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Peer-Reviewed Technical Communication

NEMO-SN1 Abyssal Cabled Observatory in the Western Ionian Sea

Paolo Favali, Francesco Chierici, Giuditta Marinaro, Gabriele Giovanetti, Adriano Azzarone, Laura Beranzoli, Angelo De Santis, Davide Embriaco, Stephen Monna, Nadia Lo Bue, Tiziana Sgroi, Gianfranco Cianchini, Lucio Badiali, *Member, IEEE*, Enkelejda Qamili, Maria Grazia De Caro, Giuseppe Falcone, Caterina Montuori, Francesco Frugoni, , Giorgio Riccobene, Mario Sedita, Giovanni Barbagallo, Giorgio Cacopardo, Claudio Calì, Rosanna Cocimano, Rosa Coniglione, Michele Costa, Antonio D'Amico, Francesco Del Tevere, Carla Distefano, Francesco Ferrera, Valentina Giordano, Massimo Imbesi, Dario Lattuada, Emilio Migneco, Mario Musumeci, Angelo Orlando, Riccardo Papaleo, Paolo Piattelli, Guido Raia, Alberto Rovelli, Piera Sapienza, Fabrizio Speziale, Agata Trovato, Salvatore Viola, Fabrizio Ameli, Maurizio Bonori, Antonio Capone, Rocco Masullo, Francesco Simeone, Luca Pignagnoli, Nevio Zitellini, Federico Bruni, Francesco Gasparoni, and Gianni Pavan

Abstract*—The NEutrino Mediterranean Observatory—Submarine Network 1 (NEMO-SN1) seafloor observatory is located in the central Mediterranean Sea, Western Ionian Sea, off Eastern Sicily (Southern Italy) at 2100-m water depth, 25 km from the harbor of the city of Catania. It is a prototype of a cabled deep-sea multiparameter observatory and the first one operating with real-time data transmission in Europe since 2005. NEMO-SN1 is also the first-established node of the European Multidisciplinary Seafloor Observatory (EMSO), one of the incoming European large-scale research infrastructures included in the Roadmap of the European Strategy Forum on Research Infrastructures (ESFRI) since 2006. EMSO will specifically address long-term monitoring of environmental processes related to marine ecosystems, climate change, and geohazards. NEMO-SN1 has been deployed and developed over the last decade thanks to Italian funding and to the European Commission (EC) project European Seas Observatory NETwork—Network of Excellence (ESONET-NoE, 2007–2011) that funded the Listening to the Deep Ocean—Demonstration Mission (LIDO-DM) and a technological interoperability test (http://www.esonet-emso.org). NEMO-SN1 is performing geophysical and environmental long-term monitoring by acquiring seismological, geomagnetic, gravimetric, accelerometric, physico-oceanographic, hydroacoustic, and bioacoustic measurements. Scientific objectives include studying seismic signals, tsunami generation and warnings, its hydroacoustic precursors, and ambient noise characterization in terms of marine mammal sounds, environmental and anthropogenic sources. NEMO-SN1 is also an important test site for the construction of the Kilometre-Cube Underwater Neutrino Telescope (KM3NeT), another large-scale research infrastructure included in the ESFRI Roadmap based on a large volume neutrino telescope. The description of the observatory and its most recent implementations is presented. On June 9, 2012, NEMO-SN1 was successfully deployed and is working in real time.

***Index Terms*—Bioacoustics, European Multidisciplinary Seafloor Observatory (EMSO), geohazards, high-energy astrophysics, Kilometre-Cube Underwater Neutrino Telescope (KM3NeT), NEutrino Mediterranean Observatory—Submarine Network 1 (NEMO-SN1) cabled observatory.**

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NEMO Collaboration: G. Riccobene, M. Sedita, G. Barbagallo, G. Cacopardo, C. Calì, R. Cocimano, R. Coniglione, M. Costa, A. D'Amico, F. Del Tevere, C. Distefano, F. Ferrera, V. Giordano, M. Imbesi, D. Lattuada, E. Migneco, M. Musumeci, A. Orlando, R. Papaleo, P. Piattelli, G. Raia, A. Rovelli, P. Sapienza, F. Speziale, A. Trovato, and S. Viola are with the Istituto Nazionale di Fisica Nucleare (INFN), Catania I-95123, Italy.

F. Ameli, M. Bonori, A. Capone, R. Masullo, and F. Simeone are with the Istituto Nazionale di Fisica Nucleare (INFN), c/o Physics Department, "La Sapienza" University, Rome I-00185, Italy.

L. Pignagnoli and N. Zitellini are with the Consiglio Nazionale delle Ricerche, Istituto di Scienze Marine (CNR-ISMAR), Bolonia I-40129, Italy.

F. Bruni and F. Gasparoni are with Tecnomare S.p.A., Marghera, Venice I-30175, Italy.

G. Pavan is with CIBRA, Università di Pavia, Pavia I-27100, Italy.

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I. Introduction

NEUTRINO Mediterranean Observatory—Submarine Network 1 (NEMO-SN1) is located in the Western Ionian Sea off Eastern Sicily, Italy, and it is the first real-time multiparameter observatory operating in Europe in cabled configuration since 2005 [1], [2]. NEMO-SN1 is a fully integrated system for multidisciplinary deep-sea science, which includes the real-time acquisition and distribution of data to the scientific community and to the general public. NEMO-SN1 consists of two different platforms: the SN1 abyssal station and the OνDE abyssal acoustic station (Ocean Noise Detection Experiment), powered from shore and linked to the acquisition and control station in Catania harbor with a 25-km-long electro-optical cable. At about 20 km offshore, the cable is spliced into two 5-km-long tails, ending in two sites, namely, test site north (TSN) and test site south (TSS). The OνDE acoustic station, which is equipped with a tetrahedral array of four wideband hydrophones and connected to TSS from 2005 to 2006, recovered in 2008, was upgraded and redeployed in 2012. The SN1 abyssal station, connected to TSN, has been upgraded with a

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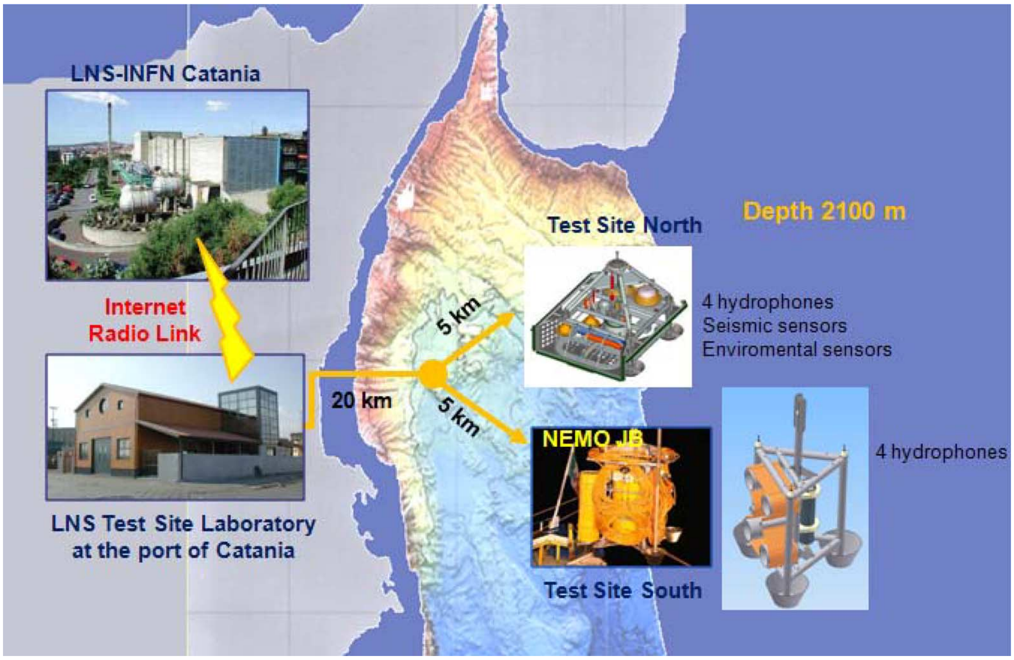

Fig. 1. Sketch of the east Sicily site with refurbished deep-sea abyssal stations (SN1 at TSN and OνDE at TSS). The Ionian Sea swath bathymetry was published in [8].

number of geophysical and oceanographic instruments, among them a new Tsunami Detector Prototype, and an OνDE-class abyssal acoustic station and a new low-frequency–high-sensitivity hydrophone.

Historically, SN1 originated as a lighter and smaller version of the GEophysical and Oceanographic STation for Abyssal Research (GEOSTAR) multidisciplinary abyssal observatory (e.g., [3] and [4]). SN1 was developed in 2000–2002 in an autonomous version (one long-term mission completed between 2002 and 2003), upgraded into a cabled version in 2003–2004 performing a 3.5-year mission in 2005–2008 [2], and reached its present configuration in 2009–2010 in view of the new mission started in June 2012. It is the first operative node of the European Research Infrastructure EMSO [5]. The whole system is connected and powered from the shore, and synchronized with Global Positioning System (GPS), adopting a fiber-optic telemetry to communicate in real time with a shore station at the Laboratori Nazionali del Sud, Istituto Nazionale di Fisica Nucleare (LNS-INFN), located in the Catania harbor (Fig. 1). In its present configuration, SN1 keeps the original mechanical frame, the deployment and recovery system Mobile Docker for Underwater Sciences (MODUS) [6], the seismometer installation procedure, and the interface with the electro-optical cable. Significant novel aspects include new optical telemetry, TCP/IP networking, new power supply, an increased scientific payload, a satellite unit for magnetometers, a completely new acquisition, and control software with sensors individually accessible and configurable from shore [7]. The 3-D vision of the SN1 abyssal station is shown in Fig. 2(a) and (b). As compared with other GEOSTAR-class observatories, SN1 provides an innovative solution in the deposition of the magnetometers at the seafloor: a detachable satellite module which distances the sensors up to 15 m away from the main frame [Fig. 2(c)] to diminish the effects of the magnetic fields generated by the electrical currents inside the observatory. The magnetic module is operated by a remotely operated vehicle (ROV) after bottom station deployment. The tsunami detector prototype installed on SN1, called Tsunameter, has been previously tested in the Gulf of Cadiz for about two years in the framework of the European Commission (EC) project "NEAR shore sourcES of Tsunamis: toward an early warning system" (NEAREST, http://nearest.bo.ismar.cnr.it). Moreover, the observatory has been equipped to study acoustic and magnetic tsunami precursors [9], [10]. After a long series of tests in laboratory to check all the functionalities, the NEMO-SN1 observatory (i.e., SN1 abyssal station at TSN and OνDE abyssal acoustic station at TSS) was successfully deployed on June 9, 2012, using the cable ship *Certamen* owned by Elettra Tlc (Catania, Italy). The SN1 station is currently working properly to send data to the shore in real time; the OνDE station is deployed and will be soon connected to TSS. NEMO-SN1, besides being the first permanent operative EMSO node, is also the first permanent tsunami detection station in the Mediterranean, and hopefully the first seed of the future Mediterranean Tsunami Early Warning System.

There are many projects and programs to establish a permanent seafloor network (single-node systems and large-scale networks) at the international level. The first category includes the pioneer Long-term Deep Sea Floor Observatory off Hatsushima island (installed in 1993, http://www.jamstec.go.jp/scdc/top_e.html) in Japan; the Victoria Experimental Network Under the Sea (VENUS, http://www.venus.uvic.ca) in Canada; the Monterey Accelerated Research System (MARS, http://www.mbari.org/mars) and the Aloha Cabled Observatory (ACO, http://aco-ssds.soest.hawaii.edu/) in the United States; and the Marine Cable Hosted Observatory

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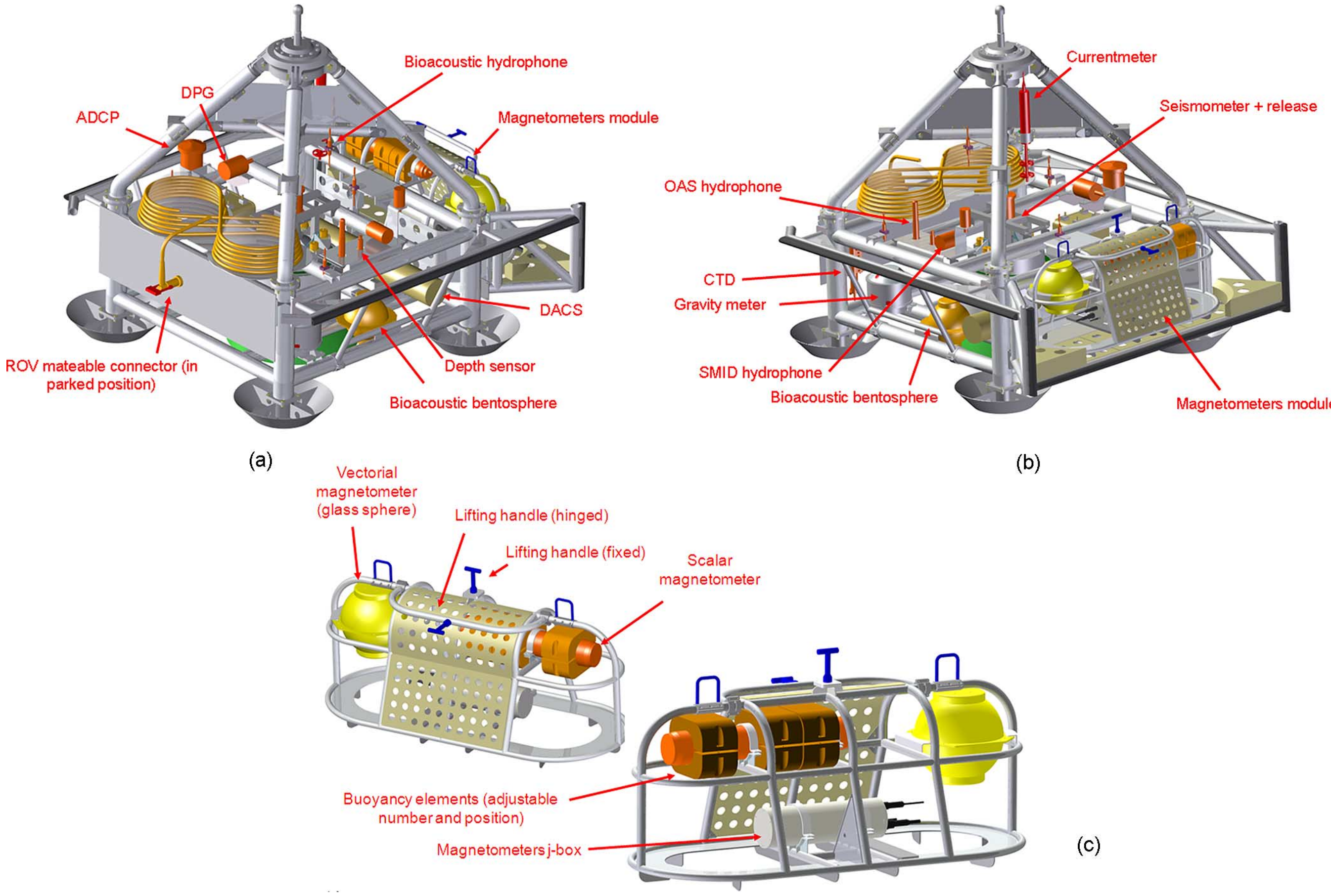

Fig. 2. (a) and (b) Three-dimensional vision of the SN1 abyssal station in its current configuration. (c) Details of the magnetometer module.

(MACHO, http://macho.ncu.edu.tw) in Taiwan. The second category comprises: the North East Pacific Time-series Underwater Networked Experiments (NEPTUNE, http://www.neptunecanada.ca) in Canada; the Ocean Observatories Initiative (OOI, http://www.oceanobservatories.org), particularly, the Regional-Scale Nodes (RSN, http://www.ooi.washington.edu/), in the United States; the Long-term Deep Sea Floor Observatory off Muroto Cape (installed in 1997, http://www.jamstec.go.jp/scdc/top_e.html), the Long-term Deep Sea Floor Observatory off Kushiro-Tokchi in the Kuril trench (installed in 1999, http://www.jamstec.go.jp/scdc/top_e.html), and the Dense Oceanfloor Network system for Earthquakes and Tsunamis (DONET, http://www.jamstec.go.jp/donet/e) in Japan; and EMSO (http://www.emso-eu.org) in Europe [11].

The NEMO-SN1 infrastructure represents an important test site for the construction of the Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) (http://www.km3net.org/). KM3NeT is another European large-scale research infrastructure within the ESFRI Roadmap. EMSO and KM3NeT are presently in the Preparatory Phase funded under the EC-FP7, grouping a large partnership across Europe [2], [5], [12].

II. Scientific Objectives

The scientific objectives of the NEMO-SN1 observatory cover a wide range of deep-sea research activities: high-energy astrophysics, physical oceanography, bio-acoustics, environmental sciences, geophysics, and heo-hazards [2] contribute in answering to the needs of society [13].

The NEMO-SN1 observatory is located in an area particularly suited to multidisciplinary studies. In fact, the site of deployment of NEMO-SN1 observatory is one of the most seismically active areas of the Mediterranean [14]. Some of the strongest earthquakes (M7+) shook the area in 1169 (M 6.6), 1693 (M 7.4), and 1908 (M 7.2) [15], also causing very intense tsunami waves [16]. SN1 recorded a significant number of events not recorded by the on-land seismic network, despite its very dense coverage. The analysis of these seismic signals shows two main categories of events, earthquakes, and submarine slumpings, which point to seafloor instabilities [14]. The quality of the SN1 seismic recordings is high, with good signal-to-noise ratio (SNR), mainly thanks to good coupling of the seismometer to the seabed [17]. The good quality seismic signal in a broad frequency band (0.0027–50 Hz) allows us to tackle many different scientific problems, such as the study of the energy propagation as pressure waves within the water masses of the Ionian Sea. Fig. 3 clearly shows tertiary (T) waves that are generated by an earthquake and propagate in the seawater.

Another interesting feature of the SN1 site is its vicinity to Mount Etna, one of the largest and most active volcanoes in Europe. The roots of this volcano sink down to seafloor depth, but their actual extension is almost unknown and geophysical measurements at sea, together with land-based observations, can

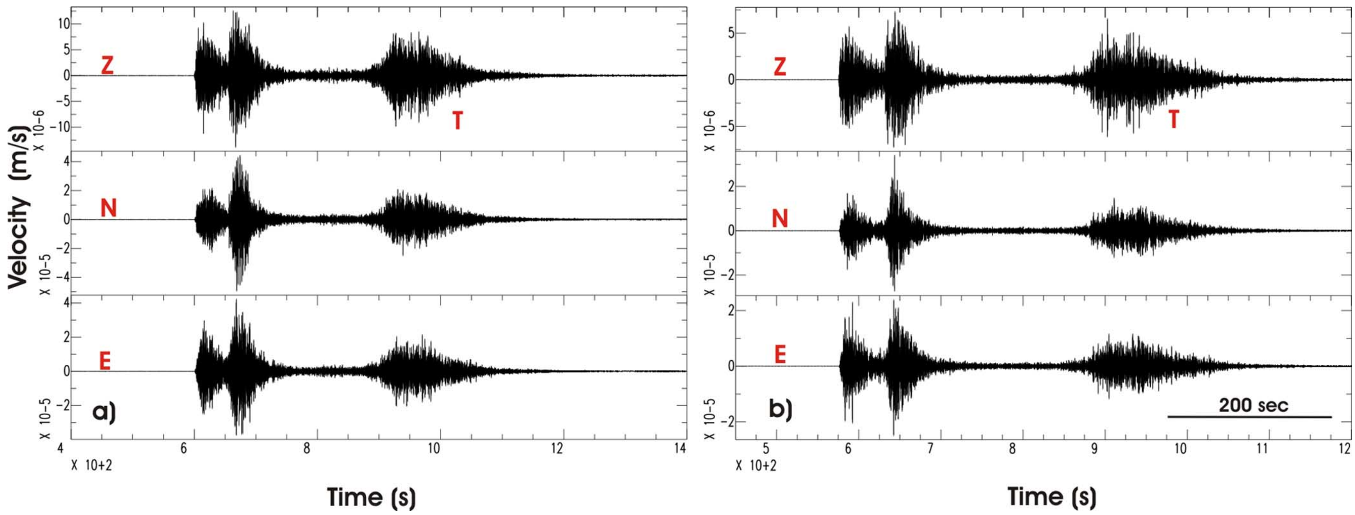

Fig. 3. Earthquakes occurring offshore from Peloponnesus (Greece, February 14, 2008) recorded by the SN1 3-C broadband seismometer (Z = vertical component; N and E = horizontal components): (a) M_W 6.9; (b) M_W 6.2. T waves are clearly visible.

greatly improve our knowledge of Mount Etna. In particular, with seismic tomography [18], it would be possible to have a more complete 3-D image of Mount Etna thanks to the integration seismic waveforms recorded by SN1 with data from land seismometers. SN1 can also help to study the behavior of the Etna volcano, thanks to its "particular" point of view, which is about 25 km from the volcano axis and, therefore, less affected by the high-frequency noise induced by the different phases of the volcano activity. Fig. 4 shows a good example of Etna degassing activity and its power spectral density (PSD) diagram. In addition, the measurements of land-based sensors and the seafloor gravity meter can be used to detect density variations in the different layers forming Mount Etna, while a magneto-variational method applied to the time variations of the seafloor three-component magnetic data will allow us to discriminate the conductivity structure in depth of the surrounding area [19].

The NEMO-SN1 deployment area is also a key site for monitoring deep-water dynamics in the Ionian Sea. In fact, this area plays a crucial role in the circulation between the eastern and western Mediterranean Sea, connecting the Levantine basin to the southern Adriatic basin where intermediate (Levantine intermediate water) and deep (Adriatic deep water) waters arise, respectively. The deep-water mass which originates in the Adriatic Sea spreads into the Ionian basin following the bathymetric contour and mixes with the intermediate water coming from the eastern basin [20]. The site is a permanent observation point of the bottom thermohaline circulation in this area, and oceanographic sensors [conductivity–temperature–depth (CTD), acoustic Doppler current profiler (ADCP), 3-C single point current meter, turbidity meter; see Table I] will allow us to monitor hydrological parameters and follow the dynamics of the bottom layer.

The astroparticle physics community is very interested in high water depth sites to improve neutrino detection capabilities. At first, the monitoring of acoustic noise by hydrophones, having a very large bandwidth and high resolution, was mainly addressed to novel high-energy astrophysics studies on acoustic neutrino detection. A goal of the observatory is

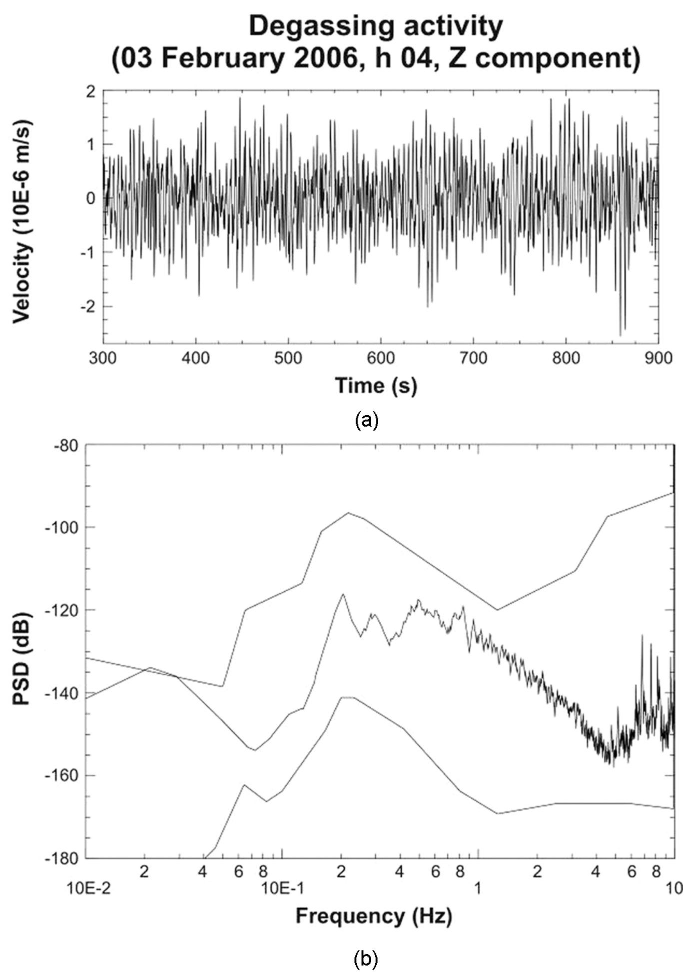

Fig. 4. Seismogram (Z component) recorded by the seismometer of SN1, showing (a) an example of degassing activity of Etna, which is the normal continuous activity of the volcano in the absence of eruptive phases, and (b) the relative PSD diagram.

the characterization of the ambient noise used to discriminate acoustic background (e.g., surface waves, biological sources,

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TABLE I
NEMO-SN1 Payload and Sampling Rate (The Sensors Mounted on OνDE Abyssal Acoustic Station Are Also Indicated)

Sensor	Manufacturer & model	Sampling rate
3-C Broad band seismometer	Guralp CMG-1T (band 0.0027-50 Hz)	100 Hz
Gravity meter	IFSI-INAF prototype #2	1 Hz
Scalar magnetometer	Marine Magnetics Sentinel 3000	1 sample/h
Vectorial magnetometer	Sulas Company prototype	0.5 Hz
Low frequency hydrophone	OAS E-2PD	100 Hz
Low frequency hydrophone	SMID DT-405D(V)1	2 kHz
Inertial Measurement Unit (IMU)	Landmark LMRK20-AHRS 150-02-100	100 Hz
Absolute Pressure Gauge (APG)	Paroscientific 8CB4000-I	4 samples/min
Differential pressure gauge (DPG)	SCRIPPS-UCSD prototype	100 Hz
CTD	Seabird SBE37-SM	1 sample/h
3-C single point current meter	Nobska MAVS-3	2 Hz
Turbidity meter	Wet Lab	1 sample/h
ADCP	RDI Workhorse Sentinel 600 kHz	1 profile/h
Bioacoustics	4 + 4 hydrophones SMID TR-401(V)1	96/192 (OvDE) kHz
Compass	Falmouth Ostar Compass	1 Hz

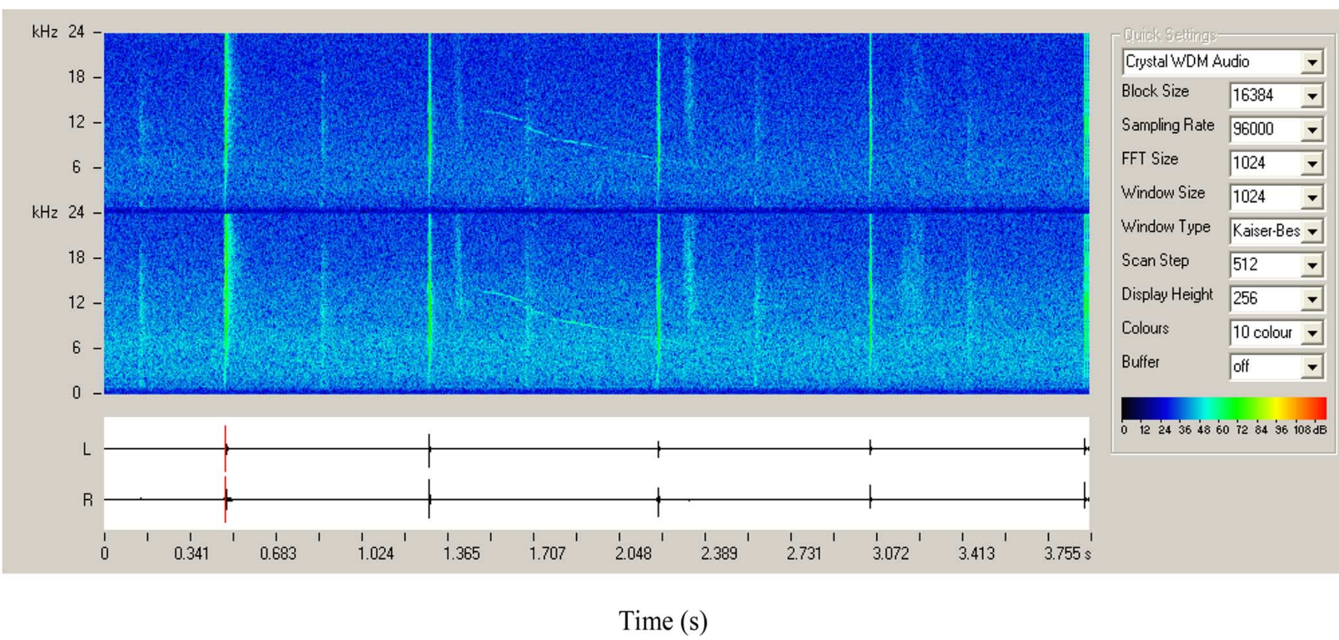

Fig. 5. Spectrogram (frequency versus time graph) and amplitude plot of 4 s of acoustic data from two hydrophones of NEMO-SN1: intense sperm whale clicks appear as vertical green–yellow lines; dolphin whistles appear as quasi-horizontal lines (frequency-modulated acoustic tonals).

ships) from the bipolar (10–40 kHz) signature of high-energy cosmic neutrinos interacting with seawater [21] and also from the low-frequency (about 0.05–1 Hz) hydroacoustic wave generated by possible sea bottom motions [9]. Thanks to their large bandwidth, acoustic detectors are also used to localize and fully track cetaceans, and to identify their species. Thanks to NEMO-SN1, a high number of sperm whales (*Physeter macrocephalus*), which up until then have been thought to have disappeared from the area and have been considered endangered by the International Union for Conservation of Nature (IUCN) [22], were revealed to exist by detections (Fig. 5) in more than 50% of the recorded days [23]. In both observed years, 2005 and 2006, the sperm whale number peaked during April and October, when the largest group sizes were recorded. Results suggest that this deep-sea platform is an efficient long-term monitoring system for sperm whales and an invaluable instrument for the management and conservation of the endangered Mediterranean population [23]. The use of new hydrophones, with a larger bandwidth from tens of hertz to about 70 kHz, will allow the detection of different species of marine mammals, from fin whales (tens of hertz) to Cuvier's beaked whales (up to 50 kHz) [24].

The characterization of hydroacoustic environmental noise and signals is also very important for tsunami generation and precursor studies. Chierici *et al.* [9] developed a theoretical work on hydroacoustic signals and tsunami waves generated by the seafloor motion. In particular, modulated hydroacoustic waves are generated in the water layer by the seafloor motion and propagate up-slope and outside the generation area with low attenuation. The main and surprising feature of these waves is their modulation which carries information about the seafloor motion and the tsunamigenic source main parameters. The existence of these waves, which have a frequency inversely proportional to water depth, was first observed during the

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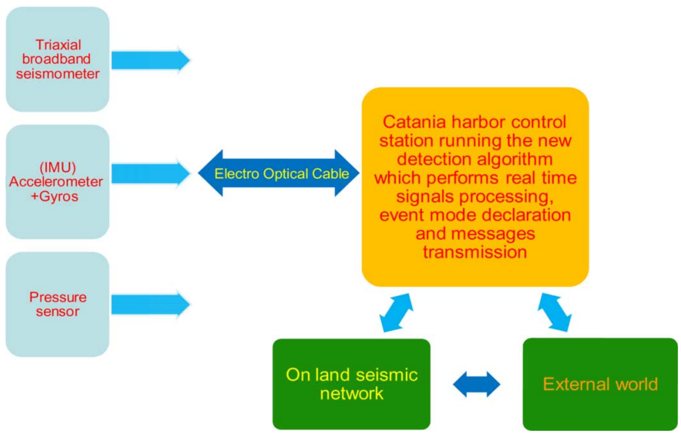

Fig. 6. Logic scheme of the tsunameter.

Tokachi-Oki 2003 event [25], [26]. These acoustic waves travel much faster than the tsunami waves well preceding the tsunami arrival. Moreover, information on the source parameters, for instance, the seafloor motion velocity, the source size, and the amount of displacement may be extracted from the very first pulses of the modulation [9]. These hydroacoustic waves may also help to clarify the relationship between the main parameters of the tsunamigenic earthquakes and the tsunami generation.

The modulation of these acoustic waves acts as a hydroacoustic tsunami precursor and could be integrated in the new generation of the Tsunami Early Warning System. NEMO-SN1 has been equipped with high-sensitivity–low-frequency hydrophones (OAS E-2PD and SMID DT-405DV1; see Table I) to study low-frequency environmental acoustic noise and to detect the possible hydroacoustic signals generated by the sea bottom motion. Interestingly, the four SMID TR-401V1 hydrophones, mainly tailored for bio-acoustic studies, can be also used for this task.

The tsunameter prototype is specifically designed to operate in tsunami generation areas [27]. The tsunameter was built and tested at a standalone GEOSTAR observatory with acoustic link to a surface buoy and, then, to a shore by a satellite link. GEOSTAR was deployed in the Gulf of Cadiz, inside the activities of the EC project NEAREST (http://nearest.bo.ismar.cnr.it). The tsunameter consists of: a high-precision bottom pressure sensor (Paroscientific with 0.01% accuracy and 1 over 10^8 resolution), an accelerometer [inertial measurement unit (IMU)], and a 3-C broadband seismometer. All the instruments are connected to a processing unit running a new tsunami detection algorithm. The tsunameter logic scheme is shown in Fig. 6. Possible dynamic and kinematic effects due to the seafloor motion during a local seismic event, which may bias the tsunami signal measurement in generation areas, are considered. The onboard accelerometer allows the correction of the pressure effects due to the sea bottom displacement and to the possible motion of pressure sensors. The data acquired by the tsunameter are processed in real time by dedicated algorithms to establish the tsunami detection.

The tsunami detection procedure is based on double-checking both pressure and seismic signals to enhance reliability. The seismic data are processed using the Short Term Average over Long Term Average (STA/LTA) algorithm. The bottom pressure data are analyzed by the new high-performance tsunami detection algorithm, with a chain of digital filters. Each filter can be included or excluded in real time by the processing procedure [27]. The raw pressure data are de-spiked, de-tided, and band passed. The application of this filtering cascade to the bottom pressure time series drastically reduces the dynamic range of sea level perturbations, from about several meters of equivalent water to a few centimeters, thus obtaining a tsunami detection sensibility less than 1 cm and greatly reducing detection times. The filtered bottom pressure data are then matched against an appropriate tsunami amplitude threshold: once it is exceeded, detection is declared. This filtering process needs to recover the main tidal and basin coefficients so it is fully operative after a minimum of 15 days of pressure data acquisition. In the first 15 days, tsunami detection is performed using a polynomial linear prediction. The tsunami detection algorithm scheme is shown and explained in Fig. 7. To test the reliability of the tsunami detection algorithm we used Deep-ocean Assessment and Reporting of Tsunamis (DART) data, as we await the NEMO-SN1 data to check it over again.

Finally, with NEMO-SN1, it is possible to study the correlation between bottom pressure signals caused by tsunami waves, electromagnetic (EM) signals, and low-frequency hydroacoustic waves. These studies can help us identify tsunami hydroacoustic and magnetic precursors [9], [10] and may improve the timeliness and reliability of tsunami early warning systems.

The seawater particle motion generated by tsunami wave fronts are coherent enough to generate electric current circuits in the ocean and to create observable EM fields on the seafloor: in particular, a unipolar temporal variation of the horizontal geomagnetic component at the tsunami passage, and a bipolar variation of the vertical component which changes sign before and after the tsunami passage. The variation of the EM vertical component generated by a tsunami precedes the tsunami waves' arrival. Bottom geomagnetic observatories can detect tsunami-induced EM signals for earthquakes larger than M8 in most of the oceanic areas other than equatorial regions.

Recently, Toh *et al.* [10] showed that a seafloor geomagnetic observatory in the northwest Pacific succeeded in capturing tsunami-induced EM signals, which included not only the geoelectric field but also the geomagnetic field. An important advantage of EM sensors over conventional tsunami sensors, such as seafloor pressure gauges, is their capability of vector measurements. For this reason, the addition of vector EM sensors could represent a significant improvement of tsunami warning systems. SN1 abyssal station is equipped with vectorial and scalar magnetometers (see Table I) to study geomagnetic signals and possible EM tsunami precursors. Even if M8 earthquakes have not been historically reported in south eastern Sicily, nevertheless M7+ earthquakes, such as the 365 Crete earthquake, and 1169, 1693, and 1908 western Ionian events, generated important destructive tsunamis along the Ionian coasts. The simultaneous acquisition of the bottom pressure, and low-frequency hydroacoustic and magnetometric data by

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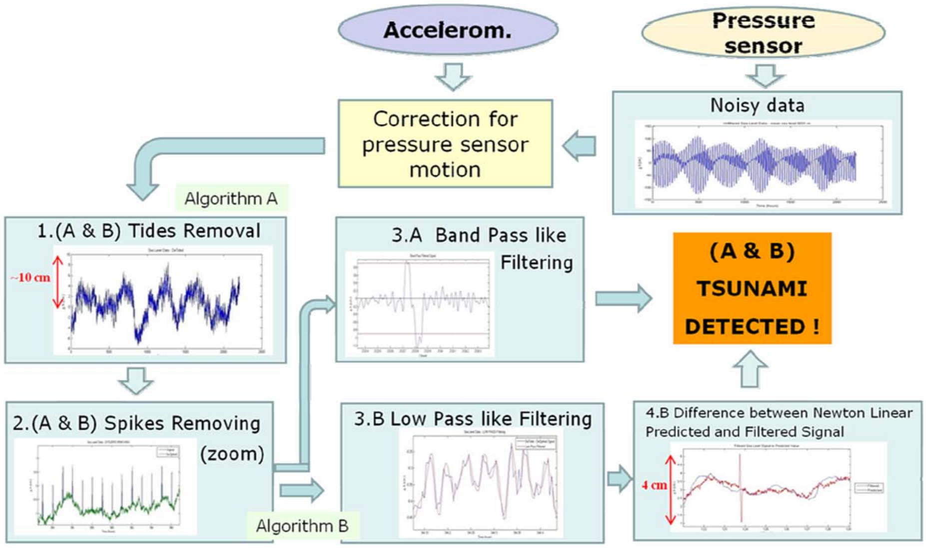

Fig. 7. The tsunami detection algorithm scheme. The dynamic range of the signal is reduced from about 2 m to about 1 cm by the filtering chain. The plots are obtained by one-year real bottom pressure data (the bottom pressure record acquired in 2001 by D165 buoy, located at 50 31.84′ N 164 56. 47′ W, courtesy of DART) with superimposed synthetic tsunamis. The last frame shows an example of the detection capability of the new algorithm in this very noisy bottom pressure record with the presence of spikes of the same amplitude of the synthetic tsunamis. A 10-min period, 1-cm amplitude tsunami is captured in its first quarter of a period, against a threshold (horizontal red lines) of 0.9 cm. Here the pressure is given in equivalent water height, where 1 cm corresponds to 100 Pa.

Fig. 8. The refurbished and upgraded SN1 abyssal station during the laboratory tests at the LNS shore station lab in Catania harbor.

the SN1 abyssal station give us the chance to test and compare different tsunami detection methods.

III. Architecture of the NEMO-SN1 Cabled Observatory

The underwater infrastructure (moored at 2100-m water depth) is linked to the shore with a 25-km electro-optical cable (six power conductors and ten single-mode optical fibers). The termination of the main electro-optical cable, connecting the deep-sea infrastructures to shore, is housed in the Catania Laboratory (CL) of the LNS, located in the harbor of Catania. At about 20 km offshore, the cable is spliced into two 5-km-long tails, which ends in TSN and TSS. Each tail is terminated with

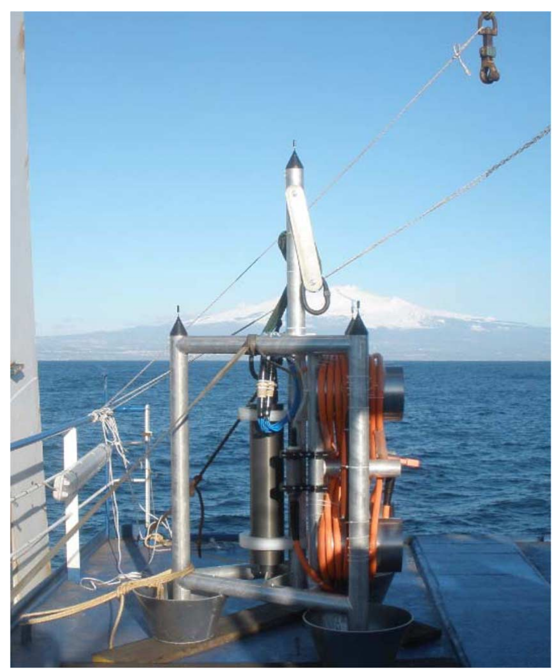

Fig. 9. The deep-sea frame (about 2.5 m high) holding the refurbished OνDE station ready for deployment.

a titanium frame equipped with two electro-optical ROV-mateable connectors [2] (Fig. 1): At TSN, four optical fibers and two conductors arrive; and at TSS, six optical fibers and four conductors arrive; each of the two tails is completely independent from the other in terms of power supply and communications.

The CL hosts the main power supply, and the onshore data acquisition and data storage units. The CL completely fulfils the requirements of power, physical space, and logistics in general for the east Sicily node. A 100 Mb/s, the radio link between CL and LNS is also available and operational, allowing an Internet access through network infrastructure of the LNS-INFN, where high-speed connection to the Internet is available.

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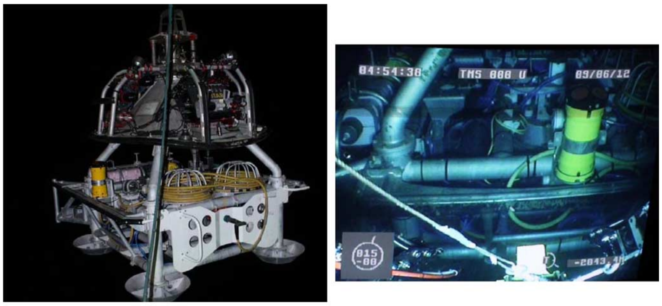

(a) (b)

Fig. 10. The SN1 abyssal station with the deployment/recovery vehicle MODUS on top: (a) ready to be deployed into the water, and (b) deployed on the seafloor at about 2100-m water depth, during the deployment operation in June 2012.

In January 2005, the NEMO-SN1 observatory was deployed and connected to the submarine cable, starting its first real-time phase [1]. In April 2008, all the underwater systems were recovered in very good condition after almost 3.5 years; all the sensors, vessels, and devices were recovered functioning and in a good shape, except the vessels for supplementary acoustic transmission with evident corrosion. Given that this part was derived by previous hybrid configuration (i.e., cabled configuration with auxiliary acoustic transmission system), we decided to go toward a cabled system without any auxiliary acoustic way of communications. In the last years, the two experiments have been refurbished, adding new sensors and functionalities. Table I shows the list of sensors with data sampling rates and models in the new observatory configuration.

The refurbished and upgraded SN1 abyssal station (Fig. 8), upgraded with magnetometers, ultrawide-bandwidth, low-frequency–high-sensitivity hydrophones, pressure sensors and accelerometers, and the refurbished OνDE platform (Fig. 9), upgraded with ultrawide-bandwidth hydrophones and novel acoustic data acquisition system, are completely assembled and tested. In the beginning of June 2012, NEMO-SN1 was deployed again, and it is operative in real time, powered from the shore and with two-way fiber-optic communications sending data to the shore and receiving commands (Figs. 9 and 10). Some examples of the new data acquired in real time are shown in Fig. 11.

The future implementation of the installation in east Sicily is represented by the completion of a new cabled deep-sea infrastructure. A 100-km electro-optical cable already extends from the south easternmost tip of Sicily (Capo Passero) to the deep Ionian basin at 3500-m water depth and terminates with a junction box (JB). The site is a candidate for the installation of the KM3NeT neutrino telescope, and the infrastructure will soon host neutrino telescope prototypes and Earth and Sea Science Observatories.

IV. Power System

The technology for power transmission from shore to the deep-sea infrastructure was assessed and tested with the operation of NEMO-SN1 (i.e., SN1 abyssal station and OνDE abyssal acoustic station). All these apparatuses deployed at the Catania site infrastructure were fed from the shore using the alternating current (ac) power supply. Thanks to the short cable distance, the ac solution was chosen to use passive elements in power conversion.

The SN1 abyssal station was powered from the shore using a dedicated power supply, powered by the 220-V ac line, and equipped with a power step-up transformer to 500-V ac (Fig. 12). The voltage at the offshore cable termination is about 400-V ac. In the new SN1 abyssal station layout, the power line is split into two different lines: one dedicated to the acoustic front–end electronics, hosted inside a glass benthosphere, and the other one dedicated to the geophysical instrumentation and to front–end and data transmission electronics, hosted inside a JB vessel, hooked to the SN1 mechanical frame.

The power cabling scheme of the refurbished OνDE acoustic station is similar to the one used for NEMO Phase 1 (http://nemoweb.lns.infn.it/) devoted to the test of a small-scale technological demonstrator for KM3NeT [28]. An electro-optical jumper cable is used to link the TSS cable termination frame to the JB (Fig. 13), which holds several hybrid (electro optical) ROV-mateable connectors, four of them available for further experiments. The power provided by the JB is 380-V ac in three phases. An electro-optical jumper, 80 m long, will connect the refurbished OνDE station to the JB. Within a pressure vessel, the feeding power at 380-V ac is transformed to low-voltage direct current (dc) power lines used for electro-optical media converters, hydrophone preamplifiers, and analog digital converters (ADCs).

The 100-km cable from Capo Passero down to the deep Ionian Sea (3500-m water depth) is powered by 10-kV dc, and is capable to sustain up to 60 kW. The converter is a NEPTUNE-like Alcatel medium voltage converter (MVC).

V. Data Acquisition

Data are continuously transmitted from deep-sea stations to the CL through optical fibers. Three coarse wavelength division multiplexing (CWDM) optical lines for data transmission are implemented onboard SN1 abyssal station, while another line is implemented for control transmission from shore. A bidirectional solution based on dense wavelength division multiplexing (DWDM) is implemented onboard OνDE for controls and data transmission. The data rate from the deep-sea acoustic detectors is about 24 Mb/s of data payload on SN1 abyssal station (96-kHz sampling, 24 b, four channels) and about twice for the OνDE station (two 192 kHz, 24 b, stereo sigma delta ADC). A limited bandwidth (few kilobits per second) is occupied by the data of the other sensors installed on SN1, by the compass and "slow" sensors (e.g., humidity, temperature, voltage, and current gauges) installed onboard OνDE and for the control lines from shore to the two stations. Slow-rate instruments (i.e., absolute pressure gauge, accelerometer, gravity meter, magnetometers, CTD, turbidity meter, and current meter) are plugged with telemetry system via serial cables (RS232/RS485). Here electrical signals are converted into optical, and transferred over TCP/IP protocol to shore, where they are converted back to RS232 electrical signals. Time stamping of data is done onshore by the acquisition server, synchronized via a network time protocol (NTP) with a GPS receiver. For seismometer and low- and mid-frequency hydrophones, GPS signal is propagated from the

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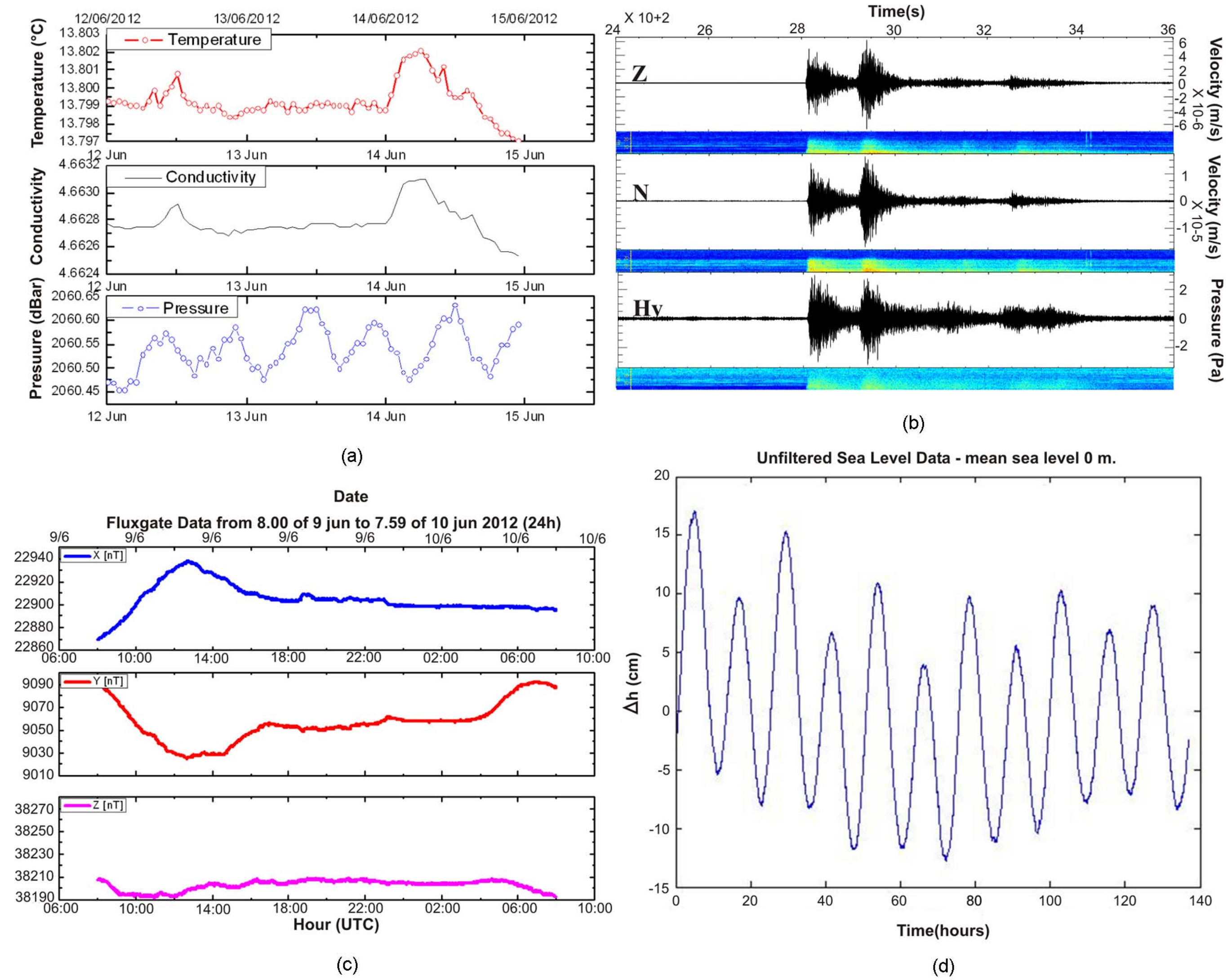

Fig. 11. Examples of real-time data acquired by NEMO-SN1. (a) CTD June 12–14, 2012, temperature (°C), conductivity and pressure (dBar). (b) Regional seismic event occurred in Greece on June 10, 2012 (M6.0). Z = seismometer vertical component, N= seismometer horizontal component, and Hy= hydrophone; horizontal axis time (s), vertical axis velocity (m/s) for Z and N, and pressure (Pa) for Hy. (c) Fluxgate magnetometer, 24-h recordings of the Earth magnetic field from June 9 to 10, 2012, X and Y = horizontal components, Z = vertical component; vertical axis nT and horizontal axis time (hour). (d) APG raw data from July 2 to 8, 2012.

onshore receiver down to underwater instruments, so that data are time stamped on-site.

Both north and south site high-frequency hydrophones, suitable for bioacoustics and high-energy physics, send data through the acquisition and transmission system [29]. In this system, data and clock signal are transmitted through the optical fiber over the same synchronous stream, derived from standard optical fiber telecom protocols. The master clock for the whole electronic system is derived from the GPS signal and distributed to the underwater apparatus. The used data transmission system performs a root mean square (rms) timing resolution of the apparatus' master clock of about 20 ps, a resolution suitable for the purposes of high-energy physics. From this very precise clock, time stamping of high data rate and synchronization of slow data rate (e.g., serial port interfaces) sensors is performed with optimal performances.

Onshore, all the data are analyzed and eventually stored in a large database hosted at LNS-INFN, which permits access both for the collaboration and to the general public. The data acquisition scheme is sketched in Fig. 14. Acoustic data, which represent the largest payload from deep sea, are acquired by the acoustic data server that receives the raw data stream and makes it available on the CL local area network (LAN) for processing. Processed and compressed acoustic data, together with geophysical, oceanographic, and status data, are thus continuously transferred to LNS, to be stored in the database. Another storage unit is deployed at LNS for the general public access, fully compatible with the Global Earth Observation System of Systems (GEOSS, http://www.earthobservations.org/geoss.shtml) for open access. The NEMO-SN1 observatory combines two different architectures for data transmission and timing. The first one, coming from previous SN1 experiments, is used for oceanographic geophysical sensors, while the second one, derived by INFN NEutrino Mediterranean Observatory (NEMO, http://nemoweb.lns.infn.it/) project data transmission system, is

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Fig. 12. Photo of the power supply rack installed at the shore station to power the SN1 abyssal station.

Fig. 13. The JB, deployed at TSS, is connected to the frame, and it provides several electro-optical connections for deep-sea experiments.

used for high-bandwidth hydrophones for physical/bioacoustic applications.

VI. Data Management

A wide range of oceanographic, seismic, acoustic, and geophysical data are acquired by NEMO-SN1. The first data structure for storage and dissemination has been file-system oriented. This system allowed a first hierarchical data storage in a directory structure. The file formats have often been determined by the instrument manufacturers and hence converted toward

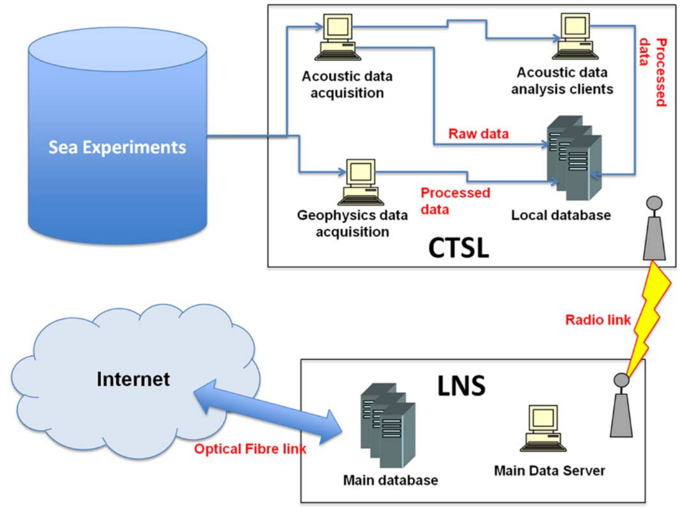

Fig. 14. Schematic view of the NEMO-SN1 data flow from the underwater systems (sea experiments) to CL and to LNS by a broadband radio link, and then to the interested users through the Internet.

a human readable files. In the framework of several European Commission projects such as ESONET-NoE (http://www.es-onet-emso.org/) and EMSO (http://emso-eu.org), the data management is evolving toward a comprehensive information system. A structured relational database has been designed and implemented, in which all the time series are stored and automatically indexed. Huge data, such as seismic and acoustic data, are still stored in a file system but indexed and described by up-to-date metadata standards. Recently, the acquisition software module of SN1 abyssal station has been modified so it can include data directly in a relational database. With this enhancement the users can more easily extract data and the system administrators can monitor the system remotely, as all the sensor status files are stored in the database on the fly. The data are then migrated and integrated in the central database using conventional procedures for database replication and data synchronization.

VII. Conclusion

NEMO-SN1 is based on a wide interdisciplinary effort. The different research fields are geophysics with a special focus on geohazards, physical oceanography, marine biology, and astroparticle physics. NEMO-SN1 is the first real-time multiparameter deep-sea observatory in Europe that is developing into an open submarine laboratory, also able to host other new experiments. It is the first operative node of the EMSO research infrastructure, the large and integrated network of underwater observatories distributed around the European continental margin. With the NEMO-SN1 abyssal observatory, it is possible to have a unique long-term, real-time, high-sampling rate multiparametric monitoring in an area where there is a high volcanic and seismic hazard and possible near-coast tsunami generation. The new tsunami detector installed onboard SN1 is the first permanent bottom pressure tsunami warning device in the Mediterranean Sea, thus representing an important step for the future Mediterranean Tsunami Warning System. Moreover, the combination of the pressure sensors with the low-frequency hydrophone and the magnetometers can help us to understand

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tsunami precursors and tsunamigenic earthquakes, and bring a much needed improvement in tsunami early warning systems. On June 9, 2012, NEMO-SN1, after a long series of laboratory tests, has been successfully deployed, and currently sends data from the different sensor packages to the shore in real time.

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Paolo Favali received a degree in geology from the University "La Sapienza," Rome, Italy, in 1976.

He is the Research Director at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), the main Public Research Institution in Rome, Italy for Earth Sciences and Hazards. He has about 30 years of experience with main fields of interest in natural hazards (mainly seismic), seismotectonics, geodynamics, applied geophysics, and environmental sciences. He cooperates in research and technological projects with many Italian/international universities, scientific institutions, and industries. He is the coordinator of many European and Italian projects for the development and scientific use of multidisciplinary seafloor observatories and networks, and related infrastructures. Since 2001, he has been the Head of the Marine Unit of INGV, RIDGE Unit (GEomarine InterDisciplinary Researches), which was and is involved in many national and international projects, mostly related to the same scientific topics. Currently, he is the Coordinator of the Preparatory Phase of the infrastructure European Multidisciplinary Seafloor Observatory (EMSO, http://www.emso-eu.org/), a Research Infrastructure of the ESFRI Roadmap (European Strategy Forum on Research Infrastructures, http://cordis.europa.eu/esfri/roadmap.htm/), which is the European network of fixed seafloor and water-column observatories constituting a distributed infrastructure for long-term monitoring of environmental processes, including geohazards. He has been teaching physics of solid Earth and Earth physics at Italian universities since 1994. He is a tutor to many students during their degree theses and Ph.D. dissertations. Since 2000, in the frame of the 5th, 6th, and 7th Framework Programme of the European Commission, he has acted as Expert Evaluator of projects. He published more than 100 papers in international and Italian journals and proceedings.

Francesco Chierici received a degree in physics from the University of Bolonia, Bolonia, Italy, in 1994.

Currently, he is a Researcher at the Istituto di Radioastronomia (IRA), Istituto Nazionale di AstroFisica (INAF), Rome, Italy, and collaborates with the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy, and with the Consiglio Nazionale delle Ricerche, Istituto di Scienze Marine (CNR-ISMAR), Bolonia, Italy. His research interests include tsunami generation processes, algorithms for signal analysis, tsunami early warning systems, and tsunami detectors design.

Giuditta Marinaro received a degree in physics from the University of Roma "La Sapienza," Rome, Italy, in 2002 and the Ph.D. degree in polar sciences from the University of Siena, Siena, Italy, in 2012.

She is a Physicist working as a Technologist at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), the main Public Research Institution in Rome, Italy, for Earth Sciences and Hazards. She has worked in the field of submarine observatories engineering for ten years. She is responsible for the scientific payload of seafloor observatories managed by the Marine Unit of INGV (GEomarine InterDisciplinary Researches). She was a member of the Data Management Council of the European Commission (EC) ESONET NoE; INGV Local Project Manager for the EC Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) project; and WP1 leader in the CE HYPOX project. She was part of the technical management team of the Preparatory Phase of the infrastructure European Multidisciplinary Seafloor Observatory (EMSO, http://www.emso-eu.org/), the European network of fixed seafloor and water-column observatories constituting a distributed infrastructure for long-term monitoring of environmental processes, including geohazards. She is the Technical Manager for INGV of the NEutrino Mediterranean Observatory—Submarine Network 1 (NEMO-SN1) cabled observatory (EMSO node in southern Italy) and SN4 standalone observatory (EMSO node in Marmara Sea—Turkey).

Gabriele Giovanetti was born in Rome, Italy, in 1976. He graduated in physics—electronics cybernetics from "La Sapienza" University of Rome, Rome, Italy, in 2002.

Since 2002, he has dealt with digital electronics, digital signal processing, firmware, and real-time software. After three years working in telephony electronics, in 2006, he started collaborating in R&D projects for scientific purposes, first with the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy, and then with the Physics Department, "La Sapienza" University. He started his collaboration with the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy, in 2009, where he still works as an R&D Engineer. He took part in the development of the electronic system for data acquisition and transfer for the NEMO project, an underwater neutrino telescope. He also developed software for data acquisition transfer and storage for SN-1, an underwater multidisciplinary observatory.

Adriano Azzarone received the scientific high school degree from the high school of science "Federigo Enriques," Livorno, Italy, in 1998.

He has been a Web and ICT Developer at the Geomagnetism, Aeronomy and Environmental Geophysics Department, Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy, since April 2007. He is involved in research of new web technologies, focusing on the open ones. He is knowledgeable about main activities for the creation of systems for managing content, such as database design, graphics, and programming. Currently, he is engaged in the development of a platform management and visualization of marine data and metadata (MOIST) connected to the European Multidisciplinary Seafloor Observatory (EMSO) project.

Laura Beranzoli received a degree in physics from the University "La Sapienza," Rome, Italy, in 1986.

She has been a Technology Director at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy, since 2003. From 1988, she was a Researcher at INGV and, from 1994, she was responsible for geophysical and oceanographic sensor setup and installation on mono and multiparameter seafloor GEophysical and Oceanographic STation for Abyssal Research (GEOSTAR)-class observation systems and networks. She is presently a member of the scientific management teams of European Commission (EC) projects and is involved in the European Multidisciplinary Seafloor Observatory (EMSO) Research Infrastructure construction. Her research interests include processing and analysis of geophysical time series for the study of the interactions between different physical phenomena at seafloor.

Angelo De Santis was born in Rome, Italy, in 1955. He received the Ph.D. degree in physics from the First University of Rome, Rome, Italy, in 1984.

He is now the Director of Research of the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy, where he has worked since 1977. He is a Geophysicist working from deep seafloor to outer space phenomena to characterize Earth dynamics. He teaches geophysics at the G. D'Annunzio University, Chieti, Italy, and has tutored more than 25 Ph.D. and graduate students.

Dr. De Santis is the American Geophysical Union (AGU) and the European Geoscience Union (EGU) member, and he is the Vice-President of Earth Magnetism and Rock Physics Division of EGU.

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Davide Embriaco received the Laurea degree in physics from the University of Pisa, Pisa, Italy and the Diploma degree in physics from the Scuola Normale Superiore of Pisa, Pisa, Italy, in 1997, and the Ph.D. degree in physic from the University of Pisa in 2001.

He is currently a Researcher at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy. His major activity focuses on experiments with benthic observatories at deep sea.

Stephen Monna received a degree in physics from the University "La Sapienza," Rome, Italy, in 1993.

He is currently a Seismologist at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy. His research interests include processing and analysis of the seismic signals recorded by seafloor stations, the study of the crust and the upper mantle by attenuation and local/teleseismic tomography using data from land and seafloor stations, and the study of the background seismic noise models in the Mediterranean seafloor.

Nadia Lo Bue received a degree in natural science from the University of Palermo, Palermo, Italy, in 2002. Currently, she is working toward the Ph.D. degree in physical oceanography, collaborating with Ifremer for the study of dense water formation in the western Mediterranean Sea.

Since 2003, she has been working at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy, with the RIDGE group dealing with the analysis of oceanographic data acquired by benthic stations.

Tiziana Sgroi received a degree in geology from the University of Catania, Catania, Italy, in 1997 and the Ph.D. degree in geophysics from the University "G. d'Annunzio," Chieti-Pescara, Italy, in 2012.

She is currently a Seismologist at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy. Her research interests include volcano seismology, with particular emphasis on seismic and volcanic source processes, and processing and analyses of local seismicity recorded from land and seafloor stations to define crustal structures and seismotectonics of land and marine environment.

Gianfranco Cianchini received the M.S. degree in physics from "La Sapienza" University, Rome, Italy, in 2009. His undergraduate research involved analysis of satellite magnetic data in search of possible signatures of large earthquakes with Prof. M. Caputo and Prof. A. De Santis as advisors.

With a permanent position as a Technician at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy, since 2000, he is currently working in the fields of seismology (chaos and entropy concepts applied to data analysis) and geomagnetism (at present, as a Ph.D. student, he studies the flow in the Earth's core as inferred from magnetic data and models).

Lucio Badiali (M'06) received a degree in physics, majoring in cybernetics, from "La Sapienza" University, Rome, Italy, in 1992.

From 1998 to 2003, he was a Technologist and from 2003 to present, he has been a Chief Technologist at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy. From 2008 to present, he has been a member of the Italian Grid Infrastructure board, branch of the European Grid Infrastructure (EGI), expert consultant for the United Nations Office for Project Services (UNOPS) and for the Italian Ministry of Foreign Affairs. He is currently Head of Information and Communication Technology at the National Earthquake Centre of the INGV, contract Professor of Informatics at "La Tuscia" University, Viterbo, Italy, and focal point at INGV for telecommunication of the Comprehensive Test Ban Treaty Organization (CBTBO).

Dr. Badiali is a member of the European Framework Programme (EU FP7) Science Data Infrastructure for Preservation—Earth Science (Scidip-ES), the Italian Antarctic Program, the IEEE Computer Society, the Associazione Italiana per l'Informatica e il Calcolo (AICA), and the American Geophysical Union (AGU).

Enkelejda Qamili received the M.Sc. degree in physics from the University of Tirana, Tirana, Albania, in 2005 and the Ph.D. degree in polar sciences from the University of Siena, Siena, Italy, in 2011.

Currently, she has a Research Grant at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy. Her research interests include studies in seismology and geophysics, i.e., identification of possible seismic precursors before large earthquakes, and global warming and geomagnetic field (statistical analysis, global and regional modeling, Earth's dynamo, etc.).

Mariagrazia De Caro received a degree in physics from the University "Roma Tre," Rome, Italy, in 2006.

She is currently a Research Senior Fellow at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy. Her research interests include: processing and analysis of the seismic signals recorded by seafloor stations; analysis of the gravimetric measurements in volcanic areas, and the study of the background seismic noise models in the Mediterranean seafloor.

Giuseppe Falcone received a degree in physics and the Ph.D. degree in geophysics of the Environment and Territory from the Messina University, Messina, Italy, in 2004 and 2007, respectively.

He is currently a Research Associate at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy. His research interests include marine seismology, seismic noise on the ocean bottom, seismic travel-time residuals, earthquake hazard assessment, stochastic modeling of seismic activity in tectonic areas, short- and long-term interactions among earthquakes, and statistical analysis of seismic catalogs.

Dr. Falcone is a member of the American Geophysical Union.

Caterina Montuori received a degree in geology from the University "La Sapienza," Rome, Italy and the Ph.D. degree in geophysics from the University "G. d' Annunzio," Chieti-Pescara, Italy, in 2004.

She is currently a Seismologist at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy. Her research interests include processing and analysis of the seismic signals recorded by seafloor stations, the study of the crust and the upper mantle by teleseismic tomography using data from land and seafloor stations, and statistical seismology (the study of the crustal tectonics by variation of the Gutenberg–Richter b-value).

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Francesco Frugoni received a degree in geology from the University "La Sapienza," Rome, Italy and the Ph.D. degree in geophysics from the University "G. d' Annunzio," Chieti-Pescara, Italy, in 2004.

He is currently a Researcher at the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy. His research interests include processing and analysis of seismic signals recorded by multiparameter seafloor stations, seismic reflection prospection in offshore areas, and recent tectonic evolution of the Italian region.

Dr. Frugoni is a member of the Italian Geological Society.

Giorgio Riccobene received the Ph.D. degree from Catania University, Catania, Italy, in 2000.

Since 2004, he has been a Staff Researcher at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy. He is a member of the Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) consortium and ANTARES and NEMO Collaborations. He was the Principal Investigator (PI) of the NEMO-OnDE experiment and PI of the Submarine Multidisciplinary Observatory (SMO).

Mario Sedita received the Technical and Industrial High School Degree from the Istituto Tecnico Industriale Archimede of Catania, Catania, Italy, in 1973.

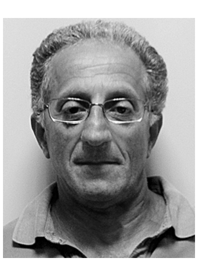
He joined the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy, in 1977. He was member of the NEMO collaboration from 1998 to 2011. He has been the INFN manager for underwater cable laying operations.

Giovanni Barbagallo received the Technical and Industrial High School Degree from the Istituto Tecnico Industriale Archimede of Catania, Catania, Italy, in 1979.

He has been a Staff Computing Technician at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy, since 1989, where he is currently the System and Network Manager. He is a member of the Submarine Multidisciplinary Observatory (SMO) project and has the responsibility of networking issues for the NEutrino Mediterranean Observatory—Submarine Network 1 (NEMO-SN1) infrastructure.

Giorgio Cacopardo received the Technical and Industrial High School Degree from the Istituto Tecnico Industriale E. Fermi of Giarre, Catania, Italy, in 1995.

He has been a Permanent Staff Technician at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy, since 2001. He is member of the mechanical engineering group of the NEMO Collaboration.



Claudio Calì received the Technical and Industrial High School Degree from the Istituto Tecnico Industriale Archimede of Catania, Catania, Italy, in 1978.

He has been a Permanent Staff Technician at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy, since 1984, where he is currently responsible for the Electronic Department. His main activity is devoted to the R&D of front–end electronics for nuclear physics experiments.

Rosanna Cocimano received the M.S. degree in electrical engineering from Catania University, Catania, Italy, in 2002.

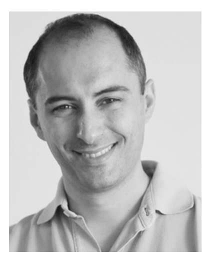
Since 2002, she has been a Technologist at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy. She is member of the Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) consortium and the NEMO collaboration. She was a member of the NEMO technical board of the NEMO phase 2 project. She is an expert in electrical power system for submarine applications.

Rosa Coniglione received a degree in physics from Catania University, Catania, Italy, in 1984.

Since 1987, she has been a Staff Researcher at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy. She is a member of the Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) consortium and ANTARES and NEMO Collaborations. She is a Physics Coordinator of the KM3 project.

Michele Costa received the Ph.D. degree from Catania University, Catania, Italy, in 2005.

Since 2002, he has been a Technologist Engineer at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy. He is a member of the Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) consortium and NEMO Collaborations. He is a structural designer.



Antonio D'Amico graduated in electronics engineering with a major in telecommunications from the University of Catania, Catania, Italy, in 2002, with a thesis on the design of the optical transmission system for NEMO neutrino detector.

He designed and realized the data transport architecture for the NEutrino Mediterranean Observatory—Submarine Network 1 (NEMO-SN1) cabled observatory. Currently, he is working at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy, in the design of optical transmission systems for NEMO-SMO and Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) projects.

Francesco Del Tevere received the Technical and Industrial High School Degree from the Istituto Tecnico Industriale Archimede of Catania, Catania, Italy, in 1976.

He is a Staff Computing Technician at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy. He is a member of the SMO project. He has collaborated in developing the onshore data storage and transmission infrastructure network of the NEutrino Mediterranean Observatory—Submarine Network 1 (NEMO-SN1).

Carla Distefano received the Ph.D. degree from Catania University, Catania, Italy, in 2004.

Since 2011, she has been a Staff Researcher at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy. She is a member of the Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) consortium and ANTARES and NEMO Collaborations. She is a person in charge of neutrino Monte Carlo simulations in ANTARES.

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Francesco Ferrera received the Technical and Industrial High School Degree from the Istituto Tecnico Industriale Archimede of Catania, Catania, Italy, in 1975.

He is a Staff Computing Technician at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy. He is a member of the SMO project. He has developed the onshore data storage and transmission infrastructure network of the NEutrino Mediterranean Observatory—Submarine Network 1 (NEMO-SN1).

Valentina Giordano received the Ph.D. degree in physics from the Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) group of the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy, in 2012

She developed statistical methods for the search of very high energy cosmic neutrinos from point-like sources located in our galaxy.

Massimo Imbesi was born in Messina, Italy, in 1973. He received the M.S. degree in computer engineering from the University of Catania, Catania, Italy, in 2006.

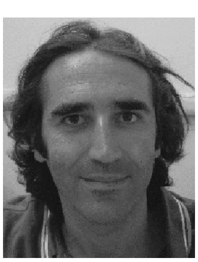
He is a member of the Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) collaboration and currently works at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy.

Dario Lattuada was born in Catania in 1979, He received the Ph.D. degree from Catania University, Catania, Italy, in 2012.

Currently, he holds a postdoctoral research position at Catania University (2012–2014). As a member of the Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) consortium and ANTARES and NEMO collaborations, he has been working on Monte-Carlo-based physics simulation since 2006 at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy.

Emilio Migneco graduated in nuclear physics from Catania University, Catania, Italy, in 1962.

He was a Full Professor at the University of Catania, Catania, Italy, until 2011. After working for a long time in nuclear physics, he was elected the spokesperson of the NEMO experiment from 1998 to 2011 and Coordinator of the Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) Preparatory Phase from 2009 to 2012.



Mario Musumeci received the Laurea degree in mechanical engineering from the University of Catania, Catania, Italy, in 1999.

He is a Staff Engineer of the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy. He joined the NEMO collaboration in 2000. He has been the Head of the Mechanics Engineering Group and Sea Operations Manager since 2005.

Angelo Orlando received a degree in electronic engineering from the University of Catania, Catania, Italy, in 2004.

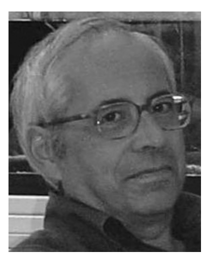
He joined the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy in 2005. His main activity in the NEMO Collaboration is devoted to the development, installation, and operation of a monitoring system for power supply system underwater laboratories.

Riccardo Papaleo was born in Milano, Italy, in 1970. He received a degree in electronic engineering from the University of Catania, Catania, Italy, in 1996.

He is an Electronic Engineer. He was a Technical Coordinator of the NEMO project for eight years. Currently, he is the Project Manager and the Team Leader for the development of a deep seafloor network of the Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) Italian project (funded by PON 2007–2013).

Paolo Piattelli received a degree in physics from the University of Catania, Catania, Italy, in 1985.

He is a Senior Staff Member of the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy, working in the field of astroparticle physics. He is a member of the NEMO, ANTARES, and Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) collaborations. His present activity is focused on high-energy neutrino astronomy.



Guido Raia graduated in nuclear engineering from Turin University, Turin, Italy, in 1975.

He is a Senior Engineer at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy, from 1984 to 2010. As a member of the NEMO Collaboration, he has managed the development and deployment of the onshore power system for the NEMO experiment.

Alberto Rovelli received a degree in physics from the University of Catania, Catania, Italy, in 1990.

He is a Senior Staff Researcher at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy. He is a member of the NEMO Collaboration and coordinates the development of the database for the NEMO experiment.

Piera Sapienza received a degree in physics from the University of Catania, Catania, Italy, in 1986.

She is a Senior Staff Physicist at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy. Since 1999, she has been a member of the NEMO, ANTARES and Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) collaborations. Her present activity is focused on high-energy neutrino astronomy.

Fabrizio Speziale received the M.S. degree in physics from Catania University, Catania, Italy, in 2007.

He received a permanent position at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy, in 1988 and became a Chief of the Cryogenic Staff in 2012. He has been involved in the acoustic acquisition systems design for neutrino astronomy and marine biology since 2002. He is also the Audio Engineering Society (AES) associate.

Agata Trovato graduated in physics from the Università degli Studi di Catania, Catania, Italy, in 2009, with a thesis about the optimization of Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) neutrino telescope performance. Since January 2011, she has been working toward the Ph.D. degree in nuclear and particle astrophysics at Catania University, dealing with the events simulation and the reconstruction code for the KM3NeT telescope.

In 2009 and 2010, her research activity was funded by an Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy, scholarship for students.

Salvatore Viola graduated in physics from the University of Catania, Catania, Italy, in 2009, with a thesis on the acoustic positioning system for a KM3-scale neutrino telescope. Currently, he is working toward the Ph.D. degree at the University of Catania.

He worked on the development and realization of the acoustic antenna installed onboard the NEutrino Mediterranean Observatory—Submarine Network 1 (NEMO-SN1) cabled observatory. He is working at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy, on a innovative underwater acoustic detector in the framework of the NEMO-SMO and Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) projects.

Fabrizio Ameli was born in Rome, Italy, in 1966. He received the "Laurea" degree (*cum laude*) from the "Sapienza" University of Rome, Rome, Italy, in 1991 and the Ph.D. degree from the INFOCOM Department, "Sapienza" University of Rome, in 2006.

Since 2010, he has had a permanent position at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy. His main interests are in digital signal processing, hardware development for physics experiments, FPGA design, and embedded systems.

Maurizio Bonori received a degree in physics from Cagliari University, Cagliari, Italy, in 1973.

He is with the Physics Department, University of Rome "La Sapienza," Rome, Italy and the Istituto Nazionale di Fisica Nucleare (INFN), Rome, Italy, Professor of Applied Electronics, now retired.

Dr. Bonori is a member of the Acoustical Society of America (ASA).

Antonio Capone received a degree in physics from the University "La Sapienza," Rome, Italy, in 1974.

Since November 2001, he has been a Full Professor at the Physics Department, University "La Sapienza," where he teaches mechanics. Previously, he also taught nuclear and subnuclear physics and astrophysics with high energy particles. He has been working at CERN as a Fellow (1981–1983), as a Staff Member (1984–1987), and then as a Scientific Associate (1994–1995). He carried on his research activity in several high-energy physics experiments (MultiGamma, CHARM, CHARM-2, CHORUS, etc.) in CERN (tests of Standard Model of ElectroWeak Interactions, Neutrino Interactions, Neutrino Oscillations). In 1994–1998, he was responsible for NESTOR. Since 1998, he has collaborated to promote the Italian project NEMO for the construction of an underwater Cherenkov detector to search for very-high-energy neutrinos from astronomical sources. At the end of 2011, in the framework of the Italian National Operative Plan (PON Ricerca e Competitività 2007–2013), a project for the construction of part of the Kilometre-Cube Underwater Neutrino Telescope (KM3NeT) has been approved and funded: this project foresees to start the construction of part of the Cherenkov Neutrino Telescope in the Mediterranean Sea before the end of 2014. In 2012, he was elected a spokesman of this project. In 2006–2012, he collaborated with the European Consortium KM3NeT and coordinated two work packages for the projects "KM3NeT-Design Study" and "KM3NeT-Preparatory Phase," funded by Europe in the framework of the Frame Programs 6 and 7, respectively. In 2007, he proposed and organized, as Chairman, the Roma International Conference on Astroparticle Physics (RICAP07, June 20–22, 2007). He will organize as Chairman the fourth edition of that Conference in 2013. In 2008, he organized, as Chairman, the Third International Workshop on the Acoustic and Radio EeV Neutrino detection Activities (ARENA08, June 25–27, 2008).

Rocco Masullo received the High School Diploma from the Istituto Tecnico Industriale E. Fermi of Rome, Rome, Italy, in 1969.

He is a Senior Member of the technical staff at the NEMO projet for the realization of the deep sea Cherenkov neutrino detector. He supports activities related to interfacing oceanographic instrumentations and power distribution in the deep sea neutrino telescope.

Currently, he is an Electronics Expert at the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy.

Francesco Simeone was born in Roma, Italy, in 1976. He received the B.E. and Ph.D. degrees in particle physics from the University "Sapienza," Rome, Italy, in 2001 and 2007, respectively.

His current research interests include astroparticle physics, in particular, high-energy cosmic ray and neutrino production, and acoustic and optic neutrino detection techniques. He is an author and coauthor of more than 70 scientific publications. He is a Temporary Researcher at the University "Sapienza."

Luca Pignagnoli received a degree in mathematics from Parma University, Parma, Italy, in 1999 and the Ph.D. in computational sciences from Milan University, Milan, Italy, in 2006.

He is currently a Collaborator of the Istituto di Scienze Marine (ISMAR), National Council of Research (CNR) and collaborates with the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy. His research interests include tsunami generation processes, algorithms for signal analysis, tsunami early warning systems, and tsunami detectors design.

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Nevio Zitellini received the Laurea degree in geology from the University of Bologna, Bologna, Italy, in 1977 and the M.A. degree in marine geophysics from Columbia University, New York, NY, in 1991.

He was a Research Scientist at in 1982, a Senior Researcher in 1996, and since 1998, he has been a Research Director at the Consiglio Nazionale delle Ricerche, Istituto di Scienze Marine (CNR-ISMAR), Bolonia, Italy. His research interests are in marine geology and geophysics ranging from magnetometric and gravimetric researches, multichannel seismic reflection data interpretation and elaboration, to structural and tectonic studies. Currently, he is a Coordinator of the European Union (EU) project NEAREST (Integrated Observation from Near Shore Sources of Tsunamis: Toward an Early Warning System).

Federico Bruni received a degree in electronic engineering from the University of Padova, Padova, Italy, in 2001.

He is a Senior Control Engineer, Robotic Systems Engineering Department, Tecnomare S.p.A., Marghera, Venice, Italy (marine engineering company subsidiary of the Italian oil company ENI). He has 11 years of experience in hardware/software development, data acquisition system for seafloor observatories and autonomous underwater vehicles (AUVs), and pipeline monitoring systems.

Francesco Gasparoni received a degree in electronic engineering from the University of Padova, Padova, Italy, in 1981.

He is a Project Manager at the Innovative Technologies Department, Tecnomare S.p.A., Marghera, Venice, Italy. He has 30 years of experience in design and development of advanced monitoring systems for marine applications. He is the inventor of the GEophysical and Oceanographic STation for Abyssal Research (GEOSTAR) multidisciplinary seafloor observatory concept.

Gianni Pavan received the Laurea degree in nature science from the University of Pavia, Pavia, Italy, in 1983.

He was a Professor of Ecology at the IUAV University of Venice, Venice, Italy (1994–2005). Currently, he teaches bioacoustics at the University of Pavia, Pavia, Italy, and runs the Centro Interdisciplinare di Bioacustica e Ricerche Ambientali that he contributed to create in 1989 to develop advanced bioacoustic research based on digital techniques. He started to work on computational bioacoustics in 1980. He developed and maintains the SeaPro and SeaWave packages for real-time sound analysis and spectral display. He also designed the underwater equipment (various types of towed arrays and analysis instruments) used for marine mammals surveys on either small boats or oceanographic ships. He has cooperated with the Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy and the Istituto Nazionale di Fisica Nucleare (INFN), Catania, Italy, to develop multidisciplinary underwater acoustic sensing systems since 2003. His main research interests are in marine mammal acoustics, the impact of underwater noise on marine mammals, and marine and terrestrial soundscapes. He cooperates with the Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS), the U.S. Office of Naval Research (ONR), NATO Undersea Research Center (NURC), Woods Hole Oceanographic Institution (WHOI), IT Navy, and other institutions to study and protect marine mammals. He maintains the Italian Strandings Online Database.