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The Italian Fixed-point Observatory Network for marine environmental monitoring – IFON

State of the art and upgrades during the Italian flagship project RITMARE (2012 – 2016)

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Abstract **– The Italian Fixed-point Observatory Network (IFON) integrates well-established ocean infrastructures managed by various national research institutions (CNR, OGS, and ENEA). The implementation of this network was one of the aim of the SP5-WP3 of the Flagship Project RITMARE. In the first four years of the project, the state of art of the 15 operative sites has been completed and 2 more stations are operative from 2015-2016. For each site, the technical characteristics and methods of transmission have been described, and for some sites, several upgrades were accomplished in order to develop, integrate, and consolidate the network. Periodically, oceanographic cruises for the maintenance and implementation of the sites were carried out.**

After the definition of the minimum requirements, the criteria for the validation of physical and biogeochemical data were determined. They include a selection of existing rules, procedures and recommendations on automatic data Quality Control (QC), and their validation in Near Real Time (NRT). These procedures are intended to unify the validation criteria of the parameters collected daily from the network and to provide the scientific community with a homogeneous and comparable set of data of the Italian seas. Within the WP3, a relocatable observing system for emergencies at sea was implemented. Some new instruments were bought and some others were upgraded. In addition, the IFON was enriched with an air-sea observatory in Lampedusa Island with a new buoy deployed during summer 2015.

I. INTRODUCTION

The Italian Fixed-Point Observatory Network (IFON) integrates the well-established ocean infrastructures managed by numerous national research institutions [1]. Within the framework of the Italian Flagship Project Ricerca Italiana per il mare (RITMARE), the main aims of Work Package 3 (WP3, Italian scientific network of fixed sites for sea observation) were the development, integration and consolidation of IFON. WP3 was part of SubProject5 (SP5), which focused on observation systems for the Italian seas with the goal of reinforcing and combining them following the concepts of 'integrated network' and 'observatories'. The main target of WP3 was to create a common, validated IFON database accessible both within the IFON network and for external users following the rules proposed in the RITMARE data policy [2].

II. THE ITALIAN FIXED-POINT OBSERVATORY NETWORK (IFON)

IFON integrates 15 fixed monitoring systems, with another one operative from 2015, and an oceanographic transect (Senigallia–Susak; Figure 1), providing multidisciplinary monitoring of coastal and deep marine environments, with high temporal resolution, for a number of marine and atmospheric variables. Next section shows a brief description of the different systems and sites. The locations and parameters measured by the systems are listed in Ravaioli et al., 2016 [1].

A. MAMBO meteoceanographic buoy (Norther Adriatic)

The Environmental Operative Monitoring (MAMBO), operative since 1998, is located at the outer limit of the Marine Protected Area of Miramare (Gulf of Trieste) over a bottom depth of 18 m and provides near real time (NRT) data acquired at a half-hour frequency. The system is equipped with surface meteorological sensors to measure atmospheric pressure, air temperature and humidity, wind speed and direction, and incident PAR radiation, and oceanographic sensors to measure temperature, salinity, dissolved oxygen and pH at both 1 and 10 m depth, and pCO2, turbidity and chlorophyll-a at 10 m depth. MAMBO is part of the coastal marine observatory site of the Gulf of Trieste which also includes a biological time-series station which is sampled on a monthly basis for the acquisition of biological and biogeochemical data.

B. PALOMA mast platform (Norther Adriatic)

The Advanced Platform Oceanographic Laboratory Adriatic Sea (PALOMA) mast platform is located 12 km offshore in the centre of the Gulf of Trieste at a bottom depth of 25 m. The system acquires meteorological data, atmospheric CO2 concentration at 10 m above the mean sea level, seawater pCO2, temperature, salinity dissolved oxygen at 3 m water depth, and temperature at 15 m and 24 m depths. Atmospheric CO2 is acquired every 2 h, seawater pCO2 every 6 h and the other parameters every 10 to 15 min. The site has been implemented with a focus on air-sea CO2 fluxes and instrumental data are integrated with monthly ship surveys to measure the inorganic carbon species and the main biogeochemical parameters along the water column [3].

C. Acqua Alta oceanographic tower (Norther Adriatic)

The Acqua Alta oceanographic tower is located 15 km offshore of Venice in the northern Adriatic Sea, at a bottom depth of 16 m. The platform is fully equipped with a large set of autonomous instrumentations that acquire atmospheric, hydrological and oceanographic data with several meteorological stations and sensors (including different measurement systems of waves and currents). At the site, biological and chemical measurements are routinely acquired, with periodic sampling of the water column.

D. S1-GB dynamic pylon and E1 meteoceanographic buoy (Norther Adriatic)

The S1-GB dynamic pylon (Ex S1 buoy) is located 5 km offshore of the Po River delta, over a bottom depth of 21.3 m. The station acquired meteorological data at 8.5 m above the mean sea level and oceanographic data at 1.6 m (superficial level) and 18 m (deep level) depths. The S1-GB pylon is located in a key monitoring area for studying the interaction between the northern Adriatic Sea and the Po River [4]. The E1 buoy is located 4 km offshore of Rimini City, over a bottom depth of 10.5 m. The station E1 accommodates meteorological instrumentation at 2.5 m above the mean sea level and oceanographic sensors at two water depths: 1.5 m and 8 m. The E1 site is a key monitoring point for studying hypoxic and anoxic events in the north Adriatic Basin and for validating "ocean colour" satellite observation with in situ data [5]. Both the stations are autonomous and equipped with data-loggers, NRT transmission devices and a power systems.

E. Senigallia–Susak Transect and Tele–Senigallia pylon (Central Adriatic)

The section from Senigallia to Susak Island (Central Adriatic) has been periodically surveyed since 1988 in order to collect Conductivity, Temperature and Depth (CTD) data and samples for dissolved oxygen and Nutrient analyses [6].

The Tele–Senigallia pylon is located at the western edge of the Senigallia–Susak transect. It is equipped with a meteorological station and several oceanographic sensors at water depths of 2 m, 5 m and 12 m. The joint system is in a key area to observe near-coastal processes (upwelling, stratifications, biological productivity) and the water masses transiting to or from the northern Adriatic.

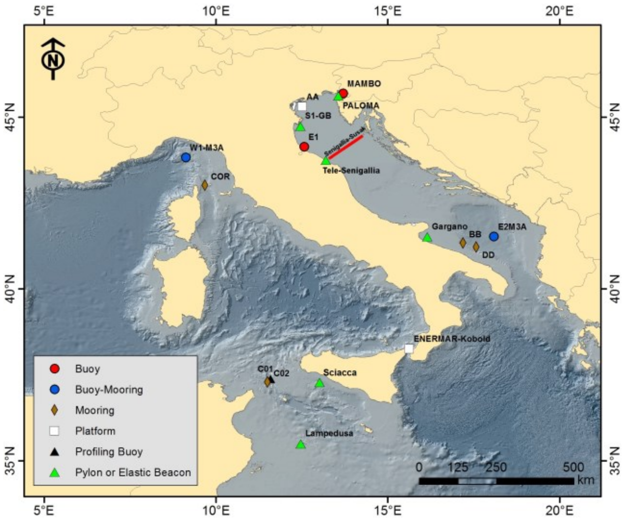

Fig. 1. Map of the site location of the Italian Fixed-Point Observatory Network (IFON), modified from Ravaioli et al., 2016. [1]

F. Gargano pylon (Southern Adriatic)

The Gargano pylon is a coastal buoy located in the Gulf of Manfredonia (southern Adriatic Sea) at about 10 nautical miles from the coast at a bottom depth of 17 m. The Gargano pylon is equipped with a data-logger, a meteorological station, a sea-surface temperature sensor (2 m depth), a CTD probe and oxygen-turbidity-chlorophyll, CDOM sensors at 5 m depth and a current meter at 17 m depth.

G. E2M3A observatory (Southern Adriatic)

The E2M3Aobservatory is located in the deepest part of the southern Adriatic. It is a two-component array, composed by a surface buoy allowing real-time data transmission and a subsurface mooring. The E2M3A is equipped with physical and chemical sensors at different nominal depths (2, 15,350,550, 750, 900, 1000, and 1200 m) and acoustic current profilers located at 320 m and 1200 m. The observatory has been deployed with the aim of monitoring air-sea interactions and the physical as well as biochemical properties of the water mass, as well as investigating the convective events in the open sea [7].

H. Moorings BB and DD (Southern Adriatic)

Two subsurface moorings, located in the Bari canyon (site BB) and on a sediment wave field (site DD) along the dispersal path of the descending north Adriatic Dense Water (NAdDW), have been deployed for the long-term monitoring of the dense water cascading able to transfer sediment, O2, nutrients and organic compounds to the benthic ecosystems of the deep southern Adriatic. Mooring instrumentations are self-recording (data in delay mode) and get serviced twice a year.

I. Kobold platform (Straits of Messina)

The Kobold platform is a prototype to study the potential of extracting energy from marine currents. The plant is moored at 25 m depth in the Straits of Messina, Italy, where tidal currents are the strongest in the Mediterranean Sea. The Kobold platform hosts an automatic monitoring system including a meteorological station, a sea surface temperature sensor and an Acoustic Doppler Current Profiler (ADCP) that provides NRT data to the turbine controller.

J. Moorings in the Corsica and Sicily Channels and the 'Yo-Yo' profiling buoy system

The Corsica and Sicily Channels are monitored by three underwater stations: CORS01, located at the Corsica Channel sill at a depth of 450 m (established in 1985), and C01 and C02, located at the western Sicily Channel sill, between Sicily and Tunisia, on the Sicilian side at a depth of 350 m (C01) and on the Tunisian side at a depth of 530 m (C02). The moorings were first deployed in 1993. They are equipped with single point current meters, ADCPs and fixed CTD probes, and provide long-term monitoring of surface and intermediate water mass exchanges through the channels, along with their hydrological characteristics. Mooring instrumentations are self-recording (data in delay mode) and get serviced twice a year. In June 2013 and for about four months, the CORS01 was the test site for an autonomous profiling buoy system named 'Yo-Yo', transmitting daily hydrological vertical profiles in NRT through the built-in Iridium transceiver. In November 2014 the Yoyo system was installed in C01. However the strong currents crossing the Sicily Channel are a serious issue for profiling autonomous devices. For this reason presently the system has again been relocated to the Corsica Channel.

K. W1M3A multidisciplinary observatory (Ligurian Sea)

The W1M3A observatory is constituted of a spar buoy and a subsurface mooring close by and it is moored in the Ligurian Sea (seabed of 1200 m, 80 km from the coast). Its position and structural characteristics make the system ideal for conducting air-sea interactions studies. The fixed platform monitors a complete set of near-surface meteorological parameters on a long-term basis, as well as physical and biogeochemical variables form the surface down to the ocean interior (0–1000 m depth). All measurements collected by the sensors installed on the surface buoy are transmitted ashore in NRT [8].

L. Sciacca beacon and Lampedusa air-sea Observatory (Sicily Channels)

The Sciacca elastic beacon was installed at the end of October 2014 in the Sicily Channel, 10 nautical miles offshore the Sicily coasts at a bottom depth of 54 m and became operative in 2015. The onboard instrumentations included a meteorological station, several oceanographic sensors and a suite of radiometers. Unfortunately after a collision in June 2015, the structure suffered significant damage both to the emerged and the submersible part. This has led to the loss of the entire structure.

South of the Sicily Channel, close to the island of Lampedusa, an elastic beacon was setup in August 2015 to investigate the air-sea interactions and the water column. The Oceanographic Observatory (bottom depth of 74 m) also complements atmospheric observations carried out at the Atmospheric Observatory on the island of Lampedusa (http://www.lampedusa.enea.it), about 15 km North-East of the buoy. The Lampedusa Oceanographic Observatory hosts instruments to measure the surface energy budget, including a meteorological station, sensors for ocean temperature at various depths, and a CTD. In addition, part of the instruments which were expected to operate on the Sciacca beacon, and in particular the suite of radiometers for the ocean colour at two depths and at the surface, have been transferred to the Lampedusa beacon.

M. Relocatable systems

A relocatable observation system consists of a number of moorings equipped with oceanographic instruments suitably configured in terms of sampling quote and data acquisition frequency. They can be properly deployed in a study area to capture the maximum spatial and temporal variability in order to solve a specific problem, whether it is of a scientific nature or a natural or anthropic event, more or less catastrophic (eg. Haven disaster, Genoa flood, Cinque Terre flood, Panarea thermal vents, Stromboli tsunami, etc.). The deployment, in a specific area, of several moorings, that acquire high-resolution data, may serve to monitor, on a preventative basis, the oceanographic properties of the site, in order to better define the final configuration and location of the mooring to best capture variability scales to determine the representativeness of data before investing in long-time series.

III. QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

The IFON network is implemented in order to ensure high-quality real-time observations based on common procedures (sensor calibration, quality control – QC and quality assurance - QA) for all the variables included in the essential ocean variables (EOVs) [9]. The application of common real time QC procedures for all fixed observing sites of the IFON network ensure a high quality of data distributed to users through exchanges at the national and international levels [10].

IV. DATA MANAGEMENT

A. The database IFON RITMARE-SP5

The creation of the IFON has created the need to build a data repository infrastructure to support the RITMARE portal to handle Near Real-Time (NTR) data provided by moorings, floats and glider (Figure 2). The collected data are made accessible through standards and formats proposed by the Open Geospatial Consortium (OGC) and compliant with the US Integrated Ocean Observing System (IOS). Data are collected in a NetCDF format coded according to international standards compliant with OceanSites encoding and are made available through a web data server THREDDS (TDS). The latter guarantees the use of standard protocols such as OPeNDAP, OGC WMS and WCS. The repository implements some features of the COPERNICUS In-situ TAC as receiving NRT data in NetCDF-CF, providing a portal access point in real time [11]

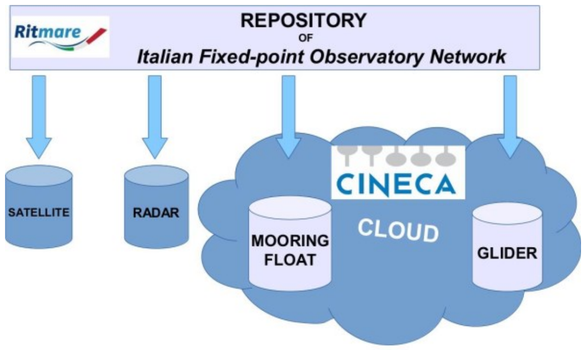

Fig. 2. Structure schema of the RITMARE portal of Italian Fixed-Point Observatory Network (IFON).

B. Towards an integrated system of interoperable and diffused data

In the context of the collaboration between RITMARE SP5 and SP7 (Interoperable Infrastructure for the Observation Network and Marine Data), the software package GET-IT (Geoinformation Enabling ToolkIT) starter kit has been adopted [12]. The application was developed starting from open source packages with the addition of packages developed for project needs. It offers an interface for data management, sharing, visualisation and (optionally) download through OGC standard web services for the following data categories:

1. maps or layers (spatial data). It permits to public and visualize spatial data (vector or raster). It use the web application GeoNode with customization for project needs. It provides the principal operations: upload data, data storing, styling and sharing data through standard services (WMS, WFS, WCS).

2. observations coming from different sensor types (buoys, glider, mooring, meteorological sensors, etc.). It uses an open-source solution based on Sensor Web Enablement (SWE) specifications, like implemented by 52° North (52N) project. It provides the operations to upload observation data, data storing and data management on a Data Base Management System, sharing observation on the web (through standard SOS

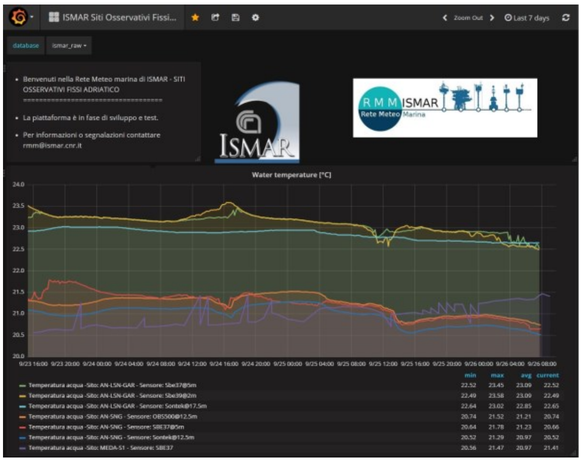
Fig. 3. Web interface of the portal rmm.dati.ismar.cnr.it

interface).
3. documents (text files, spreadsheet, images, etc.).

One of the main function of GET-IT is the metadata editing tool named EDI that permits to create, edit and read metadata about uploaded data (spatial data, observation data and documents) to describe data in a national and international standard way.

C. In-situ meteo-marine observation systems ISMAR Adriatic Sea: an integration experience

A big effort has been made in ISMAR (Institute of Marine Sciences of the Italian National Research Council) for the creation of an in-situ observational network able to: gather data from a distributed network; allow an efficient visualization of time-series data; access and share harmonised data through interoperable and standard services. During the last years, the need for a unique visible access point for the ISMAR observational network emerged from various research projects and, in particular, in the project RITMARE, in the Italian Long-Term Ecological Research network (LTER-Italy) and in the projects JERICO and JERICO-NEXT. This is also related to the request, by various European-funded projects, that data should be made discoverable, accessible and sharable using standards formats and services (NetCDF, ODV, SOS, …).

More in general, the ISMAR observational network aims to ensure archiving and storage of the historical time series data of the Institute (useful to long-term research and climate changes research) and to provide an efficient and convenient support for the operational model (through real-time data streams). These goals are achieved through harmonization of data management, using standard formats and interoperable services and creating a unique access point (rmm.dati.ismar.cnr.it) for visualizing and accessing real-time and archived data from ISMAR fixed-point stations. [13].

V. CONCLUSIONS AND PERSPECTIVES

Next steps for the developments and maintenance of the IFON network include:

1.To support marine observatories and marine technologies laboratories in strategic areas of the Mediterranean Sea, encouraging who acquire "data";
2. To develop shared database of relevant marine data, also in relation to the Marine Strategy Framework Directive (MSFD), encouraging data sharing between research groups and bodies;
3. To design a national web portal shared between all the institutions involved, for an interoperable and distributed database, consolidating actions towards an open access policy and the assignment of DOI to datasets;
4. To maintain connection with the Italian and European Long Term Ecological Research Networks (LTER-Italy and LTER-Europe) and with the Research Infrastructure LifeWatch-ERIC;
5. To be competitive and to create connections, at the European level, with other infrastructure and initiatives (e.g.: FIXO3, JERICO-NEXT, EMODnet, Copernicus, OceanSITES, ICOS-ERIC, EMSO-ERIC, Danubius, etc…);
6. To contribute to the establishment of integrated ecological observatories into key areas, such as the Northern Adriatic Sea and the Gulf of Naples (sites of the LTER-Italy network);
7. To be competitive with appropriate services and tools, so that answer to key questions on climate changes, risks, prevention, sustainability, etc ...
8. To consolidate the relationships with industry, small and medium-sized enterprises, by promoting Start-ups and offering services to end users, managers and citizens;
6. To propose an observatory infrastructure recognized at the national and European levels.

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