Marine Biodiversity Hub

National Environmental Science Programme

Arafura Marine Park Post Survey Report

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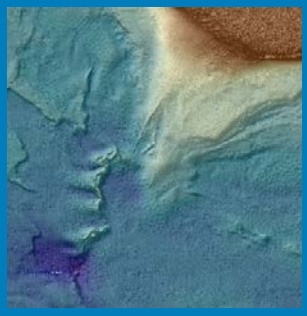
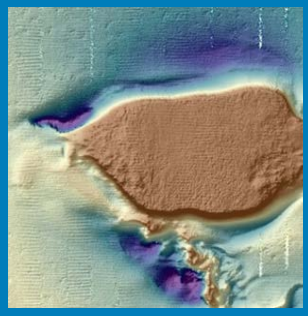
D3 – Implementing monitoring of Australian Marine Parks and the status of marine biodiversity on the continental shelf

March 2021

Milestone 22 – Research Plan v6 (2020)



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Preferred Citation

K. Picard, M. Stowar, N. Roberts, J. Siwabessy, M.A. Abdul Wahab, R. Galaiduk, K. Miller, S. Nichol *(2021). Arafura Marine Park – Post survey Report.* Report to the National Environmental Science Program, Marine Biodiversity Hub. Australian Institute of Marine Science and Geoscience Australia.

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Acknowledgement

This work was undertaken for the Marine Biodiversity Hub, a collaborative partnership supported through funding from the Australian Government's National Environmental Science Program (NESP). NESP Marine Biodiversity Hub partners include the University of Tasmania; CSIRO, Geoscience Australia, Australian Institute of Marine Science, Museums Victoria, Charles Darwin University, the University of Western Australia, Integrated Marine Observing System, NSW Office of Environment and Heritage, NSW Department of Primary Industries.

We acknowledge the Traditional Owners of the sea country on which the research took place, and pay our respects to Elders past, present and future. We honour their continuing culture, knowledge, beliefs and spiritual relationship and connection to country. We also recognise Aboriginal and Torres Strait Islander peoples as the Traditional Owners of the land and sea, and as Australia's first scientists. The Yuwurrumu members of the Mandilarri-Ildugij, the Mangalara, the Murran, the Gadura-Minaga and the Ngaynjaharr clans have responsibilities for sea country in Arafura Marine Park, which they have been sustainably using and managing for tens of thousands of years.

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EXECUTIVE SUMMARY

The Arafura Marine Park survey (SOL 7491 / GA 0366) was undertaken over the period 2 – 15 November 2020 on board RV *Solander*, as a collaboration between the Australian Institute of Marine Science (AIMS) and Geoscience Australia (GA). The survey was a contribution to the Marine Biodiversity Hub Project D3, '*Implementing monitoring of Australian Marine Parks and the status of marine biodiversity assets on the continental shelf*'; that aims to build baseline knowledge for marine parks in priority areas of the national network.

Arafura Marine Park is one of eight parks in the North Network of Australian Marine Parks, extending across the continental shelf northeast of Darwin covering an area of 22,924 km^2 within the Arafura Sea. The marine park was identified as a priority by Parks Australia for acquisition of new information on seabed habitats within the park, with a focus on reefs and adjacent soft sediment environments. Previous reconnaissance surveys within the Arafura Sea region had identified reef habitats at Money Shoal on the mid shelf (3 – 70 m water depth) and at Pillar Bank on the outer shelf (>120 m water depth).

The purpose of this survey was to apply standardised methods of data collection to build the baseline inventory of reef habitats at these locations that can be used to support ongoing monitoring of the Arafura Marine Park. In addition, the survey was designed to provide data to better understand the relationship between environmental gradients (water depth, substrate type) and benthic and demersal fish communities associated with the reefs across the marine park. The survey acquired high resolution multibeam bathymetry and backscatter data, seabed (sediment) samples and video observations from towed video and baited remote underwater video (BRUV) across two sampling areas; Money Shoal and Pillar Bank.

At Money Shoal, seabed mapping covered an area of 192 km^2, incorporating the outer margins of the reef shoal and surrounding sediment plain. Shallow water across the top of the shoal prevented safe vessel access for mapping and sampling. Seabed samples were collected at 29 sites across the mapped area, with sediment ranging from coarse carbonate sands on the reef margin and immediate surrounds, to mud (silt) on the deeper plain. Towed video was collected along 33 transects and Stereo-BRUVs were deployed at 57 sites. Preliminary observations from videos show the marine communities of Money Shoal are typical of shallow and mesophotic reef systems of the north and north-west of Australia. Money Shoal supports a diverse and abundant assemblage of coral and coral reef-associated organisms.

The shallow reef edge is dominated by medium to dense hard coral cover, although coral abundance declines with depth, with the intermediate shoal depths having a succession of habitats dominated by different animal and plant groups before the seabed levels out to a relatively homogeneous muddy substrate surrounding the shoal in ~60 m water depth.

At Pillar Bank, seabed mapping covered an area of 160 km^2 across the bank and adjacent areas of plains, troughs, depressions and smaller banks and ridges. Seabed samples were collected at 14 sites, with samples dominantly mud, with localised deposits of carbonate sand and gravel on ridges and banks. Towed video was collected along 21 transects and Stereo-BRUVs were deployed at 39 sites. Biological communities at the deeper Pillar Bank were depauperate compared with Money Shoal. Benthic invertebrates were sparse

throughout the study area, with deep soft sediment and more complex hard habitats often appearing barren. Species observed included filter feeders (hydroids, gorgonians, sponges) as well as occasional mobile invertebrates such as echinoderms. Fish diversity was also low, with community composition varying predictably with substrate types; patterns typically seen in the deeper waters in northern Australia.

In summary, the survey has shown that Money Shoal supports a diverse coral reef and demersal fish community as evidence for the conservation values of Arafura Marine Park, and which suggest it is unique within its regional setting. Pillar Bank, in contrast, is clearly a different habitat, but is an extensive area within the park that does support benthic communities on hard substrate, albeit sparse in their distribution. Further analysis will be undertaken to quantify the abundance and diversity of these biological communities and to better understand the influence of environmental gradients across the marine park. This analysis of benthic imagery will also provide insights into any recent disturbance events to the shallow water communities of Money Shoal, such as from coral bleaching, coral disease or storm damage. Habitat modelling will also be undertaken to extend the observations from sampling sites across the spatial extent of the high resolution seabed mapping for both Money Shoal and Pillar Bank as part of the next phase of this project.

1. INTRODUCTION

1.1 Background and Rationale for Survey

Survey SOL7491 / GA 0366 was designed to collect data to build upon existing information for benthic habitats of the Arafura Marine Park, within the North Network of the Australian Marine Parks (Figure 1). Beyond a general and high-level understanding of the biodiversity and environmental processes of the region, our knowledge base to inform the ongoing management of marine parks in the Northern Network is limited. This was demonstrated in the 'gap analysis' of available data for the North and Northwest Marine Regions undertaken in Project D1 that identified most marine parks in the Northern Network were data deficient (Miller et al., 2017). Key data gaps are in bathymetry coverage, benthic reef and soft sediment biological assemblages, and data to describe spatial variations in those communities.

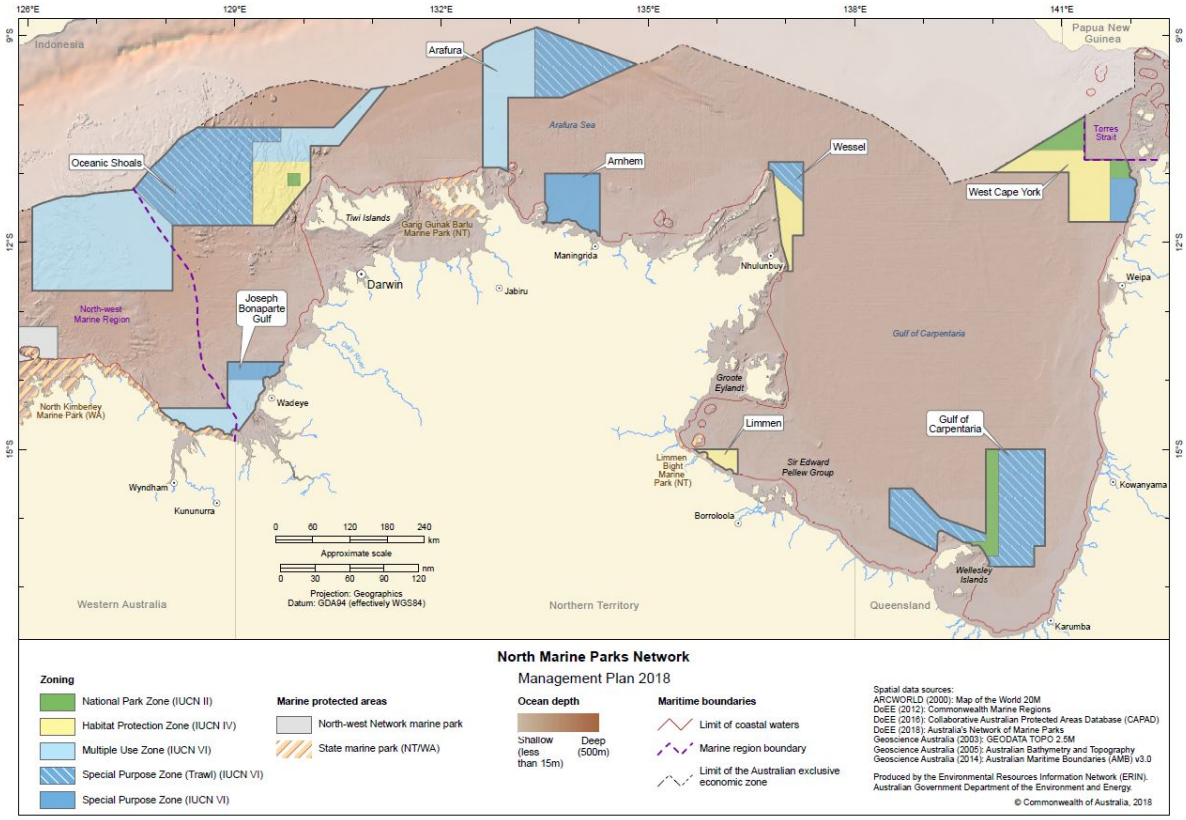


Figure 1: Northern Network of Australian Marine Parks, showing the location of Arafura Marine Park within the Arafura Sea.

Existing multibeam sonar bathymetry mapping and video observations for the Arafura Sea region has documented the existence of reef habitat associated with a 'pinnacle' reef (Money Shoal) in the southern part of the park (Edgar et al., 2017), and a large ridge (Pillar Bank) within a submarine canyon in the north of the park (Logan et al., 2006; Wilson, 2005). These reefs and canyons are recognised as Key Ecological Features (KEFs) but they remain to be fully described and quantified from a biodiversity, habitat and ecological perspective.

Additionally, there are opportunities to build our understanding of the geomorphic character of seabed habitats in the park by extending the mapping of reefs and soft sediment areas. As such, the data collected during this survey will contribute to the design of an ongoing monitoring program within the North Marine Park network as part of the current 10-year management plan (Director of National Parks, 2018).

1.2 Australian Marine Park Context

Arafura Marine Park is one of eight parks within the North Network of Australian Marine Parks. Located 250 km to the northeast of Darwin, the park extends to the limit of Australia's exclusive economic zone, covering an area of 22,924 km^2. Water depths range from 3 m at Money Shoal in the south of the Park, to over 500 m on the continental slope at the northern limit of the park. Seabed geomorphic features include broad soft sediment plains across the shelf, isolated pinnacle reefs (e.g. Money Shoal), and a network of submarine canyons (Arafura canyons) and ridges that connect the continental shelf to the deeper waters of the Arafura Sea. The canyons are characterised by a range of seabed substrates (mud, sand and rock), with localised upwelling and strong tidal currents toward the canyon heads driving increased biological productivity (Director of National Parks, 2018). Benthic biological communities within the marine park include sponges, hard and soft corals associated with Money Shoal and hard substrates within canyons, but information on these communities is limited (Edgar et al., 2017). Pelagic species observed within the region include whale sharks, sawfish and turtles.

Arafura Marine Park is designated IUCN category VI, with three management zones, including: Multiple Use Zone (VI), a Special Purpose Zone (VI), and a Special Purpose Zone (Trawl) (VI). The mapping and sampling areas for this survey are located within the Multiple Use Zone (Money Shoal) and Special Purpose Zone (Trawl) (Pillar Bank) (Figure 2).

1.3 Traditional Owners

The Arafura Sea region is valued culturally as Sea Country for a number of Indigenous groups who have native title determined over the region that incorporates Arafura Marine Park. The Northern Land Council (NLC) is the Native Title Representative Body for the northern region and is the point of contact for indigenous interests in the marine park. In particular, the Yuwurrumu members of the Mandilarri-Ildugij, the Mangalara, the Murran, the Gadura-Minaga and the Ngaynjaharr clans have responsibilities for sea country in the marine park, which they have been sustainably using and managing for tens of thousands of years. Following consultation, the NLC approved this survey through the issue of a permit to allow the research to proceed in their Sea Country (see Appendix D).

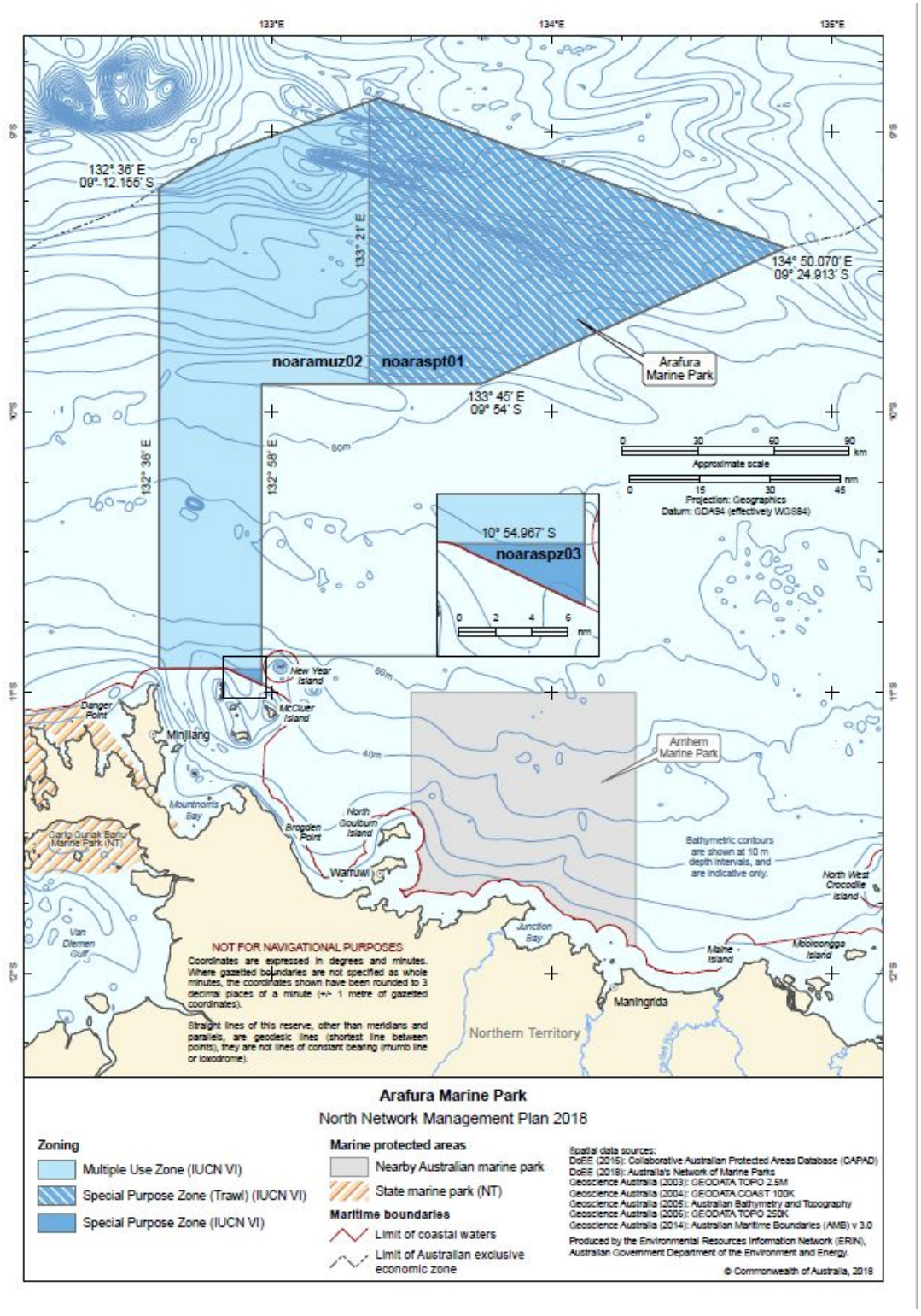


Figure 2: Arafura Marine Park showing IUCN zones as defined in the management plan for the North Network

1.4 Aims and Objectives

The overall aim of the survey is to build baseline information for key benthic habitats within Arafura Marine Park. Information from the survey will support the management and monitoring of the park and inform future assessments of the effectiveness of the management plan for the North Network. In mapping and characterising these reef habitats, the survey also collected data to address the following research questions:1) do benthic and demersal fish communities vary in composition across the environmental gradients represented in Arafura Marine Park, including: with distance offshore, depth, geomorphology and substrate type; and 2) how effective are available platforms (i.e. tow-video, BRUVs, grabs) for monitoring benthic communities in a tropical turbid setting, and what are the practical limitations?

2. SURVEY AREA

2.1 Survey Grids

The availability of legacy bathymetry data for reef and canyon features within the Arafura Marine Park has guided the prioritisation of areas to improve and extend mapping and sampling coverage of these features. Data acquisition focused on two areas of reef in shallow and deep areas of the marine park, as described below (Figure 3).

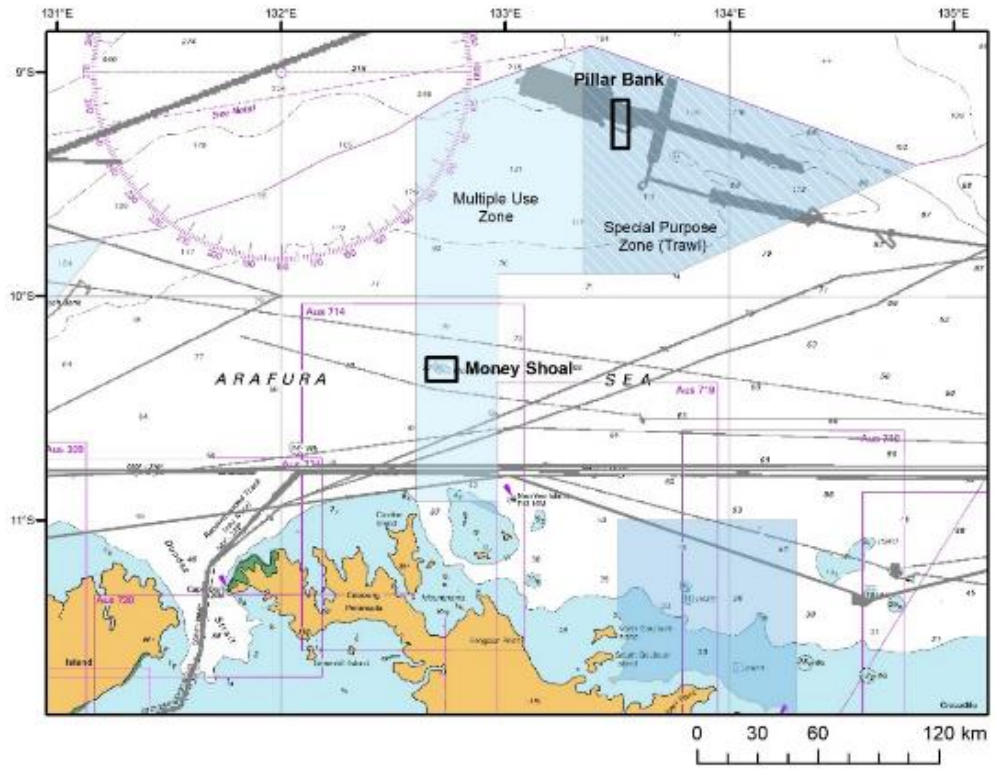


Figure 3: Location of survey grids (Money Shoal, Pillar Bank) within Arafura Marine Park. Grey lines and areas represent available legacy multibeam bathymetry data.

Money Shoal (10.274 S, 132.648 E to 10.377 S, 132.798 E): The Money Shoal survey grid encompasses the shoal and surrounding seabed, covering an area of ~190 km^2. Money Shoal is located within the Multiple Use Zone of the marine park and covers an area of approximately 24 km^{2,} rising from 65 m water depth at its base to ~3 –10 m on the summit. The area surrounding Money Shoal is generally flat, soft sediment plain in 65–70 m water depth. However, existing bathymetry data is at a resolution of 250 m, and it is likely that finer scale seabed features (e.g. sedimentary bedforms, pockmarks) are present, as found in other shelf areas offshore northern Australia (e.g. Carroll et al., 2012; Nichol et al., 2013).

Pillar Bank (09.124 S, 133.478 E to 09.305 S, 133.798 E): Pillar Bank is located within the Special Purpose (Trawl) Zone of Arafura Marine Park and is likely representative of the deep water reef habitats associated with the Arafura canyons. The planned mapping area covers a grid area of ~180 km^2 where previous mapping of the Arafura canyons includes a large ridge (Pillar Bank) and towed video that recorded coral and sponge communities in water depths of

~80 to ~110+ m (Logan et al., 2006). The mapping and sampling area overlaps these sites on Pillar Bank and incorporates adjacent canyon, apron/fan and ridge geomorphic features that extend to 190 m water depth.

3. SURVEY DESIGN AND SCHEDULE

3.1 General information

The survey applied the standard operating protocols (SOP) for all mapping and sampling operations, as set out in the NESP Marine Biodiversity Hub Field Manuals as the standard and consistent approach to survey-based inventory and monitoring (Przeslawski and Foster, 2018). This included application of a random, spatially balanced design for sampling stations within areas of high-resolution mapping coverage.

3.2 Survey design

Mapping grids were designed to provide 100 percent bathymetry and backscatter coverage of each survey area (excluding inaccessible shallow areas of Money Shoal) incorporating 10 percent overlap between survey lines. Line spacing was estimated based on swath coverage for dual sonar heads of up to 10x water depth for areas less than 60 m water depth, and less (4x - 6x) in deeper water.

Sampling stations for towed video and BRUV deployments were determined using a Generalized Random-Tessellation Stratified (GRTS) survey design (Stevens and Olsen 2004) to randomly distribute sites across each survey grid in a spatially balanced pattern (Przeslawski and Foster, 2018). The design was stratified by water depth and geomorphology as represented by the national seabed geomorphology dataset (Heap and Harris, 2008). This ensured each large-scale geomorphic feature (reef, shelf, ridge, canyon, apron/fan) was sampled across the bathymetric range of the survey grids (Figure 4; Figure 5).

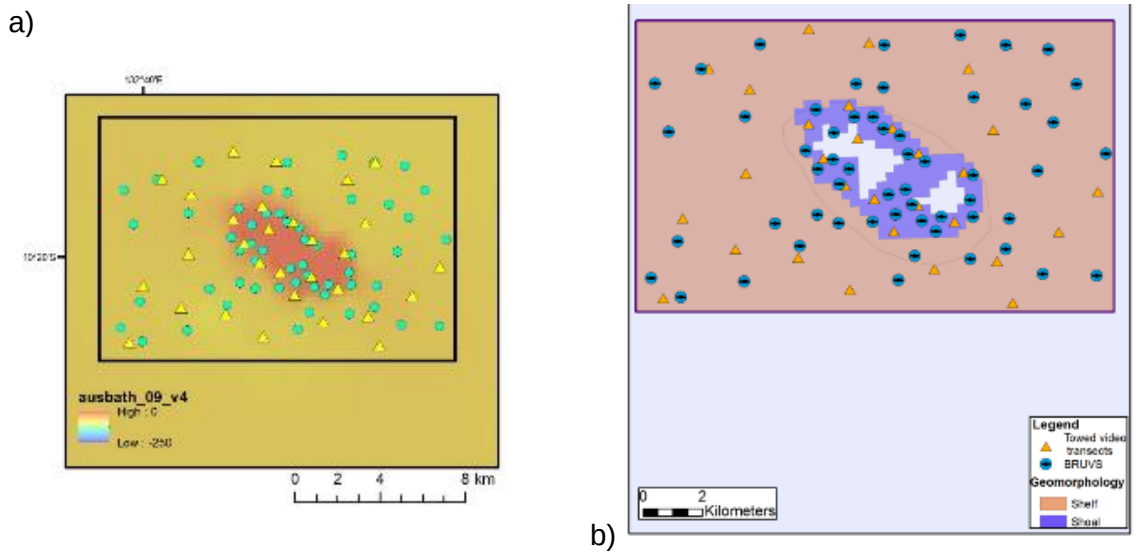
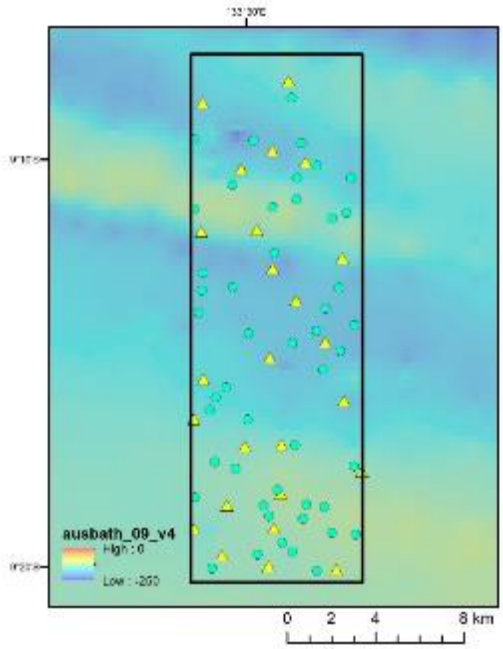


Figure 4: Location of planned sampling stations within the Money Shoal survey grid, as stratified by: (a) water depth and; (b) geomorphology. Note: The area shown in white is too shallow for vessel access, based on the 250 m bathymetry grid.

a)



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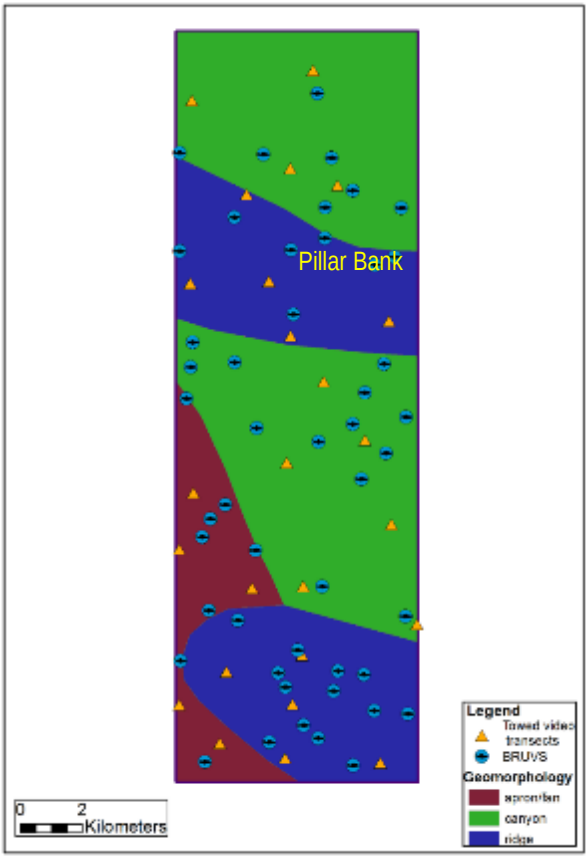


Figure 5: Location of planned sampling stations within the Pillar Bank survey grid, as stratified by: a) water depth and; b) geomorphology.

3.3 Survey timetable

The survey was completed to the following daily schedule, incorporating a modification that added one day of acquisition at Money Shoal and reduced acquisition at Pillar Bank by one day.

Survey Departure Port	DARWIN, Northern Territory	
Mobilisation activities – Pearl Marine Wharf		
01 November	Loading/installation of equipment/provisions	
02 November	Complete loading/install – Commence transit ~ 22:00 hrs	
Survey activities – Money Shoal		
	Day	Night
03 November	Transit to Money Shoal [~ 24 hrs; ~ 240 Nm] + patch test	
04 November	BRUV; TV; GRAB	MB mapping
05 November	BRUV; TV; GRAB	MB mapping
06 November	BRUV; TV; GRAB	MB mapping
07 November	BRUV; TV; GRAB	MB mapping
08 November	BRUV; TV; GRAB	MB mapping /transit ~10 hrs
Survey activities – Pillar Bank		
	Day	Night
09 November	BRUV; TV; GRAB	MB mapping
10 November	BRUV; TV; GRAB	MB mapping
11 November	BRUV; TV; GRAB	MB mapping
12 November	BRUV; TV; GRAB	MB mapping/transit ~ 10 hrs
Survey activities – Money Shoal		
	Day	Night
13 November	BRUV; TV	MB mapping/transit
14 November	Transit to Port [~30 hrs; ~ 300 Nm]	
De-mobilisation activities – Pearl Marine Wharf		
15 November	Unloading of equipment & samples	
16 November	Travel day	

Note: MB – multibeam sonar; TV – towed video; BRUV – baited remote underwater video; GRAB – sediment sample

4. METHODS AND DATA COLLECTED

4.1 Seabed mapping

Bathymetry and backscatter data were acquired using a Kongsberg EM2040C multibeam echo-sounder in dual-head mode, with sonar heads mounted in the moon-pool of RV Solander. Vessel navigation and data acquisition used the Kongsberg Seabed Information System (SIS) software (Figure 6), with vessel motion data collected using an Applanix POS MV motion referencing system (see Appendix A for detailed Mobilisation report).

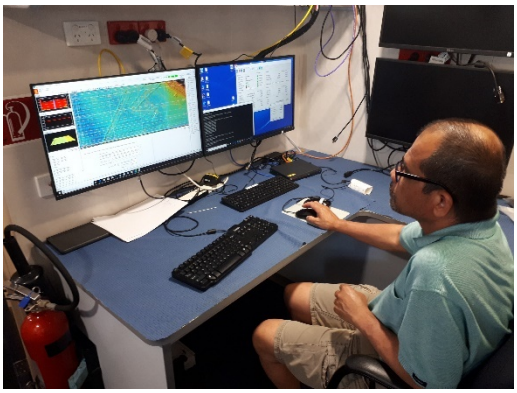
a)  b) 

Figure 6: Multibeam acquisition control room on board RV Solander, showing: a) acquisition station and; b) data processing station.

Data processing was completed using the Caris HIPS & SIPS suite v.11.3.10. The data was corrected for ship motion (pitch, roll and heave), navigation and sound velocity. The data was reduced to the ellipsoid datum using the Applanix 000 files and gridded at 1 m horizontal resolution using the CUBE algorithm (Calder and Wells, 2007). Outliers were removed using surface filters with the last remaining outliers removed manually after visual inspection. Bathymetry surfaces at 1 m horizontal resolution were exported to both the ellipsoid and the mean sea level (MSL) datum. Transformation to MSL was executed by subtracting the earth gravitational model (EGM) 2008 geoid height model (using tile s45e90).

Money Shoal
The total area mapped for Money Shoal study area covered 192 km^2 (1530 line km), in water depths ranging between 13 to 81 m, with a mean of 66 m and acoustic reflectance (backscatter strength) ranging between -9 and -30 dB, with mean of -15 dB (Figure 7). Acquisition of multibeam bathymetry data did not extend across the top of the shoal due to shallow water limiting safe vessel access.

Pillar Bank
The total area mapped for Pillar Bank study area covered 160 km^2 (887 line km) in water depths ranging between 117 m and 219 m, with a mean depth of 160 m. Acoustic reflectance (backscatter strength) ranged between 0 and -35 dB, with mean of -17 dB (Figure 8). Mapping coverage of the Pillar Bank survey area did not extend to the full extent as defined in the voyage plan. This was due to a decision to reduce the survey time at Pillar Bank by 24 hours and reallocate that time to additional mapping and sampling at Money Shoal. This decision was based on the low visibility which compromised data quality for all towed-video and BRUV deployments at Pillar Bank.

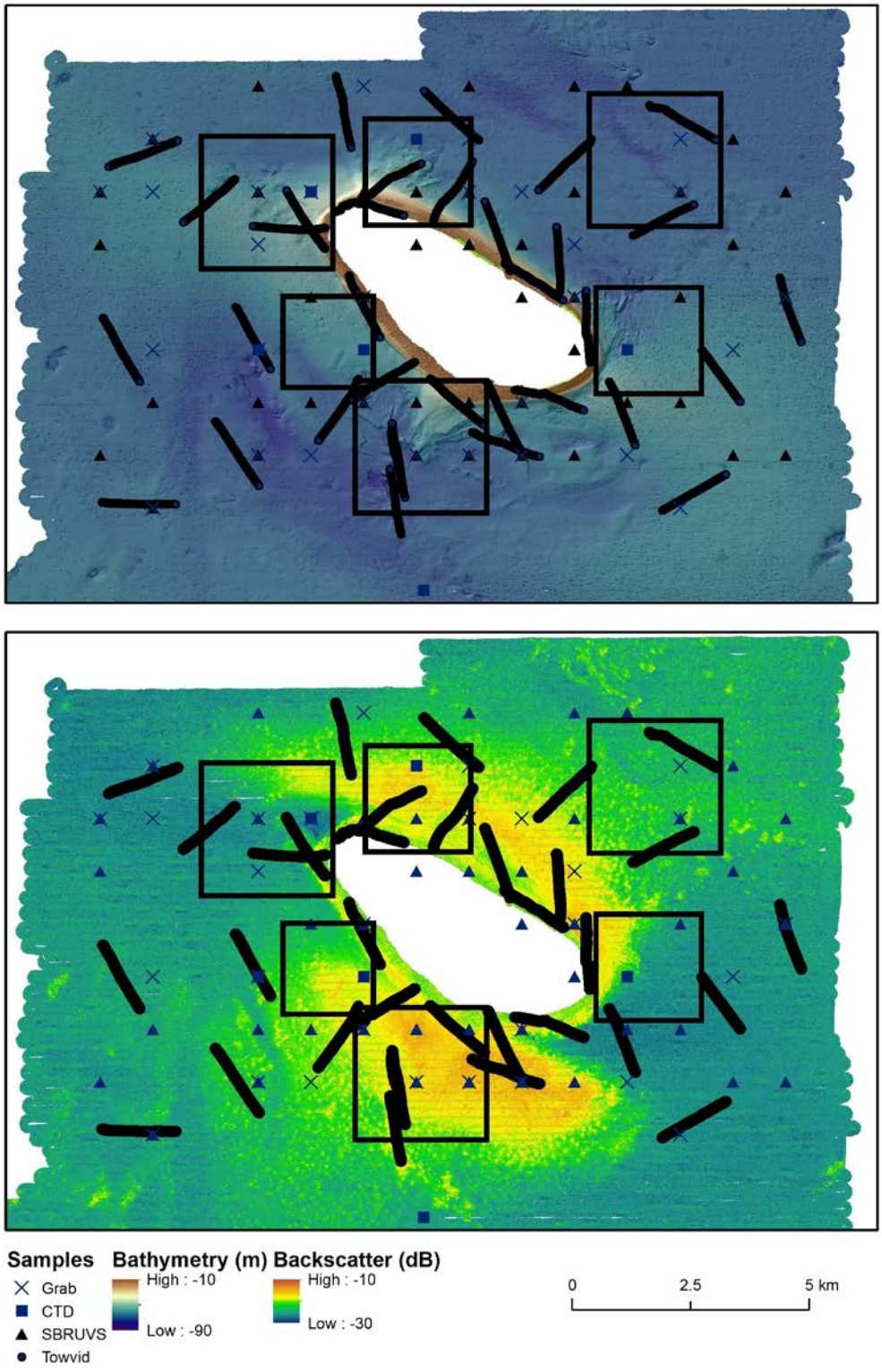


Figure 7: Bathymetry (top) and backscatter (bottom) maps of the Money Shoal study area with sampling locations shown. Boxes show the locations of the insets shown in **Error! Reference source not found.**.

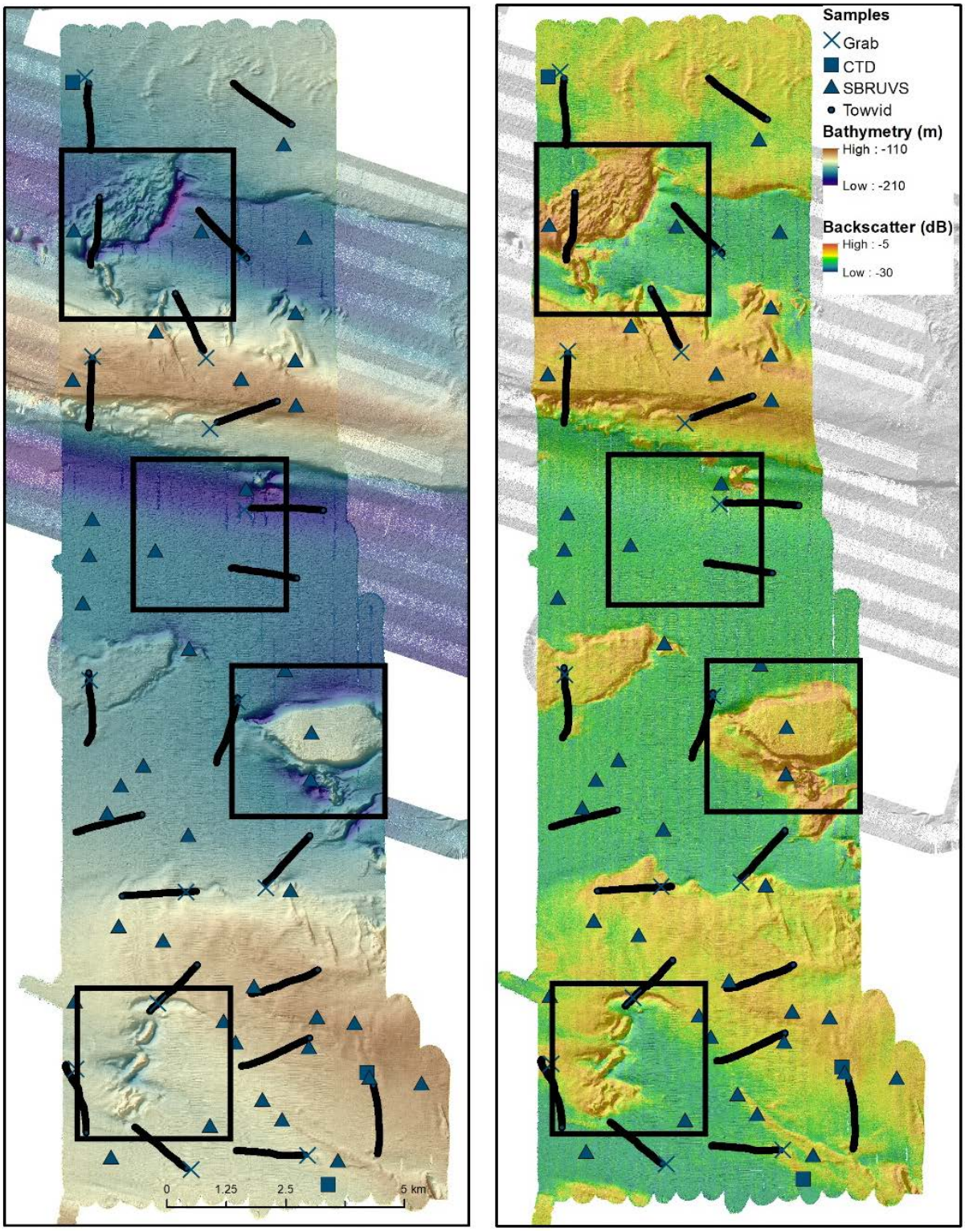


Figure 8: Bathymetry (left) and backscatter (right) map of the Pillar Bank study area with sampling locations shown. Boxes show the locations of insets shown in Figure 16: Examples of seabed features in the Pillar Bank study area, showing bathymetry (left panel) and acoustic backscatter data (right panel) for: A) Complex field of ridges interpreted as eroded carbonate basement; B) Ridges and depressions scoured by tidal currents; C)

Pockmark field within the trough and plain to the south of Pillar Bank; D) Flat bank with tidal current scoured depressions.

4.2 Seabed sampling

Seabed sediment samples were collected using a Smith-McIntyre grab at 29 locations at Money Shoal in water depths ranging from 34 m on the margins of the shoal to 72 m on the adjacent plain (Figure 7; Figure 9; Appendix C). At Pillar Bank, grabs were collected at 14 locations in water depths between 124 m on the top of the ridge of Pillar Bank to 200 m in the adjacent trough (Figure 8; Appendix C). Samples were described in the field following the Standard Operating Procedure for Grabs set out in the NESP field manuals and subsampled for measurement of grain size and carbonate content by the Geoscience Australia sedimentology laboratory.

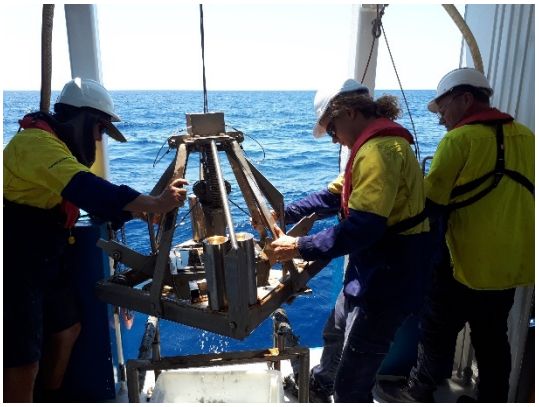
a)  b) 

Figure 9: Smith-MacIntyre sediment grab, showing: a) grab deployment, and b) a typical sample of muddy sand collected from the plain adjacent to Money Shoal (~68 m water depth) prior to sub-sampling and grain size analysis.

4.3 Benthic community observations

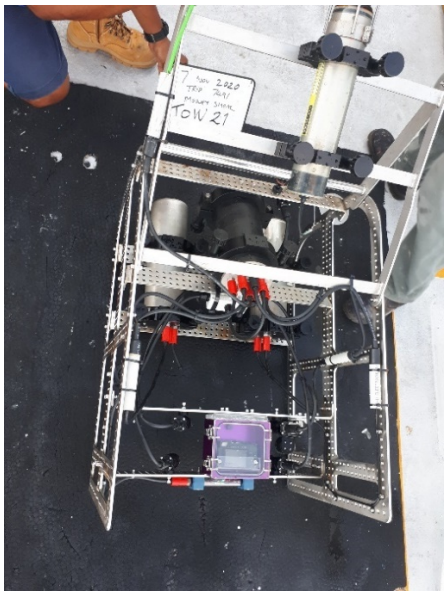
4.3.1 Towed video

The towed-video comprised a towed camera platform with live camera feed to a vessel-based image classification system (Figure 10). The towed platform incorporated a forward-facing video camera with lights and a downward-facing high resolution still camera and lighting system programmed to take sequential still images at fixed (5 second) time intervals. The towed platform was deployed over the stern of the RV Solander and towed at 1-2 knots at ~0.5 metres above the seabed for a minimum transect distance of 1.5 km. The tow body was fitted with an altimeter that assisted with its positioning over the seabed under turbid conditions where visualising the seabed was challenging.

At Money Shoal, towed-video transects were completed at 33 stations across the survey area, spanning water depths from ~10 m on the outer edge of the shoal to 73 m on the sediment plain (Figure 7; Appendix C). On Pillar Bank, towed-video transects were completed at 21 stations in water depths between 121 m on the crest of the ridge and 200 m in the floor of the trough to the south of Pillar Bank (Figure 8; Appendix C). The completed towed-video transects represent a modified sampling effort, resulting from the reduction of one day of sampling at Pillar Bank. Thus, five transects that were planned along the eastern

part of the Pillar Bank area were not completed; and an additional five transects were completed at Money Shoal (plus re-deployments at two sites where technical issues had compromised image quality on the first deployment).

a)



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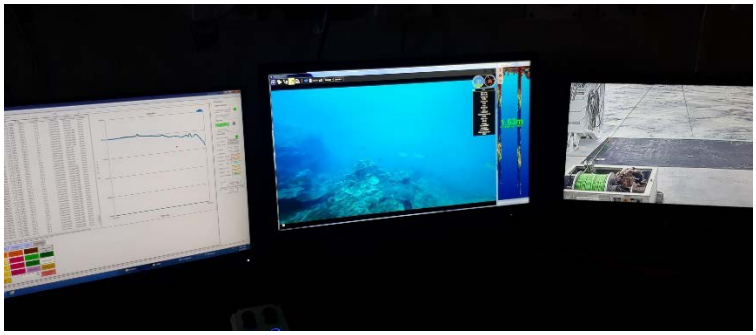


Figure 10: a) Towed video system, showing deployment and the video/camera frame; (b) Acquisition computers showing the real-time scoring (left), video (centre) and the navigation (right) screens.

During towed-video deployments, imagery was described in real-time to characterise the general substrate type (e.g. sand, mud, rubble, limestone) and benthos category (e.g. hard coral, filter-feeders), with positions of each recorded by ultra-short baseline (USBL).

4.3.2 STEREO-BRUVS

Observations of demersal fish communities on and around Money Shoal and Pillar Bank were undertaken using baited remote underwater video (stereo-BRUV) units. Each stereo-BRUVS comprises a pair of high-definition video cameras (GoPro Hero5) set to record at 1080p resolution at a rate of 30 frames per second. The cameras are separated by 750 mm and each inwardly converged at 5º to provide an overlapping field of view (Figure 11). To maximise calibration stability, the cameras and housings are precision mounted on a base bar to eliminate camera movement within the housing and between the cameras. For surveys in low light at depths >70 m, a white LED light (Birt et al., 2019) was attached to each stereo-BRUV to provide sufficient illumination of the field of view.

Each stereo-BRUV was baited with approximately 1 kg of crushed pilchards (*Sardinops spp.)* held within a plastic-coated wire mesh basket, attached to a stainless steel bait arm and positioned 1.5 m in front of the cameras. Each system was deployed for 60 minutes on the seafloor. Neighbouring deployments were separated by at least 400 m to reduce the likelihood of fish swimming between neighbouring stereo-BRUV deployments.

A)  B) 

Figure 11: a) BRUV sampling gear on deck and; b) in the water where only floats appear marking the location of the BRUV on the seafloor.

At Money Shoal, stereo-BRUV units were deployed at 57 sites in water depths that ranged from 12 m on the outer part of the shoal to ~87 m on the adjacent soft sediment plain (Figure 7; Appendix C). At Pillar Bank, 39 stereo-BRUV sites were in water depths between 122 m on the top of the ridge and ~190 m in the trough to the south of Pillar Bank (Figure 8; Appendix C). Videos from all deployments will be annotated by fish biologists at AIMS using EventMeasure software and the AIMS BRUVS database to record species occurrence, their relative abundance (MaxN) and other metrics (e.g. Time of first arrival, Time of first feed); as well as classification of the seabed habitat (substrate) within the field of view. The BRUV sampling effort also represents a modified design relative to that planned due to the reduced time spent sampling the Pillar Bank area. Thus, eight planned BRUV sites along the eastern part of Pillar Bank sampling area were not completed, and four BRUV sites were added to the sampling effort at Money Shoal. These additional sites were chosen to increase data coverage for the shoal feature.

5. RESULTS AND PRELIMINARY OBSERVATIONS

5.1 Seabed features

5.1.1 Money Shoal

The Money Shoal study area is characterised by an oval-shaped reef and surrounding flat sediment plain (Figure 12). The long axis of the reef extends 6.5 km on a NW- SE alignment, is 3.3 km across at its widest and tapers to ~1.5 km at each end. The base of the reef sits in ~60 m water depth and rises on a gradient of 10 degrees to ~3 m on the reef platform. At the northwest and southeast ends of the reef margins, gently sloping aprons of sediment extend up to 1.5 km from the base of the reef. Acoustic backscatter data indicate the aprons are comprised of a slightly softer substrate than the sediments that flank the sides of Money Shoal (Figure 13). Thus, the aprons are likely the result of deposition of suspended sediments on the lee side of the reef.

In the deeper waters away from Money Shoal, the seabed is characterised by a broad plain at ~70 m water depth. Local variability in the seabed occurs where semi-circular depressions have formed in the plain with scour depths of 2–5 m and diameter of 200–300 m. To the northeast and southwest of Money Shoal, shallow troughs and discontinuous channels also add local variability to the seabed, incising to depths of 5–7 m below the adjacent seabed.

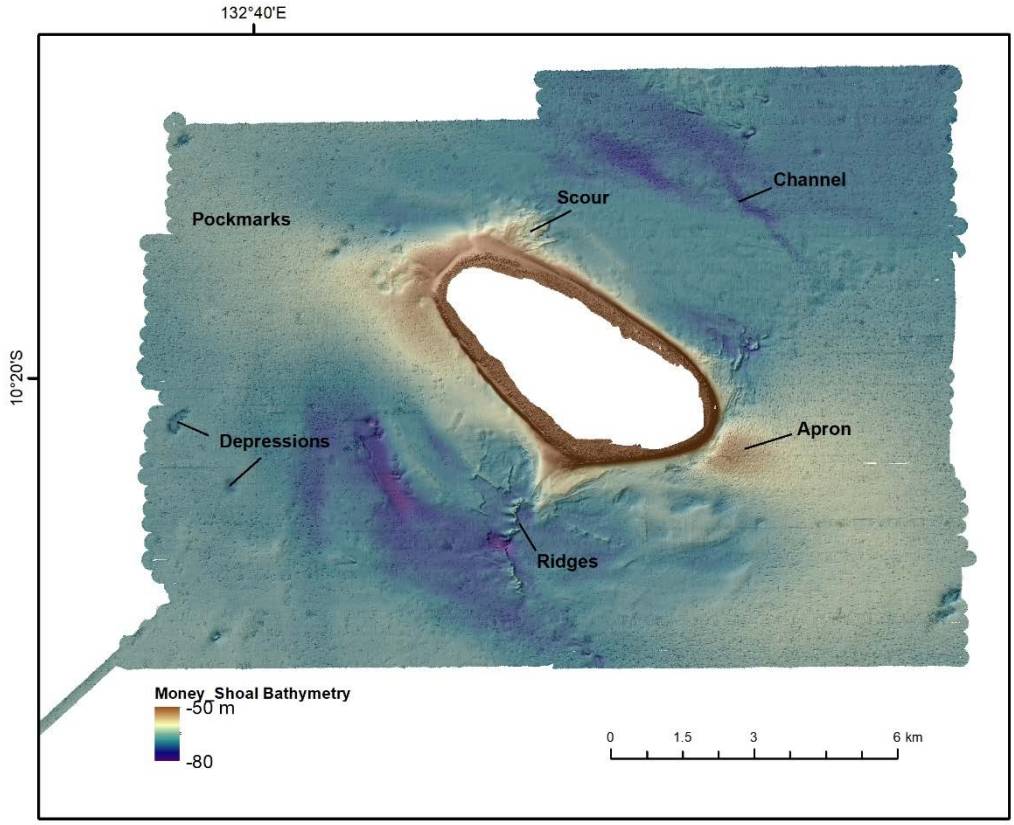


Figure 12: Money Shoal bathymetry with major seabed features indicated.

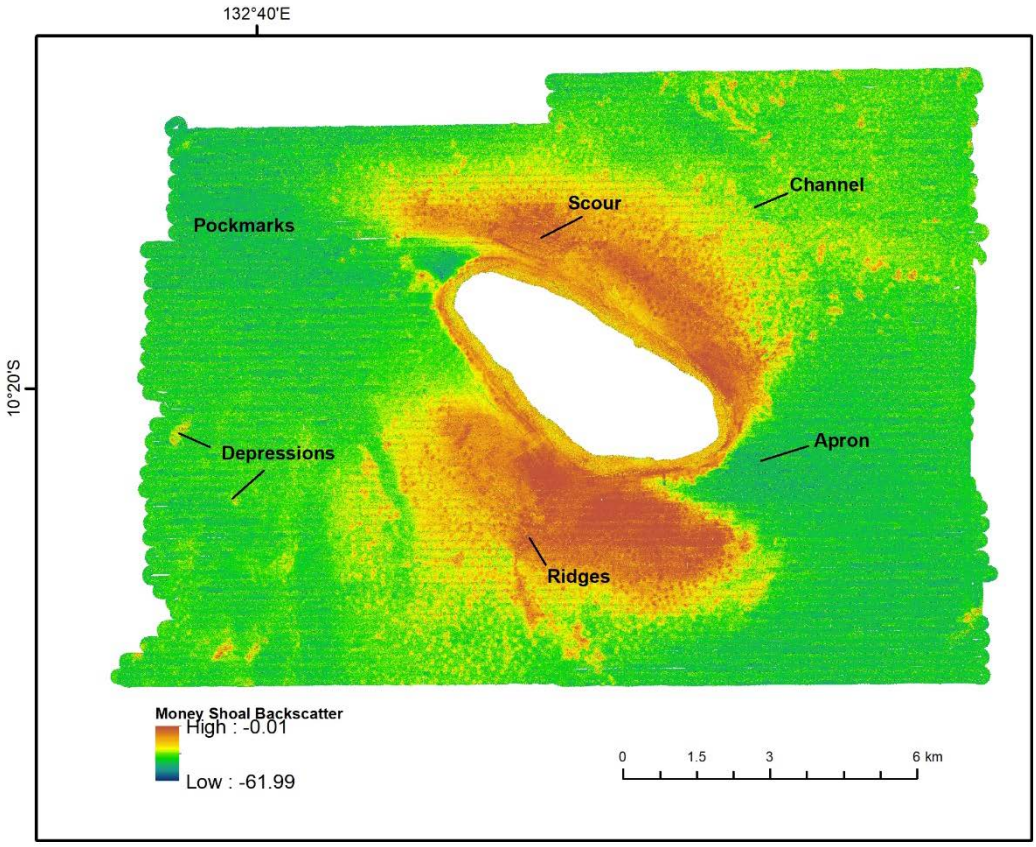


Figure 13: Money Shoal acoustic backscatter with major seabed features indicated. High backscatter (~ 0 dB) is indicative of relatively harder seabed (e.g. reef and coarse sediment).

The high resolution mapping of Money Shoal perimeter and surrounding area has also revealed a range of small-scale seabed features that provide insight to the active processes of erosion, reworking of sediment and sedimentation (Figure 14). These include:

- A rugose texture on the margins of the reef platform, defined by dense fields of small mounds less than 1 m high that are likely the product of the growth of reef-forming biota;

- Areas of scour at the base of the reef margin, as evidence for localised erosion of the soft sediments around the shoal. These areas are not extensive, however, with the largest covering a 900 × 1000 m area on the northern edge of Money Shoal;

- Pockmarks (holes) on sediment plains that extend as fields across large areas (tens of km^2), with individual pockmarks typically 10 – 20 m in diameter and less than 1 m deep. In some cases, the larger pockmarks are elongated, as evidence for scouring by near-bed tidal currents. In contrast, smaller pockmarks tend to occur in clusters and within larger depressions. Pockmarks are also characterised by a clear contrast in acoustic backscatter, with the centre having a higher intensity (-15 dB) than surrounding sediment (-20 dB), indicative of a harder (sandy?) substrate. Pockmarks are interpreted as the result of fluid (gas) escape from sediments that have high organic content (Nicholas et al., 2014);

- Low mounds on soft sediments that occur as localised clusters near the base of Money Shoal (e.g. along the southwest base). These mounds are typically ~20 m in diameter, less than 0.5 m high and evenly spaced in a regular spatial pattern. The backscatter intensity on mounds is not noticeably different from surrounding seabed, ranging from -18 to -20 dB, indicating a uniform substrate hardness (muddy sand). The origin of these mounds is unclear, but they are also possibly related to sediment diagenesis processes;

- Narrow ridges that rise up to 7 m above the flat plain in 60 m water depth and extend for ~900 m to the south of Money Shoal. In cross-section, these ridges are ~50 m wide and broadly symmetrical with sides that slope at 15–20 degrees, with low lobes of sediment accumulations on their western sides. Backscatter intensity ranges from -20 dB on the eastern side and crest of ridges to -15 dB on the downdrift side, which is consistent with a slight trend to harder substrate (e.g. mixed sand and gravel to sorted sand). In plan view, the ridges are curvi-linear, a form that is consistent with dunes and may be relict features that formed during a period of lower sea level in the late Quaternary period (15,000–12,000 years ago). Towed video transects showed the ridges are colonised by abundant biota and with a cover of coarse sand and gravel sediment.

In summary, the seabed features that surround Money Shoal show clear evidence for localised shaping of the seabed by strong tidal currents. Tidal scour is evident in depressions, linear pockmarks and areas that flank the base of the shoal. Re-deposition of sediment is most evident from the aprons that extend from the ends of the shoal and on the western side of small ridges, locations which appear to lie in the lee side of net tidal flows. These erosional and depositional features all create fine-scale variability in the seabed morphology and associated habitats.

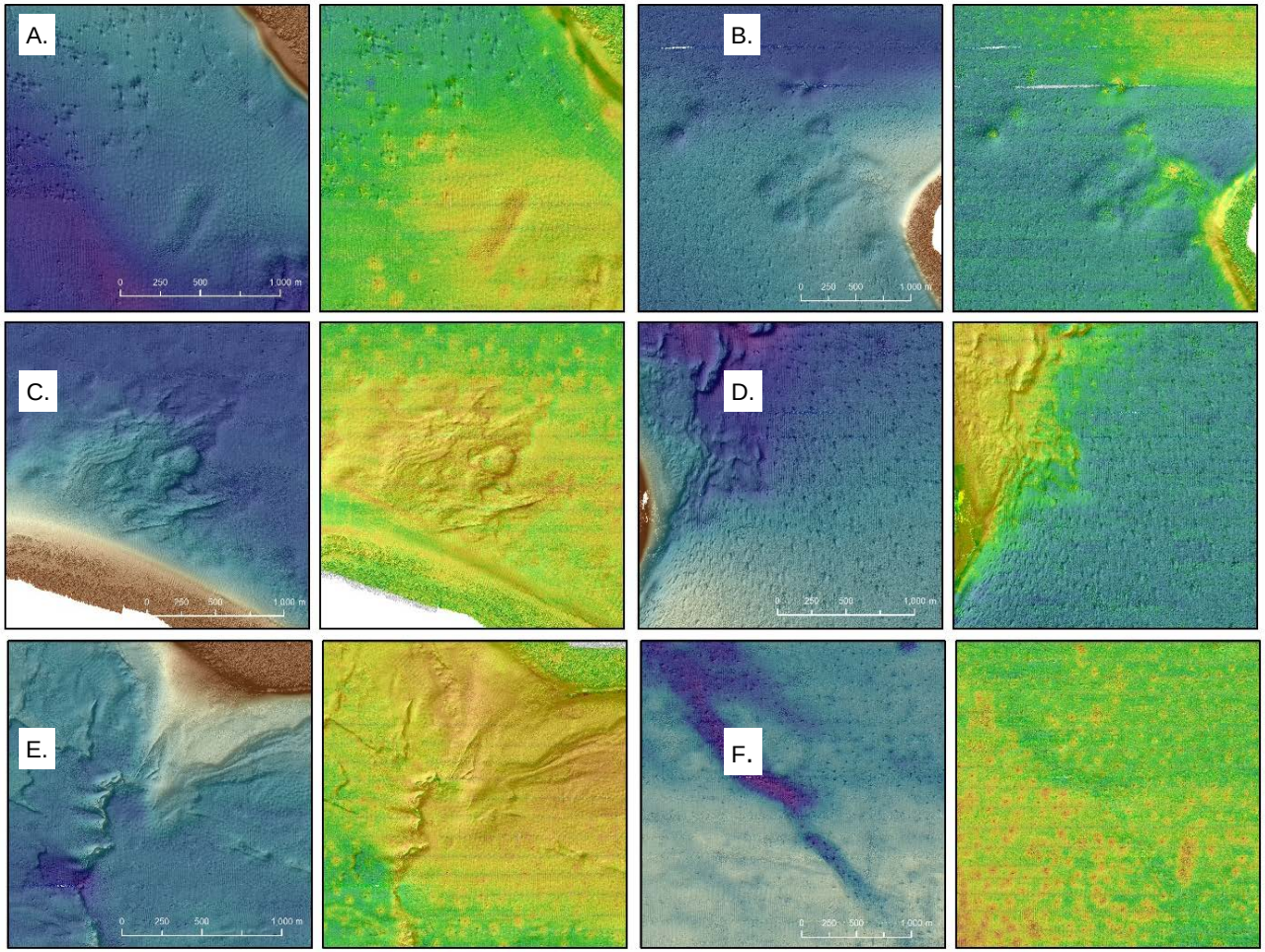


Figure 14: Examples of seabed features mapped within the Money Shoal study area, showing bathymetry (left panel) and acoustic backscatter data (right panel) for: A) Pockmarks and low mounds to the southwest of the shoal; B) Depressions and pockmarks to the west of the shoal; C) A scoured area on the northern margin of the shoal; D) unidirectional scoured pockmarks; E) A sediment apron and narrow ridges (dunes) to the south of the shoal; F) Shallow channel and extensive pockmark field formed on the deeper sediment plain.

5.1.2 Pillar Bank

The Pillar Bank study area is characterised by a diverse range of seabed morphological features, including banks, ridges, plains, pockmark fields, depressions and troughs (Figure 15). Water depths across these features range from 120 m to 200 m, with local bathymetric variation of tens of metres across the ridges and banks. Pillar Bank forms the largest ridge, rising 50 m from ~170 m water depth and extending the 6 km width of the mapped area, with a ~ 3 km north-south extent.

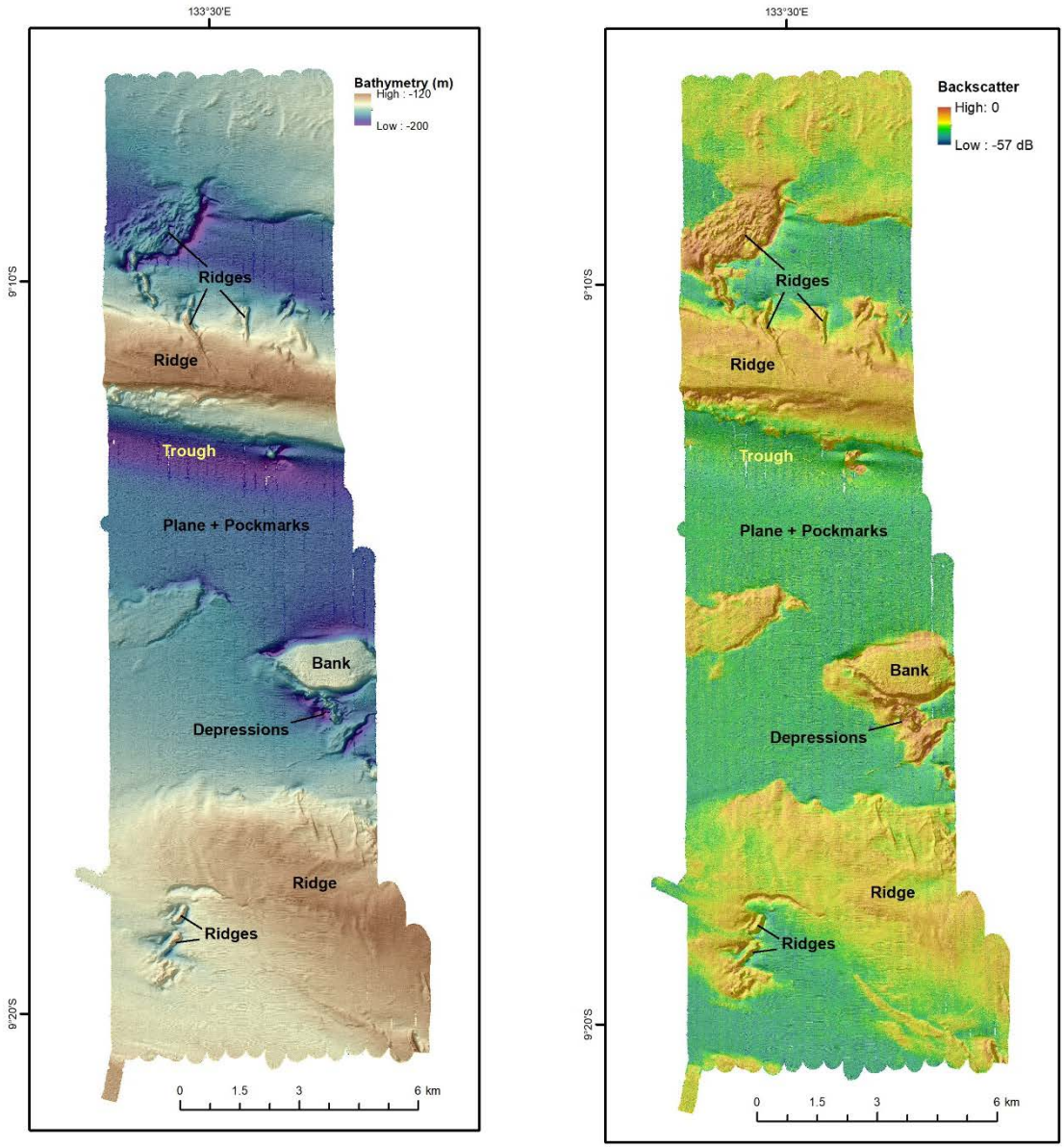


Figure 15: Pillar Bank, showing (left) bathymetry and (right) backscatter with large-scale seabed features indicated.

To the north of Pillar Bank, a series of 40 m-high ridges extend for a distance of up to 900 m onto a soft sediment plain. These ridges are up to 200 m wide and have 10 –15 m deep depressions at their base, formed by tidal current scour. A complex area of smaller ridges ('blocks') occurs further to the north of Pillar Bank, forming a highly rugose (rough) area of seabed. Together, these ridges enclose the plain that is characterised by numerous pockmarks (Figure 16). A key characteristic of Pillar Bank and the smaller ridges is their strong backscatter response, with values in the range -15 dB to -10 dB, indicating a relatively hard seabed (Figure 16). In contrast, backscatter values for the adjacent plain range from -20 dB to -30 dB, consistent with soft sediment. Towed video transects across the ridges included observations of rock outcrop, confirming the presence of hard substrate.

Pillar Bank is flanked to the south by a 1.5 km wide trough with a maximum depth of ~200 m that grades onto a soft sediment plain at ~180 m depth. This plain extends ~7.5 km to the south of the trough and is characterised by extensive fields of evenly distributed shallow pockmarks formed in the soft sediment. Pockmarks are typically 1–2 m deep and tens of metres apart. Backscatter intensity across this area is uniformly low, approximately -20 dB, in response to the soft substrate. Within this area, two well-defined banks rise 10–20 m above the plain with both characterised by strong backscatter values (-15 to -10 dB) and tidal scour depressions around their bases (Figure 16).

The southern part of the Pillar Bank study area is characterised by a broad ridge that forms an area of irregular and moderately hard seabed (Figure 15; Figure 16). This ridge is ~4 km wide, north to south, with its northern edge more clearly defined than the southern; with the latter grading onto a sediment plain. Water depths across this ridge range from 120 m to 140 m. The southwest edge is this broad ridge is a complex area of seabed, with two smaller ridges that rise 30–40 m above the adjacent seabed at 150 m water depth, with depressions forming moats around their bases that have incised the seabed to depths of ~180 m.

In summary, the diversity of seabed features within the Pillar Bank area is interpreted as a product of long-term geological processes associated with the formation of carbonate banks and ridges of various sizes and sedimentation to form the low lying plains and troughs. In addition, the influence of strong tidal currents is clearly evident in the formation of deep scour holes and depressions, particularly around the bathymetric highs (banks and ridges) that introduce localised acceleration of currents at their bases. Importantly, these raised seabed features are characterised by hard substrate, providing potential habitat for sessile fauna.

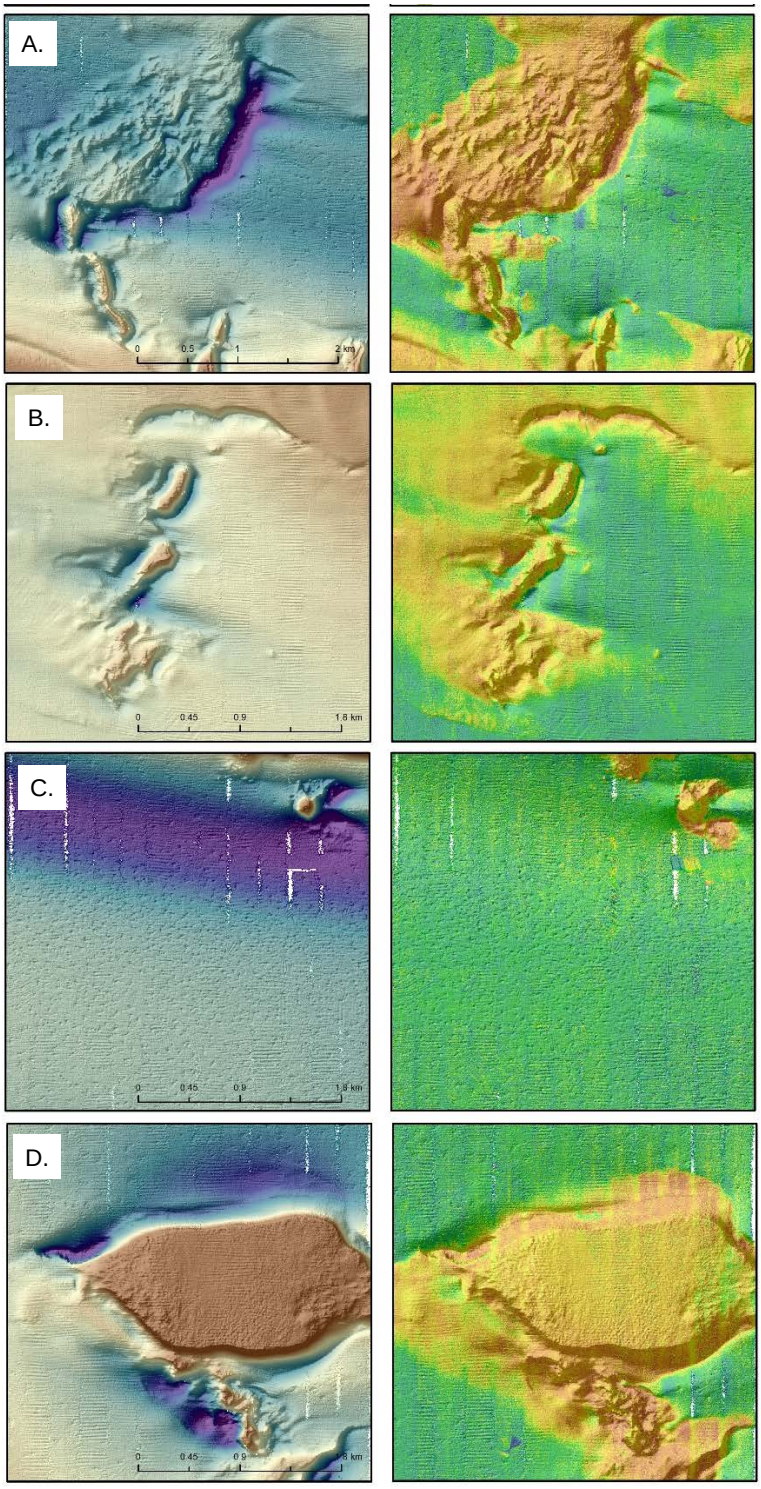


Figure 16: Examples of seabed features in the Pillar Bank study area, showing bathymetry (left panel) and acoustic backscatter data (right panel) for: A) Complex field of ridges interpreted as eroded carbonate basement; B) Ridges and depressions scoured by tidal currents; C) Pockmark field within the trough and plain to the south of Pillar Bank; D) Flat bank with tidal current scoured depressions.

5.2 Seabed sediments

Seabed grab samples from Money Shoal ranged from sandy carbonate gravel at sites on or adjacent to Money Shoal reef margin (e.g. Grab 27; 34 m water depth) to fine grained silts (mud) on the surrounding plain (e.g. Grab 25; 70.3 m) (Figure 17). At Pillar Bank, samples also range from coarse carbonate sand on raised features, such as ridges and banks (e.g. Grab 41, 131 m) to mud on the deeper plains. All samples will be analysed in the Geoscience Australia laboratory to quantify mud, sand, gravel and carbonate content, and other textural parameters (mean grain size, sorting, skewness, kurtosis). Results will be published on the AusSeabed marine data portal ausseabed.gov.au

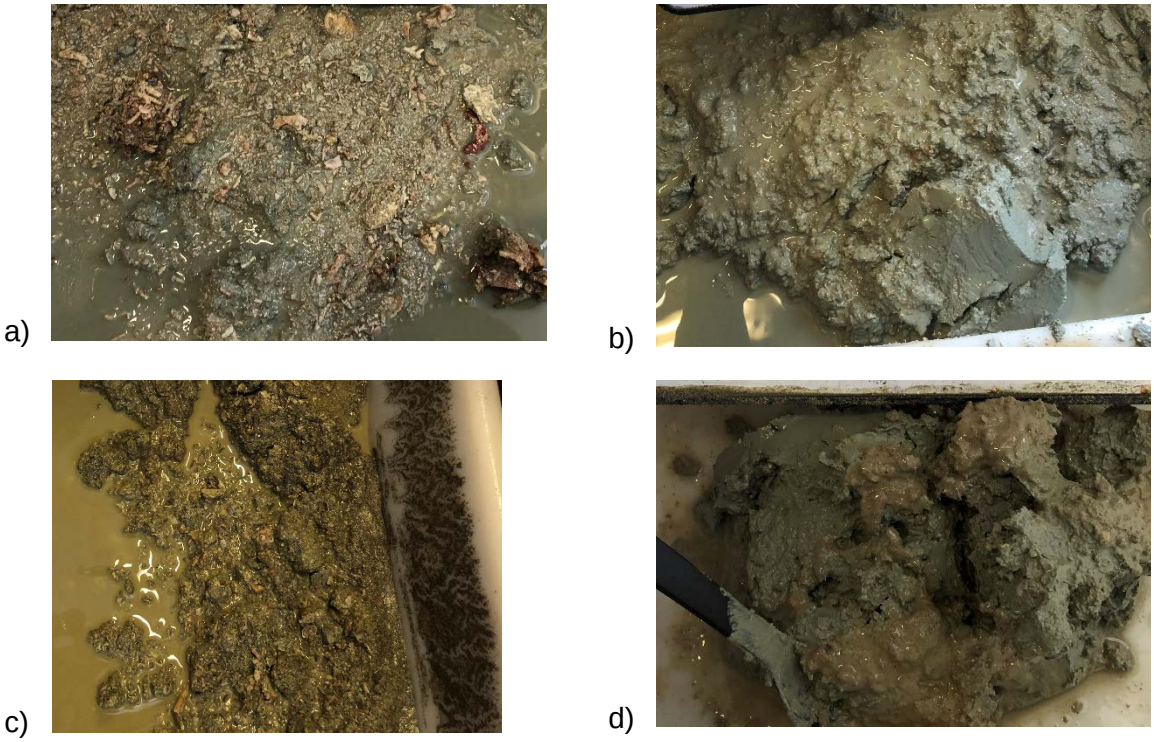


Figure 17: Representative seabed grab samples showing: (a) Coarse sandy carbonate gravel from 34 m depth on Money Shoal (Grab 27); b) Mud (silt and clay) from 70.3 m depth on Money Shoal plain (Grab 25); (c) Coarse carbonate sand from 131 m depth on Pillar Bank ridge (Grab 41); (d) Mud from 151 m depth on the margins of the pockmarked plain south of Pillar Bank (Grab 35).

5.3 Seabed biological communities

5.3.1 Money Shoal

Initial observations of Money Shoal show it supports a diverse and abundant assemblage of coral and coral reef-associated organisms (Figure 18). Although the RV *Solander* was unable to survey the very shallowest parts of the shoal (some of which lie in depths of less than 3 m but is entirely subtidal) the shallow edges of the reef were found to support a typical coral reef benthic community dominated by medium to dense hard coral cover. It is likely this habitat also occurs across the shallow shoal plateau. The hard coral dominance declines with depth giving way with the intermediate shoal depths having a succession of habitats dominated by different animal and plant groups before the seabed levels out to a relatively homogeneous muddy substrate surrounding the shoal in ~60 m.

Benthos

An abundance of hard corals with a diversity of growth forms predominate around the edges of the shoal and becomes patchy in distribution on consolidated reefal substrate in 20 – 30 m water depth. Here the coral outcrops become interspersed with areas of rubble before giving way in intermediate depths to a variety of communities dominated variously by soft corals and macroalgae. Some patches of seagrass of the genus *Halophila* were also observed in the intermediate depths although they were not extensive. In the deeper areas on consolidated substrates at the foot of the shoal filter feeding communities of gorgonians and sponges dominate. Beyond the consolidated boundaries of the shoal the substrate was almost exclusively soft sediments dominated by mud. The towed-video transects of these areas indicate sessile benthic organisms are sparse or entirely absent, although the prevalence of bioturbation suggests the biota here is mainly infaunal. For representative images of Money Shoal biota and substrate, please refer to Figures 19 to 29.

The water clarity across the shoal was exceptionally good (>15 m visibility) enabling quality imagery to be obtained. Away from the shoal over the unconsolidated sediments the visibility at the seabed was much reduced at around 2 m, but nonetheless adequate for towed video and BRUVS imaging. Detailed analysis of the towed video stills imagery will provide relative abundance and cover estimates of the benthic community at each of the sample locations. It will also provide a more quantitative assessment of any evidence of recent mortality among the hard corals that dominate the shallow areas and make this shoal regionally unique.

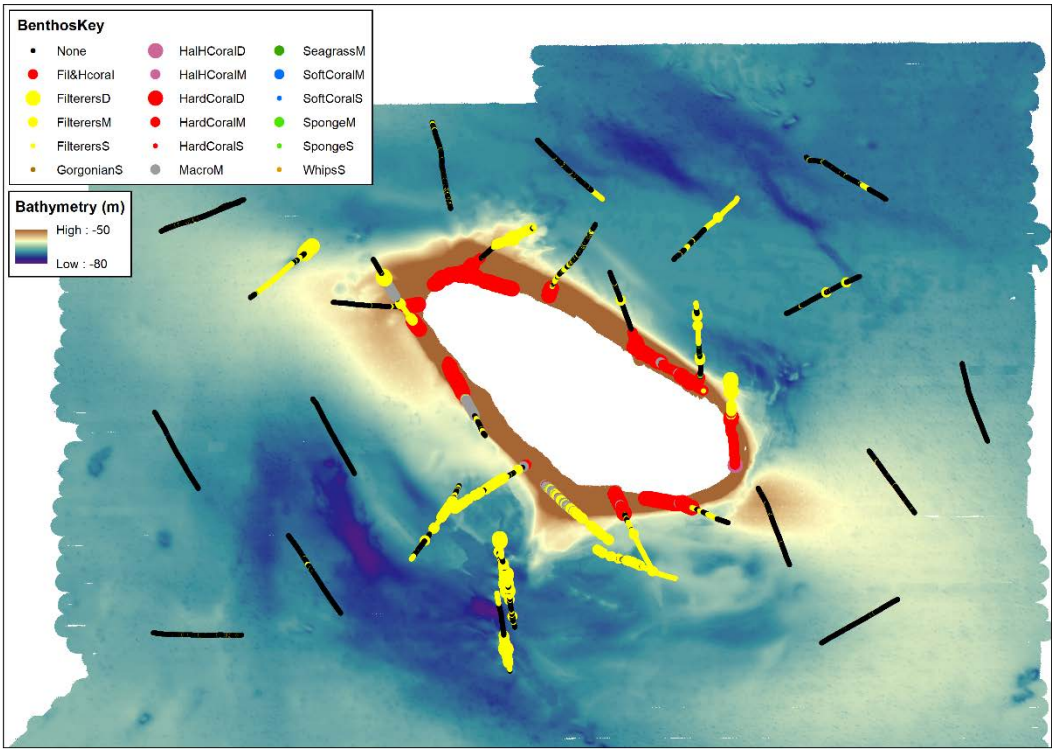


Figure 18: Benthos classes observed on towed-video transects within the Money Shoal survey grid, highlighting a concentration of hard corals on the shoal, filter feeders on the shoal margins and immediate surrounds and sparse to no benthos on the soft sediment plains in deeper areas.

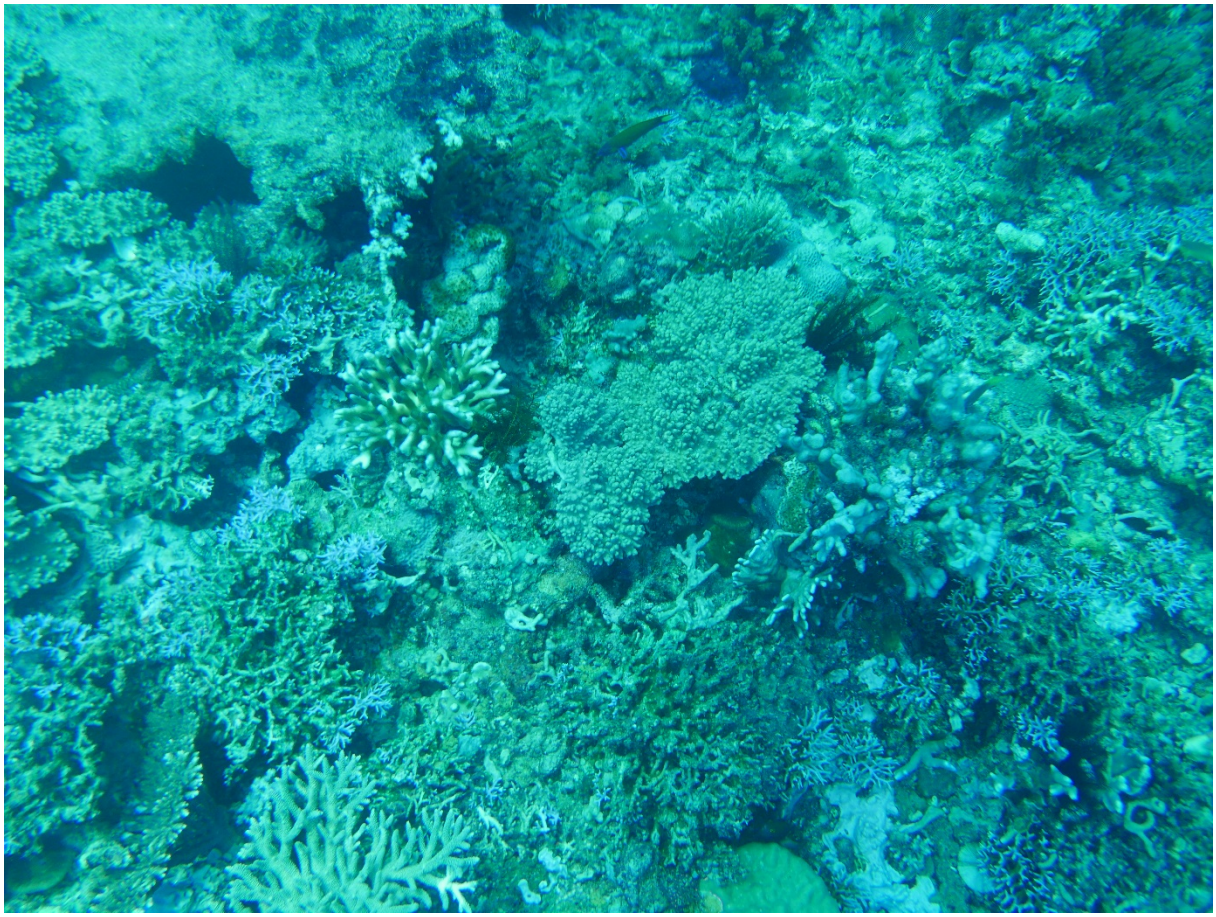


Figure 19: Example of dense branching hard corals in shallow areas of Money Shoal [image from Money Shoal TOW23]

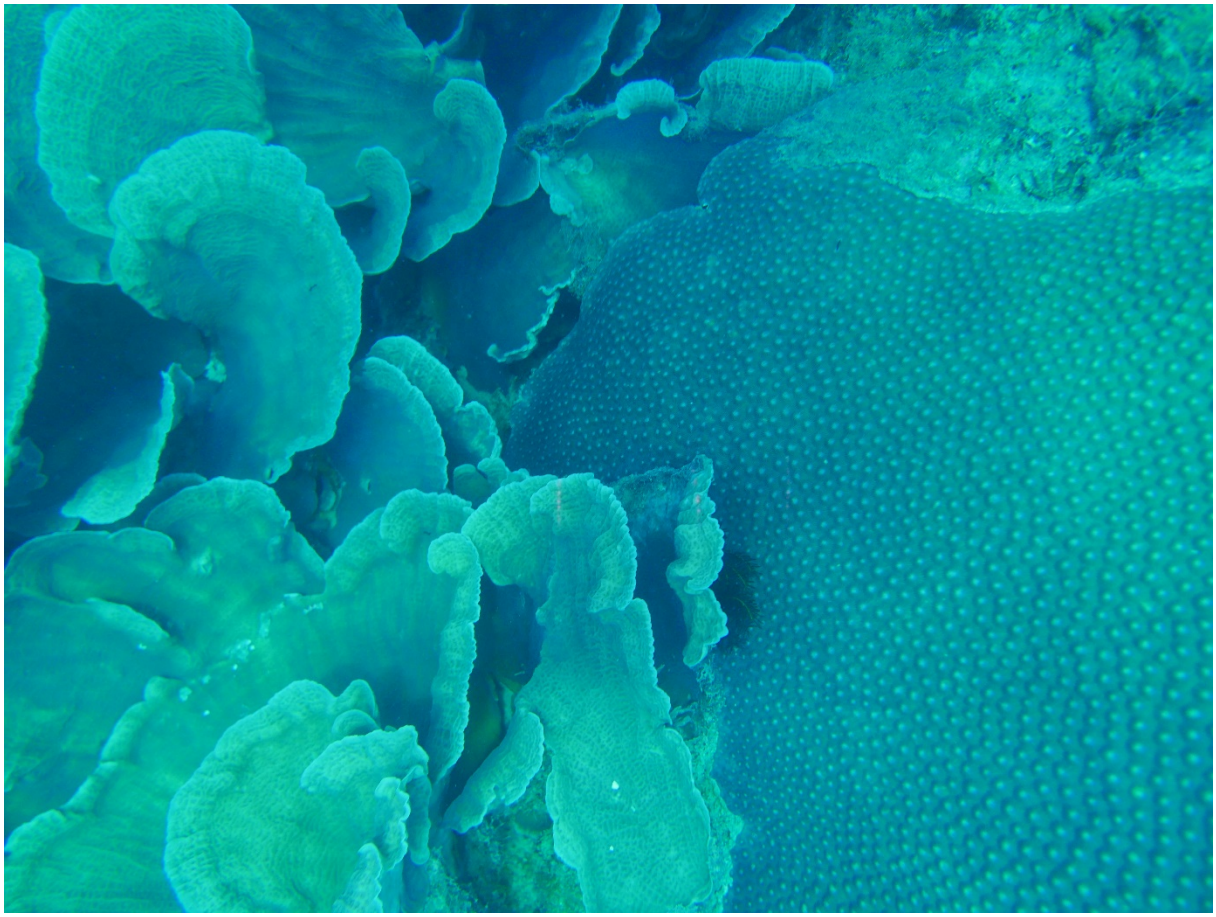


Figure 20: Example of dense foliaceous hard coral (*Montipora* sp.to left of image) in intermediate depths at Money Shoal [image from Money Shoal TOW24]

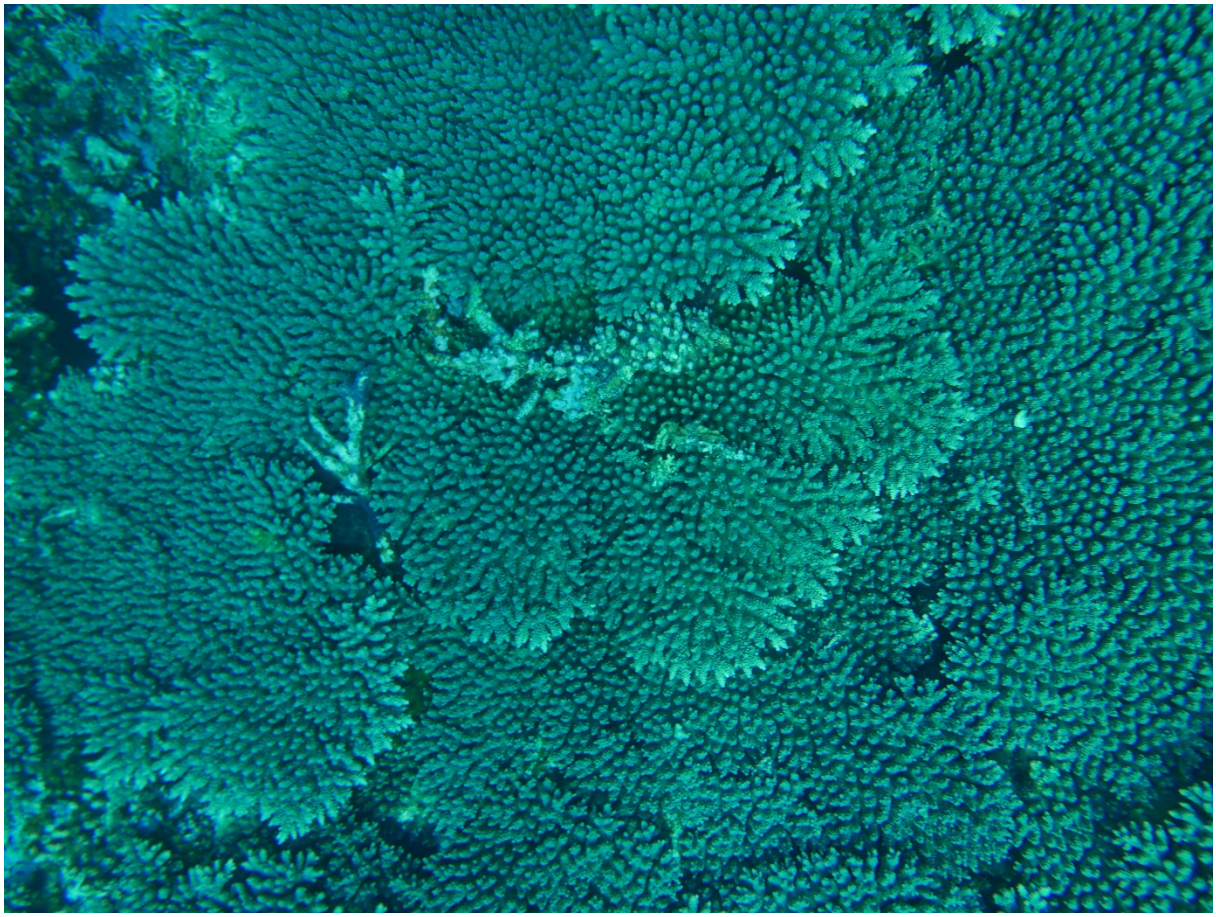


Figure 21: Dense plate (Acropora sp.) coral in shallow areas of Money Shoal [image from Money Shoal TOW26]

Figure 22: Mixed community of hard corals and filter feeding gorgonians interspersed with patches of rubble in intermediate depths at Money Shoal [image from Money Shoal TOW13]

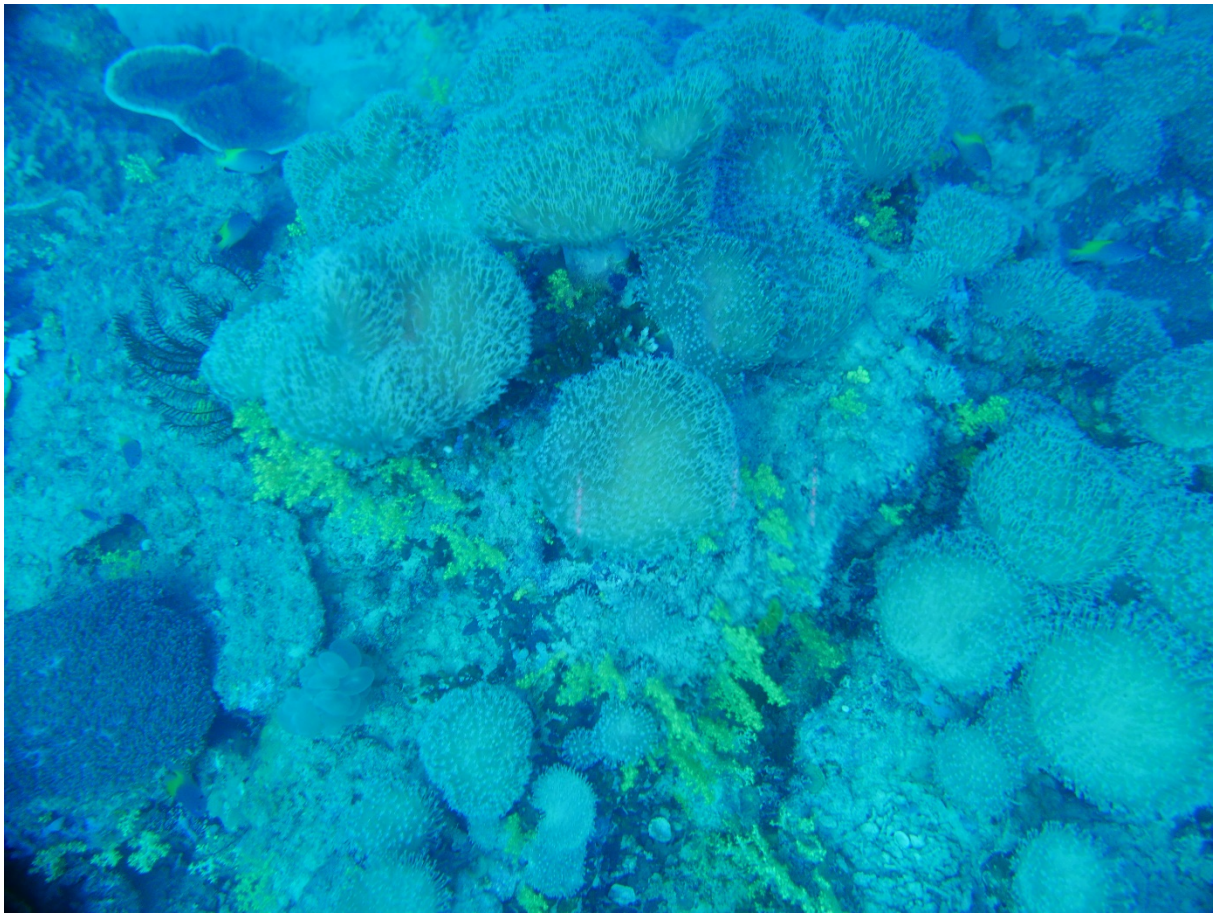


Figure 23: Soft coral and macroalgae dominated community in intermediate depths at Money Shoal [image from Money Shoal TOW32]

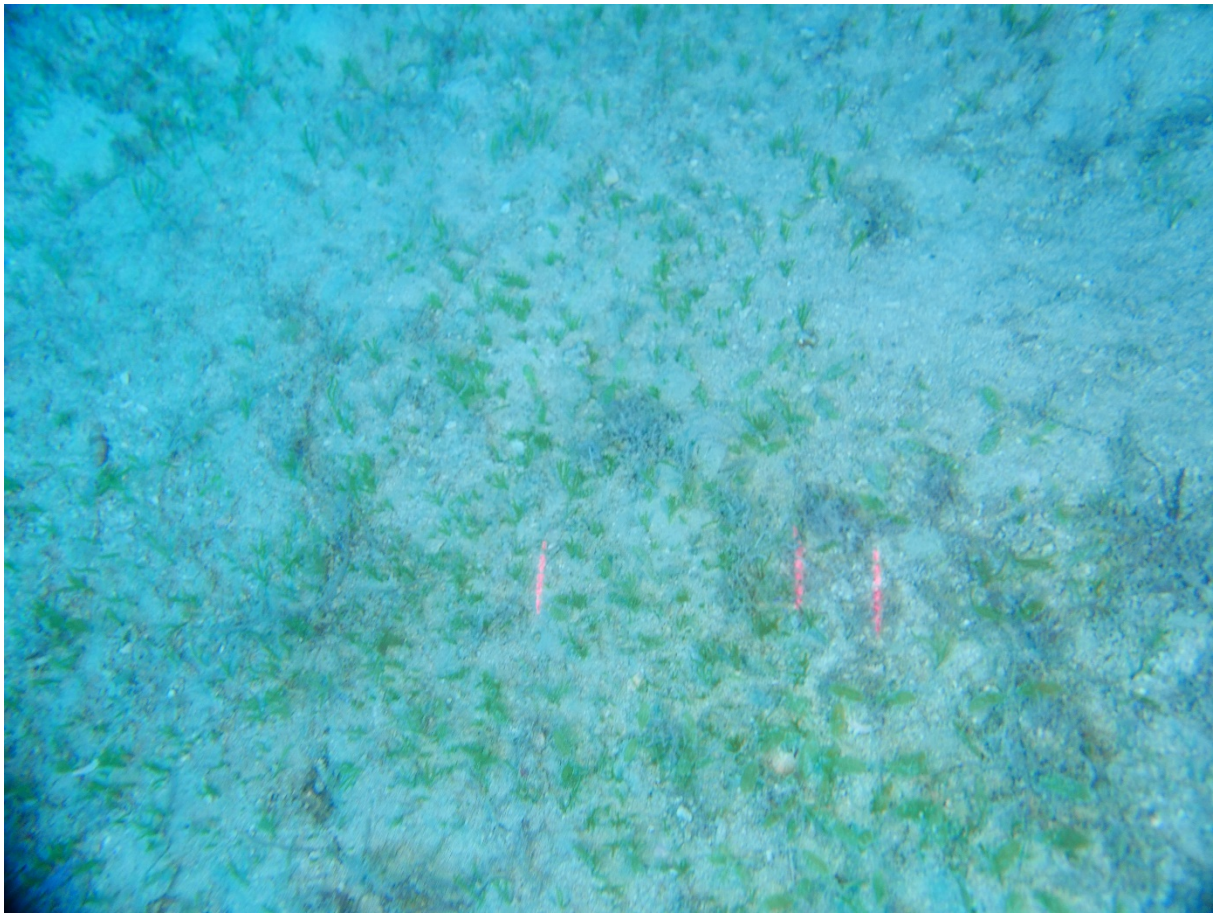


Figure 24: Macroalgae and seagrass occupying coarse unconsolidated sediment patches at Money Shoal [image from Money Shoal TOW32]

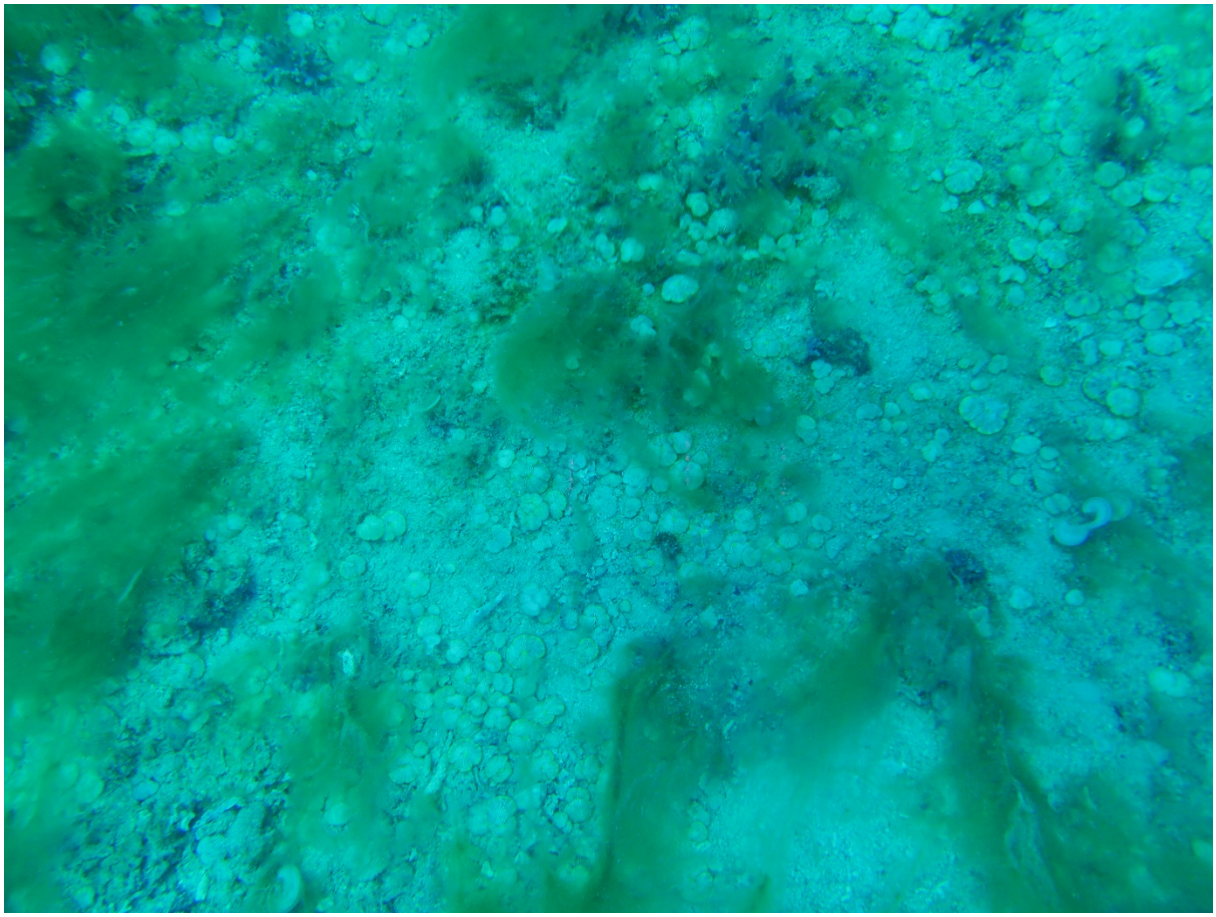


Figure 25: Macroalgae and solitary coral dominated habitat in deeper waters surrounding money shoal [image from Money Shoal TOW23].

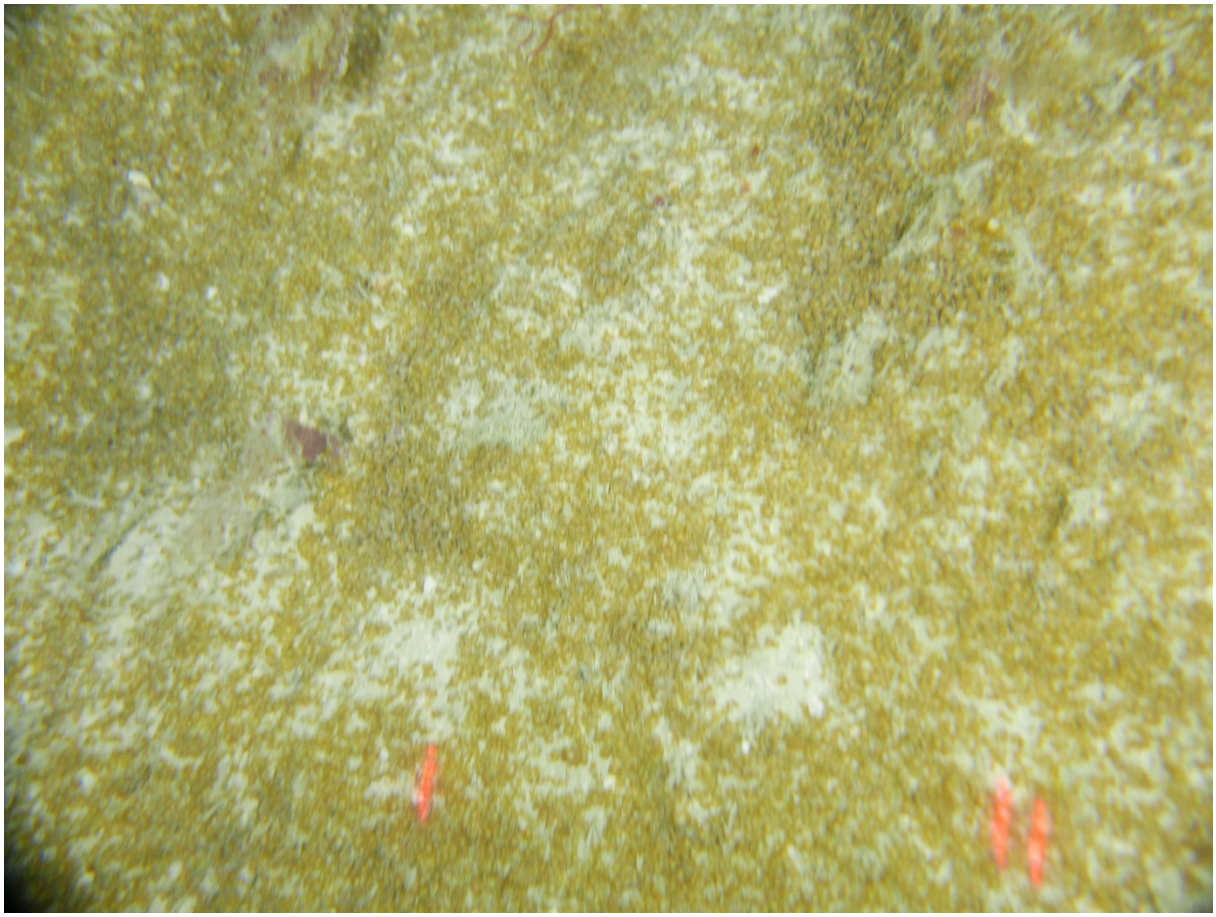


Figure 26: Dense foraminifera(?) beds on soft sediment surrounding Money Shoal [image from Money Shoal TOW31].

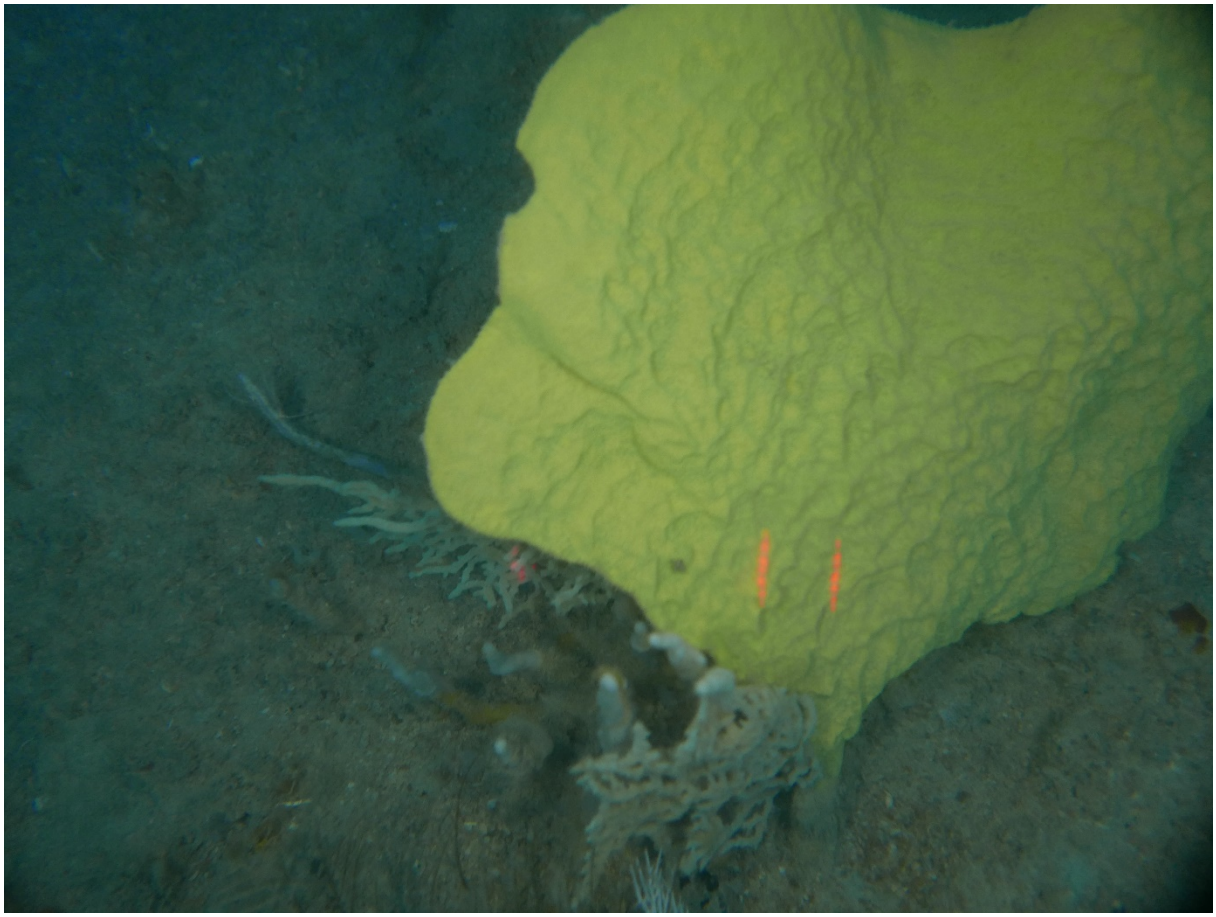


Figure 27: Sponges (here *Ianthella* sp. yellow fan) and other filter feeders on an outcrop of hard substrate in deep water surrounding Money Shoal [image from Money Shoal TOW29]

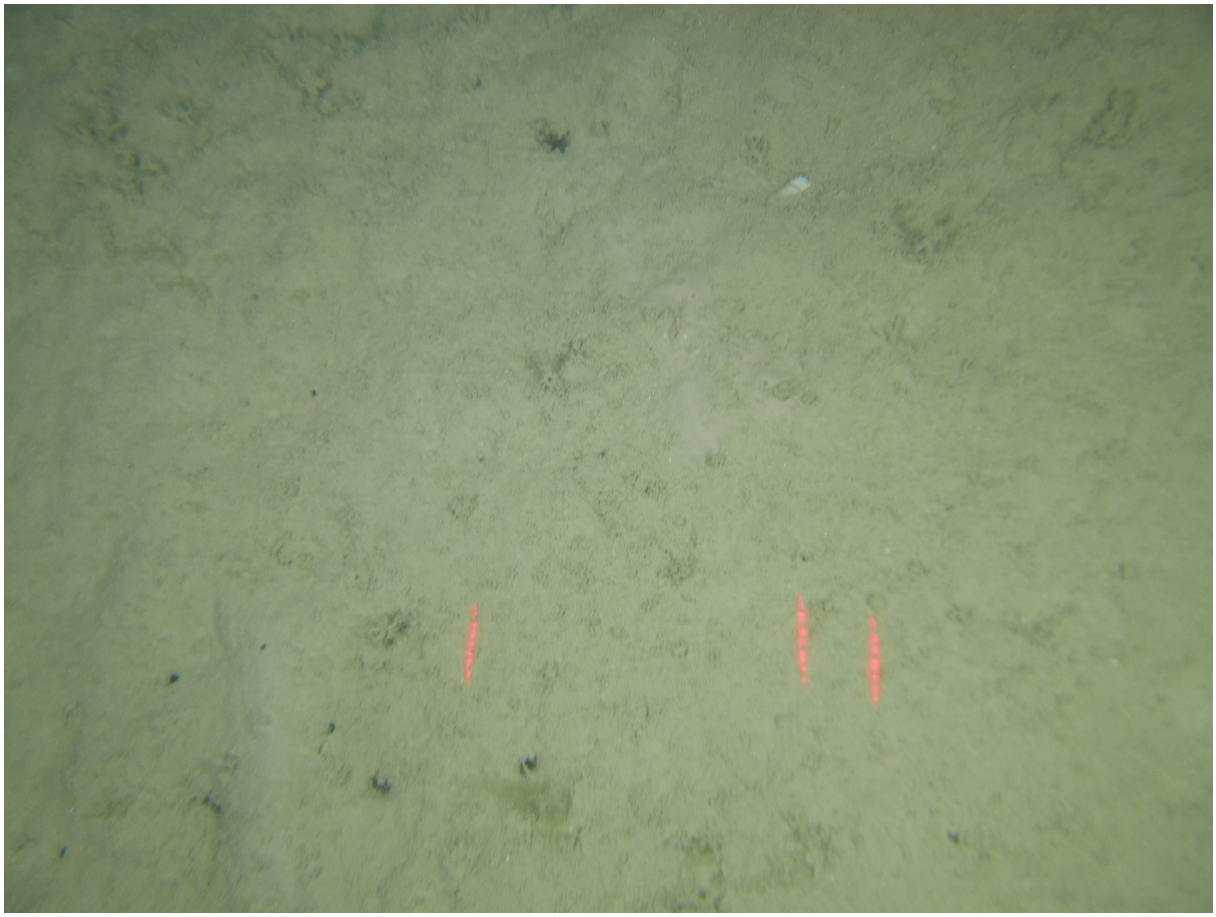


Figure 28: Fine sediments in the deeper off shoal areas surrounding Money Shoal are bare or very sparsely populated with epibenthos [image from Money Shoal TOW11]

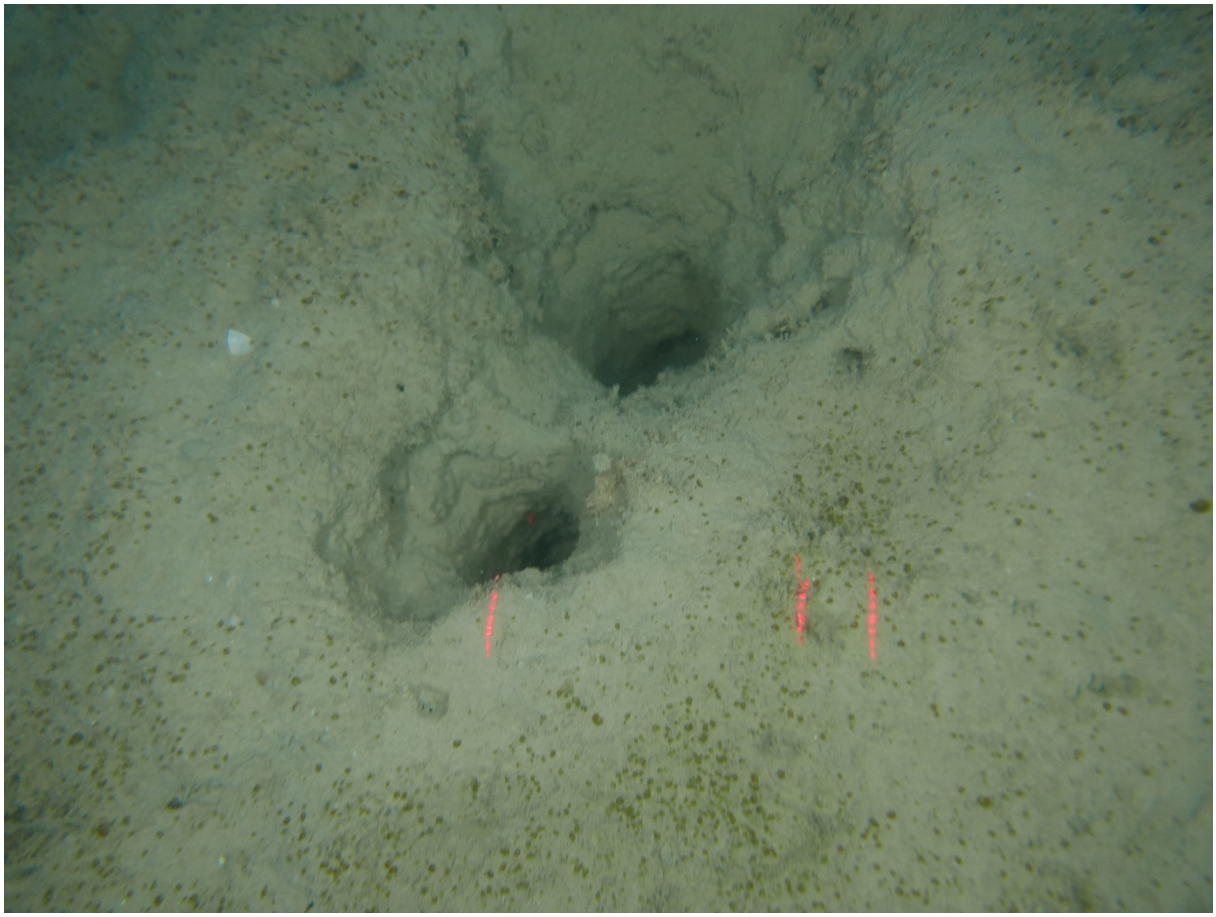


Figure 29: The benthic community on the fine off-shoal sediments is largely infaunal [image from Money Shoal TOW27].

Fishes

The fish community observed among the coral-dominated habitats was diverse and fish were abundant, typical of pristine offshore reef features (Figures 30–32). Preliminary observation indicates an abundance of a range of size classes of fish on the shoal with some notable observations including an abundance of emperors (family Lethrinidae), and some large groupers (Serranidae) and sharks. Detailed video analysis will be required to provide commentary on community composition and species abundance at Money Shoal in a regional context. As an indication of fish diversity on Money Shoal, a previous diver-based visual census survey in depths of 8-16 m identified ~149 species of fish across 29 families, with Pomacentrids and Labrids most abundant (Edgar et al., 2017; https://reeflifesurvey.imas.utas.edu.au/).

On soft substrate habitats away from the shoal the fish diversity was much lower as is typical of less structurally complex habitats (Figure 33). Species commonly observed in soft-sediment substrates in the Money Shoal area were ubiquitous across the top end of Australia, including whiptails (Family Nemipteridae), starry triggerfish (*Abalistes stellatus*) and pufferfish (*Lagocephalus* spp.) The commercially sought-after saddletail snapper (*Lutjanus malabaricus*) was commonly observed on the soft sediments habitats away from the shoal, though its distribution was patchy, possibly driven by presence of habitat structure such as pock marks.

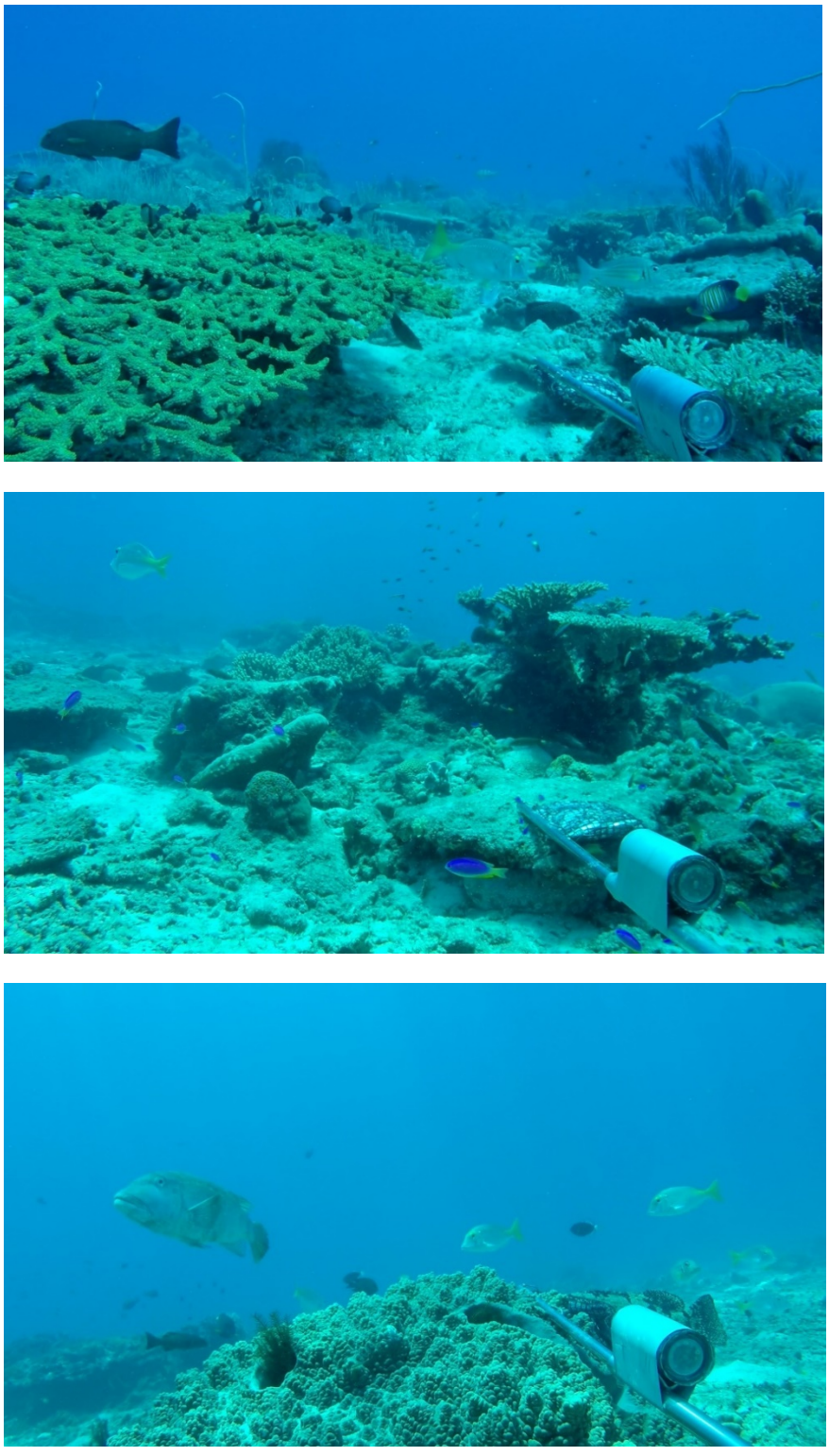


Figure 30: A diversity of coral reef associated fish species in the shallow areas of Money Shoal [Images from Money Shoal SBRUVS CAM54 (top) CAM25 (middle) CAM30 (bottom)]

Figure 31: Numerous grey reef sharks (*Carcharhinus amblyrhynchos*) were observed on SBRUVS CAM 43 although initial impressions of the overall BRUVS footage suggest sharks were not highly abundant around the shoal more generally [Image from Money Shoal SBRUVS CAM43]

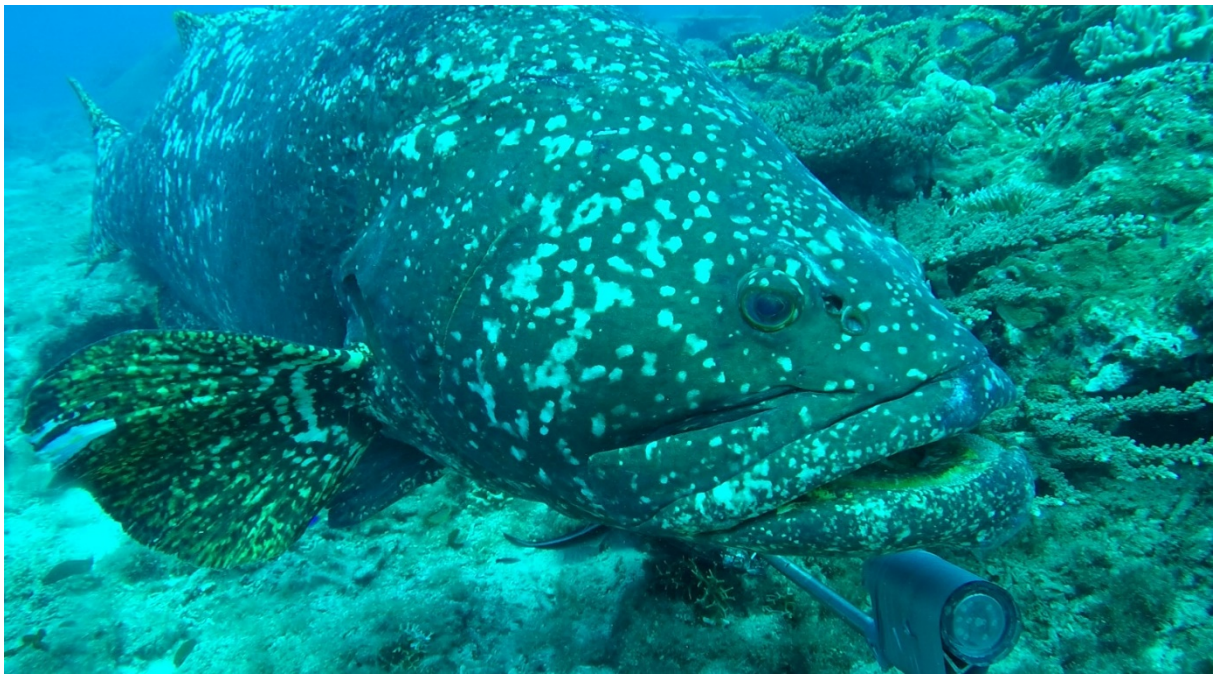


Figure 32: A particularly large specimen of the giant Queensland grouper (*Epinephelus lanceolatus*) [Image from Money Shoal SBRUVS CAM48]

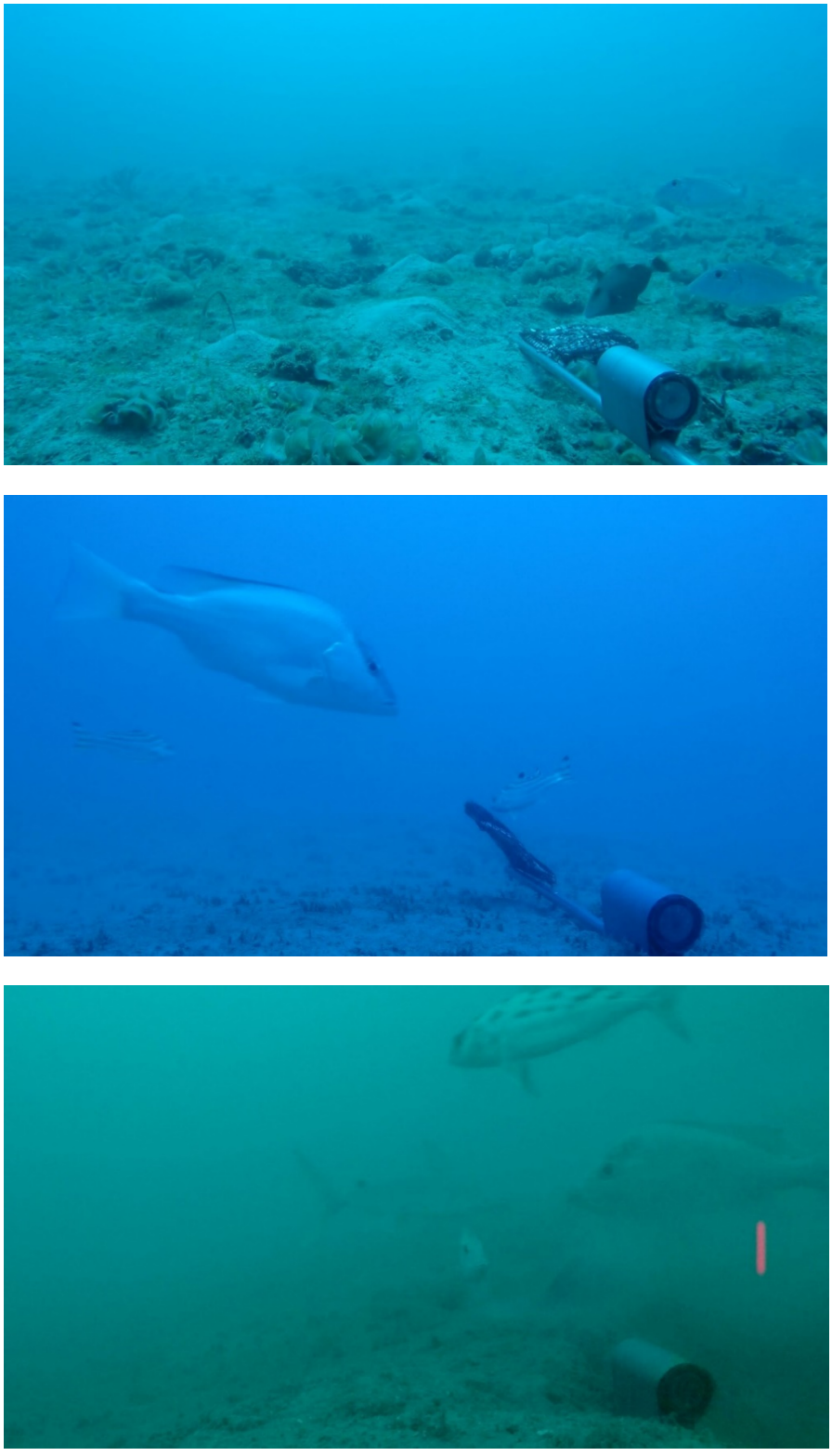


Figure 33: The fish community of soft sediment habitats in the off-shoal areas is much lower in diversity and abundance than the shoal itself. Common species in these habitats include small emperors (Family Lethrinidae), saddletail snapper (*Lutjanus malabaricus*), whiptails and threadfin breams (Family Nemipteridae) [Images from Money Shoal SBRUVS CAM50 (top) CAM12 (middle) CAM38 (bottom)]

5.3.2 Pillar Bank

The benthic communities of Pillar bank proved challenging to observe by towed video and BRUVS due to very low visibility at the seabed. This is likely a consequence of fine sediments being tidally suspended in the lowest part of the water column. The imagery obtained did, however, provide some insight into the seabed habitats and fishes throughout the Pillar Bank study area.

Benthos

The multibeam mapping showed the topography of the Pillar Bank study area to be quite diverse, however the towed video sampling revealed the diversity and abundance of benthic invertebrates to be relatively sparse throughout (Figure 34–36). In the deeper areas extensive barren areas of soft substrates were observed. Benthic fauna observations were limited to occasional small colonies of sessile filter feeders such as hydroids as well as occasional mobile invertebrates such as echinoderms. In topographically more complex areas such as the ridges and their steeper slopes, outcropping rock was observed. These hard substrates appeared to be blanketed in fine silt or mud and supported only a sparse community of filter feeders such as sponges and gorgonians

To some extent the observations of benthos in the Pillar Bank study area may have been compromised by the low visibility and resultant short range at which imaging could be undertaken, however the depth combined with the prevalence of mobile sediment and lack of ambient light in the turbid water maybe factors to suggest that this area has a relatively low abundance of epibenthic communities.

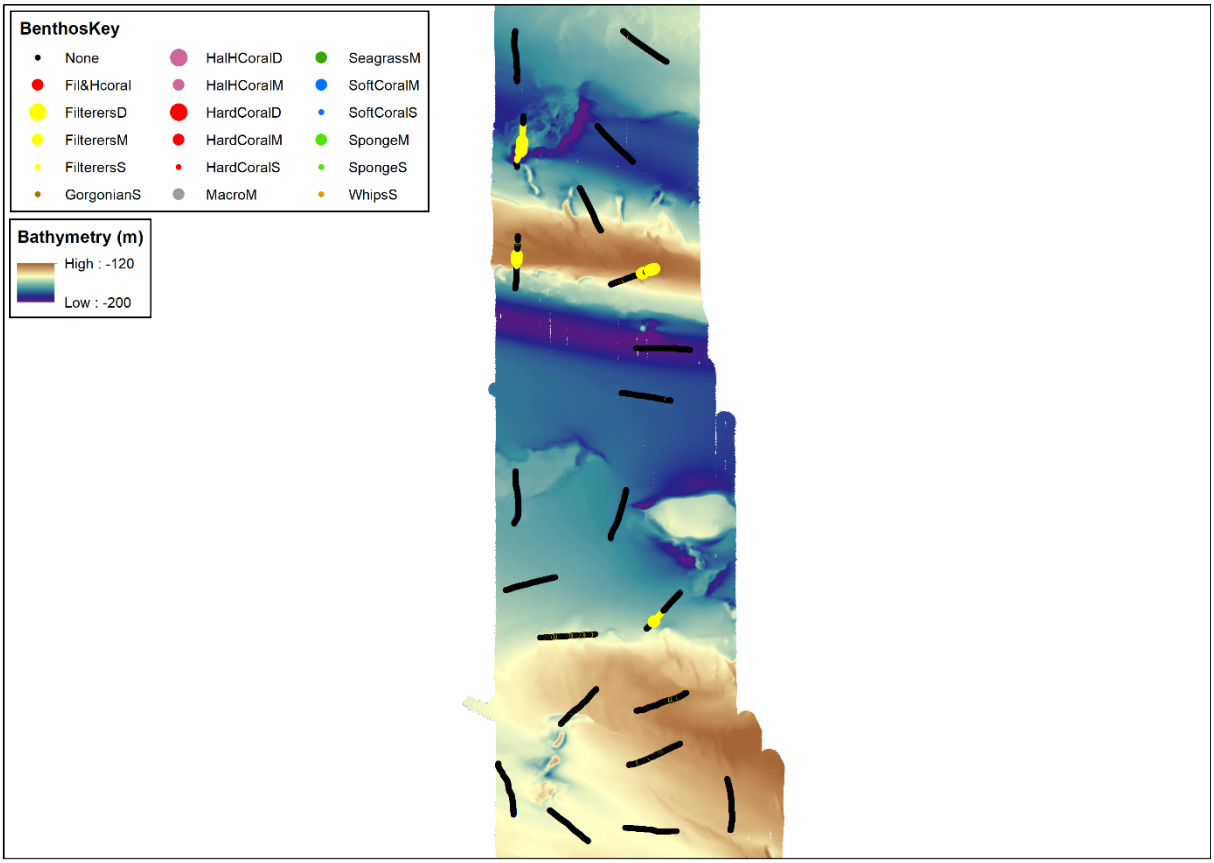
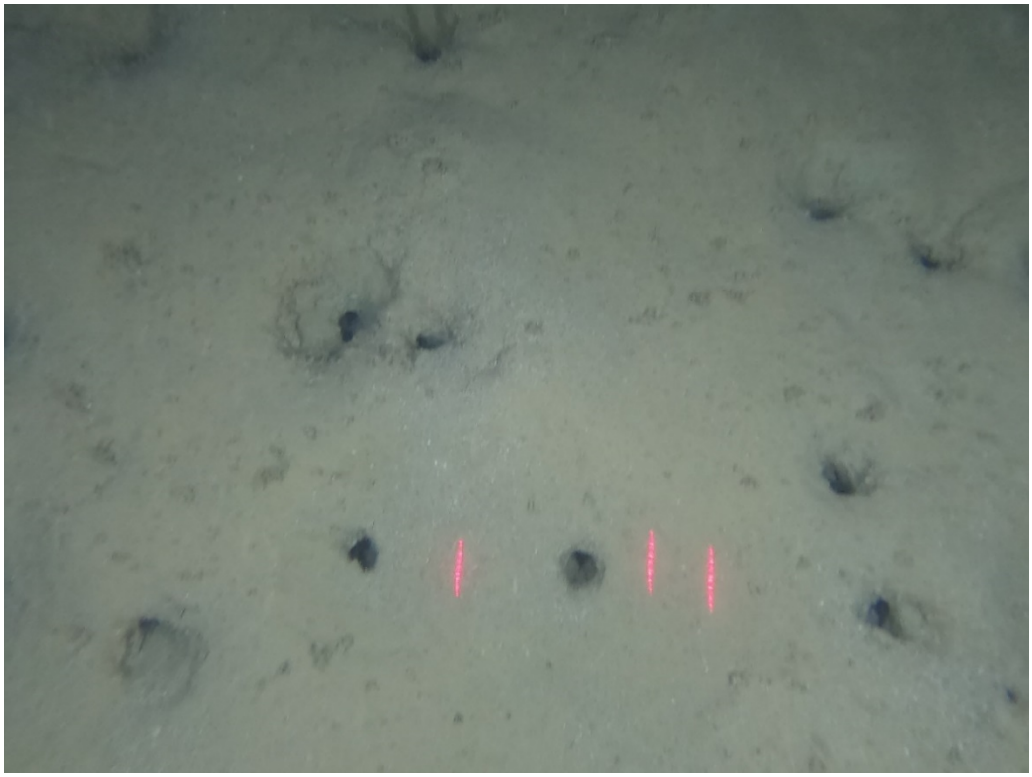


Figure 34: Benthos classes observed on towed-video transects within the Pillar Bank survey grid, highlighting a general paucity of epibenthic flora on the soft sediment plains and ridges, with filter feeders only observed on harder substrates of Pillar Bank ridge.

Figure 35: Large areas of fine mud and silt with epibenthos absent or very sparse characterised the seabed of the deeper parts of the Pillar Bank Study area [images from Pillar Bank TOW3 (top) and TOW 16 (bottom)]



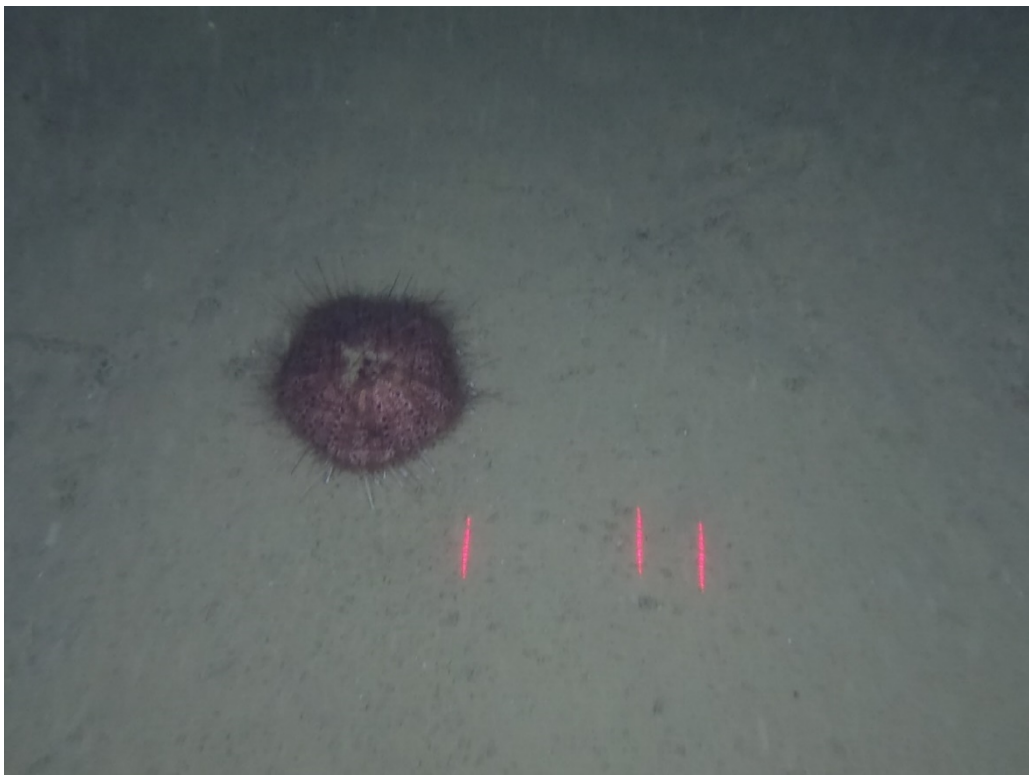


Figure 36: The extensive mud and silt areas were seen to have a low abundance of mobile benthic organisms such as sea urchins. The presence of bioturbation was patchy throughout the study area indicating infaunal communities may vary with sediment type or the hydrodynamic setting [images from Pillar Bank TOW21]

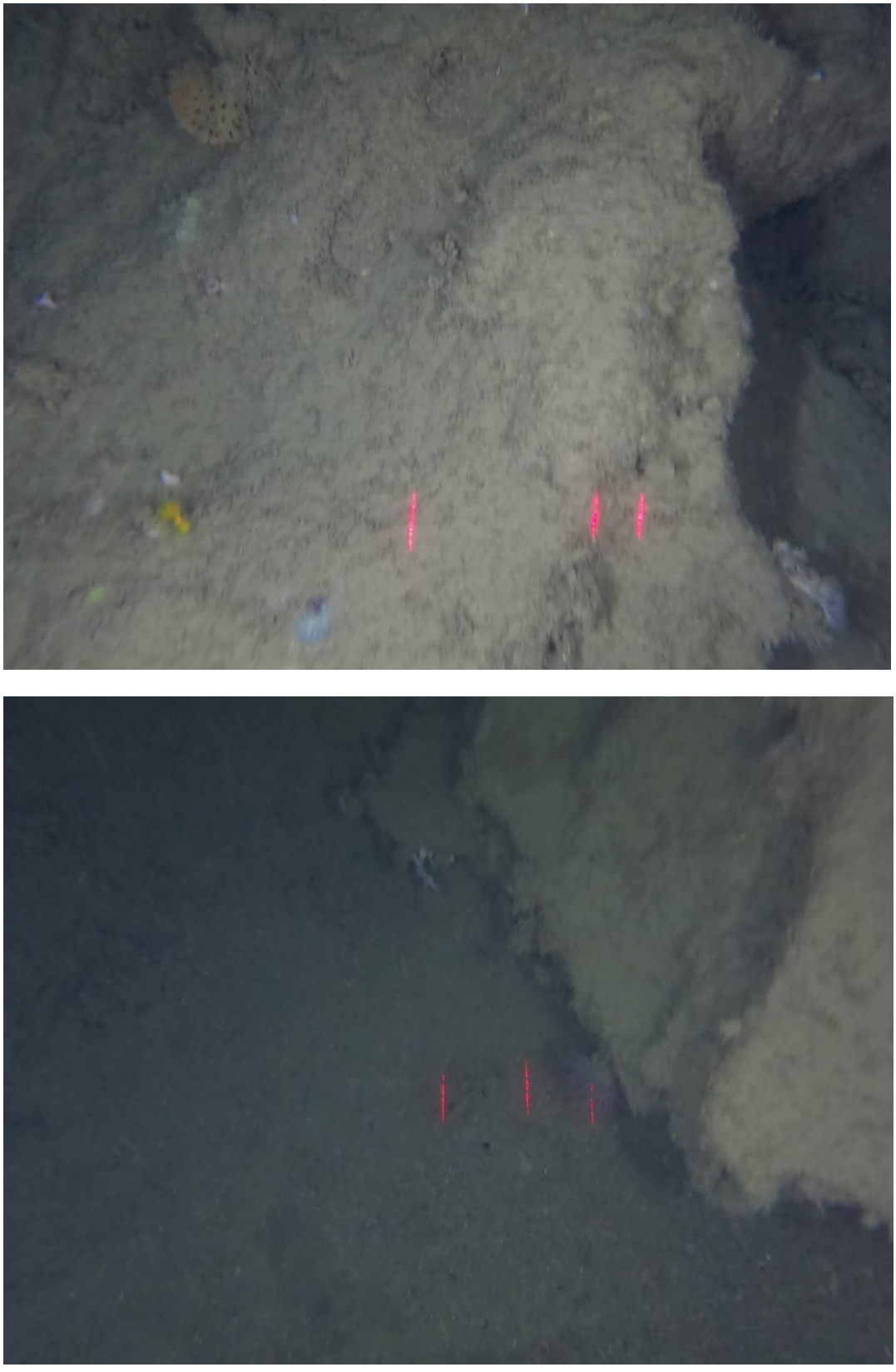


Figure 37: Rock outcrops on the ridges and canyon edges provide suitable substrates for epibenthos, however the imagery obtained indicates the outcropping hard substrates had a veneer of sediment and generally sparse epibiota [images from Pillar Bank TOW6]

Figure 38: The epibiota that was recorded in the Pillar Bank study area typically consisted of small colonies and low encrusting filter feeding organisms [image from Pillar Bank TOW11].

Figure 39: Pockets of seabed with coarser sediments were observed although they were very limited in extent [image from Pillar Bank TOW18]

Fishes

The low visibility conditions of the Pillar Bank Study area were marginal for the use of BRUVS, but was still adequate to provide an insight into the fish community composition. The fish community varied markedly with substrate. Over flat muddy and silty substrates small whiptails and threadfin breams (Family Nemipteridae) predominate (Figure 40). Some catfish (*Netuma thalassina*) and Pike eels (*Muraenesox cinereus*) were also observed in these areas (Figure 40). Fish abundance and diversity was higher in areas of coarser sediments and more topographic complexity. The commercially important gold band snapper (*Pristipomoides multidens*) was abundant over coarser unconsolidated substrates as well as around rock outcrops (Figure 41). Fish diversity and abundance was highest in these more complex outcrop areas where deep water snappers (*Pristipomoides* spp) dominated but occurred along with a several other reef-associated species including the banded grouper (*Epinephelus amblycephalus*) and seabream (*Dentex* sp.). In relative terms, the fish diversity observed at Pillar Bank was low, a pattern commonly observed in North Australian waters where the deeper areas contain considerably lower fish diversity than the shallows.

Figure 40: The expansive areas of soft, muddy and silty sediments had a low diversity fish community dominated by fishes such as whiptails (Family Nemipteridae) and pufferfish (*Lagocephalus* spp. and an occasional pike eel (*Muraenesox cinereus*) [Images from Pillar Bank SBRUVS CAM33 (top) CAM38 (middle) CAM30 (bottom)]

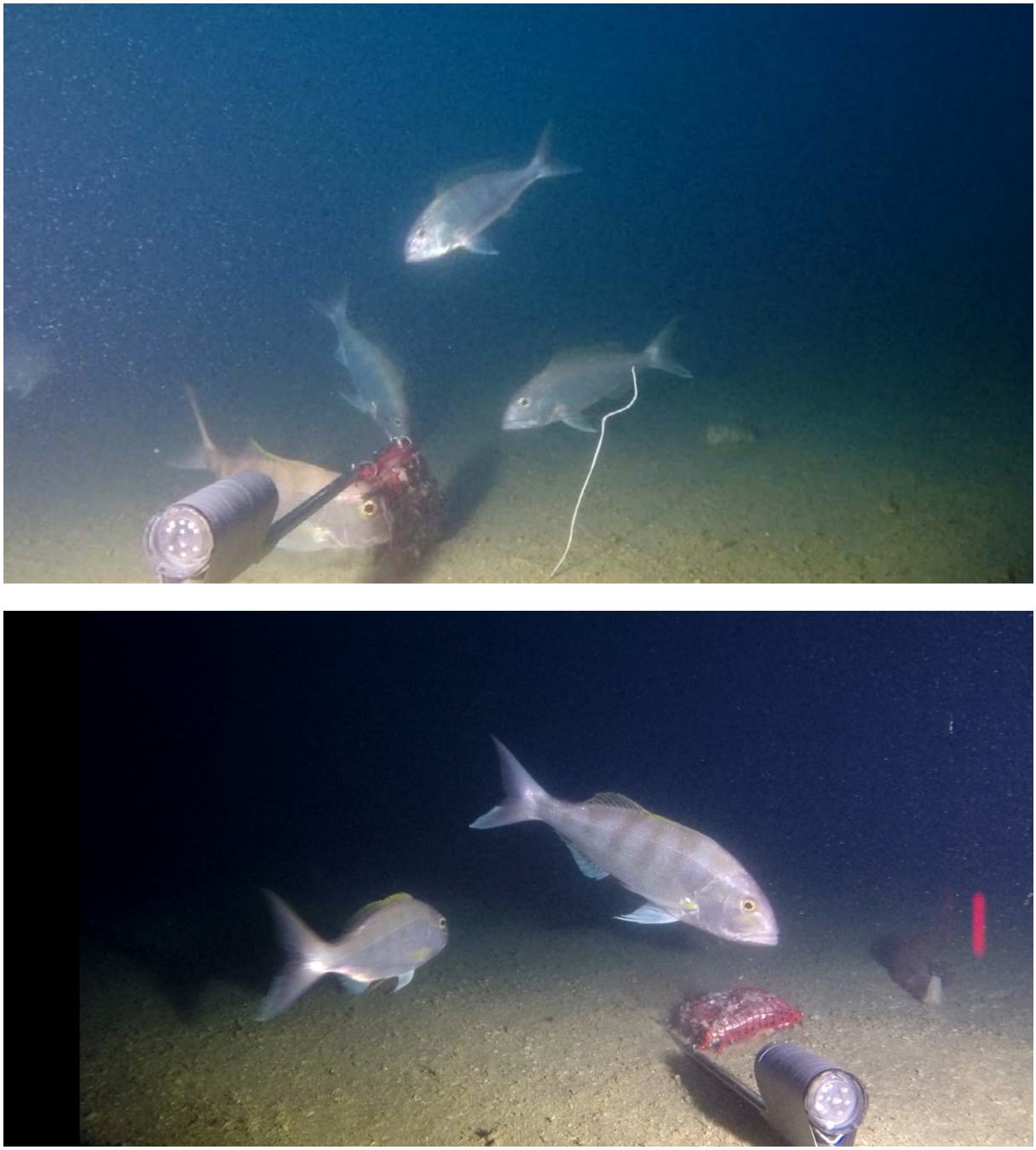


Figure 41: The commercially important gold band snapper (*Pristipomoides multidens*) was frequently recorded over areas of hard substrate and coarser sediment [Images from Pillar Bank SBRUVS CAM23 (top) and CAM36 (bottom)]

5.4 New Discoveries

Money Shoal is clearly a very rich coral reef habitat and unique within its regional setting in having exceptionally clear water and abundant hard coral communities not commonly seen in the Arafura region (Figure 42). However, detailed quantitative analysis of the imagery obtained will be required to make informed commentary on any new discoveries or unique biological features of both the Money Shoal and Pillar bank study areas. This analysis will also go towards addressing the research objectives of this survey, in particular to better understand the influence of environmental gradients (depth, light) across Arafura Marine Park.

The detailed analysis of imagery obtained of the benthic and fish communities can also be used to provide regional context and enable assessment of any unique biological attributes of this shoal. Its geographic location as a coral reef intermediate between the Pacific and Indian oceans, yet distinct from coastal reef habitats is of particular biogeographic interest for to the detailed analyses that will follow.

The quantitative analysis of the benthic imagery from Money Shoal may also provide some insight into its recent disturbance history in terms of coral bleaching, coral disease and storm damage. These aspects are topical in light of the increasing pressures on coral reef ecosystems globally and will add to knowledge of the condition of coral habitats throughout Australian waters. Even though the visibility was very poor within the deeper areas of Pillar Bank, the ridges were confirmed as hard substrate (rock) that support biological communities, albeit low in abundance and sparse in their distribution.

The high resolution seabed mapping completed for Money Shoal, Pillar Bank and surrounding areas has provided new insights into the geomorphic diversity of the seabed of Arafura Marine Park, particularly at spatial scales of metres that are important for understanding benthic habitats. Thus, features such as extensive field of small mounds on the margins of Money Shoal, pockmarks in muddy sediments of the deeper plains, depressions formed by tidal scour and isolated ridges that form raised hardground are all features that were not previously documented for the marine park. Mapping at the spatial resolution that this survey has undertaken has therefore provided a robust basis for habitat modelling as part of the next phase of this project.

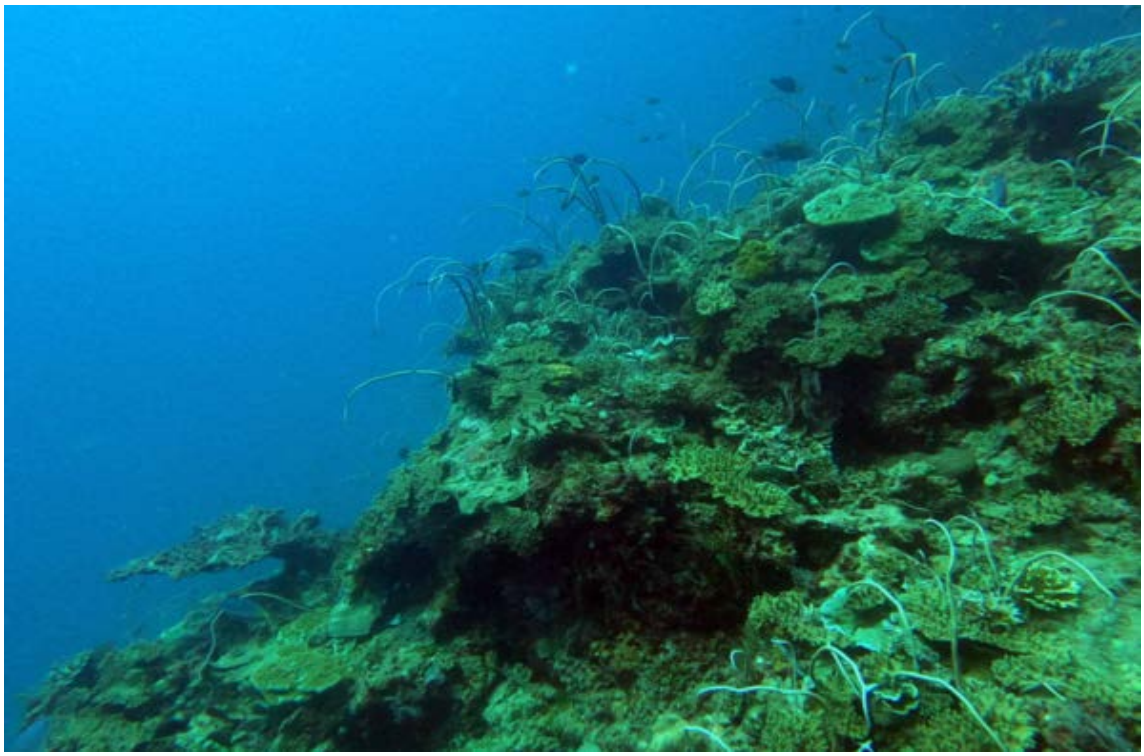


Figure 42: Money Shoal had exceptionally clear water and abundant hard corals not commonly seen offshore of Australia's Northern Territory.

6. FUTURE WORK

Quantitative analysis of imagery (benthos and fish) from the voyage will be undertaken in early 2021. Epibenthos will be quantified from digital still images from the towed video using the point-intercept method to determine percent cover of benthic groups, with benthos identified to the lowest possible taxonomic level using CATAMI classification. BRUVS videos will be analysed using EventMeasure, to determine fish species diversity and relative abundance (as MaxN). Diversity data will be summarised to provide species inventories, quantitative descriptions of the marine communities at Money Shoal and Pillar Bank as well as to inform an assessment of the regional context of the benthic and fish communities present in the Arafura Marine Park. These quantitative data will also inform an objective assessment of the effectiveness of the different survey platforms (BRUV, Towed video) for monitoring benthic communities in high energy, turbid environments.

Benthic and fish diversity and abundance data will be combined with multibeam bathymetry to predict the distribution and abundance of species across the survey areas, and maps of predicted habitat and species distributions will be developed that can be used to inform spatial planning and management actions. In addition, GA will explore the potential to generate satellite-derived bathymetry data for the shallow unmapped areas of Money Shoal.

Results from the study will be provided back to Parks Australia as an Eco-Narrative report that summarises key physical and biological characteristics of the Arafura Marine Park, including previous work undertaken on Money Shoal by Reef Life Survey. We also plan to return results to the traditional owners, ideally through visits on country and in conjunction with the Northern Land Council and Parks Australia in 2021.

7. REFERENCES

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APPENDIX A – DAILY SUMMARY OF SURVEY ACTIVITIES

2 November	Port of Darwin, vessel mobilisation; commenced transit to survey area
3 November	Transit to Money Shoal; arrived 17:00; commenced multibeam mapping of Money Shoal area
4 November	BRUV deployment, 16 stations; multibeam mapping of shallow areas around Money Shoal
5 November	BRUV deployment, 16 stations; Towvid deployment, 6 transects; multibeam mapping overnight
6 November	BRUV deployment, 16 stations; Towvid deployment, 5 transects; multibeam mapping overnight
7 November	Grab deployment, 4 stations; Towvid deployment, 10 transects; multibeam mapping overnight
8 November	Grab deployment, 16 stations; Towvid deployment, 7 transects; commenced transit to Pillar Bank study area overnight
9 November	BRUV deployment, 16 stations; Towvid deployment, 3 transects; multibeam mapping overnight
10 November	BRUV deployment, 16 stations; Towvid deployment, 4 transects; Grab deployment, 1 station; multibeam mapping overnight
11 November	Grab deployment, 9 stations; Towvid deployment, 9 transects; multibeam mapping overnight
12 November	BRUV deployment, 8 stations; Towvid deployment, 5 transects; Grab deployment, 4 stations; commenced transit to Money Shoal study area overnight
13 November	BRUV deployment, 8 stations; Towvid deployment, 5 transects; multibeam mapping overnight
14 November	Towvid deployment, 1 transects; multibeam mapping overnight an commenced transit to port
15 November	Arrived port of Darwin, demobilisation and unloading

APPENDIX B – PERSONNEL ON BOARD

Name	Principal Role	Responsibility
AIMS Personnel		
Marcus Stowar	Cruise Leader	Voyage lead, comms
Neill Roberts	Marine ecologist	TowVid operations / data management
Muhammad Wahab	Marine ecologist	BRUV operations / data management
GA Personnel		
Kim Picard	GA Lead Scientist	Geoscience lead, multibeam operation, sampling operations, comms
Justy Siwabessy	Seabed acoustician	Multibeam sonar acquisition and processing, SBP acquisition

APPENDIX C – SAMPLES LISTS

TOWED VIDEO

Sample	Longitude	Latitude	Depth	UTC Time	Gear	Repository
NESP_7491_MoneyShoal_Tow1	132.7468	-10.3300	12.9	05/11/2020 03:57	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow1	132.7464	-10.3166	68.9	05/11/2020 04:27	Tow End	AIMS
NESP_7491_MoneyShoal_Tow2	132.7608	-10.3184	69.3	05/11/2020 04:48	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow2	132.7727	-10.3124	70.1	05/11/2020 05:22	Tow End	AIMS
NESP_7491_MoneyShoal_Tow3	132.7640	-10.2935	71.3	05/11/2020 05:39	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow3	132.7767	-10.3003	71.4	05/11/2020 06:21	Tow End	AIMS
NESP_7491_MoneyShoal_Tow4	132.7886	-10.3253	67.5	05/11/2020 06:36	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow4	132.7929	-10.3387	65.3	05/11/2020 07:04	Tow End	AIMS
NESP_7491_MoneyShoal_Tow5	132.7727	-10.3383	64.2	05/11/2020 07:18	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow5	132.7814	-10.3502	61.6	05/11/2020 07:47	Tow End	AIMS
NESP_7491_MoneyShoal_Tow6	132.7661	-10.3709	66.4	05/11/2020 08:04	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow6	132.7787	-10.3637	62.5	05/11/2020 08:39	Tow End	AIMS
NESP_7491_MoneyShoal_Tow7	132.6867	-10.3066	65.9	06/11/2020 04:21	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow7	132.6757	-10.3158	61.9	06/11/2020 04:56	Tow End	AIMS
NESP_7491_MoneyShoal_Tow8	132.6746	-10.3003	67.1	06/11/2020 05:34	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow8	132.6616	-10.3053	64.3	06/11/2020 06:06	Tow End	AIMS
NESP_7491_MoneyShoal_Tow9	132.7032	-10.3168	9.5	06/11/2020 06:35	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow9	132.6888	-10.3165	58.8	06/11/2020 07:03	Tow End	AIMS
NESP_7491_MoneyShoal_Tow10	132.6601	-10.3334	67.7	06/11/2020 07:20	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow10	132.6676	-10.3463	70.1	06/11/2020 07:57	Tow End	AIMS
NESP_7491_MoneyShoal_Tow11	132.6856	-10.3316	68.8	06/11/2020 08:11	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow11	132.6923	-10.3436	70.3	06/11/2020 08:35	Tow End	AIMS
NESP_7491_MoneyShoal_Tow12	132.7325	-10.3008	71.4	06/11/2020 22:28	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow12	132.7215	-10.2909	72.1	06/11/2020 23:01	Tow End	AIMS
NESP_7491_MoneyShoal_Tow13	132.7232	-10.3161	10.9	06/11/2020 23:48	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow13	132.7308	-10.3040	70.1	07/11/2020 00:18	Tow End	AIMS
NESP_7491_MoneyShoal_Tow14	132.7379	-10.3254	12	07/11/2020 00:33	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow14	132.7330	-10.3119	67.9	07/11/2020 00:54	Tow End	AIMS
NESP_7491_MoneyShoal_Tow15	132.7535	-10.2997	72.1	07/11/2020 01:08	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow15	132.7432	-10.3097	69.9	07/11/2020 01:43	Tow End	AIMS
NESP_7491_MoneyShoal_Tow16	132.7044	-10.2875	68.5	07/11/2020 02:07	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow16	132.7076	-10.3017	69	07/11/2020 02:53	Tow End	AIMS
NESP_7491_MoneyShoal_Tow17	132.6596	-10.3686	67.3	07/11/2020 04:44	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow17	132.6744	-10.3692	68.2	07/11/2020 05:24	Tow End	AIMS
NESP_7491_MoneyShoal_Tow18	132.6812	-10.3530	71.7	07/11/2020 05:45	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow18	132.6901	-10.3657	71.6	07/11/2020 06:23	Tow End	AIMS

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NESP_7491_MoneyShoal_Tow19	132.7014	-10.3572	69.9	07/11/2020 07:15	Tow End	AIMS
NESP_7491_MoneyShoal_Tow20	132.7201	-10.3422	19.3	07/11/2020 07:31	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow20	132.7079	-10.3496	68	07/11/2020 08:07	Tow End	AIMS
NESP_7491_MoneyShoal_Tow21	132.7153	-10.3538	71.6	07/11/2020 08:17	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow21	132.7178	-10.3680	72.1	07/11/2020 08:47	Tow End	AIMS
NESP_7491_MoneyShoal_Tow22	132.7047	-10.3142	11.2	08/11/2020 00:35	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow22	132.7175	-10.3146	11.6	08/11/2020 01:11	Tow End	AIMS
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NESP_7491_MoneyShoal_Tow24	132.7335	-10.3463	12.5	08/11/2020 03:48	Tow Start	AIMS
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NESP_7491_MoneyShoal_Tow28	132.7528	-10.3429	9.6	08/11/2020 07:04	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow28	132.7520	-10.3289	67.7	08/11/2020 07:35	Tow End	AIMS
NESP_7491_MoneyShoal_Tow29	132.7223	-10.3453	27.7	13/11/2020 03:36	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow29	132.7328	-10.3543	65.9	13/11/2020 04:03	Tow End	AIMS
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NESP_7491_MoneyShoal_Tow32	132.7085	-10.3124	12.5	13/11/2020 05:54	Tow Start	AIMS
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NESP_7491_MoneyShoal_Tow8a	132.6747	-10.3004	67.6	13/11/2020 08:35	Tow End	AIMS
NESP_7491_MoneyShoal_Tow21a	132.7177	-10.3682	71.4	13/11/2020 23:27	Tow Start	AIMS
NESP_7491_MoneyShoal_Tow21a	132.7153	-10.3540	71	13/11/2020 23:56	Tow End	AIMS
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PillarBank_Tow1	133.5020	-9.2981	135.1	09/11/2020 05:31	Tow End	AIMS
PillarBank_Tow2	133.5116	-9.3037	133.4	09/11/2020 07:07	Tow Start	AIMS
PillarBank_Tow2	133.5250	-9.2990	127.3	09/11/2020 07:46	Tow End	AIMS
PillarBank_Tow3	133.5098	-9.3175	142.4	09/11/2020 08:06	Tow Start	AIMS
PillarBank_Tow3	133.5236	-9.3117	128.6	09/11/2020 08:45	Tow End	AIMS

PillarBank_Tow4	133.4780	-9.2732	162.1	10/11/2020 05:12	Tow Start	AIMS
PillarBank_Tow4	133.4917	-9.2696	166.8	10/11/2020 05:49	Tow End	AIMS
PillarBank_Tow5	133.4811	-9.2568	168.5	10/11/2020 06:11	Tow Start	AIMS
PillarBank_Tow5	133.4816	-9.2427	169.4	10/11/2020 06:46	Tow End	AIMS
PillarBank_Tow6	133.4812	-9.1970	174.6	10/11/2020 07:11	Tow Start	AIMS
PillarBank_Tow6	133.4822	-9.1830	124.2	10/11/2020 07:47	Tow End	AIMS
PillarBank_Tow7	133.4820	-9.1448	179.5	10/11/2020 08:05	Tow Start	AIMS
PillarBank_Tow7	133.4815	-9.1309	167.5	10/11/2020 08:43	Tow End	AIMS
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PillarBank_Tow9	133.5069	-9.2230	182.5	11/11/2020 01:40	Tow Start	AIMS
PillarBank_Tow9	133.5210	-9.2247	184.2	11/11/2020 02:13	Tow End	AIMS
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PillarBank_Tow10	133.5098	-9.2475	179.9	11/11/2020 03:11	Tow End	AIMS
PillarBank_Tow11	133.5142	-9.2839	155.4	11/11/2020 03:53	Tow Start	AIMS
PillarBank_Tow11	133.5234	-9.2736	173	11/11/2020 04:27	Tow End	AIMS
PillarBank_Tow12	133.5042	-9.2840	158	11/11/2020 04:44	Tow Start	AIMS
PillarBank_Tow12	133.4879	-9.2851	151.6	11/11/2020 05:17	Tow End	AIMS
PillarBank_Tow13	133.4776	-9.3158	150.8	11/11/2020 05:33	Tow Start	AIMS
PillarBank_Tow13	133.4810	-9.3302	148.7	11/11/2020 06:09	Tow End	AIMS
PillarBank_Tow14	133.4889	-9.3285	153.3	11/11/2020 06:22	Tow Start	AIMS
PillarBank_Tow14	133.5000	-9.3367	147.2	11/11/2020 06:58	Tow End	AIMS
PillarBank_Tow15	133.5082	-9.3330	147.9	11/11/2020 07:12	Tow Start	AIMS
PillarBank_Tow15	133.5242	-9.3341	141.2	11/11/2020 07:49	Tow End	AIMS
PillarBank_Tow16	133.5363	-9.3352	139	11/11/2020 08:01	Tow Start	AIMS
PillarBank_Tow16	133.5354	-9.3209	129.5	11/11/2020 08:29	Tow End	AIMS
PillarBank_Tow17	133.5042	-9.1958	149.5	12/11/2020 06:39	Tow Start	AIMS
PillarBank_Tow17	133.5173	-9.1912	121.3	12/11/2020 07:14	Tow End	AIMS
PillarBank_Tow18	133.5044	-9.1833	130.1	12/11/2020 07:35	Tow Start	AIMS
PillarBank_Tow18	133.4980	-9.1708	169.5	12/11/2020 08:05	Tow End	AIMS
PillarBank_Tow19	133.4822	-9.1662	169	12/11/2020 08:18	Tow Start	AIMS
PillarBank_Tow19	133.4836	-9.1525	185.1	12/11/2020 08:58	Tow End	AIMS
PillarBank_Tow20	133.5011	-9.1540	188.1	12/11/2020 09:30	Tow Start	AIMS
PillarBank_Tow20	133.5114	-9.1640	188.2	12/11/2020 10:04	Tow End	AIMS
PillarBank_Tow21	133.5082	-9.1301	159	12/11/2020 10:27	Tow Start	AIMS
PillarBank_Tow21	133.5200	-9.1387	162.1	12/11/2020 11:11	Tow End	AIMS

SBRUVS

Sample	Longitude	Latitude	Depth	UTC Time	Repository
MoneyShoal_CAM1_RIG23	132.7139	-10.3469	69.5	03/11/2020 22:33	AIMS
MoneyShoal_CAM2_RIG24	132.7076	-10.3444	66.4	03/11/2020 22:37	AIMS
MoneyShoal_CAM3_RIG25	132.6947	-10.3469	69.3	03/11/2020 22:43	AIMS
MoneyShoal_CAM4_RIG26	132.7018	-10.3534	70.1	03/11/2020 22:48	AIMS
MoneyShoal_CAM5_RIG27	132.6853	-10.3643	70.6	03/11/2020 22:58	AIMS
MoneyShoal_CAM6_RIG28	132.6662	-10.3689	68.2	03/11/2020 23:06	AIMS
MoneyShoal_CAM7_RIG29	132.6572	-10.3633	67.9	03/11/2020 23:11	AIMS
MoneyShoal_CAM8_RIG30	132.6650	-10.3522	68.6	03/11/2020 23:18	AIMS
MoneyShoal_CAM9_RIG30	132.6854	-10.3149	59	04/11/2020 01:40	AIMS
MoneyShoal_CAM10_RIG29	132.6625	-10.3193	64.9	04/11/2020 01:50	AIMS
MoneyShoal_CAM11_RIG28	132.6583	-10.3050	64.8	04/11/2020 01:57	AIMS
MoneyShoal_CAM12_RIG27	132.6721	-10.3006	66	04/11/2020 02:05	AIMS
MoneyShoal_CAM13_RIG26	132.6899	-10.2933	68	04/11/2020 02:14	AIMS
MoneyShoal_CAM14_RIG25	132.7273	-10.2934	71.6	04/11/2020 02:33	AIMS
MoneyShoal_CAM15_RIG24	132.7272	-10.3060	68	04/11/2020 02:40	AIMS
MoneyShoal_CAM16_RIG23	132.7191	-10.3051	60.7	04/11/2020 02:44	AIMS
MoneyShoal_CAM17_RIG23	132.7855	-10.3052	72.3	04/11/2020 22:08	AIMS
MoneyShoal_CAM18_RIG24	132.7773	-10.2950	71.9	04/11/2020 22:15	AIMS
MoneyShoal_CAM19_RIG25	132.7644	-10.2936	72.3	04/11/2020 22:21	AIMS
MoneyShoal_CAM20_RIG26	132.7508	-10.2906	74.5	04/11/2020 22:31	AIMS
MoneyShoal_CAM21_RIG27	132.7545	-10.3090	70.4	04/11/2020 22:39	AIMS
MoneyShoal_CAM22_RIG28	132.7702	-10.3112	72.1	04/11/2020 22:46	AIMS
MoneyShoal_CAM23_RIG29	132.7785	-10.3167	71.1	04/11/2020 22:51	AIMS
MoneyShoal_CAM24_RIG30	132.7942	-10.3261	68.4	04/11/2020 22:59	AIMS
MoneyShoal_CAM25_RIG30	132.7186	-10.3144	11.7	05/11/2020 00:52	AIMS
MoneyShoal_CAM26_RIG29	132.7241	-10.3150	16.1	05/11/2020 00:55	AIMS
MoneyShoal_CAM27_RIG28	132.7271	-10.3183	12.2	05/11/2020 00:58	AIMS
MoneyShoal_CAM28_RIG27	132.7321	-10.3206	14.5	05/11/2020 01:02	AIMS
MoneyShoal_CAM29_RIG26	132.7360	-10.3239	12.9	05/11/2020 01:05	AIMS
MoneyShoal_CAM30_RIG25	132.7411	-10.3263	14	05/11/2020 01:09	AIMS
MoneyShoal_CAM31_RIG24	132.7542	-10.3323	63.8	05/11/2020 01:16	AIMS
MoneyShoal_CAM32_RIG23	132.7533	-10.3399	11.9	05/11/2020 01:22	AIMS
MoneyShoal_CAM33_RIG23	132.7323	-10.3646	84.1	05/11/2020 22:00	AIMS
MoneyShoal_CAM34_RIG24	132.7369	-10.3568	70.5	05/11/2020 22:04	AIMS
MoneyShoal_CAM35_RIG25	132.7535	-10.3576	86.7	05/11/2020 22:11	AIMS
MoneyShoal_CAM36_RIG26	132.7641	-10.3545	64.6	05/11/2020 22:17	AIMS
MoneyShoal_CAM37_RIG27	132.7655	-10.3455	72.4	05/11/2020 22:22	AIMS
MoneyShoal_CAM38_RIG28	132.7741	-10.3312	72.5	05/11/2020 22:29	AIMS
MoneyShoal_CAM39_RIG29	132.7919	-10.3623	71.4	05/11/2020 22:43	AIMS
MoneyShoal_CAM40_RIG30	132.7755	-10.3620	85.6	05/11/2020 22:51	AIMS
MoneyShoal_CAM41_RIG30	132.7545	-10.3449	62.8	06/11/2020 00:47	AIMS

Sample	Longitude	Latitude	Depth	UTC Time	Repository
MoneyShoal_CAM42_RIG29	132.7432	-10.3490	21.7	06/11/2020 00:53	AIMS
MoneyShoal_CAM43_RIG28	132.7391	-10.3479	11.9	06/11/2020 00:57	AIMS
MoneyShoal_CAM44_RIG27	132.7240	-10.3465	25.8	06/11/2020 01:05	AIMS
MoneyShoal_CAM45_RIG26	132.7144	-10.3353	14	06/11/2020 01:12	AIMS
MoneyShoal_CAM46_RIG25	132.7075	-10.3307	57.7	06/11/2020 01:16	AIMS
MoneyShoal_CAM47_RIG244	132.7040	-10.3252	52.6	06/11/2020 01:20	AIMS
MoneyShoal_CAM48_RIG23	132.7067	-10.3122	14	06/11/2020 01:28	AIMS
MoneyShoal_CAM49_RIG23	132.6999	-10.3146	43	12/11/2020 23:20	AIMS
MoneyShoal_CAM50_RIG24	132.7098	-10.3100	28.2	12/11/2020 23:26	AIMS
MoneyShoal_CAM51_RIG25	132.7308	-10.3177	34.2	12/11/2020 23:36	AIMS
MoneyShoal_CAM52_RIG26	132.7269	-10.3063	68.2	12/11/2020 23:42	AIMS
MoneyShoal_CAM53_RIG30	132.7509	-10.3321	50.1	12/11/2020 23:55	AIMS
MoneyShoal_CAM54_RIG29	132.7295	-10.3483	14.7	13/11/2020 00:10	AIMS
MoneyShoal_CAM55_RIG28	132.7221	-10.3527	58.6	13/11/2020 00:14	AIMS
MoneyShoal_CAM56_RIG27	132.7159	-10.3587	67.7	13/11/2020 00:18	AIMS
MoneyShoal_CAM57_RIG27	132.7221	-10.3523	57.3	13/11/2020 01:57	AIMS
PillarBank_CAM1_RIG23	133.4858	-9.3344	148.6	08/11/2020 22:51	AIMS
PillarBank_CAM2_RIG24	133.5046	-9.3284	150.3	08/11/2020 23:07	AIMS
PillarBank_CAM3_RIG25	133.5145	-9.3235	143.3	08/11/2020 23:13	AIMS
PillarBank_CAM4_RIG26	133.5183	-9.3273	142.5	08/11/2020 23:17	AIMS
PillarBank_CAM5_RIG27	133.5288	-9.3350	140.3	08/11/2020 23:23	AIMS
PillarBank_CAM6_RIG28	133.5447	-9.3204	126	08/11/2020 23:33	AIMS
PillarBank_CAM7_RIG29	133.5348	-9.3193	129.9	08/11/2020 23:39	AIMS
PillarBank_CAM8_RIG30	133.5320	-9.3089	123.8	08/11/2020 23:47	AIMS
PillarBank_CAM9_RIG30	133.5249	-9.3078	124.7	09/11/2020 01:39	AIMS
PillarBank_CAM10_RIG29	133.5233	-9.3135	131.4	09/11/2020 01:44	AIMS
PillarBank_CAM11_RIG28	133.5095	-9.3126	140.2	09/11/2020 01:51	AIMS
PillarBank_CAM12_RIG27	133.5072	-9.3086	135.6	09/11/2020 01:55	AIMS
PillarBank_CAM13_RIG26	133.5129	-9.3019	132.5	09/11/2020 02:01	AIMS
PillarBank_CAM14_RIG25	133.4957	-9.2933	140.8	09/11/2020 02:10	AIMS
PillarBank_CAM15_RIG24	133.4872	-9.2906	145.1	09/11/2020 02:14	AIMS
PillarBank_CAM16_RIG23	133.4789	-9.3048	147.7	09/11/2020 02:23	AIMS
PillarBank_CAM17_RIG23	133.5029	-9.1588	186.1	09/11/2020 22:17	AIMS
PillarBank_CAM18_RIG24	133.4787	-9.1587	183.1	09/11/2020 22:29	AIMS
PillarBank_CAM19_RIG25	133.4786	-9.1869	126.9	09/11/2020 22:41	AIMS
PillarBank_CAM20_RIG26	133.4942	-9.2194	182	09/11/2020 22:55	AIMS
PillarBank_CAM21_RIG27	133.5115	-9.2076	189	09/11/2020 23:07	AIMS
PillarBank_CAM22_RIG28	133.5207	-9.1833	146.4	09/11/2020 23:17	AIMS
PillarBank_CAM23_RIG29	133.5105	-9.1868	122.5	09/11/2020 23:24	AIMS
PillarBank_CAM24_RIG30	133.4943	-9.1778	142.9	09/11/2020 23:33	AIMS
PillarBank_CAM25_RIG30	133.4823	-9.2133	181.6	10/11/2020 01:54	AIMS
PillarBank_CAM26_RIG29	133.4817	-9.2203	179.5	10/11/2020 01:58	AIMS
PillarBank_CAM27_RIG28	133.4805	-9.2293	179.2	10/11/2020 02:02	AIMS

Sample	Longitude	Latitude	Depth	UTC Time	Repository
PillarBank_CAM28_RIG27	133.5006	-9.2379	180.1	10/11/2020 02:14	AIMS
PillarBank_CAM29_RIG26	133.4920	-9.2601	170.7	10/11/2020 02:23	AIMS
PillarBank_CAM30_RIG25	133.4877	-9.2639	168.6	10/11/2020 02:26	AIMS
PillarBank_CAM31_RIG24	133.4851	-9.2691	166.2	10/11/2020 02:30	AIMS
PillarBank_CAM32_RIG23	133.5005	-9.2732	171.2	10/11/2020 02:38	AIMS
PillarBank_CAM33_RIG23	133.5186	-9.1423	164	11/11/2020 22:18	AIMS
PillarBank_CAM34_RIG24	133.5225	-9.1599	184.9	11/11/2020 22:26	AIMS
PillarBank_CAM35_RIG25	133.5208	-9.1742	171.4	11/11/2020 22:33	AIMS
PillarBank_CAM36_RIG26	133.5209	-9.1918	123.4	11/11/2020 22:41	AIMS
PillarBank_CAM37_RIG27	133.5188	-9.2420	185.2	11/11/2020 23:00	AIMS
PillarBank_CAM38_RIG28	133.5238	-9.2539	153.2	11/11/2020 23:07	AIMS
PillarBank_CAM39_RIG29	133.5236	-9.2627	186.4	11/11/2020 23:12	AIMS
PillarBank_CAM40_RIG30	133.5198	-9.2838	147.5	11/11/2020 23:22	AIMS

CTD CASTS

Sample	Longitude	Latitude	Depth	UTC Time	Repository
NESP_7491_MoneyShoal_CTD1	132.7152	-10.3027	65.7	04/11/2020 04:41	AIMS
NESP_7491_MoneyShoal_CTD2	132.7598	-10.3389	2.5	05/11/2020 02:43	AIMS
NESP_7491_MoneyShoal_CTD3	132.6954	-10.3094	61.4	06/11/2020 04:07	AIMS
NESP_7491_MoneyShoal_CTD4	132.6897	-10.3386	70.6	07/11/2020 04:21	AIMS
NESP_7491_MoneyShoal_CTD5	132.7125	-10.3383	62.1	08/11/2020 02:22	AIMS
NESP_7491_MoneyShoal_CTD6	132.7213	-10.3856	72.1	13/11/2020 23:09	AIMS
NESP_7491_PillarBank_CTD1	133.5255	-9.3100	126.5	09/11/2020 08:52	AIMS
NESP_7491_PillarBank_CTD2	133.4786	-9.1306	172	10/11/2020 09:04	AIMS
NESP_7491_PillarBank_CTD3	133.5270	-9.3396	146	10/11/2020 22:03	AIMS
NESP_7491_PillarBank_CTD4	133.5343	-9.3185	127.8	11/11/2020 08:35	AIMS

SEDIMENT GRABS (all samples collected using a Smith-McIntyre grab)

Sample	Longitude	Latitude	Depth	Repository
NESP_7491_MoneyShoal_GRAB01	-10.34	132.67	69.9	GA
NESP_7491_MoneyShoal_GRAB02	-10.37	132.67	67.5	GA
NESP_7491_MoneyShoal_GRAB03	-10.31	132.67	62.1	GA
NESP_7491_MoneyShoal_GRAB04	-10.31	132.66	64.9	GA
NESP_7491_MoneyShoal_GRAB04	-10.30	132.73	71.2	GA
NESP_7491_MoneyShoal_GRAB05	-10.31	132.74	70.3	GA
NESP_7491_MoneyShoal_GRAB06	-10.31	132.73	67.8	GA
NESP_7491_MoneyShoal_GRAB07	-10.31	132.73	54.9	GA
NESP_7491_MoneyShoal_GRAB08	-10.29	132.71	69.5	GA
NESP_7491_MoneyShoal_GRAB09	-10.30	132.67	65.7	GA
NESP_7491_MoneyShoal_GRAB10	-10.31	132.69	65.2	GA
NESP_7491_MoneyShoal_GRAB11	-10.32	132.69	58.2	GA
NESP_7491_MoneyShoal_GRAB12	-10.34	132.69	71.6	GA
NESP_7491_MoneyShoal_GRAB13	-10.30	132.77	71.9	GA
NESP_7491_MoneyShoal_GRAB14	-10.31	132.77	69.6	GA
NESP_7491_MoneyShoal_GRAB15	-10.32	132.75	72.1	GA
NESP_7491_MoneyShoal_GRAB16	-10.33	132.75	58.6	GA
NESP_7491_MoneyShoal_GRAB17	-10.33	132.79	66.3	GA
NESP_7491_MoneyShoal_GRAB18	-10.34	132.78	61.6	GA
NESP_7491_MoneyShoal_GRAB19	-10.37	132.77	63.5	GA
NESP_7491_MoneyShoal_GRAB20	-10.36	132.76	64.1	GA
NESP_7491_MoneyShoal_GRAB21	-10.36	132.74	65.2	GA
NESP_7491_MoneyShoal_GRAB22	-10.35	132.74	62.1	GA
NESP_7491_MoneyShoal_GRAB23	-10.36	132.73	67.2	GA
NESP_7491_MoneyShoal_GRAB24	-10.35	132.71	68.7	GA
NESP_7491_MoneyShoal_GRAB25	-10.36	132.70	70.3	GA
NESP_7491_MoneyShoal_GRAB26	-10.36	132.69	70.8	GA
NESP_7491_MoneyShoal_GRAB27	-10.33	132.71	34	GA
NESP_7491_MoneyShoal_GRAB28	-10.31	132.70	43.7	GA
NESP_7491_MoneyShoal_GRAB29	-10.36	132.72	69.9	GA
NESP_7491_PillarBank_GRAB30	-9.13	133.48	170.6	GA
NESP_7491_PillarBank_GRAB31	-9.33	133.52	141.9	GA
NESP_7491_PillarBank_GRAB32	-9.34	133.50	147.7	GA
NESP_7491_PillarBank_GRAB33	-9.32	133.48	150.8	GA
NESP_7491_PillarBank_GRAB34	-9.31	133.49	154.2	GA
NESP_7491_PillarBank_GRAB35	-9.28	133.50	151.2	GA
NESP_7491_PillarBank_GRAB36	-9.28	133.52	153.3	GA
NESP_7491_PillarBank_GRAB37	-9.25	133.51	179.1	GA
NESP_7491_PillarBank_GRAB38	-9.24	133.48	168.4	GA
NESP_7491_PillarBank_GRAB39	-9.21	133.51	199.9	GA
NESP_7491_PillarBank_GRAB40	-9.16	133.51	189.2	GA

NESP_7491_PillarBank_GRAB41	-9.18	133.50	131.2	GA
NESP_7491_PillarBank_GRAB42	-9.20	133.50	153.4	GA
NESP_7491_PillarBank_GRAB43	-9.18	133.48	124.1	GA

APPENDIX D – PERMITS

Australian Marine Park Activity Permit

Australian Government
Director of National Parks

Australian Marine Park Activity Permit

Issued under r.12.06(2) and Part 17 of the
Environment Protection and Biodiversity Conservation Regulations 2000.

Permit Number	PA2020-00071-1
Permitted Activity	Scientific research - benthic habitat surveys and sampling, for sections 354-354A of the *Environment Protection and Biodiversity Conservation Act 1999* and regulation 12.10 of the *Environment Protection and Biodiversity Conservation Regulations 2000.*
Marine Park	Arafura Marine Park
Permit Area	Special Purpose Zone (Trawl) (IUCN VI) - Zone 1 and Multiple Use Zone (IUCN VI) - Zone 2 as specified in the North Marine Parks Network Management Plan 2018 for the Arafura Marine Park available at the Federal Register of Legislation.
Commencement Date	31 October 2020
Expiry Date	31 October 2021
Permittee	Organisation: Australian Institute of Marine Science Address: IOMRC Building, 64 Fairway, Crawley, WA, 6009 Phone: 0863694007 / 0428113906 Email: k.miller@aims.gov.au
Permittee Representative	Name: Dr Karen Miller Position: Principal Research Scientist Organisation: Australian Institute of Marine Science Address: IOMRC Building, 64 Fairway, Crawley, WA, 6009 Phone: 0863694007 / 0428113906 Email: k.miller@aims.gov.au
Nominated Vessel/s	Name: RV Solander / Registration number: 858417 Type: Research Vessel / Capacity: 18 Length: 39.4m / Tonnage: 384
Activity Conditions This permit is subject to the following activity specific conditions to reduce impacts on marine park values.	1. The Permitted Activity must be undertaken in accordance with Schedule 1 (PA2020-00071 submitted application and additional information), except where inconsistent with this permit. 2. The Permittee must ensure that appropriate risk management systems, strategies and procedures are in place to minimise the foreseeable risks to the environment and heritage values of the Marine Parks and must produce evidence of such systems, strategies and procedures on request of the Director. 3. At least two weeks before entering a marine park, the Permittee must notify the Director of the dates of the proposed visit, the vessel and whether there

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	is a berth availability for a Parks Australia officer by emailing marineparks@awe.gov.au. 4. The Permittee must ensure only the following equipment and methodology is used: a) collection of up to 165 (0.5-1 litre each) benthic sediment grabs using standard methods as contained in the Marine Sampling Field Manuals for Monitoring Australia's Commonwealth Waters, b) up to 60 deployments of towed video, c) up to 110 deployments of baited remote underwater vehicles, d) collection of sea water column samples to measure salinity, temperature and depth, and e) bathymetric survey using multibeam sonar and other sensors. 5. All Nominated Vessels must display, at all times within the Park, signage with the words 'Research' of a size similar to the vessel registration number. 6. The Permittee must provide to Geoscience Australia, bathymetry data obtained within the marine park compatible with Geoscience Australia database requirements, within three months of completion of all surveys in the Marine Park. 7. The Permittee must notify the Director, within 10 business days of the submission of the bathymetry data to Geoscience Australia, by emailing marineparks@awe.gov.au. 8. The Permittee must provide the Director georeferenced images of bathymetry (multibeam) and substrate (backscatter) from the survey. The georeferenced images must comply with the Director's specifications. 9. The Permittee must provide to the Director one or more openly licensed (e.g. Creative Commons Attribution license) spatial datasets representing all deployments of vessels, multibeam, baited remote underwater vehicles (BRUVs), towed video, grab or corer. The spatial dataset(s) will comply with Parks Australia's specification for a Standard Record of Deployments or a negotiated alternative specification. 10. The Permittee must provide to AusSeabed all raw and processed swath data files and publish an accompanying metadata record to the Australian Ocean Data Network (AODN) as soon as possible after it has been quality checked. Refer to section 5.3.2 of the Australian Multibeam Guidelines (http://dx.doi.org/10.11636/Record.2018.019) for detailed AusSeabed data and metadata requirements. The Permittee must include their Authorisation ID (PA2020-00071-1) in all correspondence with AusSeabed (ausseabed@ga.gov.au) regarding the submission. 11. The Permittee must upload to one or multiple Campaigns within a Project on GlobalArchive (https://globalarchive.org), all quality controlled annotation data under the public data option.

Site Conditions This permit is subject to the following location specific conditions to reduce impacts on marine park values.	12. During any overnight stay or overnight passage within the Park the Permittee must ensure that lighting on the Nominated Vessels is kept to the minimum necessary for safety and navigation (to minimise behavioural impacts to turtles).

General Conditions The following conditions apply to all permits.	*General conditions* 13. The Permittee must not conduct the Permitted Activity before the commencement date or after the expiry date shown on the permit. 14. An electronic or hard copy of this permit and attached application (Schedule 1) must be kept on board each Nominated Vessel and must be produced for inspection on request by a Warden. 15. The Permittee must inform the Director of proposed changes to the Nominated Vessels at least 14 days before the proposed trip. 16. If a Permittee is a company or other incorporated body the Permittee must not, without the approval of the Director, have as a director or officer holder a person who has been convicted of an offence against the EPBC Act or the EPBC Regulations within the previous 10 years.

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	17. The Permittee must not, without the approval of the Director, use directly in the conduct of the Permitted Activity the services of any person who has been convicted of an offence against the EPBC Act or the EPBC Regulations within the previous 10 years. *Compliance and auditing* 18. The Permittee must comply with the EPBC Act, the EPBC Regulations, the Management Plan, all permit conditions and any other notices or directions issued by the Director relating to the Permitted Activity or Marine Parks specified on this permit. 19. Unless specifically authorised by this or another permit, the Permittee must comply with all prohibitions and determinations made by the Director under the EPBC Regulations. 20. The Permittee must comply with all Commonwealth and State or Territory law relating to the Permitted Activity and hold all permits, licences and other relevant authorisations required by law for the conduct of the Permitted Activity. 21. The Permittee must ensure that all Participants are fully informed of and understand these permit conditions before they take part in the Permitted Activity. 22. The Permittee must take all reasonable steps to ensure all Participants comply with all permit conditions. 23. The Permittee must allow a Warden access to Nominated Vessels at any time for the purpose of performing the functions and powers of Wardens under the EPBC Act. 24. The Permittee must, and must take reasonable steps to ensure all Participants in the Permitted Activity, comply with all lawful directions issued by a Warden. 25. The Permittee must, at no cost to the Director but subject to availability and the provision of reasonable notice, allow a member of the Director's staff to accompany a trip conducting the Permitted Activity for the purpose of evaluating compliance with these Permit conditions. *Training and qualifications* 26. The Permittee must maintain relevant training, qualifications and experience to competently conduct the Permitted Activity. 27. The Permittee must ensure that all Participants are appropriately trained and/or accredited to competently conduct the Permitted Activity. *Safety* 28. The Permittee must ensure that appropriate risk management systems, strategies and procedures are in place to minimise foreseeable risks to the Participants in the Permitted Activity and members of the public and must produce evidence of such systems, strategies and procedures on request of the Director. 29. The Permittee must ensure that they fully inform themselves of, and equip themselves for, all potential hazards and conditions they may encounter while conducting the Permitted Activity. 30. The Permittee acknowledges that the Director has no ability to monitor or warn the Permittee of changing environmental hazards or developing hazards within a Marine Park. 31. The Permittee must inform the Director of any potential safety hazard or risk encountered or discovered while in a Marine Park as soon as practicable. 32. If anyone taking part in the Permitted Activity is seriously injured, becomes seriously ill or goes missing while in a Marine Park, the Permittee must ensure: (a) notification to the relevant emergency response authority as soon as possible; (b) compliance with any requests or directions from those authorities in relation to the safety of that person or any other person; and

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	(c) notification to the Director's Marine Compliance Duty Officer as soon as practicable. *Note:* The Director is not an emergency response agency and all relevant emergency response agencies should be contacted prior to informing the Director of any incident or safety hazard/risk. *Vessel operations* 33. The Permittee must ensure, or satisfy themselves, that all Nominated Vessels are registered, are suitable for the conduct of the Permitted Activity, have appropriate safety equipment on board at all times, and are operated and maintained in accordance with all relevant and applicable Commonwealth, State and Territory laws. The Permittee must, if requested by the Director, provide copies of all relevant certificates and other documents demonstrating compliance with this condition. 34. The Permittee must ensure that a person qualified to operate each Nominated Vessel remains on board at all times to monitor and assure secure anchorage. 35. The Permittee must: (a) Use appropriate moorings if available; or (b) (if moorings are not available) ensure that minimal damage is caused to the marine environment as a result of anchoring. Anchoring cannot occur on coral. 36. When using an existing Parks Australia mooring, the Permittee must: (a) not exceed the weight capacity of the mooring. (b) not tie to a vessel already using a mooring. 37. The Permittee must ensure that Nominated Vessels do not discharge any fuels or chemical wastes into a Marine Park. 38. The Permittee must not, and must take reasonable steps to ensure all Participants in the Permitted Activity do not, litter in a Marine Park. All refuse must be placed in containers on board Nominated Vessels which are designed to fully contain refuse material. 39. The Permittee must ensure that Nominated Vessels have been antifouled within the last two years and are generally free from fouling. Vessels cannot be cleaned of fouling inside a Marine Park. *Environment and heritage protection* 40. Unless specifically authorised by this permit, the Permittee must not, and must take reasonable steps to ensure that all Participants in the Permitted Activity do not: (a) behave contrary to any warning or regulatory signs displayed at boat ramps used by the Permittee to access a Marine Park or displayed on marker buoys within a Marine Park; (b) collect, pick, interfere with, feed, handle or disturb any native flora or fauna, or handle or disturb the dwelling place of any native fauna; (c) remove shells, coral, plants or animals from a Marine Park. (d) touch, interfere with, or capture images or sound of, Indigenous Cultural and Intellectual Property without the consent of the owner; or (e) impede public access to any part of a Marine Park. 41. The Permittee must take all reasonable steps to prevent the introduction of pests into a Marine Park or the transfer of pests between locations within a Marine Park. Reasonable steps can include, but are not limited to, scheduled inspection and cleaning of the vessel and any in-water equipment, and/or passenger briefings. 42. The Permittee must ensure that all gear, equipment, and other articles lost in a Marine Park that are likely to cause environmental harm, are reported to the Director's Marine Compliance Duty Officer as soon as practicable, and within 10 days in any event, after the loss occurs. The report must include a description of what was lost, the location of loss/suspected loss and the date and time of loss.

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Failure to adhere to this permit and the conditions above may result in a variation to or cancellation of this permit or the imposition of criminal penalties under the EPBC Regulations. A person convicted under the EPBC Regulations may be ineligible for future permits in Australian Marine Parks.

Reporting of potential noncompliance and notifications in accordance with General Conditions 31, 32 and 42 should be made to the **24-hour Marine Compliance Duty Officer on 0419 293 465**. For all other enquiries relating to this permit, please contact: marineparks@awe.gov.au.

Stephen Weber
Director
Authorisations and Compliance
Marine Parks Branch
Delegate of the Director of National Parks
16 October 2020

Interpretation

In the permit and permit conditions:

Agreement means the agreement executed by the Permittee when applying for this permit.

Director means the Director of National Parks and the Director's delegates, and includes any statutory successor to the Director.

EPBC Act means the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

EPBC Regulations means the *Environment Protection and Biodiversity Conservation Regulations 2000* (Cth).

Indigenous Cultural and Intellectual Property means all aspects of Aboriginal or Torres Strait Islander people's cultural products, expressions knowledge and heritage, whether (a) intangible, such as songs, dances, stories, and ecological and cultural knowledge; or (b) tangible, such as human remains, artworks and artefacts.

Marine Park means the Australian Marine Parks under the EPBC Act for which this permit is issued.

Management Plan means the management plan or management plans made under the EPBC Act in operation from time to time for the Marine Parks specified by this permit.

Participants means the Permittee's employees, contractors, other agents and other individuals who take part in the Permitted Activity.

Permittee means each person (individual, company or other legal entity) to whom this permit is issued.

Permitted Activity means the specified activity or activities for which this permit is issued.

Warden means a person appointed as a warden under s.392 of the EPBC Act.

Zone means the relevant zone as specified by the Management Plan

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Northern Land Council Permit

NORTHERN LAND COUNCIL PERMIT #73881

Status	Issued
Permit type	Work
Primary location	Arafura Marine Park
Date in	31 Oct 2020
Date out	25 Nov 2020
Company name	Australian Institute of Marine Science
Work permit type:	Research
Method of transport	Water, Company
Purpose of trip	Marine benthic biodiversity surveys of offshore regions of the Arafura and Arnhem Marine Parks

For any questions, please use our Contact Centre at www.permits.nlc.org.au. Alternatively email permits@nlc.org.au or phone 1800 645 299

Leg 1 - Arafura Marine Park	**31st Oct 2020 - 25th Nov 2020**	**Approved**

Purpose of this leg
Marine biodiversity surveys and research

Local Information
None

Further Condition
None

Leg 2 - Arnhem Marine Park	**31st Oct 2020 - 25th Nov 2020**	**Approved**

Purpose of this leg
Marine biodiversity surveys and research

Local Information
None

Further Condition
None

Applicant x1

Karen Miller — P: 0428113906 — E: k.miller@aims.gov.au — AREW ID: — A: IOMRC UWA M096 35 Stirling Highway, Crawley , 6009, AUS

Company x1

Australian Institute of Marine Science
P: 08 8920 9216
E: c.stronach@aims.gov.au
A: 23 Ellengowan Dr, Brinkin, Northern Territory, 0810, AUS
NLC agreement type/no:
Position: Principal Research Scientist
Contracting to:
Tender no:

Passengers x4

Jamie Colquhoun	P:	E:	AREW ID:
Marcus Stowar	P:	E:	AREW ID:
Kim Picard	P:	E:	AREW ID:
Justy Swiabessy	P:	E:	AREW ID:

Accommodation x1

RV Solander- Aust. Institute of Marine Science — Private — P: 0428113906 — A: Both: aboard the Research Vessel Solander

NLC authorised this permit on 02 Sep 2020 at 10:50:45 am under the Aboriginal Land Act 1976

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www.nespmarine.edu.au

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