National Oceanography Centre, Southampton

Cruise Report No.13

RRS *Charles Darwin* Cruise CD179
14 APR – 17 MAY 2006

Hotspot ecosystem research in the
Setúbal, Lisbon, Cascais and Nazaré canyons
on the Portuguese continental margin

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2006

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ABSTRACT

RRS *Charles Darwin* Cruise 179 was one of a series of cruises studying the biology, geology, biogeochemistry and physical oceanography of the Portuguese margin canyons. The cruise contributed to the European Union Framework Programme VI Integrated Project HERMES (Hotspot Ecosystem Research on the Margins of European Seas). Four key canyon areas on the European margin are being studied in HERMES: the Portuguese margin, the Irish margin and the Western and Eastern Mediterranean. On the Portuguese margin four canyons had been selected for multidisciplinary studies by the HERMES community: the Nazaré Canyon, Setúbal Canyon, Lisbon Canyon and the Cascais Canyon.

RRS *Charles Darwin* cruise 179 was divided into two legs (Cartagena to Lisbon, 14 April to 1 May 2006; Lisbon to Falmouth, 1 to 17 May 2006). Leg 1 focused on the upper and middle parts of the Setúbal and Lisbon canyons, which join together at a depth of about 2000m, and the upper and middle Cascais Canyon. Leg 2 sampled the lower Cascais and Setúbal canyons and a wide variety of depths in the Nazaré Canyon. The principal sampling activities were seabed photographic and video imaging (NOCS SHRIMP system), deep-tow 30 kHz sidescan sonar imaging (NOCS TOBI system), coring (Megacorer, Piston Corer and Box Corer), trawling (Agassiz Trawl), and benthic boundary layer particulate biogeochemistry using CTD-mounted Stand Alone Pump Systems (SAPS).

Seabed photo-transects at depths between 300 and 4500m confirmed that large parts of all the canyons were covered in a sediment drape, with little evidence of epifaunal megafauna within the canyon axis, but with localised communities of suspension feeding sponges, cnidarians (soft and stony corals), crinoids and asteroids on rocky ledges around the thalweg (central channel) of the canyons. Photo-transects across the thalwegs of the canyons revealed fascinating changes in the nature of the seabed (e.g. ripple patterns) and fauna (e.g. xenophyophores (giant protozoans) on the flanks of the Nazaré Canyon thalweg). New sidescan sonar images were obtained of the Lisbon and Cascais canyons and the base of the continental slope in the vicinity of the Cascais and Setúbal canyons. Coring and trawling focused on comparable sites at c. 3400m and 4400m in the lower canyons. Burrowing holothurians were evident in all three canyons at c. 3400m, but only in the Nazaré Canyon were they superabundant.

This was the penultimate scientific cruise of RRS *Charles Darwin*. The ship has given UK and European marine science many years of excellent service. She will be greatly missed, and will be succeeded by RRS *James Cook* in 2006.

KEYWORDS abyssal, Agassiz Trawl, asteroid, box corer, bathyal, benthic communities, canyons, Cascais Canyon, *Charles Darwin*, coral, crinoid, cruise 179 2006, CTD observations, HERMES, Lisbon Canyon, macrobenthos, meiobenthos, megabenthos, Megacorer, molpadiid holothurian, Nazaré Canyon, Northeast Atlantic, piston corer, Portuguese margin, SAPS, seabed photography, sediments, Setúbal canyon, SHRIMP, sidescan sonar, Stand Alone Pump System, submarine canyons, thalweg, TOBI, xenophyophores

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ITINERARY

Sail Cartagena, Spain	(Leg 1)	0700 (UTC) Friday 14 April 2006
Arrive Lisbon		1330 (UTC) Monday 1 May 2006
Sail Lisbon	(Leg 2)	1530 (UTC) Monday 1 May 2006
Arrive Falmouth, UK		0730 (UTC) Wednesday 17 May 2006

INTRODUCTION

RRS *Charles Darwin* Cruise 179 was one of a series of cruises studying the biology, geology, biogeochemistry and physical oceanography of the Portuguese margin canyon systems. The cruise contributed to the European Union Framework Programme VI project HERMES (Hotspot Ecosystem Research on the Margins of European Seas), a large Integrated Project (IP) coordinated by the National Oceanography Centre Southampton. HERMES includes research on cold seeps, anoxic microbial systems, deep-water corals, canyons and open slopes. Within canyon systems, four key areas had been identified: the Portuguese margin, the Irish margin and the Western and Eastern Mediterranean. HERMES aims to compare canyons in different biogeochemical settings across the European continental margin. Within each area, canyons with different environmental settings are being studied. On the Portuguese margin this includes 1) the Lisbon and Setúbal canyons that have close links to the Tagus and Sado rivers, and 2) the Cascais and Nazaré canyons that are not connected to rivers, but which bisect the continental shelf and transport large quantities of sediment and associated materials into the deep sea. The Cascais Canyon is thought to have acted as the major conduit of sediment from the continental shelf to the abyssal plain at the time of the Lisbon earthquake in 1755. However, the most active canyon today, in terms of sediment transport, appears to be the Nazaré Canyon which bisects the shelf almost to the low tide mark, and consequently acts as a large sediment trap for materials being carried along the shelf from the north. Activity in the Nazaré Canyon appears to be particularly vigorous during periods of winter storms.

A lot of work was completed on the environmental variables in the Nazaré and Setúbal canyons during the EU Framework V project EUROSTRATFORM. HERMES and EUROSTRATAFORM have provided detailed sidescan sonar images and swath bathymetry maps with which it has been possible to plan biological, sedimentological and physical oceanographic studies. In particular, the biological communities of the canyon systems are poorly known, mainly because of the difficulties of sampling the steep and rocky terrain of the canyons. However, with the advent of Remotely Operated Vehicles (ROVs), areas like canyons are now being opened up to scientific study. RRS Charles Darwin cruise 179, apart from fulfilling its scientific aims, also aimed to learn enough about the canyons to guide a flagship ROV cruise in 2007 using *ISIS* operated from RRS *James Cook*.

The overall aim of the work is to provide the underpinning scientific knowledge for the broad environmental and resource management of the European continental margin. Work on canyons has particular relevance to carbon sinks, fast-track pollutant transfer and fisheries.

CRUISE OBJECTIVES

1. Provide detailed swath bathymetry of the upper Lisbon and Cascais canyons.
2. Provide detailed sidescan sonar images of the Lisbon and Cascais canyons.
3. Provide information of geologically recent major downslope events by running a deep-tow sidescan sonar survey along the base of the continental slope.
4. Characterise the biogeochemistry the particulate material being transported down the Lisbon, Setúbal, Cascais and Nazaré canyons during summer months using nearbed filter/pumping systems.
5. Characterise seabed ecosystems over a wide depth range in each of the canyons using suspended camera (video and still photography) systems.
6. Conduct piston coring in the deeper parts of the Setúbal and Nazaré canyons to determine the frequency and nature of large-scale events in the recent past, and whether there are any significant differences between the canyons.
7. Characterise the protozoan meiofaunal communities in the middle and lower Setúbal, Cascais and Nazaré canyons using megacore samples and to determine whether there are any significant differences between the canyons.
8. Characterise the metazoan meiofaunal communities in the middle and lower Setúbal, Cascais and Nazaré canyons using megacore samples and to determine whether there are any significant differences between the canyons.
9. Characterise the macrofaunal communities in the middle and lower Setúbal, Cascais and Nazaré canyons using megacore samples, and to determine whether there are any significant differences between the canyons.
10. Characterise the major environmental variables, such as grain size, org C, chlorophyll a and phytopigments, which might influence biological communities.
11. Obtain voucher specimens of key megafauna for comparison with the photographic transects.
12. Sample key megafauna in the middle and lower Nazaré Canyon to study trophic relationships, in particular between microorganisms and megafauna.
13. Characterise the necrophage amphipod communities in the middle and lower Setúbal, Cascais and Nazaré canyons using moored amphipod traps.
14. Sample giant protozoans and compare their distributions between canyons.

CRUISE NARRATIVE

Thursday 13 April
Scientific personnel arrive just after midday. Organising lab and preparing for sea as best we could with power off for part of the day. Evening in town at time of Easter Day parades (silent procession of the Seven Stages of the Cross through the streets of Cartagena).

Friday 14 April
Sailed 0900H Cartagena following repairs to the ship's evaporators the previous day and attending emergency muster stations practice at 0830H. Fair weather.

Saturday 15 April
Through the Straits of Gibraltar late morning, with the weather improving as we moved into the NE Atlantic. Started 12 kHz swath bathymetry at 1804Z and then deployed (1912Z) and started recording (1935Z) with the 3.5 kHz sub bottom profiler.

Sunday 16 April
Clocks were retarded 1 hour overnight to British Summer Time.

Swath bathymetry and sub bottom profiler survey running into the first station at the mouth of the Setúbal Canyon (c. 4500m depth).

Arrived on station (56801#1) at 1155Z for a CTD. Additional equipment mounted on the CTD were one Stand Alone Pump System (SAPS), sound velocity probe (SVP) and an amphipod trap release (for testing). The CTD was deployed at 1209Z having primed the SAPS with a 150 minute delay at 1201Z. The CTD was successful although it proved difficult to detect the pinger and, consequently, the return echo from the seabed. While the pinger was evident near the surface on the waterfall display the signal became weaker with increasing depth and could not be detected at 4500m. A pinger trace was also not evident (at first) on the 10 kHz display. Both systems were connected to the hull transducer because the 10 kHz fish was not available for use. With uncertainty over how far the CTD was above the seafloor the pay out rate was reduced to a slow speed as the CTD approached the bottom, arriving 7m above the seabed at 1431Z, the time pumping for the SAPS had been timed to start. The altimeter on the CTD worked well and detected the seabed at 100m above bottom. It worked perfectly throughout the pumping time of 2 hours close to the bottom. Pumping ended at 1631Z and the CTD was recovered on deck at 1823Z. Salinity samples were taken from water bottle samples and the SAPS filters frozen for further analysis. It was found that several filters had been used rather than just two and so this may have curtailed severely the volume of water sampled by the SAPS. In addition, the flow meter reading at the time the SAPS had been deployed had inadvertently not been recorded. Altogether it was a useful learning experience for using the SAPS on the CTD frame, but it is unlikely a good sample had been taken.

At 1845Z the ship made for the upper continental slope and a swath bathymetry survey of the upper Lisbon and Cascais canyons, arriving at the start of the first line at 2144Z (St. 56802#1).

Monday 17 April
Clocks were retarded overnight by one hour to Greenwich Mean Time (GMT). The swath bathymetry survey was concluded at 0905Z . The ship then steamed to the start of the TOBI deployment position while preparations were made on deck for the launch. Owing to the proximity of shallow waters off Cabo Espichel (to the east) and a freshening breeze from the northwest, care had to be taken when launching TOBI head to wind in order to position TOBI over the Lisbon Canyon head at the start of the survey.

The TOBI launch commenced at 1008Z (St. 56803#1) and all systems were outboard by 1032Z. After a brief period the TOBI signal was lost (1052Z) and the swivel/depressor was recovered (1101Z). The swivel was found to have a leak and was replaced by a second swivel from SHRIMP with TOBI still deployed in the water. The system was back in the water by 1152Z and after a long, slow turn the TOBI survey was started at 1259Z. The survey line followed the track of the Lisbon Canyon down to a depth of 1735m when the ship altered course at 1704Z to the west to take the survey line over a saddle between the Lisbon and Cascais canyons. At 2200Z at a depth of 2286m in the Cascais Canyons hauling was commenced to bring TOBI back close to the surface, so that a course change could be made into shallow water up to the head of the Cascais Canyon where the second part of the TOBI survey would be commenced.

At the start of the TOBI survey there was some interference from other sonar devices, the 3.5 kHz on board RRS Charles Darwin, and several systems being used by fishing boats in the area. The 3.5 kHz sub bottom profiler was switched off and was recovered later in the day when it was found that part of the faring had been damaged.

Tuesday 18 April
The second TOBI survey starting at the Cascais Canyon head started at 0037Z. At 0824Z the 3.5 kHz sub bottom profiler was re-launched. Recording was re-commenced with the SBP at 0826Z. TOBI surveying continued throughout the day travelling down the Cascais Canyon. The EM 12 was switched off at 1730Z for repairs to the EM12 transducer cooling pump lasting a couple of hours. Moving out of the Cascais Canyon into deeper water the TOBI survey headed southwest parallel to the base of the continental slope overnight.

Wednesday 19 April
During the morning TOBI survey the mouth of the Setúbal Canyon was crossed. Hauling was commenced at 1540Z south of the Setúbal Canyon bringing TOBI back to the surface at 1855Z. During hauling in of the TOBI umbilical the motor casing on the TOBI winch failed in spectacular fashion and ejected hydraulic fluid all over the deck. Fortunately, the weather was good and TOBI was hauled in by hand until it was under the stern and then hoisted inboard using another deck winch. TOBI was inboard by 1934Z. With all systems secure the ship then made for the next station at 1950Z. The conducting cable was switched over from TOBI to SHRIMP during the passage.

Thursday 20 April
The ship arrived on station over the Setúbal Canyon (c.3200m) at 0130Z and hove to for a drift test in order to assess the best course to drift with SHRIMP over the seabed.

The ship then repositioned for the SHRIMP deployment and deployed the Ultra Short Base Line (USBL) array. SHRIMP was shot at 0218Z (St. 56804#1). Unfortunately, with SHRIMP at a depth of 1215 m wire out there was a major short in the system when it was switched on at 0303Z. SHRIMP was recovered for repair.

While repairs were made to the system the ship repositioned over the central canyon axis for a CTD and SAPS (St. 56804#2). The CTD was shot at 0518Z and reached 10m above bottom at 0712Z. Pumping of the SAPS system started at 0715Z and continued until 0915Z. The amphipod trap release was tested at the same time and worked. Hauling commenced at 0921Z and the system was inboard at 1040Z. The pump had worked for the full 2 hours, filtering 1217 L of water. Lots of material had been gathered on the filter.

A fault was detected on the fibre optic link at the cable termination for SHRIMP, so it was decided to do a box core while further repairs were made. The box core was conducted in hopes of getting a sample and testing what sort of sediment occurred within the floor of the canyon at 3200m. The box core was shot at 1153Z (St. 56804#3) and a pinger was put on the wire 50m above it. The box corer penetrated the sediment at 1322Z. At first, the drop in tension on the wire did not make the exercise look very promising, but a good pull out of 3.47T was recorded and when the box corer was landed on deck at 1443Z it was found to have taken a good, if overfull, sample of mud.

With the box corer safely tucked away a drift test was conducted at 1518Z to assess the best direction for the next SHRIMP deployment. The ship then moved to the start of the SHRIMP transect at 1537H, moving beyond the start position by a little way in order to allow the deck officers to assess how best to handle the ship in the prevailing wind and current while SHRIMP was being paid out. SHRIMP was shot at 1632Z (St. 56804#4). There were many large particles evident in the upper 600m of the water column. As the SHRIMP was being lowered to the seabed there were many side echoes that made it difficult to assess the precise depth under the ship. The altimeter did not activate, possibly because of the softness of the bottom sediment, so the operators did not realise the proximity of the bottom until it suddenly appeared in the cameras at 1804Z. The SHRIMP impacted on the seabed at about 40 m min. Fortunately the bottom was very soft. Most of the systems appeared to survive this novel method of coring, with the exception of the laser ranging device. The tow proceeded, however, using a weight suspended below SHRIMP at a distance of 2m to guide the winch drivers. The transect proceeded downslope into the floor of the canyon and then along the axis of the canyon (c. 3250m depth). A steep scarp was crossed on the slope near the start of the tow and contact with the bottom was lost for about 2 minutes. The floor of the canyon was a very soft mud, but rock outcrops appeared every now and then. There was evidence of a lot of small scale biological disturbance, but very few epifaunal megafauna. A number of discarded oil drums and other man-made debris were seen. Benthopelagic fauna, including medusae and possibly holothurians, were quite common. The bottom was very uniform in appearance, so after just over two hours on the bottom SHRIMP was hauled at 2020Z and was back on deck at 2152Z.

The ship the repositioned on the same position as for the successful box core obtained earlier in the day. A Megacorer (St. 56804#5) with twelve 10cm diameter tubes was shot at 2254Z.

Friday 21 April

The Megacorer took a sample on the seabed at 0026Z and when the corer arrived on deck at 0152Z was found to have eleven good cores. These were used for macrofauna, meiofauna and sedimentological analyses.

A second Megacorer (St. 56804#6) was launched at 0258Z, this time with ten 10cm diameter core tubes and two 58mm core tubes (for meiofauna). All core tubes sampled the seabed effectively (0431Z) producing many happy scientists when the corer was retrieved on deck at 0600Z. The cores were used for a variety of analyses as above.

The ship then moved up canyon for operations combining SHRIMP surveys and Stand Alone Pump System (SAPS) in the upper Setúbal Canyon and at the canyon head. Unfortunately, the problems with SHRIMP were not easy resolve and it was clear that the SHRIMP engineers would need rest and time to get the system working effectively. The ship therefore proceeded to an area near the canyon head, and after negotiations with a fisherman and a fisheries research vessel (in Portuguese - through the kind assistance of Portuguese scientists onboard), a site suitable for our investigations was identified that did not interfere with other activities in the area. A SAPS mounted on the CTD frame was deployed at 1036Z (St. 56805#1) and took a half-hour long sample in the chlorophyll maximum at 30m water depth. The SAPS filter had a lot of material on it and had a very strong “marine” odour.

The ship then repositioned slightly to the northeast to lie directly over the deepest part of the canyon and a CTD (St. 56805#2, 1155Z) sampled to the bottom (c. 325m) (1212Z) and back (1230Z). As there was the potential threat of entangling the CTD in discarded fishing gear on the seabed during an hour-long deployment of a SAPS, it was decided to mount the SAPS on the coring wire and to “fish” the SAPS five metres off the seabed using a pinger mounted immediately above it on the wire. The SAPS was shot at 1308Z (St. 56805#3) and reached the bottom in good time to start pumping for one hour (1356 to 1456Z) before being recovered (1515Z). A good sample had been retained on the filter.

With SHRIMP still undergoing surgery, the ship then steamed back down canyon in a freshening breeze from the northwest to the coring site to the 3200m site to undertake further megacoring.

The Megacorer was shot on arriving on station at 1927Z (St. 56806#1) in slightly rough conditions giving some concern over what quality of sample might be achieved. The corer reached the seabed at 2059Z and appeared to take a good sample. On retrieval eleven out of twelve core tubes had been found to take a good sample although there had been slippage of the bottom part of the sediment in most cores. The closing mechanism on one Megacorer tube unit had not worked and the whole core had been lost. Of the good cores there was bubbling up through the cores as they were taken off the coring head, disturbing the core surface to a large extent. However, as the sediment surface had been recovered intact and with little

disturbance the cores were processed for macrofauna. Three 58mm diameter tubes that had been used were all good and were used for meiofauna studies.

During the second deployment of the Megacorer at the 3200m Setúbal Canyon site, which started at 2313Z, problems were encountered with the winch system.

Saturday 22 April

Sudden changes in tension occurred several times as the wire was paid out. With the corer just above the seabed, full tension on the wire was recorded suddenly. This was clearly an electric fault either with the load cell or the clam system displaying the winch information. It was decided to go ahead and take a core, but the point when the core sampled the seabed had to be guessed at (c. 0113Z). Six of nine Megacorer tubes had a sample, but they were all badly disturbed. None of the three multicorer tubes had a sample. The top 5cm and overlying murky water were retained on a 500µm sieve and preserved in alcohol for future molecular biology research.

The ship then steamed back up canyon to c. 1400m depth for a SHRIMP while the ship's engineers investigated the problems with the winch system. Concern focussed on the load cell for the coring wire. An echo sounding survey was conducted over the proposed SHRIMP track. At this stage the wind had died down considerably, but there was still a large swell running in from the northwest. The ship then returned to the start position of the SHRIMP survey. However, just as the clam system was switched over to the SHRIMP fibre optic cable, a sudden change in wire tension occurred even though there was no load on the wire. Repairs then focussed on the clam system using the combined forces of the National Marine Facilities Division (NMFD). Eventually, a possible fault in the load cell at the bottom of the spurling pipe was detected. The ship's engineers worked on this while a SHRIMP deployment was made.

The SHRIMP (St. 56807#1) was launched at 0953Z after a brief hiatus when the still camera was inserted into its pressure case. With about 800m or wire out the ship's fire alarm sounded and it was reported that there was a possible fire in the winch room. Paying out was stopped. The fire alarm proved to be a false alarm and was related to work being carried out on the coring winch load sensor. The SHRIMP altimeter did not register at 200m off and so the bottom was approached with extreme caution at a rate of 10m min^{-1}. At times it felt as though the depth was increasing at the same rate as the wire was paid out. During the final part of the descent the ship had to manoeuvre around a fishing mooring and in the process had to speed up a bit and then slow down. This coupled with the prevailing swell meant that although the bottom was approached very slowly, the system still impacted the sediment. Although the impact was only gentle, a large amount of mud collected on the video camera lens not only obscuring the view but also confusing the automatic focussing. The altimeter was working by this time, but it proved very difficult to get SHRIMP stable. It was then reported that the gearing on the winch system was trying to engage the coring winch. With all these problems it was decided to abort the SHRIMP deployment at 1138Z and the system was recovered on deck at 1205Z.

A CTD/SAP was then undertaken in the centre of the canyon axis to allow time for the swell to decrease further. The CTD was launched at 1240Z (St. 56807#2) and arrived 10m above bottom in good time for pumping (1340 to 1440Z). Many

particles were found on the filter reflecting the high back scatter values seen on the CTD sensor and the high particle load seen earlier in the day on the SHRIMP video camera.

With the wind veering to the northeast and the swell decreasing, another attempt was made to run SHRIMP over the 1000 to 1400m "coral" site in the Setúbal Canyon. SHRIMP was shot at 1621Z (St. 56807#3) and paid out to 800m wire out (about 73m above the bottom). The ship then manoeuvred into position to start the SHRIMP transect, but as it was doing so all power was lost to the system (1713Z) and it had to be recovered (1755Z).

The SHRIMP technical team decided that the only fix was to take the SHRIMP swivel off and wire SHRIMP into the fibre optic cable without the swivel assembly. Using this arrangement SHRIMP was shot at 1927Z (St. 56807#4) and arrived on the seabed at 2033Z. The swell had decreased substantially by this time, but there was still considerable movement of the camera system over the seabed. A few minor impacts occurred when the SHRIMP passed over scarps. Once the film in the still camera had all been used (2330Z) the survey continued with just video until 0038Z, when hauling commenced. The latter part of the survey was largely uneventful. However, when SHRIMP was recovered on deck (0150Z) several pieces of *Lophelia pertusa* and *Madrepora oculata* were found on top of SHRIMP, and I was clear that these had been collected when SHRIMP had impacted the seabed in the region of the scarps.

Sunday 23 April

The ship then steamed further up canyon for another SHRIMP deployment in about 400 to 700m water depth. The SHRIMP was deployed at 0329Z (St. 56808#1) and undertook a rather boring survey over the seabed between 0352 and 0936Z. At some stage between 0655 and 0721Z the stills camera ran out of film. SHRIMP was back on deck at 0821Z.

The ship then moved further up canyon for the shallowest of the SHRIMP deployments planned for the Setúbal Canyon. SHRIMP was shot at 1032Z (St. 56809#1) reaching the seabed in a short time. There was considerable variation in the degree of bioturbation evident in the video, but very few epifaunal invertebrates were evident. Two discarded trawls were seen as well as other man-made objects, including (rather appropriately for an exceedingly dull photo-transect) a toilet seat. With the SHRIMP safely on board at, and with the Ultra Short Base Line (USBL) navigation probe raised, the ship made for the deep 3200m site in near perfect weather at 1500Z. Three and half hours later the weather had turned for the worse.

A Megacorer was launched at 1840Z reaching the seabed at 2014Z just as a large wave drenched the starboard deck. A good sample was taken which survived being brought inboard in a rough sea at 2149Z. Further operations were halted until the weather improved.

Monday 24 April

With no improvement in the weather overnight it was decided to try and see if conditions were better closer inshore in the lee of Cabo da Roca. The coast off Portugal was affected by moderate northerly winds by being sandwiched between a

low pressure system over the Iberian Peninsular and the Azores high pressure area. The period for how long the winds might persist could not be determined.

On arriving at the head of the Lisbon Canyon off Cabo Espichel the sea state was found to be much calmer and so a series of CTD and SAPS were conducted to sample particles in the chlorophyll maximum layer over the canyon head and near the seabed at a depth of 400m. The first CTD (St. 56811#1) (1156Z) made a profile of the top 100m and then took a SAPS sample at a depth of 12m in the chlorophyll maximum layer between 1220 and 1250Z. The filter had a very large sample and some of the sample was lost when taking the filter off the filter unit. The next CTD (St. 56811#2) was shot at 1321Z and took a SAPS sample for one hour at 1357Z about 10m above the seabed in a water depth of 400m. High backscatter values were recorded near the seabed and the filter had a good sample of particulate material.

A similar pair of CTDs and SAPS were then carried out over the Cascais Canyon head, only in this case in 700m water depth. The first CTD (St. 56812#1) was shot at 1700Z and was paid out to the bottom (1725Z) before pumping for 30 minutes at a depth of 10m in the chlorophyll maximum (1757 to 1827Z). The second CTD (St. 56812#2) was shot at 1852Z, reaching the bottom at 1915Z and pumping for one hour (1921 to 2021Z). Backscatter values were not as high as in the Lisbon Canyon.

With the CTD safely inboard at 2049Z, the ship then made for the start position of a SHRIMP in an area of the Lisbon Canyon at about 1400m. SHRIMP was shot at 2320Z (St. 56813#1) with a USBL pinger at a height of 15m above the SHRIMP. The SHRIMP system arrived at the seabed at a depth of about 1000m at 2358Z.

Tuesday 25 April

It was immediately clear that the terrain was a lot more lumpy than experienced previously. After a brief tussle with a rock face the system was raised and then lowered once more. Another close encounter with the seabed occurred producing some strain on the wire. Despite some glitches in the transmission of the system, contact with the SHRIMP continued. It was noted that SHRIMP was still a way off from the start position planned for the system (at the top of a downhill slope). SHRIMP had reached the seabed early in front of a steep scarp that had been mapped for the first time only a few days previously during the swath bathymetry survey. Once on the right transect SHRIMP continued to work, showing what appeared to be an abundant echiuran community, but after about 10 minutes all power was lost and the system had to be hauled in (0034Z). On arrival on deck (0120Z) another biological sample was found on the top of the SHRIMP consisting mainly of bits of biogenic substrate made by oysters. The sample was preserved as a demonstration of the effectiveness of SHRIMP to act as a rock dredge.

Owing to the curtailment of the SHRIMP survey and the need to allow the CTD engineer sufficient rest, a 4-hour swath bathymetry survey was conducted around the Lisbon canyon head and in the area of the shelf break between the Lisbon and Cascais canyon heads (0245 to 0600Z) (St. 56814#1). As the wind speed had decreased significantly to less than 15 knots the ship then made for the 3200m site in the Setúbal Canyon in hopes of undertaking a piston core. Unfortunately, during the passage the wind increased once again to 25 knots and the ship was diverted to a 3200m site in the Cascais Canyon where a CTD/SAPS deployment was made starting at 0920Z (St.

56815#1). A two hour pumping sample was taken by SAPS (1102 to 1302Z) five to ten metres above the seabed.

With the CTD safely inboard at 1426Z, the ship then steamed to the 3200m site in the Setúbal Canyon to use the Megacorer. Two final deployments were made at the 3200m site in the Setúbal Canyon, the first (St. 56816#1)starting at 1605Z, reaching the seabed at 1736Z, and was back on deck at 1905Z. A full set of cores had been collected. The second Megacorer (St. 56816#2) was shot at 1936Z, took a sample at 2104Z and was inboard at 2230Z, again with a full set of cores.

An amphipod trap was then deployed at 2307Z (St. 56817#1) for retrieval early on Thursday morning. The ship then made for a SHRIMP photo-transect in the Cascais Canyon.

Wednesday 26 April

The SHRIMP line (St. 56818#1) took the camera system across the Cascais Canyon floor at depths of 3000 to 3500m. SHRIMP was launched at 0210Z, reaching the seabed at 3000m at 0408Z. A good tow was made across the canyon showing fine sediments to start with and then becoming coarser and with rock outcrops towards the thalweg. After three and a half hours the still camera ran out of film as expected, but the deployment was carried on using just the video in order to get a better impression of what the active canyon floor looked like. Unfortunately, at 0755Z, there was a short in the system and all power was lost. Hauling was commenced with SHRIMP arriving on deck at 1021Z. Repairs to the termination of the wire were carried out throughout the day.

The ship then made for a position near the thalweg of the Cascais Canyon for the first of two piston core deployments. After a period of getting all the equipment ready on deck, a 9m piston core was shot at 1216Z (St. 56819#1). It appeared to take a good core at 1353Z with a modest pull out of 4.75 tons, although there was a curious additional “pre-pull out” increase in wire tension. This may have indicated that the corer had not taken a good sample. The core was on deck at 1536Z and had only a small amount of gravely sediment in the trigger core and mud with gravel fragments on the outer surface of the core catcher.

Rather than sample closer to the centre of the thalweg, the position of the next core was changed to a sedimented terrace seen in the SHRIMP transect. A 6m piston core was shot at 1648Z and a good, short core (3.3m) taken at 1804Z. Having recovered the core on deck by 1926Z, the ship then repositioned a cable to the west to take Megacorer samples.

Two Megacorers, of a series of 5 planned for this site, were sampled over the next few hours. The first (St. 56821#1) was shot at 2045Z and took a near perfect set of samples at 2221Z. The sediment showed distinct oxidised and reduced layers, but rather than there being a gradation in colour down the core, there were a series of bands, indicative of a series of erosion events in the past. Recovery of the core on deck was tricky owing to the core wire being caught around the coring column. The weight of the corer was taken on the Rexroth winch while the main coring wire was sorted out. The corer was all in at 2345Z.

Thursday 27 April
A second Megacorer (St. 56821#2) (0030Z) returned on deck at 0330Z having taken a perfect sample of all twelve core tubes at 0201Z. The samples were used for macrofauna, meiofauna, sedimentological and sediment chemistry analyses.

The ship then made for the 3200m site in the Setúbal Canyon to pick up the Amphipod Trap (St, 56817#1) (released 0621Z) and deploy a 9m piston core (1000Z) (St. 56822#1). There were some problems with the remote deck control of the crane, but otherwise the deployment went smoothly. With 500m of wire out a spike was noted on the tension record of the wire and it was thought that the core may have pre-triggered. The piston core was brought back to the surface, but everything appeared OK. It was redeployed at 1029Z. A good 6m core was taken at 1141Z.

During the recovery it was decided that the increase in swell and wind would make future piston core deployments difficult. Once the sample had been dealt with and all the equipment on deck had been secured the ship then made for the 3200m site in the Cascais Canyon for further Megacorer sampling.

The sea was moderately rough for the three deployments of the Megacorer (Stns 56823#1, #2, #3), which may have contributed to all samples being slightly disturbed. Operations started at 1600Z with cores being taken at 1733Z, 2050Z and 0026Z (28 April). The ship then repositioned for an Agassiz Trawl.

Friday 28 April
The Agassiz Trawl was finally shot at 0413Z (St. 56824#1) after a few problems during the launch caused by a shackle caught in one of the blocks on deck. The trawl was rigged with a 50m pennant and a large clump weight ahead of the trawl with a pinger placed on the wire a further 50m higher. The plan was to lower the net vertically from the stern of the ship. Once the trawl frame had reached the bottom the ship would make way allowing the weight to skim the seabed ahead of the trawl. However, while the pinger could be detected it proved difficult to see the seabed reflected signal and so the position of the trawl relative to the seabed had to be guessed at (0534 to 0617Z). A small catch was obtained when the net was landed on deck at 0758Z. The net had parted from the head and foot ropes for about half their lengths and was repaired in preparation for the next trawl.

The ship then made for a new station in the Setúbal Canyon for a 6m piston core on a platform to the side of the main canyon axis at a depth of 3788m (uc) (St. 56825#1). The core was shot at 1121Z, reaching the seabed at 1255Z. A good core 3.34m long was obtained.

A 9m piston core was then carried out at the slightly greater depth of 4034m (uc) (St. 56826#1) (1710Z). The core sample was taken at 1850Z. A significant pull out of 6.1 tons was recorded as the core was being pulled out of the seabed and the winch stalled several times. The core was anchored in the seabed for about 10 minutes, finally coming free at 1901Z. For all the struggle it was a bit disappointing to have only a 2.82m core. However, on opening the core it showed a wide variety of sediment changes that will make the core a fascinating (and colourful) one to work on in the future.

The ship then made for an Agassiz trawl at the main 3200m sampling site in the Setúbal Canyon arriving on station at 2326Z and shooting the trawl (St. 56827#1) at 2340Z in the same configuration as described above for St. 56824#1.

Saturday 29 April

The trawl reached the seabed at 0106Z and was fished on the bottom until 0136Z. The pinger and bottom echo traces were seen clearly and the operation passed without a hitch. The net was all in at 0345Z. There was no sign of damage to the net this time, and although there were very few megafauna, the catch did include five burrowing molpadiid holothurians.

The ship then made for the Cascais Canyon 3200m station for another Megacorer to collect the final macrofauna sample for the area, and some additional samples for meiofauna and sediment chemistry. The corer was shot at 0520Z (St. 56828#1), took the sample at 0652Z and was back on board at 0820Z with a perfect set of samples.

An effort was then made to collect a box core sample of surface sediment at a site in the Cascais Canyon axis at c. 3800m. The corer was shot at 0936Z. The pull out after taking the sample at 1114Z was very disappointing, so it was no surprise that when the corer was landed on deck at 1304Z that it was nearly empty apart from a very small amount of gritty mud.

With the port call in Lisbon looming on 1 May the science programme then turned towards the shore and a series of tasks in the upper Setúbal, Lisbon and Cascais canyons. The first was to take a 6m piston core at a point at a depth of 2500m where the Cascais Canyon became one channel rather than a series of gullies and channels all joining together. The Piston Core was shot at 1451Z (St. 56830#1) and triggered at 1619Z. With a pull out of 4.06 tons a moderately long core was obtained. The piston core was then followed by a box core at the same location. The box core was shot at 1806Z (St. 56830#2) and took a sample at 1914Z. A classic pull out of 4.46 tons was obtained and a full box core was returned to the deck at 2035Z.

The ship then made for a SHRIMP photo transect in the Setúbal Canyon at depths of between 1500 and 2000m. After a few problems with the winch system SHRIMP was finally shot at 2324Z (St. 56831#1). An excellent transect downslope was obtained. SHRIMP was back inboard at 0530Z. Some problems had been experienced with raising and lowering the USBL probe, so it was decided to leave the USBL out and gently steam to the start of the next SHRIMP survey.

A photo-transect was then carried out at the confluence of the Lisbon and Setúbal canyons (St. 56832#1) again showing little in the way of fauna at first in the canyon floor. However, holothurians became more common after the joining of the two canyon systems. It was also noted at this time that the TOBI images and the bathymetry charts we had been using were probably slightly out, so bright sidescan features were not where we expected them to be. Since a good downslope transect had been obtained at St. 56831#1 with evidence of faunal zonation, the direction of the SHRIMP tow was altered during the 56832#1 tow to take SHRIMP upslope in order to see whether similar fauna and zonation was evident. Some similarities in the presence of glass sponges, synaphobranchid eels and holothurians were seen. The

transect also showed the presence of large xenophyophores (?*Syringammina* sp.) at about 1700m. SHRIMP was inboard at 1538Z.

With the USBL raised, again with some difficulty, the ship then made for the top of the Cascais Canyon to do a CTD and SAPS cast at 1400m water depth. The CTD was shot at 1715Z (St. 56833#1) and pumped for 1 hour (1813 to 1913Z) 5 to 10m off the seabed before returning to the ship at 1955Z with a filter full of particulate material. A similar exercise was then carried out at c. 1100m in the Lisbon Canyon. The CTD was shot at 2050Z (St. 56934#1), reached to 5 to 10m off the seabed for pumping with SAPS 2150 to 2250Z, and was back on deck at 2325Z.

Monday 1 May

The final action of the first leg was to repeat the photo-transect survey of the upper Lisbon canyon that had been aborted when the system crashed following its impact with the oyster pavement/wall earlier in the cruise (St. 56813#1). SHRIMP was launched at 0030Z (St. 56835#1) and conducted a long survey on the seabed between 0122 and 0628Z, often in very turbid water in the heart of the canyon axis. The system was back on deck at 0721Z and the ship made ready for steaming to Lisbon for personnel transfers, docking at 1200Z.

With new scientific personnel on board, water, mackerel for the Amphipod Trap, Portuguese pastries, more pots for macrofauna samples, the ship departed Lisbon in fine weather at 1500Z. During the port call 1000m of wire had been run off the main winch by hand onto a drum on deck, and another 1000m was run off while we made passage to the first station of the second leg. This was to allow greater torque on the coring winch for the deep piston cores we intended to take on the second leg.

The first activity was to collect the one remaining sample needed at the 3200m station in the Cascais Canyon. A Megacorer was shot at 2112Z (St. 56836#1) and collected a good set of cores at 2246Z.

Tuesday 2 May

With the corer safely back on board at 0002Z the ship then made for another target station at 4200m at the mouth of the Cascais Canyon, deploying an Amphipod Trap en route at 0143Z (St. 56837#1) near to the coring location.

A Megacorer was deployed at 0204Z (St. 56837#2) and after sampling the seabed at 0407Z was found to have taken a good set of cores when on deck at 0545Z. With this success another Megacorer was attempted at 0615Z (St. 56837#3). The sample was taken at 0817Z, but there was no appreciable pull out and when the corer reached the deck at 1010Z only short cores were found in some of the tubes. It seems that the corer had not penetrated a coarse gravely layer at about 15cm depth and as a consequences most of the cores had slipped out before the core catchers had been activated.

A 9m piston core was then carried out at the same location (1057Z; St. 56837#4), and although only a small pull out was noted in the tension on the wire (1254Z), a good 6m core was returned to deck at1440Z. The presence of several turbidites was noted with a consistent change in their thickness and frequency with time. All cores had a layer of brownish pelagic sedimentation on top of dark grey turbidites. The change in

the layers probably denotes the turbidity current caused by the Lisbon Earthquake in 1755.

Another Megacorer was shot at 1508Z (St. 56837#5). This time when the core reached the seabed at 1712Z it was allowed to stay on the bottom for an extra minute before hauling was commenced. An excellent pull out of the corer was noted and when the corer was landed on deck at 1906Z there was a full set of excellent cores. The next Megacorer failed to penetrate the sediment sufficiently to retain the cores (2128Z; St. 56837#6) despite the cores being taken in exactly the same way as the previous sample. Another Megacorer was shot at 2330Z to try again (St. 56937#7).

Wednesday 3 May

The corer landed on the seabed at 0136Z, but despite being left on the seabed for two minutes before hauling was commenced, it still returned (0320Z) short-cored. A final attempt to obtain a sample was made at 0345Z (St. 56837#8). The number of core tubes on the coring head was reduced to 10 and a good sample was taken at 0552Z, although this seemed to be due to luck of where the corer landed rather than the reduction of the number of cores tubes on the coring head. With the corer inboard and the sieving teams happy with the change over from night to day watch, a short hop was made to the amphipod trap site (St. 56837#1). The trap was released at 0800Z and reached the sea surface at 0920Z. When the trap was recovered on deck at 0953Z a good catch was evident in both DEMAR (seabed level) and VET (1 mab) traps. The gauze in one end of the VET trap had come away in part from the trap entrance.

The ship then made for a deep station at the mouth of the Setúbal Canyon. The SHRIMP was made ready and was shot at 1207Z (St. 56838#1). Once SHRIMP had reached the floor of the lower canyon axis (4402m) the stills and video cameras were switched on at 1448Z. A good set of images, if a bit boring were obtained and recording was ended at 1652Z. The SHRIMP system was back on deck at 1926Z, ending up precisely over the coring site.

A Megacorer was then shot at 1956Z (St. 56838#2) and a sample taken at 2207Z. A good pull out was recorded and a good set of samples retrieved.

Thursday 4 May

Another two Megacorers were then completed with samples being taken at 0224Z and 0627Z (Stas. 56838#3, #4). The cores were short, many less than 10cm long, but generally well plugged. It was clear there was a stiff muddy layer underlying the soft surface sediment. Once the second Megacorer was on board at 0805Z, the ship moved to deploy the Amphipod Trap about a mile and a half up canyon from the Megacorer site and about where the SHRIMP photo-transect (St. 56838#1) started. The Amphipod Trap was shot at 0858Z.

The ship then headed slightly further up canyon to take a 9m piston core sample in a debris flow to one side of the canyon floor. The piston corer was shot at 1013Z (St. 56840#1), but there was no appreciable pull out following the corer reaching the seabed at 1152Z. When the corer was recovered on deck at 1410Z there was no sample and it was found that the core catcher had sheared off. All that remained of

the core catcher were the remnants of two of the retaining nails. There was evidence of 5m of soft mud on the outside of the core.

The ship then made for a site to one side of the Setúbal Canyon to do a SHRIMP photo-transect down an open slope between depths of about 2700 and 3400m. The ship arrived on station at 1610Z and the SHRIMP was shot at 1613Z (St. 56841#1). With 500m of wire out the SHRIMP power was switched on, but it became obvious that all was not right with the system. Various tests were made and with 1200m of wire out at 1704Z it was decided to abort the deployment. With SHRIMP back on deck at 1748Z further tests were carried out on the equipment and conducting wire and a fault in the wire at a distance of about 5000m was found (probably cause by poor wire laying at the time of the previous SHRIMP deployment (wire out 4500m). As SHRIMP was vital for operations in the Nazaré Canyon it was decided to stream the wire to 5000m and relay it.

The wire was re-routed to the aft deck and the wire streaming exercise started at 2005Z with the ship heading into deeper water. The wire was all out at 2124Z and hauling was commenced, finally coming on board at 2245Z.

Friday 5 May

The ship then returned to the coring site at 4400m and took two more Megacorers at 0231Z and 0635Z (Stas. 56842#1 and 2). Both sets of cores were short, as before, in several cases less than 10cm long.

The ship then repositioned to release the Amphipod Trap (St. 56839#1) from the seabed at 0910Z. The Amphipod Trap reached the surface at 1032Z and was recovered on board at 1058Z, with a good catch.

This was then followed by a series of three deep-water piston cores (Stas. 56843#1, 56844#1 and 56845#1), the final activities to be carried out in the vicinity of the Setúbal Canyon. A NATO exercise was being conducted in the area and we had to be extremely careful to keep the authorities informed of our location and deck activities. The first two samples were taken at 1313Z and 1832Z.

Saturday 6 May

With the final piston core sample taken at 0023Z and inboard at 0227Z the ship then headed north to start a programme of work in the Nazaré Canyon, arriving on station for a SHRIMP deployment in about 4300m depth at 1230Z. SHRIMP was shot at 1240Z (St. 56846#1). With 500m of wire out the system was switched on, but none of the systems could be made to work. With 642m of wire out at 1306Z SHRIMP was hauled back in stopping at 50m wore out at 1326Z to test the system. Everything worked perfectly. So, SHRIMP was paid out again showing good images of many jellyfish in surface waters and many salps feeding at depth. All went well until the system crashed again at 1441Z with 2036m of wire out. SHRIMP was hauled in stopping again at 50m wire out at 1548Z. No communication was evident and so the haul was aborted at 1550Z and SHRIMP was landed on deck at 1556Z after a brief moment of trying to raise the termination through the block. Various tests were then performed on the system. The termination was checked and the system tested once more on deck.

With the all clear SHRIMP was deployed again at 1806Z (56846#2). The system was switched on at 50m depth and worked. However, when SHRIMP reached 1155m wire out (1850Z) communication with the system was lost. Further tests were made and the deployment was aborted at 1854H with 1240m wire out. The system was all in at 1940Z.

Tests on the conducting cable indicated that there was a kink in one of the fibre optic fibres at 8660m (there were only 8900m on the wire). Following a conversation with the Master, Chief Engineer, Scientific Bosun and the National Marine Facilities Division (NMFD) Operations team, it was decided to stream the wire to its full length to try and cure the problem. During TOBI deployments at the start of the cruise the cable had been streamed to almost its full length, so a cable problem was considered to be possible and this was borne out by the diagnostic tests on the fibre optic fibres.

As the ship was close to waters in excess of 4300m it was decided that the time was ripe for streaming the cable. The operation began at 2040Z. The wire was all out (8940m) at 2302Z.

Sunday 7 May

Following a period of getting the wire to scroll onto the drum well, hauling was commenced at 0026Z. By the time the wire streamed and back inboard at 0312Z the ship was in deep water (c. 5000m) well west of the Nazaré Canyon and had a long steam back to the east to get on station, arriving at 0735Z to deploy the Amphipod Trap (St 56847#1). In the meantime the conducting cable was tested. No signal could be transmitted down the fibre optic cable at all.

The ship then moved a mile away from the Amphipod Trap to a site for repeated coring and trawling while further work was carried out on the conducting cable. The first Megacorer was shot at 0817Z (St. 56847#2), reaching the seabed at 1026Z. While eleven out of twelve cores were recovered at 1228Z with sediment they were all disturbed. However, two large xenophyophores were found on the tops of the sediment. Another attempt was mad at 1300H (St 56847#3). The sample (1506Z) took one perfect core, but most of the other cores tubes were empty. Another Megacorer was shot at 1714Z (St. 56847#4). As the corer was lowered to the seabed the ship moved 0.6 of a mile to the north, into an area of the TOBI seabed image with a slightly different reflectivity. A poor set of cores was returned.

The ship then made for a position to run an Agassiz (Trawl) Dredge. The net was shot at 2220Z and reached the seabed at 2352Z (St. 56847#5).

Monday 8 May

The net fished along the bottom for just less than an hour (to 0043Z), but when the net returned to the surface it was found that the cod end had burst open and that no catch had been retained.

With several hours to go before daylight and the return of the amphipod trap another Megacorer as shot at 0355Z (St. 56847#6). A good set of samples were taken at 0554Z, leading to a frenzy of activity in sieving for macrofauna after the core was back on deck at 0733Z.

The Amphipod Trap (St. 56847#1) was then released from the seabed at 0809Z, reaching the surface at 0930Z and was all in at 1001Z with a fine catch of varied necrophage amphipods in both the DEMAR (seabed) and VET (1m above bottom) traps.

Another Megacorer was shot at 1022Z (St. 56847#7) to see if sufficient sediment could be retained to give a macrofauna sample. Despite an indifferent landing and little sign of a pull out, a good set of cores was delivered on deck at 1435Z. Good enough to give us hope that a full set of 5 samples might eventually be taken at this site.

During this period several phone calls were exchanged between the ship and the base, which ascertained that suitable multiplexers were on board to make a change to the SHRIMP system, which might fix the problem of attenuation down the cable. As this job might take as much as 48 hours, a programme of work was needed that filled the time and made strategic sense.

The ship therefore headed up-canyon at 1448Z, arriving over a station at 3400m at 1712Z. Three Megacorers were taken back-to-back at 1901Z, 2236Z and 0155Z (9 May 2006) (Stas. 56848#1, #2, #3).

Tuesday 9 May

With the Megacorer on board with another indifferent sample (the third in a row), the ship headed up-canyon towards the coast at Nazaré to sample the surface water chlorophyll maximum using a SAPS mounted on the CTD and to sample the bottom nepheloid layer at two different points. The first CTD/SAPS (St. 56849#1) was shot at 0730Z and took a 30-minute pump sample (0815 to 0845Z) 5 to 10m off the seabed at a depth of 715m, approaching within 1.5m of the seabed at one point. A good bottom nepheloid layer was evident on the CTD record and the SAPS filter was full of particulate material. The second CTD/SAPS was shot at 0951Z (St. 56849#2) and took a short 18-minute pump sample (1007-1025Z) in the chlorophyll maximum layer at 40m. With the CTD/SAPS inboard at 1035Z the ship then made for a deeper canyon station at 1150m depth to sample the bottom nepheloid layer once again.

The CTD/SAPS was deployed once more at 1202Z (St. 56850#1) arriving 10m off the seabed (1154m) in good time to pump from 1258 to 1358Z. A good sample of bottom nepheloid layer was taken for organic biogeochemistry.

The ship then made the long steam back to the 3500m repeat coring site arriving at 1745Z. During the day the Megacorer was given a close inspection and a thorough servicing. The reward was two near perfect (and surprising) samples at 1924Z and 2308Z (Stas. 56851#1, #2), both with 11 out of 12 core tubes; a rare feat. All cores a good length and a good sediment water interface.

Wednesday 10 May

Unfortunately, the Meagre Corer reasserted its old tendencies on the third drop (St. 56851#3, 0242Z) and only three full core tubes were recovered.

As the conducting cable had been reterminated a load test had to be made on the wire before SHRIMP was launched at 0623Z (St. 56852#1). SHRIMP reached the seabed

at 0830Z and undertook a survey across the thalweg of the Nazaré Canyon adjacent to the coring site, slowing down for the period it was passing through the canyon. An excellent video and phototransect was collected with many interesting geological, biological and sedimentological features. Hauling was commenced at 1130Z when the stills camera ran out of film.

Flushed with success the ship then headed for another SHRIMP transect up-canyon on some geological features close to the canyon axis at a depth of about 1100m. It was thought that these might be possible coral mounds. This was also the same phototransect on which the Discovery winch broke in 2005. The ship arrived on station at 1640Z and commenced a drift test. After a while and the ship repositioning, SHRIMP was finally shot just before dinner at 1724Z (St. 56832#1), reaching the seabed at 583m at 1752Z. At first the video showed a rather dull sediment environment, but after a while some rocks started to appear with brisingid asteroids and a *Neocytus* sp. fish, which caused some excitement as it had been found to be associated quite often with coral mounds. Unfortunately, just as the phototransect started to get interesting all communication with the SHRIMP was lost at 1835Z and it had to be hauled in.

Back on deck at 1903Z all systems were checked through and it was found that the transformer had blown. Repairs were made, and the SHRIMP was brought back to life. A few other errors remained, such as the loss of the laser ranging system, but it was decided to proceed with the transect at the point where the SHRIMP had reached on the previous run. SHRIMP was shot at 2237Z (St. 56832#2) and reached the seabed once more at 2307Z (584m). A mixed bottom of rock and sediment was apparent for much of the early part of the transect in the area of the target geological features, but gradually a mundane sediment environment with little epifauna reasserted itself. The rocky ledges had been disappointingly free of life apart from the occasional brisingid asteroid.

Thursday 11 May

The SHRIMP phototransect was ended at 0220Z and SHRIMP was inboard again at 0310Z.

The ship then headed back down canyon for another phototransect between 1700 and 2500m. SHRIMP was shot at 0502Z and reached the bottom at 1595m at 0610Z. A long photo and video transect was conducted downslope. Mostly it showed very few epifauna and lebenspurren, but towards the end of the transect the camera crossed two sharp drops in depth descending about 450m in 15 minutes. The incline on the other side of the thalweg appeared to be even more severe, so as soon as the depth started to rise quickly, the transect was stopped and SHRIMP was hauled in, arriving on deck at 1308Z.

The ship then headed down slope back to the 3500m coring site, dropping off the Amphipod Trap (St. 56855#1) at 3482m on the way at 1424Z.

A series of three Megacorer samples were then made at 1643Z, 2010Z and 2340Z (Stas. 56856#1, #2, #3), completing the work for macrofauna (4 samples) and meiofauna at this site.

Friday 12 May
An Agassiz Trawl (in dredge mode with a clump weight ahead of the net) was fished, starting the deployment at 0200Z (St. 56857#1). The net was fished with some difficulty as it was very hard to distinguish the pinger and bottom signals. It was likely to have taken a sample between 3334 and 3385m (0328 to 0359Z), long enough to collect a large bag of mud which was only just recovered on deck (0603Z) because most of it had ripped from the trawl frame. The bag of mud yielded a good catch, mostly molpadiid holothurians, and assisted the molecular biology studies by keeping the animals well insulated at deep-sea temperatures.

A CTD/SAPS was then deployed (St 56858#1) within the central part of the canyon thalweg, as identified by the earlier SHRIMP deployment at this site, at 0742Z. The CTD arrived at a depth of 3580m (measured as wire out), and within 10m of the seabed, to start pumping for two hours at 0930Z, and was recovered on deck at 1307Z. Following this the Amphipod Trap was recovered (St. 56855#1). This concluded the work at the 3500m middle canyon site and the ship then steamed for deeper water and the lower canyon at 1500Z.

Once back at the 4400m site three Megacorers were deployed back-to-back in hopes of completing the sampling programme at this depth for the macrofauna, meiofauna and sediment chemistry studies. Moderate success was achieved with the first core drop (St. 56859#1; 1919Z), but the next two were very poor (Stas. 56859#2, #3; 2329Z and 0335Z 13 May 2006).

Saturday 13 May
The ship then repositioned for a SHRIMP transect running obliquely through the canyon thalweg at about 4400m. SHRIMP was shot at 0630Z (St. 56860#1). Problems were experienced with the altimeter reading once again, and just as the system got within 150m of the seabed (based on the sounding and wire out; 4214m) there was an electrical short and all power was lost. The mission was aborted at 0912Z and SHRIMP was back on deck at 1135Z. Water had ingressed at the termination. The connection had a change of oil and SHRIMP was shot for the second time at 1331Z (St. 56860#2). SHRIMP arrived on the seabed (4290m) at 1608Z and passed over many varied types of seabed fabric in the course of its passage through the thalweg and the canyon valley floor ending up in terrain very similar to that in which we had been coring. The stills camera had been switched off for a period during the tow to allow us to get a good sequence of photographs of the coring ground, and when the stills camera finally ran out of film at 2019Z (4359m) SHRIMP was finally hauled in arriving on deck at 2256Z.

An assessment was then made of the prevailing surface current and ship's potential homeward speed in order to get a good idea of how long the passage to Falmouth would take. It was decided that there was time for two more Megacorers in order to get a good set of samples for the macrofauna studies that would allow good statistical comparisons to be made between the various Portuguese margin canyons and open slopes.

Sunday 14 May
The two corer deployments (Stas. 56861#1, #2) took samples at 0157Z and 0545Z, the latter taking a good set of samples. The corer was finally inboard at 0718Z and the

ship made for Falmouth. A celebratory BBQ and RPC was held on deck in the evening.

Monday 15 May.
Passage north, clearing up and packing. A science meeting was held to review the work on the cruise at 1600H followed by a G&T in the bar and a special Portuguese evening meal cooked by Xana da Silva and Teresa Amaro, aided by the galley staff.

Tuesday 16 May.
Further packing and cruise report writing and PS and Deputy PS celebration of the penultimate scientific cruise on RRS *Charles Darwin*. The ship was due to be sold to a commercial company for work in support of the offshore oil and gas industry in June 2006.

Wednesday 17 May
Docked in Falmouth at the end of the cruise, rather fittingly for it was here that Charles Darwin left HMS *Beagle* one hundred and seventy years earlier on 2 October 1836.

All in all this had been a successful cruise with a good deal of knowledge gained for the targeted ISIS ROV cruise to the Portuguese Margin in 2007. The Lisbon, Setúbal, Cascais and Nazaré canyons had all been sampled in a consistent way and at similar depths. Swath bathymetry charts and sidescan sonar images had guided the biological sampling and the seabed photo-transects intended for mapping the distribution of fauna in the canyons probably ended up being more useful for determining geological and sedimentological processes. All participants ended up with a much better feel for what canyon life must be like, although there is a great need for long-term, real-time monitoring observatories in order to study the timing, duration and magnitude of the large-scale, episodic processes that regulate the canyons. Many of these it would appear occur in the winter months and are related to storms. A good set of samples were also taken of suspended particulate material in all the canyons which will help to determine if there are any radical differences between the canyons, at least in summer months. High abundances of megafauna and macrofauna were once again evident in the middle canyon, and many xenophyophores (giant protozoans) were evident in the lower canyon, but not within the thalweg. Necrophage amphipods also appeared to be particularly active in the lower canyon. The piston cores taken in the Setúbal Canyon produced some interesting cores of graded sediments in debris flows and turbidites, the most striking being a core of pebbles decreasing in size and ending up with gravel and sand at the top.

The cruise worked exceptionally well thanks to a large extent to the support of the National Oceanography Centre's NMFD (National Marine Facilities Division) Master, officers, engineers and crew. Excellent station keeping allowed core samples to be taken within a small radius and for the SHRIMP photo-transects to follow predetermined tracks to view specific seafloor features. Problems with the technology were quickly sorted, particularly in relation to the temperamental SHRIMP (Seabed High Resolution Imaging System). Of the 14 scientists that participated on the cruise, no less than eight were PhD students, and so I was particularly grateful to the experienced hands on the cruise that allowed the work to proceed efficiently and safely. A good set of samples and observations was achieved.

SCIENCE REPORTS

1. TOBI

A single 50 hr TOBI run was carried out along the axes of the Lisbon and Cascais Canyons, followed by a short run along the lower continental slope towards the southwest crossing the lower part of the Setúbal Canyon. The aim was to identify 1) active downslope sediment transport pathways within the canyons, and 2) areas of sediment instability on the steep continental slope. A sharp change in geometry was observed between Lisbon and Cascais Canyons. Whereas the Lisbon Canyon displayed a narrow and relatively sinuous channel with a prominent meander in the middle section, the Cascais Canyon appeared to be composed of three smaller, straighter and more V-shaped channels lying adjacent to each other and leading into a flat depositional plain that then continued as a single broader channel. The most distal part of the Cascais Canyon displayed large-scale furrows and landslide blocks with comet marks, as had also been observed in the coverage obtained during RRS *Discovery* cruise 297 (July 2005).

Raquel Arzola, Veerle Huvenne, Doug Masson

2. PISTON CORING

Nine successful piston cores (from 11 attempts) were obtained, three from Cascais Canyon and six from Setúbal Canyon. Four cores in the Setúbal Canyon targeted terraces at depths that corresponded with piston cores taken in the Nazaré Canyon during RRS *Discovery* cruise 297. These were used to compare the sedimentary processes at equivalent depths in the two canyons. The Setúbal Canyon cores were very varied. Cores 56822#1 and 56843#1, at 3144m and 4300m respectively, displayed long sequences of stacked turbidites overlain by a thick layer of recent mud. These were the type of deposits we expected to recover at the sites and compared well with the equivalent deposits in Nazaré Canyon. However, the other two cores were not as expected. Core 56825#1, at 3788m, contained an entirely muddy sequence composed of alternating turbiditic and hemipelagic mud with minor silt, suggesting bypass of coarse material, even though the location of this core was a shallow terrace on the outside of a bend. Core 56826#1, at 4033m, contained an unusual clayey debris flow even though the sidescan sonar image showed no indications of such a facies on this particular terrace. The preliminary interpretation is that this is a small and localised debris flow. A core attempted on the opposite flank of the channel (at 4253m, St. 56840#1), with the intention of sampling a clear landslide deposit, failed owing to the loss of the core cutter. However, the outside of the core barrel showed evidence for about 5m of penetration through soft mud, presumably overlying coarse debris that destroyed the core catcher.

Two additional piston cores were shot in the distal part of Setúbal Canyon. Core 56844#1, at 4540m depth, targeted a linear bedform from a group oriented perpendicular to the channel, and returned a stunning graded gravel deposit overlain by a relatively thick mud layer. The fact that the gravel was graded indicates that it was transported in a turbidity current rather than in a landslide, and implies that the linear features are gravel waves. The smoothness and roundness of the individual

pebbles and cobbles point to a fluvial (or coastal?) origin, further confirming this interpretation. Core 56845#1, at 4785m, was shot in an area of alternating high and low backscatter "stripes" further downslope. It sampled a graded gravel also, but completely different in colour and lithology and of a smaller grain size compared to the previous core. It may suggest that the alternating high and low backscatter "stripes" also indicate gravel waves.

The three cores taken from Cascais Canyon were taken in order to ground-truth the recently collected TOBI data. Core 56830#1, at 2538m, was shot in a relatively flat area where the three upper channels joined together, and displayed stacked turbidites with a thin layer of recent mud on top. Further downslope, core 56820#1, at 3204m, was collected from a terrace on the outside of a bend in the channel, and sampled a muddy sequence with only minor silt, suggesting sediment bypass. Core 56837#4, at 4210m, was obtained from a dark backscatter patch in the distal section of the canyon, immediately adjacent to the area of landslide blocks with comet marks. This core showed a clear transition from thick and infrequent sandy layers to thin and much more frequent silty layers towards the top, suggesting an important change in the sedimentary transport regime over time. It also contained a small debris flow deposit at the top of the turbidite stack, confirming the interpretation of the recent erosional nature of this area.

Raquel Arzola, Veerle Huvenne, Doug Masson

3. SWATH BATHYMETRY SURVEYS

Two swath bathymetry surveys were carried out using the Kongsberg Simrad EM12 high-resolution 13 kHz multibeam echo sounding system. Eighty one beams make up the total beam width (between 1.8 and 3.5°). The swath width is up to 3.5 times the water depth, which can be surveyed accurately from 50 to 11000m water depth. Under ideal conditions, this accuracy can be up to 50-60 cm or 0.25 % of the total depth.

No calibration was carried out, but an initial sound velocity profile was entered at the start of the survey and remained unchanged. This profile was obtained from a combination of CTD and XBT data. The swath bathymetry was logged continuously during the entire cruise using Mermaid software and displayed in real-time using Merlin software.

The first swath bathymetry survey (St. 56802#1) was undertaken on the upper continental slope to determine in greater detail the positions and forms of the upper channels in the Lisbon and Cascais canyons. The second survey (St. 56814#1) was carried out during a period of bad weather around the shelf break between the Lisbon and Cascais canyon heads. The results of the surveys were consistent with what was expected and with the TOBI images and a 3D flythrough of the upper Lisbon and Cascais canyons was produced.

Raquel Arzola, Veerle Huvenne, Doug Masson

4. CTD and STAND ALONE PUMP SYSTEM (SAPS)

A total of 16 CTD casts were completed on the cruise, with the following sensor configuration:

Sea-Bird 9*plus* underwater unit, s/n 09P-31240-0720
Sea-Bird 3P Premium temperature sensor, s/n 03P-4105 (Frequency 0)
Sea-Bird 4C conductivity sensor, s/n 04C-3052 (Frequency 1)
Digiquartz temperature compensated pressure sensor, s/n 90573 (Frequency 2)
Sea-Bird 3P Premium temperature sensor, s/n 03P-4151 (Frequency 3)
Sea-Bird 4C conductivity sensor, s/n 04C-2571 (Frequency 4)
Sea-Bird 5T submersible pump, s/n 05T-2279 (Primary)
Sea-Bird 5T submersible pump, s/n 05T-2793 (Secondary)
Benthos PSA-916T 7Hz altimeter, s/n 874 (V2)
Chelsea Aquatracka MKIII fluorometer, s/n 088242 (V3)
WETLabs Light Scattering sensor, s/n BBRTD-183 (V6)
Chelsea Alphatracka MKII transmissometer, s/n 161048 (V7)
Sea-Bird 11*plus* deck unit, s/n 11P-22559-0532

Ancillary instruments & components:

Sea-Bird 32 Carousel, 24-position, s/n 32-19817-0243
NOC/SBE 'BreakOut Box', s/n BO19110
NOC 10KHz acoustic pinger, s/n B10
4 x General Oceanics10L ES Niskin bottles, s/n 06, 08, 18, 20
Challenger Oceanic Stand Alone Pump, s/n 03-03

CTD analysis & changes to configuration:

Episodic full-scale spikes were evident on the primary temperature sensor channel (Frequency 0) on casts 002 (St. 56804#2) and 011 (St. 56815#1). The cable was replaced prior to cast 013 (St. 56834#1). Carousel position number eight did not release on casts 004 (St. 56805#2) and 005 (St. 56805#3). On-deck testing revealed no problems with the firing mechanism; the lanyard tension was lessened by 2 kgs and no further closing errors were observed.

Stand Alone Pump System (SAPS)

One SAPS module was attached to the 12-way CTD frame, a configuration that worked well throughout the cruise, allowing SAPS pumping to be undertaken close to the seabed with confidence and accuracy using the CTD altimeter. The aim in many deployments was to pump for extended periods in the central channel and deepest parts of the canyon systems, often in areas with steep terrain. The CTD altimeter provided a very useful way of monitoring the position of the SAPS and providing physical oceanographic information at the same time. However, at one station, at the head of the Setúbal Canyon, where there was a lot of fishing activity, the SAP was deployed on the coring wire in order to avoid any potential problems of entangling the CTD in discarded fishing tackle on the seabed (St 56805#3).

Sixteen SAP deployments were made. As far as possible samples were taken at comparable depths in the Setúbal, Lisbon, Cascais and Nazaré Canyons in order to compare differences in the chemistry of material being transported down the canyons. Samples were taken 5 to 10m above the seabed. At the shallowest depths in each case, close to the canyon heads, a surface sample was also taken in the chlorophyll maximum (chl. max). In the Setúbal canyon, samples were taken at 4540, 3270, 1406 and 328m, with a chl. max sample (30m). In the Lisbon Canyon samples were taken at 1130 and 390m, with a chl. max sample (12m). In the Cascais Canyon the depths were 3210, 1462, 684 and 10m (chl max) and in the Nazaré Canyon, 3520, 1152, 726 and 40m (chl. max).

Pumping times varied between 18 minutes and 2.5 hours, depending on water depth. SAP s/n 03-03 was replaced with s/n 03-05 on CTD cast 005 (St. 56805#3) to enable battery re-charging. One SAPS was deployed on the core warp rather than the CTD frame (St. 56805#3). A new cage arrangement was used to carry the SAPS, and had a 90 kg weight attached to the bottom bar.

Jeff Benson, Terry Edwards, David Billett, Veerle Huvenne, Sarah Murty

5. SHRIMP (SEABED HIGH RESOLUTION IMAGING PLATFORM)

Sixteen stations were sampled successfully by SHRIMP; seven in the Setúbal canyon, three in the Lisbon canyon, one in the Cascais canyon and five in the Nazaré Canyon. At all but one station (56807#1) still photographs were taken, making fifteen rolls of film in total , of which one (56813#1 – 43 frames) was very short owing to an early abort of the run.

Video footage was collected at all stations from both the forward-looking and downward-looking video cameras. Video was also recorded at stations 56818#1-56838#1 from the wide-angle SIT camera onto Hi-8 video and in the case of 56838#1, onto DVD. After station 56838#1 the SIT camera could no longer be used owing to problems with the conducting cable.

Site Descriptions. (Main megafauna, bioturbation and geology)

Setúbal Canyon:

Station 56809#1: 350-779m
Many burrows, small mounds and many fish, including *Chimaera* sp. and other small dogfish, were observed, as well as some asteroids, holothurians and prawns. From c.460-761m, the bioturbation increased, as did the abundances of *Chimaera* sp. and dogfish. Brisingid asteroids were also present. The current appeared to be faster here, causing some resuspension. From c.761-708m, last part of the run, bioturbation was reduced, and the sediment appeared harder, with some gravel and rocks, some of which were colonised with brisingid asteroids and crinoids.

Station 56808#1: 399-1003m
Many burrows were seen in the relatively soft sediment, with some rocks or sediment; and some gravel also visible. Some of the rocks were colonised by stalked crinoids,

but the majority were totally bare. The most abundant fauna were fish, including *Coryphaenoides* sp., *Trachyrhynchus* sp., *Lophius piscatorus* and many *Synaphobranchus* sp. Also present were what appeared to be tubular sponges.

Station 56807#4: 1018-1500m
At this station the sediment was soft, with more burrows, mounds and track marks than the two stations described above. Between 1095-1209m, the most common fauna were cerianthid anemones. Brisingid asteroids, tubular sponges and other anemones were also present. *Synaphobranchus* sp. and *Coryphaenoides* sp. were also common here.

The floor of the canyon dropped away steeply at c.1200m into the thalweg, exposing a rock outcrop colonised by soft corals and sponges. At the bottom of the ledge, were more rocks, pebbles and coarse sediment. *Synaphobranchus* sp. eels were dominant and not much else was present. Below c.1400m holothurians were seen, and the rocks were colonised by soft corals and brisingid asteroids.

Station 56831#1: 1500-2200m
Between 1500-c.1560m the sediment was soft with few burrows or epifauna, except for high numbers of eels (*Synaphobranchus* sp.). Burrow density increased, as did the number of tracks between c.1560-1800m. Eels were still the most common fauna. Three different species of asteroid were seen as well as many ophiuroids. Burrows increased in size between c.1800-c.2000m, and stalked sponges were present in high abundances. The occasional boulder here was covered by brisingid asteroids. Between c.2000-c.2200m the sediment was harder and burrow density much reduced. Some large, pale holothurians were present.

Station 56804#4: 2861-3210m
The sediment here was soft with a pitted surface and fine “hairs” poking out of the sediment, which could be polychaetes. Ripples were visible on the sediment just as the floor of the canyon dropped away steeply. As the floor flattened out, burrow density increased, though there was still not much epifauna. Epifauna present included a few crinoids or brisingid asteroids on a rock, the holothurian *Benthodytes* sp. and cerianthid anemones and ophiuroids.

Station 56838#1: 4402-4498m
Umbellula sp. (pennatulid) was the most common megafauna present at this station, where the sediment was hard with a softer top layer. Large ophiuroids, swimming holothurians and two species of anemones were also noted. Few fish were observed; those seen included *Coryphaenoides* sp., eels and an unknown fish. The fauna and sediment remained the same throughout the two hour transect.

Lisbon Canyon:

Station 56813#1: 661-850m
SHRIMP reached the seabed before the planned starting position of the photographic survey. The area was very steep and rocky. SHRIMP was forced upslope against a cliff face upon which possibly *Lophelia* sp. and brisingid asteroids were observed. Most of the rock was totally bare however. On the flat sediment there were some

burrows and also “y”-shaped organisms – possibly echiurans out of their burrows. Lots of small white fauna, which could be either anemones or small sponges. Large oysters and some coral were recovered from the top of the SHRIMP system on its return to the ship.

Station 56835#1: 770-1175
Between 770-c.956m, the sediment was soft and fairly bioturbated. Cerianthid anemones and asteroids seemed to be the most common fauna, although the small white organisms were observed – anemones or small sponges. Several cidarid echinoids were seen, as well as *Plesiopenaeus* sp., *Coryphaenoides* sp., and possibly *Trachyscorpio* sp. Between c.956-c.1175m, there were fewer burrows in the still soft sediment. Some stalked crinoids and pale holothurians were observed as well as some small white anemones/sponges.

The transect after 1175m got shallower, and between 1175-c.1126m many eels were observed, as well as the continued presence of asteroids. Burrow density, however, remained low. Two large holothurians (*Benthodytes* sp.?) were also seen. SHRIMP was hauled up away from the seabed and “crabbed” to a bend in the canyon further down It was then lowered down for the last part of the transect, which rejoined a point on the original transect. In this section turbidity was very high and it was hard to see the seafloor.

Station 56832#1: 1706-2029m
Throughout this transect (positioned where the Lisbon and Setúbal canyons join), the sediment was soft with few burrows occurring deeper than c.1255m. Pennatulids were seen, including an *Umbellula* sp. type and a *Pennatula* sp. type. Stalked sponges, cerianthid anemones and eels, and a couple of holothurians were also seen.

Cascais Canyon:

Station 56818#1: 3067-3479m
The sediment at this station was soft, and covered the large boulders that were present with a thin sediment drape. There were ripples present, and few burrows. There were the small white anemones/sponges present that have been seen at many of the stations above, as well as some asteroids, ophiuroids, stalked sponges and fish, including *Coryphaenoides* sp. and *Synaphobranchus* sp. Deeper than c.3379m the abundance of stalked sponges increased, as well as burrow density. Echinoids, pennatulids and large holothurians (*Benthodytes* sp.?) also appeared below this depth.

Nazaré Canyon:

Station 56853#1 and 56853#2: 583-1120m
This transect was composed of a series of terraces, between which were stretches of steep rock ledges or less steep rocky slopes. The fauna on the flat sedimented areas included cerianthid anemones (larger species than previously seen), asteroids, few holothurians, eels and other fish. Bioturbation was relatively high. The rocky ledges did not support much epifauna, though there were two patches of high abundances of brisingid asteroids and small white anemones. Brisingid asteroids were also seen in a

patch on the flat sediment, possibly two different species. On some of the ledges burrows could be seen in the thin layer of sediment covering the rock. Few fish were noted at this station.

Station 56854#1: 1549-2693m
The sediment here was relatively soft with many burrows. The beginning of the transect (to c.1999m) was densely populated by holothurians, and ophiuroids, asteroids and anemones. Many *Synaphobranchus* sp. eels and other fish were also present. Density of all fauna, and burrows, decreased from this point through the rest of the transect. Ripples were more common deeper, becoming deep, sharp-crested and symmetrical in form suggesting the presence of a relatively fast bi-directional current. At the end of the transect, rock ledges could be seen, which are thought to be the far side of the channel.

Station 56852#1: 3460-3600m
During the first part of this transect (3460-3600m) high densities of large ophiuroids were observed, along with a few large, round, purple echinoids. Clusters of small burrows were noted (*Ypsilothuria* sp. burrows?), as well as polychaetes tubes. Ripples were present throughout, and became more and more pronounced. At the end of the first part of the transect the ground fell away steeply over a scarp, on which gullies and rills could be seen. Exposed outcrop were seen occasionally, colonised by small fauna, red in colour, possibly the sea anemone *Anthomastus* sp. This central part of the transect was probably in the canyon thalweg. Here, the ripples were lunate-type and asymmetrical, suggesting a uni-directional current. No fauna were seen in this section. At the other side of the thalweg rocks were seen colonised by the small red *Anthomastus* sp.? sea anemone and the stalked crinoid *Anachalypsicrinus* sp. Ophiuroids reappeared and increased in numbers, and a couple of gorgonian fans were also seen.

Station 56860#2: 4290- 4359m
The transect ran over what is thought to be a fairly recent landslide deposit on the edge of the channel. The rocks were not colonised by epifauna, and were not black with manganese. In the thalweg, close to the edge, some pennatulids (*Umbellula* sp.) and cerianthid anemones were seen, a tripod fish and some burrows.

There appeared to be large-scale waves (gravel waves covered by sediment?), with a long wavelength and short height. At the crest of the waves, small scale ripples were seen, which became less defined as the trough was approached. In the trough small rocks were seen. Megafauna were very scarce and the occasional fish was noted.

Around the bigger rocks, erosional scours could be seen, which appeared to be symmetrical at the start of the transect, but uni-directional towards the end. At the other side of the thalweg, megafauna reappeared; small black fauna, possibly anemones, appeared first, followed by several swimming holothurians, porcellanasterid asteroids and *Umbellula* sp. Xenophyophores were also present in quite high abundances.

Abigail Pattenden, Doug Masson, David Billett

6. BOX CORING and MEGACORING

Sampling for macrofauna

Box corer

One USNEL box corer (0.25m^2 box) was used for macrofauna analysis (Table 1). The sediment was very fine presenting a smooth surface and the overlying water was clear. This may have indicated little disturbance of the sample, but the core (51cm high) was very close to the top of the box and it is likely much of the fauna in the top layer had been lost. There were a large numbers of polychaetes tubes visible on the surface. Part of the sample was sub-sampled with a cylindrical corer (7 cm diameter) for geology.

The upper 15 cm of the sediment were sampled in five layers, 0-1, 1-3, 3-5, 5-10 and 10-15 cm. The sediment layers 0-1 and 1-3 cm were placed immediately in formalin, prior to sieving. Each sediment layer was carefully washed trough 300 and 500µm sieves including the overlying water (with the 0-1cm layer). The sieved material was fixed immediately in 10 % buffered formalin in seawater.

Table 1. Station data for the Box-corer carried out in the Setúbal Canyon during the RRS Charles Darwin cruise CD 179.

Box-Corer						
Station	**Latitude (N)**	**Longitude (W)**	**Depth (m)**	**Date**	**Sediment Layer (cm)**	**Sediment Height (cm)**
56804 #3	38º09.26	09º36.95	3275	20-04-2006	15	51

Megacorer

Six stations from each of two depths (ca.3200 and ca.4300 m) were sampled for macrofauna in the Setúbal, Cascais and Nazaré canyons (Table 2) using a Megacorer (multiple cylindrical cores of 10 cm internal diameter). At each station, 4 to 5 replicates were sampled. A total of 35 Megacorers were taken. 27 Megacorers were used for studying macrofauna diversity and 7 for molecular analyses. They were in general very good samples; all the tubes had penetrated the sediment and had clear overlying water (not disturbed).

The upper 20 cms of the sediment were sampled in six sediment layers, 0-1, 1-3, 3-5, 5-10, 10-15 and 15-20 cm. However, in a number of sites, just the upper 10 cms were sampled (Table 2) for macrofaunal biodiversity, and the upper 1-5 cm for molecular samples. When the sediment >10 cm depth was not sieved, it was examined carefully for larger fauna *i.e.* burrowing holothurians. Various Foraminifera were picked off from the sediment surface using a forceps.

The sediment layers samples 0-1 and 1-3 cm were placed immediately in formalin, prior to sieving. Each sediment layer was carefully washed with seawater through 300 and 500µm sieves, including the overlying water with the 0-1cm sample. The sieved material was fixed immediately in 10% buffered formalin in seawater. The samples used for molecular analysis were washed, sieved (500µm) and stored in ethanol 96%.

Table 2. List of the station data for the Megacorers carried out in the Cascais, Setúbal and Nazaré canyons.

Setúbal & Cascais Canyons						
Station	**Latitude (N)**	**Longitude (W)**	**Depth (m)**	**Date**	**No. of sub cores**	**Depth sampled (cm)**
56804 #5	38º09.27	09º36.93	3275	21-04-2006	8	20
56804 #6	38º09.26	09º36.94	3275	21-04-2006	8	20
56806 #1	38º09.29	09º36.96	3275	21-04-2006	8	20
56810 #1	38º09.22	09º37.02	3224	23-04-2006	8	15
56816 #1	38º09.27	09º36.94	3275	25-04-2006	8	20
56821 #1	38º17.96	09º46.87	3219	26-04-2006	8	20
56821 #2	38º17.97	09º46.89	3214	27-04-2006	8	20
56823 #2	38º18.01	09º47.02	3218	27-04-2006	8	20
56823 #3	38º17.99	09º47.07	3219	28-04-2006	7	20
56828 #1	38º18.02	09º46.98	3199	29-04-2006	8	20
56837 #2	38º22.49	09º53.40	4245	02-05-2006	8	15
56837 #5	38º22.50	09º53.48	4241	02-05-2006	8	15
56837 #7	38º22.49	09º53.52	4243	03-05-2006	8	20
56837 #8	38º22.49	09º53.52	4244	03-05-2006	8	15
56838 #2	38º06.50	09º59.98	4482	03-05-2006	8	15
56838 #3	38º06.49	09º59.94	4482	04-05-2006	8	15
56838 #4	38º06.52	09º59.99	4485	04-05-2006	7	10
56842 #1	38º06.45	09º59.94	4482	05-05-2006	8	10
56842 #2	38º06.49	09º59.97	4485	05-05-2006	8	5
Nazaré Canyon						
Station	**Latitude (N)**	**Longitude (W)**	**Depth (m)**	**Date**	**No. of sub cores**	**Sediment Sampled (cm)**
56851 #1	39º29.99	09º55.97	3517	09-05-2006	8	10
56851 #2	39º29.99	09º56.01	3517	09-05-2006	8	10
56856 #1	39º29.95	09º56.00	3519	11-05-2006	5	10
56856 #2	39º30.00	09º55.98	3522	11-05-2006	7	10
56847 #6	39º35.57	10º19.99	4403	08-05-2006	8	10
56847 #7	39º35.55	10º20.06	4404	08-05-2006	7	10
56859 #1	39º35.58	10º20.00	4418	12-05-2006	7	10
56861 #1	39º35.57	10º20.02	4404	14-05-2006	6	10
56861 #2	39º35.58	10º20.02	4403	14-05-2006	6	10
Molecular Analysis						
Station	**Latitude (N)**	**Longitude (W)**	**Depth (m)**	**Date**	**No. of sub cores**	**Sediment Sampled (cm)**
56806 #2	38º09.25	09º 36.82	3275	22-04-2006	6	5
56816 #2	38º09.35	09º36.97	3285	25-04-2006	4	5
56823 #1	38º17.97	09º46.99	3224	27-04-2006	3	3
56837 #3	38º22.48	09º53.46	4240	02-05-2006	1	1
56837 #6	38º22.53	09º53.48	4239	02-05-2006	2	1
56847 #4	39º35.62	10º19.98	4406	07-05-2006	1	1
56847 #7	39º35.55	10º20.06	4404	08-05-2006	1	1

Dário Mendes Alves

Sampling for meiofaunal metazoa and environmental variables

During the cruise 3 replicate multicores (60 mm inner diameter) were collected from each site for metazoan meiofaunal research (Table 3). The only exception was for the Setúbal deep station where only 2 replicates were taken. The sediment within the cores was extruded and sliced in layers to investigate community variability with sediment depth: 0-1, 1-2, 2-3, 3-4, 4-5, 5-10 and 10-15 cm when available. The slices were washed down into 250mL and 500mL bottles and fixed with 10% formalin, buffered with Borax, to obtain a final formalin concentration of about 5%. When no multicores were available, owing to coring failure or sampling priorities, the option was taken to subsample a megacore tube (100mm inner diameter) with a multicore tube to obtain the needed replicates (this also created the opportunity to sub-sample with a syringe around the multicore tube for environmental variables). This way we maintained consistency in the number of replicates among the sampling areas and avoided having to deal with sample size variability, an important bias when it comes down to diversity and small scale community structure variability.

The metazoan meiofauna samples will be rinsed over 1000 and 32 μm mesh-sieves in the laboratory (University of Ghent). Following a standard protocol, the samples will be resuspended and centrifuged with the colloidal silica gel LUDOX HS 40% to separate the meiofaunal organisms from the surrounding sediment. After staining with Rose Bengal, all metazoan meiobenthic organisms will then be classified at higher taxon level and counted under a stereoscopic microscope. Nematodes will be picked out and transferred over an alcohol-glycerine solution to glycerine and mounted on glass slides. Nematodes will be identified to genus/species level using relevant literature and reference drawings in the Ghent University nematode library and NeMys database (Deprez et al., 2005).

For purposes of obtaining environmental data a minimum of 3 replicate mega- or multicores (Table 3) were sliced (0-1, 1-2, 2-3, 3-4, 4-5, 5-10 cm) with the exception of the Cascais Canyon mid station where only 2 replicates were possible. The one centimetre slices cm slices were placed in Petri dishes and wrapped in aluminium foil for storage at -20°C. When time permitted, small subsamples of the slices were placed in small oscillation bottles to ease the process of analysis in the laboratory. The samples will be used for CPE (Chlorophyll a and pigment breakdown products), grain-size and C/N ratio/content analyses. Additional samples were taken for natural stable isotope analyses (^{13}C and possibly ^{15}N) and backup material for molecular work. For purposes of obtaining fatty acid data on the sediment, 3 replicate megacores (Table 4) were taken at each station. A small sample of the sediment was stored at –80^{o}C.

Table 3. Overview of the metazoan meiofauna and environmental variables samples.

Station	Site	Core	Date	Depth (m)	Analysis	Storage
56804#6	Setúbal mid	MC 8	21.IV.06	3275	Faunal	formalin
56806#1	Setúbal mid	MC 2	21.IV.06	3275	Environ. var. & isot.	-20°
56806#1	Setúbal mid	MC 6	21.IV.06	3275	Faunal	formalin
56810#1	Setúbal mid	MC2	23.IV.06	3224	Faunal	formalin
56810#1	Setúbal mid	MC5	23.IV.06	3224	Environ. var. & isot.	-20°
56816#2	Setúbal mid	MC 1	25.IV.06	3285	Environ. var. & isot.	-20°
56816#2	Setúbal mid	MC 5	25.IV.06	3285	Molecular	-20°
56816#2	Setúbal mid	MC 2	25.IV.06	3285	Molecular	-20°
56821#2	Cascais mid	MC 2	27.IV.06	3214	Faunal	formalin
56821#2	Cascais mid	MC 5	27.IV.06	3214	Environ. var. & isot.	-20°
56823#2	Cascais mid	MC 11	27.IV.06	3218	Faunal	formalin
56836#1	Cascais mid	MG 2	01.V.06	3209	Environ. var. & isot.	-20°
56836#1	Cascais mid	MC 1	01.V.06	3209	Faunal	formalin
56836#1	Cascais mid	MG 4	01.V.06	3209	Environ. var. & isot.	-20°
56837#3	Setúbal deep	MG 1	02.V.06	4240	Environ. var. & isot.	-20°
56837#3	Setúbal deep	MC2	02.V.06	4240	Environ. Var. & isot.	-20°
56837#5	Setúbal deep	MC 8	02.V.06	4241	Faunal	formalin
56837#8	Setúbal deep	MG 5	03.V.06	4244	Faunal/Environ. var. & isot.*	formalin/ -20°
56838#2	Cascais deep	MG 2	03.V.06	4482	Faunal/Environ. var. & isot.*	formalin/ -20°
56838#3	Cascais deep	MC 2	04.V.06	4482	Faunal/Environ. var. & isot.*	formalin/ -20°
56838#3	Cascais deep	MC 11	04.V.06	4482	Faunal	formalin
56838#4	Cascais deep	MC 8	04.V.06	4485	Faunal	formalin
56842#1	Cascais deep	MG 7	05.V.06	4482	Faunal/Environ. var. & isot.*	formalin/ -20°
56842#1	Cascais deep	MC 11	05.V.06	4482	Faunal	formalin
56847#3	Nazaré deep	MG 3	07.V.06	4397	Faunal/Environ. var. & isot.*	formalin/ -20°
56847#4	Nazaré deep	MC2	07.V.06	4406	Environ. var. & isot.	-20°
56847#6	Nazaré deep	MC2	08.V.06	4403	Faunal	formalin
56848#1	Nazaré mid	MG9	08.V.06	3517	Environ. var. & isot.	-20°
56848#1	Nazaré mid	MC8	08.V.06	3517	Faunal	formalin
56848#3	Nazaré mid	MG12	09.V.06	3512	Environ. var. & isot.	-20°
56848#3	Nazaré mid	MC2	09.V.06	3512	Faunal	formalin
56851#1	Nazaré mid	MC2	09.V.06	3517	Faunal	formalin
56856#1	Nazaré mid	MC2	11.V.06	3519	Environ. var. & isot.	-20°
56856#2	Nazaré mid	MC11	11.V.06	3522	Faunal	formalin
56856#3	Nazaré mid	MG9	11.V.06	3517	Molecular	-20°
56856#3	Nazaré mid	MC6	11.V.06	3517	Molecular	-20°
56859#1	Nazaré deep	MC2	12.V.06	4418	Faunal	formalin
56859#1	Nazaré deep	MC8	12.V.06	4418	Environ. var. & isot.	-20°
56859#2	Nazaré deep	MG3	12.V.06	4405	Molecular	-20°

***Sub-sampling of megacore with multicore tube for faunal purposes and with a syringe for environmental variables**

Table 4. Overview of the samples collected for fatty acids work.

Station	Equipment	Date	Depth (ucm)	Latitude N	Longitude W
56804#5	Mega 12	21.IV.2006	3275	38.09.27	09.36.93
56804#6	Mega 10+2	21.IV.2006	3275	38.09.26	09.36.94
56806#1	Mega 9+3	21.IV.2006	3275	38.09.29	09.36.96
56816#1	Mega 9+3	25.IV.2006	3275	38.09.27	09.36.94
56821#1	Mega12	26.IV.2006	3219	38.17.96	09.46.87
56823#2	Mega 9+3	27.IV.2006	3218	38.18.01	09.47.02
56823#3	Mega 9+3	28.IV.2006	3219	38.17.99	09.47.07
56848#2	Mega 9+3	08.V.2006	3523	39.30.00	09.56.00
56848#3	Mega 9+3	09.V.2006	3512	39.29.99	09.56.05
56851#3	Mega 9+3	10.V.2006	3522	39.29.95	09.56.02
56856#3	Mega 6+6	11.V.2006	3517	39.29.98	09.56.00
56859#1	Mega 9+3	12.V.2006	4418	39.35.58	10.20.00
56859#2	Mega 9+3	12.V.2006	4405	39.35.59	10.20.00
56859#3	Mega 12	13.V.2006	4405	39.35.57	10.19.99

A comprehensive set of samples have now been collected during this cruise and RRS *Discovery* cruise 297 (July 2005) for the study of meiofauna within the deeper parts of the Nazaré, Setúbal and Cascais canyons. This will also allow comparisons to be made between canyons. For the Nazaré Canyon samples were also taken at the same stations in two consecutive years (2005-2006) which will be useful in investigating temporal variability in the metazoan meiofauna at a community and/or biodiversity level.

Jeroen Ingels, Teresa Amaro

Sampling for protozoan meiofauna

The protocol used for protozoan meiofauna required one megacore and three multicores from each of three different deployments from each site. Six stations were sampled in total; 3200m and 4300m in the Nazaré, Cascais and Setúbal Canyons.

Megacorer samples for molecular analyses: The megacore was used to collect bulk material for post-molecular analysis. The core was sorted on board. Most of the supernatant water was discarded by lowering the core in the plunger. The remaining surface water was removed with a syringe and transferred to a plastic box container. A pipette was then used to sample the sediment surface before the 0-1 cm layer was cut into the plastic box. The sample was kept in a fridge for sorting onboard as soon as possible. Samples were wet sorted on ice using a Leica microscope. Specimens were hand picked into cryovials that frozen in liquid Nitrogen. The samples will be used for molecular analyses.

Multicore samples for faunal studies: The multicores from each site were sliced at 0-0.5, 0.5-1.0, 1.0-1.5, 1.5-2.0, 2-3, 3-4, 4-5, 5-6, 6-7, 7-8, 8-9 and 9-10 cm. A cutting ring was used to support the upper layers of soupy sediment. This was placed on top of multicore tube, which had been placed on a plunger. A cutting plate was used to slice off each layer. The sediment was washed off the cutting ring into a storage

bottle. Each layer was preserved in buffered formalin in 500 ml bottles. Bottles were shaken to mix the sediment with the formalin. The samples will be used for protozoan faunal community analysis.

Whenever samples had large protozoans visible on top of sediment, either using the Box corer or Megacorer, and this procedure did not interfere with other sampling protocols, the large protozoans were picked using forceps and placed in large Petri dishes with filtered cold sea water.

All material collected for protozoan meiofauna research is presented in Table 5.

Table 5. Protozoan sample collection

Canyon	Station	Depth (m)	Core type	Sample	Process
Setúbal	56804#3	3275	Box core	Surface picked protozoan	Preserved in Formalin
Setúbal	56804#5	3275	Megacore 7	0-1 cm > 300 μm	Molecular bulk analysis
Setúbal	56804#6	3275	Multicore 2	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis
Setúbal	56806#1	3275	Multicore 5	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis
Setúbal	56806#1	3275	Megacore	Surface picked *Discospirina spp*	Preserved in Formalin
Setúbal	56810#1	3224	Multicore 8	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis
Cascais	56821#1	3219	Megacore 6	0-1 cm > 300 μm	Molecular bulk analysis
Cascais	56821#2	3214	Multicore 11	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis
Cascais	56823#2	3218	Multicore 2	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis
Cascais	56828#1	3199	Multicore 5	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis
Cascais	56830#2	2550	Box core	Surface picked protozoan	Preserved in Formalin
Setúbal	56837#2	4245	Megacore 10	0-1 cm > 300 μm	Molecular bulk analysis
Setúbal	56837#5	4241	Multicore 11	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis
Setúbal	56837#7	4243	Multicore 11	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis
Cascais	56838#2	4482	Megacore 4	0-1 cm	Molecular bulk analysis
Cascais	56838#3	4482	Multicore 8	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis
Cascais	56838#4	4485	Multicore 2	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis
Nazaré	56847#2	4400	Megacore	Flat Xenophyophore picked	Preserved in Formalin
Nazaré	56847#6	4403	Multicore 8	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis

Nazaré	56847#7	4404	Megacore 7	*Galatheammina spp.* picked from surface	Preserved in Formalin
Nazaré			Multicore 2	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis
Nazaré	56848#1	3517	Megacore 10	0-1 cm	Molecular bulk analysis
Nazaré			Multicore 11	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis
Nazaré	56851#1	3517	Multicore 8	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis
Nazaré	56856#2	3522	Multicore 8	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis
Nazaré	56859#1	4418	Megacore 4	*Galatheammina spp.* picked from surface	Preserved in Formalin
Nazaré	56859#2	4405	Multicore 8	0.5 layers until 2 cm and then 1 cm layer until 10 cm	Faunal analysis
Nazaré	56859#3	4405	Megacore 3	0-1 cm	Molecular bulk analysis

Ana Aranda da Silva

Sampling for geology analyses

A box core 40 cm in height St. 56830#2 was obtained from a flat area at 2500 m water depth where three channels making up the upper section of the Cascais Canyon meet together. A cross section of the core showed 2cm of oxidised "sloppy" mud at the top, which was collected for ^{210}Pb dating. The rest was homogeneous light grey mud with a silty layer at 30 cm depth. The mud changed into a gravel deposit in one corner of the core. A piston core shot at the same station did not display any gravel, implying that this is a small localised deposit.

-cores will be split down the quence clearly and to analyse down core physical properties using Multi-Sensor Core Logging.

Raquel Arzola

Notes on samples taken

Box corer

Canyon	Station	Depth (m)	Comments
Setúbal	56804#3	3275	Very full, nearly over-full, smooth surface, possibly not very disturbed, 51 cm. Large numbers of polychaete tubes, *Ammodiscus*, pteropods and large Hormosinaceans. Very fine sediment, watery at the surface, more compacted lower down, many burrows upper 5 cm, reduced sediment deeper than 10cm.
Cascais	56830#2	2550	Total recovery of 41 cm. Good sample.

Megacorer

The NOC-UKORS Megacorer was used in a number of different configurations, sometime with the normal 12 megacore (100mm diameter) tubes and sometimes with multicore units in place of some megacores (e.g. Mega 9+3 was 9 megacore tubes + 3 multicore tubes). The system performed well over the whole cruise. At some sites, where sediments were very soft, samples were difficult to obtain but, according to Ben Boorman, it was not bad performance overall for the equipment.

Canyon	Station	Depth (m)	Cores	Comments
Setúbal	56804#5	3275	12 MG	27.5-38 cm. 11/12 good cores. 14 cm of fine brownish colour top sediment overlaying 25 cm of green/grey compacted mud. *Pelosina* in two cores.
Setúbal	56804#6	3275	10+2 MGMC	28-38 cm. all 12 cores ok, one MG bubbled through a burrow. 2 MG with gaps at 12 cm. 1 MC with gap at 7 cm. Sediment description the same as above.
Setúbal	56806#1	3275	9+3 MGMC	34-40 cm. 9/9 MG and 3/3 MC good cores. 15 cm of brownish top sediment overlaying grey compacted sediment.
Setúbal	56806#2	3275	9+3 MGMC	6/9 MG, 1/3 MC, all with disturbed sediment.
Setúbal	56810#1	3224	9+3 MGMC	32-39.5 cm. 9/9 MG, 1 not used as sediment was too disturbed. 3/3 MC. Sediment the same as above. Several cores had gaps at 4 cm.
Setúbal	56816#1	3275	9+3 MGMC	34.5-40 cm. 9/9 MG, 3/3 MC good cores, despite gaps at various depths. Sediment the same as above
Setúbal	56816#2	3285	6+6 MGMC	32-40 cm. 6/6MG, 6/6 MC good cores, 2 MGs with gap at 14cm. 1 MC with gap at 6 cm. Sediment as above.
Cascais	56821#1	3219	12 MG	25.5-34 cm.11/12 good cores although not long. 1 MG did not fire. Sediment fine brown mud overlying 10cm darker, grey-greenish very compacted mud.
Cascais	56821#2	3214	9+3 MGMC	39.5-39 cm. 9/9 MG, 3/3 MC good cores, 1 core did not fire. 2 MG had gaps at 19 and 22 cm. Sediment the same as above.
Cascais	56823#1	3224	9+3 MGMC	27-32 cm. 8/9 MG, 2/3 MC bad cores. 1 MG and 1MC didn't fire. 2 MG with gaps at 19 and 22 cm. 20 cm of compacted mud. Large cloudy water column, badly disturbed cores. Probably hit twice with a hole in the middle. Sediment the same as above.

Cascais	56823#2	3218	9+3 MGMC	21-37 cm. 8/9 MG, 3/3 MC. 1 MG empty. All cores had a sloped surface; 1 MG had a gap at 11 cm. Sediment the same as above.
Cascais	56823#3	3219	9+3 MGMC	21.5-26 cm. 7/9 MG, 1/3 MC good cores. Sediment the same as above.
Cascais	56828#1	3199	9+3 MGMC	30.5-41 cm. 9/9 MG, 3/3 MC good cores. Sediment the same as above.
Cascais	56836#1	3209	6+6 MGMC	23-40 cm. 5/6 MG, 6/6 MC disturbed cores. Sediment the same as above.
Setúbal	56837#2	4245	12 MG	10-26 cm. 11/12 MG ok cores, some short. 1 MG failed, 1 MG was too short and disturbed to be of any use. Brown yellowish sediment overlaying green grey more compacted layer of sediment.
Setúbal	56837#3	4240	9+3 MGMC	3-9 cm. 5 MG had badly disturbed sediment; the cores were too short however, to be of any use.
Setúbal	56837#5	4241	9+3 MGMC	18-39 cm. 12 undisturbed cores; some had large amount of pteropod shells and polychaete tubes at the surface.
Setúbal	56837#6	4239	9+3 MGMC	Very bad overall sample with cores less than 7 cm length. 2 MG and 1 MC empty.
Setúbal	56837#7	4243	9+3 MGMC	9-15 cm. 8/9 MG, 2/3 MC; one MG showed large burrow at surface. Brown sediment layer with 1cm biolayer overlying grey/green compacted mud.
Setúbal	56837#8	4244	9+1 MGMC	20-34 cm. 2 MC units removed to try and obtain better samples; 10 good cores. Brown, soupy mud overlaying grey/green compacted mud overlaying a mixture of shell debris and sandy, dark sediment, overlaying grey/green mud.
Cascais	56838#2	4482	12 MG	17.5-29 cm. 12 good cores, 1 MG showed a lump of sediment on surface. Brownish sediment overlaying few cm dark brown layer overlaying dark grey sediment, overlaying darker sediment overlaying larger layer of lighter greenish/grey mud.
Cascais	56838#3	4482	9+3 MGMC	14-38 cm. 8/9 MG, 3/3 MC good cores. 6.5 cm of soupy brown mud overlaying 6 cm darker grey/green mud overlaying 15 cm lighter green/grey mud.
Cascais	56838#4	4485	9+3 MGMC	6-11 cm. 8/9 MG, 2/3 MC. Little sediment recovered, mostly badly disturbed; some pteropod shells, slightly sloped. Some polychaete tubes and burrows were observed.
Cascais	56842#1	4482	9+3 MGMC	10-18 cm. All 12 succeeded, however, most sediment cores wit gaps at bottom and very unstable and as such 1MG and 1 MC dropped down when removed from corer. 7 cm of mud overlaying 7 cm of darker grey-green mud overlaying 3 cm of lighter mud.
Cascais	56842#2	4485	9+3 MGMC	5.5-12 cm. 8/9 MG, no MC. Brownish sediment overlaying grey compacted mud with thin, orange/brownish layer in between. Many pteropod shells were observed on the surface.
Nazaré	56847#2	4400	12 MG	12-17.5 cm. 1 MG failed and 6 MG that retained sediment were useless due to large gaps, disturbance and bubbling when removed from the corer. Upper layer of very fine grey sediment overlaying grey/brownish sediment. Flat Xenophyophore at

				sediment surface.
Nazaré	56847#3	4397	9+3 MGMC	12 cm. Only 1 MG could be used; all others were useless due to large gaps and sediment disturbance. *Molpadia* found in one core.
Nazaré	56847#4	4406	9+3 MGMC	11.5-26.5 cm. All cores retained sediment with variable quality of the sediment water interface. Some were badly disturbed, others had gaps and ridges. 1 MC mud had slipped down the core tube.
Nazaré	56847#6	4403	9+3 MGMC	18.5-39 cm. 2 MG failed. Lots of gaps observed and some cores badly disturbed. Lighter coloured sediment overlaying darker, sandy greyish sediment.
Nazaré	56847#7	4404	9+3 MGMC	13-28 cm. 1 MG and 2 MC failed. Brown grey sediment (min. 10 cm) overlaying grey compacted sediment with at the very bottom a layer with black plant debris. *Galatheammina* found on sediment surface of MG 7.
Nazaré	56848#1	3517	9+3 MGMC	30-40 cm. 4 MG and 1 MC did not fire and were empty. All sediment cores are sloped; fluffy, very soupy top layer; green/grey mud throughout. Few Holothurians recovered from deepest layers (>10 cm)
Nazaré	56848#2	3523	9+3 MGMC	37.5-42.5 cm. 7 MG and 3 MC failed of which some didn't fire. Sediment the same as above.
Nazaré	56848#3	3512	9+3 MGMC	14-46.5 cm. 5 MG and 1 MC failed, another MC dropped when trying to recover. Sediment the same as above.
Nazaré	56851#1	3517	9+3 MGMC	29-40 cm. 1 MG failed, another was bubbling through gaps and burrows and was very badly disturbed. Sediment the same as above.
Nazaré	56851#2	3517	9+3 MGMC	30-42 cm. 2 MG failed. MG 12 showed a large burrow. Sediment the same as above.
Nazaré	56851#3	3522	9+3 MGMC	34-36 cm. 6MG and 3 MC failed. Sediment the same as above.
Nazaré	56856#1	3519	9+3 MGMC	33-40 cm. 4 MG and 2 MC failed. Sediment the same as above. Few Holothurians recovered from deepest layers (>10 cm)
Nazaré	56856#2	3522	9+3 MGMC	30-40.5 cm. 2 MG and 1 MC failed. All other cores contained undisturbed sediment. Sediment the same as above.
Nazaré	56856#3	3517	6+6 MGMC	29-39 cm. 2 MC failed. Cores that retained sediment were somewhat disturbed. Sediment the same as above.
Nazaré	56859#1	4418	9+3 MGMC	12-25.5 cm. 1 MG failed. Most sediment cored had gaps or some form of disturbance. In MG4 a *Galatheammina* specimen was recovered. Fine brownish green/grey sediment.
Nazaré	56859#2	4405	9+3 MGMC	21.5-30 cm. 7 MG failed. Other sediment cores show gaps at various depths.
Nazaré	56859#3	4405	12 MG	25.5-30 cm. Unfortunately only 2 MG were successful. Because of large gaps and low quantity they were discarded.
Nazaré	56861#1	4404	12 MG	8/12 MG ok. Sediments the same as above.
Nazaré	56861#2	4403	12 MG	6/12 MG ok. Sediments the same as above.

No modifications, other than varying the number of tubes deployed, were required in order to recover good quality cores at the deep 4300 m Setúbal canyon site. This site had proved to be difficult to sample during RRS *Discovery* cruise 297 (July 2005)

Ana Aranda da Silva

Preliminary observations on protozoans

Setúbal Canyon 3200 m site. A box core (St. 56804#3) collected several macrofaunal foraminifera on the sediment surface. They were hand picked into cold seawater. *Reophax spp* were abundant (9 specimens in total) measuring up to 3 cm in length (Figs 1 and 2). It seemed to act as a substratum for other foraminiferal species, such as *Ammodiscus spp* and dome-shaped Foraminifera. *Ammodiscus spp* were found also on the sediment surface (Fig 3). A *Discospirina* sp. was also found lying on top of the box core surface. This was of particular interest because they have been reported and described rarely (Fig. 4). A *Pelosina*-like foraminiferan was also found laying on the sediment surface (Fig. 5).

Figure 1. *Reophax spp* collected from box core 56804#3 (3200m, Setúbal Canyon).

Figure 2. *Ammodiscus spp* and dome shaped foraminifera attached to *Reophax spp* from box core 56804#3 (3200m, Setúbal Canyon).

Figure 3. *Ammodiscus spp* from the surface of box core 56804#3 (3200m, Setúbal Canyon).

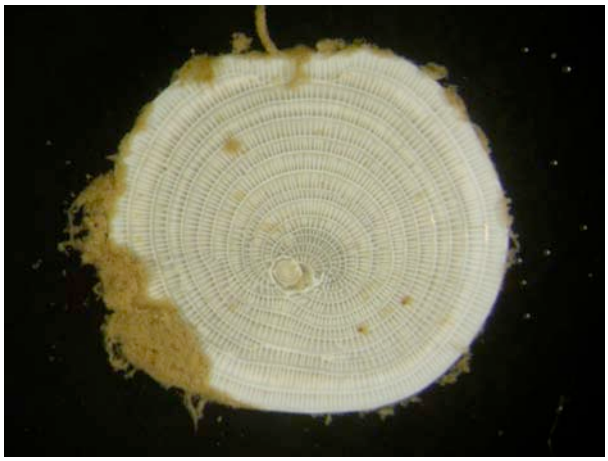

Figure 4. *Discospirina spp* from the surface of box core 56804#3 (3200m Setúbal Canyon).

Figure 5. *Pelosina*-like *spp* found on surface of box core 56804#3 (3200 m Setúbal Canyon).

A megacore from St. 56804#5 was sliced (0-1 cm layer) for molecular bulk material and sorted wet/live onboard. It yielded several macrofaunal (> 300 μm) Foraminifera, including *Reophax spp* and *Ammodiscus spp.* Other foraminiferal species picked for molecular analyses included *Ammobaculites spp, Cribrostomoides spp, Hoeglundina spp,* milliolods, *Recurvoides spp, Saccamminid spp,* and Tube spp (Fig. 6). A megacore deployment 56806#1 had a *Discospirina spp* on the surface which was collected and preserved in formalin.

Setúbal Canyon 4200 m site. A megacore from St. 56837#2 was sliced (0-1 cm layer) for molecular bulk material and wet/live sorted onboard. It yielded several macrofaunal (> 300 μm) foraminiferal organisms. Because of lack of time to document specimens, they were frozen without photographic documentation.

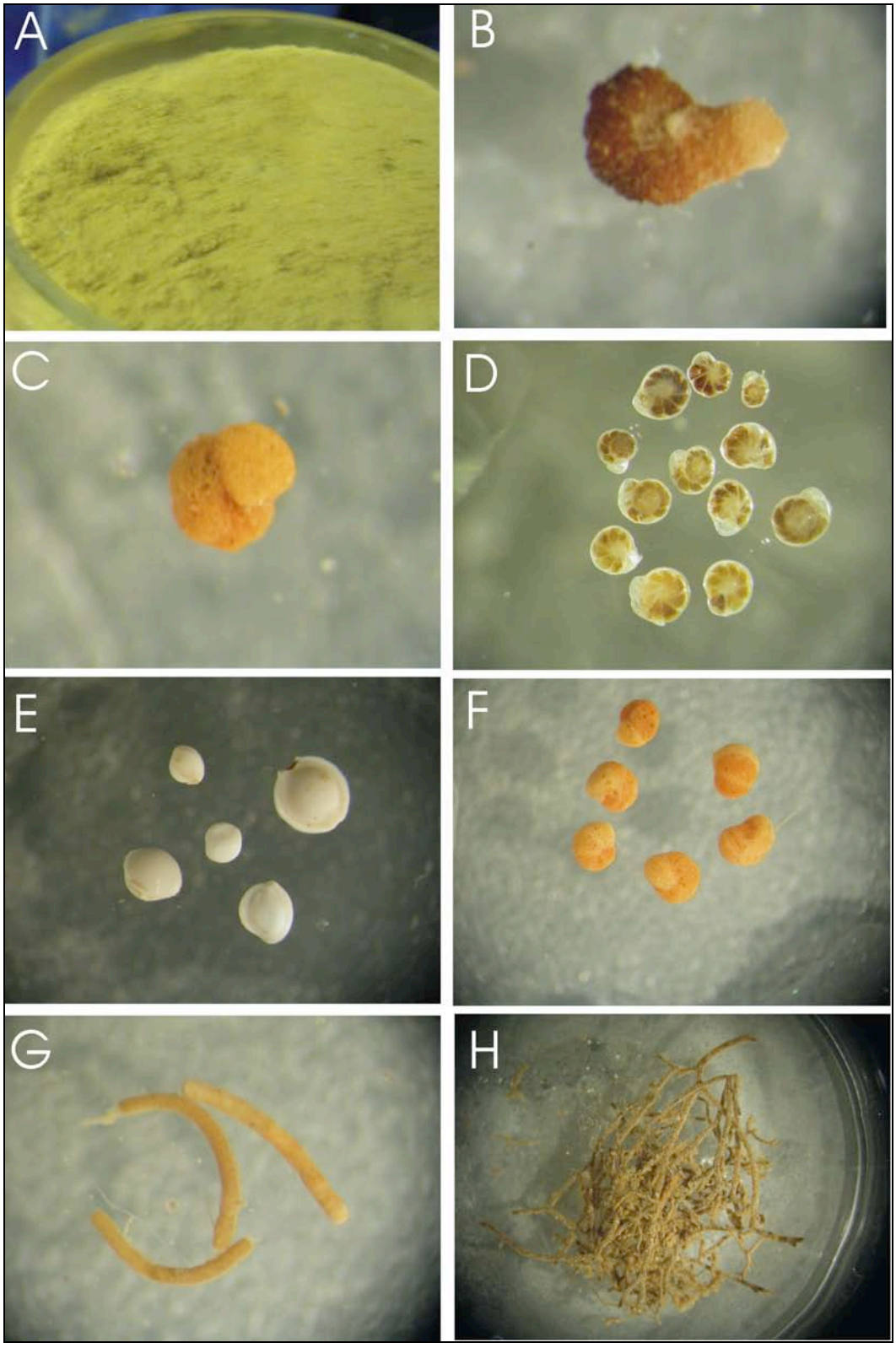

Figure 6. Megacore 56804#5 3200 m Setúbal Canoyon. **A** Core 6 surface. **B** *Ammobaculites* spp. **C** *Cribrostomoides* spp. **D** *Hoeglundina* spp. **E** milliolids. **F** *Recurvoides* spp. **G** *Saccamminid* spp. **H** Tubes.

Cascais Canyon 2500m: A box core at St. 56830#2 showed a very fine spider's web foraminifera lying on the sediment surface with some of the branches rooted down to about 4 cm in the sediment (Fig. 7).

Figure 7. Tubular foraminifera found on surface of box core 56830#2.

Cascais Canyon 3200 m site. A megacore from St. 56821#1 was sliced (0-1 cm layer) for molecular bulk material and wet/live sorted onboard. It yielded several macrofaunal (> 300 μm) Foraminifera, including a milliolid, and some species also found at the Setúbal Canyon, such as *Ammobaculites spp*, *Hoeglundina spp*, *Recurvoides spp*. Species found in the Cascais Canyon and not found in the Setúbal Canyon included *Lagenammina spp*, *Reophax spp* 2, 3 and 4 (Figure 8).

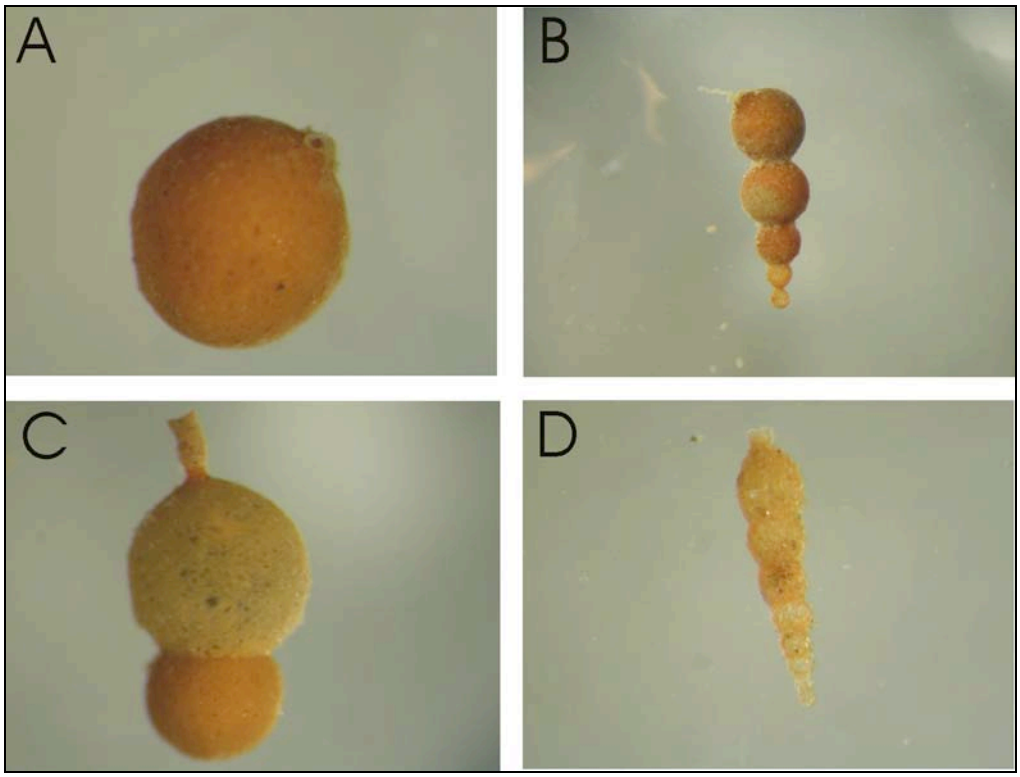

Figure 8. Megacore 56821#1 (3200 m Cascais Canyon). **A** *Lagenammina spp.* **B** *Reophax spp* 2. **C** *Reophax spp* 3. **D** *Reophax spp* 4.

Cascais Canyon 4300 m site. A megacore from St. 56838#2 was sliced (0-1 cm layer) for molecular bulk material and sorted wet/live onboard. It yielded several macrofaunal (> 300 μm) Foraminifera. However, owing to lack of time, the specimens were frozen without photographic documentation.

Nazaré Canyon 3500 m site. A megacore from St. 56848#1 was sliced (0-1 cm layer) for molecular bulk material and wet/live sorted onboard. It yielded several macrofaunal (> 300 μm) Foraminiferal. Owing to lack of time to document the specimens they were frozen without photographic documentation.

Nazaré Canyon 4300 m site. A Megacore from St. 56847#2 was sliced (0-1 cm layer) for molecular bulk material and sorted wet/live onboard. It yielded several macrofaunal (> 300 μm) Foraminifera. Because of lack of time to document specimens, they were frozen without photographic documentation. A flat Xenophyophore was picked from the surface of a megacore at St. 56847#2. It was preserved in formalin. *Galatheammina spp* were also collected from sediment surface of megacores at Stas: 56847#7 and 56859#1.

Ana Aranda da Silva

7. TRAWLING

Four Agassiz trawls were made during the cruise. Three trawls were taken at depths of c. 3200 to 3300m in the Cascais (St. 56824#1), Setúbal (St. 56827#1) and Nazaré (St. 56857#1) canyons and the fourth trawl at c. 4400m in the Nazaré Canyon (St. 56847#1). Samples were taken primarily to identify fauna observed in photographic images of the seafloor and to study the feeding strategies of holothurians. For the latter task tissue samples from the gut contents of *Molpadia* sp., or the whole animal in the case of *Ypsilothuria* sp., were taken and frozen for molecular biology studies.

All catches were collected near the bottom of each canyon and were generally rather small. The catches were retrieved with some problems. At 3200m Cascais Canyon the mouth of the net was torn away. At 4300m in the Nazaré Canyon the cod end was open when the net was retrieved. At 3200m in the Nazaré Canyon the net was badly damaged and was nearly torn away from the frame. However, apart from the station at 4300m, a sample was always retrieved.

Station 56823#3 (Cascais Canyon, 3254-3264m): In a catch with many stones there were also several gastropods, bivalves and scaphopods as well as two specimens of the burrowing holothurian *Molpadia* sp.

Station 56827#1 (Setúbal Canyon, 3174-3295m): A small and disappointing catch which nevertheless contained five specimens of the burrowing holothurian *Molpadia* sp.

Station 56857#1 (Nazaré Canyon, 3349-3401m): A very muddy sample washed using a hose when it was brought inboard. Several *Molpadia* sp. Holothurians were retrieved from the mud, which in many ways was fortuitous as the cold mud had insulated the holothurians during hauling in and retrieval on deck. From this sample

specimens were processed for work on gut micro-organisms and for fatty acid analyses as described below.

DGGE analysis of microbial populations

DGGE is a fingerprinting method that provides with an overview of the richness of the microbial community in a given sample. Sequencing of selected bands will be conducted in the laboratory to characterize the bacteria genetically.

All *Molpadia* sp. were put immediately in the Constant Temperature Laboratory at 4^{o}C. Each specimen was dissected in a sterilized petri dish. In each case the gut was taken out and put immediately into another sterilized petri dish. With a sterilized spatula a small sample of sediment was taken in three different parts of the gut (the oesophagus, the mid gut and the hind gut). Each sample was put in a small jar and stored in a –80^{o}C freezer.

Fatty acid technique

Fatty acids are particularly useful biomarkers for identification of macro-and microplankton species and their contribution to animal diets. The examination of the differences in composition of these markers in the sea cucumbers found in the canyons, as well as the sediment and overlying water should demonstrate whether or not these animals have a species-specific biochemistry.

After dissecting each *Molpadia* sp., a small part of the muscle tissue was taken out and stored in a –80^{o}C freezer.

Molecular phylogenetics of *Ypsilothuria* holothurians.

In order to assist in the identification of the *Ypsilothuria* species occurring in the canyon systems of the Portuguese margin, samples were taken of whole specimens for subsequent molecular analyses in the laboratory. Some specimens were frozen whole immediately at –80^{o}C, while others were preserved whole in 100% ethanol.

Teresa Amaro, Ben Boorman, David Billett

8. AMPHIPOD TRAP

Five amphipod trap deployments were made, two in the Setúbal Canyon at 3194m (St. 56817#1) and 4445m (St. 56839#1), on in the Cascais Canyon at 4230m (St. 56837#1) and two in the Nazaré Canyon at 3499m (St. 56855#1) and 4403m (St. 56844#1). Particularly good catches were recovered in the deep DEMAR (seabed level) and VET (1 m above bottom) traps in the Setúbal, Cascais and Nazaré canyons. However, the gauze in one end of the VET trap at St. 56837#1 (Cascais Canyon) had come away in part from the trap entrance during the deployment and recovery and so this sample may have been even larger.

Ben Boorman, David Billett

STATION LIST

Station	Canyon	Gear	Event	Date	Time_UTC	Latitude	Longitude	Depth sampler corr m	Sounding m (corr.)	Remarks
56801 #1	Setúbal	CTD	start acquisition	16/04/2006	12:09	38.1131	-10.0529	0	4562	
56801 #1	Setúbal	CTD	end acquisition	16/04/2006	18:20	38.1104	-10.0504	4540	4547	
56801 #1	Setúbal	SVP	start acquisition	16/04/2006	12:09	38.1131	-10.0529	0	4562	SVP used for rest of survey
56801 #1	Setúbal	SVP	end acquisition	16/04/2006	18:20	38.1104	-10.0504	4540	4547	
56801 #1	Setúbal	SAPS	start pumping	16/04/2006	14:31	38.1128	-10.0462	4555	4562	flow meter reading at start unknown
56801 #1	Setúbal	SAPS	end pumping	16/04/2006	16:31	38.1132	-10.0467	4540	4547	may not have filtered correctly, 7-10mab
56802 #1	Cascais	MBES	start acquisition	16/04/2006	21:44	38.4198	-9.5783		2734	
56802 #1	Cascais	MBES	end acquisition	17/04/2006	09:05	38.5345	-9.2690		242	
56803 #1	Lisbon	TOBI	start acquisition	17/04/2006	12:59	38.4898	-9.2637		500	problems at launch, swivel replaced
56803 #1	Open slope	TOBI	end acquisition	19/04/2006	15:41	37.8353	-10.5478		4337	
56804 #1	Setúbal	SHRIMP	deployed	20/04/2006	02:18				3045	short circuit, deployment aborted 1215m w.o., 0303Z
56804 #2	Setúbal	CTD	start acquisition	20/04/2006	05:18	38.1535	-9.6118	0	3258	
56804 #2	Setúbal	CTD	end acquisition	20/04/2006	10:40	38.1545	-9.6161	3280	3285	
56804 #2	Setúbal	SAPS	start pumping	20/04/2006	07:15	38.1527	-9.6155	3275	3285	
56804 #2	Setúbal	SAPS	end pumping	20/04/2006	09:15	38.1533	-9.6162	3280	3285	5 to 10mab, 1217 L water filtered
56804 #3	Setúbal	Box core	on bottom	20/04/2006	13:22	38.1543	-9.6158	3275	3275	51 cm core
56804 #4	Setúbal	SHRIMP	start	20/04/2006	18:04	38.1633	-9.5835	2872	2872	
56804 #4	Setúbal	SHRIMP	end	20/04/2006	20:19	38.1513	-9.6030	3124	3124	669 frames
56804 #5	Setúbal	Mega 12	on bottom	21/04/2006	00:26	38.1545	-9.6155	3275	3275	11/12, cores 28-38 cm
56804 #6	Setúbal	Mega 10+2	on bottom	21/04/2006	04:31	38.1543	-9.6157	3275	3275	12/12, cores 28-38 cm
56805 #1	Setúbal	CTD	start acquisition	21/04/2006	10:38	38.2908	-8.8995	0	306	
56805 #1	Setúbal	CTD	end acquisition	21/04/2006	11:20	38.2910	-8.8985	30	293	
56805 #1	Setúbal	SAPS	start pumping	21/04/2006	10:42	38.2912	-8.8997	30	308	small elbow tube not on top of the filter casing

56805 #1	Setúbal	SAPS	end pumping	21/04/2006	11:12	38.2910	-8.8988	30	297	277 L water filtered
56805 #2	Setúbal	CTD	start acquisition	21/04/2006	11:55	38.2933	-8.8958	0	328	
56805 #2	Setúbal	CTD	end acquisition	21/04/2006	12:30	38.2935	-8.8953	327	328	
56805 #3	Setúbal	SAPS	start pumping	21/04/2006	13:56	38.2932	-8.8955	317	327	Deployed on coring wire
56805 #3	Setúbal	SAPS	end pumping	21/04/2006	14:56	38.2932	-8.8940	325	327	2 to 10mab, 682 L water filtered
56806 #1	Setúbal	Mega 9+3	on bottom	21/04/2006	20:59	38.1548	-9.6160	3275	3275	12/12, cores 32-40 cm
56806 #2	Setúbal	Mega 9+3	on bottom	22/04/2006	01:13	38.1542	-9.6137	3275	3275	7/12, winch problem, cores disturbed, 18-28 cm
56807 #1	Setúbal	SHRIMP	start	22/04/2006	11:00	38.2645	-9.1512	1055	1055	
56807 #1	Setúbal	SHRIMP	end	22/04/2006	11:24	38.2657	-9.1555	1085	1085	Shrimp aborted 1205Z - bad weather & winch problem
56807 #2	Setúbal	CTD	start acquisition	22/04/2006	12:42	38.2715	-9.1568	0	1421	
56807 #2	Setúbal	CTD	end acquisition	22/04/2006	15:22	38.2690	-9.1655	1405	1410	
56807 #2	Setúbal	SAPS	start pumping	22/04/2006	13:40	38.2715	-9.1568	1403	1408	
56807 #2	Setúbal	SAPS	end pumping	22/04/2006	14:40	38.2700	-9.1587	1404	1409	5 to 10 mab, 679 L water filtered
56807 #3	Setúbal	SHRIMP	deployed	22/04/2006	16:21					power failure, deployment aborted 1715Z
56807 #4	Setúbal	SHRIMP	start	22/04/2006	20:32	38.2655	-9.1523	1100	1100	
56807 #4	Setúbal	SHRIMP	end	23/04/2006	00:37	38.2742	-9.1908	1429	1429	coral recovered from SHRIMP vehicle, 977 frames
56808 #1	Setúbal	SHRIMP	start	23/04/2006	03:52	38.2758	-9.0775	402	402	
56808 #1	Setúbal	SHRIMP	end	23/04/2006	07:36	38.2847	-9.1203	993	993	947 frames
56809 #1	Setúbal	SHRIMP	start	23/04/2006	11:06	38.2660	-8.9972	356	356	
56809 #1	Setúbal	SHRIMP	end	23/04/2006	14:40	38.2772	-9.0290	715	715	899 frames
56810 #1	Setúbal	Mega 9+3	on bottom	23/04/2006	20:14	38.1537	-9.6170	3224	3224	12/12, cores 32-39 cm
56811 #1	Lisbon	CTD	start acquisition	24/04/2006	11:58	38.5083	-9.2712	0	395	
56811 #1	Lisbon	CTD	end acquisition	24/04/2006	12:58	38.5092	-9.2705	100	373	
56811 #1	Lisbon	SAPS	start pumping	24/04/2006	12:20	38.5082	-9.2710	12	373	some material lost when filter casing opened
56811 #1	Lisbon	SAPS	end pumping	24/04/2006	12:50	38.5088	-9.2708	12	373	270 L water filtered
56811 #2	Lisbon	CTD	start acquisition	24/04/2006	13:24	38.5080	-9.2702	0	394	
56811 #2	Lisbon	CTD	end acquisition	24/04/2006	15:12	38.5088	-9.2685	390	395	

56811 #2	Lisbon	SAPS	start pumping	24/04/2006	13:57	38.5082	-9.2695	385	395	
56811 #2	Lisbon	SAPS	end pumping	24/04/2006	14:57	38.5082	-9.2692	390	395	5 to 10 mab, 591 L water filtered
56812 #1	Cascais	CTD	start acquisition	24/04/2006	17:00	38.4828	-9.4753	0	704	
56812 #1	Cascais	CTD	end acquisition	24/04/2006	18:33	38.4825	-9.4767	707	714	
56812 #1	Cascais	SAPS	start pumping	24/04/2006	17:57	38.4823	-9.4760	10	703	
56812 #1	Cascais	SAPS	end pumping	24/04/2006	18:27	38.4830	-9.4772	10	651	264 L water filtered
56812 #2	Cascais	CTD	start acquisition	24/04/2006	18:52	38.4823	-9.4768	0	669	
56812 #2	Cascais	CTD	end acquisition	24/04/2006	20:49	38.4828	-9.4780	694	699	
56812 #2	Cascais	SAPS	start pumping	24/04/2006	19:21	38.4827	-9.4763	694	699	
56812 #2	Cascais	SAPS	end pumping	24/04/2006	20:21	38.4825	-9.4780	667	677	5 to 10 mab, 774 L water filtered
56813 #1	Lisbon	SHRIMP	start	24/04/2006	23:58	38.4428	-9.3220	854	854	oyster cliff impact
56813 #1	Lisbon	SHRIMP	end	25/04/2006	00:34	38.4402	-9.3250	692	692	SHRIMP run aborted, short circuit, 43 frames
56814 #1	Cascais	MBES	start acquisition	25/04/2006	02:45	38.4150	-9.3583		565	
56814 #1	Cascais	MBES	end acquisition	25/04/2006	06:00	38.4992	-9.2937		148	bathymetric survey near of head of Cascais Canyon
56815 #1	Cascais	CTD	start acquisition	25/04/2006	09:22	38.2980	-9.7768	0	3224	
56815 #1	Cascais	CTD	end acquisition	25/04/2006	14:24	38.2925	-9.7772	3310	3315	
56815 #1	Cascais	SAPS	start pumping	25/04/2006	11:02	38.2918	-9.7777	3310	3315	
56815 #1	Cascais	SAPS	end pumping	25/04/2006	13:02	38.2920	-9.7780	3305	3315	5 to 10 mab, 1350 L water filtered
56816 #1	Setúbal	Mega 9+3	on bottom	25/04/2006	17:36	38.1545	-9.6157	3275	3275	12/12, cores 34-40cm
56816 #2	Setúbal	Mega 6+6	on bottom	25/04/2006	21:04	38.1558	-9.6162	3285	3285	12/12, cores 32-40cm
56817 #1	Setúbal	Amphipod Trap	deployed	25/04/2006	23:07	38.1528	-9.6000	3194	3194	
56817 #1	Setúbal	Amphipod Trap	off bottom	27/04/2006	06:21					
56818 #1	Lisbon	SHRIMP	start	26/04/2006	04:10	38.3047	-9.7735	3094	3094	
56818 #1	Lisbon	SHRIMP	end	26/04/2006	07:55	38.2818	-9.8050	3496	3496	short-circuit at end, all comms lost, 947 frames
56819 #1	Cascais	Piston Core 9m	on bottom	26/04/2006	13:53	38.2965	-9.8148	3516	3516	no core recovered, bounced off gravelly layer
56820 #1	Cascais	Piston Core 6m	on bottom	26/04/2006	18:04	38.2995	-9.7797	3218	3218	terrace Cascais Canyon, 3.3 m core, mainly mud

56821 #1	Cascais	Mega 12	on bottom	26/04/2006	22:21	38.2993	-9.7812	3219	3219	11/12, cores 26-34 cm
56821 #2	Cascais	Mega 9+3	on bottom	27/04/2006	02:01	38.2995	-9.7815	3214	3214	12/12, cores 30-39 cm
56822 #1	Setúbal	Piston Core 9m	on bottom	27/04/2006	11:41	38.1495	-9.6168	3157	3157	terrace Setúbal Canyon, 6 m, stacked thin turbidites
56823 #1	Cascais	Mega 9+3	on bottom	27/04/2006	17:33	38.2995	-9.7832	3224	3224	10/12, poor sample, 27-32 cm
56823 #2	Cascais	Mega 9+3	on bottom	27/04/2006	20:50	38.3002	-9.7837	3218	3218	11/12, 21-37 cm
56823 #3	Cascais	Mega 9+3	on bottom	28/04/2006	00:26	38.2998	-9.7845	3219	3219	8/12, 22-26 cm
56824 #1	Cascais	Agassiz Trawl	on bottom	28/04/2006	05:34	38.3103	-9.7930	3264	3264	
56824 #1	Cascais	Agassiz Trawl	off bottom	28/04/2006	06:17	38.3247	-9.8012	3254	3254	
56825 #1	Setúbal	Piston Core 6m	on bottom	28/04/2006	12:55	38.0667	-9.7377	3810	3810	terrace Setúbal Canyon, 3.3 m, mainly mud
56826 #1	Setúbal	Piston Core 9m	on bottom	28/04/2006	18:50	38.0887	-9.9105	4059	4059	terrace Setúbal Canyon, 2.8m, debris flow
56827 #1	Setúbal	Agassiz Trawl	on bottom	29/04/2006	01:06	38.1502	-9.6170	3174	3174	
56827 #1	Setúbal	Agassiz Trawl	off bottom	29/04/2006	01:36	38.1572	-9.6178	3295	3295	
56828 #1	Cascais	Mega 9+3	on bottom	29/04/2006	06:52	38.3003	-9.7830	3199	3199	12/12, 31-41 cm
56829 #1	Cascais	Box core	on bottom	29/04/2006	11:14	38.2937	-9.8365	3807	3807	empty core, a small amount of gravelly mud
56830 #1	Cascais	Piston Core 6m	on bottom	29/04/2006	16:19	38.3178	-9.5818	2548	2548	Cascais Canyon basin, 3.2m core, stacked turbidites
56830 #2	Cascais	Box core	on bottom	29/04/2006	19:14	38.3180	-9.5823	2550	2550	Good core 48cm
56831 #1	Setúbal	SHRIMP	start	30/04/2006	00:24	38.2662	-9.4082	1507	1507	
56831 #1	Setúbal	SHRIMP	end	30/04/2006	04:25	38.2355	-9.4025	2209	2209	821 frames
56832 #1	Setúbal	SHRIMP	start	30/04/2006	08:39	38.3047	-9.3112	1740	1740	
56832 #1	Setúbal	SHRIMP	end	30/04/2006	14:07	38.3110	-9.3522	1665	1665	greatest depth 2038m, 782 frames, rope 2.6m
56833 #1	Cascais	CTD	start acquisition	30/04/2006	17:15	38.4413	-9.4585	0	1469	
56833 #1	Cascais	CTD	end acquisition	30/04/2006	19:55	38.4423	-9.4585	1462	1474	
56833 #1	Cascais	SAPS	start pumping	30/04/2006	18:13	38.4407	-9.4567	1462	1469	
56833 #1	Cascais	SAPS	end pumping	30/04/2006	19:13	38.4405	-9.4565	1467	1474	7 to 13 mab, 744 L water filtered

56834 #1	Lisbon	CTD	start acquisition	30/04/2006	20:56	38.4313	-9.3470	0	1125	
56834 #1	Lisbon	CTD	end acquisition	30/04/2006	23:25	38.4223	-9.3502	1130	1131	
56834 #1	Lisbon	SAPS	start pumping	30/04/2006	21:50	38.4303	-9.3500	1130	1135	
56834 #1	Lisbon	SAPS	end pumping	30/04/2006	22:50	38.4305	-9.3498	1126	1131	5 to 10 mab, 754 L water filtered
56835 #1	Lisbon	SHRIMP	start	01/05/2006	01:23	38.4382	-9.3283	774	774	
56835 #1	Lisbon	SHRIMP	end	01/05/2006	06:28	38.4277	-9.3452	1171	1171	poor visibility at end, 962 frames
56836 #1	Cascais	Mega 6+6	on bottom	01/05/2006	22:46	38.2998	-9.8327	3209	3209	11/12, 23-40 cm
56837 #1	Cascais	Amphipod Trap	deployed	02/05/2006	01:43	38.3662	-9.8834	4230	4230	
56837 #1	Cascais	Amphipod Trap	off bottom	03/05/2006	08:00					
56837 #2	Cascais	Mega 12	on bottom	02/05/2006	04:07	38.3748	-9.8913	4245	4245	10/12, 21-26 cm
56837 #3	Cascais	Mega 9+3	on bottom	02/05/2006	08:17	38.3747	-9.8910	4240	4240	3/12, disturbed very short cores
56837 #4	Cascais	Piston Core 9m	on bottom	02/05/2006	12:54	38.3745	-9.8913	4240	4240	Cascais Canyon mouth, 5.1m core, stacked turbidites
56837 #5	Cascais	Mega 9+3	on bottom	02/05/2006	17:12	38.3750	-9.8913	4241	4241	12/12, 18-39 cm
56837 #6	Cascais	Mega 9+3	on bottom	02/05/2006	21:28	38.3755	-9.8913	4239	4239	9/12, short cores
56837 #7	Cascais	Mega 9+3	on bottom	03/05/2006	01:36	38.3748	-9.8920	4243	4243	10/12, 9-14 cm
56837 #8	Cascais	Mega 9+1	on bottom	03/05/2006	05:52	38.3748	-9.8920	4244	4244	10/10, 20-34 cm
56838 #1	Setúbal	SHRIMP	start	03/05/2006	14:48	38.1115	-9.9760	4436	4436	
56838 #1	Setúbal	SHRIMP	end	03/05/2006	16:52	38.1115	-9.9950	4481	4481	619 frames
56838 #2	Setúbal	Mega 12	on bottom	03/05/2006	22:07	38.1083	-9.9997	4482	4482	12/12, 18-29 cm
56838 #3	Setúbal	Mega 9+3	on bottom	04/05/2006	02:24	38.1082	-9.9990	4482	4482	11/12, 14-38 cm
56838 #4	Setúbal	Mega 9+3	on bottom	04/05/2006	06:27	38.1087	-9.9998	4485	4485	10/12, 6-11 cm
56839 #1	Setúbal	Amphipod Trap	deployed	04/05/2006	08:58	38.1095	-9.9697	4445	4445	
56839 #1	Setúbal	Amphipod Trap	off bottom	05/05/2006	09:10					
56840 #1	Setúbal	Piston Core 9m	on bottom	04/05/2006	11:52	38.1083	-9.8933	4284	4284	landslide Setúbal Canyon, core catcher lost. No sample
56841 #1	Open slope	SHRIMP	deployed	04/05/2006	16:13					loss of signal. 1200m wire out. Aborted 1900Z

56842 #1	Setúbal	Mega 9+3	on bottom	05/05/2006	02:31	38.1075	-9.9990	4482	4482	12/12, 10-18 cm short cores but OK
56842 #2	Setúbal	Mega 9+3	on bottom	05/05/2006	06:35	38.1082	-9.9995	4485	4485	8/12, 6-12 cm short cores but most OK
56843 #1	Setúbal	Piston Core 9m	on bottom	05/05/2006	13:13	38.1220	-9.9897	4332	4332	terrace Setúbal canyon, 3.2m, stacked thin turbidites
56844 #1	Setúbal	Piston Core 9m	on bottom	05/05/2006	18:32	38.1167	-10.0798	4577	4577	gravel waves Setúbal Canyon, 1.7m, graded gravel
56845 #1	Setúbal	Piston Core 6m	on bottom	06/05/2006	00:23	38.1018	-10.2500	4829	4829	sediment waves Setúbal Canyon, 0.8m, gravel
56846 #1	Nazaré	SHRIMP	deployed	06/05/2006	12:44					Aborted 1550Z. 2036m w.o. Comms failure
56846 #2	Nazaré	SHRIMP	deployed	06/05/2006	18:06					Aborted 1854Z. 1240m w.o. Comms failure
56847 #1	Nazaré	Amphipod Trap	deployed	07/05/2006	07:35	39.5917	-10.3167	4403	4403	
56847 #1	Nazaré	Amphipod Trap	off bottom	08/05/2006	08:09					
56847 #2	Nazaré	Mega 12	on bottom	07/05/2006	10:26	39.5833	-10.3332	4400	4400	5/12, 12-18 cm
56847 #3	Nazaré	Mega 9+3	on bottom	07/05/2006	15:06	39.5832	-10.3328	4397	4397	cores empty or extremely disturbed
56847 #4	Nazaré	Mega 9+3	on bottom	07/05/2006	19:17	39.5937	-10.3330	4406	4406	12/12, 12-25 cm
56847 #5	Nazaré	Agassiz Trawl	on bottom	07/05/2006	23:52	39.5930	-10.3327	4402	4402	
56847 #5	Nazaré	Agassiz Trawl	off bottom	08/05/2006	00:43	39.5915	-10.3550	4433	4433	
56847 #6	Nazaré	Mega 9+3	on bottom	08/05/2006	05:54	39.5928	-10.3332	4403	4403	10/12, 19-39 cm, some very disturbed.
56847 #7	Nazaré	Mega 9+3	on bottom	08/05/2006	12:30	39.5925	-10.3343	4404	4404	9/12, 13-28 cm
56848 #1	Nazaré	Mega 9+3	on bottom	08/05/2006	19:01	39.5000	-9.9335	3517	3517	7/12, 30-40 cm
56848 #2	Nazaré	Mega 9+3	on bottom	08/05/2006	22:36	39.5000	-9.9333	3523	3523	2/12, 38-43 cm, one with molpadiid holothurian
56848 #3	Nazaré	Mega 9+3	on bottom	09/05/2006	01:55	39.4998	-9.9342	3512	3512	6/12, 14-47 cm
56849 #1	Nazaré	CTD	start acquisition	09/05/2006	07:30	39.6247	-9.2505	0	688	
56849 #1	Nazaré	CTD	end acquisition	09/05/2006	09:15	39.6248	-9.2507	720	724	

56849 #1	Nazaré	SAPS	start pumping	09/05/2006	08:15	39.6247	-9.2502	719	724	
56849 #1	Nazaré	SAPS	end pumping	09/05/2006	08:45	39.6247	-9.2503	718	728	5 to 10 mab, 251 L water filtered
56849 #2	Nazaré	CTD	start acquisition	09/05/2006	09:51	39.6247	-9.2505	0	727	
56849 #2	Nazaré	CTD	end acquisition	09/05/2006	10:35	39.6245	-9.2505	50	727	
56849 #2	Nazaré	SAPS	start pumping	09/05/2006	10:07	39.6247	-9.2502	40	727	
56849 #2	Nazaré	SAPS	end pumping	09/05/2006	10:25	39.6248	-9.2505	40	727	chlorophyll max, 215 L water filtered
56850 #1	Nazaré	CTD	start acquisition	09/05/2006	12:02	39.6023	-9.4078	0	1163	
56850 #1	Nazaré	CTD	end acquisition	09/05/2006	14:35	39.6027	-9.4085	1156	1164	
56850 #1	Nazaré	SAPS	start pumping	09/05/2006	12:58	39.6030	-9.4083	1156	1161	
56850 #1	Nazaré	SAPS	end pumping	09/05/2006	13:58	39.6028	-9.4082	1152	1162	5 to 10 mab, 550 L water filtered
56851 #1	Nazaré	Mega 9+3	on bottom	09/05/2006	19:24	39.4998	-9.9328	3517	3517	11/12, 29-40 cm
56851 #2	Nazaré	Mega 9+3	on bottom	09/05/2006	23:08	39.4998	-9.9335	3517	3517	10/12, 30-42 cm
56851 #3	Nazaré	Mega 9+3	on bottom	10/05/2006	02:42	39.4992	-9.9337	3522	3522	3/12, 34-36 cm
56852 #1	Nazaré	SHRIMP	start	10/05/2006	08:29	39.5035	-9.9038	3442	3442	rope shortened to 2m for subsequent deployments
56852 #1	Nazaré	SHRIMP	end	10/05/2006	11:30	39.5017	-9.9280	3411	3411	Greatest depth 3564m, 937 frames
56853 #1	Nazaré	SHRIMP	start	10/05/2006	17:52	39.5588	-9.4592	586	586	
56853 #1	Nazaré	SHRIMP	end	10/05/2006	18:35	39.5548	-9.4595	597	597	All comms lost. Haul aborted after 43 mins, 215 frames
56853 #2	Nazaré	SHRIMP	start	10/05/2006	23:07	39.5552	-9.4597	587	587	
56853 #2	Nazaré	SHRIMP	end	11/05/2006	02:20	39.5365	-9.4595	1155	1155	951 frames
56854 #1	Nazaré	SHRIMP	start	11/05/2006	06:10	39.5028	-9.6968	1602	1602	
56854 #1	Nazaré	SHRIMP	end	11/05/2006	11:32	39.4632	-9.7235	2693	2693	end depth is wire out, 962 frames
56855 #1	Nazaré	Amphipod Trap	deployed	11/05/2006	14:24	39.5027	-9.9050	3499	3499	
56855 #1	Nazaré	Amphipod Trap	off bottom	12/05/2006	13:26					
56856 #1	Nazaré	Mega 9+3	on bottom	11/05/2006	16:43	39.4992	-9.9333	3519	3519	6/12, 33-40 cm
56856 #2	Nazaré	Mega 9+3	on bottom	11/05/2006	20:10	39.5000	-9.9330	3522	3522	9/12, 30-41 cm
56856 #3	Nazaré	Mega 6+6	on bottom	11/05/2006	23:40	39.4997	-9.9333	3517	3517	10/12, 29-39 cm, some disturbed

56857 #1	Nazaré	Agassiz Trawl	on bottom	12/05/2006	03:28	39.5050	-9.9260	3349	3349	
56857 #1	Nazaré	Agassiz Trawl	off bottom	12/05/2006	03:59	39.5053	-9.9365	3401	3401	
56858 #1	Nazaré	CTD	start acquisition	12/05/2006	07:42	39.5017	-9.9188	0	3611	
56858 #1	Nazaré	CTD	end acquisition	12/05/2006	13:07	39.5010	-9.9188	3595	3600	
56858 #1	Nazaré	SAPS	start pumping	12/05/2006	09:30	39.5013	-9.9190	3590	3600	
56858 #1	Nazaré	SAPS	end pumping	12/05/2006	11:30	39.5010	-9.9188	3595	3600	5 to 10 mab, 1004 L filtered
56859 #1	Nazaré	Mega 9+3	on bottom	12/05/2006	19:19	39.5930	-10.3333	4418	4418	11/12, 12-26 cm
56859 #2	Nazaré	Mega 9+3	on bottom	12/05/2006	23:29	39.5932	-10.3333	4405	4405	5/12, 22-30 cm
56859 #3	Nazaré	Mega 12	on bottom	13/05/2006	03:35	39.5928	-10.3332	4405	4405	2/12, 26-30 cm
56860 #1	Nazaré	SHRIMP	deployed	13/05/2006	06:30					Haul aborted 0853Z (4214m w.o.) No comms
56860 #2	Nazaré	SHRIMP	start	13/05/2006	16:08	39.5688	-10.2928	4321	4321	
56860 #2	Nazaré	SHRIMP	end	13/05/2006	20:19	39.5910	-10.3185	4392	4392	1011 frames
56861 #1	Nazaré	Mega 12	on bottom	14/05/2006	01:57	39.5928	-10.3337	4404	4404	6/12, 21-28 cm
56861 #2	Nazaré	Mega 12	on bottom	14/05/2006	05:45	39.5930	-10.3337	4403	4403	6/12, 20-31 cm

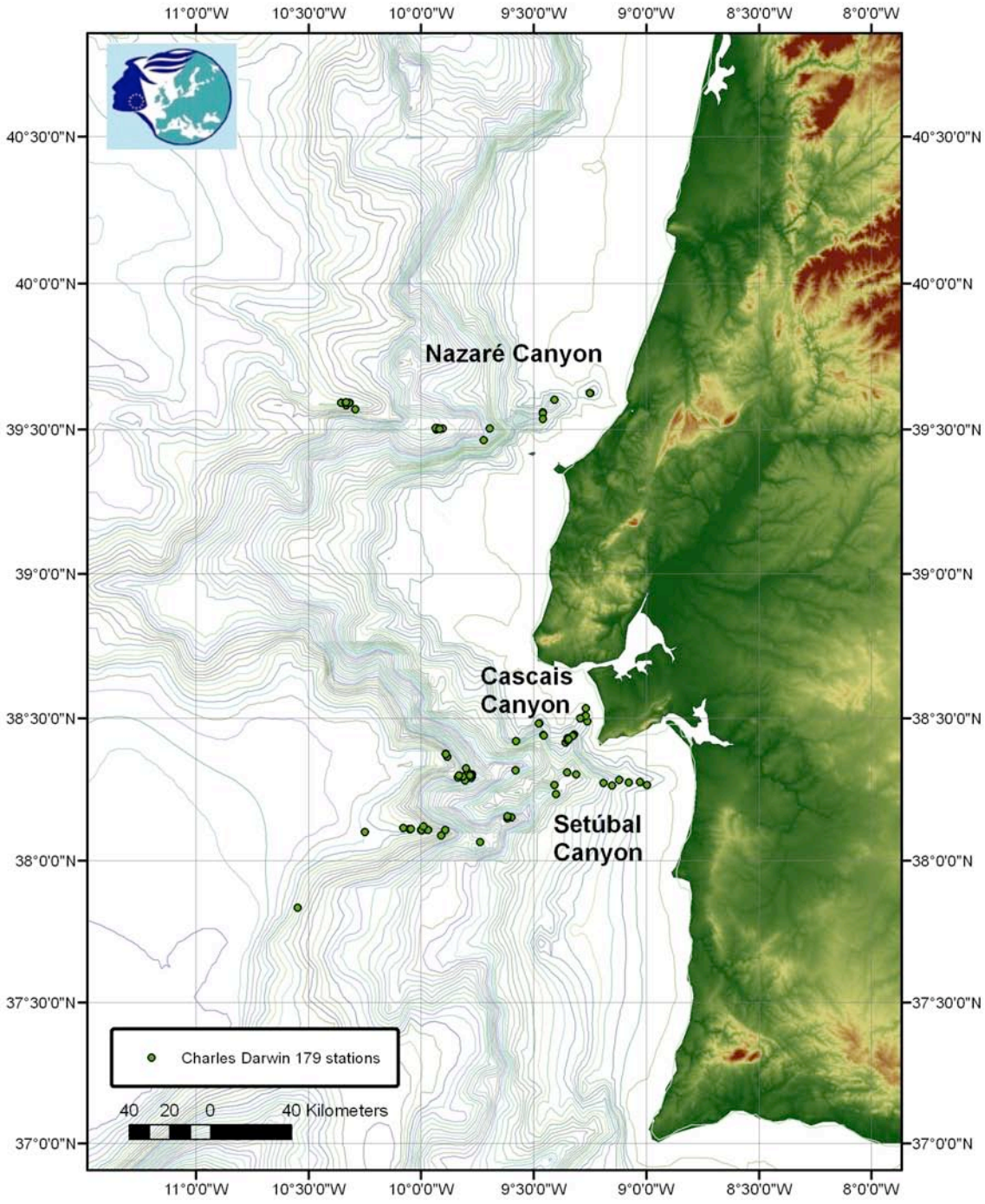

Figure 9. Bathymetric chart of Portuguese margin canyons showing station positions

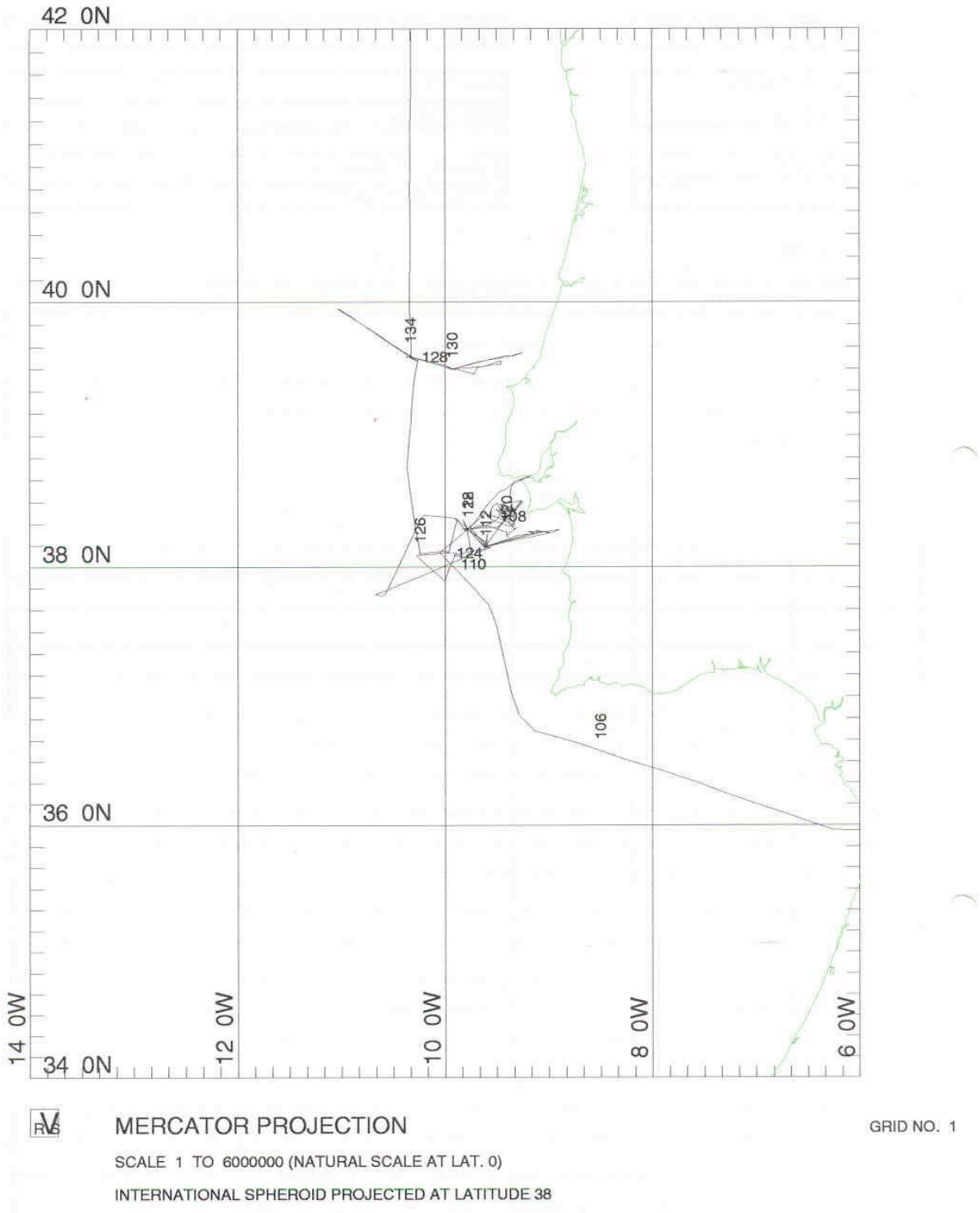

Figure 10. Cruise track plot.

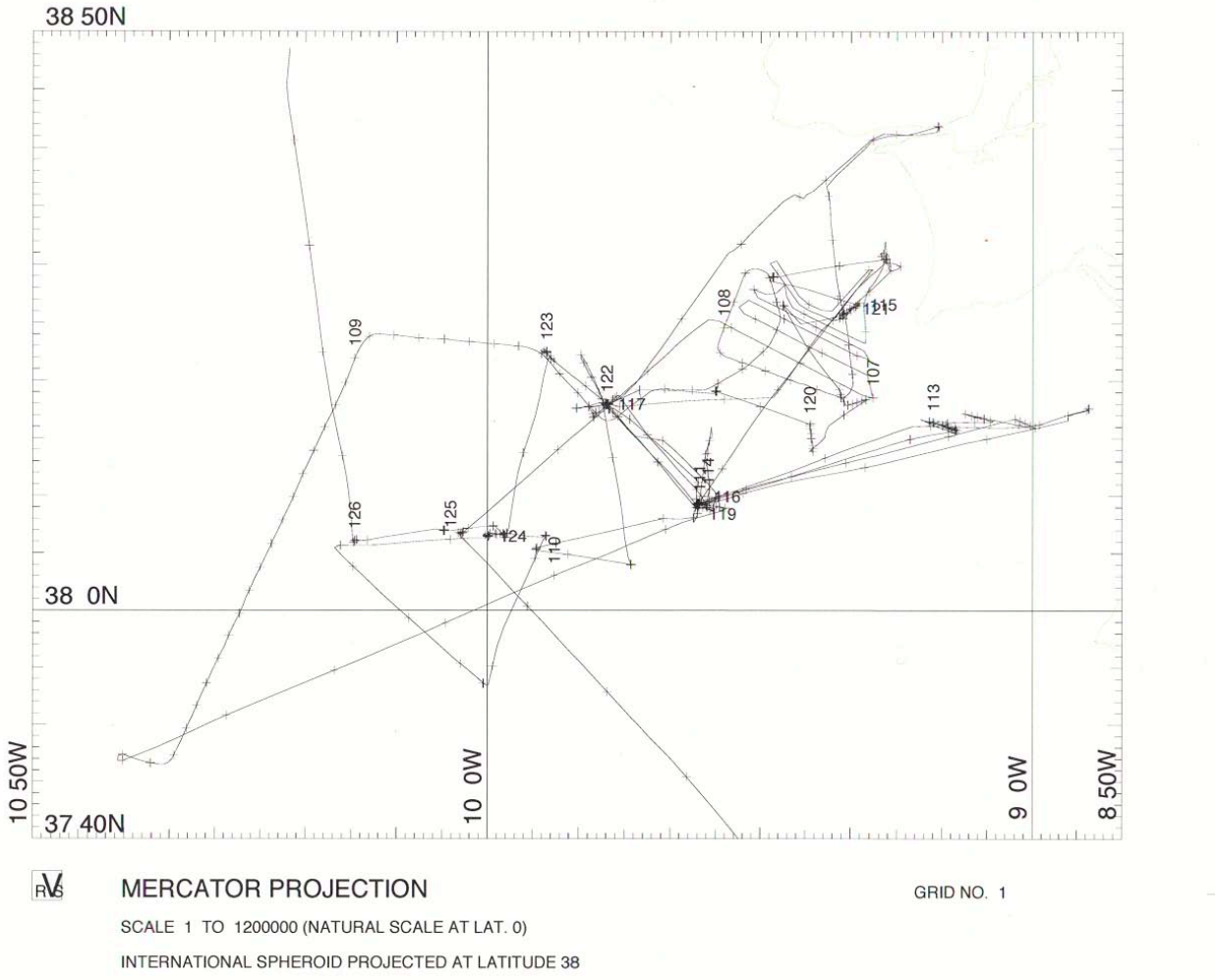

Figure 11. Detailed cruise track plot for Lisbon, Setúbal and Cascais canyons area.

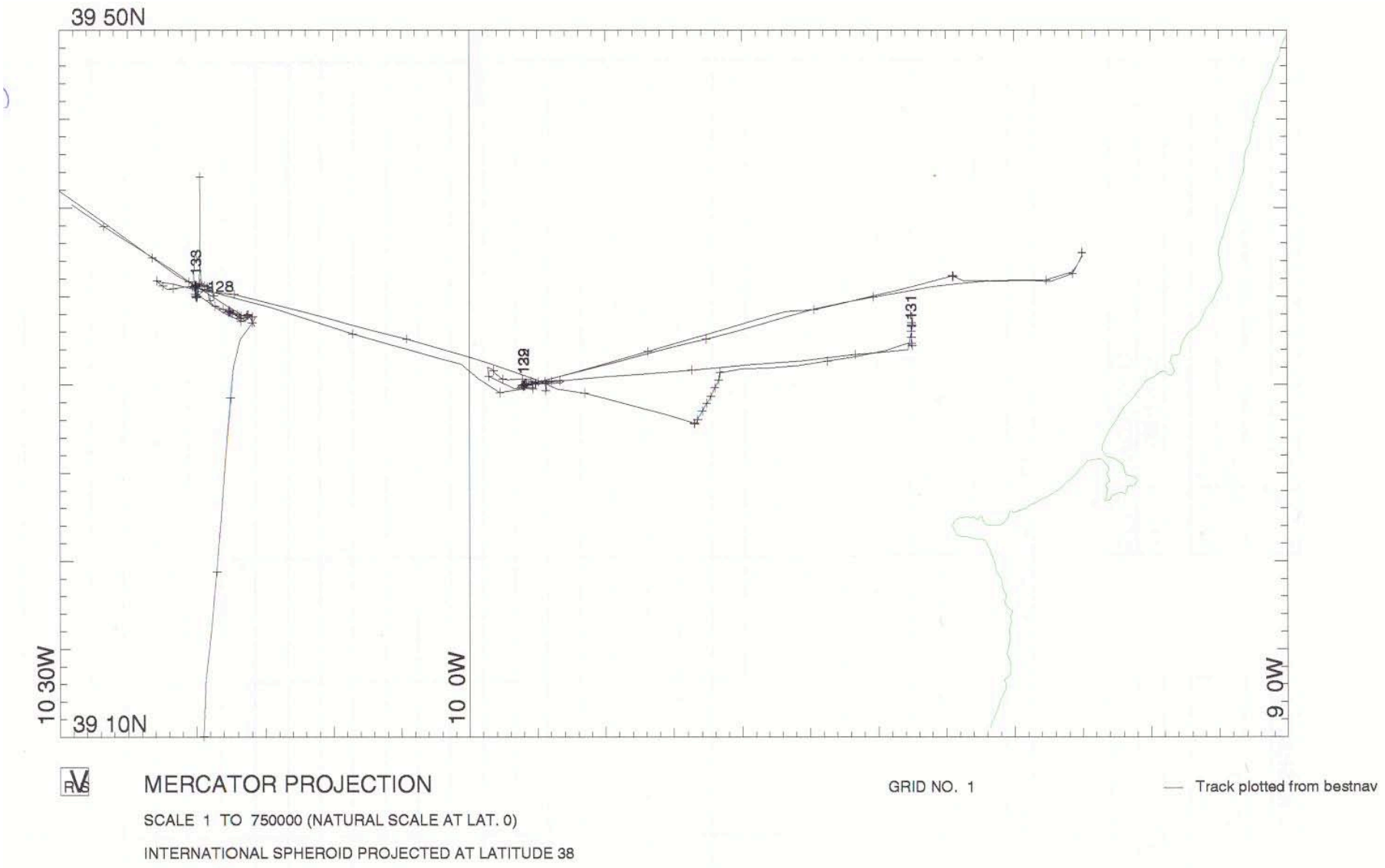

Figure 12. Detailed cruise track plot for the Nazaré Canyon areas.

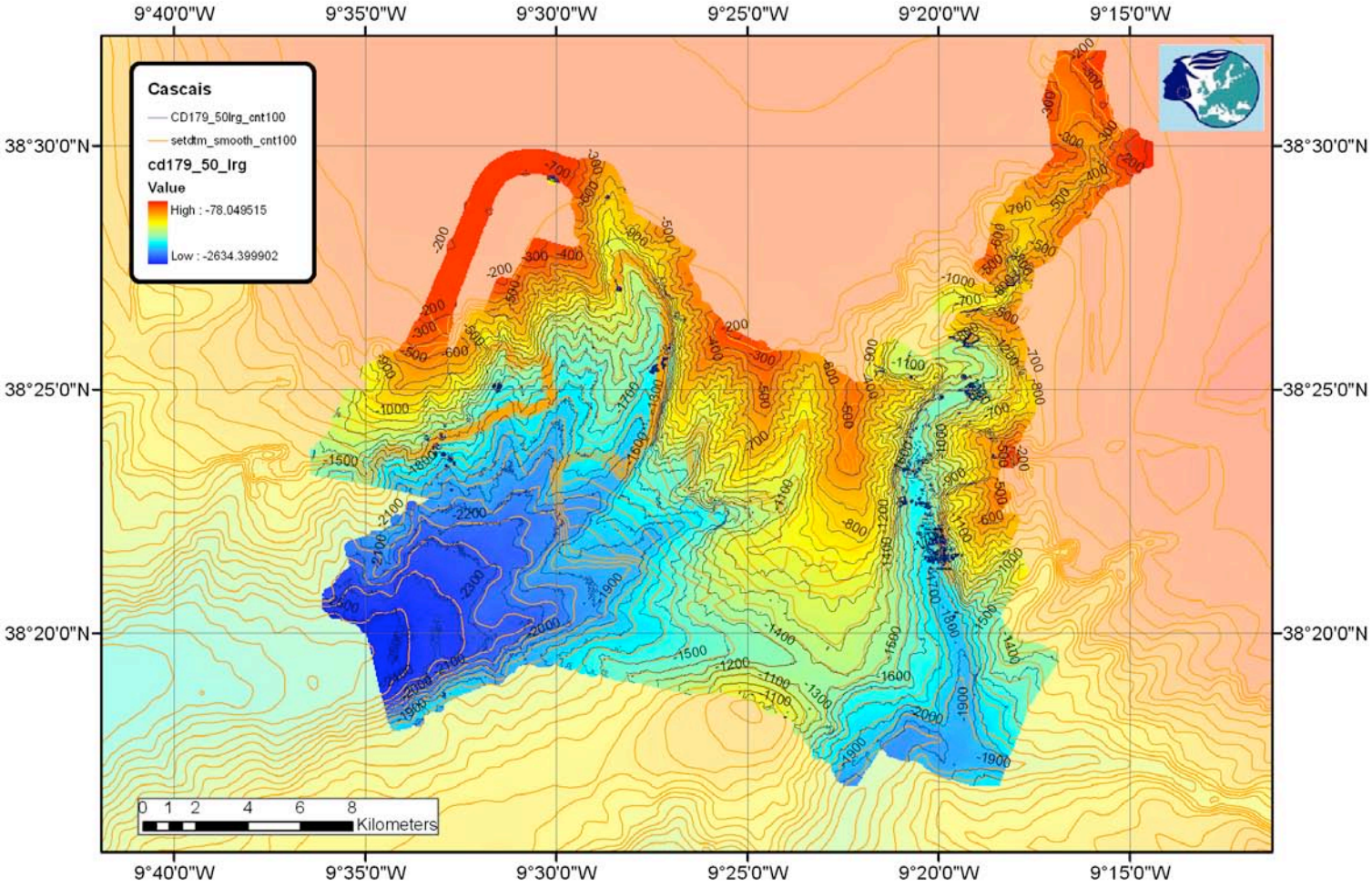

Figure 13. Swath bathymetry chart of new areas surveyed at the heads of the Lisbon and Cascais canyons

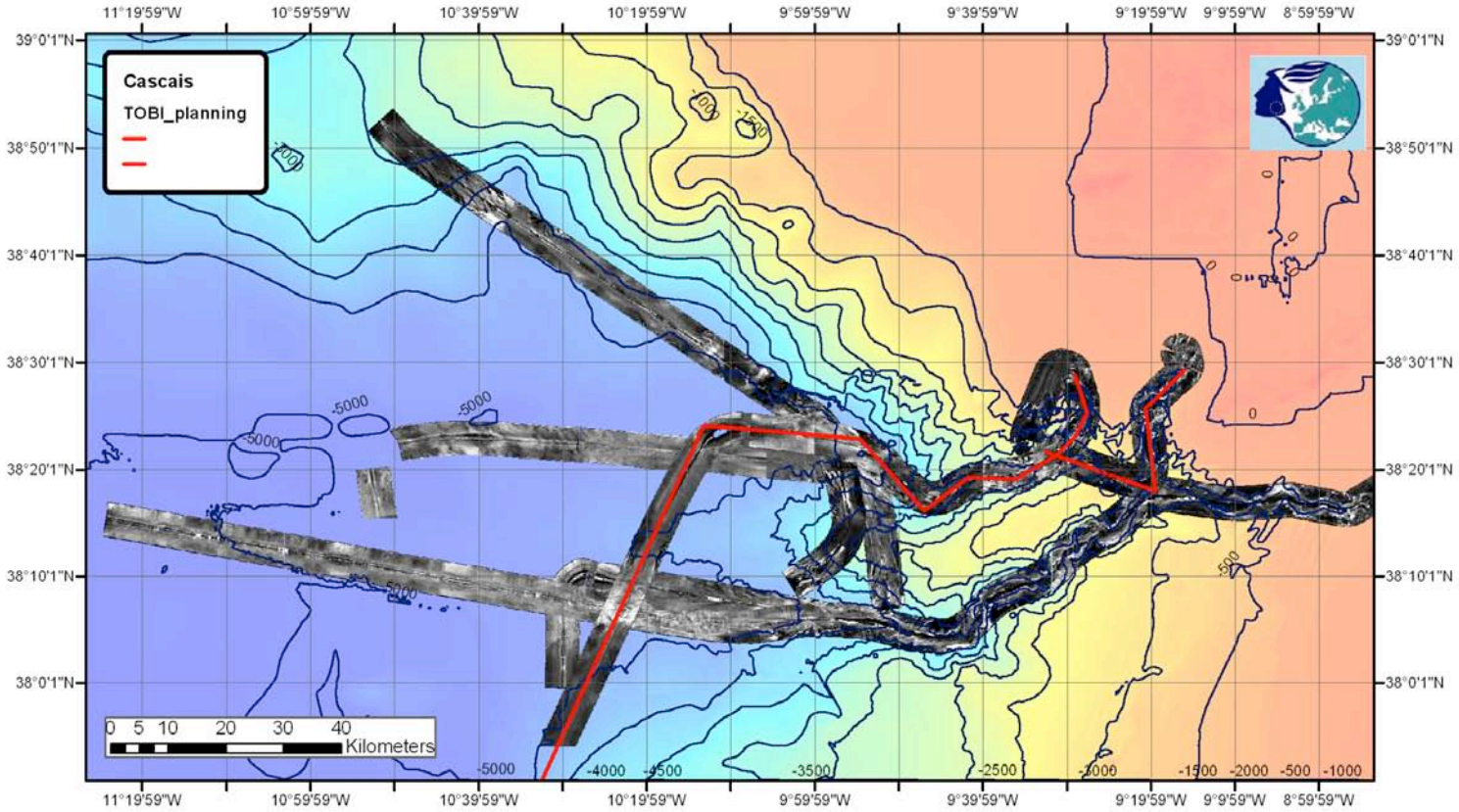

Figure 14. Chart showing existing and new (red line) TOBI side scan sonar surveys of the Portuguese margin canyons