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Foreword

This cruise report summarises operations onboard the *R/V Celtic Explorer* during cruise CE0705/BGS Cruise 07/06 on behalf of the MESH (Mapping European Seabed Habitats) European Union INTERREG IIIb project. The cruise took place between the 4th and 18th of June 2007 and surveyed an area located 320km southwest of Land's End in the SW Approaches. The aim of this cruise was twofold. Firstly, to map the variable morphology and biological communities within the canyon system of the SW Approaches with regard to assessing the extent of EC Habitats Directive (Annex I) habitats. Secondly, to test the application of the MESH Guidance framework for sea bed habitat mapping, covering all stages of a project from planning through survey, analysis, map production and finally the practical application of maps for environmental management (www.searchmesh.net).

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We would like to thank the officers and crew of the *R/V Celtic Explorer* for their professionalism, flexibility and welcome onboard. We would also like to thank Fabio Sanchetti (Marine Institute) for writing Appendix 5 and David Smith and David Wallis for contributions to Chapter 3.

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Summary

The aims of the *R/V Celtic Explorer* cruise were to acquire high resolution multibeam, sub-bottom profiler and camera data in the SW Approaches area, located approximately 320km southwest of Land's End (Figure 1). The cruise not only mapped the variable morphology of the SW Approaches area, but also investigated the biological communities within the canyon system for the assessment of potential Special Areas of Conservation (SAC) under the EC Habitats Directive (Annex I) (Johnston *et al*. 2002). The cruise also tested the application of the survey standards and protocols developed under the MESH project, being the first thorough test for the recently completed MESH Guidance Framework, and so providing a 'proof of concept' from planning to completion.

The work programme was highly successful with 1106km^2 of multibeam data, 44 photographic "ground truthing" sites and approximately 320 line km of sub-bottom data collected (Figure 2). The data revealed the predominant ground type to comprise rippled, muddy sand with boulder and bedrock only cropping out on the canyon flanks and floors. Sea cucumbers (Holothurians), squat lobster (*Munida rugosa*), numerous anemone and several starfish species, sea pens, shell debris and fish species were encountered. Interestingly, the canyon interfluves, or canyon tops, comprised numerous mounds up to 10m in height and ~80m in diameter. Significant amounts of coral rubble were observed coincident with these mounds and it is suggested that this area once hosted diverse carbonate mounds similar to those found on Porcupine Bank (ICES WGDEC Report, 2005; Roberts *et al.*, 2003) and the northern Rockall Trough (Masson *et al.*, 2003; Roberts *et al.*, 2003) but have since been destroyed.

Preliminary observations and interpretation of the data acquired during the course of this cruise suggest that several sites may fit the definition of Annex I reef under the EC Habitats Directive. If they fulfil the criteria for reef, they will be considered for SAC selection.

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1. Introduction

The objectives of the *R/V Celtic Explorer* cruise were to collect high-resolution bathymetry, backscatter, sub-bottom and camera data from the submarine canyons located in the SW Approaches. These canyons were being investigated to confirm the presence of habitats listed in Annex I of the EC Habitats Directive 92/43/EEC (EC, 1992), in particular Annex I reef habitat (Johnston *et al*. 2002), and to test the application of the MESH Guidance framework for seabed habitat mapping, covering all stages of a project from planning through survey, analysis, map production and finally the practical application of maps for environmental management (www.searchmesh.net).

The study area is located 320km to the southwest of Land's End (Figure 1). The area surveyed comprises continental shelf sloping south-westwards to the shelfbreak which occurs at a depth of approximately 200m. From there it passes down to the much steeper, deeply incised (canyoned) continental slope. The area surveyed includes two canyons and the eastern flank of a third canyon, straddling the UK/Irish median line (Figure 1). The elevated, flat topped areas between the canyons, called interfluves, vary in depth between 138 and 400m. Slope angles do not exceed 8º on the interfluves (Figure 3). The canyon heads and flanks have a complicated morphology, varying from 250m in the canyon heads to 1165m water depth at the base of the flanks with slope angles of between 16º and 71º (Figure 3). Due to the constraints of the multibeam system used for this survey, no data could be collected in water depths greater than 1165m.

The morphology of the present-day sea bed was influenced by a large scale drainage system present within the English Channel during eustatic lowstands (glacial conditions). There are two main hypotheses as to what formed the palaeovalleys located in the English Channel and the canyon systems located on the continental slope. One is that the English Channel hosted a palaeoriver, the 'Fleuve Manche', that flowed west through the English Channel, connecting with the canyons located on the continental slope feeding two deep-water fans (Bourillet *et al*., 2003). Another suggests that the palaeovalleys and canyons are a result of a catastrophic flood event caused by the breaching of a dammed pro-glacial lake located in the southern North Sea basin (Gupta *et al.*, 2007).

High resolution multibeam bathymetry and backscatter data (Figures 2 and 4) image the complex topography of these canyons. A complex gullied headwall produced by multiple retrogressive slope failures form characteristic amphitheatre-like depressions on the canyon flanks and head (Figure 5). Mounds, up to 10m in height and 80m in diameter, comprise coral rubble and may have once hosted diverse biogenic reef. These features are highlighted as areas of variable backscatter (Figure 4) and as areas of variable slope angle (Figure 3).

Sub-bottom data collected during this cruise provide information from below the sea bed and allow the evolving history of the SW Approaches area to be assessed. The topographic framework of this area was formed during the Early Cretaceous (116-107 Ma), subsidence created space for younger sediments to accumulate (Evans, 1990). Data collected image the Jones and Cockburn formations of the Neogene and the Melville and Little Sole formations of the Plio-Pleistocene (see chapter 4.1). The data reveal the upper continental slope to be

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underlain by the Little Sole Formation within which canyons were incised during periods of lower sea level in the Pleistocene (Evans, 1990). These canyons often cut through the Little Sole Formation and into the underlying Neogene and Paleogene sediments.

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2. Cruise Narrative

A list of personnel who participated on the cruise is included in Appendix 1. The daily logs are included in Appendix 2, summary seismic line logs are included in Appendix 3 and a table of camera transects is included in Appendix 4.

2.1. Description of Daily Operations

All times GMT unless stated otherwise

Monday 4th June (155)

Joined vessel at 07:30 (BST). BGS transport arrived at 08:00 (BST) and unloading of the lorry commenced at 08:20 (BST). Unloading onto the deck was completed and the transport had left Cobh dockyard by 10:20 (BST). The day was taken up with mobilising the seismic and camera equipment, securing all equipment on deck and setting up the lab with the seismic and camera computer equipment. Whilst alongside a health and safety briefing was given by Second Mate Richard Forde. Organising the laboratory space was completed by 22:15 (BST).

Tuesday 5th June (156)

The vessel sailed from Cobh at 07:00 (08:00 BST) and transited to a wet test site to deploy the Deep Tow Boomer (DTB) and the drop frame camera (51º 23.4993'N, 008º 26.8614'W, approx 90m water depth). The test of the DTB went well with data being received by the CODA software. The calibration run for the drop frame camera system began once the DTB had been secured on deck. Once the calibration photographs had been taken the calibration grid was removed and a test camera tow of 10 minutes was carried out. Problems were discovered problems with the Seatronics underwater video system HDD/DVD recorder. None of the University of Plymouth or Seatronics supplied DVDs were compatible with the Seatronics HDD/DVD recorder. Luckily, three DVD-RWs were available which were compatible with the system – a backup system has been devised on the server to ensure no data was lost. Minor glitches with the camera were rectified and the system was setup ready for our first camera work scheduled for Friday.

The weather was good, with clear skies and good visibility, wind speed 11-14 knots from the northeast.

Once the camera system was recovered and secured the vessel began transit to the start of the first multibeam line at 48º 20.7818'N, 009º 26.0828'W in the very south of the SW Canyon survey area. Due on site approx 08:00 on Wednesday morning.

Wednesday 6th June (157)

Arrived at the start of the first multibeam line at 08:20 (48º 20.6985'N, 009º 25.9696'W), CTD and SVP carried out and multibeam acquisition began by 09:30. Acquisition for this southernmost area was expected to take approximately 36 hours. The weather continued fair with good visibility, <1m wave height, 13-14 knot northeast winds. The wind strength increased to 19-22 knots from 20:00.

Thursday 7th June (158)

The day started overcast but with good visibility, <1m wave height on site and 16 knot north-easterly winds. Examination of the first 10 multibeam lines acquired revealed what appear to be a field of "mini mounds" approx 80-90m in diameter forming a band on the interfluve approx 8-10km in length in water depths of 270-320m. At the canyon head the canyons were imaged well with a change in depth of 190m on the interfluve to >800m in the canyon floor over less than 2km lateral distance. High backscatter response from the canyon floor indicated possible gravel lag / hard bottom which was not unexpected. Multibeam acquisition has been achieved in water depths down to ~950m, and occasionally in deeper water. Obviously the closer to the 1000m threshold of the capabilities of the system the quality of the data decreases slightly.

Multibeam acquisition in Area 3 (southernmost of the 3 adjoining sections) was completed at 20:00. 20 lines of multibeam had been collected in this area. The vessel transited to a location approximately 5 miles northeast of the start of the seismic line (runs down the southernmost interfluve running roughly northeast-southwest) and the BGS deep tow boomer and sparker were then deployed. After some initial problems with noise and power to the equipment SOL 1 commenced at 23:45.

Friday 8th June (159)

Seismic data acquisition was halted by 06:20 and the equipment secured on deck before transiting to the first camera site. Approximately 40 line km of DTB and sparker data were acquired. The first camera site was named C3_1 located on the crest of the southern most interfluve (48º 18.388336'N 009º 33.13774'W to 48º 18.690989'N, 009º 33.33149'W). This site comprised sand with shell debris. A number of trawl marks were identified. Fauna typically observed were asteroids, echinoids, burrowing anemones (abundant) and ophiuroids. Flat fish were abundant throughout the tow, with a single octopus and holothurian (*Stichopus tremulus*) observed.

C3_1 was completed by 08:18. Unfortunately a problem with the termination was discovered and the camera had to be reterminated before any further camera work could be undertaken. Therefore, multibeam acquisition continued in canyon Area 2; camera work was scheduled to re-commence at 07:00 on Saturday 9th June. What appeared to resemble a dried river bed approximately 800m in diameter and 6km in length was imaged at the boundary between Areas 2 and 3. The planned seismic lines were re-positioned slightly in order to best image this recently discovered feature. Seismic data acquisition (lines 3 and 4) collected (approx 66.5 line km).

The weather remained calm with wind speeds of 10-12 knots from a southerly direction. Wave height on site remained <1m.

Saturday 9th June (160)

Seismic acquisition continued until 07:00 in morning and resumed at 19:00 in the evening. The line plan for DTB and sparker acquisition had been altered to best resolve some of the sea bed features visible on the multibeam data. Following experience of acquisition on Friday night it was decided to split lines to minimise winching in and out of DTB and therefore retain data quality. In total 8 lines of seismic were collected totalling ~177 line km. Unfortunately line 2 (collected on Friday morning), collected in the deeper water section of the canyon separating Areas 2 and 3, was of poor quality due to water depth constraints of the equipment.

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Camera work scheduled for 07:00-19:00 shift was halted due to the termination failing on the first tow of the day (C3_2 over suspected mini mounds). While the camera was reterminated multibeam acquisition was resumed in Area 2. At 12:00 camera work was continued with 5 sites which covered a number of features. The remaining identified camera sites in Area 3 are scheduled to be visited on Sunday from 07:00.

C3_2 was the first of two tows in the possible mini mound area. This mounded area covered a depth range of between 270 and 370m, the shallower of the two proposed 'mini mound' tows (308m depth). The two tows revealed a sea bed comprised of predominantly fine grained sediment with coral debris. Occasionally cobbles were also visible and these were colonised by holothurians. Other dominant fauna were the squat lobster (*Munida rugosa*) and numerous anemone species.

C3_3 covered a shallow water area in the north of that surveyed (~230-260m water depth). This site was chosen to investigate a break in slope. The camera imaged a number of trawl marks with the sea bed comprising rippled sand with whole and broken shell debris. Discarded ropes were imaged on the sea bed. Over the break in slope, slope angles increased to over 20º and an increase in the number of cobble sized clasts was observed, however bedrock was not encountered at sea bed. Abundant fauna were sea pens and *Munida rugosa*, with signs of possible burrowing anemones with visible holes in the sediment.

C3_4 was chosen to investigate a significant change in backscatter at the canyon head in ~240m water depth. Due to strong currents in the area the camera tow tended to be pushed along the upper edge of an escarpment at the top of a canyon. The sea bed appears to comprise fine grained material. Burrowing anemones and *Munida rugosa* were both observed throughout the tow, with little other visible epifauna.

C3_5 followed a ridge crest in the canyon head before heading down the ridge slope of the ridge at right angles to the first section of the tow (365-470m water depth). The sea bed comprised clay/muddy material which adhered to the feet of the camera frame (sample retrieved). Roughly parallel ripples were evident on the sea bed indicative of the strong current in the area. Many burrows were visible in the soft sediment. Fauna were sparse along the tow, with only a few *Nephrops*.

C3_6 was in an area of high backscatter in the canyon floor (965-990m water depth). The sea bed was seen to be rippled but in contrast to the parallel ripples visible in C3_5, these were more chaotic, bifurcating and anastomosing, possibly indicative of strong currents from more than one dominant direction. Again the sea bed comprised clay/muddy material which adhered to the feet of the camera frame. Boulders and rock outcrop were also present, although lithology was not easily identified. Coral and shell debris were visible in areas of cobbles and boulders that may have been carried to the canyon floor by currents following being broken by trawling on the interfluves. Typical fauna attached to the boulders were the coral *Lophelia pertusa* and the holothurian *Psolus sp*, while fauna were sparse on areas of muddy substrate.

Sunday 10th June (161)

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The DTB and sparker were recovered by 07:33 and the vessel transited to the first of the days camera sites. The weather remained good with <1m swell/wave, reflected by the excellent data quality collected.

C3_7 was the second of the two tows on the mini mounds of the Area 3 interfluve (~350-365m water depth). Fine-medium grained sandy sediment was encountered. Patches of Lophelia fragments were observed which, upon analysis of their location, may correspond to the elevated mounds (up to 10m in height). Very few organisms were observed. It was suggested that perhaps extensive reef was once found in this location but had since been broken up.

C3_8 visited a site where Madrepora had been documented to exist in the past. The tow sampled water depths between 460 and 640m. Very few organisms were observed during the tow, although abundant holes in the sediment, probably from burrowing anemones, were visible throughout. The sea bed appeared to comprise fine grained sandy material near the beginning of the tow which became clay/muddy with patches of coarser material.

C3_9 was a tow to investigate biology between 660 and 790m water depth. Fauna was sparse, with a few burrowing anemones and rat-tail fish observed. The sea bed was again observed to be fine grained and rippled.

C3_10 was a tow to investigate the biology between 700 and 880m water depth. Dominant fauna were burrowing anemones, echinoids, asteroids, holothurians and fish.

C3_11 was the last tow on the southern flank of the canyon to investigate the biology at 690-760m water depth. Small burrows were visible throughout the tow (probably from burrowing anemones), and a single monkfish was visible. Again the sea bed was fine-grained and fairly homogeneous.

The last camera tow of the day was completed by 16:36. Multibeam acquisition was then resumed in Area 2. It is planned to complete acquisition in Area 2 then carry on with camera tows and seismic acquisition.

Monday 11th June (162)
Multibeam acquisition was completed in Area 2 by 12:16. The vessel then transited to the first of 3 camera tows scheduled for completion on this day.

C2_1 sampled the amphitheatre-like top of a gully at the canyon head between Areas 2 and 3 in 255-330m water depth. The tow covered a significant change in backscatter and a break in slope. Fine-grained sediments were observed and dominant fauna included brisingids (asteroids) and *Munida rugosa*, urchins, holothurians and rat-tail fish.

C2_2 sampled the flat-bottomed canyon observed between Areas 2 and 3. This is an area of high backscatter in 650m water depth. As the camera reached the seabed there were abundant fish (probably blue whiting). Along the tow, burrowing anemones and asteroids were visible in the fine-grained sediment bottom, with occasional eel-like fish.

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C2_3 Sampled the 'neck' of the canyon where the sea bed was elevated slightly compared to the deep flat-bottomed canyon to the east and the deep canyon proper to the west. The sediment observed comprised fine-grained rippled mud/clay although areas of bedrock outcrop were visible. The bedrock appeared to comprise ?Upper Cretaceous Chalk which was observed both exposed on flat sea bed and also occasionally as escarpments ~4-6m in height. Fauna were very sparse along this tow, with some blue whiting at the beginning of the tow. Throughout the tow some asteroids and anemones were visible. Where bedrock was present and there were lesser amounts of fine sediment a few small growths of coral (probably *Lophelia pertusa*) were observed.

Seismic data acquisition was resumed 20:45 with the first line located along the interfluve of Area 2. Even though a seismic line has already been collected over this interfluve, it was decided to site a second line to the north of the first. This had the dual purpose of serving as a replicate as we had experienced navigation problems during acquisition of the first interfluve line. It also acted to determine whether an infilled ?Pleistocene canyon on the top of the interfluve was laterally extensive. The second seismic line of this shift was run from ~200m to ~700m water depth down the flat bottomed canyon to get a better feel for why this canyon was more 'U-shaped' that the others observed so far which have been more typically 'V-shaped'. Another line was also collected running north across the interfluves of Areas 2 and 1.

Tuesday 12th June (163)

Seismic lines 9-11 completed by 07:05. The vessel then transited to the first of 5 camera sites to be visited today. The USBL for the camera suffered a recurring problem possibly related to a very small amount of moisture in the transponder. All the tows today were carried out using vessel position. Comparing vessel position and USBL position from previous tows revealed a high degree of confidence for the vessel position being sufficient accuracy for the camera tows. On camera site C2_6 approximately 4 minutes before the end of tow seaweed, coral fragments and other assorted debris were observed raining down onto the sea bed. The tow was completed soon after and the camera was winched up. However, it became apparent that the camera had gone under a trawl cable/net which was located roughly 70m above the sea bed at the end of the camera tow. The camera was lowered back to the sea bed and the vessel retraced its course to the beginning of the camera tow. This pulled the camera back from underneath the obstruction and the camera could be recovered. No damage was sustained to the camera frame or cable and another 2 camera stations were visited after this incident.

C2_4 was a biological transect on the canyon flank between 400 and 410m water depth. The sea bed comprised fine-medium grained sediment with shell fragments either a result of strong currents or have been transported there from shallower areas following trawl activity. There were small areas of rippled sea bed observed, but the ripples were not widespread. Fauna was sparse, with some anemones (2 species) flat fish and rat tails.

C2_5 was a biological transect on the canyon flank between 540 and 690m water depth. The sea bed was more muddy/clay in composition compared to the shallower transect of C2_4. This tow revealed a different habitat to that seen so far. From approx 350m into the camera tow the number of sea pens observed increased significantly. Near the end of the tow, blue mouth red fish were encountered indicative of nearby rock/reef habitat, however the video and camera images only sampled clay/mud sea bed although the presence of that species of fish indicated

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that we were close to reef habitat. Throughout the tow, there were abundant cerianthids holes, and anemones.

C2_6 was a deeper biological transect in water depths between 780 and 940m water depth. Again clay was observed at sea bed. Fauna was sparse throughout the tow, with only cerianthids visible, with little other organisms.

C2_7 was located at the western end of the interfluve of Area 2 in 700-840m water depth. At the start of the tow rippled muddy sand was encountered. The occasional trawl mark was observed. As the tow progressed sea pens were observed with the polyps facing downslope probably into the prevailing current direction. Other fauna that were observed were burrowing anemones, asteroids and bamboo corals (gorgonians).

On tow C2_8 fauna was sparse throughout the tow, with only a few burrowing anemones and asteroids. As the tow continued, the pencil urchin *Cidaris cidaris* was visible, and a single blue-mouth redfish.

Camera work was complete for the day by 18:30. The vessel transited to Area 1 in order to complete multibeam for the flank of the canyon between Areas 2 and 1 and the canyon head. This served the dual purpose of allowing us to choose the essential biological transects required for analysis of the two canyons allowing us to be ready to carry out transects when time/weather permits rather than having to wait until the entire area 1 had been covered by multibeam. The multibeam data would also be used to re-site the seismic lines in the canyon head area.

Wednesday 13th June (163)
Multibeam data collection in Area 1 continued until 07:20 when collection was halted in order to continue with camera work. Camera transects C2_9 and C2_10 were both biological transects at medium (~560-660m) and shallower (~390-440m) depth sections of the canyon flanks respectively. Both camera tows sampled rippled muddy sand with asteroids, echinoids, cerianthids and fish present.

Site C2_11 transected the floor of the northernmost canyon (~840-900-940m depth). Bedrock was encountered during this transect initially covered by a thin sandy veneer. Escarpments of bedrock were imaged as the tow progressed on which numerous species were anchored, including *Madrepora oculata*, anemones and gorgonians. At the end of the tow a rippled veneer of soft sediment was imaged with bedrock visible in the troughs of the ripples. Discarded rope was imaged during this tow entangled in coral.

Site C2_12 imaged a tributary in the canyon head in water depths of between 170 and 180m. At the beginning of the tow the sea bed comprised muddy sand with some shell fragments. As the tow progressed into deeper water the proportion of shell fragments increased. Several instances of discarded rope and boxes were imaged. Where bedrock was encountered, abundant crinoids were observed anchored to the hard substrate. Other fauna visible throughout the tow were squat lobsters (*Munida rugosa*) and the pencil urchin *Cidaris cidaris*.

Site C2_13 imaged an area of the canyon head of the northernmost canyon (~470-600m depth). Bedrock was encountered coinciding with a break in slope visible on the multibeam dataset.

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Attached to the exposed edges of the bedrock were small growths of *Madrepora oculata* and hydroids.

Site C2_14 was another deep transect in the northernmost canyon floor along a ridge (~830-950m). Patch biogenic reef was encountered with dead *Lophelia pertusa* framework and live *Madrepora oculata*. Other fauna present were, cerianthids, antipatharians, crinoids, crustaceans and fish. The patch reef appeared to form linear areas of reef separated by linear patches of rippled sandy sediment. It may be that bedrock was close to the sea bed and comprised an eroded, uneven surface. Where the uneven surface formed a topographic high, biogenic reef has been able to colonise the hard substrate, whereas soft sediment has pooled in the depressions.

Site C2_15 was a biological transect in ~450-660m water depth which visited a historical gorgonian record. The sea bed comprised sandy mud with numerous burrows (*Nephrops*). Epifauna was composed of holothurians and a few asteroids.

Camera work was completed by 18:40 and seismic data collection continued, starting with line 12. The weather continued to be good for the cruise, although the wind speed had increased from 10-12 knots to 18-22 knots during the course of the day. Wave height on site remained between 1 and 1.5m.

Thursday 14th June (164)
Seismic lines 12-16 were collected overnight with seismic operations completed by 08:00. In total ~320 line km of seismic has been collected in the survey area. Following completion of the seismic survey the vessel transited to Area 1 to continue the multibeam survey.

Friday 15th June (165)
Multibeam acquisition was complete in Area 1 by 15:00 allowing camera work to continue. With seismic survey complete, camera work continued overnight. Camera tows C2_16-20 were completed. All these tows centred on the northernmost canyon.

C2_16 was located on the end of the interfluve in 800-900m water depth. It was suggested that the interfluve end is subjected to strong currents as the camera was pushed along quickly and unfortunately many of the photographs were blurred as a result. However, sandy mud/muddy sand was observed with some bedrock observed at sea bed. Fauna attached to the bedrock were bamboo corals and live *Madrepora oculata*.

C2_17 and C2_19 were biological transects in 345-410m and 660-810m water depths respectively. Both covered breaks of slope observed on the multibeam data and C2_17 was also coincident with a historical coral site. The sea bed comprised muddy sand/sandy mud with little visible fauna other than ophiuroids and cerianthids.

C2_18 was a biological transect in 690-850m water depth. Bedrock was encountered at the start of the tow, probably composed of chalk. Patches of dead *Lophelia pertusa* with live *Madrepora oculata* were attached to the exposed bedrock. As the tow progressed no bedrock was encountered with sandy mud the dominant sea bed type encountered.

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C2_20 was located on the southern flank opposite C2_14 in comparable water depths to explore whether the patch biogenic reef extended onto both flanks of the canyon. Unfortunately an extensive patch reef was not observed at this location. Fauna were sparse throughout the tow, and concentrated along the exposed bedrock edge, these included anemones and burrowing ophiuroids. The sea bed predominantly comprised a muddy sand veneer overlying chalk bedrock.

Saturday 16th June (166)
A total of 13 camera tows were completed during the course of the day.

C2_21 and C2_22 were both located on the top of the central interfluve and examined mini-mounds which have a variable backscatter response. On both tows muddy sand was encountered with areas of increased proportion of coral fragments that coincided with the camera crossing over the mounds. It was suggested that the mounds were once colonised with biogenic reef that had since been broken up, possibly by trawling.

C2_23 was on the end of the interfluve and was visited to compare with C2_16 where coral was encountered on the end of the interfluve to the north. Sandy mud was encountered with varying proportions of lithic and shell gravel. Bedrock frequently cropped out at sea bed. Similar fauna were found at both sites, with two species of sea pens, cerianthids, and bamboo corals.

C2_24 and C2_25 were both biological transects on the canyon flank. Both transects encounter muddy sand. Typical fauna observed from both tow were echinoderms and sea pens.

C2_26 was located in the shallow canyon head of the southernmost canyon imaged (~300-400m water depth). The sea bed composition graded from muddy sand to muddy sand with lithic and shell gravel back into muddy sand from the start to the end of the tow. Fauna included the squat lobster *Munida rugosa*, sea pens (with associated ophiuroids) asteroids and flatfish.

C2_27 was located in the shallow water 190m in depth. The sea bed comprised rippled fine to medium grained sand.

C2_28 was located in the canyon head of the northernmost canyon imaged in 230-370m water depth. The tows began with rippled muddy sand imaged, as the tow progressed into deeper water bedrock was visible beneath a veneer of rippled muddy sand. Fauna observed within the muddy sand habitat included crinoids, ophiuroids, holothurians and squat lobsters. Fauna associated with the bedrock were ophiuroids and hydroids. Fauna was similar to that observed along C2_12.

C1_1 was a long transect along the base of the canyon flank in Irish territorial waters. The transect was in 800-880m of water and was approximately 1.4km in length. The dominant sea bed type encountered was muddy sand with varying amounts of shell debris. Bedrock was encountered and appeared to comprise chalk. The soft sediment habitat had numerous visible fauna including cerianthids, sea pens, holothurians and asteroids, while the bedrock had some isolated bamboo corals attached.

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C1_2 was located in 280-300m water depth and was in an area of high backscatter. Rippled muddy sand was imaged, few epifauna were visible, with the exception of *Munida rugosa*.

C1_3 was a biological transect in 350-440m water depth. The transect crossed a break of slope over what resembles a retrogressive slide/slump. The sea bed was composed of muddy sand with varying amounts of shells and pebbles. Cerianthid anemones were abundant throughout the tow, with little other visible fauna.

C1_4 was a biological transect in 530-700m of water. The same sea bed composition as C1_3 was encountered, along with outcrops of bedrock, which coincided with a break in slope visible on the multibeam data. Fauna were more abundant throughout this tow, with asteroids, cerianthid and sea pens visible.

Camera work was completed by midnight concluding operations of the cruise. Once the camera was secured on deck the vessel began transit to Galway.

Sunday 17th June (167)

The vessel continued transit to Galway. Equipment in the lab was demobilised and as much as possible of the seismic equipment on deck and the drop frame camera. A number of tasks had to wait until the vessel is along side in Galway.

Monday 18th June (168)

Vessel was tied up in Galway by 06:40. A post-cruise meeting took place at 10:00 between scientific personnel on board, the captain, onboard technician and RV Ops from the Marine Institute. Equipment was offloaded between 14:00 and 14:30 and all personnel had departed the vessel by 17:00.

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3. Equipment Used

Please see Figure 6 for the location of primary pieces of equipment and offsets.

3.1. Navigation

Primary navigation and positioning is by the Fugro Starfix-HP (High Precision) GPS positioning system. All data acquisition systems took their time stamp from this navigation signal ensuring seamless positioning of all the data types acquired during this cruise. The Starfix HP performed well during operations with only one significant occurrence of loss of navigation from 03:27 to 04:54 on the 9th June 2007 during seismic data acquisition on line 4.

The USBL navigation system is based upon the French-designed GAPS (Global Acoustic Positioning System). The system is fully integrated into the primary DGPS. Some problems were experienced with the USBL system, particularly towards the latter half of the cruise.

3.2. Multibeam

The Simrad EM1002 system is designed for high-resolution sea bed mapping in water depths of less than 1000 m. The hull-mounted system operates at a frequency of 93-95 kHz and precise phase and amplitude detection provide accuracy in a variety of survey conditions and water depths. A fixed swath coverage of 660m was utilised throughout, to maintain a beam spacing of at least 5% of water depth, providing the acceptable data density and data quality. In fixed coverage mode the system automatically adjusts the angular coverage to achieve the desired swath width. Survey lines were orientated perpendicular to slope in order to optimise survey time. The 660m line spacing also optimised the quality of the backscatter data. Processing was carried out onboard using CARIS HIPS and SIPS and a variety of output formats were produced including the processed xyz files, ArcGIS raster files, Geotiffs and Fledermaus files. Information on sound velocity profiles and calibration carried out during this survey are included in the report on the multibeam system (Appendix 5).

3.3. Multi-tip Sparker System

Source: EG&G, nine candle, multi-tip array with 135 tips. At times during the course of this cruise, it was sufficient to only operate with 90 tips. Power is supplied from an Applied Acoustic Engineering CSP-D HV Bangbox, running at 1000 Joules per shot on lines 1-7, 1250 Joules per shot on lines 8-11, 750-1500 Joules per pulse on line 12 and 1500 Joules per shot on lines 13-16. The CSP-D utilised the ship's main 240V 'domestic' power on a 16A circuit breaker. The Sparker was fired once every 6 seconds, interleaved with the Deep-Tow Boomer firing.

Hydrophone: SIG 7 channel, 10m hydrophone streamer and SIG preamplifier with all channels summed to give a single channel output. The summed output was fed into the British Geological Survey (BGS) own designed amplifier that incorporates low pass and anti-alias filters and manually adjustable analogue gain to compensate for acoustic losses with water depth. For the Sparker system the bandpass filter is between 100 and 1730 Hz.

Recording: The recording system is a CODA DA200 with twin displays and set up to digitally record two seismic sources simultaneously, in this case the Sparker and Deep Tow Boomer.

The output data is stored onto removable hard drive with an archive copy on two external hard drives in CODA and SEGY format. The Sparker signal was sampled at 5000Hz.

3.4. Deep Tow Boomer System

Source: The Deep Tow Boomer system is a towed negatively buoyant fish comprising a 'boomer plate' transducer, high voltage storage and discharge system, a short hydrophone streamer and various sensors and controls. The high voltage power is supplied by a 240VAC to 6000VDC transformer on the vessel. The power is transmitted down the umbilical cable to the tow fish where it is stored in a capacitor. The system has variable output powers, on this project 500J per shot was utilised. The Deep Tow Boomer was generally fired 3-4 times in every 6 seconds, depending on water depth and the height of the tow fish from the seabed, interleaved with the Sparker firing.

Depth Compensation: The Deep Tow Boomer pre-amplifier control unit has an inbuilt depth compensation unit controlled by a pressure sensor in the tow fish to allow for winching in and out of the cable during survey. The change of tow depth is automatically compensated for in the advance/delay of the recording trigger pulse. This depth compensation also acts as a very good heave filter (the advance/delay was checked prior to the MESH cruise at BGS marine operations, Loanhead and found to be correct (~1ms) for a sound velocity of 1500m/s.). This depth compensation works in increments of 200m and so the operator can switch between increments to optimise the data recorded. This action causes a delay change (advance or delayed depending on whether the tow fish is being winched in or out) in the recorded data causing the delay jump evident on the records.

Hydrophone: A 2m, 6 element deep water BGS streamer was used during this cruise. The streamer signal is fed into the Deep Tow Boomer control unit. The depth compensated analogue signal output is then fed into the BGS own design amplifier. The amplifier incorporates low pass and anti-alias filters and manually adjustable analogue gain to compensate for acoustic losses with water depth. For the Deep Tow Boomer the bandpass filter is between 450 and 4500 Hz.

Recording: The recording system is the CODA DA200 as described above in section 3.3. The Deep Tow Boomer signal was sampled at 10,000Hz.

3.5. Precision Echo Sounder (EA600)

The Simrad EA600 single beam system is a multi frequency hydrographic echo sounder. The system installed on the Celtic Explorer has three main transducers and a shared transducer with another system. The three main frequencies are 12kHz, 38kHz and 200kHz with the shared transducer at 120kHz.

3.6. Seatronics DTS 6000 Drop Frame Camera

The Seatronics drop frame system was deployed from the starboard side of the vessel. The system comprised a 5 mega pixel Kongsberg and Imenco digital stills camera, and an integrated DTS 6000 digital video telemetry system. Both video and stills cameras were mounted at an oblique angle to the sea bed to aid in species identification. Sensors monitored depth, altitude and temperature. A USBL beacon provided positional information for 14 camera tows, however, for the latter 30 tows the USBL was not working and vessel position was used.

4. Data Examples and Preliminary Observations

The following chapter describes the initial interpretations and biological observations made during this MESH cruise. The general morphology and geology of the SW Approaches survey area is described followed by an assessment of the biological communities observed. Observations of the anthropogenic debris encountered are also summarised. A comprehensive interpretation of all the data collected will be presented in the final report for this project.

4.1. Morphology and Geology of the Canyons

The area surveyed ranges in water depth from 138m on the continental shelf in the northeast of the area down to a maximum depth of 1165m in the bottom of the canyons imaged (Figure 2). The flanks and head of the canyons comprise networks of gullies which merge down into the main canyon, mimicking on-land drainage basins (Figure 7). Both v-shaped and u-shaped tributaries have been observed in the canyon heads during this survey and can be up to 250-450m in depth before joining the main canyons which are in excess of 800m in depth from the continental shelfbreak to the canyon floors (Figure 2). The slopes of north facing flanks have a smoother profile than those facing south, this is suggested to be related to northerly flowing deep water currents (Figures 2 and 7). Tributary gullies incised into the interfluve in Area 1 are incised further back into the interfluve than tributaries identified in Areas 2 and 3 (Figures 2 and 7). Why there is a difference in erosion between interfluves will be investigated in depth during further studies of the data.

The dominant sea-bed type observed during photographic 'ground truthing' was muddy sand in water depths generally less than 700m and sandy mud and mud in water depths greater than 700m (Figures 8-13). Occurrences of gravel were dominated by biogenic debris. However, lithic fragments were observed comprising a variety of lithologies, suggesting they were not derived locally. An example of biogenic gravel observed is coincident with sea-bed mounds located on the interfluves (Figure 12). The influence of currents is obvious as many of the camera tows image rippled sediment and occasionally the drop-frame camera itself was subject to strong currents.

One hypothesis for the formation of the canyons centres on the 'Fleuve Manche', a large river system that had a catchment which included many major west European rivers (Bourillet *et al.*, 2003). It is suggested that the network of palaeovalleys present in the English Channel and inner continental shelf are indicative of the palaeoriver and are connected to the canyon systems on the continental shelf (Bourillet *et al.*, 2003). An alternative theory suggests that the canyons may be the result of erosion during a megaflood event (Gupta *et al.*, 2007). It is suggested that a megaflood caused by the breach of a rock dam at the Dover Strait not only excavated the palaeovalleys of the English Channel but also aided the incision of the continental slope (Gupta *et al.*, 2007). However, a single event would not explain the series of infilled channels identified on some seismic lines.

Generally high sea levels during Late Cretaceous times led to the deposition of a blanket of Chalk 500m in thickness (Evans, 1990). The uppermost part of the Chalk lies in the Paleocene (Danian) (Evans, 1990). On top of the Chalk, the Jones and Cockburn formations of the Neogene form a progradational, deltaic sequence of sediments. A fall in sea level during the

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Late Miocene was followed by the deposition of the Little Sole Formation that represents a significant influx of sediment resulting from erosion of the inner continental shelf (Evans, 1990). Outcrops of rock observed during photographic 'ground truthing' probably comprise claystones of the Little Sole Formation in shallower water and the Cockburn and Jones formations on the deeper sections of the canyon flanks and floor.

4.2. Biological Communities

The biological communities observed during the cruise are summarised below by camera tow (for location see Figure 18) and subdivided into areas of survey listed from south to north (Figure 2).

4.2.1. Area 3

C3_1

The camera failed three times within the tow, thus there are gaps in the video/camera tracks.

The target was a change in backscatter response. The tow revealed one continuous habitat of flat sea bed consisting of medium-grained sand with some biogenic material (predominantly shell debris). There were some signs of both hydrodynamic activity, with the presence of small sand ripples, and bioturbation in the form of echinoid tracks. Typical fauna that were observed throughout the tow were echinoids (possibly 2 species), asteroids (including *Astropecten irregularis*), cerianthids, ophiuroids, tube annelids and abundant flatfish.

C3_2

The target was an area of mini-mounds (approximately 10m high) located on the interfluve of Area 3 identified using multibeam data. The cable termination failed after 4 minutes, thus the tow was abandoned and the data files logged as 2a. Once the cable had been re-terminated the tow was undertaken again, logged as 2b.

2a

The tow began on an area of shelly sand with bioturbation in the form of holes and burrows. Dominant fauna were the squat lobster *Munida rugosa.* After 4 minutes the camera failed and thus the tow aborted.

2b

The camera transect began on an area of slightly silty sand with shell debris. Throughout the tow there were patches of coral debris and occasional boulders. Towards the end of the tow, less biogenic material was apparent, but with abundant bioturbation in the form of holes (possible *Cerianthus* burrows). Dominant fauna were *Munida rugosa*, numerous anemone species and flatfish.

C3_3

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The target was a change in backscatter and slope. The tow began on an area of muddy sand with occasional deposits of biogenic material (shells). Dominant fauna were sea pens (possibly *Funiculina sp*.) ophiuroids and *Munida*. As the track continued the sediment became more silty with noticeably fewer sea pens, but with more biogenic material (shells) pebbles and ophiuroids. The camera then transversed down a slope of approximately 21^{o}, before the terrain levelled off for the remaining part of the tow. The slope coincided with a break in slope interpreted on the multibeam data and some cobbles were visible in places on the slope. There were signs of bioturbation, with the presence of holes, probably from cerianthids. Discarded fishing rope was observed.

C3_4

The target was a change in backscatter within the canyon head. The tow began on an area of flat sea bed comprised of muddy sand with mud deposits and shell debris. Conspicuous fauna were cerianthids, squat lobsters (*Munida rugosa*) ophiuroids and abundant echiurans. As the tow progressed, the substrate remained homogenous for approximately 200m. Subsequently, the camera reached a break in topography, in the form of a steep slope. As the camera progressed, both the current speed and the slope angle prevented landing of the camera. Dominant fauna that were visible throughout the latter part of the tow were mysid shrimp and *Munida*.

C3_5

The target was a ridge and ridge flank within the canyon head. The first part of the tow began on the crest of the ridge with the second half traversing down the ridge flank. The tow revealed a continuous substrate of muddy sand with prominent silt. There were signs of some infaunal activity, with the presence of holes in the sediment, which were probably from cerianthids, although none were visible. There were also signs of hydrodynamic activity in the canyon head comprising unidirectional sand ripples. The second part of the tow descended down the ridge flank into a gully in the canyon head. As the camera began to descend the flank, the ripples became more prominent and regular. Fauna were not abundant, with only a few *Nephrops* and anemones visible. As the tow progressed down the flank, the substrate was unchanged, but there were visible signs of deposition of material (mud lumps and shell debris). There was no sign of hydrodynamic activity from the latter part of the tow.

C3_6

The target was an area with high backscatter response, on the canyon floor. The tow began on an area of muddy sand with prominent ripples. Occasional boulders with attached epifauna were also visible. As the tow progressed the substrate remained homogenous, with a change from relatively flat sea bed to one of variable relief due to boulders. Fauna were not particularly abundant on the substrate, but were concentrated on the boulders. Typical fauna attached to the boulders were the holothurian *Psolus sp*. and the scleractinian coral *Lophelia pertusa*. Other fauna included large anemones, cerianthid anemones and ophiuroids. The tow continued into an area with coral debris (rubble), with silt cover, thus suggesting that the damage to the framework reef is not recent. As the camera continued into deeper water, the coral rubble became denser with larger rocks present. Again, the same fauna were observed on cobbles

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and boulders as previously seen. Discarded fishing net and plastic bags were visible. (Figure 9)

C3_7

The target was an area of mini-mounds with variable backscatter. The tow revealed two distinct habitats, intermittently dispersed. The transect began at the edge of the mound field on an area of muddy sand with some biogenic material (shell). There were patches of bioturbation (small holes) and cerianthids. As the camera tow progressed (approximately 100m along) patches of coral (*Lophelia pertusa*) debris were visible, with *Munida* present. The debris had some silt coverage and was broken up, thus suggesting that the damage to the *Lophelia* framework was not recent. The camera then passed over another area of muddy sand with cobbles and pebbles, with abundant anemones. The tow continued into another area of coral debris, similar to that previously observed. As the end of the tow was approached, the proportion of coral debris decreased and the sea-bed composition returned to muddy sand with occasional cobbles with abundant anemones. Discarded fish rope was observed.

C3_8

The target was the shallow section of the southern flank of the canyon. The transect began at the canyon edge on an area of very silty muddy sand with occasional cobbles and cerianthid anemones and a few fish. As the camera continued along the tow, the slope descended fairly rapidly over clay dominated substrate. This substrate continued to an approximate depth of 550m, after which the substrate became sandier with fine biogenic (shell and coral) material in distinct bands, with burrows present (probably cerianthids). The slope angled downward for the remainder of the tow.

C3_9

The target was approximately midway down the southern canyon flank in deeper water than C3_8. The tow began on an area of rippled muddy sand with some biogenic material (shell). A few cerianthids were visible, with little other fauna. As the camera continued along the tow, the substrate became siltier with clay lumps (deposits) and a few isolated cobbles. Grenadier fish and asteroids were observed throughout the tow.

C3_10

The target was located near the base of the southern canyon flank in deeper water than C3_9. The tow revealed a homogenous substrate: muddy, silty sand with parallel ripples observed for the majority of the tow. Conspicuous fauna were cerianthids, echinoids (*Calveriosoma fenestratum*), asteroids, holothurians and fish.

C3_11

The target was the end of the interfluve of Area 3. The tow revealed one continuous habitat of muddy sand with some cobbles scattered throughout. Parallel ripples were visible during the latter part of the tow, with some gravel deposits located in the troughs of the ripples. Small burrows were visible throughout, probably cerianthid burrows. A single monkfish (*Lophius*

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piscatorius) was seen. Other fauna observed included the echinoid *Calveriosoma fenestratum*, spider crabs and asteroids.

C3_12

The tow is located in the gullied canyon head in Area 3. The tow began on an area of muddy sand with prominent ripples. Fauna were sparse, with a few pencil urchins (*Cidaris cidaris*), eel-like fish echinoids and anemones. Approximately 270m along the tow, a slope was encountered which dropped off to an area of what appeared to be either large mud deposits or cobbles covered in mud. Very few epifauna were visible. The relief of the sea bed continued to gradually slope downwards towards an area of bedrock outcrop with a thin veneer of sediment. Subsequently, the substrate graded back to muddy sand, with patches of underlying bedrock visible, with a more abundant cover of fauna. This continued until the end of the tow when a bedrock ledge with a veneer of sediment was encountered.

4.2.2. Area 2

C2_1

The target was a change in backscatter along the upper edge of the canyon. The tow began on an area of muddy sand with poorly defined ripples. Fauna were abundant, with dominant brisingid asteroids and squat lobsters (*Munida rugosa*). As the tow progressed the substrate became coarser with some biogenic material present. *Munida* and urchins were again the dominant fauna observed. A few sea pens were also seen. As the tow proceeded the gradient increased coinciding with a decrease in the fauna observed. Once the break in slope was passed the same fauna was observed as seen previously. Where more cobbles with a fine covering of silt cover were observed, fauna included holothurians, *Munida*, urchins and a few fish. The habitat graded into muddy sand with occasional cobbles, with little fauna other than *Munida*, rat-tail fish and anemones. As the tow neared the end, the substrate became finer comprising muddy sand.

C2_2

The target was a high backscatter response in the canyon floor area of the canyon head suggesting the presence of hard substrate. The tow began on an area of flat sea bed comprised of sand, with abundant fish (blue whiting). As the tow proceeded the substrate became finer with slight rippling. Blue whiting were again present, with some cerianthids, asteroids and eel-like fish. Further along the tow occasional cobbles were present, but with little attached fauna. As the tow continued, the habitat changed to a homogenous muddy sand substrate.

C2_3

The target was an area of complex sea bed topography located at the foot of a flat bottomed canyon. At the beginning of the tow the substrate comprised fine-grained sand area with coral fragments and occasional cobbles, little fauna were present other than fish. As the tow proceeded there were bedrock ledges with a veneer of fine-grained sediment, subsequently to which boulders and rock outcrop were encountered. The bedrock appeared to comprise softer

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lithologies rich in carbonate with no visible fauna were attached with the exception of one outcrop where coral was observed to be attached. Fauna were not particularly abundant throughout the tow, with the exception of blue whiting at the beginning, other less abundant fauna included: asteroids, anemones, and a few corals. (Figure 10)

C2_4

The target was the top of the northern flank of the canyon. One continuous muddy sand substrate was observed. At the beginning of the tow, slight ripples were present, and as the tow continued, the ripples graded out to flat seabed with shell fragments. Fauna was sparse, with anemones (2 species), flatfish and rat-tail fish visible, with ophiuroids were visible throughout the tow.

C2_5

The target was a ridge of a gully located on the northern flank of the canyon. The tow revealed a homogenous habitat of sandy mud. The tow began on an area with numerous burrows (probably cerianthids) anemones, burrowing ophiuroids and fish (probably rat-tails). As the tow proceeded, the faunistic assemblage varied, with abundant sea pens and asteroids.

C2_6

The target was a deep-water ridge of a gully on the northern flank of the canyon. The tow revealed a homogenous habitat of sandy mud. At the start of the tow, typical fauna were cerianthids and sea pens, and as the tow proceeded into deeper waters, fewer fauna were visible. Along the tow the sediment type seemed to become finer, making it more difficult to see the seabed and take statistical images.

C2_7

The target was a ridge located at the Area 2 interfluve end. The camera tow began on an area of rippled sandy mud. Fauna were not particularly abundant, with some cerianthids, large anemones and asteroids visible. As the tow continued, the substrate graded into clay, and with more abundant fauna, including: sea pens (2 species) asteroids, decapods and bamboo corals.

C2_8

The target was the deeper water section of the southern flank of the northernmost canyon imaged during this survey. The camera tow began on an area of muddy sand with some silt cover and slight ripples with finer grained material in the ripple troughs. As the tow continued, occasional cobbles were visible. Fauna was sparse, with only a few cerianthids and asteroids. As the camera progressed along the tow, the substrate changed to clay. Further along the tow, a few *Cidaris cidaris* and blue-mouth redfish were seen.

C2_9

The target was a ridge on the southern flank of this canyon. The tow began on an area of muddy sand with abundant burrows (small holes - probably cerianthid burrows). Fauna was very sparse, with only a few asteroids, cerianthids, and anemones.

C2_10

The target was on the upper part of the canyon flank. The tow revealed a continuous substrate of muddy sand, with sparse fauna. A single holothurian, octopus and *Nephrops* were visible with some burrowing anemones.

C2_11

The target was an area of the canyon floor in the head of the canyon, which had a high backscatter response. The tow began on an area of rippled sand with underlying bedrock. *Cidaris cidaris* were visible. As the tow continued, continual ledges of bedrock became apparent with small growths of the coral *Madrepora oculata*. Between the ledges, areas of flat seabed comprising rippled sand were apparent.

C2_12

The target was a traverse over a shallow water tributary of the canyon. The tow began on an area of sandy seabed. Fauna included abundant sea pens, *Munida* and *Cidaris cidaris*. As the tow continued biogenic material (shell) was apparent. A crinoid (possibly *Leptometra celtica*) field was encountered, with abundant *Munida*. Further along the tow, a few boulders with small growth of coral were evident, which subsequently graded into an area of sandy, shelly gravel. As the traverse continued an area of bedrock (with shell debris) with abundant crinoids was encountered. Discarded fishing line was observed along the tow. (Figure 11)

C2_13

The target was a ridge in the head of the canyon. The tow began on an area of muddy sand with abundant shrimp in the water column. As the tow continued, it encountered bedrock outcrop with abundant ophiuroids and the occasional coral (possibly stylasterids). The bedrock, which forms planar outcrop related to bedding planes, is observed frequently along the tow, with corals (*Madrepora oculata*) and hydroids growing on the plane edges.

C2_14

The target was a ridge in the deeper water section of the canyon flank. The tow began on an area of biogenic reef, comprising dead and live *Lophelia*, with abundant live growths of *Madrepora oculata*. The dead framework (with live growths) covered an area of approximately 50% (and more locally) with sand infill. As the tow proceeded it became apparent that the reef was extensive, and continued for the duration of the tow, before ending abruptly as the substrate changed to bedrock with few visible fauna. Typical organisms inhabiting the reef were: the pencil urchin *Cidaris cidaris*, ophiuroids, anemones (including cerianthids), fish (probably *Lepidon sp.*), *Stichopathes sp.* (antipatharian coral) and crustaceans (*Bathynectes sp*., *Chaceon affinis* and *Munida rugosa*). The fauna changed slightly further along the reef,

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with abundant crinoids (*Koehlerometra porrecta*) and Brisingids becoming apparent. (Figure 13)

C2_15

The target was a change in backscatter along the flank of the canyon. The tow revealed one continuous substrate of muddy sand with sparse fauna throughout. Despite this, signs of bioturbation were obvious throughout the tow, with abundant small burrows (probably cerianthids) and *Nephrops* burrows. Conspicuous fauna observed were holothurians and a few asteroids.

C2_16

The target was a ridge on the end of the interfluve. The tow began on an area of soft sediment, probably composed of clay, with burrows and cerianthids. Other fauna were sea pens (2 species), anemones (probably *Bolocera sp.*), asteroids (probably *Pseudarchaster sp*) and echinoids (*Calveriosoma fenestratum*). As the tow continued, bedrock with a thin veneer of fine sediment became visible, with the presence of a few bamboo corals, and small patches of coral rubble with small growth of live coral (*Madrepora oculata*). Subsequently, the substrate changed back to soft mud/clay and continued to the end of the tow.

C2_17

The target was a shallow area of the canyon flank, where there were historical records for corals. The tow began on an area of soft clay, which had numerous small burrows (probably cerianthids). Fauna were sparse throughout the tow, with the exception of ophiuroids, and the number of cerianthid anemones increased after approximately 300m.

C2_18

The target was a ridge at a similar water depth on the canyon flank as the C2_14 where the biogenic reef was found. This tow was conducted to determine whether the distribution of the reef extended horizontally along the canyon flank. The tow began on an area of bedrock, with little visible fauna other than asteroids. As the transect descended the steep outcrop of bedrock, patches of coral (dead *Lophelia* with some live *Madrepora oculata*) were visible, with some fauna associated with it (*Cidaris cidaris*, echinoids and asteroids). As the transect continued, the patches of rubble graded back to bedrock, and then to muddy sand, with abundant ophiuroids, sea pens and small holes (probably cerianthid burrows).

C2_19

The target was a ridge 2km northwest of C2_14 (biogenic reef) but at a shallower water depth to try to constrain the extent of the reef. The camera tow revealed a continuous substrate of muddy sand, with very few visible epifauna, but numerous burrows (possibly cerianthids).

C2_20

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The target was the canyon flank opposite C2_14 where the biogenic reef was found, to investigate the occurrence of a reef at a similar position on the southern flank. The tow revealed a substrate of muddy sand, with numerous holes probably cerianthid burrows. As the tow progressed, a slope with bedrock outcrop and a veneer of rippled fine-grained sand was apparent. The moderate slope became a steeper, stepped bedrock escarpment before levelling out, returning to bedrock outcrop with a veneer of sediment at approximately 1020m water depth. Fauna were not particularly abundant, and were concentrated along the edge of rock outcrop. Conspicuous fauna included anemones, and what appears to be burrowing ophiuroids. (Figure 8)

C2_21

The tow began on an area of sandy sediment with little epifauna, with the exception of *Munida rugosa* and holothurians. Visibility was poor throughout the tow, due to silt cloud obscurities. Further along the tow, sea pens began to appear. As the tow neared the end, the sediment became slightly muddier.

C2_22

The target was mounds located on the interfluve of Area 2 identified on the multibeam data. The tow revealed an area of muddy sand with coarser sediment and coral fragments. Typical fauna were the crinoid *Leptometra celtica*, *Munida rugosa* and numerous fish. As the tow continued, coral debris became less common and pebbles with some larger rocks became apparent. Subsequently, coral fragments became denser, with larger pieces, in distinct bands. (Figure 12)

C2_23

The target was a ridge at the end of the interfluve in Area 2. The tow began on an area of muddy sand with abundant sea pens (2 species). Other dominant fauna were anemones (cerianthids), crinoids and bamboo corals. As the tow progressed, fauna became denser. Towards the end of the tow, a few steep ledges were encountered.

C2_24

The target was a deep-water ridge of a gully on the northern flank of the southern canyon imaged. The tow revealed a homogenous substrate of muddy sand, with cerianthid holes, anemones, occasional pennatulids, holothurians and ophiuroids.

C2_25

The tow consisted of rippled muddy sand. Fauna was sparse throughout, with only a few sea pens, asteroids and the pencil urchin *Cidaris cidaris*.

C2_26

The target was a shallow tributary to the canyon head. The tow began on an area of sand with pebbles. Fauna included *Munida rugosa*, a few fish (rat-tails and flatfish) asteroids and sea

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pens (with associated ophiuroid). After approximately 200m, a single boulder was observed, with some associated fauna (anemones). After 280m, a few boulders and cobbles and sediment deposits were apparent, with some attached fauna and abundant *Munida*. After which the substrate changed back to ripples sand. Discarded fish net and line were seem frequently throughout the tow.

C2_27

The tow revealed a continuous substrate of rippled muddy sand with some coarser material visible in the ripple troughs, occasional cobbles were present. Little epifauna was visible throughout, with occasional asteroids, crinoids and flatfish and a single *Lophius piscatorius*.

C2_28

The tow began on gravely (whole shells), muddy sand with occasional holothurians, crinoids, asteroids, *Munida rugosa* and ophiuroids. From approx 30m along the transect, the sediment became less shelly and supported less epifauna. Further along the tow, the substrate became progressively sandier. As the tow neared its end, bedrock with a veneer of sand became apparent prior to a series of bedrock ledges with associated ophiuroids and hydroids. Discarded fishing line visible.

4.2.3. Area 1

C1_1

The target was deep water transect crossing the ends of two ridges on the eastern canyon flank in Irish territorial waters. The transect was a long tow (1.4km), sampling a variety of water depths, changes in topography and areas of high backscatter. The tow began on an area of soft sediment with holothurians, asteroids, sea pens, cerianthids and fish. As the transect continued, the sea bed sloped steeply, and a small number of isolated bamboo corals were observed, before the tow resumed to a soft sediment habitat as observed previously, although with slightly less epifauna. This habitat continued until the tow traversed a near vertical drop-off before resuming a habitat of soft sediment with distinct sand ripples. Throughout the tow, not all statistical images could be taken flat on the seabed due to the silt clouds stirred up by the drop camera frame.

C1_2

The target was an area of high backscatter on the interfluve in Area 1. The tow revealed an area of even sea bed with slightly muddy sand with varying volumes of biogenic debris (shell, coral) and pebbles. Very little epifauna were visible, with the exception of *Munida rugosa*. At least two fishing nets were observed during the tow.

C1_3

The target was a slumping feature forming an amphitheatre-like depression identified on the multibeam. At the start of the tow the sea bed comprised slightly rippled, fine-grained sand with a small proportion of shell debris. As the tow continued, a steep drop off was encountered. Further ledges of bedrock were encountered as the tow progressed. Approximately 250m along the tow the terrain sloped steeply with slightly rippled muddy sand. Conspicuous fauna included, abundant cerianthid anemones, and a single blue mouth redfish and rabbit fish (*Chimera monstrosa*).

C1_4

The first 100m of the tow consisted of muddy sand with burrows in the sediment (probably cerianthids). As the transect continued along the line, a vertical drop off was encountered, with a series of bedrock ledges probably indicative of bedding. The remainder of the tow comprised a steep slope of fine-grained, muddy sand with shells, pebbles and occasional cobbles which graded into an area with no shell debris or lithic fragments, but with more abundant fauna, including asteroids, cerianthids and sea pens. Discarded fishing line was visible.

4.3. Anthropogenic Debris

Anthropogenic debris and evidence of trawling were observed on a number of camera tows. Evidence from Centre for Environment, Fisheries and Aquaculture Science (CEFAS) suggest that much of the canyon flanks and sections of the interfluves are fished at a moderate level (Eastwood *et al*., 2007, Figure 17). Observations from this cruise support the data from CEFAS with occurrences of trawl marks, ropes, cables, nets, boxes and plastic bags documented (Figure 18 and 19). In summary, 30% of the camera tows undertaken encountered anthropogenic debris deposited on the sea bed. There were also two occasions where the drop frame camera became entangled in discarded cable or rope suspended in the water column (Figure 18). Thus providing further evidence of the hazard discarded equipment poses.

4.4. Wrecks

No wrecks were identified during this cruise.

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5. Conclusions

The area surveyed is incised by a complex of canyons with slope angles of up to 71º (Figure 3). The canyon heads in the upper slope have a number of steep amphitheatre-like depressions which merge down-slope into the main canyon. Gullies cover their flanks and are predominantly v-shaped in profile (Figure 5).

Sub-bottom profiles show the unconformable Melville Formation overlying the Little Sole Bank Formation (Figures 14-16). The Little Sole Bank Formation was heavily incised during the Pleistocene when episodic periods of lower sea level led to intensification of wave and tidal action across the outer shelf and upper continental slope. In places the Jones and Cockburn formations of Neogene age can be identified.

The dominant sea-bed type observed was rippled, muddy sand in areas up to a maximum of ~700m water depth and sandy mud/mud in deeper water areas. Areas of gravel predominantly comprise biogenic shell and coral fragments. Bedrock crops out on the flanks and canyon bottoms. Further interpretation of the sub-bottom data will allow possible identification of the bedrock composition. However it is proposed that the bedrock is likely to comprise claystones and carbonates of Neogene age.

Areas of biogenic reef were identified comprising dead and live *Lophelia pertusa*, with abundant live growths of *Madrepora oculata*. For example, transect C2_14 encountered biogenic reef comprising a dead framework (with live growths) covered an area of approximately 50% (and more locally) with sand infill (Figure 13). Biogenic reef was only located in the deepest parts of the canyons. However individual cold water corals were observed anchored to cobbles and boulders throughout the survey area in a variety of water depths.

Anthropogenic debris was observed on 30% of the camera tows undertaken throughout the survey area (Figures 18 and 19). Numerous nets, ropes, cables and plastic bags were observed as well as one instance of discarded boxes.

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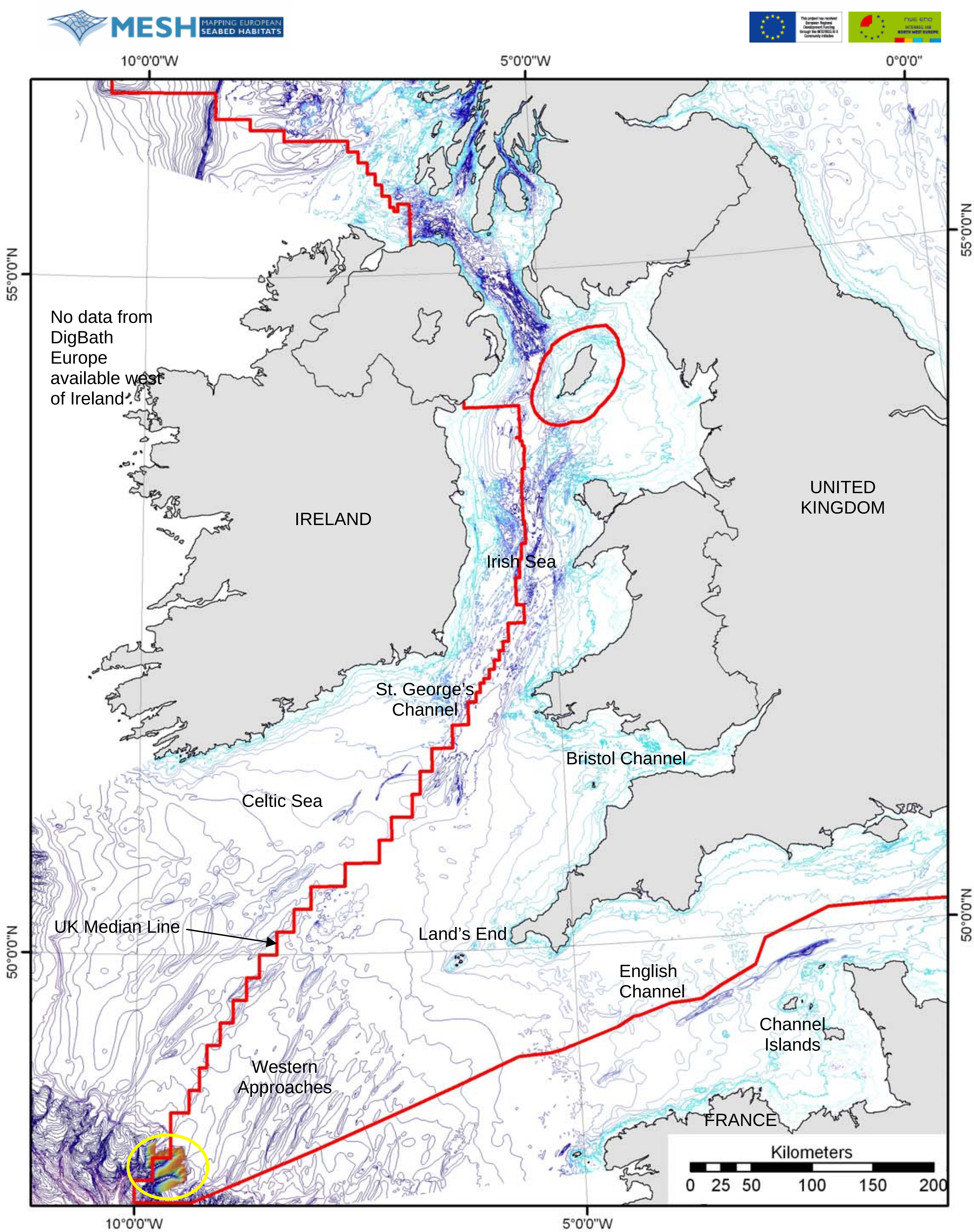


Figure 1 Location of the study area (circled in yellow) surveyed during the course of this cruise. The main bathymetric features of the area are labelled.

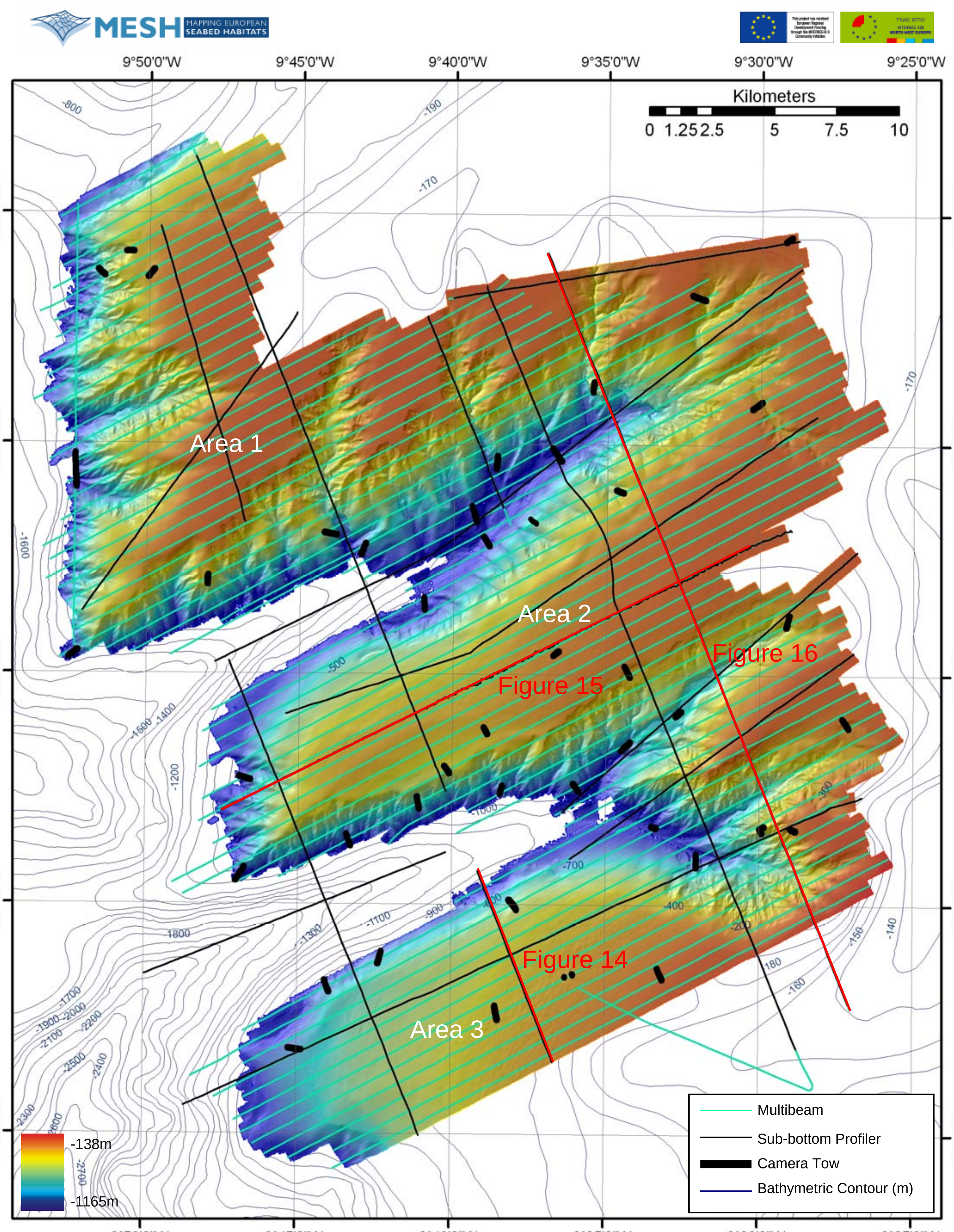


Figure 2 Track chart showing the location of data collected during cruise CE0705 / BGS 07/06. Names for camera tows can be found in Figure 18. The bathymetric contours are taken from DigBath Europe.

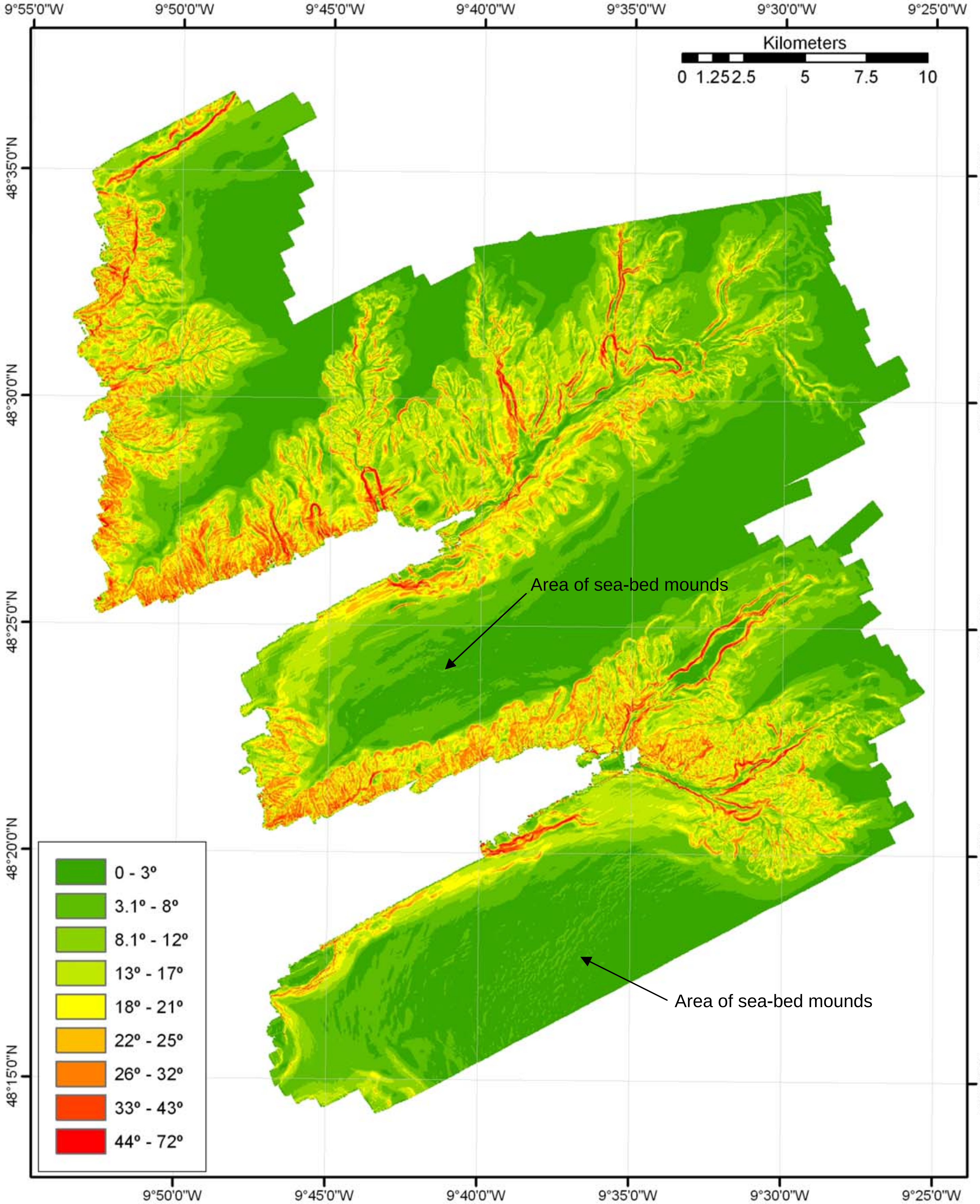


Figure 3 Slope values calculated for the survey area. The highest values can be found in the steep canyon heads and flanks. Slope values of up to 8º can be seen depicting sea-bed mounds on the southernmost and central interfluve.

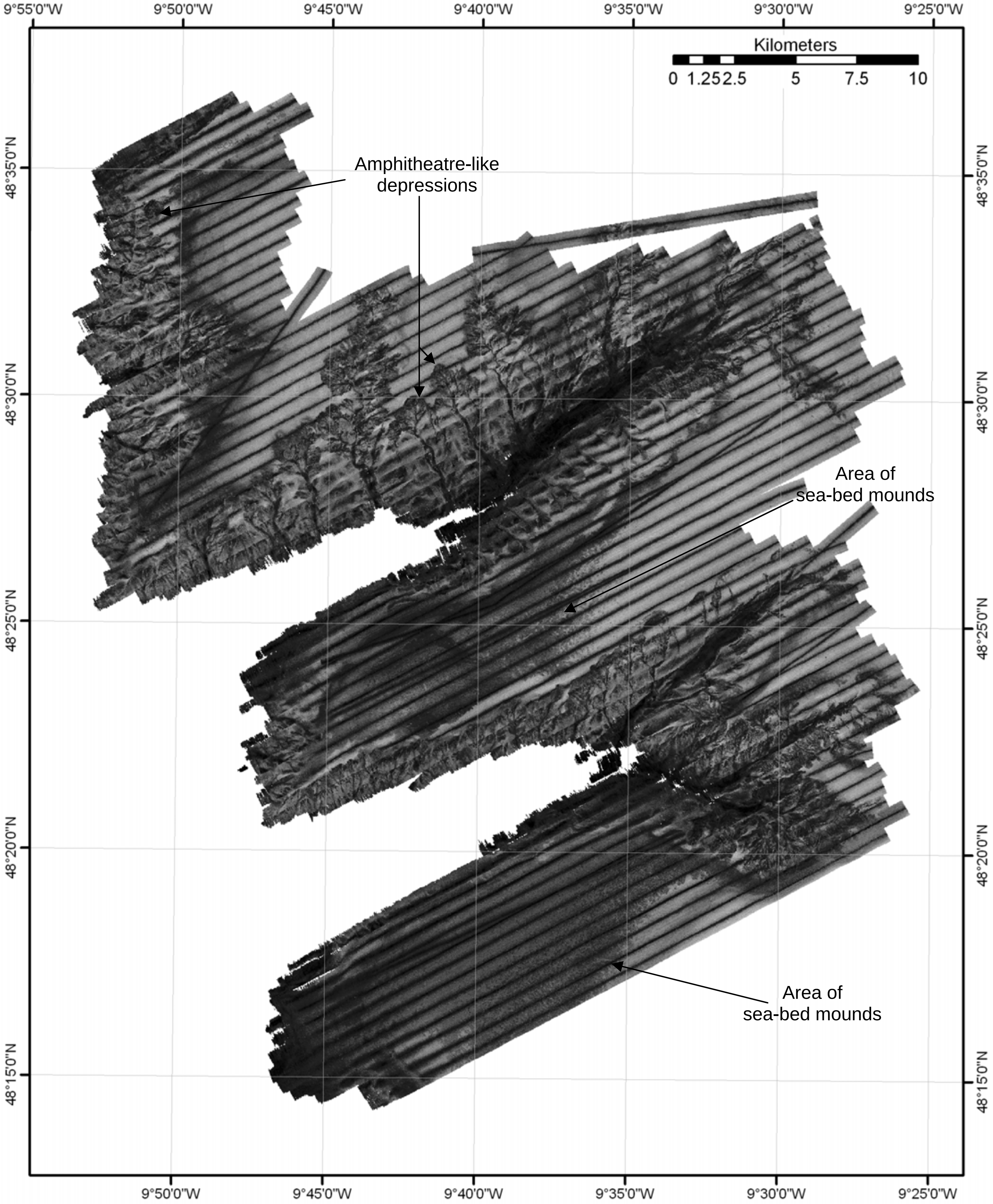


Figure 4 Backscatter image for the survey area. Areas of higher backscatter appear darker. The deepest sections of the canyons have higher backscatter than the interfluves and the change in sea-bed composition over the mounds are highlighted as areas of variable backscatter.

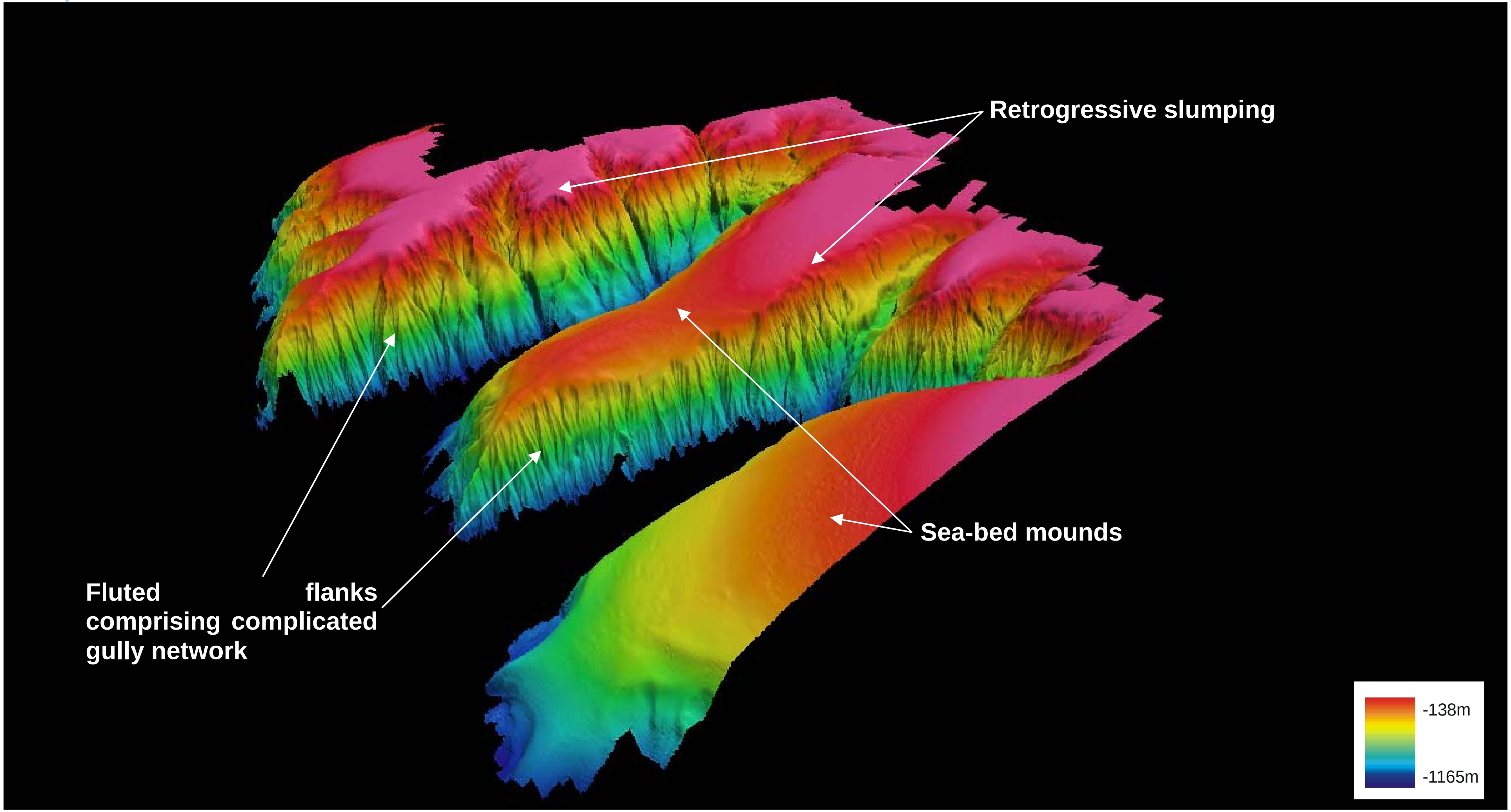
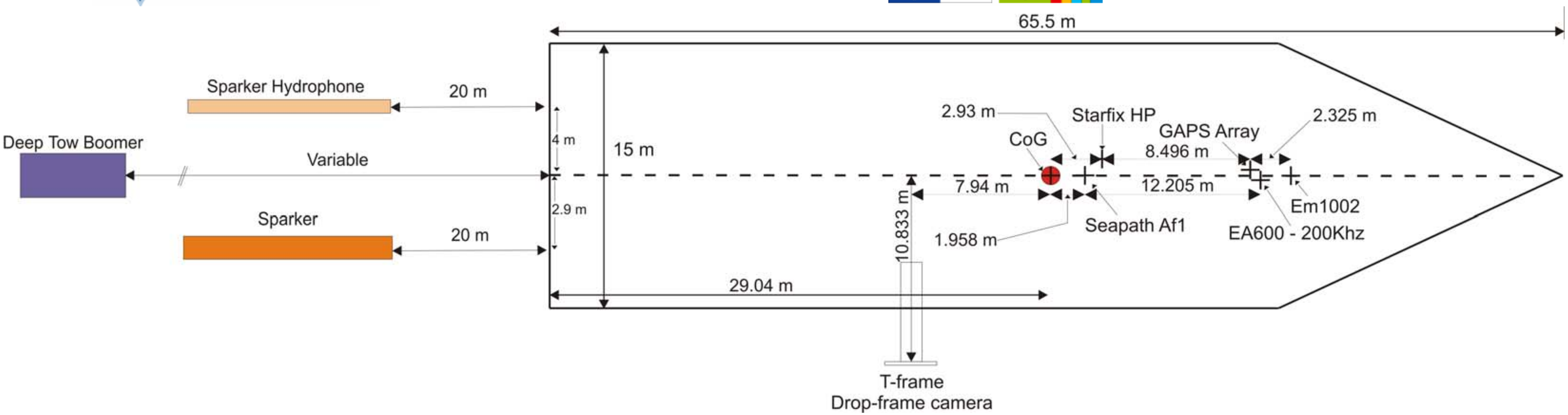


Figure 5 Perspective image of the high-resolution bathymetry data collected looking northeast. Clearly highlighted are areas of sea-bed mounds on the crests of the interfluves, the deeply incised canyons and their associated gullies.



Offsets are also listed below:
(convention is that 'X' values to port are negative, starboard positive, 'Y' values forward of CoG are positive, aft are negative and 'Z' values above CoG are positive, below negative)

	X	Y	Z
CoG	0	0	0
Seapath Af1	0.17	1.958	24.943
Starfix HP	-0.784	2.93	24.955
GAPS Array	-0.15	11.426	-10.8
EA600 – 200Khz	0.45	12.205	-10.461
Em1002	0.169	13.751	-8.228
T Frame	10.833	-7.94	0.00

Figure 6 *R/V Celtic Explorer* vessel offsets diagram. The location where primary equipment was deployed is indicated

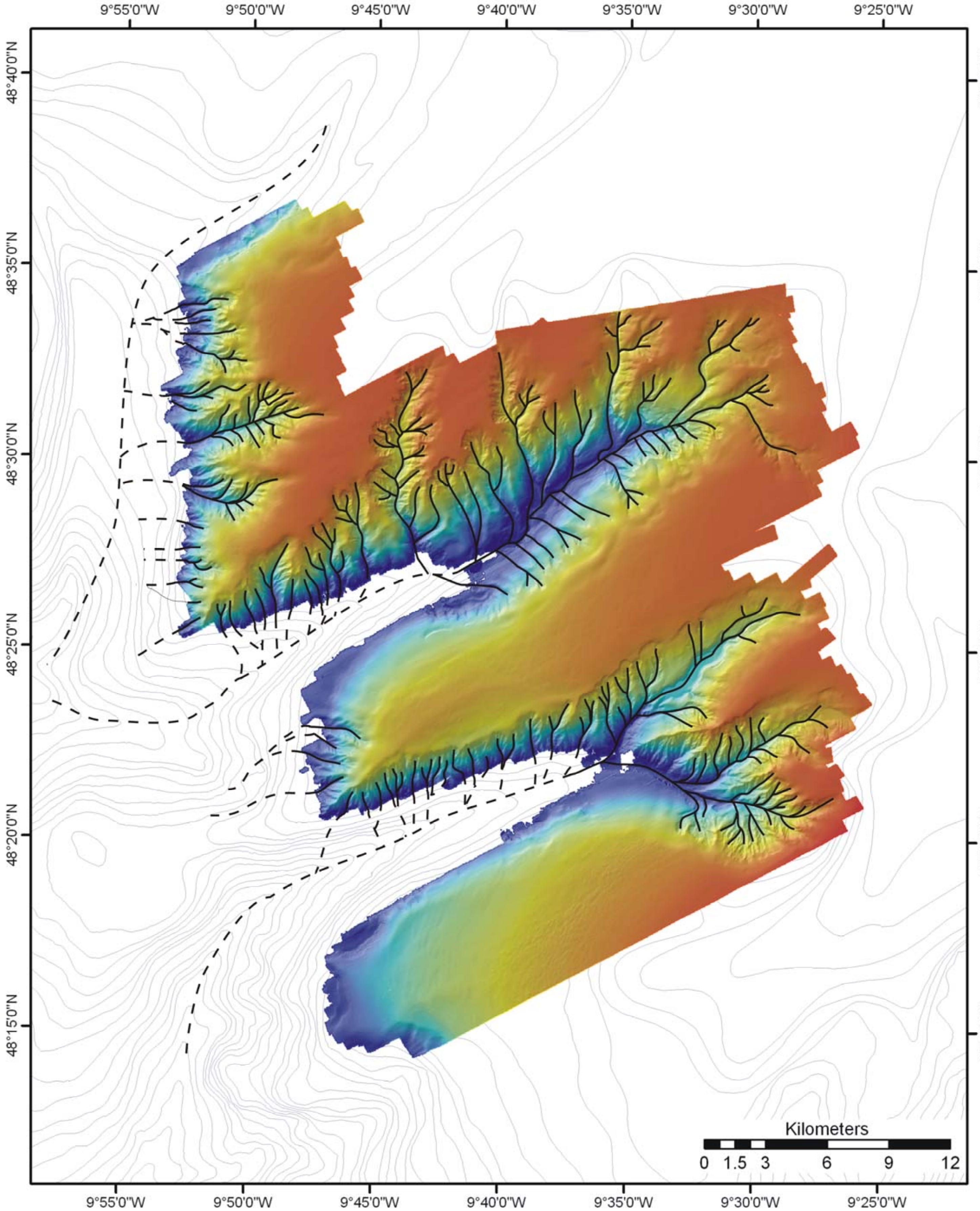


Figure 7 Canyons catchment area clearly showing the dendritic pattern of each individual canyon network. The dashed line indicates uncertainty.

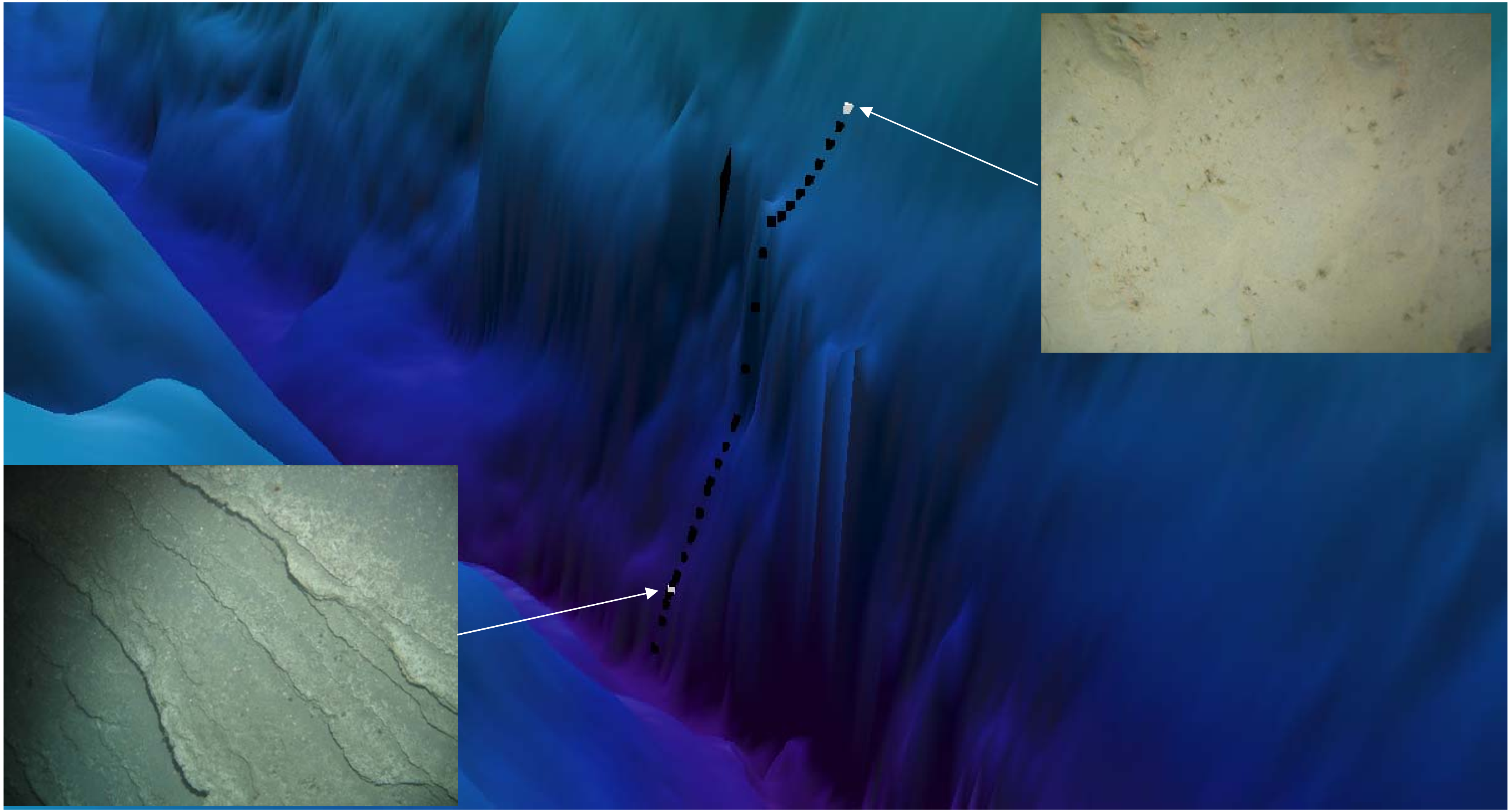


Figure 8 3D image of camera tow C2_20 looking roughly east. The camera tow began in 880m water depth and proceeded down to 1070m water depth. Selected images show the change in habitat observed.

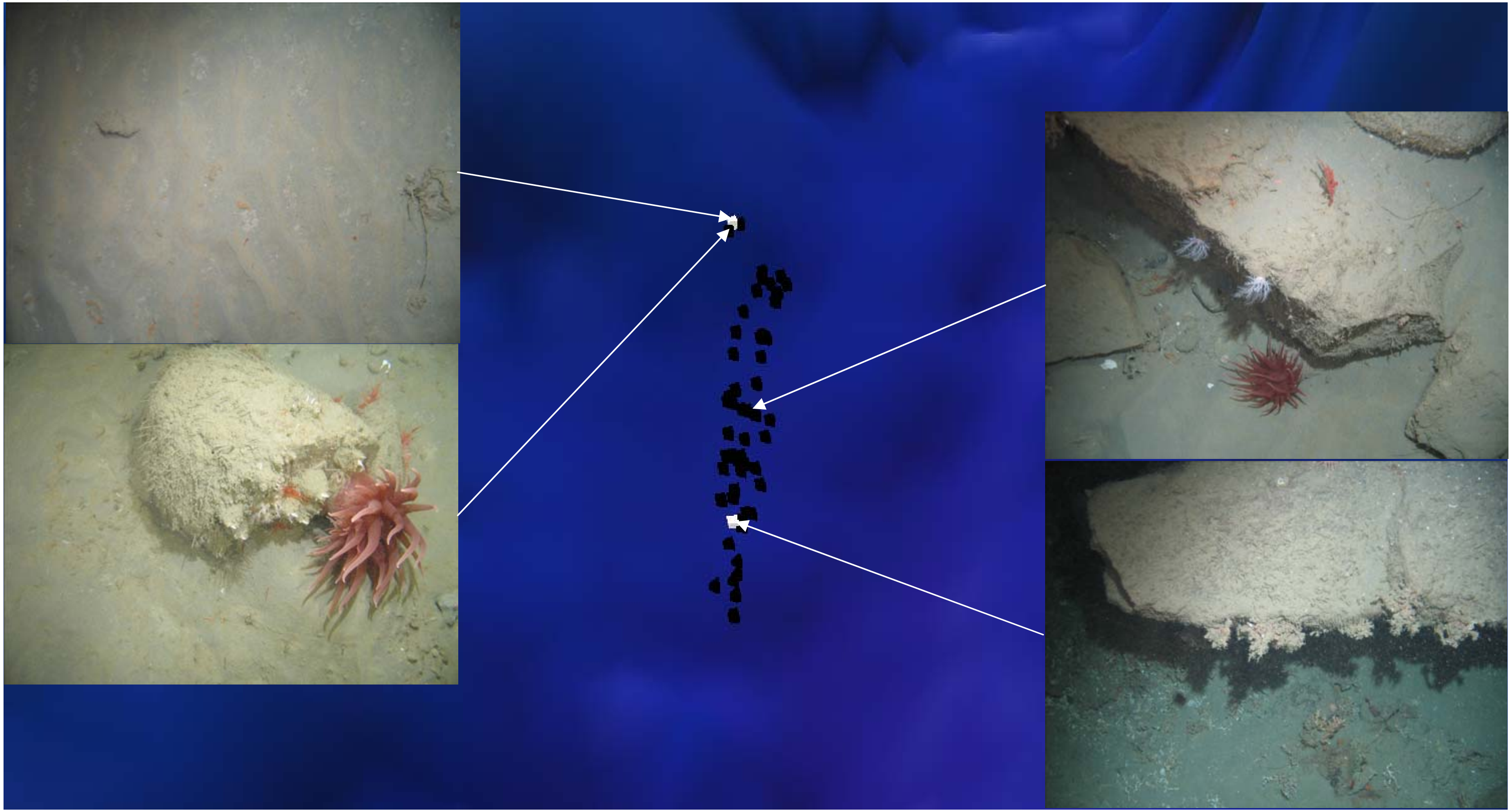


Figure 9 3D image of camera tow C3_6 looking roughly southeast. The camera tow began in 990m water depth and proceeded down to 1010m water depth. Selected images show the change in habitat observed.

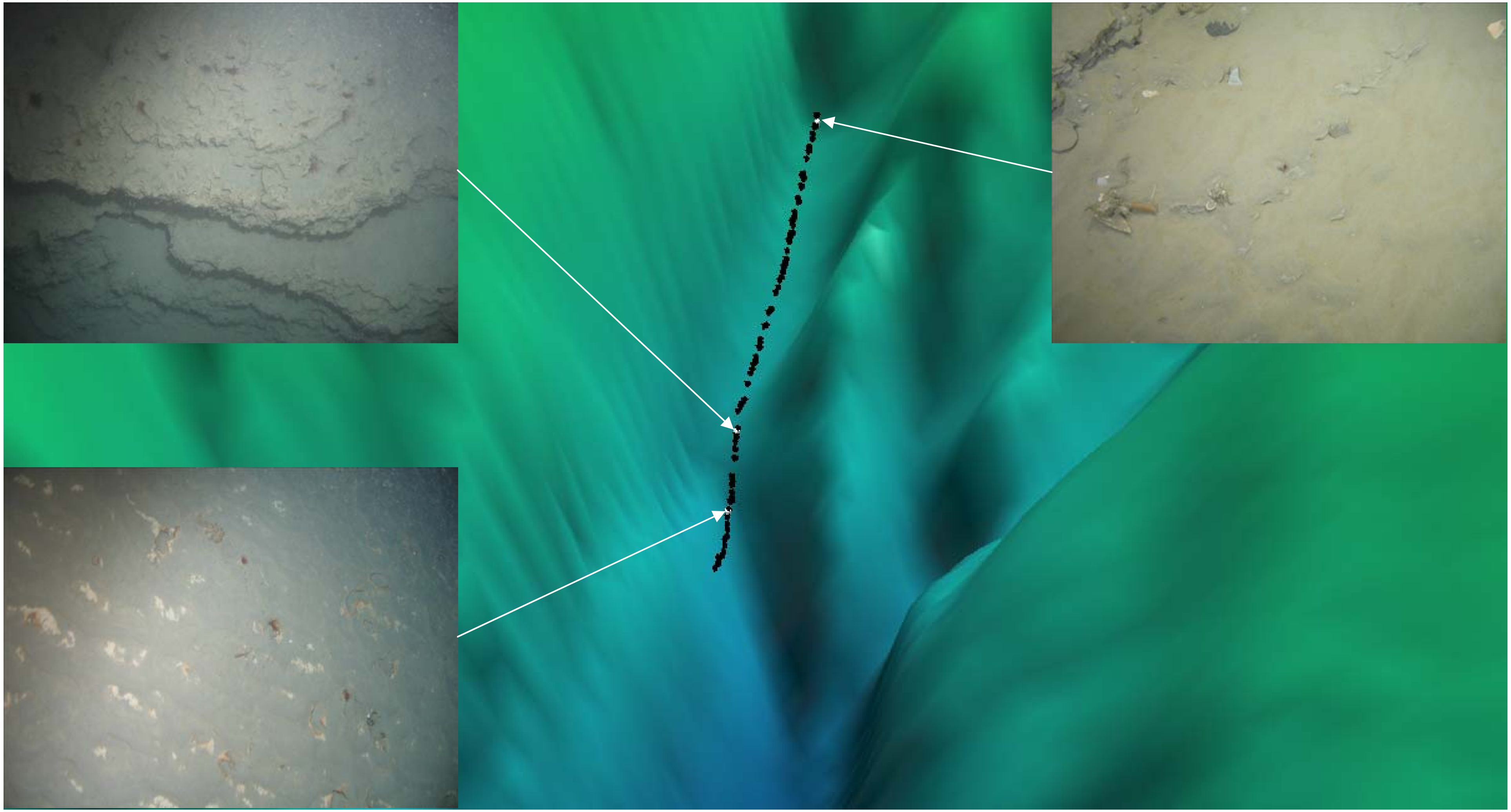


Figure 10 3D image of camera tow C2_3 looking roughly east. The camera tow began in 760m water depth and proceeded down to 830m water depth. Selected images show the change in habitat observed.

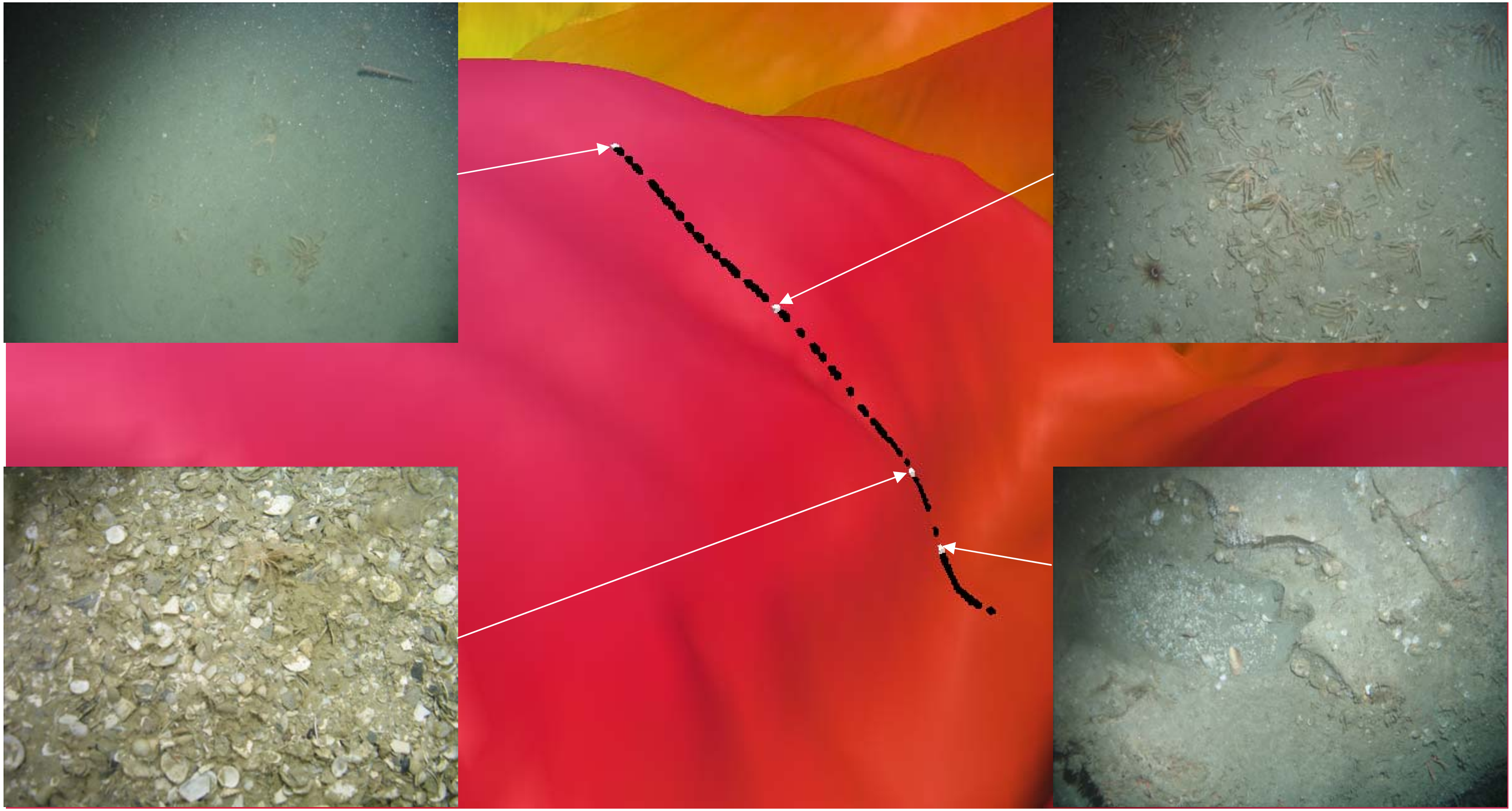


Figure 11 3D image of camera tow C2_12 looking roughly north. The camera tow began in 240m water depth and proceeded down to 320m water depth. Selected images show the change in habitat observed.

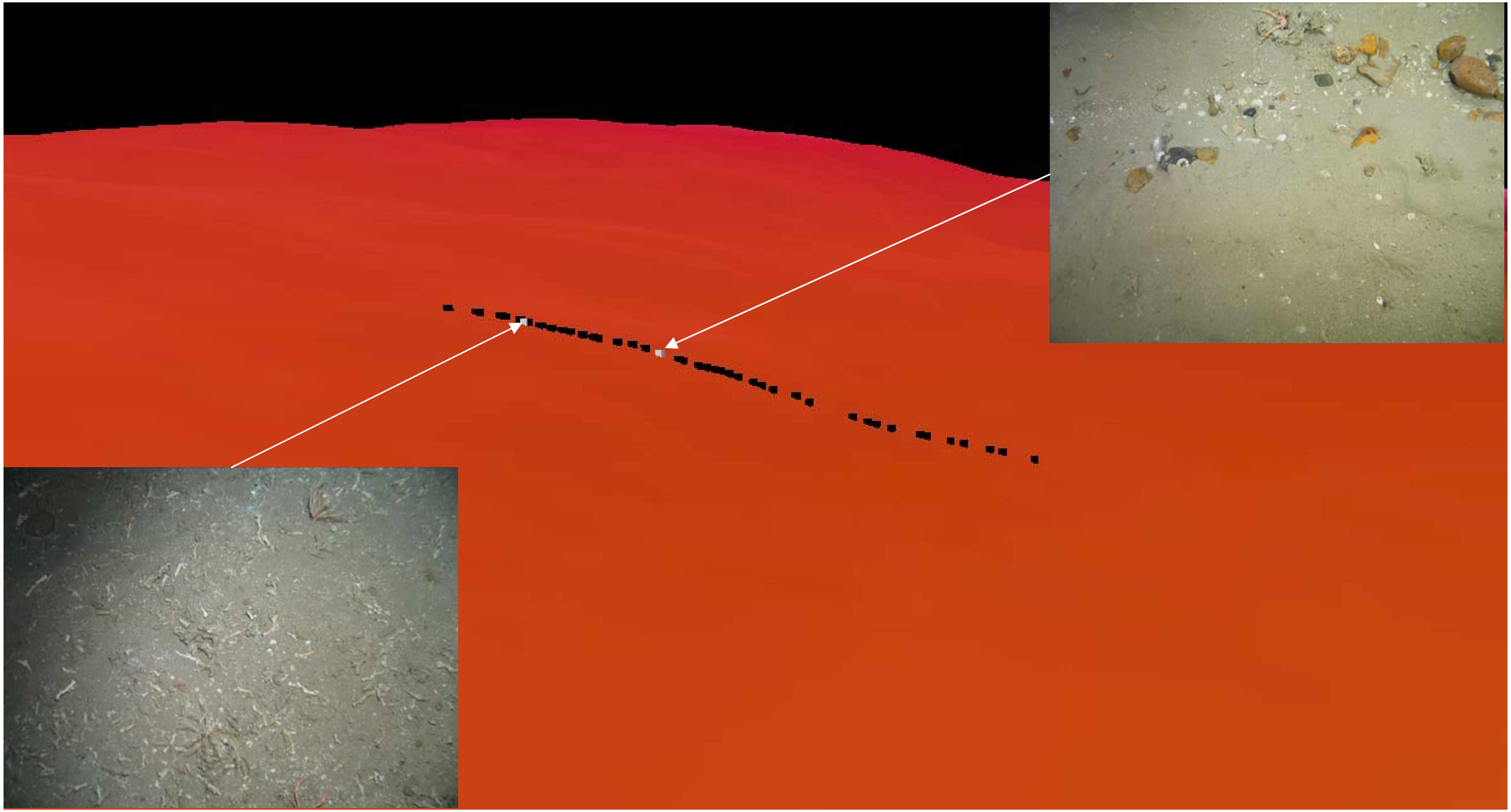


Figure 12 3D image of camera tow C2_22 over a series of sea-bed mounds looking roughly east. The camera tow began in 325m water depth and proceeded down to 340m water depth. Selected images show the change in habitat observed.

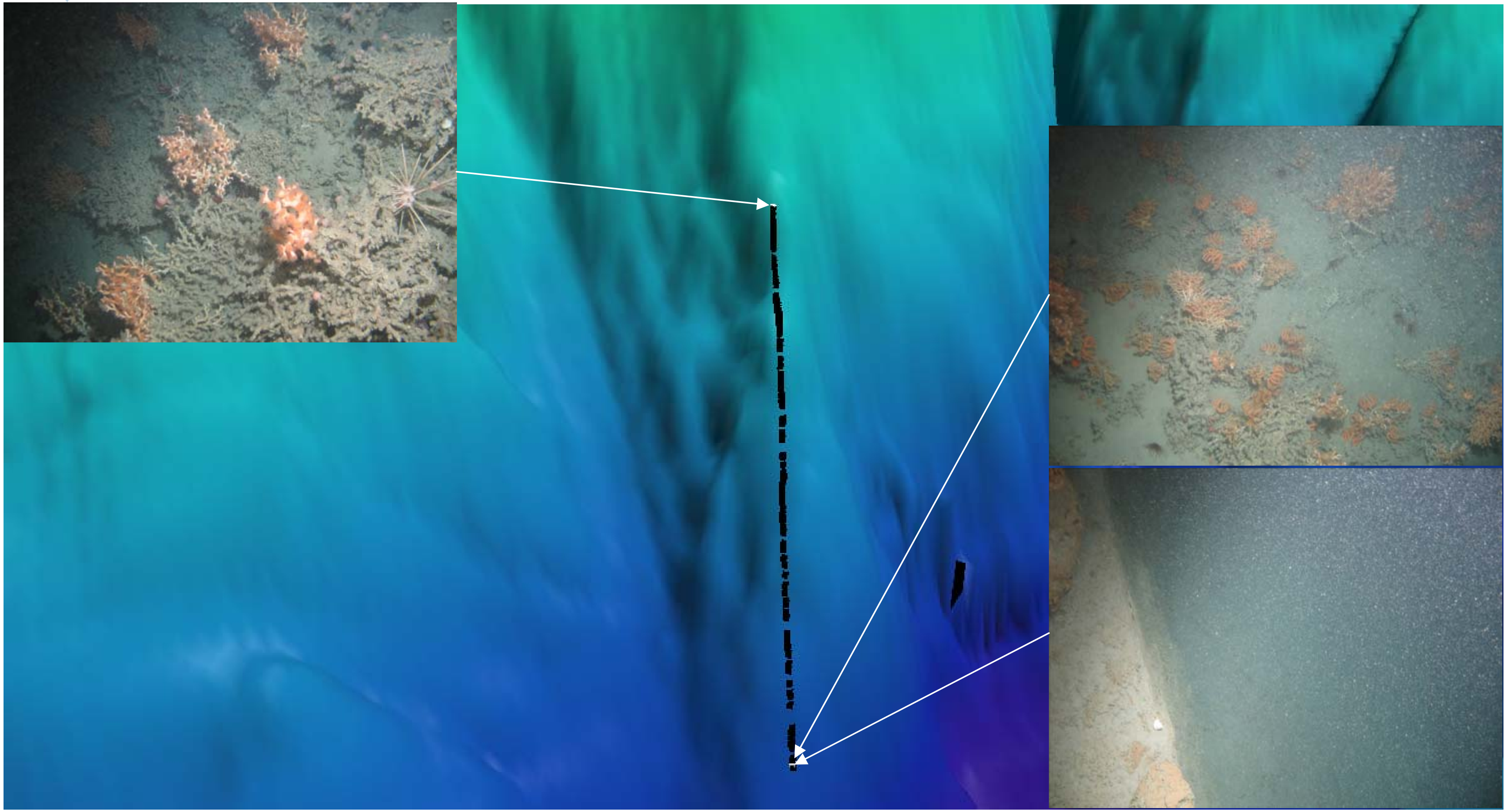


Figure 13 3D image of camera tow C2_14 looking roughly north. The camera tow began in 800m water depth and proceeded down to 950m water depth Selected images show the change in habitat observed.

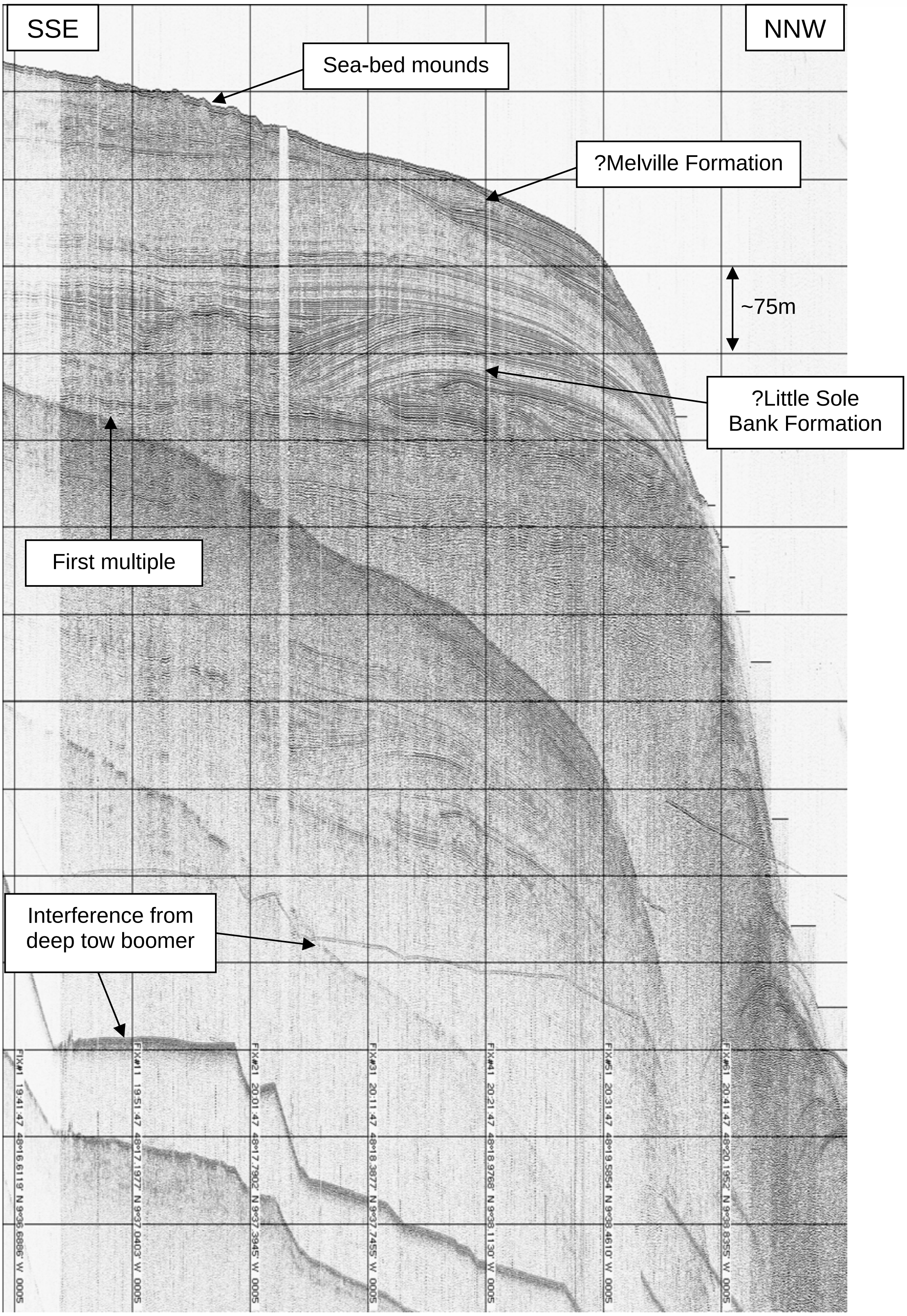


Figure 14 BGS Sparker line 2007/06-5. The Melville Formation unconformably overlies the Little Sole Bank Formation which is Pliocene to Pleistocene in age, within which the canyons are incised. The seismic line is 8.2km in length, for location see Figure 2.

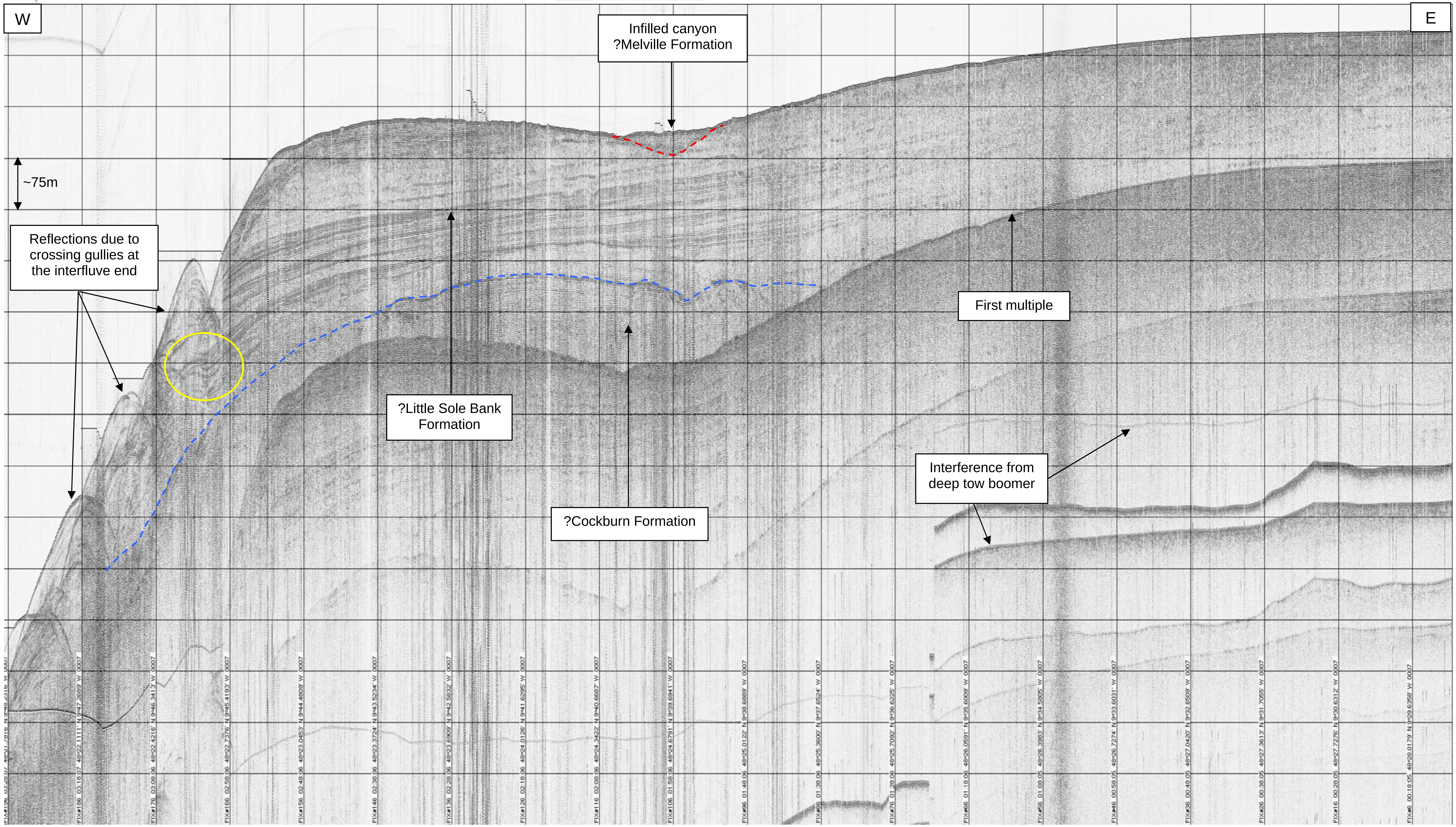


Figure 15 BGS Sparker line 2007/06-7 located on the interfluve of Area 2. The two most striking features of this line are the infilled Pleistocene canyon (base outlined in red) and the up to 25º slope angle at the interfluve end. Areas of sigmoidal reflectors (circled in yellow) may represent buried sediment waves. The line is 26.3km in length, for location see Figure 2.

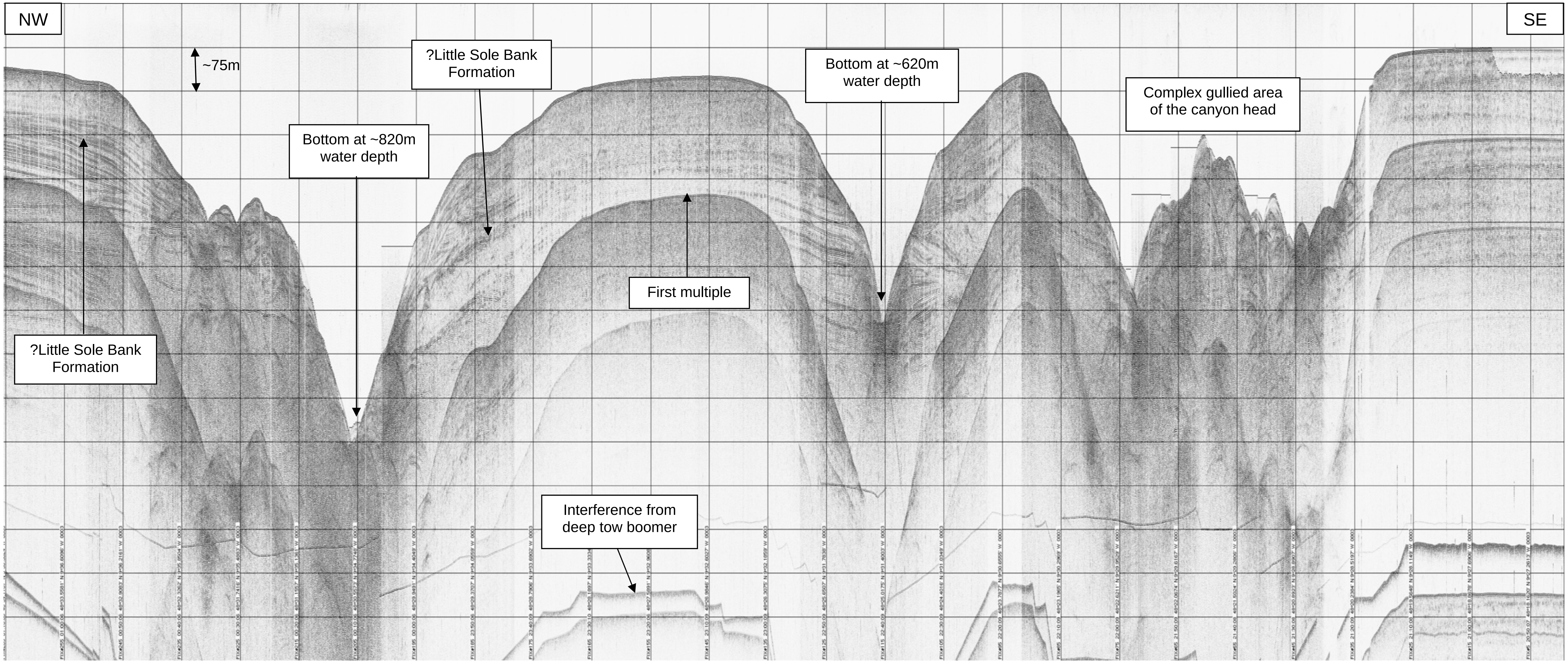


Figure 16 BG Sparker line 2007/06-3 located in the east of the survey area, crossing the canyon heads. This line illustrates the complex topography of the canyon area and thus the problems encountered during sub-bottom data collection. The line is 30.5km in length, for location see Figure 2.

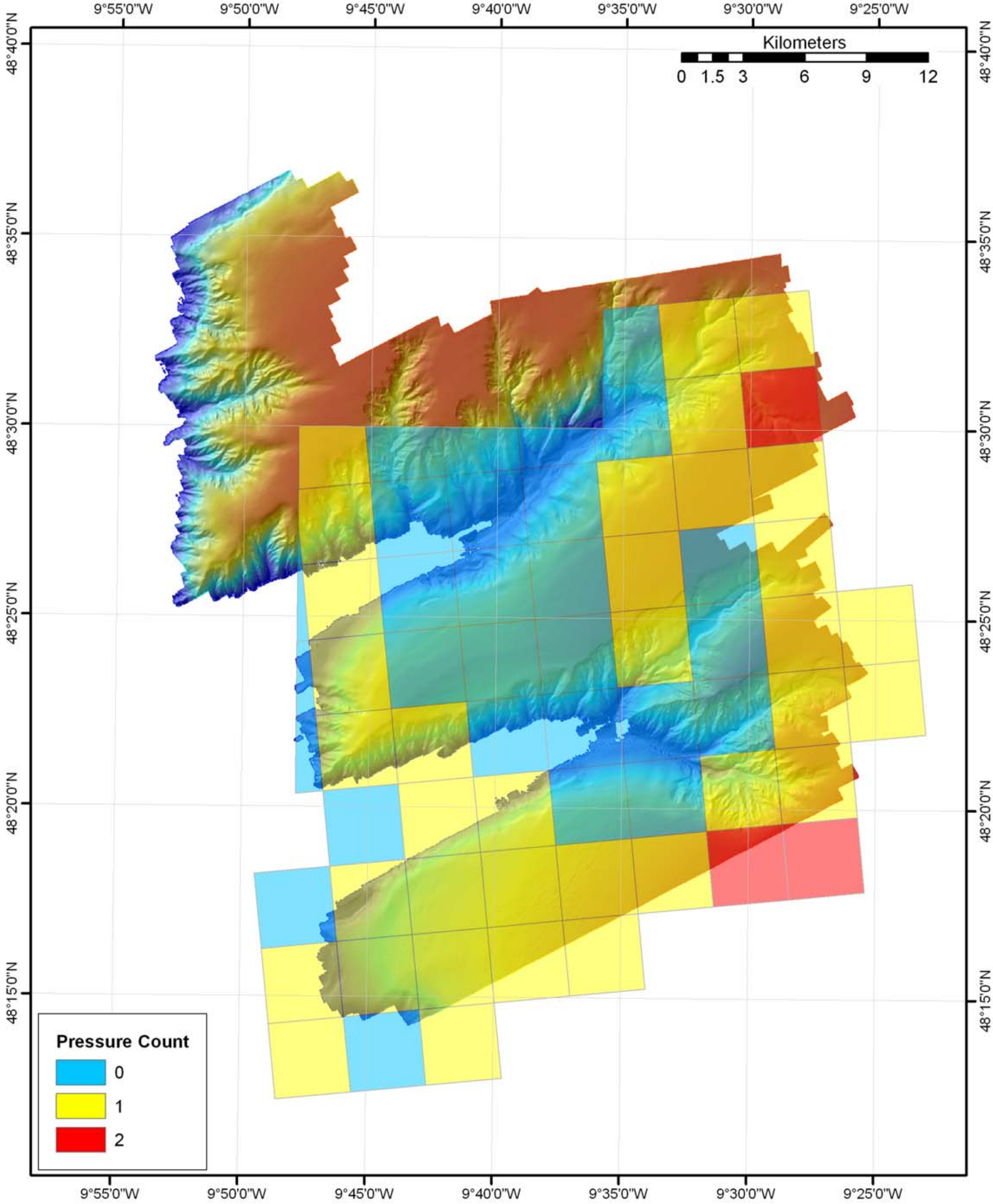


Figure 17 Fishing pressure in the area of survey. Red indicates areas of intensive fishing, with blue indicating areas of little fishing activity. Data supplied by CEFAS (Eastwood *et al.*, 2007).

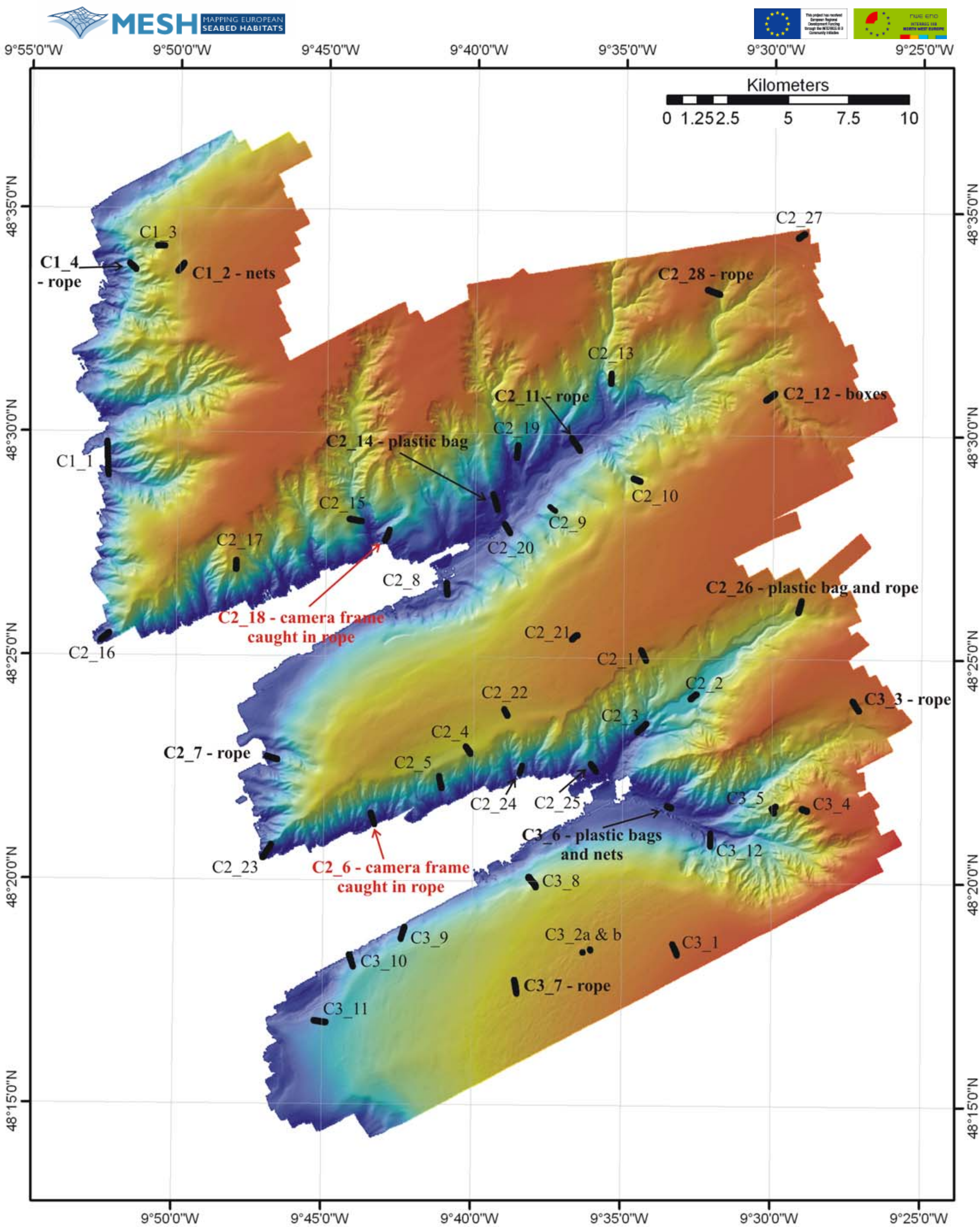


Figure 18 Location of camera transects with occurrences of anthropogenic debris in the survey area marked. Locations where the drop frame camera was caught on rope/cable within the water column during recovery are also marked.

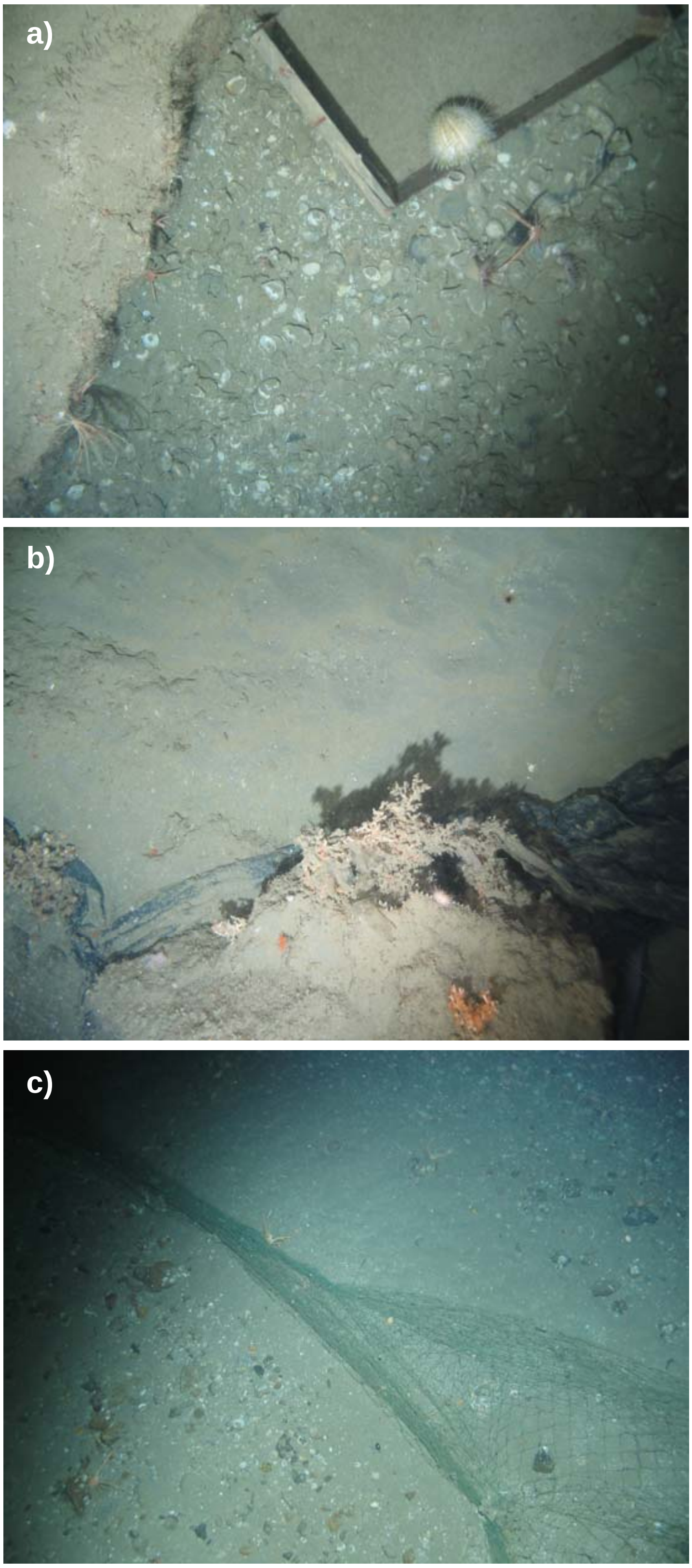


Figure 19 Example images showing the variety of debris observed during the camera survey. a) C2_12_73.jpg; b) C3_6_51.jpg; c) C1_2_022.jpg. For the location of the camera tows please see Figure 18.

6. Appendix 1 – Personnel

Scientific Personnel

Heather Stewart	Party Chief / Geologist
David Smith	Sub-bottom Engineer
David Wallis	Sub-bottom Engineer
Neil Golding	Client Representative
Jaime Davies	Senior Biologist
Charlotte Johnston	Biologist
Emma Verling	Biologist
Vivienne Blyth-Skyrme	Biologist
Tony Cran	Seatronics Underwater Camera Technician

Survey Personnel

Fabio Sachetti	Surveyor
Sorcha McCarthy	Surveyor
Slava Sobolev	Processor
Janine Guinan	Processor / GIS
Anthony Moran	Engineer

Ships Personnel

Philip Baugh	Master
Ted Sweeney	Chief Engineer
Basil Murphy	Chief Officer
Richard Forde	Officer of the Watch
Damien McCallig	2nd Engineer
Paul Wray	ETO
David Murphy	Bosun
Pat Codd	Cook
Michael Doogan	Cook / Steward
Frank Kenny	AB Deckhand
John Gallagher	AB Deckhand
Thomas Byrne	AB Deckhand
Simon Colyer	AB Deckhand
John Cunningham	AB Deckhand
Patrick O Driscoll	Technician

7. Appendix 2 – Daily Logs

Daily Log Sheet For:	**BGS2007_06 / CE0705**		
Date:	04/06/2007	**J.D.**	155
Vessel:	Celtic Explorer	**Main Task:**	Mobilisation in Cobh
Area:	SW Approaches		
Time	**Task / Description**		
07:30	H. Stewart, D. Smith, D. Wallis, J. Davies, N. Golding, C. Johnston, V. Blyth-Skyrme, E. Verling arrive on vessel.		
08:00	BGS Transport arrives on dockside		
08:20	Unloading of transport begins and equipment located onto deck		
10:20	Unloading of transport complete, transport departs Cobh		
10:20 - 18:10	Seismic equipment mobilisation and lab set-up		
19:00 - 20:30	Health and Safety Brifing and tour of vessel carried out by second mate Richard Forde		
20:30 - 22:15	Seismic equipment mobilisation and lab set-up		
Planned Operation for next 24 hours			
Due to sail from Cobh at 08:00 (07:00 BST), carry out wet test of deep tow boomer and camera, begin transit to survey area			
Weather	Fair, good visibility		
Windspeed			
Hours of Mobilisation	12	approx	
Hours of Transit	0		
Hours of Survey	0		
Hours of Weather Downtime	0		
Written By	H Stewart	**Date:**	4th June 2007
please note that times for this date are in B.S.T.			

Daily Log Sheet For:	**BGS2007_06 / CE0705**		
Date:	05/06/2007	**J.D.**	156
Vessel:	Celtic Explorer	**Main Task:**	Wet test of Boomer and Camera, transit to site
Area:	SW Approaches		
Time	**Task / Description**		
07:00	Ship sails from Cobh		
10:18	Vessel arrives at test site for boomer and camera equipment		
10:25	Boomer deployed (51º 23.4993N, 008º 26.8614W in ~90m water depth)		
11:19	End of Boomer test, data received from hydrophones		
11:28	Boomer recovered (51º 21.176N, 008º28.634W)		
11:43	Camera wet test begins, calibration photos taken with grid on deck		
11:50	Camera deployed reaches sea bed at 12:04, calibration photos taken		
12:30	Camera recovered and calibration grid removed		
12:48	Camera redeployed for 10 minutes trial camera tow		
13:15	Camera test completed, camera recovered		
13:15	Vessel transit to start of survey at southernmost area of interest: 48º 20.7818N, 009º 26.0828W		
16:05	Safety Drill		
18:00	Daily meeting with Captain, Chief Engineer, Bosun, Heather Stewart and Neil Golding		
18:30-19:00	Scientific briefing with C.J, N.G, V.B-S, E.V. J.D, H.S., F.S, J.G, D.W,		

	D.S, and T.C.		
19:00 - 19:30	Camera sampling methodology meeting.		
Planned Operation for next 24 hours			
Transit to start of southernmost section of SW Canyons survey area. Due on site approx 08:00, carry out SVP/CTD and commence multibeam survey in southernmost section			
Weather	fair, good visibiity, <1m wave height		
Windspeed	11-14 kn northeasterly		
Hours of Mobilisation	0		
Hours of Transit	17	remaining 7 hours in Cobh	
Hours of Survey	0		
Hours of Weather Downtime	0		
Written By	H Stewart	**Date:**	5th June 2007
please note that times for this date are in G.M.T.			

Daily Log Sheet For:	BGS2007_06 / CE0705		
Date:	06/06/2007	**J.D.**	157
Vessel:	Celtic Explorer	**Main Task:**	Transit to survey area and start of MB survey
Area:	SW Approaches		
Time	**Task / Description**		
08:20	Arrive at the start of multibeam survey. (48º 20.6985N, 009º 25.9696W)		
08:47	CTD deployed (48º 20.6833N, 009º 25.96762W)		
08:55	CTD recovered		
09:28	Start multibeam survey (predicted completion of this area 36 hours)		
10:20	windspeed 13-14 knots direction 53º		
11:00	First multibeam line run from northeast to southwest, multibeam signal		
	lost in water depths >850m (approx).		
13:15	BGS engineers and F. Sachetti work to get the Chirp system recording		
	through the CODA system, also added a delay and firing rate control		
14:49	Chirp signal lost. Requires Marine Institute engineer to look at.		
18:00	Daily meeting with Captain, Chief Engineer, Bosun, H.S and N.G		
22:20	Continuing multibeam survey, finished multibeam line 5		
	Wind speed 19-22 knots for last 2 hours direction 58-71º		
Planned Operation for next 24 hours			
Continue multibeam survey in southermost section of area of survey. Predicted to be complete between 20:00 and 22:00. Will begin seismic data acquisition after multibeam complete.			
Weather	fair, good visibility, <1m wave height		
Windspeed	13-14 kn increasing 19-22 late in day, northeast		
Hours of Mobilisation	0		
Hours of Transit	8.3		
Hours of Survey	15.7	(approx-multibeam and SVP/CTD measurements)	
Hours of Weather Downtime	0		
Written By	H Stewart	**Date:**	6th June 2007
please note that times for this date are in G.M.T.			

Daily Log Sheet For:	BGS2007_06 / CE0705

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Date:	07/06/2007	**J.D.**	158
Vessel:	Celtic Explorer	**Main Task:**	MB survey in southern area. Seismic at night.
Area:	SW Approaches		

Time	**Task / Description**
07:00	Wind speed 16kn, direction 62º
	Completed multibeam line 10, started line 11.
11:00	Currently on multibeam line 12, 15kn wind strength, direction 94º,
	<1m wave height. Currrent position 48º21.911N 009º33.693W
15:55	Continuing along line 15, vessel speed 7kn. Line 15 is the first of the shorter lines joining areas 2 and 3.
16:20	End of line 15. Start of line 16, vessel heading 61º, speed 8kn, wind speed 16-18kn, direction 84º
18:00	Daily meeting with captain, chief engineer, bosun, H.S and N.G.
20:00	End of multibeam survey in Area 3 (southernmost in survey area)
	48º 26.3348N, 009º 27.4096W. Transit to position to deploy seismic
20:45	Vessel arrives approx 5 miles NE of the start of the first seismic line Deep Tow Boomer (DTB) deployed.
21:35	Sparker deployed 48º 23.0331N 009º 24.7785W in around 160m water depth, vessel heading 250º, vessel speed 4kn
21:50	Vessel cathodic protection switched off for night to see if it will improve the DTB record
23:45	SOL 1 DTB and Sparker deployed

Planned Operation for next 24 hours

DTB and Sparker data collection until 07:00 on Friday, Camera work from 07:00-19:00, DTB and Sparker data acquisition resumed from 19:00 on Friday 8th June.

Weather	Overcast but with good visibility		
Windspeed	15-18kn northeast-easterly		
Hours of Mobilisation	0		
Hours of Transit	0.75		
Hours of Survey	23.25		
Hours of Weather Downtime	0		
Written By	H Stewart	**Date:**	7th June 2007

please note that times for this date are in G.M.T.

Daily Log Sheet For:	**BGS2007_06 / CE0705**		
Date:	08/06/2007	**J.Day**	159
Vessel:	Celtic Explorer	**Main Task:**	Seismic and camera acquisition, MB
Area:	SW Approaches		

Time	**Task / Description**
03:47	EOL 1 DTB and Sparker collected, transit to start of line 2
04:39	SOL 2 DTB and Sparker
06:19	Halted survey on line 2. Transit to first camera tow C3_1 on interfluve crest
07:10	Vessel on site for C3_1
07:25	Camera deployed
07:28	Camera recovered to remove debris from lense

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07:40	Camera re-deployed
07:45	Start of Camera Tow C3_1
08:18	End of Camera Tow C3_1, transit to next camera site
08:40	Camera requires to be reterminated (images were lost 3 times on C3_1 it then 'went' as it was recovered). It will take 4+hours to do. Vessel transit to start of MB line 19 in Area 2.
	windspeed 10-12kn, direction 100º, <1m wave height on site, overcast with mist at times
09:17	Start of multibeam line 21 in Area 2
15:25	windspeed 10kn, direction 170º, <1m wave height on site. Camera repair to be left to cure overnight
18:00	Daily meeting with captain, chief engineer, bosun, H.S and N.G.
19:00	Halted multibeam survey in Area 2 in order to transit to start of Seismic line 3
20:20	DTB deployed
20:23	Sparker deployed
20:45	SOL 3 DTB and Sparker recording, vessel heading 337º at 4.3kn
22:50	windspeed 12 kn, direction 120º, misty - poor visibilty.

Planned Operation for next 24 hours

Seismic until 07:00 on Saturday, Camera during day, resuming seismic at 19:00.

Weather	Overcast with thick fog		
Windspeed	10-12kn, roughly southerly		
Hours of Mobilisation	0		
Hours of Transit	3.4		
Hours of Survey	20.6		
Hours of Weather Downtime	0		
Written By	H Stewart	**Date:**	9th June 2007

please note that times for this date are in G.M.T.

Daily Log Sheet For:	BGS2007_06 / CE0705		
Date:	09/06/20097	**J.D**	160
Vessel:	Celtic Explorer	**Main Task:**	Seismic and camera acquisition
Area:	SW Approaches		

Time	Task / Description
01:10	EOL 3
01:44	SOL 4
03:21	Navigation lost
04:11	Navigation recovered
04:58	Continuing problems with navigation
05:02	Line 4 continued
06:00	EOL 4
06:15	DTB and Sparker recovered. Transit to Camera site C3_2
07:18	On camera site C3_2
07:20	Camera deployed, start of tow
07:33	Camera termination fails, camera recovered for repair.

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07:47	Transit to multibeam line 23 in Area 2, continue MB survey
10:22	Finished current multibeam line, transit to closest camera site: C3_3
12:00	Arrive at camera site C3_3
12:10	Camera deployed, start of tow
12:55	Camera recovered, end of tow
13:36	Arrive at camera site C3_4
13:48	Camera deployed, start of tow
14:09	Camera recovered, end of tow
14:43	Arrive at camera site C3_5
14:51	Camera deployed, start of tow
15:27	Camera recovered, end of tow
16:10	Arrived at camera site C3_6
16:30	Camera deployed, start of tow
16:59	Camera recovered, end of tow. Transit to C3_2 to complete tow due to earlier breakdown
18:00	Daily meeting with captain, chief engineer, bosun and N.G.
18:05	Camera deployed, start of tow
18:48	Camera recovered, end of tow. Transit to SOL 5 for seismic
19:23	Deploy DTB and sparker
19:41	SOL 5, vessel heading 339º
20:50	EOL 5
21:24	SOL 6
23:05	EOL 6
Planned Operation for next 24 hours	
Weather	Clear with good visibility during daylight, fog during hours of darkness
Windspeed	10-12kn, southeasterly

Hours of Mobilisation	0		
Hours of Transit	8.6		
Hours of Survey	15.4		
Hours of Weather Downtime	0		
Written By	H Stewart	**Date:**	9th June 2007
please note that times for this date are in G.M.T.			

Daily Log Sheet For:	BGS2007_06 / CE0705		
Date:	10/06/2007	**J.D**	161
Vessel:	Celtic Explorer	**Main Task:**	Seismic acquisition, camera and multibeam
Area:	SW Approaches		

Time	Task / Description
00:13	SOL 7, DTB and Sparker deployed
03:28	EOL 7
04:59	SOL 8
07:32	EOL 8
07:35	Sparker recovered
07:46	DTB recovered. Transit to camera site C3_7

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08:20	On site C3_7 (mini mounds #2)		
08:35	Camera deployed for start of tow		
08:45	Camera recovered due to fault with USBL transponder		
08:56	Camera redeployed, start of tow		
09:48	end of tow C3_7, problems with camera winch cannot recover camera from sea bed		
10:00	Winch fixed (minor overload) camera winched back to vessel		
10:14	Camera recovered, transit to C3_8		
10:32	Vessel on camera site C3_8		
10:50	Camera deployed, start of tow		
11:32	Camera recovered, transit to C3_9		
12:15	Arrive on site C3_9		
12:19	Camera deployed, start of tow		
13:15	Camera recovered, transit to C3_10		
14:05	Arrive on site C3_10, camera deployed, start of tow		
15:20	Camera recovered, transit to C3_11		
15:45	On site C3_11, camera deployed, start of tow		
16:36	Camera recovered, end of tow. End of scheduled camera work in Area 3		
18:00	Daily meeting with captain, chief engineer, bosun, H.S and N.G.		
18:27	Arrive on site in Area 2 to continue multibeam data acquisition		
Planned Operation for next 24 hours			
Continue multibeam to complete MB in area 2, approx completion time 11:00 on the 11th June. Begin camera work in Area 2 and seismic in evening.			
Weather	Clear with good visibility, <1m wave / swell on site		
Windspeed	10kn, southwesterly		
Hours of Mobilisation	0		
Hours of Transit	6.4		
Hours of Survey	17.6		
Hours of Weather Downtime	0		
Written By	H Stewart	**Date:**	10th June 2007
please note that times for this date are in G.M.T.			

Daily Log Sheet For:	BGS2007_06 / CE0705		
Date:	11/06/2007	**J.D.**	162
Vessel:	Celtic Explorer	**Main Task:**	Multibeam in morning, camera then seismic
Area:	SW Approaches		

Time	**Task / Description**
	Continuing with multibeam acquisition in Area 2
12:16	Completed multibeam in Area 2, transit to camera site C2_1
13:30	Camera deployed, start of tow C2_1
13:40	Problems encountered with USBL, camera recovered
13:50	Camera deployed to test USBL
14:05	Camera recovered, USBL problem recurred
14:15	Camera reployed on site C2_1
14:40	Camera recovered, USBL problem recurred
14:52	Camera redeployed, USBL problem fixed, start of tow C2_1

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15:45	Camera recovered, transit to site C2_2
16:17	On site C2_2, camera deployed, start of tow
16:41	Camera recovered, transit to site C2_3
17:33	On site C2_3, camera deployed, start of tow
18:00	Daily meeting with captain, chief engineer, bosun, H.S and N.G.
18:30	Camera recovered, transit to start of seismic line 9
20:45	SOL 9 Sparker and DTB deployed
23:42	EOL 9

Planned Operation for next 24 hours			
Seismic acquisition until ~07:00 tomorrow morning. Then continue with camera work, starting on the southern flank of Area 2 interfluve and working our way N round the flank. Multibeam in the canyon head from ~19:00 in order to better site remaining seismic lines.			
Weather	Clear with good visibility		
Windspeed	10-14kn southeasterly	1-1.5m wave/swell on site	
Hours of Mobilisation	0		
Hours of Transit	4.3		
Hours of Survey	19.7		
Hours of Weather Downtime	0		
Written By	H Stewart	**Date:**	12th June 2007
please note that times for this date are in G.M.T.			

Daily Log Sheet For:	BGS2007_06 / CE0705		
Date:	12/06/2007	**J.D.**	162
Vessel:	Celtic Explorer	**Main Task:**	Seismic, camera and multibeam
Area:	SW Approaches		

Time	**Task / Description**
00:45	SOL 10
02:45	EOL 10
03:25	SOL 11
06:48	EOL 11
07:05	DTB and sparker recovered EOL 11. Transit to C2_4
07:30	Wave/swell 1.5m, 18kn wind ~160º direction. Acoustic doppler current profiling being collected
09:20	On camera site C2_4, camera deployed
09:25	Power lost in starboard half of dry lab (on UPS circuit)
09:35	Power back on. Overload on UPS system, only have seismic or camera equipment on when it is being used
09:50	Camera recovered, recurring problem with USBL
10:10	USBL not sending signal. Decided to proceed with camera work using vessel position and vessel position overlay on video
10:20	Camera on bottom, C2_4 start tow
10:55	Camera recovered, transit to C2_5
11:15	Arrive on site C2_5, camera deployed, start of tow
12:15	Camera recovered, transit to C2_6
12:42	Camera deployed on C2_6, start of transit

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13:40	Winch trip switches tripped, problems recovering camera. Camera cable caught under possible trawl cable/net. Vessel reversing along camera tow to free camera frame.		
15:05	Camera recovered, no damage to frame or cable. Transit to C2_7		
15:25	On camera site C2_7, camera deployed, start of tow		
16:15	Camera recovered, transit to C2_8		
17:15	Camera deployed on C2_8, strat of tow		
18:00	Daily meeting with captain, chief engineer, bosun, H.S and N.G.		
18:11	End of tow C2_8		
18:30	Camera recovered, transit to Area 1 to start multibeam acquisition over flanks of canyon and canyon head only.		
18:58	Start of multibeam in area 1		
	NB all camera work carried out today utilised vessel position (Reference point for the vessel moved to camera frame) not USBL as not working		
Planned Operation for next 24 hours			
Multibeam in area 1 flanks/canyon head only until ~07:00. Camera acquisition during day. Seismic to start 19:00			
Weather	Overcast with rain in morning, clearing in afternoon. 1.5m swell/wave		
Windspeed	18kn in morning dropping to 10-12kn during day, southeasterly		
Hours of Mobilisation	0		
Hours of Transit	5.75		
Hours of Survey	18.25		
Hours of Weather Downtime	0		
Written By	H Stewart	**Date:**	13th June 2007
please note that times for this date are in G.M.T.			

Daily Log Sheet For:	**BGS2007_06 / CE0705**		
Date:	13/07/2007	**J.D.**	163
Vessel:	Celtic Explorer	**Main Task:**	multibeam, camera and seismic
Area:	SW Approaches		
Time	**Task / Description**		
07:21	halted multibeam acquisition in area 1 (flanks and canyon head) and transit to camera site C2_9		
08:00	On camera site C2_9, camera deployed		
08:50	Camera recovered, transit to site C2_10		
09:20	On site C2_10, camera deployed		
10:05	Camera recovered, transit to site C2_11		
10:25	On site C2_11, camera deployed		
11:30	Camera recovered, transit to site C2_12		
12:25	On site C2_12, camera deployed		
13:15	Camera recovered, transit to site C2_13		
14:05	On site C2_13, camera deployed		
15:00	Camera recovered, transit to site C2_14		
15:40	On site C2_14, camera deployed		

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17:15	Camera recovered, transit to C2_15		
17:35	On site C2_15, camera deployed		
18:00	Daily meeting with captain, chief engineer, bosun, H.S and N.G.		
18:40	Camera recovered. Transit to SOL 12 (seismic)		
19:15	SOL 12 Sparker and DTB deployed		
20:42	EOL 12		
22:21	SOL 13		
	NB all camera work carried out today utilised vessel position (Reference		
	point for the vessel moved to camera frame) not USBL as not working		
	Layback has to be applied to DTB as no USBL for DTB for acquisition		
Planned Operation for next 24 hours			
Seismic acquisition until ~07:00 then multibeam in Area 1			
Weather	Clear good visibility, some rain showers		
Windspeed	Windspeed 10-12 in morning increasing to 18-22 by midnight southwesterly		
Hours of Mobilisation	0		
Hours of Transit	3.7		
Hours of Survey	20.3		
Hours of Weather Downtime	0		
Written By	H Stewart	**Date:**	15th June 2007
please note that times for this date are in G.M.T.			

Daily Log Sheet For:	**BGS2007_06 / CE0705**		
Date:	14/06/2007	**J.D.**	164
Vessel:	Celtic Explorer	**Main Task:**	Seismic and MB
Area:	SW Approaches		
Time	**Task / Description**		
00:10	EOL 13		
01:03	SOL 14		
04:28	EOL 14		
04:47	SOL 15		
06:29	EOL 15		
06:40	SOL 16		
07:41	EOL 16, seismic survey complete		
08:00	Sparker and DTB recovered, transit to start of MB in area 1		
08:22	On site for continuing MB acquisition in Area 1		
18:00	Daily meeting with captain, chief engineer, bosun, H.S and N.G.		
	NB Layback has to be applied to DTB as no USBL for DTB for acquisition		
Planned Operation for next 24 hours			
Continue MB until Area 1 complete, finishing MB data collection for the entire area of interest. Camera work from now until departure from area to Galway			
Weather	Overcast but clear, good visibility		
Windspeed	28kn in early hours of morning, decreasing to 11-13 by mid-morning and		
	2-3kn by 20:00, swings easterly to southwesterly and southeasterly		

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Hours of Mobilisation	0		
Hours of Transit	1.7		
Hours of Survey	22.3		
Hours of Weather Downtime	0		
Written By	H Stewart	**Date:**	15th June 2007
please note that times for this date are in G.M.T.			

Daily Log Sheet For:	**BGS2007_06 / CE0705**		
Date:	15/06/2007	**J.D.**	165
Vessel:	Celtic Explorer	**Main Task:**	Complete MB survey
Area:	SW Approaches		Camera acquisition

Time	**Task / Description**
	Continuing MB acquisition in Area 1
10:28	Test of Sparker at full power while continuing MB acquisition.
16:05	Multibeam acquisition in Area 1 complete. End of MB survey for cruise. Arrive on Camera site C2_16, deploy camera
16:10	On camera site C2_16, camera deployed
17:20	Camera recovered, transit to site C2_17
17:50	On site C2_17, camera deployed
18:00	Daily meeting with captain, chief engineer, bosun, H.S and N.G.
18:27	end of tow C2_17
18:36	Camera recovered, transit to site C2_18
19:11	On site C2_18, camera deployed
20:20	Slight difficulty recovering camera. Once camera reached sea surface discovered a rope caught across the top of the frame, needed to be cut off.
21:00	Arrive on site C2_19, camera deployed
22:15	Camera recovered, transit to site C2_20
22:55	On site C2_20, camera deployed
23:27	End of tow C2_20, camera recovered, transit to site C2_21
	NB all camera work carried out today utilised vessel position (Reference
	point for the vessel moved to camera frame) not USBL as not working
Planned Operation for next 24 hours	

Weather	Overcast with sunny intervals and passing squalls, <1.5m wave/swell		
Windspeed	13kn in morning, increased to 23kn in afternoon, southwesterly-southerly		
Hours of Mobilisation	0		
Hours of Transit	3.05		
Hours of Survey	20.95		
Hours of Weather Downtime	0		
Written By	H Stewart	**Date:**	16th June 2007
please note that times for this date are in G.M.T.			

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Daily Log Sheet For:	BGS2007_06 / CE0705		
Date:	16/0602007	**J.D.**	166
Vessel:	Celtic Explorer	**Main Task:**	Camera acquisition
Area:	SW Approaches		

Time	Task / Description
00:27	Start of camera tow C2_21
00:47	End of camera tow C2_21, camera recovered
01:27	Start of camera tow C2_22
01:47	End of camera tow C2_22, camera recovered
02:00	Start of camera tow C2_23
02:53	End of camera tow C2_23, camera recovered
05:19	Start of camera tow C2_24
05:43	End of camera tow C2_24, camera recovered
06:37	Start of camera tow C2_25
07:03	End of camera tow C2_235, camera recovered
08:16	Start of tow C3_12
08:53	end of line C3_12, camera recovered
10:22	Start of line C2_26, camera on sea bed
10:54	end of line C2_26, camera recovered
12:24	Start of line C2_27, camera deployed. There was a delay in reaching this site due to other vessels in area.
12:45	End of line C2_27, camera recovered. Multibeam carried out to infill gap in data in canyon head, 2 short lines only.
14:55	On site C2_28
15:05	Camera deployed
15:56	Camera recovered from site C2_28. Transit to C1_1
18:00	Daily meeting with captain, chief engineer, bosun, H.S and N.G.
18.11	Start of tow C1_1, camera on sea bed
19:43	end of line C1_1
20:05	Camera recovered, transit to C1_2
20:50	On site C1_2, camera deployed
21:17	Camera recovered , end of tow C1_2. Begin calibration grid tows
22:21	Calibration grid run finished, camera on sea bed, start of tow C1_3
22:50	Camera recovered, end of tow C1_3
23:00	On site C1_4, camera deployed
23:40	End of tow C1_4, end of camera work for survey
00:00	Camera on deck, transit to Galway
	NB all camera work carried out today utilised vessel position (Reference point for the vessel moved to camera frame) not USBL as not working

Planned Operation for next 24 hours

Transit to Galway, demobilisation of equipment

Weather	Slightly overcast but bright and clear, good visibility
Windspeed	13kn, southerly in morning, swinging westerly in late evening/night 1kn
Hours of Demobilisation	0

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Hours of Transit	14.2		
Hours of Survey	9.8		
Hours of Weather Downtime	0		
Written By	H Stewart	**Date:**	17th June 2007
please note that times for this date are in G.M.T.			

Daily Log Sheet For:	**BGS2007_06 / CE0705**		
Date:	17/06/2007	**J.D.**	167
Vessel:	Celtic Explorer	**Main Task:**	Camera acquisition transit to Galway
Area:	SW Approaches		
Time	**Task / Description**		
all day	Transit to Galway, demob of equipment		
18:00	Daily meeting with captain, chief engineer, bosun, H.S and N.G.		
Planned Operation for next 24 hours			
Weather	calm seas, slightly overcast at times, good visibility		
Windspeed	3kn, 131-170º		
Hours of Demobilisation	12	approx	
Hours of Transit	24		
Hours of Survey	0		
Hours of Weather Downtime	0		
Written By	H Stewart	**Date:**	17th June 2007
please note that times for this date are in G.M.T.			

Daily Log Sheet For:	**BGS2007_06 / CE0705**		
Date:	18/06/2007	**J.D.**	168
Vessel:	Celtic Explorer	**Main Task:**	Transit to Galway. Demob Galway End of Cruise
Area:	SW Approaches		
Time	**Task / Description**		
	Continue transit to Galway		
06:40	Vessel docked in Galway		
10:00	Post cruise meeting (H.S, N.G, D.W, C.J, D.S., J.D., A.Fitzgerald, J.Ullgren B.Kavanagh, B.Dwyer, P.Baugh and P.O'Driscoll		
~13:00	Meeting B.Kavanagh, F.Fitzpatrick and H.Stewart		
~14:00	BGS transport arrives on dockside, equipment loaded		
15:00	University of Plymouth member departs vessel		
16:00	JNCC members depart vessel		
17:00	BGS members depart vessel		
Planned Operation for next 24 hours			
N/A			
Weather	Clear good visibility, some drizzle/rain		
Windspeed			

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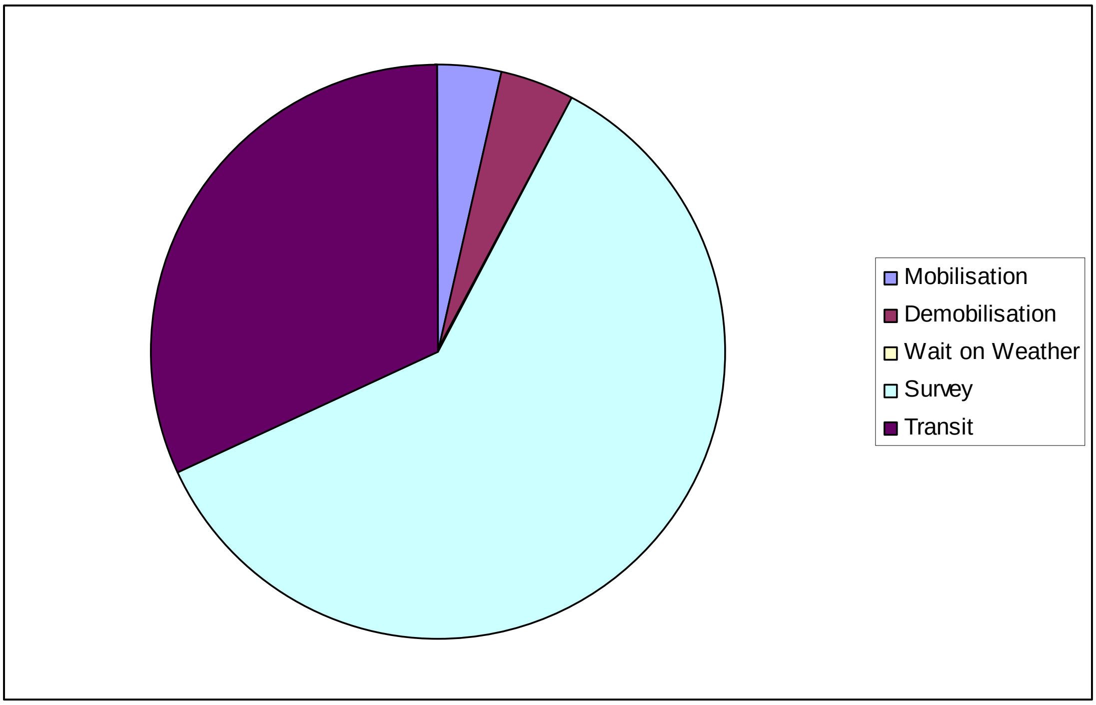
Hours of Demobilisation	2.5	most carried out during transit, includes meetings	
Hours of Transit	6.7		
Hours of Survey	0		
Hours of Weather Downtime	0		
Written By	H Stewart	**Date:**	19th June 2007
please note that times for this date are in G.M.T.			

Table 1 Summary of hours worked

Task	Approximate Number of Hours
Survey	203.85
Transit	107.85
Demobilisation	14.5
Mobilisation	12
Wait on Weather	0



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8. Appendix 3 – Sub-bottom Line Summary Log Sheets

British Geological Survey Marine Operations | **Line Summary Log**

Cruise No. BGS2007_6

Vessel: R/V Celtic Explorer

Area: SW Approaches

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Line		Start		End		Length	Total	Equipment Run		
No.	Dir	Date (dd-mm-yy)	Time (hh:mm:ss)	Date (dd-mm-yy)	Time (hh:mm:ss)	(km)	(km)	D.T.Boomer	Multitip Sparkarray	Comments
1	SW	07-06-07	0:45:09	08-06-07	3:37:08	29.93	29.93	X	X	Noise on DTB
2	NE	08-06-07	4:39:00	08-06-07	6:19:00	13.04	42.97	X	X	No usable data, water depth too deep and noise on DTB
3	N-NW	08-06-07	20:44:41	09-06-07	1:10:08	30.24	73.21	X	X	Noise on DTB
4	S-SE	09-06-07	1:44:09	09-06-07	6:00:00	33.28	106.49	X	X	Noise on DTB
5	N-NW	09-06-07	19:41:47	09-06-07	20:50:45	8.24	114.73	X	X	Noise on DTB
6	NE	09-06-07	21:24:50	09-06-07	23:01:45	14.06	128.79	X	X	
7	SW	10-06-07	0:13:05	10-06-07	3:28:05	26.32	155.11	X	X	
8	S-SE	10-06-07	4:59:03	10-06-07	7:31:04	20.59	175.70	X	X	
9	NE	11-06-07	20:45:06	11-06-07	0:23:42	24.70	200.40	X	X	
10	SW	12-06-07	0:44:05	12-06-07	2:45:11	15.80	216.20	X	X	Noise on Sparker data, from chinese? Radio station
11	NW	12-06-07	3:24:54	12-06-07	6:48:36	27.50	243.70	X	X	
12	N	13-06-07	19:14:51	13-06-07	20:42:51	12.30	256.00	X	X	
13	SW	13-06-07	22:21:40	14-06-07	0:10:39	14.90	270.90	X	X	
14	E-NE	14-06-07	1:04:03	14-06-07	4:28:05	28.50	299.40	X	X	
15	W	14-06-07	4:48:04	14-06-07	6:29:04	14.03	313.43	X	X	
16	S	14-06-07	6:40:01	14-06-07	7:41:01	7.65	321.08	X	X	

9. Appendix 4 – Table of Photographic Transect Locations

Site Label	Date	Start Time	Start Latitude (North)	Start Longitude (West)	End Time	End Latitude (North)	End Longitude (West)
C_1_1	16/06/07	18:14	48 º 29.77580' N	009 º 52.37030' W	19:44	48 º 29.03170' N	009 º 52.32370' W
C_1_2	16/06/07	20:59	48 º 33.61070' N	009 º 50.04970' W	21:17	48 º 33.77750' N	009 º 49.85010' W
C_1_3	16/06/07	22:21	48 º 34.16950' N	009 º 50.52390' W	22:40	48 º 34.16570' N	009 º 50.76060' W
C_1_4	16/06/07	23:23	48 º 33.62720' N	009 º 51.46340' W	23:46	48 º 33.82320' N	009 º 51.77730' W
C_2_1	11/06/07	15:00	48 º 25.19420' N	009 º 34.39600' W	15:33	48 º 24.94890' N	009 º 34.39610' W
C_2_2	11/06/07	16:17	48 º 24.22620' N	009 º 32.55770' W	16:40	48 º 24.10350' N	009 º 32.77610' W
C_2_3	11/06/07	17:34	48 º 23.56220' N	009 º 34.21580' W	18:11	48 º 23.34680' N	009 º 34.54630' W
C_2_4	12/06/07	10:23	48 º 22.98935' N	009 º 40.25516' W	10:44	48 º 22.86017' N	009 º 40.09166' W
C_2_5	12/06/07	11:29	48 º 22.36000' N	009 º 41.14020' W	12:02	48 º 22.08720' N	009 º 50.45220' W
C_2_6	12/06/07	12:59	48 º 21.52440' N	009 º 43.42840' W	13:31	48 º 21.28290' N	009 º 50.45220' W
C_2_7	12/06/07	15:36	48 º 22.69870' N	009 º 46.56760' W	16:06	48 º 22.77170' N	009 º 46.92640' W
C_2_8	12/06/07	17:39	48 º 26.41400' N	009 º 40.92500' W	18:11	48 º 26.68080' N	009 º 40.95140' W
C_2_9	13/06/07	08:17	48 º 28.30168' N	009 º 37.30900' W	08:42	48 º 28.40036' N	009 º 37.51150' W
C_2_10	13/06/07	09:33	48 º 28.97554' N	009 º 34.45583' W	09:54	48 º 29.03969' N	009 º 34.70167' W
C_2_11	13/06/07	10:47	48 º 29.93240' N	009 º 36.78783' W	11:29	48 º 29.64930' N	009 º 36.48080' W
C_2_12	13/06/07	12:35	48 º 30.80830' N	009 º 35.45220' W	13:05	48 º 30.95490' N	009 º 35.47800' W
C_2_13	13/06/07	14:19	48 º 31.37290' N	009 º 50.45220' W	14:45	48 º 31.15920' N	009 º 35.47110' W
C_2_14	13/06/07	16:03	48 º 28.66260' N	009 º 39.39200' W	16:48	48 º 28.31930' N	009 º 39.23990' W
C_2_15	13/06/07	17:55	48 º 28.08250' N	009 º 44.20760' W	18:27	48 º 28.04060' N	009 º 43.80580' W
C_2_16	15/06/07	16:35	48 º 25.49040' N	009 º 52.25310' W	17:05	48 º 25.33210' N	009 º 52.54380' W
C_2_17	15/06/07	18:03	48 º 27.13700' N	009 º 48.01150' W	18:27	48 º 26.93690' N	009 º 48.01720' W
C_2_18	15/06/07	19:27	48 º 27.84610' N	009 º 42.87860' W	20:00	48 º 27.60890' N	009 º 43.01810' W
C_2_19	15/06/07	21:25	48 º 29.76850' N	009 º 38.57970' W	21:58	48 º 29.47940' N	009 º 38.60230' W
C_2_20	15/06/07	22:59	48 º 27.78490' N	009 º 38.81330' W	23:28	48 º 28.01160' N	009 º 39.01616' W
C_2_21	16/06/07	00:29	48 º 25.51830' N	009 º 36.55330' W	00:47	48 º 25.42090' N	009 º 36.74080' W
C_2_22	16/06/07	01:28	48 º 23.85210' N	009 º 38.98320' W	01:47	48 º 23.70722' N	009 º 38.87650' W

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Site Label	Date	Start Time	Start Latitude (North)	Start Longitude (West)	End Time	End Latitude (North)	End Longitude (West)
C_2_23	16/06/07	03:12	48 º 20.79220’ N	009 º 46.75650’ W	06:54	48 º 20.49820’ N	009 º 47.03920’ W
C_2_24	16/06/07	05:22	48 º 22.60219’ N	009 º 38.35420’ W	05:43	48 º 22.41580’ N	009 º 38.44100’ W
C_2_25	16/06/07	06:40	48 º 22.63588’ N	009 º 36.06100’ W	07:04	48 º 22.47510’ N	009 º 35.89030’ W
C_2_26	16/06/07	10:21	48 º 26.32470’ N	009 º 29.03730’ W	10:54	48 º 26.06650’ N	009 º 29.15010’ W
C_2_27	16/06/07	12:25	48 º 34.53540’ N	009 º 28.99210’ W	12:45	48 º 34.43940’ N	009 º 29.20290’ W
C_2_28	16/06/07	15:12	48 º 33.26370’ N	009 º 32.24500’ W	15:48	48 º 33.17030’ N	009 º 31.81760’ W
C_3_1	08/06/07	07:40	48 º 18.45603’ N	009 º 33.13128’ W	08:21	48 º 18.63600’ N	009 º 33.29094’ W
C_3_2a	09/06/07	07:27	48 º 18.44590’ N	009 º 36.28510’ W	07:32	Line aborted	
C_3_2b	09/06/07	18:06	48 º 18.44590’ N	009 º 36.28760’ W	18:39	48 º 18.68940’ N	009 º 36.11270’ W
C_3_3	09/06/07	12:18	48 º 24.06150’ N	009 º 27.29560’ W	12:49	48 º 23.85030’ N	009 º 27.08130’ W
C_3_4	09/06/07	13:48	48 º 21.64680’ N	009 º 28.80370’ W	14:09	48 º 21.69220’ N	009 º 28.80460’ W
C_3_5	09/06/07	14:51	48 º 21.73530’ N	009 º 29.87410’ W	15:26	48 º 21.56800’ N	009 º 29.91200’ W
C_3_6	09/06/07	16:30	48 º 21.68680’ N	009 º 33.30100’ W	16:53	48 º 21.74610’ N	009 º 33.52420’ W
C_3_7	10/06/07	09:08	48 º 17.52124’ N	009 º 38.45221’ W	09:49	48 º 27.83932’ N	009 º 38.45221’ W
C_3_8	10/06/07	10:50	48 º 19.91215’ N	009 º 37.87200’ W	11:32	48 º 20.11400’ N	009 º 38.21170’ W
C_3_9	10/06/07	12:36	48 º 18.74760’ N	009 º 42.36310’ W	13:14	48 º 19.05010’ N	009 º 42.22440’ W
C_3_10	10/06/07	14:24	48 º 18.12795’ N	009 º 43.96920’ W	15:02	48 º 18.42630’ N	009 º 44.13040’ W
C_3_11	10/06/07	15:58	48 º 16.84420’ N	009 º 44.85770’ W	16:36	48 º 16.89800’ N	009 º 45.31810’ W
C_3_12	16/06/07	08:18	48 º 20.83650’ N	009 º 32.05000’ W	08:53	48 º 21.12820’ N	009 º 32.04830’ W

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10. Appendix 5 – Navigation and EM1002 Swath Bathymetry Data

Author: Fabio Sachetti, Surveyor for the Marine Institute, Galway.

Geodetic Parameters and projection for SW Approaches MESH Survey

Geodetic Parameters	
Datum	ITRS89
Spheroid	World Geodetic System 1984 (WGS-84)
Semi-Major Axis (a)	6378137.000 m
Semi-Minor Axis (b)	6356752.314 m
First Eccentricity Squared (e^2)	0.0066943800
Inverse Flattening (1/f)	298.257223563
Local Datum Geodetic Parameters	
Datum	ETRS89
Spheroid	World Geodetic System 1984 (WGS-84)
Semi-Major Axis (a)	6378137.000 m
Semi-Minor Axis (b)	6356752.314 m
First Eccentricity Squared (e^2)	0.0066943800
Inverse Flattening (1/f)	298.257223563
Projection Parameters	
Grid Projection	Universal Transverse Mercator
Central Meridian Zone 29 (CM)	009º West
Origin Latitude (False Lat.)	00.0°
Hemisphere	North
False Easting (FE)	500000.0 m
False Northing (FN)	0.0 m
Scale Factor on CM	0.999600
Units	Metres

Table 2 Geodetic parameters.

Vertical Datum

Chart Datum will be consistent with the Lowest Astronomical Tide as shown below.

Tidal levels are quoted relative to chart datum (approximately the lowest level due to astronomical effects and excluding meteorological effects).

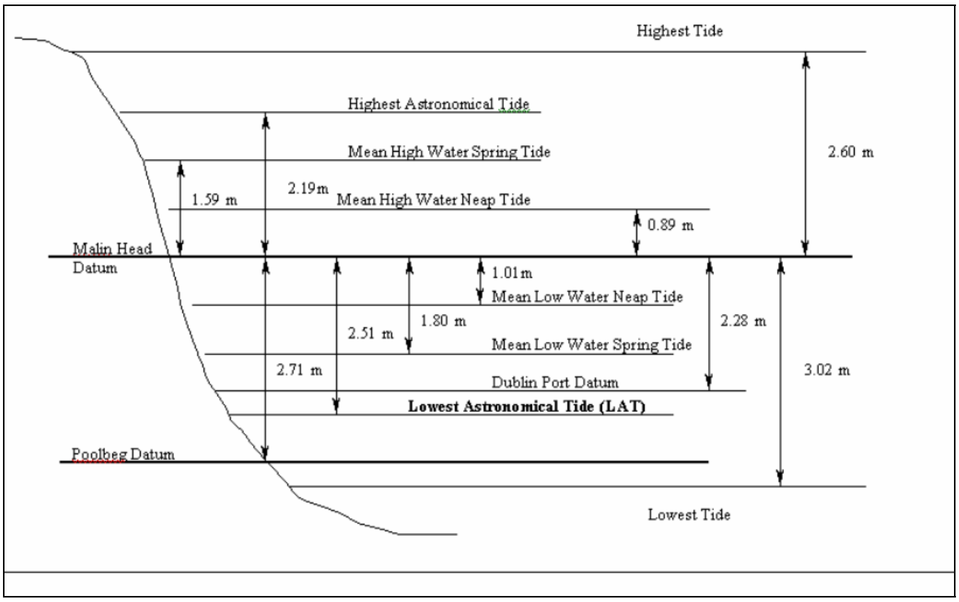

Figure 20 Irish Tide and Level Datum differences at Dublin, as supplied by the Ordnance Survey.

General survey information and results.

A total of 91 multibeam survey lines, cross lines and infill lines were completed between the 6th June and 17th June 2007. During seismic acquisition multibeam as been acquired and these lines have been used as cross lines.

A total of 3 CTD casts were acquired during the cruise.

A total of 1106 km^2 coverage and 1688 line km were surveyed during the course of this cruise (refer to multibeam statistics for full details).

Positioning

Primary positioning was the Fugro Starfix-HP (High Precision) GPS positioning system. The HP position output is delivered simultaneously to the EM1002 transceiver unit (as primary position) and to the Fugro Starfix navigation suite for data logging and quality control purposes.

The Starfix HP performance was generally good and reliable during its period of use. One exception took place on the 9th June when the navigation software did not log part of seismic line 4 and also changed geodesy during acquisition.

Starfix Navigation Suite

A Fugro Survey Ltd Starfix-HP (High Precision) GPS unit is installed on the vessel as the primary positioning source. The specified accuracy for Starfix HP is 0.2m (horizontal) and 0.3m (vertical) at the 95% confidence level. As well as horizontal positioning, derived GPS height from the HP system is used as an optional source of observed tide for bathymetric sounding reduction.

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In 2007 Fugro starfix software version 8.1 was installed on three PC's: Fugro Nav, Fugro21 and Helmsman (On bridge). Fugro Nav is the primary Navigation PC handling input/output data, configurations and display and the logging of data. Fugro HP was the primary navigation. The Fugro21 PC is utilised for navigation processing with VBA Proc.

The following software has been configured to run on each machine:

Fugro Nav (Master Nav PC):

Starfix.MM	
Starfix.Time	
IOWIN	(Oistar Bus & Digicard, HP Mux)
Starfix.SEIS	
Starfix.DISPLAY	
Starfix.LOGGING	(NEL & SPL format)
MSS.Tide	
USBL	

Helmsman (Bridge PC):

Starfix.MM
Starfix.Time
Starfix.DISPLAY

Fugro 21

VBA Proc 8.1

The suite of programs runs over a local area network utilizing Message Manager to link programs and Starfix installations. Starfix Time selects and broadcasts the most reliable time source on to all machines across a network. Primary timing source is an Ashtech Z12 PPS signal direct from the HP unit. Time stamping of serial data is also available through the Oistar Fieldbus. The Seis module acts as control for the systems - project settings, integration of inputs, vessel setup, offsets and fixing. Vessel offsets are entered into the Seis module according to a standard referenced frame. The centre of gravity of the vessel was set as common reference point.

OISTAR FIELDBUS.

Nine Oistars are installed and configured for serial data input to Starfix. The Oistar Fieldbus is time stamped using the Ashtech Z12 PPS signal and connected to Fugro PC Com3, where the sensor data is decoded. Four spare units are stored onboard.

Oistar interfacing problems were encountered originally when using the COMPAC PC's internal ports. This was overcome by using a Dig board port (Com3). The TX frequency of the sensor data sent to the Oistars was reduced to stop the Bus from overloading.

Current (2007) Oistar configuration as follows:

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Oistar	Sensor
1	Master Oistar
3	Octans MRU/HDG (Secondary)
4	Starfix_HP Position In
5	EA600 Sounder In
6	Gaps
9	Gravity In
10	HP to Bridge
11	
12	Robertson Bridge Gyro In

Table 3 Oistar inputs.

System Inputs

Sensors are interfaced to Starfix via the IOWIN program. IOWIN decodes RS-232 data and makes it available to all programs within the Starfix Suite by publishing the decoded data as specific messages in Message Manager. Once data is published it is available to any machine / Starfix application across the network regardless.

The following is a list of sensors providing inputs to the Starfix system:

Positioning:

Starfix HP Position (Primary Position Source)
Seapath DGPS NMEA Position (Secondary Position Source)
Starfix GSS Position (Tertiary Position Source – uses same GPS Rx as HP)
Seapath Pitch / Roll / Heave and Heading (Primary Heading & P/R/H Source)
Robertson Bridge Gyro (Secondary Heading Source)
Starfix HP Multiplexer - for system config.

Sounders:

EM1002 – Center beam (Nadir) depth
EA600 – 12Khz, 38Khz and 200Khz frequencies plus backscatter for each channel. The backscatter values have been recorded in Starfix Logging and in Simrad datagram files.

System Outputs

In addition to decoding sensors for input, IOWIN can also output RS-232 data for external sensors requiring fix or position information. Any information available in Message Manager can be broadcast to an external device.

Coda	Fix and Position output.
Video overlay	Liebnitz-Lann overlay input into Seatronics camera system

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Port No	Item	Group	DLL	Baud	Name
1	Raw Ashtech Z	GPS Receivers	Ashtech Z12	115200 N,8,1	Default
3	Oistar Bus	Oistar Fieldbus	Oistar Ports	57200,N,8,1	Default
4	Coda output	ASCII Outputs	CODA Out	9600,N,8,1	Celtic Explorer/ Pinger
6	MVP Water Depth	Config In/Out	Configurable Output	9600,N,8,1	MVP DBS Output
7	Starfix MUX	GPS receivers	SPM Remote Control (type = serial, com)	115200 8,n,1	Default
10	EM1002 centre Beam	Config In/Out	Configurable Input	9600,N,8,1	EM1002
17	Magnetometer	UW Sensors	SeaSpy Magnetometer	9600,N,8,1	SeaSpyMagin
18	Maggy position	Position Output	NMEA,GGA & ZDA	9600,N,8,1	Default
Hardware	Fixing	Fix triggers – Serial Fix out (type = hardware)	Serial Fix Out	9600,N,8,1	SEIS
OIS1	Master Oistar				
OIS3	Octans	Motion Sensors	Ixsea Octans	19200,N,8,1	Octans
OIS4	Starfix_HP	Position Input	Geco-Prakla Position In	9600,N,8,1	Starfix_HP
OIS5	EA 600 Sounder	Sounders	Simrad EA 600	9600,N,8,1	EA600
OIS9	Gravity	New/Unvalidated	GravityMeter	9600,N,8,1	GravityMeter
OIS10	Starfix_HP Output	Position Output	NMEA,GGA,VTG,ZDA	9600,N,8,1	MainVessel_CRP
OIS 12	Bridge Gyro	Heading Sensors	NMEA	4800,N,8,1	Bridge Gyro
UDP	Seapath Motion	Motion Sensors – Seapath GPS attitude Sensor	NMEA PRH		SeaPath_PRH
UDP	Seapath Position	Position input - NMEAGPS	GGA, ZDA, VTG		Seapath_DGPS

Mux 01S2	Corrections	GPS Corrections	SCF	9600,N,8,1	Default	Multiplex Starfix corrections
Mux 01S3	Starfix_GSS	Position Inputs	NMEA,GGA	9600,N,8,1	Starfix_VBS	Multiplex Starfix_VBS position

Starfix Reference Stations

HP and differential corrections are delivered to the vessel user by SCF broadcast message via the EA-SAT Spot satellite. HP reference stations in use are shown in Table 4.

Station	Latitude	Longitude
Aberdeen	57° 11' 56.297" N	002° 03' 32.313" W
Shannon	52° 41' 30.208" N	008° 55' 04.743" W

Table 4 Starfix reference stations

Starfix Logging

Starfix navigation data is logged in FBF format and then re-named to an agreed naming convention (L_XXX_datetime_fbf) and backed up to the server at the end of each survey line.

Selected FBF data are merged using VBA Proc and exported to csv as required.

Starfix VBA PROC

VBA Proc is installed on a dedicated PC – Fugro PC. VBA Proc is used to extract required information from FBF files and to then generate merged navigation files for the following data sources:

- USBL boomer position in Coda format
- Sparker position in Coda format

Seatex Seapath 200 System

The Seapath 200 provides a real-time heading, attitude, position and velocity solution by integrating the best signal characteristics of two technologies, Inertial Measurement Units (IMU's) and the Global Positioning System (GPS). The system utilises a MRU 5 inertial sensor and two GPS carrier phase receivers as raw data providers. The raw sensor data is integrated in a Kalman filter in the processing unit. The Kalman filter is a proven and effective filtering technique for the integration of various sensors in a real-time environment. The filtered output provides heading, attitude and position data as required to the following systems.

- EM1002 Multibeam Echo Sounder
- EA600 Singlebeam Echo Sounder
- Starfix Navigation Software
- CODA dual sensor seismic record/playback system

The system performed well during BGS 07/06 / CE07_05 cruise acquisition.

Bathymetry EA600 SBES

The Simrad EA600 single beam system is a multi frequency hydrographic echo sounder. The system installed on the Celtic Explorer has three main transducers and a shared transducer with another system. The three main frequencies are 12kHz, 38kHz and 200kHz with the shared transducer at 120kHz. The backscatter values for all frequencies have been logged in the Fugro Starfix system and in Simrad datagram files.

The system has three main components, which consists of the transducers, a general purpose transceiver and a PC based display interface running on Microsoft Windows®. Most of the echo sounder functions are implemented in the software. The bottom detection algorithm is implemented solely in the software with a separate computation for each frequency channel.

Interfaces are provided for the depth telegram output as well as navigation data, temperature sensor and heave sensor inputs. The system installed takes the navigation and heave data input from the Seapath 200 and velocity profiles directly from any SVP instrument. The EA600 is interfaced to the Fugro Starfix navigation system; all three channels are logged in the FBF file.

Data is also logged in Simrad format on the local hard drive. EA600 data has been processed in Caris.

Bathymetry EM 1002 MBES

The primary system for gathering the bathymetric data was the Kongsberg Simrad EM1002 multibeam echosounder, hull mounted on the vessel and operating at a frequency of 93khz to 95 kHz. Vessel heading and attitude is input to the EM1002 from the Seapath 200 to correct bathymetric data in real time.

A fixed swath coverage of 660m was utilised throughout, to maintain a beam spacing of at least 5% of water depth, providing the acceptable data density and data quality. In fixed coverage mode the system automatically adjusts the angular coverage so that it attains the desired swath width. More detailed information about swath coverage for particular lines is present in the Simrad Linestat files.

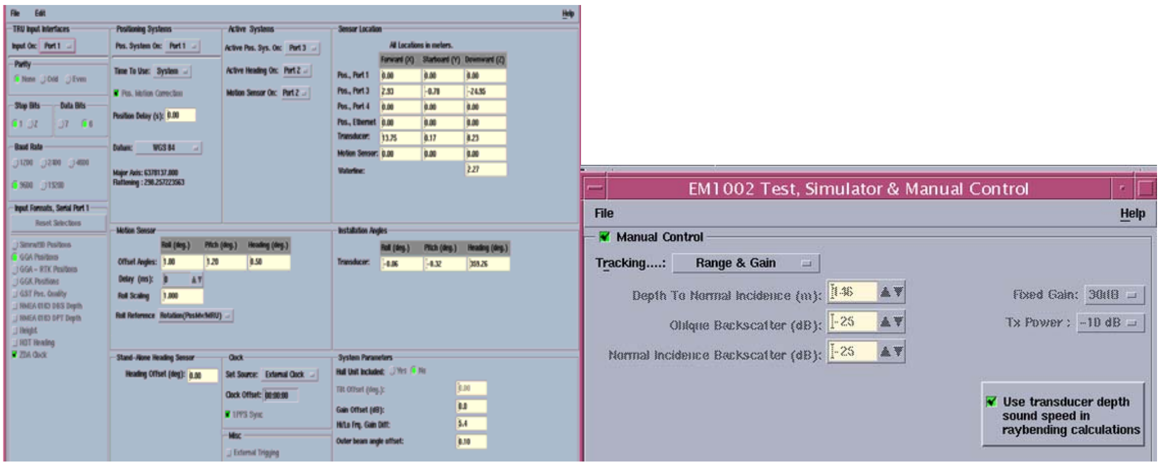

Figure 21 Multibeam setting for this cruise.

Starfix HP is set as the primary positioning on Com 3. Position is sent directly from the HP unit. Com 2 is hardwired to Seapath motion data, Com 1 is secondary positioning - Seapath Position with HP differential corrections. Set-up parameters can be viewed by selecting MBES>View>Installation Parameters: note that the offset for the Seapath is at 0,0,0 as Seapath

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data is corrected for offset at source. Time synchronisation for the multibeam is through a ZDA (Standard NMEA timing message) string and 1PPS signal from the Seapath.

The settings for Ping Mode, Beam Spacing and Absorption coefficients haven't be changed during the cruise in order to ensure the quality of the backscatter information.

Ping Mode = deep
Beam Spacing = Equidistant
Sound Speed at transducer = Sensor
Absorption coefficients: from profile

Settings should only be changed if required by the party chief for Hydrographic reasons.

The sound speed at transducer must be set to sensor. The sound speed at transducer is not used for depths calculations (only the actual profile is) but for electronic beam steering.

Quality Control.

Bathymetric data quality was monitored online and corrective actions were taken in the case of data quality deterioration i.e. CTD's were taken as necessary. Regular checks of processed lines displayed in the Caris seabed mapping system were performed to check for mismatches between lines due to differences in sound velocity or other sources of error.

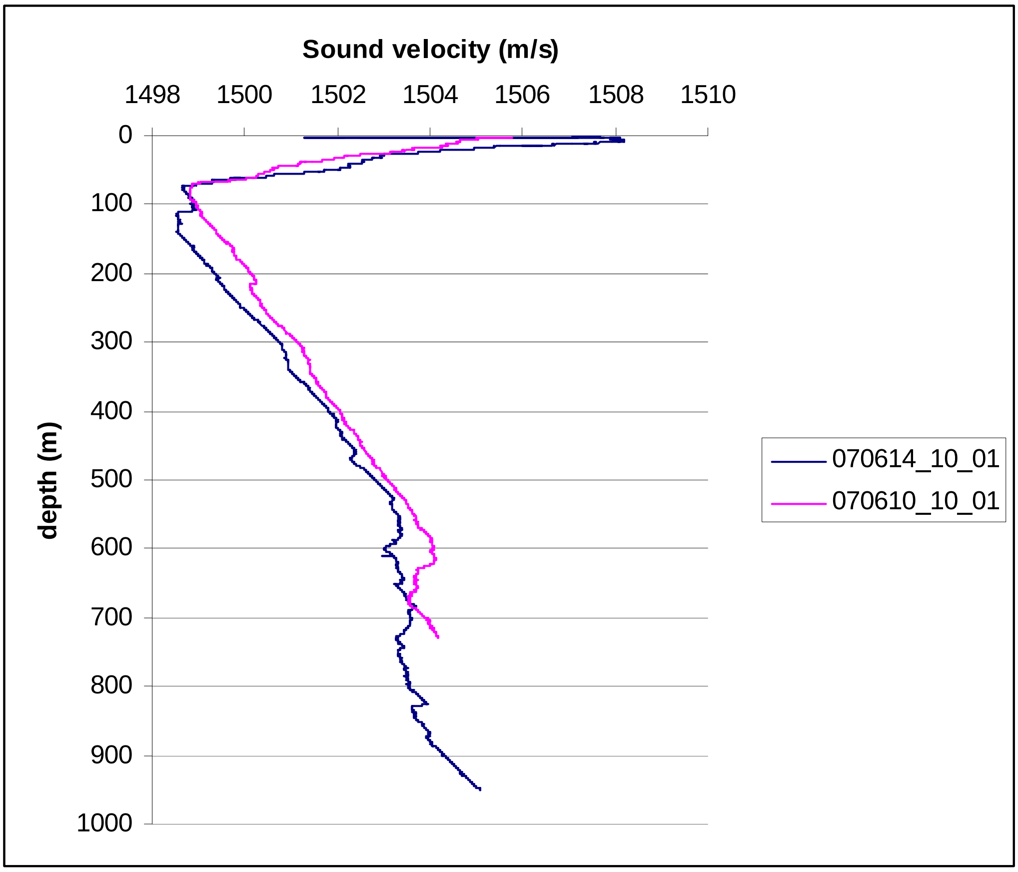

Figure 22 CTD comparison

ANALYSIS OF INTERNAL CONSISTENCY.

Even if the main survey area was on deep water and tidal error can be considered of minor importance an analysis of internal consistency was performed regularly by the processors using Caris Subset Editor. A consistent match was observed, so no adjustments were made due to unpredicted tide changes throughout this leg.

Quality Assessment of Cruise BGS07/06 / CE0705

REQUIREMENTS

In the MESH Scope of work it is stated that bathymetric data should be acquired to meet the IHO_S44 Order 2 as a minimum for multibeam standards.

Order 2 hydrographic surveys are intended for areas with depths less than 200 m not covered by Special Order and Order 1 and where a general description of the bathymetry is sufficient to ensure there are no obstructions on the seafloor that will endanger the type of vessel expected to transit or work the area. It is the criteria for a variety of maritime uses for which higher order hydrographic surveys cannot be justified. Full bottom search may be required in selected areas where the bottom characteristics and the risk of obstructions may be potentially hazardous to vessels.
Order 1 surveys are intended for harbours and general inter-coastal and inland navigation channels including those approaching harbours where vessel drafts have a greater clearance above the seafloor or where the bottom characteristics are less hazardous (e.g. silt or sand) than for Special Order survey areas.

RESULTS.

Depth Accuracy across swath width:
To calculate the depth accuracy for CE0705 data, an overall statistical comparison of data between the main survey and the cross lines was performed. The assessment was performed for 8 cross lines. The quality assessment was done as a function of the new CARIS HIPS 6.0 program generating a HIPS quality control report. Digital terrain models (DTM) were created for main lines and were compared with the accepted soundings of cross lines by means of special tools in Caris Hips 6.0. The program creates a quality report file, which generates statistics, the fit of the cross line with the DTM and calculates Pass/Fail by IHO S-44 Standards for Hydrographic surveys. The quality report was generated for each cross line (can be found in multibeam/caris/qc folder). Together with standard statistical parameters there are also parameters of data acceptance based on IHO S-44 Standards for Hydrographic surveys (S-44 Ed). The 4 depth dependant criteria used for generating the Pass/Fail results were as follows:

- Error Limit (Tolerance) = Sqrt $((a^2+(b*z)^2)$ where:
- a - constant depth error, i.e. the sum of all constant errors
- b*z - depth dependent error, i.e. the sum of all depth dependent errors
- b - factor of depth dependent error
- z - depth

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Statistics are given for different Order surveys in the table below:

Special Order surveys	Order 1 surveys	Order 2 and 3 surveys
a = 0.25 m and b = 0.0075	a = 0.5 m and b = 0.013	a = 1 m and b = 0.023

Table 5 Parameters for IHO S-44 standard

Standard statistical parameters calculated in the Quality control report were used for evaluation of data against IHO orders.

A summary of the results against IHO Special Order, Order 1 and 2 Multibeam standards is presented in the table below.

Single_beam_line	Count	Max (+)	Min (-)	Mean	Std Dev	SO	Order 1	Order 2
L_32	360023	19.38	22.43	0.11	1.34	100	100	100
L_29	1210023	43.94	44.73	-0.0	2.34	99	100	100
L_28	1273227	37.84	32.94	-0.0	2.18	99	99.	100
L_35	467574	19.51	21.55	-0.0	1.86	99	100	100
L_48	970571	68.91	64.15	-0.0	3.66	99	99.	100
L_57	539949	5.855	6.351	0.06	0.76	99	100	100
L_61	305749	47.4	39.5	0.2	4.6	98.	99.	100
L_89	136332	44.9	46.0	0.06	6.08	99.	100	100

Table 6 IHO standards for statistical analysis of depth differences for cross lines vs. main survey on Leg CE07_05.

As can be seen from Table 6, the repeatability of the system is inside specification requirements for the MB Survey Data Accuracy of IHO Order 1 and Order 2.

Data density:
Simrad line statistic files were used to analyse the distance between beams as calculated along and across track. Results are well inside 5 % of water depth. For example, in 1000 m of water the required data density is 1 point every 50 m but as can be seen from Figure 23, the density achieved is well above this requirement.

Swath to Swath Area Coverage:
The survey was performed with approximately 10 % overlap of the swath for every survey line. Parallel line planning was adhered to for the duration of the survey, and determination of line spacing was based on water depth. A maximum swath coverage setting was input for each survey line. Overlap requirements were taken into account when determining line spacing but in some cases the overlap deviated from the 10 – 20% nominal value due to a complicated line configuration to avoid gaps in the coverage and facilitate line running.

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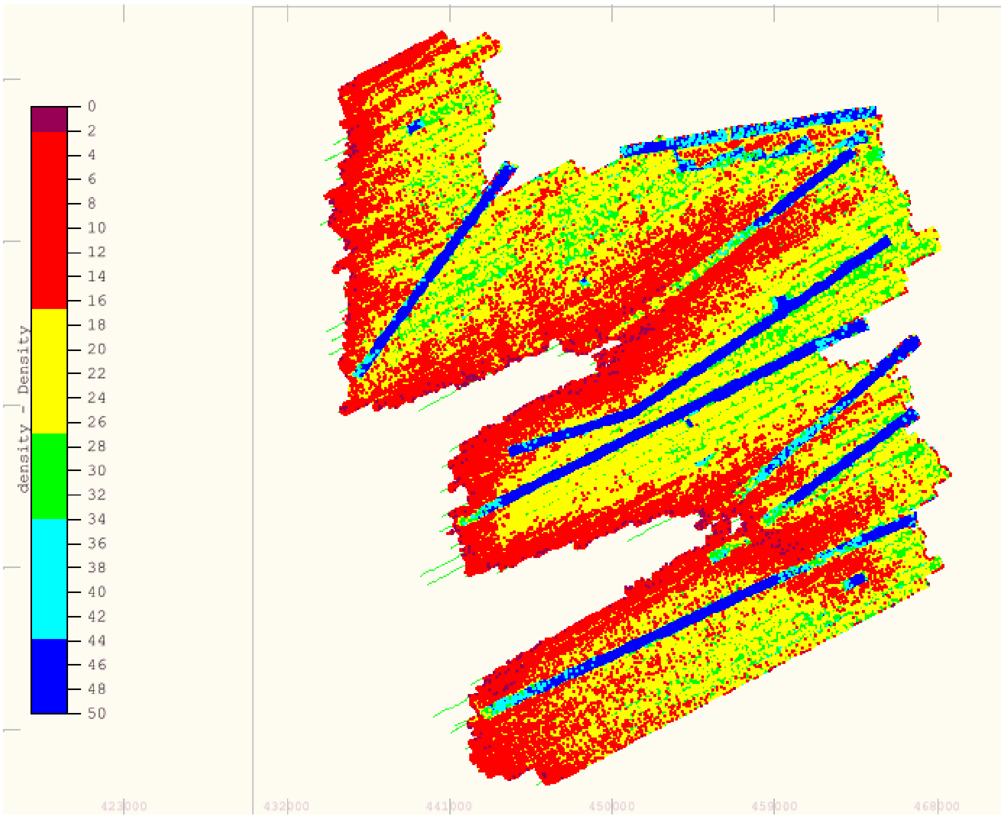

Figure 23 Illustration of data density for the 25m grid

EM1002 Processing

The multibeam echo sounder data was processed utilising CARIS HIPS and SIPS 6.1 multibeam processing software. Multibeam raw data was converted into a CARIS HIPS project directory using the Import command.

To facilitate data processing, preliminary, each survey line was tidally corrected using predicted tides derived from Polpred software from the Proudman Oceanographic Laboratory. The Polpred model used was: Continental shelf Model CS3-30HC.

Each survey line was processed separately in Swath Editor, and after that in the Subset Editor with other adjacent lines.

The refraction editor was used when necessary to correct minor sound velocity discrepancies. After additional manual cleaning, all accepted points were saved. Accepted XYZ-Ascii bathymetry data was exported using the VB based Export program in the following, agreed with GSI formats:

- Latitude, Longitude, Amplitude (db), Beam number, Line number, tab delimited
- Latitude, Longitude, depth, tab delimited.

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EA600 processing.

The EA600 data for this cruise was processed in Caris after being directly imported from EA600 raw file. Only the 200 kHz EA600 bathymetry has been processed in Caris.

The same tide zone files were applied for the EA600 data as for the EM1002 data. After manual cleaning in Caris Single Beam Editor data was exported using the VB based Export program in the following format: Latitude, Longitude, Depth, tab delimited.

Mapping

The digital terrain models were constructed using an appropriate grid size (25m) for the produced charts. Sun illuminated and backscatter images were produced using Caris HIPS.

Sound Velocity Profiles

During this leg, the CTD sensor available onboard was used to acquire sound velocity profiles. In total 3 CTD casts (one for each canyon) were acquired up to a depth of 1000m.

SVP numbering convention

The numbering convention for SVP casts is based on various sensors in use within the MI and cater for data being gathered by other organisations. The following demonstrates the agreed format.

yymmdd_xx_zz

where :-

- yy Year
- mm Month of the year
- dd Day of the month
- _xx Instrument used (serial number justified)
- _zz Consecutive number of the cast during that day (unique no. per day)

With reference to the numbering system the instrument ID nos. are as follows:

02	AML SVP 12 Plus s/n 3288
03	AML SVP 12 Plus s/n 3350
05	AML SVP s/n 4791
08	MVP CTD probe 7136
10	Seabird CTD s/n 0678
11	MVP CTD s/n 7114
12	MVP AML SV s/n 4546

Example:

030711_03_05 Fifth cast of day on 11th July 2003, using AML SVP 3350

030711_01_06 Sixth cast of day 11th July, using MVP

Acoustic Doppler Current Profiler (ADCP)

ADCP data has been acquired during the course of this survey. Although it will not be worked up as such in the scope of this project, the data is available through MESH.

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The ADCP was left in acquisition mode during the all duration of the survey. The Ocean Surveyor ADCP installed on the drop keel can be used to measure real-time current profiles of open ocean water current structures and is capable of providing detailed maps of the distribution of water currents and suspended materials through the water column. No interference with multibeam and single beam frequencies could be observed.

Data has been delivered as part of the survey data structure.

Data deliverables

During the planning of this MESH cruise, it was agreed between the Marine Institute and the JNCC that:

All survey data (navigation, multibeam, svp/mvp etc.) will be delivered in digital format only with maps and draft charts produced as requested to monitor survey progress.

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11. Appendix 6 - Marine Mammal Observer report

11.1. Date and location of the survey

The *R/V Celtic Explorer* cruise CE0705 on behalf of MESH left Cobh, Ireland on Tuesday 5th June and returned into Galway, Ireland on Monday 18th June. The cruise surveyed an area located 320km southwest of Land's End in the SW Approaches (9º25'W-9º55'W and 48º10'N-48º40'N).

11.2. Name and address of MMOs on the vessels

The accredited Marine Mammal Observer (MMO) onboard the *R/V Celtic Explorer* for the duration of the cruise was Fabio Sachetti, a hydrographic surveyor with the Marine Institute, Galway, Rinville, Oranmore, Co.Galway.

11.3. MMO Qualification

Irish Whale and Dolphin Group –Irish Marine Mammal Observer course

11.4. Name of any other vessels involved in the survey

Only the *R/V Celtic Explorer* was utilised during the course of this cruise.

11.5. Grid references for the area surveyed

The area surveyed was 320km southwest of Land's End located 9º25'W to 9º55'W and 48º10'N to 48º40'N.

11.6. Details of watches made for marine mammals and the acoustic survey activity during watches (using standard forms)

The MMO onboard was a hydrographic surveyor who was working the midnight to midday shift during cruise operations. As the accredited MMO he informed the party chief (Heather Stewart, British Geological Survey, West Mains Road, Edinburgh, EH9 3LA) about implementation of soft start procedures should cetaceans be observed breaching the sea surface within 500m of the vessel for the hour prior to sub-bottom seismic data acquisition.

At no time during this cruise were marine mammals observed during the hour prior to the start of sub-bottom seismic data collection. Therefore soft-starting was not required to be undertaken. During the cruise sub-bottom seismic data collection always started within UK waters. As there were no interruptions to data gathering during each 12 hour shift, at no point were the equipment powered down in Irish waters, so there was no requirement for soft starts to be undertaken in Irish waters.

It should be noted that many of the regulations refer specifically to airgun operations. This cruise did not use airguns, but rather the British Geological Survey Sparker and Deep Tow Boomer systems which operate at frequencies of between 200 and 1000 Hz, and 1000 and 3000 Hz respectively.

11.7. Marine mammal sightings (using standard forms).

Although marine mammals were observed intermittently during the cruise the occurrences were not during or just prior to sub-bottom seismic acquisition and no official logs were made.

11.8. Reports from any observers on board.

No reports were officially recorded.

11.9. A record of all occasions when the airguns or other sound sources were used

Please see Appendix 3 of the *R/V Celtic Explorer* operations report (Stewart and Davies, 2007). For details on specific systems used during the cruise please see Chapter 3 of the operations report (Stewart and Davies, 2007).

11.10. The vessel's operations report

STEWART, H A, and DAVIES, J S. 2007. SW Approaches MESH Survey, *R/V Celtic Explorer* Cruise CE0705, BGS Project 07/06, Operations Report. *British Geological Survey Commissioned Report,* CR/07/123.

12. Glossary

MESH **M**apping **E**uropean **S**eabed **H**abitats. MESH has been undertaken by an international consortium of 12 partners across the UK, Ireland, the Netherlands, Belgium and France and is funded under the European Union INTERREG IIIb fund. It began in the spring of 2004 and is due to complete in December 2007 producing a range of ground-breaking maps and reports, including a web-delivered geographic information system (GIS) showing the habitat maps, templates for future marine mapping projects with protocols and standards, a report describing case histories of habitat mapping, and a stakeholder database (www.searchmesh.net).

13. References

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MESH MAPPING EUROPEAN SEABED HABITATS

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