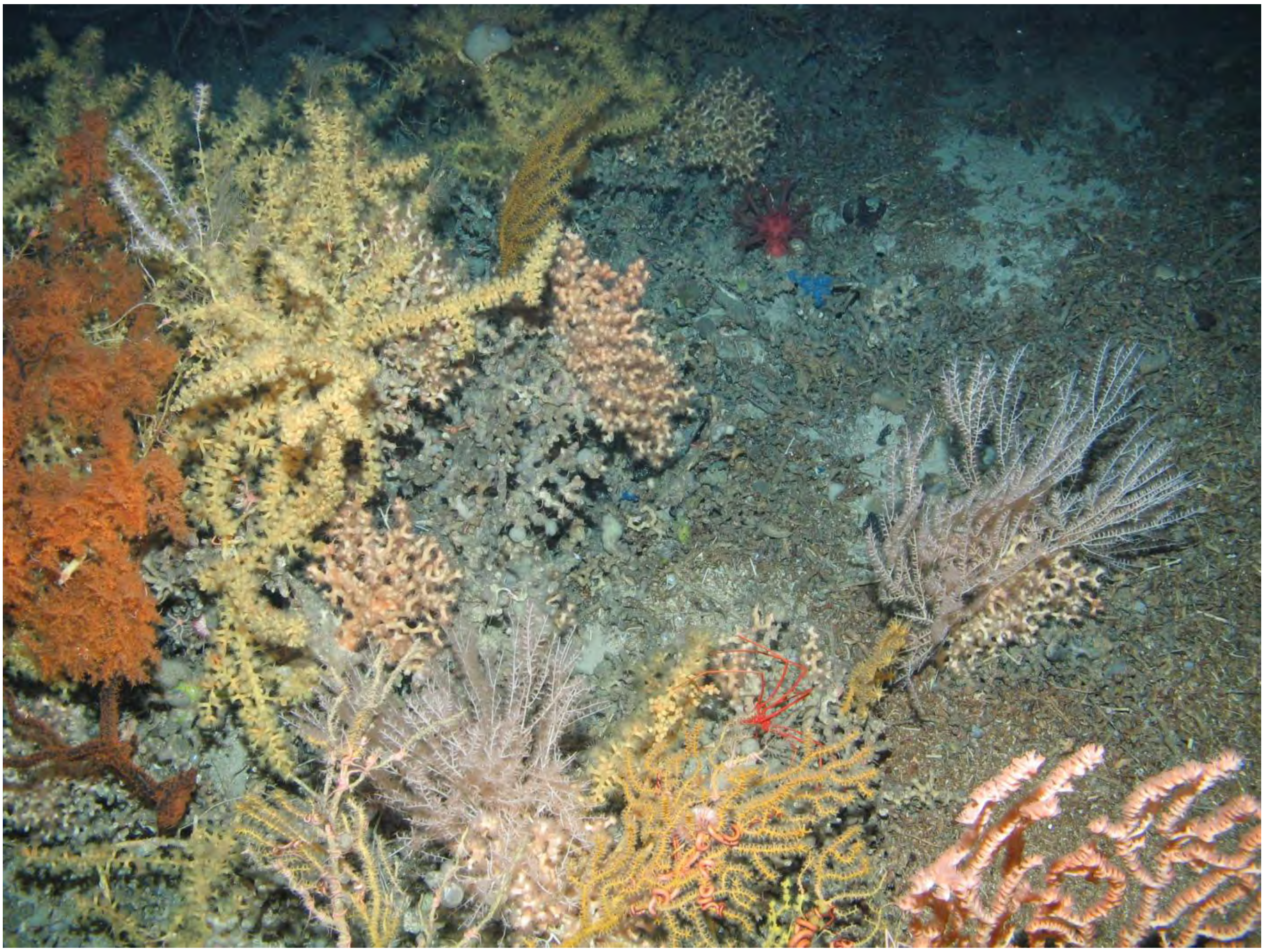
JNCC Offshore Natura Survey

Anton Dohrn Seamount and East Rockall Bank Areas of Search

2009/03-JNCC Cruise Report

Report Number CR/09/113



[1] Annex I reef observed in deep-water to the northwest of Anton Dohrn Seamount (AD_DC_13_073.jpg).

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Document Version Control

Version and Issue Date	Amendments Made By	Issued To
Version 1 30th June 2009	H Stewart	Template updated and put together ahead of survey for SIC
Versions 2-9 1-28th July 2009	D Long	Not issued – written during survey
Version 10 17th August 2009	H Stewart	D Long and K Hitchen for internal BGS review before circulation to all partners
Version 11 25th August 2009	H Stewart, D Long and J Davies	Circulated to all partners ahead of post-cruise meeting
Version 12 4th September 2009	H Stewart	In response to feedback from UoP and BGS.
Version 13 9th September 2009	H Stewart following feedback from N Golding (JNCC)	Final report issued to all partners.

Executive Summary

This cruise report summarises operations and initial observations onboard the *M/V Franklin* during cruise 2009/03-JNCC on behalf of the Joint Nature Conservation Committee (JNCC). The cruise took place between the 1st and 29th of July 2009 and surveyed two Areas of Search (AoS) for offshore Special Areas of Conservation (SACs): Anton Dohrn Seamount located 155km west of the St Kilda archipelago, and East Rockall Bank located 260km west of the St Kilda archipelago (Figure 1).

The main aims of the survey were to acquire acoustic and photographic “ground-truthing” data to enable geological, geomorphological and biological characterisation of the Anton Dohrn Seamount and East Rockall Bank AoS. Specifically, the data acquired will lead to the production of broadscale habitat maps, the identification and description of Annex I reef habitats with particular attention to the occurrence of bedrock, stony and biogenic reef, to identify and record any anthropogenic impacts in the areas of search and finally to evaluate data acquisition methods, techniques and equipment.

The work programme was highly successful with 215 line kilometres of multibeam echosounder and 10 photographic “ground-truthing” sites acquired in the Anton Dohrn Seamount AoS, and 692 line kilometres of multibeam echosounder and 168 line kilometres of sidescan sonar data and 17 photographic “ground-truthing” sites acquired in the East Rockall Bank AoS. No physical sea-bed samples were acquired during this cruise. The data revealed the flanks and area immediately adjacent to Anton Dohrn Seamount to comprise predominantly gravel-rich sediment with bedrock outcropping on the steeper sections of the Seamount flanks. East Rockall Bank comprised predominantly gravelly muddy sand on the eastern flank of the Bank with gravel- and sand-rich sediments dominating the crest of the Bank. Interestingly, the parasitic cones surveyed within the Anton Dohrn area of search comprised predominantly corals, including large gorgonian species, small bamboo coral, the soft coral *Anthomastus* sp. and the antipatharian *Leiopathes* sp. Significant bedrock reef was encountered during the course of this cruise along an escarpment located on the eastern flank of Rockall Bank roughly coincident with the 500m bathymetric contour. This laterally extensive feature primarily comprises volcanic bedrock with possible sedimentary bedrock cropping out at sea bed colonised by large stylsaterid hydrocorals and sponges.

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 Annex I reef, they will be assessed against site selection criteria as possible areas for consideration as SACs.

1. Introduction

The key objectives of the cruise were to:

a. To acquire high quality data within the logistical, time and cost constraints of the project, leading to the production of broadscale habitat maps;

b. To acquire acoustic data capable of identifying and describing Annex I habitat (principally reef). In particular, methods used should enable relevant physical sub-types of reef to be distinguished, such as bedrock, stony and biogenic reef (formed by organisms such as *Lophelia pertusa*);

c. To acquire sea-bed imagery (digital video and digital stills) to enable the geomorphological / geological interpretation of datasets, and to describe the range of sea-bed habitats and associated epifauna that exist within the AoS.

d. To acquire sea-bed samples where permissible, to describe the biological communities which characterise these habitats, and to enable the geomorphological / geological interpretation of datasets interpretation of datasets.

e. To identify and record the nature and location of any obvious human impacts in the AoS (e.g. trawl marks, dumped or discarded material, gear or nets);

f. To record and describe any new habitat types discovered in UK offshore waters, in line with draft proposals for modifications to the deep-water EUNIS classification in *Howell, (in prep)*;

g. To evaluate the effectiveness of data collection methods, techniques and technical equipment;

h. To present findings of the survey as detailed in the contract specification.

The cruise visited two AoS for offshore SACs: Anton Dohrn Seamount and East Rockall Bank, both are located in the northeast Atlantic Ocean to the west of the Scottish mainland (Figure 1).

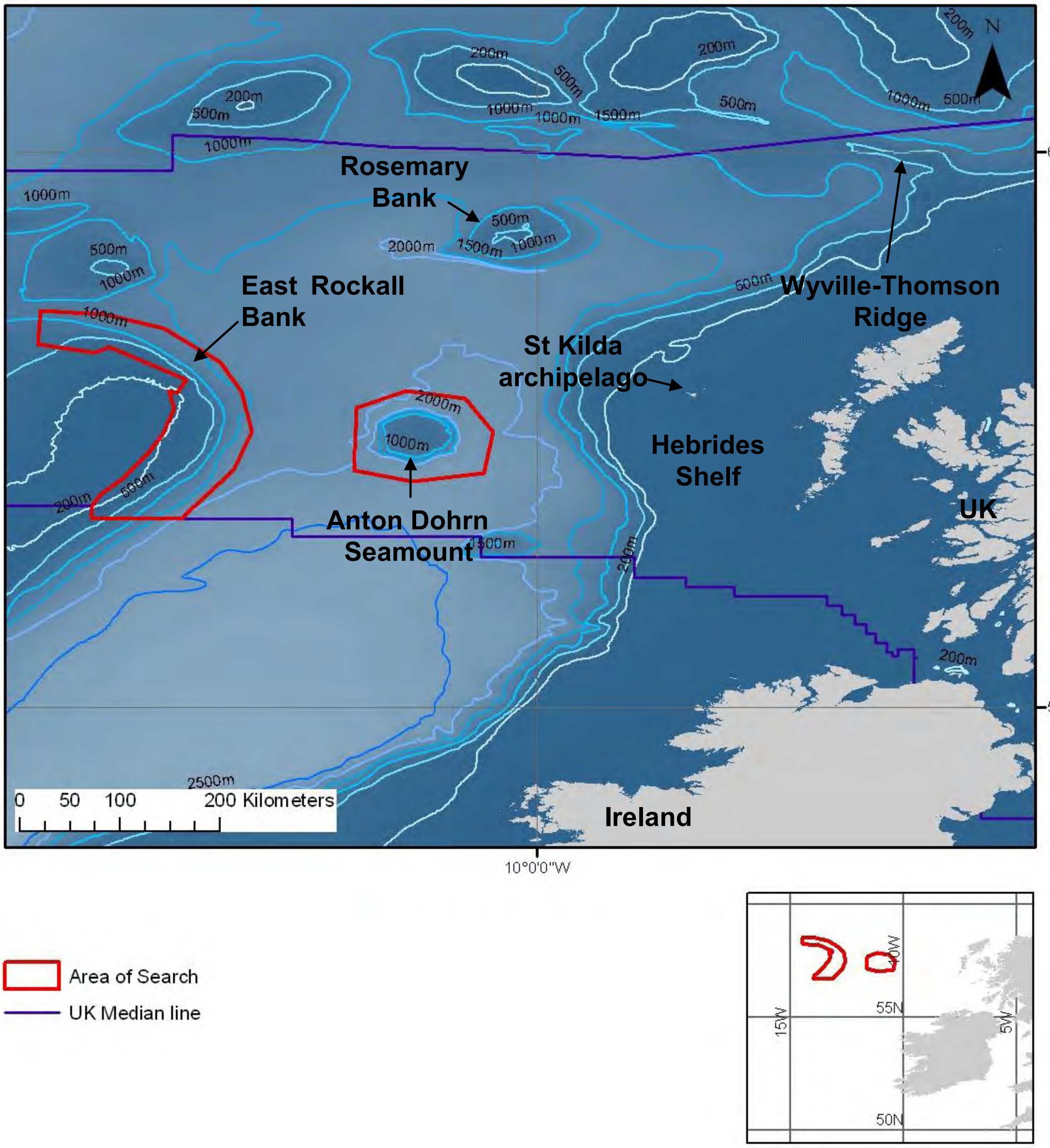


Figure 1 Location of the two areas of search visited during the course of this cruise. The main bathymetric features of the area are labelled. General bathymetric contours have been generated from GEBCO.

1.1 Geological and Biological Context

Anton Dohrn Seamount is a former volcano located in the central Rockall Trough and is approximately 1800m high from the deepest point of the surrounding bathymetric moat (around 2330m below sea level) to the crest of the feature (Figure 2). The highest point is about 530m below sea level. Simplistically the feature is roughly circular in plan view, is approximately 40km in diameter, has a moderately flat top and steep flanks with slope angles of between 25º and 50º (Figure 3). Seismic records acquired by the BGS show that Anton Dohrn seamount comprises basalts at/near sea bed on its crest with Eocene and post-Eocene sediments onlapping its flanks. A wedge of Eocene sediments is also present on the summit of the seamount. Research suggests that volcanic activity at this location extended over a 29 million year period, prolonged for a volcanic centre, but that activity was episodic with volcanism occurring in discrete phases due to a hot, pulsing Iceland plume.

East Rockall Bank is the bathymetric expression of the underlying structural Rockall High. The East Rockall Bank area of search comprises water depths of between 2175m and 190m with maximum slope angles of 48º encountered in the vicinity of a laterally extensive bedrock escarpment roughly coincident with the 500m bathymetric contour (Figure 4). A second bedrock escarpment has also been identified in existing multibeam echosounder data in the southern part of the eastern flank of Rockall Bank roughly coincident with the 1100m bathymetric contour. Extensive volcanic rocks overlie the basement rocks of Rockall High. These are mainly Late Paleocene (57 million years old) to Early Eocene (53 million years old) basaltic lavas (Hitchen 2004) but less basic lavas and tuffs have also been recovered by sea-bed sampling and drilling. A composite, latest Paleocene to mid Eocene (57-53 million years old), eastward-prograding sediment wedge, drilled by BGS borehole 94/3 (McInroy *et al*., 2006) is present on the top of the Bank. A major latest Eocene unconformity (termed C30) is prominent on, and adjacent to, the eastern flank of Rockall High. The C30 boundary is onlapped by fine-grained Oligocene to Recent sediments which blanket most of the Rockall Trough. Some local erosion and the development of ‗moats' along the eastern margin of the Rockall Bank, suggest strong bottom currents are active.

In the deepest waters of the Rockall Trough mud-prone sediments dominate. The majority of the muds present on the floor of the Rockall Trough are indistinguishable from the underlying glacial sediments. The overall depositional rate in the area, away from deposition by slides and mass failures, is low.

On Rockall Bank itself, mean sediment grain size decreases with water depth. In water depths shallower than ~1000m in the northern and central sectors of the Bank, and ~1300m in the southern sector of the Bank, gravelly muddy sand is common with gravel-prone sediments common on the summit. Gravel-prone sediment is also common at the base of the south-eastern slope of the Rockall Bank associated with a deep southwards moving current.

Between Anton Dohrn Seamount and Rockall Bank muddy sand and sand are found in water depths >1000m forming a thin, mobile sheet. Sand-prone sediments have also been sampled from the moat of Anton Dohrn Seamount. This may reflect some form of current activity and winnowing related to current movements around this topographic high. Gravel-prone sediments are also found on the summit of Anton Dohrn Seamount, and like Rockall Bank, they are assumed to comprise a thin layer reworked by storm and deep oceanic currents.

The Rockall Trough, within which the Anton Dohrn Seamount is located and the eastern flank of Rockall Bank descends into, hosts two main water masses referred to as the Eastern North Atlantic Water (ENAW) and the Labrador Sea Water (LSW). The ENAW forms a water mass that occupies the upper 1200 to 1500 m of the water column with water derived from the Labrador Sea located underneath the ENAW mass. The overall direction of flow of the ENAW is to the north-east although the ENAW is known to be complex with internal eddies and gyres. Norwegian Sea Overflow Water (NSOW) enters the Rockall Trough from the north-east over the Wyville-Thomson Ridge, some of this water mass is deflected southward down the western Rockall Trough where it combines with the anticlockwise circulation of LSW to form North Atlantic Deep Water (NADW). The LSW mass circulates in an anticlockwise direction around the Rockall Trough, constrained by the topography of the Hebrides Shelf and the eastern flank of Rockall Bank. It is thought that the circulation of water masses in the Rockall Trough may influence the distribution of fauna on the sea bed.

Previous photographic surveys of the Anton Dohrn Seamount (undertaken in 2005, one was carried out on behalf of the then DTI as part of their Strategic Environmental Assessment and the other by the Fisheries Research Services (FRS) and the JNCC) focused on rocky areas identified on the sidescan sonar track. As a result Narayanaswamy *et al.* (2006) observed that on the broad summit of Anton Dohrn Seamount the sessile fauna were dominated by brachiopods as well as large barnacles. Although echinoderms dominated the mobile megafauna there was a subtle difference in the dominant species with depth, although this observed difference is likely an artefact of the different sediment types occurring over the depth range examined. Throughout the stations examined, few fish were seen and there were no observations of large sessile epifauna such as gorgonians, other corals and massive sponges. However, gorgonians and live *Lophelia pertusa* have been sampled on Anton Dohrn Seamount as bycatch in the FRS trawl surveys.

The SEA7 2005 survey concluded that Rockall Bank was more diverse in terms of species and habitats than Anton Dohrn Seamount (Narayanaswamy *et al.* 2006); however this is most likely a reflection of the greater range of depths and substrate types sampled on Rockall Bank and the higher number of sample stations acquired. Howell *et al.*, 2009 identified a number of *Lophelia pertusa* reef areas on the eastern summit of Rockall Bank. More extensive *Lophelia pertusa* reefs were encountered on the western and north-western parts of the Bank. The eastern flank of Rockall Bank (390-1600m water depth) is more complex in terms of habitat than any of the summit areas sampled to date. Analysis of multibeam echosounder data suggests the area comprises steep slopes between 400-750m water depth. Mixed substrates of boulders, cobbles and pebbles with areas of exposed bedrock and bedrock outcrop were observed between 391-674m depth with no one habitat type described as dominant. Clumps of *Lophelia pertusa* reef were also observed within this region with associated coral rubble fringes. The more southerly stations on the upper eastern flank (551-736m water depth) were less complex with no bedrock outcrop observed. However, these stations are located within an area of the flank identified as a sediment drift from the multibeam echosounder analysis. The deeper stations in this region (>1000m water depth) exhibited very little habitat diversity with sandy mud giving way to mud as the dominant habitat type. Near the 1000m bathymetric contour areas of cobbles and pebbles were still encountered, however with increasing depth the only hard substrate was provided by the occasional boulder.

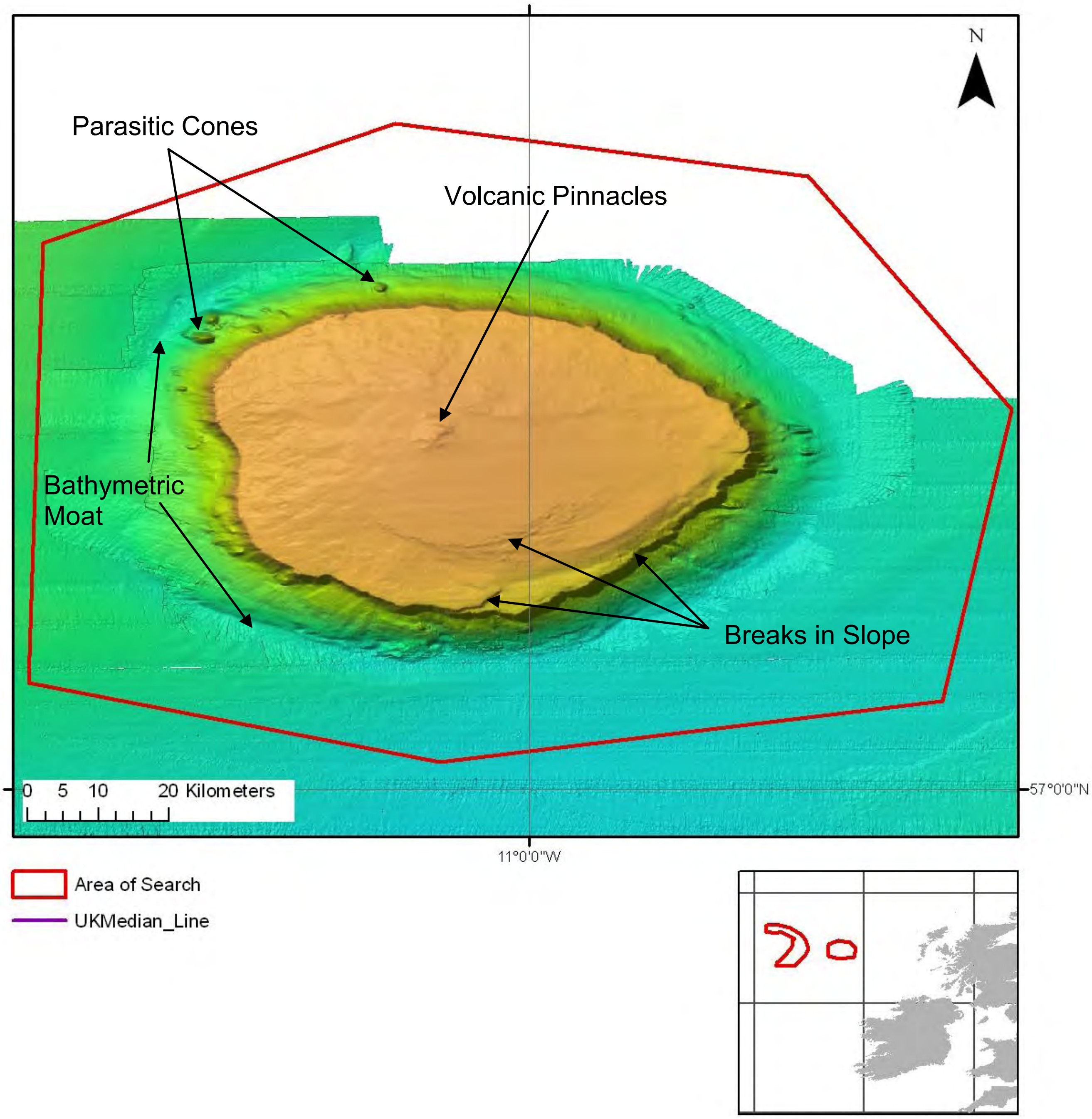


Figure 2 Existing multibeam echosounder data acquired in 2005 as part of the DTI SEA7 and BGS/MESH surveys showing overall morphology of Anton Dohrn Seamount.

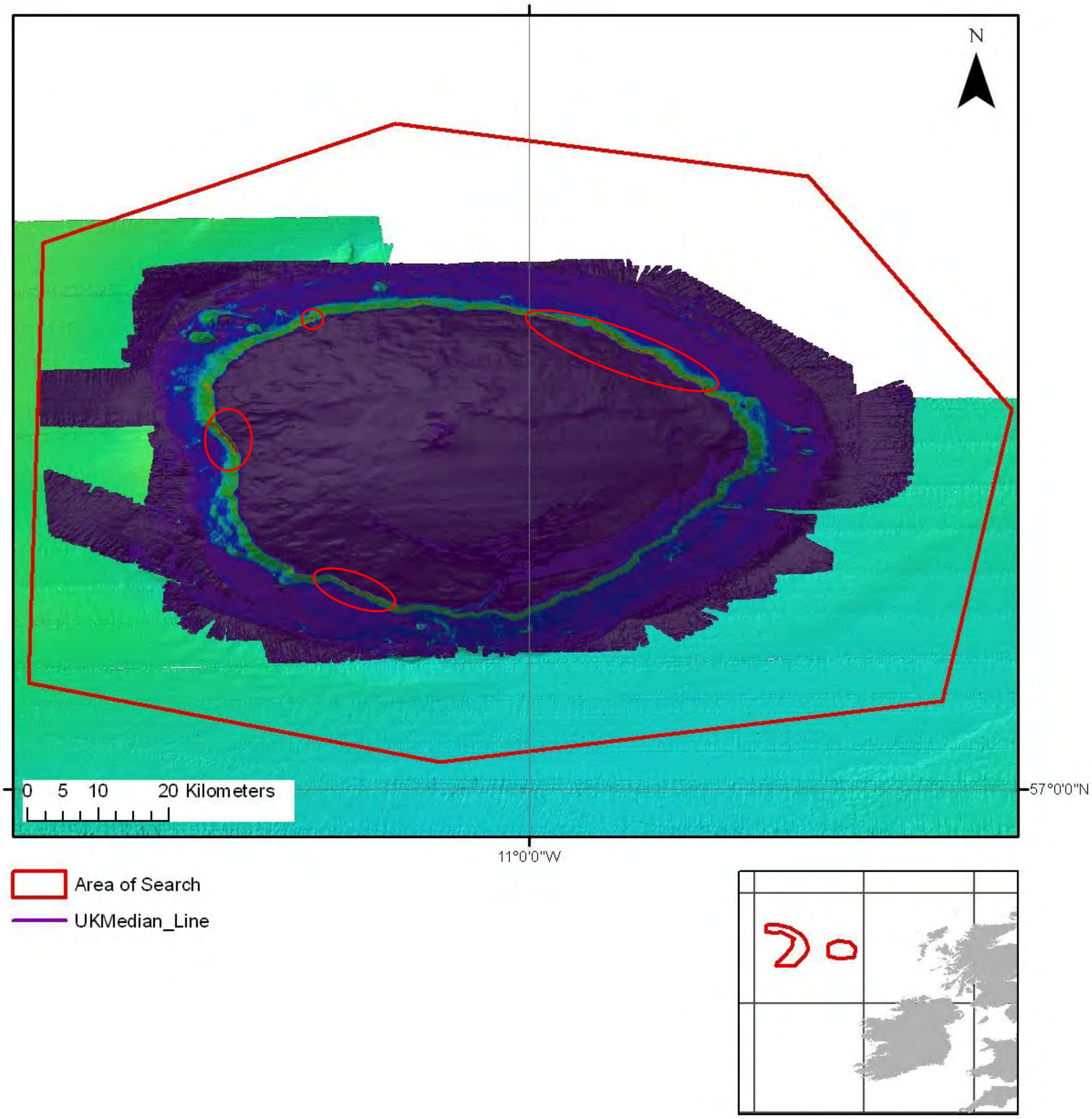


Figure 3 Existing multibeam echosounder data acquired in 2005 as part of the DTI SEA7 and BGS/MESH surveys over Anton Dohrn Seamount calculated for slope angle. Steepest slope angles of between 41º and 50.5º show as red (also circled), slope angles of between 22º and 41º shade from green to orange in colour, slope angles of less than 22º shade from light to dark blue.

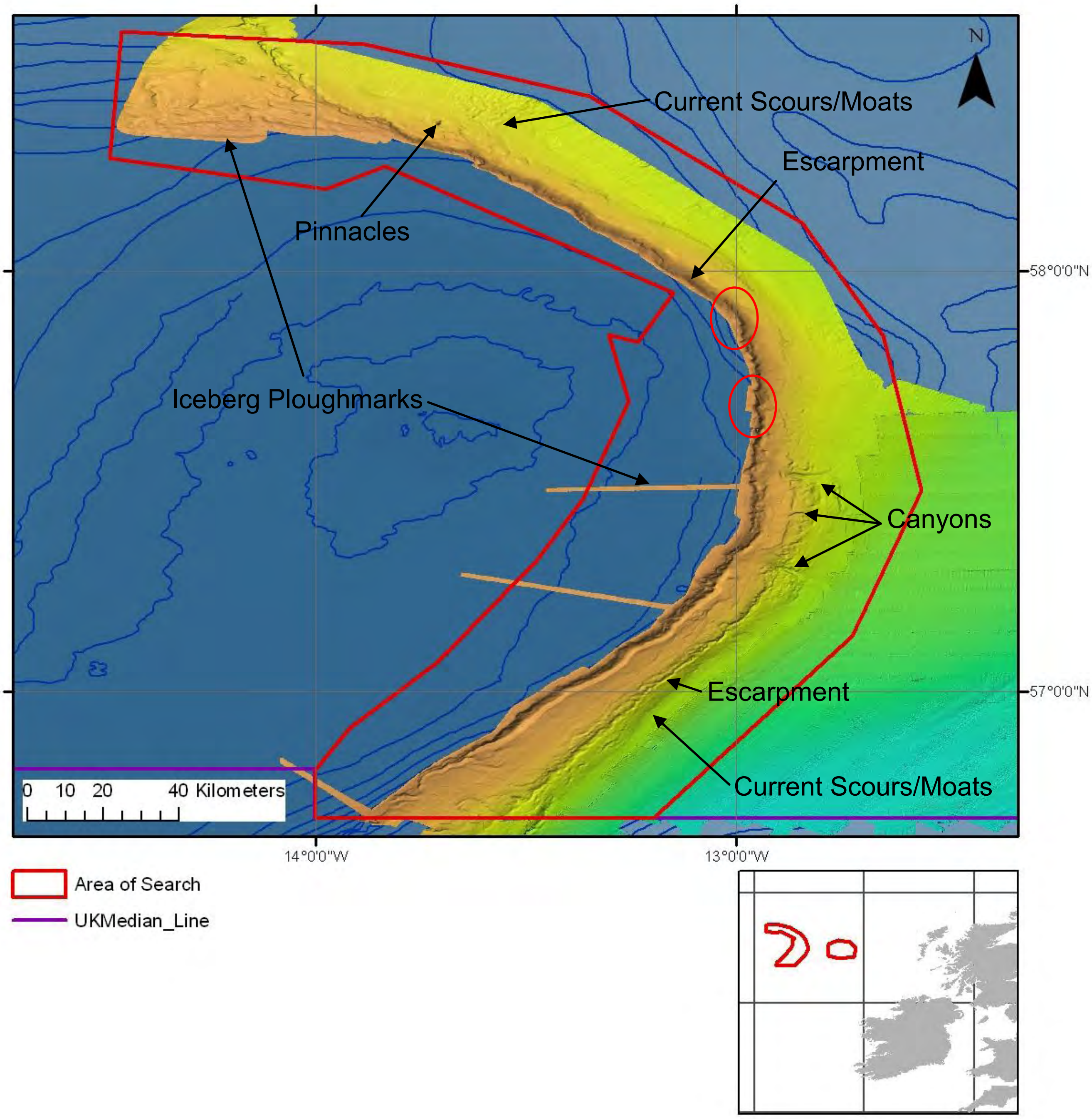


Figure 4 Existing multibeam echosounder data acquired in 2005 as part of the DTI SEA7 and BGS/MESH surveys showing overall morphology of East Rockall Bank. The two areas of steepest slope angle are indicated by the red circles. The data are gridded at 25m resolution. General bathymetric contours have been generated from GEBCO.

1.2 Personnel 1st July -20th July 2009

Scientific Personnel

David Long	Scientist in Charge / Geologist	British Geological Survey
Neil Golding	Client Representative	Joint Nature Conservation Committee
Jaime Davies	Senior Deep-Sea Biologist	University of Plymouth
Maria Campbell	Deep-Sea Biologist	University of Plymouth
Therese Cope	Biologist/data management	Joint Nature Conservation Committee
Bethany Stoker	Biologist/data management	Joint Nature Conservation Committee
Emma Verling	Biologist/data management	Joint Nature Conservation Committee

Survey Personnel

Erik Lindström	Offshore Manager
Helena Strömberg	Project Manager
Matthias Weslien	Senior Surveyor
Robert Mastad	Surveyor
Robin Bergenklev	Surveyor
Anton Westerberg	Surveyor
Anders Adriansson	Senior Processor
Therese Harrysson	Processor/GIS
Cajsa Hermansson	Processor/GIS

Ships Personnel

Christer Rönnblom	Master
Ola Pettersson	Chief Officer
Patrik Waghorn	Chief Engineer
Niklas Stenström	Officer of the Watch
Helena Pettersson	2nd Engineer
Jimmie Österman	Motorman
Cimmy Eklund	Cook/Steward
Magnus Nilsson	AB Deckhand
Jenny Larsson	AB Deckhand
Martin Bengtsson	AB Deckhand

1.3 Personnel 20th July – 29th July 2009

Scientific Personnel

Ken Hitchen	Scientist in Charge / Geologist	British Geological Survey
Neil Golding	Client Representative	Joint Nature Conservation Committee
Jaime Davies	Senior Deep-Sea Biologist	University of Plymouth
Maria Campbell	Deep-Sea Biologist	University of Plymouth
Bethany Stoker	Biologist/data management	Joint Nature Conservation Committee
Emma Verling	Biologist/data management	Joint Nature Conservation Committee

Survey Personnel

Joakim Holmlund	Offshore Manager
Helena Strömberg	Project Manager
Petter Tillmar	Senior Surveyor
Robert Aridun	Surveyor

Karl Rhedin	Surveyor
Robin Bergenklev	Surveyor
Lars Persson	Senior Processor
Cajsa Hermansson	Processor/GIS
Waldemar Karlsson	Marine Biologist/Processor/GIS

Ships Personnel

Richard Olsson	Master
Ola Pettersson	Chief Officer
Håkan Holmqvist	Chief Officer
Ulf Larsson	Chief Engineer
Niklas Stenström	Officer of the Watch
Joakim Gräbner	2^{nd} Engineer
Jimmie Österman	Motorman
Cimmy Eklund	Cook/Steward
Magnus Nilsson	AB Deckhand
Jenny Larsson	AB Deckhand
Martin Bengtsson	AB Deckhand

2. Cruise Plan

A comprehensive cruise plan was compiled by project partners prior to operations beginning.

This cruise supplemented data acquired on comparative surveys of Rockall Bank, Hatton Bank and Anton Dohrn Seamount (SEA7) in 2005, Hatton Bank, George Bligh Bank and Rosemary Bank (SEA7) in 2006 and in the canyons of the south-western approaches (MESH) in 2007 that investigated deepwater habitat mapping methodologies.

The original planned survey lines involved acquiring deep-tow sidescan sonar and multibeam echosounder data simultaneously. A review of the survey plan on the 1st July 2009 prior to sailing, highlighted that turns with the deep-tow sidescan sonar in water depths of 2000m could take up to 3 hours to complete, with 5km of cable out behind. Also in the deepest water (2000m) the survey speed would be reduced to 1.5 knts and only over the relatively shallow water depths on top of Anton Dohrn Seamount and East Rockall Bank could the vessel reach 3 knts during data acquisition. This meant a considerable reduction in the number of lines possible to acquire during the course of vessel operations should deep-towed sidescan sonar data be acquired coincident with multibeam echosounder data.

To overcome the time constraints it was suggested that the backscatter data from the multibeam echosounder may provide comparable data to the sidescan sonar, sufficient to select sites for photographic ground truthing and to characterise the sea bed. Therefore it was proposed that a comparison test be undertaken as part of the acceptance trials over an area with bedrock outcropping at sea bed to assess and compare the sea-bed characterisation produced both by the sidescan sonar and the multibeam echosounder backscatter.

For the acoustic survey over Anton Dohrn Seamount it was agreed to focus the survey in two areas, the south-eastern flank and the north-western flank (Figure 5), with an along slope sidescan sonar and multibeam echosounder line at the top of the break in slope and one in deeper water.

By visiting these two discreet areas the data acquired would provide a contrast between the south-eastern area primarily subject to —southern” water masses and the north-western area occasionally influenced by waters from the Wyville-Thomson Ridge. The two case study areas also differ in the height of the cliff surrounding the Seamount. In the north-western area the break in slope is at around 845m below sea level with the cliff descending to around 2195m below sea level, the south-eastern area comprises a subtle break in slope at around 875m below sea level and a major break in slope at around 1100m below sea level before the cliff descends to around 2300m water depth. The range of morphological features observed on the lower slopes of both areas also differs (Figures 2 and 5).

The survey plan was modified further when the EdgeTech 2400-DSS sidescan sonar malfunctioned during the acceptance test on the 3rd July 2009 and it was agreed to gather a block of multibeam echosounder data covering the south-eastern case study area and use the backscatter data to select a range of acoustic textures for photographic ground truthing using the drop camera frame.

A suite of 10 camera transects (Table 1) were identified by onboard scientists in light of the multibeam echosounder data acquired during the equipment trials and data acquired in the south-eastern case study area. The proposed tows aimed to cover a range of seafloor topographies, water depths and backscatter facies. They were also selected to have a reasonable geographic spread within the two separate multibeam echosounder areas. Out of the 10 transects initially selected, 6 were actually acquired (AC_DC_01-04, 07-08). Transects AC_DC_05-06 were not acquired in light of data acquired from the earlier camera tows. Line AC_DC_09 was proposed following camera equipment failure along AC_DC_07 although it was ultimately not acquired during the course of this survey. The data acquired before the equipment failure on AC_DC_07 was sufficient to qualify as a camera transect as the data acquired covered a distance of ~620m, greater than the 500m minimum transect length required.

Table 1 Proposed camera transects in the south-eastern case-study area of Anton Dohrn Seamount.

Name	Easting SOL	Northing SOL	Easting EOL	Northing EOL
AD_DC_01	390000	6351000	390000	6352000
AD_DC_02	395000	6359000	394000	6359000
AD_DC_03	391000	6354000	391000	6355000
AD_DC_04	391000	6357000	391000	6357000
AD_DC_05	391000	6359000	392000	6359000
AD_DC_06	398000	6364000	398000	6363000
AD_DC_07	396000	6367000	398000	6365000
AD_DC_08	396000	6369000	397000	6369000
AD_DC_09	396000	6364000	399000	6364000
AD_DC_10	387000	6352000	388000	6351000

For the north-western case study area of Anton Dohrn Seamount 8 camera transects were proposed (Table 2). Proposed transect 13 had 2 way points where the proposed transect turned slightly to ensure 2 primary targets were crossed. Due to the camera equipment failure and deteriorating weather conditions only 4 transects were actually acquired in the north-western case study area: AD_DC_9, 12-13 and 16.

Table 2 Proposed camera transects in the north-western case-study area of Anton Dohrn Seamount.

Name	Easting SOL	Northing SOL	Easting EOL	Northing EOL
AD_DC_09	366000	6387000	367000	6386000
AD_DC_10	369000	6387000	369000	6388000
AD_DC_11	368000	6388000	367000	6388000
AD_DC_12	361000	6383000	358000	6385000
AD_DC_13	355000	6384000	357000	6385000
AD_DC_14	369000	6390000	369000	6391000
AD_DC_15	362000	6385000	362000	6385000
AD_DC_16	367000	6388000	367000	6388000

For the eastern flank of Rockall Bank the original survey plan comprising a series of combined multibeam echosounder and sidescan sonar lines were replaced with a long double swath width of multibeam echosounder data acquired along the upper break in slope (escarpment roughly coincident with the 500m bathymetric contour) as imaged previously by the SEA 7 2005 multibeam echosounder datasets (Figure 6). This was chosen as being the most likely place to host Annex I reef habitats, in particular as potential sites for *Lophelia pertusa*. A number of perpendicular lines were added to the along escarpment line to better characterise features of interest observed on the 2005 multibeam echosounder dataset. The planned survey lines located on the top of the Bank, across an area of suspected iceberg ploughmarks were acquired during the course of this survey. Research suggests that the slightly raised edges of such features often have winnowed boulders that could provide the initiation point for reef development and a refuge for mobile species. It should be noted that this area coincides with a known area of fishing activity which is potentially destructive for any reef fauna that might be established. Due to equipment failure with the EdgeTech deep-tow sidescan sonar system the MMT AB Remotely Operated Towed Vehicle (ROTV) system was used during survey where water depths were generally <500m.

Based on the multibeam echosounder and ROTV sidescan data acquired during this survey a suite of 20 camera transects were proposed by the onboard science party for acquisition (Table 3). Of these proposed transects all were acquired apart from ER_C1_07, ER_C1_12, ER_C1_16, ER_C2_19 and ER_S_20. The transect name for ER_C2_19 was utilised for an additional tow downslope from ER_C2_06, both these transects ran alongslope rather than the proposed downslope transect for ER_C2_06. Transect name ER_S_20 was also recycled for an alongslope transect. The orientations of ER_N_01 and ER_C2_05 were altered from downslope to alongslope and the location of ER_N_03 was shifted slightly north. The total length proposed for transect ER_C1_14 was halved during acquisition due mainly to time constraints during survey.

Table 3 Proposed camera transects in the East Rockall Bank area of search.

Name	Easting SOL	Northing SOL	Easting EOL	Northing EOL
ER_N_01	571000	6464000	572000	6465000
ER_N_02	554000	6481000	554000	6481000
ER_N_03	589000	6450000	589000	6450000
ER_N_04	575000	6468000	575000	6467000
ER_C1_07	616000	6350000	617000	6349000
ER_C1_08	628000	6352000	628000	6351000
ER_C1_09	628000	6376000	629000	6377000
ER_C1_10	600000	6351000	600000	6349000
ER_C1_11	597000	6340000	597000	6340000
ER_C1_12	599000	6343000	599000	6342000
ER_C1_13	610000	6340000	609000	6340000
ER_C1_14	604000	6343000	603000	6344000
ER_C1_15	593000	6351000	594000	6351000
ER_C1_16	601000	6346000	601000	6346000
ER_C2_05	619000	6411000	620000	6411000
ER_C2_06	622000	6401000	622000	6401000
ER_C2_19	622000	6401000	622000	6401000
ER_S_17	586000	6306000	587000	6306000
ER_S_18	602000	6325000	603000	6325000
ER_S_20	608000	6332000	608000	6332000

For actual camera transect locations please see Figures 12-13 and 27-30.

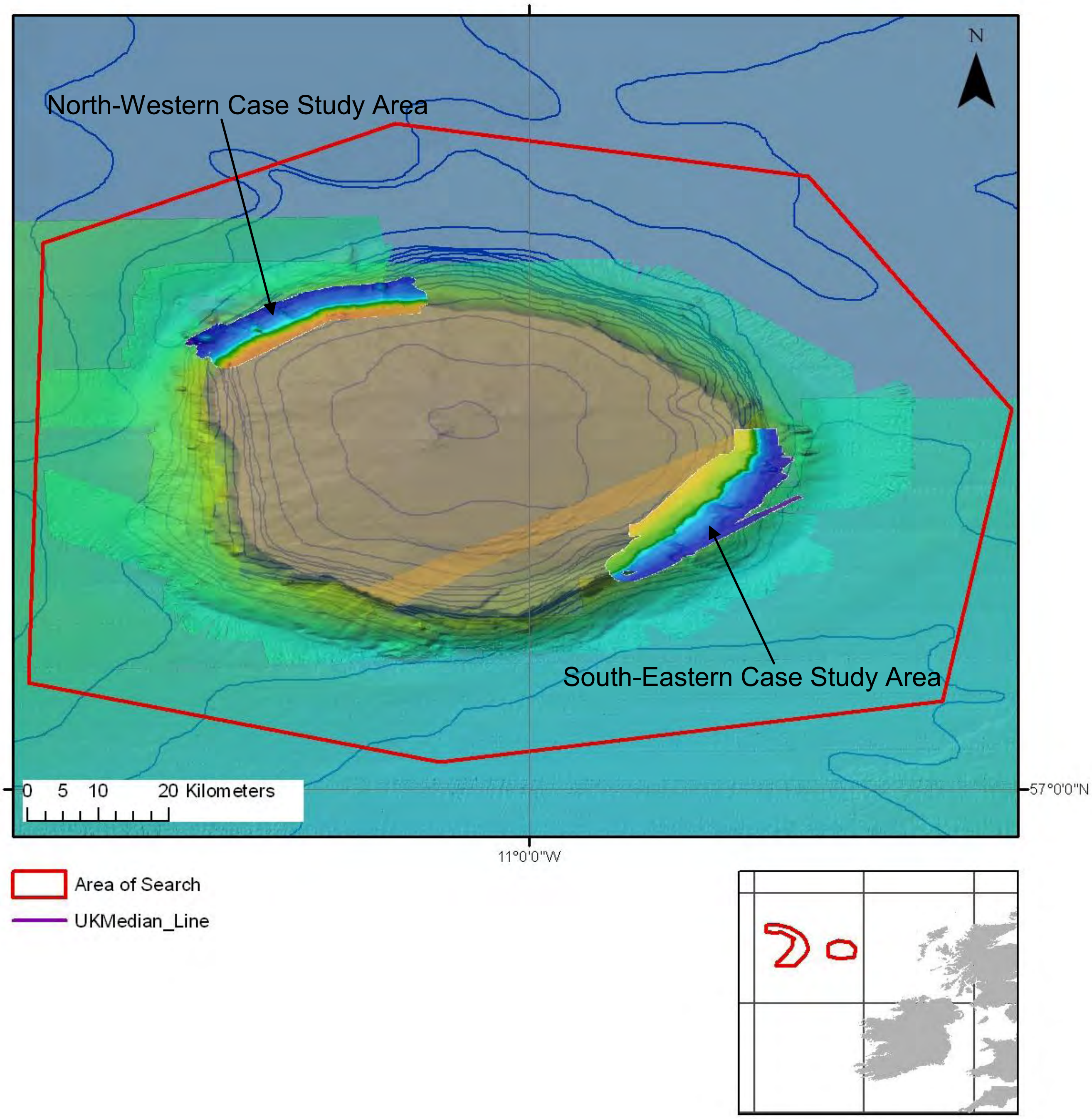


Figure 5 Overview of acoustic data acquired over Anton Dohrn Seamount during the course of this survey.

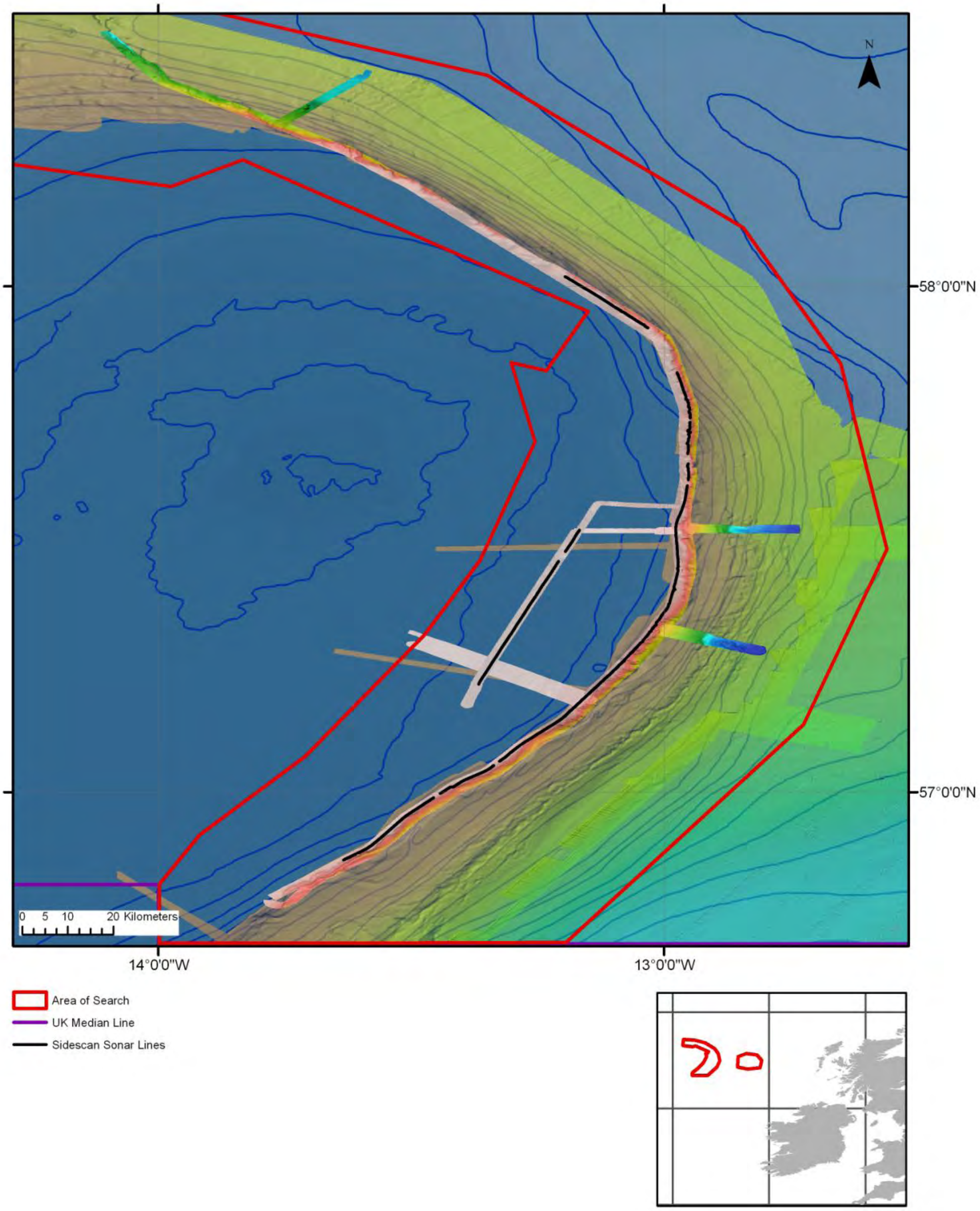


Figure 6 Overview of acoustic data acquired over East Rockall Bank during the course of this survey.

3. Cruise Narrative

The daily logs for the cruise are included in Appendix 3, survey metadata are included in Appendix 4 which includes summary line logs.

3.1 Description of Daily Operations

All times are GMT unless otherwise stated.

Wednesday 1st July (JD 182)

The complete scientific party joined vessel at 1030 at Regents Quay, Aberdeen. A discussion was held with the Offshore Manager and the Project Manager to consider the time constraints on deep tow sidescan sonar data acquisition. It was agreed to assess the suitability of the multibeam echosounder backscatter data with a possible trial over Geikie Escarpment. The Seatronics engineer installed and set up the drop frame camera equipment. The vessel departed Regents Quay at 1800 for a bunkering station. The vessel departed the bunkering station at 2200 to carry out test deployment of the drop frame camera system just east of Aberdeen Harbour. The vessel arrived at the wet test area at 2300 and the drop frame camera system was deployed at 2315.

Thursday 2nd July (JD 183)

Test deployment of the drop frame camera system was completed by 0300 and the vessel began transit to Anton Dohrn Seamount via the Pentland Firth. Safety tours of the ship were conducted for all new personnel and a fire drill was held at 1415. A second test deployment of the drop frame camera system was conducted south of Solan Bank between 1500 and 1730 to set optimum camera positions, light positions and amend the camera settings. Ship engine dynamics were tested offshore Cape Wrath between 2000 and 2200 before the vessel continued its transit to Anton Dohrn Seamount.

Friday 3rd July (JD 184)

The vessel continued transit to Anton Dohrn Seamount with a stop for further testing of the vessels dynamic positioning system between 0800 and 1000. The southeast flank of Anton Dohrn Seamount was reached at 1600. A SVP was undertaken between 1600 and 1745 for calibration of the multibeam echosounder. A north-easterly test line was acquired with the vessel running at a speed of ~4.5knts (Line 1) with only multibeam echosounder data being acquired to assess optimum speed for deep water multibeam echosounder acquisition and to ensure the sea bed was suitable for a deep-tow sidescan sonar test line to be run in the opposite direction. The multibeam echosounder survey was extended 9km beyond the end of the test line to allow adequate distance for the sidescan sonar to be lowered to the sea bed. The deep-tow sidescan sonar was deployed at 2005 and the vessel proceeded southwest to the start of the test line at a speed of 1.5knts. Communication with the sidescan sonar was lost at 2300 and the equipment was recovered to deck. A discussion meeting with the whole scientific party on video tows took place between 1915 and 2030.

Saturday 4th July (JD 185)

The scientific party agreed a suite of multibeam echosounder lines to be acquired once the sidescan sonar equipment was retrieved. The deep-tow sidescan sonar equipment was recovered to deck at 0045 with a twisted cable observed close to the sidescan fish. This is thought to be due to slow winch speed and insufficient vessel speed which combined caused the tow fish to spin in the water column. Acquisition on a suite of NE-SW orientated multibeam echosounder lines began at 0120 starting upslope of the seamount's break of slope, running at an acquisition speed of 4 knts. This suite of lines extended downslope to merge with the test line acquired on 3rd July. Upon completion of that series of lines a series of shorter north-south orientated lines were acquired on the eastern flank of Anton Dohrn Seamount extending the area of multibeam echosounder data coverage northwards to image in better detail a taller cliff feature. The multibeam echosounder survey in this area was completed at 2000.

The drop frame camera was deployed at 2130 to begin the first camera tow AD_DC_01 across a canyon-like feature observed on data from the multibeam echosounder test area. The drop frame camera was at the start of line at 2300.

Sunday 5th July (JD 186)

Camera tow AD_DC_01 was completed at 0100 and showed a range of bedforms along its 1km length including a near-vertical cliff of chalk-like sedimentary rocks. Winch spooling problems delayed the recovery of the drop frame camera until 0630. It was necessary to spool out the cable and conduct manual control of the spooling gear. On recovery of the drop frame camera it was noted that two of the LED lamps had failed. This was subsequently considered due to current leakage and earthing through the screws at the front and back of the lights. Two further 0.5km camera tows were conducted at the top and bottom of the main cliff feature surrounding the seamount (AD_DC_03 and 04). There were problems encountered with the USBL and it was realised that a reduction in vessel noise might improve communication with the USBL on the drop frame camera, future lines were reassessed to minimise signal to noise ratio. Camera tow AD_DC_04, located at the break of slope, imaged lost fishing gear ghost-fishing. A meeting between H. Strömberg, E. Lindström, N. Golding, J. Davies and D. Long reviewed survey operations so far and discussed the plan for the next 2-3 days. A subsequent camera tow along a deep water ridge (AD_DC_02) proved extensive bedrock in deep water with a high faunal cover. Problems were encountered whilst spooling the cable back onto the winch which delayed the recovery of the drop frame camera.

Monday 6th July (JD 187)

Camera tow AD_DC_08 over the break in slope at the northern end of the area of multibeam echosounder data was acquired to examine an extensive area of high backscatter response at the top of the slope. This showed the sea bed above the break in slope to comprise patches of cold-water coral colonies together with fragments of *Lophelia pertusa* in an area of finer sediment and gravel with occasional boulders. Rock outcropped at sea bed coincident with the break in slope with an area of extensive boulders located downslope showing possible sorting and may represent a palaeo-scree. Limited fauna were observed on this substrate. Regrettably the quality of the video had deteriorated on this camera tow. A second camera tow (AD_DC_07) was intended to extend the full distance down slope; however, the entire drop frame camera system failed after 30 minutes and was recovered to deck. A fault was diagnosed within the DTS6000 control box (suspected water ingress) for which no spare had been provided by Seatronics and a decision was made to collect another from port. Prior to steaming to Stornoway an area of multibeam echosounder data was acquired across key sites identified on the top of Anton Dohrn Seamount. The multibeam echosounder survey was completed at 1230 so as to arrive in Stornoway at the same time as the Seatronics spares.

Tuesday 7th July (JD 188)

The vessel continued transit to Stornoway arriving at 0900. Provisions were taken onboard and the Seatronics spares arrived shortly after midday. Testing showed that the interference observed on the video occurred when the drop frame camera unit was in the water. The drop frame camera cable was spooled off the winch to allow modification to the winch and improve launch and recovery time.

Wednesday 8th July (JD 189)

Work continued on the starboard winch. Hydraulics engineer arrives. Cable spooled back onto winch.

Thursday 9th July (JD 190)

The vessel departed Stornoway at 0830 for trials of the deep-tow winch in an area 3-5 km east of the Eye peninsular. The hydraulics engineer departed the vessel by the vessels inflatable at 1800. The wet test of the drop frame camera revealed the altimeter was not working. The vessel returned to Stornoway by midnight. Testing of the drop frame camera unit, cables and communication ports on topside and the DTS6000 units continued and Seatronics were informed of the results of those tests.

Friday 10th July (JD 191)

Damage to the antennae of the vessels Global Acoustic Positioning System (GAPS) was noted and also dislocation of hoist and chain holding the GAPS unit. MMT AB divers photographed the unit and repairs were started to hoist. A spare GAPS unit was sourced from another MMT AB vessel.

Saturday 11th July (JD 192)

Seatronics engineer and spares arrived at 0100 and began diagnostic analysis of the drop frame camera.

Sunday 12th July (JD 193)

Seatronics engineer continues testing both DTS6000 units and both topside units. This revealed consistent loss of communications ports after about 10 minutes. It is agreed that all Seatronics equipment to be returned to Seatronics in Aberdeen. The MMT AB replacement GAPS unit arrived and divers completed fitting, the GAPS unit was tested by 2000. The vessel waited on weather in Stornoway from 20000 until a storm located in Rockall Trough abated.

Monday 13th July (JD 194)

All Seatronics drop frame camera equipment was offloaded from the vessel for the ferry back to Ullapool and subsequent transport to Aberdeen. The vessel departed Stornoway at 0800 to start transit to northwest Anton Dohrn Seamount. The GAPS and GAPS hoist was tested in deepwater en route to the survey area.

Tuesday 14th July (JD 195)

Following the acquisition of a SVP a multibeam echsounder survey was conducted over the northwest sector of Anton Dohrn Seamount. This revealed the sea bed to comprise a series of small pinnacles located on the shelf break edge and a scalloped edge to the shelf break. Several conical mounds on the lower slope were imaged and a single radial ridge. One of the scallops on the shelf break was located at the head of a steep gulley which discharged out onto the lower slope of the seamount as a hummocky debris flow. This may be evidence of a palaeo-landslide or rockfall.

Wednesday 15th July (JD 196)

Multibeam echosounder acquisition was completed in the northwest Anton Dohrn Seamount area at 0100 and the vessel transited towards East Rockall Bank. A SVP was acquired prior to beginning multibeam echosounder data acquisition at 0700 following the line of a canyon up onto the top of the Bank. Once on the crest of the Bank a multibeam echosounder line was acquired across an area of iceberg plough/trawl marks. This line was repeated with the MMT AB remotely operated towed vehicle (ROTV) to collect sidescan sonar and CHIRP profile data. Comparison of the ROTV and multibeam echosounder data showed strong similarities between the backscatter response and possible coral accumulations identified on the ROTV data (see Appendix 5 section 8 for the comparison). As the ROTV was recovered to deck a SVP was acquired.

Thursday 16th July (JD 197)

On completion of the ROTV survey the multibeam echosounder survey was continued out to the break of slope/cliff feature on the eastern edge of Rockall Bank. Data acquisition continued north following the line of the cliff. The long north trending line was halted at 58.32°N to survey a small mound and hummocky terrain located in deeper water to the east. This revealed a group of small mounds, 50m in diameter and 2-3m high, at the foot of the cliff (Figure 7). A larger mound, located in deeper water to the smaller mounds discovered at the base of slope, had been identified previously on the 2005 SEA7 survey. New data revealed that instead of an individual mound as previously identified, the feature actually comprised three individual conical, possibly volcanic, features up to 200m high and 800m in diameter (Figure 7). Data acquisition continued along the line of the cliff feature and terminated in around 1100m of water between Rockall Bank and George Bligh Bank. A parallel line of multibeam echosounder data was acquired heading in a southerly direction, overlapping the existing line of data.

Friday 17th July (JD 198)

The ROTV was launched at 0430 on northward part of the cliff parallel line to acquire sidescan sonar data where water depths became less than 400m. ROTV data acquisition was undertaken from 0500 at vessel speeds of 5knts and at times in water depths in excess of 500m. A line of sidescan sonar data was collected along the cliff feature where water depth permitted. Difficulties with the ROTV winch delayed recovery of the equipment.

Saturday 18th July (JD 199)

Multibeam echosounder survey of eastern Rockall Bank was completed at 2300. In summary multibeam echosounder data were acquired over the cliff feature/escarpment and one line out into deep water to cover a canyon. A block of four lines (totalling 8hrs of survey time) were acquired on the crest of the Bank within an area currently being considered as an exclusion zone. That included areas thought to be heavily fished and areas currently avoided by fishing boats (based on VMS data). The vessel departed the survey area, adding a line of multibeam echosounder data parallel to that collected running onto Rockall Bank, acquired on the 15th July, and began to transit back to Stornoway for a crew change and to collect a repaired and tested Seatronics drop frame camera system.

Sunday 19th July (JD 200)

Due the poor weather and predicted wave heights the transit back to Stornoway was via Barra Head and The Minch. The opportunity was taken to collect multibeam echosounder data when the vessel was in shallow waters (<150m). The online acquisition display showed very good data quality even though the vessel was making 11knts in a rough sea. The route taken included a crossing of the Mingulay coral reef complex at the southern end of the Minch.

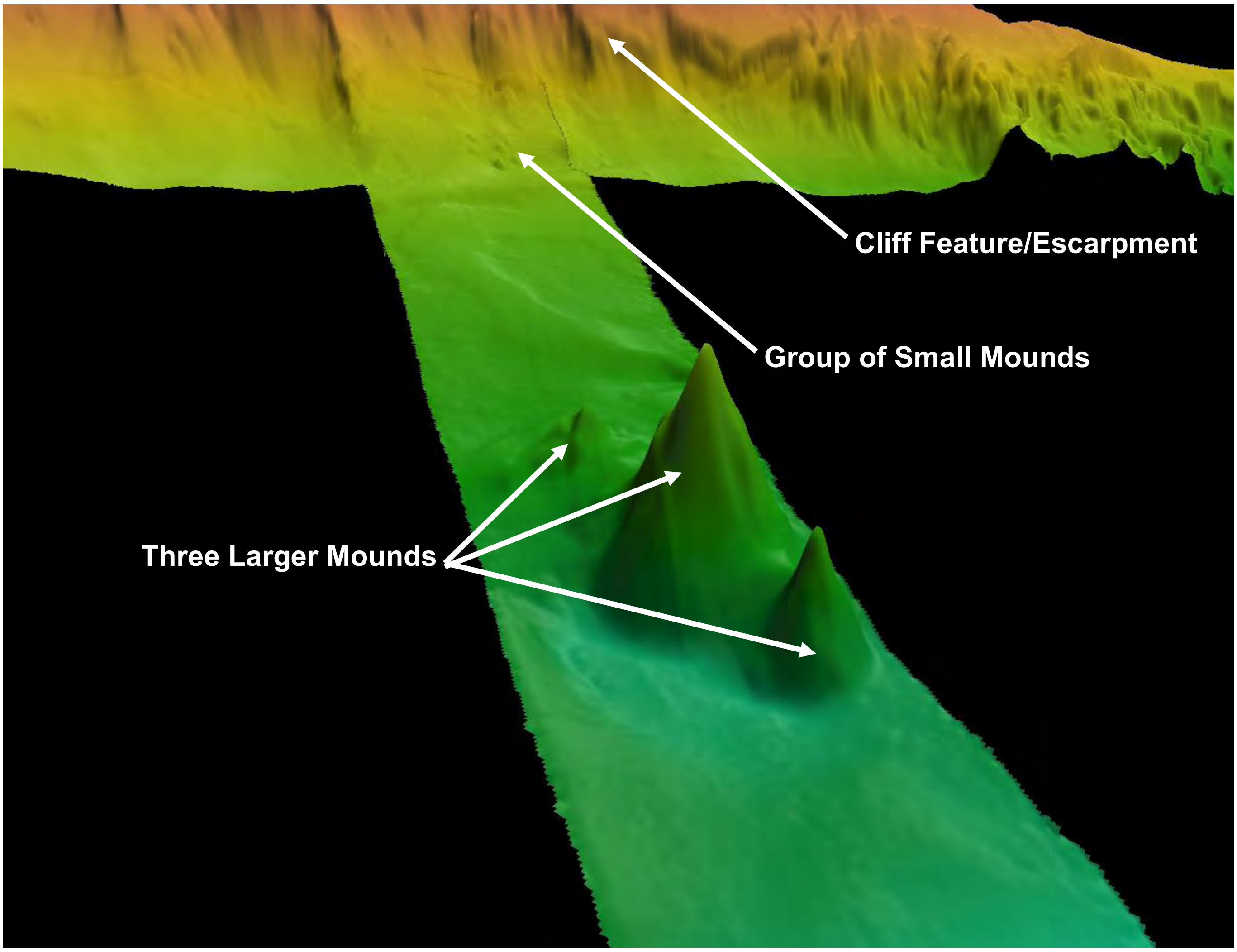


Figure 7 Perspective view looking west towards the eastern flank of Rockall Bank. The largest mound is ~800m in diameter and ~200m in height. Vertical exaggeration is x5.

Monday 20th July (JD 201)

The vessel arrived into Stornoway for crew change and equipment mobilisation which continued until 1920 when the vessel departed Stornoway to transit to a wet test site to test the Seatronics drop frame camera system. Wet test of equipment was completed by 2130 and no problems were encountered. Seatronics were informed that equipment satisfactory and the vessel began transit to East Rockall Bank heading south through the Minch.

Tuesday 21st July (JD 202)

The vessel continued its transit to East Rockall Bank. All scientific personnel attended a meeting from 0800-1300 to identify potential drop frame camera tows on East Rockall Bank. A survey planning meeting with J. Holmlund, H. Strömberg, N. Golding, J. Davies and K. Hitchen followed. It was decided to transit to the northern end of East Rockall Bank first to begin drop frame camera data acquisition.

Wednesday 22nd July (JD 203)

The vessel arrived on tow ER_N_02 at 0202 and minor problems were encountered with communications between the vessel and the deployed equipment. These minor problems were resolved quickly and the tow was completed by 0551. The proposed camera tows in these areas were re-ordered to make best use of survey time and to take account of dominant wind and current direction. Tows ER_N_01, ER_N_04 and ER_N_03 were all acquired successfully in the northern sector of East Rockall Bank. The vessel transited to the start of camera tow ER_C2_05 in the central sector of East Rockall Bank and acquisition along this tow was ongoing at midnight.

A survey planning meeting between J. Holmlund, H. Strömberg, N. Golding and K. Hitchen took place at 1140 to discuss the survey plan in light of poor weather forecast. MMT AB informed the scientific party that the vessel must be in Scrabster by 0400 on the 30th July for crew change marking the end of the cruise.

Thursday 23rd July (JD 204)

Camera tows ER_C2_05, ER_C2_06, ER_C2_19, ER_C1_09, ER_C1_10, ER_C1_11 and ER_C1_15 were all acquired successfully.

Continuous discussion took place between scientific and survey personnel with regard to the weather and potential contingency plans for alternative data acquisition or port visit to wait weather out.

The vessel transited to the start of camera tow ER_C1_14 in the central sector of East Rockall Bank and acquisition along this tow was ongoing at midnight. Minor problems with navigation on this tow were encountered during the first ~30 minutes of this tow, the tow was restarted once the problem was rectified.

Friday 24th July (JD 205)

The weather remained suitable for data acquisition. Camera tows ER_C1_14 and ER_C1_13 were completed in the central sector of the East Rockall Bank before the vessel transited to the southern sector of East Rockall Bank to complete camera tows ER_S_20, ER_S_18 and ER_S_17. The drop frame camera lights failed for a duration of 1 minute during the tow. No cause for this was discovered and this problem was not encountered again.

Whilst the vessel transited between camera tow ER_S_17 in the southern sector and ER_C1_08 in the northern sector the plankton net was deployed (1306-1310) and a sample recovered. An emergency drill was held at 1320.

The vessel arrived at the start of camera tow ER_C1_08 at 1625 and all camera operations were completed on East Rockall Bank by 2052 when the vessel began transit to the northwest sector of Anton Dohrn Seamount.

Saturday 25th July (JD 206)

The vessel arrived on site, northwest Anton Dohrn, at 0050. Camera tows AD_DC_13, AD_DC_12, AD_DC_09 and AD_DC_16 were completed successfully before the vessel had to transit for shelter at Glen Bay, St Kilda due to deteriorating weather conditions.

Tow AD_DC_12 was ~3km in length and observed bedrock outcropping at sea bed on the flank of the Seamount with cold-water coral and associated fauna observed as the tow continued over a parasitic volcanic cone in deeper water adjacent to the main Seamount. The biogenic communities are probably anchored to rock outcropping at sea bed although the bedrock is not always visible due to encrusting fauna.

A survey planning meeting took place at 1400 with J. Holmlund, H. Strömberg, N. Golding, J. Davies, E. Verling and K. Hitchen to discuss the daily progress report, the upcoming period of poor weather and future survey plans should the weather improve sufficiently.

The vessel departed Anton Dohrn Seamount at 1921 to transit to St Kilda.

Sunday 26th July (JD 207)

The vessel spent the day sheltering in Glen Bay, St Kilda waiting on weather. Meetings took place throughout the day between survey and scientific personnel for survey planning in light of poor weather and forecast. Updates of the daily progress reports were made after agreement between survey and scientific personnel.

Monday 27th July (JD 208)

The vessel moved from Glen Bay to Village Bay, St Kilda during morning. Meetings took place throughout day between survey and scientific personnel for survey planning in light of poor weather and forecast. Due to prolonged period of bad weather forecast, the survey would probably be halted as there would be no possibility of returning to Anton Dohrn Seamount before 30th July. However, as yet the weather had not improved sufficiently for the vessel to leave the shelter of St Kilda.

Tuesday 28th July (JD 209)

The vessel left St Kilda at 0500 to begin transit to Scrabster for demobilisation. The vessel docked in Scrabster 2105 and demobilisation began.

Working copies of the data acquired during the cruise were supplied by MMT AB. These were preliminary copies of data and not completely processed. Final data delivery from MMT AB will take place by 31st August as per the contract.

Wednesday 29th July (JD 210)

University of Plymouth personnel departed vessel at 0710, JNCC and BGS personnel departed vessel at 0915. Demobilisation of hired equipment and vessel personnel continued until 2100.

4. Data Examples and Preliminary Observations

The following chapter describes the initial interpretations and biological observations made during this cruise. The general geomorphology and geology of both Anton Dohrn Seamount and East Rockall Bank are described followed by an assessment of the biological communities observed. A comprehensive interpretation of all the data collected will be presented in the final report for this project.

4.1 Geomorphology and Geology of Anton Dohrn Seamount

Integration of the two multibeam echosounder datasets acquired in 2005 as part of the SEA7 and as part of the BGS/MESH regional mapping showed Anton Dohrn Seamount to comprise an upper surface (~530-1100m water depth) surrounded by a steep cliff extending down towards a moat at up to ~2400m water depth (Figures 2, 5, 8 and 9). The case study areas, surveyed on the south-eastern and north-western flanks, showed that this cliff has a number of features coincident with it and several smaller topographic features located adjacent to the cliff in deeper waters (Figures 8 and 9).

Figure 8 images the south-eastern case study area and shows several ridges orientated radially from the centre of the seamount. A gully was also imaged that extends down from the break in slope. In this case study area the cliff extends from a depth of 1100m to the bathymetric moat at 2300m water depth (data acquired during the course of this cruise extends down to ~2180m water depth).

The radial ridge along which camera traverse AD_DC_02 was acquired (Figure 12) is ~100m high with ~15º slope on its northern side compared with its southern flank which is ~200m high with ~23º slope due to the presence of a broad gully on its southern side. A similar asymmetry occurs on the smaller ridge to the northeast of camera transect AD_DC_02 and may reflect erosion and/or deposition by currents circulating around Anton Dohrn Seamount.

The north-western case study area of Anton Dohrn Seamount has a sharp break in slope at ~900m depth with a number of small mounds, reaching up to 55m high, located on the edge (Figure 9). Beyond the break in slope the cliff is steep, locally reaching 64°. It has a scalloped appearance suggestive of slope failure. In deeper water located beyond the cliff a range of features were identified (Figure 9).

Two small ridges ~1 km length and orientated radially from the centre of the seamount were imaged (Figure 10). These radial ridges stand up to ~270m above the surrounding seafloor. The eastern most of the radial ridges imaged on data acquired by this cruise has a narrow moat at its lower limit that extends about half way up its western edge but is orientated along slope on its eastern side. This suggests that the presence of the mound is influencing and diverting a current that runs clockwise (?) around the seamount.

Two parasitic cones were imaged, a third occurs just outside the north-western case study area. The larger, at the western end, is ~400m high and ~1300m in diameter and is surrounded by a moat, ~400m wide. Although broadly conical in appearance its ridgeline suggests that it is positioned along an arc (red dashed line in Figure 9) centred on the parasitic cone to the north east, which is located just beyond the area surveyed. The cone at the eastern end of the survey area is ~230m high, ~960m wide and surrounded by a moat ~300m wide.

Towards the western end of the survey area there is a raised area of uneven topography (Figures 9 and 10). This appears to be linked with a wide gully or shute on the cliff wall and could be interpreted as a submarine landslide or rockfall (Figures 10 and 11). It is 3.5km in length from cliff top to the toe of the debris flow and falls a height of 850m. The debris flow is up to 70m in thickness. Unlike the other evidence for mass movement on the cliff wall this failure is clearly linked with its debris flow. This may reflect its younger age or the larger size of individual failed blocks.

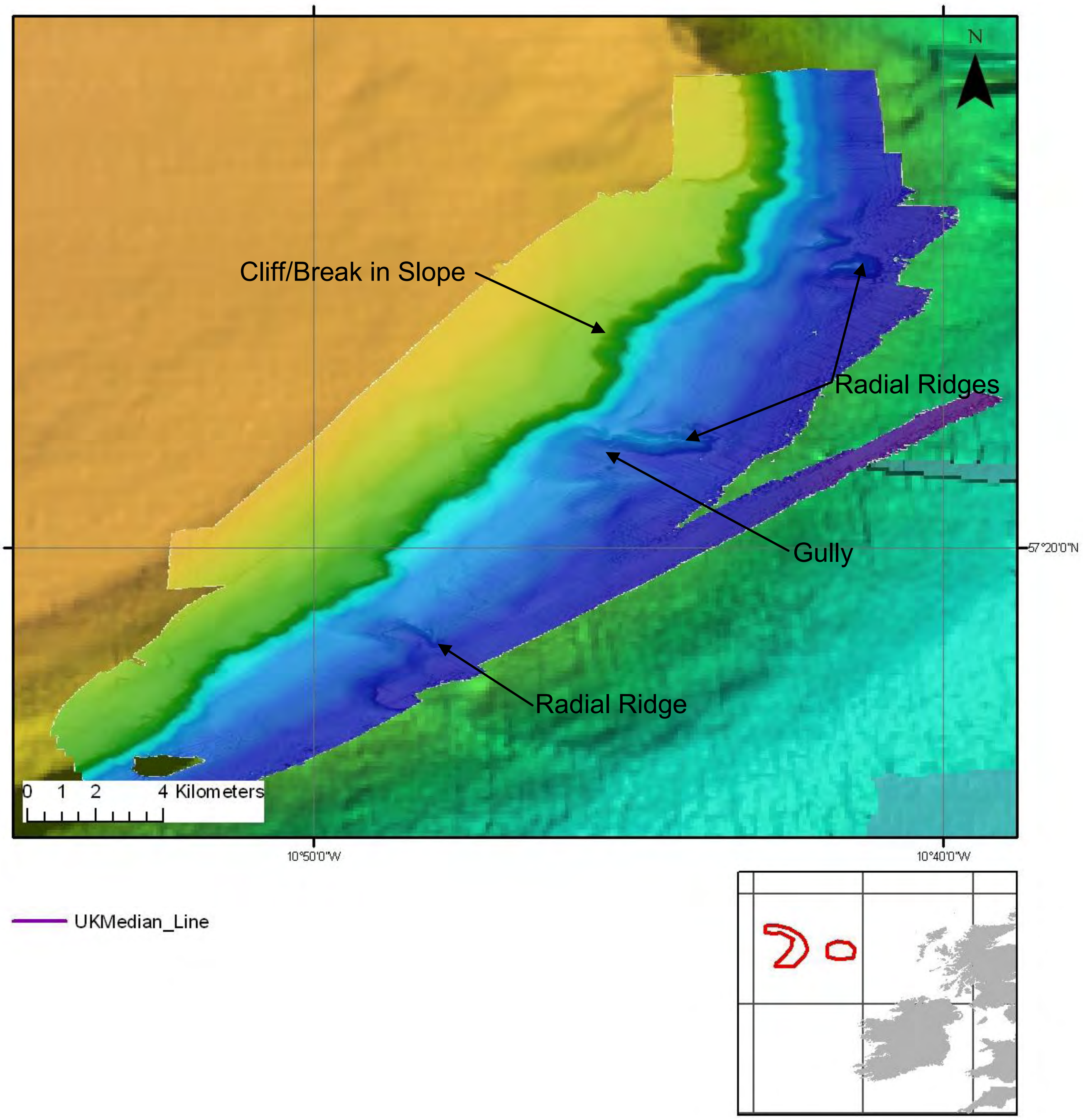


Figure 8 Multibeam echosounder data acquired during this cruise in the Anton Dohrn Seamount south-eastern case study area (for location see Figure 5). The image has been superimposed on top of merged 2005 SEA and BGS/MESH multibeam echosounder data.

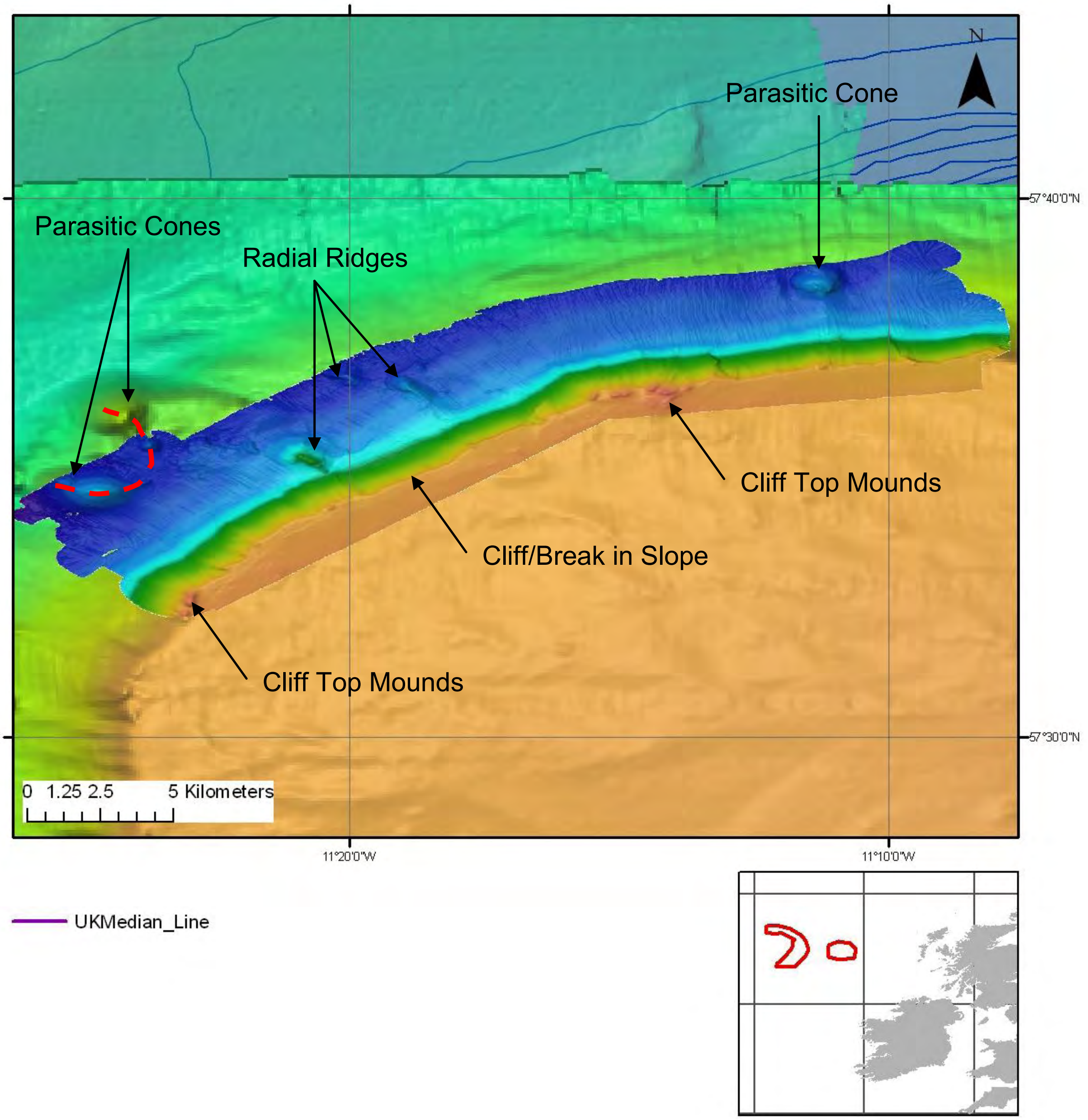


Figure 9 Multibeam echosounder data acquired during this cruise in the Anton Dohrn north-west case study area (for location see Figure 5). The image has been superimposed on top of merged 2005 SEA and BGS/MESH multibeam echosounder data.

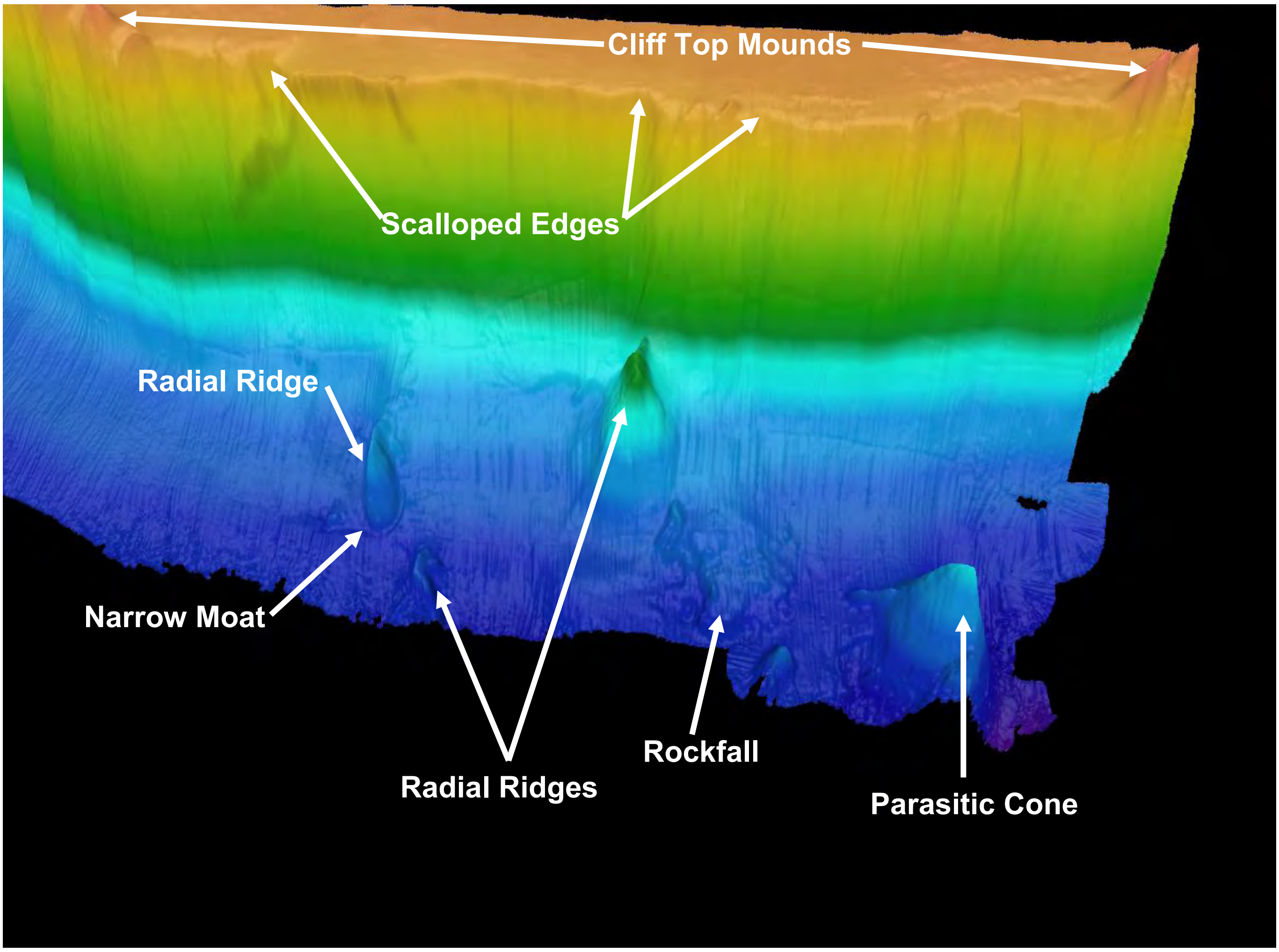


Figure 10 Perspective view looking southeast towards the north-western case study area of Anton Dohrn Seamount. Vertical exaggeration is x5.

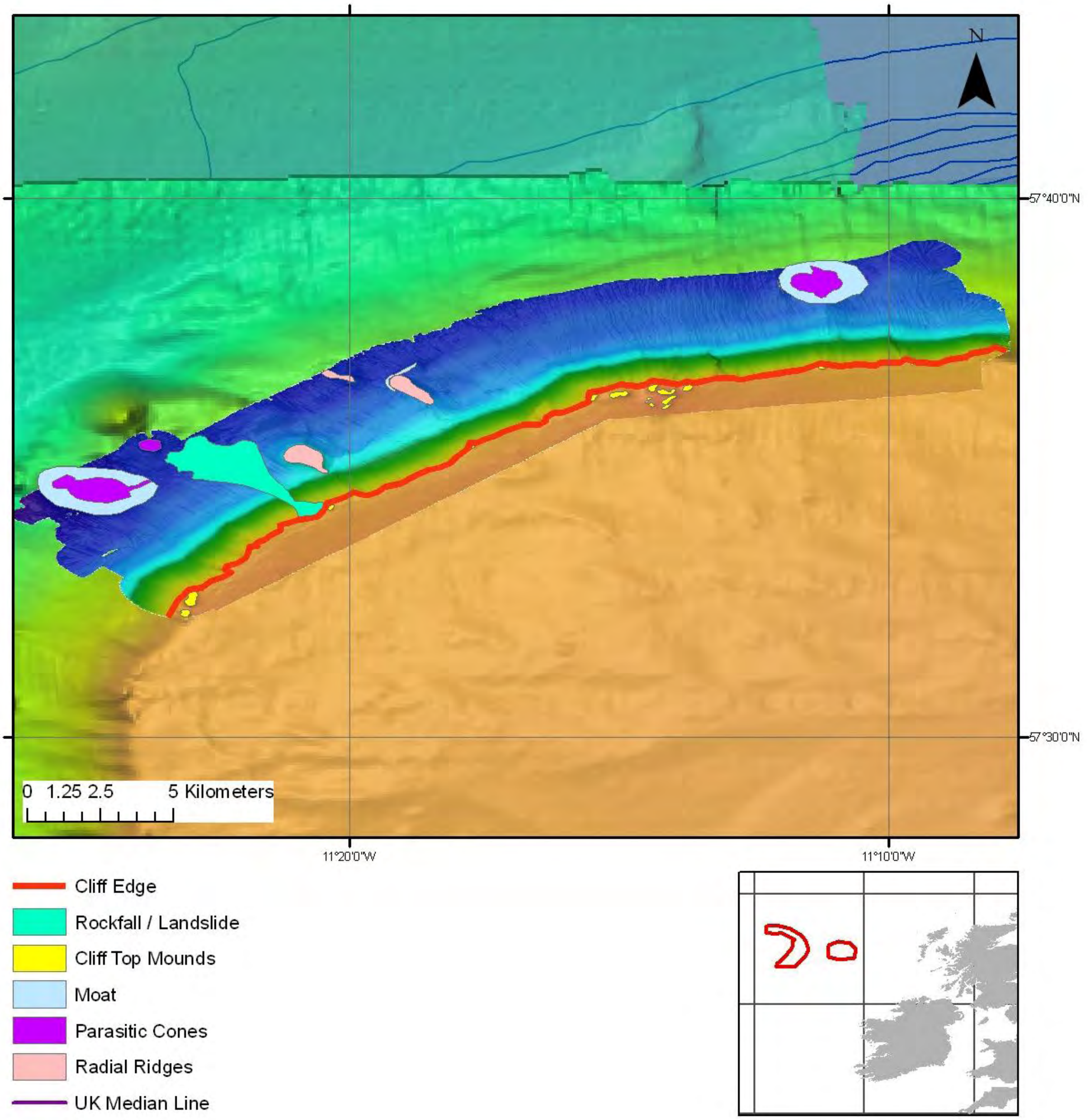


Figure 11 Initial interpretation of main geomorphological features of the north-western case study area of Anton Dohrn Seamount.

4.2 Biological Assemblages of Anton Dohrn Seamount

The biological assemblages observed during this cruise are summarised below by camera tow (see Figures 12 and 13 for location).

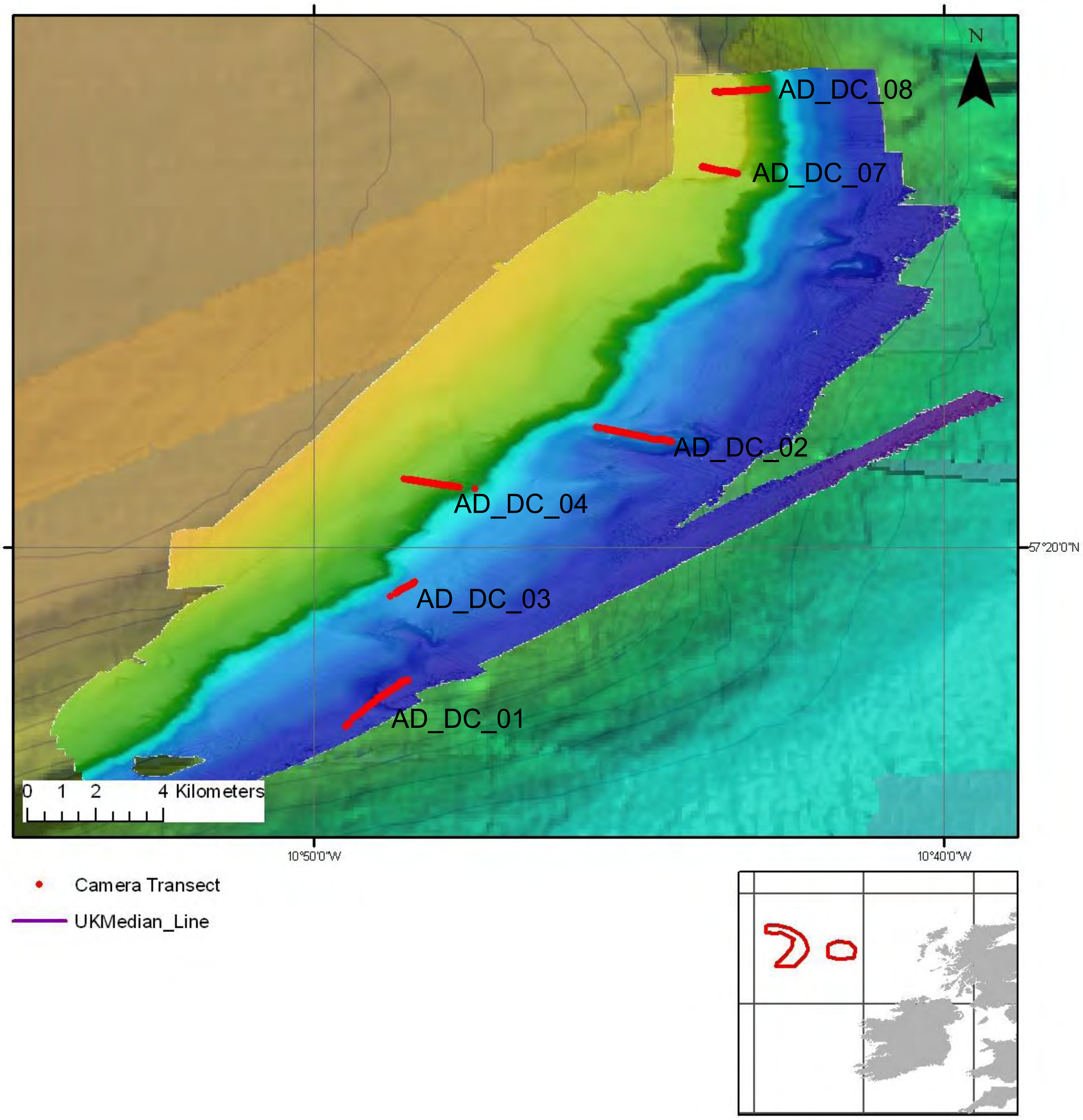


Figure 12 Map showing the location of camera transects acquired in the south-eastern case study area of the Anton Dohrn Seamount area of search.

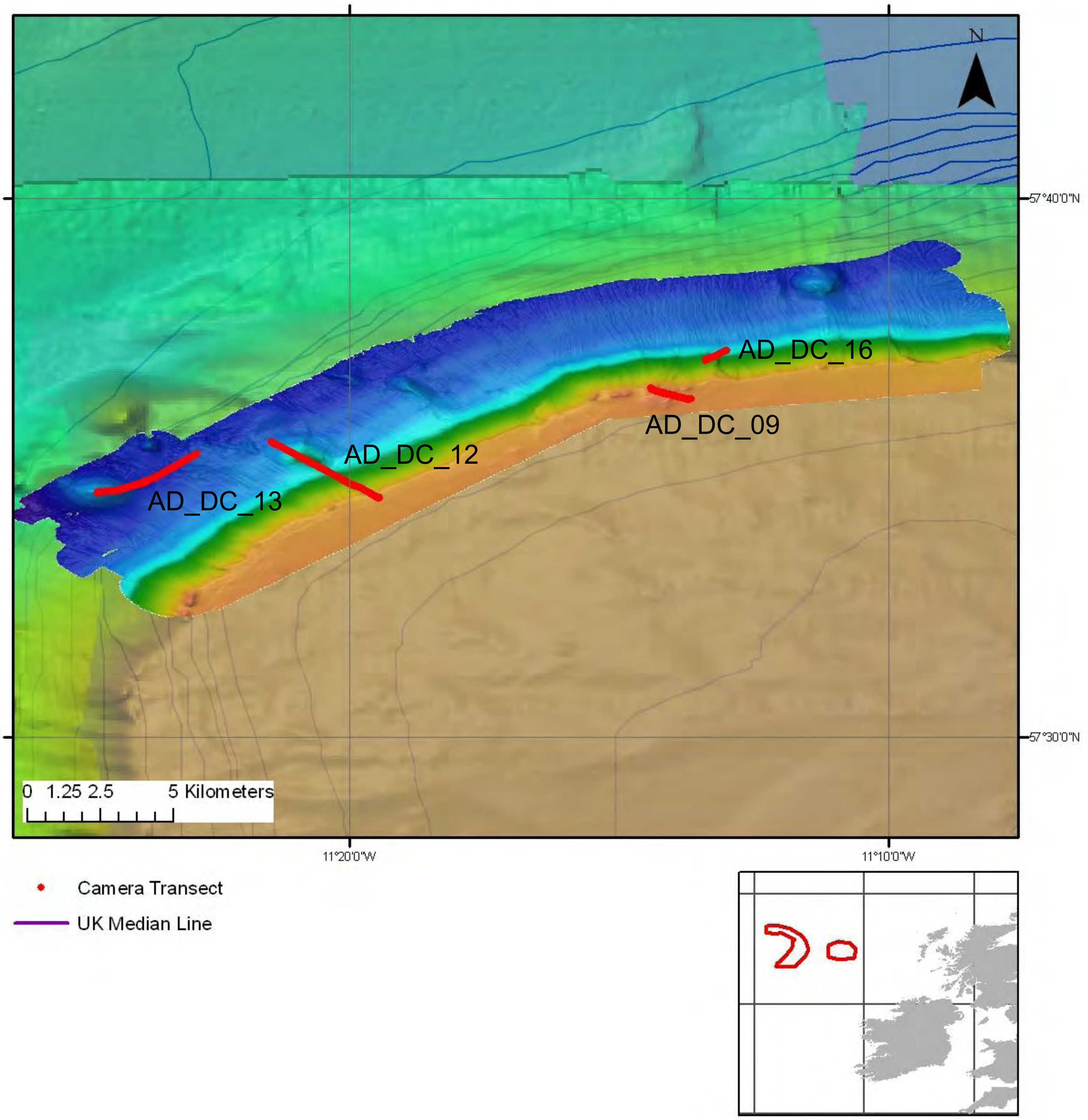


Figure 13 Map showing the location of camera transects acquired in the north-western case study area of the Anton Dohrn Seamount area of search.

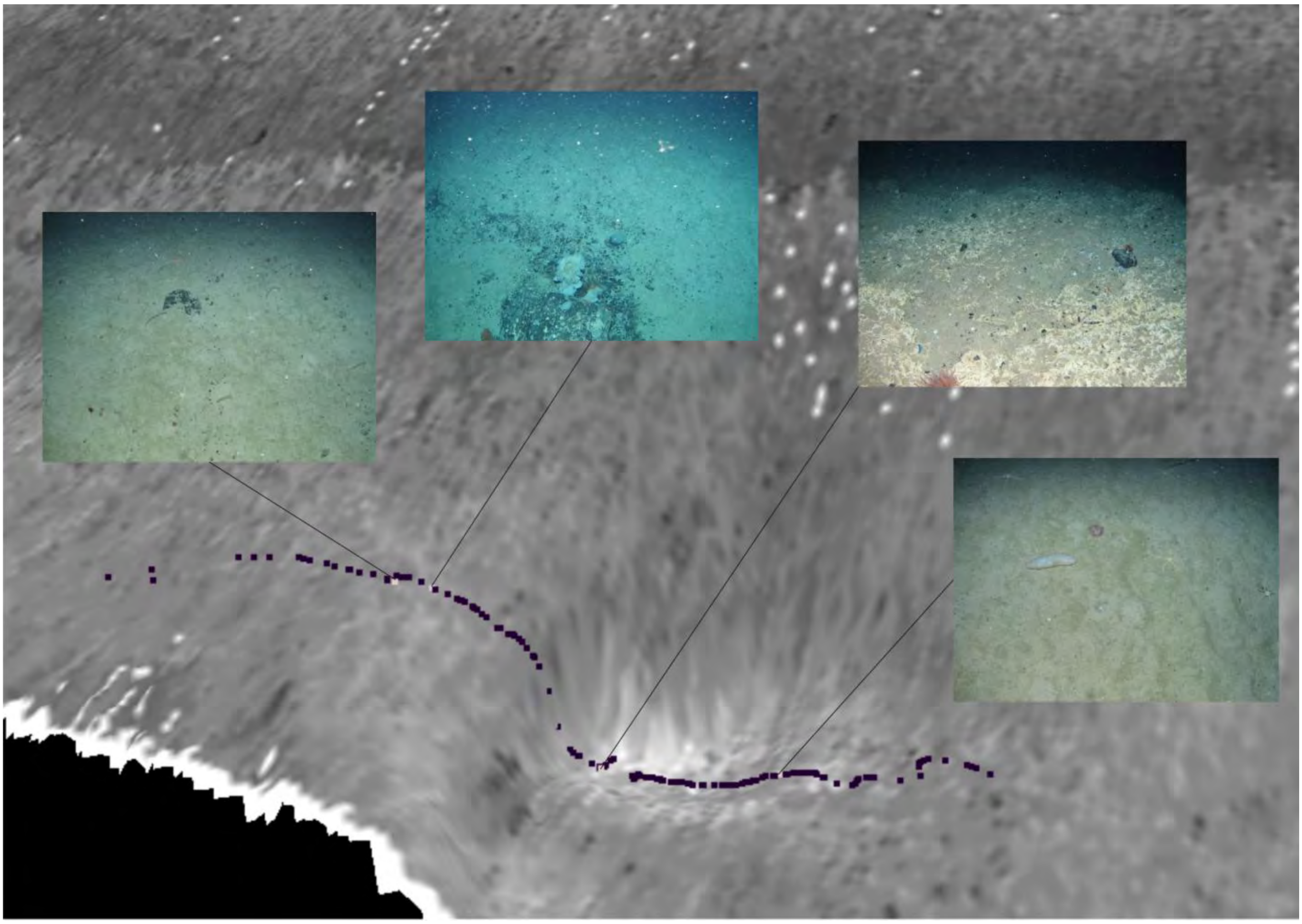


Figure 14 3D image of canyon feature with the camera tow AD_DC_01 draped. Selected images show the spatial change in habitat.

AD_DC_01

The target was a canyon feature in approximately 1800m water depth which crossed a number of backscatter responses (Figure 14).

The tow began on an area of pebbles on sand with abundant *Ophiomusium lymani*, stalked crinoids and ceriantheid anemones. Occasional boulders were visible with attached fauna such as large lobose sponges, encrusting sponges and crinoids. As the tow progressed there was a progressive increase in the density of cobbles as a break in slope was approached. At the base of the slope an area of high backscatter corresponded to outcrop of possible carbonate rich bedrock at sea bed with little attached fauna with the exception of stalked crinoids and feature-like antipatharians corals. As the tow continued down the slope, the substrate comprised mixed sediment with caryophyllids and antipatharians present. Mixed substrate continued with the occurrence of the ophiuroid *O. lymani*, and as the proportion of pebble size fragments increased caryophyllids and large unidentified anemones were apparent. As the tow neared completion, an area of finer sediment with sand ripples was encountered, with *O. lymani* and cerianthids present. The remainder of the tow consisted of sand with occasional cobbles, again with *O. lymani*, occasional stalked crinoids, echinoids, cerianthids and holothurians.

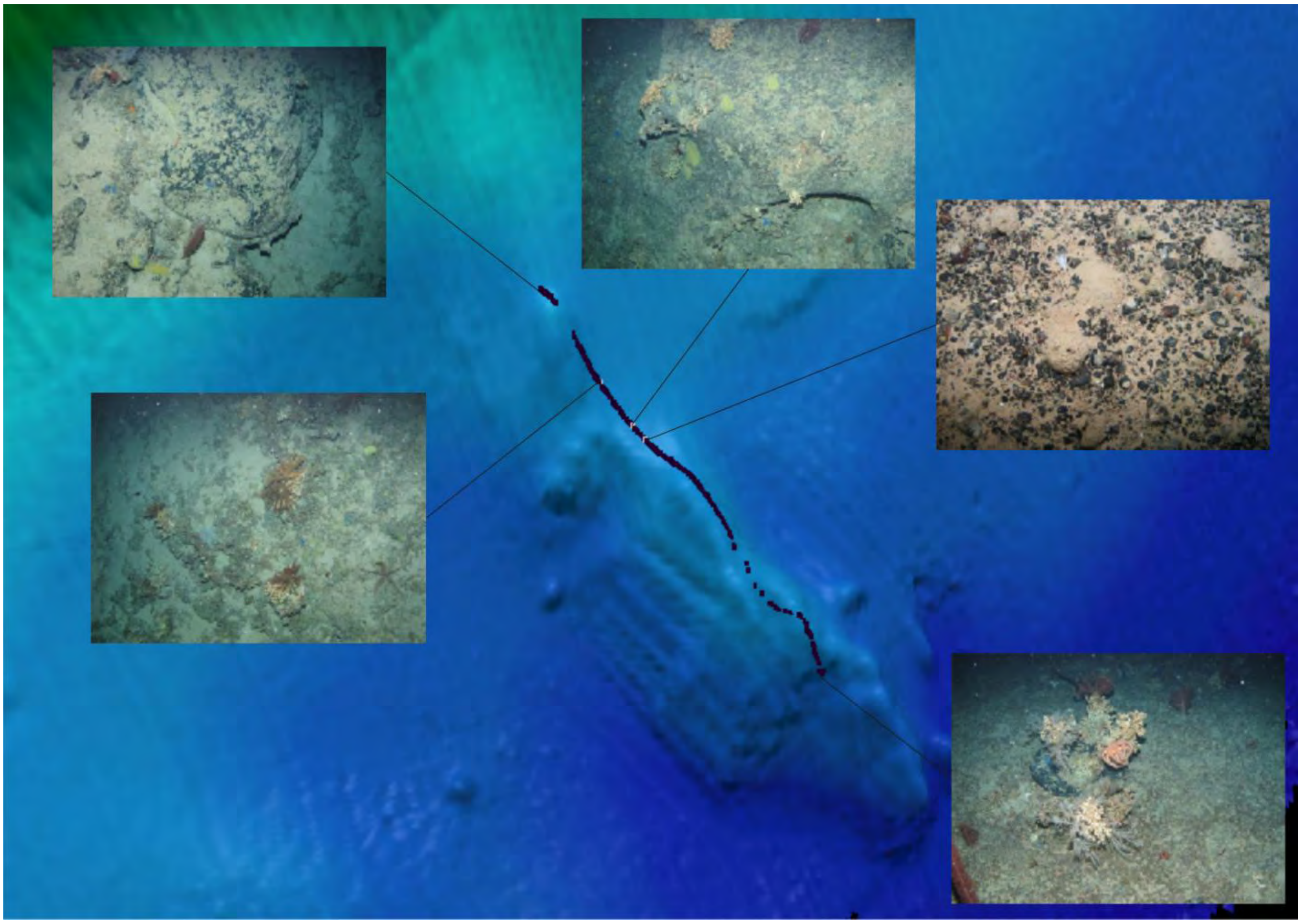


Figure 15 3D image of deep ridge with the camera tow AD_DC_02 draped. Selected images show the spatial change in habitat.

AD_DC_02

The target was a radial ridge near the base of the SE flank of the Seamount (Figure 15). The tow began on top of the ridge on an area of exposed bedrock with small clumps of *Lophelia pertusa* and associated bamboo coral. Large sea whips, small whip-like antipatharians, feather-like antipatharians and encrusting sponges were also present. As the tow continued along the ridge into a small depression, an area of low lying coral rubble with some live *Lophelia pertusa* was encountered. Fauna associated with the rubble were encrusting sponges, ophiuroids, brisingids, echinoids, glass sponges and abundant fish. Further along the ridge the exposed bedrock is covered by a mixed substrate with associated xenophyophores. Where the tow intersected the top of the ridge feature and the depressions, bedrock reef habitat and rubble reef habitat are inter-dispersed.

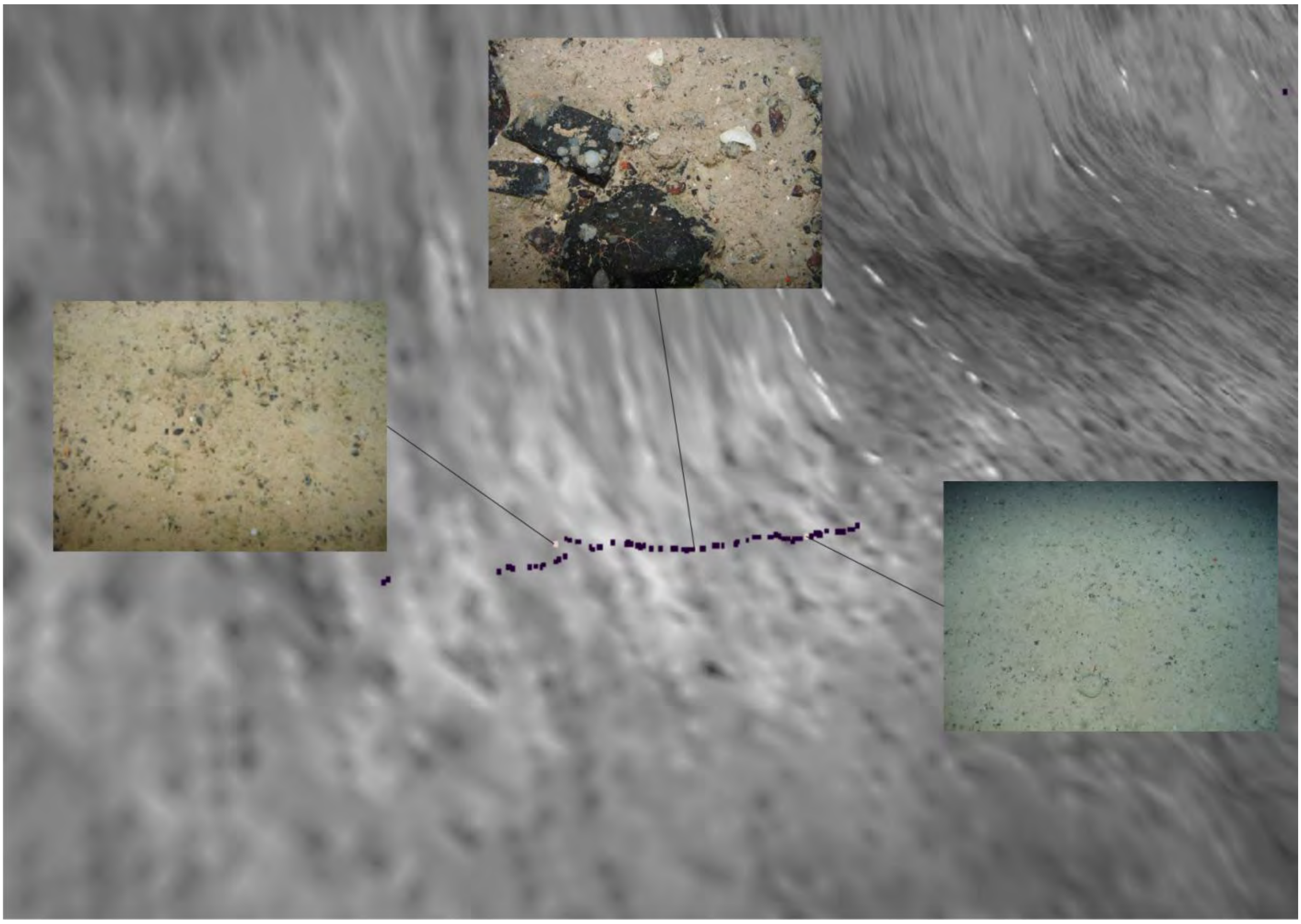


Figure 16 3D image of backscatter with the camera tow AD_DC_03 draped. Selected images show the spatial change in habitat.

AD_DC_03

The target was at a water depth of around 1500m and crossed a backscatter response boundary (Figure 16). The tow began on an area of mixed substrate consisting of pebbles on sand. The dominant fauna encountered were xenophyophores, the eel *Synaphobranchus kaupi* and corallimorph anemones. The habitat briefly changed to an area of cobbles with encrusting sponges present but reverted back to a xenophyophores dominated habitat.

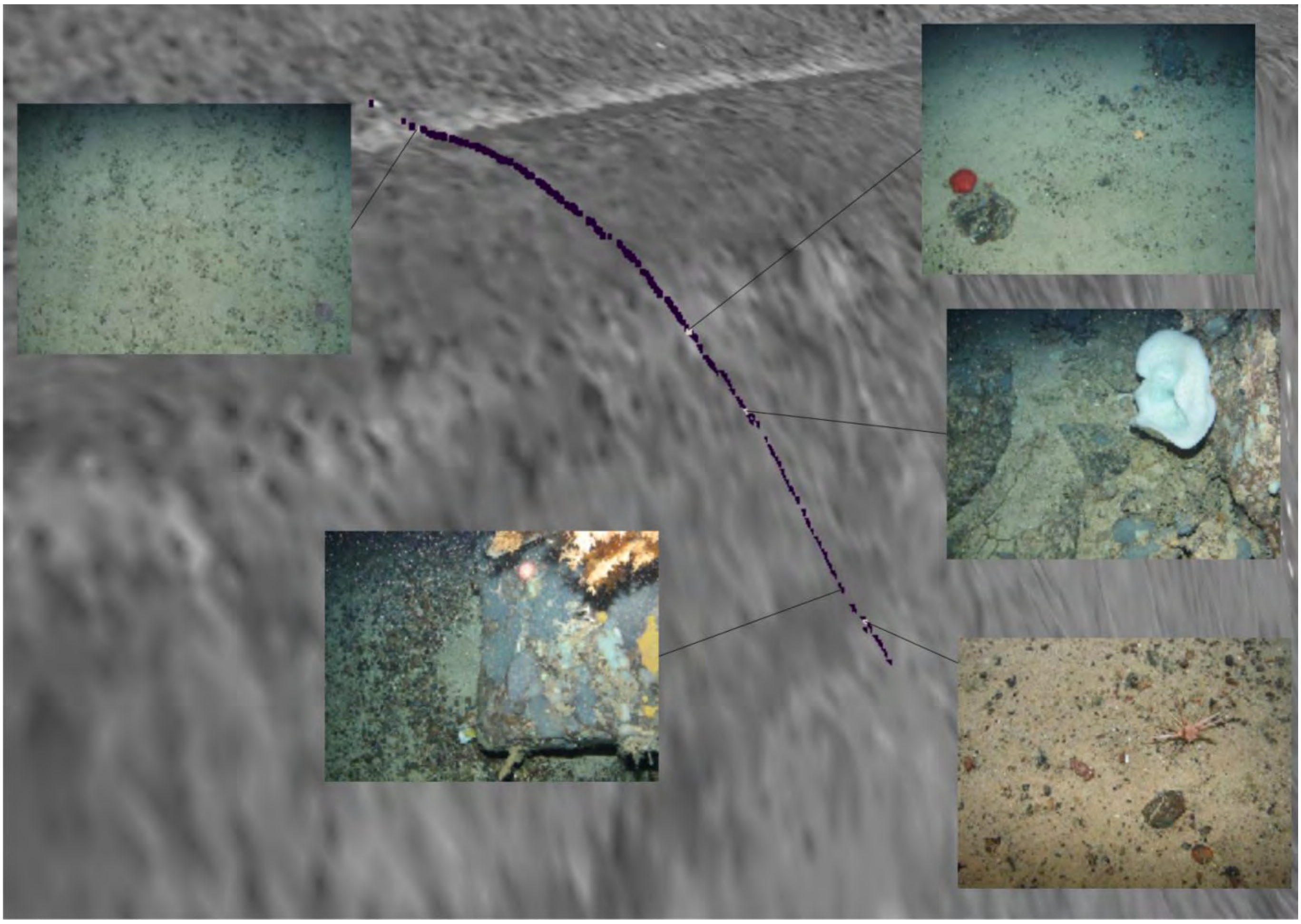


Figure 17 3D image of the backscatter on the slope edge with the camera tow AD_DC_04 draped. Selected images show the spatial change in habitat.

AD_DC_04

The target was an area of high backscatter response on the slope edge (Figure 17). At the start of the tow discarded fishing gear was encountered. The tow began on an area of relatively flat sea bed on the break in slope surrounding the Seamount. The substrate consisted of abundant pebbles on sand, dominated by xenophyophores. As the tow traversed the break of slope and crossed the area corresponding to high backscatter, the substrate changed to large lithic clasts, up to boulder sized, with abundant encrusting sponges, the sessile holothurian *Psolus* sp., ascidians and large sponges. The substrate changed back to the homogenous substrate encountered at the start of the tow, followed by another boulder habitat with encrusting sponges, large antipatharians and small clumps of *Lophelia pertusa* were visible. Near the end of the tow a small ledge was traversed before the substrate reverted back into pebbles with xenophyophores and the pencil urchin *Cidaris cidaris*.

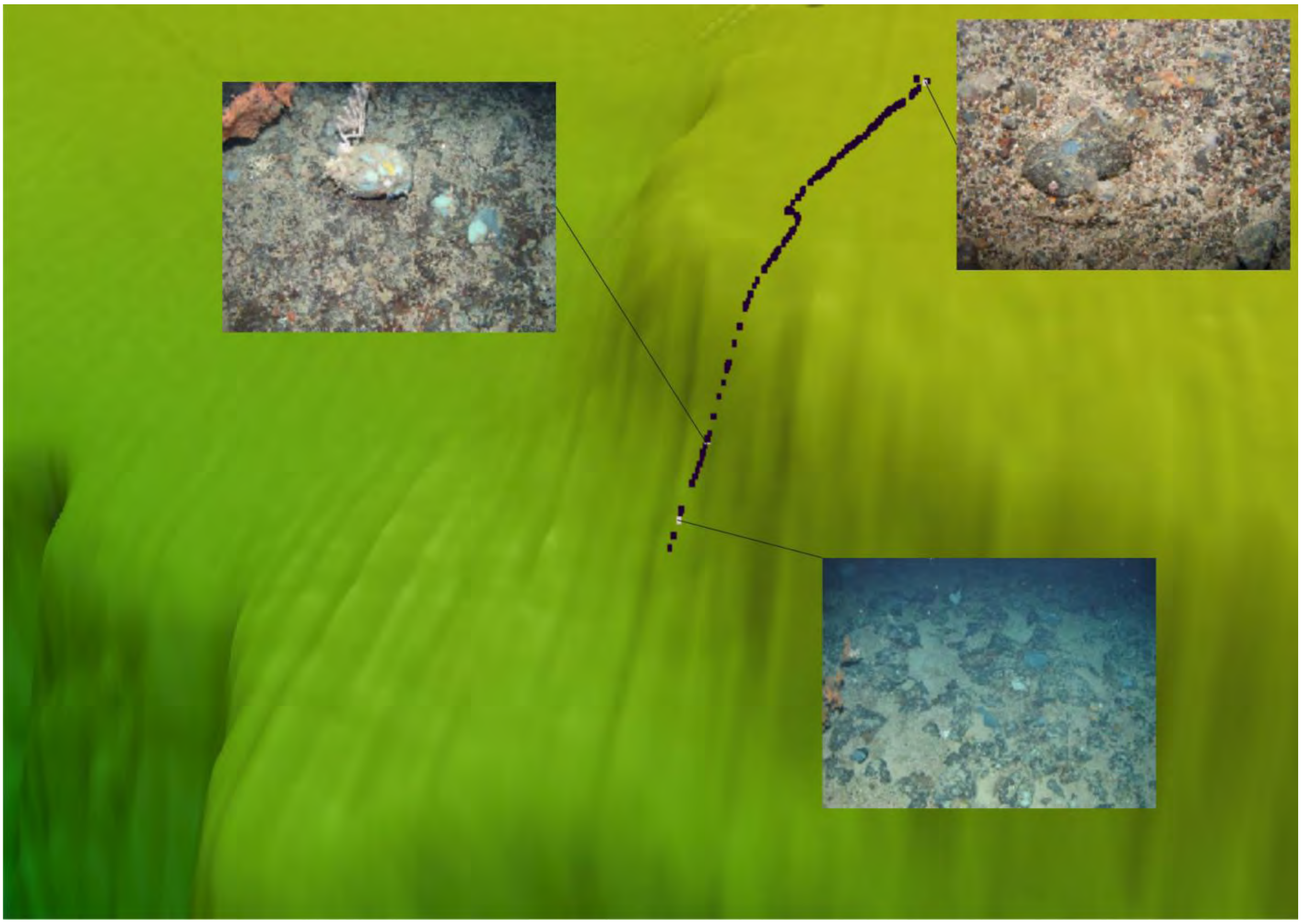


Figure 18 3D image of the slope edge with the camera tow AD_DC_07 draped. Selected images show the spatial change in habitat.

AD_DC_07

The target was intended to be a full down-flank tow (
Figure 18), but due to equipment failure tow only sampled the break of slope. The tow began on an area of mixed substrate consisting of pebbles and cobbles. Conspicuous fauna were encrusting sponges, the sessile holothurian *Psolus squamatus*, a number of echinoderm species, the soft coral *Gersemia* sp., a zoanthid species and ascidians. As the tow progressed the substrate become coarser with boulders present, fauna observed included large sponges, encrusting sponges and live growths of *Lophelia pertusa*. The substrate gave way to bedrock with the same fauna observed but with the addition of gorgonians, antipatharians (including *Leiopathes* sp.), stylasterids and soft corals (including *Anthomastus* sp.).

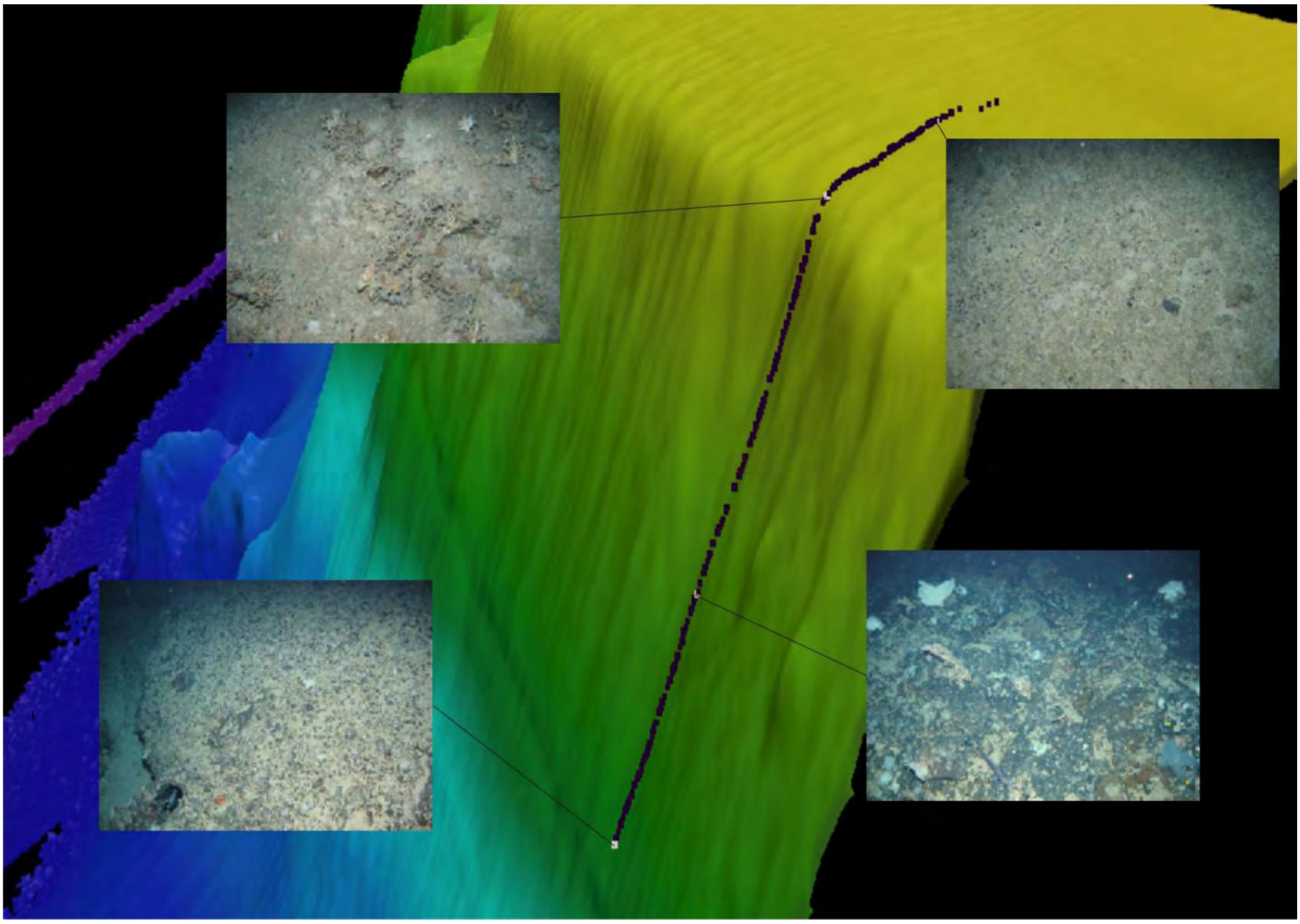


Figure 19 3D image of break of slope with the camera tow AD_DC_08 draped. Selected images show the spatial change in habitat.

AD_DC_08

The target was the break of slope in the north-western case study area (Figure 19). The tow began on an area of mixed sediment consisting of lithic cobbles and pebbles with coral debris infill. Typical fauna inhabiting this area were fauna attached to the pebbles/cobbles, including the sessile holothurian *Psolus* sp., encrusting sponges and large ascidians. The coral fragments provide a structural habitat for the ophiuroid *Ophiactis balli* and caryophyllids. As the tow traversed down the break of slope, the coral gravel gave way to more structural low lying coral rubble with some live *Lophelia pertusa* observed. A number of mobile species were present amongst the rubble including the pencil urchin *Cidaris cidaris* and the asteroid *Henricia* sp. Large epifauna including lobose sponges, corals (bamboo corals, stylasterids), corallimorph anemones and the squat lobster *Munida* sp. were also associated with the rubble habitat. As the tow continued down the flank a large expanse of steep bedrock outcrop was encountered with abundant axinellid sponges, encrusting sponges, large antipatharians including *Leiopathes* sp. and the corkscrew antipatharian *Stichopathes* sp. Towards the end of tow the substrate changed from bedrock to mixed boulder, cobble and pebbles with abundant encrusting sponges, echinoid species and fish, including *Lepidion eques*.

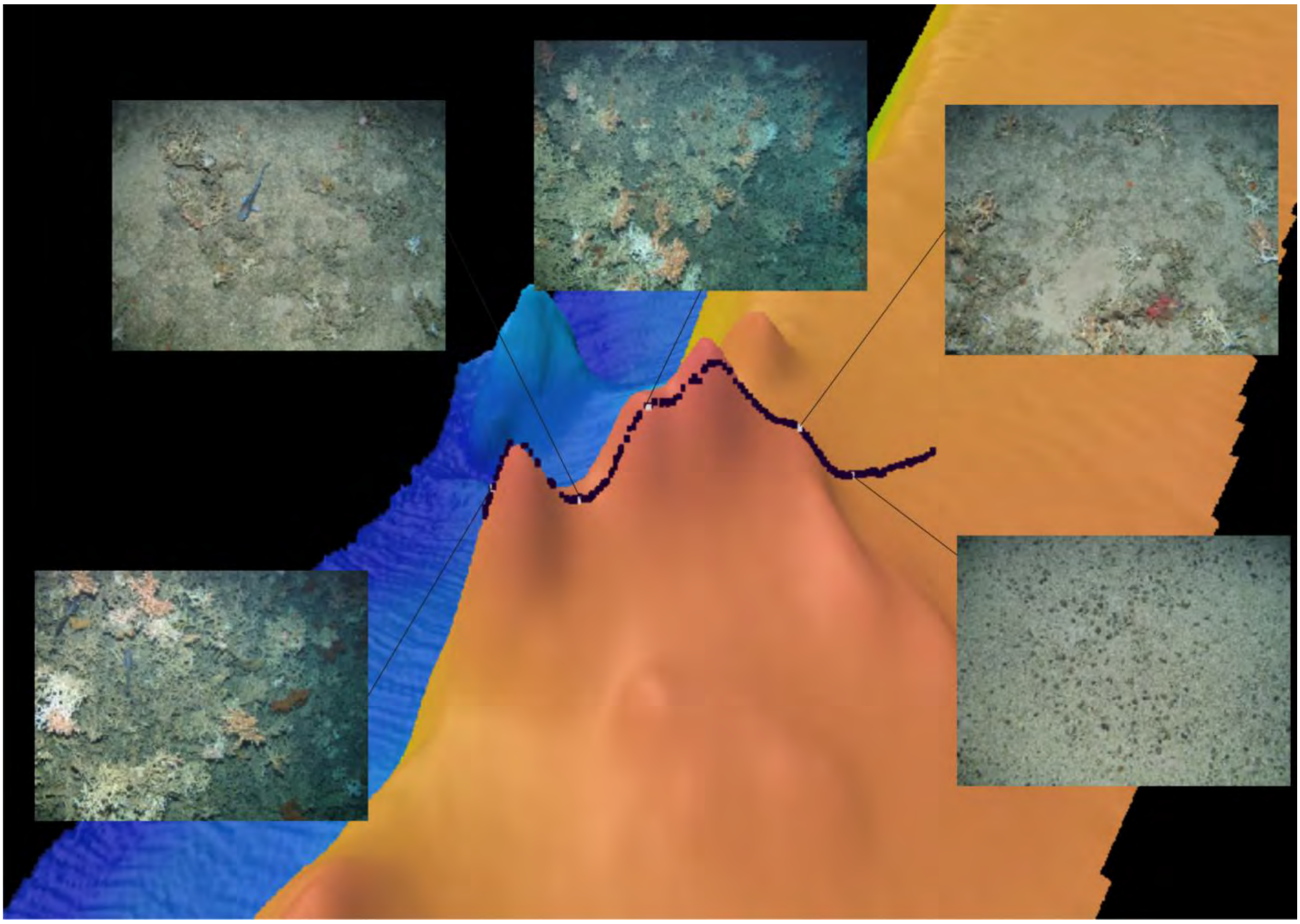


Figure 20 3D image of mound feature on slope edge with the camera tow AD_DC_09 draped. Selected images show the spatial change in habitat.

AD_DC_09

The target was a number of small mound features on the slope edge (Figure 20). The tow began on the mound to the northwest and traversed to the southeast. An area of biogenic reef made of the reef-building coral *Lophelia pertusa* was encountered on top of the first mound crossed by the tow. The reef was teeming with life ranging from antipatharian and gorgonian coral species, anemone species, echinoids, decapods and fish. As the tow traversed down the shoulder between mounds the biogenic reef graduated into rubble reef with sand patches. The rubble consisted of predominantly dead fragments of *Lophelia pertusa* with some small clumps of live coral, as well as the scleractinian *Madrepora oculata*. Typical fauna associated with the rubble area were corallimorph anemones, the pencil urchin *Cidaris cidaris*, sponges and abundant fish. As the tow progressed onto the summit of the second mound biogenic reef habitat was present with the same species encountered on the first mound. The biogenic reef again graded into reef rubble towards the base of the mound before changing to a more mixed substrate on the surrounding flatter lying sea bed of the Seamount summit. Fauna were not abundant on the surrounding mixed substrate with only encrusting sponges and small anemones associated with the pebbles encountered.

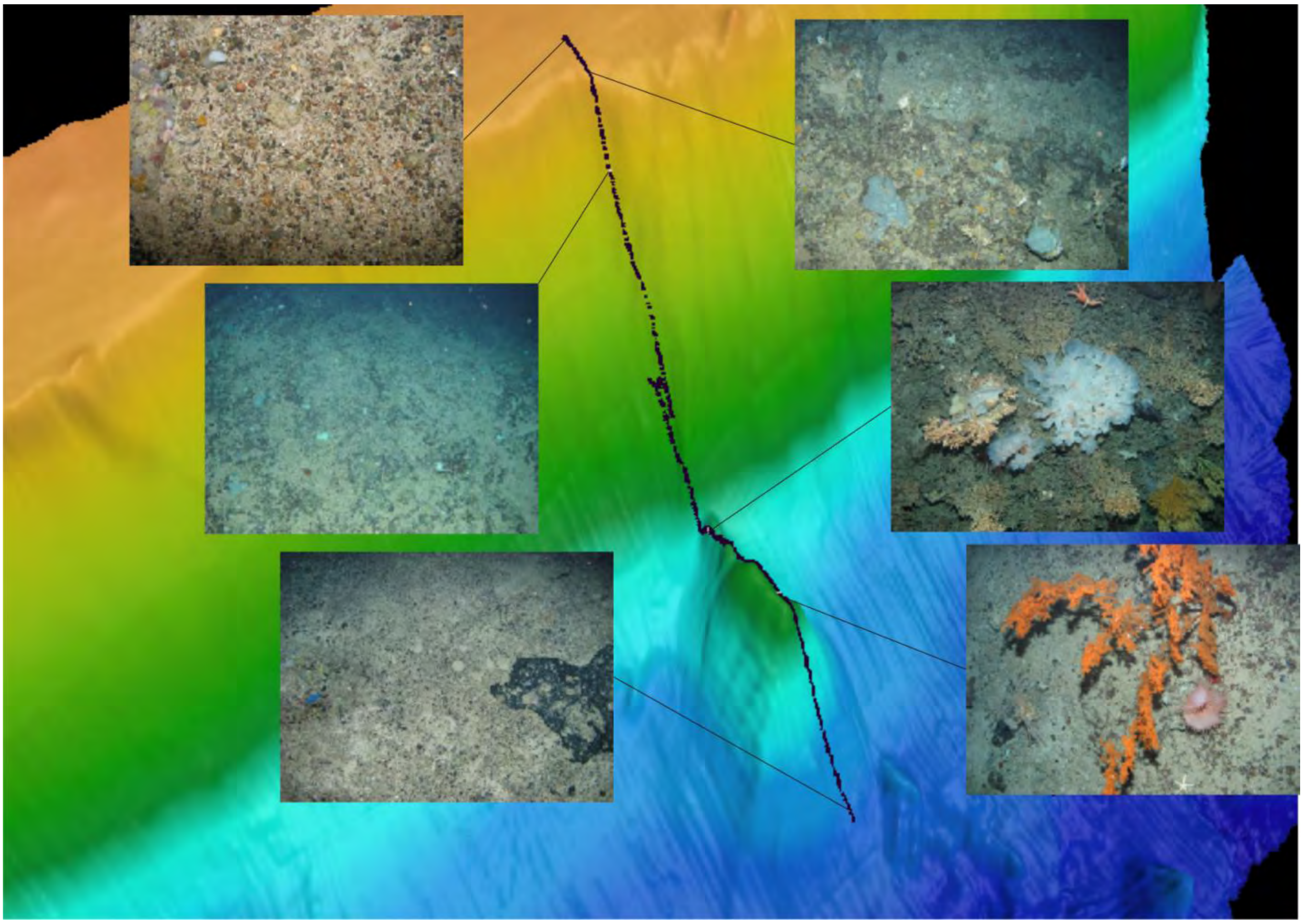


Figure 21 3D image NW flank with ridge feature with the camera tow AD_DC_12 draped. Selected images show the spatial change in habitat.

AD_DC_12

The target was down the flank in the north-western case study area (Figure 21). The tow began on relatively flat lying sea bed on the edge of the Seamount, and encountered a mixed cobble and pebble substrate. Associated fauna were the sessile holothurian *Psolus* sp., several encrusting sponge species and ascidians. As the tow continued towards the break of slope, the number of boulders increased until bedrock was encountered outcropping at the break of slope. The bedrock was dominated by encrusting sponges, lobose sponges, small clumps of *Lophelia pertusa*, the antipatharian *Leiopathes* sp. and echinoids. Bedrock was observed at sea bed down the Seamount flank with associated lamellate and lobose sponges. Towards the base of the flank the tow traversed a radial ridge which hosted structural biogenic reef along its top. The extensive reef had an abundance of live *Lophelia pertusa* clumps with associated bamboo coral, also brisingids asteroids and crinoids, large gorgonians and several sponge species.

Along the radial ridge the biogenic reef graded into reef rubble with visible bedrock outcrop with typically the same associated fauna although less abundant. As the tow continued to the edge of the ridge crest bedrock was again observed at sea bed with large gorgonians and antipatharian corals. At the base of the ridge the substrate was mixed and comprised of boulders and pebbles with small patches of *Lophelia pertusa*, encrusting sponges and xenophyophores.

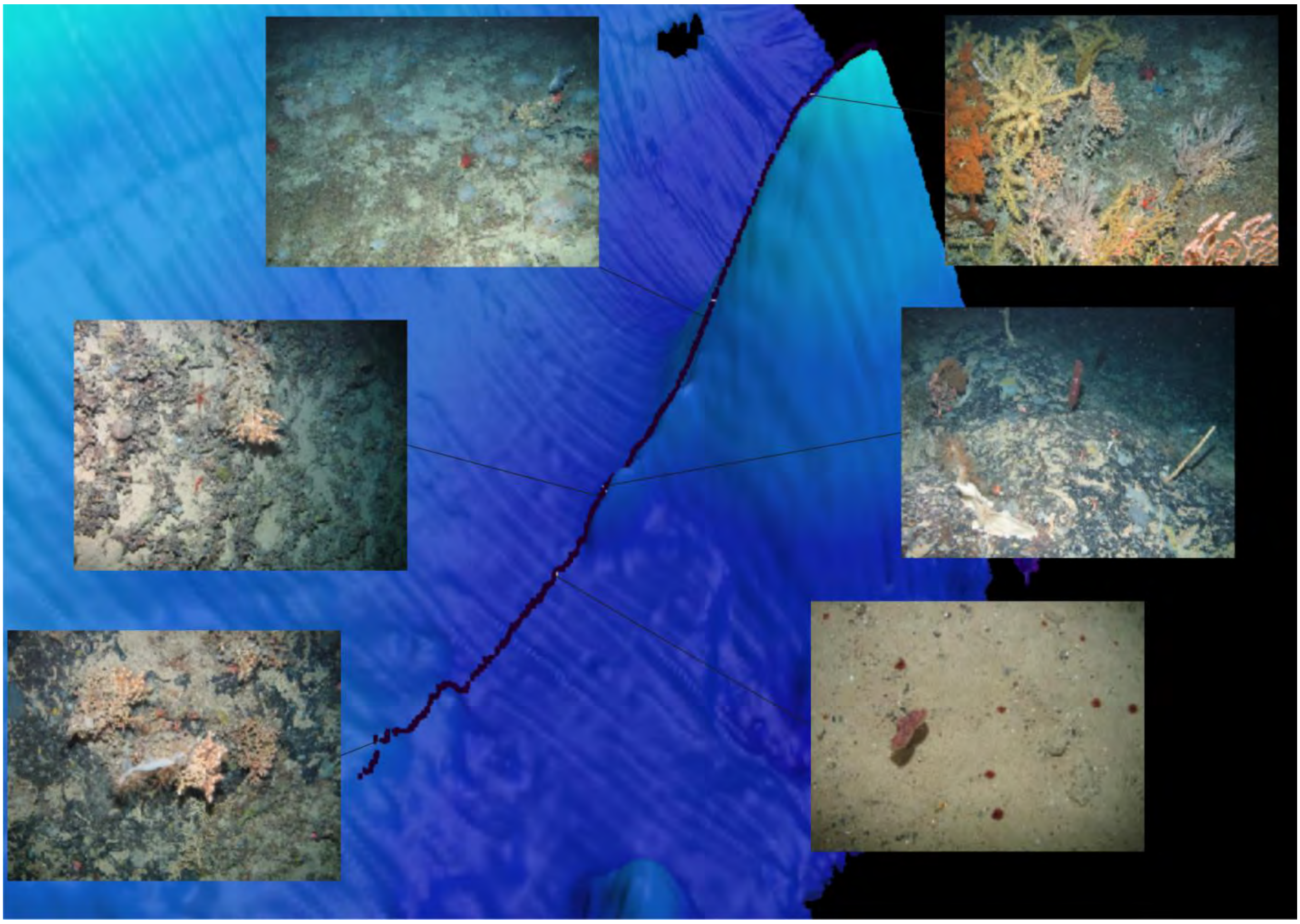


Figure 22 3D image of a deep parasitic cone with the camera tow AD_DC_13 draped. Selected images show the spatial change in habitat.

AD_DC_13

The target was a deep parasitic cone and a debris flow (Figure 22). The tow began on the summit of the parasitic cone where the data reveal an extensive reef comprised of patches of low lying stoney coral and bedrock outcrop. Dominant fauna encountered were corals, including large gorgonian species, small bamboo coral, the soft coral *Anthomastus* sp. and the antipatharian *Leiopathes* sp. Other invertebrate species present were pycnogonids, brisingids, glass sponges, while the dominant fish species was *Neocyttus* sp. As the tow continued down the side of the parasitic cone the extensive reef gave way to a more mixed substrate habitat with small patches of live *Lophelia* and biogenic gravel. Fauna associated with this habitat were encrusting sponges, the holothurian *Psolus* sp. and caryophyllids attached to cobbles, while glass sponges, ophiuroids, the soft coral *Anthomastus* and encrusting sponges dominated the surrounding coral rubble/debris area. Towards the base of the parasitic cone, larger expanses of bedrock outcrop with associated whip-like gorgonians and feature-like antipatharians dominated, which graded into low-lying coral rubble with typical rubble associated species such as crinoids, glass sponges and soft corals. The flat lying sea bed encountered at the base of the cone was dominated by small anemone species and the seapen *Pennatula phosphorea*. As the tow traversed along the debris flow, it revealed another bedrock reef habitat with live *Lophelia pertusa*, lamellate and encrusting sponges, gorgonians and a number of echinoderm species.

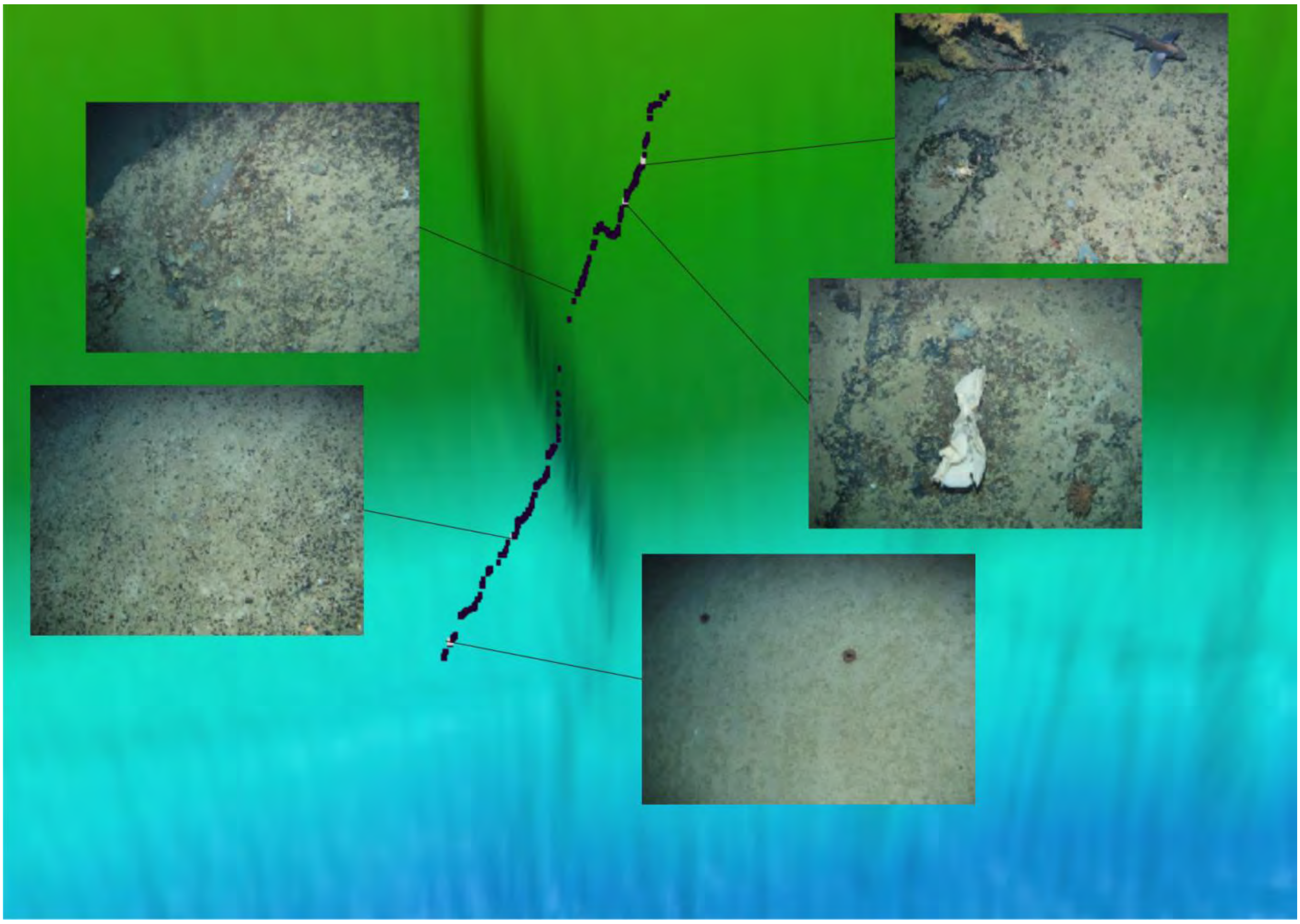


Figure 23 3D image of slope with the camera tow AD_DC_16 draped. Selected images show the spatial change in habitat.

AD_DC_16

The target was a deep down-slope tow (Figure 23). The tow began on an area of exposed bedrock with a sediment veneer and mixed substrate. Typical fauna associated with the cobbles were encrusting sponges, cup corals and ophiuroids, while large gorgonians and sponges were attached to the bedrock outcrop. As the tow progressed down the slope, the bedrock graded into mixed pebbles and cobbles substrate with a number of associated species, although not as abundant. At the end of the tow soft sediment with large cup coral species, the sponge *Pheronema carpenteri* and corallimorph anemones were observed.

4.3 Geomorphology and Geology of East Rockall Bank

Due to the constraints on time allocated to acquire sidescan sonar data it was decided to maximise the acquisition of multibeam echosounder data and to utilize the derived backscatter information to characterise the sea bed (Figure 6). A double line of multibeam echosounder data was acquired along the length of an escarpment, roughly coincident with the 500m bathymetric contour, from 56.774ºN to 58.504ºN with the aim of better visualizing the escarpment. Three shorter sections of data were acquired at right angles to the escarpment heading into deeper water to the east of the Bank. A suite of lines, roughly northeast-southwest orientated, were acquired on the shelf to characterise areas of suspected iceberg plough/trawl marks, and previously recorded occurrences of cold-water coral. In addition a block of data, roughly northwest-southeast orientated, was acquired located within an area currently being considered as an exclusion zone. This includes an area thought to be heavily fished and an area currently thought to be avoided by fishing boats (based on VMS data). A range of features were observed on the lower eastern flanks of Rockall Bank.

In the northern section of the Bank, at 13.7079ºW 58.3529ºN, 3 individual mounds, or cones, of possible volcanic origin were imaged (Figure 24). The largest of these cones is ~200m high and ~800m in diameter. Scouring, which is more established on the south-eastern side of the group of cones, may be in induced by accelerated currents around the collective topographic high the cones form. These cones had previously been identified as comprising only one discreet feature on the 2005 multibeam echosounder dataset. Upslope of these features a group of smaller mounds, 2-3m high and 50m in diameter, were also imaged. These comprise biogenic and lithic gravel/pebble-prone sediments with occasional cobbles, some biogenic communities are seen to be encrusting onto the coarser sediments. All along the escarpment landslides have also been identified, either with more subtle headwalls as in Figure 24 located on the lower flanks, or as more obvious amphitheatre rims, comparable to those identified during the 2007 MESH canyons survey, located on the upper flanks of the Bank.

Two major features imaged during the course of this survey are two canyons on the eastern flank of Rockall Bank located at 57.5183ºN and 57.2968ºN (Figure 25). The northern canyon imaged is sinusoidal with smooth canyon edges. The canyon is asymmetric with the steeper side switching from north to south with each meander in the canyon course. The head of the canyon begins in ~900m water depth and runs out at ~1500m water depth. The southern canyon imaged is straight with uneven flanks possibly indicating that this canyon is no longer active and is being actively reworked by oceanic currents. The headwall of this canyon is in ~1040m of water, although there is some evidence of slope failure/landslide upslope from this depth which may also have fed sediment into the canyon. This canyon runs out at ~1500m water depth.

On the crest of Rockall Bank, down to the escarpment top a different set of features to those identified on the flanks can be observed. Of particular interest was an area on the crest of the Bank which is subject to fishing activity and also hosts iceberg ploughmarks (Figure 26). Iceberg ploughmarks are troughs, or scours, scratched onto the sea-bed surface by the keels of icebergs calved from glaciers and ice sheets. These features are commonly found in water depths <500m of currently or past glaciated margins. Iceberg ploughmarks comprise a linear depression and positive berm features either side of the depression caused by the keel of the iceberg casting aside the sea-bed substrate as it makes contact with the sea bed. Iceberg ploughmarks form havens for biological communities. It can be seen on Figure 26 that both iceberg ploughmarks and trawl marks are cross cutting and of varying orientation. However iceberg ploughmarks are more easily identifiable in the backscatter data than the subtler trawl marks due to the weight and momentum difference between an iceberg and towed bottom fishing gear. Also the longer time for the trough to infill with reworked fine-grained material and for the winnowing of the berm makes a greater contrast between the berm and trough in a ploughmark than for a trawlmark.

The backscatter data derived from the multibeam echosounder dataset also reveal ridges and rings of higher reflectivity which are thought to be cold-water coral patches as well as areas of ‗blotchy' sea floor which may indicate areas of broken coral.

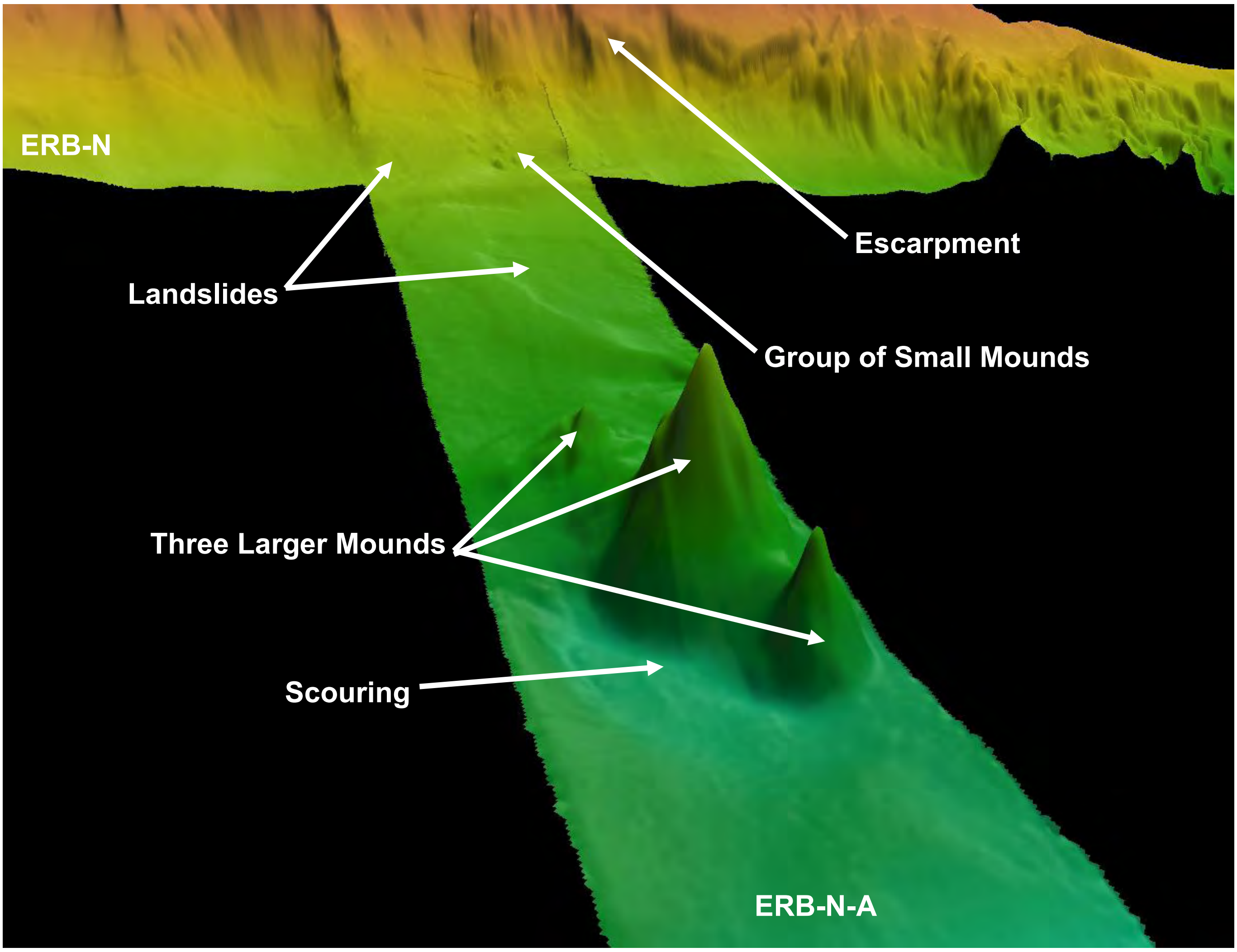


Figure 24 Perspective view looking west of geomorphological features identified on sections ERB-N-A and ERB-N located in the East Rockall Bank area of search. Vertical Exaggeration is x5.

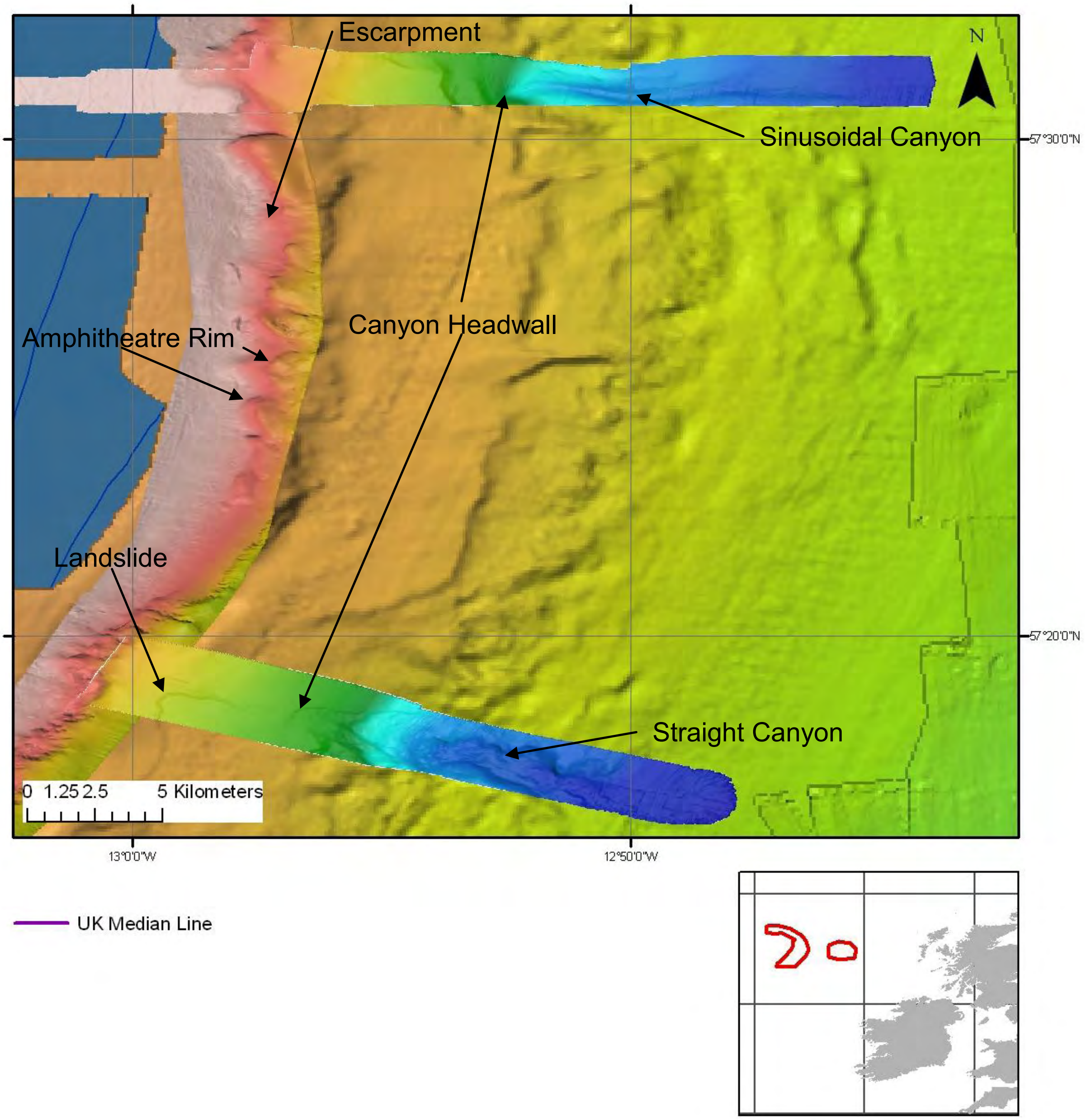


Figure 25 Multibeam echosounder data acquired during this cruise over two canyon features located on the eastern flank of Rockall Bank.

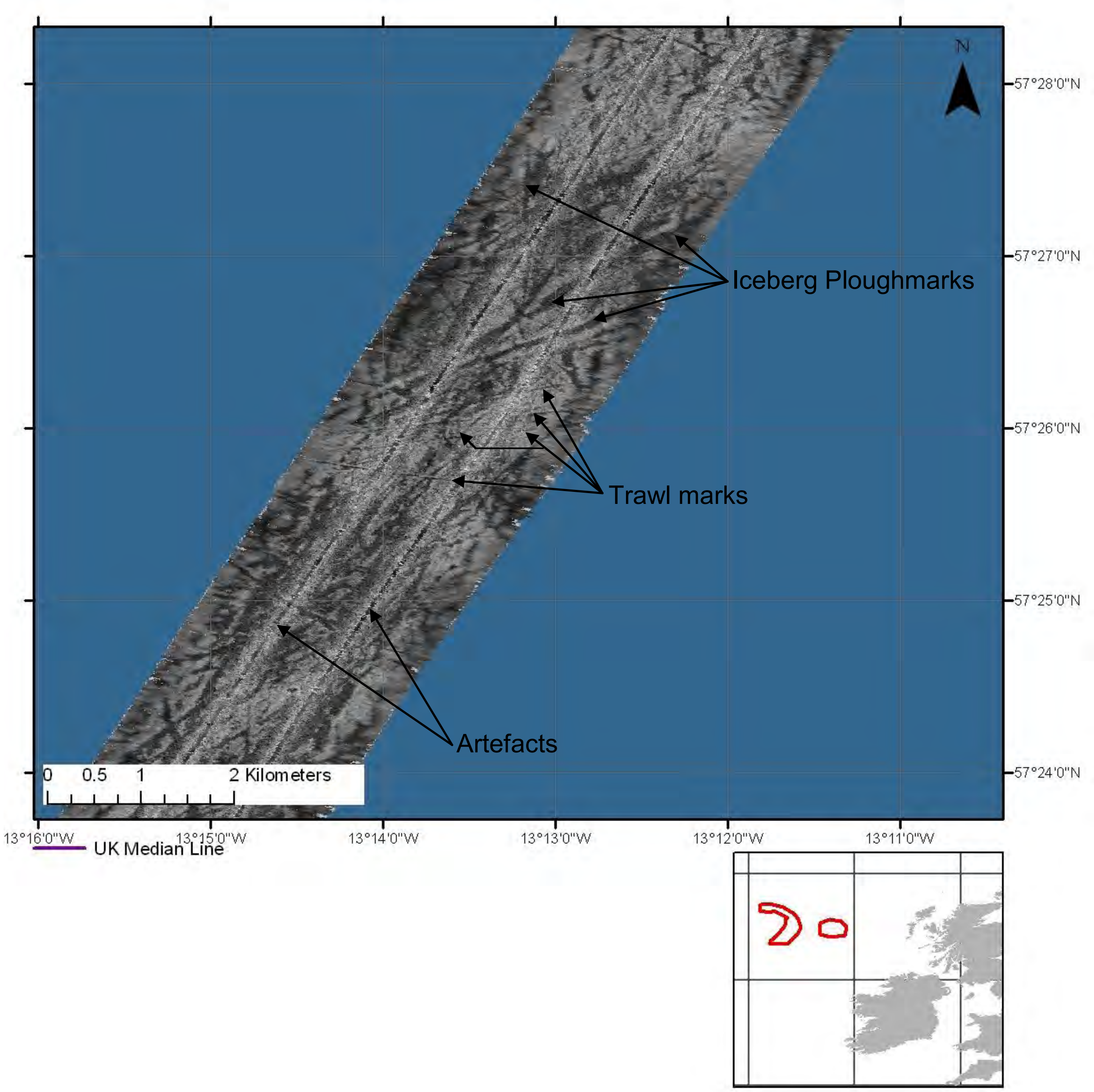


Figure 26 Multibeam backscatter data acquired during this cruise from the crest of Rockall Bank. Both iceberg ploughmarks and trawl marks can be identified.

4.4 Biological Assemblages of East Rockall Bank

The biological assemblages observed during this cruise are summarised below by camera tow (see Figures 27-30 for location).

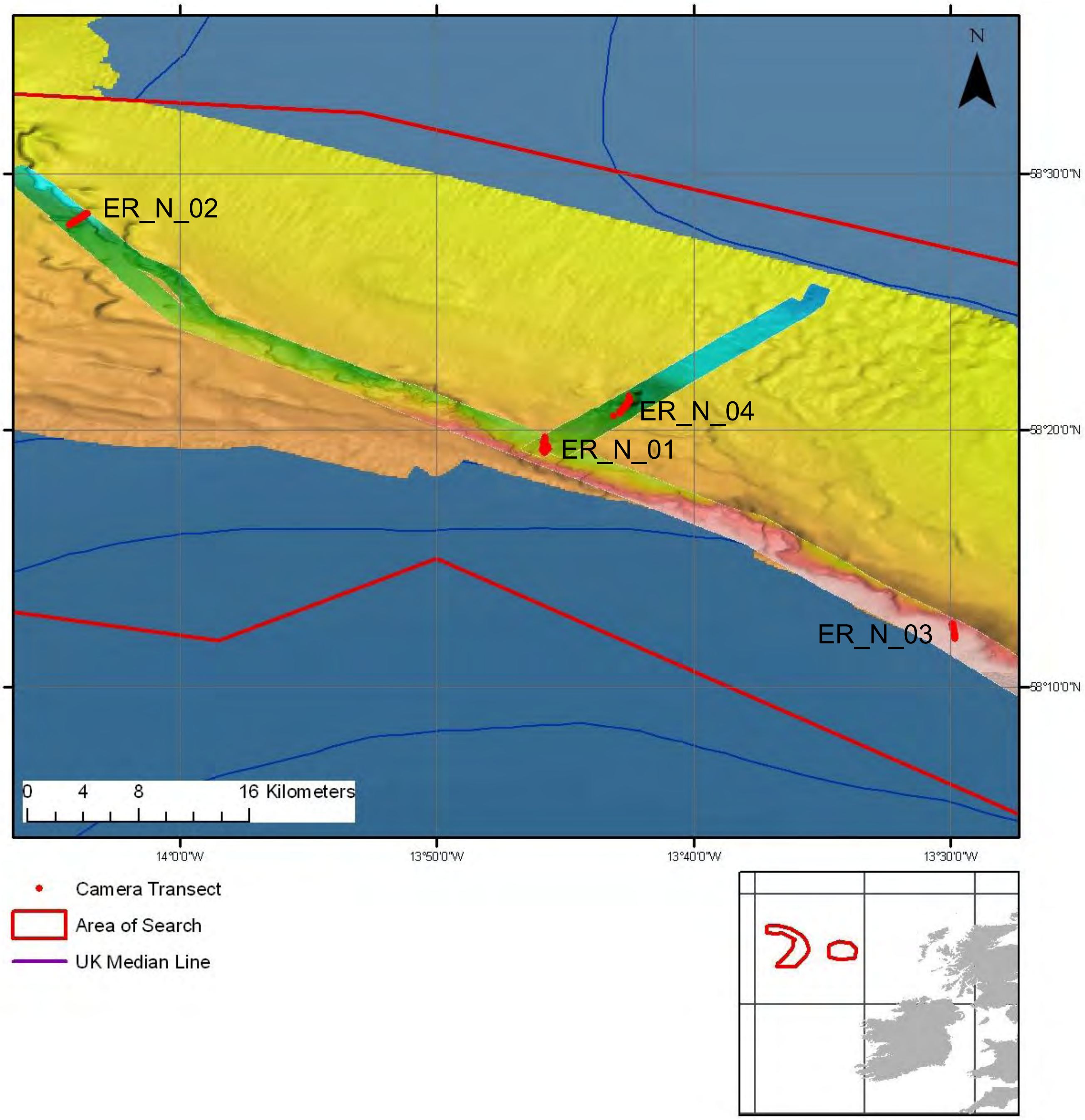


Figure 27 Map showing the location of camera transects acquired in the East Rockall Bank north area of search.

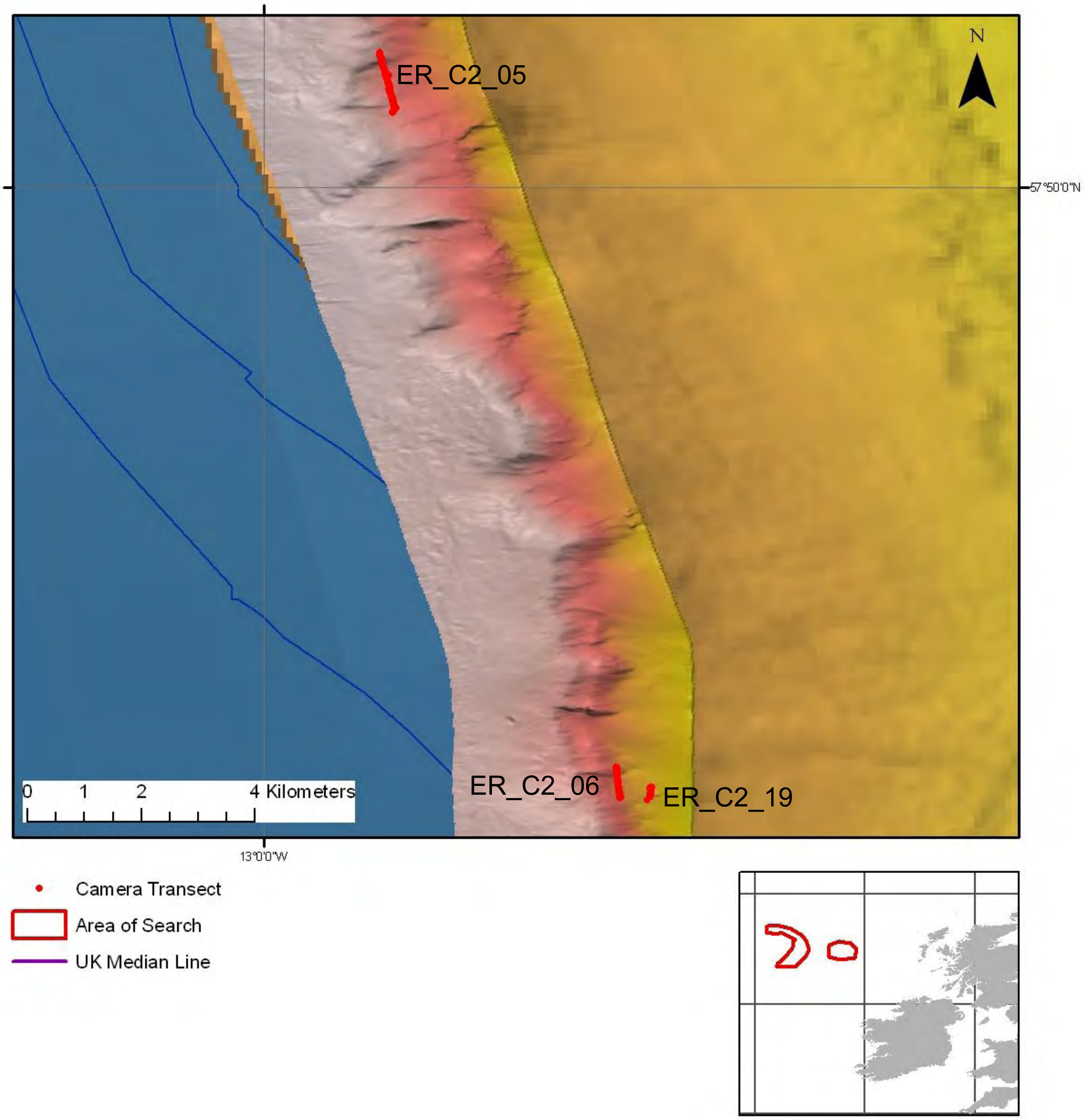


Figure 28 Map showing the location of camera transects acquired in the East Rockall Bank centre 2 area of search.

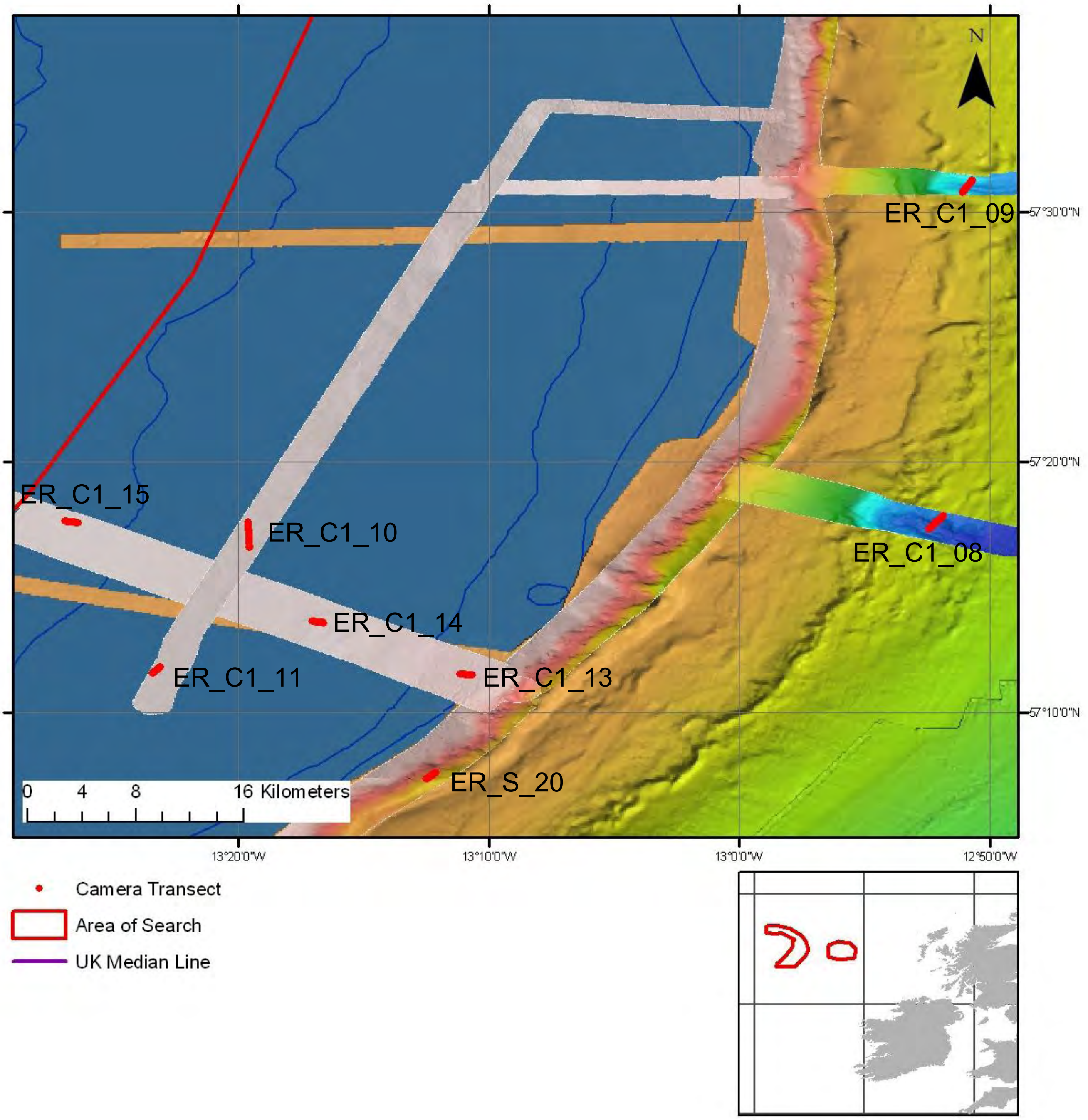


Figure 29 Map showing the location of camera transects acquired in the East Rockall Bank centre 1 area of search.

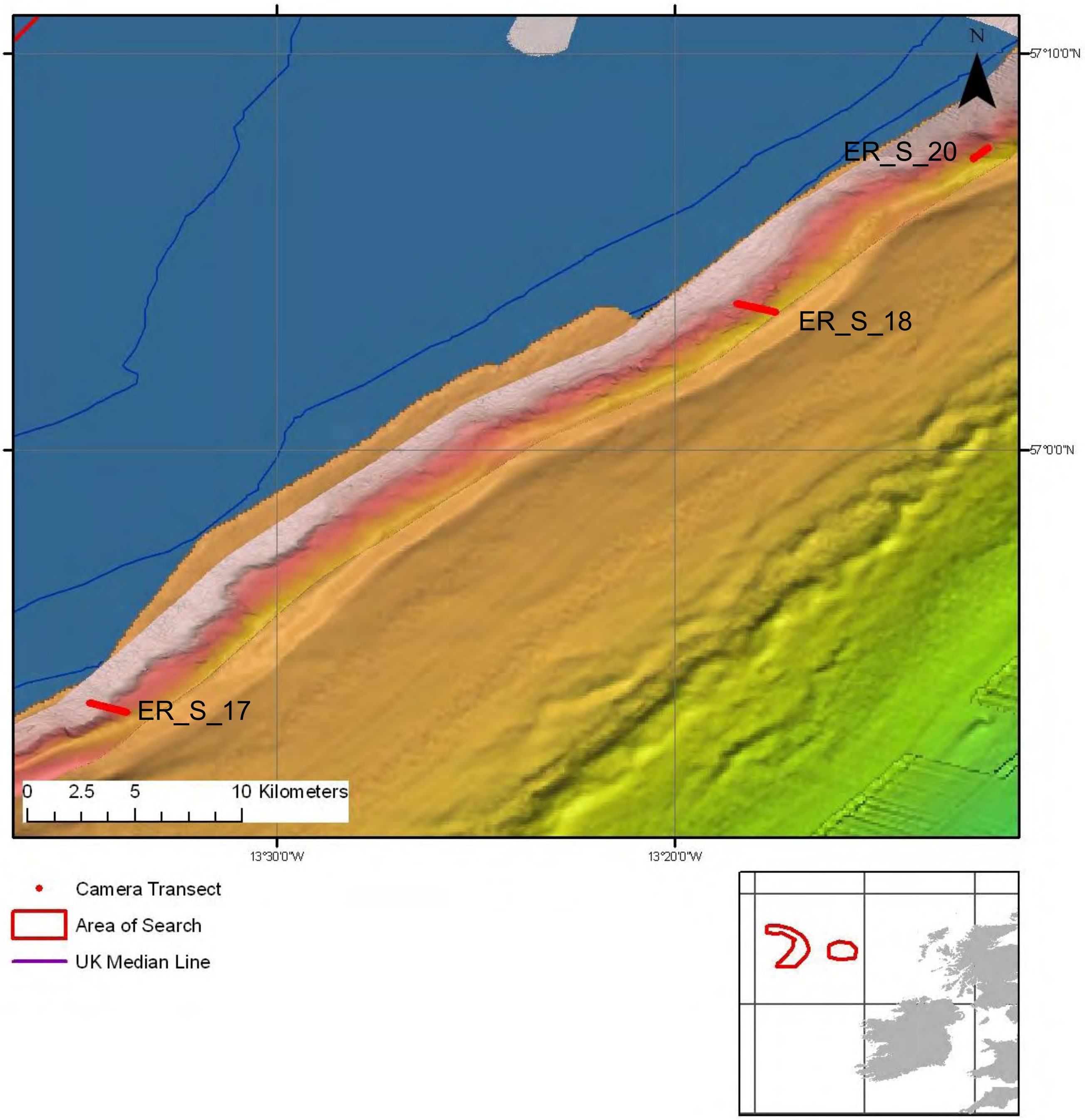


Figure 30 Map showing the location of camera transects acquired in the East Rockall Bank south area of search.

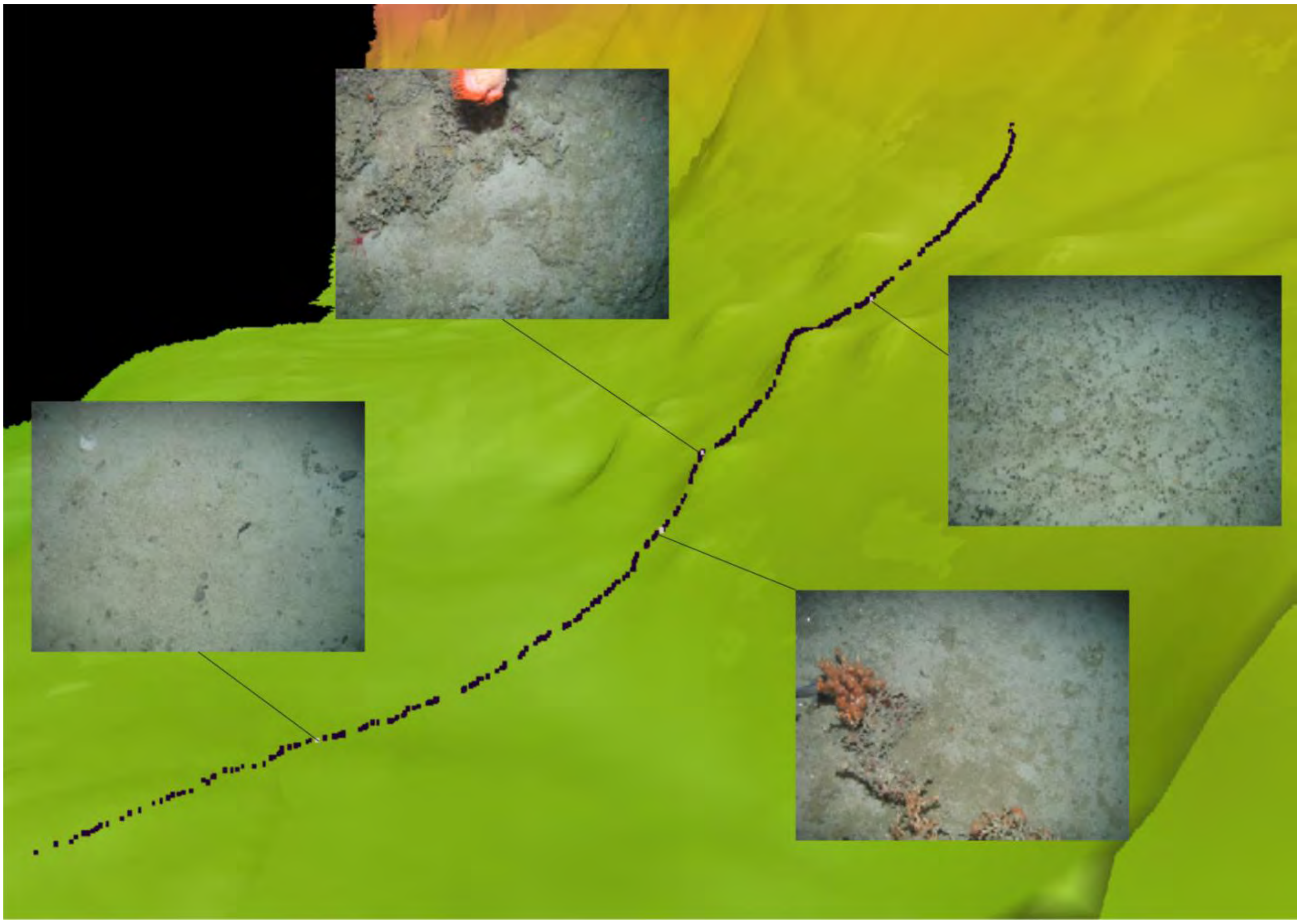


Figure 31 3D image of small mound features with the camera tow ER_N_01 draped. Selected images show the spatial change in habitat.

ER_N_01

The target was over two small mound features at the base of the flank (

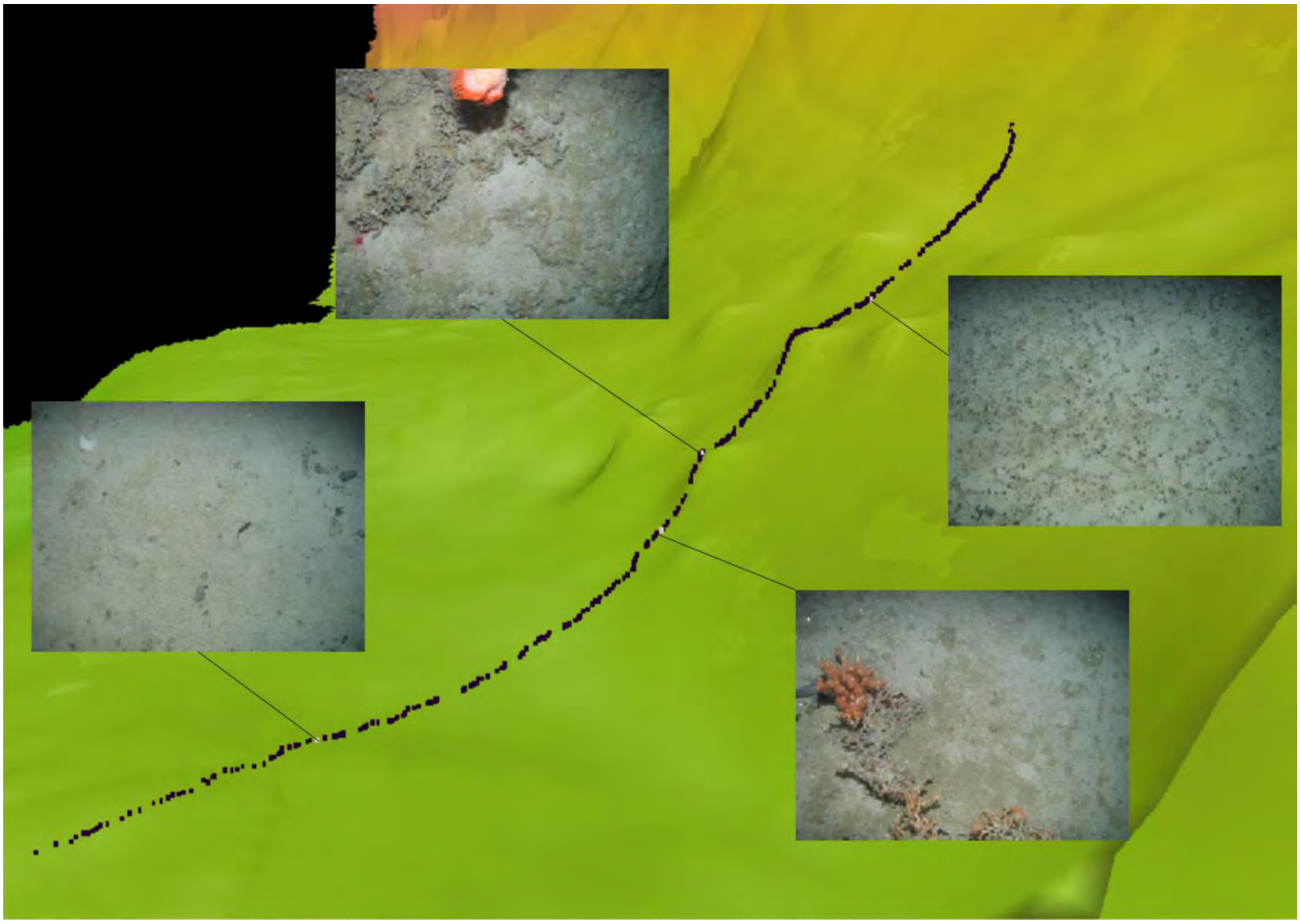


Figure 31). The tow began on an area of gravel-rich sand with little fauna other than crabs. As the tow continued, coral debris with the holothurian *Stichopus tremulus* were observed. The area of sea bed on top of the mounds consisted of coral rubble habitat with patches of more structural coral with live pieces of *Lophelia pertusa*. Fauna associated with the reef rubble were ascidians, echinoids and small sponges. As the tow continued, the substrate became mixed with small fragments of rubble. Fauna were not particularly abundant with only the urchin *Cidaris cidaris* and large crabs observed. The mixed substrata progressively changed into small patches of live *Lophelia pertusa* pieces with visible glass sponges, ascidians and abundant halcampoid anemones. The area of reef rubble increased on top of the mounds and thus providing a more complex habitat for the associated fauna. As the quantity of rubble increased, the large anemone *Phelliactus* sp. and echinoderms (*Stichopus tremulus* and *Cidaris cidaris*) were conspicuous. Isolated cobbles with the sessile holothurians *Psolus* sp., saddle oysters and *Lophelia pertusa* clumps attached were also scattered throughout the area.

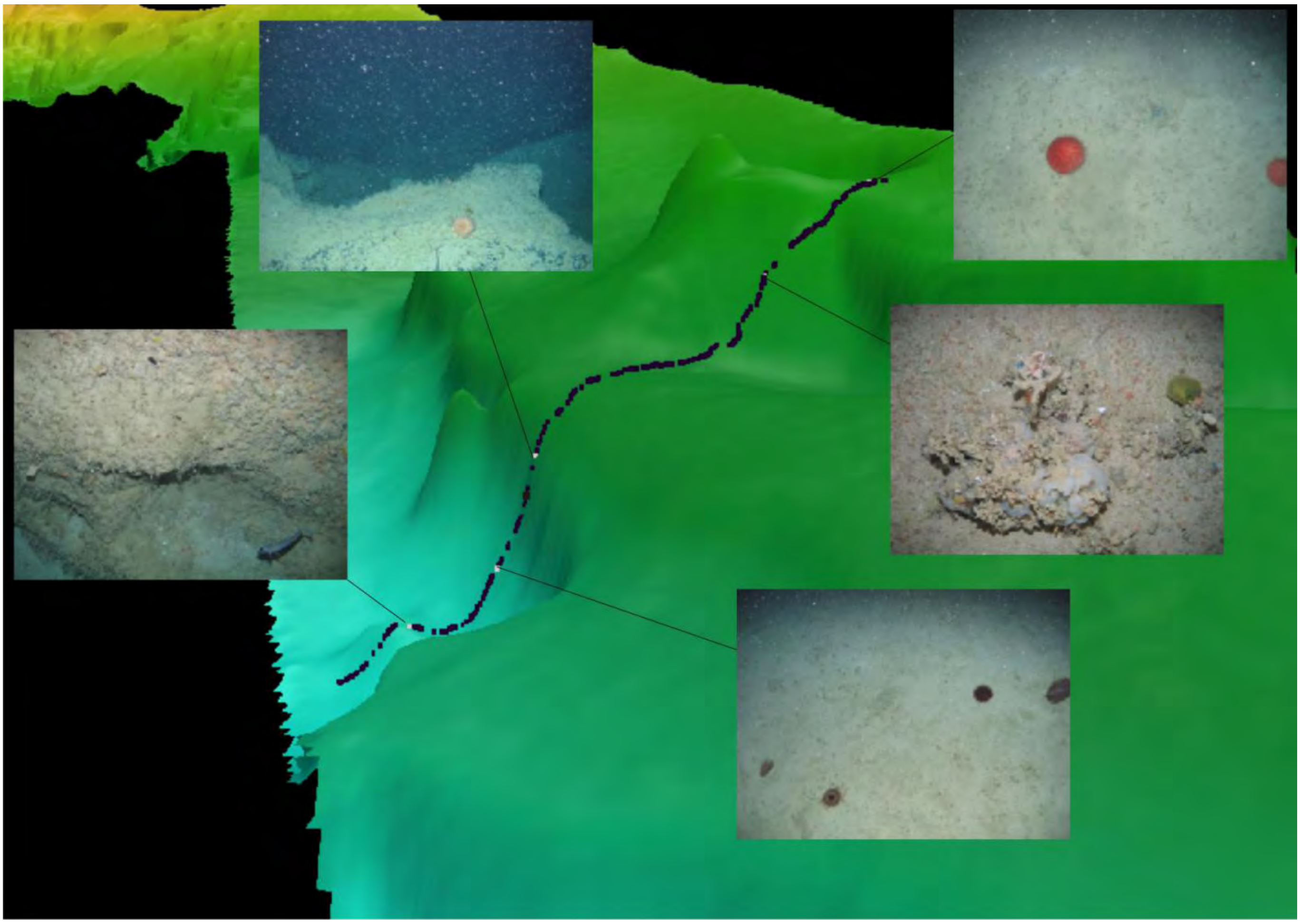


Figure 32 3D image of a deep cliff with the camera tow ER_N_02 draped. Selected images show the spatial change in habitat.

ER_N_02

The target was a deep cliff at the base of the slope (Figure 32). The tow began on an area of sand with abundant small halcampoid anemones, larger anemones and xenophyophores. Occasionally the seapen *Pennatula phosphorea* was visible. As the tow traversed down the slope, coral rubble was visible with the large anemone *Phelliactus* sp., glass sponges, ascidians and the squat lobster *Munida* sp. associated. As the tow continued towards the cliff, the rubble graded to coarse sand substrate with the same halcampoid anemones, sea pens and large anemones present. As the tow traversed the steep cliff edge exposed bedrock was encountered, although this changed to mixed rock with some sand veneer subsequently. Down slope from the cliff edge soft sediment was dominated by cerianthid anemones and the sea pen *Penntaula phosphorea*, at the end of the tow a small mound was traversed at the base of the slope which comprised a number of steep ledges with abundant brachiopod species associated.

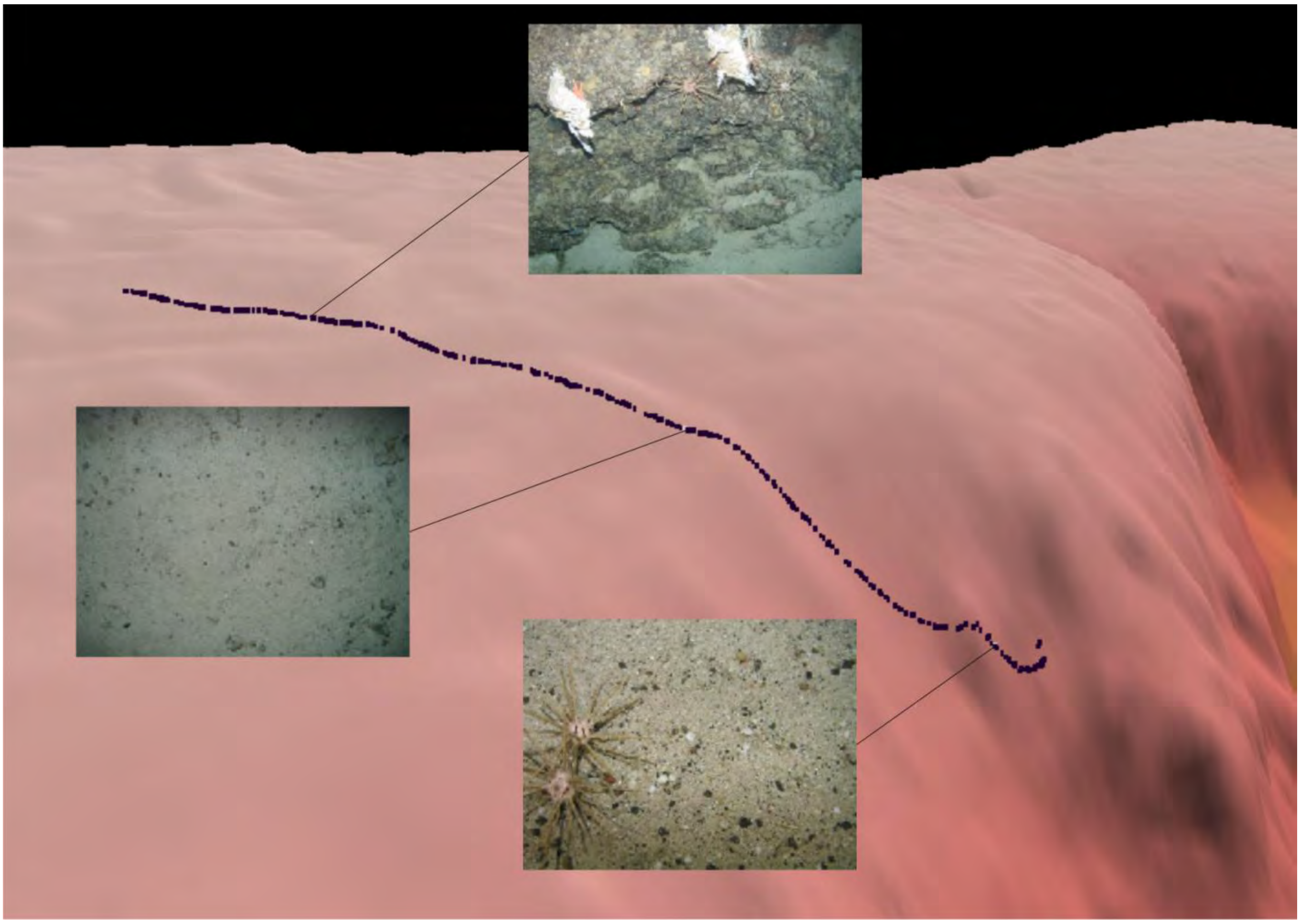


Figure 33 3D image of a break of slope with the camera tow ER_N_03 draped. Selected images the show the spatial change in habitat.

ER_N_03

The target was the break in slope associated with an escarpment (Figure 33). The tow began on an area of mixed substrate with biogenic gravel infilling between larger clasts. As the tow continued it encountered bedrock outcropping at sea bed. Large stylasterids hydrocorals were the dominant fauna, but also the pencil urchin *Cidaris cidaris* and many other less dominant invertebrate species were present. As the tow continued to the edge of the escarpment the substrate changes to gravel with mobile echinoderm species present, this graded into an area of mixed cobbles and pebbles with associated encrusting sponges, some stylsaterid corals and the blue-mouth redfish *Helicolenus dactylopterus.* The substrate reverted back to gravel with *Cidaris cidaris* towards the end of the tow.

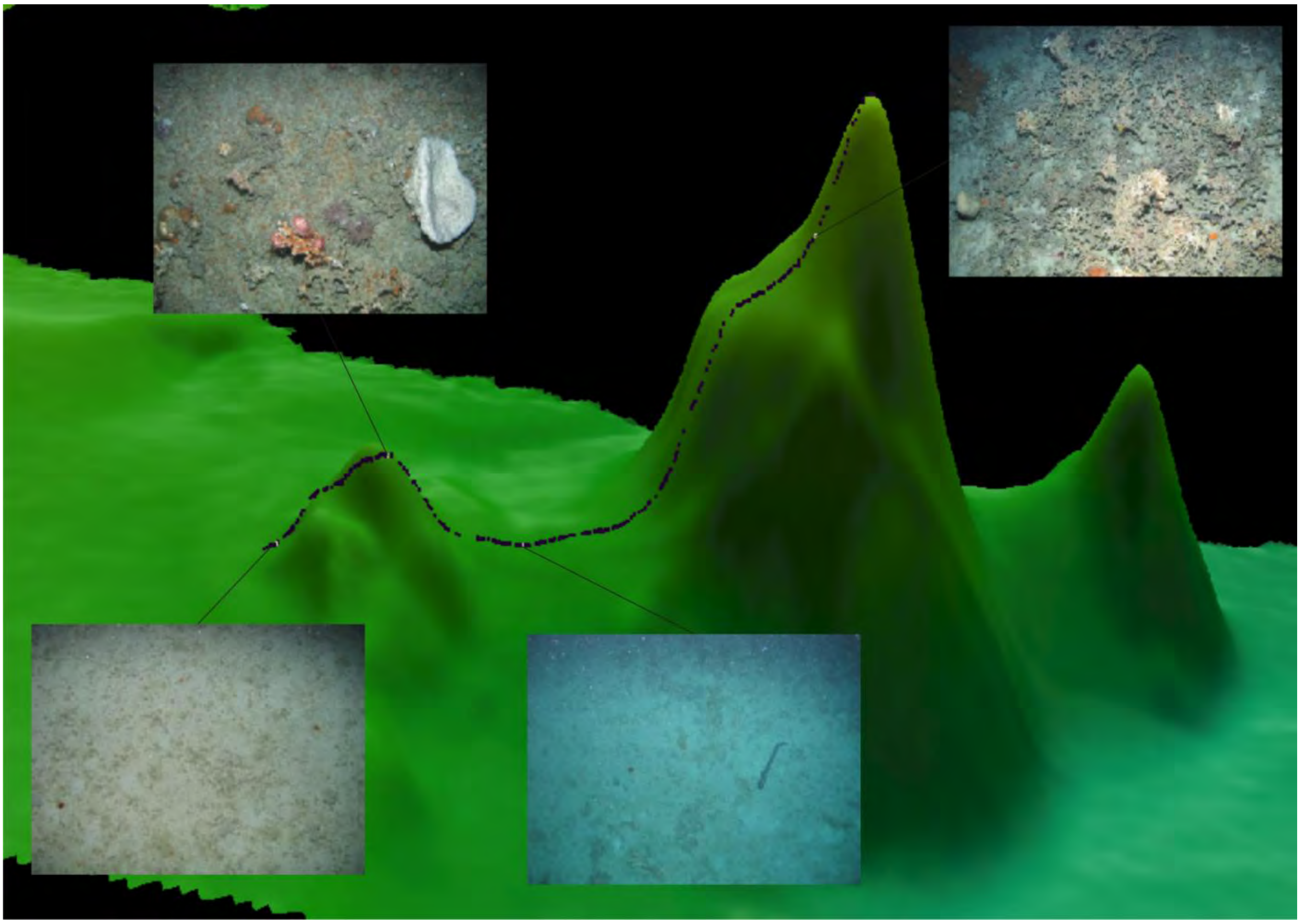


Figure 34 3D image of a deep pinnacle with the camera tow ER_N_04 draped. Selected images show spatial change in habitat.

ER_N_04

The target was a group of mounds in deeper water (Figure 34). The tow began on the summit of the largest mound with an expanse area of low lying coral (rubble) observed. Dominant fauna were the large anemone *Phelliactis*, glass sponges and a number of antipatharian species. As the tow continued down the flank of the largest mound the quantity of live *Lophelia pertusa* observed decreased with intermittent sparser rubble areas encountered instead. As the tow reached the base of the mound a number of xenophyophores and large anemones where observed. The tow continued to traverse up a second, smaller mound which was carpeted by orange halcampoid anemones. Low-lying coral rubble was also present with a number of associated species as well as large conspicuous fauna such as sponges. At the end of the tow, off the mound feature, the substrate encountered was sand-rich with halcampoids, xenophyophores and large anemones.

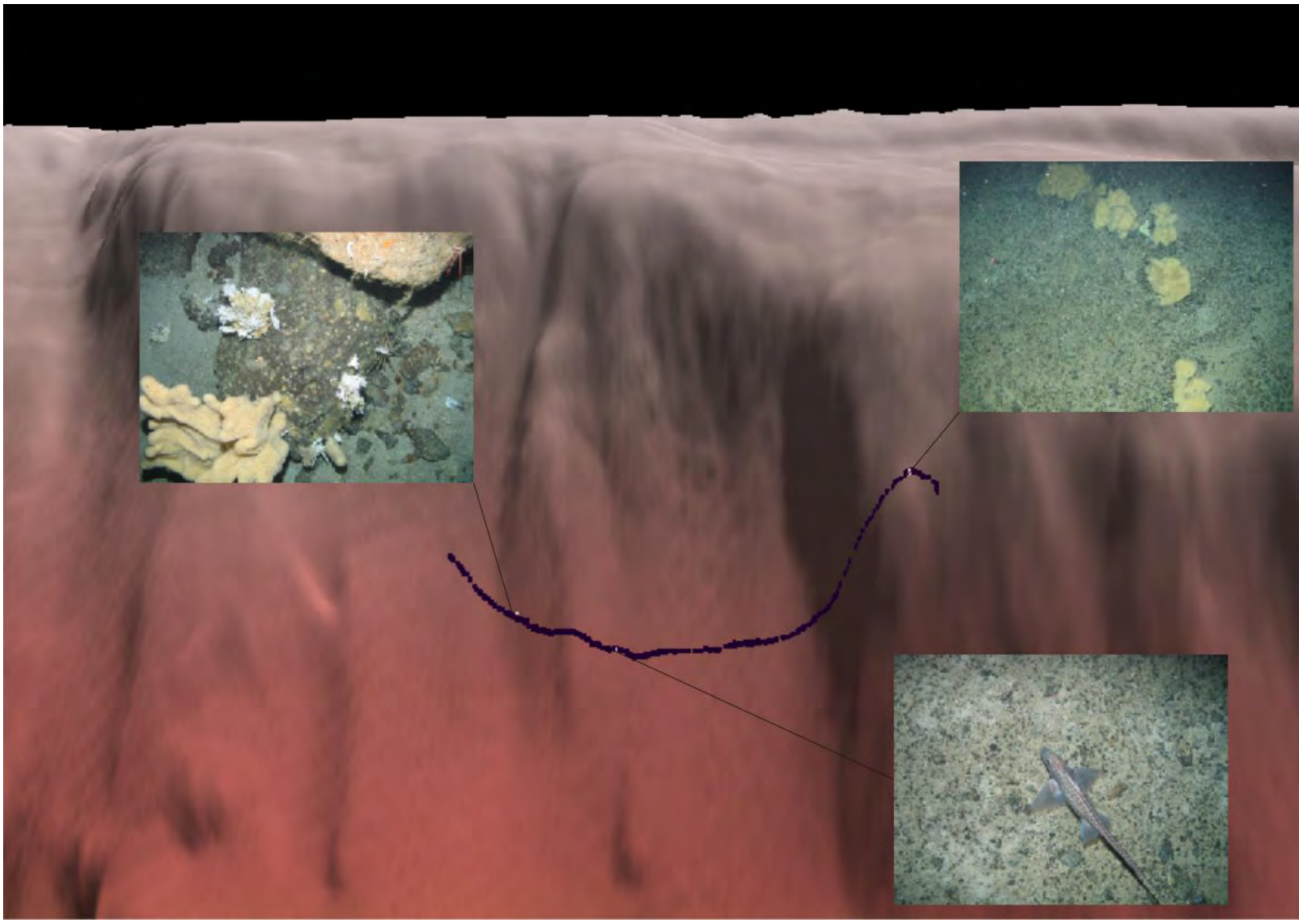


Figure 35 3D image of ridge feature on slope with the camera tow ER_C2_05 draped. Selected images show the spatial change in habitat.

ER_C2_05

The target was a ridge feature along the slope (Figure 35). The tow began on the crest of the ridge on an area of mixed rock, stylasterid hydrocorals and lobose sponges. Further along the transect, the camera passed over an area of bedrock outcrop with encrusting sponges, and subsequently encountered an area of mixed substrate with little visible epifauna with the exception of the pencil urchin *Cidaris cidaris*. Towards the end of the tow another area of bedrock outcrop was encountered, dominant fauna included the same lobose sponge and stylasterid species.

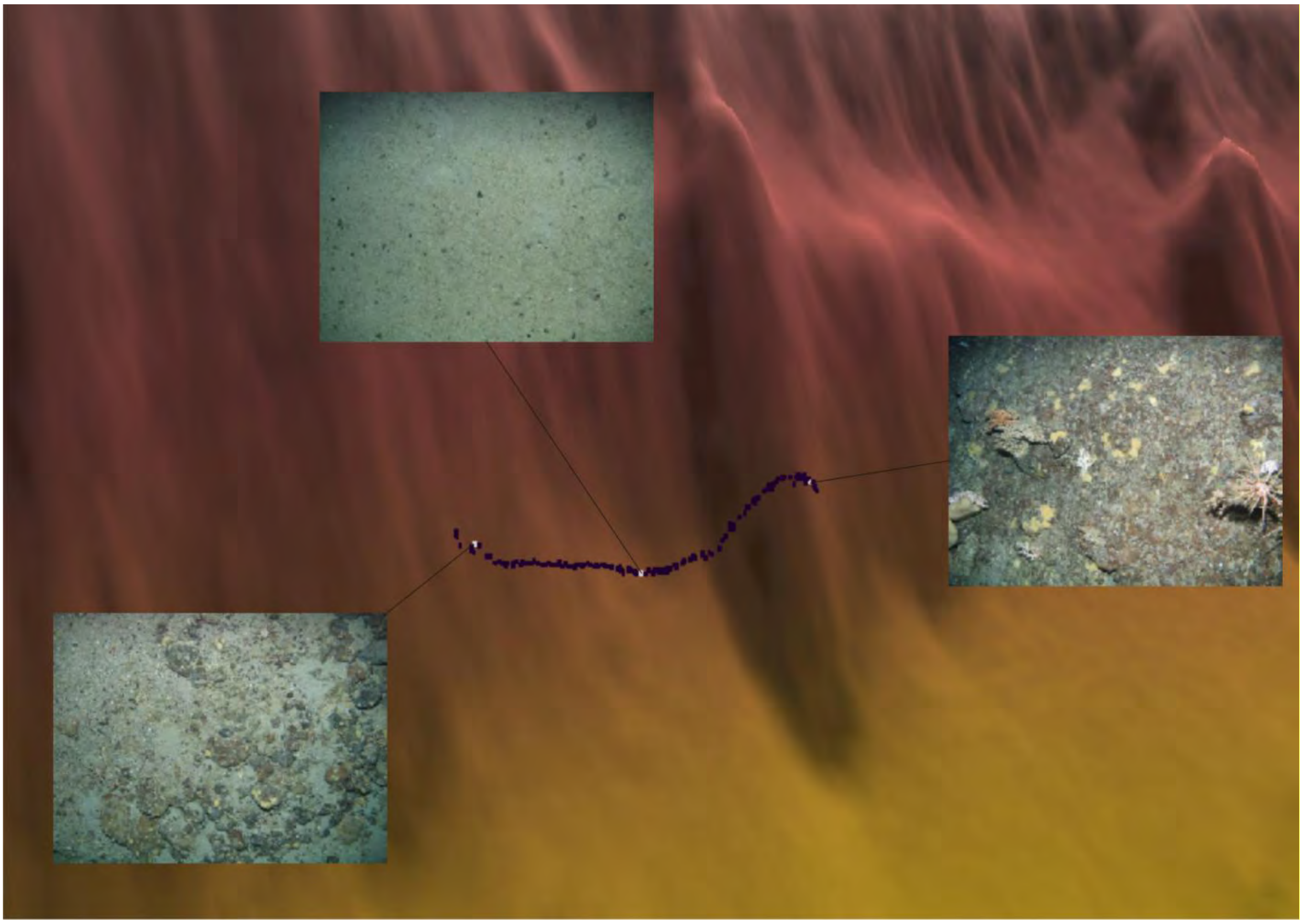


Figure 36 3D image of along slope with the camera tow ER_C2_06 draped. Selected images show the spatial change in habitat.

ER_C2_06

The target was over an area of uneven ground along the slope of the Bank (Figure 36). The tow began on an area of bedrock outcrop dominated with yellow globose sponges, small growths of *Lophelia pertusa* and the pencil urchin *Cidaris cidaris*. As the transect continued along the slope, the bedrock gave way to mixed substrate with biogenic gravel infill, with fish and cidarids present. Towards the end of the transect the cobble content increased with the occurrence of the same species at the beginning of the tow.

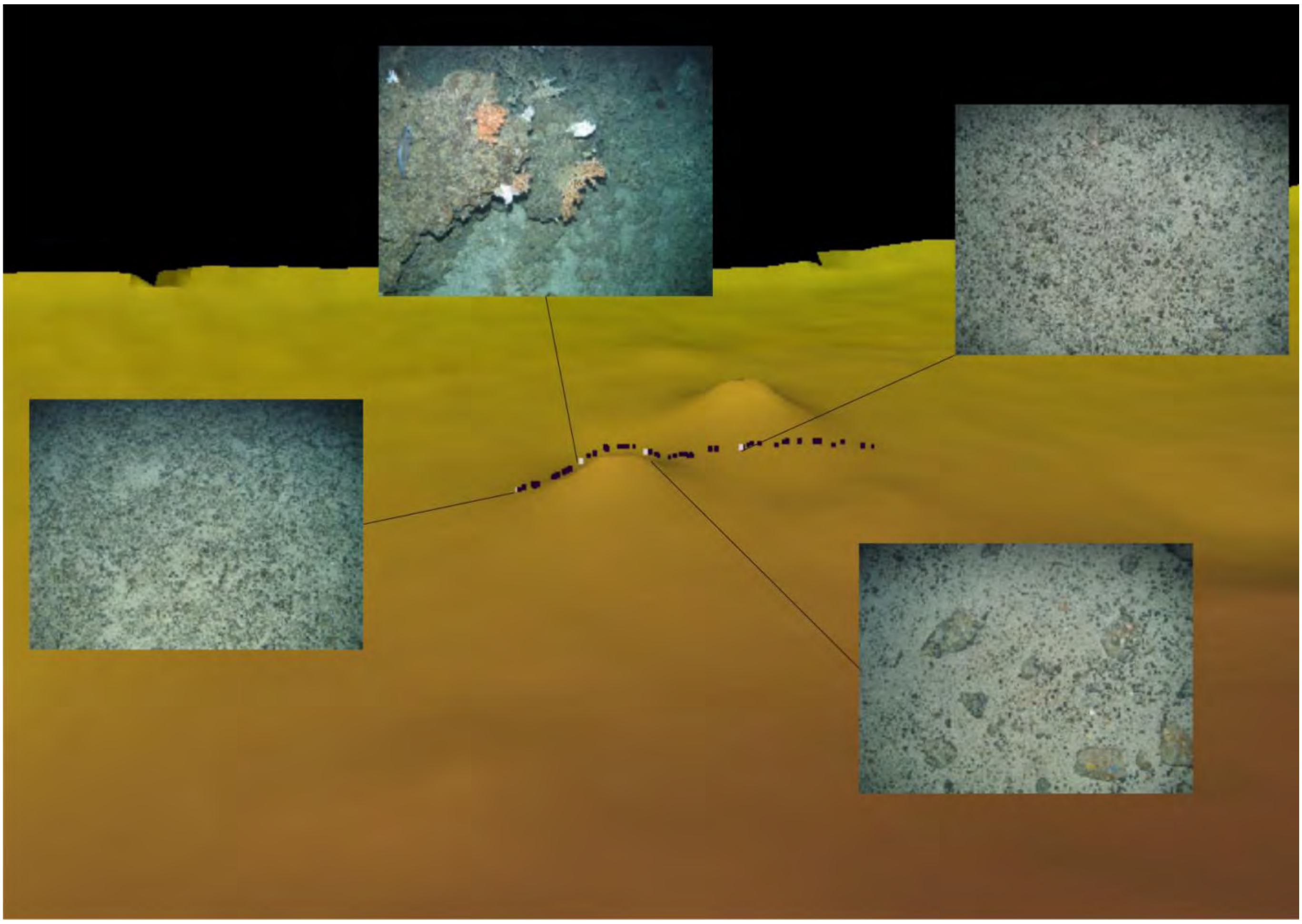


Figure 37 3D image of small mound feature with the camera tow ER_C2_19 draped. Selected images show the spatial change in habitat.

ER_C2_19

The target was a small mound feature (Figure 37). The tow began on an area of mixed substrate (predominantly pebbles) with occasional echinoid species. As the camera traversed the small mound, coral rubble appeared. Towards the summit of the mound, areas of bedrock with associated coral reef and rubble reef surrounding were encountered. Typical fauna were live *Lophelia pertusa*, the fish *Lepidion eques*, echinoderms (including *Cidaris cidaris*), cerianthid anemones and the squat lobster *Munida* sp. As the camera reached the base of the mound, mixed rock with encrusting and erect sponges, the sessile holothurian *Psolus* sp. and occasional clumps of dead *Lophelia* were apparent.

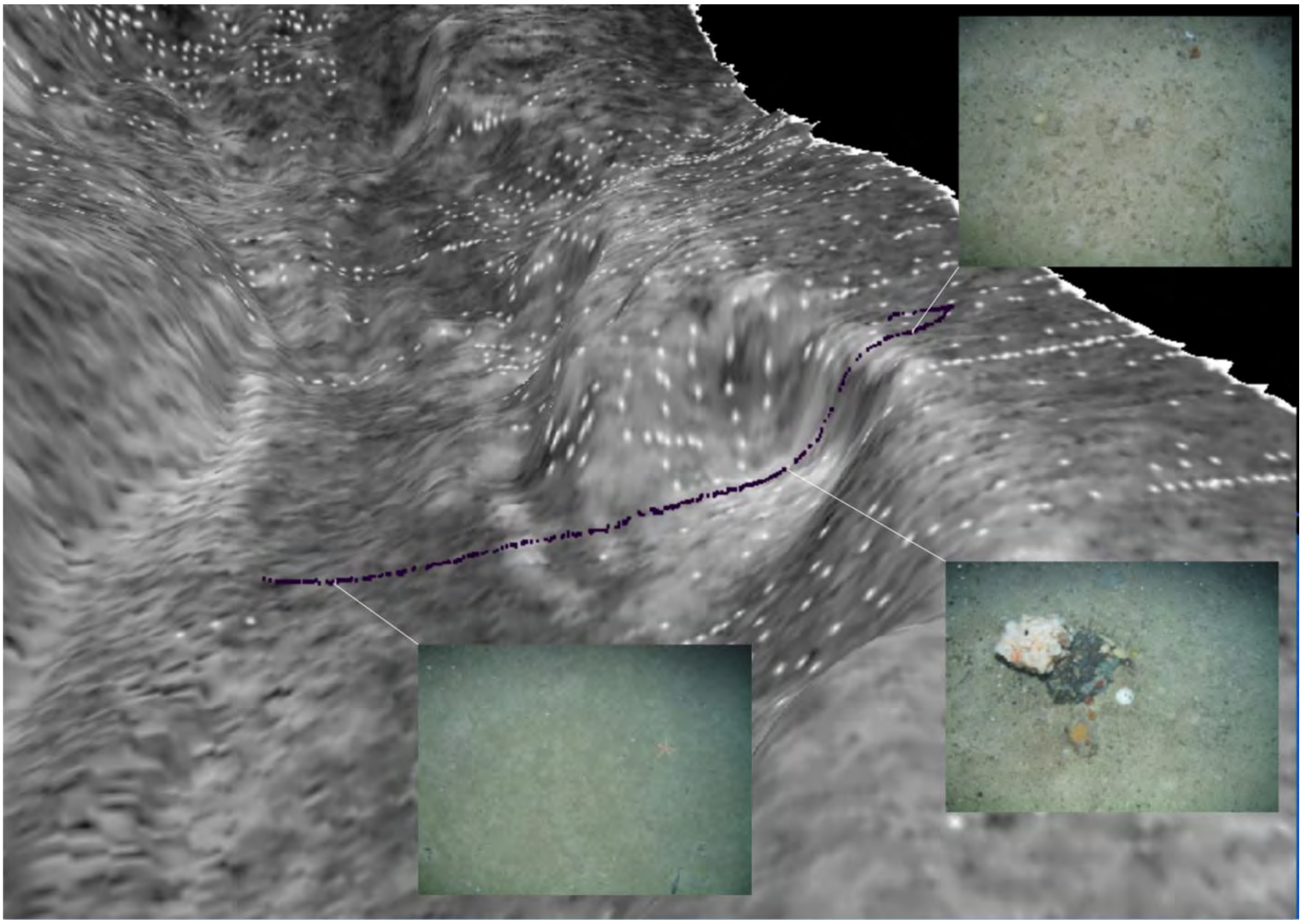


Figure 38 3D image of small canyon feature with the camera tow ER_C1_08 draped. Selected images show the spatial change in habitat.

ER_C1_08

The target was a circular area of high backscatter observed in a canyon (Figure 38). The tow began on an area of finer substrate (mud/fine sand) with xenophyophores. As the tow continued boulders and cobbles with encrusting fauna, large sponges were visible, with xenophyophores still observed amongst the rock. As the tow traversed the slope of the canyon fine substrate with very little epifauna was encountered. At the bottom of the slope, through the area of high backscatter an area of boulders progressing to cobbles was observed. Typical fauna associated with the area of high backscatter were encrusting sponges, caryophyllids, xenophyophores and large lobose sponges. As an area of low backscatter at the end of tow was approached fine substrate was again observed with xenophyophores, cerianthids and occasional sea pens.

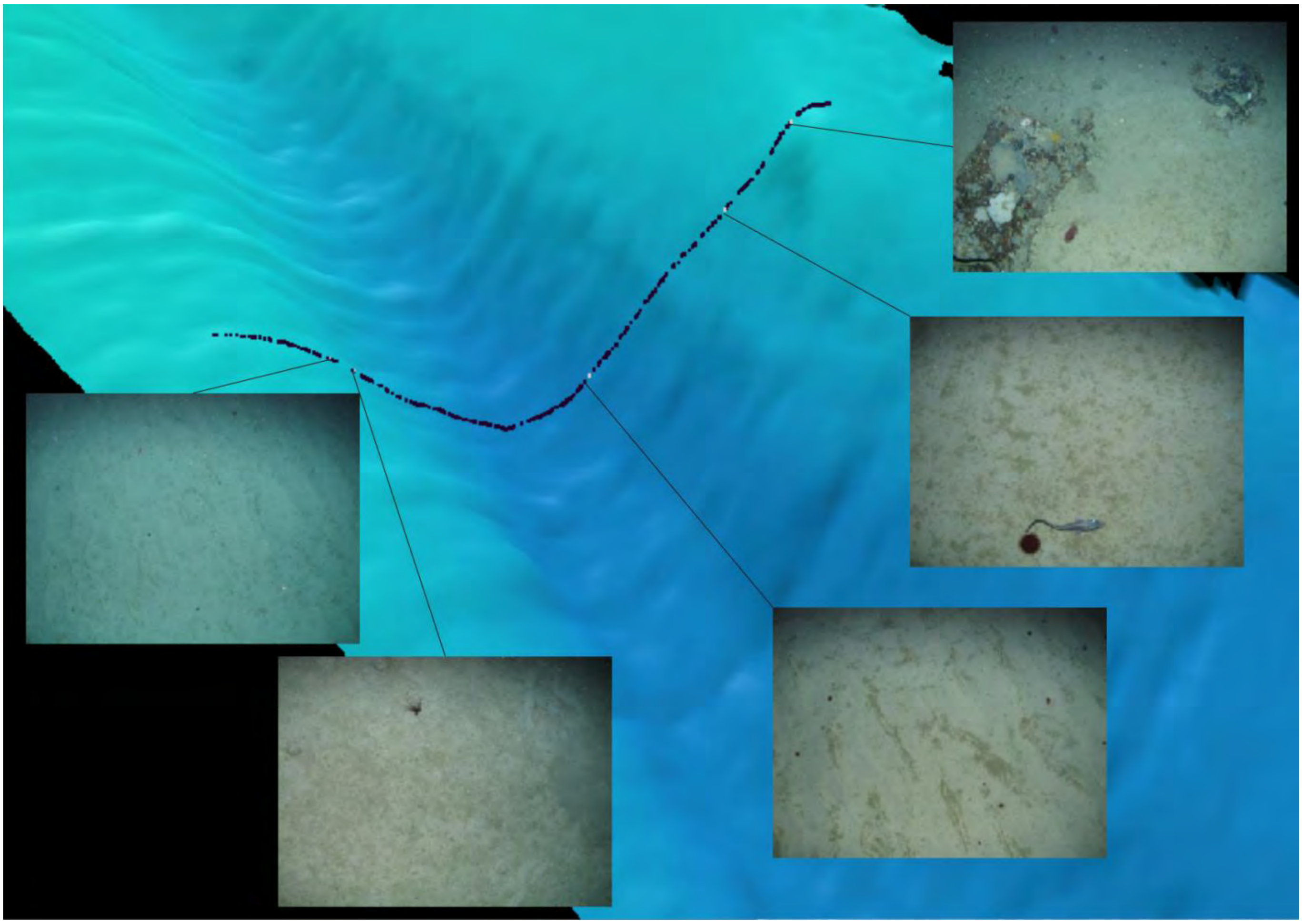


Figure 39 3D image of canyon feature with the camera tow ER_C1_09 draped. Selected images show the spatial change in habitat.

ER_C1_09

The target was a small canyon (Figure 39). The tow began on the northern flank of the canyon on a slightly raised area of sea bed comprising mixed cobbles and boulders with encrusting sponges, ascidians and caryophyllids. As the tow traversed down the northern side of the canyon, soft sediment with cerianthid anemones and xenophyophores were encountered. Towards the base of the canyon, sediment ripples were visible dominated by small anemones. As the tow traversed up the less steep, southern, flank of the canyon it was dominated by fine-grained (probably mud-rich) substrate with occasional sea pens, cerianthids, *Pheronema* sponges and xenophyophores.

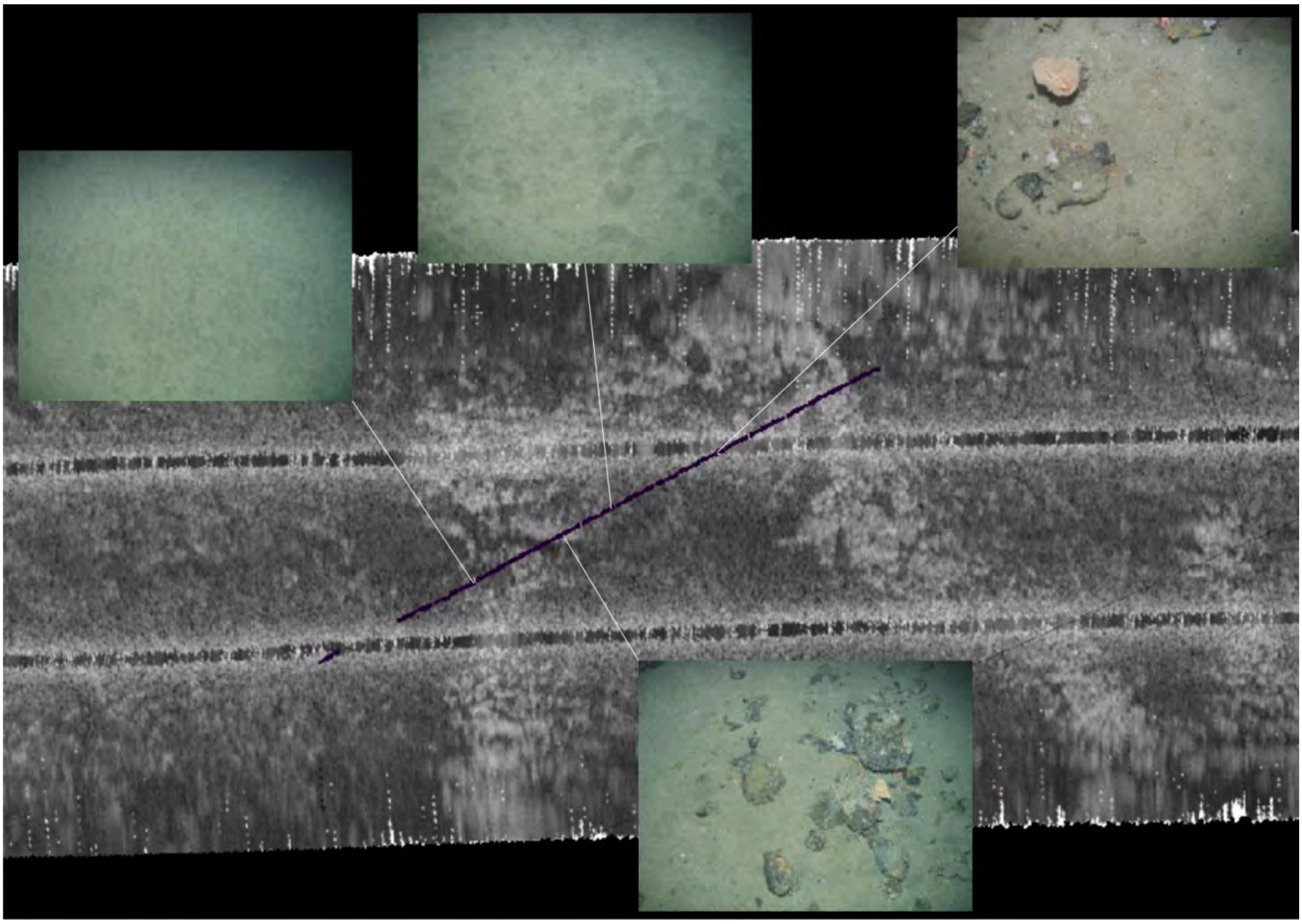


Figure 40 3D image of an area of interesting backscatter with the camera tow ER_C1_10 draped. Selected images show the spatial change in habitat.

ER_C1_10

The target was an area of interesting backscatter response that may indicate the presence of coral (Figure 40). The transect began on an area of low backscatter response which corresponded to fine sediment with occasional visible epifauna, including flatfish and asteroids. As the transect crossed the first boundary onto an area of high backscatter response, the substrate changed to mixed cobbles and boulders with lamellate and encrusting sponges with the squat lobster *Munida* sp. As the transect continued the same habitats were encountered corresponding to the same backscatter response.

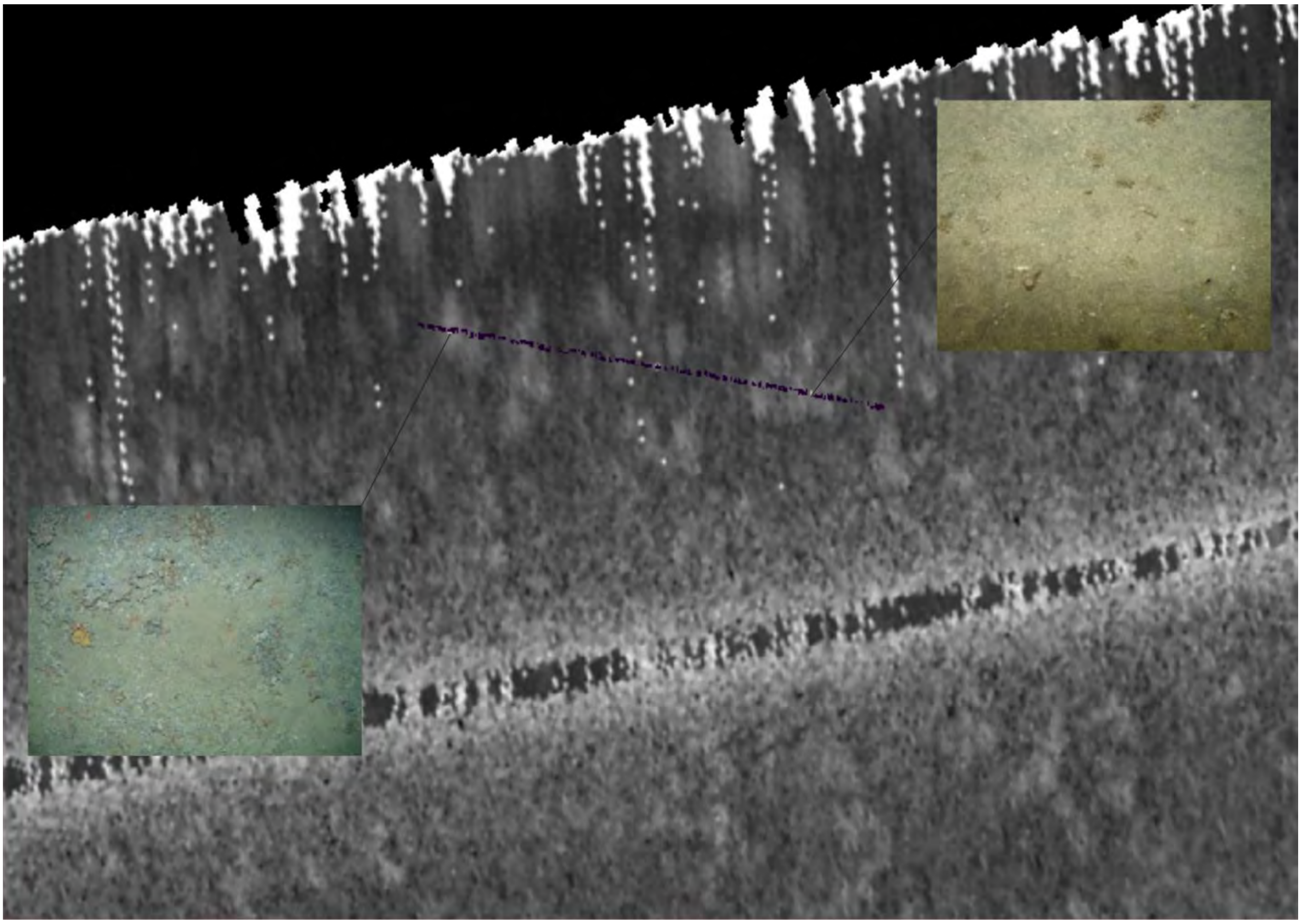


Figure 41 3D image of uneven sea bed with the camera tow ER_C1_11 draped. Selected images show the spatial change in habitat.

ER_C1_11

The target was an area of uneven sea bed (Figure 41). Two distinct habitats were encountered, at the beginning of the transect an area of flat sea bed with rippled sand and little epifauna was observed, while towards the end of the transect, coral rubble dominated by *Munida* sp., caryophyllids, anemones and ophiuroids was observed.

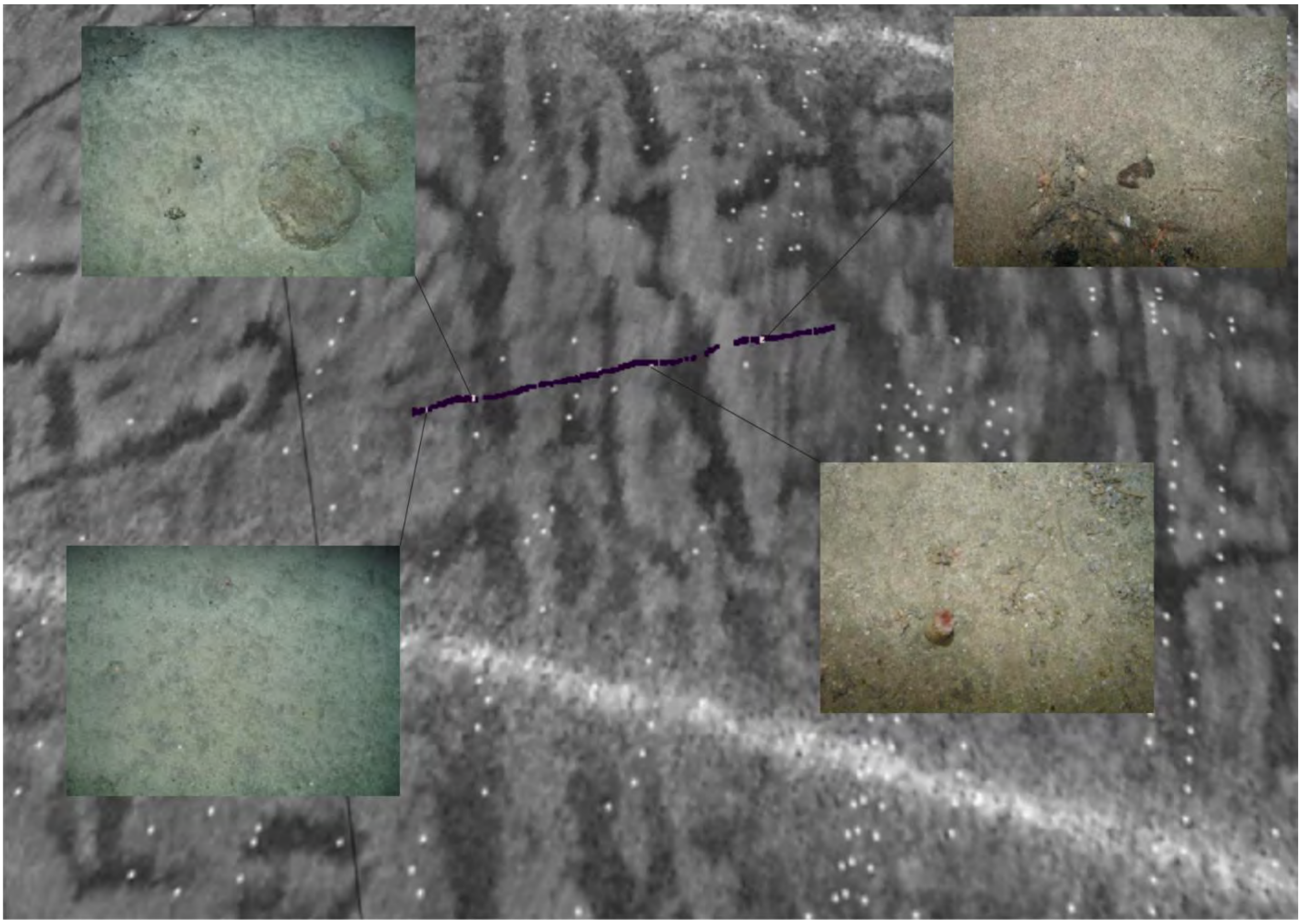


Figure 42 3D image of linear marks with the camera tow ER_C1_13 draped. Selected images show the spatial change in habitat.

ER_C1_13

The target was an area of linear marks on the sea bed identified best on the backscatter data (Figure 42). The transect began on an area of dominantly fine-grained sediment with visible squat lobsters. As the camera traversed the area of lower backscatter response it corresponded to mixed cobble substrate with large anemones and squat lobsters. As the transect continued a number of backscatter boundaries were crossed which represented a change from areas of mixed substrate and fine-grained sediments.

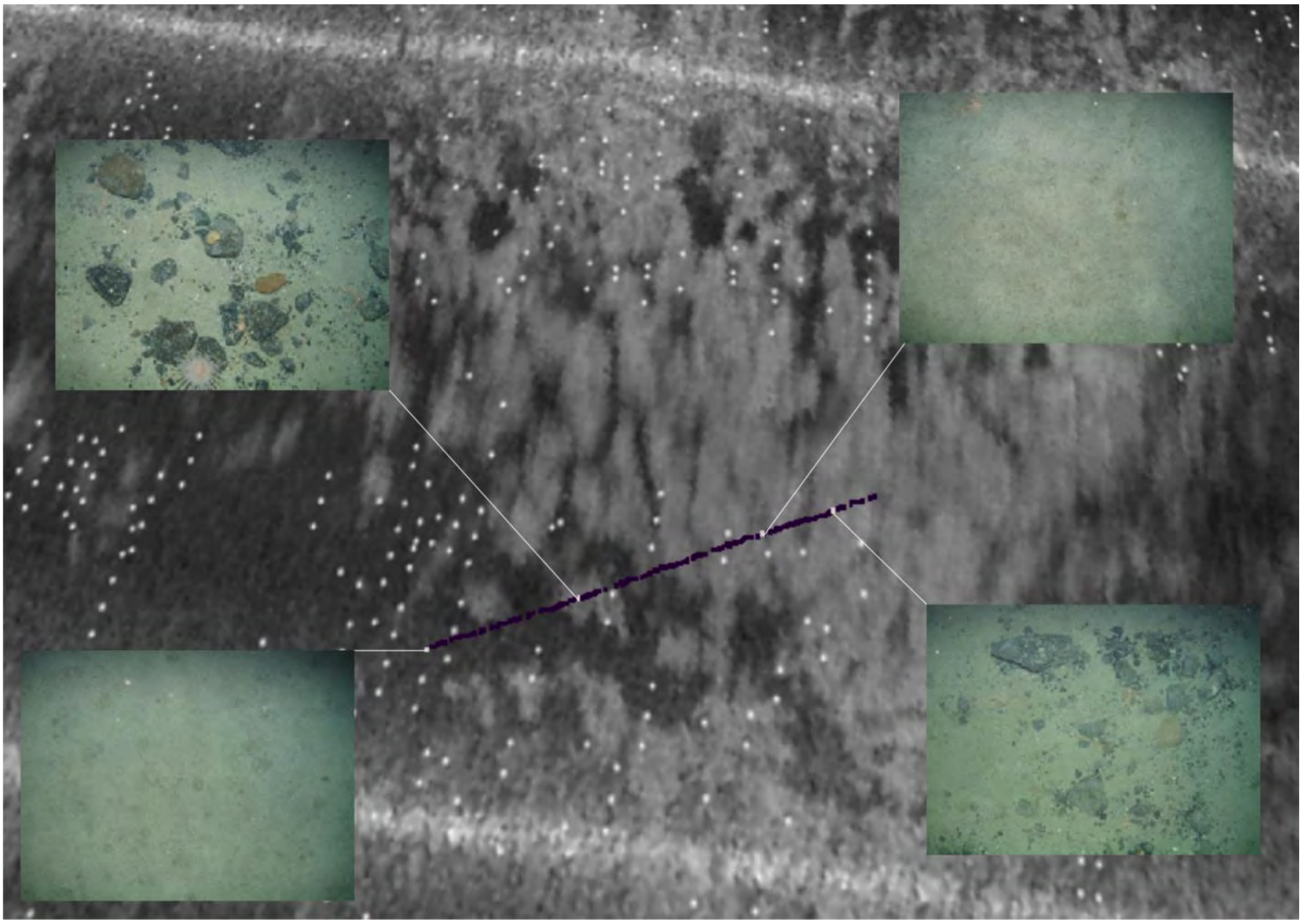


Figure 43 3D image of varying backscatter with the camera tow ER_C1_14 draped. Selected images show the spatial change in habitat.

ER_C1_14

The target was an area of varying backscatter response which may represent the presence of coral (Figure 43). The transect began on an area of low backscatter response representing fine-grained sediment with abundant infaunal mounds. As the tow traversed onto an area of higher backscatter response it encountered mixed cobbles and boulders which were dominated by encrusting sponges and squat lobsters. Throughout the remainder of the tow further backscatter boundaries that correspond to the same habitats as already observed were crossed.

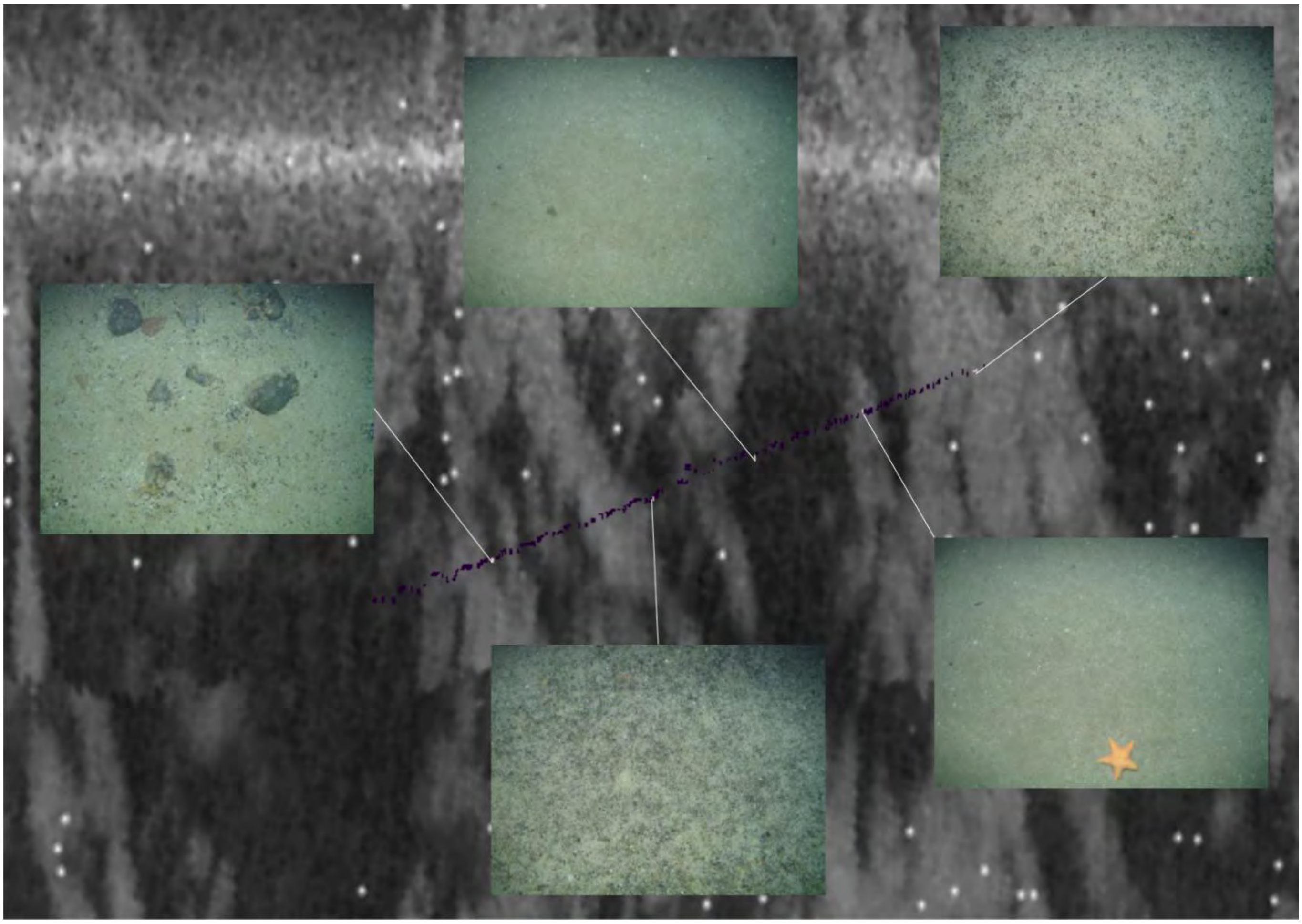


Figure 44 3D image of varying backscatter with the camera tow ER_C1_15 draped. Selected images show the spatial change in habitat.

ER_C1_15

The target was an area of sea bed which had no VMS data with bedrock outcrop (Figure 44), thus suggesting reason for not fishing. The tow began on an area of coarse substrate which corresponded to a high backscatter response. Little epifauna were visible, with the occasional asteroid. As the tow continued it crossed a number of backscatter boundaries before encountering another area of coarse substrate, towards the end of the tow an area of mixed cobbles with abundant squat lobsters, encrusting sponges and a zoanthid species were encountered.

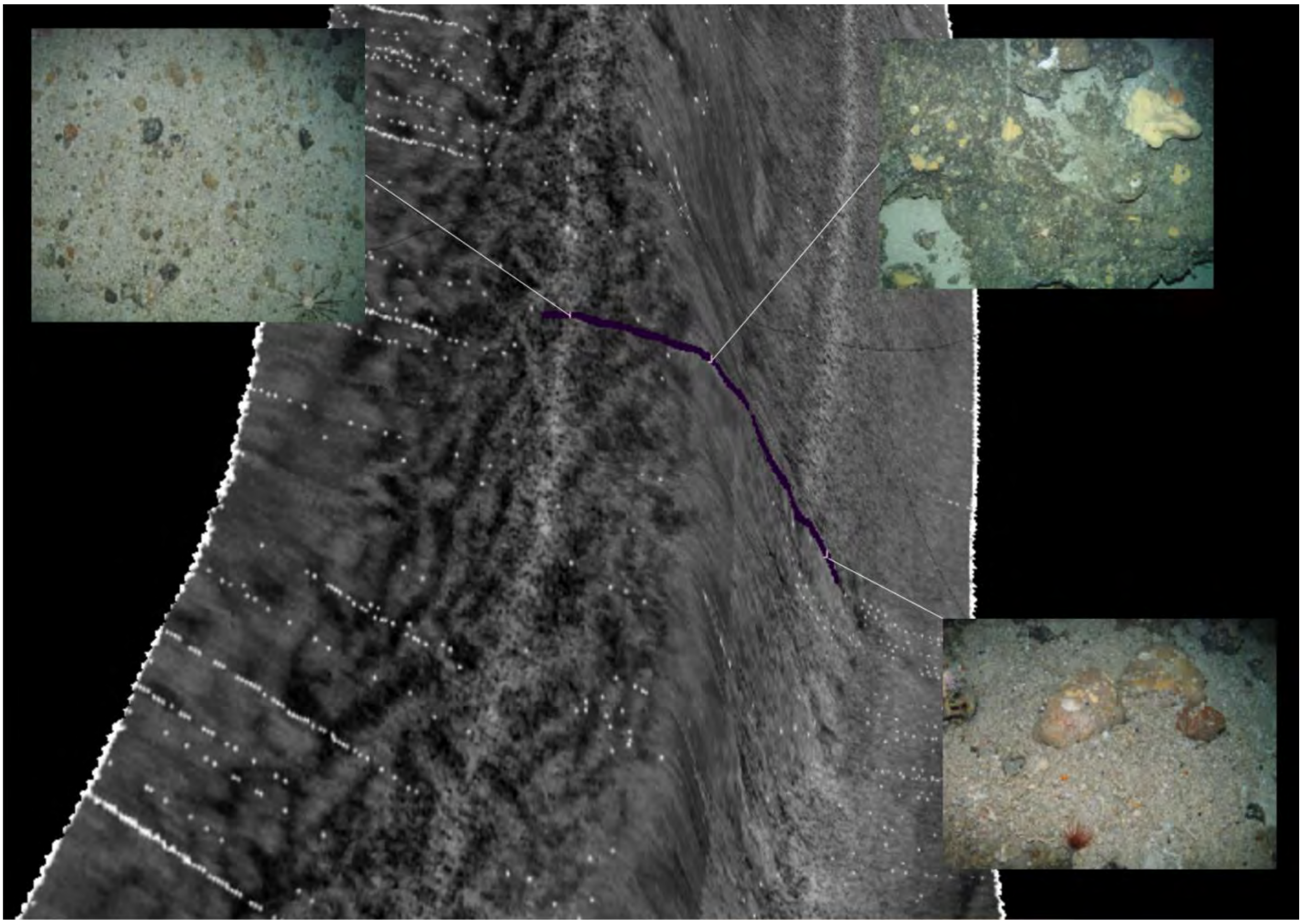


Figure 45 3D image of ploughmarks with the camera tow ER_S_17 draped. Selected images show the spatial change in habitat.

ER_S_17

The target was an area of iceberg ploughmarks, down the break of slope and along a ridge (Figure 45). The tow began on an area of iceberg ploughmarks which were clearly visible from the backscatter data. The ploughmarks corresponded to mixed cobbles with biogenic gravel infill, cidarids and encrusting sponges were the dominant fauna associated with this area. As the transect traversed the break of slope it encountered bedrock outcrop and boulders encrusted by sponges, with serpulid worms, saddle oysters and cidarids. As the transect continued down the slope, the amount of bedrock increased as did the abundance of fauna with large lobose sponges and stylasterids appearing.

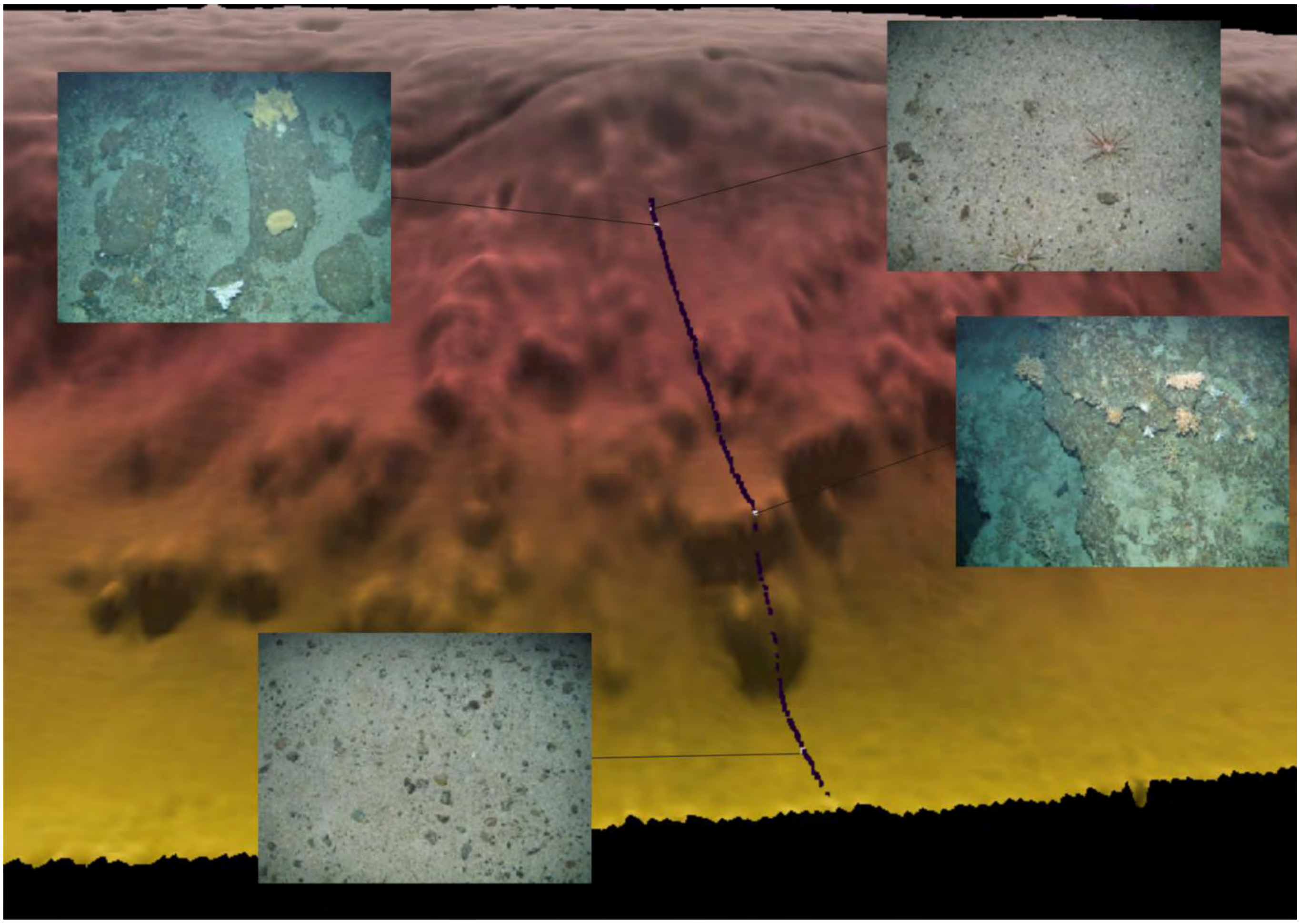


Figure 46 3D image of terraces at base of slope with the camera tow ER_S_18 draped. Selected images show the spatial change in habitat.

ER_S_18

The target was an area over terraces to the base of slope (Figure 46). The tow began on an area of coarse substrate with biogenic gravel, with cidarids as the dominant fauna. As the camera continued down the slope it encountered large boulders inhabited by stylasterid hydrocorals and lobose sponges. As the camera crossed the terraces at the base of the slope bedrock with growths of *Lophelia pertusa* and small patches of reef rubble beneath the rock were observed. Towards the base of the slope the substrate became mixed and was dominated with sponges and stylasterid hydrocorals. Subsequently a mixed cobbles habitat with the holothurians *Stichopus tremulus* and *Cidaris cidaris* was encountered towards the end of the tow.

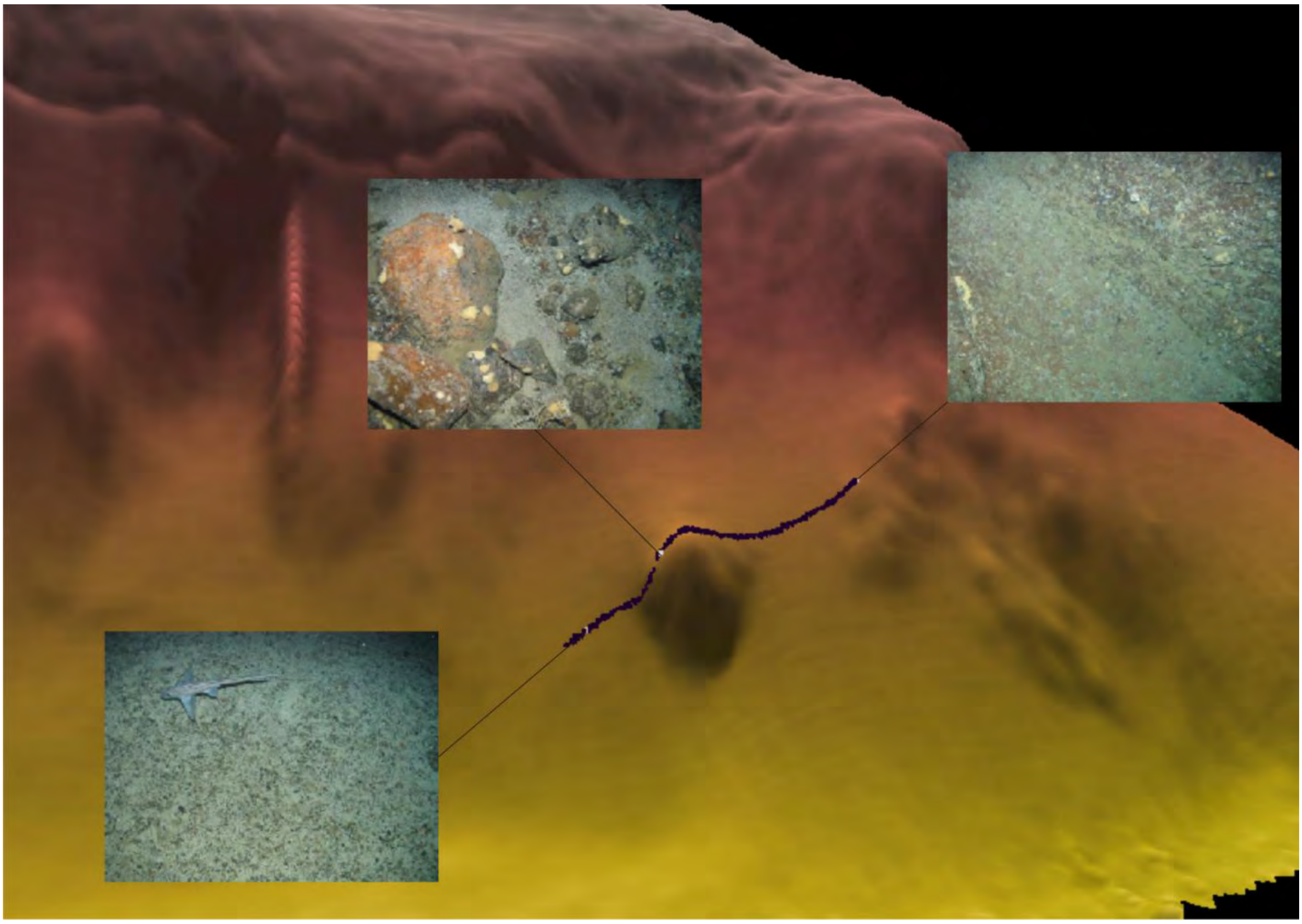


Figure 47 3D image of terraces at base of slope with the camera tow ER_S_20 draped. Selected images show the spatial change in habitat.

ER_S_20

The target was a small mound at the base of the flank (Figure 47). The tow began off the mound feature on an area of mixed substrate with abundant cidarids. As the tow traversed the mound feature, large boulders and bedrock outcrop dominated by encrusting sponges and the holothurian *Psolus* sp. were observed. At the end of the tow, the camera traversed an area of uneven sea bed which corresponded to bedrock terraced with less epifauna.

5. Anthropogenic Impacts

During the course of this cruise a number of anthropogenic impacts were observed on both Anton Dohrn Seamount and East Rockall Bank. Trawl marks were observed on the sea bed of Rockall Bank in water depths <300m (Figure 26). On a number of occasions, discarded and lost fishing gear was also observed (Figure 48 and 49).

For example camera transect AD_DC_04 (see Figure 12 for location) began by landing adjacent to a wire and net at 57.3516ºN, 10.8094ºW (Figure 48). A crab appeared trapped within it and is a potential example of ―ghost fishing".

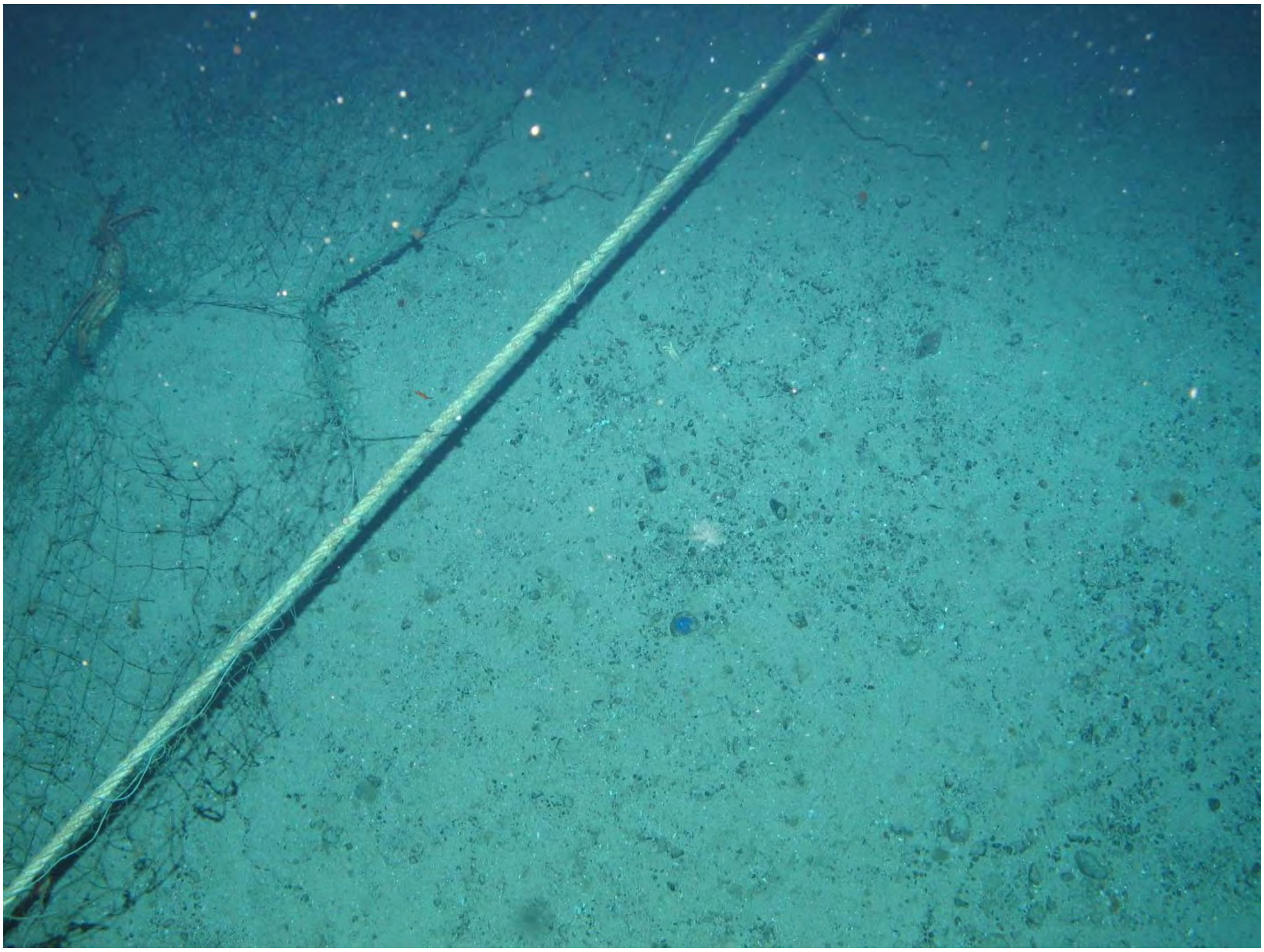


Figure 48 Fishing wire and net encountered at start of camera tow AD_DC_04 (image AD_DC_04_005.jpg).

A bag or sack thought to be associated with the fishing industry was seen on camera tow AD_DC_01 (see Figure 12 for location and Figure 49 for image) at 57.2948°N, 10.8142°W.

On Rockall Bank both the multibeam echosounder and the sidescan sonar data showed numerous examples of sea bed disturbance which is imaged in the data as long ‗lines' occurring on the sea bed. These could be subdivided into two categories: lines with diffuse edges and an irregular orientation occasionally changing direction or ending in a circular depression, and narrow lines with sharp straight edges and often occurred as parallel pairs of lines. The first were interpreted as iceberg ploughmarks of about 10,000 years and older. The second were interpreted as trawl scars or marks associated with modern fishing activity formed when gear (most notably otter boards or trawl doors) are dragged across the seafloor (Figure 26).

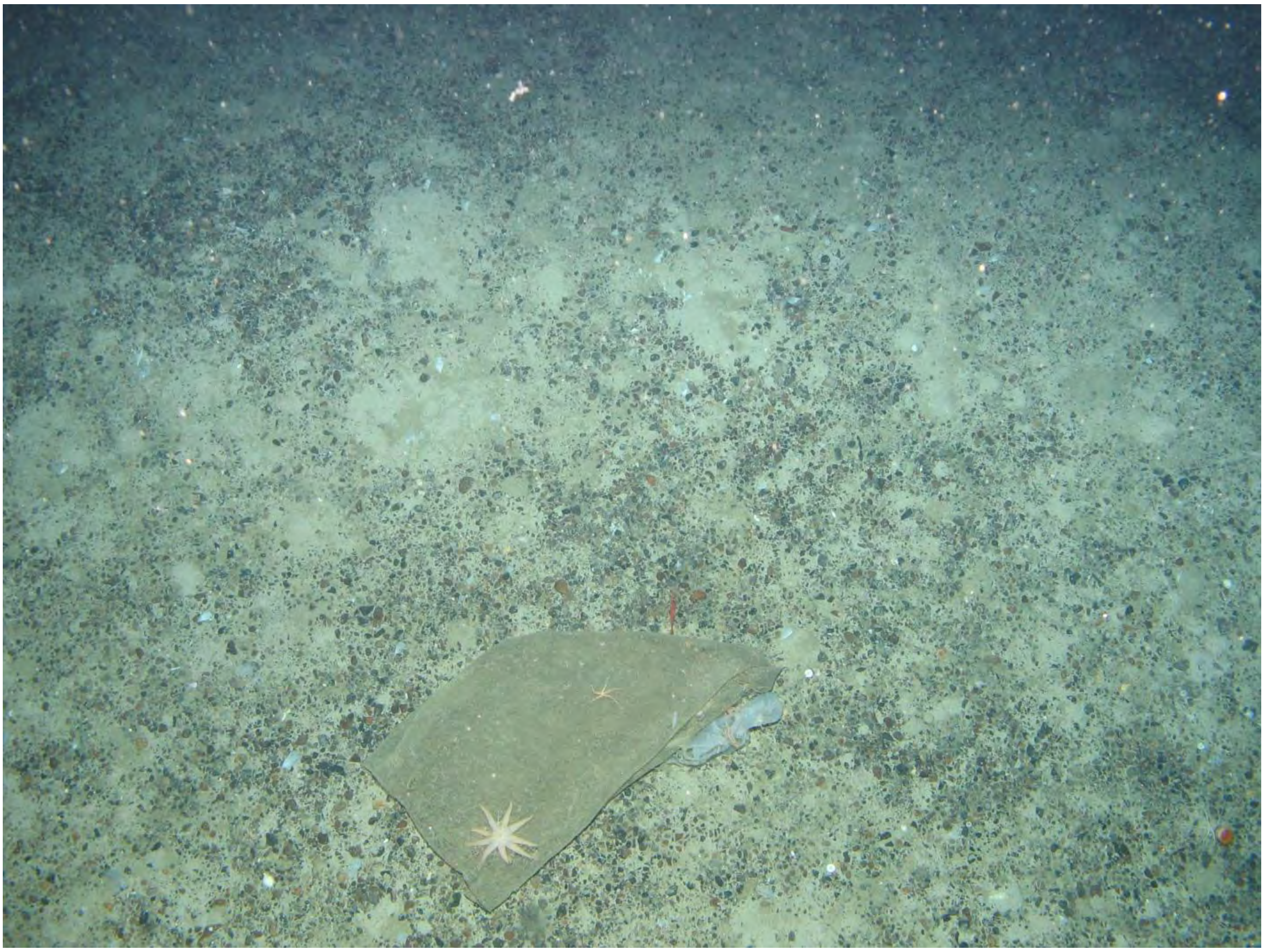


Figure 49 Bag or sack thought to be associated with the fishing industry observed on camera transect AD_DC_01 (image AD_DC_01_099.jpg).

6. Quality Control

6.1 Positioning

For details on the survey quality assurance and quality control procedures for the navigation system see Appendix 5 section 3. For details on the heading system see Appendix 5 section 4.

A working example of quality control during this survey was when there was a loss of navigation position from the GPS. This was observed during routine quality control observations of positional systems as detailed in Appendix 5 sections 3 and 4. Data acquisition was halted and the vessel turned back on itself to restart the survey line once the navigation system came back online. This occurred on the 4th July 2009 at 1340 and the turn was completed in about ten minutes thereby minimising the lost survey time.

For details on the calibration and quality assurance and quality control procedures for the USBL system onboard the vessel see Appendix 5 section 10.

A working example of quality control during this survey was when the USBL for the drop frame camera system went offline. This was observed during routine quality control observations of positional systems as detailed in Appendix 5 sections 3 and 4. The problem was shown to be related to vessel noise, with failure in the USBL occurring when vessel noise rose above 90dB. The transponder and receiver on the camera frame were repositioned to improve signal to noise ratio and therefore minimise USBL failure.

6.2 Multibeam Echosounder

For details on sensor offsets, Kongsberg SIS offsets and survey quality assurance and quality control procedures for multibeam echosounder acquisition see Appendix 5 section 2. For details on the multibeam calibration see Appendix 5 section 5. For details on the total propagated uncertainty and survey quality assurance and quality control procedures see Appendix 5 section 6. For details on the positional repeatability of soundings on the sea bed and survey quality assurance and quality control procedures see Appendix 5 section 7.

During the course of this cruise 215km of MBES collected on Anton Dohrn Seamount. As a quality control check, data acquired during the 2005 SEA7 survey was compared with data acquired during this survey (Figure 50).

Some multibeam was collected on an initial traverse between the south-eastern and north-western parts of Anton Dohrn. It was collected over a shallow escarpment noted south of the seamount centre. However, the quality of the raw data appeared poor and it was discovered that a filter used in collecting multibeam in deepwater had not been removed for surveying in less than 800m water depth. This meant the multibeam system had difficulty in locking on to the sea bed and hence recorded spurious data.

The quality of the multibeam echosounder data was maintained with regular updating of the water column profile with SVP data (Table 4). These were obtained by using a Valeport SVX2. These data were supplemented when the Remotely Operated Towed Vehicle (ROTV) Focus II was deployed by data collected from the Valeport Mini SVS that was mounted on the Focus II.

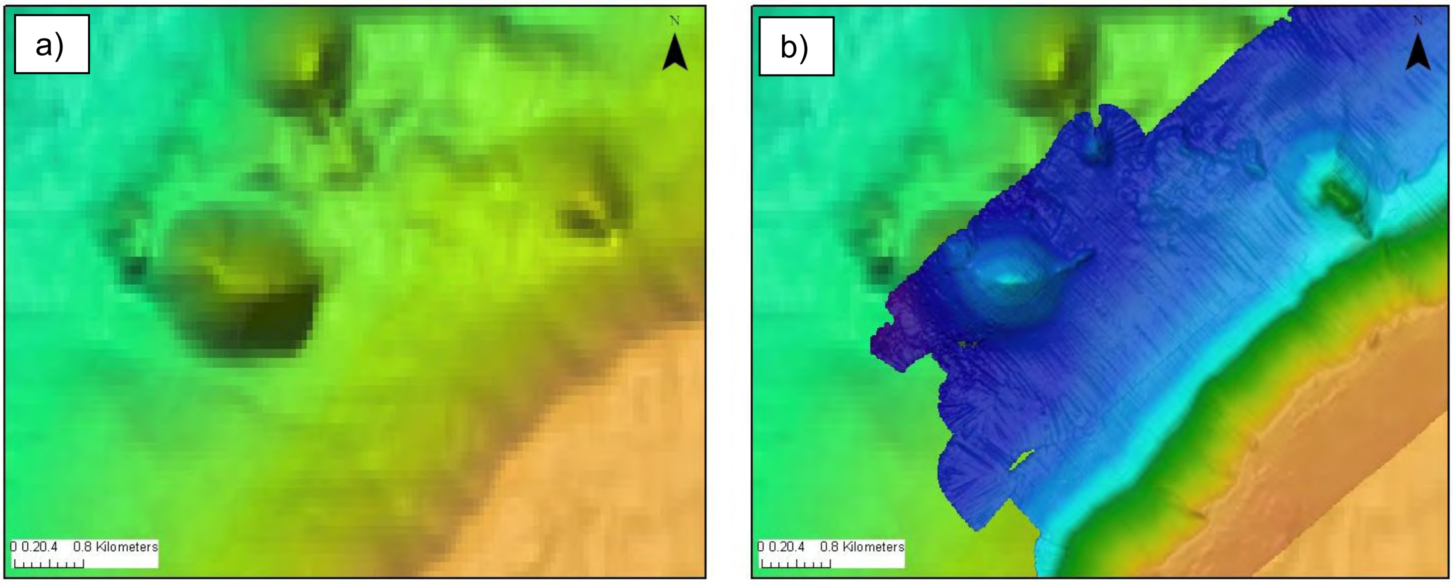


Figure 50 a) Multibeam echosounder data acquired during the 2005 SEA7 survey over the north-western sector of Anton Dohrn Seamount. b) Multibeam echosounder data acquired during this cruise over the same area.

Table 4 Position and time of SVP profiles gathered during the course of this cruise.

SVP	Area	Easting	Northing	Date	Time
1	ADSE	391101	635301	2009:07:03	15:29
2	ADSE	390500	635322	2009:07:03	15:51
3	ADNW	374824	638794	2009:07:14	02:11
4	ER	276630	637842	2009:07:15	07:30
5	ER	261920	6386581	2009:07:17	01:25
6	ER	262256	6388537	2009:07:16	15:06
7	ER	262870	642419	2009:07:16	09:09
8	ER	249715	634417	2009:07:16	06:03
9	ER	228616	630769	2009:07:18	11:55

6.3 Sidescan Sonar

ROTV FOCUS II

For details on the positioning verification and quality assurance and quality control procedures for data acquisition using the EdgeTech 2200-MP sidescan sonar see Appendix 5 section 8. For details on the calibration and adjustment of the integrated EdgeTech sub-bottom profiler see Appendix 5 section 9.

6.4 Sea-bed Camera and Video Data

Each transect was planned to be at least 500m in length, although there were a few exceptions to this (for example if the terrain or currents became too difficult to control the camera during the tow). For the majority of tows, vessel speed was approximately 0.5 knots, with most tows lasting around 1.5 hrs. The drop frame was towed in the water column 1-3m from the sea bed (dependant on substrate type, slope angle and currents). A total of 27 camera transects were acquired during the course of this cruise to ‗ground truth' the multibeam echosounder and sidescan sonar data. These transects represent a range of geomorphological features, substrates, water depth ranges and also include a number of replicate transects. It is only through rigorous sampling such as this that we can determine what is *normal* as well as *exceptional*.

At the beginning of each tow, starting from when the sea floor became visible, the camera was allowed to stabilise before starting the tow. Images were taken approximately every minute for statistical rigour, with the images not only acting as a quadrat but also to aid in species identification, habitat boundary mapping, substrate identification and were also acquired over interesting features such as sediment bedforms and anthropogenic debris. Where the substratum was extremely rocky, uneven, delicate (for example areas of coral, sea fans and sponges), or descending a cliff face; the camera was not landed and images were taken at an elevation off the sea bed.

The fields of view of both the stills and video cameras were calibrated using a gridded quadrat of known dimensions. Calibrations were made for ‗on bottom' (drop frame fully landed on the sea bed; Figure 51) and at 1m, 2m and 3m elevation off the sea bed. Evaluation during the calibration trials identified optimum settings for focal length and filters to produce sea-bed images of a higher quality than had been obtained with similar equipment in 2006 and 2007.

Figure 51 Calibration image (0m) for the video and stills camera with an example image AD_DC_012.jpg. The grid size is 4.9cm (vertical in figure) by 5.5cm (horizontal in figure).

7. Health and Safety Events

Risk assessments, emergency response plan and health and safety documentation for operations during the course of this cruise were written by MMT AB prior to operations being undertaken. All scientific personnel were given access to this documentation for reference and a full health and safety briefing including a tour of the vessel for non-MMT AB personnel was held by the ship's safety officer on 2nd July 2009. Additional health and safety guidance notes were included in the survey plan document and circulated to all scientific personnel ahead of operations.

Safety drills involving a muster of all personnel aboard the *M/V Franklin* were carried out on the 2nd, 24th and 27th July 2009. A meeting of the *M/V Franklin* safety committee took place on the 17th July 2009.

During the course of this cruise there were no health and safety incidents or need for first aid or medical treatment.

Appendix 1 – Equipment Used

1.1 Vessel

Name:	M/V Franklin	Port of Registry:	Gothenburg, Sweden
Length:	55.6m	Beam:	12m
Draft (max):	4.2m	Required Water Depth:	6m
Gross Tonnes:	1178	Net Tonnes:	353
Owner:	Shipriders AB		

See Table 5 for offsets onboard the *M/V Franklin*. Please note that a USBL was used for positioning of all towed equipment (Seatronics drop frame camera system and deep-tow sidescan sonar) and not layback, therefore offsets to tow points for these equipment have not been included in this report. See Appendix 5 section 10 for details on the USBL system used during the course of this survey.

See Appendix 5 section 2 for full details of all sensor offsets.

Table 5 Sensor antennas and reference points used during calibration, and POS/MV Offsets.

Fixpoints	X (m)	Y (m)	Z (m)
Antenna PosMV 1	2.387	-1.564	-20.246
Antenna PosMV 2	2.411	1.944	-20.249
Antenna Fugro Starpack	2.407	1.547	-20.262
Point 311 SB Bollard	3.644	18.034	7.011
CG of Vessel	0.000	0.000	0.000
From Reference Point To:	**X (m)**	**Y (m)**	**Z (m)**
Reference Point	0.000	0.000	0.000
IMU	0.000	0.000	-0.168
Primary Pos/MV Antenna	2.387	-1.564	-20.246
Sensor 1 (MBES Reference)	0.000	0.000	0.000

1.2 Navigation

Primary Positioning System	Applanix Pos/MV 320 with RTG corrections from CNAV
Secondary Positioning System	Fugro HP Starpack with XP and HP corrections
Gyro/Motion Sensor	Applanix POS/MV 320
Sound Velocity Probe	Valeport SVX2

See Appendix 5 sections 3 and 4 for details on navigation and heading systems onboard the vessel.

1.3 Multibeam Echosounder – Kongsberg EM710

The *M/V* Franklin is fitted with a Kongsberg EM710 multibeam echosounder system designed for high-resolution sea-bed mapping in water depths of up to 2000m. The operating frequency range for the system is 70-100 kHz. Details on the calibration and quality control of the multibeam echosounder system can be found in Appendix 5 and Chapter 6 of this report.

The multibeam echosounder data acquired during this survey was processed during the cruise by MMT AB staff with remaining processing being carried out post-cruise in advance of final data delivery on the 31st August 2009. Overall, good quality data were obtained and are a significant improvement on the existing multibeam echosounder data acquired during surveys in 2005.

1.4 EdgeTech 2400-DSS Integrated Sidescan Sonar and Sub-Bottom Profiler

No lines of sidescan sonar data were acquired using the EdgeTech 2400-DSS integrated sidescan sonar and sub-bottom profiler.

1.5 MacArtney FOCUS II Remotely Operated Towed Vehicle (ROTV) with Integrated Sidescan Sonar and Sub-Bottom Profiler

MMT AB's ROTV was offered as an alternative to the EdgeTech 2400-DSS sidescan sonar for use in shallow water (<300m). This piece of equipment provided a steerable vehicle with both sidescan sonar and CHIRP sensors. The ROTV is fitted with an altimeter to help ensure that the equipment maintains an even height above the seafloor. The FOCUS II uses fibre optic telemetry for vehicle and sensor communication providing high data capacity.

The system comprised the towed platform together with a user selected instrumentation package; an electro-optic tow cable and a winch with a combined fibre optic & electrical slip ring and a user friendly control and display unit with input and output for user selected sensors and instruments.

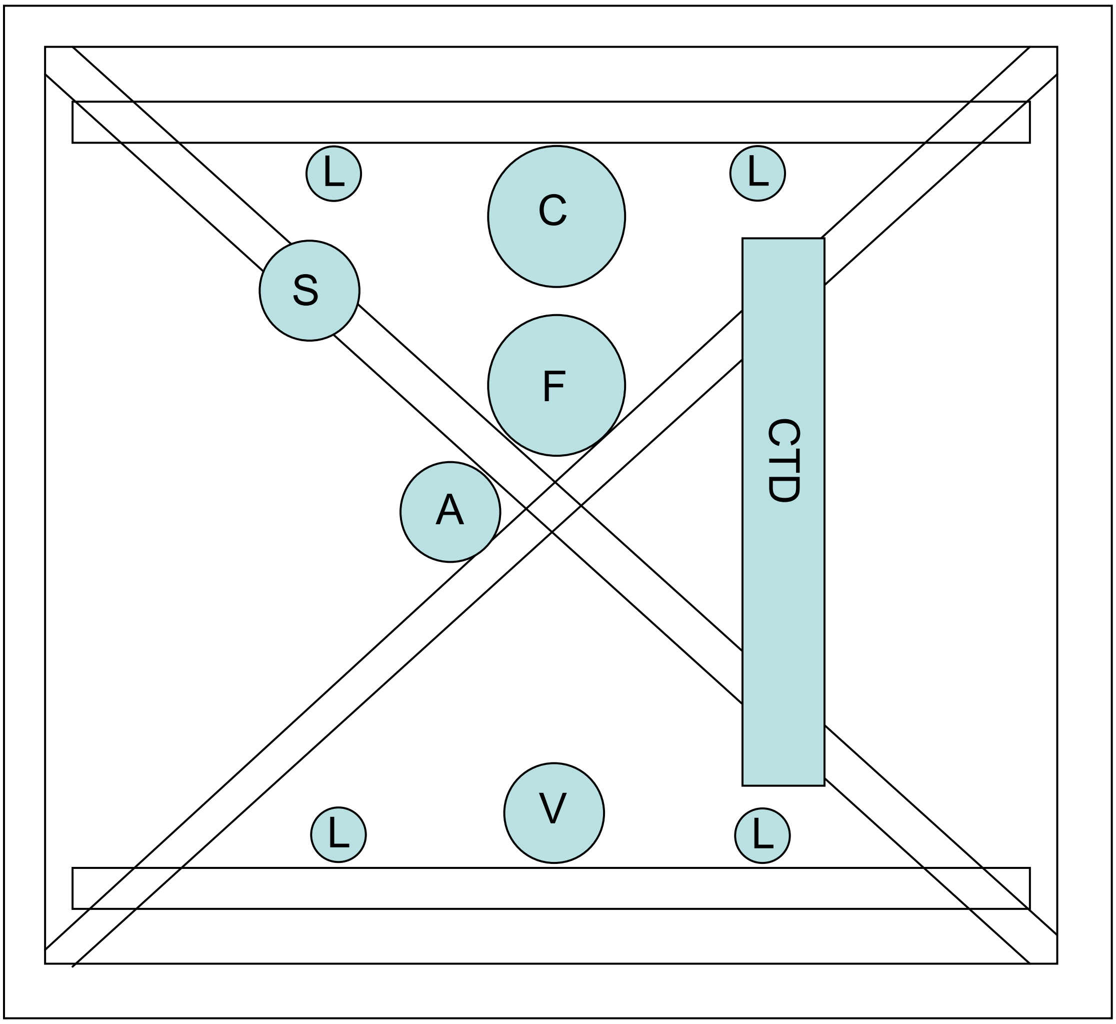
The system was operated to 400 metres water depth at 5 knots with a layback of up to 1 kilometre. The vehicle was deployed from the A-frame at the stern of the ship using its own dedicated winch.

Processed data will be provided by MMT AB.

1.6 Seatronics Drop Frame Camera

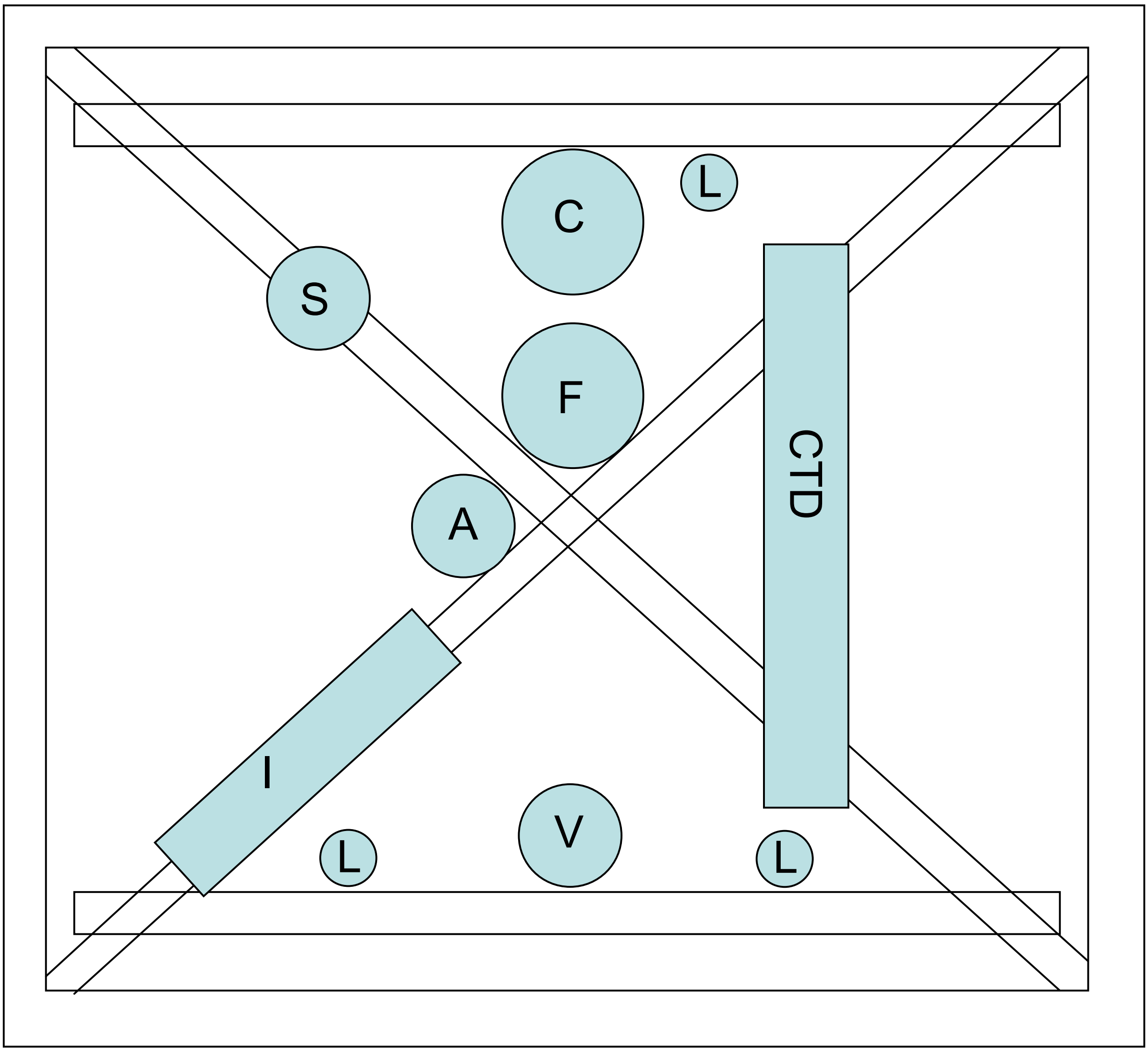
The Seatronics drop frame camera system was designed to replicate what was used on the 2006 SEA7 and the 2007 Canyons surveys for the DTI and JNCC to maximise comparative data analysis. It was deployed from the starboard side of the vessel. The system comprised a 5 megapixel Kongsberg and Imenco digital 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, and a USBL beacon provided accurate position data for the equipment during data acquisition. The drop frame camera system included four Mk2 SeaLED lamps which produce a typical 1067lux at 1m. These were mounted obliquely, similar to the video and stills cameras, to maximise the illumination of the areas of sea bed covered by the video and stills cameras and to aid in biological species identification.

For a plan of camera frame see Figure 52. When two lights had failed on the first camera drop, the remaining three lights were arranged with two adjacent to the video camera and a single light located to the left of the stills camera as in Figure 53. After further repairs and component testing by Seatronics the final configuration of the drop frame camera, used from the 20-28 July 2009 was as detailed in Figure 52.



A **Kongsberg MS1007 Precision Altimeter**
C **Konsberg Simrad OE14-208 Digital Stills Camera**
CTD **Valeport Midas CTD Probe**
L **24Vdc Seatronics MKII LED Subsea Lamps**
S **Seatronics Attitude Sensor**
V **Kongsberg 14-366 Colour Video Camera**

Figure 52 Schematic drawing of the configuration of the drop frame camera system at the beginning of the survey prior to the failure of 2 LED lights.



A Kongsberg MS1007 Precision Altimeter
C Konsberg Simrad OE14-208 Digital Stills Camera
CTD Valeport Midas CTD Probe
I Ixsea Transponder
L 24Vdc Seatronics MKII LED Subsea Lamps
S Seatronics Attitude Sensor
V Kongsberg 14-366 Colour Video Camera

Figure 53 Schematic drawing of the configuration of the drop frame camera system to compensate for the failure of 2 LED lights.

1.7 SAHFOS Plankton Sampling

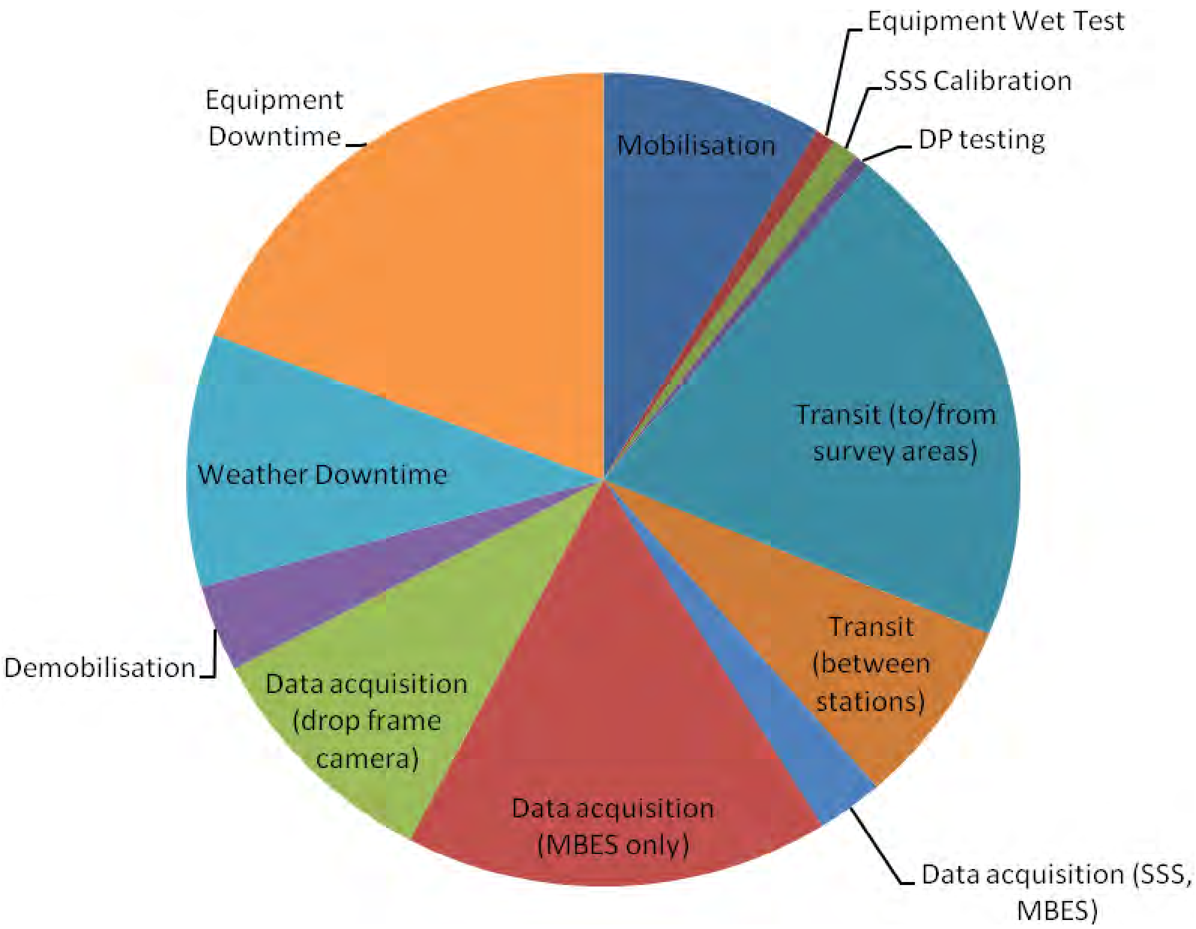
Although not part of the objectives for this cruise, plankton sampling was undertaken on behalf of SAHFOS at one site on East Rockall Bank on the 24th July 2009. A plankton net supplied by SAHFOS was used for sampling with the recovered samples stored in 4% formalin and 70% alcohol. The samples will be processed by Marianne Wooton and Claudia Castellani at Sir Alistair Hardy Foundation for Ocean Science.

Appendix 2 – Daily Logs

Daily Progress Reports were produced by the offshore survey team and signed off by the Offshore Manager, Scientist in Charge and Client Representative. Copies of the logs (from 1st July – 29th July 2009) have been removed to reduce document size, and are available from JNCC on request to OffshoreSurvey@JNCC.gov.uk.

Appendix 3 – Breakdown of Survey Time

Task	Approximate Number of Hours
Mobilisation	59.33
Calibration	16.50
Transit (to/from survey area)	140.33
Transit (between stations)	51.50
Survey	250.25
Demobilisation	23.92
Weather Downtime (whole survey or individual pieces of equipment)	69.67
Vessel/Equipment Downtime	133.01



Appendix 4 – Survey Metadata

A full database with completed survey metadata was provided along with this cruise report, and is available from JNCC on request to OffshoreSurvey@JNCC.gov.uk

4.1 Sidescan Sonar Line Summary Log Sheets

Line Number	Direction (º)	Start		Start		End		Length (km)	Total (km)	Comments
		Date	Time	Easting	Northing	Easting	Northing			
0_JNCC_FRANKLIN_2009_ER_C1_SS_001	67	15072009	19:25	598655	6342247	600712	6348842	6.929	6.929	
1_JNCC_FRANKLIN_2009_ER_C1_SS_001	67	15072009	20:11	600713	6348846	602875	6355541	7.059	13.988	
2_JNCC_FRANKLIN_2009_ER_C1_SS_001	66	15072009	20:57	602876	6355545	605053	6362154	6.987	20.975	
3_JNCC_FRANKLIN_2009_ER_C1_SS_001	66	15072009	21:43	605054	6362158	607218	6368839	7.079	28.054	
4_JNCC_FRANKLIN_2009_ER_C1_SS_001	68	15072009	22:28	607223	6368847	607262	6368982	0.142	28.196	Short
5_JNCC_FRANKLIN_2009_ER_C1_SS_001	65	15072009	22:30	607263	6368988	607468	6369565	0.616	28.812	Short
6_JNCC_FRANKLIN_2009_ER_C1_SS_001	66	15072009	22:48	608198	6371732	609773	6376508	5.073	33.885	
13_JNCC_FRANKLIN_2009_ER_C1_SS_001	254	17072009	12:32	622243	6386697	621642	6367246	20.131	54.016	Less data due to rapid increase of deepths in beginning of line.
14_JNCC_FRANKLIN_2009_ER_C1_SS_001	240	17072009	14:28	621641	6367232	616262	6348909	20.601	74.617	Positioning jump between 621326,6364179 - 621242,6363420. And steep sea bed from 619496, 6356446 to end

										of line.
15_JNCC_FRANKLIN_2009_ER_C1_SS_001	232	17072009	16:23	616261	6348907	606557	6332222	19.943	94.56	Less data due to steep sea bed in beginning of line.
7_JNCC_FRANKLIN_2009_ER_C2_SS_001	230	17072009	07:26	606555	6432256	616593	6421219	15.568	110.128	
8_JNCC_FRANKLIN_2009_ER_C2_SS_005	-	-	-	-	-	-	-	-	-	Lost when surveying
9_JNCC_FRANKLIN_2009_ER_C2_SS_005	-	-	-	-	-	-	-	-	-	Lost when surveying
10_JNCC_FRANKLIN_2009_ER_C2_SS_005	246	17072009	09:59	620292	6411466	622123	6401580	10.949	121.077	Less data due to steep sea bed and rapid increase of deepths at places.
11_JNCC_FRANKLIN_2009_ER_C2_SS_005	242	17072009	11:06	622156	6400636	622072	6393675	7.831	128.908	Less data due to steep sea bed and rapid increase of deepths at places.
12_JNCC_FRANKLIN_2009_ER_C2_SS_005	250	17072009	12:02	622193	6391495	622315	6387957	3.753	132.661	Less data due to rapid increase of deepths in end of line.
16_JNCC_FRANKLIN_2009_ER_S_SS_010	228	17072009	18:19	606555	6332219	601539	6325388	8.607	141.268	Less data due to steep sea bed in beginning of line.
17_JNCC_FRANKLIN_2009_ER_S_SS_010	219	17072009	19:15	600906	6324471	594579	6318113	9.227	150.495	Positioning lost at 597348,6321066 and back again at 595770,6319574.
18_JNCC_FRANKLIN_2009_ER_S_SS_010	229	17072009	20:16	593843	6317192	585369	6305180	14.937	165.432	Less data due to steep sea bed at 590533,6313024 - 590156,6312431.
19_JNCC_FRANKLIN_2009_ER_S_SS_010	216	17072009	21:43	585363	6305174	583285	6303259	2.943	168.375	

Appendix 5 – Calibration/Acceptance Report from MMT AB

Written by H. Strömberg (cruise Project Manager from MMT AB) and edited by E. Lindström (cruise Offshore Manager from MMT AB).

Document is 37 pages long – available from JNCC on request to OffshoreSurvey@JNCC.gov.uk

Glossary

Berm	Positive topographic feature often associated with the rear of a beach, or the edges of features such as iceberg ploughmarks.
BGS	British Geological Survey (www.bgs.ac.uk).
DTI	Department of Trade and Industry (now Department of Energy and Climate Change, DECC www.decc.gov.uk).
GEBCO	General Bathymetric Chart of the Oceans. The GEBCO dataset has been generated from quality controlled ship-depth soundings with interpolation between points using satellite-derived data where needed (www.gebco.net).
GPS	Global Positioning System.
JNCC	Joint Nature Conservation Committee (www.jncc.gov.uk).
MESH	Mapping European Seabed Habitats, EU-funded project (www.searchmesh.net).
MMT AB	Marin Mätteknik AB.
Plume	Localised, hot, buoyant material thought to be rising through the mantle possibly originating from near the Earth's core—mantle boundary.
SAHFOS	Sir Alister Hardy Foundation for Ocean Science, part of the Plymouth Marine Sciences Partnership (www.sahfos.ac.uk).
SEA7	Strategic Environmental Assessment area 7 (www.offshore-sea.org.uk).
SVP	Sound velocity profile.
USBL	Ultra Short Base Line.

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