Schmidt Ocean Institute Post Expedition Report

Australian Mesophotic Coral Examination

Chief Scientist Dr. Karen Miller

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1 Overview

SOI Expedition ID	FK210409
Vessel	R/V *Falkor*
Expedition Name	Australian Mesophotic Coral Examination
Expedition Dates	2021/04/09 - 2021/04/27
Departure Port	Darwin, Australia
Termination Port	Darwin, Australia
Ocean	Indian Ocean

1.0.0.1 Map of Expedition Location

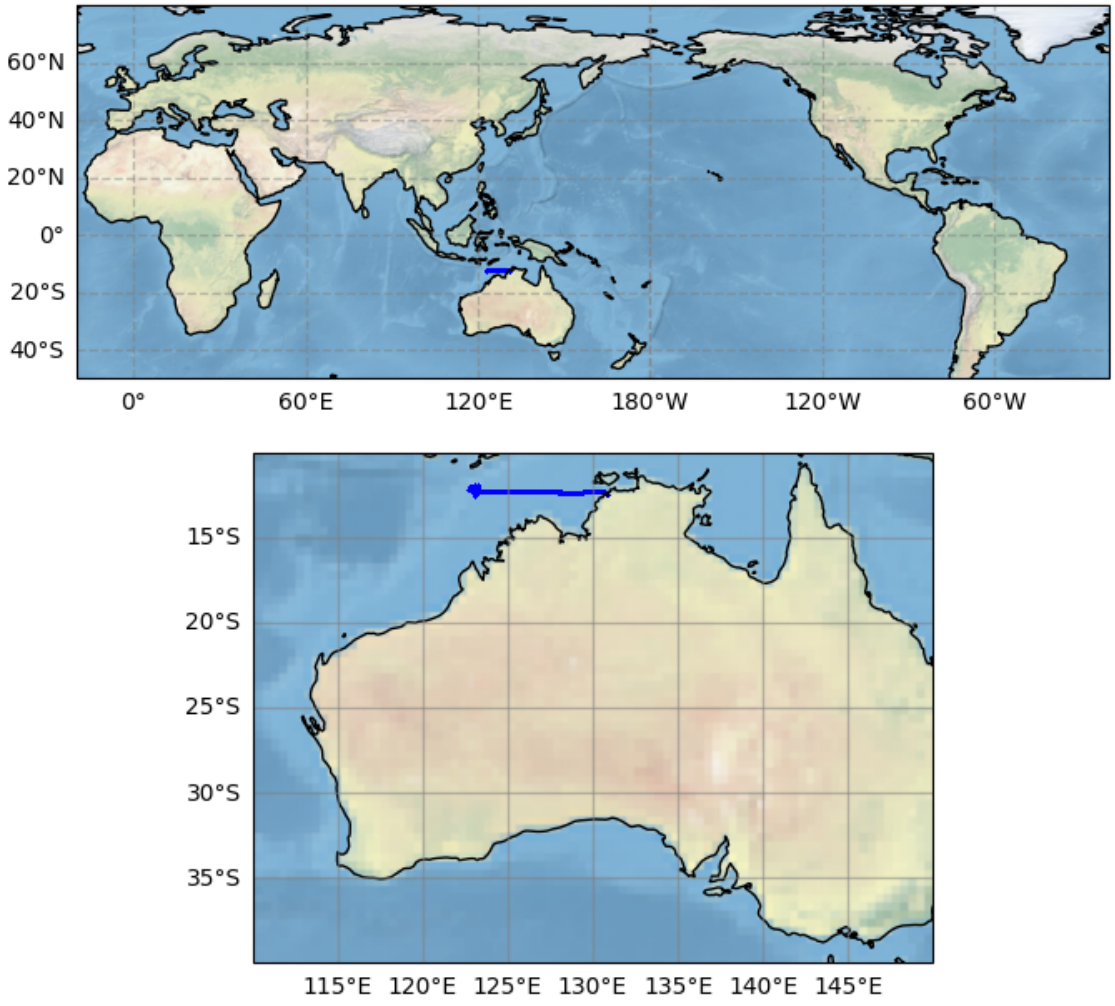

Figure 1. Map of Expedition Location.

1.1 Expedition Overview

While the waters of Australia are famous for shallow coral systems such as the Great Barrier Reef, Ashmore Reef Marine Park is home to unique Mesophotic Coral Ecosystems (MCEs), which remain largely unexplored. MCEs exist at depths between 50-200 meters and are hypothesized to have significant ecological importance, including the potential to reseed shallow water corals under environmental stress. The ability of MCEs to provide a refuge for shallow-water species may be critically important, as shallow reef corals face a range of stressors, including a changing climate. However, little is known about MCE community structure, what ocean processes control their composition, geographic distribution, and connectivity to other coral systems. A better understanding of these ecosystems will help inform Marine Park managers of the naturally valuable ecosystems of the park.

1.2 Authorizations and Permitting

Permit Number	Permit Authority	Permit Focus
PA2019-00131-7	Australian Marine Park Authority	Scientific Research
AU-COM2021-508	Australian Government	Collection of biological material

1.3 Expedition Timeline

The expedition commenced on April 9, 2021, departing from Darwin, Australia, and returned to Darwin, Australia, on April 27, 2021.

1.4 Expedition Objectives

The expedition's primary goal was to address important knowledge gaps in understanding MCEs and lay a foundation for effective future monitoring and protection of MCEs across the globe. Taking place in Ashmore Reef Marine Park (Figure 2), the expedition aimed to understand the connectivity between mesophotic coral populations and the biodiversity and biology of mesophotic reefs and test new methods and technologies for monitoring the health of MCEs. The data collected provide a foundation for the broad application of state-of-the-art analysis tools beyond Australia, as MCEs across the globe will benefit.

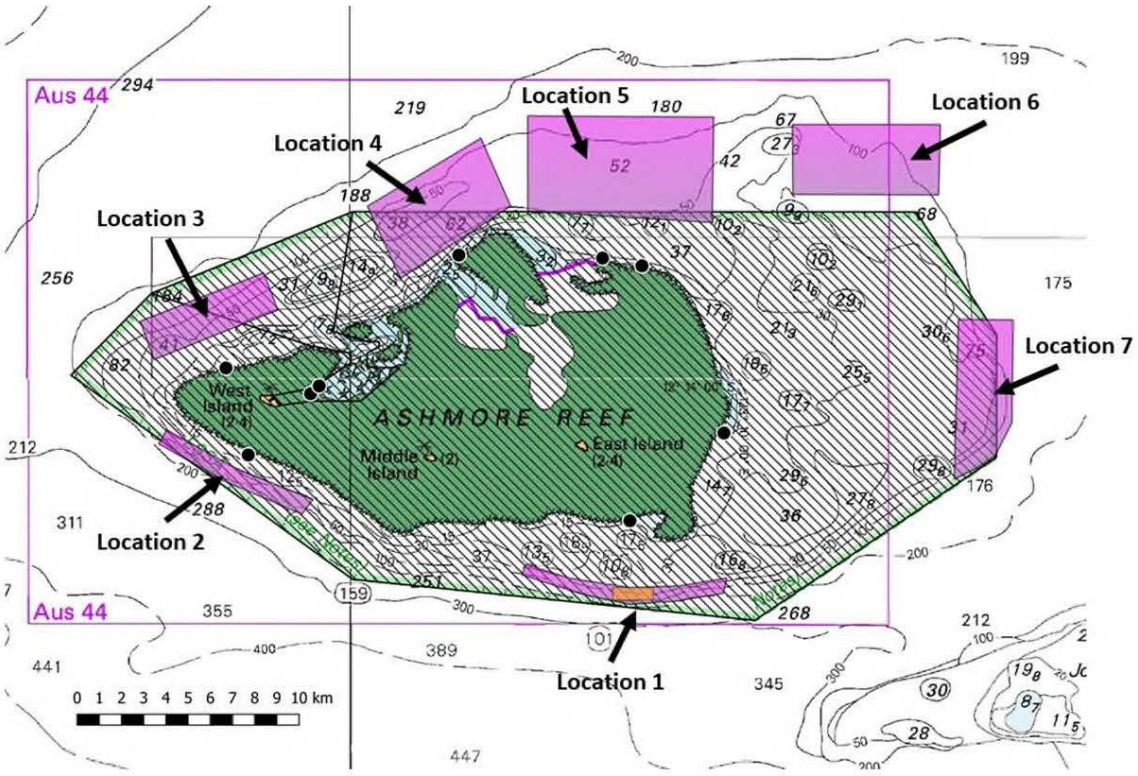

Figure 2. Study locations around Ashmore Reef targeted for sampling during FK210409 (from Miller et al., 2022).

2 Expedition Accomplishments

2.1 At-sea Accomplishments

To understand the connectivity between mesophotic coral populations, the expedition marked the first time a remotely operated vehicle (ROV) and autonomous underwater vehicle (AUV) were used to collect specimens for genetic analysis and reproductive studies from mesophotic coral ecosystems in the region. Analysis of the collected samples provided insights into how individual MCEs are related and established baseline knowledge of community structure and reproductive strategies. Ecosystems in the northwest continental shelf of Australia, including the Ashmore Reef, face a myriad of anthropogenic and natural impacts. Therefore, recognizing what species exist, how they are maintained, and what physical processes drive the existence of MCEs is an important first step for conservation.

Additionally, to enhance the precision of current monitoring methods, the expedition focused on testing innovative in situ classification systems to monitor key habitats on

mesophotic reefs. Using underwater robotics and novel imaging technology, the research team captured high-definition video across each shoal and created a streamlined system to collect, process, and analyze the imagery using R/V *Falkor's* High-Performance Computing (HPC) systems, which vastly improved the quality and efficiency of data collection. In parallel, ROV *SuBastian* collected biological samples from corals and sponges. The collected specimens were used to ground-truth the data from the new imaging technique for biodiversity studies and taxonomic identification. These new sampling and analysis approaches represented an important scientific benchmark enabling future monitoring standardization and comparability of MCE data globally.

2.1.1 Science

High-resolution multibeam bathymetry data was collected around Ashmore Reef, covering 965km2 of the seafloor and enabling the production of a bathymetric map of the entire mesophotic zone of Ashmore Reef (Figures 3 and 4). Imagery from the ROV was used to quantify benthic community composition at three depths (50, 100 and 150m) at seven locations around Ashmore Reef, providing the first quantitative baseline data for this area.

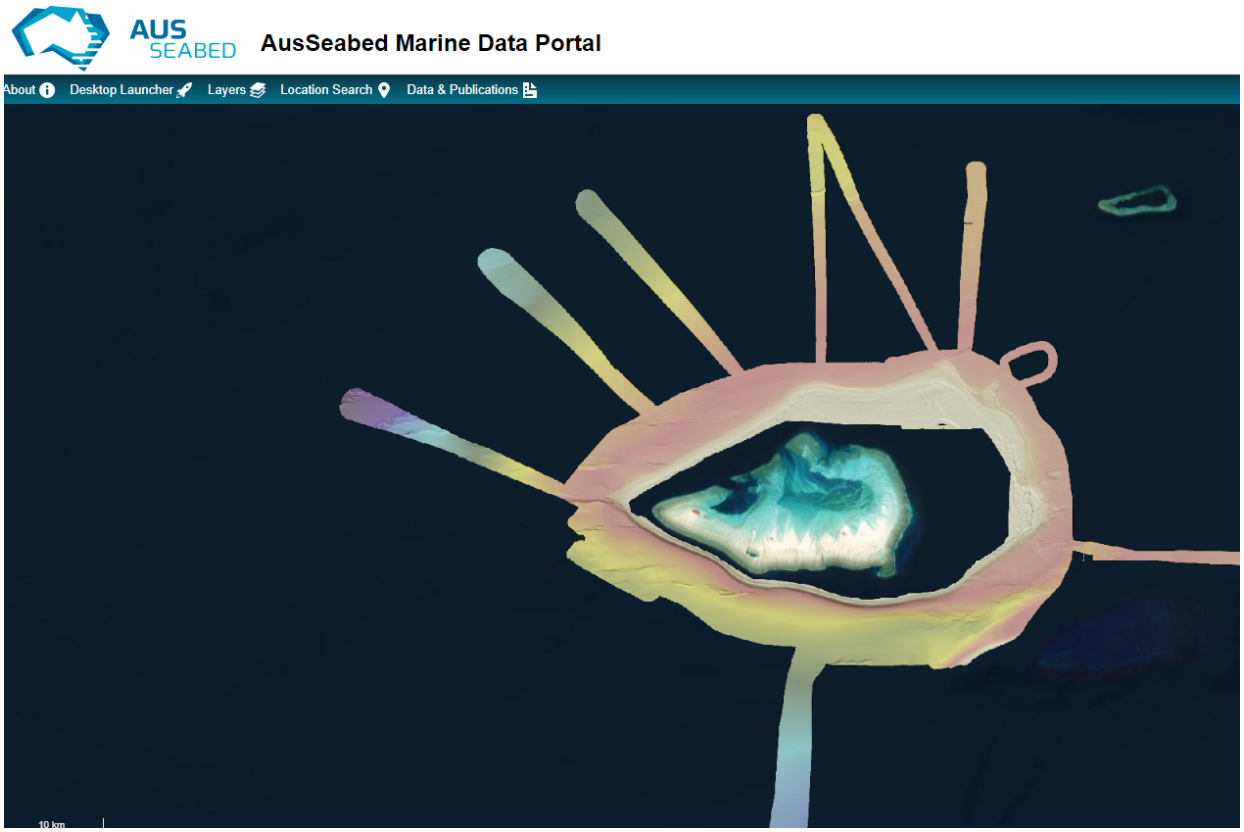

Figure 3. Multibeam bathymetry (16m grid) processed by Geoscience Australia and available on AusSeabed data portal.

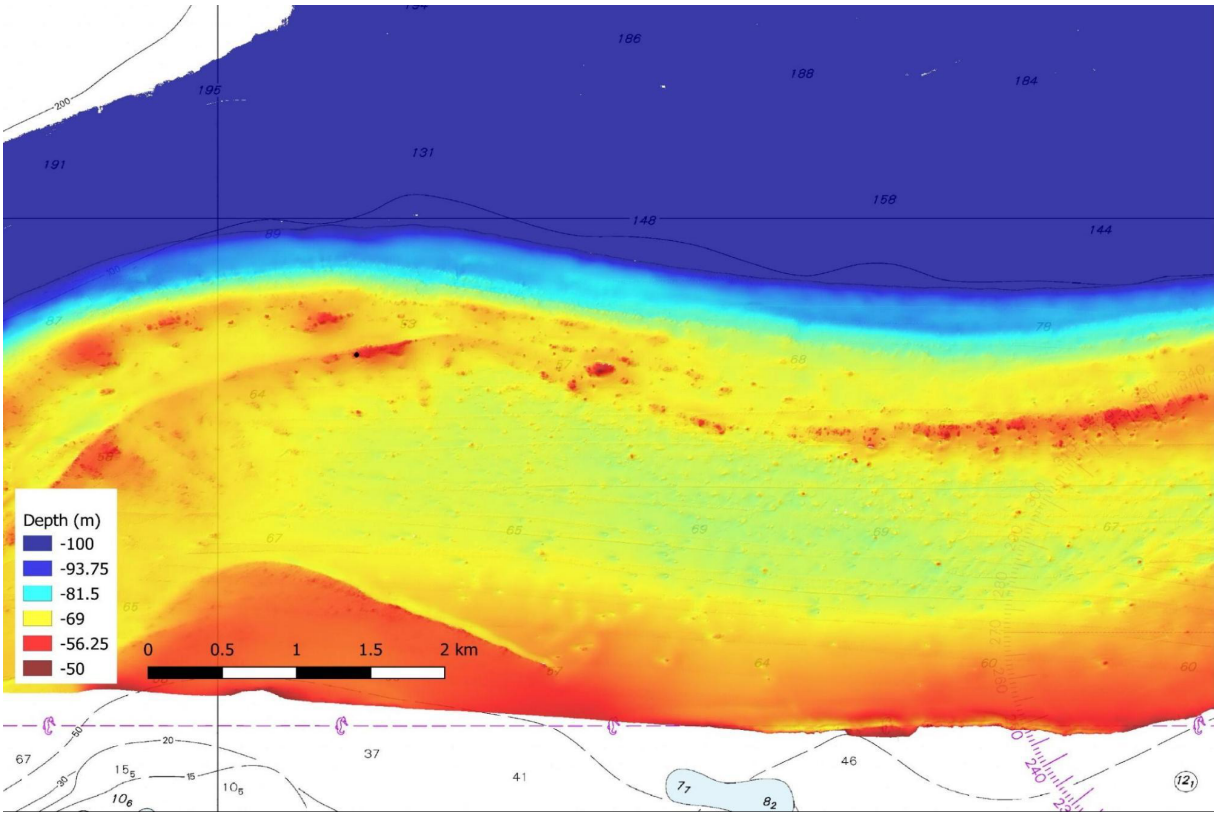

Figure 4. Multibeam bathymetry off the north coast of Ashmore Reef 50-100 m depth (from Parnum et al., 2023).

Specimen collections targeted key benthic invertebrate taxa including scleractinian corals, molluscs, and echinoderms. For all collections, in-situ and deck photographs were taken of live specimens to facilitate taxonomic identifications, and tissue samples were preserved for later genetic analysis. For scleractinian corals, samples were taken for stable isotope analysis, and pulse amplitude-modulated fluorometry was used to compare levels of autotrophy and heterotrophy across depth gradients. Samples were also collected for histological examination of the presence of gametes to provide insight into the timing of reproduction. We tested the usefulness of the ROV for collecting imagery suitable for 3D photogrammetry of mesophotic reefs.

2.1.2 ROV

- Benthic imagery was collected on 14 ROV *SuBastian* dives, totaling 148 hours of dive time.
- 600 specimens from 270 sampling events were collected while exploring a range of habitats across Ashmore Reef's mesophotic zone.
- A hyperspectral camera mounted on ROV *SuBastian* collected hyperspectral images of mesophotic reefs
- 56 Water samples were collected, for eDNA analysis of biodiversity.

2.1.3 Innovative Technologies

The mesophotic reefs of Australia's Northwest Shelf are largely unexplored, thus the use of the ROV *SuBastian* and other technologies represented a unique opportunity to further understanding of the unique ecosystems. Highlights of innovative approaches utilised or tested during the voyage include:

- Adaptation of the ROV *SuBastian* to operate efficiently in relatively shallow, warm, tropical waters
- Addition of hyperspectral cameras to the ROV *SuBastian* to test the efficacy of hyperspectral imaging to understand mesophotic reef biodiversity and health
- Testing the suitability of ROV imagery to be applied to 3D photogrammetry techniques
- Testing novel, deep-water rated cameras (CurtinRX0Cam-6000 cameras).

2.2 Post expedition Activities and Accomplishments

2.2.1 Overview

The expedition offered some of the first detailed glimpses of the complex and diverse mesophotic ecosystems of Ashmore Reef. Through outreach activities, the research team raised awareness of Australian mesophotic reef systems and the incredible diversity they support. In addition, through direct support and engagement with Parks Australia, the research team provided quantitative baseline data of the Ashmore Marine Park that will be integral to future management, research, and monitoring activities within the park and from which future research opportunities can be leveraged.

2.2.2 New Discoveries & New Species

The 600 specimens collected on this expedition represent an important contribution to ongoing taxonomic work, providing specimens from a rarely sampled mesophotic environment. Analysing and incorporating these specimens into taxonomic monographs is underway. To date, sea stars, black corals, and heterobranch molluscs are being sequenced for one or two genes, enabling additional data to compare to other taxa and geographic regions. Preliminary data suggests there may be some new scleractinian coral species distributions and depth ranges.

2.2.3 Data

Datasets acquired during this expedition and those derived from the analysis of collected data and samples as of the date of this report's publication.

Data Type	Curator	Completed
Raw environmental sensor data	Rolling Deck to Repository	Yes
Benthic imagery	Australian Institute of Marine Science (AIMS)	Yes
Estimates of benthic cover analyzed from collected benthic imagery	Australian Institute of Marine Science (AIMS)	Yes
Multibeam bathymetry (16m grid)	Marine Geoscience Data System (MGDS)	Yes
CTD Data	Australian Institute of Marine Science (AIMS)	Yes
Acoustic backscatter, swatch bathymetry, CTD and navigation data	Marine Geoscience Data System (MGDS)	Yes
Curated marine invertebrate species	Atlas of Living Australia (ALA)	Yes
Multilocus genotypes of targeted marine invertebrates species		No
eDNA metabarcoding data	Australian Institute of Marine Science (AIMS)	No

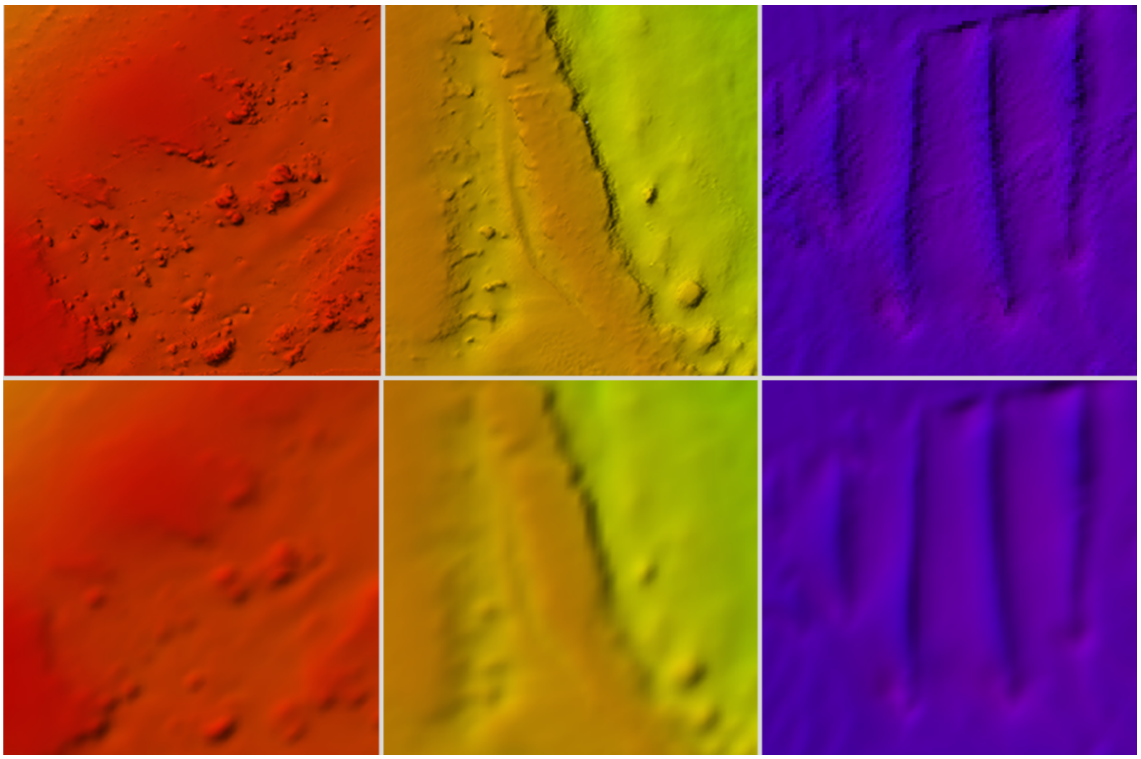

Figure 5. Comparison between improved resolution (upper), and 16m resolution grid (lower), covering sample surfaces (from Mularczyk, 2023).

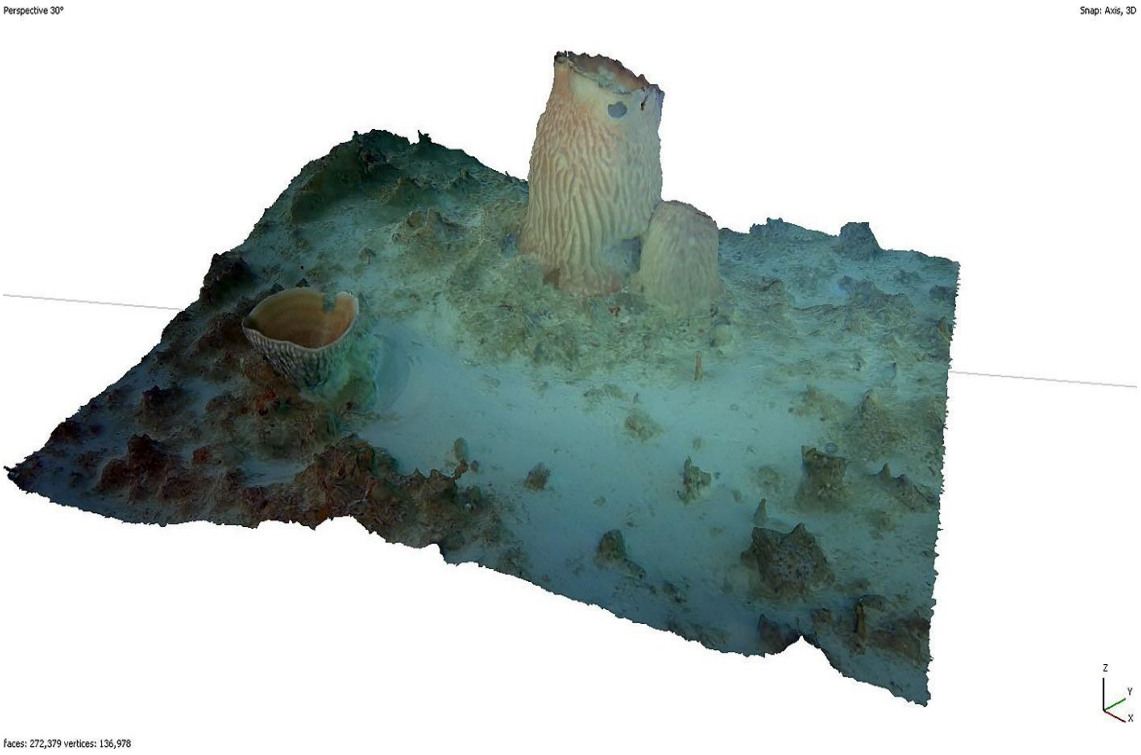

Figure 6. Screenshot of a 3D model of a group of sponges found within a mesophotic

coral ecosystem at Ashmore Reef, created from still images captured from CurtinRX0Cam-6000 cameras deployed on ROV *SuBastian* (from Parnum et al., 2023).

2.2.4 Publications

Carmignani, Amy, Veronica Z. Radice, Kathryn M. McMahon, Alex I. Holman, Karen Miller, Kliti Grice, and Zoe Richards. 2023. "Levels of Autotrophy and Heterotrophy in Mesophotic Corals Near the End Photic Zone." *Frontiers in Marine Science* 10 (May). https://doi.org/10.3389/fmars.2023.1089746.

Miller, Karen, Conrad W. Speed, Nerida G. Wilson, Jonathan Kok, Jamie Colquhoun, and Mark Case. 2022. "2021 Ashmore Reef Mesophotic Reef Survey and Sampling: Voyage Report. Report Prepared for Parks Australia."

Speed, Conrad W., Nerida G. Wilson, Ruchira Somaweera, Vinay Udyawer, Mark G. Meekan, Corey Whisson, and Karen Miller. 2022. "Video Surveys of Sea Snakes in the Mesophotic Zone Shed Light on Trends in Populations." *Frontiers in Marine Science* 9 (September). https://doi.org/10.3389/fmars.2022.921542.

3 Appendix

3.1 Science Party Information

List of scientists and students aboard *Falkor*.

Scientist	Institution
Karen Miller	Australian Institute of Marine Science
Iain Parnum	Curtin University
Nerida Wilson	Western Australian Museum
Jonathan Kok	Australian Institute of Marine Science
Corey Whisson	Western Australian Museum
Chloe Anderson	University of Western Australia
Amy Carmignani	Curtin University
Declan Stick	University of Western Australia & Australian Institute of Marine Science

3.2 Conferences/Presentations/Posters

- Beaman, R., Picard, K., and Miller, A. (2022). RV *Falkor* Surveys in Australia 2020-2021. Oral Presentation and Conference Paper, Hydrospatial 2021 Conference, Australasian Hydrographic Society, Cairns, Australia. [Abstract and presentation are OPEN ACCESS].

- Parnum I, Woods A, Belton D, Helmholz P (2023). Underwater 3D mapping of Ashmore Reef, Australia. Poster presented at GeoHab conference, 2023.
- Sharon Vavra (2023). Exploring mesophotic coral reef communities with eDNA metabarcoding. School of Biological Sciences Monthly Seminar Series, The University of Western Australia.
- Carmignani, A., Radice, V., McMahon, K., Holman, A., Miller, K., Grice, K., and Richards, Z. (2023). Levels of autotrophy and heterotrophy in mesophotic corals near the end photic zone. Poster presented at the Royal Society of Western Australia 2023.

3.3 Student Thesis

- Amy Carmignani (2021). An investigation of the biodiversity and ecophysiology of mesophotic corals (Ashmore Reef, Western Australia). Bachelor of Coastal and Marine Science (Honours) Thesis, Curtin University.
- Chloe Anderson (2021). How the deep-sea sea star Pterasteridae conquered the Antarctic shelf. University of Western Australia, WA. Honours Thesis, University of Western Australia.
- Timothy Mularczyk (2023). Enhancing bathymetric data processing of Ashmore Reef through analysis of CUBE parameters and vertical correction methods. Honours Thesis, Curtin University.
- Sharon Vavra (2023). Exploring mesophotic coral reef communities with eDNA metabarcoding. Master of Biological Science Thesis, University of Western Australia & Australian Institute of Marine Science.

3.4 Cruise Records

- Cruise Logs.
- ROV *SuBastian* Dive List.

3.5 Media

- Diving into Ashmore Reef's mesophotic zone, Australian Marine Parks Science Atlas.
- Exploring Mesophotic Coral Ecosystems of Australia's Northwest Shelf (Ashmore Reef), AIMS Data Repository.
- Half-light Mesophotic Coral Reef Exhibition.
- First Comprehensive study of NW Australia's Deep Corals Completed, SEVENSEAS Media.
- Discovery of Kimberley reef-building coral lifeline against climate change, RTRFM The Sound Alternative.
- Coral's Make Light Work of Photosynthesis Despite Lack of Sunshine, Marine Technology News.