NEAREST (INTEGRATED OBSERVATIONS FROM NEAR SHORE SOURCES OF TSUNAMIS: TOWARDS AN EARLY WARNING SYSTEM)

http://nearest.bo.ismar.cnr.it

NEAREST 2007 CRUISE PRELIMINARY REPORT R/V *URANIA*

10th Aug 2007 - 10th Sept 2007

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CONSIGLIO NAZIONALE DELLE RICERCHE
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Cover: Rodeo on the Buoy

We are grateful for all pictures to: Innocenzi L., Angeletti L., Veronesi F., D'Oriano F., Tola M.
Graphics and maps by Carrara G., D'Oriano F., Tola M.

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Fig 1 – The Geostar communication buoy.

ABSTRACT

During the NEAREST 2007 Cruise were performed the following operations:

- the deployment of a seafloor multiparametric station GEOSTAR like
- the deployment of a communication buoy
- the deployment of 22 OBSs
- the sampling of the seabed by gravity and SW coring and grabs.

All these operations were foreseen by the European Project Nearest (GOCE, contract **n. 037110**) that include the collaboration among INGV, TFH, AWI, FFCUL and CSIC and other european scientific institutions with the common aim to identify and characterize the large potential tsunami sources located near shore in the Gulf of Cadiz (SW Iberian Margin).

The seafloor station and its communication buoy were deployed on the first leg, the 25th of August 2007, whereas the OBS array and the seafloor sampling were performed on the second leg. In addition during the second leg three quality control checks on the acoustic systems installed on the buoy were done.

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Fig 2 - NEAREST Team

1. Introduction: NEAREST Project

NEAREST is an EU-funded project (GOCE, contract **n. 037110)** which is mainly addressed to the identification and characterisation of large potential tsunami sources located near shore in the Gulf of Cadiz (fig. 3) through the near real-time detection of signals by a multiparameter seafloor observatory GEOSTAR like.

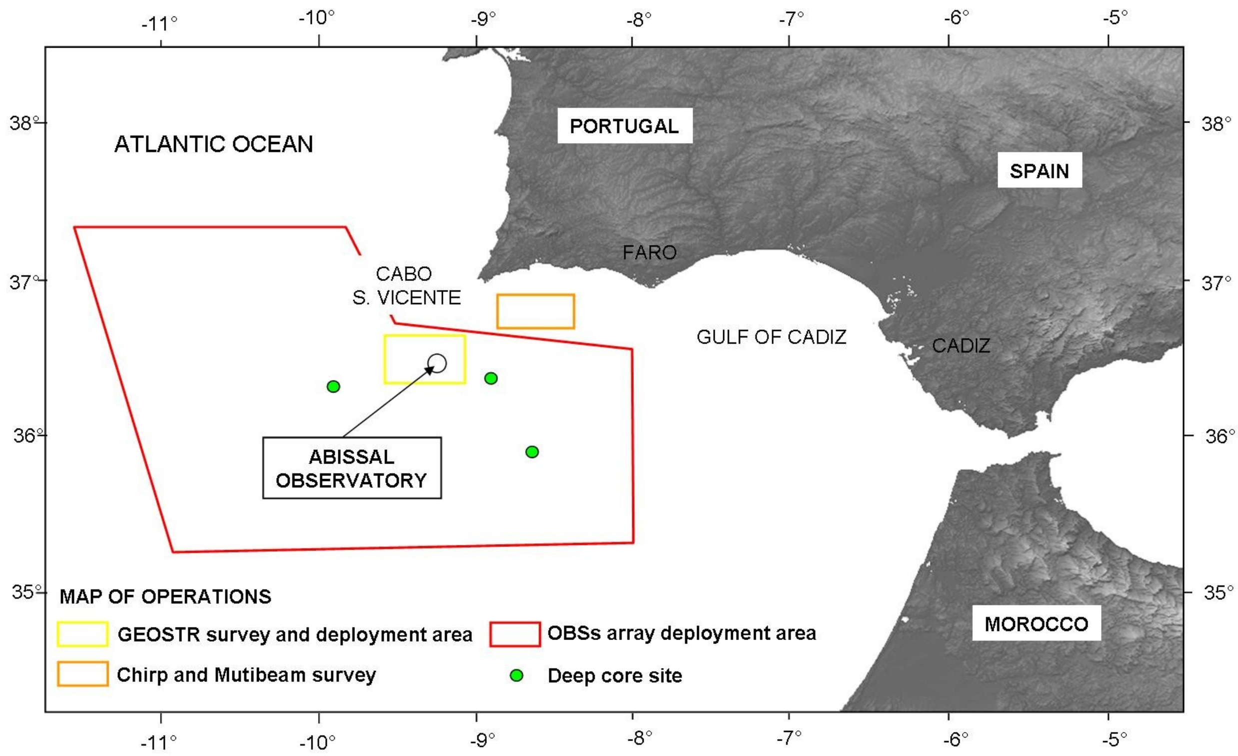


Fig. 3 - Working area

In this area, highly populated and prone to devastating earthquakes and tsunamis (e.g., 1755 Lisbon earthquake), a very good geological/geophysical knowledge has already been acquired in the last decade so it represent an excellent place in which test the near real-time detection of seismic signals.

The methodological approach will be based on the cross-checking of multiparameter time series, acquired on the seafloor by a long-term deep-sea station, equipped with real-time communication to an onshore main station, and by broad band Ocean Bottom Seismometers. All these data series also will be integrated with those coming from land seismic and tide gauge stations, actually active, to be used in a feasibility study for an Early Warning Systems (EWS) prototype in this peculiar area. The EWS will be based on reliable procedures to pass the needed parameters and information to the decision-makers (e.g., local civil protection authorities).

NEAREST, moreover, will search for sedimentological evidence tsunamis records to improve the knowledge on the recurrence time for extreme events and will try to measure the key parameters for the comprehension of the tsunami generation mechanisms.
Another aspect investigated by the project is the improvement of integrated numerical models for the building of more accurate scenarios of tsunami impact and the production of accurate inundation maps in selected areas of the Algarve (SW Portugal), highly hit by the 1755 tsunamis.
To realize all these aims a first NEAREST cruise was planned in august 2007 in order to deploy the abyssal multipurpose observatory and the array of ocean bottom seismometers (OBS).

1.1. Geological setting

The SW Iberian Margin is located at the eastern end of the Azores-Gibraltar-Fracture zone, wich is the Eurasia-Africa plate boundary in agreement with the plate-kinematic reconstructions (Olivet et al. 1996; Srivastava et al., 1990).
The area could be divided in two main morphotectonic domains (Tortella et al., 1997): the first between the Gorringe Bank and Cabo Sao Vicente to the west, and the Gulf of Cadiz, between the Cabo Sao Vicente and the Strait of Gibraltar to the east (fig.4).
The first area is characterized by a complex and irregular topography, dominated by large seamounts, deep abyssal plains, and massive rises (e.g. Bergeron and Bonnin, 1991; Gràcia et al., 2003a, Terrinha et al., 2003; Zitellini et al., 2004) such as the Gorringe Bank. The second area is characterized by a smoother topography and by a prominent NE-SW trending positive free-air gravity anomaly (Dañobeitia et al., 1999; Gràcia et al., 2003b).
During the Triassic-Jurassic break-up of Pangea, the eastward drifting of Africa respect to Iberia led to the formation of a rift basins between the new continental margins; this divergent stage ended in early Late Cretaceous. Subsequent northwards migration of Africa with respect to Eurasia led to subduction of western Tethis toward East (Late Cretaceous-Paleogene) and final continental collision with the formation of the Betics-Rif mountains belts and the Gibraltar Arc (Miocene). The Gibraltar Arc emplacement produced a number of allochthonous units identified from the Gulf of Cadiz to the Horseshoe Abyssal Plain (Bonnin et al., 1975; Torelli et al., 1994; Flinch et al., 1996; Maldonado et al., 1999; Gràcia et al., 2003b; Medialdea et al., 2004).
From Tertiary up to now the main compression direction has rotated anticlockwise, currently the latest GPS kinematic models (Nocquet et al., 2004), show a WNW-ESE main direction of the relative movements between the African and Iberian plates.

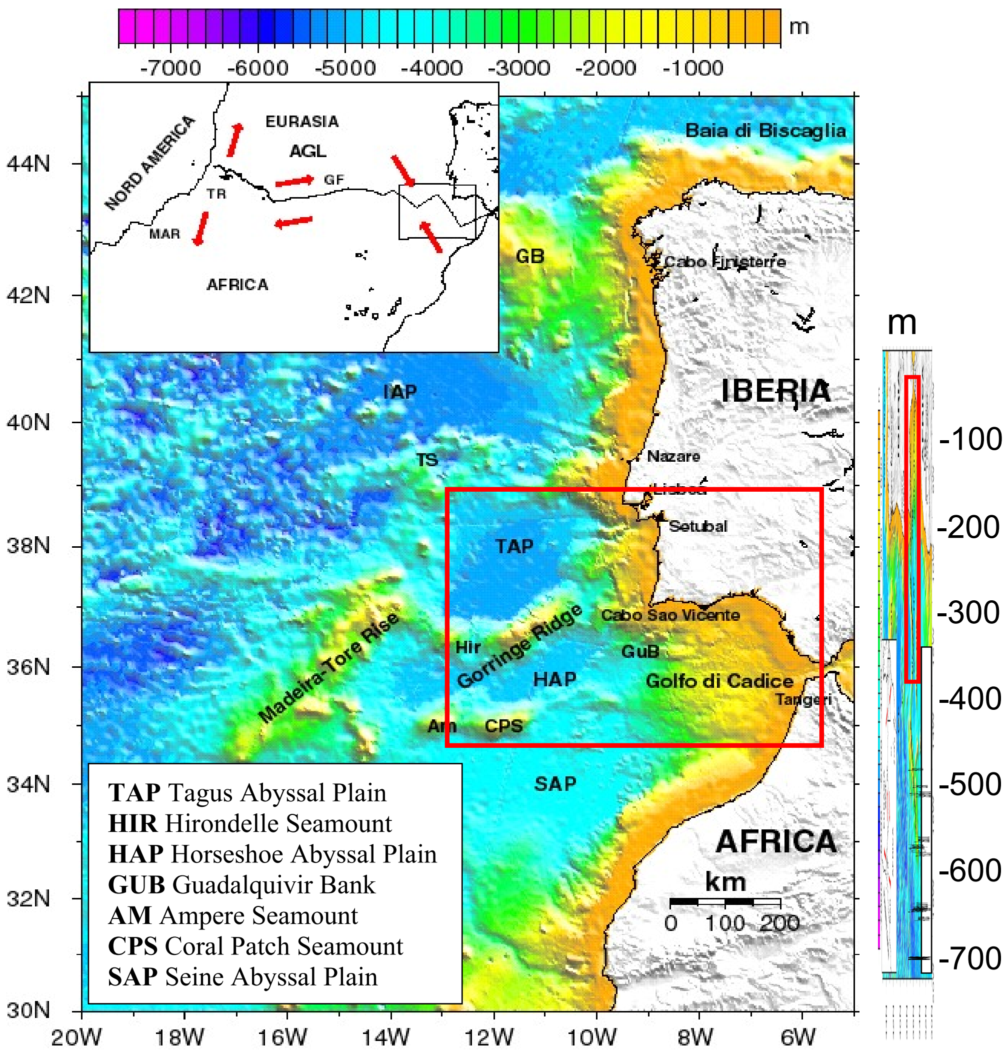


Fig. 4 – SW Iberian margin

Plate convergence of 4 mm/yr (Argus et al., 1989; Nocquet et al., 2004) is accommodated, in this area, over a wide and diffuse deformation zone (Sartori et al., 1994; Hayward et al., 1999) characterized by significant and widespread seismic activity (e.g., Grimison and Chen, 1986). This tectonically active deformation zone was been source of the largest earthquakes that affected the East Atlantic cost since historical times (i.e. 1531, 1722, 1755, 1969) (Fukao, 1973, Martins and Mendes-Victor, 1990). The 1st of November 1755 occurred the most catastrofic of this event, the Lisbon Earthquake, this event was followed by a tsunami that struck the city and impact all the West Europe and Nord African cost. A moment magnitude >8.5 (MW) has been estimated for the Lisbon Earthquake (Martins and Mendes-Victor, 1990; Abe, 1989). The location of the tectonic structure that caused the earthquake end the tsunami has been debated during the last decades (e.g., Udías et al., 1976). After 15 years of geophysical investigation (Rifano-1992, Eu_Bigsets-1998, Parsifal-2000, Hits-2001, Voltaire-2002, Sismar-2003, ESF_Swim-2003) a series of regional tectonic active structures was described and showed to be the possible tsunamigenic tectonic sources, the Marquise de Pombal fault, the Horseshoe fault and the Portimao fault (e.g. Zitellini et al., 2001; Gràcia et al., 2003; Terrinha et al., 2003). This structures converge in a relatively small area located 100 miles offshore Cabo Sao Vicente, the SW culmination of Iberian peninsula that was choosen for the deployment of the seafloor observatory.

1.2. State of the Art for Tsunami Detection

The reason for developing a real-time, deep ocean tsunami measurement system was to foreseen the impact of tsunamis on coastal areas in time to save lives and protect property.

The first approach to Tsunami waves monitoring was a combination of tide gauges and seismometers. After that, in order to provide a much earlier warning of an approaching tsunami, NOAA (National Oceanic and Atmospheric Administration), developed the research project for Deep-ocean Assessment and Reporting of Tsunami (DART), using buoys in deep sea, acoustically linked to sea-floor pressure gauges. In turn, the buoys would relay the sensor data to a central land site by satellite radio links.

The first-generation DART was based on an automatic detection and reporting algorithm triggered by a threshold wave-height value. The DART II design incorporated two-way communications that enables tsunami data transmission on demand, independent of the automatic algorithm.

Each DART gage was designed to detect and report tsunamis on its own, without instructions from land. The tsunami detection algorithm developed in the gage's software works by firstly estimating the amplitudes of the pressure fluctuations within the tsunami frequency band and then testing these amplitudes against a threshold value. The amplitudes are computed by subtracting predicted pressures from the observations, in which the predictions closely match the tides and lower frequency fluctuations. The predictions are updated every 15 seconds, which is the sampling interval of the DART gages. The detection threshold was defined using statistical analysis on background oceanic noise. Based on past observations, a reasonable threshold for the North Pacific was fixed to 3 cm. When the amplitude exceeds the threshold, the gage goes into a rapid reporting mode to provide detailed information about the tsunami.

1.3 Tsunami modelling

The life of Tsunami can usually be divided in three phases: generation (source), propagation and inundation.

Using different models to generate the initial displacemment of the seafloor and long waves or shallow water models to decribe tsunami propagation and to calculate the inundation, tsunami modelling has proved to be an important tool to evaluate the impact of tsunami waves in coasts and to assess the candidate sources for historical tsunamis in the possible tsunamigenic zones along the studies area.

However several authors investigated the tsunami sources in the SW of Iberia and Gulf of Cadiz, Fukao (1973), Johnston (1996), Baptista (1998,2003), Zitellini (1999) and Gutscher(2003), in the purpose to explain observable data for historical tsunamis (the great Lisbon earthquake and tsunami of 1755 with estimate magnitude 8.5-9), or to confirm instrumental records for recent tsunamis (the 1969 Horseshoe fault (HSF) earthquake MW 7.9).

The present study led in this area consists to use tsunami modelling to determine the impact of waves in the different coasts and, afterward, evaluate tsunami risk and vulnerability. Modelling was performed with COMCOT code, from Cornell University (Liu et al., 1994). The simulation domain covers the eastern part of the Atlantic Ocean offshore Morocco and the Gulf of Cadiz, from the most prone tsunami generation area. Three nested grid layers of different resolution (0.008º, 0.002º and 0.0005º) are incorporated to obtain a good description of bathymetric and topographic effects near shore. Results of the numerical simulations are discussed in terms of wave heights, flow depth and maximum velocity.

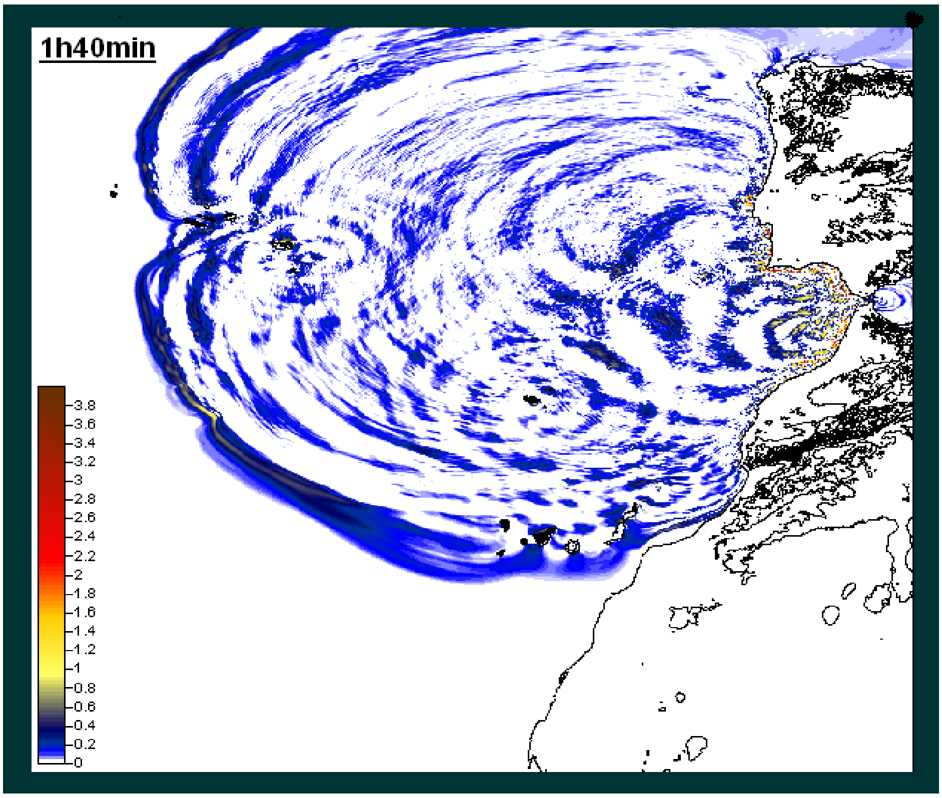


Fig:5 - Modelling of tsunami propagation for the 1755 tsunami for the source proposed by Zitellini et al. (1999) and Baptista et al. (2003)

2. NEAREST 2007 CRUISE

2.1 Objectives

The scientific survey was performed between 16th August and 4th September 2007 offshore Cabo Sao Vicente and in the Gulf of Cadiz, in portuguese and international waters. The main goals of the cruise were the deployment of a multiparameter seafloor observatory (GEOSTAR), its communication buoy and an array of 24 oceanic bottom seismeters (OBS). In addition subbottom profiles, multibeam data and seafloor sampling were collected. These data will improve both the geological and the geophysical knowledge of the tectonic architecture of the area, that is presumed it was the source of the 1755 Lisbon Earthquake. The cruise was splitted in two legs cause the huge volume of the instruments to be deployed: the first leg was from 16th of August until the 27th of August and the second one from 28th of August until 4th of September 2007.

2.2 NEAREST 2007 First Leg: GEOSTAR and Buoy deployment

The main goal of the first leg was the deployment of the seafloor multiparametric station, GEOSTAR like, linked to land receiving stations by an acoustic communication system assembled on a buoy. The seafloor station, equipped with a seismometer and oceanographic sensors, will record seismicity and oceanographic data for one year. After detailed tectonic and morphological studies and during the first meeting of the NEAREST team (Lisbon, may 2007) was identified the GEOSTAR deployment area (9°29.00'W, 36°18.00'N, 9°28.00'W, 36°24.00'N, see Fig 11 and 12). To detect possible presences of geomorphological instabilities that could compromise the site safety, a subbottom (CHIRP) survey was performed before the deployment (Fig.13 and 14). Moreover two CTD measures were collected before the deployment in order to determine the main oceanographic characteristics of the Geostar area and to calibrate the multibeam with an appropriate sound velocity function (Fig 29 and 30 ,chapter 3).

2.2.1 Technical description of the Geophysical seafloor observatory and instruments

The Geostar system is a single-frame autonomous seafloor observatory able to collect multiparameter data with a unique time reference for long-term investigations.

The technology of this observatory derives by the synergy among research institutes and industries starting from 1995 to develop seafloor systems able to operate from shallow water up to deep sea.

During these years, a fleet of observatories has been built up with the economical support of European Commission (i.e. GEOSTAR; GEOSTAR-2; SN-1;ORION-GEOSTAR-3; ASSEM etc.), bringing more and more improvements at the main technology of benthic observatories. These systems satisfy the main conditions of seafloor observatories: multidisciplinary, long-term monitoring, unique time reference, autonomy, and development of (near) real-time communication system for warning of local events.

The last generation of Geostar seafloor observatory, planned in the framework of NEAREST project, is equipped with:

- geophysical and oceanographic sensor package
- central acquisition, control unit (central clock)
- data processing unit
- local memory storage
- acoustic communication system

All of these characteristics are indispensable to be able to acquire scientific multiparametric data, to detect real-time events (seismic and water pressure) and to communicate possible warning messages.

The observatory is constituted by three main sub-systems:

1. Bottom station constituting the monitoring system (fig.6)
2. MODUS vehicle that allows deployment and recovery procedures (fig.7)
3. Buoy system representing the communication system (fig.8)

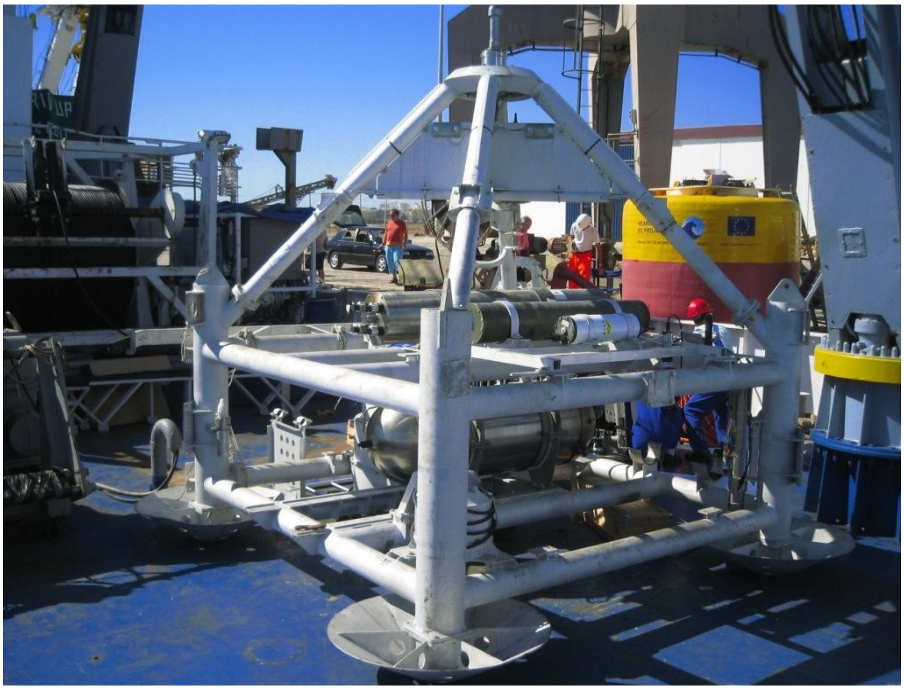


Fig 6 - GEOSTAR bottom station

The Bottom station consists in a marine aluminum frame hosting instrumental sensor packages (see table 1), compass controlling heading, pitch and roll of the observatory during the deployment, lithium batteries for power supply, echosounder to determine the distance between Geostar and bottom surface during the deployment, electronic for data acquisition, hard disks for data storage, underwater part of acoustic communication system.

The acquisition data is entirely controlled by a central unit (DACS: Data Acquisition and Control System) that prepares and updates the hourly data messages, performs the TDA algorithm and transmit data messages on request; also it is able to send in real-time warning messages of detected events towards the surface communication system (buoy).

DACS manages a wide set of data having quite different sampling rate (from 100 Hz to 1 sample/15 sec), tagging each datum according to a unique time reference set by a central high-precision clock.

Sensor	Sampling rate	Acquisition
3-comp. broad band Seismometer	100 Hz	Continuous
3-comp. Accelerometer	100 Hz	Continuous
Hydrophone	100 Hz	Continuous
Pressure sensor	1 smp/15 sec	Continuous
Gravity meter	1Hz	Continuous
CTD & Transmissometer	1 smp/min	Continuous
ADCP	1 smp/ hour	Continuous
3 comp. Currentmeter	5 Hz	Continuous

Table1: GEOSTAR main sensors

Fig 7 – The Modus Module

MODUS is an underwater vehicle dedicated to deploy and recover the bottom station. It is equipped with a latch/release device, thrusters, video cameras, compass, sonar and altimeter mounted on the frame to visual control during the observatory diving and assisting the docking procedure (see MODUS characteristics in Table 2).

Modus is remotely controlled from the ship through a telemetry system (umbilical cable) that provides the primary communication link with the station during the deployment phase.

Sensors	**Material**		**Dimension & Weight**	
Horizontal thruster	Frame	Aluminum	Total length-L	2878 (cm)
Vertical thruster	Docking device	Stainless steel	Total width-W	2348 (cm)
Heading accuracy (degree)	Pressure Vessel	Titanium	Total height –H	1700 (cm)
Tilt accuracy (degree)			Weight in air	ca. 10 (kN)
360º sonar range (m)			Weight in water	ca. 7 (kN)
Video Cameras (+ lights)				

Table 2: Modus main characteristics

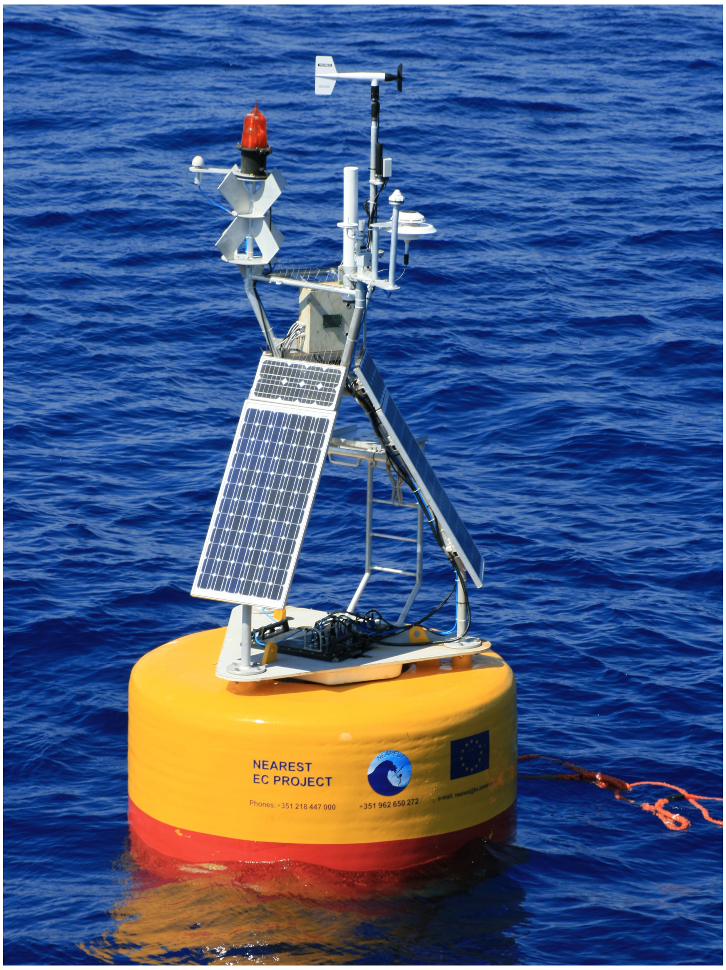


Fig 8 – The Buoy

The buoy is a surface system that works as relay between the hydro-acoustic communication system (toward the bottom station) and the satellite system (towards the shore station) assuring a (near) real-time transmission of the messages acquired. It hosts:

- An acoustic communication system able to transmit message request (status sensors, status message, etc.) at the bottom station by a land operator and also to receive periodic message (each 6 hours) of pressure and status sensors and warning message related to possible events (trigger time and pressure data).
- A satellite system as support of communication system between benthic observatory and shore station. It is able to send the received bottom station messages via GLOBALSTAR satellites. Further, a storage system inside the buoy allows to save the received messages when the satellite cover is not available and to send them subsequently.
- A meteo station equipped also with auxiliary sensors as temperature, humidity, anemometer, etc. (see Table 3) acquires and store meteorological information.
- A GPS positioning system managed from the buoy as well as an autonomous positioning system (ARGOS Beacon) working with a different satellite constellation.
- Six Photovoltaic Panels
- A acoustic transducer (ATS) communicating with the bottom observatory

Sensors	**Measured Parameter**	**Sampling Rate**
Meteo Station	Barometric pressure (mbar)	2 smp/sec
	Wind velocity (m/sec)	2 smp/sec
	Measured wind direction (deg)	2 smp/sec
	True wind direction (deg)	2 smp/sec
	Heading (deg)	2 smp/sec
	Air Temperature (º C)	2 smp/sec
	Air Humidity (%)	2 smp/sec
Tiltmeter	Tilt x	1 smp/sec
	Tilt y	1 smp/sec
	Heading (deg)	1 smp/sec
GPS	Longitude (deg)	1 smp/sec
	Latitude (deg)	1 smp/sec
	Drift (m)	Derived by lat and long values

Table 3: Scientific payload of the buoy

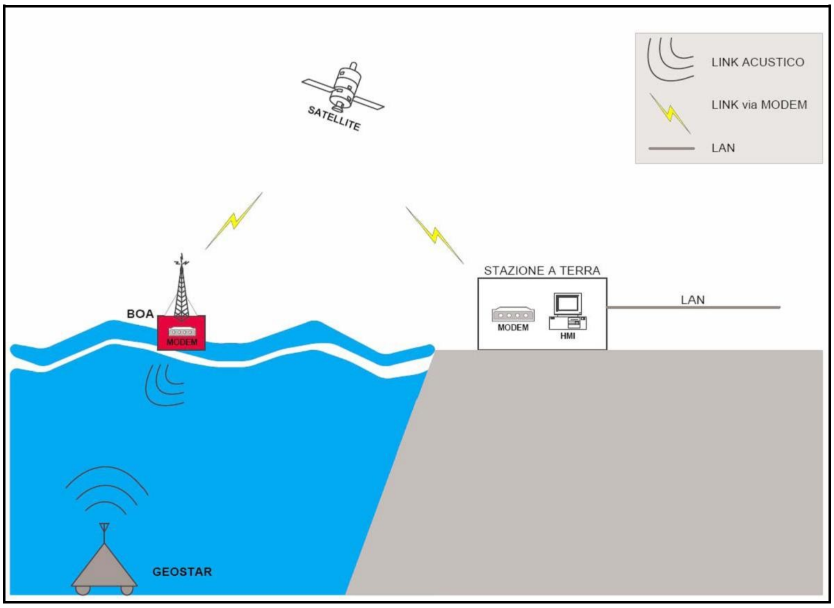


Fig. 9 Communication systems scheme.

The buoy anchorage system is shown in chapter 3

2.2.2 Geostar Deployment

The buoy and abyssal station deployments were performed during 25th of august (as described in the daily report). Before deployment a detailed chirp dataset was acquired in order to definitively identify a place free from instability phenomena, but, the presence of military submarine drill closest to the area and the forbiddance to cross the 9°30' W of longitude by the Portuguese authority, have forced the shift toward east of the instrument position (Fig 11 and 12).

The buoy anchorage system was deployed at 3217mt depth with the following official coordinates: 36°22.058' of latitude North 9°28.812' longitude West.

The GEOSTAR station was deployed at 3207 mt depth with the following official coordinates: 36°21.875' of latitude North 9°28.885' longitude West.


Fig 10 - GEOSTAR deployment

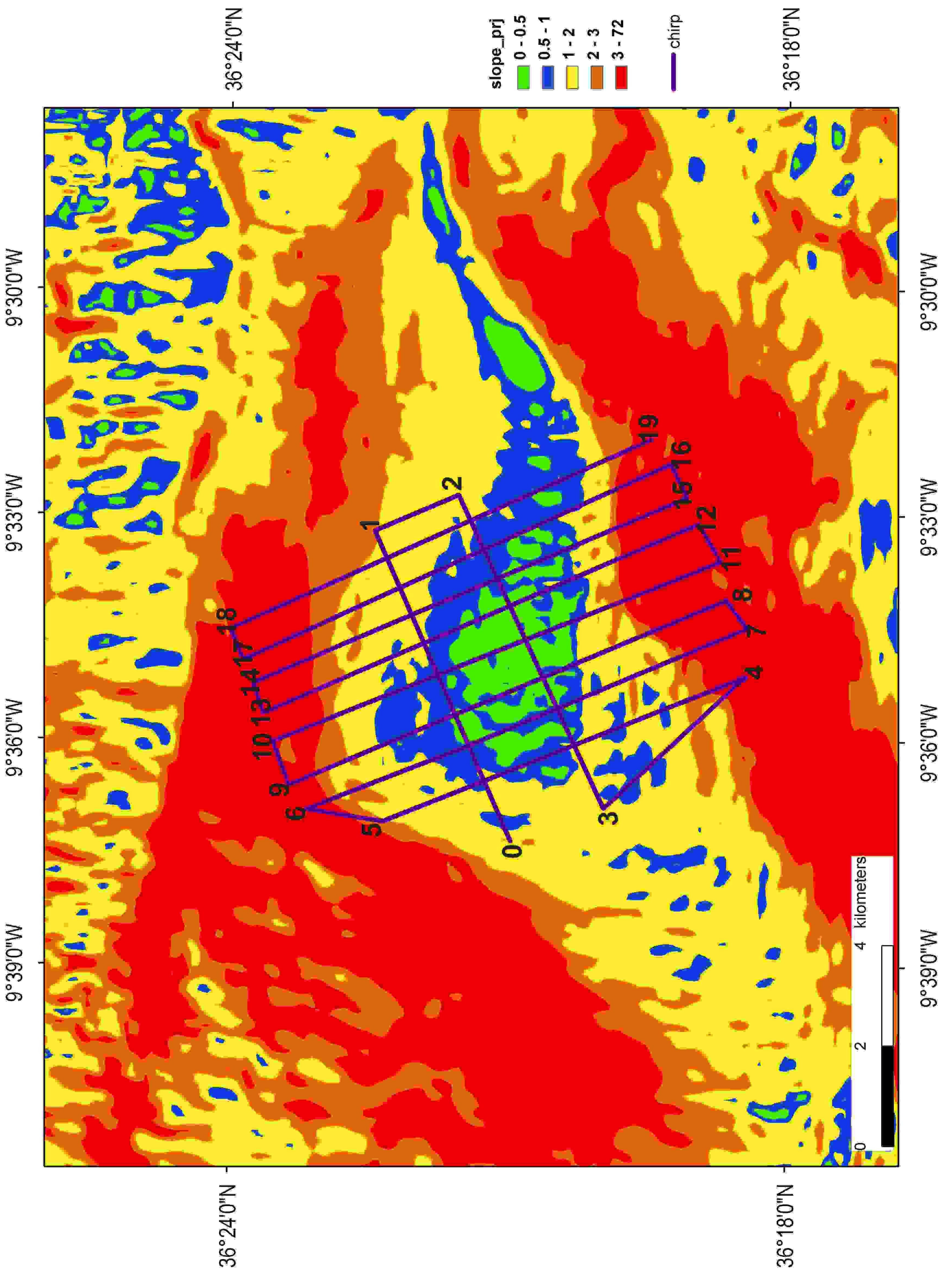


Fig. 11 - Foreseen chirp survey, on the slope distribution map.

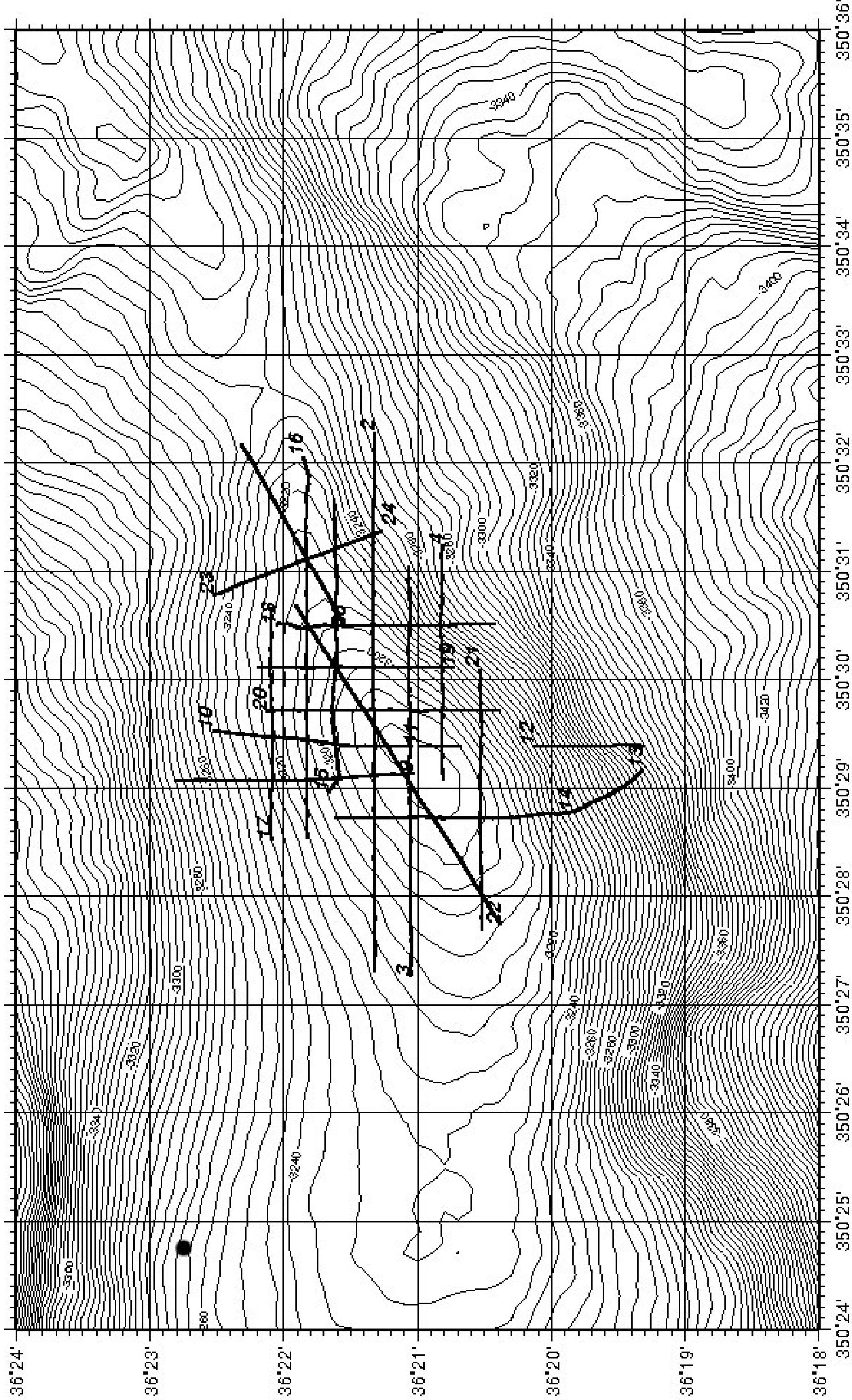


Fig 12 - Performed chirp survey on the Geostar site.

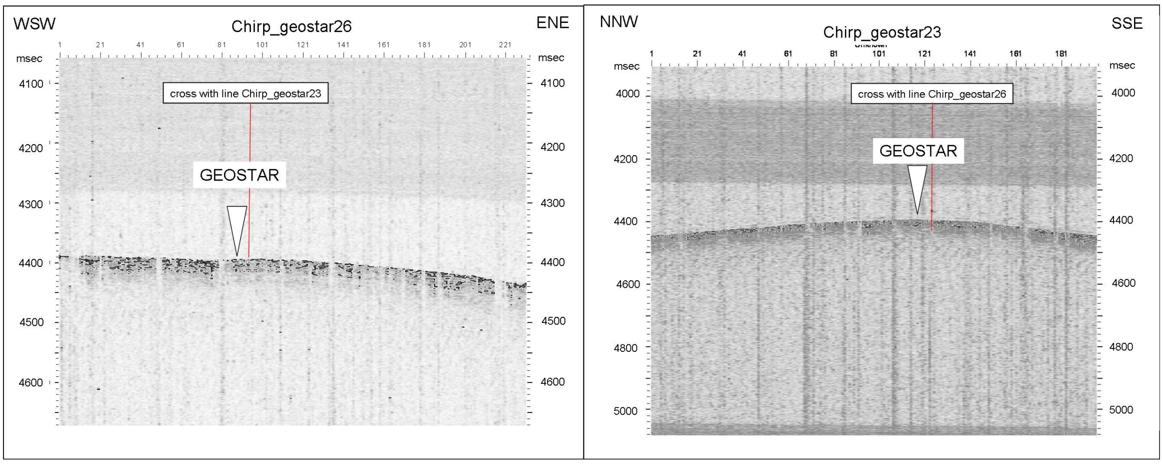


Fig 13 - Example of chirp data and Geostar location

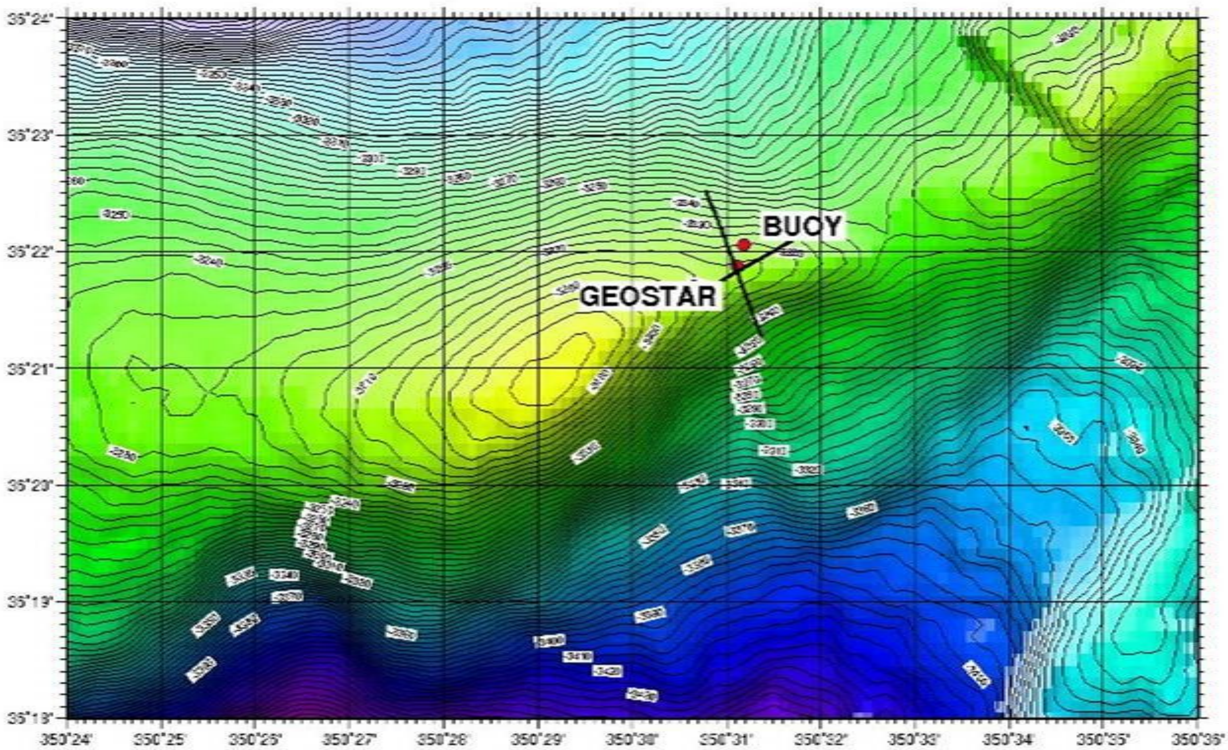


Fig 14 - Geostar and buoy site deployment

2.3 NEAREST 2007 SECOND LEG: OBS DEPLOYMENT AND SAMPLING

Tectonic structures in the transition from the Azores fracture zone to the postulated subduction zone in the area of the Strait of Gibraltar will be localized and characterized that have the potential to cause Tsunamis. For this purpose we deployed 22 broadband ocean bottom seismometers (OBS) from the German DEPAS instrument pool coordinated by the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven and the GeoForschungsZentrum, Potsdam. Seismicity studies and passive seismic imaging techniques will be performed after 12 months recording, when the OBS have been recovered. During the transfer among the OBSs Chirp and Multibeam data were collected. Despite the project to build an array of 24 OBSs, cause technical problems during the second leg, it was possible to deploy only 22 of them. The last 2 are scheduled to be deployed as soon as possible.

Fig 15 – OBSs on board

2.3.1 OBS DEPLOYMENT

24 DEPAS LOBSTER (**L**ongterm **O**cean **B**ottom **S**eismometer for **T**sunami and **E**arthquake **R**esearch, see Fig 15 and 17) K/MT 510 manufactured by K.U.M. Umwelt- und Meerestechnik Kiel GmbH, Germany, are used during the experiment. They are equipped with a Güralp CMG-40T broadband seismometer incorporated in a titanium pressure housing, a hydrophone, and a GEOLON MCS (**M**arine **C**ompact **S**eismocorder) data logger from SEND GmbH Hamburg, Germany. The electric power supply for the recorder and the seismometer is granted by 132 lithium power cells. Each sensor channel is sampled with 100 Hz, preamplifier gain of the hydrophone channel is 4 and 1 for the three seismometer components. The total disk space of the stations is 20 GB. Depending on the local seismic activity and active seismic surveys in the region the disk space can cover a recording time of 11 to 12 months. The clock of the data loggers were synchronized by GPS time before deployment and will be synchronized again after recovery of the instruments. The time difference during the recording period will then be corrected linearly. The seismometers are equipped with a cardanic levelling mechanism, which will be initiated a few hours after deployment, when the OBS is located on the seafloor, and then every 15 days (see Fig 17).

Fig 16 - Photograph of the LOBSTER (adapted from the LOBSTER manual).

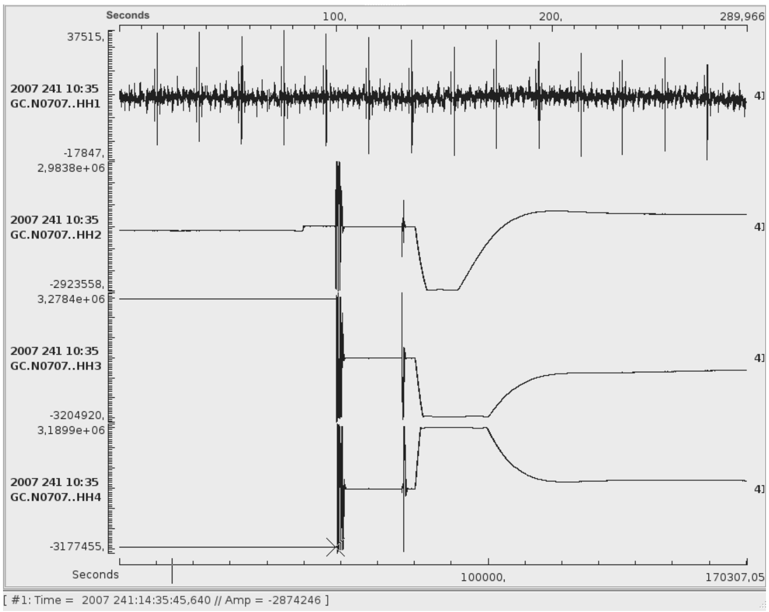


Fig 17 - Seismogram example of first levelling of OBS07 on the seafloor 4 hours after recording started. The uppermost trace is the hydrophone channel, where shooting signals of the RV Atalante can be seen. Below are the three seismometer channels. The time scale on top belongs to the time window showed; the time scale on the bottom shows gives the position of the time window within the whole recording interval.

2.3.2 Release test

The KUMQUAT release unit is the most important part of the OBS for a secure recovery. To proof the proper operation of the release units under deployment conditions in the deep sea we performed two release tests with 13 release units, each. The releasers were brought down to 3500 m depth using the geological winch of R/V Urania. Then the acoustic release code of each release unit was send three times. Due to the noisy conditions beneath the vessel not all acoustic responses from the release units could be received by the deck unit. After recovery onboard all release hooks were open confirming the proper operation of the release units at the average operation depth.

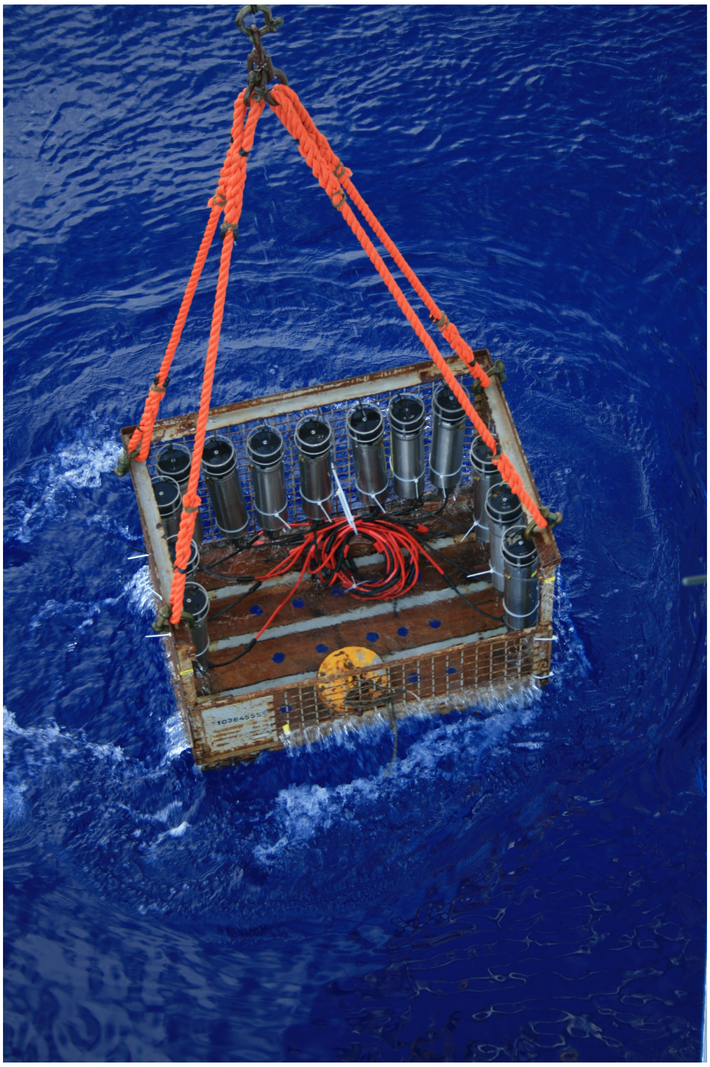


Fig 18 - Photograph of the releaser test configuration.
Parameters of test 1: 29.08.2007, 02:00 UTC
36°21.977'N 09°44.975'W, 3500 m depth
all tested 13 releaser units released
test 2: 29.08.2007, 06:30 UTC
36.21.684' N 09°44.711'W, 3500 m depth
all tested 13 releaser units released

2.3.3 Stations deployment

During the cruise 22 of 24 instruments were deployed (Figure 19, table 4). Unfortunately, the power connector of one recorder pressure tube was damaged. Therefore the 24^{th} OBS could not be deployed. The remaining anchor was used to conduct a test measurement with OBS07 close to the position of the GEOSTAR observatory. OBS07 was successfully recovered after 2 days. This station was planned to be re-deployed at the end of the cruise. During deployment of OBS14 another problem occurred, because the head buoy became trapped below the OBS that could prevent its recovery. To save the OBS we released it from its anchor before it reached the ground.

OBS14 was re-deployed with the last available anchor. Finally, the OBSs n. 7 and 24 remain onboard at the end of the cruise. We will try to deploy them in the near future by another vessel.

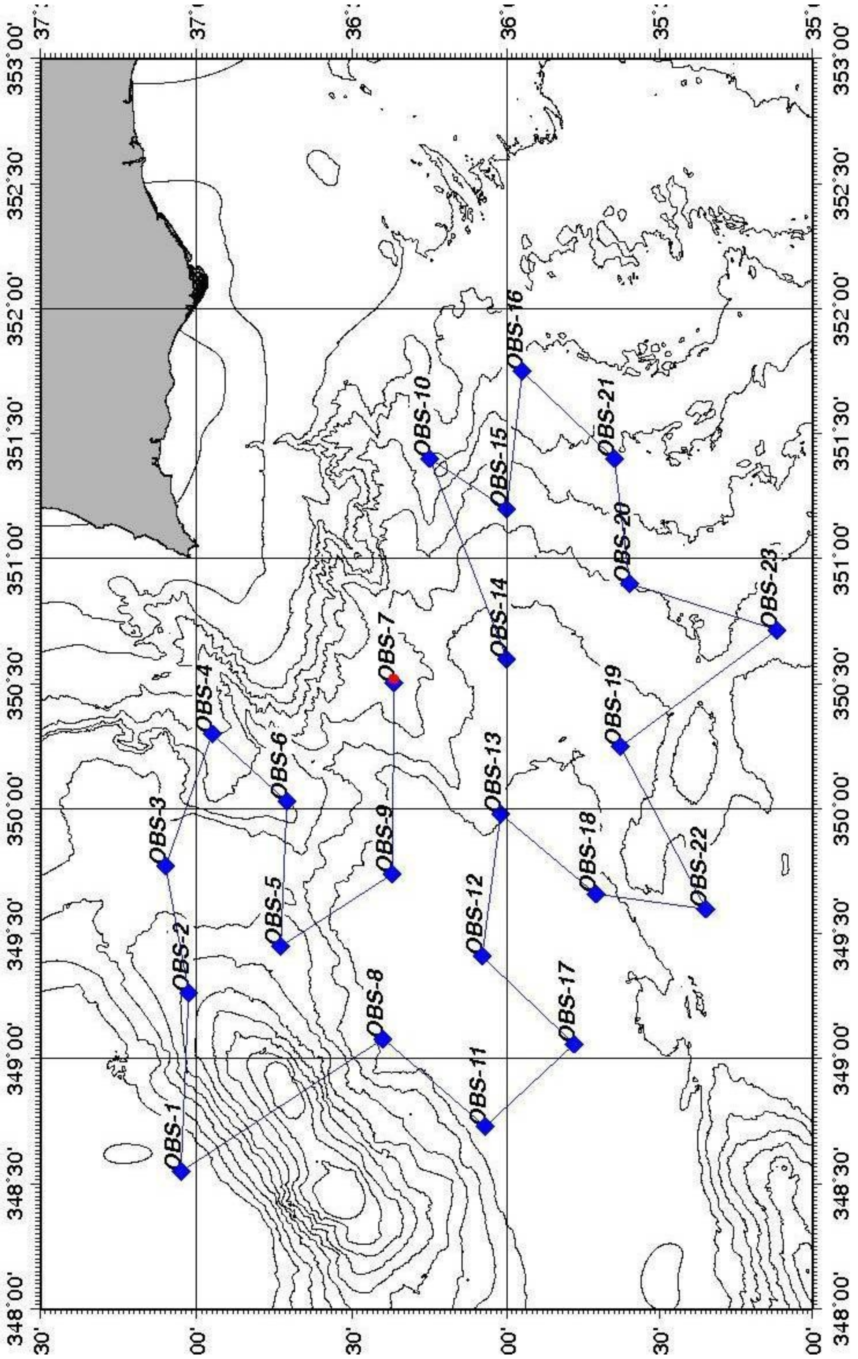


Fig 19.- Locations of the deployed OBS.

OBS	date (UTC)	time (UTC)	latitude	longitude	water depth

OBS 01	30.08.2007	10:26 h	37° 3.023' N	11° 26.997' W	4800 m
OBS 02	30.08.2077	06:42 h	37° 1.535' N	10° 44.061' W	2269 m
OBS 03	30.08.2007	03:13 h	37° 6.029' N	10° 13.796' W	3935 m
OBS 04	29.08.2007	23:00 h	36° 56.998' N	9° 42.008' W	1980 m
OBS 05	29.08.2007	17:52 h	36° 43.809' N	10° 33.002' W	3095 m
OBS 06	29.08.2007	20:44 h	36° 42.585' N	9° 58.161' W	2948 m
OBS 07*	29.08.2007	11:04 h	36° 21.902' N	9° 29.812' W	3205 m
OBS 08	30.08.2007	16:43 h	36° 23.997' N	10° 55.191' W	4668 m
OBS 09	29.08.2007	14:59 h	36° 22.199' N	10° 15.607' W	4811 m
OBS 10	01.09.2007	22:02 h	36° 14.974' N	8° 35.993' W	2061 m
OBS 11	30.08.2007	19:39 h	36° 4.154' N	11° 16.224' W	4858 m
OBS 12	31.08.2007	01:23 h	36° 4.787' N	10° 35.401' W	4858 m
OBS 13	31.08.2007	13:28 h	36° 1.208' N	10° 1.218' W	4500 m
OBS 14	02.09.2007	04:11 h	36° 0.010' N	9° 24.008' W	4209 m
OBS 15	01.09.2007	19:54 h	35° 59.988' N	8° 48.008' W	3360 m
OBS 16	01.09.2007	12:45 h	35° 56.990' N	8° 14.974' W	2061 m
OBS 17	30.08.2007	22:30 h	35° 46.783' N	10° 56.335' W	4764 m
OBS 18	31.08.2007	16:09 h	35° 42.593' N	10° 20.418' W	4605 m
OBS 19	31.09.2007	22:57 h	35° 37.796' N	9° 45.024' W	4394 m
OBS 20	01.09.2007	06:45 h	35° 35.987' N	9° 6.011' W	3442 m
OBS 21	01.09.2007	09:39 h	35° 38.984' N	8° 35.997' W	2575 m
OBS 22	31.08.2007	18:39 h	35° 21.009' N	10° 24.015' W	4101 m
OBS 23	01.09.2007	3:19 h	35° 7.009' N	9° 17.108' W	4745 m
OBS24	not deployed yet				
OBS07	Recovered and not re-deployed				

Table 4. OBS deployment parameters.

2.3.4 Test measurement: OBS07 close to GEOSTAR site

To test the operation of the seismic acquisition system of the GEOSTAR observatory OBS07 was deployed close to the GEOSTAR position for only 2 days to allow parallel recording of the seismic activity. The deployment on August 29th and the recovery on August 31st 2007 (Fig 20, table 5) was conducted without any problems. Levelling of the seismometer was performed 4 hours after recording started and again one day later. The sample rate was 100 Hz, preamplifier gain was 4 for the hydrophone, and 2 for the seismometer channels. The instrument operated without any errors. About 134 MB were recorded. Data retrieval from MCS recorders was performed using send2x software. However, airgun signals from an active seismic survey of Spanish scientists onboard the French R/V Atalante performed during that time (Fig 17) dominated the recorded signals. Nevertheless, two small local earthquakes could be detected. One from August 31st 2007 is shown in figure 22.

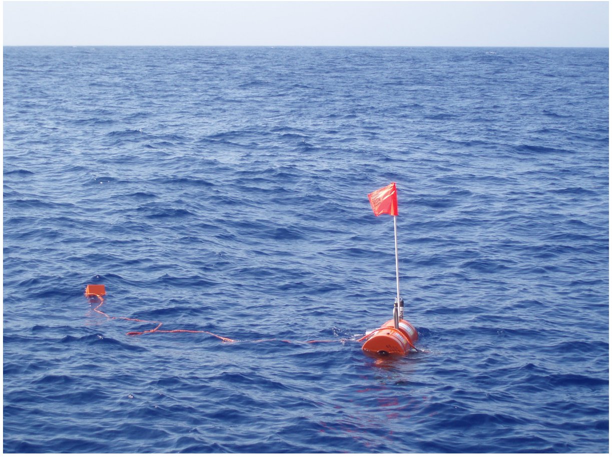


Fig 20 - Recovery of OBS07 at the sea surface.

	first release		on surface		on deck		coordinates		
station	date (UTC)	time (UTC)	date (UTC)	time (UTC)	date (UTC)	time (UTC)	latitude	longitude	water depth
OBS07	31.08.2007	08:52 h	31.08.2007	09:32 h	31.08.2007	09:54 h	36° 21.959' N	9° 29.724' W	3207 m

Table 5. Recovery parameters of OBS07 close to the GEOSTAR site.

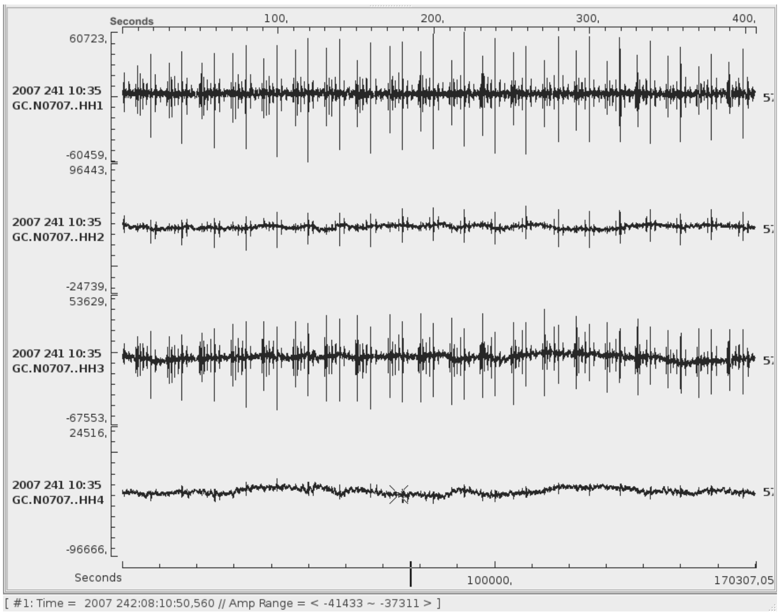


Fig 21 - Record example of OBS07. The data is dominated by strong airgun signals from a seismic survey of RV Atalante. The prominent signal on the three seismometer channels (bottom) is the S wavelet of the earthquake.

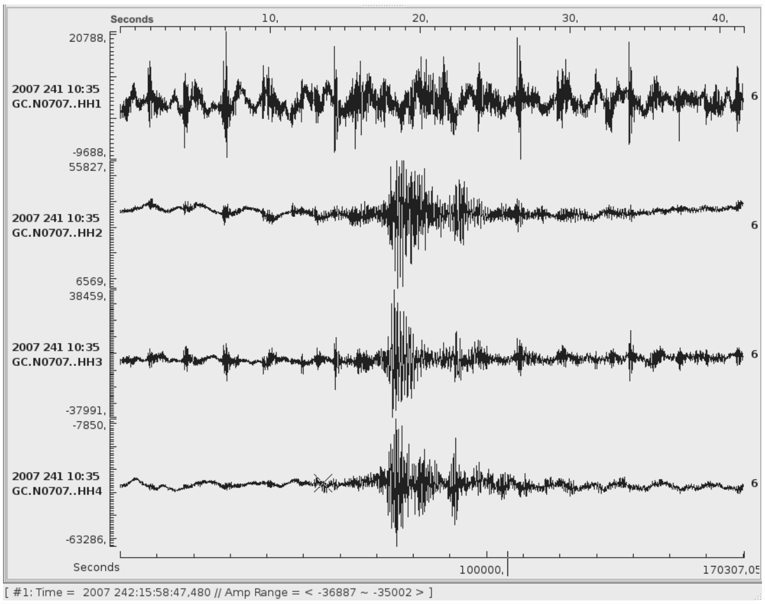


Fig 22 - Example of a local seismic event recorded by OBS07 on August 31st 2007.

2.3.5 Sampling

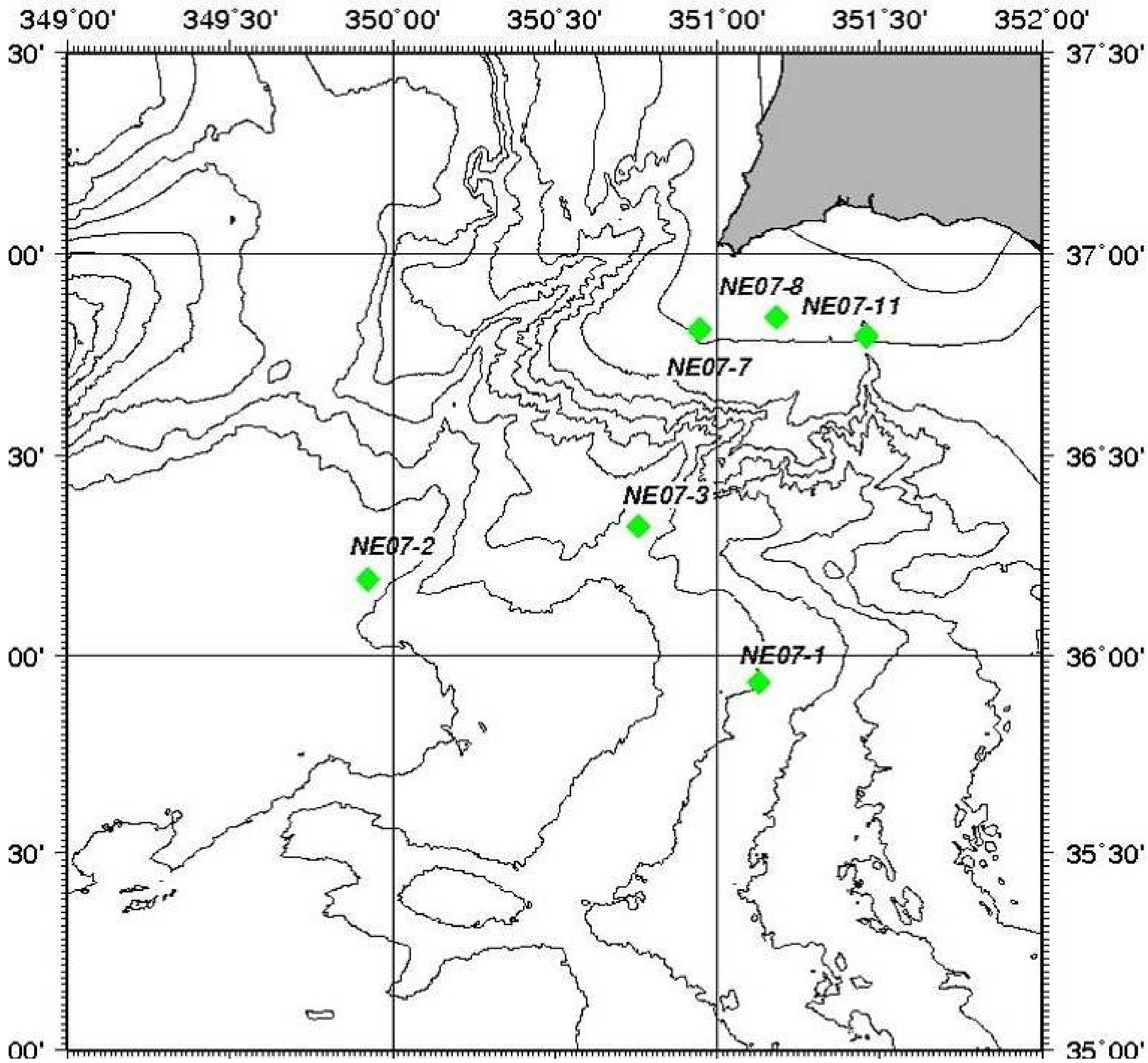
Sampling of the seafloor were performed by gravity and Sediment/Water interface (SW) coring to:

- detect sedimentological evidences and the distribution of paleoseismic events related to tsunami activity,
- determine the faults activity in the Gulf of Cadiz area,
- estimate the sedimentary contribution of the 2 channels of the Portimao Canyon
- found the evidences of historical tsunamis (e.g. Lisbon, 1755) in the first 10-20 centimetres of undisturbed sediments.

The sites choosen are located in the deepest part of the Lagos Canyon, near the Horseshoe Fault and in the South Portimao Bank and Boca do Rio offshore. The cores were not opened on board and the SW will be analyzed in the ISMAR- Bologna Labs and the three gravity cores will be analyzed by CSIC labs. In addition 5 (Van Veen, ~60 lt) grab sampling were performed to explore the bio-sedimentologic characteristics of the SW Portuguese shelf and the Portimao canyon between -250 and -700 meters deep.

Fig 23 – Grab sampling

Fig 24 -



Sampling location.

Table 6. – samples coordinates and depth.

Name	Date	Gear	Depth	Lat	Long	Recovery
NE07-1	1/09/2007	GC	-3583m	35°55.776'N	08°52.229W	1.67m
NE07-2	2/09/2007	GC	-4800m	36°11.312N	10°04.475W	1.75m
NE07-3	2/09/2007	GC	-3600m	36°19.342N	09°14.409W	0.8 m
NE07-4	2/09/2007	SW	-246m	36°48.789N	09°03.206W	No
NE07-5	3/09/2007	SW	-247m	36°48.791N	09°03.223W	No
NE07-6	3/09/2007	Grab	-242m	36°48.787N	09°03.212W	Yes
NE07-7	3/09/2007	Grab	-327m	36°50.592N	08°48.996W	Yes
NE07-8	3/09/2007	SW	-327m	36°50.597N	08°48.996W	Yes
NE07-9	3/09/2007	Grab	-630m	36°47.844N	08°32.420W	No
NE07-10	3/09/2007	Grab	-630m	36°47.846N	08°32.427W	No
NE07-11	4/09/2007	Grab	-370m	36°47.836N	8°32.428w	Yes

Table 7 – cores recovery data

sample	Lat/Long/Depth	Penetration	Stress	Recovery
NE07-1	35°55.776'N/8°52.229'W/ -3583 m	4 m	4600 kg	1.67 m
NE07-2	36°11.312'N/10°04.475'W / -4800 m	5.2 m	4900 kg	1.75 m
NE07-3	36°19.342'N/9°14.409'W/ -3600 m	4 m	4000 kg	0.8 m (0.2 m recovered in the core catcher)

Table 8 – Preliminary description of grab samples

sample	Recovery	Descritption
NE07-6	Yes	30 l of coarse bioclastic Saod, rich in molluscs and concrections; very rich in *Limopsis aurita*, *Cavolinia inflexa*, *Pseudamussium clavatum*, *Cariophyllia smithii*, *Lophelia pertusa*, serpulids, rodoliths, ecc.
NE07-7	Yes	40 l of mud; top 1-2 cm of oxidized (brownish) highly bioturbated by sepulids; bottom stiff mud (olive-gray) highly bioturbated by serpulids
NE07-8	No	
NE07-10	No	
NE07-11	Yes	60 l of mud; top 1-2 cm of oxidized (brownish) mud slightly bioturbated; bottom stiff mud (olive-gray) with some pocket of dark organic matter, no evidence of living fauna

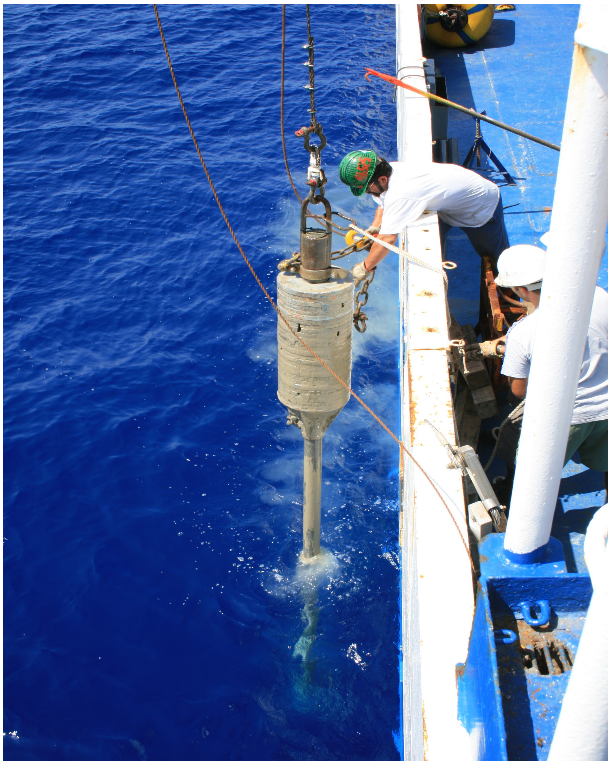


Fig. 25 - Gravity core NE07-2 recovery.

Fig 26 - Grab and SW Corer.

3. Survey maps , data examples and schemes

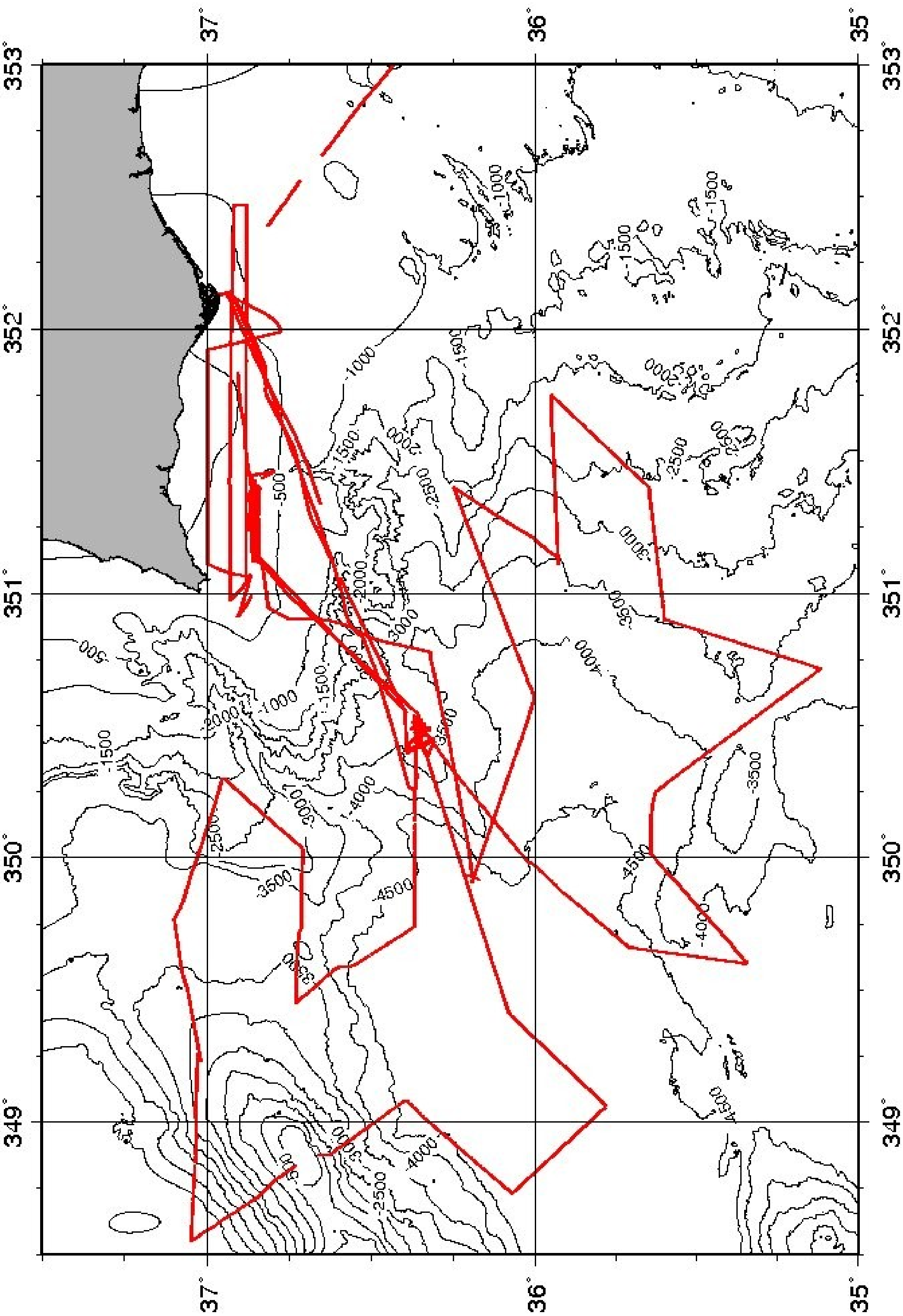


Fig 27 – CHIRP and Multibeam navigation tracks.

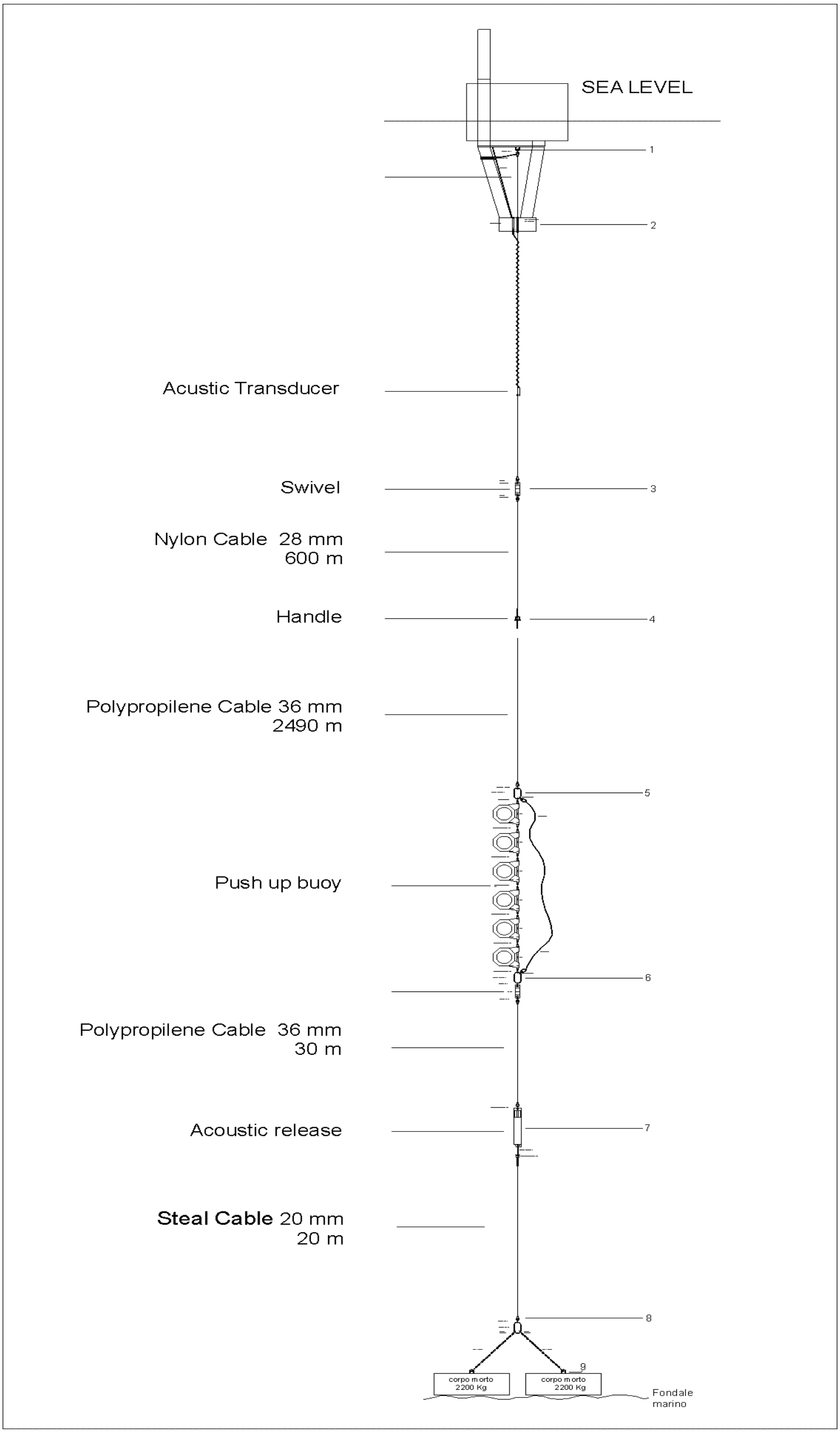
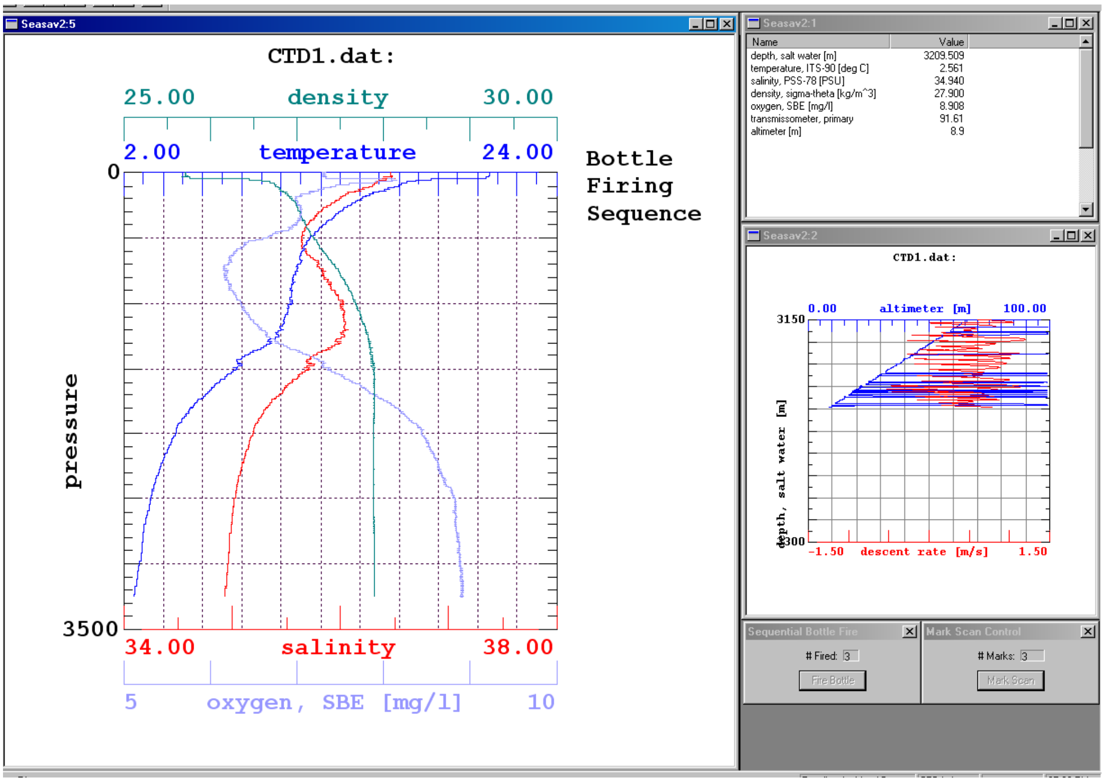


Fig 28 – Buoy anchorage system



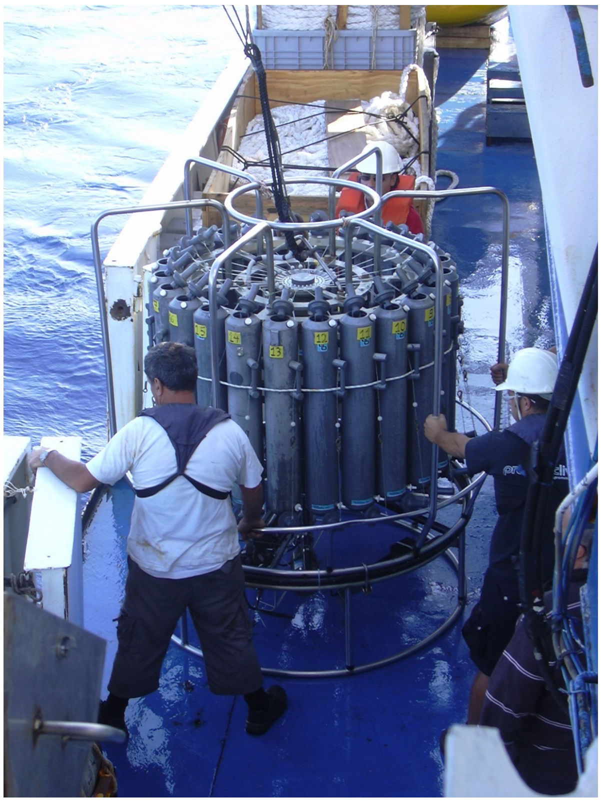


Fig 29 - Example of CTD data sampling.

During the cruise a multibeam bathymetric survey was collected, with a RESON 8160 multibeam. The data were acquired with success on the SW Iberian continental shelf south of Portimao (Portugal). (see Fig 31 and 32)

To perform a correct bathymetric acquisition we use the previous CTD analysis to calculate the appropriate sound velocity function to be loaded in the multibeam acquisition program (Fig.30).

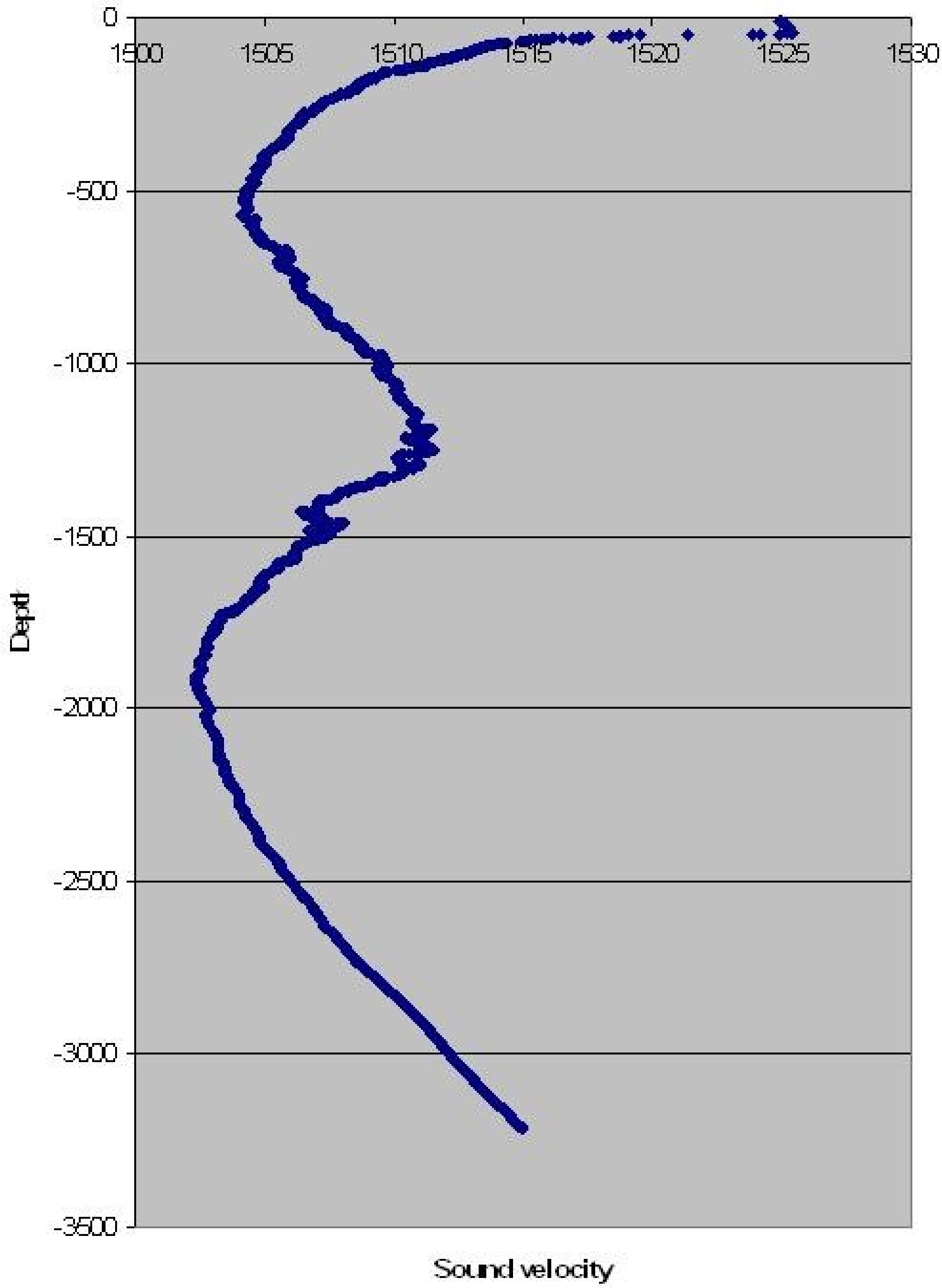


Fig 30 – Sound velocity profile derived from CTD-1 data.

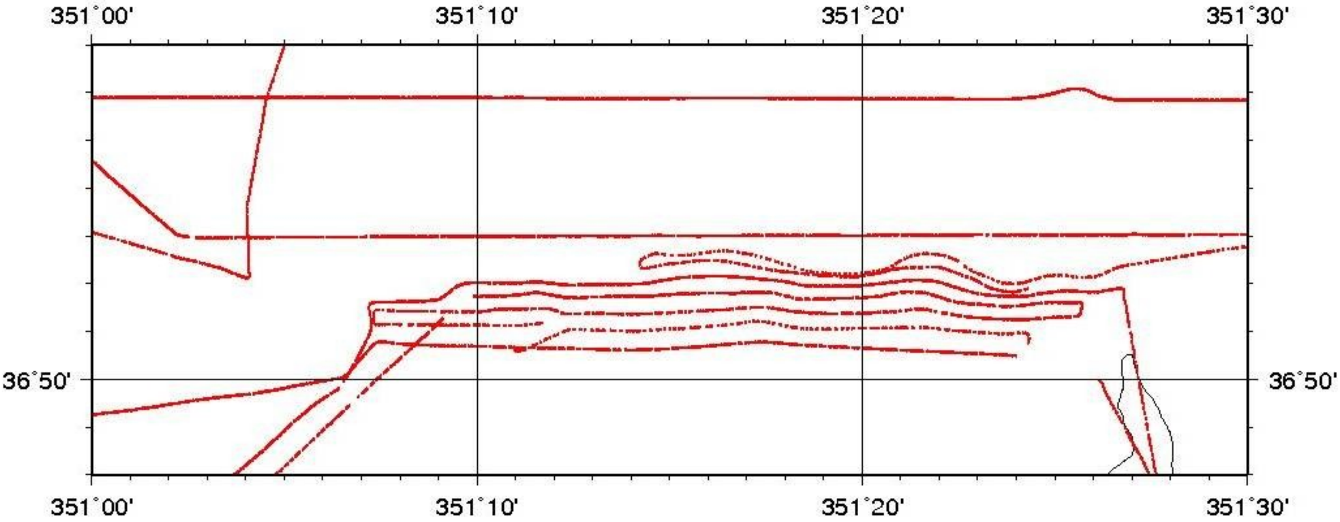


Fig 31 – Multibeam survey navigation tracks.

Fig 32 – Example of acquired multibeam data.

4. Survey and sampling instruments

The research cruise was carried out with the 61 meter R/V Urania, owned and operated by SO.PRO.MAR. and on long-term lease to CNR. The Ship is normally used for geological,

geophysical and oceanographical work in the Mediterranean Sea and adjoining waters, including but not limited to, the Atlantic Ocean, the Red Sea, and the Black Sea.
R/V Urania is equipped with DGPS positioning system (satellite link by FUGRO), singlebeam and multibeam bathymetry and integrated geophysical and oceanographical data acquisition systems, including ADCP, CHIRP SBP and other Sonar Equipment, other than water and sediment sampling. Additional equipment can be accommodated on the keel or towed, like Side Scan Sonars.

4.1 MULTIBEAM

Model	RESON 8160
Operating frequency:	50KHz
Swath angle:	150°
Operating Depth:	5 - 5000mt
Beam number:	126
Vertical resolution:	1.4cm with range until 750m 2.9cm with range between 1000m and 1500m 8.6cm with range between 1500m and 2500m

Table 9 – Multibeam instrument parameters

4.2 Chirp

Factory	Benthos
Model	Chirp II
Installation	Hull mounted
Number of transducers	16
Transducers type	AT 471
Signal generator / DSP	CAP-6600 Chirp II Workstation
DSP Sonar Signal Processing	16 bit A/D, continuous FFT
Operating sweep frequency	2 – 7 kHz
Ping rate	Variable, operator selectable (max 12 ping/sec)
Sweep Length	Variable, operator selectable
Multiping option	yes
Gain	Automatic gain control
Bottom tracking	Interactive
Navigation / Annotation	NMEA 0183
Data format	SEG Y
Printer	Alden
Acquisition software	SwanPRO / ChirpScan II
Processing software	SeisPRO / SwanPRO
Location controller / recorder	Recording room (room # 525)

Table 10 – Chirp II instrument parameters

4.3 Gravity corer

The ISMAR gravity core was constituted by a head of 120 cm length, total weight of the head is 1.2 tons made by 12 anular masses of lead. For coring we used a FeZn core-tube, 4 meters long and inner ø100mm, outer ø105mm. We perform the coring with a mud-type core catcher (Fig 25).

For recovery samples we perform the corer with a PVC liner with a inner ø84mm and outer ø90mm. The core paid off ca. 1.1 m/s.

4.4 Corer SW

The Gravity Corer SW-104 is a valid instrument for the in-situ sampling of undisturbed sediment-water interface in muddy and sandy sea-bed conditions (Fig 26). The corer was armed with lead's masses for a total weight of 110 Kg, that is the maximum weight supported by the corer. A Fe-Zn core tube (1.5 mm thickness, 135 cm length and an outer diameter of 104 mm) supports a PVC liner (110 mm of inner diameter and 115 mm of outer diameter, 3 mm thickness, 135 length) that contains the sediment core and bottom water sample, that was drained out because it wasn't useful to the aim of the study.

The recovery mechanism consist in a load-bearing lattice located in the front of the liner that works like a duck closing device.

A service tri-pod with a variable tilt carrier was used for hold the corer in a vertical position or at different angles to optimise on-board operations on the corer itself or on the recovered sample.

4.5 CTD

The CTD probe *SeaBird 9Plus* measures conductivity, temperature, pressure and parameters from up to eight auxiliary sensors at 24 scans per second (Fig 29).

The main housing contains the acquisition electronics, telemetry circuitry and pressure sensor while temperature and conductivity sensors are modular units. It's operating max depth is 6800m.

During Nearest_2007 cruise the CTD SBE 9Plus was used in full configuration with an Altimeter, Oxygen sensor, Salinity, Transmissometer.

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