University of Plymouth - Cruise Summary Report

DEEP LINKS PROJECT

RRS James Cook, Cruise No. JC136

14th May – 23rd June, Southampton (UK) – Southampton (UK)

Principal Scientists
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2016

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TITLE
RRS James Cook, Cruise No. JC136, 14th May – 23rd June, DEEPLINKS: Influence of population connectivity on depth-dependent diversity of deep-sea marine benthic biota.

REFERENCE
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ABSTRACT

Cruise JC136 is associated with a NERC joint standard research grant (NE/K011855/1 and NE/K013513/1) entitled "Influence of population connectivity on depth-dependent diversity of deep-sea marine benthic biota". The aims of this project are to investigate connectivity among deep-sea populations at different depths and spatial scales using: 1) larval dispersal modelling using Lagrangian particle tracking, driven by hydrographic models, 2) population genetics/genomics, and 3) benthic community analysis. The aims of cruise JC136 were then to sample a range of sites and depth bands to:

1. obtain physical samples of 4 model organisms for molecular analysis,
2. gather benthic biological survey data for community level analysis,
3. collect oceanographic data to validate high resolution oceanographic models with which we will model larval dispersal.

We visited 5 sites in the NE Atlantic (Rockall Bank, George Bligh Bank, Anton Dohrn Seamount, Wyville-Thomson Ridge, and Rosemary Bank) undertaking 27 ROV dives, 12 AUV missions, 43 CTD casts, 2 mooring deployments and equipment trials. All cruise aims were broadly met. We obtained 3630 biological samples, including sufficient depth and site coverage for molecular analysis of 3 target species. We obtained video transect data with sufficient replication and depth stratification from 3 sites and near complete sampling from a 4th. We obtained sufficient oceanographic data to validate our models. In addition, we gathered 5811.66 km^2 of seafloor multibeam to contribute to ongoing efforts to map the North Atlantic, including the first multibeam from the Geike Slide and Hebridean Slope Nature Conservation Marine Protected Area (NCMPA). Poor visitbility at the seabed prevented a planned resurvey of the Darwin Mounds Marine Protected Area (MPA) (see JC60).

KEYWORDS
Connectivity, Autosub6000, AUV, ROV, Rockall Bank, George Bligh Bank, Anton Dohrn Seamount, Wyville-Thomson Ridge, Rosemary Bank.

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A pdf of this report is available for download at: www.deepseacru.org

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1 Participants

1.1 Scientific personnel – leg 1

No.	Name	Role	Affiliation
1	Kerry Howell	Principle scientist	Plymouth University
2	Amber Cobley	Scientist	Southampton University
3	Joshua Davison	Scientist	Plymouth University
4	Grace English	Scientist	National University of Ireland, Galway
5	Samuel Faithfull	Scientist	British Geological Survey
6	Chloe Game	Scientist	Plymouth University
7	Neil Golding	Scientist	Joint Nature Conservation Committee
8	Kerstin Kröger	Scientist	Joint Nature Conservation Committee
9	Alex Nimmo Smith	Scientist	Plymouth University
10	Nils Piechaud	Scientist	Plymouth University
11	Manuela Ramos	Scientist	IMAR/DOP (Azores)
12	Alex Rogers	Scientist	Oxford University
13	Nicolai Roterman	Scientist	Oxford University
14	Marcus Shirley	Scientist	Plymouth University
15	Michelle Taylor	Scientist	Oxford University
16	Richard Ticehurst	Scientist	Plymouth University
17	Gareth Knight	SST	NERC National Marine Facilities
18	Lisa Symes	SST	NERC National Marine Facilities
19	Allan Davies	Tech	NERC MARS
20	David Edge	Tech	NERC MARS
21	Howard King	Tech	NERC National Marine Facilities
22	Russell Locke	Tech	NERC MARS
23	Rachel Marlow	Tech	NERC MARS
24	Antonio Campos	Tech	NERC MARS
25	David Paxton	Tech	NERC MARS
26	James Perrett	Tech	NERC MARS
27	David Turner	STO	NERC MARS
28	Josue Rivero	Tech	NERC MARS
29	Andrew Webb	Tech	NERC MARS
30	John Wynar	Tech	NERC MARS

1.2 Scientific personnel – leg 2

No.	Name	Role	Affiliation
1	Michelle Taylor	Principle scientist	Oxford University
2	Peter Spooner	Scientist	-
3	Stacey DeAmicis	Scientist	Plymouth University
4	Grace English	Scientist	National University of Ireland, Galway
5	Kirstin Crombie	Scientist	British Geological Survey
6	Nataliya Stashchuk	Scientist	Plymouth University
7	Laura Robson	Scientist	Joint Nature Conservation Committee
8	Karen Webb	Scientist	Joint Nature Conservation Committee
9	Vasiliy Vlasenko	Scientist	Plymouth University
10	Nils Piechaud	Scientist	Plymouth University
11	Rebecca Ross	Scientist	Plymouth University
12	Nina Faure Beaulieu	Scientist	Oxford University
13	Nicolai Roterman	Scientist	Oxford University
14	Otis Brunner	Scientist	Plymouth University
15	Virginia Russell	Scientist	Southampton University
16	Gareth Knight	SST	NERC National Marine Facilities
17	Lisa Symes	SST	NERC National Marine Facilities
18	Allan Davies	Tech	NERC MARS
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21	Russell Locke	Tech	NERC MARS
22	Rachel Marlow	Tech	NERC MARS
23	Antonio Campos	Tech	NERC MARS
24	David Paxton	Tech	NERC MARS
25	James Perrett	Tech	NERC MARS
26	David Turner	STO	NERC MARS
27	Josue Rivero	Tech	NERC MARS
28	Andrew Webb	Tech	NERC MARS
29	John Wynar	Tech	NERC MARS

1.3 Ship's personnel – both legs

Name	Role
John Leask	Master
Philip Gauld	C/O
Malcolm Graves	2/0
Sean Hoxby	3/O
Stuart Campbell	C/E
Michael Murray	2/E
Lawrence Porrelli	3/E
Gavin Nicholson	3/E
Sebastian Ulbricht	ETO
Vivian Wythe	D/E
Paul Lucas	PCO
Martin Harrison	CPOS
Philip Allison	CPOD
David Price	POD
Philip Hansen	ERPO
Stephen Day	SG1a
Barry Edwards	SG1a
Brian Burton	SG1a
Andrew Dwyer	SG1a
Darren Caines	H/Chef
Christopher Keighley	Chef
Carl Piper	Stwd
Clementina Mantinha	A/Stwd

2 Summary

Port of mobilisation: Southampton, UK

Departure: Southampton, 13th May 2016

Half landing: Stornoway, 3rd June 2016

Return: Southampton, 23rd June 2016

Number of days: 40

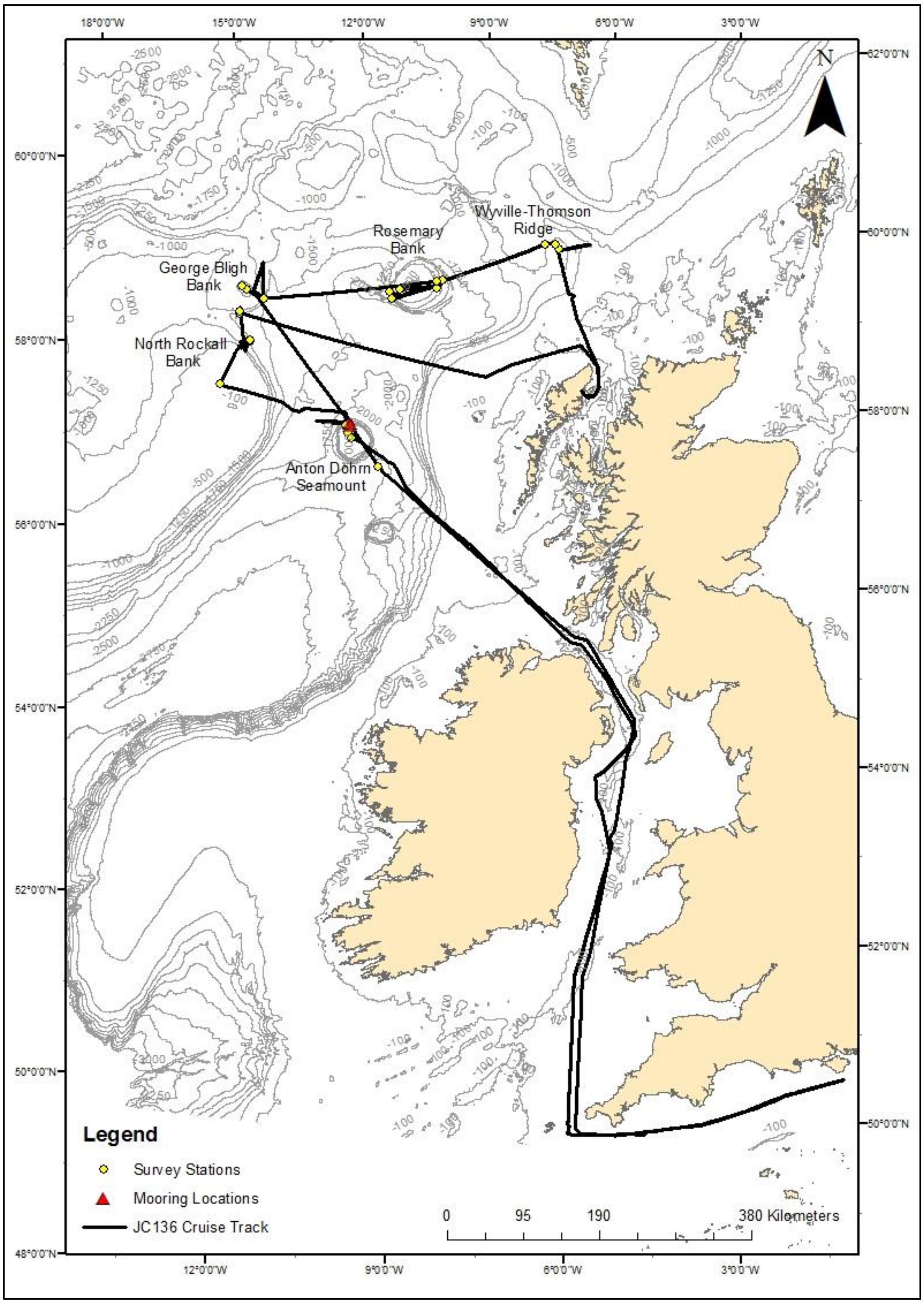

Figure 2.1: Working area and track chart of RRS James Cook, Cruise JC136. Bathymetry from GEBCO.

3 Research Programme/Objectives

Many marine organisms have a pelagic larval dispersal phase that results in a flow of individuals among sites, maintains genetic diversity, and expands the species' range (Graham et al. 2008; Palumbi 2003; Treml et al. 2008). Over evolutionary timescales, larval dispersal in ocean currents has influenced the global distribution of many taxa (Heck & McCoy 1978) and impediments to dispersal may have contributed to the mechanisms of diversification that have led to the emergence of new species (Ellingsen et al. 2005; Taylor & Hellberg 2006). On ecological timescales, connectivity is a vital demographic process underpinning the persistence and productivity of populations (Hughes & Tanner 2000). Patterns of larval connectivity define the size of metapopulations and guide the appropriate scale at which populations should be managed (Kritzer & Sale 2004). Understanding connectivity is, thus, critical to our understanding and effective management of marine systems.

The deep sea represents the largest ecosystem on earth and 90% of the marine realm. Thus, understanding these processes here will contribute significantly to our growing knowledge in this area. The bathyal region has been identified as the primary site of adaptive radiation in the deep sea from molecular and morphological studies (Etter et al. 2005) and is also where the peak in species diversity occurs in many ocean basins (Rex, 1981, 1983; Howell et al., 2002; Stewart and Rex, 2009). Gene flow is low over the depth gradient (Etter et al. 1999; Howell et al., 2004), suggesting either limited larval exchange or poor survival of larvae outside natal depths. Recent research has suggested that larval dispersal potential may vary with depth (Howell et al. in prep). This variation in larval dispersal potential coupled with the limited vertical exchange may provide a mechanism for population isolation, divergence and speciation in the bathyal region.

This study aims to investigate connectivity among deep-sea populations using three complementary methods: 1) larval dispersal modelling using Lagrangian particle tracking driven by hydrographic models 2) population genetics and 3) benthic community analysis. The study will test the following hypotheses:

H1: Population connectivity varies with depth and is lowest at bathyal depths, corresponding to recorded peaks in diversity.

H2: The decrease in connectivity from the shelf break to bathyal depths is correlated to current flow, as predicted by hydrodynamic models.

H3: Hydrodynamic model predictions are borne out by empirical genetic data and community level data, and can therefore be used as tools for management and spatial planning within the region.

The aims of this research cruise are to sample a range of sites and depth bands to:

1. obtain physical samples of 4 model organisms for molecular analysis,
2. gather benthic biological survey data for community level analysis,
3. collect oceanographic data to validate high resolution oceanographic models with which we will model larval dispersal.

This survey also represents an important opportunity for JNCC (Joint Nature Conservation Committee) to improve the evidence base for existing Marine Protected Areas (MPAs) within the UK deep-sea region and to support development of an ecologically coherent network of MPAs as required under the Marine and Coastal Access Act 2009, the Marine (Scotland) Act, 2010, the OSPAR Convention for the NE Atlantic, and the Convention on Biological Diversity.

MPAs have been designated within deep-waters to the west of Scotland through the Marine (Scotland) Act, 2010 (Nature Conservation MPAs) and the Habitats Directive (Special Areas of Conservation (SACs)). However, understanding the habitat types and species occurring within these MPAs has been limited to data collected from a small number of research surveys and literature searches due to the high costs of deep-sea research. An additional objective of the survey is therefore to gather high-resolution seabed imagery to improve the evidence-base for existing MPAs, particularly Rosemary Bank Seamount NCMPA and Anton Dohrn Seamount candidate Special Area of Conservation/Site of Community Importance (cSAC/SCI), where data are more limited. Additionally, increased data on the location of protected vulnerable marine ecosystems within deep-sea MPAs can support the development of management measures.

A final objective is to build JNCC’s understanding of the connectivity of the current deep-sea MPA network. Understanding connectivity between MPAs, and the interactions with neighbouring habitats, is an important consideration when developing an ecologically coherent MPA network. This survey will undertake important research looking at deep-sea population genetics for a number of species (including habitat forming cold-water coral), providing an insight into larval dispersal/transport and the connectivity of these dispersed species/habitats across a suite of MPAs. The results of this research will be crucial in allowing JNCC staff to develop their knowledge of how deep-sea communities are connected, as well as helping us understand the effectiveness of the MPA network.

4 Narrative of the Cruise

All times reported are GMT (UTC, -1 hr BST), the vessel operated in BST.

14th May 2016

Science party were inducted at 07:00 followed by a safety briefing, vessel departed Southampton Docks at 08:00. A safety drill was conducted at 15:15. Vessel on route to Anton Dohrn Seamount. All science and technical staff attended a science meeting at 18:00. V-Sat system failed.

15th May 2016

Vessel continued on route to Anton Dohrn Seamount. Masters daily meeting held at 07:30. V-Sat system still down.

16th May 2016

Vessel continued on route to Anton Dohrn Seamount. Masters daily meeting held at 07:30. V-Sat system still down.

17th May 2016

Arrived on station at Anton Dohrn Seamount at 05:00. Deployed the CTD at 05:05 to a depth of 2200 m (STN_001). CTD recovered to the deck at 07:06. ROV tether streamed to remove twists prior to commencing dive programme. Tether and weight recovered to the deck at 10:14. Transit to shallow water mooring deployment site (~800 m). Ship board multibeam acquired on route logging pelagic data. Arrived on station at 14:38, mooring deployed at 14:47 (STN_002). Transit to deep-water mooring deployment site (~1200 m).Arrived on station at 15:22, mooring deployed at 15:28 (STN_003). Transit to first ROV dive site, ROV deployed at 16:22 (STN_004, D269), arrived at the seabed at 18:00. ROV dive overnight collecting samples for population genetics and running seafloor transects for diversity analyses.

18th May 2016

ROV dive terminated at 08:00 and recovery began. During recovery, ROV lost all comms and was recovered to the deck dead at 09:10. Vessel transited to first Autosub6000 dive site on seamount summit and a CTD was deployed at 10:25 to obtain SVP for Autosub6000. CTD recovered to deck (STN_005) and Autosub6000 deployed at 12:26 (M113). 13:24 Autosub developed a fault and returned to the surface. Sub recovered to the deck at 14:33. Both Autosub6000 and Isis ROV had faults and could not be deployed. Weather worsened beyond a level for safe deployment of the vehicles therefore a CTD location was chosen based on oceanographer requirements and the vessel moved to STN_006. CTD deployed at 15:30 and recovered to deck at 16:30. Isis fault could not be found, Autosub fault under investigation, weather still too poor for Isis deployment therefore a further CTD location was selected. Vessel transited to STN_007 and CTD deployed at 19:00. Recovered to deck at 20:30. Vessel moved to deep mooring site (SNT_003) and ‘pinged’ the mooring. Communication was successful, however, the port USBL pole became stuck and could not be retrieved. Vessel remained in position overnight.

19th May 2016

USBL pole recovered. Weather remained too poor for vehicle deployment. CTD deployed at 08:10 (STN_008). CTD yoyo-ed on station throughout the day to a maximum depth of approximately 1200 m, retrieving to approximately 100 m below surface each time. At 20:40, CTD yoyo operation ceased and the CTD was recovered to deck. The weather was still too poor to allow an ROV deployment, Autosub6000 fault still under investigation.

20th May 2016

Still waiting on weather to enable ROV deployment. The CTD was deployed at 08:39 to a depth of 1200 m and successfully recovered (STN_009). Weather was improving by the hour and reassessed throughout the day with respect to deploying the ROV. ROV finally deployed at 18:17 to a depth of approximately 800 m at the Franklin Coral Mounds on Anton Dohrn Seamount (DIVE 270, SNT_010).

21st May 2016

ROV Dive 270 continued until 14:35 and the ROV was recovered to the ship at 15:26. A great deal of biological material was collected from a very successful dive. The ship repositioned to the 1200 m sample site on Anton Dohrn Seamount and the ROV redeployed at 18:04 (DIVE 271, STN_11).

22nd May 2016

ROV Dive 271 continued throughout the day. The ROV was recovered to the vessel at 17:31 after a successful dive collecting biological material. The vessel moved to the 500 m sample site on Anton Dohrn Seamount and the ROV was redeployed at 20:42 to a depth of approximately 600 m (DIVE 272, STN_012).

23rd May 2016

ROV Dive 272 (STN_012) continued throughout the day. The ROV was recovered to deck at 14:51 following a successful dive to the 500 m box. The CTD was deployed at 16:10 to a depth of ~500 m (STN_014). The vessel repositioned to the 2000 m box and the ROV was redeployed at 19:24 (DIVE 273, STN_013, NOTE: the CTD and ROV Dive 273 are numbered out of sequence due to a station numbering error)

24th May 2016

Continuation of Anton Dohrn ROV Dive 273 (STN_013). ROV was recovered to the deck at 07:09, completing work at the Anton Dohrn Seamount. The vessel then set course for Rockall Bank at a speed of 8 nm/hr (knots) to obtain good multibeam swath data from an area of the Rockall Trough and Bank lacking in multibeam coverage in an effort to aid the Atlantic Mapping Initiative, coordinated by BGS. Vessel arrived on station at Rockall Bank at 18:48 and the CTD was immediately deployed to a depth of ~180 m (STN_015). The CTD was recovered at 19:16 and the ROV was deployed at 19:46 to a depth of ~180 m (DIVE 274, STN_016)

25th May 2016

ROV recovered to deck at 11:33 after another successful dive collecting biological material and running transects for diversity analysis. The vessel then moved to the 200 m box on Rockall for deployment of Autosub6000 multibeam and oceanographic survey. Upon arrival at the 200 m box at ~14:30 a Norwegian long liner was found to be operating in the area with approximately 24 miles of line deployed in the vicinity of planned AUV operations. Therefore, the vessel repositioned to the 1200 m box as an alternative site for operations. The AUV was deployed at 15:48 (M114, STN_017). The AUV was tracked for a period of 4 hrs, before the vessel repositioned to the 800 m box and the ROV was deployed at 21:15 (DIVE 275, STN_018)

26th May 2016

The ROV was recovered to the deck at 13:08 after another successful dive. The vessel moved to position to recover the AUV. Autosub6000 was recovered at 15:50. Upon recovery, it was discovered the multibeam had failed shortly after tracking of the AUV was completed, and thus little useful data were acquired. All oceanographic sensors had continued to operate in addition to the side scan sonar and sub bottom profiler, therefore, some potentially useful oceanographic data were collected. The CTD was deployed at 16:05 (Cast 23 STN_019) and recovered to deck. The ship then repositioned to the start of the first 1200 m transect and the ROV was deployed at 18:20 (DIVE 276, STN_020).

27th May 2016

ROV was recovered to the deck at 12:34 and a CTD cast undertaken to a depth of ~1200 m (Cast 24, STN_021). The ship repositioned and the AUV was deployed at 15:20 to undertake a near bed camera and multibeam survey of the 1200 m box (M115, STN_022). Initial tracking of the AUV suggested that it would not descend below 10 m off bottom, most likely as a result of an error from the collision avoidance sensor and therefore would not collect the image data needed for the project. The ship repositioned to the 500 m box and the ROV was deployed at 19:40 (DIVE 277, STN_023).

28th May 2016

ROV operations continued overnight and the vehicle was recovered at 10:20. The vessel repositioned to the 1200 m box to recover the AUV. The AUV was recovered at 13:24. There were some problems in communication with the vehicle resulting in some delays to its recovery. Following recovery, the vessel repositioned to the 500 m box to deploy the Plymouth University towed camera system DS2 for its first field test. DS2 was deployed at 14:57 (STN_024) and recovered at 15:52 following a successful trial. The vessel then repositioned to the 800 m box and the ROV was deployed at 17:08 (DIVE 278, STN_025).

29th May 2016

ROV operations again continued overnight and the ROV was recovered at 12:43. The vessel repositioned to the 1200 m box to deploy the AUV for a repeat run of the planned photo-transect work. The AUV was deployed at 14:16 (M116, SNT_026), however, there was a problem with the acoustic comms at the ship end resulting in delays to the vehicle commencing its mission. Once the mission had commenced, the ship repositioned for an ROV deployment. The ROV was deployed at 17:25 to a depth of ~1000 m (DIVE 279, STN_027).

30th May 2016

The ROV was recovered at 11:16 and the ship repositioned to recover the AUV. The AUV was recovered at 13:33. The ship repositioned to deploy the ROV and the ROV was deployed at 18:09 (DIVE 280, STN_028).

31st May 2016

The ROV was recovered at 07:34 and the ship repositioned to George Bligh Bank (GBB) undertaking multibeam acquisition while underway. The vessel arrived on station at 12:18. The CTD was deployed at 12:30 (Cast 25, STN_029) and recovered successfully. The ROV was deployed at 15:09 to a depth of ~950 m on a suspected carbonate mound (DIVE 281, STN_030).

1st June 2016

The ROV was recovered at 07:26 and the vessel repositioned to deeper water. The ROV was redeployed at 09:41 for a short dive (DIVE 282, STN_031) and recovered at 15:45. A CTD was deployed 15:58 (Cast 26, STN_032). The vessel commenced multibeam swathing at 17:53 on route to the half landing in Stornoway.

2nd June 2016

Ship continued *enroute* to Stornoway at 8 knots, acquiring multibeam data while underway. The planned route allowed acquisition of a line of multibeam through the Geike Slide and Hebridean Slope NCMPA.

3rd June 2016

Vessel arrived alongside in Stornoway at 08:00. Vessel departs Stornoway at 19:00 heading to towards the Wyville-Thomson Ridge.

4th June 2016

Ship arrives on station at 08:00. Unsuccessful CTD attempt (Cast 27, STN_035) due to electrical problem and wire requires re-termination. AUV deployed at 09:20 (M117, STN_033) at 1200 m site. Vessel moved to 500 m site and ROV deployed at 14:40 (DIVE 283, STN_034). ROV arrived on the seabed at 580 m, i.e. too deep, and sampling lines are even deeper at 700 m. We assessed where the best location was to conduct the "500 m" species collections whilst undertaking first diversity video transect. However, strong tidal currents resulted in a temporary ascent to 200 m pushing the ROV to the northeast of transect 2. While at the seafloor, we were informed that moving northwest (where the sampling sites and transect 3 are located) was impossible. We therefore headed northeast (with the current) on transect 1. With no other option but to travel in this direction, we located a ridge to the northeast of the end of transect 1, hoping to collect samples there. Transect 1 was eventually possible, making just two transects for this dive. The remainder of time was spent searching for the thinly spread Scleractinian coral samples that were only present in small patches on rocks. Sediment cores were not possible as the floor was pebbly or rock, no sediment to note. A full collection of *Parastichopus* and *Cidaris* (feasting on fish heads and/ or in breeding clusters) was easily collected, and around half the required number of *Madrepora* and *Lophelia* was collected.

5th June 2016

ROV recovered at 06:00. Vessel returned to 1200 m AUV site for AUV retrieval at 09:15. Successful full water CTD to 1115 m (Cast 28, STN_037). ROV was deployed at 11:46 at the 1200 m site (DIVE284, STN_036). From tidal predications, we estimated the current to be running southwest and, thus, started the dive to the northeast corner. Zero visibility was encountered due to marine snow and the ROV dive was aborted. After discussions with oceanographers about the potential for the marine snow to be a short-term phenomenon, it was decided it was not, and was likely that this poor-visibility water was sloshing around the basin and unlikely to disperse. The decision was taken to move to the AUV site as there was valid concern that any photo survey at 4 m off bottom would also have zero visibility and we wanted to assess what depth the turbidity started at the AUV site. A CTD was undertaken at the 1000 m site (STN_038, Cast 29) to the northeast point of the AUV site that had been elongated from the 1200 m box towards the shallower area of the basin at the northwest. At the top of the AUV area multibeam, we could clearly see 3-5 m high mounds. The AUV could not be deployed over these areas and with the turbidity layer to the south, there was therefore just a thin band between 1040 m and 1100 m that could be photo surveyed. However, given the unusual nature of the bottom water at this location, the oceanographers were keen to collect Acoustic Doppler Current Profiler (ADCP), temperature and salinity data from this area at a finer scale, so, the AUV dive planned for the 6th June was considered but later abandoned for reasons detailed below. The ship was moved to the Darwin mounds site (1000 m) to deploy the CTD in an effort to find an area with less current and less turbidity (Cast 30, STN_039). The CTD indicated ~95% beam transmission (1200 m box CTD was 60%) and much lower turbidity than the 1200 m site. So, the ROV was prepared to go to the 1000 m transect that was completed in 2011. The ROV was deployed at 19:22 (DIVE 285, STN_040). The tide was found to be moving to the southeast at around 0.6 knots (ROV cannot deviate from current above 0.5 knots), so the beginning of the transect was not possible. At the seabed, zero visibility was encountered due to marine snow and the dive was aborted. Currents and turbidity meant that further successful collections and surveys were unlikely, so the vessel moved to Rosemary Bank (RB).

6th June 2016

The ship arrived on site at 08:00. CTD (Cast 31 , STN_041) conducted at the 1300 m site. The AUV was deployed at the east RB site at 10:00 (M118, STN_42). The CTD showed stronger turbidity and lower transmission than at the previous site that was heavy with marine snow. The CTD altimeter reading of seafloor was lost at 5 m above the seafloor, potentially indicating thick turbidity and low visibility. This raised concern for the upcoming AUV photo transect. The AUV team suggested that one measure of water clarity could be to use the reflectance intensity measure on the ADCP. The reflectance intensity on mission 1 of JC136, when photo transects were successful, was markedly different from that taken at the last site where visibility was near zero. The vessel was moved to the 500 m site at west RB. To check water turbidity, we deployed the CTD with a GoPro camera array (3000 m rated) and light source (1250 m rated) to check for marine snow intensity (Cast 32, STN_043). Water at the seafloor was found to be clear. ROV deployed at the same site at 16:02 (DIVE 286, STN_044). Three video transects were completed and with collections of *Cidaris*, *Parastichopus*, and *Lophelia* in population genetics quantities, with 15 samples of *Madrepora*.

7th June 2016

The ROV was retrieved at 07:00. Vessel transited to the central RB zone to retrieve the AUV (at 09:00) at the designated halfway point between east and west RB sites. The AUV intensity reflectance data from ADCP inferred that the 1200 m site had intermittent blooms at around 1300 m, probably tidal. There are, however, long periods of time with clear water, so we proceeded with the photo survey. The vessel returned to the west RB 1200 m site. A CTD cast (STN_045, Cast 33) with a downward facing GoPro found no indication of turbidity. The ROV dive (DIVE287, STN_046) went ahead as planned, with deployment at 13:51. Three video transects were completed over sand. The ROV then transited in blue water for 6 hrs to transect 13 to collect samples.

8th June 2016

The ROV retrieved from 1200 m at 15:01. The AUV was deployed at 16:16 (M119, STN_047) to multibeam the 1200 m and 2000 m boxes and transect 13 (sample collection area from DIVE287, M119). The vessel moved to the 800 m site to deploy the ROV at 19:45 (STN_048, DIVE 288). Three successful video transects were completed followed by moderately successful sampling collections, limited by the loss of hose and lack of *Parastichopus*.

9th June 2016

The ROV was retrieved at 14:50 and the vessel moved to transect 13 to retrieve the AUV post multibeam dive. A CTD cast was completed with a SVP (sound velocity profiler) (Cast 34, STN_049). The ROV was deployed at the 800 m box at 18:01 (DIVE 289, STN_050) to collect the few remaining required specimens.

10th June 2016

The ROV was retrieved at 06:58 after a successful night of collections and filming. The vessel was moved to east RB to survey the sponge site. The AUV was deployed at 10:46 to photo-multibeam the sponge area (M120, STN_051). The vessel moved to the 1000 m sampling transect and deployed a CTD cast (STN_052, Cast 35) to check water turbidity at depth. Water turbidity was verified as high, but this was not verified on the GoPro as the memory card was too full. The vessel moved to new site to the west of the sponge area and the water quality was assessed with a CTD cast (STN_053, Cast 36). Despite a new memory card, the GoPro stopped filming after 5 mins in the water. Water quality had improved so the ROV dive went ahead with deployment at 17:58 (DIVE 290, STN_054).

11th June 2016

The ROV dive consisted of a relatively steep slope of coarse sand and boulders. An extra 15 specimens of each of the 4 main target species were collected, as well as some beautiful deep-sea animal footage. The ROV was recovered at 06:00. The vessel transited to the AUV collection site. Winds speeds were relatively high (30 knots) but Autosub was retrieved without incident (09:30). Autosub images indicated some turbidity at depth but enough visibility to collect *Pheronema*. However, wind speeds remained border line and a second weather report (11.30) indicated winds were not going to improve, so transit to GBB commenced.

12th June 2016

The vessel arrived on site at 07:00. A CTD cast to 1200 m (Cast 37, STN_055) was undertaken before deploying the AUV at the 1200 m at 08:06 (M121, STN_056). The vessel transited to the 500 m ROV site to undertake transects and sampling and the ROV was deployed at 12:08 (DIVE 291, STN_057).

13th June 2016

The ROV was retrieved at 05:00 and the vessel moved to retrieve the AUV from the 1200 m site at 07:54. The ROV was deployed at 08:21 (DIVE 292, STN_058) to survey and sample the 1200 m site over the afternoon and through the night. One transect was attempted but unusable as currents were too strong. The ROV left arm had some problems and, given sampling was successful, it was decided to retrieve the ROV at 02:00, and it was on deck for 03:15 at the ROV team switch over.

14th June 2016

A number of hours ROV repair downtime were filled with CTD work and the AUV was prepped for its mission. Three CTDs were deployed, two across the top of GBB (Cast 38, STN_059; Cast 39, STN_060), and one to the west (Cast 40, STN_061). The AUV was deployed at 14:45 (M122, STN_062). The ROV was deployed at the 800 m site at 17:45 (DIVE 293, STN_063). The ROV area was covered in dense marine snow and the first transect was abandoned. Planned video transects were not completed but three alternative video transects were achieved to the northwest of the original survey area. Unusually, *Parastichopus* was not found at this depth on GBB. Other target species were collected.

15th June 2016

The ROV was retrieved at 12.31 and the vessel was moved to retrieve the AUV (14:00). The AUV flash had failed on the photo dive. The vessel transited to the sponge target area to the northwest on GBB (3 hrs) to undertake the 1200 m ROV dive (DIVE 294, STN_064). Clear water was observed from the surface down to 11 m off bottom; however, from 10 m off bottom to the seafloor, it was thick marine snow; possibly the densest we had observed. After 500 m of transect, the ROV dive was abandoned due to zero visibility and the ROV was retrieved at 20:30. The vessel transited to the GBB 500 m site to prepare for an early morning AUV deployment.

16th June 2016

The AUV was deployed to multibeam a previously ROV ground-truthed 500 m site at 06:00 (M123, STN_065). The vessel moved to a 1000 m site that on a previous AUV multibeam survey (western edge of the 1200 m AUV multibeam dive) was found to have a 4 m high ridge, potentially suitable habitat for *Lophelia*. The ROV was deployed at 08:36 (DIVE 295, STN_066). *Madrepora* was found in abundance but just one colony of *Lophelia* was found. *Pheronema* was also relatively common here. The ROV was retrieved at 17:24 and the AUV was retrieved after successfully completing it’s multibeam mission at 18:35. Vessel transit to ADS commenced.

17th June 2016

The 1200 m mooring was retrieved at 09:16 and the short distance to the 800 m mooring was transited, followed by recovery of the mooring at 10:26. A CTD cast to 800 m (Cast 41, STN_067) was undertaken followed by a CTD at 650 m (Cast 42, STN_068). The vessel was moved to the 1000 m site and the AUV was deployed at 15:49 for a multibeam mission (M124, STN_069). The vessel moved to the 1100 m ROV site for the last overnight collection dive and the ROV was deployed at 18:37 (DIVE 296, STN_070).

18th June 2016

The ROV successfully collected *Madrepora*, *Lophelia* and some *Cidaris*, and the ROV was retrieved at 10:35. The AUV successfully completed the multibeam mission and was successfully retrieved at 13:43. A CTD cast was taken over the summit (STN_071, Cast 43). Transit to Southampton commenced.

19th June 2016

Vessel continued at 8 knots until the early hours to enable multibeam of unmapped sections of seafloor to be undertaken. The Ship then continued to port at a speed of 10 knots. Predicted arrival time was the afternoon of the 22nd June, a day early, as we had heavy weather chasing us that would have made science impossible.

5 Station log

Table 5.1: Survey details from all locations during JC136 cruise. Location abbreviations: Anton Dohrn Seamount (ADS), North Rockall Bank (NRB), George Bligh Bank (GBB), Wyville-Thomson Ridge (WTR), Rosemary Bank (RB).

Station no.	Gear	JC Ref No	Transect no. (station code)	Location	Start Lat	Start Long	Depth (m)	Date	Time (UTC)	Remarks/Recovery
1	CTD	Cast 1		ADS	57 10.178	-10 30.000	2229	17/05/16	05:07	
2	Mooring			ADS	57 35.803	-11 10.352	808	17/05/16	14:47	
3	Mooring			ADS	57 37.240	-11 11.250	1220	17/05/16	15:28	
4	ROV	D269	ADS_1200_3 ADS_1200_2	ADS	57 37.500	-11 12.880	1499	17/05/16	16:28	ROV lost comms on recovery.
5	CTD	Cast 2		ADS	57 30.276	-11 12.026	651	18/05/16	10:25	
NA	AUV	M113		ADS	NA	NA	NA	17/05/16	12:26	Mission aborted after 20 mins due to sub failure
6	CTD	Cast 3		ADS	57 30.241	-11 12.000	652	18/05/16	15:33	
7	CTD	Cast 4		ADS	57 36.999	-11 14.576	1280	18/05/16	18:59	
8	CTD	Cast 5		ADS	57 36.976	-11 14.444	1238	19/05/16	08:10	CTD yoyo in position (casts 5-19)
9	CTD	Cast 20		ADS	57 35.738	-11 15.487	818	20/05/16	08:40	
10	ROV	D270	ADS_800_3, ADS_800_2, ADS_800_1	ADS	57 35.730	-11 15.490	813	20/05/16	18:25	Successful dive
11	ROV	D271	ADS_1200_1	ADS	57 37.050	-11 13.660	1300	21/05/16	18:07	Successful dive
12	ROV	D272	ADS_500_1, ADS_500_2, ADS_500_3	ADS	57 27.857	-11 10.621	632	22/05/16	20:46	Successful dive
13	ROV	D273	ADS_2000_1, ADS_2000_2, ADS_2000_3	ADS	57 41.161	-11 17.458	2142	23/05/16	19:24	Successful dive
14	CTD	Cast 21		ADS	57 27.874	-11 07.128	568	23/05/16	16:13	Station numbering error with STN13. Left as organisms already labelled.
15	CTD	Cast 22		NRB	57 50.904	-13 58.793	190	24/05/16	18:50	

Station no.	Gear	JC Ref No	Transect no. (station code)	Location	Start Lat	Start Long	Depth (m)	Date	Time (UTC)	Remarks/Recovery
16	ROV	D274	NRB_200_1, NRB_200_2, NRB_200_3	NRB	57 50.905	-13 58.791	180	24/05/16	19:46	Successful dive
17	AUV	M114		NRB	58 20.33	-13 36.98	1200	25/05/16	15:48	Multibeam failed so limited data collected
18	ROV	D275	NRB_800_1, NRB_800_2	NRB	58 18.344	-13 39.421	800	25/05/16	21:19	Successful dive
19	CTD	Cast 23		NRB	58 22.764	-13 29.947	1085	26/05/16	16:06	
20	ROV	D276	NRB_1200_3, NRB_1200_1, NRB_1200_2	NRB	58 23.605	-13 33.900	1200	26/05/16	18:26	Successful dive
21	CTD	Cast 24		NRB	58 23.359	-13 31.483	1228	27/05/16	12:52	
22	ROV	D277	NRB_500_2, NRB_500_3	NRB	58 18.290	-13 44.630	500	27/05/16	19:42	Successful dive
23	AUV	M115		NRB	58 23.38	-13 34.45	900	27/05/16	15:20	Vehicle would not fly below 10 m above bottom. Dive numbered out of sequence. Multibeam collected
24	Towed frame			NRB				28/05/16		
25	ROV	D278	NRB_800_3, NRB_500_1	NRB	58 19.120	-13 41.719	893	28/05/16	17:15	Successful dive
26	AUV	M116		NRB	58 23.45	-13 34.65	1180	29/05/16	14:34	Multibeam collected and 160000 images captured
27	ROV	D279	Sampling only	NRB	58 20.701	-13 42.895	995	29/05/16	17:30	Successful dive
28	ROV	D280	Sampling only	NRB	58 15.760	-13 35.352	793	30/05/16	18:18	
29	CTD	Cast 25		GBB	58 39.232	-13 49.478	1272	31/05/16	12:31	
30	ROV	D281	Sampling only	GBB	58 42.730	-13 50.020	929	31/05/16	15:16	
31	ROV	D282	Sampling only	GBB	58 40.430	-13 49.878	1215	01/06/16	10:48	
32	CTD	Cast 26		GBB	58 40.800	-13 49.900	1143	01/06/16	14:09	
35	CTD	Cast 27		WTR	59 46.846	-07 03.996	1115	04/06/16	07:13	Aborted CTD--Wire needed to be reterminated. Station numbers in wrong order due to error in CTD logs
33	AUV	M117		WTR	59 45.89	-07 03.67	1115	04/06/16	09:20	Multibeam collected but no sidescan due to fault.
34	ROV	D283	WTR_500_2, WTR_500_1	WTR	58 40.430	-13 49.878	500	04/06/16	14:40	Successful dive
37	CTD	Cast 28		WTR	59 46.331	-07 03.136	1115	05/06/16	09:36	Station numbers in wrong order due to error in CTD logs
36	ROV	D284	Dive aborted	WTR	59 47.767	-07 04.856	1146	05/06/16	11:46	Aborted dive – deep-water turbidity at 1115 m

Station no.	Gear	JC Ref No	Transect no. (station code)	Location	Start Lat	Start Long	Depth (m)	Date	Time (UTC)	Remarks/Recovery
38	CTD	Cast 29		WTR	59 49.679	-07 07.404	1085	05/06/16	15:54	
39	CTD	Cast 30		WTR	59 49.450	-07 20.994	966	05/06/16	17:52	
40	ROV	D285	Dive aborted	WTR	59 47.767	-07 04.856	1000	05/06/16	19:22	Darwin Mounds - aborted dive, turbidity at bottom
41	CTD	Cast 31		RB	59 19.510	-09 32.558	1376	06/06/16	07:06	Turbidity recorded
42	AUV	M118		RB	59 16.49	-09 35.43	1000	06/06/16	10:00	Multibeam collected for science tracks only, but no sidescan due to fault.
43	CTD	Cast 32		RB	59 10.172	-10 27.491	600	06/06/16	14:53	With GoPro.
44	ROV	D286	RB_500_3, RB_500_2	RB	59 10.1733	-10 27.491	593	06/06/16	16:05	Successful dive
45	CTD	Cast 33		RB	59 03.526	-10 34.198	1273	07/06/16	11:49	With GoPro.
46	ROV	D287	RB_1200_2,RB_1200_1,RB_1200_3	RB	59 03.525	-10 34.203	1200/ 1000	07/06/16	14:00	Successful Dive
47	AUV	M119		RB	59 03.837	-10 33.566	1200/ 2000	08/06/16	16:16	Double box and part of transect. Sidescan collected and some multibeam
48	ROV	D288	RB_800_3, RB_800_1, RB_800_2	RB	59 07.173	-10 30.448	800	08/06/16	09:36	Successful dive
49	CTD	Cast 34		RB	59 08.278	-10 41.093	1136	09/06/16	15:22	SVP CTD
50	ROV	D289	Sampling only	RB	59 07.173	-10 30.448	800	09/06/16	18:00	Successful dive
51	AUV	M120		RB	59 16.492	-09 35.592	1180	10/06/16	10:46	Multibeam, sidescan and camera images (although slightly further off the seabed than hoped).
52	CTD	Cast 35		RB	59 13.741	-09 39.774	1095	10/06/16	13:59	CTD showed high turbidity at depth
53	CTD	Cast 36		RB	59 18.274	-09 40.312	1101	10/06/16	16:08	Test new W Rosemary site. Looks clearer
54	ROV	D290	Sampling only	RB	59 18.294	-09 40.33	1100	10/06/16	18:30	
55	CTD	Cast 37		GBB	58 52.319	-13 22.537	1080	12/06/16	06:08	CTD showing good visibility
56	AUV	M121		GBB	58 53.97	-13 23.74	950	12/06/16	08:06	Multibeam data collected (sidecan not collected due to fault)
57	ROV	D291	GBB_500_3, GBB_500_1, GBB_500_2	GBB	58 55.323	-13 36.323	544	12/06/16	12:08	Successful dive
58	ROV	D292	GBB_1200_2	GBB	58 51.077	-13 21.278	1100	13/06/16	12:08	Currents strong so difficult to maintain transect path. One transect attempted but unusable as transect.

Station no.	Gear	JC Ref No	Transect no. (station code)	Location	Start Lat	Start Long	Depth (m)	Date	Time (UTC)	Remarks/Recovery
59	CTD	Cast 38		GBB	58 52.025	-13 21.104	1133	14/06/16	06:44	
60	CTD	Cast 39		GBB	58 56.401	-13 48.352	453	14/06/16	09:58	
61	CTD	Cast 40		GBB	58 57.998	-13 52.201	459	14/06/16	11:29	
62	AUV	M122		GBB	58 57.333	-13 23.537	900	14/06/16	14:45	Multibeam collected, sidescan not required, images did not work due to flash fault
63	ROV	D293	GBB_800_3, GB_800_1, GB_800_2	GBB	58 54.941	-13 29.846	800	14/06/16	18:15	Transect 3 aborted and repeated due to poor visibility. Most but not all samples collected
64	ROV	D294		GBB	59 16.06	-13 30.38	1200	15/06/16	18:36	Unsuccessful dive due to zero visibility. Dive aborted
65	AUV	M123		GBB	58 55.210	-13 36.291	550	16/06/16	06:00	Successful mission
66	ROV	D295	Sampling only	GBB	58 51.227	-13 23.942	1000	16/06/16	09:30	Successful dive
67	CTD	Cast 41		ADS	57 35.861	-11 10.096	809	17/06/16	11:13	
68	CTD	Cast 42		ADS	57 30.265	-11 12.032	651	17/06/16	13:37	
69	AUV	M124		ADS	57 35.80	-11 15.85	800	17/06/16	15:49	Successful mission
70	ROV	D296	Sampling only	ADS	57 36.839	-11 13.627	1050	17/06/16	19:31	Successful dive
71	CTD	Cast 43		ADS	57 27.631	-11 07.188	559	18/06/16	15:12	Additional CTD to complete oceanography work at Anton Dohrn

6 NMF systems reports

6.1 Isis ROV report

Figure 6.1: Isis ROV during launch
From RRS James Cook

Dates: 15th May to 22nd June 2016
Principle Scientist: Leg 1 Kerry Howell
Leg 2 Michelle Taylor

NMFSS Senior Tech
/ROV Supervisor: Dave Turner
NMF ROV Team: Andy Webb Dave Edge
Russell Locke Alan Davies
Josue Viera Antonio Campos

NMF AUV Team: Dave Paxton Racheal Marlow
James Perrett

NMF Tech Team: John Wyner Gareth Knight
Howard King Lisa Symes

6.1.1 Cruise Outline

The proposed work is the collection of samples of sessile and limited mobility species for molecular analysis using the ROV (Isis). The aim will be to collect at least 20 samples of each species from each of the 6 study sites at each of 4 depth horizons (500 m or summit depth, 1000 m, 1500 m, 2000 m).

The Autosub6000 and the Isis ROV equipped with stills and high definition video cameras respectively are to be used for gathering new image and video transect data from stations >1000 m at 5 of the study sites (not ADS). The use of the Autosub6000 will maximise the available ship time by acquiring benthic megafaunal sample data while the Isis ROV and vessel focus on acquiring physical samples for genetic analysis and species identification. Autosub will aim to undertake a minimum of 5 transects at each of the 5 study sites. Autosub6000 will be flown 3 m off the seabed (subject to terrain and collision avoidance requirements) and stills images taken at sufficient frequency to provide overlap between adjacent images.

Additional stills images and video transects will be taken using the ROV stills camera to aid in species identification.

For both platforms, an Ultra Short Baseline system (USBL) will provide accurate positioning data, and a CTD will provide data on conductivity (salinity), temperature and depth.

To provide some in situ validation of our oceanographic modelling, the collection of fundamental hydrographic profiles (temperature, salinity, density) via CTD will be undertaken at each sampling site.

ADCP velocity data from the ECS/ FASTNEt site is to provide confidence of the model implementation in a slope setting. To constrain the transferral of the modelling to a seamount, two ADCP moorings will be deployed at the ADS site for a period of at least 28 days, one each at the 750 m and 1750 m contours. Each will comprise a bed-mounted upward looking 300 kHz ADCP to provide high resolution (2 m) data within and above the bottom boundary layer (to a range of 75 m), with a second upward looking 75 kHz ADCP moored at 50 m above bottom to provide lower resolution (16 m) data from this height up into the water column (to a range of 500 m). The moorings will be deployed on Day 2/3 and recovered on Day 35/36.

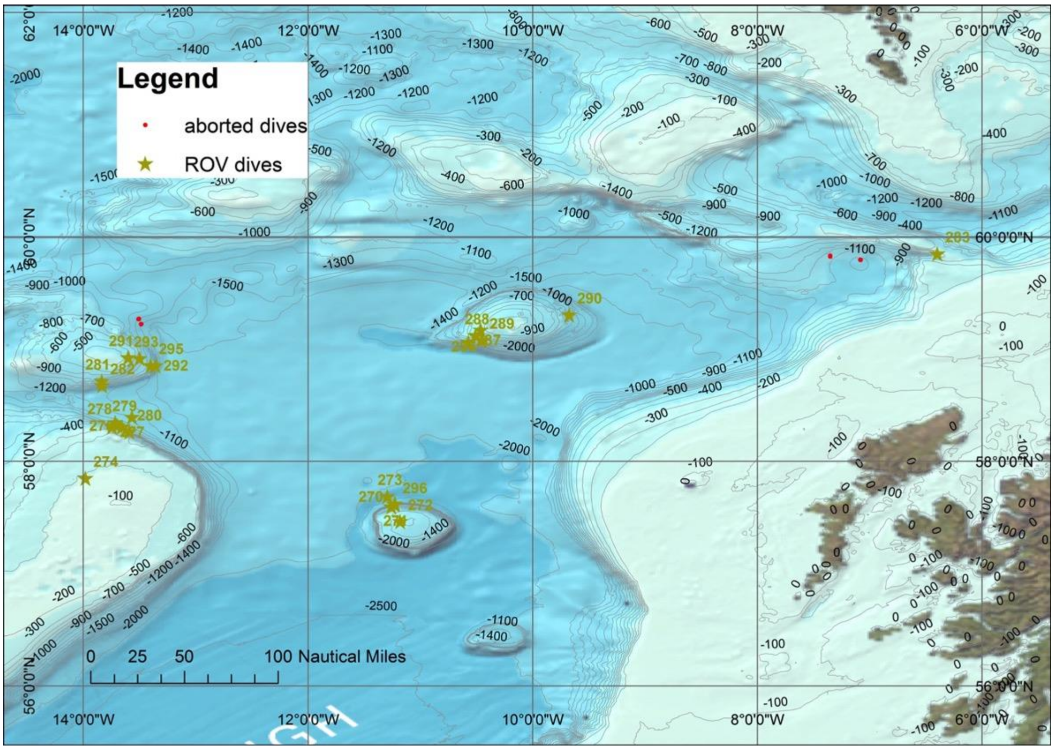

Figure 6.2: ROV Dive locations from the JC136 cruise in the NE Atlantic

ROV Dive Stats

No. of dives JC136	28 (Dive nos. 269 to Dive no. 296)
Total run time for (JC136) thrusters:	415.67 hrs
Total time at seabed or survey depth:	362 hrs
Isis ROV total run time:	4196.5 hrs
Max Depth and Dive Duration:	2150 m and 7.6 hrs (Dive 273) (11.75 hrs in water)
Max Dive Duration and Depth:	22.97 hrs at 1045 m (Dive 287) (25.17 hrs in water)
Shallowest Depth and Duration	194 m for 14.43 hrs (Dive 274) (15.8 hrs in water)
Recorded Data:	Techas (13.84 GB) CTD (549.8 MB) DVLNAV (32.77 GB) Sonardyne (8.67 GB) OFOP Event Logger (609.7 MB) Video (58.180 TB) Scorpio Digital Still (48.81 GB)

Master 1 & 2 LaCie Raid units SER# MRVL0001B6DE9700EEA9 and SER# TBC provided to Principal Scientist for access at remote NOC location.

Backup 1 & 2 LaCie Raid units SER# MRVL0001B6E7D34C2A7F and SER# RVL0001B6C5996AF041 will be installed in the NOC media room for BODC to archive and provide access for scientists post cruise.

6.1.1.1 Mobilisation

Southampton (NOC): 3rd May to 6th May 2016

The Isis ROV system was mobilised in Southampton. This was a straightforward installation with a 7000 kg and 9000 kg load test planned. Following the refurbishment of the Dynacon HPU, it was deemed necessary to carry out a static and luffing load test to establish that the functionality of the system had not been compromised during the power unit overhaul. During the load test, a correction factor was applied to the LCI control unit, adjusting the sheave wrap angle, to correct the outboard tension in line with the calibrated load cell supplied with the water-weights water bag.
Following the termination of the umbilical, a 7000 kg load test was applied using the integral lugs of the LARS, and the winch/a-frame to apply the required load.

The traction winch/storage drum baseplate had also been modified to allow transportation within a standard 20' container. These modifications worked well and made the installation and alignment of the winch/storage drum much easier.

6.1.1.2 De-Mobilisation

Southampton (NOC): 23rd June to 24th June 2016

The ROV was relocated on the aft deck during the passage home. This manoeuvre was carried out in the sheltered waters of the NE coast of Ireland. This enabled the ROV handling system to be hydraulically stowed and isolated whilst the vessel steamed back to Southampton. All equipment was made ready for lifting ashore at NOC on arrival Wed 23rd June at 15:00 hrs
All containers and equipment were lifted shore side without any problems.

6.1.1.3 Operations

Historically, eight ROV engineers have been deployed onto cruises to support 24 hr ROV operations. Typically, this would be four engineers on each watch to cover a 12 hr period. With the right combination of engineers on each watch, the ROV could be deployed and recovered any time throughout the 24 hrs. As the ROV group only has seven engineers, the eighth engineer has always been an ROV contractor with many years of experience in this type of specialist vehicle (namely an ex WHOI pilot).

Generally, the operation of the ROV can be covered by three engineers once the vehicle has been deployed. This requires one engineer to pilot the vehicle and other engineer to take the samples. The third engineer operates the cameras and monitors the system, making all the necessary checks. This process is rotated giving the required breaks from each roll as the engineer's cycle through. Providing the sampling demand is manageable, this process with three pilots can be sustained for a few hrs. The addition of the fourth pilot eases the workload allowing for more frequent breaks over a 12 hr period and allows enough cover during meal breaks.

In an attempt to reduce the amount of manpower to operate the ROV, it was decided that the ROV group of engineers (7) would run 24 hr operations without the additional cost of a contractor for this cruise.

To allow this to happen and to make the watches manageable it was necessary to run two 12 hr watches of three pilots (04:00 to 16:00 hrs and 16:00 to 04:00 hrs) and one watch of 12 hrs covering both watches for an even period of 6 hrs (10:00 to 22:00 hrs). This watch pattern meant that the ROV could only be launched or recovered in the 12 hr period of 10:00 to 22:00 hrs, when four engineers were available, unless a technical issue came to light where the vehicle needed to be recovered, and an engineer needed to be disturbed out of hrs.

From previous cruises, this deployment /recovery window would generally have not been an issue or too restrictive in the general operations of the cruise. This was why it seemed like a feasible option.

Prior to this cruise the science team were informed of the ROV operating schedule, and were happy to plan around this requirement. For the majority of this cruise this worked very well with a few hours here and there of flexibility required from both parties to meet the daily plans.

A couple of contributing factors to the limitations that the science party had to endure was the scheduling of the AUV and CTD operations around the ROV and vice versa. With these systems

only available for a 12 hr period (days) this limited the flexibility of running the 24 hr operations. With the AUV able to support 24 hr operations, this would greatly improve this capability. Joint operations in deep water with the AUV will be hampered by lack of endurance of AUV and amount of time required to monitor AUV before ROV operations can begin. This will lead to limited bottom time for ROV operations.
Future modification/requirements:

- Investigate wireless headsets for outside ROV operations this would also be useful during post and pre dive ROV checks
- Investigate a more compatible headset for use with hard hats.

6.1.1.4 Handling Systems

6.1.1.4.1 Hydraulic Power Unit (HPU)

Prior to the mobilisation, 4 x quick connects were installed by Pirtek for the connection of the traction head and storage drum to the HPU. During power up it was noted that two of these connectors were leaking.
To save time and to keep things moving, the quick connects were removed and replaced with conventional JIC fittings. Pirtek were informed and investigated the leaking connectors. These were replaced with new but of the same design. If these continued to be a problem then Pirtek suggested that they would need to machine the fitting. We did not change the fittings, as we were not confident that they would be any better, and that time was short. During the cruise, the other two fittings also slightly leaked.

It was noted following the recovery of Dive 292 that the HPU motors behaved a little differently whilst powering down. One motor went off and then proceed to start again. (Note: the stop button on remote panel is 'momentary break' not 'latching' type so it is always necessary to continue to apply figure pressure during the power down sequence to allow back emf in both motors to dissipate before releasing the button otherwise it may be possible for a motor to restart - this has not been a problem in the past, however it might be possible to reconfigure the panel to introduce a 'drop-off contactor' in the circuit though this would add a further level of complication to the start-up procedure as this would have to be reset before starting).

Prior to this cruise, the HPU saw a complete overhaul. For the duration of the cruise, the HPU has performed well with no major problems encountered.

Future modification/requirements:

- Pirtek to replace 4 x quick connect couplings (this may require machining on their side, and the use of a dowty seal to overcome the problem)
- Possible look at a manifold for the quick releases. Needs some thought!
- Replace pressure gauge on consul, appears to be empty.

6.1.1.4.2 Storage Drum/Traction Winch

The brake on the storage drum started to squeak and needed a minor adjustment. (It was discovered that the brake securing bolts were done up tight rather than slightly loose which allows the body to float and thus self-centre, once this was addressed and pins lubricated the squeaking disappeared).
During the tensioning of the storage drum, it was noted on a couple of occasions that the drum would suddenly turn, making a banging noise. This may be due to some extra slack being generated when

the system is switched off; causing the drum to turn more than normal gaining momentum before the slack is taken up.

Future modification/requirements:

- Careful monitoring required when the system is tensioned up on the next cruise.
- Check brake assembly.
- Add an over-side drainage facility to reduce water swilling around on deck.
- One tombstone on storage drum baseplate will require small amount of modification on return to Southampton as unable to fit mounting bolt.
- Small rear storage baseplate requires painting on return to Southampton.

6.1.1.4.3 Launch and Recovery System (LARS)

As a precautionary measure, the tugger wheel was removed and re-fitted securing the bolts with a stainless steel locking ring that had been manufactured back at base. This worked well with no further problems of the bolts becoming loose during operation.

During the cruise, the docking head developed a squeak when the frame was extended and the docking head was moved either outboard or inboard. Some greasing was carried out, but unfortunately, the joints that required the lubrication were out of reach whilst at sea. It has been suggested that we use slow release grease units on the out of reach areas, or hard pipe down to a manifold.

It was noted on one recovery that a ‘knocking’ noise could be heard when the tugger wheel was engaged. The noise was less prominent when the wheel was disengaged, but could still be heard. Upon inspection during the next post/pre-dive, it was noted that one of the welds holding the drive chain to the stainless steel disc had broken. This in turn created a small piece of loose chain that was knocking every time it passed the drive motor. As this appeared to be a minor problem, with no real danger of getting worse or causing further problems down the line it was decided that a weld repair would not be carried out. The chain and drive was fully lubricated. This appeared to cure the ‘knocking’ sound, with no further issues encountered.

Future modification/requirements:

- Look at lubrication options for docking head joints out of reach during a cruise.
- Inspect and repair weld on sheave drive sprocket/chain.
- Build the new control cable, to remove the need for the extension cable and unnecessary connector joint.
- Check tugger wheel.

6.1.1.4.4 Umbilical

The umbilical was terminated and load tested during the mobilisation. A load of 7000 kg was applied and held for 5 mins.
Based on the attenuation for each fibre, see below, the black fibre was chosen to be used for the vehicle telemetry and the red fibre for the CWDM and HD cameras.
The attenuation for each fibre was recorded as:

Black	1310 – 6.8db	1550 – 6.1db
Red	1310 – 9.6db	1550 – 8.2db
Grey	1310 – 14.5db	1550 – 13.3db

On arriving station at the Anton Dohrn Seamount, which was to be the deepest site of the cruise, the umbilical was vertically streamed to a depth of 2220 m using the ROV weight assembly of 1750 kg. During this process, the ROV C5 and G6 (WMT) beacons were tested, attached to the deployment weight, in their bespoke mounting brackets. In addition to this, a second ROV G6 (WMT) was attached to the umbilical via a new quick release bracket. The wire was lowered at a max rate of 40 m/min, and remained at depth for one hour before being hauled to the surface at 40 m/min. All beacons tracked well.

During the first dive, (Dive 269) the vehicle lost communication, and was unable to re-establish despite several attempts. Fortunately, this was at the end of the dive causing no loss to the science objectives. The vehicle was recovered in the dead sub configuration with no real issues encountered. During the recovery, the scrolling on the storage drum came out of sync by one lay. This was most likely due to the speed at which it might have been turned when retrieving the floats in the dead sub configuration.
Following the recovery of the vehicle, it was powered up, and appeared to have no communication issues. The vehicle fibre (black) and the CWDM (red) were checked through form the vehicle JB to the control container, with similar attenuation readings recorded as when the termination was made.

To remove the gap in the scrolling on the storage drum the umbilical was pulled off the drum until the gap was reached. During this process, it was identified that torque had built up in the umbilical, making it impossible to turn back onto the drum without causing damage. This torque was then transferred back through the traction head all the way back to the vehicle so that the winch and storage drum could be scrolled and tensioned accordingly. At this point, it was thought that the loose turns now transferred to the vehicle could remain in place for the next few dives until further understanding of the umbilical could be established. Unfortunately, following the inspection of the termination bullet it became apparent that there was more turns present than originally thought. The termination and fibre/electrical connection were removed from the vehicle, taking out all turns, and then reconnected. All three fibres again checked out ok with no faults or events recorded over the 8 km length.

As no real fault had been identified following the vehicle blackout on the first dive, it was decided that the fibres used to control the ROV should be switched and that the black fibre, which had been problematic on the previous cruise, should not be used. As the grey fibre appeared to have a higher attenuation than the other two (approx. 18db) it was checked through and narrowed down to the fibre from the slipring to the junction box on the side of the winch (cheese box) was seeing approx. 10db losses. To rectify this, the interconnect lead from the drum JB through the slipring to the winch JB was switched, putting the now not to be used black fibre on it, passing the grey fibre though a lower attenuated path.

Red fibre now used for the vehicle telemetry (1310 8.06dB 1550 6.64dB {vehicle to container})
Grey fibre now used for the CWDM (1310 4.80dB 1550 5.90dB {vehicle to container})

The change of fibres worked well with no further problems reported for the duration of the cruise.

The management of the umbilical this cruise was carried out in a different manner to previous cruises. The addition of a Sonardyne G6 WMT beacon attached to the umbilical proved to work very well. This beacon was attached to the umbilical approximately 50 m after the last football float, generally around the 150 m wire out position with the ROV stopped at 100 m depth. For the shallower dives of between 100 m and 500 m water depth, the beacon was attached at approximately 100 m wire out with the ROV stopped at 45 m depth. During operations, the attached umbilical beacon gave a good indication of the vertical wire position enabling the ROV to maintain a good position relative to the umbilical and the ship. This proved to work well with the umbilical showing no signs of turns or 'kinks' as experienced on the previous cruise

Throughout the cruise, the ROV termination and gimbal arrangement was monitored for any turns or twists, which previously had been problematic. No turns developed throughout the cruise.
Future modification/requirements:

- Replace interconnect lead (currently connected to black umbilical fibre) that passes through the slipring. (As this means removing the slipring, it would be best to replace all the F/O patch leads from the slipring to both JBs with new commercially available ones.)
- Look at replacement umbilical (possible torque related issue with black fibre. (Ref JC125 cruise report)

6.1.1.4.5 CCTV & Lighting

No problems other than a dirty lens now and then.

Future modification/requirements:

- Look at moving camera position to look more centrally through LARS. Possible mounting onto top of winch cab.

6.1.1.4.6 Containers

Control 1

As per control 2

Control 2

The gutter arrangement that joins two containers failed on a couple of occasions, during heavy rainfall, causing a minor flood into the work space. Working in darkness with a high contrast from multiple large monitors may be causing eyestrain for some operators.
Future modification/requirements:

- Look into improving the draining arrangement and the sealing of the bottom rubber gasket.
- Check CSE plates for next cruise.
- Touch up paint defect for next cruise.
- Investigate if working in different type of van lighting during ROV operations would be more comfortable for the operators.
- Reduce profile size of container fan outlet duct as this is at head height and is a H&S issue as more than one person during cruise banged head on duct.

Workshop

Future modification/requirements:

- Look at options for new bench tops
- Check CSE plates for next cruise.

- Fit permanent earth bonding link (as per control van) rather than apply temporary lead each time.
- This van and spares should be linked into ships fire system.

6.1.2 ROV External and Sampling Equipment

6.1.2.1 Sonardyne Beacons

Compatt 5 Midi Beacon

The Compatt5 beacon address 110 was attached to the ROV for the duration of the cruise. This beacon was only on the vehicle for back up and was not tracked during the dives.

Future modification/requirements:

- Batteries to be disconnected and stored in LI battery store at NOC.

G6 WMT Beacons

Beacons 2709 and 2702 were used for the duration of the cruise. 2709 was used for the tracking of the ROV and 2702 was attached to the umbilical. It was established that the 2702 could potentially operate for approximately 48 hrs on one charge, however, the beacon was charged routinely between each dive for the time available. Both units performed well for the duration of the cruise.

During each dive, it was noted that the depth of beacon 2709 was reading consistently 21 m shallower than the depth of the Isis ROV pressure sensor.

Future modifications/recommendations/maintenance

- Connect to terminal and switch off both beacons.
- Procure spare beacon as part of capital expenditure.
- Investigate the calibration of the Isis pressure sensor or the option to apply an offset. (fault log entry 43)

6.1.2.2 Football Floats

8 x 6000 m floats were used for the duration of the cruise.

Future modifications/recommendations/maintenance:

- Check and re-tighten float latches where necessary.
- Check quantities and order replacements if necessary.

6.1.2.3 Suction Sampler

Prior to the first dive, it was noted that the hydraulic rotator motor was leaking oil. The unit was removed from the suction sampler and stripped down for inspection. Some corrosion was noted and slight clean-up was made before re-assembly. Bench testing revealed that the unit was still leaking. The unit was replaced with a new spare, with no further leaking reported.

On several occasions, the suction hose was pulled off the suction nozzle. This was generally operator error. Following Dive 275, the suction hose through the vehicle was replaced as the old one was showing signs of collapse and preventing the unit from operating properly.

Future modifications/recommendations/maintenance:

- Procure replacement spare drive motor.
- Fit clear solid pipe arrangement on rear of drawer and through vehicle, with flexible hose only use for where drawer comes out and connection to the nozzle.
- Procure spare suction hose.
- Suction sampler has become unglued and requires repair before next cruise.

6.1.2.4 Push Cores

Only a few push cores were taken during the cruise, with only one crate of six tubes used at one time on the vehicle.

Future modifications/recommendations/maintenance:

- Service units and make ready for next cruise.

6.1.2.5 Magnetic Tubes

Following Dive 284, it was noted that the top plate off one of the crate of six tubes, complete with magnetic lids, was missing. It is assumed that the cable ties were removed following Dive 285 for the scientists to take the tubes away and were not replaced prior to the next dive.

Future modifications/recommendations/maintenance:

- Look at new lids with magnets on the top plate and not the lids.
- Look at the tubes being taller than top plates so that cross contamination of samples is less likely when putting the samples into the tubes.

6.1.3 Isis ROV

6.1.3.1 Thrusters

During the pre-dive for Dive 270, the Port Vertical thruster would not enable. Following a diagnostic process it was identified the pod would need to be removed and opened. The driveblock and capblock were replaced with spare units. No further problems were encountered.

All six thrusters plus the hydraulic motor unit required no maintenance during the cruise. Following each dive the units had the compensation oil flushed through, and were checked for bearing noise and leaking seals

During some dives, the FL thruster would occasionally shutdown when lateraling in very strong currents. Topside was receiving a fault message “Phase over-current” from the driveblock and would then re-enable the driveblock. By backing up a little on the joystick, this could be prevented.

The SH showed once or twice “Motor fault” error in the GUI. Not sure of the origin of this problem.

Future modification/requirements:

- Check broken drive block 250007359 and 250007367 DB900820609 and CB90408502.
- Heatsink over temperature fault. Cleared and marked as faulty.
- Investigate if parameter misconfiguration (page 90 of the Driveblock manual) or modify topside code.
- Right off broken driveblock and capblock if not repairable. Replenish spare.
- All motors to be stripped, with bearings and seals replaced. This should take place following the Discovery trials in August.
- Consider adding Swagelok barbed tap to all thruster motors to reduce mess when flushing.

6.1.3.2 Hydraulic System

Towards the end of the cruise, and for the last few dives, it was noted that the hydraulic oil had lost some of its clarity, and was probably experiencing some water ingress. This may be a result of the slightly deeper dives that have taken place, and where it was thought that the draw ram might be allowing some seepage, if it is not exercised on the dives decent.
As the oil clarity was nowhere near as bad as seen on deeper dives and previous cruises, it was left until the last dive before it was drained and flushed.

Future modifications/recommendations/maintenance:

- Flush oil system and change all filters.
- Service all hydraulic motors and actuators.
- Check to see if the draw function is fitted with a pilot check valve block?

6.1.3.3 Manipulators

Kraft Predator

The Kraft Predator arm was used extensively for sampling on most dives and worked reliably for the majority of the cruise. The push button on the master became a little sticky over time and was cleaned a couple of times to improve operation. During dive 292, the arm developed a slight twitch, which made some operations a little precarious. As this type of fault historically was diagnosed as one of the potentiometer starting to fail, it was decided that the arm would be repaired following the dive. Following extensive tests on deck, the mini master unit was identified as having positional error fault; when in a certain position it would cause the slave unit (arm) to behave in an erratic manner. As this is a complex drive unit, and no spares components are carried, a replacement spare unit was put into place. Following a full axis calibration of the arm, no further issues were reported.
Future modifications/recommendations/maintenance:

- Return mini master to the USA for repair
- Service Jaws
- Flush compensation oil
- Flush through with clean hydraulic oil.
- Clean and inspect for corrosion/oil leaks

Schilling T4

This arm was used extensively for the duration of the cruise with no faults or issues recorded. The new camera and light assembly proved to be very beneficial for many sampling operations.

- Future modifications/improvements/maintenance:
- Perform visual inspection of Schilling T4.
- Flush compensating oil.
- Remove camera and lights in preparation for ≥4000 m dives

6.1.3.4 Vehicle Compensation System

The vehicle main compensation system worked well for the duration of the cruise. A constant loss of oil occurred on each dive, but gave no reason for concern. It is noted that the area around the transformer housing is particularly oily following a dive. During dive 269, it was noted that one of the main system comp gauges was reading zero, despite the visible conformation that the comps were still full. Following the dive, this was removed and replaced with a spare. Following each dive, oil samples were taken from each junction box, with no signs of water present.

Future modifications/improvements/maintenance:

- Time permitting, it may be advisable to remove the vehicle floatation and give the transformer an inspection and new lid gasket. (Fault log entry 44)
- Check all comps for cracks and general wear.
- Purchase replacement spare Span gauge.
- Inspect compensator hoses for splits and UV damage and replace if necessary.
- Check tops of compensators for trapped air.

6.1.3.5 Thruster Compensators

The thruster compensators worked well with no faults. UV damage spotted on some of the ¼" ID Tygon hoses.
Future modifications/improvements/maintenance:

- Perform visual inspection of compensators for leaks/damage.
- Inspect compensator hoses for splits and UV damage and replace if necessary.
- Check tops of compensators for trapped air.

6.1.3.6 Manipulator Compensators

The manipulator compensators worked well with no faults. Neither Schilling nor Kraft compensators lost any significant amount of oil during dives. UV damage spotted on some of the ¼" ID Tygon hoses.
Future modifications/improvements/maintenance:

- Perform visual inspection of compensators for leaks/damage.
- Inspect compensator hoses for splits and UV damage and replace if necessary.
- Check tops of compensators for trapped air.
- Consider removal of starboard Kraft compensator, which is no longer used.

6.1.3.7 Pan & Tilt Units

During the mobilisation, it took some time to set up the cameras on these units. This was due to the camera harnesses and comp lines that get snagged when the units pan and rotate.
Following Dive 284, it was noted that the pilot unit was moving, and appeared to be loose. Upon inspection, it was found that the central screw on the rotate axis had come free. To make secure, the unit was removed and the bolt tightened.
During the cruise, science again struggled with the Logitech Joystick system since its behaviour is not smooth.

Future modification/requirements:

- Start immediately a development project to produce a new camera controller that communicates with the Pan & Tilts.
- Loctite (Medium strength) centre screws on both units and on both axes.
- Suggested by science to have a hardware still photo button on the new controller.
- Look at a better way of running harness line to the cameras and pan/tilt units

6.1.3.8 Cameras

6.1.3.8.1 Mini Zeus HD (pilot & science)

During operation, especially when moving the pan and tilt or when a moving object like one of the manipulators is being captured, it showed a small delay in the video signal that makes the picture look like a slow motion video. The effect is rare and it only lasts for one second, but it can be annoying, especially during sampling with the arms. Since the video feeds are going directly to the recorders and from the recorders to the screens, possible delay induced in the system signal path.

Future modification/requirements:

- Investigate delay

6.1.3.8.2 Scorpio

For some reason, the reds are more appreciated in the Scorpio camera than in the rest and this may be due to the quality of the camera itself. However, we do not really know which picture is closer to the real life colour and therefore some form of reference is required.

Future modification/requirements:

- Install a colour scale card attached to one of the arms in order to compare colours from the different cameras
- The HD Pilot and Science cameras were procured and installed just prior to the cruise and tested in air together with their associated controllers, which had the additional facility of a single push white balance button. However, there was available a software GUI installed on the device controller PC that enabled more detailed control of the cameras setup. This was overlooked during the cruise and may have enabled fine-tuning of the cameras response when setting the white balance.

6.1.3.9 Lights

DSPL Multi Sealite (LED)

During Dive 279, the bullet light failed. Upon inspection, it was noted that the fitting had moved putting a strain on the connector and harness. This was most likely to have happened during the inspection of the docking head where it was lowered close to the vehicle to make accessibility easier. A replacement light did not work on the bullet harness, as it is likely to be a fuse failure inside the high power Wecon. The bullet light was then tested on a different harness revealing that it had also failed. To replace the bullet light, draw light 2 was repositioned, and the harness for the bullet light was removed and cut back to the junction box. The cut end was potted into the same repair as the

deck cable that had also failed and needed isolation. Further inspection of the tail revealed that it had been repaired previously with a splice.
At a later stage in the cruise, it was deemed necessary that the draw 2 light should be re-instated to aid illumination of the tool sled. To do this one of the new Y splice cable harnesses was plugged into the draw 1 harness and both draw 1 and 2 lights were plugged into the new harness. The GUI was modified to reflect these changes.
The starboard aft light lead was also found damaged following dive 283. This most likely occurred during the recovery as no GF was noted. The damaged harness was isolated and made safe and the use of a new Y slice tail was used to connect the two aft lights together on the same circuit. The GUI was modified to reflect this change.

Future modification/requirements:

- Repair the Bullet light. (250007738) (Fault 25)
- Acquire more LED spares.
- Acquire more Y-Slice leads.
- Change the bullet light lead and the starboard light lead.
- Change the fuse in the High power Wecon (#86?)
- Position draw lights to give better illumination

Aphos 16 LED
Following the first Dive, the light positions on the light bar were modified to give a wider area of illumination. This modification worked well and remained for the duration of the cruise. During the pre-dive for 274, it was noted that the port inner unit had a loose reflector on one of the LED's. This did not seem to reflect performance, and remained the same for the duration of the cruise. Not all sacrificial anodes seem to be connected to light housings.

Future modification/requirements:

- Return light unit xxx for repair (Fault 15)
- Look at serial port connection for dimming option
- Check continuity of anodes to housing.

6.1.3.10 Lasers

NOC Lasers
The NOC lasers were mounted onto the Scorpio stills science camera. No faults occurred during the duration of the cruise.

Future modifications/improvements/maintenance:

- Perform visual inspection of lasers. Check and re-grease o-rings as required.
- Build two more NOC lasers from components already procured.

Sidus Lasers
The Sidus lasers were mounted onto the pilot HD camera. Prior to the first ROV dive, it was noticed that the Sidus lasers showed signs of corrosion. They were disassembled and cleaned before mounting onto the vehicle. No faults occurred during the duration of the cruise.

Future modifications/improvements/maintenance:

- Perform visual inspection of lasers. Check and re-grease o-rings as required.

6.1.3.11 CWDM F/O Multiplexor

This unit performed well for HDSDI video transmission of the Pilot, Science and Scorpio cameras and Ethernet download of Scorpio images.

6.1.3.12 Sonars

6.1.3.12.1 Doppler

During strong currents, the Doppler track will divert strongly in DVLNAV. The origin of the problem is not clear if it is an instrument parameter misconfiguration or a DVLNAV internal calculation.

Future modification/requirements:
- Consider a training course for some of the team members.
- Possible liaise with WHOI

6.1.3.12.2 Tritech Imaging

This unit worked well for the duration of the cruise.

Future modification/requirements:
- Check oil levels in sonar head.
- Look at options with regards to connectors and compatibility with HyBIS 4K unit (as a spare)

6.1.3.12.3 Digiquartz Pressure Sensor

Some differences were noted in the depth between Digiquartz sensor and the Sonardyne WMT beacons. As a result, it may be worth having the sensor checked for any discrepancies that may have creeped in over the years. Note: comparing an acoustic derived USBL beacon depth to a pressure sensor is not an accurate method.
Future modification/requirements:
- Look to get unit calibrated.

6.1.3.13 CTD

The CTD worked well for the duration of the cruise. The data recorded were used and plotted up by our physical oceanographers on-board.

Future modification/requirements:
- Check the last calibration date and find out if a recalibration is needed.

6.1.3.14 High Voltage Power/ Starboard Junction Box

During the post dive of dive 279, it was found that the male subcon connector and blanking plug were damaged and showing signs of a short (burnt). Further investigation revealed that a current path was also present between the positive 240v pin and the vehicle chassis. This fault was most likely the DC ground fault that had appeared during the previous dives. To avoid timely junction box draining and re-comping of the vehicle, it was decided that the connector be removed and the conductors be potted in a 3M splice kit. Once repaired, the DC ground fault disappeared and no more DC GF happened during the rest of the cruise.

Future modification/requirements:

- Replace the DC deck lead connector and the isolating AC-DC relay inside the Starboard junction box.
- Check no voltage is present on the DC plug when the AC is turned on.

6.1.4 ROV Topside Systems

6.1.4.1 GF Monitoiring

During several dives, we encountered different DC and AC problems. The DC problem was finally solved once the Aft light lead and the DC deck lead connectors were repaired. The AC GF usually appeared when Isis was on deck and during the first hundred meters of the dive. During the diving immersion, the AC GF gradually disappeared. It is not clear were the origin is from, but probably a Subconn connector.

Future modification/requirements:

- Investigate GF

6.1.4.2 Jetway

During one of the dives, the Jetway temperature rose up to XX degrees, this being noticed during the hourly rounds that the 3rd engineer performs. The inspection found that the Jetway AC unit had frozen due to the misplacement of the thermocouple. This caused the unit to never defrost.

Future modification/requirements:

- Inspect all A/C units.
- Remove transformer lid and inspect transformers. Replace oil if necessary.

6.1.4.3 Engineer PC

No problems reported for the duration of the cruise.

6.1.4.4 Pilot PC

No problems reported for the duration of the cruise.

6.1.4.5 Topside PC

No problems reported for the duration of the cruise.

6.1.4.6 Database PC

The new database /telemetry logging software version was tested on this cruise. This new version suffered from different issues compared to the previous version, whereby crashing during the dives was taking place. The main issues found were:

- Unexpected length and data format messages received, making the main process crash.
- Application and graphical environment crashing due to system memory run out.

To help resolve these issues during the cruise, the data processes have been significantly improved by filtering of the received data. This has worked well with no more crashes happening for this reason. The dynamic memory allocation was improved saving memory in the buffers, but this has not been totally successful, with some leak or high consumption use occurring. To avoid crashing, the memory has been cleared between dives. The improvements made during the cruise have proven to work well for the last 6 or 7 dives.

Future modification/requirements:

- Special attention required in the start-up procedure and memory management.
- Improve dynamic memory allocation

6.1.4.7 Overlay Data Display

An overlay data injector has been implemented on the pilot HD camera for this cruise. The data are injected directly from the database/telemetry logging software. The overlay display seems to work well and was proven to be useful during the vehicle flying, with different options to display data through the software interface. However, some data seem to be more useful than others, therefore some improvements need to be considered within the team about what data are found to be more useful and where in the screen to display them. Different screen layouts can be implemented for the choice of different users

Future modification/requirements:

- Look at options with team as to how we progress.
- Possible use of buttons for selection of displays as per HyBIS system?
- Scientists asked about displaying vehicle coordinates in the science camera. This request can be considered by the means of adding a secondary injector for the use in the science camera, with different options for scientist data display if requested, and the possibility to record this data with the video. To be considered/discussed for future cruises.
- One particular issue about the HDMI injector unit is that it needed to be power cycled almost every time the vehicle and cameras were powered up. This needs to be investigated and reported to the manufacturer.

6.1.4.8 CLAM PC

During Dive 274, the CLAM computer stopped receiving the serial output from the Winch control unit. After a quick check on the serial line of the computer and the output of the CLI, it was found the COM Port of the computer had failed. This was a severe problem not because of the loss of the Delta calculation, but due to the fact that CLAM software includes several scripts that perform data conversions for other computers. Therefore, no data was being sent to DVLNAV, OFOP and Techsas.
To be able to continue operations, the serial output was connected to a Moxa and forwarded to the CLAM computer. The Labview software was also modified to be able to use the new virtual COM Port. This allowed the CLAM software to run again correctly and all the data conversions be done.

Future modification/requirements:

- Buy new servers since the HP G5 servers are 10 years old and are at their End of Life. Not doing this could put in risk the ROV operations. Note: Some machines run Windows XP, so compatibility issues could arise and a testing period needs to be done.
- Study how to move the conversions scripts from Labview to another computer.
- Investigate integration of the translation of the ROV Sonardyne coordinates from the Sonardyne system to DVLNAV into the main topside system (Antonio notes)

6.1.4.9 DVLNAV PC

Occasionally, the GYRO would stop being received. Rebooting the machine solved the issue. Also, it was noted at the middle of the cruise the server had a yellow fault light in the front. A reboot of the machine solved the issue and it did not appear any more.

Future modification/requirements:

- Buy new servers since the HP G5 servers are 10 years old and are at their End of Life. Not doing this could put in risk the ROV operations. Note: Some machines run Windows XP, so compatibility issues could arise and a testing period needs to be done.

6.1.4.10 Tritech PC

This computer has a failed COM Port, so a Moxa is being used to have a virtual COM Port on the computer.
This PC is continuously asking for a window's licence key.

Future modification/requirements:

- Buy new servers since the HP G5 servers are 10 years old and are at their End of Life. (Not doing this could put in risk the ROV operations). Note: Some machines run Windows XP, so compatibility issues could arise and a testing period needs to be done.
- Investigate window's license.

6.1.4.11 Device Controller PC

Occasionally on some dives, the Scorpio software will hang and the intervalometer will stop making auto photos. Closing and opening the software resolved the issue.

6.1.4.12 Sonardyne PC

The battery charging of the Sonardyne WMT beacon is currently done from the laptop used to download the Scorpio images. The software to connect to the beacons is also installed in the Sonardyne PC, which could be easily used to do this task. Unfortunately, there is not a serial port available and no drivers for a serial to USB converter.

Future modification/requirements:

- Investigate the addition of serial port and associated drivers.

6.1.4.13 Techsas

During 288, Techsas computer froze. Rebooting the machine solved the issue. This was probably caused by the X-server (IsisData) server crashing and stopping the transfer of the data.

6.1.4.14 X-server

This unit crashed during dive XXX, causing the network folder "IsisData" to be inaccessible. Rebooting the machine solved the issue. Further checks showed that the machine has a faulty RAM module.
Future modification/requirements:

- This unit is becoming obsolete. Need to study the feasibility of moving the IsisData folder to the mac mini with the LaCie drives or buying a dedicated NAS solution (e.g. QNAP rack server).

6.1.4.15 Workshop PC

This computer broke. It was used to access the spares list from the workshop.

Future modification/requirements:

- Needs repair.

6.1.4.16 Prizm

During dive XXX, the diagnostic software showed a warning that the power supply voltage of the Subsea XXX unit was 4.9V, just below the recommended 5.0V-5.1V. Since it was not a serious problem to the ROV operations, this problem was regularly checked to identify if it became worse.

Future modification/requirements:

- Needs investigation to determine if the power supply or the modem board is breaking down.
- Consider buying a spare modem board.
- Investigate possibility of relocating the PRISM unit so that connections are more accessible.

6.1.4.17 Joybox

Occasionally, the unit powered off and restarted two seconds later. Probably the internal PC is becoming obsolete and faulty.

Future modification/requirements:

- Start a development project to produce a joybox that communicates with topside.

6.1.4.18 Network Time Protocol (NTP) Server

Prior to the cruise, an NTP server and remote network time/ date display were installed in the control van. The server is configured with dual network ports so that one can be sited on the ship network for synchronisation with the ship NTP server and the other sited on the ROV network for all control van synchronisation. Additional Longitudinal Time Code (LTC) outputs allowed for connection of video recording devices, namely AJA KiPro decks to be permanently synchronised, eliminating previous manual setting procedures.

This setup worked well, though occasionally the ROV server would lose lock with the ship server. This could be resolved by manually resetting the ROV server. The handbook did not detail any information relating to this so will require clarification with the manufacturer on return.

6.1.4.19 Remote Computers and Displays

Two Imac computers were setup in the main laboratory connected to the ROV network. This enabled read only access to the ROV data recorders for scientific analysis.

An HDSDI fibre live video feed was routed from the ROV video recorders via the hangar to the main lab infrastructure fibres for display at the plot table.

A remote KVM matrix station also enabled scientists to access and display some of the ROV computers in the main lab. This was also extended to the plot table display.

The ROV 4 channel Axis video server was attached to the ship network for broadcast of compressed reduced frame rate video. This could then be viewed on any computer attached to the network.

To provide the Bridge with this display, software was installed on the Ship OFOP computer connected to the Avocent matrix.

The Bridge was also provided with the ROV Sonardyne Ranger2 display by installation of a vga splitter and ship Avocent matrix unit in the Control Van.

6.1.5 Isis ROV Dive Hr Summary

Table 6.1: Isis dive summary.

Cruise No.	Dive No.	Dive Hrs Decimal	Dive Hrs:Mins:Sec	Cruise Total Hrs Decimal	System Total Hrs decimal	Max Depth (m)	Bottom Time Hrs:Mins:Sec	Bottom Time (Hrs Decimal)
JC136	269	16.950	16:57:00			1530	14:15:00	14.250
	270	21.050	21:03:00			830	19:17:00	19.283
	271	23.333	23:20:00			1298	20:57:00	20.950
	272	18.983	18:59:00			632	17:33:00	17.550
	273	11.750	11:45:00			2150	7:37:00	7.617
	274	15.800	15:48:00			194	14:26:00	14.433
	275	15.883	15:53:00			870	13:52:00	13.867
	276	18.100	18:06:00				16:58:00	16.967
	277	14.800	14:48:00			610	13:25:00	13.417
	278	19.433	19:26:00			893	17:45:00	17.750
	279	17.633	17:38:00			1013	15:20:00	15.333
	280	13.283	13:17:00			884	11:46:00	11.767
	281	16.200	16:12:00			934	14:03:00	14.050
End of Leg 1	282	5.983	5:59:00			1216	3:48:00	3.800
	283	15.400	15:24:00			593	13:48:00	13.800
	284	3.367	3:22:00			1100	1:07:00	1.117
	285	2.183	2:11:00			963m	0:27:00	0.450
	286	14.967	14:58:00			589	13:24:00	13.400
	287	25.167	25:10:00			1045	22:58:00	22.967
	288	17.917	17:55:00			891	16:21:00	16.350
	289	12.867	12:52:00			859	11:11:00	11.183
	290	12.083	12:05:00			1147	10:19:00	10.317
	291	17.717	17:43:00			591	16:15:00	16.250
	292	18.017	18:01:00			1202	15:53:00	15.883
	293	19.017	19:01:00			851	17:27:00	17.450
	294	3.033	3:02:00			1277	1:03:00	1.050
	295	8.700	8:42:00			1057	6:37:00	6.617
	296	16.050	16:03:00			1163	14:09:00	14.150
JC136 Totals	28		415:40:00	415.67	4196.48	2150	362:01:00	362.017

6.1.6 Appendix-Cruise Daily Event Notes

Sat 14th May

Set sail from Southampton 09:00 hrs

- Umbilical termination and load test (7000 kg held for 5 mins)
- Vehicle connected to umbilical and HV tests carried out

Sun 15th May

- Continue steam to work site

Mon 16th May

- Continue steam to work site
- Rigged deployment weight and termination for wire stream.

Tues 17th May

Arrive on station 05:00 hrs Anton Dohrn Seamount

Operation	CTD Cast 1
Deployed	05:07 hrs
Recovered	07:03 hrs
Max Depth	2220 m

Operation	Wire Stream
Deployed	08:00 hrs
Recovered	11:00 hrs
Max Depth	2220 m

- 1 x C5 beacon attached to streaming weight
- 1 x WMT attached to streaming weight
- 1 x WMT attached to wire at approx. 100 m from weight
- All tracked well (however, tracking 2 x beacons at once gave better results, faster update/turnaround time)

Operation	Shallow Mooring Deployment
Deployed	
Depth	800 m

Operation	Deeper Mooring Deployment
Deployed	
Depth	1750 m

Operation	ROV Dive 269
Deployed	16:29 hrs
Recovered	09:26 hrs (18th May)
Max Depth	1530 m

- Suction nozzle came off hose whilst sampling first sight
- Depth bias set at -57 kg (57 kg of buoyancy with 2 x throw away weights)
- Vehicle configured with 2 x crates of 6 magnetic tubes, 12 x large magnetic tubes, bio boxes, scoop, and suction sampler
- With 1 x WMT beacon on the ROV and 1 x WMT beacon on the wire at 150 m wire out, gave a much better indication as to where the umbilical is relative to the ROV.

Wed 18th May

Recover ROV (Dive 269) 09:26 hrs

- Following the end of the dive, the vehicle lost coms at approx. 08:20 hrs. An attempt to regain communication was made, but without success.
- Dead vehicle recovery took place without problems
- Samples retrieved once secured on deck.
- Vehicle powered up to check coms. All appeared ok with no F/O issues
- Torque identified in umbilical following the removal of the wire from the storage drum, when a few lays opened up on recovery. This torque was transferred through the traction winch back to the vehicle termination. At this point, it was thought that the loose turns could remain for the next dive or so. Following the removal of the bullet from the vehicle, it was noted that there was more turns than first thought.
- The termination and Fibre/Electrical connection was removed from the vehicle, inspected, tested and reconnected. All 3 x fibres had the same attenuation as per start of cruise. The OTDR identified no faults or events in the 8 km of umbilical.
- During pre-dive, the Port Vertical thruster would not enable. Following diagnostics, it was identified the pod would need to be removed and opened. Possible driveblock replacement.

Relocate for AUV deployment

CTD Deployed	Cast 02	10:26 hrs
CTD Recovered		11:21 hrs
AUV deployed	Dive 01	13:20 hrs
AUV recovered		15:00 hrs

- Vehicle dropping its abort weight (fault to be investigated)

Weather too rough for any further ROV and AUV deployment, with forecast to worsen over next 24 hrs
(concerns over the reliability of the ROV, and the very short window of time for a dive in marginal conditions)

CTD Deployed	Cast 03	15:33 hrs
CTD Recovered		16:29 hrs

CTD Deployed	Cast 04	18:59 hrs
CTD Recovered		20:24 hrs

Ship relocated to mooring positions, for health check of ADCPs

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Thurs 19th May

07:30 hrs Weather still not suitable for AUV or ROV operation

CTD Deployed	Cast 05	08:10 hrs
CTD Recovered	Cast 19	20:38 hrs

Multiple casts without returning to deck. This was done to reduce the risk of damage during the launch and recoveries in the marginal sea state.

ROV
- ROV PV thruster drive block replaced and tested.
- Lights adjusted to try improve spread of illumination (4 x Aphos 16)

AUV
- Possible fault identified with sub. Water ingress into battery harness Burton connector

Sitrep 01 sent to: nocs_nmfss_deptheads@noc.ac.uk
nocs_nmfss_progman@noc.ac.uk
masterjc@noc.ac.uk

Friday 20th May

Weather evaluated	(WOW)	05:00 hrs
Weather evaluated	plan to CTD until improvement	08:30 hrs
CTD Deployed	Cast 20	08:40 hrs
CTD Recovered		09:39 hrs

WOW
Sudden change of plan with regards to Isis F/O issue encountered.
It was decided that we should use different fibres for next dive, even though existing ones checked out ok.
Red to be used as vehicle
Grey to be used for CWDM
Grey appeared to have 18dB attenuation when checked through. This was narrowed down to the fibre from the slipring to the junction box on the side of the winch. (cheese box) approx. 10dB losses.
The interconnect lead from the drum JB through the slipring to the winch JB was switched, putting the now not to be used black fibre on it.

Red F/O from vehicle to container	1310 8.06dB	1550 6.64dB
Grey F/O from vehicle to CWDM	1310 4.80dB	1550 5.90dB

Note: As the red fibre did not fail on the previous dive, it was thought this would be the safest to use for the vehicle, leaving the grey for the CWDM and HD cameras. From the previous cruise, it was noted that the black had indeed been the one that failed first due to possible torque issues.

Operation	ROV Dive 270
Deployed	18:25 hrs
Recovered	15:27 hrs (21st May)
Max Depth	830 m

Sat 21st May

Continued ROV dive
ROV Recovered 15:27 hrs
All sample tubes, bio boxes and chambers filled with samples
No signs of torque in the umbilical, and no issues with F/O during the dive.

Operation	ROV Dive 271
Deployed	18:09 hrs
Recovered	17:29 hrs (Sun 22nd May)
Max depth	1298 m
24 x magnetic tubes	
1 x large bio box	

Sun 22nd May

Continued ROV dive
ROV Recovered 17:29 hrs

(Marginal 25-27 knots weather recovery, no problem encountered)
All sample tubes, bio boxes and chambers filled with samples
No signs of torque in the umbilical, and no issues with F/O during the dive.
Suction sampler nozzle replaced after getting broken whilst trying to stow at the start of the dive. Fortunately, most sampling could be achieved using the manipulator jaws.

Need to check umbilical termination for signs of turns following next dive

Operation	ROV Dive 272
Deployed	20:48 hrs
Recovered	15:47 hrs (23rd May)
Max depth	632 m
18 x magnetic tubes	
6 x push cores	
1 x large bio box	

Slight improvement in weather, wind decreasing to 22-24 knots
Good deployment.

- Umbilical WMT beacon stopped working. More than likely battery is flat.

Mon 23rd May

ROV recovered 15:47 hrs

- Proposed that we take the beacon off the vehicle each time, as it will be fully charged. Charge the one off the umbilical as much as possible and then use on ROV where it can continue to charge. This will require the change of name of the beacon on the Ranger 2 software to avoid confusion.

CTD deployed Cast 21 16:13 hrs
CTD Recovered 16:47 hrs

Transit to 2000 m site (Anton Sea mount)

Operation	ROV Dive 273
Deployed	19:24 hrs
Recovered	07:09 hrs (24th May)
Max Depth	2150 m
18 x magnetic tubes	
6 x push cores	
1 x large bio box	

- With the swap of the beacons from the vehicle to the umbilical, the ident on the software was also changed. In this process, the telegram must also be modified, to account for the programs taking outputs from Ranger 2 (OFOP, DVLNAV)
- AC ground fault developed at approx. 200 m depth 167/400000
- During the dive, a GF was found on the HV light that was thought to be the cause.

Tue 24th May

ROV Recovered 07:09 hrs

- Post dive the HV light was re-wired with the external water contacts removed. New wires and tube were fitted, as there appeared to be water present. Unit tested and proved good.
- Port inner Aphos 16 has a LED with what looks like a loose lens (Ser. No. 0199); this does not appear to affect the performance output.
- During the post dive checks for the thrusters, it was noted that the 40000 kohms was seeing a reduction in resistance when they were energised. This was narrowed down to the PV, PH, which showed a reduction in reading when they were disconnected from the thruster pods. The HPU also seemed to influence this reading when it was also energised. As this seemed to indicate that the fault was not related to the pods or the connectors, investigation into their commonality was carried out. It was decided that the next dive would carry on with the known fault, and could be managed by the isolation of the contributing power supplies as and when required. This next dive was to be short and shallow.

Steam to Rockall (est. 12 hrs, multibeam on the way)

CTD Deployed 18:50 hrs

CTD Recovered 19:11 hrs

Operation	ROV Dive 274
Deployed	19:46 hrs
Recovered	11:34 hrs (25th May)
Max Depth	194 m (shallow)
18 x magnetic tubes	
6 x push cores	
1 x large bio box	

- Due to the shallow water depth, no beacon was put on the umbilical, and only 6 x football floats were attached.
- Known GF on PV, PH and HPU
- GF on HV light.
- CLAM stopped receiving serial data from winch. Identified as com port fail. MOXA put in place and CLAM labview modified for new port configuration.
- GF issues appear to have improved and returned to 40 Mohnms, no GF on any thrusters or HPU?
- GF on HV light disappeared, with no indication visible that the light was now on. Possible complete failure.

Wed 25th May

ROV Recovered 11:34 hrs

- HV light found to have wire not made correctly into DGO pin in connector. Repair made and tested.
- Termination appears ok, no turns visible

Vessel steams to AUV deployment area. On arrival, a fishing vessel was long lining which required the ship to re-locate to a new dive site

Operation	AUV Dive 02 (M114)
Deployed	15:50 hrs
5 hrs on station to monitor AUV	
Recovered	15:00 hrs (Thurs 26th May)

Vessel relocates to ROV Dive site.

Operation	ROV Dive 275
Deployed	21:12 hrs
Recovered	13:04 hrs (26th May)
Max Depth	870 m
24 x magnetic tubes	
1 x large bio box	

- Suction Sampler not sucking as well as it should
- Current washed Isis into -1.5 turns. Turns removed with no F/O issues recorded.

Thurs 26th May

ROV Recovered 13:04 hrs

- Suction sampler hose replaced.
- WMT umbilical beacon charged
- Umbilical vehicle termination checked

Vessel steams back to AUV recovery area.

AUV Recovered 15:00 hrs (23 hr mission)
- EM2040 appears to have stopped working following the departure of the monitoring stage.
- No EM2040 data obtained for the survey area
- Team are hopeful they can pull enough information from side scan data to determine terrain and suitability for running camera survey?

CTD Deployed (Cast 23) 16:00 hrs
CTD Recovered 17:15 hrs

Vessel steams to new ROV dive site

Operation	ROV Dive 276
Deployed	18:26 hrs
Recovered	12:32 hrs (27th May)
Max Depth	1221 m
18 x magnetic tubes	
1 x large bio box	
6 x push cores	

- GF fault on AC side appears on power up and deployment GF 214/26000K. As vehicle dives this improves to full 214/40000K. Still remains a bit of a mystery.

Sitrep No.2 Sent

Fri 27th May

ROV dive continued

ROV Dive Recovered 12:32 hrs

- Joy box controller connector check due to occasional switching off when moved. Slight wear on outer sheave, so new piece of protective tube put into place.

Vessels steams to AUV deployment site

CTD Deployed Cast 24 12:52 hrs

CTD Recovered		14:16 hrs
AUV Deployed	Dive 3 (M115)	15:00 hrs

- Issue with AUV achieving correct depth for camera survey. Decision made to continue dive and take EM2040 data from a lower altitude than original planned. This will mean the ends of the lines may suffer from gaps, but the planned diagonals should give good overlap.

Vessel relocated to ROV deployment site

Operation	ROV Dive 277
Deployed	19:34 hrs
Recovered	10:22 hrs (28th May)
Max Depth	610 m
24 x magnetic tubes	
1 x large bio box	

- GF an AC 214/90000K on deployment. Again, improved as the ROV descended.

Sat 28th May

Continued ROV Dive

ROV Recovered 10:22 hrs

- Visual inspection of bullet termination.
- Visual inspection of tugger wheel assembly

Vessel relocates to AUV recovery station

AUV Recovered 14:00 hrs

- As noted on deployment, the avoidance sonar prevented the AUV from descending to a suitable altitude for carrying out the camera survey. The mission was completed using the EM2040 multibeam system, where suitable was obtained for the duration of the dive.

DS2 (Mr ROV Sled) Deployed 15:00 hrs

Operation	ROV Dive 278
Deployed	17:14 hrs
Recovered	12:40 hrs (Sun 29th May)
Max Depth	893 m
24 x magnetic tubes	
1 x large bio box	

- ROV movement from side to side. Possible tugging from fishing line entanglement, or caught off small cliff face.

- Floats seen in rear camera. Umbilical beacon appears to be streaming away from vessel and ROV
- Change of heading and course.
- Football floats disappear from rear view.
- Umbilical beacon moves 50 m to a more expected location. Vehicle behaviour appears normal again.

Sun 29th May

Continued ROV Dive

ROV Recovered 12:40 hrs

- On recovery, 4 x football floats were pushed together on the umbilical, indicating signs of being caught. No damage to umbilical recorded.

Vessel relocates to AUV launch station

AUV Deployed Dive 4 (M116) 14:30 hrs

Vessel relocates to ROV launch station

Operation	ROV Dive 279
Deployed	17:35 hrs
Recovered	11:13 hrs (Mon 30th May)
Max Depth	1013 m
24 x magnetic tubes	
1 x large bio box	

- Bullet light failed. GF seen on monitor. Unable to switch light off to isolate GR -6/40000K

Mon 30th May

Continued ROV Dive

- Bullet light fail was later able to be switched off on GUI?

ROV Recovered 11:13 hrs

- DC deck lead has seen water ingress and signs of an electrical fault to ground. Connector blank damaged, and connector charred.
- Tests reveal when on HV 90V DC can be seen between a pin and the vehicle chassis.
- Conclusion that relay in HV JB may be faulty.
- To avoid timely junction box draining and re-comping of the vehicle, it was decided that the connector be removed and the conductors be potted in a 3M splice kit.

- Bullet light had been knocked, pulling the tail and connector tight, such that water would have been able to reach the pins. Possible knock could have taken place when the docking head was lowered for snubber inspection.
- Bullet light failed to work after testing.
- Bullet tail found to be spliced (badly) with signs of water ingress. Again, to avoid draining the HV JB the tail was also potted into the same 3M splice kit that the DC cable tail had been.
- Draw 2 light re-positioned as bullet light. GUI altered to reflect change.

Vessel relocates to AUV Recovery station

AUV Recovered 13:00 hrs

- Good AUV dive with near bottom images collected. Visual indication that the SUV had made contact with the seabed on occasion.

Vessel relocates to ROV launch station

Operation	ROV Dive 280
Deployed	18:15 hrs
Recovered	07:32 hrs (Tue 31st May)
Max Depth	884 m
18 x magnetic tubes	
1 x large bio box	
2 x Grinders (on trial)	
3 x Marcus GoPro's	

- White suction chamber mesh removed to improve suction. White chamber only used for passing water through.
- Strong currents encountered.
- Motor controller over current fault encountered whilst on full laterals

---

Tue 31st May

Continued ROV Dive

ROV Recovered 07:32 hrs

- Grinders appeared to work ok.
- Water blocked DC deck cable and bullet light tail worked well, no faults reported.

Vessel steams to new work site.
CTD Deployed Cast 25 12:30 hrs
CTD Recovered 13:30 hrs

Operation	ROV Dive 281
Deployed	15:15 hrs
Recovered	07:28 hrs (Wed 1st June)
Max Depth	934 m

24 x magnetic tubes
1 x large bio box
Cutter
Suction sampler
3 x GoPro's

- Control box connector needs replacing.
- Keep an eye on Altimeter, possible issue developing.

Wed 1st June

Continued ROV Dive

ROV Recovered 07:28 hrs

Short steam to location slightly deeper on the seamount

Operation	ROV Dive 282
Deployed	09:42 hrs
Recovered	15:41 hrs
Max Depth	1216 m

24 x magnetic tubes
1 x large bio box
Cutter
Suction sampler

- Short dive with a few samples taken

CTD Deployed Cast 26 15:59 hrs
CTD Recovered 13:30 hrs

Ship starts multibeam survey and steam to Stornoway

Thurs 2nd June

Continued steam to Stornoway
Sitrep 03 sent

Fri 3rd June

Vessel Arrives Stornoway 08:00 hrs
Change of scientists and Sat dish repairs
Vessel Departs 18:30 hrs

Sat 4th June

Arrive on station 08:00 hrs

CTD Deployed Cast 27	08:00 hrs
CTD Recovered	09:00 hrs

- CTD having issues with topside control. Re-termination required.
- Re-termination carried out (4-5 hrs)

Change of plan. CTD cancelled and AUV operations brought forward.

Vessel relocates to AUV launch station

AUV Deployed	Dive 5 (M117)	08:55 hrs

Vessel relocates to ROV launch station

Operation	ROV Dive 283
Deployed	14:34 hrs
Recovered	05:58 hrs (Sun 5th June)
Max Depth	593 m
24 x magnetic tubes	
1 x large bio box	
1 x box push cores	
Suction sampler	

Prior to dive:

- Rear light cable harness damaged by thrusters, stbd side. This must have occurred during recovery, as no GF noticed.
- The new two-way light harness has been joined to the existing port side connector. The damaged starboard harness has been cut short and blanked off. Both rear lights now to run off single power supply and harness.
- GUI modified to reflect changes. Rear port light now turns on both rear units. Starboard light isolated.
- Strong currents encountered, unable to maintain required for transect. Up to 1.0 knots
- Decision to follow tidal curve where possible. Prediction supplied by Russian scientists (matlab)
- Subsea cables running W to E, 4 km to the north
- GF 215/40000K for full duration of dive
- CLAM crashes during the accent and recovery period

Sun 5th June

Continued ROV dive	
ROV recovered	05:58 hrs

Vessel relocates to AUV Recovery station

AUV Recovered	08:37 hrs

- Good multibeam data achieved

CTD Deployed Cast 28	09:36 hrs
CTD Recovered	10:35 hrs

Operation	ROV Dive 284
Deployed	11:41 hrs
Recovered	15:03 hrs
Max Depth	1200 m
24 x magnetic tubes	
1 x large bio box	
1 x box push cores	
Suction sampler	

- Dive aborted due to zero visibility/strong currents
- 1 x set of magnetic lids lost. Cable ties appear to have been removed for sampling and when not used forgotten to be replaced
- Pilot pan and tilt rotate centre screw was noted as loose during pre-dive. Unit removed and bolt secured.

Vessel move for CTD

CTD Deployed Cast 29	15:54 hrs
CTD Recovered	16:48 hrs

Vessel move to new ROV dive site

CTD deployed Cast 30	17:52 hrs
CTD Recovered	18:43 hrs

- Turbidity reading significantly better than previous ROV deployment site.

Operation	ROV Dive 285
Deployed	19:16 hrs
Recovered	21:30 hrs
Max Depth	963 m
24 x magnetic tubes	
1 x large bio box	
1 x box push cores	
Suction sampler	

Various discussions held to determine best option to utilise time and to deal with the subsea conditions (high turbidity)

- Due to visibility being pretty much zero, it was decided to abort the dive and relocate to the next work site (Rosemary Bank)

Start steam to Rosemary Bank 22:00 hrs (approx.)

Mon 6th June

Arrive Rosemary Bank 07:00 hrs

CTD Deployed Cast 31 07:06 hrs
CTD Recovered 08:10 hrs

- High turbidity encountered
- At 5 m off bottom, altimeter not able to read. With CTD raised 2 m altimeter reading 7 m
- Concerns over suitability for AUV camera dive.
- Possible option to add GoPro to CTD with light to record turbidity, and compare to ROV conditions experienced previously.

Decision made to run AUV multibeam dive, then look at ADCP data to try to see if again high turbidity is present, to determine if camera run is feasible. In addition, this will determine if the topography is also suitable, which could rule out turbidity concerns.

Note: this high concentration of marine snow is a very rare occurrence with experiments deployed over three years to try to capture it. Some excited physical oceanographers, but not why we are here!!!

AUV Deployed Dive 6 (M118) 09:58 hrs (multibeam)

Vessel relocates to 500 m ROV dive site (approx. 2 hrs)

CTD Deployed Cast 32 14:53 hrs
CTD Recovered 15:31 hrs

- GoPro and light attached to check visibility for ROV dive.
- Couple of images achieved with clarification of clear water.

Operation	ROV Dive 286
Deployed	16:02 hrs
Recovered	07:01 hrs (Tue 7th June)
Max Depth	589 m
24 x magnetic tubes	
1 x large bio box	
1 x box push cores	
Suction sampler	

- Good dive with no vehicle problems encountered.

Tue 7th June (light winds calm seas)

Continued ROV dive (Rosemary Bank)
ROV Recovered 07:01 hrs
Vessel steam to pick up AUV (approx. 1.5 hrs)

AUV Recovered 09:30 hrs

-

Vessel steam to new ROV deploy site (approx. 2 hrs)

CTD Deployed Cast 33 11:49 hrs
CTD Recovered 13:06 hrs

- GoPro + light attached

Operation	ROV Dive 287
Deployed	13:52 hrs
Recovered	15:02 hrs (8th June)
Max Depth	1045 m

24 x magnetic tubes
1 x large bio box
1 x box push cores
Suction sampler

-

Wed 8th June

Continued ROV dive
ROV Recovered 15:02 hrs
Vessel steam to deploy up AUV (approx. 1.5 hrs) Rosemary Bank

AUV Deployed Dive 7 (M119) 16:15 hrs (multibeam dive)
Approx. 2 hrs for monitoring decent

Vessel steam to new ROV deploy site (approx. 1.5 hrs)

Operation	ROV Dive 288
Deployed	19:39 hrs
Recovered	13:34 hrs (Thurs 9th June)
Max Depth	891 m

12 x magnetic tubes
1 x large bio box
6 x tubes without lids
Suction sampler

- GF @ 214/20000Kohm at power up. Within an hr into the dive, GF up to 246/40000kohms
- Techas crashed twice during dive
- DVLNAV gyro stopped. Software re-started.

Thurs 9th June
Continued ROV dive

Sitrep 04 Sent

ROV Recovered 13:34 hrs (18 hr dive)

- Vehicle at capacity with samples
- Techas issue may be resolved, and found to be connected to the database.

Vessel steam to recover AUV

AUV Recovered	15:15 hrs

- EM2040 seem to have stopped working at the later stages of the dive. Looks like most of the area required for the camera survey has been completed and only the additional transits line is missing.
- Further investigation required, possible change in altitude could have caused the issue

CTD Deployed Cast 34	15:22 hrs
SVP	
CTD Recovered	16:16 hrs

Vessel steam to ROV deploy site, 800 m

Operation	ROV Dive 289
Deployed	18:02 hrs
Recovered	06:54 hrs (Fri 10th June)
Max Depth	859 m

12 x magnetic tubes
1 x large bio box
6 x tubes without lids
Suction sampler

- Wireless Joystick appears to have failed. Replaced with spare unit.
- GF dropped to 214/9000Kohm during deployment. Recovered up to 216/40000kohms during dive.

Fri 10th June (slight increase in weather 15-20 knots)
Continued ROV dive

ROV Recovered	06:54 hrs (13 hr dive)

Vessel steam to AUV deployment site (camera run on sponge area)

AUV Deployed	Dive 8 (M120)	10:46 hrs (camera dive)

Approx. 2 hrs for monitoring decent

Vessel move to 800 m site

CTD Deployed Cast 35	13:59 hrs
CTD Recovered	15:03 hrs

- Turbidity reading high.
- GoPro camera not recording

Due to the likelihood of a poor visibility dive, the decision to move to a new site was made.
Vessel re-locates to new dive site

CTD Deployed Cast 36	16:08 hrs
CTD Recovered	17:14 hrs

- GoPro images not worked
- Turbidity at 98% 9 (so much better)

Operation	ROV Dive 290
Deployed	17:53 hrs
Recovered	05:58 hrs (Sat 11th June)
Max Depth	1147 m

12 x magnetic tubes
1 x large bio box
6 x tubes without lids
Suction sampler

- Good dive with all sample objectives achieved
- Lost SV thruster – no comms-thruster re-enabled, no further problems.

Sat 11th June (wind 25-27 knots, sea moderate/increasing)
Continued ROV dive

ROV Recovered 06:54 hrs (12 hr dive)

Vessels move to AUV recovery site.

AUV Recovered 07:30 hrs

- Camera run. Alt achieved 3 to 4 m. 150K images taken
- Multibeam also run for low alt high resolution.
- Good dive worked well

Vessel move to 1300 m ROV site

Weather reviewed at 11:45 following update forecast.
Decision made to delay deployment until a decrease in wind and sea state becomes apparent.
Science to review option to stay on site or start move to GBB station

Decision made to steam to GBB (approx. 16 hrs)

Sun 12th June

Vessel arrive GBB station 06:00 hrs

CTD Deployed Cast 37 06:08 hrs
CTD Recovered 07:14 hrs

AUV Deployed Dive 9 (M121, 1200 m) 09:00 hrs (multibeam dive)
Approx. 2 hrs for monitoring decent

Vessel move to 500 m site

Operation	ROV Dive 291
Deployed	12:08 hrs

Recovered	05:51 hrs (Mon 13th June)
Max Depth	591 m

12 x magnetic tubes
1 x large bio box
2 x blenders
Suction sampler

- Good dive with full payload of samples.
- 2 x blender experiments worked well
- No vehicle faults

Mon 13th June

Continued ROV dive

ROV Recovered 05:51 hrs (17.7 hr dive)

Vessels move to AUV recovery site.

AUV Recovered 07:30 hrs

- Multibeam dive for terrain check for next dive of camera survey

Operation	ROV Dive 292
Deployed	09:19 hrs
Recovered	03:20 hrs (Tue 14th June)
Max Depth	1200 m

12 x magnetic tubes
1 x large bio box
2 x blenders
Suction sampler

- Port Kraft manipulator has developed a slight twitch. This would appear to be on the SA and is likely to be the potentiometer starting to fail.

Tue 14th June

Continued ROV dive

ROV Recovered 03:20 hrs (18 hr dive)

- ROV recovered on watch change. Plan was to give more hrs for the arm repair if required.
- Arm repair narrowed down to the master unit not operating properly.
- Master unit replaced with spare. Arm calibrated and made ready for next dive.
- (time probably logged as down time for ROV, which is unfortunate as the repair could have been easily made in the normal turn-around time.)

CTD Deployed Cast 38	06:44 hrs
CTD Recovered	07:52 hrs

CTD Deployed Cast 39	09:58 hrs
CTD Recovered	10:32 hrs

CTD Deployed Cast 40 11:29 hrs
CTD Recovered 12:05 hrs

Vessel steam to AUV deploy site (1200 m)

AUV Deployed Dive 10 (M122, 1200 m) 14:45 hrs (camera dive)
Approx. 2 hrs for monitoring decent

Vessel move to ROV deploy site (800 m)

Operation	ROV Dive 293
Deployed	17:45 hrs
Recovered	12:31 hrs (Wed 15th June)
Max Depth	851 m

12 x magnetic tubes
1 x large bio box
2 x blenders
Suction sampler

- Successful blender experiments carried out
- Dive completed with all samples collected.

Wed 15th June (weather good 10-15 knots slight sea)

Continued ROV dive

ROV Recovered 12:31 hrs (17.8 hr dive)

AUV Recovered 07:30 hrs (last dive of the cruise)

- Camera flash not working, all images black

Vessel steams to 1200 m ROV sponge dive location (approx. 3 hr)

Operation	ROV Dive 294
Deployed	17:22 hrs
Recovered	20:34 hrs
Max Depth	1277 m

1 x rock box
1 x plastic box
1 x bucket
Suction sampler

- Dive pulled due to poor visibility

Change of plan. Due to no suitable images obtained from AUV it has been decided that the 500 m video survey site from ROV will be used as a video transect, and that the AUV will no run a short low alt multibeam dive to ground truth the video data.
AUV experiencing the same power issues as previous cruise where the use of more than one major sensor (multibeam, side-scan or camera) generally causes a failure.

Vessel steam back to 500 m site

Thurs 16th June

AUV Deployed Dive 11 (M123, 500 m) 06:00 hrs (multibeam)
Approx. 1.5 hrs for monitoring decent

Vessel move to ROV 1000 m site

Operation	ROV Dive 295
Deployed	08:34 hrs
Recovered	17:16 hrs
Max Depth	1057 m
12 x magnetic tubes	
1 x large bio box	
6 x magnetic tubes	
Suction sampler	

ROV Recovered 17:16 hrs (9 hr dive)

AUV Recovered 18:30 hrs

- Multibeam survey worked well.

Vessel steam to Anton Dohrn Seamount (approx. 14 hrs)

Sitrep 05 Sent

Fri 17th June

Arrive Anton Dohrn Seamount 08:30 hrs

Release 1175 m mooring 08:47 hrs
On surface 09:01 hrs
Recovered 09:35 hrs

Release 795 m mooring 10:00 hrs
On surface 10:09 hrs
Recovered 10:45 hrs

CTD Deployed Cast 41 11:13 hrs
CTD Recovered 12:29 hrs

CTD Deployed Cast 42 13:37 hrs
CTD Recovered 14:36 hrs

AUV Deployed Dive 12 (M124, 800 m) 17:00 hrs (multibeam) Final AUV Dive
Approx. 1 hrs for monitoring decent

- Ground-truthing of ROV video transect, in light of not obtaining good camera run from AUV

Operation	ROV Dive 296 (Final ROV Dive)
Deployed	18:32 hrs
Recovered	10:35 hrs (Sat 18th June)
Max Depth	1163 m

12 x magnetic tubes
1 x large bio box
6 magnetic tubes
Suction sampler

- Good dive with all samples achieved
- On the vehicle accent a turns test was carried out. CWDM fibre cut out after 1 turn counter clockwise. Decision for further turns cancelled.
- Testing of hydraulic motor for drill on next cruise. Due to the use of small-bore hose, the motor was only able to achieve a low rpm.

Sat 18th June (weather starting to deteriorate)

Continued ROV dive

ROV Recovered 10:35 hrs (16 hr dive)

- Start of HV isolation and removal of umbilical.
- Inspection of inner umbilical under the termination revealed no signs of turns.
- First cruise where no re-termination was required.

AUV Recovered 13:40 hrs

- Good multibeam dive.

CTD Deployed Cast 43 15:12 hrs
CTD Recovered 15:45 hrs

End of Science

6.1.7 Appendix - ROV Vehicle Specification

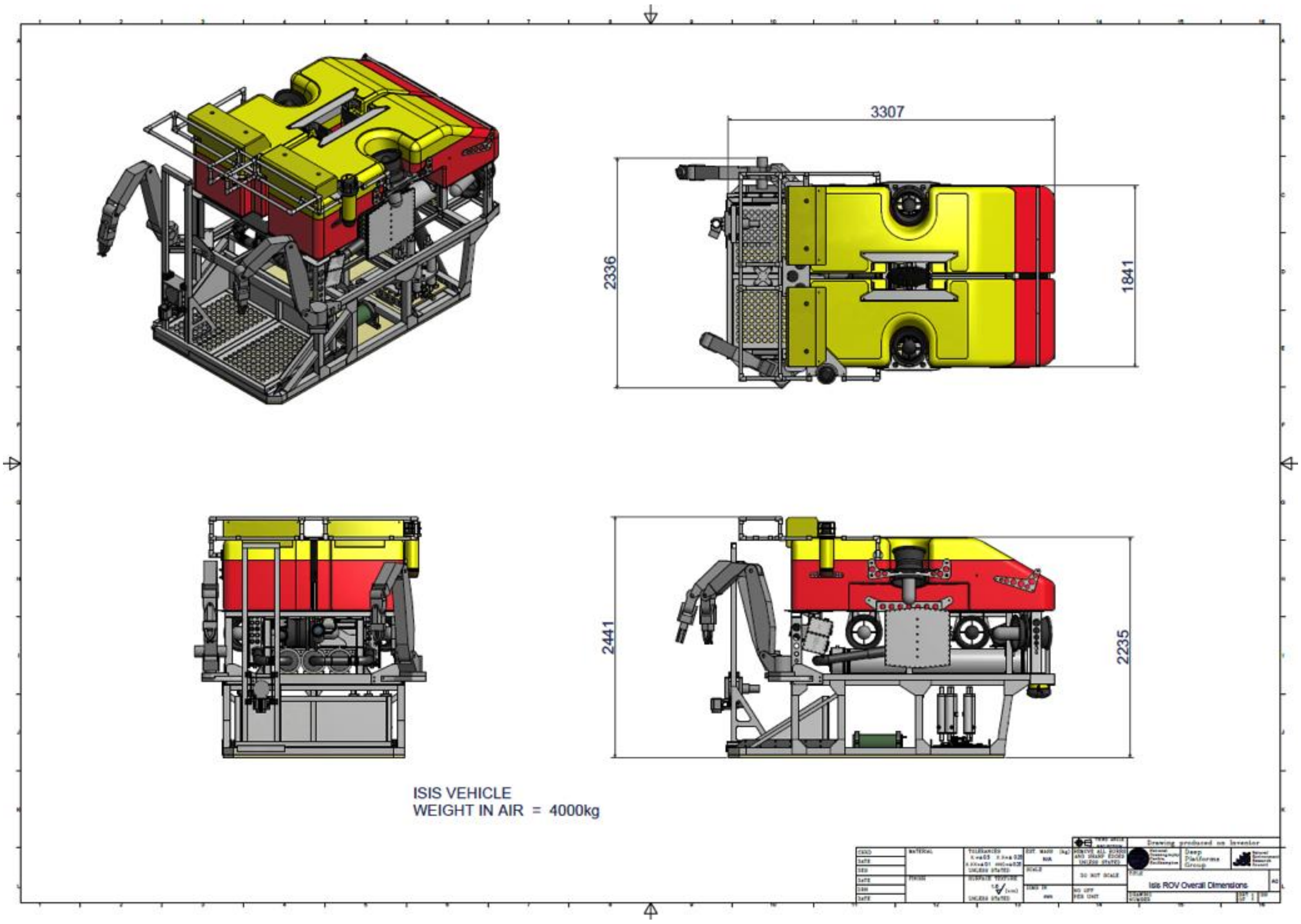

Figure 6.3: Schematic of the Isis ROV used during the JC136 cruise

Maximum Operating Depth	6500 m
Size	3.3 m (L) x 2.3 m (W) x 2.4 m (H)
Weight	In air: ~3750 kg In water: neutrally buoyant
Payload	up to 90 kg (in water weight)
Propulsion	6 x 5HP Brushless DC Electric Thrusters (113 kg force/motor)
Umbilical	Rochester 0.68" (17.4 mm dia 3 core triple armoured 3 fibre single mode (Part No. A302351)
Electrical Power	Pmax: ~18 kW at 6500 m (2800 V@ 400 Hz)
Hydraulic Power	1 x 3.7 Kw (5HP) HPU Max pressure 3000 psi (207 bar) Max Flow 21 L/min @ <1700 psi Max Flow 12.5 L/min @ > 1700 psi 8 Function Manifold
Max Vehicle Speed	Fwd: 1.5 knot, Lateral: 0.5 knot, Vertical: 0.7 knot
Max on Bottom Transit Speed	0.5 knot
Descent/Ascent Rate	40 m/min
Auto Functions	Depth (+/-1m), Altitude (+/-1m), Heading (<=+/-1°)
Manipulators	1 x Schilling Titan 4 (7 function) 1 x Kraft Predator (7 function with force feedback)

6.2 Autosub6000 AUV missions

Lead persons – Nils Piechaud and Autosub 6000 team: James Perrett, Rachel Marlow, Dave Paxton

6.2.1 Introduction

The Autosub6000 AUV was used for a total of 12 missions on the JC136 campaign for multi-beam, side scan and photographic surveys. The ADCP intensity data were also used to give an indication of the clarity of the water for later photographic missions and ROV dives. At the end of the campaign, the AUV had collected approximately 120,000 useful images, surveyed over 690 km of EM2040 multibeam track and had collected side scan data on 148 km of track, with a total survey length of 838 km.

6.2.2 Vehicle Build

Table 6.2: Autosub6000 configuration.

Scientific Sensors used	***Sub configuration***
1) RDI workhorse ADCP 300 kHz downwards set to measure up to 30 4 m water bins. 2) Kongsberg EM2040 multi-beam 3) EdgeTech 2200-M 120-425 kHz side scan and 2-16 kHz sub-bottom profiler 4) 2 x Point Grey Grasshopper 2 cameras + Flash (1 x downwards, 1 x forward) 5) Seabird 911 CTD with 2 x SBE3plus, 2 x SBE4C, 1 x SBE43, Seapoint turbidity sensor, EH sensor, Fluorimeter. 6) Applied Physics 1540 tri axis magnetometer.	1) Rear winglets set at 6º pitched downwards. 2) Autosub 6k recovery line retention system with nylon springer lines 3) 17kg positive buoyancy at surface for a water density of 1028 Kg/m^3. 4) 6 x Mk2 lithium polymer battery packs. 5) Lawson Engineering Autosub6000 launch and recovery system (LARS) 6) Ixsea PHINS combined with RDI 300 kHz ADCP for attitude measurement and navigation. 7) Tritech Sea King mechanically steered sonar for obstacle avoidance and altitude control. 8) Linkquest acoustic telemetry. 9) Sonardyne G6 USBL positioning transponder.

Figure 6.4: Autosub6000 on gantry before launch during the JC136 cruise.

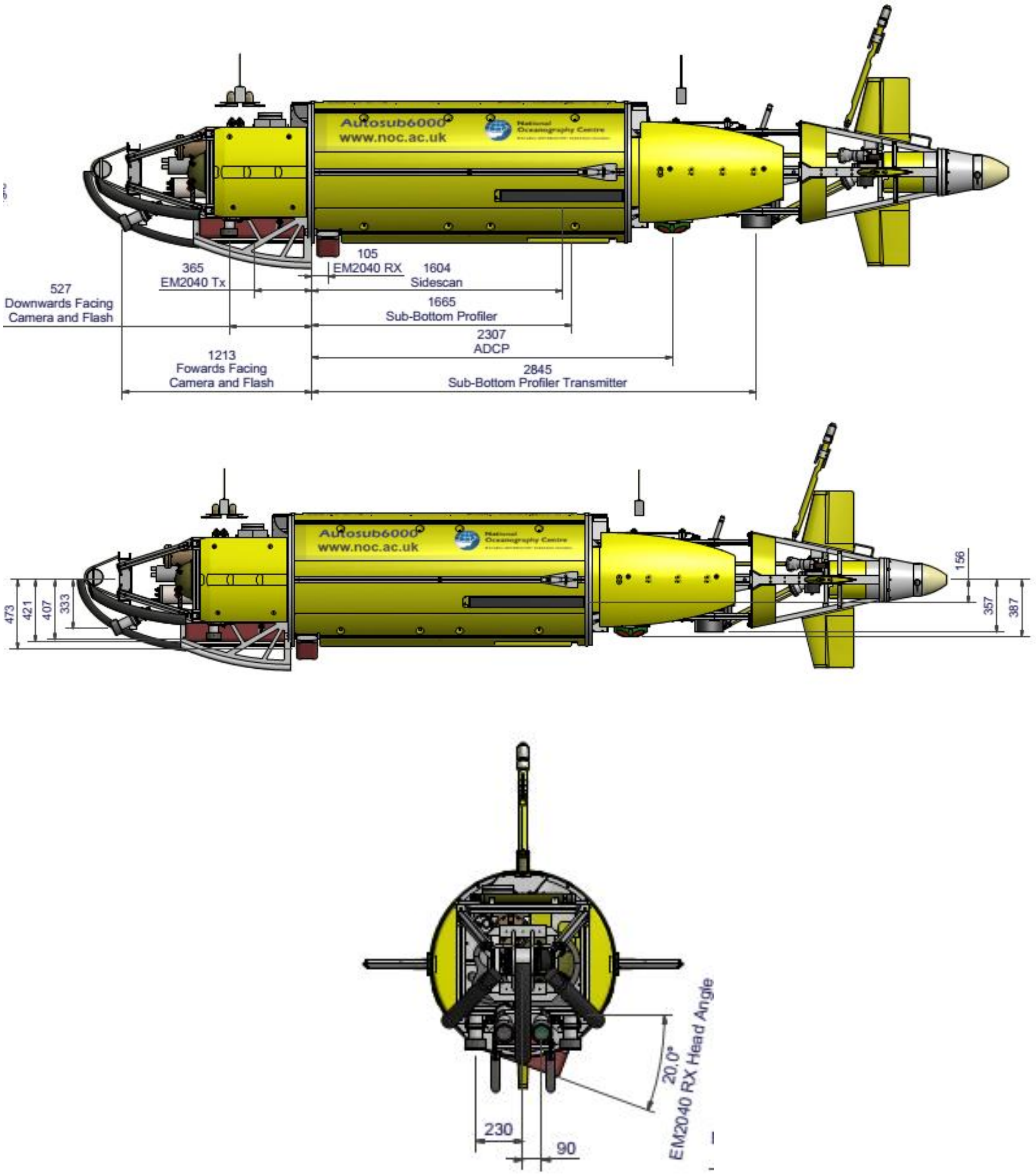

Figure 6.5: Schematic of Autosub6000 showing Sensor locations (measurements in mm). The EM2040 RX head was horizontal for all missions.

6.2.3 Mission Summaries

The following missions were conducted during JC136.

6.2.4 Data by Mission

(All missions collected ADCP, CTD, Oxygen, Turbidity, EH and Magnetometer data in addition to the sensors mentioned in the table below.)

Table 6.3: Summary of Autosub6000 missions. In the Site column, ADS=Anton Dohrn Seamount, GBB= George Bligh Bank, NRB = Rockall Bank, ERB=East Rosemary Bank, WRB=West Rosemary Bank and WTR = Wyville-Thomson Ridge.

Mission	Launch Date	Survey Distance	Site/Depth	Notes on the data
113	10/5/16	0 km	ADS 500 m	Mission aborted due to battery harness problem.
114	25/5/16	83.8 km	NRB 1200 m	All good except multibeam, which stopped after test section of mission.
115	27/5/16	72.9 km	NRB 1200 m	Altitude was too high for successful camera images but wider than expected multibeam obtained instead.
116	29/5/16	81.8 km	NRB 1200 m	Good images and high multibeam obtained, although AUV made contact with the seabed at one point.
117	04/6/16	83.8 km	WTR 1200 m	Good multibeam but side-scan failed to start pinging.
118	06/6/16	84.8 km	ERB 1200 m	Multibeam stopped after grid survey. Side-scan failed to start.
119	08/6/16	65 km	WRB 1200-2000 m	Good side-scan for whole mission data but multibeam stopped working after first 1200 m box. High water currents caused 2000 m survey lines to be short.
120	10/6/16	74.6 km	ERB 1200 m	All sensors worked as expected although there were too many particles in the water for good photographs for much of the mission. The forward range sensor also prevented the vehicle going below 4 m altitude.
121	12/6/16	86.7 km	GBB 1000-1400 m	Good multibeam data.
122	14/6/16	84.2 km	GBB 1000 m	Flashes failed on initial dive but good multibeam data at 3 m altitude. Good altitude control
123	16/6/16	36.9 km	GBB 500 m	Good multibeam data at 15 m altitude.
124	17/6/16	84.2 km	ADS 800 m	Good multibeam data at 15 m altitude

6.2.5 EM2040 Multibeam System

The vehicle is fitted with a Kongsberg EM2040 multibeam sonar system offering (under the most favourable conditions) up to 400 beams with an angular range of +/-70 degrees across track and a 0.4 degree beamwidth along track. On JC136, it was used at 200 kHz (which gives an 0.7 degree along track beamwidth), 300 kHz and 400 kHz (which gives an 0.4 degree along track beamwidth) depending upon the type of mission. As an experiment, it was run at up to 20 Hz ping frequency during the low altitude camera runs, which resulted in some very detailed sonar images.

Table 6.4: The main configuration changes between missions.

Mission Number	Sound Speed Data Source	Frequency (kHz)	Beam Count	Max Ping Rate (Hz)	Water Column Data	Max Range (m)	Range Gate Strength
114	Fixed Value	300	256	4	On	300	1
115	Fixed Value	300	256	4	Off	300	1
116	Fixed Value	200	256	4	Off	300	1
117	Fixed Value	300	256	4	Off	300	1
118	Fixed Value	300/200	256	4	Off	300	1
119	Fixed Value	300	256	2	Off	300	1
120	Fixed Value	400	256	20	Off	150	1
121	Fixed Value	200	256	2	Off	300	2
122	Fixed Value	400	256	20	Off	150	1
123	Profile	400	256	20	Off	150	1
124	Profile	400	256	20	Off	150	1

All other settings were set to default apart from the ones below:

- APS=2, AHS=2, - sets active heading and position inputs
- PTY=0, - sets ping type to automatic
- VSN=1, - sets active velocity sensor (although this is not present it must be set for FM pulses to be enabled)
- FME=2, - FM enabled without attitude velocity

The data are stored in the standard Kongsberg format as *.all files in /EM2040/RAW directory for each mission.

6.2.6 Edgetech Sidescan/Sub-bottom Configuration

Autosub is fitted with an Edgetech 2200-M multi-frequency sidescan sonar and sub-bottom profiler.

All sidescan missions used the low frequency system with a 120 kHz, 12 kHz bandwidth, 8.3 ms FM pulse together with a 2-13 kHz 32 ms sub-bottom chirp pulse running at 1 Hz or 2 Hz repetition rate. The data is stored in Edgetech's .jsf format in the /Edgetech/RAW directory for each mission. There are 5 channels of data in the output file – sub-bottom, sidescan low frequency (processed), sidescan high frequency (processed), sidescan low frequency (raw) and sidescan high frequency (raw). A single file contains up to half an hour of data and a new file was started at the beginning of each line.

The system worked intermittently with usable data returned only from missions 114 and 119. We are currently investigating the cause of the problem but it appears likely that it is power related.

6.2.7 Camera Configuration

Autosub was fitted with two Point Grey Grasshopper 5 mega pixel colour cameras at the nose of the vehicle with NOC designed flash units. Serial number 1331848 was pointing directly downwards while serial number 11370835 was at a downwards angle of 30 degrees? to the horizontal pointing forwards.

Camera model: Grasshopper2 GS2-GE-50S5C
Camera vendor: Point Grey Research
Sensor: Sony ICX625AQ (2/3" 2448x2048 CCD)
Resolution: 2448x2048
Image pixel format: PIXEL_FORMAT_RAW8
Bayer tile format: GBRG

6.2.8 CTD Configuration

Autosub was fitted with a Sea Bird Electronics 9 unit, fitted with 2 x SBE 3 temp sensors, 2 x SBE4 conductivity sensors and 2 x 5T Pumps. In addition, a Seapoint turbidity sensor, an SBE 46 oxygen sensor, a WET Labs ECO-AFL/FL fluorometer and Koichi Nakamura's EH sensor were also connected to the CTD system. The data was logged on the AUV's main logger. All subsequent data processing used the JC136.xmlcon configuration file, which contains calibration information on each sensor. All sensors appeared to work well and there were no faults seen.

6.2.9 Vehicle Navigation

Autosub uses a combination of GPS, inertial navigation and ADCP bottom tracking in order to determine its position. The bottom topography on JC136 was generally smooth enough for good bottom tracking and where we were able to track the vehicle at the end of a mission we found less than 100 m drift in an 80 km long mission. The only exception was mission 121, where the bottom terrain was much more rugged and the currents pushed the vehicle off track by around 500 m.

A new UBlox M8N GPS/GLONASS receiver was fitted which, when the AUV was on the surface, gave fixes quickly and proved much more reliable than the old Thales receiver.

The standard practice for each mission was to allow the vehicle to circle while diving with a fixed rudder. In this mode, the vehicle drifts with the current. When the vehicle is close to the bottom, it changes mode and tries to go to a fixed point. Using the ships USBL acoustic positioning system, we measure the offset between the vehicle's actual position and the demanded position and then use this offset to command the vehicle to move to the demanded position. The USBL data in the /TrackingAndTelemetryRawData for each mission should be used to give the most accurate AUV positions at the start of each mission.

6.2.10 Launch and Recovery

The Lawson Engineering Ltd gantry was mounted on the stern of the ship slightly towards the port side. This allowed a comparatively simple launch procedure where the AUV was lowered into the water when the ship was moving through the water at approximately 0.7 knots and a pair of pins on ropes are pulled away, which release the vehicle and allow it to float slowly astern. The AUV team leader would then proceed to the bridge with a tablet computer connected via Wifi to the main mission control computer, where they could easily consult with the officer of the watch in order to position the ship in the safest place for the AUV dive and then send a command to start the AUV mission.

Recovery is carried out by grappling for a line that runs along the top of the centre section of the AUV. When pulled this pulls out the recovery lines stored in hoppers at each end of the centre section, which are then pulled onboard and attached to lines connected to the gantry. These lines are then wound into the gantry while ensuring that the AUV stays a safe distance from the ship and moving astern of it. Once fully astern, the AUV is pulled up, out of the water and into the gantry. In general, this process worked smoothly although the grapnels had a habit of catching on the AUV wings or masts (which are deliberately designed to break in a safe way when this happens) and the AUV team are very grateful to the crew of the James Cook for their invaluable assistance with launch and recovery.

6.2.11 Significant Faults/Issues

There were a relatively small number of issues and faults associated with this campaign compared with previous campaigns, although they had a fairly big effect on the amount of scientific data obtained. The major faults and issues are listed below:

- Insecure battery connectors, which caused the abort of the first mission and damaged the power control board. This meant that we were unable to use the AUV at all during the first visit to the Anton Dohrn site.
- There were issues with the EM2040 multibeam system and Edgetech sidescan sonar, which were likely to be due to insufficient power availability – possibly also associated with the issue above. These two systems cannot be used simultaneously at present.
- The camera flashes stopped working shortly into mission 122 and the cause has not yet been determined as they worked after the AUV was recovered.

6.2.12 Data Outputs

Table 6.5: Output from Main processing stored in mission directory.

ProcessedLogData\Mxxx.mat	The variable data extracted from the log file and stored as Matlab workspace variables.
ProcessedLogData \MxxxCTD.cnv	The CTD data converted into engineering units.
ProcessedLogData\Mxxx_CTD.mat	The converted CTD data stored as Matlab workspace variables.
ProcessedLogData\Mxxx_ADCPdown.mat	The ADCP data stored as Matlab workspace variables.
ProcessedLogData\MxxxLS2.mat	Contains interpolated variable data from different nodes of Autosub logger, data are reduced to a common time base set to an interval of 2 seconds currently. Saved as Matlab workspace variables.
ProcessedLogData\MxxxLS2.ls2	Contains interpolated variable data from different nodes of Autosub logger, data are reduced to a common time base set to an interval of 2 seconds currently. Saved as a

	comma separated file.

Table 6.6: Output from SensorProcess.m (mainly science data).

ProcessedLogData\MxxxScienceLS2.csv	Contains the position along with the date and time for every recording of a variable. Saved as a comma separated file.
ProcessedLogData\Mxxxcam.txt	Contains the date, time, size and filename of every frame taken.
ProcessedLogData\MxxxScienceLS2.mat	Contains the position along with the date and time for every recording of a variable. Saved as Matlab workspace variables.

6.3 CTD

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6.3.1 CTD System Configuration

See separate Sensor Information document.

6.3.2 CTD Operations

There were 43 CTD casts made, including one "yo-yo" station (casts 5 to 19 inc.). During the yo-yo station, the CTD was not landed on deck but brought up to 101 m, a new file started and the cast repeated. Obviously, this was not possible for the LADCP so the yo-yo appears in one file. Log sheets were scanned and included with the data from this cruise.

The pressure sensor was located 33 cm below the bottom and approximately 72 cm below the centre of the 10 L water sampling bottles.

The configuration file used is included in the appendix at the end of this report. This was initially JC136_1257_SS_nmea.xmlcon but this was later amended to JC136_1257_SS_nmea1.xmlcon due to a revision of the blanked and in-air values of the WET Labs C-Star transmissometer s/n: 1718TR.

Cable CTD2 was used for all casts. The wire was terminated at the start of the cruise; an insulation figure of >1000 MΩ o/c was initially obtained and a s/c value of 76 Ω. Following the mid-cruise port call in Stornoway, the next CTD cast (#27) had to be aborted at a depth of approximately 167 m due to a deck unit alarm. The wire required to be re-terminated. Subsequent values for the wire were an insulation figure of 534 MΩ o/c and a s/c value of 78Ω.

Sensor Failures

There were no sensor failures as such, but the rosette pylon SBE32 s/n: 0243 was replaced with s/n: 1005 from cast 25 onwards. This was necessary due to a failure in operation in position 14. On investigation, this was due to corrosion issues in solenoid 14 and several others.

6.3.3 LADCP Configuration

The TRDI WHM 300 kHz LADCP (s/n: 24397) was deployed in a downward-looking orientation on the CTD frame. Battery voltage could not be monitored as the cable was diode protected. The instrument was configured to ping as fast as possible, use 25 bins, a zero blanking distance and a depth cell size of 8 m, thus yielding a range of approximately 200 m in ideal conditions. The ambiguity velocity was set to 400 cms^{-1} and ensemble time of 1.3 seconds.

Built-in pre-deployment tests *(PA, PT200 and PC2)* were run before each cast, and then the following command file sent *(F2)*:

Master command file (JC136_LADCP_script_file.txt)

```
CR1
RN
WM15
TC2
LP1
TB 00:00:02.80
TP 00:00.00
TE 00:00:01.30
LN25
LS0800
LF0
LW1
LV400
SM1
SA011
SB0
SW5500
SI0
EZ0011101
EX00100
CF11101
CK
CS
```

Data Processing

Basic post-processing of the CTD cast data was done to guidelines established with BODC (ref. Moncoiffe 7th July 2010).

6.3.4 Salinity measurement

A Guildline Autosal 8400B salinometer, s/n: 65764, was used for salinity measurements. The salinometer was sited in the Electronics workshop. Initially, the bath temperature was set at 27°C, the ambient temperature being approximately 24.5°C. Subsequently, due to a fall in ambient temperature, the bath was reduced to 24°C and later further reduced to 21°C. A bespoke program written in Labview called "Autosal" was used as the data recording program for salinity values.

Salinity samples were taken and analysed from most casts except the yo-yo, the results being tabulated in a spreadsheet SALFORM_ss.xlsx.

6.3.5 APPENDIX

***Configuration file used for the stainless system*:**

Instrument configuration file: C:\Users\sandm\Documents\Cruises\JC136\Seasave Setup files\JC136_1257_SS_nmea.xmlcon

Configuration report for SBE 911plus/917plus CTD

Frequency channels suppressed : 0
Voltage words suppressed : 0
Computer interface : RS-232C
Deck unit : SBE11plus Firmware Version >= 5.0
Scans to average : 1
NMEA position data added : Yes
NMEA depth data added : No
NMEA time added : No
NMEA device connected to : PC
Surface PAR voltage added : No
Scan time added : Yes

1) Frequency 0, Temperature

Serial number : 3P-4116
Calibrated on : 22 July 2015
G : 4.42598185e-003
H : 6.84431420e-004
I : 2.44678966e-005
J : 2.01851279e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 4C-2164
Calibrated on : 21 July 2015
G : -1.02203927e+001
H : 1.40865750e+000

I : -2.39575609e-003
J : 2.35193042e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 134949
Calibrated on : 9 November 2015
C1 : -3.695717e+004
C2 : -2.691791e-001
C3 : 1.143300e-002
D1 : 3.349300e-002
D2 : 0.000000e+000
T1 : 3.049225e+001
T2 : -3.372510e-004
T3 : 3.990980e-006
T4 : 3.875890e-009
T5 : 0.000000e+000
Slope : 1.00000000
Offset : 0.00000
AD590M : 1.280300e-002
AD590B : -9.092836e+000

4) Frequency 3, Temperature, 2

Serial number : 3P-5494
Calibrated on : 21 July 2015
G : 4.32428851e-003
H : 6.26150151e-004
I : 1.95606050e-005
J : 1.50973213e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 4C-2858
Calibrated on : 21 July 2015
G : -1.02337303e+001
H : 1.43815676e+000
I : 6.69671592e-004
J : 2.25896305e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Oxygen, SBE 43

Serial number : 43-2818
Calibrated on : 24 January 2015
Equation : Sea-Bird
Soc : 4.58000e-001
Offset : -5.06000e-001
A : -4.66690e-003
B : 2.11410e-004
C : -2.64070e-006
E : 3.60000e-002
Tau20 : 1.45000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Altimeter

Serial number : 47597
Calibrated on : 22 February 2010
Scale factor : 15.000
Offset : 0.000

9) A/D voltage 3, Turbidity Meter, WET Labs, ECO-BB

Serial number : BBRTD-169
Calibrated on : 9 August 2013
ScaleFactor : 0.004011
Dark output : 0.092400

10) A/D voltage 4, Free

11) A/D voltage 5, Free

12) A/D voltage 6, Fluorometer, Chelsea Aqua 3

Serial number : 88-2960-163
Calibrated on : 6 August 2014
VB : 0.230300
V1 : 2.115100
Vacetone : 0.343000
Scale factor : 1.000000
Slope : 1.000000
Offset : 0.000000

13) A/D voltage 7, Transmissometer, WET Labs C-Star

Serial number : 1718TR
Calibrated on : 15 April 2015
M : 21.3038
B : -0.1278
Path length : 0.250

Changes to configuration file as follows and re-named:

Instrument configuration file: C:\Users\sandm\Documents\Cruises\JC136\Seasave Setup files\JC136_1257_SS_nmea1.xmlcon

13) A/D voltage 7, Transmissometer, WET Labs C-Star

Serial number : 1718TR
Calibrated on : 15 April 2015
M : 21.5144
B : -0.1291
Path length : 0.250

6.4 Mooring Operations Summary

Main objectives

1. To deploy two ADCP moorings around the Anton Dohrn seamount.
2. To recover both moorings at the end of JC136.

All echo sounders were switched off or put in passive mode during acoustic interrogation to avoid interference.

The deck unit used was Ixsea TT801, s/n: 178 and the ship's mooring transducer located in the drop keel.

The moorings being relatively short did not require the use of a winch.

All times given below are in UTC unless stated otherwise

6.4.1 Releases Test

A test of four releases for potential use in the moorings was carried out during the first CTD cast on the 17th May and at a depth of 2200 m. This was well beyond the pressure that the moorings would be subjected to, the deepest being around 1200 m. The results were as follows:

s/n: 1470;	range: 2203m; release OK
	range: 2203m; release OK
s/n: 1496;	range: 2204m; release OK
	range: 2204m; release OK
s/n: 1751;	range: 2203m; release OK
	range: 2203m; release OK
s/n: 1919;	range: 2205m; release OK
	range: 2205m; release OK

6.4.2 Instrument Configuration

TRDI Sentinel 600 kHz ADCP s/n: 21071; downward looking orientation and to be used in the shallow mooring.

1st bin:	3m
Bin size:	2m
Number of bins:	20
Pings/ensemble:	75
Ensemble interval:	2 minutes
Time/ping:	1.6 seconds

Clock set and started recording at 13:08:00 on 16th May 2016.
Confirmed pinging on deck

On recovery:
Logging stopped: 09:25:00 on 18th June 2016
Data file #21071 (13MB)

TRDI Sentinel 600 kHz ADCP s/n: 21072; downward looking orientation and to be used in the deep mooring.

1st bin:	3 m
Bin size:	2 m
Number of bins:	20
Pings/ensemble:	75
Ensemble interval:	2 minutes
Time/ping:	1.6 seconds

Clock set and started recording at 13:19:10 on 16th May 2016.
Confirmed pinging on deck

On recovery:
Logging stopped: 08:41:00 on 18th June 2016
Data file #21072 (13MB)

TRDI Long Ranger 75 kHz ADCP s/n: 5476; upward looking orientation and to be used in the shallow mooring.

1st bin:	26 m
Bin size:	16 m
Number of bins:	62
Pings/ensemble:	65
Ensemble interval:	15 minutes
Time/ping:	13.84 seconds

Clock set and started recording at 14:02:30 on 16th May 2016.
Confirmed pinging on deck

On recovery:
Logging stopped: 15:55:45 on 17th June 2016
Data file #5476 (4.2MB)

TRDI Long Ranger 75 kHz ADCP s/n: 20247; upward looking orientation and to be used in the deep mooring.

1st bin:	26 m
Bin size:	16 m
Number of bins:	62
Pings/ensemble:	65
Ensemble interval:	15 minutes
Time/ping:	13.84 seconds

Clock set and started recording at 13:45:30 on 16th May 2016.
Confirmed pinging on deck

On recovery:
Logging stopped: 16:16:00 on 17th June 2016
Data file #20247 (4.2MB)

6.4.3 Deployments

6.4.3.1 Shallow Mooring

Lat:	57° 35.803' N
Lon:	11° 10.352'W
Time/Date:	14:47 on 17th May 2016
Depth:	808 m

Acoustic release: AR861; s/n: 1470

Arm:	09BB
Diagnostic:	Arm & 0949
Release:	Arm & 0955

6.4.3.2 Deep Mooring

Lat:	57° 37.240'N
Lon:	11° 11.250'W
Time/Date:	15:28 on 17th May 2016
Depth:	1220 m

Acoustic release: AR861; s/n: 1751

Arm:	1A06
Diagnostic:	Arm & 1A49
Release:	Arm & 1A55

There was an opportunity on the following day, the 18th May, to interrogate the releases. At 21:03 near (about 100 m from the nominal position) the Deep site the diagnostic command gave a slant range of 1296 m and a vertical orientation. Similarly, at the Shallow mooring site at 22:16 a range of 809 m and a vertical orientation was obtained.

6.4.4 Recovery

6.4.4.1 Deep Mooring

Time/date of release: 08:47 on 17th June 2016
Vessel position: Lat: 57° 37.18'N; Lon: 11° 11.53'W
Water depth: 1175 m
Acoustic telemetry:
Diagnostic – Vertical; OK
Range – 1320 m, 1320 m, 1319 m
Ascent rate: approx. 100 m/min
Observed time on surface: 09:02
All on board: 09:35

6.4.4.2 Shallow Mooring

Time/date of release: 10:00 on 17th June 2016
Vessel position: Lat: 57° 35.62'N; Lon: 11° 10.88'W
Water depth: 798 m
Acoustic telemetry:
Diagnostic – Vertical; OK
Range – 1063 m, 1064 m, 1062 m
Ascent rate: approx. 90 m/min
Observed time on surface: 10:09
All on board: 10:45

6.4.5 Notes and Recommendations

Both recoveries were slightly hindered due to the recovery line becoming tangled with the wire to the acoustic release beneath the water line instead of streaming out as was intended. I believe substituting a more buoyant 17" sphere in place of the 10" sphere ,which was used in the recovery line, would reduce the tendency for the line to become entangled.
All times given in this report are in UT.

6.5 Ship Systems Computing Cruise Report

Technicians:
Gareth Knight (Science Systems Tech) gareth.knight@noc.ac.uk
Lisa Symes (Science Systems Tech) lisa.symes@noc.ac.uk

6.5.1 Ship scientific computing systems.

Data was logged by the Techsas data acquisition system into NetCDF files. The format of the NetCDF files is given in the file ***NMFSS_NetCDF_Description_Cook_v2_1.docx***. The instruments logged are given in JC136_Ship_fitted_information_sheet.docx. Data were additionally logged into the RVS Level-C format, which is described in the same documentation. On leaving Southampton on J135 14/05/2016, the VSAT system had a bandwidth of 512 kbps (This is the residual time remaining on the increased connection provided during JC131/132 for NMF testing). The Fleet Broadband system was also operational and had a bandwidth of 256 kbps. At 16:30 on J135 14/05/2016, the VSAT system lost connection and could not be re-established. It was then found that the Anacom C Band Transceiver unit within the Satellite dome had failed. There was no spare Anacom unit onboard, therefore, the problem could not be fixed until the next port call, where the replacement unit would be installed by a Rignet Engineer.

From this point until the J155 03/06/2016, the ships only satellite communications was the Fleet Broadband system. During this period, the bandwidth was throttled down on two occasions as it was deemed by Inmarsat the satellite communications provider that the ships throughput had exceeded their Fair Usage Policy. This left the ship with just under 70 kbps bandwidth from J140 19/05/2016 to J144 23/05/2016, as a good will gesture Inmarsat decided to up the bandwidth to 256 kbps until our port call in Stornoway on J155 03/06/2016. However, during this period the bandwidth suffered again and was capped at 130 kbps for a period of four days from J148 27/05/2016 to J153 01/06/2016.

During this period, the network was affected by poor connection speeds, which adversely affected the local area network due to the ships router "Untangle" not being able to resolve external and internal DNS. Due to this, some individuals PCs and MACs could no longer connect to both the network drives and local web interfaces if connecting via the DNS name instead of IP address.

At the port call in Stornoway, a Rignet Engineer came onboard to swap out the faulty Anacon unit in the VSAT satellite dome. Once the replacement had been fitted, normal service was restored, still with a bandwidth of 512 kbps. After this point, both the VSAT system and Fleet Broadband system ran as intended for the duration of the cruise.

During leg 1, from J135 14/05/2016 to J155 03/06/2016, reports from the on board Exinda (Network Optimizer/Monitor) system showed daily inbound throughput of approximately 1.7 GB/day and <1.0 GB of outbound traffic. On Leg 2, from J155 03/06/2016 to J175 23/06/2016, Exinda showed daily inbound throughput of approximately 3.4 GB/day and 1.4 GB/day of outbound traffic.

Note: A max. of 53 people on board (29 science/technicians and 24 ships crew).

6.5.2 Position and attitude

All GPS and attitude measurement systems were run throughout the cruise except for the CNAV system. The Applanix POSMV system is the vessel's primary GPS system, outputting the position of the ship's common reference point in the gravity meter room. The POSMV is the GPS sent to all systems and is repeated around the vessel.

The Kongsberg Seapath 200 would normally have been used as the position and attitude source sent to the EM120 and EM710 due to its superior real-time heave data. However, since the failure of the Seapath 200 on JC132, the Seapath system has been intermittently rebooting itself when on station. Therefore, the Applanix POSMV was used for position and attitude, plus the POSMV TRUE heave was used, for use in postprocessing. The *.ath files can be found on the **data disk in Ship_Systems\Acoustics\EM-120\Delayed Heave**.

On J142 21/05/2016, there were issues with Sonardyne Ranger2 claiming that it was receiving insufficient heading and position information, resulting in the transducer icon warning coming on. Noticed that the POSMV position indicator was red and that the accuracy was >10 m, also the POSMV GAMS kept changing between Not Ready and Online. In the end, we resorted to rebooting the POSMV unit, this solved the problem and the accuracy went back to <2 m.

Table 6.7: The POSMV unit.

Applanix POSMV receiver data gaps	
Data Stopped	**Data Restarted**
J137 16/05/2016 12:21:38	J137 16/05/2016 12:40:21

The Differential GPS CNAV system, which feeds positional corrections to the Applanix POSMV, failed at approximately 15:30 on J144 23/05/2016. On further investigation, the CNAV antenna seems to be at fault. A new antenna has been ordered and will be fitted at the next port call in Southampton. Therefore, from J144 23/05/2016 the POSMV accuracy was greater than 3.5 m.

Table 6.8: The Seapath 200 rebooted itself on six occasions whilst on station at various ROV sites.

Seapath 200 receiver data gaps	
Data Stopped	**Data Restarted**
J137 16/05/2016 08:30:36	J137 16/05/2016 12:40:22
J146 25/05/2016 16:10:02	J146 25/05/2016 16:18:01
J160 08/06/2016 18:01:19	J160 08/06/2016 18:14:12
J164 12/06/2016 09:03:31	J164 12/06/2016 15:35:56
J165 13/06/2016 06:58:29	J165 13/06/2016 11:06:43
J168 16/06/2016 06:39:59	J168 16/06/2016 11:32:32

Table 6.9: The data logging of the gyro had to be restarted on two occasions.

Gyro data gaps	
Data Stopped	**Data Restarted**
J137 16/05/2016 12:21:39	J137 16/05/2016 12:40:21
J151 30/05/2016 13:00:17	J151 30/05/2016 14:15:45

6.5.3 Speed Logs

The single axis bridge Skipper Log and the dual axis Chernikeef science log were logged. The Cherinkeef log was calibrated in Oct 2015 and is known to be inaccurate below 4 knots due to weather conditions not allowing low speed runs during the calibration. Data from the Chernikeef should be used with caution.

6.5.4 Meteorology and Sea Surface monitoring package

The Surfmet system was run throughout the cruise. Please see the separate BODC information sheet JC136_Surfmet_sensor_information_sheet.docx for details of the sensors used and the calibrations that need to be applied. **Calibration sheets are included in the directory Ship_Systems\Met\SURFMET\calibrations.**
The non-toxic water supply was active/stable (unless stated in table below) f**rom 12:20:00 15/05/2016 (J136) until 08:00 22/07/2016.**

Table 6.10: Details of changes to the non-toxic water supply

Underway non-toxic water supply data gaps			
Date	**J Day**	**Time**	**Event**
15/05/2016	136	12:20	Underway water turned on
03/06/2016	155	05:45	Underway water turned off near Stornoway
03/06/2016	155		Cleaning of fluorometer/transmissometer
04/06/2016	156	08:00	Underway water turned on
22/06/2016			Underway turned off

Table 6.11: Surfmet data gaps

Surfmet data gaps		
Data Stopped	**Data Restarted**	**Event**
J137 12:21:38	J137 12:40:21	Noticed Techsas Froze and Restarted
J153 17:50:25	J153 17:53:15	Noticed GPS Time on display not displaying
J153 17:54:04	J153 18:10:42	Noticed GPS Time on display not displaying
J153 18:11:06	J153 18:20:31	Noticed GPS Time on display not displaying
J156 05:30:07	J156 05:32:33	Techsas Froze and Restarted

NetCDF SurfMet Data is found at: 'JC136\Ship_Systems\TECHAS\NetCDF\SURFMETV2'
ASCII Data is found at: JC136\Ship_Systems\Level-C\pro_data\ascii\from_levelC

6.5.5 IXBlue Oceano PET661S Rugged Transducer (Drop-Keel)

The IXBlue Oceano PET661S Rugged Transducer mounted on the drop keel was used successfully for acoustic releases by Sensors and Moorings during the recovery of the LADCP mooring.

6.5.6 Kongsberg EA600 12 kHZ single beam echo sounder.

The EA600 single-beam echo-sounder was run throughout most of the cruise. There are breaks in the data due to the acoustic instrumentation being isolated during AUV deployment and recovery as well as mooring release. It was used with a constant sound velocity of 1500 ms^{-1} throughout the water column to allow it to be corrected for sound velocity in post processing. As well as depths being logged to the Techsas and Level-C data loggers, files were saved as .BMP images and in raw Kongsberg format.

Data Disk Location: 'JC136\Ship_Systems\Acoustics\EA-600'

6.5.7 Kongsberg EM120 Deep Water Multi-beam echo sounder.

The EM120 multi-beam echo sounder was run throughout the cruise. Data was logged in Kongsberg .all format. The centre beam depth was logged to Techsas and Level-C. There are breaks in the data due to the acoustic instrumentation being isolated during AUV deployment and recovery as well as mooring release.

The EM120 was fed altitude and position data from the Applanix POSMV.

The following figures show the system installation configuration. The values originate from the ships BLOM survey report, which is included on the data disk. The altitude angular corrections for use with the Seapath 200 system were derived from a post refit trial calibration on JC108 Sept 2014. The altitude angular corrections for use with the Applanix Posmv system are from calibration during JC103 May 2014.

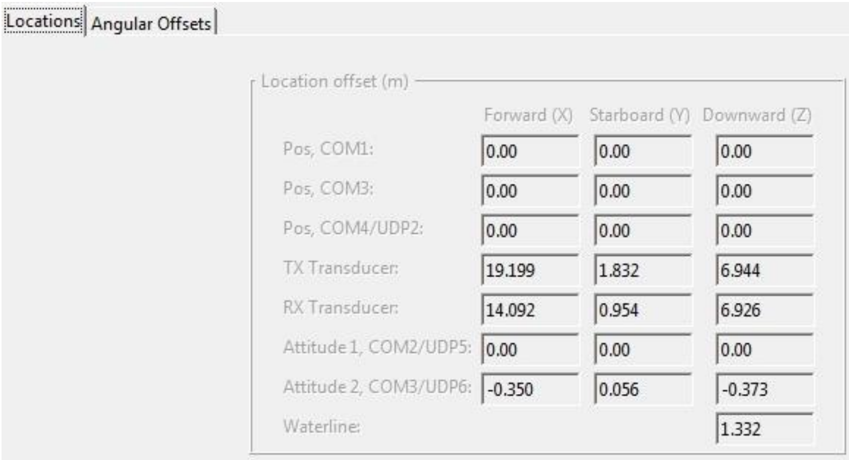


Figure 6.6: EM120 transducer locations

Figure 6.7: EM120 transducer offsets

Refer to SVP section for sound velocity information.

Data Disk Location: 'JC136\Ship_Systems\Acoustics\EM120'

6.5.8 Kongsberg EM710 Shallow Water Multi-beam echo sounder

The EM710 multi-beam echo sounder was used when the depth was less than 700 m. There are breaks in the data due to the acoustic instrumentation being isolated during AUV deployment and recovery as well as mooring release.

The Data was logged in Kongsberg .all format. The EM710 was fed attitude and position data from the Applanix POSMV.

Data Disk Location: 'JC136\Ship_Systems\Acoustics\EM710'

6.5.9 Kongsberg EK60 SCIENTIFIC ECHOSOUNDER.

The EK60 scientific echosounder was used from J140 19/05/2016 to J141 20/05/2016. During this period, the ROV was on deck due to an intermittent fault and it was decided to run the EK60 in the interim whilst the ROV was being fixed.

Data Disk Location: 'JC136\Ship_Systems\Acoustics\EK-60'

6.5.10 75 kHz and 150 kHz hull mounted ADCP systems.

Both the 75 kHz and 150 kHz ADCP systems were run during the cruise. The raw data files and configurations files are included on the data disk. The configuration files used throughout were set to a default configuration file:

OS75kHz Configuration File used – OS75BB_48bin_16m_BTON_sync.txt
OS150kHz Configuration File used - OS75150BB_96bin_4m_BTON_sync.txt

Data Disk Location: 'JC136\Ship_Systems\Acoustics\OS75kHz & OS150kHz'

To summarise the configuration, the 75 kHz was run in broadband mode with 48 bins of 16 m in bottom tracking mode. The 150 kHz was run in broadband mode with 96 bins of 4 m in bottom tracking mode.

6.5.11 Sound Velocity Profiles.

A Valeport Midas SN 22355 sound velocity profiler was used for all SV deployments. During the cruise, the probe was attached to the CTD to collect profiles during the casts. The profiles are included on the data disk. The raw files downloaded from the instrument have a file extension .000. The files were then processed using the SVP Editor in the Kongsberg SIS program. A file is then produced with extension .asvp and is the sound velocities and depths of the entire cast. The profile is extended to 12000 m by the SVP editor and finally then thinned by the SVP editor with a scale factor of 0.2. The thinned file was then loaded into SIS on the EM120/EM710 systems. A .pro file derived from the edited .000 file was also loaded into the SonarDyne Ranger 2 system.

Data Disk Location: 'JC136\Ship_Systems\Acoustics\Sound_Velocity_Profiles\SVP_Probe'

Table 6.12: SVP fitted to CTD frame

SVP fitted to CTD frame			
Installation Date (SIS/Ranger2)	Profile	Location	Depth
J138 17/05/2016	17052016_sorted_thinned.asvp	57°10.170'N, -10°30.000'W	2230 m
J145 24/05/2016	24052016_sorted_thinned.asvp	57°50.904'N, -13°58.791'W	180 m
J152 31/05/2016	31052016_sorted_thinned.asvp	58°39.232'N, -13°49.479'W	1270 m
J153 01/06/2016	20160601_edited_thinned.asvp	58°40.796'N, -13°49.901'W	1185 m
J157 05/06/2016	05062016_edited_thinned.asvp	59°46.331'N, -7°03.136'W	1110 m
J169 17/06/2016	17062016_edited_thinned.asvp	57°35.814'N, -11°15.858'W	103 m

The following Profiles were derived from the CTD calculated sound velocity for every 1 m depth bin.

Data Disk Location: 'JC136\Ship_Systems\Acoustics\Sound_Velocity_Profiles\SVP_Probe\CTD_Derived'

Table 6.13: Sound Velocity derived from CTD

Sound Velocity derived from CTD			
Installation Date	Profile	Location	Depth

(SIS/Ranger2)			
J144 23/05/2016	23052016_sorted_thinned.asvp	57°27.874'N, -11°07.129'W	559 m
J161 09/06/2016	09062016_sorted_thinned.asvp	59°08.278'N, -10°41.092'W	1126 m

6.5.12 Gravity Meter.

The gravity meter S40 was run throughout the cruise as an NMF test as it was thought that there was an issue with noisy data occurring from the gyros. Data from the first seven days of JC136 was sent back to Andrew Moore (Science Systems Tech) for data analyses. From this, it was noted that the data from the gyro fitted in the long axis seemed noisy. On 08/06/2016, the gyro in the long axis position was swapped out with the onboard spare. Another seven days' worth of data were sent to Andrew Moore for further analysis.

NetCDF Gravity Data is found at 'JC136\Ship_Systems\TECHAS\NetCDF\AIRSEAII' – this is logged from the ASCII serial output from the meter.

The meter also creates local daily files in the format ***.DAT** (1Hz sampling) and ***.ENV** (environmental data – logged every minute). 'gravity_output msg format.pdf' has information on the datagrams. The gravity meter had a GPS feed from the Applanix Pos-MV system. This position is logged in the *.DAT files.

6.5.13 Sonardyne USBL

The Sonardyne USBL system was used to track the Autosub on deployment and recovery. Position information was recorded to the Techsas data acquisition system in NetCDF format. Ascii files were created when the Autosub was deployed and recovered and saved in the following location:

Data Disk Location: 'JC136\Ship_Systems\Level-C\pro_data\ascii\from_Level-C

6.5.14 Caris

Throughout the cruise, the data taken from the multibeam systems have been post processed onboard by Hydrographic Surveyors from BGS. They will be responsible for producing the data to BODC. Therefore, there is no post processed data from Caris on the data disk provided.

Leg 1 BGS Hydrographic Surveyors – Sam Faithful – samf@bgs.ac.uk
Leg 2 BGS Hydrographic Surveyors – Kirstin Crombie – kirrst@bgs.ac.uk

7 Science Operations

7.1 Multibeam and sub bottom profiler

Lead persons – Sam Faithfull & Kirstin Crombie

7.1.1 Methods

Post processing of the multibeam data collected on board the James Cook, cruise JC136, was carried out by Hydrographic Surveyors from BGS, Edinburgh. Further processing will be carried out in the office. A total of 5811.66 km^2 was processed during the cruise, using Caris HIPS and SIPS 9.1.

All data processing was conducted in accordance with the standard UKHO SOP for Kongsberg Maritime MBES Data in CARIS HIPS and SIPS (Talbot, Read). The Simrad raw .all files were imported in to CARIS HIPS using the Conversion Wizard. Zero tide was applied.
To ensure that there were no major artefacts or other issues within the acquired data set, a Base Surface was generated for initial QC purposes and evaluated using the CARIS Subset Editor. Cleaning of the soundings was performed using either the Combined Uncertainty and Bathymetry Estimator (CUBE) algorithm or the SWATH angle algorithm, within CARIS. Manual edits/examination of the CUBE or Swath Angle surface took place, and soundings that significantly deviated from the surface were rejected.

Data collected by the Autosub6000 was processed with a SWATH angle surface with a resolution of either 3 m or 50 cm. The SVP data needs to be checked on return to the office as a constant SVP may have been applied when the data was collected instead of an SVP profile.
Data collected by the ships systems EM120 (used at depths greater than 800 m) and EM710 (used at depths less than 800 m) were processed using a CUBE surface of 100 m resolution.
The data were then exported to Fledermaus and a final check of the surface in CUBE/Swath was conducted for any further spurious data points.
A suite of bathymetric and backscatter products were produced in Projected UTM Zones, using Fledermaus and ArcGIS 10.1. Bathymetric products include: XYZ, SD, Tiff, Arc Grid asci, bathymetric surface, aspect, slope, hillshade, rugosity, and a layer file.
Backscatter products were also produced using FMGT: – Arc Grid asci, tiff images, SD and XYZ.

The AUV recorded two geophysical surveys (side scan sonar and chirp data), which have not been examined offshore. These will be processed at BGS.

7.1.2 Survey Areas

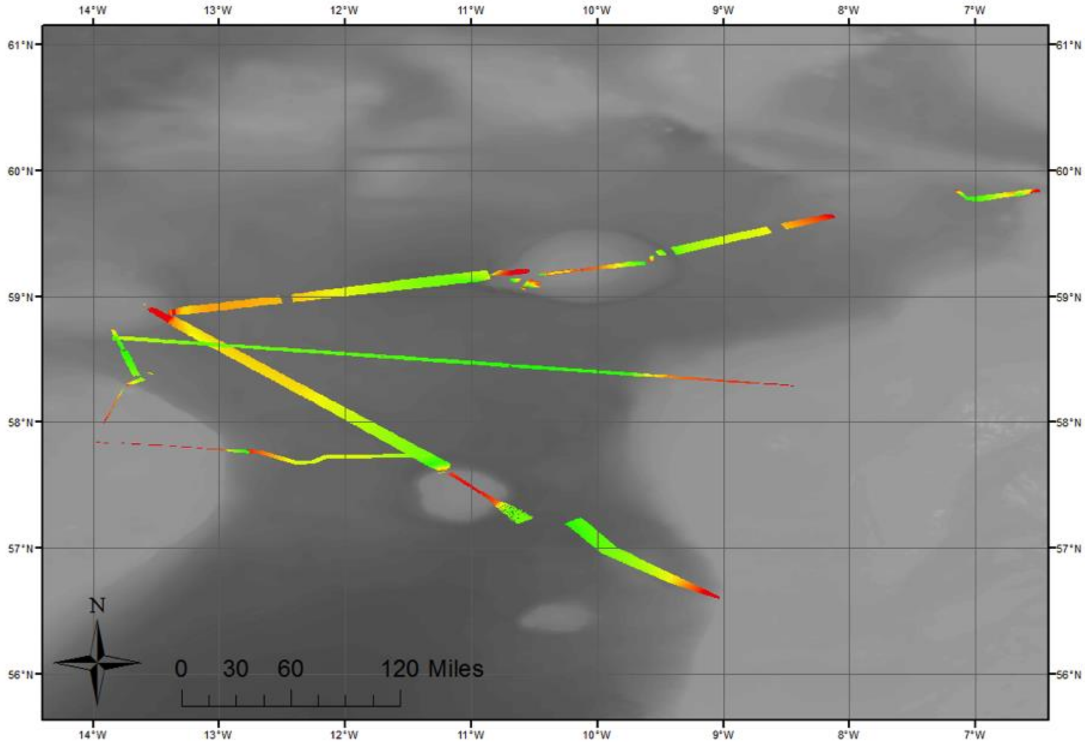


Figure 7.1: Hydrographic survey areas during the JC136 cruise in the NE Atlantic.

7.1.2.1 Survey Areas Leg 1 – 1636.56 km^2

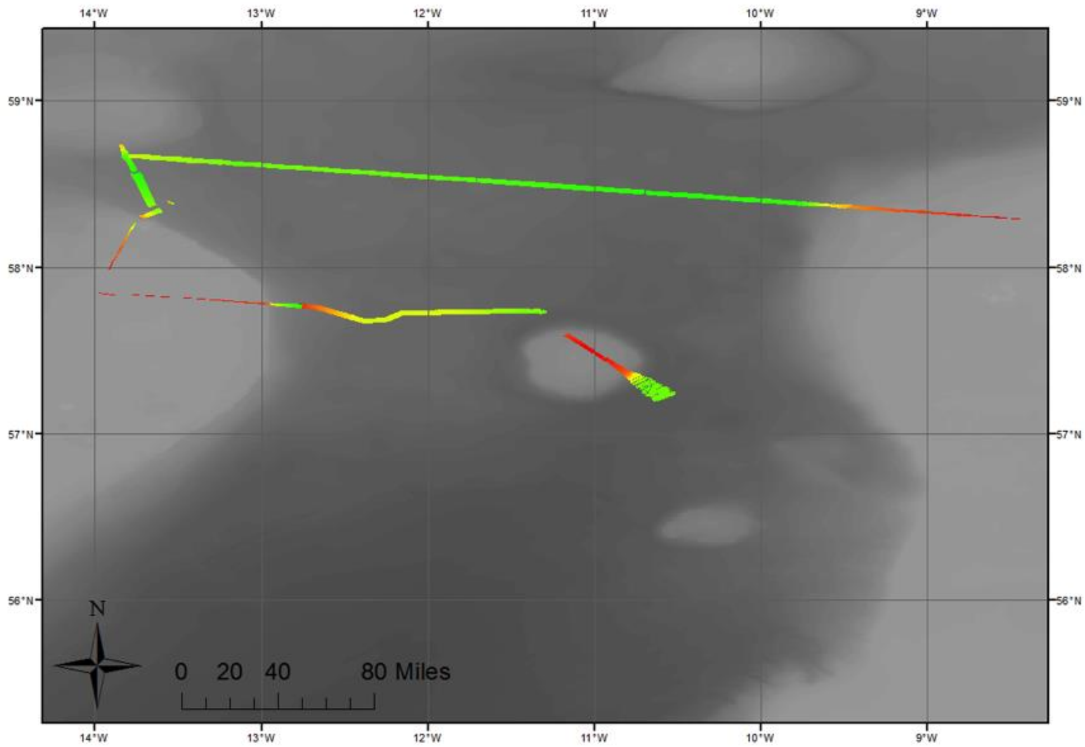


Figure 7.2: Hydrographic survey areas during Leg 1 of the JC136 cruise.

Data collected on 17, 19 and 24-26th May 2016 using Autosub EM2040 and the ships systems EM120 and EM710. Post processing and data products to be carried out in the BGS office.
532 line kms collected using the EM120.
83 line kms of multibeam collected using the EM2040 autosub.
89 line kms (*2) of side scan and chirp data collected using the EM2040.

17/05/2016
Line length: 64.6 km
Equipment: EM120 and EM710
EM120 line numbers: 0000-0019
EM710 line numbers: 0000-0014

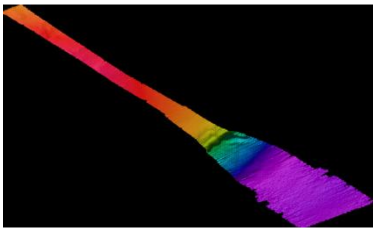


Figure 7.3: Field sheet name: JC136_JamesCook_17052016_50m_CUBE (CUBE, 50m, JC136_Leg_1)

24/05/2016
Equipment: EM120 and EM710
EM120 line numbers: 0023-0042
EM710 line numbers: 0042-0051
Line length: 52.34 km

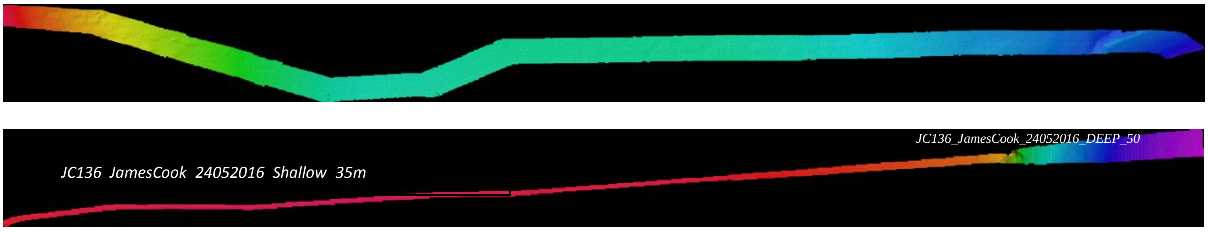


Figure 7.4: Fieldsheet names: JC136_JamesCook_24052016_SHALLOW_35m
JC136_JamesCook_24052016_DEEP_50m (CUBE, 50m, JC136_Leg_1)

25/05/2016
Equipment: EM710
EM710 line numbers: 0052-0055
Line length: 162.3 km

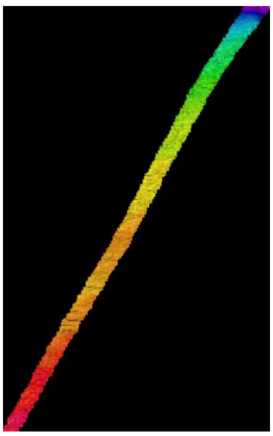


Figure 7.5: Field sheet name: JC136_JamesCook_25052016_50m_CUBE (CUBE, 50m, JC136_Leg_1)

28/05/2016
Line length: 9 km
Equipment: EM120 and EM710
EM120 line numbers: 0049-0054
EM710 line numbers: 0060-0062

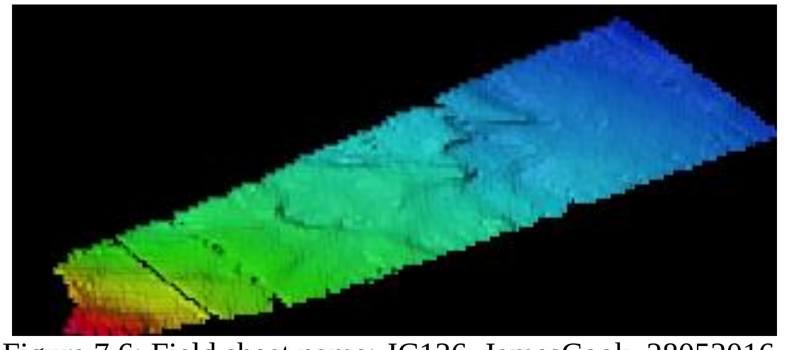


Figure 7.6: Field sheet name: JC136_JamesCook_28052016_50m_CUBE (CUBE, 50m, JC136_Leg_1)

31/05/2016
Line length: 52 km
Equipment: EM120
EM120 line numbers: 0056-0067

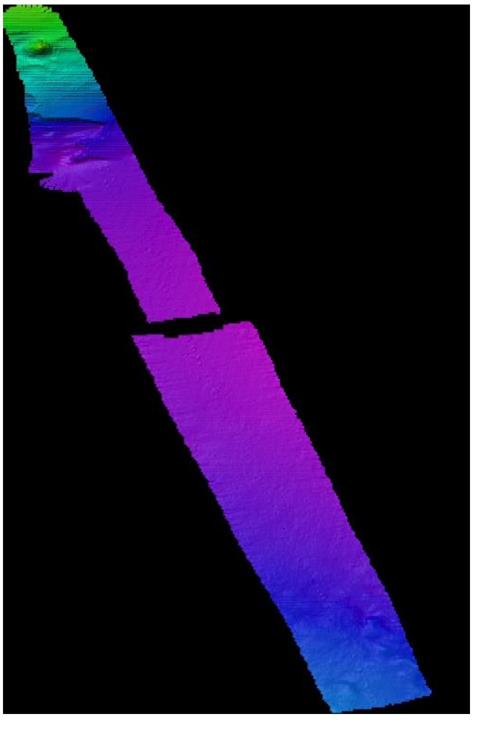


Figure 7.7: Field sheet name: JC136_JamesCook_31052016_50m_CUBE (CUBE, 50m, JC136_Leg_1)

Return transit to Stornoway (including Geike slides) 01/06/2016-02/06/2016
Line Length: 317. 6 km
Equipment used: EM120 and EM710
EM120 line numbers: 0068-0110
EM710 line numbers: 0068-0075

Figure 7.8: Field sheet name: JC136_JamesCook_L1returntransit_50m_Cube
(CUBE, 50m, JC136_leg_1)

Autosub 25/05/2016-26/05/2016
Line Length: 12.8 km
Equipment used: Autosub EM2040
Line numbers: 0001-0012
(Swath, 3m, JC136_leg_1)
No image as still being processed.

Autosub 27/05/2016- 28/05/2016
Line Length: 81 km
Equipment used: Autosub EM2040
Line numbers: 0001-0079
(Swath, 3m, JC136_leg_1)
No image as still being processed.

7.1.2.2 Survey Areas Leg 2 – 4175.10 km^2

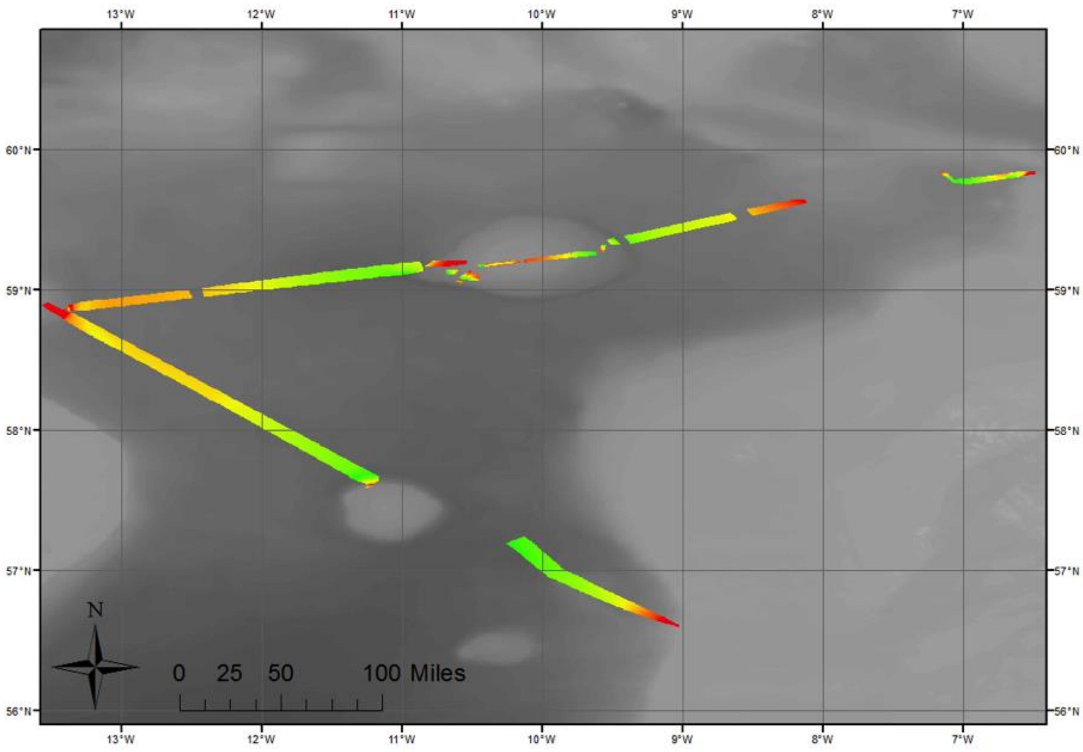


Figure 7.9: Hydrographic survey areas from Leg 2 of the JC136 cruise.

WyvilleThomson Ridge – 5th June 2016
Autosub EM2040 line numbers 1-88
88.47 line kms

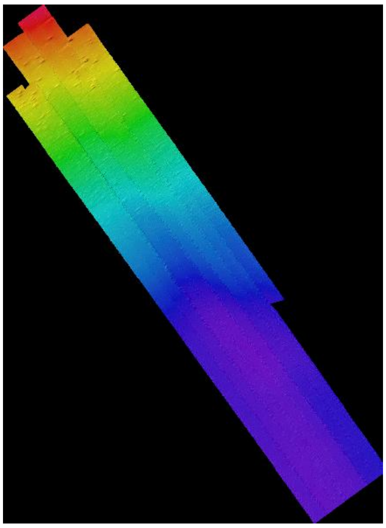


Figure 7.10: Fieldsheet name: Wyville-Thomson_swathe_3m
(swath angle, 3m, project JC136_LEG2)

Wyville-Thomson – Darwin Mound Transits – 4th and 5th June 2016
EM120 line numbers 112-124
80.98 line kms
Multibeam results effected by bad weather.

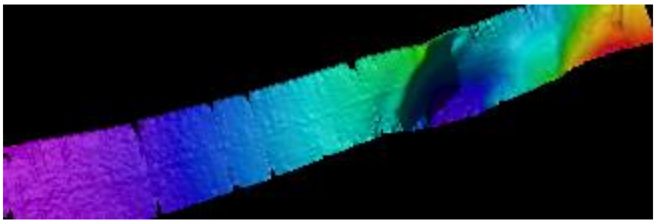


Figure 7.11: Fieldsheet name: WyvilleThomson_DarwinMound_transit
(cube1a, 100m, project JC136_LEG2)

Wyville-Thomson _Rosemary Bank Transit – 6th June 2016
EM120 line numbers 125-139
87.98 line kms

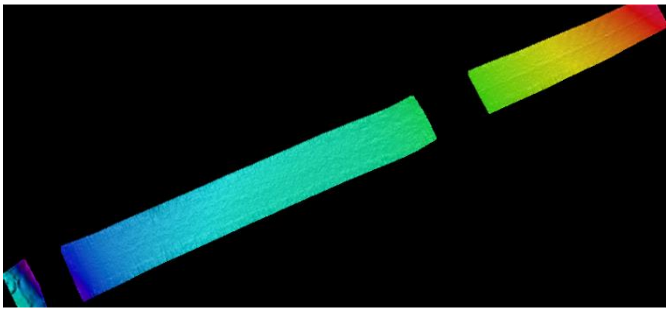


Figure 7.12: Fieldsheet name: WyvilleThomson_RosemaryBank_transit
(cube1a, 100m, project JC136_LEG2)

East Rosemary Bank – West Rosemary Bank – 6th June 2016
EM120 line numbers 140-147
48.12 line kms

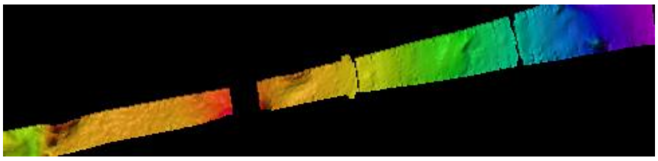


Figure 7.13: Fieldsheet name: EastRosemaryBank_WestRosmaryBank_EM120 (cube1a, 100m, project JC136_LEG2)

East Rosemary Bank – West Rosemary Bank – 6th June 2016
EM710 line numbers 77-79
19.16 line kms

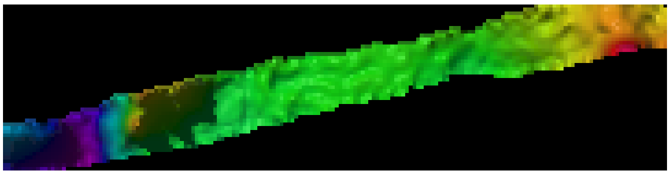


Figure 7.14: Fieldsheet name: EastRosemaryBank_WestRosmaryBank_EM710 (cube1a, 100m, project JC136_LEG2)

East Rosemary Bank – 7th June 2016
Autosub EM2040 line numbers 1-52
52.51 line kms

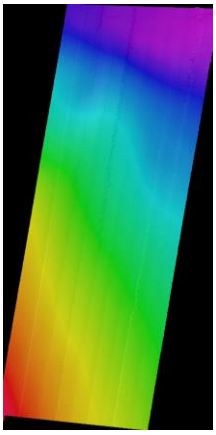


Figure 7.15: Fieldsheet name: EastRosemaryBank_swathe_3m (swath, 3m, project JC136_LEG2)

West Rosemary Bank Transits – 8th and 9th June 2016
EM120 line numbers 148-153
13 line kms

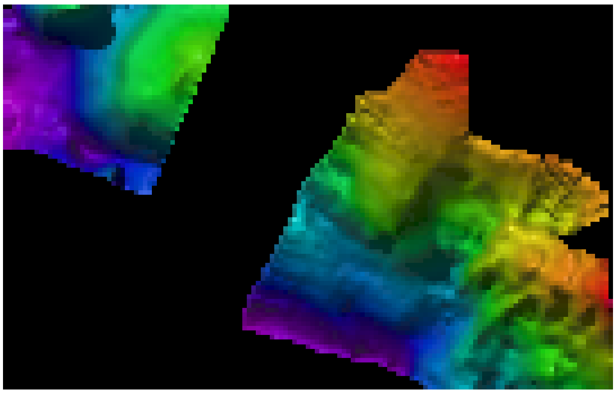


Figure 7.16: Fieldsheet name: WRB_transit_3
(cube1a, 100m, project JC136_LEG2)

West Rosemary Bank – 9th June 2016
Autosub EM2040 multibeam lines 1-29 and geophysical lines DATA0000381-DATA0000451.
29.68 line kms (*2)

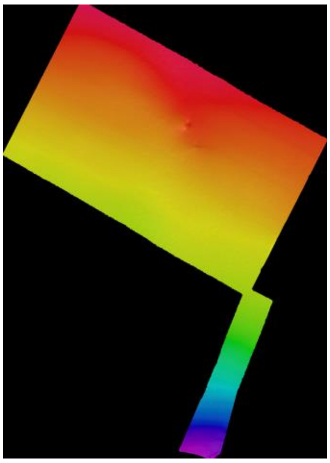


Figure 7.17: Fieldsheet name: WRB_1200m_swathe_3m (swath, 3m, project JC136_LEG2)

Geophysical data to be looked at onshore at BGS Edinburgh office.

East Rosemary Bank 50cm – 11th June 2016
Autosub EM2040 multibeam lines 1-76
74.35 line kms
Fieldsheet name: ERB_1200m_50cm (swath, 50cm, project JC136_LEG2)
Fieldsheet still to be processed.

Rosemary Bank – George Bligh Bank Transit – 11th and 12th June 2016
EM120 lines 155-179
162.07 line kms

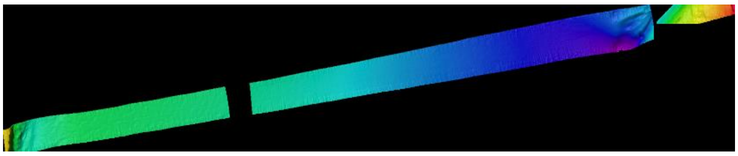


Figure 7.18: Fieldsheet name: RB_GB_Transit_1 and RB_GB_Transit_2
(cube1a 100m, project JC136_LEG2)

George Bligh Bank – 13th June 2016
Autosub EM2040 lines 1-89
70.25 line kms

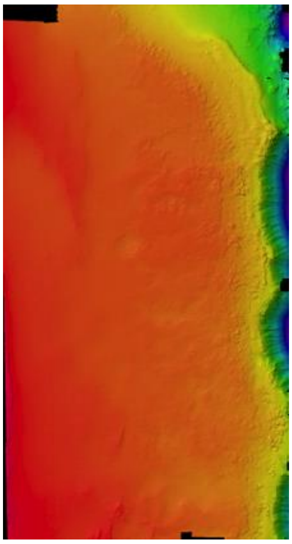


Figure 7.19: Fieldsheet name: George Bligh Bank_1200m_2_swath_surface (swath, 3m, project JC136_LEG2_2)

Navigation errors occurred from lines 53 onwards. The lines need to be shifted west by approx. 500 m. These lines were not in the area of interest so they were not included in the swath surface.

George Bligh Bank 50 cm Area 1 – 15th June 2016
Autosub EM2040 lines 1-82
78.55 line kms
Fieldsheet name: GeorgeBlighBank_Area1_sw_50cm_2
(swath, 50cm, project JC136_LEG2_2)
Fieldsheet still to be processed.

George Bligh Bank 50cm Area 2 – 16th June 2016
Autosub EM2040 lines 1-38
37.07 line kms
Fieldsheet name: GeorgeBlighBank_Area2_swathe_50cm
(swath, 50cm, project JC136_LEG2_2)
Fieldsheet still to be processed.

George Bligh Bank – Anton Dohrn Transit – 16th and 17th June 2016
EM120 lines 181-209
198.32 line kms

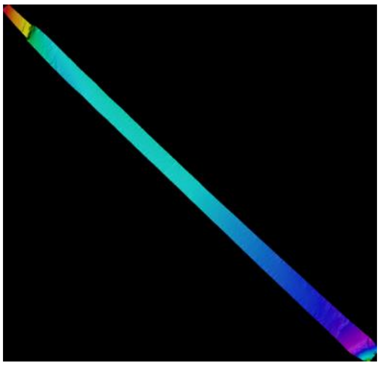


Figure 7.20: Fieldsheet name: GBB_AD_Transit
(cube1a, 100m, project JC136_LEG2_2)

Anton Dohrn 50 cm – 18th June 2016
Autosub EM2040 lines 1-80
84.09 line kms

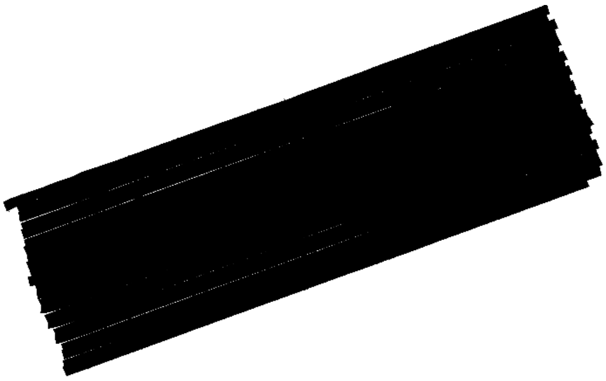


Figure 7.21: Fieldsheet name: AntonDohrn_swath_50cm
(swath, 50cm, project JC136_LEG2_2)

Anton Dohrn Transit – Northern Ireland Transit – 18th, 19th June 2016
EM120 lines 210-231
208.36 line kms

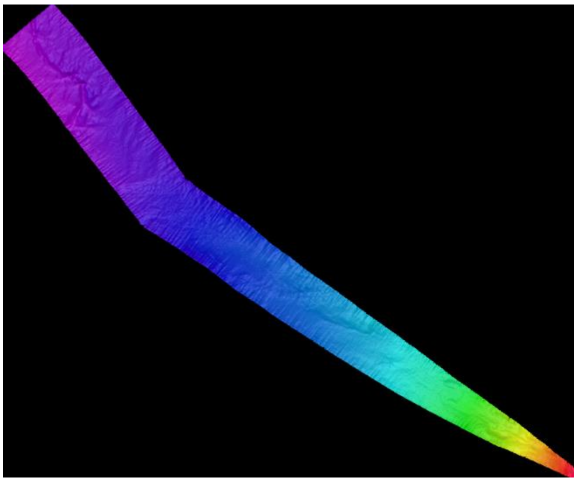


Figure 7.22: Fieldsheet name: AntonDohrn_NI_Transit
(cube1a, 100m, project JC136_LEG2_2)

7.2 Physical oceanography

Lead persons – Alex Nimmo-Smith, Nataliya Stashchuk & Vasiliy Vlasenko.

Oceanographic measurements during the JC136 cruise included 43 CTD stations, deployment of two moorings, as well as additional data collected by the AUV and ROV. The principal aim of these measurements was to provide background information on oceanographic parameters of sea water in the areas of the Isis ROV operation during the cruise and for further biology data analysis.

7.2.1 Equipment

The equipment used for oceanographic measurement included:

A) CTD Sea-Bird 9plus underwater unit that recorded a set of standard parameters of sea water in a binary format. CTD cast data were post-processed routinely by a member of the scientific personnel in accordance with the Sea-Bird data processing routines and the guidance required by BODC.

B) TRDI WHM 300kHz Lowered Acoustic Doppler Current Profiler (LADCP) installed in a downward-looking orientation on the CTD frame for measurements of the velocity components. Velocity data recorded at each station was post-processed using "Visbeck" routines recently adapted and improved (A.M. Thurherr, 2008, 'How to process LADCP data with the LDEO software') and identified as LDEO IX.5. They were combined with CTD data to provide accurate information on vertical velocity.

C) Moorings. Moorings were equipped with upward-looking TRDI 75kHz ADCPs for measurements of current velocities in the whole water column and 300KHz downward-looking ADCP for measurements in the bottom layer. The specifications of all units deployed with the mooring are shown in Figure 7.24.

Figure 7.23: CTD zone Sea-Bird 9plus with downward-looking LADCP.

D) ROV and AUV recorded data

ROV recorded depth and water temperature during each dive and the AUV was equipped with depth, temperature and salinity sensors, as well as an ADCP for velocity measurement (in a separate report).

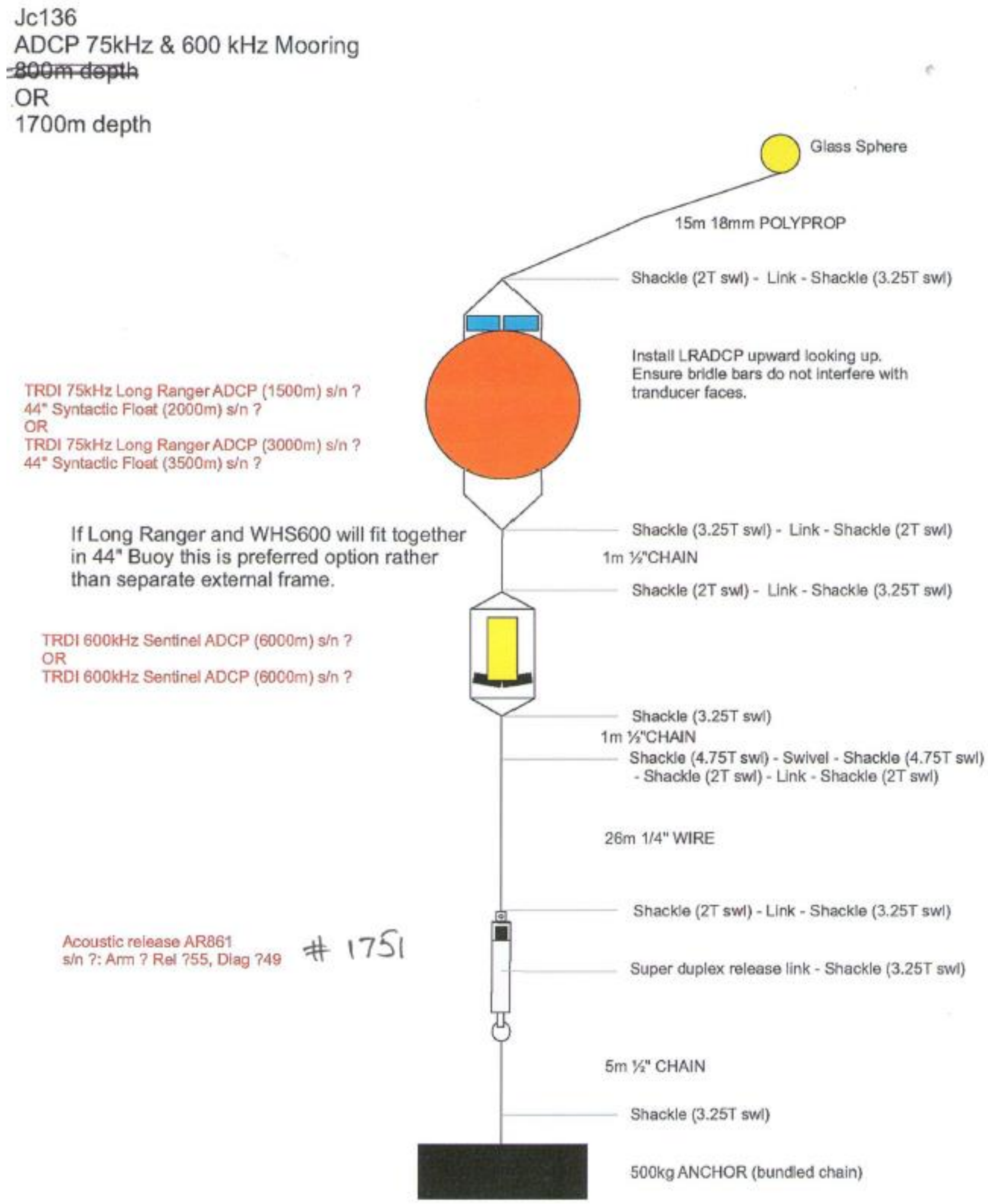


Figure 7.24: Mooring deployed at Anton Dohrn Seamount

7.2.2 Collected data

Oceanographic data were collected in five areas: Anton Dohrn Seamount (ADS), North Rockall Bank (NRB), George Bligh Bank (GBB), Rosemary Bank (RB), and Wyville-Thomson Ridge (WTR). The details of the mooring deployment and CTD stations are as follows:

Table 7.1: Mooring deployment details at Anton Dohrn Seamount.

Mooring	Lat	Long	Depth (m)	Date	Time (UTC)	Remarks
M1	57 35.803	-11 10.352	808	17/05/16	14:47	Deployed
M1	57 35.76	-11 10.37		17/06/16	10:26	Recovered
M2	57 37.240	-11 11.250	1220	17/05/16	15:28	Deployed
M2	57 37.3	-11 11.3		17/06/16	9:16	Recovered

Table 7.2: Location, depth and time of all CTD stations taken during the cruise.

Station	Location	Lat	Long	Depth (m)	Date	Time (UTC)
LEG 1						
1	ADS	57 10.178	-10 30.000	2229	17/05/16	5:07
2	ADS	57 30.276	-11 12.026	651	18/05/16	10:26
3	ADS	57 30.241	-11 12.000	652	18/05/16	15:33
4	ADS	57 36.999	-11 14.576	1280	18/05/16	18:59
5-19	ADS	57 36.976	-11 14.444	1238	19/05/16	St.5 8:10
5-19	ADS	57 37.289	-11 12.442	1100	19/05/16	St.19 20:38
20	ADS	57 35.738	-11 15.487	818	20/05/16	8:40
21	ADS	57 27.874	-11 07.128	568	23/05/16	16:13
22	NRB	57 50.904	-13 58.793	190	24/05/16	18:50
23	NRB	58 22.764	-13 29.947	1085	26/05/16	16:06
24	NRB	58 23.359	-13 31.483	1228	27/05/16	12:52
25	GBB	58 39.232	-13 49.478	1272	31/05/16	12:31
26	GBB	58 40.800	-13 49.900	1143	01/06/16	15:59
LEG 2						
27	WTR	59 46.331	-07 3.136	1115	05/06/16	9:36
28	WTR	59 46.331	-07 03.136	1115	05/06/16	9:36
29	WTR	59 49.679	-07 07.404	1085	05/06/16	15:54
30	RB	59 49.450	-07 20.994	966	05/06/16	17:52
31	RB	59 19.510	-09 32.558	1376	06/06/16	7:06
32	RB	59 10.172	-10 27.491	600	06/06/16	14:53
33	RB	59 03.526	-10 34 198	1273	07/06/16	11:49
34	RB	59 08.276	-10 41.093	1126	09/06/16	15:20
35	RB	59 13.770	-09 39.790	1083	10/06/16	13:50
36	RB	59 18.266	-09 40.302	1150	10/06/16	16:02
37	GBB	58 52.320	-13 22.540	1080	12/06/16	6:08
38	GBB	58 52.030	-13 21.100	1131	14/06/16	7:40
39	GBB	58 56.400	-13 45.350	453	14/06/16	10:50
40	GBB	58 58.000	-13 52.200	458	14/06/16	11:40
41	ADS	57 35.860	-11 10.100	767	17/06/16	11:00
42	ADS	57 30.290	-11 12.040	646	17/06/16	13:30
43	ADS	57 27.610	-11 07.188	557	18/06/16	15:14

7.2.3 Preliminary data analysis

7.2.3.1 Anton Dohrn Seamount

24 CTD stations were done over Anton Dohrn Seamount (ADS), 21 at the beginning of the cruise during Leg 1 (St.1-21), and 3 CTD stations (St. 41-43) at the end of the cruise; they are shown in Figure 7.25.

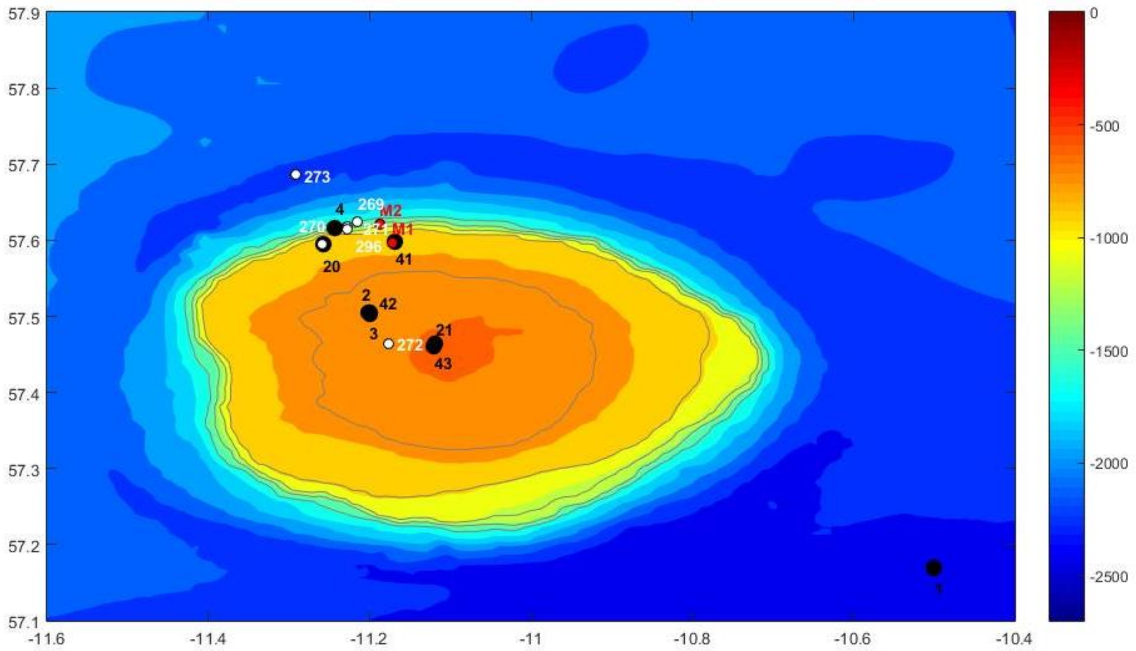


Figure 7.25: Positions of CTD stations (black), moorings (red), and ROV dives (white) in the Anton Dohrn Seamount area.

Station 1 was conducted in the deep part outside ADS in order to get the background stratification around the bank, and stations 2, 3, 4 could show the spatial variability of the oceanographic parameters across the bank. Summarizing, the first CTD stations have shown an absence of a seasonal pycnocline at the end of May, with maximum temperature at the free surface of about 10°C and weak stratification in the surface layer (Figure 7.26, middle panel). The main pycnocline is better presented at station 4, showing moderate stratification below 900 m depth. The current profiles recorded by the LADCP show evidence of baroclinic motions that most probably were of tidal origin (Figure 7.26, left panel). Water is mostly stratified due to temperature gradients, because the salinity range is only 0.25 ppt over 1200 m thick water column.

CTD stations 5-19 were conducted at the same position near the shelf break in the regime of yo-yo sampling with roughly 45-50 minute time intervals between stations. In fact, the weather was bad and did not allow deployment of the ROV and AUV, and the only possible activity was CTD sampling. Comparative analysis of temperature profiles recorded over one tidal cycle has shown great baroclinic tidal activity at the depth of the shelf edge.

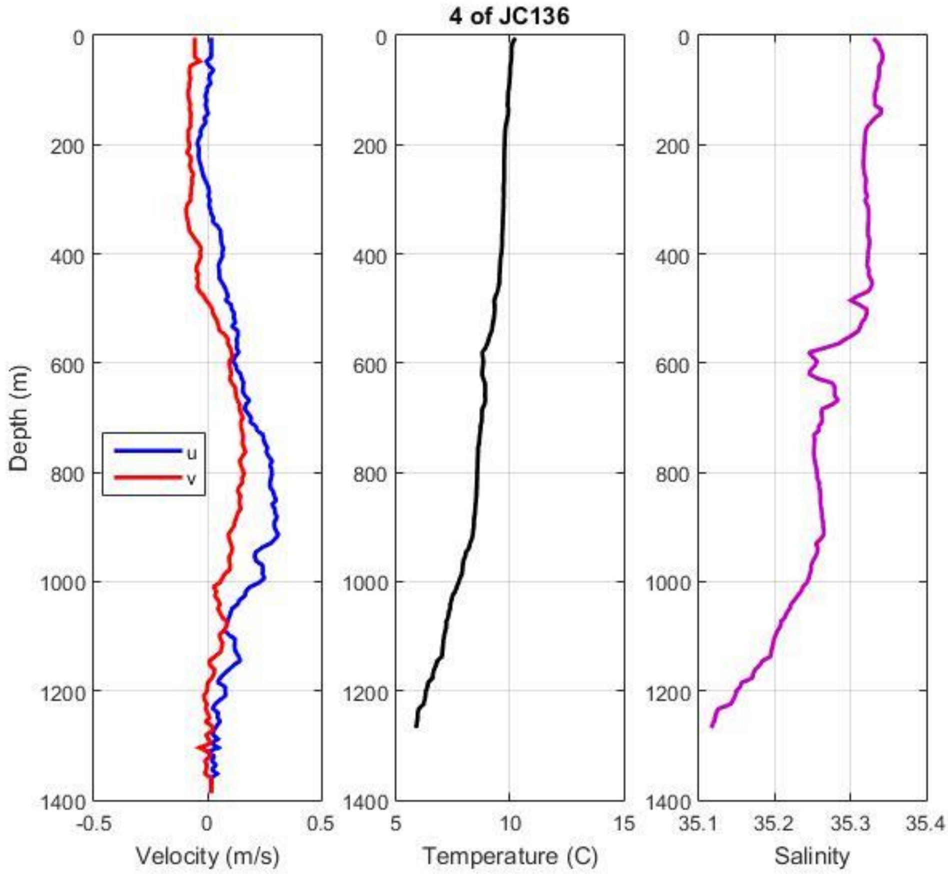


Figure 7.26: Profiles of the horizontal velocities (left), temperature (middle), and salinity (right) recorded at station 4.

The background oceanographic conditions radically changed over the cruise duration. CTD station 41, conducted one month later in nearly the same position as station 4 revealed the presence of a well-developed seasonal pycnocline in the surface 50 m layer, with a temperature gradient of about 2°C (left panel of Figure 7.27). Below this level, not mach changed over one month, both in the temperature and salinity profiles (compare Figures 7.26 and 7.27). The velocity profiles at station 41 again show evidence of intensive baroclinic motions (left panel of Figure 7.27), which should be a matter of further scrutiny on the role that baroclinic tidal motions play in the area of Anton Dohrn Seamount. This statement is confirmed by the spatial variability found at the section across the bank that was conducted at the end of the cruise, specifically at stations 41, 42, and 43.

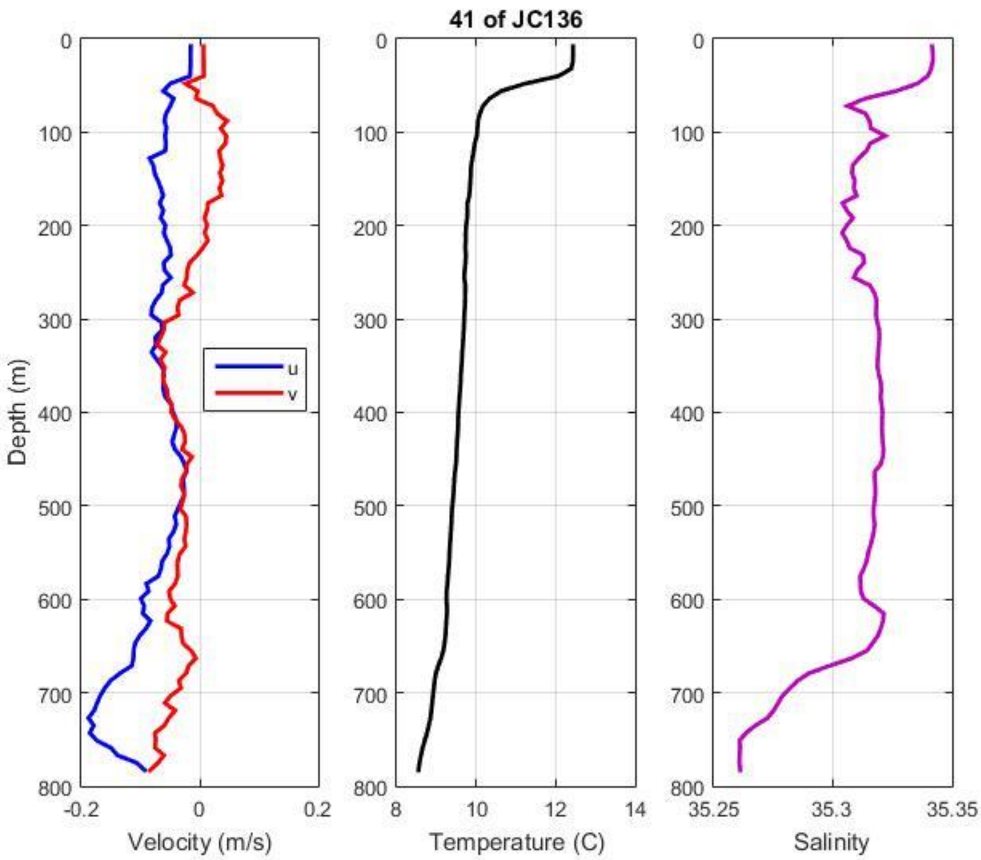


Figure 7.27: Profiles of the horizontal velocities (left), temperature (middle), and salinity (right) recorded at station 41.

ROV records of temperature were also available for the analysis. The positions of ROV dives 269-273 and 296 at the ADS seabed are marked in Figure 7.25.

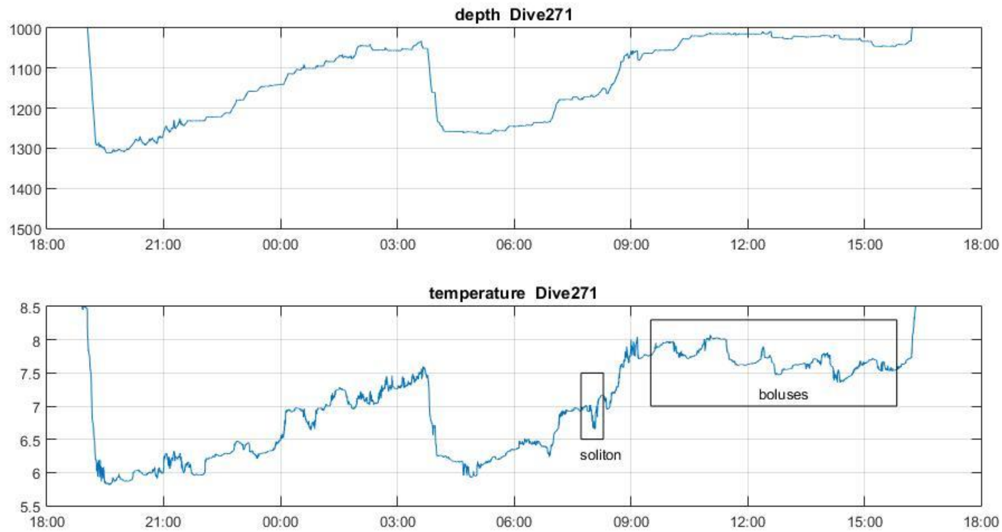


Figure 7.28: Time series of depth and temperature recorded during ROV Dive 271. Periods of internal wave activity are marked by rectangles.

The ROV is a slow moving vehicle (maximum speed of 0.4 knots) with most of its time spent sitting on the sea floor and collecting samples. This property makes the ROV another measuring device, which is very efficient for measurements of fast developing nearbottom processes. As an example, Figure 7.28 shows a temperature time series recorded during one of the ROV's missions to the ADS seabed. These records, together with the depth time series, allow one to identify a number of dynamically driven fluctuations shown in Figure 7.28, shown in rectangles, which presumably are footsteps of internal waves passing through the area. Further scrutiny of these records along with temperature and velocity profiles is required to make them more informative.

7.2.3.2 Rockall Bank and George Bligh Bank

Another area of interest during the JC136 cruise is shown in Figure 7.29.

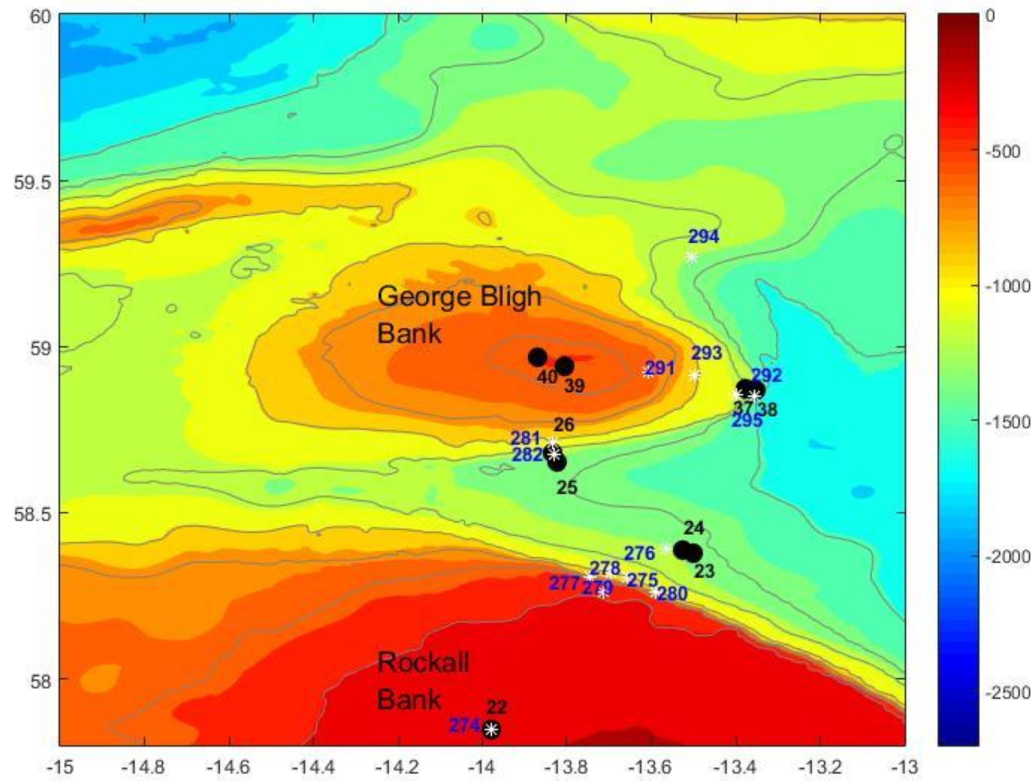


Figure 7.29: Topography of George Bligh Bank (GBB) and a part of North Rockall Bank (NRB) with positions of CTD stations (black), and ROV dives (white stars).

CTD measurements here were conducted during Leg 1 (stations 22-26) and Leg 2 (stations 37-40). Comparative analysis of the water properties (see Figures 7.30 and 7.31) reveals warming of a surface 50 m layer over two weeks. The increase of temperature comprises 2°C. Below this depth, the thermohaline structure of sea water remained mostly the same, although the velocity profiles are different.

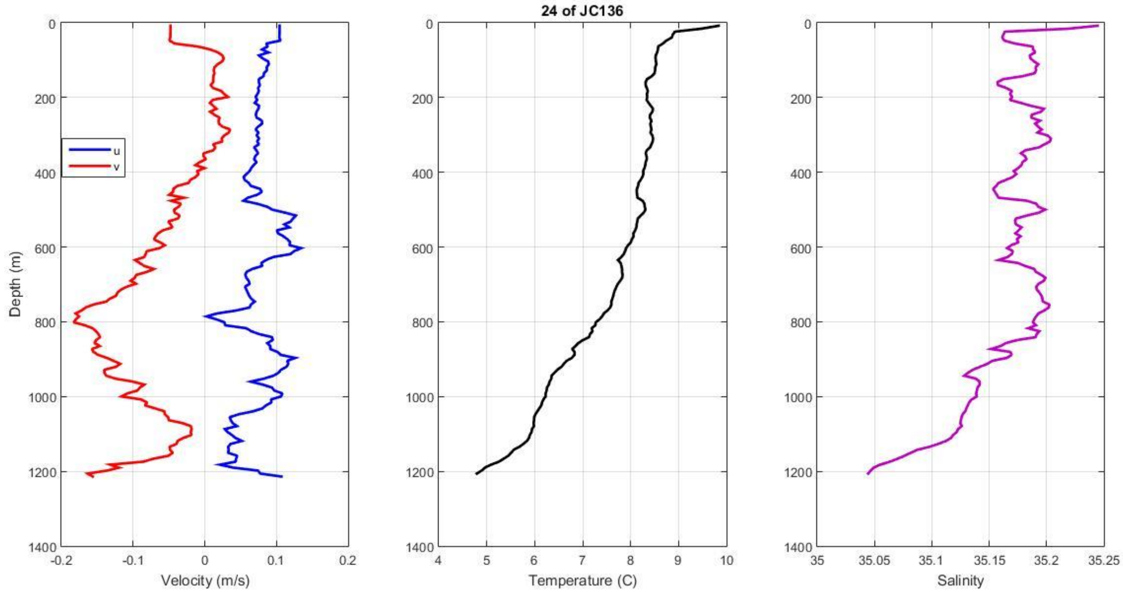


Figure 7.30: Profiles of the horizontal velocities (left), temperature (middle), and salinity (right) recorded at station 24 on 27th of May 2016.

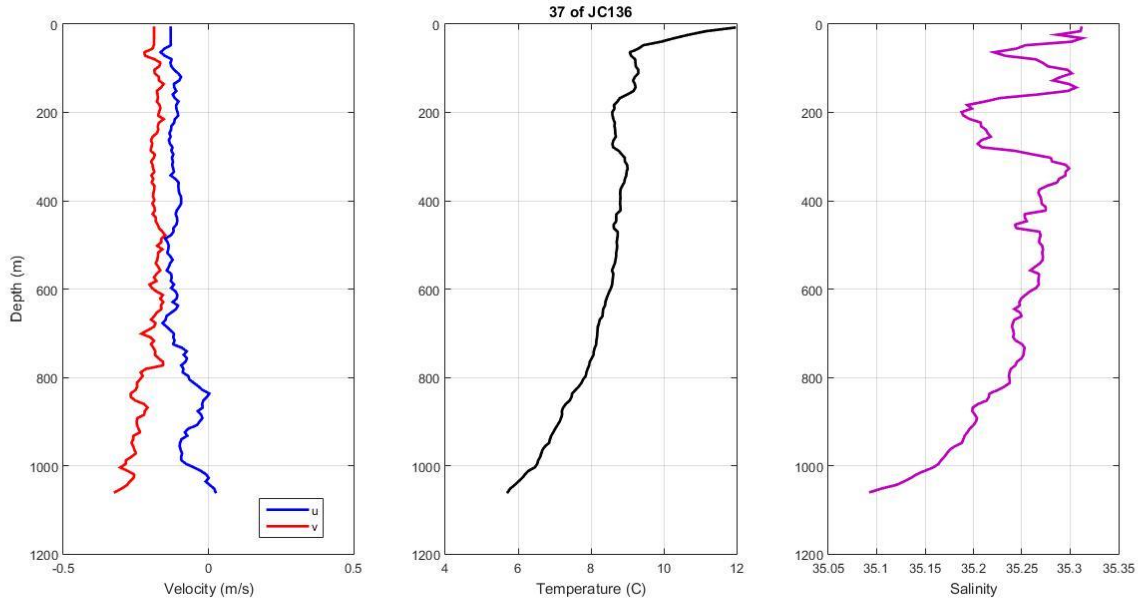


Figure 7.31: Profiles of the horizontal velocities (left), temperature (middle), and salinity (right) recorded at station 37 on 12th of June 2016.

At station 24, quite a strong baroclinic signal was recorded (v-velocity profile resembles first baroclinic mode), whereas at station 37, which was conducted at the eastern flank of GBB, the baroclinic signal is weak, but strong barotropic west-south current is obvious, which occupies the whole water column. It is interesting that the current keeps its characteristics stable in time. It was recorded at the very same position two days later at station 38, with nearly the same strength and direction (see Figure 7.32).

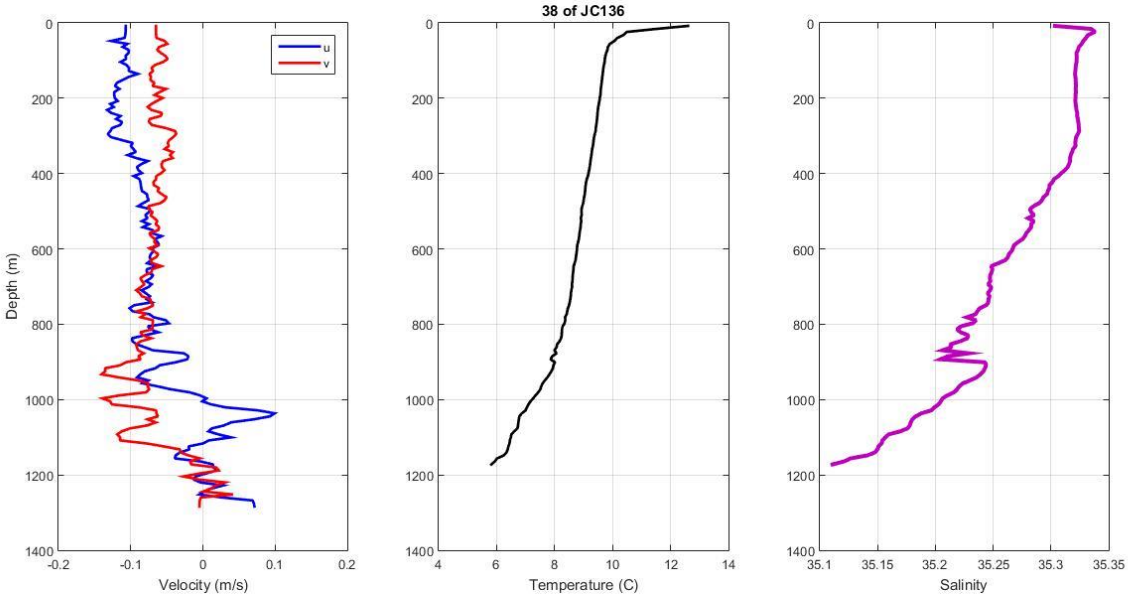


Figure 7.32: Profiles of the horizontal velocities (left), temperature (middle), and salinity (right) recorded at station 38 on 14th of June 2016.

Interpretation of this current requires further scrutiny. It looks like a barotropic one that occupies the whole water depth but its tidal origin is under question. The TPXO inverse tidal model predicted for the neap tide (12-15th June) maximum tidal currents at the level of 3 cm/sec, which is well below LADCP measured velocities shown in Figures 7.31 and 7.32.

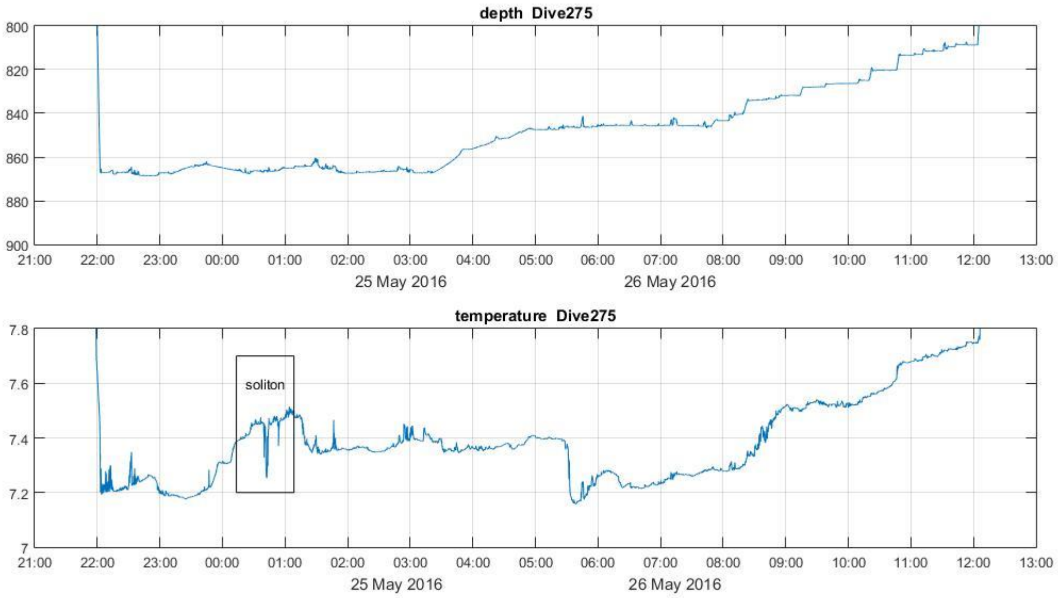


Figure 7.33: Time series of depth and temperature recorded during ROV Dive 275. Strongest internal wave signal is marked by a rectangle.

A number of ROV dives in the area were conducted for collection of samples, both on Leg 1, and Leg 2 (see Figure 7.29). Internal wave activity was recorded during each dive. Typical manifestation of internal waves looks like that shown in Figure 7.33. Zoom of the fragment of the temperature time series (Figure 7.34) recalculated as vertical displacement of isotherms shows that the amplitude of the internal wave was about 40 m, which can be classified as large amplitude internal wave.

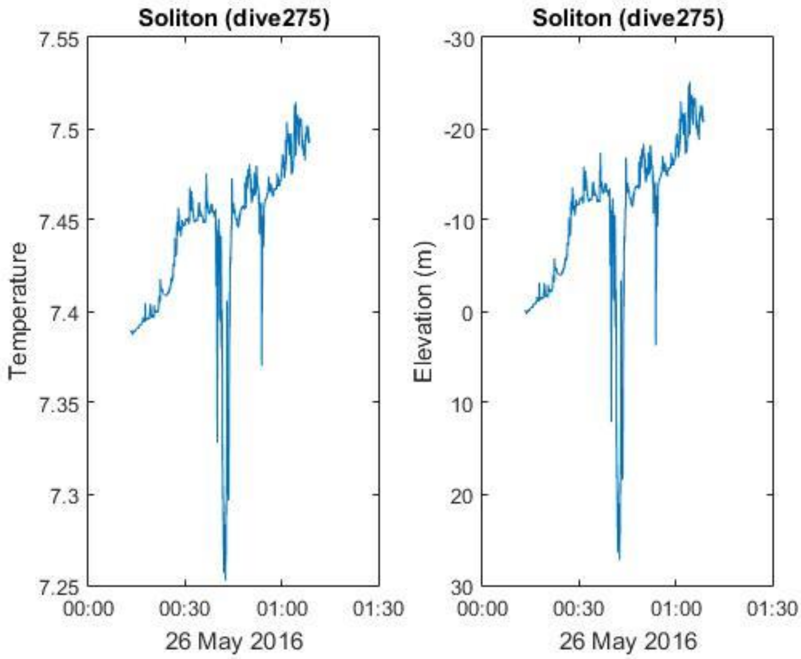


Figure 7.34: Zoom of the fragment marked in Figure 7.33. Right panel represents the same time series but recalculated as isotherms displacement.

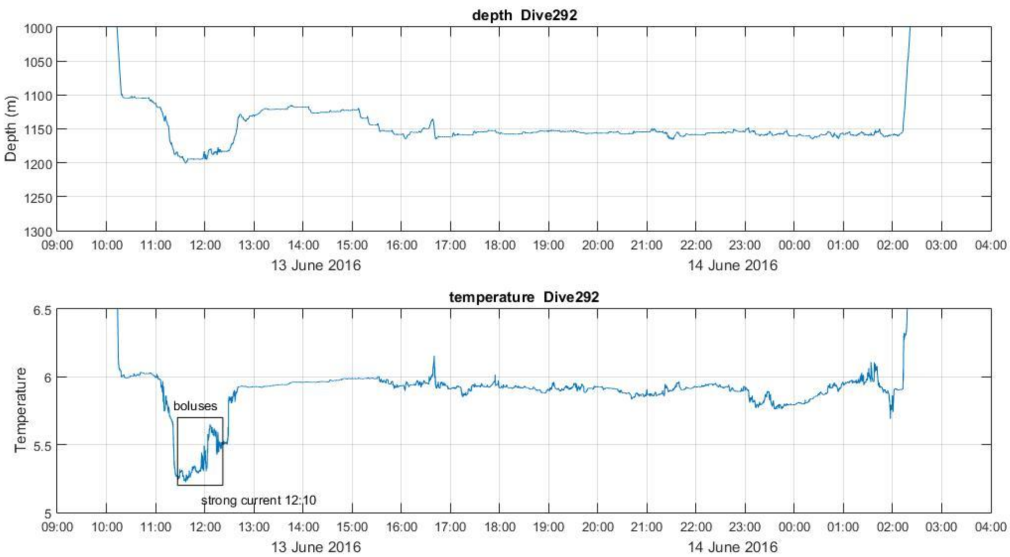


Figure 7.35: Time series of depth and temperature recorded during ROV Dive 292. Strongest internal wave signal is marked by a rectangle.

7.2.3.3 Rosemary Bank

Seven CTD samplings (stations 30-36) were conducted over RB during the second leg between the 5th and 10th of June. Their positions are shown in Figure 7.36.

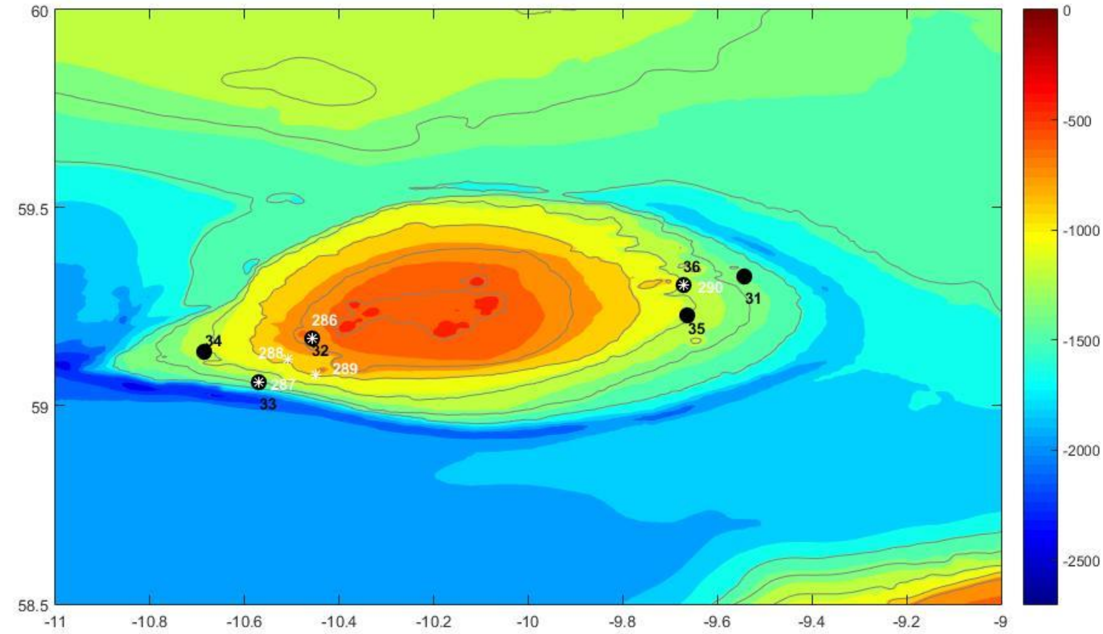


Figure 7.36: Topography of Rosemary Bank (RB) with positions of CTD stations (black), and ROV dives (white stars).

These CTD stations allowed monitoring of the sea water parameters before each ROV dive. The latter (dives 286-290) are shown in Figure 7.36. In fact, high levels of turbulence near the bottom and low water transparency due to resuspension of bottom sediments has led to termination of two ROV missions, so it was decided to measure a level of near bottom turbidity before each ROV dive.

Figures 7.37 and 7.38 show sea water parameters measured at CTD stations 31 and 34 conducted at the beginning and at the end of the RB field campaign. Tidal activity during this period was at the level of 15-20 cm/sec (left panels), which is strong enough for sediment resuspension. Temperature profiles revealed quite a developed seasonal pycnocline in the surface 50 m layer, followed by a less stratified intermediate layer (up to 900 m depth), below which the main pycnocline is clearly seen. The stratification in the area is controlled by the temperature as the salinity gradient is quite weak, less than 0.2 ppt over surface 1000 m layer, see Figures 7.37 and 7.38.

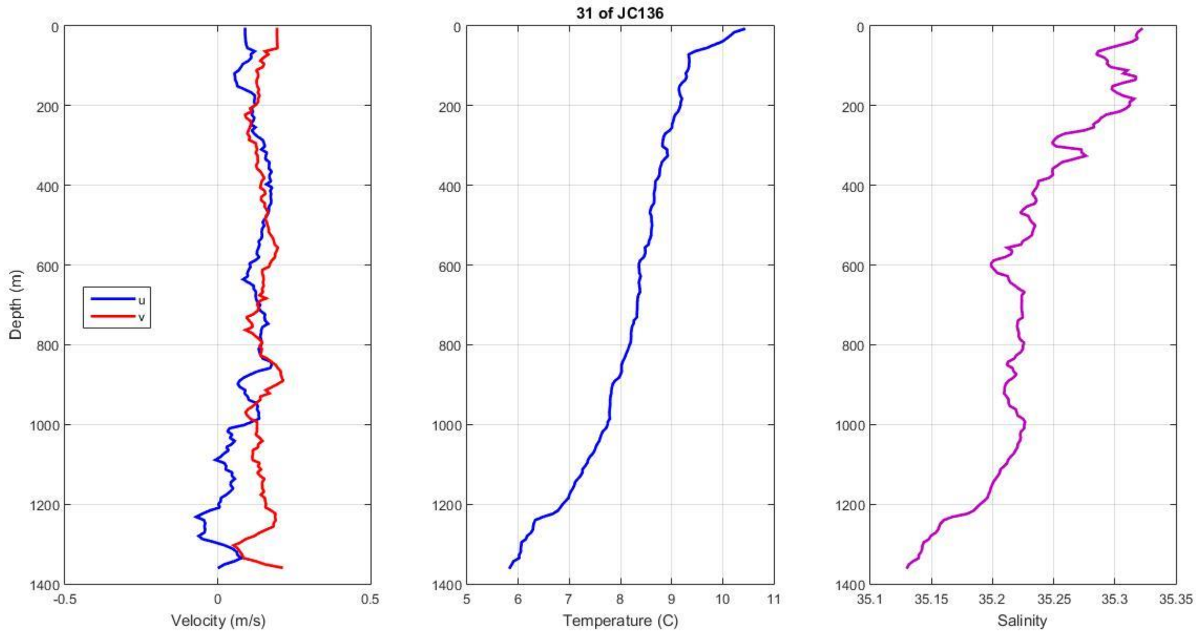


Figure 7.37: Profiles of the horizontal velocities (left), temperature (middle), and salinity (right) recorded at station 31 on 6th of June 2016.

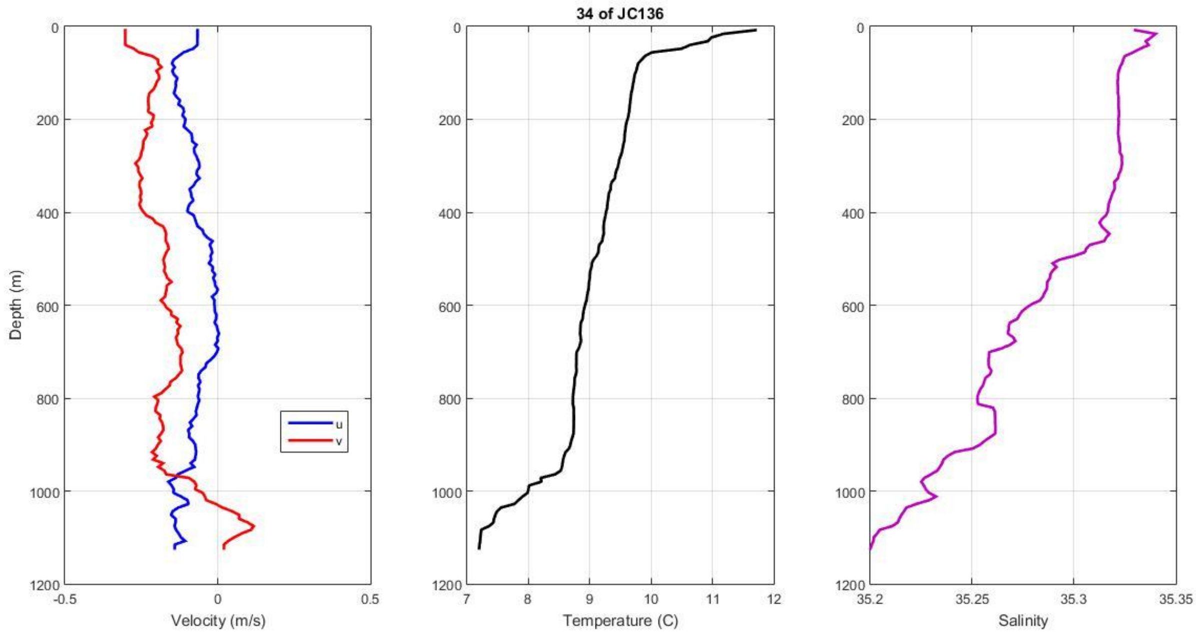


Figure 7.38: Profiles of the horizontal velocities (left), temperature (middle), and salinity (right) recorded at station 34 on 9th of June 2016.

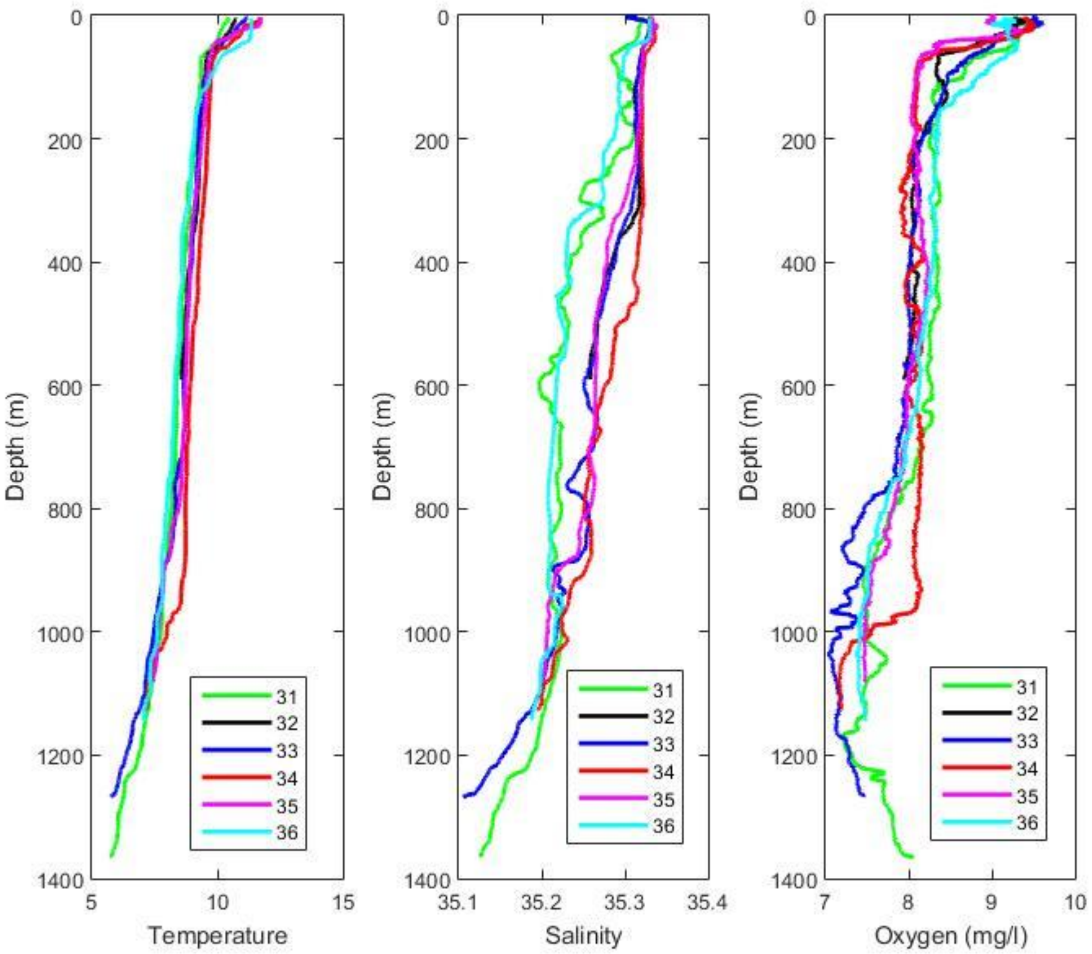


Figure 7.39: Profiles of temperature (left), salinity (middle), and oxygen (right) recorded at stations 31-36 over RB.

CTD samplings have shown spatial and temporal variability of temperature and salinity profiles (see figure 7.39). It can be a consequence of both spatial variability of near-bank circulation and developed internal tidal activity. In favour of the latter, we witnessed the near-bottom intensification of currents (below 900 m, Figure 7.37 and 7.38, left panels) and buoyancy frequency profiles (Figure 7.40) that show local maximums at 1000 m depth, i.e. close to the shelf break where internal waves are normally generated by tidal currents. Strong water stratification there is a prerequisite for a high level of tidal energy conversion.

Overall, the data collected in the Rosemary Bank area during spring tide and in transition to neap tide show great potential to be a “hot spot” for tidal energy conversion and source of oceanic turbulence.

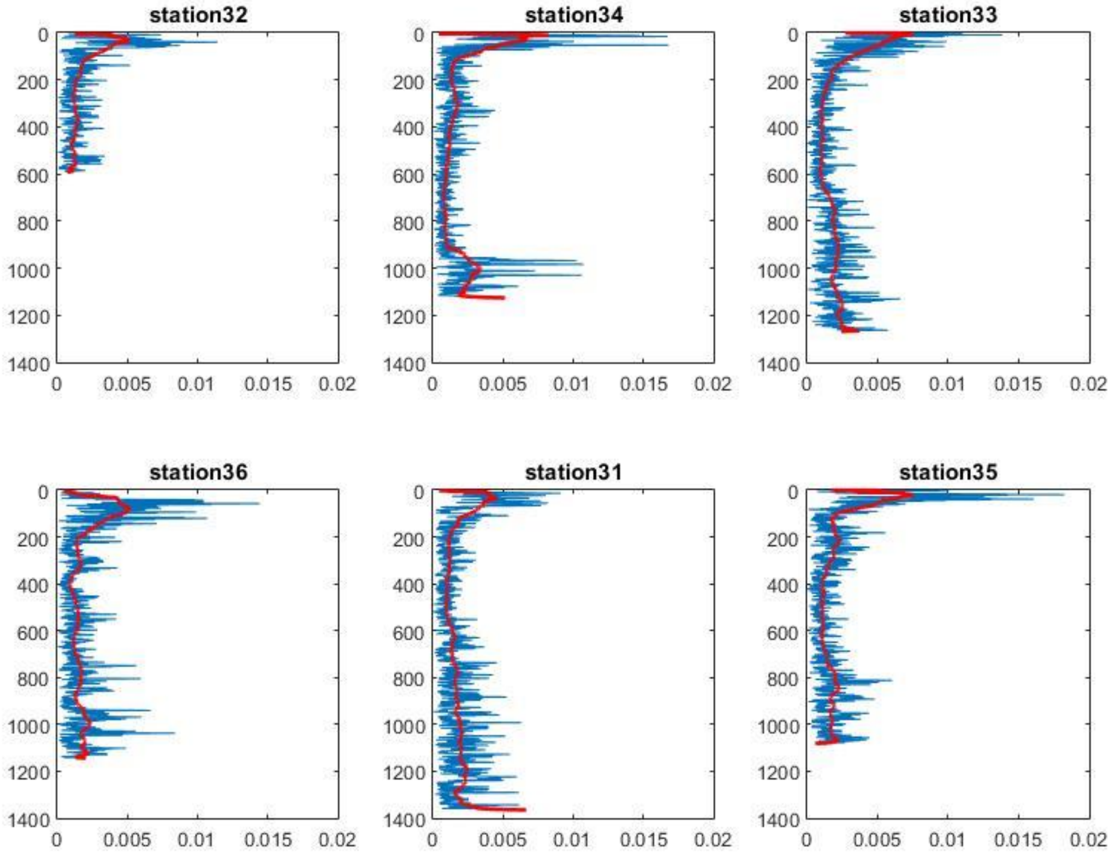


Figure 7.40: Buoyancy frequency for the positions of CTD stations 31-36.

7.2.3.4 Wyville-Thomson Ridge

Only three CTD stations (28-30) and two ROV dives (283 and 284) were conducted in the Wyville-Thomson Ridge (WTR) area (Figure 7.41). The programme on ROV dives was terminated because of high levels of turbidity in the bottom layer and low visibility (the ROV operators could hardly see the arms of their vehicle, Figure 7.42). The reason for strong resuspension of bottom sediments is not clear at the moment, although it is quite evident in the turbidity profilers shown in the right panel of Figure 7.42.

In terms of oceanographic parameters, temperature profiles show quite a thin surface mixed layer over a seasonal pycnocline below it, which is still not well developed in the beginning of summer (surface temperature is only about 11°C). The main pycnocline starts below 800 m depth, but in the western part of the basin (station 30) it is closer to the free surface.

Presented here, results of the CTD and LADCP samplings can be complemented by ROV and AUV data, as well as ADCP time series collected at moorings M1 and M2, and by ship mounted ADCP time series.

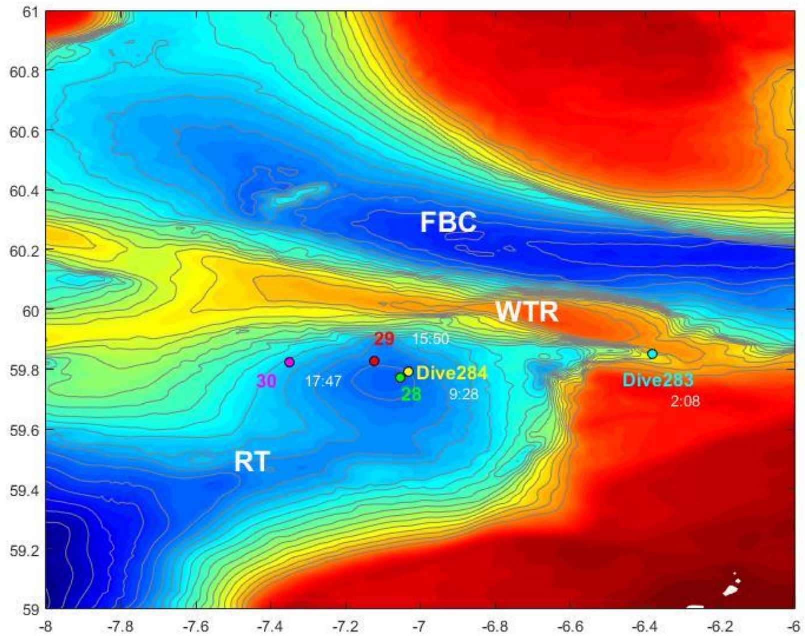


Figure 7.41: Topography of the Rockall Trough (RT) and Wyville-Thomson Ridge (WTR) with positions of CTD stations (red), and ROV dives 283 and 284. FBC – Faroe Bank Channel.

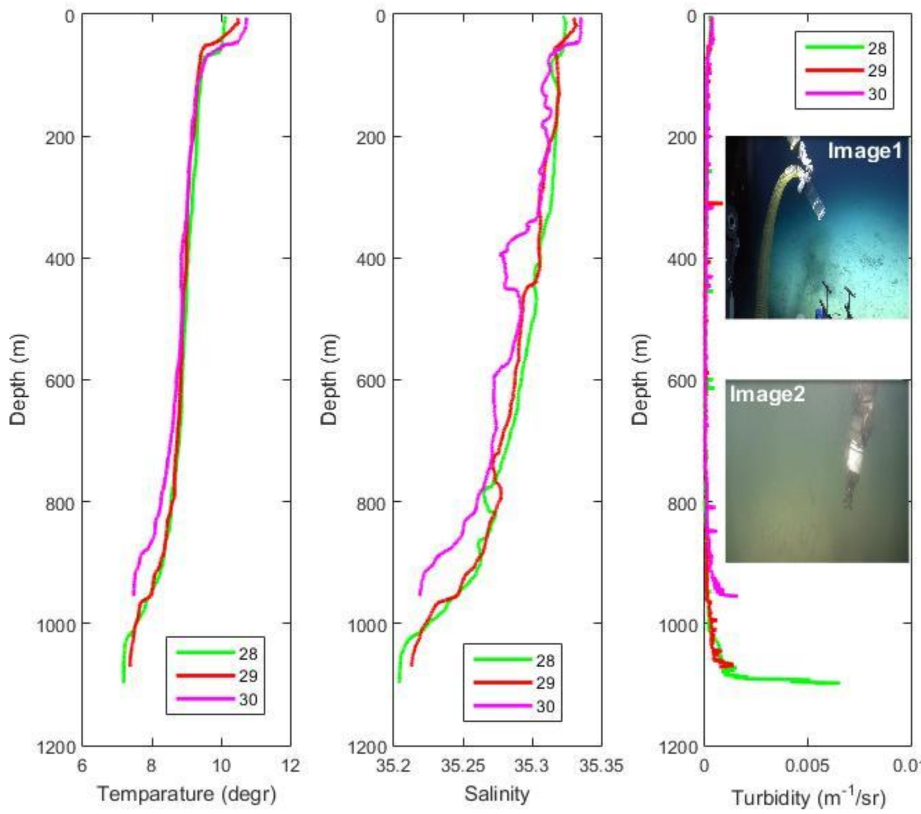


Figure 7.42: Profiles of temperature (left), salinity (middle), and turbidity (right) recorded at stations 28-30 in the WTR and RT area. Images 1 and 2 indicate reduced visibility at the site during the ROV dive.

7.3 Population genetics and organism collections

Lead person – Alex D. Rogers, Michelle L. Taylor, Nicolai Roterman and all other project members contributing.

7.3.1 Rationale

Compared to the terrestrial world, the ocean is a relatively open medium, rendering the elucidation of patterns of population genetic structure and diversity difficult. Many deep-sea benthic marine organisms have a pelagic larval dispersive phase that results in a flow of individuals (gene flow connectivity) among discrete sites, thus maintaining genetic diversity over large areas. This flow of larvae is therefore key to the persistence and productivity of deep-sea benthic populations; defining the scale at which population spatial structuring occurs (Creasey & Rogers 1999). A sound understanding of patterns of connectivity is therefore important in the effective management and sustainable exploitation of benthic marine systems. Patterns of population connectivity between seamount communities, which are determined by physical (currents, geology, water temperature and chemistry changes) and biological factors (dispersal method, prey availability), could range from isolated populations, to inter-connected subpopulations exhibiting island model, source-sink, stepping-stone or metapopulation dynamics.

Much of the current literature on marine population connectivity is derived from shallow-water research; studies of the deep sea are relatively rare and have focused on hydrothermal vent systems and commercial fish species (Creasey & Rogers 1999; Vrijenhoek 2010). The deep-sea fauna exhibit broad geographic ranges with many species having a cosmopolitan distribution (McClain & Hardy 2010). Such broad geographic ranges coupled with a relatively stable environment suggest that deep-sea populations may be ‘open’ and hence lacking in spatial genetic structuring. Evidence from molecular studies in general supports this theory, suggesting that gene flow is maintained over considerable horizontal distances (Bucklin *et al.* 1987; France *et al.* 1992; France 1994). However, recent research has suggested that although gene flow does occur over basin scales, it may occur in a stepping-stone like manner (Etter *et al.* 2011). In contrast, population genetic studies across the depth gradient within the deep sea suggest that in many cases connectivity is poor over vertical distances, with increasing evidence of bathymetric reproductive isolation and speciation among species of a variety of continental slope taxa (Bucklin *et al.* 1987; France & Kocher 1996; Etter *et al.* 1999; Chase *et al.* 1998; Quattro *et al.* 2001; Cho & Shank 2010; Miller *et al.* 2011). In addition, morphological and molecular evidence suggests that levels of population divergence vary with depth; with organisms from bathyal depths exhibiting much greater population structuring than those from abyssal depths (Zardus *et al.* 2006; France & Kocher 1996; Etter *et al.* 2005). This pattern, restated as the Depth-Differentiation Hypothesis (DDH), has led to the suggestion that the bathyal region may be the primary site of adaptive radiation in the deep sea (Etter *et al.* 2005). The nature of potentially isolating mechanisms associated with depth are unclear but have been attributed to water mass structure (Miller *et al.* 2011) oxygen minima (Rogers 2000), pressure and temperature tolerances (Chase *et al.* 1998) and historical factors (Quattro *et al.* 2001; Rogers 2000).

This study will take deep-sea molecular ecology into the population genomics era by applying next generation sequencing methods; gaining datasets that will provide an unprecedented level of genetic detail with which to test the DDH across several seamount-inhabiting benthic taxa exhibiting different life history traits and dispersal strategies. The results attained herein will be used to validate and refine hydrographic and larval dispersal models, with the ultimate aim of gaining a better understanding of how patterns of population structure relate to realised dispersal and connectivity in deep-sea populations. Such knowledge will be of key importance to those tasked with managing and sustaining ecosystems and resources in the deep sea.

7.3.2 Specific aims and objectives

This section specifically covers data collection in regards to Hypothesis 1: Population connectivity varies with depth and is lowest at bathyal depths, corresponding to recorded peaks in diversity.

Aim: To collect at least 20 specimens of at least 4 species of deep-sea organisms across three depth bands (500, 800, 1000 m) and over 4 sites in the NE Atlantic for population connectivity analysis.

Molecular studies will be undertaken to (i) confirm the morphological identification of the main study taxa (e.g. ascertain the presence of cryptic or pseudocryptic species) (ii) estimate both the magnitude and the relative direction of gene flow among sample populations at the same and different depths (iii) to determine the relative effective population sizes of sample populations at the same and different depths (iv) to investigate whether other factors, especially directional selection may be influencing genetic connectivity in the vertical. The final objective here will be achieved using high-throughput sequencing technologies which are now providing population geneticists with access to information on genetic variation across the entire genome. We will attempt to apply one such method, RNA-Seq (Wang et al., 2009), to identify whether there is evidence for depth-related directional selection in expressed genes, an alternative explanation for the generation of genetic differentiation between depth-separated populations. This method not only provides an increase in the resolution of population structure through analysis of variation of numerous single nucleotide polymorphisms simultaneously but also allows the detection of the effects of balancing or divergent selection on a large number of expressed genes (Garcia et al., 2012; de Wit et al., 2012).

Original target species: *Acanella arbuscula, Parastichopus tremulus, Cidaris cidaris,* and *Lophelia pertusa*

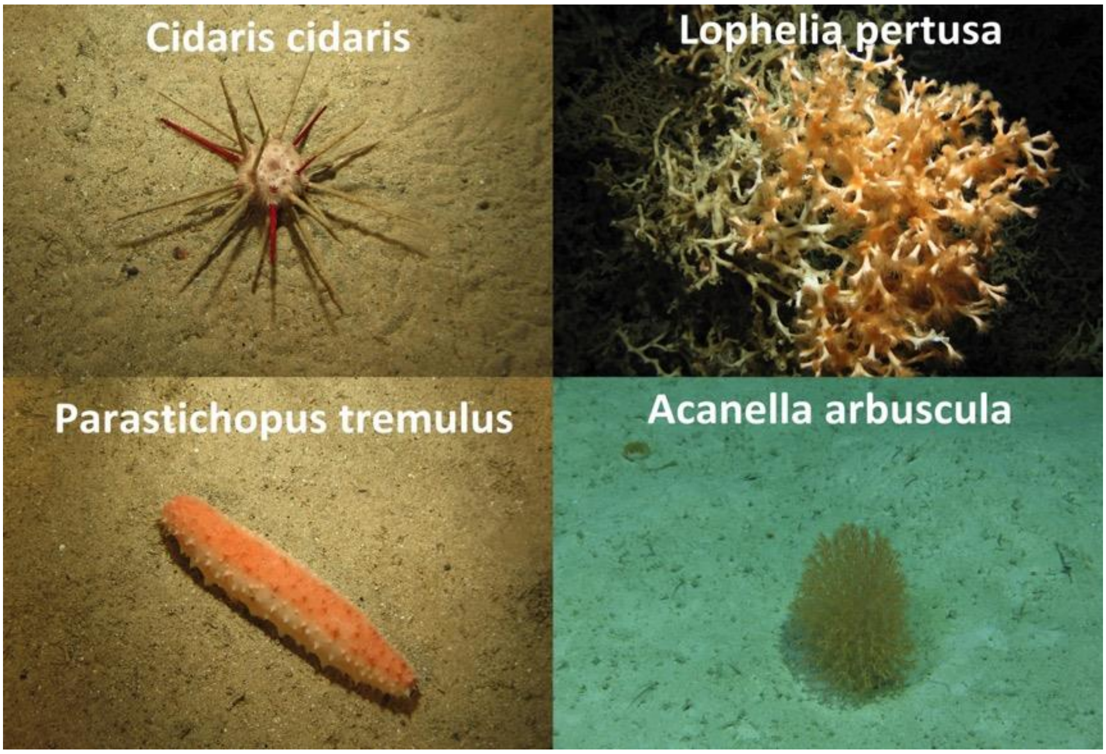


Figure 7.43: Images of four target species: *Acanella arbuscula*, *Parastichopus termulus*, *Cidaris cidaris*, and *Lophelia pertusa.*

7.3.3 Methodology

7.3.3.1 Specimen collection

The ROV Isis is an ideal platform for the collection of discrete, small samples of deep-sea organisms for genetic study as the tray on the front is capable of holding 18-24 tubes of containers and a double biobox, in addition to the 5 suction chambers and 2 wing bioboxes. This variety of small and large containers makes for flexible (and ultimately very successful) sampling collections. Once video transects were complete (and often between transects), target species were found and placed into containers on Isis. Each collection was given an event number and that event and location on the tray, time, lat/long, etc. were noted (in the Isis tray layout and event logsheets, found in Appendix 1). When Isis had completed the dive and was returning to the surface, these log sheets were photographed and parent codes written into the specimen logbook for each container with a specimen/s. These uniquely numbered "parent code" labels were placed individually into a variety of buckets (bucket size depends on container size e.g. bioboxes require 25 L buckets whereas tubes require 2-4 L buckets). Buckets were all taken outside to retrieve specimens (spare label paper was taken in case there were specimens out of containers on the tray / stuck to the vehicle). Isis tray layout (where event numbers are written) was placed into a waterproof see-through bag and taken outside as well to help inform which specimens go into which labelled buckets. Once all specimens were removed from Isis they were taken into a 4°C temperature controlled wet lab where sorting, labelling and genetic subsampling took place. Each specimen in a bucket was given a new unique identifying label (the parent code of which was the bucket i.e. Isis tray location number). That unique identifier and the event code, as well as details about the preservation, genetic subsample and any details about the organism, were written into the specimen logbook (this was eventually digitised, creating the specimen database).

7.3.3.2 Genetic subsampling

Tissue preservation is crucial for successful genetic research. To maximise the potential for future research, we preserved each target species specimen in both RNALater (kept at 4°C for several hours before being moved into a -80°C freezer) and 100% ethanol (replaced with fresh 100% ethanol after a few hours and then maintained at -20°C). Ethanol stored sample tubes contained a unique ID code on the exterior of the tube (2 ml or 5 ml cryovials) alongside the specimen description e.g. *Cidaris cidaris,* and a small label inside; RNALater tubes were just labelled externally with a unique ID code and the specimen description.

Two to three polyps of *Lophelia* were placed in each subsample, 4-5 polyps of *Madrepora* and at least 3 cm of a branchlet of *Acanella*. A ~1 cm^3 sample of the longitudinal muscle of *Parastichopus* was dissected for subsampling and gonad tissue from *Cidaris* was targeted.

7.3.4 Outputs

Early in collection dives it became apparent that *Acanella arbuscula,* one of the four original target species, was not being found in suitable numbers for depth differentiation population genetics and was only found at "deep" 1200 m sites, likely only living in the deeper water mass (the switch was often between 1000-1200m depth). However, *Madrepora oculata* was being found regularly in population genetics abundances (min. 20 / site) across the different depth bands (500, 800, 1000 m, sometimes 1200 m), as were the commensal polychaete worm, *Eunice norvegica,* and at least one species of ophiuroid. Other species were found across a limited depth range but widely through the geographic area studied, e.g. *Solenosmilia variabilis*.

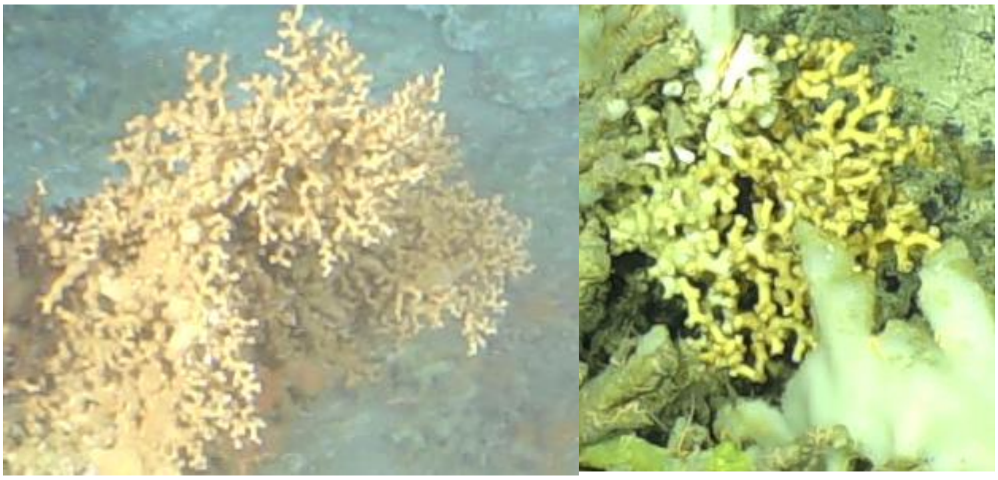


Figure 7.44: Image of *Madrepora in situ* (left), *Solenosmilia in situ* (right).

There are 1822 samples in RNALater and 3182 in 100% ethanol in total. Of these 1448 RNALater samples are for population genetic analyses of the species mentioned above and 1461 in 100% ethanol.

For information about specifics of samples collected please contact lead persons.

7.4 Faunal diversity and community composition

Lead persons – Kerry Howell & Rebecca Ross, all other project members contributing.

7.4.1 Rationale

If H1 (Section 3) is true and the bathyal region is the primary site of adaptive radiation in the deep sea as a result of poor connectivity, we might expect to observe 1) endemism being higher at mid slope depths, 2) changes in taxonomic distinctness with depth, and 3) a peak in diversity at mid slope depths. While there is existing support for 3 (Stewart & Rex 2009), insufficient data are available to address 1 and 2.

Our aim on the cruise was to undertake benthic megafaunal surveys of the test sites using image sampling, building on an existing dataset for the region analysed by Plymouth University over a period of 11 years (Howell et al. 2007; Howell et al. 2009; Howell et al. 2010a; Howell et al. 2010b; Davies et al. 2014; Davies et al., 2015). The sample regime followed a stratified random sampling approach and was planned to sample 6 sites of equivelent slope at 3 depths bands (500, 800, and 1200 m) with 3 replicate transects per depth band, with additional sampling in a 4th depth band (2000 m or 200 m) where depth of the site allowed. Transects were initially planned as 1 km long based on preliminary analysis of species accumulation curves and multivariate statistical analysis, which suggested transects should be at least 600 m long. However, transects were shortend on the cruise to 750 m to make best use of available ship time.

Transects were run in the following manner: The Isis ROV was stopped at the start of the transect line and brought to rest on the seabed. The scaling lasers were swiched on on the fixed Scorpio camera, and the camera zoomed in to a standard zoom determined by the distance between the lasers. The ROV then commenced the transect running the line undisturbed. The ROV tried to maintain a constant height above bottom (thus standardising the field of view); however, at sites in the 800 m depth band, slope and current were often a problem meaning the field of view was altered. This was unavoidable and is a limitation of the survey method. For all transects undertaken, GIS shapefiles were created and xls spreadsheets incorporating navigation log and CTD data.

Forty-two transects were achieved during the cruise in the following configuration (Table 7.3). Wyville-Thomson Ridge transects were aborted due to marine snow, and the third transect at 500 m was subject to strong currents such that the ROV could not stay on the bottom. George Bligh Bank 1200 m diversity transects were in an area of high current speed and steep topography making them untenable (the one completed transect may also not be viable). An additional 1200m site was attempted with the aim of completing this set (station 64, dive 294); however, poor visibility due to marine snow forced this dive to be aborted (one whole video transect was completed, however, there is zero visibility throughout, and therefore this transect is excluded from the count in Table 7.3).

Table 7.3: Numbers of diversity transects undertaken by the ROV throughout the cruise, by site and depth.

Depth	ADS	NRB	WTR	RB	GBB
200 m		3			
500 m	3	3	2	3	3
800 m	3	3		3	3
1200 m	3	3		3	1
2000 m	3				

The transect video data will be reviewed and all organisms larger than 1 cm identifed and quantified. Organism identification from video will be supported by reference to physical specimens that were aquiried during animal collection work on ROV dives (see section 6.3). A species image catalogue will be created for the cruise and combined with the existing catalogue held by Howell. To test H1, changes in taxonomic distinctness with depth will be assessed by calculating values of average taxonomic distinctness, $\Delta+$ ("taxonomic breadth" (Clarke and Warwick 2001a)) and variation in taxonomic distinctness $\Lambda+$ (Clarke and Warwick 2001b) for each sample. Both multivariate (PRIMER and PERMANOVA) and univariate statistical approaches will then be used to test for the effects of depth and population connectivity upon assemblage composition and similarity within and between sites and depths, and taxonomic diversity and distinctness

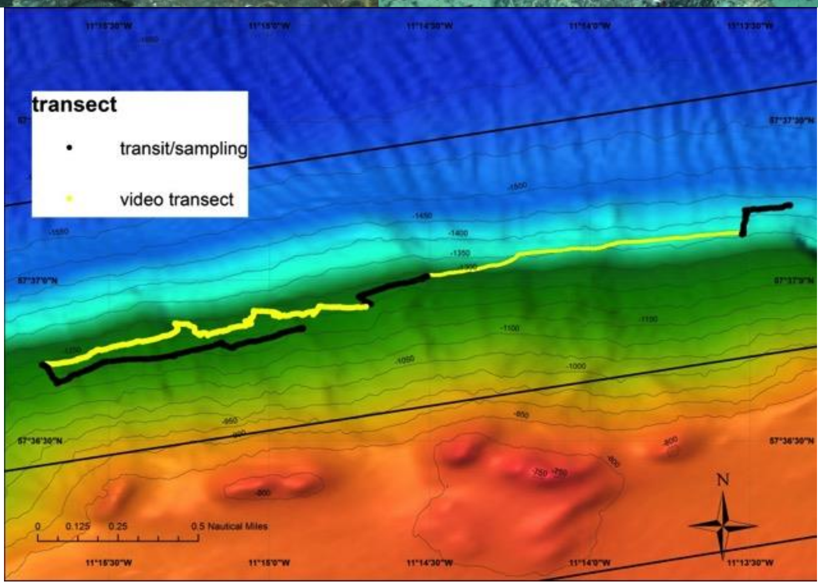
All meta data for all ROV dives, including transect data, will be archived at OBIS and will include contact information. For access to raw ROV video data, please contact Kerry Howell (kerry.howell@plymouth.ac.uk).

8 Dive tracks and dive narratives

Below is a brief description of each dive site visited.

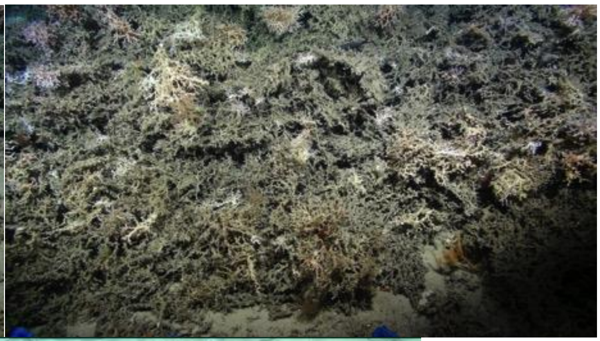
8.1 DIVE 269 (Station 4) – ADS, 1200 m

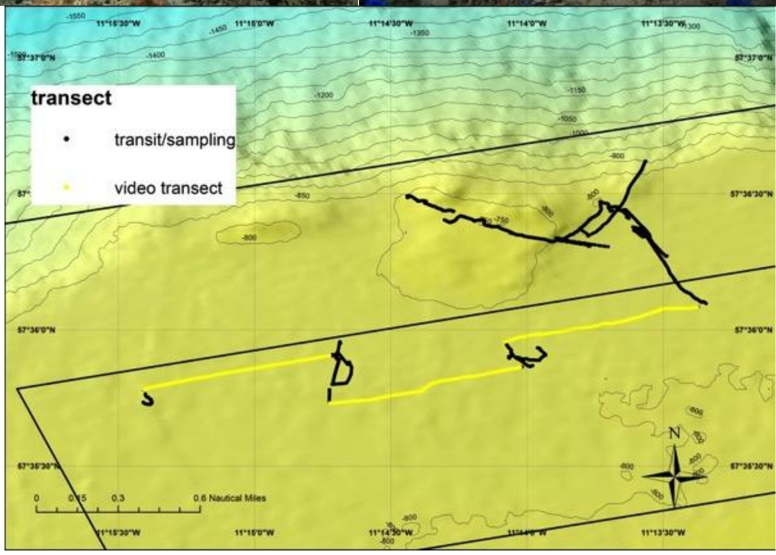
Starts with sandy substrate as Anton Dohrn Seamount is approached. Area occasionally scattered with rocks that are dominated by encrusting sponges. Sloping rocky seamount substrate is reached. Benthic fauna becomes rich, with a diverse array of sponges, anemones, corals and brisingids. Several fish species are also seen, such as orange roughy. Two 1200 m transects were undertaken before strong current forced the dive to be aborted.



8.2 DIVE 270 (Station 10) – ADS, 800 m

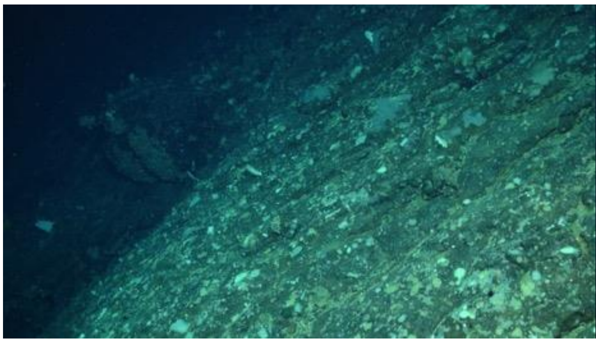
The dive begins with coarse sandy sediment and three video transects. *Cidaris cidaris* are quickly found. The sand becomes coarser as the dive continues and becomes interspersed with gravel and small boulders, which host both target coral species. An extensive, sloping reef was encountered towards the end of the dive, consisting of a mixture of dead and live *Madrepora* and *Lophelia*. Two large monkfish and a sorcerer eel were also spotted.

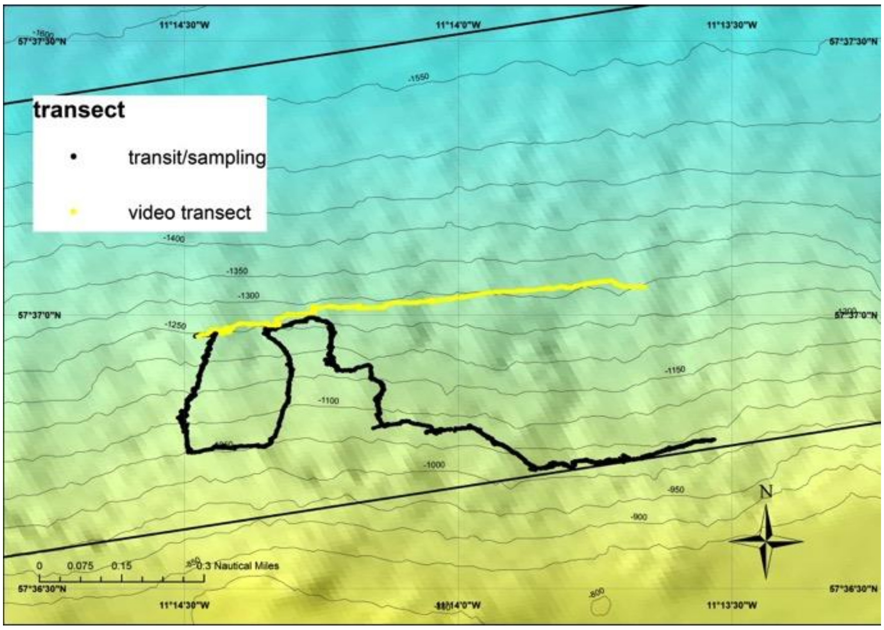




8.3 DIVE 271 (Station 11) – ADS, 1200 m

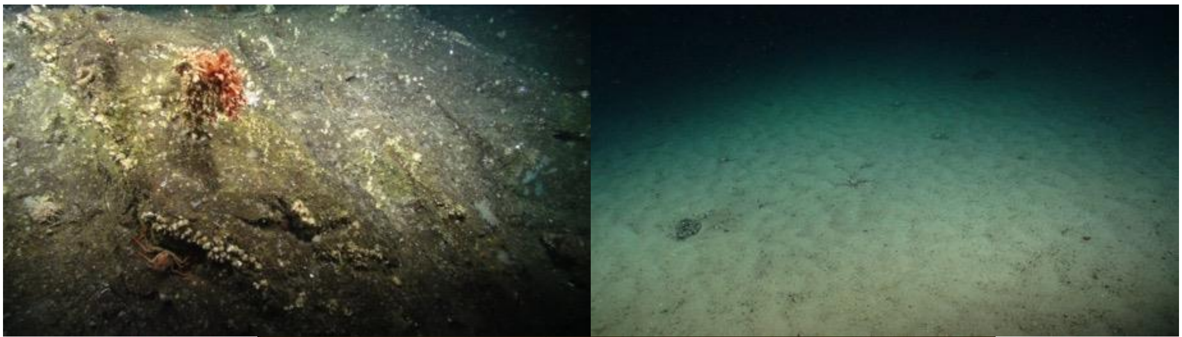
This dive completed the third transect at 1200 m (after the early end to dive 269). The dive is similar to the previous two, beginning with coarse sand that is scattered with benthic fauna, such as sea stars and sponges, with some fish present. At first, the slopes appear to be steeper and sandier, resulting in less abundant and diverse benthic fauna. As the dive progresses, rocky patches becomes more prevalent and coral samples could be collected. Towards the end of the dive, the rock becomes smooth and steep, a few large fissures, outcrops and boulders occur, where the majority of the fauna is located. Significant sightings include a large *Enallopsammia*, *Pheronema*, Farreidae and another large white sponge.

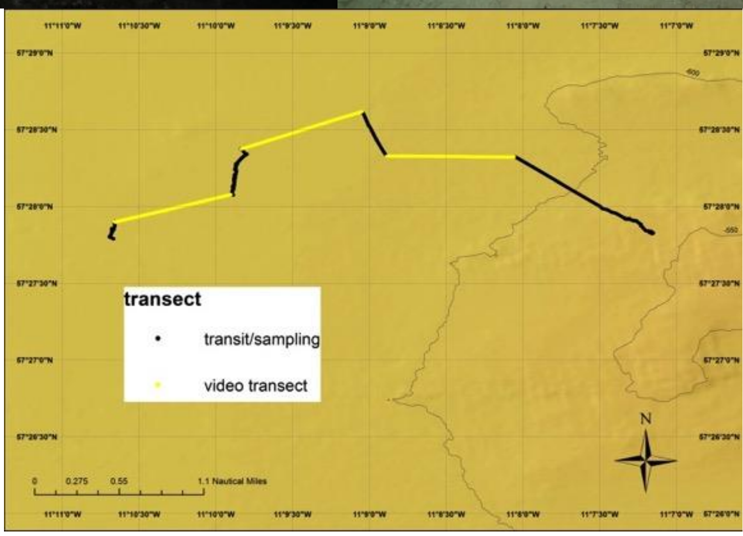




8.4 DIVE 272 (Station 12) – ADS, 500 m

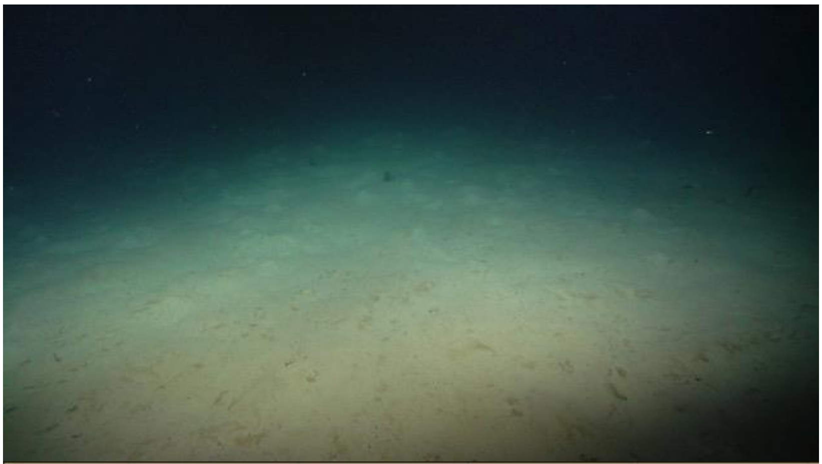
A patch of 5 white *C. cidaris* occurs at the very start of this dive, on a fine rippled sandy bottom. This substrate persists for the majority of the dive, resulting in the presence of numerous *Cidaris* and *Parastichopus*, with orange roughy and chimeras also being spotted. Discarded fishing gear was found midway through the dive. Rocks appear towards the end, with small clumps of both white and orange *Madrepora* and orange *Lophelia*. At the end of the dive, a very large, tall rock outcrop was found, covered in large barnacles, anemones, corals and a pink *Cidaris*. Three transects were completed.

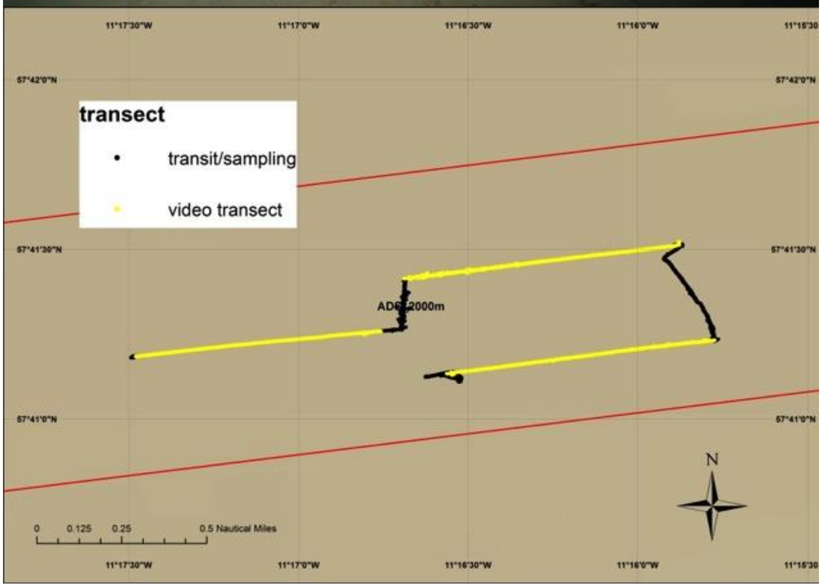




8.5 DIVE 273 (Station 12) – ADS, 2000 m

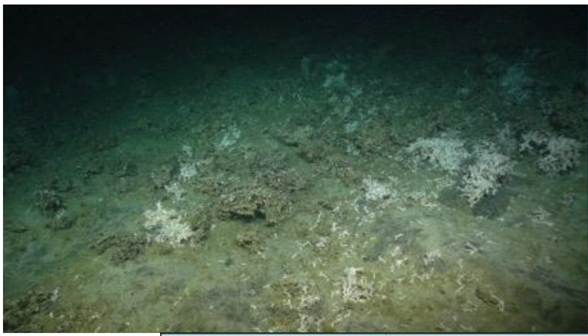
Fine sand with plenty of lebenspurren, but little to no other benthic fauna apart from one or two solitary anemones. Two rays were seen at the beginning of the dive and 3 other species of fish. No target species were present. Three transects were completed.

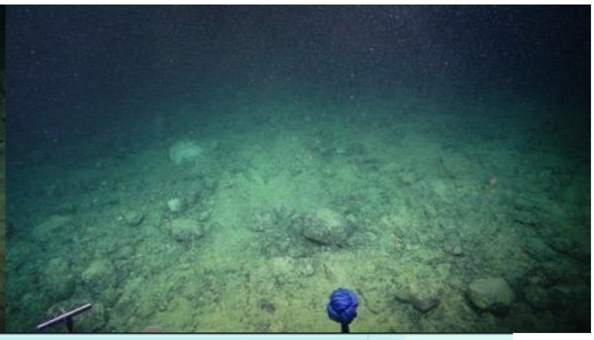


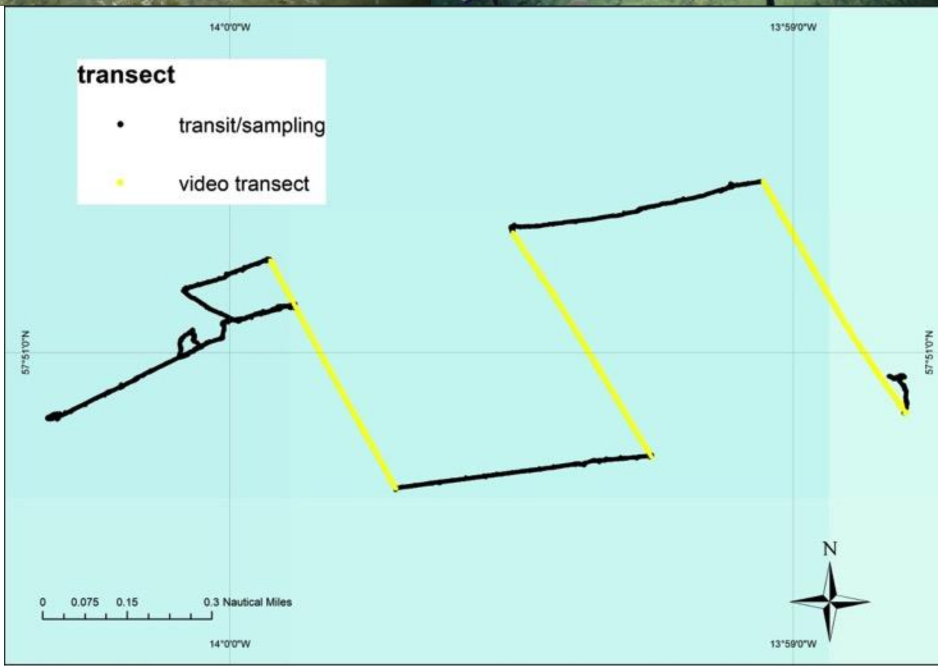


8.6 DIVE 274 (Station 16) – NRB, 200 m

The substrate during this dive fluctuates between fine sand and regions of small rounded stones. Plenty of *Parastichopus* and several other benthic taxa, including anemones and 2 small octopus. There were two regions of rock that are particularly interesting, one hosting 5 squat lobsters and the other providing shelter for several small juvenile orange roughy. The dive ends in a large reef that is mostly dead, but still hosts may associate species, particularly anemones. Three transects were completed.

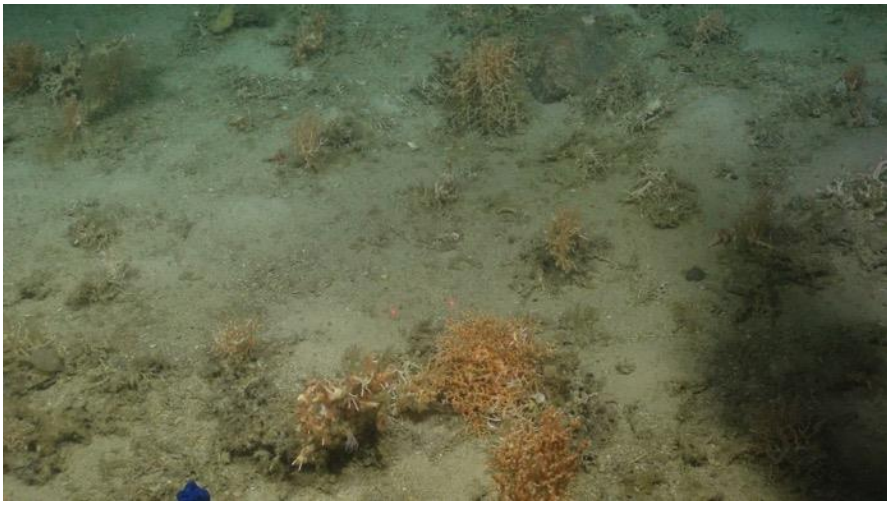


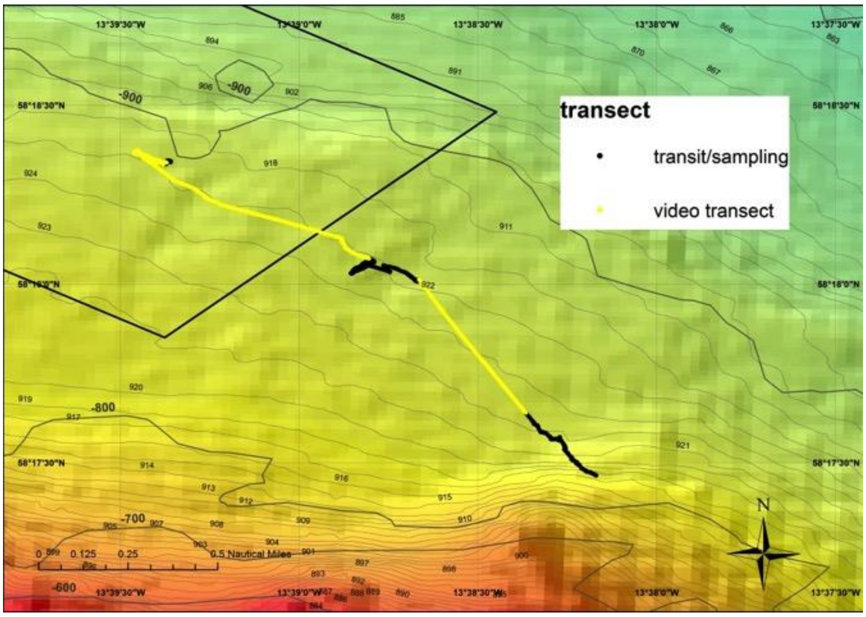




8.7 DIVE 275 (Station 18) – NRB, 800 m

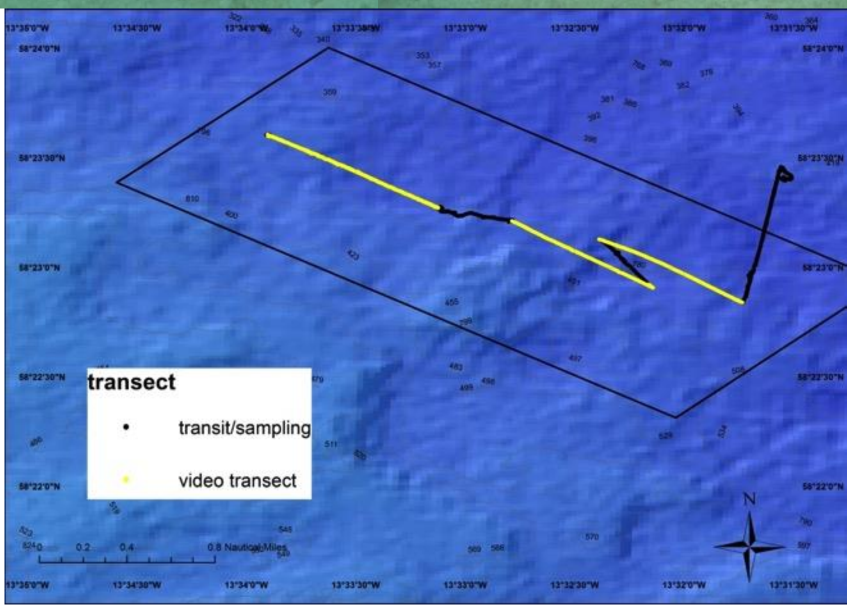
The entirety of this dive is soft sandy sediment covered in patches of mostly dead coral, but with new growth of all target coral species. *Lophelia* and *Madrepora* are found in both white and orange morphotypes. Two to three *Parastichopus* are also seen. Two transects were completed during this dive.





8.8 DIVE 276 (Station 20) – NRB, 1200 m

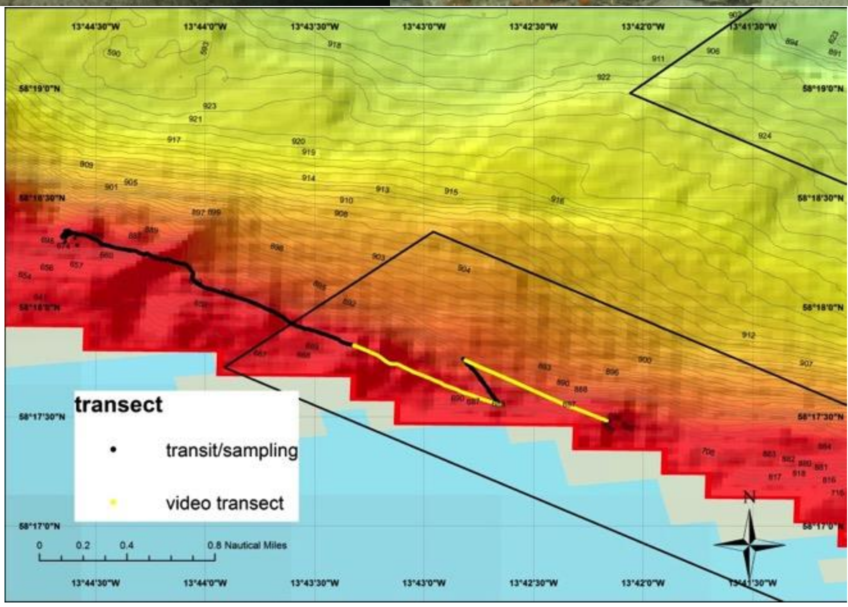
Flat fine sand resulting in few benthic species, except 2 sea-pens and several *Echinus elegans*. No target species were found during this dive, however, there was an abundance of fish species such as ratfish, rhino chimera, orange roughy and lantern sharks. Three transects were completed on this dive.



8.9 DIVE 277 (Station 22) – NRB, 500 m

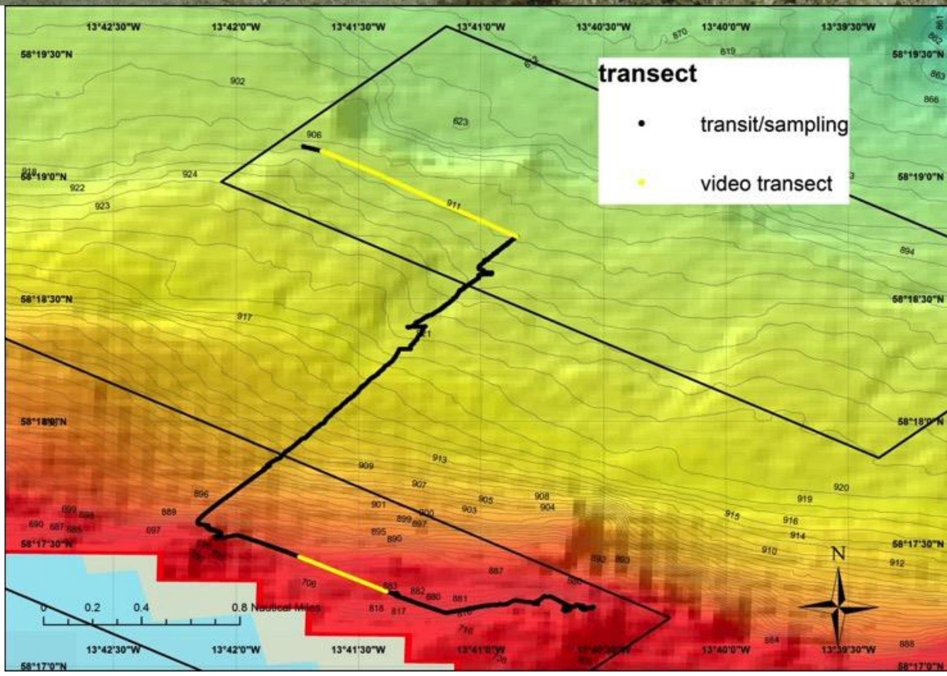
White *Cidaris* are found at the start of this dive, as well as a large patch of both target coral species, both white and orange accompanied by many anemones and a sponge. Following this, the dive continues over a flat region of dead broken coral, which hosts more orange anemones, small patches of target coral and two juvenile orange roughy. The site slopes as the dive continues and rock becomes more prominent but with the same species persisting. Other significant species include a large patch of cauliflower sponges. Two transects were completed during this dive.





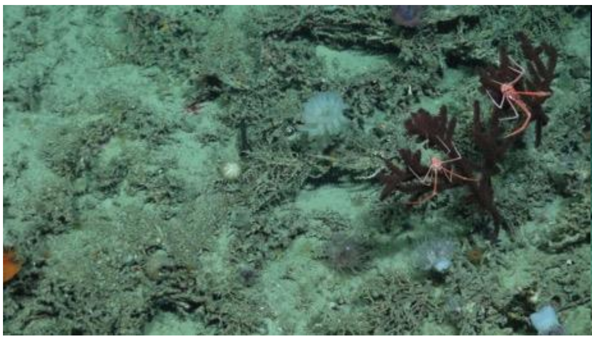
8.10 DIVE 278 (Station 25) – NRB, 800 m and 500 m

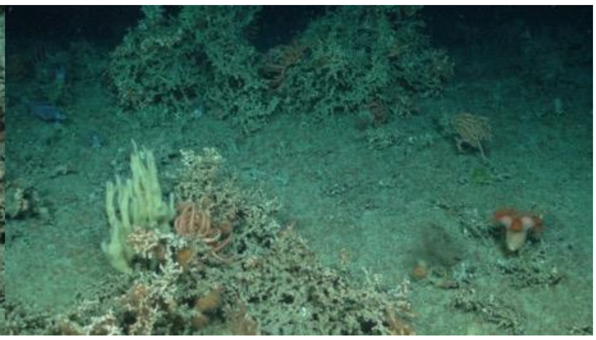
Sand is the dominant substrate in this dive, with no target species being found at first. However, as it progresses, like the previous dive, the bottom becomes littered with dead coral, which hosts target corals, anemones and *Cidaris*. The remaining transects at both 800 m and 500 m were completed on this dive (800 m first, ending at 500 m).

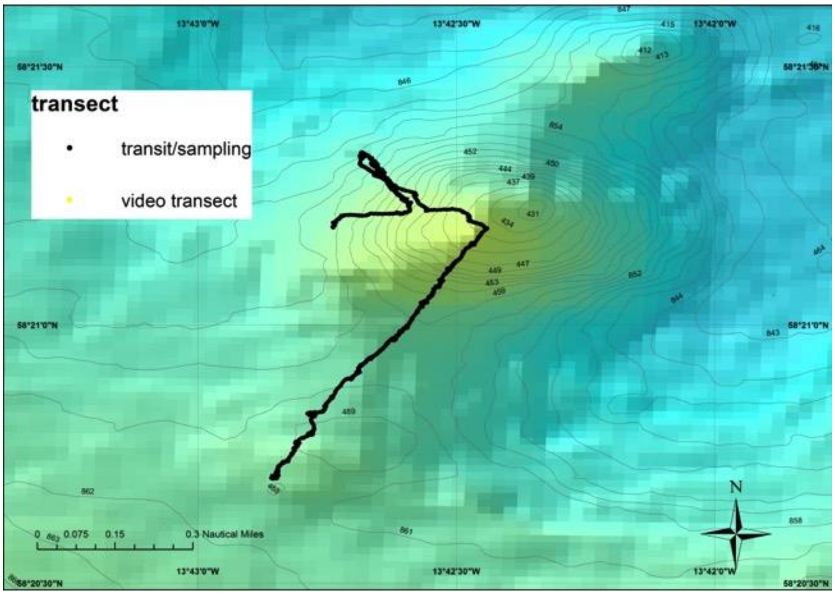


8.11 DIVE 279 (Station 27) – NRB, 1000 m

Characterised by rough coarse bottom. Amidst the gravel and dead coral are small patches of orange *Lophelia* and *Madrepora*. White and orange anemones also litter the sediment. At the end of the dive a large reef is reached, where large non-target corals can be seen, including a black coral hosting squat lobsters. This dive was for sampling only, no diversity transects were undertaken.

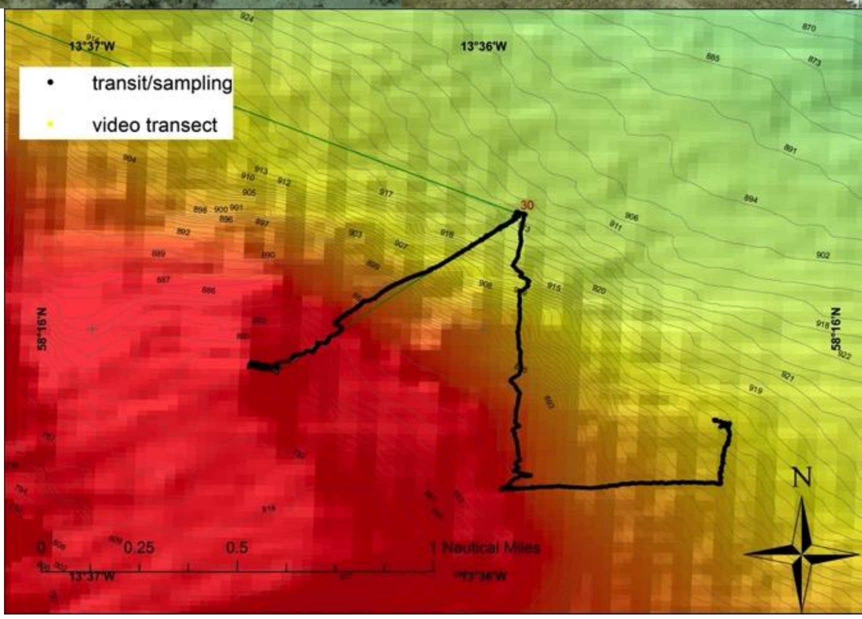






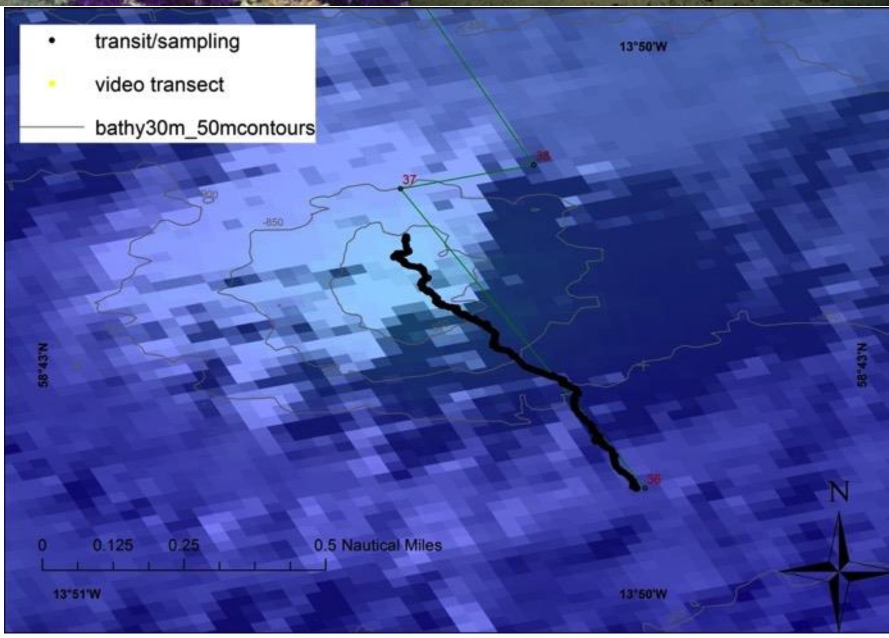
8.12 DIVE 280 (Station 28) – NRB, 800 m to 500 m

The dive starts in a rocky region, semi-buried in fine sand. On these rocks, both white and orange *Madrepora* and orange *Lophelia* were found, with other species, such as anemones and a large brisingid. As the dive continues, the rocky region is left and the bottom becomes sandy. Target corals can still be found in coarser regions with sponges and anemones. This dive was for sampling only.



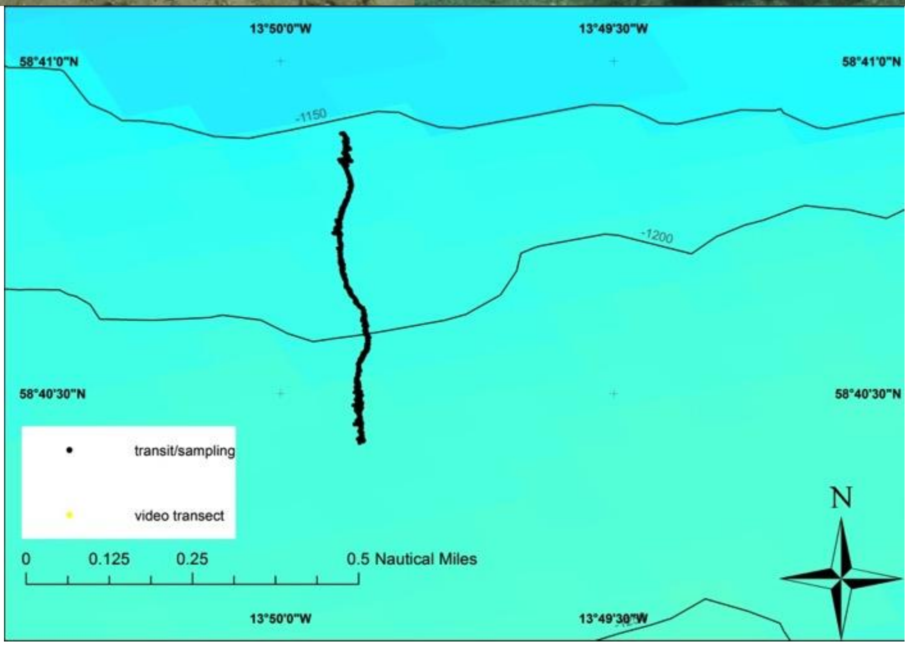
8.13 DIVE 281 (Station 30) – GBB, 800 m

This Dive investigated a suspected coral mound (Chei-gwydn Mound). There are several interesting features in this dive. It begins with a huge solitary orange soft coral on a large rock, hosting hundreds of small white squat lobsters and some white *Madrepora* at the base. Second is a large pink *Paragorgia* that has fallen, which leads into a region of higher rock coverage giving rise to lots of target corals and a black coral. The dive ends in a large cold-water coral reef (Chei-gwydn Mound), covered in purple octocorals. This dive was for sampling alone.



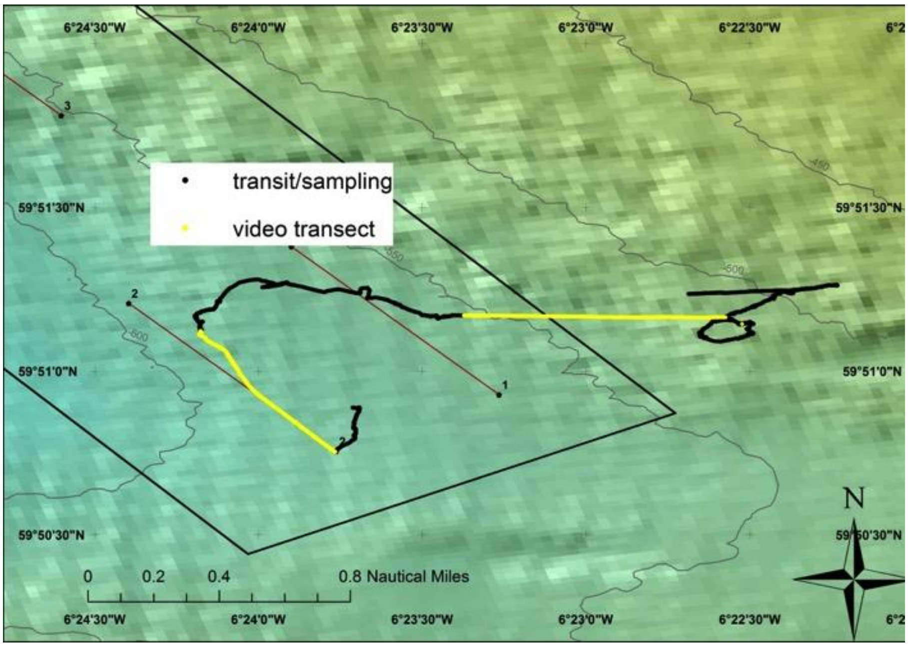
8.14 DIVE 282 (Station 31) – GBB, 1200 m

Visibility is poor initially, due to heavy marine snow, but clears quickly. The dive is dominated by rough and rocky terrain, with a small overhang hosting a large portion of orange and white *Madrepora*. Other notable fauna include a small pink octopus and several *Echinus*. This dive was for sampling only.



8.15 DIVE 283 (Station 34) – WTR, 500 m

This dive takes place over an area of rough rock, which is covered in small sponges and tiny fragments of white coral. Other than one *Parastichopus* and a couple of white *Cidaris*, no targets are found. There is evidence of human impacts in the area; a tin can is lodged beneath a rock and can be seen midway through the dive and a large section of rope, possibly from fishing, is visible at the very start and end. Only two transects were completed during this dive, and in different locations from planned due to very strong currents.

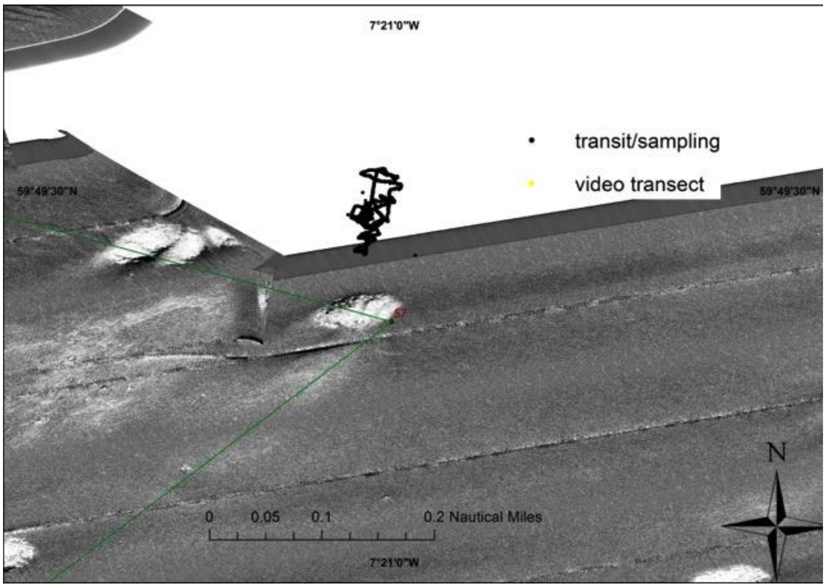


8.16 DIVE 284 (Station 36) – WTR, 1200 m (AUV box)

Upon reaching the bottom at this dive site, it became clear that visibility was zero and could pose a hazard. The dive was aborted shortly after and the ROV recovered. Nothing was seen or sampled.

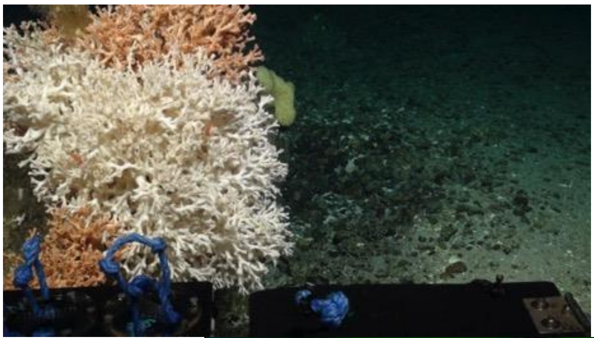
8.17 DIVE 285 (Station 40) – WTR, 1200 m (Darwin Mounds)

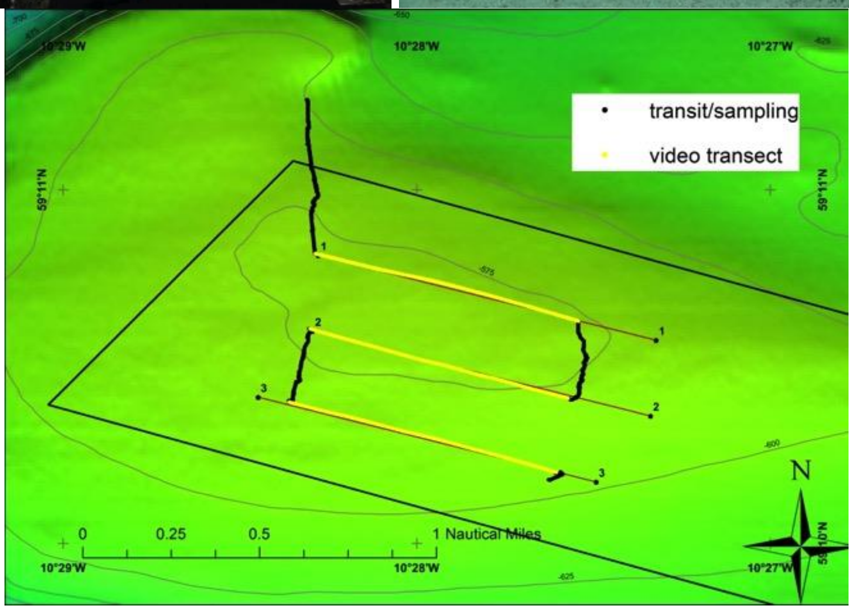
Reached the bottom at 20:11 to find zero visibility once again, Dive aborted. (No video or pictures taken).



8.18 DIVE 286 (Station 44) – RB, 500 m

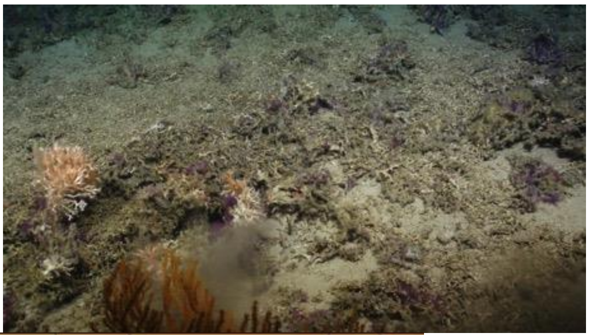
Three video transects, plus sampling, were conducted over a sand/gravel bottom with sparse rocky outcrops and common small rocks and boulders. Visibility was good. Numerous *Cidaris* and *Parastichopus* on sand and scleractinians and anemones on rocks. At 02:29, there is a large rock with good examples of both the white and orange forms of *Lophelia pertusa*.

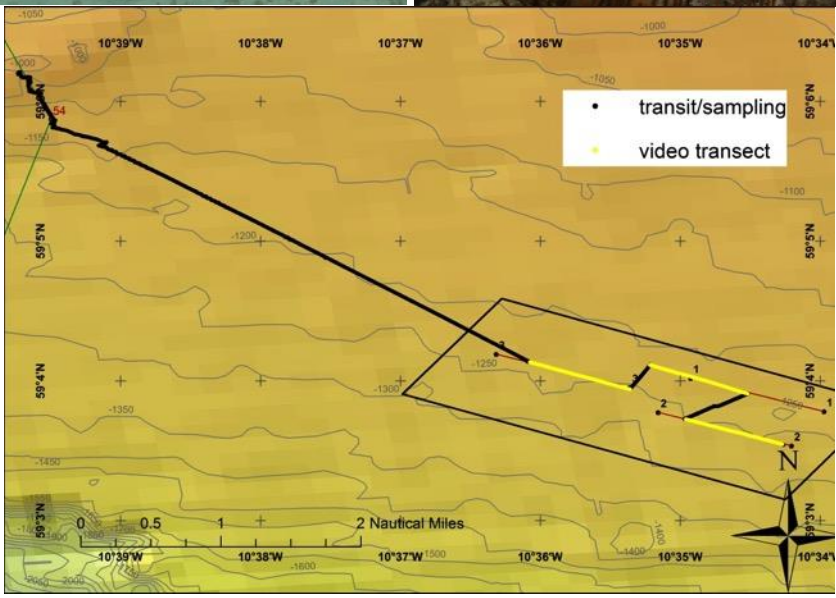




8.19 DIVE 287 (Station 46) – RB, 1200 m

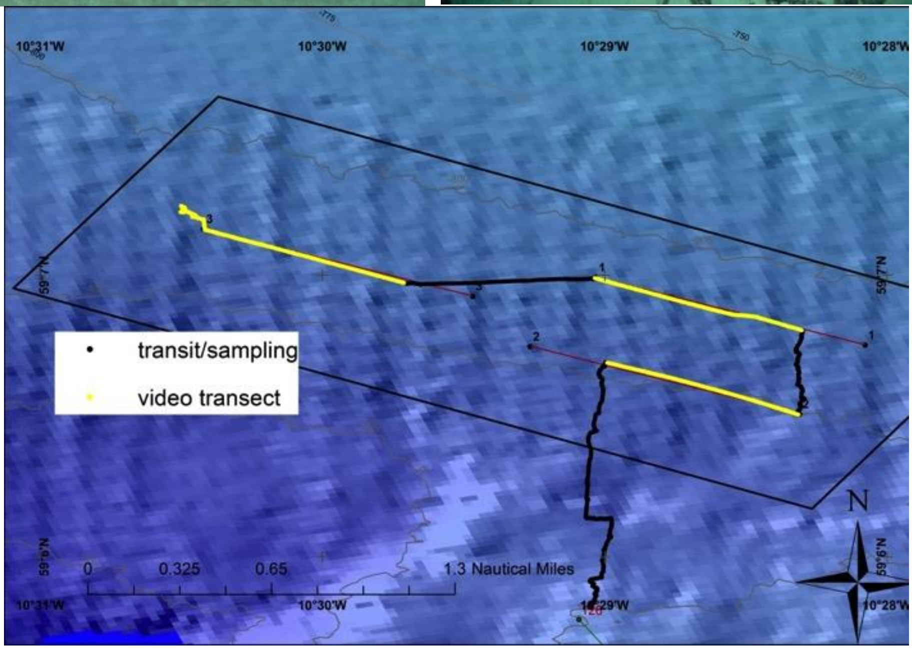
The dive started with three video transects over a sandy bottom. Visibility was poor towards the end of Transects 1 and 2. Blue water after transect 3 for six hours, with two short stops to check the seabed (both poor visibility and strong currents were encountered). After blue water, the dive drops onto steeper terrain with abundant dead scleractinian reef structure and rubble hosting live corals and associates, including lots of small purple soft coral. The dive ends on a sandy slope with coral rubble and boulders hosting black coral and *Paragorgia.*





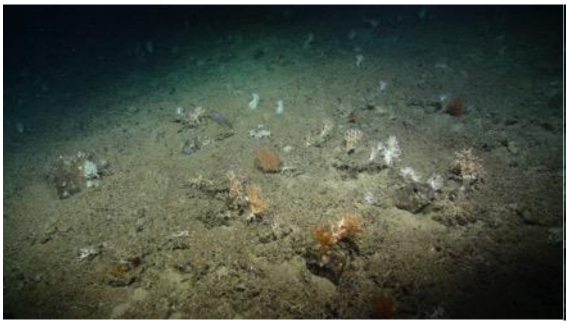
8.20 DIVE 288 (Station 48) – RB, 800 m

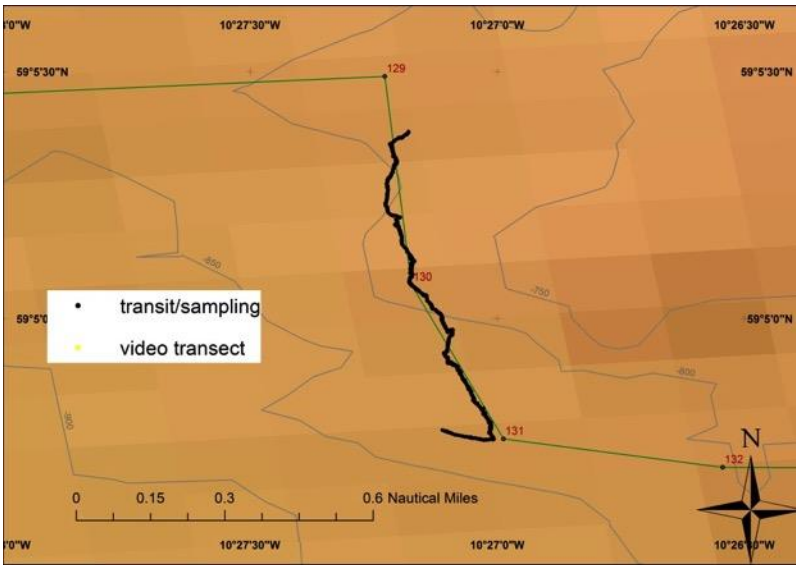
Dive begins with three transects over a flat sandy bottom, which starts to have more common gravel, rocks and boulders from 00:30. Sampling between transects and afterwards, with quite regular *Cidaris* sampling. From 07:56, for two hours, the dive follows a low rocky ledge with quite abundant corals, which is picked up again further through the dive after patches of sand/gravel.



8.21 DIVE 289 (Station 50) – RB, 800 m

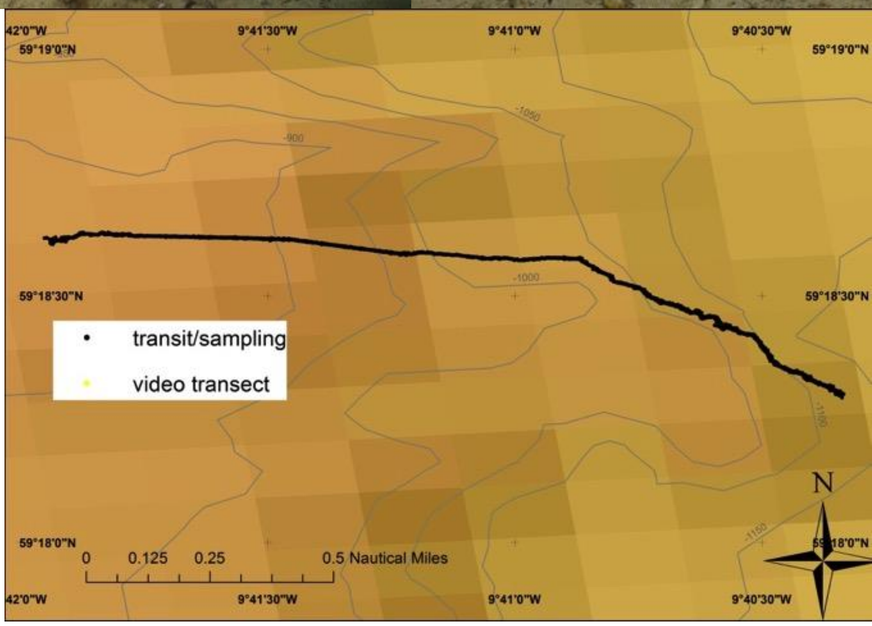
The dive begins with coarse sediment, with corals encountered immediately – orange *Madrepora* and orange and white *Lophelia*. Sand makes up the majority of the middle of the dive, with little benthic fauna. At the end, there was rocky coverage with *Acanella*, black coral with squat lobster associates, and several prawn cracker sponges (possibly Farreidae). A few different fish species were present, such as ling and a ray.





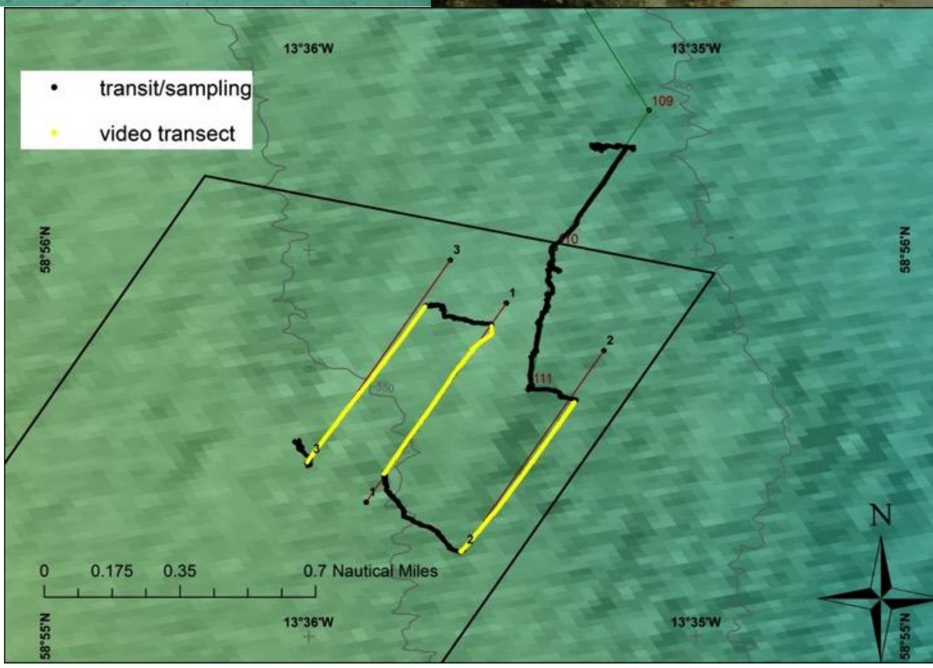
8.22 DIVE 290 (Station 54) – RB, 1000 m to 800 m

No transects were undertaken for the dive, only sampling. The dive consisted of coarse sediments with occasional patches of boulders with attached stylasterids, *Madrepora*, *Acanella*, octocorals, brisingids and large white *Geodia* sponges. Later in the transect, a large purple octopus was seen alongside boulders covered in *Desmophyllum* and yellow encrusting sponges. *Cidaris* and *Parastichopus* were sampled.



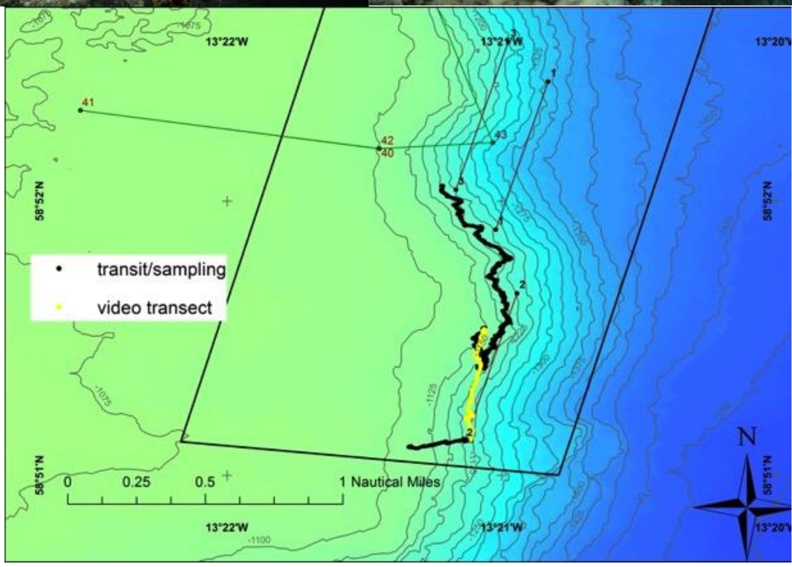
8.23 DIVE 291 (Station 57) – GBB, 500 m

The 500 m dive at George Bligh Bank began with transects before moving into sampling. The area consisted of plain sandy sediments with *Cidaris* and occasional large clumps of dead reef framework. The reef frameworks had attached epifauna, including anemones, yellow and blue encrusting sponges, *Anthomastus* and bivalves. Fish species included chimaera, monkfish and gadoids. Occasional *Parastichopus* were seen on the sandy sediments. Towards the end of the dive, larger reef areas were seen consisting of dead framework with live *Lophelia pertusa* (orange and white), *Madrepora*, *Gorgonocephalus*, octocoral and many anemones. Overgrown fishing gear was also seen at the end of the dive.



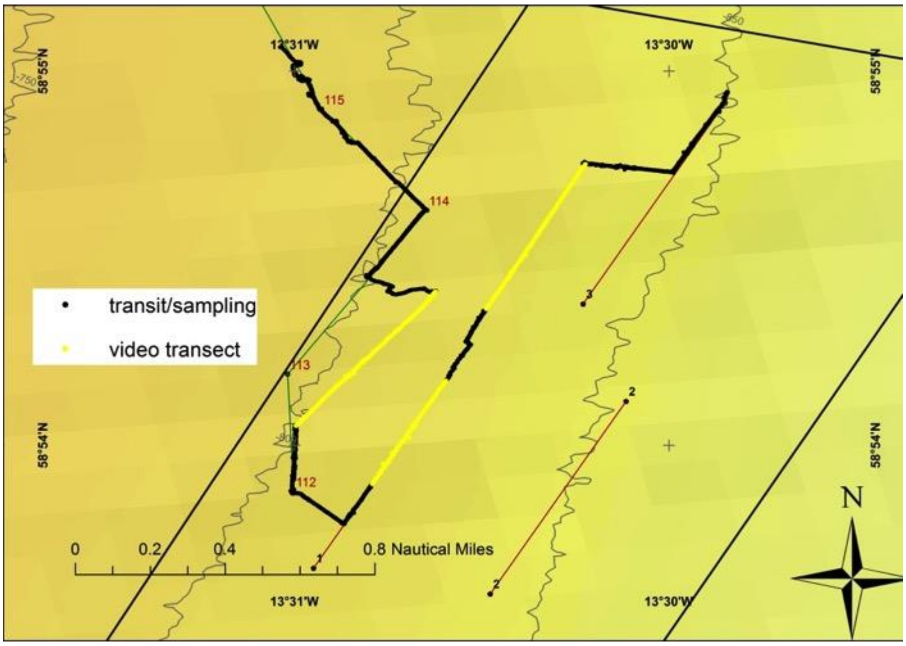
8.24 DIVE 292 (Station 58) – GBB 1200 m

The 1200 m dive at George Bligh Bank began with a single transect before sampling, however, the cliffs were steep and had strong currents not conducive to transects. Transects were aborted at this site and attempted at an alternate site with more comparable substrate to other sites and better conditions. The seabed started as coarse sediment with multiple epifauna-rich boulders, including white sponges, glass sponges, octocorals, and *Solenosmilia*, before moving to a downhill transit on bedrock with *Solenosmilia* reef and vase sponges but poor visibility. The dive then moved into bedrock with encrusting sponges followed by a cliff of *Solenosmilia* and an array of corals, including *Styalasterids*, octocorals, yellow soft corals (zoanthids?) and *Paragorgia*, plus sponges, brisingids, small sharks and fish. The rocky outcrops continued through the dive with *Desmophyllum*, glass sponges, white sponges, *Anthomastus* and large anemones. Mid-dive an area was covered with yellow zoanthids and another had a large pink *Paragorgia*. Some occasional areas of coral rubble were seen towards the middle and end of the dive.



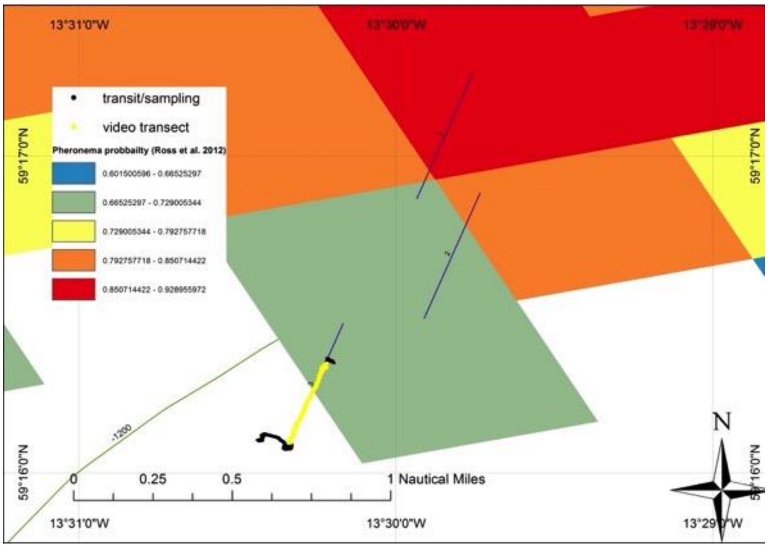
8.25 DIVE 293 (Station 63) – GBB, 800 m

This 800 m dive at George Bligh Bank began with transects, although the first was aborted and restarted due to very poor visibility from marine snow. The seabed started as rippled sandy sediment with one boulder with attached *Callogorgia* coral. Through the dive, the seabed remained as sparse sandy sediment with the occasional *Cidaris* before moving into patches of dead coral framework reef with attached epifauna, including live *Lophelia pertusa*, *Madrepora oculata*, Hexactinellidae sponges, cup sponges, Primnoidae, *Stichopathes*, *Leiopathes*, *Paramuricea* and anemones. Some areas of reef were quite large but would then transition back into rippled sands. A monkfish and large crab were also seen.



8.26 DIVE 294 (Station 64) – GBB, 1200 m

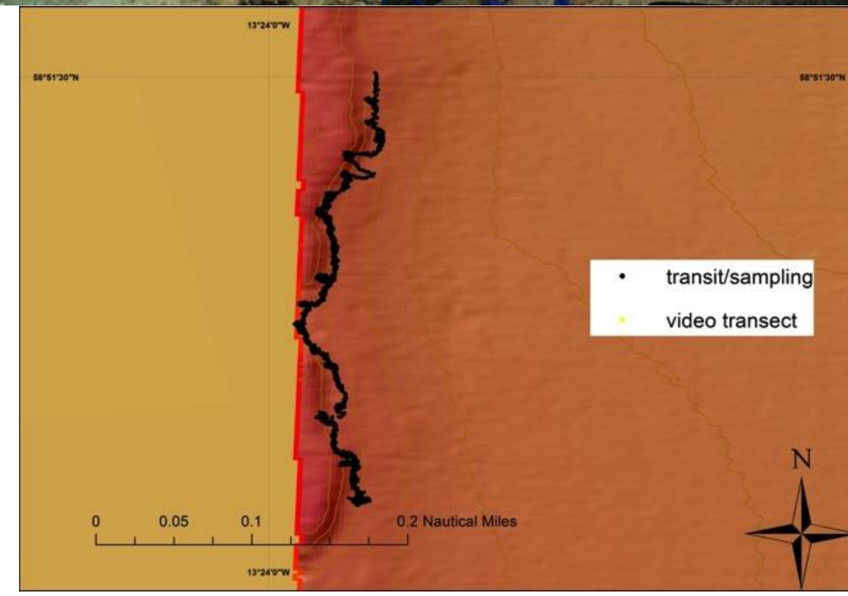
This 1200 m dive at George Bligh Bank was abandoned due to marine snow making images impossible to collect.



8.27 DIVE 295 (Station 66) – GBB, 1000 m to 1200 m

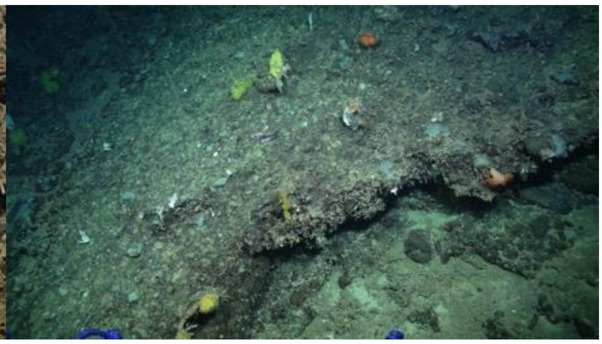
The sampling track began on sandy sediment with areas of boulders with attached epifauna, including glass sponges, anemones and *Cidaris*. This quickly moved into planes of layered bedrock covered with epifaunal species, such as cup corals, glass sponges (*Aphrocallistes)*, *Cidaris* and the occasional *Leiopathes* and *Bathypathes.* The dive moved onto a ridge with bamboo corals, *Paragorgia* and white fan-shaped sponges (probably *Phakellia* sp.) before moving back to the bedrock planes, at times an orange-terracotta colour, covered with coarse to sandy sediments. Some *Pheronema* sponges were found scattered across the sediment areas with the occasional, but rare, *Lophelia* clumps.

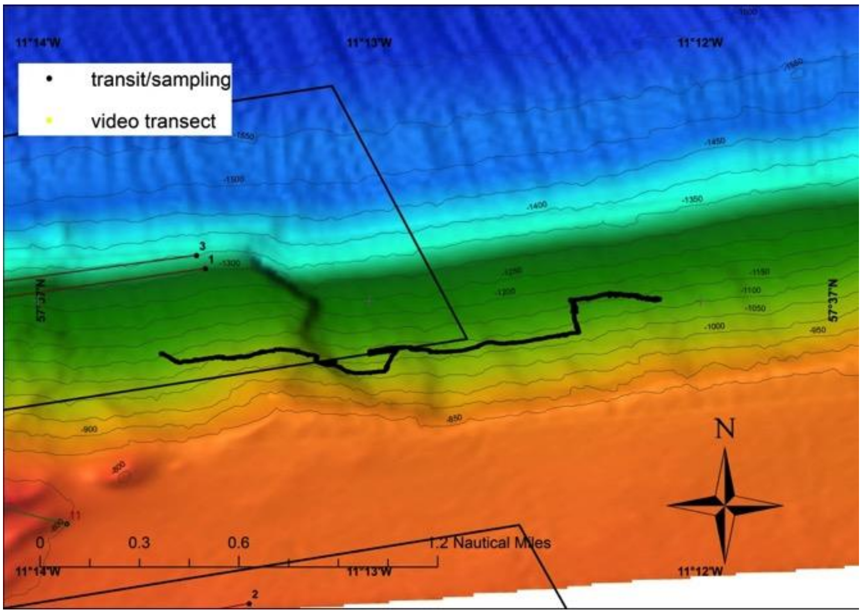
N.B. It was decided the original planned transect was unlikely to host *Lophelia* or *Madrepora* being only 30 m shallower than points of the previous 1200 m site's dive (292), which only hosted *Solenosmilia*. The dive was therefore moved to a small ridge feature, which was detected by the Autosub multibeam.



8.28 DIVE 296 (Station 70) – ADS, 1000 m to 1200 m

The sampling track began with bedrock and boulders with occasional *Lophelia pertusa* and *Madrepora oculata* clumps, sponge species, including a large Cathedral sponge, and mats of dead coral framework. Larger epifaunal species, such as *Enallopsammia, Leiopathes* and *Phaleactis* anemone, were seen attached to large boulders and bedrock but these were sparsely dispersed throughout the video tow. A metal fishing cable was seen towards the middle of the dive. Towards the end of the dive, the bedrock became interspersed with areas of coarse to sandy sediments and epifauna remained sparse.




transit/sampling
video transect
11°14'W
11°13'W
11°12'W
57°37'N
N
0
0.3
0.6
1.2 Nautical Miles

9 Acknowledgements

We would like to thank the Master and crew of the RRS James Cook, the Isis and Autosub 6000 teams for their skill, patience and dedication.

10 References

Breiman L (2001). "Random Forests." *Machine Learning*, 45, 5–32.

Bucklin A, Wilson RR Jr, Smith KL Jr (1987). Genetic differentiation of seamount and basin populations of the deep-sea amphipod *Eurythenes gryllus*. *Deep-Sea Research Part I: Oceanographic Research Papers*, 34, 1795–1810.

Chase MR, Etter RJ, Rex MA, Quattro JM (1998). Bathymetric patterns of genetic variation in a deep-sea protobranch bivalve, *Deminucula atacellana. Marine Biology*, 131, 301–308.

Cho W, Shank TM (2010). Incongruent patterns of genetic connectivity among four ophiuroid species with differing coral host specificity on North Atlantic seamounts. *Marine Ecology*, 31, 121–143.

Clarke KR, Warwick RM (2001a). Change in marine communities: an approach to statistical analysis and interpretation, 2nd edition. Primer-E, Plymouth, UK, 172pp.

Clarke KR, Warwick RM (2001b). A further biodiversity index applicable to species lists: variation in taxonomic distinctness. *Marine Ecology Progress Series*, 216, 265–278.

Creasey SS, Rogers AD (1999). Population genetics of bathyal and abyssal organisms. *Advances in Marine Biology*, 35, 1–151.

Davies JS, Howell KL, Stewart HA, Guinan J, Golding N (2014). Defining biological assemblages (biotopes) of conservation interest in the submarine canyons of the South West Approaches (offshore United Kingdom) for use in marine habitat mapping. *Deep-Sea Research II: Topical Studies in Oceanography*, 104, 208–229.

Davies JS, Stewart HA, Narayanaswamy BE, Jacobs C, Spicer J, Golding N, Howell KL (2015). Benthic Assemblages of the Anton Dohrn Seamount (NE Atlantic): Defining Deep-Sea Biotopes to Support Habitat Mapping and Management Efforts with a Focus on Vulnerable Marine Ecosystems. *PLoS ONE*, 10(5), e0124815.

De Wit P, Pespeni MH, Ladner JT, Barshis DJ, Seneca F, Jaris H, Therkildsen NO, Morikawa M, Palumbi SR (2012). The simple fool's guide to population genomics via RNA-Seq: an introduction to high-throughput sequencing data analysis. *Molecular Ecology Resources*, 12, 1058–1067.

Etter RJ, Boyle EE, Glazier A, Jennings RM, Dutra E, Chase MR (2011). Phylogeography of a pan-Atlantic abyssal protobranch bivalve: implications for evolution in the Deep Atlantic. *Molecular Ecology*, 20, 829–843.

Etter RJ, Rex MA, Chase MC, Quattro JM (1999). A genetic dimension to deep-sea biodiversity. *Deep-Sea Research Part I: Oceanographic Research Papers*, 46, 1095–1099.

Etter R, Rex MA, Chase MR, Quattro JM (2005). Population differentiation decreases with depth in deep-sea bivalves. *Evolution*, 59, 1479–1491.

France SC (1994). Genetic population structure and gene flow among deep-sea amphipods, *Abyssorchomene* spp., from six California Continental Borderland basins. *Marine Biology*, 118, 67–77.

France SC, Kocher TD (1996). Geographic and bathymetric patterns of mitochondrial 16S rRNA sequence divergence among deep-sea amphipods, *Eurythenes gryllus*. *Marine Biology*, 126, 633–643.

France SC, Hessler RR, Vrijenhoek RC (1992). Genetic differentiation between spatially-disjunct populations of the deep-sea, hydrothermal vent-endemic amphipod *Ventiella sulfuris*. *Marine Biology*, 114, 551–559.

Garcia TI, Shen Y, Crawford D, Oleksiak MF, Whitehead A, Walters RB (2012). RNA-Seq reveals complex genetic response to deepwater horizon oil release in *Fundulus grandis*. *BMC Genomics*, 13, 1–9.

Howell KL, Davies JS, Hughes DJ, Narayanaswamy BE (2007). Strategic Environmental Assessment/Special Area for Conservation Photographic Analysis Report. Department of Trade and Industry, Strategic Environmental Assessment Report, UK, 163pp.

Howell KL, Davies JS, Jacobs C, Narayanaswamy BE (2009). Broadscale survey of the habitats of Rockall Bank and mapping of Annex I 'reef' habitat. JNCC report 422, 244pp.

Howell KL (2010). A benthic classification system to aid in the implementation of marine protected area networks in the deep/high seas of the NE Atlantic. *Biological Conservation*, 143, 1041–1056.

Howell KL, Mowles S, Foggo A (2010a). Mounting evidence: near-slope seamounts are faunally indistinct from an adjacent bank. *Marine Ecology*, 31, 52–62.

Howell KL, Davies JS, Narayanaswamy BE (2010b). Identifying deep-sea megafaunal epibenthic assemblages for use in habitat mapping and marine protected area network design. *Journal of the Marine Biological Association UK*, 90, 33–68.

McClain CR, Hardy SM (2010). The dynamics of biogeographic ranges in the deep sea. *Proceedings of the Royal Society B: Biological Sciences*, 277, 3533–3546.

Miller KJ, Rowden AA, Williams A, Häussermann V (2011). Out of their depth? Isolated deep populations of the cosmopolitan coral *Desmophyllum dianthus* may be highly vulnerable to environmental change. *Plos One*, 6, e19004.

Phillips SJ, Dudik M, (2008). Modeling of species distribution with maxent: new extensions and a comprehensive evaluation. *Ecography* 31, 161–175.

Quattro J, Chase M, Rex M, Greig T, Etter R (2001). Extreme mitochondrial DNA divergence within populations of the deep-sea gastropod *Frigidoalvania brychia*. *Marine Biology*, 139, 1107–1113.

Rogers AD (2000). The role of the oceanic oxygen minima in generating biodiversity in the deep sea. *Deep-Sea Research Part II: Topical Studies in Oceanography*, 47, 119–148.

Ross LK, Ross RE, Stewart HA, Howell KL (2015). The influence of data resolution on predicted distribution and estimates of extent of current protection of three 'listed' deep-sea habitats. *PLoS ONE*, 10(10), e0140061.

Stewart CT, Rex MA (2009), Bathymetric patterns of deep-sea gastropod species diversity in 10 basins of the Atlantic Ocean and Norwegian Sea. *Marine Ecology*, 30, 164–180.

Vrijenhoek RC (2010). Genetic diversity and connectivity of deep-sea hydrothermal vent metapopulations. *Molecular Ecology*, 19, 4391–4411.

Wang Z, Gerstein M, Snyder M (2009). RNA-Seq: a revolutionary tool for transcriptomics. *Nature Reviews Genetics*, 10, 57–63.

Weersing K, Toonen RJ (2009). Population genetics, larval dispersal, and connectivity in marine systems. *Marine Ecology Progress Series*, 393, 1–12.

Zardus JD, Etter RJ, Chase MR, Rex MA, Boyle EE (2006). Bathymetric and geographic population structure in the pan-Atlantic deep-sea bivalve *Deminucula atacellana* (Schenck, 1939). *Molecular Ecology*, 15, 639–651.

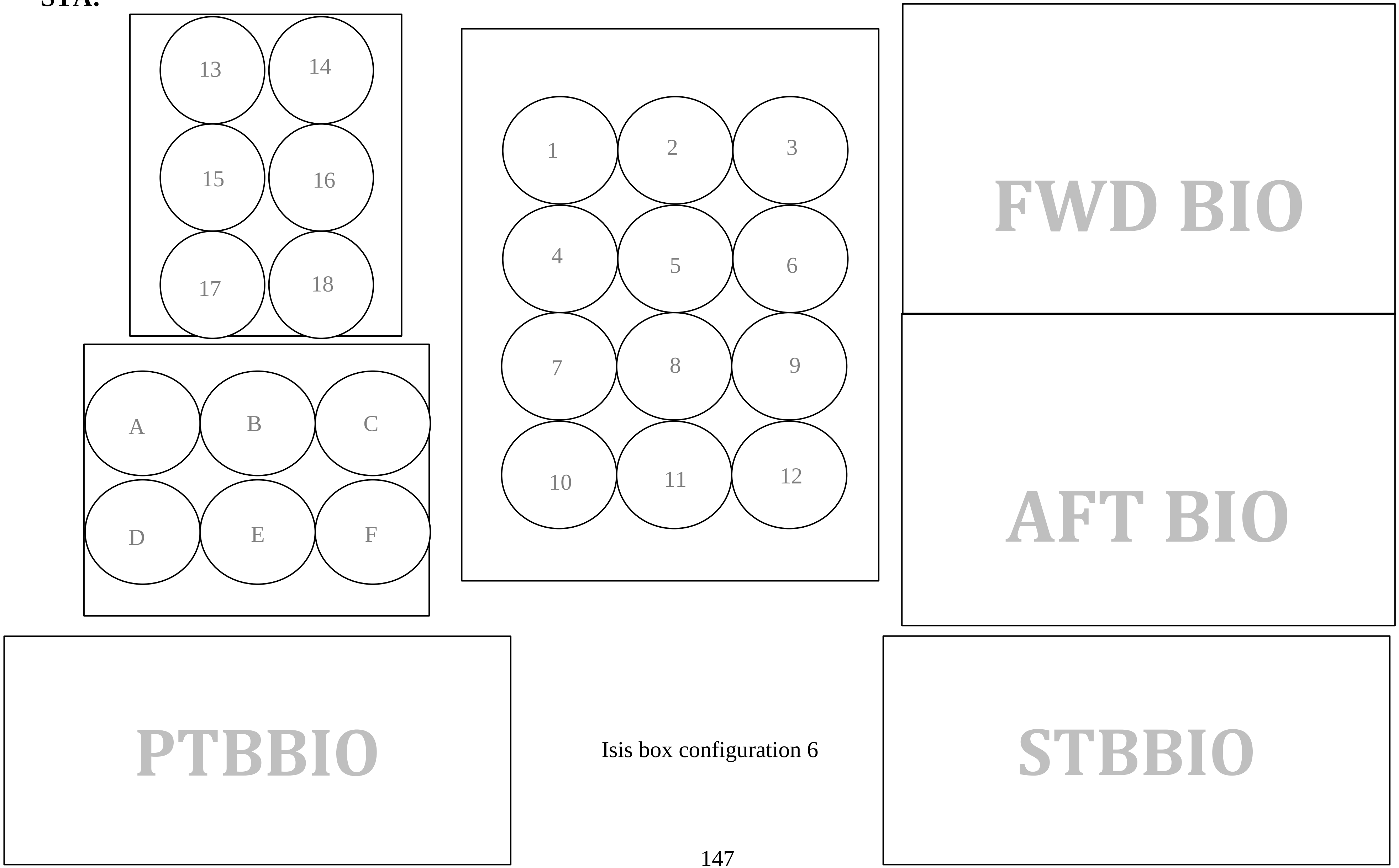
11 Appendices

11.1 Appendix 1 – Isis Tray map logsheets

On next page...

JC136 **ROV *ISIS* DIVE:** **DATE:** **PAGE 1 of 2**

STA:



Isis box configuration 6

JC136 ROV *ISIS* DIVE: **DATE:** **PAGE 2 of 2** DEEP LINKS

STA:

WHITE/ BLUE
Lrg mesh
2 stripes stripe

RED
Fine mesh
2 stripes

YELL
med mesh
3 stripes

BLACK
med mesh
4 stripes

GREEN
fine mesh
5 stripes

11.2 Appendix 2 – Observation log sheet

DEEP LINKS **Date:**	**JC136: Station #:**	**Location:**	**ISIS Dive #:**	**Sheet #:**

Transect	Synched Time (GMT)	Lat (DD)	Long (DD)	ROV Depth (m)	Notes (start / end transect, fauna, litter, errors, photo, etc.)	Photo Taken ? (Y/N)	Scribe	High light (tick)	High light camera

11.3 Appendix 3 - Event log sheet

DEEP LINKS **Date:**	**JC136: Station #:**	**Location:**	**ISIS Dive #:**	**Sheet #:**

Event #	**Gear**	**Time (GMT)**	**Lat (DD)**	**Long (DD)**	**ROV Depth (m)**	**Organism (descriptive details, colour, shape etc)**	**Comments/ transect no.**	**Tool Tray Location**	**Photo ID**	**Scribe**

SLP - Slurp PSH - Push core SCP - Scoop ARM - Arm