RRS Discovery

DY088 Cruise Report

The Geology, Glacial History and Bathymetry of the South Scotia Ridge and South Orkney Shelf

The Geology, Glacial History and Bathymetry of the South Scotia Ridge and South Orkney Shelf

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Report of *RRS Discovery* Cruise DY088, March 2017 – April 2018

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1. Summary

RRS Discovery cruise, DY088, took place from the 7th March 2018 to the 2nd April 2018. The vessel departed Punta Arenas, Chile and proceeded to the South Scotia Ridge and the South Orkney Islands region (Fig. 1) where 14 days' ship time was dedicated to seafloor survey and sampling, followed by a 24 hour period of dedicated bathymetric survey south of the North Scotia Ridge.

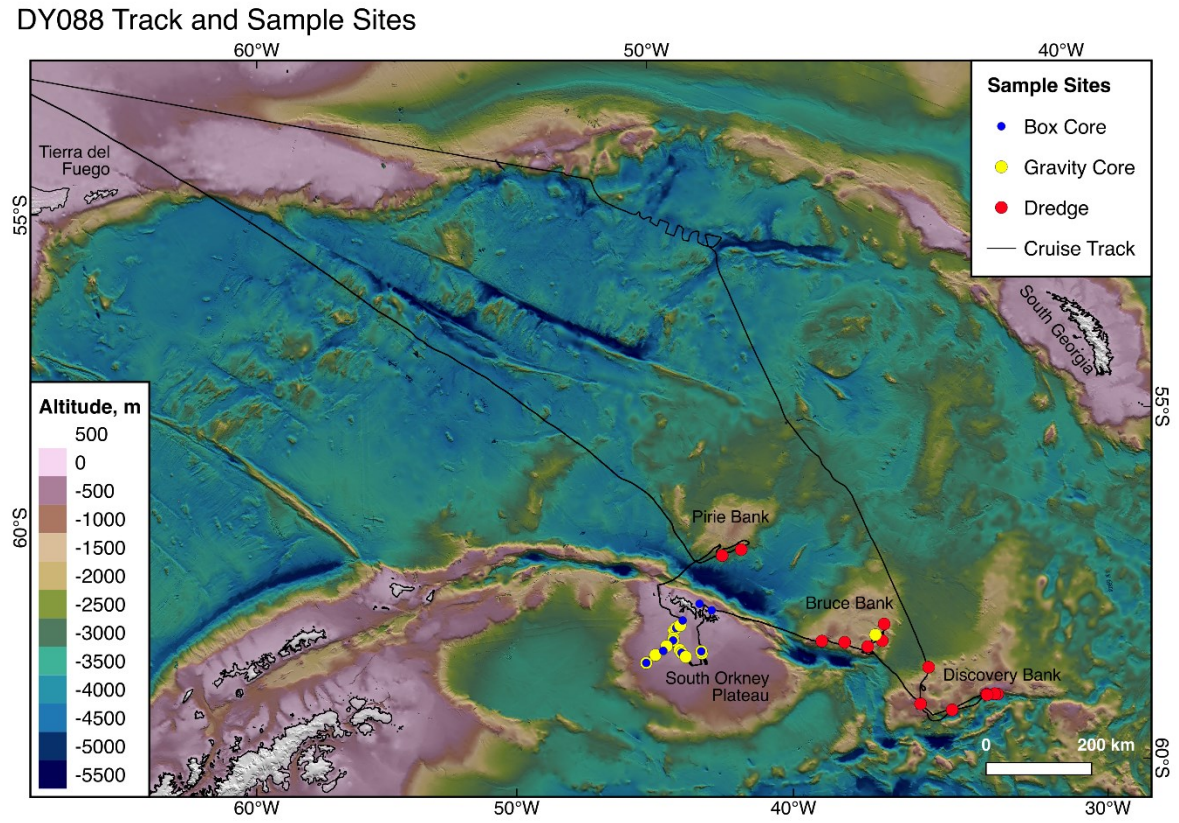

Figure 1: Complete ship's track of the DY088 science cruise and sampling sites.

2. Cruise Objectives

2.1 Overview

The scientific work of cruise DY088 described in this report falls into four separate areas:

i) Investigating the topographic highs of Pirie, Bruce and Discovery banks of the South Scotia Ridge (Fig. 2) to understand their geologic and tectonic history and to understand their influence on palaeo-ocean currents.

ii) The recent glacial history (since the last glacial maximum) of the South Orkney plateau investigating the morphology and age of the Signy and Orwell glacial troughs.

iii) How changes in the position of the southern westerly winds impact on ocean conditions in the northern Weddell Sea region. Located along the boundary between the Antarctic Circumpolar Current and the Weddell Gyre, the South Orkney Plateau is ideally placed to establish how changes in the position of the southern westerly winds impact ocean conditions in the region.

iv) Contributing to the bathymetric map of the Scotia Sea with dedicated and opportunistic mapping of previously un-surveyed areas using the ship's on-board multibeam acoustic system.

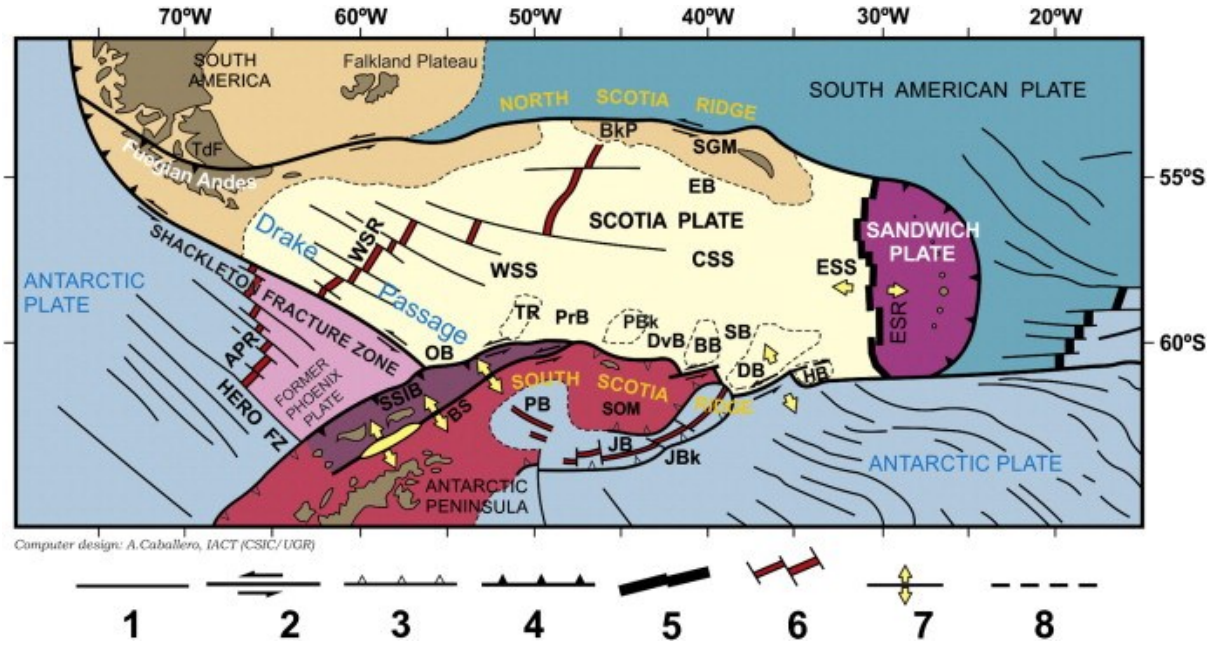

Figure 2: Present day tectonic setting of the Scotia Arc.

2.2 Further detail

i) Determining the tectonic history of the basins and bathymetric highs of the South Scotia Ridge is essential to understand the palaeo-current history of cold dense waters which escape the Weddell Sea and connect with the Atlantic Ocean, as well as understanding the pre-break up configuration of the South America - Antarctic Peninsula land bridge and how and when the South Scotia Ridge formed. Determining the origin of these blocks requires direct sampling by dredging for petrological, geochemical and geochronological study. Discovery Bank is the prime target for dredge sampling followed by Bruce and Pirie banks (Fig. 3). Sampling of sediments deposited on the basement highs for biostratigraphic, petrological and geochemical analyses of ice-rafted debris will afford the potential to investigate how ice discharge from the Antarctic Ice Sheet has changed over time.

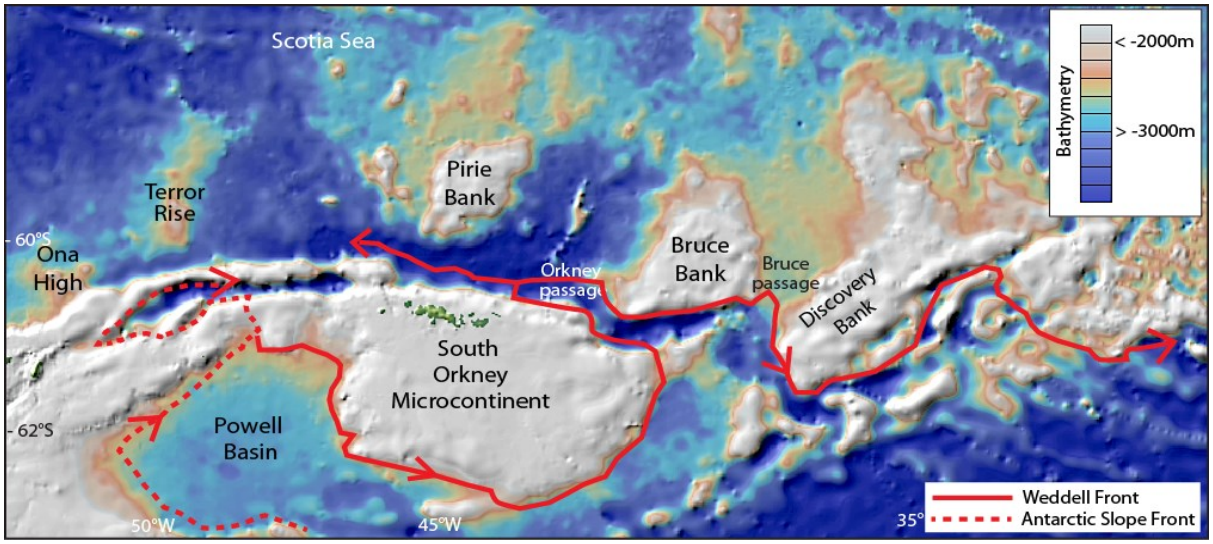

Figure 3: Modern day positions of the Weddell and Antarctic Slope Fronts in the Southern Scotia Sea

ii) Geophysical surveys and direct sampling of sediments of the South Orkney Plateau will investigate glacial landforms and deposits that were formed by fast-flowing ice during the last glacial maximum (approximately 20,000 years ago). We aim to identify and map features that will elucidate how far the South Orkneys ice cap extended and how it retreated from its maximum extent. For example, landforms such as suites of small (<5 m high) moraines, which can only be identified by high-resolution 3D mapping of the seafloor and acoustic profiling of sub-surface sediments, and indicate "episodic" retreat of grounded ice back towards the landmasses have been identified in a large glacial trough extending south-eastwards from the islands. By mapping glacial landforms and taking seafloor cores targeting the transition between subglacial and postglacial sediments it is possible to establish a chronology of the South Orkney Islands ice-cap retreat.

iii) The South Orkney Plateau is located along the boundary between the Antarctic Circumpolar Current (ACC) and the Weddell Gyre current (Fig. 4) and is ideally positioned to investigate how shifts in the south westerly winds (SWW) impact ocean conditions in the northern Weddell Sea. It is well established that strengthening and poleward migration of the southern westerly winds (SWW) increases upwelling of Circumpolar Deep Water (CDW) along the southern boundary of the ACC (Spence et al., 2017). These SWW shifts are likely to deliver warm CDW into the northern Weddell Sea, reducing sea-ice cover, enhancing glacial ice melt and potentially affecting the northern limb of the Weddell Gyre (WG). Box cores sampled from the SOP will recover undisturbed sediment records of the recent past (decades to centuries). Sedimentary and microfossil proxies will be analysed to reconstruct sea-ice cover, surface and deep ocean temperatures, productivity, iceberg discharge, water mass distribution and stratification in the SOP region. The multi-proxy records will provide the

necessary information to determine how the boundary between the ACC and Weddell Gyre changes in response to a poleward shift and strengthening of the SWW.

iv) Over the last 20 years large amounts of multibeam bathymetric data have been acquired across the Scotia Sea and have allowed the publication of two detailed sea floor maps of Drake Passage (Bohoyo et al. 2017) and the South Sandwich Islands (Leat et al., 2015). The data has been acquired through passage tracks and dedicated survey. The cruise DY088 will also acquire new data by mapping parallel to existing data and undertaking dedicated surveys in support of the sampling work.

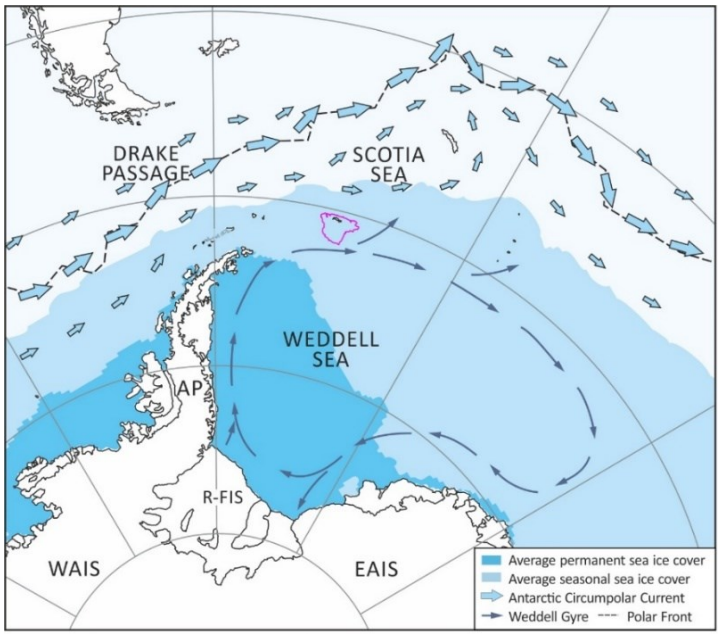

Figure 4: Map showing the location of the South Orkney Plateau (pink outline) and the typical circulation routes of the Antarctic Circumpolar Current and Weddell Gyre. AP – Antarctic Peninsula; WAIS – West Antarctic Ice Sheet; EAIS – East Antarctic Ice Sheet; R-FIS – Ronne-Filchner Ice Shelf.

3. Geological Setting and Glacial History

3.1 Geologic and tectonic setting

The Scotia Arc is composed of the South Sandwich arc, the North Scotia Ridge, the South Scotia Ridge, the South Shetland Islands Block and the Shackleton Fracture Zone (Fig. 2). The Scotia Sea contains several spreading ridges, some of which were simultaneously active and resulted in the opening of Drake Passage. The Cenozoic opening of the central Scotia Sea involved the tectonic translation of crustal blocks to form the North Scotia Ridge, which today forms a major topographic barrier to the flow of the Antarctic Circumpolar Current that has created the thermal isolation of Antarctica from warmer ocean waters. A model for the opening of the Scotia Sea in four phases has been proposed by Maldonando et al. (2014); it is the final phase during the Early Oligocene/Late Miocene (24 – 6 Ma) that shaped the Scotia Sea we recognize today with West Scotia Ridge spreading and continental block dispersal along the North and South Scotia ridges (Fig. 2).

The South Scotia Ridge (SSR) is a formidable barrier to deep water flow the regional bathymetry has a strong influence on the main fronts associated with the Antarctic Circumpolar Current (ACC; Fig. 4).

We know very little about the presumed continental fragments of the South Scotia Ridge, as we only see exposure at the South Orkney Islands. The geology and early history of the South Scotia Ridge are poorly known and yet they define the nature of early ocean circulation following the opening of Drake Passage. The crucial factor from a palaeo-oceanographic perspective is where the crustal blocks were positioned at the onset of glaciation, prior to 25 Myr ago. There is also the question as to whether the fragments may form part of an ancestral island arc prior to the development of the present day arc of the South Sandwich Islands.

3.2 Glacial setting

The South Orkney Plateau (SOP) is a large, shallow continental fragment that forms part of the SSR (Fig. 3) with four islands emergent from the sea: Coronation Island, Powell Island, Laurie Island and Signy Island. Today, the four islands remain extensively glacierised (~90 % on Coronation Island; 32 % on Signy Island), despite previous studies showing significant retreat since the mid-20th Century. For example, on Signy Island where most work has been done, a more than 35% reduction in ice cover was observed from 1949-1989 (Jones et al., 2000) , and over 100 m of ice-margin retreat was accompanied by a 7-8 m reduction in ice thickness from the 1960sto the 1980s (Smith, 1990). Like the other sub-Antarctic islands, the South Orkneys are likely to be highly susceptible to climatic and oceanographic changes owing to maritime climate and their position between major ocean water masses and under the influence of the SWW (Fig. 4).

The longer-term glacial history of the SOP is relatively poorly known. Geomorphological mapping undertaken in the 1970s (Sugden & Clapperton, 1977), together with piston cores and seismic-reflection profiles from the 1980s (Herron & Anderson, 1990) provided the only published data constraining the LGM ice extent on the SOP. These workers proposed an ice cap extending to the 200-300 m isobath through glacially-eroded troughs that radiate out from the islands. Evidence supporting a mid-shelf LGM ice extent comes from deep drilling ODP Leg 113, Site 696 on the southeastern SOP (650 m water depth) and a series of nearby gravity cores (Pudsey et al., 1987), neither of which recovered glacial sediments indicating that grounded ice had not extended this far out on the SOP during the Quaternary. Drilling at Site 696 recovered Oligocene to Pleistocene age sediments, with a change in the clay mineralogy and increased ice-rafted material in Late Miocene units interpreted to indicate growth of the WAIS (Barker et al., 1988). Concurrent ice cap growth on the SOP is possible although there currently exists no direct evidence for such an event.

In 2011, a cruise of the RRS *James Clark Ross* (JR244) performed the first multibeam and high-resolution sub-bottom profiler surveys of two glacial troughs on the SOP, Orwell Trough and Coronation Trough to the SE and NW of the islands, respectively (Larter et al., 2011; Dickens et al., 2014). Glacial landform mapping from these data confirm that LGM ice extended to an outer-shelf morainal bank on the southern SOP, followed by episodic retreat to the mid-shelf and then relatively uninterrupted retreat to the islands. Only a few deglacial ages were returned from gravity cores acquired during JR244 but they suggest initial, episodic retreat of the SOP ice cap from around 16.6 ka to 14.6 ka (Dickens, 2016). Despite these new data we know little about the extent and behavior of the LGM ice cap on the remainder of the SOP, or about the recent (last ~50 years) environmental changes driving glacier retreat on the South Orkneys today. Surveying of the largest bathymetric trough of the SOP, Signy Trough, and the outer shelf moraine, as well as targeted coring efforts will provide chronological constraints on both LGM and recent environmental change. Knowledge of the rates of environmental change and their drivers is critical for improving the numerical models that are used to simulate and predict future ice sheet retreat.

3.3 Oceanographic setting

Dense deep and bottom waters exported from beneath the sea-ice and ice shelves of the Weddell Sea form a critical component of the Atlantic meridional circulation, regulating global ocean circulation. It is now well established that strengthening and poleward migration of the southern westerly winds (SWW) increase upwelling of Circumpolar Deep Water (CDW) along the southern boundary of the ACC (Spence et al., 2017). These SWW shifts are likely to deliver warm CDW into the northern Weddell Sea, reducing sea-ice cover, enhancing glacial ice melt and potentially affecting the northern limb of the Weddell Gyre (WG). The predicted continuation of the SWW poleward migration through the 21st century (Bracegirdle et al., 2013) would likely intensify warming and freshening in the northern Weddell Sea and have a profound impact on the local ecosystem as well as implications for global ocean circulation. To date, the impact of poleward migrations of the SWW exerts on the Weddell Sea region has not been investigated.

4. Cruise diary for DY088

The cruise track for all of DY088 is shown in Figure 1; a summary diary of the primary cruise events are listed below:

Date	Julian Day	Events, weather and ice conditions
5.3.18	64	Scientific Party (Riley and Hogan) joined ship at Punta Arenas for mobilization.
6.3.18	65	Scientific Party (Allen, Burton-Johnson, Chadwick, Leat, Peck, Roseby) joined ship at Punta Arenas for mobilization.
7.3.18	66	*RRS Discovery* sailed at 22.15 UTC from Punta Arenas.
8.3.18	67	Passage towards South Scotia Ridge (Pirie Bank). Preparing laboratory space. Weather: Clear skies 15 knots SE.
9.3.18	68	Passage towards South Scotia Ridge (Pirie Bank). EM122 turned on at 10.30 UTC. Weather: 8/8 stratus, 20 knots E. 6°C. Science talk pm.
10.3.18	69	Passage towards South Scotia Ridge (Pirie Bank). Weather: 8/8 stratus am, pm 3/8 stratocumulus, 20 knots S. 3°C. Toolbox talks 14.00 Z.
11.3.18	70	Passage towards South Scotia Ridge (Pirie Bank). Weather: 2/8 altocumulus, 10 knots NW. 3°C. MB editing training. Tabular bergs.
12.3.18	71	Pirie Bank swath and sub-bottom profile survey. Dredge site DR.220. Weather: 8/8 stratus, 15 increasing to 30 knots NNW. 3°C. Tabular bergs.
13.3.18	72	Pirie Bank dredge site DR.221 and continued swath survey. Weather: 8/8 stratus, 30-40 knots NW. 3°C. Sea conditions prevent DR.222. Passage to South Orkney Shelf pm. EM710 survey. Tabular bergs and bergy bits.
14.3.18	73	South Orkney Shelf swath survey. Box and gravity core sites. Weather: am fog, 20 knots NW, pm 7/8 stratus, 25 knots W. 3°C. Tabular bergs and bergy bits.
15.3.18	74	North Orkney Trough swath survey. Box (5) and gravity core (4) sites. Weather: am 8/8 stratus, light & variable winds, pm mist 10 knots WSW. 3°C. Tabular bergs and bergy bits.
16.3.18	75	Signy Trough swath survey. Box and gravity core sites. Weather: 7/8 stratus with bright spells, 15 knots NW. 1°C. Tabular bergs and bergy bits.
17.3.18	76	Swath survey between Signy and Orwell troughs. Box and gravity core sites late pm. Weather: 7/8 strato-cumulus, 15-20 knots SE. 2°C. Large isolated bergs, bergy bits and growlers.
18.3.18	77	Orwell Trough survey, box and gravity core sites. Weather: 8/8 stratus and fog later, light winds. -4°C. Large isolated bergs, bergy bits and growlers.

19.3.18	78	Washington Strait passage (many Fin whales). Box coring north of Coronation Island. Passage to Bruce Bank pm. Weather: 8/8 stratus and fog later, light winds. -1°C. Large tabular and eroded bergs.
20.3.18	79	Bruce Bank swath survey and dredge sites. Weather: 6/8 strato-cumulus and 25-40 knots SW. -2°C. Isolated bergs.
21.3.18	80	Eastern Bruce Bank swath survey, dredge sites. Weather: 4/8 cumulus & alto-cumulus and 20-35 knots SW backing NW. 1°C. Few bergs.
22.3.18	81	Bruce Bank core and dredge site early am, passage to Discovery Bank pm. Discovery Bank swath survey late pm. Weather: Fog and 20 knots WNW. 2°C. Large bergs and bergy bits.
23.3.18	82	Discovery Bank swath survey and dredge sites. Weather: Fog and 20 knots NW. 3°C. Few bergs, brash ice.
24.3.18	83	Discovery Bank swath survey and dredge sites. Weather: Fog and 25 knots NW. 3°C. Few growlers.
25.3.18	84	Western Discovery Bank seamount swath survey and dredge sites, pm. Passage to North Scotia Ridge. Weather: Fog and 20 knots SW. Fog cleared pm to a clear evening 1°C. Multiple isolated large bergs.
26.3.18	85	Passage to North Scotia Ridge. Weather: 8/8 stratus and 25 knots S. 2°C. Large tabular and eroded bergs.
27.3.18	86	Swath survey area south of North Scotia Ridge. Weather: am 8/8 strato-cumulus 20 knots N backing W, pm clear. 6°C.
28.3.18	87	am Swath survey area south of North Scotia Ridge, pm passage towards Punta Arenas. Weather: am mostly clear 7/8 cirrus + 2/8 alto-cumulus, 20 knots SW. 9°C.
29.3.18	88	Passage to Punta Arenas. Weather: am 8/8 stratus, 50 knots W easing to 35 knots and 4/8 cumulus. 9°C.
30.3.18	89	Passage to Punta Arenas. Weather: 8/8 stratus, 35 knots N, becoming 25 knots NW and clearing. 10°C.
31.3.18	90	Passage to Punta Arenas. Weather: 4/8 cirrus, sunny, 25 knots WNW. 9°C.
1.4.18	91	Passage to Punta Arenas. Weather: 15 knots NW and 5/8 Cirrus. 9°C. Dungeness Pilot 14.00 UTC.

2.4.18	92	Alongside Punta Arenas.
3.4.18	93	Alongside Punta Arenas. Scientists leave the vessel at 10.30 Z for transport to Punta Arenas airport and return to the UK.

5. Activity Reports

5.1 Rock dredging

The rock dredge was deployed at fifteen separate localities, which are detailed in Appendix 3a and summarised in Appendix 3b, indicating the location, the water depth at the start and end of the dredge trawl and the time the dredge apparatus was considered to be on the seafloor. Comments regarding the success of the dredge deployment are also included, indicating any problems (weak links failing) that were encountered. The samples recovered during the fifteen dredges are listed in Appendix 3c, with sample descriptions and also an assessment of whether the material is likely to represent in situ or local material, or material that has been glacially deposited.

Three main sites were selected for dredging along the South Scotia Ridge, these are the three prominent topographic highs of Pirie, Bruce and Discovery banks (Fig. 5). GEBCO, bathymetric and limited seismic data indicated that the eastern and southern margins of these banks would provide the most suitable sites for rock dredging as they were characterised by steeper slopes (>25°) and less likely to have accumulated sediment on their flanks (Fig. 6). The dredge positions across all three sites are shown in Fig. 7, with a broad interpretation made on the dominant lithologies that were sampled at each site and whether ice rafted debris is present.

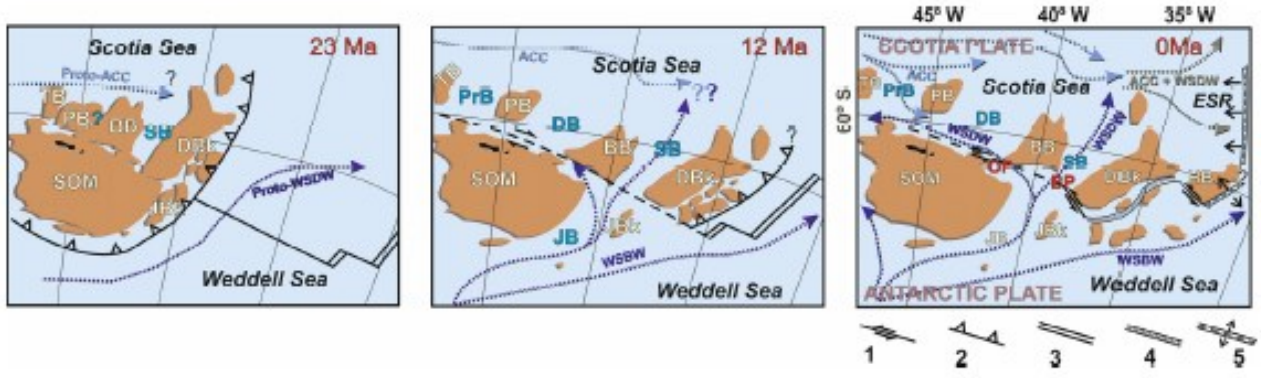

Figure 5: Paleogeographic and paleoceanographic reconstruction along the South Scotia Ridge (Perez, 2014). 1, transcurrent fault; 2, subduction zone; 3, inactive spreading center; 4, fracture zone; and 5, activespreading center. Abbreviations: BB, Bruce Bank; BP, Bruce Passage; DB, Dove Basin; DBk, Discovery Bank; HB, Hermand Bank; JB, Jane Basin; JBk, Jane Bank; OP, Orkney Passage; PB, Pirie Bank; PrB, Protector Basin; SB, Scan Basin; SOM, South Orkney Microcontinent; and TB, Terror Bank.

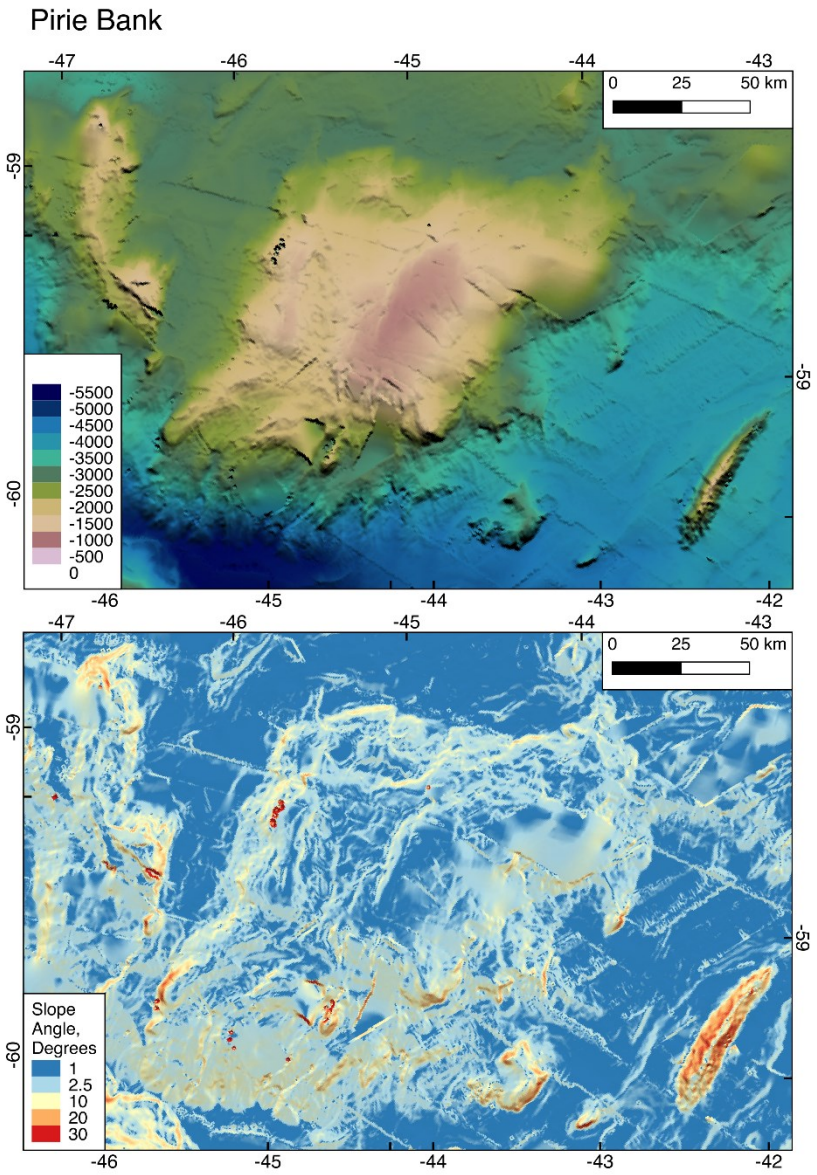

Figure 6: GEBCO data and slope angle interpretation of Pirie Bank.

5.1.1 Pirie Bank

The geologic and tectonic origins of Pirie Bank are not known (Lodolo et al., 2010) although it has been interpreted by several authors to represent thinned continental crust (e.g. Galindo-Zaldivar et al., 2006). Reconstructions of the South Scotia Ridge during the opening of the Scotia Sea indicate that Pirie Bank, along with Bruce Bank may have had close affinity to the South Orkney microcontinent (Perez 2014).

The first dredge sites (DR.220, DR.221) were on the south eastern margin of Pirie Bank. Both sites were characterised by fine grained sedimentary rocks and low grade metasedimentary rocks (mudstone, siltstone, sandstone, slate, and phyllite) and rare schists. The dredge haul was also characterised by medium grained granitoids (typically tonalite, granodiorite, granite), which are

interpreted to be dropstones. The provenance of the metasedimentary lithologies is uncertain; some are characterised by glacial striations and are likely to be ice rafted debris, but many of the angular fragments could well be in situ. The lithologies bear a close resemblance to the range of metasedimentary rocks identified from the adjacent South Orkney Islands (Flowerdew et al, 2011) and geological reconstructions of Perez (2014) indicate that the SOM and Pirie Bank were part of the same microcontinental block at 23 Ma.

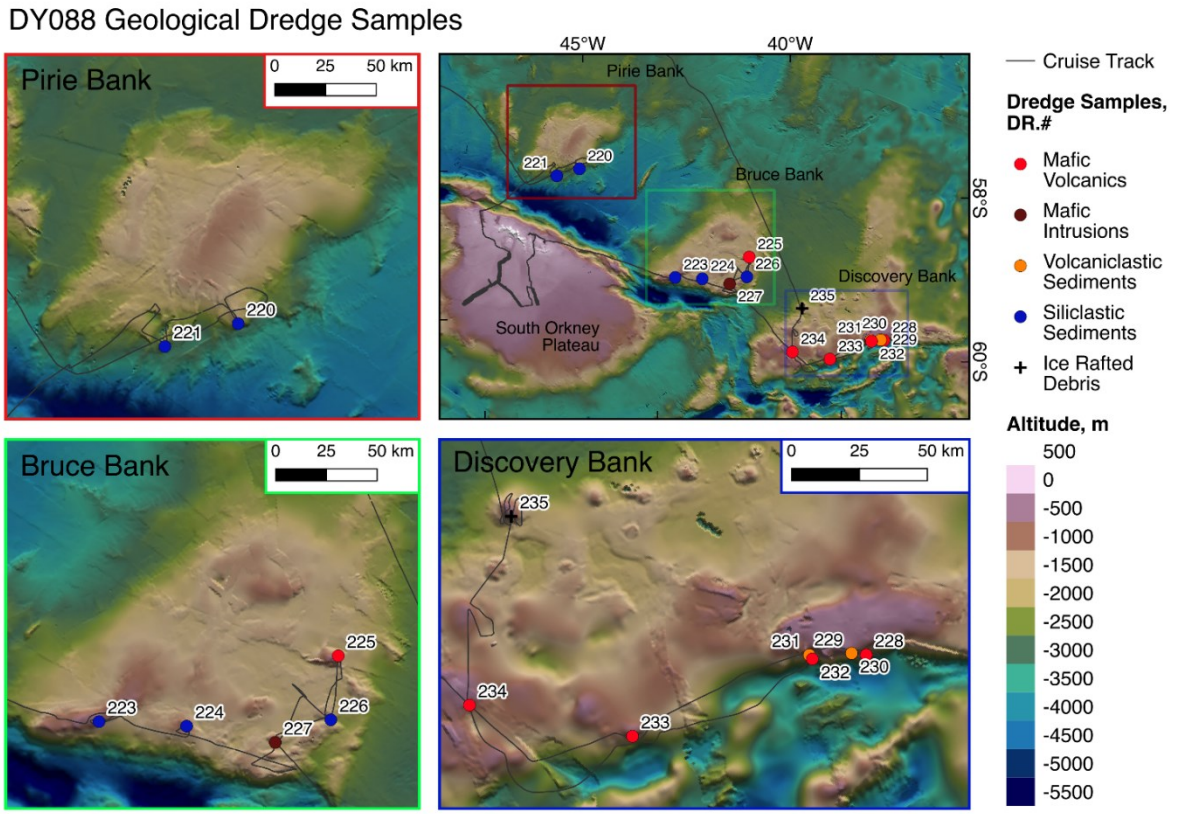

Figure 7: Location of dredge sites on Discovery, Bruce and Pirie banks.

5.1.2 Bruce Bank

The geological provenance of Bruce Bank is also uncertain, but akin to Pirie Bank is interpreted to be thinned continental crust (Galindo- Zaldívar et al., 2006). In a study of Scan Basin to the east of Bruce Bank, Perez (2014) discussed the nature of the basement geology of the adjacent banks of Bruce and Discovery. Seismic data indicate that the eastern margin of Bruce Bank has facies of continental or transitional nature, which are extremely thin in the vicinity of their margins (Galindo-Zaldívar et al., 2002; Maldonado et al., 2006b; Bohoyo et al., 2007; Lodolo et al., 2010). The margins of Scan Basin and the adjacent banks were interpreted to be characterised by widespread intrusions that generally outcrop at the seafloor.

Dredge sampling took place at five separate sites along the southern and eastern margins at Bruce Bank, where the slopes were interpreted to be the steepest and therefore free of any significant

sediment cover (Fig. 8). At least three of the dredge sites (DR.223, DR.224, DR.226; Fig. 7) were dominantly (80-90%) very fine grained, pale grey-brown, poorly lithified sedimentary rocks. Some preserve slightly undulose bedding surfaces, but generally there is no evidence for internal structures (except one mudstone). The sediments are possibly relatively recent (Cenozoic) cover rocks.

Two dredge sites (DR.225 and DR.227; Fig. 7) are dominated by mafic volcanic, hypabyssal and intrusive rocks including gabbro and pyroxenite (probable cumulates), an assemblage that could represent a sub-volcanic magmatic system and is in agreement with the interpretation of Perez (2014) that the the margins of Scan Basin are characterised by widespread intrusions.

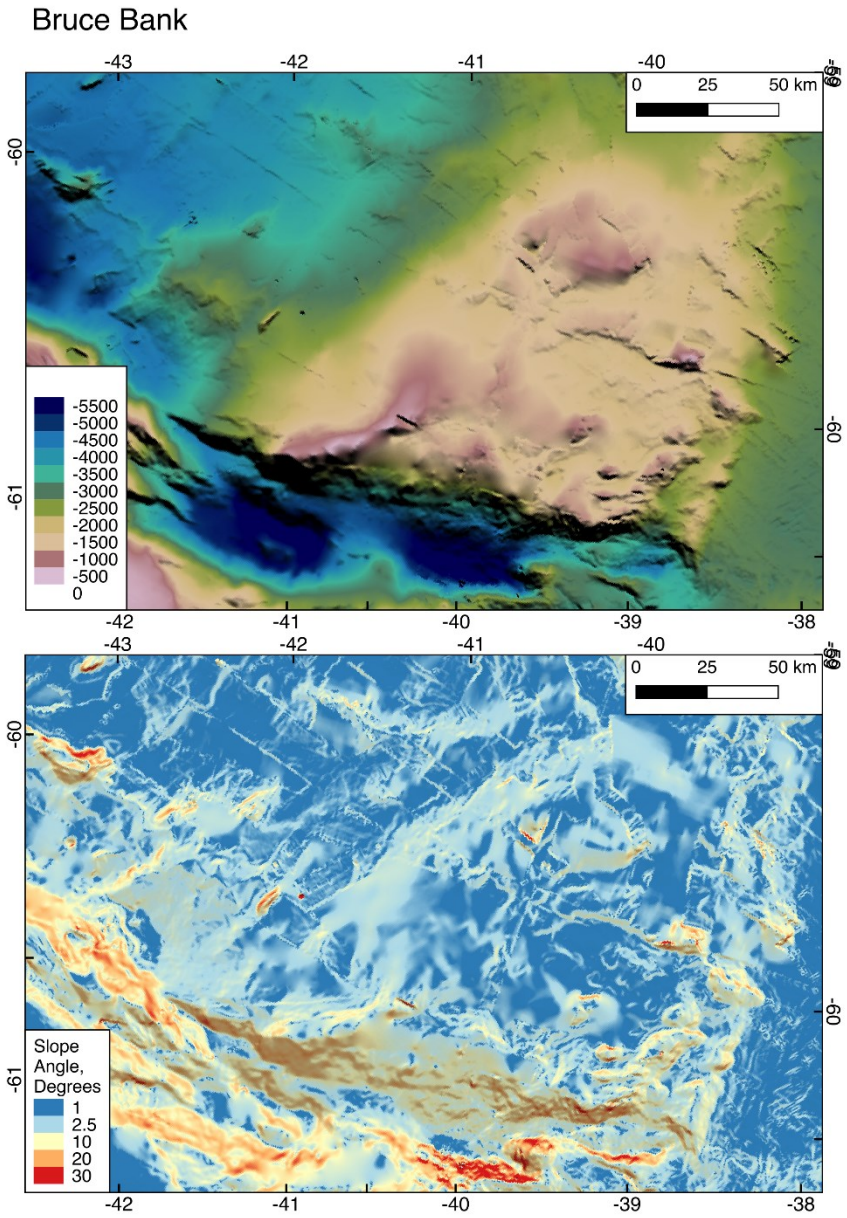

Figure 8: GEBCO data and slope angle interpretation of Bruce Bank.

5.1.3 Discovery Bank

Discovery Bank constitutes the largest of the topographic highs in the eastern part of the South Scotia Ridge (Fig. 2). Available seismic and magnetic data have been used to interpret Discovery Bank as continental in nature characterized by basic igneous rocks intruded into crustal material Bohoyo et al., 2007). The southern margin of Discovery Bank is complex, with multiple normal faults and the development of narrow perched basins.

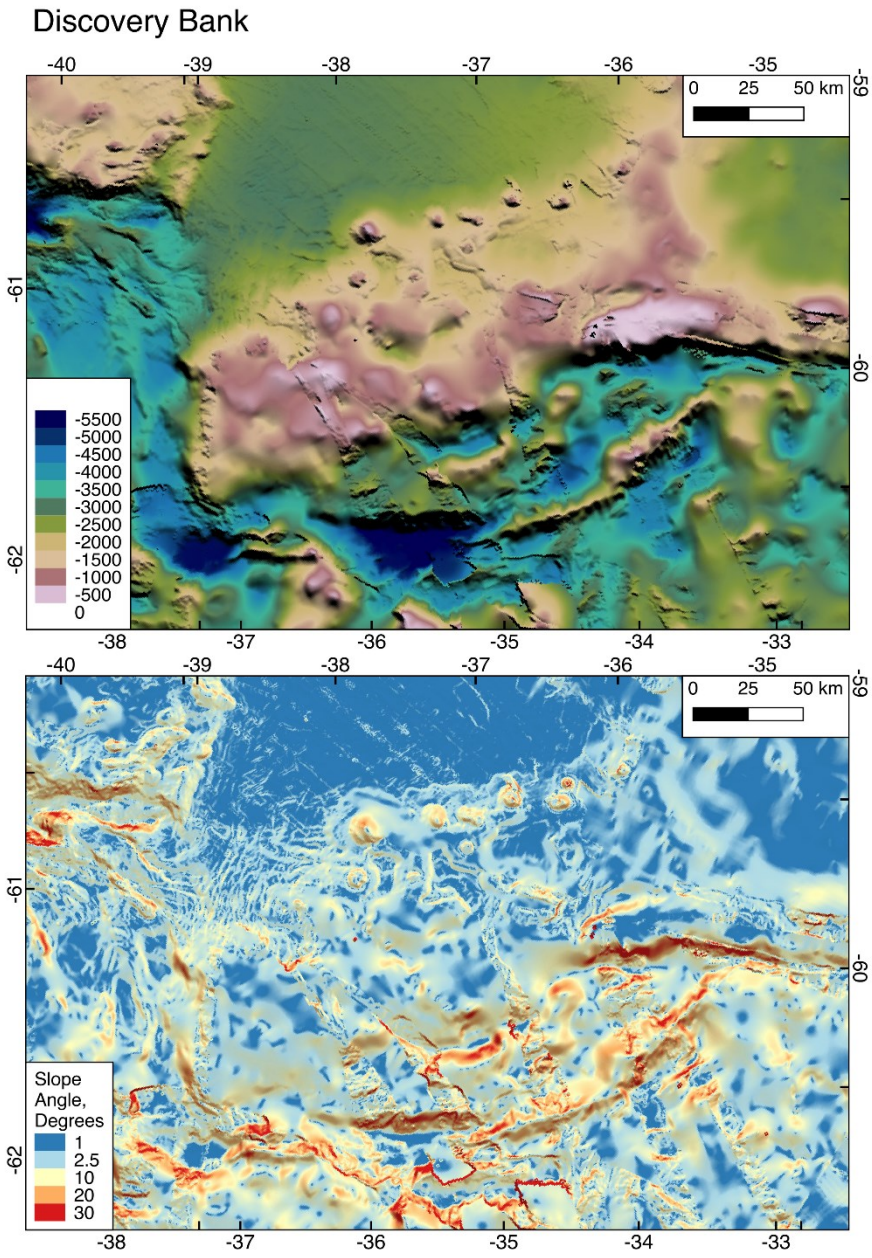

Figure 9: GEBCO data and slope angle interpretation of Discovery Bank.

Eight sites were selected for dredging on Discovery Bank (Fig. 7) based on the high relief and slope angle maps (Fig. 9) combined with newly acquired bathymetric data and sub bottom profile data. Overwhelmingly the recovered dredge material showed a high level of similarity, allowing a high degree of confidence to be placed on the lithologies being in situ. The dominant lithologies are

volcanic, including pyroxene and plagioclase-phyric basalts or basaltic andesites, volcaniclastic sediments, palagonitized tuffs or palagonitized lavas, volcanic lithic conglomerates and agglomerates. The dominance of these lithologies strongly point to the southern flank of Discovery Bank being volcanic in origin and is potentially consistent with Discovery Bank forming part of an ancestral South Sandwich island arc system (Pearce et al., 2014). Existing dredge material from Discovery Bank was also overwhelmingly volcanic, including basaltic lavas believed to be Miocene in age (Pearce et al., 2014). Rarer lithologies dredged from Discovery Bank also include granitoids blocks and metasedimentary material, which may be ice-rafted in origin.

Dredge site DR.235 was targeted on the northwestern flank of Discovery Bank as the bathymetric data indicated it may represent part of a chain of NE-SW trending seamounts. The imaged seamount is show in Fig. 10 and is 25 km in diameter with an eroded and pene-plained summit. The dredge material was dominated by <5cm pebbles of mixed lithologies implying a dominantly ice rafted debris derivation. Only ~2% of the recovered material was basaltic in composition, which was the anticipated lithology.

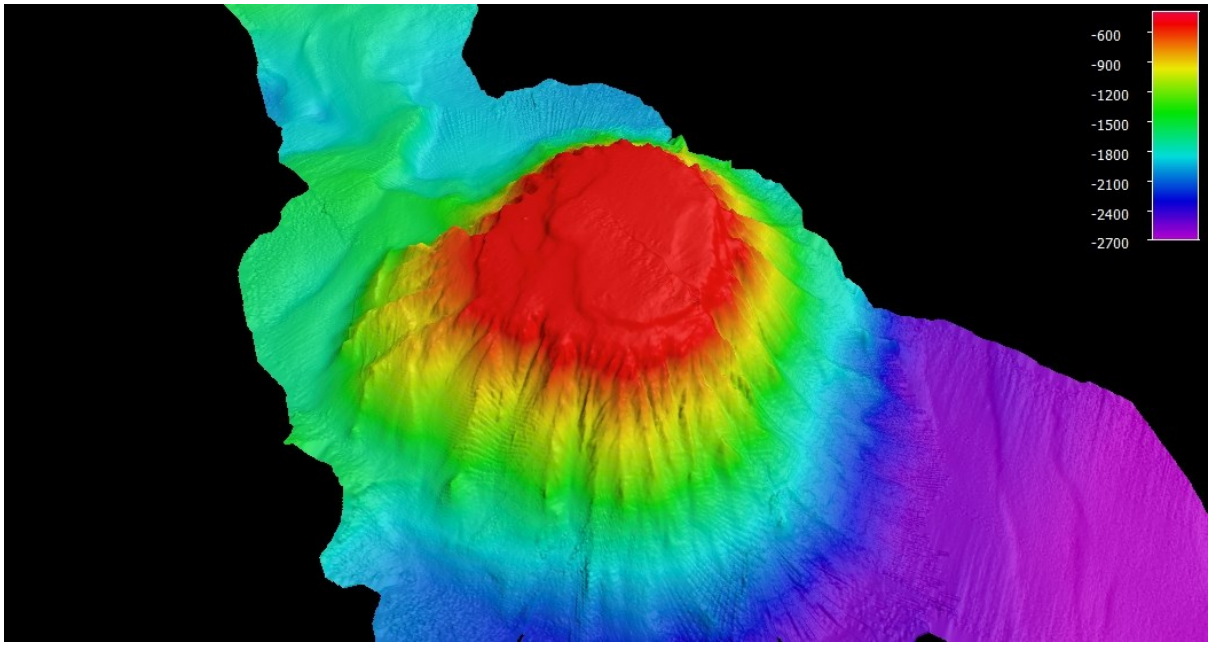

Figure 10: Northern Discovery Bank seamount image, dredge site DR.235.

5.2 Swath bathymetry surveys (EM122/EM710) and sub bottom profile surveys (SBP120)

5.2.1 Objectives

The objectives of the marine geophysical work undertaken on DY088 were:

i. To acquire new high-resolution bathymetric data and sub-bottom profiles in targeted survey areas in order to map the seafloor geomorphology and to image the sub-seabed sedimentary architecture.

ii. To aid identification of potential sites for strategic coring activities.
iii. To provide important geological context for sediment cores, and any ice, climate, and oceanic records contained therein.

Shipborne geophysical data were acquired using hull-mounted Konsberg-Simrad EM122 and EM710 echosounders for the bathymetric data, and a SBP120 echosounder for the sub-bottom profile data.

The SBP120 and one multibeam echosounder were run simultaneously for the majority of the cruise with the multibeam data divided into 7 surveys correlating with work areas and transit legs. In deep water areas (> 700 m) the EM122 was run, in shallow water (< 700 m) the EM710 was used. The exception was on station at coring locations where data were not logged on the multibeam echosounders. The main geophysical survey sites for DY088 were: (1) Pirie Bank; (2) Signy Trough and Orwell Trough, South Orkney Plateau (SOP); (3) Bruce Bank; (4) Discovery Bank; (5) NW Scotia Sea (Fig. 11). The remaining two surveys were transit data acquired between the five survey areas. Prior to the cruise existing multibeam data were collated and coarsely gridded (500 m grid-cell size) by the BAS Polar Data Centre (PDC) in ASCII raster and GeoTIFF image formats. The GeoTIFFs were loaded as background images in the multibeam acquisition software (SIS) to aid survey planning at sea. A coarse grid of multibeam data collected by a very recent Spanish cruise to Bruce and Discovery banks (DRAKE2018; PIs Carlotta Escutia, Fernando Bohoyo Muñoz) were also available, as was a recent regional bathymetric grid for the SOP with a 300-m cell size (Dickens et al., 2014). These data, together with regional topographic compilations (e.g. GEBCO), were used as the principle forms of planning, navigation and survey design.

5.2.2 Work at sea

Hull-mounted Kongsberg-Simrad multibeam echo sounders were used near continuously during cruise DY088. The EM122 was run in deep water areas i.e., transit and survey over the banks in the South Scotia Sea and the survey area in the NW Scotia Sea. The EM122 has up to 432 beams per swath (1° × 1° configuration on RRS *Discovery*) with a normal operating frequency of 12 kHz (frequency range of 11.25-12.75 kHz). This provides a spatial resolution of between c. 10-70 m (dependent on water depth). The projected swath width of the EM122 is generally 6 times the survey water depth to almost 4000 m depth with full beam width (75°/75° beam angles), or 5 times the water depth with c. 68° beam angles. During DY088, swath coverage EM122 was typically between 4-5 times the survey water depth with beam angles varying between 60°-75° dependent on sea state; typical beam angles were around 65°. The EM710 was utilised in shallow water areas i.e., survey on the SOP. It emits up to 200 pings per swath (2° × 2° configuration) and operates at frequencies between 70 and 100 kHz. Typical beam angles for the EM710 during DY088 were 65° with swath coverage about 4 times water depth. There was no significant difference in swath coverage between the EM122 and EM710 echosounders

on the SOP so it was decided to only log data on the EM710 in that area. Beam raypaths and seafloor depths for both the EM122 and the EM710 were calculated in near real-time using sound velocity profiles derived from the NMF Sound Velocity Probe (SVP) during DY088. A table of the sound velocity profiles used during DY088 is given in Table 1.

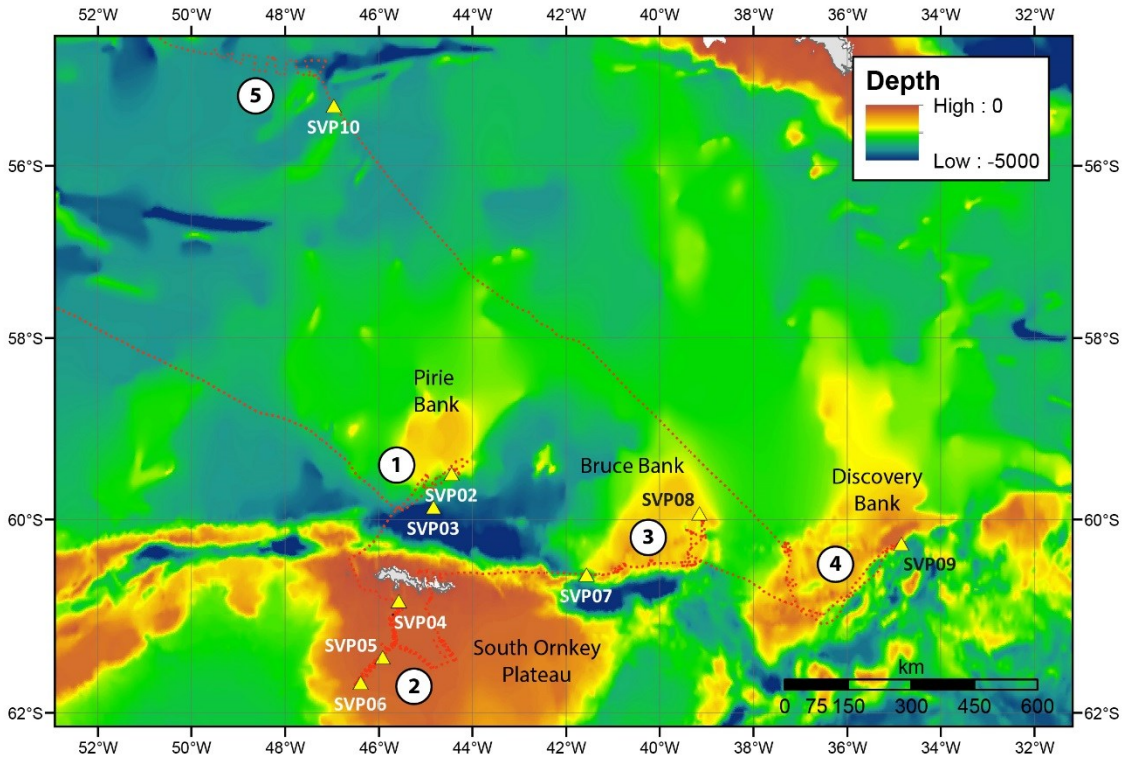

Figure 11: Cruise location map showing and DY088 tracklines (red) and main working areas (numbered): (1) Pirie Bank; (2) Signy Trough and Orwell Trough, SOP; (3) Bruce Bank; (4) Discovery Bank; (5) NW Scotia Sea. Regional bathymetry from GEBCO; map projected with a Mercator (WGS84) projection.

Sub-bottom profiles were acquired with a hull-mounted Kongsberg SBP120 6°x6° chirp echosounder that is integrated with the multibeam system. This system operates with a frequency range of 2.5-7 kHz and can record data from 11 beams with 6° separation. The system has an approximate resolution of 0.35 ms (~70 cm) and penetration is 50-200 m in clayey ocean sediments. The SBP120 performed well on DY088 and data was logged for all 11 beams.

Multibeam-bathymetric and SBP120 surveys were focused at each dredge locality (Pirie, Bruce and Discovery banks), in Signy and Orwell troughs on the SOP, and in an area in the NW Scotia Sea; survey locations are shown in Figure 1X. Where features of interest were identified, blocks of the seafloor were mapped out with a survey of overlapping swaths; swath overlap was between 10-15% in surveyed areas. Outside of the target areas individual lines were recorded routinely on transit

between survey areas, as well as on passage to and from Punta Arenas at the start and end of the cruise, respectively. The following sections describe and illustrate the coverage of the DY088 survey data. Table 2 lists the different multibeam surveys recorded during the cruise, along with their start/end times, the number of lines collected, and a brief description of the working locality.

File name (Raw data file name)	Latitude collected (degrees dec. min. S)	Longitude collected (degrees dec. min. W)	Date-time collected/ SVP Station	Date-time active	Notes
20180125 (DY087 Profile)			07/03/2018	09/03/2018 10:45	(DY087) Pre-loaded at start of cruise. Survey: dy088_a
10032018 (FILE20.000)	57° 10.2’	54° 54.0’	10/03/2018 16:20 SVP01	10/3/2018 22:05	JD069 – 4009 m; Line 0066. Survey: dy088_a
12032018 (FILE24.000)	59° 30.0’	44° 27.0’	12/03/2018 11:14 SVP02	12/03/2018 12:13	JD071 – 600 m; Line 0015
13032018 (FILE28.000)	59° 40.8’	44° 49.8’	13/03/2018 06:53 SVP03	13/03/2018 07:40	JD072 – 600 m; Line 0028
14032018 (FILE32.000)	60° 51.6’	45° 34.8’	14/03/2018 01:41 SVP04	14/03/2018 03:37	JD073 – 310 m
14032018_2 (FILE36.000)	61° 26.4’	45° 55.2’	14/03/2018 17:00 SVP05	14/03/2018 17:37	JD073 – 300 m; Line 0026
15032018 (FILE40.000)	61° 41.4’	46° 23.4’	15/03/2018 07:09 SVP06	15/03/2018 07:37	JD074 – 401 m
20032018 (FILE45.000)	60° 34.8’	41° 33.0’	20/03/2018 03:42 SVP07	20/03/2018 05:37	JD079 – 2154 m
21032018 (FILE49.000)	59° 55.8’	39° 09.6’	21/03/2018 17:45 SVP08	21/03/2018 18:37	JD080 – 680 m
23032018 (FILE53.000)	60° 15.0’	34° 51.0’	23/03/2018 19:05 SVP09	23/03/2018 19:05	JD082 – 800 m
27032018 (FILE57.000)	55° 16.23’	46° 58.13’	27/03/2018 11:53 SVP10	27/03/2018	JD086 – 900 m; Line 0000

Table 1: Summary table of Sound Velocity Profiles (SVPs) used on DY088 including the dates and times that each one was active for EM122/EM710 logging. Note that the saved file name used in SIS has the suffix “_sorted_thinned.asvp” after the number string listed above. A SVP station list is also given in Appendix A5.

Survey name	Name of survey area	Start time (Date/time)	Start time of last file (Date/time)	No. of lines
dy088_a	Transit Punta Arenas to/from South Scotia Sea	09/03/2018 10:45	30/03/2018 21:53	179
dy088_b	Pirie Bank survey	12/03/2018 04:41	13/03/2018 17:48	44
dy088_c (EM710)	South Orkney Plateau (SOP) survey	14/03/2018 03:04	19/03/2018 18:34	227
dy088_d	Transit banks-SOP-Scotia Sea	13/03/2018 17:59	27/3/2018 13:24	133
dy088_e	Bruce Bank survey	19/03/2018 21:22	22/03/2018 18:01	90
dy088_f	Discovery Bank survey	22/03/2018 18:06	25/03/2018 16:44	101
dy088_g	Northwest Scotia Sea survey	27/03/2018 13:32	29/03/2018 11:10	93

Table 2: Multibeam surveys acquired on DY088. All surveys were acquired with the EM122 except for dy088_c which was acquired using the EM710.

In total, approximately 105000 line-kilometers of multibeam-bathymetric data were collected (includning passage data). SBP120 data were collected simultaneously. The process of ping editing to remove anomalous depths was begun whilst onboard, using the MB-system in Linux (see Appendix A11). A first-pass cleaning of surveys dy088_b, dy088_e, dy088_f and dy088_g was completed on board; processing of the remaining surveys will be completed on return to BAS Cambridge.

5.2.3 Rationale, approach, and preliminary observations by working area

(1) Pirie Bank

Rationale and Approach: The aim was to survey for potential dredge sites on the southeastern flank of the bank in areas with no appreciable sediment cover.

Preliminary observations: Dredge sites were identified based primarily on multibeam survey data but were cross-checked on SBP120 data to identify areas with no or little sediment cover.

(2) Signy Trough and Orwell Trough, South Orkney Plateau (SOP; Fig. 12)

Rationale: The extent of the Last Glacial Maximum (LGM) ice cap on the South Orkney shelf is poorly constrained. Previous studies of the onshore (Sugden and Clapperton, 1977) and offshore (Herron and Anderson, 1990) glacial geomorphology led to proposed LGM ice-extent limits at the 200 m isobath and 300 m isobaths, respectively. Cruise JR244 of the RRS *James Clark Ross* in 2011 performed the first detailed geophysical surveys on the SOP with focussed coring and mapping work in Coronation

and Orwell troughs to the NE and SW of the islands (Larter et al., 2011). This work confirmed a more expansive glaciation of the southern Orkney shelf to an outer shelf morainal bank system (Dickens et al., 2014; Dickens, 2016). The aim of geophysical surveys on DY088 was to identify glacial limits in the larger Signy Trough, east of Orwell Trough, and to collect sediment cores to date the withdrawal of ice from that trough, and from the morainal bank in Orwell Trough. The geophysical survey work provided locations for gravity coring. The existence of Signy Trough and glacial landforms at its head was already known from earlier published bathymetric data (e.g. King and Barker, 1988; Dickens et al., 2014).

Approach: One large glacial trough (Signy Trough) was mapped, including an eastern branch of the trough, out to the outer-shelf moraine bank. Surveys focussed along trough axes and out beyond the trough margins. Our objective was to map the geographical extent of the troughs, characterise their geomorphology and decipher their origin, as well as image the sediments within them.

Preliminary observations: Signy Trough has a series of three overdeepened basins along its length generally shoaling seawards towards a shallower outer shelf. The innermost basin is the deepest of these basins with maximum depths around 390 m. This reverse-slope profile is typical of troughs formed by other (but much larger) outlet glaciers along the northern and western Antarctic Peninsula margins. Eastern Signy Trough also shoals in a seaward direction. Preliminary observations from the data include:

- Former ice grounding is evident in Signy and eastern Signy troughs by the presence of bedforms, though the nature and age of these is unclear at present. Often, the glacially-scoured surface is obscured by subsequent sedimentary infill, or has been removed by scouring or winnowing at shallower levels.
- Evidence for the continuation of the outer-shelf moraine bank was discovered in Signy and eastern Signy troughs.
- Glacial landforms in Signy Trough indicate three former grounding positions for ice retreating in that trough (including the outer shelf moraine). Buried features presumed to relate to ice retreat were visible on sub-bottom profiles from the middle and outer basins.
- SBP120 profiles revealed thick sedimentary sequences of postglacial sediments in the deepest parts of the troughs. The sequence can be separated into a semi-transparent upper unit and a well-stratified lower unit, which is similar to what is observed in Orwell Trough (Dickens, 2016). Both units pinch out against the trough flanks and the northern and southern boundary of the basins.
- Multibeam data and sub-bottom profiles adding to JR244 coverage of the outer shelf moraine in Orwell Trough confirmed the presence of multiple grounding events on the bank, notably a a wedge on the northern crest of the bank, which appears to be the result of the most recent grounding of ice on the bank.

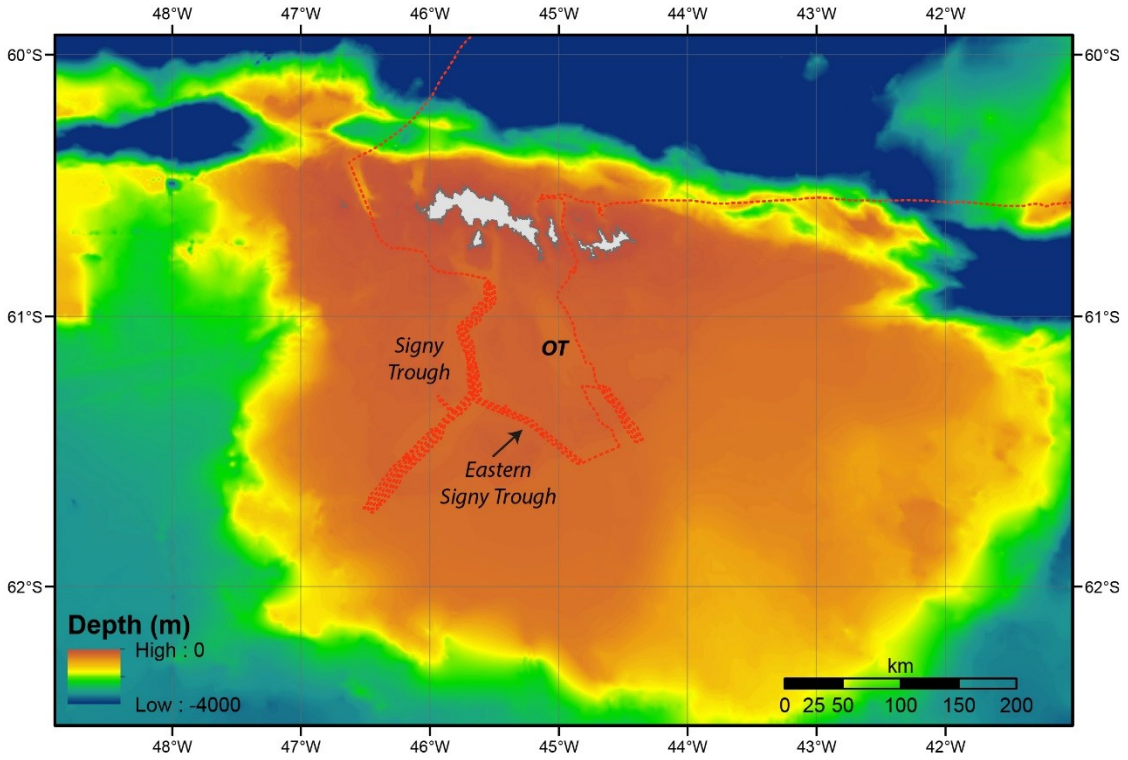

Figure 12: Survey coverage in the vicinity of the South Orkney Plateau (SOP); OT is Orwell Trough. Transverse Mercator projection.

(3) Bruce Bank

Rationale and Approach: The aim was to survey for potential dredge sites on the southern and eastern flanks of the bank in areas with no appreciable sediment cover. A secondary aim was to identify a potential core site on the top of the bank with thick laminated sediments.

Preliminary observations: Dredge sites were identified based primarily on multibeam survey data but were cross-checked on SBP120 profiles. After dredging, a survey line targeting deeper/smoother areas on the top of the bank was run to identify basins and sedimentary sequences.

(4) Discovery Bank

Rationale and Approach: On Discovery Bank surveying for potential dredge sites focussed on the southern and eastern flanks of the bank to identify steep (> 20°) slopes areas with no appreciable sediment cover. After the initial survey and dredge sites two submarine volcanoes off the south-western flank of the bank, identified on recently acquired bathymetric data from the DRAKE2018 cruise, were mapped and a dredge site identified.

Preliminary observations: Dredge sites were identified based primarily on multibeam survey data but were cross-checked on SBP120 profiles. The survey over the two volcanoes complimented existing

data to ensure full coverage over these features with north-south survey lines over the northern seamount.

(5) NW Scotia Sea (Fig. 13)

Rationale and Approach: Due to adverse weather moving in to our primary work area in the southern Scotia Sea our original survey area south of Discovery Bank had to be abandoned. A new survey area in the north-western Scotia Sea was identified, north of the Endurance and Quest fracture zones. Due to wind and wave directions an east-west survey pattern was not an option and NE-SW to N-S survey lines were carried out for the majority of the survey.

Preliminary observations: The survey filled in a gap between clear basalt ridges west of the relict West Scotia Ridge spreading centre and a more mixed seafloor morphology further north (Fig. 13).

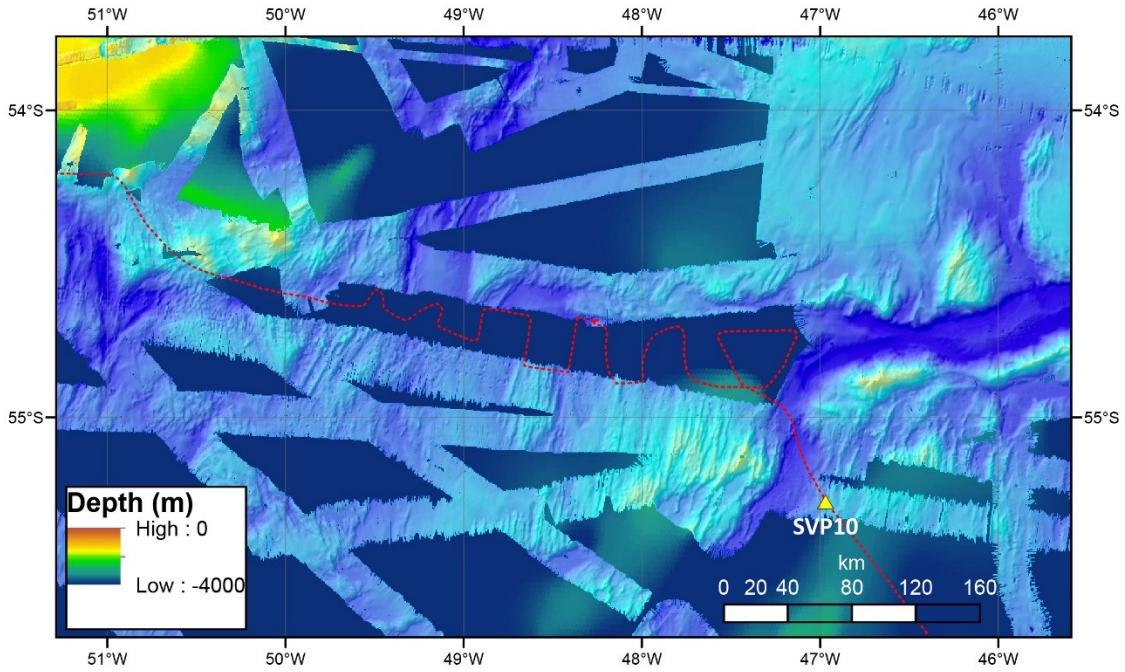

Figure 13: Survey coverage in the NW Scotia Sea close to the relict West Scotia Ridge. The blue hillshade data is a 500-m grid of existing BAS multibeam datasets and shows the survey area "filling the gap" between existing lines. Transverse Mercator projection.

5.3 Gravity and box coring

Coring activities were divided into 3 main topics of investigation: 1) uncovering the glacial history of the South Orkney Plateau; 2) assessing the influence of poleward shifts in the south westerly winds (SWW) on the water masses to the north and south of the South Orkney Plateau and 3) understanding the evolution and provenance of Antarctic ice-rafted debris (IRD). The first two themes both took place in four areas around the South Orkney Plateau – Signy Trough, East Signy Trough, Orwell Trough to

the south of the islands and Bennett and Laurie Troughs to the north (Figs 14, 15). An additional coring target in Coronation Trough (NW of Coronation Island), intended to be collected on route to Signy Trough, had to be waived due to inclement weather conditions.

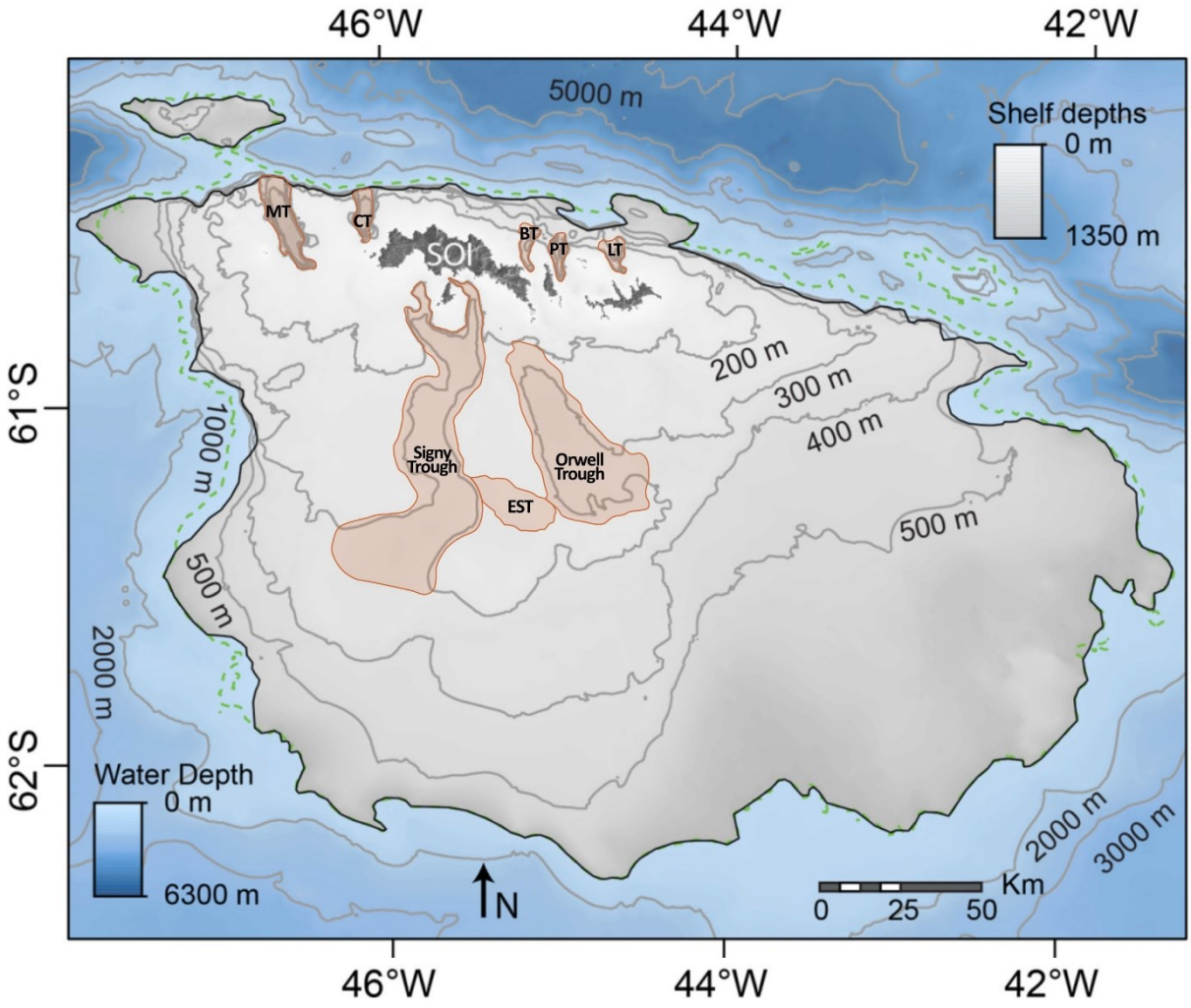

Figure 14: Map of South Orkney Plateau (SOP) illustrating the main cross shelf troughs: MT – Monroe Trough; CT – Coronation Trough; BT - Bennett Trough; PT – Powell Trough, LT – Laurie Trough and EST - East Signy Trough (modified from Dickens et al., 2014).

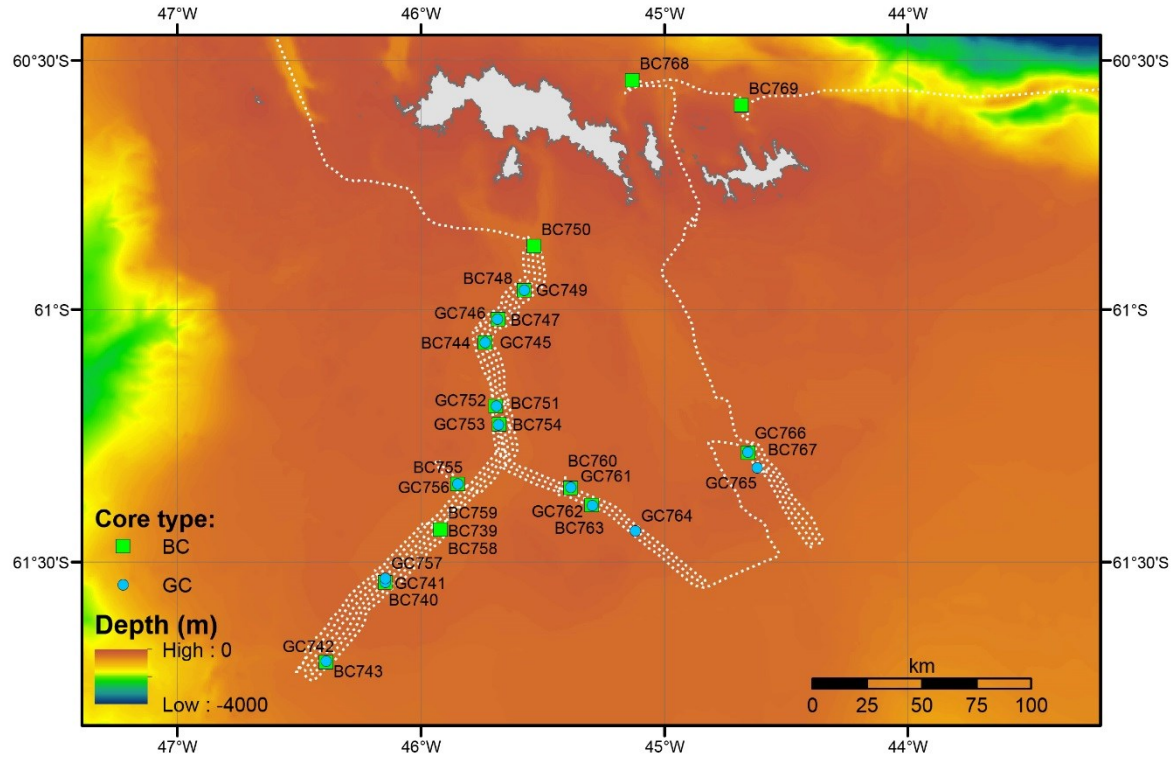

Figure 15: Map of SOP showing core site locations south and north of the islands. Note the different symbols for box cores (BC) and gravity cores (GC); the cruise trackline is in white.

5.3.1 Signy Trough

BC739: High-resolution box core site (CASS-139)

The site of BC739 was selected on account of the high sedimentation rates suggested by the thick drape of post-glacial sediments (Fig. 16). Elevated sedimentation rates afford the best opportunity to deliver high resolution reconstructions of recent oceanographic conditions for the CASS project.

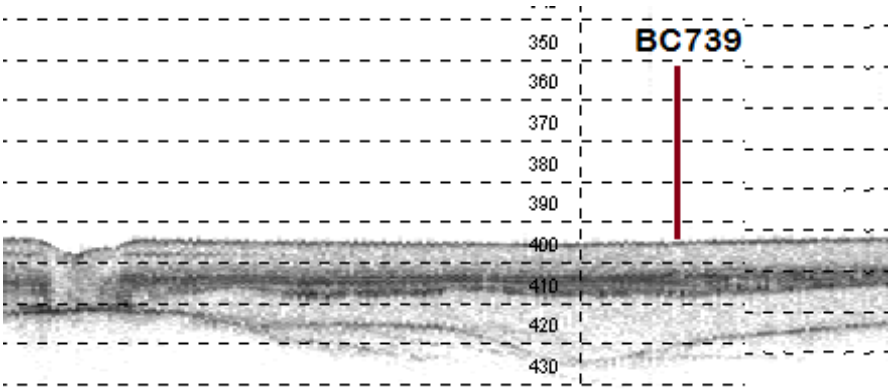

Figure 16: Section of SBP120 acoustic profile showing location of BC739.

This was the first deployment of the box corer on DY088. A good sediment surface was recovered with penetration to 0.30 m. Water drained from the box corer as it was retrieved, removing the unconsolidated surface sediments. Removal of the sediment-water interface was undesirable for the anticipated analyses on these sediments. We revisited this site on 17th March 2018 to recore the sediments in an attempt to recover an intact sediment-water interface. Unfortunately, BC758 and BC759 were unsuccessful in recovering suitable cores at this site.

BC740/GC741: South Orkney glacial history

The site of BC740 and GC741 was chosen as a site on the landward side of the outer shelf moraine in Signy Trough with a thin postglacial unit potentially allowing a 6-m gravity core to penetrate in to "glacial" underlying units and hopefully date the withdrawal of ice from the moraine (Fig. 17). The acoustically-transparent wedge in the figure below was interpreted as a glacial till overlain by a <4 m post-glacial drape. The core site is located ~11 km landward of the moraine crest.

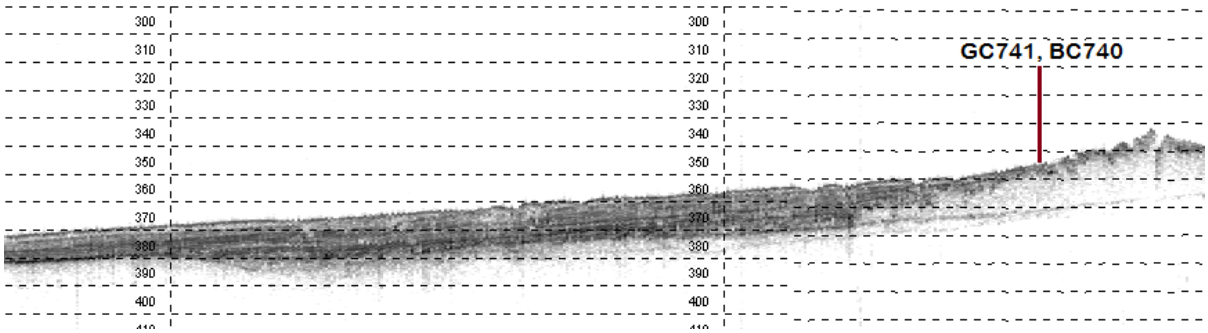

Figure 17: Section of SBP120 acoustic profile showing location of BC740/GC741.

BC740 deployed well and recovered 0.32 m of sediment, maintaining the sediment-water interface. 4 sub-cores were collected (two sub-cores to provide an alternative site for the CASS project given the failure to preserve the water-sediment interface at GC739) and two additional sub-cores sampling the box core following drainage. GC741 was the first deployment of the gravity corer on DY088. Deployment went well, but following recovery it was found that a nail had snapped within the join between the top barrel and the bomb. After an hour and a half attempting to remove the barrel from the bomb by force, an angle grinder was used to separate the barrel from the bomb. The core (4.25 m) was recovered, but the sediments had been very disturbed by the attempts to separate the barrels. The site was revisited and successfully re-cored on 17th March 2018 (GC757).

GC742/BC743: South Orkney glacial history

The site of GC742 and BC743 was on the seaward side of the outer shelf moraine in Signy Trough to investigate whether glaciers have advanced beyond the moraine (Fig. 18). Based on the SBP120

profiles, the core site was thought to be beyond the area of debris-flow deposits sourced from the morainal bank (Dickens, 2016).

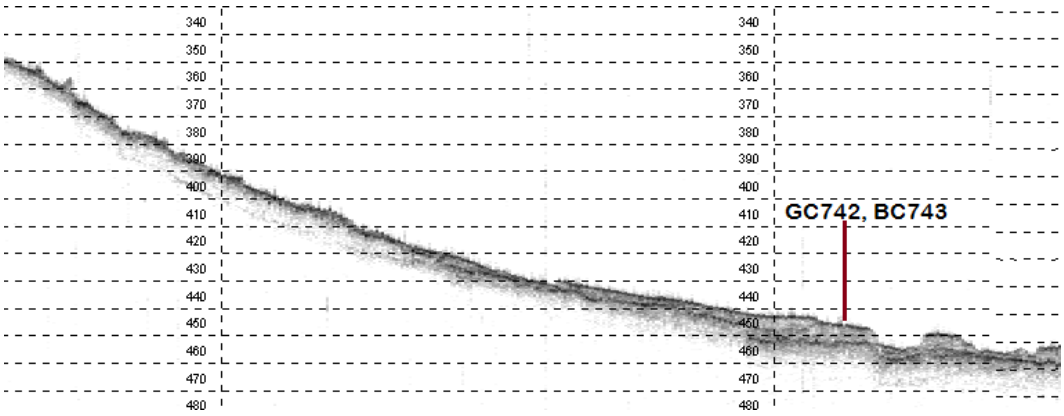

Figure 18: Section of SBP120 acoustic profile showing location of GC742/BC743.

The gravity core was deployed before the box core in order to minimise the number of wire changes required. The core recovered over 2 m of sediment, with the upper most sediments retained as a bagged sample owing to their being too unconsolidated and insufficient to warrant a core section. Although mud on the bomb suggested the corer over penetrated the sea floor, the modest recovery may indicate that the corer had fallen over after shallow penetration. The box corer drained during recovery and did not preserve the sediment-water interface.

BC744/GC745: South Orkney glacial history

The site of BC744 and GC745 was selected to penetrate through a relatively thin post-glacial drape unit to an underlying reflection thought to represent buried moraines (Fig. 19). These features are located in the middle basin in Signy Trough and may represent an additional stillstand location between the two grounding-zone wedges (GZWs) located at the margins of this basin.

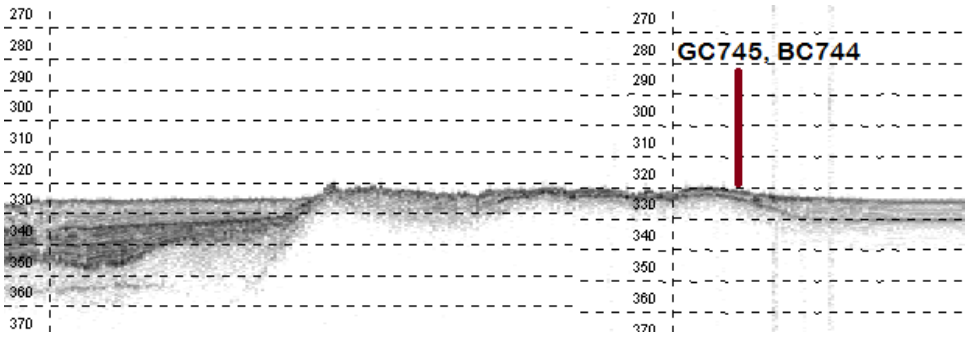

Figure 19: Section of SBP120 acoustic profile showing location of BC744/GC745.

The first deployment of the box corer did not trigger. A second attempt was successful and recovered 0.26 m of sediment. 2 sub-cores and 2 surface bagged samples were collected. GC745 recovered 2.19 m of sediment.

GC746/BC747: South Orkney glacial history

The site of GC746 and BC747 was selected based on its position just seaward of a GZW (on the LHS of the image below) between the inner and middle basins in Signy Trough (Fig. 20). An area with relatively thin post-glacial unit (<5 m) was targeted to try to recover glacial sediments below this.

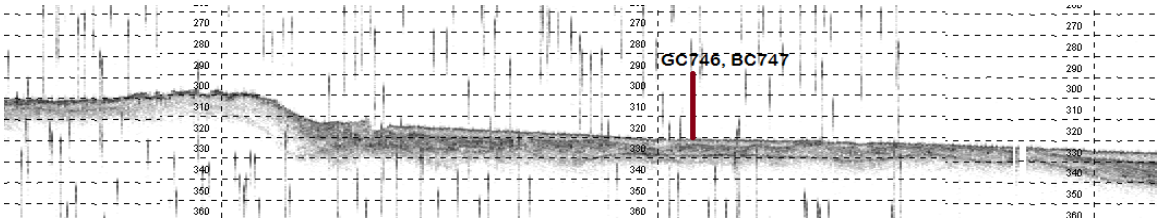

Figure 20: Section of SBP120 acoustic profile showing location of GC746/BC747.

The gravity core recovered 4.91 m of sediment. The box corer recovered 0.30 m of sediment.

BC748/GC749: South Orkney glacial history

BC748 and GC749 (Fig. 21) were acquired on the landward side of the GZW between the inner and middle basins in Signy Trough (identified from SBP120 profiles). Again, an area with thin post-glacial drape was targeted but an additional factor was selecting a site that had not been obviously scoured by iceberg ploughmarks.

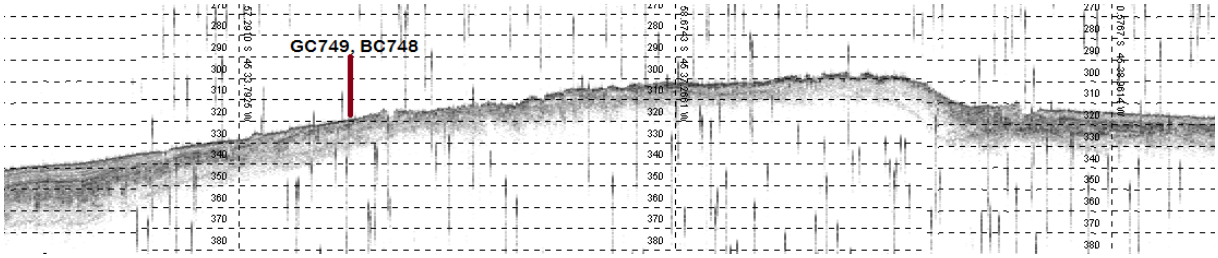

Figure 21: Section of SBP120 acoustic profile showing location of BC748/GC749.

The box corer recovered 0.23 m of sediment and the gravity corer recovered 2.74 m.

BC750: High resolution box core site (CASS-139)

The site of BC750 was chosen to sample the uppermost sediments of the thick drape of post-glacial sediments (Fig. 22). The depth of the acoustic returns suggest elevated sedimentation rates and the

potential to deliver high resolution reconstructions of recent oceanographic conditions for the CASS project.

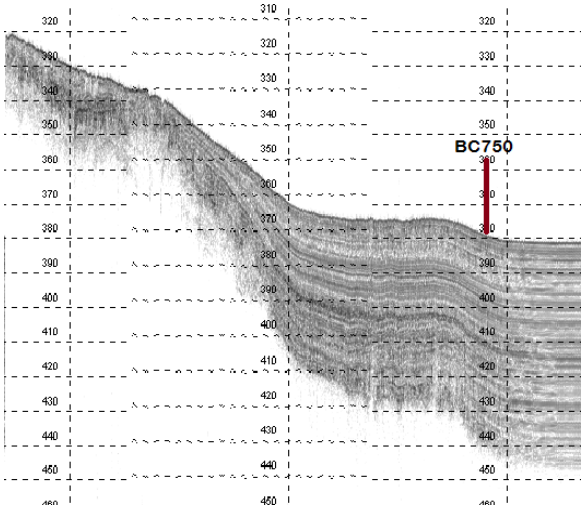

Figure 22: Section of SBP120 showing location of BC750.

The box corer deployed well and recovered 0.44 m of sediment with the sediment-water interface preserved. Three sub-cores were collected with a head of water which was settled and frozen before sub-sampling.

BC751/GC752: South Orkney glacial history

The site for BC751 and GC752 was selected on the landward side of the GZW between the middle and outer basins in Signy Trough to try to date the withdrawal of grounded ice from this feature (Fig. 23). Post-glacial sediments in the middle basin are several tens of meters thick so the "pinch out" on the landward slope of the GZW was targeted to try to penetrate in to the glacial units below. The core site is ~4 km from the crest of the GZW.

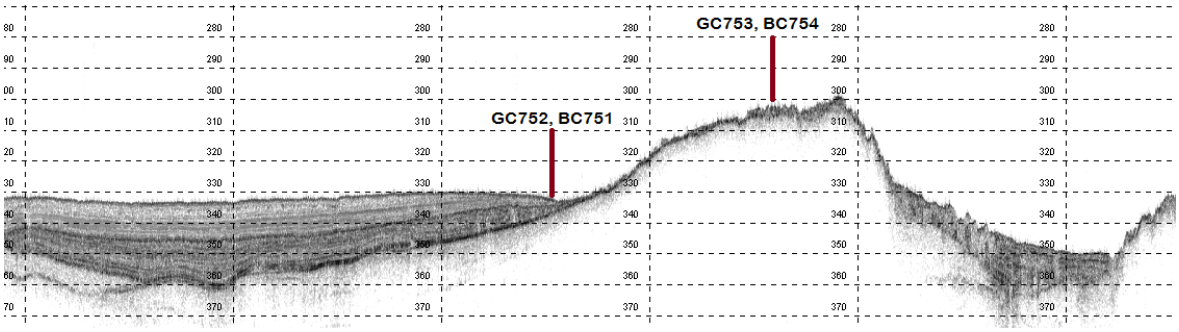

Figure 23: Section of SBP120 acoustic profile showing locations of BC751/GC752 and GC753/BC754.

Two attempts with the box corer were made to recover BC751 as on the first deployment the spade did not trigger. The second deployment was successful and recovered 0.29 m of sediment, but a rock trapped between the spade and the box dented the box causing the water to drain and the sediment-

water interface was not preserved. The gravity corer deployed well and recovered 2.09 m of sediment, but the barrel was bent slightly on recovery.

GC753/BC754: South Orkney glacial history

GC753 and BC754 were acquired on the crest of the GZW between the middle and outer basins in Signy Trough in an area thought to be undisturbed by iceberg ploughmarks (Fig. 23). This core site was selected to target the initial withdrawal of grounded ice from the GZW.

The gravity corer deployed well and recovered 1.93 m of sediment. The box corer deployed well on but a rock dented the wall of the box and caused the box corer to drain and the sediment-water interface was lost.

BC755/GC756: South Orkney glacial history

The site for BC755 and GC756 was selected on the NE flank of the outer basin just seaward of the GZW between this and the middle basin (Fig. 24). Postglacial sediment units in the outer basin of Signy Trough are at least 40 m thick in the deepest part, thicken quickly, and appear to be affected by downslope movement on the seaward (front) side of the GZW so a core site on the flanks of the basin was chosen over a site along the axis of the trough.

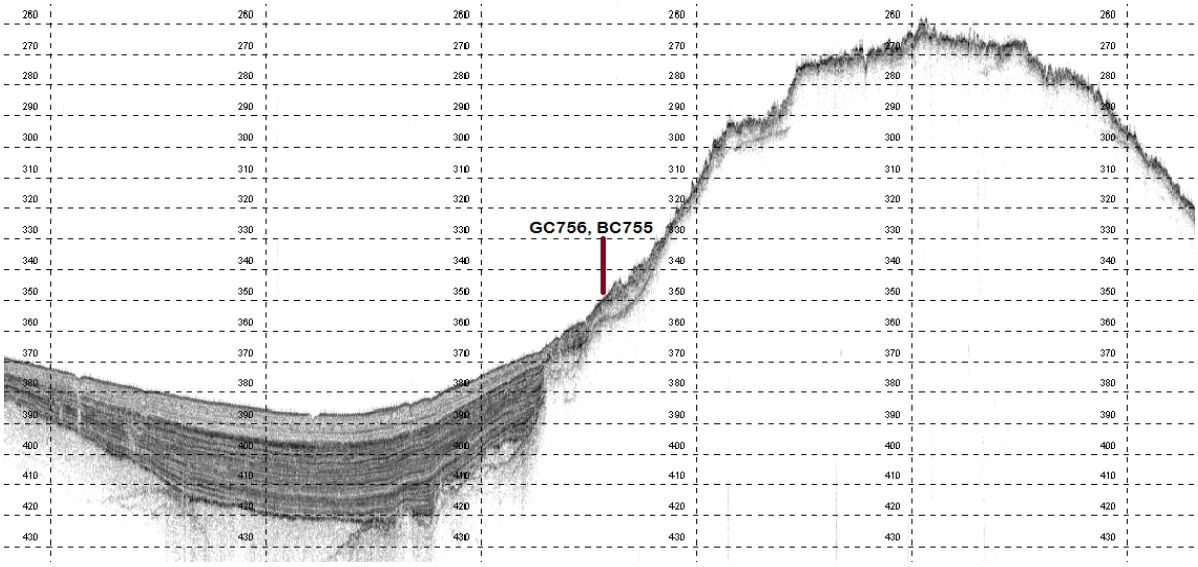

Figure 24: Section of SBP120 acoustic profile showing location of BC755/GC756.

The box corer deployed well and recovered 0.32 m of sediment, but the water drained and the sediment-water interface was not preserved. The gravity corer recovered 3.22 m of sediment.

GC757: Successful repeat core at site of GC741.

BC758/BC759: Unsuccessful deployments of box core to re-core site BC739 in order to recover an intact water-sediment interface. The box corer deployed well on the first attempt (BC758) but sediment appeared to be disturbed and was not sampled. A second repeat deployment of the box corer (BC759) did not trigger the spade. No further attempts were made.

5.3.2 East Signy Trough

BC760/GC761: **South Orkney glacial history**

BC760 and GC761 were the first core sites in East Signy Trough where the seafloor appeared to be pervasively scoured by icebergs in shallow areas (Fig. 25). The site was chosen in an area with thin postglacial sediment cover, on the landward side of a bathymetric shallowing thought to be a possible grounding-line position.

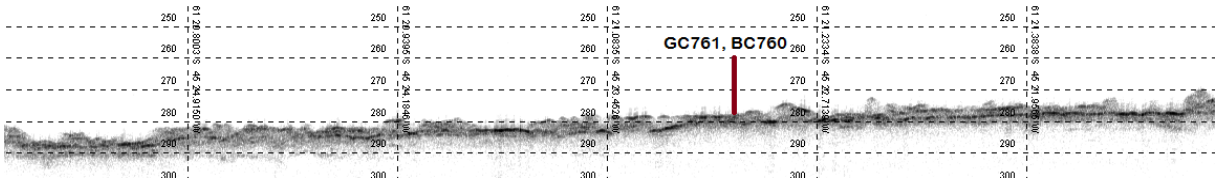

Figure 25: Extract of SBP120 acoustic profile showing location of BC760/GC761.

The first two deployments of the box corer (61.3520 S; 45.3858 W) were unsuccessful as the box failed to drop and the spade was not triggered. Although there was no obvious reason for the failure, the corer frame appears to have fallen on its side as indicated by mud on the top shackle. The ADCP was activated to test for strong currents at the seafloor and the topography resolved in the EM710 was checked for bed forms that could account for the up-tipped corer. After allowing the ship to drift ~100 m, a third attempt was made (61.3530 S; 45.3850 W) that successfully retrieved sediment but was drained during recovery so did not preserve the sediment-water interface.

GC762/BC763: South Orkney glacial history and high resolution box core site (CASS-139)

The site of GC762 and BC763 was selected in an area with convincing, undisturbed postglacial sediment cover just seaward (SE) of a presumed grounding-line position in the trough (Fig. 26). The postglacial sediment cover was <10 m thick with the aim being to recover an undisturbed sequence ideally penetrating in to the underlying acoustically-homogenous units thought to be glacial in origin.

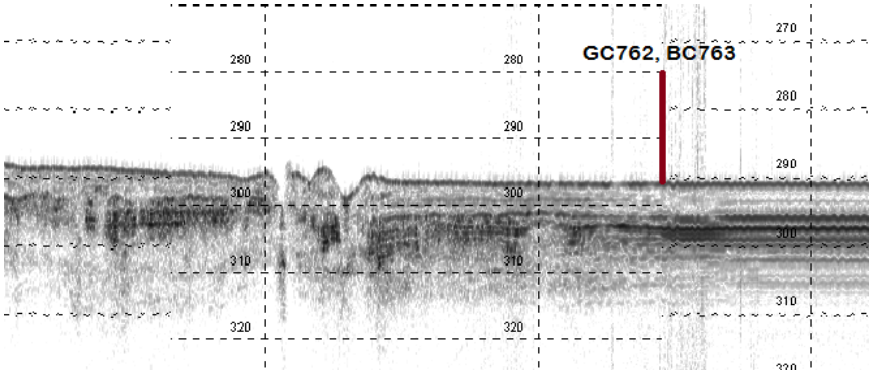

Figure 26: Section of SBP120 showing location of GC762/BC763.

The gravity corer recovered 4.89 m of sediment. The box corer deployed well and recovered 0.34 m of sediment with the water-sediment interface preserved. Given the failure to collect a box core with preserved water-sediment interface at the site of BC739 additional sub-cores were collected for use in the CASS-139 study.

GC764: South Orkney glacial history

GC764 targeted an area of sediment overlying an acoustically-impenetrable/homogenous unit that is thought to represent a glacially-scoured surface. The location on GC764 on the backside of the outer shelf moraine in East Signy Trough was chosen to try to date the retreat of grounded ice from this feature (Fig. 27).

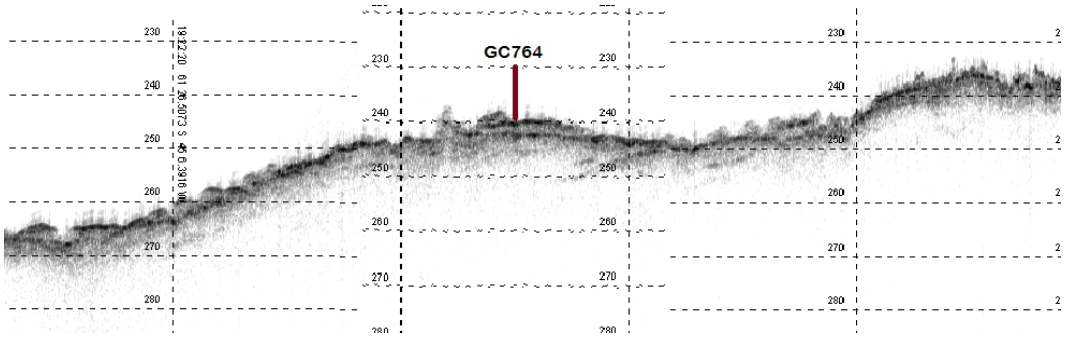

Figure 27: Section of SBP120 showing location of GC764.

The gravity corer recovered 1.45 m of sediment.

5.3.3 Orwell Trough

GC765: South Orkney glacial history

The site of GC765 was selected as an undisturbed area close to the (wide) crest of the morainal bank in Orwell Trough (Fig. 28). Previous cores from this trough were significantly further north of the bank and did not penetrate in to glacial sediments (Dickens, 2016).

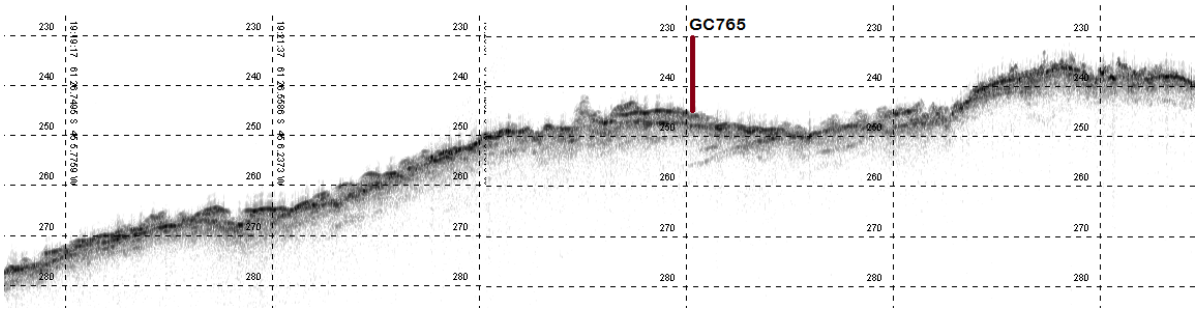

Figure 28: Section of SBP120 showing location of GC765.

The gravity corer recovered 0.94 m of sediment.

GC766/BC767: South Orkney glacial history

The site of GC766 and BC767 is located 8 km north of core site GC765 and these cores were taken to compliment that gravity core (Fig. 29). SBP120 profiles reveal undisturbed, but relatively thin (<5 m), postglacial sediment cover overlying an acoustically-homogenous, variable thickness unit interpreted to be a glacial till. This site was chosen to target these units on the back slope of the morainal bank in Orwell Trough.

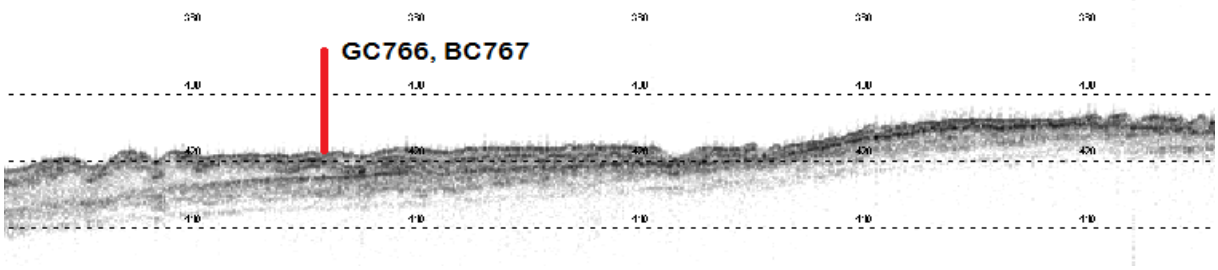

Figure 29: Section of SBP120 showing location of GC766/BC767.

Box corer sampled the exact location of GC766, as the penetration hole of the gravity corer was evident in the surface sediments. Box corer deployed well but drained and did not preserve sediment-water interface.

5.3.4 Bennett and Laurie troughs

Two box cores were collected from high sediment-accumulation sites in troughs to the north of the South Orkney islands to complement BC750 and BC763 recovered on the southern shelf for the associated CASS-139 project.

BC768: High resolution box core site (CASS-139)

Site BC768 was selected in Bennett Trough on account of the expanded sediment sequences indicative of high sediment accumulation rates (Fig. 30).

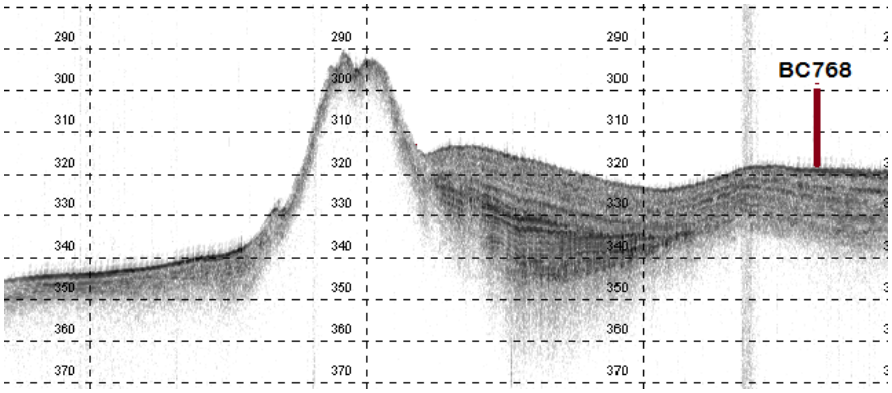

Figure 30: Section of SBP120 showing location of BC768.

The box corer deployed well, recovering 0.49 m of sediment with the sediment-water interface preserved. This site has since been referred to as the best box core ever!

BC769: High resolution box core site (CASS-139)

The site of BC769 was selected within Laurie Trough (Fig. 31). Expanded sediment units comparable to those within Bennett Trough were not identified within Laurie Trough, but the thickest sediments observed within the SBP were targeted.

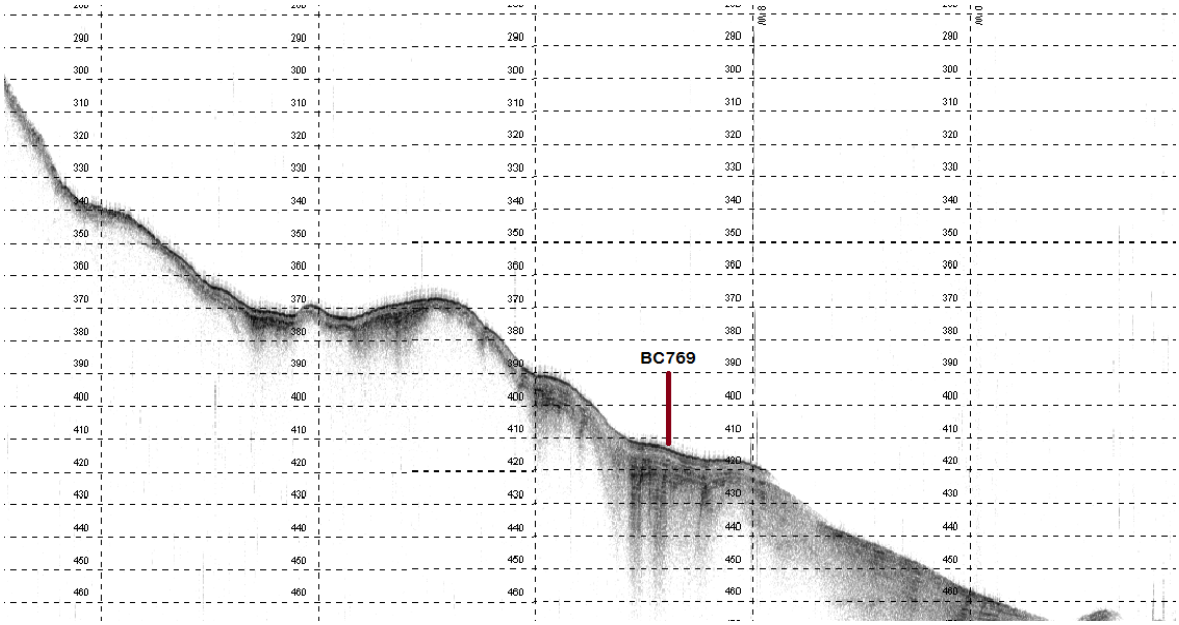

Figure 31: Section of SBP120 showing location of BC769.

The box core deployed well and recovered 0.32 m of diatom ooze with the sediment-water interface preserved.

5.3.5 Summary of CASS project work

Aims: The CASS project aims to assess the influence of a poleward shift in south westerly winds (SWW) on the regional water masses around the South Orkney Plateau (SOP). The SOP in the SW Atlantic straddles the South Scotia Ridge between the Scotia and Weddell Seas (Fig. 4). Located along the boundary between the ACC and the WG (Figure 4), the SOP is ideally placed to establish how changes in the position of the SWW impact on ocean conditions in the northern Weddell Sea region.

Methods: In order to characterize sediments influenced by the ACC and the WG and investigate potential changes in the positions of these water masses relative to the recent poleward migration and strengthening of the SWW, we recovered box cores from deep basins within four troughs on the SOP. This project will analyse two box cores recovered from the south of the South Orkney Islands in Signy Trough (BC750) and East-Signy Trough (BC763), and two from north of the islands in Bennett Trough (BC768) and Laurie Trough (BC769) (Figs. 14, 15). Sub-cores were recovered from the box corer using the methodology outlined in section 6.5. One sub-core from each site was subsampled at 10 mm intervals, in order to carry out diatom and foraminifera assemblage composition analysis on board. The remaining material from these subsamples will be used to determine diatom fluxes and foraminiferal stable isotope ratios post-cruise. The remaining subcores from each site were kept intact as archive samples and for post-cruise analysis. Post-cruise analysis will include ^{210}Pb and ^{14}C dating, measurements of terrigenous material/IRD composition, and magnetic susceptibility measurements.

During the cruise, samples from BC750 and BC768 were analysed for diatom and foraminiferal assemblage composition (Fig. 32). Diatom smear slides were made from each 10 mm interval subsample from 0-310 mm in BC750, and 0-410 mm in BC768. Counts of 300+ diatom valves were made every 80 mm down-core, to quantify the relative abundance of different species down-core. In order to assess foraminiferal assemblage changes in BC750 and BC768, ~15 ml of sediment was sieved at 63 µm every 40 mm down-core. Up to 300 individual foraminifera were picked from the dry >63 µm fraction and the species identified.

Results: Fragilariopsis curta and *Fragilariopsis cylindrus* are the dominant diatom species for all depths in both BC750 and BC768. An example of a diatom from BC768 is shown in Fig. 33.

Initial analysis of the foraminiferal assemblages shows that both cores BC750 and BC768 are dominated by calcareous species *Fursenkoina fusiformis.* Other calcareous specimens present include *Fursenkoina earlandii, Nonionella bradii, Globocassidulina crassa* and *Epistominella cf exigua*. *Milliamina spp*. is the dominant agglutinated species.

Figure 32: PhD student Zoe Roseby identifying foraminifera on board RRS Discovery during DY088.

Further post-cruise work will include an analysis of the foraminifera and diatom species assemblages within BC750 and BC768 at higher sampling resolutions, followed by interpretation of the changes in palaeo-environmental conditions on the SOP that these data represent.

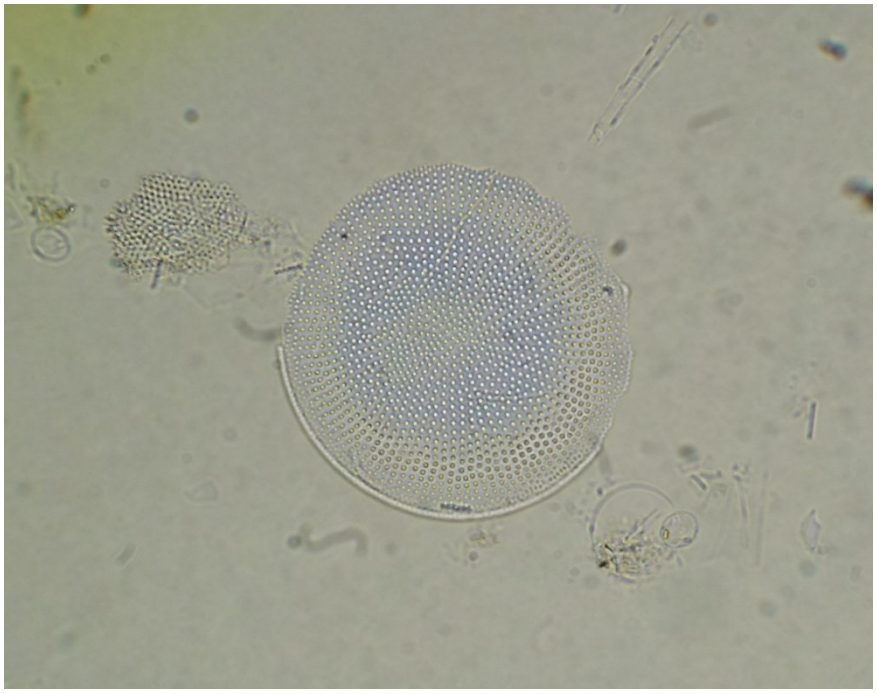

Figure 33: Light microscope image of a Thalassiosira lentiginosa *valve (x 1000). Taken from sample 240-250 mm, BC738.*

6. Equipment Reports and Performance

6.1 Rock dredging

The 'dredge system' consists of a steel chain basket approx. 0.4 x 1 m and 1.2 m deep. A steel bucket (pipe dredge; 0.3 m diameter x 0.7 m length) is attached to end of dredge. At the front of the dredge basket a heavy 3 m long chain is used as a 'weight' to ensure the dredge opening is in contact with the seabed (Fig. 34). It is standard practice to attach a pennant wire between the chain and ship's cable – this is solely to prevent the ship's winch cable coming into contact with the seabed. The pennant and dredge are deployed via an auxiliary deck winch via a second sheave mounted on stern gantry or the Sormec crane. The load is transferred to main trawl warp (and main sheave) on the stern gantry and deployed at 1.0 m/s.

The objective is to pull the dredge across the seabed using the ships winch, not relying on ships movement. This allows a more controlled operation and helps with the control of tension. There are 2 methods of dredging:

a) Lower dredge vertically to seabed. Manoeuvre vessel at 1 knot in desired direction whilst paying out warp slowly (0.2 – 0.3 m/s) to keep dredge static (tension reduced as dredge on seabed). Vessel stops at waypoint then dredge can be hauled slowly (0.2 m/s) until dredge is clear of bottom.
b) Dredge to be lowered whilst ship is travelling at slow speed. When USBL pinger is at desired height indicating dredge is on bottom continue with ship movement for desired distance

The dredge has a number of safety releases to assist overcoming obstacles on sea bed.

1) The steel towing arm has 2 bolts securing basket tow position. These 'part' and allow basket to ride over an obstacle
2) There is a 3T 'weak link' between pennant wire and basket. If this shears the dredge basket is 'strangled and basket is rotated 90 degrees and recovered on separate' tow wire' (Fig. 35).
3) There is also a 5T weak link which is there to protect the ship's cable. If the load reaches 5T at the seabed, the dredge and bucket are both released and lost (Fig. 35).

On DY088 the dredge apparatus was connected to a 400m pennant cable attached to an aft deck fitted winch. This was deployed using the *Sormec* crane (Fig. 36). Once 400m of wire was deployed the apparatus was connected to the main trawl warp winch on the stern gantry and lowered to the seabed using a veer rate of 1.0 m/s. Just prior to reaching the sea floor, the veer rate was slowed to 0.2m/s until contact was made, which was determined from the bathymetric depth reading and the change in wire tension recorded on the CLAM system. An additional 50-70m of cable was paid out once the dredge apparatus was on the sea floor and the ship then moved to the dredge end point at a speed of

1 knot, whilst continuing to pay out additional wire at a rate of 0.2 m/s. Once the ship had reached the end point of the dredge line, the cable was hauled on the winch system at a rate of 0.2m/s whilst closely observing the wire tension. If the wire tension exceeded 4.7T the CLAM system automatically rendered; stopped hauling and changed to veer mode to reduce the wire tension, before manually resuming hauling. Once it was certain that the dredge apparatus was clear of the sea floor, the haul rate was increased to 1.0 m/s until the main winch cable was recovered. The final 400m of hauling was then completed on the pennant wire using the aft deck winch.

The first dredge deployment was fitted with an acoustic pinger (USBL) attached 400 m along the dredge cable to monitor the dredge position relative to the seabed, but all later dredges were conducted without the USBL device following damage on the first deployment.

The dredge apparatus was fitted with 3 and 5 tonne weak links at the join between the dredge net support and the 3m chain, as well as the connection between the dredge net and the safety strop cable (Fig. 35).

Figure 34: The dredge net and pipe bucket and attachment of the weak links.

Figure 35: Detail of the attachment of the weak links which link to the 3m chain and the safety strop.

Figure 36: Initial deployment of the dredge apparatus from the aft deck using the Sormec crane and deck winch.

6.2 EM122 & EM710 Multibeam echosounders

Logging of multibeam (EM122) data was initiated at 1045 (UTC) on JD 068, south of the Falkland Islands. One of the multibeam echosounders was operated at virtually all times when the vessel was in motion, until logging was stopped at 2153 on JD 089, once again south of the Falkland Islands.

6.2.1 Standard settings

For the majority of the cruise, the multibeam echsounders were run independently of the other acoustic instruments on board, i.e. they were not synchronised with the SBP120 or EK60. Thus, the EM122 and EM710 calculated their ping-cycles based on depth alone; the EM122 and EM710 were run together only for a short time on JD 073 but did not show any significant interference (see **point 3.** below). The width of the swath was set to a level appropriate for the water depth and weather conditions. Under favourable conditions, beam angles were set as wide as 65°-70°, but were reduced if the outer beams became discordant or noisy; neither the EM122 nor EM710 had particular problems fixing the bottom. Minimum and maximum depths were set as appropriate for the regional bathymetry. Sound velocity profiles, derived from SVP (sound velocity probe) casts carried out on during DY088, were changed as necessary to be appropriate for the water structure of the survey area (see **section 5.2.2**, Table 1).

6.2.2 Problems encountered

Only minor problems were encountered with the multibeam echosounders during the cruise:

1. During survey dy088_a the warning colours for a mismatch in sound velocity (SV) between the "SV profile" and the "SV used" on the SIS *Numerical Display* were not functioning. These windows go yellow if the SV being used is more than three units away from the SV at the sensor, or red if the difference is more than five units. This meant that watch keepers had to keep checking these parameter windows during the early surveys on the cruise. No changes in the SIS display had any effect on this issue but the problem corrected itself after SIS (for the EM122) restarted. The problem is thought to be due to the order in which the SV sensor and SIS were initiated at the start of the cruise. This error did not occur on the EM710, presumably because the SV sensor had been initiated prior to SIS for the EM710.

2. The SIS display for the echo-sounders crashed a total of seven times (once for EM710; six times for EM122) during the cruise. A "crash" involved the SIS screen going white and an error saying that "SIS is not responding"; in one instance SIS appeared to continue working but none of the menus could be accessed by the mouse indicating that the SIS software was at least partially "frozen". These crashes were most often solved by restarting the computer as well as the SIS software although occasionally a SIS software restart was sufficient; about half the times a second computer/SIS restart was necessary before SIS functioned again. Watch keepers did not consistently press "Line Count" on SIS after

restarts resulting in some surveys having more than one file with the same number (e.g. on dy088_e there are three files starting "0056_"; however, each of these files has a different timestamp associated with it so are easily identified as unique files in the survey).

3. At the start of survey dy088_c on the SOP (JD 073), an attempt was made to synchronise the EM710, SBP120 and EM122 through the K-Sync unit in order to remove persistent noise interference (diffraction smiles every 4-5 pings) in the EM710 data. This was unsuccessful but proved unnecessary once the bridge switched off their echo-sounders, which operating at 50 and 100 kHz, were interfering badly with the EM710 (frequencies 70-100 kHZ).

4. At 00:24 on JD081 a red error on the EM122 time (PU ZDA) display occurred (line 0066). This error was due to an issue with the PosMV GPS feed to the EM122 which showed both position and velocity errors. The EM122 was temporarily switched to the Seapath 330 GPS for navigational input whilst a reboot of the PosMV system was completed, including a 30-minute settling period for the PosMV system once it had restarted. At 01:54 navigation for the EM122 was switched back to the PosMV system; lines acquired using Seapath 330 navigation are 0066-0069 (dy088_e).

6.3 SBP120 sub-bottom profiler

Logging was started at 1315 (UTC) on JD 068, and used near-continuously during the cruise until 1604 on JD089 in the NW Scotia Sea on passage back to Punta Arenas.

6.3.1 Standard settings

Typical parameter settings on the control workstation are listed in Appendix A10. The SBP120 trigger was set to internal with the ping interval being 4000-6000 ms. In deeper water (> 700 m; i.e. when the EM122 was used) the SBP120 bottom tracker was set to follow the EM122 depth so that the delay changed automatically with the depth reading from the multibeam echo-sounder. This is a clear advantage over the system on the JCR whereby the watchkeeper has to manually change the delay window as the depth changes. Unfortunately, this option is not connected for the EM710 echo-sounder. In shelf areas (<700 m) a lower ping interval was tested out, to increase the ping frequency (and so the resolution of the incoming data). However, this resulted in an unmanageably large volume of data being recorded and reduction of the data being necessary to identify glacial landforms and the ping interval was increased again to ~4000 ms. The SBP120 system was operated almost entirely using a chirp (chirp linear down) source throughout the cruise, with a source power around -30 dB. A burst source was tried for only a few minutes during deep water transit to see if this would improve the received signal. A matched filter correction, gain correction and attribute processing were applied during acquisition.

6.3.2 Problems encountered

The SBP120 is a different sub-bottom profiler than is used on the JCR, which has a TOPAS parametric echo-sounder, however the principles of the two systems are similar and the penetration and quality of the sub-bottom profiles was expected to be similar. Noise levels increased significantly when the ship's thrusters were in use and when other low frequency echo-sounders were used (e.g. EK60, EM122). The use of a chirp transmission pulse and matched filter to correlate the signal, which were used almost exclusively during DY088, is thought to suppress the lowest frequency noise (~100 Hz) as it does for the TOPAS echo-sounder. Several minor problems were encountered on the cruise:

1. Two types of noise were observed to interfere with the SBP120 receive signal. First, after being stopped on station when the ship's thrusters were used for positioning the low frequency of the thrusters severely impacted the signal received on the SBP120. This interference, which led to an almost continuous grey screen on the SBP120 with no visible bottom detected, continued even after the ship had moved off and the thrusters were no longer in use. This situation was resolved by restarting the power unit to the SBP120

2. On JD081 the timestamps on the SBP120 malfunctioned with time seemingly jumping forwards and backwards randomly. This issue has affected the .RAW and .SEGY files for that time which use the timestamp as their filenames and, therefore, do not run sequentially from around 00:20 to 01:54 on JD081. There was a simultaneous red error on the EM122 time (PU ZDA) display. These issues stemmed from a problem with the PosMV GPS navigation input which showed both position and velocity errors. A shut-down and restart of the PosMV followed by a settling period of 30 minutes resolved the issue; SBP120 data remained on dead reckoning navigation (from PosMV) with a positional accuracy of ~10 m during this reboot.

3. There was no hardcopy (printer) output from the SBP120 during DY088. (This could have been provided by NMF if the correct box had been ticked on the SME form.) As a result, watch keepers took screengrabs from the SBP120 during survey dy088_c when we were surveying for core sites; these images were saved as .PNG files and named with the timestamp at the time they were taken.

6.4 Gravity coring

Once the gravity core (Fig. 37) was secure on the framework and horizontal, the core barrels were detached from the bomb and transferred to the trestles for the liner to be removed. The cutter nose and core catcher were extracted from the base of the liner and retained for sampling. The excess (empty) core liner was cut off using the rotary cutter to avoid a gap between the base of the sediments and end cap. The core liner was then pulled out of the barrel and cut incrementally into 1 m sections. As each 1 m section was cut, a smear slide sample was taken from the base before the end caps were

fitted. Cut sections were then transferred to the hangar where they were cleaned, securely taped at both ends and labelled ready for storage in the +4˚C cool store.

6.4.1 Magnetic Susceptibility and core lengths

Magnetic Susceptibility readings were completed for all gravity core sections using a Bartington Instruments® 125 mm loop sensor. Readings were taken at 2cm intervals down each core. The lengths of the cores were measured from the rule on the magnetic susceptibility stand. Cumulative depths were then calculated and labelled on subsequent sections.

6.4.2 Recommendations for future cruises

- Consider investing in: either paint pens, underwater pens, a large-format label-writer, or plasticized printer labels for core labelling.
- Grease/lubricant cleaner for maintaining tools (especially rotary/pipe cutter)
- Designated box core camera
- Remove redundant stationery (eg. Calculators, CD roms, etc.)
- Repair and remodel magnetic susceptibility track for larger/heavier cores.
- Make larger diameter, individual core holders (12-20?)

Figure 37: Initial deployment of the gravity core using the starboard crane.

6.5 Box coring (Fig. 38)

Sub-core liner pushed into sediment prior to draining of the box-corer to preserve the sediment-water interface (Fig. 39). End caps added to the top of the liner to avoid contamination. Water was drained from the box core, photos of the sediment surface were taken and the depth of sediment recovered was measured. A plastic scoop was used to collect surface sediment samples (0-2 cm). Surface samples were stored in plastic sample bags in the +4˚C. The detachable side of the box-corer was removed. A photo and measurement of the side wall was taken. The sub-cores were dug out of the sediment and end caps placed on the base of the core. Sub-cores were washed down, the base end cap taped and the liner and top cap labelled. Sub-cores were kept vertical throughout the sampling process to minimise disturbance then secured in an upright position in the -20˚C freezer until frozen.

Once frozen, sub-core liners were cut to ~5 mm above the sediment surface and stored in +4˚C.

A sub-core from each of the high-resolution box core sites (BC750, BC763, BC768 and BC769) were sliced at 10 mm intervals with a drop/circular saw while frozen. The circular disks of frozen sediment (7.5 mm thick) were pushed out of the plastic liner and plastic 'swarf' was removed before samples were stored in individual plastic sample bags in the +4˚C cool store.

Figure 38: Recovery of the box corer onto the starboard deck.

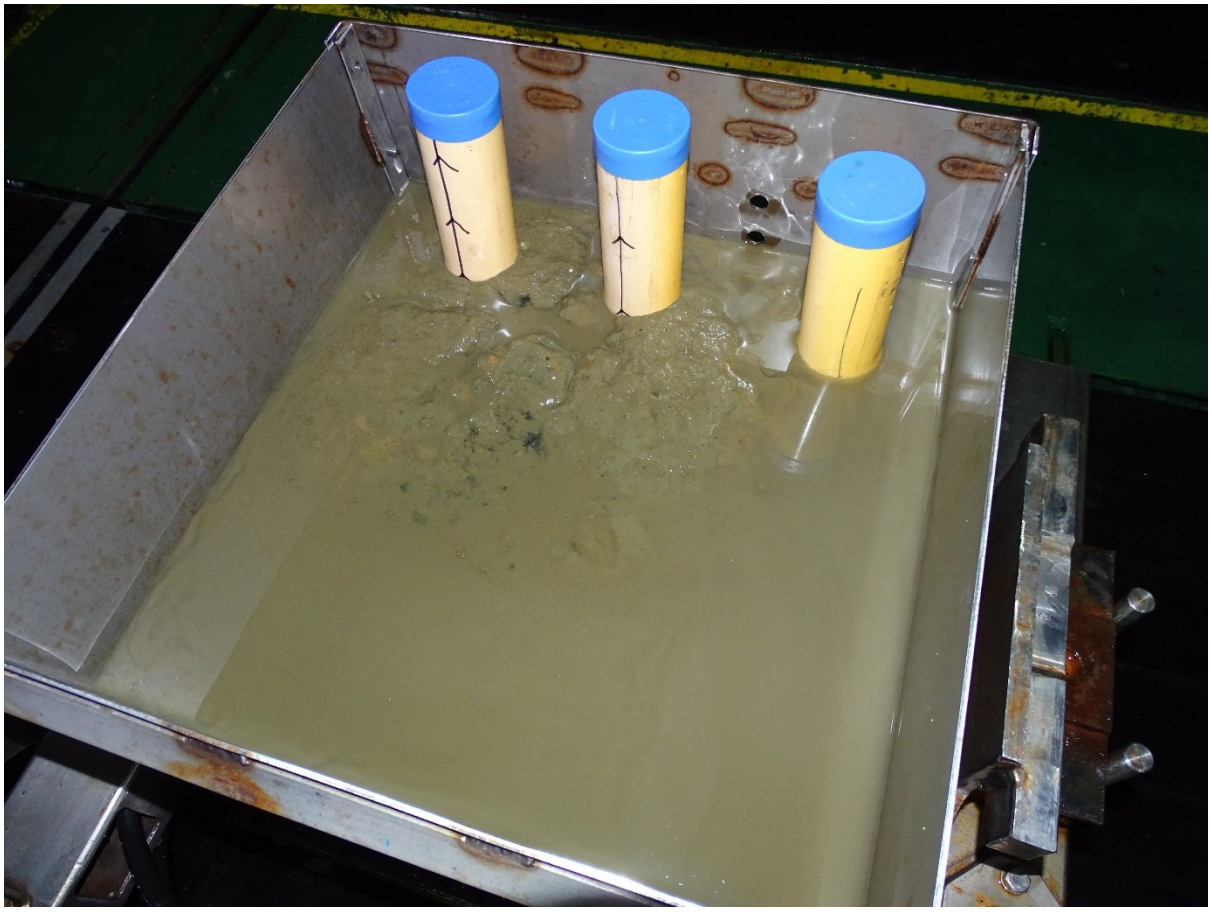

Figure 39: Taking sub cores of the box core. Shown after seawater drainage. BC.750.

6.6 Ultra-short base line 'pinger' (USBL)

The Ultra-Short Base Line acoustic positioning system was only used during the early phase of the cruise; the deployment of the first dredge (DR.220) and first gravity core (GC.745). Beacon S/N:303272-005 (Type. 8270 WSM6, 4000m rated) was attached to the cable on dredge DR.220 (water depth approximately 2300m) but was damaged during the deployment and did not provide a useable position. At the first core site beacon S/N:290249-002 (Type. 8190, WMT 7000m rated) was attached to the corer and deployed. The logged beacon position was satisfactorily close to that of the vessel, and it was decided to not use the system for future coring or dredging operations.

6.7 Cable Logging and Monitoring (CLAM) system

The CLAM system was used for monitoring the amount of wire out, hauling and veering rates and wire tension during gravity corer, box corer, dredge and SVP deployments. The system uses a depth reading from the EA640 single-beam echosounder (operating frequency of 10 kHz during DY088) and performed well throughout the cruise.

6.8 Sound Velocity Probe (SVP)

Sound velocity profiles were taken with the MIDAS Valeport SVP (SN:41603). The probe was deployed from the starboard deck using the starboard crane. The SVP accurately measures temperature (to ±0.01°C accuracy) and pressure (depth; to ±0.01% accuracy) concurrently and calculates a sound-velocity profile (accuracy 0.02 m/s) from these data. The SVP setup, data extraction and display was performed in MIDAS DataLogger Express PC-based software. Sound-velocity profiles were then applied to the EM122 and/or EM710 systems shortly after acquisition.

The SVP was deployed to varying depths during DY088, ranging from full ocean depth to 600-900 m, and performed well during the cruise (Appendix 4).

6.9 Towed magnetometer

The Marine Magnetics SeaSPY (MK1) magnetometer was used during longer survey/passage components of the cruise. The two instruments used were S/N:13428 and 13357. Marine Magnetics BOB Magnetometer Software (Version 2.5.0.0) was used for the acquisition and logging. A serial GPS input was used from the Applanix POSMV (via the ships serial splitter) to provide the system with navigation information (GGA and RMS NMEA183 messages).

A layback of 300m was calculated as the distance between the deployed instrument and the GPS system central reference point. This equated to 280m of deployed cable and the remaining distances were calculated from the ships Survey Report (based on GPS reference point and the position of the electric winch).

The BOB acquisition software was set up to apply this layback to the survey database for all Magnetometer survey operations. However on inspection of the exported files there is an issue where sections of data the layback has not been applied. This is discussed in the NMF IT report.

6.10 Shipboard gravimeter

The gravity meter (S-084) was operational during the entire DY088 cruise - running directly from the vessel's 110V AC supply available in the 'Gravity room'. The unit was configured to use Control Module 2 (CM2) and Power Module 1 (PM1). At the conclusion of the previous cruise, DY087, the gravity meter was tied in at CLPUQ (Punta Arenas). This acts as a pre-cruise tie in for DY088 as power was maintained to the instrument. Post-cruise tie in was also completed on return to Punta Arenas.

The instrument has an NMEA183 GPS RMC input from the Seapath330 system to provide position, course and speed information. Lacoste & Romberg Model G land gravity meter serial number G-167 was used for the CLPUQ tie-ins.

6.11 Navigation systems

6.11.1 Applanix PosMV

This combined GPS and motion reference unit is the primary scientific GPS on RRS *Discovery* and provides navigational data for the Kongsberg EM122, EM710 and SBP120 echosounders. Position fixes, attitude and velocity data from this unit were logged on to the Kongsberg multibeam echosounders, the SBP120, and on the Techsas system. Differential corrections are obtained from te C-Nav 3050 GPS, and applied in real-time to the PosMV data.

The Applanix PosMV system had an error (position and velocity) at 0020 on JD081 and had to be restarted, including a 30-minute settling period. The EM122 echosounder was temporarily switched to take position information from the Seapath 330 until 0155 on JD081. The cause of this failure has not been determined.

6.11.2 Kongsberg Seapath 330

The Kongsberg Seapath 300 system is the vessel's secondary GPS system; position fixes and attitude data are logged to the Techsas system. The Seapath 330 is input to the gravimeter because the PosMV does not have vessel course available in its RMC NMEA string. Position, attitude and velocity data from the Seapath 330 were temporarily used as inputs to the EM122 echosounder during a failure of the Applanix PosMV on JD081 (see 6.11.1). On the RRS *Discovery* differential corrections (RTCM DGPS) to the Seapath 330 data are obtained from a Fugro Seastar 9205 GPS system, however the input service from this system was not working during DY088 and differential corrections were not applied to the Seapath 330 data.

6.11.3 C-Nav 3050

The CNav 3050 GPS system is a differential correction service. It provides the Applanix PosMV system with RTCM DGPS corrections (greater than 1m accuracy). The position fixes data are logged to the Techsas system.

6.12 Scientific computing systems

On the RRS Discovery scientific data is logged by the Techsas 5.11 data acquisition system. Data was recorded in both NetCDF and ASCII (comma-delimited) formats on a central "read-only" drive on the on-board fileserver. The NMF 'RVDAS/Level-B' raw data logger also records raw data streams as a backup/QC option to the primary Techsas logger. These data are recorded as raw ASCII files. Data was additionally logged into the legacy RVS Level-C format. ASCII dumps of all the Level-C streams recorded are stored on the data disk; full details of the pathnames to these data files and the format of the data are provided in Appendix A10 (NMF ship's system report).

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Appendices

A1. List of Personnel

A2. Science event log

A3. Dredging (a: Site information and dredge log sheets; b: Summary table; c: sample descriptions)

A4. Sound velocity probe table

A5. Coring station table

A6. Smear slide list

A7. Typical Sonar System Parameter Settings (EM122, EM710, SBP120)

A8. Magnetometer timesheet

A9. Mulitbeam data editing

A10. NMF ship's systems report

A11. NMF technical support summary

A12. Box core photographs

Appendix A1: Ship's Personnel

Officers and crew for DY088

GATTI Antonio	Master
MACKAY Stewart	Chief Officer
OVENDEN Robert J	2nd Officer
LEGGETT Colin J	3rd Officer
BROOKS Felix RA	ETO
BILLS James	Chief Engineer
KEMP Christopher M	2nd Engineer
MURREN, Michael G	3rd Engineer
EVANS Daniel C	3rd Engineer
HORNE Scott MJ	Cadet
ROONEY Sean RH	Cadet
WATTERSON Ian C	Purser
McLENNAN William	CPOD
MACDONALD John	CPOS
SPENCER Robert G	POD
HOPLEY John M	SG1A
BURTON Brian J	SG1A
LEIGHTON Stephen J	SG1A
GOUGH John	SG1A
WILLIAMS Emlyn G	ERPO
ASHFIELD Mark J	Head Chef
WHALEN Amy K	Chef
PIPER Carl	Steward

Scientific party and support

RILEY, Teal R.	BAS Scientist (PSO)
ALLEN Claire S	BAS Scientist
BURTON-JOHNSON, Alex	BAS Scientist
CHADWICK Matthew	CASS Scientist
HOGAN Kelly A	BAS Scientist
LEAT Philip T	CASS Scientist
PECK Victoria L	BAS Scientist

ROSEBY Zoë A	CASS Scientist
SCOTT Jason E	NMF STO
MOORE Andrew S	NMF SST
COMBEN Daniel H	NMF Tech
PORTER Michael K	NMF Tech
SCOTT Jason E	NMF Tech
SHAH Hatim	NMF Tech
SMITH Matthew J	NMF Tech

Appendix A2: Event Log (DY088)

Event Number	Date	Time (UTC)	Julien Date	Latitude (S)	Longitude (W)	Water depth (m)	Instrument deployed (GC, PC, BC, DR, XBT, SVP, EM122/710, Topas) and station number (e.g. DR.220)	Time at deploy-ment	Time at seafloor contact	Duration on sea floor	Time off sea floor	Recovery latitude (S)	Recovery logitude (W)	Recovery water depth (m)	Maximum wire tension during deployment (tonnes)	Dredge distance horizontal (nm)	Dredge distance vertical (m)	Event notes/observations
DY088 - 001	09/03/18	10:45	18068	54.743	61.705	891	EM122	10:45										dy088-a, survey start
DY088 - 002	09/03/18	12:05	18068	54.86	61.4	1787	EM710	12:05										EM710 stopped pinging and logging
DY088 - 003	09/03/18	16:20	18068	57.17	54.89	4451	SVP01	16:20			20:20	57.17	54.89					Deploy SVP
DY088 - 004	09/03/18	16:24	18068	57.17	54.89	4451	EM122											Stopped logging
DY088 - 005	09/03/18	20:33	18068	57.17	54.89	4429	EM122	20:33										Restart logging
DY088 - 006	12/03/18	04:41	18071	59.71	46.02	3563	EM122											dy088-b, new survey start
DY088 - 007	12/03/18	11:01	18071	59.513	44.454	2300	Magnetometer											Pulled in Magnetometer for SVP deployment
DY088 - 008	12/03/18	11:14	18071	59.502	44.451	2114	SVP02	11:22			11:44	59.5	44.45					Deploy SVP, stop EM122 logging
DY088 - 009	12/03/18	12:13	18071	59.502	44.448	2117	EM122	12:13										Restart logging
DY088 - 010	12/03/18	15:16	18071	59.498	44.441	2068	Magnetometer	12:16										Deploy Magnetometer
DY088 - 011	12/03/18	15:25	18071	59.444	44.402	1806	EM122											Stopped logging
DY088 - 012	12/03/18	16:00	18071	59.508	44.286	1763	Magnetometer					59.508	44.286					Magnetometer back on deck
DY088 - 013	12/03/18	16:33	18071	59.508	44.284	2294	DR220		17:47	03:17	21:04	59.495	44.302	1868	3.7	0.9	440	Dredge 220

DY088 - 014	12/03/18	23:17	18071	59.446	44.467	1737	EM122										Restart logging
DY088 - 015	13/03/18	01:56	18072	59.685	44.825	2541	DR221	02:14	03:27	01:09	04:36	59.681	44.834	2295	2.99	0.42	230 Stopped logging of EM122
DY088 - 016	13/03/18	06:53	18072	59.681	44.834	2302	SVP03	06:53			07:10 (6(	59.681	44.834	2276			Deploy SVP to 600m depth
DY088 - 017	13/03/18	08:08	18072	59.668	44.864	2147	SBP120										Restart logging SBP120
DY088 - 018	13/03/18	08:24	18072	59.665	44.885	2685	EM122										Restart logging, line 028
DY088 - 019	13/03/18	13:44	18072	59.818	45.437	3036	EM122										Stopped logging
DY088 - 020	13/03/18	15:25	18072	59.912	45.651	3995	EM122										Restart logging
DY088 - 021	13/03/18	17:59	18072	60.245	46.126	2457	EM122										dy088-c, new survey
DY088 - 022	13/03/18	19:00	18072	60.341	46.365	2489	EM122										Reboot SIS on dy088-d
DY088 - 023	13/03/18	19:15	18072	60.359	46.421	2082	EM710										Start survey dy088-d
DY088 - 024	14/03/18	01:41	18073	60.857	45.577	370	SVP04										Stopped logging EM710 and EM122, SVP deployed
DY088 - 025	14/03/18	03:04	18073	60.856	45.561	370	EM710										Restart logging
DY088 - 026	14/03/18	03:22	18073	60.905	45.539	378	Magnetometer										Magnetometer deployed
DY088 - 026	14/03/18	16:46	18073	61.261	45.552	400	Magnetometer										Magnetometer back on deck
DY088 - 027	14/03/18	17:00	18073	61.435	45.919	387	SVP05										
DY088 - 028	14/03/18	17:21	18073	61.435	45.919	387	BC739	17:21	17:39	00:03	17:42	61.436	45.919	390	0.89		Box core deployed

DY088 - 029	14/03/18	17:23	18073	61.435	45.919	387	EM710									Stopped logging
DY088 - 030	14/03/18	18:26	18073	61.435	45.919	387	EM710									Restart logging with updated SVP
DY088 - 031	14/03/18	19:55	18073	61.541	46.159	340	EM710									Stopped logging
DY088 - 032	14/03/18	20:10	18073	61.539	46.146	344	BC740	20:10	20:23	00:12	20:35	61.539	46.146	344	0.8	Box core deployed
DY088 - 033	14/03/18	20:49	18073	61.539	46.146	344	GC741	21:02	21:13	00:02	21:15	61.539	46.146	360	1.91	Gravity core deployed (barrel issues)
DY088 - 034	14/03/18	23:55	18074	61.538	46.146	344	EM710									Restart logging
DY088 - 035	15/03/18	00:57	18074	61.695	46.387	431	EM710									Stopped logging
DY088 - 036	15/03/18	03:19	18074	61.694	46.388	430	GC742	04:14	04:27	00:04	04:31	61.694	46.389	430	4	Gravity core deployed
DY088 - 037	15/03/18	05:33	18074	61.694	46.389	430	BC743	05:33	05:48	00:03	05:51	61.694	46.389	430	0.75	Box core deployed
DY088 - 038	15/03/18	07:09	18074	61.694	46.388	432	SVP06									SVP deployed
DY088 - 039	15/03/18	07:27	18074	61.701	46.381	432	EM710									Restart logging
DY088 - 040	15/03/18	13:33	18074	61.065	45.737	318	EM710									Stopped logging
DY088 - 041	15/03/18	13:47	18074	61.065	45.739	320	BC744 (did not fire)	13:47	13:58	00:02	14:00	61.065	45.74	319	0.83	Box core deployed (did not fire)
DY088 - 042	15/03/18	14:25	18074	61.066	45.737	317	BC744	14:25	14:32	00:03	14:35	61.066	45.737	317	1.5	Box core deployed
DY088 - 043	15/03/18	15:00	18074	61.066	45.737	318	GC745	15:00	15:14	00:03	15:17	61.066	45.737	317	3.11	Gravity core deployed
DY088 - 044	15/03/18	15:51	18074	61.639	45.728	318	EM710									Restart logging
DY088 - 045	15/03/18	16:24	18074	61.021	45.683	315	EM710									Stopped logging

DY088 - 046	15/03/18	16:26	18074	61.02	45.684	314	GC746	16:44	17:00	00:02	17:02	61.02	45.684	314	2.02	Gravity core deployed
DY088 - 047	15/03/18	17:37	18074	61.02	45.683	314	BC747	17:37	17:52	00:03	17:55	61.02	45.683	314	1	Box core deployed
DY088 - 048	15/03/18	18:44	18074	61.026	45.675	315	EM710									Reboot EM710 and start logging
DY088 - 049	15/03/18	19:42	18074	60.961	45.574	315	EM710									Stopped logging
DY088 - 050	15/03/18	19:48	18074	60.961	45.575	314	BC748	19:48	20:01	00:03	20:04	60.961	45.575	315	0.7	Box core deployed
DY088 - 051	15/03/18	20:27	18074	60.961	45.575	314	GC749	20:27	20:38	00:04	20:41	60.961	45.575	315	2.01	Gravity core deployed
DY088 - 052	15/03/18	21:26	18074	60.965	45.568	313	EM710									Restart logging
DY088 - 053	15/03/18	22:21	18074	60.873	45.535	374	EM710									Stopped logging
DY088 - 054	15/03/18	22:27	18074	60.873	45.535	374	BC750	22:27	22:38	00:02	22:40	60.873	45.535	374	1	Box core deployed
DY088 - 055	15/03/18	23:29	18074	60.889	45.545	362	EM710									Restart logging
DY088 - 056	16/03/18	11:24	18075	61.191	45.691	326	EM710									Stopped logging
DY088 - 057	16/03/18	11:41	18075	61.192	45.692	327	BC751	11:41	11:55	00:02	11:57	61.192	45.691	327	0.86	Box core deployed (did not fire)
DY088 - 058	16/03/18	12:18	18075	61.192	45.691	327	BC751	12:18	12:31	00:03	12:34	61.192	45.691	327	0.89	Box core deployed
DY088 - 059	16/03/18	13:03	18075	61.192	45.691	327	GC752	13:03	13:17	00:02	13:19	61.192	45.691	326	1.81	Gravity core deployed
DY088 - 060	16/03/18	13:50	18075	61.192	45.692	326	EM710									Restart logging
DY088 - 061	16/03/18	14:47	18075	61.23	45.677	296	EM710									Stopped logging
DY088 - 062	16/03/18	15:09	18075	61.23	45.681	297	GC753	15:09	15:27	00:02	15:29	61.23	45.681	297	2.96	Gravity core deployed

DY088 - 063	16/03/18	16:14	18075	61.23	45.681	297	BC754	16:14	16:27	00:01	16:28	61.23	45.681	297	0.74	Box core deployed
DY088 - 064	16/03/18	17:15	18075	61.233	45.636	304	EM710									Restart logging
DY088 - 065	16/03/18	20:24	18075	61.346	45.84	354	EM710									Stopped logging
DY088 - 066	16/03/18	20:52	18075	61.346	45.85	353	BC755	20:52	21:02	00:01	21:03	61.346	45.85	353	1.09	Box core deployed
DY088 - 067	16/03/18	21:21	18075	61.346	45.85	353	GC756	21:21	21:43	00:04	21:47	61.346	45.85	353	3.07	Gravity core deployed
DY088 - 068	16/03/18	22:22	18075	61.347	45.823	346	EM710									Restart logging
DY088 - 069	17/03/18	05:38	18076	61.539	46.146	344	EM710									Stopped logging
DY088 - 070	17/03/18	05:45	18076	61.539	46.146	344	GC757	05:55	06:06	00:03	06:09	61.531	46.146	343	2.76	Gravity core deployed
DY088 - 071	17/03/18	07:06	18076	61.525	46.178	346	EM710									Restart logging
DY088 - 072	17/03/18	08:45	18076	61.435	45.919	387	EM710									Stopped logging
DY088 - 073	17/03/18	09:20	18076	61.435	45.919	389	BC758	09:20	09:35	00:04	09:39	61.435	45.919	389	1.11	Box core deployed
DY088 - 074	17/03/18	10:29	18076	61.435	45.919	389	BC759	10:29	10:40	00:03	10:43	61.435	45.919	389	0.83	Box core deployed (did not fire)
DY088 - 075	17/03/18	11:20	18076	61.435	45.919	388	Magnetometer									Magnetometer deployed
DY088 - 076	17/03/18	11:27	18076	61.421	45.96	387	EM710									Restart logging
DY088 - 077	17/03/18	15:26	18076	61.371	45.296	287	EM710									SIS crashed, stop logging
DY088 - 078	17/03/18	15:35	18076	61.375	45.271	290	EM710									Restart logging
DY088 - 079	17/03/18	22:53	18076	61.349	45.416	281	EM710									Stopped logging

DY088 - 080	17/03/18	23:05	18076	61.339	45.41	279	Magnetometer									Magnetometer back on deck
DY088 - 081	17/03/18	23:45	18076	61.352	45.385	276	BC760 (1)	23:45	23:57	00:03	00:00	61.352	45.386	276	0.72	Box core - did not fire
DY088 - 082	18/03/18	00:28	18077	61.352	45.386	277	BC760 (2)	00:28	00:40			61.352	45.386	277	0.69	Box core - did not fire
DY088 - 083	18/03/18	01:03	18077	61.352	45.386	276	GC761	01:03	01:14	00:02	01:16	61.352	45.386	276	2	Gravity core
DY088 - 084	18/03/18	02:08	18077	61.353	45.385	273	BC760 (3)	02:08	02:20	00:03	02:23	61.353	44.35	273	0.72	Box core
DY088 - 085	18/03/18	03:14	18077	61.359	45.415	278	EM710									Restart logging
DY088 - 086	18/03/18	04:10	18077	61.389	45.297	292	EM710									Stopped logging
DY088 - 087	18/03/18	04:16	18077	61.389	45.297	292	GC762									Gravity core
DY088 - 088	18/03/18	05:09	18077	61.389	45.297	292	BC763									Box core
DY088 - 089	18/03/18	06:00	18077	61.389	45.297	292	EM710									Restart logging
DY088 - 090	18/03/18	07:05	18077	61.438	45.12	242	EM710									Stopped logging
DY088 - 091	18/03/18	07:15	18077	61.438	45.12	242	GC764									Gravity core
DY088 - 092	18/03/18	08:06	18077	61.438	45.12	242	EM710									Restart logging
DY088 - 093	18/03/18	17:06	18077	61.317	44.615	292	EM710									Stopped logging
DY088 - 094	18/03/18	17:33	18077	61.314	44.619	295	GC765	17:33	17:45	00:02	17:47	61.314	44.619	295	2.06	Gravity core
DY088 - 095	18/03/18	18:38	18077	61.313	44.595	294	EM710									Restart logging
DY088 - 096	18/03/18	19:04	18077	61.281	44.651	310	EM710									Stopped logging

DY088 - 097	18/03/18	19:18	18077	61.284	44.658	308	GC766	19:18	19:31	00:01	19:32	61.284	44.658	308	3.13	Gravity core
DY088 - 098	18/03/18	19:55	18077	61.284	44.658	308	BC767	19:55	20:06	00:01	20:07	61.284	44.658	308	0.73	Box core
DY088 - 099	18/03/18	20:38	18077	61.279	44.654	312	EM710	20:38								Restart logging
DY088 - 100	19/03/18	06:41	18078				EM710									EM710 crash
DY088 - 101	19/03/18	07:00	18078	60.931	45.009	241	EM710									Restart logging
DY088 - 102	19/03/18	09:06	18078	60.836	44.883	210	Magnetometer									Magnetometer recovered
DY088 - 103	19/03/18	12:53	18078	60.539	45.13	313	EM710									Stopped logging
DY088 - 104	19/03/18	13:05	18078	60.539	45.131	313	BC768	13:05	13:19	00:01	13:20	60.539	45.131	313	1.36	Box core
DY088 - 105	19/03/18	13:48	18078	60.54	45.123	312	EM710									Restart logging
DY088 - 106	19/03/18	16:45	18078	60.589	44.684	405	EM710									Stopped logging
DY088 - 107	19/03/18	16:47	18078	60.59	44.684	405	BC769	16:47	17:02	00:01	17:03	60.59	44.684	405	1.08	Box core
DY088 - 108	19/03/18	17:31	18078	60.589	44.677	400	Magnetometer	17:32								Magnetometer deployed
DY088 - 109	19/03/18	17:34	18078	60.588	44.667	402	EM710									Restart logging
DY088 - 110	19/03/18	18:44	18078	60.56	44.288	1114	EM122	18:44								Start logging EM122, dyo88_d
DY088 - 111	19/03/18	18:52	18078	60.56	44.239	1183	EM710	18:52								Stopped logging
DY088 - 112	20/03/18	03:30	18079	60.581	41.551	2214	Magnetometer									Recovered Magnetometer
DY088 - 113	20/03/18	03:42	18079	60.581	41.566	2218	SVP07	03:42	04:22			60.581	41.546	2218		Stopped logging

DY088 - 114	20/03/18	05:26	18079				EM122										dy088_e2, new survey
DY088 - 115	20/03/18	05:30	18079				EM122										Resume logging with new SVP
DY088 - 116	20/03/18	07:01	18079	60.574	41.154	885	Magnetometer	07:01									Deploy Magnetometer
DY088 - 117	20/03/18	10:49	18079	60.554	40.913	1023	Magnetometer										Recovered Magnetometer
DY088 - 118	20/03/18	11:06	18079	60.551	40.887	1234	EM122										Stopped logging
DY088 - 119	20/03/18	11:10	18079	60.545	40.885	1061	EM122										Restart logging
DY088 - 120	20/03/18	11:11	18079	60.539	40.884	936	EM122										Stopped logging
DY088 - 121	20/03/18	11:33	18079	60.54	40.885	945	DR223	11:46	12:09	00:44	12:53	60.536	40.888	726	1.77	0.25	216 Dredge deployed
DY088 - 122	20/03/18	14:10	18079	60.54	40.885	919	EM122										Restart logging
DY088 - 123	20/03/18	17:57	18079	60.432	40.17	982	EM122										Stopped logging
DY088 - 124	20/03/18	18:06	18079	60.439	40.159	1054	DR224	18:20	19:01	00:34	19:35	60.428	40.159	939	2.04	0.34	115 Dredge deployed
DY088 - 125	20/03/18	20:22	18079	60.428	40.159	983	EM122										Restart logging
DY088 - 126	21/03/18	13:49	18080	59.787	40.092	710	EM122										Crashed
DY088 - 127	21/03/18	13:53	18080				EM122										Restart logging
DY088 - 128	21/03/18	14:02	18080	59.917	39.166	1400	EM122										Crashed
DY088 - 129	21/03/18	14:08	18080	59.923	39.156	1160	EM122										Restart logging
DY088 - 130	21/03/18	14:46	18080	59.939	39.131	807	EM122										Stop logging

DY088 - 131	21/03/18	14:47	18080	59.929	39.149	942	EM122										Restart logging
DY088 - 132	21/03/18	15:02	18080	59.926	39.152	1010	EM122										Stopped logging
DY088 - 133	21/03/18	15:22	18080	59.927	39.154	949	DR225	15:22	15:51	00:59	16:50	59.929	39.16	730	2.71	0.4	219 Dredge deployed
DY088 - 134	21/03/18	17:45	18080	59.929	39.16	734	SVP08	17:45	18:02		18:02	59.929	39.16	680	0.97		SVP deployed
DY088 - 135	21/03/18	18:31	18080	59.931	39.16	790	EM122										Restart logging
DY088 - 136	21/03/18	20:51	18080	60.192	39.018	1879	EM122										Stopped logging
DY088 - 137	21/03/18	20:58	18080	60.192	39.018	1880	DR226	21:13	21:53	00:41	22:34	60.192	39.022	1807	2.15	0.15	105 Dredge deployed
DY088 - 138	22/03/18	00:08	18081	60.175	39.131	1334	EM122										Restart logging
DY088 - 139	22/03/18	01:50	18081	60.111	39.427	1640	EM122										Stopped logging
DY088 - 140	22/03/18	03:23	18081	60.142	39.294	1653	GC770	03:23	03:55	00:02	03:57	60.142	39.294	1649	3.46		Gravity core
DY088 - 141	22/03/18	05:23	18081	60.151	39.4	1683	EM122										Restart logging
DY088 - 142	22/03/18	07:20	18081	60.37	39.382	1713	EM122										Stopped logging
DY088 - 143	22/03/18	07:33	18081	60.366	39.396	1234	DR227	07:52	08:31	00:38	09:09	60.364	39.398	1092	2.13	0.16	140 Dredge deployed
DY088 - 144	22/03/18	10:01	18081	60.368	39.392	1491	EM122										Restart logging
DY088 - 145	22/03/18	10:58	18081	60.423	39.158	1523	Magnetometer	11:12									Magnetometer deployed
DY088 - 146	22/03/18	18:06	18081	60.805	37.604	1736	EM122	18:06									Stopped logging dy088_e2
DY088 - 147	22/03/18	18:09	18081	60.808	37.593	1712	EM122										Started logging dy088_f

DY088 - 148	22/03/18	19:47	18081	60.872	37.264	454	EM122										Crashed
DY088 - 149	22/03/18	19:57	18081				EM122										Restart logging
DY088 - 150	22/03/18	20:13	18081	60.892	37.274	381	EM710										Start logging
DY088 - 151	23/03/18	13:08	18082	60.271	34.925		EM122										Crashed
DY088 - 152	23/03/18	13:40	18082				Magnetometer										Recovered Magnetometer
DY088 - 153	23/03/18	14:12	18082	60.255	34.842	2544	EM122										Stopped logging
DY088 - 154	23/03/18	14:33	18082	60.255	34.844	2560	DR228	14:33	15:55	01:22	17:16	60.252	34.849	2219	5.1	0.23	341 Dredge deployed
DY088 - 155	23/03/18	18:22	18082	60.252	34.849	2212	SVP09 (Disco Bank DR2	18:22			18:58						SVP deployed
DY088 - 156	23/03/18	19:26	18082	60.266	34.9	1542	EM122										Restart logging
DY088 - 157	23/03/18	19:39	18082	60.273	34.927	1339	EM122										Stopped logging
DY088 - 158	23/03/18	19:53	18082	60.272	34.932	1081	DR229	19:55	20:21	00:38	20:59	60.272	34.933	997	2	0.16	84 Dredge deployed
DY088 - 159	23/03/18	21:38	18082	60.271	34.933	991	DR230	21:38	21:58	01:02	23:00	60.268	34.937	602	5	0.18	389 Dredge deployed
DY088 - 160	23/03/18	23:34	18082	60.267	34.941	549	EM122										Restart logging
DY088 - 161	24/03/18	01:31	18083	60.333	35.175	1082	EM122										Stopped logging
DY088 - 162	24/03/18	01:36	18083	60.333	35.174	1080	DR231	01:37	02:03	00:46	02:49	60.331	35.179	991	2.24	0.13	89 Dredge deployed
DY088 - 163	24/03/18	04:02	18083	60.34	35.147	2182	DR232	04:03	04:56	00:53	05:53	60.339	35.151	1966	3.98	0.17	277 Dredge deployed
DY088 - 164	24/03/18	07:07	18083	60.339	35.151	2121	EM122										Restart logging

DY088 - 165	24/03/18	13:48	18083	60.799	35.997	1007	EM122										Stopped logging
DY088 - 166	24/03/18	13:56	18083	60.8	35.997	1100	DR233	13:56	14:28	00:52	15:20	60.796	36	655	3.12	0.22	445 Dredge deployed
DY088 - 167	24/03/18	16:01	18083	60.81	39.967	2301	EM122										Restart logging
DY088 - 168	24/03/18	16:01	18083	60.81	39.967	2301	Magnetometer										Magnetometer deployed
DY088 - 169	24/03/18	21:35	18083	60.938	37.017	1295	Magnetometer										Magnetometer recovered
DY088 - 170	24/03/18	21:47	18083	60.923	37.038	1009	EM122										Stopped logging
DY088 - 171	25/03/18	22:07	18084	60.916	37.052	844	DR234	22:08	22:27	01:16	23:43	60.916	37.064	607	3.47	0.33	237 Dredge deployed
DY088 - 172	25/03/18	00:16	18084	60.917	37.065	606	Magnetometer										Magnetometer deployed
DY088 - 173	25/03/18	00:17	18084	60.917	37.065	606	EM122										Restart logging
DY088 - 174	25/03/18	08:50	18084	60.314	37.255	1170	Magnetometer										Magnetometer recovered
DY088 - 175	25/03/18	09:04	18084	60.312	37.26	1036	EM122										Stopped logging
DY088 - 176	25/03/18	09:16	18084	60.312	37.261	1008	DR235	09:16	09:44	00:48	10:32	60.31	37.268	791	2.4	0.22	215 Dredge deployed
DY088 - 177	25/03/18	11:38	18084	60.323	37.261	1300	EM122										Restart logging
DY088 - 178	25/03/18	11:52	18084	60.342	37.274	1818	Magnetometer										Magnetometer deployed
DY088 - 179	25/03/18	12:12	18084	60.317	37.327	626	EM122										Crashed
DY088 - 180	25/03/18	12:13	18084	60.316	37.327	626	EM122										Restart logging
DY088 - 181	27/03/18	11:48	18086	55.271	46.968	3943	Magnetometer										Magnetometer recovered

DY088 - 182	27/03/18	11:53	18086	55.271	46.969	3944	SVP10	11:59	12:20	SVP deployed
DY088 - 183	27/03/18	11:55	18086	55.271	46.969	3944	EM122			Stopped logging
DY088 - 184	27/03/18	12:52	18086	55.267	46.972	3929	Magnetometer	12:53		Magnetometer deployed
DY088 - 185	27/03/18	12:53	18086	55.267	46.972	3929	EM122	12:53		Restart logging
DY088 - 186	27/03/18	13:30	18086				EM122			Stopped logging
DY088 - 187	27/03/18	13:32	18086				EM122			Restart logging, dy088_g
DY088 - 188	27/03/18	13:42	18086	54.946	47.274	4207	EM122			Started survey area
DY088 - 189	28/03/18	03:20	18087				EM122			Crashed
DY088 - 190	28/03/18	03:30	18087				EM122			Restart logging
DY088 - 191	29/03/18	11:33	18088	53.906	54.8	2222	EM122			Stopped logging
DY088 - 192	29/03/18	12:38	18088				EM122			Restart logging, dy088_a
DY088 - 193	30/03/18	11:41	18089	53.452	59.464	1499	Magnetometer			Magnetometer recovered
DY088 - 194	30/03/18	21:53	18089	53.193	61.636	493	EM122			Stopped logging, end of dy088_a

Appendix A3a: Dredge site information and dredge details

Dredge site selection

Dredge number: DR.220

Start position

Latitude: 59.508° S

Longitude: 044.285° W

Depth: 2275 m

Finish position

Latitude: 59.496° S

Longitude: 044.302° W

Depth: 1880m

Dredge distance (horizontal): 0.95 nm

Ship's heading: 325°

Wind direction: 310°

Sea state: 2

Dredge Number: DR.220

Location Description: Eastern Pirie Bank, southeast point of spur

JDAY/Time in water: 18071/16.35

Depth: 2329m

JDAY/Time at seabed: 18071/17.47

Depth: 2329m

JDAY/Time leaving seabed: 18071/21.04

Depth: 1868m

JDAY/Time out of water: 18071/21.57

Depth: 1887m

Dredge comments: 3T weak link failed, dredge inverted. Pipe dredge full. USBL damaged. Total wire out 3114m, includes 400m pennant wire.

During haul, wire tension 1.1-1.7T and whilst dredging, 1.6-2.3T

Tension peak of 3.5T at 2080m.

Dredge site selection

Dredge number: DR.221

Start position

Latitude: 59° 41.10’ S

Longitude: 044° 49.51’ W

Depth: 2450 m

Finish position

Latitude: 59° 40.86’ S

Longitude: 044° 50.04’ W

Depth: 2180m

Dredge distance (horizontal): 0.42 nm

Ship’s heading: 320°

Wind direction: 310°

Sea state: 3

Dredge Number: DR.221

Location Description: Eastern Pirie Bank, southeast flank of spur

JDAY/Time in water: 18072/02.14

Depth: 2522m

JDAY/Time at seabed: 18072/03.27

Depth: 2501m

JDAY/Time leaving seabed: 18072/04.36

Depth: 2295m

JDAY/Time out of water: 18072/06.01

Depth: 2296m

Dredge comments:

Dredge site selection

Dredge number: DR.223

Start position

Latitude: 60° 32.370'S

Longitude: 040° 53.094'W

Depth: 944 m

Finish position

Latitude: 60° 32.172'S

Longitude: 040° 53.307'W

Depth: 728m

Dredge distance (horizontal): 0.24 nm

Ship's heading: 330°

Wind direction: 295°

Sea state: 2

Dredge Number: DR.223

Location Description: Southwest Bruce Bank

JDAY/Time in water: 18079/11.46

Depth: 944m

JDAY/Time at seabed: 18079/12.09

Depth: 944m

JDAY/Time leaving seabed: 18079/12.53

Depth: 720m

JDAY/Time out of water: 18079/13.23

Depth: 714m

Dredge comments: Ship moved at 1 knot SOG.

Dredge site selection

Dredge number: DR.224

Start position

Latitude: 60° 25.902'S

Longitude: 040° 09.541'W

Depth: 1053 m

Finish position

Latitude: 60° 25.724'S

Longitude: 040° 09.576'W

Depth: 930 m

Dredge distance (horizontal): 0.34 nm

Ship's heading: 002°

Wind direction: 260°/ 35 knots

Sea state: 5

Dredge Number: DR.224

Location Description: South Bruce Bank. Topographic high on SE trending spur.

JDAY/Time in water: 18079/18.28

Depth: 1058m

JDAY/Time at seabed: 18079/19.01

Depth: 1054m

JDAY/Time leaving seabed: 18079/19.35

Depth: 939m

JDAY/Time out of water: 18079/19.56

Depth: 983m

Dredge comments: 3T weak link failed. Lots of small (<10cm) cobbles.

Dredge site selection

Dredge number: DR.225

Start position

Latitude: 59° 55.626'S

Longitude: 039° 09.209'W

Depth: 981 m

Finish position

Latitude: 59° 55.746'S

Longitude: 039° 09.582'W

Depth: 740 m

Dredge distance (horizontal): 0.4 nm

Ship's heading: 240°

Wind direction: 260°

Sea state: 5

Dredge Number: DR.225

Location Description: Eastern margin of Bruce Bank.

JDAY/Time in water: 18080/15.22

Depth: 949m

JDAY/Time at seabed: 18080/15.51

Depth: 942m

JDAY/Time leaving seabed: 18080/16.50

Depth: 730m

JDAY/Time out of water: 18080/17.12

Depth: 726m

Dredge comments: Excellent haul of large (up to 80cm length) blocks.

Dredge site selection

Dredge number: DR.226

Start position

Latitude: 60° 11.550'S

Longitude: 039° 01.116'W

Depth: 1922 m

Finish position

Latitude: 60° 11.514’S

Longitude: 039° 01.326’W

Depth: 1801m

Dredge distance (horizontal): 0.22 nm

Ship’s heading: 280°

Wind direction: 280°

Sea state: 5

Dredge Number: DR.226

Location Description: South eastern margin of Bruce Bank.

JDAY/Time in water: 18080/21.13

Depth: 1878m

JDAY/Time at seabed: 18080/21.53

Depth: 1884m

JDAY/Time leaving seabed: 18080/22.34

Depth: 1807m

JDAY/Time out of water: 18080/23.12

Depth: 1805m

Dredge comments: Lots of tension snags on wire. Poor haul, mostly dropstones.

Dredge site selection

Dredge number: DR.227

Start position

Latitude: 60° 21.981’S

Longitude: 039° 23.711’W

Depth: 1350 m

Finish position

Latitude: 60° 21.846’S

Longitude: 039° 23.875’W

Depth: 1081 m

Dredge distance (horizontal): 0. 6 nm

Ship’s heading: 310°

Wind direction: 300°

Sea state: -

Dredge Number: DR.227

Location Description: Peak at south eastern corner of Bruce Bank.

JDAY/Time in water: 18081/08.01

Depth: 1234m

JDAY/Time at seabed: 18081/08.31

Depth: 1233m

JDAY/Time leaving seabed: 18081/09.09

Depth: 1093m

JDAY/Time out of water: 18081/09.35

Depth: 1100m

Dredge comments: Max cable out 935m (+400m pennant). Max tension 2.13T.

Dredge site selection

Dredge number: DR.228

Start position

Latitude: 60° 15.361’S

Longitude: 034° 50.638’W

Depth: 2600 m

Finish position

Latitude: 60° 15.179’S

Longitude: 034° 50.938’W

Depth: 2200 m

Dredge distance (horizontal): 0.23 nm

Ship’s heading: 325°

Wind direction: 340°

Sea state: 5

Dredge Number: DR.228

Location Description: Northeast Discovery Bank. SE facing scarp.

JDAY/Time in water: 18082/14.33

Depth: 2577m

JDAY/Time at seabed: 18082/15.55

Depth: 2601m

JDAY/Time leaving seabed: 18082/17.16

Depth: 2219m

JDAY/Time out of water: 18082/18.00

Depth: 2219m

Dredge comments: Max tension 5.1T.

Dredge site selection

Dredge number: DR.229

Start position

Latitude: 60° 16.344’S

Longitude: 034° 55.908’W

Depth: 1230 m

Finish position

Latitude: 60° 16.284’S

Longitude: 034° 55.998’W

Depth: 1070m

Dredge distance (horizontal): 0.16 nm

Ship’s heading: 330°

Wind direction: 340°

Sea state: 5

Dredge Number: DR.229

Location Description: Northeast Discovery Bank.

JDAY/Time in water: 18082/19.57

Depth: 1230m (stern) 1080 multibeam depth from front of vessel.

JDAY/Time at seabed: 18082/20.21

Depth: 1230m

JDAY/Time leaving seabed: 18082/20.59

Depth: 1085m

JDAY/Time out of water: 18082/21.12

Depth: 1084m

Dredge comments: Very few tension peaks. All less than 1.7T. Few samples in pipe dredge, net empty.

Dredge site selection

Dredge number: DR.230

Start position

Latitude: 60° 16.284'S

Longitude: 034° 55.998'W

Depth: 1070m

Finish position

Latitude: 60° 16.139'S

Longitude: 034° 56.221'W

Depth: 780m

Dredge distance (horizontal): 0.18 nm

Ship's heading: 330°

Wind direction: 340°

Sea state: 5

Dredge Number: DR.230

Location Description: Northeast Discovery Bank. Slope above DR.229.

JDAY/Time in water: 18082/21.38

Depth: 987m

JDAY/Time at seabed: 18082/21.58

Depth: 986m

JDAY/Time leaving seabed: 18082/23.00

Depth: 602m

JDAY/Time out of water: 18082/23.07

Depth: 596m

Dredge comments: 5T wire tension peak, followed by several 2T peaks. All weak links intact.

Dredge site selection

Dredge number: DR.231

Start position

Latitude: 60.333°S

Longitude: 035.174°W

Depth: 1080m

Finish position

Latitude: 60.331°S

Longitude: 035.179°W

Depth: 991m

Dredge distance (horizontal): 0.13 nm

Ship's heading: 340°

Wind direction: 340°

Sea state: 4

Dredge Number: DR.231

Location Description: East Discovery Bank. East lower wall of collapse scar.

JDAY/Time in water: 18083/01.37

Depth: 1089m

JDAY/Time at seabed: 18083/02.03

Depth: 1090m

JDAY/Time leaving seabed: 18083/02.49

Depth: 991m

JDAY/Time out of water: 18083/03.12

Depth: 997m

Dredge comments:

Dredge site selection

Dredge number: DR.232

Start position

Latitude: 60° 20.423’S

Longitude: 035° 08.734’W

Depth: 2330m

Finish position

Latitude: 60° 20.232’S

Longitude: 035° 09.032’W

Depth: 2038m

Dredge distance (horizontal): 0.17 nm

Ship’s heading: 340°

Wind direction: 340°

Sea state: 4

Dredge Number: DR.232

Location Description: Lower slope at southwest end of Discovery Bank. Northeast rise.

JDAY/Time in water: 18083/04.03

Depth: 2182m

JDAY/Time at seabed: 18083/04.56

Depth: 2190m

JDAY/Time leaving seabed: 18083/05.52

Depth: 1975m

JDAY/Time out of water: 18083/06.35

Depth: 1941m

Dredge comments: Max spike in tension 3,9T after a few minor peaks.

Dredge site selection

Dredge number: DR.233

Start position

Latitude: 60° 48.008'S

Longitude: 035° 59.808'W

Depth: 1100m

Finish position

Latitude: 60° 47.812'S

Longitude: 036° 00.001'W

Depth: 719m

Dredge distance (horizontal): 0.22 nm

Ship's heading: 340°

Wind direction: 340°

Sea state: 4

Dredge Number: DR.233

Location Description: SE Discovery Bank.

JDAY/Time in water: 18083/13.56

Depth: 1100m

JDAY/Time at seabed: 18083/14.28

Depth: 1100m

JDAY/Time leaving seabed: 18083/15.20

Depth: 709m

JDAY/Time out of water: 18083/15.47

Depth: 709m

Dredge comments: Max spike in tension 3,9T after a few minor peaks.

Dredge site selection

Dredge number: DR.234

Start position

Latitude: 60° 54.959'S

Longitude: 037° 03.149'W

Depth: 850 m

Finish position

Latitude: 60° 54.991’S

Longitude: 037° 03.882’W

Depth: 620 m

Dredge distance (horizontal): 0.33 nm

Ship’s heading: 265°

Wind direction: 245°

Sea state: 3

Dredge Number: DR.234

Location Description: Discovery Bank. East facing scar in central-south of the bank.

JDAY/Time in water: 18083/

Depth: 826m

JDAY/Time at seabed: 18083/22.27

Depth: 826m

JDAY/Time leaving seabed: 18083/23.43

Depth: 607m

JDAY/Time out of water: 18083/23.56

Depth: 607m

Dredge comments:

Dredge site selection

Dredge number: DR.235

Start position

Latitude: 60° 18.717’S

Longitude: 037° 15.637’W

Depth: 1010 m

Finish position

Latitude: 60° 18.627’S

Longitude: 037° 16.037’W

Depth: 795 m

Dredge distance (horizontal): 0.22 nm

Ship’s heading: 280°

Wind direction: 300°

Sea state: 2

Dredge Number: DR.235

Location Description: Northwest potential seamount on western Discovery Bank.

JDAY/Time in water: 18084/09.16

Depth: 1011m

JDAY/Time at seabed: 18084/09.45

Depth: 1011m

JDAY/Time leaving seabed: 18084/10.34

Depth: 793m

JDAY/Time out of water: 18084/10.59

Depth: 793m

Dredge comments: Tension peaks of 3.2 T. Moderate haul of mostly dropstones.

Appendix A3b: Dredge operation summary

Dredge Type	Dredge no.	Observer	Date	Time In water	At seabed	Leaving seabed	Out water	Time on seabed	Start Latitude	Longitude	End Latitude	Longitude	Place name	Description	Cruise ID	Water depth (start)	Water depth (end)	Comments	Peak tension (T)
DR	220	TRR	12/03/2018	16:35:00	17:47:00	21:04:00	21:57:00	03:17:00	-59.50800	-44.28500	-59.49600	-44.30200	Pirie Bank	Eastern Pirie Bank, SE point of spur	DY088	2329	1868	Dredge net inverted after losing 3 tonne weak link. Samples successfully collected in pipe dredge.	2.89
DR	221	ABJ	13/03/2018	02:14:00	03:27:00	04:36:00	06:01:00	01:09:00	-59.68400	-44.82500	-59.68100	-44.83400	Pirie Bank	SE flank of spur on E side of Pirie Bank	DY088	2501	2295	Successful dredge, samples collected in net and bucket.	2.99
DR	223	TRR	20/03/2018	11:46:00	12:09:00	12:53:00	13:23:00	00:44:00	-60.53783	-40.88490	-60.53620	-40.88845	Bruce Bank	Southwest Bruce Bank	DY088	944	728	Ship moved at 1 kt SOG	
DR	224	TRR	20/03/2018	18:28:00	19:01:00	19:35:00	19:56:00	00:34:00	-60.431700	-40.15902	-60.42873	-40.15960	Bruce Bank	South Bruce Bank. Topographic high on SE trending spur	DY088	1053	930	3T weak link failed. Lots of small (<10cm) cobbles	3.7
DR	225	TRR	21/03/2018	15:22:00	15:51:00	16:50:00	17:12:00	00:59:00	-59.92710	-39.15348	-59.92910	-39.15970	Bruce Bank	Eastern margin of Bruce Bank	DY088	949	726	Excellent haul of large (up to 80 cm) blocks	
DR	226	TRR	21/03/2018	21:13:00	21:53:00	22:34:00	23:12:00	00:41:00	-60.19250	-39.01860	-60.19190	-39.02210	Bruce Bank	Southeastern margin of Bruce Bank	DY088	1922	1801	Lots of tension snags on wire. Poor haul, mostly dropstones.	
DR	227	TRR	22/03/2018	08:01:00	08:31:00	09:09:00	09:35:00	00:38:00	-60.36635	-39.39518	-60.36410	-39.39792	Bruce Bank	Peak at southeastern corner of Bruce Bank	DY088	1350	1081	Max cable out 935m + 400m pennant cable	2.13
DR	228	TRR	23/03/2018	14:33:00	15:55:00	17:16:00	18:00:00	01:21:00	-60.25602	-34.84397	-60.25298	-34.84897	Discovery Bank	Northeast Discovery Bank. SE facing scarp.	DY088	2577	2219		5
DR	229	TRR	23/03/2018	19:57:00	20:21:00	20:59:00	21:12:00	00:38:00	-60.27240	-34.93180	-60.271400	-34.93330	Discovery Bank	Northeast Discovery Bank.	DY088	1230	1085	Very few tension peaks. Few samples in pipe dredge, net empty.	1.7
DR	230	TRR	23/03/2018	19:57:00	20:21:00	20:59:00	21:12:00	00:38:00	-60.271400	-34.93330	-60.26898	-34.93702	Discovery Bank	Northeast Discovery Bank. Slope above DR.229.	DY088	1070	780	All weak links intact	5
DR	231	ABJ	24/03/2018	01:37:00	02:03:00	02:49:00	03:12:00	00:46:00	-60.333000	-35.17400	-60.33300	-35.17900	Discovery Bank	East Discovery Bank. East lower wall of collapse scar.	DY088	1080	991		
DR	232	ABJ	24/03/2018	04:03:00	04:56:00	05:52:00	06:35:00	00:56:00	-60.34038	-35.14557	-60.33720	-35.15053	Discovery Bank	Lower slope at southwest end of Discovery Bank. Northeast rise.	DY088	2330	2038		3.9
DR	233	TRR	24/03/2018	13:56:00	14:28:00	15:20:00	15:47:00	00:52:00	-60.80013	-35.99680	-60.79687	-36.00002	Discovery Bank	Southeast Discovery Bank	DY088	1100	719		3.9
DR	234	TRR	24/03/2018	21:44:00	22:27:00	23:43:00	23:56:00	01:16:00	-60.91598	-37.05248	-60.91652	-37.0647	Discovery Bank	Discovery Bank. East facing scar in central south of the bank.	DY088	826	607		
DR	235	TRR	25/03/2018	09:16:00	09:45:00	10:34:00	10:59:00	00:49:00	-60.31195	-37.27728	-60.31045	-37.267280	Discovery Bank	Northwest potential seamount on western Discovery Bank.	DY088	1011	793	Moderate haul of mostly dropstones	3.2

Appendix A3b: Dredging - Site Information

Dredge Type	Dredge no.	Observer	Date	Time In water	At seabed	Leaving seabed	Out water	Time on seabed	Start Latitude	Longitude	End Latitude	Longitude	Place name	Description	Cruise ID	Water depth (start)	Water depth (end)	Comments	Peak tension (T)
DR	220	TRR	12/03/2018	16:35:00	17:47:00	21:04:00	21:57:00	03:17:00	-59.50800	-44.28500	-59.49600	-44.30200	Pirie Bank	Eastern Pirie Bank, SE point of spur	DY088	2329	1868	Dredge net inverted after losing 3 tonne weak link. Samples successfully collected in pipe dredge.	2.89
DR	221	ABJ	13/03/2018	02:14:00	03:27:00	04:36:00	06:01:00	01:09:00	-59.68400	-44.82500	-59.68100	-44.83400	Pirie Bank	SE flank of spur on E side of Pirie Bank	DY088	2501	2295	Successful dredge, samples collected in net and bucket.	2.99
DR	223	TRR	20/03/2018	11:46:00	12:09:00	12:53:00	13:23:00	00:44:00	-60.53783	-40.88490	-60.53620	-40.88845	Bruce Bank	Southwest Bruce Bank	DY088	944	728	Ship moved at 1 kt SOG	
DR	224	TRR	20/03/2018	18:28:00	19:01:00	19:35:00	19:56:00	00:34:00	-60.431700	-40.15902	-60.42873	-40.15960	Bruce Bank	South Bruce Bank. Topographic high on SE trending spur	DY088	1053	930	3T weak link failed. Lots of small (<10cm) cobbles	3.7
DR	225	TRR	21/03/2018	15:22:00	15:51:00	16:50:00	17:12:00	00:59:00	-59.92710	-39.15348	-59.92910	-39.15970	Bruce Bank	Eastern margin of Bruce Bank	DY088	949	726	Excellent haul of large (up to 80 cm) blocks	
DR	226	TRR	21/03/2018	21:13:00	21:53:00	22:34:00	23:12:00	00:41:00	-60.19250	-39.01860	-60.19190	-39.02210	Bruce Bank	Southeastern margin of Bruce Bank	DY088	1922	1801	Lots of tension snags on wire. Poor haul, mostly dropstones.	
DR	227	TRR	22/03/2018	08:01:00	08:31:00	09:09:00	09:35:00	00:38:00	-60.36635	-39.39518	-60.36410	-39.39792	Bruce Bank	Peak at southeastern corner of Bruce Bank	DY088	1350	1081	Max cable out 935m + 400m pennant cable	2.13
DR	228	TRR	23/03/2018	14:33:00	15:55:00	17:16:00	18:00:00	01:21:00	-60.25602	-34.84397	-60.25298	-34.84897	Discovery Bank	Northeast Discovery Bank. SE facing scarp.	DY088	2577	2219		5
DR	229	TRR	23/03/2018	19:57:00	20:21:00	20:59:00	21:12:00	00:38:00	-60.27240	-34.93180	-60.271400	-34.93330	Discovery Bank	Northeast Discovery Bank.	DY088	1230	1085	Very few tension peaks. Few samples in pipe dredge, net empty.	1.7
DR	230	TRR	23/03/2018	19:57:00	20:21:00	20:59:00	21:12:00	00:38:00	-60.271400	-34.93330	-60.26898	-34.93702	Discovery Bank	Northeast Discovery Bank. Slope above DR.229.	DY088	1070	780	All weak links intact	5
DR	231	ABJ	24/03/2018	01:37:00	02:03:00	02:49:00	03:12:00	00:46:00	-60.333000	-35.17400	-60.33300	-35.17900	Discovery Bank	East Discovery Bank. East lower wall of collapse scar.	DY088	1080	991		
DR	232	ABJ	24/03/2018	04:03:00	04:56:00	05:52:00	06:35:00	00:56:00	-60.34038	-35.14557	-60.33720	-35.15053	Discovery Bank	Lower slope at southwest end of Discovery Bank. Northeast rise.	DY088	2330	2038		3.9
DR	233	TRR	24/03/2018	13:56:00	14:28:00	15:20:00	15:47:00	00:52:00	-60.80013	-35.99680	-60.79687	-36.00002	Discovery Bank	Southeast Discovery Bank	DY088	1100	719		3.9
DR	234	TRR	24/03/2018	21:44:00	22:27:00	23:43:00	23:56:00	01:16:00	-60.91598	-37.05248	-60.91652	-37.0647	Discovery Bank	Discovery Bank. East facing scar in central south of the bank.	DY088	826	607		
DR	235	TRR	25/03/2018	09:16:00	09:45:00	10:34:00	10:59:00	00:49:00	-60.31195	-37.27728	-60.31045	-37.267280	Discovery Bank	Northwest potential seamount on western Discovery Bank.	DY088	1011	793	Moderate haul of mostly dropstones	3.2

Appendix 3c: Dredge sample descriptions

* Ice Rafted Debris

DR.220 Eastern Pirie Bank, southeast point of spur

	Start	End
Latitude	-59.508	-59.496
Longitude	-44.285	-44.302
Depth	2329	1868

Summary

Fine grained sediments and low grade metasediments (mudstone, siltstone, sandstone, slate, and phyllite) and granitoids in a range of sizes and angularities.

Dredge Type	Dredge no.	Sample	Observer	Date	Lithology	IRD*	Sample Description
DR	220	1	TRR	12/03/18	Granitoid	Yes	25cm sub-rounded granitoid block. Q3,plag+chl. Mn coat.
DR	220	2	TRR	12/03/18	Granitoid	Yes	20cm rounded granitoid block. Med. Grained, leucocratic. Qz + pl + hbl + bt. Mn coat.
DR	220	3	TRR	12/03/18	Granitoid	Yes	Angular 15cm med-grained granitic block. Qz, hbl, pl, kfs. Mn Coat
DR	220	4	TRR	12/03/18	Granitoid	Yes	Subangular 10cm granitoid med-grained block. Fe-Mn coat.
DR	220	5	TRR	12/03/18	Granitoid	Yes	9 assorted sub-rounded to sub-angular med-grained granitoid blocks. Typically 5-10cm diameter.
DR	220	6	TRR	12/03/18	Granitoid	Yes	Sub-rounded 12cm probable granitoid. Mn coat.
DR	220	7	TRR	12/03/18	Phyllite	?	25cm sub-rounded siltstone, phyllite block with sub-mm qz veining. Mn crust.
DR	220	8	TRR	12/03/18	Mudstone	?	25cm sub-angular slaty mudstone greywacke block. Thin Fe-Mn crust. 2 pieces, "a" & "b".
DR	220	9	TRR	12/03/18	Slate	?	~10 assorted mudstone/slate blocks/fragments. Fe-Mn crust.
DR	220	10	TRR	12/03/18	Mixed	?	Unsorted bag of <3cm gravel of DR220. No sampling bias.
DR	220	11	TRR	12/03/18	Siltstone	?	5 blocks <10cm of silt-sandstone lithologies. Typically sub-rounded.
DR	220	12	TRR	12/03/18	Sandstone	?	15cm sub-rounded sandstone block with 5mm Fe crust.
DR	220	13	TRR	12/03/18	Mixed	?	>100 <5cm cobbles of unkown lithologies. Likely to be granitoid & metasedimentary material.
DR	220	14	TRR	12/03/18	Sandstone	?	~5 micaceous sandstone blocks up to 15cm diameter. Typically ~7cm. Angular to sub-angular.
DR	220	15	TRR	12/03/18	Phyllite	?	~6cm <7cm angular fragments of schist/phyllite.
DR	220	16	TRR	12/03/18	Paragneiss	Yes	Single angular block of probable paragneiss. Mn crust.
DR	220	17	TRR	12/03/18	Vesicular basalt	Yes	3 <5cm angular fragments of probable vesicular basalt.
DR	220	18	TRR	12/03/18	Metasediment	Yes	2 sub-rounded metasedimentary probable dropstones. Striated.

DR.221 Eastern Pirie Bank, southeast flank of spur

	Start	End
Latitude	-59.684	-59.681
Longitude	-44.825	-44.834
Depth	2501	2295

Summary
Dominantly fine grained sediments and low grade metasediments (mudstone, siltstone, slate and phyllite).

Dredge Type	Dredge no.	Sample	Observer	Date	Lithology	IRD*	Sample Description
DR	221	1	TRR	13/03/18	Dolerite	Yes	Large >30cm block. Angular. Likely fine grained dolerite. Thick Mn crust. Weakly plagioclase-phyric.
DR	221	2	TRR	13/03/18	Granitoid	Yes	~5 <5cm granitoid angular fragments. Med--Coarsely crystalline. Granite/granodiorite.
DR	221	3	TRR	13/03/18	Granitoid	Yes	Mesocratic sub-rounded fine grained qz bearing granitoid block ~12cm diameter.
DR	221	4	TRR	13/03/18	Granitoid	Yes	Med-coarse grained qz-pl-bt granitoid sub rounded block ~10cm diameter.
DR	221	5	TRR	13/03/18	Mudstone	?	Sub angular fine grained metasediment. Mudstone lithology. Potentially hornfels.
DR	221	6	TRR	13/03/18	Mudstone	?	Angular fine grained mudstone block. Fe-Mn crust. 10cm diameter.
DR	221	7	TRR	13/03/18	Phyllite	?	Med-grained mica schist/phyllite. More felsic than other phyllites
DR	221	8	TRR	13/03/18	Phyllite	?	~20 phyllite/mica schist assorted fragments <10cm diameter, typically <5cm. Mostly angular.
DR	221	9	TRR	13/03/18	Siltstone	?	~18cm angular siltstone fragment. Slaty cleavage. Fe-Mn crust.
DR	221	10	TRR	13/03/18	Sandstone	Yes	Sub-rounded 15cm sandstone block. Possible Striations.
DR	221	11	TRR	13/03/18	Siltstone	?	5 <5cm micaceous siltstone angular fragments. Mn-crust.
DR	221	12	TRR	13/03/18	Schist	Yes	Angular ~15cm block. Mica-qz-chl schist. Possible striations. Dropstone.
DR	221	13	TRR	13/03/18	Sandstone	?	~10 sub rounded sandstone cobbles. Possibly conglomerate sourced. Typically <7cm diameter.
DR	221	14	TRR	13/03/18	Vesicular basalt	Yes	3 angular vesicular basalt fragment <5cm diameter.
DR	221	15	TRR	13/03/18	Gravel	Yes	Bag of unsorted/unbiased dredge finer grained material. Typically 5mm-1cm.
DR	221	16	TRR	13/03/18	Mixed	Yes	5 ~12cm sub-rounded blocks of assorted lithologies. Metasediments and granitoids.
DR	221	17	TRR	13/03/18	Mixed	Yes	~20 ~8cm sub-rounded blocks of assorted lithologies. Metasediments and granitoids.
DR	221	18	TRR	13/03/18	Gravel	Yes	10kg of 3cm fragments and gravel. Unsorted mixed lithologies.

DR.223 Southwest Bruce Bank

	Start	End
Latitude	-60.53783	-60.5362
Longitude	-40.8849	-40.88845
Depth	944	728

Summary
Dominantly (80-90%) very fine grained, pale grey-brown sedimentary rocks, of which: 6x very fine sand (15%), 24x silt (62%), 9x mud (23%). Some preserve slightly undulose bedding surfaces. No evidence for internal structures (except one mudstone). No internal bedding or laminations. No evidence for internal sorting/fining. No evidence for fossils. Thin (<1-5mm) iron oxide alteration on surfaces. Very thin (<<1mm) Mn crust. One example of slickenlines (i.e. fault surface). Sub-angular to sub-rounded specimens, 5-30cm across (most ~15cm). Beds 4 to >12cm thick for siltstones and sandstones.

Dredge Type	Dredge no.	Sample	Observer	Date	Lithology	IRD*	Sample Description
							Pale grey-brown Mud/Silt/Sandstone samples:
DR	223	1	ABJ	20/03/18	Mudstone	No	Sub-rounded 13cm pale grey-brown mudstone from which smear slide was taken.
DR	223	2	ABJ	20/03/18	Mudstone	?	Grey finely laminated mudstone with 0.5-2mm laminations. 9cm specimen. Only laminated sedimentary rock sample. Appears darker than the other mudstones (dropstone?).
DR	223	3	ABJ	20/03/18	Mudstone	No	7 examples of pale grey-brown mudstone. Sub-angular to subrounded. One specimen with well developed slickenline shear surface. No evidence for internal structures or fossils. Soft.
DR	223	4	ABJ	20/03/18	Siltstone	No	Example of siltstone with well defined upper and lower bed surfaces 4cm apart. Pale grey-brown. No evidence for internal structure.
DR	223	5	ABJ	20/03/18	Siltstone	No	Five larger examples of the pale grey-brown siltstone unit. Sub-angular 17-30cm samples. No internal sedimentary structures. Bedding surfaces ambiguous. Very thin (<0.5mm) Mn-Fe crust.
DR	223	6	ABJ	20/03/18	Sandstone	No	6 samples of pale grey-brown very fine grained sandstone. 15-22cm subangular specimens. Ambiguous bedding surfaces. No internal structure.
							Additional material (probable dropstones):
DR	223	7	ABJ	20/03/18	Gravel	Yes	Representative unsorted sample of unconsolidated mud and gravel from dredge bucket.
DR	223	8	ABJ	20/03/18	Quartzite	Yes	Pale grey-brown silicified sedimentary rock (very fine grained quartzite). Very fine sand/silt grains. Very hard (silicified) chert-like texture. Thin Mn-Fe crust. Sub-angular ~10cm sample. ~5% dark lithic grains. No visible internal structure.
DR	223	9	ABJ	20/03/18	Chert	Yes	Dark grey chert. Grains not visible with hand lens. Chert texture, very hard and dense. ~10cm sub-angular specimen. 3mm deep Fe-oxide alteration of surface.
DR	223	10	ABJ	20/03/18	Granite	Yes	Pink porphyritic coarse grained alkali feldspar granite. Minor bornite and pyrite mineralisation. Mineralogy: 5% biotite (0.5-1.5mm), 30% quartz (1-3mm), 65% pink K-feldspar (2-5mm + 25-35mm phenocrysts). Absence of plagioclase indicates that much of the K-feldspar may be secondary (i.e. K-feldspar alteration).
DR	223	11	ABJ	20/03/18	Dolerite	Yes	Medium grained aphanitic dolerite. Mineralogy: 30% plagioclase (0.5-1.5mm), 70% black pyroxene (<0.5-1mm). Thin (<1mm) black microcrystalline veins, Thin (<0.5mm) Mn-Fe crust. Subangular 18cm sample.
DR	223	12	ABJ	20/03/18	Phyllite	Yes	Micaceous phyllite with fine (~0.5mm) schistose undulose foliations. 2x 8cm samples.
DR	223	13	ABJ	20/03/18	Granitoid	Yes	8x variably hematite altered fine-medium grained granitic and dioritic samples. 2-7cm subangular specimens.
DR	223	14	ABJ	20/03/18	Basalt	Yes	Sub-rounded dark grey microcrystalline 7cm sample. Aphanitic crystalline texture. Hard and dense.
DR	223	15	ABJ	20/03/18	Sandstone	Yes	Small (<4cm) specimens of additional fine grained grey sediments.

DR.224 South Bruce Bank. Topographic high on SE trending spur

	Start	End
Latitude	-60.4317	-60.42873
Longitude	-40.15902	-40.1596
Depth	1053	930

Summary
Predominantly dropstone material <10cm (most <5cm) with one large fossiliferous 22cm specimen clearly broken from an in situ site on the seafloor.

Dredge Type	Dredge no.	Sample	Observer	Date	Lithology	IRD*	Sample Description
							Local material
DR	224	1	ABJ	20/03/18	Fossiliferous sandstone	No	22cm fossiliferous sample. Agglomeration of white broken shelly fragments (~40%) in grey sandy matrix. Porous (cavities form 10-20% of rock volume) with large 1cm wide interconnected cavities. Shell fragments (0.5-5cm long) include bivalve and possible razor shell fragments and possible corals. Matrix: pale grey, cemented, subrounded 0.2-1mm grains (0.5mm mode). Dominantly quartz with ~5% dark lithic material. No clear internal structure.
							Additional material (probable dropstones):
DR	224	2	ABJ	20/03/18	Gravel	Yes	Unbiased sample of sand and gravel from dredge bottom bucket.
DR	224	3	ABJ	20/03/18	Chert	Yes	Assortment of ~50 angular to rounded very fine grained sandstone/siltstone/mudstone/chert. Variably silicified. Most are grey silicified chert/mudstone. Variable degrees of Fe-oxide alteration.
DR	224	4	ABJ	20/03/18	Phyllite	Yes	Assortment of samples of ~30 finely laminated micaceous phyllite and slaty-mudstone samples. Most dark to light grey. One pale green-grey (chloritised). 0.5-2mm laminations.
DR	224	5	ABJ	20/03/18	Sandstone	Yes	Assorted ~50 sandstone samples. Subangular 4-7cm samples. ≤1mm grains. Fe-Mn crust.
DR	224	6	ABJ	20/03/18	Granitoid	Yes	Assorted ~20 subrounded-subangular 2-10cm samples of granitic/granitic-gneiss rocks. Leucocratic-melanocratic separation visible in some samples but not others. Variable Fe-oxide alteration. Most medium grained (1-3mm crystals).
DR	224	7	ABJ	20/03/18	Amphibolite	Yes	5 samples of dark fine to medium grained amphibolite. 3-7cm angular to sub-rounded samples. Extensive Fe-oxide alteration. 0.3-2mm black amphibole crystals, euhedral, aphyric.
DR	224	8	ABJ	20/03/18	Siltstone	Yes	Pale grey-brown siltstone samples (x2) resembling dominant lithology of DR223.
DR	224	9	ABJ	20/03/18	Sandstone	Yes	Sedimentary samples (x9) 2-5cm with extensive dissolution pitting. Included 3 samples of poorly sorted material with <1-3mm grains.
DR	224	10	ABJ	20/03/18	Pebbles	Yes	~100 unbiased assortment of 1-4cm pebbles.
DR	224	11	ABJ	20/03/18	Volcanic tuff	Yes	Possible silicic tuff dropstone.

DR.225 Eastern margin of Bruce Bank

	Start	End
Latitude	-59.9271	-59.9291
Longitude	-39.15348	-39.1597
Depth	949	726

Summary
Dredge dominated by mafic volcanic, hypabyssal and intrusive rocks including gabbro and pyroxenite (probable cumulates), an assemblage likely representing a volcanic and intrusive feeder system. Slaty mudstone xenoliths inform on deeper host rock lithologies (low-grade metasediments).

Dredge Type	Dredge no.	Sample	Observer	Date	Lithology	IRD*	Sample Description
DR	225	1	TRR	21/03/18	Granodiorite	Yes	Subrounded 20cm block of medium grained crystalline granodiorite with finer grained patches.
DR	225	2	TRR	21/03/18	Tonalite	Yes	Subangular 20cm block of medium grained crystalline tonalite. Pl, qz, hbl, bt. 2-3mm Mn crust
DR	225	3	TRR	21/03/18	Diorite	?	Subangular 10cm block of medium grained crystalline diorite. Pl, hbl, bt.
DR	225	4	TRR	21/03/18	Granitoid	Yes	Subangular 20cm block of med-fine grained granitoid. Pl, hbl, qz. No significant Mn-crust.
DR	225	5	TRR	21/03/18	Diorite	?	Subangular 20cm block of fine grained mesocratic diorite. Hbl, pl. Mn crust.
DR	225	6	TRR	21/03/18	Diorite	?	Subangular 15cm fragment of a larger block. Med. Grained possible diorite. Pl, bt, hbl, qz. 3-4mm Mn crust.
DR	225	7	TRR	21/03/18	Granitoid	Yes	Angular 15cm fragment of fine grained crystalline mesocratic granitoid. Possible diorite. Bt, Pl.
DR	225	8	TRR	21/03/18	Granitoid	Yes	Angular 10cm fragment of fine-medium grained crystalline granitic lithology. Kfsp, pl, qz, bt. 2mm Mn crust.
DR	225	9	TRR	21/03/18	Gabbro	No	15cm fragment of larger 40cm subrounded block. Melanocratic fine grained gabbroic lithology. Hbl, bt, pl.
DR	225	10	TRR	21/03/18	Granitoid	Yes	12cm angular block of Kfsp porphyritic lithology with finer grained melanocratic groundmass. Kfsp phenocrysts up to 6mm length.
DR	225	11	TRR	21/03/18	Dolerite	No	20cm subrounded block of fine grained dolerite. Melanocratic plag phenocrysts identifiable.
DR	225	12	TRR	21/03/18	Basalt	No	30cm angular basaltic block. Strongly vesicular with vesicles up to 3mm diameter. Fine grained and extensive surface hematite mineralisation. Mn crust in part.
DR	225	13	TRR	21/03/18	Lamprophyre	No	10cm subrounded melanocratic block. Lamprophyric texture. Hbl phenocrysts up to 5mm length.
DR	225	14	TRR	21/03/18	Lamprophyre	No	15cm angular fine grained possible hypabyssal block. Akin to DR.225.13, but more mesocratic. Porphyritic texture. 3mm Mn crust.
DR	225	15	TRR	21/03/18	Granitoid	Yes	8cm subangular brick red porphyritic intrusive lithology with pl and bt crystals. 2mm Mn crust.
DR	225	16	TRR	21/03/18	Tuff	No	10cm subrounded crystal tuff (?). Leucocratic pale grey, fine grained groundmass with qz, pl and hbl phases and possible lithics. 4mm Mn-crust.
DR	225	17	TRR	21/03/18	Mixed	Yes	Unsorted, undescibed fragments <8cm diameter. ~40 separate fragments.
DR	225	18	TRR	21/03/18	Paragneiss	Yes	20cm angular block of sandy metasediment/paragneiss. Veined and laminated, possibly foliated. Probable sandstone protolith. 1-2mm Mn-crust.
DR	225	19	TRR	21/03/18	Mudstone	Yes	5 angular/subangular <15cm blocks of metasediment/mudstone/slate. Very fine grained. Typically 3-4mm Mn-crust.
DR	225	20	TRR	21/03/18	Gabbro	No	12cm subrounded block of melanocratic, crystalline medium grained gabbroic lithology
DR	225	21	TRR	21/03/18	Granitoid	Yes	14cm subangular crystalline medium grained granitic (?) block. Kfsp rich.
DR	225	22	TRR	21/03/18	Quartzite	Yes	3 subrounded blocks of sandstone/quartzite up to 15cm diameter 1mm Mn crust.
DR	225	23	ABJ	21/03/18	Basalt	No	2x angular basaltic samples (1 split) with andesitic xenolith fragments. Dark grey microcrystalline aphanitic matrix. Angular xenoliths 2-12mm long of lighter grey microcrystalline igneous rock. No vesicles.

DR	225	24	ABJ	21/03/18	Basalt	No	3x angular brown altered volcanic/dyke samples (~15cm each). Original composition altered to brown material (palagonite?). Fine grained (~0.1-0.5mm) with <1% 1-3mm plagioclase phenocrysts/xenocrysts. Abundant <1mm thick white veins. No vesicles.
DR	225	25	ABJ	21/03/18	Basalt	No	Brown altered microcrystalline volcanic/dyke sample. No vesicles. Basalt protolith altered to brown material (palagonite?).
DR	225	26	ABJ	21/03/18	Andesite	No	Light grey-green very fine grained aphanitic crystalline sample. Andesite/basaltic andesite with weak chlorite alteration. ~5% 0.1-0.2mm black crystals.
DR	225	27	ABJ	21/03/18	Basalt	No	3x dark grey-purple fine grained igneous samples. 0.5mm phenocrysts (20%) in microcrystalline matrix. Phenocrysts of olive-green glassy crystals (olivine) and black (pyroxene) crystals. 2cm xenolith of porpyritic chloritised andesite with light grey-green microcrystalline matrix and 0.2-0.5mm white plagioclase and black pyroxene phenocrysts.
DR	225	28	ABJ	21/03/18	Dolerite	No	Dolerite (18cm) with abundant mudstone xenoliths. Aphanitic dark grey fine grained crystalline rock. Visible very fine grained crystals (<0.2mm). Black angular mudstone xenoliths (~1% of rock): Planar 5-15mm xenoliths, finely laminated, slaty appearance (foliated and cleaved).
DR	225	29	ABJ	21/03/18	Dolerite	No	Aphanitic grey dolerite (20cm angular sample) with very fine grained grey and white crystals (<0.2mm).
DR	225	30	ABJ	21/03/18	Pyroxenite	No	Medium grained black crystalline rock (20cm). 20% biotite (1-3mm), 5% chlorite, 75% black pyroxene (<1-3mm). Pyroxenite altered by secondary biotite (partial glimerite). Very dense. Fe and chlorite alteration in 1cm thick crust.
DR	225	31	ABJ	21/03/18	Microgabbro	No	Microgabbro. Fine grained sub-rounded 20cm black crystalline rock. 0.5-2mm black pyroxene (85%), 0.5-1mm white plagioclase (15%).
DR	225	32	ABJ	21/03/18	Microgabbro	No	Microgabbro. 3x subangular 10-15cm black fine-medium grained igneous rocks. 10-20% plagioclase (0.2-1mm), 80-90% black pyroxene (?) (0.2-1.5mm).
DR	225	33	ABJ	21/03/18	Phyllite	Yes	Micaceous foliated metamorphic rock. Subrounded 13cm sample. Schistose mica foliation within medium grained rock containing ~50% white plagioclase (0.5-2mm) and ~50% black crystals (0.5-2mm). Extensive Fe-oxide alteration.
DR	225	34	ABJ	21/03/18	Granodiorite	Yes	Granodiorite. Fine-medium grained grey crystalline rock (angular, 10cm). 10% cloudy grey-brown quartz (1-2mm), 40% white plagioclase (0.5-1.5mm), 50% black hornblende (0.5-2mm).
DR	225	35	ABJ	21/03/18	Dolerite (?)	No	Hydrothermally altered plagioclase-phyric mafic rock. Dense subrounded 15cm green and red igneous rock. 2% white plagioclase phenocrysts (2-5mm), 20% dark red clay (hematite), 75% dark green clay (chlorite).

DR.226 South eastern margin of Bruce Bank

	Start	End
Latitude	-60.1925	-60.1919
Longitude	-39.0186	-39.0221
Depth	1922	1801

Summary
Less clear than the earlier dredges, but slight tendency towards mudstones and metasediments.

Dredge Type	Dredge no.	Sample	Observer	Date	Lithology	IRD*	Sample Description
DR	226	1	TRR	21/03/18	Diorite	?	Probable diorite. Extensive replacement by biotite. Strongly crystalline. Plag and biotite. Medium grained. Very friable.
DR	226	2	TRR	21/03/18	Mudstone	?	12cm subrounded block of fine grained mudstone with 3mm Mn-crust.
DR	226	3	TRR	21/03/18	Quartzite	?	15cm subrounded block of fine-medium grained quartzite/volcanic tuff (?). 1mm Mn crust.
DR	226	4	TRR	21/03/18	Tuff	?	12cm subrounded block of medium grained crystalline silicic tuff. 3-4mm Mn crust.
DR	226	5	TRR	21/03/18	Quartzite	?	12cm angular block of sand grade metasediment. Grey, medium grained with Fe-Mn crust.
DR	226	6	TRR	21/03/18	Mudstone	?	Two <10cm subangular blocks of very fine grained mudstone with 1-2mm Mn crust.
DR	226	7	TRR	21/03/18	Mixed	?	~20 assorted cobbles <7cm diameter. Undescribed

DR.227 Peak at south eastern corner of Bruce Bank

	Start	End
Latitude	-60.36635	-60.3641
Longitude	-39.39518	-39.39792
Depth	1350	1081

Summary

Dominantly mafic/intermediate intrusive rocks.

Dredge Type	Dredge no.	Sample	Observer	Date	Lithology	IRD*	Sample Description
DR	227	1	TRR	22/03/18	Gabbro	?	20cm fragment of 60cm subrounded block. Crystalline, medium grained mesocratic pl and hbl dioritic microgabbro.
DR	227	2	TRR	22/03/18	Dolerite	?	15cm subrounded block of fine grained crystalline dolerite/microgabbro lithology. Melanocratic. 1mm Mn crust.
DR	227	3	TRR	22/03/18	Granitoid	?	25cm subrounded fragment of larger 50cm block. Crystalline, foliated melanocratic granitoid. Possible diorite protolith. Kfsp-rich vein ~1cm thick. Dominantly pl, hbl, and bt. Medium grained.
DR	227	4	TRR	22/03/18	Dolerite	?	20cm subangular block of fine grained plag.-phyric dolerite with 2mm Mn crust.
DR	227	5	TRR	22/03/18	Granitoid	?	20cm subrounded block of foliated felsic granitoid. Mafic and felsic mineral segregations. Fine-medium grained crystalline, leucocratic. Possible tonalite protolith. 1mm Mn crust.
DR	227	6	TRR	22/03/18	Mixed	?	Bag of unsorted, unbiased, undescribed lithologies. Typically gravel sized and all <5cm.
DR	227	7	TRR	22/03/18	Granitoid	?	20cm subrounded block of medium crystalline mesocratic granitoid.

DR.228 Northeast Discovery Bank, SE facing scarp

	Start	End
Latitude	-60.25602	-60.25298
Longitude	-34.84397	-34.84897
Depth	2577	2219

Summary
Small haul of ~20 10-30cm angular samples and ~30 <10cm samples. Almost entirely the same dark porphyritic basalt lithology with 3 small dropstones and 2 mudstone samples.

Dredge Type	Dredge no.	Sample	Observer	Date	Lithology	IRD*	Sample Description
							Main lithology: Porphyritic Basalt
						No	Dark grey porphyritic basalt. Microcrystalline dark grey groundmass. 5-10% white plagioclase phenocrysts 0.1-1mm (0.5mm mode). 2-5% black pyroxene phenocrysts 0.5-7mm (1mm mode). Fe-oxide alteration frequently pervasive through samples. No vesicles.
DR	228	1	ABJ	23/03/18	Basalt	No	30cm split sample of porphyritic basalt.
DR	228	2	ABJ	23/03/18	Basalt	No	18cm sample of same porphyritic basalt. 10% plagioclase phenocrysts. 5% pyroxene phenocrysts.
DR	228	3	ABJ	23/03/18	Basalt	No	12x >10cm samples of same porphyritic basalt with variable degrees of Fe-oxide alteration.
DR	228	4	ABJ	23/03/18	Basalt	No	30x <10cm samples of porphyritic basalt with variable Fe-oxide alteration.
							Additional material (probable dropstones):
DR	228	5	ABJ	23/03/18	Granodiorite	Yes	4cm chloritised fine-medium grained granodiorite. Pale grey-green crystalline rock. Quartz (5%, 0.5-1mm), white plagioclase (10%, 0.5-1.5mm), light and dark green crystalline groundmass (0.5-1.5mm crystals) of chloritised material.
DR	228	6	ABJ	23/03/18	Phyllite	Yes	4cm sample of micaceous phyllite.
DR	228	7	ABJ	23/03/18	Granodiorite	Yes	3cm sample of pale grey fine grained granodiorite. Hornblende (10%, 1-1.5mm), biotite (5%, 0.5mm), quartz (20%, 0.5-1.5%), plagioclase (65%, 0.5-1.5mm).
DR	228	8	ABJ	23/03/18	Mudstone	Yes	2x 5cm very pale yellow-brown poorly consolidated pebbles of mud with <10mm long, 3mm wide worm burrows and 1-3mm black microcrystalline clasts (1% by volume).

DR.229 Northeast Discovery Bank

	Start	End
Latitude	-60.2724	-60.2714
Longitude	-34.9318	-34.9333
Depth	1230	1085

Summary
Small haul (9 rocks) of brown volcaniclastic conglomerate material with basaltic clasts. Slate xenolith observed in basalt clast.

Dredge Type	Dredge no.	Sample	Observer	Date	Lithology	IRD*	Sample Description
DR	229	1	ABJ	23/03/18	Volcaniclastic conglomerate	No	Porphyritic basalt with attached conglomerate material. Angular sample 24cm long. Basalt fragment forms most of sample: angular 19cm fragment, dark grey-brown microcrystalline groundmass, black phenocrysts (pyroxene) form 5% (~0.5mm). One 6mm elongate black xenolith (slate?) observed. Conglomerate composed of brown mud/silt matrix (palagonite clay). Rounded and angular poorly sorted clasts: 2-25mm long (plus the large basalt clast), grey and brown microcrystalline lithologies (basalt and andesite?), plus some brown mudstone clasts.
DR	229	2	ABJ	23/03/18	Volcaniclastic conglomerate	No	Volcaniclastic conglomerate. 4 samples of brown poorly sorted conglomerate (5-7cm). Brown lithified mud/silt matrix (palagonite). Clasts (80-90% of rock): vesicular brown microcrystalline volcanics and black/grey microcrystalline rock (basalt/andesite?).
DR	229	3	ABJ	23/03/18	Volcaniclastic conglomerate	No	3x 3-5cm samples of 2-4cm basalt clasts with attached volcaniclastic conglomerate material.
DR	229	4	ABJ	23/03/18	Volcaniclastic sandstone	No	2 samples (10 and 5cm) of moderately/well sorted volcaniclastic sandstone. Brown; sand/siltstone grains with some coarser material (0.5-2mm); coarser material forms a 1cm thick bed in the larger sample.

DR.230 Northeast Discovery Bank. Slope above DR.229.

	Start	End
Latitude	-60.2714	-60.26898
Longitude	-34.9333	-34.93702
Depth	1070	780

Summary
Dominantly poorly lithified palagonitised volcanic ash deposits (tuffs) hosting worm burrows. Deposited in a marine environment.

Dredge Type	Dredge no.	Sample	Observer	Date	Lithology	IRD*	Sample Description
DR	230	1	TRR	23/03/18	Palagonitised tuff	No	20cm subrounded block of poorly sorted, lithified, fine grained, brown coloured muddy lithology OR possibly palagonitised tuff. Evidence of ~1cm length worm burrows. Relatively close to surface of sediment pile.
DR	230	2	TRR	23/03/18	Palagonitised tuff	No	~30cm subrounded block of bedded palagonite tuff unit with lenses of finer grained material and vesicular bands. Possibly palagonitised lava or tuff. Worm burrows ~1.5cm length.
DR	230	3	TRR	23/03/18	Palagonitised tuff	No	15cm subangular block of cream-grey poorly lithified "soft" volcanic tuff. Akin to DR.230.1 and DR.230.2.
DR	230	4	TRR	23/03/18	Palagonitised lava	No	7 subangular fragments up to 7cm diameter of grey-cream volcanic lithology. Fsp phyric. Possible altered lava.
DR	230	5	TRR	23/03/18	Palagonitised tuff	No	~10cm subrounded fragment of buff coloured poorly lithified volcanic lithology. Possibly tuff. Coarser, gritty outer crust.
DR	230	6	TRR	23/03/18	Palagonitised tuff	No	~20 sub-5cm fragments of grey-buff coloured poorly lithified tuffs. Akin to DR.230.1, DR.230.2 and DR.230.3.

DR.231 East Discovery Bank. East lower wall of collapse scar.

	Start	End
Latitude	-60.333	-60.333
Longitude	-35.174	-35.179
Depth	1080	991

Summary
Volcanilithic agglomerates. Hematised matrix and basaltic clasts.

Dredge Type	Dredge no.	Sample	Observer	Date	Lithology	IRD*	Sample Description
DR	231	1	TRR	24/03/18	Volcanilithic agglomerate	No	18cm subangular block of altered probable mafic-intermediate lava. Pl, pyx and ubiquitous hematite mineralisation. Coarser "agglomerate" coating on one side.
DR	231	2	TRR	24/03/18	Volcanilithic agglomerate	No	8cm subrounded block of volcanic lithology. Paler than DR.231.1, but presumed to be similar lithology. Fsp phenocrysts. Vesicular in part.
DR	231	3	TRR	24/03/18	Volcanilithic agglomerate	No	13cm subangular block of volcanic lithology akin to DR.231.1 and DR.231.2 but has an extensive "agglomerate" Mn coating. Dark grey, medium grained basaltic lava.
DR	231	4	TRR	24/03/18	Volcanilithic agglomerate	No	7cm subrounded volcanic block akin to DR.231.3.
DR	231	5	TRR	24/03/18	Volcanic	No	6x <5cm volcanic fragments.
DR	231	6	TRR	24/03/18	Coral	No	Coral fragments, 7cm length. Some with agglomerate attached to base.

DR.232 Lower slope at southwest end of Discovery Bank. Northeast rise.

	Start	End
Latitude	-60.34038	-60.3372
Longitude	-35.14557	-35.15053
Depth	2330	2038

Summary
Volcanic material. Dominantly lava (Palagonitised lava and vesicular basalt) plus tuffs and volcanilithic agglomerate.

Dredge Type	Dredge no.	Sample	Observer	Date	Lithology	IRD*	Sample Description
DR	232	1	TRR	24/03/18	Basalt	No	2x 10cm angular fragments of larger 30cm block. Very friable volcanic lithology. Possibly very fine grained basaltic lava with orange palagonitised crust.
DR	232	2	TRR	24/03/18	Basalt	No	~15 <10cm subangular blocks of identical lithology to DR.232.1.
DR	232	3	TRR	24/03/18	Agglomerate	No	~25 <7cm subangular fragments of fine grained volcanic lithology with "agglomerate" surface. Interior is melanocratic, fine grained, vesicular and possible <1mm shards.
DR	232	4	TRR	24/03/18	Basalt	No	~20 <5cm subrounded more vesicular basaltic fragments. Some are pyroxene and plagioclase phyric.
DR	232	5	TRR	24/03/18	Tuff	No	~7 <10cm more leucocratic subrounded fragments. Possibly more intermediate composition. Tuffs. Hematite mineralisation. Plagioclase phenocrysts.
DR	232	6	TRR	24/03/18	Mixed	No	~50 unsorted, unexamined <3cm fragments.
DR	232	7	TRR	24/03/18	Coral	No	Coral fragment 6cm length.

DR.233 SE Discovery Bank

	Start	End
Latitude	-60.80013	-60.79687
Longitude	-35.9968	-36.00002
Depth	1100	719

Summary

Volcanic material. Dominantly lava (pyroxene and plagioclase phyric basalt) plus agglomerate.

Dredge Type	Dredge no.	Sample	Observer	Date	Lithology	IRD*	Sample Description
DR	233	1	TRR	24/03/18	Basaltic andesite	No	24cm subangular massive block of fine-medium grained volcanic lithology. Probable basalt-intermediate lava. Plagioclase and pyroxene phyric. Some Fe-alteration. Thin Mn crust.
DR	233	2	TRR	24/03/18	Dolerite	No	12cm subangular fragment of fsp-pyx phyric medium grained volcanic lithology. Slightly more melanocratic than DR.233.1 and more porphyritic. Mn and Fe surface coating. Probable lava. Difficult to see any pyroclastic features.
DR	233	3	TRR	24/03/18	Basalt	No	18cm subangular block of the same lithology as DR.233.1 and DR.233.2. Slightly finer grained and more melanocratic.
DR	233	4	TRR	24/03/18	Basalt	No	17cm subangular block of paler grey, more porphyritic volcanic lithology, akin to DR.233.1, DR.233.2 and DR.233.3.
DR	233	5	TRR	24/03/18	Basalt	No	20cm subangular block of porphyritic and vesicular volcanic lithology. Probable lava. Melanocratic and medium grained. More porphyritic than above. Pyx-plag.
DR	233	6	TRR	24/03/18	Basalt	No	20cm flat block of medium grained volcanic lithology akin to above with ~4cm orange-yellow palagonitised "rind" and 2-3mm Mn crust.
DR	233	7	TRR	24/03/18	Volcanic agglomerate	No	~25cm subangular block of poorly cemented agglomerate with clasts typically angular and <1cm diameter. Rarely up to 3cm length, including clasts of lithology described above.
DR	233	8	TRR	24/03/18	Volcanic agglomerate	No	2x ~10cm subangular agglomerate fragments. Clasts are typically angular and include basalt lava, hematised mineralised fragments. Poorly cemented.
DR	233	9	TRR	24/03/18	Volcanic agglomerate	No	>20cm angular block of well cemented agglomerate with 6cm vesicular coarse grained, buff coloured material cutting agglomerate. Possibly palagonitised lava or tuff?
DR	233	10	TRR	24/03/18	Volcanic agglomerate	No	>20cm block, subangular of very coarse grained agglomerate. Clasts are subangular and up to 5cm length. Grey-brown, poorly cemented and friable.
DR	233	11	TRR	24/03/18	Basalt	No	4x ~8cm subangular fragments of porphyritic volcanic lithology. Medium grained with dark grey-red colouration groundmass. Fsp and pyx phyric. Strongly weathered plag.
DR	233	12	TRR	24/03/18	Basalt	No	4x ~10cm subangular hematite stained medium grained volcanic fragments. Probable lavas.
DR	233	13	TRR	24/03/18	Volcanic agglomerate	No	3x <10cm subrounded buff coloured agglomerate fragments.
DR	233	14	TRR	24/03/18	Volcanic agglomerate	No	~20cm angular fragment of larger (50cm) block of dark brown agglomerate with poorly cemented volcanic fragments. Cut by 3-4cm palagonitised sandy "ash" band.
DR	233	15	TRR	24/03/18	Mixed	?	3 assorted small (<10cm) blocks. Phyllite, vesicular lava and finer grained volcanic fragments.

DR.234 Discovery Bank. East facing scar in central-south of the bank.

	Start	End
Latitude	-60.91598	-60.91652
Longitude	-37.05248	-37.0647
Depth	826	607

Summary
Volcanic material. Lava (variably pyroxene and plagioclase phyric basalt), volcaniclastic sandstone and volcanic agglomerate.

Dredge Type	Dredge no.	Sample	Observer	Date	Lithology	IRD*	Sample Description
DR	234	1	TRR	24/03/18	Volcaniclastic conglomerate	No	20cm subrounded block of coarse, gritty volcaniclastic lithology with individual fragments typically 2-3mm, but up to 5-6mm. Poorly lithified and bedded and ~1cm scale.
DR	234	2	TRR	24/03/18	Volcaniclastic sandstone	No	10cm subrounded block of coarse, gritty volcaniclastic rock. Poorly cemented. ~1cm paler gritty bands, interbedded with 2mm darker bands.
DR	234	3	TRR	24/03/18	Volcaniclastic agglomerate	No	~15cm subrounded block of poorly cemented agglomerate "clinker" lithology with individual, subangular clasts typically <1cm diameter. Friable. Uncertain if it's primary or redeposited.
DR	234	4	TRR	24/03/18	Tuff	No	18cm subangular specimen of a larger ~50cm block of "soft" fine grained muddy tuff unit. Grey/brown colouration. Plag. Crystals up to 5mm length. Cut by more gritty bands 6cm width akin to the volcaniclastic lithology.
DR	234	5	TRR	24/03/18	Tuff	No	15cm subrounded block of soft, fine grained muddy tuff unit essentially the same as DR.234.4 without the gritty bands. Able to gouge with fingernails. Poorly lithified. Patches of Mn crust. Potentially discernible bedding on a 5-7cm scale. Possible minor lithic fragments.
DR	234	6	TRR	24/03/18	Volcaniclastic sandstone	No	2x flat 15cm blocks of gritty volcaniclastic material. More melanocratic than buff coloured units DR.234.1 and DR.234.2 but with similar texture and grain size (2-3mm). Better cemented. Plag and pyx crystals.
DR	234	7	TRR	24/03/18	Basalt	No	5x <10cm subangular vesicular volcanic (?) lava blocks. Pl and pyx phyric. Strongly weathered and medium grained.
DR	234	8	TRR	24/03/18	Tuff	No	12cm subangular fragment of larger (30cm) palagonitised lithology. Possibly a tuff. Well developed 7-8mm Mn crust. Orange-brown palagonite. Friable.
DR	234	9	TRR	24/03/18	Paragneiss	Yes	20cm angular block of high grade metasediment/paragneiss. Medium grained, silt-sandstone protolith. Generally dark coloured with pale felsic bands 2-3mm thickness. Probable dropstone.
DR	234	11	TRR	24/03/18	Tuff	No	5x ~10cm subrounded blocks of mesocratic volcanic lithologies. Likely intermediate composition. Possibly lava or recrystallised crystal tuff.
DR	234	12	TRR	24/03/18	Basaltic andesite	No	25cm angular block of fine-medium grained hematite mineralised basaltic-andesite lava. Porphyritic with plagioclase phenocrysts up to 6mm length. Groundmass is hematite stained and altered.
DR	234	13	TRR	24/03/18	Basalt	No	15cm subrounded block of very fine grained melanocratic, presumably mafic lava with pyx phenocrysts up to 4mm diameter. 1-2mm weathering crust.
DR	234	14	TRR	24/03/18	Mudstone	?	3x subangular blocks of very fine grained muddy metasediment with <1mm Mn crust. Flatter sample is more coarsely grained.
DR	234	15	TRR	24/03/18	Basalt	No	12cm subrounded fragment of fine grained, partly recrystallised mafic lava. Possible plag. Phenocrysts. Fe-Mn mineralisation.

DR	234	16	TRR	24/03/18	Basalt	No	15cm subrounded block of medium grained, slightly (?) foliated basaltic lava. Recrystallised.
DR	234	17	TRR	24/03/18	Basalt	No	~10x <10cm subrounded fine-medium grained mafic lava blocks. Generally phenocryst poor.
DR	234	18	TRR	24/03/18	Granitoid	Yes	15cm subrounded megacrystic/coarsely crystalline leucocratic granitoid block. Qz, pl, bt and hbl, plus epidote. Dropstone.
DR	234	19	TRR	24/03/18	Basalt	No	2x ~10cm subrounded hematite mineralised, basaltic lava blocks.
DR	234	20	TRR	24/03/18	Mixed	?	Assorted, undescribed ~20 cobbles <7cm diameter.
DR	234	21	TRR	24/03/18	Tuff	Yes	14cm fragment of coarse crystal-lithic volcanic tuff. Pale grey and weathered. Possible dropstone.

DR.235 Northwest potential seamount on western Discovery Bank

	Start	End
Latitude	-60.31195	-60.31045
Longitude	-37.27728	-37.26728
Depth	1011	793

Summary
Dominantly <5cm pebbles of mixed lithologies, implying a dominantly dropstone composition. Lithologies are (approx. % by number of rocks): Granitic (~30%), avesicular basalt/dolerite (~20%), mudstone/slate (~20%), quartzite (~10%), gabbro/diorite (~5%), avesicular andesite (~5%), micaceous phyllite (~4%), silicified sandstone (~2%), vesicular basalt (~2%), paragneiss (~1%), pumice (<1%), plus sand and gravel.

Dredge Type	Dredge no.	Sample	Observer	Date	Lithology	IRD*	Sample Description
DR	235	1	ABJ	25/03/18	Vesicular basalt	?	5x <5cm and 1x ~10cm samples of grey and black vesicular basalt. Variable vesicle abundance (30-60% of rock). Empty vesicles (no infill). Angular samples. Microcrystalline aphyric groundmass.
DR	235	2	ABJ	25/03/18	Basalt/dolerite	Yes	Selection of avesicular basalts/dolerites (<5cm), fine grained to microcrystalline.
DR	235	3	ABJ	25/03/18	Gabbro/diorite	Yes	Selection of fine grained gabbroic/dioritic rocks (<5cm).
DR	235	4	ABJ	25/03/18	Andesite	Yes	Selection of avesicular andesite rocks.
DR	235	5	ABJ	25/03/18	Granitoid	Yes	Selection of granitic rocks (<5cm).
DR	235	6	ABJ	25/03/18	Mudstone/slate	Yes	Selection of mudstones/slates.
DR	235	7	ABJ	25/03/18	Phyllite	Yes	Selection of micaceous phyllite rocks.
DR	235	8	ABJ	25/03/18	Quartzite	Yes	Selection of quartzites/silicified sandstones.
DR	235	9	ABJ	25/03/18	Paragneiss	Yes	Foliated paragneiss with fine grained texture and well defined melanocratic and leucocratic foliations.
DR	235	10	ABJ	25/03/18	Pumice	Yes	5cm white pumice sample (only pumice rock in dredge).

Appendix A4: SVP (Sound Velocity Probe) station table

Name	DATE/JDAY	TIME (UTC)	LAT (S)	LONG (W)	STATION	LOCATION/FILE
SVP01	10/03/2018 JD68	16:20	57° 10.2’	054° 53.40’	SVP only	Central Scotia Sea (on transit) **10032018**
SVP02	12/03/2018 JD071	11.14	59° 30.12’	044° 27.24’	SVP only	South of Pirie Bank, start of dy088_b multibeam survey **12032018**
SVP03	13/03/2018 JD072	06:53	59° 51.66’	044° 50.04’	DR.221	SE side of Pirie Bank, dredge station DR.221 **13032018**
SVP04	14/03/2018 JD073	01:41	60°51.42’	045° 34.62’	SVP only	Inner Signy Trough start of survey dy088_d **14032018**
SVP05	14/03/2018 JD073	17:00	61° 26.10’	045°55.14’	BC739	Outer basin of Signy Trough, landward of moraine **14032018_2**
SVP06	15/03/2018 JD074	07:09	61° 41.64’	046° 23.28’	GC742 BC743	Outer Signy Trough, seaward of moraine **15032018**
SVP07	20/03/2018 JD079	03:42	60° 34.86’	041° 33.96’	SVP only	Southern Bruce Bank **20032018**
SVP08	21/03/2018 JD080	17:45	59° 55.64’	039° 09.60’	DR.225	Northern Bruce Bank **14032018**
SVP09	23/03/2018 JD082	18:22	60° 15.12’	034° 50.94’	DR.228	NE Discovery Bank **23032018**
SVP10	27/03/2018 JD86	11:53	55° 16.23’	046° 58.13’	SVP only	North Scotia Sea survey area **27032018**

Appendix A5: Coring Station Table

Date	Gear	#	Location	Latitude	Longitude	Depth (m)	Core recovered (m)	
14/03/18	BC	739	Signy Trough	-61.4350	-45.9190	387	26	3 subcores (X: 0-24; Y: 0-24 ; Z: 0-25.5 cm); 1 bagged surface sample
14/03/18	BC	740	Signy Trough	-61.5390	-46.1460	344	0.24	4 subcores (X: 0-19.5; Y: 0-24; Z: 0-24; S: 0-23 cm); 2 bagged surface samples
14/03/18	GC	741	Signy Trough	-61.5390	-46.1460	344	4.25	5 sections (0-33, 33-127, 127-221, 221-323, 323-425 cm); 1 core catcher; 1 core cutter
15/03/18	GC	742	Signy Trough	-61.6940	-46.3890	430	2.01	2 sections (0-100, 100-201 cm); 1 core catcher; 1 bagged core top sample
15/03/18	BC	743	Signy Trough	-61.6940	-46.3888	431	0.22	2 subcores (Y: 0-21.5; Z: 0-19.5 cm); 1 bagged surface sample
15/03/18	BC	744	Signy Trough	-61.0659	-45.7368	317	0.23	2 subcores (X: 0-18; Y: 0-23 cm); 2 bagged surface samples
15/03/18	GC	745	Signy Trough	-61.0659	-45.7368	317	2.19	3 sections (0-22, 22-122.5, 122.5-218.5 cm); 1 core catcher and cutter sample
15/03/18	GC	746	Signy Trough	-61.0196	-45.6836	314	4.91	5 sections (0-101.5, 101.5-202.5, 202.5-303.5, 303.5-405, 405-490.5 cm); 1 core catcher ; 1 core cutter sample; bagged core top sample
15/03/18	BC	747	Signy Trough	-61.0196	-45.6830	314	0.24	2 subcores (X: 0-23.5; Y: 0-23 cm); 2 bagged surface samples
15/03/18	BC	748	Signy Trough	-60.9610	-45.5750	315	0.21	2 subcores (X: 0-18; Y: 0-21 cm); 2 bagged surface samples
15/03/18	GC	749	Signy Trough	-60.9610	-45.5750	314	2.74	3 sections (0-73, 73-173, 173-274 cm); 1 core catcher and cutter sample
15/03/18	BC	750	Signy Trough	-60.8730	-45.5350	374	0.34	3 subcores (X: 0-33; Y: 0-33; Z: 0-34 cm); 2 bagged surface samples
16/03/18	BC	751	Signy Trough	-61.1920	-45.6915	327	0.26	2 subcores (X: 0-25.5; Y: 0-22 cm); 2 bagged surface samples
16/03/18	GC	752	Signy Trough	-61.1920	-45.6910	326	2.09	3 sections (0-73, 73-140, 140-209 cm); 1 core catcher and cutter sample
16/03/18	GC	753	Signy Trough	-61.2300	-45.6810	297	1.93	2 sections (0-101, 101-193 cm); 1 core catcher sample
16/03/18	BC	754	Signy Trough	-61.2300	-45.6810	297	0.21	2 subcores (X: 0-20.5; Y: 0-21 cm); 1 bagged surface sample
16/03/18	BC	755	Signy Trough	-61.3460	-45.8500	353	0.23	2 subcores (X: 0-22; Y: 0-23 cm); 1 bagged surface sample
16/03/18	GC	756	Signy Trough	-61.3460	-45.8500	353	3.22	4 sections (0-27.5, 27.5-129.5, 129.5-229, 229-322 cm); 1 core catcher and cutter sample
17/03/18	GC	757	Signy Trough	-61.5309	-46.1463	344	5.18	6 sections (0-36, 36-126.5, 126.5-227, 227-327.5, 327.5-428.5, 428.5-517.5 cm); 1 core catcher; 1 core cutter sample
17/03/18	BC	758	Signy Trough	-61.4348	-45.9193	389	N/A	None
17/03/18	BC	759	Signy Trough	-61.4348	-45.9193	389	N/A	None
18/03/18	BC	760	East Signy Trough	-61.3530	-45.3850	273	0.24	1 subcore (0-24 cm); 1 bagged bulk sample; 1 bagged surface sample
18/03/18	GC	761	East Signy Trough	-61.3520	-45.3858	276	0.51	1 section (0-51 cm); 1 core catcher sample; 1 core cutter sample
18/03/18	GC	762	East Signy Trough	-61.3892	-45.2971	292	4.89	5 sections (0-96, 96-196, 196-296, 296-396, 396-489 cm); 1 core catcher; 1 core cutter
18/03/18	BC	763	East Signy Trough	-61.3892	-45.2971	292	0.34	4 subcores (X: 0-27.5; Y: 0-24.5; Z: 0-27.5; A: 0-27.5 cm); 1 bagged surface sample
18/03/18	GC	764	East Signy Trough	-61.4378	-45.1200	242	1.45	2 sections (0-53, 53-145 cm); 1 core catcher sample
18/03/18	GC	765	Orwell Trough	-61.3140	-44.6190	295	0.94	1 section (0-94 cm); 1 core catcher sample; bagged core top sample
18/03/18	GC	766	Orwell Trough	-61.2838	-44.6581	308	4.02	5 sections (0-98, 98-109, 109-209, 209-310, 310-402 cm); 1 core catcher; 1 core cutter
18/03/18	BC	767	Orwell Trough	-61.2838	-44.6581	308	0.21	2 subcores (X: 0-21; Y: 0-20 cm); 1 bagged surface sample
19/03/18	BC	768	Bennett Trough	-60.5396	-45.1319	313	0.43	3 subcores (X: 0-35.5; Y: 0-43; A: 0-37.5 cm); 2 bagged surface samples
19/03/18	BC	769	Laurie Trough	-60.5897	-44.6835	405	0.38	3 subcores (X: 0-30.5; Y: 0-38; Z: 0-35.5 cm); 2 bagged surface samples
22/03/18	GC	770	Bruce Bank	-60.1421	-39.2943	1648	2.41	3 sections (0-46, 46-145,145-241 cm); 1 core catcher sample

Appendix A6: Smear slides

BC	739	0-2 cm	GC	742	Core Top	GC	752	2	GC	762	1
BC	740	0-2 cm	GC	742	1	GC	752	3	GC	762	2
BC	743	0-2 cm	GC	742	2	GC	753	1	GC	762	3
BC	744	0-2 cm	GC	745	1	GC	753	2	GC	762	4
BC	747	0-2 cm	GC	745	2	GC	756	1	GC	762	5
BC	748	0-2 cm	GC	745	3	GC	756	2	GC	764	1
BC	750	0-2 cm	GC	746	Core Top	GC	756	3	GC	764	2
BC	751	0-2 cm	GC	746	1	GC	756	4	GC	765	1
BC	754	0-2 cm	GC	746	2	GC	757	1	GC	766	1
BC	755	0-2 cm	GC	746	3	GC	757	2	GC	766	2
BC	760	0-2 cm	GC	746	4	GC	757	3	GC	766	3
GC	741	1	GC	746	5	GC	757	4	GC	766	4
GC	741	2	GC	749	1	GC	757	5	GC	766	5
GC	741	3	GC	749	2	GC	757	6	GC	770	1
GC	741	4	GC	749	3	GC	761	1	GC	770	2
GC	741	5	GC	752	1	GC	761	CN	GC	770	3

Appendix A7: Typical sonar system parameter settings

A8.1 EM122 Acquisition Parameters

MBES screen, "EM122 Runtime Menu"
Ping Mode: AUTO
Dual swath mode: FIXED
Sector Coverage

Max Port Angle:	50 - 75°
Max Starboard Angle:	50 - 75°
Angular Coverage:	Auto
Beam Spacing:	Equidistant (HD EQDST)

Pitch stabilization: On
Yaw stabilization: On in 'Rel. Mean Heading' mode
Min Depth: used to constrain depth when bottom lost or using SBP 120 chirp Tx on fixed cycle
Max Depth: used to constrain depth when bottom lost or using SBP 120 chirp Tx on fixed cycle

Sound Speed at Transducer:

Sound Speed:	1500 m/s
From:	Sensor
Sensor Offset:	0.0 m/s
Filter:	60 s

Filtering

Spike Filter Strength:	Strong
Range Gate:	Small
Phase Ramp:	Normal
Penetration Filter Strength:	Off
Aeration:	On
Sector Tracking:	Off
Slope:	On
Interference:	Off

Absorption Coefficient

Source:	Salinity
Salinity (parts per thousand):	35

Normal incidence sector

Angle from nadir (deg.):	6

Mammal protection

TX power level (dB):	Max.
Soft startup ramp time (min.):	0

A8.2 EM710 Acquisition Parameters

MBES screen, "EM710 Runtime Menu"

Ping Mode: AUTO

Sector Coverage

Max Port Angle:	50 - 75°
Max Starboard Angle:	50 - 75°
Angular Coverage:	Auto
Beam Spacing:	Equidistant (HD EQDST)

Pitch stabilization:	On
Yaw stabilization:	On in 'Rel. Mean Heading' mode

Sound Speed at Transducer:

Sound Speed:	1488 m/s
From:	Sensor
Sensor Offset:	0.0 m/s
Filter:	60 s

Filtering

Spike Filter Strength:	Medium
Range Gate:	Normal
Phase Ramp:	Normal
Penetration Filter Strength:	Off
Slope:	On
Aeration:	On
Sector Tracking:	Off
Interference:	Off

Absorption Coefficient

Source:	Salinity
Salinity (parts per thousand):	35

Normal incidence sector

Angle from nadir (deg.):	6

Mammal protection

TX power level (dB):	-10
Soft startup ramp time (min.):	0

A8.3 SBP 120 Acquisition Parameters

System Runtime parameters (Acquisition/ Transmitter Menu)

Pulseform:	Linear chirp down	
	Chirp start frequency (Hz):	2500
	Chirp stop frequency (Hz):	6500
	Length (ms):	20
	Transmit mode:	Normal
	Ping interval (ms):	6000 (sometimes changed manually depending on water depth)
	Acquisition window (ms):	500
	Synchronisation:	Fixed rate (did not get K-Sync unit to work effectively during DY088)
	Power level (dB):	-30
	Number of beams:	11
	Beam spacing (deg.):	6
	Transducer sound speed:	1466
Delay control:	Automatic (Calculate delay from depth ticked on, calculates delay from EM122 depth; manual used during dy088_c survey as cannot calculate delay from EM710)	

Processing Menu

Filters Menu:	Enabled	
	Filter type:	Matched
	Corner frequencies:	Auto
	Filter:	ON
	Replica shaping:	ON
Bottom Tracker Menu:	Enabled	
	Show master depth:	Disabled
	Autosearch:	Enabled
Gain Correction Menu:	Enabled	
Data Plotter 1 Menu:	Enabled	
Data Plotter 2 Menu:	Enabled	
Automatic Gain Control Menu:	Enabled	
	Window length (%):	20.0
	Apply point (%):	0.0
	Amp. Scaling:	100.0
Processing/ Attribute Processing:	Enabled	
	Attribute:	Inst. amplitude
Processed Data Logger Menu:	Enabled (records SEGY files)	
	File close/append:	25
	Maximum file size:	100 MB
	Number of beams:	11

Log selected beam only:	OFF (i.e. all 11 beams recorded)

Appendix A8: Magnetometer Time Sheet

NMFSS - NOC - NERC
DY088 - Punta Arenas, Chile to South Scotia

Sail Date: 43166
SSS-Technician: Andrew Moore
SSS-Technician-(T2) Hatim Shah

Leyback in BOB (meters) : 300m
Laptop : #6719
Deck Lead: Purple 03
PSU: 05 Serial Lead : 03
Isolation Transceiver Cable: 5278/1
Winch: 250005101

Magnetometer S/N:	Survey Name	Date In	Jday In	Logging Star Time	Date Out	Jday Out	Logging Stop Time	Total Hours
13428	dy088_mag_a	43168	68	0.804166667	43169	69	0.665972222	20hr41min
13428	dy088_mag_a	43169	69	0.854166667	43171	71	0.452777778	38hr22min
13428	dy088_mag_a	43171	71	0.526388889	43171	71	0.657638889	03hr09min
13428	dy088_mag_a	43173	73	0.147800926	43173	73	0.6875	12hr58min
13428	dy088_mag_a	43176	76	0.486111111	43176	76	0.95431713	10hr14min
13357	dy088_mag_b	43177	77	0.987002315	43178	78	0.365972222	09hr06min
13428	dy088_mag_b	43178	78	0.740277778	43179	79	0.131273148	09hr55min
13428	dy088_mag_b	43179	79	0.318113426	43179	79	0.446909722	04hr21min
13428	dy088_mag_c	43181	81	0.470775463	43182	82	0.559027778	27hr08min
13357	dy088_mag_d	43183	83	0.677083333	43183	83	0.899305556	05hr20min
13357	dy088_mag_d	43184	84	0.04375	43184	84	0.358333333	07hr33min
13357	dy088_mag_d	43184	84	0.504166667	43186	86	0.475694444	47hr19min
13357	dy088_mag_d	43186	86	0.545138889				

Total: 190hr06min

Appendix A9: Cleaning, processing and gridding multibeam data

MB Processing with Virtualbox

The EM122 and EM710 multibeam data were cleaned manually using MB System software version 5.5.2321 (25th November2017). RRS *Discovery* did not have MB software available for regular use, unlike the RRS *James Clark Ross* (*JCR*), on which it is available on the Linux server. MB was installed on laptops via Oracle VM VirtualBox software. Both pc and Mac laptops were successfully used to run VirtualBox and MB.

Oracle VM VirtualBox Manager needed to be installed on PC laptops (and one Mac) in order to run MB through a virtual box package including MB System and GMT. Older laptops were found to have insufficient processors to run VirtualBox (intel i5 CORE or better required). The installation instructions below follow notes provided by Jeremy Robst (BAS) on 18 December 2017.

1. Install Virtualbox 5.2.2 (or better).
2. Run Oracle VM Virtualbox
3. Machine, Add, D:\VirtualBox VMs\bsl-mbcruise-v1\bsl-mbcruise-v1.vbx
4. Select bsl-mbcruise-v1, Start
5. To login, click “Not listed?”
6. Username: mbproc
7. Password: 75!BROAD!egypt!FORGET!89
8. To process, start a terminal from the icon on desktop
9. Mb programs, GMT, SU are all included in the path, so e.g just type mbedit to start using
10. To setup a shared folder to get files on/off the linux machine
    1. Devices, Shared Folders, Shared Folders Settings
    2. Click Folder Icon with + symbol
    3. Path – e.g D:\shared
    4. Folder name: shared
    5. Make Permanent
    6. Then to access from linux enter the command (the mkdir only needs to be done once)

mkdir /local/users/mbprox/Shared

sudo mount –t vboxsf –o uid=1000,gid=1000 Shared /local/users/mbproc/Shared

    7. Any files placed in D:\Shared can then be access from the virtual machine in /local/users/mbproc/Shared and vice-versa

Note, the virtual machine should be treated like a real machine, and shutdown properly from the menu in the top right (the battery symbol, then the Off button) before shutting down Windows.

To copy to a new laptop, copy all the files in the D:\VirtualBox VMs\bsl-mbcruise-v1 directory and then use as above.

Once Virtualbox has been installed and the shared folders set up, the processing software was accessed as follows:

1. Run Oracle VM Virtualbox (double-click) (it takes a little while to start)
2. Select bsl-mbcruise-v1, Start
3. To login, click "Not listed?"
4. Username: mbproc
5. Password: 75!BROAD!egypt!FORGET!89
6. To process, double-click on a terminal from the icon on desktop
7. Use the up arrow and scroll to the command: "sudo mount –t vboxsf –o uid=1000,gid=1000 processed /local/users/mbproc/processed" Hit Enter.
8. Re-enter the mbproc password
9. Type "cd processed/[survey_name]" (changes directory into the processed directory for the survey that you want to work on)
10. Check the Processing Logsheet (printed out A4 sheet) and initial by the next available multibeam file
11. To start the multibeam editor just type "mbedit &" and open file to start editing.

Data preparation

Raw Kongsberg multibeam data (.all files) are converted to MBSystem format using the mbcopy command. This was done using the "mbcopy_em122" script, which was written by Jeremy Robst and is the same script used on the *JCR*. This script parses individual .all files through the mbcopy command and creates an MBSystem format file (.mb59) for each raw datafile. In the case of both the EM122 and EM710 the raw datagrams (MB format ID 58) are converted into MB format ID 59. The script also renames the files so that only the suffix changes, for example "0041_20180313_162544_discovery.all" becomes "0041_20180313_162544_discovery.mb59"; auxiliary files (.inf, .fbt, .fnv) are also created for each .mb59 file.

The script mbcopy_em122 was run manually each day converting the previous day's files to make ready for processing.

Data cleaning Using MB Edit

Data cleaning followed procedures described in previous cruise reports using MB on RRS *JCR* (e.g. JR259). Data, which are stored as half hour files on *Discovery*, were loaded into the

mbedit window cleaned ping by ping in waterfall view and in groups using acrosstrack view. Points flagged for removal by SIS were displayed in green as sonar edits, and were not reinstated. Points removed manually are displayed in red. Erroneous depths were removed manually, and each ping examined for topographic realism so that only correct depth data were preserved. Both the EM122 and the EM710 generated generally clean data, and no file contained large numbers of noisy pings, even in bad weather.

MB editing screen controls

Tabs

File tab (the larger, lower one): opens a file. Click on the file names that don't have a suffix. Navigating between survey folders is by using the filter tab.

View tab: alternates between 'alongtrack view' and 'waterfall view'. You will need to go through the file using both views.

Start tab: goes to start of file.

Reverse tab: reverses by one 'step' or group of pings. The size of the step is set on the sliding bar (see below).

Forward tab: advances by one 'step'. NB a right mouse click does the same as this command.

End tab: goes to the end of the file.

Done tab: exits the file, saving the edits.

Mode

Click on the diamonds as follows

Erase to edit out pings (using the mouse)

Restore to restore

Sliding bars

There four sliding bars: a. 'Across track width' – changes the horizontal exaggeration of the pings; b. 'Vertical exaggeration' – scales height of pings; c. 'Pings shown' changes the number of pings on the screen at one time; d. 'Pings to step' changes the number of ping lines advanced when you advance the view. This is set either the same as 'Pings shown', or a smaller number to fit pings on the screen more clearly.

Shortcuts

Click on a line then:

J = delete line to left

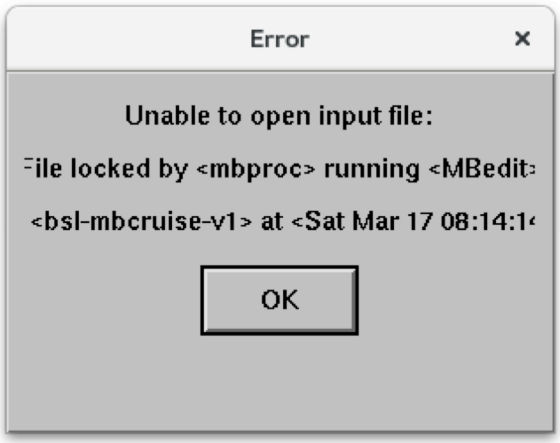
L = delete line to right

M = delete whole line

K = restore whole line

Locked files

Files sometime become ‘locked’, which prevents access by mbedit, and generating this error message:



The solution is to unlock the file by removing the .lck files.

To remove .lck files, type rm [the part of the file you want to delete/.lck file name]. You can copy and paste the file name through highlighting it and clicking the central mouse button. This is shown in the example below, in which file 0020 of survey dy0088_c has become locked:

```
[mbproc@bsl-mbcruise-v1 ~]$ pwd
/local/users/mbproc
[mbproc@bsl-mbcruise-v1 ~]$ ls
Acoustics  Documents  Music     processed  Templates
Desktop    Downloads  Pictures  Public     Videos
[mbproc@bsl-mbcruise-v1 ~]$ cd processed
[mbproc@bsl-mbcruise-v1 ~/processed]$ ls
dy088_a  dy088_b  dy088_c  dy088_em710_test_a
[mbproc@bsl-mbcruise-v1 ~/processed]$ cd dy088_c
[mbproc@bsl-mbcruise-v1 dy088_c]$ ls * 0020_*

[mbproc@bsl-mbcruise-v1 dy088_c]$ ls *0020_*
0020_20180314_043156_Discovery.mb59
0020_20180314_043156_Discovery.mb59.ata
0020_20180314_043156_Discovery.mb59.ath
0020_20180314_043156_Discovery.mb59.ats
0020_20180314_043156_Discovery.mb59.esf
0020_20180314_043156_Discovery.mb59.esf.stream
0020_20180314_043156_Discovery.mb59.esf.tmp
0020_20180314_043156_Discovery.mb59.fbt
0020_20180314_043156_Discovery.mb59.fnv
0020_20180314_043156_Discovery.mb59.inf
0020_20180314_043156_Discovery.mb59.lck
0020_20180314_043156_Discovery.mb59.par
0020_20180314_043156_Discovery.mb59.sta
[mbproc@bsl-mbcruise-v1 dy088_c]$ rm 0020_20180314_043156_Discovery.mb59.l
ck
```

Processing the data

Once ping-editing has been performed in mbedit these edits (saved in the . esf file) need to be applied to the raw data file (.mb59) and a processed data file (p.mb59) is created. In this way, neither the raw data file nor the edits are lost at any point, the edits are simply applied to the data and the new, processed data file is created. If additional editing had been performed (e.g. SVP corrections, navigation corrections) then these edits would also be applied at this stage; no additional editing of the data files was done on DY088.

Prior to running mbprocess the raw_datalist (created by mbcopy_em122 script) needs to be reformatted so that it can be read by MBSystem using the *mbdatalist* command:

```
mbdatalist –F-1 –Iraw_datalist > tmplist

mv tmplist raw_datalist

rm tmplist
```

To process, the command used is *mbprocess* in the form:

```
mbprocess –Iraw_datalist -F-1 -V
```

The command runs through the list of raw files and processed each one, also outputting auxiliary data files (.inf, .nav, .fbt) for each processed file.

After mbprocess has been run a processed data list was created using the commands:

```
ls *p.mb59 > tmplist

mbdatalist –F-1 –Itmplist > proc_datalist

rm tmplist
```

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Appendix A10: DY088 NMF Scientific Ship Systems Cruise Report

Andrew Moore (anmo@noc.ac.uk)

Scientific Ship Systems, NMF, National Oceanography Centre

Compiled on 25 March 2018

Printed on 31 March 2018

CONTENTS

1 CRUISE OVERVIEW

Cruise	Departure	Arrival	Technicians
DY088	07/03/18 (CLPUQ)	02/04/18 (CLPUQ)	Andrew Moore (anmo@noc.ac.uk) Hatim Shah (Trainee)

Scientific Ship Systems (SSS) is responsible for managing the Ship's network infrastructure, data acquisition, compilation and delivery, the email system and a range of ship-fitted instruments and sensors.

Unless stated otherwise all times in this report are UTC

2 SCIENTIFIC COMPUTER SYSTEMS

2.1 ACQUISITION

Network drives were setup on the on-board file server; firstly a read-only drive of the ships instruments data and a second scratch drive for the scientific party. Both were combined at the end of the cruise and copied to disks for the PSO and BODC.

Data was logged by the Techsas 5.11 data acquisition system. The system creates NetCDF and ASCII output data files located in the below 'TechSAS' directory. The format of the data files is given per instrument in the "Data Description" directory:

Cruise Disk Location:
'DY088/Cruise_Documentation/Data_Description_Documents/'
'DY088/Ship_Fitted_Scientific_Systems/TechSAS'

The Ship-fitted instruments that were logged are listed in the below file (includes BODC/Level-C notes):

'DY088_BODC_ship_fitted_information_sheet_DY.docx'
Cruise Disk Location: ***'DY088/Cruise_Documentation/'***

The NMF 'RVDAS/Level-B' raw data logger also records raw data streams as a backup/QC option to the primary Techsas logger. These raw ASCII files are located in the below cruise directory:

Cruise Disk Location: ***'DY088/Ship_Fitted_Scientific_Systems/Level-B'***

Data was additionally logged into the legacy RVS Level-C format.

There are ASCII dumps of all the Level-C streams included on the data disk in the directory:

Cruise Disk Location: ***'DY088/Ship_Fitted_Scientific_Systems /Level-C/enterprise-pro_data/ascii/'***

2.1.1 Main Acquisition Period

Techsas logging for 'DY088' commenced whilst alongside in CLPUQ (Punta Arenas, Chile) on 06/03/2018 (J065). Legacy 'Level-C' logging started on 07/03/2018 (J066). Following departure from CLPUQ approx. 19:00 07/03/2018 (J066) further acoustic data collection was started.

All logging was concluded 03/04/2018 (J0xx) at arrival in CLPUQ (Punta Arenas, Chile).

2.1.2 Events/Data Losses

On J081 (22/03/2018) there was a failure of the Applanix GPS system from between 00:20 → 01:155 where the position and attitude data should be treated with caution. This period included an initial failure of the GPS resolution (with the nav status reduced to dead reckoning but with correctly operating attitude information), and was followed by a system restart which results in reduced attitude performance for 30 minutes. This occurred during a EM122/SBP120 survey period – during this time the Seapath 330 was used to provide the require EM122 input.

Underway sampling acquisition gaps (from cleaning, etc.) are tabulated in the Surfmet section of this document and may also be found in the event log sheets in the Surfmet directory.

2.2 COMMUNICATIONS

On board for the cruise were 22 marine staff, 6 NMF technicians, and 8 members of the science party.

2.2.1 INTERNET PROVISION

Satellite Communications were provided with both the Vsat and FBB systems. The Vsat had a guaranteed speed of 1.5Mbps unlimited data (and provides 3 on board phone lines to cabins/work areas) and the FBB had a maximum un-guaranteed speed of 256kbps with a 20GB monthly plan.

2.2.2 EMAIL PROVISION

Email communications were provided primarily through user email clients, web-browser clients and via the AMS system (available as a back up if primary communications were lost).

3 INSTRUMENTATION

3.1 POSITION AND ATTITUDE

GPS and attitude measurement systems were run throughout the cruise.

3.1.1 APPLANIX POSMV

The ***Applanix POSMV*** system is the vessel's primary scientific GPS system, outputting the position of the ship's common reference point in the gravity meter room (Refer to Parker Report, 2013 – Enclosure 3/Coordinate System 2). The POSMV is available to be sent to all scientific systems and is repeated around the vessel. The position fixes attitude and gyro data are logged to the Techsas system. Position fixes and attitude data is logged to the Techsas system.

The POSMV was the position and attitude source used by the EM122/EM710/SBP120 as appropriate during this cruise.

3.1.2 KONGSBERG SEAPATH 330

The ***Kongsberg Seapath 300*** system is the vessel's secondary GPS system. It provides an input to the Gravity meter due to the POSMV not having vessel course available in its RMC NMEA message. Position fixes and attitude data is logged to the Techsas system.

3.1.3 C-NAV 3050

The ***CNav 3050*** GPS system is a differential correction service. It provides the Applanix POSMV system with RTCM DGPS corrections (greater than 1m accuracy). The position fixes data are logged to the Techsas system.

3.1.4 FUGRO SEASTAR 9205

The **Fugro Seastar 9205** GPS system is a differential correction service. It provides the Seapath system with RTCM DGPS corrections, but this input service was not functional during the DY088 cruise. Fugro NMEA output messages are logged to the Techsas system.

3.2 METEOROLOGY AND SEA SURFACE MONITORING PACKAGE

The NMF Surfmet system was run throughout the cruise, excepting times for cleaning, entering and leaving port and whilst alongside. Please see the separate information sheet for details of the sensors used and whether calibrations values have been applied:

'DY084_Surfmet_sensor_calibrations.docx'
Cruise Disk Location: ***'DY088/Ship_Fitted_Scientific_Systems/Surfmet/'***

Instrument calibration sheets are also included within this directory.

3.2.1 UNDERWAY TSG DATA

Events, including cleaning and any observed issues/flow adjustments (e.g. occasions when the transmissometer was noisy) were recorded and scans of these log sheets are also included on the disk in the above 'Surfmet' directory.

Date:	Julian Day:	Time:	Event:	Notes:
09/03/2018	068	14:20	Underway started	
09/03/2018	068	16:40	Underway stopped	Broken pipe in engineering – non-toxic off (including SBE38 sensor in engine room)
10/03/2018	069	11:42	Underway started	Above repair completed.
10/03/2018	069	17:00	Levels Adjusted	Noisy on station.
25/03/2018	084	00:22	Underway stopped	Broken non-toxic valve on aft deck – system turned off for repair.
25/03/2018	084	17:56	Cleaning of instrumentation	Above repair ongoing. Cleaning of SBE45*/CST/Fluo)
26/03/2018	085	14:04	Underway started	Above repair completed.
29/03/2018	088	16:11	Underway stopped	Conclusion of cruise underway logging.

* The SBE45 requires cleaning approximately every month with sustained operation (Advised in Seabird Manual).

These events are included in the above log sheets for the underway system.

3.2.2 BAROMETER FAILURE

The Vaisala PTB210 pressure sensor mounted on the met platform failed due to freezing/water damage. This occurred first on **J072 20:44:31**. Following this time there were some brief periods of operation, but the data should be disregarded from this point to the conclusion of the cruise.

3.3 KONGSBERG EA640 10 & 12 KHZ SINGLE-BEAM

The EA640 single-beam echo-sounder was run throughout the cruise. The 10kHz transducer was used. This depth was primarily used as the input for the CLAM (Cable Logging and Measurement) during dredging and coring activities. During these deployments the ping interval was increased to 1 second where appropriate.

The system used a constant sound velocity of 1500 ms^{-1} throughout the water column to allow it to be corrected for sound velocity in post processing if required.

Salinity (35 PSU) and Temperature (10degreeC) and Conditions (salt water) were also left at their initial constant values for the cruise duration.

Kongsberg *.raw files (100MB maximum file size) and *.xyz files are logged and depths were logged to Techsas and Level-C.

3.4 KONGSBERG EM122 MULTI-BEAM ECHO SOUNDER.

The EM122 multibeam echo-sounder was configured to free-run throughout the cruise. SIS was used to record and display multi-beam data.

The position, attitude and velocity data was provided by the Applanix POS-MV.

Between 00:29 →01:55 J081 (22/03/18) the Seapath330 temporarily provided GPS/Attitude data due to a failure of the Applanix system.

Cruise Disk Location: ***'DY088/Ship_Fitted_Scientific_Systems/Acoustics/*EM122**

3.4.1 SURFACE SOUND VELOCITY

Surface sound velocity is provided to Kongsberg's SIS systems (EM122 and EM710) by the AML MicroX-SV sensor installed on the bottom of the drop keel. This data is broadcast over the scientific/Kongsberg network to the EM122 and EM710 SIS computers. 'Runtime Parameters' within SIS allow the use of this surface sound velocity sensor data ('SENSOR'). If surface sensor data is unavailable SIS can use the near-surface SV value from the currently loaded sound velocity profile ('PROFILE').

During the beginning of the cruise SIS would not accept the broadcasted 'SENSOR' datagram into the EM122 SIS, so profile value was used and variation between profile surface and SV sensor was monitored in order to identify when a new SV profile would be required. This issue was resolved around 19:00 13/03/2018 (J072) and then allowed surface SV values to be used in real-time to improve data acquisition, as well as indicate more clearly (using yellow and red SIS indication for 3m/s and 5m/s deviations respectively) to the SIS watchkeeper when a new SV profile would be required.

3.4.2 INSTALLATION CONFIGURATION

Installation and runtime screenshots can be found in the Appendices of this report. Installation was verified during mobilisations against the vessel's Parker Survey Report). This report is included with the cruise documentation on the data disk.

3.5 KONGSBERG EM710 SHALLOW MULTI-BEAM ECHO SOUNDER

The EM710 multibeam echo-sounder was run for shallow water (<900m) surveys. Data was logged between 19:15 13/03/2018 and 18:50 19/03/2018.

The position, attitude and velocity data was supplied by the Applanix POS-MV.

The EM710 used the drop keel-mounted surface sound velocity sensor for calculating sound speed at transducer, and identifying the requirement for taking a new sound velocity profile.

Cruise Disk Location: ***'DY088/Ship_Fitted_Scientific_Systems/Acoustics/*EM710**

3.5.1 INSTALLATION CONFIGURATION

Installation and runtime screenshots can be found in the Appendices of this report. Installation was verified during mobilisations against the vessel's Parker Survey Report. This report is included with the cruise documentation on the data disk.

3.6 SBP120

The Kongsberg Sub-Bottom Profiler (SBP120) was run for the duration of the cruise. The system uses the EM122 receive (RX) array.

The position, attitude and velocity data was provided by the Applanix POS-MV.

3.6.1 RUNTIME PARAMETERS

For shallow-water operations the SBP ping interval was set at fixed rate to no less than 2000ms. Deep-water operations used a varying ping interval that enabled maximum data resolution. The system acquisition window was generally set at 500ms for all depths, due to not requiring high-

resolution data for more shallow operations. Power was mainly set to the minimum levels (-30dB), to a maximum of -27dB. The maximum 11 beams were used for acquisition. Automatic slope correction was off.

Cruise Disk Location: ***'DY088/Ship_Fitted_Scientific_Systems/Acoustics/SBP120'***

3.6.2 INSTALLATION PARAMETERS

The SBP uses the vessel survey (Parker Report 2013 – Coordinate System 2, enclosure 3) to define Installation settings and enable positional calculations for between the vessel central reference point (CRP) and transducer.

Installation and runtime screenshots can be found in the Appendices of this report. Installation was verified during mobilisations against the vessel's Parker Survey Report. This report is included with the cruise documentation on the data disk.

3.7 SOUND VELOCITY PROFILES

Sound velocity profiles were taken with the MIDAS Valeport SVP SN:41603 and applied to the EM122 and EM710 systems shortly after their acquisition.

Time	Profile	Position	Notes
07/03/2018	20180125 (DY087 Profile)	-	(DY087) Pre-loaded at start of cruise.
10/03/2018 22:37	10032018 (FILE20.000)	Lat: -57.17 S Lon: -54.90 W	J069
12/03/2018 12:37	12032018 (FILE24.000)	Lat: -59.50 S Lon: -44.45 W	J071
13/03/2018 08:37	13032018 (FILE28.000)	Lat: -59.68 S Lon: -44.83 W	J072
14/03/2018 03:37	14032018 (FILE32.000)	Lat: -60.86 S Lon: -45.58 W	J073
14/03/2018 17:37	14032018_2 (FILE36.000)	Lat: -61.44 S Lon: -45.92 W	J073
15/03/2018 07:37	15032018 (FILE40.000)	Lat: -61.69 S Lon: -46.39 W	J074
20/03/2018 05:37	20032018 (FILE45.000)	Lat: -60.58 S Lon: -41.55 W	J079
21/03/2018 18:37	14032018 (FILE49.000)	Lat: -59.93 S Lon: -39.16 W	J080

23/03/2018 19:05	23032018 (FILE53.000)	Lat: -60.25 S Lon: -34.85 W	J082
27/03/2018 14:02	27032018 (FILE56.000)	Lat: -55.27 S Lon: -46.97W	J086

Cruise	Disk	Location:
'DY088/Ship_Fitted_Scientific_Systems/Acoustics/Sound_Velocity_Profiles/'		

3.8 AIRSEAII GRAVITY METER

At the conclusion of DY087 the gravity meter (S-084) was tied in at CLPUQ (Punta Arenas). This acts as a pre-cruise tie in for DY088 as power was maintained to the instrument. The instrument was operational during the cruise - running directly from the vessel's 110VAC supply available in the Gravity room. The unit was configured to use Control Module 2 (CM2) and Power Module 1 (PM1). Post-cruise tie in was completed at the return to Punta Arenas.

The instrument has an NMEA183 GPS RMC input from the Seapath330 system to provide position, course and speed information.

3.8.1 INCLUDED TIE IN INFORMATION

Lacoste & Romberg Model G land gravity meter serial number G-167 was used for the CLPUQ tie-ins. The meter's interval factor table is included in the 'Tie_In_Files' directory and referred to on the tie in documentation which is also included (scans and an electronic copy of the calculation).

Cruise Disk Location: ***'DY088/Ship_Fitted_Scientific_Systems/Gravity/tie_in_files'***

3.8.2 S-084 CONFIGURATION & COEFFICIENT INFORMATION

Configuration information is included in sub-directories of the main Gravity_meter directory – the main meter config files are specific to the Control Module used (CM2): 'ASII_Hw.ini' and 'ASII_Sw.ini'. The meter coefficient (for converting from Counter Units to milligals is found in the ASII_Hw.ini file as 'Coeff1'.

For S-084 Coeff1 = 0.9967

This data is also included on the individual tie in records.

3.8.3 GRAVITY DATA FILES

Gravity data is logged by the Techsas logger in ASCII and NetCDF format (refer to Techsas section for more information) but also included on the disk is the ASCII data that is logged locally on the meter (**refer to below about timing offsets for local files**).

The AirSeaII Meter data files (*.DAT and *.ENV) can be found in the below location. *.ENV files are environmental data files that are logged at 10-second intervals. *.DAT files are 1-second resolution and contain the gravity data. AirSeaII data format information can be found in the file ***'Air Sea II Manual v2_Oct_2010.pdf'*** located in the Manuals sub-directory of the Gravity_Meter directory.

Cruise Disk Location: ***'DY088/Ship_Fitted_Scientific_Systems/Gravity/data'***

3.8.4 LOCAL FILE TIMING OFFSET

Gravity data for cruise use was a later addition – and as a consequence checks were not made during the mobilisation period to set the gravity software to match the GPS input time. The AirSea software reads the PC clock on its initial power up – however PC clocks drifts. If this clock is not reset prior to the restart of the software a incorrect time will be maintained by the instruments accurate rubidium clock.

This means that local files (*.DAT) will be offset to the GPS time (not position). This offset is a GPS time 97seconds ahead of the local log file time (the time logged in the *.DAT file).

In order to avoid this issue potentially occurring, an additional time stamp is applied at the point of acquisition (Level-A) so this means all gravity netcdf files (logged by the Techsas acquisition system) contain the correct GPS time.

3.8.5 RECALCULATION OF GRAVITY

It is advised that gravity values should be recalculated using raw values as described in *'Air Sea II Manual v2_Oct_2010.pdf'*.

This is primarily because it has been observed that the instrument does not appear to correctly apply cross-coupling values during its internal gravity calculations. The on board gravity QC tools

(written by Professor Christine Peirce of University of Durham) allow comparison of the instrument FAA gravity data with Sandwell & Smith satellite data. This comparison shows increased errors when the vessel is listing, where there is seen a strong correlation between FAA difference error and recorded vessel roll.

A second QC tool was written that recalculated gravity from the raw data (spring tension, beam scale, cross-coupling – using the instruments configuration file cross-coupling coefficients) and the error with S&S was significantly reduced.

Recalculated gravity results in an error for most of the cruise within +/-10mGal of S&S, and with it generally not deviating beyond +/-20mGal, except in instances where other corrections (i.e. for terrain/bathymetry) would be expected to be required to be taken into account.

3.9 MAGNETOMETER

The Marine Magnetics SeaSPY (MK1) magnetometer was used during most longer survey/passage components of the cruise. The two instruments used were S/N:13428 and 13357.

3.9.1 GPS INPUT

Marine Magnetics BOB Magnetometer Software (Version 2.5.0.0) was used for the acquisition and logging. A serial GPS input was used from the Applanix POSMV (via the ships serial splitter) to provide the system with navigation information (GGA and RMS NMEA183 messages).

3.9.2 LAYBACK

A layback of 300m was calculated as the distance between the deployed instrument and the GPS system central reference point. This equated to 280m of deployed cable and the remaining distances were calculated from the ships Survey Report (based on GPS reference point and the position of the electric winch).

The BOB acquisition software was set up to apply this layback to the survey database for all Magnetometer survey operations. However on inspection of the exported files there is an issue where sections of data for the ***'Mag_Longitude'*** and ***'Mag_Latitude'*** fields actually match the ***'GPS_Longitude'*** and ***'GPS_Latitude'*** fields – meaning the layback has not been applied.

This behaviour follows a switching pattern of approximately 160secs where the layback is applied to 'Mag_' fields, and then approximately 85secs where the values match the 'GPS_' fields. Marine Magnetics have been consulted regarding this issue, but **for the purposes of this data set,**

it is advised that the GPS fields in the exported survey database files be used and then a layback of 300m be applied in post-processing.

3.9.3 DATA OUTPUT

Data was exported/transferred periodically from the networked magnetometer laptop to the DY088 cruise directory. All data can be found within the below location:

Cruise Disk Location: ***'DY088/Ship_Fitted_Scientific_Systems/Magnetometer***

- All variables were included for each exported (*.csv) survey database. Refer to the Marine Magnetics Documentation on the cruise disk for further description of this format.
- All 'mag/gps/parse error' logfiles were also transferred for the period of the cruise.
- Log sheets were completed recording events and for functional testing of the magnetometer prior to deployment. These log sheets are scanned and included in the cruise folder.

3.9.4 SUMMARY

Deployment information is tabulated in the **'NMFSS Magnetometer Time Sheet.xlsx'** file. There were four Surveys completed, spanning 13 deployments – resulting in approximately 240 hours of in-water magnetic data collection.

3.9.5 EVENTS

At 11:45 17/03/2018 magnetometer S/N:13428 was hit by a 'growler' which ran along the tow cable and then struck the instrument as it pulled it to the surface briefly. This was identified from a report from the bridge and was confirmed from inspection of the data (between 11:45:00→11:45:25). The instrument sustained damage to the tail assemble - including the loss of one of its fins. The instrument was otherwise undamaged and later used an alternative tail assembly (from 13357).

S/N: 13357 was used for a deployment following the damage to 13428. During the functional testing for its second deployment it was found to have sustained a leak. On inspection this was confirmed, but review of the previous data showed the leak did not occur until following the

conclusion of data logging (i.e. during recovery/sink-cleaning of instrument). The instrument was stripped down and cleaned and operated successfully for later deployments.

Cruise Disk Location: ***'DY088/Ship_Fitted_Scientific_Systems/Magnetometer***

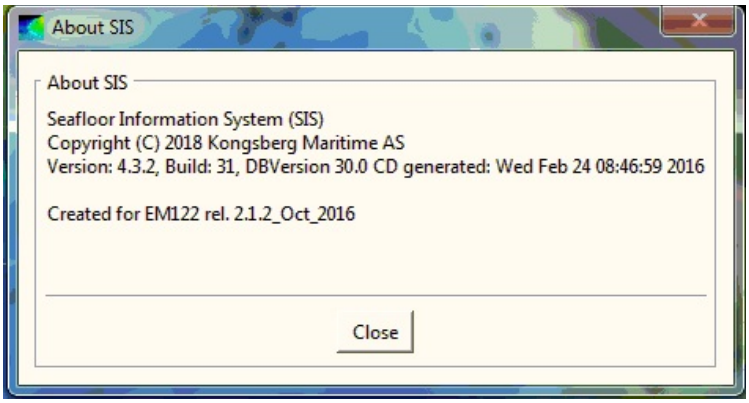
3.10 ULTRA-SHORT BASELINE ACOUSTIC POSITIONING (USBL)

The Ultra-Short BaseLine acoustic positioning system was briefly used at the start of the cruise. Beacon S/N:303272-005 (Type. 8270 WSM6, 4000m rated) was used on the first dredge (water depth approximately 2300m) but was damaged during the operation and did not provide a useable position. At the first core site beacon S/N:290249-002 (Type. 8190, WMT 7000m rated) was attached to the corer and deployed. The logged beacon position was satisfactorily close to that of the vessel, and it was decided to not use the system for future coring operations.

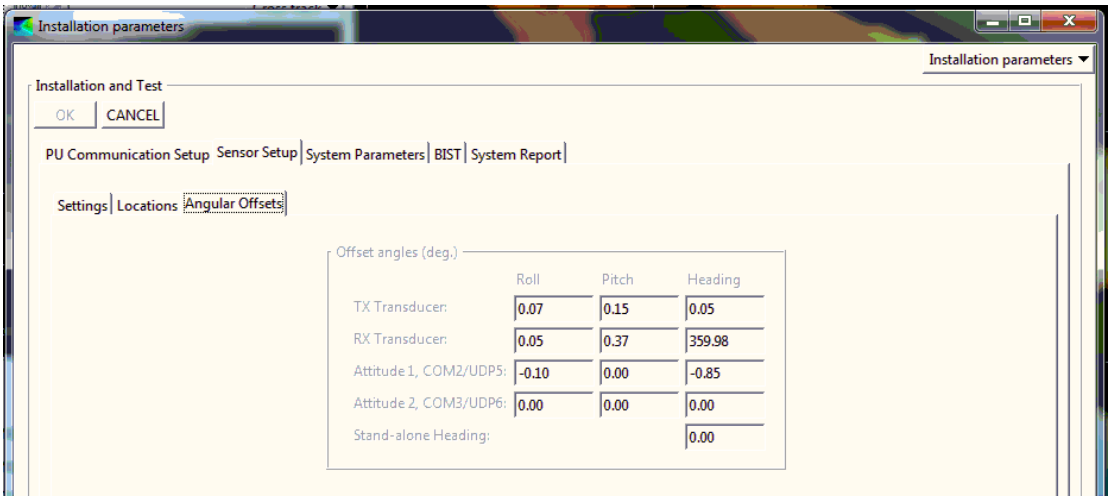
4 APPENDICES

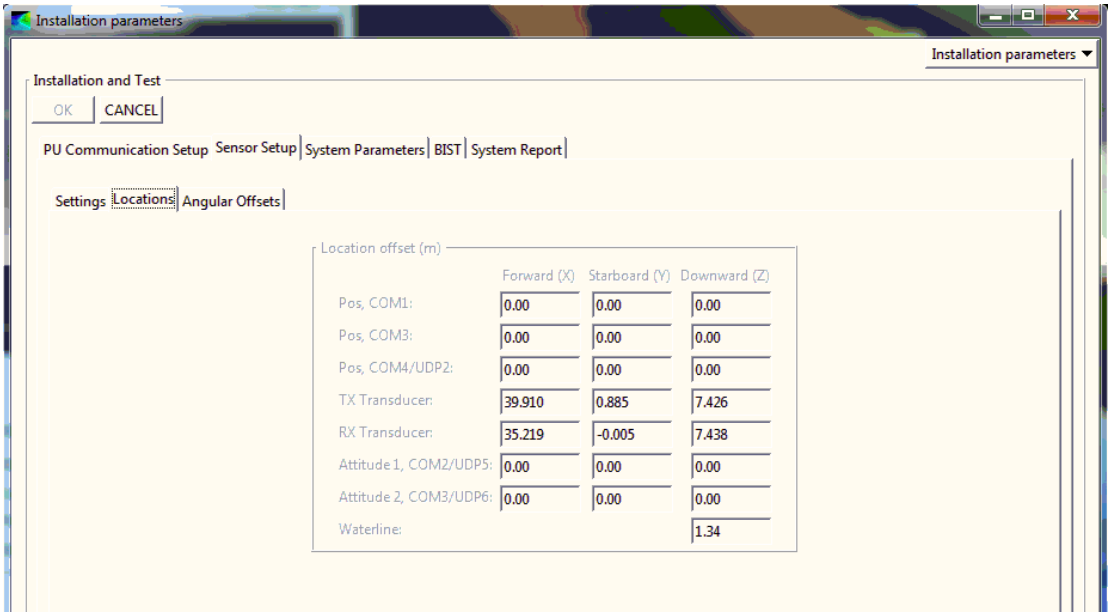
4.1 EM122 SIS INSTALLATION & RUNTIME PARAMETERS:

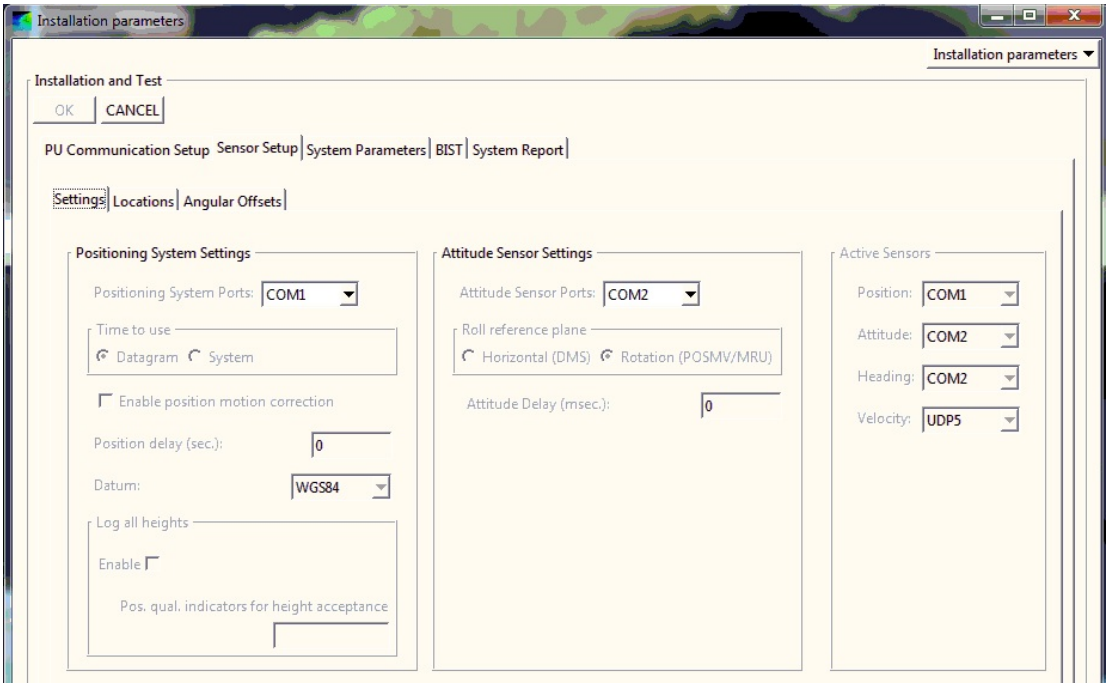
SIS Software Version:

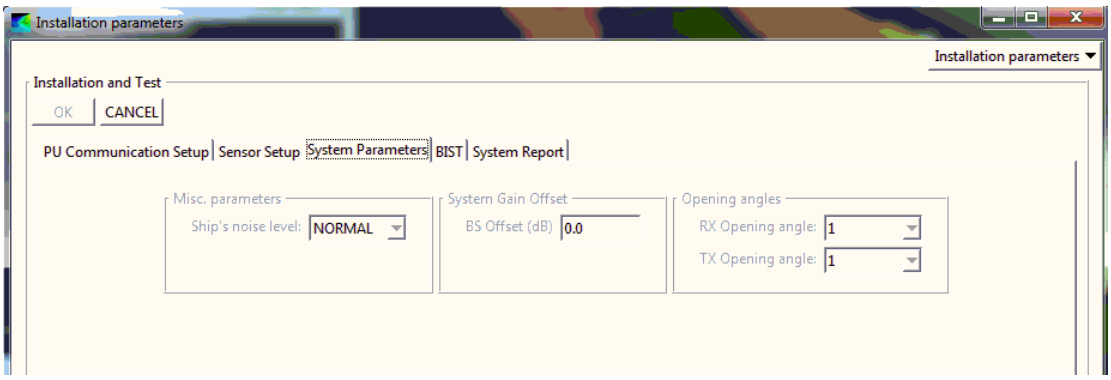


Installation Parameters (Defined prior to first Survey):




Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
Location offset (m)
Forward (X)
Starboard (Y)
Downward (Z)
Pos, COM1:
0.00
0.00
0.00
Pos, COM3:
0.00
0.00
0.00
Pos, COM4/UDP2:
0.00
0.00
0.00
TX Transducer:
39.910
0.885
7.426
RX Transducer:
35.219
-0.005
7.438
Attitude 1, COM2/UDP5:
0.00
0.00
0.00
Attitude 2, COM3/UDP6:
0.00
0.00
0.00
Waterline:
1.34


Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
Positioning System Settings
Positioning System Ports:
COM1
Time to use
Datagram
System
Enable position motion correction
Position delay (sec.):
0
Datum:
WGS84
Log all heights
Enable
Pos. qual. indicators for height acceptance
Attitude Sensor Settings
Attitude Sensor Ports:
COM2
Roll reference plane
Horizontal (DMS)
Rotation (POSMV/MRU)
Attitude Delay (msec.):
0
Active Sensors
Position:
COM1
Attitude:
COM2
Heading:
COM2
Velocity:
UDP5


Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Misc. parameters
Ship's noise level:
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System Gain Offset
BS Offset (dB)
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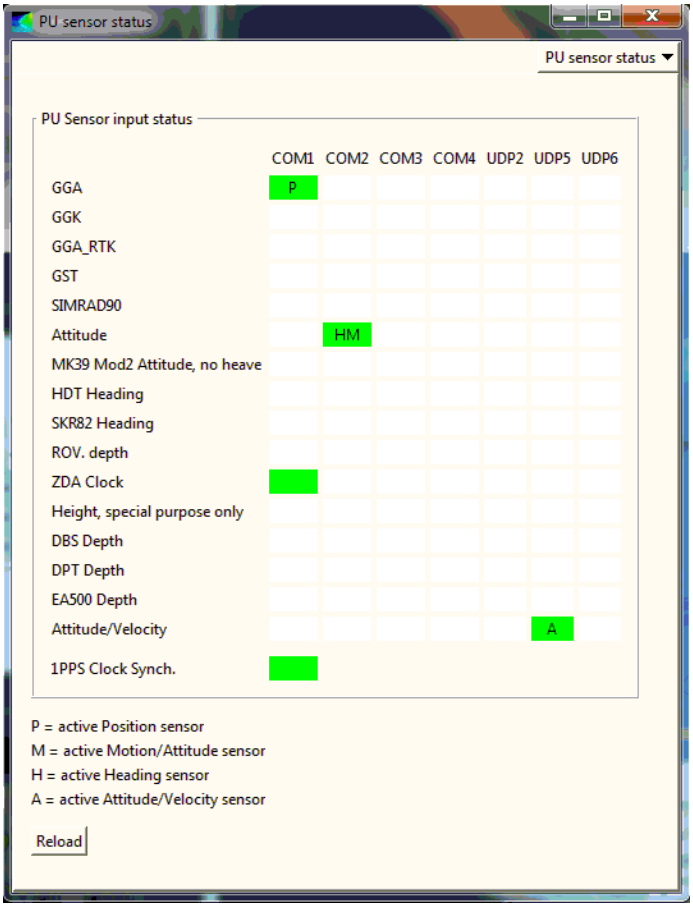
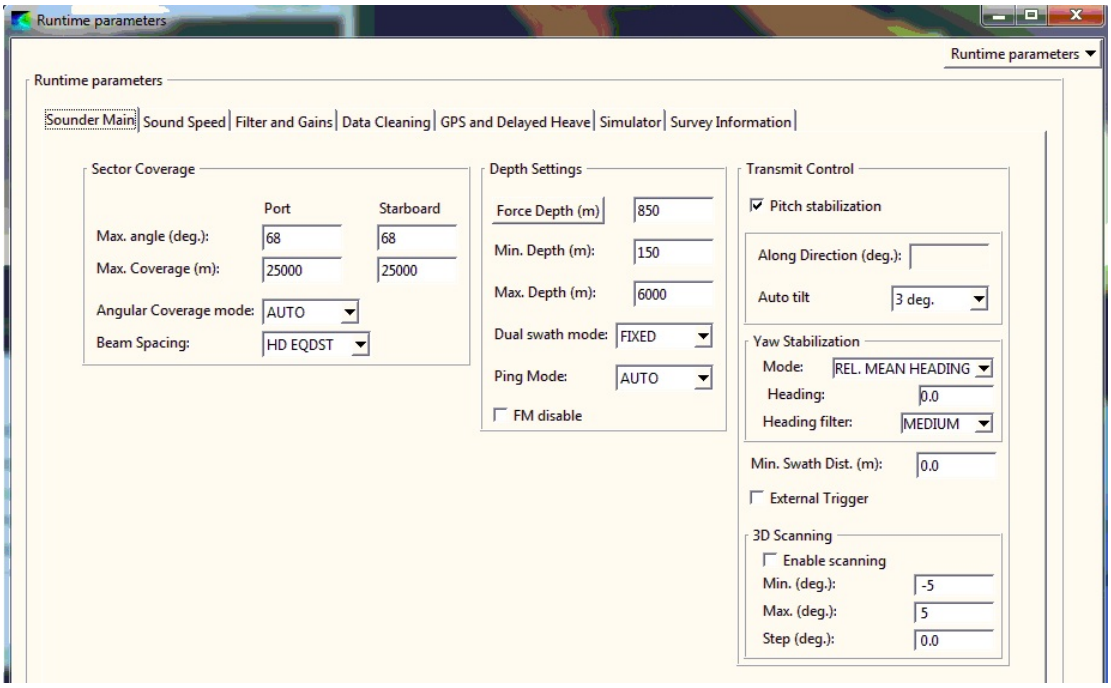
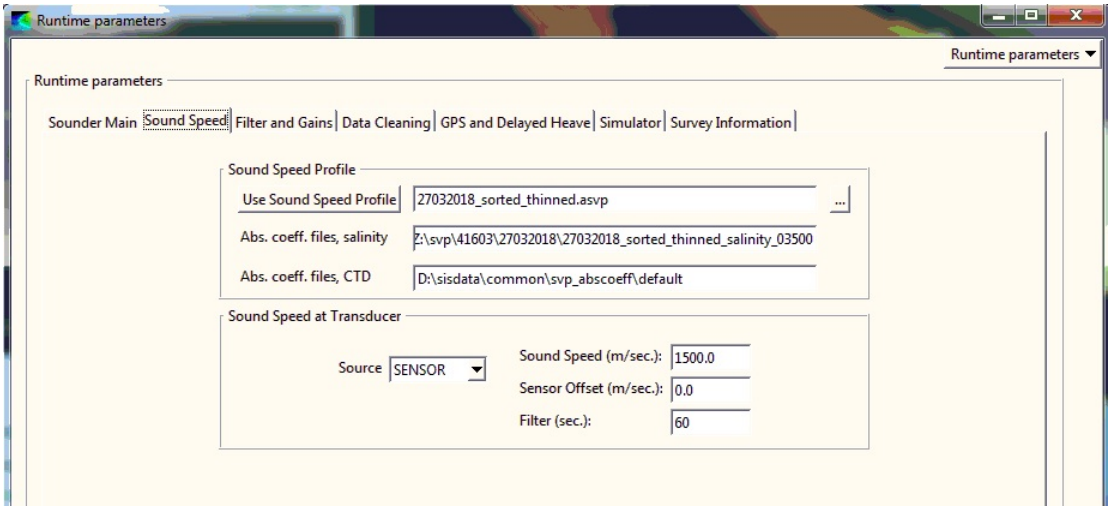
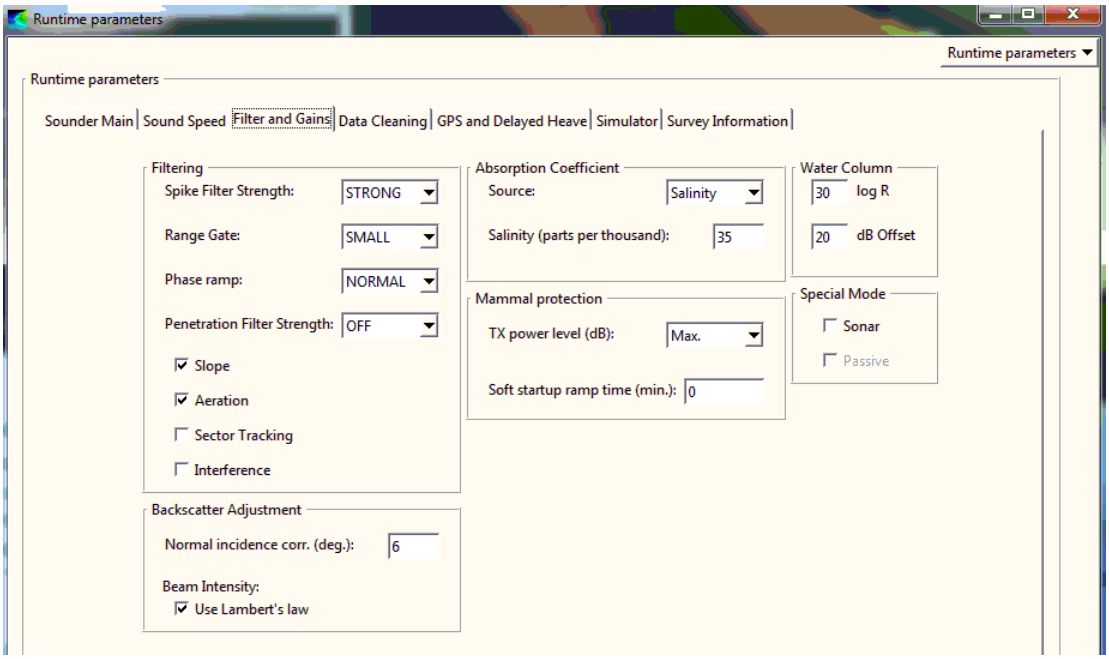
Opening angles
RX Opening angle:
1
TX Opening angle:
1

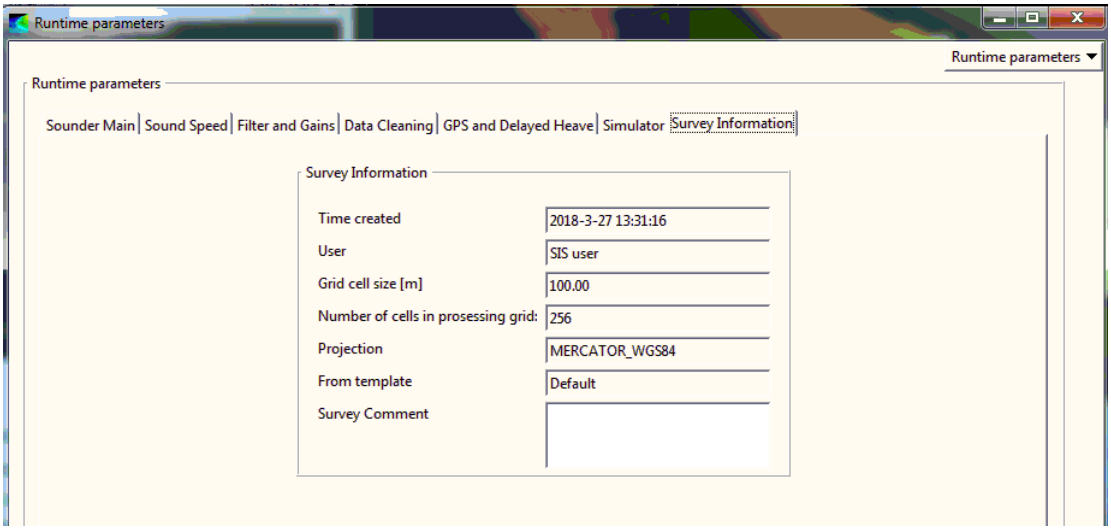


EM710 SIS Runtime Parameters (Changes made to Sector Coverage/Depth Settings as required due to conditions and desired local swath coverage):



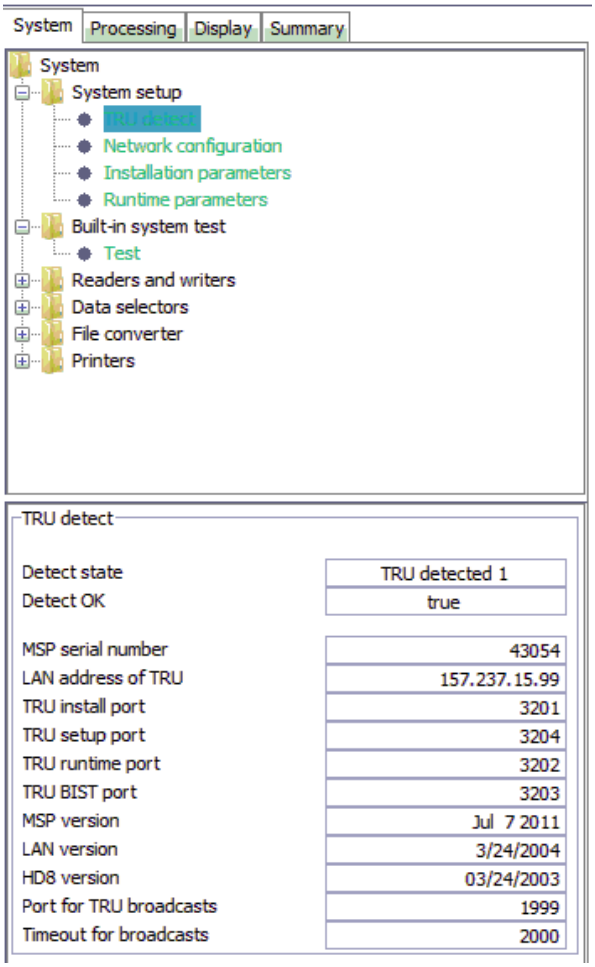

Runtime parameters
Runtime parameters
Runtime parameters
Runtime parameters
Sounder Main
Sound Speed
Filter and Gains
Data Cleaning
GPS and Delayed Heave
Simulator
Survey Information
Sound Speed Profile
Use Sound Speed Profile
27032018_sorted_thinned.asvp
Abs. coeff. files, salinity
Z:\svp\41603\27032018\27032018_sorted_thinned_salinity_03500
Abs. coeff. files, CTD
D:\sisdata\common\svp_abscoeff\default
Sound Speed at Transducer
Source
SENSOR
Sound Speed (m/sec.):
1500.0
Sensor Offset (m/sec.):
0.0
Filter (sec.):
60

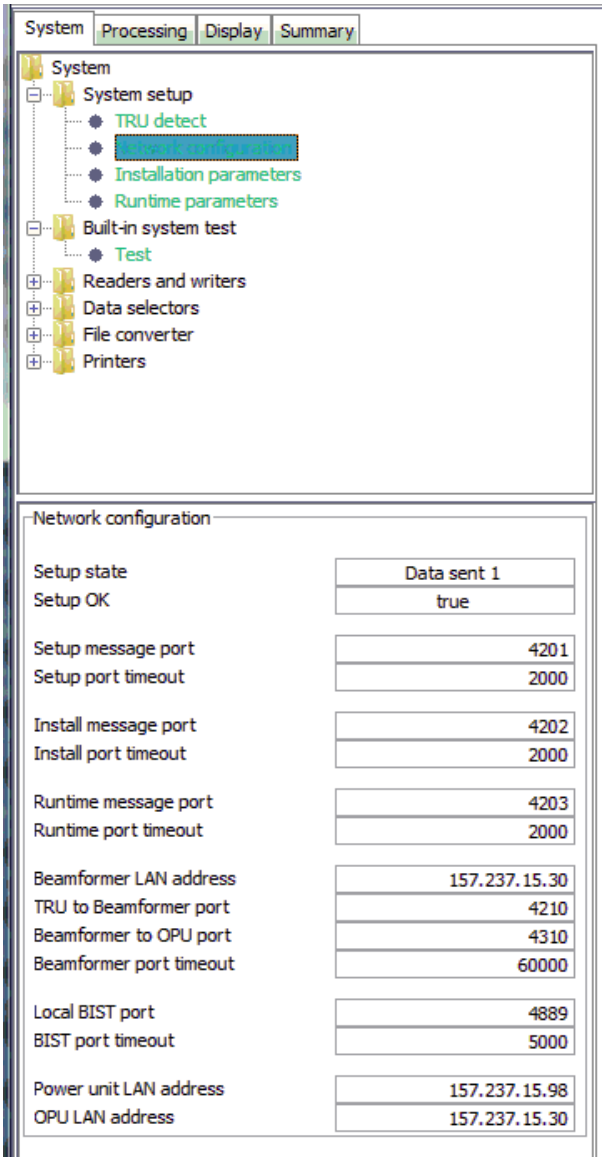

Runtime parameters
Runtime parameters
Runtime parameters
Sounder Main
Sound Speed
Filter and Gains
Data Cleaning
GPS and Delayed Heave
Simulator
Survey Information
Filtering
Spike Filter Strength:
STRONG
Range Gate:
SMALL
Phase ramp:
NORMAL
Penetration Filter Strength:
OFF
Slope
Aeration
Sector Tracking
Interference
Absorption Coefficient
Source:
Salinity
Salinity (parts per thousand):
35
Water Column
30
log R
20
dB Offset
Mammal protection
TX power level (dB):
Max.
Soft startup ramp time (min.):
0
Special Mode
Sonar
Passive
Backscatter Adjustment
Normal incidence corr. (deg.):
6
Beam Intensity:
Use Lambert's law

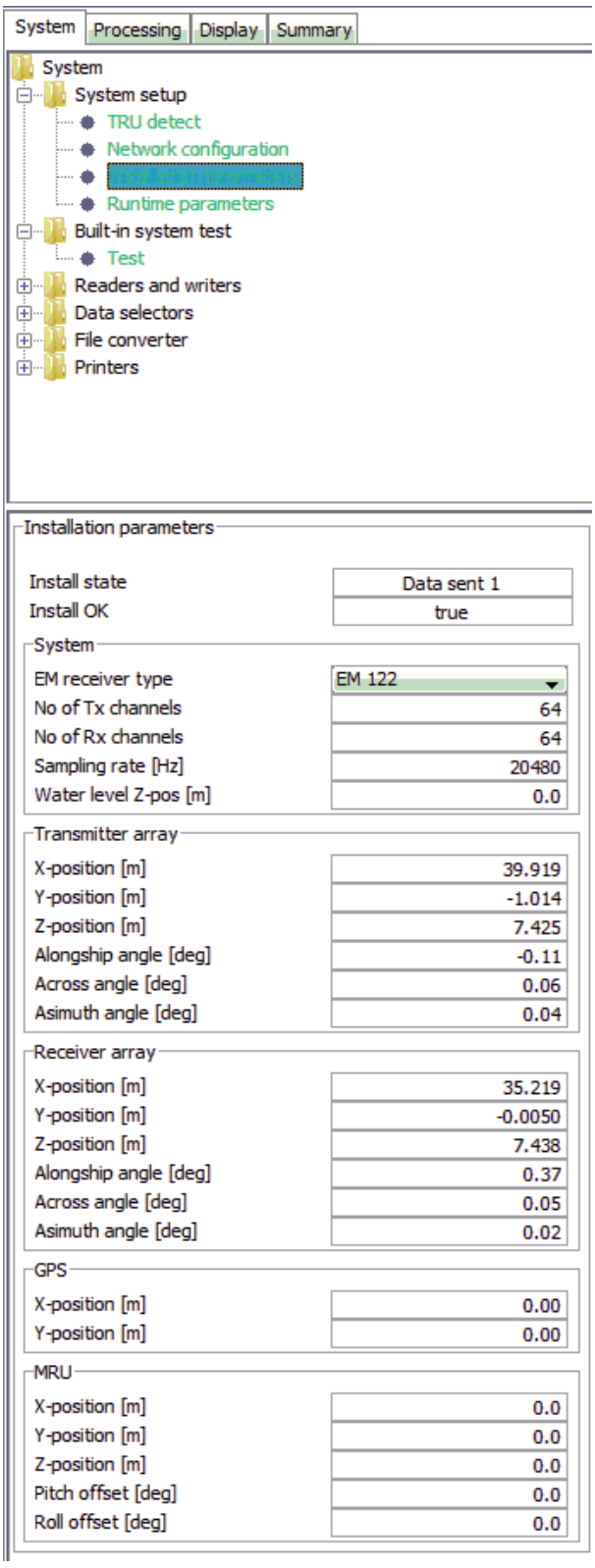

Runtime parameters
Runtime parameters
Runtime parameters
Sounder Main
Sound Speed
Filter and Gains
Data Cleaning
GPS and Delayed Heave
Simulator
Survey Information
Survey Information
Time created
2018-3-27 13:31:16
User
SIS user
Grid cell size [m]
100.00
Number of cells in prosessing grid:
256
Projection
MERCATOR_WGS84
From template
Default
Survey Comment

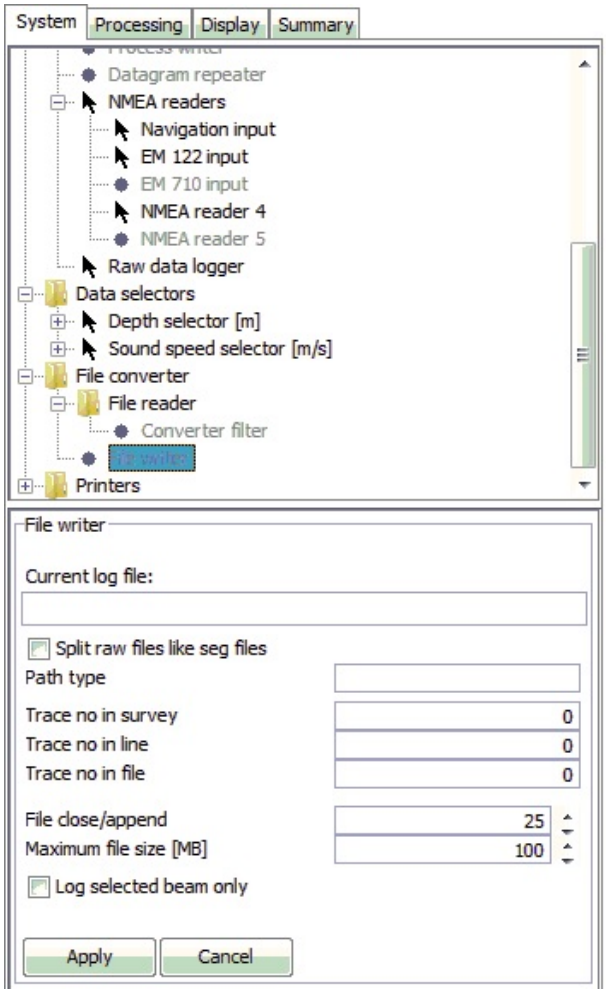
4.2 SBP120 SYSTEM & PROCESSING PARAMETERS

System:

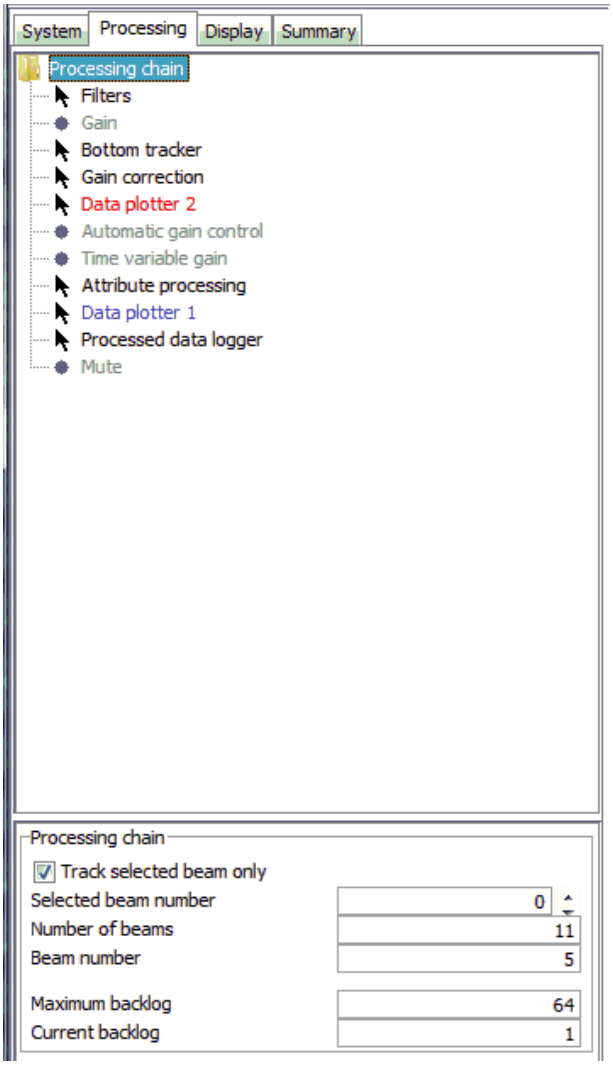


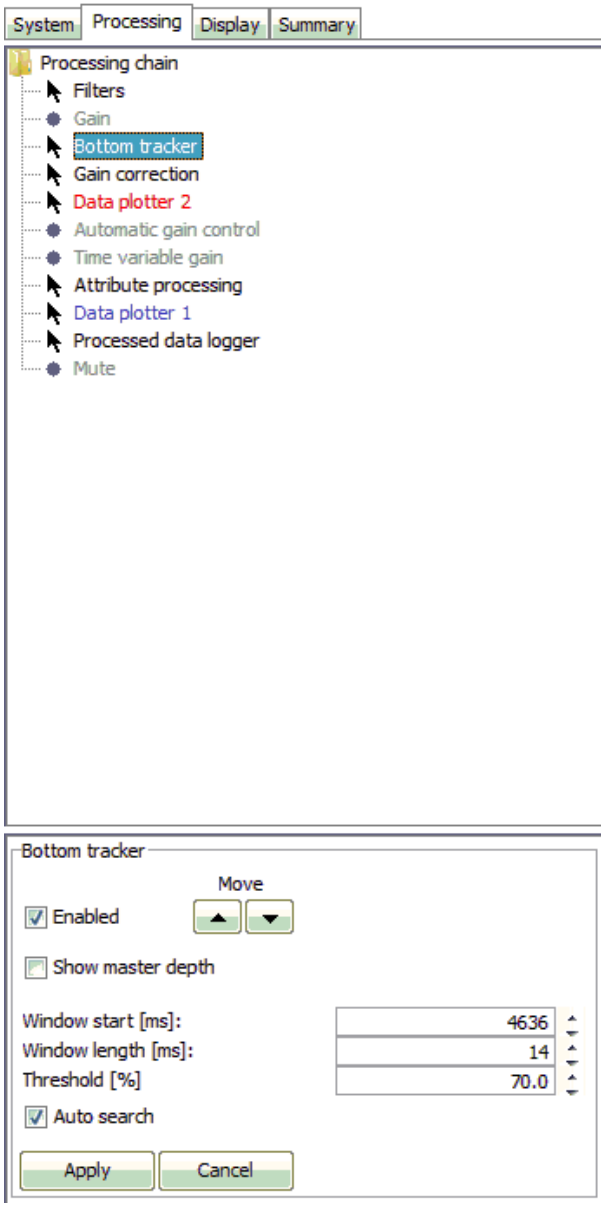


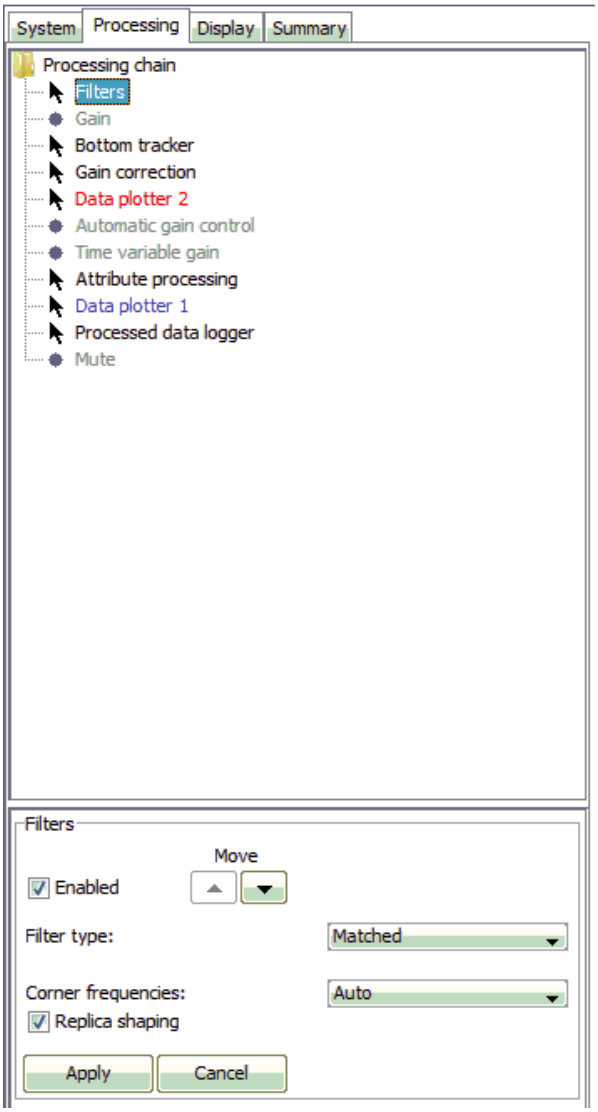


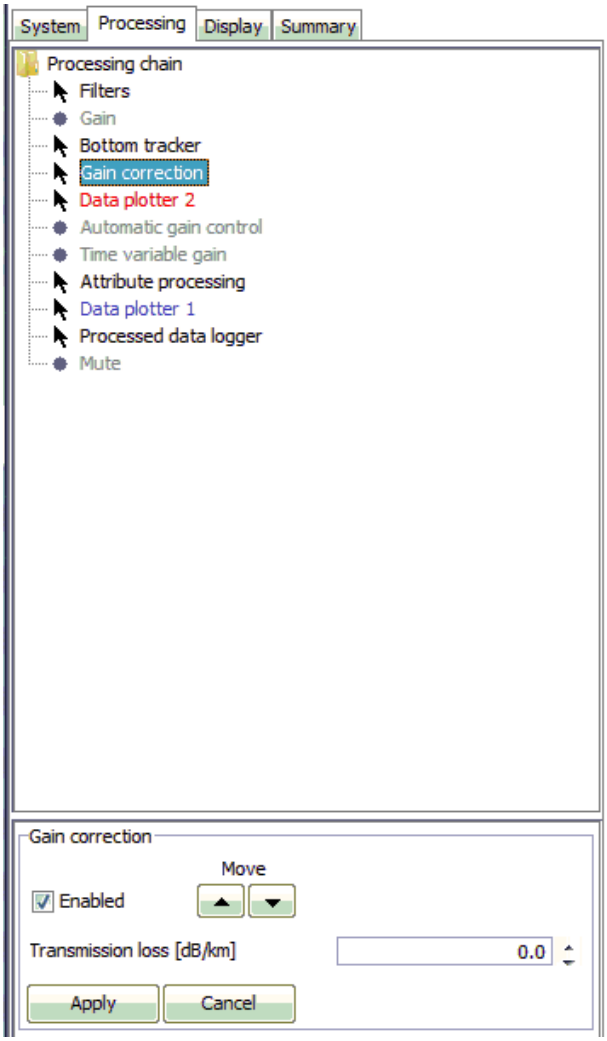


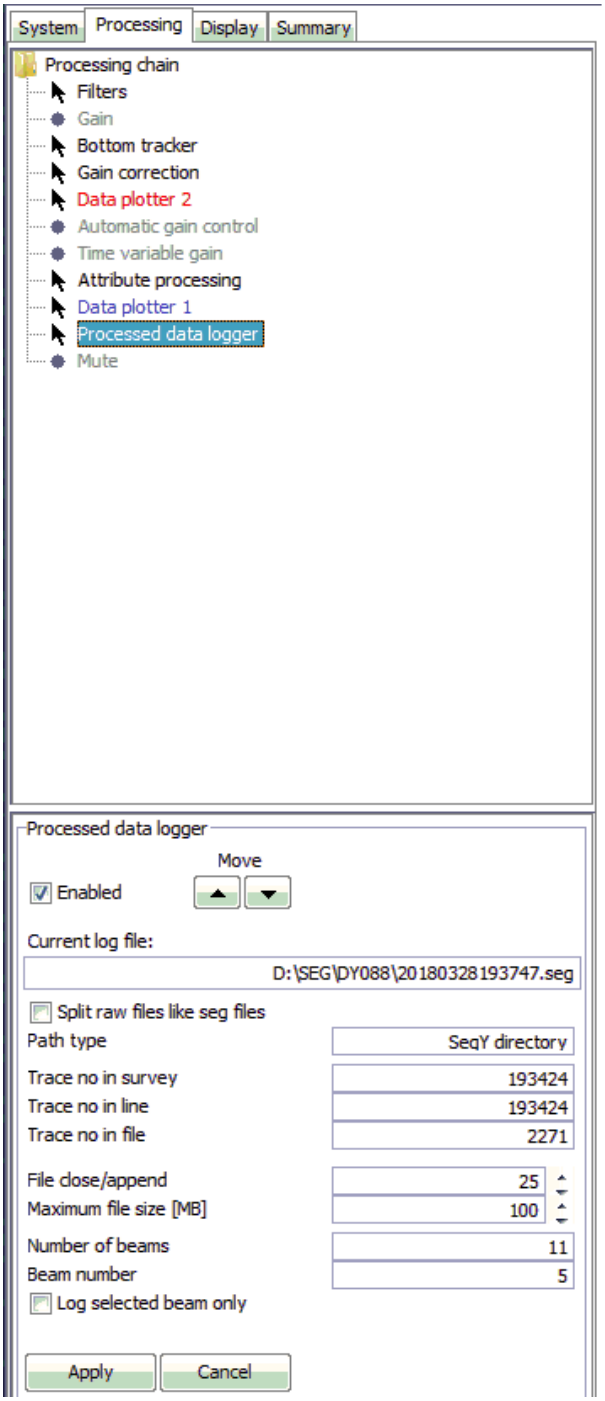
Processing Chain:

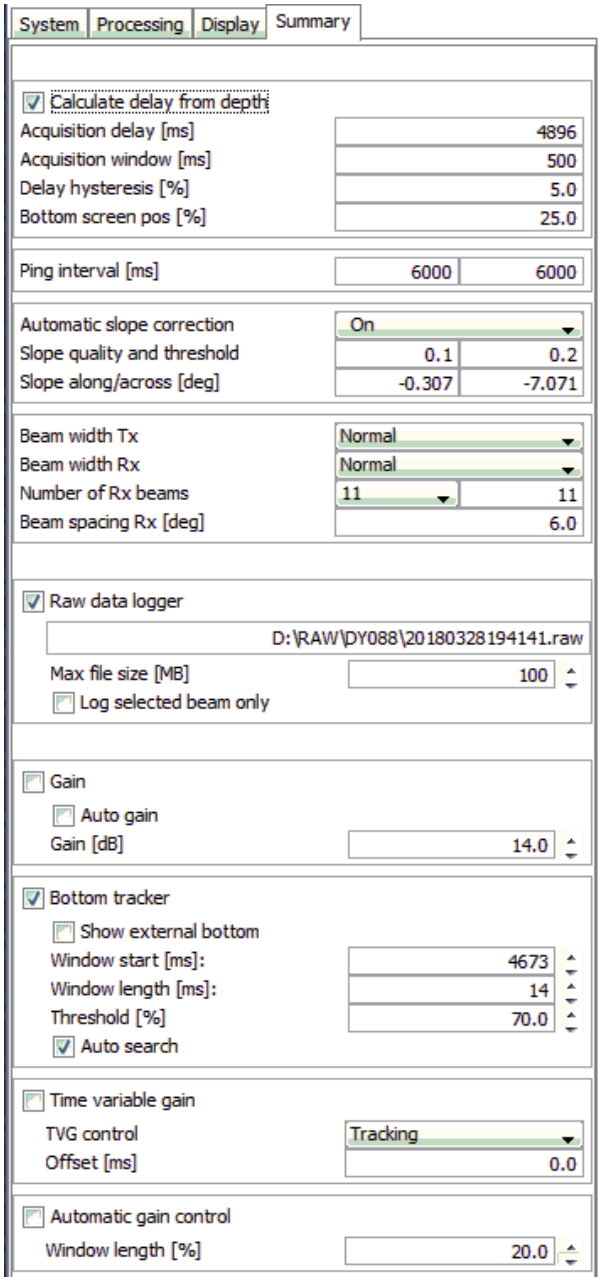

System
Processing
Display
Summary
Processing chain
Filters
Gain
Bottom tracker
Gain correction
Data plotter 2
Automatic gain control
Time variable gain
Attribute processing
Data plotter 1
Processed data logger
Mute
Processing chain
Track selected beam only
Selected beam number
0
Number of beams
11
Beam number
5
Maximum backlog
64
Current backlog
1


System
Processing
Display
Summary
Processing chain
Filters
Gain
Bottom tracker
Gain correction
Data plotter 2
Automatic gain control
Time variable gain
Attribute processing
Data plotter 1
Processed data logger
Mute
Bottom tracker
Move
Enabled
Show master depth
Window start [ms]:
4636
Window length [ms]:
14
Threshold [%]
70.0
Auto search
Apply
Cancel


System
Processing
Display
Summary
Processing chain
Filters
Gain
Bottom tracker
Gain correction
Data plotter 2
Automatic gain control
Time variable gain
Attribute processing
Data plotter 1
Processed data logger
Mute
Filters
Move
Enabled
Filter type:
Matched
Corner frequencies:
Auto
Replica shaping
Apply
Cancel


System
Processing
Display
Summary
Processing chain
Filters
Gain
Bottom tracker
Gain correction
Data plotter 2
Automatic gain control
Time variable gain
Attribute processing
Data plotter 1
Processed data logger
Mute
Gain correction
Move
Enabled
Transmission loss [dB/km]
0.0
Apply
Cancel





SBP120 Summary (above)

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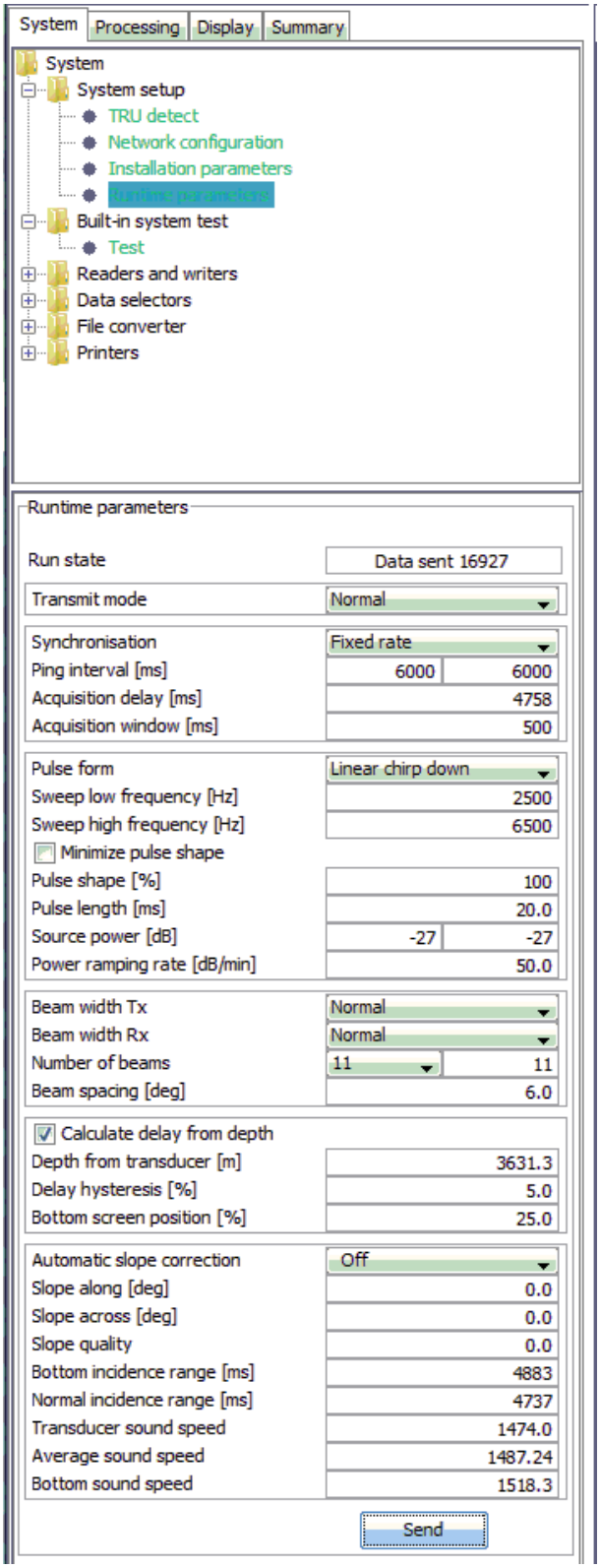
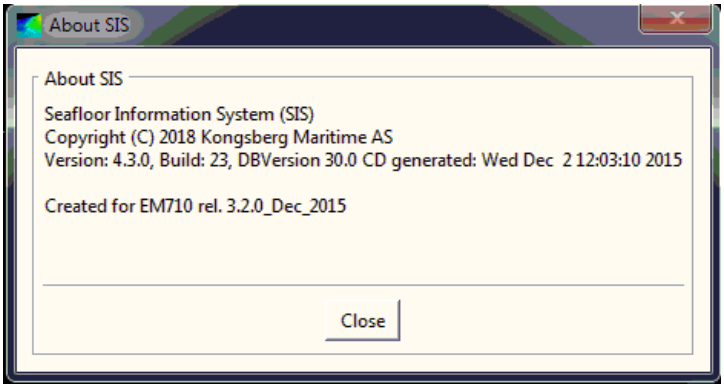
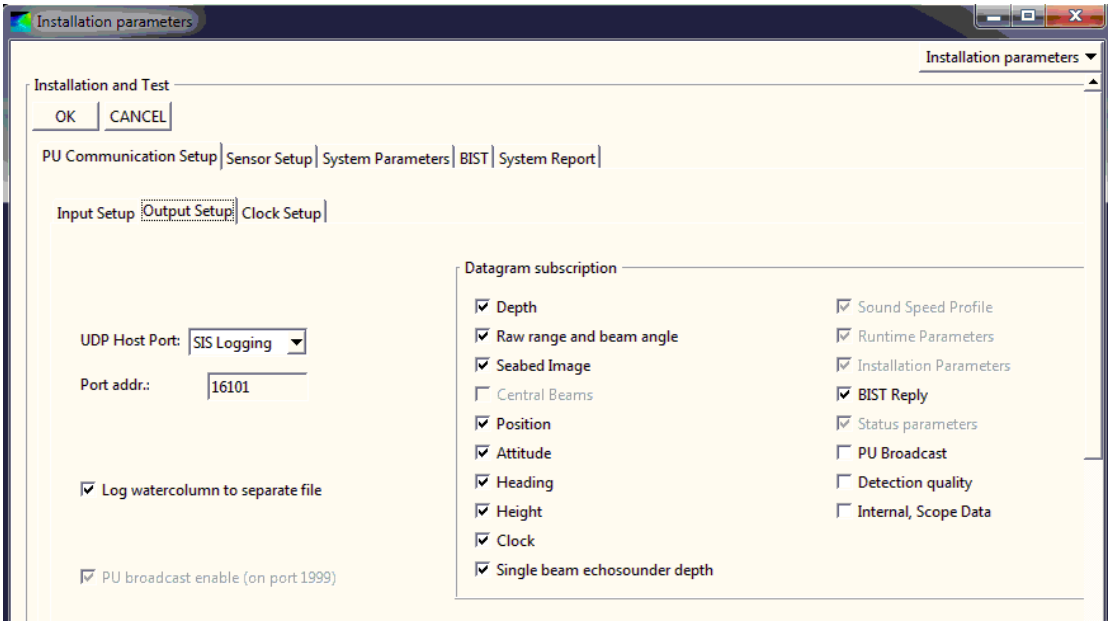


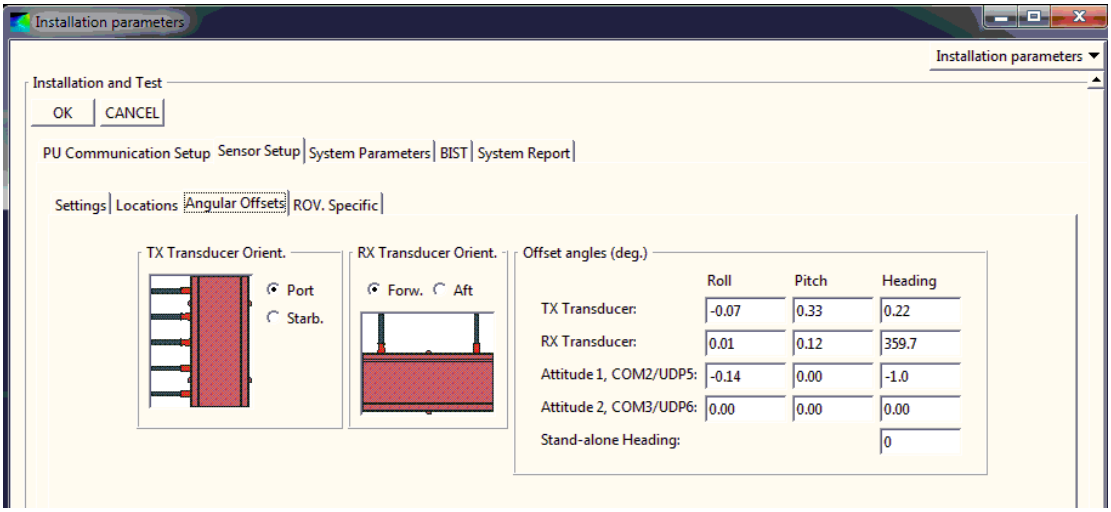
4.3 EM710 SIS INSTALLATION & RUNTIME PARAMETERS:

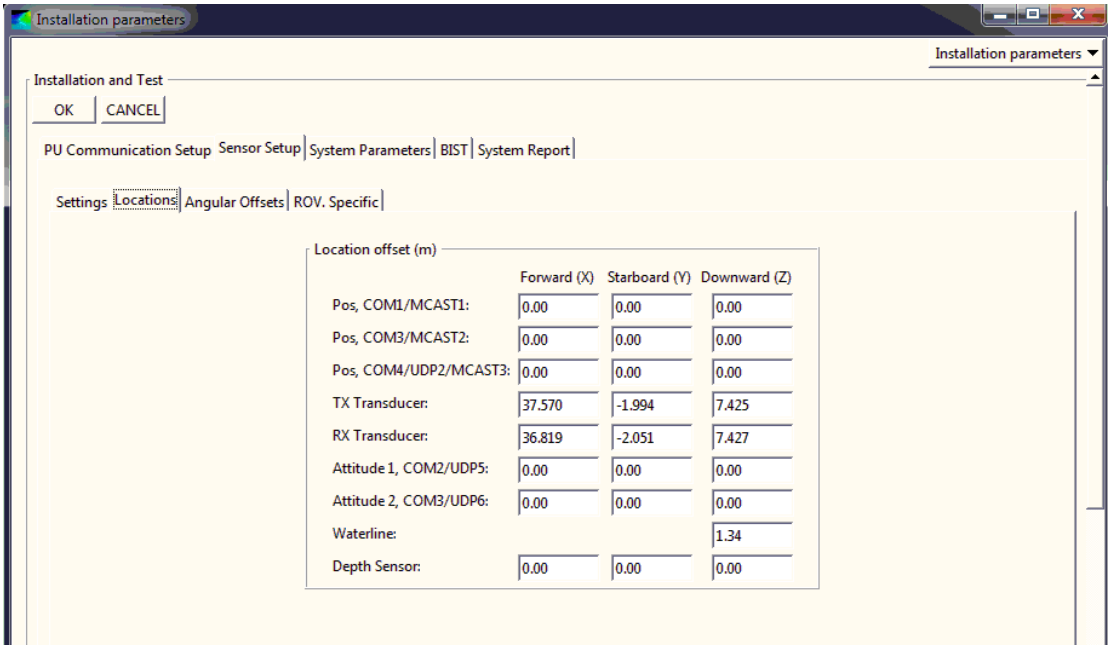
SIS Software Version:

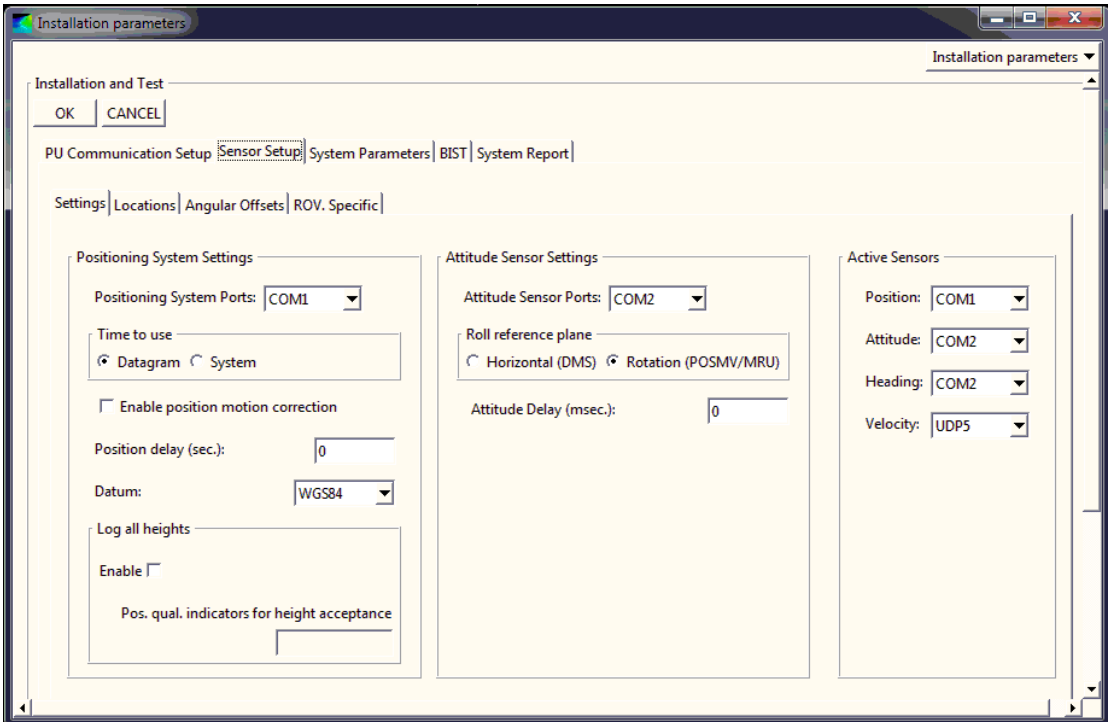


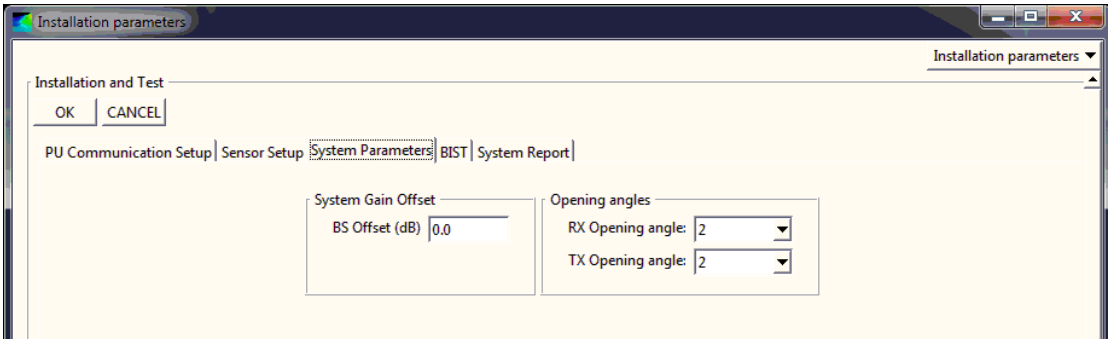
Installation Parameters (Defined prior to first Survey):



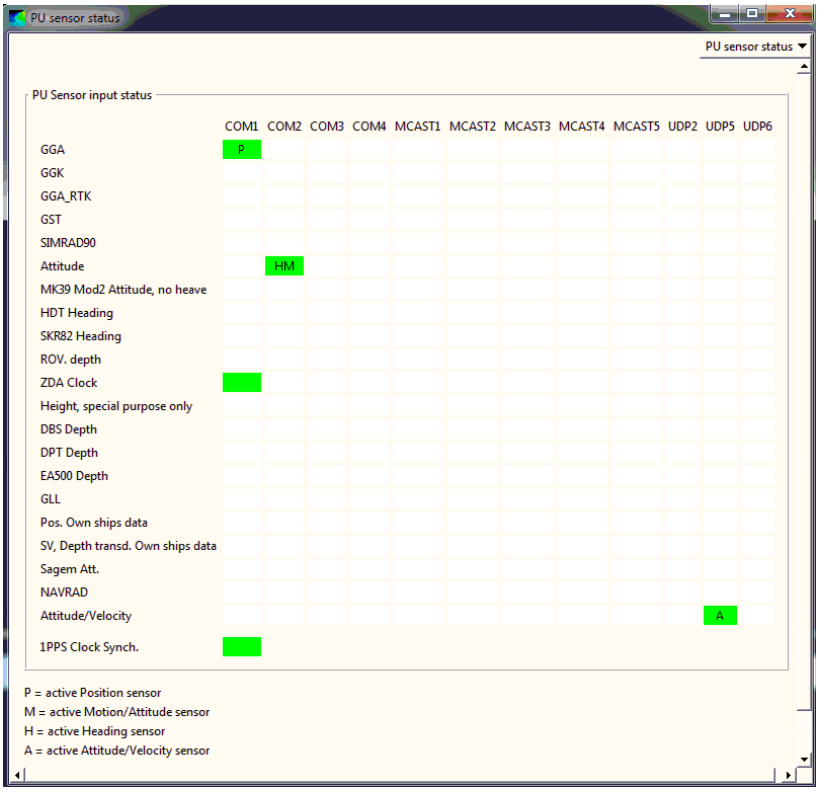

Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
TX Transducer Orient.
Port
Starb.
RX Transducer Orient.
Forw.
Aft
Offset angles (deg.)
Roll
Pitch
Heading
TX Transducer: -0.07 0.33 0.22
RX Transducer: 0.01 0.12 359.7
Attitude 1, COM2/UDP5: -0.14 0.00 -1.0
Attitude 2, COM3/UDP6: 0.00 0.00 0.00
Stand-alone Heading: 0


Installation parameters
Installation parameters
Installation and Test
OK
CANCEL
PU Communication Setup
Sensor Setup
System Parameters
BIST
System Report
Settings
Locations
Angular Offsets
ROV. Specific
Location offset (m)
Forward (X)
Starboard (Y)
Downward (Z)
Pos, COM1/MCAST1: 0.00 0.00 0.00
Pos, COM3/MCAST2: 0.00 0.00 0.00
Pos, COM4/UDP2/MCAST3: 0.00 0.00 0.00
TX Transducer: 37.570 -1.994 7.425
RX Transducer: 36.819 -2.051 7.427
Attitude 1, COM2/UDP5: 0.00 0.00 0.00
Attitude 2, COM3/UDP6: 0.00 0.00 0.00
Waterline: 1.34
Depth Sensor: 0.00 0.00 0.00

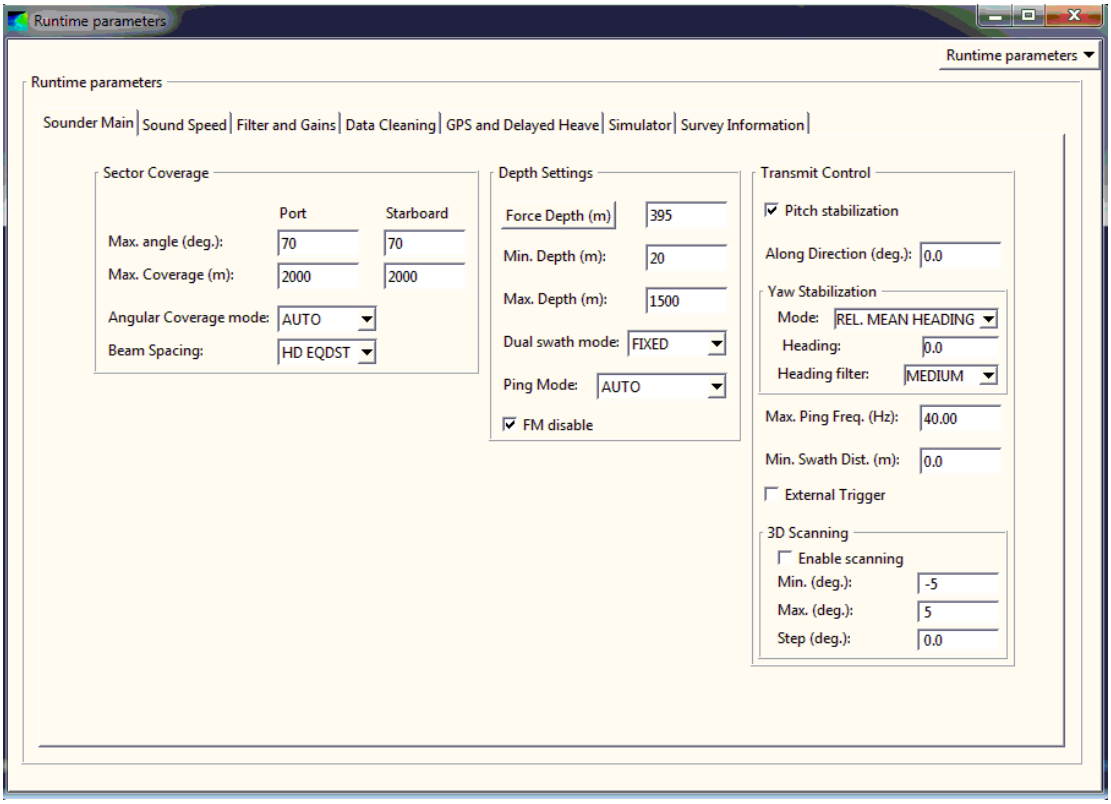


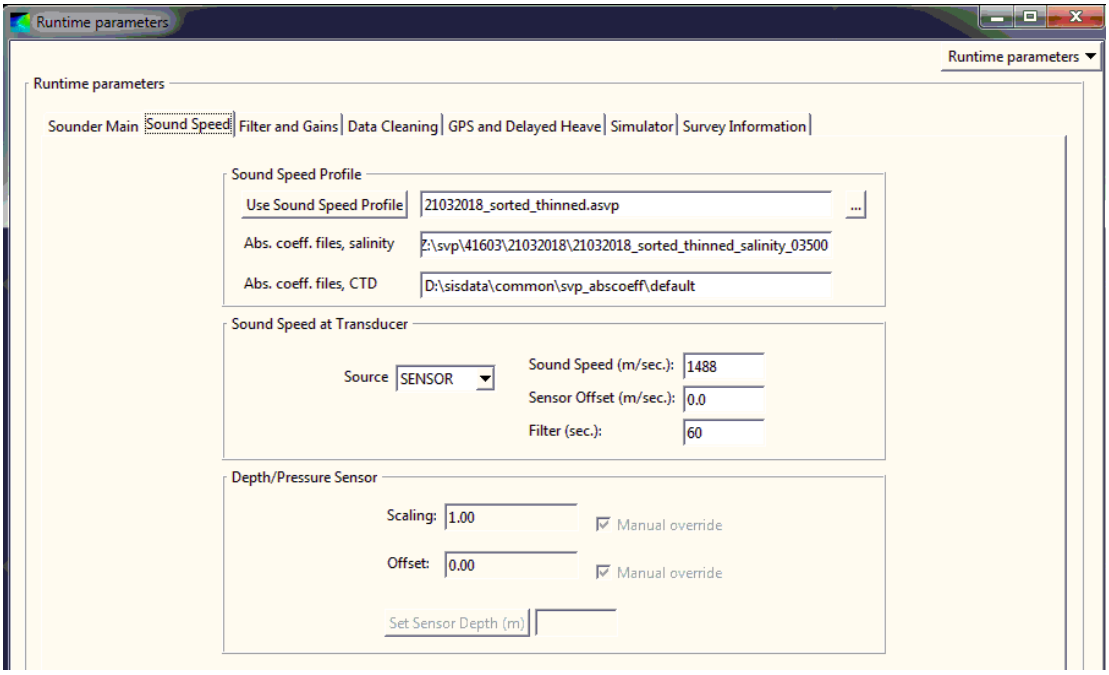


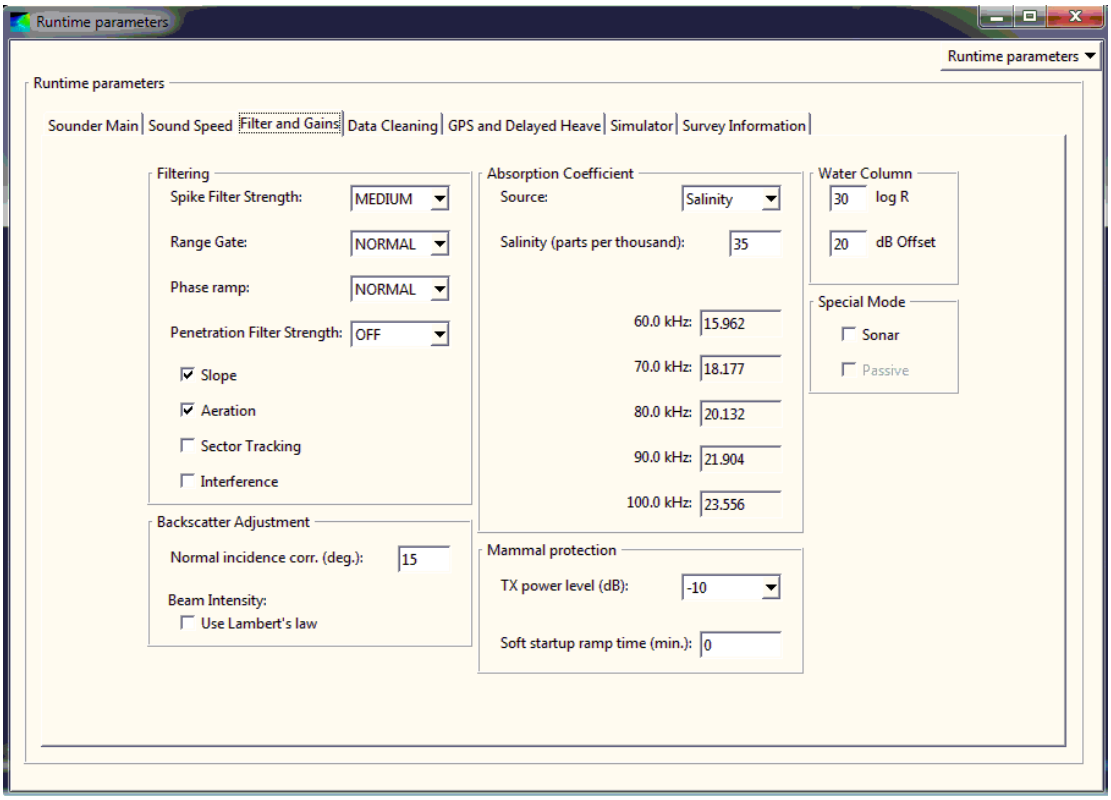
PU Sensor Status:

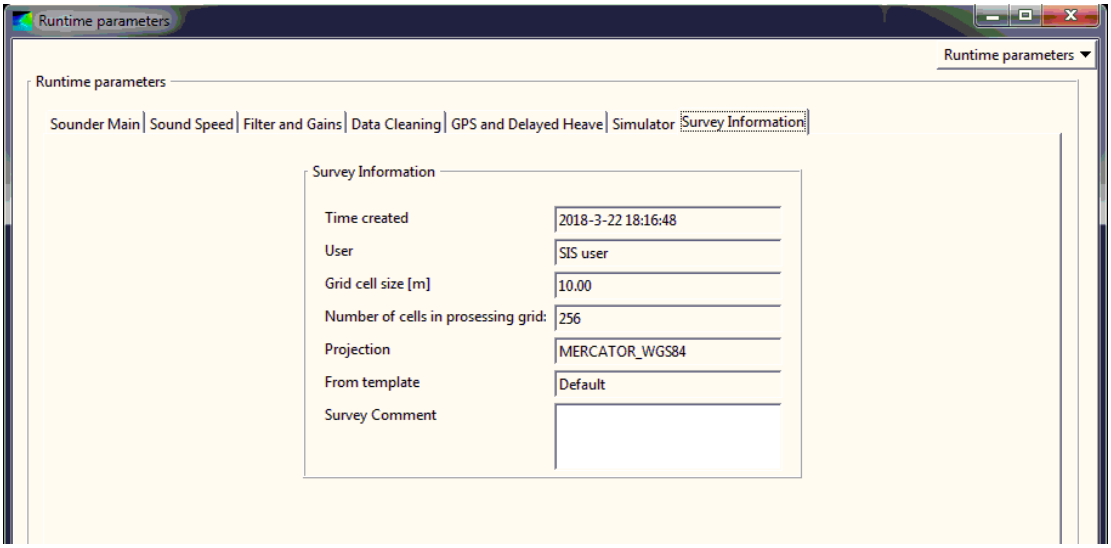


EM710 SIS Runtime Parameters:




Runtime parameters
Runtime parameters
Runtime parameters
Sounder Main
Sound Speed
Filter and Gains
Data Cleaning
GPS and Delayed Heave
Simulator
Survey Information
Sound Speed Profile
Use Sound Speed Profile
21032018_sorted_thinned.asvp
...
Abs. coeff. files, salinity
Z:\svp\41603\21032018\21032018_sorted_thinned_salinity_03500
Abs. coeff. files, CTD
D:\sisdata\common\svp_abscoeff\default
Sound Speed at Transducer
Source
SENSOR
Sound Speed (m/sec.):
1488
Sensor Offset (m/sec.):
0.0
Filter (sec.):
60
Depth/Pressure Sensor
Scaling:
1.00
Manual override
Offset:
0.00
Manual override
Set Sensor Depth (m)


Runtime parameters
Runtime parameters
Runtime parameters
Sounder Main
Sound Speed
Filter and Gains
Data Cleaning
GPS and Delayed Heave
Simulator
Survey Information
Filtering
Spike Filter Strength:
MEDIUM
Range Gate:
NORMAL
Phase ramp:
NORMAL
Penetration Filter Strength:
OFF
Slope
Aeration
Sector Tracking
Interference
Backscatter Adjustment
Normal incidence corr. (deg.):
15
Beam Intensity:
Use Lambert's law
Absorption Coefficient
Source:
Salinity
Salinity (parts per thousand):
35
60.0 kHz:
15.962
70.0 kHz:
18.177
80.0 kHz:
20.132
90.0 kHz:
21.904
100.0 kHz:
23.556
Mammal protection
TX power level (dB):
-10
Soft startup ramp time (min.):
0
Water Column
30
log R
20
dB Offset
Special Mode
Sonar
Passive


Runtime parameters
Runtime parameters
Runtime parameters
Sounder Main
Sound Speed
Filter and Gains
Data Cleaning
GPS and Delayed Heave
Simulator
Survey Information
Survey Information
Time created
2018-3-22 18:16:48
User
SIS user
Grid cell size [m]
10.00
Number of cells in prosessing grid:
256
Projection
MERCATOR_WGS84
From template
Default
Survey Comment

National Oceanography Centre

NATURAL ENVIRONMENT RESEARCH COUNCIL

Appendix A11:
Ocean Engineering Group.

DY088 Equipment Technical Report.

DY088 Coring Systems.

Throughout the expedition we had two coring systems on board, the SMBA box corer and the gravity core which was the piston core barrels and bomb and we used the piston core system. Below is a run-down of the equipment which will cover usage, if the equipment worked well, issues with the systems, modifications recommended, and any ideas for future equipment that could have aided us.

Box Corer.

This was used for 22 deployments throughout cruise. During an early deployment the main warp caught under box corer head, freeing itself when exiting water. After this we had a number of non-firing deployments. The head mechanism was removed, cleaned and re fitted ensuring clearance for trigger cable link and trigger pin were free. A number of cores after resulted with poor or no samples due to corer falling over on hilly, hard terrain (mud on head).

The original box was also damaged by rocks during 2 deployments. This was replaced with the spare and did not fully seal. The box and spade were reground and then used successfully with non disturbed samples for last 3 deployments..

Gravity Corer.

This was used 15 times with the piston core barrels, liner, and Core bomb. Due to the cutter ID being smaller than liner ID it was noticed that the 1st metre of sample was not filling the liner. We believe this was caused by the speed of corer penetrating plus the cutter / liner difference causing this flaw.

A 9m gravity was attempted however hard sediment only allowed 3-4m core sample

The diameter difference is to reduce friction when carrying out piston coring.

2 x 6m barrels were bent (tough sediment) plus 1 barrel damaged (broken nail)

All cores were successful with various lengths in different sediments

Dredge system

This was used 15 times during Dy88 on shallow hilly sites. All dredges returned with samples, some a lot less than others. 3t weak links sheared on a number of operations, 1 x 5t Weak link was damaged but dredge was recovered with sample.

A USBL beacon was fitted to first deployment – the beacon did not talk then due to no signal we managed to drag beacon and trawl warp along seabed damaging beacon.

The one dredge we used for the 15 deployments shows heavy signs of wear and damage due to use. Recommend replacing chain link bag and mouth / arm.

Issues/Modifications/Upgrades.

The box corer could do with a revamp – there are many hammer rashes on box connectors which will start to make joining awkward.

The alloy spares box has a hole in the bottom – this needs to be replaced to prevent spares getting rusty

Most of the piston / gravity core nails are rusty – new ones are needed within a watertight box to prevent this

Coring container has a good number of slings and strops but no test certs – a manual with certs, msds (aerosols) plus workshop inventory would improve

The plastic door is broken – this needs to be replaced with suitable steel bulkhead and door. OEG need to decide if container requires a ‘lobby’ to stow wet items (power washer etc).

The heater and glanding for container power has been fitted.

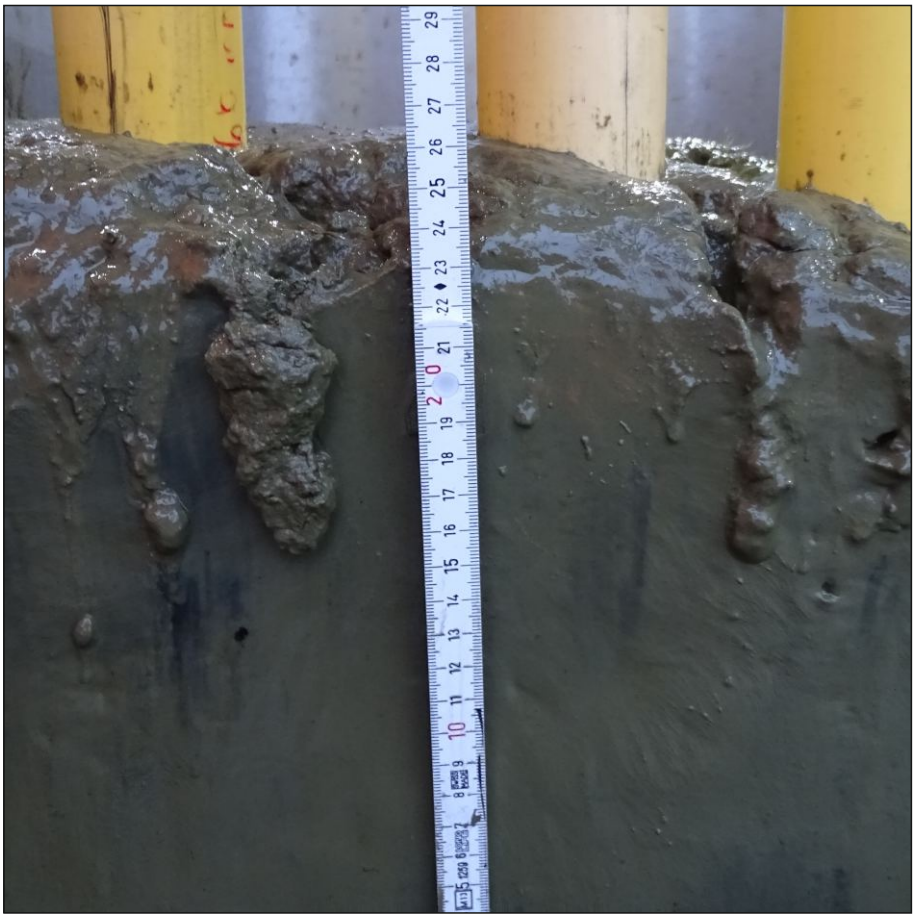
Suitable tie backs for side access doors is required – these are ‘like a kite’ in wind!

Liner lathe has been ‘tweaked’ to allow even thickness of each section for gluing.

We only had one non- return valve that was ‘snug’ in barrels. The spares were loose.

BC739

BC740



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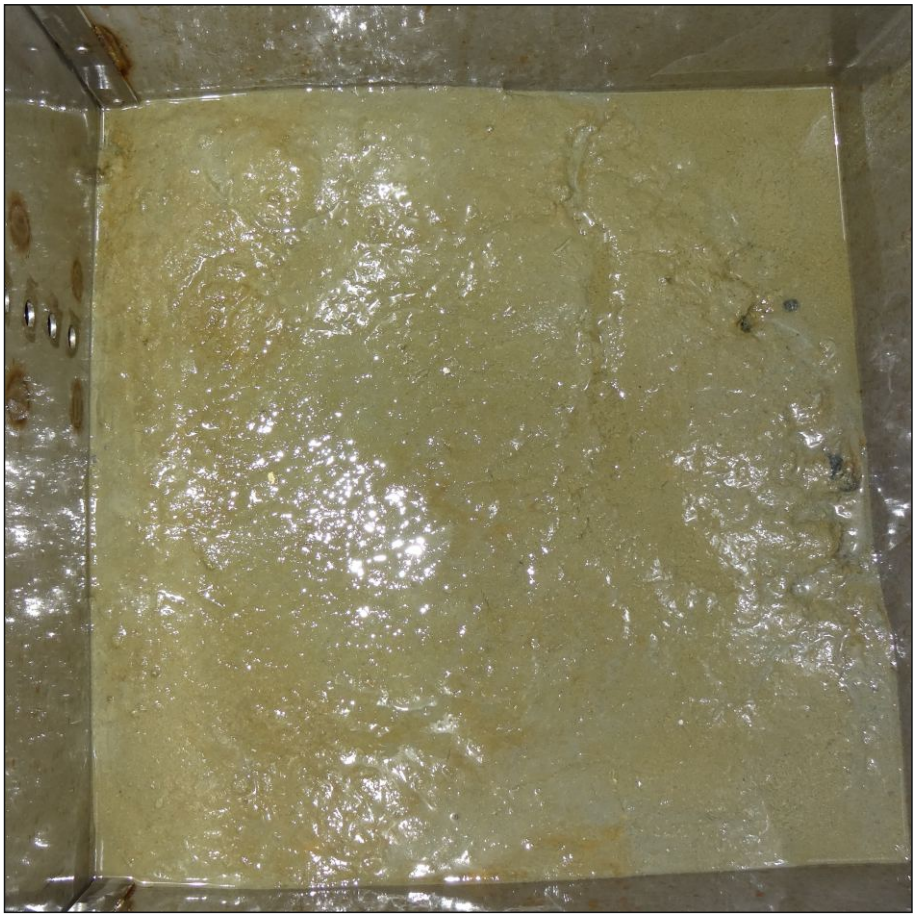

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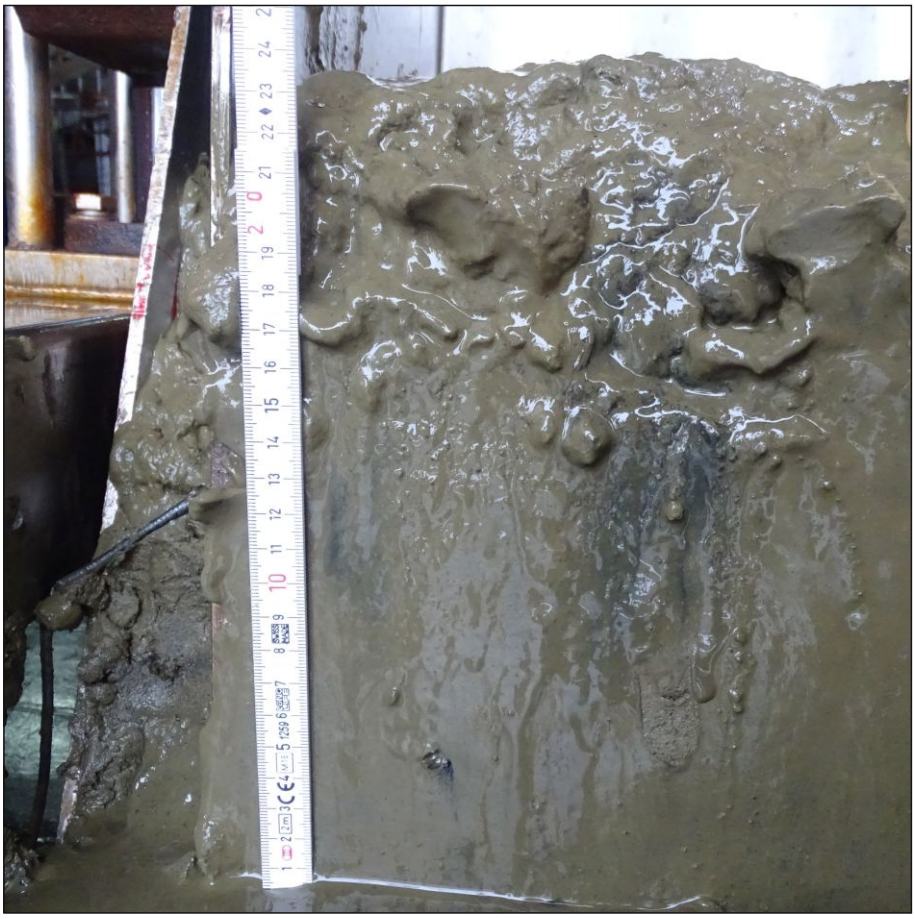
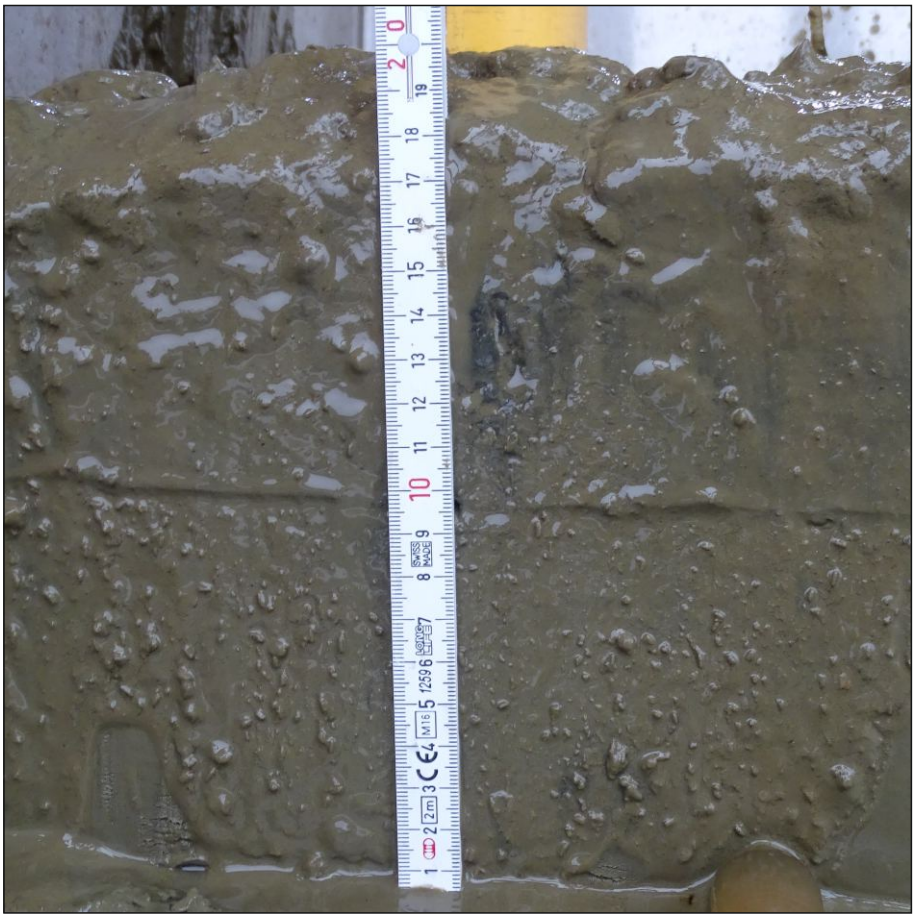


BC747

BC748



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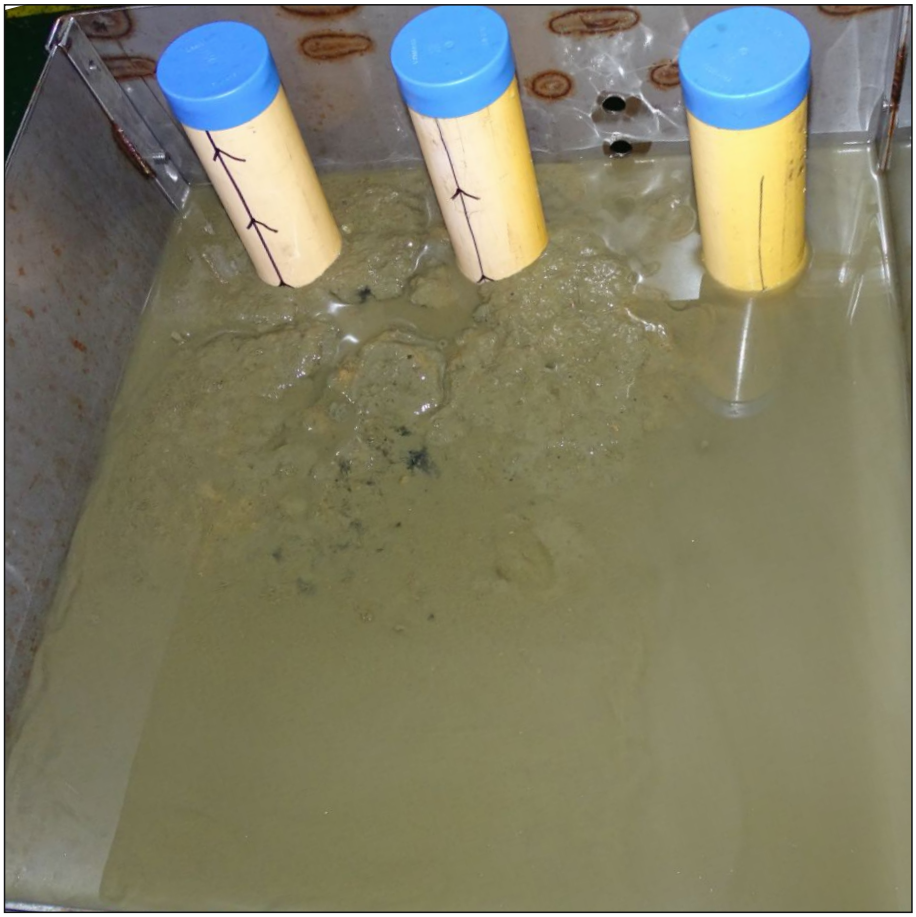

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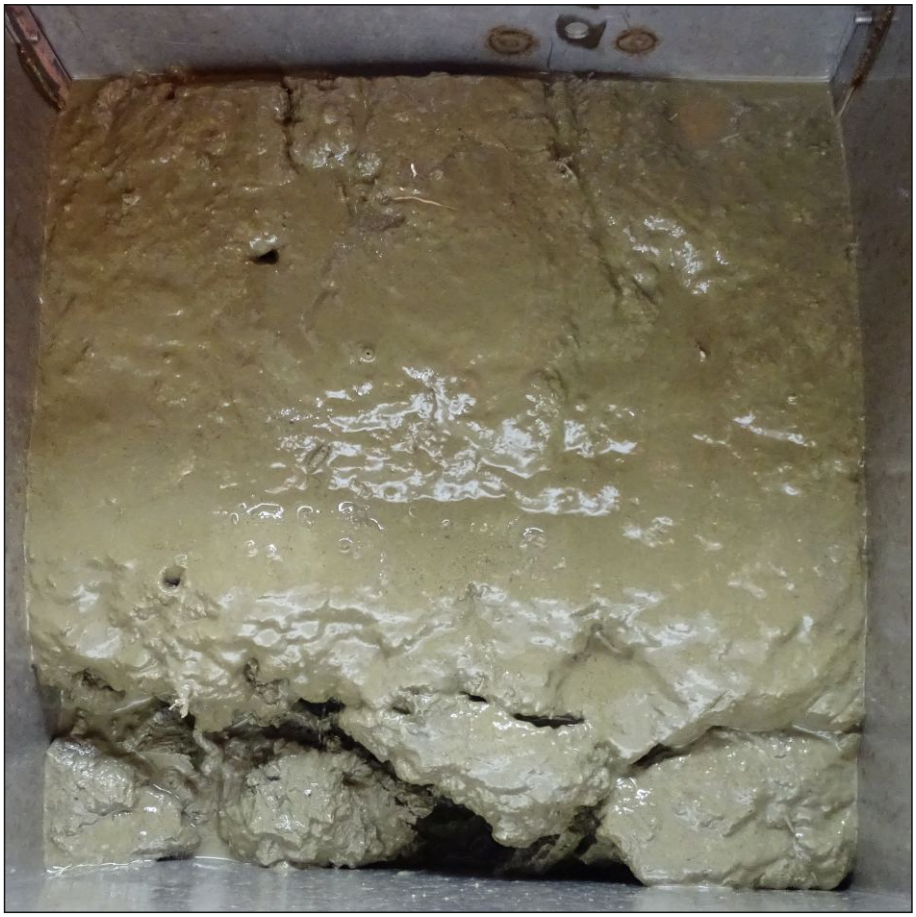
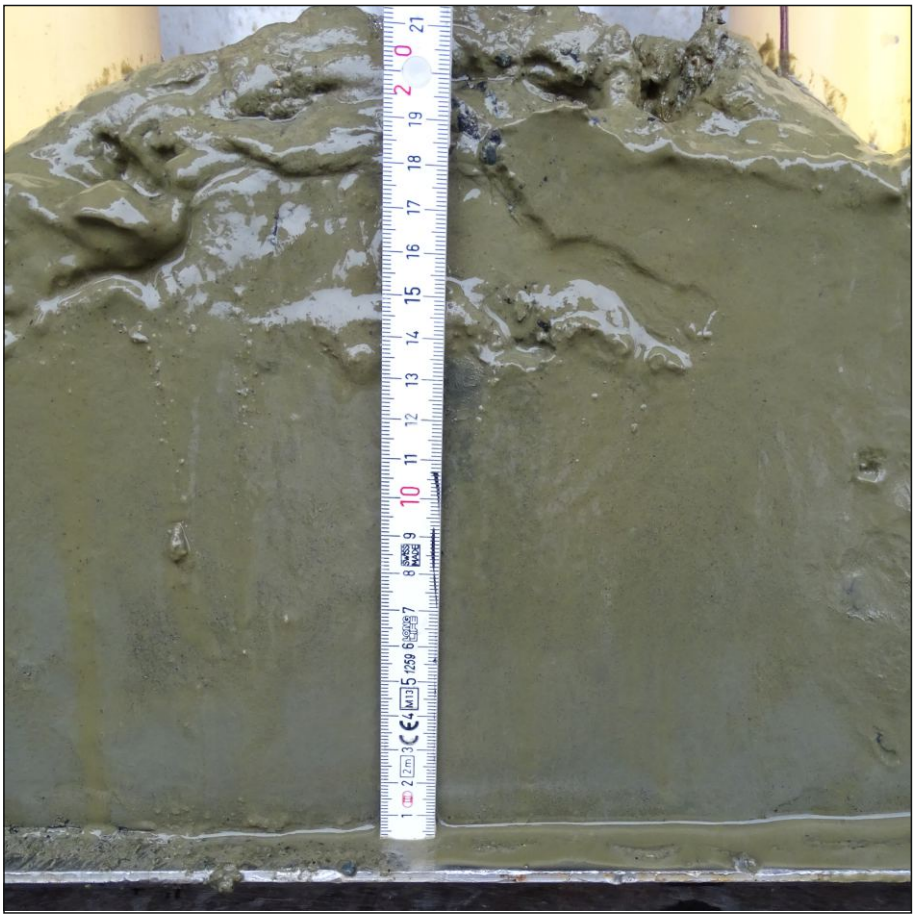
BC754





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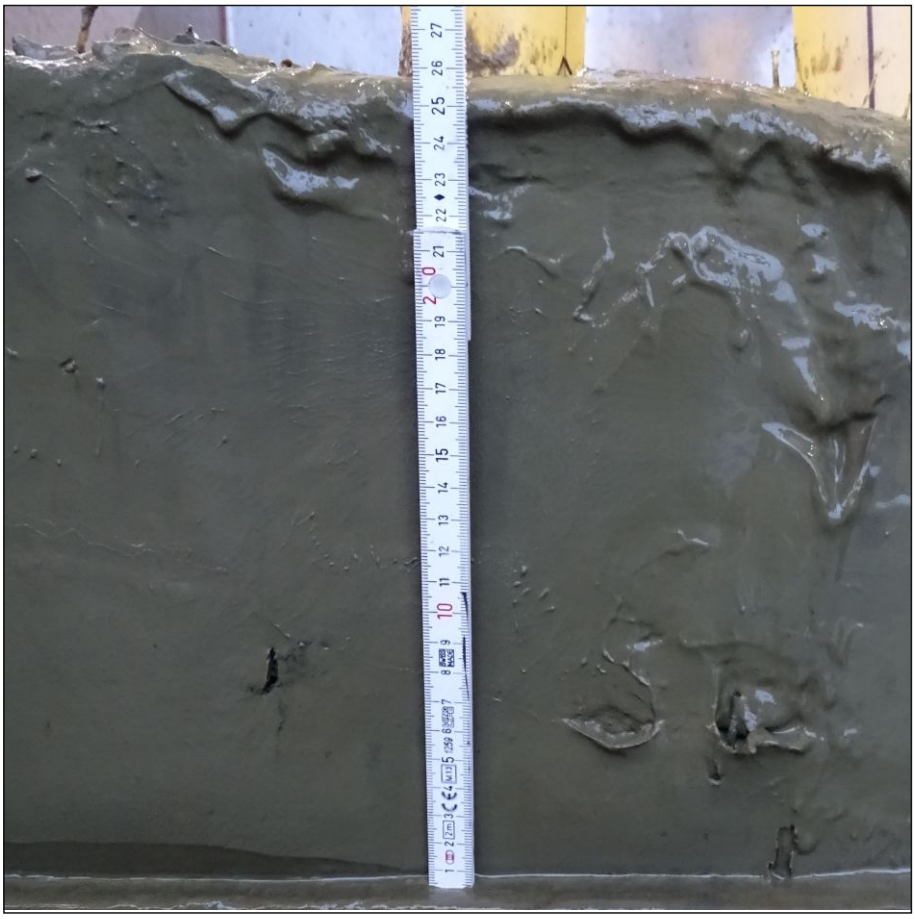

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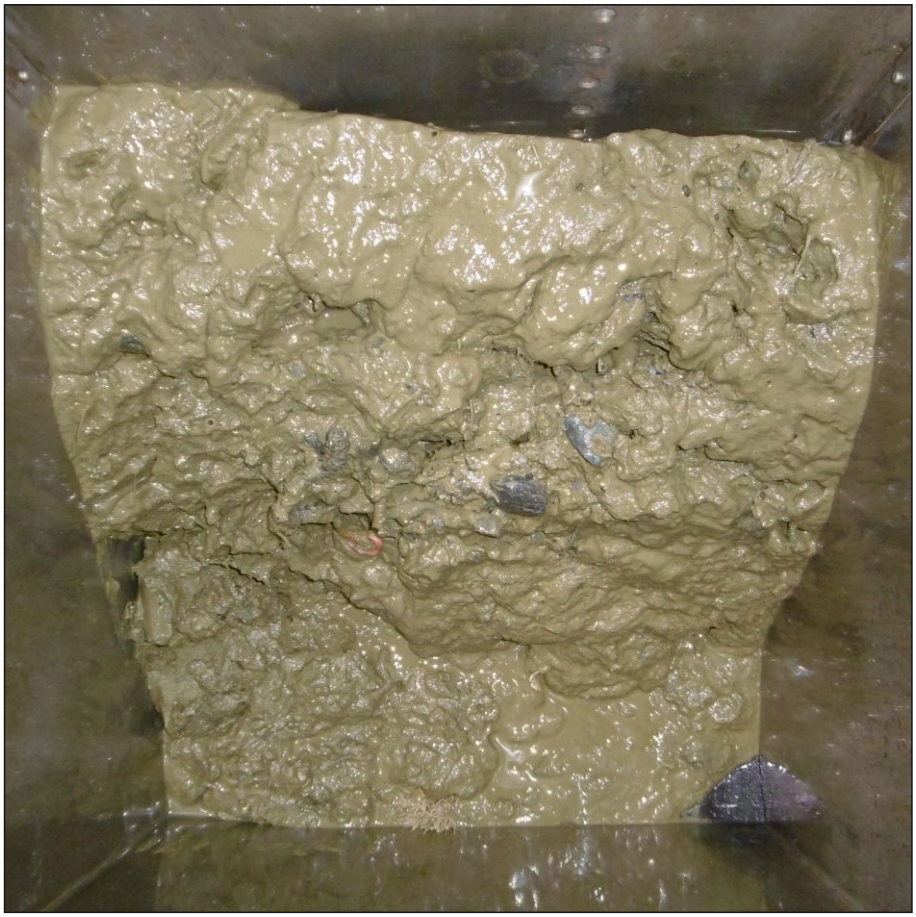

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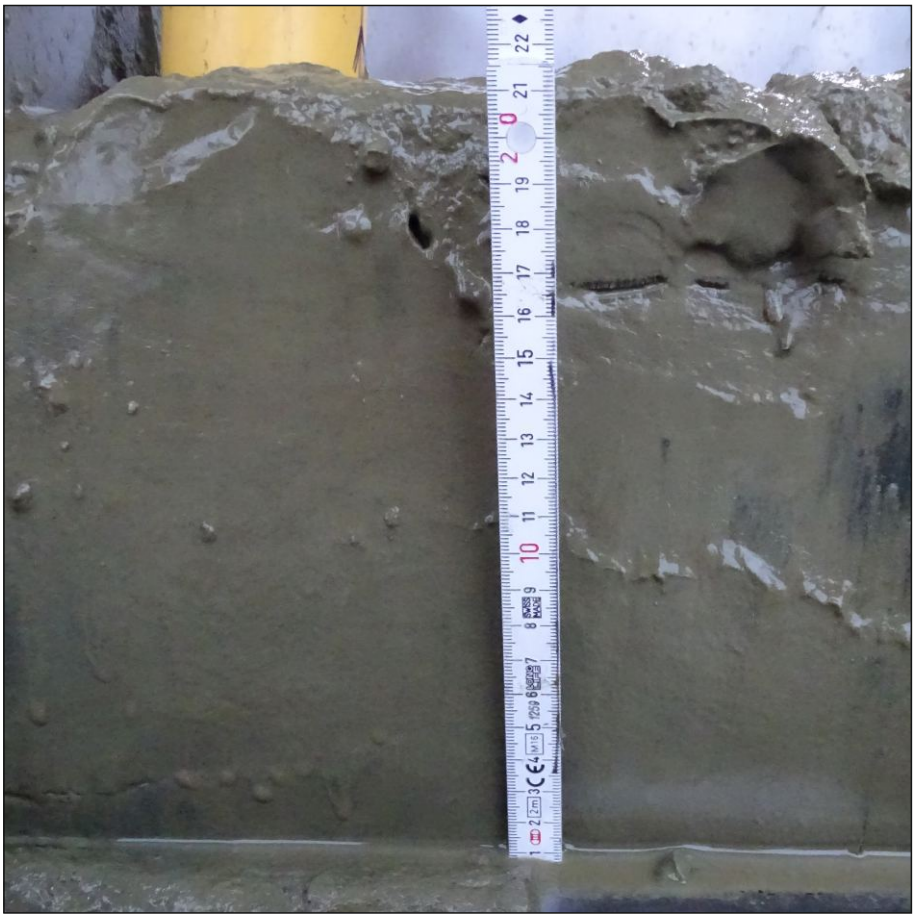

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