DY094 Cruise Report

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Summary

On the 20th October 2018 the Royal Research Ship (RRS) *Discovery* sailed to the Rio Grande Rise in the South Atlantic, 1400 km east of Brazil, to investigate cobalt-rich mineral deposits of interest to potential deep-sea mining.

The expedition used robotic vehicles, moored scientific instruments, and novel sampling methods to study the environment that deep-sea mineral deposits form in. Of special interest are crusts of iron and manganese that are rich in cobalt and other metals, and how their geological evolution, over tens of millions of years, affected the formation of these mineral deposits. The team includes biologists that are studying the vulnerability of deep-sea fauna to disturbances that would arise if the sites were mined.

The autonomous underwater vehicle (AUV) Autosub6000 was launched from RRS *Discovery* to map the Rio Grande Rise in extraordinary detail. Using high-resolution sidescan sonar, the seafloor was mapped with sufficient detail to see rocks and boulders a few tens of centimetres across. The AUV created black and white images of the seafloor showing where the mineral deposits are located. Once we mapped the area, high definition video cameras on the remotely operated vehicle *HyBIS* were used to explore, sample and photograph features on the seafloor, including a huge rift over 1000m deep, sinkholes and the ancient remains of beaches long since drowned.

Formed 82 million years ago and submerged 40 million years ago beneath the South Atlantic ocean, the relatively shallow Rio Grande Rise is a lost land of ravines and plateaus the size of Wales. It is of interest for seafloor mineral deposits rich in iron, manganese and other metals important to modern society. Two of these in particular are critical to any future efforts for renewable energy: cobalt and tellurium. Cobalt is essential in rechargeable batteries that are

needed if we are to move to electric vehicles. Tellurium is essential for high-efficiency solar-electric power generation. Although our work is focused on the potential of deep-sea mineral deposits and possible mining, the results could help reduce our dependence on environmentally damaging carbon-based energy."

This expedition is part of the Marine E-tech project, which is an international collaboration between the NOC, British Geological Survey (BGS), HR Wallingford, the UK Universities of Edinburgh, Bath and Leicester, and the Brazilian University of Sao Paulo, and is jointly funded by the governments of the UK and the State of Sao Paulo, Brazil.

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Chapter 1: Narrative

Rio Grande Rise (RGR) is a shallow (600m), aseismic oceanic rise in the South Atlantic Ocean located between the Brazil and Argentine basins (Figure 1-1). Located at 30°S, 35°W, the RGR rises from abyssal depths of 3800m to form a plateau at ~700m water depth. Some 120km in diameter, the RGR is divided by a 1300m deep, 24km wide channel that has a flat seafloor and near vertical, 600m high walls. The RGR is thought to have formed by hot-spot volcanism on or close to the Mid-Atlantic Ridge ~80Ma producing eMORB lavas. A later Eocene (40Ma) event produced a phase of uplift and alkali lavas.

The NERC/FAPEP funded MarineE-tech project aimed to explore the processes affecting the distribution and composition of ferromanganese crusts (FeMnC) on the RGR. The RGR is of interest for seafloor mineral deposits rich in iron, manganese and other metals that are important to modern society. Two of these metals in particular are critical to any future effort to reduce our dependence on hydrocarbons: cobalt and tellurium. Cobalt is essential in rechargeable batteries that are needed if we are to move to electric vehicles. Tellurium is essential for high-efficiency solar-electric power generation. Our voyage aims to enhance understanding of the processes controlling the formation and composition of these deep-ocean mineral deposits and the biology that colonises them. We also aimed to explore the processes shaping the palaeo-seafloor.

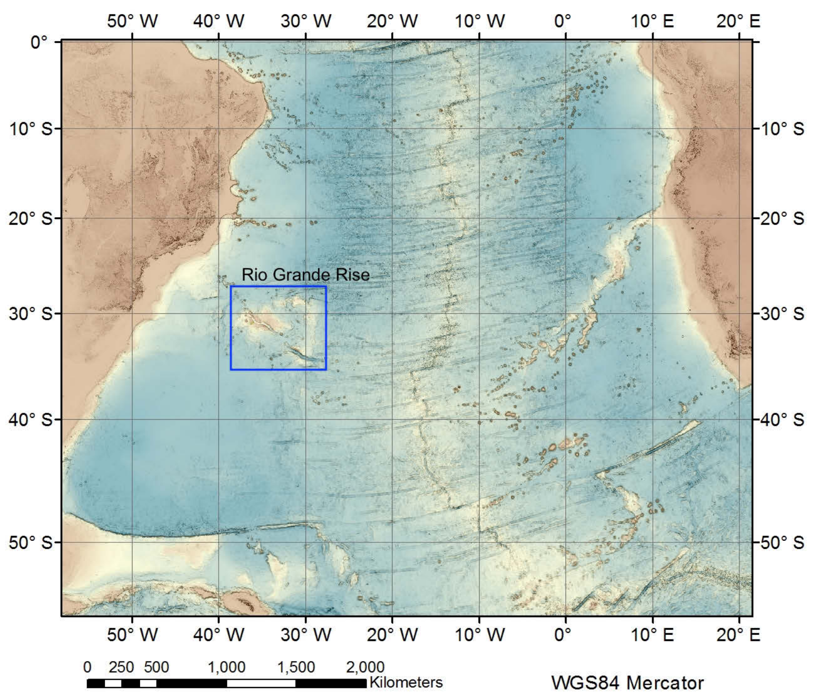


Figure 1-0-1: Map showing the location of the Rio Grande Rise (courtesy of GEBCO).

Cruise DY094 on the RRS Discovery sailed from the Brazilian port of Santos on the 20th October and retuned on the 9th November 2018. The expedition mapped the central western part of the Rio Grande Rise with the ship's 10kHz multibeam echo sounder system, made five missions with the autonomous underwater vehicle 'Autosub6000' deploying a 10kHz sidescan sonar and sub-bottom profiler, thirteen dives with the remotely controlled vehicle 'HyBIS', six gravity cores and twenty two dredges, of which three were lost. We lost three days to poor weather when we had to run from an unseasonable cyclone.

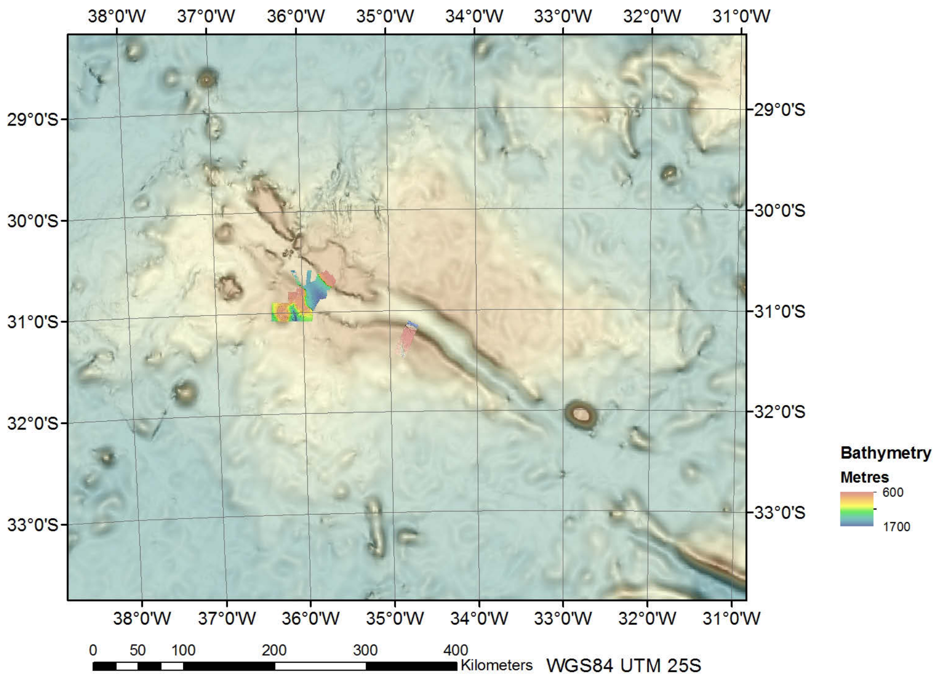


Figure 1-0-2: Our work area, shown by the multibeam bathymetry coverage in bright colours. The Great Rift divides the RGR in two.

We based the work programme on bathymetry and dredge data acquired in February 2018 by our project partners, University of Sao Paulo, during their cruise to the area on board the R/V Alpha Cruzis. Our ship-board multibeam coverage (Simrad EM122) is shown in Figures 1-2 and 1-3. The R/V Alpha Cruzis data were re-projected to WGS84, UTM zone 25 South and registered with the RRS Discovery data. Stations were numbered consecutively for each over-the-side operation. Please refer to the Master Log Sheets in the appendix for more details.

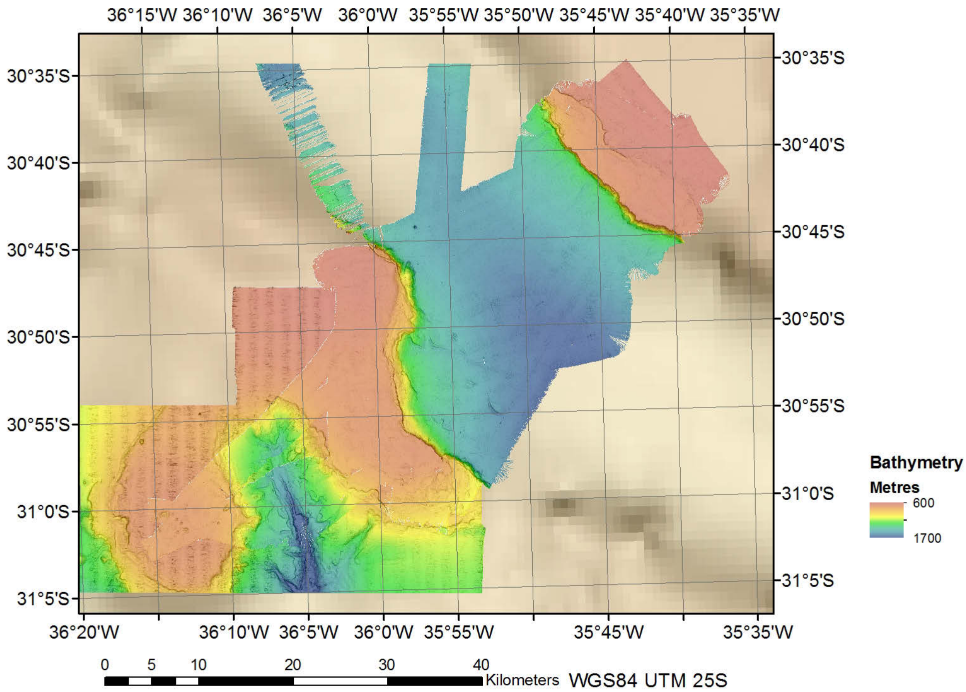


Figure 1-0-3: RRS Discovery EM122 multibeam coverage of the central RGR (smooth map) with the R/V Alpha Cruzis data behind (noisy data) and GEBCO background (pale colours). The RRS Discovery data are gridded at 15m, the R/V Alpha Cruzis data are gridded at 25m.

Five AUV dives were completed on the plateau areas each side of the Great Rift. These were initially optimised for the EM2040 multibeam echosounder data acquisition, but after the system was found to be inoperable, later missions were optimised for the Edgetech 4200, 100kHz sidescan sonar. Line spacing was initially 280m and later 600m. The sidescan sonar data were processed in SonarWhiz™ and imported into ArcGIS™. It was noted that a heading error on the Autosub6000 required an anticlockwise rotation of the track lines by 11.3°. This was applied to the processed sidescan data, but not any of the other data, during the expedition.

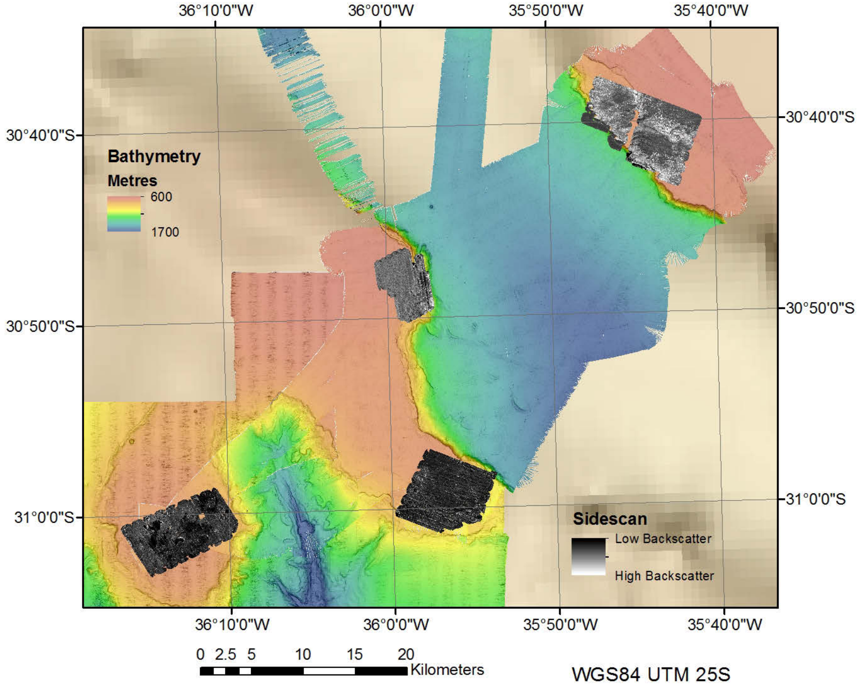


Figure 1-0-4: Map showing the coverage of sidescan sonar data by the Autosub6000 missions. A total of 5 missions were acomplished, each were 24 hours in duration, and were acquired every other day (each 24 hour mission was followed by a 24 hour charging and preparation period).

Thirteen HyBIS dives were accomplished, at an average of one each day. The HyBIS was configured with the manipulator arm and sampling tray module. Cameras included the Scorpio HD video and 12MP stills camera, with two standard dfinition PAL cameras to aid piloting. Two 500W LED lighting units (Aphos™) were used in a parallel forward position, with a 15° downward tilt. An additional halogen light was fitted to aid sampling. A Tritech™ sector scanning sonar, altimeter and depth sensor were also used to aid piloting.

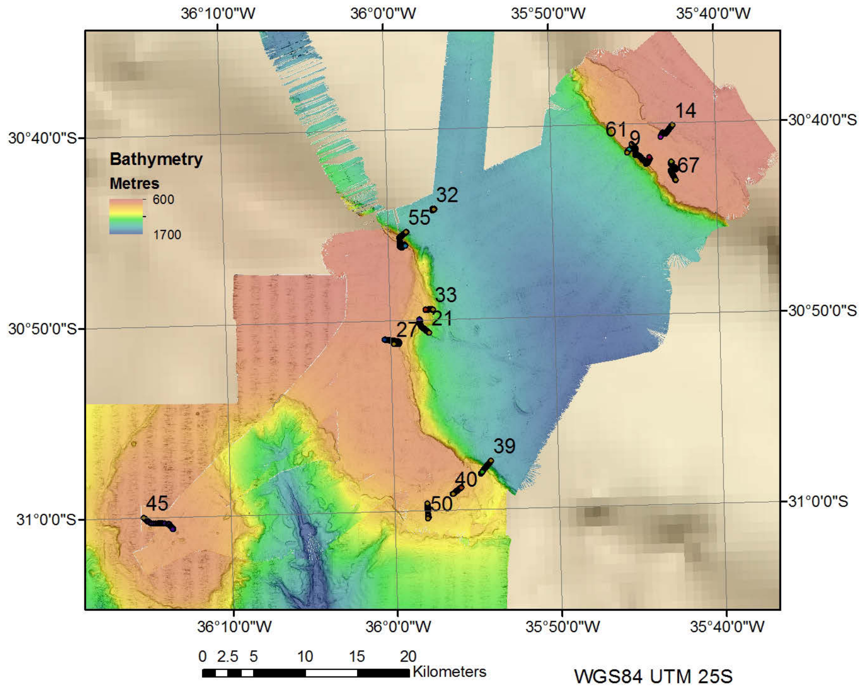


Figure 1-0-5: Map showing locations of all thirteen HyBIS dives. Numbers refer to stations.

Twenty-two dredges were occupied with a square jaw dredge, chain mail bag and 50cm long, 30cm diameter pipe dredge behind. The dredge was preceded by a 6m length of heavy chain and a 200m sacrificial pennant. Weak links of 3 and 5 tonnes were set to initially strangle the dredge and then release it if caught fast on the bottom. The locations were on the plateaus to each side of the Great Rift (Figure 1-6). Six gravity cores were occupied, all on the Great Rift floor, including two in a 70m deep by 300m wide pit 'the blue hole' on the floor of the Great Rift (Figures 1-6 and 1-7).

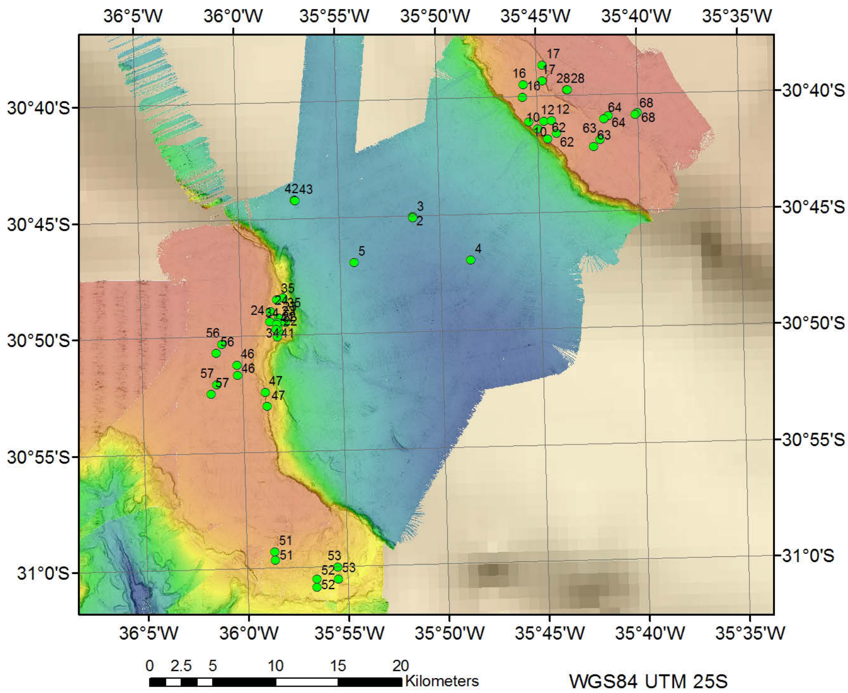


Figure 1-0-6: Map showing locations of all dredge and gravity core locations. Numbers refer to stations.

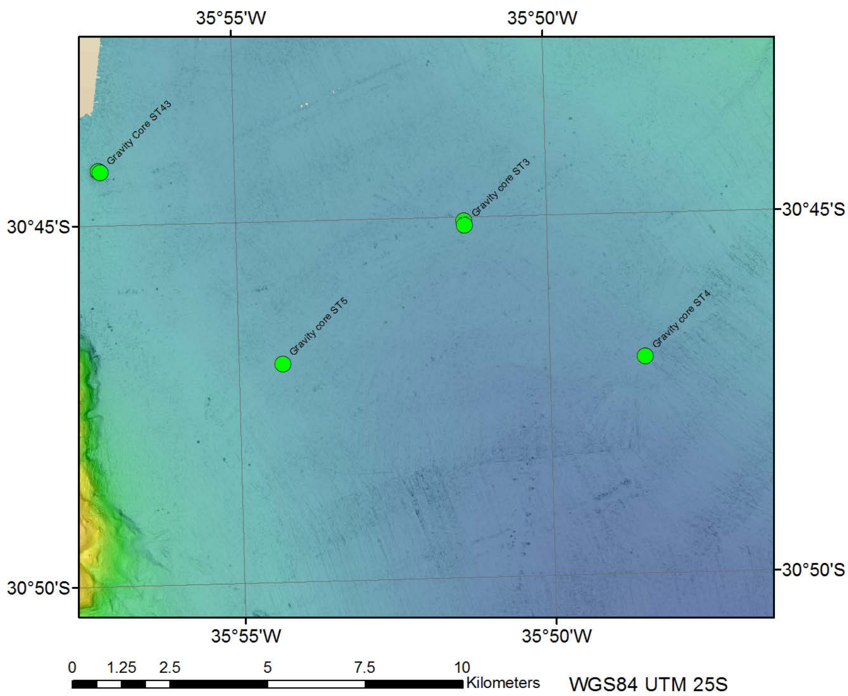


Figure 1-0-7: Map showing locations of all six gravity core locations. Numbers refer to stations.

Our findings include

1. A shallow (800m deep) flat plateau split by a 1400m deep rift, the Great Rift, 24 km wide, with 600m near vertical walls of massive lavas.
2. Large areas of thin FeMn crust, much eroded and concentrated on the flanks of the Great Rift.
3. Palaeo-land surfaces of sub-aerial lava flows with columnar jointing and lateritic weathered tops or boles.
4. Beach deposits of calcareous arenite, boulders and gravel.
5. Palaeo-sea-cliffs, some of which are 600m high, vertical and made of massive lava flows.
6. Calcareous torus-shaped concretions, similar to thrombolites found in the Portland Jurassic formation, UK.
7. Sink-holes and cast topography in a chalk basement on the floor of the rift valley.
8. 2-3 km long, linear, parallel scours stretching for several kilometres across the plateau that resemble current or ice-sheet scour marks.
9. Several fossilised sharks teeth and whale ear bones.
10. A fossilised mammal bone.
11. A fossil trilobite.

Diary

20th October
After departing Santos on the morning of Saturday the 20th of October, we sailed 750 nautical miles WSW to the work area on the RGR. During passage, the HyBIS and Autosub6000 were prepared for operations. The HyBIS was found to have a fault with the thrusters cutting out which was later rectified by reducing the motor power (reducing the frequency on the motor controllers to 35 Hz). The Autosub6000 had problems with the inertial navigation unit that was replaced. The ship's local time was set to GMT-2, all science operations were recorded in GMT.

22nd October
Our first HyBIS dive (HyBis Dive 30, station 1) was a test dive to the bottom of the Great Rift at 1457m. The seafloor was hard with a veneer of light sediment, a few centimetres thick. This was followed by two, 3m long, gravity cores in the Great Rift floor, that yielded no samples.

23rd October
Two more gravity cores were attempted in the Great Rift, with no success. This was followed by a Multibeam survey and AUV buoyancy test at station 7. The second HyBIS dive (station 9) was launched at 18:11 GMT (z) at the bottom of the rift wall on the NW side of the Great Rift and proceeded up the 600m tall near vertical scarp. It finished at 20:56z and was followed by dredging.

24th October
Dredge stations 12 and 13 were completed by 07:50h and followed by a multibeam survey. The third HyBIS dive was launched at 16:36z heading southwest from the top of a terrace on the NE plateau of the RGR (623m) and heading towards the Great Rift scarp. It was recovered at 21:42z and the AUV launched on its first science mission to the NE plateau.

25th October
Two dredge stations were occupied (16 and 17) followed by the recovery of a University of Sao Paulo glider at 08:45z. The AUV was recovered at 14:45z followed by the forth HyBIS dive to the bottom of a gully, at 11217m, on the SW side of the Great Rift scarp. The dive was completed at 22:01z at the top of the plateau, at 821m, followed by dredging at station 22.

26th October
Dredge stations 23 and 24 were occupied during the night and the AUV was launched at 09:34z. This was followd by a shipboard multibeam survey until the HyBIS was launched at 17:22z and recovered at 21:29z (station 27). This short dive was on the western plateau, starting from the top of the Great Rift's western scarp and close to the end of dive station 27.

27th October
The night programme began with a dredge at station 28 followed by shipboard multibeam until 06:30z when the AUV was recovered. There then followed a cyclone that we avoided by steaming 200 nautical miles to the north and hove too until the 30th October.

28th October
Hove to in a cyclone

29th October
Hove to in a cyclone, then transit back to work area.

30th October
AUV launch at 08:09z station 31. Followed by a HyBIS dive (station 32, HyBIS consecutive Dive #35) at 13:40z. This dive was into a 200m wide x 70m deep pit on the Great Rift floor. The objective of the dive was to investigate this unusual feature, which is unexpected in a hard seabed at 1400m water depth, and to see if we can sample the substrate of the Great Rift. The dive revealed a 70m deep, flat bottomed hole with vertical sides made of layered calcareous chalk. Following a short transit, another HyBIS dive (station 33, Dive #36) was made up the western scarp of the Great Rift, ascending 500m almost vertically across massive and columnar jointed lavas with patches of red weathered clays in between flows. The dive finished on deck at 22:08z and was followed by a dredging programme, starting with stations 34.

31st October
The night time dredges continued with station 35, and then at 05:23z, a shipboard multibeam survey. The AUV was recovered at 08:03z, followed by more multibeam surveying until 12:53z when the HyBIS was launched at station 39 (HyBIS Dive 37). This occupied a location on the SW scarp of the Great Rift, traversing from the rift floor to the top of the cliff. It was followed by another HyBIS dive (station 40, HyBIS Dive 38) on the SW plateau are, close to the top of the previous Dive, in an area of smooth seafloor. Divers were completed by 21:53z, followed by a night time dredging programme (station 41).

1st November
Gravity coring at stations 42 and 43 were completed in the Great Rift floor. The AUV was deployed at station 44. At 12:48z, Hybis was deployed at station 45, on a plateau on the far western side of our study area and recovered at 18:57z. Station 46 was dredging that continued until mid-night.

2nd November
Station 47 was another drege during the night, followed by a multibeam survey ands transit to the AUV recovery at station 49. HyBIS was deployed at 16:10z at station 50 (HyBIS Dive #50). This occupied an area on the southern edge of the western plateau. At 22:13, station 51 commended the night programme of dredging.

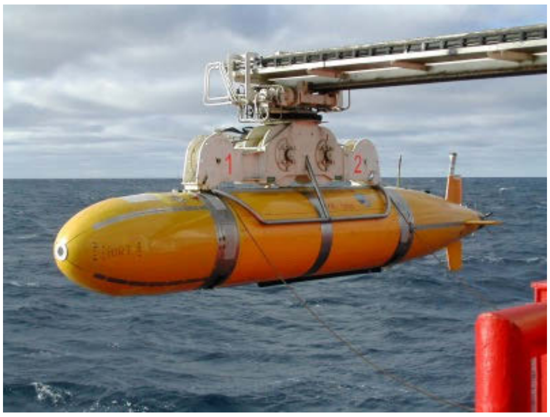
3rd November
Dredging continued with stations 52 and 53. The AUV was launched for its forth mission at station 54, 08:18z. This was followed by a transit and HyBIS dive (station 55, HyBIS Dive #41) at 16:10z, located on the northern edge of the great Rift, ascending from the floor to the top of the scarp and then moving southeast along the edge. Notable were the massive lava flows forming the scarp and terraces with lateritic weathered tops to the lavas. The dive was completed and HyBIS on deck by 21:31z, followed by transit and dredging, starting at station 56.

4th November
Station 57 was a dredge, followed by a multibeam survey that continued until the AUV was recovered at 08:30z (station 60). HyBIS was launched at 12:07z at station 61 (HyBIS Dive #42) where it ascended the northeastern side of the Great Rift scarp. The dive finished at 21:30z and after a brief transit, dredging commenced at 22:15z, station 62.

5th November
Dredging continued the night programme with stations 63 and 64. A multibeam survey followed, filling in key areas, until 12:09z when the final HyBIS dive was made at station 67 (HyBIS Dive #43). This, the final dive, was located across a series of parallel striations, 3km long and 20-200m wide, that are apparent on the sidescan sonar images for the edge of the eastern plateau. The dive finished at 19:03z and the final station, 68, was occupied by a dredge that was lost.

6th November
Steaming west back to Santos began at 00:00z, with an ETA of 4:00z, 8th November, for the Pilot.

Chapter 2: Autosub6000 operations



The objectives of the Autosub6000 operations were to map the seafloor using a Simrad EM2040 multibeam echosounder and Edgetech sidescan sonar running at 100kHz. The Autosub6000 was also used to collect sub-bottom profiler data, three-component magnetics and CTD data. Early on in the expedition we found that the multibeam echosounder was non operational and/or the data were corrupted. We therefore optimised further missions for the sidescan sonar. This changed our line spacing from 380m for the multibeam echosounder to 600m for the sidescan sonar.

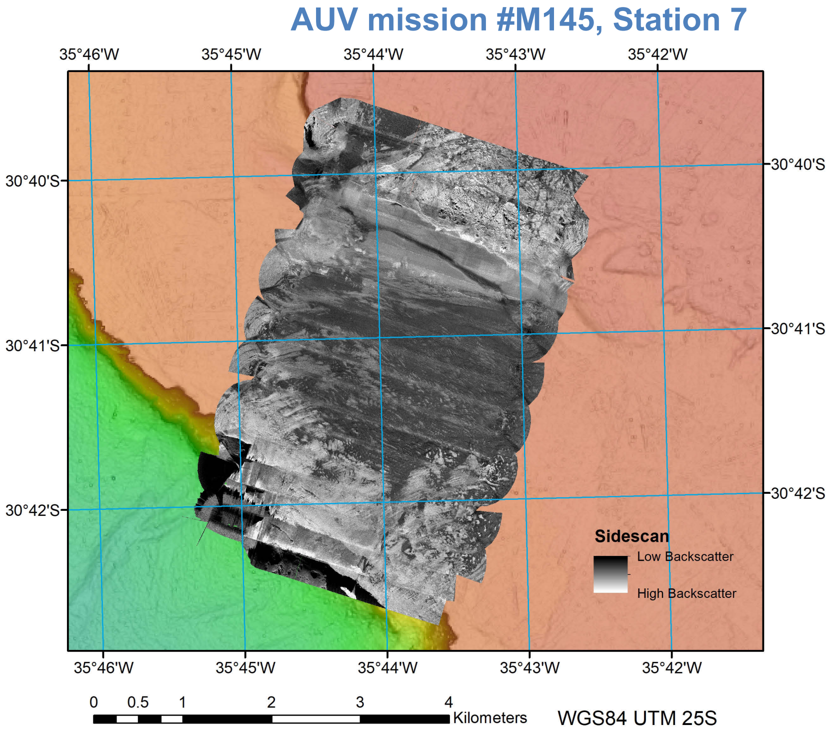


Figure 2-0-1: Map showing location of AUV mission M145 with acquired sidescan sonar imagery.

Mission objectives were to compare multibeam and sidescan sonar imagery of the plateau on the north-eastern side of the Great Rift, to test relationship between imagery and FeMn crust occurence. The multibeam system failed, and was not able to acquire any data throughout the cruise. The track spacing was optimised for the multibeam, with a spacing of 280m. This was subsequently changed to 600m to optimise for the sidecan sonar coverage. Dark is low acoustic albedo (reflectivity) and represents areas of soft sediment. The bright areas are hard ground and, especially where the sidescan images show chaotic terrain, FeMnC.

AUV mission #M146, Station 15

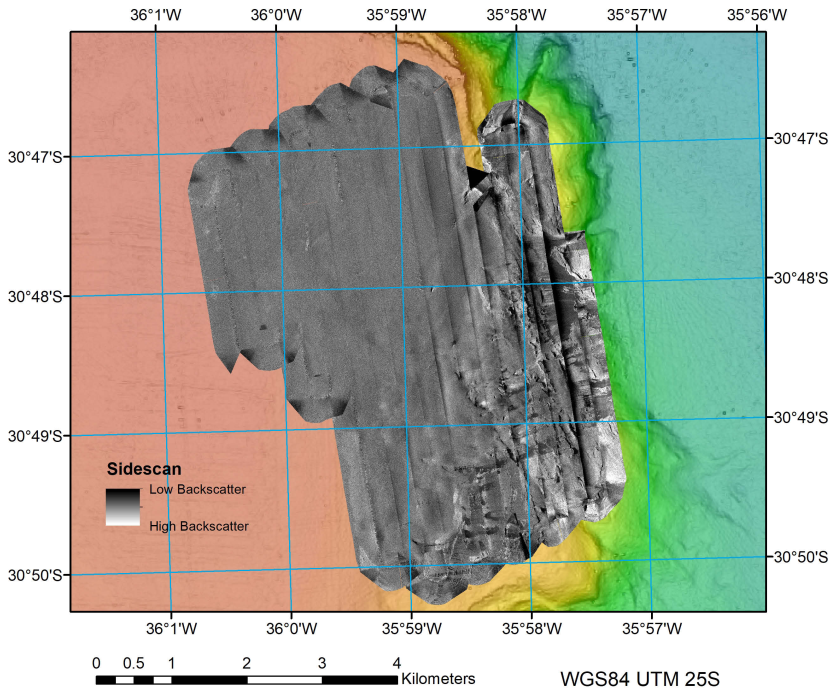


Figure 2-0-1: Map showing location of AUV mission M146 with acquired sidescan sonar imagery.

Mission objectives were to multibeam map the plateau on the north-western side of the Great Rift, and acquire sidescan sonar imagery. The main area of the plateau is homogeneous in albedo and found to be covered in calcareous hard ground with a thin (few centimetres thick) cover of soft sediment.

AUV mission #M147, Station 25

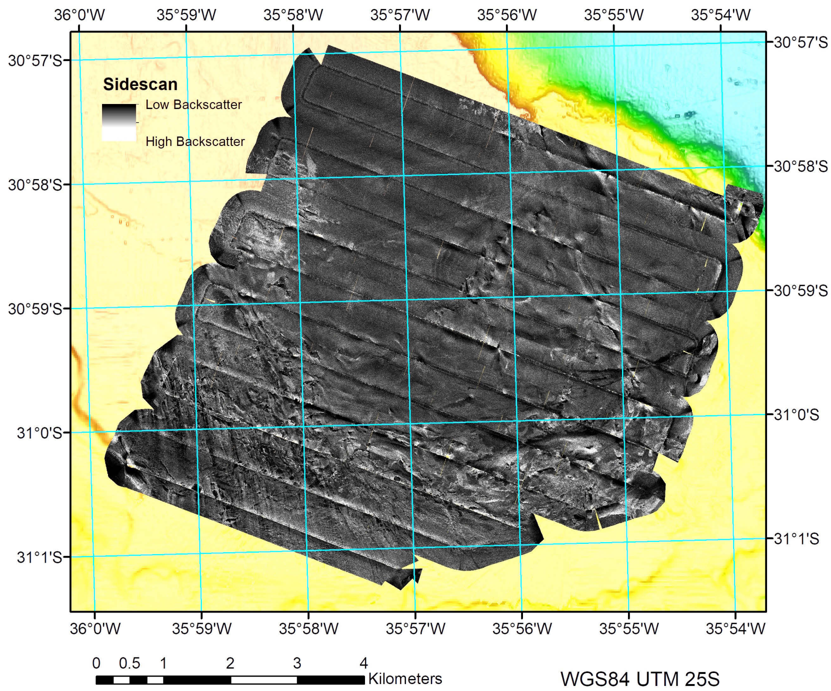


Figure 2-0-2: Map showing location of AUV mission M147 with acquired sidescan sonar imagery.

Mission objectives were to multibeam map the southwestern plateau on the side of the Great Rift, and acquire sidescan sonar imagery. The image shows striations NNW-SSE in the western side of the survey area, and E-W cracks in the SE side of the area.

AUV mission #M148, Station 31

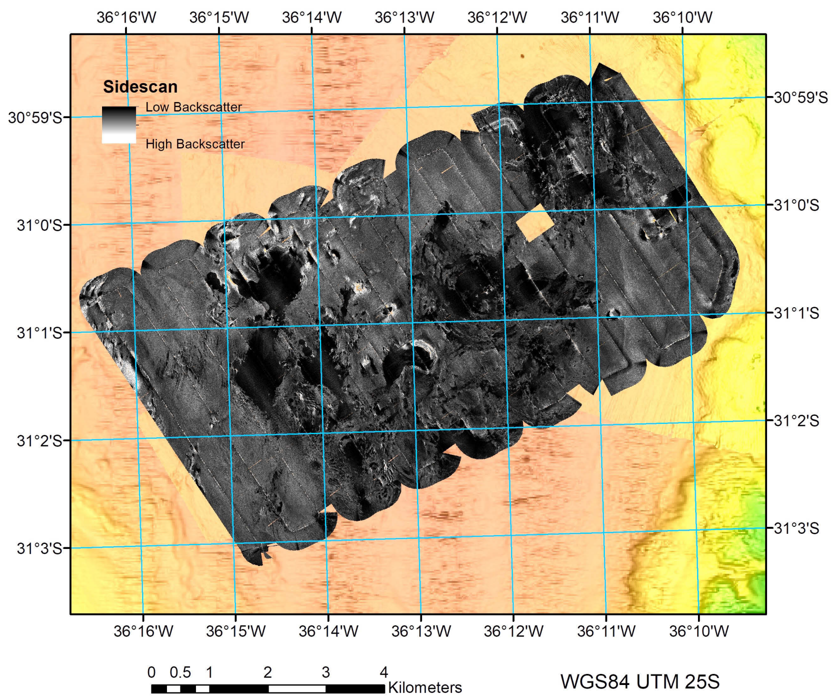


Figure 2-0-3: Map showing location of AUV mission M148 with acquired sidescan sonar imagery.

Mission objectives were to multibeam map the western plateau with seafloor depressions and acquire sidescan sonar imagery. The image shows low albedo in the depressions associated with accumulations of soft sediment.

AUV mission #M149, Station 44

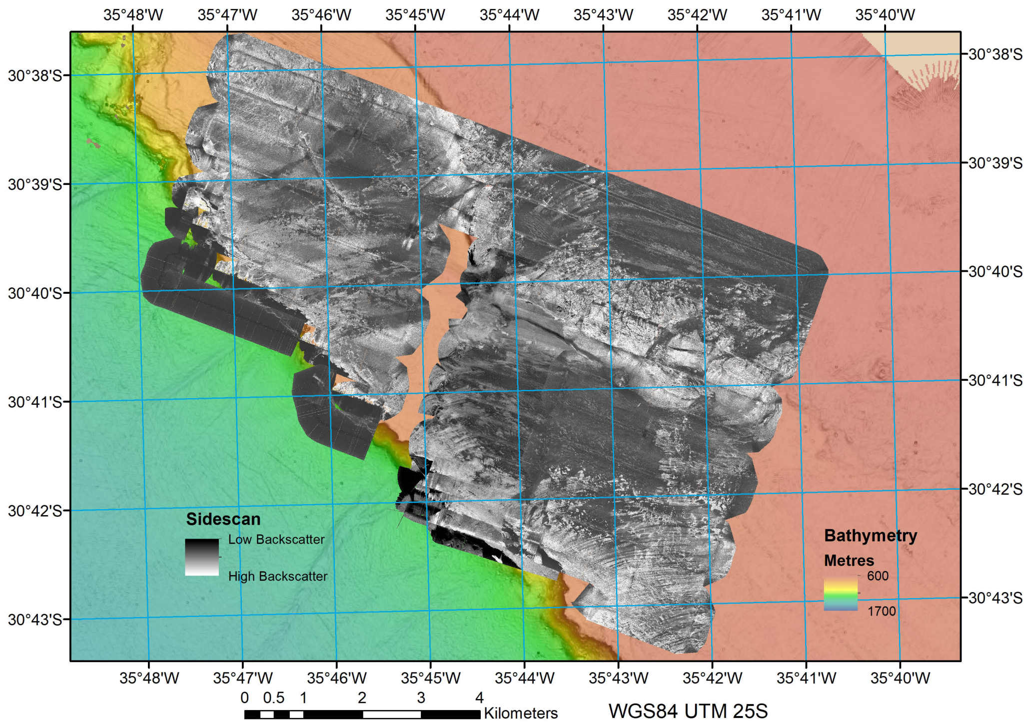


Figure 2-0-4: Map showing location of AUV mission M149 with acquired sidescan sonar imagery.

Mission objectives were to acquire sidescan sonar imagery for the eastern plateau and upper terrace where the seafloor shows a fractured high-albedo character. The image shows high albedo close to the Great Rift scarp, low albedo in a central area between the scarp and upper terrace, high albedo on the upper terrace that reduces northwards away from the terrace edge. Significantly, we see 3km long striations that are parallel on the seafloor in the south-western quarter of the area. Note the large coverage when the AUV was optimised for sidescan sonar imagery and a 600m line spacing. Also note that the image includes the sidescan sonar data from the first mission. The gap between the surveys was the result of a heading error in the AUV (11.3° anticlockwise) that had to be corrected, post-processing.

Autosub 6000 Technical Report

By: Rachel Marlow, Owain Shepherd, Richard Austin-Berry, Dale Carter, Phil Bagley (STO)

Table 2-1: summary of AS6K missions

Mission	Survey Time	Distance Travelled	Maximum Depth
M145	14 hrs 39 mins	62 km	621.6 m
M146	19 hrs 53 mins	88.9 km	1009.6 m
M147	20 hrs 06 mins	88.3 km	985.6 m
M148	21 hrs 15 mins	93.3 km	671.8 m
M149	21 hrs 52 mins	88.1 km	710.8 m
Total	**4 days 00 hrs 04 mins**	**420.6 km**	**-**

The Autosub 6000 achieved 5 missions, acquiring Sidescan sonar, CTD, and magnetometer data throughout. However, an ongoing issue with the EM2040 resulted in potentially little useable multibeam sonar data. At the start of the cruise an Inertial Navigation System (INS) failure required the Phins (fibre optic gyroscope based INS) to be replaced. Post processing of the first and last Autosub missions (M145 and M149) has identified an Autosub heading error of approximately 11.3 degrees when compared to ship based multibeam data. More analysis is required to confirm the presence of this issue, however if this error is confirmed a heading correction to the sidescan data will be required.

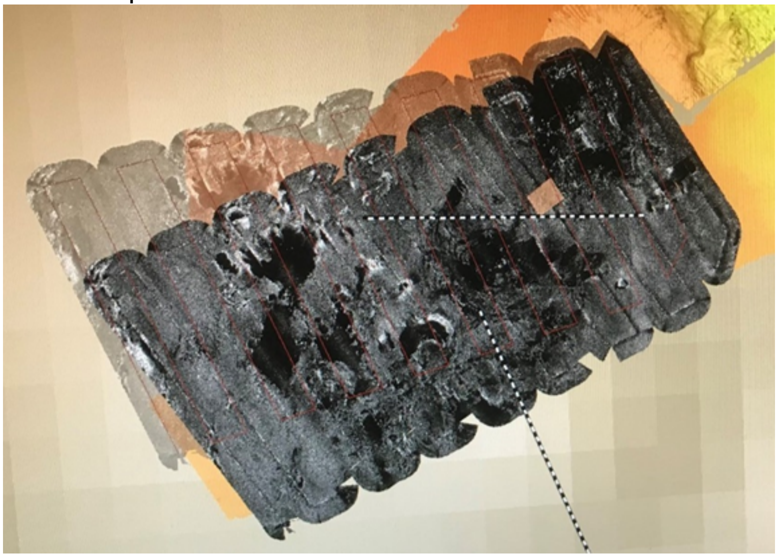


Figure 2-0-5: Autosub 6000 sidescan data (dark grey) overlaid against ship based multibeam data (light grey), potentially showing an Autosub 11.3 degree heading error. More analysis required to confirm the presence of the heading offset.

Mission 145
The AUV was launched and dived successfully, there were some issues monitoring the vehicle with the ships USBL but the AUV was eventually located and a navigation offset applied to the vehicle. The vehicle was then sent on its way and it successfully navigated the science tracks. The vehicle surfaced and was successfully recovered. On recovery approach the Edgetech sidescan sonar was heard still pinging, and subsequently disabled via remote desktop inspection of the control programs showed a number of issues.

Mission 146
The AUV was launched successfully. The AUV dived to depth and monitored by the ships USBL and LinkQuest. A navigation offset was not sent as the USBL data was too intermittent although it improved once the vehicle started along its track, at this point the navigation offset (the value required to be applied to the AUV navigation) was estimated to be 15m north and 95m west. The AUV completed the science tracks, surfaced and was recovered successfully. The Edgetech appeared to have recorded data for the entire mission, the EM2040 appeared to have stopped a number of times.

Mission 147
The AUV was launched and dived successfully. The vehicle was monitored via the Ships USBL and the Linkquest, a navigation offset was sent and the vehicle sent on its way. Towards the end of the mission, on the final track the mission aborted because the AUV reached its abort depth. As a consequence, it surfaced a couple of hours early and its position was picked up via the Novatech Iridium beacon. The abort was caused by an error setting the configuration limits for the mission. The vehicle was recovered back on deck without incident.

Mission 148
The AUV was launched and dived successfully. The vehicle was monitored successfully by Linkquest but there were issues with the Ships USBL and so no navigation offset was sent to the vehicle. The AUV was sent on its way and completed the mission. On surfacing the vehicle

appeared to be about 1 mile off the final waypoint although this could have been because it was drifting whilst waiting for a valid GPS position. The wind (F7) and seas at the time of surfacing were not suitable for recovery so the vehicle was kept alongside the ship and monitored until the weather improved sufficiently for a recovery to be attempted. The recovery was successful with minor damage to the Rudder and stern planes but no major damage to the AUV. The recovery was challenging, with the vehicle going under the stern and then being hooked from the aft deck rather than the side of the ship.

Mission 149
The AUV was successfully launched and dived. The vehicle was monitored on both the Linkquest and the ships USBL. A navigation offset was successfully sent to the AUV and the sub sent on its way. The vehicle performed the science tracks and surfaced without incident. The weather was not as predicted on surfacing with stronger wind and a larger swell but it was deemed safe to recover. Recovery was successful with only a snapped Wi-Fi/GPS antenna. Edgetech data was successfully captured but as previous missions the EM2040 exhibited problems.

Chapter 3: HyBIS Operations

Station 1, HyBIS Dive #30

Test dive to 1400m floor of the Great Rift.

Station 9, HyBIS Dive #31

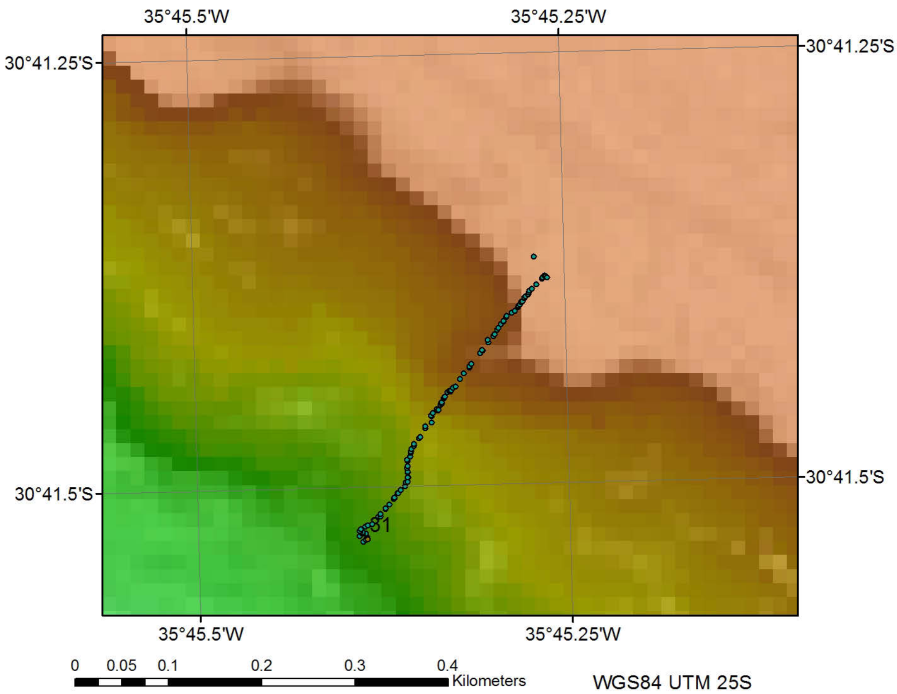


Figure 3-0-1: Map showing location of HyBIS Dive #31 with background bathymetry.

Dive objectives were to explore the eastern wall of the Great Rift. Dive observed massive lavas and boulders, little FeMnC.

Station 14, HyBIS Dive #32

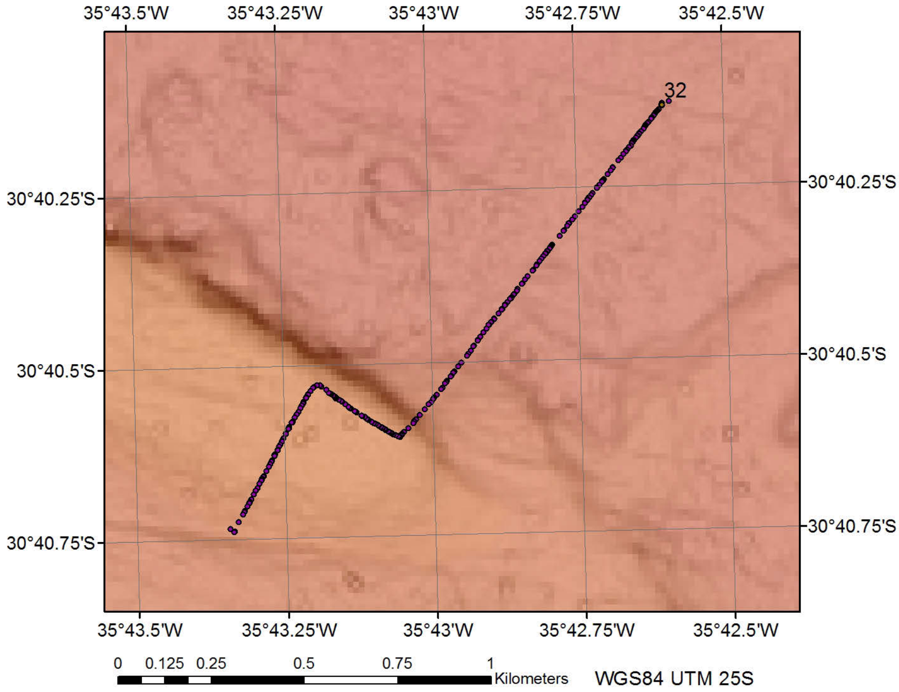


Figure 3-0-2: Map showing location of HyBIS Dive #32 with background bathymetry.

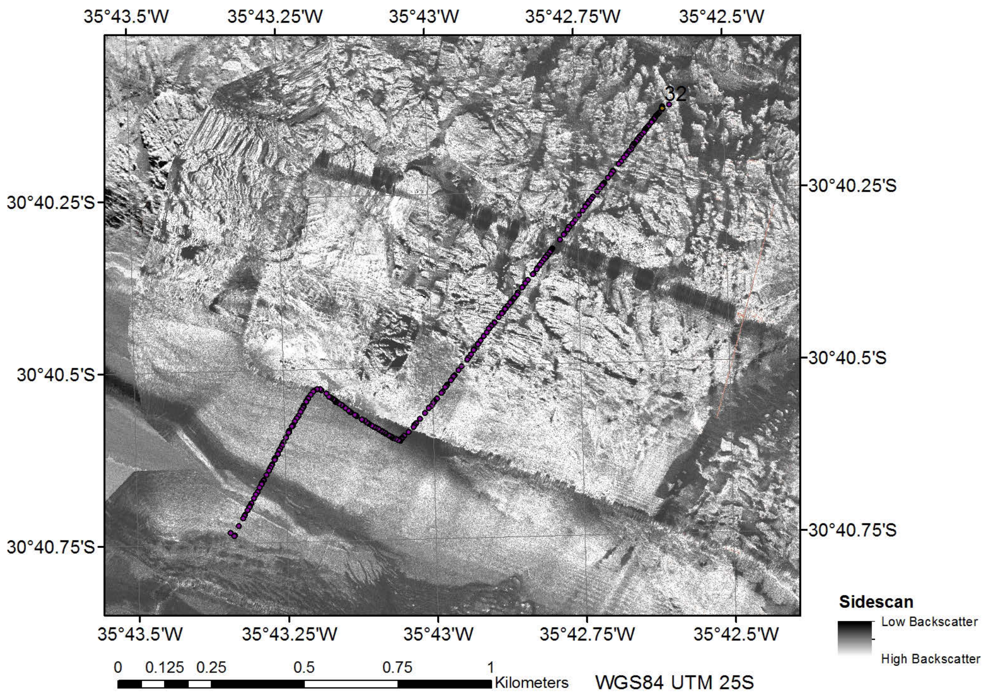


Figure 3-0-3: Map showing location of HyBIS Dive #32 with background sidescan sonar imagery.

Dive objectives were to explore the upper terrace of the eastern plateau of the RGR. Special target was the highly fractured pattern of bright reflectivity thought to be exposed basement. Dive observed fractured and rugged massive lavas and boulders with little FeMnC.

Station 21, HyBIS Dive #33

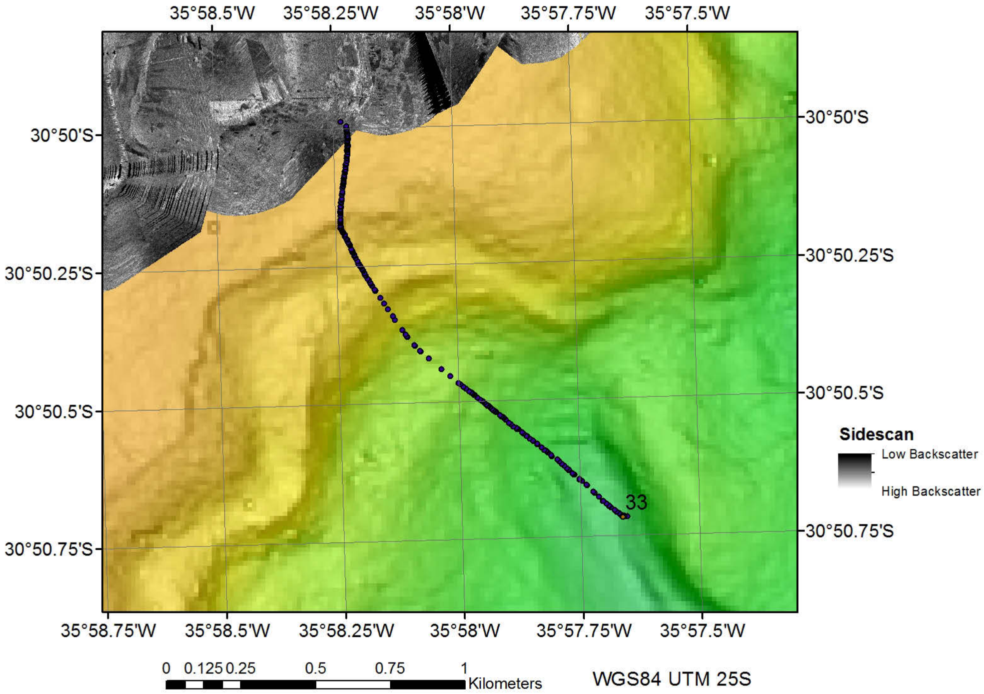


Figure 3-0-4: Map showing location of HyBIS Dive #33 with background bathymetry.

Dive objectives were to explore the western scarp of the great Rift and the origins of a gully. The dive observed smooth calcareous (chalk?) and lavas in the gully, massive lavas and volcanic breccias in the scarp wall and boulders on a hard calcareous floor at the top of the scarp on the plateau.

Station 27, HyBIS Dive #34

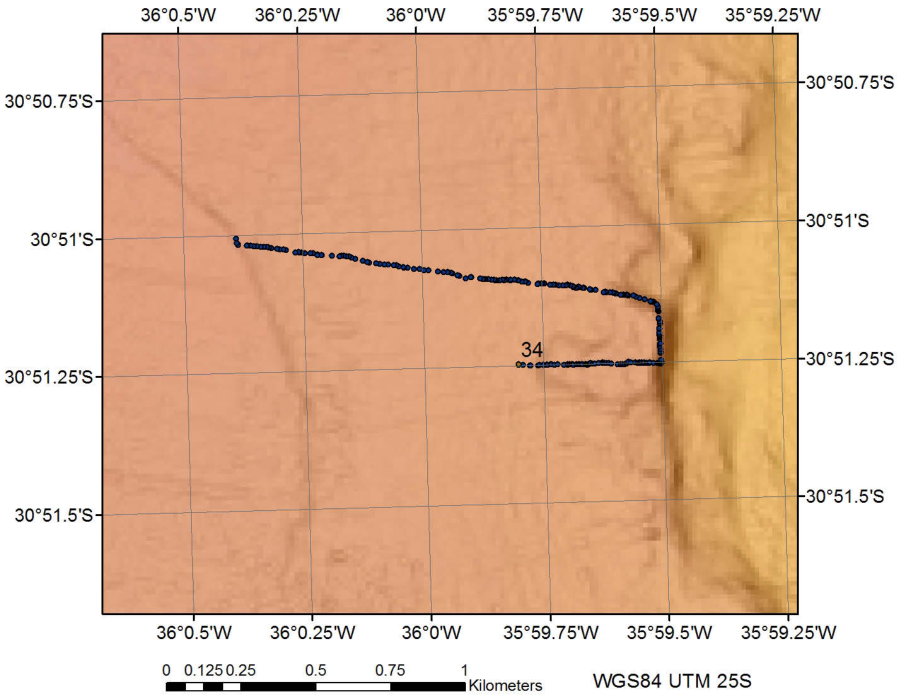


Figure 3-0-5: Map showing location of HyBIS Dive #34 with background bathymetry.

Dive objectives were to explore the top of the western plateau. The dive observed smooth calcareous hard ground and lavas at the edge of the scarp. On the plateau, a 5m high terrace, curving NW-S, rises above a hard calcareous floor and contains a thin (5cm) layer of FeMnC.

Station 32, HyBIS Dive #35

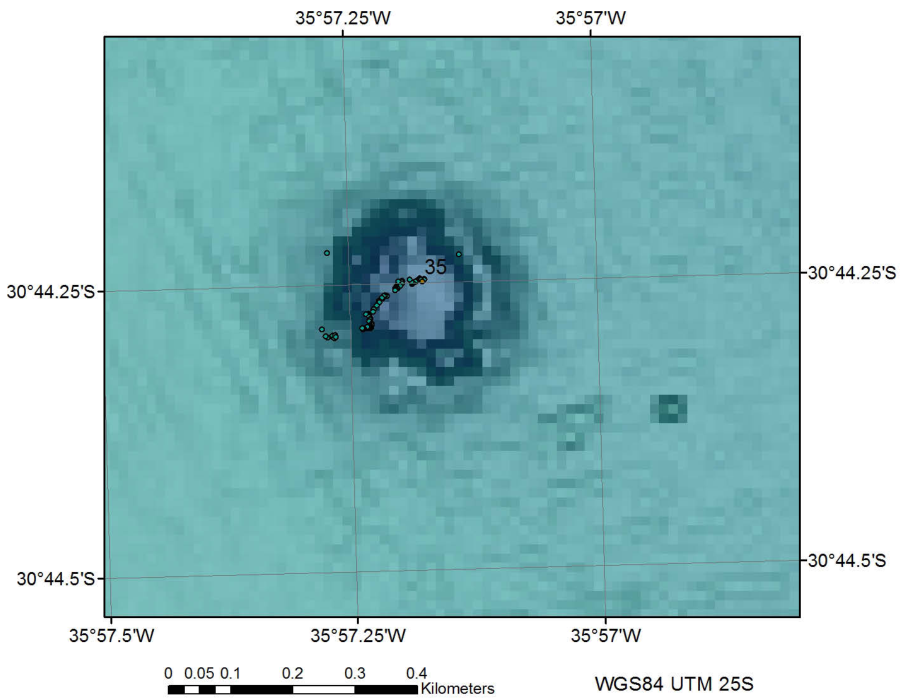


Figure 3-0-6: Map showing location of HyBIS Dive #35 with background bathymetry.

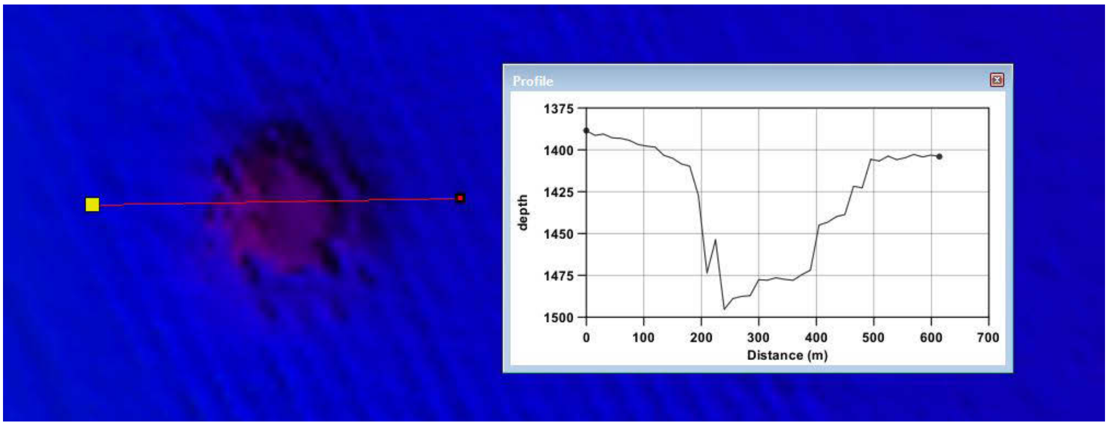


Figure 3-0-7: Map showing location of HyBIS Dive #35 with bathymetry profile of 'Blue Hole'.

Dive objectives were to explore a 70m deep, 200m wide sink-hole in the floor of the Great Rift. The dive observed smooth and layered calcareous chalks at the edge of the bottom of the hole in the near vertical walls. At the top of the hole, on the floor of the rift was found a hard calcareous sandy bottom.

Station 33, HyBIS Dive #36

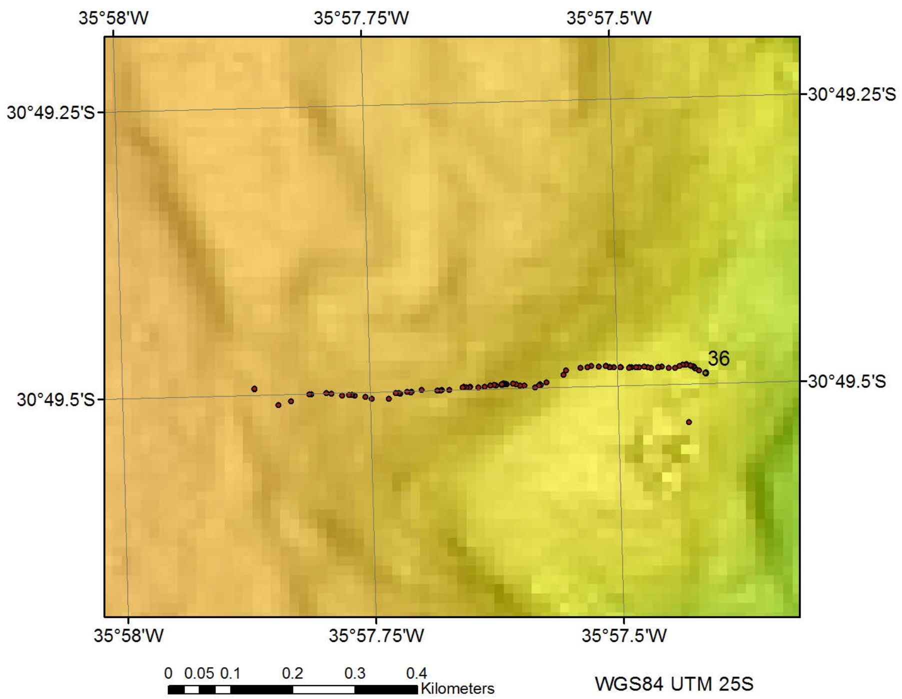


Figure 3-0-8: Map showing location of HyBIS Dive #36 with background bathymetry.

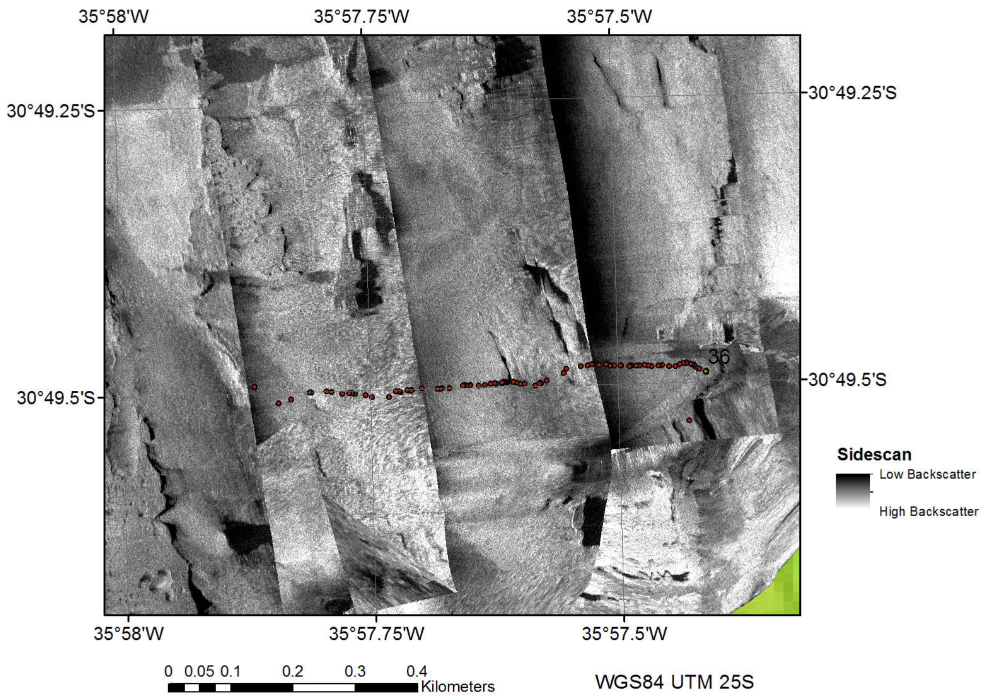


Figure 3-0-9: Map showing location of HyBIS Dive #36 with background sidescan sonar imagery.

Dive objectives were to explore the western scarp of the Great Rift, ascending 500m almost vertically across massive and columnar jointed lavas with patches of red weathered clays in between flows.

Station 39, HyBIS Dive #37

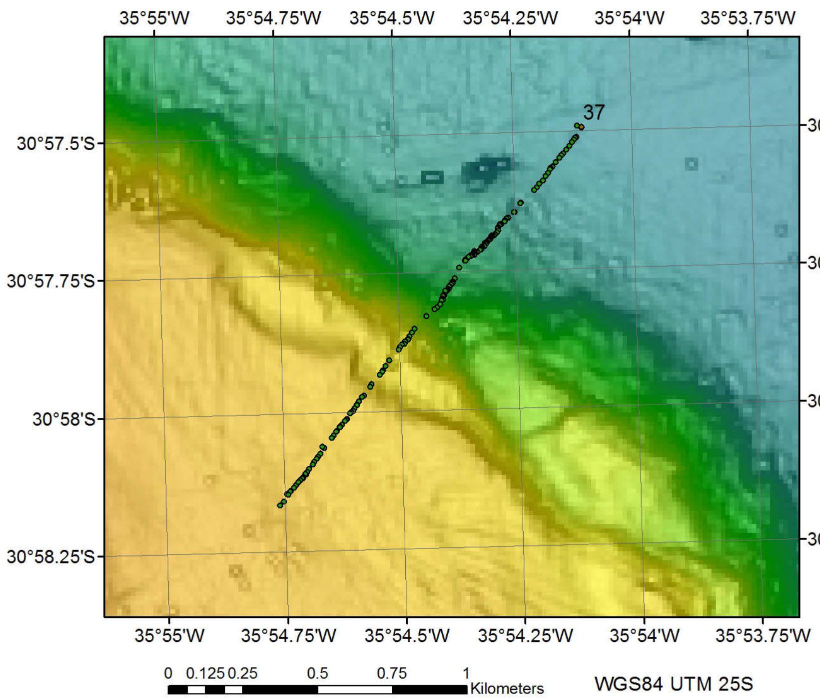


Figure 3-0-10: Map showing location of HyBIS Dive #37 with background bathymetry.

Dive objectives were to explore the northeastern rift wall, from the floor of the great Rift to the upper plateau, passing several terraces.

Station 40, HyBIS Dive #38

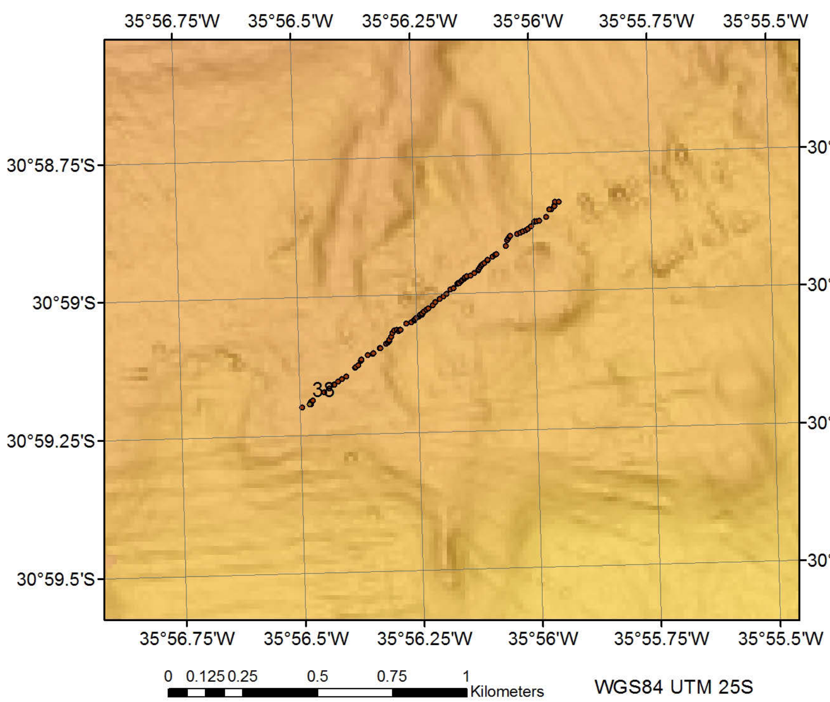


Figure 3-0-11: Map showing location of HyBIS Dive #38 with background bathymetry.

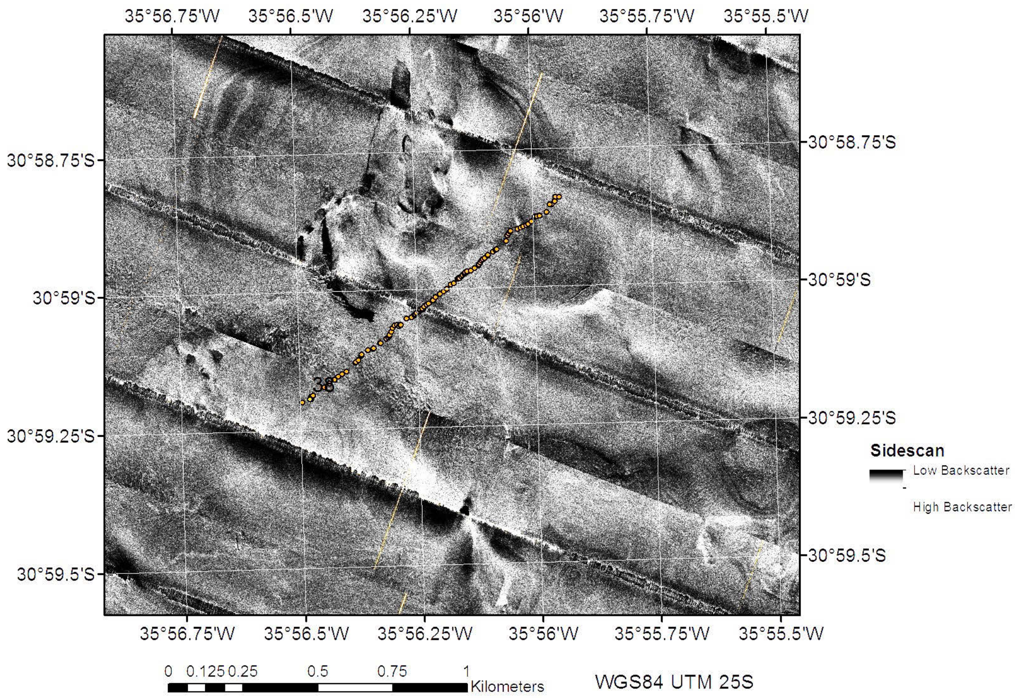


Figure 3-0-12: Map showing location of HyBIS Dive #31 with background sidescan sonar imagery.

Dive objectives were to explore the top of the southwestern plateau, in an area of rough bathymetry and heterogeneous sidescan texture.

Station 45, HyBIS Dive #39

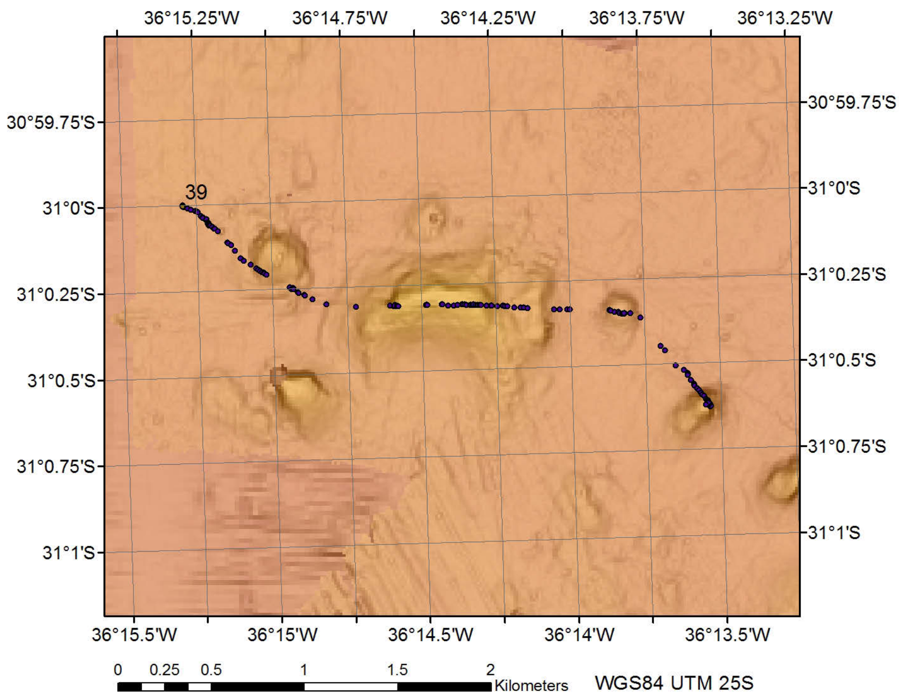


Figure 3-0-13: Map showing location of HyBIS Dive #39 with background bathymetry.

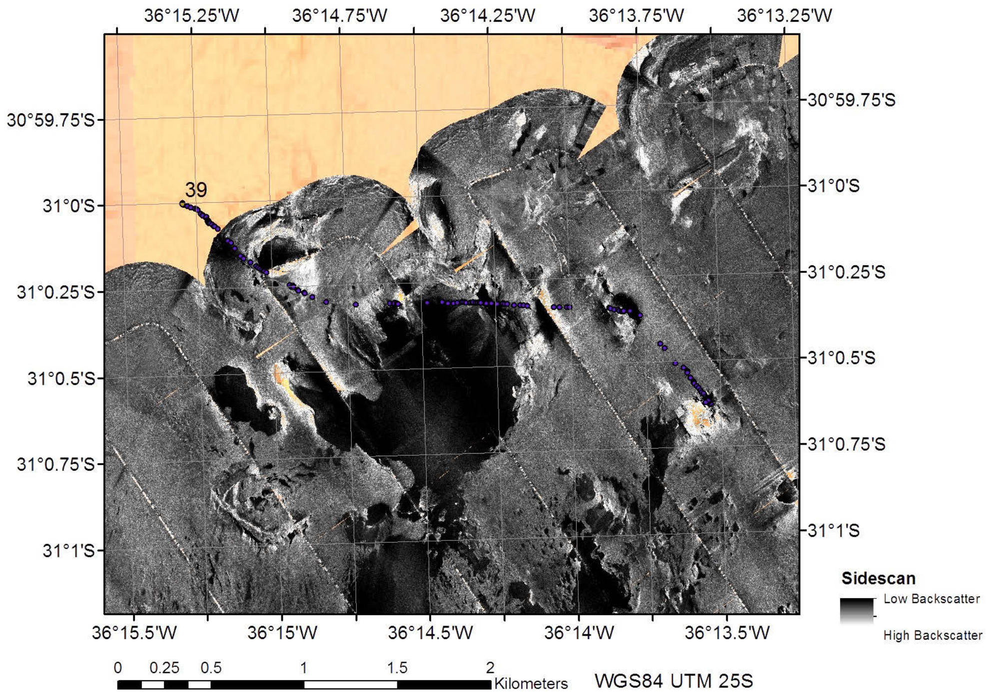


Figure 3-0-14: Map showing location of HyBIS Dive #31 with background sidescan sonar imagery.

Dive objectives were to explore depressions in the south western plateau area. The dive observed calcareous hard ground with a mixture of boulders and cobbles, many without any FeMn staining, and of volcanic origin, on top of the hard ground. The depressions contained some soft sediment and fragments of crust.

Station 50, HyBIS Dive #40

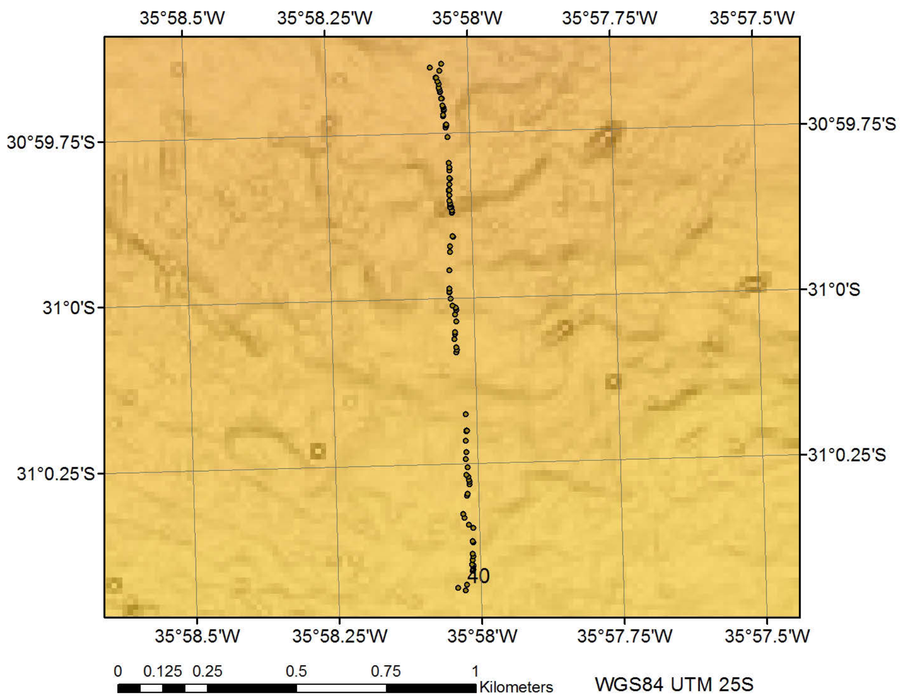


Figure 3-0-15: Map showing location of HyBIS Dive #40 with background bathymetry.

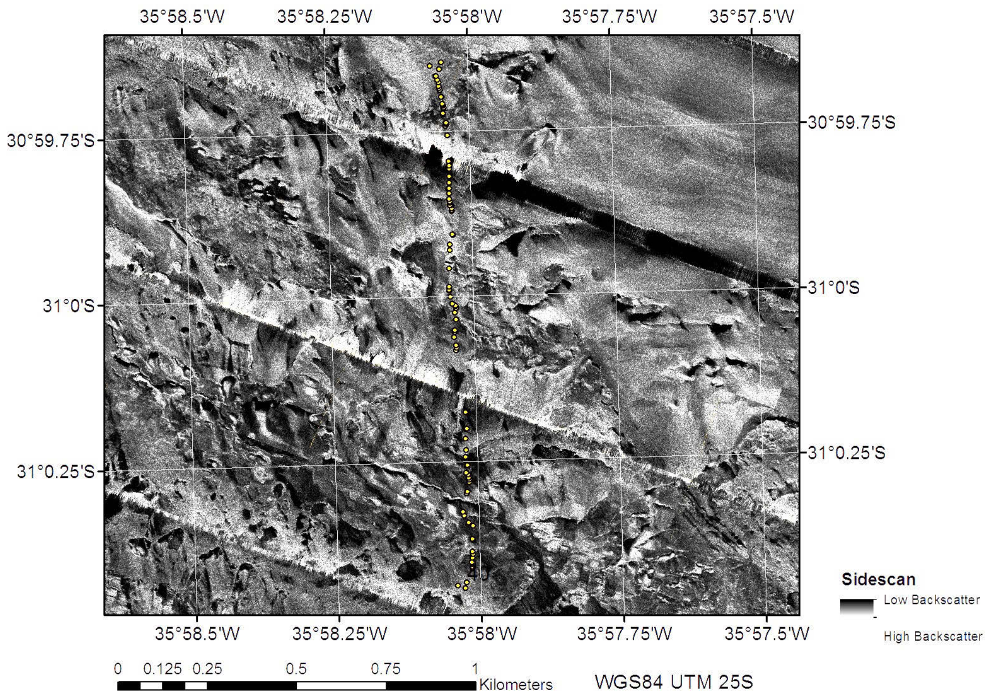


Figure 3-0-16: Map showing location of HyBIS Dive #40 with background sidescan sonar imagery.

Dive objectives were to explore the SW plateau in another area of heterogeneous seafloor. This was found to comprise calcareous hard ground with patches of thin (1-2cm) crust.

Station 55, HyBIS Dive #41

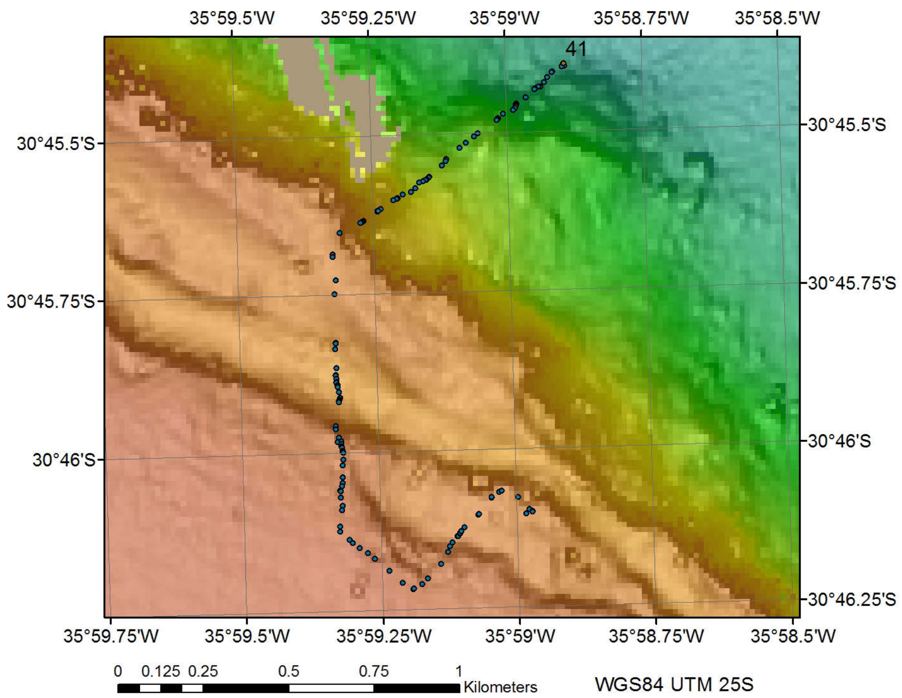


Figure 3-0-17: Map showing location of HyBIS Dive #41 with background bathymetry.

Dive objectives were to explore the NE edge of the western plateau and the scarp of the Great Rift and its terraces. The dive observed massive columnar jointed lavas and lateritic weathered beds.

Station 61, HyBIS Dive #42

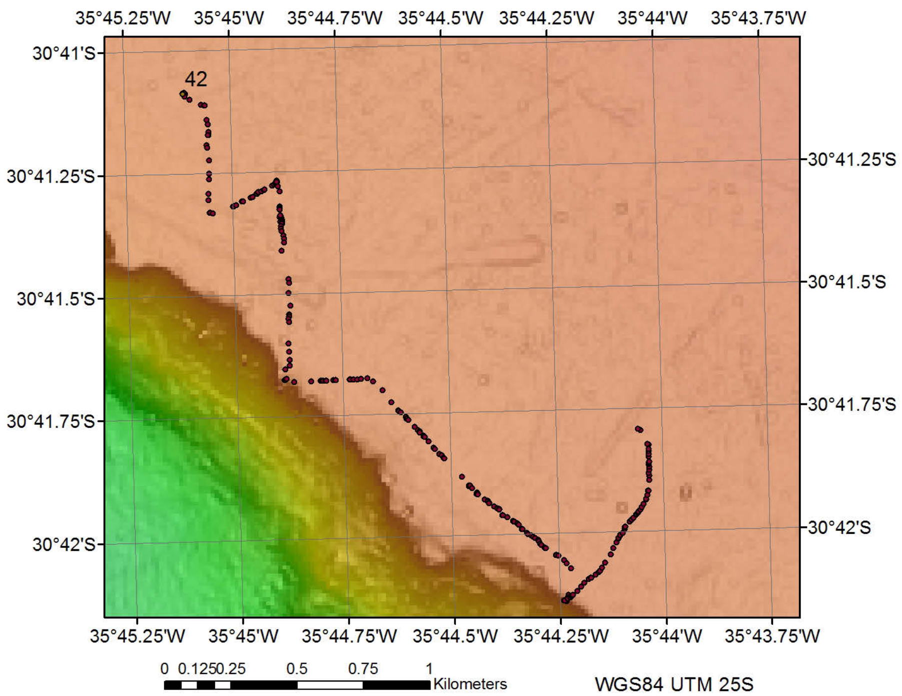


Figure 3-0-18: Map showing location of HyBIS Dive #42 with background bathymetry.

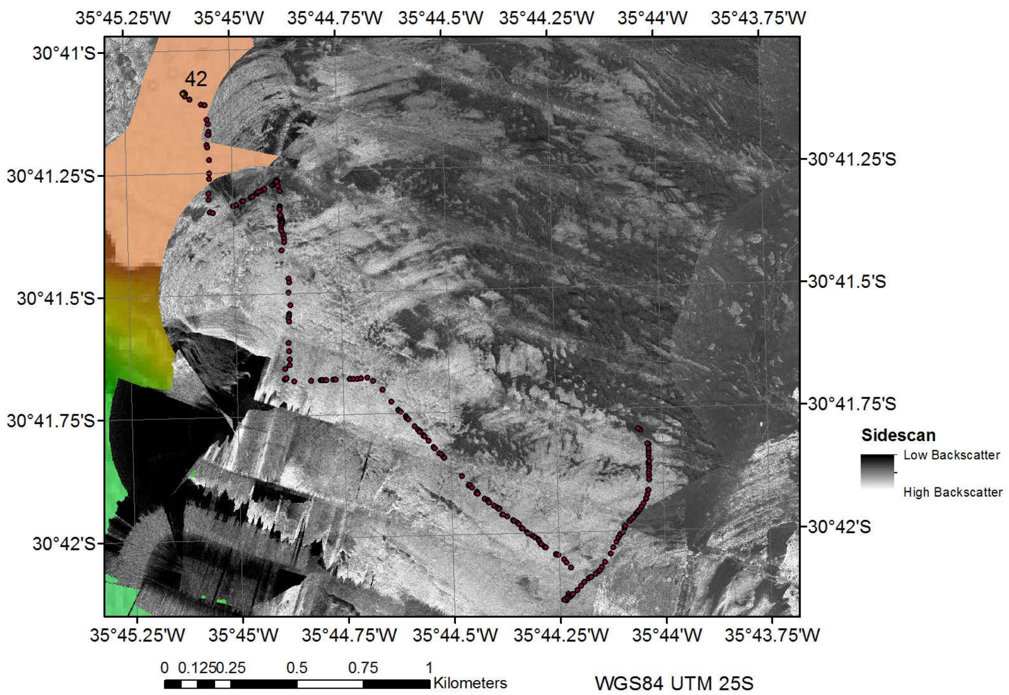


Figure 3-0-19: Map showing location of HyBIS Dive #42 with background sidescan sonar imagery.

Dive objectives were to explore the SW edge of the eastern plateau above the scarp of the Great Rift and bright areas on the sidecsan sonar images. The dive observed areas of FeMnC and patches of rippled sediment over a calcareous hard ground. Also seen where doughnut shaped calcareous forms eroding out of the hard ground.

Station 67, HyBIS Dive #43

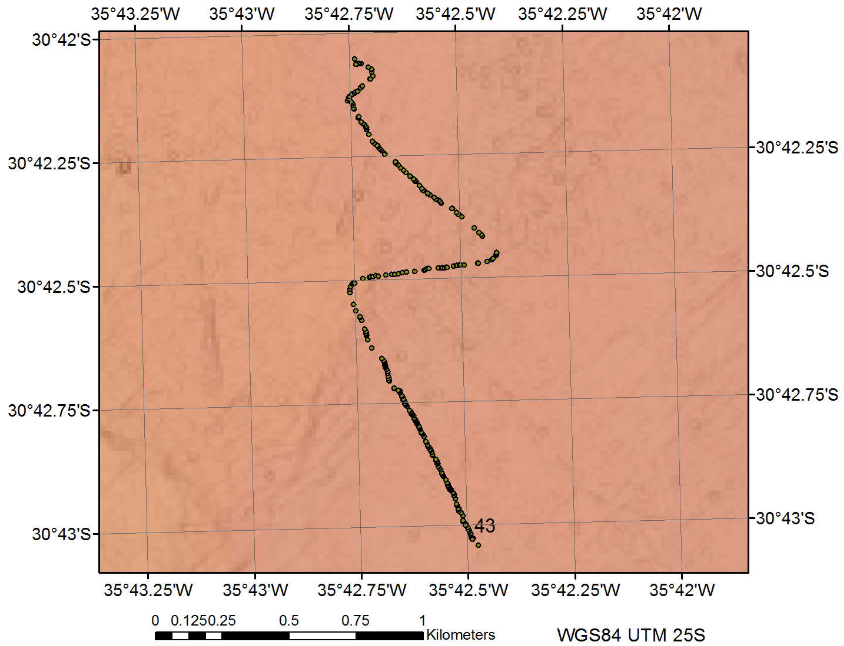


Figure 3-0-20: Map showing location of HyBIS Dive #43 with background bathymetry.

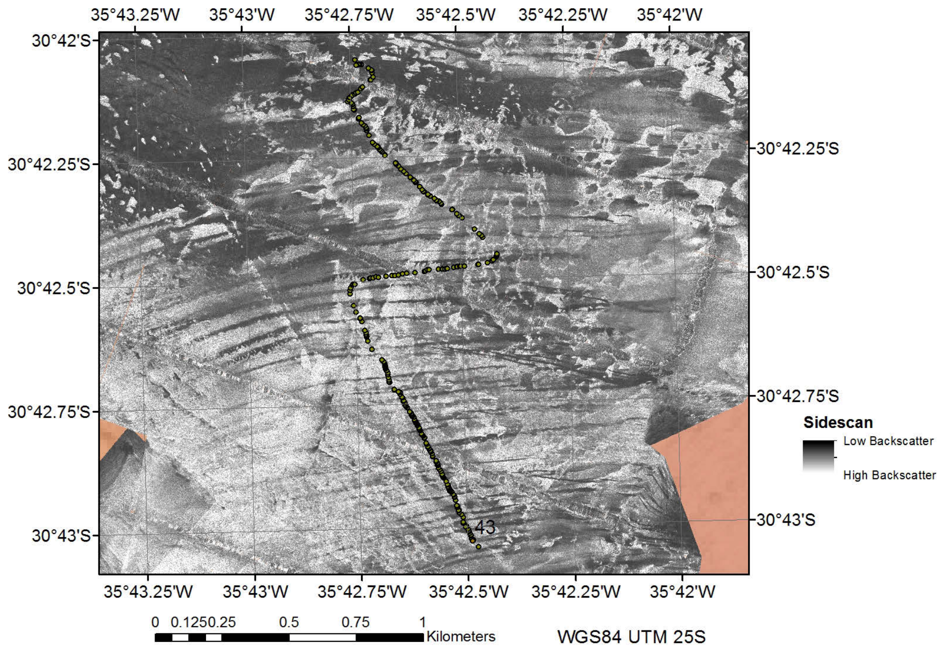


Figure 3-0-21: Map showing location of HyBIS Dive #40 with background sidescan sonar imagery.

Dive objectives were to explore an area in the eastern plateau of bright and dark striations seen in the sidescan sonar images. The striations are 20-100m wide and extend for up to 3km E-W. The dive observed linear areas of FeMnC and rippled sediment with FeMnC and calcareous hard ground underneath.

HyBIS Technical Report

By: Andy Webb, Josue Viera Rivero

Table 3-1: operational summary

Number of Dives	**14**
Depth range of dives	620m to 1480m
Total seabed survey time	50 hrs 26 mins
Total Hybis run time	69 hrs 23 mins
Data Storage	
Video (Apple ProRes 422)	HD: 2.6TBytes
	PAL: 2.53 TBytes
Total number of Scorpio Images:	13359 images (51.8 Gbytes)

The concept of operation for the scientific cruise was to use ship-borne multibeam sonar data to determine the area of interest for high resolution Autosub sonar surveys. Then use Hybis for detailed surveying and sampling of key areas of interest highlighted by the AUV sonar surveys. After the challenges of the mobilisation and some initial adjustments on the first dives, Hybis performed as designed during all the dives. Overall, HyBIS was successfully deployed for the MarineE-tech DY094 cruise, and delivered the video, data and photos that science required for their research. HyBis delivered 5305 GB of data which includes 13350 still images, more than 50 hours of video and nearly one hundred samples.

Table 3-2: Dive summary

Dive	**Seabed Survey Time**	**Water Depth**	**Scorpio Camera HD Video**	**Images**
HY30	0:27	1410m	9.42 GBytes	40
HY31	1:19	1094m	67.2 Gbytes	353
HY32	2:57	620m	157.92 Gbytes	817
HY33	3:00	1220m	160.31 Gbytes	850
HY34	3:28	712m	185.86 Gbytes	850
HY35	2:19	1420m	122.2 Gbytes	494
HY36	1:38	840m	85.02 Gbytes	490
HY37	3:32	1396m	189.89 Gbytes	894
HY38	2:20	780m	124.55 Gbytes	509
HY39	5:50	840m	313.6 Gbytes	1601
HY40	4:02	840m	215.43 Gbytes	1004
HY41	6:14	1315m	338.8 Gbytes	1863
HY42	8:16	700m	442.2 Gbytes	2330
HY43	5:04	666m	251.6 Gbytes	1498

Chapter 4: Geological surveying and observations

Surveying of the seafloor was undertaken during 13 HyBIS Remotely Operated Vehicle (ROV) dives. The key objectives were to: i) map the distribution of lithology and structure, obtain representative rock samples, and make other key geological observations; ii) ground truth the remotely sensed AUV data; and iii) identify areas for seafloor dredging based on topography and lithology. Dive tracks typically covered a distance of 2–3 km. Four primary lithologies were identified: volcanic rocks, principally basalt and volcanoclastic rocks; calcarenites, ferromanganese crusts; and superficial soft sediments, which are rare due to the high energy environment on the rift wall and plateau.
In situ volcanic rock typically comprise massive basalt and coarse-grained, poorly sorted (containing bomb size) volcanoclastics. The basalts locally display features, which may represent columnar jointing. The igneous rocks are best observed in the steep cliff faces extending from the base of the rift and where they are not coated by Fe-Mn crusts. The deposits are locally layered. Large (up 1m size), well-rounded and smooth basalt blocks are common at the base of some cliffs and on terraces. At a number of locations the basalt appears to be weathered and altered to a red-brown clay-rich material, likely to result from terrestrial weathering of the outcrops.

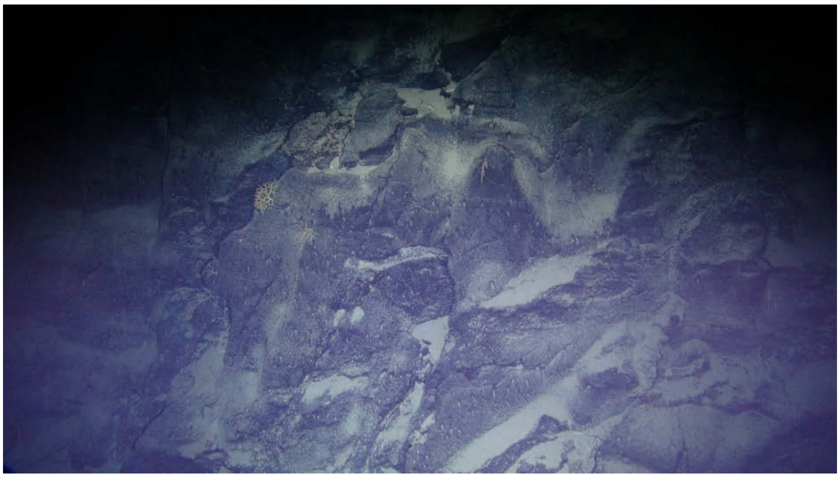


Figure 4-1: Massive basalt encountered in a cliff face in the rift wall. Sediment accumulates in gullies and other traps on the canyon wall (HY_31).

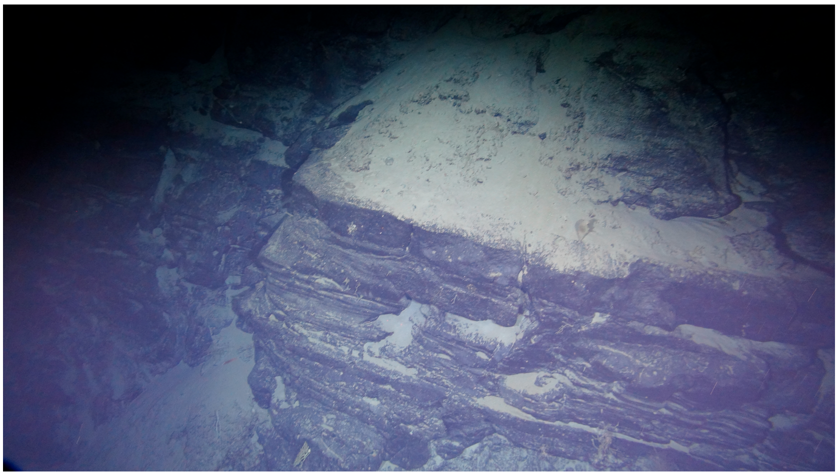


Figure 4-2: Layered basaltic rocks in the canyon wall (HY_31).


Figure 4-3: Volcaniclastic rocks in the cliff wall of the rift (HY_31).


Figure 4-4: Brecciated volcanic rocks in a cliff wall (HY37).

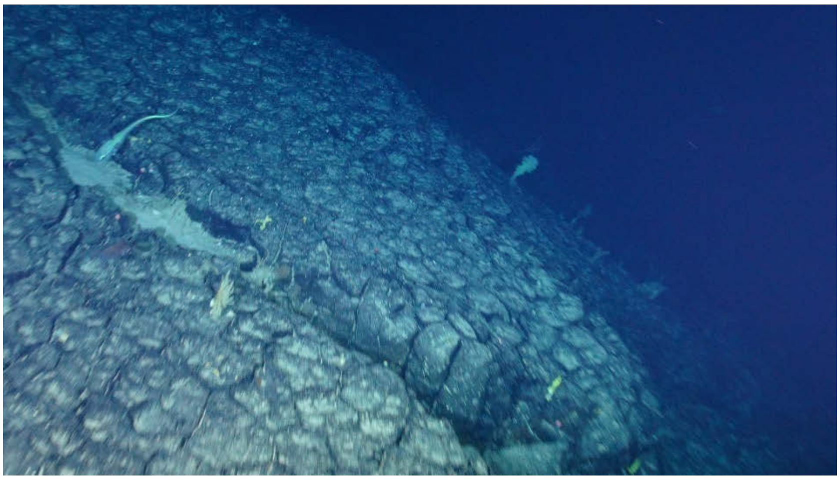


Figure 4-5: Columnar basalt observed on a moderate slope. The column range from 10-40 cm in width (HY_34).

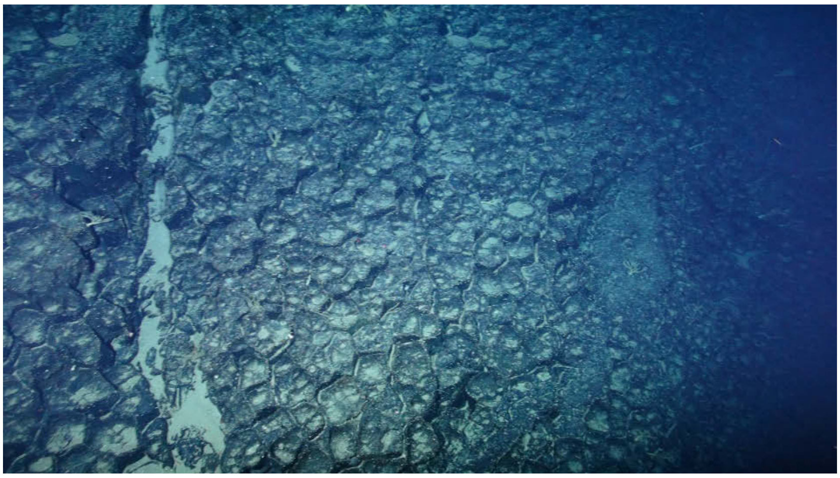


Figure 4-6: Jointing in the surface of a basalt exposure. The surface of each column has a concave structure, which acts as a trap for soft sediment (HY_34).

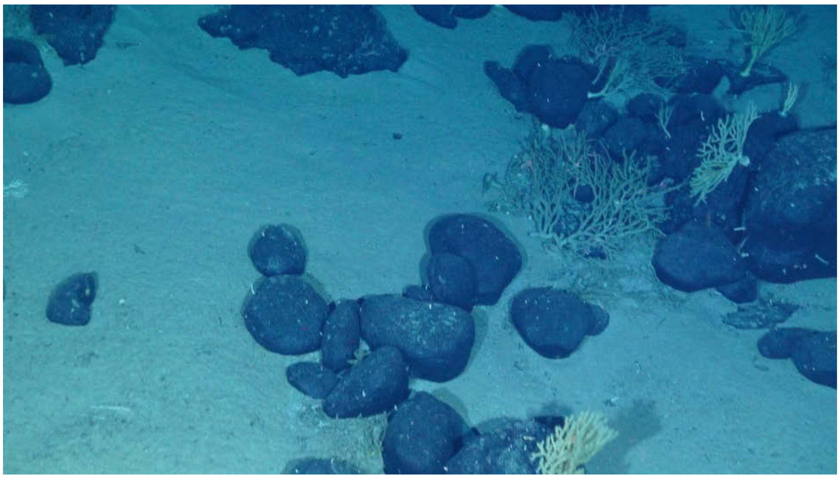


Figure 4-7: Large (typically 20-50 cm size), smooth, rounded boulders lying on top of the calcarenite (HY_36).

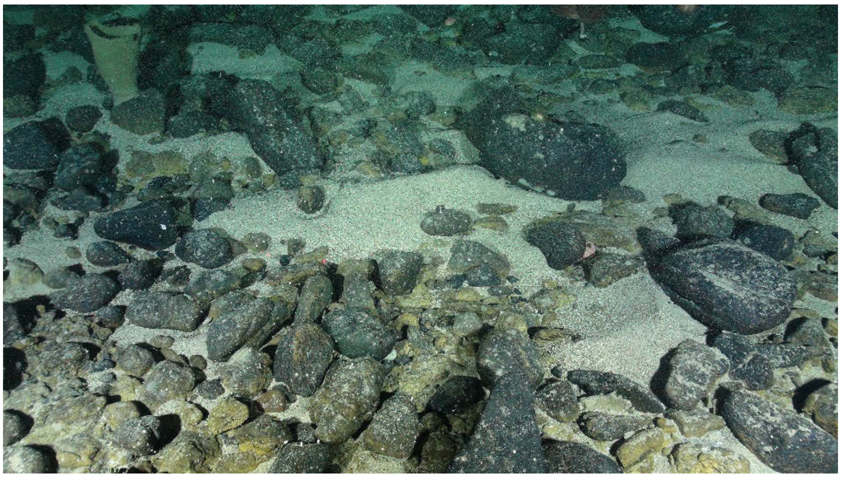


Figure 4-8: A basalt boulder field. Sand-sized loose sediment lies between the sub-rounded basalt boulders (HY_41).

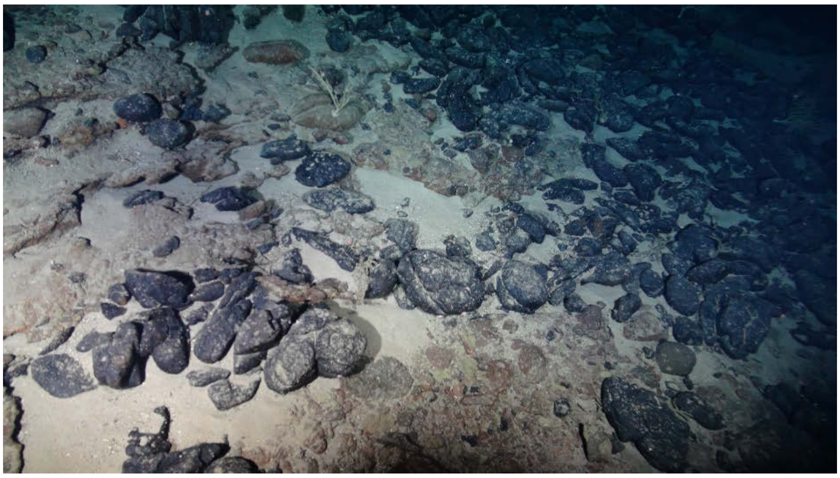


Figure 4-9: Altered basalt (light brown-red) lies beneath rounded to sub-rounded basalt boulders (HY34).

Figure 4-10: Red coloured, clay alteration locally effects the basalt (HY34).

Figure 4-11: A composite exposure comprising FeMnC over lithified calcarenite, which also occurs in the foreground. Circular toroidal-shaped features are evident in the calc-arenite and are thought to be thrombolites.. Note the small patch of red-brown clay by the laser spot (Dive HY42).

Calcarenites typically form flat exposures, which are locally obscured by soft sediment and Fe-Mn crust deposition. They are well observed at the edge of Fe-Mn crust pavements, forming the substrate, which is frequently undercut due to differential erosion. The surfaces of the exposures are typically covered in ripples and pitted at the centimetre-scale. From a height of 2-4 m above the seafloor the calcarenite is challenging to differentiate from soft sediment as it frequently has pronounced sedimentary ripple features.

Figure 4-12: Detail of the surface of the calcarenite. Laser dots are 10 cm apart (HY36).

Figure 4-13: A coarser variant of the calcarenite, containing pebble size rock and shell fragments. Laser dots are 10 cm apart (HY37).

Figure 4-14: Soft sediment in the foreground meets an eroded exposure of calcarenite. Laser dots are 10 cm apart (HY39).

Figure 4-15: Eroded calcarenite with a rugged, pitted surface with a black-brown surface coating (HY38).

Figure 4-16: Calcarenite exposed in a 1.5m high ledge. The calcarenite forms the substrate of a crust pavement and the unsupported crust is collapsing into the foreground (HY40).

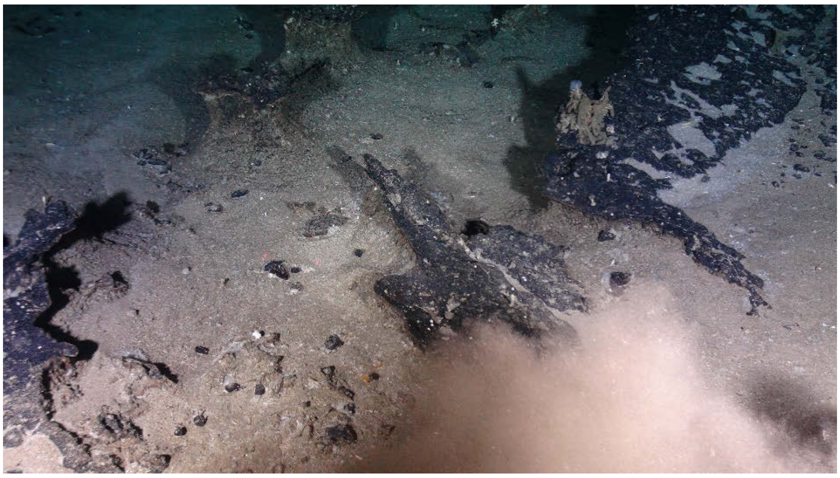


Figure 4-17: Rugged exposure of highly weather crust exposing the calcarenite substrate below (HY38).

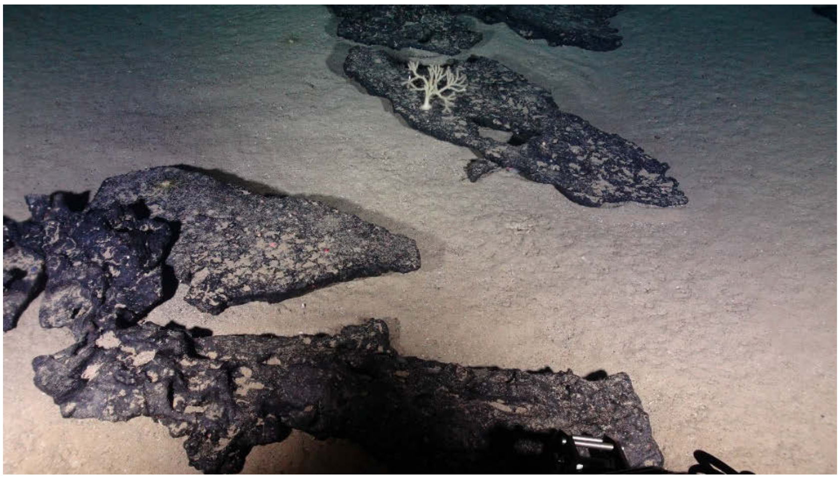


Figure 4-18: Tabular blocks of crust resting on calcarentite. Note the weathered surface of the hard calcarenite (HY34).

Figure 4-19: Rare, isolated fragments of Fe-Mn crust lying on the surface of the pale calcarenite. The final product of the erosion of an Fe-Mn crust pavement, with the earlier stages in the erosional process illustrated in the two images above (HY34).

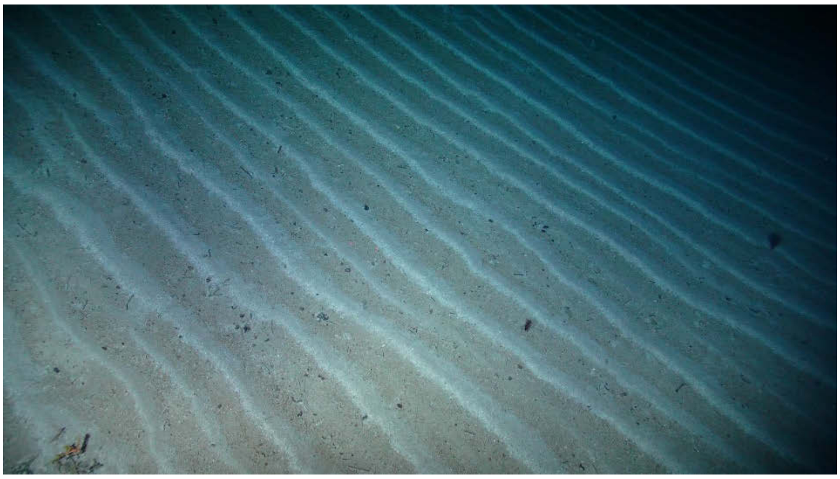


Figure 4-20: Lineation's of soft sediment on the hard surface of the calcarenite (HY37).

Figure 4-21: Ripples in the surface of the calcarenite (HY39).

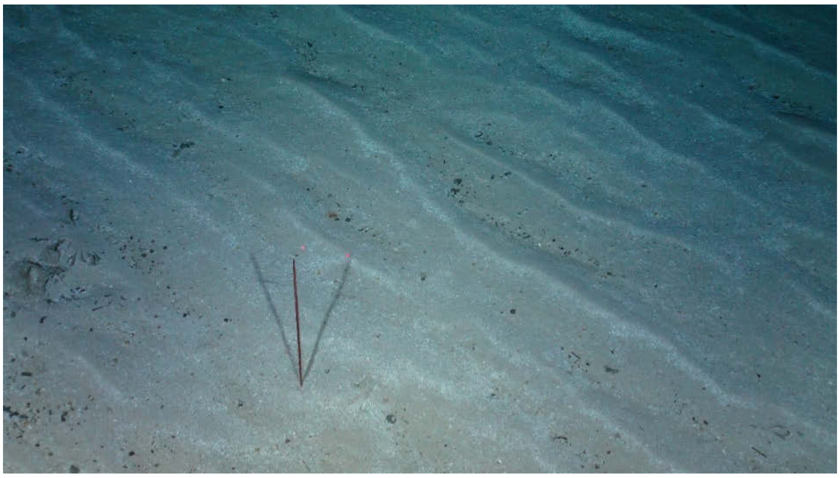


Figure 4-22: Ripple features in the surface of the calcarenite (HY37).

Figure 4-23: A brittle fracture developed in the calcarenite (HY39).

Fe-Mn crust develops as coatings on most indurated surfaces and tends to smooth out the morphology of the substrate they develop on. Where Fe-Mn crusts are well developed they form typical pavement-type exposures. However, these pavements are rarely unaltered due the high energy environment that appears prevalent across the Rio Grande Rise. The substrates to the pavements are frequently undercut. In many location the pavements appear highly eroded. This gives the surfaces a very irregular appearance. Continued ersosion results in linear channels developing in the pavements in which the substrate becomes exposed and soft sediments accumulate. Further erosion of the pavements results in there eventual disintergration into irregular shaped blocks and slabs. At some locations isolated fragments of Fe-Mn crust lying on the surface of the calcarenite are the only evidence of a pre-existing Fe-Mn pavement.

Figure 4-24: Fe-Mn crust pavement developed on calcarenite, which has been undercut by strong currents (HyBIS Dive HY33).

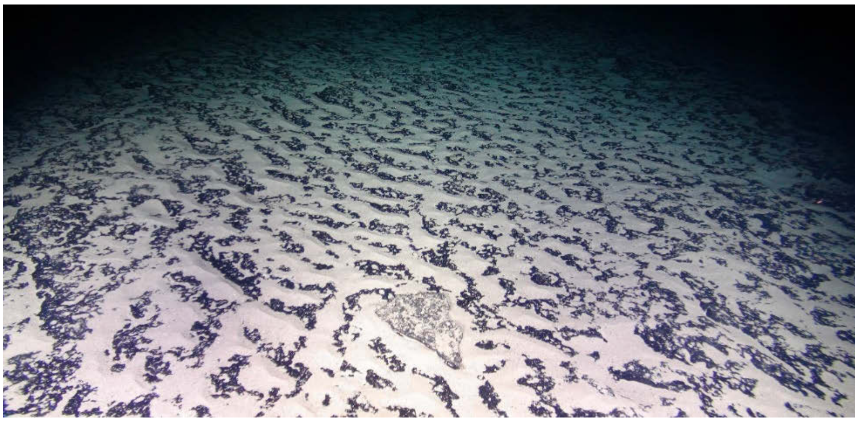


Figure 4-25: Fe-Mn crust pavement covered by mobile sediments. The presence of ripple structures highlights the strong unidirectional current (Dive HY40).

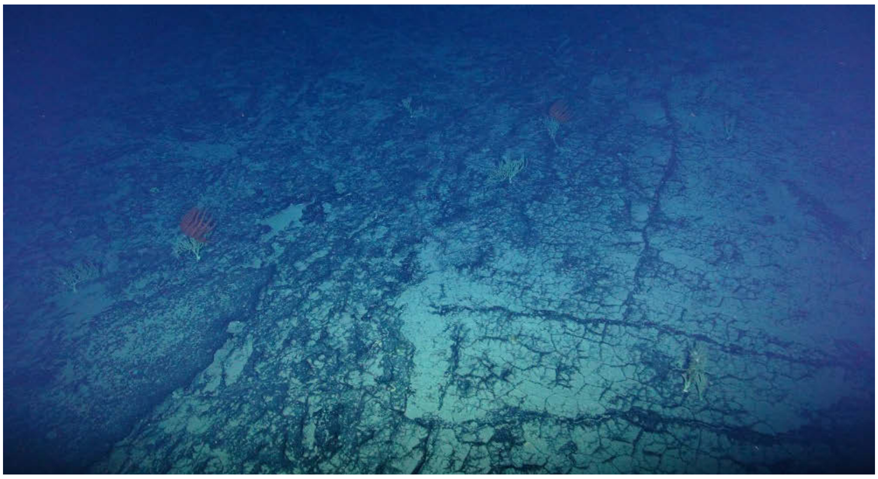


Figure 4-26: Fe-Mn crust developed on the surface of a subaerial lava-flow. Erosion has locally removed the crust pavement exposing the columnar jointing in the lava below. The linear features are encrusted veins developed within the volcanic substrate (Dive HY34).

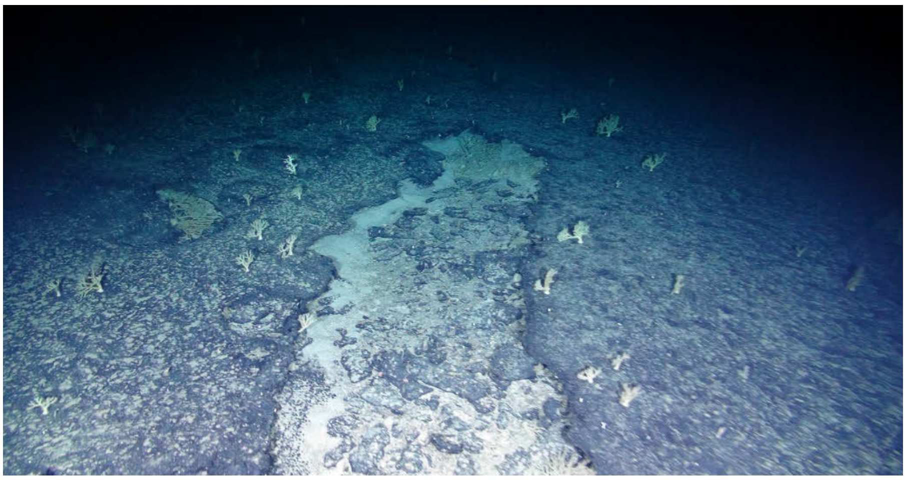


Figure 4-27: The initial stage in the disintegration of a Fe-Mn crust pavement. A localised weakness in the pavement is presumably exploited by erosion, which then becomes a focus for the channelling of sediment-laden currents (Dive HY40).

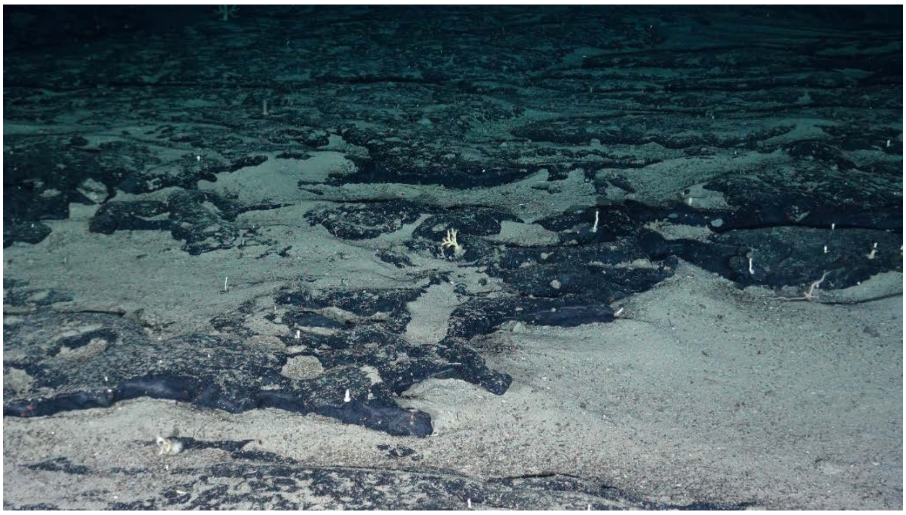


Figure 4-28: An Fe-Mn crust pavement at a more advanced stage of erosion (Dive HY40).

Figure 4-29: The eventual interconnection of erosive features results in only isolated slabs of pavement remaining on the seabed. In such area, an absence of low-energy zones lead to a near complete removal of soft sediments and exposure of the calcarenite substrate. Further erosion and more exposed settings may result in complete removal of the Fe-Mn crust (Dive HY34).

Chapter 5: Geological Sampling

Objectives

The geological sampling campaign of the Rio Grande Rise aimed to characterise ferromanganese (FeMn) crust occurrence, morphology and association with seafloor morphology substrate and currents, in order to investigate potential controls on formation, distribution and composition. In total 382 geological samples were collected over 23 dredge deployments and 13 dives of the Remotely Operated Vehicle (ROV) HyBIS. Two key regions were sampled, focussing on the contrasting regions on the two opposite sides of the Great Rift. Here, varied environments and outcrop textures were targeted based on backscatter and side scan sonar data from shipboard multibeam system and the Autonomous Underwater Vehicle (AUV) Autosub6000. The samples collected will also be used to build a formational history of the Rio Grande Rise to better understand the deposition of FeMnC in a local and sub-regional context.

Methodology

Dredging

23 dredging deployments were carried out across the Rio Grande Rise using a ~1 m-wide dredge. Dredge tracks of 0.6-1.2 km were planned to target key areas of interest. These key tracks were chosen based on interpretation of the shipboard multibeam bathymetry and backscatter, AUV side scan sonar and observation of HyBIS video transects. The main targets were areas of contrasting environments and geophysical response, e.g Great Rift margins, elevated terraces, plains and plateau, to encompass all environmental factors affecting Fe-Mn crust formation and preservation on the seafloor. In total 328 geological samples were collected across 23 dredge deployments (Figure 1). For three of these deployments, the dredge was not recovered from the seafloor due to overwhelming tension (> 5 ton equivalent) in the cable triggering the release of cable weak links. These all occurred in the NE region of the Rio Grande Rise, on the uppermost terrace, likely due to the rough topography of this area.

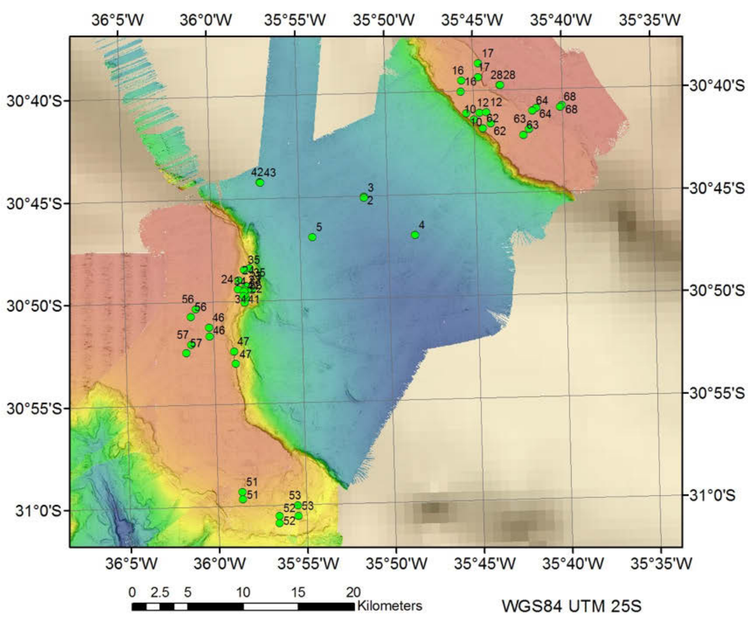


Figure 5-0-1: Map showing start and end points of dredge lines across the two key focus areas on either side of the Rio Grande Rise. Six gravity core locations are also shown in the floor of the Great Rift.

HyBIS samples

In total 59 geological samples were collected across 13 HyBIS dives. A key objective of the research was to collect FeMn crust samples and other representative geological material from a range of depths to a high degree of positional accuracy using the manipulator arm of the HyBIS ROV. As far as practicable, *in situ* samples were recovered, from overhanging Fe-Mn ledge notably, which is particularly important for the planned study of the palaeo-magnetostratigraphy of the FeMn crusts, which requires an understanding of the in-situ orientation of samples. Sample number, location and overall morphology and characteristics were noted from the high definition video footage and photographs from the SCORPIO footage were taken to facilitate the accurate labelling of samples when retrieved on deck.

Sampling Handling Procedure

The following sampling procedure was followed for all geological samples:

1. Complete, labelled samples were photographed on both sides.
2. Initial descriptions and measurements were made.
3. Samples were cut into multiple sections, size permitting.
4. A photograph of a representative subsample section was taken.
5. Sample bags were labelled externally and a printed label inserted.
6. Samples were distributed between key project partners according to research themes.

Key Lithological Results

The geological samples were dominated by 4 main lithologies:

1. Volcanics
2. Calc-arenites
3. Phosphorites
4. Ferromanganese crusts

The key characteristics of these main lithologies are summarised in Table 4-1 alongside photographs of representative sections. For more detailed descriptions of individual samples please refer to the Sample Log. In addition to these commonly observed main lithologies, other samples of note are highlighted and described in Table 4-2.

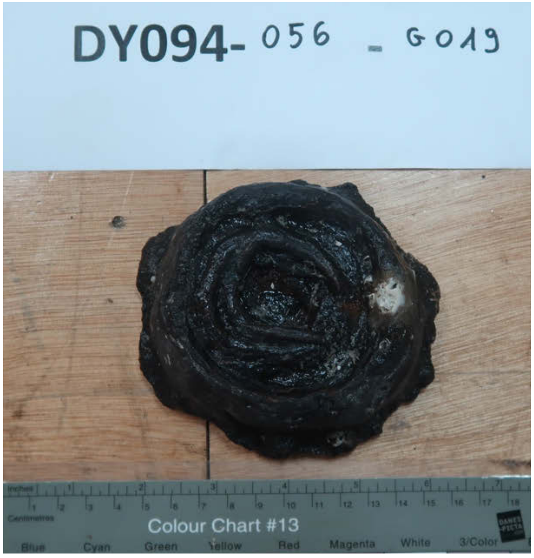
Table 5-1 Summary of main lithologies and features observed at Rio Grande Rise.

Type	Description	Representative section
Volcanics	Volcanics are varied in appearance but overall consist of a fine grained, aphanitic groundmass with phenocrysts, in particular of plagioclase feldspar and pyroxene (A). Some samples are highly vesicular, with extensive infill of vesicles with secondary minerals (amygdales, B), characteristic of subaerial volcanism. These volcanics vary in their degree of maturation and also in the degree of alteration (C).	**A**  **B**  **C** 

Calc-arenites	Coarse biogenic debris-rich sand partly cemented by carbonate. Highly porous with large void spaces.	
Phosphorites	Secondary, diagenetic mineralisation resulting in matrix replacement or infill of void space by phosphates within primary carbonates (A) (A), calc-arenite, and ferromanganese crusts, B).	A  B 
Ferromanganese crusts	FeMn crust growth on a range of substrate lithologies, with varying degrees of phosphatisation (A). Many samples show distinct deformation by orange-brown coloured goethite-rich horizons (B). FeMn crust	A 

	horizons range in thickness from 1 mm-thin coatings, up to a maximum of 120 mm, with evidence of extensive erosion.	**B** 

Table 5-2 Lithologies of note and key features.

Type	Description	Representative section
FeMn crust "donuts"	Rounded, ring-like morphologies with a central void. This morphology commonly involve a phosphatised substrate covered by FeMn crust.	
Metamorphics and granitoids	Rounded, crystalline samples showing either mafic and felsic banding (gneiss) or granitoids textures were recovered. They all present minimal or no Fe-Mn encrustations.	
Fossils	The dredge at Station 53 is of note due to the abundance of fossils collected. This included 5 shark teeth, 2 potential whale ear bones and 1 well preserved mold fossil of Trilobite.	

Chapter 6: Biology Report

Introduction

Interest in deep-sea benthic environments is recently increasing, mainly because of the human activities that have become more and more often in the last decades, like the extraction of gas and oil, fishing and mining of polymetallic nodules and ferromanganese crusts (Glover and Smith, 2003). Deep-sea mining is a potential multi-billion dollar industry, expected to become operational in all the world's oceans within the next few years, and it will invariably induce pressures in these uncharted environments (Hein and Koschinsky, 2014; Manceau et al., 2014).

The International Seabed Authority (ISA) is an autonomous international organization, operating under the United Nations Convention on the Law of the Sea (UNCLOS), through which UN member State parties organize and control resource administration in regions beyond national jurisdiction. ISA issues permits for exploration and ultimately for exploitation, provided the contracting parties comply with internationally agreed guidelines, rules and regulations. These includes that mining activities should remain sustainable and guarantee the protection of the deep-sea environment (Baker and Beaudoin, 2013; ISA, 2013). ISA also demands an environment and biodiversity baseline studies is performed before any mining tests, which should contain data about fauna and communities in the deep-sea and their variability along different habitats around the areas with crusts and nodules.
The Rio Grande Rise (RGR) is an extensive seamount region located between Brazil and Argentine oceanic basins (Cavalcanti et al., 2015). RGR has gained a special attention of researchers and governments around the world due to its potential of mining activities in the future. In 2015, the ISA and the state-owned Serviço Geológico do Brasil (CPRM) of Brazil have signed a 15-year contract for exploration in the RGR, increasing even more the need of more studies in this area.

In this scenario, there are a few and fragmented biological data on RGR (Perez et al., 2012), except for a few fish records produced by Russian exploratory fishing from 1974 and 1988–1989 (Clark et al., 2007; Perez et al., 2012). Data about fauna and communities structure furnish valuable information about the vulnerability of habitats on the deep-sea, which are used to establish “Areas of Particular Environmental Interest” (APEIs) (ISA, 2011; Wedding et al., 2013). This is a nomenclature created by ISA to designate areas that should not be leashed to contractors for mining. APEIs aim to preserve unique marine habitats, preserve marine biodiversity, structure and function of ecosystems and to make deep-sea mining activities more sustainable (ISA, 2008). Therefore, to infer the biodiversity and understand the ecologic patters of RGR become essential in the following years.

Objectives

Our objectives during expedition DY094 was to make an inventory of the fauna in Rio Grande Rise and characterize the diversity and structure of benthic and benthopelagic assemblages, and their variety according with different habitats.

Methods

Organisms were collected using a rock dredge. In addition, an extensive series of bottom footage were undertaken using the HyBIS remotely operated vehicle that was also capable of collecting small samples (i.e., rocks and organisms) through a robotic arm. The rocks collected in the dredges and by the HyBIS were initially processed by thoroughly examined for specimens on them. They were immediately photographed, carefully removed from the rock and preserved in 70% ethanol. Larger specimens had a section of the body extracted and frozen for DNA and stable isotope analysis. After the cruise, specimens will be identified to the lowest taxonomic level as possible and key taxonomic features will be photographed in more detail. Specimens will also have genetic molecular markers sequenced for barcode, namely COI and 16S, which will further aid in their identification.

Videos recorded during the HyBIS dive with organisms have locations annotated and sorted in morphotypes. A descriptive analysis of each habitat seen in the video will be made to get species compositions, diversity indices, species richness and species accumulations curves. Communities will be compared between habitats using similarity indices and cluster analysis.

Furthermore, the bathymetry and backscatter data gathered by the ship's multibeam will be used together data gathered in previous cruises to make species distribution and habitat suitability models, which provide a picture of how species and group of organisms are distributed throughout in the study area. All this information on biodiversity and ecology of RGR will significantly help to create protected areas to preserve deep-sea biodiversity and ecosystem function of this environment.

Results

We collected a total of 269 samples, 145 with the dredges and 124 with the HyBIS. Most organisms were attached to rocks, with only 50 organisms not attached in the dredges and 11 grabbed by HyBIS. The most common animals were sponges (Porifera), black corals and scleractinians (Cnidaria) and polychaetes (Annellida). The number of biological samples obtained in each station was heterogeneous, with high and low values across the stations (Figure 6.1). The figures below show some of the most common and interesting specimens that were retrieved with the HyBIS (Figure 6.2) and the dredges (Figure 6.3).

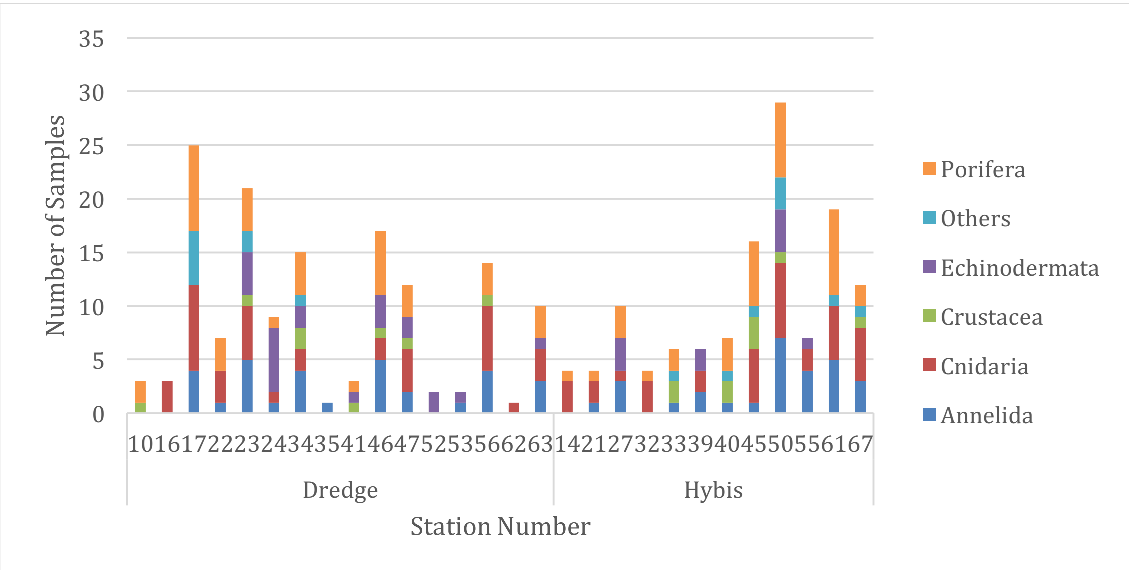


Figure 6.1: Number of samples in each station showing the major group of animals collected in the Rio Grande Rise.

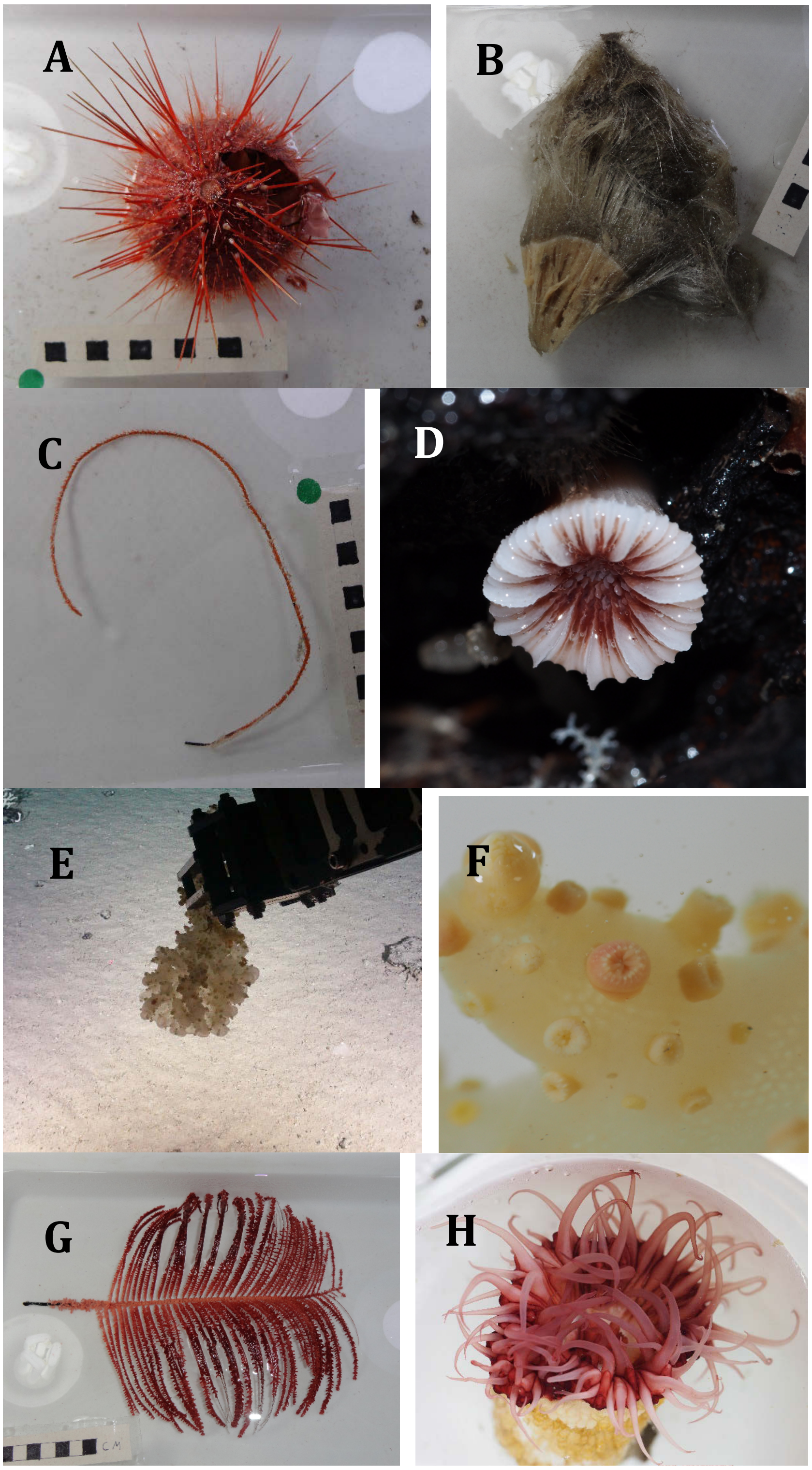


*Figure 6.2: Organisms retrieved by HyBIS. **A.** A sea urchin (Sta. 39), found frequently in pavements of rock. **B.** A sponge (Sta. 40), with a large spicules and covered with sand. It is similar to a rock through the HyBIS videos. **C.** A whip coral, a type of black coral (Sta. 45), found frequently in pavements of rock. **D.** A solitary coral (Sta. 50), found on a rock recovered by HyBIS. **E.** A sponge (Sta. 50), with zoanthid polyps. **F.** A detail of the polyp of the previous sponge. **G.** A black coral (Sta. 55), found frequently on rocks. **H.** An anemone (Sta. 61), found in a few places during the dives.*

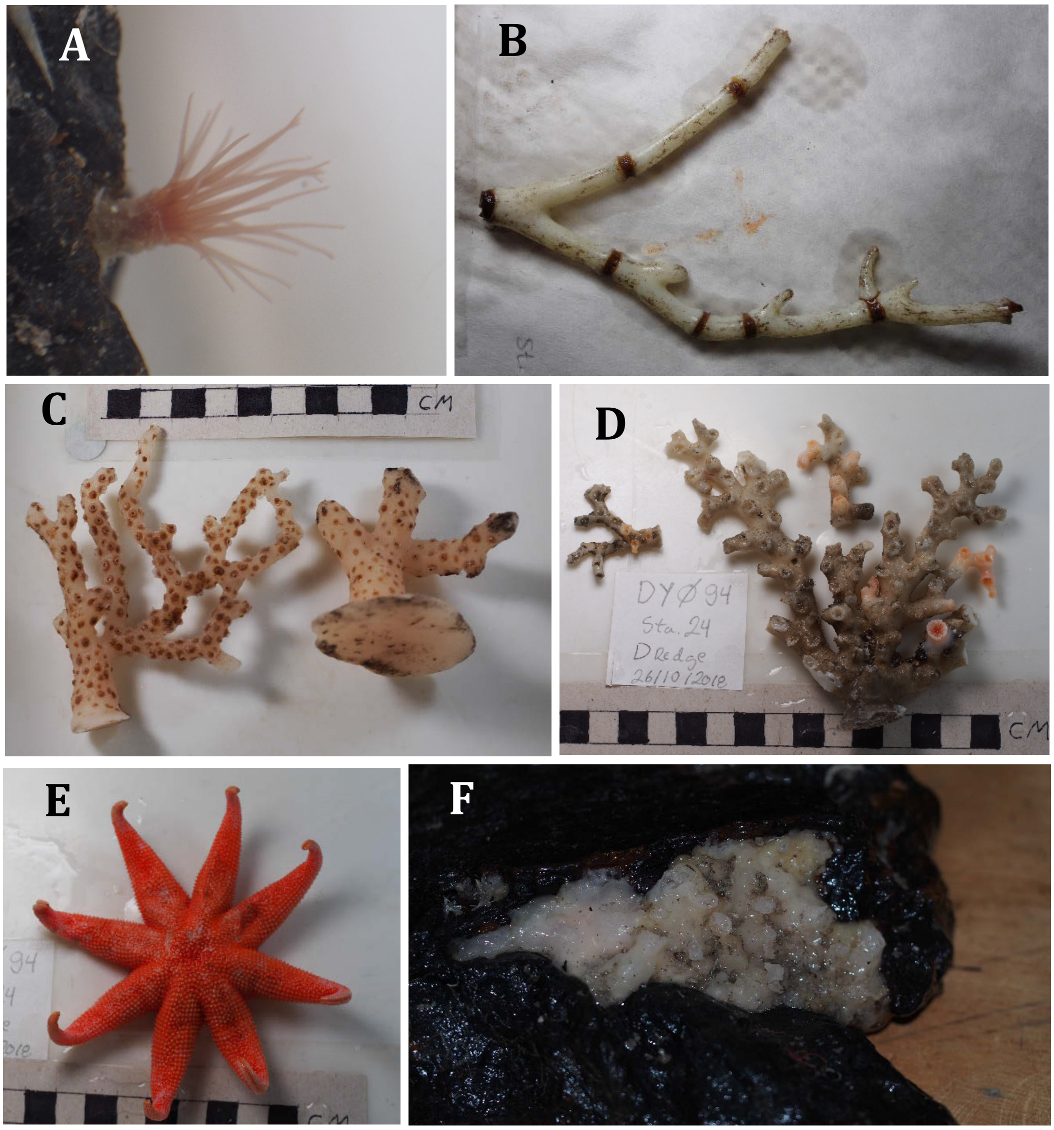


Figure 6.3: Organisms retrieved by dredging. ***A.*** *A tube-dwelling anemone of the family Cerianthidae (Sta. 17).* ***B.*** *Piece of a bamboo coral (Sta. 17).* ***C.*** *Pieces of the sponge Sarostegia oculata (Sta. 23), with zoanthid polyps that mimics a coral-like 3D framework.* ***D.*** *Pieces of the hard coral Enallopsamia rostrata (Sta. 24).* ***E.*** *A multiarmed starfish (Sta. 24).* ***F.*** *Sponge found in a hole of crust (Sta. 36).*

During the HyBIS dives, a highly heterogeneous habitat was found ranging from habitats composed of sponge gardens to places with few or no large epifauna. Some places were dominated by different organisms, namely sponges, black corals or sea urchins. In general we noticed a lower diversity of biology than what expected for this depth range (about 600 to 1500 m), which is probably caused by the low input of organic matter in this region.

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Chapter 7: Microbial Oceanography Report

By: Natascha Menezes Bergo and Pedro Marone Tura

Activities on board:

Sampling for molecular biology and microscopy analyses.

Scientific aims:

To understand the biological processes (microbial taxonomy, diversity and metabolism) in the Fe-Mn crusts on Rio Grande Rise and its influence in the crust formation by the combination of complementary techniques: 16S rRNA sequencing and microscopy.

Introduction:

A multiplicity of deep-sea habitats, including canyons, seamounts, ridges, cold seeps, pockmarks, fractures, trenches, mud volcanoes, carbonate mounds, brine pools, gas hydrates, Fe-Mn nodules and crusts can host rich and highly diverse microbial assemblages (Jørgensen & Boetius, 2007; Bartlett, 2009; Ramirez-Llodra et al., 2010; Danovaro et al., 2014; Blöthe et al., 2015). Although the formation of Fe-Mn deposits is generally assumed to occur through abiotic geochemical processes, such as the hydrogenetic and/or diagenetic precipitation of Fe- oxyhydroxide and Mn-oxide (Konhauser 2009), it has been suggested that the formation of polymetallic deposits is mediated by biochemical activity (biomineralization). In the biomineralization process, several cycles of oxidation and reduction are alternated by Bacteria, Archaea (Ehrlich 2002) and Fungi (Miyata et al. 2006).

The first evidence of microbial cells in Fe-Mn nodules was published by Ehrlich, et al. (1972). From this work, several studies have investigated the relationship of Bacteria, Archaea, Protozoa, Foraminifera and even microalgae in the formation of Fe-Mn deposits (Ehrlich, 2002; Konhauser, 2009; Hein & Koschinsky, 2014). Burnett & Nealson (1981) have identified filamentous structures as biofilms, coccus bacteria, and quantified about 10^7 bacterial cells.m^{-3} on the surface of a Fe-Mn nodule. Ehrlich (2001, 2002) has related there are three types of bacteria in Fe-Mn nodules: Mn (II) oxidants, Mn (IV) reducing agents and a group that can not oxidize Mn (II) or reduce Mn (IV). Further, Wang & Müller (2009) have proposed that the phylum Proteobacteria would be abundant in Fe-Mn oxides, including some metabolically active bacteria in the manganese and iron cycles.

More recently, culture-independent techniques as sequencing of the 16S rRNA gene (clone libraries) have been used to study the relationship of microorganisms with Fe-Mn crusts of the Pacific Ocean (Liao et al., 2011; Hein & Koschinsky, 2014; Blöthe et al., 2015; Huo et al., 2015; Nitahara et al., 2017). In the Takuyo-Daigo Seamount, northwest Pacific Ocean, it was proposed that ammonia is the main source of energy that supports the microbial ecosystem of the Fe-Mn crust (Nitahara, 2011). Based on the detection of phylotypes related to *Nitrosospira* (class Betaproteobacteria) and *Nitrosopumilus* (phylum Crenarchaeota), it was suggested that these ammonia-oxidizing chemolithoautotrophs might play a key role as primary producers in the microbial ecosystem of hydrogenetic Fe-Mn crusts. Also in the Pacific Ocean, a combination of techniques, as scanning electron microscope (SEM), transmission electron microscope (TEM) and the 16S rRNA gene (clone library) sequencing, has revealed abundant spherical aggregates of Mn-oxide filaments, which are closely associated with filamentous cells within the biofilm (biofilm mineralization) in crusts from the Clarion-Clipperton Zone (CCZ). These biofilms were dominated by Mn-oxidizing bacterial groups (Bacillus, Arthrobacter and Pseudomonas) (Xiao-Dong et al., 2017).

Despite all the increasing efforts that have been made through the 16S rRNA gene sequencing and qPCR, mainly with samples from the Pacific Ocean, molecular studies of phylogenetic and functional microbial diversity in deep-sea minerals through high-throughput DNA sequencing are still scarce (Nitahara et al., 2017). Thus, studying the Rio Grande Rise by using a combination of complementary high-throughput techniques, as 16S rRNA sequencing, metagenomics and microscopy, is fundamental to determine its microbial diversity and community structure. More importantly, implementing a combined approach is needed to effectively explore the role of microbes in the formation of deep-sea Fe-Mn deposits in the South Atlantic Ocean.

Onboard Methodology

The substrates (Fe-Mn crusts, coral, calcarenite and sediments) and crust biofilms collected by dredges were aseptically sampled from the dredge and transferred to a DNA/RNA-free plastic bag, Figure 7-1A-B. All the samples were added *RNA-latter* and stored at -80 °C until transport to the Oceanographic Institute, University of São Paulo (Brazil), for DNA extraction at Ecologia de Microorganismos Laboratory.

Also, small crusts and corals pieces were sampled for microscopy, Figure 7-1C. Marine seawater were filtered through a 0.22µm-pore-size membrane filters (Sterivex, Millipore, MA) and add to falcon tube with small crusts pieces and stored at 4 °C until transport to the Ecologia Microbiana Laboratory, at Oceanographic Institute (Brazil). The summary of samples collected to biological molecular and microscopy analyses is described in Table 7-1.

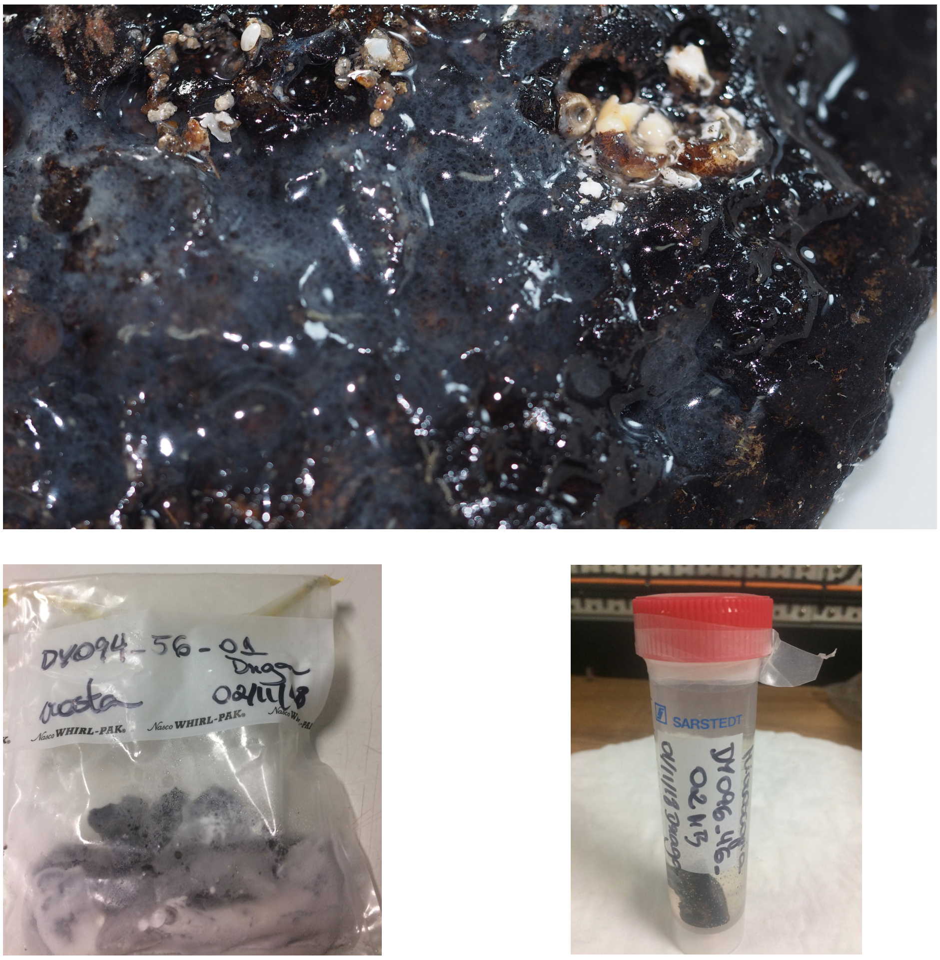

Figure 7-1. Samples collected to molecular biology and microscopy analyses: A) microbial biofilm on crust sample, B) DNA/RNA-free plastic bag with crust, and C) microscopy.

Table 7-1. Summary of stations, coordinates, operations, samples type and samples IDs.

Sample_ID	Date	Station	LAT		LONG		Operation		Depth (m)	Water Mass	Micobres Substrate	Stored (°C)
			Deg.	Dec.Min	Deg.	Dec.Min	Hybis	Dredge				
DY094_10_01_MB	23.10.18	10	-30	41.403	-35	449.357		X	705	SACW	Basalt	-80
DY094_16_01_MB	25.10.18	16	-30	40.08	-35	45.70		X	713	SACW	Basalt	-80
DY094_17_01_MB	25.10.18	17	-30	39.40	-35	44.69		X	699	SACW	Crust	-80
DY094_22_01_MB	25.10.18	22	-30	49.91	-35	58.18		X	815	SACW	Crust	-80
DY094_22_02_MB	25.10.18	22	-30	49.91	-35	58.18		X	815	SACW	Crust	4
DY094_22_03_MB	25.10.18	22	-30	49.91	-35	58.18		X	815	SACW	Sediment	-80
DY094_23_01_MB	26.10.18	23	-30	49.49	-35	58.17		X	790	SACW	Crust	-80
DY094_23_02_MB	26.10.18	23	-30	49.49	-35	58.17		X	790	SACW	Crust	-80
DY094_34_01_MB	30.10.18	34	-30	48.39	-35	57.72		X	945	AIA	Crust	-80
DY094_34_01_MB	30.10.18	34	-30	48.39	-35	57.72		X	945	AIA	Crust	4
DY094_35_01_MB	30.10.18	35	-30	48.50	-35	58.19		X	927	AIA	Crust	-80
DY094_39_02_MB	31.10.18	39	-30	58.12	-35	54.72	X		881	SACW	Crust	4

DY094_39_01_A	31.10.18	39	-30	58.12	-35	54.72	X		881	SACW	Biolfim	-80
DY094_39_01_B	31.10.18	39	-30	58.12	-35	54.72	X		881	SACW	Biolfim	4
DY094_41_01_MB	01.11.18	41	-30	49.77	-35	58.26		X	927	AIA	Crust	-80
DY094_41_02_MB	01.11.18	41	-30	49.77	-35	58.26		X	927	AIA	Crust	4
DY094_45_01_MB	01.11.18	45	-30	00.30	-35	14.71	X		758	SACW	Biolfim	-80
DY094_45_02_MB	01.11.18	45	-30	00.30	-35	14.71	X		758	SACW	Crust	4
DY094_46_01_MB	01.11.18	46	-30	51.26	-35	0.27		X	685	SACW	Crust	-80
DY094_46_02_MB	01.11.18	46	-30	51.26	-35	0.27		X	685	SACW	Crust	4
DY094_46_03_MB	01.11.18	46	-30	51.26	-35	0.27		X	685	SACW	Biolfim	-80
DY094_46_04_MB	01.11.18	46	-30	51.26	-35	0.27		X	685	SACW	Biolfim	4
DY094_47_01_MB	02.11.18	47	-30	52.47	-35	58.88		X	762	SACW	Crust Coral	-80
DY094_47_02_MB	02.11.18	47	-30	52.47	-35	58.88		X	762	SACW	Crust	4
DY094_52_01_MB	03.11.18	52	-31	0.53	-35	56.55		X	903	AIA	Crust and Coral	-80

DY094_52_02_MB	03.11.18	52	-31	0.53	-35	56.55		X	903	AIA	Crust	4
DY094_53_01_MB	03.11.18	53	-31	0.57	-35	55.49		X	901	AIA	Crust and Coral	-80
DY094_53_02_MB	03.11.18	53	-30	0.57	-35	55.49		X	901	AIA	Crust and Coral	4
DY094_56_01_MB	03.11.18	56	-30	50,26	-36	0,93		X	664	SACW	Crust	-80
DY094_56_G002	03.11.18	56	-30	50,26	-36	0,93		X	664	SACW	Calcarinite	4
DY094_57_01_MB	04.11.18	57	-30	52.48	-35	1,25		X	661	SACW	Crust	-80
DY094_61_01_MB	04.11.18	61	-30	41.34	-35	44.87	X		711	SACW	Biolfim	-80
DY094_62_01_MB	05.11.18	62	-30	41.89	-35	44.49		X	661	SACW	Calcarinite	-80
DY094_63_01_MB	05.11.18	63	-30	42.26	-35	42.21		X	663	SACW	Crust	-80
DY094_63_02_MB	05.11.18	63	-30	42.26	-35	42.21		X	663	SACW	Sediment	-80
DY094_63_03_MB	05.11.18	63	-30	42.26	-35	42.21		X	663	SACW	Calcarinite	-80
DY094_63_04_MB	05.11.18	63	-30	42.26	-35	42.21		X	663	SACW	Crust	4

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Chapter 8: Data Processing and Management

EM122 Bathymetry

The EM122 multibeam system was switched on during most of the expedition. Over 800 .all files of 30 minute duration were collected. Only a small proportion of data were used for processing as much of the data was collected whilst stationary or during very slow movement of the ship. Data was transferred from the ship network to the processing system. It was processed in CARIS HIPS and SIPS v9.1.8 using a previously defined vessel configuration and our new calibration values.

Transducer #1:	
Pitch Offset:	-1.13
Roll Offset:	0.100
Azimuth Offset:	0.000
DeltaX:	-0.005
DeltaY:	35.219
DeltaZ:	7.438
Manufacturer:	Simrad

A zero tide was assumed throughout the data processing. Sound Velocity profile data was utilised from two Sound Velocity Dips, 1 at the start of the data collection and one in the middle of data collection (after returning to the area after the storm) and processed using the nearest time model. Cleaning of the data was done using both the swath and subset editors. The data were gridded at 15m. Slope maps were created utilising the RSOBIA toolbar (as the Spatial analyst tools failed on the GeoTiff output).

Contours

Contours for the EM120 Multibeam were created at 20m intervals. The contour tool does not work with GeoTiffs, being the output from CARIS, and consequently the bathymetry grid had to be exported to Imagine images for the tool to operate.

EM120 Backscatter

The same files that were used in the bathymetry processing were entered into FM Geocoder Toolbox v7.8.3 64 bit Edition Build 1022. Certain lines and partial lines were removed dependant on data quality and coverage available. The data were gridded on a 5m grid.

AUV Mission plans

Planning for AUV Missions was done within the ArcMap GIS system. The survey lines were then inspected for line length and bathymetric variation, taking into account the flying height was usually 90m. Each mission was planned for 24 hours being the battery life for a survey (though excludes 12 hours of reserve). Ground speed for Autosub 6000 is 1.2m/s equivalent to 4.3km/hour. Survey length then depends the water depths at the beginning and end of the mission (at 30 minutes per 1000m descent or ascent), 45 minutes for magnetometer calibration and 15 minutes for mission navigation start, giving:

survey length (km) = (24 - (start depth/2000) - (end depth/2000) - 0.75 - 0.25) * 4.3

For planning a new tool was trialled. The Maritime Toolbar (from Oceanwise Ltd) calculates run lines in a specific area parallel to a known line. Areas and directional lines were therefore drawn, converted into shapefiles and input into the run lines tool. These were then run through another new tool "Create surveyline" to make a continuous trackline for passing to the Autosub mission planning system. Once the survey line was completed the datapoints plus a location map transferred to the AUV system

Autosub 6000 EM2040 Bathymetry

The EM2040 multibeam system was used on all the missions. Most missions were run on a constant altitude of 90m and a line spacing of 280m. Unfortunately the system did not produce many bathymetry files that were not corrupt and most were missing on data download.

Autosub 6000 EM2040 Backscatter

Only two of the files (from Mission 145) from all the missions that were collected were able to be entered into FM Geocoder Toolbox v7.8.3 64 bit Edition Build 1022. No data was excluded and the data were gridded on a 1m grid. The lack of more data made these data isolated.

Autosub 6000 Edgetech 4200 Sidescan - 100kHz

The Edgetech system records data in .jsf format. A utility called "SalvageCorruptZeroes.exe" can be run to repair the files but was found to be unnecessary. A conversion utility to XTF format ("JSF2XTF.exe") also failed on either of these data. Therefore initially the data was replayed using the "Discover 4200 MP 2.03.exe" program to create XTF format files. This requires the operator to play every data file individually and record the replayed data. As this was extremely tedious a different method was sought. A new executable was found called "JSFfileConverter.exe" which was similar to the Discover program, and again required the operator to play every datafile individually but was much quicker than before. It produced both the sidescan and sub-bottom XTF files. As no navigation was held in the .jsf files that could be extracted a separate navigation file was also made available. Next a utility provided by SonarWiz called "NavInjectorPro.exe" was used to add the separate navigation file to the XTF files. It was found that the version 7 of this injection program failed but the version 6 was successful.

Data was imported into SonarWiz Version 7 (64 bit) and then using the bottom track function to add altitude information from the first return. A flat bottom assumption was used. As the beam directivity pattern was not constant over the whole swath a gain setting was calculated called the "Empirical Gain Normalisation" using all the data from the mission. This table has depth and range dependant normalisation values. This generally worked well, producing equal illumination of the seafloor on overlapping swaths. Line spacing was set at 600m at an altitude of 90m for when running only sidescan surveys. During multibeam surveys the line spacing was 280m and produced large amounts of overlap. Overlap methods in SonarWiz were either "Cover up" or "Root Mean Square" depending on the data. Final mosaics were exported as Tif files at 0.3m resolution.

During the processing of one mission it was discovered that major features of the sidescan were offset from the shipboard bathymetry. A rotation from the start position of the survey of about 11.3 degrees anticlockwise matched the features together well. This was then applied to all the missions and features on the shipboard multibeam system (bathymetry and backscatter) matched very well with the sidescan imagery.

Autosub 6000 Edgetech Sub bottom profiler

Data files were produced but not processed.

ROV Dives

The planning lines for HyBIS ROV Dives was done using the bathymetry, backscatter and sidescan mosaics. Feature lines were created and then maps exported for the OFOP systems on the ROV computer system. For the OFOP maps a printable map was created in layout view with an appropriate grid spacing. The map is exported as a .jpg at 300dpi. Projection used was Mercator.

Data Management

Over 750Gb of data has been generated and put into the standard Marine Geoscience data structure. The files are divided into categories of type and then into raw and processed data and data products. The six main data categories are: Ancillary, Groundtruthing, Geophysical, Multibeam, Navigation and Reference. These are mirrored in the GIS Map structure though many of the files stored there are not displayed directly in the GIS.

The data structure was periodically (every two days) backed up onto a RAID 6 QNAP using the SyncBack v3.2.19.0 . Files were copied from the source directory 2018_DY094 to the destination directory of the same name but on the QNAP server. All the sub-directories and their files in the source were copied if new or if modified. If modified the source file replaced the destination directory. If a file is only in the destination then no change is made in the source. A second backup was then made to a portable external USB drive, though excluding all the ROV Video data.

Appendix 1: List of the Ship's Company

Name	Position	Name	Position
Mark Ashfield	Head Chef	Craig Lapsley	SG1A (seaman)
Richard Austin-Berry	Technician (AUV)	Benjamin Lawrence	Third Officer
Philip Bagley	Technician (Head)	Timothy Le Bas	Scientist (data)
Thomas Banha	Scientist	Colin Leggett	Second Engineer
Mariana Benites	Scientist	Michael Leigh	Chef
James Bills	Chief Engineer	Paul Lusty	Co-Chief Scientist
Martin Bridger	Technician (Sci. Sup)	John MacDonald	Chief Petty Officer Scientific
Dale Carter	Technician (AUV)	Stewart MacKay	Chief Officer
Brian Conteh	Efficient Deck Hand	Andrewe MacLean	Chief Petty Officer Deck
Craig Gilfillan	SG1A (seaman)	Rachel Marlow	Technician (AUV)
Denzil Williams	Assistant Steward	Natasha Bergo Mernzes	Scientist
Andrew Dwer	SG1A (seaman)	Christian Milo	Scientist
Daniel Evans	Third Engineer	Michael Murren	Third Engineer
Paulo Correa	Scientist	Bramley J Murton	Chief Scientist
Charles Fisher	ETO	Benjamin Poole	Technician (base engineering)
Valerija Forbes-Simpson	Purser	Berta Ramiro Sanchez	Scientist
Antonio Gatti	Master	Charlott Ray	Steward
Arthur Guth	Scientist	Owain Shepherd	Technician (AUV)
Nathen Harvey	SG1A (seaman)	Robert Spencer	Petty Officer Deck
Mohammad Bin Hassan	Scientist	Paulo Sumida	Scientist
Sarah Howsrth	Scientist	Pedro Tura	Scientist
Pierre Josso	Scientist	Josue Viera Rivero	Technician (HyBIS)
Luigi Jovane	Co-Chief Scientist	Emlyn Williams	ERPO (Motorman)
Christopher Kemp	Second Engineer	Andrew Webb	Technician (HyBIS)

Appendix 2: Master Log

DATE dd/mm/yy	TIME UTC hh/mm/ss	Station #	Operation	Ship deg	Lat dec min	Ship deg	Long dec min	Ship spd [kts]	Ship Crs [°]	depth [m]	Comments
22/10/2018	19:34:20	1	HyBis	-30	45.08	-35	51.36	0.5	30	1458	HyBIS launch, test dive
22/10/2018	20:01:00	1	HyBis	-30	45.08	-35	51.36	0	30	1458	HyBIS in water
22/10/2018	21:06:00	1	HyBis	-30	45.06	-35	51.32	0.2	187	1457	HyBIS on bottom
22/10/2018	21:29:38	1	HyBis	-30	45.06	-35	51.32	0.2	95	1457	HyBIS going up
22/10/2018	22:25:00	1	HyBIS	-30	45.06	-35	51.35	0	200	1457	HyBIS on deck
22/10/2018	23:26:00	2	Gravity Core	-30	45.06	-35	51.32	0		1456	Gravity Core in water Attempt 1
23/10/2018	00:01:00	2	Gravity Core	-30	45.06	-35	51.32	0		1458	Gravity Core on bottom
23/10/2018	00:33:00	2	Gravity Core	-30	45.06	-35	51.32	0		1458	Gravity Core on deck, sample DY094_002_001A
23/10/2018	00:57:00	3	Gravity Core	-30	45.13	-35	51.31	0		1458	Gravity Core in water Attempt 2
23/10/2018	01:27:00	3	Gravity Core	-30	45.12	-35	51.31	0		1459	Gravity Core on bottom
23/10/2018	01:58:00	3	Gravity Core	-30	45.12	-35	51.32	0		1458	Gravity Core in deck, no material recovered
23/10/2018	02:05:00		Transit	-30	45.12	-35	51.32	4	130	1459	Heading to next station
23/10/2018	03:05:00	4	On station	-30	46.99	-35	48.45	0	239	1475	Arriving on Station 4 for Gravity Core
23/10/2018	03:13:00	4	Gravity Core	-30	46.99	-35	48.46	0	239	1475	Gravity Core in Water Attempt 3
23/10/2018	04:00:00	4	Gravity Core	-30	47	-35	48.46	0	239	1475	Gravity Core on bottom
23/10/2018	04:32:00	4	Gravity Core	-30	47	-35	48.46	0	239	1475	Gravity Core on deck, sample DY094_004_001A
23/10/2018	04:43:00		Transit	-30	47	-35	48.47	0	239	1475	Heading to next station St5
23/10/2018	06:00:00	5	Gravity Core	-30	46.98	-35	54.29	0.5	315	1430	Arriving on Station 5 for Gravity Core
23/10/2018	06:16:00	5	Gravity Core	-30	46.979	-35	54.29	0	316	1431	Gravity Core in Water Attempt 4
23/10/2018	06:48:00	5	Gravity Core	-30	46.98	-35	54.29	0	315	1430	Gravity Core on bottom
23/10/2018	07:18:00	5	Gravity Core	-30	46.98	-35	54.29	0	316	1429	Gravity core on deck, sample DY04_005_001A
23/10/2018	07:27:00		Transit	-30	46.98	-35	54.29	0.5		1429	Transit ~100m south to try again
23/10/2018	07:42:00		Transit	-30	47.02	-35	54.27	0.5		1429	Out of time, transit to MB patch test site
23/10/2018	08:08:00		Transit	-30	47.02	-35	54.27	0.5		1429	Transit delayed need to brin- in kit on hull
23/10/2018	08:25:00		Transit	-30	46.65	-35	54.38	8	60	1431	In transit to MB patch test site
23/10/2018	09:10:00	6	Multibeam	-30	41.88	-35	45.92	6.4	34	1235	Multibeam calibration line started (Line 1)
23/10/2018	09:41:00	6	Multibeam	-30	40.06	-35	44.24	6.2	50	1376	End of multibeam line 1
23/10/2018	09:42:00	6	Multibeam	-30	40.06	-35	44.24	6.2	50	1376	Start of multibeam line 2

dd/mm/yy	hh/mm/ss	#	operation	deg	dec min	deg	dec min	[kts]	[°]	[m]	Comments
23/10/2018	10:18:00	6	Multibeam	-30	42.45	-35	46.44	5.2	200	1307	End of multibeam line 2
23/10/2018	10:30:00	6	Multibeam	-30	42.99	-35	45.84	6.1	52	1278	Start of multibeam line 3
23/10/2018	10:56:00	6	Multibeam	-30	40.46	-35	44.04	5.3	45	677	End of multibeam line 3
23/10/2018	11:36:00	6	Multibeam	-30	41.41	-35	43.35	6.2	315	671	Start of multibeam line 4
23/10/2018	12:00:00	6	Multibeam	-30	39.89	-35	45.12	6.5	305	709	End of multibeam line 4
23/10/2018	12:17:00	6	Multibeam	-30	39.88	-35	45.49	6	140.2	708	Start of multibeam line 5
23/10/2018	12:45:00	6	Multibeam	-30	41.59	-35	43.03	5.8	127.1	677	End of multibeam line 5
23/10/2018	13:43:05	7	AUV test	-30	40.38	-35	43.77	0.8	356	668	AUV test started
23/10/2018	13:48:20	7	AUV	-30	40.58	-35	43.77	0.8	356	668	AUV test completed
23/10/2018	14:50:52	7	AUV	-30	43.17	-35	45.58		10	1300	Finished at 15:41
23/10/2018	15:46:11	8	Multibeam	-30	42.9	-35	45.52	6.3	280	1289	Start of the first line of multibeam
23/10/2018	18:11:32	9	Hybis	-30	41.52	-35	45.38	0.3	191.6	951	Hybis got deployed
23/10/2018	18:19:16	9	Hybis	-30	41.52	-35	45.38	0.3	154	965	Hybis in the water
23/10/2018	18:31:08	9	Hybis	-30	41.52	-35	45.38	0.3	154	965	Hybis recovered- power issue
23/10/2018	18:36:50	9	Hybis	-30	41.52	-35	45.38	0.3	154	965	Hybis in the water
23/10/2018	19:11:02	9	Hybis	-30	41.52	-35	45.38	0.4	201		Hybis on the bottom
23/10/2018	20:34:00	9	Hybis	-30	41.37	-35	45.25	0.1	300	713	Hybis going up
23/10/2018	20:56:49	9	Hybis	-30	41.37	-35	45.25	0.1	200	708	Hybis on deck
23/10/2018	22:09:45	10	Dredge	-30	41.14	-35	45.41	0.4	200	709	Dredge in the water
23/10/2018	22:25:00	10	Dredge	-30	41.14	-35	45.41	0.3	197	709	Dredge on the bottom (chenged winch)
23/10/2018	23:05:00	10	Dredge					1	156	710	Ship is moving to the end point and giving cable
23/10/2018	23:20:00	10	Dredge	-30	41.43	-35	45	0.3	173	707	Ship at end point, starting to recover cable
24/10/2018	00:56:00	10	Dredge	-30	41.426	-35	45	0.1	176	703	Dredge on deck
24/10/2018	01:17:00	-	transit	-30	41.29	-35	44.84	3.8	16.9	696	Moving to next dredge station
24/10/2018	01:45:00	11	Dredge	-30	40.81	-35	44.66	0.5	220	689	Dredge in the water
24/10/2018	02:40:00	11	Dredge	-30	40.81	-35	44.66	0.5	220	689	Operation aborted, problem when switching winches
24/10/2018	02:52:00	11	Dredge	-30	40.81	-35	44.66	0.3	210	692	Dredge on deck
24/10/2018	03:24:00	11	Dredge	-30	40.81	-35	44.67	0.2	180	693	Fixing issues with winch, completed at 03:50
24/10/2018	04:17:00	12	Dredge	-30	40.81	-35	44.66	0.2	181	689	Dredge in water

dd/mm/yy	hh/mm/ss	#	operation	deg	dec min	deg	dec min	[kts]	[°]	[m]	Comments
24/10/2018	04:37:00	12	Dredge	-30	41.12	-35	44.66	0.2	172	705	Dredge on bottom
24/10/2018	05:12:00	12	Dredge	-30	41.11	-35	44.3	0.1	146	681	1000m cable out (+500m), started to recover dregde
24/10/2018	06:06:00	12	Dredge	-30	41.11	-35	44.29	0.1	148	682	Dregde off bottom
24/10/2018	07:06:00	12	Dredge	-30	41.11	-35	44.29	0.2	103	682	Dredge on deck
24/10/2018	07:13:00	12	Dredge	-30	41.11	-35	44.29	0.2	151	683	Dredge empty
24/10/2018	07:19:00		Transit	-30	41.12	-35	44.29	7	79	682	Transit to Multibeam survey
24/10/2018	07:59:00	13	Multibeam	-30	40.7	-35	41.55	7	300	634	Start of Multibeam line I
24/10/2018	08:41:00	13	Multibeam	-30	38.64	-35	45.92	5	300	720	End of Multibeam line I
24/10/2018	08:41:00	13	Multibeam	-30	38.64	-35	45.92	5	210	720	Start of Multibeam line II
24/10/2018	08:59:00	13	Multibeam	-30	40.29	-35	46.95	5.7	137	1196	End of Multibeam line II
24/10/2018	08:59:00	13	Multibeam	-30	40.29	-35	46.95	5.9	137	1182	Start of Multibeam line III
24/10/2018	09:34:00	13	Multibeam	-30	42.73	-35	43.86	5.2	143	1027	End of Multibeam line III
24/10/2018	09:48:00	-	Steering Test	-30	43.28	-35	43.38	5	137	727	Steering test
24/10/2018	09:51:00	13	MB	-30	43.44	-35	43.16	5.6	133	770	Start of Multibeam line IV
24/10/2018	10:25:00	13	MB	-30	46.01	-35	40.55	6.1	75	1286	End of Multibeam line IV
24/10/2018	10:25:00	13	MB	-30	46.01	-35	40.55	6.1	45	1276	Start of MB line V
24/10/2018	10:39:00	13	MB	-30	44.61	-35	40.65	7	312	707	End of Multibeam line V
24/10/2018	10:39:00	13	MB	-30	44.61	-35	40.65	7	312	707	Start of Multibeam line VI
24/10/2018	11:09:00	13	MB	-30	42.02	-35	43.22	6.2	309.6	686	End of Multibeam line VI
24/10/2018	11:25:00	13	MB	-30	41.82	-35	42.11	7.1	109	659	Start of Multibeam line VII
24/10/2018	11:55:00	13	MB	-30	44.54	-35	39.38	6.5	135.9	661	End of Multibeam line VII
24/10/2018	12:08:00	13	MB	-30	43.85	-35	38.79	7.3	341	652	Start of Multibeam line VIII
24/10/2018	12:41:00	13	MB	-30	41.05	-35	41.42	6.9	319	644	End of Multibeam line VIII
24/10/2018	12:52:55	13	MB	-30	40.61	-35	40.55	7.9	116.1	623	Start of Multibeam line IX
24/10/2018	13:20:00	13	MB	-30	43.19	-35	38.17	7.6	305.4	625	End of Multibeam line IX
24/10/2018	13:23:00	13	MB	-30	42.98	-35	38.5	8	313.6	620	End of multibeam survey, moving to AUV
24/10/2018	13:30:00	13	AUV	-30	42.98	-35	38.5	8	313.6	620	Problem with multibeam of AUV
24/10/2018	16:46:00	14	Hybis	-30	40.12	-35	42.58	0.2	221	621	Deploying Hybis
24/10/2018	16:52:00	14	Hybis	-30	40.12	-35	42.58	0.2	126	621	Hybis in the water

dd/mm/yy	hh/mm/ss	#	operation	deg	dec min	deg	dec min	[kts]	[°]	[m]	Comments
24/10/2018	18:11:00	14	Hybis	-30	40.13	-35	42.59	0.2	240	632	Bottom in sight
24/10/2018	21:00:00	14	Hybis	-30	40.73	-35	43.32	0.3	5	686	Hybis landed
24/10/2018	21:10:00	14	Hybis	-30	40.73	-35	43.32	0.3	5	686	Hybis going up
24/10/2018	21:41:00	14	Hybis	-30	40.73	-35	43.33	0.4	324	686	Hybis on deck
24/10/2018	21:53:00	15	AUV	-30	40.48	-35	42.95	3.5	37	631	In transit to AUV launch
24/10/2018	22:26:00	15	AUV	-30	40.16	-35	42.59	0.5	191	622	AUV in the water
25/10/2018	00:24:00	15	AUV	-30	40.16	-35	42.59	0.5	191		AUV on bottom, fish recovery
25/10/2018	00:37:00	16	Dredge	-30	40.16	-35	42.59	6	191	290	Transit to dredge Station 16
25/10/2018	01:29:00	16	Dredge	-30	39.29	-35	45.64	0.3		702	Arrive on Station 16
25/10/2018	01:33:00	16	Dredge	-30	39.29	-35	45.64	0.3		702	Dredge in water
25/10/2018	02:10:00	16	Dredge	-30	39.53	-35	45.65	1	181	703	Dredge on bottom, ship starts to transit
25/10/2018	02:30:00	16	Dredge	-30	39.99	-35	45.69	1	181	705	Started to trawl (1100 + 500m cable out)
25/10/2018	02:51:00	16	Dredge	-30	40.08	-35	45.7	0.5	180	706	Started to recover dredge cable
25/10/2018	04:12:00	16	Dredge	-30	40.08	-35	45.7	0.5	181	713	Dredge on deck
25/10/2018	04:30:00	17	Transit	-30	39.71	-35	45.62	5.1	31	708	Transit to Station 17
25/10/2018	04:49:00	17	Dredge	-30	38.6	-35	44.69	0.5	178	699	Arrive on Station 17
25/10/2018	05:01:00	17	Dredge	-30	38.6	-35	44.68	0.1	180	694	Dredge in water
25/10/2018	05:30:00	17	Dredge	-30	38.7	-35	44.68	1	180	699	Dredge on bottom, ship starts to transit
25/10/2018	06:13:00	17	Dredge	-30	39.4	-35	44.7	0.5	200	699	Started to trawl (1500 + 500m cable out)
25/10/2018	06:16:00	17	Dredge	-30	39.4	-35	44.7	0.5	200	699	Start to recover cable
25/10/2018	08:01:00	17	Dredge	-30	39.4	-35	44.69	0.6	190	699	Dredge on deck
25/10/2018	08:14:00		Transit	-30	39.4	-35	44.69	8.7	190	695	Transit to the recovery of the glider
25/10/2018	08:54:00	18	Glider recovery	-30	50.82	-35	44.98	0.5	65	1529	On site for glider recovery
25/10/2018	10:20:00	18	Glider recovery	-30	50.75	-35	44.99	0.2	236	1527	Glider on deck
25/10/2018	11:00:00	19	Transit	-30	51.17	-35	47.86	10.6	260	1550	Transit to swath, st 19
25/10/2018	14:20:57	20	AUV	-30	42.19	-35	43.48	4.2	70	686	AUV sighted
25/10/2018	14:47:20	20	AUV	-30	42.3	-35	42.88	0.7	211	683	AUV on Board
25/10/2018	17:27:00	21	Hybis	-30	50.71	-35	57.64	0.7	37	1150	Deploying Hybis

dd/mm/yy	hh/mm/ss	#	operation	deg	dec min	deg	dec min	[kts]	[°]	[m]	Comments
25/10/2018	17:31:00	21	Hybis	-30	50.71	-35	57.64	0.5	340	1217	In the water
25/10/2018	18:11:00	21	Hybis	-30	50.71	-35	57.64	0.3	66	1152	Hybis on the bottom
25/10/2018	20:29:00	21	Hybis	-30	49.98	-35	58.22	0.3	250	838	Hybis landed
25/10/2018	21:13:00	21	Hybis	-30	49.98	-35	50.22	0.3	21	22	Hybis going up
25/10/2018	22:01:00	21	Hybis	-30	49.98	-35	58.22	0.7	341	821	Hybis on deck
25/10/2018	22:04:00		Transit	-30	49.98	-35	58.22	0.7	341	821	
25/10/2018	22:25:00	22	Dredge	-30	50.252	-35	58.241			851	Arrive on Station 22
25/10/2018	22:31:00	22	Dredge	-30	50.252	-35	58.241			851	Dredge in the water
25/10/2018	23:55:00	22	Dredge	-30	49.91	-35	58.1	0.5	308	815	Start to recover dredge
25/10/2018	00:58:00	22	Dredge	-30	49.72	-35	58.15	0.3	7	808	Dredge on deck
25/10/2018	01:30:00		Transit	-30	48.93	-35	58.02	3	331		Moving to next dredge st
26/10/2018	01:52:00	23	Dredge	-30	48.94	-35	58.03	0.7	207	801	Arrive at dredge st
26/10/2018	01:57:00	23	Dredge	-30	48.95	-35	58.04	0.9	206	791	Dredge in the water
26/10/2018	02:33:00	23	Dredge	-30	49.28	-35	58.11	0.4	200	797	Dredge on bottom (1050 +500m cable out)
26/10/2018	02:58:00	23	Dredge	-30	49.48	-35	58.17	0.5	206	792	Start to recover dredge
26/10/2018	03:26:00	23	Dredge	-30	49.49	-35	58.17	0.5	206	786	Potential weaklink break
26/10/2018	03:37:00	23	Dredge	-30	49.48	-35	58.18	0.5	206	786	Dredge off bottom
26/10/2018	04:20:00	23	Dredge	-30	49.48	-35	58.17	0.4	206	787	Dredge on deck
26/10/2018	04:33:00		transit	-30	49.48	-35	58.17	1	206	792	In transit to st 24
26/10/2018	05:00:00	24	Dredge	-30	48.86	-35	58.52	0.5	184	1532	On st 24 for dredge
26/10/2018	05:05:00	24	Dredge	-30	48.87	-35	58.53	0.5	185	1532	Dredge in the water
26/10/2018	05:41:00	24	Dredge	-30	48.88	-35	58.52	1.9	186	1528	Winch stopped with 851 +500m cable
26/10/2018	05:51:00	24	Dredge	-30	48.99	-35	58.52	1.3	186	1516	Start to recover dredge
26/10/2018	08:01:00	24	Dredge	-30	49.43	-35	58.57	0.3	185	1549	Dredge on deck
26/10/2018	08:13:00		Transit	-30	49.51	-35	58.55	4	190	1542	In transit to AUV site
26/10/2018	08:54:00	25	AUV	-30	48.51	-36	0.34	0.5	170	643	On st 25 for AUV dive
26/10/2018	09:34:00	25	AUV	-30	48.59	-36	0.28	2	185	617	AUV in water
26/10/2018	11:42:00	26	Multibeam	-30	51.55	-36	0.79	7.6	181.4	653	Multibeam start line 1
26/10/2018	17:17:15	26	Multibeam	-30	51.25	-35	59.81	1.4	99.9	705	Multibeam finishes

dd/mm/yy	hh/mm/ss	#	operation	deg	dec min	deg	dec min	[kts]	[°]	[m]	Comments
26/10/2018	17:22:35	27	Hybis	-30	51.24	-35	59.78	0.2	345.1	718	Hybis being deployed
26/10/2018	17:33:00	27	Hybis	-30	51.24	-35	59.78	0.3	34	691	Hybis in water
26/10/2018	18:02:00	27	Hybis	-30	51.24	-35	59.78	0.9	168.9	684	Hybis on the bottom
26/10/2018	18:33:00	27	Hybis	-30	51.25	-35	59.56	0.1	297	711	Hybis landed
26/10/2018	18:40:00	27	Hybis	-30	51.25	-35	59.56	0.1	297	711	Hybis moving on
26/10/2018	21:29:00	27	Hybis	-30	51.01	-36	0.38			685	Hybis coming up
26/10/2018	22:41:00		Transit	-30	49.63	-35	57.43	9.9	48.1	963	Moving to the dredge station 28
27/10/2018	00:27:00	28	Dredge	-30	40.13	-35	43.1	1	70	593	Arrived at dredge station 28
27/10/2018	00:44:00	28	Dredge	-30	40.15	-35	42.99	0.3	306	595	Dredge in the water
27/10/2018	01:41:00	28	Dredge	-30	39.8	-35	43.49	0.3	305.3	632	Dredge on the bottom (1256 + 500m cable out)
27/10/2018	01:43:00	28	Dredge	-30	39.8	-35	43.49	0.8	305	617	Started to the recover cable
27/10/2018	03:08:00	28	Dredge	-30	39.8	-35	43.48	0.3	305	627	Dredge lost at seafloor
27/10/2018	03:37:00		Transit	-30	41.33	-35	48.12	10	246	1295	Moving to multibeam line
27/10/2018	04:45:00	29	Multibeam	-30	45.44	-35	59.99	8	260	775	Start multibeam survey
27/10/2018	05:13:00	29	Multibeam	-30	46.45	-36	3.38	8	160	636	Start turn to next multibeam line
27/10/2018	05:21:00	29	Multibeam	-30	47.25	-36	2.78	8	74	641	Start next multibeam line
27/10/2018	05:58:00	29	Multibeam	-30	46.05	-35	57.33	8	95	1355	End multibeam line
27/10/2018	06:00:00		Transit	-30	46.07	-35	57.12	8	130	1361	Transit to station 30 for AUV recovery
27/10/2018	06:23:00	30	AUV	-30	47.65	-35	57.41	0.5	70	1157	AUV recovery
27/10/2018	06:38:00	30	AUV	-30	47.66	-35	57.41	0.2	121	1096	AUV on surface
27/10/2018	07:20:00	30	AUV	-30	47.37	-35	57.3	0.3	87	1253	AUV on deck
27/10/2018	07:33:00		Transit	-30	47.37	-35	57.3	0.2	91	1255	Transit to multibeam
27/10/2018	07:54:00		Transit	-30	47.91	-35	56.57	8	30	1335	Multibeam survey cancelled- moving to avoid storm
30/10/2018	08:09:00	31	AUV	-31	1.05	-35	56.98	1.2	168	945	Back on site for AUV - Statio 31
30/10/2018	09:28:00	31	AUV	-31	1.04	-35	56.91	0.9	164	927	AUV on the water
30/10/2018	11:13:00		Transit	-31	0.83	-35	56.73	0.6	175	927	Transit to station 32 for hybis
30/10/2018	13:40:00	32	Hybis 35	-30	44.24	-35	57.17	0.4	358	1401	Hybis in water
30/10/2018	14:47:00	32	Hybis 35	-30	44.24	-35	57.16	0.3	321	1388	Hybis on the bottom
30/10/2018	15:28:00	32	Hybis 35	-30	44.28	-35	57.22	0.3	180	1488	collected 5 samples

dd/mm/yy	hh/mm/ss	#	operation	deg	dec min	deg	dec min	[kts]	[°]	[m]	Comments
30/10/2018	16:04:00	32	Hybis 35	-30	44.28	-35	57.22	0.3	180	1500	Hybis off bottom
30/10/2018	17:04:00	32	Hybis 35	-30	44.29	-35	57.25	0.3	50	1397	end of Hybis dive
30/10/2018	17:59:00	32	Hybis 35	-30	44.21	-35	57.25	0.7	227	1404	Hybis on surface
30/10/2018	17:10:00		Transit	-30	49.53	-35	57.42	0.5	326	962	Transit to Hybis Dive 36
30/10/2018	19:27:00	33	Hybis 36	-30	49.5	-35	57.4	0.9	313	969	Hybis in the water for dive 36
30/10/2018	20:04:00	33	Hybis 36	-30	49.48	-35	57.4	0.2	213	984	Hybis on the bottom
30/10/2018	21:42:00	33	Hybis 36	-30	49.48	-35	57.85	0.8	143	927	Hybis going up
30/10/2018	22:08:00	33	Hybis 36	-30	49.49	-35	57.85	0.5	108	927	Hybis on deck end of Dive 36
30/10/2018	22:41:00	34	Dredge	-30	49.44	-35	57.63	0.2	227	927	Dredge in the water
30/10/2018	23:20:00	34	Dredge	-30	49.47	-35	57.79	0.8	235	927	Dredge on bottom
30/10/2018	23:40:00	34	Dredge	-30	49.52	-35	58.09	0.6	235	927	Started to recover dredge cable (1260 + 500m)
31/10/2018	00:25:00	34	Dredge	-30	49.54	-35	58.23	0.6	235	927	Dredge off bottom (420 +500 m)
31/10/2018	00:55:00	34	Dredge	-30	49.56	-35	58.41	0.3	235	927	Dredge on deck
31/10/2018	01:23:00	-	Transit	-30	48.57	-35	57.84	2.7	40	927	Moving to next dredge station 35
31/10/2018	01:52:00	35	Dredge	-30	48.39	-35	57.72	0.6	207	945	Dredge in the water
31/10/2018	02:29:00	35	Dredge	-30	48.43	-35	57.87	1.2	220	927	Dregde on bottom
31/10/2018	02:52:00	35	Dredge	-30	48.5	-35	58.19	0.4	239	927	Started to recover cable, 1390+500
31/10/2018	04:32:00	35	Dredge	-30	48.65	-35	58.24	0.4	182	927	Dredge on deck
31/10/2018	04:35:00	-	Transit	-30	48.67	-35	58.24	2.4	175	927	In transit to multibeam survey
31/10/2018	05:23:00	36	Multibeam	-30	54.14	-35	56.86	8.2	276	1222	Start of line 1 multibeam
31/10/2018	05:58:00	36	Multibeam	-30	54.41	-36	2.02	7.5	182	1400	End of line 1 multibeam
31/10/2018	06:06:00	36	Multibeam	-30	35.26	-36	1.81	7.6	91	1411	Start of line 2 multibeam
31/10/2018	06:52:00	36	Multibeam	-30	55.32	-35	54.27	7.1	188	1371	End of line 2 multibeam
31/10/2018	07:04:00	36	Multibeam	-30	56.4	-35	54.73	7.5	270	1355	Start of line 3 MB
31/10/2018	07:40:00	36	Multibeam	-30	56.24	-35	59.6	7.4	103	1393	End of line 3 MB
31/10/2018	07:40:00	-	Transit	-30	56.24	-35	59.6	7.4	103	1393	Transit to AUV recovery
31/10/2018	08:03:00	37	AUV	-30	56.69	-35	56.89	0.9	156	1409	On site to AUV recovery
31/10/2018	09:45:00	37	AUV	-30	58.69	-35	51.49	1.2	175	1412	AUV on deck
31/10/2018	09:58:00	-	Transit	-30	58.46	-35	52.12	6.8	300	1443	In transit to MB survey

dd/mm/yy	hh/mm/ss	#	operation	deg	dec min	deg	dec min	[kts]	[°]	[m]	Comments
31/10/2018	10:15:00	38	Multibeam	-30	57.45	-35	52.9	7	270	1408	Start of line 1 MB
31/10/2018	11:16:00	38	Multibeam	-30	52.32	-36	52.18	7.8	321	1500	End of line 1 MB
31/10/2018	11:26:00	38	Multibeam	-30	56.36	-36	51.77	7.6	94	1440	Start of line 2 MB (only half a line)
31/10/2018	11:47:00	-	Transit	-30	56.51	-35	58.6	7.8	106	1380	Finished line 2 MB, transit to Hybis station 39
31/10/2018	12:54:00	39	Hybis 37	-30	57.48	-35	54.1	0.4	327	1377	Hybis in the water
31/10/2018	13:31:00	39	Hybis 37	-30	57.48	-35	54.1	0.6	53	1410	Hybis bottom at sight
31/10/2018	17:08:00	39	Hybis 37	-30	58.15	-35	54.75	0.5	151	927	Hybis off bottom
31/10/2018	17:36:00	39	Hybis 37	-30	58.05	-35	54.65	0.5	337	927	Hybis on deck
31/10/2018	18:29:00	40	Hybis 38	-30	59.19	-35	56.48	0.3	330	927	Hybis in the water
31/10/2018	18:57:00	40	Hybis 38	-30	59.19	-35	56.48	0.4	233	927	Hybis at the bottom
31/10/2018	19:28:00	40	Hybis 38	-30	59.09	-35	56.32	0.5	167	927	Hybis landed
31/10/2018	21:45:00	40	Hybis 38	-30	58.84	-35	55.95	0.5	337	942	Hybis being recovered
31/10/2018	21:53:00	40	Hybis 38	-30	58.84	-35	55.95	0.5	340	1555	Hybis on deck
31/10/2018	23:03:00	41	Dredge	-30	50.2	-35	58.19	0.5	145	927	In position to start dredging
31/10/2018	23:20:00	41	Dredge	-30	50.27	-35	58.18	0.4	0	927	Dredge in the water
01/11/2018	00:00:00	41	Dredge	-30	50.09	-35	58.21	0.7	0	927	Dregde on bottom
01/11/2018	00:23:00	41	Dredge	-30	49.78	-35	58.26	0.1	0	927	Started to recover cable, 1484+500
01/11/2018	01:50:00	41	Dredge	-30	49.77	-35	58.26	0.2	0	928	Dredge on deck
01/11/2018	02:00:00	-	Transit	-30	49.77	-35	58.26	8	8	928	In transit to gravity core at 'Blue Hole'
01/11/2018	02:56:00	42	Gravity Core	-30	44.25	-35	57.17	0.5	155	1417	On station for Gravity Core
01/11/2018	03:15:00	42	Gravity Core	-30	44.25	-35	57.18	0.3	172	1411	Gravity Core in water
01/11/2018	03:46:00	42	Gravity Core	-30	44.25	-35	57.17	0.4	18.8	1407	Gravity Core hits bottom/ Start recovering
01/11/2018	04:23:00	42	Gravity Core	-30	44.26	-35	57.14	0.3	18.8	1406	Gravity Core on deck
01/11/2018	04:38:00	-	Transit	-30	44.27	-35	57.14	0.3	5	1406	Move East to try again
01/11/2018	04:45:00	43	Gravity Core	-30	44.27	-35	57.14	0.3	5	1416	Gravity Core in water
01/11/2018	05:24:00	43	Gravity Core	-30	44.27	-35	57.14	0.4	5	1402	Gravity Core hits bottom/ Start recovering
01/11/2018	05:59:00	43	Gravity Core	-30	44.27	-35	57.14	0.4	5	1404	Gravity Core on deck
01/11/2018	06:03:00	-	Transit	-30	44.27	-35	57.14	1.4	6	1417	Transit to AUV deployment
01/11/2018	08:12:00	44	AUV	-30	58.67	-35	10.8	1.7	305	927	On site to AUV deployment

dd/mm/yy	hh/mm/ss	#	operation	deg	dec min	deg	dec min	[kts]	[°]	[m]	Comments
01/11/2018	08:52:00	44	AUV	-30	58.52	-36	10.85	0.2	152	1554	AUV on the water
01/11/2018	11:08:00	-	Transit	-30	58.93	-36	10.87	6	207	1520	Transit to Multibeam survey
01/11/2018	12:48:00	45	Hybis 39	-31	0.01	-36	15.29	0.2	160	1441	Hybis in water
01/11/2018	13:27:00	45	Hybis 39	-31	0.01	-36	15.21	0.4	252	714	HyBIS on bottom
01/11/2018	04:05:00	45	Hybis 39	-31	0.04	-36	15.2	0.3	258	740	Hybis collected 2 samples
01/11/2018	15:38:00	45	Hybis 39	-31	0.3	-36	14.71	0.4	359	758	2 samples collected (bio+Geo)
01/11/2018	15:56:00	45	Hybis 39	-31	0.36	-36	14.64	0	0	783	2 geological block samples
01/11/2018	18:57:00	45	Hybis 39	-31	0.61	-36	13.53	0.2	134	730	Hybis on deck
01/11/2018	21:45:00	46	Dredge	-30	51.7	-36	0.25	0.5	3	694	Dredge in water
01/11/2018	22:22:00	46	Dredge	-30	51.57	-36	0.26	1	5	690	Dredge on bottom
01/11/2018	22:43:00	46	Dredge	-30	51.26	-36	0.27	0.2	3	685	Started to recover cable
01/11/2018	23:50:00	46	Dredge	-30	51.26	-36	0.26	0.5	354	690	Dredge off bottom
02/11/2018	00:02:00	46	Dredge	-30	51.26	-36	0.26	0.2	353	666	Dredge on deck
02/11/2018	00:30:00	-	Transit	-30	52.59	-35	59.26	4.6	139	701	Transit to next dredge station
02/11/2018	01:30:00	47	Dredge	-30	53.07	-35	58.8	0.2	338	793	Dredge in the water (a time ago) - 300+500m
02/11/2018	01:42:00	47	Dredge	-30	52.99	-35	58.81	0.9	349	815	Dredge on bottom
02/11/2018	02:15:00	47	Dredge	-30	52.47	-35	58.88	0.2	334	743	Started to recover cable (1561+500)
02/11/2018	03:23:00	47	Dredge	-30	52.45	-35	58.89	0.5	298	762	Dredge off bottom
02/11/2018	03:47:00	47	Dredge	-30	52.44	-35	58.95				Dredge on deck
02/11/2018	04:17:00	-	Transit	-30	52.39	-35	59.41	6	280	718	Transit to Multibeam survey
02/11/2018	05:44:00	48	Multibeam	-30	58.66	-36	6.55	8	243	1264	Finished short Multibeam line
02/11/2018	05:44:00	-	Transit	-30	58.66	-36	6.55	8	243	1264	Transit to AUV recovery
02/11/2018	06:59:00	49	AUV	-31	2.46	-36	15.67	0.1	235	764	On site for AUV recovery
02/11/2018	08:49:00	49	AUV	-31	2.36	-36	14.52	1.5	315	735	Waiting for better conditions for AUV recovery
02/11/2018	10:52:00	49	AUV	-31	0.34	-36	13.97	0.4	343	1425	AUV on board
02/11/2018	16:10:00	50	Hybis 40	-31	0.44	-35	58.02	0.1	134	839	Hybis in the water
02/11/2018	16:47:00	50	Hybis 40	-31	0.44	-35	58.02	0.5	185	873	Hybis on the bottom
02/11/2018	20:51:00	50	Hybis 40	-30	59.66	-35	58.06	0.9	240	766	Hybis off bottom
02/11/2018	21:17:00	50	Hybis 40	-30	59.66	-35	58.06	0.4	239	794	Hybis on deck

dd/mm/yy	hh/mm/ss	#	operation	deg	dec min	deg	dec min	[kts]	[°]	[m]	Comments
02/11/2018	22:13:00	51	Dredge	-30	59.69	-35	58.6	0.3	355	799	Dredge in the water
02/11/2018	22:24:00	51	Dredge	-30	59.69	-35	58.61	1	353	761	Dredge on bottom (500+530m)
02/11/2018	23:27:00	51	Dredge	-30	59.33	-35	58.61	0.2	354	744	Dredge off bottom
02/11/2018	23:52:00	51	Dredge	-30	59.33	-35	58.61	0.3	352	744	Dredge on deck
03/11/2018	00:04:00	-	Transit	-30	59.6	-35	58.14	6	146	771	Transit to next dredge station
03/11/2018	00:42:00	52	Dredge	-31	0.89	-35	56.55	0.3	357	921	Dredge in water
03/11/2018	01:15:00	52	Dredge	-31	0.89	-35	56.55	0.2	315	921	Dredge on bottom (500+421m)
03/11/2018	01:43:00	52	Dredge	-31	0.53	-35	56.55	0.1	359	903	Dredgre on bottom
03/11/2018	02:18:00	52	Dredge	-31	0.53	-35	56.55	0.3	358	889	Dredge off bottom
03/11/2018	02:47:00	52	Dredge	-31	0.53	-35	56.54	2	358	908	Dredge on deck
03/11/2018	03:05:00	52	Transit	-31	0.96	-35	55.5	3	103	952	Transit to next dredge station
03/11/2018	03:20:00	53	Dredge	-31	0.92	-35	55.49	0.5	353	947	dredge in the water
03/11/2018	03:55:00	53	Dredge	-31	0.04	-35	55.49	0.8	359	925	Dredge on bottom
03/11/2018	04:15:00	53	Dredge	-31	0.57	-35	55.49	0.1	356	901	start to recover dredge
03/11/2018	05:45:00	53	Dredge	-31	0.57	-35	55.49	0.4	356	926	dredge on deck
03/11/2018	06:04:00	53	Transit	-31	0.57	-35	55.49	1.5	68	887	transit to AUV deployment site
03/11/2018	08:18:00	54	AUV	-30	42.93	-35	43.24	2	275	671	On station for AUV deployment
03/11/2018	09:18:00	54	AUV	-30	43.02	-35	43.37	0.7	179	675	AUV in water
03/11/2018	13:52:00	55	Hybis	-30	75.66	-35	98.14	0.2	219	1123	Hybis in water. Dive 41
03/11/2018	14:48:00	55	Hybis	-30	45.39	-35	58.88	0.3	253	1327	Hybis on bottom. Dive 41
03/11/2018	21:02:00	55	Hybis	-30	46.01	-35	58.96	0.2	230	735	Hybis off bottom. Dive 41
03/11/2018	21:31:00	55	Hybis	-30	46.1	-35	58.96	1	224	728	Hybis on deck, end Dive 41
03/11/2018	21:54:00		Transit	-30	46.13	-35	59.01	3.2	242		Transit to dredge Station 56
03/11/2018	22:48:00	56	Dredge	-30	50.29	-36	0.93	0.2	212	671	Dredge in water
03/11/2018	23:10:00	56	Dredge	-30	50.35	-36	0.98	0.9	212	669	Dredge on bottom (tension has dropped)
04/11/2018	00:46:00	56	Dredge	-30	50.72	-36	1.26	0.5	214	664	Dredge off bottom
04/11/2018	01:11:00	56	Dredge	-30	50.72	-36	1.26	0.5	216	668	Dredge on deck
04/11/2018	01:26:00	-	Transit	-30	50.93	-36	1.27	4	188	661	Transit
04/11/2018	01:40:00	57	Dredge	-30	52.05	-36	1.25	1	215	659	Dredge in water

dd/mm/yy	hh/mm/ss	#	operation	deg	dec min	deg	dec min	[kts]	[°]	[m]	Comments
04/11/2018	02:20:00	57	Dredge	-30	52.09	-36	1.29	1.3	208	666	Dredge on bottom (tension has dropped)
04/11/2018	02:48:00	57	Dredge	-30	52.48	-36	1.58	0.6	273	661	Start to recover the dredge (500+1350m)
04/11/2018	03:47:00	57	Dredge	-30	52.48	-36	1.58	0.4	210	694	Dredge off bottom
04/11/2018	04:11:00	57	Dredge	-30	52.48	-36	1.58	0.4	209	661	Dredge on deck
04/11/2018	04:30:00	-	Transit	-30	52.49	-36	1.6	3	220	695	Transit to multibeam station 58
04/11/2018	05:18:00	58	Multibeam	-30	54.25	-35	54.2	7.5	75	1342	Start of line 1 multibeam
04/11/2018	05:40:00	58	Multibeam	-30	53.37	-35	51.22	6.4	15	1486	End of line 1 multibeam
04/11/2018	05:41:00	-	Transit	-30	53.37	-35	51.22	6.4	15	1486	Transit to multibeam station 59
04/11/2018	07:10:00	59	Multibeam	-30	39.01	-35	48.72	8.2	33	1217	Start of line 1 multibeam
04/11/2018	07:29:00	59	Multibeam	-30	36.71	-35	47.05	8.3	82	650	End of line 1 multibeam
04/11/2018	07:31:00	59	Multibeam	-30	36.68	-35	46.88	7.6	114	617	Start of line 2 multibeam
04/11/2018	07:38:00	59	Multibeam	-30	37.15	-35	49.95	7.9	156	617	End of line 2 multibeam
04/11/2018	07:42:00	59	Multibeam	-30	37.55	-35	45.96	7.6	211	668	Start of line 3 MB
04/11/2018	08:05:00	59	Multibeam	-30	40.07	-35	47.72	7.8	207	1229	End of line 3 MB
04/11/2018	08:07:00	-	Transit	-30	40.28	-35	47.77	7	150	1241	Transit to AUV recovery
04/11/2018	08:30:00	60	AUV	-30	41.11	-35	45.15	0.5	140	698	On site for AUV recovery
04/11/2018	09:35:00	60	AUV	-30	41.26	-35	45.69	0.9	183	965	AUV on deck
04/11/2018	12:07:00	61	Hybis	-30	41.08	-35	45.09	0.4	154	699	Hybis in the water
04/11/2018	12:39:00	61	Hybis	-30	41.08	-35	45.09	0.3	154	710	Hybis on bottom
04/11/2018	20:59:00	61	Hybis	-30	41.79	-35	44.04	0.3	320	670	Hybis being recovered
04/11/2018	21:30:00	61	Hybis	-30	41.78	-35	44.04	0.4	37	650	Hybis on deck
04/11/2018	21:58:00	-	Transit	-30	41.68	-35	44.06	0.8	48	683	Transit to next dredge station
04/11/2018	22:15:00	62	Dredge	-30	41.61	-35	43.99	0.5	219	653	Dredge in water
04/11/2018	22:48:00	62	Dredge	-30	41.65	-35	44.06	0.6	220	697	Dredge on bottom (tension has dropped)
04/11/2018	23:21:00	62	Dredge	-30	41.89	-35	44.49	0.4	234	663	Start to recover the dredge (500+1350m)
05/11/2018	00:15:00	62	Dredge	-30	41.89	-35	44.49	0.3	223	661	Dredge off bottom
05/11/2018	00:47:00	62	Dredge	-30	41.89	-35	44.49	0.3	221	664	Dredge on deck
05/11/2018	00:54:00	-	Transit	-30	41.86	-35	44.43	4	119	690	Transit to next dredge station
05/11/2018	01:35:00	63	Dredge	-30	41.89	-35	41.81	0.7	213		Dredge in water

dd/mm/yy	hh/mm/ss	#	operation	deg	dec min	deg	dec min	[kts]	[°]	[m]	Comments
05/11/2018	02:00:00	63	Dredge	-30	41.98	-35	41.91	0.6	215		Dredge on bottom (tension has dropped)
05/11/2018	02:34:00	63	Dredge	-30	42.26	-35	42.21	0.1	213	663	Start to recover the dredge (500+1350m)
05/11/2018	03:22:00	63	Dredge	-30	42.26	-35	42.21	0.1	215	644	Dredge off bottom
05/11/2018	03:55:00	63	Dredge	-30	42.26	-35	42.21	0.2	216		Dredge on deck
05/11/2018	04:07:00	-	Transit	-30	42.53	-35	42.06	5.5	103	660	Transit to next dredge station
05/11/2018	04:34:00	64	Dredge	-30	40.77	-35	41.21	0.5	220	630	On station 64 for dredge
05/11/2018	04:45:00	64	Dredge	-30	40.77	-35	41.21	0.6	226	626	Dredge in water
05/11/2018	05:12:00	64	Dredge	-30	40.94	-35	41.47	1.3	225	608	Dredge on bottom (tension has dropped)
05/11/2018	05:29:00	64	Dredge	-30	41.08	-35	41.68	0.6	224	637	Start to recover the dredge
05/11/2018	06:24:00	64	Dredge	-30	41.09	-35	41.68	0.6	224	638	Dredge off bottom
05/11/2018	06:57:00	64	Dredge	-30	41.09	-35	41.68	0.6	224	629	Dredge on deck - not
05/11/2018	07:00:00	64	Dredge	-30	41.09	-35	41.68	0.6	224	629	Dredge lost at seafloor
05/11/2018	07:30:00	65	Multibeam	-30	40.71	-35	39.99	7.2	148	592	Start of line 1 multibeam
05/11/2018	08:05:00	65	Multibeam	-30	41.84	-35	37.99	9	148	600	End of line 1 multibeam
05/11/2018	08:10:00	65	Multibeam	-30	41.75	-35	38.06	8.5	320	612	Start of line 2 multibeam
05/11/2018	08:19:00	65	Multibeam	-30	39.73	-35	39.86	7.9	320	619	End of line 2 multibeam
05/11/2018	08:20:00	65	Multibeam	-30	39.7	-35	39.91	7.2	305	600	Start of line 3 multibeam
05/11/2018	09:03:00	65	Multibeam	-30	36.63	-35	45.46	8	300	639	End of line 3 multibeam
05/11/2018	09:08:00	65	Multibeam	-30	37.22	-35	45.77	7.5	133	640	Start of line 4 multibeam
05/11/2018	09:54:00	65	Multibeam	-30	40.53	-35	40.14	7.3	134	616	End of line 4 multibeam
05/11/2018	10:00:00	-	Test	-30	40.62	-35	39.5	7.1	2	617	Ship test
05/11/2018	10:41:00	66	Multibeam	-30	39.03	-35	39.02	7.1	150	575	Start of MB line 1
05/11/2018	11:09:00	66	Multibeam	-30	41.87	-35	36.88	7.6	145	597	End of MB line 1
05/11/2018	11:15:00	-	Transit	-30	41.88	-35	37.47	8	275	601	Trransit to Hybis site
05/11/2018	12:09:00	67	Hybis	-30	41.12	-35	42.4	0.6	170	1298	Hybis in the water
05/11/2018	12:29:00	67	Hybis	-30	41.93	-35	42.44	5.1	180	1308	Hybis back (striations discovered)
05/11/2018	12:54:00	67	Hybis	-30	43.04	-35	42.46	0.4	165	646	Ready to deploy again
05/11/2018	12:56:00	67	Hybis	-30	43.04	-35	42.46	0.4	201	645	Hybis in the water
05/11/2018	13:29:00	67	Hybis	-30	43.02	-35	42.48	0.4	223	671	Hybis on bottom

dd/mm/yy	hh/mm/ss	#	operation	deg	dec min	deg	dec min	[kts]	[°]	[m]	Comments
05/11/2018	18:32:00	67	Hybis	-30	42.05	-35	42.72	0.2	217	678	Hybis off bottom
05/11/2018	19:03:00	67	Hybis	-30	42.05	-35	42.72	0.5	215	674	Hybis on deck
05/11/2018	19:15:00	-	Transit	-30	41.82	-35	42.46	7	68	1330	Transit to dredge station
05/11/2018	20:44:00	68	Dredge	-30	40.76	-35	39.87	0.5	185	1207	Dredge in the water
05/11/2018	21:15:00	68	Dredge	-30	40.85	-35	40.02	0.1	241	600	On the bottom
05/11/2018	23:40:00	68	Dredge	-30	40.91	-35	40.11	0.5	224		Dredge lost
THE END											

Appendix 3: Geological and Biological Sample Log

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
#	Deg.	Deg.	[m]			[mm]			[mm]	[mm]	[mm]
DY094_002_G001	-30.7510	-35.8553	1458	Gravity core	N/A	-1	N/A	N/A	-1	-1	-1
DY094_004_G001	-30.7833	-35.8077	1475	Gravity core	N/A	-1	N/A	N/A	-1	-1	-1
DY094_005_G001	-30.7830	-35.9048	1429	Gravity core	N/A	-1	N/A	N/A	-1	-1	-1
DY094_009_G001	-30.6895	-35.7542	1102	ROV	Rock	1	Volcanic	N/A	180	80	60
DY094_010_G001	-30.6857	-35.7568	709	Dredge	Rock	2	Volcanic	N/A	150	100	40
DY094_010_G002	-30.6857	-35.7568	709	Dredge	Rock	20	Volcanic	N/A	170	80	80
DY094_010_G003	-30.6857	-35.7568	709	Dredge	Rock	1	Volcanic	N/A	170	80	80
DY094_010_G004	-30.6857	-35.7568	709	Dredge	Rock	1	Volcanic	N/A	110	100	100
DY094_010_G005	-30.6857	-35.7568	709	Dredge	Rock	0	Volcanic	N/A	120	100	60
DY094_010_G006	-30.6857	-35.7568	709	Dredge	Rock	1	Volcanic	N/A	100	90	100
DY094_010_G007	-30.6857	-35.7568	709	Dredge	Rock	0	Volcanic	N/A	120	80	40
DY094_010_G008	-30.6857	-35.7568	709	Dredge	Rock	1	Volcanic	N/A	100	80	30
DY094_010_G009	-30.6857	-35.7568	709	Dredge	Rock	1	Volcanic	N/A	90	90	50
DY094_010_G010	-30.6857	-35.7568	709	Dredge	Rock	0	Volcanic	N/A	150	50	20
DY094_010_G011	-30.6857	-35.7568	709	Dredge	Rock	10	Phosphorite	N/A	130	100	20
DY094_010_G012	-30.6857	-35.7568	709	Dredge	Rock	0	Volcanic	N/A	120	70	50
DY094_010_G013	-30.6857	-35.7568	709	Dredge	Rock	2	Sedimentary?	N/A	120	60	30
DY094_010_G014	-30.6857	-35.7568	709	Dredge	Crust	15	Phosphorite	N/A	90	60	50
DY094_010_G015	-30.6857	-35.7568	709	Dredge	Rock	1	Sedimentary?	N/A	140	50	30
DY094_010_G016	-30.6857	-35.7568	709	Dredge	Crust	23	Phosphorite	N/A	120	60	50
DY094_010_G017	-30.6857	-35.7568	709	Dredge	Rock	0	Volcanic	N/A	80	80	20
DY094_010_G018	-30.6857	-35.7568	709	Dredge	Crust	34	Phosphorite	N/A	100	40	50
DY094_010_G019	-30.6857	-35.7568	709	Dredge	Rock	0	Sedimentary	N/A	80	50	40

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_010_G020	-30.6857	-35.7568	709	Dredge	Rock	0	Volcanic	N/A	80	60	50
DY094_010_G021	-30.6857	-35.7568	709	Dredge	Rock	0	Sedimentary?	N/A	70	70	30
DY094_010_G022	-30.6857	-35.7568	709	Dredge	Rock	0	Basalt	N/A	70	60	40
DY094_010_G023	-30.6857	-35.7568	709	Dredge	Rock	0	Sedimentary	N/A	80	80	40
DY094_010_G024	-30.6857	-35.7568	709	Dredge	Rock	0	Sedimentary	N/A	30	30	10
DY094_010_G025	-30.6857	-35.7568	709	Dredge	Rock	0	Sedimentary	N/A	50	50	40
DY094_010_M001	-30.6857	-35.7568	709	Dredge	Rock	0	Volcanic	N/A	-1	-1	-1
DY094_010_B001	-30.6857	-35.7568	709	Dredge	Biological	0	N/A	Sponge	-1	-1	-1
DY094_010_B002	-30.6857	-35.7568	709	Dredge	Biological	0	N/A	Crustacea	-1	-1	-1
DY094_010_B003	-30.6857	-35.7568	709	Dredge	Biological	0	N/A	Sponge	-1	-1	-1
DY094_010_MB1	-30.6857	-35.7568	710	Dredge	Molecular Biology	0	N/A				
DY094_014_G001	-30.6767	-35.7175	704	Hybis	Nodule	-1	N/A	N/A	-1	-1	-1
DY094_014_G002	-30.6767	-35.7175	704	Hybis	Nodue	-1	N/A	N/A	-1	-1	-1
DY094_014_G003	-30.6767	-35.7175	704	Hybis	Nodule	-1	N/A	N/A	-1	-1	-1
DY094_014_B004	-30.6767	-35.7175	704	Hybis	Biological	-1	N/A	Black coral	300	-1	-1
DY094_014_B005	-30.6767	-35.7175	704	Hybis	Biological	-1	N/A	Anemone	-1	-1	-1
DY094_014_B006	-30.6767	-35.7175	704	Hybis	Biological	-1	N/A	Sponge	-1	-1	-1
DY094_014_B007	-30.6767	-35.7175	704	Hybis	Biological	-1	N/A	Solitary coral	-1	-1	-1
DY094_016_G001	-30.6665	-35.7615	705	Dredge	Rock	-1	N/A	N/A	90	60	25
DY094_016_G002	-30.6665	-35.7615	705	Dredge	Rock	-1	N/A	N/A	80	50	10
DY094_016_G003	-30.6665	-35.7615	705	Dredge	Rock	-1	N/A	N/A	70	40	15
DY094_016_G004	-30.6665	-35.7615	705	Dredge	Rock	-1	Sedimentary	N/A	50	25	25
DY094_016_G005	-30.6665	-35.7615	705	Dredge	Rock	-1	N/A	N/A	55	30	10
DY094_016_G006	-30.6665	-35.7615	705	Dredge	Rock	-1	N/A	N/A	40	30	20
DY094_016_G007	-30.6665	-35.7615	705	Dredge	Rock	-1	N/A	N/A	40	30	20
DY094_016_G008	-30.6665	-35.7615	705	Dredge	Rock	-1	N/A	N/A	30	25	15
DY094_016_G009	-30.6665	-35.7615	705	Dredge	Rock	-1	N/A	N/A	45	25	10
DY094_016_G010	-30.6665	-35.7615	705	Dredge	Rock	-1	Phosphorite	N/A	35	30	15
DY094_016_G011	-30.6665	-35.7615	705	Dredge	Rock	-1	Sedimentary	N/A	50	30	10

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_016_G012	-30.6665	-35.7615	705	Dredge	Rock	-1	Phosphorite	N/A	35	20	15
DY094_016_G013	-30.6665	-35.7615	705	Dredge	Rock	-1	N/A	N/A	35	25	10
DY094_016_G014	-30.6665	-35.7615	705	Dredge	Rock	-1	N/A	N/A	25	20	20
DY094_016_G015	-30.6665	-35.7615	705	Dredge	Rock	-1	Phosphorite	N/A	25	20	10
DY094_016_G016	-30.6665	-35.7615	705	Dredge	Rock	-1	N/A	N/A	85	60	10
DY094_016_G017	-30.6665	-35.7615	705	Dredge	Rock	-1	Phosphorite	N/A	50	40	30
DY094_016_B001	-30.6665	-35.7615	705	Dredge	Rock	-1	N/A	Anemone	-1	-1	-1
DY094_016_B002	-30.6665	-35.7615	705	Dredge	Rock	-1	N/A	Anemone	-1	-1	-1
DY094_016_B003	-30.6665	-35.7615	705	Dredge	Rock	-1	N/A	Anemone	-1	-1	-1
DY094_016_MB1	-30.6665	-35.7615	705	Dredge	Molecular Biology	-1	N/A				
DY094_017_G001	-30.6450	-35.7447	694	Dredge	Rock	1	Volcanic	N/A	120	90	60
DY094_017_G002	-30.6450	-35.7447	694	Dredge	Rock	-1	Volcanic	N/A	180	80	95
DY094_017_G003	-30.6450	-35.7447	694	Dredge	Rock	-1	Volcanic	N/A	160	90	30
DY094_017_G004	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	260	140	80
DY094_017_G005	-30.6450	-35.7447	694	Dredge	Rock	< 1 to 3	Volcanic	N/A	120	85	65
DY094_017_G006	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	100	70	50
DY094_017_G007	-30.6450	-35.7447	694	Dredge	Rock	<1	N/A	N/A	120	70	20
DY094_017_G008	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	90	60	60
DY094_017_G009	-30.6450	-35.7447	694	Dredge	Rock	< 1	N/A	N/A	100	85	20
DY094_017_G010	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	70	65	40
DY094_017_G011	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	80	50	40
DY094_017_G012	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	60	60	45
DY094_017_G013	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	80	60	30
DY094_017_G014	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	70	40	25
DY094_017_G015	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	60	85	40
DY094_017_G016	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	90	60	30
DY094_017_G017	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	65	55	20
DY094_017_G018	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	80	60	40
DY094_017_G019	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	100	70	30

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_017_G020	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	60	45	40
DY094_017_G021	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	65	55	40
DY094_017_G022	-30.6450	-35.7447	694	Dredge	Rock	-1	Volcanic	N/A	65	35	30
DY094_017_G023	-30.6450	-35.7447	694	Dredge	Rock	< 1	N/A	N/A	75	70	40
DY094_017_G024	-30.6450	-35.7447	694	Dredge	Rock	< 1	Volcanic	N/A	60	50	20
DY094_017_G025	-30.6450	-35.7447	694	Dredge	Rock	-1	Volcanic	N/A	60	45	20
DY094_017_G026	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	N/A	55	35	20
DY094_017_G027	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	N/A	40	40	20
DY094_017_G028	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	N/A	30	30	10
DY094_017_G029	-30.6450	-35.7447	694	Dredge	Rock	-1	Volcanic	N/A	100	90	55
DY094_017_G030	-30.6450	-35.7447	694	Dredge	Rock	-1	Volcanic	N/A	150	100	50
DY094_017_G031	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	N/A	135	80	55
DY094_017_G032	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	N/A	70	70	40
DY094_017_G033	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	N/A	75	50	15
DY094_017_G034	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	N/A	60	40	20
DY094_017_G035	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	N/A	70	110	20
DY094_017_G036	-30.6450	-35.7447	694	Dredge	Rock	< 1	N/A	N/A	95	80	35
DY094_017_G037	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	N/A	30	30	20
DY094_017_G038	-30.6450	-35.7447	694	Dredge	Rock	< 1	N/A	N/A	80	70	40
DY094_017_G039	-30.6450	-35.7447	694	Dredge	Rock	< 1	N/A	N/A	75	50	45
DY094_017_G040	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	N/A	40	25	15
DY094_017_G041	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	N/A	25	15	10
DY094_017_G042	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	N/A	140	190	125
DY094_017_B011	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	solitary coral	-1	-1	-1
DY094_017_B012	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	solitary coral	-1	-1	-1
DY094_017_B013	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	sponge	-1	-1	-1
DY094_017_B014	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	bivalve	-1	-1	-1
DY094_017_B015	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	sponge	-1	-1	-1
DY094_017_B016	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	spinorbid gastropod	-1	-1	-1
DY094_017_B017	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	anemone	-1	-1	-1

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_017_B018	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	sponge	-1	-1	-1
DY094_017_B019	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	polychaete	-1	-1	-1
DY094_017_B020	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	sponge	-1	-1	-1
DY094_017_B021	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	sponge	-1	-1	-1
DY094_017_B022	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	sponge	-1	-1	-1
DY094_017_B023	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	polychaete	-1	-1	-1
DY094_017_B024	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	polychaete	-1	-1	-1
DY094_017_B025	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	sponge	-1	-1	-1
DY094_017_B026	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	solitary coral	-1	-1	-1
DY094_017_B027	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	sponge	-1	-1	-1
DY094_017_B028	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	oyster?	-1	-1	-1
DY094_017_B029	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	oyster?	-1	-1	-1
DY094_017_B030	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	sponge	-1	-1	-1
DY094_017_B031	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	anemone?	-1	-1	-1
DY094_017_B032	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	polychaete	-1	-1	-1
DY094_017_B033	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	coronatae	-1	-1	-1
DY094_017_B034	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	ceriantus	-1	-1	-1
DY094_017_B035	-30.6450	-35.7447	694	Dredge	Rock	-1	N/A	ceriantus	-1	-1	-1
DY094_017_MB1	-30.6450	-35.7447	694	Dredge	Molecular Biology						
DY094_021_G001	-30.6618	-35.7603	837	Hybis	Crust	5	N/A	N/A	90	90	20
DY094_021_G002	-30.6618	-35.7603	837	Hybis	Crust	6	N/A	N/A	150	100	20
DY094_021_G003	-30.6618	-35.7603	837	Hybis	Crust	6	N/A	N/A	120	110	30
DY094_021_B036	-30.6618	-35.7603	837	Hybis	Crust	-1	N/A	coral	-1	-1	-1
DY094_021_B037	-30.6618	-35.7603	837	Hybis	Crust	-1	N/A	sponge	-1	-1	-1
DY094_021_B038	-30.6618	-35.7603	837	Hybis	Crust	-1	N/A	serpulid	-1	-1	-1
DY094_021_B039	-30.6618	-35.7603	837	Hybis	Crust	-1	N/A	solitary coral	-1	-1	-1
DY094_022_G001	-30.8158	-35.9673	791	Dredge	Crust	4	Phosphorite	N/A	190	150	10
DY094_022_G002	-30.8158	-35.9673	791	Dredge	Crust	40	Phosphorite	N/A	200	110	40
DY094_022_G003	-30.8158	-35.9673	791	Dredge	Crust	7	Phosphorite	N/A	230	110	10

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_022_G004	-30.8158	-35.9673	791	Dredge	Crust	50	Phosphorite	N/A	400	270	60
DY094_022_G005	-30.8158	-35.9673	791	Dredge	Crust	6	Phosphorite	N/A	210	180	40
DY094_022_G006	-30.8158	-35.9673	791	Dredge	Crust	6	Phosphorite	N/A	200	150	20
DY094_022_G007	-30.8158	-35.9673	791	Dredge	Crust	10	Phosphorite	N/A	280	200	20
DY094_022_G008	-30.8158	-35.9673	791	Dredge	Crust	30	Phosphorite	N/A	150	120	40
DY094_022_G009	-30.8158	-35.9673	791	Dredge	Crust	20	Phosphorite	N/A	180	130	30
DY094_022_G010	-30.8158	-35.9673	791	Dredge	Crust	20	Phosphorite	N/A	230	150	60
DY094_022_G011	-30.8158	-35.9673	791	Dredge	Crust	20	Phosphorite	N/A	200	100	20
DY094_022_G012	-30.8158	-35.9673	791	Dredge	Crust	40	Phosphorite	N/A	200	110	40
DY094_022_G013	-30.8158	-35.9673	791	Dredge	Crust	30	Phosphorite	N/A	200	180	30
DY094_022_G014	-30.8158	-35.9673	791	Dredge	Crust	40	Phosphorite	N/A	180	130	50
DY094_022_G015	-30.8158	-35.9673	791	Dredge	Crust	-1	N/A	N/A	100	80	20
DY094_022_G016	-30.8158	-35.9673	791	Dredge	Crust	-1	N/A	N/A	40	40	20
DY094_022_G017	-30.8158	-35.9673	791	Dredge	Crust	-1	N/A	N/A	70	70	20
DY094_022_G018	-30.8158	-35.9673	791	Dredge	Crust	-1	N/A	N/A	80	40	30
DY094_022_G019	-30.8158	-35.9673	791	Dredge	Crust	-1	N/A	N/A	-1	-1	-1
DY094_022_G020	-30.8158	-35.9673	791	Dredge	Crust	-1	N/A	N/A	70	40	20
DY094_022_G021	-30.8158	-35.9673	791	Dredge	Carbonate	-1	N/A	N/A	30	30	20
DY094_022_G022	-30.8158	-35.9673	791	Dredge	Crust	-1	N/A	N/A	40	40	20
DY094_022_G023	-30.8158	-35.9673	791	Dredge	Crust	-1	N/A	N/A	20	10	5
DY094_022_G024	-30.8158	-35.9673	791	Dredge	Enrusted Coral	-1	N/A	N/A	30	10	10
DY094_022_G025	-30.8158	-35.9673	791	Dredge	Sand	-1	N/A	N/A	-1	-1	-1
DY094_022_G026	-30.8158	-35.9673	791	Dredge	Crust	27	N/A	N/A	150	100	30
DY094_022_G027	-30.8158	-35.9673	791	Dredge	Crust	10	Phosphorite	N/A	50	30	15
DY094_022_G028	-30.8158	-35.9673	791	Dredge	Rock	1	Volcanic	N/A	65	50	20
DY094_022_B040	-30.8158	-35.9673	791	Dredge	Biological	-1	N/A	Porifera	-1	-1	-1
DY094_022_B041	-30.8158	-35.9673	791	Dredge	Biological	-1	N/A	Ocotocoral	-1	-1	-1
DY094_022_B042	-30.8158	-35.9673	791	Dredge	Biological	-1	N/A	Octocoral	-1	-1	-1
DY094_022_B043	-30.8158	-35.9673	791	Dredge	Biological	-1	N/A	Porifera	-1	-1	-1

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_022_B044	-30.8158	-35.9673	791	Dredge	Biological	-1	N/A	Porifera	-1	-1	-1
DY094_022_B045	-30.8158	-35.9673	791	Dredge	Biological	-1	N/A	Polychaeta	-1	-1	-1
DY094_022_B046	-30.8158	-35.9673	791	Dredge	Biological	-1	N/A	Anemone	-1	-1	-1
DY094_022_MB1	-30.8158	-35.9673	705	Dredge	Molecular Biology	-1	N/A				
DY094_022_MB2	-30.8158	-35.9673	706	Dredge	Microscopy	-1	N/A				
DY094_022_MB3	-30.8158	-35.9673	707	Dredge	Molecular Biology	-1	N/A				
DY094_023_G001	-30.8247	-35.9697	786	Dredge	Crust	12	Phosphorite	N/A	280	140	30
DY094_023_G002	-30.8247	-35.9697	786	Dredge	Crust	50	Sedimentary	N/A	420	240	60
DY094_023_G003	-30.8247	-35.9697	786	Dredge	Crust	11	Phosphorite	N/A	380	320	20
DY094_023_G004	-30.8247	-35.9697	786	Dredge	Crust	10	Phosphorite	N/A	260	140	35
DY094_023_G005	-30.8247	-35.9697	786	Dredge	Crust	15	Phosphorite	N/A	180	150	35
DY094_023_G006	-30.8247	-35.9697	786	Dredge	Crust	9	Phosphorite	N/A	155	130	30
DY094_023_G007	-30.8247	-35.9697	786	Dredge	Rock	1	Phosphorite	N/A	140	120	20
DY094_023_G008	-30.8247	-35.9697	786	Dredge	Crust	7	Phosphorite	N/A	150	115	25
DY094_023_G009	-30.8247	-35.9697	786	Dredge	Crust	5	Phosphorite	N/A	100	75	15
DY094_023_G010	-30.8247	-35.9697	786	Dredge	Rock	1	Sedimentary	N/A	95	70	30
DY094_023_G011	-30.8247	-35.9697	786	Dredge	Crust	8	Phosphorite	N/A	120	85	20
DY094_023_G012	-30.8247	-35.9697	786	Dredge	Crust	8	Phosphorite	N/A	145	90	20
DY094_023_G013	-30.8247	-35.9697	786	Dredge	Crust	3	Phosphorite	N/A	95	90	10
DY094_023_G014	-30.8247	-35.9697	786	Dredge	Rock	1	Volcanic	N/A	55	55	30
DY094_023_G015	-30.8247	-35.9697	786	Dredge	Coral/bone	1	N/A	N/A	80	30	25
DY094_023_G016	-30.8247	-35.9697	786	Dredge	Crust	17	Phosphorite	N/A	100	50	20
DY094_023_G017	-30.8247	-35.9697	786	Dredge	Crust	6	Phosphorite	N/A	125	75	25
DY094_023_G018	-30.8247	-35.9697	786	Dredge	Crust	10	Phosphorite	N/A	90	55	75
DY094_023_G019	-30.8247	-35.9697	786	Dredge	Crust	8	Metamorphic	N/A	45	35	10
DY094_023_G020	-30.8247	-35.9697	786	Dredge	Rock	-1	Sedimentary	N/A	40	30	20
DY094_023_G021	-30.8247	-35.9697	786	Dredge	Rock	1	Sedimentary	N/A	50	25	10
DY094_023_G022	-30.8247	-35.9697	786	Dredge	Rock	1	Sedimentary	N/A	100	85	40
DY094_023_G023	-30.8247	-35.9697	786	Dredge	Rock	1	Phosphorite	N/A	35	35	25

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_023_G024	-30.8247	-35.9697	786	Dredge	Bone	1	N/A	N/A	50	25	7
DY094_023_G025	-30.8247	-35.9697	786	Dredge	Crust	10	Phosphorite	N/A	220	150	20
DY094_023_G026	-30.8247	-35.9697	786	Dredge	Crust	-1	Sedimentary	N/A	120	80	50
DY094_023_B047	-30.8247	-35.9697	786	Dredge	Biological	-1	Crust	Polyplacophora	-1	-1	-1
DY094_023_B048	-30.8247	-35.9697	786	Dredge	Biological	-1	Crust	Porifera	-1	-1	-1
DY094_023_B049	-30.8247	-35.9697	786	Dredge	Biological	-1	Crust	Anemone	-1	-1	-1
DY094_023_B050	-30.8247	-35.9697	786	Dredge	Biological	-1	Crust	Porifera	-1	-1	-1
DY094_023_B051	-30.8247	-35.9697	786	Dredge	Biological	-1	Crust	Serpulid	-1	-1	-1
DY094_023_B052	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	Porifera	-1	-1	-1
DY094_023_B053	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	Polychaete	-1	-1	-1
DY094_023_B054	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	Polychaete	-1	-1	-1
DY094_023_B055	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	Polychaeta	-1	-1	-1
DY094_023_B056	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	Coral	-1	-1	-1
DY094_023_B057	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	Sponge	-1	-1	-1
DY094_023_B058	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	Ophiuroidea	-1	-1	-1
DY094_023_B059	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	Crinoidea	-1	-1	-1
DY094_023_B060	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	Anemone	-1	-1	-1
DY094_023_B061	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	Ophiuroidea	-1	-1	-1
DY094_023_B062	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	Ophiuroidea	-1	-1	-1
DY094_023_B063	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	solitary coral	-1	-1	-1
DY094_023_B064	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	Nemertes	-1	-1	-1
DY094_023_B065	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	Polychaeta	-1	-1	-1
DY094_023_B066	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	Stalked barnacle	-1	-1	-1
DY094_023_B067	-30.8247	-35.9697	786	Dredge	Biological	-1	N/A	coronata	-1	-1	-1
DY094_023_MB1	-30.8158	-35.9673	786	Dredge	Molecular Biology	-1	N/A				
DY094_024_B068	-30.8145	-35.9755	0	Dredge	Biological	-1	N/A	Sea urchin	-1	-1	-1
DY094_024_B069	-30.8145	-35.9755	0	Dredge	Biological	-1	N/A	Sponge/anemone	-1	-1	-1
DY094_024_B070	-30.8145	-35.9755	0	Dredge	Biological	-1	N/A	Sea urchin	-1	-1	-1
DY094_024_B071	-30.8145	-35.9755	0	Dredge	Biological	-1	N/A	Coral	-1	-1	-1

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_024_B072	-30.8145	-35.9755	0	Dredge	Biological	-1	N/A	Starfish	-1	-1	-1
DY094_024_B073	-30.8145	-35.9755	0	Dredge	Biological	-1	N/A	Sea urchin	-1	-1	-1
DY094_024_B074	-30.8145	-35.9755	0	Dredge	Biological	-1	N/A	Sea urchin	-1	-1	-1
DY094_024_B075	-30.8145	-35.9755	0	Dredge	Biological	-1	N/A	Starfish	-1	-1	-1
DY094_024_B076	-30.8145	-35.9755	0	Dredge	Biological	-1	N/A	Polychaete	-1	-1	-1
DY094_024_B077	-30.8145	-35.9755	0	Hybis	Biological	-1	Crust	Ophiura	-1	-1	-1
DY094_027_G001	-30.8502	-36.0062	696	Hybis	Geological	-1	Crust	N/A	200	130	100
DY094_027_G002	-30.8502	-36.0062	696	Hybis	Geological	-1	Crust	N/A	520	150	130
DY094_027_B078	-30.8542	-35.9927	0	Hybis	Biological	-1	Crust	Coral	-1	-1	-1
DY094_027_B079	-30.8542	-35.9927	0	Hybis	Biological	-1	Crust	Serpulid	-1	-1	-1
DY094_027_B080	-30.8542	-35.9927	0	Hybis	Biological	-1	Crust	Polychaeta	-1	-1	-1
DY094_027_B081	-30.8542	-35.9927	0	Hybis	Biological	-1	Crust	Sponge	-1	-1	-1
DY094_027_B082	-30.8542	-35.9927	0	Hybis	Biological	-1	Crust	Sponge	-1	-1	-1
DY094_027_B083	-30.8542	-35.9927	0	Hybis	Biological	-1	Crust	Sponge	-1	-1	-1
DY094_027_B084	-30.8542	-35.9927	0	Hybis	Biological	-1	Crust	Polychaeta	-1	-1	-1
DY094_027_B085	-30.8542	-35.9927	0	Hybis	Biological	-1	Crust	Ophiura	-1	-1	-1
DY094_027_B086	-30.8542	-35.9927	0	Hybis	Biological	-1	Crust	Ophiura	-1	-1	-1
DY094_032_G001	-30.7380	-35.9537	1504	Hybis	Rock	1	Sedimentary	N/A	200	100	80
DY094_032_G002	-30.7380	-35.9537	1504	Hybis	Rock	2	Coral	N/A	100	70	60
DY094_032_G003	-30.7380	-35.9538	1432	Hybis	Rock	1	Sedimentary	N/A	100	60	50
DY094_032_G004	-30.7382	-35.9542	1425	Hybis	Rock	1	Sedimentary	N/A	230	130	110
DY094_032_G005	-30.7380	-35.9537	1504	Hybis	Rock	1	Sedimentary	N/A	-1	-1	-1
DY094_032_B087	-30.7380	-35.9538	1504	Hybis	Biological	1	Sedimentary		100	60	
DY094_032_B088	-30.7382	-35.9542	1425	Hybis	Biological	1	Sedimentary	hydrozoa tube	230	130	
DY094_032_B089	-30.7380	-35.9537	1504	Hybis	Biological	1	Sedimentary	baby coral?	200	100	
DY094_032_B090	-30.7380	-35.9537	1504	Hybis	Biological	1	Sedimentary	carnivorous sponge	-1	-1	
DY094_033_G001	-30.8250	-35.9637	856	Hybis	Crust	30	na	N/A	240	220	30
DY094_033_B091	-30.8250	-35.9637	856	Hybis	Biological	30	na	sponge	240	220	30
DY094_033_B092	-30.8250	-35.9637	856	Hybis	Biological	30	na	sponge	240	220	30
DY094_033_B093	-30.8250	-35.9637	856	Hybis	Biological	30	na	isopoda	240	220	30

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_033_B094	-30.8250	-35.9637	856	Hybis	Biological	30	na	polyplacophora	240	220	30
DY094_033_B095	-30.8250	-35.9637	856	Hybis	Biological	30	na	barnacle	240	220	30
DY094_033_B096	-30.8250	-35.9637	856	Hybis	Biological	30	na	serpulidae	240	220	30
DY094_034_G001	-30.8253	-35.9682	927	Dredge	Crust	10	Phosphorite	N/A	100	100	20
DY094_034_G002	-30.8253	-35.9682	927	Dredge	Crust	10	Phosphorite	N/A	130	110	20
DY094_034_G003	-30.8253	-35.9682	927	Dredge	Crust	30	na	N/A	100	100	30
DY094_034_G004	-30.8253	-35.9682	927	Dredge	Crust	3	Phosphorite	N/A	140	110	20
DY094_034_G005	-30.8253	-35.9682	927	Dredge	Crust	5	Phosphorite	N/A	180	130	20
DY094_034_G006	-30.8253	-35.9682	927	Dredge	Crust	10	Phosphorite	N/A	90	80	40
DY094_034_G007	-30.8253	-35.9682	927	Dredge	Crust	30	Phosphorite	N/A	130	90	30
DY094_034_G008	-30.8253	-35.9682	927	Dredge	Crust	10	Phosphorite	N/A	130	80	30
DY094_034_G009	-30.8253	-35.9682	927	Dredge	Crust	50	na	N/A	240	180	50
DY094_034_G010	-30.8253	-35.9682	927	Dredge	Crust	30	na	N/A	150	100	30
DY094_034_G011	-30.8253	-35.9682	927	Dredge	Crust	40	na	N/A	210	200	40
DY094_034_G012	-30.8253	-35.9682	927	Dredge	Crust	100	Phosphorite	N/A	150	530	100
DY094_034_G013	-30.8253	-35.9682	927	Dredge	Crust	120	Phosphorite	N/A	420	350	120
DY094_034_G014	-30.8253	-35.9682	927	Dredge	Crust	-1	N/A	N/A	80	40	30
DY094_034_G015	-30.8253	-35.9682	927	Dredge	Crust	-1	N/A	N/A	90	70	20
DY094_034_G016	-30.8253	-35.9682	927	Dredge	Crust	-1	N/A	N/A	30	30	20
DY094_034_G017	-30.8253	-35.9682	927	Dredge	Crust	-1	N/A	N/A	30	20	10
DY094_034_G018	-30.8253	-35.9682	927	Dredge	Rock	-1	Plutonic	N/A	40	30	10
DY094_034_G019	-30.8253	-35.9682	927	Dredge	Sediment	-1	N/A	N/A	-1	-1	-1
DY094_034_G020	-30.8253	-35.9682	927	Dredge	Crust	-1	Phosphorite	N/A	150	120	100
DY094_034_B097	-30.8253	-35.9682	927	Dredge	Biological	-1	rock	stalked barnacle	N/A	N/A	N/A
DY094_034_B098	-30.8253	-35.9682	927	Dredge	Biological	-1	rock	bamboo coral	N/A	N/A	N/A
DY094_034_B099	-30.8253	-35.9682	927	Dredge	Biological	-1	rock	S. oculata	N/A	N/A	N/A
DY094_034_B100	-30.8253	-35.9682	927	Dredge	Biological	-1	rock	Ascidian	N/A	N/A	N/A
DY094_034_B101	-30.8253	-35.9682	927	Dredge	Biological	-1	rock	Ophiuroidea	N/A	N/A	N/A
DY094_034_B102	-30.8253	-35.9682	927	Dredge	Biological	-1	rock	Sponge	N/A	N/A	N/A
DY094_034_B103	-30.8253	-35.9682	927	Dredge	Biological	-1	rock	Sponge	N/A	N/A	N/A

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_034_B104	-30.8253	-35.9682	927	Dredge	Biological	-1	rock	sponge	N/A	N/A	N/A
DY094_034_B105	-30.8253	-35.9682	927	Dredge	Biological	-1	rock	Cirripedia	N/A	N/A	N/A
DY094_034_B106	-30.8253	-35.9682	927	Dredge	Biological	-1	rock	Serpulidae	N/A	N/A	N/A
DY094_034_B107	-30.8253	-35.9682	927	Dredge	Biological	-1	rock	Crinoidea	N/A	N/A	N/A
DY094_034_B108	-30.8253	-35.9682	927	Dredge	Biological	-1	rock	Polychaeta	N/A	N/A	N/A
DY094_034_B109	-30.8253	-35.9682	927	Dredge	Biological	-1	rock	Polychaeta	N/A	N/A	N/A
DY094_034_B110	-30.8253	-35.9682	927	Dredge	Biological	-1	rock	Polychaeta	N/A	N/A	N/A
DY094_034_B111	-30.8253	-35.9682	927	Dredge	Biological	-1	rock	Hard Coral	N/A	N/A	N/A
DY094_034_MB1	-30.8253	-35.9682	927	Dredge	Molecular Biology	-1	N/A				
DY094_034_MB2	-30.8253	-35.9682	927	Dredge	Microscopy	-1	N/A				
DY094_035_G001	-30.8072	-35.9645	927	Dredge	Rock	-1	Volcanic	N/A	260	180	160
DY094_035_G002	-30.8072	-35.9645	927	Dredge	Rock	-1	Volcanic	N/A	210	90	80
DY094_035_G003	-30.8072	-35.9645	927	Dredge	Rock	-1	Volcanic	N/A	180	120	60
DY094_035_B112	-30.8072	-35.9645	927	Dredge	Biological	-1	Volcanic	Polychaeta			
DY094_035_MB1	-30.8072	-35.9645	927	Dredge	Microscopy	-1	N/A				
DY094_039_G001	-30.9687	-35.9120	881	Hybis	Rock	1	Volcanic	N/A	150	100	50
DY094_039_B113	-30.9687	-35.9120	881	Hybis	Biological	1	Volcanic	urchin	150	100	50
DY094_039_B114	-30.9687	-35.9120	881	Hybis	Biological	1	Volcanic	polychaete	150	100	50
DY094_039_B115	-30.9687	-35.9120	881	Hybis	Biological	1	Volcanic	Ophiuroidea	150	100	50
DY094_039_B116	-30.9687	-35.9120	881	Hybis	Biological	1	Volcanic	polychaete	150	100	50
DY094_039_B117	-30.9687	-35.9120	881	Hybis	Biological	1	Volcanic	anemone	150	100	50
DY094_039_B118	-30.9687	-35.9120	881	Hybis	Biological	1	Volcanic	anemone	150	100	50
DY094_039_MB1	-30.9687	-35.9120	881	Hybis	Microscopy	-1	N/A				
DY094_039_MB2	-30.9687	-35.9120	881	Hybis	Molecular Biology	-1	N/A				
DY094_039_MB3	-30.9687	-35.9120	881	Hybis	Microscopy						
DY094_040_G001	-30.9805	-35.9322	800	Hybis	Rock	1	Plutonic	N/A	400	240	140
DY094_040_B119	-30.8297	-35.9710	927	Dredge	Biological	10	Phosphorite	sponge	230	120	30
DY094_040_B120	-30.8297	-35.9710	927	Dredge	Biological	10	Phosphorite	sponge	230	120	30
DY094_040_B121	-30.8297	-35.9710	927	Dredge	Biological	11	Phosphorite	stalked barnacle	230	120	30

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_040_B122	-30.8297	-35.9710	927	Dredge	Biological	12	Phosphorite	barnacle	230	120	30
DY094_040_B123	-30.8297	-35.9710	927	Dredge	Biological	13	Phosphorite	serpulidae	230	120	30
DY094_040_B124	-30.8297	-35.9710	927	Dredge	Biological	14	Phosphorite	Ascidian	230	120	30
DY094_040_B125	-30.8297	-35.9710	927	Dredge	Biological	15	Phosphorite	sponge	230	120	30
DY094_041_G001	-30.8297	-35.9710	927	Dredge	Crust	10	Phosphorite	N/A	230	120	30
DY094_041_G002	-30.8297	-35.9710	927	Dredge	Crust	5	Phosphorite	N/A	170	110	10
DY094_041_G003	-30.8297	-35.9710	927	Dredge	Crust	20	Phosphorite	N/A	130	80	30
DY094_041_G004	-30.8297	-35.9710	927	Dredge	Bone	-1	N/A	N/A	90	70	70
DY094_041_G005	-30.8297	-35.9710	927	Dredge	Crust	30	Phosphorite	N/A	130	80	20
DY094_041_G006	-30.8297	-35.9710	927	Dredge	Rock	1	Sedimentary	N/A	110	80	40
DY094_041_G007	-30.8297	-35.9710	927	Dredge	Crust	10	Phosphorite	N/A	230	100	30
DY094_041_G008	-30.8297	-35.9710	927	Dredge	Crust	1	Phosphorite	N/A	80	50	30
DY094_041_G009	-30.8297	-35.9710	927	Dredge	Rock	-1	N/A	N/A	60	40	30
DY094_041_G010	-30.8297	-35.9710	927	Dredge	Rock	10	Phosphorite	N/A	30	20	20
DY094_041_G011	-30.8297	-35.9710	927	Dredge	Rock	1	Plutonic	N/A	150	120	60
DY094_041_G012	-30.8297	-35.9710	927	Dredge	Sediment	-1	N/A	N/A	-1	-1	-1
DY094_041_B126	-30.8297	-35.9710	927	Dredge	Rock	0	N/A	sponge	-1	-1	-1
DY094_041_B127	-30.8297	-35.9710	927	Dredge	Rock	1	N/A	Ophiuroidea	-1	-1	-1
DY094_041_B128	-30.8297	-35.9710	927	Dredge	Rock	2	N/A	Crinoidea	-1	-1	-1
DY094_041_MB1	-30.8297	-35.9710	927	Dredge	Molecular Biology	3	N/A		-1	-1	-1
DY094_041_MB2	-30.8297	-35.9710	927	Dredge	Microscopy	4	N/A		-1	-1	-1
DY094_045_G001	-31.0007	-36.2533	740	Hybis	Rock	1	Phosphorite	N/A	100	70	30
DY094_045_G002	-31.0050	-36.2452	758	Hybis	Rock	15	Phosphorite	N/A	200	110	30
DY094_045_G003	-31.0050	-36.2440	783	Hybis	Rock	20	Phosphorite	N/A	260	160	100
DY094_045_G004	-31.0050	-36.2440	783	Hybis	Rock	25	Phosphorite	N/A	300	160	110
DY094_045_G005	-31.0058	-36.2302	748	Hybis	Rock	20	Phosphorite	N/A	110	60	40
DY094_045_G006	-31.0058	-36.2302	748	Hybis	Rock	20	Phosphorite	N/A	150	70	30
DY094_045_G007	-31.0058	-36.2302	748	Hybis	Rock	-1	N/A	N/A	80	60	40
DY094_045_MB2	-31.0058	-36.2302	748	Hybis	Molecular Biology	N/A	rock	Molecular biology	N/A	N/A	N/A

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_045_MB1	-31.0058	-36.2302	748	Hybis	Molecular Biology	N/A	rock	Molecular biology	N/A	N/A	N/A
DY094_045_B129	-31.0058	-36.2302	748	Hybis	Biological	N/A	rock	black coral	N/A	N/A	N/A
DY094_045_B130	-31.0058	-36.2302	748	Hybis	Biological	N/A	rock	sponge	N/A	N/A	N/A
DY094_045_B131	-31.0050	-36.2452	748	Hybis	Biological	N/A	rock	barnacle	N/A	N/A	N/A
DY094_045_B132	-31.0050	-36.2452	748	Hybis	Biological	N/A	rock	yellow anemone	N/A	N/A	N/A
DY094_045_B133	-31.0050	-36.2452	748	Hybis	Biological	N/A	rock	small anemone	N/A	N/A	N/A
DY094_045_B134	-31.0050	-36.2452	748	Hybis	Biological	N/A	rock	anemone	N/A	N/A	N/A
DY094_045_B135	-31.0050	-36.2452	748	Hybis	Biological	N/A	rock	Polychaete	N/A	N/A	N/A
DY094_045_B136	-31.0050	-36.2452	748	Hybis	Biological	N/A	rock	sponge	N/A	N/A	N/A
DY094_045_B137	-31.0050	-36.2452	748	Hybis	Biological	N/A	rock	sponge	N/A	N/A	N/A
DY094_045_B138	-31.0007	-36.2533	748	Hybis	Biological	N/A	rock	barnacle	N/A	N/A	N/A
DY094_045_B139	-31.0050	-36.2440	748	Hybis	Biological	N/A	rock	barnacle	N/A	N/A	N/A
DY094_045_B140	-31.0050	-36.2440	748	Hybis	Biological	N/A	rock	sponge	N/A	N/A	N/A
DY094_045_B141	-31.0050	-36.2440	748	Hybis	Biological	N/A	rock	sponge	N/A	N/A	N/A
DY094_045_B142	-31.0050	-36.2440	748	Hybis	Biological	N/A	rock	Ascidian	N/A	N/A	N/A
DY094_045_B143	-31.0050	-36.2440	748	Hybis	Biological	N/A	rock	anemones	N/A	N/A	N/A
DY094_045_B144	-31.0050	-36.2440	748	Hybis	Biological	N/A	rock	sponge	N/A	N/A	N/A
DY094_046_G001	-30.8543	-36.0043	690	Dredge	Crust	30	Phosphorite	N/A	310	120	30
DY094_046_G002	-30.8543	-36.0043	690	Dredge	Crust	15	Phosphorite	N/A	220	170	50
DY094_046_G003	-30.8543	-36.0043	690	Dredge	Crust	20	Phosphorite	N/A	340	170	30
DY094_046_G004	-30.8543	-36.0043	690	Dredge	Crust	20	Phosphorite	N/A	200	160	20
DY094_046_G005	-30.8543	-36.0043	690	Dredge	Crust	50	Phosphorite	N/A	250	190	50
DY094_046_G006	-30.8543	-36.0043	690	Dredge	Crust	20	Phosphorite	N/A	200	170	20
DY094_046_G007	-30.8543	-36.0043	690	Dredge	Crust	40	Phosphorite	N/A	220	160	40
DY094_046_G008	-30.8543	-36.0043	690	Dredge	Crust	20	Phosphorite	N/A	130	120	20
DY094_046_G009	-30.8543	-36.0043	690	Dredge	Crust	25	Phosphorite	N/A	170	50	50
DY094_046_G010	-30.8543	-36.0043	690	Dredge	Crust	10	Phosphorite	N/A	230	140	50
DY094_046_G011	-30.8543	-36.0043	690	Dredge	Crust	50	Phosphorite	N/A	200	180	60
DY094_046_G012	-30.8543	-36.0043	690	Dredge	Crust	20	Phosphorite	N/A	300	250	50

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_046_G013	-30.8543	-36.0043	690	Dredge	N/A	-1	N/A	N/A	-1	-1	-1
DY094_046_G014	-30.8543	-36.0043	690	Dredge	Crust	40	Phosphorite	N/A	190	130	40
DY094_046_G015	-30.8543	-36.0043	690	Dredge	Crust	20	Phosphorite	N/A	140	100	30
DY094_046_G016	-30.8543	-36.0043	690	Dredge	Crust	1	Phosphorite	N/A	150	100	60
DY094_046_G017	-30.8543	-36.0043	690	Dredge	Crust	10	Phosphorite	N/A	130	90	50
DY094_046_G018	-30.8543	-36.0043	690	Dredge	N/A	-1	N/A	N/A	-1	-1	-1
DY094_046_G019	-30.8543	-36.0043	690	Dredge	Crust	20	Phosphorite	N/A	140	70	30
DY094_046_G020	-30.8543	-36.0043	690	Dredge	Crust	1	Phosphorite	N/A	140	120	40
DY094_046_G021	-30.8543	-36.0043	690	Dredge	Crust	10	Phosphorite	N/A	130	80	40
DY094_046_G022	-30.8543	-36.0043	690	Dredge	Crust	-1	N/A	N/A	90	90	30
DY094_046_G023	-30.8543	-36.0043	690	Dredge	Crust	-1	N/A	N/A	50	20	30
DY094_046_B145	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	Ophiuroidea	N/A	N/A	N/A
DY094_046_B146	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	shrimp	N/A	N/A	N/A
DY094_046_B147	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	serpulidae	N/A	N/A	N/A
DY094_046_B148	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	serpulidae	N/A	N/A	N/A
DY094_046_B149	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	serpulidae	N/A	N/A	N/A
DY094_046_B150	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	Polychaete	N/A	N/A	N/A
DY094_046_B151	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	Polychaete	N/A	N/A	N/A
DY094_046_B152	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	solitary coral	N/A	N/A	N/A
DY094_046_B153	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	anemone	N/A	N/A	N/A
DY094_046_B154	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	green sponge	N/A	N/A	N/A
DY094_046_B155	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	very yellow sponge	N/A	N/A	N/A
DY094_046_B156	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	porridge' sponge	N/A	N/A	N/A
DY094_046_B157	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	plain sponge	N/A	N/A	N/A
DY094_046_B158	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	glass sponge	N/A	N/A	N/A
DY094_046_B159	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	black sponge	N/A	N/A	N/A
DY094_046_B160	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	Ophiuroidea	N/A	N/A	N/A
DY094_046_B161	-30.8543	-36.0043	690	Dredge	Biological	N/A	N/A	urchin	N/A	N/A	N/A
DY094_046_MB1	-30.8543	-36.0043	690	Dredge	Molecular Biology	N/A	N/A	microbiology	N/A	N/A	N/A

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_046_MB2	-30.8543	-36.0043	690	Dredge	Molecular Biology	N/A	N/A	microbiology	N/A	N/A	N/A
DY094_046_MB1	-30.8543	-36.0043	690	Dredge	Molecular Biology	N/A	N/A	microbiology	N/A	N/A	N/A
DY094_046_MB1	-30.8543	-36.0043	690	Dredge	Molecular Biology	N/A	N/A	microbiology	N/A	N/A	N/A
DY094_047_G001	-30.8832	-35.9802	815	Dredge	Rock	<1	Volcanic	N/A	260	120	60
DY094_047_G002	-30.8832	-35.9802	815	Dredge	Rock	<1	Volcanic	N/A	280	140	70
DY094_047_G003	-30.8832	-35.9802	815	Dredge	Rock	<1	Volcanic	N/A	230	140	110
DY094_047_G004	-30.8832	-35.9802	815	Dredge	Rock	<1	Volcanic	N/A	210	160	60
DY094_047_G005	-30.8832	-35.9802	815	Dredge	Rock	<1	Volcanic	N/A	150	130	100
DY094_047_G006	-30.8832	-35.9802	815	Dredge	Rock	<1	Volcanic	N/A	220	180	20
DY094_047_G007	-30.8832	-35.9802	815	Dredge	Rock	<1	Volcanic	N/A	140	110	40
DY094_047_G008	-30.8832	-35.9802	815	Dredge	Rock	<1	Volcanic	N/A	110	80	80
DY094_047_G009	-30.8832	-35.9802	815	Dredge	Rock	<1	Volcanic	N/A	130	80	50
DY094_047_G010	-30.8832	-35.9802	815	Dredge	Rock	<1	Volcanic	N/A	120	100	50
DY094_047_G011	-30.8832	-35.9802	815	Dredge	Rock	<1	Volcanic	N/A	130	70	30
DY094_047_G012	-30.8832	-35.9802	815	Dredge	Rock	<1	Volcanic	N/A	140	90	70
DY094_047_G013	-30.8832	-35.9802	815	Dredge	Rock	<1	Volcanic	N/A	90	60	50
DY094_047_G014	-30.8832	-35.9802	815	Dredge	Rock	<1	Volcanic	N/A	90	70	50
DY094_047_G015	-30.8832	-35.9802	815	Dredge	Rock	1	Volcanic	N/A	170	20	70
DY094_047_B162	-30.8832	-35.9802	815	Dredge	Biological		rock	serpulidae	N/A	N/A	N/A
DY094_047_B163	-30.8832	-35.9802	815	Dredge	Biological		loose	sponge	N/A	N/A	N/A
DY094_047_B164	-30.8832	-35.9802	815	Dredge	Biological		loose	Gorgonian	N/A	N/A	N/A
DY094_047_B165	-30.8832	-35.9802	815	Dredge	Biological		loose	Gorgonian	N/A	N/A	N/A
DY094_047_B166	-30.8832	-35.9802	815	Dredge	Biological		loose	E. rostrata	N/A	N/A	N/A
DY094_047_B167	-30.8832	-35.9802	815	Dredge	Biological		166	Cirripedia	N/A	N/A	N/A
DY094_047_B168	-30.8832	-35.9802	815	Dredge	Biological		loose	psolidae	N/A	N/A	N/A
DY094_047_B169	-30.8832	-35.9802	815	Dredge	Biological		loose	Crinoidea	N/A	N/A	N/A
DY094_047_B170	-30.8832	-35.9802	815	Dredge	Biological		rock	sponge	N/A	N/A	N/A
DY094_047_B171	-30.8832	-35.9802	815	Dredge	Biological			Yellow gorgonian	N/A	N/A	N/A

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_047_B172	-30.8832	-35.9802	815	Dredge	Biological		dead sponge	Polychaeta	N/A	N/A	N/A
DY094_047_B173	-30.8832	-35.9802	815	Dredge	Biological		loose	White sponge	N/A	N/A	N/A
DY094_047_MB1	-30.8832	-35.9802	815	Dredge	Molecular Biology		Crust	microbiology	N/A	N/A	N/A
DY094_047_MB2	-30.8832	-35.9802	815	Dredge	Molecular Biology		Crust	microbiology	N/A	N/A	N/A
DY094_050_G001	-31.0055	-35.9670	863	Hybis	crust	15	Phosphorite	N/A	80	55	40
DY094_050_G002	-31.0055	-35.9670	863	Hybis	crust	7	Phosphorite	N/A	140	90	20
DY094_050_G003	-31.0055	-35.9670	863	Hybis	crust	5	Phosphorite	N/A	120	50	15
DY094_050_G004	-31.0023	-35.9668	852	Hybis	crust	8	Phosphorite	N/A	260	200	90
DY094_050_G005	-31.0003	-35.9670	841	Hybis	crust	15	Phosphorite	N/A	180	120	70
DY094_050_G006	-30.9990	-35.9672	832	Hybis	crust	10	Phosphorite	N/A	140	130	15
DY094_050_G007	-30.9943	-35.9675	804	Hybis	crust	6	Phosphorite	N/A	150	90	15
DY094_050_G008	-30.9942	-35.9672	794	Hybis	crust	8	Phosphorite	N/A	260	70	40
DY094_050_B174	-31.0055	-35.9670		Hybis	Biological		pavement	sponge	N/A	N/A	N/A
DY094_050_B175	-31.0055	-35.9670		Hybis	Biological		174	Crinoidea	N/A	N/A	N/A
DY094_050_B176	-31.0055	-35.9670		Hybis	Biological		174	Crinoidea	N/A	N/A	N/A
DY094_050_B177	-31.0055	-35.9670		Hybis	Biological		rock	coral	N/A	N/A	N/A
DY094_050_B178	-30.9942	-35.9672		Hybis	Biological		rock	polychaeta	N/A	N/A	N/A
DY094_050_B179	-30.9990	-35.9672		Hybis	Biological		rock	polychaeta	N/A	N/A	N/A
DY094_050_B180	-30.9943	-35.9675		Hybis	Biological		rock	Ophiuroidea	N/A	N/A	N/A
DY094_050_B181	-31.0055	-35.9670		Hybis	Biological		rock	isopoda	N/A	N/A	N/A
DY094_050_B182	-31.0055	-35.9670		Hybis	Biological		loose	polychaeta	N/A	N/A	N/A
DY094_050_B183	-30.9942	-35.9672		Hybis	Biological		rock	coral	N/A	N/A	N/A
DY094_050_B184	-31.0055	-35.9670		Hybis	Biological		loose	solitary coral	N/A	N/A	N/A
DY094_050_B185	-31.0023	-35.9668		Hybis	Biological		rock	solitary coral	N/A	N/A	N/A
DY094_050_B186	-31.0023	-35.9668		Hybis	Biological		rock	Ascidian	N/A	N/A	N/A
DY094_050_B187	-31.0023	-35.9668		Hybis	Biological		rock	Ascidian	N/A	N/A	N/A
DY094_050_B188	-31.0023	-35.9668		Hybis	Biological		rock	solitary coral	N/A	N/A	N/A
DY094_050_B189	-31.0023	-35.9668		Hybis	Biological		rock	solitary coral	N/A	N/A	N/A
DY094_050_B190	-31.0023	-35.9668		Hybis	Biological		rock	serpulidae	N/A	N/A	N/A

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_050_B191	-31.0023	-35.9668		Hybis	Biological		rock	small anemone	N/A	N/A	N/A
DY094_050_B192	-31.0023	-35.9668		Hybis	Biological		rock	sponge	N/A	N/A	N/A
DY094_050_B193	-31.0023	-35.9668		Hybis	Biological		rock	sponge	N/A	N/A	N/A
DY094_050_B194	-31.0023	-35.9668		Hybis	Biological		rock		N/A	N/A	N/A
DY094_050_B195	-31.0023	-35.9668		Hybis	Biological		rock	polychaete	N/A	N/A	N/A
DY094_050_B196	-31.0023	-35.9668		Hybis	Biological		rock	polychaete	N/A	N/A	N/A
DY094_050_B197	-31.0023	-35.9668		Hybis	Biological		rock	sponge	N/A	N/A	N/A
DY094_050_B198	-31.0023	-35.9668		Hybis	Biological		rock	polychaete	N/A	N/A	N/A
DY094_050_B199	-31.0023	-35.9668		Hybis	Biological		rock	sponge	N/A	N/A	N/A
DY094_050_B200	-31.0023	-35.9668		Hybis	Biological		rock	psolidae holothurian	N/A	N/A	N/A
DY094_050_B201	-31.0023	-35.9668		Hybis	Biological		rock	bivalve	N/A	N/A	N/A
DY094_050_B202	-31.0023	-35.9668		Hybis	Biological		rock	sponge	N/A	N/A	N/A
DY094_051_G001	-30.9888	-35.9768	744	Dredging	Rock	5	Phosphorite	N/A	160	120	100
DY094_051_G002	-30.9888	-35.9768	744	Dredging	Rock	5	Phosphorite	N/A	150	100	50
DY094_051_G003	-30.9888	-35.9768	744	Dredging	Rock	4	Phosphorite	N/A	120	90	20
DY094_051_G004	-30.9888	-35.9768	744	Dredging	Rock	7	Phosphorite	N/A	100	70	40
DY094_051_G005	-30.9888	-35.9768	744	Dredging	Coral	0	Phosphorite	N/A	-1	-1	-1
DY094_052_G001	-31.0148	-35.9425	921	Dredging	Crust	21	Phosphorite	N/A	220	110	70
DY094_052_G002	-31.0148	-35.9425	921	Dredging	Rock	21	Phosphorite	N/A	60	30	20
DY094_052_G003	-31.0148	-35.9425	921	Dredging	Rock	21	Phosphorite	N/A	80	50	30
DY094_052_B203	-31.0148	-35.9425	921	Dredging	Rock	N/A	rock	Ophiuroidea	N/A	N/A	N/A
DY094_052_B204	-31.0148	-35.9425	921	Dredging	Rock	N/A	rock	Ohiuroidea and starfish	N/A	N/A	N/A
DY094_052_MB1	-31.0148	-35.9425	921	Dredging	Rock	N/A	rock	Molecular biology	N/A	N/A	N/A
DY094_052_MB2	-31.0148	-35.9425	921	Dredging	Rock	N/A	rock	Molecular biology	N/A	N/A	N/A
DY094_053_G001	-31.0095	-35.9248	901	Dredging	Crust	18	Phosphorite	N/A	120	65	50
DY094_053_G002	-31.0095	-35.9248	901	Dredging	Nodule	14	Phosphorite	N/A	140	40	25
DY094_053_G003	-31.0095	-35.9248	901	Dredging	Crust	14	Phosphorite	N/A	120	60	25
DY094_053_G004	-31.0095	-35.9248	901	Dredging	Crust	18	Phosphorite	N/A	60	50	25
DY094_053_G005	-31.0095	-35.9248	901	Dredging	Crust	7	Phosphorite	N/A	90	40	30
DY094_053_G006	-31.0095	-35.9248	901	Dredging	Crust	0	Phosphorite	N/A	50	40	25

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_053_G007	-31.0095	-35.9248	901	Dredging	Crust	13	Phosphorite	N/A	40	30	20
DY094_053_G008	-31.0095	-35.9248	901	Dredging	mixed	13	Phosphorite	N/A	30	20	10
DY094_053_G009	-31.0095	-35.9248	901	Dredging	Coral	13	Phosphorite	N/A	50	10	10
DY094_053_G010	-31.0095	-35.9248	901	Dredging	Coral	13	Phosphorite	N/A	20	20	10
DY094_053_G011	-31.0095	-35.9248	901	Dredging	Crust	35	Phosphorite	N/A	90	60	20
DY094_053_G012	-31.0095	-35.9248	901	Dredging	Rock	0	Phosphorite	N/A	50	30	20
DY094_053_G013	-31.0095	-35.9248	901	Dredging	Rock+Fossil	0	Phosphorite	N/A	40	30	20
DY094_053_G014	-31.0095	-35.9248	901	Dredging	Rock	0	Phosphorite	N/A	60	50	10
DY094_053_G015	-31.0095	-35.9248	901	Dredging	Rock	0	Sedimentary	N/A	30	20	10
DY094_053_G016	-31.0095	-35.9248	901	Dredging	Fossils	0	Fossils	N/A	-1	-1	-1
DY094_053_G017	-31.0095	-35.9248	901	Dredging	Rock	0	Igneous	N/A	40	20	10
DY094_053_B205	-31.0095	-35.9248	901	Dredging	Biological	N/A	rock	Ophiuroidea	N/A	N/A	N/A
DY094_053_B206	-31.0095	-35.9248	901	Dredging	Biological	N/A	rock	Polychaeta	N/A	N/A	N/A
DY094_053_MB1	-31.0095	-35.9248	901	Dredging	Molecular Biology	N/A	rock	Molecular biology	N/A	N/A	N/A
DY094_053_MB2	-31.0095	-35.9248	901	Dredging	Molecular Biology	N/A	rock	Molecular biology	N/A	N/A	N/A
DY094_055_G001	-30.7625	-35.9835	740	Hybis	Rock	1	Igneous	N/A	130	110	30
DY094_055_G002	-30.7662	-35.9885	721	Hybis	Rock	1	Igneous	N/A	170	80	70
DY094_055_G003	-30.7662	-35.9885	721	Hybis	Rock	0	Igneous	N/A	80	70	50
DY094_055_G004	-30.7682	-35.9827	755	Hybis	Rock	0	Igneous	N/A	19	10	50
DY094_055_G005	-30.7682	-35.9827	755	Hybis	Rock	0	Sedimentary	N/A	40	30	25
DY094_055_G006	-30.7682	-35.9827	755	Hybis	Rock	1	Igneous	N/A	115	90	50
DY094_055_G007	-30.7682	-35.9827	755	Hybis	Rock	0	Sedimentary	N/A	30	20	15
DY094_055_B207	-30.7682	-35.9827	755	Hybis	Biological	N/A	N/A	urchin	N/A	N/A	N/A
DY094_055_B208	-30.7682	-35.9827	755	Hybis	Biological	N/A	N/A	black coral	N/A	N/A	N/A
DY094_055_B209	-30.7682	-35.9827	755	Hybis	Biological	N/A	N/A	scale polychaeta	N/A	N/A	N/A
DY094_055_B210	-30.7682	-35.9827	755	Hybis	Biological	N/A	N/A	scale polychaeta	N/A	N/A	N/A
DY094_055_B211	-30.7682	-35.9827	755	Hybis	Biological	N/A	N/A	scale polychaeta	N/A	N/A	N/A
DY094_055_B212	-30.7682	-35.9827	755	Hybis	Biological	N/A	N/A	Polychaeta	N/A	N/A	N/A
DY094_055_B213	-30.7682	-35.9827	755	Hybis	Biological	N/A	N/A	solitary coral	N/A	N/A	N/A

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_056_G001	-30.8377	-36.0155	671	Dredging	Crust	30	Phosphorite	N/A	350	20	70
DY094_056_G002	-30.8377	-36.0155	671	Dredging	Rock	0	Sedimentary	N/A	230	220	100
DY094_056_G003	-30.8377	-36.0155	671	Dredging	Crust	10	Phosphorite	N/A	100	90	10
DY094_056_G004	-30.8377	-36.0155	671	Dredging	Crust	5	Phosphorite	N/A	120	100	30
DY094_056_G005	-30.8377	-36.0155	671	Dredging	Crust	20	na	N/A	110	90	20
DY094_056_G006	-30.8377	-36.0155	671	Dredging	Crust	3	Phosphorite	N/A	150	90	10
DY094_056_G007	-30.8377	-36.0155	671	Dredging	Crust	20	na	N/A	170	100	20
DY094_056_G008	-30.8377	-36.0155	671	Dredging	Crust	40	Phosphorite	N/A	160	100	40
DY094_056_G009	-30.8377	-36.0155	671	Dredging	Crust	20	na	N/A	120	100	30
DY094_056_G010	-30.8377	-36.0155	671	Dredging	Crust	30	na	N/A	90	60	30
DY094_056_G011	-30.8377	-36.0155	671	Dredging	Rock	1	Metamorphic	N/A	60	60	20
DY094_056_G012	-30.8377	-36.0155	671	Dredging	Crust	-1	N/A	N/A	90	70	10
DY094_056_G013	-30.8377	-36.0155	671	Dredging	Crust	10	Phosphorite	N/A	70	60	20
DY094_056_G014	-30.8377	-36.0155	671	Dredging	Crust	-1	N/A	N/A	60	30	20
DY094_056_G015	-30.8377	-36.0155	671	Dredging	Crust	-1	N/A	N/A	20	20	10
DY094_056_G016	-30.8377	-36.0155	671	Dredging	Crust	-1	N/A	N/A	40	40	20
DY094_056_G017	-30.8377	-36.0155	671	Dredging	Rock	-1	N/A	N/A	20	10	10
DY094_056_G018	-30.8377	-36.0155	671	Dredging	Crust	1	Phosphorite	N/A	100	80	60
DY094_056_G019	-30.8377	-36.0155	671	Dredging	Crust	40	Phosphorite	N/A	100	100	40
DY094_056_B214	-30.8377	-36.0155	671	Dredging	Biological	N/A	loose	black coral	N/A	N/A	N/A
DY094_056_B215	-30.8377	-36.0155	671	Dredging	Biological	N/A	rock	sponge	N/A	N/A	N/A
DY094_056_B216	-30.8377	-36.0155	671	Dredging	Biological	N/A	rock	sponge	N/A	N/A	N/A
DY094_056_B217	-30.8377	-36.0155	671	Dredging	Biological	N/A	rock	serpulidae	N/A	N/A	N/A
DY094_056_B218	-30.8377	-36.0155	671	Dredging	Biological	N/A	rock	Amphipoda	N/A	N/A	N/A
DY094_056_B219	-30.8377	-36.0155	671	Dredging	Biological	N/A	rock	Fluffy sponge	N/A	N/A	N/A
DY094_056_B220	-30.8377	-36.0155	671	Dredging	Biological	N/A	rock	Polychaeta	N/A	N/A	N/A
DY094_056_B221	-30.8377	-36.0155	671	Dredging	Biological	N/A	rock	Anemone	N/A	N/A	N/A
DY094_056_B222	-30.8377	-36.0155	671	Dredging	Biological	N/A	rock	Cirripedia	N/A	N/A	N/A
DY094_056_B223	-30.8377	-36.0155	671	Dredging	Biological	N/A	rock	Anemone	N/A	N/A	N/A
DY094_056_B224	-30.8377	-36.0155	671	Dredging	Biological	N/A	rock	Anemone	N/A	N/A	N/A

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_056_B225	-30.8377	-36.0155	671	Dredging	Biological	N/A	rock	Serpulidae	N/A	N/A	N/A
DY094_056_B226	-30.8377	-36.0155	671	Dredging	Biological	N/A	rock	Polychaeta	N/A	N/A	N/A
DY094_056_B227	-30.8377	-36.0155	671	Dredging	Biological	N/A	rock	Small scleratinian	N/A	N/A	N/A
DY094_057_G001	-30.8675	-36.0208	659	Dredging	crust	25	Phosphorite	N/A	70	50	30
DY094_061_G001	-30.6852	-35.7508	710	Hybis	Crust	-1	N/A	N/A	70	30	10
DY094_061_G002	-30.6888	-35.7503	715	Hybis	Rock	-1	Volcanic	N/A	130	60	50
DY094_061_G003	-30.6888	-35.7503	0	N/A	N/A	-1	N/A	N/A	-1	-1	-1
DY094_061_G004	-30.6890	-35.7478	711	Hybis	Crust	10	Phosphorite	N/A	120	80	20
DY094_061_G005	-30.6890	-35.7478	711	Hybis	Rock	5	Volcanic	N/A	170	110	20
DY094_061_G006	-30.6890	-35.7478	711	Hybis	Rock	na	N/A	N/A	140	120	70
DY094_061_G007	-30.6890	-35.7478	711	Hybis	Crust	20	Phosphorite	N/A	140	100	20
DY094_061_G008	-30.6945	-35.7515	709	Hybis	Rock	na	N/A	N/A	220	200	120
DY094_061_G009	-30.7015	-35.7362	698	Hybis	Crust	50	Volcanic	N/A	260	210	90
DY094_061_G010	-30.7015	-35.7362	698	Hybis	Rock	-1	Volcanic	N/A	140	70	20
DY094_061_G011	-30.6997	-35.7345	696	Hybis	Crust	10	Phosphorite	N/A	250	180	30
DY094_061_B228	-30.6890	-35.7478	711	Hybis	Biological		rock	Sponge	N/A	N/A	N/A
DY094_061_B229	-30.6888	-35.7503	715	Hybis	Biological		rock	Sponge	N/A	N/A	N/A
DY094_061_B230	-30.6888	-35.7503	715	Hybis	Biological		rock	Polychaeta	N/A	N/A	N/A
DY094_061_B231	-30.6888	-35.7503	715	Hybis	Biological		rock	Hydrozoa + Coronata	N/A	N/A	N/A
DY094_061_B232	-30.6890	-35.7478	715	Hybis	Biological		rock	Serpulidae	N/A	N/A	N/A
DY094_061_B233	-30.6890	-35.7478	711	Hybis	Biological		rock	Sponge	N/A	N/A	N/A
DY094_061_B234	-30.6945	-35.7515	709	Hybis	Biological		rock	coronatae	N/A	N/A	N/A
DY094_061_B235	-30.6945	-35.7515	709	Hybis	Biological		rock	Sponge	N/A	N/A	N/A
DY094_061_B236	-30.6945	-35.7515	709	Hybis	Biological		rock	solitary coral	N/A	N/A	N/A
DY094_061_B237	-30.6945	-35.7515	709	Hybis	Biological		rock	Polychaeta	N/A	N/A	N/A
DY094_061_B238	-30.6945	-35.7515	709	Hybis	Biological		rock	Anemone	N/A	N/A	N/A
DY094_061_B239	-30.7015	-35.7362	698	Hybis	Biological		rock	bivalve	N/A	N/A	N/A
DY094_061_B240	-30.7015	-35.7362	698	Hybis	Biological		rock	Orange sponge	N/A	N/A	N/A
DY094_061_B241	-30.7015	-35.7362	698	Hybis	Biological		rock	Sponge	N/A	N/A	N/A
DY094_061_B242	-30.7015	-35.7362	698	Hybis	Biological		rock	Sponge	N/A	N/A	N/A

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_061_B243	-30.7015	-35.7362	698	Hybis	Biological		rock	serpulidae	N/A	N/A	N/A
DY094_061_B244	-30.7015	-35.7362	698	Hybis	Biological		rock	solitary coral	N/A	N/A	N/A
DY094_061_B245	-30.7015	-35.7362	698	Hybis	Biological		rock	Polychaeta	N/A	N/A	N/A
DY094_061_B246	-30.7015	-35.7362	698	Hybis	Biological		rock	Sponge	N/A	N/A	N/A
DY094_062_G001	-30.6982	-35.7415	661	Dredge	Shells	-1	N/A	N/A	-1	-1	-1
DY094_062_G002	-30.6982	-35.7415	661	Dredge	Rock	na	N/A	N/A	20	10	10
DY094_062_G003	-30.6982	-35.7415	661	Dredge	Rock	na	N/A	N/A	80	70	50
DY094_062_G004	-30.6982	-35.7415	661	Dredge	Crust	1	N/A	N/A	10	10	5
DY094_062_G005	-30.6982	-35.7415	661	Dredge	Rock	-1	N/A	N/A	10	10	10
DY095_062_B247	-30.6982	-35.7415	661	Dredge	Biological		loose	black coral	N/A	N/A	N/A
DY094_063_G001	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	40	30	10
DY094_063_G002	-30.7043	-35.7035	663	Dredge	Rock	5	Volcanic	N/A	70	30	20
DY094_063_G003	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	60	40	20
DY094_063_G004	-30.7043	-35.7035	663	Dredge	Rock	-1	Sedimentary	N/A	130	110	60
DY094_063_G005	-30.7043	-35.7035	663	Dredge	Rock	-1	Sedimentary	N/A	190	180	150
DY094_063_G006	-30.7043	-35.7035	663	Dredge	Rock	-1	Igneous	N/A	150	70	75
DY094_063_G007	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	120	115	30
DY094_063_G008	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	140	80	55
DY094_063_G009	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	115	70	40
DY094_063_G010	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	115	75	30
DY094_063_G011	-30.7043	-35.7035	663	Dredge	Rock	10	Volcanic	N/A	125	10	40
DY094_063_G012	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	90	70	30
DY094_063_G013	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	120	60	40
DY094_063_G014	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	120	80	30
DY094_063_G015	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	140	80	30
DY094_063_G016	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	130	85	30
DY094_063_G017	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	90	90	25
DY094_063_G018	-30.7043	-35.7035	663	Dredge	Rock	5	Phosphorite	N/A	120	90	40
DY094_063_G019	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	90	50	25
DY094_063_G020	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	80	50	30

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_063_G021	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	110	110	40
DY094_063_G022	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	180	90	55
DY094_063_G023	-30.7043	-35.7035	663	Dredge	Rock	-1	Sedimentary	N/A	30	25	10
DY094_063_G024	-30.7043	-35.7035	663	Dredge	Rock	1	Volcanic	N/A	30	25	20
DY094_063_G025	-30.7043	-35.7035	663	Dredge	Rock	1	Volcanic	N/A	110	80	25
DY094_063_G026	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	80	75	20
DY094_063_G027	-30.7043	-35.7035	663	Dredge	Crust	15	Phosphorite	N/A	65	50	10
DY094_063_G028	-30.7043	-35.7035	663	Dredge	Crust	20	Phosphorite	N/A	40	35	15
DY094_063_G029	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	35	30	10
DY094_063_G030	-30.7043	-35.7035	663	Dredge	Crust	8	N/A	N/A	55	35	10
DY094_063_G031	-30.7043	-35.7035	663	Dredge	Shells	-1	N/A	N/A	-1	-1	-1
DY094_063_G032	-30.7043	-35.7035	663	Dredge	Sediment	-1	N/A	N/A	-1	-1	-1
DY094_063_G033	-30.7043	-35.7035	663	Dredge	Rock	-1	Volcanic	N/A	100	80	30
DY094_063_G034	-30.7043	-35.7035	663	Dredge	Rock	-1	Sedimentary	N/A	140	50	30
DY094_063_G035	-30.7043	-35.7035	663	Dredge	Crust	20	Volcanic	N/A	110	50	20
DY094_063_G036	-30.7043	-35.7035	663	Dredge	Rock	-1	Sedimentary	N/A	210	190	90
DY094_063_G037	-30.7043	-35.7035	663	Dredge	Rock	5	Volcanic	N/A	60	50	30
DY094_063_G038	-30.7043	-35.7035	663	Dredge	Rock	-1	N/A	N/A	50	40	30
DY094_063_B248	-30.7043	-35.7035	663	Dredge	Biological	N/A	rock	porridge' sponge	N/A	N/A	N/A
DY094_063_B249	-30.7043	-35.7035	663	Dredge	Biological	N/A	rock	glass sponge	N/A	N/A	N/A
DY094_063_B250	-30.7043	-35.7035	663	Dredge	Biological	N/A	rock	serpulidae	N/A	N/A	N/A
DY094_063_B251	-30.7043	-35.7035	663	Dredge	Biological	N/A	loose	black coral	N/A	N/A	N/A
DY094_063_B252	-30.7043	-35.7035	663	Dredge	Biological	N/A	rock	sponge	N/A	N/A	N/A
DY094_063_B253	-30.7043	-35.7035	663	Dredge	Biological	N/A	rock	small anemone	N/A	N/A	N/A
DY094_063_B254	-30.7043	-35.7035	663	Dredge	Biological	N/A	rock	starfish	N/A	N/A	N/A
DY094_063_B255	-30.7043	-35.7035	663	Dredge	Biological	N/A	rock	Polychaeta	N/A	N/A	N/A
DY094_063_B256	-30.7043	-35.7035	663	Dredge	Biological	N/A	rock	Coronata polyp	N/A	N/A	N/A
DY094_063_B257	-30.7043	-35.7035	663	Dredge	Biological	N/A	rock	Polychaeta	N/A	N/A	N/A
DY094_067_G001	-30.7170	-35.7080	666	Hybis	Rock	-1	N/A	N/A	50	40	25
DY094_067_G002	-30.7170	-35.7080	672	Hybis	Rock	-1	N/A	N/A	70	55	25

Sample_ID	LAT	LON	Depth	Operation	Sample Type	FeMn Thickness	Substrate	Taxa	Length Max	Width Max	Thickness Max
DY094_067_G003	-30.7170	-35.7080	672	Hybis	Rock	-1	N/A	N/A	110	70	40
DY094_067_G004	-30.7055	-35.7092	684	Hybis	Rock	-1	N/A	N/A	20	16	80
DY094_067_G005	-30.7055	-35.7092	684	Hybis	Rock	-1	N/A	N/A	110	90	25
DY094_067_G006	-30.7022	-35.7123	501	Hybis	Rock	-1	N/A	N/A	160	95	30
DY094_067_B258	-30.7170	-35.7080		Hybis	Biological	N/A	rock	octocoral	N/A	N/A	N/A
DY094_067_B259	-30.7170	-35.7080		Hybis	Biological	N/A	rock	yellow sponge	N/A	N/A	N/A
DY094_067_B260	-30.7055	-35.7092		Hybis	Biological	N/A	rock	white sponge	N/A	N/A	N/A
DY094_067_B261	-30.7055	-35.7092		Hybis	Biological	N/A	rock	barnacles	N/A	N/A	N/A
DY094_067_B262	-30.7055	-35.7092		Hybis	Biological	N/A	rock	coronatae	N/A	N/A	N/A
DY094_067_B263	-30.7022	-35.7123		Hybis	Biological	N/A	rock	Polychaeta	N/A	N/A	N/A
DY094_067_B264	-30.7022	-35.7123		Hybis	Biological	N/A	rock	coronatae	N/A	N/A	N/A
DY094_067_B265	-30.7022	-35.7123		Hybis	Biological	N/A	rock	small anemone	N/A	N/A	N/A
DY094_067_B266	-30.7022	-35.7123		Hybis	Biological	N/A	rock	solitary coral	N/A	N/A	N/A
DY094_067_B267	-30.7022	-35.7123		Hybis	Biological	N/A	rock	bivalve	N/A	N/A	N/A
DY094_067_B268	-30.7022	-35.7123		Hybis	Biological	N/A	rock	serpulid	N/A	N/A	N/A
DY094_067_B269	-30.7055	-35.7092		Hybis	Biological	N/A	rock	serpulid	N/A	N/A	N/A