# ANNEX 03: GEOPHYSICS SURVEY

# Marine geophysical survey in the Kavala bay

Preliminary Report

2nd revision

Laboratory of Marine Geology and Physical Oceanography

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# EXECUTIVE SUMMARY

This preliminary report presents the field-work that took place in the framework of a detail marine geophysical survey conducted in Kavala bay. The survey was planned and carried out by the Laboratory of Marine Geology and Physical Oceanography of the Geology Department of the University of Patras, in collaboration with GEODOMIKI. The main objective of the work is the seafloor mapping and shallow seabed stratigraphy analysis through processing and interpretation of multi-platform geophysical datasets collected from the Delta-Epsilon/Lamda-Omikron complex in the PRINOS Field at the Kavala Gulf. The marine geophysical survey took place in two separate areas; the "Base Case" and "Optional Case". The Base case area extends from the location of the New Epsilon/Lamda Platform to the location of the Existing Delta Platform. The "Optional Case" survey includes two areas located: (i) from the New Epsilon/Lamda Platform location to the future Omikron Platform location, and (ii) from the New Epsilon/Lamda Platform to Sigma Site. This report presents preliminary results concerning data analysis and interpretation only in the Base Case area.

The survey conducted using: (i) a Multi Beam (MBES) Elac Nautik Seabeam 1185 with 300m maximum operational depth, (ii) a Single Beam (SBES) Elac Hydrostar 4300 (iii) a "Chirp" Kongsberg Geoacoustics Geopulse Plus subbottom profiler system with a Universal transceiver, a acquisition display, (iv) a Sparker SIG (100-1000Hz) system with 5000V voltage on the edges of 42 electrodes, supplying energy of about 500 to 24000J, (v) an Edgetech dual Frequency (100 and 400 kHz) digital towfish 4200SP with an Edgetech 4200-P topside Processor, (vi) a SeaSpy (Marine Magnetics) marine magnetometer, (vii) ground-truthing techniques (towing u.w camera and sediment grab) and (viii) a Trimble a Hemisphere Vector VS101 Compass GPS with two multipath resistant antennas with <0.5m accuracy. The HYPACK software was used for the navigation of the vessel. The objectives, in detail, are: (i) a detailed bathymetric survey, (ii) a detailed mapping of the seabed morphological features, (iii) a detailed study of the shallow seabed seismic stratigraphy, (iv) the detection of magnetic field anomalies indicating major metallic

objects lying or being buried on the seafloor, (v) the detection and mapping of existing pipelines and cables within the Base Case area, (vi) The detection and the identification of ancient, historical and modern wrecks lying on the seabed, (vii) a ground-truthing survey consisting of visual inspection and sediment sampling based on the geophysical seabed mapping results.

The Base Case area can be separated in three parts based on the bathymetry: (i) the eastern bathymetric high plateau (where the Delta complex has been installed) which is characterized by a smooth seafloor and is deepening gently from 30m water depth at Delta complex to 34m water depth at the central part of the Base case (slope <1°), (ii) the western bathymetric high plateau (including Epsilon/Lamda platform area) (37-41m), which is deepening gently to the east and north (slope ≈1°) and (iii) an almost north-south running channel (50-52m) separating the two bathymetric high plateaus. The seafloor between the channel and the plateaus is characterized by slopes ranging from 2° to 13°.

Preliminary interpretation of the high (400kHz) and low (100kHz) frequency Side Scan Sonar (SSS) data revealed five (5) distinct acoustic types in the SSS mosaics; A, B, C, D and E based on their backscatter intensity. It should be noted that SSS sonographs portray the seafloor texture (e.g. grain size parameters) and seafloor morphology. Acoustic type A is characterized by high backscatter intensities, indicating very coarse sediments or probably well developed biogenic formations. It also exhibits an SE to NW directional texture, possibly indicating fishing activity (trawlers). Acoustic type B is located at the western and southeast end of the Base Case area, is the predominant type of the study area and exhibits relatively high backscatter with a texture of medium to low contrast representing fine grained sediments and possibly irregularly dispersed biogenic surface layers. Acoustic type C is of medium backscatter intensity and smooth texture and represents a transitional/mixture type between types A and B. Acoustic type D is located within the channel and is characterized by low backscatter intensity, signifying fine grained – incoherent sediments. Acoustic type E is characterized by medium to low backscatter intensity with an intense directional texture, indicating that the seafloor is probably affected by trawling gears.

The combined examination and the interpretation of SSS and Chirp datasets did not reveal any indication of gas-induced pockmarks on the seafloor of the survey area. A cluster of fourteen (14) small, almost circular crater-like depressions, of unknown origin, were detected at the vicinity of Delta Complex. Moreover, the magnetic survey detected major magnetic anomalies that match very well to known man-made objects (wells and pipeline).

The preliminary interpretation of the seismic data of high (Chirp) and lower (Sparker) resolution revealed a detailed seismic stratigraphy of the survey area. Three main different acoustic types (AT) in Chirp profiles and three seismic phases (S) in Sparker profiles were recorded and defined. These three acoustic types and seismic phases correspond to the three different morphological units of the survey area; the western bathymetric high plateau where the DELTA complex has been installed, the eastern bathymetric high where the new EPSILON/LAMDA platform is proposed to be constructed and the central channel separating the two high plateaus.

The interpretation of the Acoustic Types defined on Chirp profiles showed that the two bathymetric high plateaus consist of two main seismic phases. The upper phase shows different appearance at the two plateaus. At the eastern one, where the DELTA platform has been installed, the upper seismic phase can be divided to two parts. The upper part is characterized by an almost transparent internal acoustic character that represents homogeneous deposits of fine-grained sediments (sandy mud). The underlying lower part exhibits well defined high angle progradational clinoform reflectors indicating westward progradation of deltaic deposits. In the western plateau, where the EPLSION/LAMDA platform is planning to install, the upper phase has limited thickness (<7.5m) and shows an almost transparent internal acoustic character that represents homogeneous deposits of fine-grained sediments (muddy sand to silty sand). At both plateaus, the seismic upper phase overlies the lower one which is clearly defined by a surface of high reflectivity (very prolonged echo). No seismic reflections observed below the high-amplitude top reflection suggesting that represents the acoustic basement for the Chirp profiling. This high-amplitude reflector (H1) has been clearly recorded on the majority of the acquired Chirp and Sparker profiles of the area and can be considered as a main stratigraphic component in the surveyed area.

The Sparker data analysis and interpretation showed that the eastern plateau is characterized by three (3) almost parallel to sub-parallel high amplitude discontinuous reflectors packages which can be interpreted as transitions between different lithological units. The western plateau, is similar to the eastern one, but the high-amplitude reflectors top package is more discontinuous and is interrupted by zones of chaotic/transparent character. This unit can be interpreted as alternations of medium to coarse grained sedimentary deposits.

The preliminary interpretation of the Chirp and Sparker seismic profiles did not show evidence of shallow gas charged sediments in the survey area. It should be noted that the high frequencies systems (Chirp and SSS) detected numerous acoustic targets within the water column. This type of acoustic targets represents fish school and/or gas plumes. The visual inspection of the area in selected sites showed the presence of fish school but no indication of gas seepages. However, limited presence of gas charged sediments in the survey area cannot be excluded.

# 1 GENERAL

## 1.1 INTRODUCTION

The present preliminary report presents the field-work, data acquisition and processing methods that took place in the framework of the marine geophysical survey conducted in Kavala bay. It also presents some preliminary results concerning data analysis and interpretation.

The survey was planned and carried out by the Laboratory of Marine Geology and Physical Oceanography of the Geology Department of the University of Patras, in collaboration with GEODOMIKI.

## 1.2 SCOPE OF WORK

The scope of the work is seafloor mapping and shallow stratigraphy analysis through processing and interpretation of multi-platform geophysical datasets collected from the Delta-Epsilon/Lamda-Omikron complex in the PRINOS Field at the Kavala Gulf. The marine geophysical survey took place in two separate areas; the "Base Case" and "Optional Case". This report presents preliminary results only from the Base Case area.

### 1.2.1 BASE CASE

The Base case area extends from the location of the New Epsilon/Lamda Platform to the location of the Existing Delta Platform. It consists of a corridor that is 4.5 km long and 1000m wide and of a rectangular extending 1000x1000m around the Epsilon/Lamda Platform (Fig 1.1.1.2).

In the area of the New Epsilon/Lamda Platform location the marine remote sensing survey was expanded further to the south, covering an additional area of 400x2000m (Fig. 1.1.1.2).

The objectives of the high resolution marine geophysical survey conducted in this area are:

- A detailed bathymetric survey of the platform sites as well as of the corridor connecting the two platform sites (Delta and Epsilon/Lamda);
- A detailed mapping of the seabed morphological features;
- A detailed study of the shallow seabed seismic stratigraphy;
- The detection of magnetic field anomalies indicating major metallic objects lying or being buried on the seafloor;
- The detection and mapping of existing pipelines and cables lying on the seabed or buried by loose sediments, within the Base Case area;
- The detection and the identification of ancient, historical and modern wrecks lying on the seabed;
- A ground-truthing survey consisting of visual Inspection and sediment sampling based on the geophysical seabed mapping results.

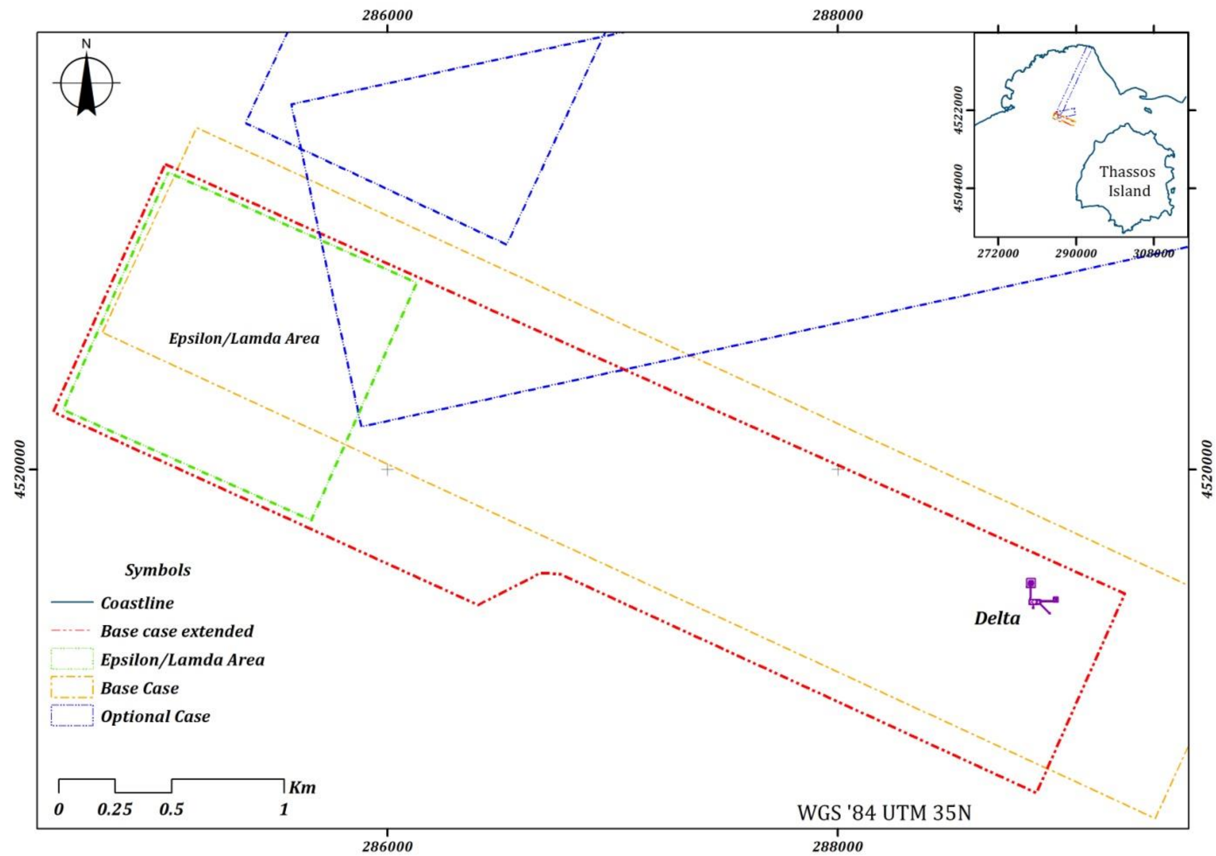



Fig 1.1.1.2. Map showing the location and the extend of the Base Case area, surveyed by mean of marine geophysical methods.

### 1.2.2 OPTIONAL CASE

The "Optional Case" survey includes two areas located:

(i) From the New Epsilon/Lamda Platform location to the future Omikron Platform location. This area forms a corridor 4.5km long and 1000m wide (Fig 1.2.2.1).

(ii) From the New Epsilon/Lamda Platform to Sigma Site. This area forms a corridor 18km long and 300m wide (Fig 1.2.2.1).

The objectives of the Optional Case survey are:

- A preliminary bathymetric survey along the two corridors;
- A preliminary mapping of the seabed morphological features;
- A preliminary study of the shallow seabed seismic stratigraphy;
- The detection and mapping of existing pipelines, cables or other man made targets lying on the seabed or buried into loose sediments;
- The detection and the identification of ancient, historical and modern wrecks lying on the seabed;

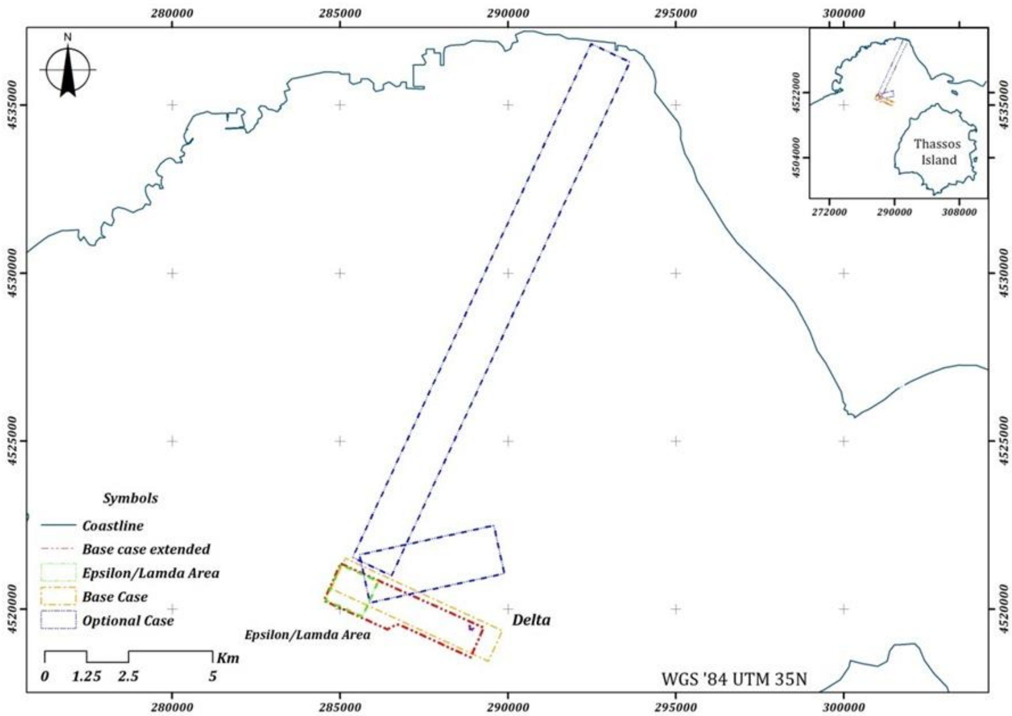



Fig 1.2.2.1. Map showing the location and the extent of the Optional Case area surveyed by mean of marine geophysical methods.

# 2 METHODOLOGY

## 2.1 FIELD WORK

The field work was designed to acquire high density and high resolution geophysical data for the examination of:

- the bathymetry of the surveyed areas;
- the seabed shallow seismic stratigraphy;
- the surficial morphology of the seafloor;
- possible man-made targets lying on the seafloor or buried in it;
- the physical characteristics of the surficial seabed components (sediments, biogenic formations, natural and/or man induced bottom features).

### 2.1.1 SURVEY VESSEL

A 16m long metallic motor-yaught long was used for the marine remote sensing survey. The vessel has been suitably modified by the Laboratory of Marine Geology and Physical Oceanography to meet the needs and the qualifications of the marine geophysical survey (Fig. 2.1.1.1, 2.1.1.2).

Fig. 2.1.1.1. The vessel 'Socrates', NP 4880 used for the survey

Fig. 2.1.1.2. The control room of 'Socrates' research vessel.

### 2.1.2 RESEARCH EQUIPMENT

#### 2.1.2.1 Positioning - Navigation

##### 2.1.2.1.1 GPS

A Differential Global Positioning System (DGPS) system was utilized for the positioning of the survey vessel. The system comprised two components:

- Primary: Trimble 5800 GNSS System (Fig. 2.1.2.1.1.1). The system worked in RTK mode with corrections from the HEPOS (HEllenic POsitioning System). The accuracy of this system was ± 8 mm + 1 ppm RMS in horizontal scale and ± 15 mm + 1 ppm RMS in real time and less than 0.5m in dynamic mode in vertical scale.
- Secondary: Hemisphere VS - 101 GNSS System (Fig. 2.1.2.1.1.2). It consists of with two multipath-resistant antennas and it is capable of using differential corrections received through an internal SBAS demodulator (Satellite Based Augmentation System). The accuracy of the system was ±0.6m at the 95% of the time.

The navigation of the vessel was carried out using the navigation software package HYPACK 2014 towards (Fig 2.1.2.1.1.3):

- storing and displaying route navigation data of the pre-planned survey lines,
- continuous graphic presentation of the vessel movement (tracks),
- across track error limits
- logging depth data and the corresponding geographical coordinates

The positioning of the equipment which was utilized during the fieldwork was linked to the above described navigation systems therefore the data acquisition was georeferenced throughout the fieldwork. In particular, the GPS systems were situated exactly above the MBES echo sounder in order to minimize the position offset uncertainty of the system.


Fig. 2.1.2.1.1.1. Trimble 5800 GNSS System.


Fig. 2.1.2.1.1.2. Hemisphere VS101 GPS.

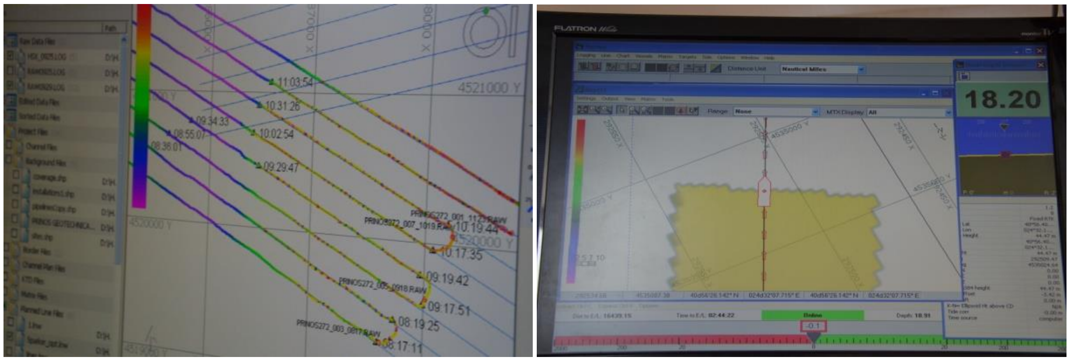



Fig. 2.1.2.1.1.3. Hypack 2014 navigation software display.

## 2.1.2.1.2 Survey Gyro

A Motion Sensor (FOG) and a heading sensor were used for the recording of the vessel movements (Fig. 2.1.2.1.2.1 ). In detail:

- A SMC IMU-108 motion senor was used for pitch, roll and heave compensation with resolution angle 0.001° (pitch, roll) and resolution Heave 0.01m.
- A hemisphere Vector VS101 GPS Compass with two multipath-resistant antennas, with heading accuracy < 0.10º RMS was used for yaw compensation.

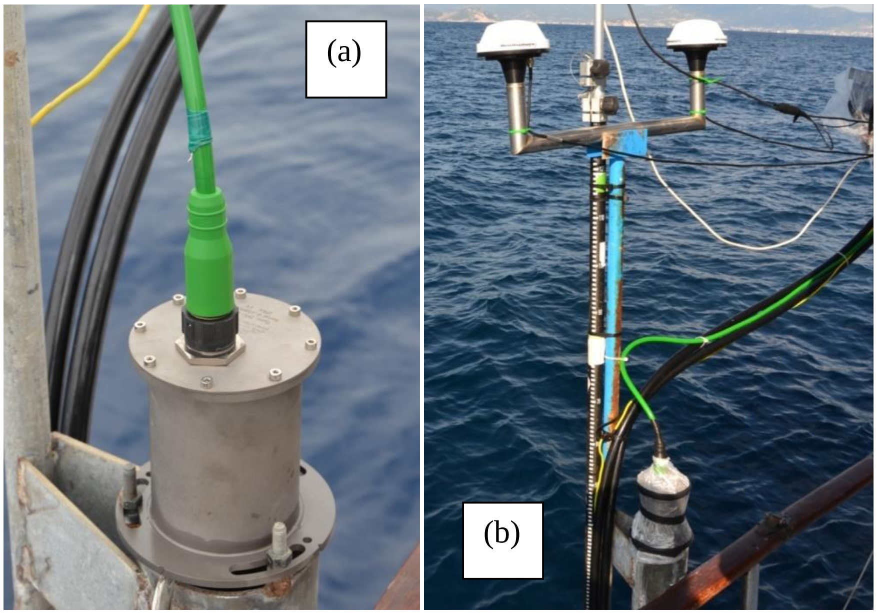



Fig.2.1.2.1.2.1 a) The SMC IMU-108 motion sensor and b) Hemisphere Vector VS101 GPS Compass and IMU-108 motion sensor.

### 2.1.2.2 Echosounders

2.1.2.2.1 Multi-beam echosounder

The ELAC Seabeam SB1185 multi-beam echosounder was used for swathe bathymetry. The maximum depth range of the SB1185 is 300m. The maximum swath coverage is 153° and the maximum number of sounding is 126 per swath.

The MBES system consists of

- The tranducers array LSE 307 mounted over the side of the vessel (Fig.2.1.2.2.1.1.).
- The Transmit/Receive Unit SEE 30 (Fig. 2.1.2.2.1.2.)
- The operating workstation (Fig. 2.1.2.2.1.3.)

Fig.2.1.2.2.1.1. ELAC tranducers array LSE 307 mounted over the side of the vessel.

Fig.2.1.2.2.1.2. ELAC Transmit/Receive Unit SEE 30.

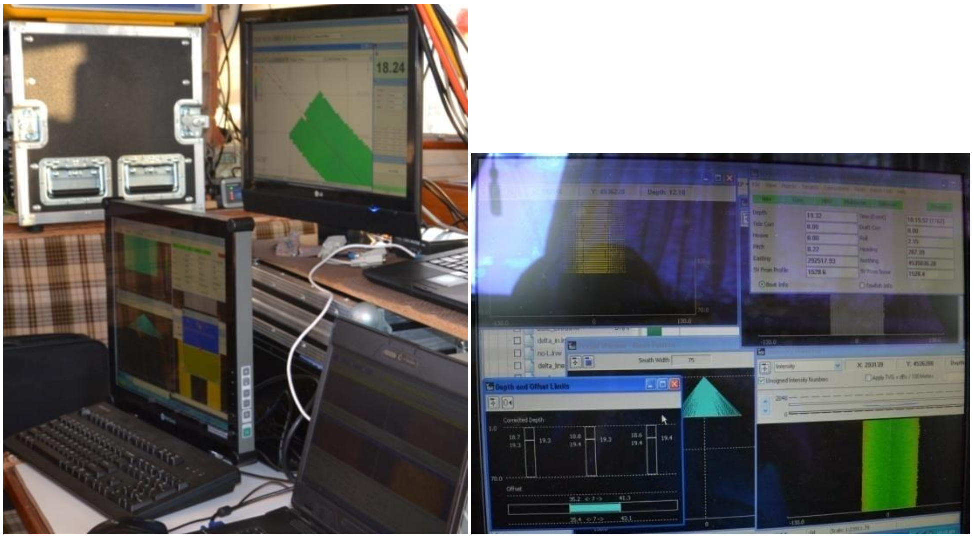


Fig.2.1.2.2.1.3. ELAC MBES operating workstation.

Acquisition of data and system control is performed on a Windows based high performance computer. In detail:

- The acquisition speed was about 4knots, offering adequate along track data resolution (<0.8m).
- The depth range was 30 to 50 meters.
- The survey has been planned so that all areas sampled at least twice through a network of parallel and perpendicular tracklines.
- A SMC IMU-108 motion senor used for pitch, roll and heave compensation with resolution angle 0.001° (pitch, roll) and resolution Heave 0.01m.
- A hemisphere Vector VS101 GPS Compass with two multipath-resistant antennas, with heading accuracy < 0.10º rms used for yaw compensation.
- A Trimble GNSS GPS system will be used with RTK accuracy used for positioning the sensor.
- Tide data provided from the RTK GPS.

- A Sea&Sun Technology Sound Velocity Profiler with resolution 0.001m/s and accuracy ±0.02m/ used for collecting sound velocity profile (Fig. 2.1.2.2.1.4.)
- Hydrostar Online software used for operation of MBES and Hypack Hysweep software used for data acquisition. The files stored in HSX format.

Fig.2.1.2.2.1.4. Sea&Sun Technology CTD which used for obtaing sound velocity profile.

The phase of data acquisition is described below:

- Sound Velocity Profile: Sound velocity profile of the seawater added to Hypack for correction of the soundings and to Hydrostar online for beam forming correction. A sound velocity profile was obtained every morning and afternoon.
- System Alignment: Using the 'Patch Test' in HYSWEEP®'s MULTIBEAM EDITOR, determined the exact mounting angles and time delays for multi-beam sonar system.

- Data Collection and Review: HYSWEEP® SURVEY running simultaneous with the HYPACK® SURVEY program performs all data collection, logging and time tagging while providing graphics for data visualization, bottom coverage and quality control.

2.1.2.2.2 Single-beam echosounder

A Single beam echosounder Elac Hydrostar 4300 (Fig. 2.1.2.2.2.1.) was used as duplicate checking system on the swathe system. The Hydrostar 4300 is a single beam echosounder designed specifically for hydrograpgic surveys. The system is configured for dual channel (30kHz/200kHz) operation and its accuracy is 0.5% the water depth. The depth from the single beam echosounder logged on Hypack Survey in the same project with MBES data.

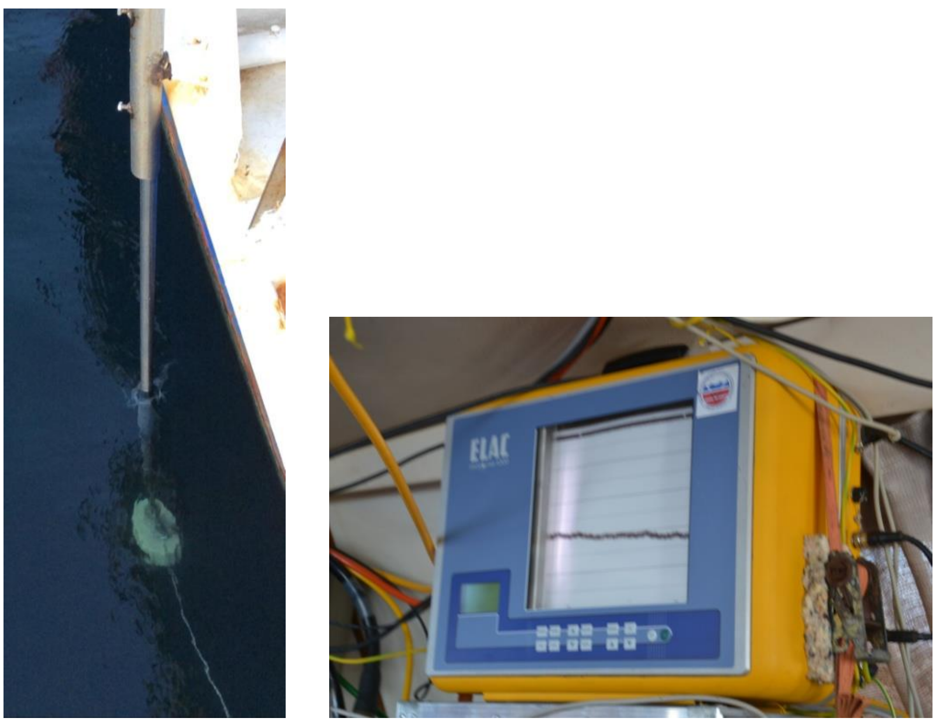


Fig.2.1.2.2.2.1. ELAC Hydrostar 4300 single beam echosounder.

### 2.1.2.3 Side Scan Sonar

An Edgetech 4200 SP Side Scan Sonar (SSS) system was used, transmit and storing at 100 kHz and 400 kHz chirp acoustic signal frequencies simultaneously (Fig 2.1.2.3.1). The ground range was set to 75m at both port and starboard sides of the towfish, providing a total swath of 150m per survey line and a resolution of approximately 2cm at the across track and 0.5m at the along track direction. The SSS system was towed at a fixed distance of 15m behind the research vessel, approximately 8m below the sea surface and functioning simultaneously with all other geophysical systems. Data acquisition was achieved through the Discover 4200 (Edgetech) software, receiving the data wirelessly from the topside unit (Fig 2.1.2.3.2).

SSS data is used to detect and outline any lithological/ morphological changes and proud targets on the seafloor, including biogenic formations, rock outcrops, wrecks, seabed obstructions, dredging sites, current- and wave-induced seafloor features, u/w pipelines and cables. Along with MBES, SSS is considered the ideal system for seabed classification and target detection.

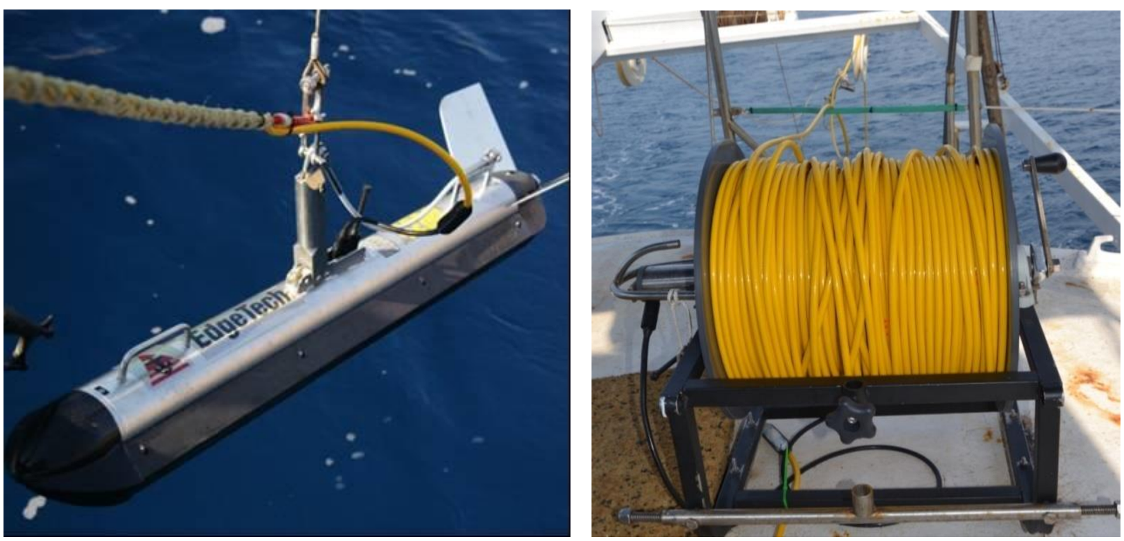



Fig.2.1.2.3.1. Edgetech 4200SP Side Scan Sonar towfish with 200m kevlar cable.

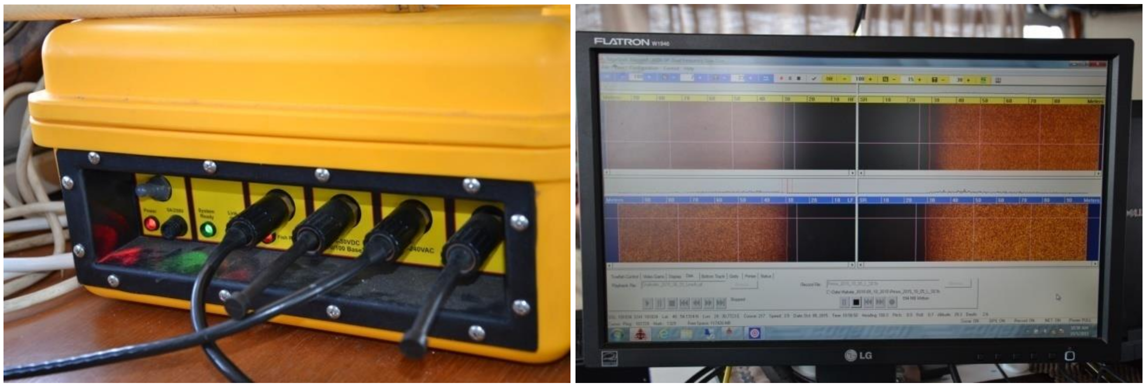



Fig.2.1.2.3.2. Edgetech 4200SP Side Scan Sonar acquisition unit and software.

### 2.1.2.4 Subbottom Profilers

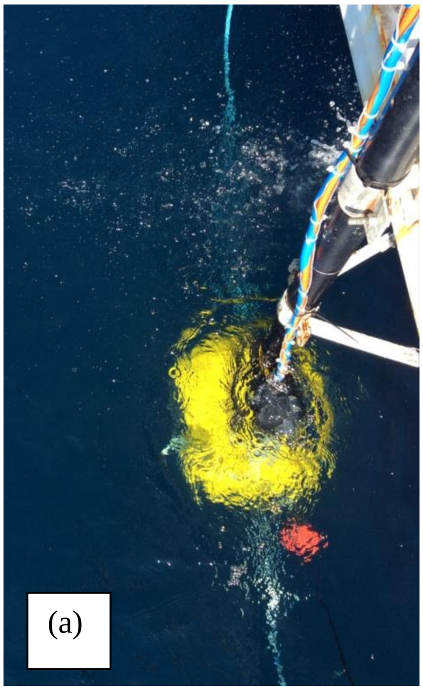
2.1.2.4.1 Chirp

A Kongsberg GeoPulse Plus (GeoAcoustics Universal) Chirp sub-bottom profiler system has been used for the examination of the upper (<30m) seismic stratigraphy of the seabed. The system can operate using various signal waveforms but for optimum performance a chirp signal with frequency ranges between 1.5 and 11.5 kHz has been used, providing high penetration - high resolution data. The penetration of the system can reach up to 80m in loose sediments and its resolution is less than 10 cm.

The GeoPulse Plus Chirp Sub-bottom Profiler consists of:

- An over-the-side Transducer Mounting and the trailing single channel hydrophone (Fig. 2.1.2.4.1.1.a),
- The subsea electronics (Fig. 2.1.2.4.1.1.a) and
- The Universal Transceiver (Fig. 2.1.2.4.1.1.b).

Data acquisition was achieved through Sonarwiz (Chesapeake Technology Inc) software (Fig. 2.1.2.4.1.2.)



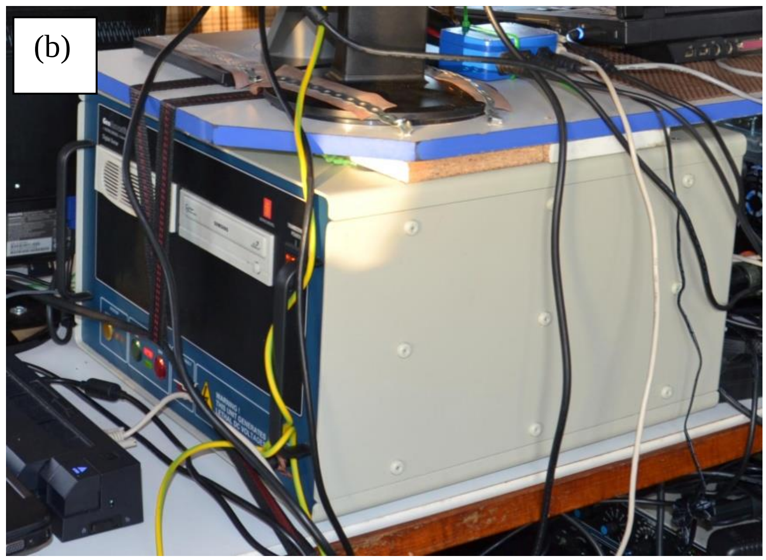




Fig.2.1.2.4.1.1. GeoPulse Plus chirp sub-bottom profiler system (a) over the side transducer mounting and subsea electronics and (b) the universal tranceiver.

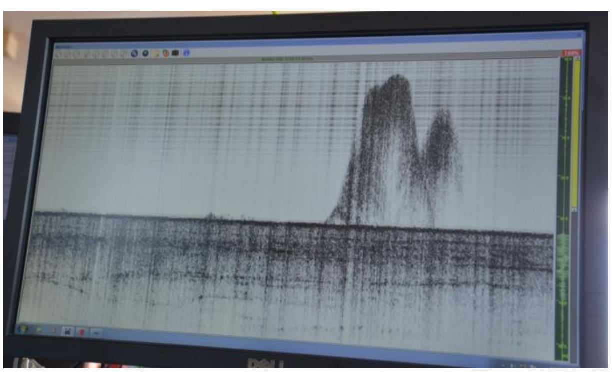


Fig.2.1.2.4.1.2. A chirp sub-bottom profile collected from the surveyed area.

2.1.2.4.2 Sparker

Sparker profilers emit omni-directional acoustic pulses generated by means of electric evacuation in the seawater column through electrodes. The acoustic pulse frequency ranges between 50 and 2000 Hz and the pulse length ranges between 4 and 15ms, based on the power of the system and the type of acoustic energy generator. Sparker system can penetrate up hundrents of meters providing a vertical resolution range between 2 and 10m.

A S.I.G. Sparker 2000A and 2000B with S.I.G. single channel hydrophones used in the survey (Fig.2.1.2.4.2.1.). The S.I.G. Sparker profiler applies up to 5000V voltage on the edges of 42 electrodes, supplying energy of about 500 to 24000J. The penetration ability is about 150-200m when the frequency ranges between 100 and 1000 Hz and the vertical resolution is a few meters. Due to the coarse-grained, relict and palimsest sediments of the seismic phases of the seabed and the strong seafloor multiple reflection, the maximum penetration of Sparker was 50-60m.
The Sparker system consist of

- S.I.G.2000A and 2000B (Fig 2.1.2.4.2.1a),
- S.I.G. Hydrophones and S.I.G. electrodes (Fig 2.1.2.4.2.1b),
- Triton Imaging digital recording Unit (Fig 2.1.2.4.2.2a) and
- Geopulse Receiver/Amplifier (Fig 2.1.2.4.2.2a).

The data acquisition was performed through the SB-Logger (Triton Imaging Inc) software (Fig 2.1.2.4.2.2b).

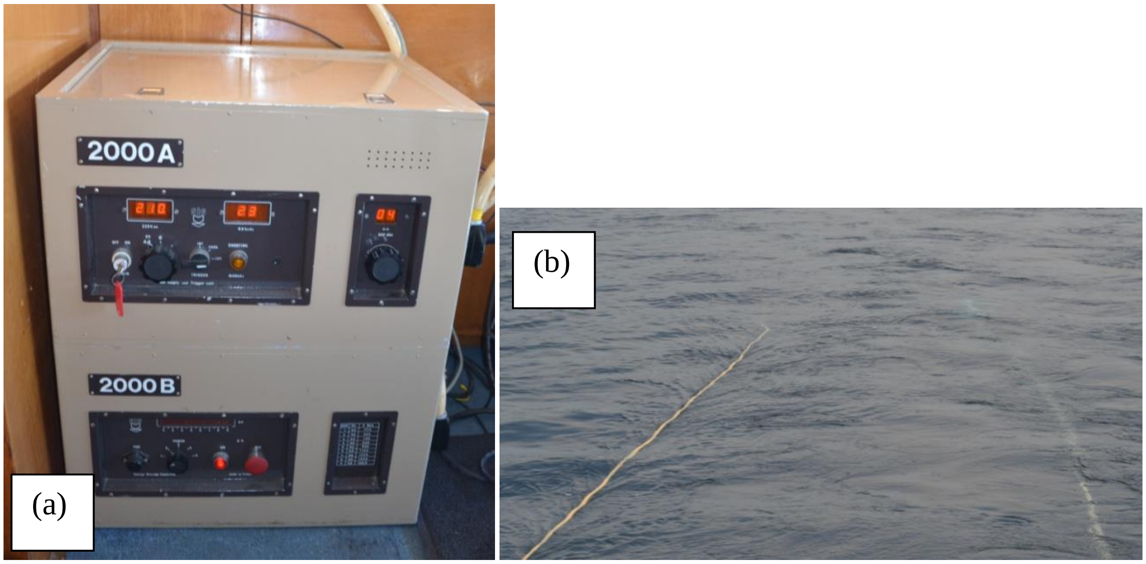



Fig. 2.1.2.4.2.1. The S.I.G. Sparker 2000A and 2000B (a) and S.I.G. Hydrophones and Electrodes (b)

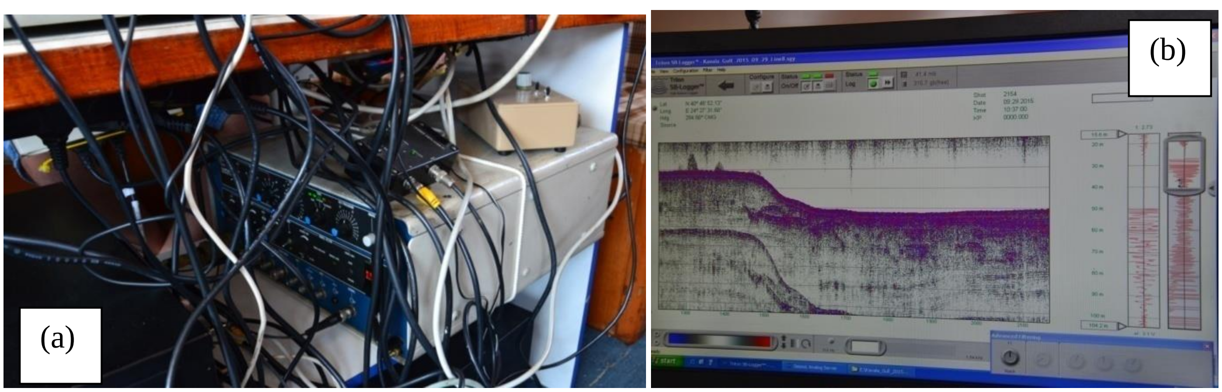



Fig. 2.1.2.4.2.2. (a) Triton Imaging digital recording Unit and Geopulse Receiver/Amplifier and (b) a typical Sparker profile from the surveyed area acquired with SB-logger software.

### 2.1.2.5 Marine Magnetometer

The marine magnetic survey has been conducted using a SeaSpy (*Marine Magnetics*) marine magnetometer (Fig 2.1.2.5.1), carrying an Overhauser Sensor which provides total magnetic field measurements of high accuracy and stability. SeaSPY magnetometer provides magnetic measurements more accurate than any other magnetometer (0.1nT), ensuring that any metalliferous natural formation or man-made objects (pipeline, cable or other metallic objects), buried or not in the seafloor, will be successively detected. The sensor was towed at a distance approximately three times the vessel length, i.e. 60m while *Sealink* software was used for data acquisition.

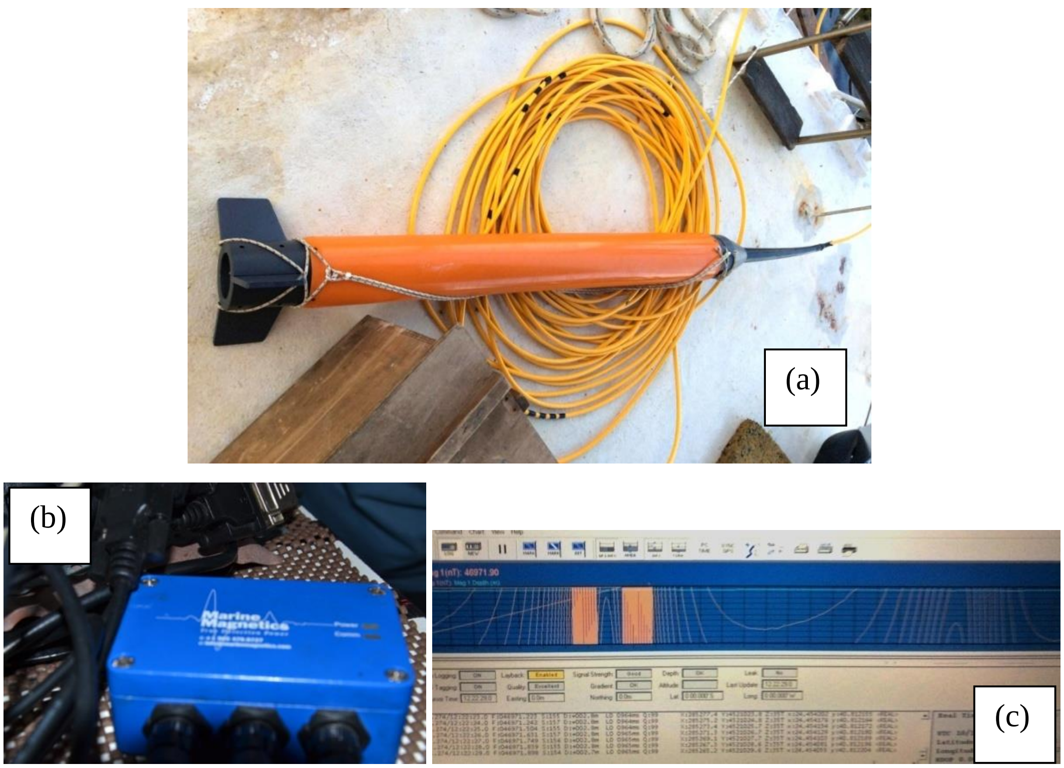



Fig 2.1.2.5.1. Marine Magnetics SeaSpy magnetometer with 200m kevlar cable (a), signal transformation box (b) and Sealink acquisition software (c).

#### 2.1.2.6 Ground-truth survey

##### 2.1.2.6.1 Van-Veen Grab Sampler

A Van-Veen Grab sampler (Fig. 2.1.2.6.1.1.) has been used to collect sediment samples from the seabed. The sampling positions were chosen after the completion of the geophysical survey. All the different detected seafloor types were sampled for verification.

Fig 2.1.2.6.1.1. The Van-Veen Grab and a collected sample.

##### 2.1.2.6.2 Underwater tow-camera

For the visual inspection of the seafloor and of man-made or natural unidentified targets, a ground truthing survey carried out using an underwater custom made tow camera (Fig. 2.1.2.6.2.1).

Fig. 2.1.2.6.2.1. Underwater tow camera which used for the visual inspection of the seafloor and on the vessel deck.

## 2.2 SURVEY PLANNING

### 2.2.1 BASE CASE

The survey in the Base Case area was planned in order to achieve full coverage mappings of the seabed through bathymetric (MBES) and side scan sonar data and a dense grid of shallow seismic (Chirp system) and magnetic profiles.

The survey lines have been planned so that all points on the seafloor were sampled at least twice, through a grid of parallel swaths, with the adjacent ones having more than 70% overlap (50m distance to each other) at average survey depths (40m). All areas have been sampled by the close range pulses (0 – 50$^o$) offering sample spacing ranging between 0.8 and 2.2 m per swath. According to the above, the point density can be estimated to an average of 2.7 points/m$^2$, if perpendicular lines exist (at platform area) and 1.3 points/m$^2$ if not.

Near the area of Delta complex and due to the presence of buys and wire ropes close to the sea surface, the initial network of parallel lines could not be achieved. Instead of that, a grid of parallel and sub-parallel tracklines with the wire ropes was carried out.

Table 1 summarizes information regarding the total surveying conducted at the Base Case area based on the above requirements (Fig 2.2.1.1.):

Table 1 Information regarding the survey lines conducted at the "Base Case" area.

| Instrumentation used | No. of survey-lines | Total length (km) | Line Order/ Orientation | Line spacing (m) | Area |
|---|---|---|---|---|---|
| **MBES, SSS, Chirp and Magnetometer** | 26 | 137 | Parallel, NW to SE | 50 | Base Case |
| **MBES, SSS, Chirp and Magnetometer** | 20 | 27 | Perpendicular to the Base Case, SW to NE | 50 | Epsilon/Lamda platform |
| **MBES, SSS, Chirp** | 34 | 33 | Variable | Variable | Delta Complex |
| **MBES, SSS, Chirp and Magnetometer** | 5 | 13.5 | Perpendiculars to the Base Case tracklines to cross check Chirp and Magnetometer data | Variable | Base Case |
| **Sparker** | 8 | 36 | Parallel, NW to SE | 150 | Base Case |

The initial examination of the acquired geophysical datasets revealed 9 sites as the most important for ground truthing. Therefore surface sediment samples were collected at those sites. In addition, over 4.1km long survey lines have been conducted to retrieve video footage using an underwater tow-camera at water depths between 38 and 55m.

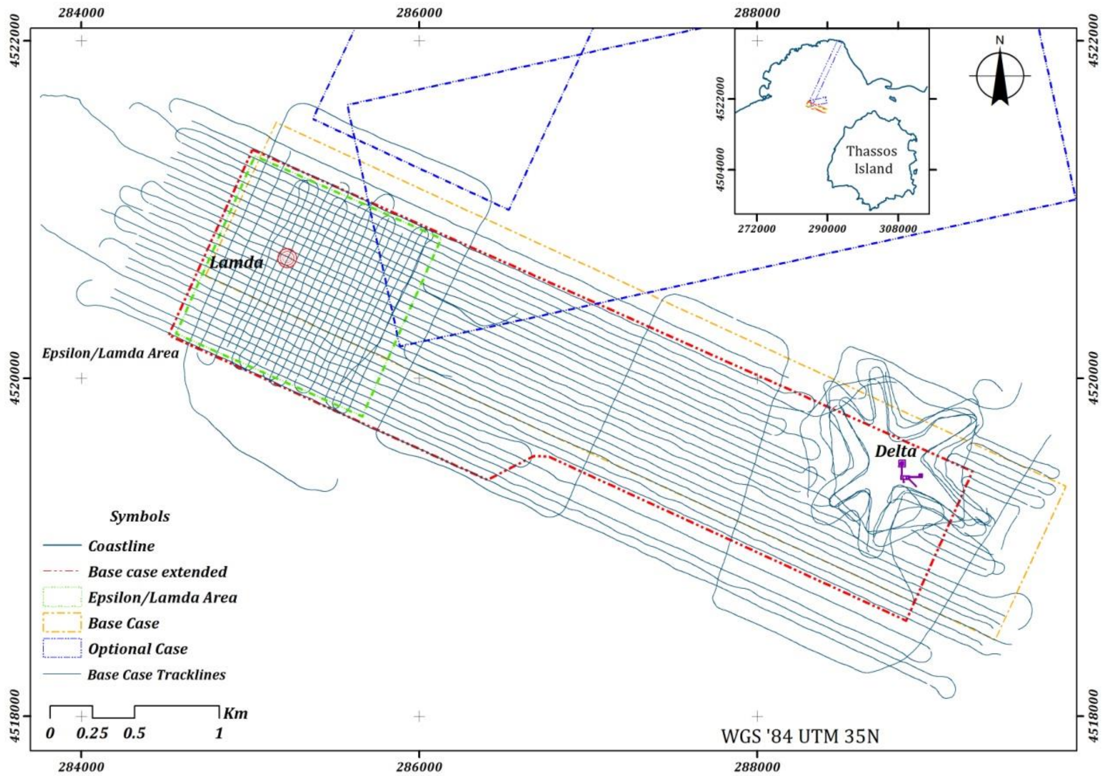



Fig. 2.2.1.1. MBES, SSS, SBP Chirp and Magnetometer tracklines carried out at Base Case Area.

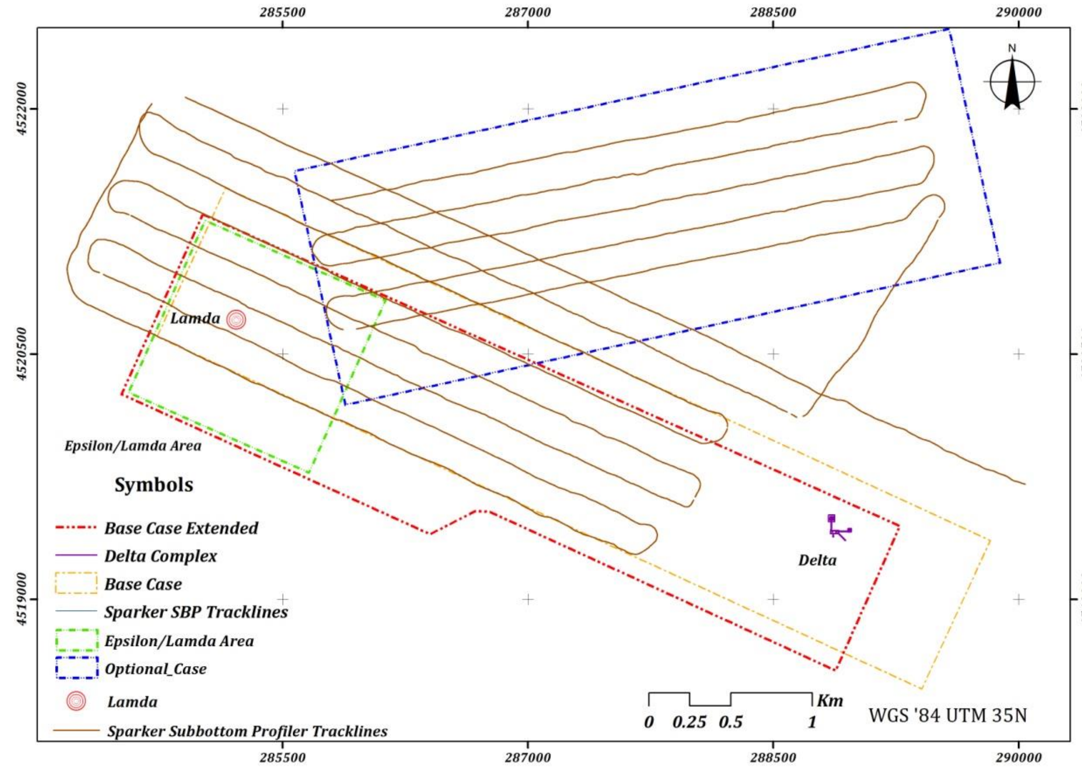



Fig. 2.2.1.2. Sparker SBP tracklines carried out at Base Case Area and Optional Case Area.

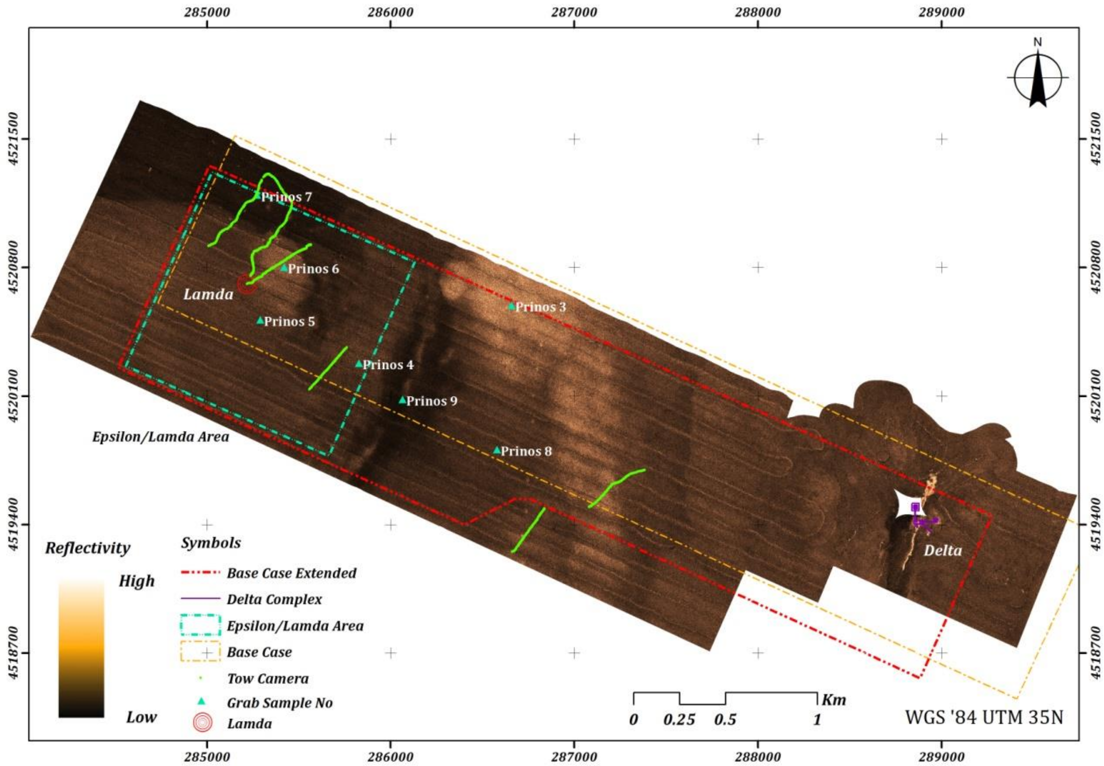



Fig. 2.2.1.3. Sample locations and tow camera tracklines carried out at the Base Case Area.

## 2.2.2 OPTIONAL CASE

The survey in the Optional Case consists of two surveyed sub-areas:

- The first area extends from the Epsilon/Lamda platform to a site north of Delta Complex, called as Omicron Site. The surveying in this area included bathymetric (MBES), side scan sonar, seismic profiling (Chirp and Sparker) and marine magnetic investigation.
- The second area is a corridor extending from the Epsilon/Lamda platform to Sigma Site at Kavala harbor. In this area, the survey included a rougher grid of waylines using Multi-

Beam Echo Sounder, Side Scan Sonar, Seismic profiling (Chirp and Sparker) and marine magnetometer.

Table 2 summarizes information regarding the total surveying conducted at the Optional Case areas (Fig 2.2.2.1.).

Table 2 Information regarding the survey lines conducted at the "Optional Case" area.

| Instrumentation used | No of survey-lines | Total length (km) | Line Order/ Orientation | Line spacing (m) | Area |
|---|---|---|---|---|---|
| **MBES, SSS, Chirp and Magnetometer** | 5 | 20 | Parallel, WSW to ENE | 200 | From Epsilon/Delta to Omicron Sites |
| **Sparker** | 5 | 22 | Parallel, WSW to ENE | 200 | From Epsilon/Delta to Omicron Sites |
| **MBES, SSS, Chirp and Magnetometer** | 2 | 36 | Parallel, SW to NE | 150 | From Epsilon/Delta Site to Sigma Site |

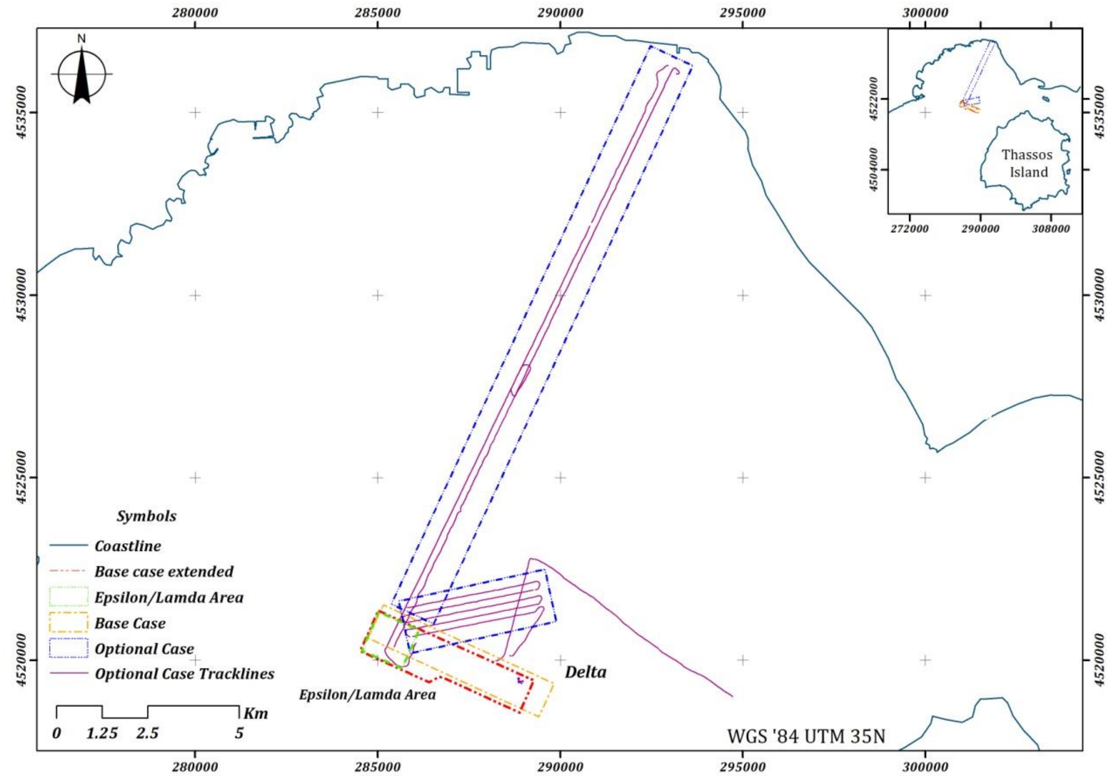



Fig. 2.2.2.1. MBES, SSS, SBP Chirp and Magnetometer tracklines carried out at Optional Case Area.

## 2.3 DATA PROCESSING AND ANALYSIS

Analysis of multi-platform data led to a multi-layer interpretation, each layer of which corresponds to different components of the seafloor. While backscatter and ground truth data describe the uppermost sediment layer as well as other surficial seabed characteristics, seismic profiling reveals the seabed stratigraphy, up to approximately 60m beneath the seafloor. Combination of the above three dimensional information into a single two dimensional map is challenging but on the other hand provides to the end-user, a valuable management tool. Figure 2.3.1 shows a simplified flow diagram regarding the systems that have been sequentially used for the data acquisition and post-processing stages.

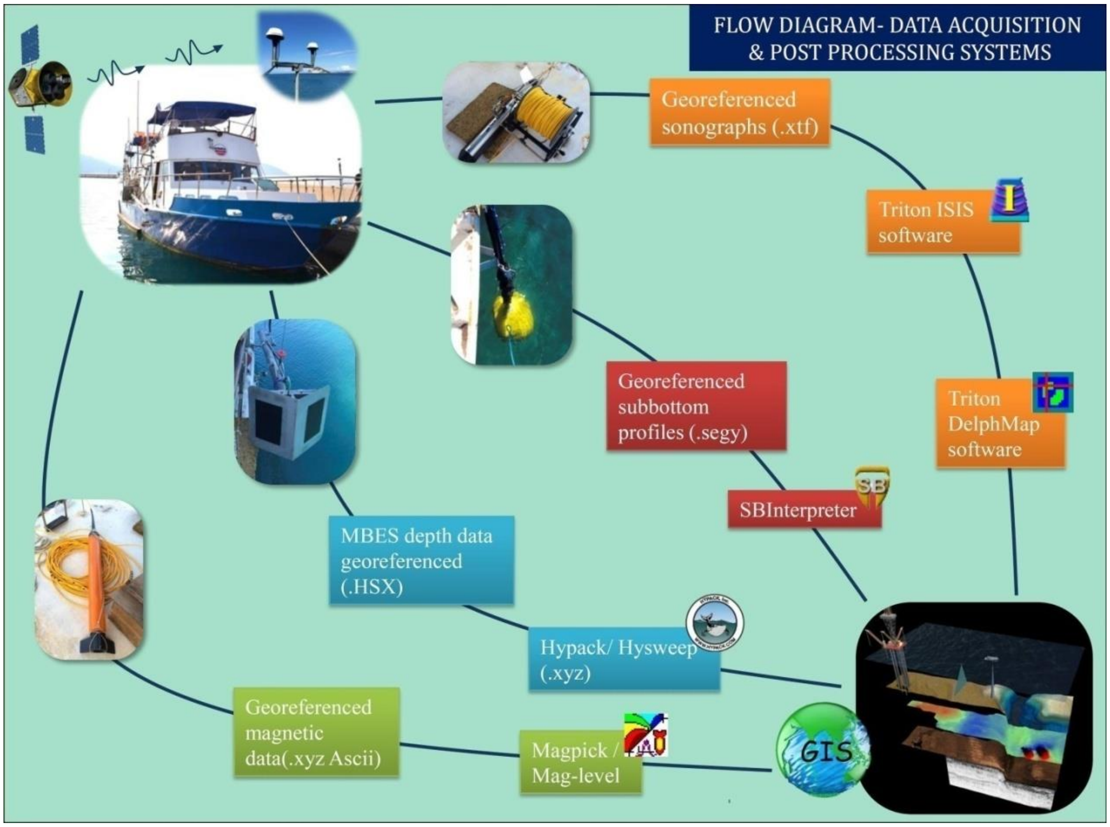



Fig. 2.3.1. Simplified flow diagram showing the data acquisition and post-processing systems.

# 3 PRELIMINARY RESULTS

## 3.1 BATHYMETRY

### 3.1.1 BASE CASE AREA

The water depth at Base Case area ranges between 30 and 52m (Fig 3.1.1.1.; 3.1.1.2). The area can be separated in three parts based on the bathymetry. The eastern part (-the area between Delta complex and the central part of Base Case area-) constitutes a bathymetric high plateau and is characterized by a smooth seafloor, deepening gently from 30m water depth at Delta complex to 34m water depth at the central part of the Base case (slope <1°) (Fig 3.1.1.3). The western part (including Epsilon/Lamda platform area) also constitutes a bathymetric high plateau (37-41m water depth), which is deepening gently to the east and north (slope ≈1°). The two bathymetric high plateaus are separated by a deep part (50-52m water depth) which forms a channel, running almost north-south. In the area between the channel and the western plateau, the seafloor is deepening with a low slope to the west (2° - 4°) and a medium slope to the north (3° - 9°). The seafloor between the eastern part and the channel is characterized by low slopes towards south and by medium to high slopes (up to 13°) towards north.

Based on the bathymetric data a bathymetric profile of the proposed pipeline route between the New Lamda Platform location and the Delta complex has been constructed and it is presented in the Figure 3.1.1.4.)

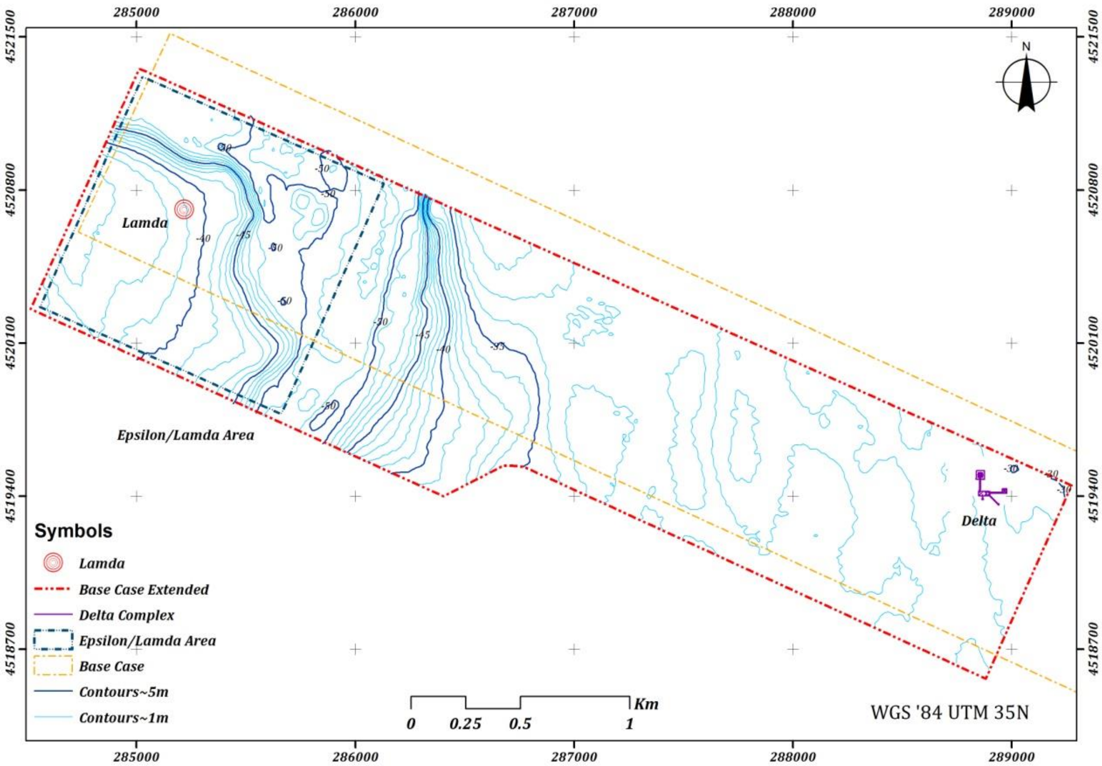



Fig. 3.1.1.1. Bathymetric Map of the Base Case Area.

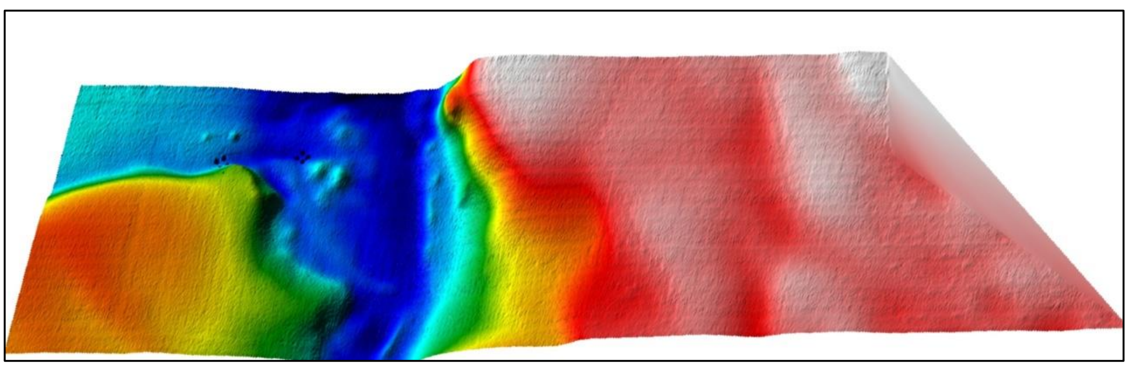


Fig. 3.1.1.2. 3-D representation of the Base Case Area (Delta complex area has been extcluded).

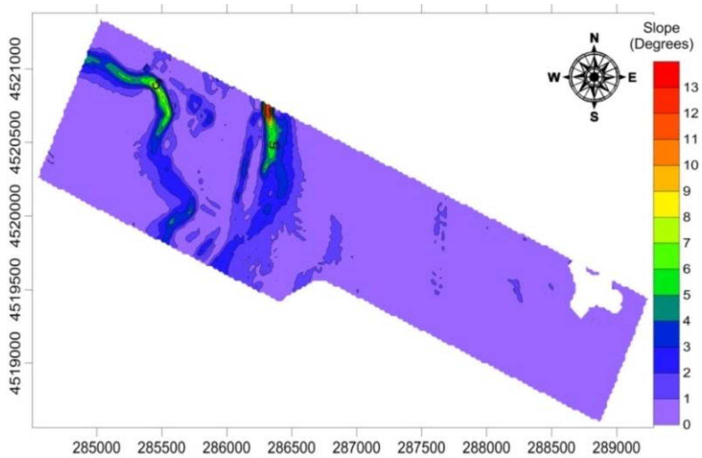



Fig. 3.1.1.3. Isocline Map of the Base Case Area.

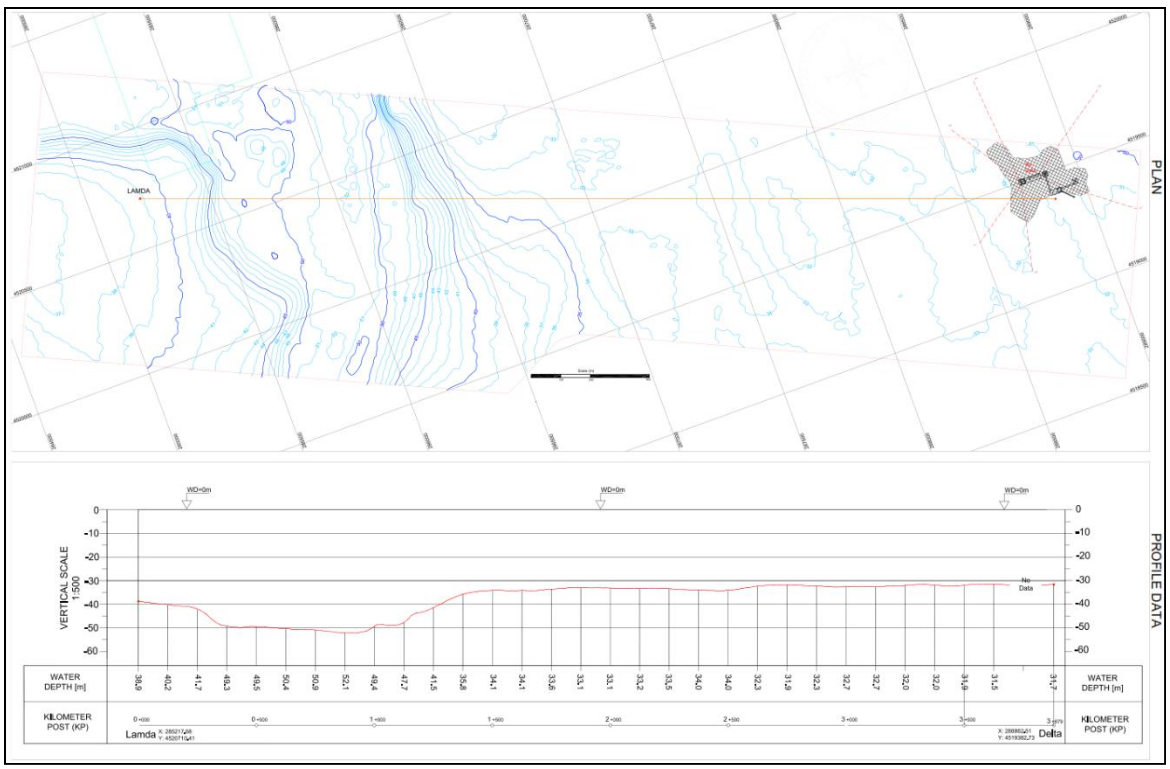



Fig. 3.1.1.4. Bathymetric map and bathymetric profile along the proposed pipeline route between New Lamda Platform and Delta complex.

### 3.1.1.1 Epsilon/Lamda Area

The bathymetry of the Epsilon/Lamda platform area (Fig. 3.1.1.1.1; 3.1.1.1.2) is characterized by a plataeu at the western part, as described above, with water depth ranging from 37 to 41m and a channel (deeper part) at the eastern and northern part of the area. The slope (Fig. 3.1.1.1.3) between these two morphological units is low to medium at the southern part and medium at the northern part. At the northern part of the area, within the deeper part, eight small scale, circular deepenings about 25m in diameter and 1.5m deep were recorded. The locations of the deepenings form two rectangles. Most probably these deepenings have been formed by the weight of the legs of two old well platforms.

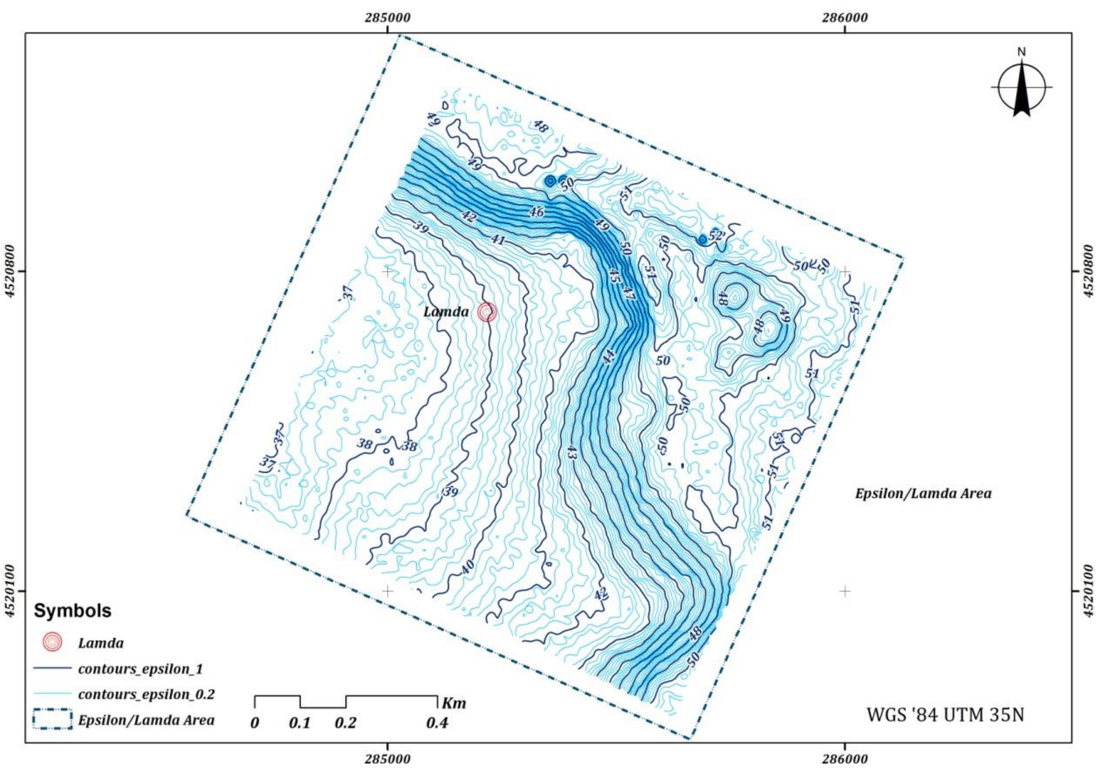



Fig. 3.1.1.1.1. Bathymetrical map of Epsilon/Lamda platform Area.

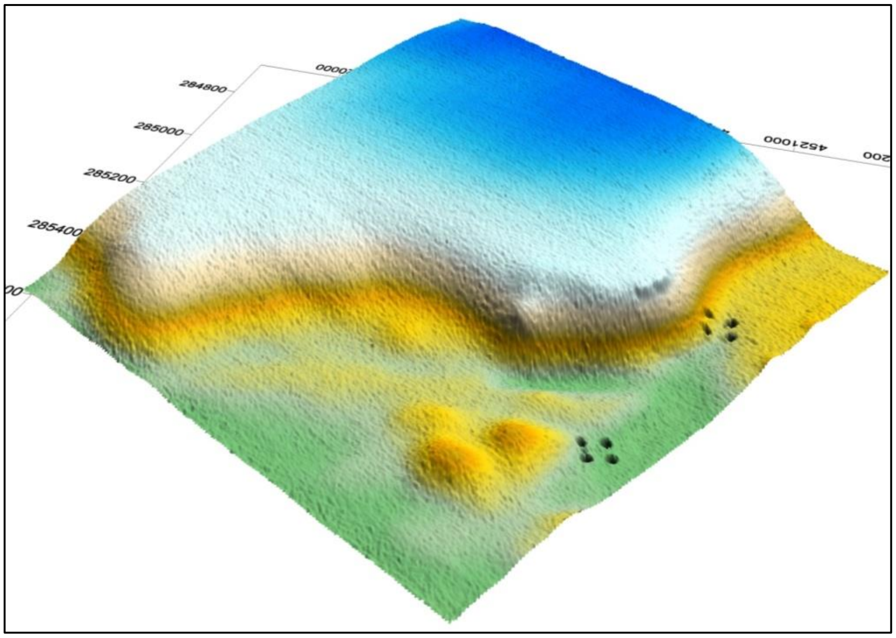



Fig. 3.1.1.1.2 3-D representation of Epsilon/Lamda platform Area. The deepenings that have been formed by the weight of two old well platforms are also shown.

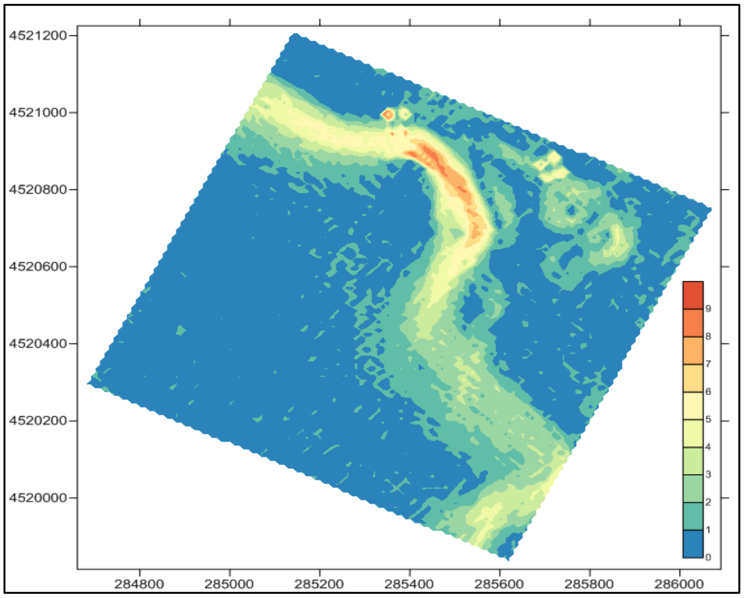



Fig. 3.1.1.1.3 Isocline map of Epsilon/Lamda platform Area.

## 3.2 ACOUSTIC BACKSCATTER

Acoustic backscatter is considered the most essential derivative towards seabed characterization, providing information about the texture, the hardness and the lithology of the seabed. Relatively high backscatter regions declare coarse grained - hard-packed sediments or hard biogenic formations while lower reflectivity indicate areas consisting of fine grained - soft sediments. In the present study, light tones represent high reflectivity areas and dark tones low reflectivity sites. The SSS system used in the present study is capable to operate in two pulse frequencies (100 and 400kHz). The sonographs obtained from the low frequency are usually used for the mapping of the main morphological and textural elements of the seafloor, achieving a small penetration of up to a few centimeters, depending on the sediment compactness. The sonographs obtained from the high frequency are usually used for the mapping in more detail the surficial texture of the seafloor, as well as for detecting small scale seafloor features such as natural or man-made targets lying on the seafloor.

The two mosaics constructed using the low and high frequency SSS data are presented in Figures 3.2.1 and 3.2.2, respectively. Preliminary examination revealed a similar pattern of acoustically different areas in both mosaics, from now on called Acoustic Types. Each acoustic type represents different backscatter intensity and textural characteristics, possibly indicating a unique natural seabed type, which will be determined in a later stage, after their close correlation to ground truth data.

Preliminary interpretation revealed five (5) distinct acoustic types in the mosaics; A, B, C, D and E based on their backscatter intensity. Acoustic type A corresponds to the highest observed intensity values and D to lowest ones. Two or more appearances of the same acoustic type observed in different areas were differentiated using a sequential integer indicator (e.g. A1, A2).

- Acoustic type A is characterized by high backscatter intensities with a moderate to high texture contrast, indicating very coarse sediments or probably well developed biogenic formations. It is observed in two areas, the first (A1) located in the center of the survey area, and the other at the north of Epsilon/Lamda Area. A1 also exhibits an SE to NW directional texture, possibly indicating fishing activity (trawlers). This acoustic type is better distinguished on the low frequency SSS mosaic.

- Acoustic type B is located at the western and southeast end of the Base Case area, is the predominant type of the study area and exhibits relatively high backscatter with a texture of medium to low contrast. It may represent fine grained sediments and possibly irregularly dispersed biogenic surface layers.
- Acoustic type C is located around the A1 type appearance and is of medium backscatter intensity and smooth texture. It represents a transitional/mixture type between types A and B.
- Acoustic type D is characterized by low backscatter intensity, signifying fine grained – incoherent sediments. Both of appearances, D1 and D2 are located within the channel in the central – western part of the Base Case Area and are separated by a higher intensity zone; the acoustic type E.
- Acoustic type E is characterized by medium to low backscatter intensity with an intense directional texture, indicating that the seafloor is probably affected by trawling gears. This acoustic type is better distinguished on the high frequency SSS mosaic.

The examination and the interpretation of both high- and low-frequency SSS datasets did not reveal any indication of gas-induced pockmarks on the seafloor of the survey area. Eight small circular crater-like deepenings about 25m in diameter and 1.5m deep were recorded at the northwestern and deeper part of the area (see also paragraph 3.1.1.1). Most probably these deepenings have been formed by the weight of the legs of two old well platforms. A cluster of twelve small, almost circular crater-like depressions, of unknown origin, were also detected at the vicinity of Delta Complex (see also paragraph 3.8).

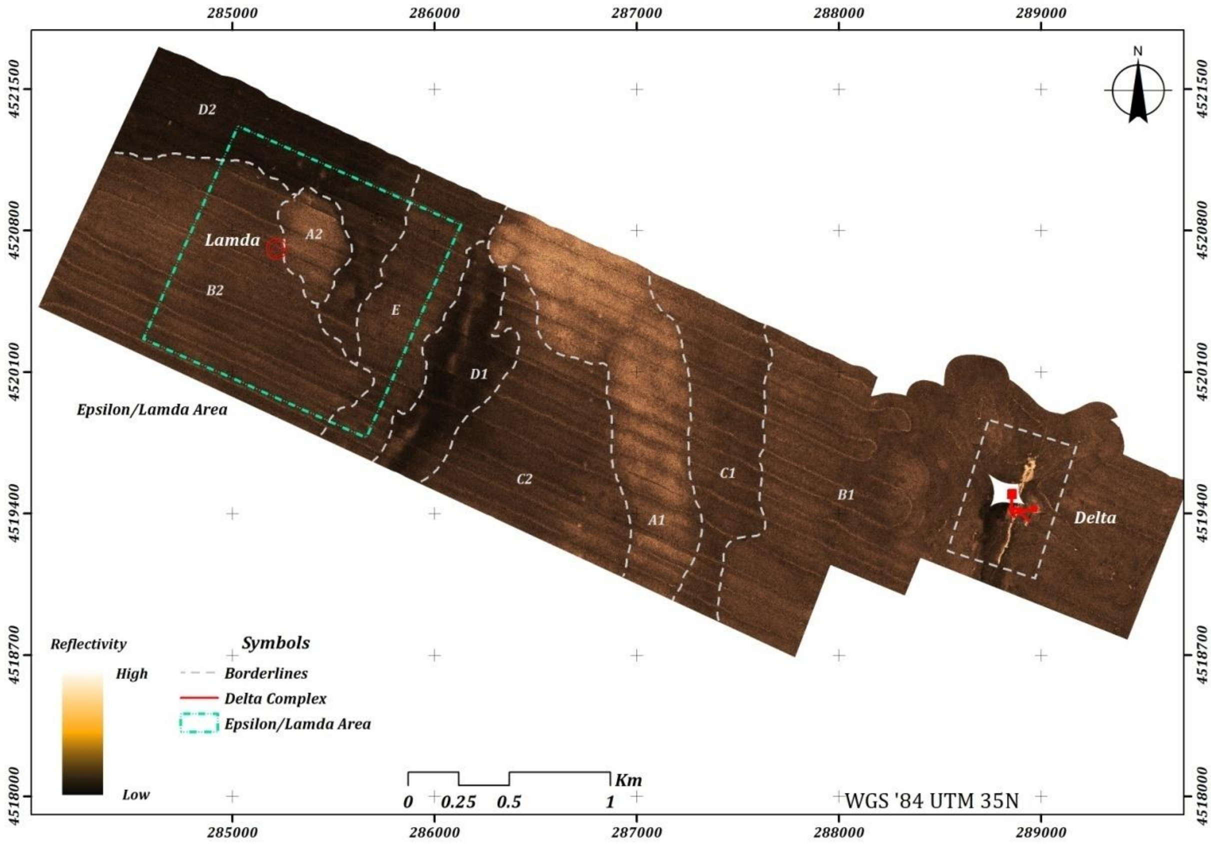



Fig. 3.2.1. Low frequency (100 kHz) SSS mosaic of the Base Case area showing the preliminary delineation of the five distinct acoustic types.

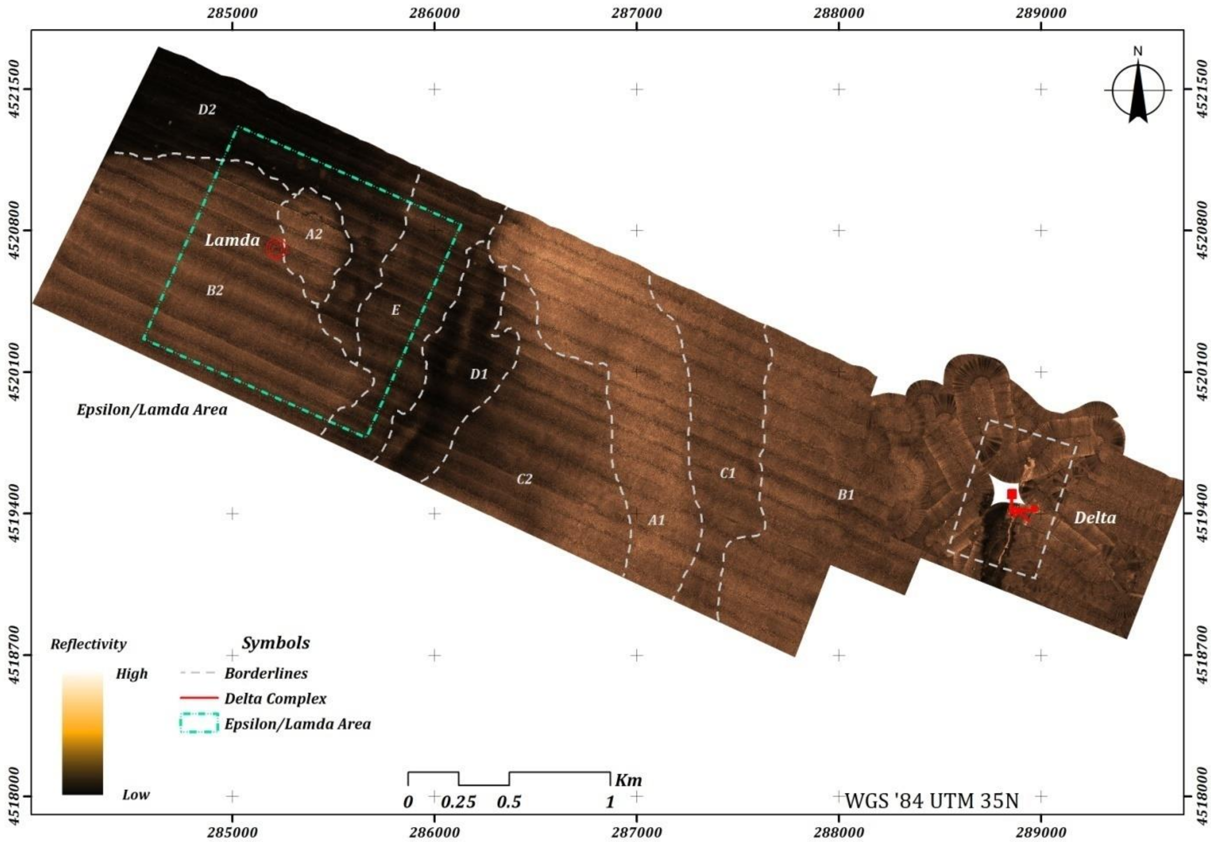



Fig. 3.2.2. High frequency (400 kHz) SSS mosaic of the Base Case area showing the preliminary delineation of the five distinct acoustic types.

## 3.3 SEISMIC STRATIGRAPHY

The preliminary interpretation of the seismic data revealed three main different acoustic types (AT) in Chirp profiles and three seismic phases (S) in Sparker profiles. These three acoustic types and seismic phases correspond to the three different morphological units of the survey area; the western bathymetric high plateau where the DELTA complex has been installed, the eastern bathymetric high where the new EPSILON/LAMDA platform is proposed to be constructed and the central channel separating the two high plateaus. This chapter presents the acoustic types and the seismic phases on representative Chirp and Sparker profile, respectively. The position of those two profiles is shown in Figure 3.3.1.

As mentioned above, the interpretation of the Chirp seismic data revealed different acoustic types (AT) (Fig. 3.3.2). A rough estimation of the spatial distribution of the acoustic types is given in the Figure 3.3.3. The channel which is the main morphological unit on the profile is characterized by an acoustic type (AT1) that can be distinguished into two seismic phases (Fig. 3.3.2 and 3.3.3). The upper phase (AT1a) is almost transparent with a lack of internal reflectors. This phase is related to deposits of homogenous material consisting possibly of mud. The lower phase (At1b) of the channel consists of locally highly deformed strong reflectors with almost transparent layers/zones suggesting episodic sedimentation (Fig. 3.3.2 and 3.3.3).

The two topographic/bathymetric highs plateau are also characterized by two acoustic types (AT 2 and AT 3) which each of them can be distinguished into two seismic phases (Fig. 3.3.2 and 3.3.3). The upper phase (AT2a and AT3a) shows completely different appearance at the two plateaus (Fig. 3.3.2). At the eastern one, where the DELTA platform has been installed, the upper seismic phase can be divided to two parts (AT2ai and AT2aii) (Fig. 3.3.2). The upper part (AT2ai) is characterized by an almost transparent internal acoustic character that represents homogeneous deposits of fine-grained sediments (sandy mud). The underlying lower part (AT2aii) which is restricted at the southeastern end of the plateau exhibits well defined high angle progradational clinoform reflectors having dips of 1.5$^o$ - 2$^o$. That lower part of the upper phase indicates the westward progradation of deltaic deposits.

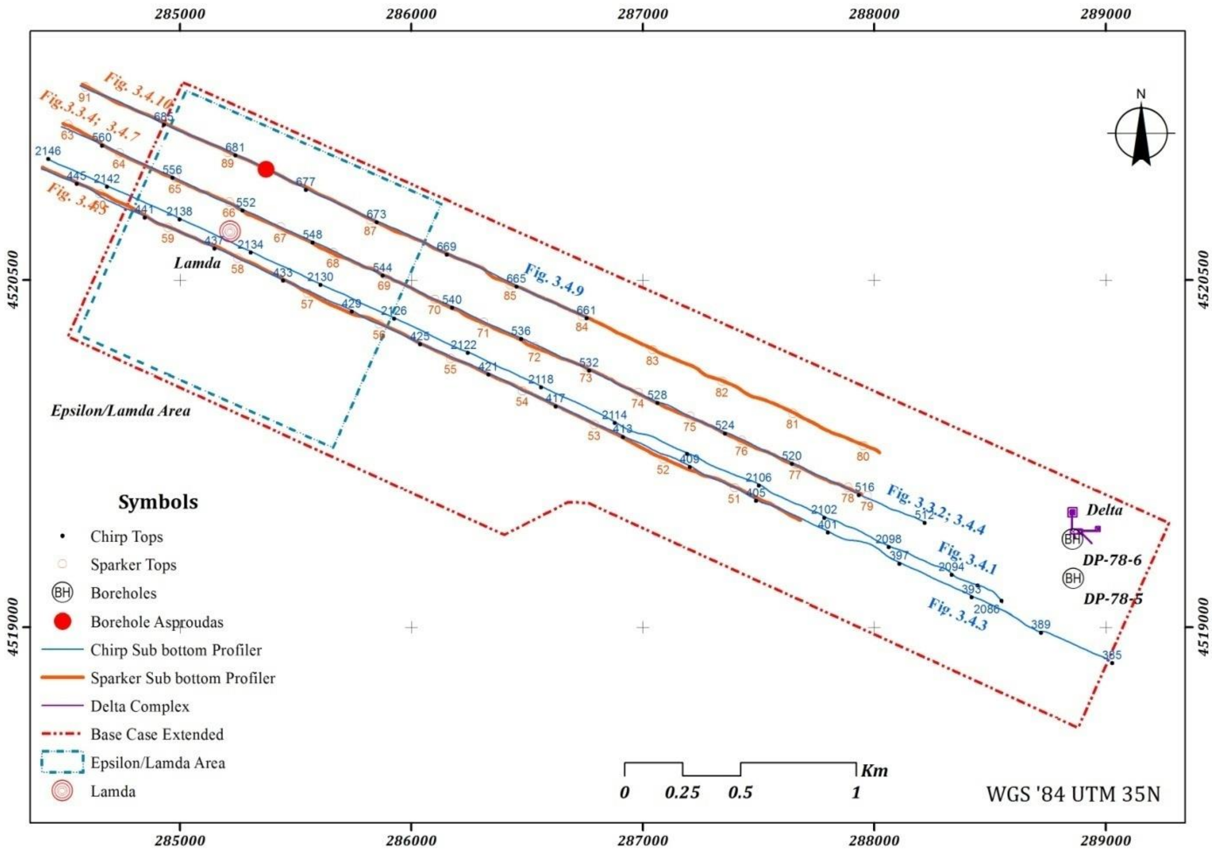



Fig. 3.3.1. Map of the Base Case Area shown the position of boreholes and the position of the profiles that have been used for the presentation of the seismic stratigraphy (Chapter 3.3.) and the correlation between seismic and lithological data (Chapter 3.4.).

In the western plateau, where the EPLSION/LAMDA platform is planning to install, the upper phase (AT3a) has limited thickness (<7.5m) and shows an almost transparent internal acoustic character that represents homogeneous deposits of fine-grained sediments (muddy sand to silty sand) (Fig. 3.3.2 and 3.3.3).

At both plateaus, the upper phase (AT2a and AT3a) overlies the lower one (AT2b and AT3b) which is clearly defined by a surface of high reflectivity (very prolonged echo) (Fig. 3.3.2). In the lower phase no seismic reflections observed below the high-amplitude top reflection suggesting that represents the acoustic basement for the Chirp profiling (AT2b and AT3b) (Fig. 3.3.2).

At the western end of the survey area, the abrupt termination of a thick layered phase (AT 4) against the western plateau probably suggests a fault (F) (Fig. 3.3.2). The seismic reflections exhibit a concave-upward geometry indicating a normal drag (Fig. 3.3.2 and 3.3.3). It should be mentioned that the AT4 was detected beyond the limit of the Base Case area. Thus, due to very limited data the spatial distribution of that acoustic type (AT4) is not shown in the map of Figure 3.3.3.

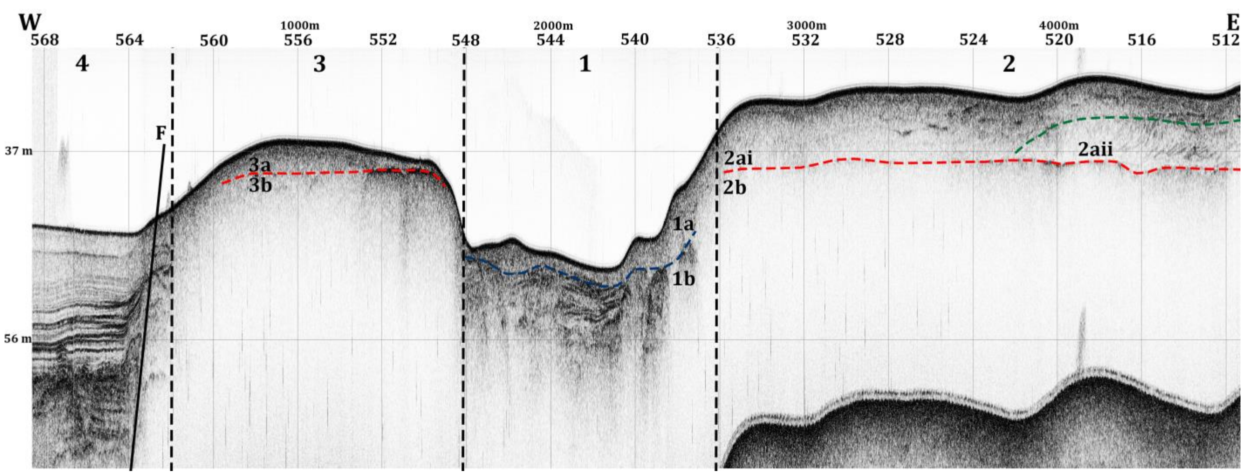



Fig. 3.3.2. Sub-bottom Chirp high resolution seismic profile acquired from the Base Case Area, The main Acoustic Types (AT) of the area are also marked on the profile. It should be noted that the AT 4 is located out of the limits of Base Case Area. (F: fault).

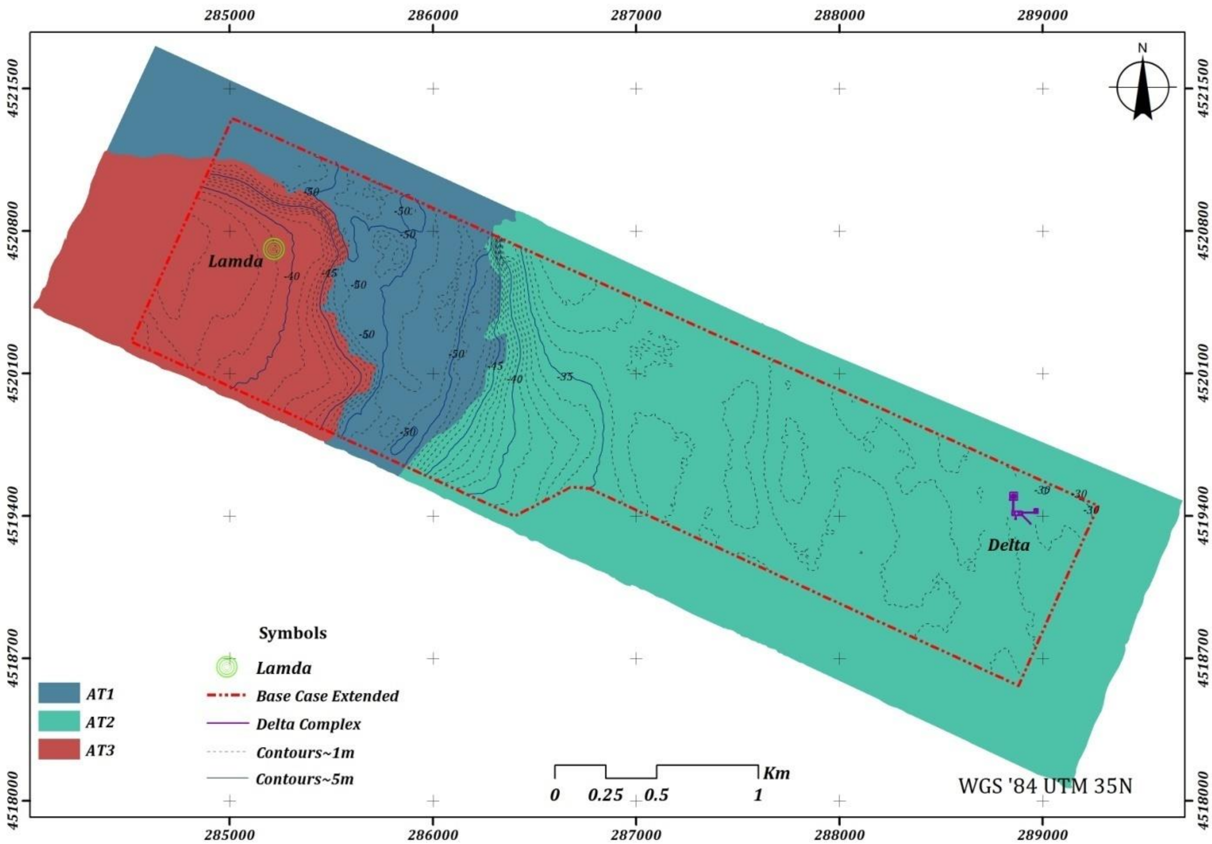



Fig. 3.3.3. Map showing the spatial distribution of the Acoustic Types (AT1, AT2 and AT3) in the survey area, as resulted from the Chirp data analysis and interpretation.

The Sparker system achieved a maximum penetration of about 50m. The deeper sediments are largely obscured by the strong seafloor multiple reflections (Fig 3.3.4). The preliminary interpretation of Sparker profiles generally showed high amplitude reflector packages with high discontinuity, often interrupted by zones of almost transparent and/or chaotic character (Fig 3.3.4). A rough estimation of the spatial distribution of the seismic phases, as resulted from Sparker data analysis, is given in the Figure 3.3.5.

The three main morphological units (channel and two bathymetric highs), which are presented along the corridor connecting the DELTA platform site and the proposed EPSILON platform site, also revealed different seismic phases (S1, S2 and S3) in Sparker profiles (Fig. 3.3.4. and 3.3.5.). The central channel (S1) is characterized by three seismic phases (Fig. 3.3.4.). The upper, S1a, is almost transparent with a lack of internal reflectors (Fig. 3.3.4.). The intermediate, S1b, is characterized by a high-amplitude top reflection package overlying an almost transparent unit locally with weak discontinuous internal reflectors (Fig. 3.3.4.). The lower seismic phase, S1c, is characterized by high amplitude reflector packages (Fig. 3.3.4.).

The eastern plateau (S2) is characterized by three (3) almost parallel to sub-parallel high amplitude discontinuous reflectors which can be interpreted as transitions between different lithological units (Fig. 3.3.4. and 3.3.5.).

The western plateau, (S3), is similar to the eastern one, but the high-amplitude reflectors top package is more discontinuous and is interrupted by zones of chaotic/transparent character (Fig. 3.3.4. and 3.3.5.). This unit can be interpreted as alternations of medium to coarse grained sedimentary deposits.

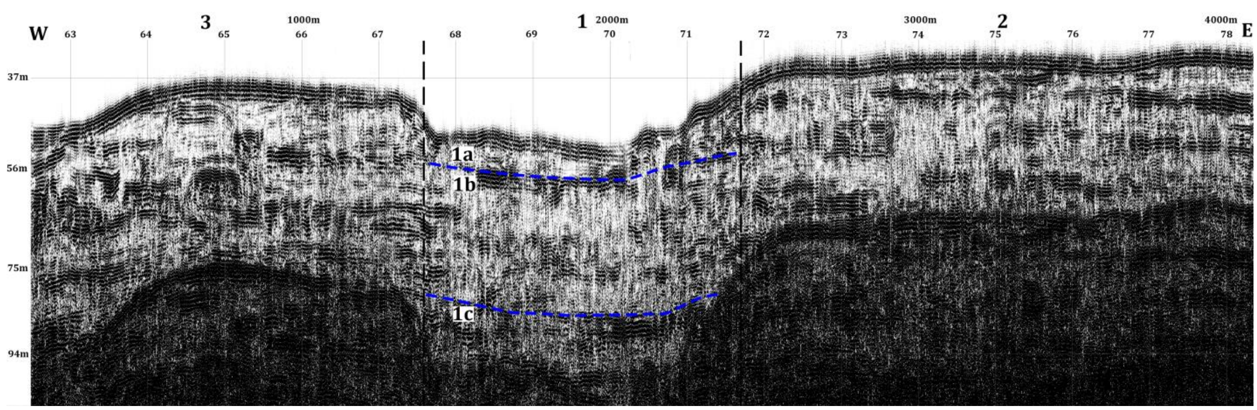



Fig. 3.3.4. Sub-bottom Sparker seismic profile acquired from the Base Case Area, The main seismic phases (S1, S2, S3) of the area are also marked on the profile.

The preliminary interpretation of the Chirp and Sparker seismic profiles did not show evidence of shallow gas charged sediments in the survey area. The analysis of the seismic profiles did not reveal acoustic characters indicative of extensive presence of gas in sediments interstices. It should be noted that the high frequencies systems (Chirp and SSS) detected numerous acoustic targets within the water column. This type of acoustic targets represents fish school and/or gas plumes. The visual inspection of the area in selected sites showed the presence of fish school but no indication of gas seepages. However, limited presence of gas charged sediments in the survey area cannot be excluded.

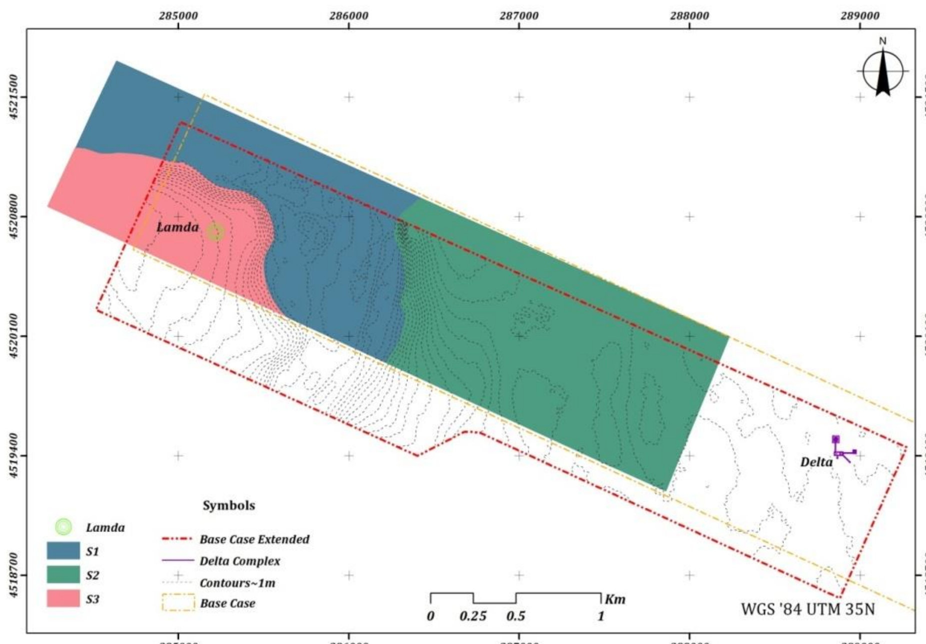



Fig. 3.3.5. Map showing the spatial distribution of the Seismic Phases (S1, S2 and S3) in the survey area, as resulted from the Sparker data analysis and interpretation.

## 3.4 COMPARISON BETWEEN THE RESULTS OF THE SEISMOSTRATIGRAPHY AND THE GEOTECHNICAL PROPERTIES OF THE SEDIMENTS ALONG THE CORRIDOR DELTA-EPSILON PLATFORM

The comparison between the seismic data and the results of the previous geological-geotechnical report was mainly focused on the data revealed from the sediment bore holes No D-78-5, No D-78-6 and BH-1. No D-78-5 and No D-78-6 boreholes are located at DELTA complex while the BH-1 borehole is located at the north-western end of the Base Case, at the deeper part of the area. The comparison between the seismic data and the physical/geotechnical properties of the sediments obtained from boreholes is a challenging issue, especially in areas when the sites of the boreholes are not along the profiles. In these cases the seismic interpretation via the examination of the sediment datasets incorporates always uncertainty. Here, two out of three boreholes are not located along the acquired profiles. Specifically, the boreholes No D-78-5 and No D-78-6 are located 500m and 1 km away from the closest Chirp and Sparker trackline, respectively. Those two boreholes have been drilled into the eastern bathymetric high plateau providing sediment geotechnical data for the upper 35m (No D-78-5) and 60m (No D-78-6) of the seabed stratigraphy. Since the western bathymetric high plateau exhibits quite similar seismic stratigraphy to the eastern one, the sediment geotechnical data obtained by the boreholes could aid in understanding of the stratigraphy of the area where the new EPSILON/LAMDA platform is planning to install. The fact that the high-amplitude reflectors top package, in the Sparker profiles, is more discontinuous in the western than the eastern plateau introduces significant amount of uncertainty in the above hypothesis.

However, efforts were given to correlate roughly these sediments datasets with the closest seismic profiles. As a first step, the borehole sediment data was correlated with the closest Chirp profile.

Then, the Chirp data was associated with the adjacent Sparker profile and thus a rough correlation between borehole data and Sparker data was obtained.

The sediment datasets from the boreholes No D-78-5 and No D-78-6 compared with a Chirp profile (line 6) situated 500m away (Fig. 3.4.1; 3.4.2.). The comparison between the sediment datasets and the seismic data presented a relative positive correlation with acoustic anomalies to coincide with changes of the physical/geotechnical properties of the sediments. Although the Chirp profiler system presents limitations in acoustic penetration, the quite well correlation of the datasets improves the overall interpretation of the examined area based on the seismic data.

The upper phases (AT2ai and AT2aii) in the Chirp profile 6, which have a total thickness between 3m and 11.5m, correspond to the upper two lithological units of borehole No D-78-5. Those two units represent grey to brown fine to medium sand, sandy silt, silty sand (SM) and silt (ML) with shell and shell fragments. Within these sediment units the water content is ranging between 25 and 40% and the blow counts values between 3 and 15. These two upper units show (CPT) Cone resistance values ranging between 50 and 100 kgf/cm$^2$.

The lower phase (AT2b-AT3b) which is marked by a top surface of high reflectivity (H1) (very prolonged echo) with no other seismic reflectors, coincides well with the abrupt increase of the (CPT) Cone resistance values up to 200-300 kgf/cm$^2$ in the No D-78-5. The reflector H1 has been clearly recorded along the profile 6 all over the eastern bathymetric high (where the DELTA complex has been installed) and also towards west at the western bathymetric high (at the proposed EPLSION/LAMDA site).

In addition, this reflector (H1) has been clearly recorded on the majority of the acquired Chirp profiles of the area and when is recorded constitutes always the acoustic basement. The above implies that the H1 reflector is a main stratigraphic component in the surveyed area. The Figures 3.4.3 and 3.4.4 show the Chirp profiles 5 and 9.

The comparison between the sediment datasets from the borehole No D-78-6 and the Chirp seismic data showed similar results with the above supporting further the findings for the stratigraphy of the area.

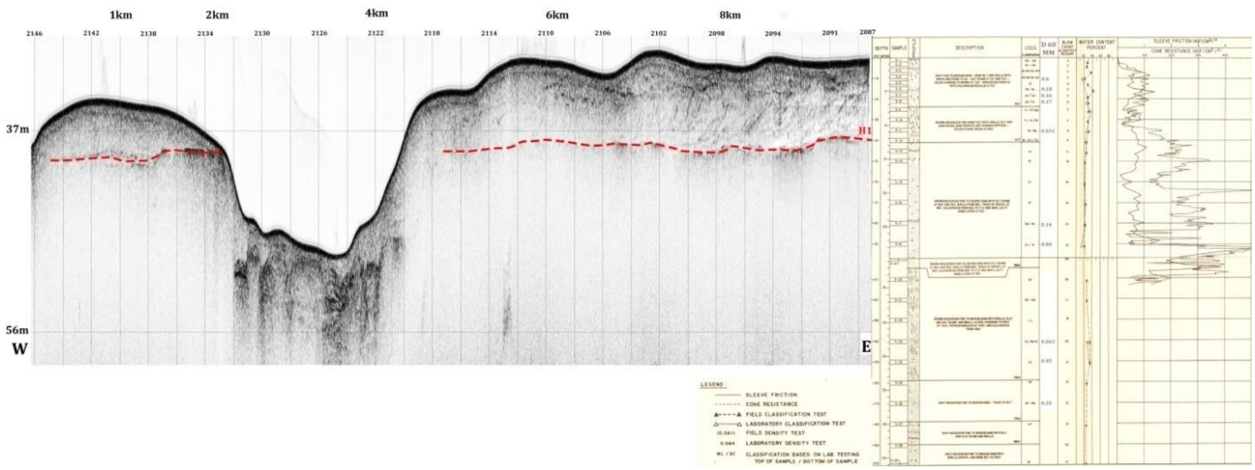



Fig. 3.4.1. The Chirp Line **6** seismic profile and the bore hole log DP78-5 . The position of the profile and borehole are shown in Fig. 3.3.1.

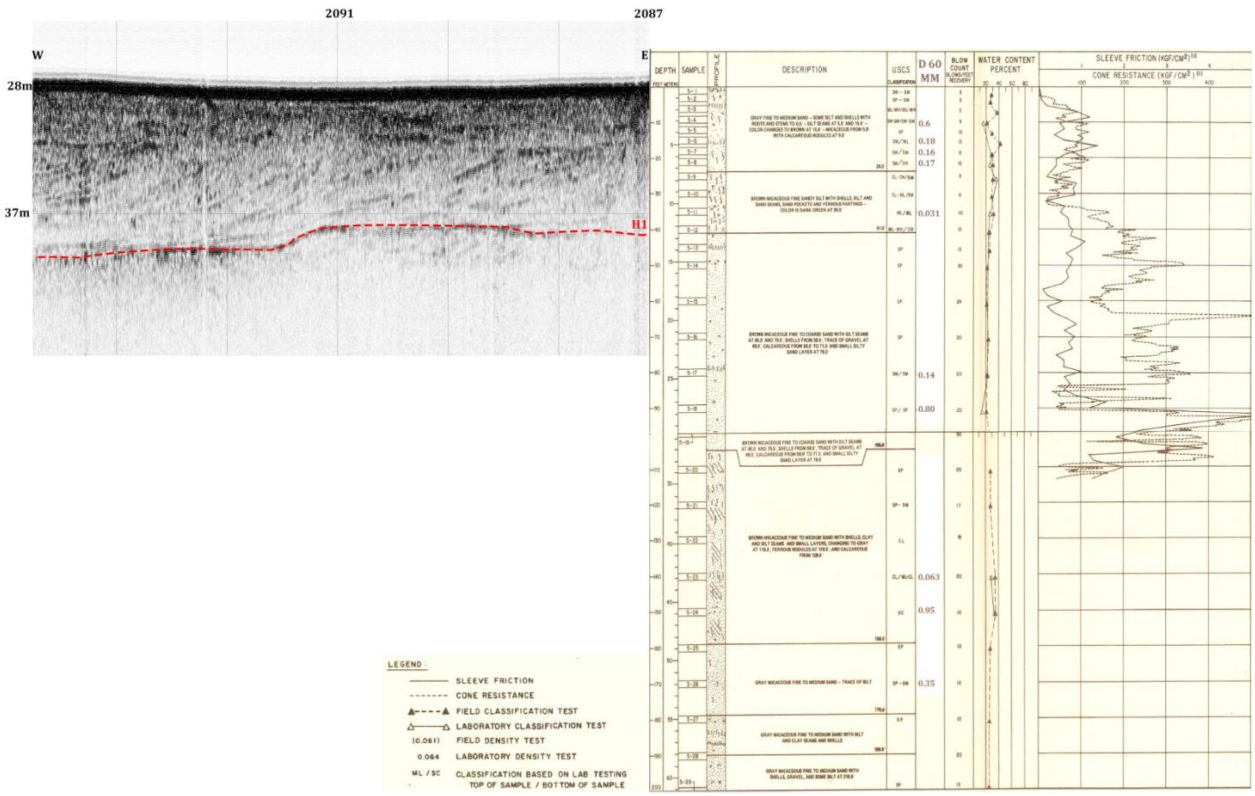



Fig. 3.4.2. The correlation between the Chirp Line 6 seismic profile and the bore hole log DP78-5.

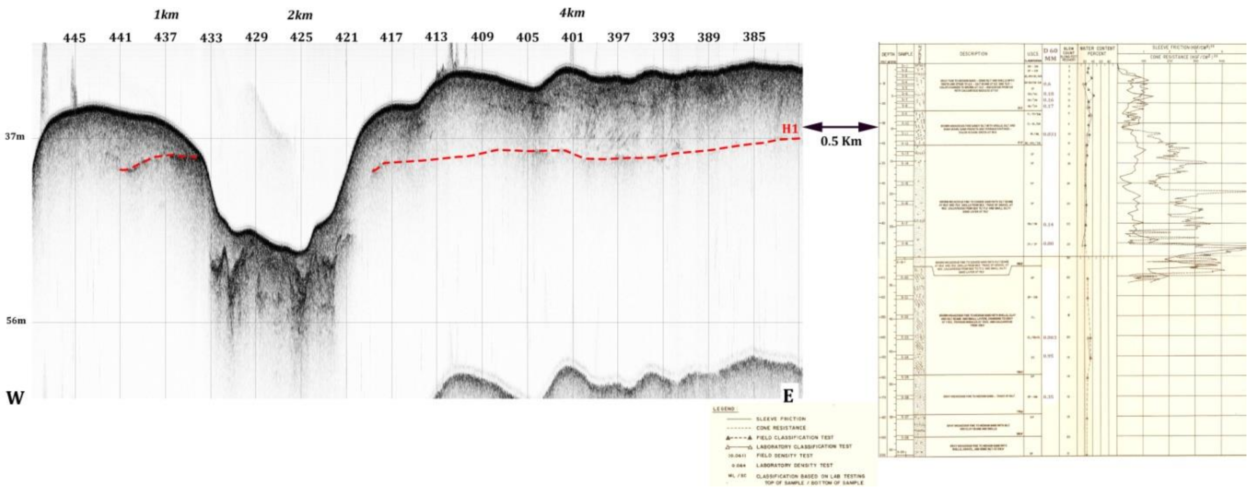



Fig. 3.4.3. The Chirp Line **5** seismic profile and the bore hole log DP78-5 . The position of the profile and borehole are shown in Fig. 3.3.1.

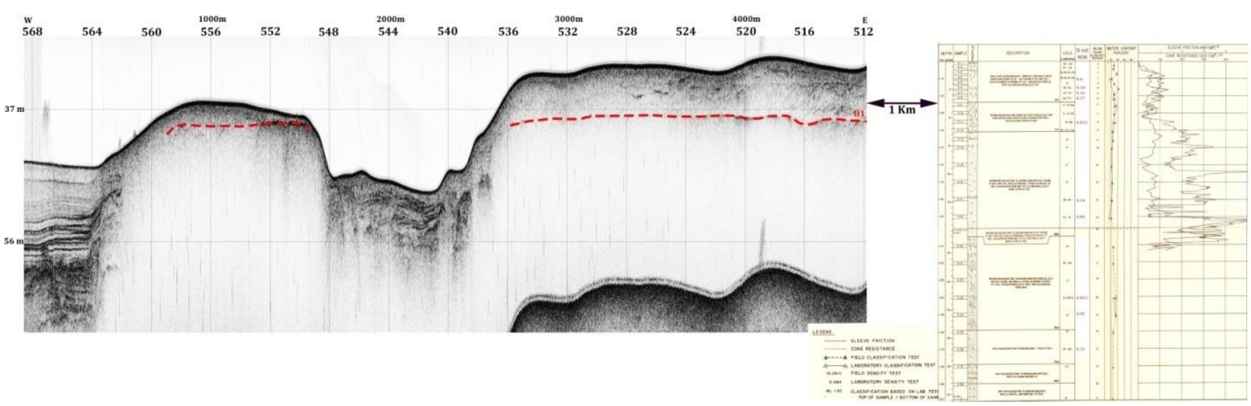



Fig. 3.4.4. The Chirp Line **9** seismic profile and the bore hole log DP78-5 . The position of the profile and borehole are shown in Fig. 3.3.1.

Efforts were given to compare also the profiles collected by the Sparker profiler with the sediment data from the boreholes. This was based on the findings of the above mentioned correlation between Chirp profiles and boreholes and on the preliminary interpretation of the Sparker profiles. This interpretation showed that a subsurface package of high amplitude reflectors recorded about 8-9m beneath the seabed surface on the sparker profiles corresponds to the H1 reflector of the Chirp profiles (Fig. 3.4.5., 3.4.7.). Then the sparker seismic data could be compared with the sediment data from the boreholes and thus to expand the seismic interpretation of the area to greater sediment depths than provided by the (limited) acoustic penetration of the Chirp system and (as previously) to wider areas around the sites of the boreholes and particularly from the DELTA platform plateau to the EPSILON platform plateau.

The upper stratigraphic phase on the Sparker profile, which has a thickness between 4m and 12m, represents the upper two lithological units in No D-78-5 (Fig. 3.4.6, 3.4.8.). In more detail, these upper two units represent grey to brown fine to medium sand, sandy silt, silty sand (SM) and silt (ML) with shell and shell fragments. In these units the water content ranges between 25 and 40% and the blow counts values between 3 and 15. These two upper units show (CPT) Cone resistance values between 50 and 100 kgf/cm$^2$.

The transition to the underlying (third) lithological unit represents in the sediment data sets an abrupt increase of the (CPT) Cone resistance values up to 200-300 kgf/cm$^2$. The material is coarser in relation to the overlying sedimentary units and consists of fine to coarse-grained sand with silt seams and locally traces of gravel. In this unit the water content is about 20% and the blow counts values between 15 and 30 showing a strong increase in relation to the overlying deposits. This lithological unit coincides rather well with the seismic package H1.

Two more abrupt increases of the (CPT) Cone resistance values up to 400-500 kgf/cm$^2$ within the third lithological unit of bore hole No D-78-5 seem to coincide well with high amplitude reflector packages (H2 and H3). A very important finding is that seismic packages H1, H2 and H3 are characterized by strong discontinuity along the DELTA-EPSILON corridor. The discontinuity of those reflector packages is more intense towards the western bathymetric high.

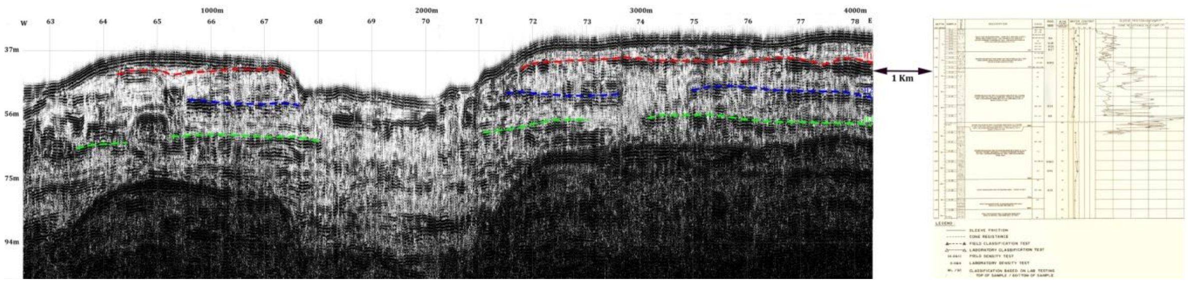


Fig. 3.4.5. The Sparker Line 5 seismic profile and the bore hole log of DP78-5. The position of the profile and borehole are shown in Fig. 3.3.1.

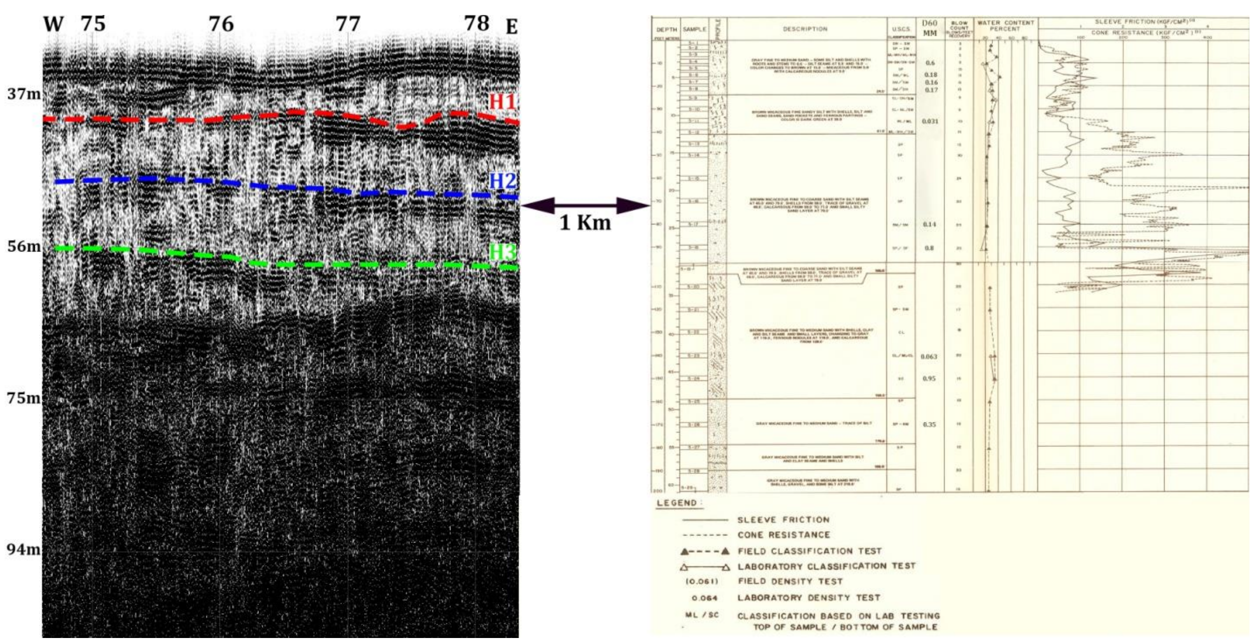



Figure 3.4.6. The correlation between the Sparker seismic profile and the bore hole log DP78-5.

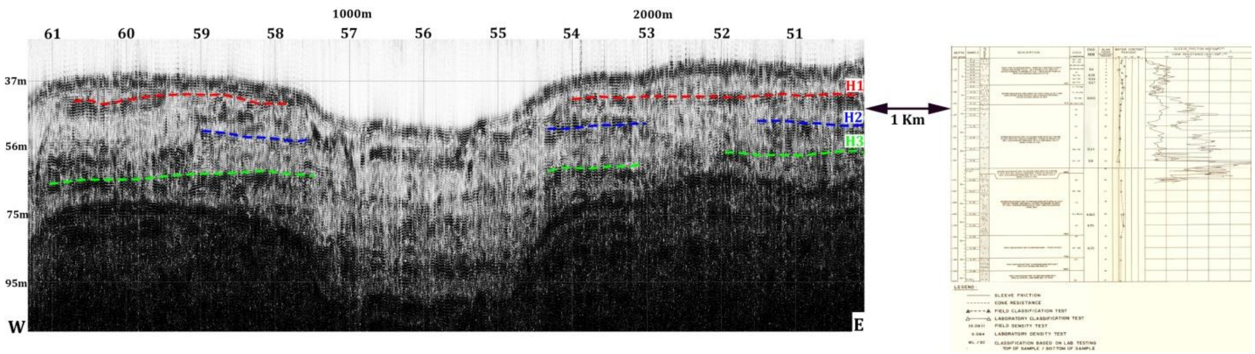



Fig. 3.4.7. The Sparker Line 4 seismic profile and the bore hole log of DP78-5. The position of the profile and borehole are shown in Fig. 3.3.1.

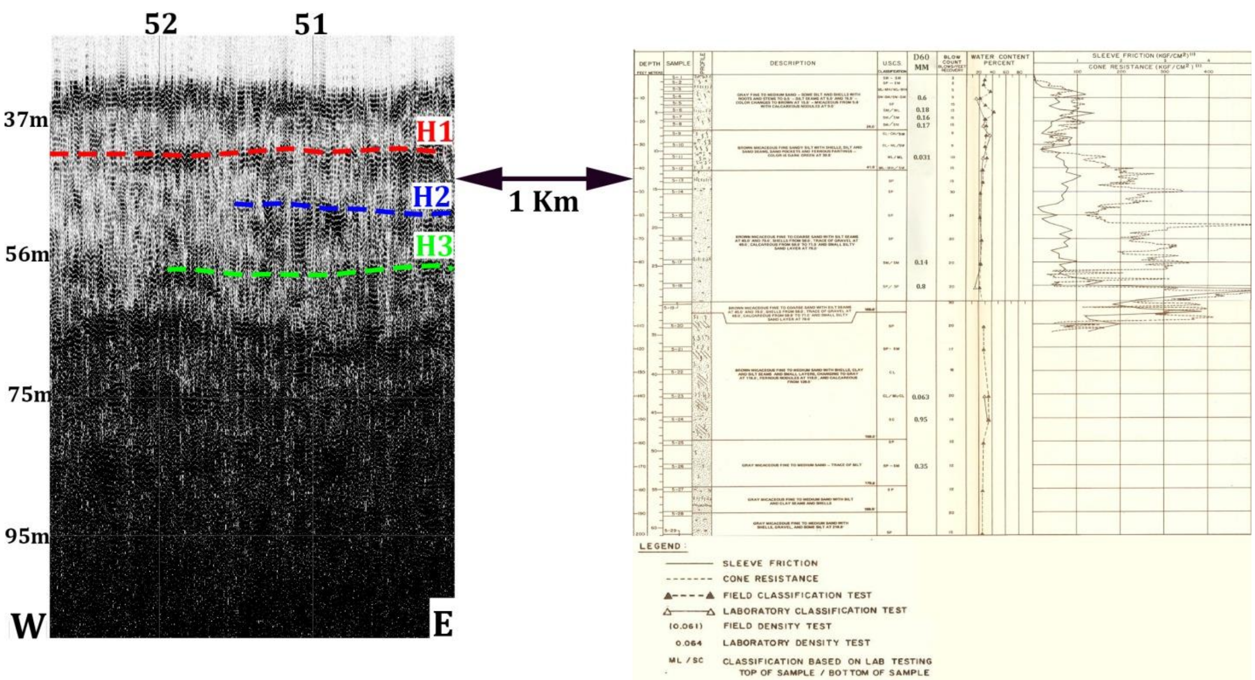



Figure 3.4.8. The correlation between the Sparker Line 4 seismic profile and the bore hole log DP78-5.

Another comparison between Chirp and Sparker data and previous collected geotechnical data has been also done. Specifically, the seismic data has been correlated to the data obtained from borehole BH-1, which has been collected at the north-western end of the Base Case, at the deeper part of the area. The comparison between the seismic data and the geological properties of the sediments showed a relative positive correlation on both Chirp and Sparker data (Fig 3.4.9.; 3.4.10), but this interpretation of the seismic data cannot be precisely extended to the channel area due to the presence of highly deformed and discontinuous reflectors.

The correlation between Chirp profile and geotechnical properties could not be done in the exact position of the borehole, due to the presence of the tube of the well E-1. Those well-tubes produce strong hyperbolic echoes on Chirp records and consequently disturb the continuity of the sediment reflectors. Due to highly deformed reflectors in the area, the thickness of the seismic phases and the lithological units cannot be matched precisely. However, the upper phase in Chirp profile, which is almost transparent with weak discontinuous internal reflectors, seems to be correlated with the three upper lithological units (LU) of the borehole. Specifically, the upper unit consists of very soft silt (ML) while the second and third units consist of loose silty sand (SM) and clayey sand (SC) with shell fragments. The reflectors H1 and H2 could be the transition between LU1 - LU2 and LU2 - LU3, respectively. The lower seismic phase is characterized by a very prolonged top reflector (H3) with rough morphology. The reflector H3 is probably correlated with the transition between LU3 and LU4. The LU4 consists of interchanged layers of silty sand (SM) and silty clay (CL). The borehole ends at 10.5m depth below the seabed, where H4 reflector is presented.

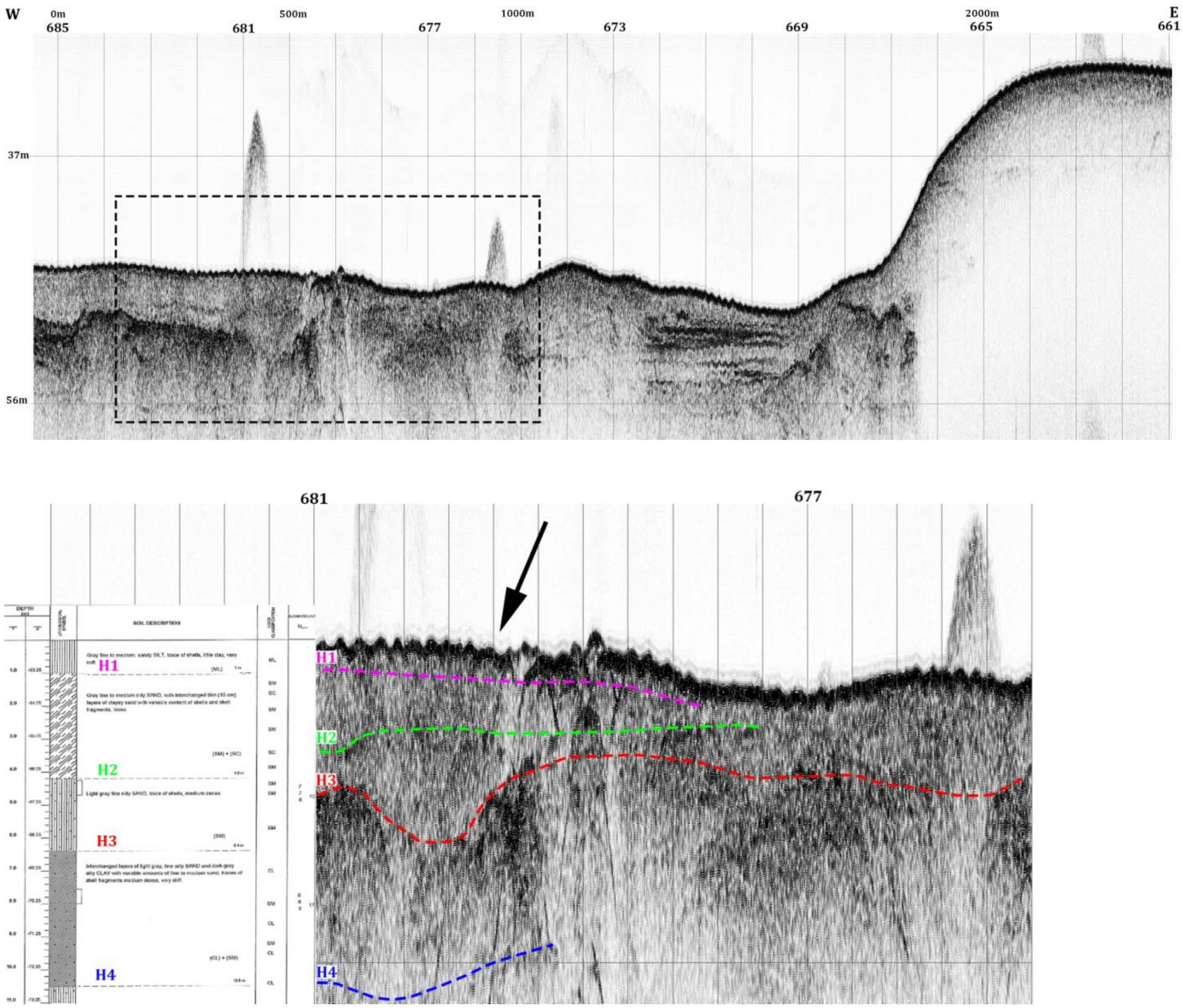
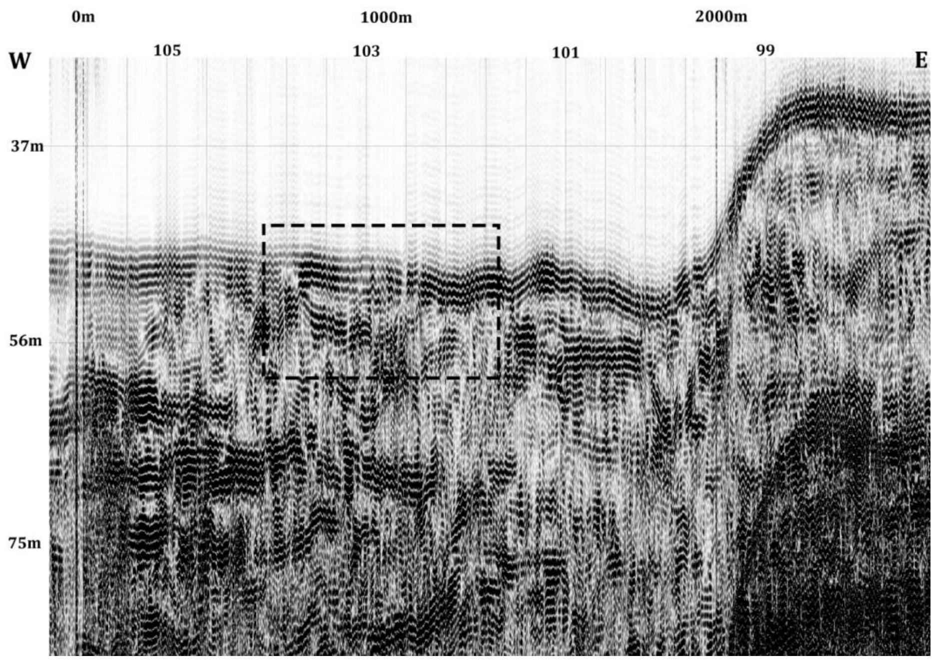



Fig. 3.4.9. The Sub-bottom Chirp seismic profile Line 13 and the correlation between the seismic reflectors and lithological units of borehole BH-1. The position of the profile and borehole are shown in Fig. 3.3.1.


0m
1000m
2000m
W
105
103
101
99
E
37m
56m
75m

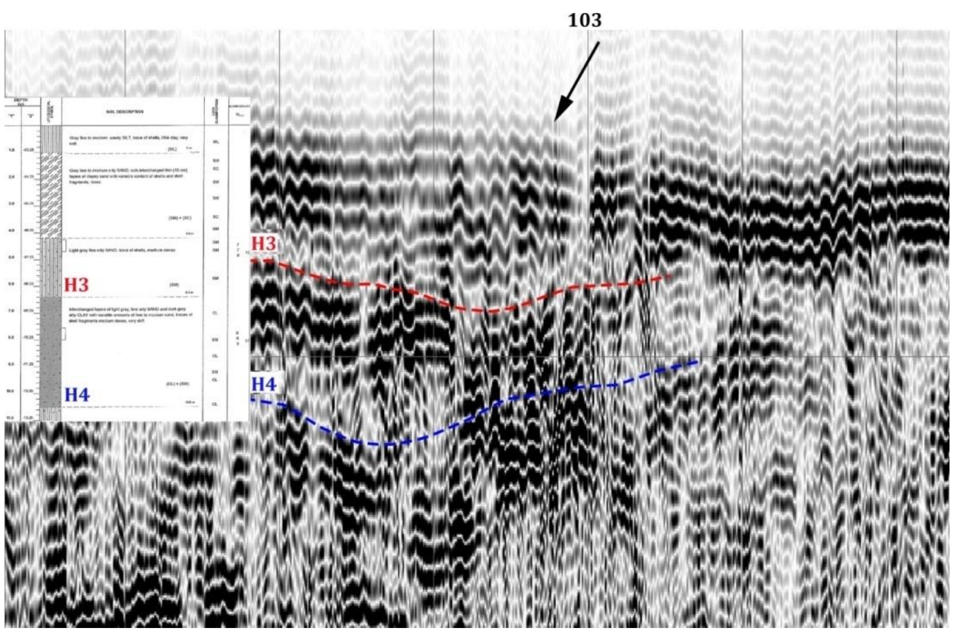

103
H3
H3
H4
H4

Fig. 3.4.10. The Sub-bottom Sparker seismic profile Line 6 and the correlation between the seismic reflectors and lithological units of borehole BH-1. The position of the profile and borehole are shown in Fig. 3.3.1.

The upper stratigraphic phase in Sparker profile, which is almost transparent, roughly corresponds to the upper three lithological units (LU1, LU2, LU3) in BH-1. The intermediate reflectors (H1 and H2) of Chirp profile cannot be distinguished in Sparker profile due to the lower resolution of that system. On the other hand, reflector H4 is more clearly visible on the Sparker profile compared to its appearance on Chirp profile.

## 3.5 MAGNETIC FIELD

The map of the magnetic field deviation (Fig. 3.5.1) exhibits correlations both to geologic components of the seafloor as well as to metallic objects lying on it. The geologic components are expressed as low range (-5 - 5nT) deviations, while metallic objects as major magnetic anomalies (12 - 180nT). All major magnetic anomalies matches very well to known man-made objects, which are four wells and a pipeline, having magnetic signatures of about 180 and 12nT, respectively.

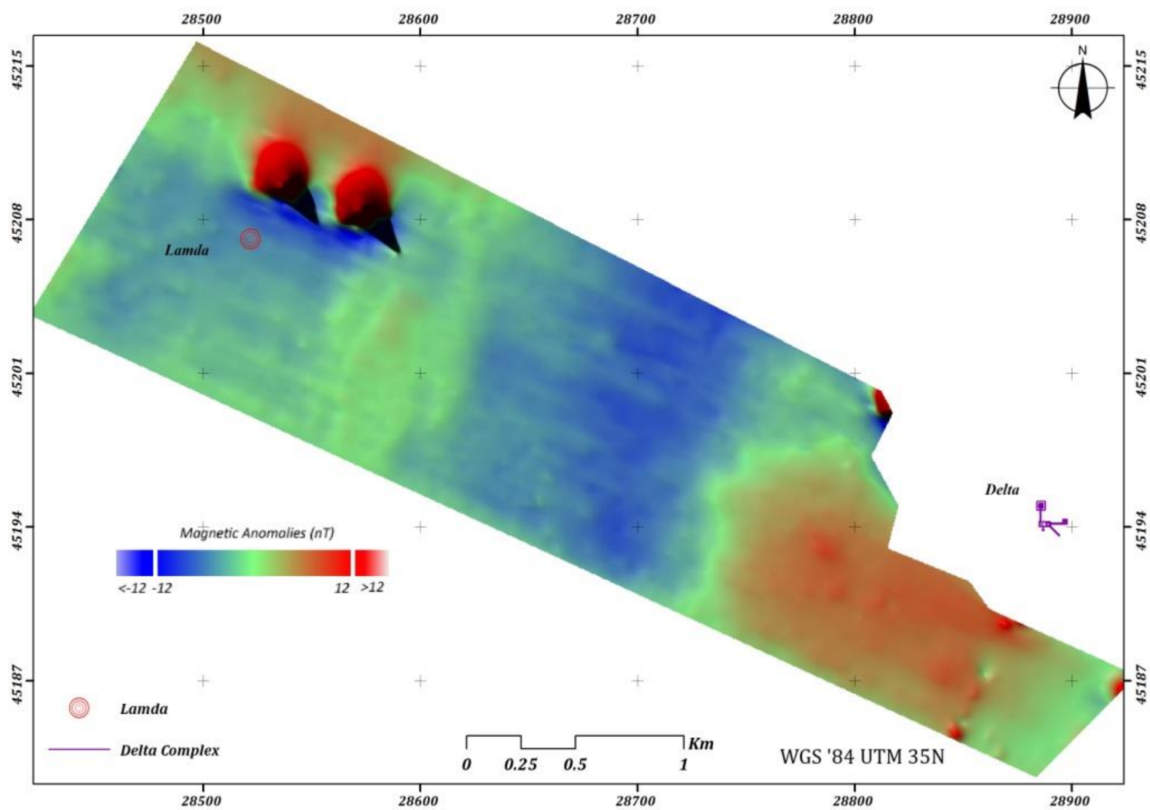



Fig.3.5.1. The magnetic map showing the magnetic field deviation of the study area.

## 3.6 SEDIMENT SAMPLES

Table 3.6.1 presents information about the collected sediment samples, concerning: (1) location, (2) depth, (3) sample code, (4) indicative photos and (5) macroscopic/qualitative description. The grab samples locations are shown in Figure 2.2.1.3.

Table 3.6.1. Information about the sediment samples collected during the ground-truth survey. Color coding was held according to the ''Munsell Soil Color Chart''

| X | Y | Depth (m) | Sample | Picture | Macroscopic description |
|---|---|---|---|---|---|
| 286657 | 4520588 | 28.3 | *PRINOS_3* |  | **<u>Top Layer</u>**: Maerl (thickness >5 cm) **<u>Base Layer</u>**: Light brownish gray (2.5Y 6/2) silty sand with high presence of biogenic fragments |
| 285826 | 4520273 | 50.3 | *PRINOS_4* |  | Grayish brown (2.5Y 5/2) silty sand with high presence of biogenic fragments, gastropods and bivalve shells |
| 285289 | 4520508 | 39.6 | *PRINOS_5* |  | Dark grayish brown (2.5Y 4/2) silty sand with presence of biogenic fragments and plant residues |

| X | Y | Depth (m) | Sample | Picture | Macroscopic description |
|---|---|---|---|---|---|
| 285419 | 4520795 | 40.6 | *PRINOS_6* |  | **Top Layer**: Maerl (thickness >5 cm) and bivalve shells **Base Layer**: Grayish brown (2.5Y 5/2) sandy silt |
| 285272 | 4521187 | 47.7 | *PRINOS_7* |  | Gray (2.5Y 5/1) silt with low presence of biogenic fragments and gastropods. It is covered by a thin veneer of brown (10YR 4/3) watery, clayey layer |
| 286577 | 4519802 | 37.7 | *PRINOS_8* |  | Grayish brown (2.5Y 5/2) silty sand with presence of biogenic fragments and gastropods |
| 286064 | 4520076 | 50.4 | *PRINOS_9* |  | Grayish brown (2.5Y 5/2) sandy silt with presence of biogenic fragments |

## 3.7 SEAFLOOR VIDEO FOOTAGE

A sample of characteristic snapshots of the video footage acquired in the Base Case Area during the ground truth survey is given in figure 3.7.1.

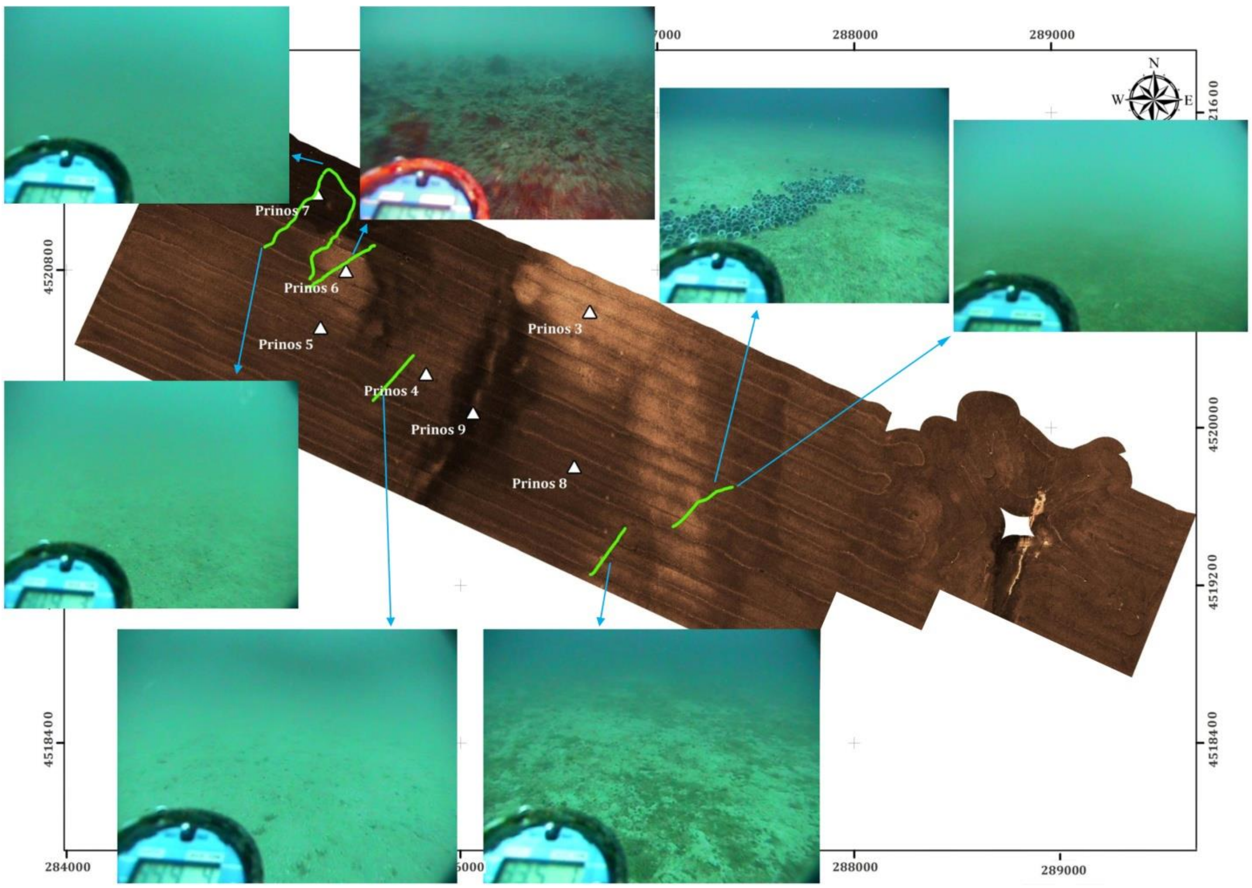



Fig. 3.7.1. Characteristic snapshots of the video footage acquired in the study area during the ground truth survey.

### 3.8. DELTA COMPLEX SITE

The seafloor at the surrounding area of Delta complex is smooth and deepens gently from NE to SW from 30 to 32 meters water depth (Fig. 3.8.1).

Three pipelines were detected and mapped; two originating from the north part of Delta Complex running towards N-NE and one from the south part of the complex having a general direction of SW (Fig. 3.8.1). At the proximity of the Delta complex the pipelines have been covered by protective gravel layer. This layer is almost flat and 50m in width at the two north pipelines. The south pipeline is covered by a narrow gravel layer (<10m in width) having a positive height of about 0.8m compared to the surrounding seafloor (Fig. 3.8.2).

In the Delta Complex area, two submarine cables were also detected and mapped in the vicinity of the two north pipelines (Fig. 3.8.1). The first cable is originated from the northern end of the gravely protective cap and runs towards north for about 200m. The chirp data suggests that the cable continues further towards north but buried. Similarly, the second cable is originated from the eastern side of the Delta complex running towards north for almost 200m at the seabed surface and then buried into the sediments.

Six concrete anchoring blocks (AP1, AP2, AP3, AP4, AP7 and AP9) were detected and mapped around Delta complex which are used for the anchoring of the Energean Force Vessel (Fig. 3.8.1). Another two concrete blocks were recorded south - southwest of Delta complex. The one seems to be the LP buoy anchorage and the other is unknown use.

East of Delta Complex, twelve small, almost circular crater-like depressions were recorded (Fig. 3.8.1). Their diameter ranges between 5 and 8 meters and their depth is up to 1 meter. Other two depressions, with the same characteristics were also detected at the northern end of the gravel protection layer. The origin of these depressions is unknown.

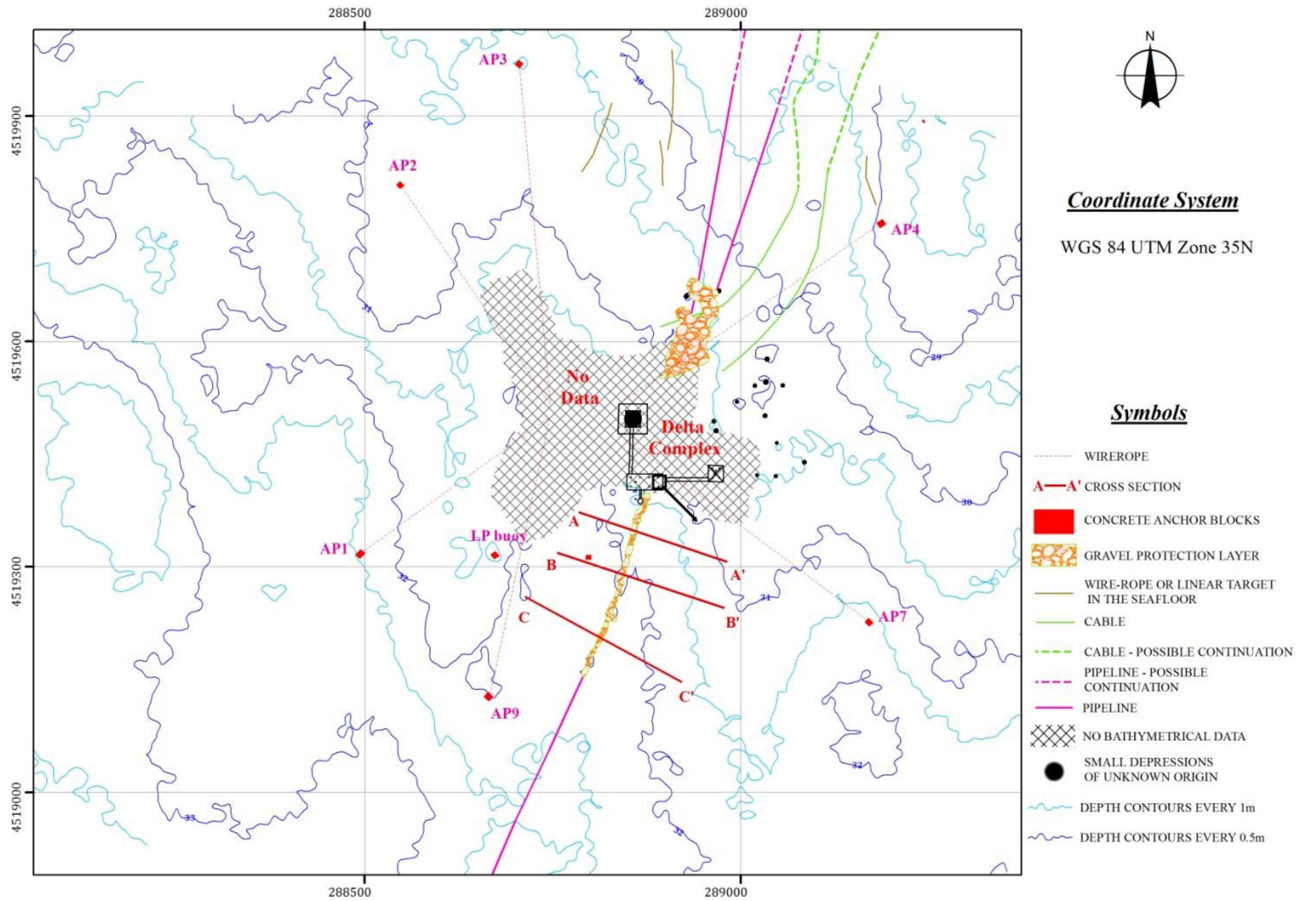



Fig. 3.8.1 Delta Site plan view.

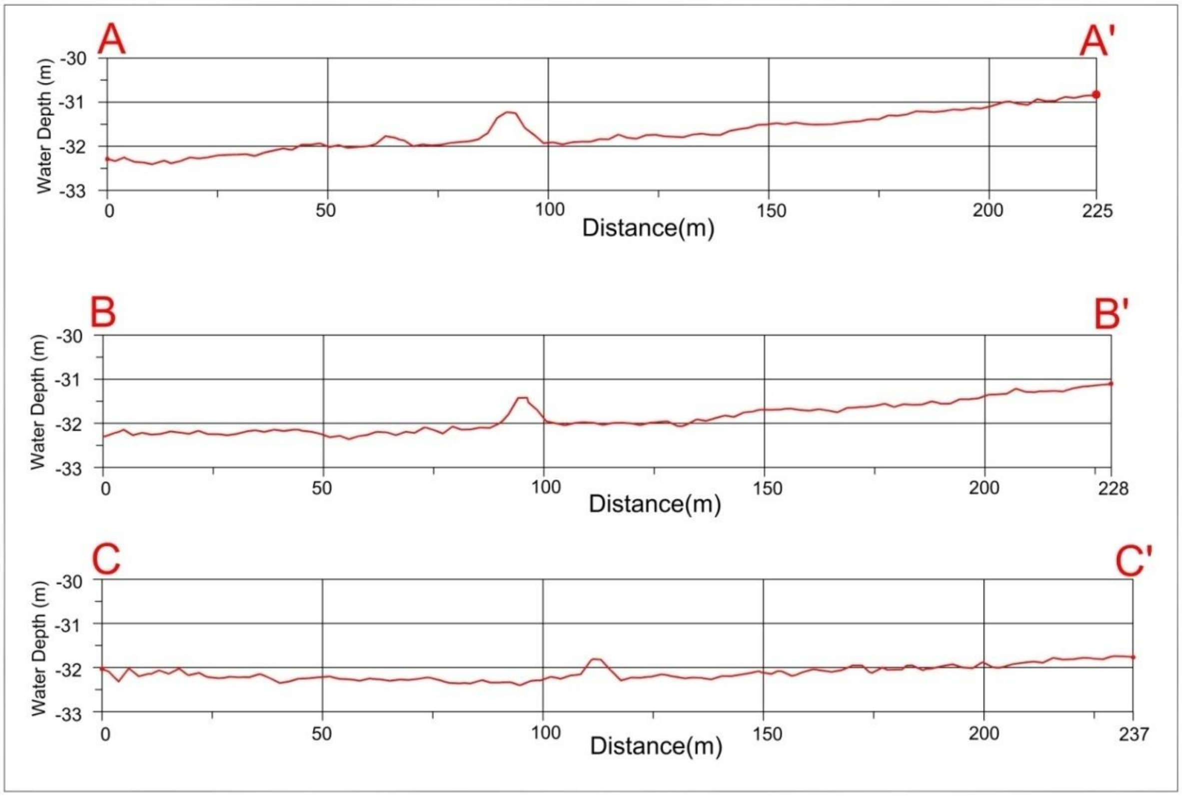



Fig. 3.8.2 Cross sections of gravel protection layer.

# 4 PERSONNEL

The following personnel were employed for the field work operations and data processing in the office.

**Dr. George Papatheodorou,** Professor, Department of Geology, University of Patras
Chief Marine Geologist - Geophysicist. Project Manager

**Dr. Dimitris Christodoulou,** Research Associate, Department of Geology, University of Patras
Marine Geologist - Geophysicist - Surveyor.

**Dr. Elias Fakiris,** Research Associate, Department of Geology, University of Patras
Marine Geologist - Geophysicist.

**Nikos Georgiou, MSc.**, Research Associate, Department of Geology, University of Patras
Geologist - Geophysicist.

**Xenofon Dimas, MSc.**, Research Associate, Department of Geology, University of Patras
Geologist - Geophysicist.

**Spiros Sergiou MSc.**, Research Associate, Department of Geology, University of Patras
Geologist - Sedimentologist.

# 5 DAILY REPORTS AND TIMELINE OF ACTIVITIES

**23.09.2015** Mobilization on site for personnel and equipment

**24.09.2015** Installation of equipment on the vessel

**25.09.2015** Installation of equipment on the vessel. Survey vessel trials with personnel and crew working on survey conditions (MBES, SBES, SSS, ChirpSBP, MAGN).

**26.09.2015** Installation and tests of tide-gauge station. Bad weather conditions for geophysical survey.

**28.09.2015** Very bad weather during morning. Survey vessel trials with Sparker subbottom profiler during afternoon.

**29.09.2015** Sparker Subbottom profiler survey at Base Case Area (Epsilon/Lamda to Delta) and at Optional Case Area (Epsilon/Lamda to Omicron).

**30.09.2015** Multi-beam echosounder patch tests

**01.10.2015** MBES, SBES, SSS, ChirpSBP, MAGN survey at Base Case Area

**02.10.2015** MBES, SBES, SSS, ChirpSBP, MAGN survey at Base Case Area

**03.10.2015** MBES, SBES, SSS, ChirpSBP, MAGN survey around Depta complex and at Base Case Area

**04.10.2015** MBES, SBES, SSS, ChirpSBP, MAGN survey at Base Case Area (rectangular 1000x1000m around the Epsilon/Lamda Platform).

**05.10.2015** MBES, SBES, SSS, ChirpSBP, MAGN survey at Optional Case Area (Epsilon/Lamda to Sigma Site) and at Base Case Area

**06.10.2015** Visual inspection (tow-camera survey) at Base Case Area

**07.10.2015** MBES, SBES, SSS, ChirpSBP, MAGN survey at Optional Case Area (Epsilon/Lamda to Omicron) and collection of surficial seabed samples with Van-Veen Grab.

**08.10.2015** Unloading of equipment from survey vessel

**09.10.2015** Return to headquarter

**20.10.2015** Presentation of preliminary results - Delivery of Epsilon/Lamda Site Bathymetry

**6.11.2015** Preliminary report submission

**13.11.2015** 1st Revision of preliminary report submission

**16.11.2015** 2nd Revision of preliminary report submission