3 billion in leisure and recreation, and £1.3 billion in fisheries and other resources (Pugh, 2008).

The French maritime economy in 2005 contributed almost 21.5 billion Euros of value added with a workforce of more than 486,000 (see figure 3). This industry is supported by public marine research spending of 324.5 million Euros which gives a benefit cost ratio of66. The research, amongst other things supplies the data and information on the state of the ocean needed to monitor the global environmental state and climate change, seasonal forecasting, safety at sea, developing applications for offshore industry and fisheries, responding to

[5] EUROARGO is also an ESFRI project, it will finish its Preparatory Phase in 2010 and build an ERIC.

[6] OBSEA (Spain), MEDON (France and UK), Koljøfjord (Sweden), Smart Bay (Ireland)

accidents or pollution, and to defence requirements, and includes investment in operational oceanography and the development of ocean observatories. An Australian study, “The Economics of Australia’s sustained ocean observation system, benefits and rationale for public funding, 2006” estimates the impact of ocean observatories on a variety of sectors and especially agriculture through improved weather and seasonal forecasts. The total annual benefit to the economy of agricultural productivity, oil production and the fishing industry was $616.9 million with an annual cost for ocean observation of $27.3 million giving a cost benefit ratio of 22.6.

There are a number of ocean observatories that are funded by private sector companies such as BP’s Deep-ocean Environmental Long-term Observatory System (DELOS) project which deployed, in February 2009, seafloor instrumentation within 50 metres of a sea floor well, and a second 16 km from any sea floor infrastructure. These observatory sites are situated off Angola, in the Atlantic Ocean at a depth of 1400m. They are deployed for 25 years and serviced every 6 months by ROV. Statoil-Hydro cooperates with ESONET and Hermione to deploy cabled observatories in the vicinity of oil and gas fields, the first one being Snøhvit gas field in the Barents sea North of Norway, probably included in EMSO.

Ocean real time monitoring may be considered as a business, it has been shown for instance by Lighthouse Research and Development Enterprises Inc. of Houston who include cabled monitoring subsea instrumentation among the services offered to petroleum industry development projects[7]. I

A market intelligence approach has been initiated by ESONET. A review of invitations to tender awards on public procurement websites indicates major new deep-ocean observatory infrastructures are under construction such as NEPTUNE Canada, MARS in the US DONET (Dense Oceanfloor Network system for Earthquakes and Tsunamis) funded by the Japanese government.

Meanwhile the USA (nearly $400M over 5 years of construction, 25 to 30 years of scientific operation are expected), Canada (nearly CDN$100 over 3 years of construction and $43M for operation over following years), Japan (DONET Phase 1 nearly €46M over 3 years – €80M over 4 years for extension in Phase 2) are investing public money in ocean observatories to advance deep-ocean research and provide core services to national agencies responsible for environmental monitoring, geohazard early warning and marine natural resource management. The awareness of the public and the dissemination to scientists through a cyber infrastructure is included is those projects.

The implementation of the European Strategy Forum for Research Infrastructures (ESFRI) Roadmap projects for the construction (or major upgrade) of research facilities of pan-European interest has led to increased attention to studies measuring the scientific, social and economic benefits deriving from these infrastructures. The disciplines related to environment and more particularly those dealing with marine sciences are not as accustomed as other disciplines such as physics to build trans-national infrastructures in common for long term operation. It is a challenge that EMSO as other projects of the first group of ESFRI Preparatory Phases is targeting to win.

There are several types of impact from the setting up a Research Infrastructure[89].

[7] In 1995 they built their first cabled seabed environmental monitoring system designed to provide scientists with real-time, time series data on the dynamic marine environment in the Gulf of Oman.

[8] The June 2009 workshop was organized by the European Commission in order to show how Research Infrastructures should identify gaps, needs and specifications for possible future impact and foresight studies http://ec.europa.eu/research/infrastructures/impact_studies_en.html

- Direct benefits relate to the economic effects of investment in the construction and operation of the infrastructure, IT systems, software, equipment and staff. In the case of EMSO, member states could benefit from providing services to the Research Infrastructure during the design and build phase. Employment opportunities will be available to staff to work on the RI. Vessels and other marine services will be required on an ongoing basis.
- Development of European SMEs is expected. The level of interest in the ocean observatory service sector is such that in ESONET NoE, several Small & Medium Enterprises (SMEs) from member states have formed an association, PESOS (Providers of Equipment and Services for Observatory Systems). ESONET is establishing a database of suppliers of equipment and services for ocean observatories that meet the ESONET standards. The database, known as the ESONET Yellow Pages, is a showcase for European technology and service companies to promote their capability internationally and allows observatory owners to purchase quality, standardised and interoperable equipment and services.
- Indirect effects extend beyond the original objectives of the Research Infrastructure and include various learning effects, scientific and technological innovation, networking opportunities, standardisation and interoperability methods, modes of management, and the availability of a critical mass of scientists and engineers
- There are separate impacts and direct economic effects for the *users* of the RI – in the case of EMSO, they are not only the partners of the infrastructure but the whole VISO community. They will be provided access to the observatory facilities for new short or long term experiments, an ability to leverage additional research funding and therefore the development of instrumentation techniques, methods, model validation,… which are revenue generating in their own right.
- In the case of EMSO, one may anticipate a "propagation effect" related to the *distributed nature* of the Research Infrastructure. The economic return in the long term in all the regions of observatory sites or cyber department facilities, as estimated on the basis of previous experience, indicates that over 70% of the operation costs (personnel, supplies, utilities) end up in the local economy[10].
- In a process comparable to EMSO, the estimated benefit of integration within NOAA[11] to provide more efficient access to data, (collected once and used many times) through standards and a common Data Management and Communications (DMAC) infrastructure is projected to deliver a Net Present Value of $42m over 15 years. It is termed 'network effects' – making data more readily and consistently available generates unexpected new uses which add to the benefit of integration.

The timing is appropriate to initiate the European partnership that will deliver deep-ocean observation services to government agencies and industry in Europe and compete with US, Canada, Japan and India to deliver services to Africa and the Asia/Pacific Region.

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[9] The Biobanking and Biomolecular Resources Research Infrastructure (BBMRI) have begun one economic and health impact study and have found that the benefits of the infrastructure will extend well beyond the boundaries of the partners in the RI. http://ec.europa.eu/research/infrastructures/pdf/bach_06_09.pdf

[10] Report from the 2008 ESFRI Regional Issues WG http://www.eu-openscreen.de/fileadmin/user_upload/ESFRI_documents/ESFRI_Regional_Issues_WG_2008.pdf

[11] NOAA IOOS study, entitled "The Business Case for Improving NOAA's Management and Integration of Ocean and Coastal Data"

5.0 GOVERNMENTAL SUPPORT

Europe, through the development of ocean observatory infrastructure will have the capacity to competitively deliver deep-ocean data, knowledge, and services internationally. The European Union has invested in deep-ocean scientific research for decades. Consecutive EU Framework Programmes have invested in the successful integration of the geoscience, physical oceanography, biogeochemistry, and marine ecology research communities. The same programmes also invested through competitive calls in the standardisation of deep-ocean observatory infrastructure, protocols, data management and interoperability[12]. In Europe the effort to investigate a seafloor observation infrastructure was first supported by EU through ESONET-Concerted Action (European Seas Observatory NETwork-CA) followed by the European Seas Observatory Network Implementation Model. Then the ESONET-NoE was created aimed at gathering together the community, selected by these previous calls, interested in multidisciplinary ocean observatories Through the EMSO Preparatory Phase (PP) project aimed at establishing the legal entity charged of the construction and management of the observatory infrastructure. Several EC funded research projects are running in association with the ESONET NoE and EMSO PP[13]. EuroSITES for instance with rather than focusing of planning of future effort, has been organising ongoing research using water column ocean observatories around Europe. The projects have many participants in common. These efforts have been advanced by the agencies of member states and the EC and industry to provide services to society such as environmental monitoring and earthquake and tsunami early warning systems.

It is now recognised by the European Union that EMSO infrastructure will be a marine segment of the Global Monitoring for Environment and Security (GMES) and Global Earth Observation System of Systems (GEOSS) initiatives and will contribute to the provision of information on global change, natural hazards and sustainable management of the European Seas. The GMES observational infrastructure has a space component and an *in-situ* component. The MyOcean project is developing the Marine Services of GMES. The market for GMES Marine Services has been segmented into four areas, the “marine safety” area; the “marine resources” area; the “marine and coastal environment” area, and the “climate and seasonal forecasting” area.

ESONET/EMSO sites will provide, on an operational basis, continuous information and information tools required by European environment policies and to contribute to the implementation of the GEOSS international cooperative effort. One of the Core Services of EMSO is defined as the capacity to deliver basic, established, standardized, data products and data services that will be provided by future operational deep-ocean observatories to international agencies responsible for Earth monitoring. In that context, the sub sea observatory infrastructure of ESONET-EMSO would like to integrate and complement the Marine Services of the GMES satellite, sea surface and subsurface observing systems. EMSO will provide the required synchronous measurements from fixed locations in four of the five areas defined by Marine Services in the Global Ocean, North East Atlantic, Arctic and Mediterranean Sea. It will provide the reference observation of Eulerian data away from the coast and should provide verification of the consistency of the oceanographic modelling of GMES.

The EMSO infrastructure is also the natural partner to ICG/NEAMTWS (Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and connected Seas) providing earthquake monitoring in marine seismogenic areas not covered at present by observations and accurate seafloor pressure sensors for real-time warning of tsunamis. GMES recognises the near term value of the seismic monitoring component of EMSO that complements satellite observations. For example one of the

[12] GEOSTAR, ALIPOR, ASSEM, ORION (continuation of GEOSTAR, clustered with ASSEM), EXOCET/D,

[13] HERMES, HERMIONE, MERSEA, NEAREST (Integrated observations from NEAR shore sourcES of Tsunamis: towards an early warning system), SeaDataNet, EuroSITES, HYPOX, MyOcean, KM3Net Design Phase and proposals SIOS, JERICO

ESONET/EMSO sites is in the Sea of Marmara, which connects the Black Sea to the Mediterranean south of Istanbul, Turkey. The site monitors underwater seismic activity and ESONET researchers will try to determine a possible link between seismicity and fluid expulsion along the North-Anatolian Fault (running through the Sea of Marmara), which triggered several devastating earthquakes in the recent past (1999 M_W 7.4 Izmit and M_W 7.2 Duzce earthquakes). Another site is the Gulf of Cadiz where scientific activities are performed since over 10 years and in the recent times through the EC project NEAREST.

6.0 ESONET LABEL – STANDARDISATION AND INTEROPERABILITY

Industry and public sector customers purchasing ocean observatory services (R&D tests at sea, processed data, models validated by in-situ measurements,…) in the international market will have a variety of service providers to choose from. The technological and scientific components of the European multidisciplinary ocean observatories will need to be standardised and interoperable to integrate into efforts worldwide. The ESONET community has initiated a continuous debate on standardisation of subsea observatories in 2006[14] ; it is one of the basis of cooperation with US, Canadian and Japanese subsea observatory teams. The ESONET NoE partners have adopted an innovative and incremental approach to standardisation in data management, sensor interoperability, underwater intervention procedures and quality assurance, creating a sensor registry reference, adapting standards such as IEEE 1451, CanOpen, Puck etc. and complying with the Open Geospatial Consortium (OGC), for example.

The ESONET Label is a quality guideline of standardisation and reliability for equipment and procedures that is underpinned by technical auditing, equipment testing, calibration, and reliability analysis and data management protocols. The ESONET Label establishes a set of criteria that ensures that observatories have a highly controlled quality level and capacity for integration. This includes acceptable constraints on hardware and software design to deploy environmentally friendly sea observatories.

A preliminary data management plan is available to all ESONET partners and is being adopted and expanded with quality assurance/quality control procedures by each of the ESONET Demonstrations Missions (DMs) as well as with other observatory efforts such as EuroSITES. By working with other data organisations and industry there is an aim deliver ocean observatory data and interpretations in a format suitable for integration into many data management systems to improve effectiveness through improving standardisation of data delivery and data products.

A number of basic, standardised ocean observatory core services based on customer needs are under definition process by ESONET. ESONET core services complement the satellite sea surface Marine Core Services (MCS) of the Global Monitoring for Environment and Security (GMES). With respect to environmental monitoring, oil and gas companies, such as BP and StatoilHydro, have defined core service needs and are deploying ocean observatories following ESONET recommendations, associated with some ESONET partners, to establish marine biodiversity baseline surveys and monitor environmental impact of production activities.

[14] Paris workshop 1st-2nd February 2005 -
http://www.ifremer.fr/dtmsi/programmes/fondocean/standardisation.htm -
user : standard05 password: st0102pa

The EMSO infrastructure will be serviced by a combination of research vessels and ROV operations provided by EU members States in a co-ordinated network established by EUROFLEETS.

The SME group of private companies, PESOS, works with ESONET to establish and maintain standards and interoperability. Standardisation and interoperability reduces overall costs of operating ocean observatories and increases European competitiveness in the growing ocean observatory services market.

7.0 LEGAL OPTIONS – ERIC REQUIREMENTS FOR EMSO

In order to support the development of new Research Infrastructures, a new legal framework was adopted by the European Council in May 2009 which will facilitate the setting up of a number of projects on the ESFRI Roadmap – a legal framework for a European Research Infrastructure Consortium (ERIC). The principal task of an ERIC is to establish and operate a research infrastructure. Although the EC can be a member, it is not necessarily so and has no obligation to make financial contributions to the construction and operation of the Research Infrastructures . An assessment of European legal structures concluded that an ERIC is currently deemed the most suitable legal form for EMSO to adopt[15].

The ESONET and EMSO projects have been advised by their respective EC officers that it is vital that some commitments (particularly financial commitments towards construction costs) from Member States be agreed over the coming months. In particular, the EC would like to see a core group of Member States, lead the implementation of the EMSO RI over the next six month period. The ESFRI Roadmap will be reviewed in 2010 and without some strong indications that ESONET/EMSO partners and member states are willing to set up an RI, the EMSO infrastructure may be removed from the ESFRI Roadmap. Given the investment of the EC to date in deep-sea observatory projects, this would represent a significant setback to the observatory community if the momentum towards full implementation is not maintained.

ESFRI acknowledges that the global financial crisis may delay some investments in RIs. However, investments in RIs have a potential to provide short- to medium term economic impacts through immediate, high quality help to relevant industries; an increase in innovation and Technology Transfer associated with the RI; an ability to attract the very best science and technology researchers, engineers and technicians and in the longer term, an ability to attract high-tech and more competitive industries. Several countries and Member States are acting on this unique opportunity to develop an ERIC through stimulus packages and structural funds.[16]

A suggestion is that EMSO PP consider constituting an ERIC over the course of the next number of months with a core partnership comprising member states involved in some of the most mature sites. In terms of membership, the ERIC must have a minimum of three Member States, but associated countries (e.g., Turkey, Norway,…), third countries and some intergovernmental organisations may also participate. Member States can join at a later date on fair and reasonable terms as set out in the Statutes. The remaining partners could also apply for observer status of the EMSO ERIC. The definition of an observer is in the ERIC statutes (Article 6): “Observers are Members contributing to the ERIC, but which

[15] D3.1 – Report on Core Legal Entity for EMSO

[16] Prof. Carlo Rizzuto - http://www.mvzt.gov.si/fileadmin/mvzt.gov.si/pageuploads/pdf/znanost/2_The_ESFRI_Roadmap_and_Regional_perspectives_for_Slovenia.pdf

do not meet the requirements set for full membership." As the phased construction of the EMSO sites continues, member states could move from observer to full members as required. Observer members will be required to make a contribution to the EMSO RI core services.

An analysis by the ESONET NoE WP5 shows that the governance structure of an ERIC could reduce personnel and operating costs by 31% during construction and 60% during the operations phase (Figure 4) by avoiding any duplication. Additional cost saving should come from collective bargaining in the tender process. The centralised management of an ERIC will cultivate interoperability and standardisation. It will also synchronise the development of the regional observatories with European funding opportunities, revenue generation and operate European Investment Bank financing initiatives such as Risk-Sharing Finance Facility. The centralised ERIC will be in a stronger commercial position to secure the operational support of public and private sector ship support for underwater intervention and maintenance of the regional infrastructures. The ERIC established for ocean observatory infrastructure management will increase European competitiveness and be the counterpart of NEPTUNE Canada and the US Ocean Observatories Initiative (OOI).

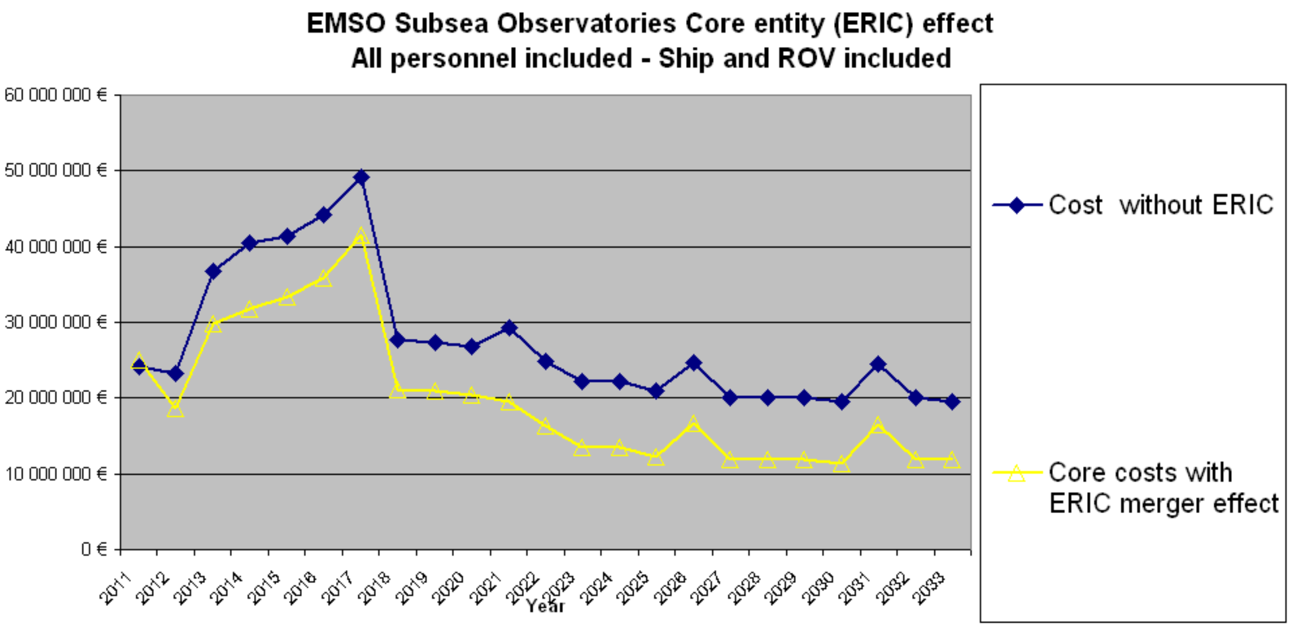

Figure 4. EMSO Subsea Observatories Core entity (ERIC) effect. Total costs are preliminary and corresponds to the scenario of Table 3.

In order to qualify for the ERIC label, consortia wishing to establish this legal form will need to apply to the EC which will assess the merits of the proposal through the advisory of experts. An important consideration is that as an international organisation, the ERIC will be exempt from VAT and excise duties and will not have to follow the standard public procurement rules. It will have an extensive legal personality and be able to enter into legal arrangements on behalf of its members. In terms of the important issue of liability, an ERIC is liable for its debts but the liability regime can be amended and limited in the Statutes as required by members. Some economic activities are permitted by an ERIC in order to promote innovation and technology transfer.

An example of the kind of commercialisation the ocean observatory ERIC hopes to achieve is that of NEPTUNE Canada, which is operated by Ocean Networks Canada[17], a not-for-profit society created by the University of Victoria. Principal funding for NEPTUNE Canada comes from Canadian federal and provincial funding agencies. The NEPTUNE Canada core infrastructure is designed by Alcatel-Lucent Submarine Networks and their chief subcontractors L-3 Maripro and Texcel. The science platforms were built by UVic with junction boxes supplied by Oceanworks Inc. of Vancouver. ONC has developed a Centre for Enterprise and Engagement (ONCCEE) to position Canada as an international leader in the science and technology of ocean observation systems and to maximise the associated economic and social benefits.

[17] ONC, www.oceannetworks.ca

8.0 GOVERNANCE OF OCEAN OBSERVATORY - ERIC

(Note: The following is issued from the Deliverable D2.2 of EMSO[18])

A review of existing European research infrastructure and of the function that EMSO will have to carry out suggests that the organisation that will manage the European network of deep-ocean observatories must include on its governing council representatives of the funding agencies and the scientific institutions that operate the infrastructure. The organisation structure should include an Assembly of Members, a Scientific Advisory Committee and an appropriate representation of the end users community to liaise with the scientific community (VISO) and the industry. Data sharing and distribution, on-line operation as well as maintenance functions will be required. The organisation must be a legal entity with the power to contract ocean observatory operation services, manage ownership of data and industrial property rights, raise funds, trade in data and services, and accept limited liability.

The organisation that manages the European ocean observatory infrastructure should also have a commercialisation arm that works with industry to market new technology around the world for other emerging ocean observatories, offshore petroleum production facilities and port security systems. Several models are under study in EMSO. The model used in this report is assuming a central governance body with a network of operational capacities. The headquarters are hosting the main governing bodies while the operational structure is organized as cyber virtual departments, a network of skilled personnel either positioned inside expert teams in Europe, at the vicinity of the observatory site or at headquarter.
A model of possible governance structures based on the creation of a single legal entity (the ERIC for instance) is presented in Figure 5.

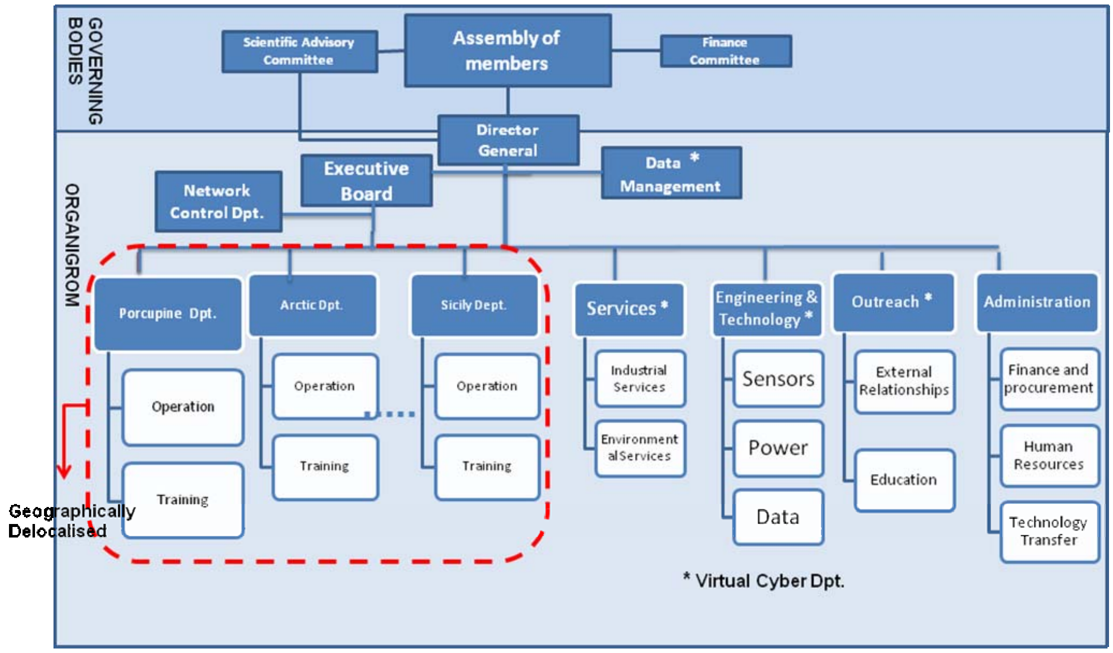

Figure 5: Possible governance model for a single legal entity scenario

[18] EMSO PP Deliverable 2.2 - Report on RLE structure – November 2009 – Version 4.

9.0 CURRENT AND PLANNED EMSO INFRASTRUCTURE

Eleven sites have been selected for their scientific, technological and socio-economic interests. The proposed network stretches from the Arctic Ocean near Svalbard to the mid Atlantic Ridge, and eastward through the Mediterranean to the Black Sea (see Figure 6). The network of proposed sites includes abyssal plains, open slopes, seamounts, canyons, ridges, faults, fluid seeps, hydrothermal vents, gas hydrates, mud volcanoes, deep-sea corals, carbonate mounds, and marine areas affected by geo-hazards (earthquakes, tsunamis, volcanoes and slope instabilities). The sites also span the major biogeochemical provinces found in European waters. Some sites have more specialized science objectives. The modular design has two fundamental components with one addressing core services, which includes supplying data on standard generic parameters such as temperature, conductivity (salinity), depth (pressure), currents and another that incorporates the appropriate site specific data services such as seismic, biogeochemical fluxes, or faunal abundances. EMSO will constitute the permanent underwater observing infrastructure complementary of satellite oceanographic data, climatic data, air-sea interface data, and the known distribution and abundances of marine fauna. Exploiting the yearly maintenance cruises, the ROV and mobile systems like autonomous underwater vehicles (AUVs) will greatly improve the potential of an observatory. The modular and expandable network is adaptable and can also support highly specialized monitoring and experimental systems as needed. *In situ* infrastructures include sensors and samplers attached to seafloor cables, communicating moorings and communicating benthic stations. On several sites, seafloor cables provide substantial power and bandwidth for data transfer, and provide highly accurate time synchronization and real-time shore-side alerts to episodic events, such as seismic activity. Connected moorings provide a critical link to the water column that connects surface conditions to the solid Earth.

Fig. 6 EMSO PP Initial proposed sites

The current infrastructure at each site is listed in Table 2 hereafter:

ESONET Site	Current Infrastructure
Arctic	Hausgarten site is a deep-sea observatory visited each year mainly by German scientists. It is at the verge of the ice cover of the Arctic in Summer season. 15 permanent sampling sites are monitored along a depth transect from Vestnesa Ridge to the Molloy Hole (1000-5500m) using moorings and long-term lander systems since 2000. First exchange of ship time and ROV time in Europe took place during one of those cruises (French VICTOR 6000 on board PolarsternR/V). Arctic Ocean ESONET Mission Demonstration Mission of ESONET is integrating experiments with long-term observation potential. One of them monitors the whole Fram Strait with moorings, acoustic tomography and gliders. The other one, co-funded by Statoil-Hydro and HERMIONE, is performing a minimum 2-year deployment to monitor rates and processes of Arctic methane dissociation in the same area.
Nordic Sea	Measurements deep-water flows have long been conducted in this important area of meridional overturning and thermohaline circulation at the convergence of the ARCT and SARC biogeochemical regions. This site benefits from the use of an existing sub-sea cable and an existing decadal scale data record of currents at the site. This site is also in the vicinity of Weather Station M which has been conducting hydrography surveys to several thousand meters depth since the 1950's and produced detailed evidence of the penetration of secular warming to depths greater than 2000 m.
Norwegian	The Snøhvit gas production field operated by Statoil-Hydro is equipped with a junction capacity for a scientific monitoring node several km away. Haakon Mosby Mud Volcano is a unique fluid flow area. It is monitored by the Long-term Observations On Mud-volcano Eruptions (LOOME) Demonstration Mission.
Celtic/ Porcupine	EuroSITES deployed a stand-alone observatory on Porcupine Abyssal Plain. Since 2002, a mooring has been in place with sensors collecting biogeochemical and physical measurements of the upper 1000 m of the water column. Some of these data are transmitted in near real-time by satellite. Additional infrastructures used the site include seafloor photography systems and biogeochemical flux measurement systems. Time-series data on biogeochemical fluxes and deep-sea ecology extend back to 1989. It is the site of the MODOO ESONET Demonstration Mission. MODOO will demonstrate in 2010-2011 a benthic observatory and geo-hazard early warning component with an acoustically linked infrastructure enabling seafloor to shore telemetry. Cold-watercoral sites are under study by the CoralFISH project. A funding decision for the SmartBay coastal observatory imminent, providing potential for onshore infrastructure, IT equipment, local data archive, personnel and associated expertise that may be in place from 2011 at Marine Institute (ships R.V. Celtic Explorer, R.V. Celtic Voyager, R.O.V. Holland based in Galway).
Azores	The MoMAR scientific team was constituted in 1998 for the study and Monitoring of the Mid Atlantic Ridge hydrothermal site south of Azores. It organized one or two scientific cruises each year since 2006. The mapping of the Lucky Strike vent field area was performed at a decimetric scale with Victor 6000 ROV. Since 2006, the observatory included seismometers, temperature, pressure, current measurements. A camera and a chemical analyzer were also deployed for two years during the EXOCET/D project. MoMAR-D is a Demonstration Mission of ESONET. It deploys more instruments and will transmit data in near-real time through acoustic links, a buoy and satellite communication.
Iberian	The area is the Gulf of Cadiz (Portugal) in which the destructive and tsunamigenic 1755 earthquake occurred destroying Lisbon. During The EC NEAREST project, GEOSTAR was installed in August 2007 south-west of Cape St. Vincent at over 3200 m w.d. and recovered in August 2008 always using R/V Urania of CNR. In this experiment, GEOSTAR was equipped with geophysical instruments and oceanographic instruments, and with a new prototype of

ESONET Site	Current Infrastructure
	"tsunameter". This tool has been suitably designed to operate in areas that generate tsunami waves in order to send automated alert messages to the shore through an acoustic link to a surface buoy and than through a satellite link from the buoy to land. The tsunameter is based on both seismic and pressure signals and takes into account seafloor movements. The infrastructure (seafloor observatory and surface buoy) was re-deployed to continue the experiment in the same site in November 2009 using the new Spanish ship, R/V Sarmiento de Gamboa, thanks to the LIstening to the Deep Ocean environment (LIDO) Demonstration mission of ESONET. The system is currently operating sending periodic messages. Also bio-acoustic issues are considered and antenna for mammal tracking will be added later. Work at the site is done in cooperation with HERMIONE and NEAREST.
Ligurian	The Var canyon is under monitoring with a communication link through a buoy since 2005. The unstable slope offshore Nice airport is under monitoring by a piezometer using a stand alone SEAMON station. The Dyfamed site has been monitored for a decade, it is a reference site for the validation of satellite sensors by ESA. An Integrated Ocean Drilling Programme (IODP) instrumented drill hole proposal is pending in this area. The ANTARES neutrino telescope site south of Toulon has been able to measure currents, temperature, acoustic and optical parameters during the past 5 years. A junction box is under construction in order to provide an extension 500m away for Earth-Sea science in the vicinity of Antares. It is designed according to several of the ESONET label requirements. The TEST Demonstration of ESONET will use this infrastructure in 2010.
Sicily	The NEMO-SN1 seafloor observatory is connected to the Shore Station, a laboratory located in the harbour of Catania, by electro-optical cable. (NEMO is a neutrino telescope infrastructure) The cable lies 20 km towards East and then is split into 2 branches (5 km each): northern (TSN) and southern (TSS) It is operating in real time since 2005 and is the first operative node. TSN is equipped with geophysical and oceanographic sensors and it is integrated in the Italian land-based networks, transmitting data in real time to the National Seismological Service Centre, in Rome. TSS hosts an acoustic station, equipped with hydrophones that characterise the acoustic environmental noise and records the "voices" of marine mammals. NEMO-SN1 is also a test site for the realisation of underwater neutrino telescope. Starting from April 2008, NEMO-SN1 was recovered and has been refurbished, adding sensors and functionalities, particularly taking into account geo-hazards, including sensors for tsunami prone signal detection, and bio-acoustics. It is planned the re-deployment and re-connection to the cable early 2010. These activities are performed in the frame of the PEGASO project funded by "Regione Siciliana", and the LIDO Demonstration Mission funded by ESONET-NoE. Also deep-sea (4000 m) handling systems have been realised in the PEGASO project (ROV with 2 manipulators and DSS-Deep-Sea Shuttle to manoeuvre heavy platforms. The Test Demonstration of ESONET will use this site for interoperability tests in 2010.
Hellenic	A complete survey of the West Peloponese site was performed. A stand alone station manufactured by Oceanor is operated by HCMR for monitoring, it is integrated in the Poseidon data processing System. The IODP site BUTT-1 is also in this area. Monitoring at the site has examined benthic-pelagic interactions, benthic respiration, biogeochemical fluxes, and photography based ecology, as well as more geophysical objectives such as monitoring seismic processes, seabed methane fluxes, and oil and gas industry activities.. The NESTOR (neutrino telescope infrastructure) cable is announced to be in operation soon.
Marmara	In 2008 the Marmara Demonstration Mission was approved in the framework of ESONET-NoE. This DM entitled "Multidisciplinary Seafloor Observatories for Seismogenic Hazards

ESONET Site	Current Infrastructure
	Monitoring in the Marmara Sea" aims at contributing to the establishment of optimized permanent seafloor observatory stations for earthquake monitoring in the Marmara Sea. A complete survey was performed during cruises using AUV and submersible (Marnaut) for local survey. A multidisciplinary seafloor observatory (SN4,) was deployed in October 2009 in the eastern part of the sea at the westernmost end of the fault rupture caused by the 1999 Izmit earthquake using the oceanographic vessel R/V Urania of CNR. Its major scientific goal is to contribute to the knowledge on the relationship between gas seepage and earthquake occurrence It is well known that gas migration and surface gas anomalies, seepage and even eruptions of mud volcanoes, substantially increase in connection with earthquakes. Other observatory devices were deployed recently like pore pressure sensors, acoustic sonar for bubble detection. The experiment is currently running. The five KOERI cabled observatories are under test after deployment. They include seismometers, accelerometers, current-meters and temperature sensors.
Black Sea	Cruises deploying landers and cooperation between oxygen depletion phenomenon specialists are planned within EC funded project HYPOX (2009-2012).

Table 2 Current Infrastructure at EMSO sites

The eleven ESONET sites were assessed based on their defined architecture; maturity of planning; identified stakeholders, number of European countries supportive of the site; funding commitments and links to GMES and GEOSS objectives. The results are shown in Figure 8 overleaf. The East Sicily infrastructure described above has been realised with the strong support of Italian and Regional Sicilian Governments. The use of the Antares cable for associated Earth-Sea science benefits from a junction box in 2010, supported by Ifremer and the Region Provence Alpes Côte d'Azur. Two other sites (Arctic and Norwegian margin) have a perspective of commitment from member states and industry to develop a long term, deep-sea observatory, with some infrastructure already in place. These two observatory sites are also of interest to Statoil-Hydro in connection with environmental monitoring of production activities. Some member states working at the Celtic/Porcupine also have planning in progress with a view to participating in the formation of a formal organisation for the set up and operation of ocean observatories.

Over the course of the next five years, many sites will become fully operational as part of EMSO. Partners will build on projects and infrastructure already *in-situ*, by the deployment of stand-alone systems, extensions to cables currently in place, and by the deployment of new cabled systems where required (see Table 3). The timing and order in which each site will be developed will be dependent on partners and Member and Associate State ability to access a combination of national, European and Structural funding, and some anticipation capacity gained through European Investment Bank financial products.

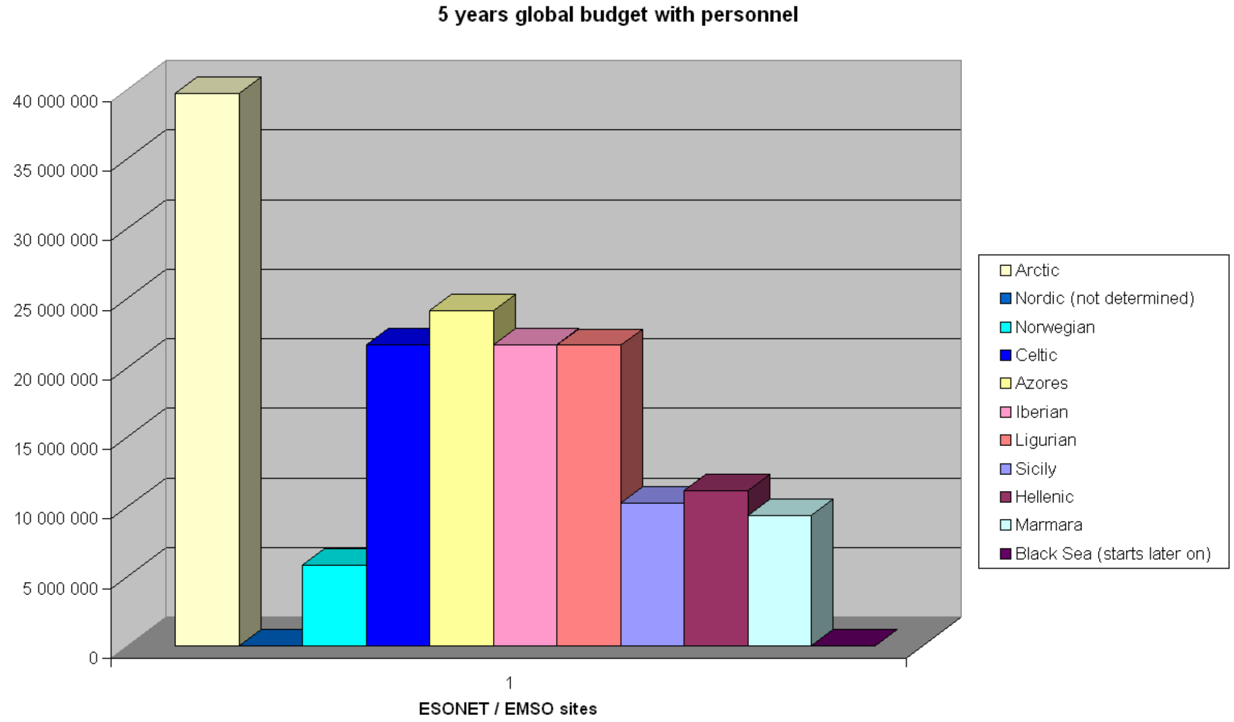

Figure 7 Estimated construction and operational costs across the 11 ESONET/EMSO sites for the first 5 years. Scenario used according to Table 3. This costing includes 16M€ for the generic sensor systems as outlined by ESONET NoE and for a provision for specialised sensors(Deliverable 11, 13).

		UPDATED FEBRUARY 2010		
Site	**Well Defined Architecture - Maturity of Planning (including well defined Stakeholders)**	**Infrastructure either planned or in place**	**Multiple countries interested**	**Critical contribution to European/Global Issues - links to GMES and GEOSS**
Arctic	Phased implementation - cabled system ~190 km long (20 kV and 4 Amp power). The end-point @ central Hausgarten node, operational ocenaography across Fram Strait. A node for the MASOX site join to main cable.	Hausgarten, SIOS, New Cryosphere Institute, ice breaker, Svalbard / Fram Strait research	Norway, Germany, UK	Global Change
Azores	Two stand alone acoustic observatories will monitor after Esonet Demo Mission : one at the same site, the other at a different location over to 2017. Same sites cabled , construction starting in	MoMAR Demo mission	France, Portugal	Geohazards - hydrothermal
Black Sea	Two stand alone observatories from 2021 to 2026	HYPOX FP7 project	Bulgaria, Germany, Italy, Turkey	Gas seepage, anoxy
Porcupine	Permanent stand alone observatory at Porcupine Abyssal Plain site. Two sites monitored with stand alone observatories from 2013 .	PAP (EuroSITES), MODOO Demo mission, related to SmartBay (coastal)	Ireland, UK, Germany, Netherlands	Global Change/Ecosystem
East Sicily	Off Catania 30-km cabled and it will be extended- Off Capo Passero 100-km cabled, it will be operative from 2010-2011	2 cables in place , 1 30-km long with 4 ROV mateable female connectors and 1 junction box with 6 other ROV mateable connectors, and 1 100-km long with a Junction box. 2 laboratories (1 Catania harbour, 2 Capo Passero) with broadband connections	Italy, Spain, Portugal, Greece,Germany	Geo-hazards (including tsunami early warning), ecosystem monitoring, bio-acoustics, deep current circulation, global change.
Hellenic Node	Continuity of stand alone observatory over to 2014. One cabled node extended from the NESTOR/KM3Net site with equipment according to Esonet standard. Construction in 2013	EuroSITES & Pylos	Greece & Italy	KM3NET
Iberian Margin	Two stand alone acoustic observatory with acoustic link seafloor/surface buoy and satellite link surface buoy/shore station	NEAREST FP6 project LIDO ESONET Demo Mission	Portugal, Spain, Italy, Morocco	Geo-hazards Including tsunami early warning), ecosystem monitoring,bio-acoustics, deep current circulation, global change .
Norwegian Margin	Snohvit offshore field (Statoil)– 5km extension in 2012. Available for further extensions	Snohvit	NOON consortium plus Statoil	Global change, anthropogenic impacts, O&G production etc
Nordic Sea	No request at this stage	Telecom cable free in 5 years	?	Global Change
Ligurian Sea	Stand alone observatory at Nice (Var-Dyfamed) area from 2012 to 2016. Cabled extension of Antares/KM3Net cable from 2010. New cable with two nodes, construction starting in 2013.	Telecom cable in place	France, Italy , Germany	Mediterranean site
Marmara	Cabling of the underwater observation platforms, foreseen in 2010-2012.	DM standalone nodes, Stand-alone platforms with cable connection in the future.	Turkey, France & Italy	Geo-hazards, environmental monitoring, physical oceanography

Figure 8 Current Status of ESONET/EMSO sites

10.0 PHASED PROGRAMME OF IMPLEMENTATION

Within FP7 the EMSO-Preparatory-Phase was launched in April 2008, to design and create the legal and organizational structure to coordinate the financial effort of the Member States in charge of managing EMSO. The commitments and scientific interests already expressed (see Table 2), indicate that a coordinated phased implementation of the eleven sites can now commence as outlined in Table 3. Each site will be progressively upgraded to a real-time observatory in a phased manner as dictated by government agency needs and depending on the available resources (also considering private funding). The challenge will be to work in a collaborative way with financial and resource contributions from government, research institutions and businesses to upgrade the operating EMSO sites to cabled observatories.

ESONET Site	Preliminary scenario of planned development (used for the first cost analysis and advisory meetings)
Arctic	Two sites monitored with stand alone observatories from 2011 to 2015. 2 nodes cabled observatory construction starting in 2014
Norwegian	Snøhvit offshore field (Statoil)– 5 km extension in 2012. Available for further extensions
Celtic-Porcupine	Permanent stand alone observatory (EuroSITES) at Porcupine Abyssal Plain site. Two sites (coral reef and slope) monitored with stand alone observatories from 2013. A potential third sub-site is being discussed.
Azores	Two stand alone acoustic observatories will monitor after Esonet Demo Mission : one at the same site, the other at a different location over to 2017. Same sites cabled , construction starting in 2015.
Iberian	Two stand alone acoustic observatories will monitor after Esonet Demo Mission : one at the same site, the other at a different location over to 2015. Same sites cabled , construction starting in 2013
Ligurian	Stand alone observatory at Nice (Var-Dyfamed) area from 2012 to 2016. Cabled extension of Antares/KM3Net cable from 2010. New cable with two nodes, construction starting in 2013
Sicily	off Catania 30-km cabled and it will be extended- Off Capo Passero 100-km cabled, it will be operative from 2010-2011.
Hellenic	Continuity of stand alone observatory over to 2014. One cabled node extended from the NESTOR/KM3Net site with equipment according to Esonet standard. Construction in 2013
Marmara	Cabled extension of the underwater observation platforms, foreseen in 2010-2012.
Black Sea	Two stand alone observatories from 2021 to 2026

Table 3 EMSO First scenario of planned developments

The decision to use cabled or stand-alone mooring infrastructure is primarily made by considering the scientific requirements, particularly for power, communication, and time synchronization requirements. The cost effectiveness of both systems is also considered over the full anticipated lifetime of the infrastructure. Ultimately some sites may initially have stand-alone systems prior to fully cabled infrastructures, while others will remain stand-alone with satellite-based telemetry.

Member and Associate States that manifest a commitment can first announce their intention to the EC to establish a European Research Infrastructure Consortium (ERIC). This declaration will be a statement of intent and benefit from advice provided by the EC. These first members will formally apply for an ERIC as soon a their national decision process is determined, the two processes being running in parallel. The new EMSO ERIC membership will include the rest of the EMSO Member and Associate States as observers with the option to become full members at a later stage. The first sites to be implemented will be existing ones and those of direct interest of the States participating to the ERIC.

Figure 9 shows the roadmap for the staged implementation of EMSO. The drivers for the implementation will be the existing EMSO governance structure, which will be the core for the formation of the EMSO ERIC. The establishment of the EMSO ERIC and the securing of initial financing is Phase 1 and Phase 2. The development of the stand-alone/cable EMSO sites available is Phase 3.

Phase 4 will involve the orderly implementation and construction of observatories based on the extension of current ESONET demo missions, the roll out of additional stand-alone systems, the extension of existing cabled infrastructures to incorporate equipment and instrumentation in accordance with the ESONET Label and finally, in the full operation of the infrastructure. All of this will take place over a 20 year timeframe (refer to Table 3 – *Preliminary scenario of planned development* for details).

As more sites mature and are required by government agencies and industry more member states, represented by their funding agencies will be invited to join the EMSO ERIC or to upgrade their status from an observer (Phase 5). It will be followed by a phase 6 of extension to other sites than those originally planned; some of them are already associated to ESONET and participating to the VISO.

A permanent concern will be the close relationship with other subsea observatories in Canada, USA and Japan. It may lead to a large organization involving EMSO ERIC.

The financing of the implementation will be through a combination of grant aid, and possibly bank debt, equity involvement by the private sector and revenue generated by selling deep-ocean observatory services and patents developed by partners and sub-contractors. The EIB could provide a Risk-Sharing Finance Facility over 20 years for 50% of part of the whole cost thus covering the risk of delays on member state budget allocation and specific project risks such as public budget cut on ship and ROV intervention**.**

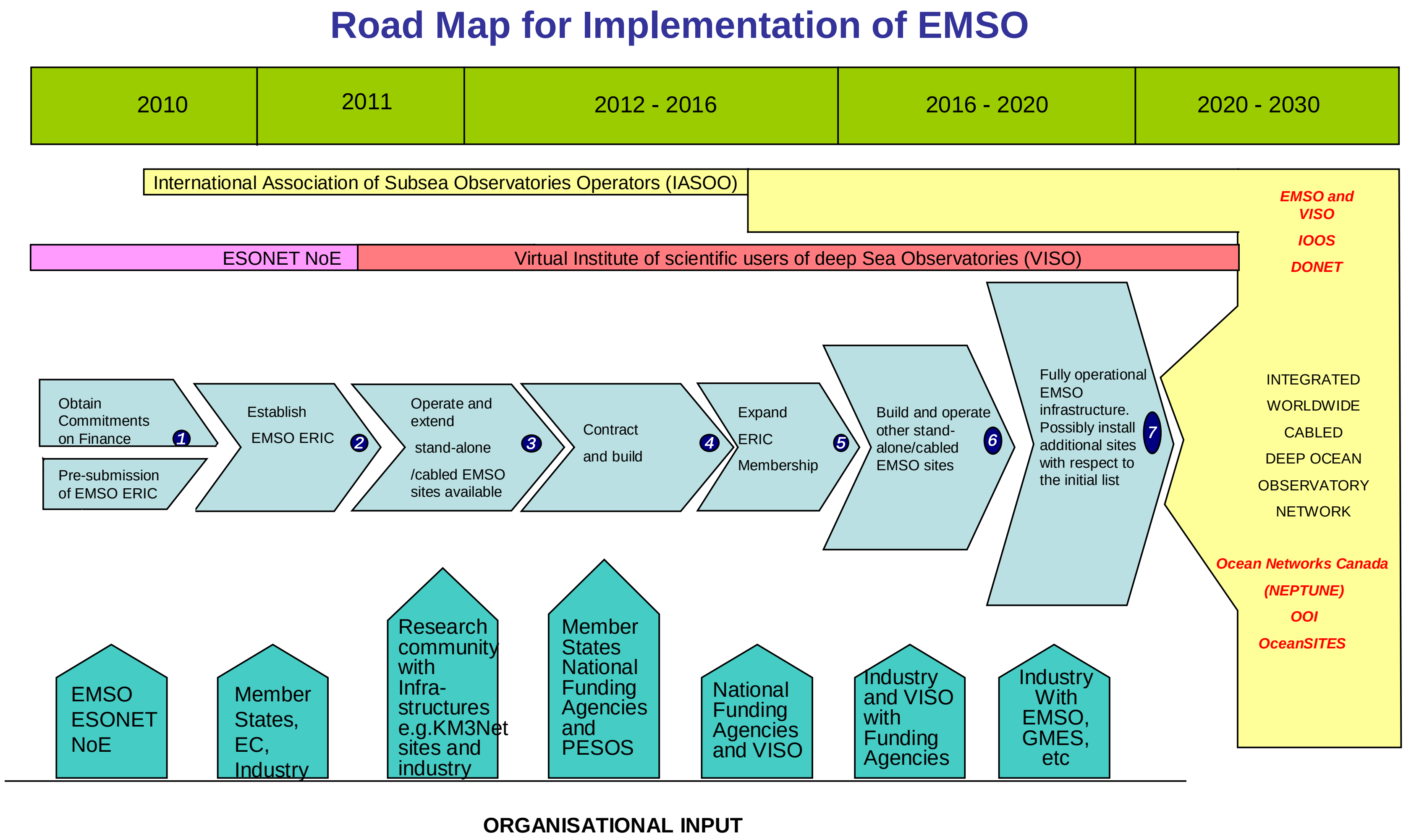

Figure 9 Road Map for the Implementation of EMSO

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First Indicative budgets and timelines according to the implementation scenario

Although the Preparatory Phase of EMSO has only reached the 22nd month of its 48 month duration, a major milestone was the full review of the candidate sites of the Observatory during All Regions Workshop 2 in October 2009[19]. From the discussions on scientific needs and funding involvements collected during this workshop and from the initial work on the generic observatory cost analysis, an implementation scenario has been described as outlined in Table 3. A number of different scenarios have been assessed for Capital and Operational Expenditure (CAPEX & OPEX). For each site, a suggested solution is outlined in Table 3. These engineering solutions in some places build on infrastructure already in existence, through the phased deployment of stand-alone systems, extensions to existing cabled infrastructures and the planned deployment of new cabled observatories.

Figure 9 and Figures 10a, 10b and 10c set out the timelines for the full implementation of EMSO and provide some guidance on the financing requirements. Each phase has an associated cost which allows decisions to be made with respect to funding and membership before proceeding.

The total cost of the EMSO infrastructure has also been assessed on three different timescales – on a five year, ten year and 22-year timescale. This allows us to identify the short-, medium and long-term goals and needs of EMSO. It also demonstrates the relative costs associated with each site, and how the proportions change over the proposed lifetime of the ERIC.

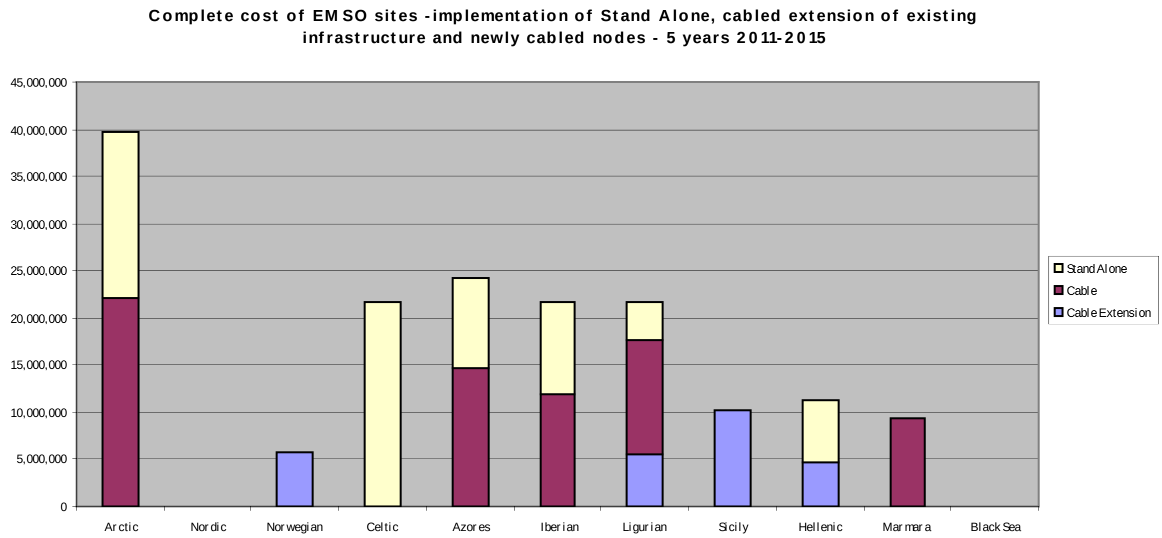

Figure 10a Complete cost of EMSO sites – implementation of stand-alone, cabled extension of existing infrastructure and newly cabled nodes – 5 years (2011-2015)

[19] Paris, October 5th to 7th 2009**,** http://www.esonet-noe.org/news_and_events/esonet_workshops_and_meetings/2009_05_14_esonet_all_regions_workshop_2

As outlined in Fig. 10a and Table 3, the estimated total cost of EMSO over the first five years of its lifetime is estimated at somewhere in the region of €100M for total capital and operational costs.

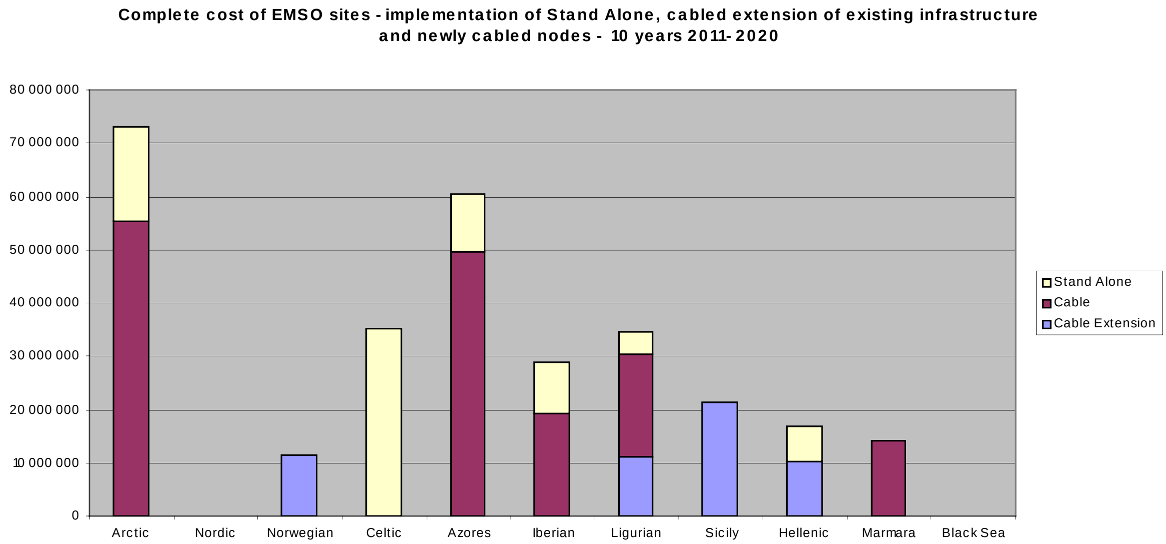

Figure 10b Complete cost of EMSO sites – implementation of stand-alone, cabled extension of existing infrastructure and newly cabled nodes – 10 years (2011-2020)

After ten years, it is expected that all sites will have an optimum configuration mixing newly installed cable, extensions to existing cabled infrastructures, and real-time communicating stand alone systems where required. The estimated costs after year 10 of the EMSO ERIC are €18.5M per year including construction, salaries, ship, ROVs, consumables.

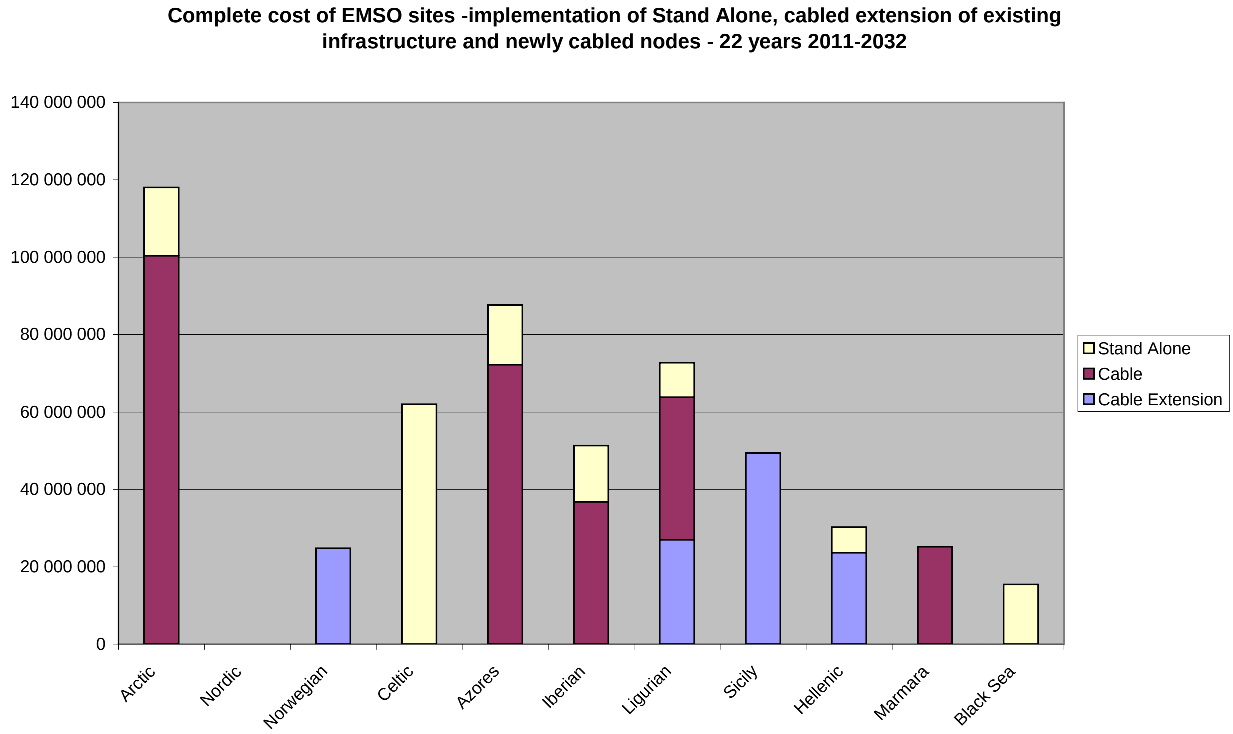

Figure 10c Complete cost of EMSO sites – implementation of stand-alone, cabled extension of existing infrastructure and newly cabled nodes –22 years (2011-2032) meaning 20 years after the end of EMSO PP

By the time each element of the EMSO ERIC has been rolled out and has two decades of service to the scientific community and the whole society, the entire infrastructure and its operation is estimated to cost €310M. (corresponding then to €13.5M average per year over the whole period). By this stage, other sites will be attractive for permanent monitoring as observatories. It is expected for the Black Sea with two stand-alone observatories at sites focusing the involvement of several nations. Detailed costs for the Nordic site remain outstanding, hence some long-term plans and costs associated with this site remain unaccounted for.

Intellectual Property Rights (IPR) management strategy

There is a growing interest from the private sector to invest in deep-ocean observation. In particular the oil industry needs site specific environmental monitoring around oil production facilities. The IP and patents developed by ocean observatory technology companies and research institutes have commercial value that could be sold and the proceeds invested in the building and operating of deep-ocean observatories.

The ERIC structure seems to allow for the establishment of a Special Purpose Vehicle to commercialise IP developed (ONCCEE plays that role for NEPTUNE Canada). How can the value realised from commercialisation be re-invested in the infrastructure? The IPR will need to be clearly defined and ERIC will need to ensure that it retains full ownership of any IP developed during the design phase of deep-sea observatories. Likewise the EMSO ERIC will promote their observatory services to the private sector, although not as a primary activity. EMSO will be able to enter into service agreements with customers and derive revenue from providing data and analysis to other stakeholders. The revenues will be re-invested in the infrastructure to meet some operational costs.