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ESONET European Seas Observatory Network

Instrument: Network of Excellence (NoE)
Thematic Priority: 1.1.6.3 – Climate Change and Ecosystems
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PP	Restricted to other programme participants (including the Commission Services)	
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)	

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EXECUTIVE SUMMARY

Overview of general project objectives

The long-term monitoring of environmental processes related to ecosystem life and evolution, global changes and geohazards, is now recognised as necessary by the scientific community. To better understand geophysical, biogeochemical, oceanographic and biological active phenomena, scientists need long time-series of data to identify temporal changes, cyclic changes and to capture episodic events related to oceanic circulation, deep-sea processes and ecosystem evolution. In addition, long-term monitoring will detect episodic events such as earthquakes, submarine slides, tsunamis, benthic storms, biodiversity changes, pollution and other events that cannot be detected and monitored by conventional oceanographic sea-going cruises. To understand the mechanisms involved and to forecast natural events long time series of measurements are needed to feed numerical models.

The implementation of a bi-directional link between an observatory and a control station is fundamental to ensure the collection of long data series. Three types of observatories are typically described: acoustically linked to a surface buoy, electrically linked to a surface buoy, and cabled. Technology today allows us to build sophisticated deep-sea observation systems. Considerable engineering development work has been done by the NEPTUNE and MARS projects in North America. NEPTUNE Canada implemented one of the first deep-sea, cabled networks. The DONET project in Japan implemented the first part of a very large monitoring network intended to measure seismic and tsunami events in the Tokai-Tonankai trench. The second part is funded. However, the costs associated with the construction and operation of these systems are high and funds usually attributed to marine science do not typically involve this kind of investment. The ESONET community is highlighting the importance of sub-sea observatory infrastructures to governments to encourage investment in this type of research infrastructure.

At the European level, the goal of the ESONET NoE is the lasting integration of European research on deep-sea multidisciplinary observatories and the creation of a network of excellence. Over the four years, the approach has been to merge the programmes of member organisations through research activities addressing the scientific objectives and networking activities specially designed for integration and spreading excellence. Its objective is to produce a practical plan for long-term monitoring of the environment of the open ocean and its margins around Europe with capabilities in geophysics, geotechnics, chemistry, biochemistry, oceanography, biology and fisheries. To reach this ambitious objective, it is necessary to organise the deep-sea observatory community around ESONET sites and to unify it through common scientific objectives that must reach the top levels of marine research.

- **Specific objectives**

  - *Integration*

Currently, ESONET manages 11 permanent observatories sites, identified and selected for their scientific, technological and socio-economical interests by the ESONET community. Three coastal sites (Koster Fjord, Koljo Fjord and OBSEA) have been added later for test purposes because of their ease of access, in shallow coastal waters. Several groups of scientists, engineers and technicians were already working on those sites having built up considerable knowledge and expertise. However, there was a lack of communication, of sharing resources, knowledge and of harmonization of standards and procedures. Consequently, the first objective of the NoE is to consolidate the deep-sea observatory communities at European scale by creating a large infrastructure project. This was partly achieved after one year of ESONET NoE thanks to the success of the EMSO-PP proposal. The second objective is to foster the creation of operating entities at regional scales, the **Regional Implementation Groups** that integrate the international community: engineers, scientists, technicians, on each ESONET site. The creation of these groups is a first step toward the existence of Regional Legal Entities (RLEs) that will coordinate each regional observatory. These RLEs and their legal framework are being designed and implemented by the EMSO-PP project.

  - *A sustainable structure: The Virtual Institute*

One important objective of the ESONET NoE project (defined in the Annex 1 of the contract: Description of Work) is to permanently integrate at European level of the ESONET consortium from the numerous laboratories towards the creation of a Virtual Institute.
The Virtual Institute would:
- Organize staff exchange in-between its members,
- Organize joined experiments on ESONET observatories,
- Promote development of new sensor packages on the existing observatories,
- Organize conferences on the ESONET observatories data exploitation,
- Organize specialized workshops on data management, data dissemination, new sensors, new technologies, inter-comparison of results, etc.

In its final name, ESONET Vi, Vi stands for “vision”

▪ *A standardization and interoperability level to guarantee: the ESONET Label*

The ***ESONET Label*** is a set of criteria to be applied for the specifications of deep-sea observatories. It contains mandatory aspects as well as recommended solutions or options.

The ESONET Label is aimed at sub-sea observatories which are intended to be designed, deployed and used with a high quality control level.

This label guarantees that the equipment can be fully integrated in the scientific community network, with generally free access to data.

It is intended to provide benefits for:

- **Users** who will have a guidance for interfaces and planning of experiments;
- **Funding agencies** who will have a description of the standardisation level needed for European sub-sea Observatory Infrastructures;
- **Providers** who will benefit from a set of specifications common to all European sub-sea Observatory Infrastructures.

❑ **Main Achievements**

During the first period, the main ESONET working groups were formed and the objectives of the various themes were identified. The initial regional implementation groups were also set up. Some were more active than others, depending on the regional node, while the main partners successfully initiated the preparatory phase of the project for a large European research infrastructure, EMSO-PP. Integration within and between sites matured through the launching of 6 demonstrations missions, 3 calls for exchange of personnel, and the selection of tests experiments on 4 sites. During the fourth period the community fulfilled the ESONET objectives, by: (i) converging on interoperability, standardisation and data access issues; (ii) preparing the ESONET Label report; (iii) documenting deployments and tests at sea; (iv) providing an observatory implementation strategy; (v) producing education and outreach documents and films.

▪ *Scientific objectives and sensors design*

The starting point of ESONET activity deals with the ESONET sciences. Indeed starting from science and societal needs in term of long-term time-series, of high frequency measurements and of real time, the scientific challenges that open-sea observatories can meet have been reviewed and continuously updated. The related sensor packages that feed these scientific requirements have been actively discussed and explored. The scientific objectives have been in peer reviewed and accepted in "Progress in Oceanography". The core science objectives have also been communicated at international meetings including the GEOSS Workshop XXXVIII – Evolution of Oceans Observing Systems. A position statement on monitoring in areas of industrial activity has received an initial ratification at the final ESONET General Assembly and an expanded version of this statement has been accepted by Nature for their

Commentary section. These were the WP3 task, managed by NOCS, and reported in deliverable D11 and D13

- *Standardization and interoperability*

The goal of the ESONET project has been to compile the expertise and knowledge that exist in European organizations and companies about operating equipment in the ocean over long time periods and how to optimize the operation and maintenance aspects. Together with the scientific requirements, the technology needs were addressed, mainly to develop recommendations on best practices and standardization and interoperability concepts. The consortium worked on best practices aspects by organizing 3 workshops. These workshops allowed the community to discuss important topics like sensor interfaces, calibration and testing procedures, underwater intervention, quality control, corrosion and biofouling aspects, material choice for 20 years plus operation, international standardisation initiatives, and data management. As a result of these activities, reports have been compiled that can be used as a base for implementing ocean observatories around Europe.
In this framework, it was also decided to organise test experiments on cable sites only, to test procedures, new technologies, data flow, and infrastructures, related to cable infrastructures, in shallow water sites (OBSEA: off Barcelona and Koljofjord) and deep-sea sites (ANTARES, Var Ligurian Sea and NEMO-SN1, East Sicily). The proposal was adopted at the end of period 3 with a deployment in period 4. These were WP2 tasks, managed by KDM/UniHB; their output is distributed over 16 deliverables. Special attention was paid to continue collaborative work with activities regarding Data infrastructure, as common issues apply on sensor interface. It has been decided that a group of experts consisting of project members from France, UK, Germany, Italy, Spain, Portugal and Greece will continue to work on these topics and will be ready to provide the knowledge that have been collected during the project to all interested parties in Europe. This group shall be part of the ESONET Virtual Institute and by this will be the primary point of contact for groups outside of Europe to interact on technological issues.

- *Data infrastructure*

The productive ESONET data infrastructure is the result of intensive networking and cooperative efforts including both observatory and sensor experts contributing knowledge on observatory architectures, as well as Information Technology and data management specialists experienced in scientific knowledge and data handling. This fruitful cooperation from several European projects, EuroSITES, SeaDATAnet, EMSO and ESONET and a ‘bottom-up’ approach led to the current standard-based infrastructure architecture as well as its productive implementation. The data infrastructure for ESONET is designed as a distributed system. Several observatory nodes and data centres already provided both observatory data as well as data archiving services. The ESONET web portal, namely the “ESONET knowledge base” distributes the available data and information to the public. It is based on a Google map user interface from which the users can search and get data. To build a standardized data flow several developments were performed: development of a sensor registry, and other hardware/software tools based on international standards. Beneath common standards for metadata description and exchange such as OAI-PMH and ISO19139, ESONET has chosen to implement core standards of the Open Geospatial Consortium (OGC) Sensor Web Enablement (SWE) suite of standards, namely the OGC standards SensorML, Sensor Registry, Catalogue Service for Web (CS-W), Sensor Observation Service (SOS) and Observations and Measurements. Facing the importance of the related tasks, these activities, initially managed in WP1 during the first two ESONET years, were then organized in a dedicated WP9 during the 3rd and 4th year, always under leadership of KDM/UNIHB. Four main deliverables were issued: D9, D43-44, D70, and D71.

Most of conclusions from WP2 and WP9 are synthesized in the ESONET Label document, namely the deliverable D68. It gathers recommendations and mandatory rules to be applied at different levels of the entire observatory network:

- the infrastructure:
    - recommendation on power supply, connectors
    - recommendation for stand alone observatories
    - recommendation on material
- generic and scientific sensors modules including
    - description of the modules
    - module interface
    - metrology issues
- qualification and testing procedures
- deployment and Maintenance
- data management
- environnemental impact

- *Demonstration missions*

ESONET NoE, according to the Description of Work (DoW), supports pilot experiments at sea and site surveys that help to define the monitoring strategies and the most appropriate parameters to be measured in order to meet the scientific objectives. These pilot experiments are implemented in the Demonstration Missions (DMs) which are part of the Jointly Executed Research Activities of ESONET NoE and are planned, implemented and screened in WP4. Demonstration Missions are considered a mean to strengthen the integration process of the ESONET NoE scientific and technological community. They bring at high level of excellence, implementing the standardisation and interoperability of the different platforms from the consortium. Demonstration Missions are also aimed at acquiring relevant scientific time-series. They are relevant for integrated studies, common workshops and a raw material to demonstrate the integration of data management.
As stated by the DoW, Demonstration Missions were advertised to all ESONET partners by applying an internal Call for Proposals. For each DM call, ESONET NoE coordinator team and Chairs of the 3 Councils with the support of WP4 Leaders led the selections procedure for the DMs and presented the outcomes of the selection to the Steering Committee. The DMs evaluation and selection is based on the combination of two elements:

- The proposal assessment by external, non-European reviewers according to evaluation criteria agreed internally among ESONET partners.
- The final negotiation, internally managed by the Steering Committee, to reach the final agreement on the DMs to be funded.

After selection, the deployment of six Demonstration Missions over seven regional sites cover the main themes of sub-sea observatories: LIDO addresses the monitoring of marine mammal acoustics and geophysics (particularly geo-hazards), MARMARA addresses earthquake hazard in a sensitive region, LOOME is interested in the functioning of a mud volcano both in its geophysical and biological aspects, MoMAR-D addresses the functioning of a deep hydrothermal vent using a multidisciplinary approach, MODOO addresses long-term biochemical functions at the Porcupine Abyssal Plain site in the North Atlantic, while AOEM examines physical and biochemical parameter interactions in Fram Strait. The Demonstration Missions organized themselves as projects with several Work Packages, deliverables and internal meetings. These demonstration missions boosted scientific activities, technological aspects such as deployment procedures, sensor testing and more generally standardisation and interoperability issues. These activities were managed in WP4 by INGV, and main outputs can be read in Deliverables D12 and D45c with one appendix per mission.

- *Implementation Strategies*

The first year was devoted to support the submission of EMSO Preparatory Phase to the European Commission call for ESFRI Infrastructures. Two working groups were set up under the auspices of WP5 (Implementation Strategies). The two working groups (WGs) were the Generic Cable Site WG, led by Jaume Piera of CSIC and the Standalone Site WG, led by Olaf Pfannkuche of IFM-Geomar. The Generic Standalone WG was tasked with updating the science, engineering and business plans developed during the ESONIM project. The Standalone WG has prepared a scientific, engineering and business plan for a mooring incorporating two-way communications and near real-time data transfer. Outputs were a base to prepare observatories implementation plans taking in account legal, ethical, logistical, engineering and technical aspects.

An additional element involved the preparation of a Legal, Ethical and Environmental database (http://www.ifremer.fr/esonet/) and a report was prepared to establish a set of "good practices" in legal aspects for ESONET.

At the end of the project, activities focussed on preparing and discussing the legal configuration of the network (the EMSO-ERIC and "regional" departments), this activity is continuing and is being finalised through EMSO-PP. A report on Implementation Strategies was delivered to EMSO, who will manage the high level and regional implementation. These were the WP5 activities led by IMI, and 7 main deliverables D5, D14, D46, D47, D48, D61 were issued.

- *Socio-economic users*

To prepare business plan and implementation strategy of observatory an important effort was drawn to collaborate with private sector that acts as a "client" and as a "supplier". Indeed supplies input information on available products, a range of equipments from simple, isolated sensors or parts, to communication systems or even integrated observatories. Economical information could be directly used for the business plan and implementation strategy. The general information was managed by a public tool, the ESONET Yellow pages, built upon a database with descriptions of available products, as well as information from manufacturing companies that design and assemble them. In this database, not only the technical specifications (from stand-alone to complex inter-operative systems) but also, compatibility and standardization requirements should be easily accessed in the descriptive synopsis of each item. It was also a way to promote involvement of SMEs and private sectors companies; this was lead by organizing the PESOS group (Providers of Equipment and Services for Observatory Systems). One of the fields where deep-sea observatories are of large interest, is oil industry, due to the needs related with the exploration of hydrocarbon resources in the deep seafloor. In the frame of ESONET several dedicated meetings were organised and the main output is a community statement reported in deliverable D16 and published as short notice in Nature. These activities were related to the ESONET promotion and SME policy which are reported in deliverables D17-2009 and D76.

In parallel to the development of links with private sector, a special attention was paid to well involve core services stakeholders and regional stakeholders. Core services of ESONET are defined as a number of data products and data services which will be provided by the future operational network on a stable basis and with enough standardization to be used as basic input for global players in the fields of Earth Monitoring. Core Services address a specific category of stakeholders, which can be private, profit, or nonprofit organizations, that have the means and the interest to buy information, services or equipments developed by ESONET. These stakeholders are listed in deliverable D76. A special attention was paid on relations with GMES and GEOSS (deliverable D16). The stakeholders as well as the researchers and actors of ESONET NoE have been informed through ESONEWS, distributed to 400 persons all over the world.

These were WP6 activities managed under the leadership of FFCUL.

- *Education and Public Awareness*

In addition to the stakeholders and private companies, ESONET intended to reach people from diverse areas, such as general public, 10-14 years old students and pupils, engineering and PhD students. To meet this objective, several communication tools and support material were developed. A newsletter, the ESONEWS, was edited and distributed several times a year by WP6. The Main ESONET web site http://www.esonet-emso.org was continuously updated to include ESONET activities information. Specific education and outreach in ESONET was supported by the development of a dedicated program of activities including a dedicated web site with scholar material available, movies, flyers, courses and workshops. The Educational site is accessible from a dedicated menu in the main ESONET web site or directly at http://mars-srv.oceanlab.iu-bremen.de/schoolmaterials.html. There diverse material translated in several languages can be found: quizzes (Deliverable D38) as well as ESONET School materials: a 47-page pdf teaching aid produced to introduce ocean science to 10–14 yr olds, the deliverable D49, introduction pages to the ESONET demonstration missions (D32), introductive information on Carbon Capture Storage (D63). Two ESONET Training workshops and a training workshop on “Seafloor observation Techniques for Marine Geohazards Monitoring” were also organised (D4 & D40). Some topic-specific training activities were also dedicated to infrastructure and ROV deployment (D64). For public outreach ESONET was support by a 3-aquaria network located in Lisbon, Heraklion and Brest that inform and educate the public with regard to ESONET-NoE goals and scientific and technological achievements. Students from institutions participating in the ESONET-NoE are taking advantage of the links developed and exchanges are still underway. A set of short films on ESONET and related activities were produced (Deliverable D77). These films, entitled “Ocean under observation” (movie #1), "Deep-sea observatories, Internet in the Oceans" (movie #2), "Observing Europe's open ocean, seafloor and hotspots regions" (movie

#3) and "Dyfamed mission" (movie #4) are available on the ESONET web page. The movie #3 was broadcasted during the GEO summit in Bejing (summer 2010) and the movies #1 & 2 were broadcasted during the EGU 2011 meeting in the Geocinema room. The coordination team prepared successively two versions of a 6-page fact sheet to be distributed in workshops and conferences. 1,000 copies of each were available. They were updated according to the activities of the project to include new input like selected DMs description.

- *Integration toward a sustainable structure*

In a quantitative sense, ESONET had to network about 300 persons distributed over 54 institutions in 14 countries, initially working with different objectives. Two "All Regions Workshops" were organised in order to show to the community that common objectives were addressed on a geographically distributed observatory. The 2009 All Regions Workshop measured the engagement on the various sites presented during the 2007 All Regions Workshop.

To face the integration challenge, a major part of ESONET activities were based on the selection of proposals received after several internal calls: calls for Demonstration missions, for Staff Exchange and for Test Experiment. Indeed, in addition to the scientific and technical objectives fixed by the calls, special attention was paid to integration. These internal calls acted as a lever, booting activities, focusing interests on common topics across interdisciplinary boundaries. In parallel the organisation of many ESONET workshops unified people from different research and engineering fields to share their knowledge and build common activities upon their specialities. Both workshops and internal calls for proposals were the keys to open the door toward integration in ESONET.

The strong and early integration of the ESONET Core partners, Steering Committee and WP5 team enabled the success of the EMSO PP proposal and the good position of EMSO in the ESFRI roadmap. Interaction and relations with funding agencies have evolved over the course of the project and a clear path to the EMSO ERIC has been put in place [see Deliverables D23 (2008, 2009, 2010)]. Three Strategic Committee meetings were organized. The first one in September 2007 in Barcelona decided to appoint identical responsible persons to the EMSO Strategic Committee. The second in Faro in October 2008 reviewed the relations between partners and their own ministry or funding agencies. The third meeting in February 2010 in Strasbourg was common with EMSO. It reviewed the ESONET report to EMSO on implementation plan (D46), checked the member states commitments for long-term funding and addressed the topics of ESONET contributions to GMES and Marine Strategy Framework Directive. The relations with funding agencies are now taken over by EMSO PP.

As a main result of the integration activities in the NoE, the permanent infrastructure EMSO will be supported by a large user community. As a result the demonstration missions involved 27 partners, on 7 sites. Additionally it generated cross activities with other ESONET sites even if they were not specifically funded in the frame of DMs. For instance the 26 exchanges of personnel facilitated the sharing of knowledge and know-how within and between nodes (see deliverable D73). As a result of this successful integration, the constituted groups were well stabilized, leading to start the preparation of a permanent structure, the virtual institute (initially named VISO). A first dedicated workshop was organised in Tromso in June 2009, then a second one inside the 3rd ESONET general Assembly week in Marseille the 16th December 2010. During this last meeting it was decided to change the name of the virtual institute to ESONET-Vi (the Vision) and to build the institute upon the ESONET consortium agreement (deliverables D53 & D72). Most of the involved working groups will continue their activities in the Virtual institute, in EMSO-PP and EMSO-ERIC as was decided during the "After ESONET" session of the General Assembly" (Deliverable D69). Dedicated networking and integration activities such as the organisation of the "All regions workshop", constitution of regional core group per ESONET node, organisation of Staff exchanges, and preparation of the virtual institute were managed in the WP1. Initially this WP1 was led by UniHB and included tasks dedicated to data infrastructure. Facing the increasing importance of this task, a specific WP9 was created. The new WP1 was then managed by IPGP, until the end of the contract.

- **Conclusion**

Thanks to a great involvement of ESONET partners and an efficient management from WP leaders, the project concludes in a fruitful way, with expected achievements. Indeed, thanks to the operation of Demonstration mission, testing experiment, exchange of personnel; the structured ESONET community is now strengthened and well recognized at international level. Standardisation and interoperability are issued in the ESONET Label document. The creation of a permanent structure is now accepted and expected to be finalised soon, demonstrating the integration effect of the Network of Excellence.

Tasks devoted to initiate the large infrastructure of sub sea observatories were successfully transferred to EMSO PP. Constitution of Core Legal entity (CLE) is now the building block of the EMSO ERIC (European Research Infrastructure Consortium). The Constitution of the Regional Legal Entities (RLEs) is now the development of EMSO departments. ESONET impact is worldwide and will continue after the end of the contract. Indeed, the success of European integration of the ESONET Community gained a lot from the successful example of federal integration of sub-sea observatory policies in Canada (Neptune and Venus), in USA (OOI) and to a certain extent in Japan.

The member states funds expected at the beginning of the project will reach a lower level due to the economical crisis. The implementation plan is robust enough to allow for the phased deployment at all ESONET sites, involving more stand-alone observatories at first.

With this successful integration we can consider that ESONET succeeded in establishing the network: we are ensured that the traditional European fragmentation has been overcome sufficiently to carry on the ESONET activities in the ESONET- Vi virtual institute and in EMSO-ERIC for the future. Thus it well met the NoE-typical challenges according to the European Commission 6th Framework Program.

I. Introduction: Objectives of the Network

Presentation of the document and its contents.

I.1 History of Deep sea observatories in Europe and international initiative

Held in March 2007, kick-off meeting of ESONET NoE project was the starting point of many actions whose ultimate goal is the building of a European Deep Sea Observatory Community.
Before this step, predecessors were ESONET CA and ESONIM projects, several Geostar class experiments, technological development addressing disciplinary demonstrations (ASSEM, EXOCET/D), plus several regional initiatives. Facing the fragmentation of deep-sea observatory initiatives in Europe, it was decided to unify efforts and to tackle common objectives. This started with ESONET CA (2002-2006), led by Imants G. Priede, from the University of Aberdeen that made the first assessment of available European capacity in ocean observatories. Then ESONIM, a European Specific Support Action (SSA), led by Mick Gillooly from the Irish Marine Institute (IMI), took the ESONET CA plan a step further by producing a practical and flexible business plan to establish a seafloor observatory based on the ESONET Celtnet Porcupine site. In June 2007, the European Marine and Maritime Science and Technology Community defined a strategy for the community through Aberdeen Declaration: this was the actual beginning of ESONET NoE. The two-step process of the ESONET NoE submission was the occasion to strengthen the core partnership and to enlarge it to major countries such as Spain, Turkey and Norway and to key players such as NOCS (UK). Concurrently, EMSO project was submitted and accepted in the ESFRI road map to prepare the implementation of the infrastructure according to ESONET initiative.

I.2 ESONET NoE in a few lines

I.2.1 ESONET characteristics figures

The European Seas Observatory NETwork (ESONET, http://www.esonet-emso.org) is a Network of Excellence (NoE), launched in March 2007 for 4 years (2007-2011). ESONET is coordinated by IFREMER (France) and co-funded by the European Commission in the Sixth Framework Programme (FP6).
ESONET aims to promote the implementation and the management of a network dedicated to long-term multidisciplinary ocean observatories in deep waters around Europe. It has an objective to overcome research fragmentation in Europe by unifying European initiatives of observatories implementation in Europe. It involves 14 European countries, more than 50 institutions and SMEs, about 300 scientists, engineers and technicians. ESONET is consolidating the deep seas observatories community at regional and European scale.

ESONET is working closely to an infrastructure project EMSO (European Multidisciplinary Seafloor Observatory) for which the Preparatory Phase (EMSO-PP) is co funded by the European Commission in the Seventh Framework Programme (FP7) since April 2008 (www.esonet-emso.org). The success of the EMSO proposal was an objective of ESONET NoE during the first year.

I.2.2 ESONET and EMSO associated

- Links and differences between ESONET and EMSO:

EMSO-PP project officially started one year after ESONET to prepare the infrastructure implementation according to ESONET initiative. Whereas ESONET prepares the community and the technical specifications of ESONET-EMSO observatories, EMSO works at implementing them, preparing the legal context of the infrastructure and legal bodies of people and looking for funding at national and international levels.

- Definition of an ESONET-EMSO observatory

An ESONET-EMSO observatory is a open-sea station linking marine sensors to the shore by 2-way communication via acoustic, satellite, or cable connection in real or near-real time (see Figure I.2-1). These observatories enable coherent data acquisition on oceanographic and climatic phenomena at relative high frequency over long-timescales, at least ten years

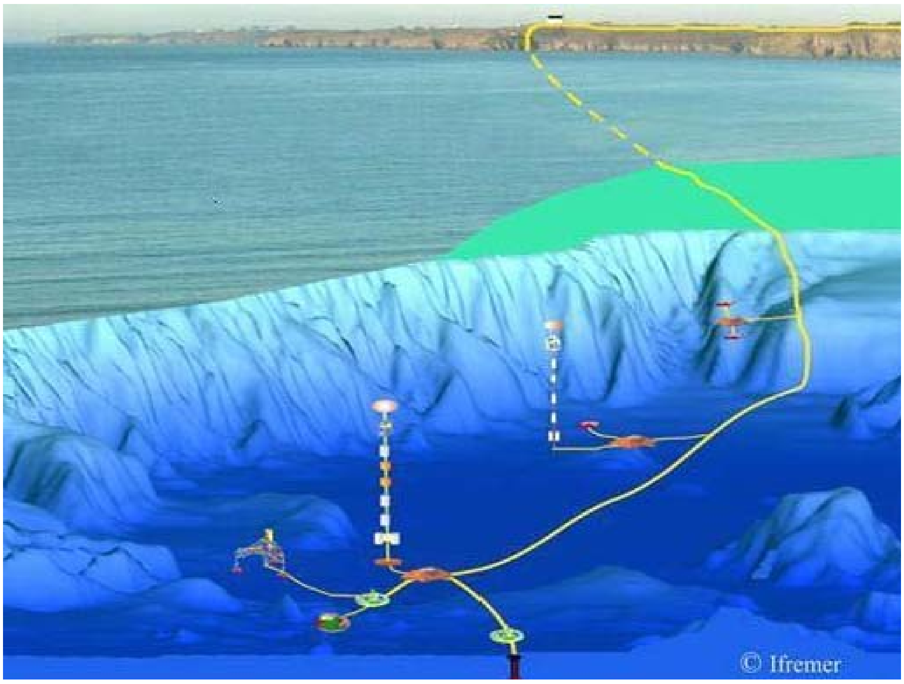


Figure I.2-1: An ESONET observatory

I.3 Why do we need these deep-sea observatories?

Long-term observatories are crucial for European scientists to maintain a high level research that was developed through past and present framework programs. Only long-term observatories allow continuous observations over long-timescales (at least 10 years) of large numbers of parameters collected through power intensive sensors. This capability is crucial

for observing natural processes that are either very episodic or statistically require long time series to be detected because they are hidden by noise of higher frequency. These long-term observatories are also an opportunity for society to monitor the sea in "real-time" and thus to prevent geo-hazard as for instance earthquakes and tsunamis. It also allows monitoring of long-term phenomena such as those due to global warming.
As deep-Sea observatories turn out to be a complementary tool to usual practices as satellite images, oceanographic cruises and moorings, it will ultimately benefit all maritime activities in Europe, which are considerable. The open-access policy for collected data will also increase access for general public, stakeholders and socio-economic users. By the way, it will also support those research areas where access to high-quality data is relatively rare, and it will enlarge the access to deep-sea research for a wider pan-European community and attract worldwide research cooperation.

I.4 Expected results

I.4.1 Integration across sites, sciences fields and teams

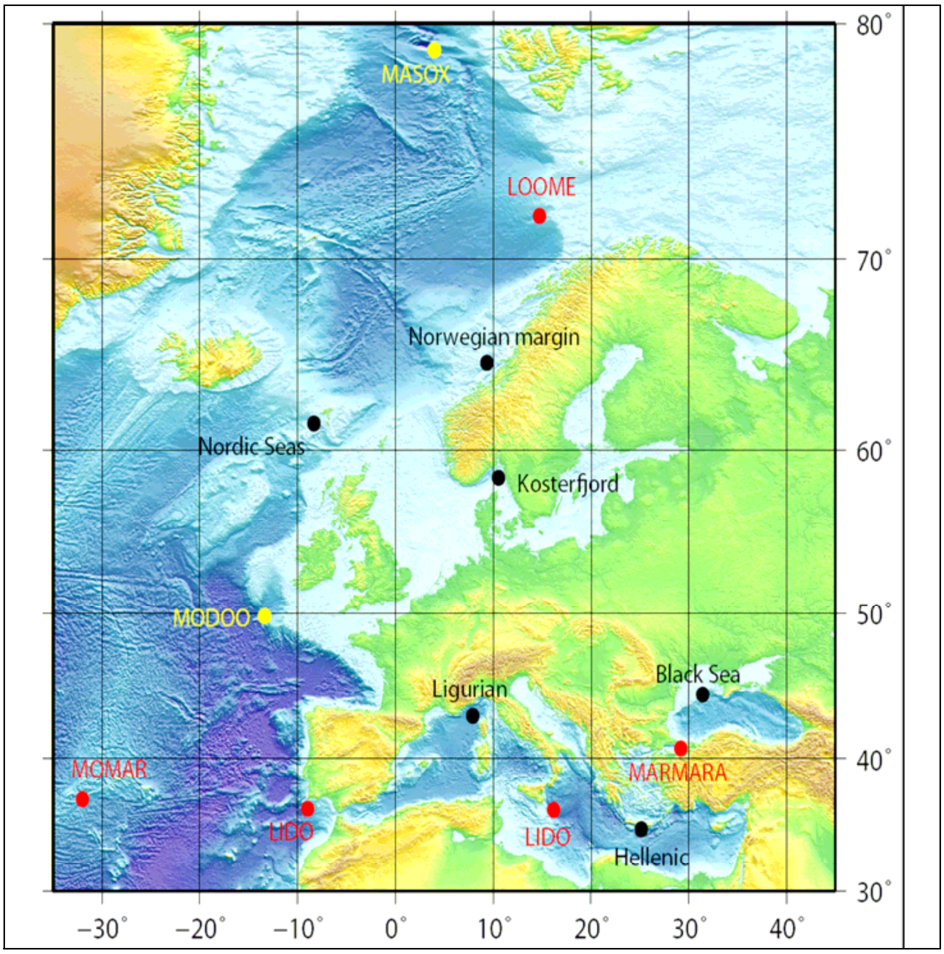


Figure I.4-1: ESONET permanent observatories
LIGURIAN SEA offshore Nice; EAST SICILY site (2100 m deep, 25 km off Catania, NEMO-SN1 Observatory); The PELOPONNESUS site (4000 m deep, 10 km off Pylos); PORCUPINE

ABYSSAL PLAIN (4900 m, SW off Ireland); AWI-Hausgarten (1000 to 5500 m, west of Spitzbergen); NORDIC Seas (1000 m; Haakon Mosby mud volcano); AZORES - MoMAR site; HELLENIC site (Cretan Sea, Rhodos Basin and deep basin South of Crete); CADIZ site: (2000 to 3000 m); BLACK SEA site.; KOSTERFJORD site (NE Skagerrak, Sweden, 90 m deep, 500 meters offshore); The MARMARA SEA.

Currently, ESONET manages 11 permanent observatories sites (see Figure I.4-1), identified and selected for their scientific, technological and socio-economical interests after ESONET community. Two coastal sites (OBSEA and Koljo Fjord) were added later for test purposes because of their ease of access, in a shallow coastal environment. Mobile observatories were described to monitor special-event circumstances as needed. Consequently, the first objective is to consolidate the deep-sea observatory community at European scale by creating a large infrastructure project. This was partly achieved after one year of ESONET NoE thanks to the success of the EMSO-PP proposal. The second objective is to foster the creation of operating entities at regional scales, the **Regional Implementation Groups** that integrate the international community: engineers, scientists, technicians, on each ESONET site. The creation of these groups is a first step toward the creation of each Regional Legal Entities (RLE) that will coordinate each regional observatory. These RLEs and their legal framework are being described and implemented by the EMSO-PP project.

I.4.2 A sustainable network

One important objective of the ESONET NoE project (defined in the Annex 1 of the contract: Description of Work) is to permanently integrate the ESONET consortium at European level of by the creation of a Virtual Institute.
The Virtual Institute would:
- Organize staff exchange in-between its members,
- Organize joined experiments on ESONET observatories,
- Promote development of new sensor packages on the existing observatories,
- Organize conferences on the ESONET observatories data exploitation,
- Organize specialized workshops on data management, data dissemination, new sensors, new technologies, inter-comparison of results, etc.

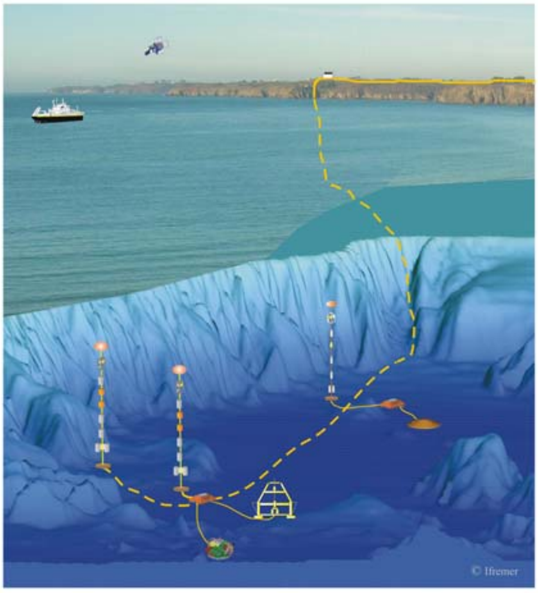
However, this contractual objective was set up before the EMSO PP proposal selection. This consequently raised the need to resize the virtual institute purposes in accordance with the EMSO ones.

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. The members are funding agencies or institutes representing member states. An assessment of European legal structures concluded that an ERIC is currently deemed the most suitable legal form for EMSO to adopt. EMSO, in cooperation with the ESONET NoE and observatory users worldwide, is preparing to submit proposal to become an ERIC.

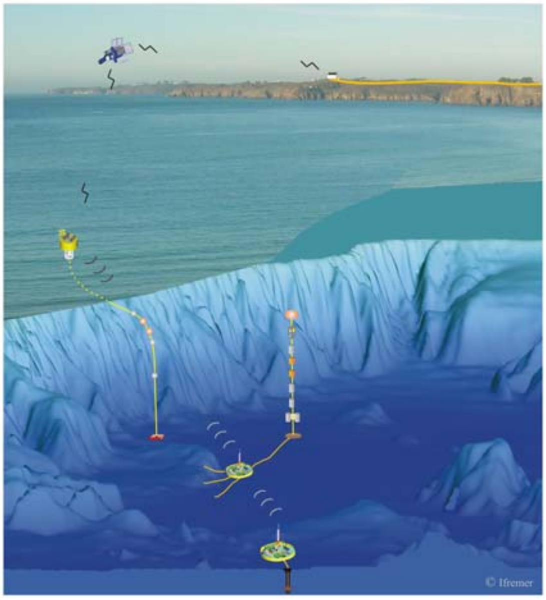
I.4.3 The ESONET Label

The ESONET Label is a set of criteria to be applied to open-sea observatories in order to ensure:
- a high controlled quality level and a durable integration of the sea observatory community at European level, with generally free access to the data, to users for whom those observatories would be observing systems
- minimized implementation costs and operational operations for funding agencies, based on standardisation, interoperability and technical exchanges between operators

Most of the criteria would be applied to 2 considered classes of observatory (figure I.4-2):
- Stand-alone observatories;
- Cable-observatories.



Cabled observatory



Standalone observatory

Figure I.4-2: Two observatory classes

The label document also allows users to propose a new scientific experiment on one site (available power, communication links, time reference, mechanical interfaces, deployment procedures, …) and to ensure of a certain data quality level.

I.4.4 Method and project organisation to achieve the objectives

The major challenge to manage such a wide range of activities was solved through the definition of major milestones as referred in the Annex I to the ESONET contract (Description of Work: DoW), mainly key meetings. (regional –All Regions Workshop, technological- Best Practices Workshops, science meetings, Virtual institute meetings,…).

This 4-year agenda was fulfilled whatever unpredictable events (longer internal calls duration, longer decision processes and sea operations). The frontier between Integrating activities and joint program activities has not be too tight, the major aim being to mobilize the energy on a common networking strategy. To be successful the project organisation was based on several important activities listed here after.

- Starting from science and societal needs in term of long term time-series, high frequency measurements and of real time, the scientific challenges that open-sea observatories can met have been reviewed and continuously updated. The related sensor packages that feed these scientific requirements have been discussed and are presented in the "**Scientific objectives and expected design**" section as a beginning point. This is led in the ESONET WP3.

- The definition of sensor packages, their deployment at sea and the utilisation of the out coming data necessarily lead needs of expertise in the sensors development or update for long-term use in deep water. Facing the cost of such observatory system, the need to select lowest cost sensors, easily replaceable, but also with certain reliability for long term in deep conditions is a compulsory condition. To reach these objectives several standardization and interoperability issues are addressed, such as: underwater intervention, data management; quality control and quality management, sharing of testing facilities, contribution to internationally recognized standards and consortia. This was animated in WP2, WP8 and WP9, through the organisation of several workshops building on Best Practices and innovation, and applied to a complementary activity so-called "Test Experiment on cable sites" to end up with the final ESONET label document. Related topics are presented in the section titled "**Standardisation and interoperability, The ESONET Label**".

- The technical and engineering definition of open sea observatories was updated from an economical model, the "*European Seafloor Observatory Network Implementation Model*", ESONIM EC funded project, built on the ESONET CA project; it produced a practical and flexible business plan to establish typical cable and stand-alone sea observatories. Outputs are a base to prepare observatories implementation plans taking in account legal, ethical, logistical, engineering and technical aspects. Issues are delivered to EMSO PP who manages core and regional implementations of Regional groups in RLEs. This was managed in WP5 and is presented in the "**Implementation strategies**" section.

- Most of these previously listed activities are experimented in the so-called ESONET Demonstration Missions (DMs), cornerstone of the ESONET project. They are pilot experiments at sea and site surveys that help to define the monitoring strategies and the most appropriate parameters to be measured in order to meet the scientific objectives. DMs are considered means to strengthen the integration process of the ESONET NoE scientific and technological community bringing at high level of excellence the technology at different development phases, implementing the standardisation and interoperability of the different platforms from the consortium. DMs are also aimed at acquiring relevant scientific time-series. They are input for integrated studies, common workshops and a raw material to demonstrate the integration of data management. DMs are consisting of almost 50 % of the ESONET activities, in terms of funding, invested energy and results. This is led in ESONET WP4 and presented in the “**Demonstration missions**” section.

- The disseminating of ESONET NoE perspectives and results, such as those from ESONET DMs, but not only, was organised at several levels by developing permanent links to socio-economic users and stronger links between the present and future stakeholders of ESONET (WP6). An emphasis is given on the connection between ESONET and the private sector from oil and gas industry. The group of providers was active and participated to several events; most of them associated with exhibitions. Promoting the state of the art of the network to the large public was addressed through a dedicated Education and Outreach WP7. Results are presented in the “**Communication**” section.

- Considering the number of involved partners (54) and persons (~300), the heterogeneity of scientific topics, technical topics, the number of investigated locations (12); the basic challenge was their integration to build a network and to sustain their activities. Even if “integration” is the common ESONET activity, it was more specifically the topic of the WP1, with dedicated actions such as organising staff exchanges, dedicated “All Regions workshops” and the preparation of a Virtual Institute. Results are presented in “**A successful NoE: Integration in ESONET and a sustainable structure project**” section.

Principal Reference documents (deliverables, reports, articles)

Authors	Titles	Dates/versions	Where to find it (URL, Annex of this report)
IFREMER	Annex 1 to the contract, Description of Work	2010	ESONET website, protected area.

Other reference documents:

-Previous versions of the Annex 1 from 2007-2009.

II. Main achievements and results

II.1 Scientific objectives and expected design (WP3)

II.1.1 Scientific Objectives

This activity included investigating recent advances in marine research, garnering individual inputs from subject experts within ESONET NoE and elsewhere, as well as investigating science priorities of various organizations from regional to international levels. It covered the major international science priorities in the four interconnected fields of geoscience, physical oceanography, biogeochemistry, and marine ecology, as well as the practical ways in which these questions can be addressed using ESONET.

The outline of the science objectives and basic design requirements presented was based initially on the work of the ESONET Concerted Action (CA) and ESONET Network of Excellence (NoE) proposal. The first "All regions workshop" held in September 2007 in Barcelona, Spain launched the multidisciplinary exchanges and the perspective of the first Demonstration missions call. Then, active input was importantly sought during a meeting of the ESONET NoE General Assembly in Faro in October 2008, and a special joint meeting of several major European and international ocean science programs, and the Scientific Objectives Workshop held close to the final General Assembly (see Deliverable D31 chapter 5, for more information). The activities included:

1) having representatives from recent and current programs discuss their objectives and, in particular, how they relate to the science objectives of ESONET;
2) presenting the proposed ESONET science objectives with integrated discussions of the preceding external inputs and;
3) making recommendations and decisions about the scope and detail of ESONET science objectives.

Inputs at these meetings included those from the Hotspot Ecosystem Research on the Margins of European Seas (HERMES), Hotspot Ecosystem Research and Man's Impact on European Seas (HERMIONE), European Network of Excellence for Ocean Ecosystems Analysis (Eur-OCEANS), Global Ocean Observing System (GOOS), the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER), EuroSITES Open Ocean Observatory Network (EuroSITES), CARBOOCEAN, MERSEA, CoralFISH, and Deep-ocean Environmental Long-term Observatory System (DELOS) programs. These meetings resulted in an important consensus on the science objectives that might be addressed by ocean observatories, both directly and with the input of other types of information such as atmospheric, satellite, or other data. Input was also gathered from the Marine Biodiversity and Ecosystem Functioning (MARBEF), Developing Arctic Modelling and Observing Capabilities for Long-term Environmental Studies (DAMOCLES) programs, the US National Science foundation Ocean Observing Initiative (OOI), Neptune Canada, the Monterey Bay Aquarium Research Institute, and operational oceanography programs such as MyOcean (MyOcean). A web-based survey of the ESONET General Assembly and associated program participants also provided a mechanism for individuals within ESONET to voice their inputs either by name or anonymously. All of these inputs were gathered with oversight from the ESONET Steering Committee and Scientific Council. This activity led to the deliverable 11, which was revised in 2009 for submission in Progress in Oceanography entitled "*Societal* *need for improved understanding of climate change, anthropogenic impacts, and warning geohazard drive development of ocean observatories in European seas*" by Ruhl et al.

At the end of 2010 the article was updated following comments from reviewers after the journal peer-review and from the Steering Committee and the Science Council at the final General Assembly meeting. The core science objectives have also been communicated at international meetings including the GEOSS Workshop XXXVIII –Evolution of Oceans Observing Systems.

This should provide substantial outreach and garner further inputs on science objectives from the international ocean science community.

II.1.2 Science and sensor packages

To feed the scientific requirements and needs in marine sciences, the WP3 team discussed the needed development of sensor modules. Sensor modules have been separated in 2 groups: the "*Generic sensors module*" and the "*Specific sensor module*".

The Generic sensor module:

Taking only those sensors that are rated to operate at the deepest ESONET sites, have an established endurance of approximately a year or more, and are commercially available, the remaining sensors make up a rather minimal subset of sensors now available for deep-sea research. This minimal set of instruments has been widely viewed as the best solution by the General Assembly, a meeting ESONET workpackage 3 and 5 members, Best Practices workshops, and the ESONET Science Council.

Defining a list of 'generic sensors' or 'the' generic sensor immediately gives rise to discussions between members of different research disciplines (biology, geophysics, microbiology, oceanography) and working areas (shallow or deep, open ocean or coastal) about what a generic sensor should be able to measure. However, defining a list of generic sensors and variables is important to ensure a consistent set of data acquired at the ESONET sites. The sensor definition helped to setting up accuracy, calibration, and data handling standards for specific purposes.

The generic sensor should be available to a very wide group with as little effort as possible with respect to purchasing and operating the sensor. Thus, commercially available sensors that reliably measure over a long period of time are the most suitable sensors to be used in a generic sense. In this respect, a platinum resistance thermometer (PRT) linked to a simple logging unit is possibly the most generic sensor. Systems that combine these thermometers with other basic sensors are already available from several companies in several countries and are frequently used in the scientific community. These are multi-probe, CTD-type (conductivity temperature, and depth [pressure]) systems which often come with a basic set of sensors and possibilities to add a wide variety of other sensors. The advantage of such systems is that data capture and power supply units already have some integration and interoperability standardization and can be used for quite different sensors and thus parameters.

The generic variables cover several of the Global Climate Observing System (GCOS) Essential Climate Variables to contribute to the UN Framework Convention on Climate Change (UNFCCC, table 1) and the IPCC. Continued interest for these variables is noted in the proceedings of the OceanObs'09 Conference (www.OceanObs09.net). To account for the different research areas and needs outlined in the scientific objectives of ESONET, a first list of sensors/variables has been compiled based on the criteria "most commonly needed", "availability", "ease of use", "deep sea compatible" and "capability for long-term monitoring (corrosion, calibration periodicity, stability…)" of the water column (Table 2). The presented list shows basically a CTD configuration plus a few additional variables. This operation of these sensors will need to meet some basic criteria (Table 3) which are currently met by a variety of manufacturers.

Table 1: GCOS Essential Climate Variables.

Surface	Sub-surface
Sea-surface temperature	Temperature
Sea-surface salinity	Salinity
Sea level	Current
Sea state (how is this quantified?)	Nutrients
Sea ice	Carbon (what types?)
Current	Ocean tracers (which ones?)
Ocean colour (for biological activity)	Phytoplankton (via Chl-*a*?)
Carbon dioxide partial pressure	

Table 2: Generic ESONET variables in the water column and at the seafloor surface.

Variable	Geosciences	Physical Oceanography	Biogeochemistry	Marine Ecology
Temperature	X	X	X	X
Conductivity	X	X	X	X
Pressure	X	X	X	X
Dissolved O_2	X	X	X	X
Turbidity	X	X	X	X
Ocean currents	X	X	X	X
Passive acoustics	X			X

Table 3: Overview of specifications under consideration for generic sensor modules that may be used across European ocean observatory sites.

Type of sensor	Range†	Accuracy†
Conductivity	0 to 9 S/m	0.001 S/m
Temperature	-5 to +35°C	0.01 K
Pressure	0 to 600 bar	0.1 % FSR
Dissolved oxygen	0 to 500µM	5%
Turbidity	0 to 150 NTU	10%
Currents	0 to 2 m/s	2%
Passive acoustics	50 - 180 dB re 1 µPa	+/-3dB

†Range and accuracy given are often adjustable through calibration and given here as suggestions.

These generic sensors can be used to directly address a wide range of scientific applications related to understanding natural and anthropogenic variation and the possible impacts of climate change, they will contribute to geohazard monitoring. The generic systems will also provide supporting data to a large set of additional uses. Firstly these systems will be able to detect passing tsunami waves and associated low frequency sounds related to earth motions. In the observatory setting these data can then be relayed back to shore via seafloor cable or satellite telemetry within minutes. Because nearly all tide gauges are along shorelines, offshore data can improve warning time. The system will be able to detect storm and tide wave loading, sedimentation dynamics that influence turbidity such as resuspension, and benthic boundary layer (BBL) dynamics. By linking the tide, turbidity, and current meter readings the interaction strengths and thresholds for resuspension and sediment transport can be further described. Furthermore determination of these parameters at the seabed and in the water column can help determine how seabed processes interact with ocean circulation, biogeochemistry, and ecological parameters. Combining the generic sensors with specific sensors such as seismometers, geodesy, bubble flux observing systems, hydrothermal flow meters and piezometers the remaining key questions outlined in Deliverable 11 can be addressed. These questions include; how are seismic activity, fluid pore chemistry and pressure, and gas-hydrate stability, and slope failure related? And, what are the feedbacks between deformation, volcanism, seismic, and hydrothermal activity?

The generic sensors can address fully the questions related to physical oceanography. However, a generic sensor module at the surface, mid water and/or at the seafloor can only answer these questions partially. The use of salinity and conductivity sensors spaced regularly along strings and additional ADCP coverage can, however, fully capture the themes related to ocean physics. These include understanding wind driven and deep-ocean circulation, planetary waves, and interactions between the BBL and seabed. Mobile systems used in conjunction with the fixed infrastructures can also augment the impact of the generic sensors.

The oxygen sensor in the generic specification can address several aspects of biogeochemistry. Oxygen itself is important for aerobic life in the ocean which includes all metazoans (e.g. zooplankton, fish, and benthic invertebrates). Oxygen is primarily replenished in the ocean by inputs related to photosynthesis and equilibration at the air-sea interface. By making some crude assumptions one can estimate how much oxygen has been utilized by measuring how much remains compared to saturation levels (apparent oxygen utilisation [AOU]), Garcia et al. 2006). So, variations in oxygen minimum zones, as well as oxygen dynamics in the rest of the water column are of interest. The generic module will also be able to make sensitive measurements of how oxygen consecrations relate to turbidity and temperature, which both have connections to time variant respiration and/or remineralisation. As sensor technology develops biogeochemical sensors will likely transition from specialized to generic in the coming months and years. This will include Chl-*a*, $p\mathrm{CO}_2$, $p\mathrm{CH}_4$ and pH. Moreover the more specialized measurement of particulate fluxes greatly augments the breadth of biogeochemical themes that can be addressed. The most elemental of these themes is oceanic carbon and greenhouse gas uptake and storage dynamics and estimating how anthropogenic change might alter the efficiency of the biological pump.

An ecological sensor in the generic specification is the hydrophone(s) which will be capable of detecting marine mammals. Currently there are hydrophone-based systems that can detect the position and species of mammal sounds and thus come up with estimates of density and distribution. Other sounds can also be detected including anthropogenic sounds like those of passing ships, rain, and the sounds of certain plankton and fish. Including these systems with other ecology systems will provide verification data that is need to improve the detection of more sounds. ADCP systems are sensitive to zooplankton and fish distributions, as well as currents. For example the relative density variations associative with diurnal vertical migrations and their variation from hours to decades can be quantified and calibrated (Flagg and Smith 1989, Kaufmann et al. 1995). The addition of cameras and active acoustic systems like scanning sonar or synthetic aperture systems can greatly augment the quantification of abundances. Fluorometers, zooplankton samplers, and advanced microbial sensing systems also add to the impact of the generic system to address the diverse set of ecological question in Deliverable 11.

During the GA held in December 2010 in Marseille, it was agreed to keep the basic generic sensor composed of: conductivity, temperature, pressure, oxygen sensor, optical backscatter sensor (transmissiometer), current meter (ADCP), and passive acoustics; and have additional sensors important for specific tasks (e.g. adding geo-chemical sensors for geo-chemical monitoring campaigns) as optional for the specific sensor module (see D13).

The Specific sensor Module

Specific sensors and parameters are those not listed as generic one in the previous section. They are specific to the scientific objectives of the studied area, for instance Ocean Bottom Seismometers for seismic zones. Typical output data are acoustic data, HD video and photos, biogeochemical fluxes, and biological and ecological parameters such as density and biodiversity. Acoustic tomography has been addressed by several ESONET partners and experienced in the Arctic (DM AOEM). Several examples have been presented in keynote speeches and case studies during the first Science workshop in Faro. Many examples are given in the ESONET document "*D13 - Science Modules of the European Seas Observatory NETwork (ESONET)*" and its annexes.
Several innovative specific modules were developed by ESONET NoE partners during the project, some of them are listed hereafter as examples.

- The IODA: CNRS/LMGEM developed a new device to measure in situ O2 dynamics through the water column (up to 6,000m-depth) called IODA6000 in the framework of the French ANR program POTES in collaboration with the ESONET partner CNRS/CPPM. Parameters such as T, S and O2 concentration and O2-consumption are currently measured at 2,000m-depth at the ANTARES site (NW Mediterranean Sea). These provide high-frequency in situ real-time data.
- The UVP (Underwater Vision Profiler) developed by CNRS/LOV allows calculating sedimenting or resuspension rates and monitors the plantonic community near the bottom. This instrument is used for the image acquisition followed by data analysis of macrozooplankton and marine snow like particles from 60 microns to several cm in size.
- Integration of innovative radon sensors (KATERINA patent) and Passive Aquatic Listener (PAL) in the Hellenic node. PAL is deployed at 500m-depth for ambient noise like rainfall, wind and marine mammal detection. A PAL consists of a broadband, low noise omnidirectional (zenith angle) hydrophone (Hi-Tech-92WB), a signal processing board, a low-power microprocessor (Tattletale-8) with a 100 kHz A/D digitizer, a 2 GB memory card and a 60 Amp-hour battery pack.

Among other innovations, the Demonstration missions and the test experiments were the occasion to experiment new instruments dedicated to the specificity of the sites such as flux chemical analysers (in MOMAR-D), scanning sonars for bubble detection (in MARMARA DM and LOOME), magnetometers (LIDO), …

Main reference documents (deliverables, reports, articles):

Authors	Titles	Dates/versions	Where to find if (URL, Annex of this report)
Ruhl H.	D11 “*Report on scientific background and objectives”*	2010	ESONET website/Gallery
Ruhl H.	D13 – “*Science Modules of the European Seas Observatory NETwork (ESONET)”*+ appendixes	2011	ESONET website/Gallery
Ruhl H. et al.	*Societal need for improved understanding of climate change, anthropogenic impacts, and warning geohazard drive development of ocean observatories in European seas)*	2010	On line soon

Other Reference documents (deliverables, reports, articles):

-Previous versions of Deliverables D11 and D13

- Reports of Demonstration missions Annexes of D45c

II.2 Demonstration Missions: DMs (WP4)

II.2.1 Main objectives of the Demonstration Missions in ESONET

ESONET NoE, according to the Description of Work (DoW), supports pilot experiments at sea and site surveys that help to define the monitoring strategies and the most appropriate parameters to be measured in order to meet the scientific objectives. These pilot experiments are implemented in the Demonstration Missions (DMs) which are part of the Jointly Executed Research Activities of ESONET NoE and are planned, implemented and screened in WP4. Demonstration Missions are considered means to strengthen the integration process of the ESONET NoE scientific and technological community bringing at high level of excellence the technology at different development phases, implementing the standardisation and interoperability of the different platforms from the consortium. Demonstration Missions are also aimed at acquiring relevant scientific time-series. They are input for integrated studies, common workshops and a raw material to demonstrate the integration of data management. DMs were drawn to support pilot experiments on both sciences and technologies according to Scientific Areas and Technological Areas defined in the calls for proposals

Concerning the Scientific Areas, Demonstration Missions were drawn to allow the comprehension of the links between natural and anthropogenic processes on one hand and ocean circulation on the other hand because it is essential for predicting the magnitude and impact of future changes in Earth's climate. In this respect, the knowledge of deep-water circulation close to the seafloor (i.e. currents at the Benthic Boundary Layer) is a fundamental objective. More generally, understanding the interactions between ocean, biosphere and geosphere (lithosphere, and solid earth below), leading to natural hazards (e.g. tsunami, seismicity, submarine landslides) or environmental changes (e.g. sea-level, ecosystem changes, greenhouse gas budget) is one of the main scientific challenges for the next few decades.

To support this objective, Concerning the Technical Areas, ESONET Demonstration Missions were dedicated to facilitate the introduction and adoption of standards in the realm of scientific investigations to enable interoperability on the system and component level, enhancing the capacity of building in the context of long term operation of observatory systems.
Demonstration Missions sites situated around a cabled and/or non-cabled observatory and with existing infrastructures or/and facilities such as services with research vessels and ROVs, which allows of time and cost effective implementation, were favoured. DM sites had also to be situated at nodes of the proposed ESONET key sites and to contribute to the development of these strategic nodes.

As DMs were expected to address ESONET topics in agreement with the scientific and technological objectives, the document published as call for proposal indicated these Scientific Areas, Technological Areas and site locations.

II.2.2 Organisation of DM Calls and selection of proposals

The organisation of the calls and the selection procedure are fully described in the ESONET deliverable D12.

As stated by the DoW, Demonstration Missions were proposed to all ESONET partners by applying an internal Call for Proposals. For each DMs call, ESONET NoE coordinator team and Chairs of the 3 Councils with the support of WP4 Leaders were charged to operate the selections procedure for the DMs and presented the outcomes of the selection to the Steering Committee.

The DMs evaluation and selection is based on the combination of two elements:

- The proposal assessment by external, non-European reviewers according to evaluation criteria agreed internally among ESONET partners.
- The final negotiation, internally managed by the Steering Committee, to reach the final agreement on the DMs to be funded.

The Reviewers were asked to judge individually and independently against the evaluation criteria those proposals that the Coordinator and the Chairs of the Councils have assigned to him according to his expertise in the scientific and technological areas dealt within the DM proposal.
The proposals passing all the evaluation thresholds are ranked by total score decreasing. The Steering Committee selected the proposals starting from the one with the highest total score. The allocation of the granted budget to each proposal is defined in a Steering Committee meeting on the basis of the total budget assigned to the DMs by the Steering Committee itself. The option of the Steering Committee to negotiate with proposal coordinators on budget issues was foreseen. This negotiation was only intended to increase the number of funded proposals.

II.2.3 Selected DM proposals

Two Calls for Demonstration Missions were opened during the ESONET project. The first one was launched in May 2007 and closed in October 2007 and the second one was launched in September 2008 and closed in November 2008.
Four proposals were selected during the first call and two proposals during the second call (see Table 3.1).

Table 4: List of selected ESONET Demonstration Missions.

Call	DM Name	Coordinator	Start date	End date	Partners involved
First Call	LIDO	Universitat Politècnica de Catalunya (E) Michel Andrè	01.09.2008	31.08.2010	KDM-UniHB, INGV, ISMAR, INFN, Tecnomare, FFCUL, CSIC, UPC, BHT-Berlin, DBSCALE
	LOOME	Max Planck Institute -MM (D) Dirk de Beer	01.02.2008	31.12.2010	KDM-AWI, KDM-IFM-GEOMAR, KDM-UniHB, KDM-MPIMM, Ifremer, UIT
	MARMARA-DM	Ifremer (F) Luis Geli	01.04.2008	30.09.2010	Ifremer, CNRS-Cerege, INGV, ISMAR, ITU, DEU-IMST
	MOMAR-D	Ifremer (F) Pierre-Marie Sarradin	01.09.2008	31.08.2010	Ifremer, UAC, FFCUL, IPGP, NOCS, CNRS-LMTG, CNRS-IUEM, KDM-UniHB, SOPAB
Second Call	AOEM	National Oceanographic Center Southampton (UK) Ian Wright	01.07.09	31.10.2010	KDM-AWI, KDM-IFM-GEOMAR, FORTH, NERSC, NOCS, UIT
	MODOO	IFM-GEOMAR (D) Johannes Karstensen	01.05.09	30.09.2010	KDM-IFM-GEOMAR, NOCS, IMI, NIOZ, UniABDN, KDM-AWI

LIDO (Listening the Deep-Ocean environment)

LIDO objective is to enhance of the present capabilities of the observatories working in the ESONET key-sites of Eastern Sicily (NEMO-SN1, cabled observatory) and of the Iberian Margine (Gulf of Cadiz, GEOSTAR stand-alone observatory and configured for NEAREST pilot experiment) by installing not-already-included sensor equipments related to Bioacoustics and Geohazards.

Participants: CSIC/UPC, KDM/UniHB/Marum, FFCUL/ CGUL , INGV, ISMAR, INFN, CSIC-UTM, dBScale, BTH-Berlin, TECNOMARE.

- ***Scientific Objectives***

Bioacoustics: LIDO aimed at evaluating the human and natural contributions to marine ambient noise and f at describing the long-term trends in ambient noise levels for the first time, especially from human activities (influenced for example by increasing shipping) and in marine mammals populations (migration patterns, presence, and habitat use of key species, like sperm-, fin- and beaked whales).
Geo-Hazards: LIDO aims at improving the real-time and near-real-time detection of signals received by a seafloor multiparameter observatory network at regional scale for the characterisation of potential tsunamigenic sources. Its methodological approach is based on the cross-checking of geophysical, oceanographic and environmental time series acquired on the seafloor and in the water column.

- ***Technological Objectives***

The technological objectives of LIDO are the development of the first nucleus of a regional multiparameter seafloor network of homogeneous observatories (same sensors) and its long-term operability beyond the duration of LIDO DM in two ESONET key-sites, East Sicily (cabled) and Gulf of Cadiz (stand-alone, acoustically linked with a surface buoy).

- ***Main Results and references***

LIDO developed enhancements of existing NEMO-SN1 and GEOSTAR observatories and infrastructures to open the nodes of a first nucleus of regional network to other disciplines (bioacoustics) and homogenise the geophysical equipments of these observatories by integrating additional sensor, devices, and software. The development of the pilot experiment for long-term operation of the observatories and comparative tests was also included.
Within this demonstration mission the data stream from two sites were integrated into a common data acquisition and distribution service.
Real-time transmission of marine mammal acoustic signals and acoustic images from seafloor cabled observatory to public institutions (e.g., Scientific Museums, Aquaria) where the whole ESONET network is available together with the "sonic imagery" of the LIDO stations (http://listentothedeep.com). It is also a research tool thanks to the real time and automatic analysis software (long-term recording and analysis of natural, artificial and biological sound sources; identification and tracking of cetaceans; long-term noise interactions and masking).
The LIDO framework is currently implemented at the following sites:

- NEMO observatory in Sicily, redeployment of two instrumentation lines is expected in the second week of December 2010; 4 channels are available at 96 kHz and 4 at 192 kHz.
- ANTARES observatory near Marseille; 36 channels are available sampled at 250 kHz.
- OBSEA, shallow water platform in Catalonia; 1 channel is available at 96 kHz.
- NEPTUNE, 3 hydrophone data streams from different locations are publicly available in; all channels are sampled at 96 kHz.

The deployment in the Gulf of Cadiz was done in autumn 2009. The operation was deeply affected with the effect of rough sea conditions in 2010 which interrupted the buoy transmission. A recovery cruise is expected in mid 2011.

LOOME (Long-term Observations on Mud-Volcano Eruptions)

The LOOME Demonstration Mission was based at the Haakon Mosby Mud Volcano, which is an active submarine mud volcano located in the Norwegian Sea at 1250 m deep and measuring 1.4 km wide and 15 m high. The particularity of this volcano is that it sits on top of a giant chimney from which warm methane-rich fluids are pressed upwards towards the cold seawater.

Participants
KDM/UNIB/Marum, KDM/AWI, KDM/IFM-GEOMAR, Ifremer, UiT,

- ***Scientific Objectives***

One major objective was to investigate the temporal variability at an active gas-emitting mud volcano, covering the sequence of events before, during and after an eruption, and to analyse their effects on gas-hydrate stability, on seafloor morphology and on the distribution and colonization patterns of benthos communities. Sensor packages were used at the sediments surface (Temperature-strings, chemo-sensor-strings, camera), and in the water column (CTD, scanning sonar).

- ***Technological Objectives***

The major technical objectives were to integrate existing technology to establish an autonomous, non-cabled observatory. Sensor systems and biological experiments were to integrate around a combination of deeply penetrating, *in-situ*, temperature and geo-acoustic recording units, which gave an early warning of eruptive events. Test integration of these sensors, and their endurance were also to be performed.

- ***Main Results and references***

LOOME benefited from a good organization and started early enough to deploy a complete observatory in POLARSTERN ARK-24/2 cruise in July 2009 and obtain its results during the RV Merian cruise of September 2010. The deployment and recovery cruises involved temperature mapping and numerous samplings for geochemical and microbial analysis, during recovery cruise, an AUV performed detailed bathymetric mapping and chemistry distribution measurements. The lander observatory from KDM with its Ifremer COSTOF electronics and all the associated sensors worked remarkably well. Data collected includes seismics (full period), T-lance (full period), video (6 months), surface T dynamics (full period), water column DO, pH and T (full period).
Although the Haakon Mosby Mud Volcano has been visited every year since 2001, the ESONET observatory approach allowed for the first time the monitoring of eruptive event(s). First conclusions are not complete but report exciting input for scientific studies. Dramatic changes have been collected by the various sensors such as a raise of 0.5 m of the observatory frame with pH drop at the same time followed after 4 weeks by an eruption observed with a sharp rise in temperature. The T-lance moved and was pulled out of the sediment. The first estimate of the LOOME scientists is a motion of 500 000 m^3 of sediment corresponding to a methane release of 60 000 000 m^3 at 1 atm. A first publication is expected in September 2011.

MARMARA-DM (Earthquake Monitoring in the Marmara Sea)

The Sea of Marmara presents an exceptionally high earthquake risk and deformation rates are very high compared to any other marine sites in Europe, resulting in active submarine processes that can be measured on short time scales. In addition, numerous fluid vents and related features have been discovered in the area.

<u>Participants</u>
ITU, IFREMER, ISMAR-CNR, INGV, CNRS/IUEM, DEU-MST

- ***Scientific Objectives***

MARMARA-DM was designed to contribute to the establishment of optimised permanent seafloor observatories for earthquake related hazards (including landslides and tsunami) monitoring in the Marmara Sea. Objectives were also to characterize the temporal and spatial relations between fluids and seismic activity in the Marmara Sea. More exactly it intended to characterize the temporal and spatial relations between fluid expulsion, fluid chemistry and seismic activity in this zone and to test the relevance of permanent seafloor observatories for an innovative monitoring of earthquake related hazards, and possible precursors, appropriate to the Marmara Sea specific environment.

- ***Technological Objectives***

The technological objectives of MARMARA-DM were to test the relevance of long-term seafloor observatories for an innovative monitoring of earthquake related hazards and to propose the technological option (cable, buoys, etc) that is the most adapted for the Marmara Sea. It intended to conduct a feasibility study to optimize the submarine infrastructure options (fiber optic cable, buoys with a wireless meshed network, autonomous mobile stations with wireless messenger).

- ***Main Results and references***

A total of 6 cruises were conducted, allowing the selection of the optimum sites for the future multi-parameters sea-floor observatories. The successful deployment of bubble observatory using sonar and autonomous SN4 observatory (with oxygen sensor, methane sensor and a large bandwidth seismometer) in addition to piezometers and seismometers demonstrated the possibility of a long term monitoring.
First site, on Istanbul-Silivri segment site located in the seismic gap immediately south of Istanbul where intense bubbling is observed on a structural High, 1 km south of the main fault trace; is the first priority for the seismic precursor studies. The second site, the Western High gas hydrate area, is also important due to the link with gas seeps from the Thrace basin. The third site, the entrance of the Izmit Gulf, is near the end of the surface rupture.

The Marquake proposal was submitted to the EC in September 2010, it was selected but not accepted for negotiation. The Mardep proposal, which may be considered as a Regional EMSO project, has been submitted to the Turkish Government end of April 2011.

MOMAR-D (Monitoring the Mid-Atlantic Ridge)

This project focuses on a deep-sea hydrothermal system on the Mid-Atlantic Ridge, south of the Azores Islands. On the fractured seafloor, seawater circulates through the permeable oceanic crust, exchanges chemicals with the surrounding rocks and is heated to high temperatures. These hot fluids flow upwards and are expelled through hydrothermal vents, forming emissions of different chemical properties.

Participants
DOP/UAÇ, FFCUL/CGUL, IPGP, NOC, CNRS – F, CNRS – C, Univ. Bremen, Ifremer, SOPAB (Oceanopolis Aquarium)

- ***Scientific Objectives***

MOMAR-D will study the temporal variability of active processes such as hydro-thermalism, ecosystem dynamics, volcanism, seismicity and ground deformation, in order to constrain the dynamics of mid-ocean ridge hydrothermal ecosystems.

- ***Technological Objectives***

The technological objectives of MOMAR-D are to deploy a multidisciplinary acoustically linked observing system, with satellite connection to shore and to demonstrate the overall management of this system during 1 month even if its operation will actually continue during 12 months.

- ***Main Results and references***

The observatory infrastructure is composed of two Sea Monitoring Nodes (SEAMON) acoustically linked to a surface relay buoy (BOREL), ensuring satellite communication to the land base station in Brest (France). The entire system was deployed during the MoMARSAT cruise (The Pourquoi Pas ? /Victor6000, http://www.ifremer.fr/momarsat2010/) in October 2010. A SEAMON WEST node, dedicated to large scale geophysical studies, was moored in the centre of the large lava lake present in the Lucky Strike vent field. This node hosts an Ocean Bottom Sismometer (OBS) and a permanent pressure gauge (JPP) that were connected underwater using wet matable connectors. A SEAMON EAST node was deployed at the base of the Tour Eiffel active edifice to study the links between faunal dynamics and variations of physico-chemical factors. This node is composed of a High Definition (HD) video camera, 6 LED lights, an Aanderaa optode (oxygen, temperature) and two in situ chemical analysers. These two nodes communicate via underwater acoustics to a BOREL buoy that is moored on the ocean surface within acoustic range of the SEAMON stations. This buoy is equipped with two identical back up data transmission channels to ensure uninterrupted data flow. Scientific and technical data (including a low-resolution photo) are transmitted daily to the data centre in Brest. Autonomous instruments (OBS, ocean bottom tiltmeter, current meters, particle trap, colonisation experiments and temperature probes) were also deployed in the Lucky Strike vent field. They will store their data for the whole duration of the experiment (1 year).

Treatment of data sets is conducted in two stages: in near real time for the subset that is transmitted through the SEAMON system; and after the 12 months for the whole data set. The near real time data serves both as support for scientific interpretation, and as an indicator that an event is occurring. Volcanic (eruption, underground dinking event, or rapid degassing of the magma chamber), tectonic (displacement along axial faults), or hydrothermal events are all expected to occur on the MAR. Understanding the impact of these events on biological communities is one of our key objectives. The data can be viewed online (now, temporary access through http://www.ifremer.fr/WC2en/allEulerianNetworks). The system will be recovered and redeployed in summer 2011.

AOEM (Arctic Ocean ESONET Mission)

The Arctic Ocean off the western Svalbard shelf and Fram Strait is a critical site to document climate-change induced change where the Arctic Ocean geosphere, hydrosphere and biosphere are the most sensitive to irreversible perturbation. The challenges were the lack of sustained real-time seafloor and water-column measurements, and the data transmission from a hostile environment with seasonal sea-ice cover. The AOEM demonstration mission is an integration of 2 proposals, namely ARCOONE and MASOX ones, merged in order to better manage cost and integration of activities, upon request of the ESONET Steering Committee.

Participants: KDM/AWI, FORTH, KDM/IFM-GEOMAR, NERSC, UiT

- ***Scientific Objectives***

AOEM aimed to demonstrate and deploy observatory lander technology for dissociating hydrate studies in high-latitude, but warming Arctic Ocean shelf sites.

- ***Technology Objectives***

The technological objectives of AOEM were to design and evaluate data acquisition and real-time transmission methodologies for Fram Strait oceanography, including an acoustic network for future ocean tomography and glider navigation and docking. Its objective was also to develop the scientific and policy case for the Arctic ESONET site to become a sustained cabled observatory network within ESONET/EMSO initiatives, and Norwegian and EU ESFRI programme SIAOS/SIOS.

- ***Main Results and references***

The AOEM MASOX observatory was deployed on the 13th October offshore Prins Karls Foreland in water depth of 389 m. The seabed shows gravel with a sand/clay matrix. The AOEM observatory was deployed at a flare cluster with a surrounding community of bacteria, probably methanotrophic. It is located at the theoretical gas hydrate stability outcrop zone using present day ocean temperature conditions. The locality of the observatory lies within the highest concentration of southern flares in cluster B at 78°33.272 N, 09°28.699 E.

As planned, with the additional budget from Norway and Statoil, in July and August 2011 the observatory will be recovered and launched again. The instruments will be cleaned and any broken sensors will be replaced, a complete battery change will occur to extend operation for a further 12 months. In the summer of 2012 the observatory will be recovered.

In parallel, the AOEM ARCOONE team made a technological status study on tomography arrays in the FRAM straits involving also moorings, floats and gliders. Component tests were performed in 2010 on gliders, horizontal acoustic transmission and winch profilers.

MODOO (Mobile and modular Deep Ocean Observatory)

Seafloor and mesopelagic processes are in many cases closely linked by physical and biogeochemical processes in the surface ocean and euphotic zone. To investigate the functioning of such processes, observatories that monitor the full water column as well as the sea floor are required. MODOO aimed at demonstrating the integration of both science and technology from the surface to seafloor at a single site, the Porcupine Abyssal Plain.

Participants: NERC-NOCS, IM, NIOZ, UniAbdn, AWI

- ***Scientific Objectives:***

Major scientific objectives of MODOO were to study the ocean circulation, the mixed layer dynamics, the benthic boundary layer dynamics, the link surface and deep ocean, the biogeochemical cycling in water column and sea floor, the deep-sea marine life, the lateral transfer of matter, the sinking particles and to monitor seismic activity.

- ***Technological Objectives:***

The technological objectives of MODOO were to integrate a multitude of sensors and to increase the observatory capability with new data transmission system, telemetry data and real time quality control.

- ***Main Results and references***

The MODOO system design and testing was completed during the demonstration mission. Despite the failure of the deployment at the PAP part of the Porcupine node and the tremendous loss that occurred with the loss of the BOBO lander, most part of the functioning of the MODOO system could be demonstrated.
Given the short time of 17 months only available (May 2009 –Sept. 2010) the MODOO partnership operated surprisingly efficiently. This was in part due to the input from the work that has been done in the ESONET NoE core project – via discussion, exchange (in particular exchange of personnel "MODOO Connect") and also already available standards. One other and very important part was joint activities with other, non- ESONET NoE projects, and in particular with the FP7 EuroSITES project. EuroSITES not only provided the deep-water mooring for the installation at the Porcupine node but also "contributed" a data dissemination structure, which was already so flexible that it could handle the MODOO specific data streams.
MODOO has already contributed significantly to future observatory design. One example is a MODOO consisting of 2 moorings and 7 landers all communicating with each other and with the outside world via a surface telemetry system (German BMBF project Molab). It is envisaged by UK and other countries to fund a permanent observatory on the PAP inside EMSO.

Main Reference documents (deliverables, reports, articles)

Authors	Titles	Dates/versions	Where to find if (URL, Annex of this report)
INGV and IFREMER	D12 *"First periodical report on demonstration missions"* + *appendix*	2009	ESONET website/Gallery
INGV and DM leaders	D 45, c *"Periodical reports on Demonstration missions*" including all DM deliverables as appendixes	2011	ESONET website/Gallery

Other reference documents:

-The periodic reports of demonstration missions included in Deliverables D45a &b.
-Bibliographic references of each demonstration missions (included in D45c).

II.3 Standardisation and interoperability, The ESONET Label (WP2, WP9, WP8)

II.3.1 Context: The Needs of standardisation:

Standardisation and interoperability are topics that cover a very broad range so that ESONET can only address selected issues.. Consequently, ESONET restricted its activities to, the following topics: sensor interfacing, description of calibration procedures, related quality management issues, underwater intervention procedures, and data infrastructure. The aim was not to cover the theme in full breadth but to investigate, understand, evaluate and recommend selected practices and standards for future use. To do so, it is necessary to form teams on the European and international level. The activities carried on intended to

- develop a strategy for evaluating sensor interface standards and demonstrate their applicability.
- set up a quality management framework in regards to operational considerations within the framework of sea observatories.
- increase capabilities and share usage of existing facilities.
- formulate recommendations on underwater intervention procedures within the framework of sea observatories.
- develop links to GEOSS activities.
- organise equipment tests on cabled sites
- to prepare data infrastructure for observatories users

To fulfil this broad topic, the activities have been organised in well-defined tasks and corresponding task leaders, with the support of active working groups. Considering the issues, the stimulation of these groups and the follow-up up of their activities was crucial, and this was mainly managed in the frame of dedicated workshops, the ESONET Best Practices workshops:

- Best Practices workshop # 1: Bremen, Feb. 2008, reported in Deliverable D6
- Best Practices workshop # 2: Brest, Oct. 2009 reported in Deliverable D50-2011
- Best Practices workshop # 3: Marseille, Dec. 2010, reported in Deliverable D69

In addition a Technology workshop was organized by UniABDN, near Aberdeen, in Nov. 2010, reported in Deliverable D61.
Those workshops brought around experts in the field of marine technology from different European institutions together. With the involvement of partners from the US and other countries outside Europe, the obtained results should have a broader impact.

II.3.2 Starting from scientific sensors packages and sensor interface

Within WP3 of the ESONET NoE, sensor packages have been classified into two categories: generic ones and specific ones (see § II.1, WP3 report). This classification was based on the scientific demand as defined by participating experts in the field of deep-sea research. WP2 addresses standardisation and interoperability issues of both types of sensor packages. Along with Data management activities in WP9 (see §II.3.9 in the following pages), different levels of interoperability were addressed, starting on the sensor interface level and moving up to the level of a service-oriented architecture of data distribution (see deliverable D8). This was mainly managed by applicative experiments and tests.

For instance, during 2009, the 2nd Ocean Science Interoperability Experiment managed by SURA (South-eastern University Research Association) was carried out. The main goals were:

- to demonstrate automated retrieval and installation of IEEE 1451 and OGC SWE components from instruments that implement the PUCK protocol of Monterey Bay Aquarium Research Institute (MBARI). These components included IEEE 1451 TEDS, Sensor Model Language (SensorML) documents and instrument driver software to be executed on the instrument "host" computer.
- to experiment with approaches to automatically detect when a sensor has been installed, removed or exchanged.

This experiment is synthesized in D52 deliverable and the full report of the objectives achieved can be downloaded from:

http://www.oostethys.org/ogc-oceans-interoperability-experiment.

The successful completion of this experiment within ESONET part is based on an active group composed of UPC, IFREMER, KDM-UniHB and the companies dBscale and SEND. IFREMER suggested using a newly developed micro-controller board that also allows for Ethernet access. In association with MARUM and CSIC, IFREMER implemented the prototype of the Sub-Sea Smart Sensor (4S) tested on OBSEA (project set up with MBARI and NEPTUNE Canada). In 2009, IFREMER designed and manufactured the first set of "Smart Sensors" electronic boards. These prototypes were fully tested and qualified from a hardware point of view. They enable to interface to a cabled network any sensor as an IP sensor. A library of drivers was developed by IFREMER and UPC/SARTI in C language, to drive all embedded sub-assemblies. The development of the "Smart Sensors" software application took place in 2010. It will be mainly used for sensors not directly interfaced by the manufacturer according to ESONET recommended standards. This approach will allow for implementing different strategies to realize the concept of web enabled sensor systems or underwater sensor networks in a sustainable way.

Another demonstration was carried out at the MARTECH conference in Barcelona, Spain, November 2009. The last one was during the ESONET General Assembly where a new scheme, the so called Sensor Interface Descriptor, demonstrated that with that approach the integration of new sensor systems into the overall standardized architecture can be done much faster. The overall framework is formed by the OGC Sensor Web Enablement which was actually implemented within WP9 of ESONET. Since this activity has been carried out as part of an international initiative led by the Open Geospatial Consortium, these concepts will have an impact on the ocean science community worldwide. A particular emphasis has been put on integrating manufacturers of ocean instruments into the task. The PESOS group (see § II.5) has been active by integrating also partners from outside the project into the information exchange loop. The success of all standardization activities is heavily dependent on the acceptance by the potential users. It is important to get them early involved into the process and also find supporters on the international level. Therefore the close cooperation set up by ESONET with the MBARI, the Open Geospatial Consortium, a standards organisation, NEPTUNE Canada and groups involved in the US Ocean Observatory Initiative is essential. Initiatives as MBARI PUCK protocol (for RS232 or IP), interfaces like the SmartSensorBoard

(Ifremer, UPC) or recently the SID, Sensor Interface Descriptor (52North), were tested at the OBSEA in the framework of the ESONET Test Experiment (see § II.3.9). This is reported in Deliverable D59.

Then within the final year of ESONET activities this work has been applied to the Demonstration Missions like MoMAR-D, MODOO and the "Test experiments" on cabled observatory sites (see § II.3.8). New sensor principles have been evaluated and integrated into packages that already fulfil requirements set out within ESONET to make them interoperable between the different European observatory sites. An example has been given within the MODOO Demonstration Mission activities where different sensors like Seabird CT (with attached additional sensors, OBS, fluorometer), RDI ADCP (1200kHz), and the Technicap sediment trap were adapted to a commercially available acoustic modem and data-logging unit. These sensors have been implemented in the modem source code for bi-directional communication and are now available for other users as fixed part of the acoustic modem.
A more modular approach was applied at MOMAR-D site with the two SEAMON stations. A central SEAMON electronics using CAN/CANopen internal bus was able to host instruments from three different partners. The acoustic modem, sub-sea Wifi and inductive links are the communication modules linked to the COSTOF. The same COSTOF was used as an electronic common to the main lander instruments from several institutes for LOOME DM deployment.

Testing and evaluating selected interface standards such as IEEE 1451 has led to demonstrations of plug-and-work capabilities for certain sensor types. This was a major step towards confirming the capabilities of IEEE 1451 and also helped walk through the different procedures that are necessary to make implementing this standard possible. With the software modules that have evolved from work on this topic, other ESONET Partners can easily contribute to the evaluation of the sensor interface standardisation concepts.

II.3.3 Quality assurance, Quality control

Transferring quality management concepts into practical recommendations

The University of Aberdeen produced the ESONET quality manual, paying special attention to the requirements for implementing the ESONET label. For the quality management of sensors and instruments, procedures have been defined and reported in D39-2011 "*Prototype quality management manual* these procedures have been evaluated during the course of the Demonstration Missions. The results are summarized in deliverable D26 "*Specification report for demonstration actions- quality assurance*".

Harmonisation with other EU projects

Through their involvement in ESONET, KM3NET EuroSITES, HYPOX and other EC funded projects, Univ. Aberdeen, Ifremer NOCS, HCMR, AWI, INGV have been able to provide insight into the quality assurance plans on all these projects.

As part of the quality assurance of sensor systems it is important to follow accepted calibration work flows. Only few laboratories in Europe have actually the capabilities to carry calibration out with an adequate accuracy. And those existing laboratories often do not strive to get certified according to ISO or national standards. ESONET Label includes recommendations on the sensor calibration and mandatory requirements for the establishment of procedures.

II.3.4 Sharing testing facilities

Practical implementation of device testing concepts

This activity focuses on promoting discussion and exchanges of information between ESONET Partners on

- existing testing facilities: on land, in coastal water areas or deep-sea sites;
- functional and environmental test procedures of equipment;
- calibration of sensors and measuring systems.

The final objective was to attain shared use of Partner facilities and to draw up an agreed set of testing and calibration procedures for common use by the ESONET community.
ESONET Partners were requested to provide information on their existing testing facilities and the test and calibration procedures that they use. An overview of the results was initiated in Deliverable D10 and finalized in Deliverable D 36; most of the documents is available on the restricted area of ESONET web site:
http://www.esonet-noe.org/partners_only/work_package_space/wp2_standardization_and_interoperability

Notes on some of the available facilities:

- In addition to this available information, it is noticed that in January 2010, UPC received the renewal of its ISO 17025 accreditation by ENAC (Spanish National Accreditation Body). Facilities, such as the hyperbaric chamber, temperature chamber, shake table, etc., and calibration procedures to, for example, validate the junction box of the marine observatory OBSEA and marine instruments, such as ocean-bottom seismometers, CTDs, etc. were thus officially endorsed. UPC also developed calibration procedures for hydrophones. It is recommended that other European laboratories follow this example and seek accreditation according to this ISO standard.

- Ifremer presented its accreditation certified by the French committee for accreditation (COFRAC COmité FRancais d'Accréditation, http://www.cofrac.fr/), and metrology perspective in oceanography during the Best Practices Workshop #2.

- As part of on site testing operations, two new testing facilities have been prepared on the Antares site: (i) a secondary junction box (BJS) has been built by IFREMER and plugged to the principal one, offering the possibility to deploy and test new sensors platforms upon request (procedures are also available). Then (ii), connected to this BJS a re-locable facility has been built by CNRS/LMGEM and INSU namely the MII Module where several sensors are already connected (see § II.3.8).

II.3.5 Underwater intervention

From concepts to operations: feedback on underwater intervention procedures

To optimise intervention time and efficiency, as well as to ensure the interoperability of the various users' equipment, four items were identified regarding levels of interoperability for work tasks' definitions:

* **Item1 - Precise technical conditions for enlarging/increasing the number and flexibility of welcoming vessels**: such an action would ideally guarantee that any European ROVs could be easily launched from several European ships, in order to avoid unnecessary transit times and/or transport costs.

*** Item 2 - Facilitate exchange of sensors, equipments, payloads** on the different vehicles, by "standard" interfaces.

*** Item 3** - Provide the scientific users and operators with standard **qualified procedures or recommended practices** to operate equipment in a safe and productive way.

*** Item 4** - Provide **recommendations for training (crew) and testing (procedures).**

Considering that the first two items are mainly covered by different European initiatives (Ocean Facilities Exchange Group (OFEG) – EUROFLEETS 2008), ESONET team focused on item 3 and item 4 which represent the content of the Deliverable D27 managed by JF. Drogou (Ifremer). The document is structured by the various steps of the construction and maintenance of an underwater observatory [Site surveys-Module lifting-Cable laying & underwater connections-Inspection & Maintenance work-Training & Testing]. It includes three main axes of development:

1 – Review of existing standards in offshore industry and the possible benefits for the scientific community.
2 - Review of company or institute specifications
3 - General recommendations for marine science observatory interventions.

The document presents general recommendations, taking into account the elements of (1) and (2), giving a guide for general requirements for marine operations. This document was broadly distributed and presented during ESONET workshops like Best Practices one in order to share the knowledge and to enrich it with feedback get from deployments in the frame of ESONET demonstration missions and ESONET Test Experiment. For instance, the rules and procedure to allow access with a minimum of disturbance has been defined in a user's guide for access to the ANTARES infrastructure (GUASA) which is now publicly available. As part of the MoMAR-D Demonstration Mission, strategies to implement the deployment of the SEAMON-COSTOFF standalone observatory system at the Azores node of ESONET were developed in cooperation with all participating partners of this particular Demonstration Mission. During the deployment of the LOOME observatory, the UniHB implemented the recommended practices and reported their experience to the task leader. A report for the LOOME DM summarises the deployment procedure. The operations at the NEMO-SN1 site have followed the recommendations coming from this task in the Test Experiment work-plan.

The main directives are synthesized in the ESONET Label Document.

Development of Best Practices from simulation procedures

Some of these procedures can be used for servicing and maintenance of future ocean observatories. However, a necessary prerequisite will be that the personnel in charge for the underwater intervention operation will be trained accordingly. At different research institutions in Europe (MARUM, IFREMER) initiatives have been started to build up simulator for training purposes. In line with this idea, a review of experiences existing on different compatibility levels was performed:

Level a: Compatibility for sharing platforms and ships
Level b: Compatibility between ROVs in Europe (tooling and payloads)
Level c: Compatible procedures

Simulation facilities to train pilots for observatory maintenance procedures are currently under construction at IFREMER and KDM-UniHB. Although commercial systems are available, they do not provide the flexibility that is needed for simulating scientific operations. Both partners are working closely together to tackle particular issues such as simulating the plugging process for underwater connectors.

With this wealth of information at hand it will be possible to continue to work on the simulation of ROVs and the operation of according tools (manipulators, drilling systems) based on realistic scenarios. The work has reached a state where additional underwater vehicles could be easily integrated into the system as well. However, the main goal was to build up a tool to simulate underwater intervention operations and harmonize the procedures within European research institutions. The ESONET deliverable D51 "*Training and Simulation manual*" has been developed according to the specifications of IFREMER and KDM-MARUM. The importance of this activity cannot be overstated as it helps minimize training time for the intervention crew and also allows better control over the course of the underwater operations. Links has also been built up to other ongoing EU projects like for instance EUROFLEETS.

II.3.6 Comparison of underwater acoustic modems

Acoustic modems are the key segment of the bi-directional link for the stand-alone observatories. Extensive tests of acoustic modems were conducted as part of ESONET and resulted in a report that describes a comparison of systems from different commercial suppliers.
After a first selection of modems by considering their technical specification, five modems were deployed for short term trial at 2200 m for 2 weeks. Then the best two modems were deployed off Nice for testing the acoustic link between the seafloor and surface buoys. This is reported in deliverable D57 and conclusions participate to the recommendations stated in the ESONET Label Document (D68).

II.3.7 Contribution to GEOSS standardisation and implementation activities

Organisation of GEOSS workshop and active participation in GEOSS committee meetings

One of the major activities within GEOSS is the introduction of standards for data collection and dissemination. The idea is to use open standards and an open architecture to allow for the best use of the available information. Contributions to GEOSS standardization and implementation activities have been carried out on different levels.

ESONET Partners are involved in different initiatives related to GEOSS, such as the Standards and Interoperability Forum and the regular attendance of GEO task team meetings (S&T, ADC, etc.). GEOSS principles have been taken into account in setting up a web front-end for the ESONET sensor registry and to make it fully compatible with the OGC SWE standard, which is one of the recommended standards within GEOSS.

In May 2009, a GEOSS workshop was organised in Bremen that addressed ocean-related issues. The final report of the workshop can be found on: http://www.ieee.org/organizations/pubs/newsletters/oes/html/spring09/GEOSS_Workshop.pdf. Partners of ESONET acted as co-organizer of a GEOSS meeting in September 2010 in Seattle addressing specifically the integration of ocean observation systems into GEOSS. A number of GEOSS relevant topics have been discussed starting from data management issues to developing concepts on how to make the information derived from ocean observations available to potential end user. Recommendations have been developed to establish a GEOSS Community of Practice to be able to make better use of existing observational infrastructures.

In addition to these GEOSS-related activities, other activities are involved in this Task, including continuous update of ESONET for the GEOSS website, the report on the GEO SIF meeting in Washington DC held at IEEE headquarters.

This is reported in deliverable D41-2011

II.3.8 Organisation of equipment tests on cabled sites with training activities

Call and Proposal preparation

In the frame of standardisation and interoperability activities new technologies or sampling programs needed to be experimented. Real-time data connections are allowing ESONET operators and developers to immediately gauge progress. But after 2 years, the ESONET NoE still suffered from insufficient access to online data and several DMs were run with lander deployment/retrieval and subsequent delayed data publication. The stand-alone observatories, such as MOMAR-D SEAMON stations, were not offering unused plugs. ESONET needed to feed its Web portal with real-time web interface from online observatories. Consequently, ESONET Steering Committee decided to organise some tests on ESONET cable-sites, taking benefit from the recently built infrastructure components in Europe. From cabled sites, the Web portal could be tested with a real-time web interface and provide incoming data to all users (the ESONET community, public, industry and politicians).

Particularly at coastal test sites, ESONET operators would be able to send a maintenance ship and ROV to the study sites on short notice in case of problems. Coastal test sites thus provide the best sites to try out new equipment for ESONET. However, deep-sea tests are also required to develop and validate deployment procedures and to test instruments in deep water.

Consequently, a call for test experiments, “Integrated organisation of tests and observatory methodologies on cabled ESONET observatory sites” was published in June 2009. Emphasis was put on ten key issues. The call focussed on long-term deployment in deep-sea water and technical issues.

The ESONET Coordinator received six proposals generally involving only one site each. Only three of them involved ESONET sites: ANTARES, NEMO-East Sicily, Koster Fjord. Three proposed sites were in shallow water: Koster Fjord, Koljo Fjord, OBSEA. The steering committee decided to include deep-water and shallow-water sites, with the shallow-water sites having the role of a test bed and a demonstrator for concepts. For instance, at OBSEA, standardisation concepts were implemented that were of importance for future observatory systems, not just in Europe but also in other parts of the world. Koljo Fjord is ideal for testing the performance of biochemical sensors in a highly diverse environment. The ANTARES and NEMO-SN1 observatories were used for the evaluation of ROV manipulation procedures at deep-water sites. Common training of engineer and students were part of the work programme and due to the fact that this call addresses sites with real-time capabilities, public outreach could be included as well. The Coordination team was mandated by the Steering Committee (07 October 2009) to manage a proposal integrating a maximum of proposed tests in a coherent way.

A "Consensus" meeting involving participants was organised in Barcelona, Spain on 20-21 November 2009 to prepare a merged proposal. Then the test experiment proposal was discussed during the Best Practices Meeting #2 held in Brest (08 October 2009). Main recommendations were defined based on the discussions and according to the list of items considered for analysing the proposals. A single proposal was compiled and evaluated by external reviewers. It was considered to demonstrate the degree of integration that we have reached during the lifetime of ESONET. After the acceptance of the last version of the proposal, the activities foreseen in the test experiment, object of evaluation to judge the degree of integration reached, were performed. The process is summarised in Deliverable D58.

Main results:

The experience collected within this part of ESONET is very valuable to identify potential issues in the operation of long-term installations in the sea in particular in the deep sea and also to demonstrate the value of having real time to access to all deployed equipment. In the following a few examples of the activities are described.

- **Koljöfjord** (shallow water experiment)

For the Koljöfjord observatory the cable was deployed early 2011, the complete system is working. A data collection scheme and a data archiving and dissemination strategies have been developed. The standardization concepts that have been recommended have been adapted to the operation scenario. A set of reference sensors was tested in various conditions before being plugged as a generic instrumentation package.

- **OBSEA** (shallow water experiment)

At OBSEA observatory in Spain, calibration and testing procedures as well as several standards studied in ESONET were tested. For instance, IEEE1451 TEDS interoperability with the ESONET Sensor Registry has been implemented. The production of a short manual, downloadable from the SRI (Sensor Registry Interface), to allow for repeatability of the process from other observatories/entities in ESONET, has been finalized. The real time data is available from ESONET data portal.

- **ANTARES** (deep-water experiment)

The ANTARES infrastructure offers deep-sea capacities with instrumentation between 2 000 and 2 500m. In this context the main objective of the experiment is to install earth sea science appropriate instrumentation via the deployment of an interface equipment, the Secondary Junction Box. The ANTARES observatory instrumentation is composed of a seafloor module, the MII (Instrumented Interface Module for marine sciences) and an instrumented mooring line. The mooring line, named ALBATROSS (Autonomous Line with a Broad Acoustic Transmission for Research in Oceanography and Sea Sciences) intended to enhance the framework for multidisciplinary study along the water column work around the ANTARES astrophysical telescope with a sub-sea real time acoustic communication extension from the Secondary Junction Box. Various sensors have been provided to the MII (Doppler current profiler, optode, CTD), a turbidimeter and a pressure sensor. The MII has been deployed in November 2010 during the TEXREX cruise on the “Pourquoi Pas?” RV. Unfortunately, it hasn't been possible to deploy the acoustic modem and the instrumented mooring line. The data flow is operational and data are available on the ESONET data portal.

- **NEMO-SN1** (deep-water experiment)

For the NEMO-SN1, the following activity were performed in the Test Experiment:

- Integration of sensors: besides sensors already foreseen in the LIDO Demonstration Mission (see WP4) additional sensors have been installed in order to extend the measurement capability of the observatory like for instance a scalar and a three-axis magnetometer. In this specific case special devices were built to minimize the electronic noise induced by the station equipment's on the magnetometers' signal (charged on the INGV institutional budget).
- Standardization of procedures for the installation of the new sensors and devices;
- Standardization of ROV-connection procedures applied to the use of the SeaEye Cougar ROV (owned jointly by INGV and INFN) and demonstration of interoperability in the connection of the sensors provided by CNRS
- The PEGASO ROV has been refurbished, with respect to the commercial Cougar version, for operation down to 4000-m water depth and upgraded with a manipulator for fast and safe connection of ROV operated wet-mateable connectors.
- A calibrated acoustic transmitter was also installed onboard the ROV to test possibility of acoustic tracking of ROV underwater movements. Tests of the transmitted on-shore (in air) have been successfully carried out

For more information on each site, the reader can refer to the Deliverable D59. In a general way, the results showed the interest of cabled observatories and of an integration of their activities at European level. Although it was started quite late in the project, the Test Experiment has been able to prove the high potential of European teams to operate cabled observatories. They showed the way for an increased number of cabled observatories in ESONET EMSO. The tests benefited of infrastructure building budgets outside ESONET on ANTARES, SN-1, Koljöfjord and OBSEA sites. The experiments performed by ESONET have shown the advances made in sensor interfaces, data management, sub-sea intervention and sensor qualification. It is an achievement of the 4-year work in ESONET for all the tasks of WP2 (especially sensor interfaces, sub-sea intervention and sharing testing facilities), WP3 (generic instrumentation and specific instrumentation) and application of the latest results of WP9 such as sensor registry. The main deviations came from ROV unavailability (OBSEA, SN-1, Koljofjord) and delays of providers. The thick ice coverage of winter 2010-2011 in Koljofjord was quite unexpected. The reaction of the teams to these deviations was efficient.

The principle of data available in real time from the sub-sea is now applied on the 4 cabled sites; it is not planned to stop these operations. The “test experiments” end up as pre-operational observatory functioning, representative of a long lasting EMSO infrastructure at ANTARES and NEMO-SN1 sites.

II.3.9 ESONET Data infrastructure

Overview of the data infrastructure and implemented standards

The productive ESONET data infrastructure is the result of intensive networking and cooperative efforts including both observatory and sensor experts contributing knowledge on observatory architectures, as well as Information Technology and data management specialists experienced in scientific knowledge and data handling. This fruitful cooperation from several European projects, SeaDATAnet, EuroSITES and ESONET/EMSO and a ‘bottom-up’ approach led to the current standard-based infrastructure architecture as well as its productive implementation.

The data infrastructure for ESONET is designed as a distributed system. Several observatory nodes and data centres already provide both observatory data as well as data archiving services (Figure II.3.1).

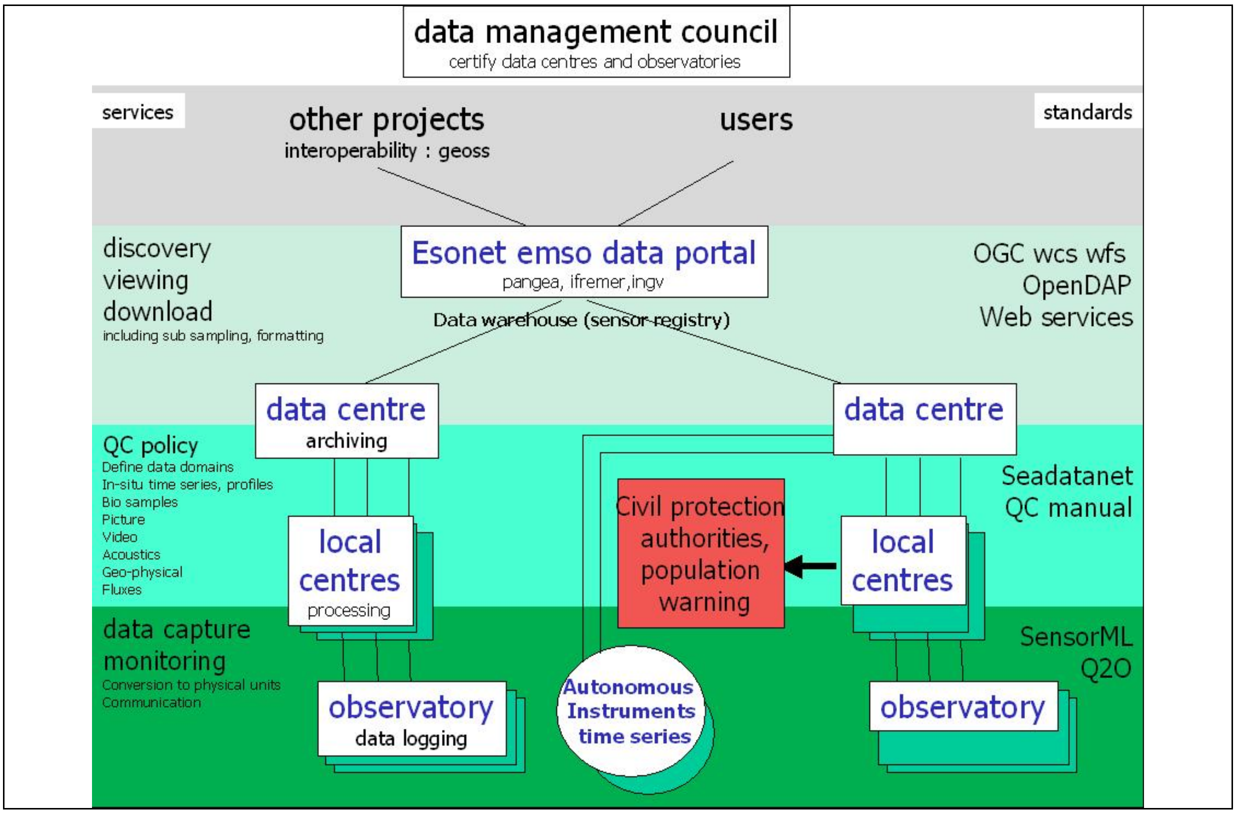


Figure II.3-1: ESONET Data infrastructure

Therefore, the main challenge for the ESONET data infrastructure was to provide a technical architecture based on international standards to implement data management policies and work flows. ESONET also has developed an online knowledge base for general information about the observatory system and how ESONET data management fits into a larger context. Beneath common standards for metadata description and exchange such as OAI-PMH and ISO19139, ESONET has chosen to implement core standards of the Open Geospatial Consortium (OGC) Sensor Web Enablement (SWE) suite of standards, namely the OGC standards SensorML, **Sensor Registry**, **Catalogue Service for Web (CS-W)**, **Sensor Observation Service (SOS)** and Observations and Measurements (Figure II.3-2).
(O&M). The deliverable D43-D44 describes the ESONET implementation of the above-mentioned OGC standards as integral part of the ESONET data infrastructure as well as the knowledge base representing the user interface to the ESONET data infrastructure. Here after is a summary that can be extracted.

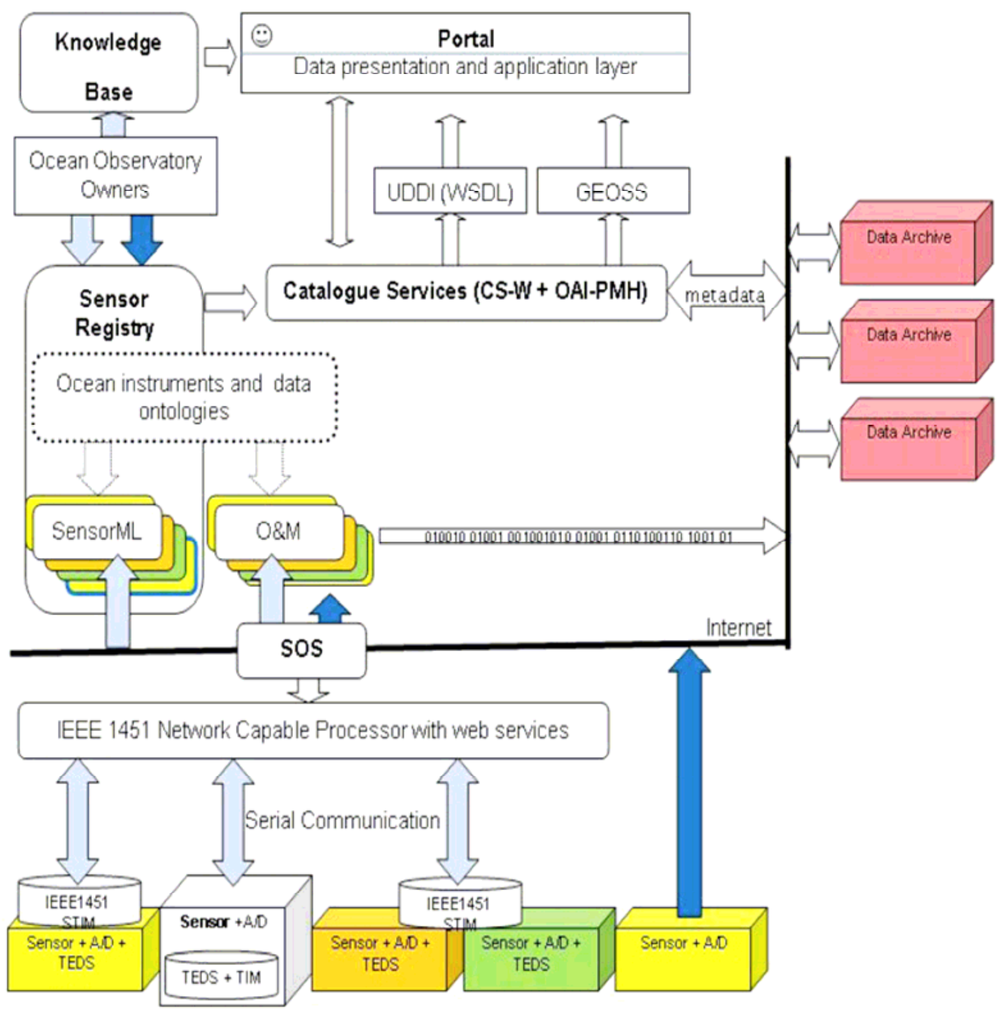


Figure II.3-2: Overview of the main standard components used for the ESONET technical infrastructure.

Catalogue Service for the Web(CS-W)

The OGC Standard CS-W provides the methodology to publish and access digital catalogues of metadata for geospatial data, services, and related resource information. It defines for example a suite of standardised requests in XML format to retrieve geospatial metadata, e.g. via the common Internet http protocol. The development of the Sensor Registry and of the catalogue service have been closely related. Within the ESONET data infrastructure, a CS-W service allows access to SensorML data which is stored in the Sensor Registry. The Sensor Registry is the repository where all sensor-related information is stored; the catalogue service CS-W provides the possibility to access this information in a standardized way.

Sensor Registry Registration Interface (SRI)

The Sensor Registry Registration Interface (SRI)'s objective was to plan, develop and deliver a process which facilitates the registration and register maintenance of a network of instruments and sensors with the goal that the collected observations be packed with relevant sensor metadata encoded in an open standard format. SensorML was chosen on the basis of ESONET internal consultation and international acceptance. The overall goal was to minimize human intervention by facilitating the discovery of sensors across the global network. The SRI web interface permits the input of metadata from a deployed sensor or multi-sensor instrument (CTD, ADCP, etc.). The sensors are converted into smart sensors as they provide sufficient information for machines to process observations and deliver information. A detailed description of the SRI functionalities is provided in Deliverable D71.

Sensor Observation Service (SOS)

The OGC standard Sensor Observation Service (SOS) allows direct access to the data of a cabled ESONET observatory. SOS is a standard web service interface for requesting, filtering, and retrieving observations and sensor system information. It allows to e.g. directly retrieve the latest data collected by a sensor or to use the service to harvest or download data for example on a daily or weekly basis. Observatory data provided by the SOS is ideally represented in the OGC standard format Observations & Measurements (O&M). Beneath providing a data access protocol, a SOS enables a sensor or observatory to describe itself by providing a SensorML document containing the sensor's metadata. Therefore, the observation service closely relates to the Sensor Registry as well as the catalogue service described above.
Compatibility with other international observatory systems was a priority during the development of the SOS. Some other initiatives also use this standard; however, due to the already mentioned generic definition of OGC standards, each community may already use their own application profiles which may only be partially compatible. From the beginning we have therefore cooperated with other initiatives, for example with members of the fp6 OSIRIS8 and the SANY project. The OSIRIS team used the 52°North9 SOS implementation. 52°North currently adopts this package for the Tsunami Early Warning System. Most important was the cooperation with the EuroSITES and OceanSITES project led by Ifremer.
This excellent cooperation resulted in a common implementation of OGC standards which can be regarded as the basis for a European marine observatory standardisation effort which will be continued within EMSO.

As part of ESONET's data management work package, three different SOS implementations have been tested and evaluated with regard to importing sensor data into PANGAEA. Until now, several EuroSITES sites are available from the SOS server among those CIS, ESTOC, PAP, E1M3A and PYLOS. These services are currently tested and will successively be included to the ESONET data portal. During our tests with available SOS servers it turned out that some ESONET partners would need a lightweight SOS solution which should be easier to adapt to an observatory's need as well as to available technical platforms than the available solutions. Initiated by the UPC and Uni-HB we therefore started to implement a simple PHP based SOS server, which was decided to be offered as Open Source.

To include SOS delivered data to the ESONET data portal, the WDC-MARE has implemented a generic SOS web client, which is able to interpret responses from the 3 SOS servers (52°NORTH, OOSThethys Python, Ifremer servers), as well as the ESONET open source SOS server. The generic SOS web client is used for the productive version of the ESONET data portal to visualize data from the PAP, PYLOS and ANTARES observatory (Figure II.3-3).

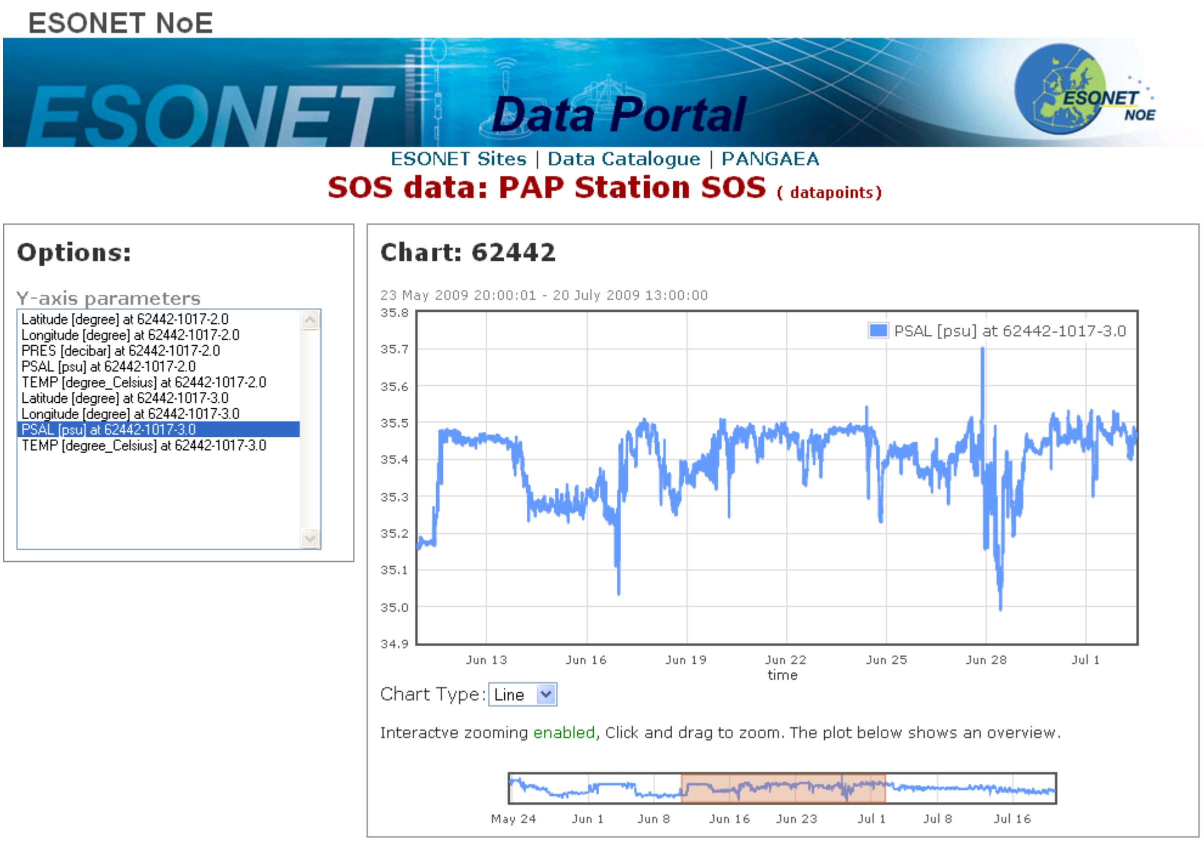


Figure II.3-3: The generic ESONET SOS web client showing data delivered by a SOS server (Ifremer) from the PAP station.

ESONET knowledge base

The most obvious application of the standards mentioned above is the ESONET knowledge base, the general information platform for ESONET. It serves data from ESONET sites and observatories via the Internet. The ESONET knowledge base can be found at:

http://dataportals.pangaea.de/esonet

It offers information from the sensor and observatory information given by the ESONET Sensor Registry, access to archived data from the ESONET data catalogue as well as access to real-time data via SOS interfaces. Furthermore, it allows including useful information from the legal & ethical issues database (see § II.4.2) as well as some more general information on each site, such as the coordinates, descriptions and links to further readings on the main ESONET homepage.

It consists of three major components:

- the ESONET 'Sites View', which allows a quick overview on the data and information for each ESONET site,
- the ESONET data catalogue, which allows querying within archived data as well as the data analysis and charting tool.
- the knowledge base allows embedding SOS data and provides a SOS client tool, which was already described in the section above.

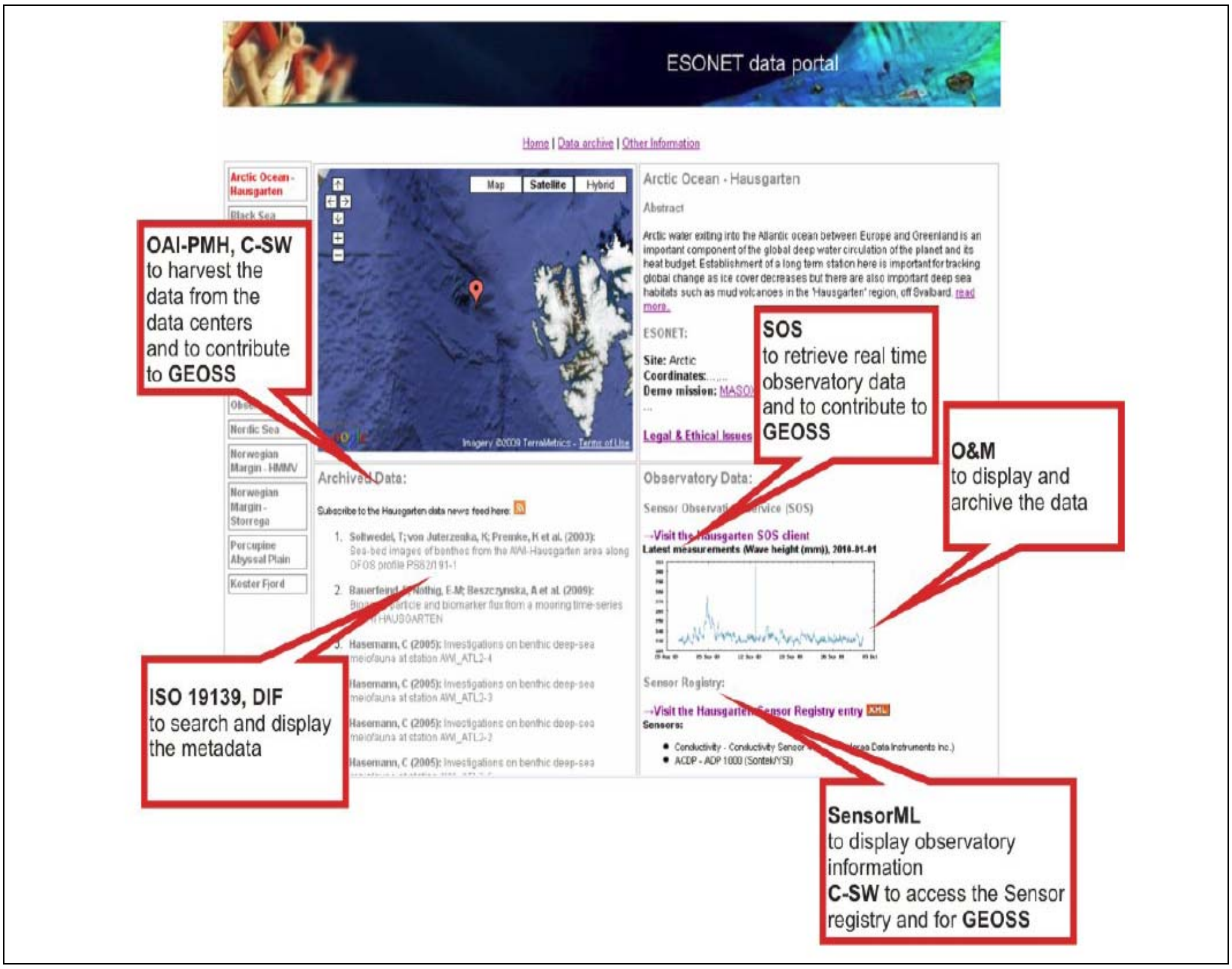


Figure II.3-4: Design study of the 'Sites View' page of the knowledge base indicating which standards of the data infrastructure mentioned above are used for each part of the portal. This 'mockup' page was used to implement the ESONET Sites View.

- ***The ESONET Sites View page***

It is the main entry page of the ESONET knowledge base. It offers a user-friendly overview on the most important and recent information and data products for each ESONET site (see Figure II.3-4 & II.3-5). The site view is navigable through a menu structure, which currently lists ESONET sites as well as the ESONET demo sites. If available, the Sites View displays a preview chart of selected real-time data retrieved by the SOS which links to the ESONET

SOS client. Also, links and overview information on Sensor Registry data as well as the ESONET Legal & Ethical Issues Database are shown at the Sites View.

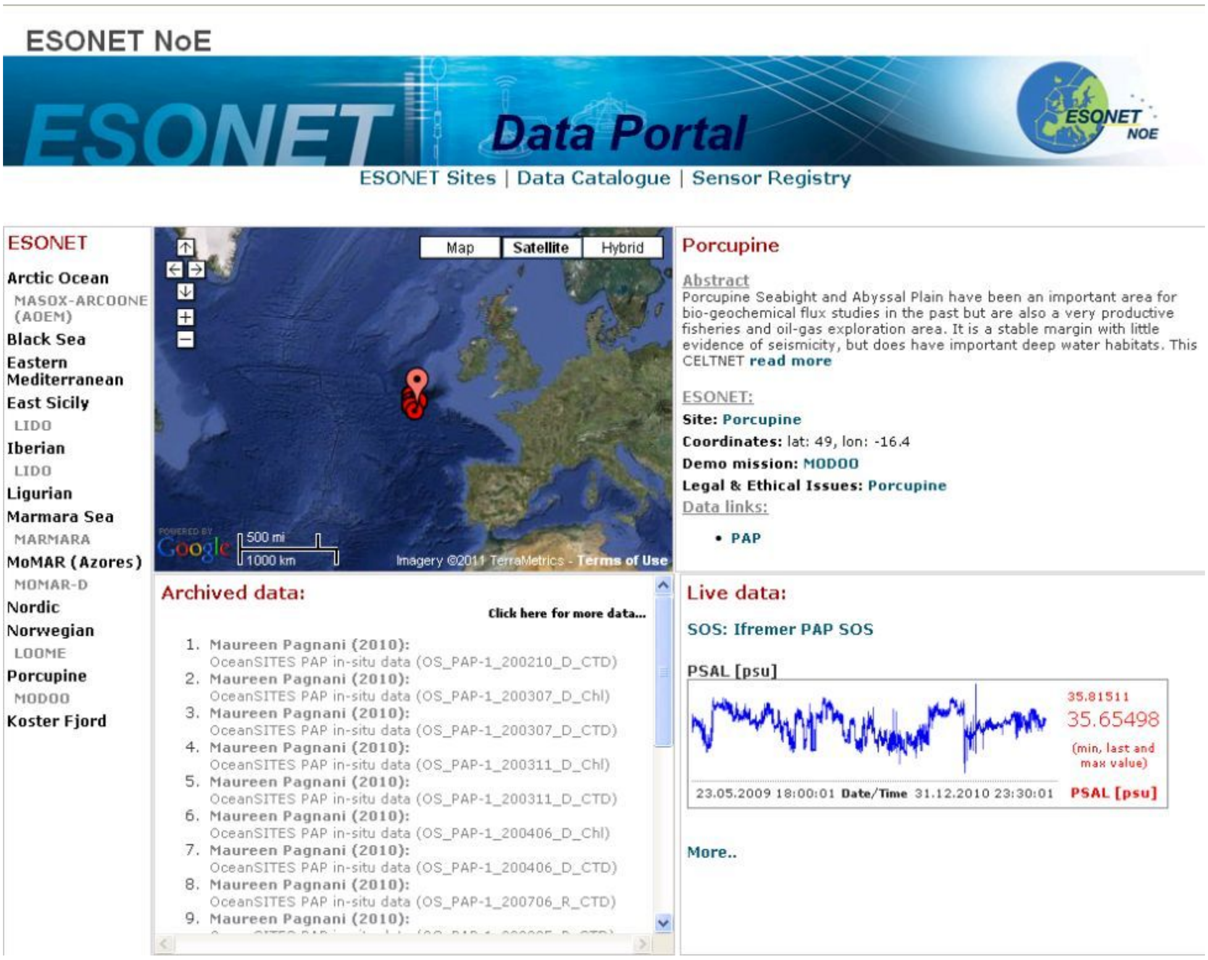


Figure II.3-5: Screenshot of the ESONET Sites View showing overview information, archived data as well as life data from the PAP station

- ***<u>The ESONET data catalogue:</u>***

It currently contains data archived by the WDC-MARE, Ifremer, INGV and HCMR data via SeaDataNet. The data portal provides two different search tools: a "Simple Search" and an "Advanced Search". Whereas the simple search represents a simple keyword based search engine similar to common Internet search engines such as Google, the advanced search has additional functionalities (Figure II.3-6). It allows narrowing a search by using different categories and can be used to formulate more complex queries by combining these search terms. These queries can be combined with geographical and a date/time related query parameters. Each data set delivered in an appropriate data format (currently PANGAEA ASCII as well as ESONET O&M) can be visualized by using the new ESONET data analysis and charting tool.

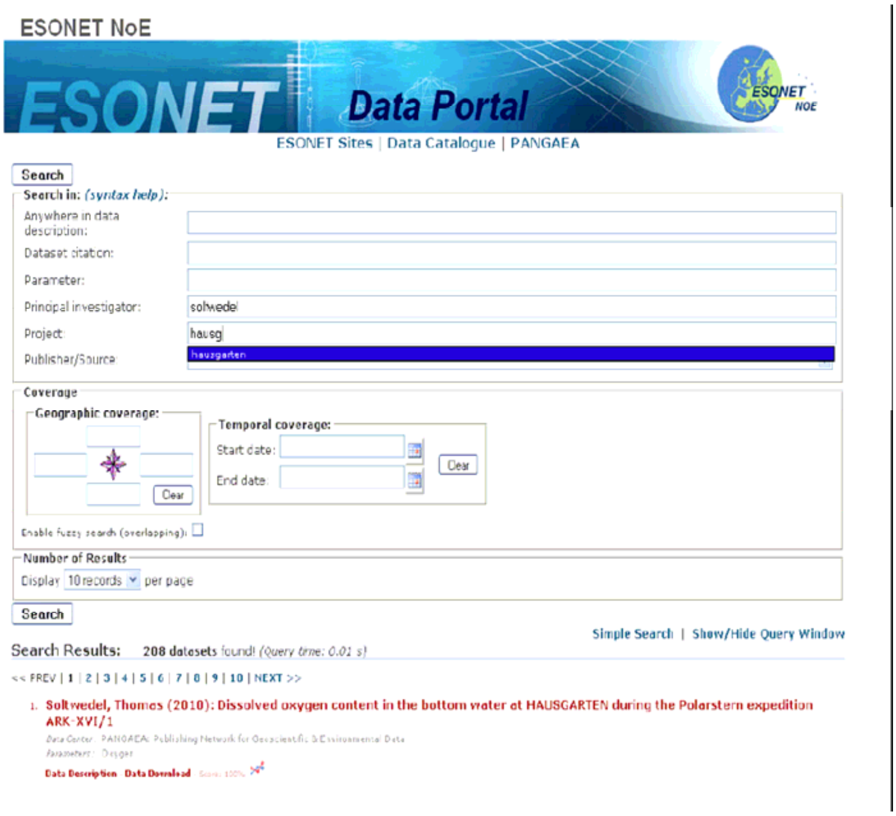


Figure II.3-6: The advanced search window of the ESONET data catalogue

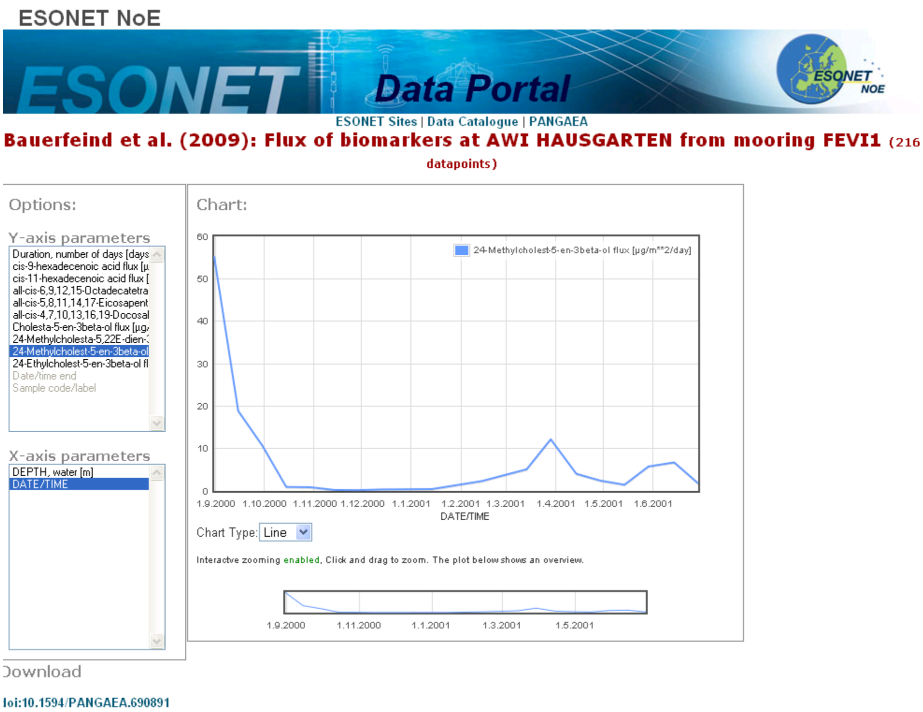


Figure II.3-7: The ESONET data analysis and visualisation tool showing archived data from the HAUSGARTEN observatory

Data policy and overview of the Data management plan

For an overview of the ESONET data management plan the reader can refer to the deliverable D70 – *Updated management plan*, built upon deliverable D9, which gives a broad overview of existing data management policies, their importance and how these relate to the ESONET. The D70 report also provides descriptions of the Data distribution, Meta-Data description, and data encoding. Some examples are provided with templates. This document aimed to give a detailed overview of how a specific data management policy can be implemented at a site. The report contains detailed instructions on covering the workflow from data acquisition, data quality management and data archiving and elaborates best practices for providing metadata. A major result of this work was the definition of a generic workflow for semi automatized data archiving based on accepted ESONET OGC standards. As mentioned above, this was tested with data coming from the ANTARES site. In detail, UPC and UniHB have worked on a strategy to integrate LIDO acoustic data into the ESONET data infrastructure, which included UPC and UniHB's efforts in designing a SOS data harvesting and archiving procedure.

Some recommendations for observatories users and PIs can be extracted:

1. Provide an overview of the sensors (and set-up) in SensorML (ESONET provides templates for various sensors)
2. Define the process of how data is managed; it remains to be decided where this is best placed.
3. Encode data in XML files when the data flow is not ‘too’ high
4. Provide schema files for the data encodings that allow automatic validation and interpretation of the data
5. Offer public distribution of the data through the Sensor Observation Service, initially using the Oostethys PERL server and templates for the main requests (as provided in Appendix III).
6. Within a SOS response, provide data in O&M format or simple tab separated text

Following the current use of SensorML in the ESONET to describe sensors, the same specification is applied for the description of meta-data. Meta-data should be defined for each data set that is distributed, where a data set is a collection of data gathered over a specific time interval. The meta-data may change between data sets from the same site. The description should include at least:

1. sensor information (possibly through a link to a specific SensorML file);
2. procedure information (experiment set-up);
3. algorithms (some measurements might the result of operations performed on the raw data);
4. data descriptions (data types, bounds);
5. institute/citation information;
6. clock information;

These simple recommendations have been useful to guide the implementation of data management activities within the ESONET demo missions. For example the INGV has set up an operational marine data management platform to store observatory data which already offers metadata for both, data as well as sensors which enabled a smooth integration of data from the Iberian margin and will also be used to integrate data from the SN-1 observatory.

II.3.10 . ESONET Label

The ***ESONET Label*** is a set of criteria to be applied in order to make choices for the specifications of deep-sea observatories. It contains mandatory aspects, in point of view expressed and experienced in ESONET, as well as recommended solutions or options. It is one of the main ESONET deliverable to be issued after a 4-year period.

The ESONET Label is aimed to sub-sea observatories which are intended to be designed, deployed and used with a high controlled quality level.

This label guarantees that the equipment can be fully integrated in the scientific community network, with generally free access to data.

It is intended to provide benefits for:

- **Users** who will have a guidance for interfaces and planning of experiments;
- **Funding agencies** who will have a description of the standardisation level needed for European sub-sea Observatory Infrastructures;
- **Providers** who will benefit from a set of specifications common to all European sub-sea Observatory Infrastructures.

Two class of observatories are considered:

- Stand alone observatories;
- Cabled observatories.

This set of criteria and the way to apply them are currently described in the Label Definition Document, Deliverable D68. It informs on the definition of the label and its implementation modalities, including rules, control and, protection of the label.
This document includes recommendations and mandatory rules to be applied at different levels of the entire observatory network:

- the infrastructure:
    - recommendation on power supply, connectors
    - recommendation for stand alone observatories
    - recommendation on material
- generic and scientific sensors modules including
    - description of the modules
    - module interface
    - metrology issues
- qualification and testing procedures
- deployment and Maintenance
- data management
- environmental impact

This document will be updated continuously with the evolution of technology, the experience gained in operation and evolution of the needs.

Main Reference documents (deliverables, reports, articles)

Authors	Titles	Dates/versions	Where to find if (URL, Annex of this report)
C. Waldmann (KDM/UniHB)	D6: "*Proceedings of Best Practices workshop: sensor interface, quality insurance and specification for demonstration actions*".	2008	ESONET website/Gallery
C. Waldmann (KDM/UniHB)	D8: "*Prototype implementation of example standardised sensor system*"	2010	ESONET website/Gallery
M. Diepenbroek (KDM/UniHB)	D9: "*Data Management plan"*	2008	ESONET website/Gallery
J. Marvaldi (Ifremer)	Part 2 of D10 "*Report on Exchange of personnel, Common schedule and methodology of Test*"	2008	ESONET website/Gallery
C. Waldmann (KDM/UniHB)	D25 *"Specification report for demonstration actions-Sensor interface"*	2009	ESONET website/Gallery
A. Holford (UniABDN)	D26 *"Specification report for demonstration actions- quality assurance"*	2009	ESONET website/Gallery
JF Drogou (Ifremer)	D27 *"Specification report for demonstration actions-underwater intervention"*	2009	ESONET website/Gallery
J. Marvaldi (Ifremer)	D36 *"Report on testing facilities survey"*	2009	ESONET website/Gallery
A. Holford (UniABDN)	D39-2011 *"Prototype quality management manual"*	2011	ESONET website/Gallery
E. Delory (Dbscale)	D41-2011 *"Result and analysis of GEOSS and standards survey in ESONET"*	2011	ESONET website/Gallery
R. Huber (KDM/UniHB)	D43-44 *"Data infrastructure productive version-The ESONET knowledge base."*	2011	ESONET website/Gallery
C. Waldmann (KDM/UniHB)	D50-2011: *"Report on Best Practices Workshop#2"*	2011	ESONET website/Gallery
Ifremer and UniHB	D51-2011 *"Training and simulation manual"*	2011	ESONET website/Gallery
C. Waldmann (KDM/UNIB)	D52 *"Report on the contribution to international standardisation initiatives"*	2010	ESONET website/Gallery
J. Blandin (Ifremer)	D57 *"Intermediate report from underwater acoustic modems inter-comparison experiment"*	2010	ESONET website/Gallery
Ifremer & UniHB	D58 "*Report on selected test experiments on cabled sites"*	2010	ESONET website/Gallery
JF Rolin (Ifremer)	D59 "*Final report on Test Experiments performed on cabled sites and return from training activities"*	2011	ESONET website/Gallery
I. Puillat (Ifremer)	D69 *"Report from the 3rd ESONET General Assembly"*	2011	ESONET website/Gallery
R. Huber (KDM/UniHB)	D70-2010: *"Updated Data management plan*"	2010	ESONET website/Gallery
R. Huber (KDM/UniHB)	D71-*"ESONET Sensor registry"*	2011	ESONET website/Gallery

Other reference documents:

- D42: "*Sensor registry documents*" led by R. Huber (UniHB) was a first version of the Sensor registry document

II.4 Implementation strategies (WP5)

The observatories implementation strategy was prepared in WP5 which was led by IMI. The economic, legal, technological and environmental impact aspects of implementation were addressed. This work was built on the outputs of the ESONIM SSA. In 2007, the WP5 group prepared the way to the EMSO PP submission and supported the EMSO PP proposal writing team. Following a meeting held in Barcelona in March 2008, two Working Groups (WG) were set up to develop science, engineering and business plans for a Generic Cable and Standalone Sites.

II.4.1 Science, Engineering and business plan for generic sites

These WGs were led by Jaume Piera (CSIC) and Olaf Pfannkuche (KDM/IFM-Geomar). Another meeting was held over the course of the Faro General Assembly and the final workshop was dedicated to engineering issues - this was held in Paris in January 2009. The Generic Cable and Standalone site solutions were compared before a report to EMSO on the implementation strategies was prepared.

Generic cable Observatory:
Financial estimates for each of the ESONET sites were prepared using the ESONIM model. The presentation of these highlighted the need for urgent updates of the cost model. The original ESONIM model was developed based on a cabled observatory solution with 1,500 km of cable - but the engineering required for an observatory of this scale is not appropriate for all sites, particularly ones which may be at a much closer distance to shore and which are not in the same water depths. The updating engineering and financial estimates work was undertaken by CSIC in conjunction with Ifremer colleagues in Brest using the experience of ANTARES deployment, of OBSEA coastal observatory deployment and data kindly transmitted by Neptune Canada. These important updates to the financial cost model were then used to do a detailed assessment of the network.

Generic Standalone observatories:
The Generic Standalone WG was tasked with developing the science, engineering and business plans for a mooring incorporating two-way communications and near real-time data transfer. Ifremer colleagues tasked with developing plans for at-sea interventions provided updates for the operation and maintenance plans for deep-sea observatories, using their experience such as MoMAR experiments during EXOCET/D EC project. These are being linked to initiatives such as EurOcean shared infrastructures and EUROFLEETS.

The science, business and engineering backgrounds for each solution were firstly described in Deliverable D5, in 2009.

Aside from this work and in addition to these technical and economical aspects, practices relevant to legal, ethical and environmental were reviewed for all ESONET sites in Europe; this is the so-called LEE activity in WP5.

II.4.2 Legal, Ethical and Environmental (LEE)

LEE document assembles synthesis of relevant legal and best practice documents (international, EU, national, local). It provides a homogeneous atlas describing the ESONET sites on all parameters needed for environmental assessment and permits (http://www.ifremer.fr/esonet/). Michel André (CSIC/UPC,) developed terms of reference/working plan incorporating mammal and environmental components and circulate it. Participating partners input material relevant to national legal requirements and update legal practices relevant to ongoing programmes (e.g. Antares, Nemo etc). In relation to mammals, impacted species were identified for each site, recommendation frequency and levels were defined and a monitoring system to assess the impact on cetaceans at each site was advised. G.André (Altran/Atlantide) worked with M. Andre to identify relevant legislation (through the issuing of a WP1 questionnaire). Results are formatted in a database that includes local national and European legal ethical and environmental (LEE) documents since early 2010 for use by project partners and the EMSO PP project. This database is available on the main page of the ESONET website, as deliverable D14 and updated in deliverable D47. It proved an invaluable information source for the preparation of material on Regional Legal Entities for EMSO permanent structure.

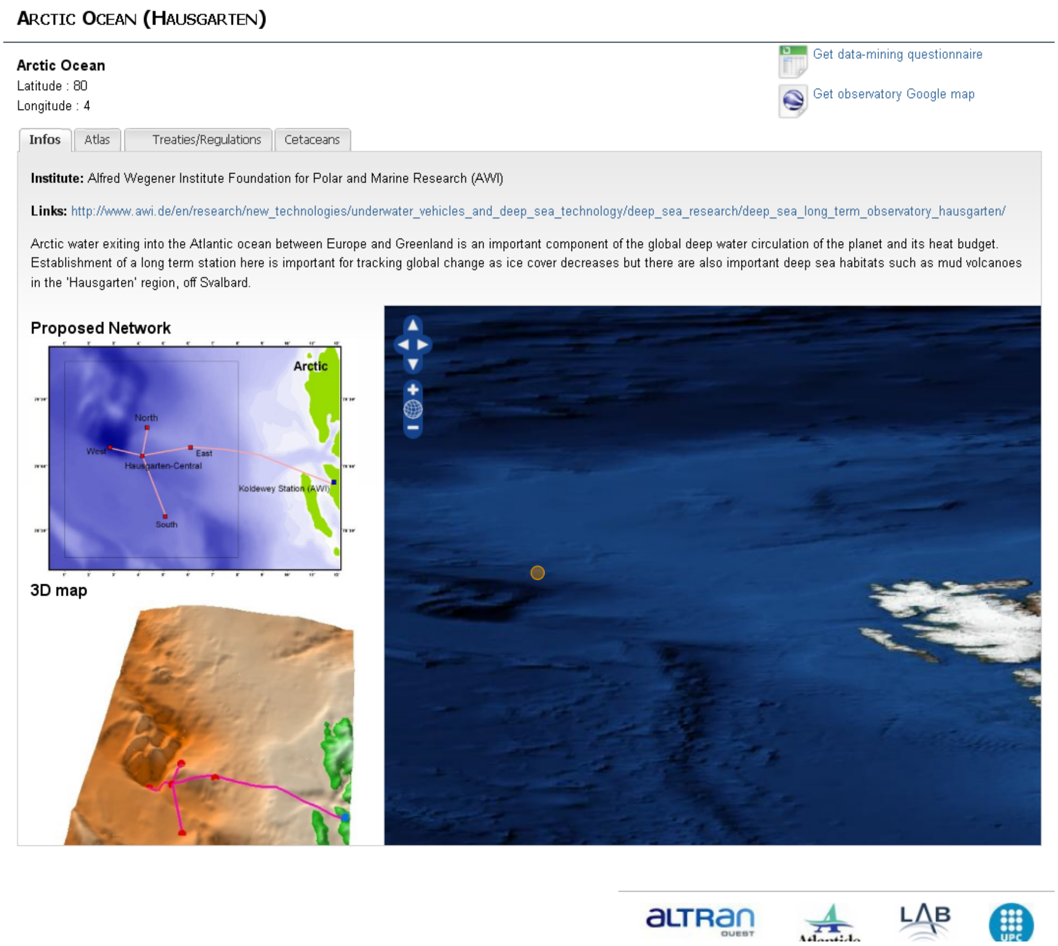


Figure II.4-1: Example of available information in the LEE database

The 2 activities were then consolidated by a comparative work between the two WGs from a science, engineering and business plan/costing perspective. There was also an update for some of the legal issues around the application for ERIC status and decommissioning. This is reported in the Deliverable D48.

II.4.3 Reporting to EMSO

There were considerable synergies between the ESONET and EMSO projects throughout the duration of ESONET NoE, which is one of the main tasks of this work package. After supporting its launching, the WP5 leader, Mick Gillooly organized with the two coordinators a precise description of the respective roles of ESONET NoE WP5 and EMSO PP WP2 to 5. It was then ensured that no double funding could be suspected. The principle for a task of EMSO PP interest is to correspond to a "deliverable to EMSO PP". Indeed, a part of the Implementation Strategies task was to liaise and report to EMSO on the types of legal structure appropriate for ESONET/EMSO observatories. The various steps of ESONET-EMSO collaboration are described in reports D20 (2008-2009-2010).

WP5 dedicated 3 tasks to report to EMSO:

- One on long-term strategy funding plan (Deliverable D46)
- One on logistical, engineering and technical aspects of deep-sea observatories (D61)
- High level implementation structure/organization and regional integration bodies (D62)

A special attention was paid to well distribute roles and tasks between ESONET and EMSO in order to strictly avoid any double funding possibility.

On mobilising the NoE on long-term strategy funding plan

With refinement of the cost models to revise the observatory implementation plans, a collaborative effort was led by Nick O'Neill of SLR Consulting under advice of the ESONET Steering Committee to prepare an important document developing long-term strategy funding plan to be presented to the ESONET and EMSO STRAC committee (Strategic Committee) in late February 2010 in Strasbourg. It contents information on socio economic drivers, possible legal options for an ERIC type infrastructure with description of cost effectiveness related to the expected infrastructure in a global way and per site. Titled "*Report to EMSO on Implementation Model (ESONET NoE)*" – D46, this document was the first presented to the ESONET EMSO Funding agencies in Strasbourg.

On High level implementation structure/organization and regional integration bodies

As outlined in the DoW, one of the tasks of WP5 was to advance activities to develop and refine a High Level implementation structure/organization for ESONET-EMSO and associated Regional Integration Bodies (in conjunction with WP1). The structure will be flexible and adaptive to reflect the changing priorities of the Commission, Member States and partners. It will inform and advise the appropriate legal frameworks for a Core Legal Entity and Regional Legal Entities to be set up under EMSO. This Core Legal Entity is referred to as the EMSO ERIC.

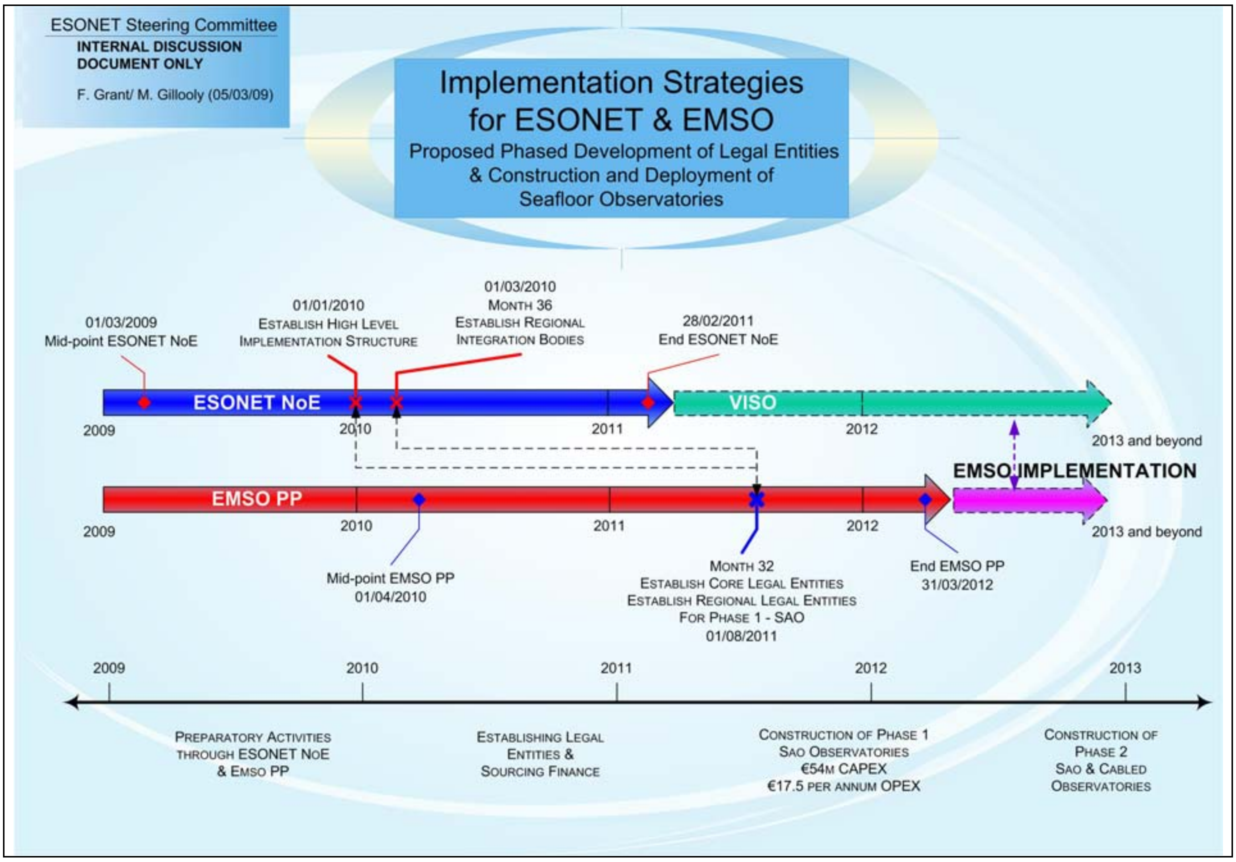


Figure II.4-2: Implementation model

The objective of EMSO ERIC is to coordinate the operation of the distributed infrastructure, servicing the scientific community and other users in the public, private, and policy sectors. EMSO observatories will be deployed to monitor relevant environmental processes around Europe in deep-sea and water column. EMSO will make available observatory data following an open access policy.

A dedicated legal workshop with many of the ESONET SC members was held in Galway in November 2010 under the auspices of the EMSO PP project. Following on from this meeting, extensive discussions and exchanges took place between ESONET-EMSO partners. Legal advice has been engaged as part of the project through Xavier Rebardy of Ifremer's legal office and Bird & Bird, a European law firm. Other legal department representatives were participating on behalf of ITU, INFN and UGOT.

The objective of EMSO ERIC is to coordinate the operation of the distributed infrastructure, servicing the scientific community and other users in the public, private, and policy sectors. For this issue, IMI led a final report D62 "*Report on High Level Implementation Structure and Regional Integration Bodies for ESONET*" on the legal work. It outlines the main governance structure and its translation into a set of legal statutes. This document explains how EMSO will be founded as an ERIC (European Research Infrastructure Consortium). The ERIC will be established as an organization to coordinate the activities of EMSO observatories. The main components of EMSO-ERIC structure shall be:

- Assembly of Members (AoM)
- Scientific and Technical Advisory Committee (STAC)

- Executive Board (EB)
- Director General (DG)
- EMSO Departments (outside the ERIC but inputting to them on important matters).

For more information on the EMSO-ERIC structure, its functioning, roles of members and committees, expected staff involvement and roadmap, please see deliverable D62.

On mobilizing the NoE on logistical, engineering and technical aspects of deep-sea observatories

Through various European funding initiatives we have gained experience with developing and operating technologies that are used in the implementation of deep-sea observatories. In order to federate the different approaches Oceanlab in Newburgh, Scotland, convened a workshop on 2nd and 3rd November 2010. It involved 23 participants from the ESONET/EMSO, KM3NeT and EuroSITES programmes. The aim of this workshop was to discuss the different concepts and technologies under development and using this experience to assess the best approach for ensuring and maintaining an integrated European capability. As a result, this workshop showed the interest to discuss best practices between research institutions involved in technology and engineering. Relations with coastal project are also of interest: OBSEA, YTHAN and SMART BAY. Some technical recommendations were given and are issued in deliverable D61.

Main Reference documents (deliverables, reports, articles)

Authors	Titles	Dates/versions	Where to find if (URL, Annex of this report)
IMI	D5 *"First elements of individual implementation plans for specific cabled observatory sites"*	2009	ESONET website/Gallery
IMI	D14 "*Report on workshops to facilitate and broker partnership, Tutorials/Meetings on implementation plans and replies to infrastructure proposals; on-site assessment, legal model, environmental constraints and their associated ethical issues"*	2010	ESONET website/Gallery
N. O'Neill (SLR)	D46: "*Report to EMSO on Implementation Model (ESONET NoE)"*	2010	ESONET website/Gallery
M. andré (UPC)	D47 "*Online database to include local, national and European legal, ethical and environmental (LEE) documents"*	2010	ESONET website/Gallery
IMI	D48 "*Final report on Best Practices, Guidelines for LEE issues and implementation plans"*	2010	ESONET website/Gallery
IMI	D61 "*Report to EMSO on logistical, engineering and technical aspects of observatories*"	2011	ESONET website/Gallery
IMI	D62 "*Report on High Level Implementation Structure and Regional Integration Bodies for ESONET"*	2011	ESONET website/Gallery

II.5 Communication: A support basis for the future

This section includes effort supported by the Network all along the contract duration on communication purpose at different levels and dedicated to various targets. These activities included links with socio-economic users, stakeholders, providers and SMEs, communication to general public and outreach, education and training (WP6 and WP7 – some links with the institutions are related to WP5).
The targets were to determine:

- direct clients for data, information and/or infrastructure;
- indirect users of information as in education or outreach programs;
- possibilities for integration within decision support tools.

This meant: **(i)** Development of systematic contacts with identified potential users like **Core Services stakeholders (ii)** Discussion with the military and the **industry** to explore possible synergy; **(iii)** Identification of limitations of available observation technology, to foster development by the European private sector (**SME**s) of new tools for the submarine monitoring of the Earth, either sensors, data browsers or value added services; **(iv)** development of **educational support material, outreach programme**, **(v) production of newsletters, movies, flyers, posters** etc …

Link with Socio economic users: Core services stakeholders and Regional Stakeholders
CORE SERVICES of ESONET are defined as a number of data products and data services which will be provided by the future operational network on a stable basis and with enough standardization to be used as basic input for global players in the fields of Earth Monitoring.
Core Services address a specific category of stakeholders which may be private, profit or nonprofit organizations, that have the means and the interest to buy information, services or equipments developed by ESONET. These organizations may be at national, regional, and international levels and financed by their membership, commercial activity or government subsidies.
Stakeholders were identified in the following areas:

- Oceanographic Monitoring (Physical and Biological parameters),
- Seismological Networks,
- Tsunami Early Warning Systems,
- Biodiversity assessment,
- Education and Training,
- Environmental protection, conservation and restoration or mitigation monitoring.

These stakeholders are listed in Deliverable D76.

A special attention was paid on relations with GMES and GEOSS. Whereas links with GEOSS were managed directly in a dedicated WP2 task (see § II.3.7) and resulted in deliverable D41, the association with GMES services was more difficult. Indeed, as a Network and not an operational infrastructure, ESONET is not designed to deliver a continuous data flow: it is not an operational system. Consequently the coordination team could only work on an anticipation basis, considering prototype-data out coming from the ESONET pilot experiments such as the so-called Demonstration Missions and Test experiment. The relation between ESONET and MyOcean Marine core service of GMES was initiated early in the project and carried on in the frame of workshops. In order to manage the link with GMES in a general way, the coordination team wrote a support document to be presented to MyOcean project for the Marine Core Service of GMES and PREVIEW project for Emergency Response Core Service. This document was included in Deliverable D16. Core service stakeholders were addressed by ESONET coordination team and by the strategy applied to the two main dissemination tools: ESONEWS and ESONET Yellow Pages.

Links with industries

Within ESONET the private sector acts as a "client" and as a "supplier". One of the fields where deep-sea observatories are of large interest, is oil industry, due to the needs related with the exploration of hydrocarbon resources in the deep seafloor. In this sense, a meeting with oil industry was held in Brussels November 26th 2008. The sessions of the ESONET-VISO workshop in Tromsoe dedicated to the link with industry (mainly oil and gas and fisheries) were successful. Then a specific initiative was taken by a group of ESONET scientists as a result of their experience and of the Deepwater Horizon incident in the Gulf of Mexico. A "Community Statement" was presented during the ESONET NoE General Assembly in Marseille and is reported in Deliverable D16. Later this statement was enriched and published by H. Ruhl (NOCS) as a short note in Nature *(Nature, vol 473, 12 May 2011, page 154)* as following:

The Deepwater Horizon blowout in the Gulf of Mexico stimulated policy reviews and moratoriums on activity. But there is still a pressing need for independent experts to be able to observe and understand industry impact from such remote operations. For example, unexpected amounts of hydrocarbon have been observed at midwater depths and on the seafloor in the Gulf of Mexico. In situ observatory systems can monitor areas of industrial activity provide a means to better understand impacts.

Real-time observatory systems already deliver images and data from the deep sea to desktops worldwide. Wider use of such installations, combined with in situ sample collection and existing marine-industry impact assessment, can help untangle natural vs. anthropogenic influences on change and would ultimately facilitate sustainable resource use.

Several national and European projects are already investigating how to improve deep-sea monitoring using observatories. International industrial and research groups are working together in the DELOS project in an Angolan offshore oil field; other projects involving industry and ocean observation are also under way. ESONET, EMSO, DONET, MARS, VENUS and NEPTUNE Canada efforts already use systems that enable early warning, data discovery and archiving. Cameras and sensors to measure currents, hydrocarbons, and other variables are available. Information infrastructures have also been developed.

We suggest these concepts be considered for policy discussion. In expanding such initiatives, the Group on Earth Observation and the UN Convention on the Law of the Sea could help in implementing high-level discussion and in disseminating agreed terms to regional and national stakeholders.

Societies around the world depend on access to natural resources from the ocean. Publicly available data from in situ observing, when combined with in situ sample and satellite data and climate and quantitative modeling, will give a better picture of potential impact. Such open data would make an important contribution to the Global Earth Observation System of Systems.

Promotion and SME policy

- ***PESOS***

During the preparation phase of ESONET a stable association called PESOS (Group of Providers of Equipment and Services for Observatory Systems) was foreseen as an important step towards a better integration of SME in the future network. A representative has been appointed to participate to the ESONET Steering Committee. The idea was modified by the ESONET private companies members into a non-formal group. To enlarge the group, direct contacts were made with most of the private companies dealing with deep seafloor instrumentation or services during the Oceans 07 in Aberdeen and OI 08 in London. Several dozens of companies expressed their interest. Then, interest of industry increased since the ESONET Demonstration Missions. As a result companies have become more pro-active in populating the yellow pages of ESONET Yellow Pages (see below) and the number of companies, that are now suppliers to existing cabled observatories (such as NEMO and Neptune), grew up.
It was not in the scope of the NoE to play a role of contract intermediary between public and private ESONET members. A lot of cross relations ended with actual purchase of sub-sea observatory components produced by PESOS members. Some of these contacts are mentioned in the **confidential** reports D22 (2008,2009,2010). All PESOS members had contracts dealing with sub-sea observatories from ESONET members and from other institutes during the project duration.

- ***ESONET Yellow Pages***

The ESONET Yellow Pages aim to organize the information concerning *available* products for the development and maintenance of Deep-Sea Observatories, provided by the private sector.

Figure II.5-1: Welcome page of the ESONET Yellow pages

This includes a range of equipment, from simple, isolated sensors or parts, to communication systems, integrated Observatories or services. ESONET Yellow Pages (EYP) are built upon a database with descriptions of available products, as well as information from manufacturing

companies that design and assemble them. In this database, not only the technical specifications (from stand-alone to complex inter-operative systems) but also, compatibility and standardization requirements should be easily accessed in the descriptive synopsis of each item. EYP were developed using MYSQL, HTML, JavaScript and CSS. The EYP are directly accessible from the main ESONET web site www.esonet-emso.org.
Activities related to promotion and SME policy was firstly reported in deliverable D17-2009, and then updated in D76.

Development of educational support material, outreach programme

Education and Outreach in ESONET was supported by the development of a dedicated program of activities including a dedicated web site with scholar material available, movies, flyers, courses and workshops.

- ***Educational tools of the Education and Outreach web site***

+Educational support material
A host of educational material has been produced and is available from the ESONET Training and Outreach website. Much of this material is aimed at school children of 10-14 years age, although there is a range of material aimed at more mature and junior audience. This was developed by JUB, a KDM member of ESONET. KDM/JUB proceeded with the translation of outreach pages into 14 EU languages. The system is online and visible from the main ESONET web site and also embedded into the ESONET Education pages. http://mars-srv.oceanlab.iu-bremen.de/ (Deliverable D18). Different outreach and training activities are offered: for example quizzes (Deliverable D38) as well as ESONET School materials: a 47-page pdf teaching aid produced to introduce ocean science to 10–14 yr olds, the deliverable D49 and http://mars-srv.oceanlab.iu-bremen.de/schoolmaterials.html.

This material is also aimed at promoting the use of time series data in marine science, and demonstrating how a network of observatories around Europe can produce more useful and interesting data than individual observatories on their own.

During the 2010-2011 period downloadable flash modules have been added to the teaching aids and educational material already on the ESONET website (Deliverable D3). These new modules focus on different aspects of ESONET work and deep-sea research, dealing with diverse topics such as Carbon sequestration, observatory instrumentation and tsunami warning. These modules and teaching aids will still available for use on educational websites in the future.

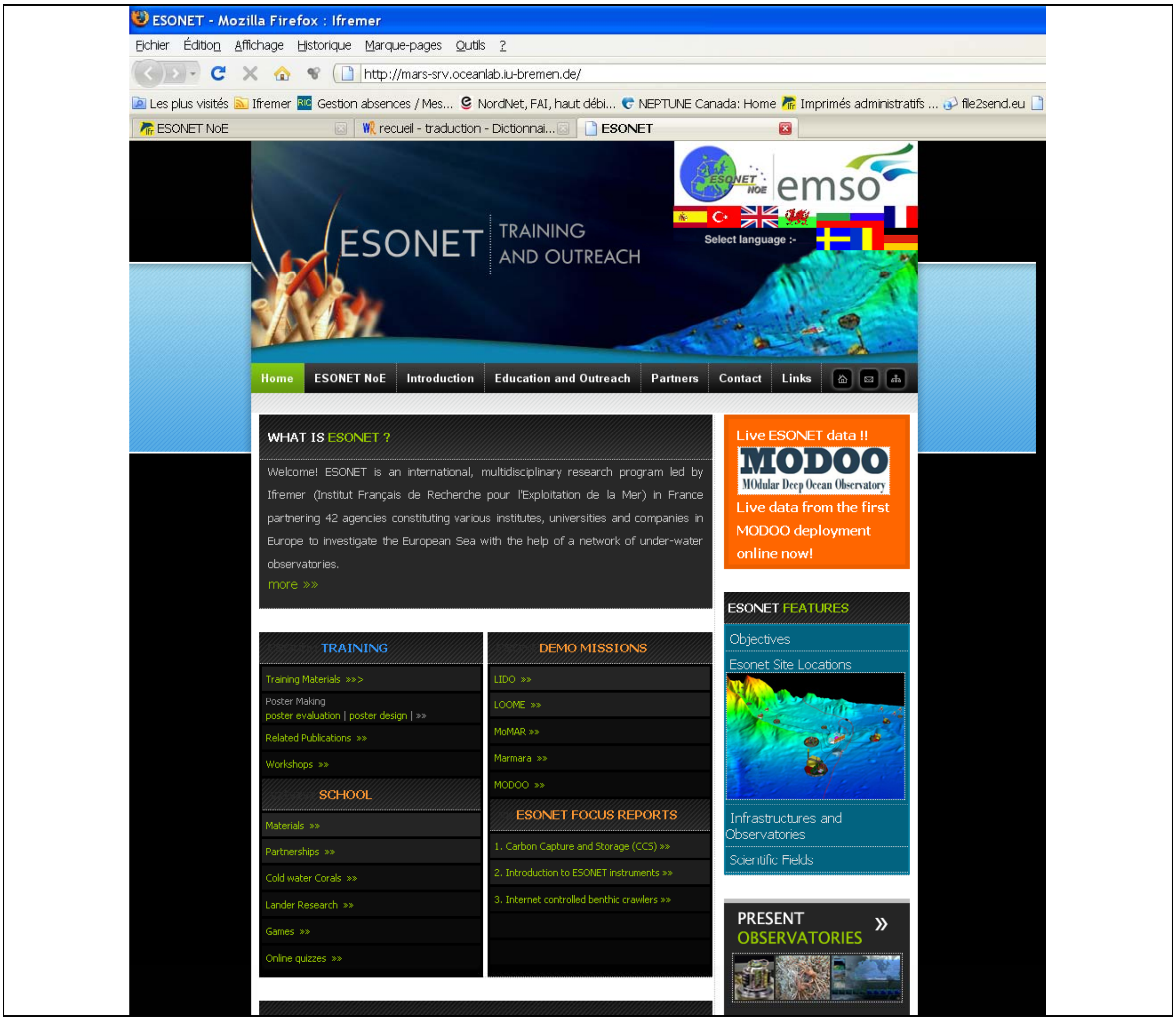


Figure II.5-2: Welcome page of Education and Outreach web site

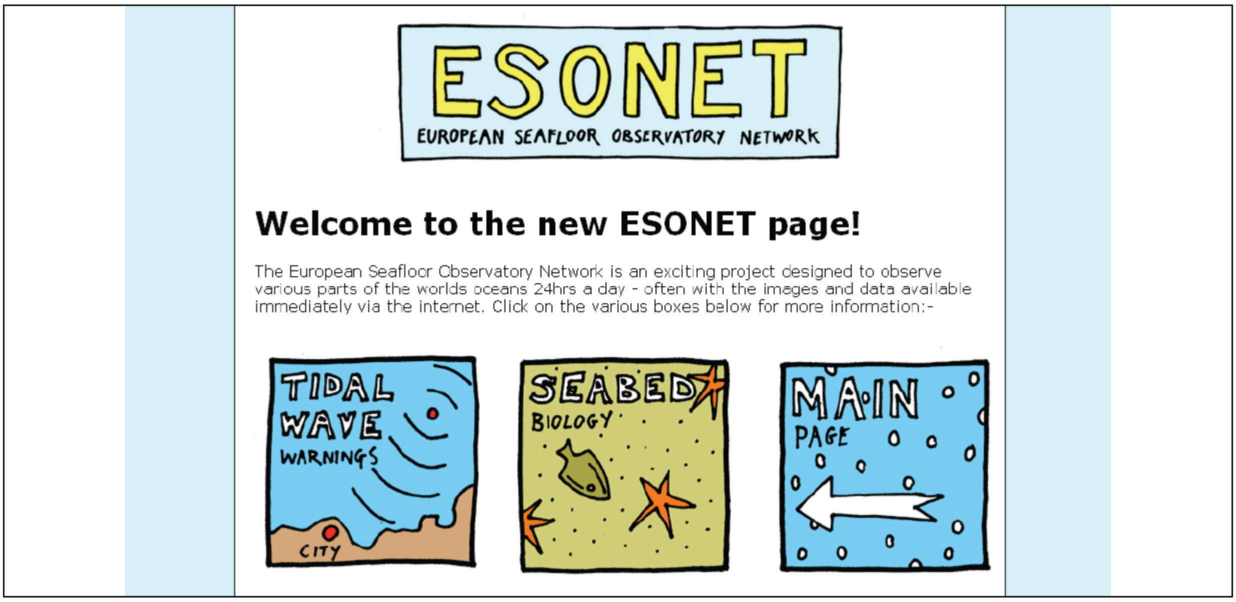


Figure II.5-3: Example of teaching aid modules
+Web portal with real-time web interface: a reality show

In 2007, UAç installed a KDM/JUB webcam on the deep-sea hydrothermal vent of the mussel aquaria for a short in live demonstration. Mussels were maintained since May 2007 by a team of technicians.

During the 2010 - 2011 reporting period a couple of the Demonstration Missions started to produce on-line data from deployment sites. These data were provided on-line via the outreach webpage for the MODOO and LIDO missions. LIDO own homepage link (http://listentothedeep.com) allows online, aquaria or museum users (wherever an access terminal is deployed) to listen in real-time to ocean acoustics using a novel and intuitive web interface. The page provides information for the general public on ocean noise pollution and the importance of acoustics for cetaceans. The visitors, in real time, can listen to the acoustic sources flowing through the Sicily Antenna for instance, carry out statistical analysis and track the different sources. In addition, during 2009-2011, partner CNRS/CPPM developed a web interface dedicated to publish live the Antares oceanographic data for the general public. Efforts were also made to manage this dataflow until the completion of the ESONET data portal.

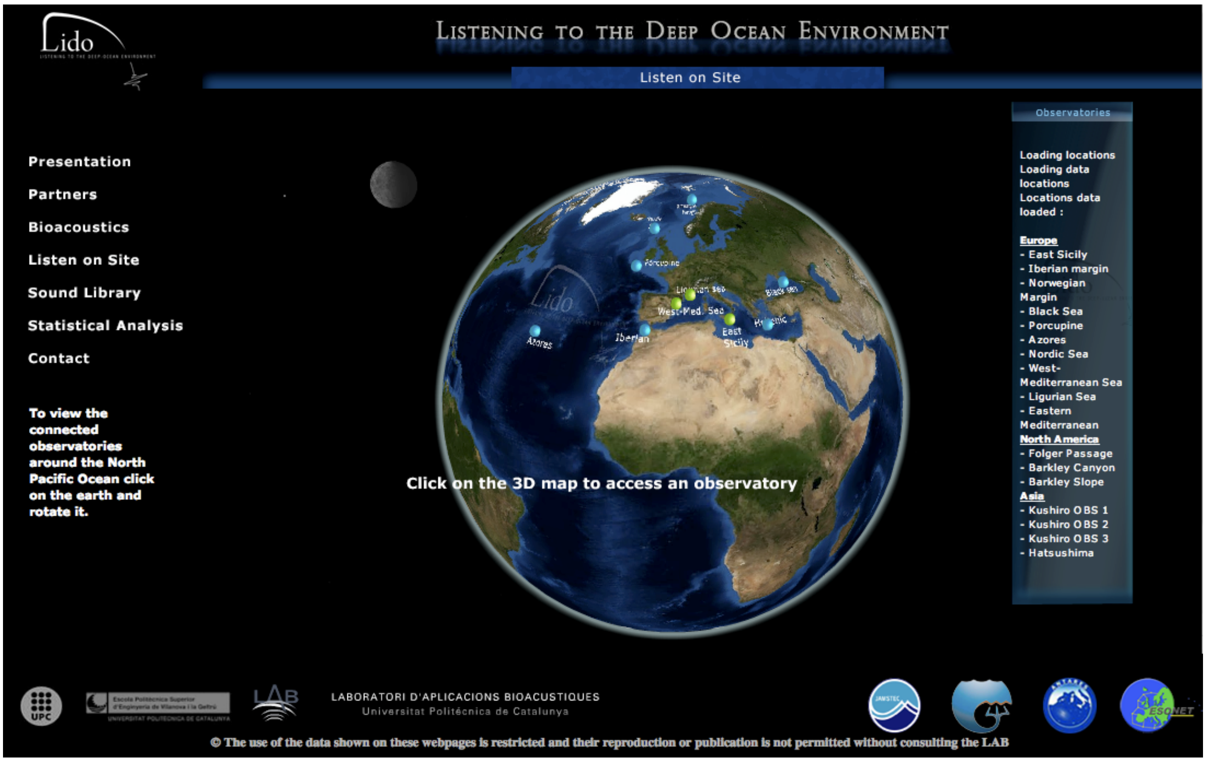


Figure II.5-4: The front page of the website http://listentothedeep.com

+ Introduction to Demonstration missions

Introductory pages were published online for the following DMs: LIDO, LOOME, MoMAR, Marmara and MODOO. Links and up-to-date information for each mission is provided. This is the Deliverable D32.

+Introduction to Carbon Capture and Storage CCS (Deliverable D63)
The introductory, interactive module on Carbon Capture and Storage (CSS) within the oceans is interactive and online. The module contains up-to-the-minute links to news reports, projects and reviews on each CSS technique. The online module has an additional 'Seismic' section.

In response to the 2009 recommendations of the reviewers in Brussels Annual review meeting, the ESONET outreach pages have been reciprocally linked to a selection of European FP6 and particularly FP7 programmes.

- ***Outreach from Aquaria*** **(Deliverable D65)**

The ESONET-NoE public outreach network consists of 3 aquaria (Lisbon, Brest, Heraklion) that inform and educate the public with regard to ESONET-NoE goals and scientific and technological achievements. Students from institutions participating in the ESONET-NoE are taking advantage of the links developed and exchanges are still underway.

+Through Thalassokosmos, HCMR built an educational website displaying ongoing research projects and class material for students and the general public. A variety of academic courses (introduction to the marine environment, marine pollution, marine biodiversity, tropical ecology, etc.) are available as deliverables of the EU project ORION. ESONET is taking advantage of the course material produced within ORION and has added a technological perspective. Outreach initiatives were undertaken at various levels. TV, radio and press interviews and articles presented the main aims of ESONET to the general public in Greece and to the visitors of Thalassokosmos. The necessary hardware and equipment were purchased and the relevant camera and network systems were installed.

+A series of meetings were held between FFCUL and Lisbon Aquarium to discuss the installation of a plasma screen to diffuse outreach information prepared by ESONET. As a result an agreement was reached and communicated to WP7 coordination.

+SOPAB installed a webcam in an aquarium of Océanopolis: http://axis-7557fa.axiscam.net:9000/ (deliverable D30).

- ***Training workshops***

Two ESONET dedicated training workshops were organised in Bremen, Germany: the first one took place in Feb. 2008, the second one was organised aside from an IEEE workshop, OCEANS'09 in May 2009 in Bremen. Both are reported in deliverables D4 and D40. An other training workshop on "Seafloor observation Techniques for Marine Geohazards Monitoring" was organized by ITU in Istanbul on 18-19 August 2009. More than 50 participants from different organisations in Turkey and Europe attended the workshop. The abstracts and presentations are published on the project website: http://www.esonet.marmara-dm.itu.edu.tr) and a summary can be read in D40.

- ***Training infrastructures and simulators***

+Training on Koljofjord site (Deliverable D64)
UGOT made an ROV available as an educational tool. UGOT coordinated and supported actively the Koljofjord shallow-water observatory as a site for educational activities as well as

tests. UGOT has in charge deliverable D64 "Training on test site". This deliverable has been switched from the Kosterfjord site to the Koljofjord test site.

+Training and simulation for ROV deployment.

In the frame of WP2 activities Ifremer and KDM/UniHB prepared a document that describes the existing systems and development activities related to training and simulation in scientific underwater operations. The overall aim is to reach interoperability on the European and international scale for tele-robotic hardware development and operational procedures as part of today's challenges in marine science. The example of the simulator platforms developed at IFREMER and MARUM is described in detail to provide a view of the state of the art and evaluate perspective integration plans. This is reported in the WP2 deliverable D51 (see in § II.3.5).

Production of newsletters, movies, flyers, posters, press releases

- ***The ESONET NEWSLETTER: ESONEWS***

One of the products of ESONET was designed as a Newsletter devoted to the dissemination of (i) the importance of scientific issues, (ii) the mastering of the technology and business plan, (iii) the role of political support for underwater observatories, (iv) the partnership with successful implementations in North America and Japan, and (v) complementary role of ESONET *in situ* observation with satellite, coastal surface and subsurface ocean layer data collection. An issue of "ESONET News - Europeans observe the deep sea" was planned to be produced every 3 months. It was prepared in digital form and distributed to a large mailing list prepared by ESONET central office. Each issue, with 8 pages, was also printed to be disseminated among partners and distributed in international meetings.

The design and production of ESONEWS, the newsletter of the European Sea Observatory Network, has been developed and constantly improved. All ESONEWS Newsletters intended to spread basic information on ESONET initiatives and basic aspects of technology and science associated with deep seafloor observation. Most of the partners of ESONET contributed to the Newsletter. ESONEWS letters are collected in yearly deliverables D15, and are downloadable from the *"News and Events"* section of the ESONET web site http://www.esonet-noe.org/News-and-events. ESONEWS issues were e-mailed to 400 subscribing persons and several hundreds distributed in their printed format through partners, workshops and exhibitions.

- ***ESONET Movies***

SOPAB-Oceanopolis has produced a selection of short films on ESONET and related activities (Deliverable D77). These films, entitled "Ocean under observation" (movie #1), "Deep-sea observatories, Internet in the Oceans" (movie #2), "Observing Europe's open ocean, seafloor and hotspots regions" (movie #3) and "Dyfamed mission" (movie #4) are available on the ESONET web-page. The movie #3 was broadcast during the GEO summit in Bejing (summer 2010) and the movies #1 & 2 were broadcasted during the EGU 2011 meeting in the Geocinema room. SOPAB-Oceanopolis has also conducted a number of interviews with ESONET researchers for future educational use and hosting on websites.

Some movies were also produced individually in the frame of ESONET DMs, for instance a LOOME video, a MARMARA video, all-available on line. INGV produced also a 3D movies but not visible on the web site for technical reasons.

- ***Flyers, Poster and Press releases***

The coordination team prepared successively two versions of a 6-page factsheet to be distributed in workshops and conferences. 1,000 copies of each were available. They were updated according to the activities of the project to include new input like selected DMs description. Several partners published articles and interviews in the press of their own country (for instance GEO magazine in Turkish and French). The coordination team took also care of publishing press articles all along the project durations, and more specifically in the frame of big workshops held in France like during the ESONET 3rd General assembly held in Marseille in Dec. 2010. Main articles came from the famous newspapers: La Provence, le Figaro, Nice matin-Var matin, La croix, Le Monde, Les Echos. These articles are included in the General assembly report D69. In addition to the material produced by JUB for educational purpose, a generic poster is also available on the ESONET website

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Main Reference documents (deliverables, reports, articles)

Lead Authors	Titles	Dates/versions	Where to find if
L. Thomsen (JUB)	D3 *"ESONET class material on science background"*	2008	ESONET website, select Education and outreach tab
L. Thomsen (JUB)	D4 *"Report on First educational and training workshops."*	2008	ESONET website, select Education and outreach tab
JM Miranda (FFCUL)	D15 "*ESONET News "ESONET News-Europeans observe the deep sea"*	Updated each year	ESONET website/News and events
N. O'Neil (SLR)	D16 "*Report on Core service Stakeholders*"	2009	ESONET website/Gallery
JF. Rolin (Ifremer)	D17-2009 *"Report on Promotion and SME policy"*	2009	ESONET website/Gallery
L. Thomsen (JUB)	D18 "*Published draft of ESONET Portal"*	Updated each year	ESONET website, select Education and outreach tab
L. Thomsen (JUB)	D32 *"Introduction to demonstration missions"*	2010	ESONET website, select Education and outreach tab
L. Thomsen (JUB)	D38 *"Game and Quiz section completion"*	2009	ESONET website, select Education and outreach tab
L. Thomsen (JUB)	D40 "*Report on second training workshop"*	2009	ESONET website, select Education and outreach tab
L. Thomsen (JUB)	D49 *"Fully established outreach web page"*	2010	ESONET website, select Education and outreach tab
L. Thomsen (JUB)	D63 *"ESONET intro on CCS ocean technologies"*	2010	ESONET website, select Education and outreach tab
P. Hall (UGOT)	D64 "*Training on Koljofjord"*	2011	ESONET website/Gallery
L. Thomsen (JUB)	D65 *"Outreach and communication in ESONET via aquaria network"*	2010	ESONET website, select Education and outreach tab
JM Miranda (FFCUL)	D76 *"Final report on WP6 activities (PESOS, Yellow Pages)"*	2011	ESONET website/Gallery
S. Gihron (SOPAB/Oceanopolis)	D77 "*General public film"*	2010	ESONET website/Gallery

II.6 A successful NoE: Integrations in ESONET and sustainable structure project:

A major impediment to establishment of the proposed network of observatories is multiple fragmentations across boundaries that are: disciplinary, geographical, national, legal, institutional, technological, operational and micro economical. In a quantitative sense, this meant ESONET had to network about 300 persons distributed over 54 institutions, in 14 countries, initially working with different objectives. To face this challenge, a major part of ESONET activities was based on the selection of proposals received after several internal calls: calls for Demonstration missions, for Staff Exchange and for Test Experiment. Indeed, in addition to the scientific and technical objectives fixed by the calls, a special attention was paid on integration. These internal calls acted as a lever, booting activities, focusing interests on common applicative topics across boundaries. In parallel the organisation of many ESONET workshops unified people from different research and engineering fields to share their knowledge and build common activities upon their specialities. Both workshops and internal calls for proposals were the keys to open the door toward integration in ESONET. As a main result a permanent structure is in preparation.

II.6.1 The keys of integration in ESONET

Internal calls for proposals

Seven of the ESONET sites run six Demonstration Missions (DMs) that have been awarded after two calls for proposals (one in 2007 and one in 2008) (see §2.2). They had for objectives to demonstrate the possibility of integrating activities from several research fields, strengthening the teams on each site.
These 6 DMs brought together 28 ESONET partners from 10 European countries. All ESONET scientific and engineering topics were treated. This is fully documented in the 3 reports D45a-c. DMs were a success to favour sharing of knowledge in the frame of each DM, by grouping people from different institutions, countries, research and technical specialities, to work on one node. In addition, several partners were involved in several sites for instance KDM members worked on MODOO (PAP site), MOMAR D (Azores site), LIDO (Sicily and Iberian site), AOEM (Arctic site). IFREMER was involved MOMAR D, MARMARA, LOOME. INGV was involved in LIDO and MARMARA. NOCS was involved in AOEM and MODOO. The organisation of the DMs induced several workshops of high level between DM participants.

Then, staff exchanges selected after internal calls as well, provided support to ESONET partners to share their practices across demonstration mission's sites. Indeed 27 proposals from 27 partners were selected by the Steering Committee after review.
Amongst the selected exchanges, 9 of them addressed observatory design, standardization, or other technical issues, other 19 projects are more focused on particular node/topic, of which 12 are concerning Marmara node. This is a good example to show how Exchange of personnel helps integration of people and activities on nodes. 3 proposals concerned LIDO on 2 sites, 2 proposals concerned the Ligurian node, 2 proposals concerned Momar site. There is also the MODOO connect proposal which is accounted in the 19 proposals for the focus on acoustic link. This is reported in deliverables D10, D54, with a final feedback in D73.

During the last ESONET period an effort was given on 4 nodes selected in the frame of the Test Experiment because of their cable infrastructure. This experiment was the last integration applicative step by gathering 9 partners across 4 sites.

ESONET workshops:
Several kinds of workshop were organised according to their objectives.

- ***The All regions workshops*** **(**Barcelona, Spain, Sept. 2007 and Paris, Oct. 2009)

They were dedicated to assemble partners on each ESONET node. In Barcelona a review of the observatory projects was presented for each node, in preparation of Demonstration missions proposals submission. Two years after in Paris, achievements and state of art were addressed as well as observatories plans for the future. Those workshops are reported in deliverables D7 and D55. Most of node PIs attended as well as most of the partners. Consequently it was a good opportunity to put people together. It was also an opportunity to update the list of involved persons and PIs for each site after a circulated survey. (Deliverable D56+ D24-2009) Those workshops used to involve about 80 persons.

- ***The Best Practices workshops and other technical workshops*** (Bremen, Germany: Feb. 2008, Brest, France: Oct 2009, Aberdeen, UK: Nov. 2010, Marseille, France: Dec. 2010):

They gather people per technical field, like data management, sensor interfaces, underwater intervention, infrastructure. It was the basis to manage technical working groups and standardization and interoperability all along the project duration. Those workshops used to involve about 50 persons.

- ***The Sciences Workshops*** (Faro, Portugal: Oct. 2009, Marseille,France: Dec. 2010) :

They were the ESONET scientists *rendez-vous* to break boundaries across science disciplines, and of course, across countries and institutions. Indeed, organised by the WP3 leader, H. Ruhl (NOCS) the workshops and the entire Work package aimed at garnering individual inputs from subject experts with ESONET NoE and elsewhere, as well as investigating science priorities of various organizations from regional to international levels This activity included researching recent advances in marine research. Considering outputs reported in WP3 deliverables (see section II.1) this was successful. Those workshops used to involve about 30 persons.

- ***Training workshops*** (Bremen, Germany, Feb. 2008, Bremen May 2009, Istanbul, Turkey, Aug. 2009):

They were dedicated to train student, technician, engineers and Ph Student about observatory technologies. They brought about 20 persons each time from various institutions and countries. This is a good mean to spread ESONET knowledge to the future generation.

- ***Provider (PESOS) workshops and meetings*** (London, UK, March 2008; Faro, Portugal, October 2008; Southampton, UK, April 2009; Bremen, Germany, May 09; Brest, France, July 2009; London, UK, March 2010; Hamburg, Germany, June 2010). They were organized first during international exhibitions and during the last year at national level in order to stimulate the interest of SMEs and industrial companies on the sub-sea observatory market.

II.6.2 The next steps: a sustainable structure

Long term funding commitments of funding agencies

Thanks to ESONET results and outreach ,it is now well understood by several member states that a permanent monitoring of the seafloor, the water column above and the sub-seafloor must be started as soon as possible for a long period to ensure an observatory function. Thanks to the WP5 and coordination teams, the relations with funding agencies have evolved from curiosity to involvement [see Deliverables D23 (2008, 2009, 2010)]. Three Strategic Committee meetings were organized. The first one in September 2007 in Barcelona decided to appoint identical responsible persons to the EMSO Strategic Committee. The second in Faro in October 2008 reviewed the relations between partners and their own ministry or funding agencies. The third meeting in February 2010 in Strasbourg was common with EMSO. It reviewed the ESONET report to EMSO on implementation plan (D46), checked the member states commitments for long-term funding and addressed the topics of ESONET contributions to GMES and Marine Strategy Framework Directive. The relations with funding agencies are now taken over by EMSO PP.

International integration

The success of European integration of the ESONET Community gained a lot from the successful example of federal integration of sub-sea observatory policies in Canada (Neptune and Venus), in USA (OOI) and to a certain extend in Japan. ESONET has been recognized since its Kick off meeting as the contact in Europe. This also stimulated specific relations, visits and MoUs between ESONET partners, Japanese and North American teams. Experts outside Europe were kind enough to review the Demonstration Missions and Test Experiment proposal of ESONET NoE.

The virtual Institute: ESONET -Vi

Contractually a permanent structure was expected to take over the ESONET consortium and activities after the ESONET contract; in order to organize ESONET in a sustainable way. Indeed a permanent structure to ensure the continuity of the effort made by the ESONET-community was necessary to make perennial integration at European level of the ESONET consortium from the numerous laboratories. The follow up of this activity is reported in Deliverables D24 (2008, 2009, 2010). It was contractually decide to drive this sustainable structure towards the creation of a Virtual Institute, initially named "Virtual institute for Scientific users of deep-sea Observatories" (VISO)

The Virtual Institute would:

- Organize staff exchange in-between its members,
- Organize joined experiments on ESONET observatories,
- Promote development of new sensor packages on the existing observatories,
- Organize conferences on the ESONET observatories data exploitation,
- Organize specialized workshops on data management, data dissemination, new sensors, new technologies, inter-comparison of results, etc.

By the time, a call for infrastructure open in the FP7 and the EMSO PP proposal was submitted in 2007 (see §1.1). Consequently there was a need to update the objectives of the ESONET permanent structure in agreement with EMSO consortium and contract.

A first workshop, namely the VISO workshop, was organized by UiT, in Tromso, Norway on 11-12 June 2009. The objective was to provide the planned large-scale marine infrastructure, partner countries and interested organizations, such as fisheries and the petrol & gas industry, with strategies for ensuring the durability of observatory data. This workshop is reported in deliverable D53.
After this general acknowledgement concerning the need of a virtual institute a second workshop was organized in Marseille (France) by UiT in December 16th 2010 in order to help answering some questions raised during the first workshop. Details on these activities may be found in deliverable D72 "Scenarios of VISO implementation".
As a main result it as been decided that the virtual institute, initially named VISO, will be called “ESONET Vi” (Vi for Vision), and it will be built upon the ESONET consortium. ESONET -Vi will be a very useful structure to interact with industry through the ESONET-EMSO community, and will also link ocean scientists and engineers into an international team in marine science. ESONET -Vi will be a way to disseminate methods, data and equipment outside Europe and to identify locations for observatories where the system installed satisfies the needs of industry as well as science. More information is available on the website: http://visobservatories.webs.com/. Facing the need to clearly separate activities to be continued in ESONET –VI and those to be continued in EMSO a complementary workshop was organized at the end of the 3rd ESONET General Assembly in Marseille (Dec. 2010), the “After ESONET session”.

Who will carry on what, after ESONET NoE?

This question is central to any Network of Excellence supported by the European Commission. ESONET has launched two main initiatives in this direction: EMSO infrastructure included in the ESFRI roadmap and supported by EC for a Preparatory Phase and the Virtual Institutes discussed during the previous section, concluding on ESONET Vi. This question was mainly addressed at the end of the last General Assembly meeting week in Marseille (Dec. 2010), the “After ESONET session”. During this meeting EMSO representative was involved as well as many common ESONET and EMSO partners. The output can directly be read in the chapter 7 of the deliverable D69. Here are summarised the main conclusions.

- ***ESONET-Vi membership must be enlarged with respect to:***
    - Potentially associated partner of EMSO ERIC
    - Potentially regional actor of EMSO ERIC (represented by an EMSO ERIC partner through the participation inside the EMSO Departments who gather observatory owners and stakeholders)
- ***The continuation of ESONET specific activities and WG has been stated as follow:***

Scientific Council and Scientific Work Package activities and WG (WP3)
will be followed by a strong commitment of the same community in EMSO PP. Their involvement in ESONET-Vi is clear and a yearly workshop should be organised.

Technical and Operational Council as well as programming capabilities shown for the Demonstration missions of WP4

The general involvement will be maintained in EMSO PP and ESONET Vi will take into account the whole group of engineers and motivate it to support the EMSO ERIC activity. Regarding the underwater intervention group it was underlined that the advisory by specialists in sub-sea intervention who worked on ESONET is necessary for the preparatory phase of EMSO and the future. The participants from Neptune Canada and MBARI stressed the interest of such collaboration including training visits. The international aspect is very important. It is considered that involvement in EUROFLEETS and the existing ship-time sharing consortium OFEG plays a key role in the future ship time and ROV logistics.

Technical Expert groups, such as specialists in as quality management, environmental assessment, engineering disciplines, will be involved in ESONET –Vi.

More specifically the test and calibration group with expertise on components, material, mechanical and electrical interfaces will be involved in EMSO PP and the collaboration for EMSO ERIC infrastructure is important.

Data Management council and Data management WP activities:

This activity must be continuous and includes the user interface aspects, web portal, etc. Consequently, ESONET Vi will take into account the whole group of software specialists to support the EMSO ERIC activity. The upcoming activities will take care to continue to work with other EC funded projects, such as Seadatanet, the reference project. Seadatanet 2 is now under negotiation. Data management will be a major topic for the call for Integrated Infrastructure Initiative foreseen in 2011. At least one meeting a year is mandatory for an update of the specifications of a data portal. It will still an international activity through international standards and international cooperation, supported in many cases by EU funds.

ESONET Label

The label will be delivered to EMSO PP who will take care to apply it, with the support of ESONET-Vi consortium. The collaboration with coastal monitoring projects such as I3 JERICO is foreseen on some topics

Sensor web group in charge of sensor interoperability and ESONET Yellow Pages

This very active community is already convening workshops, it is advised that at least one of them is organized in Europe in order to promote a larger impact, especially to the industry. This will continue the work performed during the Best Practices workshops of ESONET. The group is not only European, as it is supported by MBARI and Neptune Canada. The ESONET Yellow Pages are needing a permanent (although limited) budget. A support by coastal I3 project Jerico is certain, the new I3 envisaged for a call in 2011 could also support this initiative for the deep-sea part. The group activity will continue to take place in EMSO PP and ESONET –Vi.

Outreach and ESONET web sites, ESOnews.

This will be one of the ESONET-Vi activities in collaboration with other EC project and upcoming I3 project.

Legal group

The ESONET WP5 group already transferred its activity to EMSO PP at the end of 2009it will continue in EMSO ERIC

Exchange of personnel
ESONET Vi will take into account the will to continue exchanges and visits. It will prepare the recruitment phase of EMSO. Involvement in upcoming EC project can be managed through a Marie Curie proposal in science and technology

- ***The membership of ESONET regional core groups has been updated***

Here after the table summarise the membership for Each ESONET node. Nevertheless the list of involved persons is non exhaustive. More information can be found in the deliverable D24-2009-appendix 5. Indeed more persons are listed, including principal investigators and other scientists, engineering staff, Strategic Committee Referent, associate partners, data manager and for each contact listed person are included the fields of research or engineering and contact references (Email, postal address).

Node #	Node name	Reference persons	Other contact persons	Demo-mission
1	Arctic	M. Klages (AWI) I. Wright (NOCS), Eberhard Fahrbach (AWI)	T. Soltwedel (AWI),	AOEM (MASOX-ARCOONE)
2	Norwegian Margin	J. Mienert (Univ. Tromso), D. de Beer (MPI-MM),	B. Ferré (UiT), Antje Boetius (KDM-MPIMM), Stéphanie Dupré (Ifremer), Stefan Buenz (UiT)	LOOME
3	Nordic Sea	P. Sigray (Stockholm univ.)		none
4	Porcupine	R. Lampitt, K. Larkin, H. Ruhl, D. Billett (NOCS), Fiona Grant, Mick Gillooly (IMI) and Olaf Pfannkuche (KDM-IFM-GEOMAR)	**NOC, Southampton:** John Allen, Teresa Amaro, Brian Bett, David Billett, Ben Boorman, Jon Campbell, Louise Darroch, Andy Gooday, Thanos Gkritzalis, Sue Hartman, Stephanie Henson, Ross Holland, Richard Lampitt, Kate Larkin, Adrian Martin, Maureen Pagnani, Corinne Pebody, Richard Sanders, Peter Statham, Mike Thurston, Nina Rothe, Henry Ruhl, Denise Smythe-Wright, Paul Tyler, Mike Zubkov. **University of Southampton:** Debora Iglesias-Rodriguez, Bethan Jones, Sonia Blanco, Alberto Naveira Garabato **University of Liverpool:** George Wolff **NOC, Liverpool:** Kevin Horsburgh **University of Aberdeen,** Oceanlab: Phil Bagley, Martin Collins, Anne Holford, Alan Jamieson, Monty Priede, Ursula Witte **John Moores University, Liverpool: Kostas Kiriakoulakis,** **University of Glasgow:** David Bailey **University of Newcastle:** Ben Wigham **Hellenic Centre for Marine Research, Crete, Greece:** Nikos Lampadariou, Vicki Kalogeropoulou **German Centre for Marine Biodiversity, Wilhelmshaven, Germany:** Pedro Martinez Arbizu **Universidad de Valparaíso, Chile:** Eulogio Soto **UK Met Office:** Peter Fenna, Steven Lankester **Natural History Museum, London:** Gordon Paterson	MODOO

Node #	Node name	Reference persons	Other contact persons	Demo-mission
			IFREMER, France: Joelle Galéron and 'in kind' PAP data management (**CORIOLIS** Data Centre) **Marine Institute, Ireland:** Fiona Grant, Glenn Nolan **IFM-GEOMAR, Kiel, Germany:** Johannes Karstensen, Olaf Pfannkuche **Université de la Méditerranée LMGEM, Marseille, France:** Dominique Lefèvre, Christian Tamburini, Anne Robert **NIOZ, Netherlands:** Jens Greinert **University of Ghent, Belgium:** Ann Vanreusel	
5	Azores	A. Colaco (Univ. Azores), R. Santos (Univ. Azores), Mathilde Cannat (IPGP), Pierre Marie Sarradin (IFREMER)	Maria Gabriella Queiroz (Univ. Azores), Miguel Miranda (FFCUL) and scientists and engineers involved in MoMAR- D.	MoMAR-D
6	Iberian Margin	L. Matias (FFCUL), M. Andre (UPC-CSIC), N. Zitellini (ISMAR), ,	J.M. Miranda (FFCUL), Francesco Gasparoni (TECNOMARE), Francesco Chierici (IRA-INAF and ISMAR-CNR), Luca Pignagnoli (ISMAR-CNR), Juanjo Dañobeitia (CSIC)	LIDO
7	Ligurian Sea	Dominique Lefèvre and Christian Tamburini (LMGEM), Laurent Coppola (LOV),	Claude Vallée, Jean-Jacques Destelle, Stéphanie Escoffier, Christian Curtil (CPPM), Gabriel Gorsky (LOV), Etienne Ruellan (DT-INSU), Nabil Sultan, Jerôme Blandin, Vincent Rigaud, Ricardo Silva Jacinto, Jean-François Rolin (Ifremer), Achim Kopf (UNIHB), Pierre Henry (CNRS-CEREGE), Philippe Charvis et Anne Deschamps (GEOAZUR, CNRS), Mathilde Cannat (IPGP).	ESONET Test Experiment on Antares site
8	East Sicily	L. Beranzoli (INGV), P. Favali (INGV), R. Papaleo (INGV), G. Riccobene (INFN)	**Laboratory of Applied Bioacoustics (LAB)**, **Tecnological University of Catalonia (UPC)** : Michel André, Ludwig Houegnigan, Alex Mas, Antonio, Sánchez, Mike van der Schaar, Serge Zaugg; **University of Bremen (MARUM)**: Christoph Waldman; **FFC/CG Universidade de Lisboa**: Jorge Miranda, Luis Matias; **INGV**: Lucio Badiali, Laura Beranzoli, Maria Grazia De	LIDO

Node #	Node name	Reference persons	Other contact persons	Demo-mission
			Caro, Angelo De Santis, Fawzi Dumaz, Davide Embriaco, Paolo Favali, Gabriele Giovanetti, Nadia Lo Bue, Giuditta Marinaro, Stephen Monna, Stefano Vinci; **CNR-ISMAR**: Luca Pignagnoli, Nevio Zitellini; IRA-INAF: Francesco Chierici; INFN: Giorgio Riccobene, Mario Sedita, Giovanni Barbagallo, Giorgio Cacopardo, Claudio Cali, Rosanna Cocimano, Rosa Coniglione, Michele Costa, Antonio D'Amico, Francesco Del Tevere, Carla Distefano, Francesco Ferrera, Valentina Giordano, Massimo Imbesi, Dario Lattuada, Emilio Migneco, Mario Musumeci, Angelo Orlando, Riccardo Papaleo, Paolo Piattelli, Guido Raia, Alberto Rovelli, Piera Sapienza, Fabrizio Speziale, Agata Trovato, Salvatore Viola, Fabrizio Ameli, Maurizio Bonori, Antonio Capone, Rocco Masullo, Francesco Simeone ; **UTM-CSIC, CMIMA**: Juanjo Dañobeitia; **dBscale Sensing Technologies,**: Eric Delory; CIBRA, **Università di Pavia**,: Gianni Pavan; **TFB- BHT Berlin**: Hans W. Gerber, Wifried Langner, Haiko de Vries; **Tecnomare S.p.A.**: Francesco Gasparoni, Federico Bruni, Flavio Furlan, Fabio Zanon.	
9	Hellenic	Vasilios Lykousis (HCMR), Tassos Tselepides (Un Pireaus)).	Kostas Nittis, Leonidas Perivoliotis, Paris Pagonis, Thanasis Chondronasios, Dimitris Kassis, Dionisis Ballas, C. Chambaris (HCMR),	none
10	Marmara Sea	N. Çagatay (ITU), L. Géli (IFREMER),	G. Cifci. (DEU-IMST), L. Gasperini. (ISMAR), P. Henry (CNRS-CEREGE), Paolo Favali (INGV)	MARMARA
11	Black Sea	L. Dimitrov (IO-BAS), H. Sahling (Univ. Bremen), N.Çagatay		none

Main Reference documents (deliverables, reports, articles)

Authors	Titles	Dates/versions	Where to find if (URL, Annex of this report)
M. Cannat (IPGP)	Part I of D10 *"Report on Exchange of Personnel; common schedule and Methodology of Tests"*	2009	ESONET website/Gallery
JF. Rolin (Ifremer)	D24-2009 *"Report on integration between respective teams and working relationships beyond the life of ESONET"*	2009	ESONET website/Gallery
B. Ferré (UiT)	D53 "*Report on creation of VISO"*	2009	ESONET website/Gallery
M. Cannat (IPGP)	D54 *"Report on first and Second call for exchange of Personnel"*	2010	ESONET website/Gallery
M. Cannat (IPGP)	D56 *"Membership of Regional implementation groups"*	2010	ESONET website/Gallery
B. Ferré (UiT)	D72 *"Scenarios of VISO implementation"*	2011	ESONET website/Gallery
M. Cannat (IPGP)	D73 *"Final report on exchange of Personnel"*	2011	ESONET website/Gallery

III. Conclusion: broken boundaries thanks to ESONET NoE

Thanks to a great involvement of ESONET partners and an efficient management from WP leaders, the project concludes in a fruitful way, with expected achievements. Indeed, thanks to the operation of Demonstration mission and testing experiment, exchange of personnel, the structured ESONET community is now strengthened and well recognized at international level. Standardisation and interoperability are issued in the ESONET Label document. The creation of a permanent structure is expected to be finalised over the coming months, demonstrating the integration effect of the Network of Excellence. With this successful integration we can consider that ESONET succeeded in establishing the network despite the initial fragmentation across boundaries that were: disciplinary, geographical, national, legal, institutional and technological.

- ***Disciplinary boundaries***

The NoE encouraged interdisciplinary cooperation by organising internal calls and Best practices workshops (science disciplines and technology disciplines) as well as sciences workshops. One important objective for ESONET NoE was to encourage the cooperation of scientists from water column research with those from seafloor research. To fill this gap we oriented the Scientific Areas of the second call for demonstration missions in a way to favour proposals that would involve both topics. This resulted in the MODOO and AOEM proposals selection on the PAP site and Arctic sites respectively.

- ***Geographical boundaries***

Europe is surrounded by 4 great marine basins - the Arctic, Atlantic, Mediterranean and Black Sea basins with their subdivisions and connecting shallow seas such as the North Sea and Baltic. An important function of the NoE was to coordinate work in these disparate areas so as to create a unified system with global relevance and common standards. After four years, the north-south European boundary between teams persists even if it is attenuated. Indeed, it is apparent that northern demonstration missions (LOOME, MODOO, AOEM) involve more partners located in northern Europe, whereas southern Demonstration missions (MARMARA, LIDO, MOMAR D) involve more partners from the southern Member States. It will take time to overcome the history of each site and of their related community. This can mainly be solved by continuing thematic workshops like those led in ESONET. For illustration, the organisation of the two “All Regions Workshops” and the three “Best Practices Workshops” were successful ways to overcome geographical boundaries.
In addition, late in the project ESONET integrated the PLOCAN initiatives, off Canaries; and the NOON project, off Norway.. European seas are understood as a basis of networking activities extending well beyond the European member states EEZ.

- ***National boundaries***

The ESONET consortium originates in 14 different countries. Consequently all activities in ESONET were reflecting this diversity of nationalities. Moreover the activities carried on ESONET nodes in the frame of demonstration missions and/or of the test Experiment were issued from fruitful collaborations between partners from several countries. None of the

ESONET activity has been, or will be continued as a national one. The added value of the EU support is evident and well accepted in academic sub sea observatory ocean research.

- ***Legal boundaries***

Linked to the issues of national jurisdictions, there are legal barriers to the establishment of extensive infrastructure extending from land into the sea. In ESONET, one activity, namely LEE (for Legal Ethical and Environmental), was partly dedicated to survey the legal constraints at each ESONET node such as protected marine areas, cable occupation, military zone etc. (See deliverables D47 & D48 in § II.4.3). When EMSO PP proposal was selected for funding in FP7 with objective to implement observatories on selected nodes, these activities were transferred from ESONET to EMSO. For this reason one objective of an EMSO –PP WP is to take care of the legal framework to build observatories.

- ***Institutional boundaries (private-public)***

Within or across member states, division of responsibilities between institutions can form artificial barriers to development of the ESONET observatory network. There are further differences in relation to private enterprise and the degree to which private enterprise can be responsible for public infrastructure in different countries. Different funding and employment models can be barriers to collaboration. The barrier would be more easily removed when a private institution can engage on long term with a sustainable return on investment, for instance to promote a market on long-term. As ESONET was dedicated to prepare technical specification for deep-sea observatories but not to implement them quickly (in the 5 years, to be compared with market and trade life period), the involvement of the private sector could be expected to be less effective than later when observatories will be implemented in EMSO.
Nevertheless the involvement of private companies in ESONET was well supported by most of the private partners. Some companies preferred not to claim their cost on ESONET contract even if a minimum activity was effective. In fact, the purchasing process could not be included in the NoE, where investment budget was not accepted.
Breaking of boundaries was initiated by involving SMEs in the PESOS group and in the ESONET Yellow pages, adding to relations in parallel to the project between members who used ESONET as an opportunity to meet. ESONET initiated a worldwide market intelligence which served as basis to prepare the economical implementation plan (WP5). It shows a real start of sub-sea monitoring infrastructure contracts. A next step would be to build on this partnerships with providers in the frame of the ESONET certification of delivered products to be compatible with the ESONET Label.

- ***Institutional boundaries***

ESONET NoE has been very active to be recognized by all institutions at national, European and international level. Thanks to Strategic Committee meetings, we have been able to present to the funding agencies the requirement for a concerted European strategy. EMSO ERIC will hopefully be the result of this ESONET NoE
The core partner principle (one country one institute), used to select the Steering Committee members, was applied to EMSO PP. It helped to overcome inter-institute boundaries at national level. It may lead to misunderstanding between scientific excellence and infrastructure operating responsibility but we may be confident this may be well managed by the ESONET Vi to EMSO partnership in the future.
The impact of ESONET NoE on institutional policies was limited by its late achievements in actual monitoring, For instance, on the side of geo hazard and early warning it will be of

paramount importance to coordinate information and efficient data exchange among civil protection of different countries.

- ***Technical boundaries***

The building blocks of the proposed ESONET system were already in existence, like sub-sea sensors, observatory platforms, cables, junction boxes and data centres. However sensors in different disciplines were developed independently and operated to different standards. This tended to require a certain amount of extra work by specialists for any inter-comparison of data collected by different teams. To fill this gap the ESONET Best practices meetings were set up.
The definition of stand-alone, short and long cabled observatories eased performance to cost comparisons and in many ways built the spirit of participating to the same adventure of sub-sea observatories construction, whatever the budget/logistic constraints or technological choice.
Agreements on common standards were formalised through the ESONET label. Some standards were tested and selected like for sensor interface (highly innovative), data management, infrastructure technologies, and underwater intervention methods. Of course a lot of work remains to do in this domain. We consider that at European scale a great effort was done and the issues are widely shared. Here again competitiveness of European SMEs was specifically addressed by testing some equipment for unofficial qualification.

Consequently we have ensured that traditional European fragmentation has been overcome sufficiently to carry on the ESONET activities through ESONET- Vi virtual institute and in the EMSO-ERIC for the future. Tasks devoted to initiate the large infrastructure of sub-sea observatories were successfully transferred to EMSO PP. Constitution of Core Legal Entity (CLE) is now the building of the EMSO ERIC (European Research Infrastructure Consortium). The development of the Regional Legal Entities (RLEs) is relevant in the context of the EMSO "regional departments" (or groups). ESONET impact is worldwide and will continue after the end of the contract.

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All together we successfully faced a four-year challenge!

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