Schmidt Ocean Institute Post Expedition Report

Northern Depths of the Great Barrier Reef

Chief Scientist Dr. Robin Beaman

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1 Overview

SOI Expedition ID	FK200930
Vessel	R/V *Falkor*
Expedition Name	Northern Depths of the Great Barrier Reef
Expedition Dates	2020/09/30 - 2020/11/17
Departure Port	Brisbane, Australia
Termination Port	Brisbane, Australia
Ocean	South Pacific Ocean

Map of Expedition Location

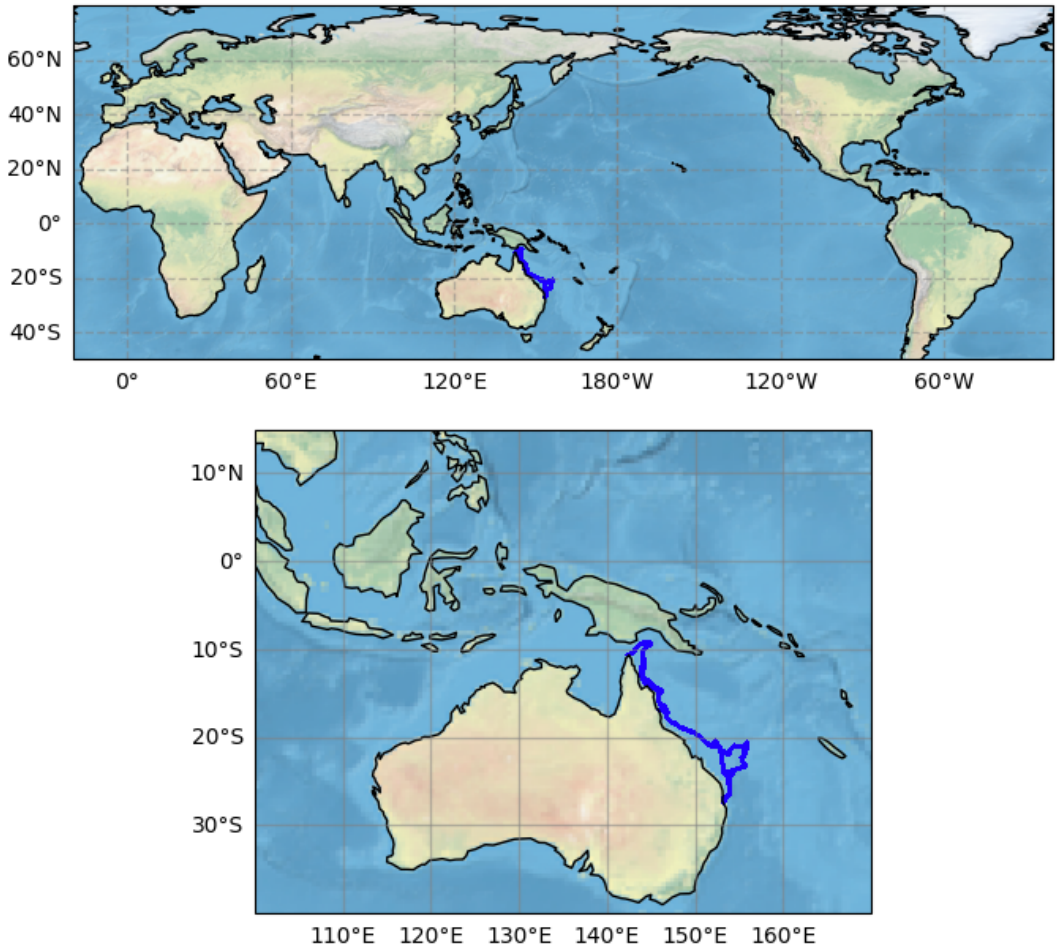

Figure 1: Map of Expedition Location

1.1 Expedition Overview

This voyage focused on the offshore Cape York area, northern Great Barrier Reef (GBR) Australia, through geophysical mapping and ROV dives of the shelf edge and continental slope adjacent to the shelf barrier reefs, and around the seven 'detached' reefs lying north of Cape Weymouth, including within the large Wreck Bay (Figure 2). The shelf edge and upper slope of the northern GBR are known to preserve a record of submerged (or drowned) reefs that now represent a key habitat for mesophotic reef communities. The continental slope in the offshore Cape York area is heavily incised with submarine canyons to near-abyssal depths. Around the seven detached reefs is a deep platform upon which these reefs have grown but have had limited prior mapping. Additionally, no deep (i.e., greater than ~100 m) ROV imagery has ever been collected in the offshore Cape York area to view marine life.

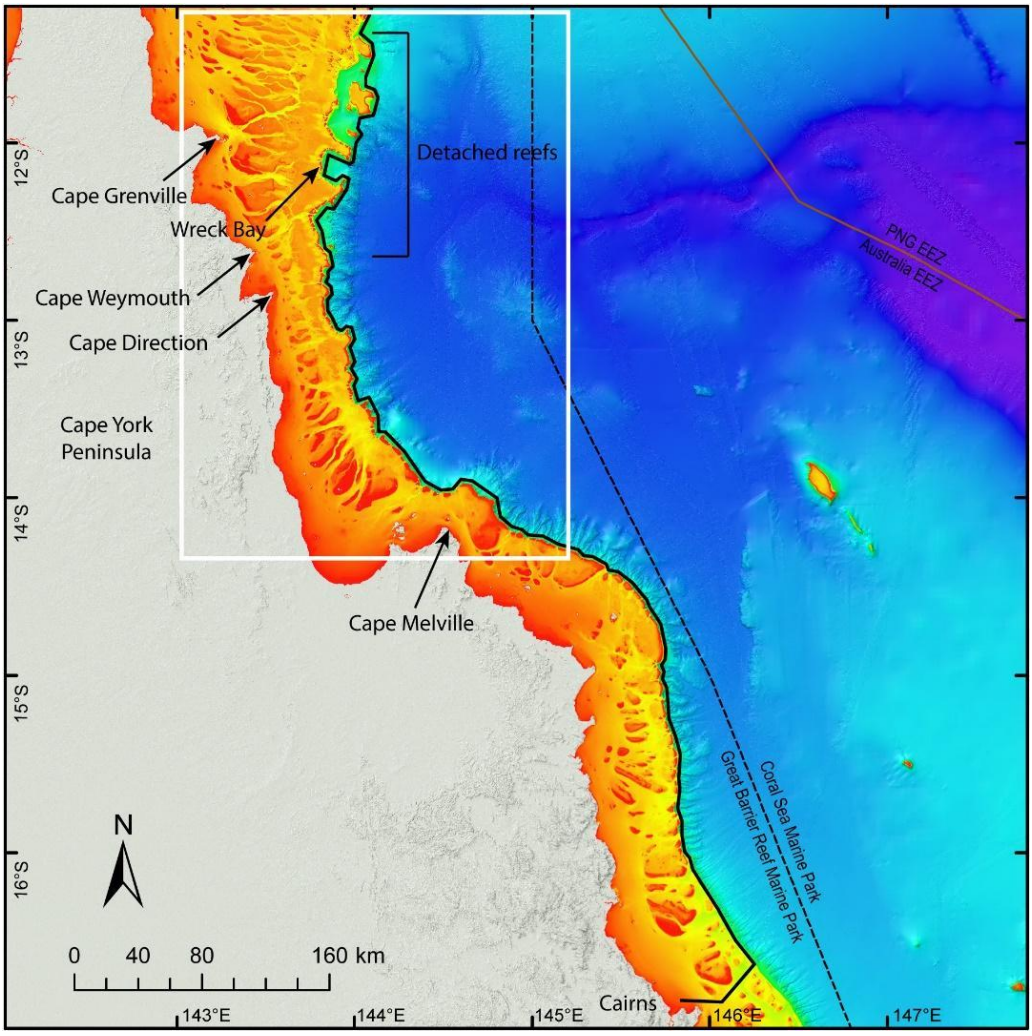

Figure 2: Map of the Cape York study area (white box) with the proposed ship track (black line) from Cairns and along the continental slope of the northern Great Barrier Reef.

1.2 Authorizations and Permitting

Permit Number	Permit Authority	Permit Focus
G20/43974.1. Version 2.	Great Barrier Reef Marine Park Authority permit	ROV, AUV, CTD; coral; other macrofauna; sponges
G19/393641. Reissue.	Great Barrier Reef Marine Park Authority permit	ROV, sleds, hand; coral; invertebrates; fish
G20/43838.1 Version 3.	Great Barrier Reef Marine Park Authority permit	multibeam, ROV, CTD; coral; invertebrates; sponges
PA2019-00131-12. Version 3.	Australian Marine Park Activity Permit	MBES, SBES, ADCP, SVP, XBT, CTD, ROV, aerial drone
PA2020-00040-1.	Australian Marine Park Activity Permit	ROV images & coral and sponge samples; AUV images
AU-COM2020-484.	Parks Australia Access to Biological Resources in a Commonwealth Area for Non-Commercial Purposes	Plankton/Jellyfishes
AU-COM2020-483	Parks Australia Access to Biological Resources in a Commonwealth Area for Non-Commercial Purposes	Corals and Sponges

1.3 Expedition Timeline

The FK200930 voyage was conducted in three legs: (1) Brisbane to Cairns, 30 September to 07 October 2020; (2) Cairns to Cairns, 07 October to 30 October 2020; and (3) Cairns to Brisbane, 31 October to 17 November 2020 (Figure 3).

1.4 Expedition Objectives

Two key interrelated objectives are being addressed in this voyage:
1) Conduct multibeam surveying of the shelf edge and upper continental slope offshore of the Cape York area, with the aim to 'fill the gaps' between the existing lidar bathymetry data collected over the shallow, shelf edge barrier reefs, together with any existing multibeam data coverage along the upper and lower slope. Broad-scale systematic surveys are required to map some of the larger areas of the unmapped lower slope towards abyssal depths, while closer adjacent lines are required that parallel the shelf edge for upper slope survey areas. This mapping will reveal the full inventory of any submerged reefs extending farther north of the Ribbon Reefs and reveal the full character of the northern GBR canyons to provide a complete coverage of their morphologic variability from head to foot.

2) Conduct multibeam surveying of the steeper flanks of the seven detached reefs found offshore the Cape York area and their surrounding deeper platform, including within the large Wreck Bay. Mapping is to be conducted as high up the flanks of these detached reefs as is navigationally safe, to prove the existence of any possible fossil fringing reefs and/or wave-cut caves that might indicate Last Glacial Maximum (LGM) lowstand, similar to the LGM lowstand-generated features observed at the GBR shelf edge farther south. The multibeam

mapping aims for 100% coverage around their flanks and over the deeper platform to reveal the connections between the shelf, slope, platform and deep basin.

2 Expedition Accomplishments

2.1 At-sea Accomplishments

2.1.1 Science

The *Falkor's* Kongsberg EM 302 and EM710 multibeam systems were run nearly continuously and concurrently wherever depths were suitable over the entire voyage, from Brisbane to Brisbane during 30 September to 17 November 2020 (Figure 3). Additionally, ten ROV *SuBastian* dives were also conducted during the voyage (Dives 393 to 402). Table 1 shows the summary statistics of the FK200930 voyage over the total of the three legs.

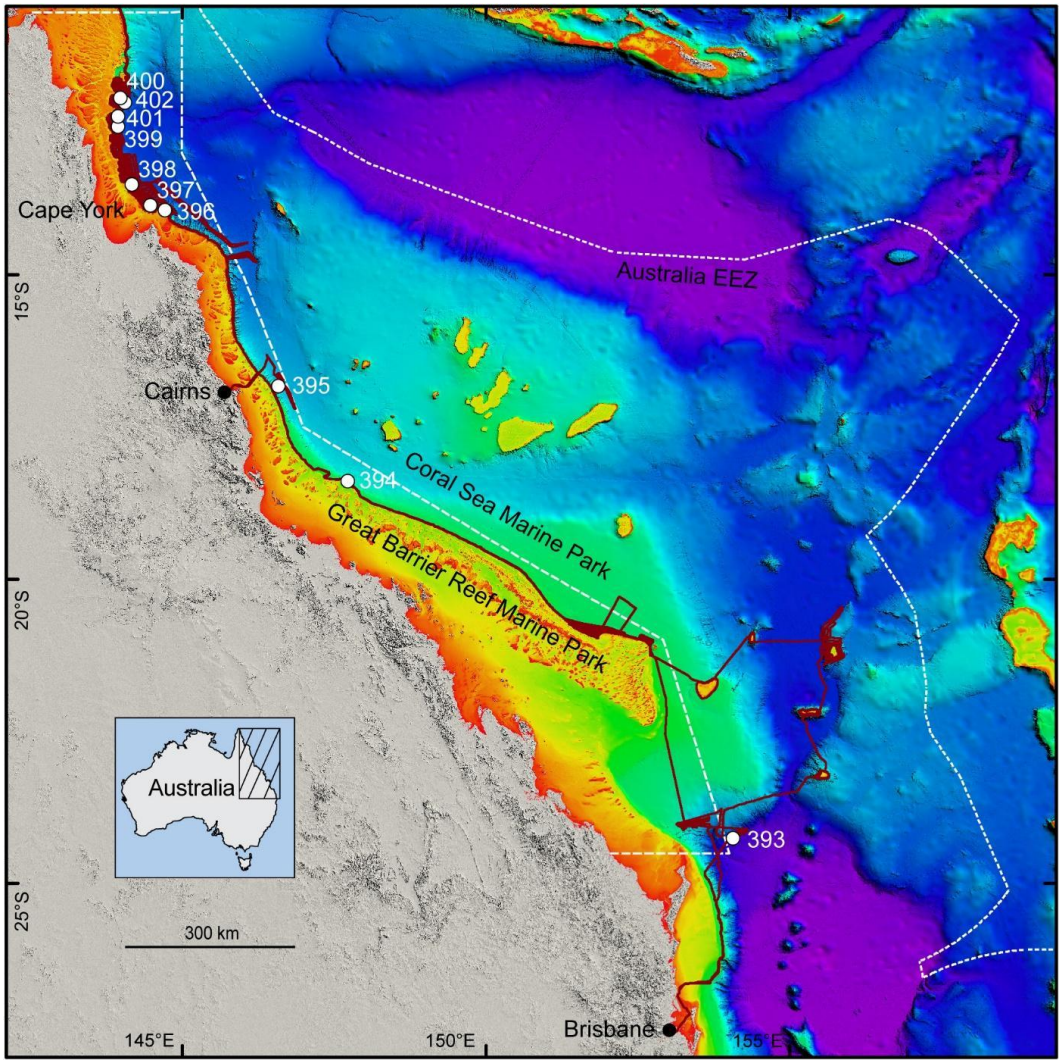

Figure 3. Regional map of the FK200930 voyage, Brisbane to Brisbane, 30 September to 17 November 2020. Brown line is ship track. White dots are the ROV *SuBastian* dives.

Summary statistics	Value
Duration (days)	49
Ship track line (km)	15262
Multibeam coverage (sq km)	27509
Minimum depth (m)	23
Maximum depth (m)	4081
ROV dives	10
CTD casts	4
Sound speed profiler casts	2
XBT casts	6
Data size (TB)	19

Table 1. Summary statistics of the FK200930 voyage.

The following mapping descriptions are broken into separate geographic areas: Southern GBR (Figure 4), Central GBR (Figure 6) and Northern GBR (Figure 8), as the three individual legs overlapped within each geographic area, thereby contributing additional multibeam mapping coverage to these areas as the voyage progressed.

Southern GBR:

The leg 1 transit northward from Brisbane to Cairns provided mapping along the Fraser shelf edge, in the vicinity of Fraser Island, before heading into the deep Tasman Sea basin and the first ROV *SuBastian* dive 393 – a midwater plankton dive (Figure 4). This leg 1 transit was also an opportunity to complete the mapping of the newly discovered Swain slide (Figure 5). This extensive underwater landslide near the Swain Reefs had only been partly mapped during previous expeditions, and so the full mapping of the slide debris field provided an understanding of the full spatial limits of the slide area. Mapping was important to demonstrate how natural hazards have shaped the GBR reef edge in the geological past.

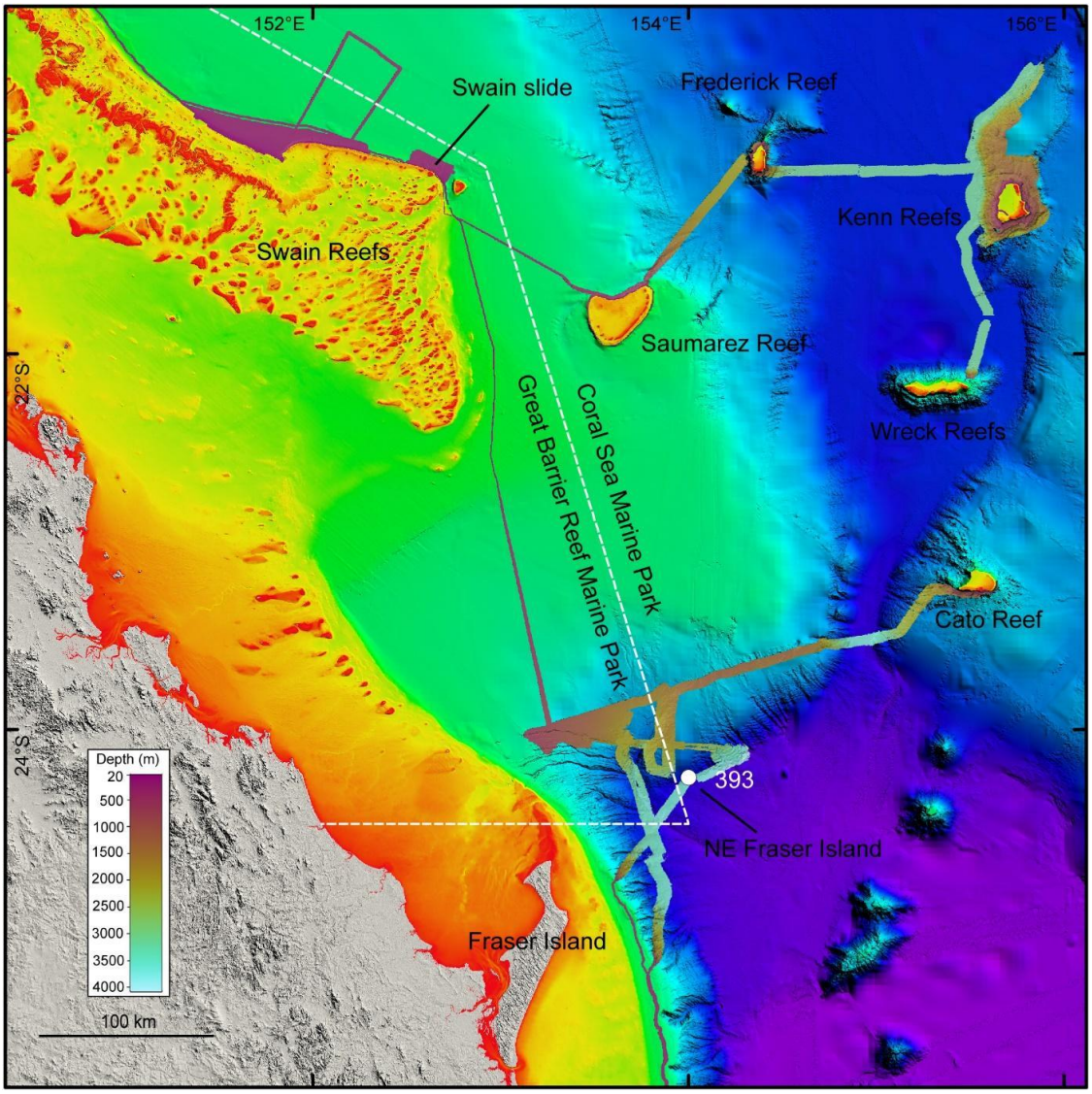

Figure 4. Southern GBR area of FK200930 voyage showing multibeam coverage. White dots are ROV *SuBastian* dives.

The Swain slide survey overlapped the previous R/V *Investigator* voyage IN2019_T02 multibeam coverage and mapped landward towards the Swain Reefs shelf edge. Combined together, depths at the seaward extent of landslide are 358 m, rising gently to around 220 m at the base of the reef slope, then rise steeply into the landslide scarp to about 80 m depth. The excavated scarp face is ~10 km wide meaning that a 10 km portion of the GBR shelf edge has completely collapsed and the remains, both hard limestone rock and excavated softer sediments, now lie as a complex debris field upon the northern Marion Plateau. The run-out distance of the slide is 20 km, but the seaward limit of the debris field is not known.

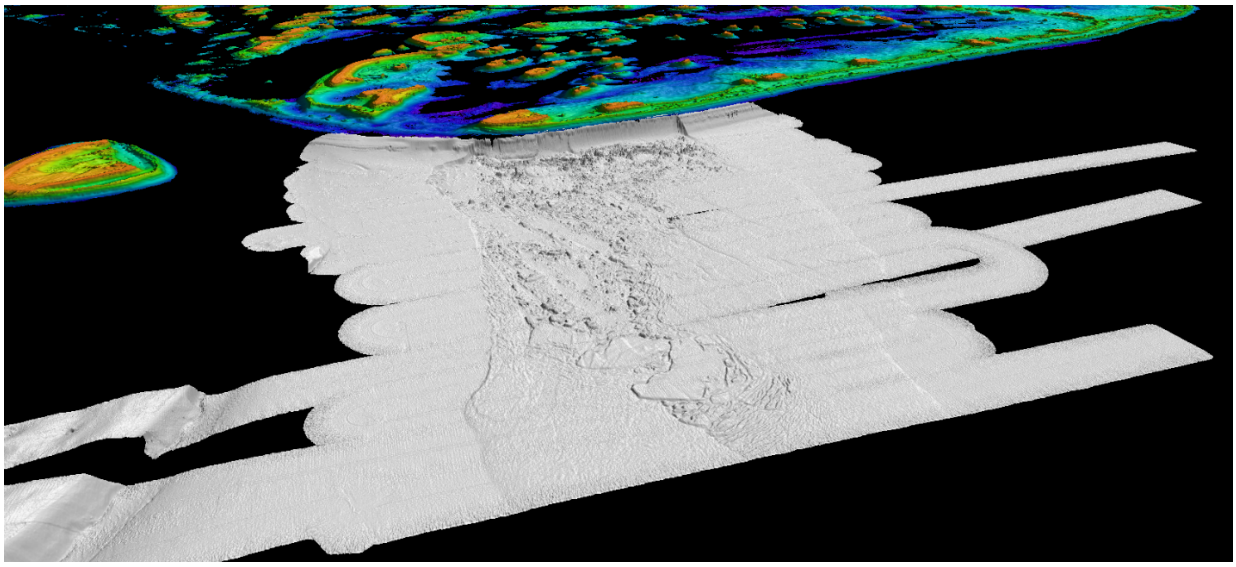

Figure 5. 3D view of the extensive Swain slide to seaward of the Swain Reefs, southern GBR.

The debris field width at the distal end has a width of ~11 km. The widest part of the field is ~14 km wide. The debris field is a mass of several large >2 km intact blocks, or rafts of seabed material about 20 m thick (from IN2019_T02 sub-bottom data). Closer to the scarp, are numerous (100+) medium-sized <1 km debris blocks. The seafloor appears excavated beneath this large debris field, so the various larger rafts and smaller blocks are likely the remains of flat seafloor pushed by harder rock material from up-slope. Between 1-2 km distance of the scarp are the remains of the collapsed limestone rock shown as lines of pinnacles parallel to the scarp.

The leg 3 transit southward from Cairns to Brisbane provided an opportunity to map a ~70 km section of the Swain Reefs shelf edge that had had no previous multibeam data. The location was important because we did not know where the edge of the GBR was in this remote section of the Swain Reefs area. Leg 3 was also an opportunity to map around the steeper flanks of the Coral Sea Marine Park's Saumarez, Frederick, Kenn, Wreck and Cato reefs. These coral reefs grow upon the remains of extinct volcanoes - the Tasmantid Seamounts. Mapping around their steeper flanks helped reveal the interface between the deeper basaltic base and the limestone cap. Crew visits to several of the islands at these reefs were also conducted to provide photographic records of their present condition for Parks Australia managers.

Central GBR:

The leg 1 transit northward from Brisbane to Cairns (after leaving the Swain slide) provided additional mapping coverage along the GBR shelf edge/upper slope, edge-matching previous multibeam data coverage to extend the mapped area to seaward (Figure 6). This is a long-term effort over many years led by Dr Beaman (James Cook University) to improve detailed mapping coverage of the deep GBR. By the 2021 departure of R/V *Falkor* from Australia, there were three full Brisbane-Torres Strait mapping transits along the GBR shelf edge/upper slope. The leg 1 transit northward paused at the previously mapped Bowl slide for ROV dive 394.

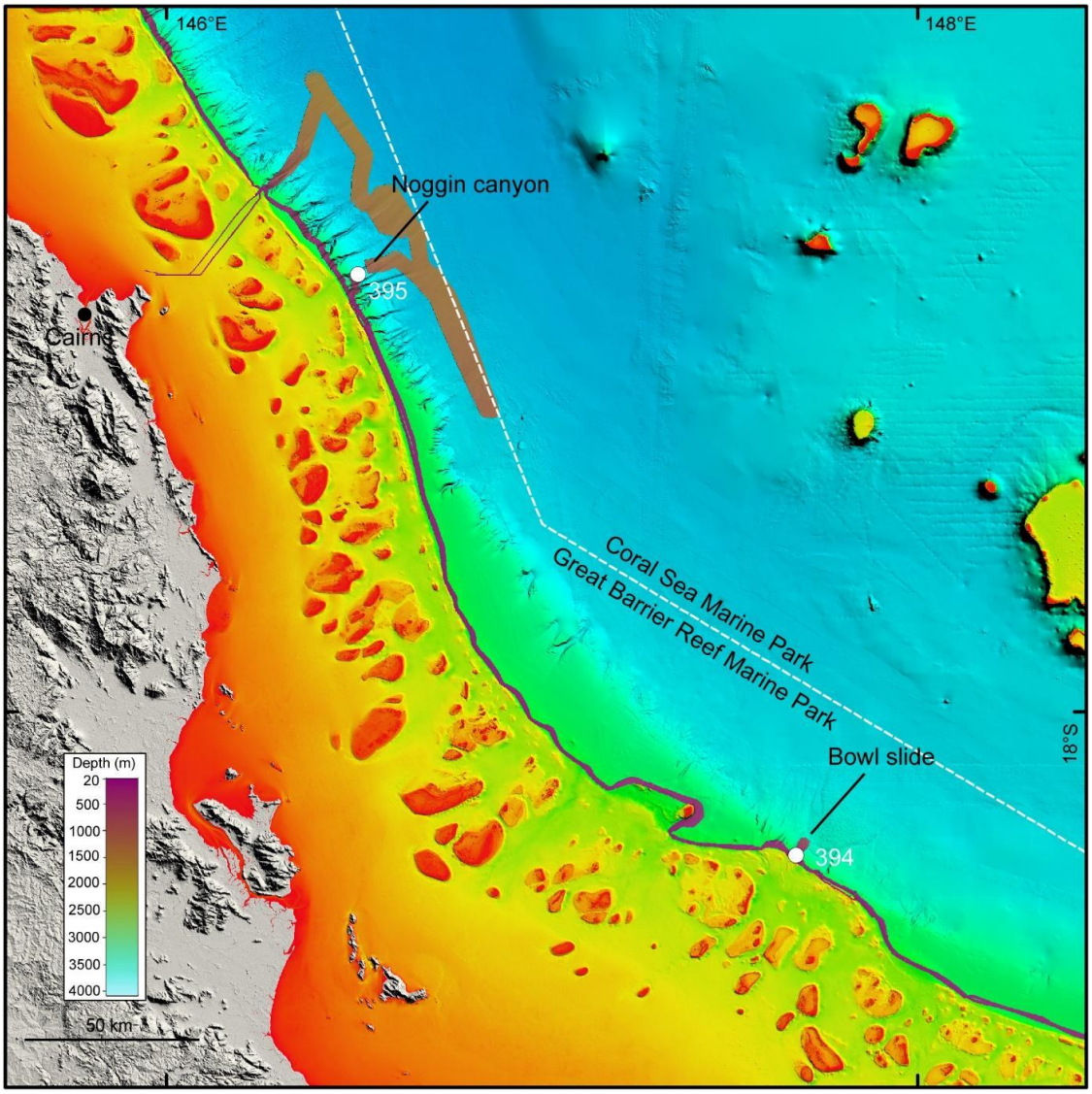

Figure 6. Central GBR area of FK200930 voyage showing multibeam coverage. White dots are ROV *SuBastian* dives.

Bowl slide is named as it lies to seaward of Bowl Reef on the central GBR shelf (Figure 7). Discovered in 2017, there have been several passes by other vessels to map the full extent of the slide. During the FK200930 voyage, mapping was planned to edge-match previous R/V *Investigator* IN2016_V05 multibeam data across the shallowest part of the scarp face. The runout distance is now mapped at ~30 km from the scarp. The widest part of the debris field is 26 km wide but narrows to a width of about 12 km wide across the scarp face itself. The scarp extends from ~100 m depth then to about 1000 m depth on the basin floor.

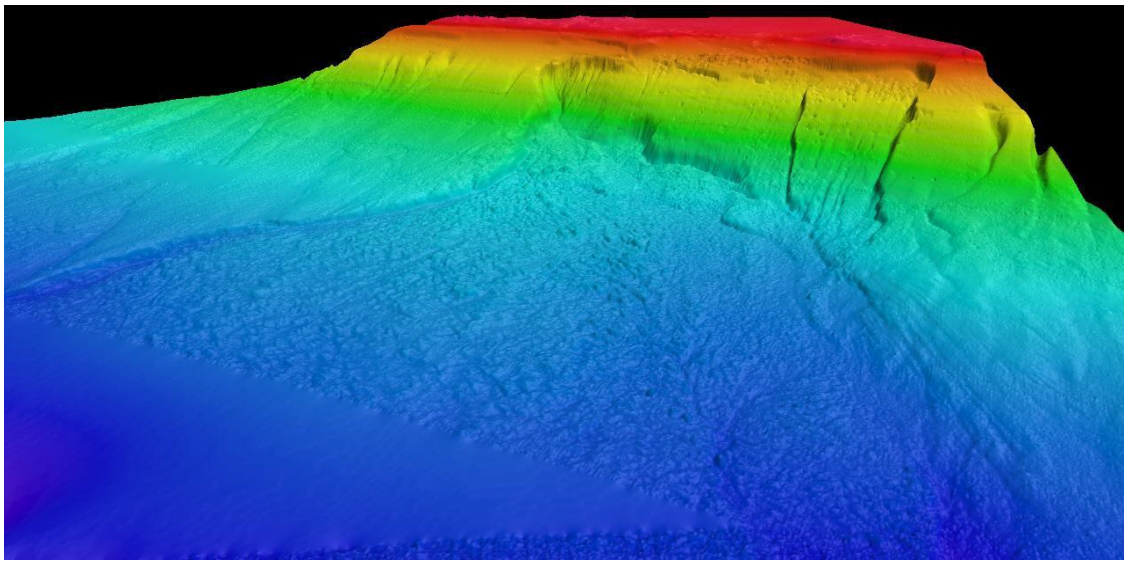

Figure 7. 3D view of Bowl slide with numerous small debris blocks.

Leg 1 continued mapping northward and provided another pause at Noggin canyon for ROV dive 395. Noggin canyon was chosen as it was well mapped and is classified as a 'shelf-connected canyon' with a paleochannel at its head. A dive here complemented the previous FK200802 voyage dives to understand any marine life trends between 'reef-blocked', 'shelf-connected' and 'slope-confined' canyons on the GBR margin. Leg 1 concluded at Cairns for a crew change over and the commencement of leg 2 towards Cape York.

Following completion of leg 2 offshore of Cape York and a subsequent crew change over back in Cairns, the returning southward leg 3 provided additional mapping data by edge-matching the earlier northward leg 1 transit along the central GBR shelf edge/slope. The proximity to shallow barrier reefs makes this shelf edge area challenging to map. The R/V *Falkor* was able to map in depths ~80 m to about 300 m to help reveal the extensive line of drowned reefs known to exist along the central GBR, and the transition into the shelf break at about 100 m and the upper slope morphology to seaward of the shelf break.

Northern GBR:

Leg 2 from Cairns northward to the offshore Cape York area in the northern GBR and then back to Cairns was the primary focus of the FK200930 voyage (Figure 8). The new mapping data fully covers the continental slope opposite Cape Melville and north as far as Great Detached Reef over ~300 km distance. An incredibly complex seafloor was revealed, including deeply incised submarine canyon systems, numerous submerged reefs 10s of m tall, vertical walled 'plunge pools', and large debris blocks broken off the sides of reefs. A highlight was to discover a new ~500 m-tall detached reef, unknown through any previous mapping. Leg 2 had most of the ROV dives (396-402) to discover rarely seen marine life here in the offshore Cape York area.

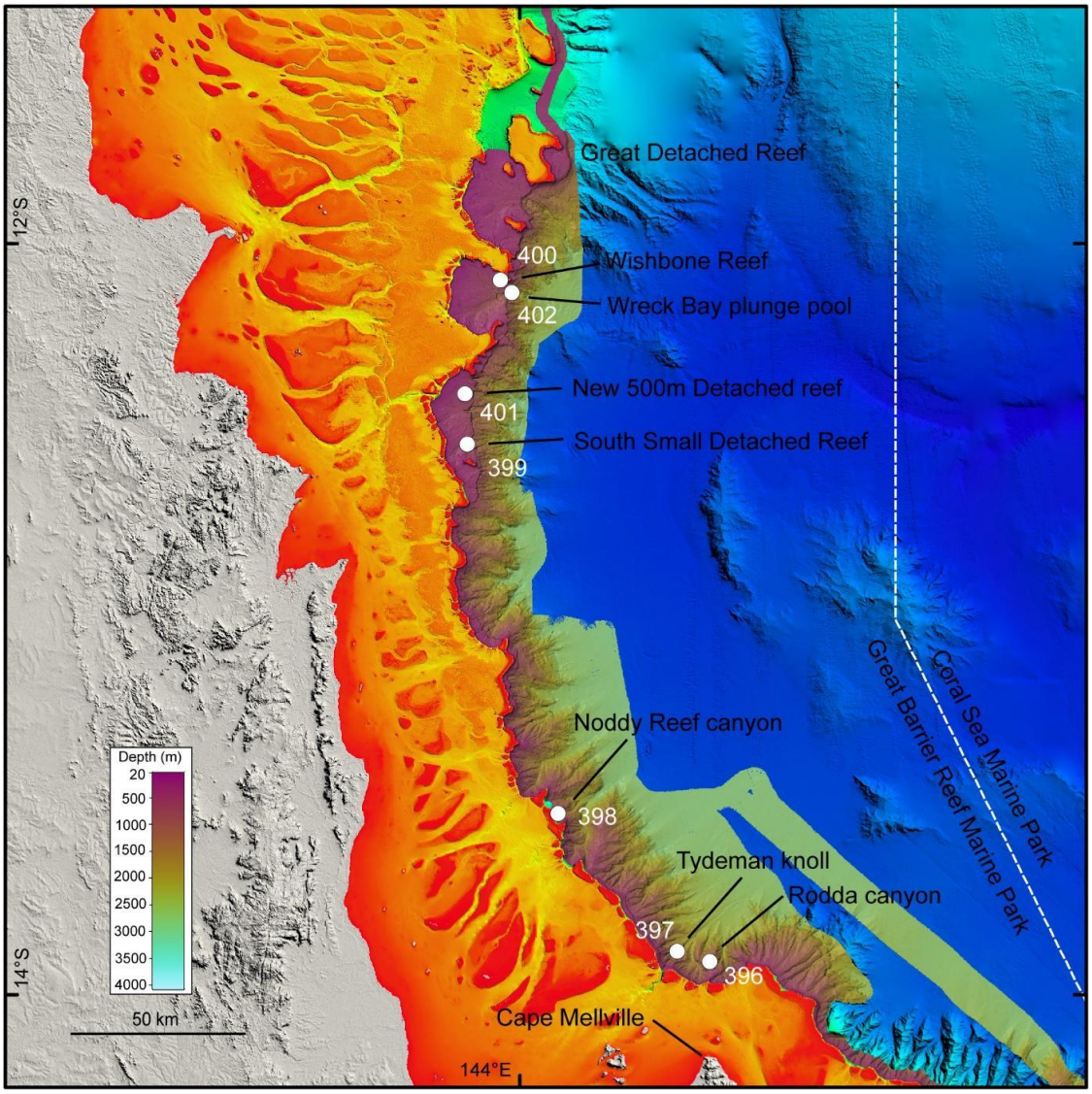

Figure 8. Northern GBR area of FK200930 voyage showing multibeam coverage. White dots are ROV *SuBastian* dives.

On 21 October 2020, the R/V *Falkor* discovered and mapped a new detached reef lying 2.6 km north-northeast of Northern Small Detached Reef (Figure 9). This monumental reef rises ~500 m in vertical height above the surrounding broad platform. The reef is blade-like with the summit area of the reef about 300 m long by 50 m wide. The shoal depth was measured at ~40 m as the R/V *Falkor* passed carefully over the summit. The centroid position is: 12° 23.498' S, 143° 51.486' E. The reef lies wholly within a Habitat Protection Zone. Modern nautical charts do not show any indications of this ~500 m-tall reef, nor do any older charts dating from the late 1800s.

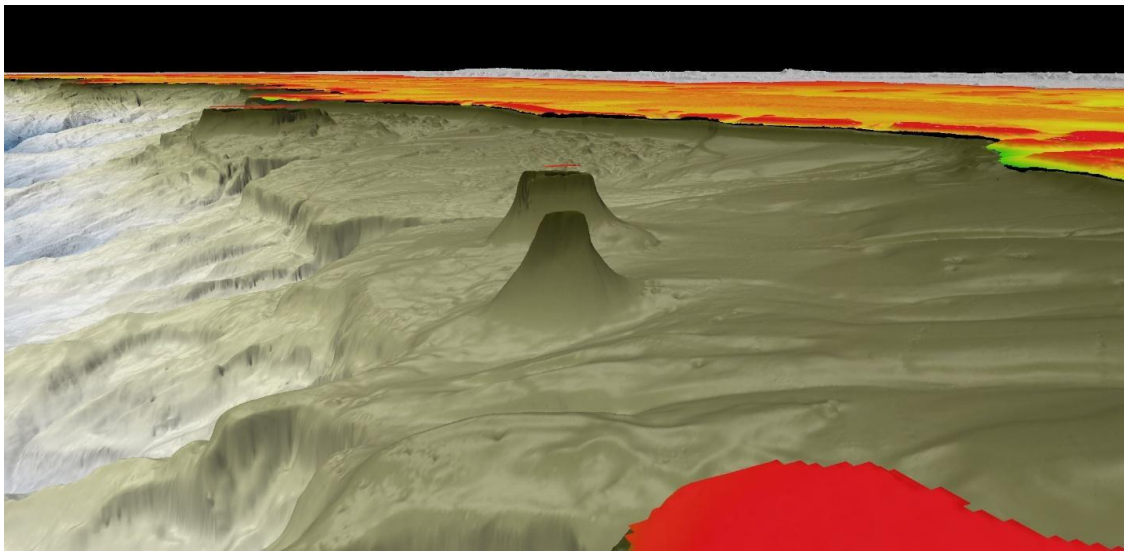

Figure 9. 3D view of new 500 m-tall detached reef, with Northern Small Detached Reef behind.

The multibeam mapping during the FK200930 voyage revealed dozens of smaller drowned reefs 10s of m tall on the northern GBR upper slope, including a broad platform ~160 km in distance and up to 12 km wide extending out from the shelf edge in depths ~200-800 m, upon which the seven previously known (now eight) detached reefs have grown, i.e. the Southern and Northern Small Detached Reefs, Yule Detached Reef, Wood Reef, Great Detached Reef, Raine Island Reef and Saunders Reef. ROV dives confirmed these smaller drowned reefs and the broad platform itself are made of limestone.

Similarly, the new ~500 m-tall reef is also made of limestone with reefal layering obvious from depths ~340 m up to the summit at 40 m depth. The summit portion of the reef is likely Pleistocene to Holocene in age, where the living corals exist within the photic zone. However, the deeper base at ~500 m depth, as are the other detached reefs, points to a much older origin age that predates the origin of the GBR shallow shelf reefs. The reef origin is likely Miocene to Pliocene in age coincident with the initiation of other reefs found in the northern GBR/Gulf of Papua as the Australian plate drifted northward into warmer waters away from Antarctica.

2.1.2 ROV

Ten (10) *ROV SuBastian* dives were conducted during the FK200930 voyage. Table 2 shows the summary statistics of the dives. All dives were live streamed on YouTube and Facebook to a world-wide audience. The large science team ashore were also able to view and give commentary in real-time or to help guide the selection of geological and biological samples by the onboard science team members. The Cruise Blogs section below summarize each dive and include links to the streamed YouTube videos. Note some dive videos had multiple parts due to satellite dropouts and these are given as Part One, Part Two etc. Figure 10 shows some examples of marine life found during the dives.

Dive	Location	Start dive (UTC)	Latitude	Longitude	Depth (m)	Time (h:m:s)
393	NE Fraser	2020-10-01 02:22:24	-24.256000	154.000000	1212	04:52:39
394	Bowl slide	2020-10-04 23:16:30	-18.382200	147.674800	237	06:52:14
395	Noggin canyon	2020-10-05 23:20:42	-16.835500	146.509000	970	05:32:30
396	Rodda canyon	2020-10-09 23:27:33	-13.884600	144.418670	1785	08:15:16
397	Tydeman knoll	2020-10-11 23:25:28	-13.912400	144.504800	549	05:55:38
398	Noddy Reef canyon	2020-10-14 23:13:19	-13.517800	144.101600	824	04:51:24
399	South Small Detach Reef	2020-10-17 23:17:25	-12.534000	143.860000	1108	07:03:34
400	Wishbone Reef	2020-10-19 23:10:17	-12.097971	143.948176	507	07:14:52
401	New 500m Detached reef	2020-10-25 23:09:11	-12.400500	143.854500	578	07:45:57
402	Wreck Bay plunge pool	2020-10-26 23:12:37	-12.131700	143.979200	2017	09:06:16

Table 2. Summary statistics of the ROV dives during the FK200930 voyage.

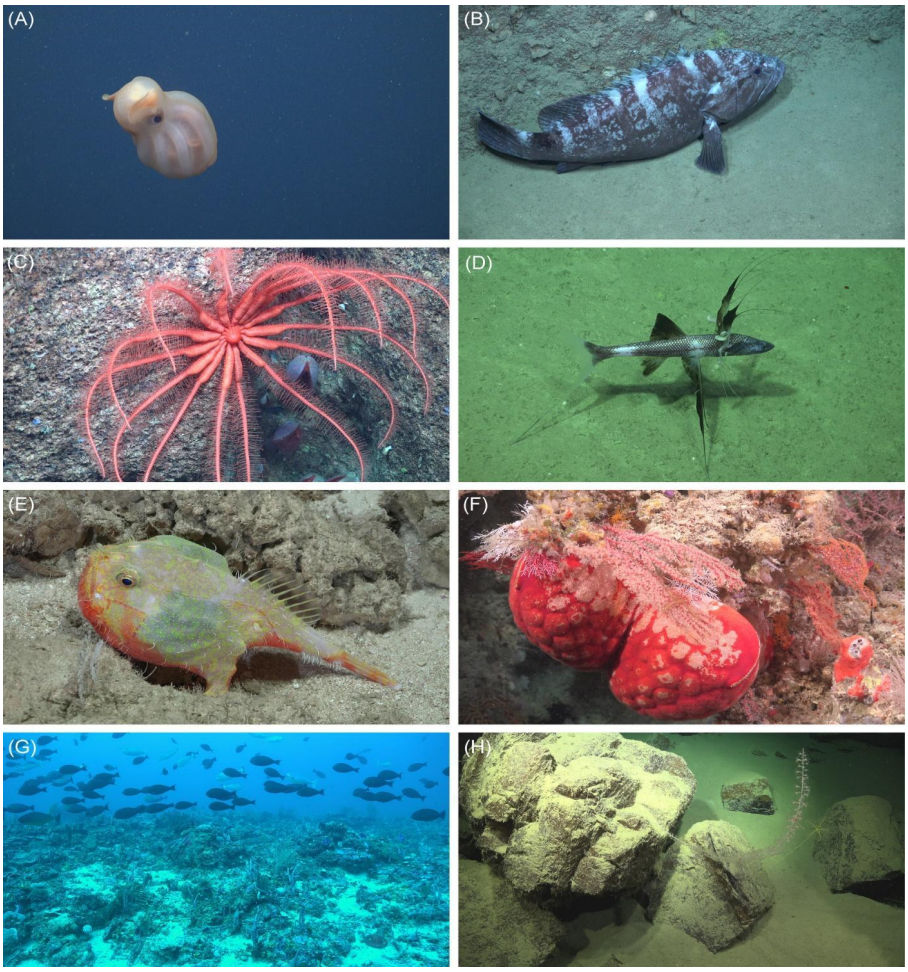

Figure 10. Selection of ROV images from the FK200930 voyage. (A) Dumbo octopus, dive 395, Noddy canyon, 917 m. (B) Eightbar grouper, dive 397, Tydeman knoll, 335 m. (C) Brisingid seastar, dive 398, Noddy Reef canyon, 335 m. (D) Tripod fish, dive 399, South Small Detached Reef, 1082 m. (E) Coffin fish, dive 400, Wishbone Reef, 394 m. (F) Pumpkin star, dive 401, new 500 m Detached reef, 119 m. (G) Surgeon fish school, dive 401, new 500 m Detached reef, 49 m. (H) Bamboo coral, stalked crinoid, dive 402, Wreck Bay plunge pool, 1145 m.

2.2 Post expedition Activities and Accomplishments

2.2.1 Overview

The Great Barrier Reef (GBR) is the world's largest extant coral reef system and is listed as a UNESCO World Heritage Area according to Criteria vii, viii, ix and x. Criteria viii (significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features) and Criteria ix (significant on-going ecological and biological processes in the evolution and development of marine ecosystems) are highly relevant to FK200930. The submarine canyons, northern detached reefs, and submerged coral reefs and banks (mesophotic coral ecosystems) have all been identified as having Outstanding Universal Value (OUV) of the GBR. This voyage has revealed that offshore of Cape York are the most complex submarine canyon systems found along its entire ~2000 km length, and the northern detached

reefs exist on a wide platform of exposed Australian continental crust. These reefs likely are Miocene to Pliocene in origin, predating the existence of the GBR shallow shelf reefs, but continue to support thriving mesophotic coral ecosystems.

This voyage demonstrates that the Australian Government and community values the Criteria under which the GBR was inscribed as a UNESCO World Heritage Area. The submarine canyons, northern detached reefs, and submerged coral reefs and banks (mesophotic coral ecosystems) are significant geological and geomorphic features of the deep GBR landscape, so this voyage shows the world and UNESCO that Australia wants to preserve these values and is working to extend knowledge of their properties.

Additionally, the extensive multibeam data collected by the R/V *Falkor* expeditions were used in the development of a new 250m-resolution bathymetry model for the Australian region, by a team from Geoscience Australia, James Cook University, the Australian Hydrographic Office, and the University of Sydney. This compilation provides a national dataset and shows in greater detail the transition between land and sea, its applications extend across a wide range of industries including tourism, fishing, aquaculture, renewable energy, defence, search and rescue, marine research, environmental protection and marine infrastructure.

Moreover, the multibeam data collected by the R/V *Falkor* during the FK200930 voyage were used to develop a new 30m-resolution bathymetry model for the Torres Strait region – a critical shipping channel between northern Australian and Papua New Guinea and the home of the Indigenous Torres Strait Islander communities.

2.2.2 Rock Samples

Four sedimentary rock samples collected from outcrops on the continental slope during dive 402 (at depths 1496-2004 m) were sent for analysis at James Cook University in Townsville. Work is currently underway by PhD candidate Casey Lee to determine the accurate depositional ages, provenance, tectonic setting, and depositional environment using a combination of sandstone petrography, zircon grain morphology, U-Pb zircon geochronology, Lu-Hf and O isotopes, and major and trace element geochemistry.

Preliminary results for U-Pb zircon geochronology (Figure 11) reveal large Palaeozoic age peaks and minor Proterozoic input (both with known local sources) and a small population of magmatic zircons with Jurassic-Early Cretaceous ages. This younger age population is significant because it indicates previously undocumented magmatism in the Cape York region and may challenge current tectonic models along the margin of northeast Gondwana during the Mesozoic. Maximum depositional ages (MDAs) show these rocks were deposited during the Early Jurassic to Early Cretaceous and are likely Gilbert River Formation rocks.

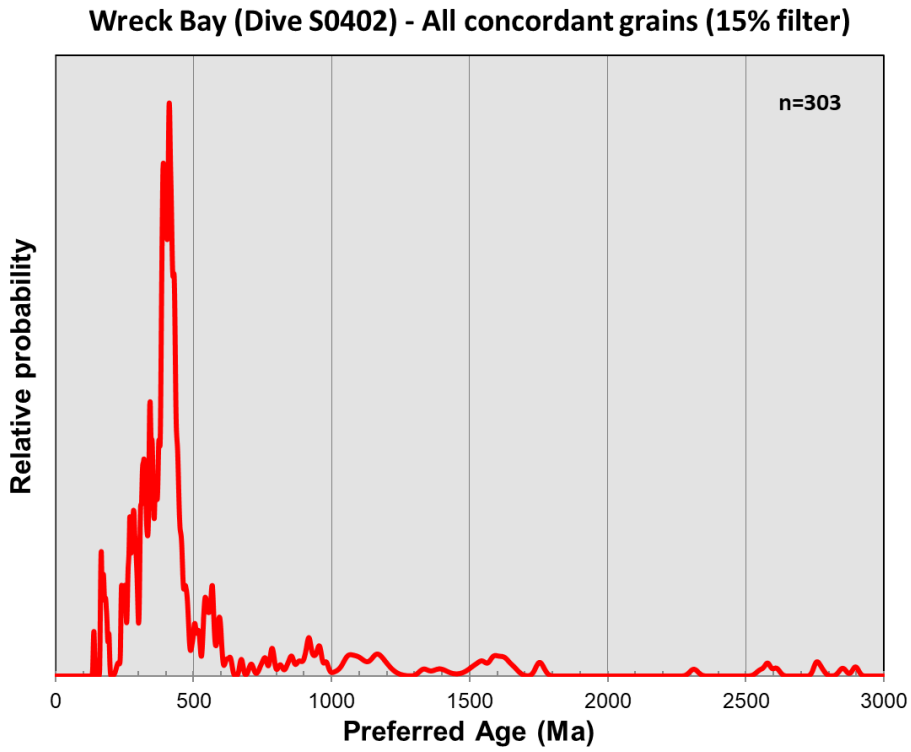

Figure 11. Probability density plot showing preliminary U-Pb ages of all concordant zircon grains analyzed (using a 15% discordance filter) from sedimentary rock samples collected from the continental slope at Wreck Bay during dive 402.

Analysis of sandstone petrography and zircon grain morphology is still underway; however, an initial assessment reveals a terrestrial depositional environment changing to a shallow marine environment moving up stratigraphy. Initial assessment of zircons with concordant U-Pb ages show dominant euhedral grain morphologies (including older grains), with minor representation of grains exhibiting abraded to anhedral morphologies. This suggests that many grains have been transported only a short distance from their source and have not been recycled through previous sedimentary cycles.

In addition to previously undocumented Mesozoic magmatism, the initial provenance data also reveals striking similarities (e.g., MDAs, zircon age spectra, depositional environments) between the sedimentary rocks at Wreck Bay and the Jurassic-Early Cretaceous sedimentary successions of the Laura Basin to the south. This validates previously unverified assumptions in the literature that the offshore northern limit of the Laura Basin lies as far north as Cape Grenville (west of Wreck Bay) and that it likely extended much further to the east, prior to the Late Cretaceous rifting of Gondwana. This would place the boundary much farther north than the portrayed limit of the offshore Laura Basin (Figure 12).

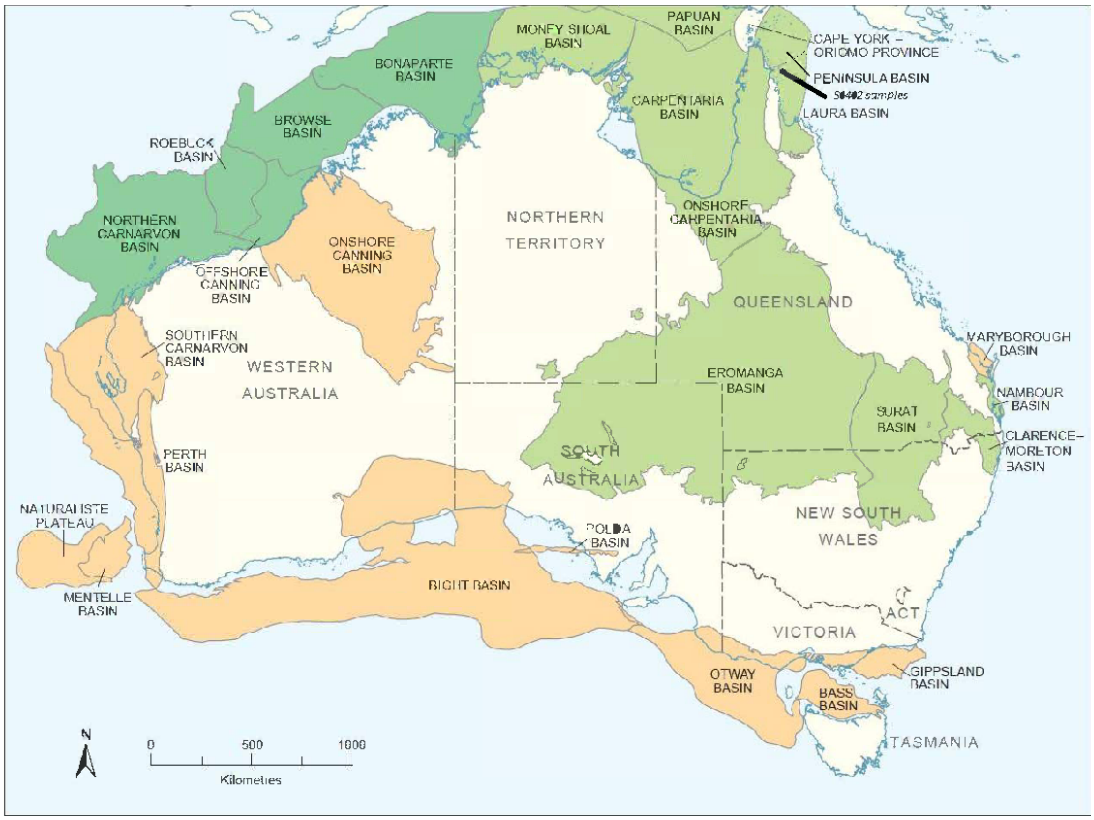

Figure 12. Rock samples from dive 402 marked on the Laura Basin. Modified from Jell, P.A., 2013. Geology of Queensland. Geological Survey of Queensland, Brisbane, Australia.

The remaining analytical work is planned for 2024, which will be interpreted and submitted for publication and as a chapter in a PhD thesis. Work to be completed includes additional U-Pb detrital zircon geochronology, which will serve to further constrain maximum depositional ages and provide a more robust dataset for provenance interpretation. Zircons with concordant Mesozoic ages will then be analyzed using Lu-Hf and O isotopes as well as major and trace element geochemistry to determine magma source and tectonic setting.

2.2.3 Biological Samples

All biological samples have been formally registered by the Queensland Museum and given unique registration numbers (see data link to Qld Museum registered bio specimens below). The black corals (Anthozoa; Antipatharia) collected across all the north-eastern Australia R/V *Falkor* voyages have been studied and new species named (see table and Publications below). Additionally, the carnivorous sponges from the R/V *Falkor* voyages have been studied and new species from the family Cladorhizidae have been named (see table and Publications below). The following species were discovered during the FK200930 voyage.

Kingdom	Phylum	Class	Subclass	Order	Family	Genus	Species
Animalia	Cnidaria	Anthozoa	Hexacorallia	Antipatharia	Aphanipathidae	Aphanipathidae	*Rhipidipathes helae* **sp. nov.**
Animalia	Cnidaria	Anthozoa	Hexacorallia	Antipatharia	Cladopathidae	Hexapathes	*Hexapathes bikofskii* **sp. nov**.
Animalia	Porifera	Demospongiae	Heteroscleromorpha	Poecilosclerida	Cladorhizidae	Axoniderma	*Axoniderma wanda* **sp. nov.**
Animalia	Porifera	Demospongiae	Heteroscleromorpha	Poecilosclerida	Cladorhizidae	Abyssocladia	*Abyssocladia jeanvaceleti* **sp. nov.**

Table 3. Taxonomic classification of the newly discovered species from the FK200930 voyage.

2.2.4 Multibeam

The extensive multibeam collected during the FK200930 voyage, and indeed during the entire Australian campaign by the R/V *Falkor* during 2020-21 (totaling ~200 thousand square km) has been used to compile a new 3D depth model for the Australian region at 250 m-resolution, in addition to a 30 m-resolution 3D depth model for the northern GBR and Torres Strait, all available at the AusSeabed Marine Data Portal.

2.2.5 ROV

The rich collection of ROV imagery, both 4K and HD video, and 5sec interval screenshots from this FK200930 voyage are still being analyzed, together with the ROV imagery collected during the other R/V *Falkor* voyages to the north-east Australia region: FK200429 and FK200802. Analysis is being conducted using Squidle+ annotation software. Efforts are underway to develop a crowd-sourced annotation team using retired members of the public who have an interest in the deep GBR and Coral Sea marine life, to scale-up the rate of image annotations across the total of 42 ROV dives conducted during 2020.

2.2.5.1 Software Utilized

- QPS Fledermaus and Qimera software.
- Teledyne CARIS HIPS&SIPS software.
- ESRI ArcGIS software.
- SQUIDLE+ image annotation software.

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
Environmental sensor data	Rolling Deck to Repository	Y
ROV data	MGDS	Y
ADCP DATA	University of Hawaii	Y
Multibeam data (raw & processed)	CUBE-gridded bathymetry data available on the AusSeabed Marine Data Portal. *Search Map Layers > Elevation and Depth > Bathymetry – Survey > 'Northern Great Barrier Reef 2020 64m'* Multibeam data also provided to Geoscience Australia, Australian Hydrographic Office, James Cook University	Y
ROV geological, biological and CTD samples	James Cook University – Excel spreadsheets of samples	Y
Seabed sediment samples given International Geo Sample Numbers	IGSN/Geoscience Australia Marine Sediments (MARS) Database. *Search keyword: 'FK200930'*	Y
Onboard Wetlab and ROV collection of biological samples	James Cook University - biological samples images	Y
ROV *SuBastian* dive reports (S0393-S0402)	James Cook University - dive reports	Y
Geological sample images - onboard Wet Lab and ROV collection of geological samples.	James Cook University - geological samples images	Y
Google Earth	James Cook University - Google Earth	Y
Multibeam images - Geotif images of multibeam data around ROV dives	James Cook University - multibeam images	Y
Ashore QUT Dry Lab images of sliced geological rock samples	James Cook University - rock samples	Y
SCS data	James Cook University - Excel spreadsheets of 1 sec interval ROV SCS dive tracks	Y
Zipped shapefiles of ROV 1 sec interval scs dive tracks,	James Cook University - shapefiles	Y

geological and biological sample sites, and 5 sec interval squidle framegrab sites		
Ship track - Excel spreadsheet of 1 min interval ship track:	James Cook University - ship track	Y
Annotated images	Squidle+. *[Platform = SOI* ROV *Subastian, deployment = FK200930].*	Y
Qld Museum registered specimens	James Cook University - registered bio specimens	Y

Table 4. List of all publicly available data.

4 Publications

Ekins, Merrick, and John N. A. Hooper. 2023. "New Carnivorous Sponges from the Great Barrier Reef, Queensland, Australia Collected by ROV from the RV *FALKOR*." *Zootaxa* 5293 (3): 435–71. https://doi.org/10.11646/zootaxa.5293.3.2.

Horowitz, Jeremy, Dennis Opresko, Tina N. Molodtsova, Robin J. Beaman, Peter F. Cowman, and Tom C. L. Bridge. 2022. "Five New Species of Black Coral (Anthozoa; Antipatharia) from the Great Barrier Reef and Coral Sea, Australia." *Zootaxa* 5213 (1): 1–35. https://doi.org/10.11646/zootaxa.5213.1.1.

Lindsay, Dhugal J., James C. Hunt, Mardi McNeil, Robin J. Beaman, and Michael Vecchione. 2020. "The First In Situ Observation of the Ram's Horn Squid Spirula Spirula Turns 'Common Knowledge' Upside Down." *Diversity* 12 (12): 449. https://doi.org/10.3390/d12120449.

5 Appendix

5.1 Science Party Information

Scientist	Institution
Robin Beaman	James Cook University
Joan Li	James Cook University
Valerie Cornet	James Cook University
Luke Nothdurft	Queensland University of Technology
Mardi McNeil	Queensland University of Technology
Vikki Lowe	University of Queensland
Jeremy Horowitz	James Cook University
Daniella Ceccarelli	Coral Sea Foundation
Brendan Brooke	Geoscience Australia
Rachel Przeslawski	Geoscience Australia
Richard Fitzpatrick	Biopixel
Dhugal Lindsay	Japan Agency for Marine-Earth Science and Technology
Jody Webster	University of Sydney
Merrick Ekins	Queensland Museum
Tom Bridge	Queensland Museum
Will White	Commonwealth Scientific and Industrial Research Organisation (CSIRO)
John Pogonoski	Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Angel Puga Bernabeu	University of Grenada

5.2 Presentations and Posters

- Beaman, R.J., 2021. Schmidt Ocean Institute R/V *Falkor* Australia campaign 2020-2021, Queensland–Smithsonian Fellowship Speaker Series. Oceans: life on the edge, 16 November 2021. Queensland Department of Environment and Science - Smithsonian Institution, Remote conference, pp. 13. https://www.deepreef.org/2021/11/17/soi-rvFalkor-australia/

- Beaman, R.J., 2021. Schmidt Ocean Institute R/V *Falkor* Australia campaign 2020-2021, Sub-Committee on Regional Undersea Mapping (SCRUM), GEBCO Week, 11-15 January 2021. General Bathymetric Chart of the Oceans (GEBCO) www.gebco.net, Virtually from Paris, France. https://www.deepreef.org/2021/01/13/soi-Falkor-campaign/

- Beaman, R.J., Picard, K., Miller, A., 2022. R/V *Falkor* surveys in Australia 2020-2021. In: Maschke, J. (Editor), Hydrospatial 2021 Conference, 16-18 Feb 2022. Australasian Hydrographic Society, Cairns, Australia. https://www.deepreef.org/2022/02/17/rv-Falkor-hydrospatial/

- Beaman, R.J., 2022. R/V *Falkor* surveys in Australia 2020-2021, SSSI NSW & ACT Asia-Pacific Spatial Excellence Awards, 10 November 2022. Surveying & Spatial Sciences Institute (SSSI), Sydney, Australia. https://www.deepreef.org/2022/11/10/rv-Falkor-sssi/

- Horowitz, J., Untiedt, C., Bridge, T., Ekins, M., McFadden, C., Beaman, R., 2021. Recent explorations of the depths of the Northern Great Barrier Reef, EIANZ Webinar, 25 February 2021. Environment Institute of Australia and New Zealand (EIANZ), Townsville, Australia (Virtual meeting).

5.3 Student Projects, Thesis, and Dissertations

- Lee, C., James Cook University PhD Candidate. Finding 'Lost Pacifica': Reconstructing Mesozoic northeast Gondwana by investigating sedimentary provenance in the Laura, Capricorn and Styx basins.

5.4 Cruise Records

ROV *SuBastian* Dive List.

- ROV dive 393: ROV dive 393 was conducted about 100 km northeast of Fraser Island in the Coral Sea Marine Park as a midwater plankton observation dive with remote audio commentary given by Dr Dhugal Lindsay from JAMSTEC. This midwater dive reached a maximum of 1212 m.
- ROV dive 394 (Part A, Part B): Dive 394 was conducted at Bowl slide. This dive was planned as a mesophotic dive to a maximum depth of 237 m, intended to cross the upper scarp face of this underwater landslide then into the shelf break region at ~100 m depth searching for mesophotic corals.
- ROV dive 395: Dive 395 was conducted at Noggin canyon to a maximum 970 m depth, with the aim to conduct a transect across the canyon axis then up the canyon sidewalls. The dive proved the canyon axis and sidewalls were quite muddy with no obvious exposed rock or strata observed, hence all associated benthic life were infaunal or muddy deposit feeders.
- ROV dive 396 (Noggin Canyon, Rodda Canyon,Rodda Canyon Part B, Rodda Canyon Part C): Dive 396 was conducted at Rodda canyon which drains between Rodda and Wilson reefs. This is a 'shelf-connected canyon' with an ancient river channel on the shelf joined to the head of the canyon. Maximum depth was 1785 m. The transect climbed up the northern sidewall of the canyon to a crest around 1370 m. A large amount of land-based vegetation, e.g., coconuts, mangrove seeds and seagrass blades, were observed in the canyon axis.
- ROV dive 397: Dive 397 was conducted at Tydeman knoll, a seamount-like feature discovered on the broad ridge extending out from Tydeman Reef. The knoll is about 1.4

km long, about half km wide and ~300 m high. The dive had maximum 549 m depth and traversed across the face looking for clues as to its geological origins and any marine life. The knoll was covered in a dark brown crust and quite hard, overlying a less resistant limestone substrate, leaving pits and caves in its surface. Large cod had taken up residence around the summit in 340 m.

- ROV dive 398: Dive 398 was at Noddy Reef canyon and chosen as the site is a 'reef-blocked canyon', i.e., a barrier reef lies at the head of the canyon. The previous dive 396 was a 'shelf-connected canyon', and so having a contrasting site was important for comparisons between biota found in each type of canyon. The maximum depth was 824 m, with a climb up a steep wall to a ledge at 500 m. The steep wall was found to be a hard limestone rock. The dive then crossed the ledge above 500 m and up vertical limestone wall into the mesophotic zone.
- ROV dive 399 (Part A, Part B): Dive 399 was conducted near the Southern Small Detached Reef within a 'plunge pool' carved into the broad platform that extends out from the GBR shelf edge and upon which these Detached reefs have grown. Maximum depth was 1108 m. Many sponges, squid and fish were observed, with rock samples taken for analysis to reveal the origin of the platform.
- ROV dive 400: Dive 400 was conducted at Wishbone Reef which forms the NE boundary of the large Wreck Bay. Maximum depth was 507 m with a transect across some ~60 m high pinnacles, looking for evidence these are drowned reefs, and then climbed up the steep reef wall into the mesophotic zone. Numerous large limestone boulders are evidence of reef platform collapse into submarine rockfalls and landslides. Sessile marine life has colonized these boulders.
- ROV dive 401 (Part A, Part B): Dive 401 was conducted at the newly discovered 500 m-tall Detached reef to a maximum depth of 578 m. The dive revealed a hard limestone substrate with much demersal fish and mobile benthos around the base of the reef, increasing in sessile benthos coverage as we ascended. The summit was covered in shallow reef fish and had numerous sharks circling. Shallow corals, sponges and coralline algae were prolific at the top of the reef in ~40 m. We confirmed this Detached reef was a significant coral habitat at both shallower and mesophotic depths, with no signs of any previous coral bleaching.
- ROV dive 402 (Part A, Part B, Part C, Part D, Part E): Dive 402 was conducted at the deep 'plunge pool' that lies at the entrance to Wreck Bay. Maximum depth was 2017 m, initially as a slow midwater descent with Dr Dhugal Lindsay from JAMSTEC narrating to describe the midwater plankton species. At the seafloor, huge blocks of hard sedimentary rock lay scattered about, broken from the steeper cliffs above. Sampling found these rocks to be non-marine sandstone as outcropping ancient continental rock, having subsided over long geological time and now exposed at these deeper depths.

5.5 Media

- Newly Discovered 500m Tall Reef - Schmidt Ocean Institute.
- Australian Scientists Discover 500-Meter-Tall Coral Reef in the Great Barrier Reef — First Discovery in over 120 Years - Schmidt Ocean Institute.

- High-Tech Seafloor Mapping Is Finding Surprising Structures Everywhere - Scientific American.
- Research Exploration: Mapping Australia's Seafloor - ECO Magazine.

5.6 Community Outreach

- Beaman, R.J. 2023. R/V *Falkor* surveys in Australia 2020-2021. Presentation to Trinity Bay High School. 07 February 2023, Cairns, Australia.
- Ocean Wonders Exhibition - Australian National Maritime Museum. November 2021, Sydney, Australia.
- One Ocean, Our Future Exhibition - Australian National Maritime Museum. 6 April 2022, Sydney, Australia.
- Exploring the Deep GBR - Regional Wrap. 26 October 2022, Cairns, Australia.

5.7 Daily Diary

Wednesday 30 September 2020 Wind 8 kn from 070°. Sea state 2. Nil swell. 0900 in position 27.441266°S 153.067820°E alongside wharf in Brisbane Port. At 1000, the *Falkor* left its berth position and headed out of the Brisbane River for the start of voyage "Northern depths of the Great Barrier Reef" FK200930. At 1100, the ship entered Moreton Bay for the ~ 3-hour pilotage through the bay. By 1600, the *Falkor* had completed the pilotage and headed east across the Fraser shelf towards the deeper shelf edge, with the aim to commence a northerly transect adjacent to the previous FK200802 ship track into Brisbane. Both the EM702 and EM302 multibeam systems were turned on to acquire new multibeam mapping data along the Fraser shelf edge and upper slope.

Thursday 01 October 2020 Wind 9 kn from 055°. Sea state 4. Low swell. 0900 in position 24.528000°S 153.827000°E in vicinity of Fraser Island. Through the night, the *Falkor* continued mapping the upper slope in depths around 150 m, directly landward and adjacent to the previous FK200802 multibeam data. Around 0700 opposite Fraser Island, the ship left the upper slope and commenced a northeast transect across the ~3500 m deep Fraser Canyon towards the planned ROV dive site near the southeast corner of the Great Barrier Reef Marine Park. At 1200, the ship stopped ~100 km northeast of Fraser Island to conduct ROV dive #393, a midwater dive with audio commentary by Dr Dhugal Lindsay from JAMSTEC. The dive continued to 1212 m depth, and then ROV *SuBastian* was recovered at 1700. By 1800, the *Falkor* had recommenced multibeam surveying across the smaller feeder canyons into the main Fraser Canyon, and then returned to the northward planned ship track.

Friday 02 October 2020 Wind 11 kn from 115°. Sea state 4. Low swell. 0900 in position 22.854567°S 153.015187°E in vicinity of Swain Reefs. Overnight, the *Falkor* continued the northward ship track towards the Swain Reefs, crossing the Capricorn Channel and south Marion Plateau at ~400 m, then crossing onto the broad terrace that extends around the Swain Reefs. The *Falkor* arrived off the southeast corner of the Swain Reefs at 1100 and then tracked north, adjacent to existing multibeam data over the 'Swain pinnacles', a cluster of many small pinnacles lying around 100 m depth. Through the afternoon, the ship continued north along the eastern edge of the Swain Reefs then passed through the 5 km wide gap between the Swain

Reefs and Elusive Reef. At 2000, the ship commenced a systematic survey over the Swain slide – a 20 km wide undersea landslide, only partly mapped by the R/V *Investigator* in October 2019.

Saturday 03 October 2020 Wind 19 kn from 100°. Sea state 4. Low-moderate swell. 0900 in position 21.018744°S 152.679009°E in vicinity of Swain slide. The ship continued on the systematic survey over the Swain slide through the night, however, stronger southeasterly winds reduced surveying speed to ~3 hours for just two passes across the slide boundaries. Slide boundaries are generally about 7.5 nm wide, slowly narrowing towards the scarp face at the Swain Reefs. The seafloor morphology is very rough within the slide debris field, with larger intact blocks lying scattered within the main debris material. Through the most of the day, the *Falkor* continued the systematic survey of the slide debris field, completing the final data gap against the previous multibeam data at 1430. The ship then headed north across the debris field to a predetermined ROV transect site in ~300 m. However, the East Australian Current (EAC) velocity was too strong (~1.5 kn) to launch ROV *SuBastian*. The ship instead completed filling small gaps in the multibeam data until 1730, and then commenced the long transit along the face of the Swain Reefs towards the next destination at the Bowl slide.

Sunday 04 October 2020 Wind 22 kn from 115°. Sea state 4-5. Low-moderate swell. 0900 in position 19.876760°S 150.591134°E in vicinity of Swain Reefs. The *Falkor* continued mapping along the Swain Reef shelf edge overnight in ~200 m, with no obvious seafloor features detected. From around 0500, the seafloor shallowed to ~100 m and more small pinnacles revealed on the seafloor. At 0930, the ship arrived at the Hydrographers Passage area, previously surveyed in 2007, and continued in a northwest direction towards the Bowl slide area on the central GBR margin. Through the afternoon and evening, the ship continued edge mapping previous upper slope multibeam data in depths around 100 m. The seafloor occasionally showed isolated boulders scattered over a relatively flat surrounding surface. Weather from the southeast made for easy sailing along the GBR upper slope towards the Bowl slide area.

Monday 05 October 2020 Wind 19 kn from 100°. Sea state 4. Low swell. 0900 in position 18.386986°S 147.670867°E in vicinity of Bowl slide. The *Falkor* continued mapping along the GBR shelf edge and upper slope through the night, occasionally revealing the ~10 m high cliff that is the shelf break around 100 m depth. Large boulders at times were observed to seaward of the shelf break on the upper slope. Around 0200, the ship crossed another well-mapped, small underwater landslide, called the Viper slide, where previous geoscience research has taken place. At 0800, the ship was in position at the Bowl slide, a large underwater landslide, for ROV dive #394. This was planned as a mesophotic dive to a maximum depth of 237 m, intended to cross the upper scarp face then into the shelf break region searching for mesophotic corals. The ship did a live audio cross with Jeremy Horowitz and Tom Bridge based at Townsville, and concluded the dive at 1600. The *Falkor* then commenced a transit westerly along the shelf break around 100 m, mapping the large embayment between the GBR shelf and Myrmidon Reef, which is a detached reef growing on the deeper Burdekin River paleo-delta that extends out from the GBR shelf. Around 2200, the ship passed the Palm Passage entrance and continued northward towards the Noggin canyon closer to Cairns in the northern GBR.

Tuesday 06 October 2020 Wind 15 kn from 105°. Sea state 4. Low swell. 0900 in position 16.836573°S 146.496636°E in vicinity of Noggin canyon. The *Falkor* continued mapping along the GBR shelf edge and upper slope through the night, heading northwards from Myrmidon Reef.

This shelf edge mapping was important to help delineate the abrupt change in slope between the relatively flat GBR shelf into the gentle gradient of the continental slope. Around 0900, the ship arrived at the Noggin canyon site, previously visited during FK200802, but could not dive then with the ROV due to strong ocean currents. Today, currents were sub-1 kn and so ROV dive #395 commenced at 1000 to 970 m depth, with the aim to conduct a transect across the canyon axis then up the canyon sidewalls. The dive proved the canyon axis and sidewalls were quite muddy with no obvious exposed rock or strata observed, hence all associated benthic life were infaunal or muddy deposit feeders. The dive concluded at 1400 and then the ship commenced mapping some large unmapped areas within the Queensland Trough in depths ~1400 m.

Wednesday 07 October 2020 Wind 17 kn from 115°. Sea state 4. Low swell. 0900 in position 16.802578°S 146.089342°E approaching Cairns port limits. Through the morning, the *Falkor* continued to map the Queensland Trough, and then made way towards the GBR shelf, entering Grafton Passage at 0730. The ship hove to off Cairns port and Leg 2 participants Joan Li, Valerie Cornett and Robin Beaman joined, while Luke Nothdurft left the ship. The *Falkor* then got underway, heading back out through Grafton Passage, and bound for the far northern GBR and offshore Cape York area. Through the afternoon, the *Falkor* mapped the upper slope, edge matching previously collected multibeam data from FK200802 Leg 2 along the front of the Ribbon Reefs.

Thursday 08 October 2020 Wind 19 kn from 150°. Sea state 4-5. Moderate swell. 0900 in position 14.614135°S 145.653227°E in vicinity of Yonge Reef. Wind and swell increased throughout the night as the ship mapped along the Ribbon Reefs upper slope. A short east-west line was made opposite Ribbon Reef No. 10 for engineering purposes, which allowed for collecting additional multibeam data in the Queensland Trough. By 0800, the *Falkor* was back mapping on the upper slope in front of Ribbon Reef No. 10, and then continued the transit northwesterly towards the Cape York region. The ship passed Two Mile Entrance with the shallow reefs on the GBR shelf becoming exposed at low tide. At 1700, the *Falkor* arrived offshore of Cape Melville, the start of the main Cape York survey area and commenced upper slope mapping within the Clack canyons area. This is a very large unmapped, and therefore unknown, area of the offshore Cape York region, and so our first mapping pass revealed a dramatic seascape of multiple canyons incising the slope.

Friday 09 October 2020 Wind 16 kn from 120°. Sea state 4-5. Low-moderate swell. 0900 in position 13.921808°S 144.484227°E in vicinity of Tydeman Reef. Overnight, the *Falkor* continued mapping this large Clack canyons (south) area lying offshore of Princess Charlotte Bay in Cape York. The mapping lines, over 70 km long, slowly revealed a seascape comprised of multiple canyons and smaller gullies draining towards larger trunk canyons. Backscatter imagery showed high reflectance pixels, likely indicating coarse sediments, focussed within the axes of the larger canyons. With daylight, the ship focussed efforts in closer towards Tydeman Reef and the other shallow barrier reefs at the shelf edge. A broad ridge extended out from Tydeman Reef into the Osprey Embayment area, which was capped with a strange peak rising to a depth of 350 m, located about 5 km from the shelf edge. Informally, we called this the Tydeman Knoll. The ship continued mapping easterly close to the shelf edge, then doubled back around 1800 to continue mapping within deeper waters through the night.

Saturday 10 October 2020 Wind 19 kn from 120°. Sea state 4. Low swell. 0900 in position 13.886375°S 144.419261°E in vicinity of Rodda canyon. The *Falkor* continued mapping within the Clack canyons (south) area, focussing on the deeper >1500 m waters during nighttime, while mapping closer to the shallow reefs during the daytime. The canyons draining the Princess Charlotte Bay region are the most spectacular of canyon systems anywhere along the GBR margin - incredibly steep, deep and diverse in morphology. The strange looking Tydeman Knoll about 5 km out from the GBR shelf edge rises from ~700 to 350 m depth. At 0930, we conducted ROV dive #396 in the Rodda canyon, so named because this large canyon drains between Rodda and Wilson reefs. This is a shelf-connected canyon with an ancient river channel directly joining to the head of this canyon. The maximum depth was 1785 m, then did a transect up the northern sidewall of the canyon to a crest around 1370 m. A highlight was seeing a large amount of land-based vegetation, e.g. coconuts, mangrove seeds and even seagrass blades in the axis of the canyon. The ROV *SuBastian* recovered onboard at 1630. *Falkor* then commenced mapping again along the continental slope filling in data gaps overnight.

Sunday 11 October 2020 Wind 23 kn from 115°. Sea state 4-5. Low-moderate swell. 0900 in position 13.777029°S 144.306999°E in vicinity of Sand Bank No 5 Reef. The *Falkor* continued mapping over the data gaps throughout the Clack canyons (south) area overnight, then running a long east-west transect over deeper waters >2000 m within the adjacent Osprey Embayment. At 1000, the *Falkor* started heading southeast along the GBR upper slope closer to the shallow reefs, conducting mapping from Sand Bank No. 5 Reef towards Rodda Reef. The aim was to map a terrace feature that extends out from the shelf break. A cluster of possibly drowned reefs some 200-300 m in length, were discovered on the upper slope in depths 380 m. At 1200, the ship mapped over the head of the canyon between Rodda and Wilson reefs, which directly connected to an ancient river channel on the GBR shelf. This river channel would have fed freshwater directly to the head of the canyon when sea levels were about 100 m lower during the last Ice Age, about 20,000 years ago. The ship then headed easterly to commence deep >2000 m mapping in the Osprey Embayment area through the night.

Monday 12 October 2020 Wind 22 kn from 110°. Sea state 4-5. Low swell. 0900 in position 13.912771°S 144.506306°E in vicinity of Tydeman Knoll. Overnight, the *Falkor* continued mapping the deeper >2000 m waters adjacent to this Clack canyons (south) site. The ship then positioned for ROV dive #397 at the Tydeman Knoll, an unusual seamount-like feature discovered on the broad ridge extending out from Tydeman Reef. The knoll is about 1.4 km long, about half km wide and ~300 m high. The backscatter showed very high reflectance compared to the surrounding broad ridge. The dive commenced at 0900 to a maximum depth of 549 m and traversed across the eastern face looking for clues as to its geological origins and any associated marine life. The knoll itself was covered in a dark brown thick crust and quite hard, overlying a less resistant limestone substrate, leaving pits and caves in its surface. Large cod had taken up residence around the summit in 340 m. We recovered the ROV *SuBastian* at 1530 and commenced multibeam mapping northward towards the Clack canyons (north) area, with the aim to commence a long southeastly deep >2000 m mapping transect in the night.

Tuesday 13 October 2020 Wind 22 kn from 125°. Sea state 5. Moderate swell. 0900 in position 13.709360°S 144.838823°E in Osprey Embayment. With stronger winds in the Cape York region, the *Falkor* commenced mapping a large data gap area over the Queensland Trough, about 170 km long by 10 km wide. Thus, about 24 hours will be required to map the 1700 sq km. When

complete, the new map data will reveal the lower reaches of the canyons that lie offshore of Lizard Island. At 1000, the ship was 60 km northwest of Cape Melville in depths 2500 m deep, within the Osprey Embayment, tracking southwest and parallel to the GBR margin. By 2200, the ship was opposite the northern Ribbon Reefs and then turned around to commence the long transit back towards the Cape York region, edge mapping against existing multibeam data.

Wednesday 14 October 2020 Wind 20 kn from 125°. Sea state 4. Low-Moderate swell. 0900 in position 13.504196°S 144.676402°E in Osprey Embayment. The *Falkor* continued edge mapping existing multibeam data along the large data gap within the Osprey Embayment and Queensland Trough. The weather eased to make the northwestern run back towards Cape York much better conditions for everyone onboard. At 1300, we commenced a southward pass along the upper slope adjacent to Creech Reef and the nearby reefs. The prominent ledge on the upper slope, observed in earlier mapping, was also found along this stretch of the reef. The ledge was near continuous around the 450 m depth, lying above a steeper gradient slope within the heads of canyons at about 700 m depth. Several closer passes to the shallower reefs found the steep wall rising to the sea surface had a base depth at ~200 m. At 1800, the ship headed offshore away from the upper slope towards the deeper Osprey Embayment for mapping overnight.

Thursday 15 October 2020 Wind 23 kn from 125°. Sea state 4. Low swell. 0900 in position 13.518197°S 144.102591°E in vicinity of Noddy Reef canyon. After an overnight mapping transect in depths greater than 2000 m, the ship approached Noddy Reef for ROV dive #398 within a very prominent bowl that is the head of a canyon draining this section of the GBR margin. The site was selected as it is reef-blocked canyon (i.e. a reef lies at the head of the canyon). The ROV *SuBastian* had previously dived at #396 within a shelf-connected canyon (i.e. head of canyon is directly connected to the shelf through an inter-reef passage), and so having a contrasting site was important for comparisons between biota found in each type of canyon. The maximum depth was 824 m, with a climb up a steep wall to a ledge at 500 m. The steep wall was found to be a very hard rock and resistant to erosion. We then crossed the ledge above 500 m and then up vertical limestone wall into the mesphotic zone at ~100 m. The ROV *SuBastian* was recovered at 1700 and we commenced mapping within the Tijou canyons survey area.

Friday 16 October 2020 Wind 21 kn from 115°. Sea state 4-5. Low swell. 0900 in position 13.356451°S 143.979235°E in vicinity of Sand Bank No. 8 Reef. Through the night, the *Falkor* continued mapping the Tijou canyons survey area. Then, as daylight arrived, we commenced mapping northward along the shallower upper slope to just seaward of the Tijou Reefs in the shallower depths. We completed the northern transit along Tijou Reef at 1230, then turned around and started edge mapping southward against our previous multibeam data. Throughout the evening, the ship continued mapping the deeper >1000 m slope, filling in data gaps to reveal a similarly complex canyon system.

Saturday 17 October 2020 Wind 21 kn from 115°. Sea state 4-5. Low swell. 0900 in position 12.800382°S 143.831274°E in vicinity of Log Reef (South). Around 0200, the *Falkor* had completed mapping the Tijou canyons survey area, and then commenced a mapping transit northward along the Bligh canyons survey area, about one nautical mile offshore of the shallower coral reefs. We continued a northward transit through the morning, mapping around the Southern Small Detached Reef, then at 0800 headed southward closer to the shallow reefs. At 1230, the *Falkor* reached Tijou Reef then turned around again and commenced mapping northward along the Bligh canyons survey area, filling in data gaps through the afternoon and into the evening.

Sunday 18 October 2020 Wind 18 kn from 125°. Sea state 4. Low swell. 0900 in position 12.535431°S 143.860730°E in vicinity of Southern Small Detached Reef. The *Falkor* continued mapping the continental slope between Tijou Reef and Bligh Reef. The ship then headed to the Small Detached Reefs survey area. The detached reefs of the far northern GBR are strange, extending several km out from the GBR shelf. These detached reefs rise up from a broad, relatively flat ledge that extends at a depth 400-600 m out from under the GBR shelf. The surface of this ledge has numerous pinnacles and even broad snaking 'river' channels, which in places lead to remarkable circular 'plunge pools' with vertical walls over 300 m high, as if the remains of ancient waterfalls. If we are looking at the remains of waterfall-carved landscape, then the 400-600 m ledge are the remains of a once exposed Australian landscape, now subsided over deep geological time. ROV dive #399 commenced at 0900 with a maximum depth of 1108 m within the base of the 'plunge pool'. Many sponges, squid and fish were seen, with samples of rock taken for later analysis. The ROV *SuBastian* was recovered at 1630 and then the ship commenced reef edge mapping.

Monday 19 October 2020 Wind 15 kn from 110°. Sea state 4. Low swell. 0900 in position 12.320923°S 143.892582°E in vicinity of Southern Small Detached Reef. The morning was spent mapping the Small Detached Reefs survey area, building upon the mapping efforts over the previous day across this prominent 400-600 m deep ledge. Submarine canyons lie to seawards of this hard rock ledge, eroding into the softer sediments of the main continental slope. With daylight, the *Falkor* commenced mapping the shallower shelf edge in depths ~60 to 200 m, working northwards around Mantis Reef and towards the prominent Wreck Bay. At 1030, the *Falkor* entered Wreck Bay for the first time, mapping in a clockwise direction around the shallower reef edge. The first lap around the inside Wreck Bay was completed at 1300, revealing a similar flat, broad ledge ~400-700 m deep, with gullies coalescing towards the centre.

Tuesday 20 October 2020 Wind 9 kn from 120°. Sea state 3. Low swell. 0900 in position 12.099041°S 143.948698°E in vicinity of Wishbone Reef. The *Falkor* continued mapping inside of Wreck Bay overnight, completing the work by daybreak. The bay is about 20 km long by 15 km wide, and is bowl-shaped with two distinct channels cut into the surface. These channels drain into a spectacular 'plunge pool' dropping to 1100 m with vertical sides 300 m high, similar to the plunge pool we dived on during ROV dive #399. Then lying below this upper plunge pool is another deeper plunge pool, with a near-vertical cliff from 1200 to 2000 m - a truly incredible seascape lying offshore of Cape York. At 0900, the ROV dive #400 commenced up the steep reef wall at Wishbone Reef, which forms the northern boundary of Wreck Bay. Happy birthday to ROV *SuBastian* on this 400th dive since the first dive in 2016. The maximum depth was 507 m with a transect across some ~60 m high pinnacles, looking for evidence these are drowned reefs, and then climbed up the steep reef wall into the mesophotic zone. The *SuBastian* was recovered at 1630 and the ship headed south past the entrance to Wreck Bay towards the Northern Small Detached Reef survey area, to map as much as possible in daylight. Throughout the remaining evening, *Falkor* continued to map around these detached reefs.

Wednesday 21 October 2020 Wind 10 kn from 110°. Sea state 3. Low swell. 0900 in position 12.363141°S 143.901765°E in vicinity of Northern Small Detached Reef. The *Falkor* continued mapping near the Northern Small Detached Reef, by mapping gaps in the previous multibeam data. At 1000, the *Falkor* discovered and mapped a newly discovered detached reef lying 2.5 km northeast of Northern Small Detached Reef. This new reef rises about 500 m in vertical height

above the surrounding broad ledge. The reef is blade-like in plan view, with the shoaler part of the reef (that part of reef shallower than 70 m depth) about 300 m long by 50 m wide. The shoal depth measured was 41.6 m, so with predicted tides of 1.6 m (Raine Island at 1000), results in a shoal depth of 40.0 m (vertical datum LAT). This new reef is not a danger to navigation, but it is still significant that one can still discover such tall reefs (~500 m high) in the far northern GBR. This new discovery points to the remoteness of the area and rarity of opportunities to map with modern technologies in these deeper waters. Looking at old charts from the late 1800s, which first mapped these detached reefs, the discovery is the first new detached reef to be mapped in the Great Barrier Reef in over 120 years. The ship then commenced mapping northward, following the shelf edge inside the bay surrounding Yule Detached Reef. At 1900, the ship completed the shallower mapping adjacent to Great Detached Reef and commenced the transit north towards the Torres Strait for refuelling.

Thursday 22 October 2020 Wind 12 kn from 120°. Sea state 3. Low swell. 0900 in position 10.091747°S 144.051876°E in vicinity of Murray Islands, Torres Strait. Through the early morning, *Falkor* continued to map the shelf edge and upper slope of the far northern Great Barrier Reef on the transit towards the Torres Strait. At 0900, the volcanic Murray Islands were within view as the ship mapped northward. The multibeam data were the first ever collected along the far northern GBR this close to the shallow barrier reefs, providing an insight into the edge of the reef, which has only ever been mapped previously using airborne lidar bathymetry. At 1500, the *Falkor* completed the northern transit along the GBR shelf edge, successfully revealing the continental slope bounding the reef. The ship then headed northeast across the Gulf of Papua towards the merchant vessel traffic corridor into Torres Strait. At 2330, all multibeam systems were turned off as the ship entered Great North East Channel for passage through Torres Strait.

Friday 23 October 2020 Wind 13 kn from 115°. Sea state 3. Nil swell. 0900 in position 10.206966°S 142.932450°E in Great North East Channel, Torres Strait. The *Falkor* continued southwest down the Great North East Channel overnight. All multibeam systems were turned off, as the channel is shallow and well surveyed. At 0500, the Pilot was taken onboard for the transit into Horn Island. We rounded Thursday Island and berthed at Horn Island at 1700. Fuelling at Horn Island was successful and the ship departed at 2100 for transit back towards the Great North East Channel.

Saturday 24 October 2020 Wind 11 kn from 110°. Sea state 3. Nil swell. 0900 in position 09.371000°S 143.650666°E in Great North East Channel, Torres Strait. Through the morning, the *Falkor* transited northeast through the Great North East Channel, passing Stephens Island at 0800. On exiting the deep-water channel at the entrance to Torres Strait at 1140, both the EM302 and EM710 multibeam systems were turned back on as the ship headed towards the previously mapped track at the far northern limits of the Great Barrier Reef. At 1500, the *Falkor* re-joined the previous track at the far northern limit of the Great Barrier Reef and then continued the track southward, edge mapping the previous multibeam data back towards the detached reefs.

Sunday 25 October 2020 Wind 9 kn from 145°. Sea state 2. Nil swell. 0900 in position 11.751253°S 144.105222°E in Great Detached Reef. Overnight, the *Falkor* continued edge mapping the previously collected map data along the far northern GBR shelf edge and upper slope. At 0600, the ship arrived at Saunders Reef, the northern-most detached reef, and passed the eastern side of Raine Island Reef. At 0830, the ship mapped the steeper flanks of Great

Detached Reef. From 1000, the *Falkor* commenced mapping Yule Detached Reef in a clockwise direction. The first circuit was completed at 1230, for another wider circuit around Yule Detached Reef. Weather conditions were calm and perfect for close shallow reef edge mapping. At 1600, the *Falkor* had completed a circuit of Woody Reef, a smaller detached reef lying north of Yule Detached Reef.

Monday 26 October 2020 Wind 7 kn from 120°. Sea state 2. Nil swell. 0900 in position 12.401896°S 143.854743°E in vicinity of Northern Small Detached Reef. With excellent weather offshore of Cape York, the *Falkor* had completed mapping about half of the Yule Detached Reef survey area. This is a similar sized bay compared to Wreck Bay just to the south. At 0500, the ship departed the Yule Detached Reef survey area to transit to the newly discovered ~500 m tall reef, about 2.5 km north of Northern Small Detached Reef. ROV dive #401 was commenced at 0900 with a maximum depth of 578 m. The dive revealed a hard limestone substrate with much mobile marine life around the base of the reef, increasing in sessile benthos coverage as we ascended. The summit was covered in reef fish and had at least four large sharks circling. Shallow corals, sponges and algae were prolific at the top of the reef. The dive confirmed the newly discovered reef was a significant reef coral habitat at shallower depths. The ROV *SuBastian* was recovered by 1700, and then the ship commenced mapping northward towards the Yule Detached Reef survey area.

Tuesday 27 October 2020 Wind 8 kn from 145°. Sea state 2. Low swell. 0900 in position 12.129181°S 143.974720°E in vicinity of Wreck Bay. Overnight, the *Falkor* completed mapping the Yule Detached Reef survey area, and mapping the waters deeper than 1000 m to seaward of Wreck Bay. At 0900, the ship arrived at the 'plunge pool' at the entrance to Wreck Bay for ROV dive #402. Maximum depth was 2017 m, initially as a slow midwater descent with Dhugal Lindsay narrating to describe the midwater plankton species. At the seafloor, huge blocks of sedimentary rock lay scattered about, broken from the steeper cliffs above. Samples found these rocks to be non-marine mudstone and sandstone, thought to be outcrops of ancient continental rock, having subsided over long geological time and now exposed at these deeper depths. The ROV *SuBastian* was recovered at 1730, then the ship commenced multibeam mapping to seaward of the Great Detached Reef survey area.

Wednesday 28 October 2020 Wind 12 kn from 125°. Sea state 3. Low swell. 0900 in position 12.531287°S 143.983370°E in vicinity of the Small Detached Reefs. We completed the mapping along the Cape York Peninsular, as far north as the Great Detached Reef survey area, then at 0600 commenced our transit return to Cairns for the Leg 2/Leg 3 crew-changeover. The mapping continued through the transit back to Cairns, along the deeper parts of the previously mapped data coverage in an effort to fill in any data gaps. At 1300, the ship was 12 km east of the tip of Tijou Reef mapping southwards over along the foot of the continental slope. Through the evening, the *Falkor* continued mapping over previously collected data gaps along the lower continental slope in depths >2000 m.

Thursday 29 October 2020 Wind 08 kn from 150°. Sea state 3. Low swell. 0900 in position 14.631951°S 146.030877°E in the northern Queensland Trough. The *Falkor* mapped the lower continental slope through the night, then at daybreak headed east into the Coral Sea Marine Park across the Queensland Trough in depths greater than 2000 m. At 1200, the ship commenced a westerly transit back towards the Great Barrier Reef margin. By 1330, the ship had returned to upper slope opposite Ribbon Reef No. 10, then headed southward mapping

along the upper slope in depths ~600 m. Weather conditions were excellent as the ship continued towards Cairns.

Friday 30 October 2020 Wind 08 kn from 150°. Sea state 3. Nil swell. 0900 in position 16.928250°S 146.780216°E at Cairns wharf. At 0300, the *Falkor* entered Grafton Passage opposite Cairns to commence the transit into Cairns Port. The Pilot boarded at 0730 and by 0800, the ship had berthed at the main Cairns Wharf. The Leg 2 Science team participants Robin Beaman, Valerie Cornett and Joan Li left the ship at 0930, while Luke Nothdurft and Aimee Catalan joined for Leg 3. The remainder of the day was spent reprovisioning and refuelling, and the ship's crew changeovers.

Saturday 31 October 2020 Wind 08 kn from 150°. Sea state 2. Nil swell. 0900 in position 16.928250°S 146.780216°E at Cairns wharf. With the ship alongside Cairns Wharf, preparations were made for sailing through the day. At 1530, emergency drills were conducted onboard, and then at 1800 the *Falkor* departed Cairns for the transit out of Grafton Passage. At 2130, the ship had exited Grafton Passage then headed southward along the upper slope towards the Swain Reefs. Both the EM710 and EM302 multibeam sonars were started and mapping recommenced.

Sunday 01 November 2020 Wind 03 kn from 090°. Sea state 2. Low swell. 0900 in position 17.948313°S 146.932616°E in vicinity of Barnett Patches reef. The *Falkor* continued mapping the upper continental slope southward from Cairns through the night. By daybreak, weather conditions were very flat and mapping commenced closer to the shelf break in depths ~150 m. At 0900, the ship was opposite the outer-shelf Barnett Patches reef. At 1300, the *Falkor* traversed the entrance to Palm Passage, then at 1400 conducting a clockwise transit around Myrmidon Reef with depths around 220 m. From around 1500 to 1800, the *Falkor* transited across the upper part of the Swain slide, close to where ROV dive #394 was previously located.

Monday 02 November 2020 Wind 11 kn from 110°. Sea state 3. Low swell. 0900 in position 19.340496°S 149.617573°E in vicinity of Joist Reef. The *Falkor* continued to make good progress through the night towards the Swain Reefs. At 0900, the vessel was near Joist Reef on the upper continental slope, conducting edge mapping against previous multibeam data. Depths were about 150 m. At 1100, the *Falkor* stopped to conduct a stationary sound velocity (SV) profile in ~180 m water depth. With the SV profiling completed at 1230, the *Falkor* continued mapping the upper slope towards Hydrographers Passage. At 1330, the *Falkor* transited across the entrance to Hydrographers Passage in depths ~120 m. Through the evening, the ship headed southeast across the north Marion Plateau towards the Swain Reefs. Numerous small pinnacles were observed in depths ~130 m.

Tuesday 03 November 2020 Wind 21 kn from 130°. Sea state 4. Low-moderate swell. 0900 in position 20.823511°S 151.995198°E in vicinity of the Swain Reefs. In the early morning, *Falkor* commenced the systematic survey of the Swain 'embayment' – a broad bay on the shelf edge and upper slope of the Swain Reefs. The origin of this embayment is unknown, and the mapping may reveal why there is a distinct change from a low gradient, but deeper shelf edge to the west, compared to a shallower but much steeper shelf edge to the east. By 0900, the ship had completed the first pass in depths ~270 m. As stronger winds developed throughout the day, effort was made to stay in relatively deep water. The second east to west pass was completed at 1330. The third west to east pass was completed at 2100, before reversing course to head west in depths ~270 m.

Wednesday 04 November 2020 Wind 14 kn from 130°. Sea state 4. Low swell. 0900 in position 20.767853°S 151.428547°E in vicinity of the Swain Reefs. Through the early morning, the *Falkor* continued westerly across the deeper waters of the Swain 'embayment'. With daybreak and easing windy conditions, the ship headed towards the reef to commence mapping closer to the shoals revealed by the lidar survey of the area. Progress was slowed to around 5-6 kn due to the unknown nature of the seafloor. Numerous small pinnacles were found to lie seawards of the shoals. At 1100, the ship was close to the southern-most part of the embayment. The seafloor here remained consistent at 60-70 m. At 1530, the ship completed the close to reef mapping, then looped back to edge map from east to west. The shelf break became far more obvious with a step revealed at ~110-140 m. Another step appeared higher up on the shelf edge at ~80-90 m. At 1820, the ship had completed this edge mapping close to the shelf edge, then reversed and conducted two more passes in depths ~200 m through the evening.

Thursday 05 November 2020 Wind 05 kn from 330°. Sea state 2. Low swell. 0900 in position 20.813045°S 151.491985°E in vicinity of the Swain Reefs. The *Falkor* continued mapping the deeper offshore areas in depths ~200 m through the night, then at daybreak transited closer to the shelf edge in depths ~100 m. By midday, the vessel had completed a shallow pass from east to west, then reversed course to map the shelf break itself at 100-120 m depth. Towards the evening, the ship broke off from the survey ground and headed north away from the GBR for engineering purposes.

Friday 06 November 2020 Wind 07 kn from 310°. Sea state 2. Low swell. 0900 in position 20.899002°S 151.725517°E in vicinity of the Swain Reefs. The *Falkor* continued to map the Swain 'embayment' revealing the shelf break at around 115 m. However, another ledge appeared below this at ~150 m, then dropping to ~175 m. This deeper ledge is unlikely to be the Pleistocene shelf break, which is typically between 90-120 m along the entire GBR margin, and so must be older than Pleistocene in age. From 1100 to 1400, the ship did a long pass across the embayment at ~150 m to delineate the limits of this deeper ledge. At 1400, the *Falkor* commenced a shallow ~60 m survey on the shelf edge in depths ~60 m at the far western area of the embayment, to reveal the lagoon-style seafloor. This shallow mapping work continued until nightfall, and then the ship transited into deeper waters ~250 m and continued mapping the remaining gaps through the night.

Saturday 07 November 2020 Wind 11 kn from 120°. Sea state 3. Low swell. 0900 in position 20.801203°S 151.521727°E in vicinity of the Swain Reefs. Through the early morning and then for most of the daytime, the *Falkor* worked on completing the mapping of the larger Swain 'embayment' area in depths around 200-250 m. By 1600, the ship had completed this area and commenced transit east towards the wedge-shaped data gap between the Swain embayment and the previously mapped Swain slide.

Sunday 08 November 2020 Wind 21 kn from 115°. Sea state 4. Low-moderate swell. 0900 in position 20.958931°S 152.392081°E in vicinity of the Swain Reefs. The wedge-shaped data gap between the Swain embayment and the previously mapped Swain slide was completed at 0830, then the *Falkor* continued easterly following the upper slope towards the Swain slide. By 1200, the ship had passed through the Swain slide scarp and then transited between the 5 km wide gap between the Swain Reefs and Elusive Reef. The ship continued to map the upper slope in depths ~65 m, then at 1230 headed east towards Saumarez Reefs. At 1500, the ship crossed from the Great Barrier Reef Marine Park and into the Coral Sea Marine Park. At 1828, the *Falkor*

arrived at the northwest corner of Saumarez Reefs and commenced a clockwise loop mapping along the steeper upper flanks of this 38 km wide reef.

Monday 09 November 2020 Wind 22 kn from 125°. Sea state 4-5. Moderate swell. 0900 in position 21.118488°S 154.168184°E in vicinity of Frederick Reef. Overnight, the *Falkor* completed the clockwise mapping loop around Saumarez Reefs, and then headed towards Frederick Reef. Depths were generally deeper than ~2000 m and relatively flat. At 1000, the ship arrived on the southwest corner of Frederick Reef and conducted a CTD dip to test the sensors in deeper waters. The CTD dip was completed at 1200, and then the ship carefully made way into the western lagoon area of Frederick Reef. Weather conditions proved too rough, so the island visit at Frederick Reef was cancelled. At 1300, the ship commenced a clockwise mapping transit around the steeper flanks of Frederick Reef. Poor weather conditions made mapping operations challenging while heading into the wind. At 1730, the ship once again tried mapping down the windward, eastern side of the reef due to the poor quality of the data form the previous lap. At 1841, the *Falkor* had completed its final pass of Frederick Reef and commenced the transit easterly towards the Kenn Reefs.

Tuesday 10 November 2020 Wind 18 kn from 125°. Sea state 4. Moderate swell. 0900 in position 21.205689°S 155.624366°E in vicinity of Kenn Reefs. Strong winds continued to make mapping operations challenging. Overnight, the *Falkor* worked easterly towards the Kenn Reefs. The ship approached the northern flanks of Kenn Reefs in the early morning and commenced a systematic survey of the deeper waters surrounding the reef. With daybreak, mapping continued down the western side. Then at 1000, the ship carefully transited across the lagoon towards the southwest sand cay. At 1019, the ship arrived close to the sand cay to assess wind and swell conditions; however, the swell was too strong. At 1040, the ship exited the lagoon and recommenced counter-clockwise mapping of the steeper flank around Kenn Reefs. At 1300, the ship had passed the eastern extremity of Kenn Reefs in depths ~400 m and then headed north. Through the night, the ship mapped the eastern flanks of the Kenn Reefs.

Wednesday 11 November 2020 Wind 16 kn from 125°. Sea state 4. Moderate swell. 0900 in position 21.275284°S 155.625095°E in vicinity of Kenn Reefs. Through the morning, the *Falkor* mapped the eastern and southern steeper flanks of the Kenn Reefs, then prepositioned to the southwest corner at 0730 to commence a transit onto the lagoon in order to drop off the boat team. At 0800, the small boat team departed the ship to commence a photographic survey of the southwest sand cay. The ship departed the lagoon and started mapping the shallower flanks on the west side of Kenn Reefs. At 1100, the ship made its way again into the lagoon to recover the boat team from the southwest cay. On recovery, the *Falkor* headed to the northern side of Kenn Reefs where a broad, deep plateau extended northward of the reef. Mapping continued through the night along the western edge of this deeper bank in depths ~1500-3000 m.

Thursday 12 November 2020 Wind 14 kn from 120°. Sea state 3. Low-moderate swell. 0900 in position 20.924996°S 155.658621°E in vicinity of Kenn Reefs. Through the early morning, the *Falkor* mapped the western side of the deeper bank extending northward of Kenn Reefs. Multibeam backscatter imagery showed high reflectance pixels, likely revealing the hard, rough volcanic rocks exposed at the seafloor on this bank. At 1030, the ship left the Kenn Reefs, and commenced transit southwards towards the Wreck Reefs. Mapping continued through the day over a relatively flat seafloor in depths around 3000 m. At 1630, the ship stopped northeast of

the Wreck Reefs to conduct a deep CTD dip. The CTD dip concluded at 1800. The ship continued to Wreck Reefs, arriving at 2100 and then mapping around the steeper reef flanks.

Friday 13 November 2020 Wind 13 kn from 050°. Sea state 3. Low swell. 0900 in position 22.153841°S 155.302983°E in vicinity of Wreck Reefs. The *Falkor* mapped around the steep upper flanks of the Wreck Reefs, then transited close to Bird Cay to drop off the boat team for their visual surveys of the cays and islands. The ship then continued mapping the upper steep flanks around Wreck Reefs while waiting for the boat crew to return. Good weather conditions allowed high quality mapping data in these shallower waters, with the vessel doing several laps around Wreck Reefs. The boat team was recovered at 1500, and then the ship departed the Wreck Reefs area heading southward towards Cato Reef.

Saturday 14 November 2020 Wind 06 kn from 325°. Sea state 2. Low swell. 0900 in position 23.149284°S 155.513713°E in vicinity of Cato Reef. The *Falkor* mapped towards Cato Reef through the morning and conducted a series of laps around the reefs steeper flanks. At 0800, the small boat team departed the ship for Cato Island – the largest island of the Coral Sea Marine Park, to conduct photographic surveys of the bird and turtle nesting. Through the day, the ship continued mapping around the steeper flanks of the island, then at 1300 the ship hove to, awaiting the arrival of the small boat team onboard. The small boat team was recovered at 1500, and the ship departed Cato Reef, heading westerly back towards the Great Barrier Reef. The *Falkor* passed over the Cato Trough at 2000, and continued to head west across the deeper flanks of the South Marion Plateau.

Sunday 15 November 2020 Wind 10 kn from 340°. Sea state 2. Low swell. 0900 in position 23.916100°S 153.847323°E in the vicinity of the Fraser Canyon. The *Falkor* mapped westerly through the morning then arrived at the head of the Fraser Canyon – a large ~100 km long canyon that drains sediments from both the Great Barrier Reef shelf and the South Marion Plateau. The ship commenced north-south mapping lines, filling in gaps until 1000, then headed west to map the smaller feeder gullies into the canyon. Good weather conditions allowed efficient surveying in ~1700 m depths across the slope feeding into the main Fraser Canyon axis. Several narrow gullies were revealed draining west-east across the slope. The mapping of the area continued through the night, filling in data gaps to reveal the large network of gullies feeding into the Fraser Canyon.

Monday 16 November 2020 Wind 06 kn from 055°. Sea state 2. Low swell. 0900 in position 24.675721°S 153.837909°E in the vicinity of the Fraser Canyon. The *Falkor* continued west-east systematic mapping through the morning, then at 0630 broke off all systematic mapping of this Fraser Canyon to commence the final transit back towards Brisbane. Through the morning, the ship mapped the middle continental slope, heavily incised with canyons, around 3000 m depth. By 1400, the *Falkor* had worked upslope onto the relatively smooth upper slope east of Fraser Island, then continued edge mapping the previous Leg 1 multibeam data in depths around 250 m.

Tuesday 17 November 2020 Wind 09 kn from 340°. Sea state 2. Nil swell. 0900 in position 27.443581°S 153.076226°E alongside wharf in Brisbane Port. At 0100, the *Falkor* completed edge mapping the upper slope along the Fraser shelf, then headed west across the shallow shelf towards the pilot boarding ground north of Stradbroke Island. The Pilot boarded at 0500 and

the ship commenced pilotage across Moreton Bay. The ship berthed at 0900 in Brisbane Port and concluded the voyage FK200930 “Northern depths of the Great Barrier Reef”.