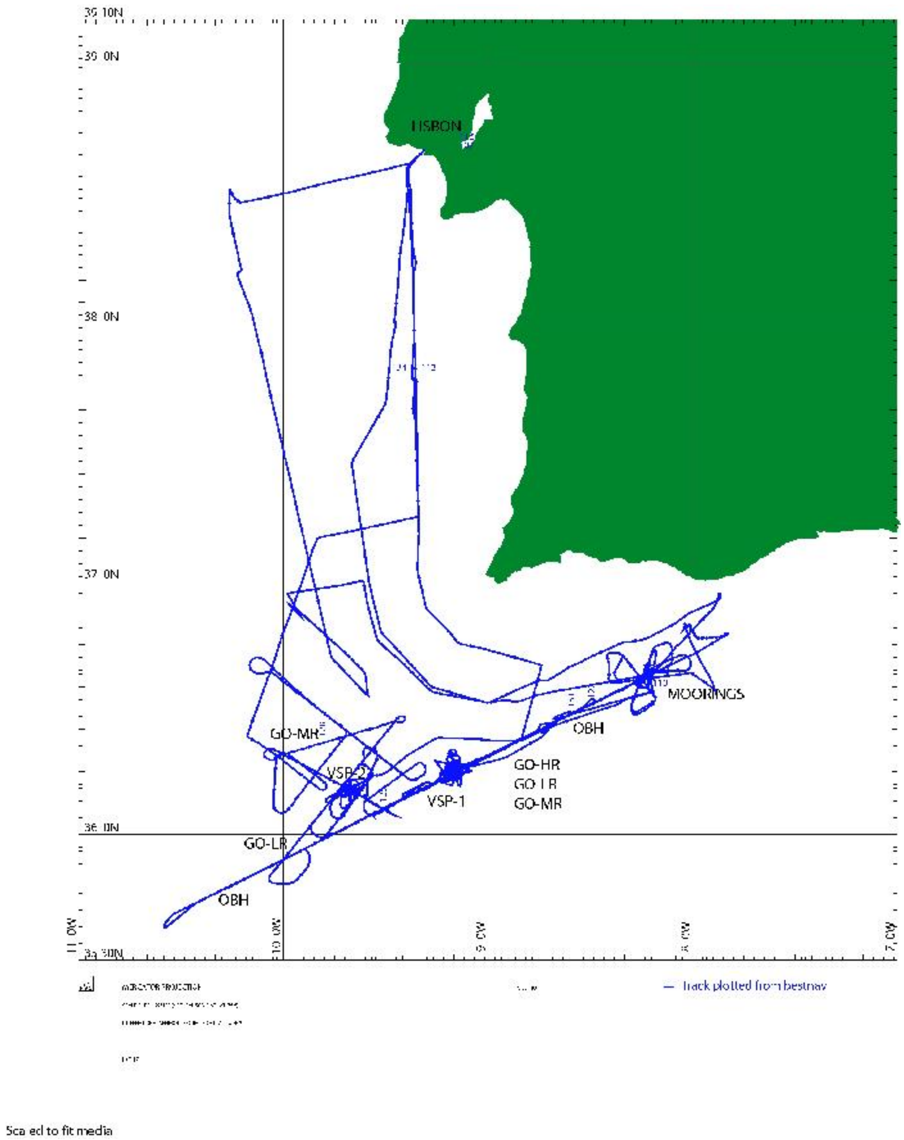
RRS Discovery D318a & D318b

Cruise Report

GO – Geophysical Oceanography
EU funded project contract number: 15603 (NEST)

website: www.dur.ac.uk/eu.go



D318a – 17 April 2007 – 23 April 2007
Trials – 23 April 2007 – 29 April 2007
D318b – 29 April 2007 – 14 May 2007

Lison (Portugal) – Lisbon (Portugal) /Faro (Portugal) – Lisbon (Portugal)

RRS Discovery D318a & D318b

Cruise Report

GO – Geophysical Oceanography
EU funded project contract number: 15603 (NEST)

website: www.dur.ac.uk/eu.go

Dr Richard Hobbs

Department of Earth Sciences
University of Durham
South Road
Durham
DH1 3LE

r.w.hobbs@durham.ac.uk

July 2007

List of Figures

List of Tables

Summary

We conducted a joint oceanography and multichannel seismic in the Gulf of Cadiz on the *RRS Discovery* (D318a & D318b). The cruise was funded under an EU grant as part of the Framework 6 NEST programme and involved 8 partners (CSIC, ENEA, IFREMER, IFM-GEOMAR, POL, Universities of Brest (UBO), Durham, and Lisbon (Lisbon acting as a lead for a consortium of Portuguese institutions)). The cruise objectives were to provide a calibration between seismic images of water structure and conventional oceanographic measurements, also to test various seismic acquisition systems and novel geometries for seismic imaging of water structure. The data are of high-quality and fulfil expectations though we suggest several areas for improvement that would benefit future surveys. The cruise was split into to legs to accommodate the large diversity of equipment used during this cruise. During leg D318a we used CTD casts, deployed 8 moorings provided by POL and NMF, launched XBTs/XCTDs and used a high-resolution system provided by Genvair through project partners IFREMER. For leg D318b we were joined by the *FS Poseidon* (funded under a separate grant from the German research council with project partners IFM-GEOMAR). During this leg we acquired conventional seismic reflection and refraction data using the NMF (NERC Marine Facility) airgun system and a hydrophone streamer hired from Exploration Electronics, oceanographic control used both XBT/XCTD and CTD casts from the *FS Poseidon* and *RRS Discovery.* During this leg, we also tested acquisition of oceanographic Vertical Seismic Profiles and multi-resolution seismic data with sources tuned to different frequency bands fired in a 'flip-flop' mode. Towards the end of the leg we successfully recovered the moorings deployed during leg D318a.

A major pre-cruise problem was the conclusion by NMF that their multichannel seismic steamer was beyond repair. Alternative academic owned systems were unavailable so a system was hired from a commercial company, Exploration Electronics Ltd. Though a significant part of the costs were covered by NMF against the estimated costs of using their own streamer, extra funds were required from within the EU grant. This necessitated a reorganisation of the budget as no extra funds would be provided by the EU. The ramification of this budget adjustment on the overall project outcomes is as yet unknown. During D318a, the moorings were deployed efficiently but there were a intermittent problems with the CTD system that were rectified by using spares. There was an issue with deployment of the Genvair airgun system, their davits were not located near enough to the stern so the airguns were dragged under the vessel. This was resolved by using the stern cranes on *RRS Discovery*. Near real-time navigation for the seismic data during this leg was computed by Genvair/IFREMER. Prior to D318b there was a 2 day trials cruise to familiarise people with the NMF airgun deployment system and to test compressors. During D318b the airgun system worked as expected with minimal maintenance, though a better system of buoys could be developed to give better control of source tow depth. The hired streamer and data logged worked well, but there were fundamental differences in expectations between the academic and commercial worlds that caused some avoidable misunderstandings. Reduction of the raw navigation for the processing of the seismic data for D318b has been serious problem. The gravimeter was used on both legs but continuously flagged errors, however the data seem to be recorded and logged though the local clock was not synchronised to GPS. During the second leg one of the ship ADCP systems failed to record data for a significant period.

Overall the cruise was very successful and met or exceeded scientific objectives. A significant dataset was acquired with minimal downtime, only one day was lost due to weather. The international partners were impressed with the conduct of the vessel. There are recommendations that include the use of a commercial streamer system which need to be considered for the future and issues with time and location and a more transparent ship data-logging system that need to be resolved.

1. Introduction and cruise objectives

1.1 Introduction

The EU-GO project is an ambitious and challenging project that matches the spirit of adventure and risk inherent in the EU-NEST programme. Geophysical Oceanography is a new interdisciplinary research area that combines proven geophysical methods and oceanographic methods. This pioneering project is the first dedicated EU project to address this novel research area that will ultimately bring the spatial resolution of the sub-surface seismic image, as used by the hydrocarbons industry, to address problems in oceanography. The project places demands on both sides: for the geophysicists, proving how the observed reflections are linked to boundaries in the water column; for the oceanographer, being able to build models and interpret data on the 10 m scale rather than the 1 km scale; and together, understanding how a 2-D snapshot of the 3-D ocean structure can be interpreted and translated into understanding of the dynamics of heat and mass transfer. A major goal will be providing the calibration so legacy seismic data can be used to understanding ocean processes and monitor change.

Large scale circulation in the oceans is an important process on the Earth for the redistribution of heat and consequential effect on climate. Water masses of different temperature move past each other separated by relatively thin boundary layers. It is across these boundaries that thermal and mass transfer must occur to maintain the circulation. It is known that mixing in the open ocean is too low to maintain the large scale circulation patterns (Ledwell et al., 1993) and that mixing is enhanced around areas of complex topography, over continental slopes (Polzin et al., 1997; Ledwell et al., 2000) and through interaction with wind. Understanding the mixing is important: for global circulation because it affects the density distribution of the different water masses and enhances the overturning circulation (Munk & Wunsch 1998); and for controlling local biochemistry, nutrients, and the fate of biogenic particles. Models of ocean mixing and circulation are based on relatively sparse observations of temperature, salinity, flow rate and direction. Typically an oceanographic profile will sample the 1-D structure every 5 km. Either a probe lowered from a surface vessel gives one quick sample of the whole water column or moored instrument packages give time series at particular locations. More recently sampling probes have been developed that 'fly' through the water that provide a limited 2-D measurement. These measurements are used to calibrate theoretical models of laminar and turbulent flow from which estimates of mass and heat transport are made. However, the detailed spatial internal structure of these boundaries over the whole water column cannot be mapped using standard oceanographic techniques.

The multichannel seismic (MCS) method, developed by the hydrocarbon industry, provides continuous images of the sub-surface with a resolution of around 10 m. The raw data are acquired by releasing compressed air into the water to generate an acoustic pulse every 25 to 50 m. This energy propagates away from the source and at each impedance (velocity*density) interface a fraction of the energy is backscattered towards the surface where it is detected on a linear array of sensitive hydrophones up to 12 km long towed behind the vessel. Processing these data generates the final acoustic image of the sub-surface. For hydrocarbon exploitation the acquisition is repeated on adjacent tracks so after processing the geologist can visualise the true 3-D geometry of the sub-surface. In addition to reflected energy, the forward scattered energy may also be recorded on Ocean Bottom Seismometers or Hydrophones (OBS/H). These data are used mainly in academic research to compute the velocity structure of the sub-surface.

Holbrook et al. (2003) identified that weak reflectivity observed on common mid-point (CMP) stacked seismic reflection data, originally collected to image the solid geology of the Earth, was caused by structure in the water. A subsequent experiment using XBT probes (Nandi et al., 2003) confirmed that there was a correlation between the reflection image and thermal structure. We believe that reflectivity in the water layer is ubiquitous and is present on all seismic data. However, due to the lack of calibrated joint seismic and oceanographic datasets we do not have confidence in how to interpret the images. We do not know:

- how acquisition and processing effects the image;
- how sensitive is the image to out-of-plane structure;
- how to interpret the seismic snapshot in the framework of the dynamics of the water layer;
- what is the value of geophysical data for improving oceanographic models;
- what is the potential of the extensive legacy seismic database held in the EU and elsewhere.

We have identified the Mediterranean Outflow Water (MOW) in the Gulf of Cadiz as a scientifically challenging target on which to develop the methodology and provide results that can be used in a wider context. It provides a diverse environment including interactions with a continental slope, rough sea-floor topography and the generation of deep water eddy currents (Meddies) and has extensive *a priori* oceanographic and seismic databases that show both strong oceanographic and seismic signatures.

The MOW flowing out through the Strait is controlled by the shape of the strait, the tidal flow and the Earth's rotation, and is extensively modelled. The upper layer, which is about 200 m thick, consists of Atlantic Water flowing into the Mediterranean Sea. Below 200 m is the MOW body with salinity of 38.4 and a temperature of 13.5° C. Once out of the Strait, the dense MOW flows westwards along and down the sloping seabed subject to bottom friction and entrainment of North Atlantic Central Water. When the MOW reaches a depth of about 500 m the flow splits in veins, with a shallower vein flowing north-westwards close to the 500 m contour and two deeper veins flowing westwards hugging the Iberian margin interacting with the bottom topography. The steepened slope of the margin west of 8°W focusses the MW into a narrow slope-trapped flow. Here the water depth has increased to over 1000 m, the warm saline MOW becomes neutrally buoyant and breaks free from the seabed, flowing from there on with two main cores, a less saline core (centred at 800 m) over a more saline core (centred at 1200 m) (Figure 1.1.1). At Cape St Vincent the southern margin of Iberia abruptly ends with a deep canyon and bank. A phenomenon associated with this abrupt change is the formation of MOW eddies – “Meddies”. These sub-surface eddies are typically 40-150 km in diameter and 500-1000 m thick, rotate anticlockwise and propagate slowly south-westwards into the Canary Basin where they eventually dissipate against sea-mounts or the mid-Atlantic ridge.

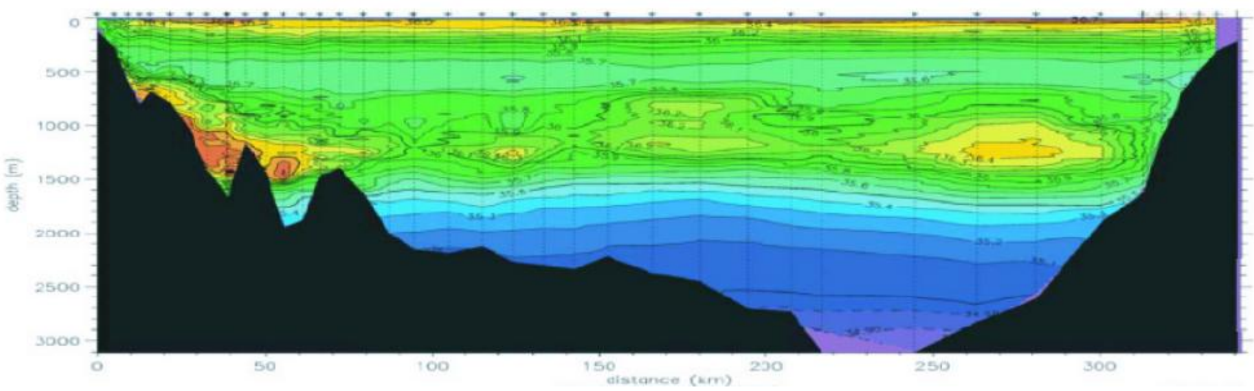


Figure 1.1.1. North-south oceanographic section through the Gulf of Cadiz at 8 deg 20' W showing salinity (contours in psu). The saline westward flowing MW forms a distinct layer between 800 and 1500 m on the northern margin extending 50 km into the Gulf (km 20-70). The smaller upper lobe can be seen higher on the margin at 700 m depth km 20. Above the MW is the warm North Atlantic Central Water and beneath is the colder and fresher Labrador Sea Water and Northeast Atlantic Deep and Bottom Waters. The other large saline body off the north African margin (km 250-300) is an eddy current of MW.

1.2 Scientific Objectives

The principle aims of the D318a and D318b cruises were:

- to collect a co-located and co-incident seismic reflection and physical oceanography calibration dataset including:
  - seabed measurements of both oceanographic and seismic data
  - conventional CTD casts
  - seismic multichannel reflection data over 5 octave of bandwidth
  - underway oceanographic data measurement
- to test and develop novel acquisition strategies for geophysical oceanography by exploiting opportunity of two-ship operations
- to demonstrate quantitative links between seismic and oceanographic measurements and their application to understanding dynamics and mixing in the oceans.

1.3 Scientific Plan

As the objective of the cruise was to map water structure which was both space and time variant, the detailed location of profiles had to determined on ship during the cruise to maximise the value of the data. The initial survey plan is shown in figure 1.3.1. We targeted the MOW along the margin slope using legacy oceanographic and seismic data to identify where the MOW becomes neutrally buoyant and where possible eddies might form. Satellite data and detailed weather charts were collected to track any eddies and potential weather induced Ekman transport prior and during the cruise. The planning for the cruise required careful evaluation of available seismic and oceanographic equipment to meet our aims. OBS/H sensors (IFM-GEOMAR) were deployed on the seabed and tethered in the water column. These were to give a direct measurement of the seismic source wavelet and its directivity that could be used for deterministic deconvolution and true amplitude studies and to constrain large-scale velocity structure. The multichannel seismic (MCS) survey used conventional source arrays (Bolt-gun) with a bandwidth of 5-60 Hz and also an alternative source (mini GI-gun 40-250 Hz) (IFREMER), to give source frequencies over 5½ octaves. For the highest frequencies we deployed a short high-resolution hydrophone cable (IFREMER) with a minimum source-receiver offset. The use of a short streamer for part of the survey gave the ship enough manoeuvrability to do a number of repeat passes over one target area to image the movement and decay of the internal waves. The oceanographic component consisted of moored and under-way measurements, and static dips (equipment supplied by POL, NMF, FFCUL and IFM-GEOMAR). The moored seabed instruments continuously sampled the seabed processes and temperature and velocity in the water column for the duration of the survey. During MCS operations expendable probes were used to sample temperature (XBT), or together with (XCTD) to 1.8 km depth. Shipborne ADCP provided information on the water structure and currents in the upper 600 m. Detailed CDT/LADCP profiles were made at each mooring site and in deeper water. Additional CTD casts and XBT launches were performed by *FS Poseidon*.

1.3.1 Pre-cruise changes to scientific plan

The cruise was split into 2 legs (D318a and D318b) and a trials cruise with a port call to demobilise from leg 1 and mobilise for leg 2. This was done for several reasons:

- it was not possible to load all the equipment on the the vessel at one port call. The main issue was the two multichannel seismic systems needed to occupy the same space on the back deck and because of the oceanographic moorings and CTD there was not any free deck space that could be used to temporarily store the equipment on-board;
- the cost of hire for the equipment and personnel from Genvair (IREMER) was on a day rate so it was not economic to keep the system on-board and not in use;

- it was necessary to have a trails cruise prior to using the NMF airgun system to familiarise the technical crew with its operation and to test compressors.

The port call date was chosen to maximise time for two-ship operations with *FS Poseidon* during leg D318b as she could only be present for part of the cruise

The use of tethered OBH to record the source signature was retained, as was a short OBH profile, but the cruise objective to define the 3D water structure was revised to use a novel vertical seismic profile arrangement with the *FS Poseidon* deploying a vertical array of hydrophones and *RRS Discovery* providing a multi-azimuth and range source. The original plan was to use containerised compressors from IFREMER during D318a but these were found to have the wrong voltage so a NMF containerised compressor (that was already scheduled to be on the vessel) was used instead. An option to use NMF Moving Vessel Profiler (MVP) was dropped as the system was serviceable at the time of the cruise.

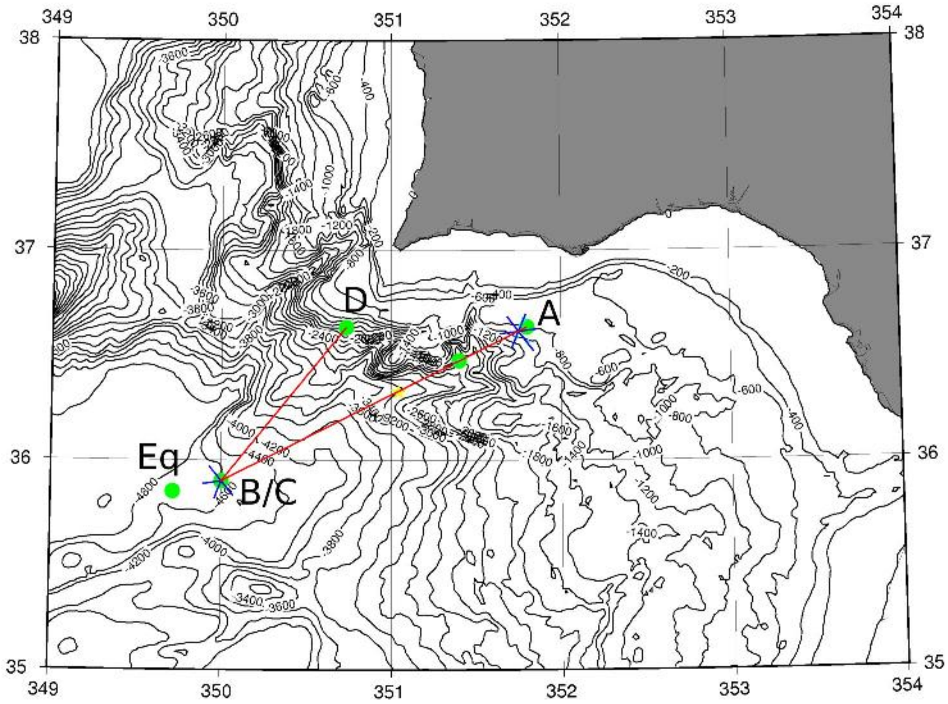


Figure 1.3.1. Initial cruise plan. A is the location of the moorings; profile A->B/C is the main multichannel seismic transect; profile B/C->D was the second profile but D was located in the traffic separation zone; B/C was the planned location of OBH survey; and Eq is the location of the 12 February 2007 M6.0 earthquake.

1.3.2 Intra-Cruise changes to scientific plan

The survey area crossed the principal shipping lanes between the Straits of Gibraltar and Cape St Vincent. The moorings site (A) was just to the north of the lanes and the deep water survey area (B/C) was to the south and west (Fig. 1.3.1). It was agreed that operations within the heavy shipping area would be minimised provided it would not impact the scientific objectives. In particular, location (D) (Fig. 1.3.1) was moved to the southwest as this was inside an internationally agreed shipping separation zone.

The ship track was revised on an irregular basis depending on the underway MCS and oceanographic data. During the survey period the target body of MOW drifted the west-north-west so profile locations and orientations were revised accordingly.

Given the success of the IFREMER high-resolution system during leg D318a, the source for part of D318b was modified to provide both a deep (low frequency) and shallow (high-frequency) arrays that could be fired alternatively to provide simultaneous images to help correlate events and measure any frequency dependence. Also the survey area was extended to the west so we could track a possible Meddy and try specific profile orientations to measure internal wave propagation velocity.

1.4 Mobilisation and Trials

As discussed above the cruise mobilised for each leg separately using Lisbon for all equipment movements to ease logistics. All the major equipment to join the vessel was transported by road from France, Germany and the UK. This cruise was particularly demanding on both equipment and personnel as we were planning to do a full physical oceanography survey with moorings, CTD and underway XBT/XCTD work and full multichannel seismic work with OBH.

This was further complicated for leg D318a as the seismic system provided by IFREMER had not previously been operated on *RRS Discovery* so mounting brackets had to be fabricated and load tested as part of the mobilisation. The IFREMER high-resolution system consisted of two 10' containers on the back deck with a streamer deployment winch, two air-gun cradles and two air-gun deployment davits. Necessary power and data-link (ship navigation and timing) were provided as was compressed air at 2000 psi for the air-guns. The POL and NMF ocean mooring systems (4 ADCP systems and POL STABLE) were stowed along the starboard side adjacent to the CTD system and winch. (Deck Plan:
http://www.noc.soton.ac.uk/nmf/mfp/upload/d1/p135/D318A_DECK_PLAN.pdf)

Mobilisation for the second leg (D318b) involved removing all the IFREMER system and installing the NMF air-gun cradles, umbilical winches and cherry picker on the port side. Also the installation of the Exploration Electronics streamer winch. This required fabrication of an additional stand to give operational clearance over the deck. Also during the mobilisation the ram used to operate the stern port beam was found to be unserviceable, a replacement was ordered from NOC and was delivered by boat transfer at Faro prior to start of leg D318b. (Deck Plan:
http://www.noc.soton.ac.uk/nmf/mfp/upload/d1/p190/D318b_deck_plan.pdf

Before the start of the second leg, NMF ran a two day trails cruise (D318t) to build and test the air-gun deployment system and train operators. This was done whilst the ship transited from Lisbon to Faro. At Faro, 3 NMF technicians left the ship by boat transfer and the new ram for the port side aft beam was delivered and fitted.

Personnel on cruise detailed in Annex-1.

2 Work conducted and data collected.

Pre-cruise operations included obtaining permission from the Portuguese Authorities for the survey and an environmental audit of the area (Annex-7). This highlighted the risk of cetaceans and provided background information for the marine mammal observer who was on-board throughout both legs of the cruise (report see Annex-8).

Diary
Detailed spreadsheet in Annex-2. Here is a just a summary report.

Day	*Comment*
16 April	1700 gravity base station tie
17 April	Depart Lisbon. Set clocks to GMT. Deploy PES. Train watch teams with XBT
18 April	Stn A2 CTD (CTD001) and deploy STABLE Stn A1 CTD (CTD002) and deploy 600 kHz ADCP and Minilogger Stn A3 CTD (CTD003) and deploy 150 kHz ADCP and Minilogger Stn A4 CTD/XCDT-1 (CTD004 & 4a) and deploy 150 kHz ADCP and Minilogger Stn A5 XCTD-1 and deploy 75kHz ADCP Stn OBH-1 XCTD-1 and deploy tethered OBH
19 April	Stn OBH-2 deploy tethered OBH Deploy IFREMER streamer Deploy IFREMER airguns – using aft cranes rather than IFREMER davits 0834 started MCS work deployed magnetometer started XBT launch routine complete lines GO-HR-01, -02, -03, -05, -06
20 April	complete lines GO-HR-08, -10, -11
21 April	complete lines GO-HR-13, -15, -17, -18, -20, -21
22 April	complete lines GO-HR-22, -23, -24, -25, -26, -27, -28, -29, -30, -31 1203 stopped MCS work stopped XBT launch routine recovered magnetometer recovered airguns recovered streamer launched test XCTD-2 recovered PES return Lisbon
23 April	Return clocks to local time Arrive Lisbon
23-26 April	demob IFREMER system mob NMF system with Exploration Electronics streamer
24 April	1740 gravity base station tie
27 April	Depart Lisbon for airguns/compressors trials cruise
28 April	Set clocks to GMT
29 April	Boat transfer at Faro, receive new ram for port aft beam Commence D318b deploy PES start XBT launch routine deployed airguns meet with FS Poseidon
30 April	0002 Start VSP-1 shooting into Poseidon receiver array Issue with ship control with tight turns around Poseidon increase range to give safety margin 1730 End VSP-1 recover airguns stop XBT launch routine

Day	*Comment*
	CTD in deep water (CTD005)
1 May	2 off CTD in deep water (CTD006 & CTD007) deploy streamer deploy airguns 1310 Start MCS operations start XBT launch routine
2 May	complete GO-LR-01 0600 Stop MCS operations stop XBT launch routine recover airguns recover streamer hove to - bad weather
3 May	deploy streamer deploy airguns 1000 start MCS operations start XBT launch routine complete lines GO-LR-02, -03
4 May	complete lines GO-LR-04
5 May	complete lines GO-LR-05, -06
6 May	complete lines GO-LR-07, -08, -09
7 May	complete lines GO-LR-10, -11, -12, -13
8 May	complete line GO-LR-14 1030 stop MCS work stop XBT launch routine recover airguns recover streamer 1500 photo shoot with Poseidon deploy airguns 1808 start VSP-2 shooting into Poseidon receiver array
9 May	0600 stop VSP-2 recover airguns Poseidon departs transit to moorings site (XBT launched en route) Stn A5 recover 75kHz ADCP Stn A1 recover Minilogger and 600 kHz ADCP
10 May	Stn A3 recover Minilogger and 150 kHz ADCP Stn A4 recover Minilogger and 150 kHz ADCP Stn A2 recover STABLE deploy streamer deploy airguns for flip-flop acquisition 1841 start MCS operations Start XBT launch routine
11 May	~0100 tail buoy lost from beam 1 0824 recover airgun beam for replacement buoy complete line GO-MR-01.0, -01.1 1114 stop MCS operations streamer for maintenance deploy airgun array spectral tests to optimise tow depths – looks like arrays are close to vertical! 1512 restart MCS operations complete line GO-MR-02
12 May	Note: high noise on line GO-MR-03 and -04 initially thought to be swell breakout noise but turns out to be sonar from US fleet on its way to Lisbon complete lines GO-MR-03, -04, -05
13 May	complete lines GO-MR-06, -07 0601 stop MCS operations stop XBT launch routine

Day	Comment
	recover airguns recover streamer recover PES return to Lisbon
14 May	Return clocks to local time 1017 gravity base station tie demob NMF and Exploration Electronics gear

2.1 CTD Operations

Extract of report by Dougal Mountfield (Sensors and Moorings Group NMF)

1. Summary of CTD & LADCP Operations

Eight CTD casts were done during D318 with the deepest cast to 4020m. On the first leg a total of five casts were undertaken on the shelf-break mooring sites including CTD004 which was aborted during the downcast due to problems with data spiking. After connector servicing this cast was repeated as CTD004a, though unfortunately the spiking persisted. There were also some problems with LADCP synchronisation and communication during the first leg.

Following the replacement of LADCP and CTD sensor cables during the mid-cruise port-call no further problems were experienced. During the second leg a total of three deep water casts, CTD005-CTD007, were undertaken as repeats of casts made by RV Poseidon whose CTD cable was limited to 2000m depths.

24-way Stainless Steel CTD Frame Overview

The stainless steel frame was deployed with the following instruments:

- Sea-Bird 9/11 *plus* CTD System
- Sea-Bird SBE-32 24 way rosette pylon on NMF 24 way frame
- 12 by 10L OTE external spring water samplers
- Sea-Bird SBE-43 Oxygen Sensor
- Chelsea MKII Alphatracka 25cm path Transmissometer
- NMF LADCP Pressure Case Battery Pack (Stainless Steel)
- RDI Workhorse 300 kHz Lowered ADCP (Downward-looking master configuration)
- RDI Broadband 150 kHz Lowered ADCP (Downward-looking slave configuration)
- Benthos Altimeter
- NMF 10 kHz Pinger
- Valeport MIDAS SVP 6000DB Sound Velocity Probe (Leg D318a only)

The pressure sensor was located 34cm below the bottom of the water samplers, and 124 cm below the top of the water samplers.

24-way Stainless Steel CTD Frame Deployment Notes

Configuration and Testing

The CTD system was assembled at the NOC prior to the cruise. During mobilisation on the vessel the Seabird 9+ underwater unit was found to have failed and no telemetry was possible with it. The underwater unit was removed from the frame for bench-testing, but the fault could not be found. The spare underwater unit s/n 09p-24680-0636 was then fitted on the frame and this became the ‘main’ unit for D318. A spare titanium underwater unit was sent to the vessel for D318b but this was not used. The main Seabird instrument configuration file for this frame was ‘0636.con’. An ASCII ‘conreport’ copy of the con file was exported as ‘0636.txt’. The 25cm transmissometer was calibrated using recent air and blank readings taken at the NOC prior to shipping the instrument. The calibration was applied relative to pure water. Prior to CTD deployment several deck tests were undertaken included firing of all 24 bottles. These tests were not logged to disk. A salinity sampling strategy was adopted using twelve Niskin bottles with six depths targeted based on downcast profile and two Niskins fired at each depth to mitigate poor sealing of lower caps which is occasionally experienced.

Sensor Failures
There were no major problems with the CTD suite and no sensor failures during the cruise. However occasional problems were encountered with spiking on primary temperature and dissolved oxygen concentration. The problem persisted after servicing of all connectors and blanks after CTD003 and CTD004. The cables for the primary temperature sensor and the SBE43 DO sensor were replaced after CTD004a and all subsequent casts were free from spikes.

Sensor Availability and Spares
A complete NMF 24-way CTD system was available onboard as a spare, but its use was not required.

Altimetry
The Benthos altimeter worked very reliably, obtaining a good bottom return within 60m of the bottom. The NMF pinger was also used both as a backup and as a double check on proximity to the bottom. The pinger was visualised using the NMF waterfall display. Normally the CTD was worked to around 5m from the bottom. This was increased to 25m when excessive wire angles were experienced during CTD004a due to the risk of the wire angle quickly reducing and the package deepening. The altimeter was included in bottle files to allow confirmation of bottom proximity during bottle 1 closure at the deepest part of the cast. During casts CTD005 and CTD006 the altimeter did not obtain a bottom return until around 30m from the bottom and the pinger signal was considerably attenuated. This is thought to be associated with a soft ocean floor in these positions. There was no requirement from the science party to work close to the bottom during cast CTD007 and the downcast was stopped approximately 100m from the bottom using the pinger and the waterfall display.

Valeport Sound Velocity Probe (SVP)
The internally logging battery powered SVP was clamped to one of the vertical tubes on the perimeter of the CTD frame using two jubilee clips with the normal wire deployment bridle looped over the upper ring of the frame as a safety wire. The SVP was oriented vertically with the probe downwards. The probe was approximately 30cm above the CTD sensors and sampled at 8Hz. It was deployed on all casts during the first leg (D318a) to validate the Seabird derived sound velocity calculated from CTD data, however there was a configuration problem during the first cast (CTD001) and it did not record any data. This was addressed and good data was obtained for CTD002-004a. Following the satisfaction of the science party this instrument was removed from the CTD frame and was not deployed during the second leg (D318b).

Niskin Deployment Notes
Following discussion with the science party, twelve of the twenty-four Niskin bottles were removed for the duration of the cruise. This allowed the CTD frame to be used to carry acoustic releases for testing with the additional weight of the BB150 LADCP system and should also reduce package drag and entrained water. Alternate bottle positions were used on the frame resulting in the following bottle firing order

Firing Order	1	2	3	4	5	6	7	8	9	10	11	12
Rosette & Niskin #	1	3	5	7	9	11	13	15	17	19	21	23

Table 2.1.1 – Rosette firing order to Niskin # mapping

Further Documentation
A sensor information sheet 'D318 Sensor Information.doc' and calibration & instrument history sheets were included in the main cruise archive in electronic format (Adobe Acrobat & Microsoft Word). Originals of all log sheets were supplied to the PSO in addition to the copies that NMF will supply to BODC and maintain themselves.

Station Numbering
CTD casts were numbered sequentially commencing with CTD001 CTD station numbers were also numbered sequentially and were associated with a station ID. Repeat casts used the same station number and ID but with a letter suffix on the cast number.

Cast #	CTD Stn #	Bridge Stn #	Station ID	Latitude	Longitude	Max Wire Out
CTD001	1	002	A2	36° 38.5'N	008° 12.0'W	785m
CTD002	2	004	A1	36° 40.5'N	008° 13.0'W	740m
CTD003	3	007	A3	36° 37.0'N	008° 14.5'W	850m
CTD004	4	010	A4	36° 35.5'N	008° 15.5'W	330m (ABORTED)
CTD004a	4	011	A4	36° 35.5'N	008° 15.5'W	980m
CTD005	5	263	POS006-2	36° 16.0'N	009° 06.0'W	3372m
CTD006	6	264	POS005-2	36° 11.0'N	009° 20.0'W	4020m
CTD007	7	265	POS004-2	36° 04.5'N	009° 33.5'W	4000m

Table 2.1.2 – CTD cast summary

CTD Data Processing
Time Synchronisation
The Seabird 11plus manual states that when the deck unit has an NMEA data feed that consists of $GPRMC and only $GPRMC, the deck unit will replace the system time in the data files with the GPS time. This has recently been identified as a good solution to ensure CTD time accuracy. The system on *RRS Discovery* was configured as such but initial investigation has shown that this is not in fact the case. As a backup both deck unit PCs are configured to synchronise their clocks with the GPS master clock via NTP. However Windows does not implement NTP fully, most notably the local clock is not characterised for drift, and clock errors are step changed instead of exponential pull-in to the master clock as in the NTP specification. The default synchronisation period for Windows XP is 7 days. During this time considerable clock drift can occur. It is possible to shorten this period, but regardless, clock jumps occur due to the step change that Windows implements. Hence it is highly undesirable to have NTP synchronisations during a CTD cast.

BAS have now removed NMEA feeds from their Seabird 11+ deck units on the RRS James Clark Ross and rely on a third party NTP client to synchronise their Seasave PC. A third party windows port of the UNIX NTP client by Meinberg was trialled recently on the RRS James Cook CTD system and it now seems that this is the most reasonable way forward to resolve the long-standing problem of time synchronising CTD data to GPS.

In the interim, use of the difference between the system upload time (PC time) and NMEA time (GPS time) in the header file to correct timestamps (in PC time) in the CTD data is advised. Alternatively the scan number and sample period at 24 Hz can be used in combination with the NMEA time in the header to calculate the GPS time of each sample with approximately 42 millisecond resolution.

Development of Standard CTD processing with BODC
National Marine Facilities are currently developing a standard CTD processing procedure following a discussion document written by Gwen Moncoiffé from BODC for the UK-SOLAS cruises. Although this is currently only applicable to SOLAS work and is still in development the general

philosophy has been applied here. All data has been extracted along with as much meta-data as possible.

Data Processing Convention and Nomenclature

Using the Seabird SBEDataProcessing-Win32 software the following data processing route was implemented:

- Step 1 - Data Conversion *(DatCnv.psa)*

Conversion to engineering units of raw data from the *CTDxxx.dat* files for the whole cast using the *CTDxxx.con* files for calibration coefficients and *CTDxxx.hdr* files for metadata. Produces *CTDxxx.cnv* converted data and *CTDxxx.ros* rosette file with five second scan ranges centred on bottle firing times from CTDxxx.bl. The following parameters were extracted:

1) Scan Count
2) Modulo Word
3) Modulo Error Count
4) Pump Status
5) Time, Elapsed Julian Days
6) Latitude degrees
7) Longitude degrees
8) Pressure Digiquartz dbar
9) Depth Salt Water m for 36.5° N
10) Temperature 0 ITS-90 °C (primary)
11) Conductivity 0 $mScm^{-1}$ (primary)
12) Temperature 1 ITS-90 °C (secondary)
13) Conductivity 1 $mScm^{-1}$ (secondary)
14) Oxygen Voltage SBE43 V
15) Beam Transmission
16) Altimeter m

- Step 2 – Align CTD *(AlignCTD.psa)*

Advances oxygen voltage data by four seconds to correct for the time constant of the sensor and the flow lag along the pumped flow path. Takes as input *CTDxxx.cnv* and produces *CTDxxx_alignctd.cnv*.

- Step 3 – Cell Thermal Mass Correction *(CellTm.psa)*

Corrects for conductivity errors in thermal gradients. Used with parameters alpha = 0.03 and 1/beta = 7. Takes as input *CTDxxx_alignctd.cnv* and produces *CTDxxx_alignctd_celltm.cnv*.

- Step 4 – Bottle Summary *(BottleSum.psa)*

Creates a summary of data during each Niksin bottle closure. Uses the five second scan ranges from the rosette files. Used for salinity and oxygen calibrations etc. Produces *CTDxxx.btl*.

- Step 5 – Derive *(Derive.psa)*

Generates derived data from direct measurements. Computes salinities, potential temperatures, sigma-theta densities and Chen-Millero sound velocities from each T-C sensor pair. Also computes oxygen concentrations in mll^{-1}, $umolkg^{-1}$ and % saturation. Takes as input *CTDxxx_alignctd_celltm.cnv* and produces *CTDxxx_alignctd_celltm_derive.cnv*

- Step 6 – ASCII Out *(ASCII_Out.psa)*

Exports data in ASCII format for use in external software packages. Outputs all parameters at 24 Hz and an associated header file. Due to the resolution of the elapsed time record in Julian Days, conversion to hh:mm:ss.ss but actually produces two samples with the same ms timestamp. For unique timestamps it is recommended to use the NMEA time in the header file as a base and integrate the sample period to get the time of each scan.

Takes as input *CTDxxx_alignctd_celltm_derive.cnv*
and produces *CTDxxx_alignctd_celltm_derive_asciiout.asc*
and the associated header *CTDxxx_alignctd_celltm_derive_asciiout.hdr*

- Step 7 – Seaplot Graphing *(SeaPlot.psa)*

Produces graphs of all casts for secondary temperature, salinity, density and sound velocity on the same 0-4000m scale. Takes as input *CTDxxx_alignctd_celltm_derive.cnv* and exports images as metafiles as *CTDxxx_alignctd_celltm_derive.wmf.*

Data Processing Comments
The dissolved oxygen advance time of four seconds was selected to produce the same hysteresis as primary temperature through the thermocline. Hence the four second advance will correct for the time constant of the oxygen sensor and the position of the sensor along the pumped flow-path, but not align the up-cast and downcast. The hysteresis within water property gradients is present on all sensors of those properties, however it is not an instrument artefact but a product of package drag and entrained water within the package.

During data processing it was discovered that there was in fact not a problem with the dissolved oxygen sensor cable during any casts. The spiking in oxygen concentration was seen as the algorithm for calculating concentration uses temperature from the primary temperature channel. Displaying oxygen voltage instead of concentration confirmed that there were no problems with the oxygen data.

Data spiking was experienced on primary temperature during casts CTD002 – 004a. This will affect the derivation of salinity, density, sound velocity from the primary sensor pair as well as oxygen concentrations. Several unsuccessful attempts were made to de-spike the temperature data using the Seabird Wildedit module. Further effort is recommended to de-spike this data, but another solution would be to use the secondary temperature for oxygen concentrations *(see Seabird Application Note No.64 "SBE 43 Dissolved Oxygen Sensor" for algorithm)* and rely on the secondary pair for salinity, density and sound velocity.

There were four modulo errors and associated jumps in modulo word that occurred near the start of the up-cast during CTD007. These errors occurred at scan numbers 119581, 121331, 125320 and 125779. There are some scans with bad data around 125789 which are thought to be associated with these modulo errors there is a large negative pressure value here. These modulo errors are thought to be caused by the sea-cable electrical splice starting to flood. The modulo error count and modulo word parameters were extracted during data conversion to allow further QC work to be done on this data.

RDI LADCP Configuration
Both the 300 kHz and 150 kHz LADCPs were deployed in a downward looking orientation on the CTD frame. Both units were aligned with beam three in the same orientation. The units were connected using an asterisk cable to provide deck communications, ping synchronisation and power from the NMF stainless steel BB battery pack.

The Workhorse 300 kHz was configured as a master and the Broadband 150 kHz as a slave. The instruments were configured to ping alternately 0.5 s apart with a ping interval of 1 s. Both units were configured to use 4 m bins. The 300 kHz was set to have 30 bins yielding a range of approximately 122 m. The 150 kHz was configured with 60 bins yielding a range of approximately 242 m. Both used blanks before the first bin of 176 cm. The ambiguity velocity was set to 175 cms^{-1} and pings per ensemble to 1.

Deployment Comments
For clarity all RDI ADCP commands used are included inline with the text in italicised brackets.

The LADCP battery was fully charged prior to each cast, but monitoring of the battery voltage was not possible due to the diodes in the asterisk cable. Paper log sheets were used for all casts. Each deployment BBtalk terminal session was logged to a file (*F3)* of the form *WHM_CTDxxx.txt* for the Workhorse Master and *BBS_CTDxxx.txt* for the Broadband Slave, where *xxx* is the CTD cast number. The real-time clocks of both units were checked prior to deployment *(TS?)* and resynchronised with the ship's GPS clock if they were more then 1 second in error *(TS yy/mm/dd,* *hh:mm:ss)*. Recorder space was also checked before each cast, but it was not necessary to erase data on the units to make space. After sending the command files, logging in BBtalk was stopped the deck cables removed and connector dummies fitted prior to deploying the CTD package.

Data files were downloaded after each cast using the 'Recover Recorder' menu item for the Workhorse. This does not work for the Broadband so the number of deployments was checked *(RA?)* then the latest file downloaded using the deployment number *(RY n)*. Downloaded files were renamed with the form *D318CTDxxxm.000* for the Workhorse master files and *D318CTDxxxs.553* for the Broadband slave files, where xxx is the CTD cast number. Multiple files from one cast were suffixed as *partn*, where *n* is the deployment number within that cast. Files from deck tests were renamed as such.

During cast CTD001 the Workhorse redeployed itself in the water during the start of the down-cast. This resulted in losing approximately ten minutes of data at the start of the down-cast and two data files being produced. This also occurred during the aborted CTD004 cast. During the repeat of this cast (CTD004a) the Broadband unit stopped logging approximately nine minutes before the CTD was recovered on deck at the end of the cast. Some problems were experienced in communicating with the LADCPs during preparation for CTD004. The asterisk cable was replaced with a BB150/WH300 star cable prior to CTD005 and no further problems were experienced.

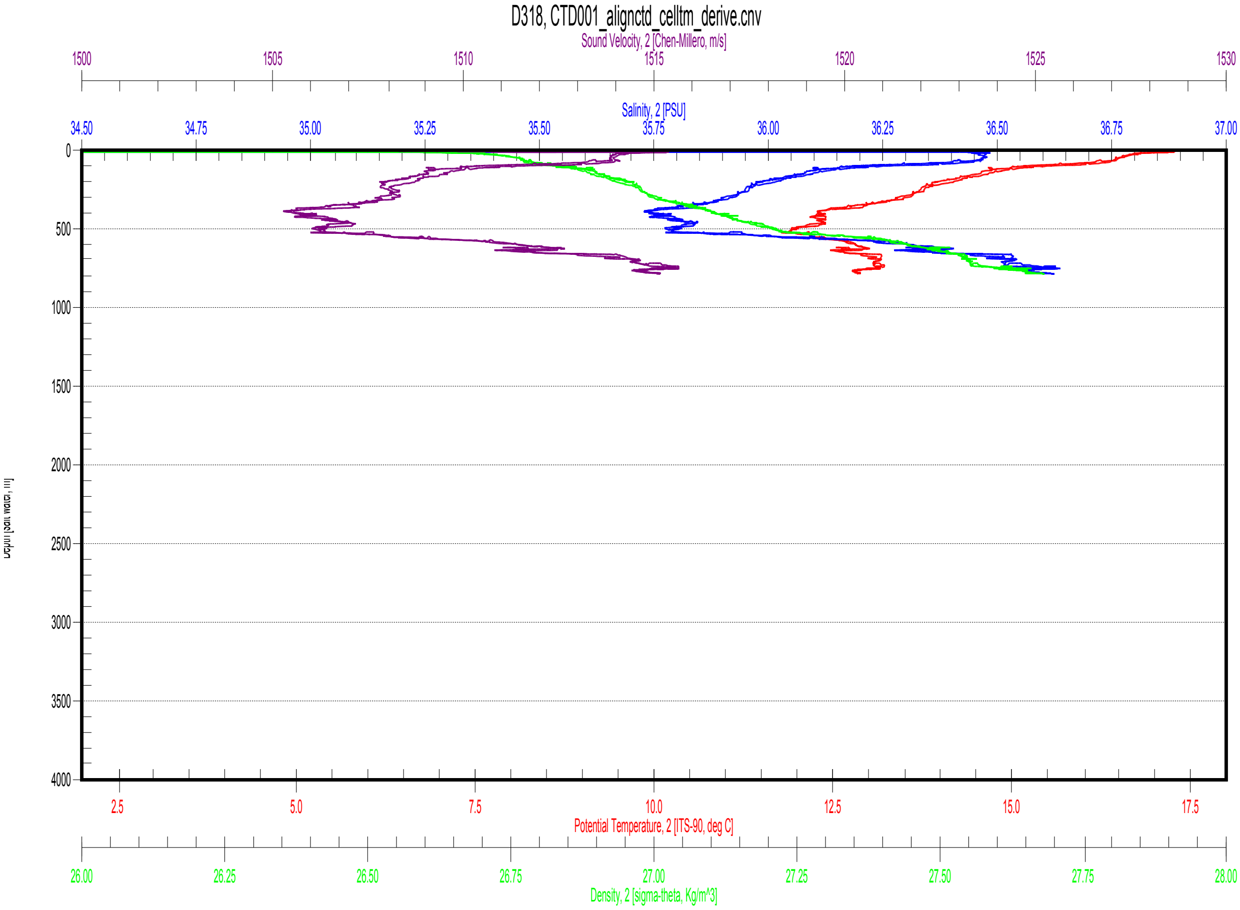
Potential for interference between the BB150 and WH300 units
There is potential for some interference between the two LADCPs as their frequencies are only one octave apart. Due to the 0.5 s difference between the pings of each unit this should translate as each unit seeing the other's direct source ping as coming from 375 m away which is outside the range of both units, however this may cause saturation of receiver circuits during reception of this direct ping. Water column echoes from the other unit's previous ping may be received during each receive window and this may produce an aberration in the data. It should be noted that this configuration has been deployed before and NMF are unaware of any serious data quality issues from past deployments. Further investigation into this issue is recommended.

Salinometry
A Guildline Autosal 8400B salinometer was used with serial number 60839. An Autosal 8400A was available as a spare but was not used.

During mobilisation a replacement Windows Softsal PC was installed following failure of the old DOS PC's BIOS backup battery. The failure of the battery caused the DOS PC to lose its hard disk settings and hence it was unable to boot. The old PC's hard disk was temporarily installed in the new machine allowing the Softsal software to be copied to a floppy disk. The new PC's hard disk was then reinstalled and the software copied onto it from the floppy. The system was tested with the Softsal software running in a DOS box under windows and all operation was confirmed before running any samples.

The salinometer was located in the constant temperature or CT lab and operated at 24°C bath temperature in 22-22.5°C ambient lab temperature. The CTD samples were taken and run using a Softsal PC by NMF. All samples were processed according to WOCE standards and protocols. A total of forty-two salinity samples using two crates were taken from the CTD, twenty-four on the first leg and eighteen on the second leg. The temperature stability in the CT lab was very good and yielded trouble free salinometry.

An NMF worked spreadsheet for CTD salinity correction was supplied to the science party in addition to the Softsal and CTD *btl* data files. The average residual of the primary sensor salinity was +5 mPSU prior to correction whereas the secondary sensor salinity average residual was -0.5 mPSU. Spiking on the primary temperature sensor obviously affected *btl* file salinities during leg D318a, particularly on cast CTD004a.



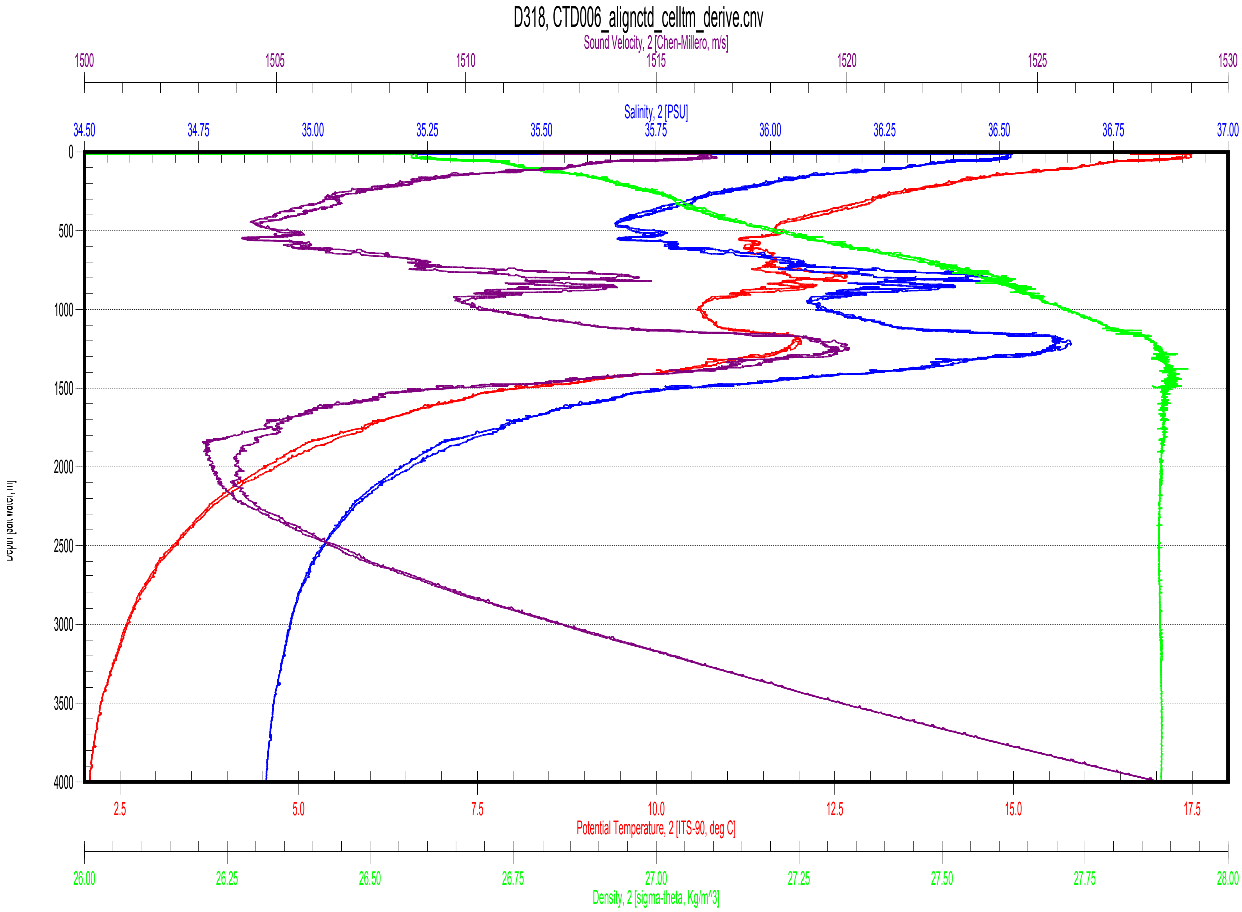
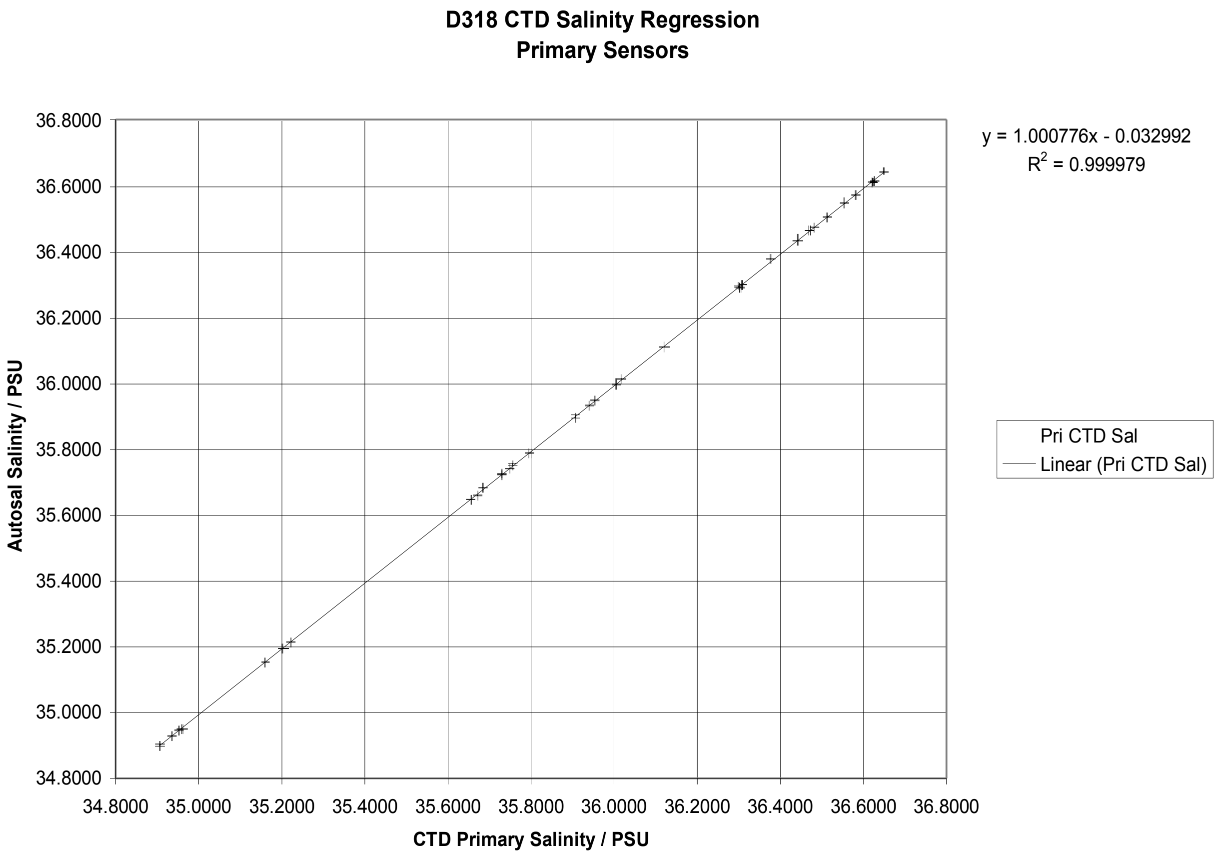


Figure 2.1.1. Examples of CTD data from a moorings site A (Fig. 1.3.1) and a deep water site near B/C (Fig. 1.3.1). Both show a rapid increase of salinity and temperature at 500 to 600m on entering the Mediterranean Outflow Water, with the deeper cast passing through the base at 1400-1600m. The dual trace shows the difference in readings between the down and up passes.



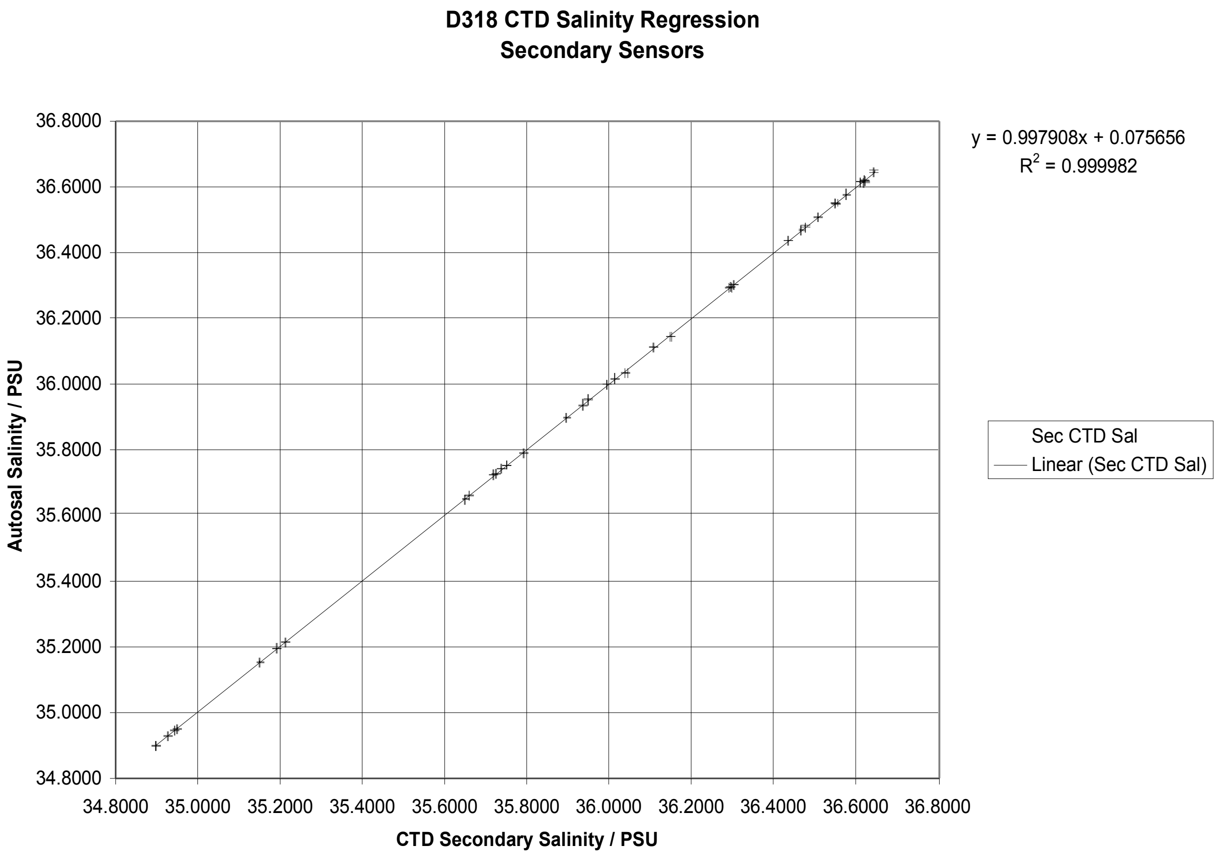


Figure 2.1.2. Salinity calibrations between the primary and secondary sensors on the CTD frame and Autosal calibrations from water sampled using the Niskin bottles.

2.2 Moorings

Report prepared by Mike Smithson (POL) (msm@pol.ac.uk)

STABLE

STABLE (Sediment Transport And Boundary Layer Equipment) consists of a 2.4 m diameter instrument frame supported on three legs such that sensors can be mounted in the water volume under the frame at the same time as minimising the effect of the instruments on the water properties being measured. Lead feet weighing 150 kg each are attached to the legs and can be released simultaneously allowing the buoyant instrument platform to float free. Two transponding releases are fitted, each able independently to release all three lead feet. A third transponder is used as a "pinger" to range to the frame when it is on the surface. A 15 m strayline is attached to facilitate recovery. Netting over the top surface prevents the strayline and shackles from washing into the instruments.

STABLE has two data logging systems – a "burst" logger which can trigger a number of sensors and sample them at high frequency, and a "mean" logger which records mean currents and pressure. The sensors connected to each logger are shown in Table 2.2.1. STABLE usually has its own fast sampling temperature and conductivity sensors connected to the burst logger but these are only rated to 500 m water depth. As this deployment was deeper, a Seabird MicroCAT supplied by the National Marine Facility (NMF) was used. This has its own internal logger and is independent of the STABLE systems but has a minimum sampling interval of 10 s. For this experiment the interval is limited to 15 s by the memory capcaity. The fast sampling pressure sensor connected to the burst logger is nomally used for collecting waves data in shallow water but will only give depth and tide information here.

Deployment was from the starboard side deck using the mid/aft crane and a 7-tonne seacatch release. STABLE free falls to the seabed at approximately 1.1 ms^{-1} and was tracked to the bottom using the acoustic transponders. Figure 2.2.1 is a photograph of STABLE onboard F.S. Poeidon in 2005, immediately prior to deployment. Figure 2.2.2 shows the sensors mounted underneath the instrument platform.

Position 36° 38.49´ N 8° 14.15´ W, water depth 792 m
Deployed at 03:29 on 18/4/2007, on seabed at 03:44

Instrument	Serial number	Logger	Height above seabed (cm)	Sampling frequency	Time (GMT) and date of first sample
POL electromagnetic current meter (ECM)	B	Burst	30	8 Hz, 20 mins per hour	14:00, 16/4/2007
POL electromagnetic current meter (ECM)	C	Burst	60	8 Hz, 20 mins per hour	14:00, 16/4/2007
Digiquartz pressure sensor (waves)	36626	Burst	205	????	14:00, 16/4/2007
Mean current rotor	1	Mean	33	1 min. average	16:30, 16/4/2007
Mean current rotor	2	Mean	51	1 min. average	16:30, 16/4/2007
Mean current rotor	3	Mean	69	1 min. average	16:30, 16/4/2007
Mean current rotor	4	Mean	87	1 min. average	16:30, 16/4/2007
Mean current vane		Mean		1 min. average	16:30, 16/4/2007
Digiquartz pressure sensor (tides)	52861	Mean	195	????	16:30, 16/4/2007
Seabird MicroCAT	3224		167	15s	12:00, 18/4/2007
Benthos acoustic transponder (release)	Receive frequency 11.5 kHz Transmit frequency 12.0 kHz Release code C				
Benthos acoustic transponder (release)	Receive frequency 14.0 kHz Transmit frequency 12.0 kHz Release code C				
Benthos acoustic transponder (pinger)	Receive frequency 15.0 kHz Transmit frequency 12.0 kHz				

Table 2.2.1: STABLE deployment details

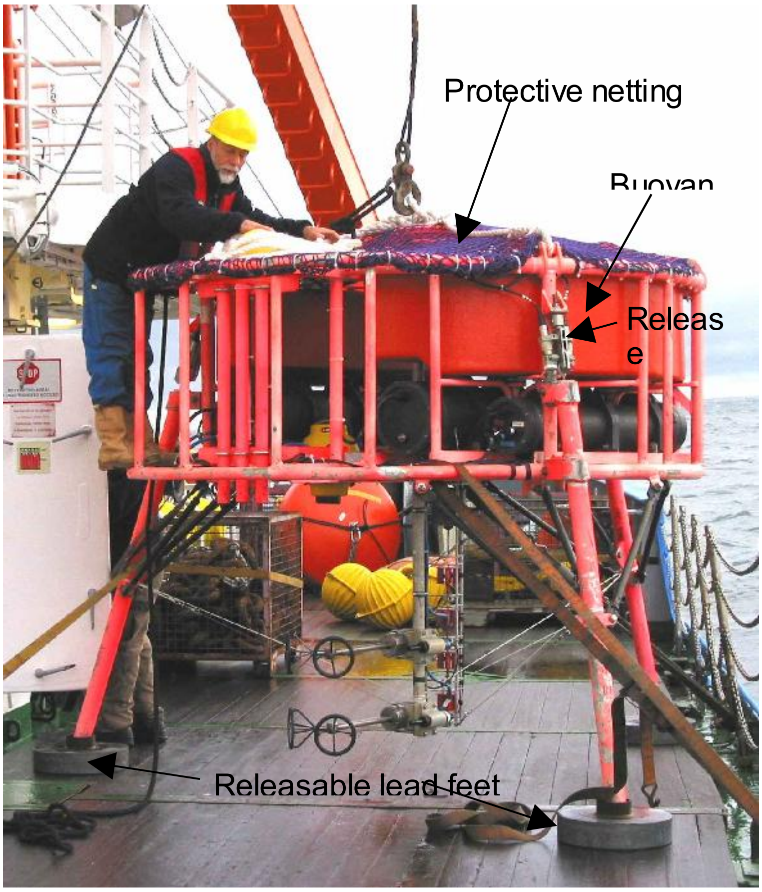


Figure 2.2.1 STABLE on board FS Poseidon in 2005

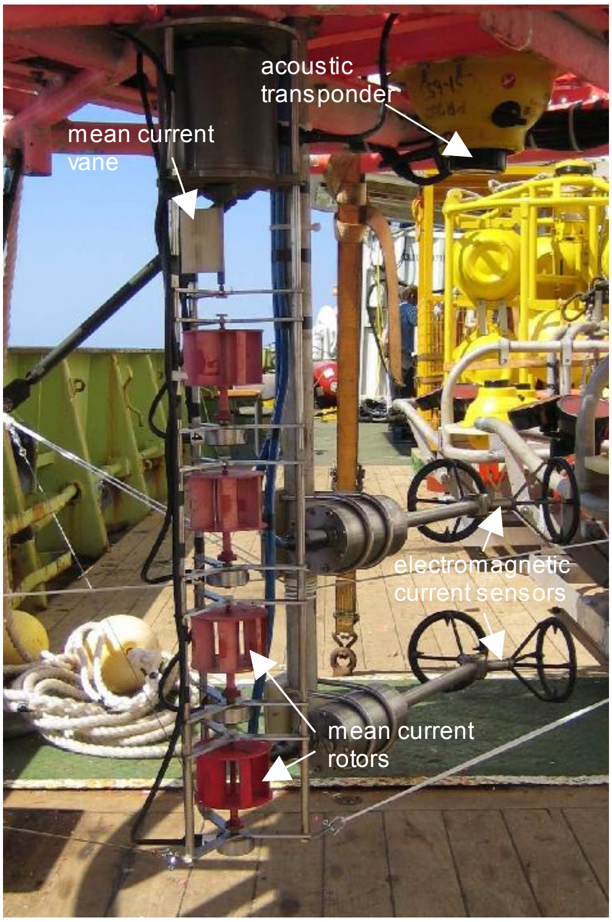


Figure 2.2.2 STABLE sensors

POL ADCP moorings

Both POL ADCPs were deployed on POL deep-sea pop-up ADCP frames. Each frame was fitted with five 43 cm diameter glass buoyancy spheres and was attached to a releasable aluminium bed frame fitted with lead ballast weights. A 12 m strayline with pellet floats was attached to the top of each frame to facilitate recovery. The release mechanism was a standard titanium release fitted with two burn wires. Each of these can be fired independently, only one being needed to release the instrument frame. Each frame was fitted with one RD Instruments 150 kHz broadband ADCP, one Vemco Minilog temperature logger and two Benthos transponding releases.

Both ADCPs were set up identically, the combination of depth cell number/size and ping regime being determined by the available memory (32 Mbytes) and battery capacity of the instruments. The setup, including the script file used to program the instrument, is shown in Table 2.2.2.

Number of depth cells	60
Depth cell size	4 m
Time per ensemble	2 minutes
Time per ping	4 s
Number of pings per ensemble	30
Data recorded	Velocity, correlation, echo intensity, percent good, heading, temperature, pitch, roll
Coordinates	Radial beam coordinates
Pitch and roll correction	No correction applied

ADCP script file:

```
CR1
EZ1111111
WN060
WD111110000
WP00030
WM4
WF0400
WS0400
TP00:04.00
WV480
TE00:02:00.00
ET0500
ES35
ED9999
EX00000
CF11101
TF07/04/16,12:00:00
CS
```

Table 2.2.2: POL ADCP setup

Deployment was from the starboard side deck using the mid/aft crane and seacatch release. The ADCP frames free-fall to the seabed. F2 was monitored to the bottom using the Benthos deck unit and over-side transducer. F1 was not monitored.

Figure 2.2.3 shows the ADCP being deployed. Figures 2.2.4 and 2.2.5 show the release mechanism and minilog in more detail. Details of the deployments are given in Tables 2.2.3 and 2.2.4.

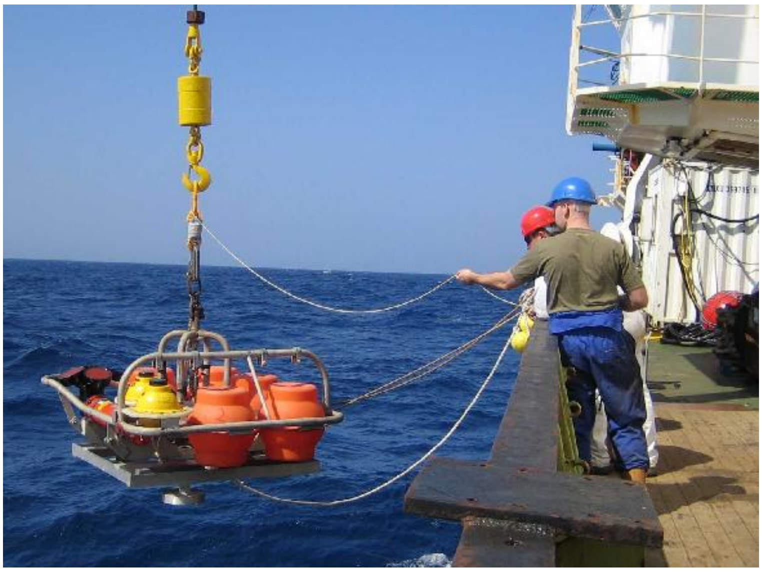


Figure 2.2.3: POL ADCP deployment

Figure 2.2.4: Titanium release and burn-wire mechanism

Figure 2.2.5: Armco minilog attached to ADCP frame

Position 36° 36.81´ N 8° 15.00´ W, water depth 866 m
Deployed at 10:14 on 18/4/2007, on seabed at 10:28

Frame F2 – deployment site A3		
Instrument	Serial number	Deployment details
RD Instruments 150 kHz broadband ADCP	1149	Clock set 08:14, 16/4/2007 Start at 15:00, 16/4/2007
Vemco 12-bit Minilog	2427	Start at 06:00, 18/4/2007 Sampling interval 2 minutes
Benthos acoustic transponder	69676	Receive frequency 11.5 kHz Transmit frequency 12.0 kHz Enable code F; Release code D
Benthos acoustic transponder	73252	Receive frequency 10.5 kHz Transmit frequency 11.0 kHz Enable code A; Release code F
Recovery details		
ADCP		
Last Data	Time Off	Data
15:28:00 11/05/07	15:29:10 11/05/07	F2ADCP.000 – F2ADCP0.27 Multiple files of length 976KB
Vemco Minilog		
Last Data	Time Off	Data
09:18:00 11/05/07	09:18:49 11/05/07	B12-2426.dat 24.7KB

Table 2.2.3: Details of ADCP deployment at site A3

Position 36° 35.15´ N 8° 15.82´ W, water depth 980 m
Deployed at 16:05 on 18/4/2007

Frame F1 – deployment site A4		
Instrument	Serial number	Deployment details
RD Instruments 150 kHz broadband ADCP	1148	Clock set 11:33, 16/4/2007 Start at 12:00, 16/4/2007
Vemco 12-bit Minilog	2426	Start at 06:00, 18/4/2007 Sampling interval 2 minutes
Benthos acoustic transponder	70354	Receive frequency 13.0 kHz Transmit frequency 12.0 kHz Enable code C; Release code D
Benthos acoustic transponder	72380	Receive frequency 10.5 kHz Transmit frequency 11.0 kHz Enable code B; Release code B
Recovery details		
ADCP		
Last Data	Time Off	Data
11:16:00 11/05/07	11:17:00 11/05/07	F1ADCP.000 27MB
Vemco Minilog		
Last Data	Time Off	Data
09:08:00 11/05/07	09:08:00 11/05/07	B12-2427.dat 24.7KB

Table 2.2.4: Details of ADCP deployment at site A4

Recoveries. Both POL ADCPs (F1 and F2) were recovered without difficulty. With the ship on station the overside transducer is lowered into the water and the enable command for the benthos acoustics is sent. The transponder can then be "pinged" to check that it is awake and to get a range to the instrument frame. The release commandis then sent. The burn wire takes several minutes to burn away and during this time the transducers are pinged at regular intervals. Reduction of the range to the acoustic is an indication that the frame has been released and is rising to the surface. Recovery was over the starboard side of the ship, the strayline being grappled and the frame being winched on board.

Data were downloaded from the ADCPs succesfully. Initial inspection of the data shows that the ADCP on frame F1 at site A4 recorded data succesfully. Initial inspection of the data shows that the ADCP on frame F2 at site A3 recorded multiple data files. The files contain the complete data set. This will need investigating upon return to POL.

Temperature logger moorings

Temperature logger moorings were close (~500 m) to the A1, A3 and A4 sites and designated A1T, A3T and A4T respectively. These moorings consisted of a 50 m mooring wire attached to a 500 kg anchor clump via an Ixsea transponding release. Buoyancy was provided by either glass buoyancy spheres (A1) or a syntactic barrel buoy (A3 and A4). Each had a 15m stray line and pickup float to aid recovery. 18 temperature recorders were attached using cable ties and PVC tape at intervals along the mooring wire. The uppermost and 9th of these were Star-Oddi temperature and depth sensors logging at 30 s intervals, the remainder were Vemco minilogs logging at 2-minute or 4-minute intervals depending on memory capacity. All temperature loggers were set to start at 06:00 on 18/4/2007.

The moorings were deployed from the afterdeck using the starboard aft-end knuckle crane. The sub-surface buoyancy is deployed first followed by the mooring wire, loggers being attached at premarked intervals on the wire as it is paid out. An inline release is attached to the bottom end of the wire followed by a 500 kg anchor clump which is released when the ship is on station. Tables 2.2.5, 2.2.6 and 2.2.7 give details of each mooring.

Position 36° 40.07´ N 8° 12.92´ W, water depth 747 m
Deployed at 07:05 on 18/4/2007, on seabed at 07:11
Logger start time 06:00 on 18/4/2007

Instrument	Serial number	Nominal height above bed (metres)	Logging interval (minutes)	Time of Last Ensemble	File size (KB)
Star-Oddi T&D logger	3133	53	0.5		
Vemco Minilog	2106	49	2	17:44 on 09/05/07 (off at 17:45:39)	22.9
Vemco Minilog	8519	45	4	17:56 on 09/05/07 (off at 17:58:19)	See text
Vemco Minilog	2699E	41	2	18:34 on 09/05/07 (off at 18:34:59)	23
Vemco Minilog	2192E	37	4	18:00 on 09/05/07 (off at 18:02:59)	11.6
Vemco Minilog	6025E	33	2	18:46 on 09/05/07 (off at 18:46:39)	23
Vemco Minilog	2197E	29	4	18:56 on 09/05/07 (off at 18:56:59)	11.6
Vemco Minilog	4476	25	2	19:14 on 09/05/07 (off at 19:14:59)	23
Star-Oddi T&D logger	3132	21	0.5		
Vemco Minilog	2189E	19	4	19:32 on 09/05/07 (off at 19:35:29)	11.7
Vemco Minilog	2108	17	2	19:24 on 09/05/07 (off at 19:25:59)	23
Vemco Minilog	8512	15	4	19:40 on 09/05/07 (off at 19:42:19)	11.7
Vemco Minilog	2111	13	2	19:48 on 09/05/07 (off at 19:49:59)	23
Vemco Minilog	8516	11	4	19:56 on 09/05/07 (off at 19:59:49)	11.7
Vemco Minilog	2420	9	2	20:04 on 09/05/07 (off at 20:05:09)	23
Vemco Minilog	8517	7	4	20:12 on 09/05/07 (off at 20:14:59)	11.7
Vemco Minilog	2424	5	2	20:34 on 09/05/07 (off at 20:34:49)	23.1
Vemco Minilog	7169	3	4	20:20 on 09/05/07 (off at 20:20:09)	11.7

Table 2.2.5: Details of A1T temperature mooring

Position 36° 37.03´ N 8° 14.95´ W, water depth 854 m
Deployed at 12:01 on 18/4/2007, on seabed at 12:07
Logger start time 06:00 on 18/4/2007

Instrument	Serial number	Nominal height above bed (metres)	Logging interval (minutes)	Time of Last Ensemble	File size (KB)
Star-Oddi T&D logger	3139	54	0.5		
Vemco Minilog	6024E	50	2	13:02 on 11/05/07 (off at 13:03:09)	24.8
Vemco Minilog	2195E	46	4	13:20 on 11/05/07 (off at 13:22:29)	12.6
Vemco Minilog	6023E	42	2	18:32 on 11/05/07 (off at 18:32:49)	25
Vemco Minilog	2188E	38	4	14:36 on 11/05/07 (off at 14:38:59)	12.6
Vemco Minilog	2425	34	2	14:10 on 11/05/07 (off at 14:10:39)	24.9
Vemco Minilog	0147E	30	4	13:48 on 11/05/07 (off at 13:48:59)	12.6
Vemco Minilog	2421	26	2	15:54 on 11/05/07 (off at 15:55:39)	25
Star-Oddi T&D logger	3125	22	0.5		
Vemco Minilog	0148E	20	4	16:24 on 11/05/07 (off at 16:24:59)	12.6
Vemco Minilog	6026E	18	2	12:52 on 11/05/07 (off at 12:53:09)	24.8
Vemco Minilog	0142E	16	4	14:48 on 11/05/07 (off at 14:48:09)	12.6
Vemco Minilog	2107	14	2	16:10 on 11/05/07 (off at 16:10:39)	25
Vemco Minilog	2191E	12	4	15:00 on 11/05/07 (off at 15:03:59)	12.6
Vemco Minilog	2104	10	2	14:00 on 11/05/07 (off at 14:00:09)	24.9
Vemco Minilog	0145E	8	4	13:20 on 11/05/07 (off at 13:21:39)	12.6
Vemco Minilog	2105	6	2	13:26 on 11/05/07 (off at 13:26:49)	24.9
Vemco Minilog	2193E	4	4	13:36 on 11/05/07 (off at 13:36:59)	12.6

Table 2.2.6: Details of A3T temperature mooring

Position 36° 35.35´ N 8° 15.69´ W, water depth 978 m
Deployed at 17:22 on 18/4/2007
Logger start time 06:00 on 18/4/2007

Instrument	Serial number	Nominal height above bed (metres)	Logging interval (minutes)	Time of Last Ensemble	File size (KB)
Star-Oddi T&D logger	3131	54	0.5		
Vemco Minilog	2406	50	2	22:28 on 10/05/07 (off at 22:29:49)	24.2
Vemco Minilog	2185E	46	4	00:04 on 11/05/07 (off at 00:05:09)	12.3
Vemco Minilog	4482	42	2	See text	
Vemco Minilog	2184E	38	4	00:08 on 11/05/07 (off at 00:11:04)	12.3
Vemco Minilog	2112	34	2	23:54 on 10/05/07 (off at 23:54:49)	24.3
Vemco Minilog	0149E	30	4	22:12 on 10/05/07 (off at 22:13:09)	12.2 Bad Data
Vemco Minilog	2701E	26	2	23:40 on 10/05/07 (off at 23:41:59)	24.3
Star-Oddi T&D logger	3130	22	0.5		
Vemco Minilog	2187E	20	4	21:48 on 10/05/07 (off at 21:50:09)	12.2
Vemco Minilog	9714A	18	2	23:00 on 10/05/07 (off at 23:01:59)	24.2
Vemco Minilog	0144E	16	4	22:44 on 10/05/07 (off at 22:47:49)	12.3
Vemco Minilog	6027E	14	2	23:30 on 10/05/07 (off at 23:31:19)	24.3
Vemco Minilog	2194E	12	4	22:40 on 10/05/07 (off at 22:41:59)	12.3
Vemco Minilog	9756A	10	2	22:00 on 10/05/07 (off at 22:01:59)	24.2
Vemco Minilog	2186E	8	4	23:24 on 10/05/07 (off at 23:25:39)	12.3
Vemco Minilog	2110	6	2	00:16 on 11/05/07 (off at 00:16:59)	24.3
Vemco Minilog	2196E	4	4	23:12 on 10/05/07 (off at 23:12:59)	12.3

Table 2.2.7: Details of A4T temperature mooring

Recoveries.
The minlogs recorded data sucesfully with the exception of s/n 8519 and s/n 4482 which suffered communication errors, the data could not be recovered. Minilog s/n 0149E gave bad data with the majority of the data reading -5 degrees.

NMF ADCP Moorings
Two further ADCP moorings were supplied by NMF. The 600 kHz was fitted to a frame which stood on the seabed. The frame was fitted with eight 17 in glass buoyancy spheres and a lead ballast weight. The release mechanism was a standard acoustic activated release with burn wire.

The setup is shown in Table 2.2.8

Number of depth cells	30
Depth cell size	2 m
Time per ensemble	2 minutes
Time per ping	2 s
Number of pings per ensemble	60
Data recorded	Velocity, correlation, echo intensity, percent good, heading, temperature, pitch, roll
Coordinates	Radial beam coordinates
Pitch and roll correction	No correction applied

Table 2.2.8: 600kHz ADCP setup

Deployment was from the starboard side deck using the mid/aft crane and seacatch release. The ADCP frame free-falls to the seabed. On release the frame inverts as it floats to the surface. Recovery also was from the starboard side.

The second system supplied by NMF was a 75kHz ADCP mounted in a 49 in syntactic foam buoy. The buoy was anchored to the sea-floor by a 800 kg anchor weight on a 4 m chain split in the middle by a standard acoustic release (Fig. 2.2.6).

Number of depth cells	30
Depth cell size	2 m
Time per ensemble	2 minutes
Time per ping	1.33 s
Number of pings per ensemble	90
Data recorded	Velocity, correlation, echo intensity, percent good, heading, temperature, pitch, roll
Coordinates	Radial beam coordinates
Pitch and roll correction	No correction applied

Table 2.2.9: 75kHz ADCP setup

Deployment was from the aft deck over the stern using the A-frame gantry. The ADCP buoy is deployed first followed by the mooring chain. An inline release is attached to the bottom end of a 2 m chain followed by another 2 m chain and an 800 kg anchor clump which is released when the ship is on station. Recovery was over the starboard side using the mid/aft crane.

Figure 2.2.6. Station A5, 75KHz buoyed ADCP

Table 4: Details of ADCP deployment at site A1

Position 36° 40.18´ N 8° 13.22´ W, water depth 742 m
Deployed at 16:05 on 18/4/2007

deployment site A1		
Instrument	Serial number	Deployment details
600 kHz broadband ADCP	not known	Clock set 12:00, 17/4/2007 Start at 06:20, 18/4/2007
Recovery details		
ADCP		
Last Data	Time Off	Data
17:58:00 9/05/07	20:22:00 9/05/07	

Table 2.2.10 Details of ADCP mooring at station A1

Table 4: Details of ADCP deployment at site A5

Position 36° 33.87´ N 8° 11.73´ W, water depth 742 m
Deployed at 18:42 on 18/4/2007

deployment site A5		
Instrument	Serial number	Deployment details
75 kHz broadband ADCP	1767	Clock set 12:00, 17/4/2007 Start at 18:52, 18/4/2007
Recovery details		
ADCP		
Last Data	Time Off	Data
16:04:00 9/05/07	19:08:00 9/05/07	

Table 2.2.11 Details of ADCP mooring at station A5

Tethered OBH
To help with source design and processing 2 OBH were tethered in the water column to measure the direct wave from the seismic array without interference from the sea-surface ghost nor the sea-bed (Table 2.2.12 and 2.2.13). The site was located at the southern margin of the shipping lanes in about 2400 m of water. The OBH were type: IFM-GEOMAR Ocean Bottom Hydrophone. The design is described in detail by Flueh and Bialas: Flueh, E. R., and Bialas, J., 1996: A digital, high data capacity ocean bottom recorder for seismic investigations; Int. Underwater Systems Design, V.18, No. 3, 18-20.

The OBH were deployed by *RRS Discovery* over the starboard side, with a 500m long rope between the OBH and the anchor weight (Fig 2.2.7). Recovery was by *FS Poseidon*.

Position 37° 28.786 N 8° 36.062 W, water depth 2480 m
Deployed at 00:39 on 19/4/2007

Deployment site OBH-1	
long anchor-cable	500m
Release IXSea (MORS Technology)	rt661 s/n 463 – Code: 3664
Time release	09/05/07 12:00 UTC
Novatech radio beacon	VHF 160.785; s/n S12-042
Novatech flasher	s/n S12-050
OAS Inc. Hydrophone type	E-2PD s/n 27
Recovered	29.04.07 13:20 UTC
MBS (Marine Broadband Seismic recorder; SEND GmbH)	s/n 020501
sample rate	1000 Hz
start rec	18.04.07 19:23:00 UTC
end rec	29.04.07 13:51:00 UTC

Table 2.2.12: Details of OBH deployment at site OBH-1

Position 36° 27.862 N 8° 38.256 W, water depth 2028 m
Deployed at 00:39 on 19/4/2007

Deployment site OBH-2	
long anchor-cable	500m
Release IXSea (MORS Technology)	rt661 s/n 471 – Code: 3629
Time release	09/05/07 13:00 UTC
Novatech radio beacon	VHF 160.725; s/n K07-024
Novatech flasher;	s/n S01-737
OAS Inc. Hydrophone type	E-2PD s/n 50
Recovered	29.04.07 12:05 UTC
MBS (Marine Broadband Seismic recorder; SEND GmbH)	s/n 020509
sample rate	1000 Hz
start rec	18.04.07 19:37:00 UTC
end rec	29.04.07 12:59:00 UTC

Table 2.2.13: Details of OBH deployment at site OBH-2

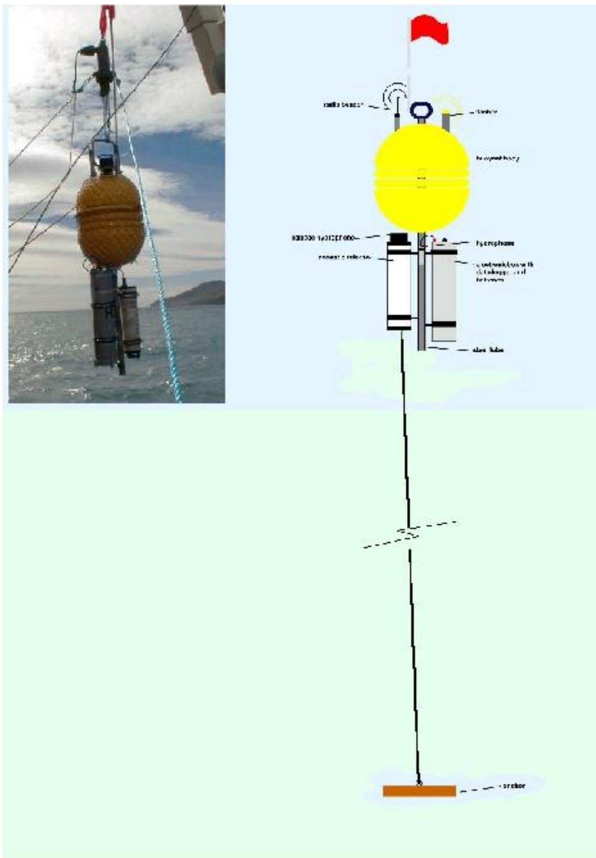


Figure 2.2.7. Tethered OBH

2.3 High Resolution Seismic Data Acquisition

Prepared from report by Louis Geli (IFREMER); details Annex 4

The seismic source
Airguns are the most common seismic source. A chamber flooded by high air pressure (140 bars), the trapped air is released on electrical signal, which operates a solenoid switch causing an imbalance in the pressures across the shuttle valve. SODERA GI gun (GI stands for : Generator-Injector) has two chambers : generator produces the primary air bubble ; injector is then released after a given time delay to limit the primary bubble oscillation.
The GO seismic source for leg 1 (D318a) was designed to meet the demand for a high-resolution source in term of frequency content, sound level and repeatability of the signal. The source consists in an array of 6 mini-GI airguns towed at 1.5 meters below sea surface, giving frequencies ranging from 15 Hz up to 350 Hz (Annex 5). Two types of airgun were used, with different chamber sizes of 24/24 and 15/15 cubic inches. The 6 mini-GI guns are deployed with two, 2-m long steel beams, towed 14 m behind the ship and spaced by 10 m (Fig. 2.3.1). A summary is provided in Table 2.3.1.

Fig. 2.3.1a : The seismic array includes 2 seismic beams (portside beam on the picture). Each seismic beam consists in 3 Sodera mini GI airguns, attached on a metallic frame hanging below the red floatation.

Fig. 2.3.1b : Detail of a mini GI airgun. The ombilicals include compressed air supply and electrical connectors (generator and injector solenoids, Time Break hydrophone).

Fig. 2.3.1c : Deplyment/recovery of airgun beam on portside, using stern crane of RRS Discovery.

Fig. 2.3.1d: Airguns beams towed 14 m behind ship. Streamer is towed between the two beams.

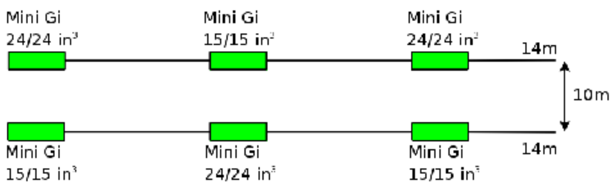


Fig. 2.3.1e : Mini-Gun array geometry. Source towed behind ship heading to the right.

The seismic streamer
Spatial sampling requirements for high resolution seismic imagery with respect to the frequency content of the source leads implies the following trace geometry :

- Trace length : 6.25 m ;
- Distance between hydrophones (8) within a trace : 0.78 m.

The 600-m long SERCEL streamer used for D318a consists of:

- 3 off 150 m active line sections (ALS) with 24 groups of 6.25 m each;
- 2 or 3 off 50 m elastic sections (1 or 2 at the head (HES) and 1 at the tail (TES));
- 1 off 75 m reinforced short head section (SHS);
- passive tail buoy with lead-in rope .

The streamer depth is controlled by 4 birds equipped with magnetic compasses which allow monitoring the streamer shape during operation. The optimal streamer towing depth is 2 m, (frequency notch at 400 Hz). The weather encountered during the leg 1 allowed most profiles to be recorded at the optimal depth except when wind and sea state increased to force 5 (Beaufort) when streamer depth was lowered down to 3 metres (frequency notch 250 Hz) to minimise surface wave noise.

Absolute positioning
Differential GPS was not available in the region and during the time of the cruise, nevertheless raw GPS was of excellent quality (standard deviation of the antenna within 2 m). Absolute time (trigger time) is recorded through an external GPS clock and the filtered GPS antenna navigation data is then interpolated to this shot time.

Source and receiver positioning
Compasses on the depth controllers of the streamer are first corrected for local magnetic declination and then interpolated. This allows the retrieval of the streamer shape and therefore the relative position of each receiver. The source relative positions are estimated assuming the source follows the ship's gyro-compass heading. The absolute positioning of source and receivers are achieved by merging absolute (GSP antenna) and relative (shot geometry) data. The accuracy in source and receiver positions is believed to better than the final processed bin size (6.25 metres). Layout of the acquisition system is shown in Figure 2.3.2. A list of profiles and basemap are given in Table 2.3.2 and Figure 2.3.3.

Dedicated quality control software SISPEED, developed by IFREMER, was succesfully applied to monitor the source / receiver positions as well as to evaluate seismic data quality through low level signal processing. Seismic and positioning data were then merged through simple water velocity NMO/stack/migration algorithms in order to assess for data quality and to provide near real-time seismic sections.

Acquisition parameters. See table 2.3.1, below :

Sampling rate	1 kHz
Mean time delay (firing order /Time Break)	23 ms
Shot spacing	6 s for lines 1 through 3 10 s for all other lines
Recording Length	5500 ms for lines 1, 3, 5, 6, 8, 10, 11 and 13 7000 ms for all other lines
Source depth	1.5 m for all lines
Streamer depth	2 m for lines 1, 3, 5, 6, 8, 10, 11 and start of 15 3 m for 2^{nd} part of line 15, and all other lines
Distance from source to 1st trace	141 m for lines 1, 3, 5, 6, 8, and 10 (Fig 2.3.2a) 91 m for all other lines (Fig 2.3.2b)

Table 2.3.1 : Summary of acquisition parameters.

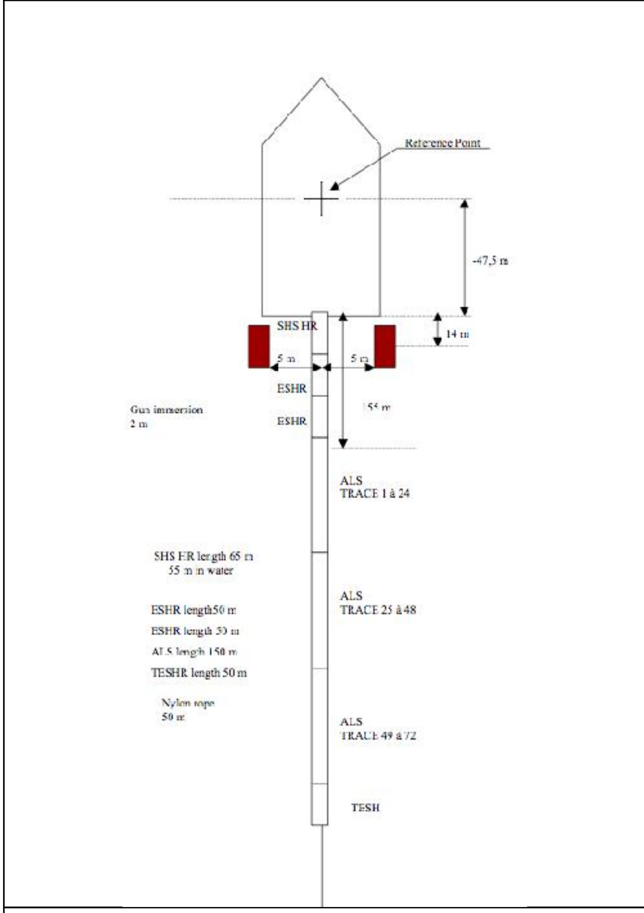


Figure 2.3.2a. Seismic streamer with 2 elastic sections, used for Lines 001 to 010. The first trace is 155 m behind the ship (see text for acronyms).

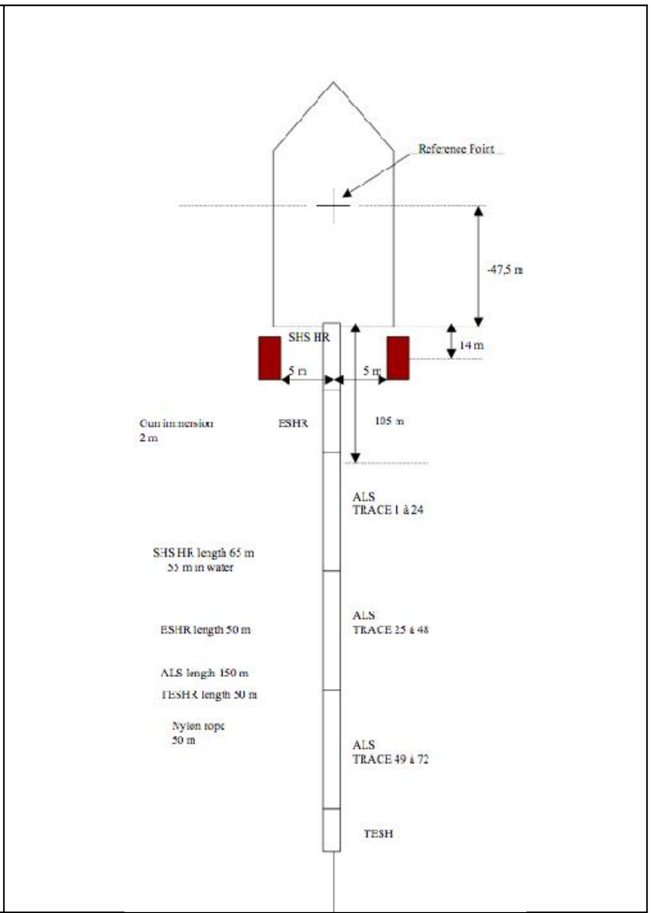


Figure 2.3.2b. Seismic streamer with only one elastic section, used for Line 011 and after. The first trace is 105 m behind the ship.

Details on the streamer are summarized as follows :

- Section arrangement
  - group interval : 6.25 m
  - Section length : 150 m
- Group arrangement
  - 8 hydrophones/channel
  - spacing : 0.78 m, linear, non overlapping
- Group Capacitance
  - nominal value (20°C, 1 bar) : 128 nF
  - channel to channel matching : ± 5 %
  - variation with temperature : 0.8 % /per °C
  - variation with pressure (only for p < 3 bars) : -3% per bar
- Low cut frequency :
  - nominal value (20°C, 1 bar) : 3 Hz
  - channel to channel matching : ± 6 %
  - variation with temperature : -0.6 % per °C
  - variation with pressure (only for p < 3 bars) : 2.4 % per bar
  - slope : 6 dB
- Group Sensitivity
  - Nominal value (20°C, 1 bar) : 15.4 V
  - Channel to channel matching : ± 15 %
  - Variation with temperature : 0.1% per °C
  - Variation with pressure : -1.7 % per bar (for p < 3 bars only)

Profile	Start Date	Start Shot	End Date	End Shot	Remarks
1	19/04/07 9:12	1	19/04/07 13:57	2860	6 Guns ; WP1 to WP5
2					Turn
3	19/04/07 15:24	3725	19/04/07 10:13	4810	1 Gun (24/24) ; WP6-WP7
4					Turn
5	19/04/07 19:16	6033	19/04/07 20:07	6343	1 Gun (15/15) ; WP8-WP6
6	19/04/07 20:11	6360	20/04/07 0:24	7880	6 Guns ; WP5 to A
7					Turn
8	20/04/07 1:56	8430	20/04/07 4:47	9435	A6 to A7
9					Turn
10	20/04/07 7:04	10280	20/04/07 9:23	11115	A8 to A9
11	20/04/07 11:51	12000	20/04/07 13:46	12695	A10 to A11 only
12					Turn
13	20/04/07 14:57	13120	21/04/07 4:44	18080	
14					Loop
15	21/04/07 7:41	19140	21/04/07 13:40	21296	
16					Loop
17	21/04/07 14:27	21573	21/04/07 20:49	23873	
18	21/04/07 20:50	23877	21/04/07 22:00	24300	repeat section
20	21/04/07 22:42	24547	22/04/07 0:06	25055	repeat section
21					Loop
22	22/04/07 0:37	25235	22/04/07 0:37	25664	repeat section
23					Loop
24	22/04/07 2:16	25830	22/04/07 3:23	26235	repeat section
25					Loop
26	22/04/07 3:52	26405	22/04/07 5:22	26950	repeat section
27					Loop
28	22/04/07 5:55	27145	22/04/07 7:24	27685	repeat section
29					Loop
30	22/04/07 9:23	27830	22/04/07 9:23	28394	repeat section
31	22/04/07 9:24	28400	22/04/07 12:03	29355	

Table 2.3.2 List of profiles acquired – prefix GO-HR-

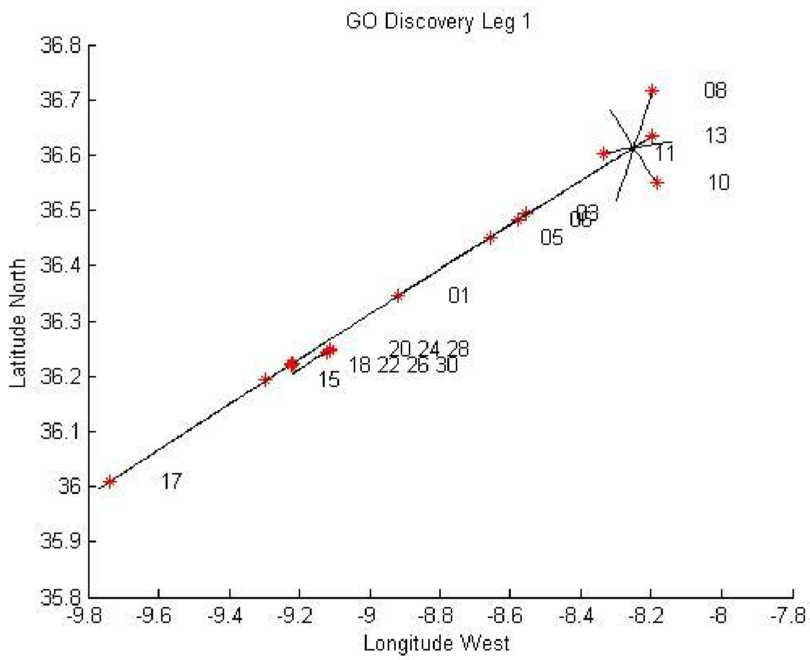


Figure 2.3.3 Map showing location of profiles GO-HR-

2.4 Low Resolution Seismic Data Acquisition

Prepared from report by Richard Hobbs (Durham); details Annex 4

The seismic source

The NERC pool supplied 6 Bolt 1500LL Airguns and these were used during the second leg D318b. There basic operation is similar to the GI guns described previously except this type of gun only has a single chamber and so cannot fire a second chamber to suppress the bubble oscillation so optimal tuning relies on using various chamber sizes to minimise the bubble pulse coda. The GO low resolution seismic source was designed using the Gundalf software (Oakwood Computing) under license to CSIC. Two identical sub-arrays were deployed each with 3 guns on a rigid steel beam and chamber sizes of 700, 300 and 160 cu in. The designed tow depth was 9m. This was modelled to provide a reasonably well balanced source with a usable bandwidth of 5-70 Hz. For the last three days of the seismic acquisition we towed a multi-resolution array. One sub-array was kept as above (700, 300 and 160 cu in) the other was redesigned with a 80, 300 and 160 cu in, with a tow depth of 4 m (Annex 5).

The two beams were both towed from the port side to leave the starboard side free for deployment of oceanographic probes (XBT/XCTD). Deployment was using the NMF 'cherry-picker' system. This was a dedicated winch system attached the the port stern crane which lifted each gun beam off of its cradle on the aft deck and swung the beam out over the side and, after attaching the a buoy to the tail of the beam and pressuring the guns, winched the beam into the water by a steel cable. This operation was done simultaneously with paying out the umbilical cable containing the pressure hoses and electrical cables. Once the first gun beam was deployed, the steel cable was unwound off the winch and tied off. The towing of each sub-array was by its umbilical. The process was repeated for the second beam. Recovery of the beams was the reverse of the deployment strategy.

A number of issues came apparent with the system:

1) during the mobilisation the ram to operate the port stern beam, necessary to keep the two sub-arrays apart, was found to be corroded beyond repair. A new one was fabricated in Southampton an flown out to Portugal and joined the ship at the end of the two day trials cruise;
2) the use of a single buoy to control depth is not ideal, evidence on recovery showed that the gun chambers had been hitting the beam, also detailed frequency analysis of the data did not show a clear notch in the frequency spectrum at around 83 Hz, for the low frequency array, but a general loss of energy above 60 Hz. We concluded that the beam was suspended from the tail buoy at a steep angle with the 700 cu in gun being over 11 m below the sea-surface. The same problem was seen for the smaller volume sub-array used for the multi-resolution profiles, even with a shorted umbilical the frequency notch suggested the actual tow depth was 6 m and not the expected 4 m. During operations (profile GO-MR-01) one tail buoy was lost, possibly because of excessive loading causing the anchorage point on the buoy to break;
3) unwinding and rewinding the steel cable on the winch for each beam meant both deployment and recovery of the airgun system was slow. Though not a problem if sea conditions were good, as they were for most of this survey, but could be a limiting safety factor for fast recovery if weather conditions deteriorated quickly;
4) when using tow sources at different tow depths in flip-flop shooting mode the shallower sub-array was towed closer to the ship to avoid damage from interaction with bubble from deeper sub-array. This towing arrangement was instigated from GO-MR-02.

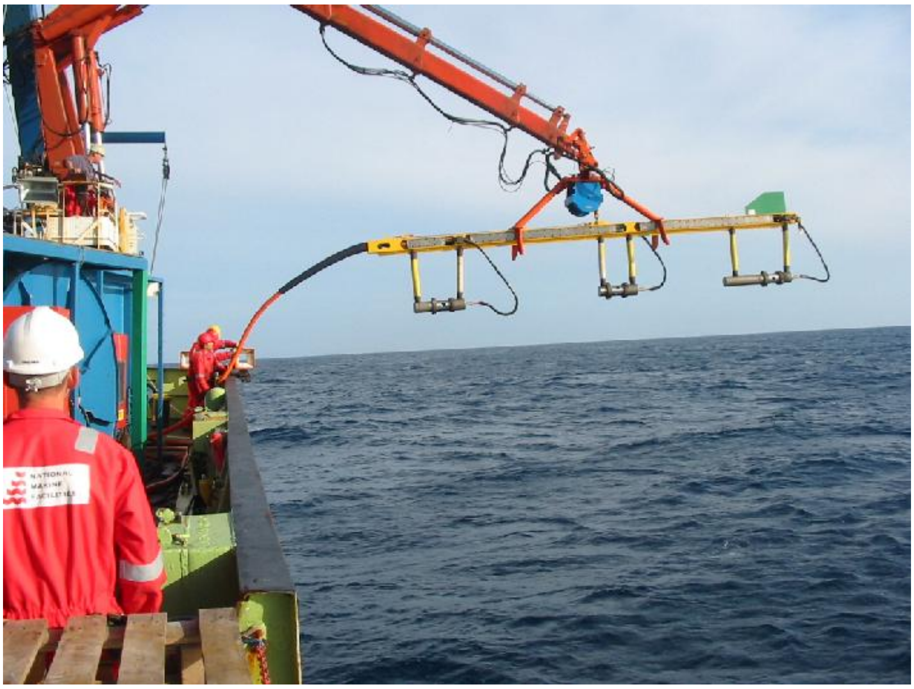
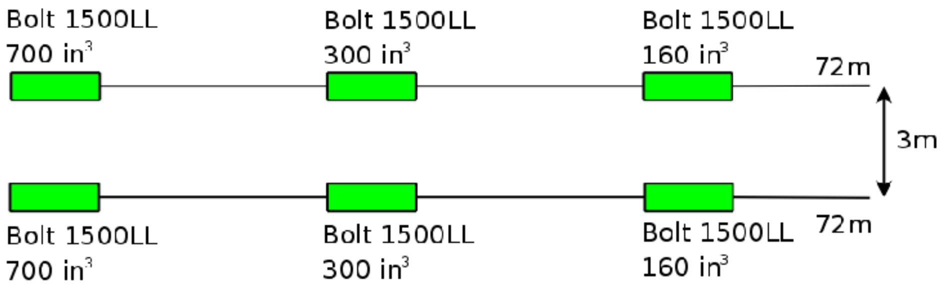
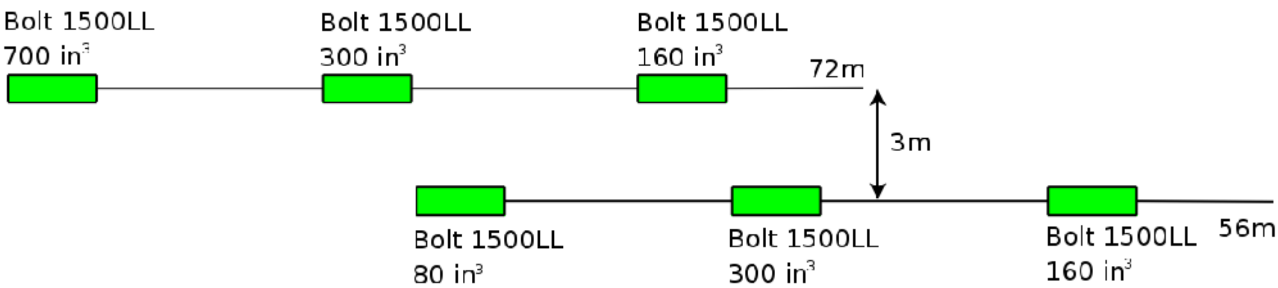


Figure 2.4.1. Deployment of sub-array using aft port knuckle crane with NMF special cherry-picker deployment/recovery system. Depth control floatation buoy is attached to the rear of the array by green fin. Then the sub-array is lowered into the water from winch on cherry-picker and is towed by the umbilical attached to the front. Umbilical winch is in foreground. The sub-array has 300, 160 and 700 cu in guns, suspension chains to main beam are enclosed in reinforced flexible tube to damp motion when fired.



(a)



(b)

Figure 2.4.2. (a) source configuration for the GO-LR profiles, total source volume 2320 cu in. (b) source configuration for the GO-MR profiles (except GO-MR-01 where both sources were towed 72m behind the ship), the two sub-arrays were fired alternately. Ship is to the right.

The seismic streamer

The seismic streamer was provided by Exploration Electronics Ltd under contract to NMF. The original budget was based on the use of NMF own 2.4 km streamer, however this was declared as unserviceable and this necessitated the hire of a commercial system. The Sercel SEAL system was similar to the IFREMER kit used for leg 1, but with longer offsets and group lengths as specified below and in Fig. 2.4.3 and Table 2.4.1.

Spatial sampling requirements for both the Low and Multi-Resolution seismic profiling was :

- Trace length : 12.5 m ;
- Distance between hydrophones (16) within a trace : 0.625m

The 2400-m long SERCEL streamer consists in :

- 16 active line sections (ALS) of 12 traces of 12.5 metres - 150 metres;
- 2 or 3 elastic sections (1 or 2 at the head (HES) and 1 at the tail (TES) -50 metres;
- 1 re-inforced short head section (SHS) -75 metres)
- passive tail buoy.

	head offset	bird offset	GO-MR	GO-LR
tow leader	0			
HESE	92			
SHS	142			
HESA	147	148	bird	
ALS	149	287	bird	bird
ALS	299	437	bird	bird
ALS	449	587		
ALS	599	737	bird	bird
ALS	749	887		
LAUM	899	1037		
ALS	899	1037	bird	bird
ALS	1049	1187		
ALS	1199	1337	bird	bird
ALS	1349	1487		
ALS	1499	1637	bird	bird
LAUM	1649	1787		
ALS	1649	1787		
ALS	1799	1937	bird	bird
ALS	1949	2087		
ALS	2099	2237	bird	bird
ALS	2249	2387		
LAUM	2399	2537		
ALS	2399	2537	bird	bird
TES	2549	2687		

Table 2.4.1. Details of streamer configuration. HES: header stretch section; SHS: armoured header section; ALS: active section; LAUM: power and signal modules; TES: tail stretch section.

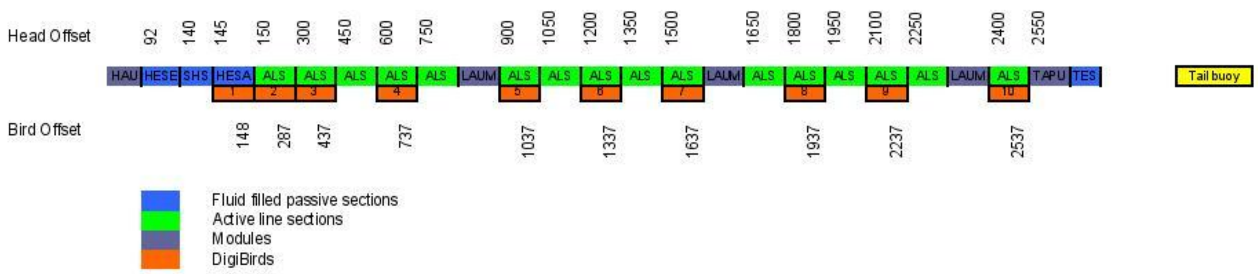


Figure 2.4.3 streamer configuration

The streamer depth is controlled by 9 birds for profiles GO-LR and 10 birds for profiles GO-MR, magnetic compasses were not requested so were not fitted, a passive tail-buoy was also supplied. The streamer towing depth for the low resolution profiles is 8 m (GO-LR-01 to 07 and 13) then was deepened to 10 m (GO-LR-08 to 12 and 14). The weather encountered during the second leg was variable, most profiles were recorded at the design depth but the streamer was towed deeper to try to avoid swell breakout noise, also occasionally the ship speed dropped below the expected 3.75 knots, at these slow speeds the birds were ineffective to control the streamer depth and the depth range exceeded the +/- 1 m specification (GO-LR-09 and GO-LR-13). For the multi-resolution survey the cable had to be towed at a shallow depth to avoid loss of the high-frequency part of the spectrum this causes some loss of low-frequency response. for GO-MR-01, 01.1 and 02 the target depth was 3m, GO-MR-03 to 07 the target depth was 5m.

Absolute Time and Positioning
Differential GPS was not available in the region and during the time of the cruise, nevertheless raw GPS was of excellent quality (standard deviation of the antenna within 2 meters). Because of the use of autonomous recorders (OBH) and 2-ship operations determination of absolute time was imperative. Exploration Electronics Ltd provided an independent GPS receiver “Verif-i” linked to their shot control box to log the exact shot instant. The original idea was for the time string to trigger a position fix from the navigation system and both these parts of information were to be passed back to the seismic data logger to be recorded in the relevant trace header. This was abandoned as too difficult, for reasons explained below, and instead the data was logged by on-board data-logging system (Techsas) though the files are difficult to decipher. The “Verif-i” GPS receiver provided a time-stamp string that started with the carriage return character so the log file reads:
“time of shot n” “location of shot n+1”
“time of shot n+1” “location of shot n+2”
....
This offset could have been sorted by post processing except for spurious triggers inserting a random number of extra lines between each true shot so the true time and location data were dislocated from each other. We also had a backup logger (Meinberg) provided by IFREMER that was triggered by the shot pulse and just recorded a time stamp. These data were used with the raw ship navigation data to derive the navigation for the profiles.

A detailed diagram of relative timing triggers is shown in figure 2.4.4.

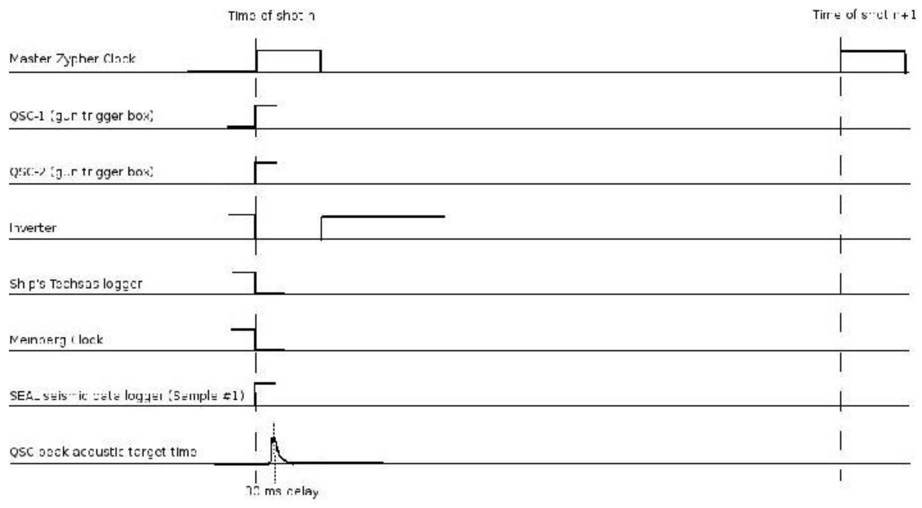


Figure 2.4.4. Timing. NB peak acoustic energy is 30ms after time zero on seismic record. Also for flip-flop operations (GO-MR) QSC-1 was set to trigger on odd shot numbers and QSC-2 was set to trigger on even shot numbers.

Source receiver Positioning
There were no compasses on the depth control birds so streamer feather was estimated by the bridge when the the tail buoy could be sighted (lack of radar reflector made it difficult to track using radar). The absolute source positions are evaluated by interpolating the GPS logged by the ship every second after editing the raw GPS data to remove spikes and offsets between the various GPS antennas (partly caused by location on ship and partly caused by using different constellations of satellites). Lacking reliable feather data it was decided to back-project the relative location along the ship track at the time of each shot. The accuracy in source and receiver positions is believed to meet the expected standards, i.e. a positioning accuracy better than the final processed bin size (6.25

metres). This is probably not correct and will be tested during the processing by the pre-stack migration algorithm with any errors being manifested as an error or uncertainty in the velocity model.

All the raw source location data was loaded into a spreadsheet to monitor average shot spacing and its standard deviation.

Acquisition parameters. See table 2.4.2, below.

Nominal shot spacing	20 m
Sample frequency	1kHz
Mean time delay (firing/peak acoustic output)	30 ms
Shot spacing	20 s for GO-LR lines 20 s flip-flop for GO-MR lines (40s interval between either source)
Recording Length	18000 ms
Source depth	nominal 8 m for GO-LR and GO-MR 'flop' shots nominal 4 m for GO-MR 'flip' shots
Streamer depth	8 m for lines GO-LR-01 to 07 and 13 10 m for lines GO-LR-08 to 12 and 14 4 m for lines GO-MR-01 to 02 5 m for lines GO-MR-03 to 07
Distance from source to 1st trace	84 m for GO-LR, GO-MR 'flop' shots 84 m for GO-MR-01 and 01.1 'flip' shots 100 m for GO-MR-02 to 07 'flip' shots

Table 2.4.2. Summary of acquisition parameters.

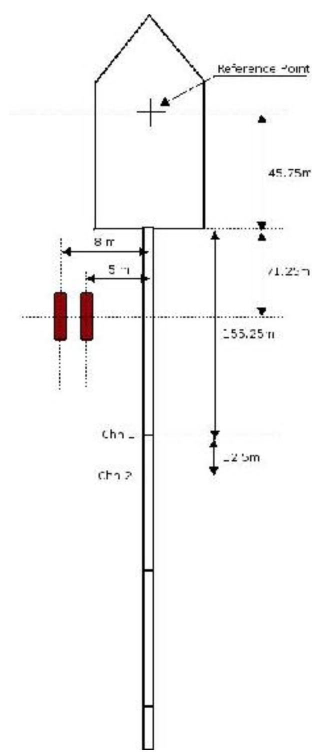


Figure 2.4.5a. acquisition geometry for profiles GO-LR-01 to 14 and GO-MR-01 and 01.1. Total streamer length 2400 m (192 channels).

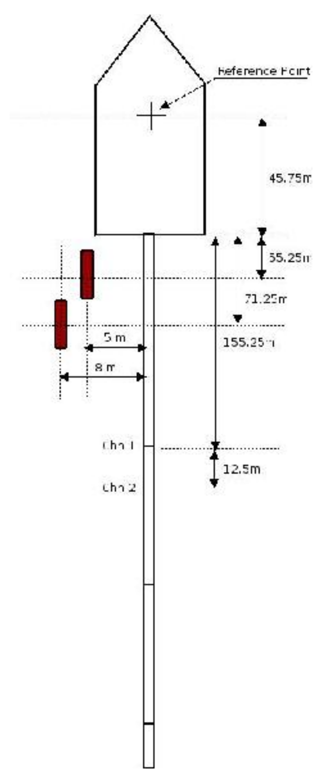


Figure 2.4.5b acquisition geometry for profiles GO-MR-02 to 07. Total streamer length 2400 m (192 channels).

Details on the streamer are summarized as follows :

- Section arrangement
  - group interval : 6.25 m
  - Section length : 150 m
- Group arrangement
  - 16 hydrophones/channel
  - spacing : 0.625 m, linear, non overlapping
- Group Capacitance
  - nominal value (20°C, 1 bar) : 128 nF
- Low cut frequency :
  - nominal value (20°C, 1 bar) : 2 Hz
  - slope : 6 dB
- High cut frequency
  - nominal value (20°C, 1 bar) : 0.8 Nyquist
- Group Sensitivity
  - Nominal value (20°C, 1 bar) : 17.4 V/bar

Profile	Start Date	Start Shot	End Date	End Shot	Mean Shot Int (m)	Standard Deviation (m)	Remarks
VSP-1	30/04/07 00:03		30/04/07 17:30				Circling Poseidon
GO-LR-01	01/05/07 13:27	100	02/05/07 05:55	2520	50.39	3.11	Weather deteriorating
							Downtime due to weather
GO-LR-02	03/05/07 09:59	100	03/05/07 13:07	662	38.46	1.58	
							Turn
GO-LR-03	03/05/07 16:46	100	03/05/07 19:34	604	38.31	1.34	
							Turn
GO-LR-04	03/05/07 21:53	100	04/05/07 01:23	728	39.07	2.30	
							Turn
GO-LR-05	04/05/07 05:07	100	05/05/07 06:42	4707	38.55	2.28	EOL d/t SEAL error
GO-LR-06	05/05/07 07:17	100	05/05/07 14:31	1401	37.01	2.90	
							Loop
GO-LR-07	05/05/07 18:46	100	06/05/07 02:08	1426	42.79	3.49	
							Turn
GO-LR-08	06/05/07 07:32	100	06/05/07 14:57	1434	41.84	3.17	
							Loop
GO-LR-09	06/05/07 19:23	100	06/05/07 20:56	380	39.03	1.88	Repeat section
							Loop
GO-LR-10	06/05/07 22:53	100	07/05/07 01:30	571	39.38	1.81	repeat section
							Loop
GO-LR-11	07/05/07 03:13	100	07/05/07 07:17	831	38.58	2.28	repeat section
							Loop
GO-LR-12	07/05/07 09:37	100	07/05/07 18:00	1607	38.03	2.61	repeat section
							Turn
GO-LR-13	07/05/07 19:23	100	08/05/07 03:02	1478	38.57	2.11	
							Turn
GO-LR-14	08/05/07 05:36	100	08/05/07 10:34	980	42.38	2.16	
VSP-2	08/05/07 18:07		09/05/07 06:00				Circling Poseidon
							Recover Moorings
GO-MR-01.0	10/05/07 18:41	100	11/05/07 08:24	4210	24.87	2.03	Gun buoy lost recover
GO-MR-01.1	11/05/07 09:47	100	11/05/07 11:14	653	25.37	2.64	flip source only
TEST2	10/05/07 13:56	100	10/05/07 14:13	261			Change tow configuration
							Turn
GO-MR-02	11/05/07 15:12	100	11/05/07 17:46	870	24.43	1.32	
							Turn
GO-MR-03	11/05/07 20:44	100	12/05/07 05:37	2736	27.36	1.66	high noise (us fleet sonar?)
							Loop
GO-MR-04	12/05/07 08:49	100	12/05/07 14:02	1665	26.00	1.35	
							Turn
GO-MR-05	12/05/07 15:00	100	12/05/07 20:06	1630	25.26	1.78	
							Loop
GO-MR-06	13/05/07 00:53	100	13/05/07 20:50	574	30.05	3.52	
							Loop
GO-MR-07	13/05/07 04:07	100	13/05/07 06:01	556	34.28	2.05	repeat section

Table 2.4.3. Profile acquisition details

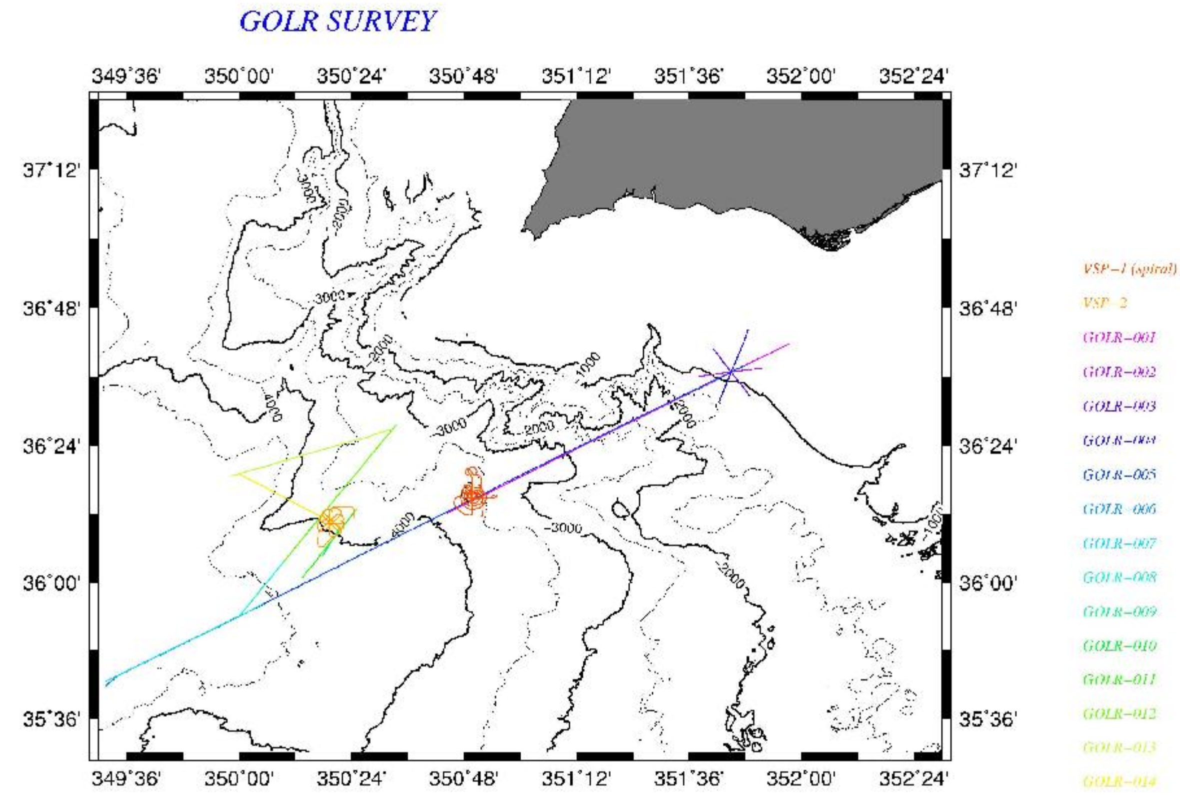


Figure 2.4.6 Map of profiles acquired – prefix GO-LR-

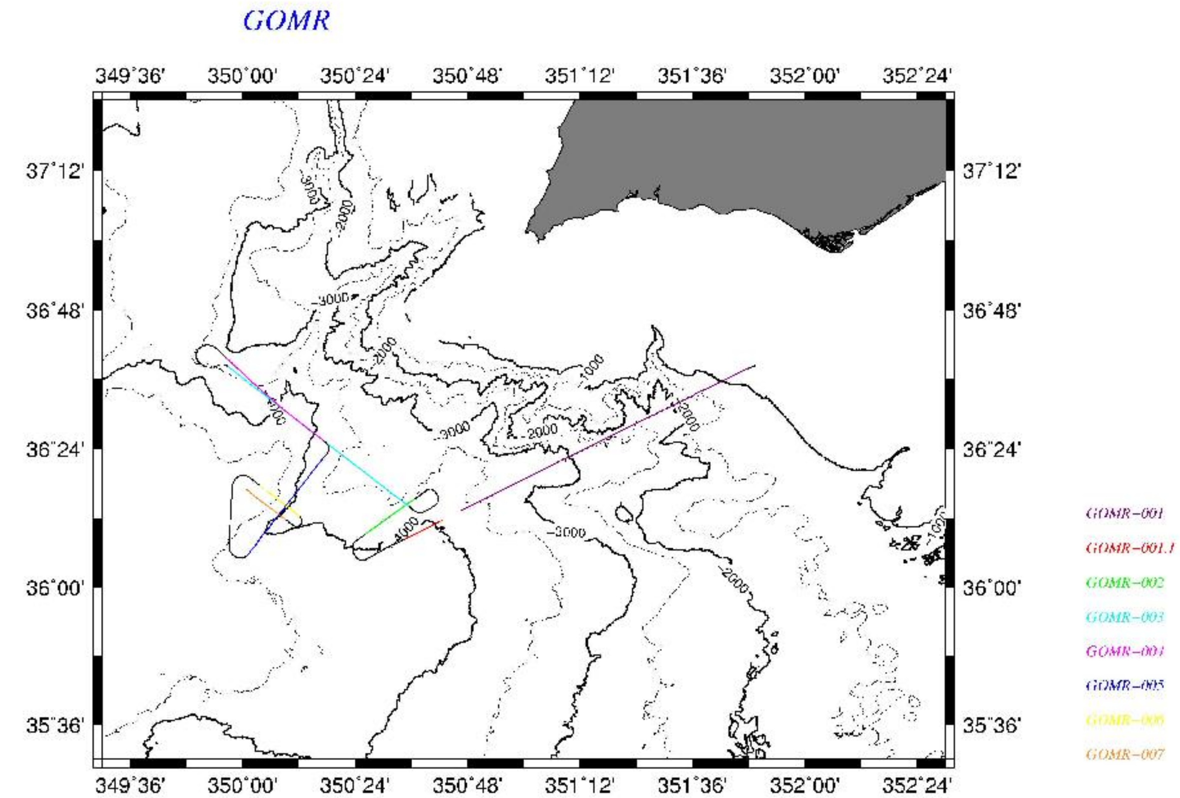


Figure 2.4.7 Map of profiles acquired – prefix GO-MR-

2.5 On-Board seismic data processing

Report by Dirk Klaeschen (IFM-Geomar)

GO-Leg 318a - Seismic Data Processing GO-HR-01 to GO-HR-31
The HR- seismic data was transferred manually by ftp from the acquisition computer system to the quality control (QC) computer system. The transferred data were multiple shot files in segy-format . The geometry was already included with shot-receiver distance, and cmp numbers binned to 6.25m. The data were not frequency filtered. All data are originally corrected for a time delay of 23ms except profile GO-HR-13, here a time shift of -23ms must be additionally applied. Further the navigation of GO-HR-13 shows a gap in the latitude and longitude stored the trace headers, but not in the cmp and shot point numbering.

The QC processing steps included:

- splitting the continuous segy-file into individual shot-gather files
- balancing traces by subtracting the mean (de-bias)
- 100 ms taper at the start of traces to zero to avoid frequency filter artifacts
- zero phase Butterworth bandpass filter with: 5 Hz low cut stop band, 50 Hz low cut pass band, 250 Hz high cut pass band and 375 Hz high cut stop band
- gain correction multiplication of data by t
- calculation of source receiver distance in m*100 (original in the header offset only integer values in meter)
- static shift for velocity reduction of 1525 m/s calculated from offset in m*100 and with sample rate /8 and applied (sustatic only shift in ms which is not accurate enough)

Direct water wave removal:

- 9 trace mix-filter application and the mix result stored as temporary trace
- calculation of a scaling factor between the originally trace and the mixed trace with in 60 ms smoothed sliding time window. The mixed trace is scaled by the scaling factor with a maximum factor of 3 and a minimum factor of 0.005 in the centre of the sliding window to fit the originally trace and subtracted.
- removal of the static shift from the velocity reduction.

Noise reduction (1 iteration) by time variant scaling:

- 5 trace mix-filter application and the mix result stored as temporary trace
- calculation of a scaling factor between the originally trace and the mixed trace with in 120 ms smoothed sliding time window. The originally trace is scaled by the scaling factor with a minimum factor of 1/300 and a maximum factor of 1 in the center of the sliding window.
- near offset top mute at channel number (channel 1 near trace): 1,2,3,72 at times: 0.15,0.15,0,0 s

Stack:

- merge all single shot-gather and sort into cmp-gather
- removal of gain correction multiplication of data by t and application of gain correction multiplication of data by sqrt t (to avoid noise in the weak signal for long travel times)
- nmo based on offsets in m*100 with a constant velocity of 1510 m/s and a stretch mute of 3.5
- trace normalisation by rms in a time window of 0 – 0.9s
- cmp-stack

All the processing is made with Seismic Unix (SU) and shell script programming.

A data example of the processing steps is shown in figure 2.5.1. A shot-gather is with uncorrected times, with water wave time correction (lmo – linear move-out), and nmo (normal move out) is depicted in unprocessed (raw) and processed (proc) sequence respectively.
The raw data is dominated by the water wave and noise traces from the birds of the streamer. After water wave removal shallow reflections become more visible and the noise reduction of the traces

eliminated strong amplitudes events from the birds. The nmo-corrected show the wave reflections in almost horizontal alignment.

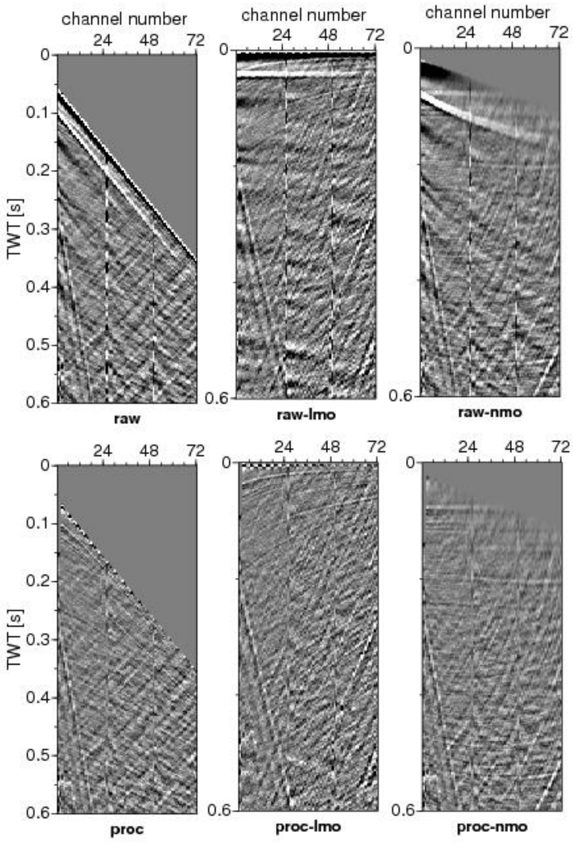


Figure 2.5.1: raw and processed GO-HR shot gather with different dynamic corrections.

Data examples of the Profiles

- Crossing the moorings

The mooring station area were crossed by GO-HR-08 and GO-HR-10, fig 2.5.2. A strong thin reflectivity band at 0.8s document the top of the MOW. The crossing point on GO-HR-08 with GO-HR-10 is at cdp 1841 and on GO-HR-10 with GO-HR-08 at cdp 1665. The time difference of shooting at the crossing point is 4h 30min.

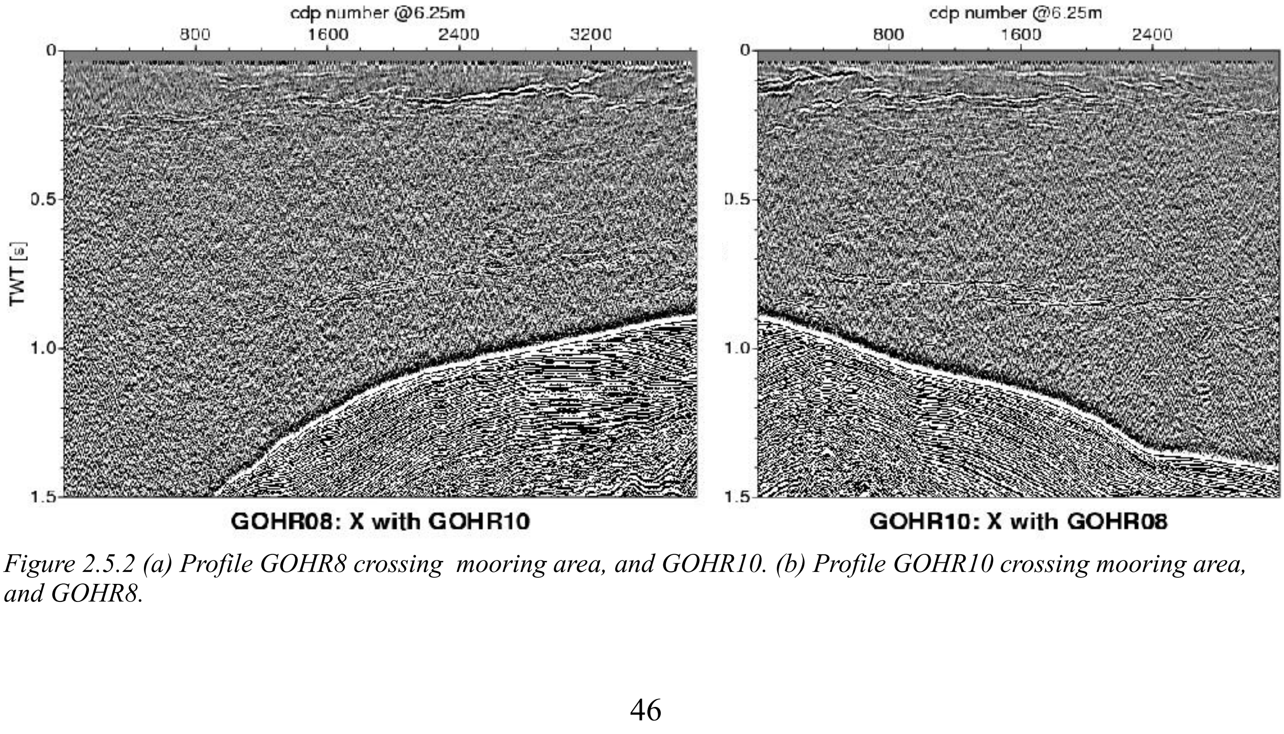


Figure 2.5.2 (a) Profile GOHR8 crossing mooring area, and GOHR10. (b) Profile GOHR10 crossing mooring area, and GOHR8.

● Time variant repeats

The profiles GO-HR-15 and GO-HR-17 in fig 2.5.3 were repeated in reverse direction. This results in a time variant repeat so that GO-HR-15 at cmp 672 and GO-HR-17 at cmp 202 had a time difference of only 30 min. At cmp 3061 on GO-HR-15 and cmp 2602 on GO-HR-17 the time difference was 3 hours. The main structure is the same but the reflector positions and shape even moved in a time period of 30 min.

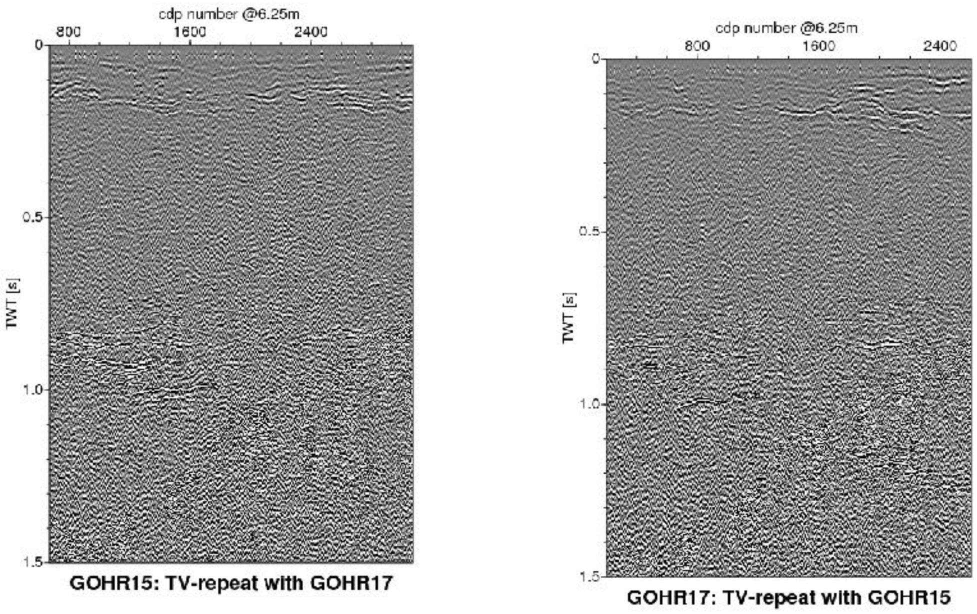


Figure 2.5.3 (a) Profile GOHR15 with time variant repeat to GOHR17. (b) Profile GOHR17 with time variant repeat to GOHR15.

● Constant time repeats

The profile GO-HR-13 and GO-HR-31 (fig. 2.5.4) were shot in the same direction resulting in a constant time repeat of 13 hours. It can been clearly seen that structure and the shape changed significantly the position.

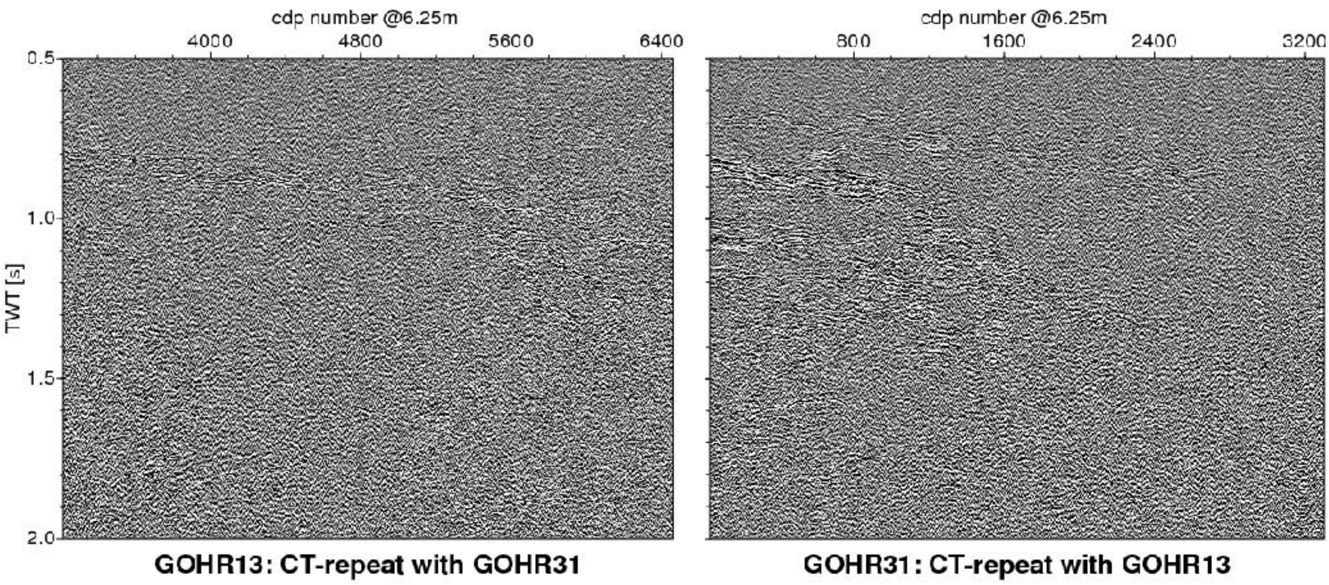


Figure 2.5.4 (a) Profile GOHR13 with constant time repeat to GOHR31. (b) Profile GOHR31 with constant time repeat to GOHR13.

The profiles GO-HR-18, GO-HR-22, GO-HR-26, GO-HR-30 (fig 2.5.5) have a constant time repeat of 3hours 30min. Whereas GO-HR-13 in fig 2.5.6 has a time repeat of 13 hours relative to GO-HR-30 in fig. dk11. All sections show that the fine structure change as well the big scale structure which may be driven by oblique transported MOW and tidal movements .

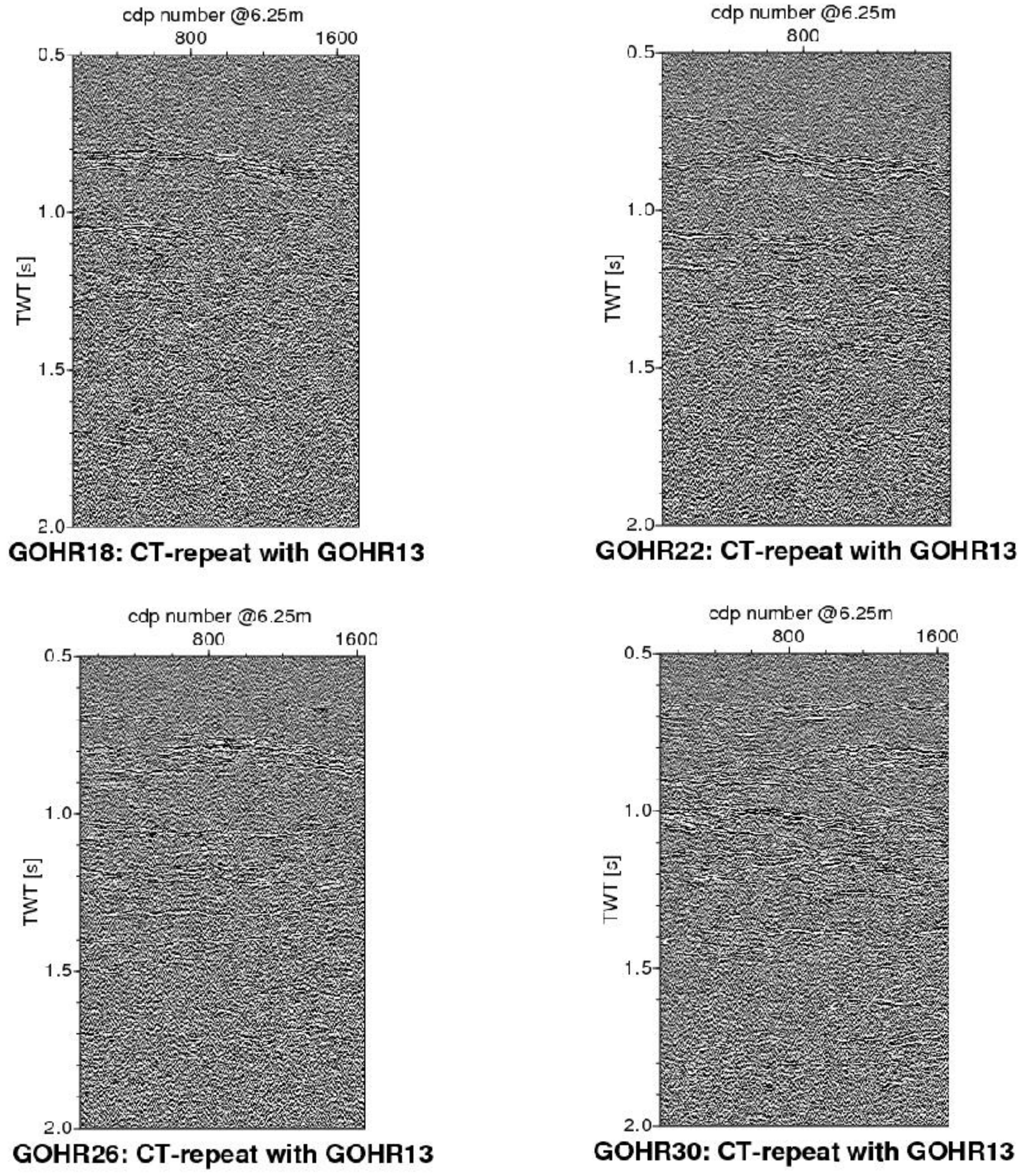


Figure 2.5.5 (a) Profile GOHR18 with constant time repeat to GOHR13. (b) Profile GOHR22 with constant time repeat to GOHR13. (c) Profile GOHR26 with constant time repeat to GOHR13. (d) Profile GOHR30 with constant time repeat to GOHR13.

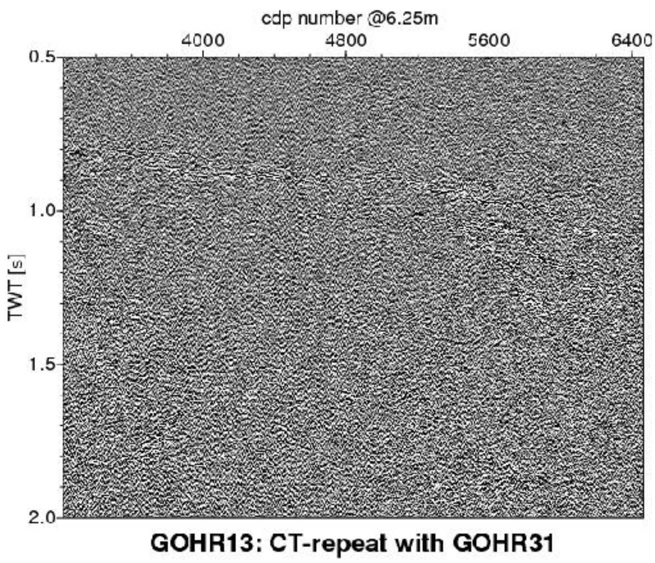


Figure 2.5.6 Profile GOHR13 a constant time repeat to GOHR31.

GO-Leg 318b - Seismic Data Processing GO-LR-01 to GO-LR-14

The LR- seismic data was transferred automatically from a SUN- acquisition system to a windows pc. The disk from the windows pc was mounted to the QC processing computer. All the shots arrived nearly online for processing. The transferred data were single shot files in segd-format. The shot times, related to the time of the acquisition computer were stored in the segd headers. The online stacks had a binning of 6.25m and an ideal constant shot point distance was assumed based on the predefined ship speed. After finishing a profile a mean average shot point distance was calculated of the real navigation to re-stack the profiles. The raw data were not frequency filtered. All data are not corrected for a time delay of 30ms therefore a time shift of -30ms must be additionally applied. To get online stacks three shell scripts were running in the background all the time. The scan_segd.sh program scanned the data arriving to the disk and made a master list with the directory path , the file name and a sequential arrival counter. The proc_segd.sh program was reading the master list and processed each shot individually based on the sequential counter (computation time approx. 6 sec). If no more data was on the disk, the proc_segd.sh program waited until new data arrived. The third program stack_su.sh made a stack of predefined cmp-width (4800cmps approx every 2 hours, 1200 cmps approx. 30 min). If not enough data were processed from proc_segd, the program was waiting until enough data was ready to produce a stack with 200 cmps overlap to avoid edge artefacts. If no more data arrived for the actual profile in a predefined time window, a new profile was assumed the old profile completed , and scanned the location and name of the new profile.

The QC processing steps included:

- reformatting into segy-file with a modified version segdread within SU
- geometry definition of streamer and gun position (see notes below)
- balancing traces by subtracting the mean (de-bias)
- 100 ms taper at the start of traces to zero to avoid frequency filter artefacts
- zero phase Butterworth low cut filter with: 4 Hz low cut stop band, 8 Hz low cut pass band
- gain correction multiplication of data by t
- calculation of source receiver distance in m*100 (original in the header offset only integer values in meter)
- static shift for velocity reduction of 1520 m/s calculated from offset in m*100 and with sample rate /8 and applied (sustatic only shift in ms which is not accurate enough)

Direct water wave removal:

- 9 trace mix-filter application and the mix result stored as temporary trace
- calculation of a scaling factor between the originally trace and the mixed trace with in 60 ms smoothed sliding time window. The mixed trace is scaled by the scaling factor with a maximum factor of 3 and a minimum factor of 0.005 in the center of the sliding window to fit the originally trace and subtracted.
- removal of the static shift from the velocity reduction.

Noise reduction (1 iteration) by time variant scaling:

- 5 trace mix-filter application and the mix result stored as temporary trace
- calculation of a scaling factor between the originally trace and the mixed trace with in 240 ms smoothed sliding time window. The originally trace is scaled by the scaling factor with a minimum factor of 1/500 and a maximum factor of 1 in the center of the sliding window.
- near offset top mute at channel number (channel 1 near trace): 1,2,3,12,14 at times: 1.5,1.0,0.5,0.3,0.0 s
-

Stack:

- application of the static shift for water wave reduction
- trace normalisation by rms in a time window of 0 – 0.5s
- removal of the static shift from the velocity reduction.
- removal of gain correction multiplication of data by t and application of gain correction multiplication of data by sqrt t (to avoid noise in the weak signal for long travel times)

- nmo based on offsets in m*100 with a constant velocity of 1495 m/s and a stretch mute of 3.5 for the on-line stack and time variant velocity application for the re-stack with profile averaged shot point distance (see notes below)
- merge all single shot-gather and sort into cmp-gather
- cmp-stack

All the processing is made with Seismic Unix (SU) and shell script programming. For further details contact dklaeschen@ifm-geomar.de

Notes:
The streamer gun geometry for the LR survey:
offset from gun to near trace: 85m
offset between channels: 12.5m
number of channels: 192

The averaged shot point distances in meters for the profiles:
GO-LR 01= 50.4
GO-LR 02= 38.4
GO-LR 03= 38.2
GO-LR 04= 39.0
GO-LR 05= 38.5
GO-LR 06= 37.0
GO-LR 07= 42.8
GO-LR 08= 37.0
GO-LR 09= 38.9
GO-LR 10= 39.3
GO-LR 11= 38.5
GO-LR 12= 38.0
GO-LR 13= 38.5
GO-LR 14= 42.5

Time variant velocity application during the re-stack of the profiles:
TWT (s):
0, 0.25, 0.5, 0.75, 1.0, 1.25, 1.5, 1.75, 2.0, 2.25, 2.5, 2.75, 3.0, 3.25, 3.5
Velocity (m/s):
1518, 1515.17, 1512.55, 1510.59, 1510.08, 1511.04, 1512.25, 1513.20, 1513.33, 1512.77, 1512.02, 1511.31, 1510.74, 1510.30, 1510.06

A data example of the processing steps is shown in figure 2.5.7. A shot-gather is with uncorrected times, with water wave time correction (lmo – linear move-out), and nmo (normal move out) is depicted in unprocessed (raw) and processed (proc) sequence respectively.
The raw data is dominated by the water wave and gun bubble pulse. After water wave removal shallow reflections become more visible. The nmo-corrected show the wave reflections up to 2 s in almost horizontal alignment.

Data examples of the Profiles
- Crossing the moorings

The mooring station area were crossed by GO-LR-03 and GO-LR-04, Fig 2.5.8. A strong reflectivity band at 0.7s document the top of the MOW. The crossing point on GO-HR-03 with GO-LR-04 is at cdp 3912 and on GO-LR-04 with GO-LR-03 at cdp 4036. The time difference of shooting at the crossing point is 5h 50min.

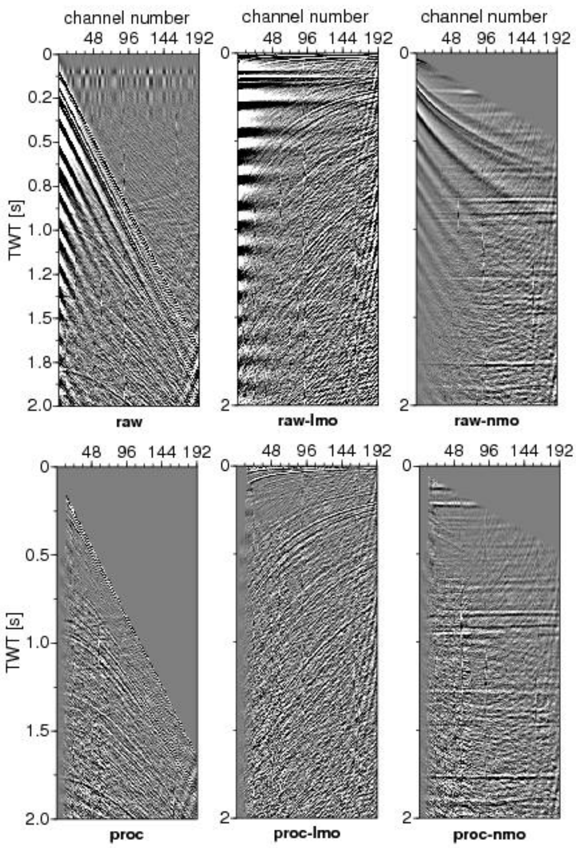


Figure 2.5.7. Raw and processed GO-LR shot gather with different dynamic corrections.

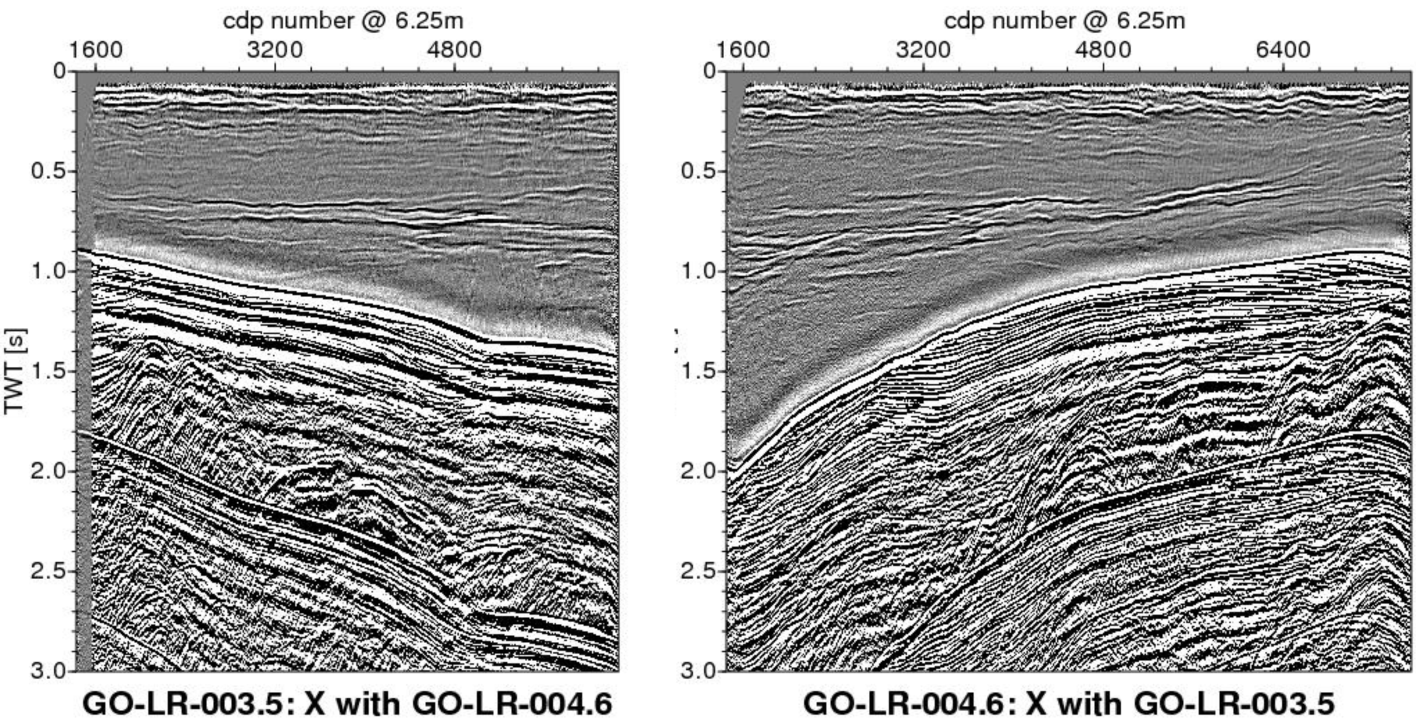


Figure 2.4.8 (a) Profile GOLR3 crossing mooring area, and GOLR4. (b) Profile GOLR4 crossing mooring area, and GOLR3.

- Time variant repeats

The profiles GO-LR-06 and GO-LR-07 in fig 2.5.9 were repeated in reverse direction. This results in a time variant repeat so that GO-LR-06 at cmp 2669 and GO-LR-07 at cmp 4000 had a time difference of 7 hours. At cmp 10669 on GO-LR-06 and cmp 12000 on GO-LR-07 the time difference was 16 hours. The main structure is the same but the reflector positions and shape moved.

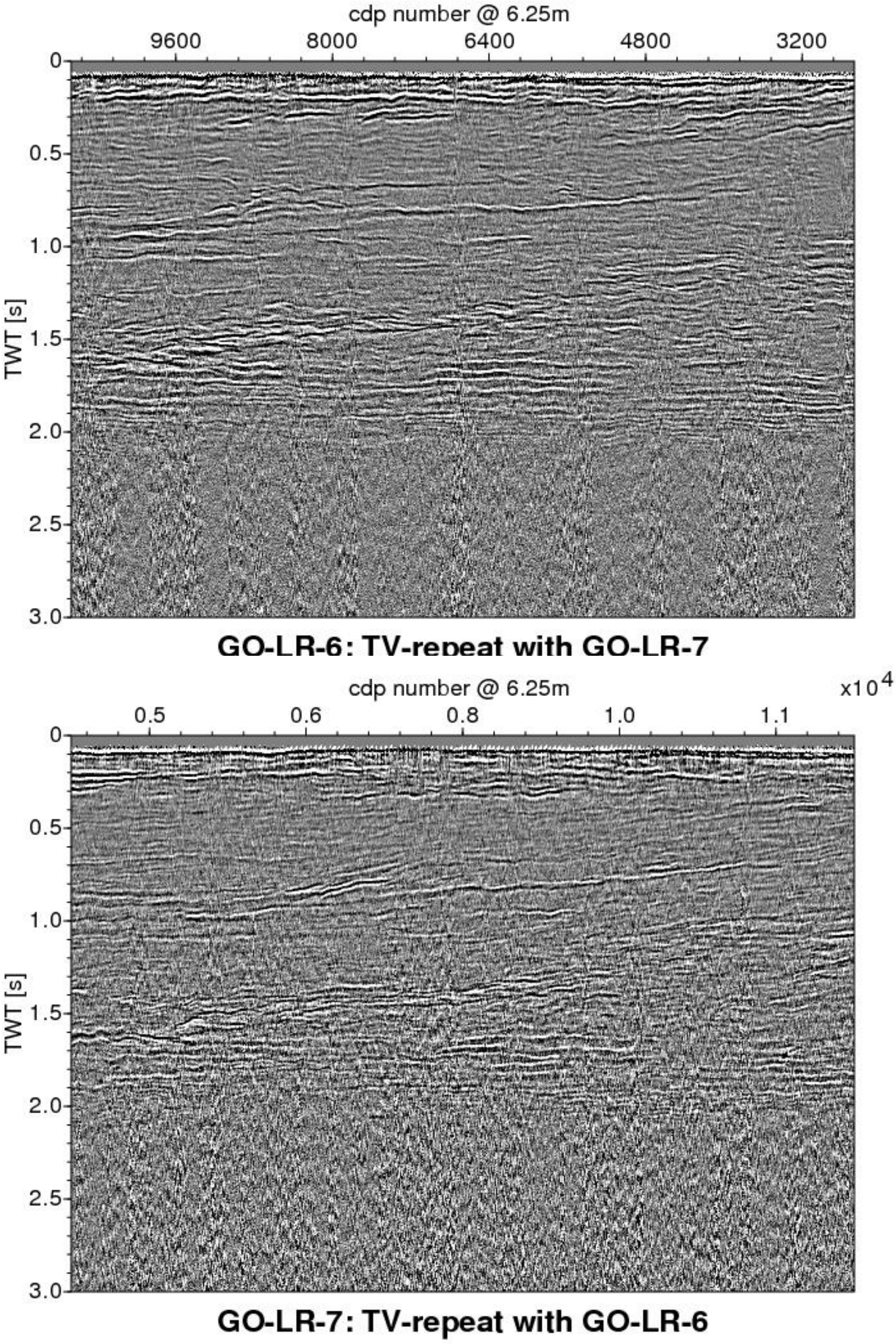


Figure 2.5.9 (a) Profile GOLR6 with variable time repeat to GOLR7. (b) Profile GOLR7 with variable time repeat to GOLR6.

- Constant time repeats

The profile GO-LR-08 , GO-LR-10, and GO-LR-12 (fig. 2.5.10) were shot in the same direction resulting in a constant time repeat of 11 hours between GO-LR-08 and GO-LR-10 and 12 hours between GO-LR-10 and GO-LR-12. It can been clearly seen that the front of the MOW laterally moved and the reflectivity from the inside the MOW changed with a different lateral movement speed. An first estimate of the movement of the MOW front calculates to and average movement speed of 350m/hour or 10 cm/sec which may be biased by additional tidal movements.

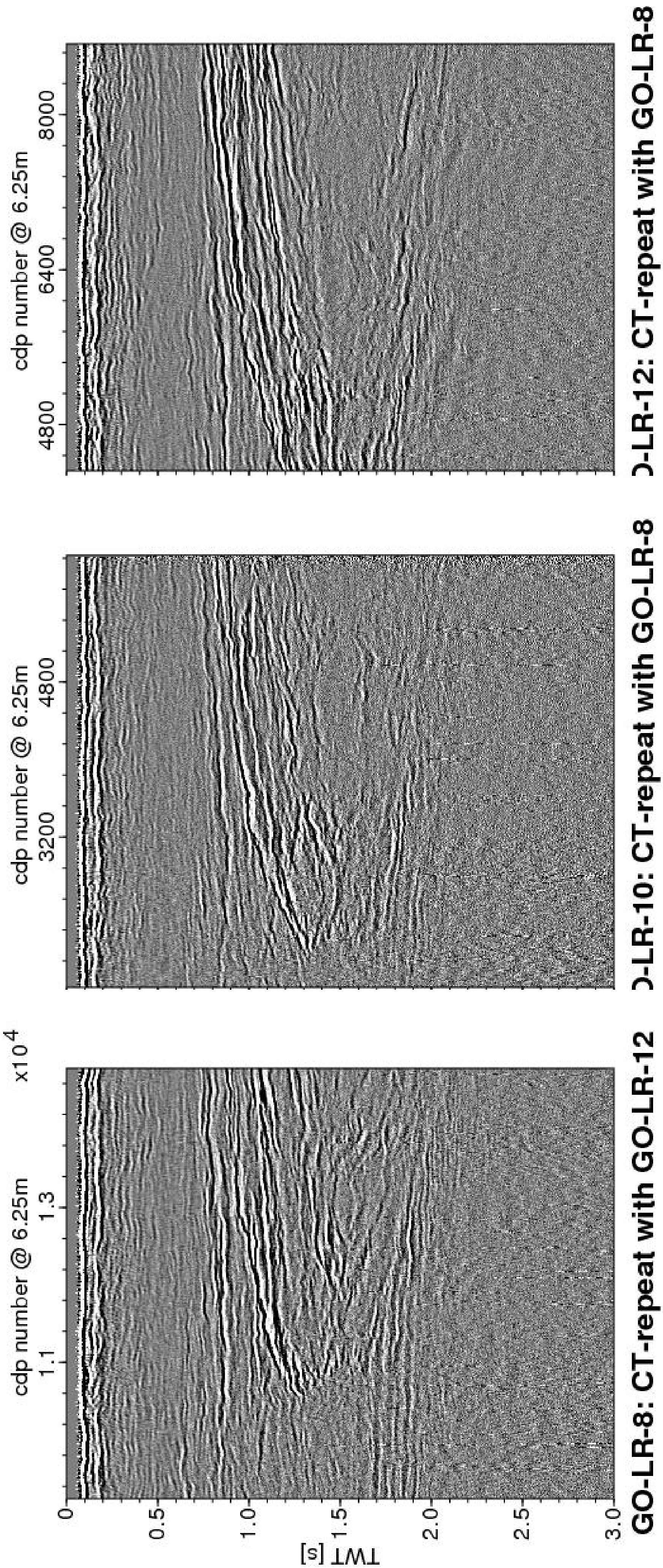


Figure 2.5.10 (a) Profile GOLR8 with constant time repeat to GOLR12 (b) Profile GOLR10 with time variant repeat to GOLR8. © Profile GOLR12 with time variant repeat to GOLR6.

- MOW core

The profile GO-LR-05 (fig.2.5.11) runs in the SE of the working area and cuts a MOW structure which may be a cord of a MOW core. The profile GO-LR-12 (fig.2.5.12a) is a cord running in the NW of the working area and show a more unreflective zone in the center of the MOW. Profile GO-LR-14 (fig.2.5.12b) is crossing GO-LR -12 at cdp 8905 and on GO-LR-12 the crossing point is cmp 6185. The time difference of the two profiles at the crossing point is 21 hours.

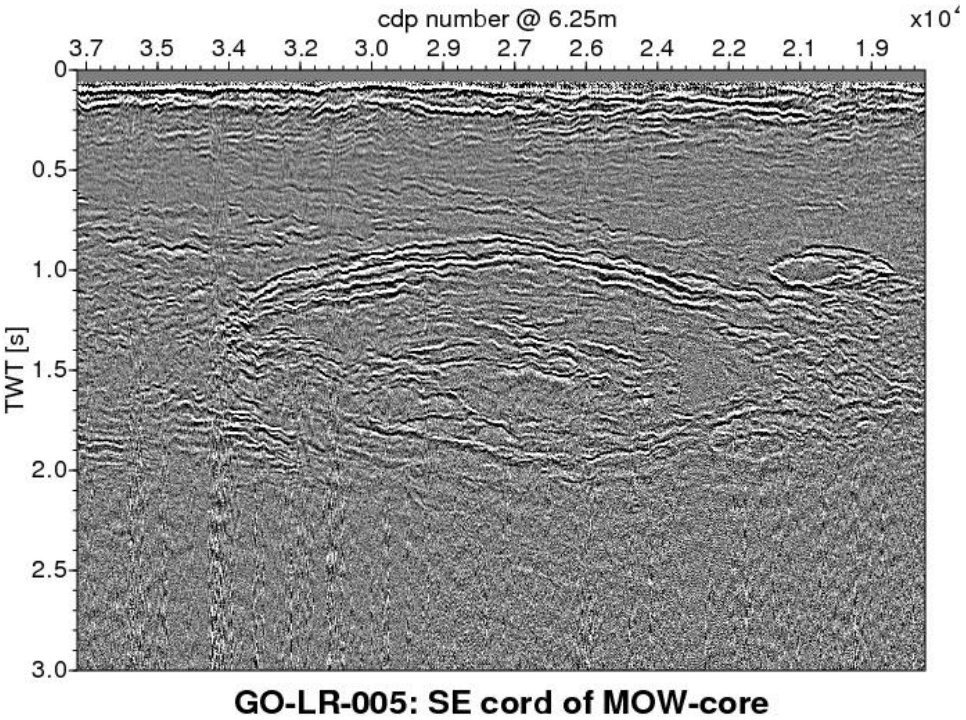


Figure 2.5.11. Profile GOLR5 cross cutting MOW structure in the SE working area.

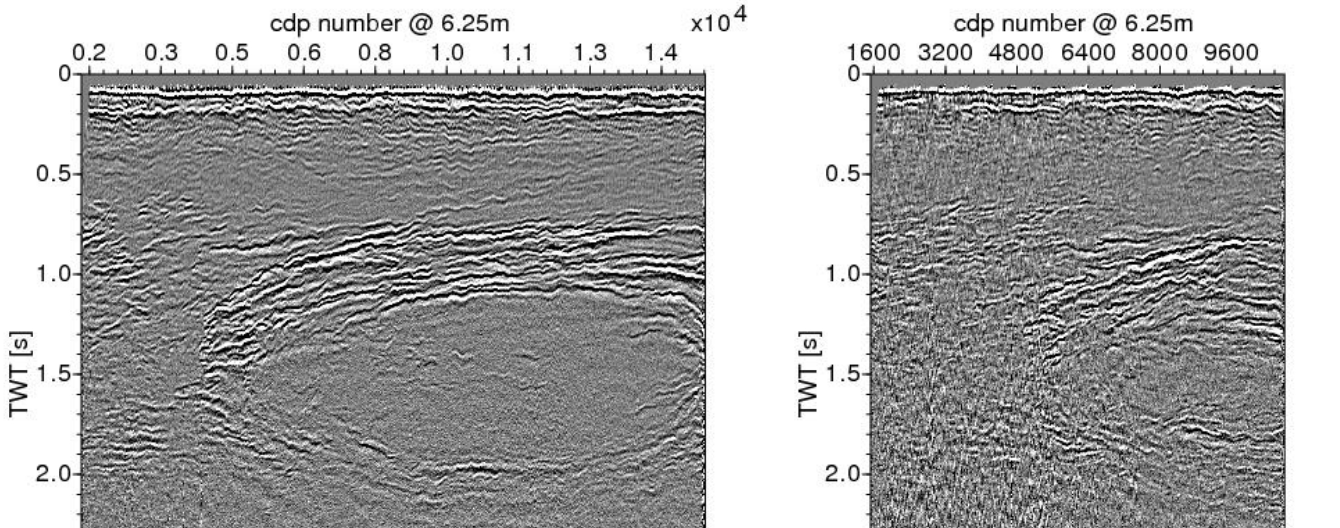


Figure 2.5.12. (a) Profile GOLR12 cross cutting MOW structure in the NW working area. (b) Profile GOLR14 cross cutting MOW structure in the NW working area and GOLR12.

Seismic Data Processing GO-MR-01 to GO-MR-07
The preprocessing for the multi resolution mixed shot array profiles GO-MR was the same as for the GO-LR.
Differences occur in the shot to receiver offset and the shot point spacing. The spacing documented below are average distances for the whole profile and is the distance between the pop of the low resolution gun array and a pop of the medium resolution gun array. An example of the Profile GO-MR-05 is show in fig.2.5.13 and fig.2.5.14 for the small airgun array and the big airgun array respectively.

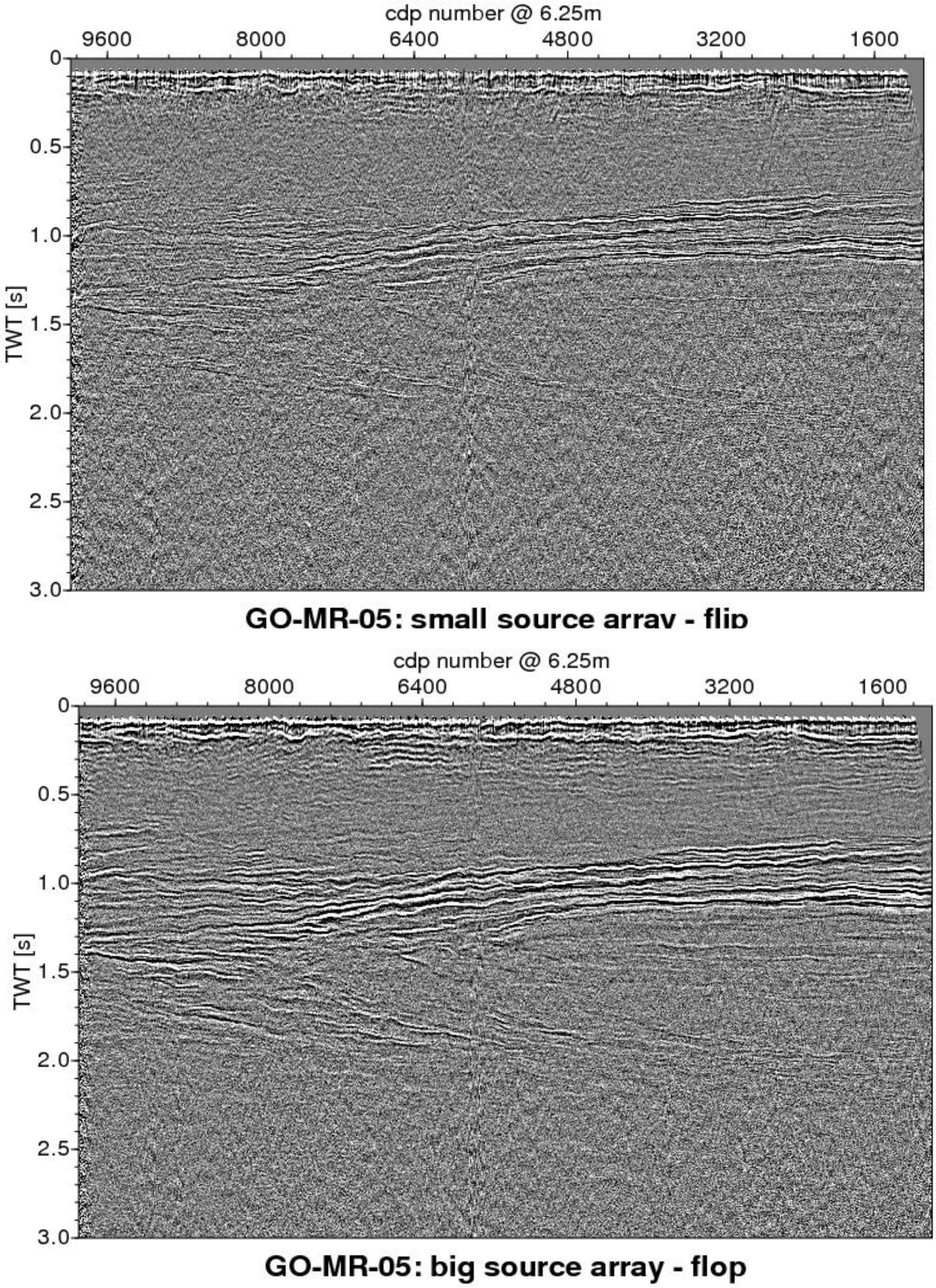


Figure 2.5.13 (a) Profile GO-MRH-005 cross cutting MOW structure with the small gun array - flip
(b) Profile GO-MRL-005 cross cutting MOW structure with the big gun array - flop

The averaged shot point distances in meters for the profiles:
GO-MR 01-1= 25.2
GO-MR 01= 24.8
GO-MR 02= 24.3
GO-MR 03= 27.6
GO-MR 04= 26.0
GO-MR 05= 23.7
GO-MR 06= 34.2
GO-MR 07= 34.2

The flip-flop shooting result in even and odd shot point numbers which contain the lower and higher resolution (MR-L and MRH) information respectively. Below is a listing of the even and odd relation of shot point numbers to MR-L and MRH. During the shooting some times the odd even relation swapped of a short period of time:

GO-MR 01-1: MRH=odd, MRL=even
GO-MR 01: MRH=even, MRL=odd
GO-MR 02: MRH=even, MRL=odd
GO-MR 03: MRH=odd, MRL=even
GO-MR 04: MRH=even, MRL=odd
GO-MR 05: MRH=even, MRL=odd
GO-MR 06: MRH=even, MRL=odd
GO-MR 07: MRH=even, MRL=odd

For the MRH array the offset from the near trace to the guns changed during the survey. Below a listing of the near trace offset for the individual profiles:

GO-MRH 01-1: 85m
GO-MRH 01: 85m
GO-MRH 02: 100m
GO-MRH 03: 100m
GO-MRH 04: 100m
GO-MRH 05: 100m
GO-MRH 06: 100m
GO-MRH 07: 100m

2.6 Underway Oceanographic data (XBT/XCTD)

Report prepared by Patricia De Silva (FFCUL), John Huthnance (POL) and Elise Quentel (UBO); details in Annex 3.

In the D318 cruise we used two different types of Lockheed Martin Sippican expendable probes: the expendable bathythermograph (XBT) probe and the expendable conductivity/temperature XCTD probe. There were two types of XBT probe: the XBT-T5, with a maximum depth of 1830 m and maximum vessel speed of 6 knots; and the XBT-T7, with a maximum depth of 760 m and maximum vessel speed of 15 knots. There also were two types of XCTD probe: the XCTD-1, with a maximum depth of 1000 m and maximum vessel speed of 12 knots; and the XCTD-2, with a maximum depth of 1850 m and maximum vessel speed of 3.5 knots.

The XBT probe measures water temperature verses depth (actually measures time from entering water as proxy for water depth as the decent speed is known). It also calculates and displays sound velocity verses depth, based on the temperature data acquired by the XBT probe, assuming a constant salinity of 35 psu.
The XCTD probe measures both water temperature and conductivity verses water depth (same caveat as above), and calculates and displays the salinity, water density and sound velocity from the temperature and conductivity data acquired initially by the XCTD probe.

In total 496 XBT-T5, 19 XBT-T7, 12 XCDT-1 and 20 XCTD-2 were launched. Most of the XBT used on this survey were old stock held by Qinetiq (British Defence Company) and were out of their calibration date, only one box of 12 XBT-T5 probes showed any corrosion and these where discarded. All the XCTD were purchased specifically for this cruise.

Operation
Trial casts while towing the Ifremer seismic array (air guns and hydrophone streamer) resulted in the XBT wire quickly being carried by the wind and flow astern to contact the towed array. In order to keep the XBT wire further out to the (starboard) side, clear of the towed array, a guide pipe was rigged. This was about 5 m of surplus rubberised tubing; conveniently ~ 6 cm diameter, it just accepted the XBT probe casing. The guide pipe was held fairly straight by taping to a metal bar along its length. One end was lashed to the rear starboard side of the ship; the other was held outboard by the rear starboard crane on full extension; thus the pipe was angled down by about 45º and somewhat astern (Fig 2.6.1). Thereby the lower end of the guide pipe was about 3 m to starboard of the rear of the ship and 1-2 m above the sea surface (in a moderate sea, waves sometimes washed over it). In operation, the XBT casing (mounted in the gun) was positioned in the top of the guide tube; on release, the probe fell down the tube and out into the sea below, away from the line of the towed array. The arrangement worked very well though a number of the longer XCTD probes got stuck and had to be shaken out. Figure 2.6.2 shows the deployment sites used during the survey.

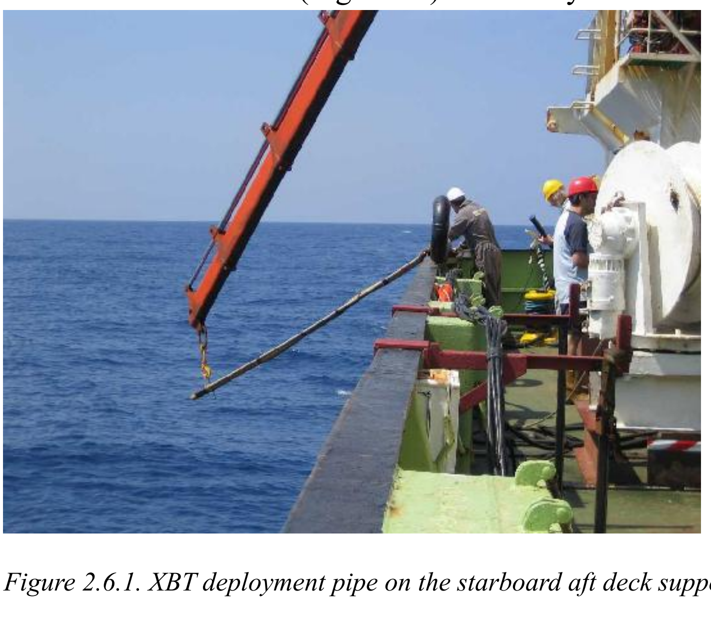


Figure 2.6.1. XBT deployment pipe on the starboard aft deck supported by knuckle crane.

“Production” casts while towing the seismic array were typically every 20 minutes, mostly using T-5 XBTs. During leg-1 an XCTD was cast every 100-120 minutes, during leg-2 this period was longer as CDT control was provided by the *FS Poseidon*. Spikes in XCTD-2 data prompted some longer periods with T-5s only. The T-5s and XCTD-1s performed very well. Indeed, the range of the T-5s was increased (through the Options-Probe menu) to 2200 m with no apparent loss of quality with depth (Figure 2.6.3). Some stations acquired by the XBT probe and with depths greater than the maximum predetermined depth, the temperature profile at water bottom (Deep Atlantic Water) starts to increase slightly for an undetermined reason. However, the CTD data did not show this trend, thus these data are likely not representative of true ocean structures.

The spikes in XCTD-2 rendered some portions of these data too troublesome to use. Ship speed, sea state, the guide pipe and the air-guns were all considered as possibilities but a final trial profile with the ship at rest in excellent conditions still had some spikes, albeit fewer. However, most of the spikes in the temperature and conductivity (i.e. primary data) could be removed by filtering to retain only status 8000 scans. With these filtered data and final editing, clean values of salinity, density and sound speed could be calculated. Some XBT stations that started to measure temperature values before submersion, thus modifying the true water surface temperature and consequently the depth values. Due to this, the data are only considered of good quality after some seconds and when the temperature values began to decrease with depth. This problem was cured by changing the recording system from the 'Plot' to a more modern system in the 'Deck Lab'. Also some stations with sporadic spikes at the surface layer.

Note that at stations with less than the maximum depth predetermined for each type of probe, the acquired data have non-real values at the bottom due to the deliberate break of the probe's copper wire when it reached the ocean bottom. There are several occurrences of accidentally broken copper wire due to wind and/or marine surface current changes. These weather conditions caused the very sensitive and thin copper wire to cross into the area of the seismic equipment, thus breaking the wire and acquiring non-real values at the bottom. A lot of XBT wire was 'recovered' when the 2.4 km streamer was brought on board at the end of the survey.

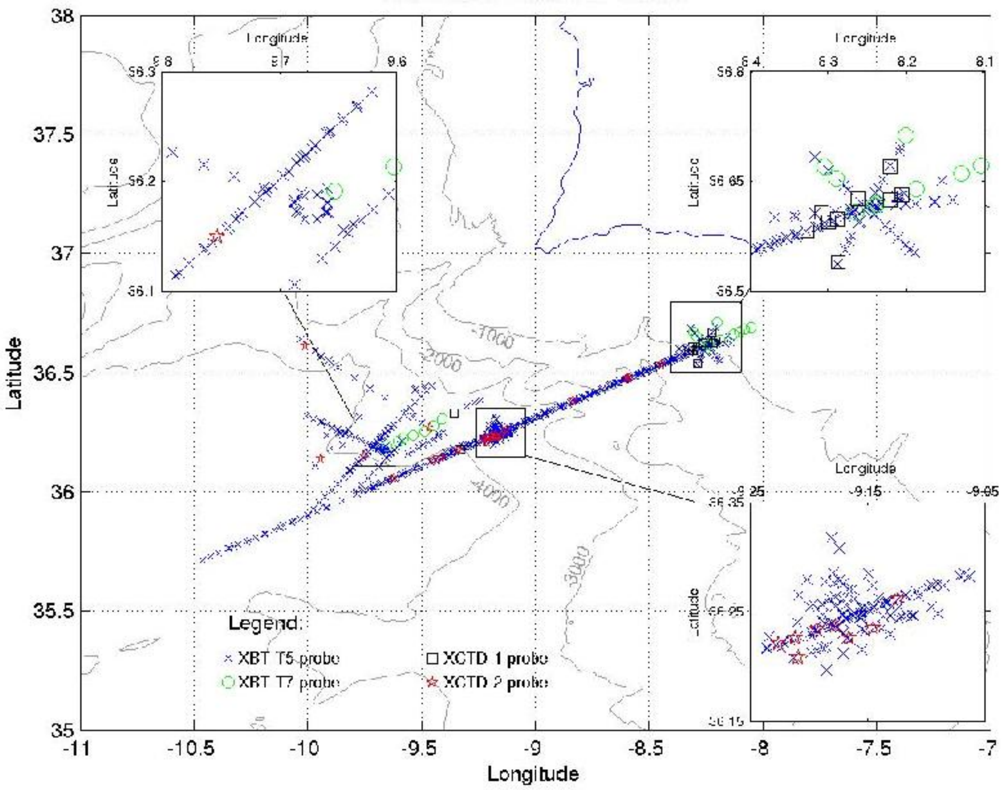


Figure 2.6.2. Deployment map of XBT and XCTD probes

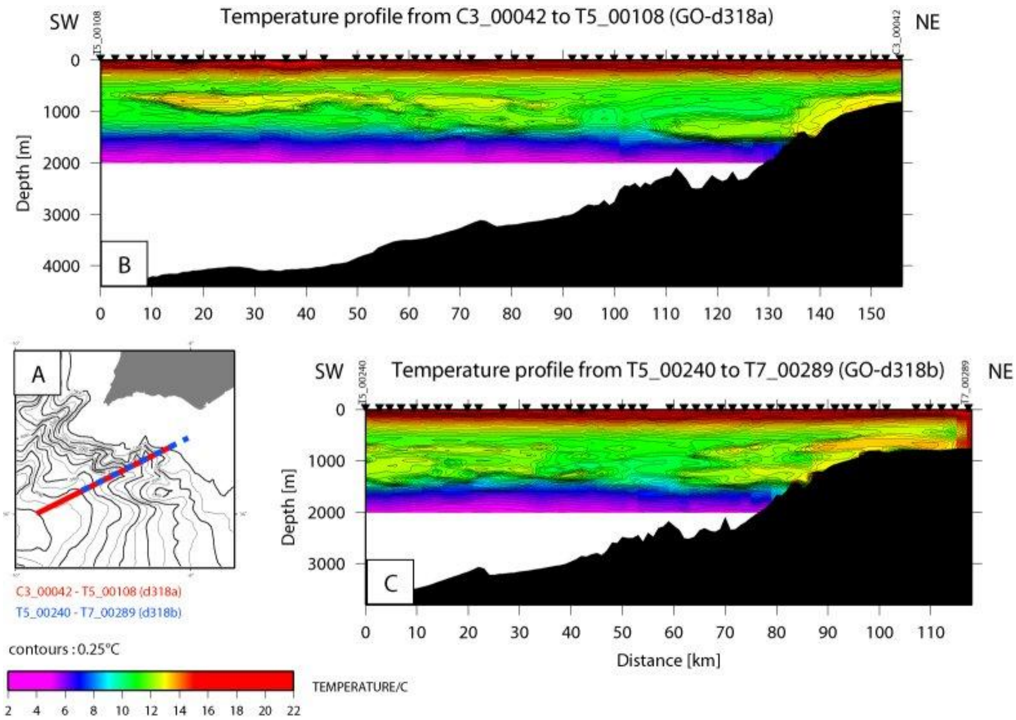


Figure 2.6.3. Temperature sections obtained using data from the XBT/XCTD probes

2.7 Computing and Instrumentation Report

For any further information on this report please contact:

Chris Barnard
341/31 National Marine Facilities
National Oceanography Centre
Waterfront Campus
Southampton
SO14 3ZH
+44(2380) 596383
E-mail: cvb@noc.soton.ac.uk

RVS LEVEL ABC System
The LEVEL ABC system is a system comprised of multiple components that can be adjusted and altered to suit the needs of the cruise in progress. The system is due to be retired due to its age and the difficulty in acquiring spares. The ABC system is created of 3 tiers:

- Level A - The Level A's role in the system is to acquire the data from an instrument, parse the data stream into the necessary format to be recorded by the level B and also place a timestamp on each piece of data. The instruments are connected to the Level A's via RS-232 and are also connected to the level B in the same way. This allows simple interrogation of messages when attempting to track a problem with the system.

- Level B - The level B is sent all data from the Level A's and allows you to view all the data as it is coming in. The Level B allows the backup of the data to magnetic disks which are backed up on the Level C in compressed Zip format. The Level B transmits the data to the Level C and the data is parsed directly into the RVS data files that we use now. All data, errors, comments can be viewed for each individual instrument.

- Level C - The level C system is a Sun Solaris 10 UNIX Workstation discovery1 also known as ABCGATE. The RVS software suite is available on this machine. This suite of software allows the processing, editing and viewing of all data within the RVS data files. This system also has monitors that allow us to ensure that the level C is receiving data from the level B.

The Level A's acquire their timestamp from a Radio code GPS Clock that is distributed via the RVS Master / Slave Clock System.

The ABC system still remains the main data logging format for the ship, this is being run in parallel with the new Ifremer Techsas Sensor Acquisition System. This system is currently being proven and a database of drivers being built to enable us to interface with the instruments on board. This system will then become the primary system for data logging.

For this cruise the Level A system were used to log:

17) Ashtec ADU-2 multi antenna GPS with attitude (gps_ash)
18) Ashtec GPS G12 integral to the FUGRO Seastar DGPS receiver (gps_g12)
19) Simrad EA500 Precision Echo Sounder (ea500d1)
20) NMFD Surface-water and Meteorology instrument suite (surfmet)
21) NMFD Winch Cable Logging And Monitoring CLAM (winch)
22) Chernikeef Log – Ship's speed through water (log_chf)

The RVS level ABC system suffered no major issues during the cruise with the exception of the full loss of power to all ships systems, total loss of data was around 2 hours for most instruments, mainly due to the need to reset almost all devices that are used in the data logging process. During the power outage the computer room clean supply was turned off incase of spiking in order to protect equipment. This was successful and no further damage occurred to the ABC system or the Ifremer Techsas system.

Ifremer Techsas System
The Ifremer data logging system is the system that will inevitably replace the existing Level A + B system while for the most part the Level C will remain as the main system for outputting, viewing and editing the acquired data.

The Techsas software is installed on an industrial based system with a high level of redundancy. The operating system is Red Hat Enterprise Linux Edition Release 3. The system itself logs data on to a RAID 0 disk mirror and is also backed up from the Level C using a 200GB / 400GB LTO 2 Tape Drive. The Techsas interface displays the status of all incoming data streams and provides alerts if the incoming data is lost. The ability exists to broadcast live data across the network via NMEA.

The storage method used for data storage is NetCDF (binary) and also pseudo-NMEA (ASCII). At present there are some issues on some data streams with file consistency between the local and network data sets for the ASCII files. NetCDF is used as the preferred data type as it does not suffer from this issue.

The Techsas data logging system was used to log the following instruments:

1) Trimble GPS 4000 DS Surveyor (converted to RVS format as gps_4000)
2) Chernikeef EM speed log (converted to RVS format as log_chf)
3) Ships Gyrocompass (converted to RVS format as gyronmea)
4) Simrad EA500 Precision Echo Sounder
5) NMFD Surface-water and Meteorology (SURFMET) instrument suite
6) ASHTECH ADU-2 Altitude Detection Unit
7) Marine Magnetics Magnetometer (converted to magnet for RVS format)
8) NMFD Lacoste and Romberg S40 Gravimeter (converted to gravity for RVS format)
9) GPS Synchronizer shot time information

This system is still being trial run by the platform systems as the replacement to the aging RVS system, no major issues occurred during this cruise and no substantial data losses occurred. The data losses that did occur were during the Trails cruise of the Enterprise Electronics SEAL system. At this time we were attempting to create a logging system in order to log their GPS Synchronizer and then pass back data on our location to the SEAL system. The loss of data was caused by an error in the program which was causing it to log the data being parsed through the program for transmission to the SEAL at an alarming rate causing large files to be created. Eventually the system was not able to cope with the file sizes and stopped writing. This only occurred with the NetCDF parsing and so NetCDF was turned off and NMEA data logged only. The system was monitored for the memory leak that plagues this version of the software and was restarted in order to clear the memory and allow logging to continue.

Level A Began on 07105190800
Level A stopped Logging 07134112600

Techsas NetCDF to RVS Data Conversion
During this cruise there is no reliance upon the data provided by Techsas, however it has been included on the data archive in the standard rvs form using a piece of software used to make it compatible with the RVS ASCII data structure. The University of Rhode Island instruments were logged using the Techsas system and had to be converted to the RVS format in order to be able to

create data logs that included multiple variables from other RVS streams.

An in house application was used to handle the conversion of NetCDF files to the RVS format. This was then parsed back to the data file and was processed as normal. These 2 new applications being ncvars and nclistit.

These new binaries require to environment variables in order to function:

$NCBASE – the base for the NetCDF binaries system, set to /rvs/def9

$NCRAWBASE – the base for the raw data files, set to /rvs/pro_data/TECHSAS/D318/NetCDF

The existing $PATH variable must also include the path to the nc binaries, the path /rvs/def9/bin was appended to the $PATH variable.

All Techsas data file names are in the format of YYYYMMDD-HHMMSS-name-type.category with the data/timestamp being the time the file was created by Techsas.

The files were each processed in the following way for this cruise:

nclistit 20060813-000001-gyro-GYRO.gyr - | sed s/head/heading > $DARAWBASE/gyro.225

At this stage the data is converted to the correct format and its header replaced by the header required by the RVS software suite.
Another issue with the conversion of the files to the RVS format is that the top timestamp is always outputted as 00 00/ 00:00:00. The file outputted with nclistit is then edited in VI in order to alter that timestamp to the correct time and day. This is done as it would not be imported into the RVS data format with this timestamp error.

The file is then passed to the titsil application which simply reads the data from the text file that was created and enters it as records in the RVS data file.

cat $DARAWBASE/gyro.225 | titsil gyronmea –

This command reads the gyro.225 file in the /rvs/raw_data directory and passes it to titsil for input in the gyronmea file. The – dictates that all variables will be included.

The TECHSAS system was set to create a new file for each day, however on days when errors occurred multiple files were created as that is normal practice for Techsas when it is restarted.

During this cruise techsas was successfully used to log 3 new sensors bought on board by the University of Rhode Island, after slight tinkering due to differences in data output (lost in translation in e-mail correspondence) the logging procedure began and there were few issues with techsas logging these instruments. Despite having checked the devices cabling and route to the system some confusion at the beginning of the cruise resulted in the 2 of the devices (both Gas Tension devices) being logged by the opposite name. The devices were swapped at the beginning of the cruise and it is now apparent that they should not have been. This is easily rectified using the RVS systems applications.

Fugro Seastar DGPS Receiver
The Fugro Seastar is the source of custom differential corrections based on its position fixed by its internal Ashtec G12 GPS module. It outputs corrections via RS-232 using the standards RTCM message. The message is distributed among all GPS receivers where they are used to compute their own DGPS positions.

The Fugro Seastar functioned correctly throughout the cruise. There have been issues with this system previously not detecting the correct satellites due to location. However in this instance it performed correctly and differential positions were calculated throughout the cruise.

This system will be removed at the end of the cruise due to a need to reprogram the EPROM chip that contains the programming inside the device. This was due to be done earlier in the cruise however time did not allow for that to happen. The overall performance of the device will not be affected however Fugro will no longer be supplying the same message to the unit and each unit must be reprogrammed to function after the end of July of this year.

Trimble 4000 DS Surveyor
The Trimble 4000DS is a single antenna survey-quality advanced GPS receiver with a main-masthead antenna. It uses differential corrections from the Fugro Seastar unit to produce high quality differential GPS (DGPS) fixes. It is the prime source of scientific navigation data aboard RRS Discovery and is used as the data source for Navigation on the ships display system (SSDS)

This device suffered a failure within the first leg of the cruise which was noticed by the science party who were using the Scientific Ships Display System in order to log down the drop points of XBTs. The unit appeared to be in a state of constant reset as it did not seem to complete its power up cycle. This was traced back to the Battery backup that is located within the unit being faulty. A spare has been requested from the ships agent however we were not able to procure a spare in time and so if any blackouts or minor power losses in the comms room had occurred it could have caused data to be lost.

Ashtec ADU-2
This is a four antenna GPS system that can produce attitude data from the relative positions of each antenna and is used to correct the VMADCP for ship motion. Two antennae are on the Bridge Top and two on the boat deck.
The Ashtec system worked reliably throughout the cruise with some gaps that are quite usual with this system due to the amount of calculations necessary. No Large data gaps are present. The ADU-2 forms part of the bestnav system which is an assembly of multiple GPS signals including the gyronmea and emlog stream in order to calculate the best possible position, speed heading pitch and roll of the ship.

The Ashtech lost data during the logout of the Level C, this data was reobtained from the TECHSAS logging system which was programmed to log the ADU-2 during this cruise meaning that nav data was not lost when the Level C failed.

Gyronmea
The Gyronmea is a file that receives its data from the Ships gyro compass located on the bridge. There are two such Gyros on the bridge and we are able to use either one of them as a source of heading. The selected Gyro is logged by the TECHSAS system and is used as part of the bestnav calculation.

Dartcom satellite imaging system.
The dartcom system is able to receive signals from satellites that take images of cloud coverage, these images can be used to see the type of atmospheric and weather conditions nearby. During the power failure of D313 the Dartcom satellite was being automatically controlled by the dartcom HRPT grabbing software. The system is known to be easily damaged while the system has no power and the ships roll can cause the satellite to come crashing down. The dartcom system has not been working correctly since the blackout of D313 and no satellite images have been grabbed since, the issues involved are:

1) Unable to contact the ships network from the controlling pc to gather satellite pass

prediction data.
2) Unable to communicate with the orbit system itself.
3) Unable to receive Gyro Compass information from the vessel.

Following the D313 blackout the Gyrocompass was repaired however still seemed to have issues with the gyrocompass, this was taken to NOC for comparison with our old Charles Darwin system where it was discovered that it may be a damaged card within the dartcom unit. However, not long after the device was returned it began to receive gyro updates. The other issues regarding networking and communication between units were still an issue up until the beginning of this cruise. At this point I removed the dartcom unit from its pedestal and began to trace back the location of the failure. The failure appeared to be coming from a USB connection between the Dartcom PC and Orbit Controller however this was not the case the issue was actually a Network Hub that is mounted in the back of the unit. This was replaced by a temporary hub and the system was able to function as normal. A spare hub was shipped out with the spares for D318B and the unit has now been put in to good working order using the proper components and performed well during the entire 2 legs of the cruise.

RDI Ocean Surveyor 75KHz Vessel Mounted ADCP (VMADCP)
Data from the RDI Ocean Surveyor was logged throughout the cruise and backed up to the /data32 shared data area. The ADCP 75 was setup to follow the settings outlined in the Supply Agreement. These were :
Number of Bins: 100
Bin Size: 8m
Blank After Transducer : 8m
Transducer Depth : 5m
Bottom Tracking : On
Maximum Depth : 700m
Time Between Pings : As fast as possible (5s)
Low Resolution Long Range Processing Mode

This can also be viewed in the command files that were used for both legs of the cruise that are included in the ADCP area of the data archive. The ADCP computer was time synced to the NTP server at the beginning of each leg prior to the commencement of logging.

ADCP 75Khz Time Synced to NTP Clock 07107065200

ADCP 75Khz Logging 07107101820
ADCP 75Khz Stopped Logging 07113065400

ADCP 75Khz Time Synced to NTP Clock 071171233
ADCP 75Khz Logging At 07117123900
ADCP 75Khz Stopped Logging 07134062500

During the D318b it was requested that we attempt to make the ADCP a longer range by increasing the bin size The command file was changed from D318a as usd throughout the cruise to D318b on 07130151700

RDI 150KHz Vessel Mounted ADCP (VMADCP)
Following several difficulties in the previous cruises with this system the transducer head was replaced prior to sailing D317. The ship was attended by a Teledyne RDI consultant who assisted in checking over the setup of the ADCP 150Khz and ADCP 75Khz systems. The transducer had been giving several errors during the cruise which would indicate that the transducer head was damaged. Problems also existed with the PC that was in use. No navigation signals were being received by the unit and the ensemble out would not function. This ensemble out allows the RVS system to grab

data on a 2 minute interval from the ADCP 150Khz system. Following the visit by the RDI Consultant the system was able to handle both navigation input and ensemble output. However that seems to have now changed once more. The ADCP 150 is still receiving the GPS messages and still has the setup within its file to handle the data however it does not seem to function correctly. This appears to be a fault in the way that the VMDAS software is handling the navigation or possibly the comm ports. The system was logged without navigation to the local hard disk and also to the RVS Level C where it can be concatenated with the navigation data. This system is due for upgrade next year during the 2008 dry dock.

ADCP Settings
Number of Bins: 100
Bin Size: 8m
Blank After Transducer : 8m
Transducer Depth : 5m
Bottom Tracking : On
Maximum Depth : 700m
Time Between Pings : As fast as possible (5s)
Low Resolution Long Range Processing Mode*
No option for this as it is a narrow band system this is the default mode.

The ADCP computer was time synced to the clock before logging began. Due to the age of the system it is not possible to use an NTP service. The clock is synced through visual comparison to the ships GPS display.

ADCP 150Khz Time Synced at 07107065500

ADCP 150Khz Logging 07107064920
ADCP 150Khz Stopped Logging 07113065400

ADCP 150Khz Time Synced at 071171241
ADCP 150Khz Logging At 071171242
ADCP 150Khz Stopped Logging 07134062500

Chernikeef EM log
The Chernikeef EM log is a 2-axis electromagnetic water speed log. It measures both longitudinal (forward-aft) and transverse (port – starboard) ships water speed. The EM log was not calibrated prior to the cruise and was reading at -0.8 knots astern when alongside (-0.8 knots). The system was logged by the TECHSAS logging system and also the RVS Level A system. Data loss of the log_chf occurred during the Logout of the Level C this data was recovered from the TECHSAS logging system in order to remove the gaps from the data.

Simrad EA500 Precision Echo Sounder (PES)
The PES system was used throughout the cruise, with a variation between use of the Fish and use of the hull transducer. The hull was used for the trials cruise and the PES Fish was put out during most of D318a and D318b. The PES outputs its data to a stream called ea500d1 on the RVS System and is also logged by the TECHSAS System.

PES System Turned On 071070627
PES 10Khz Fish in water 071071045
PES 10Khz Fish on board 071121500
PES System turned off 07113065859
PES System Reactivated 07117124159
PES 10Khz Fish in water 071191900
PES 10Khz Fish aboard 071330920

PES Stopped Logging 07134072304

Surfmet System
This is the NMFD surface water and meteorology instrument suite. The surface water component consists of a flow through system with a pumped pickup at approx 5m depth. TSG flow is approx 25 litres per minute whilst fluorometer and transmissometer flow is approx 3 l/min. Flow to instruments is degassed using a debubbler with 40 l/min inflow and 10/l min waste flow.

The meteorology component consists of a suite of sensors mounted on the foremast at a height of approx 10m above the waterline. Parameters measured are wind speed and direction, air temperature, humidity and atmospheric pressure. There is also a pair of optical sensors mounted on gimbals on each side of the ship. These measure total irradiance (TIR) and photo-synthetically active radiation (PAR).

The Non Toxic system was enabled as soon as we were far enough away from land. It was also turned off for the return to Lisbon and then reactivated as we left on the trials cruise.

Surfmet receiving good water flow: 07107080000
Surfmet Non Toxic Off: 07112212600

Surfmet Non Toxic Good Flow: 07 117 1257
Surfmet Non Toxic Off: 07 133 150400

The Transmissometer and Fluorometer were cleaned at the end of the previous cruise. During which time the system was turned off. The System was then flushed with Fresh Water which remained in the system until the Non Toxic Supply was made available.

Salinity samples were taken on a daily basis while the Non toxic supply was taken, on average 2 samples a day were taken for calibration of the TSG. For Times and Salinity Values Please see the Excel Sheet in the D318/Salinities folder

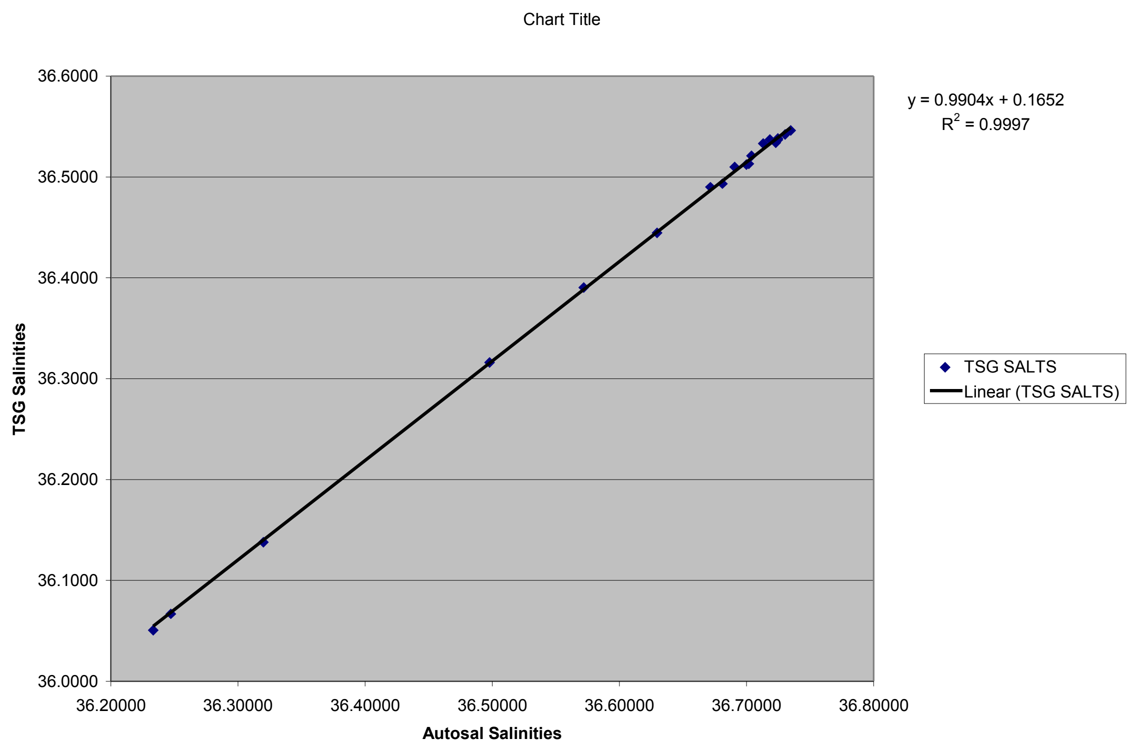


Figure 2.7.1. Salinity calibration for pumped surface water

The data here shows a good standard trend for all data points used. Some data points were removed due to them affecting the regression. This amounted to a small number of points and indicates a bad sample. The TSG shows that it is reading quite a bit higher salinity value than the autosal samples done.

Meteorological Instrumentation

Measurement	Wind Speed	Spec : Range 0.4-75m/s, output: 0-75m/s = 0-750Hz, Accuracy: +/-0.17m/s^2
Manufacturer	Vaisala	
Model N^o	WAA151	

Measurement	Wind Direction	Spec : Range: 0-360^o, output: 6bit parallel grey code
Manufacturer	Vaisala	
Model N^o	WAV151	

Measurement	PAR	Spec : Range 350-700nm output depends on sensor, (see cal sheet), Accuracy: +/-5%
Manufacturer	ELE	
Model N^o	DRP-5	

Measurement	TIR	Spec : spectral Range 335-2200nm (95%) irradiance 0-1440W/m^2, Sensitivity 9-15uv/W/m^2
Manufacturer	Kipp & Zonen	
Model N^o	CM 6B	

Measurement	Temp & Humidity	Spec : Temp, -20 - +60^{o}C, accuracy at 20^{0}C, +/-0.4^{0}C Humidity, 0-100% RH Accuracy, +/-4%
Manufacturer	Vaisala	
Model N^o	HMP45	

Measurement	Barometric Pressure	Spec : Range 800-1060mbar, Accuracy at 20^{o}C : +/-0.3mbar
Manufacturer	Vaisala	
Model N^o	PTB100A	

Surface Sampling

Measurement	Housing Temperature	Spec Range:-2 - +32^{o}C, accuracy: +/-0.003^{o}C, res:0.0001^{o}C Stability: +/-0.0005 ^{o}C
Manufacturer	FSI	
Model N^o	OTM	

Measurement	Remote Temperature	Spec Range:-2 - +32^{o}C, accuracy: +/-0.003^{o}C, res:0.0001^{o}C Stability: +/-0.0005 ^{o}C
Manufacturer	FSI	
Model N^o	OTM	

Measurement	Conductivty	Spec : Range 0.4-75m/s, output: 0-75m/s = 0-750Hz, Accuracy: +/-0.17m/s^2
Manufacturer	FSI	
Model N^o	OCM	

Measurement	Turbidity	Spec : Range 0-100% or 90-100%, Output: 0-5vdc Or -5 - +5vdc Accuracy: 0.1%
Manufacturer	Seatech	
Model N^o	20cm	

Measurement	Fluorescence	Spec : Output ∞ emitted light at 685nm Output: 0-+5vdc
Manufacturer	Wetlabs	
Model N^o	WETStar	

Table 2.7.1 Meteorological Instrumentation

CASIX PCO2 System
This system is an autonomous pCO2 system developed by PML and Dartcom. I am not entirely sure of the full details of this and so Im not going to pretend like I do for fear of being incorrect. I advise that you contact Nick Hardman-Muntford at PML for information.
The system was run at the same time as the Surfmet system.

PCO2 Turned On 07 107 091000
PCO2 Turned Off 07 112 212900

PCO2 Turned On 07 117 130300
PCO2 Turned Off 07 133 150500

Marine Magnetics Magnetometers
These magnetometers were first used this cruise and had previously never been deployed. The computer system was setup in the deck lab at the beginning of the cruise and following on from some shortness of cable issues the system was deployed over the port crane. On the first deployment the system was not functioning well and no communication with the magnetometer was possible. It was found after some checking with the spare system that the deck unit had somehow become blocked and power cycling the deck unit fixed the problem. I did not do this during deployment as I was unsure how it would affect the magnetometer while in water. The magnetometer was redeployed on Leg A following work on the Ifremer streamer. The magnetometer maintained good communications during this deployment and was logging for 2 days with excellent signal quality.

Magnetometer Logging 109 09:06
Magnetometer Stopped Logging 110 08:53

Magnetometer Logging 110 10:58
Magnetometer Stopped Logging 112 11:56

The magnetometers first deployment included a navigational feed which, following the failure of the Old XBT system was removed and used for the new XBT software that was installed on the same PC.

Gravimeter
During the cruise we also logged the Lacoste and Romberg S40 Gravimeter. The gravimeter was loaded during the D317 Mobilisation where it appeared to have many issues with the Gyro 200Hz Power Supply. The unit remained on board and had its Power Supply swapped out during the D318a Mobilisation. At this time the unit started up correctly however for an unknown reason the screen is displaying Interrupts on a very high basis. It does not seem to be regular and the Interrupts can very on the amount received. An attempt was made to rectify the situation by swapping the Data Input card that communicates with the Gravimeter; however nothing seems to have changed. The data however is logging as it should to the TECHSAS system and to the System Hard Drive, whether the hard drive log is recording the interrupts in its files will remain to be seen. 3 Base Station Tie Ins were conducted during the cruise, 1 at mobilization, 1 at D318a/b port call and one at the end of D318b. It should also be noted that at the end of the cruise I noticed that there was a time offset with the gravitymeter clock being around 40 – 50mins higher than GMT. This is not present in the data from the TECHSAS system as the time from the gravity meter is ignored. It is best to use this data however the TECHSAS data does not have the first 2 days data or base station tie in and some post processing will be required to correct this error.

3.5Khz Octopus System
This system was setup at the beginning of the cruise and run on the first leg in order to attempt to see data in the water column. This however did not seem to work. The Sweep Delay was altered and

controlled by the scientists. The output was saved to an external drive mounted on discovery2ng and then backed up to LTO. The output was also printed to the Raytheon Printer.

Valeport Sound Velocity Probe

During the first CTD Casts on Leg A the Sound Velocity Probe was placed on to the CTD frame in order for the scientists to compare the sound velocity data from the probe against the one on the CTD. This was done on the first 5 casts where both Datasets where comparatively similar. The first casts data from the SVP was irrecoverable after I attempted to rename the file. It would appear that the rename function lost signal with the SVP during the operation and the name became corrupted, leading to it not being able to be downloaded. The SVP was on board the CTD for the next 4 casts and worked as expected during each cast. After a comparison was established and both proved similar the SVP was removed and stowed.

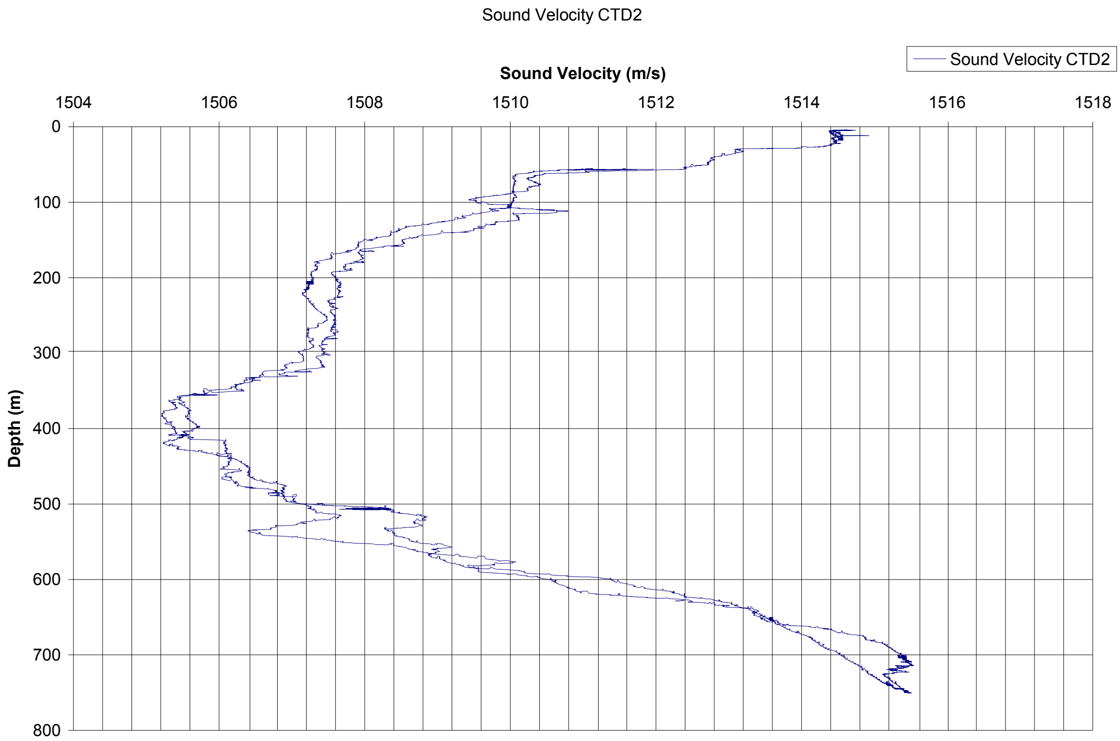


Figure 2.7.2. Velocity probe vs derived velocity from CTD data

XBT System

The XBT's were used at the discretion of the science party to deploy around 400 XBT T-5's and also several XCTD 1's and 2's. We began leg A using the old Sippican system that is installed in the plot. This system is a computer containing a serial card able to communicate with the XBT Launcher. Following several varied firing methods with this system it began to pre trigger XBT's before they hit the water and so the new system was installed on the same computer as the Maggie. This system has no card to be installed in the PC and is instead a deck unit that simply has a USB interface to the computer. Following some rewiring of the cable to the interface box the system remained stable throughout the cruise. An issue was noticed upon resarting the software. The software would be closed however upon on reloading the software it would not have access to the serial ports. This was due to the software running in the background despite the GUI having closed down. The fix was to either kill WinMK21.exe in the Task Manager or perform a system reboot. Each method worked as well as the other.

The science party modified some files in order to remove inconsitencies within the naming and sequence numbers of the probes. A file was created in the XBTNew folder under D318b in order to show these changes as well as some files that include all the nav data of where the XBT's XCTD's were conducted.

Shot Times
A Sensor module was developed to log the shot times from the GPS Synchronizer that was provided by Exploration Electronics during the second leg, D318b. Several attempts to log this correctly failed for 2 reasons. 1) The NetCDF format of saving this data seemed to create inordinately large files and so NetCDF saving was disabled. The second problem was that due to TECHSAS's handling of messages is based on the NMEA messaging system which the GPS Synchronizer is not capable of producing. The issue was attributed to the position of the Cursor Return Line Feed characters which was at the start of the line and not at the end. Techsas would not parse the data until 1 shot after the data had been received. Creating an offset of 1 shots length in the files. The output files currently contain The time that TECHSAS received the <CR><LF> characters, The Time of the shot previous to the current shot, the Nav at the point Techsas received the <CR><LF>. In the end the data was logged with this offset however we were unable to transmit the data back to the SEAL system for inclusion in the header due to its offset causing issues within the file. Extensive Post Processing will be required to rectify this situation.
Shot time data was recorded via an Ifremer system used on D318a, this system was able to provide shot times to us that we were able to manipulate using a simple VB program and then add the data to the RVS system. The data was then added with nav using the addvar program and the data set was returned to the science party for plotting.

Network Services
The Network ran well throughout the cruise for all users attached via a fixed IP address. During the D318a port call a communications system to the FS Poseidon was setup that would be used on D318b, this system was connected through the ships network. When communication between RRS Discovery and RV Poseidon was established computers requesting DHCP addresses were not always able to access the network. This was due to some users being issued with IP Addresses that were coming from the FS Poseidon's DHCP server. There were two methods of solving this issue. One was to issue Static IP addresses and the other to block the communication port on the gateway that was allowing DHCP traffic to leave the ship. The first method was introduced as the second would have taken a much longer time to arrange and would have possibly not solved the problem as were unsure at the time whether the gateway was the laptop communicating with Poseidon or the Antenna itself.

Wireless network
Previous known network issues had been addressed prior to the cruise allowing the existing system to continue to work uninterrupted. Wireless worked throughout the cruise where available.

E-mail system
The email system worked fairly well for the entire length of the cruise. Some issues occurred with large files being moved through the system causing timeouts of the satellite link. These issues were addressed and no problems with the email service arose.

Data Storage
Two USB external hard drives are being use as a RAID 0 mirror hosted by Discovery3 at the /data32 export. The mirror uses the modern meta device commands available in Solaris 10. This increases storage robustness by providing another layer of redundancy at the online storage level. The maintenance and administration of the disk set is minimal and the performance more than adequate.

All cruise data except for the /rvs path were stored on this storage area. Access was given to scientists to some of the folders via Samba shares.

Level C data was logged to the discovery1 internal disk, Techsas backs its data to here under /rvs/pro_data/TECHSAS and also stores it on its own internal raided drive array.

Data Backups
Daily backups of the Level C data was done as a tar file to DLT tape. The following paths were included in the tar file:

/rvs/raw_data
/rvs/pro_data
/rvs/def7/control
/rvs/users

In addition to the redundancy provided by the RAID 0 pair, daily backups of the /data32 directory were done by a level tar of the file system to the LTO 2 tape. The whole disk was backed up not just current cruise data.

The LTO2 system was backed up on a daily basis in a rolling 2 tape system.

Data Archiving
The proposed data archive will consist of the following components.

- All CTD data
- All LADCP and VMADCP data
- All TECHSAS NMEA and NetCDF data files
- ALL RVS Data Streams
- All Magnetometer Data logged via TECHSAS and SeaSpy
- All Gravimeter Data logged internally and Via TECHSAS
- All XBT Data (RDF and EDF) logged by each system.
- All Moorings data from ADCP's and miniloggers.

All data was written to DVD with 4 copies made.
1 copy for BODC
2 copies for PSO
1 copy for RRS DISCOVERY
1 copy for return to NOC

Cruise Site
During the cruise a website was produced in order to display images, videos and information regarding the cruise and the activities that were to occur and the weather that was to come. The site was hosted using apache on the discovery2ng package server.

The sites address was http://discovery2ng.discovery/d318/

The site can be used elsewhere however it was created using a proprietary software package available on the Mac OS X. The software is called Rapid Weaver available from RealMac software.

GPS Positions

Antenna Name	Distance From Stern	Height above Water Line	Distance From Centre of ship –P +S
ASHTECH ADU-2 GPS Antenna 31 (21)	64.35m	9.9 bottom 12.21m top	-3.45m
ASHTECH ADU-2 GPS Antenna 4 (22)	64.35m	9.9 bottom 12.21m top	3.45m
ASHTECH ADU-2 GPS Antenna 2 (23)	51.65m	14.9 bottom 12.21m top	-3.45m
ASHTECH ADU-2 GPS Antenna 1 (24)	51.65m	14.9 bottom 12.21m top	3.45m
Trimble 4000 DS (28)	45.75m	23.6m	-1m
Meinberg GPS Clock	35.05m	7.76m bottom 11.03m top of antenna	-1.52m
GPS Synchronizer (Verif'i)	23.85m	8.68m	4m
Zyfer Clock	22.90m	7.1 bottom 9.21 top	6.4m
Meinberg Steatite NTP SERVER (ATTACHED to 24)	51.85m	12.10m top	-3.45m

Table 2.7.2 GPS Antenna Positions

2.8 Ship to Ship Communications

During leg D318b *RRS Discovery* was working with *FS Poseidon*. *FS Poseidon's* role was to run CDT casts behind *RRS Discovery*, launch XBT, deploy and recover OBH and act as a receiver for VSP surveys.

UT was used as a common time base and as the OBH and FS Poseidon recorded data autonomously it was imperative that the shot-point time was logged with sufficient accuracy (better than 1 ms).

Agreeing track changes and survey plan was done through VHF radio link on the bridge of both vessels. This ensured the ship's officers were party to the discussions. Planning and day-to-day discussions were done through a dedicated computer on RRS Discovery that was part of the FS Poseidon network over a VHF radio link using 'WinTalk' software. The link also made transfer of documents, maps, seismic sections and other pictures relatively easy as a SAMBA shared folder could be set up so that data transfer was as simple as a 'drag 'n drop' operation. Though in practice it would take several minutes for large files to transfer as the radio link speed was range dependant. The VHF aerial on *RRS Discovery* was mounted on the railing of the Monkey Island over the bridge with excellent 360 deg coverage. However, the aerial on the *FS Poseidon* was mounted in front of the bridge which meant the link was only operational when *FS Poseidon* was behind *RRS Discovery*. This was not a major issue as this was the normal configuration but it did lead to 'dead' periods during the VSP operation.

Minor irritation with the system was *FS Poseidon* DHCP server would 'see' all requests from computers on *RRS Discovery* and occasionally a computer would be linked to the wrong network. This was fixed by assigning static IP addresses.

3 Performance and Recommendations

3.1 Equipment Performance

In general the ship, ship systems and scientific equipment all worked well. Though a number of issues had to be dealt with during the cruise (mentioned in the proceeding reports and summarised here) and a number of other issues have been found during the initial reduction of the data.

- 2.1 CTD and related operations
  - failure of the CTD data logger; replaced by spare no impact on science plan;
  - spikes on data, tracked down to damaged cables thought to have been caused by inappropriate handling on a prior cruise by pulling connectors apart holding the cable not the plug; replaced minor impact one cast aborted and a second with spikes;
  - problems with LADCP, again tracked down to be a cable problem, replaced; minor impact on science;
  - Valeport sound velocity probe lost data on one cast, this was for calibration purposes only; no impact on science.
- 2.2 Moorings
  - No issues with deployment or recovery.
- 2.3 High Resolution Seismic
  - major issue here with deployment of airgun beams using IFREMER supplied davits, davits were not set close enough to the stern so on launch beams were drawn under ship; quickly solved by running cable through pulleys on aft knuckle cranes; minor delay but no significant impact on science;
  - voltage of IFREMER compressor not compatible with ship supply, this was sorted prior to cruise and they used NMF containerised compressor already on ship; no impact on science.
- 2.4 Low resolution Seismic
  - floatation arrangement on beams is not adequate to ensure correct tow depth at all towing speeds, for all of the survey the beams were sub-vertical suspended by single buoy at far end of beam; could be tolerated but will impact on science as it lost some high-frequency data;
  - failure of ram on port aft beam due to corrosion, replacement was fabricated and dispatched to meet ship at Faro just prior to start of D318b; no impact on science but could have been a major problem if replacement ram had not worked;
  - streamer winch needed extra clearance from deck to operate with a 2.4 km streamer, this was fabricated at Lisbon; no impact on science;
  - insufficient personnel to operate seismic recording system 24/7; Exploration Electronics supplied 2 people but it was necessary to train a NMF technician to help stand watches;
  - major issue with logging shot instant and location; in theory Exploration Electronic supplied GPS clock linked to ship navigation system should have provided direct navigation, in practice this had sequencing and false triggering issues which made the system practically useless; fortunately backup system provided by science party (IFREMER) worked flawlessly logging timestamps only and it required 4 man-months to construct the final navigation data; this had a significant impact on science;
  - no radar reflector on streamer tail buoy; streamer feather had to be estimated by bridge as tail buoy was not reliably detected on radar; some impact on science as exact streamer geometry has had to be estimated which will effect resolution of data;
- 2.5 Online data processing
  - worked well though fragile as it largely depended on a single member of the science party.
- 2.6 underway oceanography
  - failure of original data logging computer in 'Plot' early in cruise; replaced by newer system in 'Deck Lab' which work without problem; no impact on science
  - XBT/XCTD wire being caught on airgun array; solved by using launch pipe worked

well though longer XCTD tended to jam; no impact on science
    - depending on line orientation some time difficult for XBT/XCTD to reach maximum depth before wire snagged on 2.4 km receiver array; no obvious cure though data loss will have an impact on science
- 2.7 Computing and Instrumentation Report
    - some logging issues reported by Chris Barnard above though no data loss; no impact on science;
    - issues with ship ADCP eight day data loss between 30 April and 8 May; minor impact as these days are covered by ADCP on FS Poseidon;
    - ship-to-ship internet worked well except when Poseidon was ahead of Discovery because of location of aerial on Poseidon;
    - gravimeter continuous interrupts, system stripped down and comms card replaced but to no effect, data logged looks OK; no impact on science;
    - initially gravimeter data was not logged on Techsas system, though logged locally at the gravimeter, but gravimeter local clock was not synchronised to ship time, data can be recovered; no impact on science.

3.2 Recommendations

Serious thought is needed to fully integrate commercial and academic systems. It is imperative that future planning meetings include representatives from any sub-contractors especially if they are supplying vital pieces of the kit and personnel. Issues such as logging shot times would have been identified at that stage and there would have been sufficient time to engineer a robust solution rather than trying to sort it out on the ship. Also possible manning issues would have been identified.

Adding extra buoys to help control depth on airgun arrays. This maybe problematic as the rope from an additional buoy as the front of the sub-array may get tangled with cherry-picker deployment system.

A more obvious watch-keeper overview system. Some ship ADCP data was lost because it was not obvious to the watch keepers that the system had failed. A screen with a list data being logged against a 'traffic light' indicator that shows green for good, yellow for a predefined number of misses and then red for data lost would help alert watch keepers to possible problems.

A system that allows shooting on distance rather than time for MCS operations.

Safety issue: not all the intercoms were working especially in Main Lab. The master was aware of the situation and the system was being actively serviced to correct problems.

4 Deliverables

1) CTD data with salinity calibrations
2) Underway meteorological data
3) Underway surface water data
4) Ship ADCP
5) Gravity
6) Magnetics
7) Seabed Moorings
    1. ADCP
    2. temperature
    3. current
8) High-resolution seismic reflection data
9) Low-resolution seismic reflection data
10) Echo-sounder records
11) Underway oceanographic data (XBT/XCTD)
12) Pre-cruise Environmental Audit (Annex-7)
13) Marine Mammal Observer Report (Annex-8)

Data reserved for GO partners for 3 years then available though data repositories

Full list of data held by British Oceanography Data Centre (BODC) in ROSCOP forms in Annex 6

5 Acknowledgements

Richard Hobbs (PSO) and Co-ordinator of the EU-GO project (on behalf of the GO project partners) wish to thank the officers, engineers, crew, and NMF and POL technical personnel on-board *RRS Discovery* during D318a and D318b for their tireless work on a very successful cruise.

In particular, I which to thank the Master, Roger Chamberlain, and Technical Liaison Officer, Jason Scott, for their support and help during the cruise; Dirk Klaeschen (IFM-Geomar) who single handedly processed all the data; Bruno Marsset (IFREMER) for the backup clock; and the XBT/XCTD launch and watch-keeping teams.

Acknowledgement is also given to the EU Commission for funding this ambitious research project (EU-NEST project GO 015603)

Annex 1: Personnel

D318a

Roger Chamberlain	Master	
Richard Warner	Chief Officer	
Philip Oldfield	2nd Officer	
Malcolm Graves	2nd Officer	
David Hartshorne	Purser	
George Parkinson	Chief Engineer	
Stephen Bell	2nd Engineer	
Alan Stevenson	3rd Engineer	
Ian Collin	3rd Engineer	
Robert Masters	ETO	
Khan Sprague	Deck Cadet	
Micheal Drayton	CPO (Deck)	
Stephen Smith	CPO (Sci)	
Iain Thompson	POD	
Gerry Cooper	SG1A	
Mark Moore	SG1A	
Jason Marsden	SG1A	
Joseph Lambert	SG1A	
Eric Downie	SG1B	
Matthew Sangster	EPRO	
Peter Lynch	Head Chef	
Wilmot Isby	Chef	
Jeffrey Orsborn	Steward	
Jason Scott	NMF SS TLO	
Dougal Mountifield	NMF SS	
John Wynar	NMF SS	
Chris Barnard	NMF SS	
Richard Hobbs	PSO	Durham
Ekaterina Vsemirnova		Durham
Emlyn Jones		POL
John Kenny		POL
Michael Smithson		POL
John Huthnance		POL
Dirk Klaeschen		IFM-Geomar
Elise Quentel		UBO
Louis Géli		IFREMER
Frauke Klingelhoefer		IFREMER
Bruno Marsset		IFREMER
Yohann Kergoat		Genavir
Gilles Le Beuz		Genavir
Serge Louzaouen		Genavir
Claude Guéguen		Genavir
Jean-Luc Le Philippe		Genavir
Emmanuel Cosquer		Lisbon
Patricia De Silva		Lisbon
Berta Biescas		CSIC
Grant Buffet		CSIC
Richard Woodcock	Marine Mammal Obs.	

D318b

Roger Chamberlain	Master	
Richard Warner	Chief Officer	
Philip Oldfield	2nd Officer	
Malcolm Graves	2nd Officer	
David Hartshorne	Purser	
George Parkinson	Chief Engineer	
Stephen Bell	2nd Engineer	
Alan Stevenson	3rd Engineer	
Ian Collin	3rd Engineer	
Robert Masters	ETO	
Khan Sprague	Deck Cadet	
Micheal Drayton	CPO (Deck)	
Stephen Smith	CPO (Sci)	
Iain Thompson	POD	
Gerry Cooper	SG1A	
Mark Moore	SG1A	
Jason Marsden	SG1A	
Joseph Lambert	SG1A	
Eric Downie	SG1B	
Matthew Sangster	EPRO	
John Haughton	Head Chef	
Wilmot Isby	Chef	
Graham Mingay	Steward	
Jason Scott	NMF SS TLO	
Dougal Mountifield	NMF SS	
John Wynar	NMF SS	
Chris Barnard	NMF SS	
Emma Northrop	NMF SS	
Iain Miller	Gun Tech	
Tim Bridge		Exploration Electonics
Stephan Patterson		Exploration Electronics
Richard Hobbs	PSO	Durham
Ekaterina Vsemirnova		Durham
Katy Sheen		Cambridge
John Kenny		POL
Raymond Edun		POL
Ruben Alvarado Bustos		POL
Dirk Klaeschen		IFM-Geomar
Elise Quentel		UBO
Marc Gutscher		UBO
Emmanuel Cosquer		Lisbon
Patricia De Silva		Lisbon
Rafael Bartolome		CSIC
Grant Buffet		CSIC
Richard Woodcock	Marine Mammal Obs.	

Day	Time	Station or Line name	N° station Bridge	Latitude	Longitude	depth	file	New file	Sweep delay in ms	Comments
04/17/2007	**07:00**									Depart Lisbon
	09:00									Meeting scientists
	10:30									Meeting crew
	11:30									3,5 kHz in water
	17:00		001	**37°01.2'**	**-9°35.2'**					XBT training
04/18/2007	**01:00**	CTD01	002	**36°38.328'**	**-8°11.861'**					CTD release test
		(point A)								the CTD stops at 750 m . Good readings so far
										maximun depth 785 m
										Mooring releaser test at 750 m. it works
										Another mooring releaser test at 500m
	02:38		002	**36°38.73'**	**-8°11.88'**					CTD burk at surface
	02:40									inboard
	02:45			**"**						Water samples from the rosette bottles had been takes
										(samples for the salinometer)
	03:29	A2	003	**36°38.49'**	**-8°14.145'**					STABLE deployment : in water 792 m
	03:44									on bottom
	04:19	CTD02	004	**36°40.26'**	**-8°13.10'**					CTD at A1 into water
	04:40			**36°40.40'**	**-8°12.98'**	739				at bottom release tests at 700m; succesful
	05:31			**36°40.85'**	**-8°12.73'**	726				CTD at surface
	05:32									inboard
	06:08	A1	005	**36°40.18'**	**-8°13.225'**	742				A1 ADCP 600 kHz in water & released
	(07:13)									(contacted on bottom)
	06:38	A/t		**36°40.01'**	**-8°13.34'**					A/t minilogger mooring. Start with buoy over side
	06:48									paying out, clipping on line straight astem, shep head 105°
	07:05		006	**36°40.07'**	**-8°12.92'**					mooring

						747				released. This puts it SE of A1
	07:11									on bottom
	08:15	CTD03	007	**36°36.90'**	**-8°14.75'**	858				CTD A3 in water
	08:46		007	**36°37.03'**	**-8°14.76'**	851				on bottom
	08:52		007	**36°37.046'**	**-8°14.72'**	800				close two bottles relesae tests at 800
	08:58		007	**36°37.08'**	**-8°14.75'**	700				Release test at 700
	09:04		007	**36°37.09'**	**-8°14.75'**	500				Release test at 500
	09:13		007	**36°37.09'**	**-8°14.65'**	200				Release test at 200
	09:21		007	**36°37.23'**	**-8°14.63'**	50				Release test at 50
	09:24		007	**36°37.13'**	**-8°14.60'**	10				Release test at 10
	09:27									at suitife
	09:29		007	**36°37.13'**	**-8°14.55'**					
										on board
		A3								A3 POL 150 kHz ADCP (F2)
	10:14		008	**36°36.81'**	**-8°15.00'**	866				release
	10:28		008	**36°37.02'**	**-8°14.97'**	832				on bottom
	11:16		009	**36°37.16'**	**-8°16.31'**	869				Mooring A3t, minilogger
										buoy in water
	12:01		009	**36°37.03'**	**-8°14.86'**	854				Release

	12:07			36°37.05'	-8°14.86'	852				on bottom
	13:22	A4	010	36°35.18'	-8°15.83'	995				CTD release succesful
	13:33		010	36°35.30'	-8°15.68'	983.5				at 300 m cable out
										spikes in CTD display
										-not related to pump
										-lost "primary temp"
	13:38		010	36°35.35'	-8°15.61'	980				-recovering CTD to 10 m
										to investigate problem
										-seems to be "cable problem"
	13:41		010	36°35.37'	-8°15.58'	978				as CTD is brought up
										problem resolved itself at 260 m cable depth
										seems to be pressure related
	13:50		010	36°35.47'	-8°15.43'	972				the CTD its already inboard
										checking the connections of the CTD
	14:34		011	36°35.14'	-8°15.84'	1000				CTD release
										testing if the cables/connections are all OK
	14:50		011	36°35.36'	-8°15.63'	978				Registing spikes again at 440m in the CTD acquisition
	15:06		011	36°35.53'	-8°15.53'	964				CTD coming up
										The data its looking good without any spikes
	15:40		011	36°35.88'	-8°15.09'	932				CTD arrives inboard
	16:00			36°35.12'	-8°15.93	1000			C3_00003	XCTD release
	16:05		012	36°35.15'	-8°15.82'	980				A4 POL 150 kHz ADCP F1 (Release)
										(not followed to bottom)
	16:31	A4t	013							minilogger mooring - buoy out
	17:22		013	36°35.35'	-8°15.69'	978				minilogger mooring - released
		A5								
	18:50		014	36°34.12'	-8°11.885'	1007			C3_00004	XCTD at A5

	18:45		015	**36°33.86'**	**-8°11.71'**	1015				75 kHz ADCP released
	18:53									on bottom
	21:05		016	**36°28.27'**	**-8°36.10'**	2480			C4_00005	XCTD at OBH1
		OBH1								
	21:45		017	**36°28.27'**	**-8°36.11'**	2470				OBH1 deployment
	21:47		017							start : another station in water
										pay out bulk of mooring line
	22:17		017							overside releases OBH & buoy into line (hitched)
	22:21		017							buoy & attachment winched hanging outboard
	22:22		017							line unhitched
	22:23			**36°28.785'**	**-8°36.062'**	2466				deployed
										ship drifts heavy traffic
										OBH2 deployment start
04/19/2007	**00:10**			**36°27.7131'**	**-8°38'**					
		OBH2								
	00:39		018	**36°27.85'**	**-8°38.25'**	2069				OBH2 deployed
	00:57			**36°28.25'**	**-8°38.18'**					heading south
										start 2 hours transit approx.
										to go 6 miles before start of line to start streamer deploy
	05:47		019	**36°16.36'**	**-9°07.37'**	3345				Seismic streamer in water
	06:17		019	**36°16.98'**	**-9°05.50'**	3170				Airgun (right) in water
										▼
										Problems during the deployment
										airgun in board again
	07:40			**36°18.31'**	**-9°01.29'**	3241			4000 ms	
	07:45		019	**36°18.37'**	**-9°01.105'**	3095				airgun (right) in water
	08:15		019	**36°18.92'**	**-8°59.58'**	3223				port airguns in water
	08:23		019	**36°19.47'**	**-8°59.13'**	3217				deployments complete
										(airguns ~symmetrically artem)
	08:25									increasing speed to 4 knots
	08:37		019	**36°19.47'**	**-8°58.20'**	3184				started with airguns @ 6 sec going along section OBHs

	09:12	**GOHR001**	019	**36°20.65'**	**-8°55.25'**				SP1	seismic line GOHR001
	09:30		019	**36°20.19'**	**-8°56.45'**					Magnetometer in water
	09:41			**36°22.02'**	**-8°51.87'**	3099			3600	
	10:20		020	**36°23.02'**	**-8°49.44'**		*T5_00006*			XBT launched serial number: 206353
	10:29			**36°23.36'**	**-8°48.62'**	2723			3200	
	10:40		021	**36°23.765'**	**-8°47.680'**		*T5_00007*	**old**		XBT launched serial number: 206354
	11:15			**36°25.02'**	**-8°44.45'**	2340			2800	
	11:35		022	**36°25.75'**	**-8°42.66'**	2298	*T5_00008*	**old**		XBT T-5 XBT#8
	12:04			**36°25.75'**	**-8°40.13'**	2133			2400	
	13:05		023	**36°28.935'**	**-8°42.66'**	2284	*T5_00009*	**old**		XBT T-5 XBT#9 --> delay ~720m
	13:30		024	**36°29.869'**	**-8°32.413'**	2289	*T5_00010*	**old**		XBT T-5 XBT#10 --> delay ~85m
	13:43			**36°30.33'**	**-8°31.23'**				1000	
	13:45		025	**36°30.39**	**-8°31.08**		*T5_00011*	**old**		XBT T-5 XBT#11
	13:57			**36°30.85'**	**-8°29.94'**	2293			500	
	14:00	**GOHR001**	026	**36°30.93'**	**-8°29.77'**		*T5_00012*	**old**		XBT T-5 XBT#12
	14:21	**GOHR002**		**36°31.54'**	**-8°28.92'**	2000			3000	
	15:23	**GOHR003**		**36°29.62'**	**-8°33.45'**	2109				start GO HR003 seismic (Heading 236.2)
	17:00		027	**36°26.26'**	**-8°41.36'**	2447		**T5_00002**		XBT-T5 XBT #13
		GOHR003								
	19:20	**GOHR005**	028	**36°27.43'**	**-8°38.54'**	2202		**T5_00003**		XBT-T5 XBT #14
	19:35		029	**36°27.81'**	**-8°37.67'**	2180		**T5_00004**		XBT-T5 XBT #15
	19:48		030	**36°27.82**	**-8°36.63'**	2470		**T5_00005**		XBT-T5 XBT #16
	19:59		031	**36°28.6'**	**-8°35.69'**	2010		**C4_00006**		XCTD-2 #17
		GOHR005								

	20:18	**GOHR006**	032	**36°29.31'**	**-8°34.09'**			**T5_00007**		XBT-T5 #18
	20:36			**36°29.96'**	**-8°32.48'**				2500	Sweep delay
	20:41		033	**36°30.10'**	**-8°32.10'**			**T5_00008**		XBT-T5 #19
	20:58		034	**36°30.65'**	**-8°30.53'**			**T5_00009**		XBT-T5 #20
	21:18		035	**36°31.32'**	**-8°28.75'**			**T5_00010**		XBT-T5 #21
	21:29			**36°31.72'**	**-8°27.78'**				1935	Sweep delay
									2300	
	21:39		036	**36°32.10'**	**-8°26.84'**			**C4_00011**		XCTD-2 #22
	21:53			**36°32.60'**	**-8°25.55'**	1650			2000	
	21:56			**36°32.65'**	**-8°25.44'**	1531		**T5_00012**	1800	XBT-T5 #23
	22:08			**36°33.08'**	**-8°24.30'**				1600	
	22:18		038	**36°33.45'**	**-8°23.44'**			**T5_00013**		XBT-T5 #24
	22:39		039	**36°34.20'**	**-8°21.56'**			**T5_00014**		XBT-T5 #25
	22:59		040	**36°34.96'**	**-8°19.67'**			**T5_00015**		XBT-T5 #26
	22:18			**36°31.50'**	**-8°20.60'**	1241			1500	
	21:51			**36°31.68'**	**-8°20.60'**	1186			1400	
	23:06			**36°35.21'**	**-8°18.95'**	1052			1200	
	23:18		041	**36°35.53'**	**-8°17.96'**			**C3_00016**		XCTD-1 #27
	23:28			**36°36.00'**	**-8°16.97'**	951			1100	
	23:38		042	**36°36.36'**	**-8°16.12'**			**T5_00017**		XBT-T5 #28
	23:46			**36°36.65'**	**-8°15.35'**	883			900	
	23:58		043	**36°37.06'**	**-8°14.34'**			**T5_00018**		XBT-T5 #29
04/20/2007	**00:19**	**GOHR006**	044	**36°37.85'**	**-8°12.36'**			**T5_00019**		XBT-T5 #30 (last before line turn)

	02:14	**GOHR008**	045	**36°41.24'**	**-8°12.44'**			**T5_00021**		XBT-T5 #31 (first after line turn)
										Note : missing T5-00020 file (EDF)
										but this is normal. File never existed anyway
	02:37		046	**36°40.18'**	**-8°13.24'**			**C3_00022**		XCTD-1 #32 EDF file #C3_00022
	03:01		047	**36°38.45'**	**-8°14.16'**			**T5_00023**		XBT-T5 #33
	03:19		048	**36°37.14'**	**-8°14.84'**			**T5_00024**		XBT-T5 #34
										Note : large spike at 867m consistent with 850 m depth
										from "green screen" taken at launch time
	03:40		049	**36°35.59'**	**-8°15.66'**			**T5_00025**		XBT-T5 #35
	04:01		050	**36°34.12'**	**-8°16.38'**			**T5_00026**		XBT-T5 #36
	04:25		051	**36°32.35'**	**-8°17.25'**			**C3_00027**		XCTD-1 #37
	04:40			**36°31.20'**	**-8°17.81'**	1487			2000	change sweep delay
		GOHR008							1500	
	06:28			**36°30.70'**	**-8°11.92'**	1171			1250	change sweep delay
		GOHR010								
	07:07	A8	052	**36°33.18'**	**-8°11.41'**	1043		**T5_00028**		XBT T5 #38 first after line turn
	07:18		053	**36°33.82'**	**-8°12.07'**	1028		**T5_00029**		XBT T5 #39
	07:35	line		**36°34.83'**	**-8°13.05'**	1011			1500	change sweep delay
		SE to NW								
	07:40	over	054	**36°35.04'**	**-8°13.24'**	994		**T5_00030**		T5 #40 (T5_00030)
		moorings								
	08:00		055	**36°36.32'**	**-8°14.50'**	889		**T5_00031**		T5 #41 (T5_00031)
	08:20		056	**36°37.55'**	**-8°15.71**	836		**C3_00032**		XCTD-1 #42
	08:40		057	**36°38.71'**	**-8°16.82'**	796		**T5_00033**		XBT T5 #43
	09:00		058	**36°39.20'**	**-8°17.97'**	730		**T5_00034**		XBT T5 #44
	09:00									Magnetometer being handed in
	09:20		059	**36°41.05'**	**-8°19.07'**	677		**T5_00035**		XBT T5 #45 file #35
		GOHR010								

	09:29	A9		**36°41.07'**	**-8°19.07'**	665				end of file commente turn no XBTs/XCTDs on turn
	10:00 - 10:45			**~36°40'N**	**-8°22' W**					on turn between lines streamer dummy length
		GOHR011								ie between 'A9' and 'A10'
	10:55			**~36°38.06'**	**-8°22.09'**	800				Magnetometer back out
	11:08			**36°37.89'**	**-8°22.92'**	906			200	
	11:21			**36°37.03'**	**-8°22.38'**	1095			2400	
										end of turn
	11:49	A10	060	**36°36.15'**	**-8°20.414'**	1075		**T5_00036**		XBT T5 #46
	12:08	line	061	**36°36.43'**	**-8°18.45'**	940		**C3_00037**		XCTD #47
		W to E								
	12:29	over	062	**36°36.67'**	**-8°16.18'**	898		**T5_00038**		XBT T5 #48
		moorings								
	12:48		063	**36°36.88'**	**-8°14.18'**	852		**T5_00039**		XBT T5 #49 (file 39)
	13:08		064	**36°37.13'**	**-8°12.04'**	825		**T5_00040**		XBT T5 #50 (file 40)
	13:28	A11	065	**36°37.35'**	**-8°09.82'**	818		**T5_00041**		XBT T5 #51
		GOHR011								
		GOHR013								
	15:05	Line A-B	066	**36°37.85'**	**-8°12.34'**	802		**C3_00042**		XCTD #52
	15:28		067	**36°37.22'**	**-8°14.01'**	838		**T5_00043**		XBT T5 #53
	15:46		068	**36°36.68'**	**-8°15.30'**	882		**T5_00044**		XBT T5 #54
	16:06		069	**36°36.1013'**	**-8°16.7539'**	942		**T5_00045**		XBT T5#55
	16:26		070	**36°35.51'**	**-8°18.236'**	1012		**T5_00046**		XBT T5#56
	16:46		071	**36°34.938'**	**-8°19.679'**	1116		**C3_00047**		XCTD-1 #57
	17:05		072	**36°34.318'**	**-8°21.245'**	1285		**T5_00048**		XBT T5#58
	17:25		073	**36°33.807'**	**-8°22.55'**	1492		**T5_00049**		XBT T5#59
	17:45		074	**36°33.15'**	**-8°24.16'**	1384		**T5_00050**		XBT T5#60
	18:03		075	**36°32.58'**	**-8°25.60'**	1577		**T5_00051**		XBT T5#61

	18:26			076	**36°31.82'**	**-8°27.41'**	1893		**C3_00052**		XCTD-1 #62
	18:45			077	**36°31.19'**	**-8°28.97'**	2071		**T5_00053**		XBT T5 #63
	19:06			078	**36°30.53'**	**-8°30.73'**	?		**T5_00054**		XBT T5 #64
	19:25			079	**36°29.91'**	**-8°32.27'**	2210		**T5_00055**		XBT T5 #65
	19:45			080	**36°29.24'**	**-8°33.98'**	2116		**T5_00056**		XBT T5 #66
	20:03			?	**36°28.72'**	**-8°35.24'**	1885		**C4_00057**		XCTD-2 #67
	20:25			081	**36°28.11'**	**-8°36.79'**	2170		**T5_00058**		XBT T5 #68 (file T5_00057)
	20:46			082	**36°27.36'**	**-8°38.70'**	2153		**T5_00059**		XBT T5 #69 (file T5_00059)
	21:05			083	**36°26.64'**	**-8°40.47'**	2171		**T5_00060**		XBT T5 #70
	21:25			084	**36°25.94'**	**-8°42.23'**	2253		**T5_00061**		XBT T5 #71
	21:45			085	**36°25.20'**	**-8°43.96'**	2330		**T5_00062**		XBT T5 #72
	22:05			086	**36°24.52'**	**-8°45.80'**	2764		**T5_00063**		XBT T5 #73
	22:25			087	**36°23.79'**	**-8°47.53'**	2791		**T5_00064**		XBT T5 #74
	22:45			088	**36°23.10'**	**-8°49.22'**	2837		**T5_00065**		XBT T5 #75 (file T5_00065)
	23:05			089	**36°22.48'**	**-8°50.76'**	2998		**T5_00066**		XBT T5 #76 (file T5_00066)
	23:25			090	**36°21.79'**	**-8°52.53'**	3051		**T5_00067**		XBT T5 #77 (file T5_00067)
	23:45			091	**36°21.11'**	**-8°54.01'**	3089		**T5_00069**		XBT T5 #78 (file T5_00069)
04/21/2007	**00:03**			092	**36°20.51'**	**-8°55.56'**	3139		**T5_00070**		XBT T5 #79 (file T5_00070)
	00:25			093	**36°19.79'**	**-8°57.36'**	3182		**T5_00071**		XBT T5 #80 (file T5_00071)
	00:47			094	**36°19.05'**	**-8°59.20'**	3215		**T5_00072**		XBT T5 #81 (file T5_00072)
	01:10			095	**36°18.30'**	**-9°01.07'**	3099		**T5_00073**		XBT T5 #82 (file T5_00073)
											the probe only start at 120m (bad data)
	01:25			096	**36°17.75'**	**-9°02.41'**	3158		**T5_00074**		XBT T5 #83 (file T5_00074)

	01:45		097	**36°17.08'**	**-9°04.03'**	3300		**T5_00075**		XBT T5 #84 (file T5_00075)
	02:05		098	**36°16.43'**	**-9°05.69'**	3347		**T5_00076**		XBT T5 #85 (file T5_00076)
	02:25		099	**36°15.72'**	**-9°07.42'**	3419		**T5_00077**		XBT T5 #86 (file T5_00077)
	02:45		100	**36°15.08'**	**-9°08.96'**	3456		**T5_00078**		XBT T5 #87 (file T5_00078)
	03:05		101	**36°14.33'**	**-9°10.81'**	3482		**T5_00079**		XBT T5 #88 (file T5_00079)
	03:25		102	**36°13.63'**	**-9°12.57'**	3577		**T5_00080**		XBT T5 #89 (file T5_00080)
	03:45		103	**36°12.99'**	**-9°14.13'**	3742		**T5_00081**		XBT T5 #90 (file T5_00081)
	04:05		104	**36°12.29'**	**-9°15.81'**	3889		**T5_00082**		XBT T5 #91 (file T5_00082)
	04:25		105	**36°11.59'**	**-9°17.48'**	3954.8		**T5_00083**		XBT T5 #92 (file T5_00083)
	04:35	**GOHR013**		**36°11.173'**	**-9°18.492'**					shot 18080 end of profile 013
										need to change recording length (from 5.5 to 7 sec)
										in order to record sea bottom reflection
	04:47		106	**36°10.74'**	**-9°19.56'**	4034.21		**C3_00084**		XCTD-2 #93 (file C3_00084)
										end of the meddy
	05:15		107	**36°09.76'**	**-9°22.09'**	4048.27		**T5_00085**		XBT T5 #94 (file T5_00085)
	05:40		108	**36°08.96'**	**-9°23.96'**	4027		**T5_00086**		XBT T5 #95 (file T5_00086)
	06:00									boat turn
	06:10		109	**36°10.14'**	**-9°23.70'**	4152		**T5_00087**		XBT T5 #96 (file T5_00087)
	06:33		110	**36°10.93'**	**-9°21.75'**	3968		**T5_00088**		XBT T5 #97 (file T5_00088)
	06:35								500	change sweep delay (please keep this)
	06:57		111	**36°11.86'**	**-9°19.48'**	3947		**T5_00089**		XBT T5 #98 (file T5_00089)
	07:39			**36°11.585'**	**-9°17.638'**					end profile 014
	07:40	**GOHR015**	112	**36°11.52'**	**-9°17.70'**	3933		**T5_00090**		XBT T5 #99 (file T5_00090)

	07:40				**36°11.523'**	**-9°17.766'**					smart profile 015
											note : signal from water colums redvired on 3.5kHz
	08:05			113	**36°10.73'**	**-9°19.63'**	3834		**T5_00091**		XBT T5 #100 (file T5_00091)
	08:25			114	**36°10.09'**	**-9°21.19'**	3985		**T5_00092**		XBT T5 #101 (file T5_00092)
	08:45			115	**36°09.44'**	**-9°22.73'**	4000		**T5_00093**		XBT T5 #102 (file T5_00093)
	09:05			116	**36°08.822'**	**-9°24.22'**	4051		**T5_00094**		XBT T5 #103 (file T5_00094)
	09:25			117	**36°08.15'**	**-9°25.90'**	4013		**T5_00096**		XBT T5 #104 (file T5_00095)
	09:30										slowing to 3 knots
	09:36			118	**36°07.78'**	**-9°26.77'**	4022		**C4_00095**		XCTD-2 #105 (file C3_00095)
	09:48			119	**36°06.82'**	**-9°27.61'**	4021		**T5_00097**		XBT T5 #106 (file T5_00096)
	09:50										speeding to 4 knots
	10:10			120	**36°06.82'**	**-9°29.12'**	3986		**T5_00098**		XBT T5 #107 (file T5_00097)
	10:30			121	**36°06.16'**	**-9°30.72'**	3986		**T5_00099**		XBT T5 #108 (file T5_00098)
	10:50			122	**36°03.46'**	**-9°37.24'**	4122		**T5_00100**		XBT T5 #109 (file T5_00099)
	11:10			123	**36°01.84'**	**-9°33.94'**	4045		**T5_00101**		XBT T5 #110 (file T5_00100)
	11:30			124	**36°04.13'**	**-9°35.66'**	4081		**T5_00102**		XBT T5 #111 (file T5_00102) bad near surface to ~50m
	11:50			125	**36°03.46'**	**-9°37.24'**	4122		**T5_00103**		XBT T5 #112 (file T5_00103)
	12:10			126	**36°02.82'**	**-9°38.83'**	4165		**T5_00104**		XBT T5 #113 (file T5_00104)
	12:30			127	**36°02.15'**	**-9°40.39'**	4229		**T5_00105**		XBT T5 #114 (file T5_00105)
	12:48			128	**36°01.50'**	**-9°41.96'**	4274		**T5_00106**		XBT T5 #115 (file T5_00106)
	13:09			129	**36°00.785'**	**-9°43.70'**	4275		**T5_00107**		XBT T5 #116 (file T5_00107)
	13:29			130	**36°00.089'**	**-9°45.39'**	4316		**T5_00108**		XBT T5 #117 (file T5_00108)

	13:40	**GOHR015**		**35°59.736'**	**-9°46.213'**					end profile 015 start giration
	14:32	**GOHR017**	131	**36°00.710'**	**-9°43.93'**	4280		**T5_00109**		XBT T5 #118 (file T5_00109)
	14:49		132	**36°01.263'**	**-9°42.55'**	4082		**T5_00110**		XBT T5 #119 (file T5_00110)
	15:09		133	**36°01.92'**	**-9°40.93'**	4200		**T5_00111**		XBT T5 #120 (file T5_00111)
	15:30		134	**36°02.68'**	**-9°39.12'**	4166		**T5_00112**		XBT T5 #121 (file T5_00112)
	15:55		135	**36°03.40'**	**-9°37.40'**	4166		**C4_00113**		XCTD-2 #122 (file C4_00113)
	16:10		136	**36°03.76'**	**-9°36.45'**	4046		**T5_00114**		XBT T5 #123 (file T5_00114)
	16:30		137	**36°04.40'**	**-9°34.93'**	4071		**T5_00115**		XBT T5 #124 (file T5_00115)
	16:50		138	**36°05.039'**	**-9°33.40'**	4037		**T5_00116**		XBT T5 #125 (file T5_00116)
	17:10		139	**36°05.75'**	**-9°31.68'**	4000		**T5_00117**		XBT T5 #126 (file T5_00117)
	17:29		140	**36°06.34'**	**-9°30.27'**	3979		**T5_00118**		XBT T5 #127 (file T5_00118)
										speed of the boat to 6 knots
										no launch!
										no XBT, no XCTD-2
	18:34		141	**36°08.60'**	**-9°24.78'**	4212		**C4_00119**		XCTD-2 #128 (file C4_00119)
	18:50		142	**36°09.04'**	**-9°23.67'**	4117		**T5_00120**		XBT T5 #129 (file T5_00120)
	19:10		143	**36°09.73'**	**-9°22.00'**	4472		**T5_00121**		XBT T5 #130 (file T5_00121)
	19:30		144	**36°10.41'**	**-9°20.38'**	3998		**T5_00122**		XBT T5 #131 (file T5_00122)
	19:50		145	**36°11.12'**	**-9°18.644'**	3935		**T5_00123**		XBT T5 #132 (file T5_00123) bad data
	20:03		146	**36°11.55'**	**-9°17.66'**	3915		**T5_00124**		XBT T5 #133 (file T5_00124)
	20:12		147	**36°11.88'**	**-9°16.86'**	3898		**T5_00125**		XBT T5 #134 (file T5_00125)
	20:30	**GOHR017**	148	**36°12.50'**	**-9°15.30'**	3885		**T5_00126**		XBT T5 #135 (file T5_00126)
		GOHR018								
	20:50	loop	149	**36°13.25'**	**-9°13.51'**	4300		**C4_00127**		XCTD-2 #136 (file C_00127) wire run out

	21:10	loop	150	**36°13.94'**	**-9°11.69'**	3840		**T5_00128**		XBT T5 #137 (file T5_00128)
	21:30	loop	151	**36°14.68'**	**-9°09.94'**	3460		**T5_00129**		XBT T5 #138 (file T5_00129)
	21:50	loop	152	**36°15.39'**	**-9°08.18'**	3446		**T5_00130**		XBT T5 #139 (file T5_00130)
		GOHR018								
										waiting on turn
		GOHR020								
	22:48		153	**36°14.70'**	**-9°07.24'**	3462		**T5_00131**		XBT T5 #140 (file T5_00131) aimed at G1
										bad below 1150m
	23:08		154	**36°14.09'**	**-9°08.70'**	3504		**C4_00132**		XCTD-2 #141 (file C_00132) short! Signal stopped
	23:28		155	**36°13.53'**	**-9°10.08'**	3557		**T5_00133**		XBT T5 #142 (file T5_00133) signal wrong ~1200m
	23:48	**GOHR020**	156	**36°12.87'**	**-9°11.62'**	3740		**T5_00134**		XBT T5 #143 (file T5_00134)
		GOHR021								
04/22/2007	**00:37**	**GOHR022**	157	**36°13.46'**	**-9°12.94'**	3850		**T5_00135**		XBT T5 #144 (file T5_00135) point F
	01:03		158	**36°14.32'**	**-9°10.84'**	3477		**T5_00136**		XBT T5 #145 (file T5_00136)
	01:22		159	**36°14.97'**	**-9°09.26'**	3454		**T5_00137**		XBT T5 #146 (file T5_00137)
		GOHR022								
	02:16	**GOHR023**	160	**36°14.63'**	**-9°07.40'**	3458		**T5_00138**		XBT T5 #147 (file T5_00138) point G'
		GOHR024								
	02:37		161	**36°13.92'**	**-9°09.17'**	3519		**T5_00139**		XBT T5 #148 (file T5_00139)
	02:59		162	**36°13.09'**	**-9°11.12'**	3650		**T5_00140**		XBT T5 #149 (file T5_00140)
	03:23	**GOHR024**								
	03:23	**GOHR025**								
	03:50	**GOHR026**								
	03:55		163	**36°13.44'**	**-9°12.94'**	3602		**T5_00141**		XBT T5 #150 (file T5_00141) point F
	04:10		164	**36°14.02'**	**-9°11.56'**	3512		**T5_00142**		XBT T5 #151 (file T5_00142)
	04:34		165	**36°14.62'**	**-9°10.02'**	3465		**T5_00143**		XBT T5 #152 (file T5_00143)
	05:02		166	**36°15.54'**	**-9°07.85'**	3440		**T5_00144**		XBT T5 #153 (file T5_00144) point G
	05:14	**GOHR026**	167	**36°15.92'**	**-9°06.97'**	3372		**T5_00145**		XBT T5 #154 (file T5_00145) point H
	05:24	**GOHR027**								
	05:54	**GOHR028**								

	05:56	loop	168	**36°14.75'**	**-9°07.09'**	3461		**T5_00146**		XBT T5 #155 (file T5_00146) point G'
	06:10	loop								speed boat 3 knots
	06:17	loop	169	**36°14.12'**	**-9°08.68'**	3502		**T5_00147**		XBT T5 #156 (file T5_00147)
	06:36	loop	170	**36°13.55'**	**-9°10.00'**	3556		**C4_00148**		XCTD-2 #157 (file C4_00148)
	07:05	loop	171	**36°12.72'**	**-9°11.95'**	3655		**T5_00149**		XBT T5 #158 (file T5_00148)
	07:14	loop	172	**36°12.47'**	**-9°12.57'**	3683		**C4_00150**		XCTD-2 #159 (file C4_00150)
	07:20									turn
		GOHR028								
	07:27	**GOHR029**								
	07:46	**GOHR029**								
	07:49	loop	?	**36°13.34'**	**-9°13.26'**	3626		**T5_00151**		XBT T5 #160 (file T5_00151) point E
		GOHR030								
	07:59		173	**36°13.55'**	**-9°12.64'**	3582		**C4_00152**		XCTD-2 #161 (file C4_00152)
										run out of wire ~1750m
	08:12		174	**36°13.89'**	**-9°11.55'**	3527		**T5_00153**		XBT T5 #162 (file T5_00153)
	08:21		175	**36°14.16'**	**-9°11.27'**	3491		**T5_00154**		XBT T5 #163 (file T5_00154)
	08:29		176	**36°14.41'**	**-9°10.68'**	3470		**T5_00155**		XBT T5 #164 (file T5_00155)
	08:38		177	**36°14.62'**	**-9°10.09'**	3463		**T5_00156**		XBT T5 #165 (file T5_00156)
	08:50		178	**36°14.93'**	**-9°09.31'**	3455		**T5_00157**		XBT T5 #166 (file T5_00157)
	09:00		179	**36°15.19'**	**-9°08.70'**	3258		**T5_00158**		XBT T5 #167 (file T5_00158)
										tube end lowered after last two sweep on way down
	09:12		180	**36°15.50'**	**-9°07.97'**	3442		**T5_00159**		XBT T5 #168 (file T5_00159)
	09:20		181	**36°15.23'**	**-9°07.40'**	3413		**C4_00160**		XCTD-2 #169 (file C4_00160)
		GOHR030								wire ran out at 1800
		GOHR031								
	09:36		182	**36°16.13'**	**-9°06.43'**	3368		**T5_00161**		XBT T5 #170 (file T5_00161)
	09:44		183	**36°16.35'**	**-9°05.89'**	3353		**T5_00162**		XBT T5 #171 (file T5_00162)
	09:53		184	**36°16.58'**	**-9°05.34'**	3332		**T5_00163**		XBT T5 #172 (file T5_00163)

	10:10		185	**36°17.01'**	**-9°04.24'**	3287		**T5_00164**		XBT T5 #173 (file T5_00164)
	10:30		189	**36°17.53'**	**-9°02.88'**	3323		**T5_00165**		XBT T5 #174 (file T5_00165)
										going from 3 knots up to 4 knots
	10:50		187	**36°18.20'**	**-9°01.29'**	3100		**T5_00166**		XBT T5 #175 (file T5_00166)
	11:11		188	**36°18.90'**	**-8°59.51'**	3220		**T5_00167**		XBT T5 #176 (file T5_00167)
	11:30		189	**36°19.59'**	**-8°57.85'**	3190		**T5_00168**		XBT T5 #177 (file T5_00168)
	11:50		190	**36°20.26'**	**-8°56.10'**	3150		**T5_00169**		XBT T5 #178 (file T5_00169)
	11:57			**36°20.05'**	**-8°55.05'**					magnetometer hauling in completed
	12:02	**GOHR031**								
										hauling in guns & streamer
	12:10			**36°22.09'**	**-8°50.01'**					
	13:25									
	13:33		191	**36°23.08'**	**-8°50.00'**	2907		**C4_00170**		XCTD-2 #179 (file C4_00170)
										ship was stationary no tube was used,
										shot directly overboard

Day	Time	Station or Line name	N° station Bridge	Latitude	Longitude	depth	File	New file name	Comments
04/29/2007	**11:51**		192	**36°37.02'**	**-8°14.38'**	854	T5_00171	**T5_00171**	Vessel velocity 6 knots
									only XBT station #180
	12:16		193	**36°35.71'**	**-8°17.68'**	989	T5_00172	**T5_00172**	XBT #181
									Vessel velocity 6 knots
									note: the coordinates system wasn't get the true position.
									The correct coordinates were manually entered in the ed file
									(the system NAV was OFF)
	12:36		194	**36°34.59'**	**-8°20.49'**	1219	T5_00173	**T5_00173**	XBT station #182
	12:56		195	**36°33.61'**	**-8°23.15'**	1368	T5_00174	**T5_00174**	XBT station #183
	13:16		196	**36°32.61'**	**-8°25.50'**	1552	T5_00175	**T5_00175**	XBT station #184
									visual/radio contact with Poseidon
	13:35		197	**36°31.59'**	**-8°28.06'**	1960	T5_00176	**T5_00176**	XBT station #185
									6 knots - 7 knots speed
	13:51		198	**36°30.79'**	**-8°30.18'**	2290	T5_00177	**T5_00177**	XBT station #186
	14:10		199	**36°29.71'**	**-8°32.75'**	2249	T5_00178	**T5_00178**	XBT station #187
	14:31		200	**36°28.47'**	**-8°35.91'**	2481	T5_00179	**T5_00179**	XBT station #188
	14:52		201	**36°27.53'**	**-8°38.31'**	2019	T5_00180	**T5_00180**	XBT station #189
									last XBT for time being
	18:05			**36°17.68'**	**-9°09.68'**	3435			join with Poseidon
			202						start of airguns tests
	19:20		203	**36°15.68'**	**-9°10.83'**	3420	T5_00181	**T5_00181**	XBT station #190
	19:50								End of test 1 beam
	20:27								Start of ramp-up for full-array
	21:35			**36°16.12'**	**-9°08.20'**	3385			

	21:58			**36°17.81'**	**-9°08.32'**	3316			Still going on
	22:24			**36°18.73'**	**-9°09.91'**	3524			
	22:57			**36°19.09'**	**-9°11.14'**	3514			
	23:26			**36°19.00'**	**-9°09.04'**	3500			
	23:42			**36°20.11'**	**-9°09.08'**	3491			
04/30/2007	**00:08**		204	**36°19.04'**	**-9°10.80'**	3540	T5_00182	**T5_00182**	XBT station #191 (bad data)
									wire cut with airguns
	00:20		205	**36°18.47'**	**-9°10.42'**	3559	T5_00183	**T5_00183**	XBT station #192 (bad data)
									wire cut with airguns
	00:30			**36°17.86'**	**-9°10.27'**	3479			the seismic line as started
	00:50		206	**36°16.55'**	**-9°10.23'**	3413	T5_00184	**T5_00184**	XBT station #193
									we had to stop because the tube to launch
									the probe had to be prepared
									and put in position
	01:05		207	**36°15.62'**	**-9°10.25'**	3420	T5_00185	**T5_00185**	XBT station #194
									The data is not 100% good
									about 1300m at the wire has been cut
									at the surface the data its among
	01:15		208	**36°14.86'**	**-9°10.26'**	3452	T5_00186	**T5_00186**	XBT station #195
									staircases from 1300m down
									and intrusions of Mad Water (MW)
	01:30		209	**36°13.82'**	**-9°10.24'**	3530	T5_00187	**T5_00187**	XBT station #196
									2 intrusions of MW and staircases at 1300m
	01:45		210	**36°12.72'**	**-9°10.24'**	3617	T5_00187a	**T5_00188**	XBT station #197
									file was saved as T5_00187a because
									program asked to overwrite.
									We decided to save with a new name
	02:05		211	**36°11.78'**	**-9°11.078'**	3676	T5_00189	**T5_00189**	XBT station #198
	02:25		212	**36°12.44'**	**-9°12.76'**	3698	T5_00190	**T5_00190**	XBT station #199
	02:45		213	**36°13.59'**	**-9°14.02'**	3700	T5_00190a	**T5_00191**	XBT station #200

									changed file name to 190a to avoid overwriting
	03:28		214	**36°14.82'**	**-9°11.29'**	3454	T5_00191	**T5_00192**	XBT station #201
	03:45		215	**36°14.81'**	**-9°09.70'**	3460	T5_00193	**T5_00193**	XBT station #202
	04:06		216	**36°14.81'**	**-9°07.70'**	3471	T5_00194	**T5_00194**	XBT station #203
	04:20		217	**36°14.80'**	**-9°06.56'**	3437	T5_00195	**T5_00195**	XBT station #204
									calls itself sequence #194 note)
	04:35		218	**36°15.27'**	**-9°05.70'**	3396	T5_00195a	**T5_00196**	XBT station #205
	04:50		219	**36°14.89'**	**-9°05.38'**	3372	T5_00196	**T5_00197**	XBT station #206
	05:03		220	**36°14.76'**	**-9°06.72'**	3442	T5_00197	**T5_00198**	XBT station #207
	05:20		221	**36°14.72'**	**-9°08.23'**	3478	T5_00198	**T5_00199**	XBT station #208
	05:35		222	**36°14.66'**	**-9°09.39'**	3475	T5_00199	**T5_00200**	XBT station #209
	05:50		223	**36°14.91'**	**-9°10.31'**	3570	T5_00200	**T5_00201**	XBT station #210
	06:00		224	**36°15.71'**	**-9°09.64'**	3415	T5_00201	**T5_00202**	XBT station #211
	06:10		225	**36°15.22'**	**-9°09.33'**	3307	T5_00202	**T5_00203**	XBT station #212
	06:17								line stopped for safety reasons
	06:20		226	**36°14.68'**	**-9°09.96'**	3462	T5_00203	**T5_00204**	XBT station #213
	06:30		227	**36°14.24'**	**-9°10.67'**	3485	T5_00205	**T5_00205**	XBT station #214 wrong
	06:40		228	**36°14.56'**	**-9°11.34'**	3468	T5_00206	**T5_00206**	XBT station #215
	07:00		229	**36°15.78'**	**-9°10.63'**	3416	T5_00207	**T5_00207**	XBT station #216
	07:20		230	**36°15.22'**	**-9°09.25'**	3439	T5_00207a	**T5_00208**	XBT station #217
	07:40		231	**36°14.45'**	**-9°10.27'**	3472	T5_00208	**T5_00209**	XBT station #218
	08:00		232	**36°15.47'**	**-9°11.35'**	3429	T5_00210	**T5_00210**	XBT station #219
	08:20		233	**36°16.22'**	**-9°09.93'**	3409	T5_00211	**T5_00211**	XBT station #220

	08:40		234	**36°15.208'**	**-9°08.67'**	3451	T5_00212	**T5_00212**	XBT station #221
	09:00		235	**36°14.09'**	**-9°09.33'**	3516	T5_00213	**T5_00213**	XBT station #222
	09:20		236	**36°14.159'**	**-9°10.93'**	3490	T5_00214	**T5_00214**	XBT station #223
	09:40		237	**36°15.412'**	**-9°11.240'**	3430	T5_00215	**T5_00215**	XBT station #224
	10:00		238	**36°16.20'**	**-9°09.69'**	3407	T5_00216	**T5_00216**	XBT station #225
	10:20		239	**36°14.98'**	**-9°08.006'**	3472	T5_00217	**T5_00217**	XBT station #226
	10:40		240	**36°14.07'**	**-9°08.26'**	3498	T5_00218	**T5_00218**	XBT station #227
	11:00		241	**36°13.423'**	**-9°09.916'**	3571	T5_00219	**T5_00219**	XBT station #228
	11:20		242	**36°13.868'**	**-9°11.450'**	3520	T5_00220	**T5_00220**	XBT station #229
	11:40		243	**36°15.30'**	**-9°11.92'**	3446	T5_00221	**T5_00221**	XBT station #230
	12:00		244	**36°16.65'**	**-9°11.08'**	3430	T5_00222	**T5_00222**	XBT station #231
									bad data temp jumped to 27°
									suddenly trying again
	12:08		245	**36°16.69'**	**-9°10.44'**	3419	T5_00223	**T5_00223**	XBT station #232
	12:26		246	**36°16.47'**	**-9°08.75'**	3384	T5_00223a	**T5_00224**	XBT station #233
									renamed file T5_00233a
									to avoid overwrite
	12:48		247	**36°15.26'**	**-9°07.37'**	3454	T5_00225	**T5_00225**	XBT station #234
	13:09		248	**36°13.77'**	**-9°07.82'**	3498	T5_00226	**T5_00226**	XBT station #235
									upper som are rubbish
									probe stuck in tube
	13:28		249	**36°12.94'**	**-9°09.28'**	3577	T5_00227	**T5_00227**	XBT station #236
	13:49		250	**36°13.02'**	**-9°11.28'**	3622	T5_00228	**T5_00228**	XBT station #237
	14:08		251						bad probe corroded

	14:14		252	**36°14.42'**	**-9°12.59'**	3513	T5_00229	**T5_00229**	XBT station #239
	14:34		253	**36°15.92'**	**-9°12.47'**	3481	T5_00230	**T5_00230**	XBT station #240
	14:58		254	**36°17.14'**	**-9°10.72'**	3438	T5_00231	**T5_00231**	XBT station #241
									4 min delay in launch
									due to radio comm problem
	15:15		255	**36°17.10'**	**-9°08.94'**	3385	T5_00232	**T5_00232**	XBT station #242
									spike in profile at start could be
									due to XBT stuck in tube for a few seconds
	15:35		256	**36°15.77'**	**-9°08.45'**	3419	T5_00233	**T5_00233**	XBT station #243
									data lost after 1355m depth, wire was still
									spooling however
	15:56		257	**36°15.39'**	**-9°10.06'**	3425	T5_00234	**T5_00234**	XBT station #244
	16:14		258	**36°15.46'**	**-9°11.88'**	3443	T5_00234a	**T5_00235**	XBT station #245
									possible offset T5_00234
	16:34		259	**36°16.74'**	**-9°12.05'**	3495	T5_00235	**T5_00236**	XBT station #246
	16:54		260	**36°16.57'**	**-9°10.68'**	3419	T5_00236	**T5_00237**	XBT station #247
	17:14		261	**36°15.27'**	**-9°10.61'**	3429	T5_00237	**T5_00239**	XBT station #248
									airguns stopped
	17:28		262						XBT
	17:31								arret des tirs
	20:33		263	**36°16.01'**	**-9°05.81'**	3377			begin of mooring CTD #006
	21:39			**36°16.03'**	**-9°05.96'**	3352			CTD at 3300m depth
	21:44			**36°16.33'**	**-9°05.97'**	3353			reach 3370m depth
	21:47								début de la rentrée
	23:24			**36°16.36'**	**-9°06.38'**	3344			CTD on board
05/01/2007	**01:16**		264	**36°10.56**	**-9°19.52'**	3987			CTD deployed #005
	02:37			**36°10.91'**	**-9°19.86'**	3999			CTD at bottom

	04:09		264	**36°11.25'**	**-9°20.29'**	3984			CTD on board
									CTD 006 station 6 (PO5 005-2)
	05:34		265	**36°04.92'**	**-9°32.93'**	4041			CTD station, deploying
	06:35			**36°04.69'**	**-9°33.57'**	4057			CTD at 2900m
	06:57			**36°04.62'**	**-9°33.73'**	4058			CTD at 4000m
									stopping before landing
									the profile is classic for deep waters
	07:59			**36°04.70'**	**-9°34.03'**	4052			CTD at 900m
	08:15			**36°04.06'**	**-9°33.09'**	4056			CTD at 200m
	08:25	station P4		**36°04.65'**	**-9°33.98'**	4055			CTD on board
	08:53		266	**36°05.06'**	**-9°32.97'**	4034			start deploying streamer 3 knots
	10:07			**36°07.10'**	**-9°27.82'**	4009			streamer deployed completely
	11:00			**36°08.58'**	**-9°24.24'**	4069			
	11:14			**36°08.99'**	**-9°23.29'**	4025			deployment first array of guns
	11:38			**36°09.64'**	**-9°21.66'**	4024			first beam OK
	12:00			**36°10.25'**	**-9°20.19'**	3997			important : note precisely the time
									hour, min and sec
									of the first shot starting the ramp up (13:07)
	12:22								first shot but pb with streamer
	12:37			**36°11.27'**	**-9°17.68'**				decide to put the streamer to 10m depth
	13:01			**36°11.94'**	**-9°16.01'**				bring back the streamer to 8m
	13:07	SW							shots are recorded
	13:27	**GOLR001**							start seismic line
	13:40		267	**36°13.38'**	**-9°13.38'**	3671	T5_00240	**T5_00240**	XBT station 249
	14:03		268	**36°13.69'**	**-9°11.78'**	3546	T5_00241	**T5_00241**	XBT station 250

	14:20			269	**36°14.15'**	**-9°10.60'**	3491	T5_00242	**T5_00242**	XBT station 251
	14:39			270	**36°14.69'**	**-9°09.26'**	3473	T5_00243	**T5_00243**	XBT station 252
	15:00			271	**36°15.29'**	**-9°07.76'**	3453	T5_00244	**T5_00244**	XBT station 253
	15:21			272	**36°15.87'**	**-9°06.35'**	3392	T5_00245	**T5_00245**	XBT station 254
	15:41			273	**36°16.43'**	**-9°05.02'**	3335	T5_00246	**T5_00246**	XBT station 255
	15:58			274	**36°16.93'**	**-9°03.75'**	3269	T5_00247	**T5_00247**	XBT station 256
	16:20			275						XBT station 257 (failed)
	16:30			276	**36°17.89'**	**-9°01.41'**	3116	T5_00249	**T5_00248**	XBT station 258
	16:50			277	**36°18.37'**	**-9°00.24'**	3085	T5_00250	**T5_00250**	XBT station 259
	17:10			278	**36°18.98'**	**-8°58.74'**	3204	T5_00251	**T5_00251**	XBT station 260
	17:30			279	**36°19.50'**	**-8°57.44'**	3174	T5_00253	**T5_00253**	XBT station 261
	17:50			280	**36°20.10'**	**-8°55.97'**	3146	T5_00254	**T5_00254**	XBT station 262
	18:10			281	**36°20.65'**	**-8°54.67'**	3118	T5_00255	**T5_00255**	XBT station 263
	18:30			282	**36°21.23'**	**-8°53.35'**	3092	T5_00256		XBT station 264 (failed)
								not saved		probe wire torn by sphip's motion swells
	18:40			283	**36°21.60'**	**-8°52.49'**	3048	T5_00257	**T5_00257**	XBT station 265
	19:00			284	**36°22.02'**	**-8°51.24'**	3027	T5_00258	**T5_00258**	XBT station 266
	19:20			285	**36°22.64'**	**-8°49.77'**	2924	T5_00259	**T5_00259**	XBT station 267
	19:40			286	**36°23.27'**	**-8°48.23'**	2706	T5_00260	**T5_00260**	XBT station 268
	20:00			287	**36°23.86'**	**-8°46.86'**	2704	T5_00261	**T5_00261**	XBT station 269
	20:20			288	**36°24.552'**	**-8°45.238'**	2585	T5_00262	**T5_00262**	XBT station 270
	20:43			289	**36°25.189'**	**-8°43.567'**	2388	T5_00263	**T5_00263**	XBT station 271
	21:00			290	**36°25.837'**	**-8°41.921'**	2483	T5_00264	**T5_00264**	XBT station 272

	21:20				**36°26.23'**	**-8°41.00'**	2307	T5_00265	**T5_00265**	XBT station 273
	21:40			291	**36°26.85'**	**-8°39.41'**	2141	T5_00266	**T5_00266**	XBT station 274
	22:00			292	**36°27.45'**	**-8°37.92'**	2050	T5_00267	**T5_00267**	XBT station 275
	22:20			293	**36°28.09'**	**-8°36.28'**	2477	T5_00268	**T5_00268**	XBT station 276
	22:40			294	**36°28.67'**	**-8°34.88'**	2389	T5_00269	**T5_00269**	XBT station 277
	23:00			295	**36°29.269'**	**-8°33.366'**	2217	T5_00270	**T5_00270**	XBT station 278
	23:20			296	**36°29.861'**	**-8°33.916'**	2259	T5_00271	**T5_00271**	XBT station 279
	23:40			297	**36°30.38'**	**-8°30.60'**	2315	T5_00272	**T5_00272**	XBT station 280
05/02/2007	**00:00**			298	**36°30.96'**	**-8°29.22'**	2127	T5_00273	**T5_00273**	XBT station 281
	00:21			299	**36°31.55'**	**-8°27.78'**	1887	T5_00274	**T5_00274**	XBT station 282
										depth taken at end of XBT
	00:40			300	**36°32.19'**	**-8°26.27'**	1816	T5_00275	**T5_00275**	XBT station 283
	01:01			301	**36°32.75'**	**-8°24.92'**	1525	T5_00276	**T5_00276**	XBT station 284
	01:21			302	**36°33.33'**	**-8°23.48'**	1334	T5_00277	**T5_00277**	XBT station 285
	01:40			303	**36°33.89'**	**-8°22.10'**	1490	T5_00278	**T5_00278**	XBT station 286
	02:02			304	**36°34.47'**	**-8°20.39'**	1241	T5_00279	**T5_00279**	XBT station 287
	02:24			305	**36°35.22'**	**-8°18.70'**	1061	T5_00280	**T5_00280**	XBT station 288
										at 1077m data went at constant temperature
										though Sonar shows depth at 2090
	02:41			306	**36°35.77'**	**-8°17.47'**	966	T5_00281	**T5_00281**	XBT station 289
										see previous note both proes from
										same shiping box
	03:00			307	**36°36.36'**	**-8°16.03'**	927	T5_00282	**T5_00282**	XBT station 290
										bad data starting at about 750m …
										changing to anew box of XBT5 old probes
										have humitity???

	03:24		308	**36°37.06'**	**-8°14.31'**	860	T5_00283	**T5_00283**	XBT station 291
									the depth value is not right
	03:45		309	**36°37.73'**	**-8°12.71'**	806	T5_00284	**T5_00284**	XBT station 292
	04:05		310	**36°38.36'**	**-8°11.09'**	759	T5_00285	**T5_00285**	XBT station 293
									change to T7
	04:28		311						XBT
	04:30		312	**36°39.13'**	**-8°09.18'**	768	T7_00285	**T7_00285**	XBT station 294
	04:50		313	**36°39.68'**	**-8°07.67'**	769	T7_00286	**T7_00286**	XBT station 295
	05:10		314	**36°40.27'**	**-8°06.18'**	780	T7_00287	**T7_00287**	XBT station 296
	05:30		315	**36°40.91'**	**-8°04.67'**	760	T7_00287b	**T7_00288**	XBT station 297
	05:50		316	**36°41.53'**	**-8°03.07'**	747	T7_00289	**T7_00289**	XBT station 298
		NE							XBT finished streamer & guns recovering
	05:55			**36°41.07'**	**-8°02.33'**	740			Last shot fired 2520
	08:15								streamer coming back on board
	09:16			**36°47.35'**	**-7°49.94'**	600			streamer and buoy on board
	10:25			**36°47.58'**	**-7°50.21'**	617			stay on station
	12:00			**36°46.91'**	**-7°51.91'**	622			stay on station
05/02/2007	**04:00**		note	Since we are in shallow waters (<1000m) the deep sounder in the main lab needed to be adjusted to make the "minimuml depth" sufficiently low so that these shallow waters can be mapped. If the "minimum depth" is too high, the depth on the green screen will be wrong. So please watch that the green screen values are reasonable by doucble checking with a nautical chart (map room).					
				to change the minimum value on the depth sounder, go to "bottom detection menu-1" and by using the joystick adjust the "minimum depth" value currently it is set to 300m which is loww enough, but when going in deeper waters it will need to be increased again so that the min-max values are not too far apart.					
			note 2	Ship will be finished this line at about 5:30am or 6:00am. Ship will then turn course					
				WEATHER DOWN TIME start work 0600 tomorrow					

05/03/2007	**08:00**			**36°38.13'**	**-8°00.08'**	749			streamer in water 8 m depth speed 3 knots
	08:04								start deploying 1st beam of guns
	09:15		317						start ramp-up shots every 20s
	09:35			**36°37.69'**	**-8°06.41'**	837			ramp-up
	09:50:59								test shot on seal display
	09:50:59								SEC-D header
	09:51								Chris LOG
	09:51:20								on Bruno system "meinberg" time calibration
	09:59:00	**GOLR002**							
	10:00	A11	318	**36°37.478'**	**-8°08.536'**	840	T5_00290	**T5_00290**	XBT station 299
	10:20		319	**36°37.314'**	**-8°09.875'**	818	T5_00291	**T5_00291**	XBT station 300
	10:40		320	**36°37.165'**	**-8°11.342'**	820	T5_00292	**T5_00292**	XBT station 301
	11:00		321	**36°37.038'**	**-8°12.872'**	835	T5_00293	**T5_00293**	XBT station 302
	11:20		322	**36°36.845'**	**-8°14.489'**	859	T5_00294	**T5_00294**	XBT station 303
	11:40		323	**36°36.69'**	**-8°16.00'**	894	T5_00295	**T5_00295**	XBT station 304
	12:00		324	**36°36.51'**	**-8°17.49'**	926	T5_00296	**T5_00296**	XBT station 305
	12:20		325	**36°36.35'**	**-8°19.05'**	977	T5_00297	**T5_00297**	XBT station 306
	12:41		326	**36°36.18'**	**-8°20.66'**	1086	T5_00298	**T5_00298**	XBT station 307
	12:59	A10	327	**36°36.03'**	**-8°22.10'**	1245	T5_00299	**T5_00299**	XBT station 308
	13:07:00								end of line A11-A10
									moving to line A9-A8
		note	spiral start : 00:50 30:04		**T5= 57**				
			spiral finish : 17:14 30:04						
			LR001 start : 13:27 01/05		**T5=46 T7=5**				

			finish : 06:55 02/05						
			A10-A11 start : 09:59 03/05		**T5= 10**				
			finish : 13:06	03/05					
			total : T5=113 T7=5						
			remaining XBT :						
				T5 = 248 units					
				T7 = 26 units					
				XCTD 1 = 13 units					
				XCTD 2 = 9 units					
			NB : for all long profiles A-B/C B/C - D etc XBT every 30 mins						
	16:09			**36°42.62'**	**-8°20.71'**	680			turning on to profile
	16:46	**GOLR003**							
		A9							start 16:40
	16:49			**36°40.73'**	**-8°18.78'**	693			on line pt A9
	17:00		328	**36°40.20'**	**-8°18.23'**	716	T7_00300	**T7_00300**	XBT station 309
	17:20		329	**36°39.22'**	**-8°17.31'**	771	T7_00301	**T7_00301**	XBT station 310
	17:40		330	**36°38.27'**	**-8°16.39'**	812	T5_00302	**T5_00302**	XBT station 311
	18:00		331	**36°37.24'**	**-8°15.43'**	848	T5_00303	**T5_00303**	XBT station 312
	18:20		332	**36°36.26'**	**-8°14.49'**	892	T5_00304	**T5_00304**	XBT station 313
	18:40		333	**36°35.32'**	**-8°13.58'**	970	T5_00305	**T5_00305**	XBT station 314
	19:00		334	**36°34.33'**	**-8°12.61'**	1017	T5_00306	**T5_00306**	XBT station 315
	19:20		335	**36°33.36'**	**-8°11.72'**	1041	T5_00307	**T5_00307**	XBT station 316
	19:35	A8		**36°32.52'**	**-8°11.00'**	1066			arrived at point A8
	21:53:40	**GOLR004**							first shot recorded for profile A7-A6
		A7							
	22:00		336	**36°32.24'**	**-8°17.29'**	1350	T5_00308	**T5_00308**	XBT station #317
	22:20		337	**36°33.43'**	**-8°16.68'**	1175	T5_00309	**T5_00309**	XBT station #318

	22:40		338	**36°34.58'**	**-8°16.09'**	1058	T5_00310	**T5_00310**	XBT station #319
	23:00		339	**36°35.81'**	**-8°15.51'**	938	T5_00311	**T5_00311**	XBT station #320
	23:20		340	**36°35.85'**	**-8°14.94'**	863	T5_00312	**T5_00312**	XBT station #321
	23:40		341	**36°38.083'**	**-8°14.344'**	801	T5_00313	**T5_00313**	XBT station #322
05/04/2007	**00:00**		342	**36°39.188'**	**-8°13.788'**	768	T5_00314	**T5_00314**	XBT station #323
	00:19		343	**36°40.30'**	**-8°13.21'**	739	T5_00315	**T5_00315**	XBT station #324
	00:40		344	**36°41.53'**	**-8°12.57'**	706	T5_00316	**T5_00316**	XBT station #325
	01:00	A6	345	**36°42.76'**	**-8°12.01'**	673	T7_00317	**T7_00317**	XBT station #326
	01:05								in transit to point A
									the seismic line
		NE							it will takes 4h(+/-) to get there
	05:06:00	**GOLR005**							
	05:10		346	**36°37.94'**	**-8°12.17'**	796	T7_00318	**T7_00318**	XBT station #327
	05:40		347	**36°37.10'**	**-8°14.26'**	843	T5_00318	**T5_00318**	XBT station #328
	06:10		348	**36°36.29'**	**-8°16.31'**	897	T5_00319	**T5_00319**	XBT station #329
	06:40		349	**36°35.45'**	**-8°18.41'**	1019	T5_00320	**T5_00320**	XBT station #330
	07:10		350	**36°34.56'**	**-8°20.61'**	1236	T5_00321	**T5_00321**	XBT station #331
	07:40		351	**36°33.73'**	**-8°22.71'**	1480	T5_00322	**T5_00322**	XBT station #332
	08:10		352	**36°32.848'**	**-8°24.952'**	1495	T5_00324	**T5_00324**	XBT station #333
	08:40		353	**36°32.013'**	**-8°27.051'**	1862	T5_00325	**T5_00325**	XBT station #334
	09:10		354	**36°31.258'**	**-8°28.898'**	2071	T5_00326	**T5_00326**	XBT station #335
	09:40		355	**36°30.417'**	**-8°31.025'**	2286	T5_00327	**T5_00327**	XBT station #336
	09:55		356	**36°30.004'**	**-8°32.114'**	2280	T5_00328	**T5_00328**	XBT station #337 (test)
	10:10		357	**36°29.520'**	**-8°33.299'**	2290	T5_00329	**T5_00329**	XBT station #338 (test)

	10:30			358	**36°29.02'**	**-8°34.54'**	2232	T5_00330	**T5_00330**	T5 port side (test)
		note		The five XBT were wrong due to current bringing them through the streamer and airgun. A test on port side at 10:30 was also wrong						
	10:45			359	**36°28.62'**	**-8°35.53'**	2486	T5_00331	**T5_00331**	T5 port side again (test)
				the files from T5_00328-00331 are testing to get a good data acquisition						
	10:56			360	**36°28.34'**	**-8°26.22'**	2498	T5_00332	**T5_00332**	XBT T5 stat 341 (test) wrong
	11:28			361	**36°27.491'**	**-8°38.424'**	2104	T5_00333	**T5_00333**	XBT T5 stat 342 (test)
	13:10			362	**36°24.51'**	**-8°45.68'**	2785	T5_00334	**T5_00334**	XBT T5 stat 343 (test) Bad data
	13:50			363	**36°23.40'**	**-8°48.43'**	2748	T5_00335	**T5_00335**	XBT T5 stat 344 Bad data
										testing to launch XBT from the upper deck
										not sucessful!
				from T5_00328 to T5_00335 the data is not completed (it is stoping at +/- 300m) due ti problems with the launching						
	15:03			365	**36°21.50'**	**-8°53.23'**	3058	T5_00336	**T5_00336**	XBT T5 station 345 data clipped at 1039m
	16:03			365	**36°19.71'**	**-8°57.66'**	3189	T5_00337	**T5_00337**	XBT T5 station 346 data clipped at 400m
	17:00			366	**36°18.12'**	**-9°01.54'**	3102	SN 192155	**T5_00338**	XBT station #347 clipped at 1600m
	18:02			367	**36°16.41'**	**-9°05.73'**	3352	T5_00339	**T5_00339**	XBT station #348 clipped at 1800m
										problem with file numbers, is fixed
	19:00			368	**36°14.81'**	**-9°09.62'**	3459	T5_00340	**T5_00340**	XBT station #349
	20:00			369	**36°12.96'**	**-9°14.19'**	3739	T5_00341	**T5_00341**	XBT station #350
	21:00			370	**36°11.237'**	**-9°18.24'**	3930	T5_00342	**T5_00342**	XBT station #351
	22:00			371	**36°04.625'**	**-9°22.242'**	4025	T5_00343	**T5_00343**	XBT station #352
										TDD=1730m
	23:00			372	**36°07.85'**	**-9°26.46'**	4019	T5_00344	**T5_00344**	XBT station #353
										terminal depth of data = 1487,3m(TDD)
05/05/2007	**00:00**			373	**36°06.22'**	**-9°30.51'**	3981	T5_00345	**T5_00345**	XBT station #354
										TDD = 962m

	01:00		374	**36°04.59'**	**-9°34.55'**	4054	T5_00346	**T5_00346**	XBT station #355
									at 700m to 800m the data is with a lot of
									spikes, but the rest looks until it
									reaches the TDD
									terminal depth of data = 1736m(TDD)
	02:00		375	**36°02.83'**	**-9°38.71'**	2974	T5_00347	**T5_00347**	XBT station #356
									the wire was cuted at 400m TDD=426m
	03:00		376	**36°01.14'**	**-9°42.79'**	3160	T5_00348	**T5_00348**	XBT station #357 (TDD=812)
	04:00		377	**36°59.42'**	**-9°46.85'**	2231	T5_00349	**T5_00349**	XBT station #358 (TDD=568m)
									spike at the surface (20m)
	05:00		379	**36°57.81'**	**-9°50.89'**	3230	T5_00350	**T5_00350**	XBT station #359 (TDD=800m)
	06:00		380	**36°56.08'**	**-9°55.02'**	3787	T5_00351	**T5_00351**	XBT station #360 (TDD=1900m)
	06:50	SW		**36°54.53'**	**-9°58.70'**	3847			EOL 06:42 S.O. crushed
	07:00								technical problems XBT station #361
	07:09		381	**35°54.07'**	**-9°59.84'**	3873	T5_00352	**T5_00352**	XBT station #362 clipped at 1400m
	07:17	**GOLR006**							
	08:05		382	**35°52.50'**	**-10°03.70'**	3930	T5_00353	**T5_00353**	XBT station #363 TDD=1200m
	09:00		383	**35°51.05'**	**-10°07.27'**	3782	T5_00354	**T5_00354**	XBT station #364 TDD=1500m
	10:00		384	**35°49.42'**	**-10°11.31'**	3962	T5_00355	**T5_00355**	XBT station #365 TDD=950m
	11:00		385	**35°47.77'**	**-10°15.39'**	3967	T5_00356	**T5_00356**	XBT station #366 TDD=1900m
	12:00		386	**35°46.16'**	**-10°19.38'**	3612	T5_00357	**T5_00357**	XBT station #367 TDD=1900m
	13:00		387	**35°44.48'**	**-10°23.61'**	4057	T5_00358	**T5_00358**	XBT station #368 TDD=1080m
									depth reading from green screen is not reliable
	14:00		388	**35°42.80'**	**-10°27.73'**	4154	T5_00359	**T5_00359**	XBT station #369 TDD=1800m
	14:30:00								
		↓							turning to line n°7

	18:45	**GOLR007**							turn complete, on profile
	18:58		389	**35°42.86'**	**-10°27.63'**	4800	T5_00360	**T5_00360**	XBT station #370 TDD=2200m full
	19:30		390	**35°43.70'**	**-10°25.56'**	4678	T5_00361	**T5_00361**	XBT station #371 TDD=1500m
	20:00		391	**35°44.61'**	**-10°23.40'**	4593	T5_00362	**T5_00362**	XBT station #372
	20:30		393	**35°45.62'**	**-10°20.84'**	4545	T5_00363	**T5_00363**	XBT station #373 (BAD PROBE)
									last probe to consider revision! Or check it!
	20:33		393	**35°45.78'**	**-10°20.45'**	4490	T5_00364	**T5_00364**	XBT station #374
									almost a plat vertical line = strange pile!
									with no variations
	21:00		394	**35°46.65'**	**-10°18.30'**	4510	T5_00365	**T5_00365**	XBT station #375
	21:30		395	**35°47.56'**	**-10°16.09'**	4589	T5_00366	**T5_00366**	XBT station #376
	22:00		396	**35°48.50'**	**-10°13.59'**	4620	T5_00367	**T5_00367**	XBT station #377
	22:30		397	**35°49.482'**	**-10°11.251'**	4624	T5_00368	**T5_00368**	XBT station #378
	23:00		398	**35°50.454'**	**-10°08.78'**	4620	T5_00369	**T5_00369**	XBT station #379
	23:30		399	**35°51.37'**	**-10°06.49'**	4615	T5_00370	**T5_00370**	XBT station #380
05/06/2007	**00:00**		400	**35°52.30'**	**-10°04.23'**	4592	T5_00371	**T5_00371**	XBT station #381
	00:30		401	**35°53.22'**	**-10°01.90'**	4564	T5_00372	**T5_00372**	XBT station #382
									1300/1600m good staircases very sharp!
	01:00		402	**35°54.09'**	**-9°59.78'**	4557	T5_00373	**T5_00373**	XBT station #383
	01:30		403	**35°55.04'**	**-9°57.47'**	4524	T5_00374	**T5_00374**	XBT station #384
									sequence staircases at 1400/1600m
	02:00	B	404	**35°56.04'**	**-9°55.26'**	4512	T5_00375	**T5_00375**	XBT station #385
									the deep water layer is not homogenous
	02:05	C							start turning to line C-D
		SSW							(end of line A-B, line 7)
	07:31	**GOLR008**							

	07:35		405	**35°54.12'**	**-9°59.89'**	4558	T5_00376	**T5_00376**	XBT station #386
	08:00		406	**35°55.61'**	**-9°58.40'**	4535	T5_00377	**T5_00377**	XBT station #387
	08:30		407	**35°57.18'**	**-9°56.86'**	4506	T5_00378	**T5_00378**	XBT station #388
	09:00		408	**35°58.75'**	**-9°55.32'**	4470	T5_00379	**T5_00379**	XBT station #389
	09:30		409	**36°00.55'**	**-9°53.50'**	4403	T5_00380	**T5_00380**	XBT station #390
	10:00		410	**36°02.00'**	**-9°52.00'**	4340	T5_00381	**T5_00381**	XBT station #391
	10:30		411	**36°03.68'**	**-9°50.39'**	4265	T5_00382	**T5_00382**	XBT station #392
	11:00		412	**36°05.27'**	**-9°48.82'**	4187	T5_00383	**T5_00383**	XBT station #393
	11:30		413	**36°07.032'**	**-9°47.104'**	4127	T5_00384	**T5_00384**	XBT station #394
	12:00		414	**36°08.32'**	**-9°45.78'**	4079	T5_00385	**T5_00385**	XBT station #395
	12:30		415	**36°09.91'**	**-9°44.22'**	4043	T5_00386	**T5_00386**	XBT station #396
	13:00		416	**36°11.41'**	**-9°42.72'**	3920	T5_00387	**T5_00387**	XBT station #397
	13:30		417	**36°13.22'**	**-9°40.92'**	3806	T5_00388	**T5_00388**	XBT station #398
									Bad Data! The station was repeated (#399)
	13:38		418	**36°13.42'**	**-9°40.71'**	3791	T5_00389	**T5_00389**	XBT station #399
	14:00		419	**36°14.66'**	**-9°39.48'**	3697	T5_00390	**T5_00390**	XBT station #400
	14:30		420	**36°16.11'**	**-9°38.01'**	3545	T5_00391	**T5_00391**	XBT station #401
	14:56								line break to repair inboard airgun
	19:22	**GOLR009**							
	19:30	NE	421	**36°09.37'**	**-9°38.71'**	3918	T5_00392	**T5_00392**	XBT station #402
		SW							clipped at 500m
	20:56:00								
	22:53:00	**GOLR010**							
	23:00		422	**36°08.58'**	**-9°45.46'**	4069	T5_00393	**T5_00393**	XBT station #403
	23:15	SW	423	**36°09.317'**	**-9°44.79'**	4042	T5_00394	**T5_00394**	XBT station #404

	23:30		424	**36°10.15'**	**-9°43.98'**	4035	T5_00395	**T5_00395**	XBT station #405
	23:45		425	**36°10.789'**	**-9°43.355'**	4000	T5_00396	**T5_00396**	XBT station #406
05/07/2007	**00:00**			**36°11.492'**	**-9°42.619'**	3914	T5_00397	**T5_00397**	XBT station #407
	00:15:00		426	**36°12.21'**	**-9°41.89'**	3875	T5_00398	**T5_00398**	XBT station #408
	00:30:00		427	**36°12.94'**	**-9°41.18'**	3824	T5_00399	**T5_00399**	XBT station #409
	00:45:00		428	**36°13.64'**	**-9°40.42'**	3772	T5_00400	**T5_00400**	XBT station #410
	01:00:00		429	**36°14.51'**	**-9°39.67'**	3713	T5_00401	**T5_00401**	XBT station #411
	01:15:00		430	**36°15.27'**	**-9°38.91'**	3645	T5_00402	**T5_00402**	XBT station #412
	01:30:00		431	**36°15.99'**	**-9°38.15'**	3555	T5_00403	**T5_00403**	XBT station #413
									After 1940m bad data
	01:40	D (NNE)							end of line and turning to do loop
									paralel section to line C-D
	03:15	D (NNE)							Start of the line paralel to C-D line
	03:13	**GOLR011**							
	03:18		432	**36°12.75'**	**-9°35.06'**	3699	T5_00404	**T5_00404**	XBT station #414
									After 1130m bad data
	03:30		433	**36°12.13'**	**-9°35.65'**	3724	T5_00405	**T5_00405**	XBT station #415
									afetr 1950m bad data
	03:45		434	**36°11.38'**	**-9°36.33'**	3807	T5_00406	**T5_00406**	XBT station #416
									after 1800m bad data
	04:00		435	**36°10.53'**	**-9°37.18'**	3863	T5_00407	**T5_00407**	XBT station #417
									after 1413m bad data
	04:15		436	**36°09.93'**	**-9°37.76'**	3900	T5_00408	**T5_00408**	XBT station #418
									after 1445m bad data
	04:30		437	**36°09.26'**	**-9°38.42'**	3928	T5_00409	**T5_00409**	XBT station #419
									clipped at 1400m

	04:45		438	**36°08.49'**	**-9°39.14'**	3957	T5_00410	**T5_00410**	XBT station #420
									clipped at 500m
	05:00		439	**36°07.82'**	**-9°39.78'**	3995	T5_00411	**T5_00411**	XBT station #421
									clipped at 1250m
	05:30		440	**36°06.41'**	**-9°41.15'**	4058	T5_00412	**T5_00412**	XBT station #422
									full 2200m w. course change
									highly marked structure
	06:00		441	**36°04.85'**	**-9°42.69'**	4139	T5_00413	**T5_00413**	XBT station #423
									full 2200m w. course change
									calm structure
	06:30		442	**36°03.39'**	**-9°43.99'**	4211	T5_00414	**T5_00414**	XBT station #424
									full 2200m w. course change
									calm structure
	07:00		443	**36°01.67'**	**-9°45.76'**	4299	T5_00415	**T5_00415**	XBT station #425
									full 2200m w. course change
									calm structure
		End Of							
	07:35	SSW	444	**36°00.07'**	**-9°47.29'**	4321	T5_00416	**T5_00416**	XBT station #426
		Line							full 2200m w. course change
									calm structure
	09:37:00	**GOLR12**							begin turn - GPS TIME!
		SW							
	09:45		445	**36°03.95'**	**-9°50.10'**	4237	T5_00417	**T5_00417**	XBT station #427
	10:00		446	**36°04.63'**	**-9°49.48'**	4213	T5_00418	**T5_00418**	XBT station #428 (9:58:40)
	10:15		447	**36°05.397'**	**-9°48.716'**	4186	T5_00419	**T5_00419**	XBT station #429 (10:14:13)
	10:30		448	**36°06.10'**	**-9°47.96'**	4149	T5_00420	**T5_00420**	XBT station #430 (10:29:00)
	10:45		449	**36°06.86'**	**-9°47.268'**	4130	T5_00421	**T5_00421**	XBT station #431 (10:39:57)
	11:00		450	**36°07.56'**	**-9°46.56'**	4106	T5_00422	**T5_00422**	XBT station #432 (10:59:21)
	11:15		451	**36°05.397'**	**-9°45.78'**	4078	T5_00423	**T5_00423**	XBT station #433 (11:14:50)
	11:30		452	**36°08.99'**	**-9°45.13'**	4052	C4_00424	**C4_00424**	XCTD-2 station #434 (11:30:00)

	11:45			**36°09.62'**	**-9°44.53'**	4038	T5_00425	**T5_00425**	XBT station #435 (11:44:02)
	12:00		453	**36°10.32'**	**-9°43.042'**	4028	T5_00426	**T5_00426**	XBT station #436 (11:58:40)
	12:15		454	**36°11.17'**	**-9°42.97'**	3946	T5_00427	**T5_00427**	XBT station #437 (12:16:17)
	12:30		455	**36°11.79'**	**-9°42.27'**	3895	T5_00428	**T5_00428**	XBT station #438 (12:29:42)
	12:46		456	**36°12.60'**	**-9°41.50'**	3844	T5_00429	**T5_00429**	XBT station #439 (12:46:13)
	13:02		457	**36°13.38'**	**-9°40.74'**	3771	T5_00430	**T5_00430**	XBT station #440 (13:02:39)
	13:16		458	**36°14.04'**	**-9°40.12'**	3743	T5_00431	**T5_00431**	XBT station #441 (13:16:03)
	13:31		459	**36°14.82'**	**-9°39.35'**	3691	T5_00432	**T5_00432**	XBT station #442 (13:31:28)
	13:45		460	**36°15.50'**	**-9°38.64'**	3615	T5_00433	**T5_00433**	XBT station #443 (13:45:35)
	14:00		461	**36°16.17'**	**-9°37.96'**	3526	T5_00434	**T5_00434**	XBT station #444 (13:59:28)
	14:15		462	**36°16.94'**	**-9°37.22'**	3452	T5_00435	**T5_00435**	XBT station #445 (14:15:23)
	14:45		463	**36°18.24'**	**-9°35.93'**	3307	T5_00436	**T5_00436**	XBT station #446 (14:44:09)
	15:15		464	**36°19.75'**	**-9°34.36'**	3223	T5_00437	**T5_00437**	XBT station #447 (15:15:15)
	15:45		465	**36°21.15'**	**-9°33.00'**	3192	T5_00438	**T5_00438**	XBT station #448 (15:44:54)
	16:15		466	**36°22.54'**	**-9°31.59'**	3237	T5_00439	**T5_00439**	XBT station #449 (16:14:47)
	16:45		467	**36°24.02'**	**-9°30.10'**	3329	T5_00440	**T5_00440**	XBT station #450 (16:45:30)
	17:15		468	**36°25.50'**	**-9°28.59'**	3288	T5_00441	**T5_00441**	XBT station #451 (17:15:40)
									full 2200m
	17:45	End Of	469	**36°26.90'**	**-9°27.16'**	3235	T5_00442	**T5_00442**	XBT station #452
		NE							beautiful jagged profile (TDD= 2200m)
		Line							
	18:00								point D' begin turn
		ENE							new line to the WSW
	19:23:00	**GOLR013**							
	19:45		470	**36°26.38'**	**-9°29.21'**	3265	T5_00443	**T5_00443**	XBT station #453 TDD=900m

									bad profile
	20:15		471	**36°25.78'**	**-9°31.60'**	3361	T5_00444	**T5_00444**	XBT station #454 (20:15:30) TDD=500m
	20:18		471 repeated	**36°25.64'**	**-9°31.89'**	3374	T5_00445	**T5_00445**	XBT station (20:19:40) TDD=370m
		WSW							repeat the station
	03:02:00								
			note:	the XBT's stations stops till change line, because we have a strong cross current and wind					
05/08/2007	**05:30**		472	**36°19.12'**	**-10°00.28'**	4688	T5_00446	**T5_00446**	XBT station #455 TDD=2200m
	05:33	**GOLR014**							
	06:00		473	**36°18.19'**	**-9°58.25'**	4771	T5_00447	**T5_00447**	XBT station #456 TDD=2200m (boring)
	06:30		474	**36°17.46'**	**-9°56.39'**	4844	T5_00448	**T5_00448**	XBT station #457 TDD=2200m (boring)
	06:50		475	**36°16.81'**	**-9°54.83'**	4764	T5_00449	**T5_00449**	XBT station #458 TDD=2200m (boring)
	07:10		476	**36°16.14'**	**-9°53.31'**	4581	T5_00450	**T5_00450**	XBT station #459 TDD=2200m (boring)
	07:30			**36°15.32'**	**-9°51.54'**	4265	T5_00451	**T5_00451**	XBT station #460 TDD=2200m
									(interest. profile)
	07:50			**36°14.74'**	**-9°50.05'**	3994	T5_00452	**not save**	XBT station #461 TDD=400m
									technical probe
	07:57		477	**36°14.62'**	**-9°49.76'**	3971	T5_00453	**T5_00453**	XBT station #462 TDD=2200m
									(interest. profile)
	08:10		478	**36°14.06'**	**-9°48.49'**	3875	T5_00454	**T5_00454**	XBT station #463 (08:11:00)
	08:30		479	**36°13.50'**	**-9°47.25'**	3790	T5_00455	**T5_00455**	XBT station #464 (08:28:10)
	08:50		480	**36°12.829'**	**-9°47.706'**	3780	T5_00456	**T5_00456**	XBT station #465 (08:48:45)
	09:10		481	**36°12.257'**	**-9°44.929'**	3823	T5_00457	**T5_00457**	XBT station #466 (09:09:39)
	09:30		482	**36°11.614'**	**-9°42.75'**	3900	T5_00458	**T5_00458**	XBT station #467 (09:28:55)
	09:50			**36°10.927'**	**-9°41.175'**	3879	T5_00459	**T5_00459**	XBT station #468 (09:49:01)
	10:10		483	**36°10.239'**	**-9°39.555'**	3875	T5_00460	**T5_00460**	XBT station #469 (10:09:40)
	10:30	SW	484	**36°09.613'**	**-9°38.123'**	3905	T5_00461	**T5_00461**	XBT station #470 (10:28:00)

									Recover airguns/streamer
									Meet with Poseidon
									Deploy airguns only for 2^{nd} VSP
			485						begin shooting star pattern
	18:19		486	**36°11.23'**	**-9°40.73'**	3868	T5_00462	**T5_00462**	XBT station #471 (point 1 of the star)
	18:36		487	**36°09.90'**	**-9°40.72'**	3916	T5_00463	**T5_00463**	XBT station #472 (point 6 of the star)
	19:54		488	**36°10.33'**	**-9°39.60'**	3872	T5_00464	**T5_00464**	XBT station #473 (point 4 of the star)
	20:13			**36°11.36'**	**-9°40.90'**	3866	T5_00465	**T5_00465**	XBT station #474 (point 1 of the star)
	21:04		489	**36°10.31'**	**-9°40.91'**	3896	T5_00466	**T5_00466**	XBT station #475 (point 7 of the star)
	21:20		490	**36°10.30'**	**-9°39.48'**	3873	T5_00467	**T5_00467**	XBT station #476 (point 4 of the star)
	22:14		491	**36°11.60'**	**-9°39.56'**	3823	T5_00468	**T5_00468**	XBT station #477 (point 2 of the star)
	22:36		492	**36°10.26'**	**-9°41.10'**	3897	T5_00469	**T5_00469**	XBT station #478 (point 7 of the star)
05/09/2007	**00:42**		493	**36°09.94'**	**-9°40.06'**	3899	T5_00470	**T5_00470**	XBT station #479 (point 5 of the star)
									(00:42:18)
	00:57		494	**36°11.24'**	**-9°40.06'**	3842	T5_00471	**T5_00471**	XBT station #480 (point 2 of the star)
									(00:57:45)
	01:58		495	**36°10.86'**	**-9°41.18'**	3881	T5_00472	**T5_00472**	XBT station #481 (point 8 of the star)
									(01:58:33)
	02:15		496	**36°09.93'**	**-9°40.05'**	3902	T5_00473	**T5_00473**	XBT station #482 (point 5 of the star)
									(02:15:20)
	03:15		497	**36°10.85'**	**-9°39.59'**	3848	T5_00474	**T5_00474**	XBT station #483 (point 3 of the star)
									(03:15:49)
	03:33		498	**36°10.84'**	**-9°41.28'**	3883	T5_00475	**T5_00475**	XBT station #484 (point 8 of the star)
									(03:33:01)
	04:39		499	**36°09.94'**	**-9°40.70'**	3912	T5_00476	**T5_00476**	XBT station #485 (point 6 of the star)
	04:55		500	**36°10.85'**	**-9°39.54'**	3847	T5_00477	**T5_00477**	XBT station #486 (point 3 of the star)
									spikes between 1490-1600m

	06:00:00								end of VSP
									Recover airguns
	08:18		501	**36°11.45'**	**-9°39.19'**	3807	T7_00478	**T7_00478**	XBT station #487 TDD=800m
	08:34		502				T7_00479	**T7_00479**	XBT station #48? Bad Probe
	08:37		503	**36°12.06'**	**-9°36.02'**	3670	T7_00480	**T7_00480**	XBT station #488 TDD=800m
	08:47		504	**36°13.42'**	**-9°34.40'**	3637	T7_00481	**T7_00481**	XBT station #489 TDD=800m
	09:01		505	**36°14.07'**	**-9°32.30'**	3583	T7_00482	**T7_00482**	XBT station #490 TDD=800m
	09:17		506	**36°15.15'**	**-9°29.16'**	3480	T7_00483	**T7_00483**	XBT station #491 TDD=800m
	09:31		507	**36°16.64'**	**-9°26.84'**	3390	T7_00484	**T7_00484**	XBT station #492 TDD=800m
	09:45		508	**36°18.23'**	**-9°24.51'**	3309	T7_00485	**T7_00485**	XBT station #493 TDD=800m
	10:01		509	**36°19.84'**	**-9°21.45'**	3302	C3_00486	**C3_00486**	XCTD-1 station #494 TDD=1100m
	10:21		510	**36°21.52'**	**-9°18.03'**	3335	T5_00487	**T5_00487**	XBT station #495 TDD=2200m
	10:40		511	**36°22.54'**	**-9°15.93'**	3550	T5_00488	**T5_00488**	XBT station #496 TDD=2100m
	10:55		512	**36°23.02'**	**-9°14.40'**	3523	T5_00489	**T5_00489**	XBT station #497 TDD=2000m
	16:02	A5							mooring released
	16:28								Onboard
	17:15	A1t							Minilogger released
	17:48								Onboard
	18:38	A1							mooring released
	18:41								Onboard
05/10/2007	**06:18**	A3t							Minilogger released
	07:12								Onboard
	07:21	A3							mooring released

	07:50								Onboard
	08:25	A4t							Minilogger released
	08:42								Onboard
	09:18	A4							mooring released
	10:03								Onboard
	10:50	A2							STABLE released
	11:20								Onboard
	11:36								Start deploying streamer
	15:35								Rebalance streamer
	15:51								Start deploying Airguns
	18:40								Soft start
	18:41	**GOMR001**	A						
	19:02		514	**36°37.43'**	**-9°13.36'**	822	C3_00490	**C3_00490**	XCTD-1 station #498 TDD=539,8m
	19:20		515	**36°36.94'**	**-8°14.61'**	857	T7_00491	**T7_00491**	XBT station #499 TDD=750m
	19:40		516	**36°36.38'**	**-8°16.02'**	913	T7_00492	**T7_00492**	XBT station #500 TDD=800m
	20:00		517	**36°35.82'**	**-8°17.43'**	964	C3_00493	**C3_00493**	XCTD-1 station #501 TDD=930m
	20:20		518	**36°36.38'**	**-8°19.08'**	1061	T5_00494	**T5_00494**	XBT station #502 TDD=1050m
	20:40		519	**36°34.57'**	**-8°20.51'**	1215	T5_00495	**T5_00495**	XBT station #503 TDD=1200m
	21:00		520	**36°34.03'**	**-8°22.08'**	1483	T5_00496	**T5_00496**	XBT station #504 TDD=1480m
	22:00		521	**36°32.24'**	**-8°26.49'**	1880	T5_00497	**T5_00497**	XBT station #505 TDD=1830m
	23:00		522	**36°30.54'**	**-8°30.73'**	2312	T5_00498	**T5_00498**	XBT station #506 TDD=2200m
05/11/2007	**00:00**		523	**36°28.66'**	**-8°35.363'**	2443	T5_00499	**T5_00499**	XBT station #507 TDD=1840m

	01:00			524	**36°26.74'**	**-8°40.22'**	2091	T5_00500	**T5_00500**	XBT station #508 TDD=1023m
										(01:00:18)
	02:00			525	**36°24.88'**	**-8°44.83'**	2415	T5_00501	**T5_00501**	XBT station #509 TDD=2200m
										(02:00:07)
	03:00			526	**36°23.00'**	**-8°49.40'**	2858	T5_00502	**T5_00502**	XBT station #510 TDD=1777m
										(03:00:07)
	04:00			527	**36°21.27'**	**-8°53.80'**	2577	T5_00503	**T5_00503**	XBT station #511 TDD=2200m
										(04:00:16)
	05:00			528	**36°19.46'**	**-8°58.23'**	2555	T5_00504	**T5_00504**	XBT station #512 TDD=2190m
	06:00			529	**36°17.65'**	**-9°02.69'**	2589	T5_00505	**T5_00505**	XBT station #513 TDD=2200m
	07:00			530	**36°15.79'**	**-9°07.24'**	2625	T5_00506	**T5_00506**	XBT station #514 TDD=2200m
	07:30			531	**36°14.88'**	**-9°09.50'**	2635	T5_00507	**T5_00507**	XBT station #515 TDD=2200m
	08:00			532	**36°13.97'**	**-9°11.70'**	2787	T5_00508	**T5_00508**	XBT station #516 TDD=1820m
	08:24									Recover 1 airgun beam for maintenance lost tail buoy
	08:30			533	**36°13.18'**	**-9°13.68'**	3682	T5_00509	**T5_00509**	XBT station #517 TDD=2200m
	09:00			534	**36°12.42'**	**-9°15.43'**	3813	T5_00510	**T5_00510**	XBT station #518 TDD=2000m
	09:20			535	**36°11.78'**	**-9°17.02'**	3903	T5_00511	**T5_00511**	XBT station #519 TDD=1820m
	09:24	**GOMR001-1**								
	09:40			536	**36°11.10'**	**-9°18.77'**	3937	T5_00512	**T5_00512**	XBT station #520 TDD=2200m
										data wrong 18°C at 2200m? Yes!!
	10:00			537	**36°10.52'**	**-9°20.13'**	3996	C4_00513	**C4_00513**	XCTD-2 station #521 TDD=850m
	10:20			539	**36°09.88'**	**-9°21.61'**	4019	T5_00514	**T5_00514**	XBT station #522 TDD=2200m
	10:40			540	**36°09.27'**	**-9°23.10'**	4022	T5_00515	**T5_00515**	XBT station #523 TDD=1880m
	11:00			541	**36°08.70'**	**-9°24.64'**	4044	T5_00516	**T5_00516**	XBT station #524 TDD=2200m
	11:14:24									End of Profile

	11:20		542	**36°08.02'**	**-9°26.25'**	4012	T5_00517	**T5_00517**	XBT station #525 TDD=1500m
	11:28								Recover streamer and airguns
	13:14								Deploy streamer
	13:32								Deploy airguns only for 2nd VSP
		GOMRtest2							Spectral tests to optimise
									tow depth of guns
	15:12	**GOMR002**							
	15:16		543	**36°09.43'**	**-9°33.45'**	3820	T5_00518	**T5_00518**	XBT station #526 TDD=2200m
	15:35		544	**36°10.19'**	**-9°32.15'**	3813	T5_00519	**T5_00519**	XBT station #527 TDD=2200m
	15:55		545	**36°11.12'**	**-9°30.60'**	3758	T5_00520	**T5_00520**	XBT station #528 TDD=2200m
	16:15		546	**36°11.72'**	**-9°29.53'**	3682	T5_00521	**T5_00521**	XBT station #529 TDD=2200m
	16:35		547	**36°12.52'**	**-9°28.19'**	3693	T5_00522	**T5_00522**	XBT station #530 TDD=2200m
	16:55		548	**36°13.26'**	**-9°26.85'**	3603	T5_00523	**T5_00523**	XBT station #531 TDD=2200m
	17:15		549	**36°14.02'**	**-9°25.60'**	3595	T5_00524	**T5_00524**	XBT station #532 TDD=2200m
									interesting profile
	17:35		550	**36°14.82'**	**-9°24.17'**	3737	T5_00525	**T5_00525**	XBT station #533 TDD=2200m
	17:46								
	20:44	**GOMR003**							
	21:00		552	**36°14:62'**	**-9°25.46'**	3568	T5_00526	**T5_00526**	XBT station #534 TDD=2200m
	21:30		553	**36°16:13'**	**-9°27.88'**	3443	C4_00527	**C4_00527**	XCTD-2 station #535 TDD=1500m
	22:00		554	**36°17:41'**	**-9°29.93'**	3440	T5_00528	**T5_00528**	XBT station #536 TDD=2200m
	22:30		555			3347	T5_00529	**T5_00529**	XBT station #537 TDD=XXXm
									bad probe
	22:33		556	**36°18:97'**	**-9°32.41'**	3292	T5_00530	**T5_00530**	XBT station #538 TDD=2200m

	23:00		557	**36°20:21'**	**-9°34.34'**	3204	T5_00531	**T5_00531**	XBT station #539 TDD=2200m
05/12/2007	**00:00**		558			3515	T5_00532	**T5_00532**	XBT station
	00:10		559	**36°23:66'**	**-9°39.91'**	3552	T5_00533	**T5_00533**	XBT station #540
									2 intrusions of MW at 760 and 970m
	01:02		560	**36°25:86'**	**-9°43.39'**	3813	T5_00534	**T5_00534**	XBT station #541 TDD=2200m
									small intrusions of MW at 600, 730, 790m
	02:00		561	**36°28:61'**	**-9°41.71'**	4147	T5_00535	**T5_00535**	XBT station #542 TDD=2200m
									rapid change at 700m until 900m
	03:00		562	**36°31:30'**	**-9°52.10'**	4059	T5_00536	**T5_00536**	XBT station #543 TDD=2200m
									3 intrusions of MW (760,880,990m)
									and good staircases at 1400m
	04:00		563	**36°33:99'**	**-9°56.40'**	3520	T5_00537	**T5_00537**	XBT station #544 TDD=2200m
	05:00		564	**36°36:61'**	**-10°00.53'**	3421	C4_00538	**C4_00537**	XCTD-2 station #545 TDD=1771m
	05:37	↓							line finished in turn
	09:04	**GOMR004**							Profile GOMR-004
	09:15		566	**36°38:53'**	**-10°01.87'**	3205	T5_00539	**T5_00539**	XBT station #546 TDD=2200m
	10:15		567	**36°35:53'**	**-9°57.95'**	3465	T5_00540	**T5_00540**	XBT station #547 TDD=2200m
	11:15		568	**36°32:96'**	**-9°54.26'**	3637	T5_00541	**T5_00541**	XBT station #548 TDD=1000m
									stop at 1000m depth
	11:20		569	**36°32:66'**	**-9°53.83'**	3700	T5_00542	**T5_00542**	XBT station #549 TDD=1000m
									same pb stop at 1000m
									wind and current
									wait for new instructions
	14:02:00								
		↓							
	15:00:00	**GOMR005**							new line
	16:00		570	**36°18:73'**	**-9°46.36'**	3678	T5_00543	**T5_00543**	XBT station #550 TDD=1950m
									nice profile

	17:00		571	**36°15:70'**	**-9°49.29'**	4013	T5_00544	**T5_00544**	XBT station #551 TDD=1300m
									stop at 1300m
	17:30		572	**36°14:05'**	**-9°50.91'**	4003	T5_00545	**T5_00545**	XBT station #552 TDD=2200m
									launch with coarse change
	18:30		573	**36°10:84'**	**-9°54.00'**	3918	T5_00546	**T5_00546**	XBT station #553 TDD=?m
									launch with coarse change
	19:15		574	**36°08:26'**	**-9°56.50'**	4106	C4_00547	**C4_00547**	XCTD-2 station #554 TDD=?m
									launch with coarse change
	19:49		575	**36°06:54'**	**-9°58.05'**	4159	T5_00548	**T5_00548**	XBT station #555 TDD=2200m
									launch with coarse change
	20:00								turning to next line
05/13/2007	**00:50**	**GOMR006**							start of the seismic acquisition
	01:00		576	**36°17.38'**	**-9°55.88'**	4833	T5_00549	**T5_00549**	XBT #556 TDD=2200m
	02:00		577	**36°14.76'**	**-9°51.68'**	4092	T5_00550	**not save**	XBT #557 TDD=bad probe bad data
	02:07		578	**36°14.52'**	**-9°51.31'**	4079	T5_00551	**T5_00551**	XBT #558 TDD=2200m
									its possible to observe the same structure
									and at the same depth
									in file T5_00535 (#548)
	02:50:00								
	04:00	**GOMR007**	579	**36°11.72'**	**-9°50.76'**	3822	T5_00552	**T5_00552**	XBT #559 TDD=2200m
	05:00		580	**36°14.28'**	**-9°54.93'**	4533	T5_00553	**T5_00553**	XBT #560 TDD=2200m
	06:01:00								
	06:10:00								Recover airguns
	07:10:00								Recover streamer
	09:10:00								Onboard
									Rtn Lisbon

OLD_SYSTEM

file name	date	time	seq #	lat (N)	long (W)	serial #	type	comments
C3_00003.edf	04/18/2007	15:58:47	3	36.5875203	8.2660603	6079647	XCTD-1	
C3_00004.edf	04/18/2007	18:17:46	4	36.5687257	8.1982553	6079648	XCTD-1	
C3_00005.edf	04/18/2007	21:05:15	5	36.4715250	8.6009267	6100543	XCTD-2	
XT5_00008.edf	04/19/2007	11:35:49	8	36.4287232	8.7124053	210907	T-5	

file name	date	time	seq #	lat (N)	long (W)	serial #	type	comments
T5_00002.EDF	04/19/2007	17:02:24	2	36.4384480	8.6872732	210909	T-5	
T5_00003.EDF	04/19/2007	19:24:18	3	36.4556315	8.6468415	210911	T-5	
T5_00004.EDF	04/19/2007	19:37:06	4	36.4633788	8.6279602	267489	T-5	
T5_00005.EDF	04/19/2007	19:48:58	5	36.4704793	8.6105693	251103	T-5	
C4_00006.EDF	04/19/2007	19:59:50	6	36.4767945	8.5949372	6100544	XCTD-2	
T5_00007.EDF	04/19/2007	20:18:23	7	36.4885823	8.5682433	267488	T-5	
T5_00008.EDF	04/19/2007	20:41:21	8	36.5015950	8.5350382	267487	T-5	
T5_00009.EDF	04/19/2007	20:58:17	9	36.5108235	8.5088298	267486	T-5	
T5_00010.EDF	04/19/2007	21:18:05	10	36.5220500	8.4791077	267485	T-5	
C4_00011.EDF	04/19/2007	21:39:53	11	36.5349568	8.4473887	6100537	XCTD-2	
T5_00012.EDF	04/19/2007	21:58:30	12	36.5457317	8.4201883	267484	T-5	
T5_00013.EDF	04/19/2007	22:18:14	13	36.5575725	8.3906077	267482	T-5	
T5_00014.EDF	04/19/2007	22:38:26	14	36.5699992	8.3593678	230642	T-5	
T5_00015.EDF	04/19/2007	22:58:44	15	36.5826417	8.3278055	251102	T-5	
C3_00016.EDF	04/19/2007	23:17:40	16	36.5938720	8.2993673	6079649	XCTD-1	
T5_00017.EDF	04/19/2007	23:38:10	17	36.6059285	8.2685883	251112	T-5	
T5_00018.EDF	04/19/2007	23:57:50	18	36.6177123	8.2390757	210936	T-5	
T5_00019.edf	04/20/2007	00:19:02	19	36.6309123	8.2060517	210937	T-5	
T5_00021.EDF	04/20/2007	02:14:02	21	36.6956868	8.2073985	210939	T-5	
C3_00022.EDF	04/20/2007	02:37:37	22	36.6697103	8.2205922	6079650	XCTD-1	
T5_00023.EDF	04/20/2007	03:01:31	23	36.6408977	8.2360057	210940	T-5	
T5_00024.EDF	04/20/2007	03:19:04	24	36.6190552	8.2473735	210941	T-5	
T5_00025.EDF	04/20/2007	03:40:32	25	36.5931843	8.2609762	210942	T-5	
T5_00026.EDF	04/20/2007	04:01:03	26	36.5685913	8.2730133	210943	T-5	
C3_00027.EDF	04/20/2007	04:25:24	27	36.5393067	8.2876577	6089651	XCTD-1	
T5_00028.EDF	04/20/2007	07:07:52	28	36.5530313	8.1902283	210947	T-5	
T5_00029.EDF	04/20/2007	07:18:50	29	36.5636840	8.2012918	205680	T-5	
T5_00030.EDF	04/20/2007	07:38:48	30	36.5840738	8.2207428	210946	T-5	
T5_00031.EDF	04/20/2007	08:00:36	31	36.6053995	8.2415507	210945	T-5	
C3_00032.EDF	04/20/2007	08:21:00	32	36.6258097	8.2618743	6089652	XCTD-1	
T5_00033.EDF	04/20/2007	08:40:11	33	36.6452188	8.2803915	210944	T-5	
T5_00034.EDF	04/20/2007	08:59:53	34	36.6651612	8.2994313	187361	T-5	
T5_00035.EDF	04/20/2007	09:19:12	35	36.6842367	8.3178945	187358	T-5	
T5_00036.EDF	04/20/2007	11:49:07	36	36.6025390	8.3402415	187356	T-5	
C3_00037.EDF	04/20/2007	12:08:01	37	36.6070882	8.3074483	6089653	XCTD-1	

T5_00038.EDF	04/20/2007	12:29:25	38	36.6111125	8.2697388	187360	T-5	
T5_00039.EDF	04/20/2007	12:48:06	39	36.6146443	8.2364065	187367	T-5	sequence number wrong should be 40
T5_00040.edf	04/20/2007	13:08:04	39	36.6187907	8.2006520	187365	T-5	
T5_00041.EDF	04/20/2007	13:28:34	41	36.6225098	8.1635885	187362	T-5	
C3_00042.EDF	04/20/2007	15:05:37	42	36.6309042	8.2056223	6089654	XCTD-1	
T5_00043.EDF	04/20/2007	15:28:33	43	36.6202800	8.2334330	187364	T-5	
T5_00044.EDF	04/20/2007	15:46:25	44	36.6112955	8.2549967	187357	T-5	
T5_00045.EDF	04/20/2007	16:06:21	45	36.6016887	8.2792318	187359	T-5	
T5_00046.EDF	04/20/2007	16:26:44	46	36.5918335	8.3039337	211283	T-5	
C3_00047.EDF	04/20/2007	16:46:29	47	36.5823080	8.3279998	6089655	XCTD-1	
T5_00048.EDF	04/20/2007	17:07:33	48	36.5721313	8.3535442	211279	T-5	
T5_00049.EDF	04/20/2007	17:24:43	49	36.5635335	8.3757578	211275	T-5	
T5_00050.EDF	04/20/2007	17:45:03	50	36.5526570	8.4026173	211282	T-5	
T5_00051.EDF	04/20/2007	18:03:35	51	36.5430217	8.4267130	211274	T-5	
C3_00052.EDF	04/20/2007	18:26:28	52	36.5304687	8.4569417	6089656	XCTD-1	
T5_00053.EDF	04/20/2007	18:45:10	53	36.5201293	8.4821035	211281	T-5	
T5_00054.EDF	04/20/2007	19:06:41	54	36.5088378	8.5121988	211278	T-5	
T5_00055.EDF	04/20/2007	19:25:19	55	36.4986083	8.5379375	211277	T-5	
T5_00056.EDF	04/20/2007	19:45:38	56	36.4875243	8.5661713	211273	T-5	
C4_00057.EDF	04/20/2007	20:03:41	57	36.4787435	8.5874552	6100546	XCTD-2	
T5_00058.EDF	04/20/2007	20:24:01	58	36.4685668	8.6131713	211272	T-5	
T5_00059.EDF	04/20/2007	20:45:46	59	36.4560750	8.6449300	211276	T-5	
T5_00060.EDF	04/20/2007	21:05:08	60	36.4439697	8.6745250	211280	T-5	
T5_00061.EDF	04/20/2007	21:25:13	61	36.4322795	8.7039002	211145	T-5	
T5_00062.EDF	04/20/2007	21:44:48	62	36.4200237	8.7327483	211140	T-5	
T5_00063.EDF	04/20/2007	22:05:05	63	36.4086100	8.7633027	211141	T-5	
T5_00064.EDF	04/20/2007	22:25:10	64	36.3965495	8.7921570	211142	T-5	
T5_00065.EDF	04/20/2007	22:44:58	65	36.3850667	8.8202972	211144	T-5	
T5_00066.edf	04/20/2007	23:03:52	65	36.3747640	8.8459757	211143	T-5	wrong sequence number should be 66
T5_00067.EDF	04/20/2007	23:25:09	67	36.3752685	8.8447743	211148	T-5	time right man log file gives 36.363167 8.875500
T5_00069.EDF	04/20/2007	23:43:28	69	36.3752685	8.8447743	211146	T-5	time right man log file gives 36.351833 8.900167
T5_00070.EDF	04/21/2007	00:03:22	70	36.3417603	8.9259663	211147	T-5	
T5_00071.EDF	04/21/2007	00:25:10	71	36.3300293	8.9554778	211149	T-5	
T5_00072.EDF	04/21/2007	00:47:13	72	36.3174398	8.9866760	211150	T-5	
T5_00073.EDF	04/21/2007	01:09:50	73	36.3050740	9.0178417	187545	T-5	
T5_00074.EDF	04/21/2007	01:25:46	74	36.2958700	9.0402445	187536	T-5	

T5_00075.EDF	04/21/2007	01:45:01	75	36.2847453	9.0672088	187537	T-5
T5_00076.EDF	04/21/2007	02:04:55	76	36.2738525	9.0948070	187538	T-5
T5_00077.EDF	04/21/2007	02:25:53	77	36.2619467	9.1236542	187539	T-5
T5_00078.EDF	04/21/2007	02:44:24	78	36.2514202	9.1494303	187540	T-5
T5_00079.EDF	04/21/2007	03:06:08	79	36.2388997	9.1801372	187541	T-5
T5_00080.EDF	04/21/2007	03:26:14	80	36.2271565	9.2095225	187542	T-5
T5_00081.EDF	04/21/2007	03:44:06	81	36.2164835	9.2355795	187543	T-5
T5_00082.EDF	04/21/2007	04:03:25	82	36.2049275	9.2635263	187544	T-5
T5_00083.EDF	04/21/2007	04:22:58	83	36.1935140	9.2906148	187547	T-5
C3_00084.EDF	04/21/2007	04:47:59	84	36.1792928	9.3254547	6089657	XCTD-1
T5_00085.EDF	04/21/2007	05:16:09	85	36.1631795	9.3671733	187546	T-5
T5_00086.EDF	04/21/2007	05:40:46	86	36.1495483	9.3991170	211299	T-5
T5_00087.EDF	04/21/2007	06:12:49	87	36.1685995	9.3964987	211298	T-5
T5_00088.EDF	04/21/2007	06:33:47	88	36.1822957	9.3626495	211303	T-5
T5_00089.EDF	04/21/2007	06:57:34	89	36.1976888	9.3246877	211151	T-5
T5_00090.EDF	04/21/2007	07:40:51	90	36.1920125	9.2964233	211307	T-5
T5_00091.EDF	04/21/2007	08:04:56	91	36.1787842	9.3271882	211302	T-5
T5_00092.EDF	04/21/2007	08:25:01	92	36.1681437	9.3531728	211306	T-5
T5_00093.EDF	04/21/2007	08:44:50	93	36.1572592	9.3787537	211305	T-5
T5_00094.EDF	04/21/2007	09:03:48	94	36.1470458	9.4036082	211301	T-5
T5_00095.edf	04/21/2007	09:24:17	95	36.1360230	9.4311930	211297	T-5
C4_00096.EDF	04/21/2007	09:36:32	96	36.1298177	9.4461680	6100538	XCTD-2
T5_00097.EDF	04/21/2007	09:49:21	97	36.1238728	9.4601908	211296	T-5
T5_00098.EDF	04/21/2007	10:08:24	98	36.1137328	9.4852855	211300	T-5
T5_00099.EDF	04/21/2007	10:28:25	99	36.1026897	9.5120830	211304	T-5
T5_00100.EDF	04/21/2007	10:49:10	100	36.0911865	9.5393535	191604	T-5
T5_00101.EDF	04/21/2007	11:09:13	101	36.0806193	9.5657348	191605	T-5
T5_00102.EDF	04/21/2007	11:29:58	102	36.0688640	9.5942748	191606	T-5
T5_00103.EDF	04/21/2007	11:49:46	103	36.0577312	9.6205933	181549	T-5
T5_00104.EDF	04/21/2007	12:09:20	104	36.0469605	9.6471690	191607	T-5
T5_00105.EDF	04/21/2007	12:28:45	105	36.0358113	9.6731120	191608	T-5
T5_00106.EDF	04/21/2007	12:48:04	106	36.0250528	9.6993825	191609	T-5
T5_00107.EDF	04/21/2007	13:09:13	107	36.0130900	9.7282765	191610	T-5
T5_00108.EDF	04/21/2007	13:29:51	108	36.0014852	9.7565053	191611	T-5
T5_00109.EDF	04/21/2007	14:32:12	109	36.0118245	9.7321523	191612	T-5
T5_00110.EDF	04/21/2007	14:49:34	110	36.0210450	9.7092255	191613	T-5

T5_00111.EDF	04/21/2007	15:09:56	111	36.0320678	9.6822173	191614	T-5	
T5_00112.EDF	04/21/2007	15:32:51	112	36.0446288	9.6519978	211284	T-5	
C4_00113.EDF	04/21/2007	15:54:57	113	36.0566568	9.6232758	6100539	XCTD-2	
T5_00114.EDF	04/21/2007	16:10:13	114	36.0627685	9.6078288	211288	T-5	
T5_00115.EDF	04/21/2007	16:30:15	115	36.0733887	9.5826283	211289	T-5	
T5_00116.EDF	04/21/2007	16:50:16	116	36.0839925	9.5567118	211285	T-5	
T5_00117.EDF	04/21/2007	17:11:37	117	36.0958090	9.5286072	211290	T-5	
T5_00118.EDF	04/21/2007	17:29:51	118	36.1057698	9.5045492	211286	T-5	
C4_00119.EDF	04/21/2007	18:34:10	119	36.1434530	9.4130860	6100541	XCTD-2	
T5_00120.EDF	04/21/2007	18:50:31	120	36.1506958	9.3949300	211287	T-5	
T5_00121.EDF	04/21/2007	19:11:04	121	36.1621908	9.3667450	211291	T-5	
T5_00122.EDF	04/21/2007	19:29:33	122	36.1733073	9.3405427	211292	T-5	
T5_00123.EDF	04/21/2007	19:51:03	123	36.1854898	9.3107432	211293	T-5	
T5_00124.EDF	04/21/2007	20:02:41	124	36.1924275	9.2943247	0	T-5	serial number not filled in probably 211294
T5_00125.EDF	04/21/2007	20:12:10	125	36.1979167	9.2809600	211295	T-5	
T5_00126.EDF	04/21/2007	20:30:00	126	36.2082723	9.2549458	206306	T-5	
C4_00127.EDF	04/21/2007	20:50:11	127	36.2207602	9.2252065	6100540	XCTD-2	
T5_00128.EDF	04/21/2007	21:10:11	128	36.2324097	9.1947927	206309	T-5	
T5_00129.EDF	04/21/2007	21:29:55	129	36.2446005	9.1657003	206310	T-5	
T5_00130.EDF	04/21/2007	21:49:54	130	36.2565633	9.1362558	206313	T-5	
T5_00131.EDF	04/21/2007	22:48:36	131	36.2449992	9.1207367	206314	T-5	
C4_00132.EDF	04/21/2007	23:08:33	132	36.2349080	9.1450378	6100542	XCTD-2	
T5_00133.EDF	04/21/2007	23:28:26	133	36.2254598	9.1680165	206311	T-5	
T5_00134.EDF	04/21/2007	23:48:26	134	36.2144572	9.1936625	206307	T-5	
T5_00135.EDF	04/22/2007	00:37:41	135	36.2242675	9.2155995	206308	T-5	
T5_00136.EDF	04/22/2007	01:03:05	136	36.2386312	9.1806823	206305	T-5	
T5_00137.EDF	04/22/2007	01:22:39	137	36.2495240	9.1547628	206304	T-5	
T5_00138.EDF	04/22/2007	02:16:25	138	36.2438680	9.1233460	206312	T-5	
T5_00139.EDF	04/22/2007	02:37:24	139	36.2320760	9.1529338	205574	T-5	
T5_00140.EDF	04/22/2007	02:59:21	140	36.2181275	9.1852508	194127	T-5	
T5_00141.EDF	04/22/2007	03:55:43	141	36.2240723	9.2156545	194126	T-5	
T5_00142.EDF	04/22/2007	04:13:43	142	36.2334228	9.1935180	194125	T-5	
T5_00143.EDF	04/22/2007	04:34:19	143	36.2436687	9.1674775	194128	T-5	
T5_00144.EDF	04/22/2007	05:02:38	144	36.2590047	9.1313863	211211	T-5	
T5_00145.EDF	04/22/2007	05:13:52	145	36.2653565	9.1166637	194131	T-5	
T5_00146.EDF	04/22/2007	05:56:52	146	36.2462322	9.1170868	194129	T-5	

T5_00147.EDF	04/22/2007	06:17:13	147	36.2355672	9.1441752	194130	T-5
C4_00148.EDF	04/22/2007	06:36:07	148	36.2260253	9.1661997	6100545	XCTD-2
T5_00149.EDF	04/22/2007	07:04:12	149	36.2124105	9.1981740	194132	T-5
C4_00150.EDF	04/22/2007	07:13:37	150	36.2080770	9.2091350	6100548	XCTD-2
T5_00151.EDF	04/22/2007	07:49:02	151	36.2222982	9.2216380	194133	T-5
C4_00152.EDF	04/22/2007	07:59:16	152	36.2259033	9.2106913	6090317	XCTD-2
T5_00153.EDF	04/22/2007	08:11:43	153	36.2314860	9.1975495	211207	T-5
T5_00154.EDF	04/22/2007	08:20:43	154	36.2359538	9.1878408	211210	T-5
T5_00155.EDF	04/22/2007	08:29:39	155	36.2401002	9.1780283	211203	T-5
T5_00156.EDF	04/22/2007	08:38:22	156	36.2436483	9.1682048	211206	T-5
T5_00157.EDF	04/22/2007	08:50:23	157	36.2488363	9.1551828	211202	T-5
T5_00158.EDF	04/22/2007	09:00:05	158	36.2532063	9.1450552	211201	T-5
T5_00159.EDF	04/22/2007	09:11:44	159	36.2584107	9.1328308	211205	T-5
C4_00160.EDF	04/22/2007	09:20:34	160	36.2621908	9.1232747	6090318	XCTD-2
T5_00161.EDF	04/22/2007	09:35:38	161	36.2688232	9.1070913	211209	T-5
T5_00162.EDF	04/22/2007	09:44:02	162	36.2725708	9.0981883	211200	T-5
T5_00163.EDF	04/22/2007	09:52:42	163	36.2763102	9.0890687	211204	T-5
T5_00164.EDF	04/22/2007	10:10:01	164	36.2834513	9.0706248	211208	T-5
T5_00165.EDF	04/22/2007	10:29:54	165	36.2922403	9.0480092	206559	T-5
T5_00166.EDF	04/22/2007	10:49:59	166	36.3032918	9.0215738	206565	T-5
T5_00167.EDF	04/22/2007	11:10:41	167	36.3150268	8.9918558	206564	T-5
T5_00168.EDF	04/22/2007	11:29:56	168	36.3264688	8.9641012	206556	T-5
T5_00169.EDF	04/22/2007	11:49:58	169	36.3376912	8.9350057	206566	T-5
C4_00170.EDF	04/22/2007	13:33:39	170	36.3846150	8.8333293	6100547	XCTD-2
T5_00171.EDF	04/29/2007	11:51:26	171	36.3845093	8.8333353	206561	T-5
T5_00172.EDF	04/29/2007	12:16:54	172	36.5951667	8.2946667	194136	T-5
T5_00173.EDF	04/29/2007	12:37:56	173	36.5766032	8.3415457	206558	T-5
T5_00174.EDF	04/29/2007	12:57:32	174	36.5602092	8.3852498	206557	T-5
T5_00175.EDF	04/29/2007	13:16:36	175	36.5435547	8.4250478	206560	T-5
T5_00176.EDF	04/29/2007	13:35:41	176	36.5264445	8.4676228	194135	T-5
T5_00177.EDF	04/29/2007	13:51:26	177	36.5132080	8.5030050	194134	T-5
T5_00178.EDF	04/29/2007	14:10:15	178	36.4951823	8.5458455	206562	T-5
T5_00179.EDF	04/29/2007	14:31:58	179	36.4744913	8.5984843	206563	T-5
T5_00180.EDF	04/29/2007	14:52:03	180	36.4588013	8.6385437	206567	T-5
T5_00181.EDF	04/29/2007	19:20:34	181	36.2619018	9.1808380	211368	T-5
T5_00182.EDF	04/30/2007	00:10:16	182	36.3177653	9.1803457	211370	T-5

T5_00183.EDF	04/30/2007	00:20:35	183	36.3078980	9.1736277	211369	T-5
T5_00184.EDF	04/30/2007	00:50:53	184	36.2758057	9.1704377	211371	T-5
T5_00185.EDF	04/30/2007	01:04:52	185	36.2603963	9.1708303	211372	T-5
T5_00186.EDF	04/30/2007	01:15:36	186	36.2477498	9.1710673	211373	T-5
T5_00187.EDF	04/30/2007	01:29:54	187	36.2302978	9.1707163	211374	T-5
T5_00188.edf	04/30/2007	01:45:16	188	36.2120280	9.1707052	211375	T-5
T5_00189.EDF	04/30/2007	02:06:13	189	36.1963785	9.1846527	211375	T-5
T5_00190.EDF	04/30/2007	02:25:38	190	36.2074015	9.2126852	211377	T-5
T5_00191.edf	04/30/2007	02:45:01	191	36.2265585	9.2336415	211378	T-5
T5_00192.EDF	04/30/2007	03:28:40	192	36.2469727	9.1882040	211379	T-5
T5_00193.EDF	04/30/2007	03:45:58	193	36.2467610	9.1617625	211377	T-5
T5_00194.EDF	04/30/2007	04:06:39	194	36.2468507	9.1300720	211117	T-5
T5_00195.edf	04/30/2007	04:19:31	195	36.2467245	9.1102387	211118	T-5
T5_00196.edf	04/30/2007	04:31:49	196	36.2542847	9.0955730	211119	T-5
T5_00197.EDF	04/30/2007	04:48:54	197	36.2482788	9.0893433	211120	T-5
T5_00198.EDF	04/30/2007	05:03:39	198	36.2460165	9.1116527	211121	T-5
T5_00199.EDF	04/30/2007	05:20:05	199	36.2453938	9.1364360	211122	T-5
T5_00200.EDF	04/30/2007	05:33:40	200	36.2442505	9.1559723	211123	T-5
T5_00201.EDF	04/30/2007	05:46:10	201	36.2474732	9.1708058	211124	T-5
T5_00202.EDF	04/30/2007	06:00:10	202	36.2617838	9.1614207	211125	T-5
T5_00203.EDF	04/30/2007	06:08:46	203	36.2548665	9.1536733	211126	T-5
T5_00204.EDF	04/30/2007	06:17:30	204	36.2471070	9.1627828	211127	T-5
T5_00205.EDF	04/30/2007	06:30:54	205	36.2373780	9.1780100	192687	T-5
T5_00206.EDF	04/30/2007	06:39:51	206	36.2423340	9.1888753	4529	T-5
T5_00207.EDF	04/30/2007	06:57:54	207	36.2630005	9.1774200	192685	T-5
T5_00208.edf	04/30/2007	07:18:21	208	36.2537110	9.1543000	328594	T-5
T5_00209.EDF	04/30/2007	07:38:33	209	36.2408488	9.1709300	328596	T-5
T5_00210.EDF	04/30/2007	07:58:38	210	36.2574260	9.1890238	328597	T-5
T5_00211.EDF	04/30/2007	08:20:06	211	36.2704508	9.1665110	192691	T-5
T5_00212.EDF	04/30/2007	08:40:42	212	36.2540162	9.1447763	328598	T-5
T5_00213.EDF	04/30/2007	08:59:35	213	36.2338745	9.1544830	328599	T-5
T5_00214.EDF	04/30/2007	09:19:52	214	36.2355672	9.1815715	328599	T-5
T5_00215.EDF	04/30/2007	09:39:23	215	36.2561848	9.1875092	328601	T-5
T5_00216.EDF	04/30/2007	10:00:27	216	36.2702230	9.1626892	328602	T-5
T5_00217.EDF	04/30/2007	10:20:23	217	36.2595337	9.1345662	328603	T-5
T5_00218.EDF	04/30/2007	10:40:09	218	36.2347250	9.1376252	328604	T-5

T5_00219.EDF	04/30/2007	10:59:48	219	36.2238607	9.1644063	199750	T-5
T5_00220.EDF	04/30/2007	11:19:58	220	36.2311483	9.1908397	199752	T-5
T5_00221.EDF	04/30/2007	11:40:19	221	36.2541545	9.1990052	199753	T-5
T5_00222.EDF	04/30/2007	12:00:41	222	36.2772583	9.1856028	199749	T-5
T5_00223.EDF	04/30/2007	12:08:07	223	36.2781860	9.1740692	199754	T-5
T5_00224.edf	04/30/2007	12:26:51	224	36.2744385	9.1457977	199755	T-5
T5_00225.EDF	04/30/2007	12:48:16	225	36.2543010	9.1227600	199756	T-5
T5_00226.EDF	04/30/2007	13:09:47	226	36.2295492	9.1302988	199751	T-5
T5_00227.EDF	04/30/2007	13:28:20	227	36.2156535	9.1547108	199757	T-5
T5_00228.EDF	04/30/2007	13:49:19	228	36.2170003	9.1879923	199758	T-5
T5_00229.EDF	04/30/2007	14:14:09	229	36.2402792	9.2098450	199760	T-5
T5_00230.EDF	04/30/2007	14:34:33	230	36.2653647	9.2078532	187476	T-5
T5_00231.EDF	04/30/2007	14:58:54	231	36.2855265	9.1786255	187477	T-5
T5_00232.EDF	04/30/2007	15:15:47	232	36.2850138	9.1490570	187478	T-5
T5_00233.EDF	04/30/2007	15:35:23	233	36.2628133	9.1408152	187485	T-5
T5_00234.EDF	04/30/2007	15:56:11	234	36.2564372	9.1676250	187486	T-5
T5_00235.edf	04/30/2007	16:14:06	235	36.2571818	9.1963978	192690	T-5
T5_00236.EDF	04/30/2007	16:33:46	236	36.2789388	9.2010813	187487	T-5
T5_00237.EDF	04/30/2007	16:53:48	237	36.2766113	9.1780782	187484	T-5
T5_00238.EDF	04/30/2007	17:12:42	238	36.2549887	9.1768595	181510	T-5
C4_00239.EDF	04/30/2007	17:27:52	239	36.2367310	9.1771240	6090319	XCTD-2
T5_00240.EDF	05/01/07	13:40:23	240	36.2169597	9.2229898	187480	T-5
T5_00241.EDF	05/01/07	14:03:30	241	36.2280802	9.1963033	187481	T-5
T5_00242.EDF	05/01/07	14:20:13	242	36.2358723	9.1766368	187482	T-5
T5_00243.EDF	05/01/07	14:39:39	243	36.2448730	9.1543793	187483	T-5
T5_00244.EDF	05/01/07	15:01:17	244	36.2548625	9.1293112	191136	T-5
T5_00245.EDF	05/01/07	15:21:33	245	36.2645060	9.1059062	191137	T-5
T5_00246.EDF	05/01/07	15:40:56	246	36.2738200	9.0836680	191138	T-5
T5_00247.EDF	05/01/07	15:58:59	247	36.2822713	9.0625702	191139	T-5
T5_00248.EDF	05/01/07	16:30:38	248	36.2973673	9.0258555	191141	T-5
T5_00250.EDF	05/01/07	16:49:50	250	36.3063110	9.0038890	191142	T-5
T5_00251.edf	05/01/07	17:10:40	251	36.3162353	8.9795888	191143	T-5
T5_00253.EDF	05/01/07	17:29:24	253	36.3248820	8.9579213	191144	T-5
T5_00254.edf	05/01/07	17:50:05	254	36.3348795	8.9335225	191145	T-5
T5_00255.EDF	05/01/07	18:09:38	255	36.3441407	8.9116373	191146	T-5
T5_00256.EDF	05/01/07	18:29:51	256	36.3538370	8.8895283	191147	T-5

T5_00257.EDF	05/01/07	18:42:09	257	36.3599325	8.8755035	192167	T-5
T5_00258.EDF	05/01/07	18:59:46	258	36.3669922	8.8543813	192166	T-5
T5_00259.EDF	05/01/07	19:20:13	259	36.3772338	8.8298960	192156	T-5
T5_00260.EDF	05/01/07	19:40:08	260	36.3873860	8.8058330	192157	T-5
T5_00261.EDF	05/01/07	19:59:50	261	36.3976685	8.7815735	192158	T-5
T5_00262.EDF	05/01/07	20:20:41	262	36.4083537	8.7557718	192159	T-5
T5_00263.EDF	05/01/07	20:43:34	263	36.4195882	8.7270885	192160	T-5
T5_00264.EDF	05/01/07	21:00:31	264	36.4273397	8.7065328	192162	T-5
T5_00266.edf	05/01/07	21:40:05	265	36.4474772	8.6574635	192163	T-5
T5_00265.EDF	05/01/07	21:19:16	265	36.4370768	8.6838023	192161	T-5
T5_00267.EDF	05/01/07	21:59:23	267	36.4573242	8.6330180	192164	T-5
T5_00268.EDF	05/01/07	22:21:06	268	36.4681355	8.6052327	192165	T-5
T5_00269.EDF	05/01/07	22:39:52	269	36.4777465	8.5817830	211060	T-5
T5_00270.EDF	05/01/07	22:59:48	270	36.4873902	8.5572582	199889	T-5
T5_00271.EDF	05/01/07	23:20:13	271	36.4972127	8.5333363	208715	T-5
T5_00272.EDF	05/01/07	23:40:08	272	36.5062093	8.5107035	208708	T-5
T5_00273.EDF	05/02/07	00:00:33	273	36.5159342	8.4869720	211058	T-5
T5_00274.EDF	05/02/07	00:21:16	274	36.5258748	8.4628733	211056	T-5
T5_00275.EDF	05/02/07	00:42:47	275	36.5364420	8.4377593	211057	T-5
T5_00276.EDF	05/02/07	01:01:12	276	36.5456950	8.4153615	211059	T-5
T5_00277.EDF	05/02/07	01:21:01	277	36.5554118	8.3912710	194045	T-5
T5_00278.EDF	05/02/07	01:40:07	278	36.5648803	8.3683442	171116	T-5
T5_00279.EDF	05/02/07	02:02:10	279	36.5744955	8.3398092	211061	T-5
T5_00280.EDF	05/02/07	02:24:47	280	36.5870850	8.3116200	189814	T-5
T5_00281.EDF	05/02/07	02:41:33	281	36.5962362	8.2911570	189813	T-5
T5_00282.EDF	05/02/07	03:01:20	282	36.6060140	8.2671438	189812	T-5
T5_00283.EDF	05/02/07	03:24:09	283	36.6176962	8.2388530	215340	T-5
T5_00284.EDF	05/02/07	03:46:22	284	36.6288290	8.2119517	215339	T-5
T7_00285.EDF	05/02/07	04:31:18	285	36.6520548	8.1539622	39966	T-7
T5_00285.edf	05/02/07	04:06:51	285	36.6390300	8.1860473	215341	T-5
T7_00286.EDF	05/02/07	04:50:18	286	36.6611980	8.1285777	39967	T-7
T7_00287.EDF	05/02/07	05:09:41	287	36.6709798	8.1037100	39968	T-7
T7_00288.edf	05/02/07	05:29:34	288	36.6817993	8.0782908	39972	T-7
T7_00289.EDF	05/02/07	05:50:44	289	36.6921468	8.0513622	39969	T-7
T5_00290.EDF	05/03/07	10:02:04	290	36.6248007	8.1408305	189815	T-5
T5_00291.EDF	05/03/07	10:19:40	291	36.6219970	8.1634420	215343	T-5

T5_00292.EDF	05/03/07	10:39:15	292	36.6194905	8.1881673	215344	T-5	
T5_00293.EDF	05/03/07	10:59:36	293	36.6173462	8.2138337	215345	T-5	
T5_00294.EDF	05/03/07	11:20:09	294	36.6141235	8.2412933	215347	T-5	
T5_00295.EDF	05/03/07	11:39:58	295	36.6115845	8.2663218	215346	T-5	
T5_00296.EDF	05/03/07	11:59:50	296	36.6086873	8.2911000	215348	T-5	
T5_00297.EDF	05/03/07	12:20:30	297	36.6058675	8.3175527	215342	T-5	
T5_00298.EDF	05/03/07	12:41:05	298	36.6030273	8.3443472	189817	T-5	
T5_00299.EDF	05/03/07	12:59:37	299	36.6004842	8.3682658	189816	T-5	
T7_00300.EDF	05/03/07	17:00:01	300	36.6702148	8.3041310	39971	T-7	
T7_00301.EDF	05/03/07	17:20:01	301	36.6538697	8.2886902	39970	T-7	
T5_00302.EDF	05/03/07	17:39:08	302	36.6380737	8.2734985	215349	T-5	
T5_00303.EDF	05/03/07	17:59:46	303	36.6208130	8.2573353	215350	T-5	
T5_00304.EDF	05/03/07	18:19:32	304	36.6047485	8.2418010	189818	T-5	
T5_00305.edf	05/03/07	18:38:51	304	36.5889405	8.2266582	189819	T-5	wrong sequence number in header should be 305
T5_00306.edf	05/03/07	18:59:06	305	36.5724407	8.2105337	189820	T-5	wrong sequence number in header should be 306
T5_00307.EDF	05/03/07	19:18:55	307	36.5562297	8.1955933	189821	T-5	
T5_00308.EDF	05/03/07	21:59:58	308	36.5371215	8.2884948	189822	T-5	
T5_00309.EDF	05/03/07	22:19:56	309	36.5569987	8.2782105	189823	T-5	
T5_00310.EDF	05/03/07	22:39:42	310	36.5762452	8.2684010	210852	T-5	
T5_00311.EDF	05/03/07	23:01:04	311	36.5964478	8.2588368	210853	T-5	
T5_00312.EDF	05/03/07	23:19:46	312	36.6139973	8.2492930	210854	T-5	
T5_00313.EDF	05/03/07	23:40:00	313	36.6340170	8.2395722	210855	T-5	
T5_00314.EDF	05/03/07	23:59:43	314	36.6525798	8.2301463	210856	T-5	
T5_00315.EDF	05/04/07	00:19:17	315	36.6715862	8.2201843	210857	T-5	
T5_00316.EDF	05/04/07	00:40:17	316	36.6921672	8.2095480	210858	T-5	
T7_00317.EDF	05/04/07	01:01:08	317	36.7126017	8.2002075	40261	T-7	
T5_00318.EDF	05/04/07	05:38:51	318	36.6185710	8.2371562	210861	T-5	
T7_00318.edf	05/04/07	05:08:34	318	36.6325398	8.2024475	40266	T-7	
T5_00319.EDF	05/04/07	06:08:54	319	36.6049805	8.2713867	210859	T-5	
T5_00320.EDF	05/04/07	06:38:49	320	36.5910930	8.3065338	210860	T-5	
T5_00321.edf	05/04/07	07:09:11	321	36.5763997	8.3427327	210862	T-5	
T5_00322.EDF	05/04/07	07:39:09	322	36.5622965	8.3779155	210863	T-5	
T5_00324.EDF	05/04/07	08:10:26	324	36.5479818	8.4142628	328629	T-5	
T5_00325.EDF	05/04/07	08:41:16	325	36.5338420	8.4495188	328630	T-5	
T5_00326.EDF	05/04/07	09:09:24	326	36.5209798	8.4816345	328631	T-5	
T5_00327.EDF	05/04/07	09:40:14	327	36.5069620	8.5170848	192144	T-5	

T5_00328.EDF	05/04/07	09:56:48	328	36.4995972	8.5362977	211130	T-5
T5_00329.EDF	05/04/07	10:10:41	329	36.4930013	8.5523488	192145	T-5
T5_00330.EDF	05/04/07	10:30:45	330	36.4838908	8.5752930	192146	T-5
T5_00331.EDF	05/04/07	10:46:10	331	36.4771403	8.5922852	192149	T-5
T5_00332.EDF	05/04/07	10:56:19	332	36.4725260	8.6033610	192148	T-5
T5_00333.EDF	05/04/07	11:28:59	333	36.4581990	8.6404165	192147	T-5
T5_00334.EDF	05/04/07	13:12:06	334	36.4085245	8.7614573	192150	T-5
T5_00335.EDF	05/04/07	13:51:55	335	36.3899698	8.8078928	192151	T-5
T5_00336.EDF	05/04/07	14:59:34	336	36.3582805	8.8873047	192152	T-5
T5_00337.EDF	05/04/07	16:03:30	337	36.3286743	8.9605927	192153	T-5
T5_00338.edf	05/04/07	16:59:51	338	36.3022257	9.0251750	192155	T-5
T5_00339.edf	05/04/07	18:02:09	339	36.2736857	9.0950805	192154	T-5
T5_00340.edf	05/04/07	18:58:21	340	36.2469970	9.1598715	211131	T-5
T5_00341.EDF	05/04/07	20:02:27	341	36.2162028	9.2361613	211135	T-5
T5_00342.edf	05/04/07	20:59:40	342	36.1881063	9.3027760	69184	T-5
T5_00343.EDF	05/04/07	21:58:56	343	36.1609253	9.3698853	190895	T-5
T5_00344.EDF	05/04/07	23:01:13	344	36.1313640	9.4401795	190892	T-5
T5_00345.EDF	05/05/07	00:00:59	345	36.1042115	9.5077708	190885	T-5
T5_00346.EDF	05/05/07	01:00:29	346	36.0765788	9.5758515	190884	T-5
T5_00347.EDF	05/05/07	02:00:28	347	36.0471517	9.6452312	190886	T-5
T5_00348.EDF	05/05/07	03:00:20	348	36.0189820	9.7131745	190887	T-5
T5_00349.EDF	05/05/07	04:00:33	349	35.9903808	9.7809010	190888	T-5
T5_00350.EDF	05/05/07	04:59:05	350	35.9636882	9.8477223	190889	T-5
T5_00351.EDF	05/05/07	05:59:48	351	35.9349040	9.9166637	190890	T-5
T5_00352.EDF	05/05/07	07:08:57	352	35.9016153	9.9968068	190893	T-5
T5_00353.EDF	05/05/07	08:05:21	353	35.8751790	10.0612498	190894	T-5
T5_00354.EDF	05/05/07	08:59:33	354	35.8510580	10.1207072	192765	T-5
T5_00355.EDF	05/05/07	09:59:07	355	35.8240845	10.1882243	192766	T-5
T5_00356.EDF	05/05/07	10:59:53	356	35.7963623	10.2559692	192767	T-5
T5_00357.EDF	05/05/07	11:59:25	357	35.7695800	10.3227213	192758	T-5
T5_00358.EDF	05/05/07	13:01:28	358	35.7412638	10.3934428	192757	T-5
T5_00359.EDF	05/05/07	14:01:26	359	35.7140707	10.4609090	192756	T-5
T5_00360.EDF	05/05/07	18:57:53	360	35.7141602	10.4612955	192759	T-5
T5_00361.EDF	05/05/07	19:28:18	361	35.7282470	10.4264180	192760	T-5
T5_00362.EDF	05/05/07	19:58:46	362	35.7432902	10.3905335	192761	T-5
T5_00363.EDF	05/05/07	20:30:38	363	35.7604003	10.3474457	192762	T-5

T5_00364.EDF	05/05/07	20:33:48	364	35.7622273	10.3431355	181568	T-5
T5_00365.EDF	05/05/07	21:00:30	365	35.7769653	10.3067698	192764	T-5
T5_00366.EDF	05/05/07	21:29:10	366	35.7926188	10.2680073	190798	T-5
T5_00367.EDF	05/05/07	22:01:11	367	35.8080688	10.2268342	190801	T-5
T5_00368.EDF	05/05/07	22:30:10	368	35.8244955	10.1883017	190804	T-5
T5_00369.EDF	05/05/07	23:01:29	369	35.8406778	10.1470418	190807	T-5
T5_00370.EDF	05/05/07	23:30:11	370	35.8560140	10.1088643	190799	T-5
T5_00371.EDF	05/06/07	00:01:23	371	35.8714885	10.0709727	190802	T-5
T5_00372.EDF	05/06/07	00:32:19	372	35.8870240	10.0316162	190800	T-5
T5_00373.EDF	05/06/07	01:00:34	373	35.9014893	9.9962758	190803	T-5
T5_00374.EDF	05/06/07	01:31:11	374	35.9174235	9.9579203	190805	T-5
T5_00375.EDF	05/06/07	02:01:26	375	35.9339600	9.9209513	190806	T-5
T5_00376.EDF	05/06/07	07:32:45	376	35.9016562	9.9985778	190809	T-5
T5_00377.EDF	05/06/07	07:59:42	377	35.9264323	9.9738262	190808	T-5
T5_00378.EDF	05/06/07	08:29:20	378	35.9528890	9.9480398	163898	T-5
T5_00379.EDF	05/06/07	08:59:01	379	35.9785442	9.9227865	163899	T-5
T5_00380.EDF	05/06/07	09:30:19	380	36.0062175	9.8949667	163900	T-5
T5_00381.EDF	05/06/07	10:00:08	381	36.0330078	9.8679007	163897	T-5
T5_00382.EDF	05/06/07	10:29:55	382	36.0598837	9.8416555	163896	T-5
T5_00383.EDF	05/06/07	11:01:33	383	36.0876668	9.8141267	163892	T-5
T5_00384.EDF	05/06/07	11:34:42	384	36.1165608	9.7859253	163894	T-5
T5_00385.EDF	05/06/07	11:59:45	385	36.1382528	9.7637380	163890	T-5
T5_00386.EDF	05/06/07	12:30:57	386	36.1651448	9.7369883	163889	T-5
T5_00387.EDF	05/06/07	12:59:37	387	36.1902465	9.7120555	163891	T-5
T5_00388.EDF	05/06/07	13:34:19	388	36.2203653	9.6820068	211188	T-5
T5_00389.EDF	05/06/07	13:38:23	389	36.2237223	9.6785950	211192	T-5
T5_00390.EDF	05/06/07	14:02:32	390	36.2444417	9.6579753	211193	T-5
T5_00391.EDF	05/06/07	14:30:25	391	36.2685222	9.6334585	211189	T-5
T5_00392.EDF	05/06/07	19:28:59	392	36.1565877	9.6447805	211196	T-5
T5_00393.EDF	05/06/07	23:01:15	393	36.1423298	9.7585998	211197	T-5
T5_00394.EDF	05/06/07	23:16:32	394	36.1551147	9.7467937	211198	T-5
T5_00395.EDF	05/06/07	23:30:14	395	36.1667318	9.7356690	211194	T-5
T5_00396.EDF	05/06/07	23:46:31	396	36.1798583	9.7226888	211190	T-5
T5_00397.EDF	05/06/07	23:59:58	397	36.1909993	9.7111125	211199	T-5
T5_00398.EDF	05/07/07	00:15:18	398	36.2035807	9.6981608	211191	T-5
T5_00399.EDF	05/07/07	00:29:43	399	36.2155925	9.6863495	211195	T-5

T5_00400.EDF	05/07/07	00:45:10	400	36.2282552	9.6737345	190640	T-5
T5_00401.EDF	05/07/07	01:00:43	401	36.2418823	9.6612183	190641	T-5
T5_00402.EDF	05/07/07	01:15:54	402	36.2544922	9.6485220	190642	T-5
T5_00403.EDF	05/07/07	01:30:48	403	36.2664470	9.6358998	190643	T-5
T5_00404.EDF	05/07/07	03:17:48	404	36.2125367	9.5843903	190644	T-5
T5_00405.EDF	05/07/07	03:30:26	405	36.2021932	9.5941397	190645	T-5
T5_00406.EDF	05/07/07	03:45:30	406	36.1897462	9.6055095	190646	T-5
T5_00407.EDF	05/07/07	04:02:56	407	36.1758178	9.6193177	190647	T-5
T5_00408.EDF	05/07/07	04:15:41	408	36.1655843	9.6293213	190648	T-5
T5_00409.EDF	05/07/07	04:29:39	409	36.1544963	9.6401245	190649	T-5
T5_00410.EDF	05/07/07	04:45:19	410	36.1417440	9.6520945	190650	T-5
T5_00411.EDF	05/07/07	04:59:20	411	36.1306072	9.6627603	190651	T-5
T5_00412.EDF	05/07/07	05:28:47	412	36.1069825	9.6856862	189776	T-5
T5_00413.EDF	05/07/07	06:00:33	413	36.0809612	9.7112823	189777	T-5
T5_00414.EDF	05/07/07	06:28:03	414	36.0567180	9.7328715	189778	T-5
T5_00415.EDF	05/07/07	07:03:02	415	36.0280843	9.7623617	189779	T-5
T5_00416.EDF	05/07/07	07:35:28	416	36.0014160	9.7878042	189780	T-5
T5_00417.EDF	05/07/07	09:45:25	417	36.0655437	9.8355215	189781	T-5
T5_00418.EDF	05/07/07	09:58:35	418	36.0768798	9.8252127	189782	T-5
T5_00419.EDF	05/07/07	10:14:23	419	36.0895630	9.8125672	189783	T-5
T5_00420.EDF	05/07/07	10:29:09	420	36.1011922	9.8001058	189784	T-5
T5_00421.EDF	05/07/07	10:44:08	421	36.1140097	9.7882630	189785	T-5
T5_00422.EDF	05/07/07	10:59:35	422	36.1258260	9.7765310	189786	T-5
T5_00423.EDF	05/07/07	11:15:04	423	36.1384400	9.7636332	189787	T-5
C4_00424.EDF	05/07/07	11:30:12	424	36.1498577	9.7523183	6090322	XCTD-2
T5_00425.EDF	05/07/07	11:44:17	425	36.1601033	9.7425822	191204	T-5
T5_00426.EDF	05/07/07	11:58:54	426	36.1722208	9.7311290	191205	T-5
T5_00427.EDF	05/07/07	12:16:17	427	36.1862020	9.7162110	191196	T-5
T5_00428.EDF	05/07/07	12:29:42	428	36.1965658	9.7045888	191206	T-5
T5_00429.EDF	05/07/07	12:46:13	429	36.2099365	9.6917103	191203	T-5
T5_00430.EDF	05/07/07	13:02:39	430	36.2230672	9.6789500	191207	T-5
T5_00431.EDF	05/07/07	13:16:03	431	36.2339112	9.6686493	191197	T-5
T5_00432.EDF	05/07/07	13:31:28	432	36.2469605	9.6558523	191198	T-5
T5_00433.EDF	05/07/07	13:45:35	433	36.2583090	9.6440603	191199	T-5
T5_00434.EDF	05/07/07	13:59:28	434	36.2695272	9.6327037	191200	T-5
T5_00435.EDF	05/07/07	14:15:23	435	36.2823365	9.6202718	191201	T-5

T5_00436.EDF	05/07/07	14:44:09	436	36.3048298	9.5971558	191202	T-5
T5_00437.EDF	05/07/07	15:15:15	437	36.3292440	9.5726868	189800	T-5
T5_00438.EDF	05/07/07	15:44:54	438	36.3525228	9.5500052	189801	T-5
T5_00439.EDF	05/07/07	16:13:45	439	36.3754923	9.5269103	189802	T-5
T5_00440.EDF	05/07/07	16:44:52	440	36.4001993	9.5019480	189803	T-5
T5_00441.EDF	05/07/07	17:14:48	441	36.4248942	9.4769217	189804	T-5
T5_00442.EDF	05/07/07	17:44:00	442	36.4482463	9.4528483	189805	T-5
T5_00443.EDF	05/07/07	19:44:37	443	36.4397827	9.4865285	189806	T-5
T5_00444.EDF	05/07/07	20:15:37	444	36.4301880	9.5253795	189807	T-5
T5_00445.EDF	05/07/07	20:19:50	445	36.4279460	9.5306030	189808	T-5
T5_00446.EDF	05/08/07	05:30:41	446	36.3189047	10.0051972	189809	T-5
T5_00447.EDF	05/08/07	05:58:27	447	36.3052815	9.9733195	189810	T-5
T5_00448.EDF	05/08/07	06:27:55	448	36.2909342	9.9397878	189811	T-5
T5_00449.EDF	05/08/07	06:48:28	449	36.2803223	9.9139893	251113	T-5
T5_00450.EDF	05/08/07	07:08:23	450	36.2690958	9.8888957	251114	T-5
T5_00451.EDF	05/08/07	07:27:16	451	36.2590617	9.8654673	251116	T-5
T5_00453.EDF	05/08/07	07:55:04	453	36.2441080	9.8305247	251118	T-5
T5_00454.EDF	05/08/07	08:11:34	454	36.2349772	9.8098368	251119	T-5
T5_00455.EDF	05/08/07	08:28:35	455	36.2251505	9.7875682	251122	T-5
T5_00456.EDF	05/08/07	08:49:01	456	36.2138225	9.7617687	251120	T-5
T5_00457.EDF	05/08/07	09:09:45	457	36.2042847	9.7382132	251123	T-5
T5_00458.EDF	05/08/07	09:28:59	458	36.1937825	9.7132863	191532	T-5
T5_00459.EDF	05/08/07	09:49:06	459	36.1823853	9.6870057	191533	T-5
T5_00460.EDF	05/08/07	10:09:40	460	36.1709392	9.6600708	191534	T-5
T5_00461.EDF	05/08/07	10:28:02	461	36.1606078	9.6364603	191535	T-5
T5_00462.EDF	05/08/07	18:19:18	462	36.1869182	9.6788747	191536	T-5
T5_00463.EDF	05/08/07	18:36:22	463	36.1651327	9.6787130	191537	T-5
T5_00464.EDF	05/08/07	19:54:30	464	36.1721680	9.6601063	191538	T-5
T5_00465.EDF	05/08/07	20:13:07	465	36.1891765	9.6812713	191539	T-5
T5_00466.EDF	05/08/07	21:06:29	466	36.1719605	9.6825897	191540	T-5
T5_00467.EDF	05/08/07	21:21:03	467	36.1717692	9.6585733	191543	T-5
T5_00468.EDF	05/08/07	22:14:08	468	36.1934042	9.6594482	191542	T-5
T5_00469.EDF	05/08/07	22:36:34	469	36.1727050	9.6851165	191541	T-5
T5_00470.EDF	05/09/07	00:42:18	470	36.1657308	9.6677012	328632	T-5
T5_00471.EDF	05/09/07	00:57:45	471	36.1872680	9.6677195	328633	T-5
T5_00472.EDF	05/09/07	01:58:33	472	36.1810140	9.6863872	328634	T-5

T5_00473.EDF	05/09/07	02:15:20	473	36.1655395	9.6675172	328635	T-5
T5_00474.EDF	05/09/07	03:15:49	474	36.1807943	9.6599702	328636	T-5
T5_00475.EDF	05/09/07	03:33:01	475	36.1806763	9.6880982	328637	T-5
T5_00476.EDF	05/09/07	04:39:41	476	36.1656860	9.6784760	328638	T-5
T5_00477.EDF	05/09/07	04:55:31	477	36.1808553	9.6590942	328639	T-5
T7_00478.EDF	05/09/07	08:20:33	478	36.1909830	9.6531820	40272	T-7
T7_00479.EDF	05/09/07	08:34:28	479	36.2089478	9.6119222	40271	T-7
T7_00480.EDF	05/09/07	08:38:02	480	36.2131632	9.6031952	40267	T-7
T7_00481.EDF	05/09/07	08:47:01	481	36.2237305	9.5818237	40268	T-7
T7_00482.EDF	05/09/07	09:01:13	482	36.2346028	9.5383952	40265	T-7
T7_00483.EDF	05/09/07	09:17:50	483	36.2525513	9.4860005	40262	T-7
T7_00484.EDF	05/09/07	09:31:04	484	36.2768067	9.4486492	40264	T-7
T7_00485.EDF	05/09/07	09:45:05	485	36.3039795	9.4086050	40263	T-7
C3_00486.EDF	05/09/07	10:01:28	486	36.3307617	9.3576050	6089658	XCTD-1
T5_00487.EDF	05/09/07	10:21:11	487	36.3587932	9.3005798	328640	T-5
T5_00488.EDF	05/09/07	10:40:26	488	36.3752727	9.2666503	328641	T-5
T5_00489.EDF	05/09/07	10:54:23	489	36.3837280	9.2408538	328642	T-5
C3_00490.EDF	05/10/07	19:00:12	490	36.6240560	8.2222972	6079643	XCTD-1
T7_00491.EDF	05/10/07	19:19:11	491	36.6157512	8.2432810	39964	T-7
T7_00492.EDF	05/10/07	19:38:47	492	36.6065185	8.2668833	40269	T-7
C3_00493.EDF	05/10/07	19:58:03	493	36.5971802	8.2901723	6079646	XCTD-1
T5_00494.EDF	05/10/07	20:20:49	494	36.5860677	8.3180328	328643	T-5
T5_00495.EDF	05/10/07	20:39:55	495	36.5764038	8.3414703	328644	T-5
T5_00496.EDF	05/10/07	21:01:06	496	36.5672485	8.3678365	328645	T-5
T5_00497.EDF	05/10/07	22:03:45	497	36.5375813	8.4411895	328649	T-5
T5_00498.EDF	05/10/07	22:59:30	498	36.5092692	8.5116110	328646	T-5
T5_00499.EDF	05/10/07	23:58:42	499	36.4777710	8.5894267	328650	T-5
T5_00500.EDF	05/11/07	01:00:18	500	36.4456543	8.6703165	328647	T-5
T5_00501.EDF	05/11/07	02:00:07	501	36.4146037	8.7471537	328648	T-5
T5_00502.EDF	05/11/07	03:00:07	502	36.3833455	8.8233257	328651	T-5
T5_00503.EDF	05/11/07	04:00:16	503	36.3545532	8.8967417	328652	T-5
T5_00504.EDF	05/11/07	04:57:56	504	36.3245565	8.9701732	328569	T-5
T5_00505.EDF	05/11/07	05:57:24	505	36.2943482	9.0445537	328570	T-5
T5_00506.EDF	05/11/07	06:57:51	506	36.2631632	9.1207215	328571	T-5
T5_00507.EDF	05/11/07	07:27:07	507	36.2482258	9.1579102	328572	T-5
C4_00508.EDF	05/11/07	07:57:53	508	36.2328492	9.1954813	6090320	XCTD-2

T5_00509.EDF	05/11/07	08:27:41	509	36.2198812	9.2277588	328573	T-5
T5_00510.EDF	05/11/07	08:58:30	510	36.2071248	9.2568898	328577	T-5
T5_00511.EDF	05/11/07	09:19:57	511	36.1964355	9.2832265	328574	T-5
T5_00512.EDF	05/11/07	09:41:18	512	36.1851970	9.3125937	328578	T-5
C4_00513.EDF	05/11/07	10:00:16	513	36.1755493	9.3350413	6090321	XCTD-2
T5_00514.EDF	05/11/07	10:21:45	514	36.1649252	9.3597677	328579	T-5
T5_00515.EDF	05/11/07	10:41:39	515	36.1546753	9.3845743	328575	T-5
T5_00516.EDF	05/11/07	11:00:52	516	36.1452515	9.4102427	328580	T-5
T5_00517.EDF	05/11/07	11:21:29	517	36.1339070	9.4367330	328576	T-5
T5_00518.EDF	05/11/07	15:16:15	518	36.1571615	9.5574625	328617	T-5
T5_00519.EDF	05/11/07	15:35:25	519	36.1699260	9.5359202	328618	T-5
T5_00520.EDF	05/11/07	15:58:25	520	36.1852987	9.5100342	328619	T-5
T5_00521.EDF	05/11/07	16:14:21	521	36.1952352	9.4924520	328620	T-5
T5_00522.EDF	05/11/07	16:35:08	522	36.2086425	9.4701670	328621	T-5
T5_00523.EDF	05/11/07	16:55:43	523	36.2208943	9.4477662	328622	T-5
T5_00524.EDF	05/11/07	17:14:50	524	36.2335612	9.4269532	328623	T-5
T5_00525.EDF	05/11/07	17:36:32	525	36.2470337	9.4031565	328624	T-5
T5_00526.EDF	05/11/07	20:58:36	526	36.2436687	9.4243723	328625	T-5
C4_00527.EDF	05/11/07	21:32:26	527	36.2688680	9.4646688	6090323	XCTD-2
T5_00528.EDF	05/11/07	22:00:27	528	36.2902670	9.4988545	328626	T-5
T5_00529.EDF	05/11/07	22:30:05	529	36.3132243	9.5355113	328627	T-5
T5_00530.EDF	05/11/07	22:34:01	530	36.3162963	9.5403248	328628	T-5
T5_00531.EDF	05/11/07	23:00:14	531	36.3369182	9.5723877	328605	T-5
T5_00533.EDF	05/12/07	00:11:00	533	36.3915730	9.6605693	328613	T-5
T5_00534.EDF	05/12/07	01:02:08	534	36.4310140	9.7232228	328606	T-5
T5_00535.EDF	05/12/07	02:00:17	535	36.4766927	9.7951365	328607	T-5
T5_00536.EDF	05/12/07	03:00:07	536	36.5217407	9.8682740	328608	T-5
T5_00537.EDF	05/12/07	04:03:00	537	36.5663452	9.9396118	328610	T-5
C4_00538.EDF	05/12/07	05:01:52	538	36.6101643	10.0086202	6090324	XCTD-2
T5_00539.EDF	05/12/07	09:14:21	539	36.6424438	10.0315358	328611	T-5
T5_00540.EDF	05/12/07	10:15:53	540	36.5923787	9.9661997	328612	T-5
T5_00541.EDF	05/12/07	11:13:51	541	36.5495850	9.9048523	328614	T-5
T5_00542.EDF	05/12/07	11:20:31	542	36.5444825	9.8975850	328615	T-5
T5_00543.EDF	05/12/07	16:02:12	543	36.3125570	9.7723227	328616	T-5
T5_00544.EDF	05/12/07	16:59:36	544	36.2619385	9.8214365	328581	T-5
T5_00545.EDF	05/12/07	17:30:25	545	36.2344563	9.8483438	328582	T-5

T5_00546.EDF	05/12/07	18:29:33	546	36.1807048	9.9000213	328583	T-5
C4_00547.EDF	05/12/07	19:15:45	547	36.1379557	9.9413005	6090325	XCTD-2
T5_00548.EDF	05/12/07	19:48:51	548	36.1091390	9.9672190	328584	T-5
T5_00549.EDF	05/13/2007	01:00:13	549	36.2897177	9.9312663	328585	T-5
T5_00550.EDF	05/13/2007	02:02:02	550	36.2460612	9.8613098	181366	T-5
T5_00551.EDF	05/13/2007	02:07:35	551	36.2420695	9.8551555	328586	T-5
T5_00552.EDF	05/13/2007	04:03:11	552	36.1946330	9.8449198	328587	T-5
T5_00553.EDF	05/13/2007	05:02:31	553	36.2379477	9.9153972	328588	T-5

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 1

Identification du profil :

Numéro / Nom du profil	**GOHR001**		
Début de profil	19/04/2007	09:11	N36°20.645 W8°55.307
Fin de Profil	19/04/2007	13h57	N36°30838 W8°29.999
Géodésie	WGS 84		
Numéro fiche flûte	1	Numéro fiche source	1
Nombre de tirs	2 860		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	belle
Vent	5 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	5,5	s
Délai	0	s
Cadence de tir	6	s
Déport centre 1er Trace	155	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	vitesse	
09h11	1	1,7 ; 2,1 ; 1,9 ; 2,1	067,0	4,6	Début de profil
12h25	1933		063,0	4,8	Problème sur un compresseur
12h35	2033		063,7	4,8	Problème résolu
13h57	2860	2,0 ; 1,9 ; 2,1 ; 2,0	063,0	4,9	Fin de profil
					Tous les Canons en Service

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 2

Identification du profil :

Numéro / Nom du profil	**GOHR002**		
Début de profil	19/04/2007	13h58	N36 30.868 W8 29.927
Fin de Profil	19/04/2007	15h23	N36 29.665 W8 33.359
Géodésie	WGS 84		
Numéro fiche flûte	1	Numéro fiche source	2
Nombre de tirs	848		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	belle
Vent	5 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	5,5	s
Délai	0	s
Cadence de tir	6	s
Déport centre 1er Trace	155	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	N/A
auxiliaire 2	TB2 Tribord	N/A
auxiliaire 3	TB3 Tribord	N/A
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	N/A
auxiliaire 6	TB3 Bâbord	N/A

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	vitesse	
13h58	2868	2,0 ; 2,1 ; 2,1 ; 2,1	063,0	4,8	Début de giration
15h23	3715	2,1;2,1;2,0;2,1	240,0	4,3	Fin de giration
					Uniquement 1 mini GI 24/24 inch³

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 3

Identification du profil :

Numéro / Nom du profil	**GOHR003**		
Début de profil	19/04/2007	15h24	N36 29.629 W8 33.438
Fin de Profil	19/04/2007	17h18	N36°25.744 - W 8°42.466
Géodésie	WGS 84		
Numéro fiche flûte	1	Numéro fiche source	2
Nombre de tirs	1 138		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	belle
Vent	5 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	5,5	s
Délai	0	s
Cadence de tir	6	s
Déport centre 1er Trace	155	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	N/A
auxiliaire 2	TB2 Tribord	N/A
auxiliaire 3	TB3 Tribord	N/A
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	N/A
auxiliaire 6	TB3 Bâbord	N/A

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
15h24	3725	2,1 ; 1,9 ; 1,9 ; 2,0	240,0	4,3	Début de profil
17h18	4862	2,0 ; 2,1 ; 2,0 ; 1,9	239,0	4,5	Fin de Profil
					Uniquement 1 mini GI 24/24 inch³

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 4

Identification du profil :

Numéro / Nom du profil	**GOHR004**		
Début de profil	19/04/2007	17h19	N36°25.649 - W 8°42.576
Fin de Profil	19/04/2007	19h13	N36°26.964 - W 8°39.790
Géodésie	WGS 84		
Numéro fiche flûte	1	Numéro fiche source	3
Nombre de tirs	1 137		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	belle
Vent	5 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	5,5	s
Délai	0	s
Cadence de tir	6	s
Déport centre 1er Trace	155	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	N/A
auxiliaire 2	TB2 Tribord	N/A
auxiliaire 3	TB3 Tribord	N/A
auxiliaire 4	TB1 Bâbord	N/A
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	N/A

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
17h19	4880	2,1 ; 1,9 ; 1,9 ; 2,0	240,0	4,3	Début de giration (canon 2B uniquement)
19h13	6016				Fin de giration
					Uniquement 1 mini GI 13/13 inch³

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 5

Identification du profil :

Numéro / Nom du profil	GOHR005		
Début de profil	19/04/2007	19h16	N36°27.058 - W 8°39.542
Fin de Profil	19/04/2007	20h07	N 36 28,912 W 008 34,991
Géodésie	WGS 84		
Numéro fiche flûte	1	Numéro fiche source	3
Nombre de tirs	311		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	belle
Vent	5 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	5,5	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	155	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	N/A
auxiliaire 2	TB2 Tribord	N/A
auxiliaire 3	TB3 Tribord	N/A
auxiliaire 4	TB1 Bâbord	N/A
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	N/A

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	vitesse	
19h16	6033	2,2 ; 2,1 ; 2,0 ; 2,1	056,0	4,3	Début de profil
20h07	6343	2,1;2,0;2;02,0;2,1	056,0	4,6	Fin de profil
					Uniquement 1 mini GI 13/13 inch³ Changement de cadence de tir

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 6

Identification du profil :

Numéro / Nom du profil	**GOHR006**		
Début de profil	19/04/2007	20h10	N 36 29,039 W 008 34,719
Fin de Profil	20/04/2007	00h24	N 36 38,076 W 008 11,922
Géodésie	WGS 84		
Numéro fiche flûte	1	Numéro fiche source	1
Nombre de tirs	1 521		

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	5,5	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	155	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	belle
Vent	5 Nds

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
20h10	6360	2,2 ; 2,1 ; 2,0 ; 2,1	056,0	4,6	Début de profil
00h24	7880	2,0 ; 2,1 ;2,1 ; 2,0	048,0	4,9	Fin de profil
					Tous les Canons en Service

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 7

Identification du profil :

Numéro / Nom du profil	**GOHR007**		
Début de profil	20/04/2007	00h24	N 36 29,039 W 008 34,719
Fin de Profil	20/04/2007	01h54	N 36 43,017 W 008 11,771
Géodésie	WGS 84		
Numéro fiche flûte	1	Numéro fiche source	1
Nombre de tirs	543		

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	5,5	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	155	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	belle
Vent	5 Nds

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
00h24	7883	2,0 ; 1,9 ; 2,0 ; 2,1	020,0	4,6	Début de giration
01h54	8425	2,1 ; 2,1 ;1,9 ; 2,1	202,0	4,5	Fin de giration
					Tous les Canons en Service

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 8

Identification du profil :

Numéro / Nom du profil	**GOHR008**		
Début de profil	20/04/2007	01h55	N 36 42,959 W 008 11,801
Fin de Profil	20/04/2007	04h45	N36°30.898 - W 8°17.913
Géodésie	WGS 84		
Numéro fiche flûte	1	Numéro fiche source	1
Nombre de tirs	1 019		

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	5,5	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	155	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	belle
Vent	5 Nds

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
01h55	8430	2,1 ; 2,1 ; 1,9 ; 2,1	202,0	4,5	Début de profil
04h45	9448				Fin de profil
					Tous les Canons en Service

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 9

Identification du profil :

Numéro / Nom du profil	**GOHR009**		
Début de profil	20/04/2007	04h47	N36°30.715 - W 8°17.915
Fin de Profil	20/04/2007	06h57	N36°32.504 - W 8°10.973
Géodésie	WGS 84		
Numéro fiche flûte	1	Numéro fiche source	1
Nombre de tirs	780		

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	5,5	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	155	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	belle
Vent	5 Nds

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
04h47	9462	2,1 ; 1,9 ; 2,1 ; 1,9	075,0	4,5	Début de giration
06h57	10241				Fin de giration
					Tous les Canons en Service

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 10

Identification du profil :

Numéro / Nom du profil	GOHR010		
Début de profil	20/04/2007	07h00	N36°32.739 - W 8°11.019
Fin de Profil	20/04/2007	09h23	N36°41.289 - W 8°19.286
Géodésie	WGS 84		
Numéro fiche flûte	1	Numéro fiche source	1
Nombre de tirs	856		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	belle
Vent	5 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	5,5	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	155	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
07h00	10260	2,1 ; 1,9 ; 2,1 ; 1,9	320,0	4,3	Début de profil
09h23	11115	1,9 ; 2,1 ;1,9 ; 2,1	320,0	4,4	Fin de profil
					Tous les Canons en Service

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 11

Identification du profil :

Numéro / Nom du profil	GOHR011		
Début de profil	20/04/2007	10h 57	N36°38.598 - W 8°22.846
Fin de Profil	20/04/2007	13h46	N36°37.544 - W 8°7.860
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	1 021		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	belle
Vent	5 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	5,5	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	vitesse	
10h57	11675	2,1 ; 1,9 ; 2,1 ; 1,9	082,0	4,3	Début d'acquisition
11h50	12000	2,0 ; 2,0 ; 1,9 ; 1,9	079,6	5,1	Début de profil Flute alignée sur profil A10-A11
13h46	12695	2,0 ; 2,1 ; 2,0 ; 2,1			Fin de profil
					Tous les Canons en Service. Retrait d'un HES

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 12

Identification du profil :

Numéro / Nom du profil	**GOHR012**		
Début de profil	20/04/2007	13h47	N36°37.555 - W 8°7.769
Fin de Profil	20/04/2007	14h56	N36°38.113 - W 8°11.687
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	416		

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	5,5	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	belle
Vent	5 Nds

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
13h47	12700	2,1 ; 1,9 ; 2,1 ; 1,9	082,0	4,3	Début de giration
14h56	13115	2,0 ; 2,2 ; 1,9 ; 2,1	243,0	4,0	Fin de giration
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 13

Identification du profil :

Numéro / Nom du profil	GOHR013		
Début de profil	20/04/2007	14h57	N36°38.088 - W 8°11.747
Fin de Profil	21/04/2007	04h44	N36°10.894 - W 9°19.178
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	4 961		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	belle
Vent	5 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	5,5	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond)		
			cap	vitesse	
14h57	13120	2,1 ; 2,1 ; 2,0 ; 2,1	242,0	3,9	Début de profil A-B
23h40->00h00					probleme nav secondaire
04h44	18080				Fin de profil
					pour passage a 7 sec d'enregistrement
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 14

Identification du profil :

Numéro / Nom du profil	**GOHR014**		
Début de profil	21/04/2007	04h54	N36°10.553 - W 9°20.046
Fin de Profil	21/04/2007	07h39	N36°11.585 - W 9°17.639
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	991		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
04h54	18140	2,1 ; 2,1 ; 2,0 ; 2,1	060,0	3,9	Suite de profil A-B Enregistrement 7 Sec
07h39	19130				Fin de profil
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 15

Identification du profil :

Numéro / Nom du profil	GOHR015		
Début de profil	21/04/2007	07h40	N36°11.529 - W 9°17.766
Fin de Profil	21/04/2007	13h40	N35°59.736 - W 9°46.213
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	3 157		

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	vitesse	
07h40	18140	2,0 ; 2,3 ; 2,5 ; 1,9	240,0	4,0	Suite de profil A-B Enregistrement 7 Sec
08h20	19378	3,1 ; 3,2 ; 2,9 ; 3,0	240,0	4,2	STREAMER à 3 m
09h 20 > 09h45		3,0 ; 3,1 ; 2,9 ; 3,0	242,0	3,0	Vitesse 3 Nds pour XCTD
13h40	21296	2,5 ; 3,2 ; 2,9 ; 3,1	241,0	4,3	Fin de profil
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 16

Identification du profil :

Numéro / Nom du profil	GOHR016		
Début de profil	21/04/2007	13h41	N35°59.715 - W 9°46.266
Fin de Profil	21/04/2007		N36°0.512 - W 9°44.449
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	271		

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	vitesse	
13h41	21300	2,5 ; 2,6 ; 2,8 ; 3,2	242,0	4,3	Début de giration
14h25	21570	2,8 ; 3,1 ; 3,6 ; 3,8	063,0	4,2	Fin de giration
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 17

Identification du profil :

Numéro / Nom du profil	**GOHR017**		
Début de profil	21/04/2007	14h26	N36°0.538 - W 9°44.384
Fin de Profil	21/04/2007	20h49	N36°13.220 - W 9°13.577
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	2 299		

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
14h26	21575	3,1 ; 3,1 ; 2,9 ; 3,2	063,0	4,2	Début de profil
15h10	21840				Plus de données bathy… Réparé
15h55	22100		063,0	3,1	reduction à 3Nds pour XCTD
17h30 > 18h00			067,0	> 5,5	vitesse augmentée pour éviter un bateau
20h 49	23873	2,7 ; 2,8 ; 2,9 ; 3,2	066,0	4,1	fin de profil
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 18

Identification du profil :

Numéro / Nom du profil	**GOHR018**		
Début de profil	21/04/2007	20h50	N36°13.244 - W 9°13.517
Fin de Profil	21/04/2007		N36°15.790 - W 9°7.240
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	424		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	vitesse	
20h50	23877	2,7 ; 2,8 ; 2,9 ; 3,2	066,4	4,2	Début de profil
22h00	24300	3,0 ; 3,0 ; 2,8 ; 2,9	060,4	4,0	Fin de profil
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 19

Identification du profil :

Numéro / Nom du profil	**GOHR019**		
Début de profil	21/04/2007	22h00	N36°15.820 - W 9°7.166
Fin de Profil	21/04/2007	22h41	N36°14.892 - W 9°6.693
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	239		

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
22h00	24305	3,0 ; 3,0 ; 2,8 ; 2,9	060,4	4,0	Début de profil - Giration
22h41	24543	2,8 ; 3,2 ; 3,0 ; 3,1	251,0	3,6	Fin de profil
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 20

Identification du profil :

Numéro / Nom du profil	**GOHR020**		
Début de profil	21/04/2007	22h41	N36°14.876 - W 9°6.742
Fin de Profil	21/04/2007	00h06	N36°12.336 - W 9°13.047
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	509		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	vitesse	
22h41	24547	2,8 ; 3,2 ; 3,0 ; 3,1	251,7	3,8	Début de profil
23h00 > 23h15			253,0	2,8	vitesse réduite pour XCTD
00h06	25055	3,0 ; 3,1 ; 2,9 ; 2,8	250,0	4,2	Fin de profil
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 21

Identification du profil :

Numéro / Nom du profil	**GOHR021**		
Début de profil	22/04/2007	00h07	N36°12.316 - W 9°13.117
Fin de Profil	22/04/2007	00h35	N36°13.395 - W 9°13.116
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	171		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
00h06	25060	2,9 ; 2,9 ; 3,0 ; 3,2	250,0	4,3	Début de giration
00h35	25230		068,0	4,5	Fin de giration
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 22

Identification du profil :

Numéro / Nom du profil	**GOHR022**		
Début de profil	22/04/2007	00h37	N36°13.418 - W 9°13.042
Fin de Profil	22/04/2007	01h48	N36°15.803 - W 9°7.216
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	430		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
00h36	25235	2,9 ; 3,0 ; 3,4 ;3,2	068,0	4,5	Début de profil
01h48	25664	3,0 ; 3,6 ;3,0 ; 3,0	061,0	4,3	Fin de profil
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 23

Identification du profil :

Numéro / Nom du profil	**GOHR023**		
Début de profil	22/04/2007	01h49	N36°15.832 - W 9°7.131
Fin de Profil	22/04/2007	02h14	N36°14.678 - W 9°7.251
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	156		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
01h49	25670	2,5 ; 2,7 ; 3,1 ;3,0	067,0	4,4	Début de giration
02h14	25825	3,2 ; 3,3 ; 3,1 ; 3,0	252,0	4,8	
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 24

Identification du profil :

Numéro / Nom du profil	**GOHR024**		
Début de profil	22/04/2007	02h15	N36°14.656 - W 9°7.329
Fin de Profil	22/04/2007	03h23	N36°12.234 - W 9°13.238
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	406		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	vitesse	
02h15	25830	3,0 ; 3,2 ; 3,2 ; 3,4	250,0	4,8	Début de profil
03h23	26235		245,0	4,8	Fin de profil
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 25

Identification du profil :

Numéro / Nom du profil	**GOHR025**		
Début de profil	22/04/2007	03h24	N36°12.211 - W 9°13.314
Fin de Profil	22/04/2007	03h51	N36°13.299 - W 9°13.329
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	161		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
03h24	26240	3,1 ; 3,0 ; 3,0 ; 3,1	142,0	4,8	Début de giration
03h51	26400				Fin de giration
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 26

Identification du profil :

Numéro / Nom du profil	**GOHR026**		
Début de profil	22/04/2007	03h51	N36°13.321 - W 9°13.266
Fin de Profil	22/04/2007	05h22	N36°16.190 - W 9°6.334
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	546		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	vitesse	
03h51	26405	3,1 ; 3,0 ; 3,0 ; 3,1	062,0	4,2	Début de profil
05h22	26950				Fin de profil
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 27

Identification du profil :

Numéro / Nom du profil	**GOHR027**		
Début de profil	22/04/2007	05h24	N36°16.213 - W 9°6.188
Fin de Profil	22/04/2007	05h52	N36°14.898 - W 9°6.623
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	172		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
05h24	26960	3,1 ; 2,9 ; 3,0 ; 3,0	189,0	4,6	Début de profil
05h52	27131				Fin de profil
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 28

Identification du profil :

Numéro / Nom du profil	**GOHR028**		
Début de profil	22/04/2007	05h54	N36°14.836 - W 9°6.836
Fin de Profil	22/04/2007	07h24	N36°12.248 - W 9°13.403
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	541		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
05h54	27145	3,1 ; 3,0 ; 3,0 ; 4,0	239,0	3,8	Début de profil
07h24	27685				Fin de profil
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 29

Identification du profil :

Numéro / Nom du profil	**GOHR029**		
Début de profil	22/04/2007	07h27	N36°12.245 - W 9°13.661
Fin de Profil	22/04/2007	07h46	N36°13.271 - W 9°13.466
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	117		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
07h27	27700	3,3 ; 2,9 ; 3,3 ; 3,1		4,5	Début de profil
07h46	27816				Fin de profil
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 30

Identification du profil :

Numéro / Nom du profil	**GOHR030**		
Début de profil	22/04/2007	07h27	N36°13.336 - W 9°13.304
Fin de Profil	22/04/2007	09h23	N36°15.792 - W 9°7.245
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	566		

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	Navire (fond) vitesse	
07h49	27830	2,8 ; 3,1 ; 3,2 ; 3,0	067,0	3,0	Début de profil
09h23	28395	3,2 ; 3,1 ; 3,3 ; 3,0	064,0	3,2	Fin de profil
					Tous les Canons en Service.

Mission : GO	Navire : DISCOVERY	Fiche : Profil HR2D	N° 31

Identification du profil :

Numéro / Nom du profil	**GOHR031**		
Début de profil	22/04/2007	09h24	N36°15.818 - W 9°7.181
Fin de Profil	22/04/2007	12h04	N36°20.720 - W 8°54.972
Géodésie	WGS 84		
Numéro fiche flûte	2	Numéro fiche source	1
Nombre de tirs	956		

Archivage :

Volume SEGD		Go
SEAL SERCEL Version :	V5.1 p15	
Analyse « SISCHECK »		
Gravé sur DVD Numéro		

Météo :

Etat de la mer	peu agitée
Vent	10 Nds

Paramètres d'acquisition sismique :

Nombre de traces	72	
Echantillonnage	1 ms	
Gain traces sismiques	G2 (400mV)	
Filtre anti-repliement	0.8 LIN	
Passe-haut digit. (cutoff)	On	2,5 Hz
Long. d'enregistrement	7	s
Délai	0	s
Cadence de tir	10	s
Déport centre 1er Trace	105	m
Nombre de traces auxiliaires	6	
auxiliaire 1	TB1 Tribord	G1 (1600mV)
auxiliaire 2	TB2 Tribord	G1 (1600mV)
auxiliaire 3	TB3 Tribord	G1 (1600mV)
auxiliaire 4	TB1 Bâbord	G1 (1600mV)
auxiliaire 5	TB2 Bâbord	G1 (1600mV)
auxiliaire 6	TB3 Bâbord	G1 (1600mV)

Observations :

Heure TU	N°tir Ecos	Immersion flûte	Navire (fond) cap	vitesse	
09h24	28400	3,2 ; 3,1 ; 3,3 ; 3,0	064,0	3,2	Début de profil
12h04	29355				Fin de profil
					Tous les Canons en Service.

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*Go-LR-001*	**Sheet Number**	*of*	**Observer:**	*T. Bridge*
Area:	*Gulf of Cadiz*	**Heading:**	*63.3 deg*	**Re Run:**		**Near Trace:**	*20*
Field:	*N/A*	**Line Status**		**Water Depth:**	*mtrs*	**Wind Strength:**	*F - * **Sea State:** *≤ mtrs*
Job	*1099 / D318B*	**Date:**	*1/05/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*14.7Vbar^{-1}*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*2000Psi*
Near Channel	*1*	*Cable Depth*	*8m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
	Tape 3										*Noise file Avg. RMS noise = μBar*
13:07:01	100	8.3	7.6	7.4	7.3	8.0	7.8	7.5	7.5	10P	*streamer depth variable, swell noise evident.*
	140	8.0	7.6	7.4	7.5	7.5	7.8	8.1	8.1		
tape 4	180	7.7	7.7	8.0	8.1	8.2	8.2	7.9	8.2		Tape write error. First sile tape 4 108
	240	8.3	7.6	8.1	7.9	8.0	7.8	7.9	8.1	5P	
	300	7.7	6.5	6.1	7.2	8.4	8.5	8.3	8.1		
	360	7.8	7.6	7.8	7.9	8.0	8.1	8.1	8.2		
	420	8.2	7.5	7.3	8.1	7.9	7.9	8.2	7.7		
	500	8.2	7.4	6.9	7.6	7.9	8.2	8.0	7.7	5P	
	580	8.1	7.9	7.5	7.7	7.9	8.0	8.1	7.9		
	660	9.0	8.2	8.1	8.5	8.4	7.9	8.1	8.2		
17:27:55 (711)	740	8.2	7.9	7.9	7.7	8.0	7.9	8.0	8.2		last file tape 5 1044
tape 5	820	8.2	7.6	8.4	9.6	8.7	8.2	8.1	8.1		
	900	8.3	7.0	8.0	9.6	10.3	9.6	8.5	8.4		
	980	8.4	6.9	5.6	5.0	7.9	7.8	8.0	8.1		
	1060	7.9	7.5	7.1	7.6	7.9	8.0	7.9	8.1		
tape 6	1140	8.4	7.9	7.5	7.7	7.5	7.9	8.2	8.2		tape 6 files 1045-1672
	1220	7.9	7.4	7.5	7.6	7.8	8.0	8.0	8.5		
	1300	7.8	7.7	8.6	8.5	7.9	7.8	8.1	7.9	0	
	1380	7.9	8.1	8.3	8.1	7.7	8.0	8.2	8.1		
	1460	8.2	8.0	7.7	8.2	8.2	8.0	7.8	7.7		
	1540	7.9	5.6	5.6	7.7	8.0	8.4	8.2	7.9	2P	
	1620	8.5	5.8	5.6	3.7	3.2	3.8	7.7	7.7		
tape 7	1700	9.0	7.6	6.5	7.0	8.5	7.9	8.0	8.2		
	1780	9.2	7.6	8.2	7.9	7.8	8.5	8.2	8.1		
	1860	9.4	9.4	8.9	8.2	8.1	8.2	7.9	7.9		0130 weather / swell noise increasing

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*Go-LR-001*	**Sheet Number**	*1 of 2*	**Observer:**	*T. Bridge*
Area:	*Gulf of Cadiz*	**Heading:**	*63.3 deg*	**Re Run:**		**Near Trace:**	*20*
Field:	*N/A*	**Line Status**		**Water Depth:**	*mtrs*	**Wind Strength:** *F -*	**Sea State:** *≤ mtrs*
Job	*1099 / D318B*	**Date:**	*1/05/07*	**Tape Drive:**	*3*		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*14.7Vbar⁻¹*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*2000Psi*
Near Channel	*1*	*Cable Depth*	*8m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
	Tape 7										
01:57	1940	8.5	7.7	7.2	6.8	7.5	7.9	7.9	8.2		
	2020	8.7	7.7	6.1	6.6	7.6	9.1	9.1	9.1		streamer depth control worsening
	2100	9.5	8.3	7.5	8.0	8.5	7.9	8.5	8.2	5P	
	2180	9.1	7.8	8.1	8.3	8.5	9.3	8.5	9.7		Shot noise frequently >15µB
	2260	7.8	8.0	8.1	9.0	7.8	7.3	8.2	8.5		
	Tape 8										
04:27	2301	7.9	8.2	8.8	7.8	7.5	7.7	6.8	7.9		Shot noise frequently > 40µB
	2380	6.3	2.2	1.2	1.9	1.9	1.8	2.6	8.1		
	2460	9.0	6.5	3.7	1.5	2.7	1.5	2.0	3.7		
	2520	8.7	5.1	1.7	1.7	1.6	1.5	1.4	8.1		
	EOL										
	05:55										

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*Go-LR-002*	**Sheet Number**	*of*	**Observer:**	*T. Bridge*
Area:	*Gulf of Cadiz*	**Heading:**	*260 deg*	**Re Run:**		**Near Trace:**	*20*
Field:	*N/A*	**Line Status**		**Water Depth:**	*mtrs*	**Wind Strength:**	*F - **Sea State:** ≤ mtrs*
Job	*1099 / D318B*	**Date:**	*1/05/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*14.7Vbar^{-1}*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*2000Psi*
Near Channel	*1*	*Cable Depth*	*8m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
tape 9	99										*Noise file Avg. RMS noise = 7µBar*
09:59:39	100	7.9	7.9	8.1	8.0	8.0	8.0	8.1	7.0		
	160	7.9	8.2	8.2	8.1	8.0	8.2	8.1	7.9		
	220	7.7	8.0	8.0	8.0	7.8	8.1	8.1	7.5	5S	
	280	8.1	8.2	8.0	7.9	7.9	8.2	8.1	8.2		
	340	8.2	8.2	8.0	8.0	8.0	7.9	7.7	8.0		
	400	8.2	7.7	8.0	8.2	8.1	8.2	8.1	8.2		
	460	7.9	8.0	8.3	8.2	8.1	7.8	8.0	7.9		
	520	7.7	8.0	8.2	8.2	8.2	8.1	7.9	8.1		files >~540 gun pulse amplitude diminished
	600	8.0	8.0	8.0	7.9	8.1	8.1	8.1	8.1	2S	file >588 gun pressure restored
	622	7.8	8.3	7.6	7.6	8.2	8.1	8.1	7.7		WP10
1:06:59 PM	662										EOL
	663										Noise file Avg. RMS noise = 16 µBar
											note: 3 misfires recorded on QSC system after EOL

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-LR003*	**Sheet Number**	*1 fo 1*	**Observer:**	*Stefan Paterson*
Area:	*Gulf of Cadiz*	**Heading:**	*155 deg*	**Re Run:**		**Near Trace:**	*80*
Field:	*N/A*	**Line Status**		**Water Depth:**	*~1000m*	**Wind Strength:**	*F - **Sea State:** ≤ mtrs*
Job	*1099 / D318B*	**Date:**	*3/05/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*14.7Vbar⁻¹*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*2000psi*
Near Channel	*1*	*Cable Depth*	*8m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
tape 10	99										*Noise file Avg. RMS noise = 5 µBar*
16:46:19	100	8.2	8	8.1	7.8	7.9	8.2	8.3	10.2		
	160	8.6	8	8.1	8.1	7.8	7.9	8.1	9.7		
	220	8.2	8.5	8.4	7.9	8.2	8	7.9	9.8		
	280	8.3	8.2	8	8	8.1	7.9	7.9	8.9		
	340	8	8.2	8.5	8	8	7.8	8.1	10.2	2S	
	400	8.2	8	8.1	8	7.9	7.9	8.2	9.7		
	460	8.1	7.1	7.9	8.1	8.1	7.9	8.1	10		
	520	8	5.5	6.6	7.3	7.9	8	8	10.2		
	580	8.1	6.2	5.8	7.5	8.3	8.2	8.1	9.1		
19:34:19	604	7.5	8.2	8.2	8.5	9	7.9	8	8.3		
	605										Noise file Avg. RMS noise = 6 µBar
											Line cut short at point A8

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-LR004*	**Sheet Number**	*1 fo 1*	**Observer:**	*Stefan Paterson*
Area:	*Gulf of Cadiz*	**Heading:**	*deg*	**Re Run:**		**Near Trace:**	*80*
Field:	*N/A*	**Line Status**		**Water Depth:**	*~1000m*	**Wind Strength:**	*F - **Sea State:** ≤ mtrs*
Job	*1099 / D318B*	**Date:**	*3/05/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*14.7Vbar⁻¹*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*2000psi*
Near Channel	*1*	*Cable Depth*	*8m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
tape 11	99										*Noise file Avg. RMS noise = 5 µBar*
21.53.39	100	7.3	6.0	6.3	7.8	8.3	8.2	7.9	7.9		
	160	8.0	8.2	8.0	7.9	8.2	8.1	7.9	7.9		
	220	8.2	8.0	8.2	8.1	7.9	8.1	8.1	7.9		
	280	8.0	8.0	7.8	7.9	8.0	8.2	8.2	8.1		
	340	7.9	8.1	8.0	8.0	8.1	7.9	7.9	8.4	3P	
	400	8.3	7.9	7.9	8.0	8.1	8.0	8.1	8.1		
	460	7.9	8.0	8.0	8.0	8.0	8.0	8.0	7.9		
	520	7.9	8.2	7.9	8.0	7.9	8.0	8.2	7.9		
	580	7.9	7.8	8.0	8.1	8.0	8.0	8.2	8.1		
tape 12	640	7.9	8.0	8.8	8.2	8.3	7.6	8.0	8.1	3P	first file tape #12, 727
01:22:59	728	8.8	8.5	8.2	8.2	8.2	8.0	8.0	7.8		EOL
	729										Noise file Avg. RMS noise = 3.5 µBar

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-LR005*	**Sheet Number**	*1 fo 1*	**Observer:**	*Stefan Paterson*
Area:	*Gulf of Cadiz*	**Heading:**	*245 deg*	**Re Run:**		**Near Trace:**	*80*
Field:	*N/A*					**Wind Strength:** *F* -	**Sea State:** ≤ *mtrs*
Job	*1099 / D318B*	**Date:**	*4/05/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*17.4Vbar⁻¹*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*2000psi*
Near Channel	*1*	*Cable Depth*	*8m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
tape 13	99										*Noise file Avg. RMS noise = 7.5 µBar*
05:06:59	100	7.9	8.2	7.9	8.0	8.1	7.9	8.1	8.1		
	180	8.1	8.5	8.4	7.9	8.0	8.1	8.0	8.1		
	260	7.3	6.0	6.3	7.8	8.3	8.2	7.9	7.9		
	340	8.0	8.2	8.0	7.9	8.2	8.1	7.9	7.9	1S	
	420	8.2	8.0	8.2	8.1	7.9	8.1	8.1	7.9		
	500	8.0	8.0	7.8	7.9	8.0	8.2	8.2	8.1		
	580	7.9	8.1	8.0	8.0	8.1	7.9	7.9	8.4		
tape 14	660	8.3	7.9	7.9	8.0	8.1	8.0	8.1	8.1		
tape 15	740	7.9	8.0	8.0	8.0	8.0	8.0	8.0	7.9		
	820	7.9	8.2	7.9	8.0	7.9	8.0	8.2	7.9		
	900	7.9	7.8	8.0	8.1	8.0	8.0	8.2	8.1	10S	
	980	7.9	8.0	8.8	8.2	8.3	7.6	8.0	8.1		
	1060	8.8	8.5	8.2	8.2	8.2	8.0	8.0	7.8		
	1140	8.2	8.0	8.1	7.8	7.9	8.2	8.3	8.0		
	1220	8.6	8.0	8.1	8.1	7.8	7.9	8.1	8.2		
tape 16	1300	8.2	8.5	8.4	7.9	8.2	8.0	7.9	8.2		
tape 17	1380	8.3	8.2	8.0	8.0	8.1	7.9	7.9	8.0		
	1460	8.0	8.2	8.5	8.0	8.0	7.8	8.1	8.1	10S	depth control deteriorating
	1540	8.2	8.3	8.1	8.0	7.9	7.9	8.2	8.3		
	1620	8.1	7.1	7.9	8.1	8.1	7.9	8.1	8.5		
	1700	8.0	5.5	6.6	7.3	7.9	8.0	8.0	8.0		noise from astern on ch > 140
	1780	8.1	6.2	5.8	7.5	8.3	8.2	8.1	8.1		
	1860	7.5	8.2	8.2	8.5	9.0	7.9	8.0	8.3		
	1940	8.2	8.0	8.2	8.1	7.9	8.1	8.1	7.9		
	2020	8.0	8.0	7.8	7.9	8.0	8.2	8.2	8.1		depth control remains bad d/t swell
	2100	7.9	8.0	8.0	8.0	8.0	8.0	8.0	7.9		
	2180	7.9	8.2	7.9	8.0	7.9	8.0	8.2	7.9	15S	

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-LR005*	**Sheet Number**	*2 fo 3*	**Observer:**	*SP / TB / J*
Area:	*Gulf of Cadiz*	**Heading:**	*245 deg*			**Near Trace:**	*80*
Field:	*N/A*					**Wind Strength:** *F* -	**Sea State:** ≤ *mtrs*
Job	*1099 / D318B*	**Date:**	*4/05/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*17.4Vbar^{-1}*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*2000psi*
Near Channel	*1*	*Cable Depth*	*8m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
tape 18	2260	9.8	10.8	10.6	8.5	8.0	8.0	8.2	7.9		
	2340	6.6	6.9	9.9	10.7	9.4	8.9	7.9	8.1		
	2420	8.4	6.6	6.6	7.4	7.4	7.5	7.9	8.1		
	2500	8.0	9.6	7.8	8.3	8.4	7.9	8.0	7.9		
	2580	6.0	5.1	7.4	7.1	7.5	7.9	7.8	8.1	10S	
tape 19	2660	7.5	7.7	8.1	8.0	7.9	7.8	8.1	8.1		tape 19 ffid 2623
	2740	7.7	6.7	7.7	8.6	7.9	7.9	8.2	8.1		
	2820	7.5	7.4	7.8	7.8	8.0	7.2	7.2	7.9		
	2900	8.3	6.9	7.6	7.5	8.0	7.9	8.0	8.2		
	2980	8.2	6.8	9.5	8.9	8.1	8.0	8.6	9.1		
	3060	8.6	5.6	7.1	7.6	7.9	8.1	8.1	7.7		
	3140	10.6	9.3	8.9	9.0	9.4	8.3	7.6	7.7		
	3220	7.1	5.5	7.6	8.3	8.5	8.4	8.0	8.8		
tape 20	3300	7.2	4.6	5.5	5.8	7.1	7.9	8.0	9.6	12S	tape 20 ffid 3251
	3380	7.4	7.4	6.2	6.3	6.3	5.8	8.0	10.9		
	3460	9.1	9.3	9.6	8.5	8.0	8.1	8.2	8.1		
	3540	7.4	3.8	4.0	2.4	6.0	7.8	8.0	8.4		
	3620	7.9	7.9	7.4	10.0	9.8	9.6	7.8	8.6		files ~3600 very noisy d/t poor depth control
	3700	8.0	10.4	11.0	10.2	9.6	8.2	7.8	9.4		
	3780	8.1	7.2	4.7	5.0	8.0	8.4	8.0	8.2		
	3860	7.5	6.2	7.2	6.9	7.4	7.6	7.8	10.3		
	3940	5.5	5.3	4.7	7.1	7.9	8.0	7.8	8.1		
	4020	7.9	7.9	6.0	5.8	7.4	7.8	7.9	9.6	2S	
	4100	8.1	8.0	8.3	7.7	7.5	7.0	8.3	8.7		
	4180	7.7	6.9	8.0	10.0	8.4	8.6	8.4	8.4		
tape 21	4260	7.9	7.9	8.5	7.8	6.8	7.6	7.1	8.1		tape 21 ffid 3879
	4340	7.6	5.4	6.7	7.2	7.7	7.9	8.2	8.2		
	4420	8.3	8.9	11.6	12.8	10.8	8.8	8.3	8.8		

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-LR005*	**Sheet Number**	*3 fo 3*	**Observer:**	*SP / TB / J*
Area:	*Gulf of Cadiz*	**Heading:**	*245 deg*	**Re Run:**		**Near Trace:**	*80*
Field:	*N/A*	**Line Status**		**Water Depth:**	*~1000m*	**Wind Strength:**	*F - **Sea State:** ≤ mtrs*
Job	*1099 / D318B*	**Date:**	*5/05/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*14.7Vbar⁻¹*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*2000psi*
Near Channel	*1*	*Cable Depth*	*8m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
tape 21	4500	7.5	5.7	6.6	8.6	8.9	8.2	7.9	7.9		
	4580	8.0	8.1	6.6	7.9	7.6	7.8	8.0	8.3		
	4660	8.1	8.2	7.7	7.6	8.0	8.1	8.2	8.0		
06:42:38	4707										EOL d/t Seal crash d/t flooding

Digital Observers Log

Client:	R. Hobbs / NOC	**Line:**	GO-LR006	**Sheet Number**	1 fo 1	**Observer:**	SP / TB / J	
Area:	Gulf of Cadiz	**Heading:**	245 deg			**Near Trace:**	80	
Field:	N/A					**Wind Strength:**	F -	**Sea State:** ≤ mtrs
Job	1099 / D318B	**Date:**	5/05/07	**Tape Drive:**	3			

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*17.4Vbar^{-1}*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*2000psi*
Near Channel	*1*	*Cable Depth*	*8m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

		Bird Depths								Feather	Comments
UTC Time:	File	1	2	3	4	5	6	7	8	Angle	
tape 22 ?	99										
07:17:15	100	8.0	7.2	7.7	9.0	8.9	7.8	8.1	8.1		
	260	12.0	11.4	12.1	11.8	9.8	9.2	8.3	7.9		
	340	7.7	5.4	4.4	7.2	7.8	7.7	8.0	8.1		
	420	7.6	9.0	9.3	8.1	8.2	8.2	7.8	9.1		
	500	8.1	8.0	9.9	9.9	8.8	7.8	8.2	7.9		
	580	7.6	7.2	7.9	7.7	8.3	8.6	8.5	8.4	15S	
	660	6.5	5.5	7.2	8.2	8.1	8.2	8.0	7.9		
	760	8.0	7.5	8.2	8.3	8.5	9.0	8.5	8.2		
tape 22	826										first file on tape #22
11:20:20	840	7.5	7.7	8.0	8.2	8.0	8.3	8.4	7.9		
	920	7.1	5.7	6.4	7.5	7.5	7.9	8.2	8.2		
	1000	7.5	7.4	5.6	6.0	6.1	6.3	8.0	8.2		
	1080	7.4	6.1	6.2	7.4	8.3	8.6	8.2	7.7		
	1160	8.0	6.5	6.0	6.1	7.8	7.6	8.2	8.7		
	1240	7.5	7.8	7.9	8.0	8.1	8.0	7.9	7.8		Feather angle not available
	1320	11.2	11.2	10.0	9.0	8.2	8.3	8.0	8.7		
	1352										eol waypoint
14:30:55	1401	8.0	9.4	10.0	10.2	9.0	8.6	7.8	7.6		EOL
	1402										noise file rms avg = 2.2µB

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-LR_007*	**Sheet Number**	*1 of 1*	**Observer:**	*S.P*
Area:	*Gulf of Cadiz*	**Heading:**	*44 deg*			**Near Trace:**	
Field:	*N/A*					**Wind Strength:** *F* -	**Sea State:** ≤ *mtrs*
Job	*1099 / D318B*	**Date:**	*5/5/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*17.4Vbar-1*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*200Psi*
Near Channel	*1*	*Cable Depth*	*4m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
tape 23	99										*Noise file Avg. RMS noise = 10.5 μBar*
18:45:55	100	4.7	3.4	1.8	1.2	1.8	1.5	2.9	8.1		
	180	8.2	7.8	4	3.5	7.5	9.8	9.6	11.6		
	260	3.8	1.5	2.9	7.7	8.1	8.4	8.7	8.9		
	340	6.8	6.5	6.8	11.8	11.3	8.8	8.1	8.1		
	420	9.3	6.7	6.1	6.9	7.1	7.8	8.3	8.2		
	500	6.3	6.6	8	7.7	7.9	8.3	8.2	8.2		
	580	6.4	7.8	8	8.7	8.6	8.3	8.2	7.7		
	660	6.9	7.1	7.4	7.6	8	8.4	8.1	8		
	740	9.1	7.1	7.5	8.8	9.1	8.6	8.3	8.1		
	820	6.7	7.6	8.5	7.6	7.7	8	7.6	7.9		
	726										
tape 24										15P	
22:57:06	727										
	900	8.5	6.2	5.4	6.4	8.1	7.6	7.9	8.2		
	980	7.2	8.2	8.3	8.6	8.2	7.4	8.2	8.5		Changed course 15 to port (or maybe stb'd?) to avoid
	1060	6.3	8.8	8.8	7.4	7.5	7.4	8.1	7.7		Poseidon
	1140	6.5	7.4	8.6	8.3	8.4	7.5	8.1	7.9		
	1220	8.6	8.6	7.8	10.3	9.7	7.8	7.4	7.4		
	1300	8.3	4.2	3.6	6.0	7.0	7.6	8.1	8.2		
	1364										eol waypoint
02:07:55	1426										EOL
	1427	7.5	7.9	8.1	8.5	7.9	7.6	8.1	8.2		*Noise file Avg. RMS noise = 6.9 μBar*

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-LR-008*	**Sheet Number**	*1 of 1*	**Observer:**	*S.P*
Area:	*Gulf of Cadiz*	**Heading:**	*030 deg*			**Near Trace:**	*80*
Field:	*N/A*					**Wind Strength:** *F* -	**Sea State:** ≤ *mtrs*
Job	*1099 / D318B*	**Date:**	*6/5/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*17.4Vbar⁻¹*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*200Psi*
Near Channel	*1*	*Cable Depth*	*4m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
07:31:35	99										*Noise file Avg. RMS noise = 20 µBar*
:	100	7.5	8.9	8.9	8.8	8.2	8.3	8.0	8.1		*SOL*
	180	10.2	8.3	8.0	9.3	9.6	10.1	10.0	10.2		
	260	9.7	9.7	10.8	11.0	10.1	9.8	10.1	10.0		
	340	8.8	9.1	10.2	10.2	10.2	9.6	10.0	10.2		
	420	10.2	10.3	10.1	9.9	9.6	9.3	9.3	10.2		
	500	8.6	9.3	9.5	9.6	9.9	10.1	10.2	9.9		
	580	10.6	8.8	9.3	9.8	9.9	9.9	9.4	10.0		
	660	10.0	10.2	9.8	10.0	10.1	10.2	9.9	9.9	2P	
	740	9.9	10.3	10.3	10.2	9.9	10.2	10.3	9.9		
tape 27											
11:06:30											
	820	9.8	9.9	10.3	10.3	10.2	9.9	10.0	10.3		
	900	9.4	10.0	10.1	9.7	9.6	10.2	9.8	9.8		gun 3 stb side timing errors ~1.1ms
	980	10.2	10.2	10.2	9.8	10.0	10.1	10.0	10.2		
	1060	10.0	10.0	10.0	10.1	10.1	9.8	9.9	9.9		
	1140	10.0	9.4	9.8	10.0	1.2	9.9	10.1	10.0		
	1220	9.8	10.0	10.1	10.0	10.2	10.0	9.9	9.8		
	1300	10.6	10.2	9.8	9.8	10.0	10.0	10.0	10.0		timimg errors continue ±1.2ms
	1380	10.1	10.1	9.9	9.7	10.1	9.9	9.7	10.0		last file on tape 27 1354, tape 28 files 1355-1367
tape 28	1429										last record with both gun strings
14:56:55	1434	9.3	9.8	10.1	10.1	10.1	10.1	10.1	10.0		EOL rms noise 2.2µB
											tape 29 files 1367-1434

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-LR-009*	**Sheet Number**	*1 of 1*	**Observer:**	*S.P*	
Area:	*Gulf of Cadiz*	**Heading:**	*215 deg*			**Near Trace:**	*80*	
Field:	*N/A*					**Wind Strength:** *F*	*-*	**Sea State:** *≤ mtrs*
Job	*1099 / D318B*	**Date:**	*6/5/07*	**Tape Drive:**	3			

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*17.4Vbar⁻¹*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*200Psi*
Near Channel	*1*	*Cable Depth*	*10-15m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
	99										*Noise file Avg. RMS noise = 4 µBar*
19:22:52	100	10.0	9.8	9.0	9.0	9.8	10.1	10.2	10.2		*SOL*
	180	14.6	14.7	15.2	15.8	15.6	15.3	15.6	14.9		New target depth 15m
	260	15.0	15.3	15.3	15.2	15.1	15.0	14.9	14.9		
20:56:12	380	14.3	15.3	15.2	15.2	15.1	14.9	15.1	15.1		EOL
	381										
											Average RMS 2.5µBar

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-LR-010*	**Sheet Number**	*1 of 1*	**Observer:**	
Area:	*Gulf of Cadiz*	**Heading:**				**Near Trace:**	
Field:	*N/A*					**Wind Strength:**	*F - * **Sea State:** *≤ mtrs*
Job	*1099 / D318B*	**Date:**	*6/5/07*	**Tape Drive:**			

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*17.4Vbar^{-1}*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*200Psi*
Near Channel	*1*	*Cable Depth*	*4m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
tape 32	99										*Noise file Avg. RMS noise = 5.4µBar*
22:53:19	100	11.2	11.9	10.9	10.8	10.2	9.6	9.6	9.9	8S	
tape 33											
23:00:46	180	8.4	8.9	9.1	9.8	9.9	10.1	9.7	9.9		
	260	9.5	10.1	11.1	10.4	9.9	10.0	9.9	10.0		noise evident from astern
	340	9.8	9.9	9.8	10.2	9.9	10.0	9.9	10.4		
	420	10.2	9.9	9.8	10.0	10.1	10.1	10.0	9.8		
	500	10.0	10.2	9.9	9.6	9.7	10.3	10.4	10.0		
01:30:19	571									5S	EOL
	572										*Noise file Avg. RMS noise = 5.2µBar*

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-LR-011*	**Sheet Number**	*1 of 1*	**Observer:**	*S.P/T.B*
Area:	*Gulf of Cadiz*	**Heading:**	*220 deg*			**Near Trace:**	
Field:	*N/A*					**Wind Strength:** *F* -	**Sea State:** ≤ *mtrs*
Job	*1099 / D318B*	**Date:**	*7/5/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*17.4Vbar^{-1}*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*200Psi*
Near Channel	*1*	*Cable Depth*	*4m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
tape 34	99	9.6	9.7	10.1	10.1	10.8	10.0	10.2	10.0		*Noise file Avg. RMS noise = 5.4µBar*
03:13:19	100	9.6	9.7	10.1	10.1	10.8	10.0	10.2	10.0	4S	
	180	9.8	9.9	9.8	9.9	9.6	9.6	9.6	10.9		
	260	10.0	9.9	10.3	10.0	10.0	9.9	10.0	10.2		
	340	10.2	9.9	10.2	10.1	10.3	10.2	9.8	10.2		
	420	9.8	9.6	9.9	9.3	9.9	9.9	10.2	10.6		
05:26:39	500	10.1	9.7	10.4	10.2	10.2	10.1	10.0	10.4		
	580	10.9	10.9	10.8	10.4	9.9	9.6	9.8	10.0	0	
	660	10.2	9.9	8.8	8.2	9.4	9.8	9.8	10.2		
	740	9.9	9.8	10.2	10.0	10.1	10.2	10.1	9.9		
	820	9.1	9.1	9.9	10.2	10.9	10.9	10.3	10.2		
07:16:59	831	9.5	7.8	7.5	7.5	9.0	9.8	9.6	11.2		
	832										*Noise file Avg. RMS noise = 5µBar*

Digital Observers Log

Client:	R. Hobbs / NOC	**Line:**	GO-LR-012	**Sheet Number**	1 of 1	**Observer:**	TB
Area:	Gulf of Cadiz	**Heading:**	deg			**Near Trace:**	80
Field:	N/A					**Wind Strength:** F -	**Sea State:** ≤ mtrs
Job	1099 / D318B	**Date:**	7/5/07	**Tape Drive:**	3		

Streamer Type:	SEAL	S.P. Interval	20s	Recording System:	Seal V5.1.15	Low Cut filter	2Hz	Source Type	6 Bolts
Far Channel	192	Sensitivity	17.4Vbar^{-1}	Recording Format:	SegD 8058 rev 1	High Cut filter	0.8 Niquis	Source Pressure	200Psi
Near Channel	1	Cable Depth	4m	Pre Amp Gain	g1	No. of Aux Channels	6 (gun hydrophones)	Source Volume	2320
No. of Groups	192	Sample Rate	1ms	No. of channels	192			Source Tow Depth	8m
Group Interval	12.5 mtrs	Record Length	18s	Camera Gain Control	AGC	Source to Near trace	~80m		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
tape 38	99										Noise file Avg. RMS noise = 4.4 µBar
09:37:20	100	9.8	9.9	9.8	9.8	9.8	10.0	9.6	9.9		SOL
	180	10.2	10.0	9.8	9.9	10.2	10.0	10.1	10.0		
	260	9.4	9.8	9.8	10.2	10.1	10.0	10.1	10.0		
	340	9.6	10.0	10.8	10.4	9.8	9.9	10.0	9.9		
	420	11.5	8.8	7.9	8.9	9.7	10.2	9.8	10.4		
	500	9.5	8.8	9.1	9.3	9.3	9.9	10.0	10.0	10P	
	580	10.0	9.5	10.0	9.5	9.5	9.8	10.1	10.0		noise from astern evident
	660	10.1	10.0	10.0	10.1	9.9	10.0	10.1	10.0		
Tape 39	740	9.7	9.9	10.0	10.1	10.0	9.9	10.2	9.9		fist file tape 39, 727
	820	10.4	10.4	10.5	10.2	10.0	9.8	10.1	10.0		
	900	9.9	10.2	10.1	9.8	10.1	10.0	10.2	10.2		
	980	10.0	10.2	10.2	10.2	10.1	10.1	10.1	10.0		
	1060	10.3	10.2	9.9	10.0	10.1	10.1	9.9	10.0		
	1140	10.2	10.2	10.4	10.4	9.8	9.9	10.0	10.2		~1150 noise from front of cable
	1220	10.0	10.2	10.1	10.4	10.1	10.0	10.1	9.9		
tape 40	1300	10.4	10.1	10.1	10.1	10.2	10.1	10.1	10.2		first file tape 40, 1355
	1380	9.8	10.2	10.2	10.1	10.1	10.0	10.1	10.2		
	1460	10.4	10.5	10.2	10.1	10.2	10.1	9.9	10.0		
	1540	9.6	10.0	9.9	9.9	10.1	10.3	10.0	10.2		
18:00:19	1607	10.3	10.2	10.1	10.1	10.0	10.2	10.0	10.1		EOL
	1608										Noise file Avg. RMS noise = 10µBar

Digital Observers Log

Client:	R. Hobbs / NOC	**Line:**	GO-LR-013	**Sheet Number**	1 of 1	**Observer:**	S.P
Area:	Gulf of Cadiz	**Heading:**	270 deg			**Near Trace:**	
Field:	N/A					**Wind Strength:**	F - **Sea State:** ≤ mtrs
Job	1099 / D318B	**Date:**	7/5/07	**Tape Drive:**	3		

Streamer Type:	SEAL	S.P. Interval	20s	Recording System:	Seal V5.1.15	Low Cut filter	2Hz	Source Type	6 Bolts
Far Channel	192	Sensitivity	17.4Vbar^{-1}	Recording Format:	SegD 8058 rev 1	High Cut filter	0.8 Niquis	Source Pressure	200Psi
Near Channel	1	Cable Depth	4m	Pre Amp Gain	g1	No. of Aux Channels	6 (gun hydrophones)	Source Volume	2320
No. of Groups	192	Sample Rate	1ms	No. of channels	192			Source Tow Depth	8m
Group Interval	12.5 mtrs	Record Length	18s	Camera Gain Control	AGC	Source to Near trace	~80m		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
	99										Noise file Avg. RMS noise = 7μBar
19:23:19	100	7.8	8.4	8.5	8.4	8.1	8.2	8.0	8.2		
	180	7.5	7.7	7.8	8.2	8.2	7.8	8.5	8.2		
	260	11.6	10.6	8.0	7.8	8.1	8.2	8.0	7.9		
	340	8.1	7.9	7.9	8.2	7.9	7.9	8.0	7.9		
	420	8.5	7.9	8.4	8.3	7.9	7.8	8.0	7.9		
	500	8.4	7.8	8.2	8.1	8.0	7.8	7.8	8.4		
	580	8.8	7.8	8.0	8.3	8.5	8.2	7.7	8.5	30S	
	660	9.3	7.7	8.2	8.6	8.6	8.2	8.2	8.2		
	740	9.0	7.7	7.9	7.8	8.0	8.0	8.0	8.5		
tape 42											
23:10:00	727										
	820	8.8	8.0	8.3	8.1	7.2	6.5	7.6	9.3		
	900	8.8	8.2	8.0	8.0	8.0	8.0	8.1	8.4		
	980	8.2	6.9	8.7	9.2	8.0	8.0	7.9	9.3		
	1060	8.7	5.9	5.6	7.2	7.9	8.0	7.8	9.1		
	1140	9.1	6.9	7.6	7.9	7.8	8.2	8.2	9.0		
	1220	9.1	7.0	8.3	8.1	8.0	8.1	8.0	8.4	6 S	
	1300	9.4	7.6	8.1	7.9	8.1	8.1	8.2	9.4		
Tape 43	1380	8.8	7.9	8.0	7.8	7.6	7.9	8.1	8.7		First file tape 43, 1355
03:02:39	1478										EOL
	1479	8.8	8.2	8.7	8.4	8.0	7.8	8.1	8.8		Noise file Avg. RMS noise = 2.2μBar

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-LR-014*	**Sheet Number**	*1 of 1*	**Observer:**	*S.P*
Area:	*Gulf of Cadiz*	**Heading:**	*110 deg*			**Near Trace:**	
Field:	*N/A*					**Wind Strength:** *F* - **Sea State:** ≤ *mtrs*	
Job	*1099 / D318B*	**Date:**	*8/5/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*14.7Vbar^{-1}*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*200Psi*
Near Channel	*1*	*Cable Depth*	*4m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
tape 44	99										*Noise file Avg. RMS noise = 8µBar*
05:36:19	100	6.8	6.7	8.0	8.1	8.2	8.3	7.7	8.8		
	180	5.9	7.7	9.3	9.2	9.2	7.7	7.9	7.9		
	260	5.7	6.4	5.9	8.4	9.6	11.3	10.2	10.0	2P	
	340	6.2	6.4	8.4	10.4	10.1	10.2	10.1	9.9		
	420	6.5	6.6	7.5	10.0	9.9	9.9	10.2	10.2		gun 2, port array,showing intermittent low voltages
	500	6.4	7.9	9.7	10.7	10.4	9.8	9.5	10.0		
	580	6.1	5.8	7.6	9.4	9.8	9.9	9.8	10.0		
	660	7.6	8.0	9.8	10.3	10.3	9.8	10.2	10.0		
	740	9.5	9.6	9.7	10.2	10.5	10.4	10.3	9.9	2P	*shot 752, port gun 2 switched off*
tape 45											
09:15:59	727										
	820	10.1	9.7	9.9	9.9	9.9	9.8	9.9	10.0		
	900	10.2	9.8	10.0	9.3	9.8	10.1	10.1	10.2		
	980	9.2	10.3	10.1	10.0	9.9	10.2	10.1	10.0		
10:34:10											EOL
tape 46											

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-MR001*	**Sheet Number**	*1 of 2*	**Observer:**	*S.P/T.B*
Area:	*Gulf of Cadiz*	**Heading:**	*255 deg*			**Near Trace:**	
Field:	*N/A*					**Wind Strength:**	*F - **Sea State:** ≤ mtrs*
Job	*1099 / D318B*	**Date:**	*9/5/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*$14.7Vbar^{-1}$*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*200Psi*
Near Channel	*1*	*Cable Depth*	*3m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
Tape 47	99										*Noise file Avg. RMS noise = 2.7 µBar*
18:41:23	100	2.5	2.5	2.8	3.5	2.7	2.1	2.9	2.4		*both arrays firing at the same time upto shot 140*
	180	2.9	2.9	2.9	3.0	2.9	2.9	2.9	3.2		
	260	3.0	2.8	2.9	3.1	3.2	3.1	3.2	3.2		odd files stb, even files pt gun array
	340	2.9	2.9	2.9	3.0	3.2	2.9	3.0	3.1	3S	
	420	3.1	3.0	3.0	3.0	2.6	3.0	3.0	3.2		
	500	3.1	3.2	3.1	3.0	3.0	2.9	2.9	3.0	2S	
	580	2.9	3.0	3.1	3.0	3.1	3.0	3.1	3.0		
	660	3.0	3.0	3.1	2.9	3.1	3.2	2.9	3.1		
	740	2.9	3.0	3.1	2.9	3.3	3.0	3.1	2.9	2S	
	820	2.9	3.0	3.1	3.0	3.1	2.9	3.1	3.0		
	900	2.9	2.9	2.5	3.1	3.0	3.0	3.0	3.1	2S	
	980	3.1	3.1	2.4	3.1	3.0	3.1	2.6	3.1		
	1060	3.0	2.9	3.1	1.1	2.9	3.0	2.9	2.9		
	1140	2.8	2.7	2.9	3.1	3.0	3.3	3.1	3.0		
	1220	2.9	2.9	3.2	3.5	3.1	3.2	2.6	3.0	2S	
	1300	2.9	3.0	2.1	1.7	2.7	3.1	3.1	3.1		
Tape 48	1380	3.1	3.0	3.0	2.4	3.2	3.0	3.0	3.0		Tape 48 ffid1352
	1460	3.1	2.9	2.9	1.9	2.6	2.9	2.9	2.9		
	1540	2.9	2.9	3.0	2.9	3.0	3.1	2.9	2.9		
	1620	2.9	3.1	3.2	2.6	3.1	3.0	3.3	3.6	5S	
	1700	3.2	3.2	2.3	2.7	3.0	3.1	3.2	3.0		
	1780	3.2	3.1	3.3	2.4	2.9	3.0	3.1	3.2		
	1860	2.8	2.9	3.1	3.1	3.8	3.1	3.0	3.1		
	1940	3.2	3.2	3.2	0.8	2.6	3.1	3.0	3.0		
	2020	2.9	2.9	3.1	3.8	4.2	2.9	2.9	3.0		bird 3 wing reset @ file 2006
	2100	2.9	2.9	3.1	3.0	3.2	3.1	3.1	3.2	4S	depth control much improved
	2180	3.0	3.0	2.9	2.9	3.1	3.1	3.3	3.2		

Digital Observers Log

Client:	R. Hobbs / NOC	**Line:**	GO-MR001	**Sheet Number**	2 of 2	**Observer:**	S.P/T.B
Area:	Gulf of Cadiz	**Heading:**	255 deg			**Near Trace:**	
Field:	N/A					**Wind Strength:** F -	**Sea State:** ≤ mtrs
Job	1099 / D318B	**Date:**	9/5/07	**Tape Drive:**	3		

Streamer Type:	SEAL	S.P. Interval	20s	Recording System:	Seal V5.1.15	Low Cut filter	2Hz	Source Type	6 Bolts
Far Channel	192	Sensitivity	17.4Vbar⁻¹	Recording Format:	SegD 8058 rev 1	High Cut filter	0.8 Niquis	Source Pressure	200Psi
Near Channel	1	Cable Depth	3m	Pre Amp Gain	g1	No. of Aux Channels	6 (gun hydrophones)	Source Volume	2320
No. of Groups	192	Sample Rate	1ms	No. of channels	192			Source Tow Depth	8m
Group Interval	12.5 mtrs	Record Length	18s	Camera Gain Control	AGC	Source to Near trace	~80m		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
01:53:47	2260	3.1	3.0	2.7	2.4	3.4	3.1	3.1	2.7		*Tape 48 continued*
	2340	2.8	3.1	3.1	3.0	3.1	3.8	3.1	3.2		significant noise from vessel passing aft ~4km
	2420	3.0	2.8	2.9	2.1	3.8	2.9	3.2	3.7	3S	bird 3 registering motor failure, reset
	2500	3.2	3.0	3.1	1.5	2.7	2.8	2.9	2.6		bird 3 set to manual mode (-13º)
Tape 49	2580	3.1	2.9	3.1	3.0	3.2	3.1	3.1	3.2		tape 49 ffid 2604
	2660	2.8	2.8	2.9	2.7	3.2	3.1	2.9	2.9		single trace now ch50
	2740	2.9	3.1	2.9	2.9	3.2	2.8	2.9	3.0		
	2820	2.7	2.8	2.8	2.7	2.9	2.9	3.0	2.8		
	2900	2.7	2.8	2.9	3.5	3.0	3.0	3.0	3.5	0	
	2980	3.1	3.1	3.3	2.8	3.2	3.0	2.9	3.1		
	3060	3.1	3.1	2.9	2.8	3.0	3.0	3.1	3.0		
	3140	3.1	3.1	2.2	2.5	3.0	2.9	2.9	2.9		
	3220	3.2	3.2	3.2	2.1	2.2	3.0	3.0	3.1		
	3300	3.2	3.2	3.2	1.9	3.0	3.0	3.0	2.9		
	3380	3.2	3.1	3.1	2.8	2.9	3.1	3.0	3.1	0	
	3460	2.9	3.0	3.1	3.4	3.1	3.0	3.2	3.1		
	3540	3.1	3.2	3.2	3.4	3.1	3.2	3.1	3.1		
	3620	3.0	2.9	2.9	3.6	3.6	3.4	3.1	3.1		
	3700	3.0	3.0	3.0	2.9	2.8	2.9	3.1	3.0		
Tape 50	3780	3.0	3.1	3.2	2.3	3.0	3.0	3.0	3.1	4S	Tape 50 ffid 3856
	3860	3.1	3.1	3.2	3.0	3.5	3.4	3.2	3.0		
	3940	3.4	3.4	3.1	2.9	2.9	3.0	2.9	3.2		
	4020	3.2	3.2	3.2	4.0	2.9	3.0	2.9	2.9		
	4100	4.6	3.2	0.6	2.9	3.2	2.6	3.1	3.6		
	4180	3.8	2.9	3.2	3.6	3.4	3.2	3.2	3.0		
08:24:36	4210										EOL
	4211										EOL Noise Shot 4211

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-MR001-1*	**Sheet Number**	*1 of 1*	**Observer:**	*S.P/T.B*
Area:	*Gulf of Cadiz*	**Heading:**	*255 deg*			**Near Trace:**	
Field:	*N/A*					**Wind Strength:** *F -* **Sea State:** *≤ mtrs*	
Job	*1099 / D318B*	**Date:**	*9/5/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*12s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*17.4Vbar^{-1}*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*200Psi*
Near Channel	*1*	*Cable Depth*	*3m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

Continuation of line GO-MR-001 after recovery of port-beam to replace tail float.

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
Tape 51	99	3.0	3.1	3.0	1.8	2.8	3.0	2.9	2.8		Noise Shot 09:20:00 11/05/2007 GO-MR-001-1
	100	3.0	3.1	3.0	1.8	2.8	3.0	2.9	2.8		Start Soft Start 09:24:12 STB Beam only
											still flip-flop prt-stb (24s each beam)
09:47:24	216	3.2	3.2	3.5	3.8	3.0	2.8	2.8	3.0		All STB guns firing and synched EVEN SHOTS
	300	3.1	3.2	3.3	2.9	1.1	3.0	3.0	3.2		Noise from Bird 3 surfacing due to reduced v/l speed for XBT
	380	3.3	3.2	2.8	2.6	3.9	3.5	2.9	3.0		
	460	3.2	3.2	3.1	2.9	3.0	3.1	3.2	3.6		
	540	2.9	3.1	3.1	1.8	2.9	2.9	3.0	2.8		
	620	3.2	2.9	3.0	3.2	3.2	3.1	2.9	3.1		10:54, fid 551 , EOL waypoint
	700										11:14:24 Last Shot FFID 653 EOF Tailbuoy past EOL WP
											Noise Shot FFID 654 Guns Off

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-MR-test 2*	**Sheet Number**	*of*	**Observer:**	
Area:	*Gulf of Cadiz*	**Heading:**	*deg*	**Re Run:**		**Near Trace:**	
Field:	*N/A*	**Line Status**		**Water Depth:**	*mtrs*	**Wind Strength:**	*F - **Sea State:** ≤ mtrs*
Job	*1099 / D318B*	**Date:**	*6/5/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*14.7Vbar⁻¹*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*200Psi*
Near Channel	*1*	*Cable Depth*	*4m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
13:56:12	100	3.0	2.9	3.0	3.5	3.1	2.9	3.3	3.1		*port array*
tape 52	116										*gun 3 pt off, gun 1 pt on prior to file 116*
14:13:23	187										test suspended to level port beam
	188										port array gun 1 (300)
	216										test suspended to level port beam (more)
	217										stb
	218										new depth prt
	261										end of test

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-MR-002*	**Sheet Number**	*1 of 1*	**Observer:**	*S.P/T.B*
Area:	*Gulf of Cadiz*	**Heading:**	*54 deg*			**Near Trace:**	
Field:	*N/A*					**Wind Strength:** *F -*	**Sea State:** *≤ mtrs*
Job	*1099 / D318B*	**Date:**	*11/5/07*	**Tape Drive:**	*3*		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*17.4Vbar⁻¹*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*200Psi*
Near Channel	*1*	*Cable Depth*	*4m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
tape 53	99										*SOL noise file. Av. Rms noise= 1.4µB*
15:12:36	100	3.2	3.2	2.9	3.1	3.0	3.0	2.9	2.8	0	*st'b array firing on evens*
	180	3.0	3.0	2.9	2.9	2.9	3.0	3.0	2.9		
	260	2.8	3.0	3.0	2.9	2.9	3.1	3.0	3.1		
	340	2.9	3.0	3.2	3.1	3.1	3.0	3.0	2.9		
	420	2.8	3.0	2.9	2.9	3.1	3.0	3.0	3.0		
	500	3.0	3.0	2.9	3.0	3.1	3.1	3.2	3.0		
	580	3.3	3.0	2.9	3.0	2.9	2.9	3.9	3.1	0	
	660	3.1	3.0	3.0	3.2	2.9	3.0	3.2	3.0		
	740	2.9	3.1	3.1	3.2	2.9	2.9	3.1	3.2		
	820	2.9	2.9	2.8	3.0	2.9	2.9	3.1	3.0		
17:46:35	870	3.0	3.1	3.1	3.2	2.9	3.0	3.1	3.0		
	871										EOL noise file. Av.Rmsnoise= 2.1µB

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-MR-003*	**Sheet Number**	*1 of 2*	**Observer:**	*S.P/T.B*
Area:	*Gulf of Cadiz*	**Heading:**	*54 deg*			**Near Trace:**	
Field:	*N/A*					**Wind Strength:** *F -*	**Sea State:** *≤ mtrs*
Job	*1099 / D318B*	**Date:**	*11/5/07*	**Tape Drive:**	*3*		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*$17.4 Vbar^{-1}$*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*200Psi*
Near Channel	*1*	*Cable Depth*	*5m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
tape 54	99	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0		*SOL noise file. Av. Rms noise= 2.3μB*
20:44:24	100	4.9	5.0	5.0	4.9	5.0	5.3	4.8	4.8		*st'b array firing on evens, port on odds*
	180	5.1	5.0	5.0	5.1	4.9	5.0	5.1	5.0	0	
	260	6.1	5.9	6.0	6.0	6.1	6.3	6.3	6.0		NOISE
	340	6.0	6.0	6.3	6.0	5.9	6.0	6.1	6.1		NOISE
	420	6.3	6.3	5.9	6.1	6.2	5.9	6.0	6.1		NOISE
	500	6.1	6.0	6.0	5.8	5.8	5.9	6.2	6.4		swell type' noise evident
	580										
22:51:36	733										Last shot before offlining streamer for reconfiguration
22:52:38	735										*Back online*
23:02:12	761										Back online spare pwm, spare dcxu
	820	8.4	8.9	8.7	9.1	8.8	8.6	9.0	8.9		inexplicable noise continues.
	920	4.9	4.9	4.7	4.9	4.9	5.4	5.0	5.0		
	1000	5.0	4.8	5.1	5.0	5.1	5.0	5.0	5.1		
	1080	5.0	5.0	4.9	5.0	4.7	4.8	5.0	5.0		
	1160	4.9	4.9	4.9	4.9	4.8	4.9	4.9	4.9		
	1240	5.0	5.0	5.0	5.0	4.8	4.7	5.1	5.6	0	
	1320	5.1	5.1	5.1	4.8	5.0	4.2	4.7	5.0		
Tape 55	1400	5.0	5.1	5.1	4.7	5.1	5.1	4.8	4.7		first file tape 55, 1351
	1480	5.0	5.1	5.1	5.1	5.2	5.0	5.0	5.0		
	1560	4.8	4.6	5.0	5.3	5.4	5.3	5.3	5.3		
	1640	5.1	5.1	5.1	4.9	5.1	4.9	5.3	5.2		
	1720	5.0	4.9	4.9	5.0	5.0	4.8	5.0	5.2		
	1800	4.8	5.1	51.0	4.9	5.1	5.0	5.1	4.7		
	1880	5.0	5.8	5.0	5.4	5.2	4.9	4.9	5.5		1889: eol origional waypoint
	1960	5.2	5.2	4.9	4.9	5.1	4.8	4.7	4.9		
	2040	4.7	4.8	5.7	5.3	5.1	5.0	5.0	4.8		
	2120	4.8	4.9	5.1	5.1	4.9	5.2	5.0	5.1		

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-MR-003*	**Sheet Number**	*2 of 2*	**Observer:**	*S.P/T.B*
Area:	*Gulf of Cadiz*	**Heading:**	*54 deg*			**Near Trace:**	
Field:	*N/A*					**Wind Strength:**	*F - **Sea State:** ≤ mtrs*
Job	*1099 / D318B*	**Date:**	*11/5/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*20s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*17.4Vbar^{-1}*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*200Psi*
Near Channel	*1*	*Cable Depth*	*5m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
	2200	5.1	5.1	5.0	4.9	4.9	4.8	5.0	5.0		*tape 55 continued*
	2280	4.9	5.1	5.1	5.1	4.9	5.1	5.1	5.0		
	2360	5.0	5.0	5.1	5.4	5.0	4.7	5.0	4.2		
	2440	4.7	5.0	5.0	5.2	5.2	4.7	5.2	5.2	0	
	2520	5.2	5.2	5.1	5.1	5.0	5.2	5.2	5.0		
tape 56	2600	4.7	4.9	5.0	4.9	4.9	5.0	5.0	4.9		ffid 2603 tape 56
	2680	5.0	5.2	4.9	4.9	5.0	5.2	5.1	5.0		
05:37:11	2736	4.9	5.0	5.0	5.0	4.8	5.2	5.1	5.1		EOL
	2737										Average noise file RMS 6.3µBar

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-MR-004*	**Sheet Number**	*1 of 1*	**Observer:**	*S.P/T.B*
Area:	*Gulf of Cadiz*	**Heading:**	*54 deg*			**Near Trace:**	
Job	*1099 / D318B*					**Wind Strength:**	*F - * **Sea State:** *≤ mtrs*
		Date:	*12/5/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*12s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*17.4 Vbar^{-1}*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*200Psi*
Near Channel	*1*	*Cable Depth*	*5m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*1160 / 540*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m / 5m*
Group Interval	*12.5 mtrs*	*Record Length*	*9s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
08:48:00	99	5.1	5.3	4.9	5.1	4.9	4.6	5.0	5.2		*12/05/07 Tape 57 SOL noise file. Av. Rms noise= 3.48ubar*
08:49:00	100	5.1	5.3	4.9	5.1	4.9	4.6	5.0	5.2	0	
08:51:48	113	5.1	5.3	4.9	5.1	4.9	4.6	5.0	5.2		Odd/Even realigned erroneously
09:04:24	175	5.1	5.0	4.9	5.0	4.8	4.6	5.0	4.9	5S	*First production shot, port evens, stb odds*
	260	5.4	5.3	4.8	4.9	4.9	4.7	5.0	5.0		
	340	5.2	5.2	5.1	4.9	4.9	5.6	5.0	5.1		
	420	5.1	5.0	4.9	5.0	4.9	5.0	5.1	5.0		
	500	4.9	4.7	5.0	4.7	5.1	5.1	5.1	4.9		
	580	5.1	5.3	5.2	4.9	5.1	5.1	5.1	4.9		
	660	5.0	5.4	5.2	5.1	5.3	5.1	5.1	5.2	7S	
	740	5.2	5.3	4.9	5.1	5.0	5.1	5.0	5.1		
	820	5.0	5.1	5.1	5.2	5.0	5.0	5.1	4.9		
	900	4.8	4.8	5.1	4.8	5.0	4.8	4.4	4.9		
	980	4.8	4.9	4.9	4.9	4.9	4.9	4.9	5.0		
	1060	5.1	4.9	5.2	5.0	4.9	4.9	5.1	4.7		
	1140	4.8	5.4	4.8	5.3	5.1	4.8	4.8	5.0		
	1220	4.9	4.9	5.1	5.0	5.0	5.1	4.8	4.8		
	1300	5.1	5.4	5.2	5.1	4.9	5.1	4.9	5.0		
Tape 58	1380	5.0	5.0	4.9	5.2	4.9	4.9	4.9	4.9		First file tape 58, 1351
	1460	4.9	5.1	5.0	5.5	5.5	5.4	5.3	5.0		
	1540	4.7	5.0	5.0	5.1	5.0	4.8	4.8	4.9		
	1620	4.6	5.0	5.0	4.8	5.0	4.8	4.8	5.3		
14:02:22	1665										EOL
	1666										noise file 5.6μB

Digital Observers Log

Client: *R. Hobbs / NOC* **Line:** *GO-MR-005* **Sheet Number** *of*
Area: *Gulf of Cadiz* **Heading:** *218 °*
Job *1099 / D318B* **Water Depth:** *mtrs*
Date: *12/5/07* **Tape Drive:** 3

Streamer Type:	*SEAL*	*S.P. Interval*	*12s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*17.4 Vbar^{-1}*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*200Psi*
Near Channel	*1*	*Cable Depth*	*5m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*1160 / 540*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m / 5m*
Group Interval	*12.5 mtrs*	*Record Length*	*9s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
tape 59	99										*noise file. Av. Rms noise= 2.1ubar*
15:00:34	100	4.7	4.9	4.9	4.8	5.0	5.1	5.1	5.1	10S	port array evens stb odds
	180	5.1	5.1	5.0	5.0	5.0	5.1	5.0	5.1		
	260	5.1	5.0	4.9	5.0	5.0	5.0	5.1	5.1	2.5S	
	340	5.2	5.1	4.9	4.9	4.8	5.0	5.0	5.1		
	420	4.8	5.2	4.9	5.0	4.9	5.1	5.2	5.2		
	500	5.1	5.0	4.9	5.1	5.1	4.9	5.1	5.3		
	580	4.8	4.7	4.8	4.8	5.1	5.1	5.1	5.0		
	660	5.3	5.0	4.9	4.9	5.5	5.3	4.7	5.3		
	740	5.1	5.1	5.1	5.0	5.3	5.6	5.0	5.2	5S	
	820	5.1	5.1	5.3	5.1	5.0	5.0	5.3	5.1		
	900	4.4	4.5	4.9	4.7	5.0	4.9	5.4	4.7		
	980	5.0	5.1	5.2	5.1	5.1	4.8	4.9	5.0		
	1060	5.0	5.0	5.0	5.1	5.1	4.9	4.9	5.0		
	1140	6.2	6.4	5.2	5.0	5.0	4.9	5.1	4.8	3S	
	1220	4.9	5.0	5.1	5.2	5.0	4.8	4.9	5.0		
	1300	5.1	4.9	4.9	5.0	5.5	5.7	4.1	5.0		
	1380	5.7	5.3	5.1	5.0	4.8	5.1	5.0	5.3		
	1460	4.9	5.1	4.9	5.1	5.0	4.9	4.7	4.7		
	1520	5.4	5.0	5.0	5.0	5.0	4.8	4.9	5.0		
	1600	5.2	5.4	5.2	5.0	5.0	4.9	5.1	5.0		
20:06:36	1630	5.2	5.4	5.2	5.0	5.0	4.9	5.1	5.0		Last shot
20:09:12	1631	5.2	5.4	5.2	5.0	5.0	4.9	5.1	5.0		Noise shot 2.43ubar EOF Tape 60

Digital Observers Log

Client:	*R. Hobbs / NOC*	**Line:**	*GO-MR-006*	**Sheet Number**	*1 of 1*	**Observer:**	*S.P/T.B*
Area:	*Gulf of Cadiz*	**Heading:**	*124º*			**Near Trace:**	
Field:	*N/A*					**Wind Strength:** *F - * **Sea State:** *≤ mtrs*	
Job	*1099 / D318B*	**Date:**	*12/05/07*	**Tape Drive:**	3		

Streamer Type:	*SEAL*	*S.P. Interval*	*15s*	*Recording System:*	*Seal V5.1.15*	*Low Cut filter*	*2Hz*	*Source Type*	*6 Bolts*
Far Channel	*192*	*Sensitivity*	*17.4Vbar⁻¹*	*Recording Format:*	*SegD 8058 rev 1*	*High Cut filter*	*0.8 Niquis*	*Source Pressure*	*2000Psi*
Near Channel	*1*	*Cable Depth*	*4m*	*Pre Amp Gain*	*g1*	*No. of Aux Channels*	*6 (gun hydrophones)*	*Source Volume*	*2320*
No. of Groups	*192*	*Sample Rate*	*1ms*	*No. of channels*	*192*			*Source Tow Depth*	*8m*
Group Interval	*12.5 mtrs*	*Record Length*	*18s*	*Camera Gain Control*	*AGC*	*Source to Near trace*	*~80m*		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
	99										*SOL noise file. Av. Rms noise= 4.4μB*
00:53:00	100	5.1	5.1	4.2	4.2	5.0	5.0	5.3	4.8	0	*port evens*
01:19:30	169	5.0	5.1	5.1	5.1	4.6	5.0	5.1	4.9		first goog production shot (stb array) Shot time 15s
	260	5.1	5.4	5.2	5.4	5.0	5.6	5.3	5.2		swell noise avg~ 5μB
	340	4.6	4.6	4.9	5.0	5.3	5.4	5.0	5.0	5s	
	420	5.0	5.2	5.1	5.2	5.3	5.0	4.8	5.2		423, recurrence of noise pulse
	500	4.6	4.5	5.0	5.0	5.0	4.9	5.1	5.4	0	439 EOL waypoint
02:50:45	574	5.4	5.0	5.5	5.5	5.0	4.7	4.6	5.5		EOL
	575										noise file 6.4μB

Digital Observers Log

Client:	R. Hobbs / NOC	**Line:**	GO-MR-007	**Sheet Number**	1 of 1	**Observer**	S.P/T.B
Area:	Gulf of Cadiz	**Heading:**	304º			**Near Trace**	
Field:	N/A					**Wind Strength:** F -	**Sea State:** ≤ mtrs
Job	1099 / D318B	**Date:**	13/05/07	**Tape Drive:**	3		

Streamer Type:	SEAL	S.P. Interval	15s	Recording System:	Seal V5.1.15	Low Cut filter	2Hz	Source Type	6 Bolts
Far Channel	192	Sensitivity	17.4Vbar-1	Recording Format:	SegD 8058 rev 1	High Cut filter	0.8 Niquis	Source Pressure	2000Psi
Near Channel	1	Cable Depth	5m	Pre Amp Gain	g1	No. of Aux Channels	6 (gun hydrophones)	Source Volume	2320
No. of Groups	192	Sample Rate	1ms	No. of channels	192			Source Tow Depth	8m
Group Interval	12.5 mtrs	Record Length	7s	Camera Gain Control	AGC	Source to Near trace	~80m		

UTC Time:	File	Bird Depths 1	2	3	4	5	6	7	8	Feather Angle	Comments
	99										SOL noise file. Av. Rms noise= 11.3µB
04:06:58	100	5.0	5.1	5.1	4.9	4.5	4.6	4.1	4.1		
	180	5.2	5.0	5.1	5.0	5.1	5.2	4.8	5.1		
	260	5.3	5.3	5.2	5.2	5.1	5.0	4.7	5.1		
	340	4.9	4.8	5.1	5.0	5.0	5.0	5.1	5.1		
	420	4.2	4.9	4.8	5.0	5.1	4.9	5.2	5.1		
	500	4.9	4.8	5.1	5.1	4.9	5.2	5.0	4.8	10P	
06:00:58	556	5.3	4.8	4.9	5.0	5.0	5.1	5.4	5.2		
	557										EOL noise file. Av.Rms noise=12.3µB

GUNDALF array modelling suite - Array report

Gundalf revision AIR5.1i, Date 2007-01-05

Fri Mar 02 17:04:10 Hora estándar romance 2007 (Valenti)

Contents

Signature filtering policy

For marine environmental noise reports, Gundalf performs no signature filtering other than that inherent in modelling at a sample interval small enough to simulate an airgun array signature at frequencies up to 100kHz.

For all other kinds of reports, Gundalf performs filtering in this order:-

- If a pre-conditioning filter is chosen, for example, an instrument response, it is applied at the modelling sample interval.
- If the output sample interval is larger than the modelling sample interval, Gundalf applies appropriate anti-alias filtering. (This can be turned off in the event that anti-alias filtering is included in the pre-conditioning filter, in which case Gundalf will issue a warning.)
- Finally, Gundalf applies the chosen set of post-filters, Q, Wiener and band-pass filtering as specified, at the output sample interval.

In reports, when filters are applied, they are applied to the notional sources first so that signatures, directivity plots and spectra are all filtered consistently.

Finally note that modelled signatures always begin at time zero for reasons of causality.

Anti-alias and pre-condition filtering

In this case, no pre-conditioning filter has been applied.

In this case, no anti-alias filtering was necessary.

Post filtering

Details of the post-filtering used in this report follow. Post filters are applied at the output sample interval after any pre-conditioning and anti-alias filters have been applied.

Q filtering

No Q filtering performed.

Wiener filtering

No Wiener filtering performed.

Band-pass filtering

No band-pass filtering performed.

Some notes on the modelling algorithm

The Gundalf airgun modelling engine is the end-product of 15 years of state of the art research. It takes full account of all air-gun interactions including interactions between sub-arrays. No assumptions of linear superposition are made. This means that if you move sub-arrays closer together, the far-field signature will change. The effect is noticeable even when sub-arrays are separated by as much as 10m.

The engine is capable of modelling airgun clusters right down to the 'super-foam' region where the bubbles themselves collide and distort. It has been calibrated against both single and clustered guns for a number of different gun types under laboratory conditions and accurately predicts peak to peak and primary to bubble parameters across a very wide range of operating conditions.

In many cases, the predicted signatures are good enough to be used directly in signature deconvolution procedures.

Array summary

The following table lists the statistics for the array quoted in various commonly used units for convenience. Note that the rms value is computed over the entire modelled signature.

Array parameter	Array value
Number of guns	6
Total volume (cu.in).	117.0 (1.92 litres)
Peak to peak in bar-m.	28.1 (2.81 MPa, 249 db re 1 microPascal. at 1m.)
Zero to peak in bar-m.	14.7 (1.47 MPa, 243 db re 1 microPascal. at 1m.)
RMS pressure in bar-m.	0.856 (0.0856 MPa, 219 db re 1 microPascal. at 1m.)
Primary to bubble (calculated peak to peak)	21.5
Bubble period to first peak (s.)	0.06

Maximum spectral ripple (db): 10.0 - 50.0 Hz.	10.9
Maximum spectral value (db): 10.0 - 50.0 Hz.	191
Average spectral value (db): 10.0 - 50.0 Hz.	188
Total acoustic energy (Joules)	7605.7
Total acoustic efficiency (%)	28.7

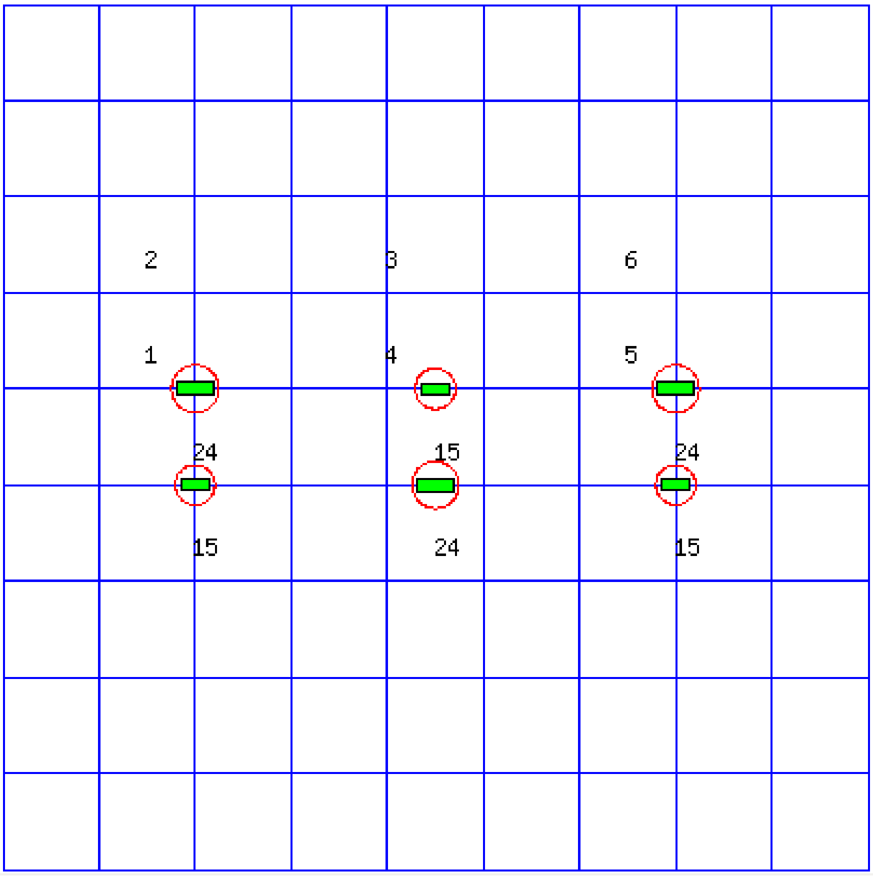
Array geometry and gun contribution

The following table lists all the guns modelled in the array along with their characteristics. The last column is completed only if the array has actually been modelled during the interactive session and contains the contribution of that gun as a percentage of the peak to peak amplitude of the whole array. Please note that the relationship with volume is only as the cube root of the volume for the same gun type so that even small guns contribute significantly. This is particularly relevant to drop-out analysis.

Gun	Pressure (psi)	Volume (cuin)	Type	x (m.)	y (m.)	z (m.)	delay (s.)	sub-array	p-p contrib (pct.)
1	2000.0	G 15.0/I 15.0	GI-GUN	10.000	0.500	4.000	0.000/(G->I 0.000)	1	18.0
2	2000.0	G 24.0/I 24.0	GI-GUN	10.000	-0.500	4.000	0.000/(G->I 0.000)	1	15.4
3	2000.0	G 15.0/I 15.0	GI-GUN	12.500	-0.500	4.000	0.000/(G->I 0.000)	1	17.9
4	2000.0	G 24.0/I 15.0	GI-GUN	12.500	0.500	4.000	0.000/(G->I 0.000)	1	15.3
5	2000.0	G 15.0/I 15.0	GI-GUN	15.000	0.500	4.000	0.000/(G->I 0.000)	1	18.0
6	2000.0	G 24.0/I 24.0	GI-GUN	15.000	-0.500	4.000	0.000/(G->I 0.000)	1	15.4

Hydrophone position: Infinite vertical far-field

<----- Direction of travel ----- --, (1m. grid, plan view)



The red circles denote the maximum radius reached by the bubble. Please note that pressure-field interactions take place over a much larger distance than this, (typically 10 times larger). However when bubbles touch or overlap, super-foam interaction can be expected. In this zone, significant peak AND bubble suppression will normally be observed.

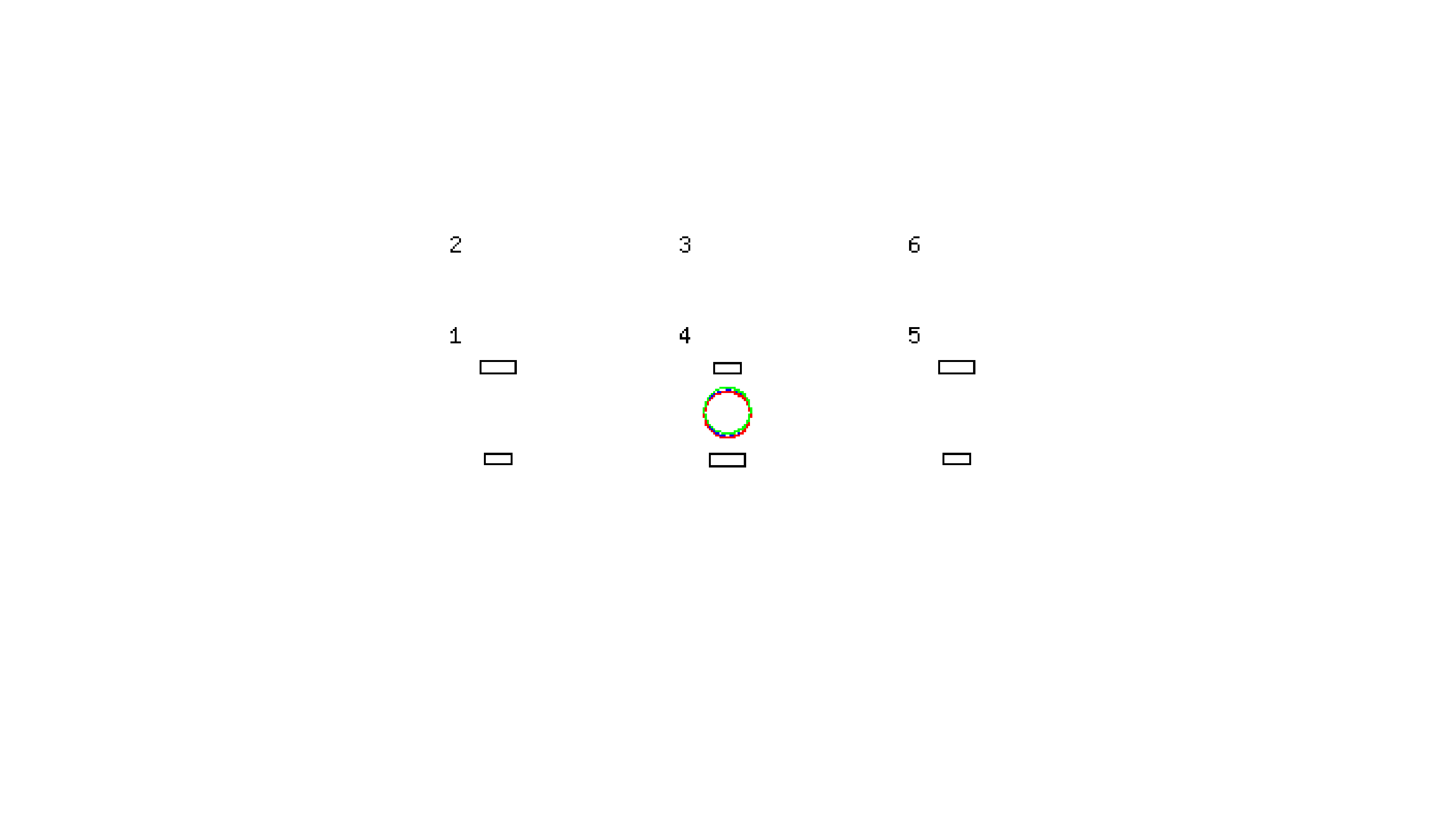
Note also that a green rectangle represents a single gun and an orange rectangle indicates that the gun is currently dropped out. Where present, a yellow rectangle represents a vertical cluster (V.C.) of guns. Please see the geometry table above for more details. The small number to the above left of each gun is its reference number in this table. For clusters of guns, these reference numbers mirror the symmetry of the cluster.

Back to top

Array centres

The following diagram shows the array geometric centre, the centre of pressure and the centre of energy. The centre of pressure is defined to be the array centre when each gun position is weighted by its contribution to the overall peak to peak pressure value. The centre of energy is computed by weighting the coordinates by the self-energy of the gun at that position. In an interacting array this may be a long way from the centre of pressure as some guns may absorb energy giving a negative self-energy. Depending on how first breaks are calculated, these can be used for first break analysis.

Array centres



Note that the geometric centre is shown as a blue circle, the centre of pressure is shown as a red circle and the centre of energy is shown as a green circle.

The geometric centre is at (12.5, 0, 4)

The centre of pressure is at (12.5, 0.0129, 4)

The centre of energy is at (12.5, -0.0345, 4)

Back to top

Array directivity

The following tables show the inline and crossline directivity of the array in both (angle-frequency) and (angle-amplitude) form and optionally, the azimuthal directivity (theta-phi) form.

Note that the effects of cable ghosting if present are not shown in Gundalf directivity displays although source ghosting is included. This matches common practice in such displays.

For inline directivity displays, the x-axis is the inline angle from the vertical with the word fore indicating the end nearest the boat. For crossline directivity displays, the x-axis is the crossline angle from the vertical with the word port indicating the port side.

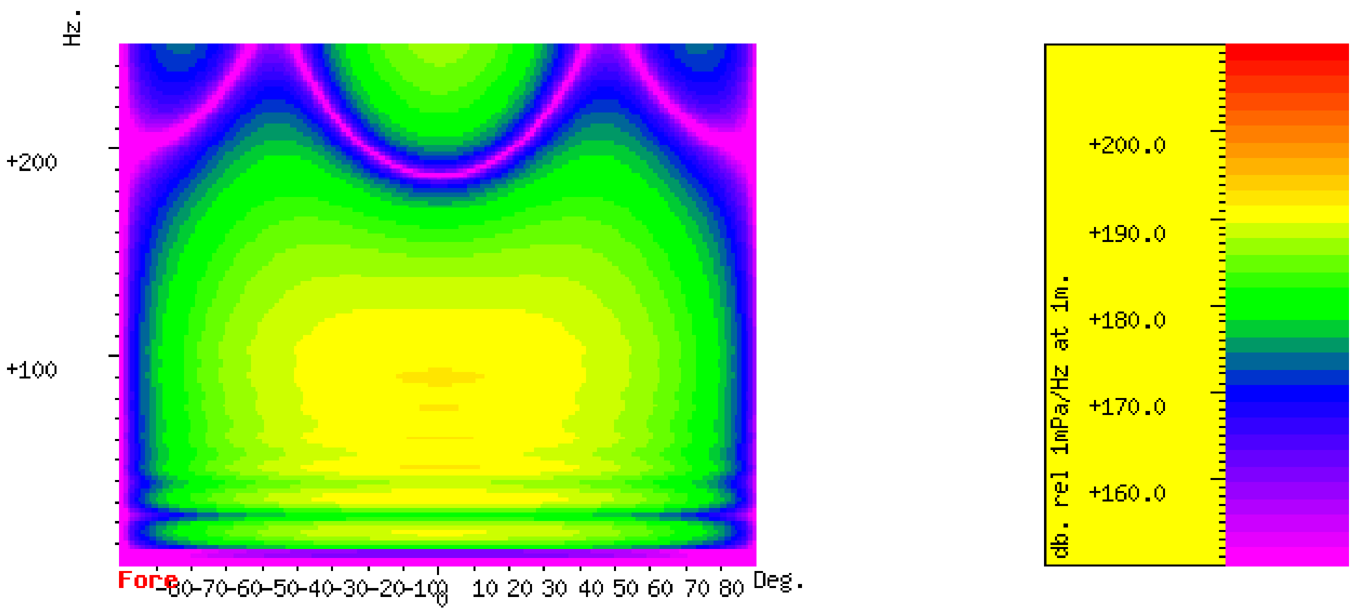
Note that *inline* is used nominally to mean any angle within +/- 45 degrees of the boat direction (which corresponds to a bearing of zero degrees). Similarly, *crossline* is used nominally to mean any angle within +/- 45 degrees of the perpendicular to the boat direction which is measured as a bearing of 90 degrees, (i.e. starboard). The nominal inline and crossline angles can be set by the user in the report options. The values used are indicated in the diagram titles below as bearings.

Where shown, the azimuthal plots show contours at four chosen frequencies as a function of phi (angle from the x-axis, opposite to the boat direction) and theta (the angle from the vertical). A bearing of zero degrees corresponds to a value of phi of 180 degrees.

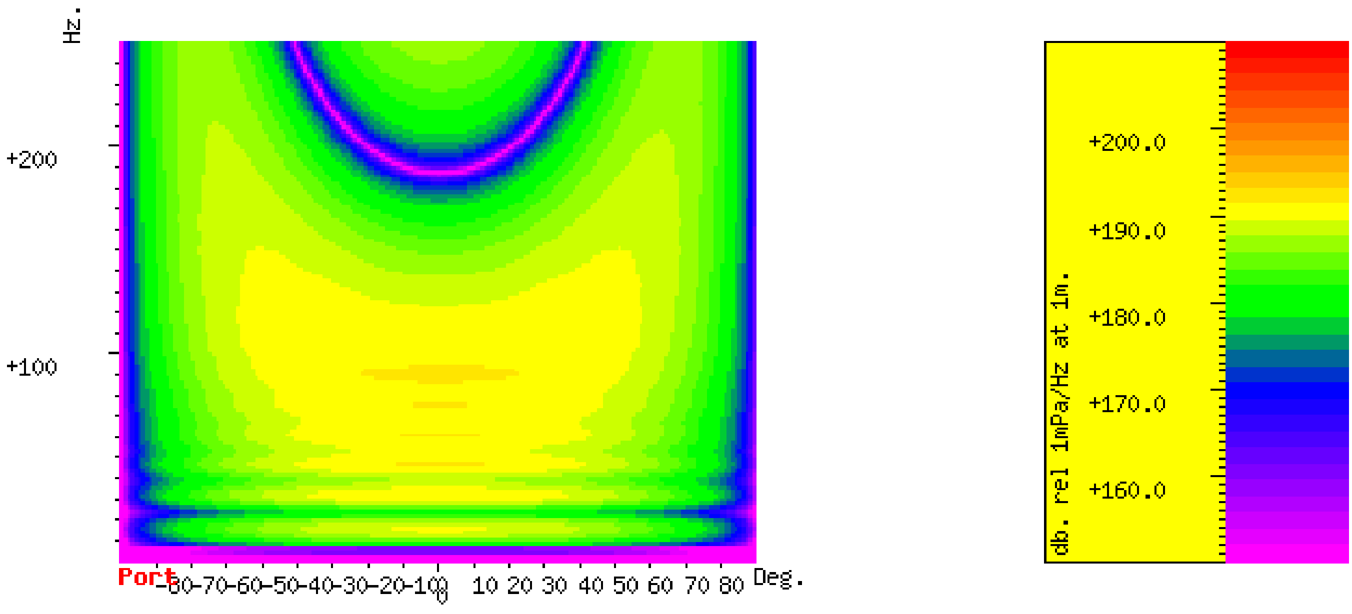
Angle-frequency form

The following tables show the inline and crossline directivity of the array in (dip angle-frequency) form. Both plots are scaled as db. relative to 1 microPa. per Hz. at 1m.

Inline directivity, bearing = 0 degrees



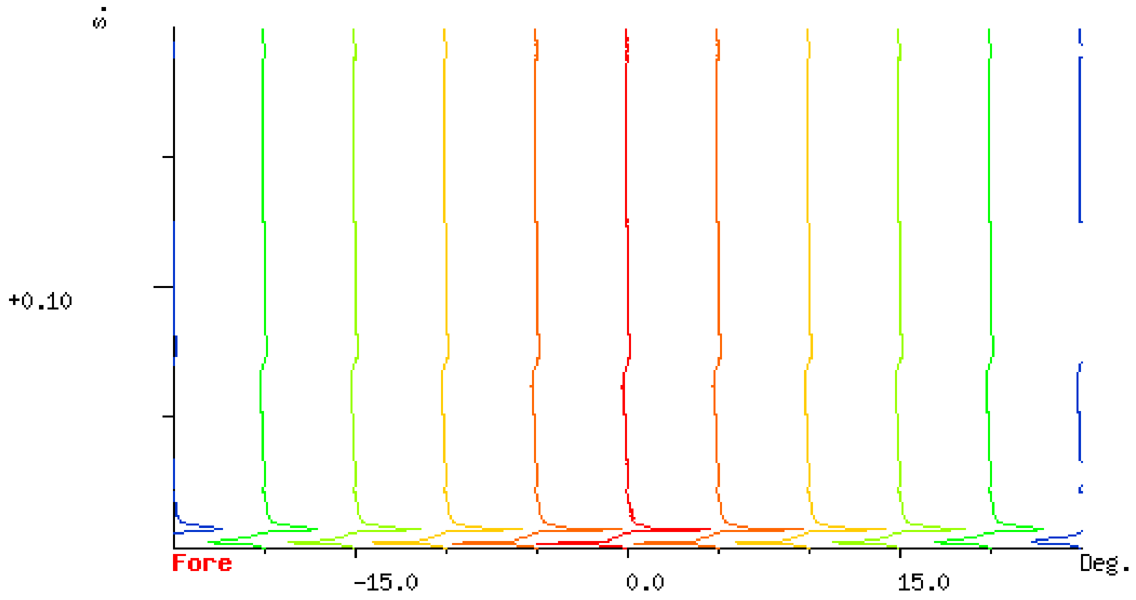
Crossline directivity, bearing = 90 degrees



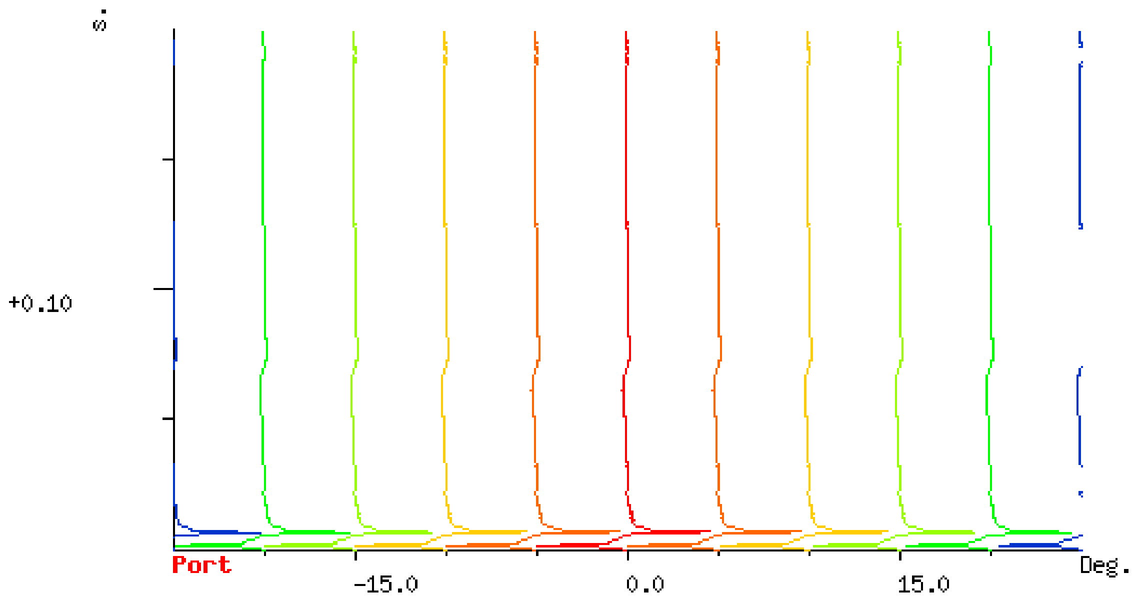
Angle-amplitude form

The following tables show the inline and crossline directivity of the array in (dip angle, amplitude) form. The computed signature (or under option the amplitude spectrum) for each angle is shown in colour varying form with red signatures shown in the centre, shading to blue at the furthest angles computed. The vertical scale indicates the type of plot, time or frequency. Both types of plot are individually scaled and plotted with the same units as the corresponding plots in the Signature Characteristics section.

Inline directivity, bearing = 0 degrees



Crossline directivity, bearing = 90 degrees



Back to top

Signature characteristics

The following tables show the signature parameters, the signature and the amplitude spectrum of the modelled signature.

The amplitude spectrum is shown in units of db. relative to 1 microPa. per Hz. at 1m.

The position of the bubble by default is determined internally but can be overridden by interacting with the modelled signature using the right hand mouse button to determine the start of the bubble.

Signature ghost information

The source ghost has been included. The source ghost was input directly with the value -1.0.

The cable ghost has been switched off.

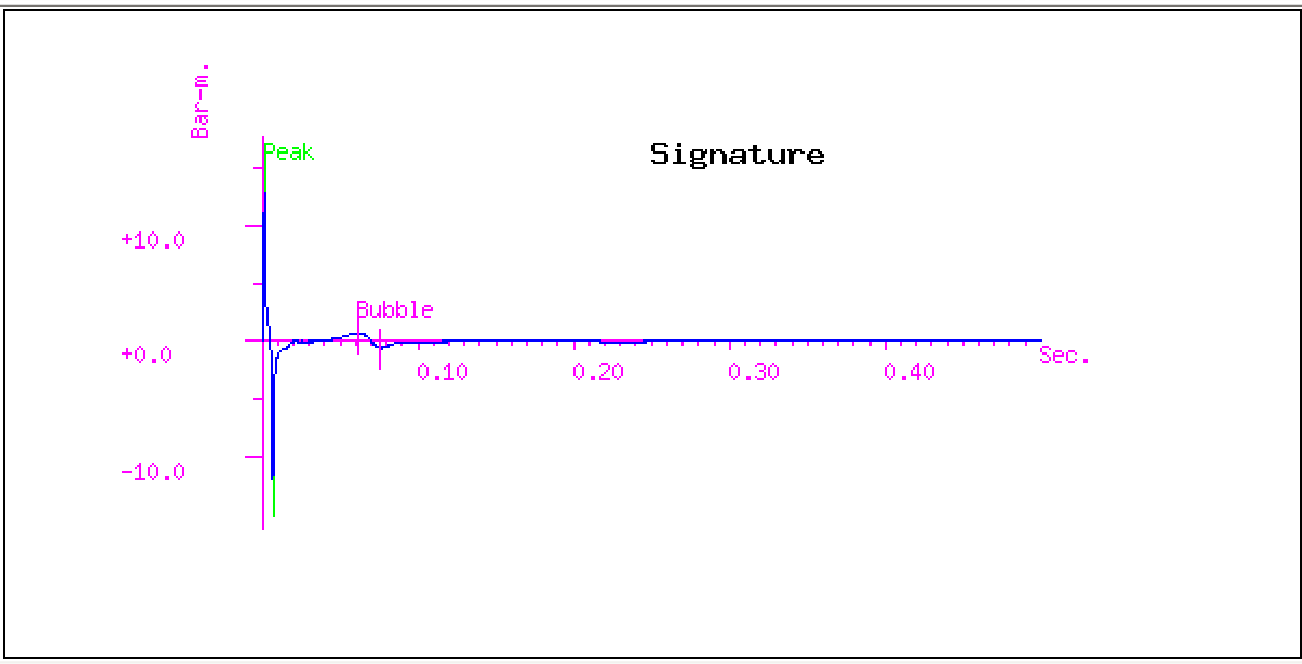
Output signature parameters

Signature filtering details	Number of samples in signature	Sample interval (s.)	Hydrophone position
No filtering specified	1000	0.0005	Infinite vertical far-field

Signature and statistics

In this case, the bubble position was determined internally. The start of the search window for the bubble was: 0.04 (s.)

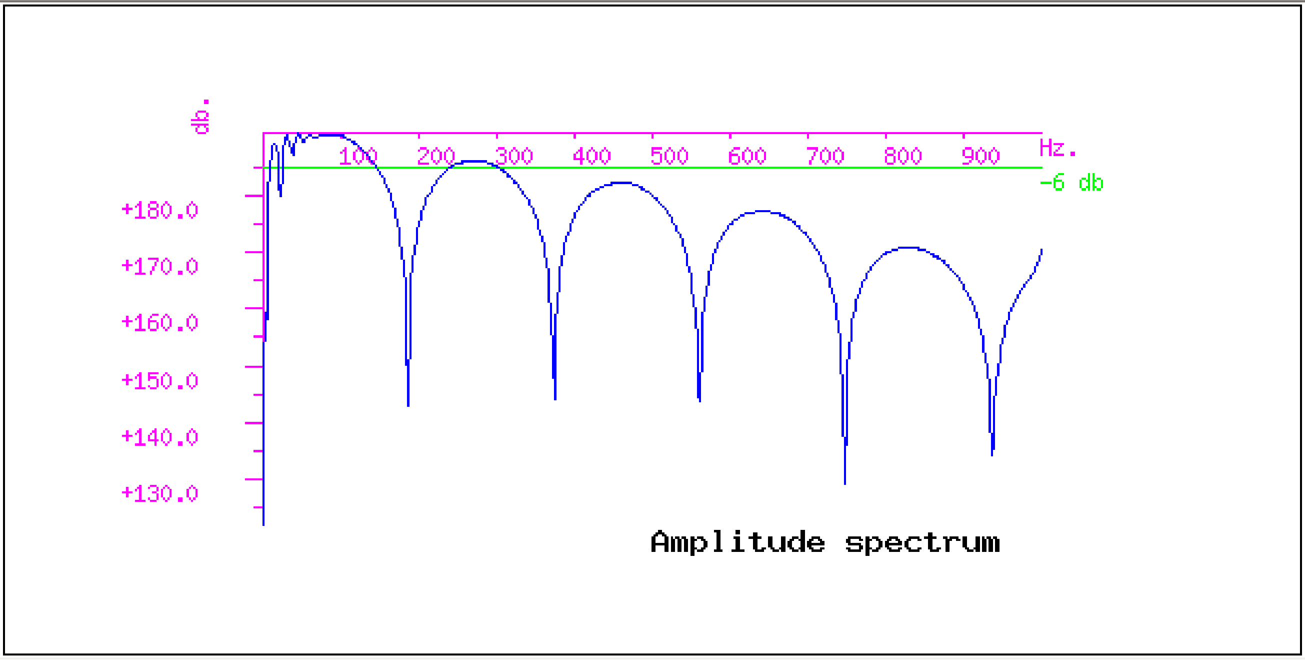
Peak to peak in bar-m.	Zero to peak in bar-m.	Primary to bubble (calculated peak to peak)	Bubble period to first peak (s.)
28.1	14.7	21.5	0.06



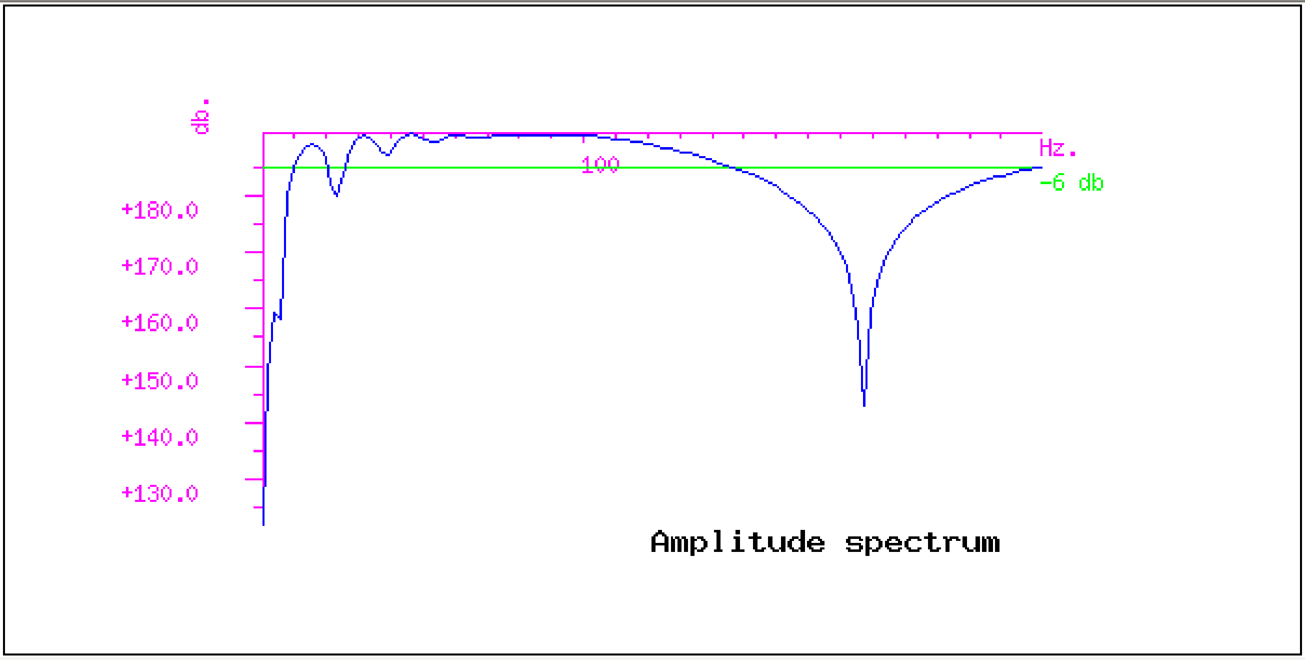
No filtering specified

Filtered amplitude spectrum

Amplitude spectrum. Units are db. relative to 1 microPascal / Hz. at 1m.



Close up of amplitude spectrum



Back to top

Acoustic energy characteristics

The following table lists the individual gun contributions to the acoustic energy field in joules. A negative value means the gun is actually absorbing energy. This is very common in interacting arrays. It does not however mean that the gun is damaging the array performance. Rather it is acting as a catalyst to allow the other guns to perform more efficiently. The total acoustic energy gives the true performance of the array as a whole. See Laws, Parkes and Hatton (1988) Energy-interaction: The long-range interaction of seismic sources, Geophysical Prospecting (36), p333-348 and 38(1) 1990 p.104 for more details. Note that internal energy is not included in the data below. The true acoustic efficiency of airgun arrays is typically < 5% of the total initial energy.

Overall acoustic energy contribution

Total acoustic energy output (j.)	Acoustic energy output due to energy-interaction (j.)	Total potential energy available in array(j.)	Percentage of total potential energy appearing as acoustic energy

7605.7	1910.5	26463.2	28.7%

Individual acoustic energy contributions

Volume (cuin)	x (m.)	y (m.)	z (m.)	Acoustic energy contribution (j.)
15.0	10.00	0.50	4.00	687.1
24.0	10.00	-0.50	4.00	2012.5
15.0	12.50	-0.50	4.00	36.7
24.0	12.50	0.50	4.00	2167.2
15.0	15.00	0.50	4.00	686.5
24.0	15.00	-0.50	4.00	2015.7

Back to top

Amplitude drop-out characteristics

The following table lists those 1 and 2 gun combinations which would cause the drop-out percentage limit for amplitudes to be breached. If the drop-out limit is set to 0.0 or if the far-field signature parameters have not been calculated, this analysis is not done. (Note that this calculation is by its very nature, approximate as it is calculated from the notional sources. In order to do drop-out calculation correctly, each combination of 1, 2 and potentially more guns must be physically dropped out and the array recalculated because the overall interaction balance changes. Gundalf can do this under option for various gun drop-outs but the calculation can be very expensive. The simple amplitude drop-out calculation described in this section is a first approximation.)

The maximum allowable percentage drop in peak to peak amplitude was set to 10.0

Single gun percentage amplitude drop breaches

Drop-out detail	Approximate percent amplitude loss
GUN 1; GI-GUN: Vol 15.00	18.0
GUN 2; GI-GUN: Vol 24.00	15.4
GUN 3; GI-GUN: Vol 15.00	17.9
GUN 4; GI-GUN: Vol 24.00	15.3
GUN 5; GI-GUN: Vol 15.00	18.0
GUN 6; GI-GUN: Vol 24.00	15.4

Double gun percentage amplitude drop breaches

Drop-out detail	Approximate percent amplitude loss

GUN 1; GI-GUN: Vol 15.00 and GUN 2; GI-GUN: Vol 24.00	33.4
GUN 1; GI-GUN: Vol 15.00 and GUN 3; GI-GUN: Vol 15.00	35.9
GUN 1; GI-GUN: Vol 15.00 and GUN 4; GI-GUN: Vol 24.00	33.3
GUN 1; GI-GUN: Vol 15.00 and GUN 5; GI-GUN: Vol 15.00	36.0
GUN 1; GI-GUN: Vol 15.00 and GUN 6; GI-GUN: Vol 24.00	33.4
GUN 2; GI-GUN: Vol 24.00 and GUN 3; GI-GUN: Vol 15.00	33.3
GUN 2; GI-GUN: Vol 24.00 and GUN 4; GI-GUN: Vol 24.00	30.7
GUN 2; GI-GUN: Vol 24.00 and GUN 5; GI-GUN: Vol 15.00	33.4
GUN 2; GI-GUN: Vol 24.00 and GUN 6; GI-GUN: Vol 24.00	30.8
GUN 3; GI-GUN: Vol 15.00 and GUN 4; GI-GUN: Vol 24.00	33.2
GUN 3; GI-GUN: Vol 15.00 and GUN 5; GI-GUN: Vol 15.00	35.9
GUN 3; GI-GUN: Vol 15.00 and GUN 6; GI-GUN: Vol 24.00	33.3
GUN 4; GI-GUN: Vol 24.00 and GUN 5; GI-GUN: Vol 15.00	33.3
GUN 4; GI-GUN: Vol 24.00 and GUN 6; GI-GUN: Vol 24.00	30.7
GUN 5; GI-GUN: Vol 15.00 and GUN 6; GI-GUN: Vol 24.00	33.4

Back to top

Spectral drop-out characteristics

Information only available in Gundalf Optimiser

Back to top

Physical parameters

The following table summarises the physical parameters used in modelling.

Sea temperature (C)	Velocity of sound in water (m./s.)	Expected dominant frequency in signature (Hz)	Observed wave height (m)
10.0	1496.0	20.0	0.0

Note that the gun controller variation was set to 0.0 (s.)

Back to top

Gundalf calibration details

All modelling software requires calibration against convincing experimental data. Gundalf provides accurate modelling of airguns across a wide range of gun types, gun parameters and operating environments, however, we do not expect you to take this simply on trust. It is therefore our policy to keep users of Gundalf aware of its latest calibration status and up to date information is available under Help -> Calibration.

The latest information, including technical references can be found here.

For sales enquiries please contact: Gundalf sales.

Back to top

Product code : GDF5.1Designer

Licenced to : vsalleras@cmima.csic.es

Organisation : UTM

Maximum users : 1

GUNDALF array modelling suite - Array report

Gundalf revision AIR5.1i, Date 2007-01-05

Mon Mar 05 10:07:48 Hora estándar romance 2007 (Valenti)

Contents

Signature filtering policy

For marine environmental noise reports, Gundalf performs no signature filtering other than that inherent in modelling at a sample interval small enough to simulate an airgun array signature at frequencies up to 100kHz.

For all other kinds of reports, Gundalf performs filtering in this order:-

- If a pre-conditioning filter is chosen, for example, an instrument response, it is applied at the modelling sample interval.
- If the output sample interval is larger than the modelling sample interval, Gundalf applies appropriate anti-alias filtering. (This can be turned off in the event that anti-alias filtering is included in the pre-conditioning filter, in which case Gundalf will issue a warning.)
- Finally, Gundalf applies the chosen set of post-filters, Q, Wiener and band-pass filtering as specified, at the output sample interval.

In reports, when filters are applied, they are applied to the notional sources first so that signatures, directivity plots and spectra are all filtered consistently.

Finally note that modelled signatures always begin at time zero for reasons of causality.

Anti-alias and pre-condition filtering

In this case, no pre-conditioning filter has been applied.

In this case, no anti-alias filtering was necessary.

Post filtering

Details of the post-filtering used in this report follow. Post filters are applied at the output sample interval after any pre-conditioning and anti-alias filters have been applied.

Q filtering

No Q filtering performed.

Wiener filtering

No Wiener filtering performed.

Band-pass filtering

No band-pass filtering performed.

Some notes on the modelling algorithm

The Gundalf airgun modelling engine is the end-product of 15 years of state of the art research. It takes full account of all air-gun interactions including interactions between sub-arrays. No assumptions of linear superposition are made. This means that if you move sub-arrays closer together, the far-field signature will change. The effect is noticeable even when sub-arrays are separated by as much as 10m.

The engine is capable of modelling airgun clusters right down to the 'super-foam' region where the bubbles themselves collide and distort. It has been calibrated against both single and clustered guns for a number of different gun types under laboratory conditions and accurately predicts peak to peak and primary to bubble parameters across a very wide range of operating conditions.

In many cases, the predicted signatures are good enough to be used directly in signature deconvolution procedures.

Array summary

The following table lists the statistics for the array quoted in various commonly used units for convenience. Note that the rms value is computed over the entire modelled signature.

Array parameter	Array value
Number of guns	6
Total volume (cu.in).	2320.0 (38 litres)
Peak to peak in bar-m.	48.4 (4.84 MPa, 254 db re 1 microPascal. at 1m.)
Zero to peak in bar-m.	25.2 (2.52 MPa, 248 db re 1 microPascal. at 1m.)
RMS pressure in bar-m.	2.87 (0.287 MPa, 229 db re 1 microPascal. at 1m.)
Primary to bubble (calculated peak to peak)	18.6
Bubble period to first peak (s.)	0.165

Maximum spectral ripple (db): 10.0 - 50.0 Hz.	4.4
Maximum spectral value (db): 10.0 - 50.0 Hz.	206
Average spectral value (db): 10.0 - 50.0 Hz.	205
Total acoustic energy (Joules)	125173.4
Total acoustic efficiency (%)	23.9

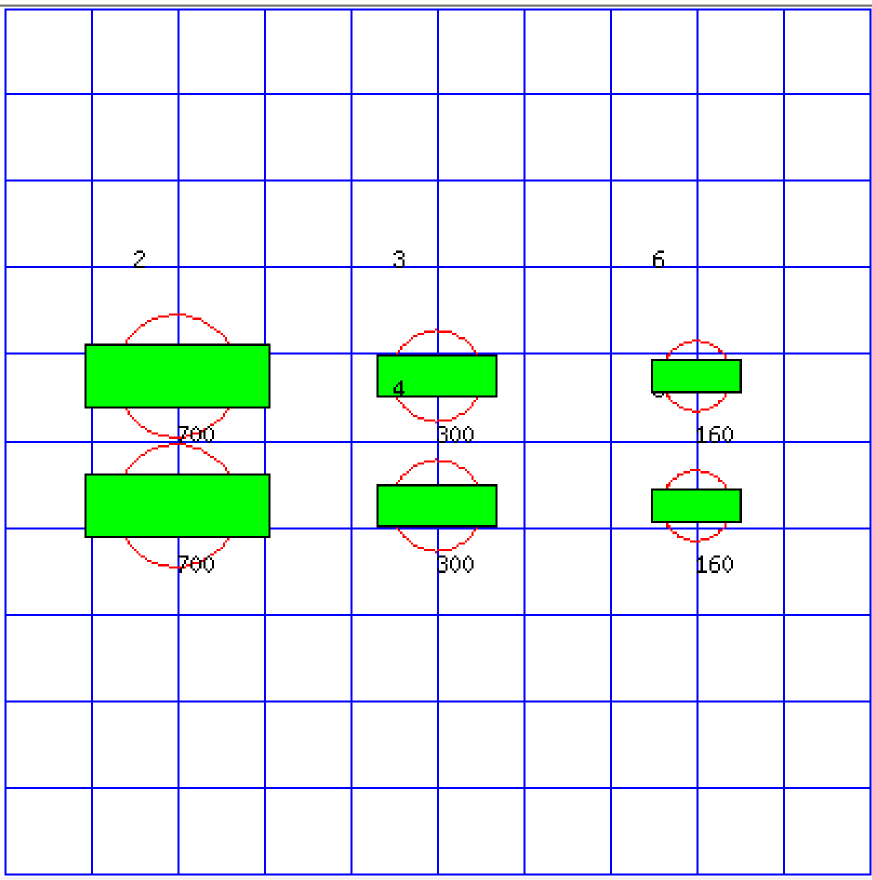
Array geometry and gun contribution

The following table lists all the guns modelled in the array along with their characteristics. The last column is completed only if the array has actually been modelled during the interactive session and contains the contribution of that gun as a percentage of the peak to peak amplitude of the whole array. Please note that the relationship with volume is only as the cube root of the volume for the same gun type so that even small guns contribute significantly. This is particularly relevant to drop-out analysis.

Gun	Pressure (psi)	Volume (cuin)	Type	x (m.)	y (m.)	z (m.)	delay (s.)	sub-array	p-p contrib (pct.)
1	2000.0	700.0	1500LL	10.000	0.750	9.000	0.000	1	20.2
2	2000.0	700.0	1500LL	10.000	-0.750	9.000	0.000	1	20.2
3	2000.0	300.0	1500LL	13.000	-0.750	9.000	0.000	1	15.6
4	2000.0	300.0	1500LL	13.000	0.750	9.000	0.000	1	15.6
5	2000.0	160.0	1500LL	16.000	0.750	9.000	0.000	1	14.2
6	2000.0	160.0	1500LL	16.000	-0.750	9.000	0.000	1	14.2

Hydrophone position: Infinite vertical far-field

<----- Direction of travel ----- --, (1m. grid, plan view)



The red circles denote the maximum radius reached by the bubble. Please note that pressure-field interactions take place over a much larger distance than this, (typically 10 times larger). However when bubbles touch or overlap, super-foam interaction can be expected. In this zone, significant peak AND bubble suppression will normally be observed.

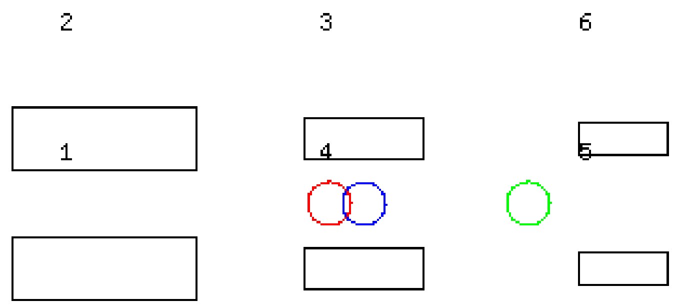
Note also that a green rectangle represents a single gun and an orange rectangle indicates that the gun is currently dropped out. Where present, a yellow rectangle represents a vertical cluster (V.C.) of guns. Please see the geometry table above for more details. The small number to the above left of each gun is its reference number in this table. For clusters of guns, these reference numbers mirror the symmetry of the cluster.

Back to top

Array centres

The following diagram shows the array geometric centre, the centre of pressure and the centre of energy. The centre of pressure is defined to be the array centre when each gun position is weighted by its contribution to the overall peak to peak pressure value. The centre of energy is computed by weighting the coordinates by the self-energy of the gun at that position. In an interacting array this may be a long way from the centre of pressure as some guns may absorb energy giving a negative self-energy. Depending on how first breaks are calculated, these can be used for first break analysis.

Array centres



Note that the geometric centre is shown as a blue circle, the centre of pressure is shown as a red circle and the centre of energy is shown as a green circle.

The geometric centre is at (13, 0, 9)

The centre of pressure is at (12.6,-0.000434, 9)

The centre of energy is at (14.9,-0.000433, 9)

[Back to top](#)

Array directivity

The following tables show the inline and crossline directivity of the array in both (angle-frequency) and (angle-amplitude) form and optionally, the azimuthal directivity (theta-phi) form.

Note that the effects of cable ghosting if present are not shown in Gundalf directivity displays although source ghosting is included. This matches common practice in such displays.

For inline directivity displays, the x-axis is the inline angle from the vertical with the word fore indicating the end nearest the boat. For crossline directivity displays, the x-axis is the crossline angle from the vertical with the word port indicating the port side.

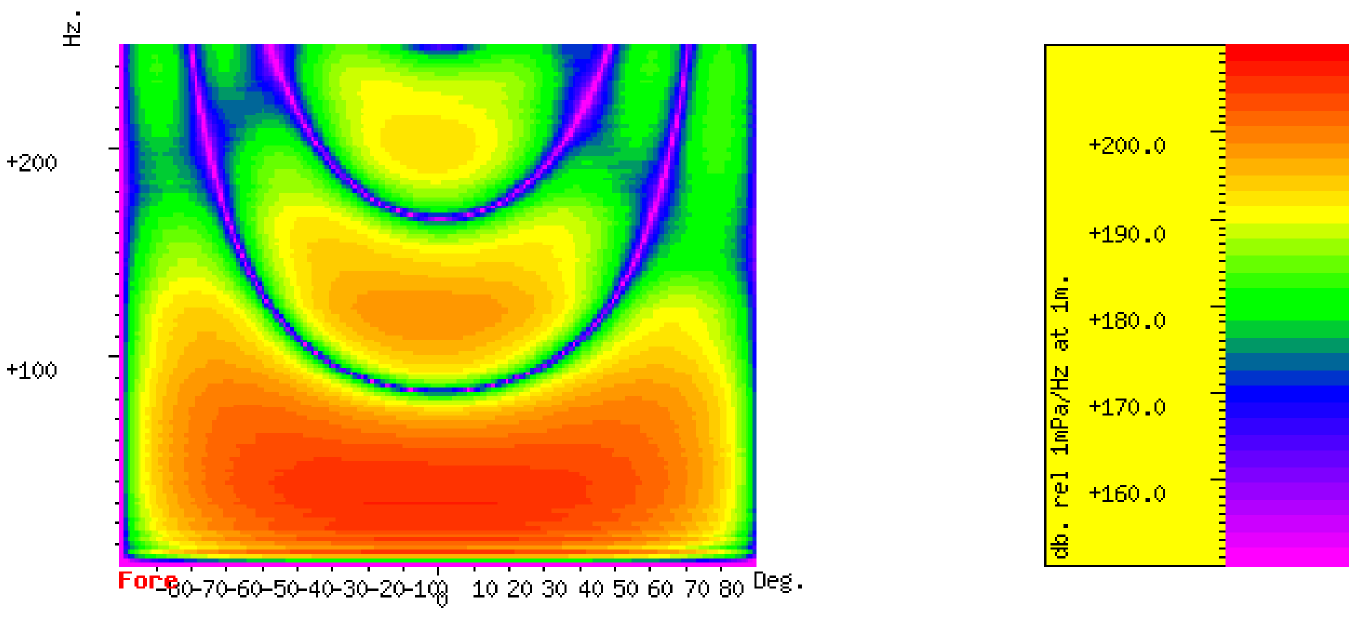
Note that *inline* is used nominally to mean any angle within +/- 45 degrees of the boat direction (which corresponds to a bearing of zero degrees). Similarly, *crossline* is used nominally to mean any angle within +/- 45 degrees of the perpendicular to the boat direction which is measured as a bearing of 90 degrees, (i.e. starboard). The nominal inline and crossline angles can be set by the user in the report options. The values used are indicated in the diagram titles below as bearings.

Where shown, the azimuthal plots show contours at four chosen frequencies as a function of phi (angle from the x-axis, opposite to the boat direction) and theta (the angle from the vertical). A bearing of zero degrees corresponds to a value of phi of 180 degrees.

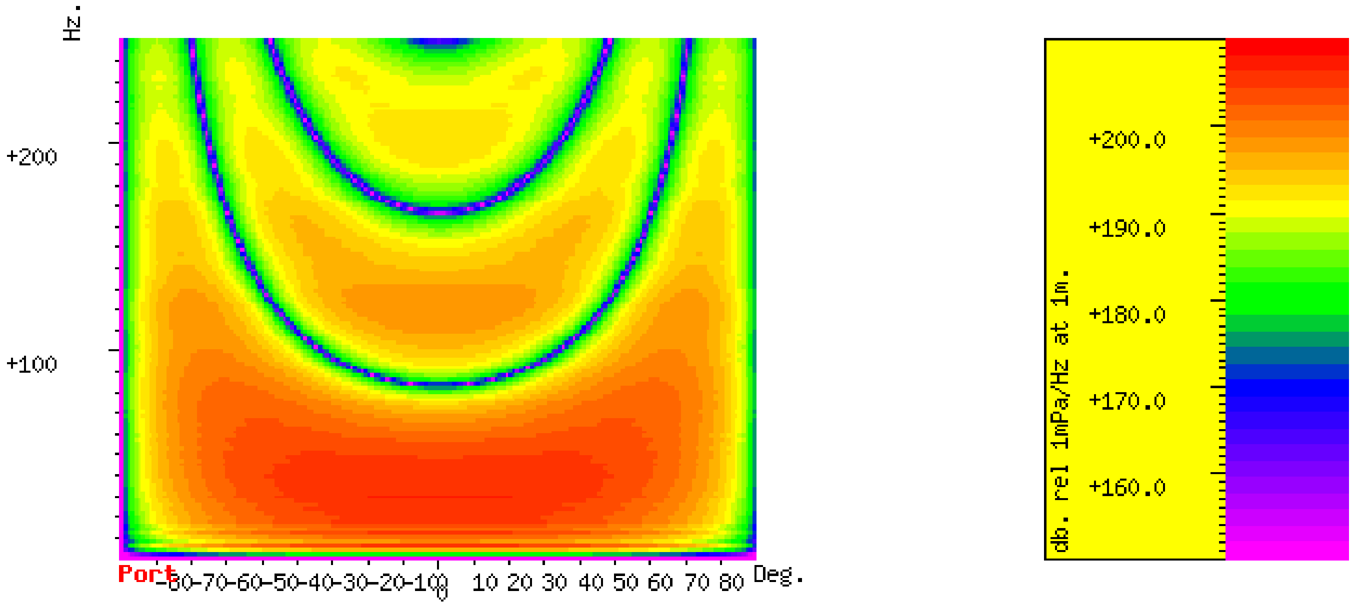
Angle-frequency form

The following tables show the inline and crossline directivity of the array in (dip angle-frequency) form. Both plots are scaled as db. relative to 1 microPa. per Hz. at 1m.

Inline directivity, bearing = 0 degrees



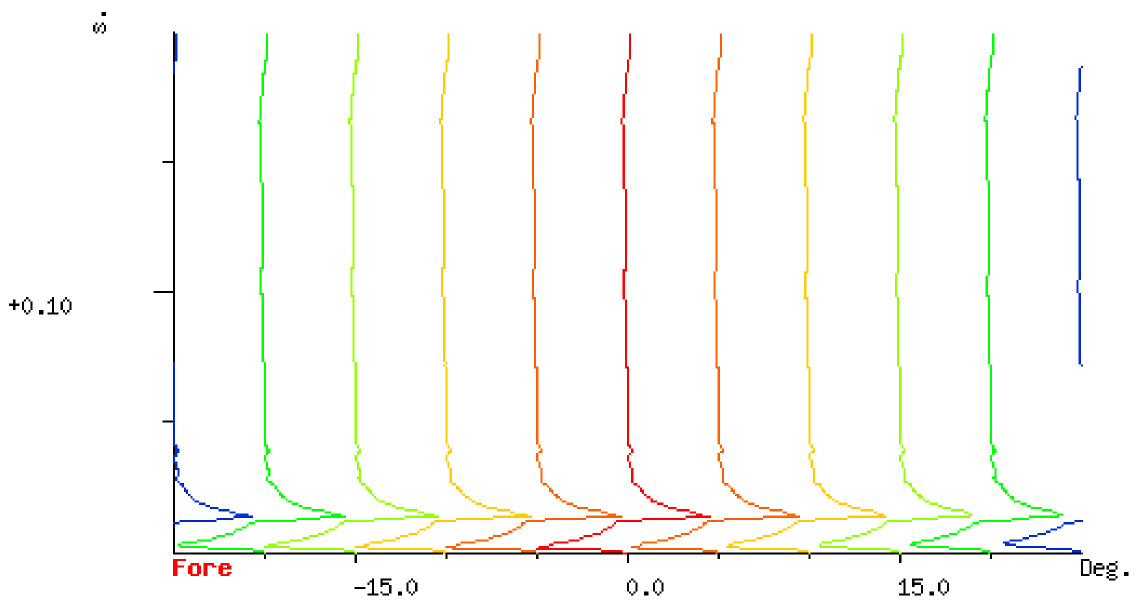
Crossline directivity, bearing = 90 degrees



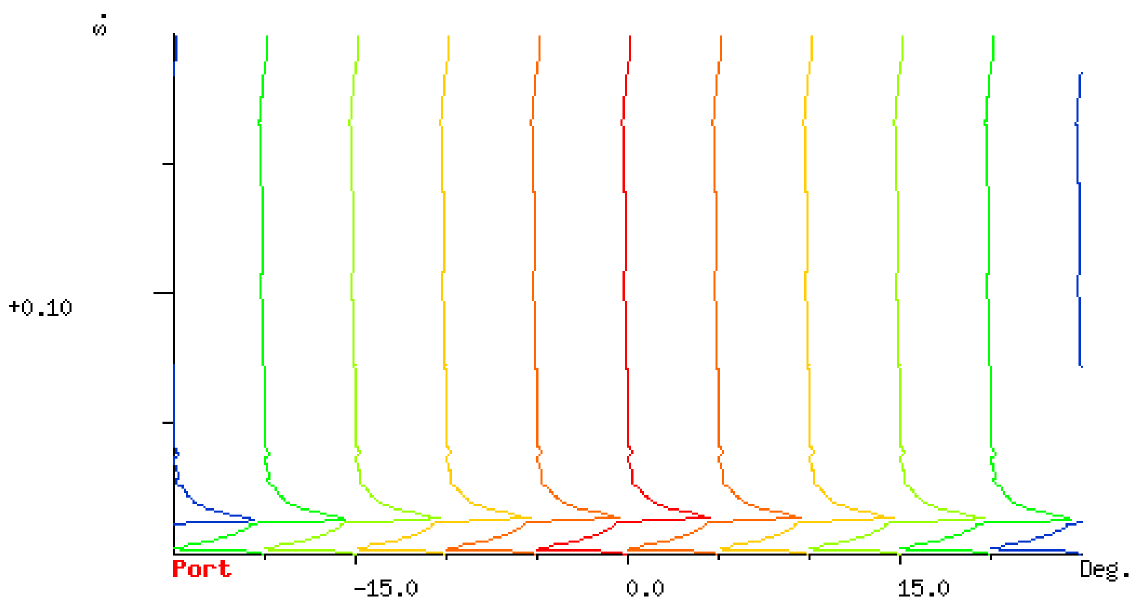
Angle-amplitude form

The following tables show the inline and crossline directivity of the array in (dip angle, amplitude) form. The computed signature (or under option the amplitude spectrum) for each angle is shown in colour varying form with red signatures shown in the centre, shading to blue at the furthest angles computed. The vertical scale indicates the type of plot, time or frequency. Both types of plot are individually scaled and plotted with the same units as the corresponding plots in the Signature Characteristics section.

Inline directivity, bearing = 0 degrees



Crossline directivity, bearing = 90 degrees



Back to top

Signature characteristics

The following tables show the signature parameters, the signature and the amplitude spectrum of the modelled signature.

The amplitude spectrum is shown in units of db. relative to 1 microPa. per Hz. at 1m.

The position of the bubble by default is determined internally but can be overridden by interacting with the modelled signature using the right hand mouse button to determine the start of the bubble.

Signature ghost information

The source ghost has been included. The source ghost was input directly with the value -1.0.

The cable ghost has been switched off.

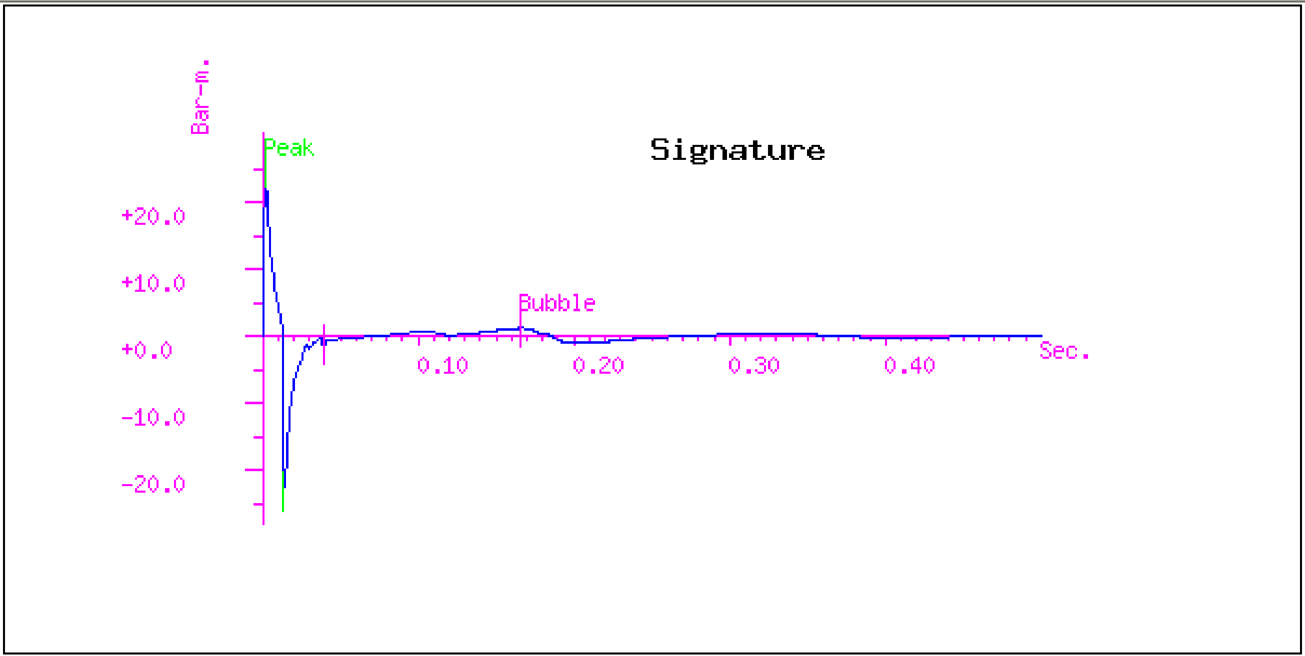
Output signature parameters

Signature filtering details	Number of samples in signature	Sample interval (s.)	Hydrophone position
No filtering specified	1000	0.0005	Infinite vertical far-field

Signature and statistics

In this case, the bubble position was determined internally. The start of the search window for the bubble was: 0.04 (s.)

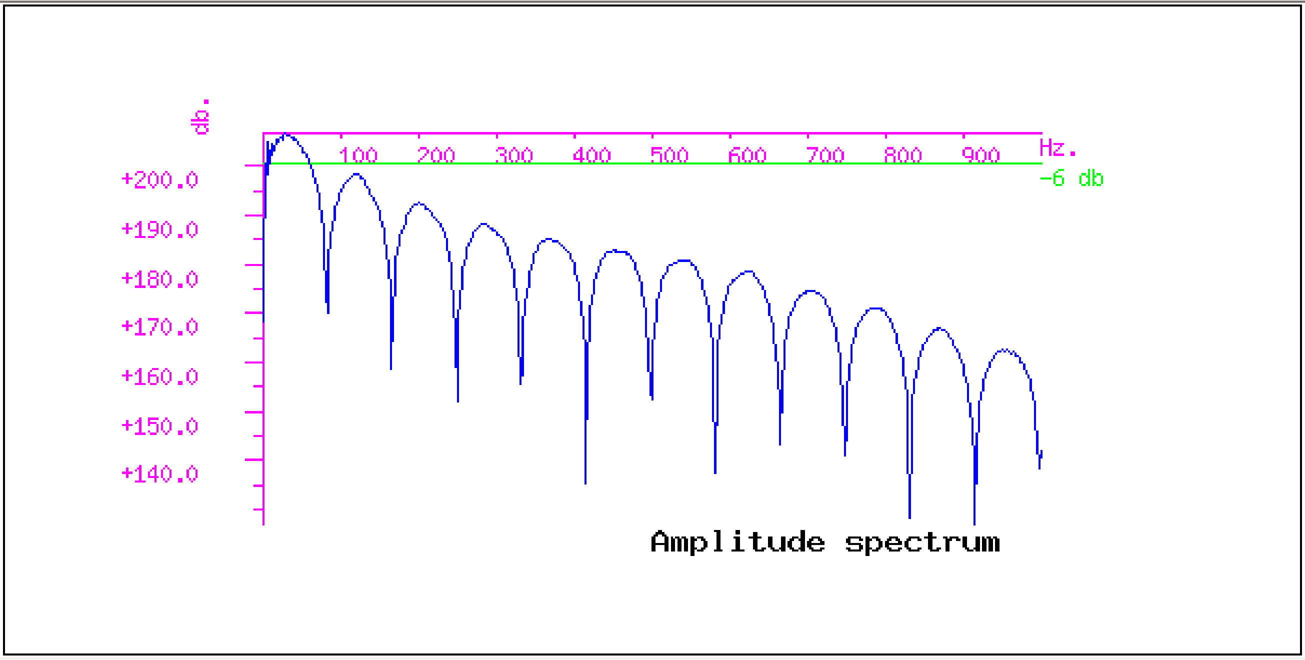
Peak to peak in bar-m.	Zero to peak in bar-m.	Primary to bubble (calculated peak to peak)	Bubble period to first peak (s.)
48.4	25.2	18.6	0.1645



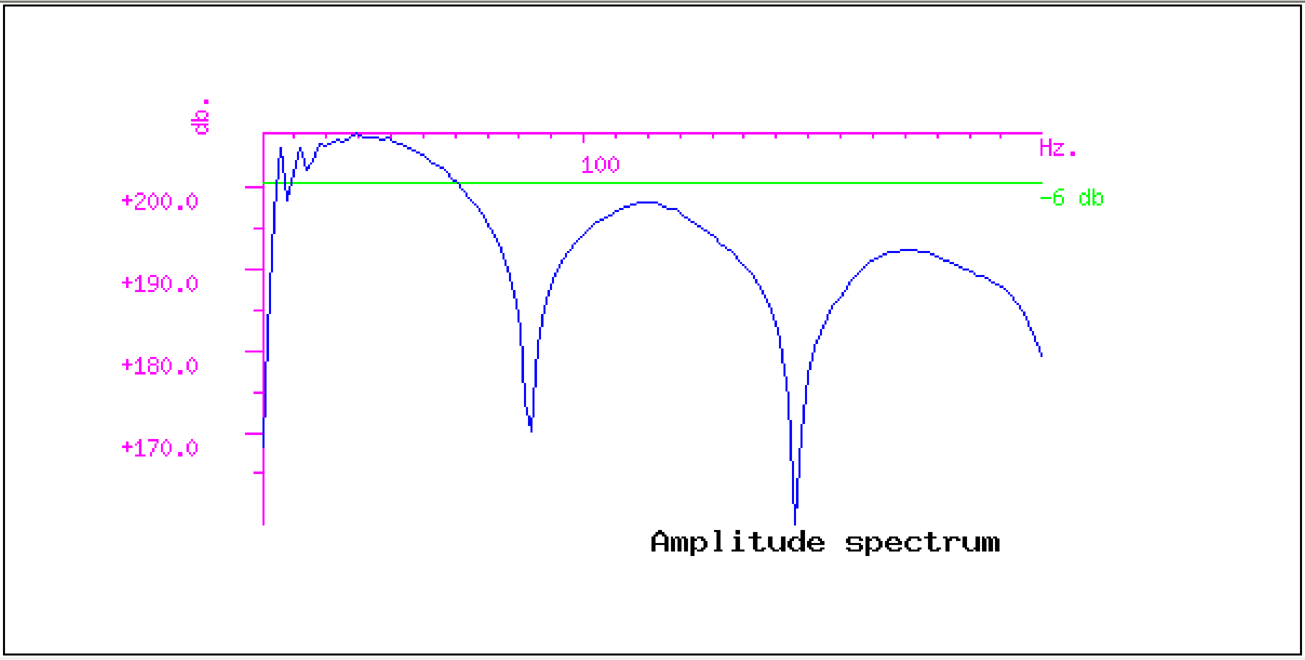
No filtering specified

Filtered amplitude spectrum

Amplitude spectrum. Units are db. relative to 1 microPascal / Hz. at 1m.



Close up of amplitude spectrum



Back to top

Acoustic energy characteristics

The following table lists the individual gun contributions to the acoustic energy field in joules. A negative value means the gun is actually absorbing energy. This is very common in interacting arrays. It does not however mean that the gun is damaging the array performance. Rather it is acting as a catalyst to allow the other guns to perform more efficiently. The total acoustic energy gives the true performance of the array as a whole. See Laws, Parkes and Hatton (1988) Energy-interaction: The long-range interaction of seismic sources, Geophysical Prospecting (36), p333-348 and 38(1) 1990 p.104 for more details. Note that internal energy is not included in the data below. The true acoustic efficiency of airgun arrays is typically < 5% of the total initial energy.

Overall acoustic energy contribution

Total acoustic energy output (j.)	Acoustic energy output due to energy-interaction (j.)	Total potential energy available in array(j.)	Percentage of total potential energy appearing as acoustic energy

125173.4	20145.3	524739.5	23.9%

Individual acoustic energy contributions

Volume (cuin)	x (m.)	y (m.)	z (m.)	Acoustic energy contribution (j.)
700.0	10.00	0.75	9.00	-7428.7
700.0	10.00	-0.75	9.00	-7331.7
300.0	13.00	-0.75	9.00	37305.0
300.0	13.00	0.75	9.00	37373.5
160.0	16.00	0.75	9.00	32605.7
160.0	16.00	-0.75	9.00	32649.5
The red entries denote guns which are catalysing the array by absorbing energy.				

Back to top

Amplitude drop-out characteristics

The following table lists those 1 and 2 gun combinations which would cause the drop-out percentage limit for amplitudes to be breached. If the drop-out limit is set to 0.0 or if the far-field signature parameters have not been calculated, this analysis is not done. (Note that this calculation is by its very nature, approximate as it is calculated from the notional sources. In order to do drop-out calculation correctly, each combination of 1, 2 and potentially more guns must be physically dropped out and the array recalculated because the overall interaction balance changes. Gundalf can do this under option for various gun drop-outs but the calculation can be very expensive. The simple amplitude drop-out calculation described in this section is a first approximation.)

The maximum allowable percentage drop in peak to peak amplitude was set to 10.0

Single gun percentage amplitude drop breaches

Drop-out detail	Approximate percent amplitude loss
GUN 1; 1500LL: Vol 700.00	20.2
GUN 2; 1500LL: Vol 700.00	20.2
GUN 3; 1500LL: Vol 300.00	15.6
GUN 4; 1500LL: Vol 300.00	15.6
GUN 5; 1500LL: Vol 160.00	14.2
GUN 6; 1500LL: Vol 160.00	14.2

Double gun percentage amplitude drop breaches

Drop-out detail	Approximate percent amplitude loss
GUN 1; 1500LL: Vol 700.00 and GUN 2; 1500LL: Vol 700.00	40.4
GUN 1; 1500LL: Vol 700.00 and GUN 3; 1500LL: Vol 300.00	35.8
GUN 1; 1500LL: Vol 700.00 and GUN 4; 1500LL: Vol 300.00	35.8
GUN 1; 1500LL: Vol 700.00 and GUN 5; 1500LL: Vol 160.00	34.3
GUN 1; 1500LL: Vol 700.00 and GUN 6; 1500LL: Vol 160.00	34.4
GUN 2; 1500LL: Vol 700.00 and GUN 3; 1500LL: Vol 300.00	35.8
GUN 2; 1500LL: Vol 700.00 and GUN 4; 1500LL: Vol 300.00	35.8
GUN 2; 1500LL: Vol 700.00 and GUN 5; 1500LL: Vol 160.00	34.4
GUN 2; 1500LL: Vol 700.00 and GUN 6; 1500LL: Vol 160.00	34.4
GUN 3; 1500LL: Vol 300.00 and GUN 4; 1500LL: Vol 300.00	31.2
GUN 3; 1500LL: Vol 300.00 and GUN 5; 1500LL: Vol 160.00	29.8
GUN 3; 1500LL: Vol 300.00 and GUN 6; 1500LL: Vol 160.00	29.8
GUN 4; 1500LL: Vol 300.00 and GUN 5; 1500LL: Vol 160.00	29.8
GUN 4; 1500LL: Vol 300.00 and GUN 6; 1500LL: Vol 160.00	29.9
GUN 5; 1500LL: Vol 160.00 and GUN 6; 1500LL: Vol 160.00	28.4

Back to top

Spectral drop-out characteristics

Information only available in Gundalf Optimiser

Back to top

Physical parameters

The following table summarises the physical parameters used in modelling.

Sea temperature (C)	Velocity of sound in water (m./s.)	Expected dominant frequency in signature (Hz)	Observed wave height (m)
10.0	1496.0	20.0	0.0

Note that the gun controller variation was set to 0.0 (s.)

Back to top

Gundalf calibration details

All modelling software requires calibration against convincing experimental data. Gundalf provides accurate modelling of airguns across a wide range of gun types, gun parameters and operating environments, however, we do not expect you to take this simply on trust. It is therefore our policy to keep users of Gundalf aware of its latest calibration status and up to date information is available under Help -> Calibration.

The latest information, including technical references can be found here.

For sales enquiries please contact: Gundalf sales.

Back to top

Product code : GDF5.1Designer

Licenced to : vsalleras@cmima.csic.es

Organisation : UTM

Maximum users : 1

CRUISE SUMMARY REPORT

FOR COLLATIMG CENTRE USE

Centre: BODC **Ref. No.:**

Is data exchange restricted ☐ Yes ☐ In part ☐ No

SHIP enter the full name and international radio call sign of the ship from which the data were collected, and indicate the type of ship, for example, research ship; ship of opportunity, naval survey vessel; etc.

Name: R.R.S. Discovery **Call Sign: GLNE**

Type of ship: Research Ship

CRUISE NO. / NAME Discovery 318a

enter the unique number, name or acronym assigned to the cruise (or cruise leg, if appropriate).

CRUISE PERIOD start 17 / 04 / 2007 to 23 / 04 / 2007 end
(set sail) day/ month/ year day/ month/ year (return to port)

PORT OF DEPARTURE (enter name and country) **Lisbon, Portugal**

PORT OF RETURN (enter name and country) **Lisbon, Portugal**

RESPONSIBLE LABORATORY enter name and address of the laboratory responsible for coordinating the scientific planning of the cruise

Name: University of Durham, Department of Earth Sciences

Address: South Road, Durham DH1 3LE

Country: UK

CHIEF SCIENTIST(S) enter name and laboratory of the person(s) in charge of the scientific work (chief of mission) during the cruise.

Dr. Richard Hobbs, University of Durham Department of Earth Sciences

OBJECTIVES AND BRIEF NARRATIVE OF CRUISE enter sufficient information about the purpose and nature of the cruise so as to provide the context in which the report data were collected.

Overall objectives in the EU GO project are to assess the promising potential of seismic imaging for physical oceanography, in view of its combination of fine resolution and coverage unmatched by conventional oceanographic measurements. D318 was to provide the means of assessment by obtaining a unique comprehensive oceanographic and seismic dataset at the same time and place.

Specific objectives for *R.R.S. Discovery* cruise 318a were to (i) deploy four ADCP moorings, three adjacent temperature-logger moorings and STABLE, in an L-shape array in 750-1000m depth east of Portimao Canyon, carrying out adjacent CTD stations, (ii) deploy two OBH moorings (iii) carry out seismic sections using the Ifremer high-frequency air-guns and streamer, accompanied by regular XBT and less frequent XCTD casts. In addition underway data was logged including ship-borne ADCP, surface temperature and salinity, metrology, gravity and magnetics (to test new NERC magnetometers).

PROJECT (IF APPLICABLE) if the cruise is designated as part of a larger scale cooperative project (or expedition), then enter the name of the project, and of organisation responsible for co-ordinating the project.

Project name: Geophysical Oceanography (GO).

Coordinating body: University of Durham, Department of Earth Sciences

PRINCIPAL INVESTIGATORS: Enter the name and address of the Principal Investigators responsible for the data collected on the cruise and who may be contacted for further information about the data. (The letter assigned below against each Principal Investigator is used on pages 2 and 3, under the column heading 'PI', to identify the data sets for which he/she is responsible)

A. Dr. Richard Hobbs, University of Durham, Department of Earth Sciences, Durham DH1 3LE

B. Dr. John M. Huthnance, Proudman Oceanographic Laboratory, 6 Brownlow Street, Liverpool L3 5DA.

C. Dr. Louis Geli, IFREMER, 29280 Plouzané, France

D.

E.

F.

G.

MOORINGS, BOTTOM MOUNTED GEAR AND DRIFTING SYSTEMS

This section should be used for reporting moorings, bottom mounted gear and drifting systems (both surface and deep) deployed and/or recovered during the cruise. Separate entries should be made for each location (only deployment positions need be given for drifting systems). This section may also be used to report data collected at fixed locations which are returned to routinely in order to construct 'long time series'.

PI	APPROXIMATE POSITION						DATA TYPE	DESCRIPTION
	LATITUDE			LONGITUDE			enter code(s) from list on last page.	Identify, as appropriate, the nature of the instrumentation the parameters (to be) measured, the number of instruments and their depths, whether deployed and/or recovered, dates of deployments and/or recovery, and any identifiers given to the site.
See top of page.	deg	min	N/S	deg	min	E/W		
B	36°	40.18'	N	8°	13.22'	W	D71	A1 = 600kHz bottom-frame ADCP, 742 m depth; deployed (released from surface) 18 April, 0608, recovered on board 9 May, 1841
B	36°	40.07'	N	8°	12.92'	W	H72	A1t = 18 mini-loggers (temperature) @ 8×4 & 9×2m intervals on line, 747 m depth; deployed (released from surface) 18 April, 0705, recovered on board 9 May 1748.
B	36°	38.49'	N	8°	14.14'	W	D01, D90	A2 = STABLE, 792 m depth; pair EMCMs and temperature at 0.3 and at 0.6 m ab, rotors at 0.33, 0.51, 0.69, 0.87 m ab and vane above; deployed (released from surface) 18 April, 0329, recovered on board 10 May, 1120.
B	36°	37.03'	N	8°	14.95'	W	H72	A3t = 18 mini-loggers (temperature) @ 8×4 & 9×2m intervals on line, 854 m depth; deployed (released from surface) 18 April, 1201, recovered on board 10 May, 0712.
B	36°	36.81'	N	8°	15.00'	W	D71	A3 = 150kHz bottom-frame ADCP and temperature, 866 m depth; deployed (released from surface) 18 April, 1014, recovered on board 10 May, 0750.
B	36°	35.35'	N	8°	15.69'	W	H72	A4t = 18 mini-loggers (temperature) @ 8×4 & 9×2m intervals on line, 978 m depth; deployed (released from surface) 18 April, 1722, recovered on board 10 May, 0852.
B	36°	35.15'	N	8°	15.82'	W	D71	A4 = 150kHz bottom-frame ADCP and temperature, 980 m depth; deployed (released from surface) 18 April, 1605, recovered on board 10 May, 1003.
B	36°	33.86'	N	8°	11.71'	W	D71	A5 = 75kHz moored ADCP, 1015 m depth; deployed (released from surface) 18 April, 1845, recovered on board 9 May, 1628.
A	36°	28.78'	N	8°	36.06'	W	G90	OBH1 ocean bottom hydrophone, in 2466 depth, deployed (released from surface) 18 April, 2223, recovered by MV Poseidon.
A	36°	27.85'	N	8°	38.25'	W	G90	OBH2 ocean bottom hydrophone, in 2069 depth, deployed (released from surface) 19 April, 0039, recovered MV Poseidon

SUMMARY OF MEASUREMENTS AND SAMPLES TAKEN

Except for the data already described on page 2 under 'Moorings, Bottom Mounted Gear and Drifting Systems', this section should include a summary of all data collected on the cruise, whether they be measurements (e.g. temperature, salinity values) or samples (e.g. cores, net hauls).

Separate entries should be made for each distinct and coherent set of measurements or samples. Different modes of data collection (e.g. vertical profiles as opposed to underway measurements) should be clearly distinguished, as should measurements/sampling techniques that imply distinctly different accuracy's or spatial/temporal resolutions. Thus, for example, separate entries would be created for i) BT drops, ii) water bottle stations, iii) CTD casts, iv) towed CTD, v) towed undulating CTD profiler, vi) surface water intake measurements, etc.

Each data set entry should start on a new line – it's description may extend over several lines if necessary.

NO, UNITS : for each data set, enter the estimated amount of data collected expressed in terms of the number of 'stations'; miles' of track; 'days' of recording; 'cores' taken; net 'hauls'; balloon 'ascents'; or whatever unit is most appropriate to the data. The amount should be entered under 'NO' and the counting unit should be identified in plain text under 'UNITS'.

PI see page 2	NO see above	UNITS see above	DATA TYPE Enter code(s) from list on cover page	DESCRIPTION Identify, as appropriate, the nature of the data and of the instrumentation/sampling gear and list the parameters measured. Include any supplementary information that may be appropriate, e. g. vertical or horizontal profiles, depth horizons, continuous recording or discrete samples, etc. For samples taken for later analysis on shore, an indication should be given of the type of analysis planned, i.e. the purpose for which the samples were taken.
B	5	casts	H10	Seabird SBE 9*plus*; conductivity (giving salinity), temperature, depth. Six salinity samples taken per cast for calibration analysis by UKORS.
B	5	casts	D71	300kHz ADCP lowered with CTD, giving profiles.
B	6	days	D71	Vessel-mounted 75kHz ADCP.
B	6	days	H71	Ship's continuous surface (at 6 m depth) recording system: temperature, conductivity, salinity, sigma (density)
A	6	days	M06	Ship's continuous meteorological recording system: wind speed (S/P), direction (S/P), air temperature, relative humidity, pressure.
A	6	days	G73	Ship's continuous echo-sounder recording system: depth.
B	178	stations	H11	XBTs (about 154), XCTDs (about 24)
A	6	days	G73	3.5kHz echo-sounder targeted on water interface
C	4	days	G76	high-frequency (50-300 Hz) seismic reflection of water interfaces and sediments
A	4	days	G90	2 OBH to measure source signature
A	6	days	G27	ship borne gravity
A	2	days	G28	towed magnetometer

TRACK CHART: You are strongly encouraged to submit, with the completed report, an annotated track chart illustrating the route followed and the points where measurements were taken.

Insert a tick(✓) in this box if a track chart is supplied ☐

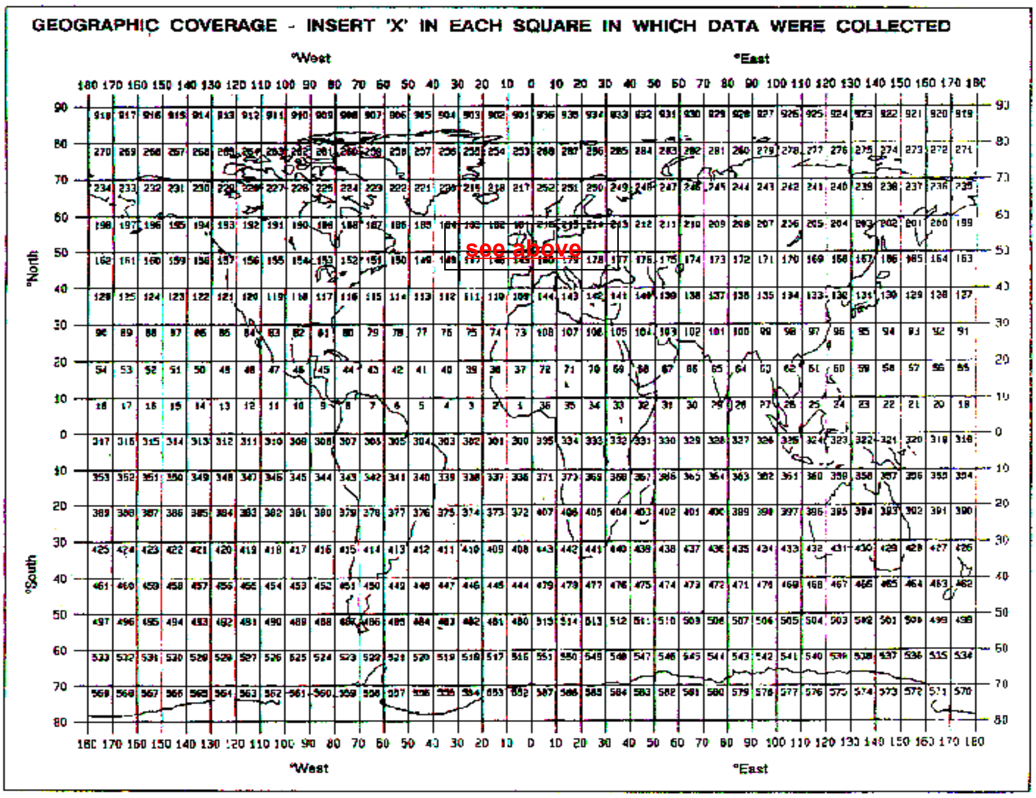
GENERAL OCEAN AREA(S): Enter the names of the oceans and/or seas in which data were collected during the cruise – please use commonly recognised names (see, for example, International Hydrographic Bureau Special Publication No. 23, 'Limits of Oceans and Seas').

NE Atlantic

SPECIFIC AREAS: If the cruise activities were concentrated in a specific area(s) of an ocean or sea, then enter a description of the area(s). Such descriptions may include references to local geographic areas, to sea floor features, or to geographic coordinates.

Please insert here the number of each square in which data were collected from the below given chart

NE Atlantic off southern Portugal: 8° - 10°W, 36° - 39°N. Square 109.



THANK YOU FOR YOUR COOPERATION

Please send your completed report without delay to the collating centre indicated on the cover page

PARAMETER CODES

METEOROLOGY

M01	Upper air observations
M02	Incident radiation
M05	Occasional standard measurements
M06	Routine standard measurements
M71	Atmospheric chemistry
M90	Other meteorological measurements

PHYSICAL OCEANOGRAPHY

H71	Surface measurements underway (T,S)
H13	Bathythermograph
H09	Water bottle stations
H10	CTD stations
H11	Subsurface measurements underway (T,S)
H72	Thermistor chain
H16	Transparency (eg transmissometer)
H17	Optics (eg underwater light levels)
H73	Geochemical tracers (eg freons)
D01	Current meters
D71	Current profiler (eg ADCP)
D03	Currents measured from ship drift
D04	GEK
D05	Surface drifters/drifting buoys
D06	Neutrally buoyant floats
D09	Sea level (incl. Bottom pressure & inverted echosounder)
D72	Instrumented wave measurements
D90	Other physical oceanographic measurements

CHEMICAL OCEANOGRAPHY

H21	Oxygen
H74	Carbon dioxide
H33	Other dissolved gases
H22	Phosphate
H23	Total - P
H24	Nitrate
H25	Nitrite
H75	Total - N
H76	Ammonia
H26	Silicate
H27	Alkalinity
H28	PH
H30	Trace elements
H31	Radioactivity
H32	Isotopes
H90	Other chemical oceanographic measurements

MARINE CONTAMINANTS/POLLUTION

P01	Suspended matter
P02	Trace metals
P03	Petroleum residues
P04	Chlorinated hydrocarbons
P05	Other dissolved substances
P12	Bottom deposits
P13	Contaminants in organisms
P90	Other contaminant measurements

MARINE BIOLOGY/FISHERIES

B01	Primary productivity
B02	Phytoplankton pigments (eg chlorophyll, fluorescence)
B71	Particulate organic matter (inc POC, PON)
B06	Dissolved organic matter (inc DOC)
B72	Biochemical measurements (eg lipids, amino acids)
B73	Sediment traps
B08	Phytoplankton
B09	Zooplankton
B03	Seston
B10	Neuston
B11	Nekton
B13	Eggs & larvae
B07	Pelagic bacteria/micro-organisms
B16	Benthic bacteria/micro-organisms
B17	Phytobenthos
B18	Zoobenthos
B25	Birds
B26	Mammals & reptiles
B14	Pelagic fish
B19	Demersal fish
B20	Molluscs
B21	Crustaceans
B28	Acoustic reflection on marine organisms
B37	Taggings
B64	Gear research
B65	Exploratory fishing
B90	Other biological/fisheries measurements

MARINE GEOLOGY/GEOPHYSICS

G01	Dredge
G02	Grab
G03	Core - rock
G04	Core - soft bottom
G08	Bottom photography
G71	In-situ seafloor measurement/sampling
G72	Geophysical measurements made at depth
G73	Single-beam echosounding
G74	Multi-beam echosounding
G24	Long/short range side scan sonar
G75	Single channel seismic reflection
G76	Multichannel seismic reflection
G26	Seismic refraction
G27	Gravity measurements
G28	Magnetic measurements
G90	Other geological/geophysical measurements

# CRUISE SUMMARY REPORT	*FOR COLLATIMG CENTRE USE* **Centre: BODC Ref. No.:** Is data exchange restricted ☐ Yes ☐ In part ☐ No

SHIP enter the full name and international radio call sign of the ship from which the data were collected, and indicate the type of ship, for example, research ship; ship of opportunity, naval survey vessel; etc.

Name: R.R.S. Discovery **Call Sign: GLNE**

Type of ship: Research Ship

CRUISE NO. / NAME Discovery 318b enter the unique number, name or acronym assigned to the cruise (or cruise leg, if appropriate).

CRUISE PERIOD start 27 / 04 / 2007 to 14 / 05 / 2007 end
(set sail) day/ month/ year day/ month/ year (return to port)

PORT OF DEPARTURE (enter name and country) **Lisbon, Portugal**

PORT OF RETURN (enter name and country) **Lisbon, Portugal**

RESPONSIBLE LABORATORY enter name and address of the laboratory responsible for coordinating the scientific planning of the cruise

Name: University of Durham, Department of Earth Sciences

Address: South Road, Durham DH1 3LE

Country: UK

CHIEF SCIENTIST(S) enter name and laboratory of the person(s) in charge of the scientific work (chief of mission) during the cruise.

Dr. Richard Hobbs, University of Durham Department of Earth Sciences

OBJECTIVES AND BRIEF NARRATIVE OF CRUISE enter sufficient information about the purpose and nature of the cruise so as to provide the context in which the report data were collected.

Overall objectives in the EU GO project are to assess the promising potential of seismic imaging for physical oceanography, in view of its combination of fine resolution and coverage unmatched by conventional oceanographic measurements. D318 was to provide the means of assessment by obtaining a unique comprehensive oceanographic and seismic dataset at the same time and place.

Specific objectives for *R.R.S. Discovery* cruise 318b were to (i) recover four ADCP moorings, three adjacent temperature-logger moorings and STABLE, from 750-1000m depth east of Portimao Canyon, (ii) perform deep water CTD casts (iii) carry out seismic sections using the NMF supplied Bolt airgun and streamer, accompanied by regular XBT and less frequent XCTD casts, iv) work with MV Poseidon to test novel seismic data acquistion strategies. In addition underway data was logged including ship-borne ADCP, surface temperature and salinity, metrology, gravity and magnetics (to test new NERC magnetometers).

PROJECT (IF APPLICABLE) if the cruise is designated as part of a larger scale cooperative project (or expedition), then enter the name of the project, and of organisation responsible for co-ordinating the project.

Project name: Geophysical Oceanography (GO).

Coordinating body: University of Durham, Department of Earth Sciences

PRINCIPAL INVESTIGATORS: Enter the name and address of the Principal Investigators responsible for the data collected on the cruise and who may be contacted for further information about the data. (The letter assigned below against each Principal Investigator is used on pages 2 and 3, under the column heading 'PI', to identify the data sets for which he/she is responsible)

A. Dr. Richard Hobbs, University of Durham, Department of Earth Sciences, Durham DH1 3LE

B. Dr. John M. Huthnance, Proudman Oceanographic Laboratory, 6 Brownlow Street, Liverpool L3 5DA.

C.

D.

E.

F.

G.

MOORINGS, BOTTOM MOUNTED GEAR AND DRIFTING SYSTEMS

This section should be used for reporting moorings, bottom mounted gear and drifting systems (both surface and deep) deployed and/or recovered during the cruise. Separate entries should be made for each location (only deployment positions need be given for drifting systems). This section may also be used to report data collected at fixed locations which are returned to routinely in order to construct 'long time series'.

PI	APPROXIMATE POSITION						DATA TYPE	DESCRIPTION
	LATITUDE			LONGITUDE			enter code(s) from list on last page.	Identify, as appropriate, the nature of the instrumentation the parameters (to be) measured, the number of instruments and their depths, whether deployed and/or recovered, dates of deployments and/or recovery, and any identifiers given to the site.
See top of page.	deg	min	N/S	deg	min	E/W		
B	36°	40.18'	N	8°	13.22'	W	D71	A1 = 600kHz bottom-frame ADCP, 742 m depth; deployed (released from surface) 18 April, 0608, recovered on board 9 May, 1841
B	36°	40.07'	N	8°	12.92'	W	H72, D90	A1t = 18 mini-loggers (temperature) @ 8×4 & 9×2m intervals on line, 747 m depth; deployed (released from surface) 18 April, 0705, recovered on board 9 May 1748.
B	36°	38.49'	N	8°	14.14'	W	D01	A2 = STABLE, 792 m depth; pair EMCMs and temperature at 0.3 and at 0.6 m ab, rotors at 0.33, 0.51, 0.69, 0.87 m ab and vane above; deployed (released from surface) 18 April, 0329, recovered on board 10 May, 1120.
B	36°	37.03'	N	8°	14.95'	W	H72, D90	A3t = 18 mini-loggers (temperature) @ 8×4 & 9×2m intervals on line, 854 m depth; deployed (released from surface) 18 April, 1201, recovered on board 10 May, 0712.
B	36°	36.81'	N	8°	15.00'	W	D71	A3 = 150kHz bottom-frame ADCP and temperature, 866 m depth; deployed (released from surface) 18 April, 1014, recovered on board 10 May, 0750.
B	36°	35.35'	N	8°	15.69'	W	H72	A4t = 18 mini-loggers (temperature) @ 8×4 & 9×2m intervals on line, 978 m depth; deployed (released from surface) 18 April, 1722, recovered on board 10 May, 0852.
B	36°	35.15'	N	8°	15.82'	W	D71	A4 = 150kHz bottom-frame ADCP and temperature, 980 m depth; deployed (released from surface) 18 April, 1605, recovered on board 10 May, 1003.
B	36°	33.86'	N	8°	11.71'	W	D71	A5 = 75kHz moored ADCP, 1015 m depth; deployed (released from surface) 18 April, 1845, recovered on board 9 May, 1628.

SUMMARY OF MEASUREMENTS AND SAMPLES TAKEN

Except for the data already described on page 2 under 'Moorings, Bottom Mounted Gear and Drifting Systems', this section should include a summary of all data collected on the cruise, whether they be measurements (e.g. temperature, salinity values) or samples (e.g. cores, net hauls).

Separate entries should be made for each distinct and coherent set of measurements or samples. Different modes of data collection (e.g. vertical profiles as opposed to underway measurements) should be clearly distinguished, as should measurements/sampling techniques that imply distinctly different accuracy's or spatial/temporal resolutions. Thus, for example, separate entries would be created for i) BT drops, ii) water bottle stations, iii) CTD casts, iv) towed CTD, v) towed undulating CTD profiler, vi) surface water intake measurements, etc.

Each data set entry should start on a new line – it's description may extend over several lines if necessary.

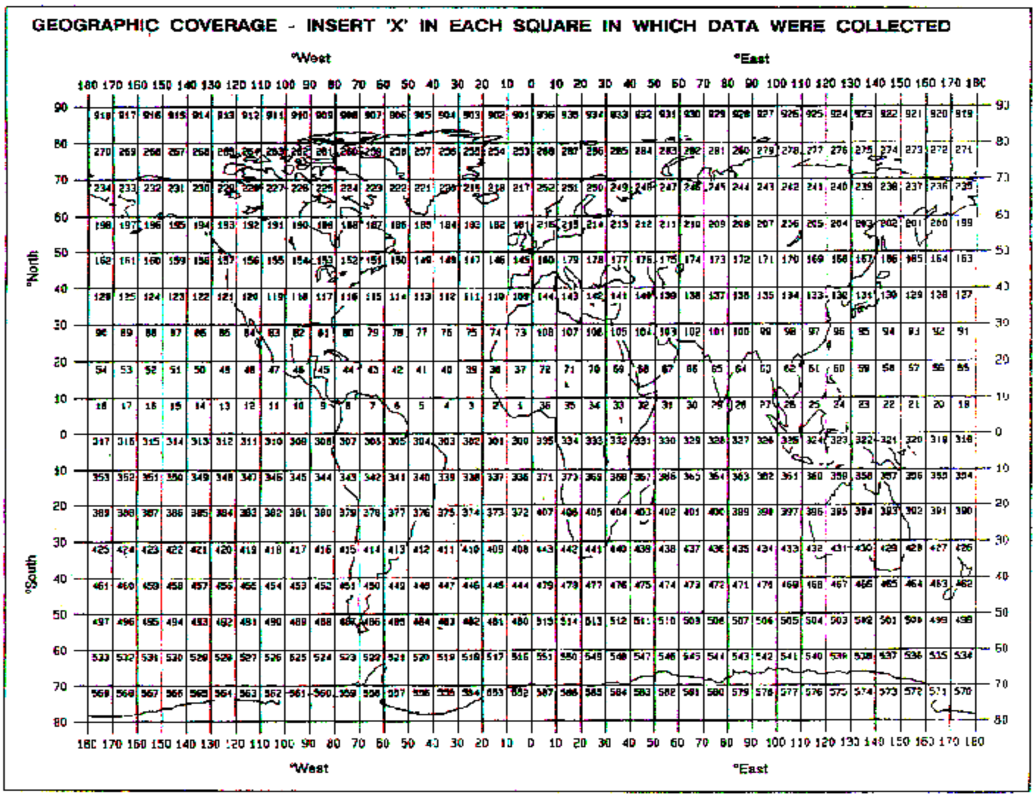
NO, UNITS : for each data set, enter the estimated amount of data collected expressed in terms of the number of 'stations'; miles' of track; 'days' of recording; 'cores' taken; net 'hauls'; balloon 'ascents'; or whatever unit is most appropriate to the data. The amount should be entered under 'NO' and the counting unit should be identified in plain text under 'UNITS'.

PI see page 2	NO see above	UNITS see above	DATA TYPE Enter code(s) from list on cover page	DESCRIPTION Identify, as appropriate, the nature of the data and of the instrumentation/sampling gear and list the parameters measured. Include any supplementary information that may be appropriate, e. g. vertical or horizontal profiles, depth horizons, continuous recording or discrete samples, etc. For samples taken for later analysis on shore, an indication should be given of the type of analysis planned, i.e. the purpose for which the samples were taken.
B	3	casts	H10	Seabird SBE 9*plus*; conductivity (giving salinity), temperature, depth. Six salinity samples taken per cast for calibration analysis by UKORS.
B	3	casts	D71	300kHz ADCP lowered with CTD, giving profiles.
B	17	days	D71	Vessel-mounted 75kHz ADCP.
B	17	days	D71	Vessel-mounted 150 kHz ADCP
B	17	days	H71	Ship's continuous surface (at 6 m depth) recording system: temperature, conductivity, salinity, sigma (density)
A	17	days	M06	Ship's continuous meteorological recording system: wind speed (S/P), direction (S/P), air temperature, relative humidity, pressure.
A	17	days	G73	Ship's continuous echo-sounder recording system: depth.
B	383	stations	H11	XBTs (about 376), XCTDs (about 7)
C	15	days	G76	low-frequency (5-100 Hz) seismic reflection of water interfaces and sediments
A	18	days	G27	ship borne gravity

TRACK CHART: You are strongly encouraged to submit, with the completed report, an annotated track chart illustrating the route followed and the points where measurements were taken.	**Insert a tick(✓) in this box if a track chart is supplied**	

GENERAL OCEAN AREA(S): Enter the names of the oceans and/or seas in which data were collected during the cruise – please use commonly recognised names (see, for example, International Hydrographic Bureau Special Publication No. 23, 'Limits of Oceans and Seas').
NE Atlantic

SPECIFIC AREAS: If the cruise activities were concentrated in a specific area(s) of an ocean or sea, then enter a description of the area(s). Such descriptions may include references to local geographic areas, to sea floor features, or to geographic coordinates.
Please insert here the number of each square in which data were collected from the below given chart
NE Atlantic off southern Portugal: 8° - 10°W, 36° - 39°N. Square 109.



THANK YOU FOR YOUR COOPERATION
Please send your completed report without delay to the collating centre indicated on the cover page

PARAMETER CODES

METEOROLOGY

M01	Upper air observations
M02	Incident radiation
M05	Occasional standard measurements
M06	Routine standard measurements
M71	Atmospheric chemistry
M90	Other meteorological measurements

PHYSICAL OCEANOGRAPHY

H71	Surface measurements underway (T,S)
H13	Bathythermograph
H09	Water bottle stations
H10	CTD stations
H11	Subsurface measurements underway (T,S)
H72	Thermistor chain
H16	Transparency (eg transmissometer)
H17	Optics (eg underwater light levels)
H73	Geochemical tracers (eg freons)
D01	Current meters
D71	Current profiler (eg ADCP)
D03	Currents measured from ship drift
D04	GEK
D05	Surface drifters/drifting buoys
D06	Neutrally buoyant floats
D09	Sea level (incl. Bottom pressure & inverted echosounder)
D72	Instrumented wave measurements
D90	Other physical oceanographic measurements

CHEMICAL OCEANOGRAPHY

H21	Oxygen
H74	Carbon dioxide
H33	Other dissolved gases
H22	Phosphate
H23	Total - P
H24	Nitrate
H25	Nitrite
H75	Total - N
H76	Ammonia
H26	Silicate
H27	Alkalinity
H28	PH
H30	Trace elements
H31	Radioactivity
H32	Isotopes
H90	Other chemical oceanographic measurements

MARINE CONTAMINANTS/POLLUTION

P01	Suspended matter
P02	Trace metals
P03	Petroleum residues
P04	Chlorinated hydrocarbons
P05	Other dissolved substances
P12	Bottom deposits
P13	Contaminants in organisms
P90	Other contaminant measurements

MARINE BIOLOGY/FISHERIES

B01	Primary productivity
B02	Phytoplankton pigments (eg chlorophyll, fluorescence)
B71	Particulate organic matter (inc POC, PON)
B06	Dissolved organic matter (inc DOC)
B72	Biochemical measurements (eg lipids, amino acids)
B73	Sediment traps
B08	Phytoplankton
B09	Zooplankton
B03	Seston
B10	Neuston
B11	Nekton
B13	Eggs & larvae
B07	Pelagic bacteria/micro-organisms
B16	Benthic bacteria/micro-organisms
B17	Phytobenthos
B18	Zoobenthos
B25	Birds
B26	Mammals & reptiles
B14	Pelagic fish
B19	Demersal fish
B20	Molluscs
B21	Crustaceans
B28	Acoustic reflection on marine organisms
B37	Taggings
B64	Gear research
B65	Exploratory fishing
B90	Other biological/fisheries measurements

MARINE GEOLOGY/GEOPHYSICS

G01	Dredge
G02	Grab
G03	Core - rock
G04	Core - soft bottom
G08	Bottom photography
G71	In-situ seafloor measurement/sampling
G72	Geophysical measurements made at depth
G73	Single-beam echosounding
G74	Multi-beam echosounding
G24	Long/short range side scan sonar
G75	Single channel seismic reflection
G76	Multichannel seismic reflection
G26	Seismic refraction
G27	Gravity measurements
G28	Magnetic measurements
G90	Other geological/geophysical measurements

Environmental Impact Assessment (EIA) in Support of the Gulf of Cadiz Cruise – 17 April to 14 May 2007

PD Ward
QinetiQ/D&TS/SEA/EIA0704992
March 2007

Requests for wider use or release must be sought from:

QinetiQ Ltd
Cody Technology Park
Farnborough
Hampshire
GU14 0LX

Administration page

Customer Information	
Customer reference number	Contract No. 1287278/0
Project title	Environmental Support for Seismic Cruise Gulf of Cadiz April/May 2007
Customer Organisation	University of Durham
Customer contact	Dr R Hobbs
Contract number	Contract No. 1287278/0
Milestone number	NA
Date due	30 March 2007

Principal author	
P D Ward	023 80596325
QinetiQ Southampton	Email: pdward@qinetiq.com

Release Authority	
Name	G A Arnold
Post	Project Manager
Date of issue	02/04/2007

Record of changes		
Issue	Date	Detail of Changes
1	March 2007	First Issue
1.1	April 2007	Revised Section 6.3.7

Environmental Impact Assessment Summary Sheet

Title of Project	EIA in Support of the Gulf of Cadiz Cruise – 17 April to 14 May 2007
Organisation responsible for Environmental Impact Assessment	QinetiQ Ltd
Location of Action	Gulf of Cadiz
EIA point of contact for further information	Dr S Healy
Designation of the EIA	Issue 1

ABSTRACT

This EIA evaluates the environmental risks associated with a Geophysical Oceanography research cruise in the Gulf of Cadiz. The cruise will make use of seismic airguns for the purposes of geophysical and oceanographic research. The devices emit high intensity underwater sound which may adversely affect marine mammals and other forms of aquatic life. Adverse effects could be physiological or behavioural. The Gulf of Cadiz is an important area for a number of species of marine mammals, sea turtles and fish, a number of species of which are endangered or critically vulnerable. The region is also dependent on a number of socio-economic activities such as commercial fishing and tourism that could be impacted upon by the operation of the airguns. The dominant frequency of the airguns is at 20 Hz and most of this is directed towards the seabed. At these frequencies, the environmental receptors at greatest risk are fish, turtles and baleen whales. Cause and effect modelling has been undertaken to quantify the impact of the airguns on the environment. This has established that impulsive effects could result in a 50% lethality to fish at distances up to 131 m from the airguns, while marine mammals with body weight of the order of 10 tonnes could approach as close as 15 m without injury arising. A submerged diver or swimmer may avoid injury at distances beyond 270 m. Permanent hearing damage may occur in marine mammals at distances up to 280 m from the array while temporary hearing damage might occur at distances up to 25 km. Behavioural effects are more difficult to quantify but such evidence as there is suggests that fish and some species of whale may be disturbed at distances up to 58 km. Related to impulsive effects, human beings (divers and swimmers) could experience body and lung vibration effects and be startled by loud underwater noises from the airguns. This EIA finds therefore, that the Gulf of Cadiz cruise has the potential to cause harm and disturbance to the marine environment, although with the application of appropriate mitigation measures, these risks may be reduced to an acceptable level, balancing environmental protection with research aims and objectives. In addition to existing JNCC guidance on reducing disturbance from airgun operations, which calls for modification of airgun operations in the event that marine mammals are encountered, this EIA recommends the implementation of the following mitigation measures: (a) the creation of exclusion zones around sensitive sites (principally coastal based but which may nevertheless, have a marine component), with the airguns being operated no closer than the distance likely to lead to TTS: (b) the undertaking of visual monitoring with at least one dedicated Marine Mammal Observer (MMO) and (c) the maintenance of verifiable environmental monitoring records. This EIA has assessed only the potential for acoustic disturbance and harm to the environment resulting from the use of seismic airguns. It is assumed that existing NERC health and safety procedures will be applied to the control of other sources of energy and substance pollution resulting from the Gulf of Cadiz cruise, as defined under national and international law.

QinetiQ Environmental Assessor	Signature : Printed : Title : Date signed :
Cruise Project Officer	Signature : Printed : Short title : Date signed :
Date of Issue	March 2007

Executive Summary

ES.1 Introduction

This document is the Environmental Impact Assessment (EIA) that has been prepared in support of a Research Cruise in the Gulf Cadiz onboard the *RRS Discovery*, as part of the EU funded Geophysical Oceanography (GO) project during the period 17 April to 14 May 2007. It is proposed to use seismic airgun arrays to investigate the Mediterranean water outflow through the Straits of Gibraltar and the Gulf of Cadiz.

The Cruise will take place in the area shown in Figure ES-1.

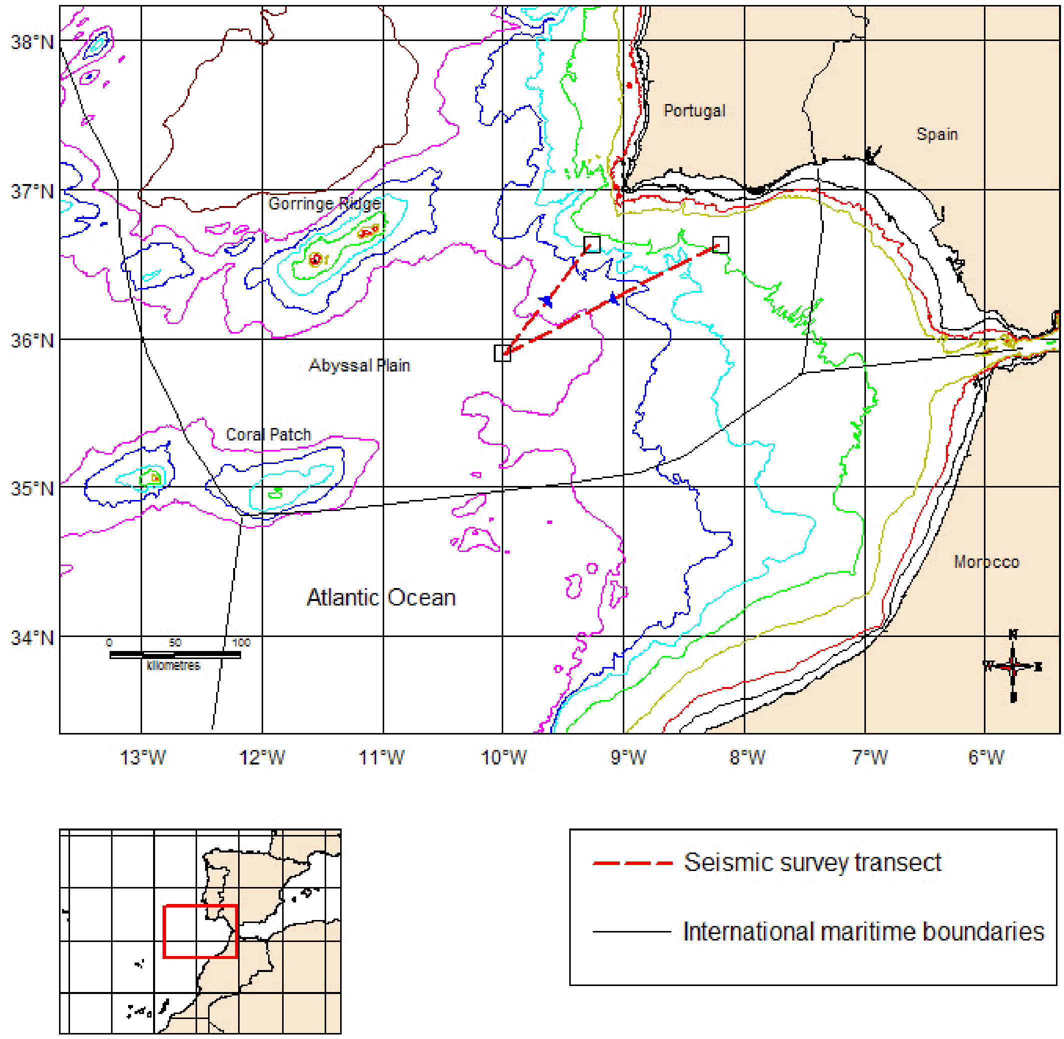


Figure ES-1 Location of Gulf of Cadiz seismic survey cruise

The EIA has been prepared by the QinetiQ Environment Team, on behalf of the GO project Coordinator. It has been undertaken the Natural environmental Research council environmental (NERC) policy and the requirements of relevant national and international environmental legislation.

The introduction of acoustic energy into the environment has the potential to cause disturbance and harm. During the Cruise the airgun arrays will emit high intensity sound underwater, which may affect sensitive receptors such as marine mammals, fish, seabirds and human beings. Adverse effects may be physiological and/or behavioural. The main aims of this EIA are to identify the potential impacts to the environment resulting from use of the airguns, and to provide a description of the environmental impact mitigation measures necessary to support the Cruise.

This Executive Summary comprises a synopsis of the findings of each of the main sections of the EIA. It is intended here to provide a concise, self-contained account of the EIA, in sufficient detail to ensure that there is a full description of the aims and purposes of the EIA and the environmental issues it addresses

ES.2 Proposed action – purpose and need

The purpose of the proposed action is to gather seismic survey data in the Gulf of Cadiz along transects that extend from the continental shelf slope to the abyssal plain. The multichannel seismic (MCS) method, developed by the hydrocarbon industry to provide continuous images of the sub-surface, can be used to image boundaries in the water layer with a horizontal resolution of around 10 m[1]. The MCS method will be deployed during the Gulf of Cadiz cruise. A towed hydrophone will be used to measure seismic returns.

The need for the proposed action is to support GO, an international research program to investigate the water circulation in the north-east Atlantic Ocean, specifically, the Mediterranean water outflow through the Straits of Gibraltar and the Gulf of Cadiz.

ES.3 Alternatives

The options that have been examined in this EIA in support of the Gulf of Cadiz cruise are as follows:

a. the Gulf of Cadiz cruise does not take place,

b. the Gulf of Cadiz cruise takes place at a different time,

c. the Gulf of Cadiz cruise takes place at a different location, and

d. the Gulf of Cadiz cruise takes place as planned.

This EAI establishes that the preferred option is (d) – the Gulf of Cadiz cruise takes place as planned, as this will make optimal use of research funds and NERC resources including the ship, equipment and personnel. Option (d) also enables UK marine scientists to play a leading international role in geophysical and oceanographic research.

ES.4 Environmental law and policy

An examination of relevant environmental law suggests that there ar a number of legal instruments which contain provisions for dealing with acoustic pollution and disturbance of the type likely to occur during the Gulf of Cadiz cruise. Since the UK is signatory to these laws and conventions (e.g. UNCLOS, ASCOBANS, ACCOBAMS) and NERC's position would appear to be that it is required to adhere to all national and international environmental laws to which the UK government is committed, it would appear that NERC has an obligation to put into place such cost-effective measures as are required to protect the environment and prevent harm to marine life. This has been done through the commissioning of this EIA and the preparation of environmental risk mitigation measures, including the production of guidelines using information supplied by JNCC and reflecting industry "best practice".

In particular, this EIA notes that NERC is required to:

a. Preserve and protect the environment,

b. Take measures to prevent, reduce and control pollution from any source and to use the "best practicable means" at its disposal and in accordance with its capabilities.

c. Take all measures necessary to ensure that activities under its control do not causer damage by pollution to other states and their environment.

d. there are no specified acoustic thresholds for waterborne noise in current international, EC and national legislation;

e. environmental law and policy is evolving rapidly in the maritime area;

ES.5 Existing environment

The physical, biological and socio-economic environments have been described for the Gulf of Cadiz region. This description extends beyond the immediate exercise areas to ensure that relevant parts of the entire ecosystem are addressed. The data that have been gathered are generally considered to be of sufficient quality for the purposes of this EIA.

Five species of baleen whale, including the endangered blue, fin and sei whales have been recorded in the Gulf of Cadiz. Twenty species of toothed whale have been observed in the area and of these, the sperm whale and harbour porpoise have been designated in the Red List of Threatened Animals as "Vulnerable". A large number of commercially important fish species occur in and around the Gulf of Cadiz. Fish are most likely to be adversely affected by sound when they aggregate prior to spawning and during the time of the Gulf of Cadiz cruise, it is noted that the scad, pilchard and anchovy are all spawning.

Five species of sea turtle have been identified in and around the Gulf of Cadiz. The green and loggerhead sea turtles are classified as endangered; and the hawksbill, leatherback and Kemp's Ridley turtles are all classified as critically endangered under the IUCN Red List of Species (IUCN, 2006). The hawksbill is seldom; seen, but the other turtle species can be found regularly in coastal and offshore waters. There are no known nesting sites close to the EIA area.

Socio-economic interests are dominated by commercial fishing and tourism including such activities as sailing, windsurfing swimming and scuba diving, although it must be noted that most of these activities take place close inshore. Whale watching is a burgeoning activity in the area.

ES.6 Environmental consequences

The assessment of the environmental consequences of the Gulf of Cadiz cruise, involving the use of the seismic airguns, has employed acoustic models, databases and bio-acoustic impact criteria to undertake "cause and effect" modelling.

The objective of this work has been to quantify the acoustic footprint of the airguns in terms of their energy, frequency content and time for which receptors may be exposed. The impact criteria employed have included the potential for tissue and organ damage from the impulsive effects of the airguns and the likelihood of hearing loss (temporary or permanent) in marine mammals, fish and turtles. In addition, this work has assessed the potential for behavioural impacts that may affect animals at lower sound pressure levels and at longer ranges than the purely physiological effects described above.

During the cruise, two airgun arrays will be used and of these, the "Large MCS" array has the potential to cause most harm and disturbance. In terms of the environmental sensitivities, the use of the "Large MCS" airgun array at the beginning of the first transect line and at the end of the second transect line, is of greatest concern. In this case, there is the potential for a negative impact on swimming or diving receptors near coastal sensitive sites. During traverses over the continental slope, whales, in particular beaked whales, could be adversely affected by airgun operations.

This EIA indicates that impulsive effects could lead to a 50% lethality to fish of body weights 1-2 kg at distances up to 131 m from the airgun array. For marine mammals of body weight around 10000 kg, the no-injury criterion is met around 15 m while human divers and swimmers may avoid injury at distances beyond 270 m. Permanent hearing loss could arise in marine mammals exposed to airgun emissions for 30 minutes, at distances up to 280 m from the array. Temporary hearing damage following a 24 hr exposure might arise at distances up to 25 km. Behavioural effects could be observed up to 58 km from the airgun array.

ES.7 Mitigation

In order to minimise the risk of potential detrimental effects on the environment from the Gulf of Cadiz cruise, a mitigation strategy has been developed that will reduce but not totally negate environmental risks. Although the risks remain finite, they are considered manageable with the application of the mitigation measures identified. These are:

a. The application of existing NERC guidelines on minimising acoustic disturbance to marine mammals, noting that these draw on JNCC guidance which calls for modification of air gun operations (e.g. delay, soft-start) in the event that marine mammals are encountered;

b. The implementation of exclusion zones around sensitive sites (principally coastal marine reserves), with the airguns being operated no closer than the stance likely to lead to TTS;

c. The undertaking of visual monitoring with at east one dedicated Marine Mammal Observer (MMO), and

d. The maintenance of verifiable environmental monitoring records.

During the planning of the activity, it is important to consider the location of environmentally sensitive areas (detailed in Section 5), so that, where practicable, proximity to them can be minimised (i.e. designated as exclusion zones, with associated buffer zones). This ensures that risk to environmental receptors through the use of the airguns is minimised before the activity begins.

During the activity, Ship's personnel should undertake visual and acoustic monitoring for environmental receptors. Following the detection of an environmental receptor within a SOR from the airgun array, appropriate mitigation measures should then be applied, such as delay, reduction or cessation of airgun emissions. It is recommended that any mitigation measures undertaken be recorded along with a description of the consequences of that activity.

After the activity, it is recommended that a permanent record be kept of any mitigation measures implemented (i.e. monitoring, modification of activities to reduce environmental impact) and that post-activity analysis of the implementation of the environmental strategy is undertaken.

Visual monitoring should, in particular, be concentrated in the 500 m zone identified in the JNCC guidance, as the closest distance to which marine mammals may approach without modification of airgun activity being required. In the case of the Gulf of Cadiz cruise, this distance generally exceeds the distance oat which permanent physiological harm may occur to marine mammals (280 m). But wherever possible, surveillance should be maintained over the largest area possible around the airguns, in order to reduce stress and harm to marine life. Particular vigilance is required for the presence of human divers and swimmers in the vicinity of the airguns.

ES.8 Missing or incomplete knowledge

Information on the physical environment of the Gulf of Cadiz is generally well documented and the sources of information used are considered reliable. However, information is sparse for other aspects of the environment. Although much is known about marine mammals likely to be in the area, precise distributions and population densities for all species have not been defined. Dive sites are another example where data on specific locations were difficult to obtain. The assessment of estimates of the potential biological and socio-economic impacts during the Gulf of Cadiz cruise, have been based on the best information available at the time of writing.

Every effort has been made to use the best available scientific evidence, particularly with regard to the modelling of acoustic impacts in fish, sea mammals and human beings. However, it is emphasised that knowledge of the precise effects of underwater sound on marine mammals and fish, particularly quantitative data concerning onset of PTS and TTS, is incomplete and limited to a few species. More is known about human hearing underwater, but the Damage Risk Criteria (DRC) based approach which has been adopted here for modelling frequency, time (dosage) and intensity dependent effects, remains speculative because of the current lack of scientific evidence.

With regard to marine mammals, there is a growing body of evidence suggest that some species (particularly beaked whales) may be sensitive to non-auditory, acoustically mediated physiological effects, while for others the long term effects of behavioural reactions could be profound if these impact on breeding and the general fecundity of the population. Knowledge of these long term and cumulative effects is incomplete and the only practicable approach to mitigation would appear to be avoidance of those areas having high densities of animals known to be at risk.

This EIA has only assessed the potential of airguns to cause disturbance or harm to marine life and human beings. It is assumed that NERC will put in place procedures for dealing with energy pollution from other sources and also for preventing substance pollution.

ES.9 Conclusions

This EIA finds that the Gulf of Cadiz cruise has the potential to cause harm and disturbance to marine life, in particular fish, marine mammals and sea turtles, through the use of airguns. In addition, the airguns have the potential to harm human beings (divers and swimmers) and to impact on elements of the socio-economic environment, in particular tourism and fisheries.

However, the potentially adverse environmental impacts associated with the use of the airguns during the Gulf of Cadiz cruise may be managed and reduced to an acceptable level through the application of appropriate mitigation measures. These measures have been designed to afford maximum protection to the marine environment and to human beings, while at the same time achieving the scientific aims and objectives of the cruise.

List of contents

1 Introduction

1.1 Background

The QinetiQ Environment Team has been tasked by the Geophysical Oceanography (GO) Project coordinator at the University of Durham to prepare an Environmental Impact Assessment (EIA) to support a forthcoming seismic survey in the Gulf of Cadiz. The survey forms part of a research program being undertaken by a European Union (EU) funded, international collaboration of scientists, from universities and research institutes in England, Germany France, Italy, Portugal and Spain[1].

The seismic survey will involve the use of airguns and a towed hydrophone array as well as a number of other oceanographic instrumentation packages. It is scheduled to take place in the period 17 April to 14 May 2007. The airgun arrays, oceanographic equipment and personnel will be embarked onboard *RRS Discovery*. A second vessel, the *MV Poseidon*, is also taking part in the cruise. It is understood however, that no seismic sources will be deployed from this vessel.

These locations are shown in Figure 1.1 which also includes the relevant geopolitical boundaries.

The planned seismic survey will be carried out over a number of locations:

a. Along the transects:

36°38´N 008°12´W to 35°54´N 010°00´W;

35°54´N 010°00´W to 36°38´N 009°16´W;

b. and at grids centred on

36°38´N 008°12´W

35°54´N 010°00´W

36°38´N 009°16´W

An EIA has been undertaken to assess the potential environmental issues associated with the proposed use of the seismic airguns. The key aims of the EIA are:

a. To put in place a formal risk assessment process,

b. To establish appropriate mitigation measures, and

c. To provide an auditable record of the assessment process.

This is a controlled document (see Release Conditions) and all requests for information relating to the EIA should be addressed to:

Dr R Hobbs,
GO Project coordinator.
Department of Earth Sciences,
Durham University,
Science Labs,
Durham DH1 3LE.
Tel: +44 (0)191 334 4295
Fax: +44 (0)191 334 2301
email: r.w.hobbs@durham.ac.uk

[1] Further details of the aims and objectives of the GO research programme may be found on-line at www.dur.ac.uk/eu.go/.

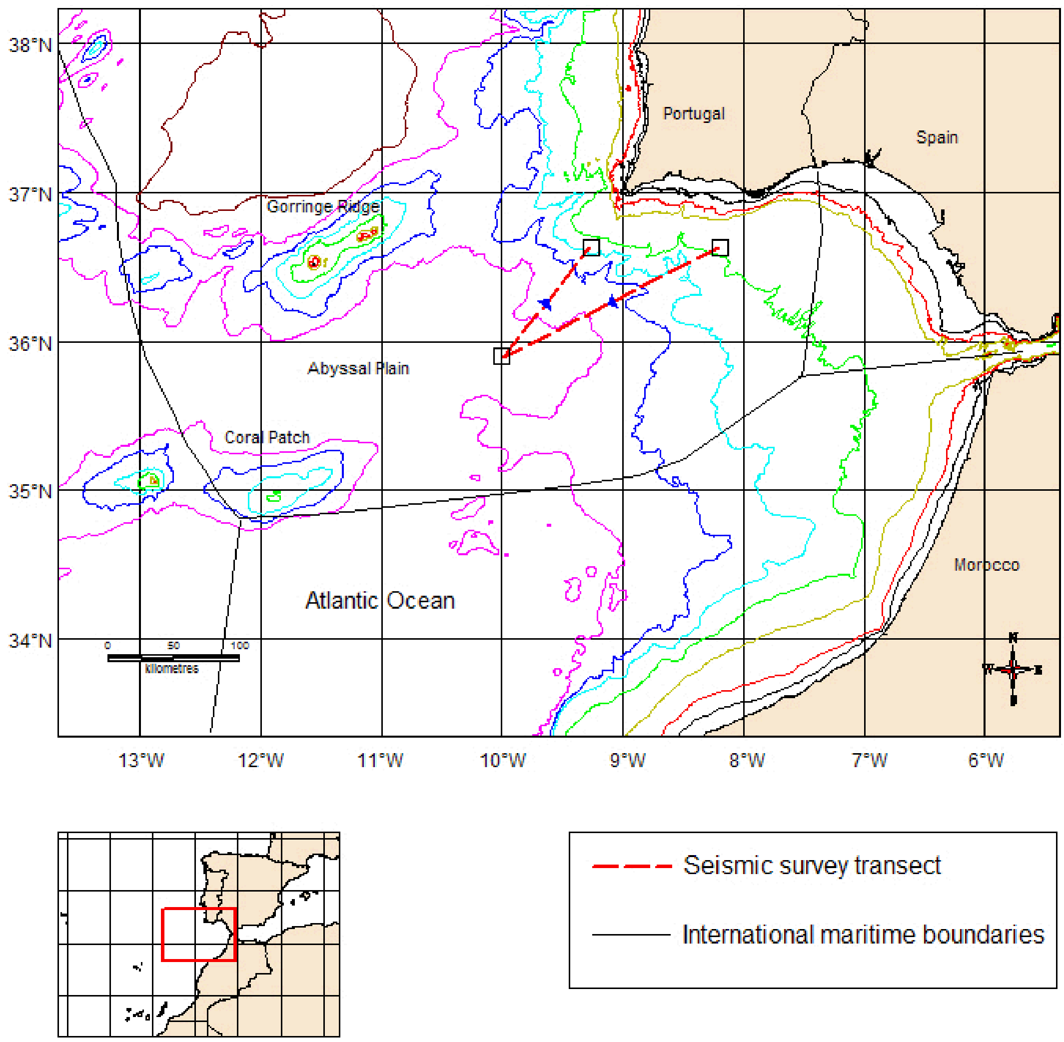


Figure 1.1 Location of Gulf of Cadiz cruise with respect to international boundaries

1.2 Scope of Environmental Impact Assessment

This EIA relates solely to the risk of potentially adverse effects resulting from the use of seismic airguns. No account is taken of acoustic disturbance from other sources, or of substance or material pollution (including disposable sensors) that may occur during the cruise.

The EIA has been prepared following best practice and processes that have been developed for the UK Ministry of Defence (MoD) and other customers, and which have been reviewed by external bodies and independent scientific and legal experts[2].

The EIA assesses the potential for adverse environmental effects arising from the proposed activity *viz.* to use airguns for seismic survey purposes and will recommend mitigation and monitoring measures to be put in place at the time of the surveys, designed to protect the environment and human beings.

[2] QinetiQ's EIAs have been reviewed by Joint Nature Conservation Committee (JNCC), Department for Environment, Food and Rural Affairs (DEFRA), Department of Trade and Industry (DTI) and Institute of Environmental Management and Assessment (IEMA).

The EIA employs impulse damage models to estimate the likelihood of fish kill and physiological effects on marine mammals in the immediate vicinity of the airguns. At longer ranges, an underwater acoustic propagation model has been used to estimate the received sound pressure levels associated with the in-water sound energy. These levels have been used with generic threshold of hearing data for fish, marine mammals and humans, and associated Damage Risk Criteria (DRC), to calculate the risk of physiological damage and behavioural impacts in those species likely to be encountered in the study area. For humans (e.g. sports divers or swimmers) the calculations have been based on the risk of adverse behaviour. Further details of the modelling assumptions and calculations are given in Section 6 of the EIA.

The findings of the EIA relate solely to the proposed action, and may not be applied or extrapolated to other locations or to other times.

The scope of the work undertaken by QinetiQ, with underlying assumptions regarding the deployment of the seismic airguns is explained further in Annex A.

1.3 Structure of document

The structure of the remaining sections of this document is as follows:

Section	Title	Contents
2	Purpose of and need for proposed action	Describes the purpose of and need for the Gulf of Cadiz cruise and the seismic activity.
3	Alternatives to proposed action	Discusses alternatives to the proposed action.
4	Environmental law and policy	Explains the environmental policy and legal issues surrounding the proposed action.
5	Existing Environment	Describes the physical, biological and socio-economic environment of the proposed seismic survey area.
6	Environmental consequences	Examines the environmental consequences resulting from proposed use of seismic airguns.
7	Mitigation	Recommends mitigation measures that are designed to protect the environment.
8	Missing or incomplete knowledge	Details missing or incomplete knowledge at the time of the assessment.
9	References	Scientific and other literature cited in document.
10	Abbreviations	Self explanatory
11	Glossary	Self explanatory
Annex A	Seismic airguns	Technical data concerning airguns and method of deployment.

2 Purpose of and need for proposed action

2.1 Purpose of proposed action

The purpose of the proposed action is to gather seismic survey data in the Gulf of Cadiz along two transects and in three grid areas that lie on the continental shelf slope and abyssal plain (see Figure 1.1). Data are required to support the EU funded GO project. In brief, GO is a tool to understand the thermal structure and dynamics of oceans and the specific aims with respect to the Gulf of Cadiz cruise are discussed below.

Seismic surveys are to be carried out during the research cruise onboard *RRS Discov*ery during two periods; 17 April to 23 April and from 29 April to 14 May 2007. The research cruise is henceforth referred to as the Gulf of Cadiz cruise.

The multichannel seismic (MCS) method, developed by the hydrocarbon industry to provide continuous images of the sub-surface, can be used to image boundaries in the water layer with a horizontal resolution of around 10 m. The MCS method will be deployed during the Gulf of Cadiz cruise.

A tuned seismic array will be used to carry out a low-resolution seismic survey along transects from 36°38´N 008°12´W to 35°54´N 010°00´W and from 35°54´N 010°00´W to 36°38´N 009°16´. In addition, high resolution seismic surveys will be undertaken on grids centred at:

36°38´N 008°12´W

35°54´N 010°00´W

36°38´N 009°16´W

The high-resolution grids lie at the start and end of both of the transect lines. For the low-resolution survey, an MCS array of total capacity 2320 cubic inches will be fired every 30 sec corresponding to a distance between airgun firings of 50 m, while for the high-resolution work, an MCS array of capacity 117 cubic inches will be fired every 10 sec, corresponding to a distance of 25 m between airgun firings.

Seismic returns will be obtained using a towed hydrophone array.

For the low-resolution survey the array configuration is referred to as “Large MCS” and the configuration for the high–resolution array is referred to as “Small MCS”

2.2 Need for proposed action

The need for the proposed action is to support GO, an international research program to investigate the water circulation in the north-east Atlantic Ocean, specifically, the Mediterranean water outflow through the Straits of Gibraltar and the Gulf of Cadiz.

Research on this topic will enable the international research community to provide new tools to aid monitoring ocean circulation and heat transport, which are important to climate change and its implications for weather patterns in Europe, and in controlling the marine ecosystem.

The Gulf of Cadiz cruise will help to establish research expertise in the EU, at centres of excellence that can be used for training and exploitation of the opportunities brought about by the cruise.

Further details can be found on the GO website (http://www.dur.ac.uk/eu.go)

3 Alternatives

3.1 Options investigated

The EIA process requires consideration of alternative courses of action (see Glasson *et al.* 1994), particularly where these may reduce or entirely eliminate the potential for adverse environmental effects. The options available to the Gulf of Cadiz cruise planners are as follows:

a. No action – the Gulf of Cadiz cruise does not take place.

b. Action takes place at a different time – the Gulf of Cadiz cruise takes place at a time when environmental risks may be lower due to seasonal variations in environmental receptor distributions or acoustic propagation conditions.

c. Action takes place at a different location – the Gulf of Cadiz cruise is carried out at a location where there may be lower numbers of animals at risk.

d. Action proceeds as planned – the Gulf of Cadiz cruise takes place as planned with environmental mitigation strategy.

Each of these options is evaluated in the following sections.

3.2 The Gulf of Cadiz cruise does not take place

If the Gulf of Cadiz cruise were not to take place, UK research efforts would be compromised and UK scientists would be denied the opportunity to participate in an important international research programme. The opportunity to benefit from EU funds would be lost and UK research interests would be affected.

3.3 The Gulf of Cadiz cruise takes place at a different time

The planned cruise period is in April and May. It is possible that undertaking the cruise at a different time of year in the Gulf of Cadiz could reduce the potential risk to the environment. The cruise period has been planned for some time and the logistical preparation is significant, thus a change in the time of year could have an impact on the logistical and scientific objectives of the cruise. Environmental data (Section 5) indicate that, while distributions of environmental receptors vary throughout the year, there are always likely to be receptors present. For example, winter and summer feeding and breeding grounds for a number of species of cetacean are found to the north and south of the area of interest and migration through the area is known to occur during the spring months.

Thus it is concluded that on balance, there is no significant environmental advantage in undertaking the cruise at a different time of year.

3.4 The Gulf of Cadiz cruise takes place in a different location

Similarly, to the case presented above, the potential for negative environmental impact might be reduced or eliminated altogether if it could be argued that the Gulf of Cadiz cruise be located elsewhere, where fewer or even no environmental receptors may be at risk.

It is possible that may be some environmental advantage if the cruise took place at an alternative location. However, any chosen alternative location must meet the cruise requirements and remain within a logistically supportable area.

This EIA indicates that beaked whales are known to populate the general area around the cruise location (Section 5). Although data concerning these elusive whales are very sparse (Section 8), they are considered to be one of the most susceptible groups of animals to high intensity noise (Section 6). Beaked whales may be observed close to the shelf edge (Section 5). The planned cruise does include some of these sensitive areas but also include areas which are of lesser sensitivity.

Relocating the cruise to an alternative location, would also have the potential for impact on the local environment. However, such a move would impact on the objectives of the cruise, denying the opportunity to build on existing research and overlooking the unique nature of the chosen research area, which has unique circulation patterns and interaction of Mediterranean water with that of the wider North Atlantic Ocean.

Thus it is concluded that there is no significant environmental advantage to be gained by moving the location of the cruise elsewhere but there is an advantage in avoiding or limiting activity in any sensitive areas identified within the cruise area.

3.5 The Gulf of Cadiz cruise takes place as planned

The Gulf of Cadiz cruise has been planned to make the most effective use of resources (e.g. research funds, equipment and scientific personnel) and to exploit the unique geological and oceanographic setting of the Gulf of Cadiz. The work is also timely, building on existing research and enabling UK marine scientists to play a leading international role in geophysical and oceanographic research. At the same time, the work will lead to advances in experimental techniques and has direct relevance to models for predicting future climate change.

Undertaking the cruise, with due regard to the environmental impact mitigation measures recommended in Section 7 of this EIA, would meet relevant environmental obligations whilst minimising adverse environmental impact.

3.6 Preferred option

The preferred option is that the Gulf of Cadiz cruise takes place as planned with the application of appropriate mitigation measures found in the course of preparing this EIA.

4 Environmental law and policy

4.1 Introduction

The seismic survey for the Gulf of Cadiz cruise is being undertaken on *RRS Discovery*, a British flagged vessel owned and operated by NERC. The proposed research, involving the use of seismic airguns, forms part of the GO project and is funded under the New and Emerging Science and Technology (NEST) initiative of the European Union. The action proponents for the cruise are the research scientists at University of Durham who are also responsible for environmental risks. It is noted that a second vessel, the *MV Poseidon* is also taking part in the cruise but is not deploying any seismic sources.

NERC takes seriously its responsibility to protect the environment especially with regards to the use of airguns and other acoustic systems (NERC 2002a). It's corporate document (NERC 2002b), makes clear the Council's commitment to global environmental research and also to the search for solutions that will reduce the impact of man on the environment and lead to sustainable economic development. This EIA also notes that NERC, through its adoption of Joint Nature Conservation Committee (JNCC) guidelines (NERC 2005), recognises that there may be a need for Environmental Impact Assessments (EIAs) in regard to certain of its scientific research activities.

Because of its ability to penetrate seawater and ocean sediments, underwater sound through the multichannel seismic (MCS) method, has emerged as the principal means of studying ocean currents, mapping the seabed and performing geophysical research of the type proposed in the Gulf of Cadiz cruise. As noted above and discussed below, underwater sound has the potential to cause adverse effects on marine life. However, there are at present no other means of obtaining the data required from the Gulf of Cadiz cruise, and given the overall benefits of the proposed research to society, NERC considers the use of seismic airguns to be acceptable practice, given the application of appropriate controls. It is the function of this EIA to quantify any potential environmental impact and to find suitable mitigation measures.

In the following section, NERC's position on this matter is examined in the framework of national and international environmental law.

4.2 Environmental law and obligations concerning acoustic pollution

There is substantial evidence to show that man-made sound levels in the ocean have increased over the past 50 years (Gisiner, 1998; Curtis et. al., 1999) and there are growing concerns about its potential to harm marine life (e.g. the Whale and Dolphin Conservation Society (WDCS) report "Oceans of Noise", WDCS, 2004). While there is a move to recommend defined or regulated safe levels for underwater sound, (IACMST[3], 2006) such regulations are not yet in place. This is in stark contrast to the measures taken to protect human beings from intense or persistent sound, e.g. under water (Marine Technology Directorate (MTD), 1996) and in the workplace (Health and Safety Executive (HSE), 1989, 2005).

While further research is required to establish the significance of potentially adverse effects, there seems little doubt that intense and persistent sources of underwater sound have the potential to cause actual physical harm, and to cause disturbance to marine mammals and other forms of marine life (e.g. fish, seabirds). The issue is not only one of source level (i.e. the intensity of the sound); it also concerns sound

[3] Inter-Agency Committee on Marine Science and Technology

frequency and the length of time for which an animal may be exposed. Neither is it simply a possible cause of physiological harm; comparatively low levels of sound may result in behavioural effects, whose long-term and cumulative implications are largely unknown. In this respect the risks to rare or endangered species of animal could be high. For animals that are endangered, Kareiva (2001) has argued that mitigating the risks to even a single whale could make the difference between extinction and survival.

More needs to be done, but in the meantime, work on the definition of legal standards (e.g. Dotinga and Oude Elferink, 2000) already shows that there is a range of international and national law applicable to the situation. This deals with man-made underwater noise in two respects:

a. its presence in the marine environment as a form of 'pollution', thereby enabling it to be treated in the same way as any other pollutant,

b. its effect on the environment, thereby enabling it to be dealt with in the same way as any other form of human activity likely to lead to detrimental effects.

Key international environmental legislation dealing with underwater noise, either as a form of pollution or in terms of its impact on the environment, is listed in Table 4-1 (for full discussion see Dotinga and Oude Elferink, 2000).

International Laws/Conventions	Aspect
1982 United Nations Convention on the Law of the Sea (UNCLOS).	Provisions relevant to anthropogenic noise in the ocean: Part I – definition of pollution Parts V and VII – conservation and management of marine living resources Part XII – protection of the environment and pollution control Part XIII – Marine Scientific Research (MSR).
1992 UNEP (UN Environmental Programme) Convention on Biological Diversity (CBD).	Provisions relevant to conservation of marine species, ecosystems and habitats.
1946 International Convention for the Regulation of Whaling (ICRW).	Specifically mentions concern over potentially adverse effects of anthropogenic noise on cetaceans.
1979 Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).	Conservation of marine species, ecosystems and habitats.
UNEP Regional Seas Programme.	Protocols on Specially Protected Areas.
Annex V to the OSPAR18 Convention.	Ecosystems and biological diversity.
1992 Agreement on Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS)	Prevention of acoustic disturbance to cetaceans.
1996 Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS)	Prevention of acoustic disturbance to cetaceans
Rio Declaration and Agenda 21	Precautionary principle.

Table 4-1 International Laws/Conventions relevant to acoustic transmissions.

From Part I of UNCLOS, this EIA notes that pollution may be defined as:

'the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious

effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities'.

While the original GESAMP[19] definition of pollution (on which the UNCLOS Part I is based) referred only to pollution that resulted from the introduction of substances, this was later extended to include 'energy' so as to encompass cases of thermal pollution (e.g. from power station cooling water outflows). However, the use of the term 'energy' is now generally accepted to include all forms of energy, including noise, heat, vibration and electromagnetic radiation.

April 2002 saw the General Assembly of the United Nations (UN) review recent developments in ocean affairs. This process included review of the status of Part XII of UNCLOS. The assembly noted that Chapter 17 of Agenda 21 introduced new terminology with respect to environmental pollution; the term 'degradation' has been substituted for the term 'pollution'. Degradation is considered to include all deleterious effects resulting from anthropogenic modification of the physical, chemical or biological characteristics of the environment, as well as environmental impacts of technology. This new definition is seen to establish a broader 'catch all' requirement. It is assessed that the deployment of seismic airguns within the established definition as given above, so the broadening of the requirement under the usage of the term 'degradation' does not add to the existing duty placed on the MoD under the relevant articles in UNCLOS.

Similarly, other legal instruments (such as the Convention on Biological Diversity (CBD), International Convention for the Regulation of Whaling (ICRW), UN Environmental Programme (UNEP) and OSPAR make provision for the regulation of underwater noise pollution in regard to its effect on marine conservation, as argued by Dotinga and Oude Elferink (2000).

A resolution (IUCN, 2004) has been produced which will call upon States to seek to regulate the impact of anthropogenic noise on the marine environment and to promote scientific research to underpin this regulatory process.

The remit of the International Whaling Commission (IWC) has been expanded in recent years, making the organisation responsible for all aspects of marine mammal conservation, including those arising from the generation of anthropogenic noise in the marine environment. In 2004, the IWC's Scientific Committee (IWC, 2004) concluded that there was a clear scientific consensus concerning the adverse impacts of marine noise. The IWC has placed noise as a standing priority on its agenda. To date no amendments to the IWC convention have been proposed to regulate anthropogenic noise in general or naval sonar specifically from impacting on cetaceans. Although the IWC has also recommended measures to prevent acoustic disturbance from whale activities and advised operators to 'avoid sudden changes in speed, direction or noise'.

The UK is a Party to the Agreement on Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) (1992). Though the Convention has not been taken up in UK legislation it is recognised by the UK that the spirit of the Convention should apply. Under ASCOBANS, it is emphasised that Parties shall work towards, inter alia, 'the prevention of other significant sources of disturbance, especially of an acoustic nature'.

UK Government has recently applied the findings of ASCOBANS to all of the waters under its jurisdiction. The Convention to date has not been amended to regulate anthropogenic noise in general or seismic airguns specifically, to avoid adverse impact on cetaceans.

The ACCOBAMS[4] 3rd Scientific Committee meeting in Cairo in May 2005, discussed a draft paper on addressing the impact of noise in the marine Mediterranean environment by a permit (Consents) system (see Pavan, 2005).

From the list of international environment legislation (in Table 4-1), to which the UK government subscribes, it can be seen that the UK recognises the potential of underwater sound to cause harm to marine mammals. As a signatory to UNCLOS, the UK is obligated to take appropriate measures to protect the environment, for activities under its jurisdiction on the high seas and in international waters. Defra are the lead government department with responsibility for the development of policy on noise in the marine environment. The Joint Nature Conservation Committee (JNCC) is Defra's statutory adviser on marine environment matters. The JNCC have been involved with reviews of national and EU policy, law and science relating to acoustic disturbance of the marine environment. The main focus of Defra's policy relating to noise in the marine environment has been to minimise the disturbance caused by seismic activities from commercial oil exploration and exploitation within the UK Exclusive Economic Zone (EEZ). This places a binding requirement on the oil industry to use JNCC guidelines (JNCC, 2004).

Currently the UK Government has no published policy on the use of research seismic airguns in the marine environment other than that contained in NERC's environmental policies. In adopting a self regulatory approach, NERC, have used the JNCC guidelines as the basis of its mitigation for the management of risk to the marine environment from seismic airguns.

4.3 Application of international law and UK 'best practice' to the Gulf of Cadiz cruise

Scientific research in host nation's waters is covered by the provisions of Part XIII of UNCLOS for States undertaking Marine Scientific Research (MSR). The Gulf of Cadiz falls under this remit. However, notwithstanding these provisions, NERC are required to comply with the general requirements of UNCLOS and other national and international statutes, laws and conventions as outlined above.

From an analysis of the rules and principles embodied in Part XII of UNCLOS and following Dotinga and Oude Elferink (2000), the following general deductions can be made with regard to the Gulf of Cadiz cruise:

a. States have a general obligation to protect and preserve the marine environment.

b. This duty would appear to be unqualified and apply to all states and to all activities under their control or jurisdiction, including areas outside national jurisdiction.

c. States are required to take all necessary measures to prevent, reduce and control pollution *from any source* using 'the *best practicable means* at their disposal and *in accordance with their capabilities*'.

d. States are obliged to take *all measures necessary* to ensure that activities under their control or jurisdiction are conducted so as not to cause damage by pollution to *other states and their environment*.

e. States have a due diligence obligation to adopt measures to protect the environment in respect of activities under their jurisdiction or control (e.g. for vessels flying their flag on the high seas), and to avoid harm to the

[4] Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area.

environment or interests of other states, as well as to the environment outside national jurisdiction.

Such measures are required to be taken in respect of:

a. The activities to be undertaken and 'the use of technologies' where there is potential to cause pollution, and

b. In order to protect 'rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species and other forms of marine life'.

Concerning this last point and referring to Section 5 of this EIA, it is noted that the Gulf of Cadiz cruise is taking place:

a. In or close by two internationally declared protection areas (ASCOBANS and ACCOBAMS)

b. In the vicinity of sites that are protected by Portuguese, Spanish and Moroccan national and international laws.

This EIA also notes that UNCLOS requires states to assess the risks associated with activities under their jurisdiction or control and to assess the potential harm that may result.

Furthermore, the Rio Declaration and Agenda 21 require states to take measures to protect the environment that are based on precautionary and anticipatory approaches. Dotinga and Oude Elferink (2000) argue that these principles apply equally to acoustic disturbance as a form of pollution. This is an application of the 'precautionary principle' which states that:

"Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost effective measures to prevent environmental degradation".

The precautionary principle may also be interpreted as putting the burden of proof on the state conducting the activity, which have to demonstrate that appropriate measures have been taken to prevent harm to the environment.

Noting the above requirements and the present concerns about the effects of acoustic disturbance and harm to marine life, NERC has considered it necessary to prepare this EIA, to assess the risks and put in place appropriate mitigation measures in respect of the Gulf of Cadiz cruise.

5 Existing Environment

5.1 Introduction

This section describes the current state of the physical, biological and socio-economic environments of the Gulf of Cadiz. This description provides essential background knowledge of the area in question and is fundamental in helping to ascertain and assess any potential impacts of the proposed action. The biological and socio-economic environments are most likely to be affected by the use of seismic airgun arrays, and knowledge of their current state forms the basis for the mitigation strategy. The physical environment will affect the underwater propagation of sound emissions, and environmental information is also required to enable accurate modelling of sound propagation.

The information provided in this section has been gathered from a number of sources. Details of the physical environment have been taken from various databases and publications. The socio-economic information is taken from a wide range of sources, including OSPAR Commission for the Protection of the Marine Environment of the North Atlantic, Food and Agriculture Organisation of the United Nations (FAO), the Whale and Dolphin Conservation Society (WDCS) and the World Conservation Monitoring Centre (WCMC).

5.2 Definition of the area

The Gulf of Cadiz is defined here as the area bounded by the Algarve coast of Portugal, the southern coast of Spain from the Portuguese border to the Strait of Gibraltar and the Atlantic coast of north and west Morocco; extending out beyond the continental shelf break to longitude 10°W.

Some additional information from the surrounding area has been included in this description because many physical factors, such as ocean currents and the weather are best viewed in the context of the whole of the wider Iberian continental shelf and surrounding deep water. In addition, many marine mammal migration routes cross the boundaries between the Gulf and other regions.

5.3 Physical environment

5.3.1 Bathymetry

The information in this section is taken from the Admiralty Chart 4103. The main features of the bathymetry of this region can be seen in Figure 5.1. Around the southern coast of Portugal and Spain, the continental shelf (as defined by the 200 m depth contour) is fairly narrow, only 10 to 50 km in extent. The seabed slopes down over a distance of 100 km or so to reach a depth in excess of 4500 m over the abyssal plain. The shelf edge is incised by a number of submarine canyons systems. These are the São Vicente, Lagos, Faro and Portimão systems. In addition, there are a number of seamounts whose peaks rise to less than 200 m of the water surface. The seamounts are found on the Gorringe Ridge to the north-west and around Coral Patch to the south-west.

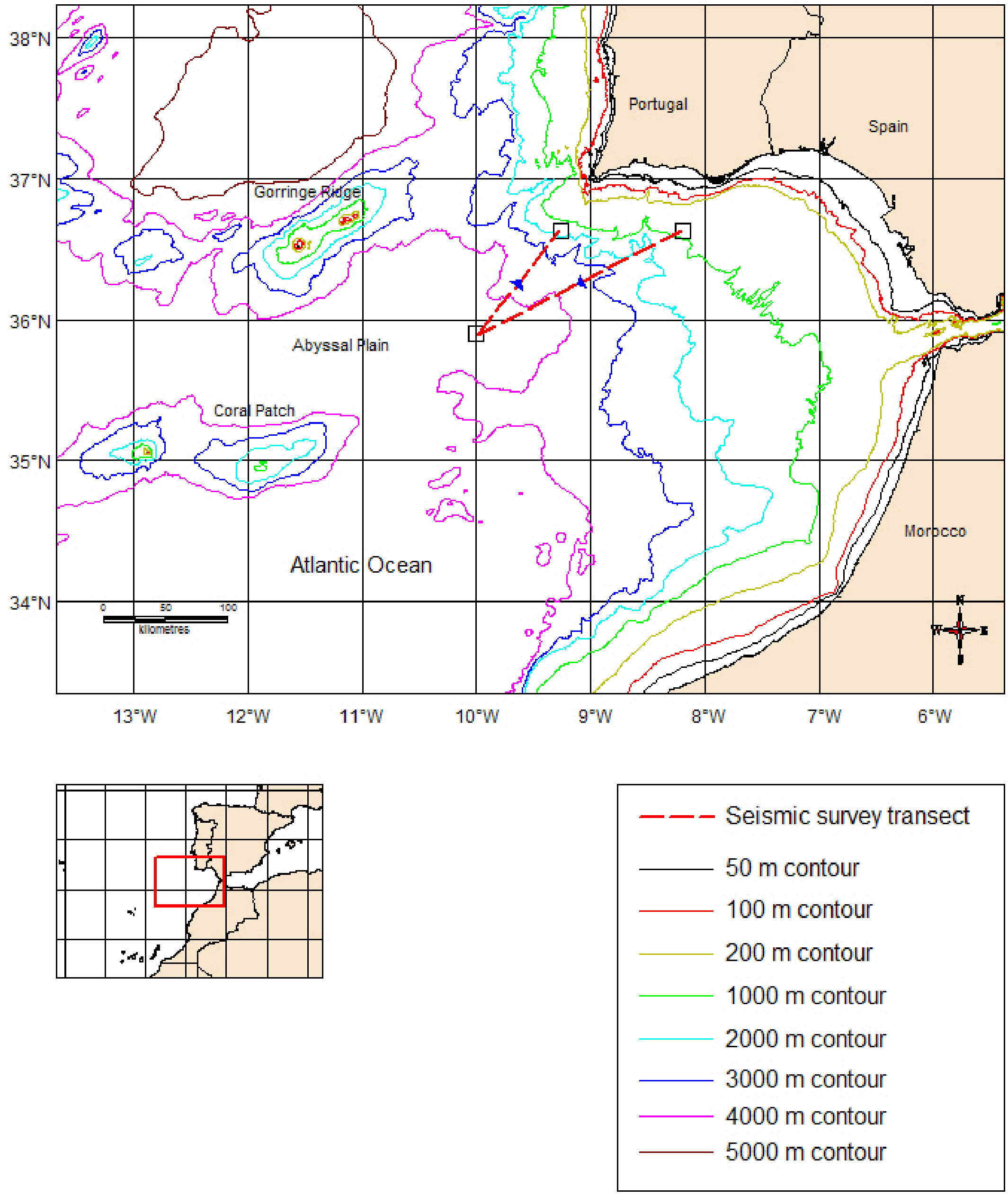


Figure 5.1 Gulf of Cadiz bathymetric features and location of the seismic survey line

5.3.2 Seabed geology

In the North Atlantic deep water, the seabed is covered almost entirely by fine-grained materials such as clay, silt and ooze. Coarser materials such as sand, gravel and shell occur over elevated features and in the region of the continental slope. This sedimentary layer has a mean thickness of between 300 m and 600 m but often exceeds 1000 m in the abyssal plains. In shelf regions, rock, gravel, sand, shell and estuarine mud all occur. Mud is rarely found as continuous cover but frequently occurs as the base material in depressions, or embedded with sand and gravel deposits. The narrow continental shelf off the coasts of Spain, Portugal and North Africa comprises a mix of sand and gravel. Some larger areas of this coarse grained sediment also exist around seamounts, such as, the Horseshoe seamounts north-east of Madeira and the Cruiser seamount south of the Azores.

The acoustic properties of the seabed are controlled by the physical properties of each geological formation, such as porosity, density and sediment grain-size. These properties are in turn controlled by the depositional environment. Unlike the overlying water column there is no seasonal variation. However, measurement of its acoustic properties is more complicated, with high spatial variability, and seabed geology is often less well defined than the oceanography. With reasonable knowledge of the geology of the region, it is nevertheless possible to predict with some accuracy the acoustic properties of the seabed.

5.3.3 Physical oceanography

Introduction

The oceanography of the North Atlantic is influenced by a generally clockwise ocean current gyre comprising the Canaries, North Equatorial and Florida currents together with the Gulf Stream and North Atlantic Drift. The oceanography of this region is also driven by the movement of deep water masses throughout the Atlantic, particularly the cold polar water and warm Mediterranean water. The coastal oceanography of the area is also affected by freshwater run-off from the many rivers that flow into it including the Tagus and Douro.

Currents

The North Atlantic is affected by a generally clockwise system of currents. The Gulf Stream, a narrow, high-velocity flow, separates the colder, denser water of the continental slope from the warmer, less dense water of the Sargasso Sea. The broad westward flowing North Equatorial Current feeds the Gulf Stream system from the south. As this current enters the Caribbean, it is reinforced by the South Equatorial Current. This current usually follows a direct route through the Gulf of Mexico to the Florida Straits, where it becomes more intense. As the Florida Current, it then flows northward from the Florida Straits to Cape Hatteras over the continental shelf. Along the coast of Florida the Antilles Current joins the Gulf Stream system. From about 33°N until it reaches the vicinity of the Grand Banks, the current is known properly as the Gulf Stream. Its width increases to approximately 150 km as it passes eastwards, south of the Grand Banks. Peak surface velocities exceed 2.5 m s-1, and appreciable current has been detected at depths greater than 2000 m. East of the Grand Banks the Gulf Stream becomes the more diffuse North Atlantic Drift. The cold Labrador Current travels south out of Baffin Bay and moves along the coast of Canada until it reaches Newfoundland where it branches off to the east and west before reaching the Gulf Stream. The cooler Canary Current flows south along the eastern side of the Atlantic, completing the clockwise circulation of the North Atlantic gyre.

Specifically in the Gulf of Cadiz, the current flow is predominantly ESE and of low constancy. Currents are mainly easterly towards the Strait of Gibraltar. The mean rate is ½kt in the west increasing to 1½kt in the east. During south-westerly gales, a current sets north along the Moroccan coast and across the entrance to the Strait of Gibraltar. A branch from this extends east through the strait. The current continues north along the coasts of Spain and Portugal before joining the north going current running off the western coast of Portugal. The current may attain 2 kt.

Water Masses

About 60% of the surface waters of the Northeast Atlantic are dominated by North Atlantic Central water, brought to the area by the North Atlantic Current. The remainder of the surface waters are influenced by cold fresh Polar water distributed by the East Greenland Current.

Between the surface and the deep/bottom waters is an intermediate layer where water masses from outside the area are present. South of Iceland, the warm and highly saline Mediterranean water entering the Atlantic through the Strait of Gibraltar exerts the most important influence. It has been identified at depths between 800 m and 1600 m as far north as 60°N and west to 20°W.

The majority of deep waters in the North Atlantic are derived from Norwegian Sea Deep Water, originating as surface water and sinking due to winter cooling. This dense cold water overflows, southwards, the ridges between Greenland, Iceland and Faeroes occupying depths below 2000 m in the North Atlantic. The deep bottom waters in the North Atlantic also consist of Sub-Arctic Bottom Water which seldom penetrates farther south than 50°N, Antarctic Bottom Water which traced as far north as 40°N and North Atlantic Deep Water originating in the Labrador and Irminger Seas.

Upwelling

The most important coastal upwelling areas in the North Atlantic are associated with the Canary Current off Morocco and the Iberian Peninsula Equatorial upwelling. Coastal and equatorial upwelling is a result of horizontal divergence of the surface waters, causing deep water to rise and become entrained in the surface mixed layer. The strongest and most persistent upwelling is associated with the easterly trade winds and the western margins of continents. Upwelling usually lasts for 6 months or less. Other coastal upwelling is associated with local offshore winds.

Eddies and cross-slope flow

As the Gulf Stream leaves the vicinity of the American continental shelf, it exhibits large meanders. These meanders pinch off and swirl around cores of warm or cold water in eddies extending down to the sea floor. Many large (up to 300 km across) cold-water rings can be found south and east of the Gulf Stream and a few smaller warm water eddies north of it. The rings rotate and move slowly toward the Gulf Stream. The cold water rings survive about three years; the warm-water rings typically last less than one year. The rings slowly lose the energy "stored" in the temperature difference between them and the surrounding water and are reabsorbed into the Gulf Stream itself.

Tides and shelf waves

Water in the North Atlantic circulates in a generally clockwise or anticyclonic direction due to Coriolis force. The bulk of the tidal energy generated in the North Atlantic is semi-diurnal in character with tidal ranges, generally at about a metre.

Offshore tidal streams are comparatively weak, but near land especially off salient points and in channels and estuaries they may be quite strong.

Sea waves are generated locally by wind and are very variable throughout the North Atlantic. Rough seas are a common occurrence during winter and tend to be significantly calmer in the summer months.

Internal tides, waves and mixing

Internal waves may occur wherever stratified water flows over bathymetric shallows, e.g. over isolated sandbanks and shelf breaks. Where the water movements are controlled by tides, the internal waves are of tidal period and are known as 'internal tides'. In stratified waters, the tides can generate internal waves that propagate along the interface between two layers.

Sound speed profiles

The sound speed profile at a given location is determined by local temperature, pressure and salinity conditions. These conditions vary hourly, daily and seasonally and of these variations, seasonal are the largest, particularly in temperate latitudes.

For the acoustic modelling described in Section 6, sound speed profiles are location specific.

5.3.4 Meteorology

In common with other ocean regions, the climate of the North Atlantic basin is dominated by the presence of a quasi-permanent sub-tropical system known as the Azores anticyclone, centred near 30°N, 30°W throughout the year. The circulation of the wind round the anticyclone drives a clockwise ocean current gyre comprising the Canaries, North Equatorial and Florida Currents together with the Gulf Stream and North Atlantic Drift.

The area considered in this EIA lies under the influence of the anticyclone with predominantly light and variable winds. In the west of the area, the weather is generally fine with little cloud. In the east of the area, the visibility is generally poorer owing to haze advected from ashore and occasional fog banks forming over the cold Canaries Current. There is also more cloud and rain, which is fairly common.

During April and May, the predominant wind direction is northerly with a mean surface wind speed of around 10 kt. Mid-spring marks the transition from the rainy period in winter to much drier conditions during summer. As a result, there will be some 20-30 mm of rain recorded each month with around 6 days recording 0.1 mm or more rainfall. Although fog is unlikely, it can sometimes be extensive and persistent especially close inshore. At sea, typical cloud cover is 2-3 oktas.

5.4 Biological Environment

5.4.1 Marine mammals

The following sections summarise the available information on the distribution of marine mammals on the continental shelf of the North Atlantic along the coastlines of Portugal, Spain and Morocco. The data has been gathered from Carwardine (1995), Harwood and MacLeod (2002)

5.4.2 Marine mammal distribution along the Eastern Atlantic Continental Shelf

A brief summary of likely distributions in the area is given below in Table 5-1. The table also show the classification (or status) of the various species as given by the World Conservation Union[5] (IUCN) Red List of Threatened Animals (IUCN, 2006).

Threatened species are listed here as ‘critically endangered’, ‘endangered’ and ‘vulnerable’, as the top three categories of at risk marine mammals, followed by ‘Lower risk: near threatened’ and ‘Lower risk: conservation dependent’. Two further categories exist for marine mammals which may be at risk but for which insufficient data exists (‘data deficient’) and ‘Status not listed’ which assumes species are not threatened.

The table shows that a total of 20 species of cetacean may be seen in and around the Gulf of Cadiz. Of these, 5 species are mysticetes and 15 are odontocetes.

No species of pinnipeds are known to be native to the waters off southern Portugal. However, wandering individuals from a total of 4 species may be seen in the region from time to time. These are the Grey seal (*Halichoerus grypus*), the common or harbour seal (*Phoca vitulina*), the Mediterranean monk seal (*Monachus monachus*) and the hooded seal (*Cystophora cristata*).

[5] Formerly the International Union for the Conservation of Nature and still known as the IUCN.

Species	Status	Distribution
Mysticetes		
Blue whale (*Balaenoptera musculus*)	Endangered	Prefer deeper waters but may be found along the eastern Atlantic continental shelf edge. More likely to be found here during the winter as they tend to feed in higher, colder latitudes in summer.
Fin whale (*Balaenoptera physalus*)	Endangered	Prefer deeper waters but may be found along the eastern Atlantic continental shelf edge. More likely to be found here during the winter as they tend to feed in higher, colder latitudes in summer.
Humpback whale (*Megaptera novaeangliae*)	Vulnerable	There is a major winter breeding ground for humpbacks along the coasts of Morocco, Western Sahara and the Canaries just south of 30ºN. Migrations occur through the eastern Atlantic from summer feeding areas in the Norwegian Sea.
Minke whale (*Balaenoptera acutorostrata*)	Lower risk: Near threatened	Found both on and off the shelf.
Sei whale (*Balaenoptera borealis*)	Endangered	Prefer deeper waters but may be found along the eastern Atlantic continental shelf edge. More likely to be found here during the winter as they tend to feed in higher, colder latitudes in summer.
Odontocetes		
Sperm whale (*Physeter macrocephalus*)	Vulnerable	Generally found in deeper waters but may be associated with submarine canyons.
Northern bottlenose whale (*Hyperoodon ampullatus*)	Lower risk: Conservation dependent	May be found along the coasts of Spain and Portugal but the Straits of Gibraltar are the southern extent of the range for this species.
Sowerby's beaked whale (*Mesoplondon biden*)	Data deficient	May be found in this area and the coast of Morocco is the southern extent of this range.
Cuvier's beaked whale (*Ziphius cavirostris*)	Data deficient	Rarely found close to the mainland except associated with submarine canyons or areas where continental shelf is narrow and coastal waters are deep.
Short finned and long finned pilot whale (*Globicephala macrorhynchus and G. melas*)	Lower risk: Conservation dependent and status not listed, respectively	The Moroccan coast is the extreme north of the range for the short finned species and the very south of the range for the long finned species, so there will be an overlap of the two in this area. Migrations may occur according to the abundance of squid.
Killer whale (*Orcinus orca*)	Lower risk: Conservation dependent	May be found here although killer whales tend to prefer cooler waters.
False killer whale (*Pseudorca crassidens*)	Status not listed	Tend to be found offshore but may occur along the shelf edge in this area.
Pygmy killer whale (*Feressa attenuata*)	Data deficient	Southern Portugal is the northern extent of the known range for this species.
Common dolphin (*Delphinus delphis)*	Status not listed	May be found throughout the eastern continental shelf area.

Species	Status	Distribution
Striped dolphin (*Stenella coeruleoalba*)	Lower risk: Conservation dependent	May be found throughout the eastern continental shelf area.
Rough toothed dolphin (*Steno bredanensis*)	Data deficient	This species is not particularly numerous anywhere but may be found on the continental shelf here.
Bottlenose dolphin (*Tursiops truncatus*)	Data deficient	Bottlenose dolphins are found both inshore and offshore.
Risso's dolphin (*Grampus griseus*)	Data deficient	Tend to prefer offshore deep waters but may be found along the continental shelf.
Harbour porpoise (*Phocoena phocoena*)	Vulnerable	Found in coastal waters in this area.

Table 5-1 Cetaceans on the Eastern Atlantic continental shelf.

5.4.3 Dive Profiles

Dive profiles of various species of cetacea and pinnipeda have been collected by various methods (e.g. tagging) in order to ascertain how great a depth marine mammals dive to and how long they stay underwater before resurfacing. Dive profile information based on Carwardine (1995) is shown in Table 5-2.

Species	Dive Profile
Mysticetes	
Blue whale	Blowing and diving patterns vary according to whale's activity. When relaxed, blows every 10 to 20 s for a total of 2 to 6 min, and then dives for 5 to 20 min (able to stay under longer). Probably dives to depths of up to 150 m but can go deeper.
Fin whale	Typically blows 2 to 5 times, at intervals of 10 to 20 s, before diving for 5 to 15 min (though can stay under for longer). Dives to depths of at least 230 m, deeper than blue or sei whales.
Humpback whale	Dives usually last 3 to 9 min (occasionally up to 45 min), followed by 4 to 8 blows at 15 to 30 s intervals. At breeding grounds, usually blows 3 to 6 times between dives. Humpbacks do not generally dive deeper than 120-150 m.
Minke whale	Typical dive sequence is 5 to 8 blows at intervals of less than 1 min, followed by a long dive, usually lasting 3 to 8 min, can stay underwater for as long as 20 min. Normally takes 1 to 2 breaths between dives when travelling. Does not dive to any great depth, less than a few hundred metres.
Sei whale	More regular dive sequence than most other rorquals and stays near the surface more consistently. Normally blows once every 40 to 60 s, though may blow every 20 to 30 s for 1 to 4 min, and then dive for 5 to 20 min. Shorter dives rarely descend deeper than a few metres, but longer dives can be down to 300 m.
Toothed whales	
Sperm whale	Can remain submerged for over 1 hrs, but typical dive time is about 45 min. Interval between dives may be up to 1 hr, but usually 5 to 15 min. Breathes at regular 12 to 20 s intervals. Whaler's rule of thumb: for every foot (30 cm) of its length, the sperm whale will breathe once at the surface and spend about 1 min underwater during the next dive. Typically dive to depths of 300-600 m, though some evidence suggests that they can dive to depths of at least 3000 m. Dive descent is at over 80 m per min.

Species	Dive Profile
Northern bottlenose whale	One of the deepest and longest diving cetaceans. Dives to over 1000 m and for 1 to 2 hrs have been recorded, but typical dive time without stress is 14 to 70 min. May remain on surface for 10 min or more, blowing every 30 to 40 s.
Sowerby's beaked whale	Spends about 1 min at the surface, with 4 to 6 quick breathes, followed by a long dive of 10 to 15 min; resurfaces up to 800 m away.
Cuvier's beaked whale	Dives typically last 20 to 40 min, possibly with 2 to 3 blows 10 to 20 s apart. A deep diver.
Long finned pilot whale	It generally takes several quick breaths and then submerges for a few min (feeding dives may last for 10 min or more). Capable of diving to at least 600 m, but most dives are 30-60 m.
Short finned pilot whale	Accomplished divers reaching depths of at least 500 m and can stay submerged for more than 15 min.
Killer whale or orca	A pod of orcas will typically dive synchronously. Residents breathing patterns consist of 4 to 5 short dives 10 to 30 s apart, followed by a longer dive of 3 to 4 min. Transients' behaviour is less consistent. Resting animals float on the surface, blowing slowly several times for a min, submerge for 3 to 4 min, then resurface in the same place.
False killer whale	No information available
Pygmy killer whale	No information available.
Common dolphin	Dives can last up to 8 min, but usually 10 s to 2 min.
Striped dolphin	Dives typically last 5 to 10 min. When feeding, dives to at least 200 m.
Rough toothed dolphin	May remain submerged for as long as 15 min.
Bottlenose dolphin	Dives rarely last longer than 3 to 4 min inshore, but sometimes longer offshore. Known to dive to depths of at least 300 m.
Risso's dolphin	Typically dives for 1 to 2 min, then takes up to a dozen breaths at 15 to 20 s intervals; can stay underwater for up to 30 min.
Harbour porpoise	While feeding, rises for breath at 10-20 s intervals, about 4 times in a row, then dives for 2 to 6 min. Dive times of up to 12 min have been recorded. While travelling, surfaces up to 8 times at 1 min intervals.
Pinnipeds	
Grey seal	Dives generally last for 4-8 min, although they can rest underwater and may remain submerged for up to 20 min. One trained seal dived to a depth of 225 m.
Common or Harbour seal	80-90% of their time is spent submerged and can dive to 400 m, although most dives are shallower than this.
Hooded seal	Accomplished divers spending >80% of their time submerged. May dive to 1000 m and can remain submerged for 50+ min. Average dives last for 5-15 min and are 100-600 m.
Mediterranean monk seal	No information available.

Table 5-2. Dive profile information for cetaceans and pinnipeds in the North Atlantic.

5.4.4 Breeding sites

No known breeding sites for cetaceans have been identified in the immediate vicinity of the location of the Gulf of Cadiz cruise. Breeding sites are known to occur further south off the Moroccan coast as well as further north in the Bay of Biscay.

5.4.5 Migration routes

Migration routes generally follow the continental shelf break at water depths of 200 – 300 m. In addition, a number of species of cetacean (e.g. fin whale, sperm whale and striped dolphin) are known to pass through the area en-route to the Strait of Gibraltar. It is observed from Figure 5.1 that although the shelf break is some distance to the north of the northern most point on the seismic survey transect, migrating cetacean my be encountered from time to time especially during the spring movements.

5.4.6 Characteristics of noise produced by marine mammals

Marine mammals rely on hearing and sound production for a variety of functions including communication, foraging, navigation and predator avoidance. Disruption of the hearing abilities of marine mammals could impair signals from vital sound cues and have important implications for survival and reproduction. For further details on the effects of underwater noise see Section 6.

Data on the hearing sensitivities of marine mammals are restricted to those species that can be kept in captivity, such as the bottlenose dolphin. However, for all species it is assumed that they are, at least sensitive to the sound frequencies of the vocalisations they use.

For some cetacean families, particularly the beaked whales (*Mesoplodon/Ziphiids*), information on their vocalisations is limited. Although there are some 20 species of beaked whales only the vocalisation of three of these species have been described: Cuvier's beaked whale, Blainville's beaked whale and the bottlenose whale.

Generally, it is assumed that the baleen whales have good hearing sensitivity to sounds of less than 1 kHz because they emit low frequency sounds. They also react behaviourally to low frequency sounds from conspecifics and man-made noise sources. The frequency ranges of baleen whale vocalisations, and therefore their assumed acute hearing sensitivity, are therefore included in Table 5-3 below.

The hearing sensitivity of odontocetes at low frequencies is generally poor. Their vocalisations, and hearing sensitivity, are mainly above 10 kHz. The upper limits of hearing sensitivity have been measured for some Odontocetes and range from 65 kHz to over 100 kHz. These species use high frequencies for echolocation and moderately high frequency calls for communication. The frequency ranges of baleen whale vocalisations, and therefore their assumed acute hearing sensitivity, are therefore included in Table 5-3 below.

Species	Signal Type	Frequency Range	Dominant Frequency	Source Level (dB re 1 µPa at 1 m)
Baleen whales (Mysticetes)				
Blue whale	Moans	12-100 Hz	16-25 Hz	195
Fin whale	Moans, downsweeps	17-40 Hz	20 Hz	160-186
Humpback whale	Song components Underwater blows Fluke & flipper slap	30-8000 Hz 100-2000 Hz 30-1200 Hz	120-4000 Hz - -	144-174 158 183-192
Minke whale	Thump trains	200-400 Hz	300 Hz	148-165
Sei whale	Frequency modulated sweeps	-	-	-
Toothed whales (Odontocetes)				
Sperm whale	Clicks	1-50 kHz	2-20 kHz	236

Species	Signal Type	Frequency Range	Dominant Frequency	Source Level (dB re 1 µPa at 1 m)
Northern bottlenose whale	Clicks	0.5-40 kHz	25 kHz	-
Sowerby's beaked whale	No Data	-	-	-
Cuvier's beaked whale	Clicks	35-45 kHz	-	-
Long finned pilot whale	Whistles Echolocation	1-8 kHz 20-100 kHz	1.6-6.7 kHz -	- -
Short finned pilot whale	Whistles Echolocation	0.5-20+ kHz 30-60 kHz	2-14 kHz -	180 180
Killer whale	Whistles Pulsed calls Echolocation	1.5-18 kHz 0.5-25 kHz 12-75 kHz	6-12 kHz 1-6 kHz -	- 160 180
False killer whale	Whistles Echolocation	- 25-120 kHz	4-9.5 kHz -	- 215
Pygmy killer whale	Growls, blats	-	-	-
Common dolphin	Whistles Echolocation	- 23-67 kHz	4-25 kHz -	140 -
Striped dolphin	Whistles	6-24+ kHz	8-12.5 kHz	-
Rough-toothed dolphin	Whistles Echolocation	- 5-32 kHz	4-7 kHz -	- -
Bottlenose dolphin	Whistles Echolocation	1.1-20.7 kHz 40-140 kHz	3.5-14.5 kHz -	125-173 218-228
Risso's dolphin	Whistles Rasp/pulse burst Echolocation	- 0.1-8+ kHz 65 kHz	3.5-4.5 kHz 2-5 kHz -	- - ~120
Harbour porpoise	Echolocation	100-160 kHz	-	135-177
Pinnipeds				
Grey seal	Clicks, hiss 6 call types knocks	- 0.1-5 kHz to 16 kHz	- 0.1-3 kHz to 10 kHz	- - -
Common or Harbour seal	Social sounds Clicks Roar	0.5-3.5 kHz 8-150 kHz + 0.4-4 kHz	- 12-40 kHz 0.4-0.8 kHz	- - -
Hooded seal	Grunt Snort Buzz	- - to 6 kHz	0.2-0.4 kHz 0.1-1 kHz 1.2 kHz	

Table 5.3 Underwater sounds produced by marine mammals found in the North Atlantic.

5.4.7 Fish (demersal and pelagic)

The North Atlantic supports two very different types of environment, the extensive areas of deep sea below 2500 m depth, and the limited but highly productive continental shelf. The commercially valuable fish species can be divided into those species which are highly migratory and those which undertake more limited movements in shallow coastal waters (<200 m). The most important commercial fish species off Spain, Portugal and Morocco include hake, blue whiting, horse mackerel,

mackerel and tuna which undergo extensive migrations as well as anglerfish, sardine and anchovy which do not.

Hake range from the coast of Morocco in the south to the north of the eastern Atlantic. It is a demersal predatory species found at depths of 30 to 500 m over both mud and sand substrates. Hake spawn in the area between December and April reaching a peak in activity during February and March off the north and eastern Iberian Peninsula. Further north hake spawn between March and July. Hake are closely related to cod and have a swim bladder.

Blue whiting are a migratory, oceanic species and two stocks have been observed in the north-east Atlantic, the northern stock from Porcupine Bank north and southern stock that are found from the Celtic Sea to the Portuguese coast. This species are known to spawn in the area along the shelf edge between March and April. Blue whiting have a swim bladder and pyloric appendages which are generally well developed.

Horse mackerel (or scad) undertake extensive migrations and spawn along the shelf edge between southern Portugal and the Celtic Sea. Spawning occurs between March and July, before the long migration north to the Norwegian coast and North Sea. Horse mackerel do not have a swim bladder.

Mackerel are also highly migratory and overwinter in deep water off the shelf edge. In late winter and early spring mackerel move towards the continental shelf edge to spawn between March and May. Mackerel have no swim bladder.

Tuna are oceanic and widespread but tend to follow generally well understood migration routes during the year. There is an important migration route in the Gulf of Cadiz and near Gibraltar. The principal species of tuna occurring in the Northeast Atlantic are albacore, bigeye, northern bluefin, yellowfin and skipjack. The albacore is known to breed in the mid-North Atlantic during the summer months and does possess a swim bladder.

Sardine or pilchard are abundant from the western English Channel to the Canaries and are found over the continental shelf out to the 150 m depth contour, but are more common in shallower (50-100 m) regions. Spawning occurs in the area on the central and southern Portuguese coasts practically throughout the year with peaks from September/October until March/April. Sardines have a swim bladder that is connected to the inner ear.

Anchovy inhabit coastal waters throughout the eastern Atlantic. This species spawns in the Gulf of Cadiz during late spring/summer with peak activity occurring between May and August. Anchovies have a swim bladder that is connected to the inner ear.

Although the precise impact of underwater acoustic activities on many fish species is not clearly understood, those with swim bladders may have an enhanced ability to react to acoustic disturbance and are more likely to swim away from the source of the disturbance. This reaction will have the most severe consequences when fish aggregate prior to spawning, but could also disrupt behaviour at other times of the year. For this reason, the locations of spawning grounds for the major commercial species (scad, pilchard and anchovy) have been identified so that this information can be used when planning acoustic trials. The known spawning grounds are shown in Figure 5.2. It is clear that other spawning grounds will exist throughout the region, particularly on the shelf, but only those known for the main commercial fish species have been mapped.

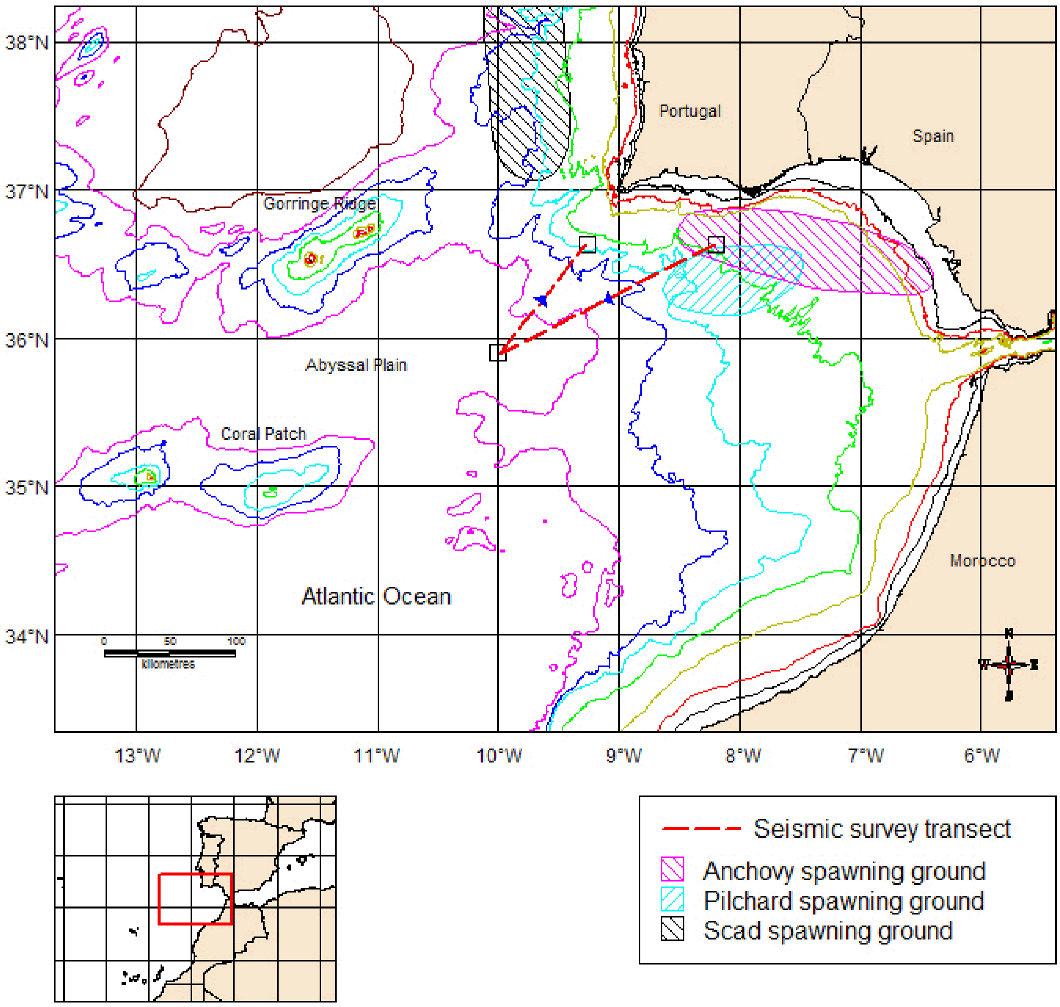


Figure 5.2 Fish spawning grounds in the Gulf of Cadiz during April and May

5.4.8 Turtles

Five species of sea turtle may be found in the waters of the North Atlantic. The green and loggerhead sea turtles are classified as endangered; and the hawksbill, leatherback and Kemp's Ridley turtles are all classified as critically endangered under the IUCN Red List of Species (IUCN, 2006). The hawksbill is seldom; seen, but the other turtle species can be found regularly in coastal and offshore waters.

The inshore waters of the Atlantic Coast are extremely important for the foraging and development of immature turtles. The distribution of turtles appears to be related to water temperature, with turtles tending to occur in waters with temperatures greater than 10°C. Turtle nesting sites therefore occur predominantly in tropical/sub-tropical regions, so nesting will not occur in the coast areas near the cruise site but may occur further south. A migration path for leatherback turtles has been identified close to the area in which seismic exploration will take place (see Figure 5.3).

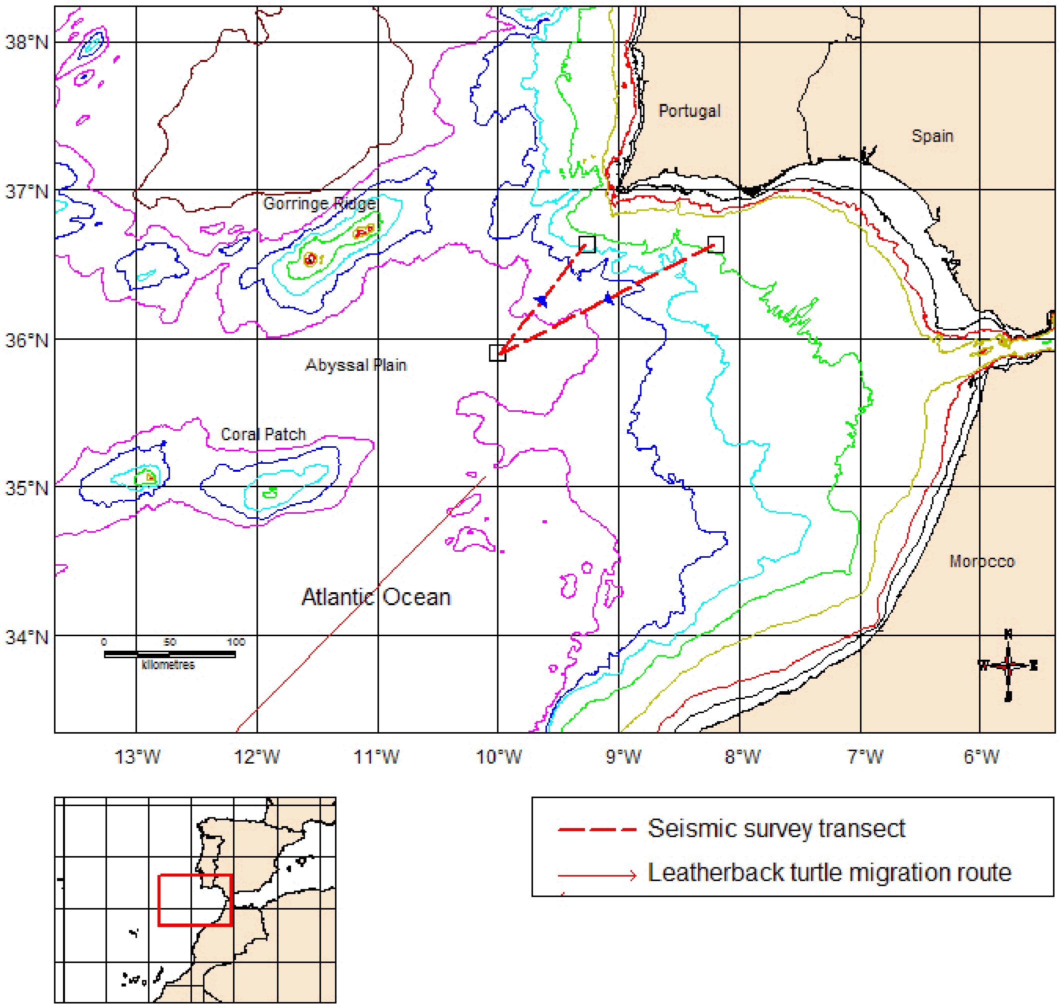


Figure 5.3 Sea turtle migration routes in the Gulf of Cadiz

5.4.9 Sea birds

The following information is based upon publications by Gubbay (1998) and Mondor *et al*. (1998).

Coastal habitats, including tidal waters, beaches, mudflats, saltmarshes and sand dunes are of major importance for birds. A recent analysis shows that 50 Species of European Conservation Concern (SPECs) use these habitats at some point in their lifecycle, out of a total 227 SPECs in Europe. Of these 42 have unfavourable concern status in Europe because they are declining, rare or highly localised. These include four globally threatened species: ferruginous duck, Spanish imperial eagle, slender billed curlew and Andouin's gull. Six other species have coastal habitats that have an unfavourable conservation status in Europe also have over half their global population in Europe including the near globally threatened pygmy cormorant. The region also supports large populations of seabirds including fulmars, petrels, shearwaters, cormorants, shags, skuas, gulls, terns, auks, seaducks and divers.

The species most vulnerable to disturbance by underwater noise are those which spend considerable amounts of time on or below the sea surface. Of those which dive, none spend more than a few minutes below the surface, and these diving species tend to spend the majority of their time airborne so are unlikely to be affected in significant numbers by short duration sounds. Other species such as shag, guillemots, razorbills and puffins spend considerable amounts of time on the sea surface, either individually or in rafts of large numbers of birds. These may be vulnerable to disturbance by seismic activity.

5.4.10 Invertebrates

Invertebrates are animals without backbones, and amongst the most important of these organisms in the marine environment are crustaceans and molluscs. Crustaceans are aquatic gill breathing animals, generally with a hard shell, including shrimp, lobster and crab. Molluscs are a large diverse group of soft-bodied animals, most living enclosed in a hard shell, including oyster, clam and mussels.

Benthos is that portion of the biomass which lives on or in the seabed. Habitats vary in type, from rock to soft mud, but also in terms of depth, temperature and light availability. Benthic animals are separated into two ecological categories based on where they live relative to the substrate. These are the infauna, living within the substrate, and the epifauna, living on or are attached to the seabed.

Shellfish are a very valuable resource in the shallow waters off the Iberian peninsular. The dominant species is the Norwegian lobster (*Nephrops*) which inhabits burrows in soft, muddy sediments at water depths between 15 and 800 m. Nephrops spawn during autumn and eggs hatch between March and July.

Species such as octopus, squid and cuttlefish are commercially valuable, particularly off the coasts of Portugal, Spain and North Africa. Octopus are important cephalopod species within the eastern Atlantic. The common octopus is widely distributed and found in a variety of habitats from the coastline to the continental shelf. The horned octopus is most commonly found in shelf waters between 60 and 150 m. Cuttlefish tend to live over sandy seabeds, at depths of less than 150 m, throughout the shelf in the eastern North Atlantic. Several species of squid are found in this area including veined, European, lesser flying and broadtail shortfin. Abundance and distribution of squid varies from year to year and is highly unpredictable.

Of the invertebrate life forms, it is assumed that those living on or above the surface of the substrate will be most at risk from damage due to seismic activities, as opposed to those living within the substrate. Some reports exist on the effects of sound from explosive charges on benthic animals. These studies have usually concluded that invertebrates such as clam, oyster and crab are highly resistant to shock (Gaspin, 1975), and that creatures were frequently unscathed unless they were within the immediate bubble pulse region of the charge. It can be expected that similar resilience will apply to electro-acoustic sound sources, and that unless sonars are operating in the immediate vicinity of organisms, it is unlikely that significant impacts would be made upon even local populations.

5.4.11 Plankton

Plankton are biological forms which have limited or no powers of locomotion, and thus are transported passively by currents. Plankton tend to be the smallest and simplest forms of marine life and are divided into two main types, phytoplankton (plant cells) and zooplankton (simple animals). Very little is known of the effect of sound on such small organisms. It might be expected that within the area immediately surrounding the airgun, plankton might be damaged or destroyed, but no recorded experimental results have been found. Due to the rapid replenishment of plankton populations, it is not expected that communities are likely to be significantly impacted.

5.5 Socio-economic environment

5.5.1 Fisheries

Information in this section has been taken from FAO (2005).

The fisheries in the North Atlantic target many species, particularly when the fish populations are aggregated for the purpose of feeding or spawning.

In the central North Atlantic, in the region of the Azores and Canary Islands the main fisheries resources are pelagic, and use handline and longline to target bream, bigeye and skipjack tuna, sharks, mackerel and sardinella. Many important fisheries target seasonal migration routes of these species and often remain fairly close to shallow water near islands and seamounts.

Fisheries inshore in the eastern Atlantic are dominated by species such as pilchard, anchovy, hake, mackerel and horse mackerel. Opportunities for exploitation of fisheries throughout the year are provided throughout the year particularly in the Gulf of Cadiz.

Further offshore seasonal fisheries for tuna are particularly important. There is an important migration route in the Gulf of Cadiz and near Gibraltar, which is exploited by fisheries. Bigeye tuna are targeted during spring and summer off the African coast.

Sharks, rays, skate and dogfish are all found in the North Atlantic and contribute to the demersal catches. Dogfish is fished and sold as rock salmon or huss, and skate (also known as thornback ray *Raja clavata* or common skate *Raja batis*) is also fished.

Long-term trends in abundance and changes in growth and maturation have been identified in the ray populations in the North Sea (Walker 1998). Although it is not possible to attribute these unambiguously to effects of fishing, there is certainly circumstantial evidence that exploitation has played a major role. The species composition of ray populations has changed in such a way that those species most sensitive to enhanced mortality (e.g. common skate *Raja batis*) have severely declined in numbers, while more resilient species (e.g. starry ray *Raja radiata*) have increased (Walker and Hislop 1998). Changes in growth and maturation have been ascertained for thornback ray *Raja clavata* and starry rays *Raja radiata* which are indicative of a decrease and increase, respectively, in density.

As the common skate has become virtually extinct, this catch supposedly consists largely of thornback rays *Raja clavata* and to a lesser extent of spotted *Raja montagui* and cuckoo rays *Raja naevus*. According to the surveys these three species have very limited distributions, which suggests that the fishery is able to maintain stable catches due to local strongholds in the population. Nevertheless, large areas have become void of the larger rays, which may be primarily caused by the extensive demersal fisheries in those areas.

Dogfish numbers are high due to its prolific breeding behaviour, this species being oviparous and laying it's young in egg cases. Two eggs are laid every 5/6 days during the breeding season between November and July and after 5-11 months (according to water temperature) the young hatch and are able to feed straight away on dead or small prey items. Angling records show the dogfish is more commonly caught in the Atlantic coastal areas than in the North Sea (Nevell, 2004).

The Common sawfish (*Pristis pristis*) is critically endangered or already extinct in the Atlantic. Smalltooth sawfish and wide sawfish (*Pristis pectinata*) are also reported to be critically endangered within the Atlantic Ocean (ICES, 2004), and overfishing as a bycatch are blamed for their decline.

5.5.2 Mariculture

Mariculture in Spain is particularly important on the north-west coast and mussels comprise around 90% of total production. Other species farmed include clams, carpet shells and oysters. Spanish fish farming grew rapidly from 1987 to 1996 mainly due to the development of turbot (OSPAR, 2000).

In Portugal mariculture occurs along the western and southern coasts, particularly in some of the more important estuaries. The Ria Formosa lagoon is particularly important for mollusc culture (OSPAR, 2000), namely clams, oysters and cockles. Fish are, however, farmed and the most important species are seabass, seabream and turbot with production of eel dramatically declining.

5.5.3 Shipping

The Atlantic, especially the North Atlantic remains the largest trading area in the world handling over 50% of trade (imports and exports), with the main cargo movements generated by the economies bordering the North Atlantic. Traffic separation schemes are in operation in many busy areas. In the region of interest, there is a scheme lying to the south of Cabo de São Vicente that separates shipping into westwards and eastwards lanes.

The approaches to the Straits of Gibraltar provide one of the main routes into the Mediterranean and to the Suez Canal (in order to reach Asian ports). The major ports in Morocco are Casablanca, Safi, Essaouira and Agadir; in Portugal are Lisbon, Sines and Porto and in Spain, Huelva, Vigo and La Coruna.

5.5.4 Military activity

There are large merchant shipping interests in this area, as more cargo is transported by sea than air. Protection of trade is the main interest and the Atlantic is a large route of incidental traffic, between the UK, the Mediterranean and US. The North Atlantic is also a major NATO exercising area, largely exercising protection of convoys. Vessels from any nations are likely to be found within this area.

Certain areas of the North Atlantic are likely to be used by the military for training and exercise purposes. Typical uses include submarine and surface ship movements, firing practice (marine- or land-based) and mine warfare activities. The Gulf of Cadiz from Cabo de São Vicente to Cabo Trafalgar is a submarine exercise area. Further details about this and other exercise areas may be seen on the relevant Admiralty Charts and Pilots.

5.5.5 Hydrocarbon and mineral exploitation

Hydrocarbon exploration

Over the last twenty years or so, the area to the south of Portugal has been licensed for seismic exploration in connection with the hydrocarbon industry. The results have been disappointing however, and currently, there is no known activity taking place. There are a number of wellheads and submarine pipelines in the Gulf of Cadiz close inshore. The exact locations of these may be determined from the relevant Admiralty charts.

Unauthorised navigation is prohibited within 500 m of platforms, structures and sub-sea production wells marked with buoys. These restrictions are in place for safety reasons, prohibiting fishermen or any other vessels entering such areas.

Mineral extraction and dredging

There may be some dredging activity around ports, aimed at keeping shipping channels clear. This activity is unlikely to occur outside port authority boundaries.

5.5.6 Cultural, historical and conservation areas

There are several Marine Protected Areas (MPAs) within the area of interest to this EIA, which are statutory and have been designated under different conventions, directives and acts. Sites in the region may be designated under International or EC Directives and Conventions, including World Heritage Sites (WHS), Biosphere Reserves, Special Areas of Conservation (SACs), Special Protection Areas (SPAs), Ramsar sites and Biogenetic reserves.

Through the UNESCO International Convention for the Protection of World Cultural and Natural Heritage (1972), protected areas known as World Heritage Sites (WHS) may be established. Not all of the sites designated under this convention are exclusively marine based, some are terrestrial and others are partially marine or coastal. Portugal, Spain and Morocco are all party to this agreement. No specific WHS have been identified as being located close to the Gulf of Cadiz.

The Convention on Wetlands of International Importance, otherwise known as the RAMSAR Convention, permits those countries party to it to establish RAMSAR sites. These sites include marine areas only where the depth does not exceed 6 m at low tide. Portugal, Spain and Morocco are signatories of this agreement. Two RAMSAR sites have been identified on the southern Portuguese coast, one on the Bahia de Cadiz in Spain and two on the NW Moroccan coast.

The Natura 2000 network of sites is an overarching European network of internationally protected areas which includes all designated SAC and SPA sites which have been formally accepted by the European Commission. SACs are designated under the EU Habitats & Species Directive and may be terrestrial, coastal or marine in nature; whereas SPAs have been designated in many countries under the EU Birds Directive. Twenty or more SPAs exist along the Atlantic coasts of Spain and Portugal.

Biogenetic reserves were set up during the 1973 European Ministerial Conference on the Environment to recognise a European network of reserves to conserve representative examples of European flora, fauna and natural areas. Five such reserves are evident along the coast of Portugal, one of which at the Ponta de Sagres, lies 75 km from the northern most point on the seismic survey transect.

The following section covers the marine protected areas set up under national legislation in Portugal, Spain and Morocco and is based on reports by Mondor *et al*. (1998), Gubbay (1998), Wells and Bleakley (1995) and on information from the World Conservation Monitoring Centre (WCMC) website www.wcmc.org.uk. The World Database on Protected Areas (WDPA) also provides a comprehensive dataset on protected areas worldwide, this is managed by UNEP-WCMC in partnership with the IUCN World Commission on Protected Areas (WCPA) and the World Database[26] on Protected Areas Consortium.

Figure 5.4 shows those marine protected sites in Portugal, Spain and Morocco for which positional data are available. Other sites have been designated, but without a reference point they cannot be mapped.

QinetiQ Proprietary

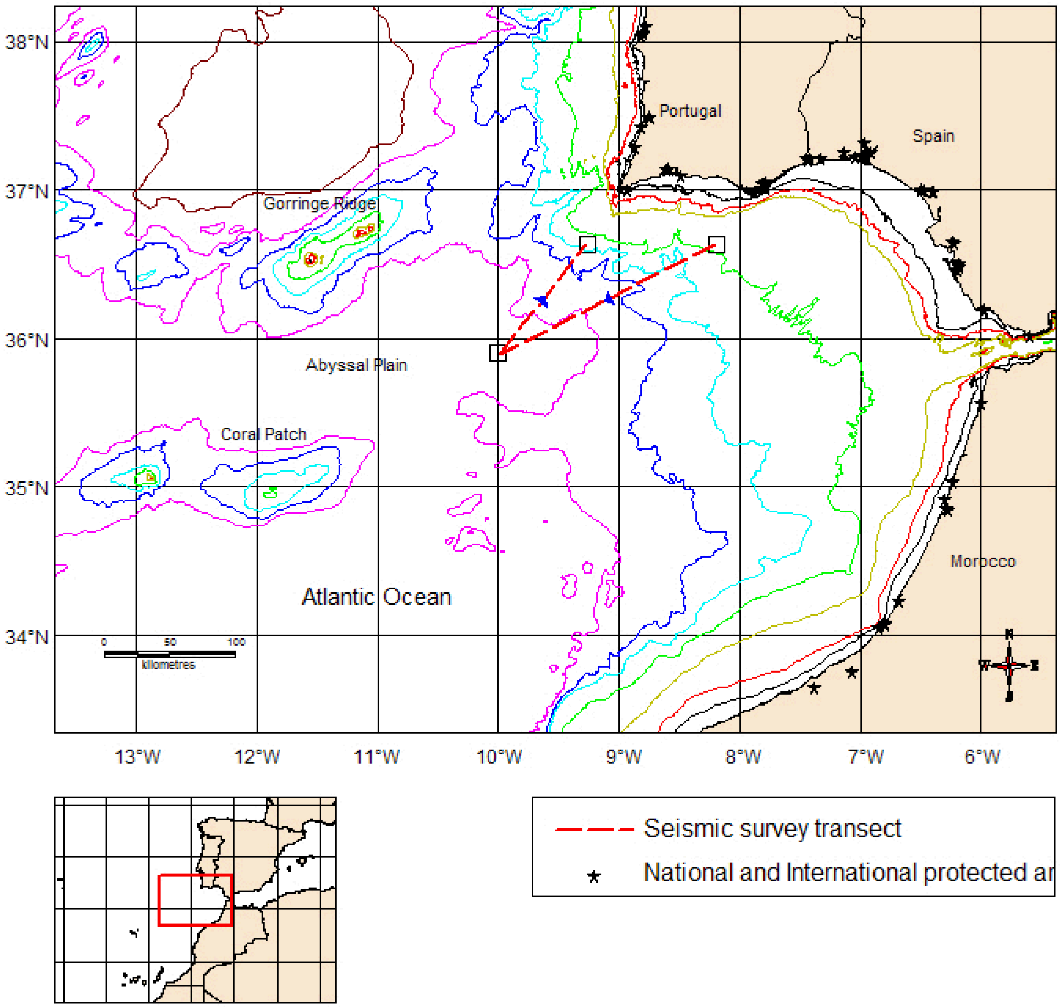


Figure 5.4 National and international legally protected sites around the Gulf of Cadiz

Portugal

Protected areas in Portugal can be set up under the National Parks and other reserves Act of 1970. These allow for the establishment of fourteen different types of protected area, but although many have been applied to coastal sites few cover marine areas. The Berlenga Nature Reserve covers the area around the islands of Berlenga and Estelas to a depth of 30 m and the Costa Vicentica e Sudoeste, Alentejano is another reserve on the Atlantic coast.

Spain

Responsibility for MPAs in Spain is the remit of the Ministry of Agriculture, Fishing and Food. Five types of protected can be set up under the Conservation Act. None are exclusive to marine areas, but the Act does specify that the provisions apply to areas of sea. Protection is implemented through the Shores Act and there are many coastal reserves, some of which include a small marine component. Donana and Acantilado are both national parks, which extend 1 nautical mile offshore.

Morocco

Morocco has designated two sites for marine protection; these are the Baie de Khnifiss Biological Reserve abundant in fish and important for migrant birds, and the

Merja Zerga Biological Reserve and RAMSAR site which is an important wintering area for birds. The first of these, however, is just south of the area of interest. Several other areas have been established as coastal protection sites.

5.5.7 Diving (commercial and recreational)

Recreational diving activities tend to be confined to waters less than 50 m in depth, although the limit set by Self Contained Underwater Breathing Apparatus (SCUBA) may be deeper. More adventurous sports divers may dive marginally deeper but this would be considered exceptional. Mixed gas breathing apparatus is becoming increasingly popular and can support divers at greater depths, however, it is highly unlikely that divers would be inhabiting waters deeper than 90 m. Recreational diving is therefore restricted to locations lying close inshore to the Portuguese, Spanish and Moroccan mainland coasts.

Although general diving regions have been identified within the EIA area, no specific sites have been highlighted due to a lack of data. It should be assumed therefore that divers might be present anywhere within the 50 m contour. Therefore, diving activity may occur around the central and southern coasts of Portugal and Spain as well as the northern coast of Morocco.

Commercial diving activity may occur in regions undergoing exploration for petroleum. When this arises, diving activity may take place down to depths of about 250 m.

5.5.8 Recreational activities

General

Water contact sports such as dinghy sailing, surfing, snorkelling, windsurfing, canoeing and swimming are popular along huge stretches of the coastline of the area. Of these activities, most occur in very shallow water and close to land, not more than a few kilometres from the coast. Any participants in the water are unlikely to be more than a few metres below the surface.

Recreational yachting, open water sports fishing and nature watching (seabird and marine mammal watching trips) occur in coastal and offshore waters, mostly over the continental shelf and within a few hours travel from coastal ports or marinas. Pleasure craft are often of fibreglass construction and underwater sound can be carried into accommodation areas below the waterline, which may extend to depths of several metres. External water-borne sound is usually only noticeable in craft which are under sail with no engine running, which is most likely to occur in open water. Sports fishing and nature watching craft usually have engines running and participants are unlikely to spend much time below the waterline.

Whale watching

Cetacean watching is a steadily expanding industry and a number of locations along the Portuguese and Spanish coasts offer opportunities to observe whales and dolphins. However, Hoyt (2001) states that there is considerable potential for whale watching off the coast of the Algarve and in the Gulf of Cadiz, but it is yet to be developed.

A number of Portuguese companies offer boat based sightseeing trips around the Sado Estuary south of Lisbon in order to observe the resident populations of harbour porpoises. By comparison, a considerable number of Spanish companies located around Cadiz and Tarifa offer excursions into the Gulf of Cadiz in order to observe more offshore based cetacean species such as pilot, sperm and fin whales.

The whale watching season is generally between May and October, dictated by the weather although the tours around the Sado Estuary take place throughout the year.

5.5.9 Whaling

Both Portugal and Spain are signatories to the International Convention for the Regulation of Whaling (ICRW) and as such, whaling is prohibited in Portuguese and Spanish waters. However, in international affairs, Morocco tends to adopt a neutral stance or even side with pro-whaling nations. Whaling is however, unlikely to occur in Moroccan waters.

5.5.10 Research and education

There are a number of marine research and education establishments located around the North Atlantic. Research work is often carried out under the auspices of a national body or of one of the universities active in marine science. Most civilian investigations in home waters are of fairly short duration, usually a few weeks or less, though stand alone equipment may be deployed for durations of several months, in both coastal and offshore areas. It is known that there are a number of Ocean Data Assimilation System (ODAS) buoys in the Gulf of Cadiz. The precise locations of these are given in the relevant Admiralty pilots.

Research into fisheries and fish stocks is undertaken in the Atlantic, particularly over the continental shelves by organisations such as the National Marine Fisheries Service (NMFS) and the International Council for the Exploration for the Seas (ICES).

Investigations into marine mammal distribution, stock sizes and behaviour may also be carried out in this region by organisations such as the Whale and Dolphin Conservation Society (WDCS) and for surveys such as the North Atlantic Sightings Survey (NASS).

Many world renowned research institutions from the UK, France, Portugal, Spain and Germany operate within this EIA area. Research is undertaken in applied ocean physics and engineering, geology and geophysics, physical oceanography, biology and marine chemistry. It is possible that other research programs are likely to be underway in the surrounding area, probably using underwater equipment.

5.6 Sources of acoustic noise in the marine environment

Acoustic noise is generated in the marine environment by a range of sources, which can be either anthropogenic or natural. The primary sources are shipping and wind, but wave action, rain, biological sounds and seismic surveying are also significant (Harland *et al.*, 2005). Acoustic noise occurs across a range of frequencies, from minor seabed earthquakes at about 1 Hz to dolphin vocalisations, sometimes as high as 200-300 kHz.

Generally there is a reasonably consistent background noise pattern at any given location, although ambient acoustic noise levels can vary because of the weather. This is due to the approximately time-independent distribution of long range shipping (merchant ships follow well defined routes) and other static sources (e.g. fishing or drilling activities). Intermittent noise includes airguns from seismic exploration, and marine fauna, primarily the vocalisation and echolocation of marine mammals.

5.7 Summary and conclusions

In relation to the aims of this EIA, this section has described the physical, biological and socio-economic attributes of the Gulf of Cadiz. Each of the sub-sections, as appropriate, has discussed elements of the environment on which sound is likely to have an effect; a full assessment of any significant, possibly adverse environmental effects is given in Section 6.

It is concluded that the data on the existing environments that have been assembled here are of a sufficient quality and have enough detail to achieve the objectives of the EIA. The biological data have been collated to provide information on fish, marine mammals, seabirds, plankton and benthic fauna. Although it is not possible to define absolute numbers of animals, the data give an indication of relative distributions. The range of activities that comprise the socio-economic environment is widespread and varied, but in most cases it is well documented.

Twenty-four species of marine mammal have been observed in and around the Gulf of Cadiz, some more regularly than others. This includes five baleen whale species (mysticetes), fifteen toothed whale species (odontocetes) and four species of pinniped. The endangered blue, fin and sei whales are seen from time to time. The critically endangered Mediterranean monk seal may transit through but is not resident in the area. Several other species of endangered and vulnerable cetaceans are also found within the Gulf of Cadiz.

The area is home to important commercial fisheries for many species, including, blue whiting, hake, mackerel, horse mackerel, sardine, pilchard, anchovy and (seasonally) tuna. Fish are considered to be most vulnerable to disturbance during their respective spawning seasons and thus spawning grounds for commercially valuable fish species are considered particularly sensitive.

Five species of sea turtle may occasionally be found in the Gulf of Cadiz: Kemp's Ridley, loggerhead, green, hawksbill, and leatherback. A possible nesting site for the loggerhead turtle exists off the coast of Morocco but this is far to the south of the area where the seismic activity will take place.

Socio-economic activities tend to be confined to coastal waters. Diving is likely to be a popular activity in these waters with the majority of activity being confined to sites less than 50 m deep, thus excluding much of the area. Recreational activities such as water sports and whale watching will predominantly be based around the coastlines of bordering countries. Protected sites have been designated under either international or national legislation within the area of interest, but the majority of these tend to be coastal in nature with a relatively limited marine element.

Section 8 describes in some detail the limitations of the information contained in the EIA for the purpose of assessing the physical, biological and socio-economic impacts in the areas considered.

6 Environmental consequences

6.1 Introduction

This section of the EIA describes and quantifies the acoustic impact of the MCS seismic arrays on the marine environment described in Section 5. Of particular concern is the potential for sound energy to impact on the marine biological environment and on elements of the socio-economic environment that depend on, or interact with the biological environment. The biological receptors that could potentially be affected are all flora and fauna that are in the water column at the time of transmission.

The potential for adverse environmental effects caused by acoustic emissions has been assessed by modelling sound emanating from the seismic array, transmission through intervening sound paths and potential impacts on a biological receptor.

Impulse modelling has been carried out using receptor body weights representative of those found in the waters of the Gulf of Cadiz. In addition, underwater acoustic propagation loss modelling has been performed using climatological environmental conditions representative of April and May and pertinent to the defined area of interest. Modelling has been performed for Sea State 0 (precautionary conditions). The climatological environmental data is considered adequate to scope the range of conditions likely to be met. However, the use of archived data from a region is rarely as satisfactory as having access to local measurements made at the time, and the calculated stand-off ranges (SORs) based on these environments, and presented in this EIA, may not necessarily represent exactly those met during the cruise.

Assessment of the likely acoustic impacts of the seismic source on the biological environment is a multi-parameter problem involving:

a. the estimated response to sound of each biological species,

b. the spatial and temporal distribution of environmental receptors within the environment,

c. those factors influencing sound propagation between the sound source and the organisms affected, and

d. the acoustic signal characteristics, distribution and the *modus operandi* of the transmitting source or sources.

Estimation of the distances over which sound energy may adversely affect marine life and human beings is therefore a complex issue, with considerable uncertainty in knowledge regarding several of the key processes. The limits in scientific knowledge concerning these processes are discussed in Section 8 of this Assessment.

Richardson *et al*. (1995) have drawn attention to the need to consider the statistical nature of information concerning the acoustic sensitivity and hearing thresholds of marine mammals, which in many cases is based on only a very limited set of observational data. The uncertainty in these data, when coupled with expected spatial and temporal variability in the undersea environments through which the sound propagates, means that the whole process of acoustic cause and effect modelling for EIA has a probabilistic as well as a deterministic aspect to it (Heathershaw *et al*., 1997).

6.2 Definition of sound source parameters

6.2.1 Introduction

For the purpose of assessing the array, sound emanating from two seismic airgun array configurations has been considered (see Section 2 for the background to this requirement):

a. the large MCS array,

b. the small MCS array.

The impact of the seismic airgun arrays on biological receptors depends on a number of parameters relating to the acoustic signal produced, including: peak pressure, impulse, total energy, peak to peak pressure and rise-time of the initial pulse. These parameters are assessed in this section based on data provided by University of Durham (Hobbs. 2007).

The impulse is defined (Richardson *et al.*, 1995) as the integral of pressure over time from the arrival of the leading edge. This has been approximated to the product of ½ the peak pressure and the duration of the first positive excursion.

The total energy in the pulse has been derived applying a Fast Fourier Transform (FFT) of the pressure-time histories. The energy density has been obtained from Equation 6.1 (Urick, 1983):

$$E = \frac{p^2 t}{\rho c} \qquad (6.1)$$

Where p is the pressure, t is the duration of the pulse and ρc is the acoustic impedance of the medium, ρ its density and c the speed of sound.

The total energy calculated in this way for both the MCS arrays may be compared with other airgun sources. This is shown in Figure 6.1 (after Verma, 1986) as a function of airgun capacity.

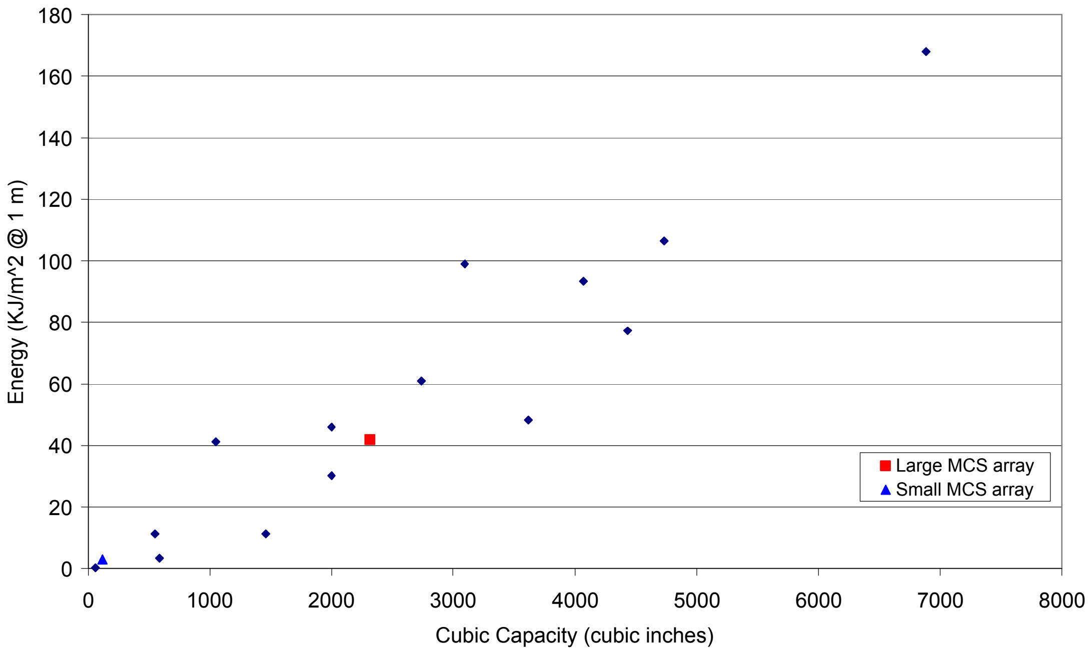


Figure 6.1 Total energy per pulse for a number of airgun arrays (after Verma, 1986). Also shown are values for the Large MCS and Small MCS arrays

6.2.2 Definition of the large MCS array

Information provided by University of Durham indicates a source level of:

- 254 dB re 1 μPa at 1 m peak-peak pressure;
- 248 dB re 1 μPa at 1 m zero-peak pressure;
- 229 dB re 1 μPa at 1 m rms pressure;

The impulse is approximately 8.3 x 10^5 Pa s.

The energy spectral density, derived by FFT analysis, is given in Figure 6.2a. The total energy is estimated at 45 kJ/m^2, this value is compared with that of other marine seismic energy sources in Figure 6.1.

6.2.3 Definition of the small MCS array

Information provided by University of Durham indicates a source level of:

- 249 dB re 1 μPa at 1 m peak-peak pressure;
- 243 dB re 1 μPa at 1 m zero-peak pressure;
- 218 dB re 1 μPa at 1 m rms pressure;

The impulse is approximately 1.8 x 10^5 Pa s.

The energy spectral density, derived by FFT analysis, is given in Figure 6.2b. The total energy is estimated at 3 kJ/m^2, this value is compared with that of other marine seismic energy sources in Figure 6.1.

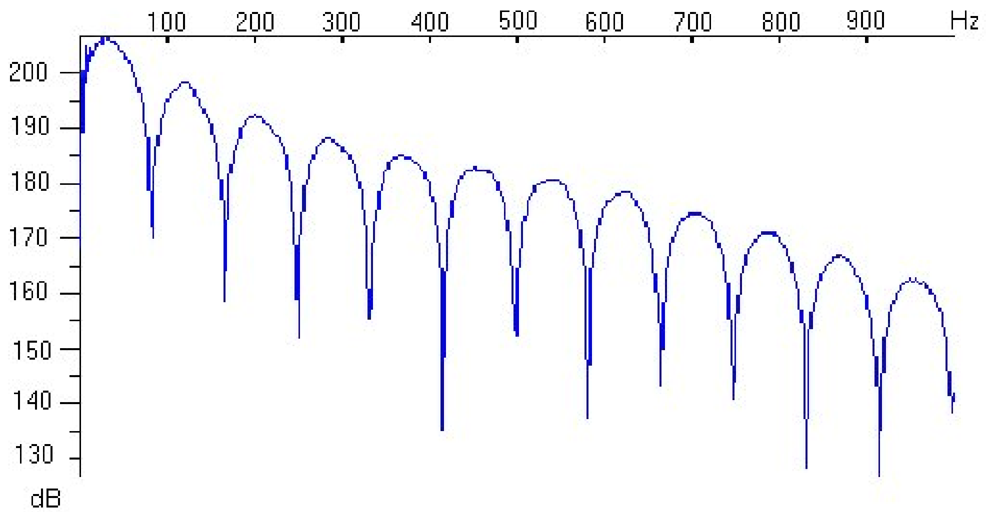


Figure 6.2a Amplitude spectrum for Large MCS airgun array

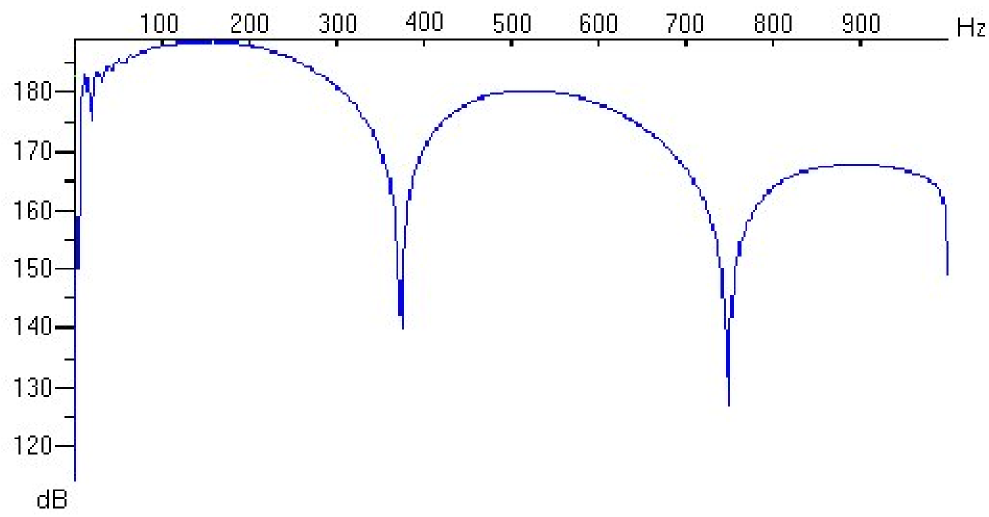


Figure 6.2b Amplitude spectrum for Small MCS airgun array

6.3 Thresholds of acoustic impact

6.3.1 Introduction

In order to assess the impact of sound on the animal species likely to be encountered in the marine environment, it has been necessary to define thresholds corresponding to various levels of severity of impact.

Thresholds for acoustic impact in fish, marine mammals and human beings have been developed by QinetiQ (see Heathershaw *et al*., 2001). Investigation of the effect of sound energy on human beings, sea mammals and fish reveals that consideration of the frequency, intensity and duration of the sound is required. It has been found that these three aspects can be brought together in terms of the concept of 'dosage', and Damage Risk Criteria (DRC) can thereby be developed.

6.3.2 Effects of duration of exposure, intensity and frequency of underwater sound

Research on damage to human hearing in air has resulted in DRC being established by a number of authorities in different countries, including the UK Health and Safety Executive (HSE). Calculation of the dosage, as defined by HSE, involves integrating the acoustic energy received by an individual human being over a 24 hr period, with the dosage being dependent on:

a. the total duration of exposure, and
b. the ratio (dB difference) between the received level and the threshold of hearing.

HSE guidance in the UK Noise at Work Regulations (NAWR) (HSE, 1989, 2005) and in particular the DRC contained therein, use the concept of sound exposure dosage to legislate against the likelihood of people at work being exposed to potentially harmful loud sounds.

The concept of sound dosage considers:

a. the intensity of sound,
b. the total duration of exposure, and
c. the frequency content of the sound.

It has been shown by QinetiQ (Heathershaw *et al.*, 2001) that these DRC can be applied to other species, such as cetaceans and fish, by utilising information on the threshold of hearing for each species in the appropriate medium (water), at the relevant frequency, and that the findings agreed with experimental data. The following sections explain how this concept may be extended to fish, marine mammals and human beings exposed to underwater sound.

6.3.3 Exposure of fish, marine mammals and human beings to underwater sound

The method developed to evaluate potential hearing damage, resulting from loud sounds generated in the marine environment, extrapolates NAWR DRC to the marine environment and utilises underwater audiograms for species likely to be affected. These audiograms are available only for a limited number of species. However, it is considered that the methodology is applicable to all hearing species that may be present.

The onset of Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) in fish, marine mammals and humans in the marine environment is dependent on the intensity of the sound to which an organism is exposed, its hearing response and the duration of exposure. In order to compute SOR from a sound source, a frequency dependent generic threshold curve (Figure 6.3) was produced, bounding the available audiograms and corresponding to the threshold of hearing of the most sensitive environmental receptor at any frequency.

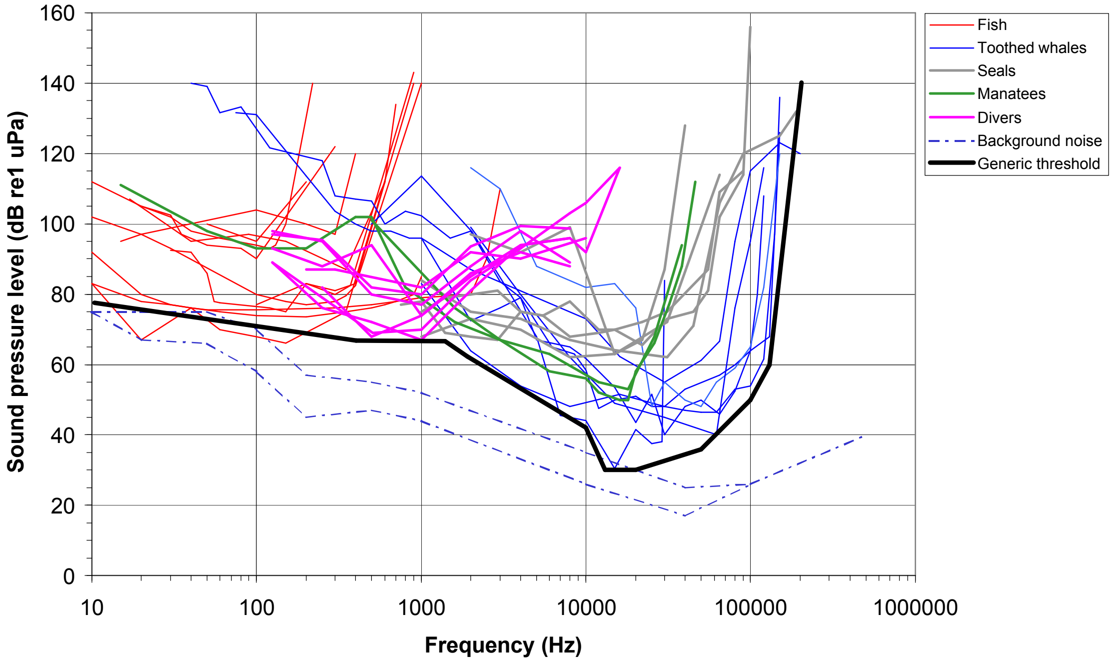


Figure 6.3 Summary of audiograms for sensitive species with upper and lower limits denoting the overall range of published measurements.

It can be seen from Figure 6.3 that no audiograms are available for baleen whales. However, it is known that some baleen whales vocalise at low frequency and it has therefore been widely assumed that they must have hearing capability at these frequencies (Richardson *et al.* 1995). Until data become available, it is assumed that baleen whales have sensitivity similar to the most sensitive fish. For the purpose of this assessment, a threshold of hearing of 70 dB re 1 μPa has been assumed at frequencies up to 500 Hz.

A number of in-water audiograms are available for pinnipeds. Species tested are harbour seals, ringed seals, monk seals, California sea lions and northern fur seals. The most sensitive hearing is at 1 kHz where the threshold is 66 dB re 1 μPa and this is also the value of the GTV at that frequency. In the event that specific protection is required for seals, it is recommended that a Generic Seal hearing curve be used based on the most sensitive of all the seal in-water audiograms. Alternatively, if the GTV is used to represent seal hearing, then this may be considered precautionary.

It can be seen from Figure 6.3 that audiograms for fish species vary widely, depending on the species of fish involved. As a general rule, fish with swim bladders tend to have better hearing than those without. For fish species with poorer hearing (including flatfish) the assumption of a 70 dB re 1 μPa threshold of hearing will be precautionary (see Section 4 for a discussion of the "precautionary principle").

The onset of PTS in fish, marine mammals or submerged human beings is possible at SPLs more than 95 dB above the threshold of hearing of the animal in question, for an exposure duration of 8 hours or more in any period of 24 hours. Similarly, the onset of TTS is possible for SPLs of 75 dB above the threshold of hearing, for the same exposure duration. The SPL at which onset of PTS and TTS may occur, increase as the sound exposure duration decreases. These SPL are, respectively, 10 dB below and 10 dB above an extrapolation of the UK NAWR DRC (HSE, 1989) to the marine environment, for total durations of exposure between 10 s and 8 hours. In common with the NAWR, these curves are equal energy curves (i.e. a ten-fold increase in duration of exposure produces a 10 dB decrease in threshold level).

6.3.4 Exposure of other species to underwater sound

Species other than those discussed in the above sub-section, including birds, reptiles (e.g. turtles and sea-snakes), and a variety of invertebrates (e.g. molluscs and crustacean) are liable to be in the water within the volume insonified by the airgun arrays. Data concerning the in-water hearing capabilities of these species are sparse and the effects of introduced acoustic energy cannot be directly determined. However, the adoption of a generic threshold audiogram caters, as well as can be expected, for all species whether or not an audiogram is available.

Although no complete audiograms are available for any species of turtles[28], it is known that they can hear low frequency (LF) sounds. It has been stated that "In the few cases in which LF hearing has been studied in sea turtle species, individuals tested showed low sensitivity to LF sound" (SURTASS, 2001). Several researchers have investigated hearing sensitivity in a variety of species of turtles (e.g. Ridgeway *et al.,* 1969; Lenhardt, 1994; Moein *et al.,* 1994), finding peak sensitivities between the frequencies of 100 Hz and 1 kHz. The US Office of Naval Research (ONR, 1998) report a behavioural study of a sixty-year-old green sea turtle's conditioned response to tones in the frequency range 100 to 500 Hz[6], indicating a hearing threshold between 107 and 119 dB re 1 μPa. Thus far, the few results available indicate that the sea turtle has a threshold of hearing not dissimilar to that of fish. It is therefore considered that adoption of the generic threshold curve is precautionary in the case of turtles.

Although there are no available audiograms for birds' in-water hearing capability, data are available for in-air hearing for a variety of bird species. A collection of bird in-air audiograms, collated by Ketten (1998), is illustrated in Figure 6.4. While the threshold of hearing shows considerable variation, they exhibit very similar frequency

[6] It should be noted that this study is not reported in a peer-reviewed, published paper.

range and indicate sensitive hearing for some bird species at the dominant operating frequencies of the airgun arrays. No audiograms specific to sea birds were identified, although there are no known grounds to assume that the hearing sensitivity of sea birds will significantly differ from the species included. Although the available audiograms are in-air audiograms, experience with other species suggests that the in-water audiological frequency range will be similar to the in-air frequency range and therefore exhibit only low sensitivity below 100 Hz.

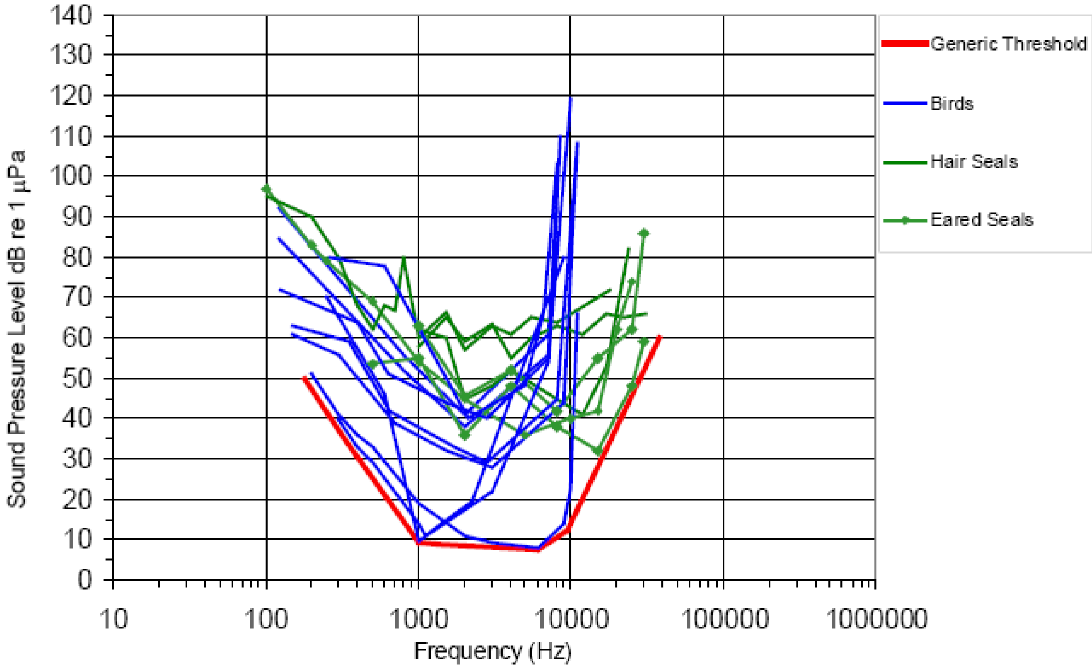


Figure 6.4 In-air audiograms for birds, hair seals and eared seals

At very high acoustic intensity, sound has the potential to be fatal to fish, marine mammals and man; the intensity at which this occurs depends on the frequency, duration and envelope of the sound. At lower sound intensities, the acoustic energy may still directly injure an organism's eyesight, hearing organs and the tissue surrounding gas-filled cavities. An organism may fully recover, if the injury is not too severe.

6.3.5 Application of dosage limits

Determining dosages likely to be experienced by environmental receptors is problematic in that receptors and transmitters are generally moving, resulting in variable sound intensity at the receptor over a period of time. All the sound received contributes to the total dosage and therefore application of a simple SOR requires careful consideration.

For generic cases, the equivalent daily dosage (*D*) for an individual (animal or human being) is given by:

$$D = 10\log_{10}\left[\frac{1}{28800}\sum_{t=0}^{t=24hr} 10^{\frac{SPL-GTV}{10}}\Delta t\right] \qquad (6.2)$$

where *SPL - GTV* is the difference between the *SPL* (dB re 1 µPa) in the water and the frequency dependent threshold of hearing (*GTV* – Generic Threshold Value (dB re 1 µPa)); *Δt* is the length of a single pulse in seconds; and the value of 28800 represents an 8 hr period, expressed in seconds, which is a normalisation constant in the NAWR DRC.

The GTV could be generic to all species (the black curve in Figure 6.3) or generic to similar species. It can be seen from Figure 6.3 that generic curves could be generated for several species groups whose audiograms are similar.

6.3.6 In-water acoustic impact thresholds

In order to establish safe distances for airgun operations from static sites (e.g. known fixed sensitive sites such as breeding grounds or MPAs – see Section 5), a generic threshold value appropriate to the species to be protected has been used. The generic threshold corresponding to the most sensitive hearing of all relevant species (including humans) is used when considering the monitoring zone around the airgun arrays (See Section 7 for discussions on monitoring). The generic threshold of hearing curve, discussed above, has been used in conjunction with a TTS dosage threshold of 75 dB and a PTS dosage threshold of 95 dB in order to estimate the dimensions of the monitoring zones.

The sound dosage depends on how the sound exposure (total energy) experienced by an animal accumulates during any 24 hr period, taking representative source distributions and movement into account. When considering distances from sensitive sites, the precautionary principle dictates that the concomitant threshold should be based upon the total duration of sound to be transmitted during any 24 hr period, and that the threshold of hearing of the most sensitive species that is identified for protection at the site be taken into account.

The PTS threshold and TTS threshold are given by Equations 6.3 and 6.4 respectively:

$$PTS\ Threshold = GTV + 95 - 10\log_{10}\frac{T}{28800} \tag{6.3}$$

$$TTS\ Threshold = GTV + 75 - 10\log_{10}\frac{T}{28800} \tag{6.4}$$

where *GTV* is the frequency dependent, generic threshold of hearing appropriate for the identified area; T is the total duration of exposure experienced by a receptor within a 24 hr period, as given by Equation 6.4.

$$T = \sum_{i=1}^{i=n} \Delta t_i \tag{6.5}$$

where $\Delta\ t_i$ (s) is the duration of the i_{th} pulse transmitted in any 24 hr period; *n* is the number of pulses transmitted in the 24 hr period; (If T > 28800, T should be set to 28800 in equations 6.3 and 6.4).

It can be seen that the range at which a receptor could be affected depends upon the receptor's total exposure duration during any 24 hr period. It may not always be straightforward to determine the duration of exposure to be considered when determining the SOR to be operated around the sound source.

The effect of airgun array movement can have a significant influence on the extent of the zone in which an impact may occur. If the airgun transmissions were made from a static vessel, the zone would increase with time. The extent of the zone will increase more slowly for an airgun array that is moving and (assuming that the receptor is stationary) will eventually reach a steady state that will depend on the mean speed of the vessel. The range calculated when platform movement is taken into account will always be less than if a stationary platform is assumed. The reduction in PTS range with ship's speed (relative to a stationary receptor) is potentially significant, although this benefit will be nullified for a receptor that moves with the platform (e.g. a bow riding dolphin). TTS ranges are generally much larger than those for PTS and the effects of platform speed on the calculation of TTS range are therefore relatively insignificant.

6.3.7 Non-auditory impact thresholds

A number of criteria have been developed to assess non-auditory impacts, including tissue shear and body vibration, resulting from impulsive sound sources.

In particular, models have been derived to estimate the potential lethal effects of underwater explosions on fish and other species. While not directly applicable to airguns (having a longer rise time than explosives), they provide a useful means of bounding the problem for powerful seismic sources (see later). For fish in particular, the model of Yelverton *et al.* (1975) would appear to be the most relevant. Yelverton's model distinguished between the effects of peak pressure and impulse, showing that organ damage is closely correlated to the positive acoustic impulse. This model has been used in this EIA. The model is most applicable in shallow water (producing conservative estimates as depth increases) and may be applied to fish with ducted or unducted swimbladders (but not fish without swimbladders, e.g. sharks).

Later work by Yelverton using submerged terrestrial mammals (Yelverton 1981, referred to in Richardson *et al.* 1995) extended these findings to a larger range of body masses possibly indicative of larger organisms e.g. sea mammals. Using these and the earlier Yelverton results, working expressions have been derived in metric units to represent No Injury, 1% Mortality and 50% Mortality cases. The resultant expressions relate the probability of injury to body weights (W kg) and the impulse (I Pa.s). The expressions are given below as Equations (6.6) to (6.11).

Fish 50% mortality $\log_e(I_{50}) = 5.8248 + 0.3201 \log_e(W)$ (6.6)

Fish 1% mortality $\log_e(I_1) = 5.2420 + 0.3201 \log_e(W)$ (6.7)

Fish No Injury $\log_e(I_0) = 4.1910 + 0.3201 \log_e(W)$ (6.8)

Mammals 50% mortality $\log_e(I_{50}) = 5.0100 + 0.3857 \log_e(W)$ (6.9)

Mammals 1% mortality $\log_e(I_1) = 4.5500 + 0.3857 \log_e(W)$ (6.10)

Mammals No Injury $\log_e(I_0) = 3.6800 + 0.3857 \log_e(W)$ (6.11)

These equations have been evaluated for a range of body weights and the results are listed in Table 6-1 and plotted in Figure 6.5 for each of the impact criteria. It should be noted that the thresholds for fish are much higher than those for terrestrial mammals of the same weight.

A note of caution is required regarding the application of the results of Equations (6.9) to (6.11) to marine mammals. In particular, and as noted by Richardson et al. (1995), the experimental data on which the models are based were "severely limited" because:

a. tests were based on submerged terrestrial mammals and not marine mammals,
b. tests were carried out in shallow water,
c. the range of animal sizes tested was limited,
d. tests considered only physiological damage evident upon necropsy.

Larson (1985) reports that mortality in the most sensitive animals occurs when the peak pressure is greater than 2.75×10^5 Pa and the rise time is less than 1 ms. For both the airgun arrays addressed in this EIA, the rise time is greater than 1 ms and therefore the criterion is not met. However, the peak pressure for the equipment considered in this EIA is greater than 2.75 x 10^5 Pa and the possibility of tissue damage should not be discounted.

Body weight (Kg)	Impulse Pressure for Fish (Pa.s)			Impulse Pressure for Marine mammals (Pa.s)		
	50% Mortality	1% Mortality	No injury	50% Mortality	1% Mortality	No injury
0.022	96.8	54.0	18.9			
0.05	130	72.5	25.3			
0.1	162	90.5	31.6			
0.2	202	113	39.5			
0.5	338	151	52.9			
1	423	189	66.1			
2	567	236	82.5			
5	708	317	111	279	176	73.8
10	883	395	138	364	230	96.4
20	1184	493	172	476	300	126
50		661	231	678	428	179
80				813	513	215
100				885	590	234
1000				2150	1360	569
10000				5230	3300	1380
50000				9730	6140	2574

Table 6-1 Impulse mortality criteria

The distances[7] at which the airgun impulse pressure equals the non-auditory impact criteria have been calculated for fish, marine mammals and humans of typical body mass. The impulse has been modelled as a shock wave decaying exponentially with range from the array and taking into account reflections of the impulse at the sea surface (Arons 1948; Roger 1977; Gaspin 1975; summarised in Richardson *et al.* 1995). In the case of the large MCS array and fish of body weight 1-2 kg, the 50% mortality impact criterion is met at a distance of around 131 m. For whales of body weight around 10000 kg, the No Injury impact criterion is likely to be met at distances around 15 m. For human divers of body weight 80 kg , the No Injury impact criterion is met at a distance of 270 m. Impact ranges from the small MCS array will be smaller.

It has been shown by a number of researchers (Parvin *pers. comm.*) that in the frequency range 15 Hz to 60 Hz, divers experience lung and body vibration when the received SPL is greater than 130 dB re 1 μPa. It should be noted that the experiments that support this data are based on longer duration pulses than those produced by the two MCS airgun arrays configurations.

[7] Distance is the slant range measured from the centre of the air gun arrays to the receptor

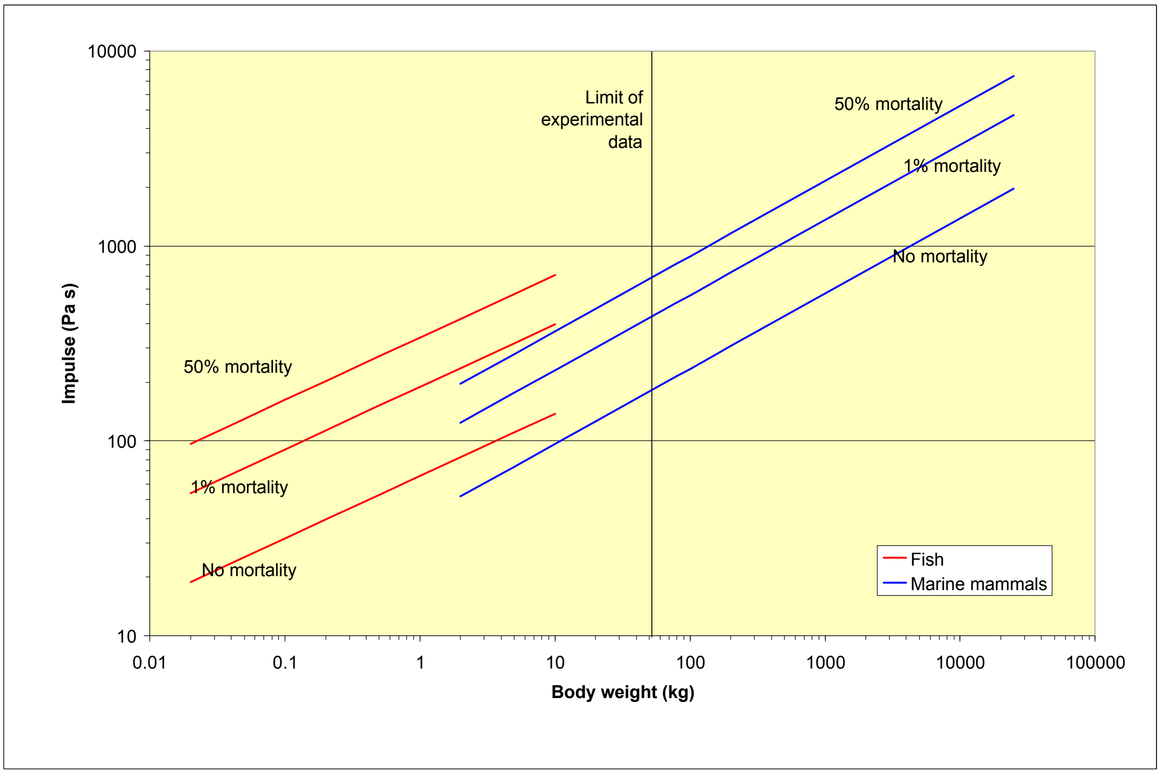


Figure 6.5 Impulse as a function of body mass for 50% mortality, 1% mortality and No mortality (No Injury)

6.3.8 Behavioural impact thresholds

The potential effects on the behaviour of marine mammals and fish that result from firings of the two MCS arrays are more difficult to determine than potential physical effects, because they are context dependent and must be statistically based. In particular the contribution to long-term disturbance is, with present knowledge, non-quantifiable.

Although researchers have reported the behavioural disturbance of marine mammals as a result of human activity or human presence, very few data are available on the specific corresponding sound levels. Richardson *et al.* (1995) state that 'almost all data on disturbance reactions, whether observational or experimental, have concerned short-term behavioural reactions.'

A marine animal may avoid an area immediately surrounding the airgun array if the sound is sufficiently disturbing. This (potentially short-term) disturbance to normal activities may result in disruption of feeding, breeding, social interaction and changes to diving cycles and other behaviour (Miller *et al.*, 2000; Clark *et al.*, 1999). Any such short-term behavioural responses may or may not be significant to the long-term well-being of individuals and populations. Equally, brief interruptions to normal behaviour can also occur as a result of natural as well as anthropogenic causes, and the effect of operating the seismic airgun array must be viewed in this context. Variations in responsiveness depend on the individual within the context of the environment and the animal's activities, thus making it impossible to define a single criterion of responsiveness.

It is possible that if fish were disrupted during the process of spawning, the opportunity to re-aggregate and continue spawning at a later date may not be available. Non-lethal disturbance outside the spawning season may alter the distribution of fish and possibly also influence commercial fishery catch rates. Little is known of the effect, if any, of acoustic energy on fish eggs and larvae in the water column during the spawning season.

In those cases where a response by marine mammals to acoustic disturbance has been detected, it usually involves a change in behaviour and movement away from the source. In most cases this will probably have little or no long-term consequence. Infrequent and minor changes in movement directions may be completely benign, while more frequent or recurrent incidents of interrupted feeding and rapid swimming, especially if of prolonged duration, could have negative effects on individuals or populations. In extremis, cetaceans may respond to loud sounds by beaching themselves, which usually results in death for the animal, often in a very public way.

A number of studies on behavioural impacts have been published in the open literature and these are discussed very briefly below.

There appears to be fairly strong circumstantial evidence linking the use of military sonar with some marine mammal stranding events (Joint Interim Report: Bahamas Marine Mammal Stranding, Balcombe and Claridge, 2001). At a meeting convened by the US Office of Naval Research and the US National Marine Fisheries Service Office of Protected Resources (Parvin, 2002), it was accepted that military sonar was responsible for a mass stranding of cetaceans in the Bahamas.

Other recent mass strandings appear to be coincident with military sonar operations. This includes the stranding of twelve animals in the Kyparissiakos Gulf, Greece, in May 1996, the stranding of five Cuvier's beaked whale in Puerto Rico, 1998, the stranding of four Cuvier's beaked whale on Madeira in 2000, and the stranding of nine Cuvier's beaked whale and three Blainville's beaked whale in the Bahamas, March 2000 and in September 2002, the stranding of beaked whales in the Canary Islands which has been linked to the military exercise Neo Tapon 2002 (Campbell, 2002). The report on the technical meeting that followed the Bahamas stranding (Parvin, 2002) recommended that:

> *"until more accurate guidance can be provided, the 'precautionary principle' that applies in Environmental Impact Assessment should ensure that beaked whales are not exposed to received SPLs in excess of 160 dB re 1 μPa".*

In a further development surrounding beached whales, Jepson *et al*. (2003) reported damage to the internal organs of a number of whales that had died following strandings. It is suggested the whales had suffered acute decompression sickness as indicated by extensive damage to the animals' internal organs, especially the liver. Two possible causative mechanisms were proposed. The first is that the damage was initiated by the acoustic excitation of nitrogen in the bloodstream, causing dissolved gas to expand rapidly while the second was that the sonar disturbed the whale so much that the animal surfaced rapidly and the resulting sudden change in pressure led to decompression sickness. These research findings are controversial and contradict the findings reported by Parvin (2002). A recent paper (Cole, 2005) suggests an alternative mechanism for damage to the animals' internal organs i.e. overheating or hyperthermia caused by modified behaviour of an animal trying to avoid a source of high intensity sound.

Although the emphasis here is on the interaction of cetaceans with military sonar, it is known that seismic surveys have also been implicated in beaked whale mass strandings e.g. Galapagos Islands, April 2000, Gulf of California September 2002 (Gentry 2002).

Gausland (2000) discussed the impact of seismic surveys on marine life and reported that fish were found to continue to swim towards active airguns whilst giving a short sideways skip as they traverse the acoustic pressure wave. Sound pressure levels were around 220 dB re 1 μPa peak-peak. Gausland stated that, in general, a behavioural effect thresholds is around 180-200 dB re 1 μPa peak-peak. Finally, he concluded that many of the reports on behavioural impacts caused by seismic surveys are difficult to compare since the measurement methods and units are not documented properly.

The characteristic momentary sideways movement by a fish as it is exposed to a high intensity acoustic wave was reported by Blaxter *et al.* (1981). It was subsequently described as a C-start response, an involuntary response where all the lateral muscles along one side of the fish contract and the fish darts off in that direction. Pearson *et al.* (1992) noted that the C-start response was apparent at received SPLs of 200 – 205 dB re 1 μPa mean-peak[8].

Richardson *et al*. (1995) define a zone of responsiveness as being an area around a sound source within which the marine mammals show observable behavioural response to that sound. Perhaps the most obvious manifestation of a behavioural disturbance is an avoidance reaction, and Richardson *et al.* classify these as being either strong or weak. A typical strong behaviour may be seen when pinnipeds stampede back into the water when blasting takes place close to their haul-out site and a weak reaction may consist of a course deflection by migrating whales as they swim by a sound source. Richardson *et al.* summarise the findings of a number of researchers by concluding that gray and bowhead whales generally avoid seismic vessels when the received SPL is between 150 and 180 dB re 1 μPa rms.

Mate *et al*. (1994) correlated changes in the distribution of sperm whales to seismic surveys in the Gulf of Mexico. Although no corresponding SPLs were given, the resulting analysis revealed that the whales remained further than 56 km away from the survey sites during firing operations.

Observations of marine life reacting weakly to seismic sound have been reported by McCauley *et al*. (1998, 2000). The subject of the first paper involved a seismic survey off the Australian coast and which made use of a 44 litre airgun array having a source level of 258 dB 1 μPa^2-m peak-peak. Avoidance reactions by humpback whales started when sound energy levels on the whales were around 159 dB 1 μPa^2-m peak-peak. The second paper reported more fully the behavioural impacts observed on whales, sea turtles and fish during the same seismic survey and also included a comprehensive report on the published literature available to date. From this a number of avoidance and behavioural impact thresholds were documented for humpback whales, sea turtles and fish. It is noted that the context of the avoidance reaction is often difficult to determine. In one study, when the seismic vessel approached a pod of humpback whales, avoidance reactions were observed at perceived SPLs on the whales of 140 dB re 1 μPa rms. However, humpback whales were seen to approach an airgun array while enduring SPLs up to 179 dB re 1 μPa rms. These sounds are put into context when McCauley *et al*. (2000) remarks that naturally occurring sounds such as whale vocalisations and fin slaps generate SPLs up to 192 dB re 1 μPa peak-peak.

---

[8] Mean-peak level is defined as the mean of the sum of maximum positive and absolute value of minimum negative pressure values (McCauley *et al.* 2000)

In addition, McCauley *et al*. (2000) noted observed reactions among a green sea turtle and a loggerhead turtle exposed to seismic sound. Behavioural impacts were observed at level of 166 dB re1 μPa, while above 175 dB re 1 μPa, the animals' behaviour became erratic, suggesting that this may be an appropriate avoidance level.

Finally, McCauley *et al*. (2000) discussed the results from a number of studies which showed that fish underwent behavioural changes at SPLs in the range 156-161 dB re 1 μPa, with avoidance occurring at higher levels.

These results from the literature search suggest that a number of impact thresholds may be tentatively established for whales, sea turtles and fish; these are given in Table 6-2. It must be noted that while gray and bowhead whales are not normally found in the Gulf of Cadiz, the thresholds to the impacts given in the table may be reasonably applied to baleen whales in general, especially as specific data on impacts relevant to those species indigenous to the north east Atlantic Ocean, e.g. blue, fin, minke and sei whales, are not available.

Animal	Impact	Threshold
Humpback whale	Avoidance	159 dB 1 ®Pa^2 peak-peak
Gray whale	Avoidance	150-180 dB 1 ®Pa rms
Bowhead whale	Avoidance	150-180 dB 1 ®Pa rms
Sea turtle	Behavioural	166 dB 1 ®Pa
	Avoidance	175 dB 1 ®Pa
Fish	Behavioural	156-161 dB 1 ®Pa rms
	Avoidance	161+ dB 1 ®Pa rms

Table 6-2 Impact thresholds selected from the published literature

The advice given in Section 5 of this EIA shows that in the shallower water region of the Gulf of Cadiz, fish and sea turtles may be at greater risk from the seismic sound source. In the deeper water, audiological impacts are likely to be mainly on baleen whales while all marine mammals are likely to be susceptible to impulse damage.

It must be noted that several of the thresholds given in Table 6.2 are expressed in terms of a "root-mean-square" pressure. Richardson *et al.* (1995) state that it is difficult to compare such values with peak-peak measurements for any waveforms other than ideal sinusoids and this therefore clearly excludes airgun array signatures. Hence the only non-audiological impact that can reliably be applied is that of the avoidance threshold for baleen whales at 159 dB 1 μPa^2 peak-peak. Consequently, only stand-off ranges for this impact criterion will be determined.

6.4 Required propagation losses

In terms of propagation loss, the PL required for each of the impact criteria discussed above are as given in Table 6-3 below.

	Propagation Loss (dB)	
	Small MCS	Large MCS
PTS(30)	45	49
TTS(24)	82	86
Avoidance	90	95

Table 6-3 Propagation loss required

6.5 Acoustic propagation modelling

6.5.1 Introduction

As explained above, assessment of the likely acoustic impacts of sound generated by seismic airgun arrays involves a wide range of parameters and processes. Modelling of acoustical environments in this EIA has been performed in-water in order to determine the levels of acoustic energy likely to be experienced by biological receptors in the vicinity of the array. The path travelled by the sound between source and receptor is a function of the environment and the location and depth of both the source and receptor. The level of acoustic energy experienced by a receptor in the region of the array depends on the source level and the Propagation Loss (PL) between the array and the receptor.

Numerous computer models are available to predict acoustic propagation in the marine environment. Each model has its own strengths and weaknesses in terms of input requirements and calculation methods, but all include some form of description of various environmental parameters, such as the water column sound speed profile (SSP) and sediment acoustic properties.

For the purpose of this EIA, acoustic modelling was undertaken using the program RAM embedded in ENGINE32® (2006). RAM is range-dependent in oceanography and in sediment properties and several sediment layers may be included. For the purpose of modelling in this EIA, range-independent sediment modelling was carried out because the detailed structure and variation in seabed type was not known at the trial locations. Engine32® is a proprietary computer program which allows for the easy implementation of environmental data. The geoacoustic model is restricted to a water layer overlying a fluid sediment which in turn, overlies a rock basement. Although it is necessary therefore to simplify the complex sedimentary structure (discussed in Section 5), it may be considered that, over the frequency range considered, this does not introduce substantial errors into the propagation process. At the lowest frequencies and therefore the longest wavelengths, the sedimentary layers are very transparent to acoustic energy. However, at the lowest frequencies, acoustic propagation in the water column is less effective. At higher frequencies, the structure of the seabed becomes more important, but less energy is transmitted by the seismic arrays at higher frequencies (see Figure 6.2a, 6.2b)

6.5.2 Oceanographic data

During the Gulf of Cadiz cruise, two transect lines will be surveyed using the large MCS array and three sites along the line will be examined in high resolution using the small MCS array. The start of the first transect line and the end of the second will be in relatively shallow water, while the end of the first transect and start of the second will be in deep water. Sound velocity profiles for the month of April for each of these locations are given in Figure 6.7. The sound speed profiles for May were found to be very similar to those for April so only those for the earlier month are illustrated.

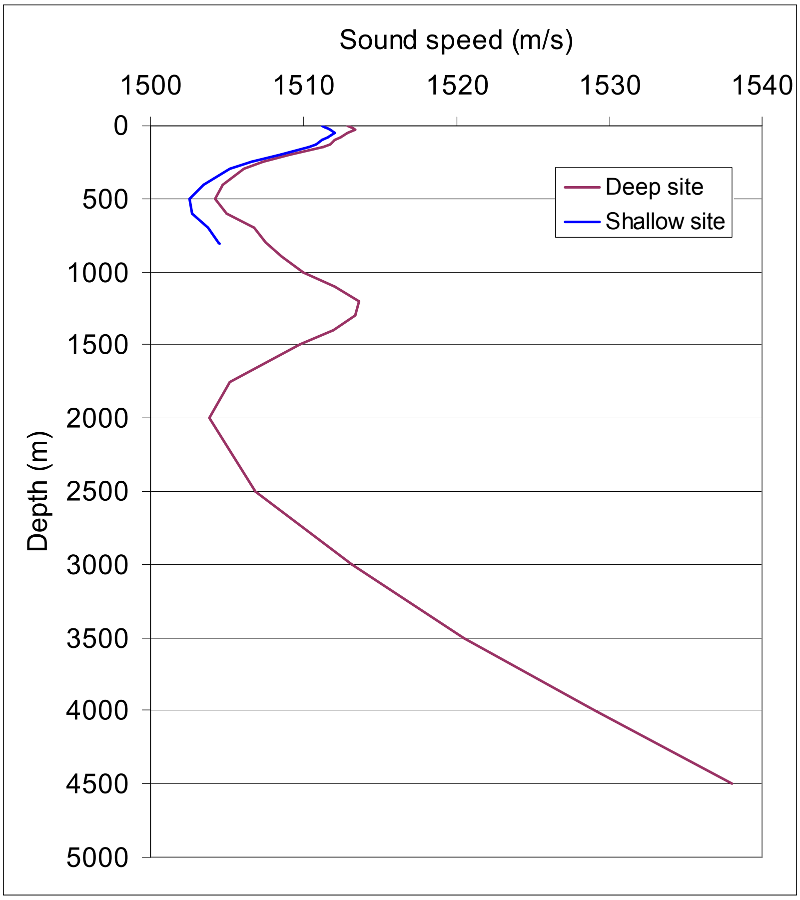


Figure 6.7 Sound speed profiles taken from along the seismic survey transects

At the deep site, the surface duct extends to a depth of 30 m. Below this, there is a strong sound channel at an axis depth of 500 m and an additional strong channel at 2000 m. The seabed is at a depth of 4600 m. In addition, there is the potential for Convergence Zone (CZ) propagation.

Both the airgun arrays are deployed at depths of less than 10 m with the result that they lie within the surface duct. Although the main beam of the seismic signal is directed downwards, the energy contained within the side-lobes has the potential to propagate over considerable distances. However, this is offset by the fact that the transmitted energy contained within the side-lobes is much less than in the main beam.

6.6 Modelling results

Using RAM embedded in ENGINE32®, acoustic propagation modelling was carried out for the dominant frequency for each airgun array of 20 Hz. Ranges to a number of acoustic impact criteria identified above were subsequently calculated. The results are as follows:

a. For an exposure duration of 30 min, the distance from the small MCS array within which PTS is likely, is approximately 180 m.

b. For an exposure duration of 24 hours, the distance from the small MCS array within which TTS is likely, is approximately 15 km.

c. For the small MCS array, the distance over which the avoidance criterion is likely to be met is 27 km.

d. For an exposure duration of 30 min, the distance from the large MCS array within which PTS is likely, is approximately 280 m.

e. For an exposure duration of 24 hours, the distance from the large MCS array within which TTS is likely, is approximately 25 km.

f. For the large MCS array, the distance over which the avoidance criterion is likely to be met is 58 km.

6.7 Summary

The potential impact of exposure to sound from the seismic airgun arrays during the Gulf of Cadiz cruise on marine mammals, fish and sea turtles has been considered by modelling underwater acoustic propagation.

At very close range, the impulsive waveforms from the airgun arrays have the potential to be fatal to fish and marine mammals. Outside this range, injury caused by the acoustic energy, may damage the swim-bladder, eyes and sensory organs of a fish, making it unable to feed and susceptible to predation. Sea mammals have gas-filled lungs and airways within the body that may resonate following exposure to sound from the airgun array and they may also be damaged by the peak pressures subsequently transmitted.

6.8 Conclusions

From the discussions in the preceding sections, it has been shown that the potential negative impact of both the large and small MCS airgun array transmissions may be described qualitatively using a range of criteria.

a. The underwater impulse from the airgun arrays has the potential to be lethal, or will cause severe injury, to a submerged diver or swimmer within a range of 270 m. To whales, the impulse will be lethal at distances less than 15 m. For fish of body weight 1-2 kg, the 50% mortality impact criterion may be met at distances up to 131 m.

b. The PTS impact criterion is met at a maximum distance from the large airgun array of 280 m.

c. The TTS impact criterion is met at a maximum distance from the large airgun array of 25 km.

In conclusion, Section 6 has put forward a number of impact criteria and distances to impact criteria which are applicable variously to fish, marine mammals and humans. The next section explains how this data should be used as part of the mitigation and monitoring strategy to be put forward for the Gulf of Cadiz cruise.

7 Environmental risk mitigation guidelines

7.1 Environmental risk mitigation measures

The following sub-sections describe a range of mitigation techniques which will reduce the potential for sound emanating from the airguns having an adverse effect on environmental receptors. There are no formal regulatory requirements for mitigation and the advice provided here is based on best practice. The recommended techniques are as follows:

a. environmental protection planning;

b. monitoring; and

c. modification of airgun activity.

7.1.1 Environmental protection planning

The location and extent of the seismic survey area has been defined in order to achieve the research objectives of the Gulf of Cadiz cruise. The timing of the survey has been constrained by the scheduling of key resources, specifically the *RRS Discovery*.

Section 5 of this report has identified that there are likely to be marine mammals in the area at the time of the survey. Divers and swimmers are likely to be present in the shallow waters close to the shore of Portugal. In addition, there are a number of sensitive sites on the Portuguese coast adjacent to the survey area. Section 6 has provided a quantitative assessment of the distance from the airgun at which potential adverse effects may occur. The use of a buffer zone around sensitive sites (based on the distance to the TTS impact criterion, 25 km) is recommended as illustrated in Figure 7.1. It will be seen that the seismic survey transect lines lie clear of the buffer zone which itself extends 25 km from the coastal based sensitive sites.

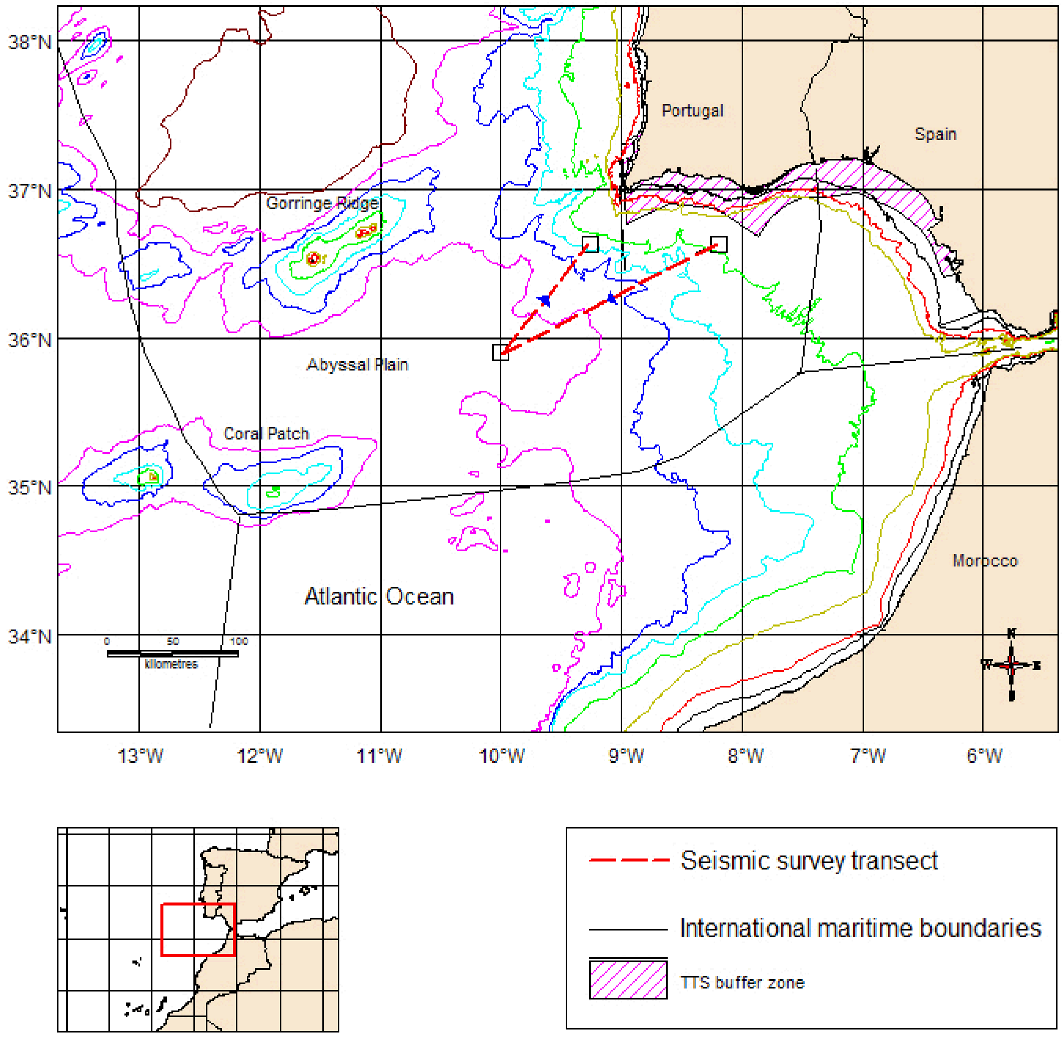


Figure 7.1 Buffer zone around coastal sensitive sites, based on TTS impact criterion

A proportion of the acoustic energy produced by the airguns will propagate horizontally and has the potential to adversely impact on marine mammals, fish, turtles and humans. To minimise the potential impact on human swimmers and divers, the following precautions should be taken to ensure that the local community is aware (as far as possible) of the activity:

a. Notices to Mariners should be issued prior to the cruise; and

b. radio communications and other signals, as appropriate, should be broadcast prior starting-up.

Environmental protection planning provides a strategy for dealing with environmental receptors and other issues that are of a 'fixed' nature; for example, breeding grounds and sanctuaries. However, many of the environmental receptors listed in Section 5, particularly marine mammals, will occur away from these largely coastal sites, and a strategy is needed for protecting animals that are encountered under 'open-ocean' conditions, or which approach the research vessel at other times. This requires visual and possibly acoustic monitoring protocols to be in place during the operation of the airguns.

7.1.2 Monitoring

The Gulf of Cadiz cruise has the potential to cause disturbance and possibly harm to marine mammals, fish and turtles. Divers and swimmers may also be at risk if allowed to approach too close to the airguns, when they are operating, but it is assumed that this risk will be dealt with through existing shipboard safety procedures (NERC, 2005).

Monitoring for the presence of marine animals considered to be at risk is an essential component of any mitigation strategy. Monitoring can identify animals that may be exposed to high intensity sound and/or impulsive effects (depending on the source of the acoustic energy) and it is most effective when combined with 'ramp up' and 'shut down' airgun operating protocols, described later in this section. Monitoring should take into account the fact that marine mammals, particularly whales, may be diving in the area and surfacing infrequently.

Monitoring for the presence of fish (in large numbers), although technically feasible is impractical in the context of the research cruise and measures to protect these species are best confined to avoidance of spawning grounds (where known) and limiting disturbance to fishing activities (commercial or artisanal). Large fish (e.g. tuna, sharks) may be seen throughout the cruise.

Of greatest importance during the Gulf of Cadiz cruise will be monitoring for the presence of marine mammals and sea turtles particularly those animals that may approach within the distances specified in these mitigation guidelines. Monitoring options include:

a. visual monitoring;

b. passive acoustic; and

c. active acoustic monitoring techniques.

The effectiveness of the various methods is discussed in the following sections. The assessment of visual monitoring requirements is based on the JNCC guidelines (JNCC, 2004).

Visual monitoring

Visual monitoring for marine mammals can be a simple and reasonably effective method for detecting animals at the sea surface in daylight hours. In addition to monitoring for the animals themselves, other clues, such as the appearance of feeding seabirds or oily slicks at the sea surface can sometimes provide evidence of their presence (JNCC, 2004). The efficacy of visual monitoring is significantly reduced at Sea State 3 or above, and some small animals are very difficult to see, even in calm conditions. Marine Mammal Observers (MMOs) should be located at positions on the ship where the all-round visibility is best, whilst maintaining good communication with the bridge.

Marine mammals may spend a considerable amount of time submerged. Visual monitoring will not detect submerged animals except in very limited circumstances (i.e. when they are very close to the surface or in exceptionally clear water). It is therefore best undertaken in conjunction with passive acoustic monitoring, which may alert MMOs to the presence of vocalising animals even when they are at depth. The time allotted to visual monitoring should take into account the fact that marine mammals may be submerged for a large fraction of the time.

Monitoring is primarily undertaken for the detection of marine mammals; however, it is important also to maintain a lookout for other environmental receptors. Turtles or large fish such as sharks and tuna will occur in the area and may be visible to visual monitors. A lookout should also be maintained for any signs of divers or swimmers in the water - such as support boats showing warning lights, shapes or flags.

Monitoring should ideally be undertaken before, during and after seismic activity. The JNCC guidelines recommend a minimum watch period of 30 minutes before shooting commences.

The successful detection of marine mammals will be dependent on the skill of the observer. Experienced and trained observers are preferable, and are likely to be more effective than untrained members of the ship's crew. JNCC (2004) guidelines state:

> *"... operators should seek to provide the most appropriately qualified and experienced personnel to act as marine mammal observers on board the seismic survey vessel. ... A prerequisite for an MMO is the attendance of a short course on implementing the guidelines and reporting procedure. ... If possible such observers should be experienced cetacean biologists."*

The JNCC guidelines provide recommendations on how to tailor this requirement, specifically for UK waters. It advises:

a. for areas/times of year where daylight hours are long, two MMOs should be used;

b. in areas known to be sensitive for marine mammals, trained cetacean biologists are required;

c. experienced cetacean biologists should attend MMO training courses; and

d. the use of ship's crew members (who will have other responsibilities) instead of experienced cetacean biologists is not considered 'an adequate substitute'.

These and other recommendations are summarised in the JNCC guidelines (JNCC, 2004). It should be noted that these guidelines apply to UK waters only and that, in terms of cetacean sensitivities and the requirements for MMOs, it is not possible to make direct comparisons with the Gulf of Cadiz cruise around Portugal. In particular, there are no comparative biological studies that would support such extrapolations, although the NERC guidelines suggest certain minimum (although not necessarily precautionary) requirements in terms of the number of MMOs and their training needs. Thus for UK waters, JNCC guidance is given in Table 7-1. From an analysis of this information and what is known about the environmental sensitivities of the research area (from Section 5) and the airgun characteristics, as a minimum requirement this EIA would recommend the use of a 'dedicated MMO'. This is particularly so, given the risks, real and perceived, of operating this equipment in an environmentally sensitive area such as the shelf edge region. However, it should be emphasised that this is a minimum requirement, and that there are no studies to support extrapolation of UK criteria to Portuguese conditions. A more precautionary approach would entail the use of trained MMOs.

As part of the EIA process, it is necessary to quantify the risks associated with each of the impact criteria identified. In the case of this EIA, SORs around the seismic source were computed using advanced modelling techniques and environmental data appropriate to the survey site. From this, a distance of 280 m (based on the distance to the PTS impact criterion) was determined as the distance over which visual monitoring should take place. It will be seen that this is somewhat less than the distance of 500 m which is recommended in line with JNCC guidance. This distance defines the zone around the airgun array within which the MMOs will need to monitor for the presence of marine mammals. It should be noted that this zone is larger that the SOR calculated for a PTS threshold and blast criteria and so can be considered robust and precautionary.

MMOs should be alert to the possibility that marine mammals may approach the vessel from astern and that 360° surveillance is therefore required at all times.

Area	Sensitivity / MMO Requirement
Southern North Sea **Irish Sea Basin**	**Cetacean sensitivities are generally low to moderate:** • seismic surveys using large sources such as those for 2D or 3D seismic surveys may require a dedicated MMO. For all other surveys a dedicated MMO is usually not required, however: • a watch should be kept for marine mammals before airgun start up; and • a report should still be submitted to the JNCC containing location, effort and sighting forms.
Central and Northern North Sea **St Georges Channel** **South West Approaches** **English Channel**	**Cetacean sensitivities are highly variable.** Requirements for MMOs are varied according to the energy, source volume, energy source pressure level, sound frequency and survey location. However, the following guidance is available: • seismic surveys using large sources such as those for 2D or 3D seismic surveys will require a dedicated MMO; and • all surveys requiring MMOs taking place between 1st April and 1st October north of 57° latitude will require two dedicated MMOs due to the longer daylight hours
Moray Firth **Cardigan Bay** **West of Britain** (includes all areas to the north and west of Shetland and to the west of Orkney and the Western Isles)	**Cetacean sensitivities are high:** • any seismic operation including site surveys will require dedicated experienced MMOs; and • all surveys requiring MMOs taking place between 1st April and 1st October north of 57° latitude will require two dedicated MMOs due to the longer daylight hours.

Table 7-1 MMO guidance for UK waters

Passive acoustic monitoring

The use of passive acoustic systems to detect vocalisations is a valuable method for marine mammal monitoring, although it is recognised that such systems will not detect silent animals transiting the area.

A wide variety of detection systems are available, ranging from sophisticated towed arrays which can be bought 'off the shelf', to sonobuoys and ball hydrophones from which a simple passive monitoring sensor can be improvised. Software, such as *Ishmael* (total bandwidth), *Whistle* (for dolphins), *Rainbow Click* (for sperm whale clicks) or *Logger* (logs location, observations and acoustic detections) is freely available from the International Fund for Animal Welfare website[9], and is advisable

[9] www.ifaw.org

for interpreting the received vocalisations. However, transmission of signals through a simple loudspeaker may enable underwater biological sounds to be heard.

Ideally, such systems need to be able to detect, classify and localise marine mammals, but unless sophisticated equipment is used, it is not always possible to achieve the latter. However, just detecting their vocalisations can both provide important clues to the presence of mammals, which may be used to inform the visual monitoring efforts.

Passive acoustic monitoring is particularly important during activities after dark, as visual monitoring will no longer be possible. The use of passive acoustic monitoring as an environmental protection tool in marine seismic operations is discussed in Walker and Hedgeland (2002).

Active acoustic monitoring

In addition to the use of passive acoustic techniques, it is also possible to detect environmental receptors using active sonar systems. Fish finding sonar is widely used by the fishing industry to detect shoals, and the US Navy are developing a sonar system designed to detect, locate and track marine mammals (CNO, 2001). While active sonar enables silent animals to be detected, the system necessarily introduces more sound into the marine environment and therefore has the potential to present additional risk to environmental receptors. This technique is therefore somewhat controversial and is not recommended for the purposes of the Gulf of Cadiz cruise.

7.1.3 Modification of airgun activity

Delay

The JNCC guidelines advise a monitoring period of 30 minutes, after which it should be possible to determine whether it is acceptable, on environmental grounds, to start seismic survey operations. If the area is clear, within the specified distance (500 m), firing of airguns may commence, however if receptors are located too close, it is recommended that firings are delayed until the area is clear.

Ramp-up

It is recommended that the airgun array should be operated initially at reduced power, increasing gradually (i.e. 'ramping up') to full operational power[10]. The JNCC guidelines recommend a ramp up period of 20 minutes. During ramping up, the sound must be continuous or near continuous, as animals find it more difficult to locate, (and thus avoid) intermittent sounds. The initial source level should be sufficiently low so as not to directly harm receptors and also to allow for a period of increase.

Shut down

The role of the monitoring techniques described above is to determine whether environmental receptors are close to the airguns. If receptors are detected within 500 m, it is recommended that firings be temporarily stopped until the animal is no longer within this range. Although a "Shut-down" procedure is not specified in the JNCC guidelines and that it is possible that it may impact on the Gulf of Cadiz cruise objectives, this mitigation measure is considered important if harm to receptors is to be avoided.

[10] Richardson *et al.*, (1995) state that "the greatest risk of immediate hearing damage might be if a powerful source were turned on suddenly at full power while a mammal was nearby" Ramp up is recommended for use during seismic exploration and has been observed to have the desired effect on bowhead whales (Richardson *et al.*, 1995).

Reduced power

It is also advisable that whenever practicable the power levels of the seismic array is kept to a minimum, as recommended in JNCC (2004) guidelines.

7.2 Recommended mitigation strategy for the Gulf of Cadiz cruise

Mitigation measures appropriate for the Gulf of Cadiz cruise are listed in Tables 7-2 to 7-5. These measures are based on best practice drawn from the JNCC guidelines, the seismic survey industry and elsewhere. It should be stressed that these measures are not mandatory. The relevant environmental legislation requires states and/or partners to take cost-effective measures with regard to acoustic disturbance, employing best practicable means and in accordance with their capabilities. The aim of the mitigation strategy, therefore, is to achieve balance between environmental protection and the aims of the Gulf of Cadiz cruise.

The decision as to which mitigation measures are to be employed is the responsibility of the 'action proponent' (i.e. University of Durham) and will, of necessity, be a trade-off between the risk to the environment and requirements of the cruise objectives and the capabilities of equipment and personnel. As stated previously, risk mitigation measures have the potential to impact on the aims of the cruise.

In Table 7-2, the mitigation strategy is divided into four stages: before, at the start, during and after the cruise. At each stage a number of options are available. An indication is provided as whether each of the possible measures is deemed essential (i.e. recommended in JNCC guidelines), strongly recommended (are considered best practice by other organisations) or just recommended because it is good practice.

Prior to the commencement of airgun operations, it is recommended that the Principal Scientist brief scientific and ship's personnel involved with the conduct of the Gulf of Cadiz cruise on environmental issues and on the need for extra vigilance to avoid environmental harm and to prevent interference with the rights of others to use the environment.

Time	Recommended Mitigation Measures	Requirements
Before the cruise	Notify the relevant authorities of the details of the cruise, including the Coast Guard and dive clubs. A Notice to Mariners should be issued to raise awareness in the wider marine community.	Recommended
	Employ one or more trained and experienced MMOs and equip them with binoculars, logbooks and handbooks. The number of personnel should be sufficient to work all daylight hours for visual monitoring (and other hours if acoustic techniques are being used).	Essential
	Obtain acoustic monitoring equipment (hardware and software) and employ experienced observers proficient in its use.	Recommended
	Undertake a pre-activity environmental briefing, so that all participants involved in the activity are fully aware of the aims and objectives of the mitigation strategy, the personnel who are involved and any activities that can be undertaken by individuals in order to reduce risk to the environment.	Essential
	Agree responsibilities of cruise personnel for environmental issues. Identify the person with overall responsibility.	Essential
	Agree an action plan in the event of situations that require the implementation of mitigation measures. Agree who needs to be informed (e.g. Principal Scientist, the ship's Captain), and what actions will be taken in various scenarios (e.g. animals present during ramp-up, or animals present during normal airgun firings).	Essential

Table 7-2 Recommended mitigation measures for the Gulf of Cadiz cruise – Before the cruise

Time	Recommended Mitigation Measures	Requirements
Start up	Undertake monitoring for marine mammals using visual techniques for a minimum of 30 minutes. Report any marine mammals or turtles seen within 500 m of the airguns.	Essential
	Undertake simultaneous monitoring for marine mammals using passive acoustic techniques for a minimum of 30 minutes.	Recommended
	If mammals or turtles are observed within 500 m of the airguns, delay the start of airgun firings for at least 20 minutes after last sighting.	Essential
	Broadcast warnings over the ship's radio to alert other users in the area	Recommended
	Commence airgun operation during daylight with good visibility	Essential
	Use ramp-up procedure before airgun firing. Build up power slowly over a period of at least 20 minutes (but no longer than 40 minutes)	Essential

Table 7-3 Recommended mitigation measures the Gulf of Cadiz cruise – Start up

Time	Recommended Mitigation Measures	Requirements
During the survey	Undertake monitoring continuously during airgun firings	Essential
	If marine mammals are observed within 500 m from the airguns, shut down the airguns, then implement monitoring and ramp-up procedures.	Strongly recommended
	Use agreed monitoring and ramp-up procedures after any substantial break in airgun operation (greater than 20 minutes)	Essential
	Ensure that activities do not impinge on or interfere with the rights of others to use the environment, e.g. for fishing, tourism etc.	Essential
	Avoid firing the airguns when close to coastlines where there is a potential risk of marine mammal embayment and stranding	Essential
	Record all monitoring activity	Strongly Recommended

Table 7-4 Recommended mitigation measures the Gulf of Cadiz cruise – During the survey

Time	Recommended Mitigation Measures	Requirements
After the survey	Check area for dead or injured marine mammals, fish or turtles and record results	Strongly Recommended
	Collate all monitoring records as permanent record	Strongly Recommended
	Undertake a post-activity environmental de-brief for that all participants involved in the activity can contribute to lessons learnt	Recommended
	Undertake post-activity analysis of the environmental risk mitigation strategy to ascertain, if possible, whether enough was done to protect the environment and whether adverse environmental effects were either observed or believed to have occurred	Recommended
	Produce a statement of lessons learnt to benefit any future activities	Recommended

Table 7-5 Recommended mitigation measures the Gulf of Cadiz cruise – After the survey

7.3 Data collation and reporting

Documentation of all environmental activities should be undertaken. An event such as a marine mammal stranding may be linked (perhaps erroneously) to the cruise, even some considerable time afterwards. Good records of the environmental mitigation measures undertaken during the cruise should avoid unwarranted correlation between the airgun firings and any alleged environmental damage. Observations of dead or injured marine mammals, fish or turtles, at any time, should be recorded.

All monitoring activity undertaken should be logged and copies retained (JNCC forms are available at http://www.jncc.gov.uk/page-1534), whether sightings have been made or not. Records to be retained should include:

a. log sheets for all monitoring effort;

b. recordings of all biological contacts;

c. observed weather; and

d. mitigation measures being implemented.

In addition to the pre-cruise briefing, daily environmental monitoring briefs are recommended. This could include information on the number of marine mammal sightings/detections made during previous watches or the presence of other environmental receptors, and discussions on optimising the monitoring capability, adapting to the survey plans of the day and resources (equipment and personnel) available. Briefings should also mention of other activities (e.g. fishing, tourism) on which the Gulf of Cadiz cruise may impinge.

7.4 Conclusions

This document recommends mitigation that, in relation to the Gulf of Cadiz cruise, will reduce but not totally eliminate environmental risks. However, although the risks remain finite, they are generally considered manageable with the application of the appropriate mitigation measures.

This section recommends a number of options for mitigation measures that individually or collectively should provide an effective risk reduction strategy. However, none of these options is mandatory in the context of the Gulf of Cadiz cruise and the final selection of mitigation measures to be applied will depend not only on their potential to reduce risk, but also on the availability of suitable equipment and personnel.

8 Missing or incomplete knowledge

8.1 Introduction

The aim of this Section of the EIA is to identify areas where knowledge is incomplete or where data have been extrapolated beyond their reliable scope. The conclusions of the EIA should be seen in the context of the reliability of the contributing information.

In order to complete this EIA, it has been necessary to utilise information from a wide variety of sources covering a range of topics. In some subject domains a large quantity of appropriate literature is available, whereas in others information is scarce and, on occasion, information appears contradictory. Wherever possible, use has been made of peer-reviewed articles or papers published in the open scientific literature. Where this has not been possible, an effort has been made to state the limitations of the data or to indicate inferences drawn from the available references.

8.2 Environmental policy and law

Currently, environmental law and policy at national, EU and international levels is rapidly evolving. The main area of emerging development in local waters is that of marine conservation and sanctuaries. The most up to date information that could be obtained at time of writing has been used in this EIA.

8.3 Existing environment

The geographical area considered within the EIA is generally well documented and sources of information are reliable. The marine environment is, however, very dynamic; information quickly becomes out of date and requires continuous updating.

Detailed knowledge of sound speed profiles in the water column and in the seabed is required in order to model the acoustic environment accurately. The climatological sound speed profiles used in this EIA only give an indication of likely conditions to be met at any time.

In this EIA, environments have been selected to illustrate both typical and atypical situations that are likely to be encountered, whilst providing a manageable amount of sonar modelling. Other environments may exist which are not represented by the environments modelled. Climatological environments will not exactly replicate the environments that will be encountered when the sonar is operated, and so cannot provide a forecast of all possible conditions to be met.

It has not been possible to show the exact numbers and locations of all protected sites in the national waters of the countries bordering the EIA area. This is due to the fact that there are a large number of sites within the coastal zone, with many different designations and levels of protection. This makes it very difficult to specify exactly how many sensitive sites are currently in existence and where exactly they are located. Dive sites are another example where data may not be comprehensive.

8.4 Marine mammals

Although data are available on the distributions of key species in this area, this information is not comprehensive. The locations of breeding grounds have not been identified for smaller whales and dolphins, although it is assumed, for resident populations that they breed inshore, in coastal waters. In addition, no breeding sites for pinnipeds have been identified in waters close to the area of interest in this EIA.

The impact of sound on marine mammals has been reported to some extent in the literature. However, the available research is limited in content compared to research on fish, as it is considered both impractical and unethical to put marine mammals into tanks or laboratories and to subject them to potentially fatal, harmful or even stressful conditions. It is also deemed unacceptable to kill and dissect mammals that have been exposed to such conditions. Other difficulties experienced by marine mammal researchers include those of attaching time/depth recorders to large mammals, and of subsequent instrument recovery. Observational data regarding changes in behaviour may, however, be considered to be too subjective for assessment purposes.

It is particularly difficult to assess behavioural changes and habituation to aquatic noise and, in particular, to cumulative effects of sources. The results reported in the literature are highly context dependent and often contradictory. It is likely that an animal's reaction to a noise will depend on the nature of the noise, as well as its intensity. Much published work gives qualitative rather than quantitative information concerning marine mammal distributions, marine mammal behaviour, the reaction of marine mammals to sound, and hearing threshold shifts caused by underwater sound.

Published audiograms for most marine mammal species are based on data from very few individual animals. The relatively few audiograms that do exist for marine mammals are for a few species of toothed whale, hair seal and eared seal. The baleen and beaked whales are entirely unrepresented. The accuracy of assessment of the impact of sound on marine mammals would benefit from more high-quality, quantitative research.

Mitigation and monitoring strategies proposed here have been based upon what is currently understood to be best practice. However, this area is constantly evolving and a watching brief should be maintained on new developments. In particular, substantial progress is likely to be seen with monitoring technologies (e.g. remotely deployed passive sonar sensors) and associated methodologies for deployment.

8.5 Fish

Information is limited concerning the impact of sound on fish. Determining the sound level at which fish behaviour is adversely affected has proved to be a difficult topic for researchers, as the data are species dependent yet the observation of behaviour has only been conducted on a few species. It has been surmised that fish may be harassed and yet will remain within the harassment area.

Data for the EIA area areas is considered to be comparatively good; however, the over capacity of some fleets and poor status of many fish stocks encourages over-reporting. Although information in these areas is good, it is not possible to define fish spawning areas precisely.

Further knowledge of the consequences of physiological damage on fish is needed before an accurate prediction of the effect of sonar on fish can be given.

8.6 Seabirds

Very few papers have been identified that indicate the distribution and behaviour of diving seabirds within the EIA area. Data concerning the effect of high intensity sound on birds, whether on the sea surface or submerged is very sparse.

8.7 Divers

The effects of underwater sound on divers have been well researched and documented. However, due to the numbers of potential dive sites along the coastal areas of Portugal, Spain and Morocco, it has been necessary to rely on the inference that the 50 m depth contour encompasses most sports diving activities. This is considered to be a realistic assumption. For precautionary reasons, it has been assumed that divers will not be protected by neoprene diving hoods. In the colder water areas, the chance of encountering a diver not wearing a neoprene hood is considered small and this assumption may lead to overly precautionary ranges being prescribed.

8.8 Airgun array modelling

For the purpose of this EIA, the operating characteristics and procedures for the airgun arrays to be deployed on the Gulf of Cadiz cruise have been assumed to be representative of a wide range of possible scenarios. In particular, the airgun combinations, (see Annex A), firing intervals and towing depths have been based on information provide by the University of Durham prior to the cruise and used by them to “tune” the arrays and arrive at configurations that were optimal for the survey work intended. It is understood that actual configurations, firing intervals and towing depths may change during the cruise, according to circumstances.

8.9 Acoustic propagation loss modelling

A set of specific environments has been selected to illustrate the typical extremes of conditions that may be encountered in the EIA area for propagation loss modelling.

The geoacoustic properties of the seabed play an important role in determining propagation loss in the ocean, particularly in shallow water and when the SSP directs the acoustic energy into the seabed. Maps of seabed sediments show that the type of sediment varies considerably throughout each component area of the region and, particularly in shallow water, possibly over comparatively short ranges. Such variation in sediment type can significantly alter the results of acoustic propagation modelling.

In-water propagation modelling was performed using the computer program RAM embedded in ENGINE32® (see Section 6.4). This model is considered sufficiently accurate to undertake the modelling required given the constraints on the input data discussed above. Impulse modelling was considered using a model based on explosive blast. It is acknowledged that this is not directly applicable to airguns but it nevertheless gives an indication of the mortality that might arise from tissue shear and body vibration.

Within the scope of this EIA, it is considered that the models and environmental data used are sufficiently robust for the purposes of acoustic modelling.

8.10 Cause and effect modelling

There has been considerable research into hearing and hearing damage in humans, both in-air and underwater. However, there is significantly less reported on marine and terrestrial mammals and fish, and most of the published literature concerning hearing damage and auditory thresholds has been conducted using CW (continuous wave) sources. PTS and TTS impact thresholds for fish and marine mammals have been derived by extrapolating the NAWR criterion developed for humans in air and, to some extent, the available experimental evidence supports the derived thresholds. The uncertain nature of this technique is recognised but, in the absence of better data, it is considered to be the most suitable approach and has been published (Heathershaw *et al* 2001).

Behavioural thresholds are even more contentious. Richardson *et al.* (1995) reviews a number of experiments involving observation of the behaviour of cetaceans that have been exposed to levels of sound that have been inferred to be in the range 105 to 125 dB re 1 μPa. It is recognised that the results are inconclusive and a significant amount of further work should be undertaken before specific SPLs can be applied to behavioural thresholds with confidence.

The experimental evidence to support the application of physiological and behavioural thresholds to animals in air is similarly sparse. The evidence reviewed in this EIA shows that the reporting of the experiments often lacks scientific rigour. Typically, source characteristics and the relative locations of source and receptor are not reported, and so it is difficult to develop accurate thresholds.

9 References

Arons A. B. (1948), "Secondary pressure pulses due to glass globe oscillation in underwater explosions II. Selection of adiabatic parameters in the theory of oscillation". *J. Acoust. Soc. Am*. 20(3):277-282.

Balcomb, K.C., and Claridge, D.E., (2001). "A mass stranding of cetaceans caused by naval sonar in the Bahamas". *Bahamas Journal of Science,* **2**:2-12.

Blaxter J. H. S., Gray J. A. B., Denton E. J., (1981), "Sound and startle response in herring shoals", Journal *of the Marine Biological Association of the United Kingdom*, 61, 851-869.

Carwardine, M., (1995). *Whales, dolphins and porpoises: The visual guide to all the world's cetaceans,* Eyewitness Handbooks. ISBN 0-7513-1030-1.

Clark, C.W., Tyack, P. and Ellison, W.E., (1999). Responses of four species of whales to sounds of SURTASS LFA sonar transmissions. In: Department of the Navy Chief of Naval Operations; 112+figs.

Cole, S., (2005). Military exercises and marine mammal strandings. Presented by Lt Cdr S Cole, Royal Australian Navy. Paper presented at the Intergovernmental conference: *The Effect of Sound on Marine Mammals* at the NATO Undersea Research Centre, 2-5 May 2005.

Curtis, K.R., Howe, B.M., Mercer, J.A., (1999). "Low frequency ambient noise in the North Pacific: long time series observations". *J. Acoust. Soc. Am.* **106**(6):3189-3200.

Dotinga H. M, Oude Elferink A. G., (2000), "Acoustic pollution in the oceans: The search for legal standards". *Ocean Development and International Law*, 31:151-182.

ENGINE32® (2006) ENGINE32® User Manual, Version 7.4. Ocean Acoustic Developments Ltd., Bude, Cornwall, November 2003.

FAO, (2005). The State of the World Fisheries and Aquaculture 2004, Food and Agriculture Organization of the United Nations ISBN 92-5-105177-1

Gaspin, J.B., (1975). Experimental investigations of the effects of underwater explosions on swimbladder fish, I: 1973 Chesapeake Bay Tests, Nav. Surf. Weapons Center. White Oak TR 75-58, 40pp and Appendix.

Gausland I., (2000), Impact of seismic surveys on marine life, SPE61127, Society of Petroleum Engineers (SPE), International Conference on health, Safety and the Environment in Oil and Gas Exploration and Production, Stavangar, Norway, June 2000.

Gentry Roger L., (2002), Mass Stranding of Beaked Whales in the Galapagos Islands , April 2000, (http://www.nmfs.noaa.gov/pr/pdfs/health/galapagos_stranding.pdf)

Gisiner, R.C., (1998). Proceedings of Workshop on the Effects of Anthropogenic Noise in the Marine Environment. Office of Naval research Marine Mammal Science Program, 141pp (http://www.onr.navy.mil/sci_tech/engineering/onrpgank.htm).

Glasson J., Therivel R., Chadwick A., (1994), Introduction to environmental impact assessment, UCL Press.

Gubbay, S., (1998). *A Global Representative System of Marine Protected Areas – Volume 1 Marine Region 5: Northeast Atlantic*.

Harland, E.J., Jones, S.A.S. and Clarke, T. (2005) SEA 6: Assessment of underwater ambient noise QINETIQ/S&E/MAC/CR050575.

Heathershaw, A.D., Ward, P.D., Jones, S, Rogers, R., (1997), "Understanding the impact of sonars on the marine environment". *Proceedings of the Underwater Bio-Sonar and Bioacoustics Symposium*. **19**(9):51-64.

Hobbs R., (2007), University of Durham, Environmental Support to Seismic Cruise, e-mail to Healy S. G., QinetiQ, SEA Division, Available email: sghealy@qinetiq.com, 8th January 2007.

Hoyt E. 2001. Whale-watching 2001: Worldwide Tourism Numbers, Expenditures, and Expanding Socioeconomic Benefits. International Fund for Animal Welfare: Crowborough, 158pp.

HSE, (1989). Health and Safety Executive: The noise at work regulations. ISBN 0 7176 04543

HSE, (2005). The Control of Noise at Work Regulations 2005. ISBN 0 1107 29846.

IACMST (2006), Underwater sound and marine life, IACMST Working Group Report No 6, January 2006.

ICES, 2004. Endangered Species: Sharks, Rays, Skates and Sawfish (Earth Crash Earth Spirit news http://ices.org/archive/ec/extinction/sharks.shtml#sources

IUCN (2004). Resolution on Undersea noise pollution. RESWCC3.068 Congress reference: CGR3.RES053.Rev1.

IUCN, (2006). IUCN 2006 Red List of Threatened Species. www.redlist.org.

IWC (2004). International Whaling Commission – 2004 Report of the Scientific Committee (Issue 12th February 2005).

JNCC, (2004). Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys - April 2004 http://www.jncc.gov.uk/page-1534

Kareiva, P., (2001). When one whale matters. *Nature*, **414**: 493-494.

Ketten, D., (1998). *A summary of audiometric and anatomical data and its implications for underwater acoustic impacts*. NOAA Technical Memorandum NMFS September 1998.

Lenhardt, M.L., (1994). *Brief presented at the 14th Annual Symposium on Sea Turtles Biology and Conservation, March 1-5 1994*, Hilton Head Island, SC, USA.

Mate B. R., Stafford K. M., Ljungblad D. K., (1994), A change in sperm whale (Physeter macroephalus) distribution correlated to seismic surveys in the Gulf of Mexico.

McCauley R. D., Fewtrell J., Duncan A. J., Jenner C., Jenner M-N, Penrose J. D., Prince R. I. T., Adhitya A., Murdoch J., McCabe K. A., (2000), Marine seismic surveys – A study of environmental implications, APPEA Journal 2000, 692-708.

McCauley R. D., Jenner M-N, Jenner C., McCabe K. A., Murdoch J., (1998), The response of humpback whales (*Megaptera Novaeangliae*) to offshore seismic survey noise: Preliminary results of observations about a working seismic vessel and experimental exposures. APPEA Journal, 38(1), 692-707.

Miller, P. J. O, Biassoni, N., Samuels, A and Tyack, P.L., (2000). "Whale songs lengthen in response to sonar". *Nature* **405**: 903-903.

Moein , S.E., Musick, J.A., Lenhardt, M.L., (1994). "Auditory behaviour of the loggerhead sea turtle (*Caretta caretta*)". In: Bjorndal, K.A., Bolten, A.B., Johnson, D.A., Eliazar, P.J., Proceedings of the 14th Annual Symposium on Sea Turtles Biology and Conservation, March 1-5 1994, Hilton Head Island, SC, USA.

Mondor, C., Mercier, F., Croom, M., and Wolotira, R., (1998). A Global Representation of Marine Protected Areas, Volume 1, Marine Region 4: Northwest Atlantic.

MTD, (1996). *Guidelines for the Safe Use of Explosives Under Water*. Marine Technology Directorate (MTD) Publication 96/101, 74pp.

NERC (2002a), NERC Science Programmes Directorate Memorandum, D Brown, M Webb to NERC Executive Board (NEB), November 7th, 2002. Acoustic disturbance of marine mammals.

NERC (2002b), NERC Annual Report for 2005-2006.

NERC (2005), NERC Research Ship (RSU), Guidelines for minimising acoustic disturbance to marine mammals.

ONR, (2002). Ocean Life: Green Sea turtle – current research. Office of Naval Research, Website. www.onr.navy.mil/focus/ocean/life/turtle4.htm

OSPAR, (2002). Overview of past dumping at sea of chemical weapons and munitions in the OSPAR Maritime Area. OSPAR Point and Diffuse Sources Series. OSPAR Commission 2002

Pavan G., 2006. Guidelines to address the issue of the impact of anthropogenic noise on marine mammals in the ACCOBAMS area. Report prepared for the 4th ACCOBAMS Scientific Committee.

Pearson W. H., Skalski J. R., Malme C. I., (1992), "Effects of sound from a geophysical survey device on behaviour of captive rockfish (*Sebastes spp.*)", *Canadian Journal of Fisheries and Aquatic Sciences* 49(7), 1343-1356.

Richardson, W. J., Greene C. R. Jnr., Malme C. I. and Thomson D. H., (1995). *Marine Mammals and Noise*, Academic Press, San Diego, USA.

Ridgeway, S.H., Wever, E.G., McCormick, J.G., Palin, J., Anderson, J.H., (1969). "Hearing in the giant sea turtles", Journal of the Acoustical Society of America **59** Suppl. 1 S46.

SURTASS, (2001). *Final Overseas Environmental Impact Statement and Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar*, Department o the Navy, Chief of Naval Operations, USA.

Urick R. J., (1983), *Principles of Underwater Sound*, McGraw-Hill Book Company 3rd Edition.

US Office of Naval Research and the US National Marine Fisheries Service Office of Protected Resources (Parvin, 2002

Verma R. K., (1986), *Offshore Seismic Exploration*, Gulf Publishing Book Company, Houston, Texas, ISBN 0-87201-498-3.

Walker, P.A. 1998. Fleeting Images: Dynamics of North Sea Ray Populations. PhD Thesis, University of Amsterdam, 145 pp.

WDCS, (2004). Oceans of Noise, Whale and Dolphin Society Report.

Yelverton J. T., (1981), "Underwater explosion damage risk criteria for fish, birds and mammals", Manuscript presented at 102nd Meeting of the Acoustical Society of America, Miami beach, Fl. USA, Dec 1981.

Yelverton J. T., Richmond D. R., Hick W., Sanders K., Fletcher E. R., Royce E., (1975), "The relationship between fish size and their response to underwater blast", Defence nuclear Agency, Dept. of Defence, Washington DC, Topical Report DNA Report 3677T, Unclassified.

10 List of Abbreviations

ACCOBAMS	Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and the Contiguous Atlantic Ocean
ASCOBANS	Agreement on Conservation of Small Cetaceans of the Baltic and North Sea
CBD	Convention on Biological Diversity
dB	Decibel
Defra	Department of Environment Food and Rural Affairs
DRC	Damage Risk Criteria
DTI	Department of Trade and Industry
EIA	Environmental Impact Assessment
EU	European Union
FAO	Food and Agriculture Organization (of the United Nations)
GO	Geophysical oceanography
GTV	Generic Threshold Value
HSE	Health and Safety Executive
Hz	Hertz
IACMST	Inter-Agency Committee on Marine Science and Technology
ICES	International Council for the Exploration of the Sea
ICRW	International Convention for the Regulation of Whaling
IFAW	International Fund for Animal Welfare
IEMA	Institute of Environmental Management and Assessment
IUCN	The International Union for the Conservation of Nature (now called the World Conservation Union but still referred to as the IUCN)
IWC	International Whaling Commission
JNCC	Joint Nature Conservation Committee
LF	Low Frequency
MCS	Marine Conservation Society
MMO	Marine Mammal Observer
MNR	Marine Nature Reserve
MoD	Ministry of Defence

MPA	Marine Protected Area
MSR	Marine Scientific Research
MTD	Marine Technology Directorate
NASS	North Atlantic Sightings Survey
NATO	North Atlantic Treaty Organisation
NAWR	Noise At Work Regulation
NERC	NATO's Environmental Research Centre
NMFS	National Marine Fisheries Service
ONR	US Office of Naval Research
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic (the joint Oslo and Paris Conventions)
Pa	Pascal (Pressure Unit)
PL	Propagation Loss
PTS	Permanent Threshold Shift
SAC	Special Area of Conservation
SCANS	Small Cetaceans in the European Atlantic and North Seas
SCUBA	Self Contained Underwater Breathing Apparatus
SL	Source Level
SOR	Stand-Off Range
SPA	Special Protected Area
SPL	Sound Pressure Level
SSP	Sound Speed Profile
SURTASS	Surveillance Towed Array Sensor System
TTS	Temporary Threshold Shift
UK	United Kingdom
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	UN Environmental Programme
UNESCO	United Nations Scientific and Cultural Organisation
US	United States
WCMC	World Conservation Monitoring Centre
WCPA	World Commission on Protected Areas

WDCS	Whale and Dolphin Conservation Society
WHS	World Heritage Sites

11 Glossary of Terms

The terms listed below have been drawn from a wide range of sources and some have been adapted to make them more applicable to the MoD. Other terms have been created, but are within the context of the generally accepted EIA genre.

ACTION/PROJECT PROPONENT	Government Department, Service, Directorate (MoD), Command or designated Project Manager responsible for proposing and executing an action/project.
BUFFER ZONE (BZ)	In order to prevent sound levels within a Marine Protected Area (MPA) exceeding acceptable thresholds, it is necessary to implement a BZ; the BZ is a region around a MPA over which sound levels attenuate to a sufficiently low level before entering the protected area.
DIVER LOUD (DL) CRITERION	DL represents a sound level that, if endured continuously, could cause TTS in a human. This level equates to that which may be construed as 'loud' by a diver, having the potential to cause a startle reaction. This is a non-injurious impact criterion.
ENVIRONMENT	The surroundings (or external) conditions in which an organisation operates, including air, water, land, natural resources, flora, fauna, humans and their interrelation.
ENVIRONMENTAL DEGRADATION	Degradation is considered to include all deleterious effects resulting from anthropogenic modification of the physical, chemical or biological characteristics of the environment, as well as environmental impacts of technology. This new definition is seen to establish a broader 'catch all' requirement. (UNCLOS).
ENVIRONMENTAL IMPACT ASSESSMENT (EIA)	An EIA takes the impacts identified in an Environmental Impact Scoping Study (EISS) and quantifies their effect.
ENVIRONMENTAL IMPACT SCREENING/SCOPING STUDY (EISS)	Is an environmental audit process that allows a project to be scoped in terms of its impact on given environmental receptors. The process is a qualitative one and uses an impact matrix to represent the outcome of the Scoping process.
GENERIC THRESHOLD VALUE (GTV)	GTV curve represents the most sensitive hearing of all marine species. Derived from unpublished survey of available audiograms and used to determine thresholds used in Section 6 of this report.
HUMAN DIVE ZONE (HDZ)	An area where humans are known to dive. Used with associated BZ to define an area where the seismic source should not be deployed.

QinetiQ Proprietary

IMPACTS	Impacts are synonymous with effects and include direct, indirect and cumulative impacts. a. Direct impacts – caused by an action and action/project and occur at the same time and place as the action/project. b. Indirect impacts – also caused by an action/project, although occurring later in time or farther removed in distance from the action/project. They are still reasonably foreseeable. c. Cumulative impacts - result from the incremental impact of an action/project when added to other past, present and reasonably foreseeable future actions/projects regardless of what agency or person undertakes such actions/projects.
LEAD AGENCY	The agency or agencies preparing or having taken the primary responsibility to prepare the EIA.
MANDATORY AREA OF CONSERVATION (MAC)	An area of conservation which is protected by law. The legal riske of operating active sonar in or near a MAC are potentially high. In European waters this term cover Special Protected Areas and Special Area of Conservation.
MARINE PROTECTED AREA (MPA)	A MPA is a known environmentally sensitive location for fish, marine mammals or an area precluded for other reasons, e.g. a dive site of HDZ. MPAs and in particular MACs are required to be protected from exposure to levels of sound energy that are potentially injurious or highly undesirable to the inhabitants or users of an area.
MITIGATION	Actions which reduce the severity or intensity of the impacts of the proposed action/project to include: a. Avoiding the impact altogether by not taking a certain action or parts of an action. b. Minimising impacts by limiting the degree and magnitude of the action and its implementation. c. Rectifying the impact by repairing, rehabilitating or restoring the affected environment. d. Reducing or eliminating the impact over time by monitoring, maintaining and/or replacing equipment or structures so that future environmental degradation due to equipment or structural failure does not occur during the life of the action/project. e. Compensating for the impact by replacing or providing substitute resources or environments. Avoidance is the preferred mitigation measure.
MONITORING ZONE (MZ)	A MZ defines the area around the sound source where fish, marine mammals or humans should be protected from the transmitted sound. The MZ is that region which is pertinent to the application of real-time mitigation procedures.

NOISE	Sound undesired by the receptor, widely regarded as a psychologically and physically harmful form of pollution. In the maritime context more commonly known as 'Acoustic Disturbance'.
PERMANENT THRESHOLD SHIFT (PTS)	PTS is irreversible physiological damage caused by rupture of the hair cells of the inner ear, resulting in a permanent loss of hearing sensitivity. The consequence of this is a permanent shift in the threshold of hearing of the receptor.
PRECAUTIONARY APPROACH	A decision to take avoiding action based on the possibility of significant environmental damage, even before there is conclusive scientific evidence that the damage will occur.
RISK	The probability of an adverse outcome, or (sometimes) the likelihood attached to different outcomes.
SIGNIFICANCE	Significance of an impact is determined by context and intensity. Context is defined by the area or process affected. Intensity refers to the severity of the impact as derived from evaluating the magnitude of effects on: a. public health or safety, b. the unique characteristics of the geographic area, c. controversy of environmental effects, d. risk analysis, e. precedents, f. relationship to other actions/projects, g. cumulative impacts, and h. the potential for violating laws imposed to protect the environment.
STAND-OFF RANGE (SOR)	The maximum ranges at which a received sound pressure level (SPL) exceeds the relevant threshold appropriate to a given acoustic impact, is referred to as a stand-off range.
SUSTAINABLE DEVELOPMENT (SD)	This concept is central to the UK Government marine stewardship policy (Defra, 2002), that the needs of future generations should not be compromised by the needs of people today.
TEMPORARY THRESHOLD SHIFT (TTS)	TTS is a temporary loss in the efficiency of the mechanical-chemical-electrical transfer function in the inner ear, resulting in a temporary loss of hearing sensitivity. The consequence of this is a temporary shift in the threshold of hearing of the receptor.
VOLUNTARY AREA OF CONSERVATION (VAC)	A VAC is an area in which marine fauna may be affected by active sonar. VACs themselves are not afforded legal protection, but should always be considered during the planning phase of any operation. This term covers designated areas including: Marine Farms, Seal Breeding Areas, Fish Breeding Areas, Fish Spawning Areas, Seal Nursery Areas, Fish Nursery Areas, Seal Haul-out Areas, World Heritage Sites and Marine Nature Areas.

A Appendix A

A.1 First Leg of cruise

D318(a) Lisbon - Lisbon; 17 April - 23 April; *RRS Discovery*

Activities:

CTD casts at

36°38'N 008°12'W

35°54'N 010°00'W

36°38'N 009°16'W

Deploy 5 off seabed moorings for oceanography at

36 deg 38'N 8 deg 12'W in a ~10 x 10 km box

Acquire 2 regional seismic lines

36°38'N 008°12'W -> 35°54'N 010°00'W

35°54'N 010°00'W -> 36°38'N 009°16'W

Acquire 3 detailed grids at

36°38'N 008°12'W

35°54'N 010°00'W

36°38'N 009°16'W

Acquisition specifications:

GI-air gun source - this will be a small source ~ 1200 cu in with largest chamber being ~450 cu in.

600m hi-resolution hydrophone streamer

XBT and XCTD deployment at a 2.5 to 5 nm interval

A.2 Second leg of cruise

D318(b) Lisbon - Lisbon; 29 April - 14 May; RRS Discovery

Funchal - Cadiz; 26 April - 10 May; MV Poseidon (German vessel)

Activities (RRS Discovery)

Acquire 2 regional seismic lines

36°38'N 008°12'W -> 35°54'N 010°00'W

35°54'N 010°00'W -> 36°38'N 009°16'W

Acquire 3 detailed grids at

36°38'N 008°12'W

35°54'N 010°00'W

36°38'N 009°16'W

Acquisition specifications:

Bolt 1500LL air gun source - this will be a medium sized source ~ 2400 cu in with largest chamber being ~600 cu in.

2400m hydrophone streamer

XBT and occasional XCTD deployment at a 2.5 to 5 nm interval

Recover 5 moorings installed at start of D318(a)

MV Poseidon to follow *RSS Discovery*

CTD casts at

36°38'N 008°12'W

35°54'N 010°00'W

36°38'N 009°16'W

Array parameters	Lo resolution survey	Hi resolution survey
Number of guns	6	6
Total volume (cu.in).	2320.0 cu in (38 litres)	117.0 cu in (1.92 litres)
Peak to peak in bar-m.	48.4 (4.84 MPa, 254 db re 1 ®Pa. at 1m.)	26.9 (2.69 MPa, 249 db re 1 ®Pa. at 1m.)
Zero to peak in bar-m.	25.2 (2.52 MPa, 248 db re 1 ®Pa. at 1m.)	14.8 (1.48 MPa, 243 db re 1 ®Pa. at 1m.)
RMS pressure in bar-m.	2.87 (0.287 MPa, 229 db re 1 ®Pa. at 1m.)	0.795 (0.0795 MPa, 218 db re 1 ®Pa. at 1m.)
Bubble period to first peak (s)	0.165	0.0625

A.3 Trial specifications:

Deployment depth(s) of array:

Hi Resolution survey 2m

Lo Resolution survey 8m

Firing rate (How many minutes or seconds between each discharge):

Hi Resolution survey ~10s

Lo Resolution survey min 15s normally 30s

Acoustic activity takes place 24 hours out of 24

Approximate times of activity

Hi res source will be used 19 April-22 April

Lo res source will be used 30 April-7 May and 9 May-13 May

Towing speed of RRS Discovery:

Hi Resolution survey 5 kts

Lo Resolution survey 3.5 kts

Distance between each firing:

Hi Resolution survey	25m
Lo Resolution survey	min 25m normally 50m

Size of detailed grid:

Each of the 3 mini grids will be 20 x 20 km and over a 48 hr period and will shoot ~16 x 20km with a duty cycle of about 80% profiles; plus one continuous spiral profile with a maximum radius of 10km over a period of 16hr

Initial distribution list

External	
Dr R Hobbs, University of Durham	1 electronic copy

QinetiQ	
Information Resources	1 electronic copy
QinetiQ server	1 electronic copy

MARINE MAMMAL OBSERVER REPORT

THE 'GO PROJECT' GEOPHYSICAL OCEANOGRAPHY RESEARCH CRUISE*: GULF OF CADIZ FOR DURHAM UNIVERSITY

17th April - 14th May 2007

* Contract No. 15603 (NEST)

Report No. : **EOE0586**

Author(s) : **Richard Woodcock**

Approved : **J Perry**

Date : **31st May 2007**

RPS Energy,
Goldsworth House,
Denton Way, Goldsworth Park,
Woking, Surrey, GU21 3LG, UK.
T +44 (0)1483 746500
F +44 (0)1483 746505
E rpsenergy@rpsgroup.com
W www.rpsgroup.com

RPS Group Plc

SUMMARY

On the 19th April, 2007 the Oceanographic Research Vessel the *RRS Discovery* (NERC) commenced the 'GO' Geophysical Oceanography cruise of the Gulf of Cadiz. The survey was completed on the 13th May, 2007.

A dedicated Marine Mammal Observer (MMO) was present onboard the research vessel to monitor and record seismic operational procedures and carry out 'pre - airgun shooting watches' for cetaceans during daylight hours as required by the United Kingdom's Joint Nature Conservation Committee Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys (JNCC, 2004).

In accordance with the JNCC Guidelines (JNCC, 2004):

- A 30 minute duration 'pre - shooting search' for marine mammals was conducted before every 'soft start' procedure occurring during daylight hours.
- A 'soft-start' was carried out on each of the 10 occasions the airgun array was recorded to have been operated.

The JNCC Guidelines (JNCC, 2004) were complied with during the research cruise, however given the location and species encountered, it is not believed that these provided sufficient mitigation against disturbance to marine mammal and turtle species.

Dedicated marine mammal observations were conducted for a total of 112.5 hours, of which 41 hours (c. 36 % of total) were during times when environmental conditions were favourable for observation (sea state slight, swell low and visibility good).

There were a total of 39 marine mammal sightings of approximately 740 individuals during the research cruise. On 6 occasions marine mammals including the Fin Whale *Balaenoptera physalus*, IUCN classification – 'Endangered' (very high risk of extinction in the wild) (IUCN, 2002), approached firing airguns and came within ranges estimated to contain sound pressure levels, SPL's, great enough to cause injury. This information is available in the Environmental Impact Assessment (EIA) prepared for the cruise (QinetiQ, 2007).

There were a total of 13 Loggerhead turtle *Caretta caretta*, sightings of 13 individuals during the research cruise. These marine turtles, IUCN classification 'Endangered' (very high risk of extinction in the wild) (IUCN, 2002), were also seen to approach firing airguns and are likely to have been exposed to SPL's exceeding those identified to cause injury in the EIA prepared for the cruise (QinetiQ, 2007).

The primary MCS airgun array, mixed Bolt airguns, utilised to acquire the survey was of: total volume 2,320 in³; operating pressure 2000 psi; Intensity 25.2. bar-m (zero to peak), c. 48.4 bar-m (peak to peak); maximum source sound pulse dB 254 dB re 1µPa@1m; of predominant frequencies c. 4 to 200 Hz, and consisted of 6 airguns. See appendix 3 for Airgun array specifications.

Airgun firing operations were conducted on 10 occasions for a total of 322:40 hours. Airguns fired during 71 hours and 37 minutes of dedicated marine mammal watches.

Several recommendations have been put forward for consideration, see section 5.

CONTENTS

Title
Contents **Page Number**

FIGURES

APPENDICES

1. INTRODUCTION

For the duration of the 'GO' Gulf of Cadiz Geophysical Oceanography research cruise the UK JNCC Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys (JNCC 2004) were followed, as recommended in the research cruise environmental impact assessment (EIA) prepared by QinetiQ (QinetiQ, 2007).

In accordance with the UK JNCC Guidelines (JNCC, 2004) a dedicated marine mammal observer (MMO) sailed with the NERC RRS Discovery and conducted marine mammal observations for the duration of the Gulf of Cadiz research cruise location.

The role of the onboard MMO was to: provide advice on the application of the UK JNCC Guidelines and monitor adherence to the same regarding airgun operations; keep a dedicated watch for marine mammals before airgun operations during daylight hours and record details of all airgun operations, weather conditions, marine mammal watches and sightings.

The seismic operation involved firing high pressure air guns approximately every 20 seconds to generate sound waves. The towed streamer (consisting of a tube filled with kerosene and hydrophone groups) was used to record reflections from these sound waves that 'bounced off' transitional interfaces in the water column below the vessel.

1.1. MARINE MAMMALS, TURTLES AND ANTHROPOGENIC NOISE

Marine mammals
Anthropogenic noises disrupt the lives of marine mammals and other marine animal species. Sounds can:

1) Frighten or make marine mammals curious, but in either way change their behaviour with possible negative effects;
2) Compete with communication signals or echolocation, by sound masking, and thus decrease the efficiency of finding food, mating, caring for young, or avoiding predators;

cause,

3a) Physical effects such as stress leading to changes in hormone levels and perhaps lowered immunity from diseases;
3b) Temporary loss of hearing (or temporary threshold shift TTS) or permanent damage to hearing (PTS); or
3c) In the worst of cases with explosions or other loud noises that also send shock waves – possible death (Richardson and Wursig, 1997).

Sound generated by the airguns used in seismic operations is predominately of low frequencies, <200 Hz. Baleen whales (Mysticetes) such as Finn Whales *Balaenoptera physalus* and Minke Whales *Balaenoptera acutorostratus* are known to use and produce sound within the lower frequencies, mostly below 3 kHz, produced by seismic surveying and are therefore considered vulnerable to disturbance by such surveys ((ed) Evans and Raga, 2001) (McCauley *et al*. 2000).

Toothed whales and dolphins (Odontocetes) predominately use much higher frequencies, between 4.8 and 300 kHz, for communication and echolocation. However, some incidental higher frequency sound, up to 22 kHz, may also be produced by air guns (Goold 1995). Previous observations have suggested Odontocetes may be vulnerable to disturbance from seismic surveys (Evans and Nice 1996).

Acoustic factors have recently been implicated in the aetiology of bubble-related disease, 'the bends,' in Cetaceans (Jepson *et al.* 2003). Such bubble formation may also result from anthropogenic noise induced behavioural changes to normal dive profiles, particularly in deep diving species i.e. Sperm Whales *Physeter macrocephalus*, (Moore and Early, 2004).

One of the most significant effects of a general increase in background noise on marine mammals may be the reduction in an animal's ability to detect biologically relevant sounds in the presence of other sounds, a phenomenon known as masking. Masking, which might be thought of as acoustic interference, occurs when both the signal and masking noise have similar frequencies and either overlap or occur very close to each other in time.

Acute responses to sounds may be difficult to quantify, but they are much more tractable to investigation than are responses to repeated or chronic sounds. Sounds resulting in one-time acute responses are less likely to have population-level effects than are sounds to which animals are exposed repeatedly over extended periods of time. Long-term population effects will have the greatest impact on marine mammal species (Ocean Studies Board, 2003).

Marine turtles
Despite considerable scientific interest in marine turtles, many species are IUCN (World Conservation Union) Red Listed as 'Critically Endangered' or 'Endangered', very little is known about their hearing. The ears of turtles are well developed, and there is some evidence that at least a few species of marine turtles can detect sounds below 1 kHz (Ocean Studies Board, 2003). Studies undertaken with industrial seismic equipment (1 x 20 in^3. airgun), in controlled conditions, have shown hearing ability reduction, behavioural changes and avoidance exhibited by exposed marine turtle species (McCauley *et al*. 2000).

The potential exists for disturbance or injury to these species from seismic airgun sources.

1.1.1. Marine mammals of the Gulf of Cadiz and their IUCN (World Conservation Union) classifications

20 species of Marine mammal may be encountered In the Gulf of Cadiz. Of these species 5 are Mysticetes (Baleen Whales) and 15 Odontocetes (Toothed Whales).

IUCN Classifications are as follows:

- Endangered very high risk of extinction in the wild
- Vulnerable high risk of extinction in the wild
- Lower risk
- Data Deficient
- Status not listed

*IUCN, 2002 (IUCN classification categories).

MYSTICETES	**IUCN CLASSIFICATION**
Blue Whale *Balaenoptera musculus*	Endangered
Fin Whale *Balaenoptera physalus*	Endangered
Humpback Whale *Megaptera novaeangliae*	Vulnerable
Minke Whale *Balaenoptera acutorostrata*	Near Threatened
Sei Whale *Balaenoptera borealis*	Endangered
ODONTOCETES	
Sperm whale *Physeter macrocephalus*	Vulnerable
Northern bottlenose whale *Hyperoodon ampullatus*	Lower risk
Sowerby's beaked whale *Mesoplondon biden*	Data Deficient
Cuvier's beaked whale *Ziphius cavirostris*	Data Deficient
Short finned and long finned pilot whale Globicephala *macrorhynchus* and *G. melas*	Lower risk

Killer whale *Orcinus orca*	Lower risk
False Killer whale *Pseudorca crassidens*	Status not listed
Pygmy Killer Whale *Feressa attenuata*	Data Deficient
Common dolphin *Delphinus delphis*	Status not listed
Striped dolphin *Stenella coeruleoalba*	Lower risk
Rough Toothed dolphin *Steno bredanensis*	Data Deficient
Bottlenose dolphin *Tursiops truncatus*	Data Deficient
Risso's dolphin *Grampus griseus*	Data Deficient
Harbour porpoise *Phocoena phocoena*	Vulnerable

1.1.2. Marine turtles of the Gulf of Cadiz their IUCN (World Conservation Union) classifications

There are 5 species (see appendix 5 for diagram) of marine turtle known to occur in the Gulf of Cadiz. IUCN Classifications are as above with the exception of 'Critically Endangered' - Extremely high risk of extinction in the wild (IUCN, 2002).

SPECIES	**IUCN CLASSIFICATION**
Green Turtle *Chelonia mydas*	Endangered
Loggerhead Turtle *Caretta caretta*	Endangered
Olive Ridley *Lepidochelys olivacea*	Endangered
Hawksbill Turtle *Eretmochelys imbricata*	Critically Endangered
Leatherback Turtle *Dermochelys coriacea*	Critically Endangered

1.2. GULF OF CADIZ RESEARCH CRUISE

The research cruise proposed to use Multi Channel Seismic (MCS) airgun arrays to investigate the Mediterranean water outflow through the Straits of Gibraltar and the Gulf of Cadiz. Data was acquired by the RRS Discovery and also the R/V Poseidon in the Gulf of Cadiz from 19 - 22/04/07 to 28 - 13/05/07.

The first leg of the cruise utilized a smaller MCS array, 117.0 cu in, and the second a larger, 2320.0 cu in. The technical specifications for these two MCS arrays can be seen in summary in section 2.2, and are detailed in Appendices 2 & 3.

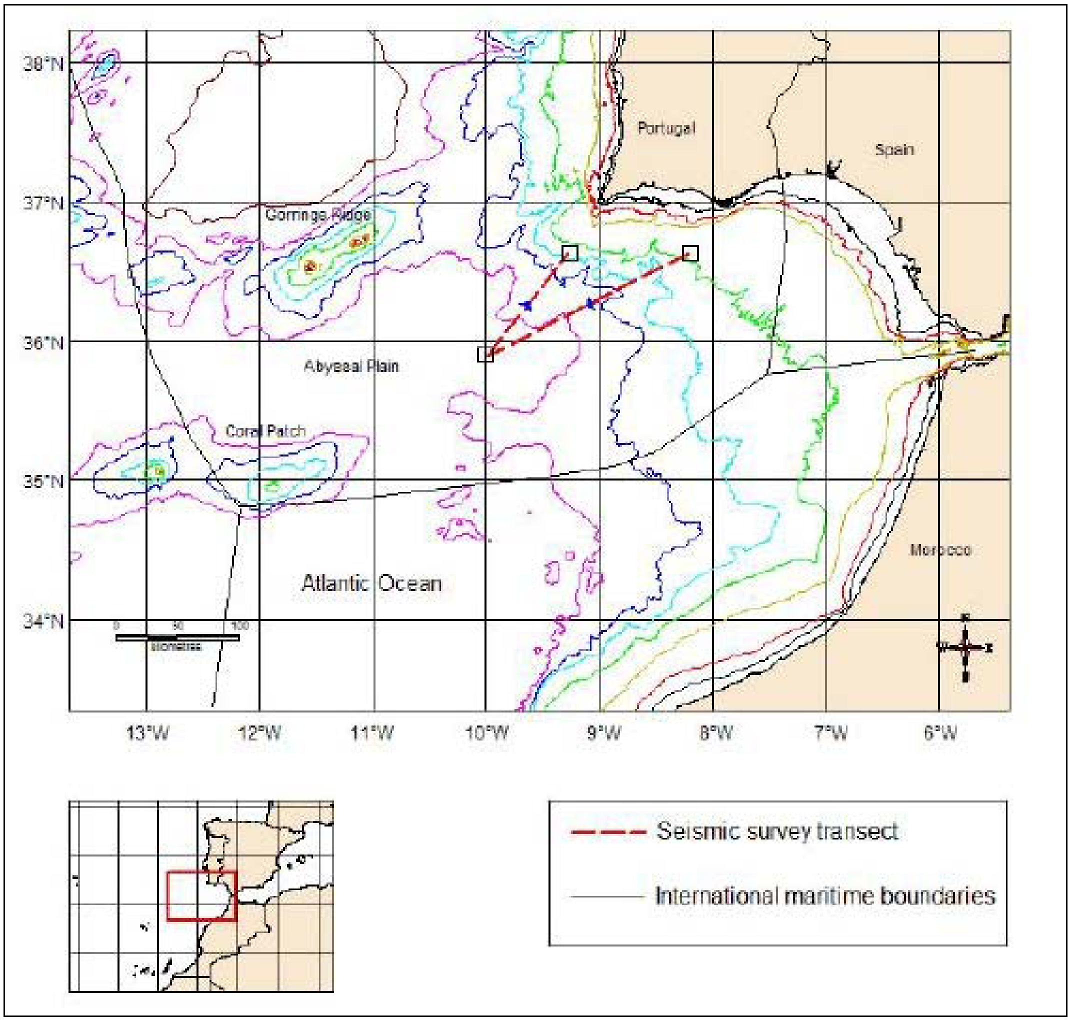
The research data was acquired primarily by the RRS *Discovery*, a vessel towing a high pressure airgun array, 2 sub-arrays, and 1 seismic streamer of 2,400 m overall length. The R/V Poseidon acted as a recording platform for some aspects of the seismic work.

The streamer was towed at c. 8 - 10 m depth and was not visible, except for a tail-buoy at its posterior end.

To maintain control over this equipment, the vessel required a minimum survey speed of c. 3.0 knots.

Other industrial operations in the immediate vicinity of the survey included heavy shipping traffic using the shipping lanes West of Cabo de Sao Vicente.

Figure 1: 'GO' Geophysical oceanography research survey: Gulf of Cadiz location



RPS Group Plc

2. SEISMIC SURVEY EQUIPMENT AND AIRGUN OPERATIONS

2.1. VESSEL

Figure 2: The NERC RRS Discovery

The research cruise was acquired by the NERC RRS Discovery, a multi purpose oceanographic research vessel. The vessel towed a 2, 320 in³ airgun array, and 1 seismic streamer of 2, 400 m (overall length).

2.2. AIRGUN ARRAY SPECIFICATION (SMALL AND LARGE MCS ARRAYS)

Small MCS array

Type of source:	GI
Total number of guns:	6
Airgun depth:	02 metres
Shot interval:	25 m
Pressure:	2, 000 psi
Total airgun volume:	117.0 in³
Frequency:	c. 4 – 1 KHz
Intensity:	c. 26.9 bar-m (peak to peak)

Large MCS array

Type of source:	Bolt
Number of arrays:	1
Number of sub-arrays:	2 (separation c. 5 m)
Source length:	08 m

Total number of guns:	6
Airgun depth:	08 metres (+/-0.5m)
Shot interval:	25 m
Pressure:	2, 000 psi
Total airgun volume:	2, 320 in³ / array in 2 sub-arrays
Frequency:	c. 4 – 1KHz
Intensity:	c. 48.4 bar-m (peak to peak)

These specifications are detailed in Appendices 2 & 3

2.3. AIRGUN SOFT START PROCEDURE

'Different age and sex classes of marine mammal are more sensitive to noise disturbance. The mitigation of startle responses to acoustic disturbance, which could result in the separation of animal groups or juveniles from mothers, are one reason seismic surveys are required to 'ramp up / soft start' the signal. Following soft start procedures will mean fewer animals experiencing the startle reaction thus allowing animals to vacate the area of loudest noise.

There is no evidence, however, that this action reduces the disturbance associated with these activities' (Ocean Studies Board, 2003).

Seismic observer crew were provided with a copy of the IAGC (International Association of Geophysical Contractors) 'soft start' procedure guidelines. Seismic observer crew described the 'soft start' procedure followed during the Gulf of Cadiz as "starting with the smallest airguns and gradually increasing airguns of greater volume until reaching the total array volume of 2, 320 in.³ over the 20 min. period."

2.4. AIRGUN OPERATIONS

Details of all recorded airgun operations are included in Appendix 4 and an airgun operation summary is shown below (See Table 1). Airgun operational times were recorded by seismic observer crew and monitored by the duty MMO.

Table 1: Summary of airgun operations

Total no. of recorded airgun operations 19.04.07 – 13.05.07	**Total No. of recorded airgun firing hours** 19.04.07 – 13.05.07	**Total No. of airgun operation starts in daylight hours** 19.04.07 – 13.05.07	**% Airgun operations with soft-starts**	**No. soft starts with duration greater than 20 minutes**	**No. soft starts with duration less than 20 minutes**
10	322: 40 mins.	10	100	10	0

3. MARINE MAMMAL OBSERVATION METHOD AND FINDINGS

3.1. MARINE MAMMAL OBSERVATION METHOD

The JNCC Guidelines require a check to be made for the presence of marine mammals within a 500 m radius of the airguns before firing. A watch was kept for marine mammals throughout daylight hours for the duration of the survey except when environmental conditions, such as high sea state, made sightings impractical. Watches for marine mammals were carried out by the duty MMO. The MMO utilised the bridge, and 'Monkey Island' areas for observations. Observer height on the bridge was c. 15 m above sea level, affording excellent visibility in good weather conditions.

Whilst surveying for marine mammals the sea was continuously scanned either with the naked eye or with binoculars. Any signs that may have indicated the presence of marine mammals were then immediately checked using the binoculars. Such signs included spray or cetacean blows, dark shapes or fins, patches of white water and circling or diving seabirds. Range to sightings from the airgun array was estimated by eye, using the known distance to any vessels in the area as a guide.

During the 'pre-firing watch' period leading up to the soft start particular attention was paid to the 500 metre area around the air guns, with the area being continuously scanned alternately with the naked eye and with binoculars. During this half-hour period prior to a soft start, any marine mammals sighted within 500 m of the air guns would have been reported immediately to the Seismic Observer Department and Principal Scientist. The activity of the marine mammals and their distance from the guns would also have been constantly monitored and reported. If marine mammals had been observed within 500 m of the airguns during the 20 minutes prior to the soft start, the soft start would have been delayed or the run into line would have been aborted if a delay was not possible.

Standard recording forms were completed by the MMO (Appendix 4). All sightings were recorded on such forms. On sighting a marine mammal the time, position of the ship and depth of the water column were immediately recorded. A description of the animals, the total number of individuals and the number of adults and juveniles were recorded. The identification of the species, and the certainty with which the identification was made, the behaviour of the animal(s), including surfacing and breathing rates when possible, and the direction of travel were also recorded on the form. A watch was made to record the closest distance that any animals seen came to the airguns. For each sighting, particular attention was paid to noting any evidence of behaviour that may have been a reaction to the presence of the vessel (attraction, avoidance, change of direction etc.). All such details were recorded on the behaviour section of the sightings form.

After each day's watch, the location and effort and record of airgun operation forms were completed. These included additional information on the length of watches and activities of the vessel.

Data requested on the duration of airgun operations and soft starts was provided by the seismic crew. Other information regarding array configuration, signature and soft start procedure etc. were provided on request. The daily environmental conditions were also recorded.

Completed recording forms including all the above details of marine mammal observations and the seismic operation were forwarded in electronic format to the JNCC and Dr Richard Hobbs, Cruise Principal Scientist.

3.1.1. Marine mammal sightings and watch details

39 sightings of a minimum number of 740 individual marine mammals were recorded during the cruise. Seven species were identified: Fin Whale Balaenoptera physalus, Sperm whale Physeter macrocephalus, False Killer whale Pseudorca crassidens, Common dolphin Delphinus delphis, Striped dolphin Stenella coeruleoalba, Long Finned Pilot Whale Globicephala melas and Short Finned Pilot Whale Globicephala macrorhynchus. These data are summarised in Table 2. Location Plots of marine mammal sightings can be seen in Appendix 6.

Table 2: Summary of marine mammal sightings

Recorded Species	Number of times each species was recorded	Minimum number of animals
Fin Whale *Balaenoptera physalus*	12	25
Sperm whale *Physeter macrocephalus*	1	1
False Killer whale *Pseudorca crassidens*	1	30
Common dolphin *Delphinus delphis*	12	86
Striped dolphin *Stenella coeruleoalba*	2	165
Long Finned Pilot Whale *Globicephala melas*	1	30
Short Finned Pilot Whale *Globicephala macrorhynchus*	1	40
Unidentified Whale Sp.	3	3
Unidentified Dolphin Sp.	6	360
Total	**39**	**740**

Table 3: Summary of marine mammal watches

Total (hours) dedicated watches for marine mammals	Total (hours) dedicated marine mammal watches during favourable environmental conditions *	Airgun firing time (hours) during dedicated marine mammal watches.	% of airgun operations in daylight hours subject to a 30 minute pre-shooting search.
112: 50 mins.	41 hours. (c. 36% of total)	71:37 mins.	100

* Sea state slight, swell low and visibility good

3.1.2. Behavioural response of marine mammals to seismic survey

Fin Whales *B. physalus*, sighted during seismic operations were observed to spend more time at the surface, move more rapidly and respire more frequently than the same Whales during periods of no airgun use. This information is anecdotal.

On 5 occasions (marine mammal sightings No.s: 4, 22, 26, 27 & 32) marine mammals passed within the zone of safely received SPL's as stated in the cruise EIA (QinetiQ, 2007) and were therefore at risk of suffering permanent injury. Fin Whales *B. physalus*, IUCN Red List classification 'Endangered' and at very high risk of extinction in the wild, were among these animals. Due to MCS source directivity, acoustic energy levels received by marine mammals would be lesser at the surface as animals surfaced to respire and greater at depth as can be seen in the source directivity plots in Appendix 7. The location of marine mammals in the water column and in relation to an operational MCS source can only be determined for animals observed surfacing to respire. Therefore, it is largely unknown what SPL's the above mentioned animals received. However, Fin Whales have been found to be capable of making regular feeding dives to 468 m and estimated maximum dives of 565 m (Panigada *et al*. 2003). How these animals and Dolphin species modify dive profiles in response to operational MCS sources is unknown.

Marine mammal watches were conducted for a maximum of 2 hour periods during daylight hours only. Therefore the number of animals present during the research cruise is likely to have been higher than recorded.

3.2. MARINE TURTLE SIGHTINGS

Of concern was the presence of World Conservation Union (IUCN), Red List classification ‘Endangered’ very high risk of extinction in the wild, marine turtle species in the Gulf of Cadiz operations area.

13 sightings of 13 IUCN Red Listed marine turtle species occurred. These were of the Loggerhead Turtle *C. caretta.* Location Plots of marine turtle sightings can be seen in Appendix 6.

Marine turtles were extremely difficult to detect at sea. All sightings were of individuals on the surface, ahead of the vessel, at ranges of less than 50 m in calm sea conditions. Individuals at greater ranges or in marginal sea conditions would not have been detected.

Table 4: Summary of Marine Turtles recorded

Recorded Species	**Number of times each species recorded**	**Minimum No. of animals**
Loggerhead Turtle *Caretta caretta*	13	13
Total	**13**	**13**

Large quantities of submerged, neutrally buoyant plastic bags and other plastic ‘trash’ items were seen whilst conducting the Gulf of Cadiz Cruise. These ‘trash’ items, commonly misidentified especially by feeding marine turtles as jellyfish, pose a significant threat to all marine turtles, mammals and birds when ingested.

3.2.1. Behavioural response of marine turtles to seismic survey

Marine turtles encountered were extremely difficult to detect at sea and those detected all passed alongside then astern of the vessel with a range to the large MCS airgun array of between 5 and 20 m. Turtles were seen to dive immediately ahead of firing airguns and were therefore exposed to considerable SPL’s. The above findings are interesting to note when considered alongside published research apparently showing turtles in controlled conditions to exhibit avoidance reactions, and therefore airgun exposure minimisation, at c. 1 km to a single 20 cu. in. airgun array. This published research also outlines hearing ability reduction and behavioural changes exhibited by exposed marine turtle species (McCauley *et al*. 2000).

It is likely that Loggerhead turtles *C. caretta* passing close to firing airguns were exposed to sound levels sufficient to cause physiological damage as a result of airgun exposure. In all 11 sightings during airgun operations (sightings No.s: 28, 29, 30, 31, 44 – 48, 50 & 51) the animals passed within the zone of safely received SPL’s (QinetiQ, 2007). Due to MCS source directivity, acoustic energy levels experienced by marine turtles would be lesser at the surface as animals respired and greater at depth as can be seen in the source directivity plots in Appendix 7. Loggerhead turtles have been found to spend the majority of their time considerably shallower than 100 m but do make dives to a maximum depth of 178 m (Balazs *et al. 2003*). How these animals modify dive profiles in response to operational MCS sources is unknown.

Such possible damage e.g. to sensory hair cells of ear structures, has been reported in fish species (McCauley *et al*. 2000). The ear structures of fish bear many similarities to those of marine mammal and possibly marine turtle species (Ocean Studies Board, 2003).

Marine turtle watches were conducted for a maximum of 2 hour periods during daylight hours only. Therefore the number of animals present during the research cruise is likely to have been higher than that recorded.

4. COMPLIANCE WITH JNCC GUIDELINES

The JNCC Guidelines (JNCC, 2004) were complied with during the research cruise, although it is not believed that these provided sufficient mitigation against disturbance to marine mammal and turtle species.

A dedicated watch for marine mammals was carried out by the duty MMO during daylight hours. This included a 30 min. 'pre-firing' scan of the 500 m radius area around the airgun array. Standard JNCC recording forms were completed by the duty MMO.

Seismic observer crew were provided with a copy of the JNCC Guidelines (JNCC, 2004), electronic and hard copy, airgun operations recording format (electronic), copy of the IAGC 'soft start' recommendations and were also made aware of key requirements of the JNCC Guidelines (JNCC, 2004) in briefings prior to survey commencement.

Number of MMO's
One dedicated MMO was aboard the NERC RRS *Discovery.*

'Pre firing' Watch
Whilst conducting the Gulf of Cadiz Research Cruise, 17.04.07 to 14.05.07, airguns were operated during daylight hours on a total of 10 occasions. A 'pre firing watch' was performed on 100 % of these occasions. Summarised airgun operations can be seen in section 2.4, Table 1.

Soft start
Whilst conducting the Gulf of Cadiz Research Cruise, 17.04.07 to 14.05.07, airguns were operated on a total of 10 occasions and in daylight hours. Soft starts were performed on all of these occasions. Soft starts ranged from 22 to 40 minutes in duration. On no occasion was a soft start shorter than the recommended 20 minute duration. Summarised airgun operations can be seen in section 2.4, Table 1.

'Firing Delay' due to Marine Mammals
The JNCC Guidelines (JNCC, 2004) state: 'If marine mammals are present (within 500 m), the start of the seismic sources should be delayed until they have moved away, allowing adequate time after the last sighting (at least 20 minutes) for the animals to move well out of range'. It was necessary to implement this guideline on 28/04/07 (sighting No. 16).

Meetings to discuss JNCC guideline compliance
Procedures to ensure contractor compliance with the JNCC Guidelines (JNCC, 2004): were discussed and verified at meetings aboard the NERC RRS *Discovery* on the following dates:

1. 17/04/07 – Survey 'start-up meeting' JNCC guidelines (JNCC, 2004) discussed with all scientific personnel present.

2. 27/05/07 - Guideline briefing of Scientific Crew as vessel sailed to Gulf of Cadiz prospect to ensure MMO requirements and working practices were understood.

Informative presentation
A presentation was given during third general science meeting: ship's company (including scientists, officers, technical support staff and Crew) informed of marine mammal encounters during the survey and potential effects of acoustic noise on marine mammals / turtles.

5. RECOMMENDATIONS

Adoption of appropriate anthropogenic noise mitigation practices
During the course of the Gulf of Cadiz research cruise the UK JNCC Guidelines (JNCC, 2004) were not believed to be adequate to mitigate against the possible disturbance and injury posed by seismic airguns to the full range of species encountered. The JNCC Guidelines (JNCC, 2004) have no provision for airgun 'shutdown' in the event that a marine mammal approaches operational seismic sources, as occurred during the Gulf of Cadiz Research Cruise. In future it is recommended that appropriate mitigation measures are considered in sensitive areas, including airgun 'shutdown,' as detailed in a set of standard mitigation guidelines (Weir, C. R, Dolman, S. J, 2007).

Passive acoustic monitoring
The use of suitable Passive Acoustic Monitoring (PAM) systems is recommended for future surveys.

The use of automated hydrophone equipment compliments visual observation methods by detecting the presence of inconspicuous but vocalising cetaceans.

Passive acoustic monitoring equipment would also alert operators to the presence of vocalising cetacean species e.g. Sperm Whale *Physeter macrocephalus* and Risso's Dolphin *G. griseus*, diving for extended time periods, which may not be detected during the 30 minute 'pre-shooting watch' by visual observers. This behaviour would result in these animals being exposed to seismic acoustic energy, of unknown intensity, at depth. This is thought to pose particular problems to these animals ((Ed) Tasker, M. I., Weir, C.1998) (Jepson *et al*, 2003) (Moore and Early, 2004).

Soft start
The use of a standardised soft start procedure is recommended. Presently the undertaking of this procedure, one of the most important mitigation measures preventing acute cetacean injury, is open to interpretation by operators.

Marine Turtle Guidelines
Future seismic surveys, especially those utilising large volume airgun arrays, need to address the potential problem of physiological damage to marine turtles with appropriate mitigation measures. Given the lack of Portuguese marine environmental legislation to ensure mitigation of detrimental industrial impacts to offshore marine turtle populations it is strongly recommended that in future surveys, suitable operational procedures are adopted, suitable mitigation measures followed (Weir, C.R, Dolman, S.J. 2007) and seismic contractor compliance monitored. The marine turtle species encountered during the Gulf of Cadiz Cruise was the IUCN Red Listed 'Endangered' Loggerhead Turtle *C. Caretta*, its conservation status being a sensitive environmental issue.

Future suitable mitigation measures would include those formulated specifically to protect marine turtles (Weir, C.R, Dolman, S.J. 2007).

Marine turtles sighted during this survey passed alongside the vessel, displaying only minimal 'concern' / avoidance at the presence of the vessel. Animals were then seen to display a 'startle' response in relation to firing airguns and dive just ahead of them.

6. CONCLUSIONS

The Gulf of Cadiz Research Cruise was carried out in accordance with the UK JNCC Guidelines (JNCC, 2004) for minimising acoustic disturbance to marine mammals from seismic surveys. The guidelines were complied with throughout the survey.

Of concern in the Gulf of Cadiz Research Cruise area was the presence of transient and seasonally migrating World Conservation Union (IUCN) Red Listed marine mammal and marine turtle species, as identified in the Research Cruise EIA (QinetiQ, 2007).

On a number of occasions marine mammals and turtles entered the area around operating airguns believed to contain SPL's (sound pressure levels) at a high enough level to cause injury.

All information requested by the MMO of the Seismic Observers regarding 'soft start' procedures and airgun firing duration times was provided upon request.

7. REFERENCES

Balazs, G.H., Howell, E., Parker, D. M., Polovina, J. J. (2003). Dive-depth distribution of loggerhead (Carretta carretta) and olive ridley (Lepidochelys olivacea) sea turtles in the central North Pacific: Might deep longline sets catch fewer turtles. Fishery Bulletin 101 (1):189–193 (2003).

Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals, Ocean Studies Board, (2003). Ocean noise and Marine Mammals. National Research Council of the national academies. THE NATIONAL ACADEMIES PRESS, Washington, D.C. USA. pp 93, 96. www.nap.edu

Evans, P.G.H. & Nice, H. (1996). Review of the effects of underwater sound generated by seismic surveys on cetaceans. Report to UKOOA, Oxford, Sea Watch Foundation.

(Ed) Evans, P.G.H., Raga, J.A. (2001). Marine Mammals Biology and Conservation. Kluwer Academic, London.

Goold, J. C. (1995). Broadband spectra of seismic survey air-gun emissions, with reference to dolphin auditory thresholds. The Journal of the Acoustical Society of America -- April 1998 -- Volume 103, Issue 4, pp. 2177-2184. John C. Goold, University of Wales Bangor, School of Ocean Sciences, Menai Bridge, Anglesey LL59 5EY, United Kingdom Peter J. Fish, University of Wales Bangor, School of Electronic Engineering and Computer Systems, Dean Street, Bangor, Gwynedd LL57 1UT, United Kingdom

Jepson, P. D., Arbelo, M., Deaville, R., Patterson, I. A. P., Castro, P., Baker, J. R., Degollada, E., Ross, H. M., Herraez, P., Pocknell, A. M., Rodriguez, F., Howie, F. E., Espinosa, A., Reid, R. J., Jaber, J. R., Martin, V., Cunningham, A. A., Fernandez, A. (2003). Gas bubble lesions in stranded cetaceans. Nature. 423: 575.

McCauley et al. (2000). Marine Seismic Surveys – A Study of Environmental Implications. Appea Journal 2000, 692 – 708.

Moore, M. J., Early, G. A., (2004). Cumulative Sperm Whale Bone Damage and the Bends. Science Vol. 306, 24 December 2004.

Panigada, S., G. Pesante, M. Zanardelli and S. Oehen. 2003. Day and night-time behaviour of fin whales in the Western Ligurian Sea. Proceedings of the Conference Oceans 2003, September 22-26, 2003, San Diego, California. Pp 466-471.

QinetiQ, (2007). Environmental Impact Assessment (EIA) in Support of the Gulf of Cadiz Cruise – 17 April to 14 May 2007. QinetiQ/D&TS/SEA/EIA0704992.

Richardson, W.J. and Wursig, B. (1997) Influences of man – made noise and other human actions on cetacean behaviour. Marine and Freshwater Behaviour and Physiology, 29, 183-209.

(Ed) Tasker, M. l., Weir, C. (1998). Proceedings of the Seismic and Marine Mammals Workshop London 23 – 25 June 1998, sect. 6

Weir, C.R, Dolman, S.J. (2007). Comparative Review of the Regional Marine Mammal Mitigation Guidelines Implemented During Industrial Seismic Surveys, and Guidance Towards a Worldwide Standard. Journal of International Wildlife Law and Policy, 10:1–27, 2007.

APPENDIX 1

GUIDELINES FOR MINIMISING ACOUSTIC DISTURBANCE TO MARINE MAMMALS FROM SEISMIC SURVEYS, April 2004

JOINT NATURE CONSERVATION COMMITTEE
Marine Advice
Dunnet House
7 Thistle Place
ABERDEEN
AB10 1UZ

Tel: 01224 655716
E-mail: seismic@jncc.gov.uk
Website: www.jncc.gov.uk/marine

These guidelines are aimed at minimising the risk of acoustic disturbance to marine mammals including seals, whales, dolphins and porpoises from seismic surveys. In addition to keeping noise levels at lowest practicable levels the recommendations contained in the guidelines should assist in ensuring that marine mammals in areas of proposed airgun activity are protected against possible injury. These guidelines reflect a precautionary approach that should be used by anyone planning marine operations that could cause acoustic or physical disturbance to marine mammals.

The guidelines have been written for use in the United Kingdom Continental Shelf (UKCS). Whilst we do not object to these guidelines being used elsewhere we would encourage all operators to determine if any special or local circumstances pertain as we would not wish these guidelines to be used where a local management tool has already been adopted (for instance in the Gulf of Mexico OCS Region). We also note that other fauna, for example turtles, occur in waters where these guidelines may be used. We suggest that, whilst the appropriate mitigation may require further investigation, the soft start procedures similar to those followed for marine mammals should also be employed for other fauna.

In relation to oil and gas seismic surveys on the UKCS, it is a legal binding condition of the consent issued for seismic surveys under regulation 4 of the Petroleum Activities (Conservation of Habitats) Regulations 2001 by the Department of Trade and Industry (DTI) that the JNCC Guidelines must be followed at all times for all seismic surveys. It should be noted that it is the responsibility of the company issued consent by the DTI, referred to as 'applicant', to ensure that these guidelines are followed and the relevant marine mammal observer reports submitted to the JNCC. We recommend that a copy of the JNCC guidelines are available onboard all vessels undertaking seismic surveys on UKCS.

Index

The guidelines are broken down in the following sections:

Terminology

High Resolution Seismic Site Survey is defined as those using an airgun array of 180 cubic inches or less.

Seismic Survey includes 2D/3D/4D and OBC (Ocean Bottom Cabling) surveys and any similar techniques

Vertical Seismic Profiling or **Borehole Seismic** is defined as seismic used in connection with well operations typically with a source size of 500 cubic inches.

Consent is the consent issued by the DTI under regulation 4 of the Offshore Petroleum (Conservation of Habitats) Regulation 2001.

Applicant is defined as the company who has applied to the DTI for PON 14A consent. This could either be an oil and gas operator or a seismic survey company.

Section 1 – General precautions to reduce the disturbance caused by seismic surveys

1.1 <u>The Planning Stage – When a seismic survey is being planned, operators should:</u>

- Consult relevant literature and if necessary, contact the Joint Nature Conservation Committee (JNCC) to determine the likelihood that marine mammals will be encountered. For instance:
  (http://www.jncc.gov.uk/Publications/cetaceanatlas/)
- Plan surveys so that their timing will reduce the likelihood of encounters with marine mammals especially during the breeding and calving seasons. If an area is particularly sensitive due to the species present an assessment of this should be included within the PON 14 application
- Seek to provide the most appropriately qualified and experienced personnel to act as marine mammal observers (MMOs) on board the seismic survey vessel (see Section 4 for further information on MMOs).
- Plan to use the lowest practicable power levels throughout the survey.
- Seek methods to reduce and/or baffle unnecessary high frequency noise produced by airguns or other acoustic energy sources.

1.2 <u>During the Seismic Survey – When conducting a seismic survey, operators should:</u>

- Ensure that the correct 'soft start' procedure is followed. Soft starts are intended as a time period to allow marine mammals to move away from an area should they wish to do so. (See Section 2)
- There should be no shooting apart from that necessary for the normal operations of a seismic survey or for a 'soft start'. Protracted shooting which is not part of a survey line is discouraged.

1.3 <u>Report after the survey</u>

A report detailing marine mammals sighted (standard forms are available from JNCC), the methods used to detect them, problems encountered, and any other comments helps to increase our knowledge and allow us to improve these guidelines. Reports should be sent to the JNCC ideally by e-mail to seismic@jncc.gov.uk or faxed/posted to the address at the face of these guidelines. Reports should include the following information:

- The Seismic Survey reference number provided to operators by the DTI
- Date and location of survey
- Number and volume of each airguns used also calculated as total volume.
- Nature of airgun array discharge frequency (in Hz), intensity (in dB re. 1μPa or bar metres) and firing interval (seconds), or details of other acoustic energy used
- Number and types of vessels involved in the survey
- A record of all occasions when the airguns were used, including the watch beforehand and the duration of the soft-start (using standard forms)
- Details of any problems encountered during marine mammal detection procedures, or during the survey
- Marine mammal sightings (using standard forms)
- Details of watches made for marine mammals and the seismic activity during watches (using standard forms)
- Reports from any observers on board

Section 2 – Guidance when carrying out a soft start

If dedicated MMOs are requested to be on board a seismic vessel they should make certain that their efforts are concentrated on keeping a watch prior to the soft start. At no time are these guidelines meant to imply that MMOs should keep a watch during all daylight hours. JNCC strongly encourage all MMOs to manage their time to ensure that they are available and at the best of their ability when carrying out a watch during the crucial time – the 30 minutes before commencement of the use of a seismic source. However, JNCC does appreciate the efforts of MMOs to collect data at other times than prior to the soft start but this should be managed to ensure these observations are not detrimental to the ability of the MMO to watch prior to a soft start. The JNCC will request that two marine mammal observers be used when daylight hours exceed approximately 12 hours per day. Where two MMO's are onboard a seismic vessel we would encourage them to collaborate to ensure cetacean monitoring is undertaken during all daylight hours and to ensure that an observer is always available to undertake a pre-start up search for the required 30 minute.

2.1 Look and Listen

Beginning at least 30 minutes before commencement of any use of the seismic sources, the dedicated MMO or if a dedicated MMO has not been requested by the DTI, a nominated member of the ships company should carefully make a visual check from a suitable high observation platform to see if there are any marine mammals within 500 metres (measured from the centre of the array).

2.2 Delay

If marine mammals are seen within 500 metres of the centre of the array the start of the seismic sources should be delayed until they have moved away, allowing adequate time after the last sighting for the animals to move away (at least 20 minutes). In situations where seal(s) are congregating immediately around a drilling or production platform, it is recommended that commencement of the seismic sources begin at least 500 m from the platform.

2.3 The Soft Start

Power should be built up slowly from a low energy start-up (e.g. starting with the smallest airgun in the array and gradually adding in others) over at least 20 minutes to give adequate time for marine mammals to leave the vicinity. This build up of power should occur in uniform stages to provide a constant increase in output. There should be a 'soft start' every time the airguns are used, even if no marine mammals have been seen.

- We encourage all seismic survey operators to ensure that, as far as possible, soft starts occur during daylight hours when MMO's or the nominated crew member can carry out the required 30 minute watch. If visual observations can not be made we continue to encourage the use of PAM for acoustic monitoring during this time.
- To minimise additional noise in the marine environment, a 'soft start' (from commencement of soft start to commencement of the line) should take no longer than 40 minutes.
- The 'soft start' procedure should be followed at all times including before test firing of the airguns.
- If, for any reason, firing of the airguns has stopped and not restarted for at least 5 minutes a full 20 minute 'soft start' should be carried out. After any break in firing of any duration a visual check should be made for marine mammals within 500 metres of the centre of the array. If a marine mammal is present then re-commencement of shooting should be delayed as per the Look & Listen, Delay and Soft Start instructions above.
- When time-sharing, where two or more vessels operate in adjacent areas and take turns to shoot to avoid causing seismic interference to each other, all vessels shooting should follow the full 'soft start' procedure for each line start.

2.4 Site Survey / Vertical Seismic Profiling (VSP) and Soft Starts

Whilst we appreciate that high resolution site surveys / VSP operation may produce lower acoustic output than 2D or 3D surveys and that firing of individual airguns may not be possible for technical reasons, we believe it is still necessary to undertake some form of a soft start to allow time for marine mammals to move away from an airgun.

We understand there are a number of options as to how a soft start may be undertaken. For reasons of flexibility we are content for high resolution seismic site surveys and VSP operations to use any of the methods below for a soft start:

A. The standard method, where power is built up slowly from a low energy start-up (e.g. starting with the smallest airgun in the array and gradually adding in others) over at least 20 minutes to give adequate time for marine mammals to leave the vicinity.
B. As the relationship between acoustic output and pressure of the air contained in the airgun is close to linear and most site surveys / VSP operations use only a small number of airguns a soft start can be achieved by slowly increasing the air pressure in 500 psi steps. From our understanding the minimum air pressure which the airgun array can be set to will vary, as this is dependent on the make and model of the airgun being used. The time from initial airgun start up to full power should be at least 20 minutes.
C. If neither of the above techniques (A or B) can be used, over a minimum time period of 20 minutes the airguns should be fired with an increasing frequency until the desired firing frequency is reached.

If an operator of an airgun array is unable to undertake a soft start using the methods above a waiver must be granted in the DTI consent. This must be applied for with the JNCC prior to the actual operation occurring ideally as part of the PON 14A submission or for VSP the PON14A or PON15B. If a waiver has not been agreed by the JNCC, and consented to by the DTI and a soft start is not implemented applicants will be in breach of their consent.

When submitting the MMO report to the JNCC for high resolution seismic site surveys operators should indicated which of the above methods was used to achieve the soft start.

2.5 Line Change

Seismic data is usually collected in lines. Line change is the term used to describe the time it takes for a vessel to turn from the end of one line to the start of the next. Depending upon the type of seismic survey being undertaken, the time for a line change can vary between five and ten minutes for site surveys to two to three hours for 3D exploration surveys. In the past this has caused some confusion as to when a soft start will be required. In order to standardise approaches the following guidance is provided:

A. For line change times greater than the time required to undertake a soft start, airguns should cease firing at the end of each line and commence a full soft start at the appropriate time before commencing the next line (i.e. a soft start of at least 20 minutes prior to commencement of the next line).
B. For line change which take less time than that required to undertake a soft start, airguns should continue firing the full array during the line turn (i.e. for a site survey line turn of 5 minutes continue firing at full power).
C. For high resolution site surveys line changes it is also permissible to reduce airgun output at the end of each line to an output of 160dB. The increase from 160 dB to full power, prior to the start of the next line, should be undertaken in a stepped manner similar to a full soft start.

We understand that, depending on the length of line turns for some surveys such as OBC, soft start methods may need to vary from those described above. If an applicant believes that for any survey a line change may not achieved using the above methods please contact JNCC at the earliest possible opportunity.

2.6 Undershoot Operations

During an undershoot operation a second vessel is employed to tow the seismic source or airguns although the main vessel will still tow the hydrophone array. This is to allow shooting under platforms or around any other obstructions at sea. It has been noted that this operation can sometimes lead to difficulties when, as a term of the consent, a dedicated MMO has been requested. The following guidance is provided:

In sensitive areas, the MMO should always be onboard the source vessel. If, following the receipt of a PON 14A application and advice from JNCC, the consent states that dedicated MMO(s) should be placed on board the seismic source vessel this condition of consent applies to all vessels including any source vessel undertaking undershoot operations.

When a dedicated MMO(s) has been requested in other areas operators should aim to ensure that the dedicated MMO is on the source vessel. If, due to difficulties in logistics (usually the health and safety issues of moving a MMO from one vessel to another) this is not possible, the operator should apply for a waiver, ideally at the time of the PON14A submission. If a waiver is given (which will depend upon the sensitivities at the survey location, and duration of undershoot operations) the look, listen and delay procedure should still be followed prior to commencing a soft start of the airgun source on the vessel undertaking the undershoot operation.

We realise that this guidance may be difficult to implement and therefore strongly encourage those applicants who foresee a problem placing an MMO onboard a vessel undertaking an undershoot operation to consult with DTI and JNCC during the PON 14A application process.

Section 3 – Marine Mammal Observers or MMOs

- A prerequisite for an MMO is the attendance of a short course on implementing the guidelines and recording procedure. Further details of the courses can be obtained by contacting seismic@ jncc.gov.uk.
- For sensitive areas including West of Britain, Moray Firth and Cardigan Bay, the MMO must also be an experienced cetacean biologist or an experienced marine mammal observer (i.e. an observer with at least three seasons worth of experience).
- When a dedicated MMO is requested, the MMO should be employed solely for the purpose of monitoring the applicants implementation of the guidelines and visual observation of marine mammals during periods of active seismic survey.
- All surveys that require MMOs taking place between 1st April and 30th September north of 57° latitude will require two dedicated MMOs due to the longer daylight hours (more than 12 hours a day at 57° latitude).
- When two dedicated MMOs are requested, the use of a crewmember with other responsibilities as the second observer is not considered an adequate substitute for a dedicated MMO.
- The MMO should be onboard the source vessel. (i.e. the vessel towing the airguns). When time sharing, if an MMO is required by DTI, MMOs should be placed on all source vessels.
- Operators are advised to contact JNCC at the earliest opportunity to request information on the need for MMOs. Every application for consent to carry out a seismic survey will be treated on a case-by-case basis by the JNCC however the following is a guide to our probable advice to the DTI on the need for MMOs.

3.1 Likely requirements for Marine Mammal Observers

Area	Sensitivity / MMO Requirement
• **Southern North**	**Cetacean sensitivities are generally low to moderate.**

Sea • **Irish Sea Basin**	• Seismic surveys using large sources such as those for 2D or 3D seismic surveys may require a dedicated MMO. For all other surveys a dedicated MMO is usually not required however • A watch should be kept for marine mammals before airgun start up (See section 2) • A report should still be submitted to the JNCC containing location, effort and sighting forms (See Section 2).
• **Central and Northern North Sea** • **St Georges Channel** • **South West Approaches** • **English Channel**	**Cetacean sensitivities are highly variable.** Requirements for MMOs are varied according to the energy source volume, energy source pressure level, sound frequency and survey location however the following guidance is available. • Seismic surveys using large sources such as those for 2D or 3D seismic surveys will require a dedicated MMO. • All surveys requiring MMOs taking place between 1st April and 1st October north of 57° latitude will require two dedicated MMOs due to the longer daylight hours.
• **Moray Firth,** • **Cardigan Bay,** • **West of Britain (includes all areas to the north and west of Shetland and to the west of Orkney and the Western Isles)**	**Cetacean sensitivities are high** • Any seismic operation including site surveys will require dedicated experienced MMOs. • All surveys requiring MMOs taking place between 1st April and 1st October north of 57° latitude will require two dedicated MMOs due to the longer daylight hours.

Section 4 – Acoustic Monitoring

JNCC will advise the DTI that passive acoustic monitoring (PAM) should be used as a mitigation tool if sensitive species are likely to inhabit the proposed survey location. This additional measure is required where there are species of particular conservation importance or where a given species or group is difficult to detect by visual observation alone. Examples of areas where PAM may be required include deep-water areas west of Britain (for large baleen and sperm whales) and the Moray Firth (for bottlenose dolphins).

In all sea areas there is a concern that visual observation can be an ineffective measure, particularly during hours of darkness or poor visibility (such as fog), as marine mammals in the vicinity of airgun sources will not be detected. In line with the revised DTI position and other Government departments, JNCC view PAM as the only available mitigation technique that, at its current stage of development, will increase the detection of marine mammals prior to the soft start whilst having no possible adverse effect on marine mammals of its own. We would therefore encourage applicants to use PAM as it will increase the detection of marine mammals and we expect that as the technology matures over the next few years, PAM will become a requirement on seismic surveys.

4.1 Use of PAM as a mitigation tool

The following guidance is provided in regard to PON 14A applications where JNCC request PAM use as a mitigation tool. In many cases, PAM is not as accurate as visual observation when determining range. In practice this will mean that the exclusion zone must reflect the range accuracy of the system and will often be more than 500m. For example, if the range accuracy of a system is +/-300 metres, animals detected within 500 + 300 (800) metres of the source would lead to a delay in the soft start. It is therefore in the operators best interests to use the most accurate system available and to factor in the range inaccuracy. Where PAM is used the PON 14A application must contain an explanation of how the operator intends to deploy PAM to greatest effect.

Some PAM systems do not have accurate range determination facilities or can only calculate range for some species. In such cases, the detection of a confirmed cetacean vocalisation should be used to initiate postponement of soft start based on the expert judgment of the PAM operator who may be able to make a judgement about the range of the marine mammal (dependent on species) from the vessel by differentiating between distant and near-field vocalisations. In the absence of PAM systems capable of range determination this expert judgement may be used to ensure an area is free from cetaceans prior to the soft start.

Section 5 - Background Information

These guidelines were originally prepared by a Working Group convened at the request of the Department of the Environment, developed from a draft prepared by the Sea Mammal Research Unit (SMRU). The guidelines have subsequently been reviewed three times by the Joint Nature Conservation Committee following consultation with interested parties and in the light of experience after their use since 1995.

5.1 <u>Existing Protection</u>

- Section 9 of the Wildlife and Countryside Act 1981 prohibits deliberate killing, injuring or disturbance of any cetacean (equivalent in Northern Ireland is Article 10 of the Wildlife (Northern Ireland) Order 1985).
- This reflects the requirements of the Convention on the Conservation of European Wildlife and Habitats (the Bern Convention) and Article 12 of the EC Habitats and Species Directive (92/43/EEC), implemented by The Conservation (Natural Habitats, etc.) Regulations 1994, The Conservation (Natural Habitats, etc.) Regulations Northern Ireland 1995 and The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001.
- In addition, the UK is a signatory to the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) and has applied its provisions in all UK waters. Amongst other actions required to conserve and manage populations of small cetaceans, the Agreement requires range states to "work towards…the prevention of …disturbance, especially of an acoustic nature".

Section 6 – Further information, comments on these guidelines and contacts

Further information on the DTI's consent procedure is available at www.og.dti.gov.uk.

A copy of these guidelines, the standard forms (electronic and hard copy) and further background information is available from the above address or on the JNCC website: www.jncc.gov.uk/marine

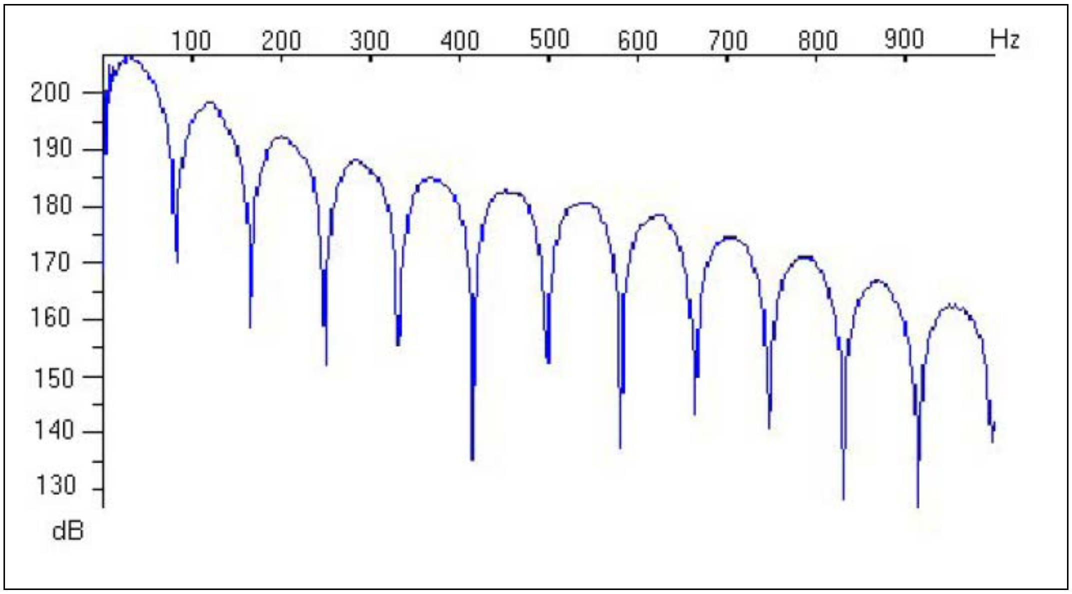
If you have any comments or questions on these guidelines, or suggestions on how they may be improved please contact the JNCC Senior Offshore Advisor at the address shown above.

APPENDIX 2

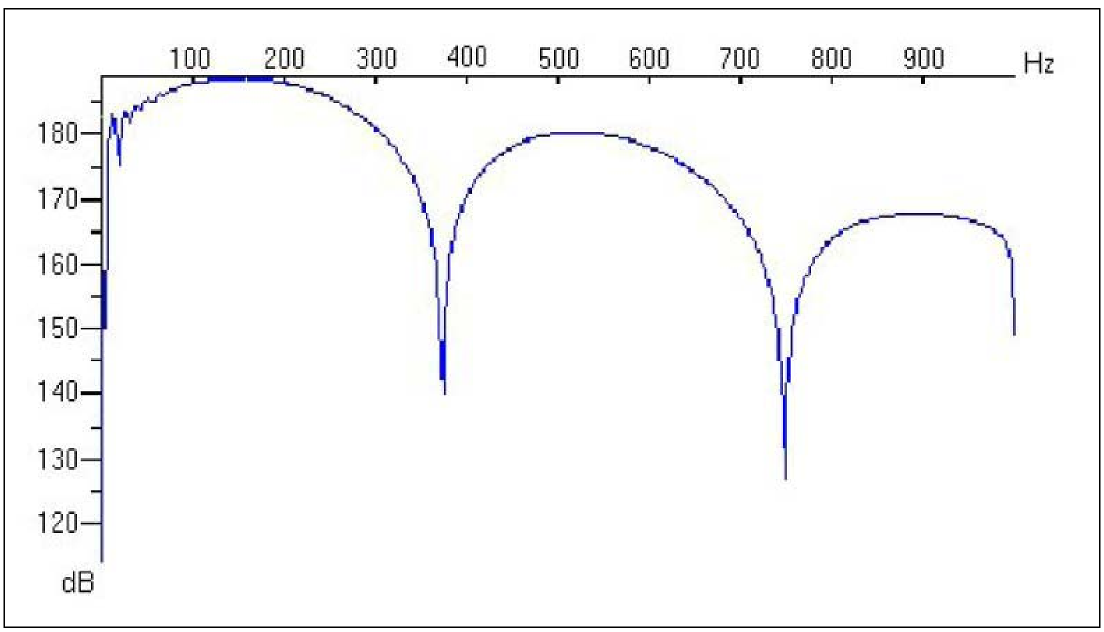
AMPLITUDE SPECTRUMS FOR LARGE AND SMALL MCS AIRGUN ARRAYS

AMPLITUDE SPECTRUMS FOR LARGE AND SMALL MCS AIRGUN ARRAYS

Amplitude Spectrum for Large MCS Airgun Array



Amplitude Spectrum for Small MCS Airgun Array



APPENDIX 3

GULF OF CADIZ WORK PROGRAMME AND AIRGUN SPECIFICATIONS

GULF OF CADIZ WORK PROGRAMME AND AIRGUN SPECIFICATIONS

A.1 First Leg of cruise

D318 (a) Lisbon - Lisbon; 17 April - 23 April; RRS Discovery
Activities:
CTD casts at

36°38'N 008°12'W
35°54'N 010°00'W
36°38'N 009°16'W

Deploy 5 off seabed moorings for oceanography at
36 deg 38'N 8 deg 12'W in a ~10 x 10 km box
Acquire 2 regional seismic lines
36°38'N 008°12'W -> 35°54'N 010°00'W
35°54'N 010°00'W -> 36°38'N 009°16'W
Acquire 3 detailed grids at
36°38'N 008°12'W
35°54'N 010°00'W
36°38'N 009°16'W

Acquisition specifications:
GI-air gun source - this will be a small source ~ 1200 cu in with largest chamber being ~450 cu in.
600m hi-resolution hydrophone streamer
XBT and XCTD deployment at a 2.5 to 5 nm interval

A.2 Second leg of cruise

D318(b) Lisbon - Lisbon; 29 April - 14 May; RRS Discovery
Funchal - Cadiz; 26 April - 10 May; MV Poseidon (German vessel)
Activities (RRS Discovery)
Acquire 2 regional seismic lines
36°38'N 008°12'W -> 35°54'N 010°00'W
35°54'N 010°00'W -> 36°38'N 009°16'W
Acquire 3 detailed grids at
36°38'N 008°12'W
35°54'N 010°00'W
36°38'N 009°16'W

Acquisition specifications:
Bolt 1500LL air gun source - this will be a medium sized source ~ 2400 cu in with largest chamber being ~600 cu in.
2400m hydrophone streamer
XBT and occasional XCTD deployment at a 2.5 to 5 nm interval
Recover 5 moorings installed at start of D318(a)
MV Poseidon to follow RSS Discovery
CTD casts at
36°38'N 008°12'W
35°54'N 010°00'W
36°38'N 009°16'W

Array parameters	Lo resolution survey	Hi resolution survey
Number of guns	6	6
Total volume (cu.in).	2320.0 cu in (38 litres)	117.0 cu in (1.92 litres)
Peak to peak in bar-m.	48.4 (4.84 MPa, 254 db re 1 ®Pa. at 1m.)	26.9 (2.69 MPa, 249 db re 1 ®Pa. at 1m.)
Zero to peak in bar-m.	25.2 (2.52 MPa, 248 db re 1 ®Pa. at 1m.)	14.8 (1.48 MPa, 243 db re 1 ®Pa. at 1m.)
RMS pressure in bar-m.	2.87 (0.287 MPa, 229 db re 1 ®Pa. at 1m.)	0.795 (0.0795 MPa, 218 db re 1 ®Pa. at 1m.)
Bubble period to first peak (s)	0.165	0.0625

A.3 Trial specifications:
Deployment depth(s) of array:
Hi Resolution survey 2m
Lo Resolution survey 8m
Firing rate (How many minutes or seconds between each discharge):
Hi Resolution survey ~10s
Lo Resolution survey min 15s normally 30s
Acoustic activity takes place 24 hours out of 24
Approximate times of activity
Hi res source will be used 19 April-22 April
Lo res source will be used 30 April-7 May and 9 May-13 May
Towing speed of RRS Discovery:
Hi Resolution survey 5 kts
Lo Resolution survey 3.5 kts

Distance between each firing:
Hi Resolution survey 25m
Lo Resolution survey min 25m normally 50m
Size of detailed grid:
Each of the 3 mini grids will be 20 x 20 km and over a 48 hr period and will shoot ~16 x 20km with a duty cycle of about 80% profiles; plus one continuous spiral profile with a maximum radius of 10km over a period of 16hr.

APPENDIX 4

MARINE MAMMAL RECORDING FORMS

LOCATION AND EFFORT
RECORD OF OPERATIONS
RECORD OF MARINE MAMMAL AND TURTLE SIGHTINGS

.

MARINE MAMMAL RECORDING FORM GULF OF CADIZ - LOCATION AND EFFORT DATA

Ship RRS Discovery   Ship type: Research   Survey type: 2D

Please record the following information every day (as many lines per day as you wish), even if no marine mammals are seen.

Date	Observer	Time you started looking for marine mammals (GMT)	Time you stopped looking for marine mammals (GMT)	Duration of watch for marine mammals (hrs & mins)	Length of time airguns were shooting while you were looking for marine mammals (hrs & mins)	Blocks transited while looking for marine mammals (or start and end position if blocks not known)	Wind force and direction (use Beaufort scale)	Sea state Choose from: **G** = glassy (like mirror) **S** = slight (no or few white horses) **C** = choppy (many white horses **R** = rough (large waves,foam crests, spray)	Swell Choose from: **O** = low (< 2 m) **M** = medium (2 - 4 m) **L** = large (> 4 m)	Visibility Choose from: **P** = poor (< 1 km) **M** = moderate (1- 5 km) **G** = good (> 5 km)
18-Apr-07	MMO	6:24	7:24	1:00	N/A	36 40.11 N 08 12. 91 W	NE 4-5	C	M	M
						36 37.19 N 08 15. 78 W	NE 4-5	C	M	M
19-Apr-07	MMO	6:00	10:00	4:00	N/A	36 16. 92 N 09 05. 71 W	NE 3	S	O	G
						36 22. 25 N 08 51. 33 W	NE 3	S	O	G
	MMO	13:00	15:00	2:00	2:00	36 29. 77 N 08 32. 65 W	NE 3	S	O	G
						36 30. 03 N 08 32. 54 W	NE 3	S	O	G
20-Apr-07	MMO	7:00	9:00	2:00	2:00	36 33. 61 N 08 11. 88 W	VAR 2	S	O	G
						36 40. 63 N 08 18. 68 W	VAR 2	S	O	G
		13:00	15:00	2:00	2:00	36 37. 06 N 08 12. 56 W	VAR 2	S	O	G
21-Apr-07	MMO	7:00	9:00	2:00	2:00	36 11. 58 N 09 17. 64 W	ENE 3	S - C	O	G
						36 09. 00 N 09 23. 77 W	ENE 3	S - C	O	G
		10:00	11:00	1:00	1:00	36 06. 12 N 09 30. 09 W	ENE 3 - 4	S - C	O	G
						36 05. 42 N 09 32. 48 W	ENE 3 - 4	S - C	O	G
		13:00	15:00	02:00	2:00	35 59. 73 N 09 46. 83 W	ENE 3 - 4	C	O	G
						36 01. 59 N 09 41. 73 W	ENE 3 - 4	C	O	G

MARINE MAMMAL RECORDING FORM GULF OF CADIZ - LOCATION AND EFFORT DATA

Ship RRS Discovery   Ship type: Research   Survey type: 2D

Please record the following information every day (as many lines per day as you wish), even if no marine mammals are seen.

Date	Observer	Time you started looking for marine mammals (GMT)	Time you stopped looking for marine mammals (GMT)	Duration of watch for marine mammals (hrs & mins)	Length of time airguns were shooting while you were looking for marine mammals (hrs & mins)	Blocks transited while looking for marine mammals (or start and end position if blocks not known)	Wind force and direction (use Beaufort scale)	Sea state Choose from: **G** = glassy (like mirror) **S** = slight (no or few white horses) **C** = choppy (many white horses **R** = rough (large waves,foam crests, spray)	Swell Choose from: **O** = low (< 2 m) **M** = medium (2 - 4 m) **L** = large (> 4 m)	Visibility Choose from: **P** = poor (< 1 km) **M** = moderate (1- 5 km) **G** = good (> 5 km)
22-Apr-07	MMO	6:00	8:00	2:00	2:00	36 12. 46 N 09 15. 41 W	VAR 2	S	O	G
						36 09. 70 N 09 27. 05 W	VAR 2	S	O	G
		9:00	10:00	1:00	1:00	36 12. 46 N 09 15. 81 W	VAR 2	S	O	G
						36 13. 81 N 09 13. 65 W	VAR 2	S	O	G
		13:00	15:00	2:00	N/A	36 22. 92 N 08 50. 11 W	VAR 2	S	O	G
						36 33. 61 N 08 46. 46	VAR 2	S	O	G
	End of first leg									
27-Apr-07	MMO	18:00	19:00	1:00	N/A	38 29. 46 N 10 14. 62 W	N 3-4	S-C	M	G
						38 30. 10 N 10 15. 16 W	N 3-4	S-C	M	G
28-Apr-07	MMO	6:00	7:30	1:30	N/A	36 45. 22 N 09 46. 91 W	N 3-4	S-C	M	G
						36 36. 37 N 09 39. 36 W	N 3-4	S-C	M	G
		8:00	10:00	2:00	0:30	36 36. 74 N 09 37. 50 W	N 3-4	S-C	M	G
						36 39. 12 N 09 37. 62 W	N 3-4	S-C	M	G

MARINE MAMMAL RECORDING FORM GULF OF CADIZ - LOCATION AND EFFORT DATA

Ship RRS Discovery | Ship type: Research | Survey type: 2D

Please record the following information every day (as many lines per day as you wish), even if no marine mammals are seen.

Date	Observer	Time you started looking for marine mammals (GMT)	Time you stopped looking for marine mammals (GMT)	Duration of watch for marine mammals (hrs & mins)	Length of time airguns were shooting while you were looking for marine mammals (hrs & mins)	Blocks transited while looking for marine mammals (or start and end position if blocks not known)	Wind force and direction (use Beaufort scale)	Sea state Choose from: **G** = glassy (like mirror) **S** = slight (no or few white horses) **C** = choppy (many white horses **R** = rough (large waves,foam crests, spray)	Swell Choose from: **O** = low (< 2 m) **M** = medium (2 - 4 m) **L** = large (> 4 m)	Visibility Choose from: **P** = poor (< 1 km) **M** = moderate (1- 5 km) **G** = good (> 5 km)
28-Apr-07	MMO	12:00	13:00	1:00	1:00	36 42. 28 N 09 49. 77 W	N 3	S-C	M	G
						36 49. 72 N 09 51. 02 W	N 3	S-C	M	G
		15:00	17:00	2:00	0:15	36 54. 13 N 09 57. 94 W	N 3	S-C	M	G
						36 54. 41 N 09 56. 95 W	N 3	S-C	M	G
29-Apr-07	MMO	10:00	11:30	1:30		39 49. 70 N 07 58. 62 W	VAR 2	S	O	G
						39 47. 46 N 07 56. 35 W	VAR 2	S	O	G
		12:00	14:00	2:00		36 35. 77 N 08 17. 52 W	NW 3	S-C	O	G
						37 32. 42 N 08 25. 93 W	NW 3	C	O	G
		17:00	23:00	3:30	2:08	36 16. 42 N 09 06. 99 W	NW 4	C	O	G
						36 14. 33 N 09 10. 03 W	NW 4	C	O	G
30-Apr-07		6:00	8:00	2:00	N/A	36 14. 31 N 09 10. 47 W	NW 4	C	O	G
						36 15. 02 N 09 09. 18 W	NW 4	C	O	G
		10:00	11:30	1:30	N/A	36 16. 10 N 09 09. 01 W	NW 4	C	O	G
						36 14. 52 N 09 11. 92 W	NW 4	C	M	G
		13:30	15:30	02:00	N/A	36 15. 98 N 09 12. 47 W	NW 4	C	M	G

MARINE MAMMAL RECORDING FORM GULF OF CADIZ - LOCATION AND EFFORT DATA

Ship RRS Discovery		Ship type: Research		Survey type: 2D

Please record the following information every day (as many lines per day as you wish), even if no marine mammals are seen.

Date	Observer	Time you started looking for marine mammals (GMT)	Time you stopped looking for marine mammals (GMT)	Duration of watch for marine mammals (hrs & mins)	Length of time airguns were shooting while you were looking for marine mammals (hrs & mins)	Blocks transited while looking for marine mammals (or start and end position if blocks not known)	Wind force and direction (use Beaufort scale)	Sea state Choose from: **G** = glassy (like mirror) **S** = slight (no or few white horses) **C** = choppy (many white horses **R** = rough (large waves,foam crests, spray)	Swell Choose from: **O** = low (< 2 m) **M** = medium (2 - 4 m) **L** = large (> 4 m)	Visibility Choose from: **P** = poor (< 1 km) **M** = moderate (1- 5 km) **G** = good (> 5 km)
01-May-07	MMO	6:00	7:30	1:30	N/A	36 04. 62 N 09 33. 72 W	NW 3	S-C	M	G
						36 04. 65 N 09 33. 98 W	NW 3	S-C	M	G
		11:00	14:00	3:00	1:45	36 12. 80 N 09 13. 88 W	N 3	S	M	G
						36 08. 43 N 09 30. 57 W	N 3	S	M	G
		18:00	19:00	1:00	N/A	36 20. 40 N 08 55. 29 W	N 3	S	M	G
						36 71. 28 N 08 51. 95 W	N 3	S	M	G
	Down for weather									
03-May-07	MMO	6:00	7:30	1:30		36 38. 61 N 07 54. 33 W	NW 4	S	M	G
						36 36. 82 N 07 57. 81 W	NW 4	S	M	G
		8:30	10:30	2:00	1:14	36 38. 08 N 08 02. 59 W	NW 4	S	M	G
						36 36. 15 N 08 11. 08 W	NW 4	S	M	G
		13:00	15:00	2:00	2:00	36 36. 02 N 08 22. 20 W	NW 4	S	M	G
						36 40. 69 N 08 24. 59 W	NW 4	S	M	G
		18:00	19:00	01:00	1:00	30 36. 70 N 08 14. 91 W	NW 4	S	M	G
						36 33. 98 N 08 12. 27 W	NW 4	S	M	G

MARINE MAMMAL RECORDING FORM GULF OF CADIZ - LOCATION AND EFFORT DATA

Ship RRS Discovery Ship type: Research Survey type: 2D

Please record the following information every day (as many lines per day as you wish), even if no marine mammals are seen.

Date	Observer	Time you started looking for marine mammals (GMT)	Time you stopped looking for marine mammals (GMT)	Duration of watch for marine mammals (hrs & mins)	Length of time airguns were shooting while you were looking for marine mammals (hrs & mins)	Blocks transited while looking for marine mammals (or start and end position if blocks not known)	Wind force and direction (use Beaufort scale)	Sea state Choose from: **G** = glassy (like mirror) **S** = slight (no or few white horses) **C** = choppy (many white horses **R** = rough (large waves,foam crests, spray)	Swell Choose from: **O** = low (< 2 m) **M** = medium (2 - 4 m) **L** = large (> 4 m)	Visibility Choose from: **P** = poor (< 1 km) **M** = moderate (1- 5 km) **G** = good (> 5 km)
04-May-07	MMO	6:00	7:30	1:30	1:30	36 35. 17 N 08 18. 39 W	NW 3	S	M	G
						36 34. 06 N 08 21. 85 W	NW 3	S	M	G
		9:00	11:00	2:00	2:00	36 31. 22 N 08 28. 99 W	NW 3	S	M	G
						36 28. 11 N 08 36. 79 W	NW 4-5	C	M	G
		13:00	15:00	2:00	2:00	36 23. 04 N 08 45. 58 W	NW 4-5	C	M	G
						36 21. 47 N 08 53. 33 W	NW 4-5	C	M	G
		18:00	19:00	1:00	1:00	36 16. 04 N 09 06. 47 W	NW 4-5	C	M	G
						36 14. 73 N 09 09. 78 W	NW 4-5	C	M	G
05-May-07	MMO	6:00	7:30	1:30	1:30	35 52. 99 N 10 09. 28 W	NW 4	C	M	G
						35 51. 80 N 10 09. 25 W	NW 5	C	M	G
		9:00	11:00	2:00	2:00	35 50. 38 N 10 09. 07 W	NW 6	C	M	G
						35 48. 30 N 10 14. 20 W	NW 6	C	M	G
		14:00	16:00	2:00	2:00	35 42. 01 N 10 29. 89 W	NW 6	C	M	G
						35 36. 57 N 10 33. 24 W	NW 6	C	M	G
		18:00	19:00	1:00	1:00	35 42. 02 N 10 29. 69 W	NW 6	C	M	G

MARINE MAMMAL RECORDING FORM GULF OF CADIZ - LOCATION AND EFFORT DATA

Ship RRS Discovery   Ship type: Research   Survey type: 2D

Please record the following information every day (as many lines per day as you wish), even if no marine mammals are seen.

Date	Observer	Time you started looking for marine mammals (GMT)	Time you stopped looking for marine mammals (GMT)	Duration of watch for marine mammals (hrs & mins)	Length of time airguns were shooting while you were looking for marine mammals (hrs & mins)	Blocks transited while looking for marine mammals (or start and end position if blocks not known)	Wind force and direction (use Beaufort scale)	Sea state Choose from: **G** = glassy (like mirror) **S** = slight (no or few white horses) **C** = choppy (many white horses **R** = rough (large waves,foam crests, spray)	Swell Choose from: **O** = low (< 2 m) **M** = medium (2 - 4 m) **L** = large (> 4 m)	Visibility Choose from: **P** = poor (< 1 km) **M** = moderate (1- 5 km) **G** = good (> 5 km)
06-May-07	MMO	6:00	7:30	1:30	1:30	35 52. 22 N 10 01. 84 W	NW 6-7	C	M	G
						35 54. 11 N 09 59. 90 W	NW 6-7	C	M	G
		9:00	11:00	2:00	2:00	36 00. 66 N 09 53. 39 W	NW 5	C	M	G
						36 04. 46 N 09 49. 60 W	NW 5	C	M	G
		13:00	15:00	2:00	2:00	36 15. 19 N 09 38. 94 W	NW 4	S-C	M	G
						36 20. 59 N 09 35. 47 W	NW 4	S-C	M	G
07-May-07	MMO	6:00	7:30	1:30	1:30	36 02. 31 N 09 45.10 W	NW 3	C	O-M	G
						35 57. 46 N 09 50. 92 W	NW 4-5	C	O-M	G
		9:00	11:00	2:00	1:35	36 03. 18 N 09 50. 92 W	NW 4-5	C	O-M	G
						36 07. 56 N 09 46. 56 W	NW 4-5	C	O-M	G
		13:00	15:00	2:00	N/A	36 15. 89 N 09 37. 84 W	NW 4-5	C	O-M	G
						36 20. 17 N 09 33. 94 W	NW 4-5	C	O-M	G
		18:00	19:00	1:00	N/A	36 28. 57 N 09 25. 32 W	NW 3-4	C	O	G

MARINE MAMMAL RECORDING FORM GULF OF CADIZ - LOCATION AND EFFORT DATA

Ship RRS Discovery Ship type: Research Survey type: 2D

Please record the following information every day (as many lines per day as you wish), even if no marine mammals are seen.

Date	Observer	Time you started looking for marine mammals (GMT)	Time you stopped looking for marine mammals (GMT)	Duration of watch for marine mammals (hrs & mins)	Length of time airguns were shooting while you were looking for marine mammals (hrs & mins)	Blocks transited while looking for marine mammals (or start and end position if blocks not known)	Wind force and direction (use Beaufort scale)	Sea state Choose from: **G** = glassy (like mirror) **S** = slight (no or few white horses) **C** = choppy (many white horses **R** = rough (large waves,foam crests, spray)	Swell Choose from: **O** = low (< 2 m) **M** = medium (2 - 4 m) **L** = large (> 4 m)	Visibility Choose from: **P** = poor (< 1 km) **M** = moderate (1- 5 km) **G** = good (> 5 km)
08-May-07	MMO	6:30	7:30	1:30	N/A	36 17. 00 N 09 51. 97 W	NW 3-4	C	O	G
						36 15. 58 N 09 52. 00 W	NW 3-4	C	O	G
		9:00	11:00	2:00	N/A	36 11. 69 N 09 42. 93 W	NW 3-4	C	O	G
						36 09. 17 N 09 37. 12 W	NW 3-4	C	O	G
		13:00	15:00	2:00	N/A	36 09. 21 N 09 35. 89 W	NW 3-4	C	O	G
						36 08. 60 N 09 35. 38 W	NW 3-4	C	O	G
		16:30	19:00	02:30	2:12	36 13. 14 N 09 39. 94 W	NW 3-4	C	O	G
						36 15. 14 N 09 50. 21 W	NW 3-4	C	O	G

MARINE MAMMAL RECORDING FORM GULF OF CADIZ - LOCATION AND EFFORT DATA

Ship RRS Discovery   Ship type: Research   Survey type: 2D

Please record the following information every day (as many lines per day as you wish), even if no marine mammals are seen.

Date	Observer	Time you started looking for marine mammals (GMT)	Time you stopped looking for marine mammals (GMT)	Duration of watch for marine mammals (hrs & mins)	Length of time airguns were shooting while you were looking for marine mammals (hrs & mins)	Blocks transited while looking for marine mammals (or start and end position if blocks not known)	Wind force and direction (use Beaufort scale)	Sea state Choose from: **G** = glassy (like mirror) **S** = slight (no or few white horses) **C** = choppy (many white horses **R** = rough (large waves,foam crests, spray)	Swell Choose from: **O** = low (< 2 m) **M** = medium (2 - 4 m) **L** = large (> 4 m)	Visibility Choose from: **P** = poor (< 1 km) **M** = moderate (1- 5 km) **G** = good (> 5 km)
09-May-07	MMO	6:30	7:30	1:30	1:30	36 08. 71 N 09 44. 53 W	VAR 2	S	O	G
						36 12. 42 N 09 37. 65 W	VAR 2	S	O	G
		9:00	11:00	2:00	2:00	36 14. 34 N 09 30. 72 W	VAR 2	S	O	G
						36 24. 30 N 08 59. 30 W	VAR 2	S	O	G
		13:00	16:00	2:00	2:00	36 22. 39 N 08 59. 40 W	VAR 2	S	O	G
						36 29. 32 N 08 27. 88 W	VAR 2	S	O	G
10-May-07	MMO	6:00	7:30	1:30	1:30	36 36. 89 W 08 14. 81 W	VAR 2	S	O	G
						36 36. 65 N 08 14. 85 W	VAR 2	S	O	G
		12:00	14:00	2:00	2:00	36 40. 49 N 08 09. 24 W	VAR 2	S	O	G
						36 42. 47 N 08 03. 85 W	VAR 2	S	O	G
		16:00	17:30	1:30	1:30	36 38. 91 N 08 04. 80 W	NW 3-4	C	O	G
						36 38. 70 N 09 01. 38 W	NW 3-4	C	O	G
		18:00	19:00	1:00	1:00	36 38. 64 N 09 09. 90 W	NW 3-4	C	O	G

MARINE MAMMAL RECORDING FORM GULF OF CADIZ - LOCATION AND EFFORT DATA

Ship RRS Discovery   Ship type: Research   Survey type: 2D

Please record the following information every day (as many lines per day as you wish), even if no marine mammals are seen.

Date	Observer	Time you started looking for marine mammals (GMT)	Time you stopped looking for marine mammals (GMT)	Duration of watch for marine mammals (hrs & mins)	Length of time airguns were shooting while you were looking for marine mammals (hrs & mins)	Blocks transited while looking for marine mammals (or start and end position if blocks not known)	Wind force and direction (use Beaufort scale)	Sea state Choose from: **G** = glassy (like mirror) **S** = slight (no or few white horses) **C** = choppy (many white horses **R** = rough (large waves,foam crests, spray)	Swell Choose from: **O** = low (< 2 m) **M** = medium (2 - 4 m) **L** = large (> 4 m)	Visibility Choose from: **P** = poor (< 1 km) **M** = moderate (1- 5 km) **G** = good (> 5 km)
11-May-07	MMO	6:30	7:30	1:00	1:00	36 15. 70 N 09 07. 60 W	VAR 2	S	O	G
						36 13. 60 N 09 12. 10 W	NW 3	S	O	G
		8:30	11:00	2:30	1:36	36 12. 00 N 09 16. 70 W	NW 3	S	O	G
						36 10. 16 N 09 32. 55 W	NW 3	S	O	G
		13:00	15:00	2:00	1:22	36 04. 70 N 09 34. 86 W	NW 3	S	O	G
						36 10. 71 N 09 32. 70 W	NW 3	S	O	G
		18:00	19:00	01:00	1:00	36 16. 01 N 09 22. 12 W	NW 3	S	O	G
						36 17. 06 N 09 19. 78 W	NW 3	S	O	G
12-May-07	MMO	6:30	7:30	1:30	1:30	36 36. 76 N 10 09. 85 W	NW 3	S	O	G
						36 41. 23 N 10 09. 43 W	NW 3	S	O	G
		9:00	11:00	2:00	2:00	36 37. 57 N 10 00. 58 W	NW 3	S	O	G
						36 34. 35 N 09 56. 27 W	NW 3	S	O	G
		13:00	15:00	2:00	2:00	36 28. 39 N 09 46. 79 W	NW 3	S	O	G
						36 16. 50 N 09 45. 50 W	NW 3	S	O	G
		18:00	19:00	1:00	1:00	36 10. 70 N 09 54. 00 W	NW 3	S	O	G

MARINE MAMMAL RECORDING FORM GULF OF CADIZ - RECORD OF OPERATIONS

Ship: RRS Dis Client: 'GO' Seismic Contractor: NERC JNCC SS ref. No.

Complete this form every time the airguns are used, including overnight, whether for shooting a line or for testing or for any other purpose.
Times should be in GMT.

Date	Airgun activiy			Pre-shooting search					Action necessary		
	Time when soft start began	Time when airguns reached full power	Time when airguns stopped	Who carried out a search for marine mammals? (Job title)	Time when pre-shooting search for marine mammals began?	Time when search for marine mammals ended	Was there any reason why marine mammals may not have been seen? (e.g. dark, swell, fog, etc.)	Were hydro-phones used? 00:30 00:31 23:59	Were marine mammals present in the 30 minutes before the airguns began firing?	If yes, give time when marine mammals were last seen	If marine mammals were present, what action was taken? (e.g. delay shooting)
19/04/2007	12:00	12:30	Firing	MMO	11:30	12:00	No	No	No	N/A	N/A
20/04/2007	Firing	Firing	Firing	N/A	N/A	N/A	No	No	No	N/A	N/A
21/04/2007	Firing	Firing	Firing	N/A	N/A	N/A	No	No	No	N/A	N/A
22/04/2007	Firing	Firing	10:35	MMO	N/A	N/A	No	No	No	N/A	N/A
28-Apr-2007	09:30	13:00	13:00	MMO	09:00	9:30	No	No	No	N/A	N/A
28-Apr-2007	16:20	NA	16:35	MMO	15:50	16:20	No	No	Yess	16:40	Delay shooting
29-Apr-2007	17:50	18:15	19:52	MMO	17:20	17:50	No	No	No	N/A	N/A
29-Apr-2007	20:24	20:51	00:00	MMO	19:54	20:24	No	No	No	N/A	N/A
30-Apr-2007	Firing	Firing	05:00	N/A	N/A	N/A	No	No	No	N/A	N/A
1-May-2007	12:15	12:55	Firing	MMO	11:45	12:15	No	No	No	N/A	N/A
2-May-2007	Firing	Firing	05:30	N/A	N/A	N/A	No	No	No	N/A	N/A
3-May-2007	09:16	09:38	Firing	MMO	08:46	9:16	No	No	No	N/A	N/A
4-May-2007	Firing	Firing	Firing	N/A	N/A	N/A	No	No	No	N/A	N/A
5-May-2007	Firing	Firing	Firing	N/A	N/A	N/A	No	No	No	N/A	N/A
6-May-2007	Firing	Firing	Firing	N/A	N/A	N/A	No	No	No	N/A	N/A
7-May-2007	Firing	Firing	10:35	N/A	N/A	N/A	No	No	No	N/A	N/A
8-May-2007	17:18	17:44	Firing	MMO	16:48	17:18	No	No	No	N/A	N/A
9-May-2007	Firing	Firing	Firing	N/A	N/A	N/A	No	No	No	N/A	N/A
10-May-2007	Firing	Firing	Firing	N/A	N/A	N/A	No	No	No	N/A	N/A
11-May-2007	Firing	Firing	08:25	N/A	N/A	N/A	No	No	No	N/A	N/A

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

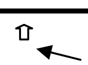
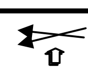
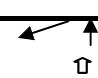
RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	1	2	3
Date	17/04/2007	19/04/2007	19/04/2007
Time (GMT)	10:44	07:00	18:30
How did sighting occur			
MMO continuous watch	x	x	
Spotted incidentally			x
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	38 00. 26 N	36 17. 86 N	36 26. 19 N
Long	09 26. 91 W	09 02. 87 W	08 44. 13 W
Water Depth (metres)	c. 1200	c. 2500	c. 2700
Species	Common Dolphin	Common Dolphin	Unidentified Dolphin sp.
ID certainty	Def.	Def.	Dolphin sp.
Total number	c. 5	c. 10	c. 10
Number of adults	4	9	Unknown
Number of juveniles	1	1	Unknown
Description	Common Dolphin	Common Dolphin	Unidentified Dolphin Sp.
Photograph taken	No	No	No
Behaviour	Approached stationary vessel as 'pez' fish deployed	Cross bow	4000 m ahead of vessel
Animal travel direction			
Rel to ship	↗ ⇧	← ⇧	↑ ⇧
Compass	N/A	180 - 000	270 - 090
Activity of ship	Deploy gear	Deploy gear	Turn cycling guns
Airguns firing	No	No	Yes
Closest distance of animals from airguns	c. 100 m	c. 100 m	c. 4000 m

R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	4	5	6
Date	19/04/2007	20/04/2007	21/04/2007
Time (GMT)	23:50	13:40	18:00
How did sighting occur			
MMO continuous watch		x	x
Spotted incidentally	x		
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	N/A	36 37. 47 N	36 07. 80 N
Long	N/A	08 08. 60 W	09 26. 67 W
Water Depth (metres)	N/A	c. 800	c. 3400
Species	Unidentified Dolphin sp.	False Killer Whales	Fin Whale
ID certainty	Dolphin sp.	Def.	Def.
Total number	c. 10	c. 30	c. 2
Number of adults	Unknown	Unknown	1
Number of juveniles	Unknown	Min. of 3	1
Description	Unidentified Dolphin Sp.	False Killer Whale	Fin Whale
Photograph taken	No	No	No
Behaviour	Close to airguns	Normal' slow swim across bow then faster when aware of vessel	Slow swim at surface with regular blows
Animal travel direction Rel to ship			
Compass	N/A	0	270
Activity of ship	Online	Online	Online
Airguns firing	Yes	Yes	Yes
Closest distance of animals from airguns	c. 10 m	c. 150 m	c. 1000 m

R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

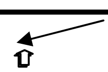
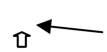
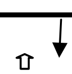
RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	7	8	9
Date	21/04/2007	22/04/2007	27/04/2007
Time (GMT)	18:00	15:00	18:15
How did sighting occur			
MMO continuous watch		x	x
Spotted incidentally			
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	36 07. 80 N	36 34. 77 N	38 29. 46 N
Long	09 26. 67 W	08 46. 07 W	10 14. 62 W
Water Depth (metres)	c. 3400	C. 1000	c. 4000 m
Species	Common Dolphins	Common Dolphins	Sperm Whale
ID certainty	Def.	Def.	Def.
Total number	Min. of 15	Min. of 8	1
Number of adults	Min. of 10	Min. of 7	1
Number of juveniles	Unknown	Min. of 1	N/A
Description	Common Dolphins	Common Dolphins	Sperm Whale
Photograph taken	No	No	No
Behaviour	' Milling' at surface	Slow swim at surface	Blowing at surface before dive
Animal travel direction	x		
Rel to ship			
Compass	100	180	N/A
Activity of ship	Online	Steaming	Deploying guns
Airguns firing	Yes	No	No
Closest distance of animals from airguns	1000 m	50 m	c. 500 m

R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	10	11	12
Date	27/04/2007	27/04/2007	28/04/2007
Time (GMT)	19:00	19:00	06:00
How did sighting occur			
MMO continuous watch	x	x	X
Spotted incidentally			
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	38 38. 10 N	38 38. 10 N	36 45. 52 N
Long	10 15. 16 W	10 15. 16 W	09 47. 00 W
Water Depth (metres)	c. 4000 m	c. 4000 m	2500 m
Species	Striped dolphin	Common Dolphin	Unid. Whale Sp.
ID certainty	Def.	Def.	Def.
Total number	c. 150	c. 10	1
Number of adults	Unknown	Unknown	Unknown
Number of juveniles	Unknown	Unknown	Unknown
Description	Striped Dolphin	Common Dolphin	Blows only
Photograph taken	No	No	No
Behaviour	Fast swim to bow then bow-ride	Fast swim to bow	Blows x 4 c. 5 m high (vertical)
Animal travel direction			
Rel to ship			
Compass	210	210	N
Activity of ship	Deploy guns	Deploy guns	Steaming
Airguns firing	No	No	No
Closest distance of animals from airguns	c. 100 m	c. 100 m	c. 200 m

R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

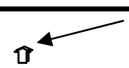
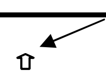
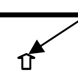
RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	13	14	15
Date	28/04/2007	28/04/2007	28/04/2007
Time (GMT)	06:30	06:55	15:50
How did sighting occur			
MMO continuous watch	x	x	x
Spotted incidentally			
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	36 41. 75 N	36 38. 40 N	36 52. 05 N
Long	09 45. 67 W	09 41. 74 W	09 55. 20 W
Water Depth (metres)	c. 2000 m	c. 2000	C. 2500 m
Species	Common Dolphin	Fin Whale	Common Dolphin
ID certainty	Def.	Def.	Def.
Total number	c. 6	c. 3	3
Number of adults	Unknown	c. 3	2
Number of juveniles	Unknown	Unknown	1
Description	Common Dolphin	Fin Whale	Common Dolphin
Photograph taken	No	No	No
Behaviour	Fast swim to bow	Normal surface swim / blows	Bow-ride
Animal travel direction			
Rel to ship			
Compass	N	N	N/A
Activity of ship	Steaming	Steaming	Turning
Airguns firing	No	No	No
Closest distance of animals from airguns	c. 100 m	c. 100 m	c. 100 m

R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	16	17	18
Date	28/04/2007	28/04/2007	29/04/2007
Time (GMT)	16:35	19:00	
How did sighting occur			
MMO continuous watch	x	x	x
Spotted incidentally			
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	36 54. 11 N	36 58. 57 N	36 34. 82 N
Long	09 56. 70 W	09 46. 17 W	08 19. 98 W
Water Depth (metres)	c. 2500 m	c. 2200 m	c. 1500 m
Species	Common Dolphin	Common Dolphin	Striped Dolphin
ID certainty	Def.	Def.	Def.
Total number	2	3	c. 15
Number of adults	2	2	c. 12
Number of juveniles	0	1	Min. of 1
Description	Common Dolphin	Common Dolphin	Striped Dolphin
Photograph taken	No	No	No
Behaviour	Bow-ride	Bow-ride	Bow-ride
Animal travel direction			
Rel to ship			
Compass	N/A	N/A	N/A
Activity of ship	Deploy guns	Steaming	Steaming
Airguns firing	No	No	No
Closest distance of animals from airguns	c. 100 m	c. 100 m	c. 400 m

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	19	20	21
Date	29/04/2007	30/04/2007	01/07/2004
Time (GMT)	13:00	06:20	09:45
How did sighting occur			
MMO continuous watch	x	x	x
Spotted incidentally			
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	36 33. 72 N	36 14. 46 N	36 08. 25 N
Long	08 22. 89 W	09 10. 25 W	09 25. 10 W
Water Depth (metres)	C. 1500 m	c. 3400 m	c. 4000 m
Species	Fin Whale	Unidentified Whale Sp.	Loggerhead Turtle
ID certainty	Def.	Def.	Def.
Total number	1	1	1
Number of adults	1	Unknown	N/A
Number of juveniles	N/A	Unknown	1
Description	Fin Whale	Unidentified Whale Sp. Multiple, large (5 m) bushy blows	Loggerhead Turtle Carapace c. 50 cm
Photograph taken	No	No	No
Behaviour	Approach dead astern and blows	Unidentified Whale Sp. Multiple, large (5 m) bushy blows	Pass down Port side of vessel
Animal travel direction	⇧	⇧	↓ ⇧
Rel to ship	↗	→	
Compass	240	160	N/A
Activity of ship	Steaming	Online	Deploy guns
Airguns firing	No	Yes	No
Closest distance of animals from airguns	c. 300 m	c. 800 m	c. 20 m

R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

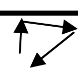
RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	22	23	24
Date	01/05/2007	03/05/2007	03/05/2007
Time (GMT)	18:35	07:20 - 30	18:10
How did sighting occur			
MMO continuous watch	X	X	x
Spotted incidentally			
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	36 21. 41 N	36 36. 82 N	36 36. 66 N
Long	08 52. 95 W	07 57. 81 W	08 14. 65 W
Water Depth (metres)	c. 1700 m	740 m	c. 900 m
Species	Common	Fin Whale	Fin Whale
ID certainty	Def.	Def.	Def.
Total number	c. 10	Min. of 2	Min. of 1
Number of adults	Min. of 6	Min. of 2	Min. of 1
Number of juveniles	Unknown	Unknown	Unknown
Description	Common Dolphin	Fin Whale	Fin Whale
Photograph taken	No	No	
Behaviour	Fast erratic swim at surface to bow then depart after c. 2 gun pulses	Multiple blows at surface Back and dorsal	Multiple blows at surface Back and dorsal
Animal travel direction		⇧	⇧
Rel to ship	⇧ ←	x	x
Compass	N/A	210	N/A
Activity of ship	Online	Deploy streamer	Online
Airguns firing	Yes	No	Yes
Closest distance of animals from airguns	c. 60 m	c. 2000 m	c. 3000 m

R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	25	26	27
Date	04/05/2007	05/05/2007	06/05/2007
Time (GMT)	09:40 - 55	10:00	07:00
How did sighting occur			
MMO continuous watch	x	x	x
Spotted incidentally			
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	36 30. 08 N	35 49. 56 N	35 52. 25 N
Long	08 31. 88 W	10 11. 01 W	10 01. 81 W
Water Depth (metres)	c. 2000 m	c. 4000 m	c. 4200 m
Species	Fin Whale	Fin Whale	Fin Whale
ID certainty	Def.	Def.	Def.
Total number	Min. of 2	Min. of 5	Min. of 2
Number of adults	Min. of 1	Min. of 3	Min. of 1
Number of juveniles	Unknown	Min. of 1	Unknown
Description	Fin Whale	Fin Whale	Fin Whale
Photograph taken			
Behaviour	Multiple blows at surface Back and dorsal	Multiple blows at surface Back and dorsal Animals confused	Cross bow at surface
Animal travel direction	x		→
Rel to ship	⇧	⇧	⇧
Compass	N/A	180	90
Activity of ship	Online	Online	Online
Airguns firing	Yes	Yes	Yes
Closest distance of animals from airguns	c. 2000 m	c. 250 m	c. 250 m

R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	28	29	30
Date	06/05/2007	08/05/2007	08/05/2007
Time (GMT)	15:00	09:35	10:45
How did sighting occur			
MMO continuous watch	x	x	x
Spotted incidentally			
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	36 17 67 N	36 11. 39 N	36 09. 18 N
Long	09 36. 49 W	09 42. 24 W	09 37. 16 W
Water Depth (metres)	c. 2000 m	c. 2000 m	c. 2000 m
Species	Loggerhead Turtle	Loggerhead Turtle	Loggerhead Turtle
ID certainty	Def.	Def.	Def.
Total number	1	1	1
Number of adults	1	1	
Number of juveniles	N/A	N/A	1
Description	Loggerhead Turtle	Loggerhead Turtle	Loggerhead Turtle
Photograph taken	No	No	No
Behaviour	Passed down starboard side of vessel 2 m from vessel	Passed down side of vessel then dived through airguns immediately before firing	Passed down port side of vessel then dived through airguns immediately before firing
Animal travel direction			
Rel to ship	⇧↓	⇧↓	↓⇧
Compass	N/A	N/A	N/A
Activity of ship	Online	Online	Online
Airguns firing	Yes	Yes	Yes
Closest distance of animals from airguns	c. 10 m	c. 5 m	c. 5 m

R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	31	32	33
Date	08/05/2007	09/05/2007	09/05/2007
Time (GMT)	18:00	05:50	06:45 - 07:00
How did sighting occur			
MMO continuous watch	x		x
Spotted incidentally		x	
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	36 13. 12 N	36 09. 00 N	36 09. 00 N
Long	09 40. 01 W	09 44. 06	09 44. 06
Water Depth (metres)	c. 4000 m	c. 2500 m	c. 2500 m
Species	Loggerhead Turtle	Unidentified Dolphin Sp.	Fin Whale
ID certainty	Def.	Def.	Def.
Total number	1	c. 50	1
Number of adults	1	Min. of 40	1
Number of juveniles	N/A	Unknown	
Description	Loggerhead Turtle	Unidentified Dolphin Sp.	Fin Whale
Photograph taken	No	No	No
Behaviour	Passed down starboard side of vessel then dived through airguns immediately before firing	Seen by crew very close to vessel and firing airguns	3 x blow and back and dorsal of animal seen at surface Passed ahead of vessel
Animal travel direction			
Rel to ship	↓⇧	⇧↙	→ ⇧
Compass	N/A	N/A	360
Activity of ship	Online	Online	Retrieve gear
Airguns firing	Yes	Yes	No
Closest distance of animals from airguns	c. 10 m	c. 5 m	c. 1000 m

R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

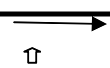
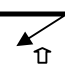
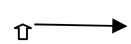
RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	34	35	36
Date	09/05/2007	09/05/2007	09/05/2007
Time (GMT)	07:30	07:30	10:00
How did sighting occur			
MMO continuous watch	x	x	x
Spotted incidentally			
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	36 07. 47 N	36 09. 00 N	36 20. 25 N
Long	09 47. 13 W	09 44. 06	09 20. 61 W
Water Depth (metres)	c. 2500 m	c. 2500 m	c. 3700 m
Species	Fin Whale	Common Dolphin	Unidentified Dolphin Sp.
ID certainty	Def.	Def.	Def.
Total number	4	c. 8	Min. of 80
Number of adults	Min. of 2	Min. of 6	Min. of 50
Number of juveniles	Unknown	Unknown	Unknown
Description	Fin Whale	Common Dolphin	Unidentified Dolphin Sp.
Photograph taken	No	No	No
Behaviour	Blows and backs and dorsals of animal seen at surface	Come to vesel bow	Resting / slow swim
Animal travel direction			
Rel to ship	⇧	⇧	⇧ x
Compass	360	360	N/A
Activity of ship	Retrieve gear	Retrieve gear	Steaming
Airguns firing	No	No	No
Closest distance of animals from airguns	c. 500 m	c. 100 m	c. 1500 m

R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

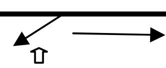
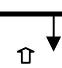
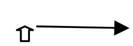
RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	37	38	39
Date	09/05/2007	09/05/2007	09/05/2007
Time (GMT)	13:00	13:30	13:30
How did sighting occur			
MMO continuous watch	x	x	x
Spotted incidentally			
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	36 23. 17 N	36 24. 87 N	36 24. 87 N
Long	08 47. 94 W	08 43. 70 W	08 43. 70 W
Water Depth (metres)	3000 m	2700 m	2700 m
Species	Short Finned Pilot Whale	Common Dolphin	Unidentified Dolphin Sp.
ID certainty	Def.	Def.	Def.
Total number	Min. of 40	Min. of 6	Min. of 10
Number of adults	Min. of 30	Min. of 4	Unknown
Number of juveniles	Min. of 3	Unknown	Unknown
Description	Short Finned Pilot Whale	Common Dolphin	Unidentified Dolphin Sp.
Photograph taken	No	No	No
Behaviour	Blows and backs and dorsals of animal seen at surface Resting	Slow swim at surface	Fast swim/feeding at surface. Feeding sea birds present
Animal travel direction			
Rel to ship			
Compass	N/A	270	90
Activity of ship	Steaming	Steaming	Steaming
Airguns firing	No	No	No
Closest distance of animals from airguns	c. 70 m	c. 100 m	c. 2500 m

R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	40	41	42
Date	10/05/2007	10/05/2007	11/05/2007
Time (GMT)	13:15	13:50	06:30
How did sighting occur			
MMO continuous watch	x	x	x
Spotted incidentally			
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	36 41. 36 N	36 42. 32 N	36 15. 70 N
Long	08 06. 88 W	08 04. 02 W	09 07. 60 W
Water Depth (metres)	c. 700 m	c. 700 m	c. 3000 m
Species	Unidentified Dolphin Sp.	Loggerhead Turtle	Long Finned Pilot Whale
ID certainty	Def.	Def.	Def.
Total number	c. 200	1	c. 30
Number of adults	Unknown	1	Min. 20
Number of juveniles	Unknown		Unknown
Description	Unidentified Dolphin Sp.	Loggerhead Turtle	Long Finned Pilot Whale
Photograph taken	No	No	No
Behaviour	Fast swim, 'milling' feeding	Float past vessel to starboard	Swim rapidly from vessel
Animal travel direction			
Rel to ship			
Compass	270 / 146	N/A	350
Activity of ship	Deploy	Deploy	Online
Airguns firing	No	No	Yes
Closest distance of animals from airguns	c. 2000 m	c. 10 m	c. 500 m
			R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	43	44	45
Date	11/05/2007	12/05/2007	12/05/2007
Time (GMT)	14:00	10:45	13:10
How did sighting occur			
MMO continuous watch	x	x	x
Spotted incidentally			
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	36 04. 70 N	36 34. 32 N	36 28. 77 N
Long	09 34. 86 W	09 56. 23 W	09 47. 54 W
Water Depth (metres)	c. 3000 m	c.2100 m	c. 3000 m
Species	Fin Whale	Loggerhead Turtle	Loggerhead Turtle
ID certainty	Def.	Def.	Def.
Total number	1	1	1
Number of adults	1	1	1
Number of juveniles			
Description	Fin Whale	Loggerhead Turtle	Loggerhead Turtle
Photograph taken	No	No	No
Behaviour	Normal' surfacing x 3	'Float' down side of vessel then dive through firing airguns	Passed down side of vessel then dived through airguns immediately before firing
Animal travel direction			
Rel to ship	↓ ⇧	⇧ ↓	⇧ ↓
Compass	200	N/A	N/A
Activity of ship	Online	Online	Online
Airguns firing	Yes	Yes	Yes
Closest distance of animals from airguns	c. 500 m	c. 20 m	c. 15 m

R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	46	47	48
Date	12/05/2007	12/05/2007	12/05/2007
Time (GMT)	13:15	13:22	14:00
How did sighting occur			
MMO continuous watch	x	x	x
Spotted incidentally			
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	36 28, 17 N	36 27. 83 N	36 25. 49 N
Long	09 46. 71 W	09 46. 28 W	09 42. 83 W
Water Depth (metres)	c. 3000 m	c. 3000 m	c. 3000 m
Species	Loggerhead Turtle	Loggerhead Turtle	Loggerhead Turtle
ID certainty	Def.	Def.	Def.
Total number	1	1	1
Number of adults	1	1	1
Number of juveniles			
Description	Loggerhead Turtle	Loggerhead Turtle	Loggerhead Turtle
Photograph taken	No	No	No
Behaviour	Passed down side of vessel then dived through airguns immediately before firing	Passed down side of vessel then dived through airguns immediately before firing	Passed down side of vessel then dived through airguns immediately before firing
Animal travel direction			
Rel to ship	⇧ ↓	⇧ ↓	⇧ ↓
Compass	N/A	N/A	N/A
Activity of ship	Online	Online	Online
Airguns firing	Yes	Yes	Yes
Closest distance of animals from airguns	c. 10 m	c. 10 m	c. 10 m

R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

Sighting no.	49	50	51
Date	12/05/2007	12/05/2007	12/05/2007
Time (GMT)	14:30	14:35	14:40
How did sighting occur			
MMO continuous watch	x	x	x
Spotted incidentally			
Other (please specify)			
Ship	**RRS Discovery**	**RRS Discovery**	**RRS Discovery**
Observer	**MMO**	**MMO**	**MMO**
Ship's Position Lat	36 24. 60 N	36 23. 65 N	36 23. 09 N
Long	09 42. 01 W	09 41. 53 W	09 42. 13 W
Water Depth (metres)	c. 3000 m	c. 3000 m	c. 3000 m
Species	Unidentified Whale sp.	Loggerhead Turtle	Loggerhead Turtle
ID certainty	Def.	Def.	Def.
Total number	1	1	1
Number of adults	Unknown	1	
Number of juveniles	Unknown		1
Description	Large blow seen only c. 4 - 5 m high. Prob. Fin Whale	Loggerhead Turtle	Loggerhead Turtle
Photograph taken	No	No	No
Behaviour	Blow at surface x 1	Passed down side of vessel then dived through airguns immediately before firing	Passed down side of vessel then dived through airguns immediately before firing
Animal travel direction			
Rel to ship	↓ ⇧	⇧ ↓	⇧ ↓
Compass	N/A	N/A	N/A
Activity of ship	Online	Online	Online
Airguns firing	Yes	Yes	Yes
Closest distance of animals from airguns	c. 1000 m	c. 20 m	c. 10 m

R Woodcock 2007

Client: *GO Research Project*
Prospect: Gulf of Cadiz
Vessel: RRS Discovery
Contractor: NERC

RECORD OF MARINE MAMMAL / TURTLE SIGHTINGS

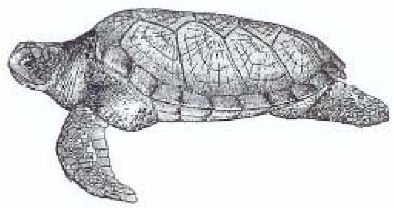
Sighting no.	52		
Date	12/05/2007		
Time (GMT)	18:30		
How did sighting occur			
MMO continuous watch	x		
Spotted incidentally			
Other (please specify)			
Ship	**RRS Discovery**		
Observer	**MMO**		
Ship's Position Lat	36 10. 87 N		
Long	09 53. 99 W		
Water Depth (metres)	c. 3000 m		
Species	Fin Whale		
ID certainty	Def.		
Total number	1		
Number of adults	Unknown		
Number of juveniles	Unknown		
Description	Fin Whale		
Photograph taken	No		
Behaviour	Surfacing x 4		
Animal travel direction	↙		
Rel to ship	⇧	⇧	⇧
Compass	N/A		
Activity of ship	Online		
Airguns firing	Yes		
Closest distance of animals from airguns	c. 1500 m		

R Woodcock 2007

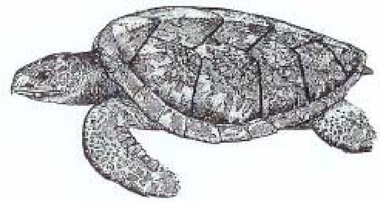
APPENDIX 5

DIAGRAM OF MARINE TURTLE SPECIES

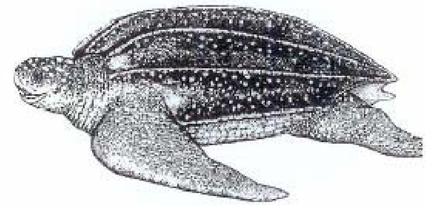
DIAGRAM OF MARINE TURTLE SPECIES



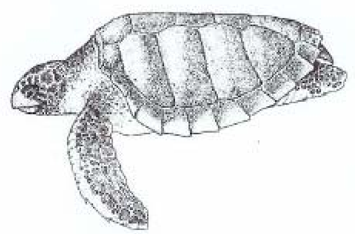
Green Sea Turtle, *Chelonia mydas*



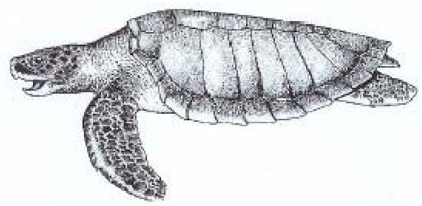
Hawksbill Sea Turtle, *Eretmochelys imbricata*



Leatherback Turtle, *Dermochelys cori*



Loggerhead Turtle, *Caretta caretta*

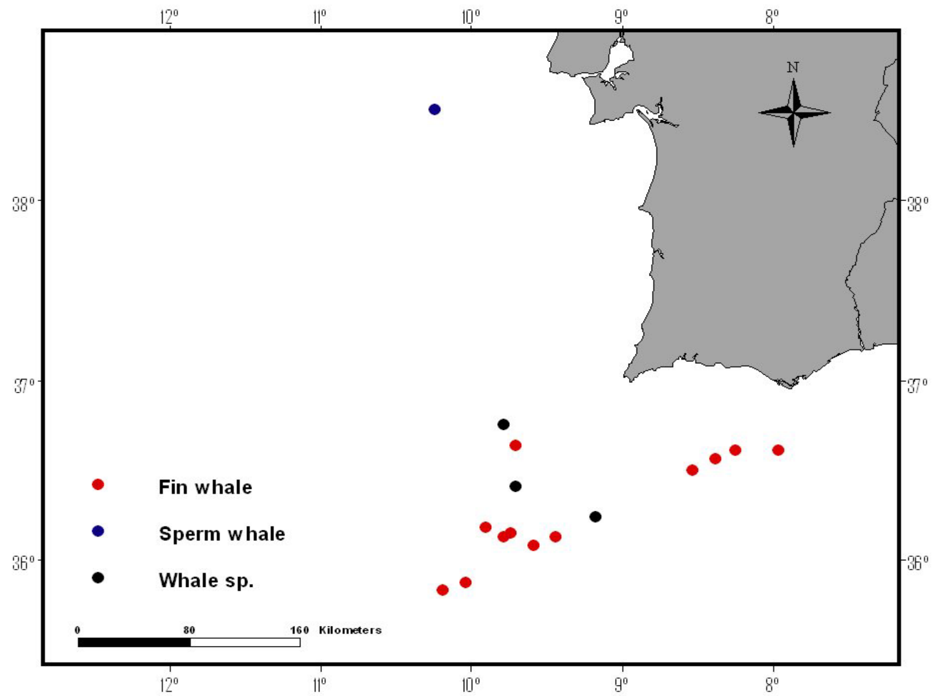


Olive Ridley Turtle, *Lepidochelys olivacea*

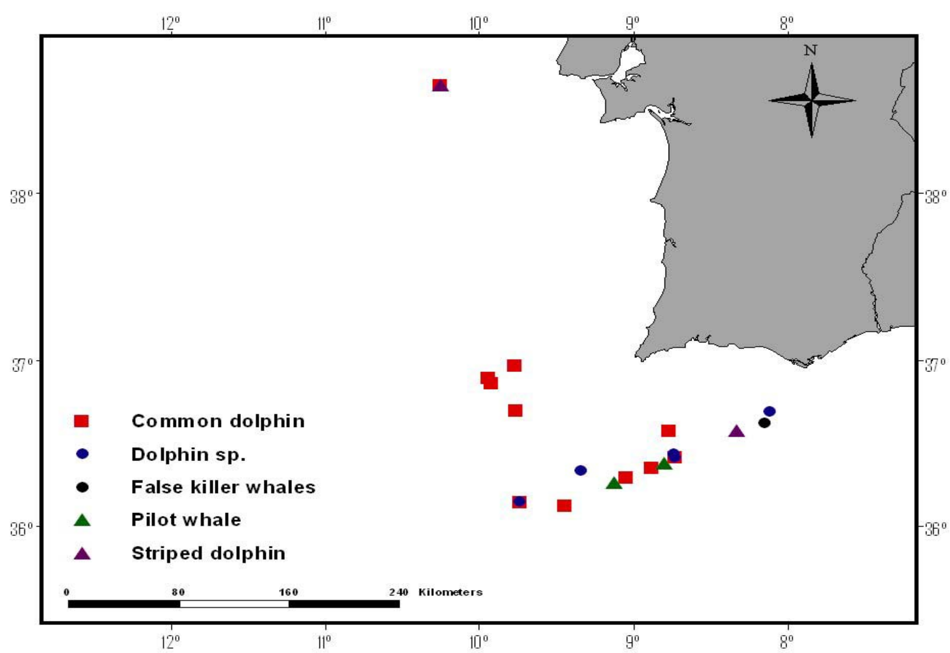
APPENDIX 6

LOCATION PLOTS OF MARINE MAMMAL AND TURTLE SIGHTINGS

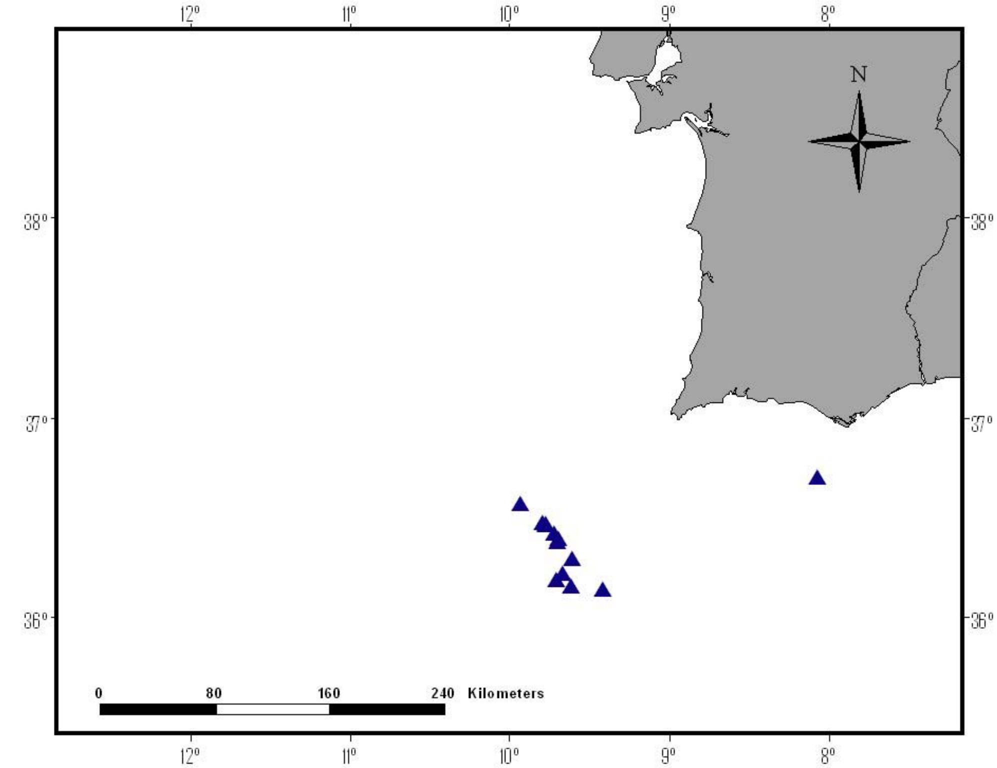
Whale sightings



Dolphin Sightings



Turtle sightings

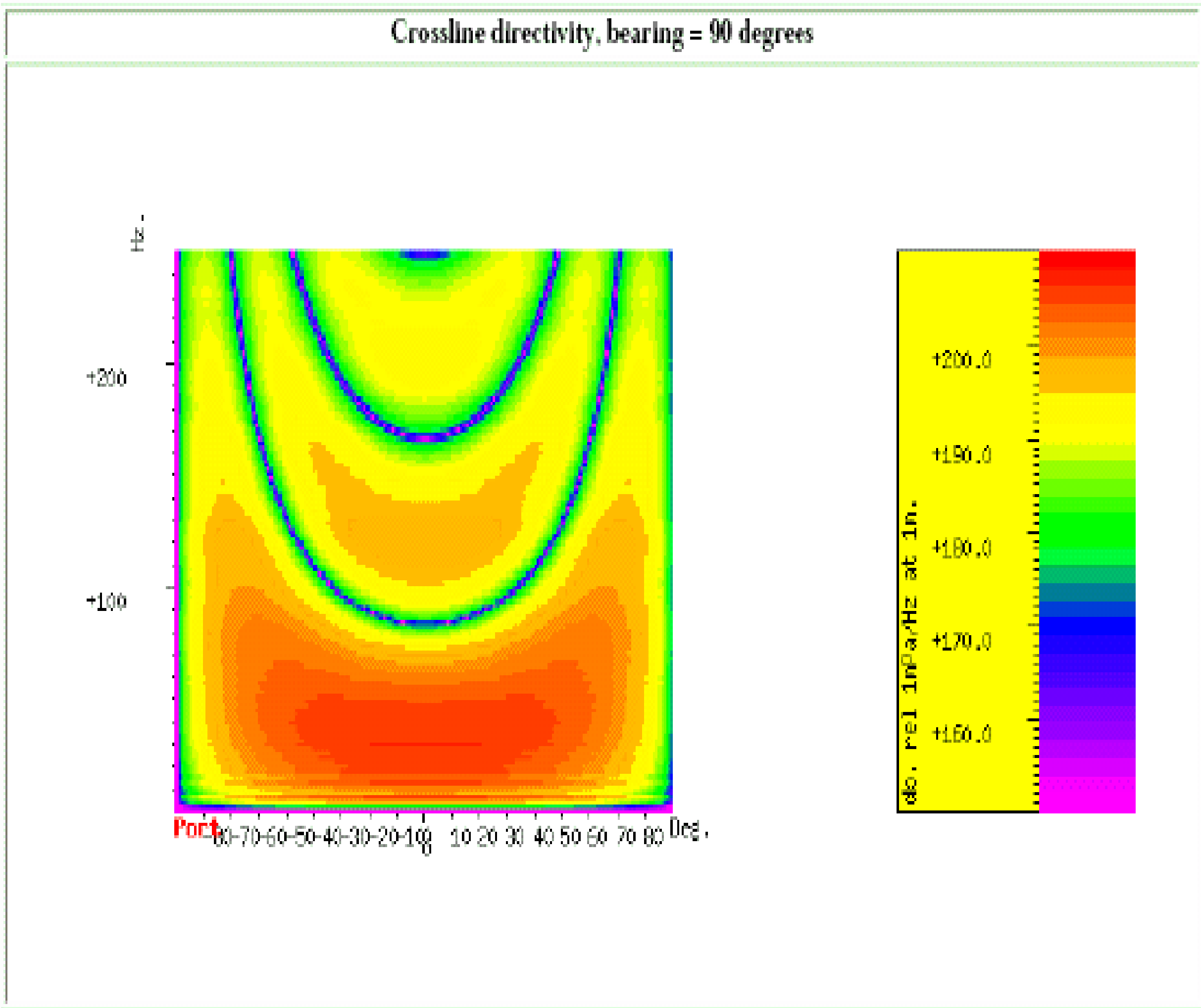


RPS Group Plc

APPENDIX 7

LOC MCS SOURCE DIRECTIVITY PLOTS

Large array (2 sub-arrays, each of 700, 300, 160 cu in).



Source:
GUNDALF array modelling suite - Array report
Gundalf revision AIR5.1i, Date 2007-01-05
Report prepared for GO-project by CSIC.