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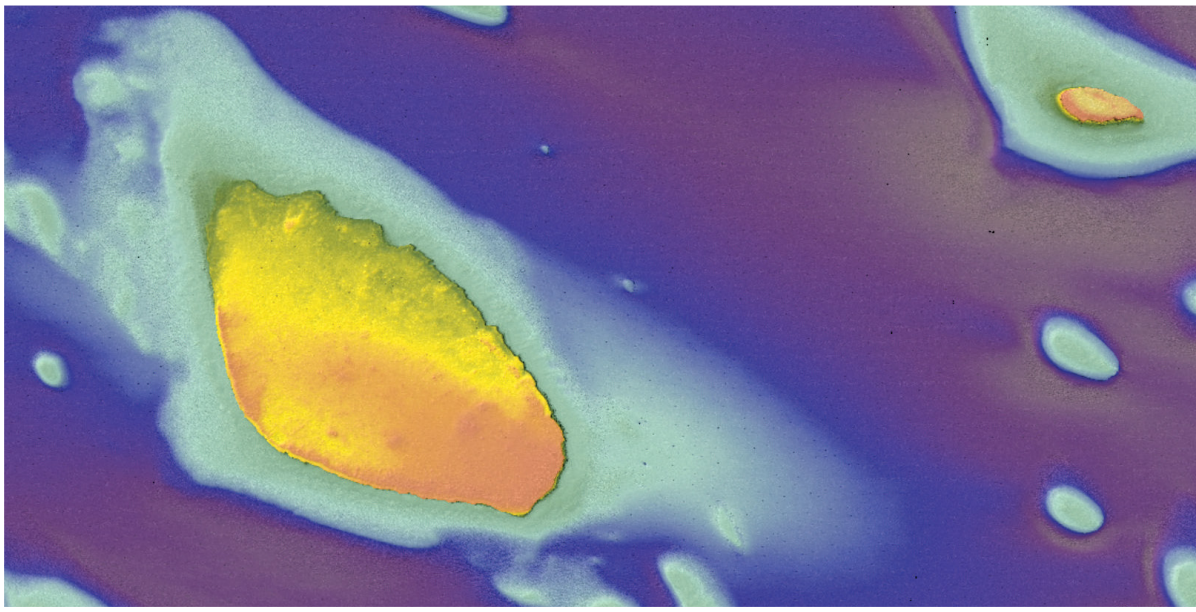

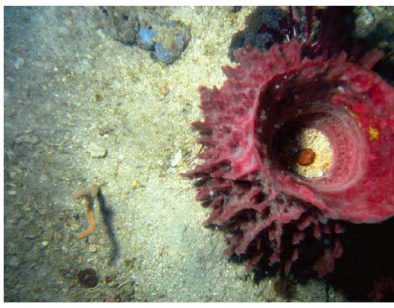

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Oceanic Shoals Commonwealth Marine Reserve (Timor Sea) Biodiversity Survey

GA0339/SOL5650 - Post-Survey Report

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S.L. Nichol[1], F.J.F. Howard[1], J. Kool[1], M. Stowar[2], P. Bouchet[3], L. Radke[1], J. Siwabessy[1], R. Przeslawski[1], K. Picard[1], B. Alvarez de Glasby[4], J. Colquhoun[2], T. Letessier,[3] A. Heyward[2]

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1. Geoscience Australia
2. Australian Institute of Marine Science
3. Oceans Institute, University of Western Australia
4. Museum and Art Gallery of the Northern Territory

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Executive Summary

This report provides details of activities undertaken by the Australian Institute of Marine Science (AIMS), Geoscience Australia (GA), the University of Western Australia and the Museum and Art Gallery of the Northern Territory during a marine biodiversity survey to the Oceanic Shoals Commonwealth Marine Reserve (Timor Sea) in 2012. The survey was an activity within the Australian Government's National Environmental Research Program Marine Biodiversity Hub and the key component of Theme 4 – Regional Biodiversity Discovery to Support Marine Bioregional Plans. Data collected during the survey will be used to support research being undertaken in other Themes of the Marine Biodiversity Hub, including the modelling of ecosystem processes for the northern region, and to support the work programs of the Department of the Environment (previously Department of Sustainability, Environment, Water, Population and Communities). These data will be made publicly available, via the Marine Biodiversity Hub website and the Australian Ocean Data Network Portal, adding to the knowledge base of Australian tropical shelf habitats and contributing to the long term management of these poorly understood areas.

The survey was undertaken between 12 September and 6 October 2012 on the AIMS Research Vessel, RV Solander, and acquired data from four areas in the western sector of the Oceanic Shoals Commonwealth Marine Reserve. Covering 507 km^2, these areas incorporate a variety of seabed geomorphic features across water depths that range from 30 to 180 m, including carbonate banks, terraces and pinnacles, as well as soft sediment plains and valleys. The carbonate banks and terraces in particular are recognised in the North and North-West Marine Region Plans as a Key Ecological Feature with potential as a biodiversity hotspot. Data acquired from each survey area included: continuous high-resolution multibeam sonar bathymetry and acoustic backscatter; sub-bottom acoustic profiles along representative transects; physical samples of seabed sediments and infauna (hard- and soft-bodied organisms); physical samples of epibenthic biota (sponges & corals); video and still camera observations of seabed habitats and associated biological communities, including demersal and pelagic fish; observations of high-order pelagic predators (whales, dolphins), and; oceanographic measurements of the water column from CTD (conductivity, temperature, depth) casts and from deployment of sea surface drifters. In total, samples and/or video observations were collected at 70 stations.

Key observations from the survey are as follows:

- The geomorphic diversity of the Oceanic Shoals Commonwealth Marine Reserve is well represented in the western part of the reserve, with numerous banks and terraces providing hard substrate for benthic communities;
- The epibenthic biodiversity on banks appears to vary as a function of water depth and related light and turbidity conditions, with shallower banks (<45 m) supporting more biodiversity than deeper banks, including hard corals;
- Species richness and endemism of sponges in the western sector of the Oceanic Shoals CMR may not be as high as those in the eastern sector, with sponges from the west comparatively dominated by species that are common across northern Australia (to be confirmed by taxonomic analysis);

- Spatial gradients in epibenthic biodiversity exist as a possible function of marked changes in substrate, light and turbidity levels along the depth transition from bank to terrace to plain;
- Tidal currents play an important role in regulating levels of suspended sediment (turbidity) and in redistributing sediment across the plains and around banks and terraces, with some smaller banks partly buried by sediment;
- Demersal fish communities respond to spatial patterns in benthic biodiversity, occurring in larger and more diverse populations on the shallower, less turbid banks, and;
- A wide variety of high-order pelagic fish species occur in these waters.

The data and information collected on this survey will be used with pre-existing data collected from the eastern part of the Oceanic Shoals CMR to develop regional scale maps and models of benthic habitats, ecosystem processes and associated biodiversity. This analysis is part of ongoing research within the Marine Biodiversity Hub and will enable an assessment of the uniqueness of habitats and biological communities observed in this survey. It will also allow the Oceanic Shoals CMR to be placed into the broader regional context of tropical northern Australia. Importantly, all available materials and data have been subject to consistent sampling and processing protocols, ensuring a uniform data standard for analysis and interpretation. Combined with the sampling design used in this survey, these consistent data standards allow the information to be potentially used as a baseline for long-term monitoring of the CMR.

1 Introduction

This report provides details of activities jointly undertaken by the Australian Institute of Marine Science (AIMS), Geoscience Australia (GA), the University of Western Australia and the Museum and Art Gallery of the Northern Territory during a marine biodiversity survey to the Oceanic Shoals Commonwealth Marine Reserve in the Timor Sea in September-October 2012 (Figure 1.1). The survey was an activity within the Australian Government's National Environmental Research Program Marine Biodiversity Hub and is the key component of Theme 4 – Regional Biodiversity Discovery to Support Marine Bioregional Plans.

Data collected during the survey will be used to support research being undertaken in other Themes of the Marine Biodiversity Hub, in particular the development of regional scale models of ecosystem processes and resultant biodiversity. This and related products will also support the work programs of the Department of the Environment (previously Department of Sustainability, Environment, Water, Population and Communities), including informing the management of the North and North-West Marine Regions. Overall, these new data will also add to the knowledge base of Australian tropical shelf habitats and contribute to the long term management of these poorly understood areas.

1.1 Background and Survey Aims

Marine habitats in Northern Australia host globally significant levels of biodiversity but remain poorly known (Richardson et al., 2009; Tittensor et al., 2010; Fisher et al., 2011). This biodiversity faces rapidly increasing pressures from human activities (i.e. offshore energy industry and fishing), while extensive regional-scale knowledge gaps threaten to compromise efforts to conserve and manage it (Commonwealth of Australia, 2008). This survey was designed to begin to fill these knowledge gaps in one of the most poorly known regions of Northern Australia, the Oceanic Shoals Commonwealth Marine Reserve (CMR), through representative sampling of both the physical environment and biological communities.

The purpose of the survey was to collect geophysical and biological data on the shallow seabed environments for targeted areas within the Oceanic Shoals CMR (Figure 1.1). Proclaimed as a Commonwealth Marine Reserve in November 2012, the Oceanic Shoals CMR is part of the National Representative System of Marine Protected Areas. The Reserve incorporates extensive areas of carbonate banks and terraces that are recognised in the North and North-West Marine Region Plans as a Key Ecological Feature (Commonwealth of Australia, 2012a, b). Previous seabed surveys to the Timor Sea undertaken by AIMS and Geoscience Australia in 2009 and 2010 provided information on habitats and shelf processes for the carbonate banks in the eastern part of the Oceanic Shoals CMR (Heap et al., 2010; Anderson et al., 2011), and these were summarised in a regional overview of seabed habitats and geo-hazards by Przeslawski et al. (2011). This survey extended this work by focusing on shelf habitats (< 200 m water depth) of the western part of the Oceanic Shoals CMR and included potential biodiversity hotspots such as pinnacles and banks. The survey also adds to previous research of open ocean shoals and reefs of the Timor Sea undertaken by AIMS (Heyward et al., 1997).

1.2 Study Area

The Oceanic Shoals CMR covers 71,740 km^2 and incorporates a range of large-scale geomorphic features on the continental shelf, including parts of the Van Diemen Rise, Malita Shelf Valley and the Londonderry Rise (Figure 1.1). Both the Van Diemen Rise and Londonderry Rise are characterised by a complex morphology of shallow flat-topped carbonate banks and terraces, separated by valleys and plains (Van Andel and Veevers, 1967; Heap and Harris, 2008). Water depths range from 10 m on the shallowest banks to over 200 m in valleys. In contrast, the Malita Shelf Valley is a broad basin that separates the two rises with water depths of 100 to 150 m. Overall, this seabed morphology is interpreted as a drowned landscape of coastal lowlands, estuarine valleys and nearshore environments that formed during the Late Quaternary Period and was inundated during the post-glacial rise in sea level of the Late Pleistocene to Holocene Epochs (West et al., 1992).

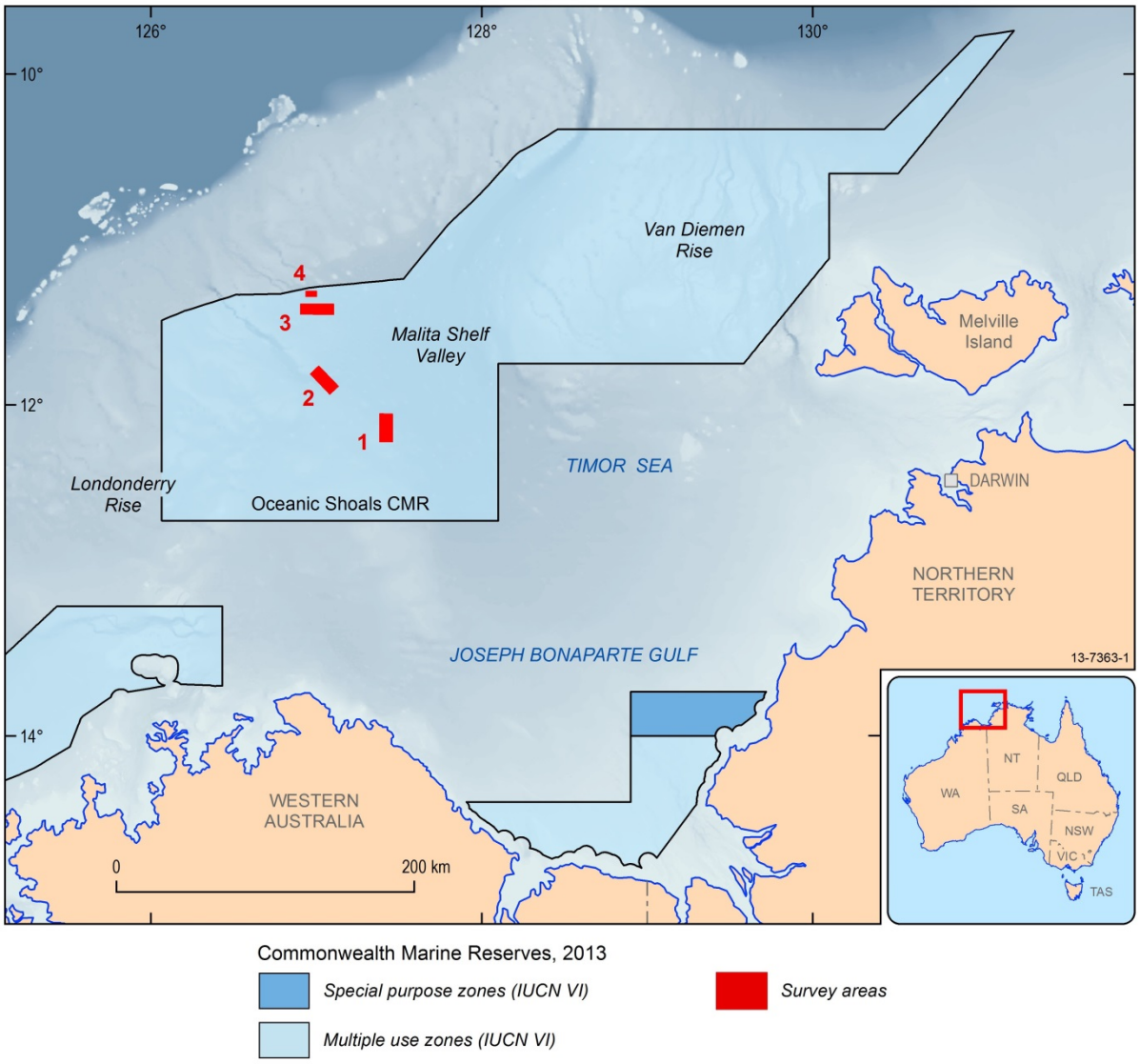

Figure 1.1 Location map of areas surveyed during the Oceanic Shoals Commonwealth Marine Reserve Biodiversity Survey.

Today, these tropical shelf environments are influenced by a range of oceanographic conditions. The Indonesian Through-Flow delivers relatively warm (~26 to 31°C) low salinity water from the north, whereas strong tidal flows, wind driven waves and seasonal cyclones influence sediment transport particularly across the banks. Coupled with sediment discharged from coastal river systems, these re-suspended seabed sediments contribute to a turbid nearshore and shelf environment that is likely to suppress photosynthetic activity at the seabed, and therefore may be an important determinant of the composition of benthic assemblages across the region.

The survey acquired data across four areas located along the transition between the Malita Shelf Valley and Londonderry Rise and spanning a cross-shelf transect of approximately 110 km (Figure 1-2). Each area was positioned to encompass a variety of seabed geomorphic features and water depths, as identified in the national geomorphic features database (Heap and Harris, 2008), as follows:

- Area 1 is the southernmost survey area covering 18 km x 4.2 km along a north-south orientation and incorporates a bank and terrace feature at the southern end, several pinnacles that rise to about 40 m water depth and plains in up to 150 m water depth.

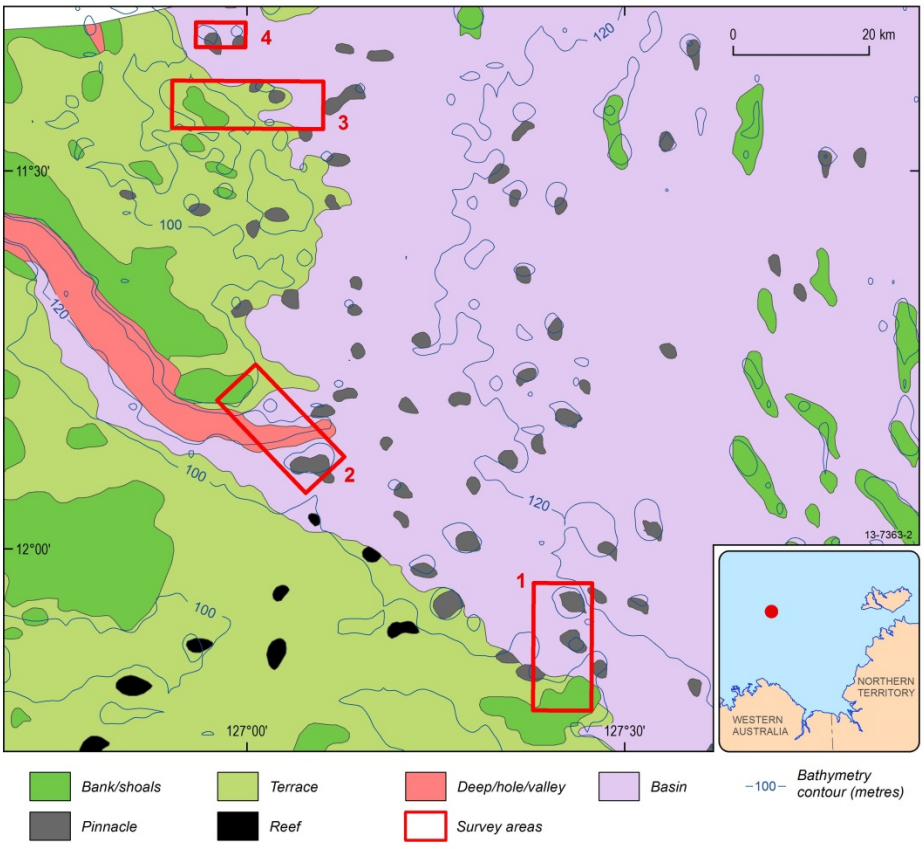

Figure 1.2 Map showing geomorphic features within the western part of the Oceanic Shoals Commonwealth Marine Reserve, with survey areas indicated. Geomorphic features are based on the Australian 250 m bathymetry grid (published October 2006), as described by Heap and Harris (2008).

- Area 2 is located 30 km to the northwest of Area 1, covers 18.6 km x 7.6 km on a northwest to southeast alignment and includes a bank and terrace at the northern end, pinnacles, valley and plains. Water depths range from 40-135 m.

- Area 3 is located 34 km directly to the north of Area 2, covers 22 km x 7 km along an east-west orientation and is characterised by a broad bank and terrace feature in the western half, pinnacles and surrounding plains in the eastern half. Water depths range from 55-110 m.
- Area 4 is located 5 km to the north of Area 3, covers 7.2 km x 3.6 km on an east-west orientation and includes two banks that rise to 40 m water depth surrounded by plains in up to 115 m water depth.

2 Methods

2.1 Survey Overview

Survey SOL5650/GA0339 was undertaken between 12 September and 6 October 2012, using the AIMS 35 m research vessel *Solander* with a science and technical support crew from AIMS, Geoscience Australia, University of Western Australia and the Museum and Art Gallery of the Northern Territory (Appendix A). The survey comprised a series of geophysical mapping and biophysical sampling activities in four areas within the Oceanic Shoals CMR. In each survey area, multibeam sonar data (bathymetry and backscatter) was collected to provide 100% spatial coverage, with sampling stations selected before the survey. Site selection used a spatially-balanced random stratified method (termed a Generalised Random-Tessellation Stratified [GRTS] design; Stevens and Olsen, 2004), that was weighted to shallow areas (<50 m water depth). Sampling included non-destructive techniques (towed underwater video, stills photography, baited underwater video) to record benthic and pelagic biota, plus physical sampling of sediments and epibenthic biota (grabs, benthic sled tows). Water column measurements (conductivity, temperature, turbidity) and sea surface samples were also taken at representative stations and during transits. To broadly characterise the sub-surface geology, shallow (<70 m) sub-surface data was collected across three of the survey areas (Areas 1, 2 and 3) with a sub-bottom profiler.

2.2 Sampling Overview

Sampling was undertaken at 70 stations across the four survey areas to characterise the geophysical and biological properties of the seabed and water column within each area; with sea surface samples collected at a further nine stations during transits (Table 2.1). At each station, the type of sampling undertaken and the gear used was determined by the seabed composition, water depth and visibility. In particular, deployment of baited remote underwater video stations (BRUVS) was limited to water depths less than ~60 m due to high turbidity and low light conditions.

Sampling activities within the four survey areas included:

- Towed underwater video transects at 52 stations to characterise seabed types and benthic communities;
- Collection of replicate sediment samples at 61 stations for sedimentology, geochemistry and infauna analyses using either a Smith-McIntyre grab (29 stations) or a box corer (32 stations);
- Benthic sled tows at 22 stations to sample epibenthos;
- Deployment of BRUVS at 56 stations to characterise demersal fish communities;
- Deployment of Stereo Imagery System for Shark and Tuna Assessments (SISSTAs) units at 120 stations to characterise pelagic fish communities;
- Deployment of a Conductivity Temperature Depth (CTD) instrument at 63 stations to characterise water column properties, and;
- Deployment of 10 ocean drifters to map surface ocean currents in the region.

Table 2.1 List of sampling and tow video operations by station. Deployment details for BRUVS, SISSTAs and drifters are listed separately in the Appendices. An asterisk denotes an unsuccessful deployment. Detailed descriptions of sampling are included in the voyage leader log (Appendix O)

Survey Area	Station	Tow Video	Sediment Grab	Box Core	Benthic Sled	CTD	Water Sample
Transit	01	-	-	-	-	-	01
Transit	02	-	-	-	-	-	02
Transit	03	-	-	-	-	-	03
Transit	04	-	-	-	-	-	04
1	05	01	01	-	-	01	-
1	06	02	02, 03	-	01	02	-
1	07	03	04, 05	-	-	03	-
1	08	04	06, 07	-	-	04	-
1	09	05	08, 09	-	-	-	-
1	10	06	010, 11, 12	-	-	05	-
1	11	07	13, 14	-	-	06	-
1	12	08	-	-	-	07	-
1	13	09	-	-	-	-	-
1	14	10	15, 16, 17, 18	-	02	08	-
1	15	11	19, 20	-	03	09	-
1	16	12, 13	21, 22	-	04	10	-
1	17	14	-	01, 02	-	11	-
1	18	-	23, 24	-	-	12	-
1	19	-	25, 26	-	-	13	05
1	20	-	-	03, 04	-	14	-
1	21	-	-	05, 06	-	15	-
1	22	-	-	07, 08	-	16	-
1	23	-	-	-	-	17	06
2	24	15	-	09, 10, 11	05	18	-
2	25	16	27	12	06	19	-
2	26	17	28, 29	-	07	20	07
2	27	18	-	14, 15	-	21	-
2	28	19	-	16, 17	-	22	-
2	29	20	30, 31	-	08	23	-
2	30	-	-	-	-	24	08
2	31	21	-	18, 19	09	25	-
2	32	22	-	20, 21	-	26	-
2	33	23	-	22, 23	-	27	-
2	34	24	-	24, 25, 26	-	28	-
2	35	-	-	-	-	29	-
2	36	25	-	27, 28	10	30	-
2	37	26	32	29	11	31	-
2	38	27	-	30, 31	12	32	-
2	39	28	-	32, 33	-	33	-

Survey Area	Station	Tow Video	Sediment Grab	Box Core	Benthic Sled	CTD	Water Sample
2	40	29	-	34, 35	-	34	-
2	41	-	33, 34	-	-	35	-
2	42	-	35, 36	-	-	36	-
Transit	43	-	-	-	-	-	09
3	44	30	37	36	13*	37	-
3	45	31	-	37, 38	-	38	-
3	46	32	-	39, 40	14	39	-
3	47	33	38, 39	-	15	40	-
3	48	-	-	-	-	41	10
3	49	34	40, 41	-	-	42	-
3	50	35	-	41, 42	-	43	-
3	51	36	-	43, 44	-	44	-
3	52	37	-	45, 46	-	45	-
3	53	38	-	47, 48	16	46	-
3	54	39	-	49, 50	-	47	-
3	55	40	42, 43	-	17	48	-
3	56	41	-	51, 52	18	49	-
3	57	42	-	53, 54, 55	-	50	-
3	58	43	-	56, 57	-	51	-
3	59	-	-	-	-	52	-
3	60	-	44, 45	-	-	-	-
3	61	44	-	58, 59	19	53	-
3	62	45	-	60, 61	-	54	-
3	63	46	-	62, 63	20	55	-
3	64	-	-	-	-	-	11
3	65	-	46, 47	-	-	56	-
3	66	-	48, 49	-	-	57	-
4	67	47	50	-	-	58	-
4	68	-	51, 52	-	-	59	-
4	69	48	-	-	-	-	-
4	70	49	-	-	-	-	-
Transit	71	-	-	-	-	-	12
2	72	-	-	-	-	60	-
1	73	50	53, 54	-	21	61	-
1	74	51	55	64	22	62	-
1	75	52	-	65, 66	-	63	-
Transit	76	-	-	-	-	-	13
Transit	77	-	-	-	-	-	14
Transit	78	-	-	-	-	-	15
Transit	79	-	-	-	-	-	16

2.3 Geophysical Data Acquisition and Processing

2.3.1 Bathymetric Mapping

High-resolution bathymetric data were collected from each survey area using a Kongsberg EM3002D (300 kHz) multibeam sonar system mounted in single head configuration (Figure 2.1). The multibeam sonar data were processed during the survey using Caris HIPS & SIPS v7.1 SP2 software and included: i) applying algorithms that compensated for tide and vessel pitch, roll and heave (e.g. elevation errors caused by dynamic draft of the vessel); ii) using sound velocity profiles (collected while underway and at several stations in each survey area) to correct for variations in the speed of sound through the water column, and; iii) software filters and visual inspection of each swath line to remove any remaining artefacts and noisy data (e.g. nadir noise and data outliers).

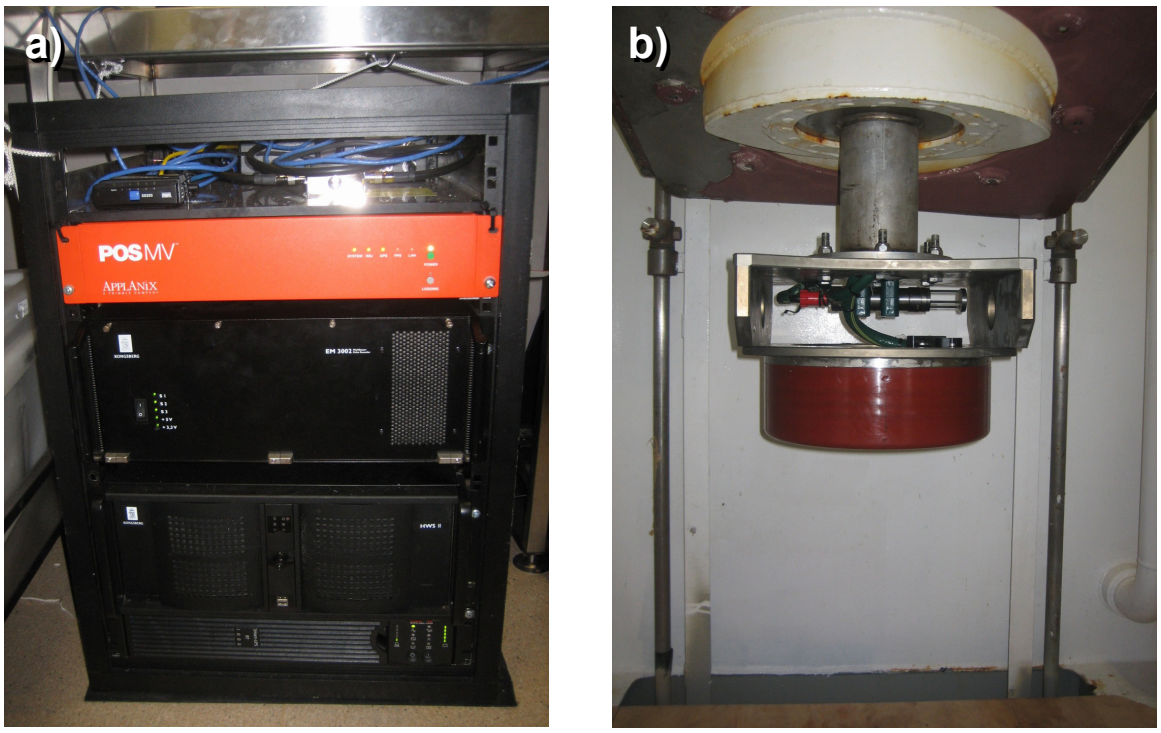

Figure 2.1 Kongsberg EM3002D multibeam sonar system installed on RV Solander, showing: (a) POS MV motion reference unit, data acquisition and processing units, and; (b) single head mounting deployed in the moon-pool.

Tidal corrections were also applied to bathymetric data, based on a co-tidal solution. This solution is derived from the average tidal amplitude at multiple tide stations weighted inversely to the distance between the tide station and the point of interest. For each survey area, a tidal zone was defined by a closed polygon and included a primary tide station of known location and two or more secondary tide stations. Predicted tides were then generated using tidal constituents requested from the National Tidal Centre within the Bureau of Meteorology for these predefined tide stations. A Zone Definition File (.zdf) for defining the zone, the primary and secondary tide stations, and the associated predicted tides was created and used in Caris HIPS & SIPS V7.1 SP2. The final surface grid (bathymetric map) was then produced to ≤10 cm vertical resolution and 2 m horizontal resolution (cell size of the surface grid).

2.3.2 Backscatter Acquisition and Processing

Seabed reflectance (backscatter), which is a surrogate for substrate hardness, was processed using the multibeam backscatter CMST-GA MB Process v10.10.17.0 toolbox software co-developed by the Centre for Marine Science and Technology (CMST) at Curtin University of Technology and Geoscience Australia (described in Gavrilov et al., 2005). Processing steps included correction for transmission loss and ensonification area, removal of the system model, calculation of the incidence angle and removal of angular dependence. The angularly equalised backscatter strengths were normalised to the backscatter strength at an angle of 25°. The final processed backscatter data were then gridded to 2 m horizontal resolution.

2.3.3 Sub-Bottom Profiler Acquisition and Processing

Shallow (<100 metres below sea floor) sub-surface data were collected along representative transects in Areas 1, 2, and 3 using an Applied Acoustics CSP-D "Sparker" sub-bottom system (Figure 2.2; Appendix B). The system comprised a Squid-2000 sound source (2000 J) towed 18 m astern of the vessel at a depth of ~30 cm and a single channel hydrophone for data collection that was deployed 33 m astern approximately 1 m below the surface. Vessel speeds during acquisition ranged from 3.5 to 4 knots (6.5 – 7.5 km h^{-1}) in Beaufort Sea States of 0 to 2. Data was processed using a C-View (Applied Acoustics Engineering) processing unit firing at a rate of 1 second with a record length of 500 milliseconds. The data were processed by applying a band-pass filter (60-600 Hz) and converted to SEGY for further processing. Depths were converted from two-way travel time (TWT) using 1,500 m s^{-1} as the speed of sound in the water column and shallow sub-surface sediments.

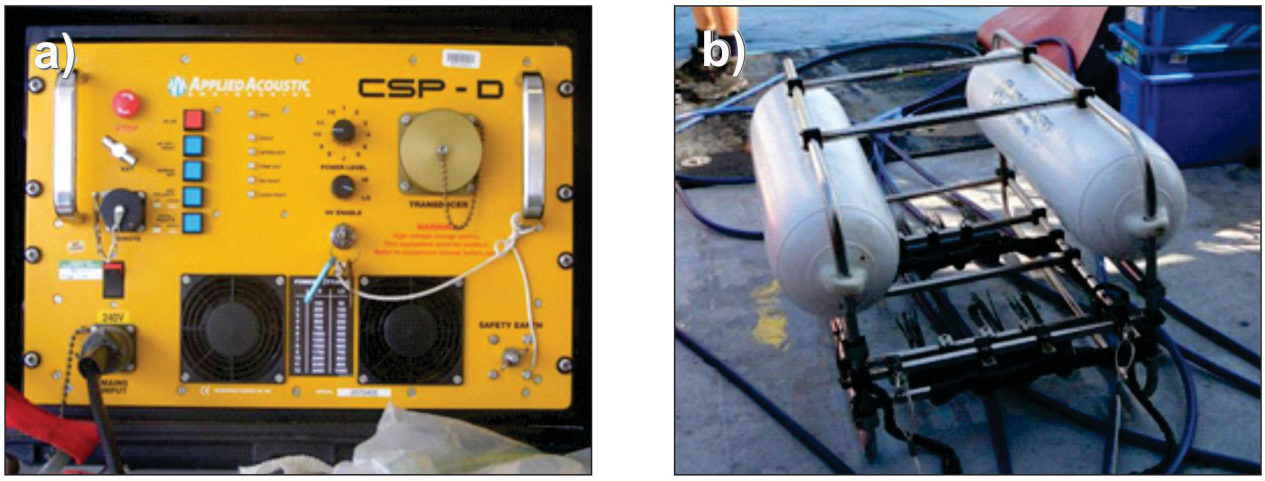

Figure 2.2 Applied Acoustics sub-bottom "Sparker" system, showing: (a) CSP-D generator unit and; (b) Squid-2000 sound source.

2.4 Oceanographic Data Acquisition

2.4.1 Water Column Measurements and Sampling

To characterise the vertical structure of the water column across the banks, terraces and valleys of each survey area, measurements were collected by CTD casts at 63 stations (Table 2.1). At each

CTD station, a Seabird Electronics SBE-911plus Livewire CTD was deployed using the hydrographic wire (Figure 2.3), and lowered through the water column to within 1–2 m of the seabed. A conducting wire (Livewire) between the ship and the CTD allowed serial information to be transmitted down to the CTD and real-time data to be transmitted back. During each deployment, the CTD continually measured conductivity (mS/cm), irradiance (%), depth (m), fluorescence (mg/m^3), nitrogen saturation (mg/l), oxygen saturation (mg/l), salinity (PSU) and temperature (degrees C). In addition to CTD casts, a hull-mounted Seabird Electronics SBE-21 thermosalinograph measured temperature and conductivity (≈salinity) of the surface water (<5 m below the sea surface) every 10 seconds for the duration of the voyage.

Samples of surface waters were also collected at 16 stations during transits (9 samples) and from within the survey areas (7 samples), using the on-board seawater circulation unit. At each station, approximately 10 litres of seawater was collected in buckets and filtered to retain suspended solids and chlorophyll-a, respectively. The timing of sample collection was scheduled to coincide with the overpass of the MODIS satellite, which remotely senses sea surface colour as a proxy for suspended solids and chlorophyll content in ocean waters.

Figure 2.3 Seabird Electronics SBE-911plus Livewire CTD prior to deployment.

2.4.2 Ocean Current Drifters

To provide insight into the circulation pattern of sea surface waters across the survey areas, ten ocean drifters were deployed at strategic locations during the survey. The drifters were sourced from the Global Ocean Drifter Program (GDP) run by the National Oceanic & Atmospheric Administration (NOAA) in the United States (www.aoml.noaa.gov/phod). The drifters are expendable instruments weighing 20 kg and comprise a surface buoy and subsurface drogue (sea anchor) designed to drift in

response to near-surface currents (Figure 2.4). The particular drifter model deployed collects sea surface temperature and transmits this data to the Argos satellite array, with the location of a drifter calculated from the Doppler shift of its transmission signal as seen by satellites (with 16-20 fixes taken per day). Interpolated positions are periodically loaded onto the GDP website for free download. Details of the drifters deployed during the survey are listed in Appendix D.

Figure 2.4 Ocean drifter prior to deployment.

2.5 Physical Sampling

2.5.1 Sedimentology

The principal aim of the sedimentology component of the survey was to determine the texture and composition of the surface sediments for seabed characterisation and to provide samples for analysis of infauna. For physical sedimentological analysis, unconsolidated sediments were collected at 62 stations using a Smith-McIntyre grab or a box corer (Table 2.1, Figure 2.5; Appendix E).

Up to 100 g of bulk sediment was sub-sampled from the top 2 cm of grabs and box cores for texture and compositional analysis. Samples were submitted to the GA sedimentology laboratory for measurement of gravel, sand and mud content by sieve separation and of particle size distributions (including mean, median, standard deviation, skewness and kurtosis indices) by laser diffraction using a Malvern Mastersizer 2000 particle size analyser. Separate sample splits were submitted for measurement of carbonate content using the carbonate digestion method (Müller and Gastner, 1971).

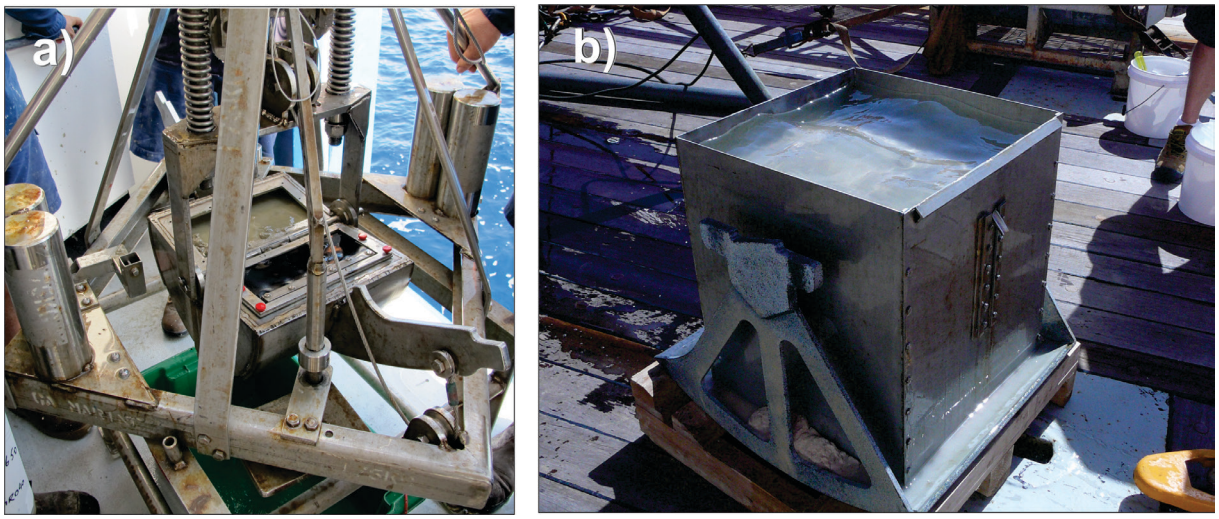

Figure 2.5 Images of the sediment sampling equipment employed on this survey. (a) A Smith McIntyre grab full of sediment, sitting in its frame. (b) A returned box corer, full of sediment.

2.5.2 Geochemistry

The principal aims of the geochemistry component of the survey were to: (i) determine the geochemical composition of surface sediment for seabed characterisation; and (ii) quantify the levels of reactive bulk organic matter and chlorin pigments in sediments that support biodiversity in the region. Unconsolidated surface sediments designated for geochemical analysis were collected at 57 stations using either a Smith-McIntyre grab (10L, 0.1 m^2 opening) or a box core (4.5L, 0.023 m^2 opening). The grabs were sub-sampled into seven or eight separate containers for the parameters listed in Appendix G, Table G.1. An account of the shipboard processing, laboratory pre-processing and analytic techniques to be undertaken on these samples is provided in Appendix H, Table H.1 and Figure 2.6. The chlorin, sediment oxygen demand and bottle/core incubation data will be used to estimate levels of reactive organic matter that support biodiversity in the region. The elemental data, including Total Organic Carbon (TOC), Total Nitrogen (TN) and their isotopic ratios, will be used in conjunction with the organic matter abundance/reactivity indicators in multivariate analyses to deduce the major geochemical gradients in the region.

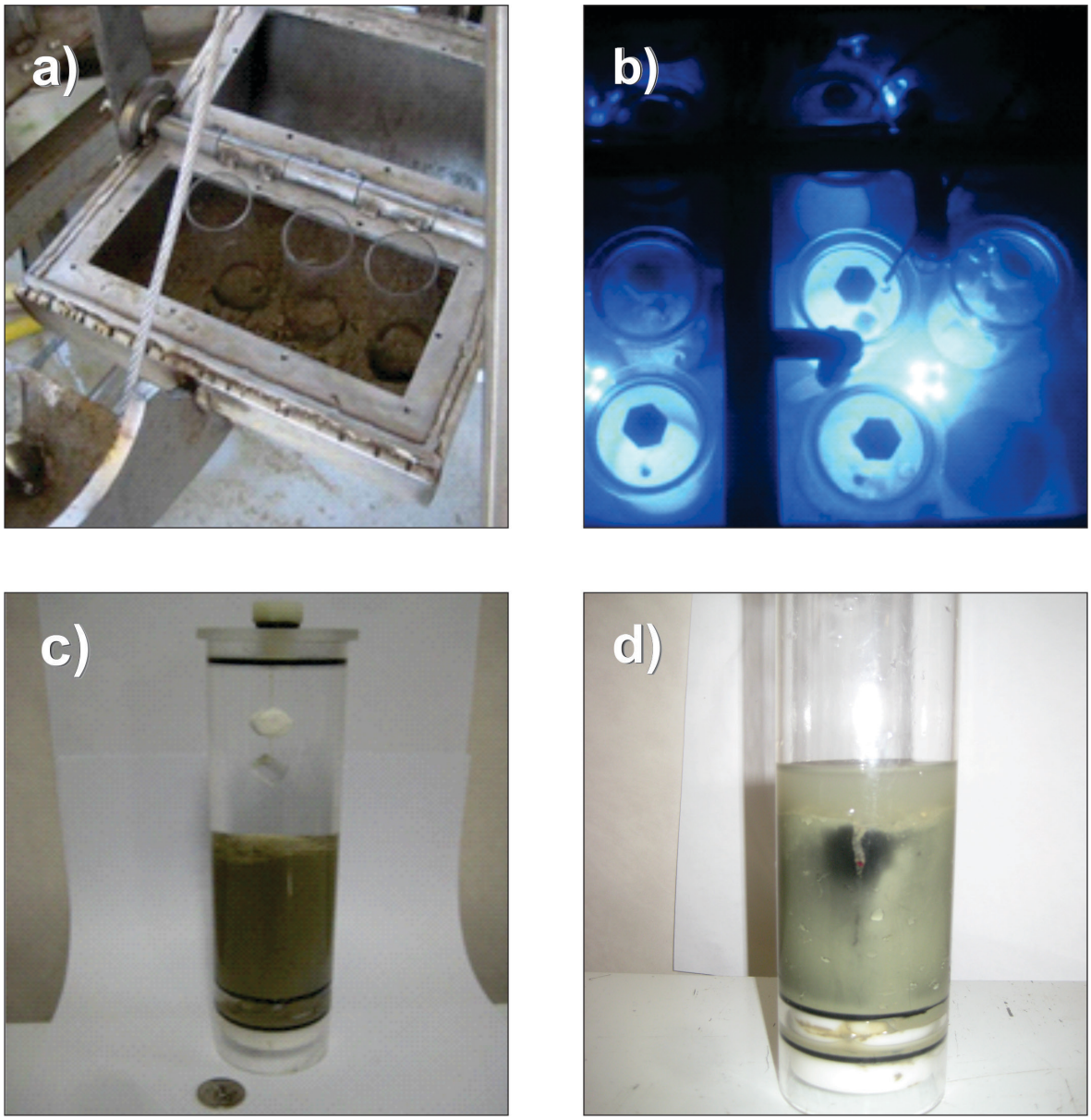

Figure 2.6 (a) Extraction of sediment cores from the Smith McIntyre grab; (b) Incubation of cores under different light treatments; (c) Example sediment core complete with stirrer, and; (d) Example of a core, post-incubation, showing sulphide accumulation around a worm burrow. The sulphide build-up is due to the occurrence of reactive carbon in the degrading worm.

2.5.3 Biology

The aim of the biological component of this survey was to characterise biological diversity and assemblages on prominent geomorphic features using several sampling methods. To quantify the bio-physical structure of these seabed environments, 57 stations (37 from banks, 13 plain, 6 terraces, and 1 valley) were surveyed and/or sampled for biology. At each of these stations, a towed-video transect was undertaken to characterise the physical structure of the seabed by substratum type, geomorphology, and topographic relief; while the biological assemblage was quantified as the presence of macro-organisms and the percentage cover of key taxa, such as sponges and octocorals. Infaunal animals (living beneath the seafloor) were sampled from 57 stations and 111 sediment samples, and epibenthic organisms (living on the seabed) were successfully sampled from 21 stations over banks.

2.5.3.1 Towed-video

Seabed habitats and benthic macro-organisms were surveyed by video and stills camera along 52 transects (17 in Area 1, 15 in Area 2, 17 in Area 3, and 3 in Area 4: Table 2.1; Appendix I) using the AIMS towed-camera system (Figure 2.7). This system was fitted with a single forward-facing video camera (Watec colour D250 model, 4 mm lens) and two high-resolution still cameras (Sea&Sea DX2G 12 mega pixel: one forward-facing and one downward-facing) and their associated lights (Figure 2.7a). At each station, an approximately 1500-m long video transect (approximately 50 minute duration) was completed, along with high-resolution still photographs captured at least every 5 seconds. Most transects ran over multiple geomorphic features and depths in order to capture habitat transitions and gradients. The camera system was deployed from the stern of the RV Solander, and towed at 0.5 to 1.5 knots at an altitude of 0.5 - 2 m above the seabed. To accurately correlate the position of seabed video and images with physical features in multibeam maps, the position of the towed-camera system was tracked using a USBL (Ultra-short Baseline) acoustic tracking system (Figure 2.7b). Video footage was transmitted in real-time to the surface via coaxial cable to enable observers to characterise the seabed environment and allow the winch operator to regulate the altitude of the towed-camera system (Figure 2.7c). Video was characterised in real-time on the vessel using the AIMS' TOWVID software and classification scheme.

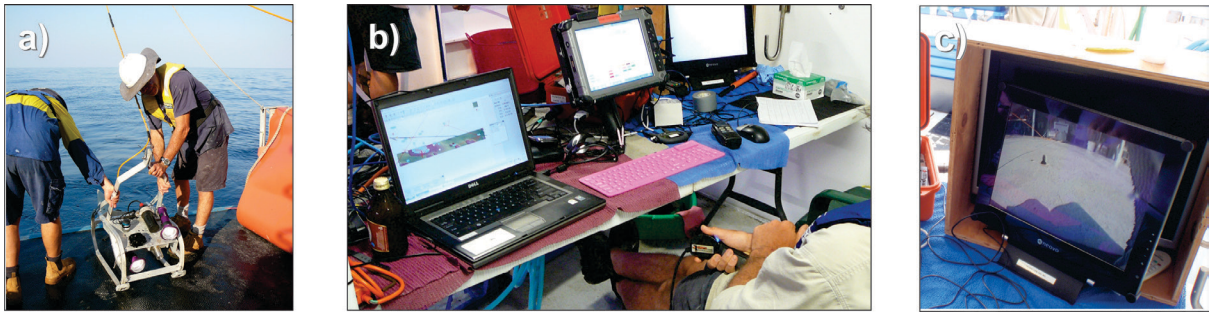

Figure 2.7 Images of the AIMS towed-video system, showing: (a) Deployment of AIMS towed-video system of the stern of the RV Solander; (b) Monitor output from the USBL acoustic tracking system, and; (c) Monitor showing real-time video footage as seen by the towed-video system.

2.5.3.2 Infaunal Sampling

Seabed infauna was sampled from 57 stations using either a Smith-McIntyre grab or box corer (Table 2.1, Appendix E). For each sample collected, a small amount of sediment (<100 g wet weight) was removed for sedimentological analysis (Section 2.5.1). For some samples, geochemical sub-samples were also removed. The remaining sediment was then released into a 52 litre Nally Bin (Figure 2.8a), excess water was decanted through a 500 µm sieve, and the sample including the bin was weighed. Sediments were then separated from infauna by elutriating in water for 5 minutes (Figure 2.8b), with infauna collected on a 500 µm sieve at the mouth of a release pipe (Figure 2.8c). Excess water was then drained from the Nally bin, and the remaining sediments (heavy fraction) searched by hand for heavier organisms (e.g. gastropods, ophiuroids, holothurians, heart-urchins and hermit crabs). These larger organisms and the elutriated material retained on the sieve were then photographed. Larger organisms were preserved/fixed in ethanol (most taxa) or formalin (polychaete worms) to be sent to the Museum & Art Gallery of the Northern Territory (MAGNT) for cataloguing and taxonomic identifications. The elutriate material was removed and preserved in ethanol to be sent to Geoscience Australia for sorting and identification to operational taxonomic unit (OTU).

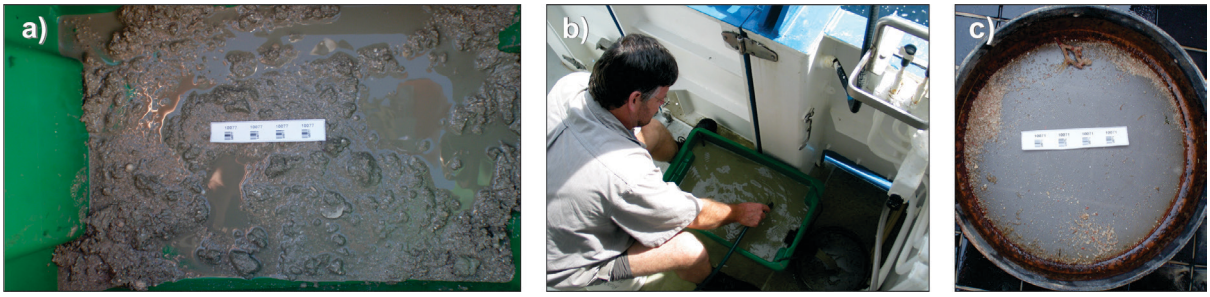

Figure 2.8 Images of the elutriating process used for infaunal sampling, showing: (a) Sediment collected from a grab sample in Nally Bin prior to elutriating; (b) Scientist elutriating grab sample with a 500 µm sieve to collect suspended organisms, and; (c) Photograph of organisms collected by sieve after 5 minutes of elutriation.

2.5.3.3 Epifaunal Sampling

Seabed epibenthos (epifauna and epiflora) was successfully sampled from 21 stations (all banks) using AIMS's epibenthic sled (Table 2.1; Figure 2.9; Appendix J). The sled is 1.5 m wide x 1 m high and fitted with a 6-m long 45 mm stretch diamond-mesh net. At each station, the sled was towed along the seabed at 1.5-2 knots for approximately 50 m. Upon retrieval, the net was emptied onto a large sorting table where researchers separated biological specimens into broad taxonomic groups (e.g. sponges, gorgonians, crinoids) (Figure 2.9b-c). The total number of animals (abundance), species (species richness) and wet weight (±10 g) for each taxonomic group was then recorded, and representatives of each taxa were photographed. Sample weights <100 g were not specified. Taxonomic voucher specimens were then preserved in ethanol (most taxa) or formalin (worms, fishes and ascidians) for post-survey identification and cataloguing by Museum Victoria (Echinoderms) and the MAGNT (all other taxa). Biological collections of infauna and epibenthos will be identified to species-level or lowest operational taxonomic units (OTU) and, in conjunction with infaunal identifications, will contribute to subsequent publications on the regional-scale biodiversity of the Timor Sea.

Figure 2.9 Examples of the epibenthic sampling process using the AIMS sled, showing: (a) Deployment of the epibenthic sled from the stern of the RV Solander; (b) A full sled net being released onto the sorting table, and; (c) Biological samples from a sled being sorted into broad taxonomic groups.

2.5.3.4 Biological Material for Biodiscovery

Since 2002, the Museum and Art Gallery of the Territory (MAGNT) has been engaged in a cooperative biodiscovery program with the US-based Coral Reef Research Foundation and the National Cancer Institute (NCI). With the collaboration of the Australian Bioresources Library (ABL) at AIMS, samples collected from Commonwealth waters have been included in this collection program. These samples are used to test and synthesise potentially useful compounds for pharmaceutical use. Biodiscovery samples collected in the current survey will be exported to the NCI under existing agreements and

permits through the ABL, which will allow biodiscovery research and commercialisation while protecting the resource provider interests in the collections. These will add to over 1000 samples which have already been sent to NCI for screening.

From biota collected from the benthic sled, selected samples (generally with weights greater than 50 g) were prepared for biodiscovery research and stored in plastic bags at -20^{o} C (Figure 2.10a-c). A total of 139 biodiscovery samples were collected on this survey, including primarily sponges as well as bryozoa, octocorals, echinoderms, and ascidians (Appendix K).

Figure 2.10 Examples of biodiscovery operations, including: (a) Biologists and crew of RV Solander sorting through a epibenthic sled sample for materials that have biodiscovery potential; (b) Sponges (centre) and octocorals (in green bucket) selected for further analysis, and; (c) Senior biologist identifying, cataloguing and processing samples with high biodiscovery potential.

2.5.3.5 Sampling of demersal fish diversity and abundance

Baited Remote Underwater Video Stations (BRUVS) have been widely used in tropical Australian waters (and elsewhere) to sample demersal fish, shark, ray and sea snake communities (e.g. Cappo et al., 2004; 2007; Schultz et al., 2012). BRUVS are generally considered the best non-destructive sampling method for fishes of all sizes and from all functional groups in non-diveable water depths. As a visual technique, the use of BRUVS is reliant on adequate underwater visibility in order to effectively identify and quantify fish visitation to the video stations.

The ability to use BRUVS to sample demersal fishes in the Oceanic Shoals survey area was limited by very poor visibility (generally <5 m) at the seabed due to tidally mobile soft sediments and a consequent lack of ambient light in waters deeper than 60 m. As a result, initial plans to deploy BRUVS throughout each survey area according to a GRTS sampling design were abandoned in favour of limited sampling only in shoal areas of ~60 m or less water depth.

During the survey, 56 stereo BRUVS were deployed for one hour according to a regular random sampling design, with minimum spacing of 400 m to ensure independence among samples (Appendix L). This included 16 BRUVS on single banks of <60 m water depth in each of Areas 1 and 2, and 24 BRUVS on each of two banks of <60 m water depth in Area 3. This yielded 56 hours of video footage which was subsequently analysed and all species and their relative abundances recorded.

Detailed analysis of the fish community data is presently ongoing and will be reported elsewhere. Preliminary analysis reveals the presence of a diversity of commercially important (e.g. deep water snappers such as *Pristipomoides* sp.) and non-commercially exploited species of fishes including sharks (Figure 2.11). Some sea snakes were also recorded. The extremely poor visibility was a limitation of the use of BRUVS in this study area and the consequent limited field of view of these samples, as well as the inability to reliably quantify benthic habitat in the field of view, is likely to affect

the direct comparability of the fish community recorded with other surveys in the broader region where visibility is typically better. Nevertheless, the data obtained will provide some insight into the fish communities of the shallower waters of the Oceanic Shoals region and their associations with other shoal areas that have previously been surveyed in northern Australia.

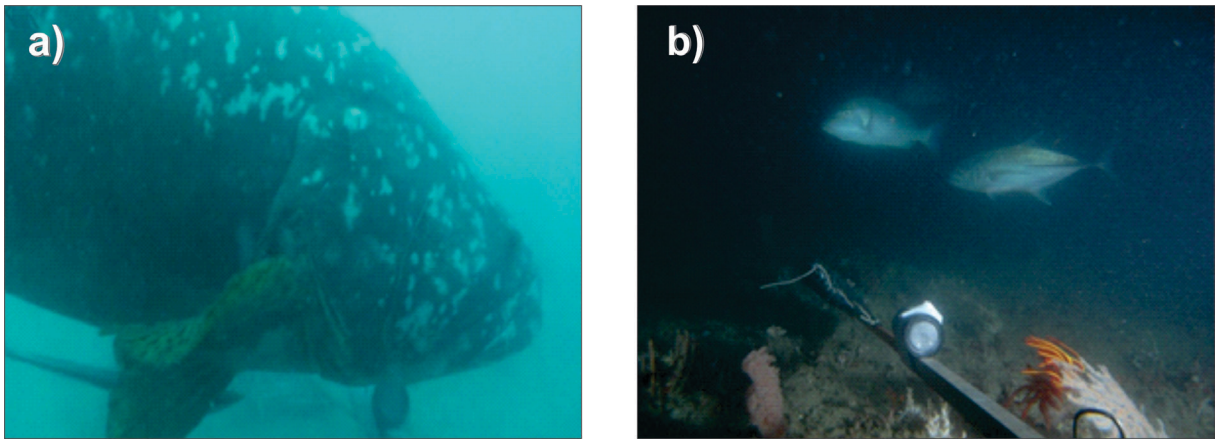

Figure 2.11 Imagery obtained from BRUVS deployed during the Oceanic Shoals survey: (a) Video frame grab of a giant Queensland groper (Epinephelus lanceolatus); (b) Still image taken by a camera mounted to a BRUVS frame showing a spangled emperor (Lethrinus nebulosus) and big-eye trevally (Caranx sexfasciatus).

2.5.3.6 Video sampling (SISSTAs) and visual surveys of marine predators

High-order mobile predators such as seabirds, marine mammals, large pelagic fish (e.g. billfish, tuna, or marlin) and sharks play a key role in maintaining biodiversity and are widely recognised as sentinels of ocean health. As such, they are often regarded as valuable ecosystem indicators and used to inform conservation planning and wildlife management initiatives. Prior to this survey, available data on the distribution and abundance patterns of these species in the Oceanic Shoals region were very limited.

To fill in these knowledge gaps, the following methods were conducted:

- Visual surveys of cetaceans and seabirds from the RV Solander's top deck, both within and in transit between survey areas. Angles and distances to sightings were measured using reticle binoculars and additional data (group size, group composition, behaviour etc.) were recorded and logged into a purpose-built database.
- Mid-water video monitoring using a new baited stereo imagery system (named SISSTAs – Stereo Imagery System for Shark and Tuna Assessments). These mid-water systems are fitted with a bait chamber to attract wildlife into the field of view of two high-resolution GoPro Hero2 cameras mounted on a central frame. The cameras are set up in stereo to allow for the calculation of individual animal lengths, and units are anchored to the seabed and tethered to a line of surface buoys to enable sampling at a variety of pre-determined depths. Units were deployed manually in sets of 10 and soaked for a minimum of two hours. Video data were uploaded and backed up immediately following unit retrieval.

During 18 hours of observations, 102 sightings of more than 300 seabirds, fish, turtles, and cetaceans were made. Mid-water systems were deployed at 117 stations at an average rate of 10 deployments per day, generating in excess of 700 hours of underwater video footage (Appendix M). Preliminary review of footage indicates that a wide range of pelagic species were observed by the systems (Figure 2.12).

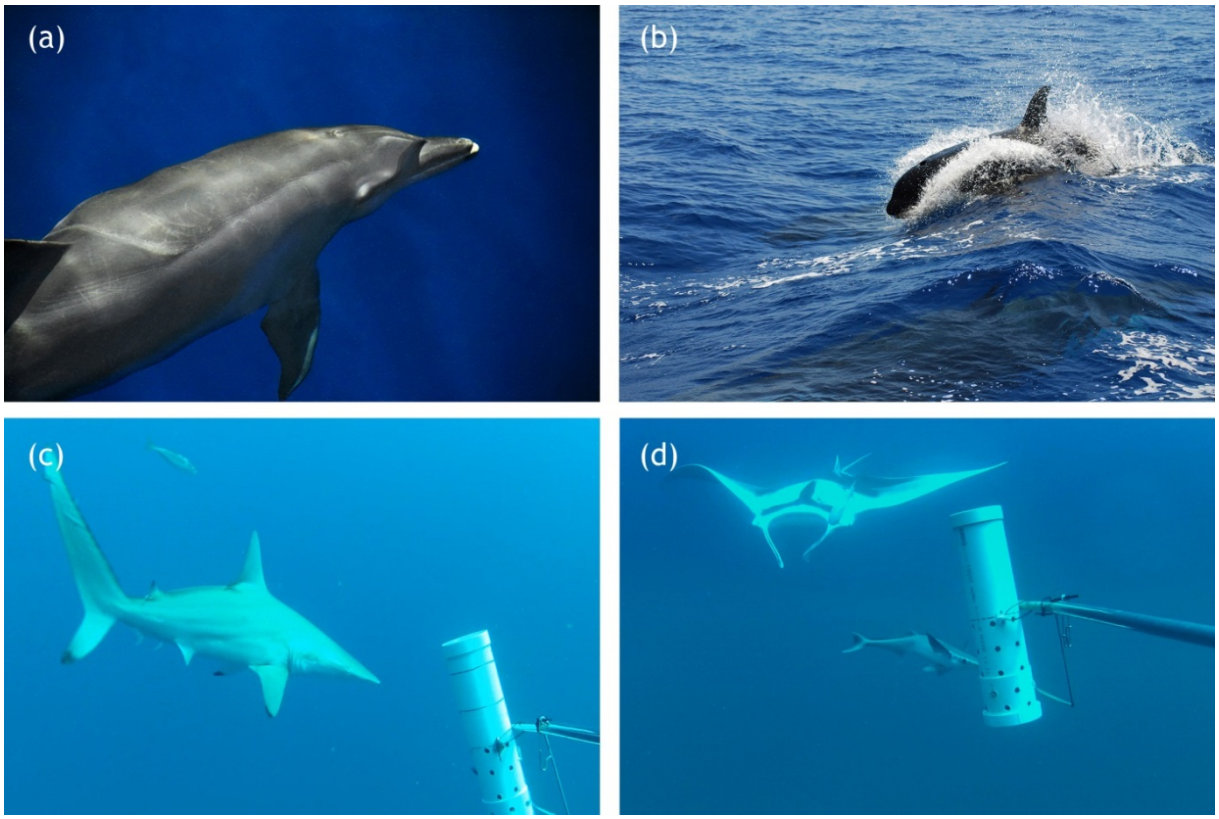

Figure 2.12 Examples of high-order marine species observed within the Oceanic Shoals CMR, including: (a) Bottlenose dolphin (Tursiops truncatus); (b) Killer whales (Orcinus orca); (c) Mid-water video observations of Australian blacktip shark (Carcharhinus tilstoni) and; (d) Manta ray (Manta birostris).

3 Preliminary Results & Interpretations

Multibeam sonar (including bathymetry, backscatter and water column) data were collected from a total area of 507 km^2, divided between the four survey areas as follows: 165 km^2 in Area 1; 155 km^2 in Area 2; 158 km^2 in Area 3, and; 29 km^2 in Area 4 (Table 3.1). In tandem with the bathymetric mapping 141.6 line-km of sub-bottom profiles were collected over three of the survey areas, as follows: 63.6 km in Area 1; 63 km in Area 2 and 15 km in Area 3 (Table 3.1; Appendix B).

Table 3.1 Areas mapped by acoustic multibeam and sub-bottom profile activities in the Oceanic Shoals CMR Survey (SOL5650), excluding transit lines.

Survey Area	Acoustic Multibeam (km^2)	Sub-bottom Profile (km)
1	165	63.6
2	155	63.0
3	158	15
4	29	0
Total	507	141.6

Within these four areas six geomorphic features were identified and mapped: bank; depression; mound; plain; scarp, and; terrace (Table 3.2). No single area contained all features, with Areas 1 and 2 being more geomorphically diverse than Areas 3 and 4, with five and four features respectively (Table 3.3). The method used to construct these interpreted geomorphic maps is described in 0.

Table 3.2 Summary of the geomorphic features mapped with definitions and datasets used to produce them. Feature definitions were based on those used by Heap and Harris (2008).

Feature	Definition	Datasets Used
Bank	Local or regional areas of elevated seafloor with one or more steep sides	2 m x 2 m Bathymetric Grids; Slope; 1 m Contour
Depression	Generally enclosed bathymetric lows on the seafloor that would act as a sediment trap.	Slope; 1 m Contour
Mound	Local areas of elevated seafloor with gently sloping rounded sides.	Slope; 1 m Contour
Plain	Extensive, flat or gently sloping areas	2 m x 2 m Bathymetric Grid; Slope; 1 m Contour
Scarp	Elongated and comparatively steep (≥10^o) slope separating more gently sloping areas	Slope
Terrace	Relatively flat or gently sloping seafloor with a moderately sloping to steep rise on one side and a moderately sloping to steep drop on the other side.	2 m x 2 m Bathymetric Grids; Slope; 1 m Contour

Table 3.3 Summary statistics for areas surveyed and their geomorphic diversity.

	Min Depth (m)	Max Depth (m)	Modal Depth (m)	Number of Geomorphic Feature Types
Area 1	35	180	109	5
Area 2	50	146	111	5
Area 3	57	169	106	4
Area 4	42	125	112	4
All Areas	35	180	109	6

3.1 Seabed Characteristics Area 1

Area 1 is the southernmost area and has the greatest range of water depths, varying between 35 and 180 m (Table 3.4; Figure 3.1). Covering 165 km^2, Area 1 incorporates five of the six main geomorphic features mapped, including 81 km^2 of plains, 69 km^2 of banks, 12 km^2 of depressions, 5 km^2 of terraces and <1 km^2 of scarps (Table 3.4).

Eight banks were identified and mapped in Area 1 (Figure 3.3). They have a modal depth of 74 m but exist in water depths ranging between 45 and 118 m. Banks have flat tops and relatively steep sides, ranging between 2 and 35^o (Figure 3.4 a and e; 0), although the northern and western margins of banks generally have lower gradients than the southern and eastern margins. Banks and the scarps that define the edges of some banks, had the highest average backscatter values of Area 1, at -35 ± 3 dB (Table 3.4; Figure 3.2), indicating that they are composed of harder substrate than other features. This was confirmed by grab and box corer samples taken on the banks which generally consisted of gravelly coarse sand, gravelly mud and sandy gravels (Appendix E).

The tops of banks in Area 1 have a bimodal depth distribution occurring at either 75 m (n = 7), or 35 m (n = 1). The deeper banks (at 75 m) could represent drowned coral reefs that formed during lower sea level but today occur within the lower limits of the photic zone. The shallow bank in Area 1 also contains a terrace that corresponds to the 75 m depth of the other banks, indicating that this surface represents a second stage of development, built atop of the earlier stage. Banks are also characterised by several smaller scale terraces notched into their flanks (Figure 3.4d and h). This notched morphology was probably formed at sea level and therefore may contain information on previous sea-level conditions during the Late Quaternary period.

Pockmarks are a seabed feature also commonly associated with the banks in Area 1, where they have formed fields of dense overlapping clusters around the base of banks and in lower density on the tops of banks (Figure 3.4 c and g). Individual pockmarks have a diameter around 13-22 m and a depth of approximately 0.6-1.4 m. Such pockmark clustering around banks has previously been shown to indicate the presence of past or current fluid or gas seepage both within this study region (George and Cauquil, 2010) and more generally (Hovland, 1990; O'Brien et al., 2002). They therefore could indicate a similar correlation between seeps and bank locations in the survey area.

Based on observations from still images (Figure 3.5), the top of the northernmost bank is dominated by sparse to moderate coverage of sessile invertebrates interspersed with expanses of coral rubble and live mushroom corals. The terrace has similar epifaunal communities with the exception of the absence of rubble and mushroom corals. The bank margin supports sparser epifaunal communities likely due to increased dominance of unconsolidated sediments; however, burrows and other signs of bioturbation suggest an abundant infaunal community.

Table 3.4 Summary of physical variables for geomorphic features mapped in Area 1.

	Area (km^2)	Percentage Total (%)	Min Depth (m)	Max Depth (m)	Modal Depth (m)	Average Slope (^{o})	Average Backscatter (dB)
Bank	68.71	41	35	118	74	2.6 ± 2.1	-35 ± 3
Depression	12.24	7	112	180	124	3.3 ± 2.9	-38 ± 3
Plain	80.73	48	94	125	109	1.8 ± 1.8	-40 ± 4
Scarp	0.56	<1	45	159	66	16.6 ± 9.3	-35 ± 3
Terrace	5.01	3	82	97	86	5.1 ± 3.8	-43 ± 3
Total	167.26	100	35	180	109	2.4 ± 2.4	-38 ± 4

Depressions occur between bank features in Area 1, with two large and deep depressions (~30 m and ~60 m deep) in the northeast part of the area (Figure 3.3). These deep depressions are unique to Area 1 and are characterised by steep sides along some of their margins. The other depression features identified in Area 1 were generally much shallower (6-10 m). Depressions had a moderate average backscatter value of -38 ± 3 dB (Table 3.4) indicating that they could be of mixed composition, with the steeper flanks generally returning higher backscatter values than the depression floors (Figure 3.2). No grab or box corer samples were taken within these features to confirm this. The location of these features between banks could indicate that they are formed by tidal current scour that is focused by the banks.

Plains are the most widespread geomorphic feature in Area 1 with a modal depth of 109 m (Table 3.4) and an increase in water depth towards the north (gradient ~0.07^o). Grabs and box cores taken from plains in Area 1 generally returned sandy silts (Appendix E) which is reflected in the plains low average backscatter value of -40 ± 4 dB (Table 3.4). Individual, non-clustering, pockmarks (with depths between 0.5-2.1 m and diameters between 16-32 m) are also ubiquitous across the soft sediment plains, with a representative example illustrated in Figure 3.4b and f. Pockmarks are seen to have a higher backscatter signal than the surrounding plain (Figure 3.4f) indicating they are composed of a harder substrate and/or larger grainsize. Furthermore, it can be seen that the closer these individual pockmark features are to banks the more frequently they tend to have an asymmetric plan shape, perhaps indicating stronger tidal current action with proximity to banks. If this is correct the direction of the asymmetry could be used to reconstruct local current direction around banks.

Finally, a large terrace feature is mapped in the southwest corner of Area 1 (Figure 3.3) occurring at ~86 m. This terrace contains dense overlapping clusters of pockmarks (Figure 3.4c and g) and returned the lowest average backscatter values -43 ± 3 dB indicating that it is composed of soft sediment with small grain size. This was confirmed by a grab sample which contained poorly-sorted, slightly-sandy silt (Appendix E).

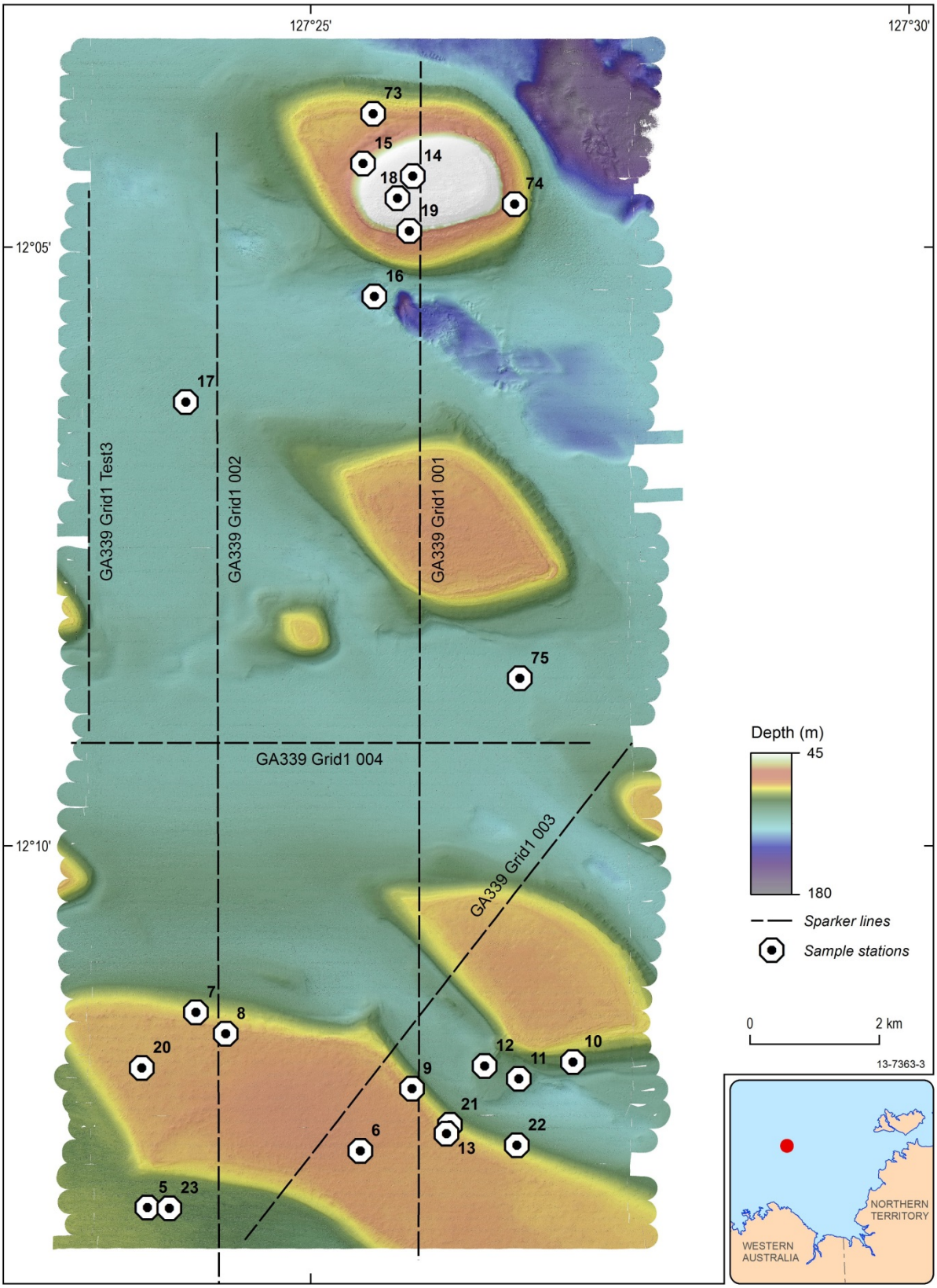

Figure 3.1 False colour bathymetry image of Area 1 with sub-bottom profile (sparker) lines and sampling stations indicated.

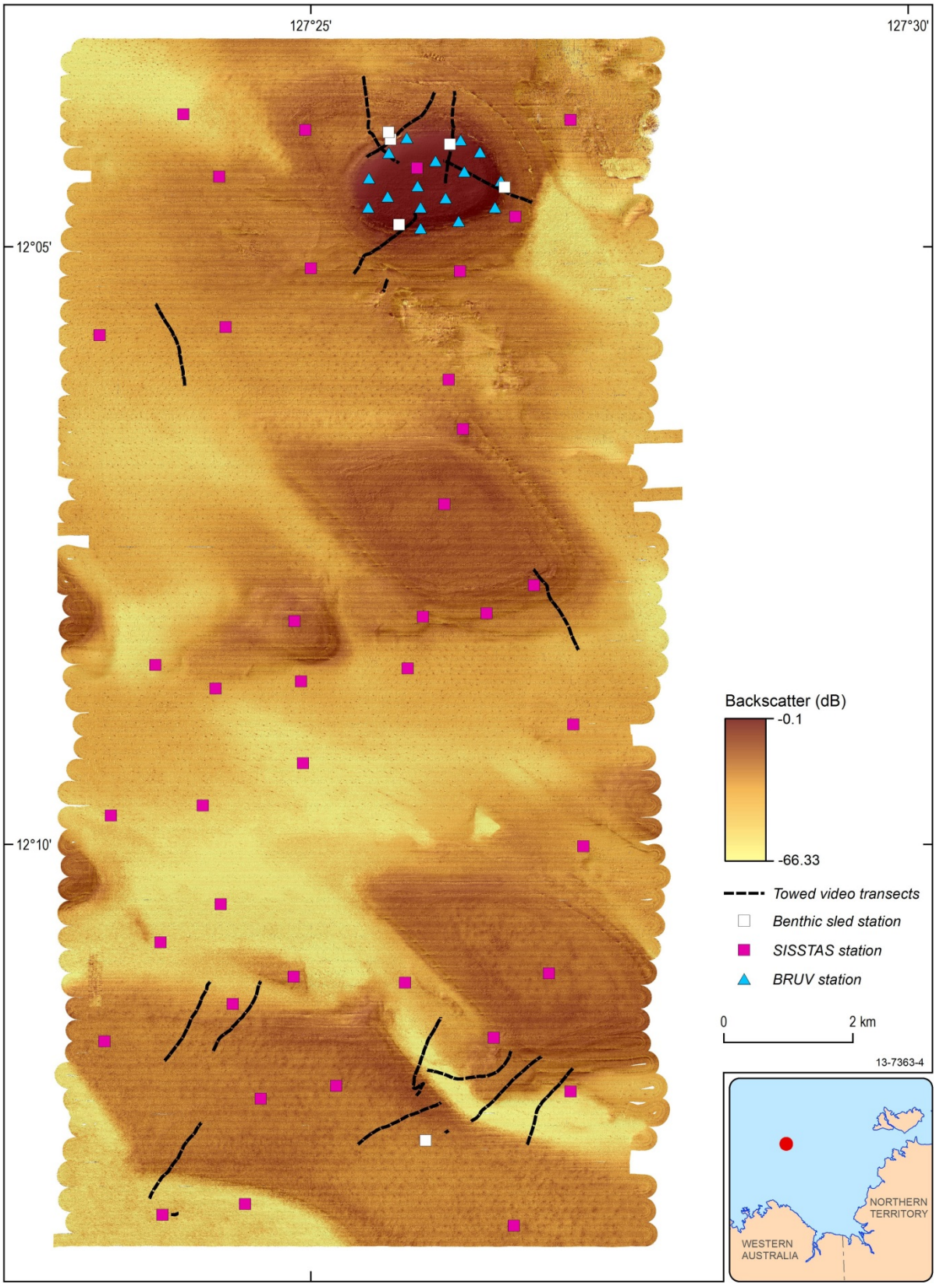

Figure 3.2 False colour backscatter image of Area 1 with towed video transects, benthic sled, baited remote underwater video (BRUVS) and baited mid-water column video (SISSTAs) stations indicated.

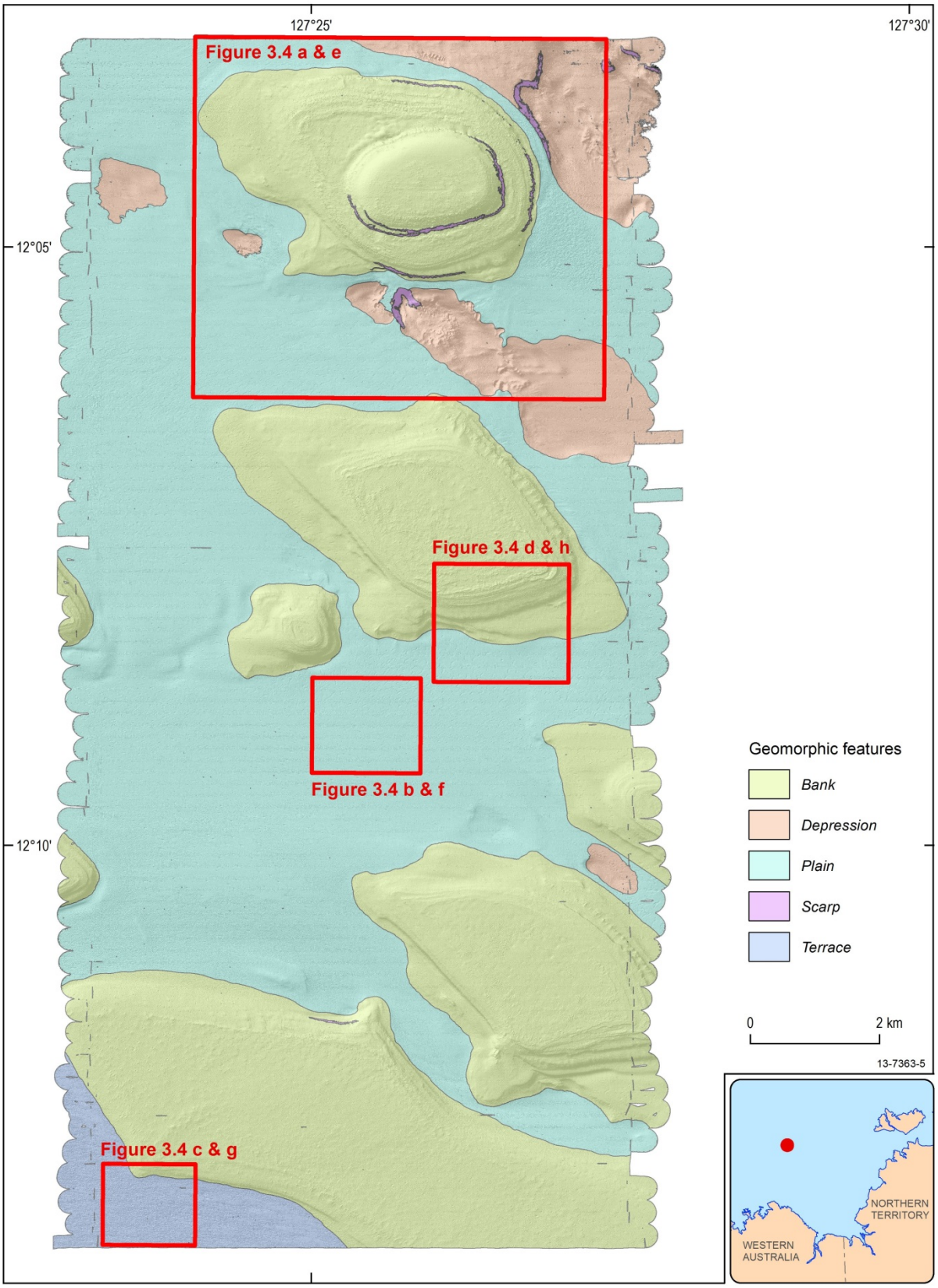

Figure 3.3 Local-scale geomorphic features mapped in Area 1 interpreted from bathymetry. Images are 30% transparent polygons overlying hill-shaded bathymetric images. Boxes indicate the location of key geomorphic features shown in Figure 3.4.

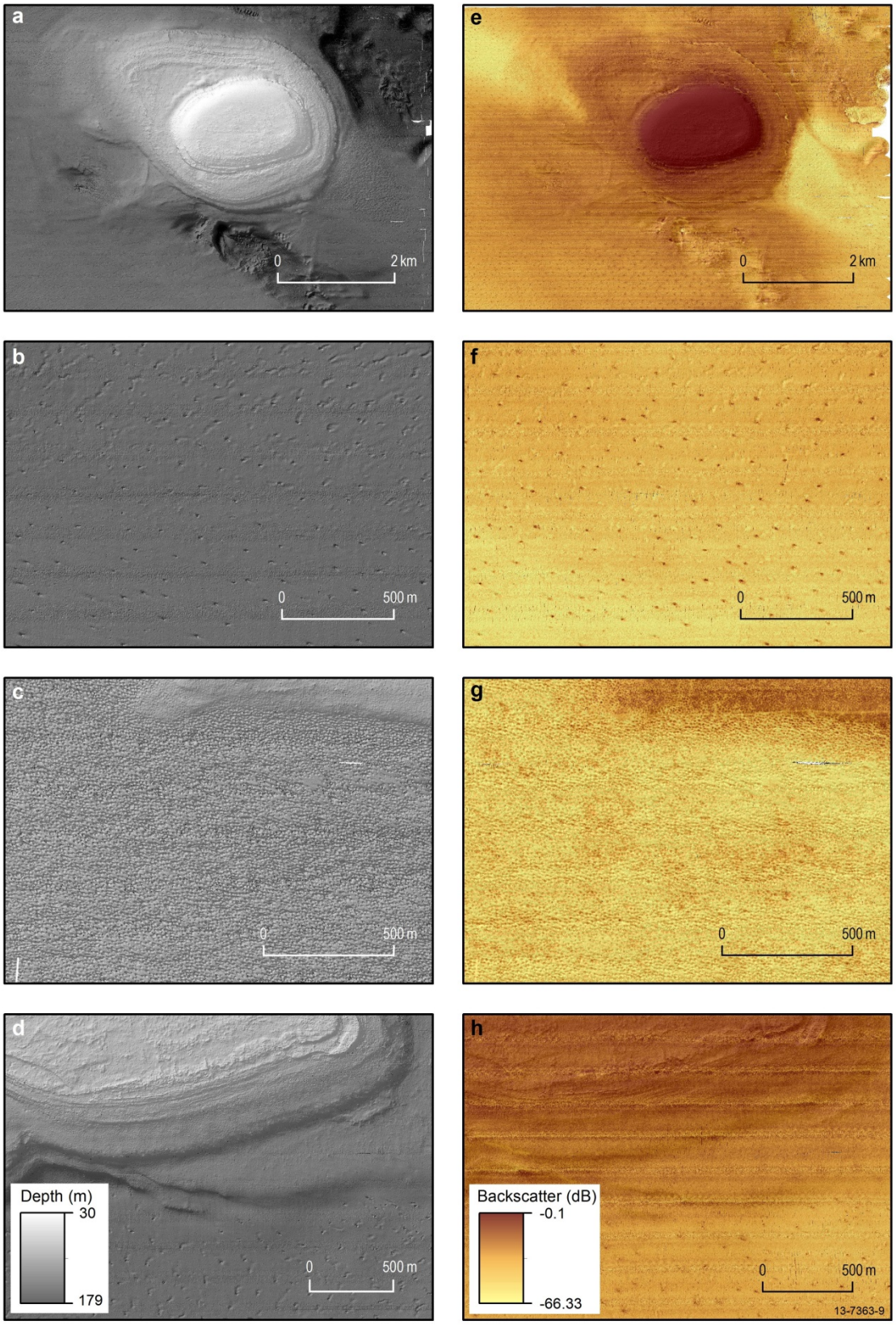

Figure 3.4 Hill shaded bathymetry (a-d) and backscatter (e-h) images of representative geomorphic features in Area 1, including: bank (a and e); sparse pockmark fields (b and f) with and without 'tails'; dense pockmark fields (c and g), and; terraced and notched morphology of the sides of banks (d and h). Although these specific examples are in Area 1 they are representative of the other areas surveyed.

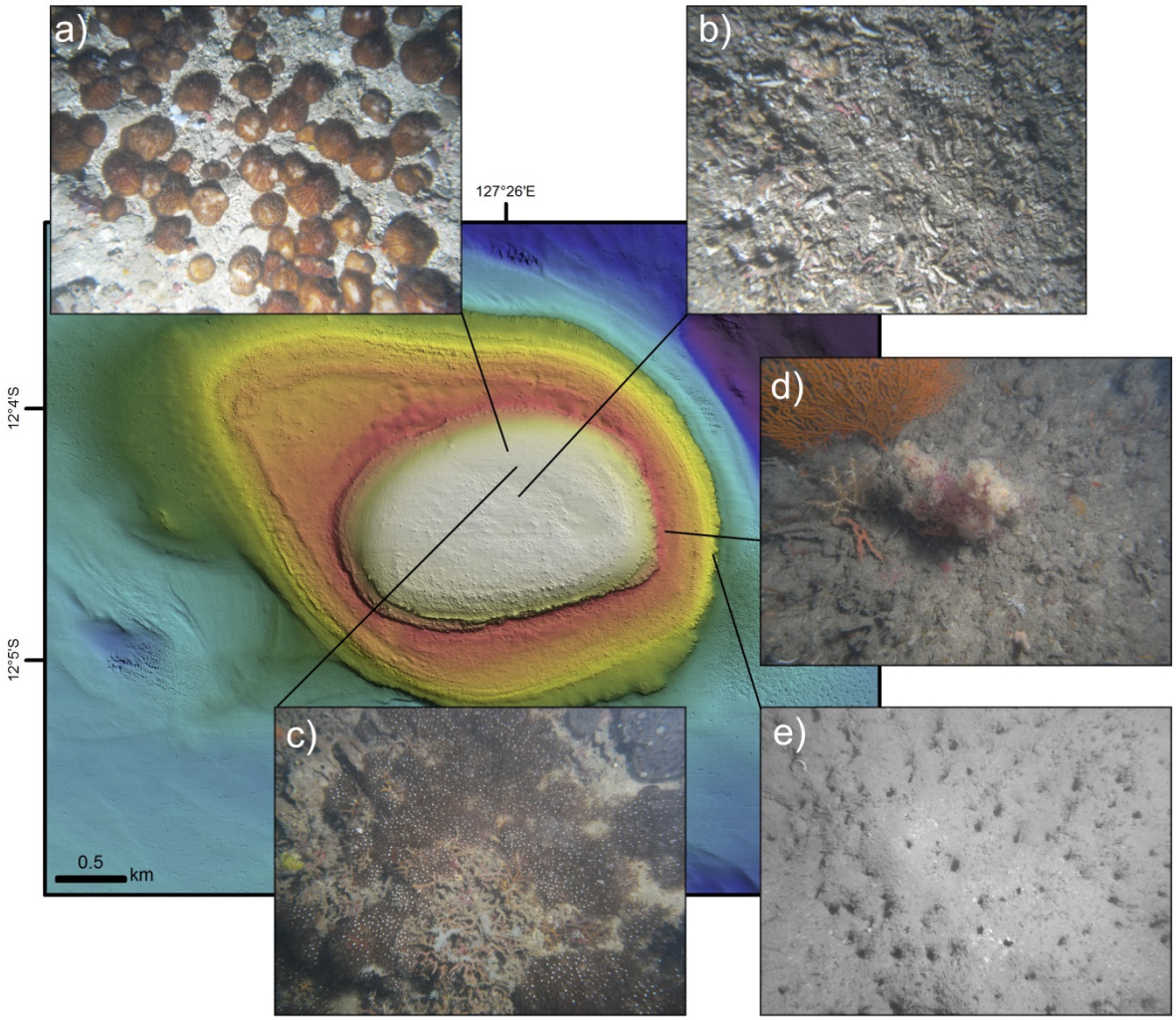

Figure 3.5 Representative still images from the northernmost bank in Area 1, showing: (a) live mushroom corals; (b) coral rubble; (c) moderate to dense epifaunal coverage (cnidarians, sponges); (d) the flank of the bank supporting scattered epifauna (sponges, Mopsella gorgonian), and; (e) high levels of bioturbation on the lower flank.

3.2 Seabed Characteristics Area 2

Area 2 is located 32 km northwest of Area 1 and sits in water depths ranging between 50 and 146 m (Table 3.5; Figure 3.6). Covering 159 km^2, Area 2 incorporates five of the six main geomorphic features mapped, including 84 km^2 of plains, 41 km^2 of terraces, 31 km^2 of banks, 2 km^2 of depressions and <1 km^2 of scarps (Table 3.5). The seafloor characteristics and environmental setting of Area 2 are very similar to those found in Area 1.

Nine banks were mapped in Area 2, ranging in water depth at their base from 50 to 123 m (Figure 3.8). They have generally flat tops with six of the banks rising to 78 m water depth. The other three bank tops in Area 2 occur at 90 m, 85 m and 60 m water depth. As in Area 1, the flanks of the banks are notched by small terraces and there is a tendency for the northern margins to have shallower slopes. This relationship breaks down, however, where banks are clustered close together, as occurs in the centre of Area 2 (Figure 3.8). Banks and their scarps had the highest average backscatter values in Area 2, at -36 ± 2 dB (Figure 3.7; Table 3.5) indicating that they are composed of a harder substrate than the other features. This was confirmed by grab and box corer samples on bank features which generally consist of poorly sorted muddy coarse sand (Appendix E).

Dense clusters of overlapping pockmarks (Figure 3.4 c and g) are associated with most bank features in Area 2, generally occurring on the flanks and adjacent to the bases of banks and to a lesser degree their tops. This is not always the case. For example, the most northerly bank in Area 2 contains almost 100% coverage of dense pockmark clusters on its flat top, and relatively smooth and pockmark free flanks.

Based on observations from still images (Figure 3.9), the top of the most southern bank is dominated by unconsolidated sediment with little evidence of bioturbation and only scattered epifauna (small sponges, gorgonians, and ascidians). The seafloor of the terrace includes a much higher proportion of harder substrate as indicated by the moderate coverage of large sponges (*Iantella*) and gorgonians (*Mopsella*). The bank margin is also dominated by unconsolidated sediment but with increased signs of bioturbation.

Plains are the most widespread geomorphic feature in Area 2, and have a modal water depth of 112 m (Figure 3.6), dipping slightly in a north-westerly direction (~0.15°). Grabs and box cores taken from plains in Area 2 generally returned silt or slightly sand silt, with the exception of grabs taken near banks (e.g. Station 34) which contained greater amounts of coarse sand (Appendix E). The soft substrate composition of plains was also reflected in their average backscatter value of -44 ± 3 dB, which was the lowest of all features in Area 2. Pockmarks are ubiquitous across the soft sediment plains in Area 2. Unlike Area 1, both dense clusters of pockmarks along with individual larger pockmarks are common on plains. The fields of dense clusters tended to occur in the deeper section of the plain, located in the centre of Area 2, or adjacent to bank features (Figure 3.6). Similar to Area 1, many individual pockmarks tended to have an asymmetric plan-shape, particularly where they occur close to banks.

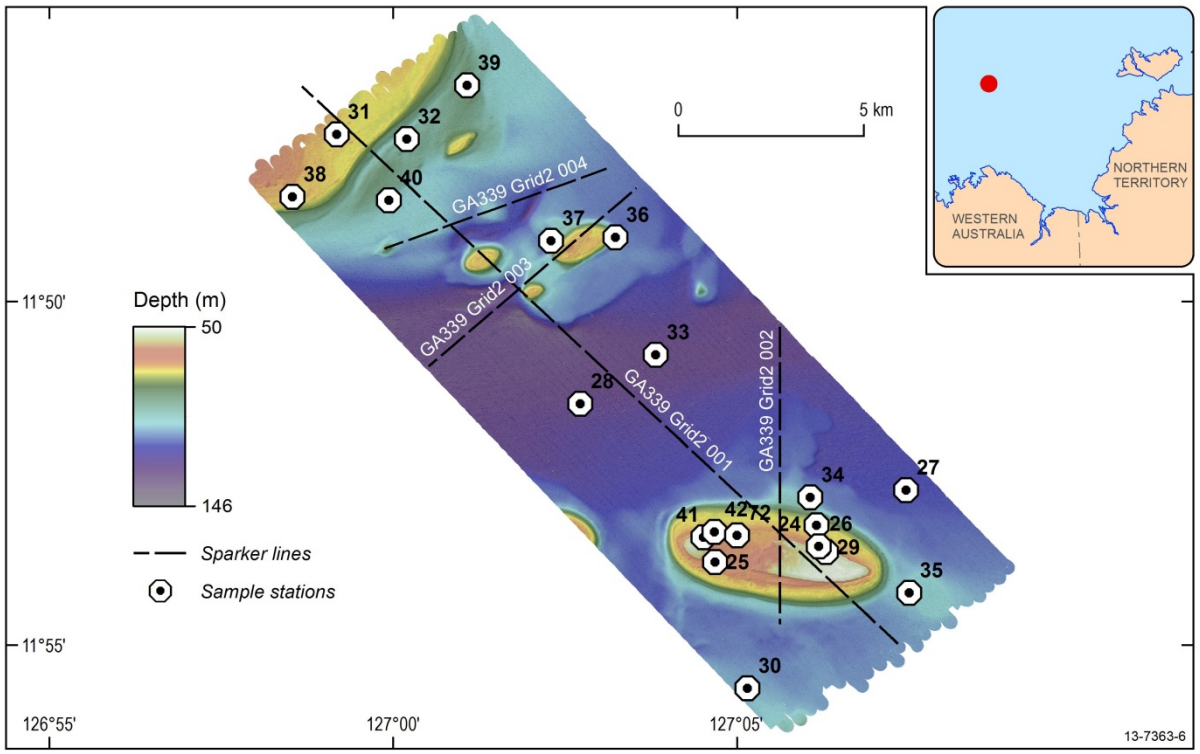

Figure 3.6 False colour bathymetry image of Area 2 with sub-bottom profile (sparker) lines and sampling stations indicated.

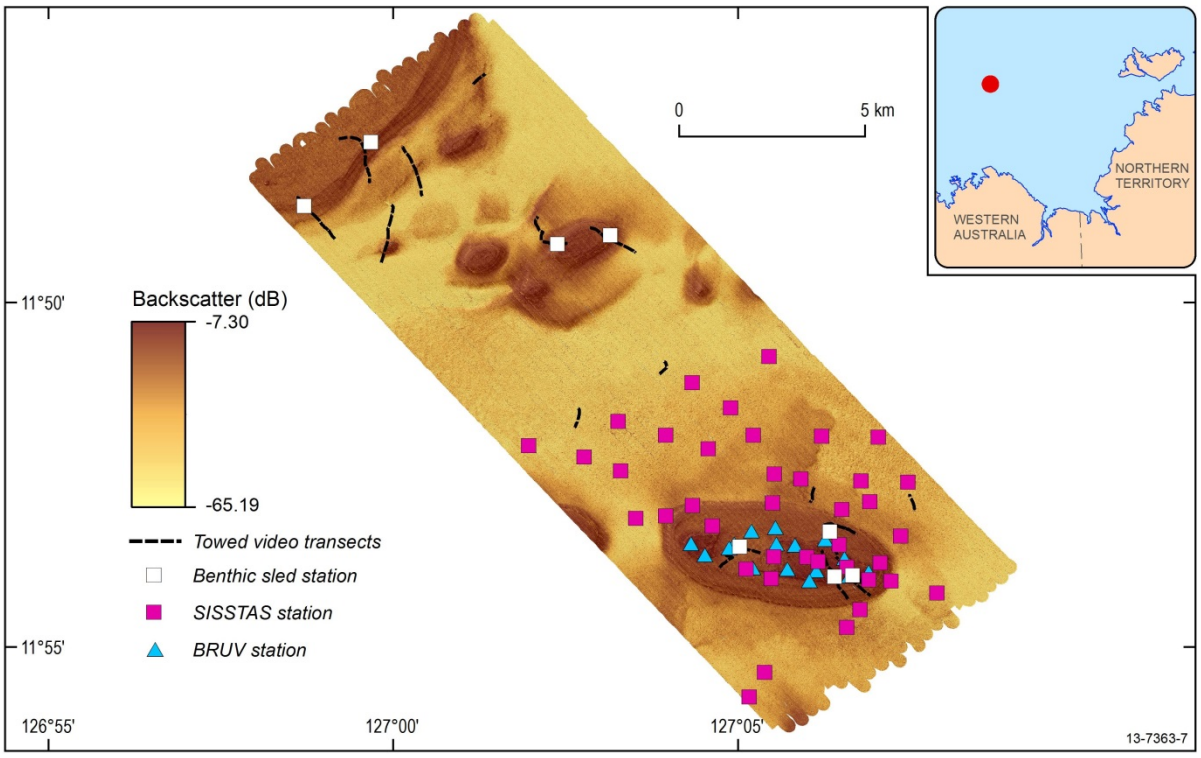

Figure 3.7 False colour backscatter image of Area 2 with towed video transects, benthic sled, baited remote underwater video (BRUVS) and baited mid-water column video (SISSTAs) stations indicated.

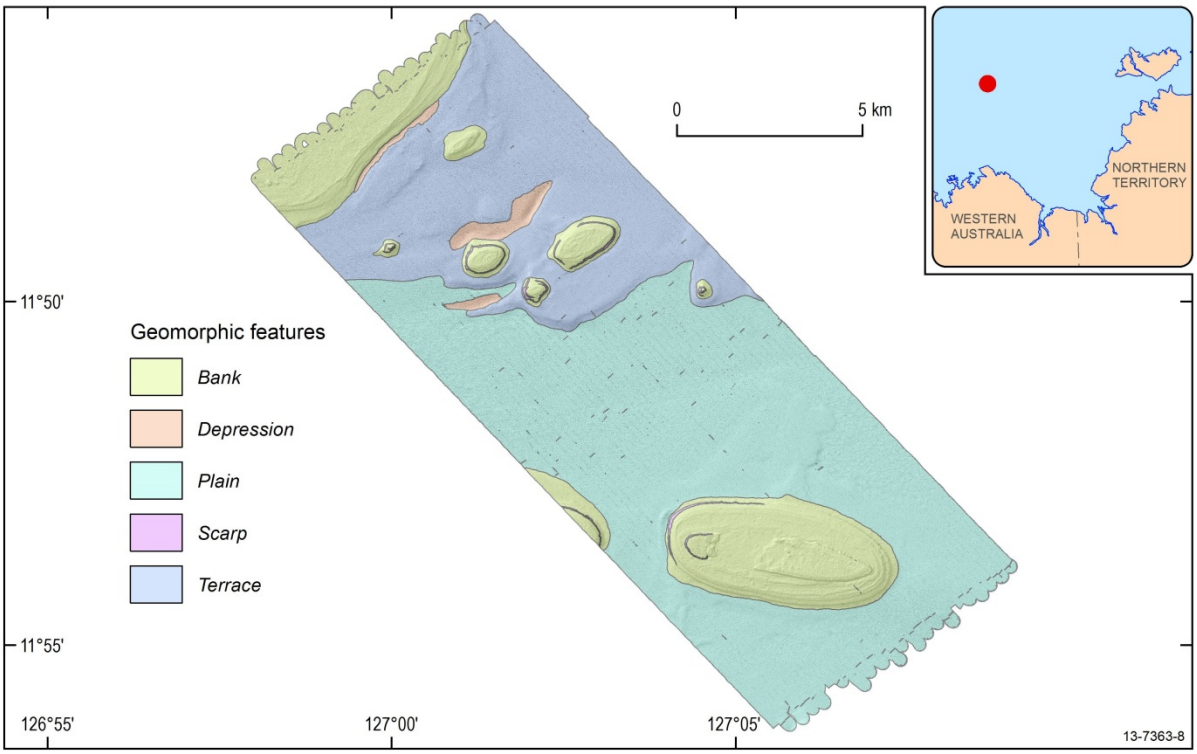

Figure 3.8 Local-scale geomorphic features mapped in Area 2 interpreted from bathymetry. Images are 30% transparent polygons overlying hill-shaded bathymetric images.

Table 3.5 Summary of physical variables for geomorphic features mapped in Area 2.

	Area (km^2)	Percentage Total (%)	Min Depth (m)	Max Depth (m)	Modal Depth (m)	Average Slope (°)	Average Backscatter (dB)
Bank	30.73	19	57	123	78	3.0 ± 2.8	-36 ± 2
Depression	2.28	1	97	138	115	3.7 ± 3.1	-43 ± 5
Plain	84.49	53	89	146	112	2.7 ± 2.7	-44 ± 3
Scarp	0.51	<1	62	111	96	16.5 ± 10.4	-36 ± 2
Terrace	40.53	26	89	137	111	2.7 ± 2.5	-43 ± 4
Total	158.54	100	57	146	111	2.8 ± 2.5	-42 ± 5

Terraces cover 41 km^2, making them the second most extensive feature in Area 2. They have a modal depth of 111 m (Table 3.5), sloping slightly in a south-easterly direction (0.15-0.35°). The eastern boundary between the plain and terrace is sharp with a steep slope (2-6°) between the two features. The western boundary is more gradual and less distinct. Grab and box core samples from the terrace returned slightly sandy silt which is reflected in their low average backscatter values of -43 ± 3 dB (Table 3.5). Similar to plains in Area 2, both fields of dense clusters of pockmarks and fields of individual, non-clustering pockmark features overprint terrace features.

Depressions cover 2 km^2 in Area 2 with a modal depth of 115 m. They are shallow (3-10 m deep), elongate features that occur between banks, perhaps indicating that they are formed by tidal current scour that is focused by these features. Depressions have a low average backscatter value of -43 ± 5 dB (Table 3.5) indicating that they are composed of relatively soft sediment. The one box core sample

from depressions in the northern part of Area 2 (Station 32), however, returned muddy, very coarse sand (Appendix E). This relatively hard substrate, when compared to the silt of the plains and terraces, is probably a consequence of the proximity of this depression to the northernmost bank, with coarse sediment being sourced from this prominent feature.

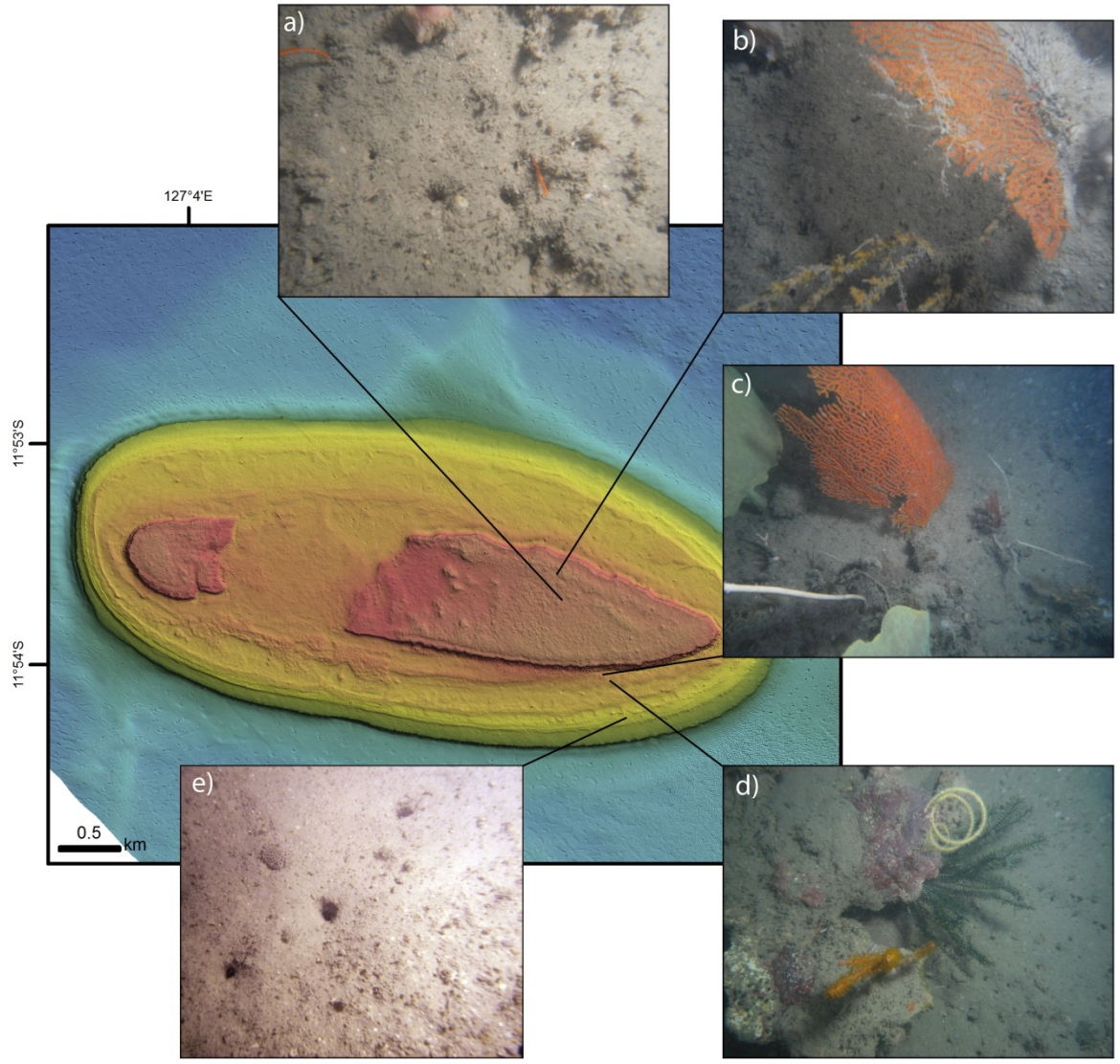

Figure 3.9 Representative still images from the main bank in Area 2, showing: (a) sparse epifauna on bioturbated sandy substrate; (b) a gorgonian growing on sand; (c) larger habitat-forming epifauna (Ianthella sponges, Mopsella gorgonian; (d) moderate to dense coverage of epifauna on the lower terrace of the bank, and; (e) moderate concentration of bioturbation on the lower flank.

3.3 Seabed Characteristics Area 3

Area 3 is located 34 km north of Area 2 and in water depths ranging between 51 and 169 m (Table 3.6; Figure 3.10). Covering 159 km^2, Area 3 incorporates four of the six main geomorphic features mapped, including: 113 km^2 of plains; 45 km^2 of banks; and <1 km^2 of mounds and scarps (Table 3.6). The seafloor characteristics and environmental setting is very similar to those observed in all other areas surveyed.

Twenty-two banks were identified and mapped in Area 3, which was the greatest amount in any area surveyed (Figure 3.12). They have a modal depth of 88 m but exist in water depths ranging between 51 and 113 m. Most banks have an elliptical footprint with long axes oriented in a southeast to northwest direction. Banks and their scarps have the highest average backscatter values in Area 3, at -38 ± 4 and -35 ± 3 dB (Table 3.6), indicating that they are composed of a harder substrate than other geomorphic features. This was confirmed by grab and box corer samples on bank features which generally consisted of poorly sorted, muddy coarse sand (Appendix E).

The banks in this area can be clustered by the depth of their tops. The most frequent bank top occurs at 84-85 m (n = 10), followed by 80-92 m (n = 5), 90-91 m (n = 4), 62 m (n = 1), 52 m (n = 1), and 101 m (n = 1). The bank tops with the greater depth ranges have rounder tops, in contrast to the generally flat tops of banks with a narrow range or single value. The two shallowest banks are also the largest in Area 3 and both have lower terraces at 84-85 m depth, representing former sea-levels (Figure 3.12). The top of the largest bank in Area 3 has a slight dip towards the northwest (gradient ~0.14^{o}) from 58 m to 65 m, but this is the only bank top to display this form.

Dense clusters of overlapping pockmarks are commonly associated with most bank features in Area 3 (Figure 3.4c and g). They generally occur on the flanks and adjacent to the bases of banks. More rounded banks also frequently had pockmark clusters on their tops while tops that were relatively flat were free from pockmark clusters.

Based on observations from still images, the top of the largest bank supports very few epifauna, with a seafloor comprised of unconsolidated sediment and limited bioturbation (Figure 3.13). The southern bank top shows more signs of bioturbation, as well as benthic algae, possibly due to comparatively lower benthic disturbance on the south of the bank. The flanks of the bank support differing biological assemblages, with the northern flanks showing only very sparse epifauna and bioturbation, and the southern flank showing more epifauna, benthic algae, and bioturbation. The margins of the bank show the most bioturbation signs, with few epifauna and no observed benthic algae.

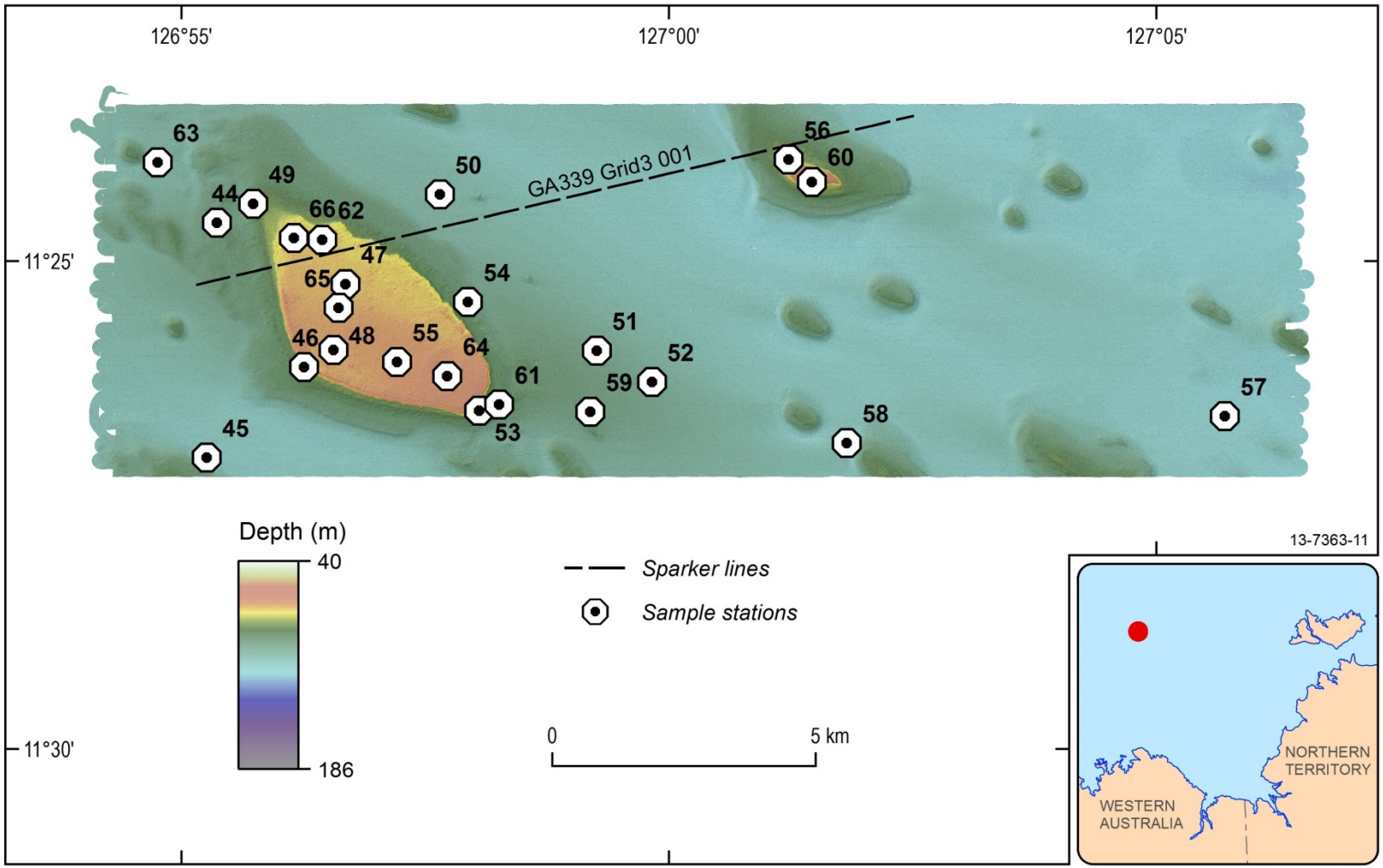

Figure 3.10 False colour bathymetry image of Area 3 with sampling stations indicated.

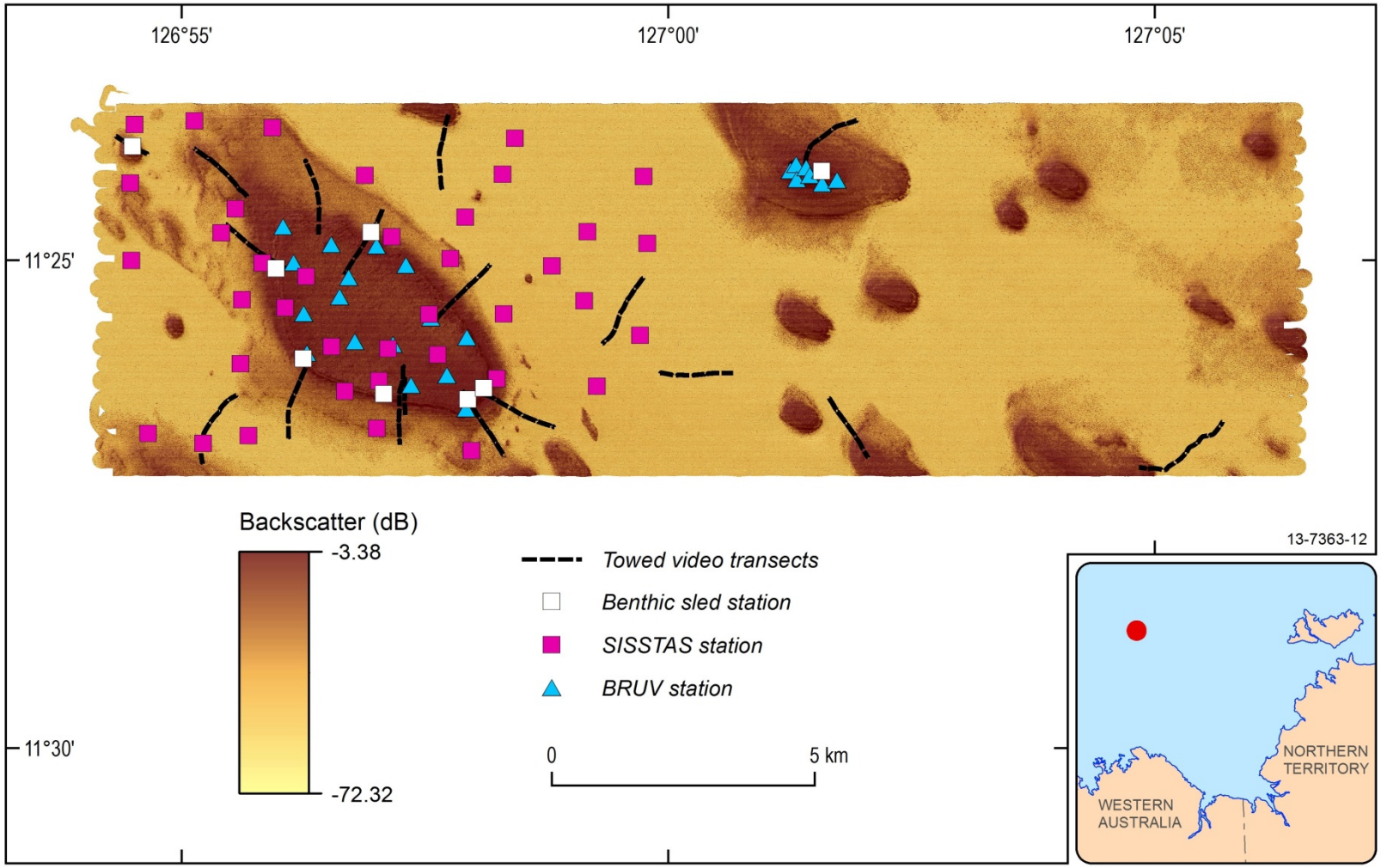

Figure 3.11 False colour backscatter image of Area 3 with towed video transects and benthic sled, baited remote underwater video (BRUVS) and baited mid-water column video (SISSTAs) stations indicated.

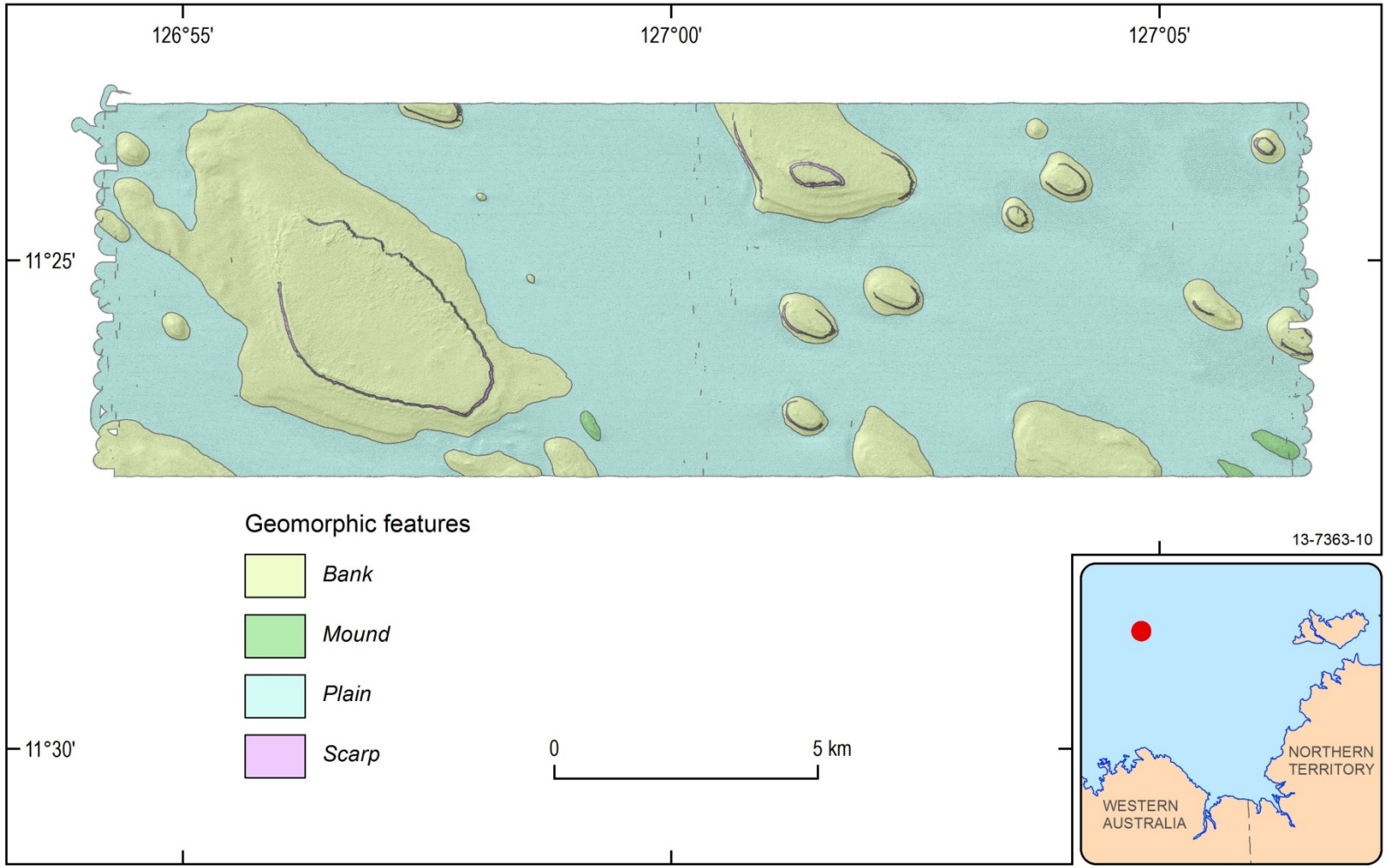

Figure 3.12 Local-scale geomorphic features mapped in Area 3 interpreted from bathymetry. Images are 30% transparent polygons overlying hill-shaded bathymetric images.

Table 3.6 Summary of physical variables for geomorphic features mapped in Area 3.

	Area (km^2)	Percentage Total (%)	Min Depth (m)	Max Depth (m)	Modal Depth (m)	Average Slope (^{o})	Average Backscatter (dB)
Bank	44.95	28	50	113	88	3.3 ± 2.8	-38 ± 4
Mound	0.49	0.5	85	112	107	5.1 ± 4.4	-43 ± 4
Plain	112.57	71	90	146	106	2.5 ± 3.0	-47 ± 2
Scarp	0.78	0.5	52	109	94	19.2 ± 11.9	-35 ± 3
Total	158.78	100	50	146	106	2.9 ± 3.3	-44 ± 5

Plains are the most widespread geomorphic feature in Area 3 with a modal depth of 106 m (Table 3.6), sloping slightly in a north-easterly direction (~0.02°). Grabs and box cores from plains in Area 3 returned well-sorted silt (Appendix E). This composition is reinforced by the low average backscatter value of -47 ± 2 dB for plains which is not only the lowest of all features in Area 3 but the lowest out of all plains in all areas. Pockmarks are ubiquitous across the soft sediment plains in Area 3, with depths of 0.5 to 2.1 m and diameters ranging from 16 to 32 m. Most pockmarks are circular, but in some cases have an asymmetric plan-shape. Fields of dense clusters of overlapping pockmarks are also common on plains, but only where they are adjacent to banks and mounds. These fields of dense clusters coincide with a higher backscatter return, particularly noticeable in the east of Area 3 (Figure 3.11).

Finally, mounds are a feature unique to Area 3, where three were mapped (Figure 3.12). They have a low, rounded profile, ranging between 3-10 m in height and although characterised by a low average backscatter of -43 ± 4 dB, they correspond to areas of distinctly higher backscatter than the adjacent plain (Figure 3.11). Like banks they are covered on their flanks by dense clusters of overlapping pockmarks.

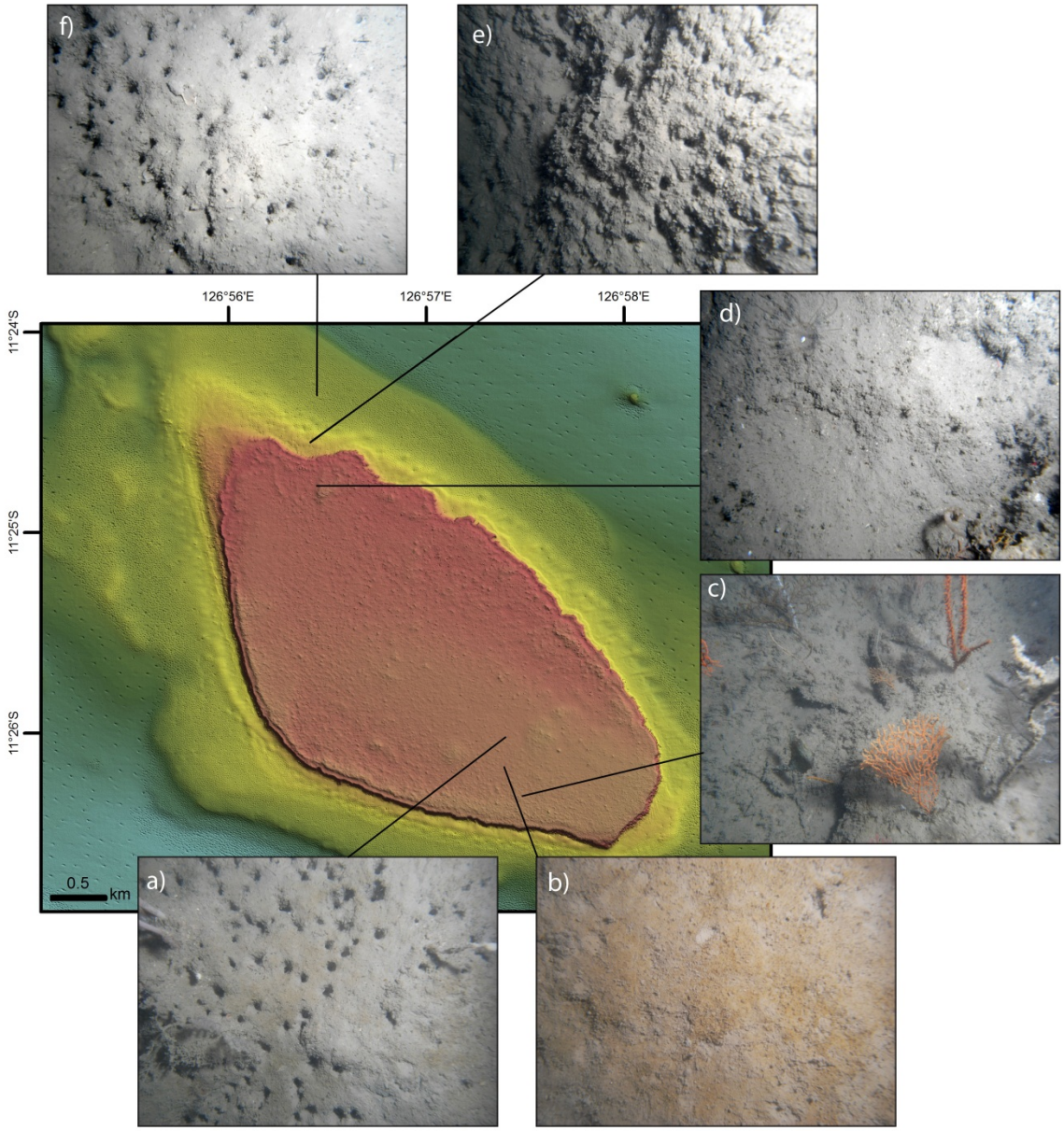

Figure 3.13 Representative still images from the main bank in Area 3, showing: (a) high density of burrows in silty sediment; (b) benthic algae; (c) scattered epifauna (sponges, gorgonians); (d) very sparse epifauna; (e) and (f) high levels of bioturbation on the lower terraces.

3.4 Seabed Characteristics Area 4

Area 4 is the northern-most survey area and sits in water depths ranging between 42 and 124 m (Table 3.7; Figure 3.14). Covering 29 km^2, Area 4 incorporates four of the six main geomorphic features mapped, including: 20 km^2 of plains, 7l m^2 of banks and <1km^2 of depressions and scarps. The seabed characteristics and environmental setting of Area 4 was similar to all other areas surveyed.

Two prominent and large banks were mapped in Area 4 (Figure 3.16). They have a modal depth of 90 m but exist in water depths ranging between 42 and 111 m. The flanks and scarps of banks in Area 4 tend to be very steep (ranging between 2 and 70°) with the northern and western margins less steep than the southern and eastern margins. Two grabs taken from banks in Area 4 returned muddy, medium to coarse carbonate sand (Appendix E). This is consistent with the high average backscatter values for banks and scarps in Area 4 of -36 ± 3 dB and -35 ± 3, respectively (Figure 3.15; Table 3.7).

The flat tops of both banks occur at different depths with the larger, western bank having a shallower and flatter top, at 44 m, than the eastern bank, which has a crestal depth of 80-90 m. The western bank, also has a large terrace at 80-90 m. Fungoid (disc) coral was found in the grab sample at Station 68 (Appendix E) on the top of the western, shallower bank, indicating that the top of this bank is a habitat for coral. Similar to the banks in the other survey areas, banks in Area 4 were notched with smaller-scale terraces.

Unlike banks in the other survey areas, the tops and flanks of banks in Area 4 were generally free of dense clusters of pockmarks. However, the areas of plain adjacent to banks, along with the less steep margins of banks, did contain dense clusters of pockmarks.

Based on observations from still images (Figure 3.17), the top of the western bank has moderate coverage of epifauna, including habitat-forming barrel sponges (*Xestospongia*), fields of mushroom corals and conspicuous fauna including species not observed in abundance at other banks (e.g. long spiny sea urchin and nubbed anemones). The flank has sparser epifauna, while the bank margin is dominated by unconsolidated sediment with few signs of bioturbation.

Plains are the most widespread geomorphic feature in Area 4, and have a modal depth of 112 m (Table 3.7). They return a low average backscatter value of -43 ± 4 dB indicating that they are likely to be composed of soft sediments. While no sediment samples were taken from plain features in Area 4, grab and box core samples from plains in the other areas indicate that it is highly likely that the plains are composed of silt or slightly sandy silt. Pockmarks are also ubiquitous across the soft sediment plains in Area 4. Unlike the other areas surveyed, dense clusters of overlapping pockmarks are by far the most common type in plains in Area 4. Fields of individual, larger pockmarks did occur but these often are coincident with the fields of larger pockmarks.

A single depression occurs in Area 4 between the two large banks (Figure 3.16) that it was likely formed by tidal current scour focused by these large banks. It is characterised by a modal depth of 114 m and is up to 6 m deep (Table 3.7). Although no physical samples were taken the depression has a low average backscatter of -43±45 dB indicating that it is formed in soft sediment. The entire depression is overprinted by dense clusters of overlapping pockmarks.

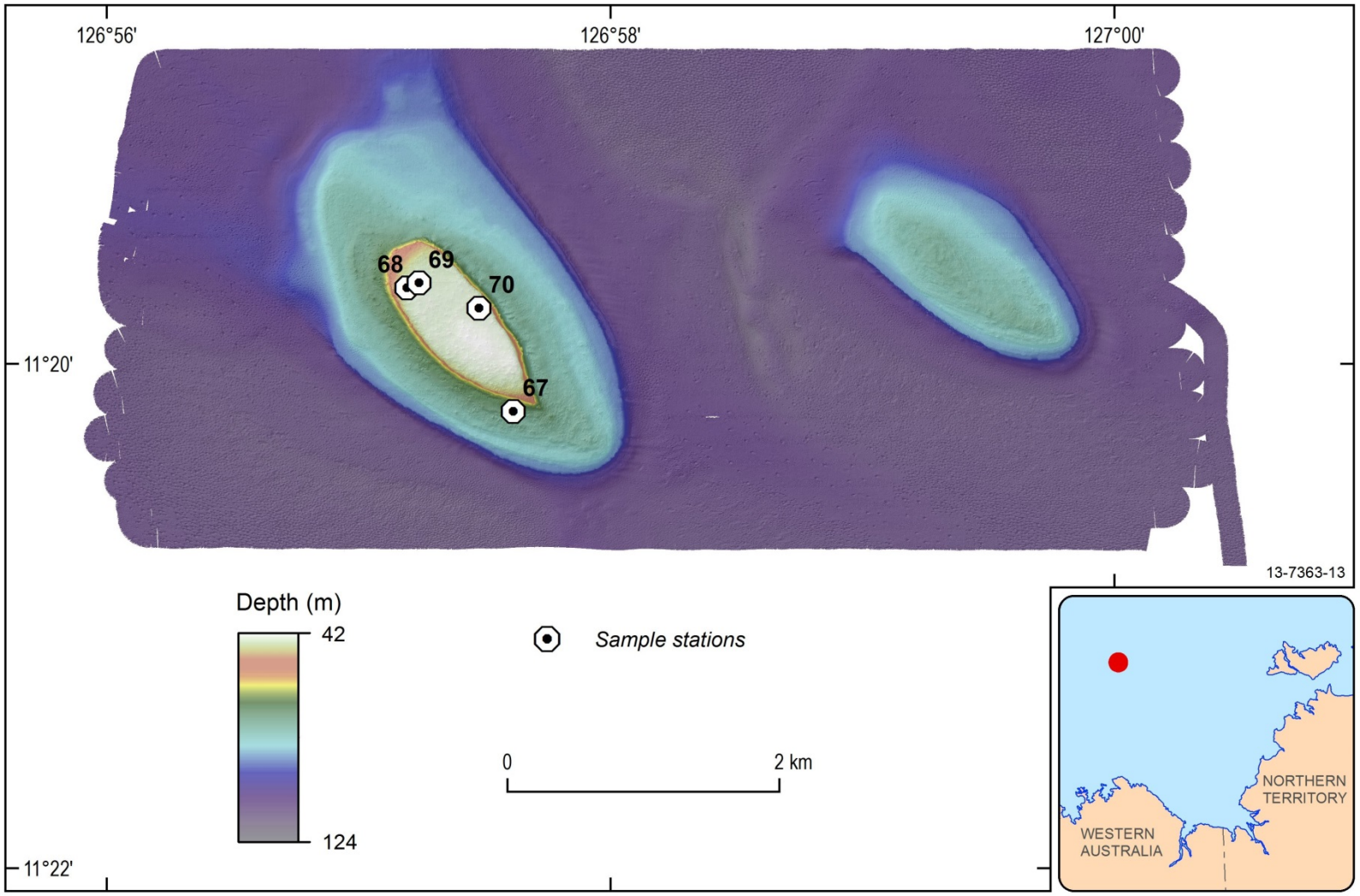

Figure 3.14 False colour bathymetry image of Area 4 with sampling stations indicated.

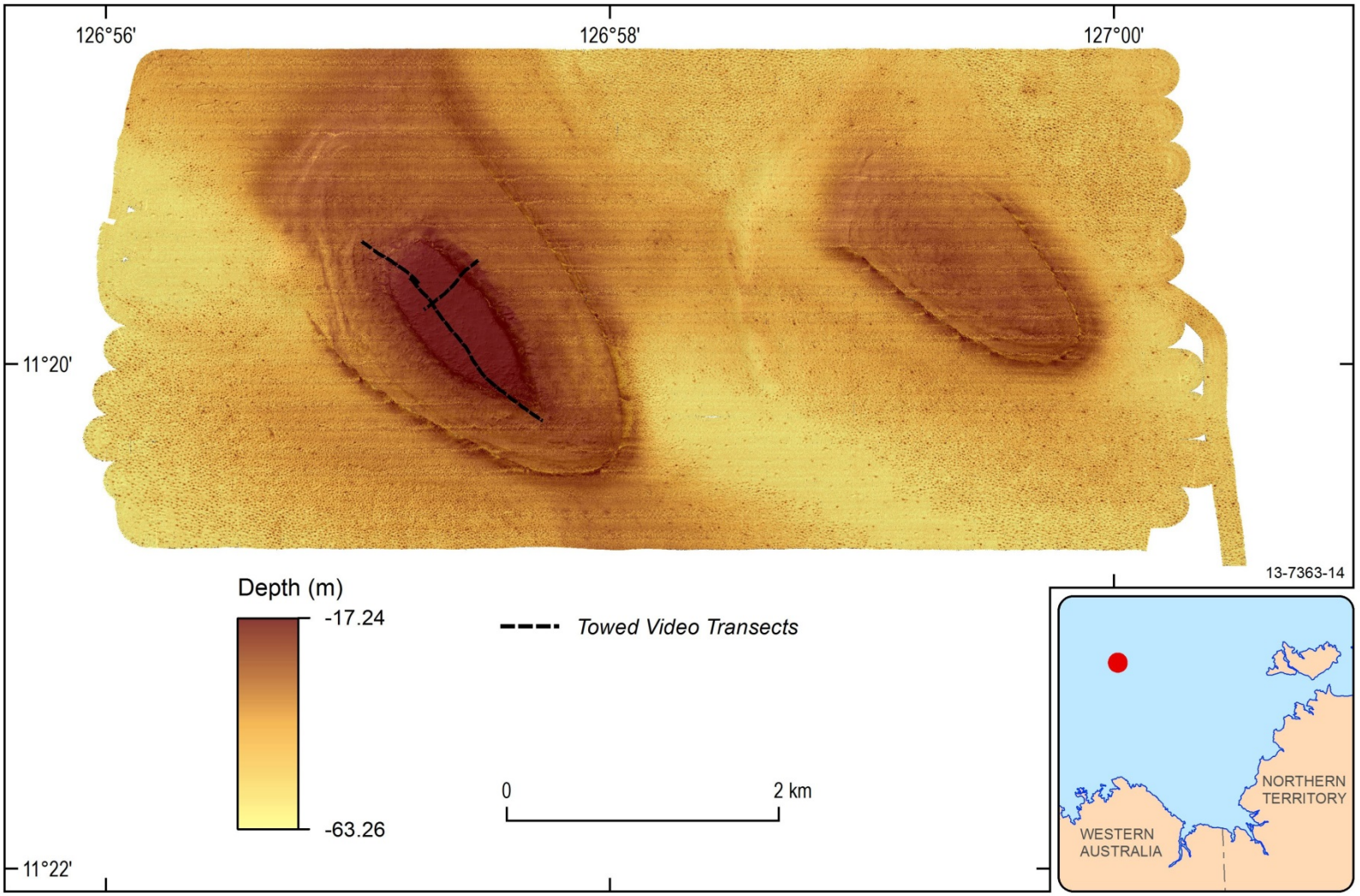

Figure 3.15 False colour backscatter image of Area 4 with towed video transects indicated (Benthic sled, BRUVS and SISSTAs were not deployed in this survey area).

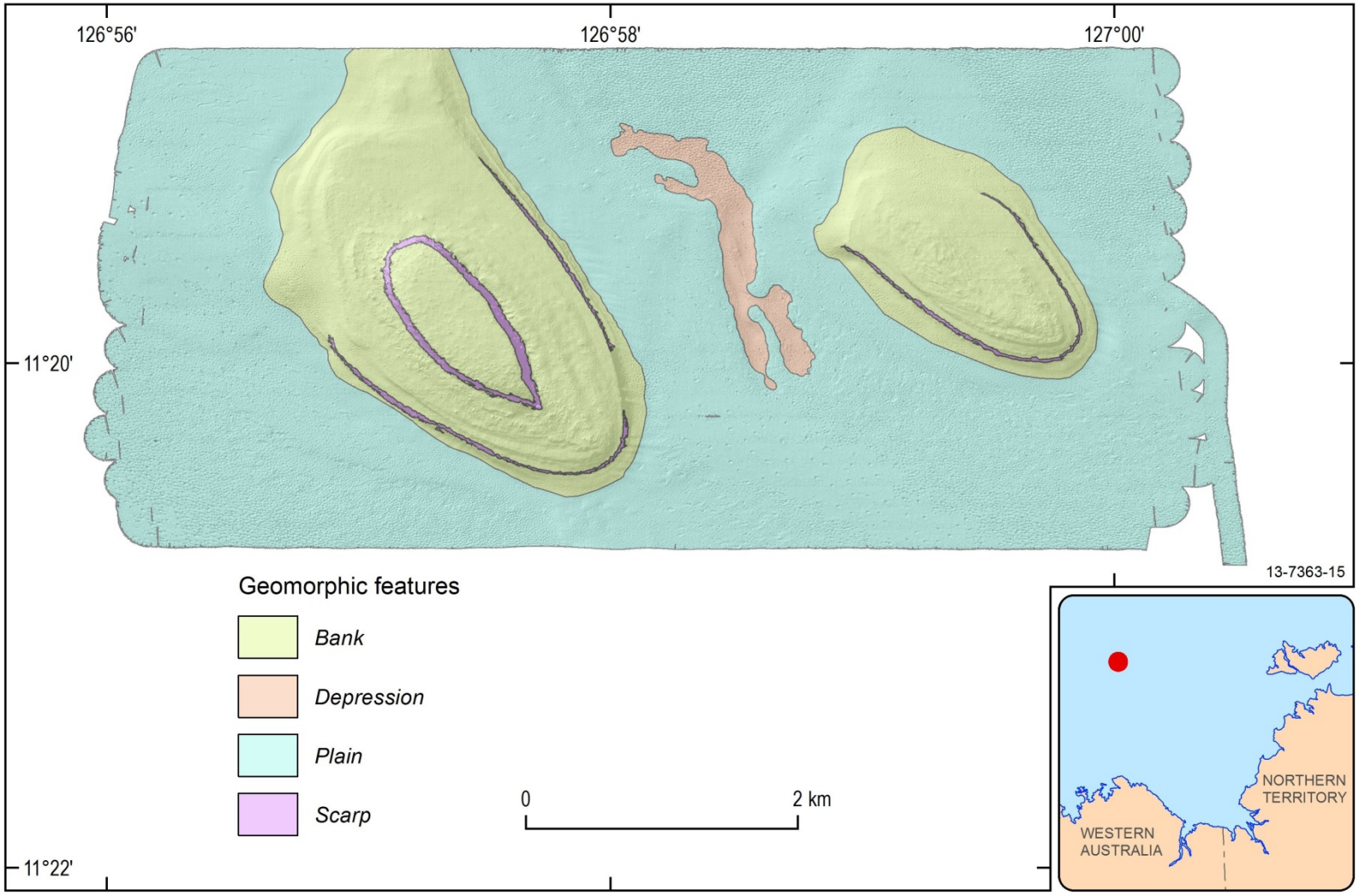

Figure 3.16 Local-scale geomorphic features mapped in Area 4 interpreted from bathymetry. Images are 30% transparent polygons overlying hill-shaded bathymetric images.

Table 3.7 Summary of physical variables for geomorphic features mapped in Area 4.

	Area (km^2)	Percentage Total (%)	Min Depth (m)	Max Depth (m)	Modal Depth (m)	Average Slope (°)	Average Backscatter (dB)
Bank	7.39	26	42	111	90	3.2 ± 2.4	-36 ± 3
Depression	0.60	2	113	119	114	3.3 ± 2.8	-43 ± 3
Plain	20.40	71	101	124	112	3.1 ± 3.0	-43 ± 4
Scarp	0.32	1	45	108	98	21.0 ± 12.6	-35 ± 3
Total	28.71	100	42	124	112	3.3 ± 3.4	-41 ± 5

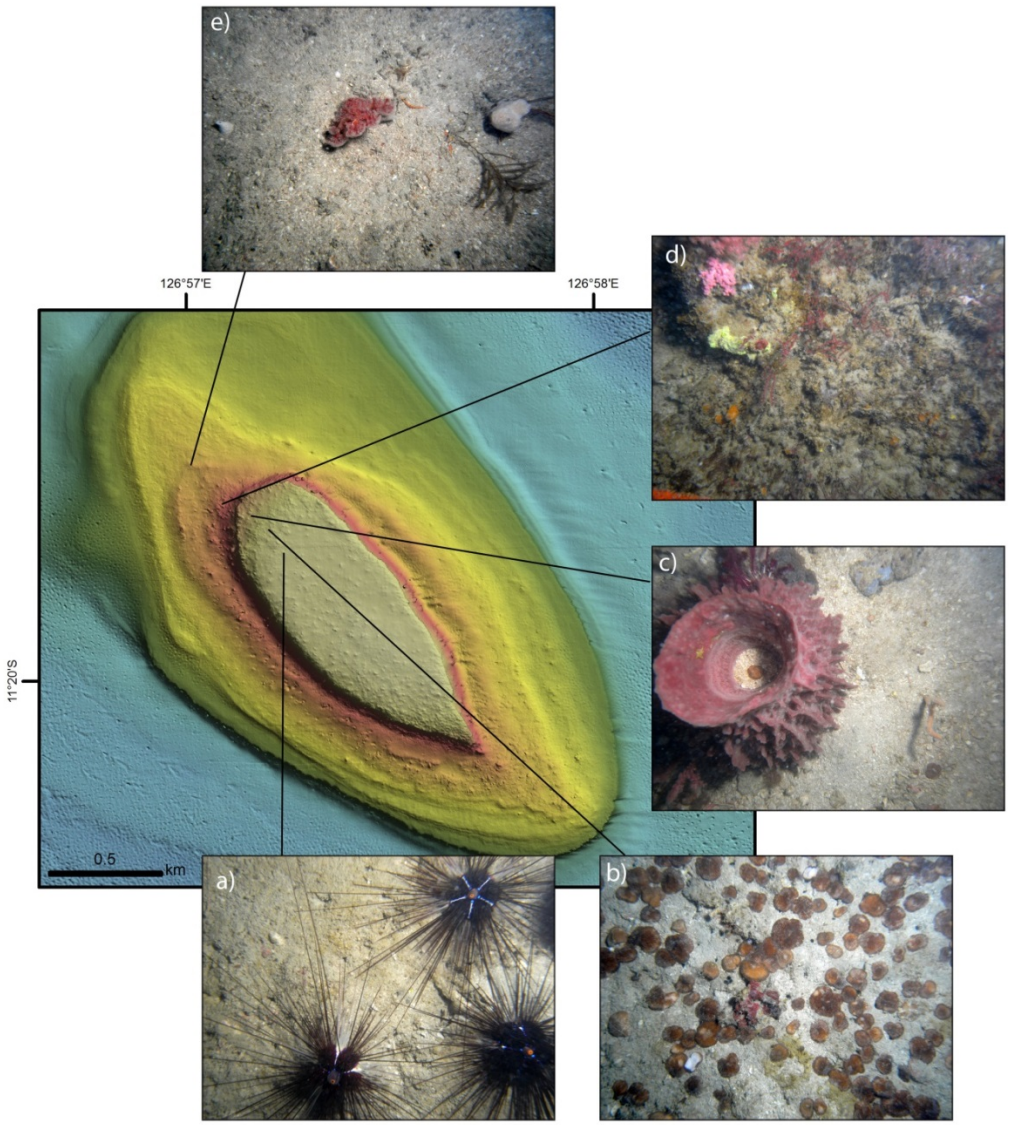

Figure 3.17 Representative still images from the main bank in Area 4, showing: (a) the top of the bank with conspicuous sea urchins; (b) mushroom corals; (c) a barrel sponge Xestospongia; (d) the flank of the bank supporting encrusting and low-relief epifauna, and; (e) the margin of the bank showing scattered epifauna and low levels of levels of bioturbation.

3.5 All Areas Summary and Comparison

Geomorphic features across all survey areas shared some common biological and habitat characteristics. Across all areas, banks and scarps were composed of the coarsest and hardest substrate as shown by grab samples returning poorly sorted, coarse muddy sand sometimes with gravel inclusions. This was reinforced by high average backscatter values for these features, relative to depressions, mounds, plains and terraces (Table 3.4; Table 3.5; Table 3.6; Table 3.7). Plains, terraces and mounds were composed of soft substrate with low average backscatter values. Grabs and box cores from these features contained predominately well sorted silt or sandy silt. Depressions were divided into two different types: deep, steep-sided features which had high backscatter values; and shallower features that had much lower backscatter values. Only one deep depression was sampled for sedimentology over all survey areas (Station 16, Area 1). It returned poorly sorted muddy, silty gravel. None of the shallow depressions were sampled for sedimentology but their average backscatter values were very similar to plains and it is inferred that their substrate is similar to these features (i.e. sandy silt to silt).

The distribution of epibenthic and infaunal communities across the survey areas shows clear associations with geomorphology and substrate types. Terraces and plains were distinguished by an almost complete lack of noticeable epifauna in the underwater video and still images (Figure 3.18b). However, burrows and mounds were very common at some stations, particularly in Area 3, indicating unconsolidated sediment with abundant or rich infaunal communities over some plains and terraces (Figure 3.18c). The single station in the deep depression showed patches of moderate to dense sponge and octocoral gardens (Figure 3.18a), indicating a hard substrate and higher epifaunal biodiversity compared to the surrounding plains. Banks were more likely than plains or terraces to have moderate to dense biological coverage and the only geomorphic feature to support reef-forming corals (Figure 3.18d). Based on observations from the video and still images, banks had no other consistent biological characteristics, with some banks supporting sponge and octocoral gardens (e.g. northern bank in Area 1) (Figure 3.18e) and others barren of epifauna (e.g. westernmost bank in Area 2) (Figure 3.18f).

Preliminary on-board estimates from sled collections showed differences in species richness and biomass between the three main survey areas, with Area 1 having the highest number of species and catch and Area 2 having the lowest number of species and catch (Figure 3.19a). These patterns may not be inherent to the survey areas, and instead may reflect the disproportionate numbers of sleds deployed on three banks, one in each area (Figure 3.2; Figure 3.7; Figure 3.11; Figure 3.15). Indeed, patterns of estimated species richness and biomass on only these three banks showed the same patterns as the survey areas, with the main bank in Area 1 having the highest number of species and catch and the main bank in Area 2 having the lowest (Figure 3.19b). Nonetheless, species richness and biomass varied considerably within each bank, as shown by the large error bars in Figure 3.19. For example, within the main bank in Area 1, Station 14 returned 3.9 kg representing approximately 35 species while Station 16 on the same bank returned over 64 kg representing approximately 89 species.

While taxonomic identifications remain pending, on board observations indicate that species richness and endemism of sponges in the western sector of the Oceanic Shoals CMR are not as high as those in the eastern sector (as sampled in 2009 and 2010; Przeslawski et al., 2011), with sponges from the west comparatively dominated by common species from northern Australia. These results are preliminary and will be verified after species-level identifications are complete.

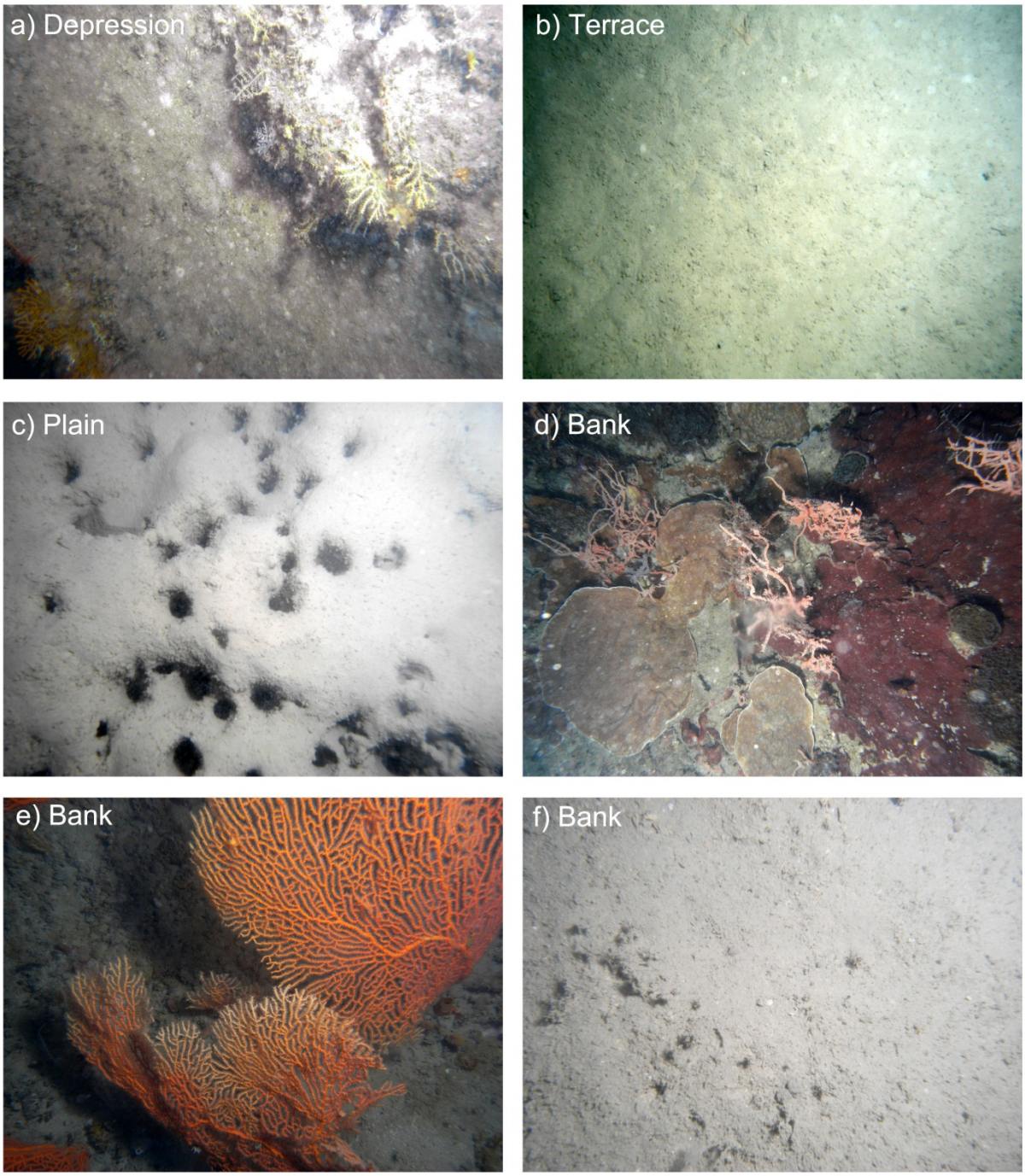

Figure 3.18 Representative still images from geomorphic features in the study area: (a) Moderate octocoral coverage at station 16CAM12 (~70 m depth); (b) Limited epifauna and bioturbation at station 32CAM22 (~105 m depth); (c) Burrows at station 57CAM42 (~110 m depth); (d) Scleractinian coral at station 16CAM13 (~35 m depth); (e) Habitat-forming gorgonian (Mopsella spp.) at station 67CAM48 (~48 m depth), and; (f) Absence of epifauna at station 47CAM33 (~68 m depth).

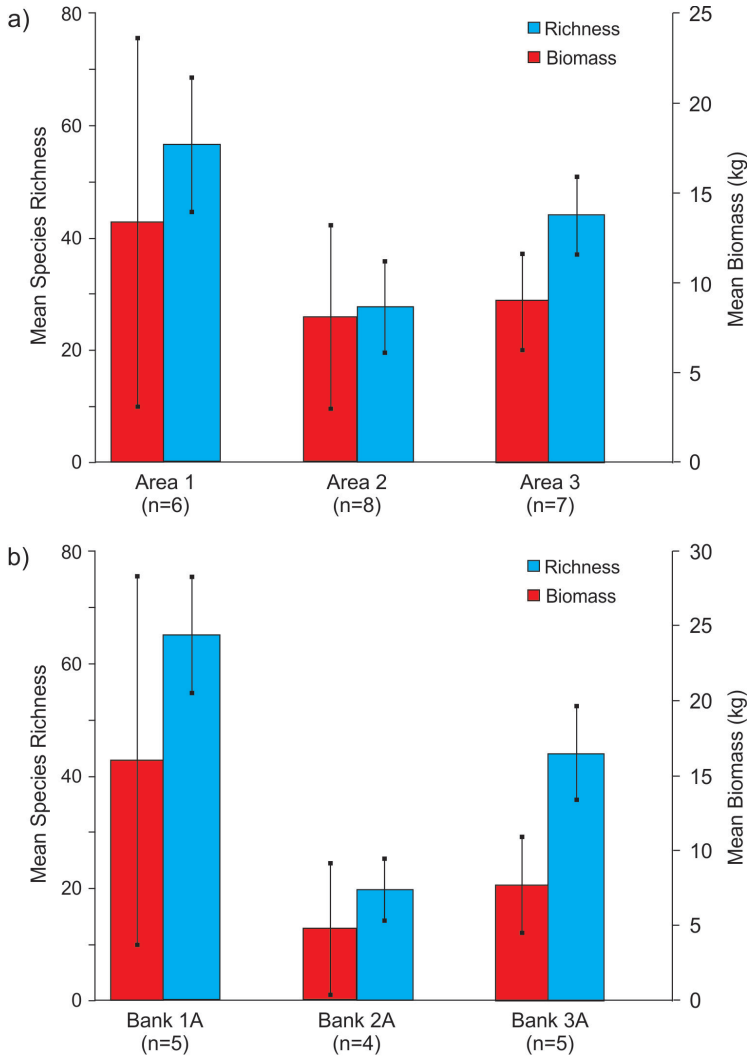

Figure 3.19 Mean species richness and biomass as estimated on-board from sled collections, based on: (a) survey area, and; (b) banks that were sampled. Numbers in parentheses indicate the number of sleds deployed, and error bars are standard error mean.

3.6 Sub-Bottom Profile Results

Sub-bottom profiles were acquired along five lines in Area 1, traversing bank, terrace and plain features (Figure 3.1; Appendix B). Signal penetration was greatest through the soft sediment plains, reaching depths of >100 m below the seabed and resolving the internal stratigraphy to metre scale. In contrast, penetration across banks and terraces was poor due to their acoustically hard carbonate surfaces, with sub-bottom profiles imaging only the seabed and a multiple thereof (Figure 3.20).

For the plains, the sub-bottom profile records a succession of acoustic facies characterised by moderate- to high-amplitude continuous reflectors. The geometry of bounding reflectors ranges from horizontal to wavy and locally irregular, with acoustic facies between the bounding surfaces characterised by conformable low-amplitude reflectors, local clinoform sets and intervals of massive structure. Facies thickness ranges from 10-30 m. This succession is interpreted as a record of horizontal and lateral accretion of the seabed, with the latter having occurred in channels as part of a repeated cut-and-fill process.

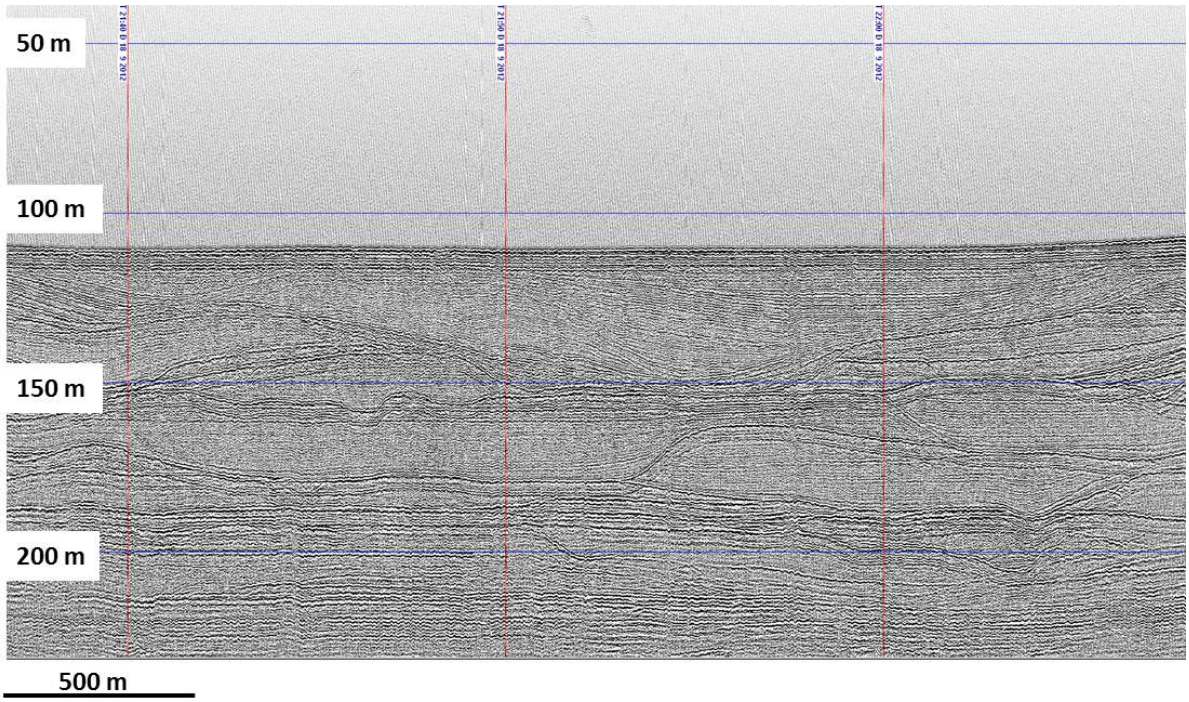

Figure 3.20 Section of sub-bottom profile from line 01 in Area 1, showing signal penetration to >100 m below a soft sediment plain through a sedimentary succession characterised by repeated channel cut-and-fill and vertical accretion depths based on sound velocity of 1500 m/s.

In Area 2, sub-bottom profiles were acquired along four lines, providing cross-sections over several banks and terraces, and adjacent plains (Figure 3.6, Appendix B). Signal penetration across the banks and terraces was limited to the upper few metres of sediment cover, below which the record is reflector-free (Figure 3.21). Penetration into the plains extended to >100 m below the seabed, with the record characterised by horizontal to wavy, continuous high-amplitude reflectors defining bounding surfaces. Seismic facies between bounding surfaces are 5-30 m thick and are characterised by low amplitude horizontal reflectors, local clinoform sets and reflector free intervals. Again, the record below the plains is interpreted as a sedimentary succession of vertical accretion with localised channel cut-and-fill.

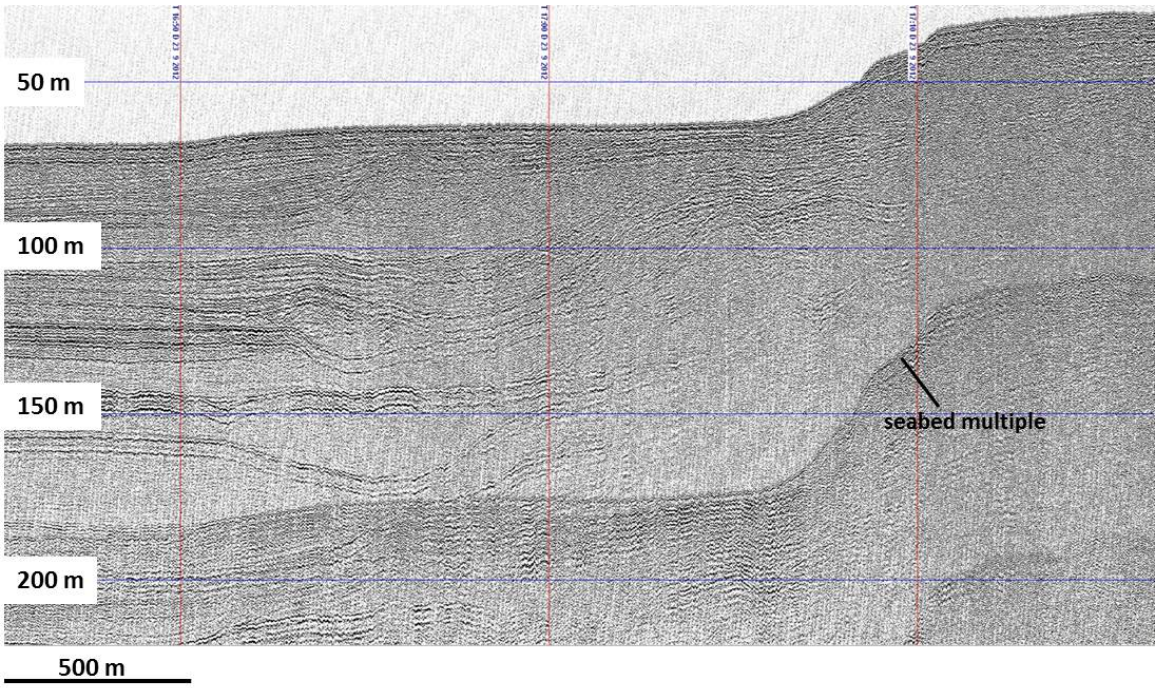

Figure 3.21 Section of sub-bottom profile from line 01 in Area 2, showing limited signal penetration into a carbonate bank and terrace and penetration to >100 m below the adjacent plain, with the latter characterised by channel cut-and-fill and vertical accretion. Depths based on sound velocity of 1500 m/s.

In Area 3, sub-bottom profiles were acquired along one 15-km line that crossed two banks and a plain feature in the north-west sector of the area (Figure 3.10; Appendix B). Signal penetration was again greatest through the sedimentary succession beneath the plains, reaching to 100 m below the seabed and characterised by continuous, horizontal to wavy high-amplitude reflectors (Figure 3.22). Penetration into the carbonate banks was limited to the upper few metres of sediment cover, below which the acoustic record is reflector-free. This sub-bottom line also revealed the partial burial of the bank feature by sediments, as evidenced by the onlap stratigraphic relationship between the convex wedge of sediment at the seabed and the base of the bank. This wedge is 10-15 m thick and is interpreted as the product of accretion of fine-grained sediment during the Holocene, potentially incorporating deposits laid down during the post-glacial transgression and sea-level highstand.

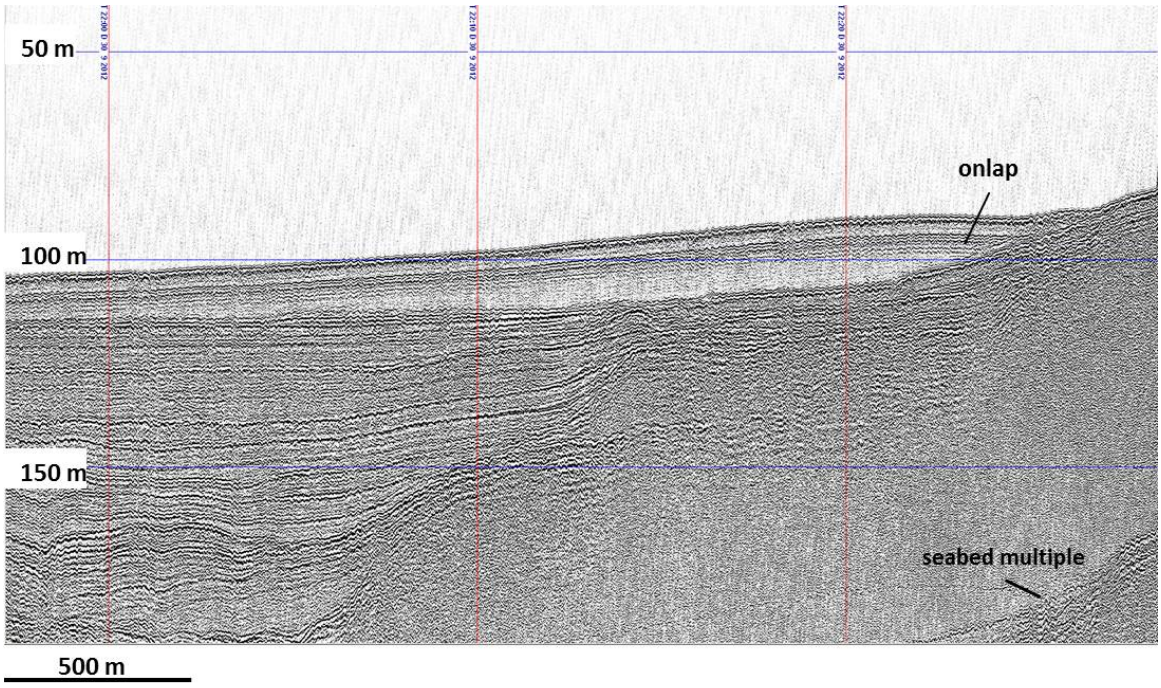

Figure 3.22 Section of sub-bottom profile from line 01 in Area 3, showing signal penetration to >100 m below the seabed through a sedimentary succession characterised by vertical accretion and draping across the edge of a bank. Depths based on sound velocity of 1500 m/s.

3.7 Initial Ocean Drifter Results

Trajectory plots for the 10 ocean drifters deployed during the survey display complex and varied patterns for the period to 5 June 2013 (Figure 3.23). Of the nine drifters deployed within the Oceanic Shoals CMR, three tracked south into Joseph Bonaparte Gulf, three washed ashore in Bonaparte Gulf and are no longer transmitting, one drifted north-northeast then turned west-southwest, one was recovered by another survey vessel, and one drifted north and west toward East Timor and has stopped transmitting. The single drifter deployed during the return transit to Broome has followed an anti-clockwise circuit north from the Kimberley region then turned south along the edge of the continental shelf. These early results suggest that current patterns in the Timor Sea are complicated, and likely a result of strong tidal influences. As of 30 June 2013, five of the ten drifters remained in active transmission.

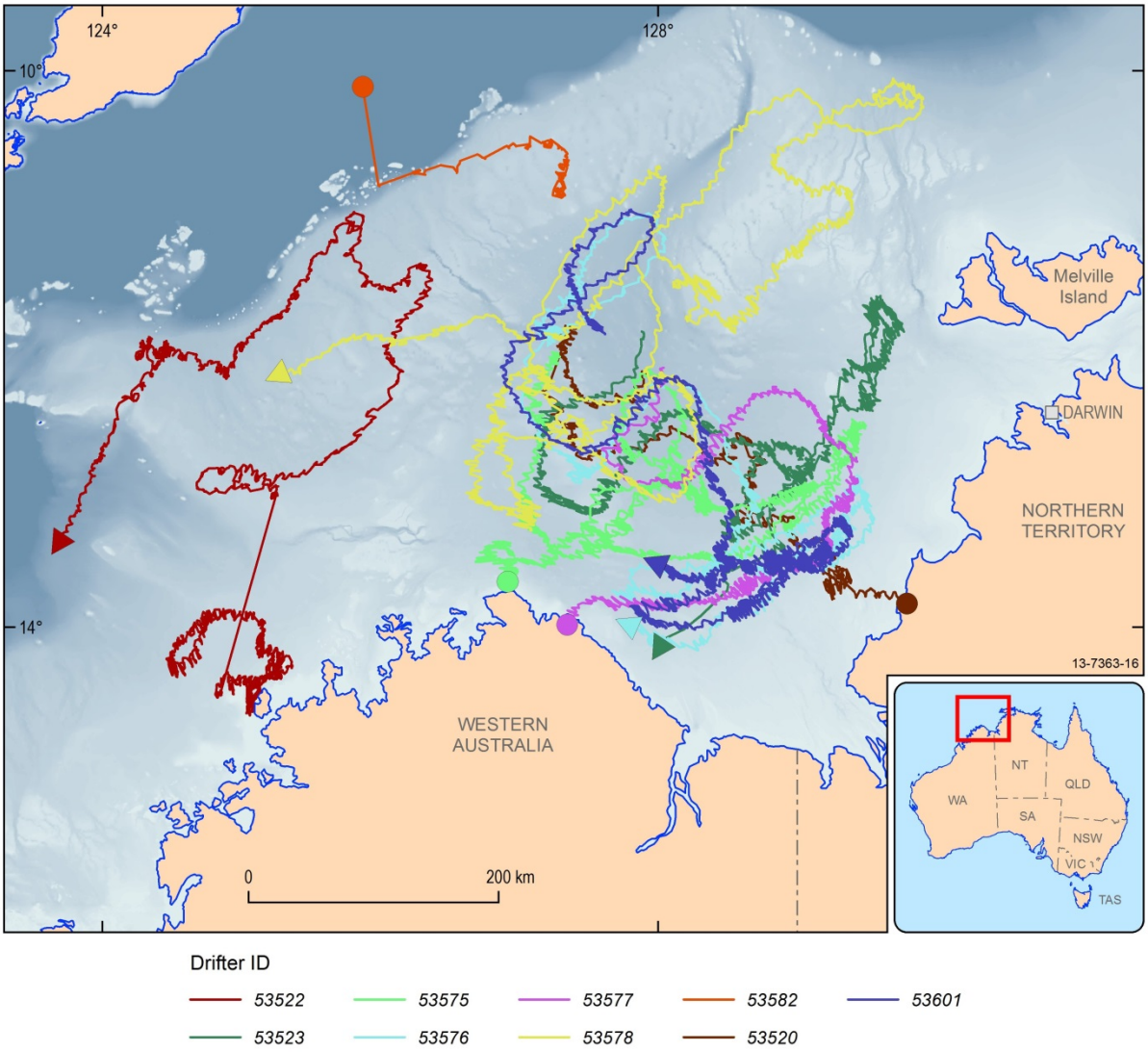

Figure 3.23 Trajectory plots for drifters released during the Oceanic Shoals survey as of 5 June 2013. Different colours represent different drifters. Tracks that end with a solid circle represent drifters that have terminated transmission and arrowheads represent ongoing transmission. Drifter 53522 (red track-line) was deployed on the return transit to Broome.

4 Conclusions and Future Work

The Oceanic Shoals Commonwealth Marine Reserve Biodiversity Survey has provided new insights into the benthic and pelagic communities and habitats of a Key Ecological Feature (the carbonate banks and terraces) within the North Marine Region. The survey acquired data from a combined area of 507 km^2 which equates to less than one per cent of the ~72,000 km^2 covered by the Oceanic Shoals CMR. The areas mapped nonetheless represent the range of seabed environments known to exist on the banks and terraces of the CMR.

Key observations from the survey are as follows:

- The geomorphic diversity of the Oceanic Shoals Commonwealth Marine Reserve is well represented in the western part of the reserve, with numerous banks and terraces providing hard substrate for benthic communities;
- The epibenthic biodiversity on banks appears to vary as a function of water depth and related light and turbidity conditions, with shallower banks (<45 m) supporting more biodiversity than deeper banks, including hard corals;
- Species richness and endemism of sponges in the western sector of the Oceanic Shoals CMR may not be as high as those in the eastern sector, with sponges from the west comparatively dominated by species that are common across northern Australia (to be confirmed by taxonomic analysis);
- Spatial gradients in epibenthic biodiversity exist as a possible function of marked changes in substrate, light and turbidity levels along the depth transition from bank to terrace to plain;
- Tidal currents play an important role in regulating levels of suspended sediment (turbidity) and in redistributing sediment across the plains and around banks and terraces, with some smaller banks partly buried by sediment;
- Demersal fish communities respond to spatial patterns in benthic biodiversity, occurring in larger and more diverse populations on the shallower, less turbid banks, and;
- A wide variety of high-order pelagic fish species occur in these waters.

The data and information collected on this survey will be used with pre-existing data collected from the eastern part of the Oceanic Shoals CMR to develop regional scale maps and models of benthic habitats, ecosystem processes and associated biodiversity. This analysis is part of ongoing research within the Marine Biodiversity Hub and will enable an assessment of the uniqueness of habitats and biological communities observed in this survey. It will also allow the Oceanic Shoals CMR to be placed into the broader regional context of tropical northern Australia. Importantly, all available materials and data have been subject to consistent sampling and processing protocols, ensuring a uniform data standard for analysis and interpretation. Combined with the sampling design used in this survey, these consistent data standards allow the information to be potentially used as a baseline for long-term monitoring of the CMR.

Datasets, imagery and related research products from this survey will be made available to all stakeholders via the Marine Biodiversity Hub website and the Australian Ocean Data Network Portal.

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References

Anderson, T.J., Nichol, S.L., Radke, L., Heap, A.D., Battershill, C., Hughes, M., Siwabessy, P.J., Barrie, V., Glasby, B., Tran, M. and Daniell, J. 2011. Seabed environments of the eastern Joseph Bonaparte Gulf, Northern Australia, GA0325-SOL5117 Post-Survey Report. Geoscience Australia Record 2010/08, Canberra, 61 pp.

Cappo, M., Speare, P. and De'ath, G. 2004. Comparison of baited remote underwater video stations (BRUVS) and prawn (shrimp) trawls for assessments of fish biodiversity in inter-reefal areas of the Great Barrier Reef Marine Park. *Journal of Experimental Marine Biology and Ecology* 302, 123-152.

Cappo, M., Speare, P. and De'ath, G. 2007. Inter-reef vertebrate communities of the Great Barrier Reef Marine Park determined by baited remote underwater video stations. *Marine Ecology Progress Series* 350, 209-221.

Commonwealth of Australia. 2008. *The North Marine Region Bioregional Plan: Bioregional Profile*. Department of the Environment, Water, Heritage and the Arts, Canberra, 241 pp.

Commonwealth of Australia. 2012a. *Marine Bioregional Plan for the North Marine Region*. Department of Sustainability, Environment, Water, Population and Communities, Canberra, 191 pp.

Commonwealth of Australia. 2012b. *Marine Bioregional Plan for the North-west Marine Region*. Department of Sustainability, Environment, Water, Population and Communities, Canberra, 260 pp.

Fisher, R., Radford, B.T., Knowlton, N., Brainard, R.E., Michaelis, F.B. and Caley, M.J. 2011. Global mismatch between research effort and conservation needs of tropical coral reefs. *Conservation Letters* 4, 64-72.

Gavrilov, A.N., Duncan, A.J., McCauley, R.D., Parnum, I.M., Penrose, J.D., Siwabessy, P.J.W., Woods, A.J. and Tseng, Y-T. 2005. Characterisation of the seafloor in Australia's coastal zone using acoustic techniques. Proceedings of First International Conference on Underwater Acoustic Measurements: Technologies and Results. Heraklion, Crete, Greece, June 2005. Vol. 1, 1075-1080.

George T. and Cauquil, E. 2010 A multi-disciplinary site investigation for the assessment of drilling geohazards and environmental impact within the northern Bonaparte Basin. Preview 2010 (148), 41–44.

Heap, A.D., Przeslawski, R., Radke, L.C., Trafford, J. and Battershill, C. 2010. Seabed Environments of the Eastern Joseph Bonaparte Gulf, Northern Australia: SOL4934 - Post Survey Report. Geoscience Australia Record 2010/09, Canberra, 81 pp.

Heap, A.D. and Harris, P.T. 2008. Geomorphology of the Australian margin and adjacent seafloor. Australian Journal of Earth Sciences 55, 555-585.

Heyward, A., Pinceratto, E. and Smith, L. 1997. Big Bank Shoals of the Timor Sea: An Environmental Resource Atlas. BHP Petroleum, Melbourne.

Hovland, M. 1990. Do carbonate reefs form due to fluid seepage? Terra Nova, 2(1), 8-18.

Müller, G. and Gastner, M. 1971. The ''Karbonat-Bombe'', a simple device for the determination of the carbonate content in sediments, soils, and other materials. *Neues Jahrbuch für Mineralogie Monatshefte* 10, 446–469.

O'Brien, G. W., Glenn, K., Lawrence, G., Williams, A. K., Webster, M., Burns, S. and Cowley, R. 2002. Influence of hydrocarbon migration and seepage on benthic communities in the Timor Sea, Australia, *APPEA Journal* 42(1), 225–239.

Przeslawski, R., Daniell, J., Anderson, T., Barrie, V., Heap, A., Hughes, M., Li, J., Potter, A., Radke, L., Siwabessy, J., Tran, M., Whiteway, T., Nichol, S. 2011. Seabed habitats and hazards of the

Joseph Bonaparte Gulf and Timor Sea, northern Australia. Geoscience Australia Record 2011/40, Canberra, 156 pp.

Richardson, A.J., Hobday, A.J., Poloczanska, E.S. 2009. Australia's Marine Life. In, *Report Card of Marine Climate Change for Australia 2009.* Eds. E.S. Poloczanska, A.J. Hobday and A.J. Richardson, NCCARF Publication 05/09.

Schultz, A.L., Malcolm, H.A., Bucher, D.J., Smith, S.D.A. 2012. Effects of reef proximity on the structure of fish assemblages of unconsolidated substrata. *PLoS One* 7(11). Doi:10.1371/journal.pone.0049437

Stevens, D.L. and Olsen, A.R. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association, 99 (No. 465), 262-278.

Tittensor, D.P., Mora, C., Jetz, W., Lotze, H.K., Ricard, D., Vanden Berghe, E., Worm, B. 2010. Global patterns and predictors of marine biodiversity across taxa. Nature 466, 1098-1103.

Van Andel, T.H., and Veevers, J.J. 1967. Morphology and sediments of the Timor Sea. Bureau of Mineral Resources, Geology and Geophysics Bulletin 83, Canberra, 172 pp.

West, B.G., Conolly, J.R., Blevin, J.E., Miyazaki, S. and Vuckovic, V. 1992. *Petroleum Prospectivity of the East Malita Graben area, Bonaparte Basin*. Bureau of Mineral Resources, Geology and Geophysics Record 1992/24.

Appendix A. Scientific and Technical Crew

Table A.1 Role and affiliation of personnel on survey GA0339/SOL5650.

Main Role	Crew Member
AIMS Voyage Leader	Marcus Stowar (AIMS)[1]
GA Chief Scientist (Sedimentology)	Scott Nichol (GA)[2]
Scientist (Geochemistry)	Lynda Radke (GA)[2]
Scientist (Marine ecology)	Johnathan Kool (GA)[2]
Scientist (Marine ecology/Biodiscovery)	Belinda Alvarez de Glasby (MAGNT)[3]
Scientist (Marine ecology)	Tom Letessier (UWA)[4]
Scientist (Marine mammals)	Phil Bouchet (UWA)[4]
Multibeam acquisition & processing	Justy Siwabessy (GA)[2]
Multibeam acquisition & processing	Kim Picard (GA)[2]
Multibeam & sub-bottom profiler acquisition	Ian Atkinson (GA)[2]
Towed Video Technician	Jamie Colquhoun (AIMS)[1]

1. AIMS – Australian Institute of Marine Science, 2. GA – Geoscience Australia; 3. MAGNT – Museum and Art Gallery of the Northern Territory; 4. UWA - University of Western Australia

Appendix B. Survey Details for Sub-bottom Lines

Table B.1 Survey details for sub-bottom profile lines.

Area	Line No.	Length (km)	Start Latitude	Start Longitude	End Latitude	End Longitude
1	1.1	18.5	-12.0573	127.4319	-12.2242	127.4317
1	1.2	18.0	-12.0672	127.4036	-12.2278	127.4039
1	1.3	10.3	-12.2214	127.4075	-12.1522	127.4614
1	1.4	8.5	-12.1522	127.4556	-12.1522	127.3833
1	Test 3	8.3	-12.1506	127.3858	-12.0753	127.3858
2	2.1	19.8	-11.7803	126.9694	-11.9155	127.1139
2	2.2	23.0	-11.9108	127.0853	-11.8386	127.0853
2	2.3	12.5	-11.8050	127.0505	-11.8483	127.0001
2	2.4	7.7	-11.8197	126.9894	-11.8003	127.0433
3	3.1	15	-11.3919	127.0419	-11.4208	126.9192

Appendix C. Survey Details for CTD Deployments

Table C.1 Survey details for CTD deployments.

Survey Area	Station	Sample ID	Latitude	Longitude	Water depth (m)
1	05	SOL5650/005CTD001	-12.21690	127.39397	84
1	06	SOL5650/006CTD002	-12.20900	127.42360	74
1	07	SOL5650/007CTD003	-12.18973	127.40072	76
1	08	SOL5650/008CTD004	-12.19272	127.40487	72
1	10	SOL5650/010CTD005	-12.19663	127.45323	89
1	11	SOL5650/011CTD006	-12.19898	127.44568	99
1	12	SOL5650/012CTD007	-12.19718	127.44092	98
1	14	SOL5650/014CTD008	-12.07332	127.43090	29
1	15	SOL5650/015CTD009	-12.07157	127.42400	56
1	16	SOL5650/016CTD010	-12.09007	127.42557	126
1	17	SOL5650/017CTD011	-12.10477	127.39930	110
1	18	SOL5650/018CTD012	-12.07640	127.42877	31
1	19	SOL5650/019CTD013	-12.08097	127.43043	49
1	20	SOL5650/020CTD014	-12.19747	127.39318	72
1	21	SOL5650/021CTD015	-12.20537	127.43607	77
1	22	SOL5650/022CTD016	-12.20823	127.44542	84
1	23	SOL5650/023CTD017	-12.21700	127.39702	86
2	24	SOL5650/024CTD018	-11.88682	127.09420	78
2	25	SOL5650/025CTD019	-11.89568	127.06962	73
2	26	SOL5650/026CTD020	-11.89193	127.09473	62
2	27	SOL5650/027CTD021	-11.87830	127.11590	116
2	28	SOL5650/028CTD022	-11.85733	127.03692	127
2	29	SOL5650/029CTD023	-11.89327	127.09652	60
2	30	SOL5650/030CTD024	-11.92632	127.07750	107
2	31	SOL5650/031CTD025	-11.79200	126.97793	78
2	32	SOL5650/032CTD026	-11.79317	126.99492	97
2	33	SOL5650/033CTD027	-11.84542	127.05523	127
2	34	SOL5650/034CTD028	-11.88003	127.09270	108
2	35	SOL5650/035CTD029	-11.90318	127.11667	106
2	36	SOL5650/036CTD030	-11.81700	127.04547	107
2	37	SOL5650/037CTD031	-11.81778	127.02990	110

Survey Area	Station	Sample ID	Latitude	Longitude	Water depth (m)
2	38	SOL5650/038CTD032	-11.80713	126.96720	77
2	39	SOL5650/039CTD033	-11.78008	127.00950	90
2	40	SOL5650/040CTD034	-11.80800	126.99058	99
2	41	SOL5650/041CTD035	-11.88967	127.06682	62
2	42	SOL5650/042CTD036	-11.88838	127.06950	74
3	44	SOL5650/044CTD037	-11.41017	126.92277	88
3	45	SOL5650/045CTD038	-11.45030	126.92107	106
3	46	SOL5650/046CTD039	-11.43483	126.93770	75
3	47	SOL5650/047CTD040	-11.42067	126.94477	64
3	48	SOL5650/048CTD041	-11.43192	126.94270	61
3	49	SOL5650/049CTD042	-11.40693	126.92902	81
3	50	SOL5650/050CTD043	-11.40532	126.96090	99
3	51	SOL5650/051CTD044	-11.43203	126.98772	92
3	52	SOL5650/052CTD045	-11.43740	126.99717	95
3	53	SOL5650/053CTD046	-11.44230	126.96760	78
3	54	SOL5650/054CTD047	-11.42373	126.96570	86
3	55	SOL5650/055CTD048	-11.43397	126.95358	59
3	56	SOL5650/056CTD049	-11.39937	127.02052	75
3	57	SOL5650/057CTD050	-11.44318	127.09513	110
3	58	SOL5650/058CTD051	-11.44780	127.03050	107
3	59	SOL5650/059CTD52	-11.4030	127.0278	52
3	61	SOL5650/061CTD053	-11.44123	126.97107	82
3	62	SOL5650/062CTD054	-11.41310	126.94082	64
3	63	SOL5650/063CTD055	-11.39983	126.91263	99
3	65	SOL5650/065CTD056	-11.42470	126.94357	62
3	66	SOL5650/066CTD057	-11.41280	126.93593	65
4	67	SOL5650/067CTD058	-11.33650	126.96023	73
4	68	SOL5650/068CTD059	-11.32833	126.95320	43
4	72	SOL5650/072CTD060	-11.88920	127.07497	75
1	73	SOL5650/073CTD061	-12.06463	127.42538	73
1	74	SOL5650/074CTD062	-12.07720	127.44508	73
1	75	SOL5650/075CTD063	-12.14323	127.44580	110

Appendix D. Survey details for Ocean Current Drifter Deployments

Table D.1 Survey details for ocean current drifter deployments.

Drifter ID	WMO Code[1]	Release Date	Julian Day	Latitude	Longitude
101918	53576	16/09/2012	260	-12° 10.8806’	127° 26.8244’
101884	53575	17/09/2012	261	-12° 08.0388’	127° 26.0007’
101765	53601	18/09/2012	262	-12° 05.3788’	127° 23.6460’
101914	53520	20/09/2012	264	-11° 52.3790’	127° 07.7039’
101917[2]	53521	21/09/2012	265	-11° 56.1269’	127° 05.1850’
101753	53577	22/09/2012	266	-11° 50.2650’	127° 05.2010’
101754	53578	24/09/2012	268	-11° 53.9040’	127° 06.3839’
101756	53582	26/09/2012	270	-11° 26.7590’	127° 54.2120’
101755	53523	3/10/2012	277	-12° 08.4460’	127° 27.3470
101752	53522	4/10/2012	278	-14° 16.7408’	124° 50.9317’

1. WMO – World Meteorological Organisation code. Used as drifter identifier on Global Drifter Program website.
2. Drifter 101917 was recovered by another survey vessel operating in the area on 27 September 2012. The drifter was later returned to Pearl Marine Engineering in Darwin then redeployed in the Arafura Sea on a Southern Surveyor transit survey (SS2012t07) on 18 October 2012; location approximately 20 nM north of the Wessel Islands.

Appendix E. Survey Details for Surface Sediment Grab (GR) and Box Core (BC) Samples

Table E.1 Surface sediment grab (GR) and box core (BC) sample locations, water depths and field descriptions (including Munsell colour code, where noted).

Area	Station	Sample ID	Latitude	Longitude	Water Depth (m)	Sample Description
1	05	GR001	-12.2178	127.3947	84	Slightly sandy silt; fragments of fine shell; poorly sorted
1	06	GR002	-12.2094	127.4224	70	Slightly gravelly silt with shell fragments; poorly sorted; 5Y 5/2 olive grey
1	07	GR004	-12.1840	127.4006	76	Slightly granular silt with shell fragments; poorly sorted; bivalves; 5Y 5/2 olive grey
1	08	GR006	-12.1924	127.4043	73	Gravelly silt and shell fragments; very poorly sorted; 5Y 5/2 olive grey
1	09	GR008	-12.2004	127.4308	73	Gravelly sandy silt; very poorly sorted; olive grey; 5Y 5/2 olive grey
1	10	GR010	-12.1956	127.4521	106	Gravelly mud; poorly sorted; 5Y 5/2 olive grey
1	10	GR011	-12.1988	127.4522	104	Gravelly mud
1	11	GR013	-12.1987	127.4471	100	Mud & gravel; poorly sorted; shell fragments; 5Y 4/2 olive grey
1	11	GR014	-12.1985	127.4469	100	Gravelly mud; poorly sorted; 5Y 4/2 olive grey
1	14	GR015	-12.0742	127.4346	30	Very coarse sandy gravel; mud trace; carbonate; very poorly sorted; 2.5Y 6/3 light yellowish brown
1	14	GR017	-12.0677	127.4361	51	Gravelly coarse sand; trace mud; poorly sorted; carbonate;
1	15	GR019	-12.0713	127.4239	59	Very poorly sorted muddy, sand & gravel; cemented clasts; carbonate; 5Y 4/2 olive grey
1	16	GR021	-12.0895	127.4259	125	Very poorly sorted muddy dandy gravel; carbonate clasts cemented; 5Y 4/2 olive grey
1	17	BC001	-12.1048	127.3996	110	Sandy silt; poorly sorted; 5Y 4/2 olive grey
1	18	GR023	-12.0749	127.4265	32	Very poorly sorted sandy gravel; carbonate; mud trace; 2.5Y 5/3 light olive brown
1	19	GR025	-12.0806	127.4297	49	Poorly sorted gravelly coarse sand; 2.5Y 5/2 greyish brown

Area	Station	Sample ID	Latitude	Longitude	Water Depth (m)	Sample Description
1	20	BC003	-12.1977	127.3940	73	Sandy silt; shell fragments in sand fraction; 5Y 4/3 olive
1	21	BC005	-12.2058	127.4364	77	Muddy coarse sand and gravel; poorly sorted; 5Y 4/3 olive
1	22	BC007	-12.2089	127.4457	81	Muddy sandy gravel; very poorly sorted; 5Y 4/3 olive
2	24	BC009	-11.8868	127.0935	78	Muddy coarse sand; 5Y 4/3 olive
2	25	BC012	-11.8969	127.0690	71	No field description
2	26	GR028	-11.8900	127.0950	73	Muddy coarse sand; poorly sorted; 5Y 4/2 olive grey
2	27	BC014	-11.8784	127.1166	116	Silt; 5Y 4/3 olive
2	28	BC016	-11.8581	127.0373	127	Slightly sandy silt; 5Y 4/3 olive
2	29	GR030	-11.8932	127.0951	58	Muddy coarse to medium sand; 5Y 5/3 olive grey
2	31	BC018	-11.7910	126.9772	76	Muddy coarse sand
2	32	BC020	-11.7944	126.9931	95	Muddy coarse to very coarse sand; poorly sorted; 5Y 4/3 olive
2	33	BC022	-11.8459	127.0559	127	Silt; 5Y 4/3 olive
2	34	BC024	-11.8799	127.0920	108	Sandy mud; sand coarse to very coarse; poorly sorted; 5Y 4/3 olive
2	36	BC027	-11.8178	127.0468	110	Muddy very coarse sand; very poorly sorted; 5Y 4/3 olive
2	37	BC029	-11.8177	127.0296	110	Muddy coarse to very coarse sand; very poorly sorted; 5Y 2/3 olive
2	38	BC030	-11.8075	126.9673	77	Muddy coarse to very coarse sand; very poorly sorted; 5Y 4/2 olive grey
2	39	BC032	-11.7801	127.0092	90	Slightly sandy silt; moderately well sorted
2	40	BC034	-11.8083	126.9905	99	Slightly sandy silt; well sorted; 5Y 4/2 olive grey
2	41	GR033	-11.8896	127.0670	64	Slightly muddy coarse to very coarse sand & gravel; very poorly sorted; 5Y 4/3 olive
2	42	GR035	-11.8887	127.0745	72	Muddy coarse sand; poorly sorted; 5Y 2/3 olive
3	44	GR037	-11.4102	126.9227	88	Slightly sandy silt; well sorted; 5Y 5/3 olive grey
3	45	BC037	-11.4504	126.9212	106	Silt; well sorted; 5Y 5/2 grey
3	46	BC039	-11.4338	126.9383	60	Slightly sandy silt; moderate sorting; 5Y 5/3 olive
3	47	GR038	-11.4204	126.9446	64	Sandy silt; poorly sorted; sand fraction medium to coarse, angular; 5Y 5/3 olive

Area	Station	Sample ID	Latitude	Longitude	Water Depth (m)	Sample Description
3	49	GR040	-11.4069	126.9291	81	Muddy coarse sand; poorly sorted; 5Y 2/3 olive
3	50	BC041	-11.4051	126.9616	99	Silt; well sorted; 5Y 5/2 olive grey
3	51	BC043	-11.4310	126.9888	95	Silt; well sorted; 5Y 5/3 olive
3	52	BC045	-11.4360	126.9971	96	Silt; well sorted; 5Y 5/3 olive
3	53	BC047	-11.4426	126.9670	79	Muddy coarse sand; poorly sorted; 5Y 4/3 olive
3	54	BC049	-11.4244	126.9660	85	Muddy medium to coarse sand; poorly sorted; 5Y 2/3 olive grey
3	55	GR042	-11.4342	126.9542	57	Muddy medium to coarse sand; poorly sorted; carbonates; 5Y 5/3 olive
3	56	BC051	-11.3993	127.0205	76	Muddy coarse sand; poorly sorted; 5Y 5/3 olive
3	57	BC053	-11.4433	127.0951	110	Silt; well sorted; 5Y 5/3 olive
3	58	BC056	-11.4483	127.0306	108	Silt; well sorted; 5Y 5/3 olive
3	60	GR044	-11.4032	127.0245	51	Slightly muddy medium to coarse sand; moderately well sorted; carbonates; 5Y 5/3 olive
3	60	GR045	-11.4033	127.0249	52	Muddy medium to coarse sand; 5Y 5/3 olive
3	61	BC058	-11.4412	126.9713	84	Muddy medium to coarse sand; poorly sorted; 5Y 5/3 olive
3	62	BC060	-11.4091	126.9396	77	Muddy coarse sand; poorly sorted; 5Y 5/3 olive
3	63	BC062	-11.3994	126.9121	98	Silt; well sorted; 5Y 5/3 olive
3	65	GR046	-11.4257	126.9445	62	Sandy mud; sand fraction coarse to very coarse carbonate; poorly sorted; 5Y 5/3 olive
3	66	GR048	-11.4143	126.9355	65	Muddy coarse sand; poorly sorted; 5Y 5/3 olive
4	67	GR050	-11.3368	126.9622	71	Muddy medium to coarse sand; poorly sorted; 5Y 5/3 olive
4	68	GR051	-11.3284	126.9543	42	Muddy coarse to very coarse sand; poorly sorted; fungoid corals (discs); 5Y 5/3 olive
1	73	GR053	-12.0647	127.4257	72	Slightly muddy medium to coarse sand; poorly sorted; carbonates; 5Y 5/3 olive
1	74	GR055	-12.0775	127.4448	73	Muddy medium to coarse sand; carbonate; poorly sorted; 5Y 5/3 olive
1	75	BC065	-12.1440	127.4458	110	Sandy silt; poorly sorted; sand fraction fine to coarse; carbonates; 5Y 5/3 olive

Appendix F. Survey Details for Surface Water Samples

Table F.1 Details of underway water samples collected during transits.

Station	Sample ID	Latitude	Longitude	UTC Date	UTC Time
01	SOL5650/001WS001	-15.84167	122.71850	13/9/2012	02:20
02	SOL5650/002WS002	-15.40833	123.01950	13/9/2012	05:15
03	SOL5650/003WS003	-13.18350	126.00383	14/9/2012	02:05
04	SOL5650/004WS004	-12.95717	126.29200	14/9/2012	05:05
19	SOL5650/019WS005	-12.08088	127.43057	18/9/2012	04:45
23	SOL5650/023WS006	-12.21718	127.39683	19/9/2012	04:58
26	SOL5650/026WS007	-11.89480	127.09093	20/9/2012	05:40
30	SOL5650/030WS008	-11.92660	127.07742	21/9/2012	05:01
43	SOL5650/043WS009	-11.53238	127.44635	26/9/2012	01:55
48	SOL5650/048WS010	-11.43192	126.94270	27/9/2012	04:53
64	SOL5650/064WS011	-11.43635	126.96218	1/10/2012	01:48
71	SOL5650/071WS012	-11.64008	127.00917	2/10/2012	04:49
76	SOL5650/076WS013	-14.22344	124.94283	4/10/2012	01:50
77	SOL5650/077WS014	-14.33861	124.75250	5/10/2012	04:50
78	SOL5650/078WS015	-16.96980	122.23950	5/10/2012	01:50
79	SOL5650/079WS016	-17.34467	122.00225	5/10/2012	04:56

Appendix G. Survey Details for Geochemical Samples

Table G.1 Details of the geochemical analyses undertaken on sediment samples. Grab numbers from Smith-McIntyre grabs (GRXXX) and box cores (BCXXX) are shown in the columns. The designation B_XX corresponds to the extensions that are applied to the sample numbers in the corporate database, in which B designates a geochemistry sample and XX designates a sub-sample type. For example, SOL5650/060GR045B_B1 refers to a geochemistry sample from station 060 and grab 45 designated for chlorin, porosity and mineralogy analysis. SOD denotes sediment oxygen demand.

Station	Sub-sample type								
	Chlorins,Porosity, Mineralogy (0-2.0 cm) (B_B1)	Chlorophyll abc (0-0.5 cm) (B_B2)	Porosity (0-0.5 cm) (B_B3)	SOD (0-2.0 cm) (B_C1)	Bottle incubation (0-2.0 cm) (B_C2)	Core incubation (B_C3)	Elements, Carbonate, Specific Surface Area (0-2.0 cm) (B_D1)	Spare (~0-2.0 cm) (B_E1)	Specimens (A_S1)
005	&	&	&	&	&		GR001	&	
006	GR003	GR003	GR003	GR003	GR003		GR003	GR003	
007	GR005	GR005	GR005	GR005	GR005		GR005	GR005	
008	GR007	GR007	GR007	GR007	GR007		GR007	GR007	
009	GR009	GR009	GR009	GR009	GR009		GR009	#	
010	GR012	GR012	GR012	GR012	GR012		GR012	GR012	
011	GR014	GR014	GR014	GR014	GR014		GR014	GR014	
014	GR016	GR016	GR016	GR016	GR016		GR016	GR016	
014	GR018	GR018	GR018	GR018	GR018	GR018	GR018	#	
015	GR020	GR020	GR020	GR020	GR020		GR020	GR020	
016	GR022	GR022	GR022	GR022	GR022		GR022	GR022	
017	BC002	BC002	BC002	@	BC002		BC002	#	
018	GR024	GR024	GR024	GR024	GR024	GR024	GR024	GR024	
019	GR026	x	x	GR026	GR026	GR026	GR026	GR026	
020	BC004	BC004	BC004	BC004	BC004$		BC004	#	

Station	Sub-sample type								
	Chlorins,Porosity, Mineralogy (0-2.0 cm) (B_B1)	Chlorophyll abc (0-0.5 cm) (B_B2)	Porosity (0-0.5 cm) (B_B3)	SOD (0-2.0 cm) (B_C1)	Bottle incubation (0-2.0 cm) (B_C2)	Core incubation (B_C3)	Elements, Carbonate, Specific Surface Area (0-2.0 cm) (B_D1)	Spare (~0-2.0 cm) (B_E1)	Specimens (A_S1)
021	BC006	BC006	BC006	BC006	BC006		BC006	#	
022	BC008	BC008	BC008	BC008	BC008		BC008	#	
024	BC011	BC011	BC011	BC011	BC011		BC011	#	
025	GR027	GR027	GR027	GR027	GR027	GR027%	GR027	#	
026	GR029	GR029	GR029	GR029	GR029	GR029%	GR029	GR029	
027	BC015	BC015	BC015	BC015	BC015		BC015	BC015	
028	BC017	BC017	BC017	BC017	BC017		BC017	BC017	
029	BC031	BC031	BC031	BC031	BC031	BC031	BC031	BC031	
031	BC019	BC019	BC019	BC019	BC019		BC019	BC019	
032	BC021	BC021	BC021	BC021	BC021		BC021	BC021	
033	BC023	BC023	BC023	BC023	BC023	BC023%	BC023	BC023+	
034	BC026	BC026	BC026	BC026	BC026	BC026%	BC026	BC026+	
036	BC028	x	x	BC028	BC028	BC028%	BC028	BC028+	
037	GR032	GR032	GR032	GR032	GR032		GR032	GR032	
038	BC031	BC031	BC031	BC031	BC031	BC031%	BC031	BC031+	
039	BC033	x	x	BC033	BC033		BC033	#	
040	BC035	BC035	BC035	BC035	BC035	BC035%	BC035	BC035+	
041	GR034	GR034	GR034	GR034	GR034	GR034%	GR034	GR034	
042	GR036	GR036	GR036	GR036	GR036	GR036%	GR036	GR036	
044	BC036	BC036	BC036	BC036	BC036	BC036%	BC036	BC036+	
045	BC038	BC038	BC038	BC038	BC038		BC038	BC038	
046	BC040	BC040	BC040	BC040	BC040		BC040	BC040	

Station	Sub-sample type								
	Chlorins,Porosity, Mineralogy (0-2.0 cm) (B_B1)	Chlorophyll abc (0-0.5 cm) (B_B2)	Porosity (0-0.5 cm) (B_B3)	SOD (0-2.0 cm) (B_C1)	Bottle incubation (0-2.0 cm) (B_C2)	Core incubation (B_C3)	Elements, Carbonate, Specific Surface Area (0-2.0 cm) (B_D1)	Spare (~0-2.0 cm) (B_E1)	Specimens (A_S1)
047	GR039	GR039	GR039	GR039	GR039	GR039%	GR039	GR039	
049	GR041	GR041	GR041	GR041	GR041	GR041%	GR041	GR041	
050	GR042	GR042	GR042	GR042	GR042		GR042	#	
051	BC044	BC044	BC044	BC044	BC044	BC044%	BC044	BC044	
052	BC046	BC046	BC046	BC046	BC046	BC046%	BC046	BC046+	
053	BC048	BC048	BC048	BC048	BC048		BC048	#	
054	BC050	BC050	BC050	BC050	BC050		BC050	BC050	
055	GR043	GR043	GR043	GR043	GR043	GR043%	GR043	GR043	
056	BC052	BC052	BC052	BC052	BC052		BC052	#	
057	BC054	BC054	BC054	BC054	BC054	BC054%	BC054	#	
058	BC057	BC057	BC057	BC057	BC057		BC057	BC057	
060	GR048	GR048	GR048	GR048	GR048	GR048	GR048	GR048	GR048*
061	BC059	BC059	BC059	BC059	BC059	BC059%	BC059	#	
062	BC061	BC061	BC061	BC061	BC061		BC061	#	
063	BC063	BC063	BC063	BC063	BC063		BC063	BC063	
065	GR047	GR047	GR047	GR047	GR047	GR047%	GR047	GR047	
066	GR049	GR049	GR049	GR049	GR049	GR049%	GR049	GR049	
068	GR052	x	x	GR052	GR052		GR052	#	
073	GR054	GR054	GR054	GR054	GR054	GR054%	GR054	GR054	
074	BC064	BC064	BC064	BC064	BC064	BC064%	BC064	#	
075	GR066	GR066	GR066	GR066	GR066		GR066	#	

(&) failed grab; (#) insufficient material; (x) inadequate surface; (@) lost sample; (%); dark incubation only; ($) Initial sample (T=0) only; (+) used sediment from incubated cores; (x) slumped surface on grab/core; (*) apparent carbonate cement

Appendix H. Geochemical Techniques

Table H.1 Details of shipboard laboratory processing and analytical techniques used to prepare and analyse the geochemistry sub-samples. Sub-sample codes (B_B1 etc) correspond to the file extension assigned to the sub-sample types in the shipboard database.

Sub-sample	Shipboard processing	Parameters measured	Laboratory pre-processing	Analytic procedures and sample post processing
B_B1	7.5 ml samples of surface sediment (0-2 cm) were syringed into plastic container wrapped in Al foil. The samples were frozen.	Porosity and wet/dry bulk densities (0.0-2.0cm)	Freeze-dry	Weight difference after drying and after correction for seawater salts (porosity) and normalisation to wet/dry volumes (bulk density).
		Total chlorins and chlorin indices	Triple extraction in 100% acetone after freeze-drying and grinding (in dark).	Fluorometry
		Mineralogy	10% Zinc oxide added to dried samples	X-Ray diffraction
B_B2	4 ml samples of surface sediment (0-0.5 cm) were syringed into plastic bags. The samples were wrapped in Al foil and frozen.	Chlorophyll a,b,c and phaeophytin	Thaw in refrigerator and then extracted in 90% acetone	Extracts analysed by spectrophotometry (630, 647, 664 and 750 nm). Individual pigments quantified by trichometric equations and expressed on a per g dry wt basis utilising data from B_B3.
B_B3	4 ml samples of surface sediment (0-0.5 cm) were syringed into plastic bags. Samples were frozen.	Porosity and wet/dry bulk densities (0-0.5cm)	Freeze-dry	Weight difference after drying and after correction for seawater salts (porosity) and normalisation to wet/dry volumes (bulk density).
B_C1	Bulk sub-sample (6.5 ml) of surface sediment (0-2 cm) incubated in BOD bottles for ~24 hrs in the dark at SST. Dissolved oxygen concentrations (and saturation values) were measured at the start and finish of each incubation.	Sediment oxygen demand	N/A	Results expressed on a per g dwt basis utilising B_B1 results.

Sub-sample	Shipboard processing	Parameters measured	Laboratory pre-processing	Analytic procedures and sample post processing
B_C2	Salinity, temperature and pH were measured on pore waters extracted from sub-samples C_D1. These pore waters were then filtered (0.45 µm) into 3 ml gas-tight vials (pre-charged with 0.025 $HgCl_2$) within 1 hr of collection (T=0). The procedure was repeated on pore waters from an additional bulk sample collected as per C_D1 and incubated for ~24 hrs at SST (T=1). All samples were refrigerated prior to laboratory analysis.	CO_2 production rates	Samples brought to room temperature in dark.	1. Dissolved inorganic carbon (DIC) determined using a DIC analyser and infrared-based CO_2 detector. (Geoscience Australia) 2. CO_2 production rates calculated by concentration differences (T=1 – T=0) over the incubation period, after correction for $CaCO_3$ fluxes. Results expressed on a per g dwt basis utilising B_B1 data.
B_C3	A 4.5cm diameter core of surface sediment overlain by 0.118L of local seawater was incubated in the dark for ~4 hours at ~26^{o}C after a ~3 hour pre-incubation period. Dissolved oxygen levels were measured at ~30 minute intervals. Samples for DIC analysis were taken at the start and finish of the incubation. At a few of the shallower stations cores were incubated at the following light levels: 0, ~5, ~25 and ~50 PAR. Blank cores (local seawater only) accompanied all incubations.	CO_2 production/consumption rates/ total oxygen consumption/production ratesrates	DIC samples brought to room temperature in dark.	1. Dissolved inorganic carbon (DIC) determined using a DIC analyser and infrared-based CO_2 detector. (Geoscience Australia) 2. CO_2/O_2 production/consumption rates were calculated by concentration differences (T=1 – T=0) over the incubation period. Results expressed on a daily per m^2 basis.
B_D1	Surface sediment (0-2 cm) was syringed into acid-washed falcon vials. Pore waters were removed within 20 minutes of collection. Residual sediment was frozen for transport to the laboratory.	Major, minor, trace and rare earth elements	1. Freeze-dry 2. Grind in tungsten carbide mill.	X-Ray Fluorescence and ICP AES (Geoscience Australia)
		Bulk carbonate	1. Freeze-dry 2. Grind	Carbonate Bomb (Geoscience Australia)
		Particle surface area	1. Freeze dry. 2. Slow heating to 350^{o}C (12 hours).	5-point BET (Geoscience Australia)
		TOC, TN and C & N isotopes	1. Freeze-dry 2. Grind 3. Acid treatment	Mass spectrometry
B_E1	Spare sample. Surface sediment (~0-2 cm) was scooped into plastic bag. Samples were immediately frozen.	TBD	TBD	TBD
B_S1	Carbonate specimens. Bagged and refrigerated.	TBD	TBD	TBD

Appendix I. Survey Details for Towed-Video Transects

Table I.1 Towed-video transect details.

Area	Station	Start Latitude	Start Longitude	Start Depth (m)	End Latitude	End Longitude	End Depth (m)	Duration (min)	No. Stills	Observations & Comments
1	005CAM001	-12.21815	127.39682	86	-12.21800	127.39784	72	12	0	USBL not logging; intermittent video signal; ended tow - plan to rerun with new cable.
1	005CAM001.1	-12.21590	127.39422	85	-12.20538	127.40145	72	44	264	Pockmarks, muddy; very sparse epibenthos; occasional urchin and crinoid, soft coral, small fish; High turbidity; small rocky outcrops; 800m slight increase in abundance upslope after 800 - 900m (< 75 m water depth).
1	006CAM002	-12.20878	127.42330	71	-12.20257	127.43480	70	40	240	Soft muddy; very sparse epibenthos; occasional pockmarks; very occasional crinoids, gorgonians and crinoids at 1400m.
1	007CAM003	-12.18530	127.39628	73	-12.18540	127.40280	95	34	204	Soft muddy substrate; very sparse barren epibenthos; pockmarks; low mounds; bioturbated; current forcing camera onto its side; very occasional crinoids; soft corals.
1	008CAM004	-12.19615	127.40213	73	-12.18562	127.40960	96	39	234	Soft muddy substrate; barren; pockmarks; burrows; very occasional crinoids; soft coral - on small rocky outcrops- very localised.
1	009CAM005	-12.20160	127.43143	74	-12.19075	127.43476	103	47	282	Muddy substrate; bioturbated; occasional gorgonian; sea whip; sponge - as small patches; fish; strong current.
1	010CAM006	-12.20843	127.44685	88	-12.19770	127.45330	99	38	228	Muddy substrate; soft; shell grit on surface; barren; occasional crinoid; burrows; fish; brittle stars; prawn; ray; soft coral; gorgonian; very sparse; more biota on northern edge of channel.

Area	Station	Start Latitude	Start Longitude	Start Depth (m)	End Latitude	End Longitude	End Depth (m)	Duration (min)	No. Stills	Observations & Comments
1	011CAM007	-12.20550	127.43892	91	-12.19617	127.44883	89	42	252	Strong tides; bioturbated; soft muddy substrate very sparse to barren epibenthos; very occasional crinoid; brittle stars; slightly more abundant at end of the tow across terrace on north side of channel; octocorals; crinoids; sea pens.
1	012CAM008	-12.19533	127.44455	88	-12.19798	127.43270	100	46	276	Soft muddy substrate; ray; sparse epibenthos; occasional crinoids, gorgonians; bioturbated, pockmarks, octocorals; prawns. USBL dropped out 08:21 - resumed 08:28. Most of channel floor barren mud with numerous mounds and pockmarks; numerous brittle stars.
1	013CAM009	-12.20660	127.43560	75	-12.20683	127.43527	75	2	0	No visibility; high suspended sediment load on bottom; tow terminated early
1	014CAM010	-12.07450	127.43548	30	-12.06152	127.43670	89	44	264	Strong tidal current, 2kn +; Hard substrate on edge of shoal; hard corals; lots of fish; irregular with mounds; gravel patches; red algae; patchy cover and epibenthos; sponges in patches; mushroom corals, very high cover in extensive continuous fields; abundance reduces below 50m W.D.; visibility OK; Large bommie at 70m covered in sponge and fish; gorgonian community below 72m.
1	015CAM011	-12.07073	127.42447	61	-12.06173	127.43388	89	43	258	Sandy gravelly substrate; sparse to patchy epibenthos; gorgonians, sponges, (relatively flat to undulating); crinoids; ~70 m = ledges with cover of sponges, gorgonians; Tide steering tow to NE; becomes sparse to barren below 70 m; with occasional bommie outcrop in sponges.
1	016CAM012	-12.08947	127.42677	118	-12.08777	127.42735	110	5	30	Muddy gravel; sparse to patchy epibenthos cover; sponges; gorgonians; sea whips; crinoids; rocky outcrops; terminated after 5 minutes due to steep rise from 100m to 30m over 100m distance.
1	016CAM013	-12.07805	127.43100	35	-12.08707	127.42258	107	47	282	Start sandy gravel, mounds; sponges, hard corals, red algae, crinoids, fish, continuous cover; steep drop offs to 70m; cover becomes sparse, occasional patches of gorgonians, sponges to 90m.
1	017CAM014	-12.10277	127.39908	110	-12.09122	127.39505	111	55	330	Soft muddy substrate; barren; sparse pockmarks; very sparse soft corals and fish.

Area	Station	Start Latitude	Start Longitude	Start Depth (m)	End Latitude	End Longitude	End Depth (m)	Duration (min)	No. Stills	Observations & Comments
2	024CAM015	-11.88680	127.09523	78	-11.88903	127.10368	87	70	420	Muddy soft substrate, very turbid, barren, sparse patches of hardground with sponges, gorgonians, bommies ~800m.
2	025CAM016	-11.89710	127.07040	71	-11.89710	127.08037	71	70	420	Soft muddy sand substrate; very sparse epifauna; 02:53_ stuck on bommie - 5min to release; very patchy epibenthos growing on isolated rocky outcrops - latter 500m of tow.
2	026CAM017	-11.89287	127.09500	61	-11.90452	127.10122	84	54	324	Soft sandy substrate; sparse sponges; gorgonians in localised patches; low visibility; fish; bommies; semi-continuous sponge gardens across crest of shoal; excellent tow transit across edge of platform on crest of shoal and onto lower shoal terrace, where biota are sparse.
2	027CAM018	-11.87965	127.11588	116	-11.88327	127.11740	115	31	186	Soft muddy substrate; barren; very poor visibility; terminated tow at 500m due to poor visibility and lack of epibenthic community.
2	028CAM019	-11.85868	127.03623	126	-11.86310	127.03540	123	20	120	Soft muddy substrate; barren; small fish; 1 or 2 crinoids; pockmarks/burrows; very turbid; low visibility; tow terminated at 500 m due to absence of epibenthos.
2	029CAM020	-11.89360	127.09842	63	-11.89360	127.09842	63	4	24	No USBL signal at start - tow terminated after 5 min to fix USBL.
2	029CAM020_1	-11.89428	127.09825	60	-11.90388	127.10677	88	64	384	muddy sand substrate; gorgonian; sponges in small scattered patches, 10s metres apart; rocky mounds after 01:40 UTC with sponges, crinoids, gorgonians, density of epibenthos increases; trevally school; hooked up under rock overhang 02:10 - had to turn boat to free up towvid; raised camera into water column while repositioning 02:14; resume 02:15; rich in gorgonian at start of lower terrace.
2	031CAM021	-11.79337	126.97838	77	-11.80403	126.98572	90	64	384	Soft muddy substrate; barren; very occasional soft coral; gorgonians; soft corals; increased abundance across step/ledge to 85m at 07:32; barren below 85-90m.
2	032CAM022	-11.79552	126.99378	93	-11.80728	126.99842	93	42	252	Soft muddy substrate; pockmarks; fish; very irregular bed across pockmarks; barren; best video and pockmarks thus far.

Area	Station	Start Latitude	Start Longitude	Start Depth (m)	End Latitude	End Longitude	End Depth (m)	Duration (min)	No. Stills	Observations & Comments
2	033CAM023	-11.84728	127.05692	127	-11.85025	127.05590	127	17	102	Soft muddy substrate; barren; terminated at 500m due to lack of bathy change at this station - substrate uniformly barren.
2	034CAM024	-11.88135	127.09223	104	-11.87757	127.09328	111	18	108	Soft muddy coarse sand substrate; low visibility; turbid; barren; pockmarks after 02:40 min.
2	036CAM025	-11.81475	127.03858	82	-11.82093	127.05007	111	52	312	No USBL at start to 06:49; mixed soft and hard substrate with patches of sponges, gorgonians, soft corals on outcrop including bommies; good visibility; semi-continuous communities of gorgonians, sponges, fish; steep drop off onto sparse muddy sands; becomes barren with distance from shoal; pockmarks.
2	037CAM026	-11.81868	127.03333	76	-11.81217	127.02643	108	53	318	Mixed substrate; muddy sand and rocky outcrop with sponge; gorgonians - relatively sparse; good visibility; rocky outcrops concentrated on edge of shoal- well colonised by biology. Excellent tow video. Improved visibility probably associated with neap tides (weaker current). Note that this tow is on the lee side with respect to dominant tides - sheltered aspect - substrate becomes barren after 09:15 UTC - Mounds at 09:21UTC.
2	038CAM027	-11.80768	126.96805	77	-11.81757	126.97727	104	59	354	Muddy sand and gravel substrate; pockmarks; mostly barren; improved visibility - likely due to weaker tidal currents on neaps; good video of pockmark holes and mounds; sparse patches of sponges on irregular substrate (rock?) across small ledges (80-90 m W.D.); barren and muddier below 90 m; pockmarks.
2	039CAM028	-11.78048	127.01048	90	-11.77778	127.01365	98	16	96	Soft muddy substrate; mounds, pockmarks, barren; terminated at 500 m due to the lack of variation across uniform bathymetry.
2	040CAM029	-11.80948	126.99110	100	-11.82332	126.98855	110	53	318	Soft muddy substrate; barren; moderate visibility; tow line crosses small knoll; sparse epibenthic community of sponges, sea whips, soft corals, gorgonians on hardground in 100-105 m W.D.
3	044CAM030	-11.41050	126.92420	88	-11.41832	126.93482	63	43	258	Soft muddy substrates; barren; pockmarks and small soft mounds; bioturbated; sparse patch of octocorals, gorgonians, sponges at 06:40 on mounds to 06:45 up to 65m - bommie at 06:47; reef-like.

Area	Station	Start Latitude	Start Longitude	Start Depth (m)	End Latitude	End Longitude	End Depth (m)	Duration (min)	No. Stills	Observations & Comments
3	045CAM031	-11.45150	126.92027	95	-11.43893	126.92602	104	59	354	Soft muddy substrate; mostly barren; isolated octocoral, gorgonian on small mounds; pockmarks, bioturbated.
3	046CAM032	-11.43402	126.93842	62	-11.44693	126.93498	108	44	264	Muddy sandy substrate; sparse to patchy epibenthos, sponges, gorgonians; good light and visibility; becomes very sparse after drop off into 80 m +; barren and pockmarked; soft mud.
3	047CAM033	-11.41918	126.94457	64	-11.41195	126.94910	881	49	294	Sandy muddy substrate; barren at start - irregular seabed, mounds; good light and visibility; occasional octocoral, small sponge, fish, bommies with 100% cover of biology; bommies spaced 10's metres; concentration of biology on small ledge drop off to 75 m.
3	049CAM034	-11.40628	126.92817	84	-11.39768	126.91885	91	49	294	Muddy sandy substrate with irregular mounds, patches of biology on mounds; gorgonians, sponges, sea whips, soft corals; becomes barren below 85 m; numerous pockmarks and mounds; very sparse small patches of biology.
3	050CAM035	-11.40462	126.96122	99	-11.39188	126.96232	81	48	288	Soft muddy substrate; bioturbated; barren; pockmarks; rocky outcrops at 10:12 near end of tow (82m); patch of hydroids, crinoids.
3	051CAM036	-11.43092	126.98882	95	-11.41962	126.99582	104	51	306	Soft muddy substrate; pockmarks; irregular mounds; barren; bioturbated.
3	052CAM037	-11.43623	126.99827	96	-11.43603	127.01115	105	44	264	Soft muddy substrate; barren; pockmarks and burrows.
3	053CAM038	-11.43918	126.96487	56	-11.45032	126.97190	91	44	264	Muddy sand and gravel substrate on bank platform; irregular surface; patchy to thin epibenthos-small sponges, gorgonians, sea whips; good light and visibility; bommies and reef at 06:38 - benthos increases in abundance; large barrel sponges; abrupt transition over drop off to 78 m with muddier substrate; still patchy gorgonians and sponges - very irregular bed with rocky outcrop; grades to barren mud by 06:45; strongly pockmarked.

Area	Station	Start Latitude	Start Longitude	Start Depth (m)	End Latitude	End Longitude	End Depth (m)	Duration (min)	No. Stills	Observations & Comments
3	054CAM039	-11.42683	126.96030	62	-11.41752	126.96945	95	38	228	Soft muddy substrate; barren, occasional bommie with cover of gorgonians, sponges, octocorals, fish; steep drop off at 09:35 to 82 m; rocky at base with gorgonians, sponges assemblages in patches becomes sparse with distance from shoal - pockmarked muds.
3	055CAM040	-11.43477	126.95460	59	-11.44968	126.95403	103	52	6	Muddy sand and gravel substrate; sparse to patchy epibenthos; bioturbated; generally flat and barren across top of shoal platform; good light and visibility; bed roughness high and benthos cover toward edge and drop off; becomes muddy and sparse on flats below shoal; pockmarks; couple of patches of sponges across lower platform edge (95 m); stills camera failed.
3	055CAM040_1	-11.43675	126.95483	59	-11.44345	126.95493	85	24	144	As above – partial re-run of transect across
3	056CAM041	-11.40055	127.02057	72	-11.40080	127.02065	74	21	126	Muddy sand substrate; barren at start then rises abruptly 20 m to top of shoal; hooked up on ledge; pull out and redeploy down-slope.
3	056CAM041_1	-11.40182	127.02313	50	-11.39285	127.03227	108	40	240	Sandy gravel (?) with semi-continuous sponge garden; lots of fish; good light and visibility; steep drop off to 77 m; muddy sand with gorgonians, sponges; becomes barren with distance from shoal and pockmarks.
3	057CAM042	-11.44437	127.09490	110	-11.45208	127.08058	90	66	396	Soft muddy substrate; barren; pockmarks; burrows; 10 m ledge at end of tow with gorgonians, crinoids, sponge community.
3	058CAM043	-11.45052	127.03443	81	-11.43987	127.02733	106	38	228	Transect starts on shoal platform perimeter; rocky outcrops (bommies) with gorgonians, sponge cover; soft muddy substrate in between with sparse cover.
3	061CAM044	-11.43950	126.98153	56	-11.44523	126.98068	93	41	246	Start of tow on shoal edge; rich assemblage of gorgonians, sponges on rocky substrate; becomes sparse to barren on flats below shoal; soft muddy substrate.
3	062CAM045	-11.41237	126.94013	64	-11.39950	126.93783	88	50	300	Tow start at edge of shoal platform; rocky with patches of sponge and gorgonians growth; bommies also with good cover of sponges; becomes barren muddy substrate (82 m W.D.); pockmarks; poor visibility; USBL cut out near end.

Area	Station	Start Latitude	Start Longitude	Start Depth (m)	End Latitude	End Longitude	End Depth (m)	Duration (min)	No. Stills	Observations & Comments
3	063CAM046	-11.39855	126.91085	97	-11.39555	126.90540	100	17	102	Night time tow; soft muddy substrate; barren tow crosses low rise/ knoll with patchy sponges and gorgonians, octocorals communities on muddy sand (?) with rocky (?) outcrops (85 m); semi-continuous cover across knoll; terminated tow at 600 m at western edge of survey area.
4	067CAM047	-11.32767	126.95342	44	-11.33712	126.96223	73	60	360	Hard pavement substrate; semi-continuous cover of soft and hard corals, gorgonians, sponges (including acropora); good light and visibility; sand in patches; bommies toward edge of platform; becomes sparse to barren below 65 m after drop off.
4	069CAM048	-11.32802	126.95400	43	-11.32540	126.95038	75	13	78	Hardground with semi-continuous cover of sponges, corals (hard and soft), gorgonians, reef fish; becomes sparse below 65 m.
4	070CAM049	-11.32968	126.95798	77	-11.32650	126.95798	77	15	90	Hardground with semi-continuous cover of sponges, corals (hard and soft), gorgonians, crinoids; becomes sparse to barren below 60 m after drop off.
1	073CAM050	-12.07165	127.42402	31	-12.05950	127.42402	99	43	258	Tow start on crest of shoal platform; with sand/gravel patches; patches of sponges; hard corals; gorgonians; good light and visibility; becomes sparse to patchy off platform (W.D > 55m; substrate flat - no pockmarks on terrace (sandy); bommies on low ridges with gorgonians and sponges.
1	074CAM051	-12.07118	127.43513	31	-12.07697	127.44807	89	40	240	and sandy gravel substrate; large 2D bedforms (31m) of gravel (~0.5m high); gravel in troughs; very sparse epibenthos; bedform field extends 10's m; transition to rocky substrate, irregular with sponges, corals, fish; bommies; 2nd bedform field after outcrops still in 31 m W.D.; 2nd area of irregular rocky outcrop, rich in hard of soft corals, fish. Transition off shoal to muddy substrate with occasional bommie.
1	075CAM052	-12.12818	127.44778	110	-12.13933	127.45395	107	49	294	Start on shoal platform, running south; mixed soft and hard substrate with coral patches of gorgonians, sponges on outcrops; poor visibility; edge of shoal characterised by small outcrops with gorgonians and sponge growth, fish; becomes barren; muddy substrate off the shoal.

Appendix J. Survey Details for Benthic Sled Transects

Table J.1 Benthic sled transect details. All transects were deployed over banks. Biota weight includes the total wet weight of all live samples collected.

Area	Station	Sample	Start Latitude	Start Longitude	Start Depth (m)	End Latitude	End Longitude	End Depth (m)	Biota wgt (kg)	Sample Description
1	6	SOL5650/006BS001	-12.2039	127.4323	72.4	-12.2037	127.4327	74.3	0.348	
1	14	SOL5650/014BS002	-12.0692	127.4361	36.5	-12.0696	127.4361	35	3.96	Carbonate gravel with sponges
1	15	SOL5650/015BS003	-12.0688	127.4275	61.2	-12.0684	127.4279	64.9	1.15	Carbonate gravel with sponges
1	16	SOL5650/016BS004	-12.0801	127.4290	44.9	-12.0803	127.4296	46.7	64.57	Sponges
2	24	SOL5650/024BS005	-11.8864	127.0971	83.7	-11.8862	127.0964	82.9	0.14	Mostly mud; limited epibenthos
2	25	SOL5650/025BS006	-11.8920	127.0753	74.1	-11.8920	127.0750	74.2	0.32	Mostly mud; limited epibenthos
2	26	SOL5650/026BS007	-11.8993	127.0981	58	-11.8989	127.0979	58	0.76	Sponges, corals, cemented carbonates
2	29	SOL5650/029BS008	-11.8990	127.1024	57.9	-11.8989	127.1027	58.4	18.02	Sponges, gorgonians
2	31	SOL5650/031BS009	-11.7945	126.9860	82.7	-11.7949	126.9856	82.3	2.12	Large cobble sized block of coral - sampled in pieces for analysis (C-14)
2	36	SOL5650/036BS010	-11.8168	127.0438	80.8	-11.8165	127.0441	81.3	2.6	Biota in muddy sand
2	37	SOL5650/037BS011	-11.8188	127.0310	91.7	-11.8182	127.0314	91.6	40.53	
2	38	SOL5650/038BS012	-11.8097	126.9699	82.5	-11.8096	126.9706	82.7	0.16	Mostly sandy mud; shell fragments; cobble sized fragment of calcareous cement retained

Area	Station	Sample	Start Latitude	Start Longitude	Start Depth (m)	End Latitude	End Longitude	End Depth (m)	Biota wgt (kg)	Sample Description
3	44	SOL5650/044BS013	-11.4181	126.9328	70.7	-11.4177	126.9327	72.6	0	Net broke, no sample (likely due to large amount of mud)
3	46	SOL5650/046BS014	-11.4335	126.9375	63.7	-11.4330	126.9371	63.7	8.92	Muddy sand, carbonate rock sample retained
3	47	SOL5650/047BS015	-11.4119	126.9491	81	-11.4116	126.9493	81.8	0.36	Mostly sandy mud, some biota
3	53	SOL5650/053BS016	-11.4405	126.9657	56.6	-11.4399	126.9653	57	4.76	Small amount of biota in muddy sand, carbonate rock retained
3	55	SOL5650/055BS017	-11.4395	126.9513	58.1	-11.4400	126.9519	59.8	19.23	Muddy sand and biology; sponge included; carbonate rock retained
3	56	SOL5650/056BS018	-11.4015	127.0263	52.5	-11.4015	127.0257	52.3	17.77	All biota, no mud
3	61	SOL5650/061BS019	-11.4385	126.9684	57.3	-11.4393	126.9682	58.1	5.44	Biota and carbonate rocks
3	63	SOL5650/063BS020	-11.3972	126.9083	86.4	-11.3969	126.9078	87.2	6.34	Several large slabs of cemented carbonates with coral base - retained
1	73	SOL5650/073BS021	-12.0683	127.4276	67.9	-12.0688	127.4269	66.1	4.18	
1	74	SOL5650/074BS022	-12.0748	127.4435	55.9	-12.0754	127.4437	65.8	5.82	Rubble, shells and biology; geological samples of corals retained

Appendix K. Biodiscovery Samples

Table K.1 Biological specimens processed for biodiscovery purposes.

Area	Station Number	Sample Number	ID Number	Phylum	Family	Genus	Species	Common Name	Weight (g)
1	16	16BS04	10382	*Porifera*				Sponge	50
3	53	53BS16	10219	*Porifera*	*Irciniidae*	*Ircinia*	Finger Balls	Sponge	110
3	53	53BS16	10220	*Porifera*	*Irciniidae*	*Ircinia*	Old Man Fingers	Sponge	<100
1	14	14BS02	10264	*Porifera*				Sponge	100
1	15	15BS03	10290	*Porifera*		*Ianthella*		Sponge	100
1	16	16BS04	10365	*Porifera*				Sponge	100
1	16	16BS04	10369	*Bryozoa*				Bryozoan	100
1	16	16BS04	10377	*Porifera*		*Reniochalina*	Sponge		100
1	16	16BS04	10380	*Porifera*	*Dictyonellidae*	*Stylissa*	carteri	Sponge	100
1	16	16BS04	10388	*Porifera*				Sponge	100
2	29	29BS08	10490	*Porifera*				Sponge	100
2	31	31BS09	MAGNT0024	*Chordata*				Ascidian	<100
2	36	36BS10	MAGNT0056	*Porifera*		*Oceanapia*	Sponge		100
2	36	36BS10	MAGNT0057	*Porifera*		*Microscleroderma*	Sponge		100
2	36	36BS10	MAGNT0058	*Porifera*		*Aka?*		Sponge	100
2	36	36BS10	MAGNT0059	*Porifera*		*Spongia*		Sponge	100
3	46	46BS14	10177	*Porifera*		*Suberea?*		Sponge	200
3	46	46BS14	10180			*Geodia?*			
3	46	46BS14	10181	*Porifera*		*Cymbastella*	Sponge		100

Area	Station Number	Sample Number	ID Number	Phylum	Family	Genus	Species	Common Name	Weight (g)
3	46	46BS14	10184	*Porifera*		*Thorecta*		Sponge	100
3	55	55BS17	10233	*Porifera*		*Ircinia*		Sponge	1600
3	55	55BS17	10235	*Porifera*		*Clathria*		Sponge	150
3	56	56BS18	20776	*Porifera*				Sponge	100
3	56	56BS18	20818	*Cnidaria*				soft coral	110
3	61	61BS19	20836	*Porifera*		*Cymbastella*	Sponge		120
3	73	73BS21	20942					Gorgonian	100
3	46	46BS14	10186	*Porifera*	*Thorectidae*			Sponge	110
2	29	29BS08	10485	*Porifera*		*Coelocarteria*	Sponge		120
3	46	46BS14	10189	*Cnidaria*				Gorgonian	120
3	46	46BS14	10187	*Porifera*		*Reniochalina*	Sponge		150
3	46	46BS14	10188	*Porifera*		*Axechina*		Sponge	150
3	55	55BS17	20743	*Porifera*		*Echinodyctium*	Sponge		200
3	56	56BS18	10249	*Porifera*	*Thorectidae*		Yellow Mucus	Sponge	200
3	53	53BS16	10221	*Cnidaria*				Gorgonian	<100
3	55	55BS17	20746	*Porifera*				Sponge	180
1	74	74BS22	20991					Sponge	200
1	16	16BS04	10375	*Cnidaria*				Gorgonian	190
1	14	14BS02	10265	*Porifera*				Sponge	200
1	14	14BS02	10267	*Porifera*				Sponge	200
1	15	15BS03	10310	*Cnidaria*				Soft coral	200
1	16	16BS04	10366	*Porifera*				Sponge	200
1	16	16BS04	10367	*Porifera*				Sponge	200
1	16	16BS04	10379	*Porifera*		*Cymbastella*	Sponge		200
2	29	29BS08	10488	*Porifera*		*Ircinia*		Sponge	200

Area	Station Number	Sample Number	ID Number	Phylum	Family	Genus	Species	Common Name	Weight (g)
3	46	46BS14	10176	*Porifera*		*Xestospongia*	Sponge		2000
3	46	46BS14	10179	*Porifera*				Sponge	200
3	46	46BS14	10182	*Porifera*	*Thorectidae*			Sponge	200
3	46	46BS14	10185	*Porifera*		*Oceanapia*	Sponge		200
3	46	46BS14	10191	*Cnidaria*				Gorgonian	200
3	53	53BS16	10216	*Porifera*	*Irciniidae*	*Ircinia*		Sponge	300
3	55	55BS17	10234	*Porifera*		*Thorecta*		Sponge	300
3	55	55BS17	10239	*Porifera*		*Spongia*		Sponge	400
3	56	56BS18	20786	*Porifera*		*Ircinia*	Reptant Fingers	Sponge	230
1	74	74BS22	20981					Sponge	<100
1	16	16BS04	10374	*Cnidaria*				Gorgonian	210
1	16	16BS04	10376	*Echinodermata*			Crinoid		210
3	55	55BS17	20739	*Porifera*	*Thorectidae*		Yellow Mucus	Sponge	210
2	36	36BS10	MAGNT0055	*Porifera*		*Theonella*	Sponge		240
3	46	46BS14	10183	*Porifera*	*Thorectidae*			Sponge	250
3	53	53BS16	10215	*Porifera*		*Microscleroderma*	Sponge		250
3	55	55BS17	10232	*Porifera*	*Thorectidae*		Corneto	Sponge	250
1	16	16BS04	10391	*Porifera*		*Ectyoplasia*	Sponge		270
3	61	61BS19	20837	*Porifera*		*Cymbastella*	Salad Bowl	Sponge	300
1	14	14BS02	10263	*Porifera*				Sponge	300
1	16	16BS04	10384	*Porifera*		*Ianthella*		Sponge	300
1	16	16BS04	10386	*Porifera*				Sponge	300
2	37	37BS11	MAGNT0079	*Porifera*		*Oceanapia*	Sponge		300
3	46	46BS14	10173	*Cnidaria*				Gorgonian	1000
3	53	53BS16	10212	*Porifera*		*Oceanapia*	Sponge		480

Area	Station Number	Sample Number	ID Number	Phylum	Family	Genus	Species	Common Name	Weight (g)
3	56	56BS18	10242	*Porifera*		*Ianthella*	basta	Sponge	300
3	56	56BS18	10247	*Porifera*		*Coelocarteria*	Orange	Sponge	400
1	73	73BS21	20925	*Porifera*				Sponge	410
1	15	15BS03	10304	*Cnidaria*		*Tubipora*		Tubipora	350
3	56	56BS18	10243	*Porifera*		*Ianthella*	flabelliformis	Sponge	350
3	61	61BS19	20835	*Porifera*		*Thorecta*	Corneto	Sponge	380
1	16	16BS04	10383	*Porifera*		*Theonella*	Sponge		370
1	16	16BS04	10381	*Echinodermata*			Crinoid		400
1	16	16BS04	10385	*Cnidaria*		*Nephtia Cf.*	Soft coral		400
1	16	16BS04	10390	*Porifera*		*Thorecta*		Sponge	400
2	29	29BS08	10486	*Porifera*		*Spheciospongia*	Sponge		400
3	63	63BS20	20879	*Porifera*		*Xestospongia*	Sponge		400
3	63	63BS20	20881	*Echinodermata*			Holothurian		400
1	74	74BS22	20984					Sponge	400
3	56	56BS18	10248	*Porifera*		*Spheciospongia*	purpurea?	Sponge	600
2	29	29BS08	10482	*Porifera*		*Xestospongia*	Sponge		420
3	53	53BS16	10214	*Porifera*	*Thorectidae*		Mucus	Sponge	420
3	53	53BS16	10222	*Cnidaria*				Gorgonian	470
3	56	56BS18	10240	*Porifera*		*Pseudoceratina*	Sponge		600
3	46	46BS14	10170	*Cnidaria*				Gorgonian	700
3	55	55BS17	10223	*Porifera*		*Ianthella*		Sponge	600
3	63	63BS20	20880	*Chordata*				Ascidian	500
1	74	74BS22	20990					Sponge	500
1	16	16BS04	10387	*Porifera*		*Oceanapia*	Sponge		600
2	29	29BS08	10483	*Porifera*		*Oceanapia*	Sponge		600

Area	Station Number	Sample Number	ID Number	Phylum	Family	Genus	Species	Common Name	Weight (g)
2	29	29BS08	10484	*Porifera*		*Oceanapia*	Sponge		600
2	29	29BS08	10487	*Porifera*		*Theonella*	Sponge		600
2	37	37BS11	MAGNT0080	*Porifera*				Sponge	600
1	73	73BS21	20943					Soft Coral	700
1	74	74BS22	20989					Sponge	700
1	16	16BS04	10371	*Porifera*				Sponge	650
1	74	74BS22	20974					Sponge	800
3	46	46BS14	10172	*Cnidaria*				Gorgonian	300
3	53	53BS16	10211	*Porifera*		*Oceanapia*	Sponge		800
3	55	55BS17	20751	*Cnidaria*				Gorgonian	700
1	74	74BS22	20999					Sponge	700
1	16	16BS04	10393	*Porifera*		*Ianthella*		Sponge	800
2	29	29BS08	10489	*Porifera*		*Cinachyrella*	Sponge		800
3	55	55BS17	10230	*Porifera*		*Oceanapia*	Sponge		800
3	46	46BS14	10171	*Cnidaria*				Gorgonian	500
3	55	55BS17	10224	*Porifera*		*Ianthella*		Sponge	900
2	37	37BS11	MAGNT0076	*Porifera*		*Xestospongia*	Sponge		17500
3	46	46BS14	10175	*Porifera*		*Oceanapia*	Sponge		1600
3	55	55BS17	10228	*Porifera*		*Thorecta*		Sponge	1399
3	55	55BS17	10229	*Porifera*		*Oceanapia*	Sponge		1300
3	55	55BS17	10231	*Porifera*		*Xestospongia*	Sponge		2000
1	16	16BS04	10395	*Porifera*		*Echinodyctium*	Sponge		1050
2	36	36BS10	MAGNT0053	*Porifera*		*Xestospongia*	Sponge		5000
2	37	37BS11	MAGNT0077	*Porifera*		*Theonella*	Sponge		16700
3	46	46BS14	10174	*Cnidaria*				Gorgonian	300

Area	Station Number	Sample Number	ID Number	Phylum	Family	Genus	Species	Common Name	Weight (g)
3	53	53BS16	10213	*Porifera*		*Xestospongia*	testudinaria	Sponge	1500
3	55	55BS17	10227	*Porifera*				Sponge	2000
3	56	56BS18	10245	*Porifera*		*Xestospongia*	testudinaria	Sponge	11000
3	63	63BS20	20878	*Porifera*		*Rhabdastrella*	Sponge		1300
1	73	73BS21	20923	*Porifera*				Sponge	1600
1	73	73BS21	20924	*Porifera*				Sponge	300
1	14	14BS02	10262	*Porifera*				Sponge	1600
1	16	16BS04	10389	*Porifera*		*Scleritoderma*	Sponge		1200
1	16	16BS04	10392	*Porifera*		*Coelocarteria*	Sponge		1200
1	16	16BS04	10394	*Porifera*		*Petrosia*		Sponge	1200
1	16	16BS04	10396	*Porifera*		*Xetospongia*	testudinaria	Sponge	30000
2	29	29BS08	10479	*Cnidaria*				Gorgonian	3920
2	29	29BS08	10480	*Porifera*		*Xestospongia*	Sponge		5000
2	29	29BS08	10481	*Porifera*		*Petrosia*		Sponge	1200
2	31	31BS09	MAGNT0025	*Porifera*		*Xestospongia*	Sponge		1200
2	36	36BS10	MAGNT0054	*Porifera*		*Xestospongia*	Sponge		5600
3	55	55BS17	10226	*Porifera*		*Suberea*		Sponge	5000
3	61	61BS19	20834	*Porifera*		*Thorecta*		Sponge	2500
3	56	56BS18	10246	*Porifera*		*Ircinia*		Sponge	1600
2	37	37BS11	MAGNT0078	*Porifera*		*Ircinia*		Sponge	5000

Appendix L. Survey Details for Baited Remote Underwater Video Stations (BRUVS)

Table L.1 Baited remote underwater videos (BRUV) station details.

Area	Rig	Camera	Latitude	Longitude	Depth (m)
1	5	8	-12.0777	127.432	33
1	5	9	-12.0777	127.4247	43
1	6	10	-12.0762	127.4274	34
1	4	11	-12.0747	127.4316	31
1	3	12	-12.0712	127.4341	33
1	7	13	-12.074	127.4432	60
1	8	14	-12.0777	127.4424	54
1	8	1	-12.0736	127.4248	38
1	7	2	-12.0701	127.4276	46
1	2	3	-12.068	127.4301	58
1	1	4	-12.0683	127.4376	47
1	3	5	-12.07	127.4403	45
1	4	6	-12.0727	127.4381	32
1	6	7	-12.0764	127.4355	31
1	1	15	-12.0796	127.4373	48
1	2	16	-12.0806	127.432	49
2	3	24	-11.8883	127.0781	77
2	3	25	-11.8914	127.0739	74
2	7	26	-11.8914	127.0841	67
2	6	27	-11.8903	127.0959	77
2	8	28	-11.8979	127.0938	59
2	4	29	-11.9003	127.0921	67
2	5	30	-11.8992	127.1017	58
2	2	17	-11.8913	127.0635	61
2	1	18	-11.8941	127.0668	64
2	5	19	-11.8924	127.0727	74
2	4	20	-11.8972	127.0784	73
2	8	21	-11.8975	127.0868	63
2	6	22	-11.8917	127.0886	61
2	7	23	-11.8874	127.0839	77

Area	Rig	Camera	Latitude	Longitude	Depth (m)
2	1	31	-11.8949	127.1006	61
2	2	32	-11.8982	127.1064	62
3	5	33	-11.4014	127.0209	55
3	4	34	-11.4004	127.022	57
3	1	35	-11.4029	127.0221	55
3	2	36	-11.4009	127.0237	52
3	6	37	-11.4022	127.0243	51
3	7	38	-11.4014	127.0262	52
3	3	39	-11.4036	127.0264	54
3	8	40	-11.403	127.029	56
3	8	41	-11.411	126.9341	68
3	7	42	-11.414	126.9424	66
3	3	43	-11.4143	126.9501	67
3	5	44	-11.4176	126.9551	68
3	6	45	-11.4266	126.9594	63
3	1	46	-11.4299	126.9656	62
3	4	47	-11.4364	126.9622	58
3	2	48	-11.4421	126.9654	58
3	2	49	-11.438	126.956	60
3	4	50	-11.4311	126.9529	61
3	1	51	-11.4306	126.9464	62
3	6	52	-11.4326	126.9382	62
3	5	53	-11.4258	126.9377	62
3	3	54	-11.423	126.9438	65
3	7	55	-11.4197	126.9454	65
3	8	56	-11.4172	126.9359	65

Appendix M. Survey Details for Baited Underwater Water Column Video (SISSTAs)

Table M.1 Baited mid water column video (SISSTAs) station details. (denotes camera not recovered)*

Station	Area	Latitude	Longitude	Depth
1	1	-12.1498	127.4533	105
2	1	-12.142	127.4302	110
3	1	-12.1552	127.4156	109
4	1	-12.1611	127.4016	107
5	1	-12.1625	127.3888	104
6	1	-12.1802	127.3957	102
7	1	-12.1749	127.4041	99
8	1	-12.1858	127.4298	106
9	1	-12.1845	127.4499	74
10	1	-12.1668	127.4547	114
11	1	-12.1415	127.395	108
12	1	-12.1448	127.4034	109
13	1	-12.1354	127.4144	77
14	1	-12.1438	127.4153	109
15	1	-12.1348	127.4323	93
16	1	-12.1343	127.4412	90
17	1	-12.1304	127.4478	79
18	1	-12.1191	127.4353	72
19*	1	-12.1086	127.4379	91
20	1	-12.1017	127.4359	125
21	1	-12.0647	127.3989	106
22	1	-12.0734	127.4039	106
23	1	-12.0669	127.4159	76
24	1	-12.0722	127.4315	31
25	1	-12.0655	127.4529	166
26	1	-12.079	127.4452	75
27	1	-12.0866	127.4375	93
28	1	-12.0862	127.4167	103
29	1	-12.0944	127.4048	112
30	1	-12.0955	127.3872	111
31	1	-12.2197	127.445	74
32	1	-12.201	127.4529	118
33	1	-12.1935	127.4422	95
34	1	-12.2002	127.4202	71
35	1	-12.185	127.4143	77
36	1	-12.1888	127.4058	85
37	1	-12.202	127.4097	71
38	1	-12.2167	127.4075	90
39	1	-12.2182	127.396	87
40	1	-12.194	127.3879	75
41	2	-11.8765	127.1159	117
42	2	-11.8895	127.1141	113
43	2	-11.9032	127.1229	103
44	2	-11.9004	127.1118	102
45	2	-11.896	127.1092	81
46	2	-11.9001	127.1064	75
47	2	-11.9073	127.1043	109
48	2	-11.9116	127.1011	111
49	2	-11.9225	127.0812	109
50	2	-11.9284	127.0775	107
51	2	-11.8946	127.0914	90
52	2	-11.8975	127.0767	74
53	2	-11.8998	127.0828	75
54	2	-11.8945	127.0834	68
55	2	-11.8957	127.0942	60
56	2	-11.897	127.1011	60
57	2	-11.8916	127.0993	78
58	2	-11.8831	127.0999	112
59	2	-11.8812	127.1067	116
60	2	-11.8762	127.1045	116

Station	Area	Latitude	Longitude	Depth
61	2	-11.8461	127.0823	127
62	2	-11.8651	127.0785	116
63	2	-11.8585	127.073	120
64	2	-11.8524	127.0637	126
65	2	-11.8684	127.0676	120
66	2	-11.8651	127.0573	121
67	2	-11.8618	127.0458	123
68	2	-11.8737	127.0464	120
69	2	-11.8704	127.0376	122
70	2	-11.8676	127.0242	126
71	3	-11.4463	126.9109	103
72	3	-11.448	126.9204	108
73	3	-11.4467	126.9281	108
74	3	-11.4873	126.9411	109
75	3	-11.4391	126.9446	79
76	3	-11.4315	126.9423	63
77	3	-11.4195	126.938	65
78	3	-11.4172	126.9305	85
79	3	-11.4235	126.927	90
80	3	-11.4344	126.9268	96
81	3	-11.4493	126.9663	94
82	3	-11.4454	126.9501	92
83	3	-11.4373	126.9505	62
84	3	-11.4318	126.9521	61
85	3	-11.4259	126.959	63
86	3	-11.4329	126.9605	59
87	3	-11.4369	126.9707	84
88	3	-11.4383	126.9878	90
89	3	-11.4296	126.9952	100
90	3	-11.4236	126.9857	99
91	3	-11.4138	126.9964	106

Station	Area	Latitude	Longitude	Depth
92	3	-11.4118	126.9862	105
93	3	-11.4177	126.9801	100
94	3	-11.4259	126.9719	91
95	3	-11.4164	126.9627	90
96	3	-11.4094	126.9653	100
97	3	-11.402	126.9716	104
98	3	-11.3959	126.9738	106
99	3	-11.3972	216.9892	105
100	3	-11.4024	126.9958	108
101	3	-11.4168	126.9081	96
102	3	-11.4035	126.9079	91
103	3	-11.3935	126.9087	99
104	3	-11.3929	126.9189	99
105	3	-11.3941	126.9322	89
106	3	-11.4022	126.9481	99
107	3	-11.4127	126.9526	85
108	3	-11.4248	126.9344	60
109	3	-11.4121	126.9235	86
110	3	-11.408	126.9259	91
111	2	-11.8656	127.1088	120
112	2	-11.8653	127.095	119
113	2	-11.8757	127.09	111
114	2	-11.8745	127.0836	114
115	2	-11.8815	127.0832	104
116	2	-1.2E+07	127.0789	79
117	2	-11.8871	127.0686	78
118	2	-11.8821	127.0638	100
119	2	-11.8847	127.0573	111
120	2	-11.8853	127.0501	114

Appendix N. Geomorphic Mapping Method

Interpreted local-scale geomorphic maps were produced for each survey area using multibeam bathymetry grids at 2 m resolution and bathymetric derivatives (e.g. slope; curvature; 1-m contours). Maps were produced in ArcGIS at a scale of 1:1 000 using a combination of both automatic extraction and hand-digitisation of polygons. Six geomorphic features, summarised in Table N.1, were identified and mapped following Heap & Harris (2008).

Table N.1 Summary of the geomorphic features mapped with definitions and datasets used to produce them. Feature definitions were based on those used by Heap & Harris (2008).

Feature	Definition	Datasets Used
Bank	Local or regional areas of elevated seafloor with one or more steep sides	2 m x 2 m Bathymetric Grids; Slope; 1 m Contour
Depression	Generally enclosed bathymetric lows on the seafloor that would act as a sediment trap.	Slope; 1 m Contour
Mound	Local areas of elevated seafloor with gently sloping rounded sides.	Slope; 1 m Contour
Plain	Extensive, flat or gently sloping areas	2 m x 2 m Bathymetric Grid; Slope; 1 m Contour
Scarp	Elongated and comparatively steep (≥10^{o}) slope separating more gently sloping areas	Slope
Terrace	Relatively flat or gently sloping seafloor with a moderately sloping to steep rise on one side and a moderately sloping to steep drop on the other side.	2 m x 2 m Bathymetric Grids; Slope; 1 m Contour

Banks were delimited using slope and curvature rasters overlain by 1-m contours, with edges defined as the point where their steep flanks met a relatively flat plain or terrace, as observed from changes in contour spacing. Since many bank features had multiple terraces the deepest break in slope was selected as the outer boundary that encompassed the entire bank. Some banks do not have distinct transitions or sharp changes in slope and in these cases the boundaries were determined by tracing along a contour that best and most smoothly connected two areas where there was a distinct transition in slope, while avoiding large and abrupt changes in elevation.

Depressions were generally defined from closed sets of contours that represented at least 2 m bathymetric change at a 1:8 000 scale. Some depressions, such as those in Area 1, were very large (10s of meters deep) and extended out of the surveyed area. These larger, deeper depression boundaries were mapped along the top of the greatest change in slope, in a similar but inverse approach to the banks.

Mounds were mapped in a similar way to banks but were distinguished from banks on the basis of having a more rounded form and a smaller change in elevation, generally 2-5 m.

Plains were defined as the generally flat regions between all other features, with relatively large spacing between 1-m contours.

Scarps were extracted by an automated process employing the ArcGIS spatial analyst and conversion toolboxes, and slope raster for each area. Firstly, *raster calculator* was used to select all areas with a slope ≥10^{o}. These areas were then converted to polygons using the *raster to polygon* tool. Polygons were subsequently filtered, retaining only those that were ≥10 000 m^{2}, using the *select* tool. The holes inside scarp polygons were removed by creating a feature dataset typology enforcing a *must not have gaps* condition. Finally, each remaining scarp was selected and used as a mask for the multibeam bathymetry using the *extract by mask* tool to check that the change in depth over each polygon is ≥ 10 ± 1 m. A polygon was only labelled as a scarp if all these criteria were met.

Terraces were defined as flat regions, in much the same way as plains. However, they are also characterised by a clear break in slope along the edge. Where plains and terraces were adjacent to one another the boundary of the terrace was defined to include the flank between the plain and terrace, determined as the point where slope changed from relatively steep to relatively flat, using 1 m contour spacing.

Polygons representing geomorphic features were then imported into Fledermaus 3D-visualisation software to check for consistency before being cross-checked by another experienced observer for quality control.

Appendix O. Survey Leader Daily Log

Oceanic Shoals Marine Biodiversity Survey SOL5650

Note: all times are in Western Australian Time

Wednesday, 12 September 2012

- In Port - Broome (Roebuck Bay)
- GA science crew arrived at wharf at 13:30 to assist with loading and setup of labs and gear stowage.
- SN met with AIMS Cruise Leader (Marcus Stowar) and Skipper (Chris Davis) to discuss voyage plan and the plan for the following 48 hrs. Aim for next 48 hours is to transit to Area 1 (southern-most grid)
- Departed Broome at 19:00 hrs.
- Welcome on board meeting with First Mate (Wayne) followed by safety briefing and tour of vessel for all science staff and support crew.
- Completed test of multibeam sonar motion reference unit outside Roebuck Bay (20:30-22:00). Sonar logging commenced 23:30.
- Calibration patch test of multibeam sonar heads not completed due to shallow water on transit; aim to complete patch test later on in the transit in deeper water.
- Smooth seas for start of transit.

Thursday, 13 September 2012

- Transit continued overnight in smooth seas.
- Deployed continuous plankton recorder (CPR) at 08:00 (-16^{o}13'03.1, 122^{o} 30'50.6)
- Emergency drill to muster station held 08:30; all went smoothly & to plan.
- Science crew spent the morning sorting & testing sampling gear.
- Collected surface water samples at two stations to coincide with overpass of MODIS satellite (01WS01 at 10:13; 02WS02 at 13:15). Samples filtered for lab analysis of Chlorophyll-a and suspended solids (TSM).
- Reviewed operation of CTD and underway thermosalinograph (TSG) with Marcus. CTD log includes depth, temperature, salinity, fluorescence & transmissivity (all recorded as HEX files that require conversion to TXT). The underway TSG data includes temperature (C), salinity (PSU), fluorescence (mg/m^3) & turbidity (NTU). Data is logged automatically to AIMS Townsville where it is QC'd and loaded to the AIMS website for public download.
- Satellite link for internet lost during the early evening. Marcus working with AIMS IT support in Townsville to rectify.
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:00 to review and plan for the following day. No major issues.

- Weather fine and warm. Sea conditions excellent with swell <0.5m and light south-easterly breeze.

Table O.1 Sampling operations completed on Thursday, 13 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
001	-15.8416	122.7185	0	Underway water sample (WS001)
002	-15.4083	123.0195	0	Underway water sample (WS002)

Friday, 14 September 2012

- Transit continued overnight in smooth seas.
- Satellite internet link still down. AIMS IT still working on the problem.
- Retrieved CPR at 09:00 to allow for calibration patch test of the multibeam system. Upon recovery we found the CPR deployment had failed due to jamming of the silk roll on the cassette. Johnathan Kool worked to successfully remove the damaged cassette unit. We plan to redeploy using a second cassette on the return transit.
- Sound velocity profile (SVP) at 09:00 (13^{o}16'20.5, 125^{o} 55'49.6)
- Patch test completed between 11:15 and 11:45. No issues.
- Collected surface water samples at two stations to coincide with overpass of MODIS satellite (03WS03 at 10:05; 04WS04 at 13:05). Samples filtered for lab analysis of Chlorophyll-a and suspended solids (TSM).
- Arrived Area 1 at 20:15. Deployed tide gauge adjacent to the southwest corner of Area 1 in 80 m water depth (-12^{o} 13.825, 127^{o} 22.01).
- Sound velocity profile at 20:40 (-12^{o} 13.825, 127^{o} 22.01). SVP only logged to 45m (battery problem). Will fix tomorrow and re-do the SVP.
- Final check on tow video setup ahead of sampling tomorrow; all ok including a functioning and accurate USBL positioning system (AIMS USBL).
- Commenced swath mapping Area 1 at 21:00; running east-west lines from the southern edge.
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:30 to review the activities from today and plan for the following day. No major issues.
- Weather fine and warm. Sea conditions excellent with swell <0.5m and light easterly breeze.

Table O.2 Sampling operations completed on Friday, 14 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
003	-13.1835	126.0038	0	Underway water sample (WS003)
004	-12.9572	126.2920	0	Underway water sample (WS004)

Saturday, 15 September 2012

- Continued swath mapping Area 1 overnight, running east-west lines and continued uninterrupted until 07:00 Saturday. Data quality is excellent with minimal noise to remove during on-board processing. Based on the current acquisition rate we expect to complete Area 1

mapping over four nights, as originally planned. The processed bathymetry images reveal the banks in the southern part of Area 1 to be mantled in soft sediment and characterised by extensive fields of pockmarks with hardground areas very limited in extent.

- Sampling commenced at 07:30 Saturday, with five stations completed by 18:00. Sampling activities included tow-video transects (1.5 km length), sediment grabs and CTD profiles at each station, with one benthic sled tow. Tow videos across the banks in 70-80 m water depth were characterised by very sparse epibenthos on soft muddy substrate. Visibility is very limited due to high suspended sediment content in strong tidal currents. The single sled tow yielded a small amount of biology mixed with mud. A second attempted sled tow failed with the loss of the tow net during recovery. We have a spare to continue with. All other sampling gear is functioning well, including the USBL on the tow video system. Minor issue with the Smith-Mac grab sampler not triggering on sites with very soft mud.
- The satellite internet connection was re-established today.
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:15 to review the activities from today and plan for the following day. No major issues.
- Weather fine and warm. Sea conditions excellent with swell <0.5m and light easterly breeze.

Table O.3 Sampling operations completed on Saturday, 15 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
005	-12.2178	127.3947	85	Camera tow (CAM001) Grab – Smith McIntyre (GR001) CTD (CTD001)
006	-12.2093	127.4224	71	Camera tow (CAM002) Grab – Smith McIntyre (GR002) Grab – Smith McIntyre (GR003) Benthic sled (BS001) CTD (CTD002)
007	-12.1902	127.4005	76	Camera tow (CAM003) Grab – Smith McIntyre (GR004) Grab – Smith McIntyre (GR005) CTD (CTD003)
008	-12.1927	127.4046	73	Camera tow (CAM004) Grab – Smith McIntyre (GR006) Grab – Smith McIntyre (GR007) CTD (CTD004)
009	-12.2004	127.4305	74	Camera tow (CAM005) Grab – Smith McIntyre (GR008) Grab – Smith McIntyre (GR009)

Sunday, 16 September 2012

- Multibeam swath mapping in Area 1 continued overnight uninterrupted until 07:30 Sunday. Data quality remains very good with a slight increase in noise across the deeper and muddier areas. We remain on track for completing the mapping of Area 1 on Tuesday night. Processed bathymetry continues to show extensive areas of soft sediment with numerous pockmarks across banks, plains and channels.
- Sampling commenced from 07:30 with the deployment of underwater video units (SISSTAS) at 10 stations for the observation of pelagic fish communities. Deployment and retrieval of the

video units took 4 hrs, with the remaining time used for sampling at four stations. We also deployed a test BRUV in the middle of the day to check for light quality at 70 m – result not promising as the video was too dark for fish observations.

- We may need to consider revising the number of SISSTAS stations if other operations are at risk of not being completed. However, at this stage we are confident of achieving 40 SISSTAS in total as the number of BRUV stations will be reduced due to the low visibility at the bed.
- Tow video (1.5 km length), grabs (including one triplicate sample for analysis of fine scale infaunal variation) and CTD were completed at each station. Tow videos incorporated bank and channel environments in 70-100 m water depth with all areas characterised by very sparse epibenthos on soft muddy substrate. Visibility for video remains very limited due to high suspended sediment content in strong tidal currents; one tow video was aborted due to zero visibility. The benthic sled was not deployed today due to very low abundance of epibenthic biological material. Repeat issue with the Smith-Mac grab not triggering in deeper sites where mud is very soft (soupy). Station 12 failed to yield a grab due to this problem.
- A note on locations of tow video lines, grabs, CTD and sleds. For all stations we have taken the planned waypoint as the start point for the tow video with the direction of the tow determined by tidal currents. Grabs have been taken at the waypoint in some cases, and in other cases at points along the towvid line that represent key depositional environments (e.g. across a bathymetric gradient or mid channel for CTD). So in some cases we don't have a grab or CTD at the exact waypoint. Sleds are located according to presence of abundant biota (e.g. along narrow ledges at the margins of banks; so again, not on the waypoint. Key point here is that our swath mapping and tow-vid observations provide us with valuable information for more informed sampling; so taking the GRTS waypoint as a start point for observations rather than the focal point for all observations.
- The first ocean drifter (ID 101918) was deployed at 17:50 within the southern sector of Area 1.
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:15 to review the activities from today and plan for the following day. No major issues.
- Weather fine and warm. Sea conditions excellent with negligible swell & no wind.

Table O.4 Sampling operations completed on Sunday, 16 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
010	-12.2084	127.4468	88	Camera tow (CAM006) Grab – Smith McIntyre (GR010) Grab – Smith McIntyre (GR011) Grab – Smith McIntyre (GR012) CTD (CTD005)
011	-12.2053	127.4389	91	Camera tow (CAM007) Grab – Smith McIntyre (GR013) Grab – Smith McIntyre (GR014) CTD (CTD006)
012	-12.1953	127.4445	88	Camera tow (CAM008) CTD (CTD007)
013	-12.2066	127.4356	75	Camera tow (CAM009)

Monday, 17 September 2012

- Multibeam swath mapping in Area 1 continued overnight until 07:30 Monday. Mapping of Area 1 is now more than 75% complete, with the processed bathymetry showing areas of banks not evident on the chart. Data quality remains very good and we are still on track for completing the mapping of Area 1 on Tuesday night. This will allow time for deployment of the sub-bottom profiler prior to completing our work in this Area on Wednesday.
- Sampling resumed from 07:30 with the deployment of underwater video units (SISSTAS) at a further 10 stations across the central sector of the grid. This was followed by sampling at four stations in the northern sector. Three stations were located on a bank that rises to 30 m, with tow video (1.5 km length), grabs and CTD completed at each station. Tow videos on the bank revealed highly diverse epibenthic communities of hard corals and sponge gardens, with grabs recovering very coarse carbonate gravel and sand. Two epibenthic sleds on the bank yielded excellent biological samples for biodiscovery research. This bank feature will be the focus of the baited underwater video (BRUV) deployment planned for tomorrow. A total of 16 BRUV stations are planned.
- The box corer was successfully deployed at Station 17 in 110 m water depth. Initial grab sample attempts at this site failed due to soft muds preventing the Smith-Mac from triggering.
- A second ocean drifter (ID 101884) was deployed at 17:45 within the central sector of Area 1.
- Recovery of SISSTAS units went smoothly, but with the loss of one camera unit that broke off its mooring tether. UWA have spares.
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:15 to review the activities from today and plan for the following day. Some concern with the amount of time required to deploy and recover the SISSTAS units; due mostly to transit distances between sites. Key point being that it consumes valuable daylight hours that could be used for other sampling activities.
- Weather fine and warm. Sea conditions excellent with swell <0.5 m and no wind.

Table O.5 Sampling operations completed on Monday, 17 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
014	-12.0742	127.4345	30	Camera tow (CAM010) Grab – Smith McIntyre (GR015) Grab – Smith McIntyre (GR016) Grab – Smith McIntyre (GR017) Grab – Smith McIntyre (GR018) CTD (CTD008) Benthic sled (BS002)
015	-12.0713	127.4239	59	Camera tow (CAM011) Grab – Smith McIntyre (GR019) Grab – Smith McIntyre (GR020) CTD (CTD009) Benthic sled (BS003)
016	-12.0894	127.4258	125	Camera tow (CAM012) Camera tow (CAM013) Grab – Smith McIntyre (GR021) Grab – Smith McIntyre (GR022) CTD (CTD010) Benthic sled (BS004)

Station	Latitude	Longitude	Depth (m)	Operations
017	-12.1048	127.3996	110	CTD (CTD011) Box core (BC001) Box core (BC002)

Tuesday, 19 September 2012

- Multibeam swath mapping in Area 1 continued overnight until 07:30 Tuesday. Mapping of Area 1 is now more than 95% complete and will be completed tonight. Deployment of the sub-bottom profiler is scheduled to follow the completion of the swath mapping, with a single north-south line planned to intersect a series of three banks and channels.
- Sampling resumed from 07:30 with the deployment of underwater video units (SISSTAS) at a further 10 stations across the northern sector of the grid. This was followed by deployment of BRUV video units at 16 stations located across the northern shoal of Area 1. Water depths of BRUV deployment ranged from 30 to 60 m with visibility satisfactory for the identification of pelagic fish communities. Initial checks on BRUV videos showed some fish present on the shoal, with fewer fish observed at the demersal video (SISSTAS) stations.
- The deployment and recovery of the SISSTAS and BRUV units occupied most of the day, with opportunistic sediment grabs and CTD casts collected between video deployments. The grabs were taken from the shoal in water depths less than 60 m to provide sediment for the benthic photosynthesis work being led by Lynda. Initial results from on-board processing of these samples are encouraging.
- Completed a camera tow at station 17 (left over from yesterday). This tow in 110 m water depth was characterised by soft muddy substrate with very sparse epibenthic communities with only an occasional soft coral and small sponge noted.
- We also collected a surface water sample on the shoal to coincide with the MODIS satellite overpass.
- A third ocean drifter (ID 101765) was deployed at 18:00 within the northern sector of Area 1.
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:15 to review the activities from today and plan for the following day. Continued concern with the amount of time required to deploy and recover the SISSTAS units. Discussed with Tom Letessier the potential for modifying the sampling design for SISSTAS for Area 2.
- All on board are well (despite a few minor colds) and are in fine spirits.
- Weather fine and warm. Clear skies. Swell <0.5 m. Light easterly breeze.

Table O.6 Sampling operations completed on Tuesday, 18 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
017	-12.1048	127.3996	110	Camera tow (CAM014)
018	-12.0749	127.4265	32	Grab – Smith McIntyre (GR023) Grab – Smith McIntyre (GR024) CTD (CTD012)
019	-12.0806	127.4296	49	Grab – Smith McIntyre (GR025) Grab – Smith McIntyre (GR026) CTD (CTD013)

Wednesday, 19 September 2012

- Multibeam swath mapping in Area 1 continued until 03:30 at which time all lines were completed. Minor infilling to complete across the top of the northern shoal.
- Sub-bottom profiler deployed at 04:00 in very calm seas (sea state 0). A single north to south profile 18.5 km along the length of Area 1 was completed by 07:15. Data very good quality with minimal noise. Excellent imaging to >100 m depth across the channels, showing multiple seismic facies including clinoforms and truncations. In contrast, the banks are characterised by a structureless (massive) seismic facies.

Table O.7 Sub-bottom profile lines completed on Wednesday, 19 September 2012.

Line	Start of Line Latitude	Start of Line Longitude	End of Line Latitude	End of Line Longitude	Distance (km)
1	-12.0573	127.4319	-12.2242	127.4317	18.5

- Sampling resumed at 08:00 with the deployment of SISSTAS video units at 10 stations across the southern sector of Area 1. Deployment completed by 09:00.
- Sighting of school of dolphins and a sun fish following SISSTAS deployment. Details captured by Phil Bouchet (UWA).
- Sampling at three stations on the southern shoal of Area 1 commenced 09:30 and completed by 11:20. Operations included CTD and box cores (for sedimentology, infauna and geochemistry) at three Priority 1 waypoints that were not sampled directly on 15/9/12. These now provide a full complement of samples at Priority 1 waypoints.
- Recovered SISSTAS between 11:30 and 13:10.
- Collected underway water sample (WS006) at 12:58 to coincide with MODIS satellite overpass. Also competed a CTD cast (STN023CTD017) at the same location.
- Transited to southwest of Area 1 to collect tide gauge at 13:50.
- Transited to northern end of Area 1 to fill gaps in multibeam coverage across the shallow part of the northern shoal. Completed by 15:50.
- Commenced transit to Area 2 at 16:00. Deployed tide gauge at 17:40 (-11.9239, 127.1441; 110 m water depth).
- Arrived Area 2 at 18:00 and commenced swath mapping, running northwest-southeast lines.
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:00 to review the activities from today and plan for the following day. No issues. Marcus in email contact with AIMS and UWA regarding SISSTAS design.
- All on board are well (despite a few minor colds) and are in good spirits.
- Weather fine and warm. Clear skies. No swell No wind.

Table O.8 Sampling operations completed on Wednesday, 19 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
020	-12.1977	127.3940	73	CTD (CTD014) Box core (BC003) Box core (BC004)

Station	Latitude	Longitude	Depth (m)	Operations
021	-12.2058	127.4364	77	CTD (CTD015) Box core (BC005) Box core (BC006)
022	-12.2089	127.4457	81	CTD (CTD016) Box core (BC007) Box core (BC008)
023	-12.2172	127.3968	86	CTD (CTD017) WS (WS006)

Thursday, 20 September 2012

- Multibeam swath mapping of Area 2 continued overnight without interruption. Data quality remains excellent, with coverage to this point including a large shoal that rises to 50 m in the southern sector of the grid and adjacent channels up to 130 m deep. Processed backscatter data is also of high quality, allowing us to identify the broad sediment types on the banks and channels and select sampling techniques accordingly.
- Sampling activities occupied the full day with the completion of five stations on and adjacent to the main shoal. Sampling operations included CTD casts, grabs (at shallow sandy sites), box cores (at deeper muddy sites) and tow video at all sites, plus benthic sled tows at two sites where epibenthic communities were observed in videos. Benthic communities range from sponge gardens across the shoal to barren mud substrate in the channels, with clear community transitions related to depth and exposure. The first sled haul collected >500 kg of mud and shell, requiring us to tow the net in the water for 45 min prior to bringing on board. The second sled across the top of the shoal recovered an excellent sample of sponges & gorgonians.
- Tow video quality remains limited due to high turbidity; however the quality of still photos is generally good. Turbidity will also limit the deployment of BRUV video units to the shallowest parts of the banks.
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:00 to review the activities from today and plan for the following day. No issues. Marcus received revised sampling design for SISSTAS; now to be concentrated into a smaller part of the Grid to reduce transit times during deployment/recovery.
- All on board are well (those with colds are on the mend) and are in good spirits.
- Weather fine and warm. Clear skies. Swell <0.5m. No wind.

Table O.9 Sampling operations completed on Thursday, 20 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
024	-11.8857	127.0932	79	Camera tow (CAM015) Benthic sled (BS05) CTD (CTD018) Box core (BC009) Box core (BC010) Box core (BC011)

Station	Latitude	Longitude	Depth (m)	Operations
025	-11.8960	127.0699	73	Camera tow (CAM016) Benthic sled (BS06) Grab– Smith McIntyre (GR027) CTD (CTD019) Box core (BC012)
026	-11.8920	127.0945	62	Camera tow (CAM017) Benthic sled (BS07) Grab– Smith McIntyre (GR028) Grab– Smith McIntyre (GR029) CTD (CTD020) Box core (BC013) Water sample (WS007)
027	-11.8785	127.1154	116	Camera tow (CAM018) CTD (CTD021) Box core (BC014) Box core (BC015)
028	-11.8585	127.0361	126	Camera tow (CAM019) CTD (CTD022) Box core (BC016) Box core (BC017)

Friday, 21 September 2012

- Multibeam swath mapping of Area 2 continued overnight without interruption. Data quality remains excellent, with coverage now showing a series of small banks not marked on the charts. Our current thinking is that these features, which rise to 75 m water depth, may be drowned coral patch reefs similar to those mapped in the Gulf of Carpentaria. There is also an indication in the multibeam data that there may be buried reefs in the deeper channels; these will be targeted on our sub-bottom profile lines planned for Sunday night. Pockmarks are again a pervasive feature across the muddy channels. Tow video across the pockmark fields shows a highly irregular seabed with holes very well defined and up to 1 metre deep.
- Sampling activities today included deployment and recovery of SISSTAS video units at 10 stations in the southern sector of Area 2, interspersed by sampling at three stations. Operations included CTD casts, grabs (at shallow sandy sites), box cores (at deeper muddy sites) and tow video. Two benthic sled tows were also completed, both retrieving good quantities of biological materials (sponges, gorgonians, soft corals etc). Initial processing of these materials points to very high biodiversity, with one sled yielding 20 species of gorgonians alone. One sled also collected a cobble-sized piece of fossil coral that likely forms the for epibenthic communities observed in tow videos and also in multibeam as small bommies. Our objective is to continue to target these sites for further sampling.
- Deployed ocean drifter number four (ID 101914) at 07:30.
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:15 to review the activities from today and plan for the following day. No issues. SISSTAS deployment noted as taking less time today, so all ok to proceed with 40 stations planned for each grid. Presence of seismic survey vessel MV Geo Atlantic to the northwest noted, with skipper to contact that vessel tomorrow to discuss intentions in the coming days.
- All on board are well (colds continue to subside) and in good spirits.
- Weather fine and warm. Clear skies. Swell <0.5m. No wind.

Table O.10 Sampling operations completed on Friday, 21 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
029	-11.8932	127.0951	58	Camera tow (CAM020, 20_1) Benthic sled (BS08) CTD (CTD023) Grab - Smith McIntyre (GR030) Grab - Smith McIntyre (GR031)
030	-11.9266	127.0774	107	CTD (CTD024) Water Sample (WS008)
031	-11.7910	126.9772	76	Camera tow (CAM021) Benthic sled (BS09) CTD (CTD025) Box core (BC018) Box core (BC019)
032	-11.7940	126.9938	95	Camera tow (CAM022) CTD (CTD026) Box core (BC020) Box core (BC021)

Saturday, 22 September 2012

- Multibeam swath mapping of Area 2 continued overnight without interruption. Mapping over the last 24 hrs occurred along the western side of the grid where the seabed is mostly >110 m deep and generally flat and pockmarked. We are well on track to complete Area 2 during Sunday night, allowing 8-10 hrs for sub-bottom profiles.
- Sampling activities today included deployment and recovery of SISSTAS video units at a further 10 stations in the southern sector of Area 2, with one unit not recovered (failed clip attachment). A pod of false killer whales was observed following the ship during the retrieval of the SISSTAS units. Many photos taken.
- Sampling was completed at four stations today. Operations included CTD casts, grabs (at shallow sandy sites), box cores (at deeper muddy sites) and tow video. A CTD cast was also completed at 12:55 to coincide with the MODIS satellite overpass.
- Deployed ocean drifter number five (ID 101917) at 07:30.
- A set of triplicate box cores was collected for analysis of fine scale patterns of infaunal biodiversity (four sites with triplicate samples now completed).
- Two benthic sled tows were also completed, both retrieving good quantities of diverse biological materials (sponges, gorgonians, soft corals) along with block of fossil coral and carbonate conglomerate. Our observations from tow video suggest that these communities occur in greatest abundance on the edges of banks on small mounds (bommies). There also appears to be an aspect effect on epibenthic communities, with higher concentrations of sponge and gorgonian communities observed on the north to northwest side of banks. This is the lee side with respect to net tidal flow, as suggested by sediment drifts around the banks. More work needed to substantiate this hypothesis however.
- Our port call in Darwin for refuelling has been confirmed for early next week. Return transit time to Darwin, including refuelling, is estimated at 45 hrs. We are scheduled to depart Area 2 early afternoon on Monday (24/9) and return to start work in Area 3 by Wednesday (26/9) afternoon.

Based on our current work rates, this will leave us sufficient time to complete Area 3 and possibly leave time for additional sampling in key areas of Area 1.

- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:30 to review the activities from today and plan for the following day. No issues. No further information on the seismic vessel MV Geo Atlantic.
- All on board are well (colds continue to abate) and in good spirits.
- Weather fine and warm. Scattered light cloud. Swell 0.5 m. Wind 5-10 knots from the southwest. Forecast for 10-15 knots maybe.

Table O.11 Sampling operations completed on Saturday, 22 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
033	-11.8458	127.0559	127	Camera tow (CAM023) CTD (CTD027) Box core (BC022) Box core (BC023)
034	-11.8798	127.0920	108	Camera tow (CAM024) CTD (CTD028) Box core (BC024) Box core (BC025) Box core (BC026)
035	-11.9033	127.1292	106	CTD (CTD029)
036	-11.8178	127.0468	110	Camera tow (CAM025) CTD (CTD030) Box core (BC027) Box core (BC028) Benthic sled (BS010)
037	-11.8183	127.0294	110	Camera tow (CAM026) CTD (CTD031) Box core (BC029) Grab – Smith McIntyre (GR032) Benthic sled (BS011)

Sunday, 23 Sunday 2012

- Multibeam swath mapping of Area 2 continued overnight without interruption. Mapping over the last 24 hrs occurred along the eastern side of the grid where the seabed is mostly >110 m deep and generally flat and pockmarked. We have one line remaining to complete tonight plus some hole-filling and additional mapping around the edge of the main southern shoal to improve resolution of the bathymetry grid on the steep sides of the shoal.
- Processing of acoustic backscatter is complete for Area 1 and Area 2. Gridded to a horizontal resolution of 2 m both grids are excellent products for showing subtle textural variations across the seabed. Key patterns include a strong backscatter contrast between the sandy crests of banks (high backscatter intensity) and surrounding muddy channels and plains (low backscatter intensity). Pockmarks are also clearly differentiated by backscatter, with the floor of the pockmark returning a higher backscatter signal than the surrounding seabed. This is consistent

with video observations which show sandier sediment within pockmarks; possibly a product of erosion/winnowing of fines associated with pockmark development.

- Sampling activities today included deployment and recovery of SISSTAS video units at a further 10 stations in the central sector of Area 2 in the deeper (off-feature) part of the grid.
- Deployed ocean drifter number six (ID 101753) at 07:25.
- Sampling was completed at three stations today. Operations included CTD casts, box cores, tow video and a benthic sled at one station. The sled tow intersected a narrow ridge (hardground) recovered mostly sandy mud with only a small number of epibenthic organisms. The sled also brought up cobble-sized clasts of cemented carbonate sediment that is weakly bedded (stratified) – representative sample retained.
- The camera tow at STN039 was terminated at 500 m due to lack of epibenthic organisms across a uniformly flat muddy seabed.
- One of the CTD station casts (STN039) was taken 10 min before the MODIS satellite overpass.
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:30 to review the activities from today and plan for the following day. No issues. No further information on the seismic vessel MV Geo Atlantic.
- All on board are well and in good spirits.
- Weather fine and warm. Scattered light cloud. Swell 0.5-1.0 m. Wind 5-10 knots from the southwest.

Table O.12 Sampling operations completed on Sunday, 23 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
038	-11.8075	126.9673	77	Camera tow (CAM027) CTD (CTD032) Box core (BC030) Box core (BC031) Benthic sled (BS012)
039	-11.7801	127.0092	90	Camera tow (CAM028) CTD (CTD033) Box core (BC032) Box core (BC033)
040	-11.8083	126.9905	99	Camera tow (CAM029) CTD (CTD034) Box core (BC034) Box core (BC035)

Monday, 24 September 2012

- Multibeam swath mapping of Area 2 was completed by 22:00 hours Sunday night. The sub-bottom profiler was deployed between 22:30 Sunday and 07:30 Monday. Four lines were completed, covering 65 km. Survey conditions very good, with wind 5-10 knots and swell less than 0.5 m. Data quality generally very good to excellent, with penetration to >150 m across the soft sediment areas between banks. No penetration across the carbonate banks, however.

Table O.13 Sub-bottom profile lines completed on Monday, 24 September 2012.

Line	Start of Line Latitude	Start of Line Longitude	End of Line Latitude	End of Line Longitude	Distance (km)
1	-11.7803	126.9694	-11.9155	127.1139	19.8
2	-11.9108	127.0853	-11.8386	127.0853	23.0
3	-11.8050	127.0505	-11.8483	127.0001	12.5
4	-11.8197	126.9894	-11.8003	127.0433	7.7

- Sampling activities today included the successful deployment and recovery of BRUV underwater video units at 16 stations across the southern shoal of Area 2. Initial checks on videos show presence of a range of demersal fish in relative abundance.
- Sampling at two stations also completed, with grabs and CTD casts. Sampling completed by 13:00 hrs.
- Collected tide gauge from southwest corner of Area 2 at 13:30 and deployed drifter number seven (ID 101754) at the same location at 13:05.
- Commenced transit to Darwin at 13:45.
- Deployed continuous plankton recorder at 14:15 (-11^{o} 56.4548", 127^{o} 17.1817)
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:30 to review the activities from today and plan for the port call in Darwin. No issues.
- Weather fine and warm. Scattered light cloud. Swell 0.5-1.0 m. Wind 5-10 knots from the southwest.

Table O.14 Sampling operations completed on Monday, 24 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
041	-11.8896	127.0669	64	CTD (CTD035) Grab – Smith McIntyre (GR033) Grab – Smith McIntyre (GR034)
042	-11.8886	127.0745	72	CTD (CTD036) Grab – Smith McIntyre (GR035) Grab – Smith McIntyre (GR036)

Tuesday, 25 September 2012

- Transit continued overnight in calm seas.
- CPR retrieved 06:45 as water depths becoming too shallow for the tow line. Upon recovery we found the CPR deployment had failed due to jamming of the silk roll on the cassette. This is the second cassette that has failed. Decided not to redeploy and run the risk of damaging the gearing in main housing unit, and wasting time with deployment and recovery. JK contacted CSIRO to advise.
- Arrived Darwin (Fishermans Wharf) at 10:20 (WA time). Commenced bunkering and re-provisioning. Ship crew and most of the science crew went ashore to run errands and purchase miscellaneous lab and office gear for the rest of the survey.
- Departed Darwin at 14:00 (WA time) and set course for a 20 hr transit to Area 3.

- Over the past 12 hours we have been in communication with the seismic survey vessel (MV Geo Atlantic, operated by Fugro) working in a large area of the Timor Sea that includes part of Area 3. The client representative from Fugro has advised that the MV Geo Atlantic should be crossing through our survey area in about 8 days. This will be after the scheduled completion of our work in Area 3. Following consultation with Andrew Heyward the decision has been made to proceed as per the voyage plan but remain in contact with Fugro.
- All on board are well and looking forward to getting to work in the final survey grid.
- Weather fine and warm. Scattered light cloud. Swell 0.5-1.0 m. Wind 10-15 knots (inshore) from the southwest.

Wednesday, 26 September 2012

- Transit to Area 3 continued overnight on calm seas.
- Further communication with the MV Geo Atlantic overnight has revised and clarified the impact of the seismic survey on our work in Area 3. The Geo Atlantic is operating a seismic array that is 1 km wide and 6000 m long, with exclusion distances of 2 Nm ahead and to each side, and 5 Nm astern. The survey pattern is following a 'race-track' path that crosses directly through the centre of Area 3 approximately every 52 hrs. The first crossing through Area 3 will be at approximately 02:00 Thursday during multibeam operations. We have advised Fugro that we will maintain a position outside the exclusion zone as the Geo Atlantic passes through Area 3; a period of 2-3 hrs. We expect to be able to continue mapping and have a line plan in place to accommodate the exclusion zone. At this stage we do not expect that the movements of the Geo Atlantic will affect our daytime sampling activities.
- Collected surface water sample during transit to coincide with overpass of MODIS satellite (043WS009 at 09:53). Samples filtered for lab analysis of Chlorophyll-a and suspended solids (TSM).
- Arrived into Area 3 at 13:10 and deployed a tide gauge outside the northwest corner of the Grid.
- Sampling completed at three stations (priority 1 waypoints), with tow video at two stations and grabs/box cores and CTD casts at all three stations. Attempted a benthic sled at station 13 but was unsuccessful with the sled net almost lost in mud.
- Commenced multibeam mapping at 18:30 following a patch test. Running east-west lines initially, starting from the southern edge of the Grid.
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:15 to review the activities from today and plan for the arrival of the Geo Atlantic into Area 3 overnight.
- Weather fine and warm. Scattered light cloud. Swell 0.5-1.0 m. Wind 5-10 knots from the southwest.

Table O.15 Sampling operations completed on Wednesday, 26 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
043	-11.5324	127.4463	127	Underway water sample (WS009)
044	-11.4101	126.9227	88	Camera tow (CAM030) CTD (CTD037) Grab - Smith McIntyre (GR037) Box core (BC036) Benthic Sled (BS013)

Station	Latitude	Longitude	Depth (m)	Operations
045	-11.4504	126.9211	106	Camera tow (CAM031) CTD (CTD038) Box core (BC037) Box core (BC038)
046	-11.4342	126.9379	61	CTD (CTD039) Box core (BC039) Box core (BC040) Benthic Sled (BS014) – deployed on following day 27/9

Thursday, 27 September 2012

- Multibeam swath mapping of Area 3 continued overnight without interruption. The Geo Atlantic crossed through the Grid between 00:00 and 03:00, during which time we mapped shorter east-west lines in the western sector of the Grid. No loss of mapping time.
- Deployed drifter number eight (ID 101756) at 07:42 in the southwest part of Area 3.
- Sampling activities today included deployment and recovery of SISSTAS video units at 10 stations in the western sector of Area 3 in an area that includes a small shoal feature and surrounding terrace. Deployment and recovery times for the SISSTAS have improved with the new set of clips being used on the moorings.
- Sampling was completed at three stations today. Operations included CTD casts, box cores or grabs, tow video at all stations with the benthic sled deployed at two stations (STN46 & 47). The sled tows both recovered small amounts of biological material from sites with thin sediment cover and patchy outcrop of rock. Sled BS014 also brought up pebble-sized clasts of cemented carbonate sediment – representative samples retained.
- The CTD cast at STN48 and underway water sample were both collected to coincide with the MODIS satellite overpass at 12:52.
- Marcus Stowar received an email from the Geo Atlantic today advising us that they had recovered a drifter float (ID 101917 deployed on 21/9 in Area 2). We replied acknowledging it as ours and asking whether redeployment was possible. Awaiting reply.
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:30 to review the activities from today and plan for tomorrow. No issues.
- Weather fine and warm. Scattered cloud. Swell 0.5-1.0 m. Wind <5 knots from the southwest.

Table O.16 Sampling operations completed on Thursday, 27 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
047	-11.4204	126.9446	64	Camera tow (CAM033) CTD (CTD040) Grab - Smith McIntyre (GR038) Grab - Smith McIntyre (GR039) Benthic Sled (BS015)
048	-11.4319	126.9427	61	CTD (CTD041) Underway water sample (WS010)
049	-11.4069	126.9291	81	Camera tow (CAM034) CTD (CTD042) Grab - Smith McIntyre (GR040) Grab - Smith McIntyre (GR041)
050	-11.4051	126.9616	99	Camera tow (CAM035) CTD (CTD043) Box core (BC041) Box core (BC042)

Friday 28 September 2012

- Multibeam swath mapping of Area 3 continued overnight without interruption. We are on track for completing the mapping of this Grid on Sunday night, allowing adequate time for sub-bottom profiling. Multibeam data quality continues to be excellent, allowing Justy and Kim to generate bathymetry and backscatter grids to 1 m resolution. At this resolution we are able to identify fine scale features such as bommies on the tops of banks and pockmarks across the deeper muddier areas. As in Areas 1 and 2, pockmarks are pervasive in this area and clearly evident on tow video as well defined holes (often providing shelter for demersal fish).
- Sampling activities today included deployment and recovery of SISSTAS video units at 10 stations in the central sector of Area 3, followed by physical sampling at four stations. To date, the SISSTAS video deployments have seen very few pelagic fish in this Grid. Operations at sampling stations included CTD casts, box cores and tow video at all stations with the benthic sled deployed at one station at the edge of the main shoal. The sled tow recovered a large (>500 kg) haul of muddy sediment with only a small amount of biological material. Sled sampling continues to be a challenge in this area due to the patchy distribution of epibenthos (as seen in tow video). Nonetheless, we are recovering adequate amounts to characterize the key groups in these shoal communities (sponges, soft corals, gorgonians). We plan for more sled attempts tomorrow.
- The Geo Atlantic has advised of an 8 hour delay in their 52 hour mapping cycle. This means that they will next pass through Area 3 about 2 pm Saturday. We have a sampling plan in place that can accommodate this interruption. The Geo Atlantic also advised that the drifter buoy they recovered was damaged and that they will attempt to return it to us in the next few days (via chaser vessel).
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:20 to review the activities from today and plan for tomorrow. No issues.
- Weather fine and warm. Clear skies. Swell <0.5 m. No wind. Sea state 0 for most of the day.

Table O.17 Sampling operations completed on Friday, 28 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
051	-11.4310	126.9888	95	Camera tow (CAM036) CTD (CTD044) Box core (BC043) Box core (BC044)
052	-11.4360	126.9971	96	Camera tow (CAM037) CTD (CTD045) Box core (BC045) Box core (BC046)
053	-11.4424	126.9671	78	Camera tow (CAM038) CTD (CTD046) Box core (BC047) Box core (BC048)
054	-11.4243	126.9659	85	Camera tow (CAM039) CTD (CTD047) Box core (BC049) Box core (BC050)

Saturday, 29 September 2012

- Multibeam swath mapping of Area 3 continued overnight without interruption. We are still on track for completing the mapping of this Grid on Sunday night, to be followed by sub-bottom profiling. Multibeam data quality continues to be excellent.
- Sampling was completed at four stations today in water depths ranging from 57 m on the main shoal to 110 m in a channel pockmark field. Operations including CTD casts, box cores and tow video at all stations with the benthic sled deployed at two stations. Both sleds recovered approximately 20 kg of biological material from the edges of carbonate banks. Sampling also included a triplicate box core set of samples for fine-scale infaunal analysis at 110 m water depth.
- The Geo Atlantic has advised that it is further delayed in its 52 hour mapping cycle. This means that they will next pass through Area 3 late Saturday night. We do not expect this to interrupt our swath mapping activities.
- Weather fine and warm. Clear skies. Swell <0.5 m and easing. No wind. Sea state 0 for most of the day.
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:20 to review the activities from today and plan for tomorrow. No issues.

Table O.18 Sampling operations completed on Saturday, 29 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
055	-11.4341	126.9542	57	Camera tow (CAM040 and 40_1) CTD (CTD048) Grab - Smith McIntyre (GR042) Grab - Smith McIntyre (GR043) Benthic Sled (BS017)

Station	Latitude	Longitude	Depth (m)	Operations
056	-11.3993	127.0205	76	Camera tow (CAM041 and 41_1) CTD (CTD049) Box core (BC051) Box core (BC052) Benthic Sled (BS018)
057	-11.4432	126.0951	110	Camera tow (CAM042) CTD (CTD050) Box core (BC053) Box core (BC054) Box core (BC055)
058	-11.4483	126.0306	108	Camera tow (CAM043) CTD (CTD051) Box core (BC056) Box core (BC057)

Sunday, 30 September 2012

- Multibeam swath mapping of Area 3 continued overnight without interruption. Data quality continues to be excellent. We have approximately 10 hours mapping left to complete the Grid tonight, after which we will run a single representative sparker line across the Area.
- Sampling activities today included successful deployment and recovery of SISSTAS water column video units at 10 stations, followed by BRUV seabed video units at 8 stations. The BRUV deployment focused on a small uncharted shoal in the northeast sector of the Grid that rises to 50 m water depth and has a rich cover of sponge and soft coral gardens on patchy sandy sediment. We attempted sediment grabs on this shoal, but with limited recovery due to the largely nature of the shoal.
- Physical sampling was also completed today at four stations to complete the priority 1 sites and all but one of the priority two sites in Area 3. We now have good sampling coverage across all environments in this grid (banks, bank margins, channels and pockmark fields). Station operations included CTD casts, box cores (or grabs) and tow video at all stations with the benthic sled deployed at one station. The sled recovered a diverse collection of sponges and soft corals, plus further samples of cemented carbonates. We now have a range of materials (fossil carbonates, hard corals) for potential geochemical analysis and dating.
- The Geo Atlantic is currently to the north of our survey area and will have no further impact on our activities. We will have departed Area 3 before it returns.
- Evening briefing between Chris Davis, Marcus Stowar and Scott Nichol held at 19:40 to review the activities from today and plan for tomorrow. No issues.
- Weather fine and warm. Clear skies. Swell <0.5 m. Wind 5 knots from the southwest.

Table O.19 Sampling operations completed on Sunday, 30 September 2012.

Station	Latitude	Longitude	Depth (m)	Operations
059	-11.4030	127.0278	52	CTD (CTD052)
060	-11.4032	127.0245	51	Grab - Smith McIntyre (GR044) Grab - Smith McIntyre (GR045)

Station	Latitude	Longitude	Depth (m)	Operations
061	-11.4375	126.9683	56	Camera tow (CAM044) CTD (CTD053) Box core (BC058) Box core (BC059) Benthic Sled (BS019)
062	-11.4091	126.9395	77	Camera tow (CAM045) CTD (CTD054) Box core (BC060) Box core (BC061)
063	-11.3994	126.9121	99	Camera tow (CAM046) CTD (CTD055) Box core (BC062) Box core (BC063)

Monday, 1 October 2012

- Multibeam swath mapping of Area 3 was completed overnight, ending at 04:30. We then deployed the sub-bottom profiler for three hours to collect a single sparker line that extended 15 km diagonally across the Grid from the northeast to southwest, crossing two carbonate banks and two channels. Sea conditions were favourable (sea state 1 – 2) and data quality is excellent with good resolution and penetration to >150 m.

Table O.20 Sub-bottom profile lines completed on Monday, 1 October 2012.

Line	Start of Line Latitude	Start of Line Longitude	End of Line Latitude	End of Line Longitude	Distance (km)
1	-11.3919	127.0419	-11.4208	126.9192	15 km

- Sampling activities today included successful deployment and recovery of SISSTAS water column video units at 10 stations, followed by BRUV seabed video units at 16 stations. These activities were interspersed by grab sampling and CTD at two stations on the main shoal to add to our coverage on this feature. We also collected an underway water sample at 09:50 to coincide with the MODIS satellite overpass.
- Sampling also included a benthic sled at STN063. This station was sampled yesterday (30/9) with rich sponge and gorgonian gardens observed on tow video. The sled was successful, recovering approximately 200 kg of carbonate rock, sponges, crinoids, holothurians and other assorted biology. The carbonate rocks included a 50 kg slab of cemented calcareous materials (worm tubes, bivalves, gastropods, corals – photos taken) and an 8 kg boulder of coral with cemented carbonates above. This sample was retained for analysis.
- Sampling ended at 17:30. Resumed swath mapping to fill in some holes in Area 3 then transited north to the “Bonus Shoal”. This shoal is located 3.5 Nm north of Area 3 and is marked on the chart as rising to 44 m. We have decided to take the opportunity to swath map this feature and collect tow video across the shoal platform.
- Weather overcast and warm. Rain squall in the afternoon. Swell 0.5-1 m. Wind 10-15 knots from the northeast. Choppy sea.

Table O.21 Sampling operations completed on Monday, 1 October 2012.

Station	Latitude	Longitude	Depth (m)	Operations
063	-11.3972	126.9082	88	Benthic Sled (BS020)
064	-11.4363	126.9622	58	Underway water sample (WS011)
065	-11.4256	126.9445	62	CTD (CTD056) Grab - Smith McIntyre (GR046) Grab - Smith McIntyre (GR047)
066	-11.4143	126.9355	65	CTD (CTD057) Grab - Smith McIntyre (GR048) Grab - Smith McIntyre (GR049)

Tuesday, 2 October 2012

- Multibeam mapping of "Bonus Shoal" was completed overnight, covering approximately 30 km^2. The shoal is correctly charted, rising to 44 m with a lower platform at 76 m and fringing sediment lobes at 85 m. A second smaller shoal 2.5 km to the east is also correctly charted and rises to 77 m. Both banks are surrounded by soft sediment areas that are pockmarked.
- Sampling activities on "Bonus Shoal" included three short tow video transects and CTD casts and grabs at two stations (note that only one grab collected at STN67 – second grab failed on irregular ground). Tow video showed the shoal platform is characterised by semi-continuous (cemented carbonates?) with occasional sand patches. Epibenthic cover is also semi-continuous and includes soft and hard corals (acropora noted), gorgonians, sponges (inc. large barrel sponges), crinoids and assorted biology. Large schools of reef fish also noted on video. Decision made not to deploy the benthic sled on this pristine ecosystem.
- Sampling ended at 10:30. Transited to collect tide gauge at northwest corner of Area 3.
- Transit to Area 2 commenced 11:15. Collected an underway water sample at 12:50 to coincide with the MODIS overpass (WS012).

Table O.22 Sampling operations completed on Tuesday, 2 October 2012.

Station	Latitude	Longitude	Depth (m)	Operations
067	-11.3368	126.9622	77	CTD (CTD058) Camera tow (CAM047) Grab - Smith McIntyre (GR050)
068	-11.3283	126.9543	42	CTD (CTD059) Grab - Smith McIntyre (GR051) Grab - Smith McIntyre (GR052)
069	-11.3280	126.9540	43	Camera tow (CAM048)
070	-11.3297	126.9545	42	Camera tow (CAM049)
071	-11.6401	127.0092	100	Underway water sample (WS012)
072	-11.8892	127.0750	75	CTD (CTD060)

- Arrived in Area 2 at 14:15 to deploy SISSTAS units at 10 stations. This brings the total number of SISSTAS deployments in Area 2 to 40, as originally planned. Soak times were reduced to 2 hrs to allow recovery before dark.

- Completed a CTD cast (STN072) while SISSTAS were soaking; also attempted a Smith-Mac grab at the same station but unsuccessful with the grab being triggered during the descent in choppy seas.
- Transited from Area 2 to Area 1 at 17:30 to commence sparker lines and swath mapping along the western edge of the Grid.
- Weather clear skies and warm. Swell 1-1.5 m. Wind 10-15 knots from the northeast. Choppy sea.

Wednesday, 3 October 2012

- Sub-bottom profiling within Area 1 was completed overnight in good sea conditions (sea state 2). Three lines were run, including: line 2 - a north-south line across the wide channels in the western half of the grid; line 3 - a diagonal line across the banks and narrow channel in the southeast sector, and: line 4 - an east-west tie line across the centre of the grid. A test line was also logged (Test 3), running north along the western edge of Area 1. Data quality is excellent, with good resolution and penetration >150 m showing multiple episodes of (fluvial?) channel cut and fill that can be tied to sea-level cycles.

Table O.23 Sampling operations completed on Monday, 1 October 2012.

Line	Start of Line Latitude	Start of Line Longitude	End of Line Latitude	End of Line Longitude	Distance (km)
2	-12.0672	127.4036	-12.2278	127.4039	18.0
3	-12.2214	127.4075	-12.1522	127.4614	10.3
4	-12.1522	127.4556	-12.1522	127.3833	8.5
Test 3	-12.1506	127.3858	-12.0753	127.3858	8.3

- Sampling activities in Area 1 were finalised at three stations. Two were located on the northern shoal which rises to 31 m and the third in a channel in the centre of the grid. Station operations included CTD casts, camera tows, grabs/box cores, and benthic sleds at two stations. The camera tow at station 74 was a highlight, incorporating the bathymetric transition from the shoal platform at 31 m to the fringing muddy terrace at 89 m. The substrate ranged from sand and gravel on the platform with extensive (100s m^2) 2D bedforms, to rocky outcrop on the platform edge and muddy sands on the terrace. Epibenthos varied from barren on the bedforms (these are presumably active during cyclones), to dense cover of large sponges and corals (including hard corals) on rocky substrates and patchy to sparse cover of smaller sponges and corals on the terrace. Visibility along the tow was also very good.
- The two benthic sleds recovered good amounts of biological material, with the sled at station 74 also recovering a large (200 kg) haul of carbonate rubble. Several samples of fossil coral were retained for potential radiocarbon dating.

Table O.24 Sampling operations completed on Wednesday, 3 October 2012.

Station	Latitude	Longitude	Depth (m)	Operations
073	-12.0647	127.4257	72	CTD (CTD061) Camera tow (CAM050) Grab - Smith McIntyre (GR053) Grab - Smith McIntyre (GR054) Benthic Sled (BS021)
074	-12.0774	127.4448	73	CTD (CTD062) Camera tow (CAM051) Grab - Smith McIntyre (GR055) Box Core (BC064) Benthic Sled (BS022)
075	-12.1439	127.4458	110	CTD (CTD063) Camera tow (CAM052) Box Core (BC065) Box Core (BC066)

- Following the completion of station 75 we deployed the ninth ocean drifter (ID 101755) and commenced the 50 hour return transit to Broome at 15:00.
- Communications with the MV Geo Atlantic support vessel during the day to make alternate arrangements for the return of the damaged drifter (ID 101917). Agreed that Fugro would deliver the drifter to Pearl Marine Engineering on its next port call in Darwin. Fugro to advise Marcus Stowar when this occurs.
- Weather clear skies and warm. Swell <0.5 m. Wind < 5 knots. Glassy seas in the afternoon.

Thursday, 4 October 2012

- Transit continued overnight and throughout today in smooth seas.
- Science crew used the day to pack samples, begin backups of digital data and continue some lab work.
- Collected surface water samples at two stations to coincide with overpass of MODIS satellite (076WS013 at 09:50; 077WS014 at 12:50). Samples filtered for lab analysis of Chlorophyll-a and suspended solids (TSM).
- Final drifter (ID 101752) deployed during transit at 12:15. Details of all drifter deployments are listed below.
- Weather clear skies and warm. Swell <0.5 m. Wind < 5 knots.

Table O.25 Drifters deployed during the survey

ID	UTC Date	JD	UTC Time	Latitude	Longitude	Depth (m)	Area
101918	16/9/12	260	09:48	-12.1813	127.4471	74	1
101884	17/9/12	261	09:16	-12.1334	127.4333	110	1
101765	18/9/12	262	10:09	-12.0896	127.3941	110	1
101914	20/9/12	264	23:28	-11.8729	127.1284	116	2
101917	21/9/12	265	23:32	-11.9354	127.0864	101	2
101753	22/9/12	266	23:25	-11.8377	127.0867	127	2

ID	UTC Date	JD	UTC Time	Latitude	Longitude	Depth (m)	Area
101754	24/9/12	268	05:06	-11.8984	127.1064	62	2
101756	26/9/12	270	23:42	-11.4460	126.9035	102	3
101755	3/10/12	277	06:38	-12.1408	127.4558	108	1
101752	4/10/12	278	04:15	-14.2790	124.8489	63	Transit

Friday, 5 October 2012

- Transit continued overnight and throughout today in smooth to slightly choppy seas.
- Packing and data backups completed.
- Datasets held on GA portable hard drives in triplicate include:
  - Multibeam bathymetry – raw, processed and grids
  - Multibeam backscatter – raw, processed and grids
  - Port to Port navigation files (daily)
  - Sub-bottom profile data – raw and SEGY files plus screen shots (TIFFs)
  - Shipboard samples database
  - Station waypoint file with all sampling operations (from AIMS)
  - Tow video - USBL navigation files and CSV characterisation files (from AIMS)
  - ArcGIS files – shapefiles with all station operations
  - Geochemical sample database
  - Benthic ecology sample database
  - Benthic ecology specimen photos
  - CTD data files raw HEX files and converted CNV (text) files
  - Survey log and daily reports
  - Sediment samples bucket list
  - Deck photos (from GA, AIMS, UWA)
- Discussed analysis of tow video & photos with Marcus Stowar and Jamie Colquhoun. AIMS will process the still photos including geo-referencing of individual photos and incorporating into the new AIMS database. No analysis of video tapes is intended, as these are generally low quality due to turbidity and in many cases the tow camera was flying too high above the bed to provide continuous video transects. This was intentional to provide the best quality downward facing still photos.
- Confirmed with Marcus that data from the underway Thermosalinograph (TSG) will be available after the survey from the AIMS website, following QC by the data manager (Marcus to also send TSG data via email).
- Arrived Broome at 16:30; at anchor overnight in Roebuck Bay.

Saturday, 6 October 2012

- Solander tied up at Broome wharf at 07:00 and unloading of gear and samples followed, with all gear of-loaded by mid-afternoon.
- All science crew disembarked late morning and checked into accommodation prior to flying out to Canberra on Sunday.