PERSEUS

POLICY-ORIENTED MARINE ENVIRONMENTAL RESEARCH IN THE SOUTHERN EUROPEAN SEAS

# Multi-parametric moorings upgrade with new sensors and expansion

**D3.2**

SEVENTH FRAMEWORK PROGRAMME

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## EXECUTIVE SUMMARY / ABSTRACT

The protection and preservation of the marine environment, as outlined in the Marine Strategy Framework Directive (MSFD), is highly based on the monitoring capacities of the oceans and regional seas. The maintenance, upgrade and expansion of the existing oceanographic observing networks has been identified as crucial for the EU maritime policy aiming to promote sustainable use of the seas and to conserve marine ecosystems, and more specifically to the implementation of the MFSD. Under the PERSEUS framework the current observing capacity in the Southern European Seas (SES) has been reviewed, and, the upgrade and expansion of this network developed towards the fulfilment of the scientific and society needs. These actions are described under WP3 "Upgrade-expand the existing observational systems and fill short term gaps" objectives.

Within this, Task 3.2 focuses on upgrading the current SES monitoring system, which combines Lagrangian and Eulerian platforms at basin scale and in the deep offshore areas. This report is the outcome of sub task 3.2.1 "Multi-parametric moorings, new sensors, upgrade and expand" and focuses on the upgrades implemented for open sea moored observatories in the Mediterranean and Black Seas; following 12 months of preparation and the adoption of Task 3.1 "Review of ocean observing systems in the SES and recommendations on upgrades to serve PERSEUS needs" (D3.1) outcomes.

The upgrades of 7 deep mooring stations mentioned in the DOW are described, namely in the Ligurian Sea, Gulf of Lion, Corsica, Ionian Sea, South Aegean, and North Aegean. At a local/coastal level the upgrades of 3 sites, again identified in the DOW, at key touristic locations in Croatia, Bulgaria and Rhone River are described,,

In addition, 7 sites not mentioned in the DOW are also presented, that have been upgraded with new sensors in key areas such as Minorca, the Cap de Creus Canyon, Saronicos Gulf and the Black Sea.

Although some minor deviations, delays and technical problems have been reported, overall the progress of upgrades has been satisfactory despite the limited time frame (24 months), and with the additional stations we exceed the goals as outlined in the DOW.

# MULTI-PARAMETRIC MOORINGS UPGRADE WITH NEW SENSORS AND EXPANSION

## Scope

Fixed point observatories of the Mediterranean and Black Sea have had a major contribution in monitoring physical and biochemical parameters in the region. The capability of recording long-term, high quality time-series, using a plethora of new state of the art sensors, upgrades scientific knowledge regarding sea processes and leads to the provision of solid grounds for the implementation of MSFD. Moreover, real-time transmission is advancing forecasting capabilities. PERSEUS 3.2.1 subtask is focused on the planning and implementation of new sensor deployments, on existing open sea multi-parametric moorings and in some cases coastal stations, that are located within key zones in the SES. The stations that have been upgraded with new biogeochemical and acoustic sensors are now capable of delivering data relevant to marine environmental monitoring and the assessment of the gaps in our knowledge specifically oriented towards MFSD, by providing enhanced information on the ecosystem dynamics, the inter-annual variability of intermediate and deep water formation and estimations of noise levels.

## Review of existing framework

### Moored observatories in the SES

The SES mooring network has been contributing to European operational oceanography activities for more than 15 years and consists of coastal and open sea Eulerian observatories that monitor a variety of atmospheric and water physical and biochemical parameters. This network of fixed point observatories is a component of the Mediterranean observing system that has been developed through major EU projects (MFSPP 1998-2001, MFSTEP 2001-2005) and national initiatives (ESEO, Adricosm, POSEIDON, CYCOFOS etc.) under the coordination of MOON (www.moon-oceanforecasting.eu) and MedGOOS (www.medgoos.net).

The EuroSITES FP7 Project was the the European contribution to OceanSITES, funded within the EU Framework 7, to aid the convergence of the efforts of the 11 European-wide deep ocean observatories which formed its core. A major output of the project was envisaged as the synergies of the 13 partners working together to create a network providing data in near-real-time and delayed-mode, which had been collected and processed in such a way as to be accessible to the wider scientific community and comparable across time and site. The common data policy agreed by all the partners at the start of the project, and the evolution of a EuroSITES quality control manual which includes all the observatories practices, have formed the framework within which each data management group has delivered datasets which now carry the EuroSITES 'brand' as well as all the originators details.

The M3A array was developed for the needs of the Mediterranean Forecasting System (MFS, an initiative of the Mediterranean Task Team of EuroGOOS) through a number of European research projects (1998-2005). The long term goal of MFS is to develop an operational ocean monitoring and forecasting system for the Mediterranean Sea with forecasting capability up to primary production. The system was then merged with other European efforts to develop a Global Ocean Monitoring and Forecasting capacity through the MERSEA (EU/FP6 funding) project, it now contributes to EuroSITES.

National buoy programmes, as well as other national infrastructures such as SOCIB[1], have also contributed to the Mediterranean buoy network. These, mainly coastal, sites generally monitor only the basic sea surface and meteorological parameters.

### Gap identification

In the framework of PERSEUS FP7 project, under WP3 actions, an overall summary of the existing observational capabilities in the Southern European Seas (SES) was undertaken,; including Lagrangian observations with floats and drifters, measurements from ships of opportunity, fixed moorings, classical oceanographic surveys, local and coastal observing networks, and observations collected by gliders and satellites. A review report (D3.1) summarized and integrated the information compiled in the six internal reports from the sub-tasks of Task 3.1 (PERSEUS D3.1 P.M. Poulain et al., 2013). Subtask 3.1.3 focused on reviewing the existing moored platforms with a water column monitoring capability and identifying the gaps in the Mediterranean Sea. A number of platforms were examined and their existing and short-term planned configuration was reviewed (sensors, depths, technology) with emphasis on their capacity to deliver data relevant to marine environmental monitoring and assessment (MSFD).

The review outcome identified several gaps, a part of which will be covered by upgrade actions under the PERSEUS 3.2 Task. The two last points mentioned in the report are particularly relevant to mooring upgrades under the 3.2.1 subtask:

a. New sensor technology (optical, acoustic, etc.) has not been integrated yet in the majority of platforms

b. Lack of monitoring additional parameters. A few biogeochemical time series are available today while water-column and seabed data are sparse

## Upgrade of existing framework

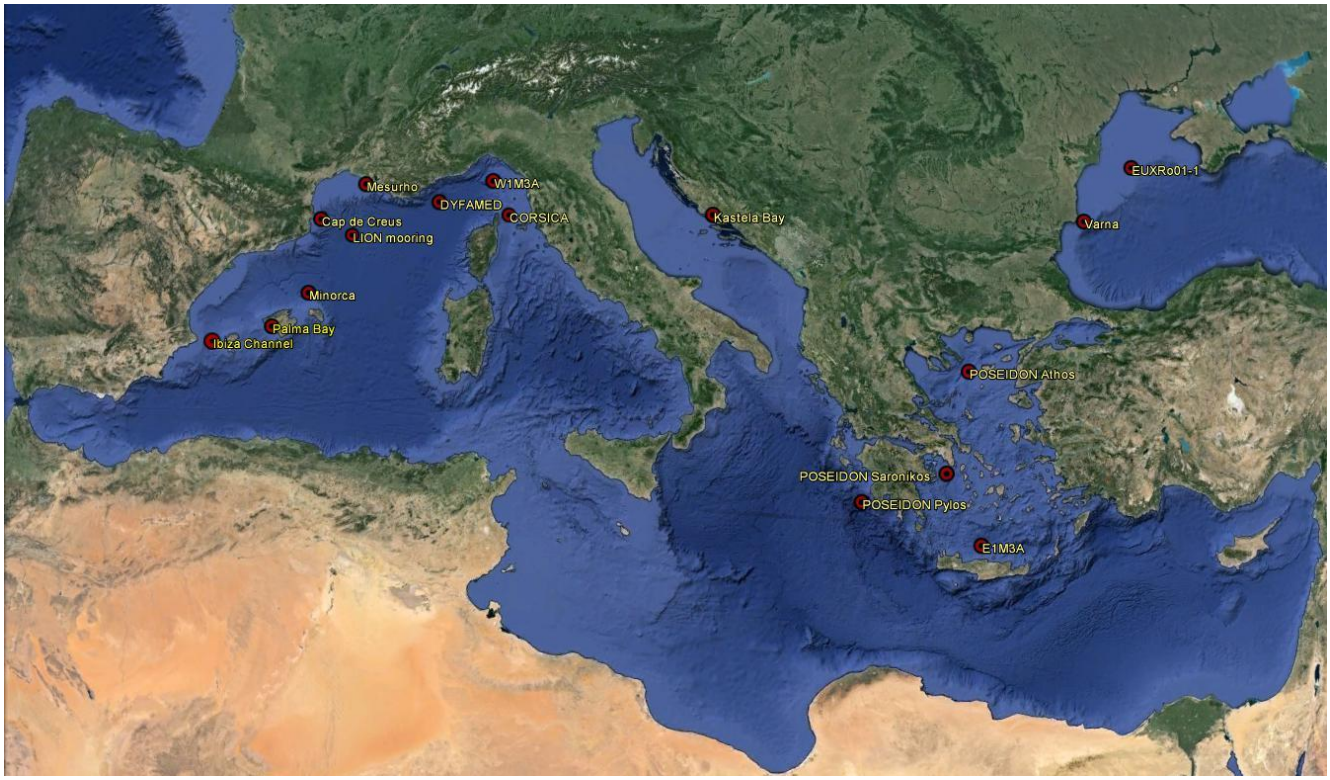
From the 21 sites reviewed in PERSEUS, 12 were identified for upgrade with new sensors or measurements from R/Vs. Four of the sites contribute to OceanSITES, whilst two are part of the M3A array.

[1] Balearic Islands Coastal Ocean Observing and Forecasting System (www.socib.es)

In the Western Mediterranean there is the Dyfamed station and W1-M3A, both located north-west Ligurian Sea. .While in the Eastern Mediterranean there are the POSEIDON-Pylos station, located in the south Ionian Sea, and the E1-M3A, located in the south Aegean Sea. Other stations participating in upgrade activities are the LION mooring in the Gulf of Lion, COR in the Corsica Channel and the POSEIDON Athos mooring in the northern Aegean region. Selected coastal stations were identified for upgrade at key touristic places in Croatia (Kaštela Bay), off Varna in Bulgaria, as well as in another key zone, the Rhone River (Mesurho).

Finally 7 additional moorings, not mentioned in PERSEUS DOW, participated in the upgrade actions namely the Saronicos buoy in Saronicos Gulf, Cap de Creus mooring in the Cap de Creus Canyon, the Minorca station north of Minorca island and the array EUXRo01-5 in the Black Sea, as well as the Ibiza Channel deep mooring, the Palma Bay (Mallorca) coastal mooring and the Mahon harbor mouth coastal station (Menorca).

At the majority of the sites frequent physical and biochemical measurements will be done by R/V as described in 3.2.3 Subtask. The following table (table 1) summarizes the planned and completed upgrade actions and map 1 indicates the location of the 16 deep and coastal stations.




Map 1. Location of the observatories

| Institute | Name of site WMO code | Sensor type Upgrade | Sensor Manuf/model | Instrument Depth [m] | Acquisition Interval | Data availability | Budget allocated within Perseus | Date of integration |
|---|---|---|---|---|---|---|---|---|
| HCMR | Saronikos WMO no. 6101001 | PAL | Horst Ltd/PALadv | 100 | 3-h | Delayed mode | YES | 01/2013 |
| | Athos WMO no. 6101003 | PAL | Horst Ltd/PAL | 100 | 3-h | Delayed mode | NO | 01/2013 |
| | Pylos WMO 68422 | PAL | Horst Ltd/PAL | 500 | 3-h | Real Time | NO | 03/2013 |
| | | | | | | | | |
| CNR | W1-M3A WMO no. 6100010 | pCO2 | Pro-Oceanus/ PSI CO2-PRO | 6 | 3-h | Real Time | YES | 09/2013 |
| | | PAL | PAL | 36 | 3-h | Real Time | NO | 06/2012 |
| | Corsica Channel | pCO2 | HydroC CO2 CONTROS | 400 | 6-h | Delayed mode | YES | 09/2013 |
| | | | | | | | | |
| CNRS | DYFAMED WMO no.68418 | O2 | Aanderaa | 400, 2000 | 6min | Delayed mode | No | 07/2012 |
| | | Nitrate | ISUS SAtlantic | 50 | 1hr | Delayed mode | Yes | 07/2013 |
| | | | | | | | | |
| Ifremer | MESURHO WMO no. 61284 | ADCP Currentmeter | Teledyne-RDI, 600kHz | 20 | 30 min | Real time | NO | 12/2012 |
| | | Laser granulometer | Sequoia, LISST T100X | 1.5 | 30 min | Delayed mode | YES | 03/2013 |
| | | Nitrates sensor | ISUS | 4 | 30 min | Real time | YES | 09/2013 |
| | | | | | | | | |
| UB | Cap de Creus CC1000 | Sediment trap | Technicap PPS3 | 970 | 15 d | Delayed mode | NO | 01/2012 |
| | | 3D Currentmeter | Aquadopp Nortek | 970 | 30 min | Delayed mode | NO | 01/2012 |
| | Minorca MIN2400 | Sediment trap | Technicap PPS3 | 2400 | 15 d | Delayed mode | YES | 09/2012 |
| | | 3D Currentmeter | Aquadopp Nortek | 2400 | 30 min | Delayed mode | YES | 09/2012 |
| | | | | | | | | |
| GeoEcoMar | EUXRo01-1 | Doppler current meter | | 5 | | Near real time | NO | End of 2013 |
| CSIC/SOCIB | Ibiza Channel | Doppler current meter | Sontek 300Hz | 2 | 20 min | Near real time | NO | 07/2013 |
| CSIC/SOCIB | Palma Bay/Mallorca | Multi parametric probe | YSI 6600 | 1 | 20 min | Near real time | NO | 07/2013 |
| CSIC/SOCIB | Mahon/Menorca | Doppler current meter | Nortek Aquadopp 1MHz | 20 m | 20 mins | Near real time | NO | 07/2013 |

Table 1. Mooring upgrades actions under PERSEUS task 3.2 as reported by each PI.

The data are transmitted to local operational data centers and then acquired in order to be integrated in the Mediterranean Data Portal (hosted by HCMR) under PERSEUS "label". All datasets follow quality assurance procedures both for data and metadata entries in collaboration with the FP7 SeaDataNet project that is standardizing the delayed mode quality control procedures in NODCs, and MyOcean GMES FP7 project that is standardizing near real time quality control procedures for operational oceanography purposes. The data integration procedure is ongoing and will be

finalized by April 2014. To date the M3A array (E1, E2 and W1), the OceanSites moorings (Dyfamed, LION and Pylos) and the Mesurho coastal station have been integrated into PERSEUS data streaming procedures.

## Mooring site details - upgrades and expansions

### Western Mediterranean

**Site: W1-M3A Ligurian Sea**

**Operated by: CNR**

**PI: Roberto Bozzano, Sara Pensieri,**

The W1M3A observatory is a part of OceanSITES network and it is moored in Ligurian Sea at a depth of 1300m. It is a multi-parametric water column oriented platform. The site has been undergoing upgrade developments through PERSEUS project with the purchase and testing of a new $pCO_2$ sensor Pro-Oceanus PSI/CO2-PRO that is still under test in the CNR laboratory (picture 1). On July 2013, the Pro-Oceanus PSI/CO2-PRO sensor (s/n 29-093-45) reported a problem with the "Onset TFX-11V2 Controller Board" which failed to run the embedded programme making it unusable. A new card was purchased from CNR through a commercial vendor and it was replaced successfully in September 2013. The sensor underwent a new laboratory session phase that is still ongoing. As a consequence of the replacement of the internal controller, the deployment of the $pCO_2$ sensor foreseen in September 2013 was postponed. A new underwater cable was acquired to support the deployment of the instrument. It constitutes of two parts: a long cable connected to the acquisition system onboard the buoy and designed to remain at sea for a long period of time, and a short pigtail connecting the sensor to the long cable. Underwater pluggable connectors are used at the end of the two cables. This solution will greatly facilitate and speed-up the installation, maintenance or recovery work performed by divers. The sensor is ready for deployment and this will likely occur early next year as soon as the sea conditions will be stable enough to ensure offshore safety.

Picture 1. The pCO2 sensor during the laboratory tests. The pump flushing the internal measuring path is visible on the right. The sensor is installed on its two support brackets that will be used to attach it to the buoy body at 6 m depth

Since June 2012, W1-M3A observatory is also integrating a Passive Aquatic Listener (PAL) sensor capable of recording ocean ambient noise. These new sensors will be used to assess the noise impact on the marine environment, transfer the knowledge across the SES, and create a database from existing registries of noise. The sensor is functioning well without any problems reported throughout this period.

**Site: COR mooring**

**Operted by: CNR**

**PI: Katrin Schroeder**

The mooring is located at Corsica channel (43° 1.50'N, 9° 41.0'E) at a depth of 440m. On October 2013, a $pCO_2$ sensor was implemented on the buoy measuring at 413 m depth (27 m from bottom) (figure 1). The sampling rate was set once daily while data are recorded internally, and will be downloaded during recovery.

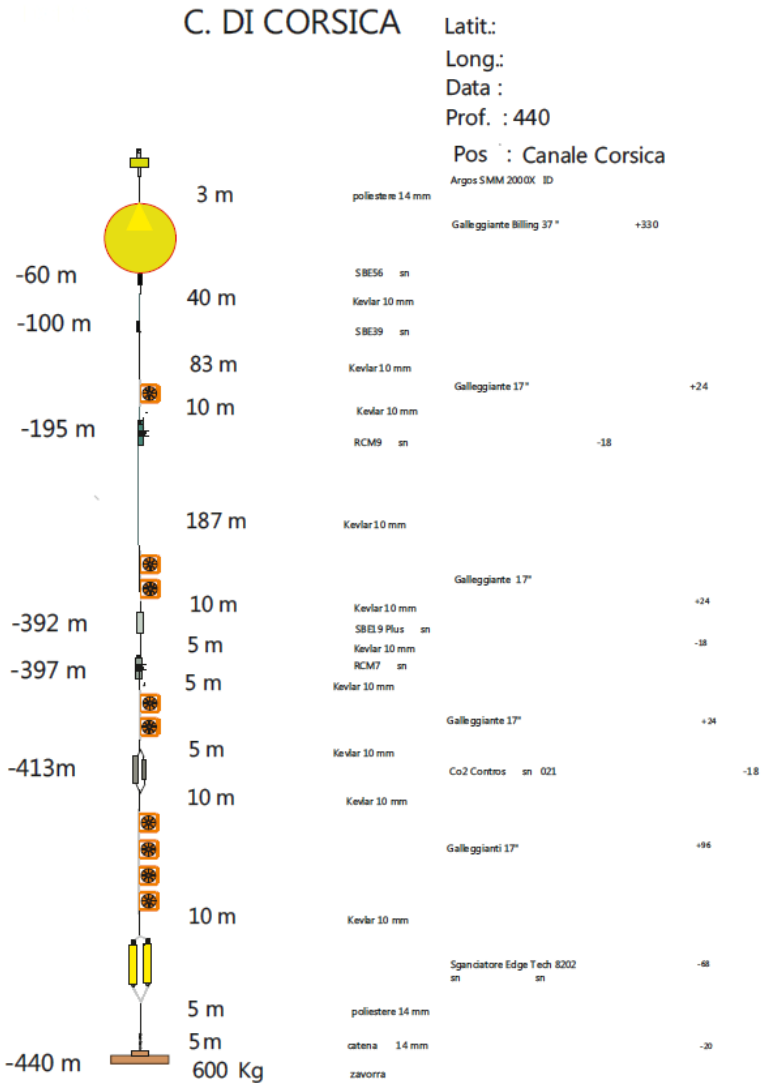



Figure 1. The architecture of CORSICA Channel mooring. The new $pCO_2$ sensor is attached on the mooring line at 413m depth.

CNR has planned one 25 days long cruise for April-May 2014 with the objective of continuing the MEDOCC series, i.e. western basin-scale surveys through hydrographic multidisciplinary sections, closing sub-volumes of the basin, following a box-model approach to allow budget computations of mass, salt, heat and biogeochemical properties. The Corsica and Sicily sections correspond to the CORSICA, C01 and C02 moorings, respectively. This survey has already been carried out in 2005, 2006, 2007 and 2008. During PERSEUS it will be done once and coordinated with the annual MOOSE cruise. The cruise is not designated as part of other projects. Parameters: CTD, oxygen, phosphate, nitrate, silicate.

**Site: DYFAMED**

**Operated by: CNRS**

**PI: Laurent Coppola**

This multidisciplinary site is located in the central Ligurian Sea, in the passage of waters between the Eastern and Western part of the Med Sea. DYFAMED has been deployed since 1988 (JGOFS) at 30 miles off the coast to monitor mainly: 1) the carbon export through two sediment traps (200 and 1000m) and 2) the intermediate and deep water masses properties (LIW and WMDW). This region is known to be a key passage for water masses coming from the Tyrrhenian Sea and circulating to the Gulf of Lions with a presence of a strong North current limiting the influence from the coast. Consequently, the biogeochemical content and the biological pump are very dependent on dusts inputs (capable to provide a large amount of nutrients during the oligotrophic period) and on the mixed layer depth variability. The DYFAMED mooring is a standalone mooring equipped since 2009 with CTD and currents sensors (EUROSITES) with an annual maintenance (Fig. 3 and 4). Regarding upgrades, two sediment traps have been deployed to collect large particles and zooplankton samples every 15 days (48 samples per year). In August 2012, two additional oxygen sensors were deployed (AADI optode 4330) to record the oxygen variability in the LIW and WDMW water masses (respectively 350 and 2000m depth). Unfortunately, data loggers stopped recording data after two months (battery malfunction). Consequently, any continuous oxygen data have been acquired during this period (only the monthly O2 profiles). Then, it was decided to postpone this implementation for July 2014 with the installation of two new SBE37 SMP-ODO sensors at the LIW and WMDW levels.

Concerning the nitrate measurements (planned to be installed at the surface layer near the mooring), a new optical sensor (ISUSv3 from SAtlantic) was tested in 2013 in order to check the quality of the data and the robustness of the data measurement (Fig.5). So far, the ISUS sensor has been deployed at 200m depth from July to October 2013 at the DYFAMED site where water sampling is usually done every month. The NO3 raw data are consistent and show a difference from 0.51 to 0.82 umol/L compared to the in-situ NO3 measurements (colorimetry method). To improve the ISUS data accuracy, the raw data need to be corrected (slope and offset). After data re-processing and lab calibration (last calibration 25 Oct 2012), the ISUS sensor will be ready for long term installation on the DYFAMED site (under the ODAS buoy near the DYFAMED mooring at the 50m depth corresponding to the annual mean DCM depth).

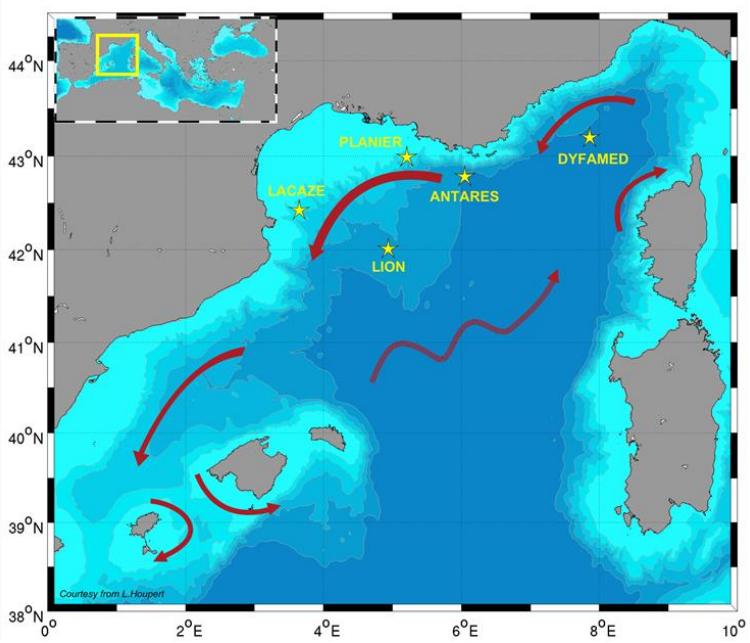



Figure 2. The five MOOSE moorings in the NW Mediterranean Sea. DYFAMED is located in the Ligurian Sea

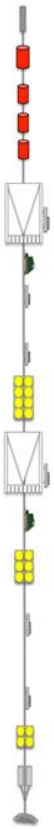


Figure 3. The present DYFAMED mooring design with 8 CTD sensors (SBE37 SMP), 2 current meters (Aquadopp) and 2 sediment traps (Technicap PPS5)

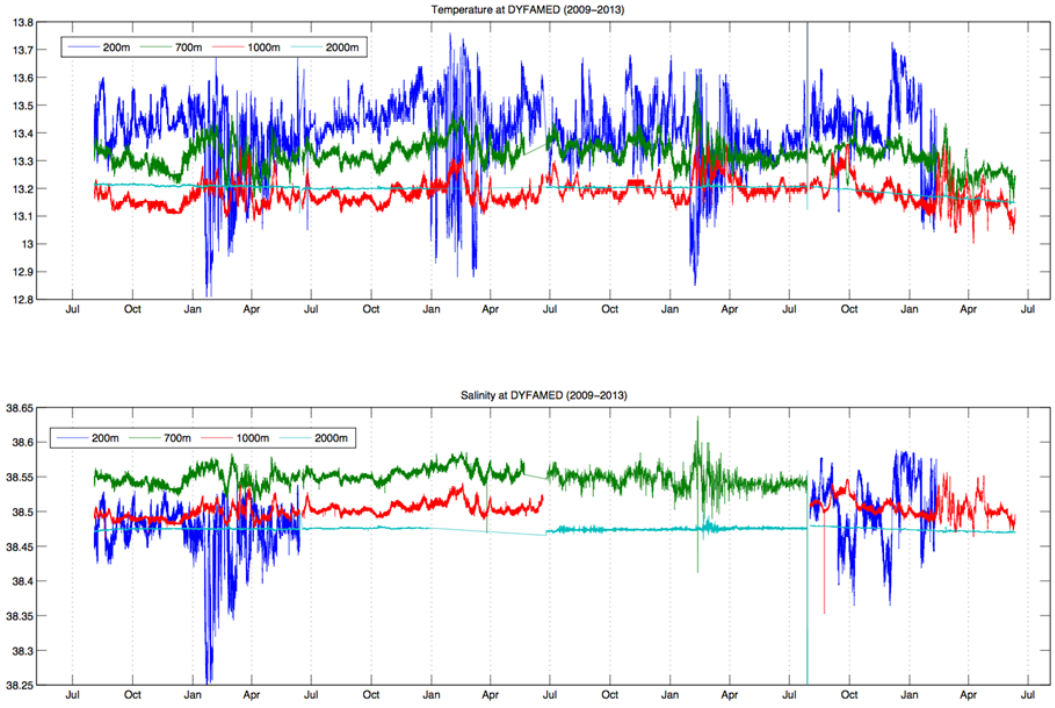



Figure 4. The long term T, S record at the DYFAMED site at different depth (time frequency acquisition 30 min)

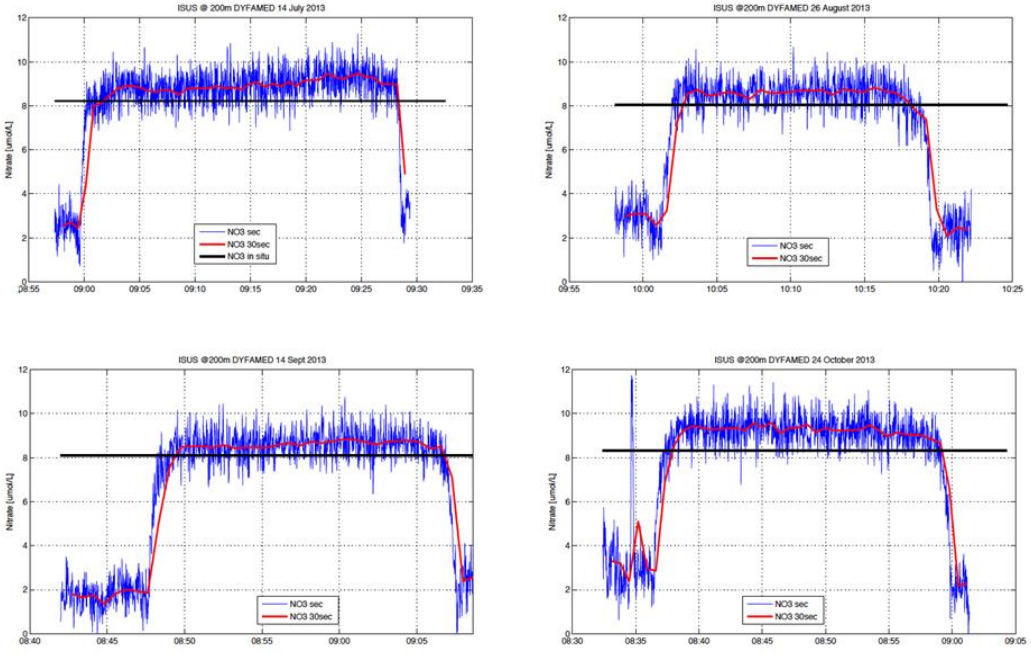



Figure 5. First NO3 raw data from the ISUS v3 sensor deployed at 200m depth at the DYFAMED site from July to Oct 2013. The blue line represent the 1s acquisition, the red line the 30 sec mean and the black line the NO3 in situ concentration (the reference).

Biogeochemical parameters are also collected every month during ship visits. CNRS planned one-day monthly cruises starting in January 2012 and ending in December 2015 with the objective of observing the long-term evolution of the NW

Mediterranean Sea in the context of the climate change and anthropogenic pressure (over > 10 yrs) in order to be able to detect and identify long-term environmental trend and anomalies of the marine ecosystem. A ship survey is performed on a monthly and yearly basis at DYFAMED station for atmospheric and marine flux transfer to the surface and deep waters. CNR has also planned one 25 day long cruise for April-May 2014 with the objective of continuing the MEDOCC series, i.e. western basin-scale surveys through hydrographic multidisciplinary sections, closing sub-volumes of the basin, following a box-model approach to allow budget computations of mass, salt, heat and biogeochemical properties. The Ligurian section crosses the DYFAMED position.

**Site: LION mooring**

**Operated by: CNRS**

**PI:**

This deep-sea mooring is located in the center of the Gulf of Lion aiming to observe the winter convection affecting the north-western Mediterranean Sea water circulation and deep-sea ecosystem (physical data). The mooring is deployed near the ODAS meteorological surface buoy (Gulf of Lion) and integrated in the MOOSE network. Presently, MOOSE is combining Eulerian observatories, autonomous mobile platforms (profilers, gliders) and research vessels. The Eulerian observation is organized in one mooring site in which a ship survey is performed on monthly and annual basis (LION in the convective zone of Gulf of Lion, the annual ship survey of this site is referred to as MOOSE-GE). MOOSE operations have been reported as on-going. Under PERSEUS subtask 3.2.3 (REPEATED CRUISES OR SECTIONS IN THE WESTERN MEDITERRANEAN SEA: MOOSE ANNUAL CRUISES are performed by CNRS). High resolution (1m) profiles have be taken at each station measuring temperature, salinity, oxygen, fluorescence (chlorophyll), and beam attenuation. Water is sampled in water mass cores for nutrients, alkalinity, dissolved inorganic carbon, phytoplankton pigment.

## Eastern Mediterranean

**POSEIDON PYLOS (Dimitris Kassis, HCMR)**

**PI: Leonidas Perivoliotis**

The site has been a part of POSEIDON buoy network since 2008 and contributes to EuroSITES since 2009. It is located in the SE Ionian Sea and incorporates the steep marginal slopes and basins of the western segment of the Hellenic Arc and Trench System. It is a typical subduction zone that is the most geotectonically active region in Europe implying a complicated submarine morphology with numerous, deep, pull apart sub-basins and a variety of geohazards like high seicmicity, slope instabilities and basin wide tsunamis. The deep waters of the sub-basins of the Ionian are sensitive to climate changes since the deep sub-basins are the ultimate destination of dense water masses formed in the Adriatic and Aegean. Consequently the temperature, salinity and dissolved oxygen of bottom waters provide an archive of the interannual and long term variability of climatic forcing in the area. Furthermore, being the most oligotrophic European Sea the deep ecosystem is sensitive to climate changes. It is also well known that the Hellenic Trench is a major pathway and

important feeding ground for cetaceans in the Eastern Mediterranean (SE Sicily-SW Peloponnese-S Crete-W Cyprus). The central node of the system is the mooring line hosting sensors in its upper 1000m, and the surface buoy for real time telemetry and air-sea interaction measurements. An autonomous seabed platform hosts a set of sensors for near bed measurements including high frequency pressure for Tsunami detection. The platform communicates with the surface buoy through acoustic modems. Both systems are deployed at 1670m depth.

The system has been upgraded with a Passive Aquatic Listener (PAL) which consists of a high sensitivity microphone capable of recording the ambient sound field in the ocean. This information is a combination of natural and manmade sounds and reveals geo-physical, biological and anthropogenic processes in the ocean. Interpretation of the ambient sound field can be used to quantify these processes. PAL was deployed on the buoy's mooring line at 500m depth since the beginning of 2012 but it was removed on April 2013 due to technical problems with the surface mooring (fig. 6). It is planned to be redeployed during the summer of 2014.

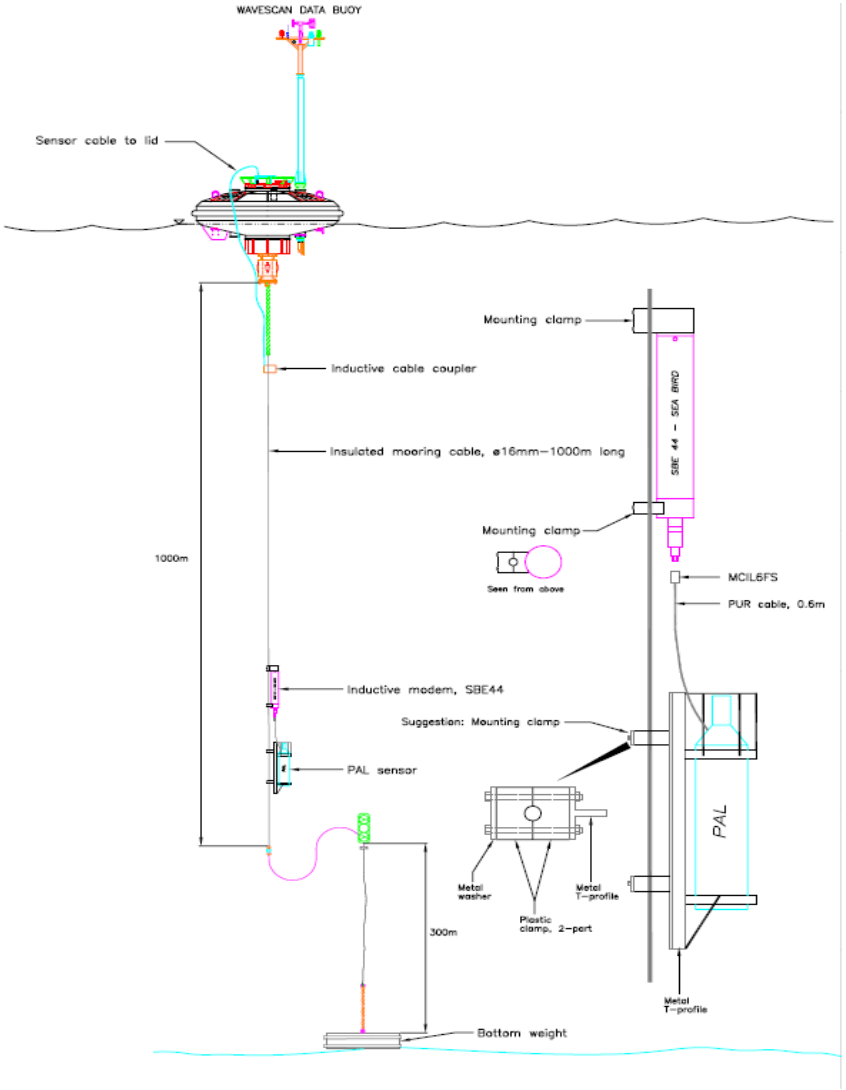



Figure 6. POSEIDON Pylos surface buoy and mooring line. PAL is attached on the inductive mooring line cable at approximately 500m depth

## POSEIDON ATHOS (Dimitris Kassis, HCMR)

### PI: Leonidas Perivoliotis

The observatory is located in the North Aegean basin at a depth of 330m. It is one of the three POSEIDON sites that monitors water column T&S properties apart from meteorological and sea surface parameters. The position of the site makes it ideal for studies regarding Black Sea and Mediterranean water masses exchanges. Inside PERSEUS project, Athos has been identified for upgrade with a PAL sensor (fig.7). The sensor would monitor anthropogenic and physical sea ambient noise and was deployed in September 2013 at 50m depth. The buoy's mooring line was cut off three months later; the instrument was recovered with minor damages and it has been redeployed successfully on the 20th of February 2014.

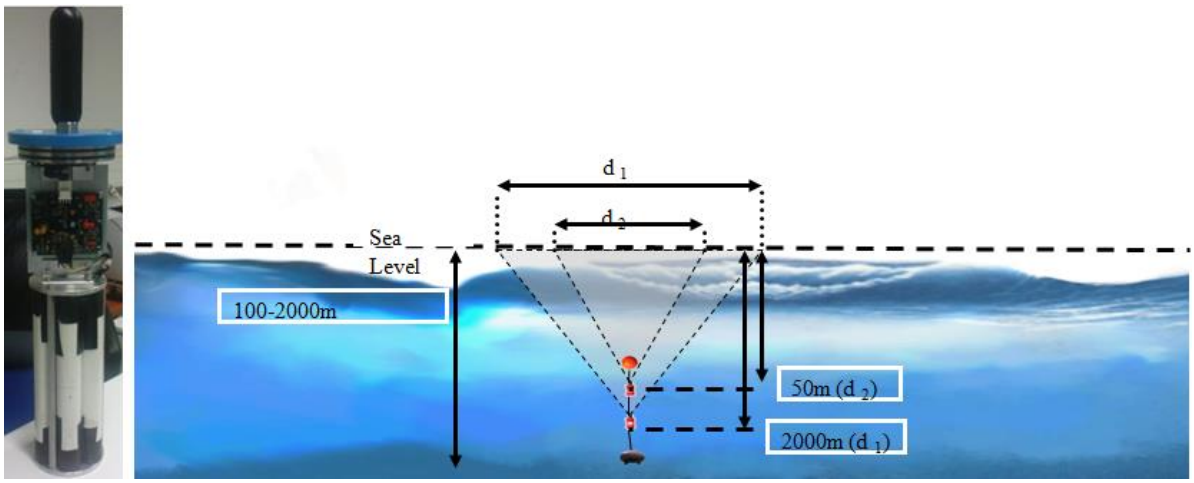



Figure 7. The Passive Aquatic Listener (PAL)

## E1M3A (Dimitris Kassis, HCMR)

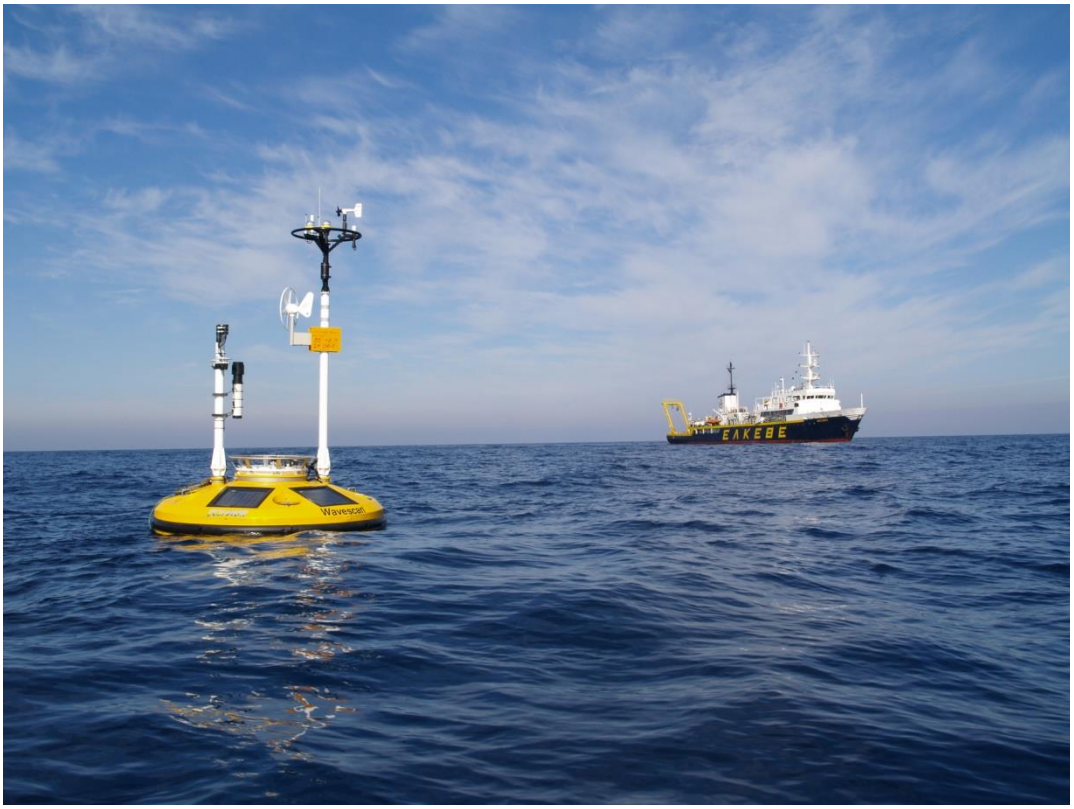
### PI: Leonidas Perivoliotis

E1-M3A observing system started in May 2007. The site has been deployed in the Cretan Sea in a transitional area with complex hydrology where water masses formed in the Levantine, the Aegean Sea and the Adriatic Seas meet and interact with the water masses of the Western Mediterranean Sea that enter through the Sicily straits. The platform, which has been upgraded through the POSEIDON II project, hosts a variety of different sensors measuring meteorological, physical and biochemical parameters. Due to an inductive mooring cable, CTD instruments are adjusted on the mooring line providing seawater salinity, temperature and pressure data down to 1000m depth. Biochemical parameters such as dissolved oxygen, chlorophyll-A, turbidity and PAR are also measured from the sea surface down to 100m depth.

Within PERSEUS, E1M3A is included in upgrade actions within subtask 3.2.3 since the monthly monitoring by R/V at the site are due to be upgraded. Repeated cruises are conducted by the HCMR to visit the E1-M3A mooring location to measure optical and physical (T, S) properties down to 150m depth and biochemical parameters (D.O, chl-a, PO4, Si, NO2, NO3, NH4) down to 100m depth.

In 2013 an upgrade of this monitoring was made in order to:

- cast deeper (down 900m depth) physical parameters (T, S) every ~6 months,
- include bacteria and zooplankton sampling at every visit,
- and sample deeper (120, 200, 500, 700, 900 m) biochemical parameters (D.O, PO4, Si, NO2, NO3, NH4) every ~6 months.




Picture 2. Repeated cruises in the South Aegean Sea (Cretan Sea) are conducted by the HCMR to visit the E1-M3A mooring location

## Selected Coastal Stations

**Site: Mesurho**

**Operated by: Ifremer**

**PI: Ivane Pairaud**

The MesuRho instrumented platform was installed at the Rhone River mouth (East Roustan buoy: 43°19.2N, 4°52E, 20 meters of water depth) in order to provide data in the fresh/saline water transition zone. It is dedicated to assess the river input and to study the impact of extreme events (floods, storms). Since June 2009, the MesuRho station (fig.8) provides near real time high frequency measurements. The system was initially equipped with two multi-parameter probes (one below the subsurface and one close to the sea bottom), a meteorological station, a photosynthetic active radiation sensor (PAR). Sampling and transmission interval has been set to 0.5 hour for all sensors. In 2012, the near real time transmission of data from an Acoustic Doppler Current Profiler (ADCP) was added (Figure1), and a nitrates sensor and a fixed benthic station with oxygen micro-electrodes for sediment mineralization studies were added. In the near future, subsurface and atmospheric sensors will be added for radioactivity monitoring in the framework of a national project.

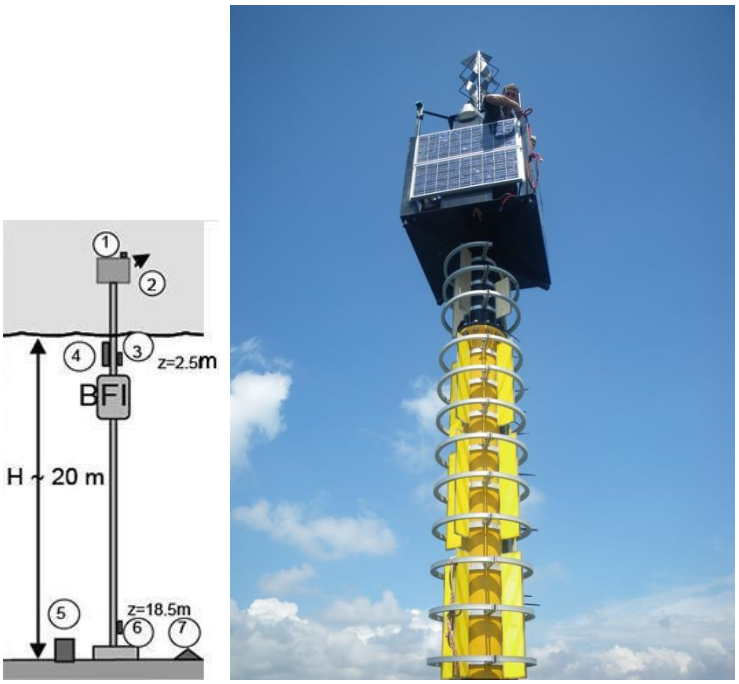



Figure 8. MesuRho observatory instrumentation: meteorological station + PAR (1), ABIN control and transmission (2), multi-parameter probes (temperature, pressure, conductivity, turbidity, fluorescence, dissolved oxygen) (3, 6), ISUS nitrate sensor (4), benthic station (5)

The following table presents the station's upgrades that were planned in the framework of PERSEUS:

| **Mooring Details**<br>**Name of site**<br>**WMO code** | **Sensor type Upgrade** | **Sensor Manuf/model** | **Instrument Depth [m]** | **Acquisition Interval** | **Real time/ Delayed mode** | **Budget allocated within Perseus** | **Planed Date of integration** |
|---|---|---|---|---|---|---|---|
| MESURHO<br>61284 | ADCP Currentmeter | Teledyne-RDI, 600kHz | 20 m | 30 min | Real time | NO | 12/2012 |
| | Laser granulometer | Sequoia, LISST T100X | 1.5 m | 30 min | Delayed mode | YES | 03/2013 |
| | Nitrates sensor | ISUS | 4 m | 30 min | Real time | YES | 09/2013 |

Table 2. Mesurho station upgrade plan

The ADCP was connected to the real-time transmission and technical issues were solved in 2013. Figure 2 illustrates the waves time series recorded in 2013.

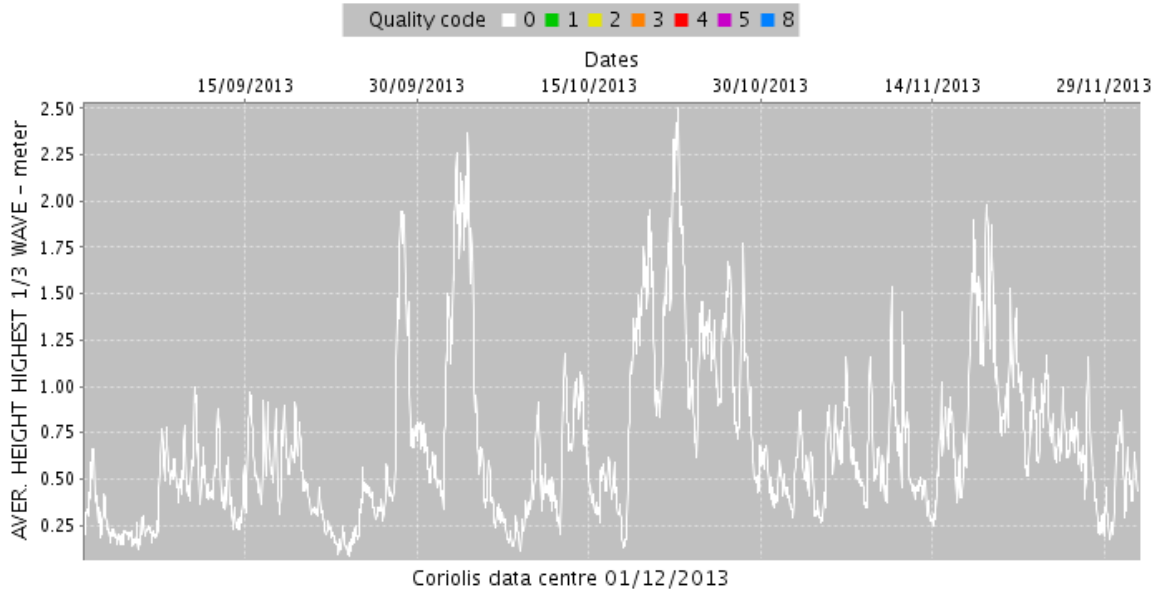



Figure 9. Waves time series measured by the ADCP and displayed by the near real-time interface for the period September-November 2013

Complementary data acquired during surveys from 2010 to 2013 were used to qualify and correct the temperature, salinity, fluorescence and turbidity time series. Data from the subsurface and bottom multi-parameter probes were compared to CTD data profiles including turbidity and fluorometer measurements. Results have shown that the temperature was slowly varying in time and space away from the buoy, whereas the turbidity, fluorescence and salinity were strongly varying both in time and space (J. Lachaise Master 2 training course).

Specific surveys were performed in April and July 2013 to acquire data very close to the buoy as the plume is rapidly diluted away from the coast, including CTD profiles and water samples at the depth of multi-parameter probes in order to get SPM and Chlorophyll-A quantification. A graphical interface has been developed using the matlab software for data post-processing and validation using different kind of data sources (files from the buoy, CTD profiles, ...) and different format (matlab and netcdf files) in collaboration with the MIO laboratory through sub-contracting. It will be made available for the project partners.

Figure 10 illustrates the entire surface temperature time series as an example, with corresponding temperatures from CTD profiles obtained during oceanographic cruises close to the MesuRho station. The comparison between the temperature measured by the SMATCH probe and the temperature measured by the CTD shows a good agreement between the two.

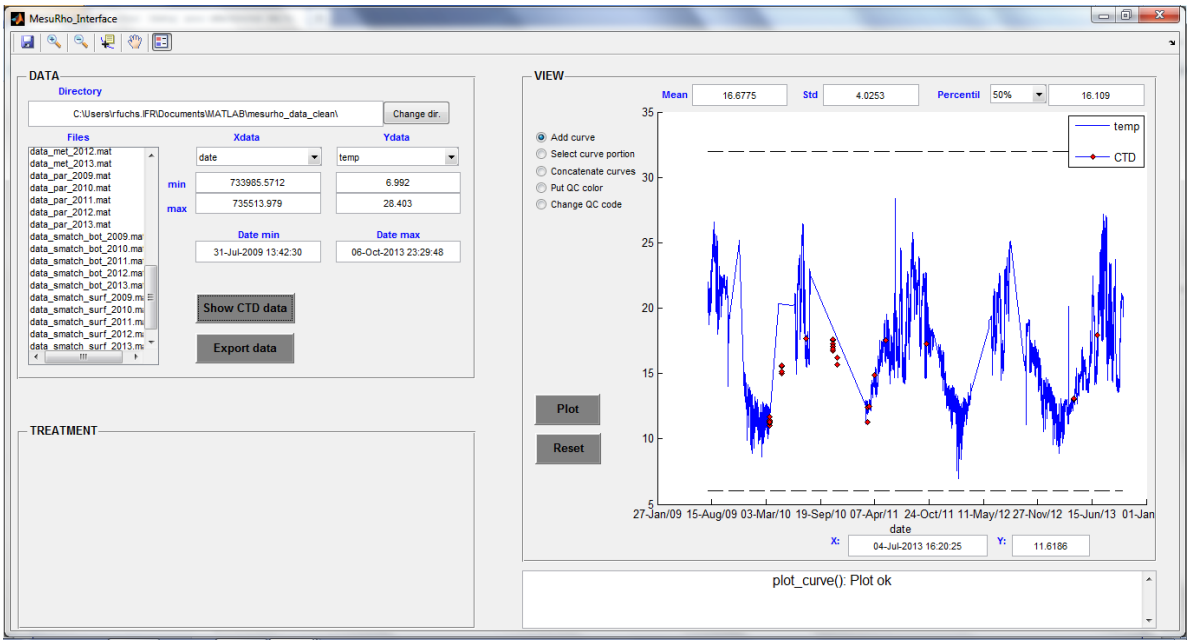



Figure 10. MesuRho subsurface temperature time series (blue) and temperature from CTD profiles (red) made close to the platform at the same depth (around 2.5 m depth) from July 2009 to October 13.

Problems reported during the upgrade actions are listed below:

a. The autonomous nitrates sensors was used at the MesuRho buoy for 2 years and a work on measurements showed that the nitrates concentration is driven by dilution close to the mouth, that is, no local consumption occurs between the nitrates concentration at the buoy and the upstream measurements in Arles in the river. Therefore the near real-time connection was not performed in 2013 as the sensor may not be needed.

b. A study on the salinity time series for the last two years showed that interferences are likely to occur when the two SMATCH probes are connected at the same time, resulting in conductivity and thus in salinity bias in the time series (Figure 10). Technical solutions (electrical isolation) are to be tested in late 2013 and early 2014 to solve the problem.

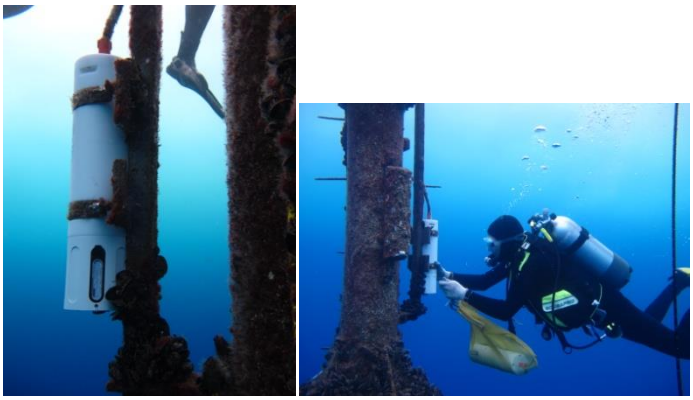
c. Real-time ADCP data transmission does not include the parameters needed for data qualification like Correlation, Percent Good or pitch and roll values. The need for these parameters to be transmitted in real-time was raised and addressed to the manufacturer (Teledyne-RDI).

Regarding near future planning the LISST is to be deployed during the next cruise TUCPA-Rhone on the ship L'Antedon that will take place at the Rhone River mouth in February 2014 in order to sample high turbidity associated with extreme events (floods, storms, etc.). The LISST was to be deployed in early 2013 but due to technical issues with the sensor, this was postponed.

The following pictures show the upgrade actions during testing and implementation:


Picture 3. Abin control and transmission

Picture 4. ADCP cage system



Picture 5. SMATCH multi-parameter probe

## Kastela - Bay (Vlado Dadic, IOF)

Buoy was set in the Kaštela Bay, Adriatic Sea at a water depth of 40 meters in order to provide "real time" oceanographic data in this coastal semi-closed and relatively polluted area. The oceanographic buoy was developed in the framework of the Croatian national oceanographic program (NOP) and deployed at the site in 2005. It

has measured standard meteorological parameters at a height of three meters above the sea surface, with more oceanographic parameters in the sea surface layers (0.5 meter depth) and current profiles in one meter tick layers along water column profile. Sampling and transmission interval has been set to either 10 minutes or one hour for all sensors, with data transmission in real time.

Regarding PERSEUS upgrades and taking into consideration that Kaštela Bay is a relatively rich marine area with nutrients, bio-fouling of the marine sensors is seen a substantial problem. Therefore, Aanderaa sensors for measuring oceanographic parameters (temperature, salinity and oxygen) were replaced by SeaCat-39 (Seabird, USA), multi-probe, which has a pumping system which is less sensitive to bio fouling.

Because of problems with power supply, AWAC-600 located at the sea bottom was replaced by downward looking RDI ADCP WHS-600, which was installed in the keel of buoy (figure 11).

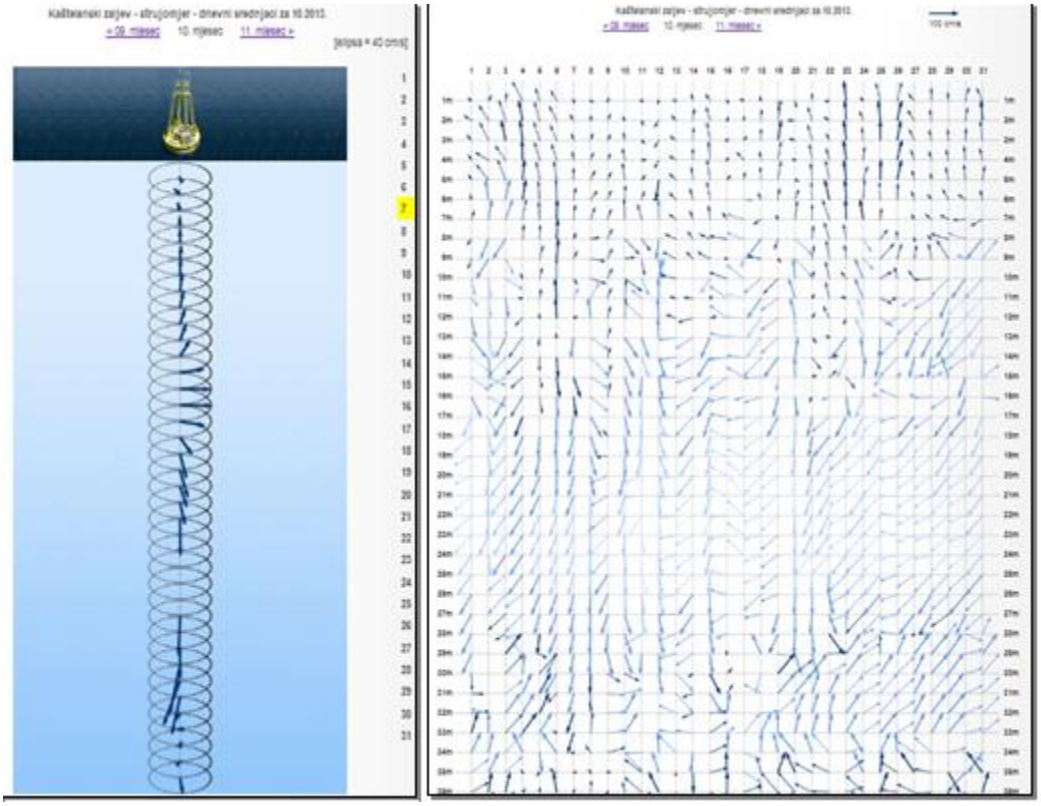


Figure 11. Graph with daily averages of currents vector (a) and daily current vectors (b) for October, 2013

In addition, FLNUTS sensor from WETLAB for measurement chlorophyll-A and turbidity was installed in June 2013. Unfortunately, during testing phase it was broken by leakage of salty water inside its body and now we are in process to find solution of this problem. This is due to be resolved during spring, 2014. In addition, there is plan to install more oceanographic sensors at the buoy in the near future.

## Additional Stations

### Cap de Creus & Minorca (Anna Sànchez Vidal & Miquel Canals UB)

University of Barcelona deployed and is maintaining two deep-water mooring stations.

**Cap de Creus mooring** station at 1000 m of water depth in the Cap de Creus Canyon, which is a critical pathway for the flow of dense shelf water from the Gulf of Lion shelf. The mooring includes a sequential sampling Technicap sediment trap at 25 m above the bottom and a Nortek Aquadopp current meter equipped with a Seapoint turbidity sensor 2 m below. This mooring has been in operation since the beginning of PERSEUS (Table 3).

**North Minorca mooring** station at 2052 m of water depth north of the island of Minorca, along the near-bottom, deep basin path of dense shelf water coming from the Gulf of Lion and the North Catalan margin. The mooring is equipped with a sequential sampling Technicap sediment trap at 25 m above the bottom, and a Nortek Aquadopp current meter equipped with a Seapoint turbidity sensor and a MicroCAT SBE37 with temperature and salinity sensors at 10 m above the bottom. This mooring has been in operation since September 2012 (Table 3, Pic. 6).

**Cap de Creus mooring**

Bottom depth (m): 1000m

Position (degrees east/north): 42°18.84N 3°33.53E

| Parameters | Depth | Sensor | Frequency | Units | Start Date | Servicing Freq. |
|---|---|---|---|---|---|---|
| Temperature | 23 mab | Nortek Aquadopp | 30 min | degrees C | Nov. 2009 | 6 months |
| Currents | 23 mab | Nortek Aquadopp | 30 min | cm/s | Nov. 2009 | 6 months |
| Particle fluxes | 25 mab | Technicap PPS3 | 15 days | mass flux | Nov. 2009 | 6 months |

Actions taken and progress so far: the mooring has been recording data every winter since the beginning of PERSEUS. It was recovered in June 2013 onboard the inspection vessel “Lluerna” (Generalitat de Catalunya), and the planned redeployment date is next November 2013.

**North Minorca mooring**

Bottom depth (m): 2052m

Position (degrees east/north): 40°28.05N 3°40.64E

| Parameters | Depth | Sensor | Frequency | Units | Start Date | Servicing Freq. |
|---|---|---|---|---|---|---|
| Temperature | 10 mab | SBE37 | 15 min | degrees C | Oct. 2012 | 1 year |
| Salinity | 10 mab | SBE37 | 15 min | PSU | Oct. 2012 | 1 year |
| Temperature | 10 mab | Nortek Aquadopp | 30 min | degrees C | Oct. 2012 | 1 year |
| Currents | 10 mab | Nortek Aquadopp | 30 min | cm/s | Oct. 2012 | 1 year |
| Particle fluxes | 25 mab | Technicap PPS3 | 15 days | mass flux | Oct. 2012 | 1 year |

Actions taken and progress so far: the mooring is actually recording the first period of data. The expected recovery and redeployment date is October 2013.

Table 3. Moorings serviced by Universitat de Barcelona


Picture 6. Photographs of the North Minorca mooring before deployment in October 2012 with the sediment trap, the current meter and the microcat SBE37. Wood (pine and oak) cubes used to study the organisms specifically associated with marine wood falls are also shown.

Site: EUXRo01-03 & EUXBg04-05 (Varna)

Operated by: Dan Secrieru, GeoEcoMar & Atanas Palazov IO-BAS (respectively)

This new network of stations is an upgrade of the Black Sea monitoring system since they are new deployments in the region. The **Black Sea Security System** was conceived as a complex system of natural monitoring and marine geohazards early warning system. The marine geohazards early warning system **Black Sea Security System** was realized in cooperation by Romania (GeoEcoMar) and Bulgaria (IO-BAS, Varna). The system was realized with European structural funds (85%) and national contributions (15%) within the program CBC Romania – Bulgaria 2007-2013 and it is operational starting from 2013.

The system consists of five moorings, three in Romanian waters (EUXRo01, EUXRo02, EUXRo03) and two in Bulgarian waters (EUXBg04 and EUXBg05), supplemented by a coastal measuring station (CG) in Romania waters at 15 m water depth in the Mangalia, close to the Romanian – Bulgarian border.

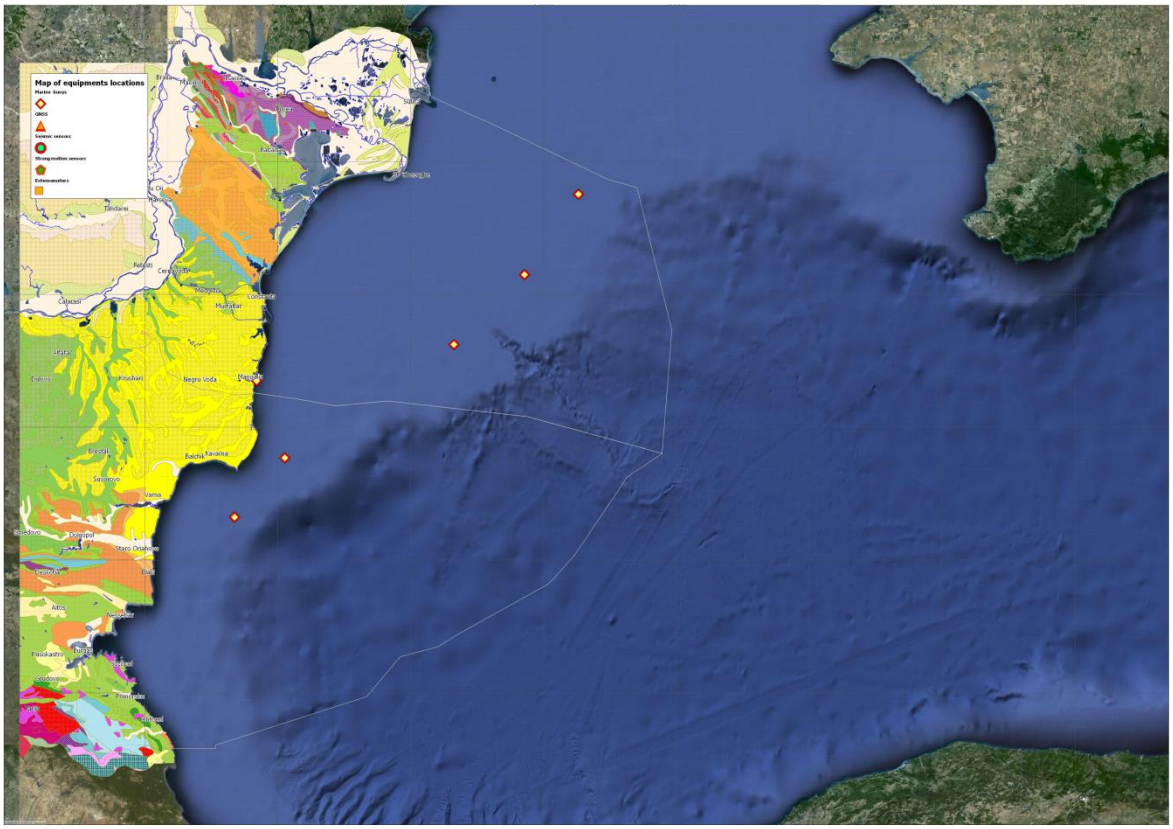
The system was completed in early May (see images) and, although fully functional, is still under testing and will remain in this stage until the end of 2013.

**Locations of the observatories** (see map)

| Station | Lat WGS84 | Long | Water depth (m) |
|---|---|---|---|
| EUXRo01 | 44.705943 | 30.778342 | 79.3 |
| EUXRo02 | 44.317831 | 30.413537 | 90.3 |
| EUXRo03 | 43.979127 | 29.936428 | 72.1 |
| Coastal Gauge (MEDA) | 43.802176 | 28.602483 | 15 |

| | | | |
|---|---|---|---|
| EUXBg04 | 43.425167 | 28.793000 | 76 |
| EUXBg05 | 43.133333 | 28.453000 | 77 |

Table 4. Location and depth of the platforms




Picture 7. Location of the moored observatories of the EUXINUS system

Picture 8. The deployment of the buoys

| Mooring Details Name of site WMO code | Sensor type | Sensor Manuf/model | Instrument Depth [m] | Acquisition Interval | Real time/ Delayed mode |
|---|---|---|---|---|---|
| EUXRo01 | Weather station: wind speed and direction, temperature, pressure, relative humidity | Climatronics P/N 102780 | 4 m above sea level | 1 hour/real time if event | Near real time |
| | Doppler current meter | Z Pulse (4420) | 5 | 1 hour/real time if event | Near real time |
| | Oxygen | AADI Optode 4835 | | 1 hour/real time if event | |
| | Temperature | AADI 4880/4880R | | 1 hour/real time if event | |
| | Conductivity | AADI 4319 | | 1 hour/real time if event | |
| | Turbidity | AADI 4112 | | 1 hour/real time if event | |
| | Pressure | AADI 4646/4646R | | 1 hour/real time if event | |
| | Chlorophyll *a* | CYCLOPS–7 | | 1 hour/real time if event | |
| | Doppler current meter | Z Pulse (4420) | ≈59 | 1 hour/real time if event | |
| | Pressure | AADI 4646/4646R | | 1 hour/real time if event | |
| | Temperature | AADI 4880/4880R | | 1 hour/real time if event | |
| | Conductivity | AADI 4319 | | 1 hour/real time if event | |
| | Tsunameter | Digiquartz absolute pressure transducers | Bottom (79.3 m) | 15 min/real time if event | |

Table 5. Configuration of the EUXRo01 mooring

Varna stations EUXBg04 – 05 will also be equipped with a variety of oceanographic sensors as shown in Table 6:

| Mooring Details Name of site WMO code | Sensor type Upgrade | Sensor Manuf/model | Instrument Depth [m] | Acquisition Interval | Real time/ Delayed mode | Budget allocated within Perseus | Planed Date of integration |
|---|---|---|---|---|---|---|---|
| EUXBg04-1<br>ϕ = 43°25'51"N | Automatic weather station<br>Ultrasonic | ALL IN ONE CLIMATRONICS | 4 m above sea level | 1 Hour | Real time | NO | April 2014 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| λ = 028°47'58"E | wind speed and direction sensor<br>Air temperature sensor<br>Pressure sensor<br>Relative Humidity Sensor | | | | | | |
| | Doppler 3D current meter, Oxygen, Temperature, Conductivity, Turbidity, Pressure and Chlorophyll | Aanderaa SEAGUARD RCM | 5 | 1 Hour | Real time | NO | March 2014 |
| | Tsunameter | ParoScientific Digiquartz Pressure Sensor model 46K-101 | 76 | On event | Real time | NO | March 2014 |
| | Doppler 3D current meter, Temperature, Conductivity and Pressure sensors | Aanderaa SEAGUARD RCM | 76 | 1 Hour | Real time | NO | March 2014 |
| EUXBg05-2<br><br>ϕ = 43°08'00"N<br>λ = 028°27'18"E | Doppler 3D current meter, Oxygen, Temperature, Conductivity, Turbidity, Pressure and Chlorophyll | Aanderaa SEAGUARD RCM | 5 | 1 Hour | Real time | NO | March 2014 |
| | Tsunameter | ParoScientific Digiquartz Pressure Sensor model 46K-101 | 76 | On event | Real time | NO | March 2014 |
| | Doppler 3D current meter, Temperature, Conductivity and Pressure sensors | Aanderaa SEAGUARD RCM | 76 | 1 Hour | Real time | NO | March 2014 |

Table 6. The planned upgrades of stations EUXBg04 and EUXBg05

Regarding near future planning, PIs will acquire WMO numbers for the buoys, integrate the system in the ICG/NEAMTWS and obtain for the system the status of "special installation of national interest" which will support its maintenance and functionality. Regarding data transmission the two data centers, one in IO-BAS –

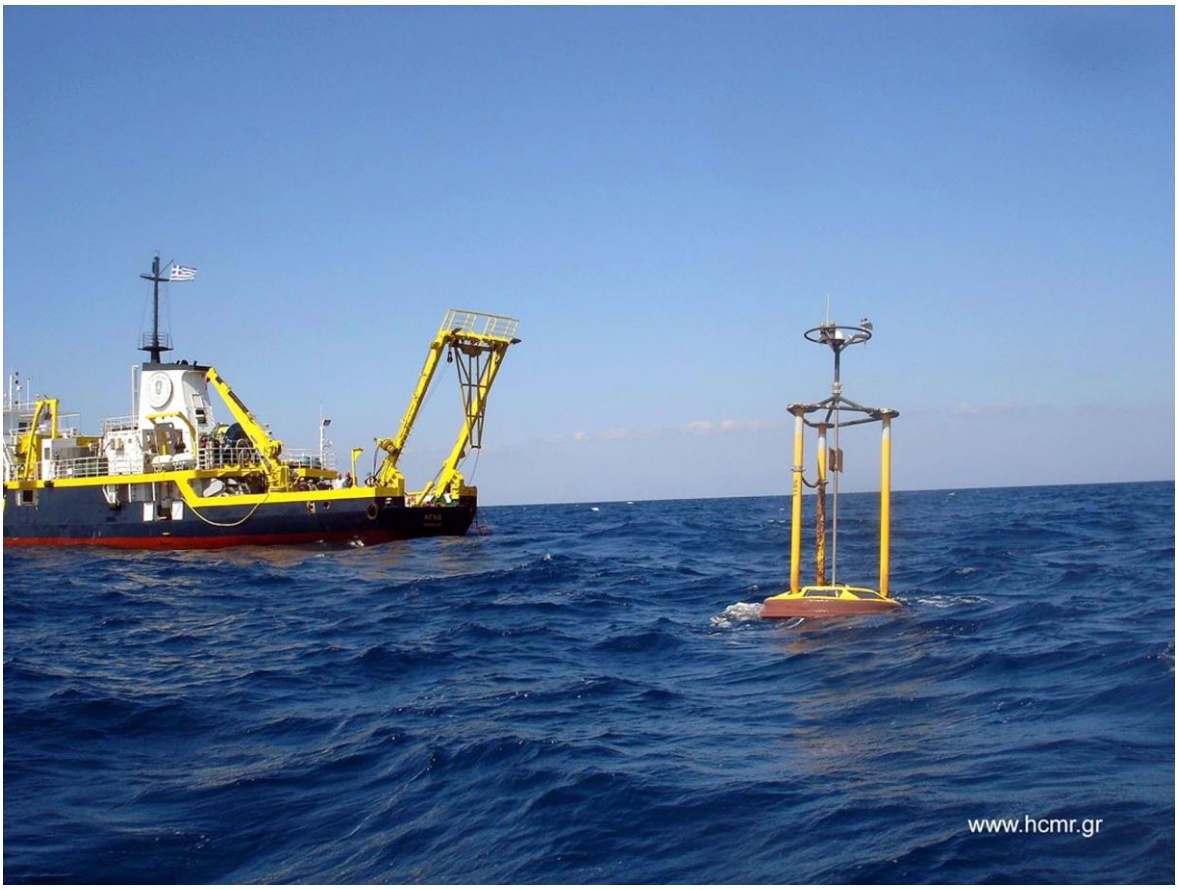
Varna and one in GeoEcoMar – Constanţa receive the data from the system on a 24 hours/7 days basis.

**Site: POSEIDON Saronicos**

**Operated by: HCMR**

**PI: Dimitris Kassis**

Saronicos buoy is located approximately 10nm from Piraeus port in the Gulf of Saronicos at a depth of 250m. It is a part of POSEIDON buoy network since 2007 and is a surface mooring with additional biochemical sensors tested such as pH sensor. Within Perseus, Saronicos buoy contributes in mooring upgrade actions with the integration of a Passive Aquatic Listener (PAL) sensor focused on measuring anthropogenic noise in the sea since the gulf presents high level of ship traffic. The sensor has been deployed successfully during the last maintenance cruise on February 2014. Additional multi-parameter measurements are ongoing with a R/V on a monthly basis.




Picture 9. Deployment of a PAL sensor on Saronicos Buoy (February 2013)

**Site: Ibiza Channel Mooring (Ibiza)**

**Operated by: SOCIB/CSIC**

**PI: Joaquín Tintoré**

The Ibiza Channel Buoy is located mid channel under 700 m depth at N38º 49.46' E0º 47.07'. It is a multipurpose environmental monitoring platform outfitted with a wide range of sensors and was deployed in September 2013 providing met-ocean near-real time data. The manufacturer of the platform is AXYS and the model of the buoy is WatchMate.

This buoy monitors atmospheric parameters (wind speed, wind gust, wind direction, air temperature, atmospheric pressure, relative humidity, and net solar radiation) and oceanic parameters: wave height (TriAxys DWS), conductivity and temperature (Seabird SBE37) at the surface, 60m and 100m (RBR duoCT), multi-parametric probe (YSI 6600), single point current meter at 1m depth (FSI), Doppler current profiler (Sontek 150Khz), and thermistor string with sensors from the surface to 100m depth (fig. 12).

All parameters are measured at 20 minute intervals, minimum.

These data (available through the SOCIB web site in real time and some through SOCIB smartphone apps) are used for scientific (including operational model forecast), commercial (cruise liners) and recreational (such as sailing) purposes.

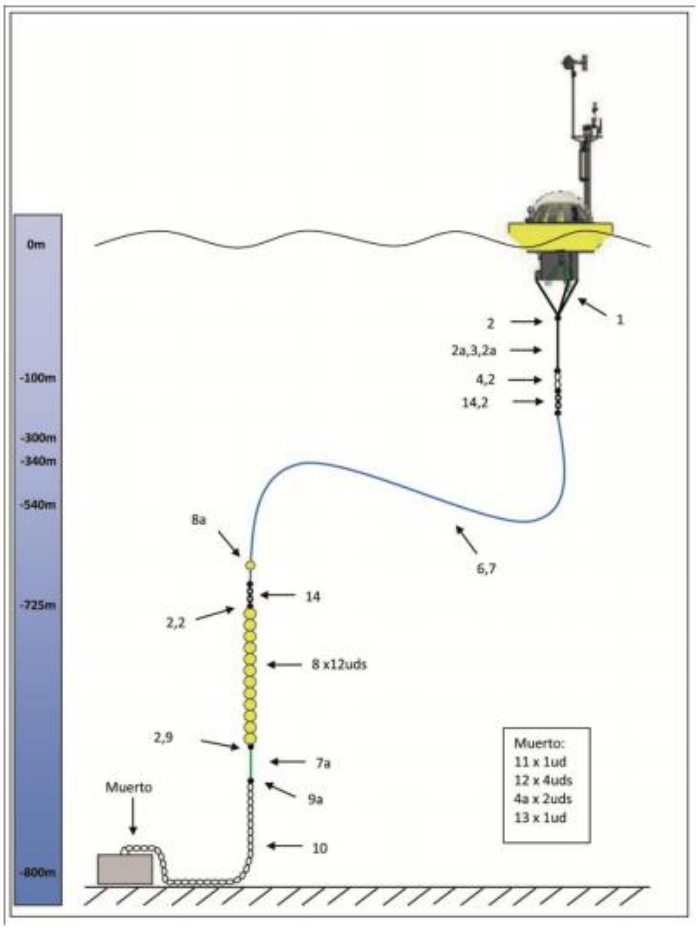


Figure 12. Schematic of the Ibiza Channel mooring

**Site: Palma Bay Mooring (Mallorca)**

**Operated by: SOCIB/CSIC**

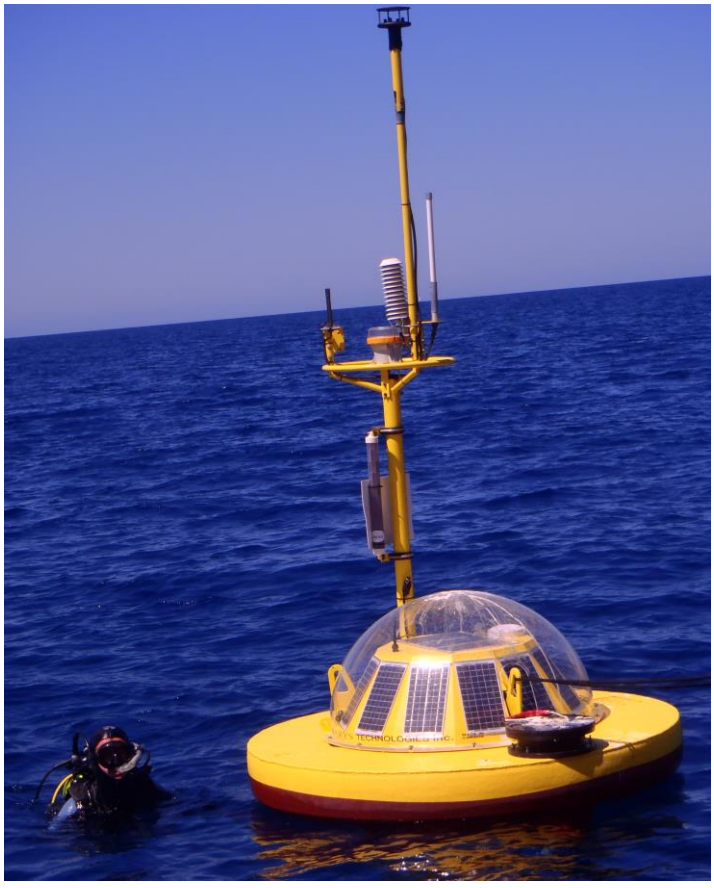
**PI: Joaquín Tintoré**

The Palma Bay Buoy (N39º 29.57' E2º 42.02') was deployed on May 2012 in order to monitor met-ocean data in a key touristic environment in near-real time. The buoy is a multipurpose environmental monitoring platform outfitted with a wide range of sensors. The manufacturer of the platform is AXYS and the buoy is WatchMate (pic.10).

This buoy monitors atmospheric parameters (wind speed, wind gust, wind direction, air temperature, atmospheric pressure, relative humidity, and net solar radiation) and oceanic parameters; wave height (TriAxys DWS), conductivity and temperature (Seabird SBE37), a multi-parametric probe (YSI 6600), single point current meter at 1m depth (FSI) and Doppler current profiler (Sontek 300Khz) (fig.13).

These data are very useful for commercial (cruise liners and harbor operations), recreational purposes (navigation, divers, and beach management) and also provides a continuous stream of data to the scientific community.

All parameters are measured at 20 minute intervals, minimum.



Picture 10. Image of the Palma Bay mooring

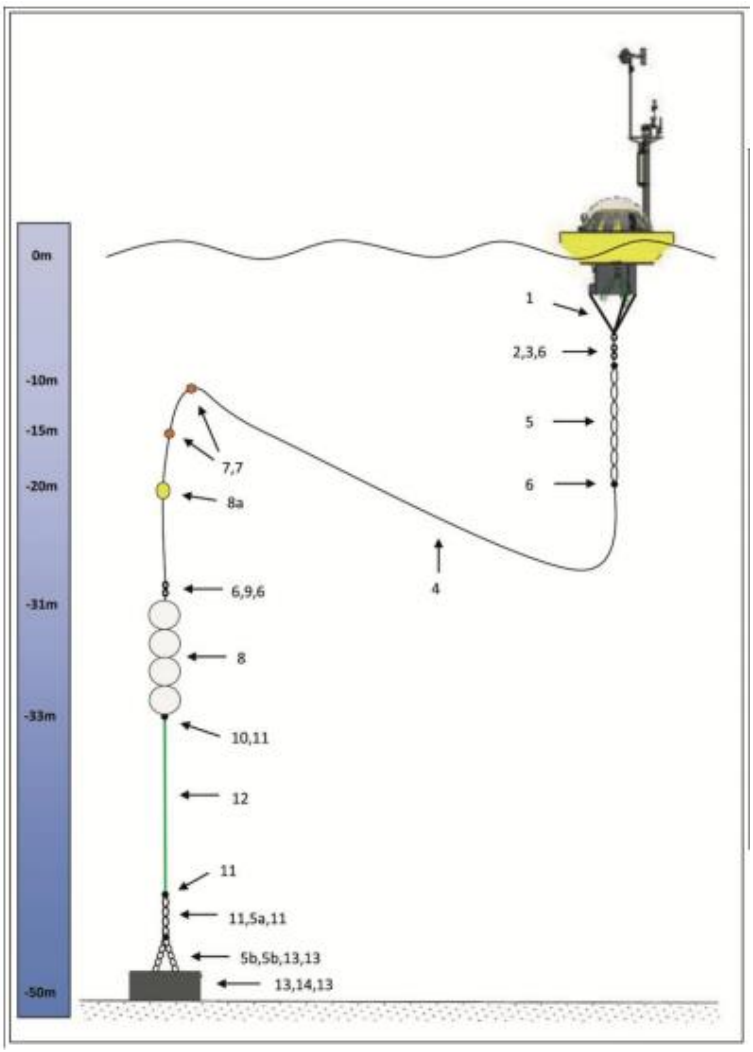



Figure 13. Schematic of the Palma Bay mooring

**Site: Mahon Harbor Coastal Station (Menorca)**

**Operated by: SOCIB/CSIC**

**PI: Joaquín Tintoré**

In June 2011, a coastal station was deployed at the Estación Biológica Jaume Ferrer (operated by IEO) at the entrance of Mahon harbor on the East coast of Menorca Island. This station is equipped whit one current profiler (Nortek Aquadopp 1MHz) located on the bottom (20m depth) looking upward and two conductivity and temperature recorders (Seabird SBE37) at 10m and 20m depths (fig.14). An atmospheric pressure sensor (Vaisala PTB 330) is installed in the station. All instruments are connected via cable to a shore station, where a computer acts as data logger and sends data to SOCIB.

All parameters are measured at 20 minute intervals, minimum.

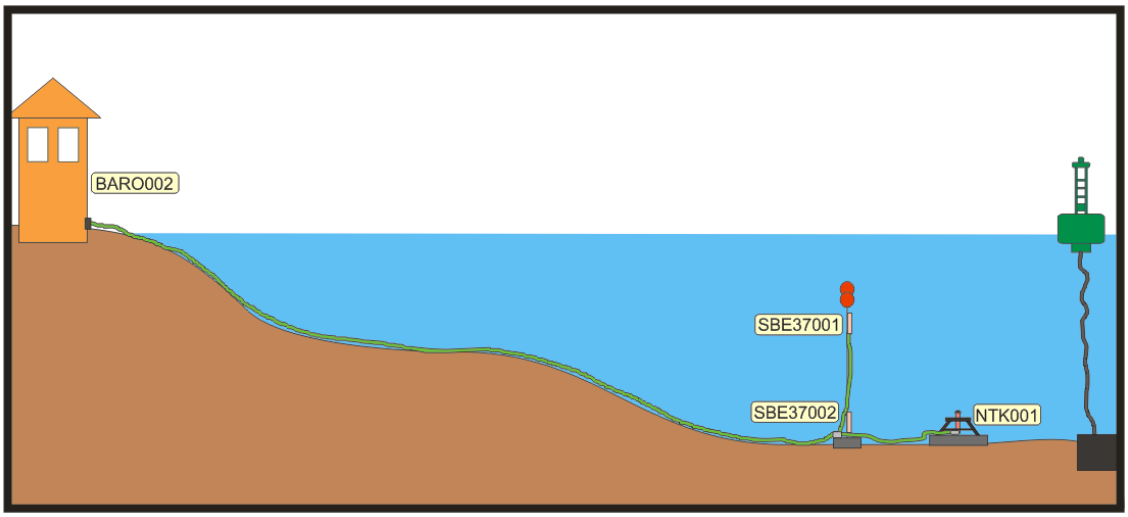



Figure 14. Schematic of the Mahon Harbor Coastal Station

## Summary - contribution and future recommendations

New sensors and platforms technologies now enable a new variety of important real time observations. These, combined with numerical models and data assimilation, create the baseline for the development of a new form of Integrated Coastal and Ocean Management in response to society needs.

PERSEUS Task 3.2 is of great importance, as the upgrade of observing capacities will allow a quantitative increase in our understanding of the SES regarding key questions on oceans and climate change, coastal ocean processes, and ecosystem variability (as described in WP1, WP2 and WP4), and will act as a driver towards a more science-based coastal and ocean management in these two key basins (WP5 and WP6).

Several indicators for the Good Environmental Status (GES) will require significant contribution from the in-situ observing components in order to be addressed. The estimation of qualitative descriptors such as eutrophication, alternations of hydrography and noise, are some examples of how in-situ observations can contribute to MSFD. In order to achieve this, ocean monitoring operations need to be consistently maintained over the long-term, integrate a variety of data and have make the data freely available. This is absolutely essential if key questions regarding climate change, coastal ocean processes, ecosystem variability are to be answered, and to improve the estimates of current ocean states and constrain model predictions, thus contributing to the proper implementation of GES as required by the MSFD.

There has been major effort during the last 18 months to achieve the goal of upgrading the selected observatories in order to expand the present observing capacity in the SES. Although some problems were raised and several delays reported, the majority of the new sensor deployments and testing has been accomplished on

time. Furthermore a number of additional stations have been added, expanding the geographical coverage and the number of upgraded platforms.

Following PERSEUS DOW and the output of Task 3.1 (PERSEUS D3.1 P.M. Poulain et al., 2013), recommendations have been addressed with the introduction of new sensor technology (optical, acoustic, etc.) and additionally the monitoring of new parameters has been initiated through the plurality of the new state of the art instruments that have been implemented. Nevertheless there are some remaining concerns regarding future planning and expansion of observing capacities in the Mediterranean and Black Sea namely:

a) The homogenization of data management policy, which includes common data quality procedures, metadata description, common vocabularies etc.
b) The still poor geographical coverage in important sub basins in the SES (Levantine, Central-South basin etc.), which are understudied in terms of a fixed point continuous monitoring
c) The lack of sufficient, sustained, long term funding for maintenance and upgrades.

Point a) will be at least partially addressed within the frame work of WP3 Task 3.4 Data Management, however the PERSEUS contribution to upgrading the observing capacity in the SES can only constitute a part of what needs to be more fully addressed by the oceanographic community in order to achieve a sufficient and reliable in situ monitoring infrastructure. The upgrade process should be continuous and well planned, at a national and European level, in order to move towards the fulfillment of the scientific and society needs with an emphasis on the characterization of the present state, increasing forecasting capabilities and the provision of solid grounds for the implementation of MSFD.



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