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ESONET European Seas Observatory Network

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Project Deliverable D59 (D59a and D59b)

Final report on test experiments performed on cabled sites and return from training activities

D59a: Test preparation: Deployment and qualification procedures
D59b: First results and access to the data after the end of ESONET NoE

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organisation name: IFREMER, France

Work Package 2
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Dissemination Level		
PU	Public	x
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)	

CONTENT

1 Executive summary

As a result of a strong demand from the European Commission during the 2009 review of the ESONET project concerning an insufficient access to online data, a call for tests on cabled sites was issued in April 2009. Its title was “Integrated organisation of tests and observatory methodologies on cabled ESONET observatory sites”. The call was focused on long-term deployment in deep sea water and technical issues, thus, science was not the main objective. Indeed, main objectives had to allow to launch a web portal with real-time web interface from online observatories and allow toshow to all users (as the ESONET community, public, industry and politicians) incoming data and underwater activities of internet operated vehicles and service-ROVs. This also had to allow enabling the ESONET partners as well as the general public to actively participate in the ESONET researches (as an access to real-time data including streaming video and even access to some interactive experiments). Moreover, for this occasion, scientists and engineers had to test, in real conditions, power-hungry sensors for future ESONET observatories.

The ESONET coordination Team received, in May 2009, nine proposals from seven institutes for five sites, from which, three are ESONET sites, (for more information, see the Deliverable D58 “ Report on selected test experiments on cabled sites). After evaluations of proposals, it was decided to merged the previously received proposals to integrate a maximum of proposed tests in a coherent way. After discussion in between partners and the Steering committee, four test sites were retained:

- ANTARES in deep water near Toulon, coordinated by Dominique Lefèvre
- East Sicily (SN1) near Catania, coordinated by Giorgio Riccobene
- OBSEA near Barcelona (Vilanova) in shallow water, coordinated by Joaquim Del Rio
- Koljo Fjord in shallow water near Goteborg, coordinated by Per Hall

ESONET Test experiments were officially granted in April 2010 (See Statement of Decision of the Virtual Steering Committee Meeting of April 2010) with a maximum funds of 620 000 €, with a starting of the related activities in July 2010.

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. The Tests benefited of infrastructure building budgets outside ESONET on ANTARES, SN-1, Koljofjord and OBSEA sites. The experiments performed by ESONET have shown the advances made in sensor interfaces, data management, subsea intervention and sensor qualification. It is an achievement of the 4 years work in ESONET for all the tasks of WP2 (especially sensor interfaces, subsea intervention and sharing testing facilities), WP3 (generic instrumentation and specific instrumentation) and application of the latest results of WP9 such as sensor registry. The principle of data available in real time from the subsea 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. (Note that it is a complement to the dataflow coming from stand alone observatories deployed by ESONET on other sites such as MOMAR-D, MODOO and Hellenic sites).

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.

At the end of ESONET (February 2011), all the experiments are not finished. They will use non ESONET budgets to operate the final sea operations on SN-1 and Koljofjord especially.

2 Introduction

This deliverable has for main objectives to report all operations carried out at the four test sites. Activity repored on each site was coordinated and carried out by each site operator and focused on the following features:

* Equipment preparation, tests on land and deployment:
actions and procedures carried out to prepare the equipment, its tests on land and its deployment at sea.

* Sensor and measuring system calibrations and qualification:
facilities used and procedures carried out to calibrate the sensors and measuring systems.

* Return of experience of operations at sea and interventions by ROV:
- procedures followed in ROV operations either for equipment deployment, monitoring or maintenance
- comparison of procedures with different ROV or on different sites

* Data management preparation:
data management procedures ments.

* Return of experience of equipment operation:
- return of experience on equipment operation and behaviour
- comparison of similar equipment on different sites will be dealt with. Yincluding any problems (corrosion, biofouling, equipment problems…) occurred during the experiments.

* Quality and inter-comparison of recorded data :
-the recorded data series and their analysis are to be studied including comparison of data acquired with different sensor models or identical equipment on different sites
* Standardization procedures:
Standardization procedures put in place during experiments are detailed

* Furthermore, this report gives emphasis on effective realized operations compared with previously planned operations. Thus, deviations from planned operations are explained and discussed.

* Moreover, a section is dedicated to test experiment contributions on public outreach and training activities.

3 ANTARES test experiments

3.1 Previously planned test experiments

3.1.1 Objectives of the ANTARES test experiments

The aim of this test experiment was to develop an autonomous instrumented line to provide real-time high-frequency time series of a variety of hydrological and biogeochemical variables. This line must have been equipped with standard sensors as well as a number of new innovative sensors. The project was based on implementing an acoustic data transmission between the autonomous line and the ANTARES cabled infrastructure.
The ANTARES site is located in the Mediterranean Sea at 42°48'N-6°10'E at a water depth of 2500 m (see Deliverable D58).

A short work plan was defined for each leader institution involved in the ANTARES test experiment:

Leader Institution	Work plan: short description of tasks by partners involved
IFREMER	IFREMER will provide a secondary junction box (SJB) on ANTARES, allowing deployment of scientific instrumentation. The ALBATROSS system will be connected to these SJB. IFREMER is in charge of deployment operation using ROV VICTOR. Deployment operations are foreseen in October/November 2010.
CNRS	CNRS is providing instrumentation, especially the ALBATROSS line. Access to data collected in real time
INGV	INGV is providing a Gamma Energy Marine Spectrometer (GEMS)
INFN	The ROV COUGAR from INFN will be used to deploy the GEMS and for interoperability test on the SJB

3.1.2 Detail of initially planned costs and grant allocation for the ANTARES site

Partners	Personnel (€)	Equipment (€)	Travel & Accommodation (€)	Other (€)	Subcontracting (€)	Indirect costs (€)	Total costs (€)	Total ESONET contribution (€)
IFREMER	29 000	0	0	186 000	0	133 300	348 300	0
CNRS	791 160	338 500	6 000	2 500	0	227 432	1 365 592	139 000
INGV	13 600	147 000	18 000	9 000	0	37 520	225 120	0
INFN	4 000	0	8 000	91 000	0	20 600	123 600	81 000
TOTAL	***837 760***	***485 500***	***32 000***	***288 500***	***0***	***418 852***	***2 062 612***	***220 000***

3.2 First results of the ANTARES test experiment

3.2.1 Equipment preparation, tests on land and deployment

- **Activities carried by the CNRS and Ifremer teams**

For this test experiment, the observatory is composed of a seafloor module, namely the MII (Instrumented Interface Module) and an instrumented moored line. The MII was designed to be connected to the main Antares infrastructure via a Secondary Junction Box (SJB); and the moored line was designed to communicate with the MII via an acoustic modem for a real time data transmission to the main cable infrastructure.

Several types of scientific instrumentation included in the MII were connected to the SJB and the infrastructure within the test TEXREX cruise, in which Esonet NoE was associated. They are listed hereafter. A key issue of technical activities associated with this test experiment is to validate the concept of a deep-sea module hosting multi-instrumentation for real time data transmission, calibration procedures of oceanographic probes as well as deployment and underwater intervention procedures and then data transmission from an autonomous line to the MII.

MII instrumentation list

CTD	Seabird	SMP37P	Conductivity, temperature, pressure
Oxygen optode	Aanderaa	3830	Dissolved oxygen concentration, temperature
ADCP	Nortek	Aquadopp	sea current velocity and direction
Camera	Institut de Physique Nucléaire de Lyon CNRS/IN2P3 Université de Lyon	Prototype BIOCAM	Bioluminescence Images
Turbidimeter	Wetlab	ECO Scatering meter	Turbidity
Pressure	Paroscientific	Pressure sensor	Absolute pressure

In the building of the project the DT INSU was involved in several steps:

- Electronic design for power distribution, monitoring of embedded systems and interfaces with oceanographic instruments
- Mechanical design for the seabed structure, mechanical linkages with instrumentation and the conception of electronic housing
- Study of the Link between BJS and seabed module
- Study for data transmission:
  - -Ethernet between the shore and the Instrumented Interface Module (MII)
  - -Acoustic between the MII and the line instrumented
  - -Inductive in the instrumented line
- Manufacturing and subcontracting for mechanical and electronical parts
- Software development for embedded systems and the data taking at the shore station
- Qualification test of interlink cable and electronic tube (hyperbaric test in Brest) took 3 working days.
- Integration, test and deployment of MII

Figure 3.1: Selection of pictures exhibit different phases of the integration and test made in close collaboration between IFREMLER and DT INSU. Photo copyright (C. Gojak).

The MII module was deployed at sea during the joint "TEXREX" cruise on the "Pourquoi Pas?" R/V in October 2010 just after the secondary junction box was deployed and connected to the ANTARES primary junction box.
During the same operation three initial instrumentation packages were connected to the BJS: an Interface Instrumentation Module (MII); a new generation seismometer

GURALP and a first phase of Deep Sea Net project. Images of these deployed elements are shown in figures 3.1 & 3.2. The development and deployment of the SJB are mainly funded on other projects, whereas the MII preparation and deployment are fully part of ESONET project.

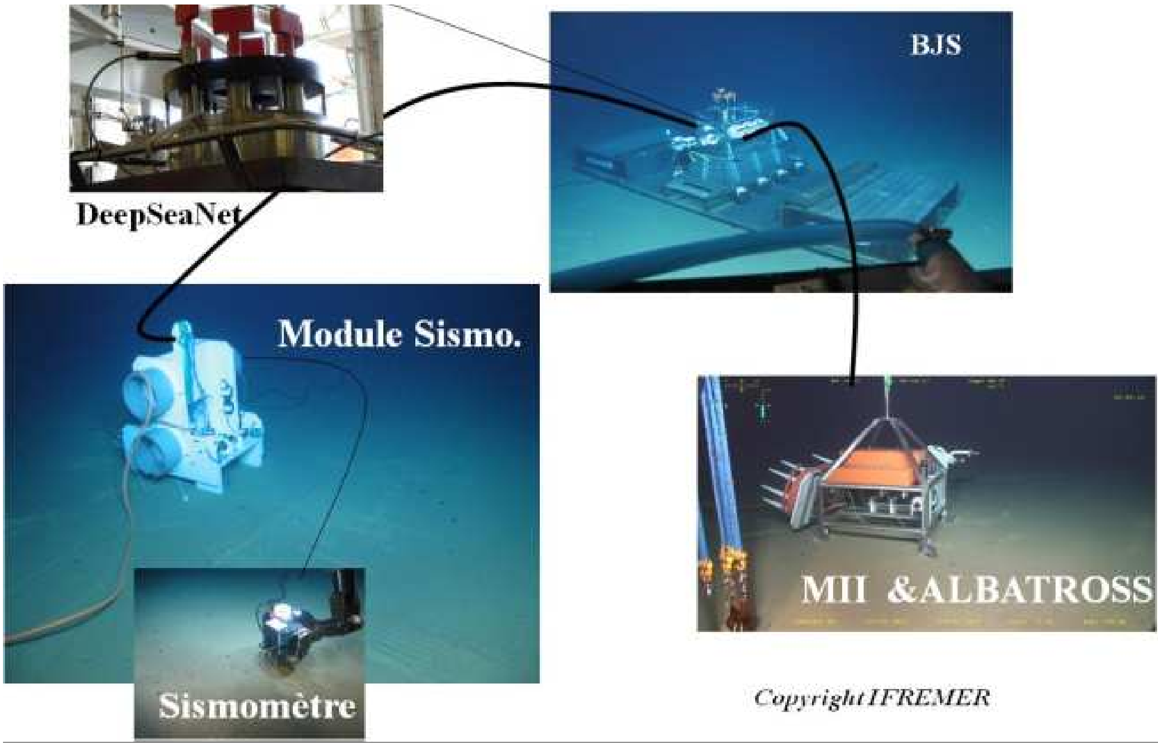


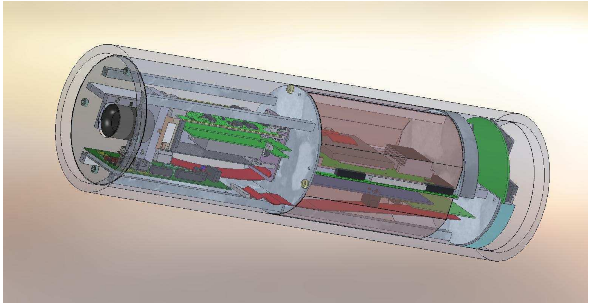
Figure 3.2 Deployed system on the Antares sites via the secondary junction Box which is connected to the primary junction box.

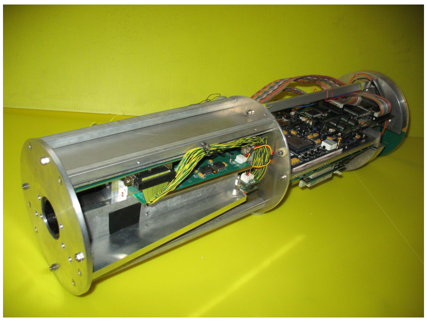
The standard user interface, the “Module Interface Instrumentation” (MII), was developed by the Technical Division of INSU/CNRS and LMGEM. This module allows users several communication protocols and the electrical power required to connect scientific instruments. Two types of port are available, either a serial link RS232 or Ethernet link 10/100 Mbps on copper. For these two types of interconnection, the available voltage is 48 V. The power available for each connector depends on the power allocated to the MII by the SJB. The integration of a system of data transmission via an acoustic modem is planned for a future version of the MII. This type of transmission allows the installation of autonomous mooring lines, with low data rates, for short time periods and provide the benefit of real-time connections without the cost of submarine operations. The electronic system is embedded inside a container attached to a frame structure. This structure hosts the wet mateable connectors for ROV operation as well as a release system.

Unfortunately, it hasn't been possible to deploy the acoustic modem and the instrumented line. That was due to the unavailability of some manufacturer's equipments (inductive and acoustic modems) and a lack of time for integration and tests. At the present time, all the equipments are bought and delivered. The acoustic module and the instrumented line are being constructed and they will be deployed in 2011. The delay is related to the late start of the project (May 2010).

ESONET NoE is also a working frame for new innovative technology development, and was an opportunity for colleagues from IN2P3 (Lyon and Marseille) to take advantages of the MII structure to deploy a new video camera for bioluminescence detection. This camera is a derivative from the LUSIPHER camera (IPNL).
This project included conception and realisation of the camera and embedded software between April and September with test realized in September 2010.

- Sensor ebCMOS built by IPNL
- Acquisition with FPGA 1 Gbits/s Ethernet (IPNL)
- PC light for data acquisition and data treatment to trigger on bioluminescent event (INPL)
- Camera control and DAQ (IPNL & CPPM)
- Marinisation (CPPM)
- Power supply (IPNL)
- Conception and development (IPNL)
- Camera bench tests (IPNL)





Biocamera : Prototype Design *BioCamera*

Figure 3.3 Biocamera Design

Internal temperature: 13°C
Runnin: 24h/24h
Trigger, after signal reconstruction from electrons to 12 photons
Frame rate 75 i/s
Bioluminescence event : 0.5 evt/jour

Data analysis :

- bioluminescent object size
- time-series of photons number
- correlation with other environmental variables

The deployment of the acoustic modem and inductive instrumented mooring line is foreseen for first semester 2011.

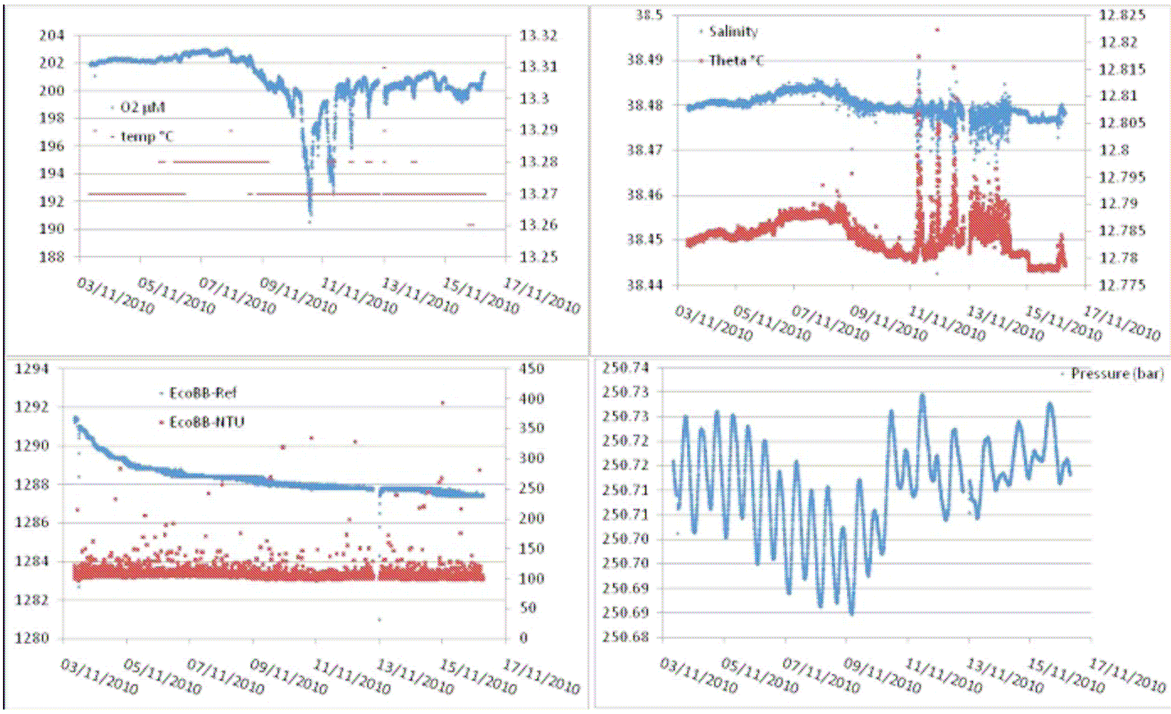


Figure 3.4: example of acquired data

- **<u>Activities carried by INFN and INGV mainly</u>**

Part of the operation scheduled in the ANTARES site (deep-sea connection tests with the PEGASO ROV at 2500m depth in the Toulon site) was moved to the Capo Passero site (South East Sicily, latitude 36°25.010 N, longitude 015°53.660 E, depth 3470 m) in the aim testing deployment, connection and operation of an ANTARES Mini-Line at 3500 m depth. The ANTARES Mini-Line consists of a sequence of 3 ANTARES storeys equipped with a total of 6 optical modules (2 per each storey) capable to record faint light signals, mainly originated by ^{40}K decay and bioluminescence bursts. The line is also equipped with oceanographic sensors to measure water physical properties. Together with proving the first test of the PEGASO ROV (see below, section NEMO-SN1) at 3500 m water depth, the goals of the operation are also: test mechanical, optical and electronic instrumentation developed for the ANTARES detector, at 3500 m depth and 100 km off-shore; biological and oceanographic monitoring of the Capo Passero site; test of the novel technology for 100 kV power transmission over 100 km electrical cable with sea return, available at the Capo Passero INFN infrastructure. The ANTARES Mini-Line was integrated and tested at the INFN shore Laboratory of the Port of Catania, under the supervision of INFN and CNRS. Thus, it was embarked onboard with the PEGASO ROV for the deployment and connection operation (Figure 3.5).

Figure 3.5. Left: The ANTARES Mini-Line integrated in the INFN premise located inside the Catania harbour. Right: The ANTARES Mini-Line on board the truck, going to be embarked on the Cable Ship Certamen.

Schedule of the sea campaign started on December 15, 2010: Mobilisation (1 day), transfer and ROV dive test (1 day), deployment of the ANTARES Mini-Line (12 hours), ROV dive for connection (12 hours), transfer and demobilisation (1 day).
Participants of the sea campaign were: INFN- M. Musumeci (Mission Chief), G. Cacopardo, M. Imbesi; CNRS –A. Cosquer, F. Gallo; ROV Crew -2 persons; Winch Control Crew- 2 persons.
The Cable Ship Certamen (Elettra Tlc) was used, under INFN request as partner of the MECMA consortium. The C/S Certamen offers DGPS-2 system and enough deck space to host: the PEGASO ROV and its control container, the 4700-m electro-optical winch and the underwater stations to be deployed (Figure 3.6).

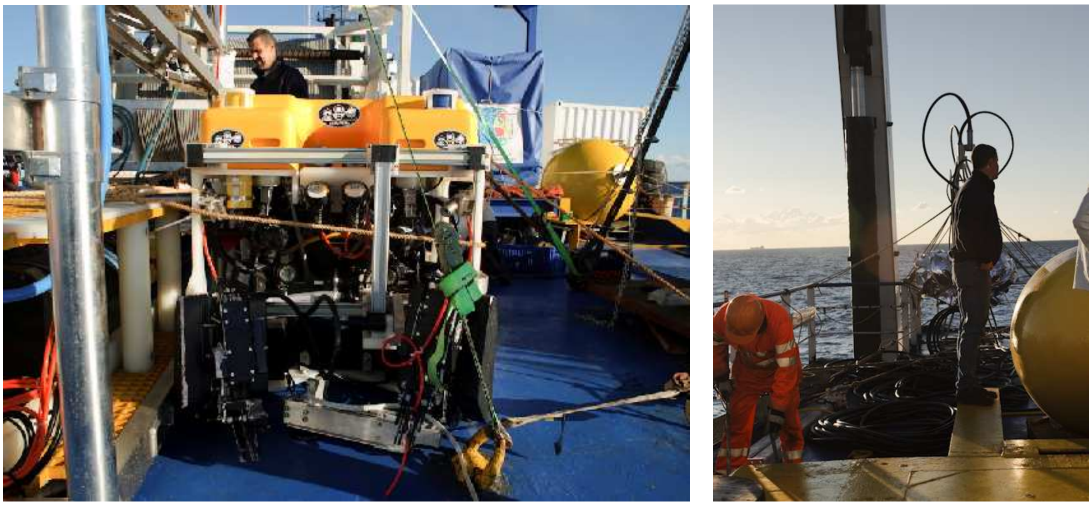


Figure 3.6. The PEGASO ROV (Left) and the ANTARES Mini-Line onboard C/S Certamen for the deployment and connection test at the Capo Passero site.

Actual agenda of the cruise: several days of adverse weather conditions (strong wind >30 knot and rough sea state) at the site prevented to perform deployment of the ANTARES Mini-Line and ROV operations for safety reasons. The sea operation was stopped on Dec

17 and the instrumentation was disembarked and brought back to the Catania shore laboratory. Another naval campaign for tentative deployment and connection of the Mini-Line was foreseen in February 2011. Due to PEGASO ROV mis-functioning and time delay in availability of the MECMA ship, the operation could not be carried out within the end of the project.

3.2.2 Sensor and measuring system calibrations and qualification

Microcat was calibrated in Seabird factory. Prior final deployment, the CTD 911 + (yearly calibrated) was deployed on a CTD rosette. A 30 minutes standby procedure was used to compare both signal between the CTD sensor and the SMP CT sensor, allowing the sampling of enough simultaneous measurements in mooring configuration (cf procedure J. Karstensen, EC Animate project).
The Turbidimeter was calibrated at IFREMER prior sending the sensor to be integrated on the MII. No further checks were made locally. It will be done on the next MII recovery.
Optode 3830 was calibrated at one temperature and 8 different oxygen concentrations using Winkler chemical titration.

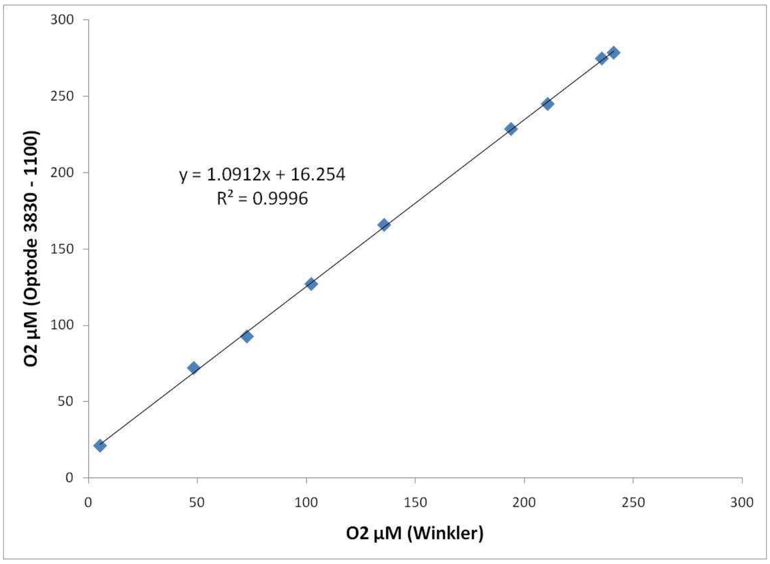


Figure 3.7: Optode calibration for O2

3.2.3 Return of experience of operations at sea and interventions by ROV

The deployment was done by VICTOR 6000 ROV for the complete extension:

- the line between the main ANTARES junction box and the BJS was sent to the sea floor on a turret, it was installed by Victor 6000 during a different dive,
- the BJS installation, positioning was done by cable

- the plugging of ODI connectors with a newly designed centering system for the ODI connectors used a reference procedure
- the plugging of the low cost IFREMER CDC connection appeared to be very fast,
- the plugging of the MII, the seismometer and other instruments was performed by VICTOR 6000 ROV. It ready to host the acoustic modem extension towards ALBATROSS experiment.

The procedures used during this cruise will be the reference for future deployments and maintenance.

3.2.4 Data management preparation

During the MII integration, communication protocols develop in Python language was done by the DT INSU. Data are collected in real time and stored in daily files.
The data management is coming from ANTARES site. A particular effort has been brought to the compatibility of the data formats and metadata in order to, in an automatic or quasi-automatic way, feed the global databases, data archive and sensor ML database which are under development in ESONET framework.

The next step was to build an interface between database and mathematical program to propose, through the web page, some tools to help data analysis.

ANTARES oceanographic data have been copied in a dedicated database (CCIN2P of Lyon, France) which was structured to contain all the ESONET require data, and meta-data. A real-time data transfer from sensors to database is done, and a real-time data control is thus available. This is made possible thanks to the creation of a website (http://marocean.in2p3.fr/antares/) which allows an easy access to the oceanographic ANTARES data, by plotting all desired parameters and/or exporting data for a later self-post-treatment. In addition, a real-time transfer is done from the Lyon database to the IFREMER (Brest) center for a European ESONET archiving.

3.2.5 Return of experience of equipment operation

The equipment as such is working perfectly as a demon for deployment, real time data transfer from deep sea sensors. It is quite frustrating to not have started the project in July 2009 as planned to complete, with time the operation within the Esonet time scale. Nevertheless, the test is fully operational and will help to go forward from this experience.

Joint tests were performed to test ROV operable wet-mateable hybrid (electro-optical) connectors. These devices are mandatory for operation and maintenance of science nodes in deep sea. ROV operated connectors are used in all the main European deep-sea experiments (NEMO-SN1, NEMO Phase 1, ANTARES) and worldwide (e.g., NEPTUNE Canada) to allow deployment and connection of underwater stations to existing deep-sea infrastructure, avoiding the high-risk operation of recovery and re-lay of deep-sea cables. Teledyne-ODI has been for years the leader of this market, patenting the so-called “rolling seal” technology. Nevertheless many users have encountered a certain level of failure in the use of such connectors for deep-sea applications. Aim of this activity was to test i) the new designs of mechanical interfaces on ANTARES BJS by VICTOR 6000, ii) the novel devices installed on the PEGASO ROV for connector cleaning (high pressure water pump) and insertion (manipulator) iii) the new NRH series of Teledyne-ODI connectors (developed for high pressure and high voltage applications). Results from tests carried on at installations deployed at different depths and using different kinds of ODI connectors (2100 m NEMO-SN1 site, 2500 m Toulon site, and 3500 m Capo Passero site) is expected to provide information about the reliability of used connectors.

3.2.6 Quality and inter-comparison of recorded data

Unfortunately since the MII has been deployed the IL07 line moored on Antares site, hosting some of the same sensors is not connected anymore; It will be done in spring 2011. We still have some sensors deployed in the vicinity of ANTARES but they will be recovered during next months for maintenance and data retrieval.

The ANTARES Mini-Line is equipped with optical and oceanographic sensors as the ones used in the ANTARES detector. This will allow direct inter-comparison of the two deep-sea sites of Capo Passero and Toulon. In particular the Mini-Line operation in Capo Passero provides first long-term and real-time monitoring of bioluminescence at 3500 water depth in the Ionian Sea. That is in a range of depths and in a marine region, well known as oligotrophic environments. Direct comparison with Ligurian Sea data will provide soon information on the possible effect of marine structure deployment in this environment. Study of correlations between bioluminescence activity, currents, and environmental conditions is also carried out in the aim of corroborating scientific results already provided by the ANTARES detectors in the Ligurian Sea.

3.2.7 Standardization procedures

CNRS are on the process to build standard procedure for optode calibration and deployment in collaboration with different partner

A large effort on standardization of deep-sea operations (deployment technique and ROV management) was conducted. Several meetings among INFN, INGV and CNRS participants have been conducted to adapt the deployment process (used by CNRS for the deployment of ANTARES) to a different site and ship logistics. ROV intervention and connection procedures have been jointly agreed among INFN, CNRS and INGV.
A step forward in standardization of materials and design of deep-sea mechanical, electronic and optical parts has been conducted. The ANTARES components (developed for 2500 m w.d., 40 km electro-optical link) were adapted to different working conditions (3500 m w.d., 100 km electro-optical link).

The interfaces of the Antares BJS are a first step towards standard junction box interfaces for ESONET EMSO (see D68 ESONET Label)

3.3 Deviation explanation

After approval by Steering committee in April 2010, the funding was available in May 2010. The deployment of the SJB and MII was planned for October 2010. We made priorities upon human resources within the few months available. Focussed was on building the MII associated with a package of generic sensors. This was achieved. The current meter Aquadopp worked well on the bench and in the pool during test deployment. The Aquadopp was supposed to be tested at sea at 2000m prior deployment but this procedure could not be achieved for 2 reasons: 1) the Aquadopp was delivered without batteries, and the wrong set of batteries was provided as spare, 2) for the second test deployment, weather was too bad to deploy any instrumentation. As a consequence the Aquadopp never provided any data when deployed on the sea bed at 2450 m.
CTD Microcat was deployed on the MII with power supply coming either from the battery pack or the MII main power supply. After 2 months of deployment the battery run out and the MII power supply did not take over. The failure happened mainly because of the lack of time to carry out test during the integration procedure.
After 2 months of deployment the pressure gave variable signal and stop sending signals after 3 months. We suspect corrosion on the connector.

The integration of the inductive instrumented mooring line is ongoing as well as the acoustic modem qualification to be deployed around the ANTARES infrastructure (See Antares access site).

Due to bad weather conditions, limited ship-time and a problem occurred to the PEGASO ROV the deployment of the ANTARES Mini-Line has been postponed and will be carried out within June 2011.

3.4 Outreach

Several sequences of film were taken during the TEXREX cruise, a movie has been issued. Parts of this movie are used in the final ESONET movie.

4 NEMO-SN1 test experiments

4.1 Previously planned test experiments

4.1.1 Objectives of the NEMO-SN1 test experiments

The objectives of the NEMO-SN1 test experiments are to perform maintenance, connection/disconnection and recovery operations on ROV electro-optical mateable connectors installed during the NEMO Phase-1 project at his test site, in different times (2005 and 2006). Once recovered, the mechanical and electrical status of ROV connectors were to be studied. Moreover, during the ROV dive, some other structures installed in the test site, were also be recovered and studied.

Two different power and data transmission systems were tested: the direct "shore-to-deep sea frame" link on TSN (Test Site North) and the link on TSS (Test Site South). The latter is realised by the use of a deep sea junction box installed in year 2006. This would also allow to test the power and data transmission systems installed on the junction box.

Real-time tests of acoustic sensors were also to be performed, through the installation of a calibrated acoustic transducer on the ROV. The acoustic transmitter were, in fact, linked to the GPS time with the aim of performing a time-and-amplitude calibration of hydrophones.

The Test Site North (TSN) and the Test Site South (TSS) are located in the Mediterranean Sea at 37°30'810N-015°06'819E and 37°30'008N-015°23'034E at a water depth of 2100 m and 2050 m respectively (see Deliverable D58).

A short work plan was defined for each leader institution involved in the NEMO-SN1 test experiment:

Leader Institution	Work plan: Tasks short description by partners involved
CNRS	CNRS will provide some sensors. Participation to deployment. Comparison of procedures
INGV	Integration of sensors on SN1
INFN	Deployment of the equipment using ROV COUGAR. Access to data collected in real time.

4.1.2 Detail planned costs and grant allocation for the NEMO-SN1 site

Partners	Personnel (€)	Equipment (€)	Travel & Accommodation (€)	Other (€)	Subcontracting (€)	Indirect costs (€)	Total costs (€)	Total ESONET contribution (€)
CNRS	0	0	15 000	0	0	3 000	18 000	11 170
INGV	45 200	220 000	15 000	325 000	12 000	121 040	738 240	79 910
INFN	4 000	200 000	0	215 000	8 000	83 800	510 800	108 920
TOTAL	***49 200***	***420 000***	***30 000***	***540 000***	***20 000***	***207 840***	***1 267 040***	***200 000***

4.2 First results of the NEMO-SN1 test experiments

4.2.1 Equipment preparation, tests on land and deployment

The operations in the NEMO-SN1 Cabled Test Site mainly consist in testing deployment and ROV connection procedures in deep-sea with remote surveillance and control from the shore. The ROV used for the experiment is the PEGASO ROV (Seaeye Cougar) owned by INFN and INGV. The PEGASO ROV has been refurbished, with respect to the commercial Cougar version, for operation down to 4000-m and upgraded with a manipulator for fast and safe connection of ROV operated wet-mateable connectors. A high pressure water pump has been also installed on the ROV to perform connector cleaning. This operation is strongly suggested by wet-mateable connector manufacturer prior deep-sea connection. Extensive tests on the ROV have been carried out on-shore to check ROV functionality and to test the novel ROV manipulator. Teledyne ODI-rolling seal connectors have been used for tests, as shown in Figure 4.1. Two kinds of ODI Rolling Seal connectors have been tested: the ODI Rolling Seal hybrid connector 8 ways (used as a standard in the NEMO-SN1 and ANTARES experiments) and the ODI Rolling Seal hybrid 6-way connector NRH (used in the NEMO Capo Passero Cabled Site, suitable for High Voltage transmission at >3000-m water depth).
The ROV and winch tests (see Figure 4.2) are carried out, under the supervision and coordination of INFN, by dedicated personnel from INFN, INGV and from Subsea Vision (ROV pilot Crew), and Marine-Tech (Winch operators Crew).

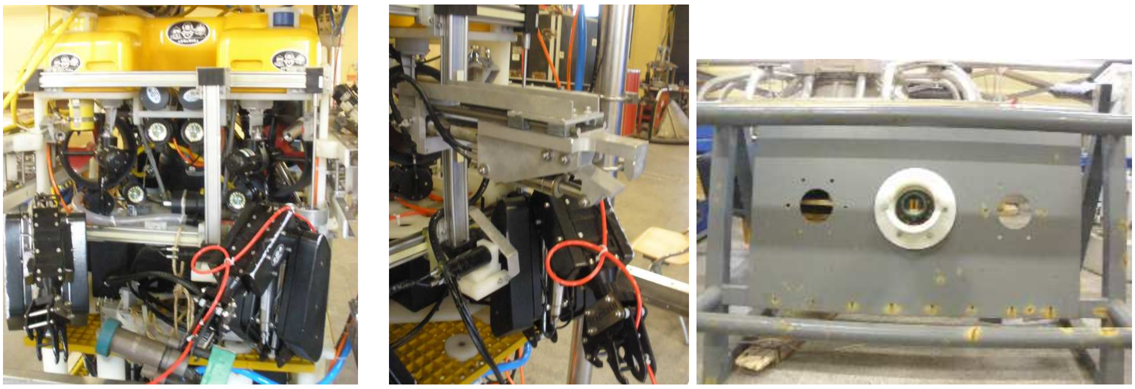


Figure 4.1. Left : The PEGASO ROV holding a Teledyne-ODI rolling seal connector. The aluminium frame between the ROV arms is the manipulator centering system. The red tube laid on the right ROV arm is used for high pressure water pumping for connector cleaning. Center: Detail of the ROV manipulator for insterion of ROV mateable connectors. Left: mockup of an underwater frame with ROV mateable connector (panel side) used for insertion tests.

Figure 4-2. Left: The PEGASO ROV control system onboard the C/S Certamen (MECMA). Right: The PEGASO ROV de-attaching and cleaning ODI connectors installed at the NEMO-SN1 (Catania) cabled test site during sea operation.

A calibrated acoustic transmitter was also installed onboard the ROV to test possibility of acoustic tracking of ROV underwater movements. Transmission tests (in air) have been successfully carried out (Figure 4.3).

The SN1 (LIDO North) is deployed at the TSN, while the LIDO South Station is deployed at TSS. The complete list of sensors is listed in the LIDO deliverables D1.4 and D4.4.

In the same time the NEMO-SN1 shore station has been upgraded. The new data transmission system allows 90-Mbit connection between the shore INFN Laboratory of the Catania harbour and INFN-LNS (where a 1 Gpbs connection to the internet is available). This is used to transmit real-time data from the submarine infrastructure and experiments. The aim is to test remote (worldwide) visualization and analysis of raw data from deep-sea instrumentation and control access to submarine devices. An AIS (Automatic Identification System) antenna and receiver were also installed in the shore infrastructure for continuous monitoring and surveillance the marine area where the NEMO-SN1 observatory is installed.

The LIDO stations and improved PEGASO ROV where embarked on February 2111 at the Catania harbour onboard the C/S Certamen with the following tentative time schedule:

- Day 1-3: ROV dive test and connection/disconnection tests of connectors installed on the NEMO Junction box.
- Day 4: Deployment, connection and calibration of the LIDO North Station
- Day 5: Deployment, connection and calibration of the LIDO South Station

On day 1 and 2 The PEGASO ROV successfully carried out first dive test in shallow water and second dive at 2100 m. The ROV carried out also cleaning and disconnection of ROV operable connectors installed on the Catania TSN frame. The ROV was thus recovered to start the LIDO deployment and connection operation. A mis-functioning of

the ROV was however found when it came back again onboard. The mis-functioning was due to water ingress in the equipment containing the ROV-TMS power electronics. The operation was interrupted and the ship came back to the Port (Day 3). Intervention of ROV pilots and experts from Seaeye was requested on site (Day 4-7). After Seaye intervention the naval operation was re started and the ship reached the TSS site. Another dive test was thus carried on (Day 8). The ROV reached successfully the depth of 2100 m. Due to bad weather conditions the PEGASO ROV was maintained within its TMS and a long-term test in deep sea (about 2 h) was carried out. After 2 hours, the TMS was recovered noticing an electrical failure happened during recovery.
The main failure was found again on the ROV-TMS POD vessel.
After first failure analysis, the manufactures, SeaEye, decided to carry out modification of the PEGASO at the manufacturer site. The sea campaign is then re scheduled in May-June 2011. The two LIDO stations are back in the Port Lab and switched on again to continue tests and to improve the Digital Acquisition software on shore.

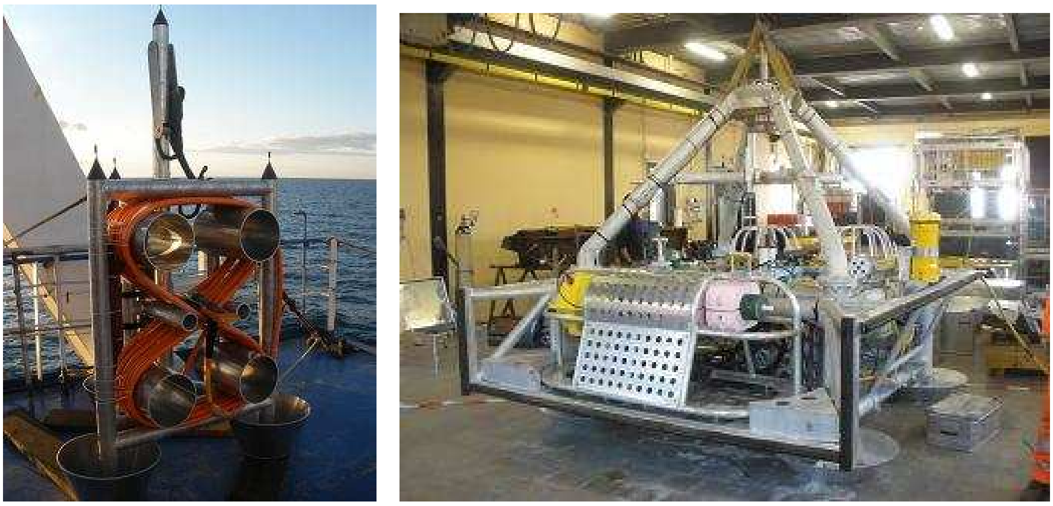


Figure 4.3. Left: The LIDO Demo Mission «South» station onboard the C/S Certamen (MECMA), ready for deployment. Right : The SN1 (LIDO Demo Mission «North») and MODUS vehicle, integrated at the INFN Lab in the Catania harbour.

4.2.2 Sensor and measuring system calibrations and qualification

During the test activity, calibration of LIDO acoustic sensors is carried out. As described in the previous section, the PEGASO ROV is equipped with an acoustic beacon, transmitting known signals at a given repetition rate. The beacon's signal is used to calibrate amplitude and phase of LIDO hydrophones, permitting monitoring of ROV movements remotely from shore. These results are compared with the actual ROV movements recorded and analysed by the ROV autonomous Ultra-Short-Base-Line system, used to guide the ROV from the ship. Signals analysis also permits calibration check of hydrophones' sensitivity. LIDO hydrophones have been, indeed, calibrated with a novel high pressure calibration method at NATO-Undersea Research Centre, La Spezia (See also LIDO Deliverable 4.2-INFN). The sea operation permits check of calibration in the hydrophone working environment (2100 m water depth).

4.2.3 Return of experience of operations at sea and interventions by ROV

The NEMO-SN1 operation is a step for ESONET, in view of EMSO, since it provides a proof for "Standardised sea operation" for science deep-sea nodes deployment and connection. The technique is based on serial use of Deep Sea Shuttles (MODUS, PEGASO) for deployment and connection. The LIDO North station is deployed by MODUS, connected to the PEGASO electro optical winch. Once anchored on the sea-bed, Modus is recovered and disconnected, and PEGASO is connected to the winch. This minimises sea operation time and, thus, costs. The capabilities of PEGASO as Deep Sea Shuttle are also tested, during the deployment of the LIDO South Station. The latter is laid on the seabed using technique similar to the Modus operation. ROV intervention is carried out without recovery of the winch cable. This procedure is optimal to save ship time and enables presence of ROV during the deployment.
Another important piece of information is recovered by the capability of the NEMO Junction Box (JB) to act as hub for several deep-sea experiments. The JB is operational in deep sea since 2005, but only one experiment was connected to the outputs. The connection of another experiments and the continuous multi-year operation opens the way to technology of underwater electro-optical hubs for science nodes. During this test call the electro optical outputs and connectors of the NEMO JB installed in the Catania Test Site were successfully tested.

4.2.4 Data management preparation

Data management is based on the LIDO data transmission (see LIDO Deliverables 4.2-INFN) and acquisition system concept. Hydrophone signals, used for phase and amplitude calibration and monitoring of ROV movements, will be sent from deep sea to shore through the Main Electro Optical Cable link. On shore, a dedicated optical signal distribution system is built permitting real-time transmission to the internet of all data. Access to data is available thanks to INFN-LNS computing and networking infrastructures, using a refurbished version of the LIDO architecture concept (see also LIDO Deliverable 4.3-INFN and 4.4-INFN). In particular, INFN has developed dedicated acoustic data-analysis software and hardware, capable to analyse the signals of the acoustic transmitter installed on the ROV, and has implemented a 100 Mbps internet link capable of real-time data transmission between the Port Laboratory and INFN-LNS

Figure 4;5. Telemetry rack for acoustic sensors (left), and data archiving and monitoring room at the INFN shore Laboratory.

(Figure 4.5). INFN-LNS provides high-speed link (1 Gbps) to users and general public. Test site raw data are, firstly, analysed by the collaboration and then distributed and uploaded to the ESONET Portal. A novel acoustic data transmission protocol over IP has been developed. The protocol holds both acoustic signal, GPS time stamp, and all sensor info (sampling frequency, full scale, Hydro ID).

4.2.5 Return of experience of equipment operation

As discussed above, the return of the experience of the NEMO-SN1 operation is many-fold and implies:

- sea operations: reliability and cost-effectiveness of deployment and connection procedures using Deep Sea Shuttles (MODUS, PEGASO);
- reliability of electro-optical ROV operated wet-mateable connectors: ODI hybrid rolling seal connectors installed on the NEMO JB and in the MEOC terminations of the NEMO-SN1 deep sea infrastructure are re-tested after 6 years from deployment.
- underwater real-time data acquisition transmission: operation of upgraded SN1-class seafloor science nodes to multi-sensor application;
- Junction Boxes: test of NEMO Junction box concept as a multi-output hub for science nodes;
- shore station architecture: definition of shore station equipment for real-time data transmission, science node control and site surveillance;

4.2.6 Quality and intercomparison of recorded data

Data quality check is a key issue for this activity. The installation of a calibrated acoustic transceiver onboard the ROV is fundamental to check LIDO hydrophones (four large bandwidth sensors and two low frequency sensors) amplitude and phase response in the working environment. In this way acoustic data acquired with LIDO will be immediately correlated with data previously recorded by the NEMO-OvDE station (see Deliverable LIDO 4.1-INFN). Thanks to refurbishment of the shore station DAQ and transmission system, data will be immediately available to the ESONET collaborators to cross check deep-sea acoustic noise recorded at the NEMO-SN1 site with other data (OBSEA, ANTARES, NEPTUNE Canada).

4.2.7 Standardization procedures

Standardization of procedures and equipment for deep-sea nodes is the guideline of this activity and, as described in previous sections, it has guided all the design and organisation steps of the activity.

-Science node deployment through the use of Deep Sea Shuttles was first validated by MODUS operation in ESONET and after long experience gained in several operations conducted within many other European Projects (e.g. GEOSTAR, NEMO and KM3NeT) is now considered as preferable solution. In this test activity both MODUS and PEGASO ROV are used aiming at consolidating this deployment technique as a reference.

-The ROV operated wet-mateable connection procedures in deep sea (following also previous experiences of ESONET, NEMO, ANTARES and KM3NeT) are standardised with the following sequence: 1) connector visual inspection (both flying receptacle and fixed bulkhead); 2) connector cleaning through high pressure water flow; 3) ROV operated connector insertion using ROV manipulator.

-The proposed “in situ” hydrophone array calibration procedure (phase and amplitude) provides also a reference for future application.

-The used acoustic data transmission IP protocol contains all the info requested by ESONET standardization documentation: sensor ID (calibration sheet, position and sampling frequency) and acoustic data, adding -for each packet- the absolute signal acquisition time (GPS). This provides a fundamental toll for study of correlations with other instruments. The protocol, based on international standards (IP, GPS, AES3-EBU), is exportable to any other future acoustic monitoring applications. The system is working and data are dispatched to the interested European Institutes collaborating in ESONET.

4.3 Deviation explanation

The main deviation with respect to planned operations was due to unexpected mal-functioning of the PEGASO ROV during the campaign. This is now mainly attributed to a not optimal construction of the TMS power POD by the supplier SeaEye. The deployment of LIDO stations is scheduled to be carried out within June 2011.

5 OBSEA test experiments

5.1 Previously planned test experiment

5.1.1 Objectives of the OBSEA test experiments

The main objectives of the OBSEA test experiments are to give access to the expandable OBSEA cabled submarine observatory, installed mid May 2009 by Spanish, to the ESONET and EMSO groups for technological testing and scientific long-term monitoring of physical variables. The main goal of the OBSEA is to provide a relatively low cost infrastructure for easy technological test bed and development of new sensor with the aim to extend it with more nodes to a regional deep-sea observatory, and alongside real time monitoring of some physical parameters.

The OBSEA site is situated 4 km offshore of the Vilanova i la Geltru coast, in a fishing protected area at 41°10'54.87"N-1°45'8.43"E at a water depth of 20 m (see Deliverable D58).

A short work plan was defined for each leader institution involved in the OBSEA test experiment:

Leader Institution	Work plan: Tasks short description by partners involved
IFREMER	Test of Smart sensor interface on MicrObs ethernet
KDM-UNIHB	Test IEEE 1451 interface
CSIC	CSIC will provide the RV for deployment by divers
UPC	UPC will provide sensors and will take in charge calibration. Access in real time to data
DBSCALE	ESONET instrument registration. Links with GEO

5.1.2 Detail planned costs and grant allocation for the OBSEA site

Partners	Personnel (€)	Equipment (€)	Travel & Accommodation (€)	Other (€)	Subcontracting (€)	Indirect costs (€)	Total costs (€)	Total ESONET contribution (€)
IFREMER	22 500	25 000	3 000	2 000	0	0	52 500	15 000
UNIHB	20 000	0	4 000	10 000	0	7 200	41 200	15 000
CSIC	20 000	22 000	0	10 000	0	33 600	85 600	22 000
UPC	95 000	6 500	2 500	3 910	0	53 390	161 300	60 000
DBSCALE	22 500	2 100	0	0	0	0	24 600	8 000
TOTAL	***180 000***	***55 600***	***9 500***	***25 910***	***0***	***94 190***	***365 200***	***120 000***

5.2 First results of the OBSEA test experiments

5.2.1 Equipment preparation, tests on land and deployment

In May 2009, the OBSEA has been deployed with 3 oceanographic instruments:

1) A “Seabird” SBE37smp CTD for the measurement of Temperature, Conductivity and Pressure;

2) A “Bjørge” Naxys Ethernet Hydrophone 02345 for the acquisition of acoustical signals; and

3) An “Ocean Presence Technologies” OPT-06 Underwater IP Camera System for the recording of video images.

In March 2010, new instruments were been added to the OBSEA, a “Nortek” Acoustic and Wave Current Meter (AWAC) for the characterization of water and waves movements. All these instruments are currently in operation. The installation of these instruments can be followed in the TV program *TRES14,* [1] from “Minute 14”.

The tests done before deployment were focused in the capacity of each component to work properly in a hyperbaric sea water environment, in the interoperability of the whole system, in the thermal stability under high power conditions and in the software stability under stress tests. All the instruments have been tested many times in the hyperbaric chamber at a pressure of 5 bars for at least 24 hours; the water-tight steel cylinder that holds the electronics (communications and power supply) can stand more pressure and it has been tested at 20 bars.

The interoperability tests have been done assembling all the components in the laboratory and checking all the possible connections and functionalities of the system. The thermal stability tests have been done loading the system at the maximum capacity and simulating the environment in which the system must operate.

The first sets of instruments were deployed on May 2009, and they worked continuously until it started the first corrosion problems with the NAXYS Hydrophone on November 2009. The problem was solved, and the instrument was recalibrated (sent to the constructors) and improved its corrosion protection in the OBSEA.

The CTD started to fail on January 2010 due to firmware problems. It was repaired, recalibrated, and in order to test interoperability functions in OBSEA, this instrument was updated with Puck Protocol capabilities, integrated by the CTD manufacturer.

The IP camera worked all the time mainly without any inconvenience (only the necessity to clean the crystal chamber periodically). In the beginning was difficult to configure properly the video server and recorder for storing the video data. Once it was correctly tune up it worked without problems.

The AWAC worked properly all the time, but its server was victim of hacking attacks and it was unavailable for some time in July 2010 until network security was improved, and as a countermeasure, all servers are now in an internal private network.

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[1] Video available on: http://www.rtve.es/alacarta/videos/television/tres14---sensores-submarinos/755801/
Or in youtube:http://www.youtube.com/watch?v=tL9w_8cYSaI

In August 2010, after maintenance operations, water ingress occurred in the cable termination box. Since then, it was decided to temporally stop the operation of OBSEA, in order to fix the leak, and more important, to upgrade and improve some parts of the system, particularly: a) the internal power supplies will be changed for better ones (better efficiency); and b) to change the internal Ethernet Switches for others with capacity for time synchronization with IEEE 1588.

The experience obtained during this period of operation has been really useful for the design of new equipments that will be deployed in a seafloor observatory. It has been demonstrated that not only is important the water tightness in the equipment deployed, but also other aspects need special consideration, as are the galvanic corrosion protection, the biofouling and the sediments, to design for easy under water operations and maintenances, and last but not least, it's very important to have a rough cable termination box.

5.2.2 Sensor and measuring system calibrations and qualification

All the sensors were calibrated in the fabric of the manufacturer before to be deployed. In order to continuously verify the quality of the measurements, two actions are carried out:

1) Before deployment, comparison tests are performed at SARTI facilities, specifically for test of watertight, temperature and pressure. At SARTI we have a hyperbaric chamber for up to 20 ATM, where water tightness and pressure are evaluated. Also, we have a thermal chamber Vötsch VC4060, which can be used for tests between -45 to +180C (10-98% relative humidity).

2) After the deployment different actions have been carried out.
   For the case of the CTD, after the deployment, periodically water samples have been taken from the surroundings of OBSEA and sent to a chemical laboratory, where the measurements of salinity of the instrument and the values of samples were compared. For the case of pressure and temperature measurements, hand field instruments have been used during the maintenance operations, by divers, and the collected data was compared with the measurements of the instruments. These same measurements are used for comparing the measurements of the AWAC device. With these procedures the stability of the oceanographic instrument was validated.

These field measurements are only a validation procedure for stability and proper working operation. When the calibration period is over, the oceanographic instrument is returned to the manufacturer for recalibration.

5.2.2.1 Geophone Calibration

In a near future it is planned to connect a cables bottom seismometer at OBSEA, which has as a sensing element a 3-axis geophone sensor, Figure 5.1_, based on the GS-11D of Geospace, which is a velocity sensor. This 3-axis structure is already built, and it has been tested and calibrated at SARTI, using a shaker table, Figure 5.2 e.

The results obtained after 4 repetitions of frequency sweep between 8 to 100 Hz in a range of 5 amplitudes is the determination of a sensibility in every axis X-Y of geophone. In Figure 5.3_ we detailed the values need for a 0.5 mm/s amplitude value in every of 5 sweeps. The DUT sensibility at the X axis is (84,061 ± 4,240) mm*s^{-1} /V.

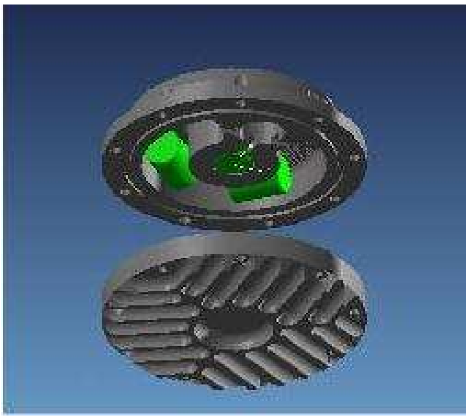


Figure5.1:3-AXIS_Geophone

Figure 5.2: Shaker_Table

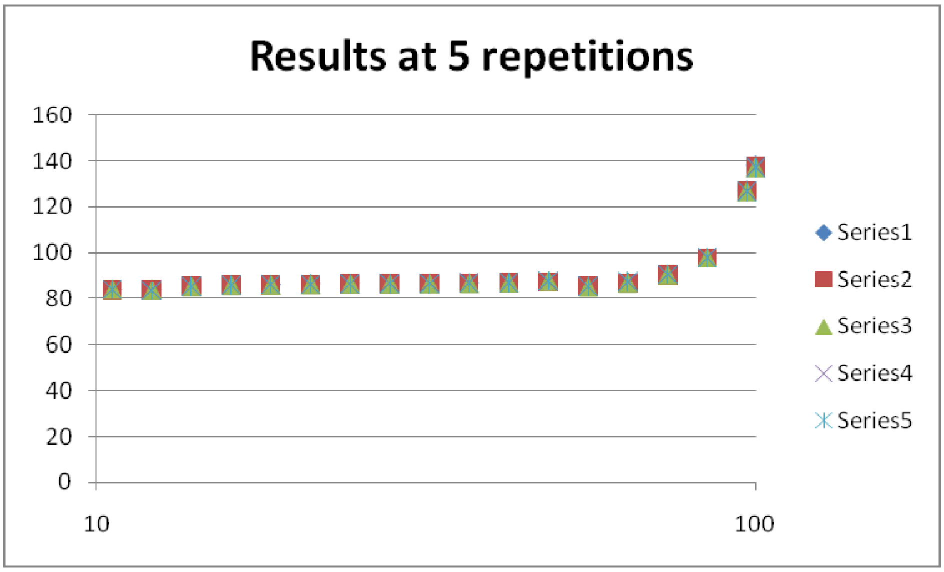


Figure 5.3: Geophone_results

5.2.3 Return of experience of operations at sea and interventions by ROV

5.2.3.1 Return of experience, LIDO-OBSEA

- By LIDO (Listening to the Deep Ocean environment)

LIDO proposes to establish a nucleus of a regional network of multidisciplinary seafloor observatories by allowing the long-term monitoring of Geohazards and Marine Ambient Noise in the Mediterranean Sea and the adjacent Atlantic waters. Specific activities are addressed by long-term monitoring of earthquakes and tsunamis, and the characterization of ambient noise induced by marine mammals (Bioacoustics) and anthropogenic noise.

The output of the acoustic sensor at the OBSEA platform has been integrated into the LIDO framework. The data has been received and processed in real-time, with special focus on noise measurements and shipping activity. The real-time stream was incorporated in the LIDO website and all outputs were made available in standard formats. The analysis results from the OBSEA was managed such that they could be made available to the public or archiving centers using the same OGC SOS framework that was developed under ESONET WP9.

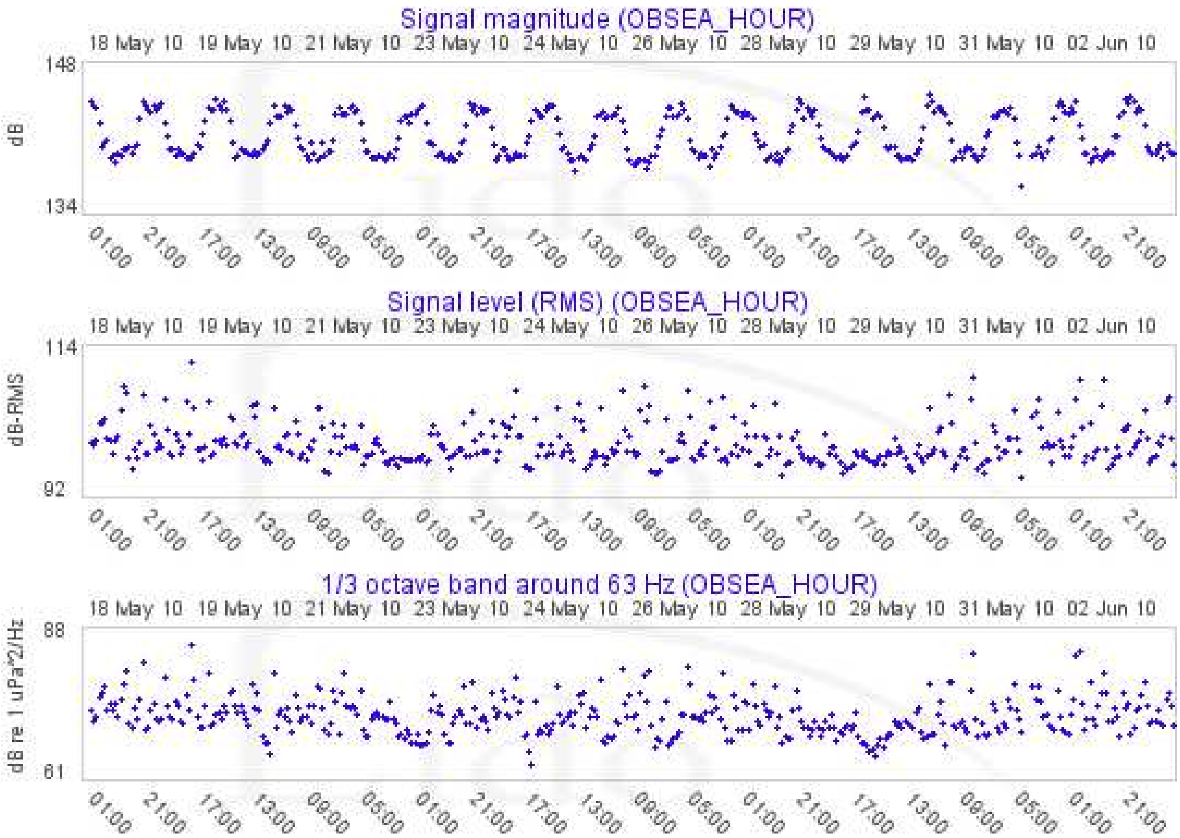


Figure 5.4: LIDO_SIGNALS

Measurements taken at the OBSEA platform showing respectively signal peak, RMS signal level and noise around the 1/3 octave centre frequency 63 Hz (one of the prime noise indicators as proposed in the Marine Strategy Framework Directive, task group 11),

Figure 5.4 Measurement levels were based on a hydrophone sensitivity of -192 dB and 40 dB gain.

5.2.3.2 Return of Experience with Underwater IP Camera

- SARTI & CSIC

Ichtyofauna Distribution by Image Analysis

The digital video camera takes real-time images of the seafloor, being useful for recognition and visual counting of several different marine organisms within the area where OBSEA is located, Figure 5.5._.

In the study, we have evaluated the fluctuations in counted individuals for several fish species by video image analysis, Figure 5.6. Long-term data sets were acquired as an example of the high scientific value and practical application of OBSEA, With derived counts we estimated the local biodiversity in an artificial reef from a marine protected area.

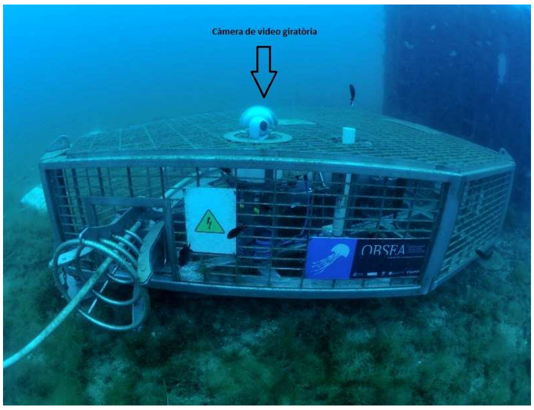


Figure 5.5:_Expandable Seafloor Observatory in front of Vilanova i la Geltrú with the side detail of the artificial barrier.

Figure 5.6_. Artificial reef in Colls Miralpeix Marine Reserve.

Digital images were acquired only during daylight hours, one each 60 min at different angles in order to cover a complete 360º rotation. This spatial and temporal transect was composed by 8 positions (images): 3 focusing on the artificial reef; 4 focusing on sandy bottom where the algae Caulerpa racemosa dominates; and finally 1 focusing on the water mass. Two images with reef and two images without reef were taken at the beginning of each hour of the day during the first two weeks of every month, on alternate days from July to November 2009. Both pairs replicas were used in order to: 1) to study the effect of reef presence/absence, on recognized fishes, biodiversity and the relative abundance of their local populations; and 2) to characterize the temporal patterns of distribution at diel and seasonal scales (i.e. intraday and seasonal replicas). Variables studied were: 1) identified fish to species 2) total fish number per species; 3) the Shannon biodiversity index, see Figure 5.7 and Figure 5.8. In frames where fish density were too large (i.e. in schools and banks) we considered the total number as equal to 50. In few clear cases total number chosen was 100.

Our results indicated that the local specific composition was similar to other Western Mediterranean areas. There were 38% of visualized but not identified fish species, since too distant individuals were not distinguishable. Fish species, such as Common two-banded Seabream (Diplodus vulgaris), Damselfish (Chromis chromis), Black Seabream (Spondylosoma cantharus), Withe Seabream (Diplodus sargus), Annular Seabream (Diplodus annularis) and Common Dentex (Dentex dentex), showed different levels of diel and seasonal variation. Daily variability is important for few species as top-down predators (D. Dentex) which appeared mostly in crepuscular hours. Seasonal variability is very important and determines the principal changes suffered in reefs populations during the year cycle. The reef exerted a strong influence on species composition. The effect of increasing structural complexity on biodiversity was already detected in several previous studies. Fish schools were often located in one side of the reef or in the other. That behavior optimizes efforts in front of strong current episodes. Some author argued fish come to feed on reefs, and concluded that energy is transferred from artificial reefs to fishes through decapods, amphipods and juvenile which are concentrated on these structures. The numbers of individuals per group and biodiversity levels were maintained within certain constancy over time sustained by the replacement of some species to another.

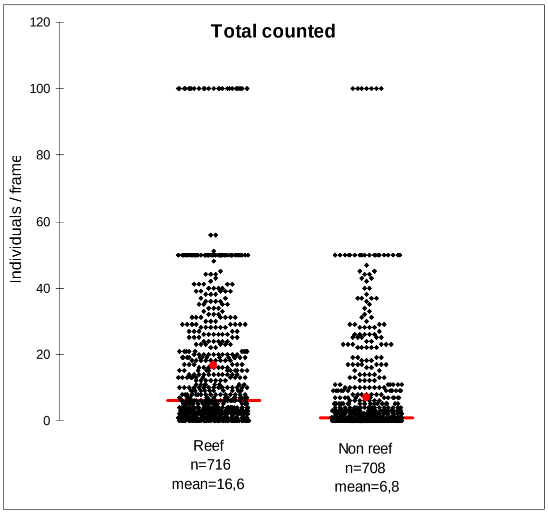


Figure_5.7. Number of fishes observed in frames from the artificial reef and non reef (seabed). Red circle corresponds to mean and red stripe to median values.

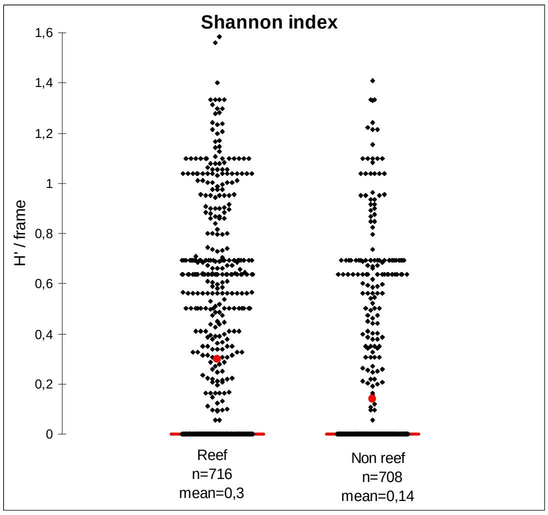


Figure 5.8. Values of Shannon biodiversity index for frames from the artificial reef and non reef (seabed). Red circle corresponds to mean and red stripe to median values.

The advantages to have the video camera located on OBSEA are: the high sampling frequency over extended temporal windows, and the avoidance of diving (which is invasive and influence fish behavior). In conclusion, long-term studies based on powerful biological data series from image analysis represent a suitable tool for observing marine species.

5.2.3.3 Return of experience with AWAC

Some specific conditions of the sea in the vicinities of OBSEA were able to be measured with the AWAC devices. The following graphs show the current speed, wave direction and the significant height wave in the period from 24th March to the 23rd June; see figures 5.9, 5.10, 5.11.

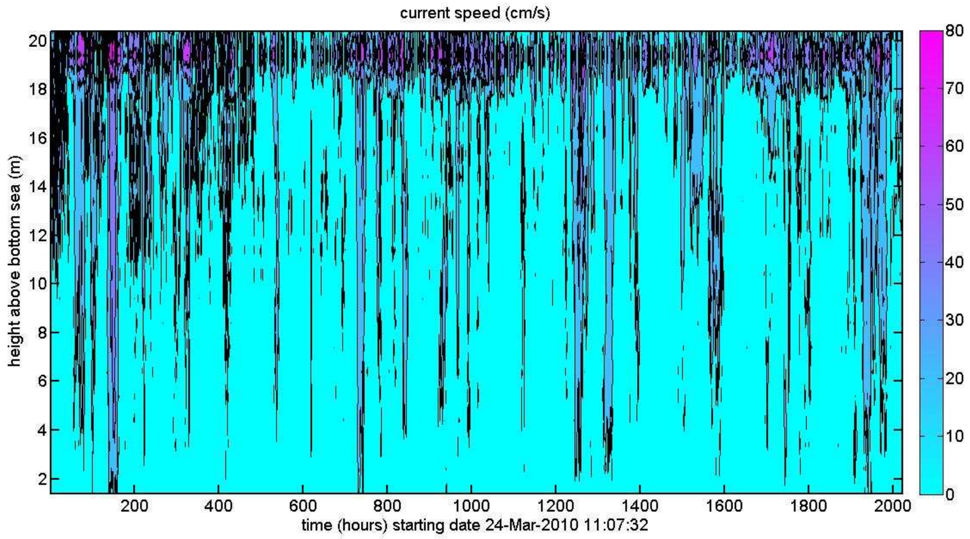


Figure_5.9 Current Speed

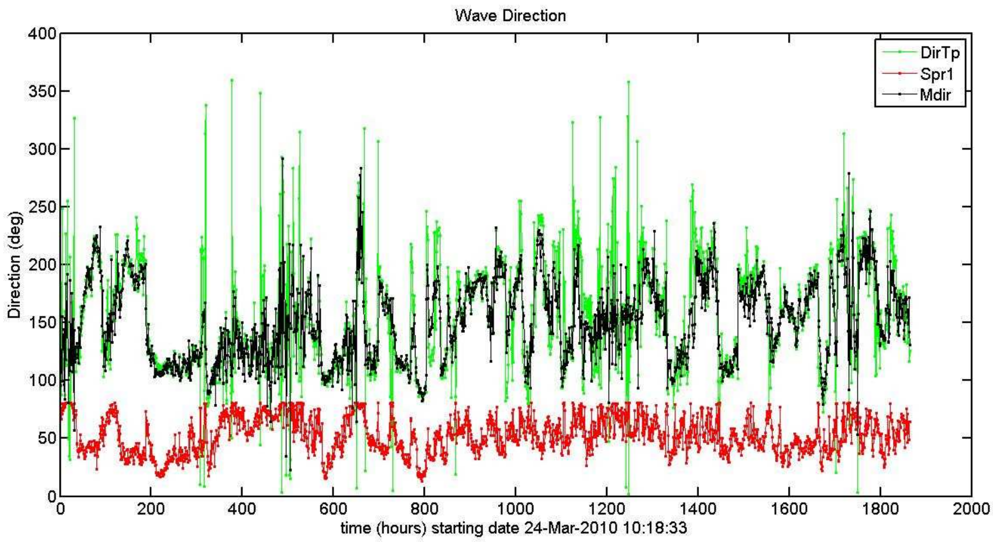


Figure 5.10:. Wave Direction

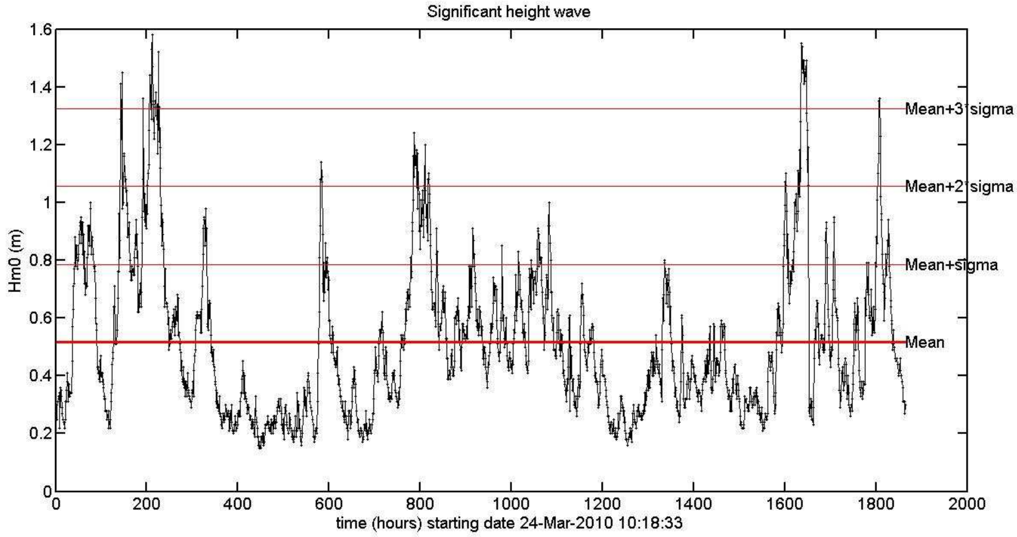


Figure 5.11: Significant_wave height

5.2.3.4 ROV test and OBSEA

SARTI conducted a test operation on the 30th November of 2009, with a small inspection ROV (Micro-ROV, from Albatros Marine Technologies) for the visual supervision of the OBSEA installation. The conclusion was that a small inspection ROVs like the one used are not the proper tool to survey the OBSEA installation, mainly because the manoeuvrability of the small ROV was strongly limited when operated from a small boat in open sea. Even with small waves in the surface it was not possible to compensate the water movement and take clear images from the observatory.

5.2.4 Data management preparation

The global view of the data management are summarised on figure 5.12. The basic mechanisms for data transmissions and interactions between the acquisition applications, and all user and systems interfaces, have been constructed by means of a model based on layers of overlapped services. The basic interfaces have been located in the centre of the system, with the instrumentation and the different layers of services overlapping, expanding to the edges with increasing complexity until reaching the communication mechanisms of the different user's applications. The services layers take care of the real-time data access, as well as the access to the data that has been saved.

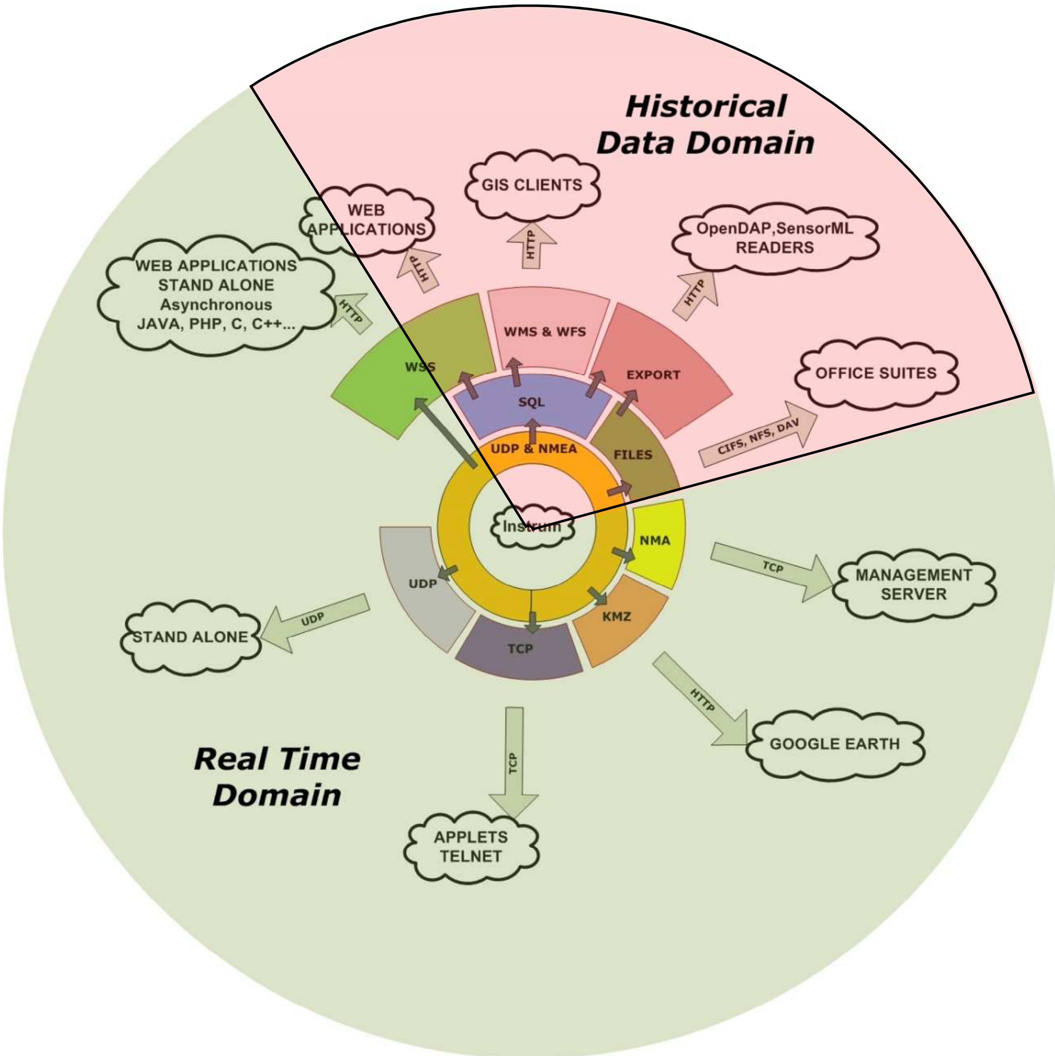


Figure 5.12: Data management view.

Basic Data Transport

The basic mechanism used for data interchange and transmission between the different service's layers and the acquisition applications, is by means of ASCII-datagram's normalized over the standard NMEA-183 and the protocol User Datagram Protocol (UDP), in "broadcast" mode.

Service's Layers for Accessing Historic Registries

On each platform, and in the central node of the network management, historic registries of all the data acquired are saved independently. In the central node, also a copy with 1 minute synchronization is saved as well. This structure provides redundancy.

RAW files and processed files

RAW data is stored in ASCII with the NMEA datagram's, and also data is stored in CSV format with codified data identifying the name and the measured variable. All ASCII files have daily extensions and are named combining the day, month and the year in which they were created, and an extension for identifying the instrument.

Relational Database service (SQL)
Layer that provides data storage related to geographical extensions (POSTGRES+POSTGIS) with the acquired date. There are three servers that store data in SQL.

- ServerOBSEA (primary server)
- MORFEO (External server. Not into OBSEA) for client's data Access.
- MEDUSA, stores data as SNMO server, for alarms control.

Data Services WMS and WFS
Layer built over the last layers. This service allows geographic reference of data in map form (Maps) and on Features using WNS and WFS standards of the Open Geospatial Consortium. Requests are started by users using the HTTP protocol, as a communication channel of WMS/WFS servers.

Data Export Services (EXP)
Over the two last layers an exportation layer has been constructed with other interchange formats, using the marine ambit (XML, SensorML, netCDF, openDAP, etc). The SensorML has been proposed as a standard for storing data sets.

KMZ Data Services
This service provides the last acquired data in compressed KML format, with a real-time update of the contents and structure. This service is oriented to a GoogleEarth client.

(NMA) Data Services Management
This layer allows the synchronous transmissions of data through a TCP channels to the ZABBIX network manager. This service allows also the monitoring of physical devices in the network, introducing data quality in the management.

Data Storage and Metadata
It has been proposed the use of LDAP trees for mapping the network of sensors and instruments and all the configuration/calibration files. The exportation layers of historic data from SensorML or OpenDAP would have to read the sensors' stored information in those trees.

Servers

The operation of all the services is done using the following servers:

- **ServerOBSEA** : Firewall, SQL, router, file manager.
- **Lluna**: Storage management (in future will replace ServerOBSEA), Data management, and in the near future will stores the AWAC images and data.
- **ServerAWAC**: AWAC data acquisition and processing
- **Pop**: Video server (for IP underwater video camera)
- **Lab**: Hydrophone data acquisition and processing (Lab Laboratory)

- **Medusa**: ZABBIX alarms and events manager. Also for the management of remote data transmissions with DataTurbine, for high speed real time data streaming.

5.2.5 Return of experience of equipment operation

The first conclusion that can be obtained from the experiment is that the real time of life of each device in the observatory can be significantly lower than the expected. In a shallow water observatory the marine life is very active for what all systems are rapidly populated with algae, crustaceans and all kinds of living things that erode the materials and hamper maintenance. For example, when there are exposed screw threads the biofouling may make it impossible to unscrew it.

Even when all exposed metals of the structure has same specification, small differences between manufacturers can generate galvanic currents that can corrode the materials, for what special attention must be taken to protect the system with sacrificial anodes, isolating the direct contact between different metals, and protecting metal surfaces with a galvanized, anodized or painting depending the material. As example, at the OBSEA a manufacturer used by error a stainless steel 360 screw, which unfortunately was not detected, with the result of a fast corrosion of the material.

This experience shows that it is very important to choose the appropriate materials for long term observatories, and to review and verify the systems before deployment.

5.2.6 Quality and intercomparison of recorded data

As a result from the comparison between OBSEA measurements and the checking measurements performed by divers at the same location, we find out that it was useful practice for validating the data of the instruments, without the need to remove it from the observatory. For the temperature measurement, it is not recommended to use a wrist sensor (as a watch) because body temperature can affect the measurement; differences over 1ºC were observed.

5.2.7 Standardization procedures

With the purpose to work in a standardized environment among the different observatories, diverse initiatives have been carried out in OBSEA in order to test and to try to implement different standards. Actually each observatory has their own software architecture and data management processes. Some standards can be applied on top of each observatory's data management in order to access data from internet in a standard way. Some of these standards can be SensorWebEnable, IEEE1451.0., or initiatives like DataTurbine for high speed real time data streaming.

The use of these standards in an observatory, like OBSEA, to access data and metadata from a general web interface can provide interoperable data visualization from the user point of view. Likewise, there are other issues that have been addressed to archive interoperability between observatories, as plug and work capabilities of the instrument. Initiatives as MBARI PUCK protocol (for RS232 or IP), interfaces like the SmartSensorBoard (Ifremer,UPC) or recently the SID, Sensor Interface Descriptor (52North), are being tested at the OBSEA.

5.2.7.1 Time Synchronization

- By SARTI

Time synchronization in cabled observatories by Ethernet networks can be achieved implementing IEEE1588 Precision Time Protocol (PTP) versus NTP or SNTP for applications with needs of synchronization under milliseconds. Actual observatories had been deployed before IEEE1588v2 was released, and for these reason junction boxes are not equipped with IEEE1588v2 Ethernet switches. In OBSEA, also the installation of IEEE15888 capable switches is planned. Figure 5.13 shows one of the test setup to provide GPS information to an instrument through a IEEE1588 synchronization network.

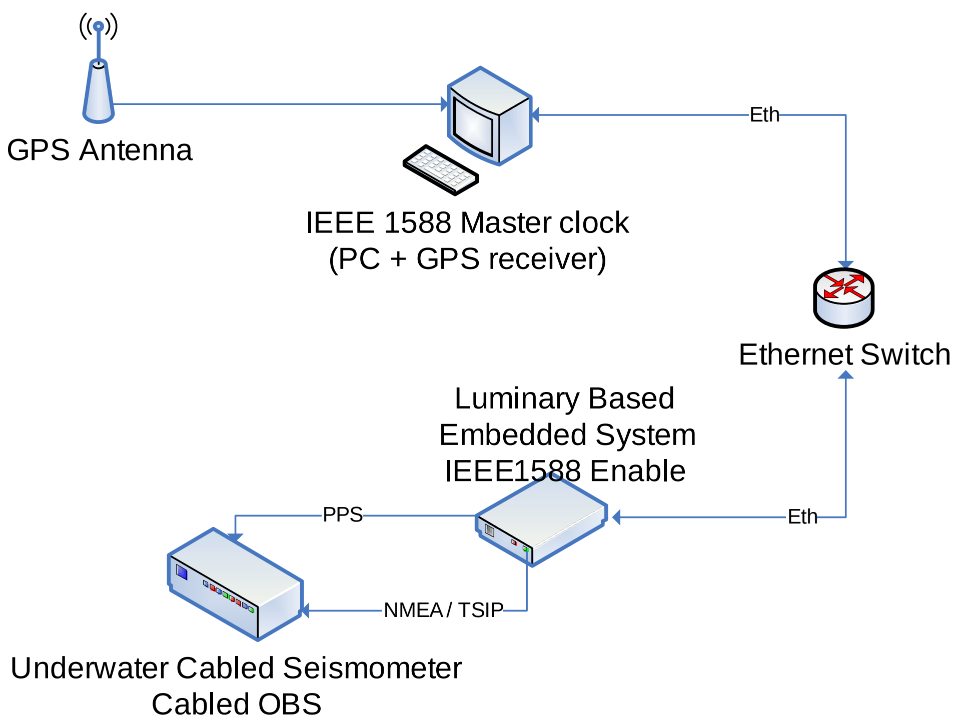


Figure 5.13: Testing IEEE1588 PTP for underwater instruments.

In OBSEA, different algorithms have been developed and implemented for automatic detection and installation of RS-232 PUCK instruments. The host computer periodically interrogates the serial ports for a PUCK enabled instrument. When the host receives a

PUCK response from the serial port, the host retrieves the UUID to determine if a new instrument has been installed. If so, the host retrieves the PUCK payload and uses this information to collect data from the instrument and register it in WEB using standards like IEEE 1451.0 or OGC SWE.

The detection algorithm for IP PUCK-enabled instruments is based on the Zeroconf standard. When an IP PUCK instrument is plugged into a local area network (LAN), it automatically gets an IP address and is registered as a PUCK service via Zeroconf. An application that runs in the same LAN can discover the instrument and retrieve the PUCK payload through PUCK protocol and automatically register the new instrument in a standard way in WEB.

Thus standard IEEE-1451 and OGC SWE components can be automatically retrieved and installed by the host when a PUCK-enabled instrument is plugged in, overcoming the difficulties of manual installation.

An important component to achieve the plug and play capability with PUCK protocol is the payload information attached to each instrument. The payload should describe entirely the functionality of the instruments in a standard way and should be machine and human readable. To accomplish this task SensorML with Sensor Interface Descriptor (SID) can be used, which provides standard models and an XML encoding for describing sensors, measurement processes, and instrument control information.

Figure 5.14 shows how services running a SID interpreter can establish the connection to a sensor and are able to communicate with it by using the sensor protocol definition of the SID. SID instances for particular sensor types can be reused in different scenarios and can be shared among user communities.

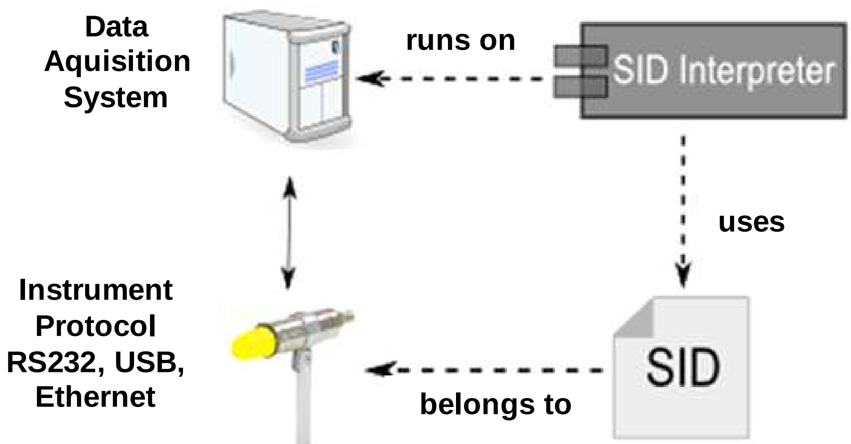


Figure 5.14: SID interpreter in a data Acquisition System (proposed to OGC by 52North)

5.2.7.2 Sensor Registration in ESONET's Sensor Registration Interface

The ESONET sensor registry is largely based on the OGC SWE architecture concept. The creation of templates for registering ESONET observatory instruments required pre-establishing the requirements, starting with a feature matrix and registration interface prototype that account for the various sensing technology areas, i.e. biological, physical, chemical, and multiparameter instruments. As all collected specifications have to be mapped to a dictionary for metadata discoverability and computer usability, the on-line templates for registration have been designed accordingly, for example using standard methods and common practice or *de facto* standard ontologies. The metadata format follows an internationally recognized standard, SensorML, which was chosen according to the following criteria: availability of open transformation tools, medium/low-complexity, ESONET scientific and system architects consensus, and global interoperability. Sensors are attributed a unique identifier. Part of the work was to organize the collection of instrument specifications and eventually make a proposal for a multi-science use case scenario, so as to evaluate the quality of, and identify gaps in, the registration process. Besides providing feedback on the effort for future improvements, this use case scenario demonstrates the benefit of the project. The figure 5.15 is a screenshot of the ESONET Sensor Registration Interface (current test URL: vps.dbscale.com:8080/esonet , at a later stage the registration interface will be accessible from ESONET SDI portal through secured access). Available functions include mapping of IEEE1451 Transducer Electronic DataSheet XML mapping. Next section (5.2.7.3) describes this operation, carried out by dBscale.

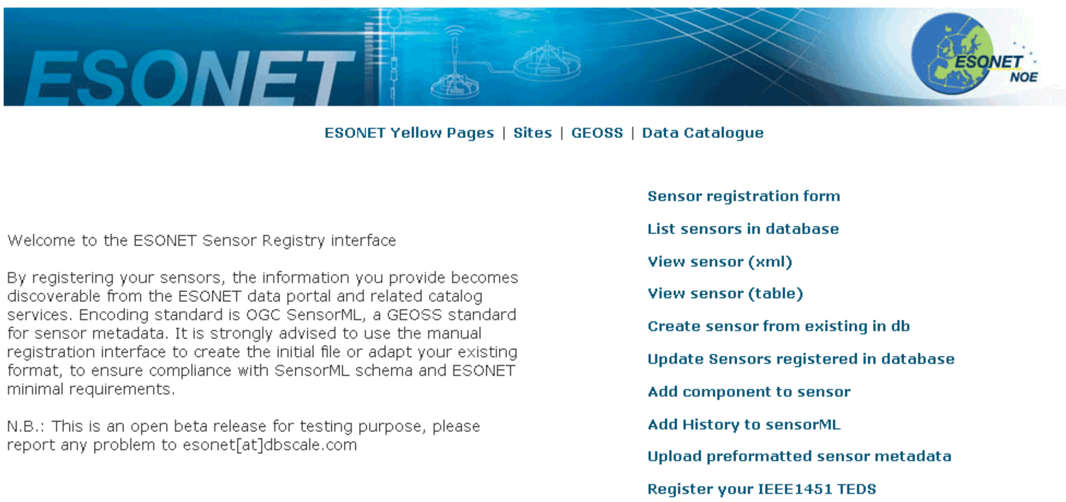


Figure 5.15: ESONET Sensor Registration Interface Portal

5.2.7.3 IEEE1451 TEDS server configuration to interoperate between OBSEA and the ESONET Sensor Registry Interface

- dBscale

In this test experiment task the effort was to interoperate between the ESONET Sensor Registry Interface and OBSEA smart sensors, transforming the IEEE1451 standard metadata into OGC SensorML metadata for seamless registration.

The ESONET Sensor Registry Interface allows users to easily create fully compliant SensorML descriptions. As SensorML is very general it is important to define minimal description content for each instrument. This interface assumes that the following minimal metadata are provided:

- Observatory Name
- Sensor Type
- Sensor Long Name
- Sensor Owner Phone Number
- Sensor Owner eMail
- Sensor Geolocation
    - Longitude
    - Latitude
    - Altitude

Users can create full sensor description using forms by filling them using this mandatory minimal metadata and optional information concerning the sensor.

The main objective is to allow users to register sensors without manual intervention using automatic mechanisms between sensors and the sensor registry Database.

IEEE 1451.0 standards were created to share sensor metadata and control in a standard way through the internet. Transducer Electronic Data Sheets (“TEDS”) are a key concept of IEEE 1451. A TEDS describes characteristics and capabilities of components such as transducers, interfaces and communications links in a standard way. Applications can retrieve TEDS through the IEEE 1451 protocols to dynamically discover instruments, sensors and actuators as well as other system metadata.

5.2.7.3.1 TEDS Server Configuration

The IEEE Standard for a Smart Transducer Interface for Sensors and Actuators (IEEE Std. 1451) defines a list of Transducer Electronics Data Sheet (TEDS) formats, as described in the following table.

IEEE Std 1451.0-2007
IEEE Standard for a Smart Transducer Interface for Sensors and Actuators—Common Functions, Communication Protocols, and Transducer Electronic Data Sheet (TEDS) Formats

Table 17—TEDS access codes

TEDS access code	TEDS name attribute	TEDS	Required/ optional
0	—	Reserved	—
1	MetaTEDS	Meta-TEDS1	Required
2	MetaIdTEDS	Meta-identification TEDS2	Optional
3	ChanTEDS	TransducerChannel TEDS1	Required
4	ChanIdTEDS	TransducerChannel Identification TEDS2	Optional
5	CalTEDS	Calibration TEDS1	Optional
6	CalIdTEDS	Calibration identification TEDS2	Optional
7	EUASTEDS	End users' application-specific TEDS3	Required
8	FreqRespTEDS	Frequency response TEDS1	Optional
9	TransferTEDS	Transfer function TEDS1	Optional
10	CommandTEDS	Commands TEDS2	Optional
11	TitleTEDS	Location and title TEDS2	Optional
12	XdcrName	User's transducer name TEDS3	Required
13	PHYTEDS	PHY TEDS1	Required
14	GeoLocTEDS	Geographic location TEDS2	Optional
15	UnitsExtention	Units extention TEDS2	Optional
16–127	—	Reserved	—
128–255	—	Manufacturer-defined TEDS	Optional

NOTES
1—A binary TEDS.
2—A text-based TEDS.
3—User-defined information content.

Beside the required metadata, the format selected for the Sensor Registry Interface is the optional Manufactured-defined TEDS (access code 128), an XML example of which is:

```
<ReadTEDSHTTPResponse xsi:schemaLocation="http://localhost/1451HTTPAPI
    http://grouper.ieee.org/groups/1451/0/1451HTTPAPI/ReadTEDSHTTPResponse.xsd">
    <errorCode>0</errorCode>
    <ncapId>4</ncapId>
    <timId>2</timId>
    <channelId>1</channelId>
    <tedsType>128</tedsType>
    <teds>
        <ObservatoryName>"obsea"</ObservatoryName>
        <SensorType>"Hydrophone"</SensorType>
        <longitude>"1.7523417"</longitude>
        <latitude>"41.1819083"</latitude>
        <altitude>"-19.32"</altitude>
        <longName>"Acoustic Sensor"</longName>
```

<Voice>"+34938967200"</Voice>
<eMail>"info@cdsarti.org"</eMail>
</teds>
</ReadTEDSHTTPResponse>

As Sensor Registry Interface mapping uses specific names for sensors and observatories, and those are case sensitive, a list of sensor and observatory names are listed below, with the corresponding Interface mapping name that MUST be used in TEDS to comply with the SRI transform engine.

Sensor Name	TEDS Name
Acoustic Doppler Current Profiler	“ADCP”
Conductivity	“Conductivity”
Conductivity, Temperature, Depth	“CTD”
Current	“Current”
Depth	“Depth”
Dissolved Oxygen	“DO”
Flow	“Flow”
Fluorometer	“Fluorometer”
Hydrophone	“Hydrophone”
pH	“pH”
Seismometer	“Seismometer”
Temperature	“Temperature”

Observatory Name	TEDS Name
Arctic	“arctic”
Black Sea	“black”
EAST SICILY	“eastSicily”
EASTERN MEDITERRANEAN	“easternMediterranean”
IBERIAN	“iberian”
Koster Fjord Demonstration Observatory Western Sweden	“fjord”
LIGURIAN Sea- Antares	“ligurian”
MARMARA SEA	“marmara”
Nordic Observatory - The MOEN	“nordic”
Norwegian	“norway”
Canary Islands PLOCAN	“plocan”
PORCUPINE/CELTIC	“porcupine”
OBSEA	“obsea”
TEST	“testObs”

5.2.7.3.2 Example

Find below a typical list of operations to register a CTD with IEEE1451 TEDS via the ESONET SRI. This CTD is connected to the OBSEA observatory located off-Barcelona, Spain.

Interface CTD request

IP Address	esonet.epsevg.upc.es	
ncap	4	
timID	1	
channelId	1	
Introduce Sensor UUID	C47A54CF-EB80-0001-205B-14E058101964	generate uuid

Load TEDS

Obsea IEEE1451 CTD response

observatory: obsea
sensor: CTD
longitude: 1.7523417
latitude: 41.1819083
altitude: -19.32
longName: Conductivity, Temperature and Depth Sensor
phone: +34938967200
eMail: info@cdsarti.org

Thank you
Sensor TEDS has been correctly loaded

Register Sensor

Registry Interface CTD SML generation

Once the sensor is registered in the database (after clicking on "Register Sensor" button), a complete CTD SensorML file has been created and uploaded to the database. The View sensor function allows you to verify if the process was a success.

See below a fragment of the SensorML file where the sensor geo-location and identifiers were acquired and processed based on the TEDS.

Station Location	Value	UOM	Reference Frame	Definition
longitude	1.7523417	deg	urn:ogc:def:crs:EPSG:6.15:4326	urn:ogc:def:phenomenon:longitude
latitude	41.1819083	deg	urn:ogc:def:crs:EPSG:6.15:4326	urn:ogc:def:phenomenon:latitude
altitude	-19.32	m	urn:ogc:def:crs:EPSG:6.15:5113	urn:ogc:def:property:OGC:altitude

```xml
<swe:Vector gml:id="STATION_LOCATION"
        definition="urn:ogc:def:property:OGC:location">
         <swe:coordinate name="longitude">
          <swe:Quantity axisID="x" referenceFrame="urn:ogc:def:crs:EPSG:6.15:4326"
                definition="urn:ogc:def:phenomenon:longitude">
            <swe:uom code="deg" />
            <swe:value>1.7523417</swe:value>
          </swe:Quantity>
         </swe:coordinate>
         <swe:coordinate name="latitude">
          <swe:Quantity axisID="y" referenceFrame="urn:ogc:def:crs:EPSG:6.15:4326"
                definition="urn:ogc:def:phenomenon:latitude">
            <swe:uom code="deg" />
            <swe:value>41.1819083</swe:value>
          </swe:Quantity>
         </swe:coordinate>
         <swe:coordinate name="altitude">
          <swe:Quantity axisID="z" referenceFrame="urn:ogc:def:crs:EPSG:6.15:5113"
                definition="urn:ogc:def:property:OGC:altitude">
            <swe:uom code="m" />
            <swe:value>-19.32</swe:value>
          </swe:Quantity>
         </swe:coordinate>
 </swe:Vector>
```

uuid	C47A54CF-EB80-0001-205B-14E058101964	urn:uuid
shortName		urn:ogc:def:identifier:OGC:shortName
longName	Conductivity, Temperature and Depth Sensor	urn:ogc:def:identifier:OGC:longName

```xml
<identifier name="uuid">
        <Term definition="urn:uuid">
         <value>C47A54CF-EB80-0001-205B-14E058101964</value>
        </Term>
      </identifier>
```

```
        <identifier name="shortName">
          <Term definition="urn:ogc:def:identifier:OGC:shortName">
            <value />
          </Term>
        </identifier>
        <identifier name="longName">
          <Term definition="urn:ogc:def:identifier:OGC:longName">
            <value>Conductivity, Temperature and Depth Sensor</value>
          </Term>
</identifier>
```

Sensor Registry Interface CTD update

Once the sensor has been created with the minimal information (longName, ownerPhone, ownerEmail, longitude, latitude and altitude), the user can update the sensor metadata using the Update sensors registered in database function.

operatingDepthCapability	100	m	urn:ogc:def:classifier:SBE:depthCapability
survivalDepthCapability	150	m	urn:ogc:def:classifier:SBE:depthCapability
quantizationResolution	5	bit	urn:x-esonet:property:quantizationResolution
sampleRate	500	Hz	urn:ogc:def:property:SBE:sampleRate

```
<capabilities name="operationalRestrictions">
        <swe:DataRecord>
          <swe:field name="operatingDepthCapability">
            <swe:Quantity definition="urn:ogc:def:classifier:SBE:depthCapability">
              <swe:uom code="m" />
              <swe:value>100</swe:value>
            </swe:Quantity>
          </swe:field>
          <swe:field name="survivalDepthCapability">
            <swe:Quantity definition="urn:ogc:def:classifier:SBE:depthCapability">
              <swe:uom code="m" />
              <swe:value>150</swe:value>
            </swe:Quantity>
          </swe:field>
```

```xml
    </swe:DataRecord>
  </capabilities>
  <capabilities name="measurementCapabilities">
    <swe:DataRecord>
      <swe:field name="quantizationResolution">
        <swe:Quantity definition="urn:x-esonet:property:quantizationResolution">
          <swe:uom code="bit" />
          <swe:value>5</swe:value>
        </swe:Quantity>
      </swe:field>
      <swe:field name="sampleRate">
        <swe:Quantity definition="urn:ogc:def:property:SBE:sampleRate">
          <swe:uom code="Hz" />
          <swe:value>500</swe:value>
        </swe:Quantity>
      </swe:field>
    </swe:DataRecord>
  </capabilities>
```

5.2.7.3.3 Current State and Next Steps

Currently the ESONET Sensor Registry Interface has developed the possibility to register new Sensors in database using IEEE 1451. Using OBSEA observatory, two sensors registration (CTD and Hydrophone) have been tested successfully. Next steps are to extend these tests to the rest of sensors managed by ESONET group and to invite other ESONET Observatories with IEEE 1451 technology to register through sensors using the Sensor Registry Interface.

5.2.7.4 Interoperability OBSEA and MARUM

- By MARUM

Within ESONET MARUM is heavily involved in the work on sensor standardization and interoperability and data management of real-time data. For the ESONET cabled test sites project work MARUM contributed with testing ROV deployment procedures for instruments at the OBSEA test site and evaluating sensor interface standardization concepts. Within the past 12 months a new component for facilitating the integration of new sensors into a standardized data collection system has been introduced – the sensor interface descriptor (SID) concept. This concept is currently implemented and was demonstrated during the 3rd Best Practices Workshop in Marseille in December 2010. The SID can be seen as filling the gap between the sensor hardware interface and the Sensor Web Enablement scheme that has been introduced by the OGC as a standard for accessing sensor data via Web services. This concept has been already tested in the lab and will be implemented by UPC on their OBSEA ocean observatory. In particular this concept opens up a new perspective on implementing the Plug and Work concept.

In regard to sensor calibration and qualification the procedures described within the ESONET deliverable report D 36 are currently under evaluation to what extent this can be used as a template within the cabled test site experiments. The main focus was to seek for an adequate description of the data quality based on the manufacturer specifications and the results from the calibration cycles. The unique description of data quality is important for defining minimum standards that ocean observatories shall comply with to qualify for the ESONET label that is currently developed.

It is planned to carry out a ROV deployment test at the OBSEA site. Before that, a simulation of the anticipated procedures can be carried out. For that purpose a simulation tool has been developed at MARUM. With the same ROV similar tests are planned at the Koljö fjord test site and therefore the operations can be compared to come up with a well evaluated intervention scheme. Until now the ROV tests could not be conducted due to the fact that the system has been used on other missions. The current plan is to carry out tests in May/June '11 at OBSEA site, in particular to go through some underwater connector tests, i.e. checking the reliability of the connection process. It is planned to publish the results on one of the OCEANS conferences or similar events.]

Data collected at OBSEA test site are available from the OBSEA Web portal but the tools are already in place to also make them available through the MARUM ESONET data portal. Both data information systems are based on Sensor Web Enablement tools that are introduced by the Open Geospatial Consortium as a standard scheme. SWE is in particular of interest for real- time data access.

5.3 Deviation explanation

The test experiment suffered some minor deviations and a delay problem.
The water ingress in August 2010 and a software problem of the Seabird CTD were solved.
The unavailability of the ROV led to postpone the ROV tests to mid 2011. It will be done on other funding sources.

5.4 Outreach

A film on Spanish TV (TV program *TRES14*,[2] from “Minute 14”)explains the OBSEA project and its link with ESONET.

[2] Video available on: http://www.rtve.es/alacarta/videos/television/tres14---sensores-submarinos/755801/
Or in youtube:http://www.youtube.com/watch?v=tL9w_8cYSaI

6 Koljo Fjord test experiments

6.1 Previously planned test experiment

6.1.1 Objectives of the Koljo Fjord test experiments

The tests in Koljo Fjord have to contribute to the European Commission funded project HYPOX that started in April 1st 2009. One of the main objectives of HYPOX is to make the collected data according to GEOSS principles available to the ocean science community. This is also in the interest of ESONET, so that synergies can be established between ESONET and HYPOX. The planned deployment will allow testing a combination of a fixed long term sensor array with an additional node to accommodate other sensors.

The Koljo Fjord site is situated on the Swedish West coast about 100 km north of Gothenburg at a water depth of 45 m (see Deliverable D58).

A short work plan was defined for each leader institution involved in the Koljo Fjord test experiment:

Leader Institution	Work plan: Tasks short description by partners involved
KDM-UNIHB	KDM will provide a ROV Cherokee. Deployment procedure. Interoperability
UGOT	UGOT will provide a ROV SPERRE if available before March 2011. Sensor calibration; Access to data in real time pending. School materials.

6.1.2 Detail planned costs and grant allocation for the Koljo Fjord site

Partners	Personnel (€)	Equipment (€)	Travel & Accommodation (€)	Other (€)	Subcontracting (€)	Indirect costs (€)	Total costs (€)	Total ESONET contribution (€)
UNIHB	25 000	10 000	5 000	10 000	0	9 000	59 000	25 179
UGOT	70 000	10 000	5 000	51 000	0	28 200	164 200	54 821
TOTAL	***95 000***	***20 000***	***10 000***	***61 000***	***0***	***37 200***	***223 200***	***80 000***

6.2 First results of the Koljo Fjord test experiments

6.2.1 Equipment preparation, tests on land and deployment

The primary goal of the Koljo Fjord/ESOFLEX observatory was to provide a platform for carrying out long-term tests under controlled conditions in an easily accessible environment. This is particularly important for biogeochemical sensors that might undergo significant drift effects during long-term deployments. The Koljo Fjord observatory is a compact, movable and flexible cabled observatory with the possibility to connect four experimental nodes (see Figure. 6.1). Because of easy access, highly variable conditions and monthly water sampling for quality control (within the Swedish

National monitoring program) the Koljo Fjord is an ideal location for advanced testing of different sensors and systems.

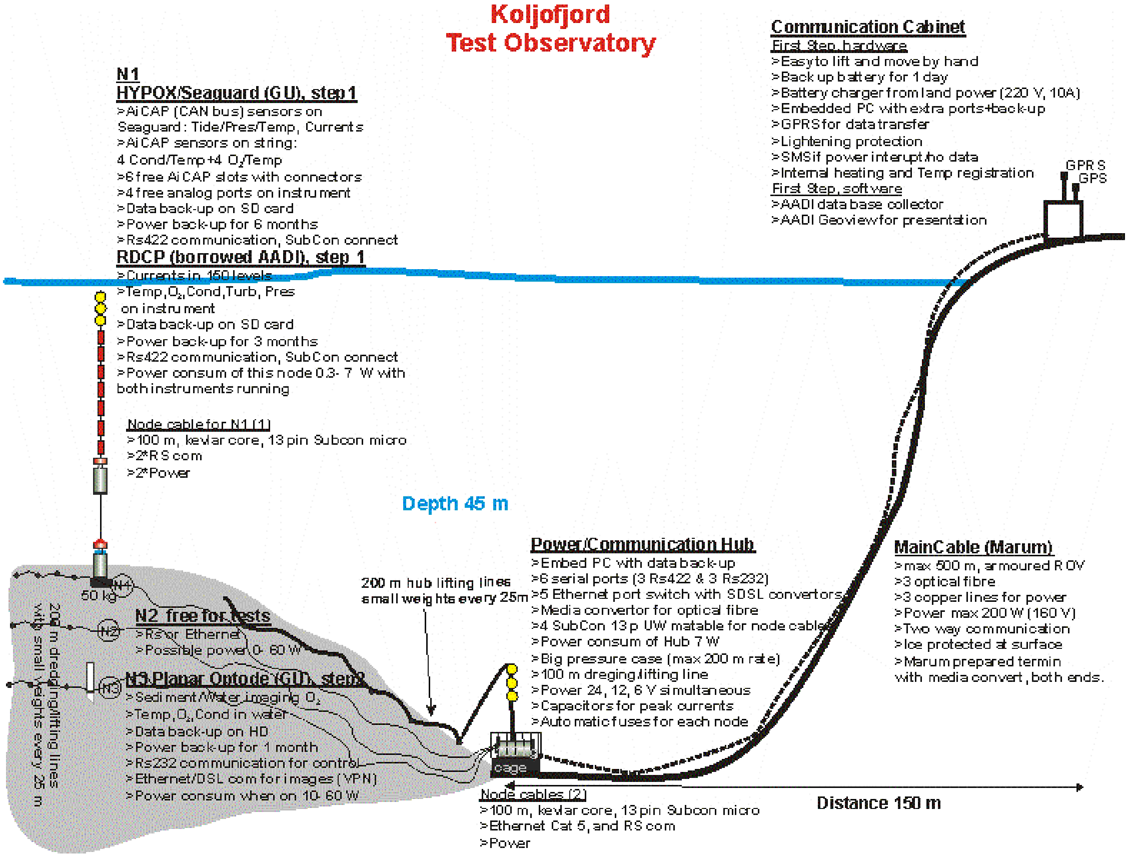


Figure 6.1: The outline of the Koljöfjord observatory.

Because of the adverse weather conditions with thick solid ice during the last few months the completed system could only be tested in the laboratory up to now. However, all necessary tests to prepare for the deployment have recently been carried out with two instruments (Seaguard and RDCP) attached with the assistance of the company Develogic in Hamburg on March 22nd. In figure 6.2 some of the essential, finalized components are displayed – the ROV cable, the shore side communication cabinet, and the underwater node.

The observatory was deployed in the Koljo Fjord on 18-19 April 2011.

Figure 6.2: Top left – 600 m of ROV cable on a drum ready for deployment.
Top right – view into the shore side cabinet containing the power supply and communication modules. Either UMTS or DSL lines can be employed to transmit data in real- time.
Lower part – A view of the central underwater node with media converter for the fiber optic transmission and control electronics.

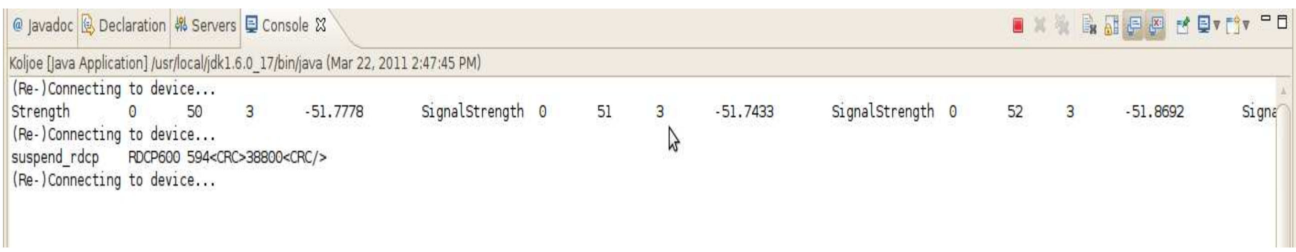


Figure 6.3: Two screenshots showing the data to be collected remotely by the MARUM SOS client.

Data flow was successfully tested employing the ROV cable and using AADI software (RT collector) and custom software developed by MARUM. In figure6.3 the basic output of an acoustic current meter and the central SEAGUARD controller are displayed within two screenshots. The interaction with the instrument for selecting the sampling configuration and the instruments status was also successfully tested. A major issue is to assure proper function of the power supply through the entire length of the ROV cable. This proved to work reliably during the lab tests. Finally the USV device was tested by disconnecting the power line when in this case the USV immediately, without any interruptions, has to take over the energy supply.
These initial tests were successful. However, more detailed information on the instruments'.

6.2.2 Sensor and measuring system calibrations and qualification

The Koljo Fjord offers highly variable and dynamic conditions of most parameters making it a suitable site to test new equipment in challenging environments. Some of the encountered variability includes:

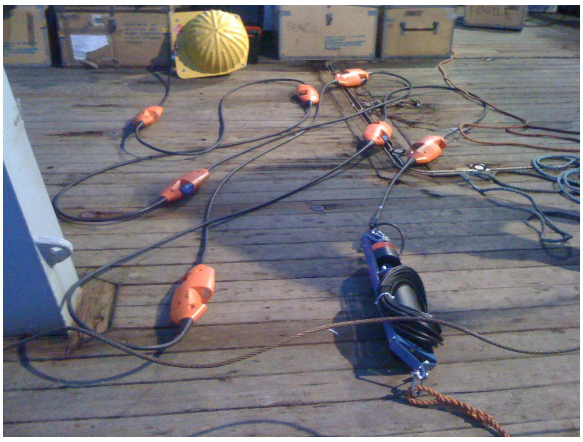
- Temperature variations from -0.5 - 25ºC
- Salinity variations from 20 - 34 psu
- Dissolved oxygen variations from 0 - 150% saturation
- Frequent occurrence of hydrogen sulfide and high concentrations of methane in deeper layers.
- pCO_2 variations from 100-4000 µatm
- High variability of nutrient concentrations
- High primary production during spring-summer-autumn
- High fouling during spring-summer-autumn

In addition high quality monthly water sampling is done close to the deployment position of the observatory by the Swedish Meteorological and Hydrological Institute (SMHI). These data are typically available about 1 month after sampling on the Internet. Data from this site exists since 1934. Sampled parameters include: Temperature, salinity, oxygen, pH, H_2S, nutrients, chlorophyll a etc. at multiple water depths.

In the first step the observatory will be deployed with instrumentation to monitor background conditions in the fjord. For this purpose a SEAGUARD string logger (acquired and used within the EU-HYPOX project, see below) is connected together with a multisensor acoustic current profiler RDCP-600 (borrowed from Aanderaa Data Instruments, Norway) to node 1 (seefigure 6.1 above).

The SEAGUARD string logger with a 20 m long sensor string have been used in the Havstens/Koljo Fjord system by the University of Gothenburg since November 2009 (figure6.3) as part of the HYPOX project. One intention of these measurements is to assess when and how frequently water exchanges in the fjord system occur. The field data are used to improve an environmental model, which has been established for the area. With a well functioning model that can mimic the present situation, different future scenarios will be simulated. In Figure 6.4 data from measurements every 30 minutes are presented and compared with results from a nearby sampling station included in the national Swedish monitoring program operated by the Swedish Meteorological and Hydrological Institute (SMHI). The intention of the monitoring program is to do monthly ship monitoring. Due to severe ice conditions in the winter of 2009-2010 there is a four-month gap in the ship data. As can be seen in Figure 6.4 sensor and monitoring results correspond fairly well (please observe that measurements and sampling are not done at the exact same locations and depths). The variability of all parameters is large and monthly data cannot resolve temporal variations at this, and probably most other, coastal sites. Monthly ship data are however very useful to check the quality rendered by in-situ sensors.

Figure 6.4: UGOT SEAGUARD with 20 m string on-deck before deployment. It measures: Currents at one level, Water level, Cond/Sal/Temp at 4 levels, O_2/Temp at 3 levels. There is room for 11 additional sensors. The autonomy of the system is about 1 year using internal batteries and set to record data at 20 min intervals.



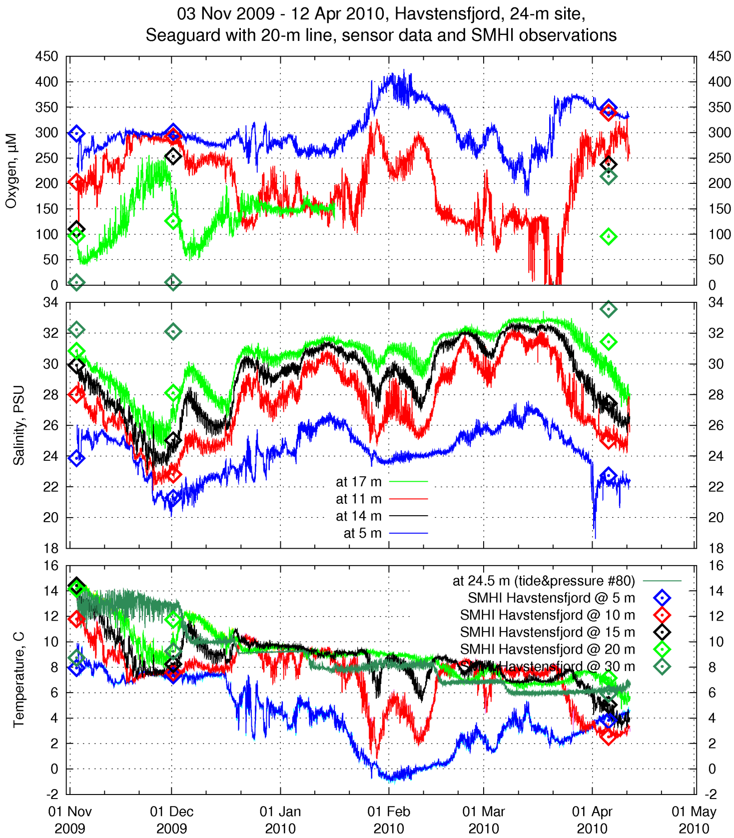


Figure 6.5: Examples of oxygen, salinity and temperature measurements obtain with a SEAGUARD with 20 m string in the Havstens Fjord. Dots in the plots represent ship monitoring data collected by SMHI from a nearby station.

The RDCP-600 is a commercially available acoustic current profiler, which does not only provide the user with information about currents (for an example see figure 6.6 below) in the water column. It is a flexible instrument with features like the ability to measure surface currents and collect data from on-board environmental sensors (salinity, temperature, oxygen, turbidity, water level and waves). In addition the acoustic signal transmitted by this instrument can also be used to track movements of e.g. zooplankton and to assess mixing depths of waves.

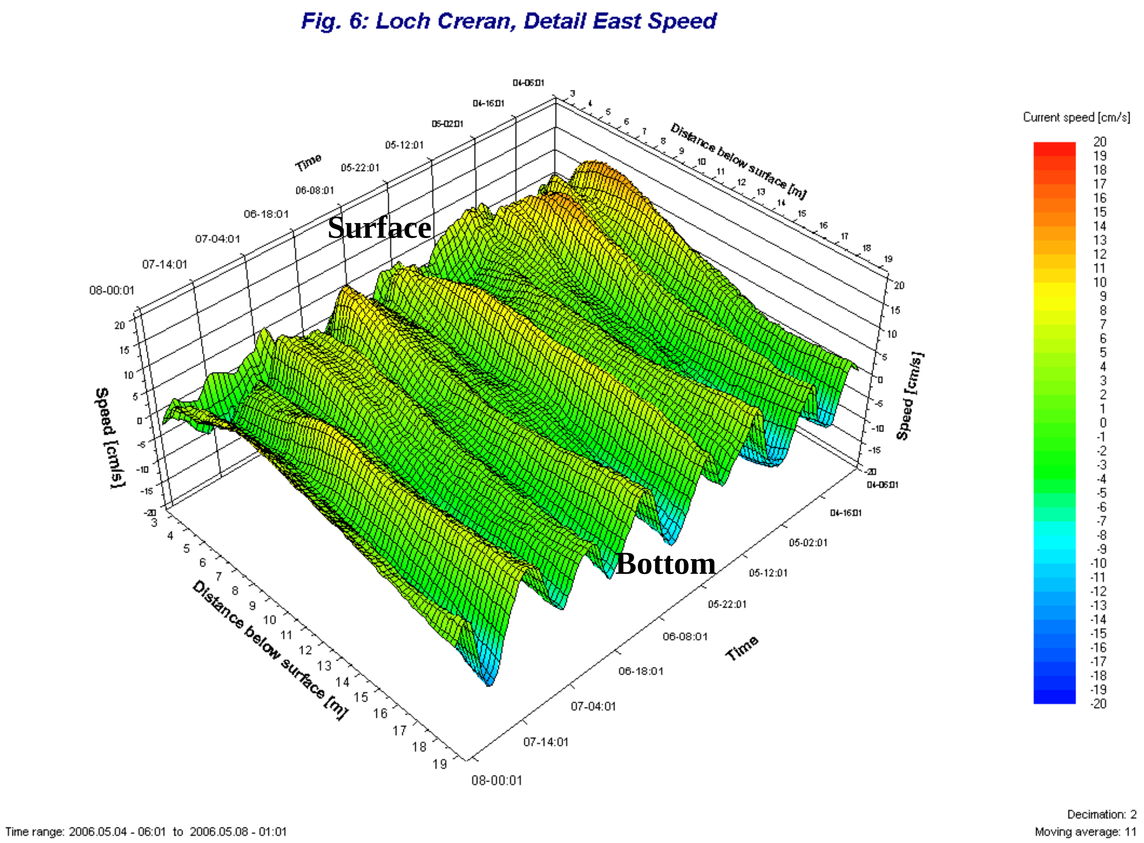


Figure 6.6: RDCP-600 data recorded in Loch Creran, western Scotland.

When the observatory is in operation in the Koljo Fjord the intention is that the following background data are provided at 10-60 minute intervals (depending on the selected set-up) by the combined SEGUARD/RDCP node:

- Horizontal currents in the entire water column at 1 m resolution
- Acoustic signal strength in the entire water column at 1 m resolution
- Water level measured at two positions
- Oxygen measured at 5 depths
- Salinity measured at 5 depths
- Temperature measured at 11 depths

A couple of months after the deployment of the observatory the intention is to add 2-3 recently developed pCO_2 optodes to empty slots on the Seaguard string for on-line testing. These will be the first sensors from a new design to be tested.

After the observatory has proven to be fully operational for some months the next step will be to add a planar optode module to one of the empty nodes. To operate this instrument both DSL and serial communications will be needed.

The planar optode technique provides two-dimensional images/photos of the oxygen distributions in the sediment and at the sediment-water interface. At the University of Gothenburg this technology has been developed for autonomous operation on benthic landers (see Figure 6.7 below).

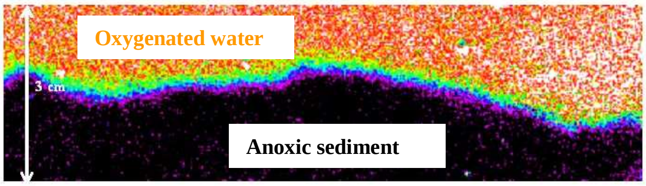


Figure 6.7: Left, the Göteborg minilander equipped with an autonomous planar optode being recovered in the Gulf of Finland (Baltic Sea). Right, example of oxygen image data provided by the planar optode in the Gulf of Finland.

6.2.3 Return of experience of operations at sea and interventions by ROV

Until now the ROV tests could not be conducted due to the fact that the system has been used on other missions and because of ice cover on the Koljo Fjord. The current plan is to carry out tests in May/June 2011 at the Koljo Fjord site and in particular to go through some underwater connector tests, i.e. checking the reliability of the connection process. It is planned to publish the results on one of the OCEANS conferences or similar events.

6.2.4 Data management preparation

Like for the OBSEA cabled test site it has been the highest priority to employ standard methods for data retrieval and dissemination. As a matter of fact the Koljo Fjord observatory is 100% compatible in that regard to the OBSEA site and the basic structure, using OGC web services, has been described in the corresponding part above. The challenge in this case lies in the integration of the existing data acquisition scheme into the ESONET data management framework.

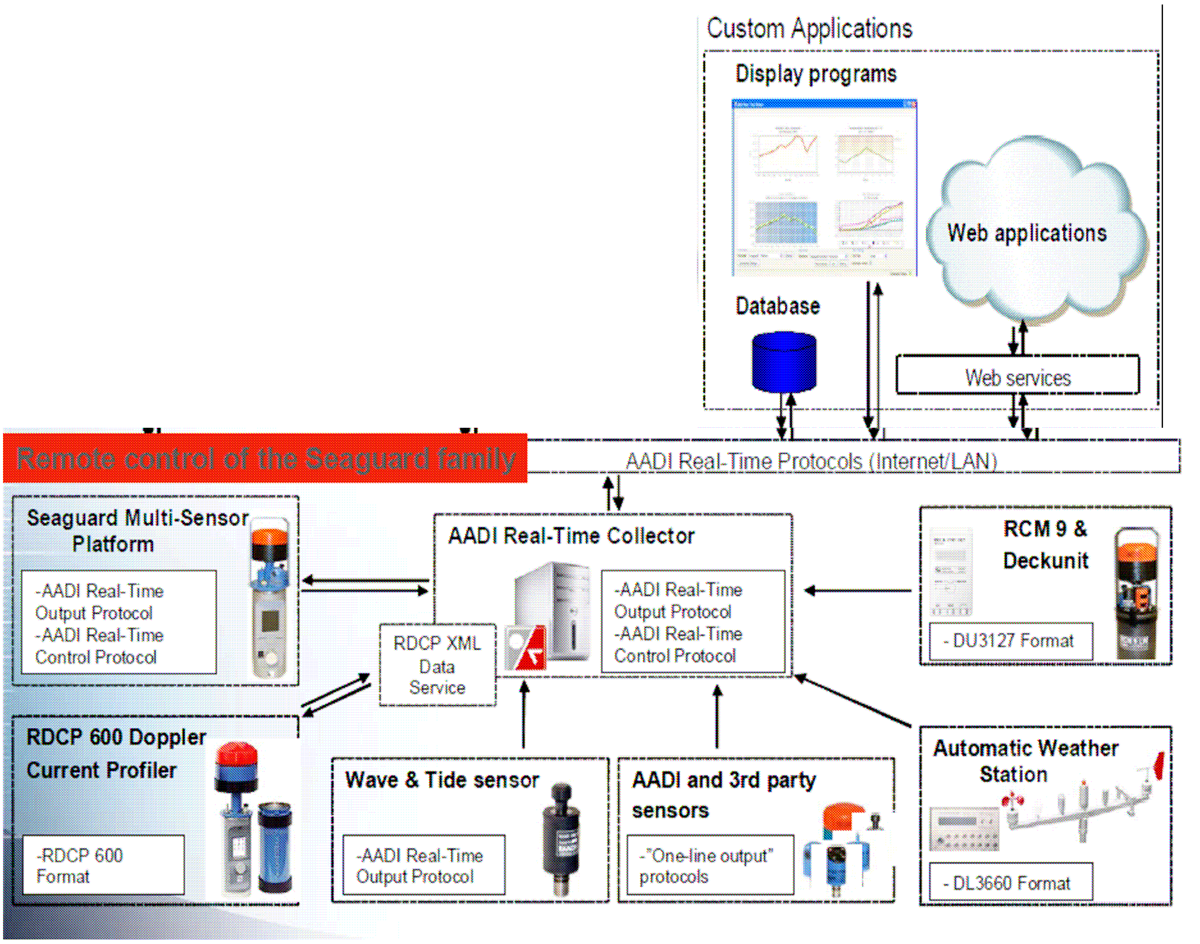


Figure 6.8: Data collection structure predetermined by the hardware manufacturer.

As seen in Figure6.8 the data access point of choice would be the AADI Real Time Collector. In the case of the Koljo Fjord observatory the data from the instruments are actually buffered in a separate controller in the wet part of the system and then send out by UMTS to the central shore based server where the AADI Real Time Collector will reside. This also offers alternative ways of processing and distributing the data. The data transmitted by UMTS will be retrieved via a TCP/IP connection from the observatory and subsequently be stored in a database on a server at MARUM. In order to access the data in a standardized way, an OGC Sensor Observation Service (SOS) has been implemented and installed. The SOS can be queried by SOS clients and will retrieve the requested data from the database and wrap it according to OGC's Observations & Measurements (O&M) standard. For PANGAEA purposes, a SOS client has been developed. This will request data from the SOS and automatically prepare it for import into PANGAEA. Once the data was imported, it will be accessible via the PANGAEA website (http://www.pangaea.de/) i.e. the ESONET web portal. As mentioned above, this scheme follows completely the structure that is also used as part of the OBSEA site.

6.2.5 Return of experience of equipment operation

See 6.3 below.

6.2.6 Quality and intercomparison of recorded data

See 6.3 below.

6.2.7 Standardization procedures

Data transport from the instruments to the hub / cabinet computers have been realized using the infrastructure and software deployed by the German company Develogic. Custom software developed by MARUM will be used to retrieve data from the hub / cabinet computers and to store it in the database. From that point onwards and as mentioned in 1.1.4, data retrieval will be realized by adhering to OGC standards (SOS and O&M).

6.3 Deviation explanation

Because of severe weather conditions and solid thick ice on the Koljo Fjord, it has not been possible to install the test observatory in the Koljo Fjord yet. Sections 6.2.5 and 6.2.6 will of this reason be reported after the installation, which is scheduled to take place on 18-19 April 2011.

6.4 Contribution on ESONET outreach and training

This is reported in the dedicated deliverable D64.

7 Conclusion

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. The Tests benefited of infrastructure building budgets outside ESONET on ANTARES, SN-1, Koljofjord and OBSEA sites. The experiments performed by ESONET have shown the advances made in sensor interfaces, data management, subsea intervention and sensor qualification. It is an achievement of the 4 years work in ESONET for all the tasks of WP2 (especially sensor interfaces, subsea intervention and sharing testing facilities), WP3 (generic instrumentation and specific instrumentation) and application of the latest results of WP9 such as sensor registry. The principle of data available in real time from the subsea 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. (Note that it is a complement to the dataflow coming from stand alone observatories deployed by ESONET on other sites such as MOMAR-D, MODOO and Hellenic sites).

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.

At the end of ESONET (February 2011), all the experiments are not finished. They will use non ESONET budgets to operate the final sea operations on SN-1 and Koljofjord especially and an additional ROV test on OBSEA.

A panel session in a Best Practices Workshop as envisaged in ESONET Vi will be needed to share the additional experience gained during these additional sea tests.