



Seamounts, Canyons & Reefs of the Coral Sea

30-day Post Cruise Report

Ship name: Falkor

Cruise Dates - Day Departed: 08/01/2020 **Day Returned:** 08/30/2020

Cruise Number: FK200802

Departure Port: Cairns, Australia **Arrival Port:** Brisbane, Australia

Mid-Cruise Port Call (if any): Cairns, Australia

Participating Organizations, Institutions, Foundations, Government Agencies, etc. Geoscience Australia, James Cook University, University of Sydney, Queensland University of Technology, Queensland Museum, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Parks Australia, University of Wollongong, University of Tokyo

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Name of Chief Scientist: Brendan Brooke

Organization: Geoscience Australia

Country: Australia

Phone: +61 427203899

Email: Brendan.Brooke@ga.gov.au

Name of Co - Chief Scientist: Scott Nichol

Organization: Geoscience Australia

Country: Australia

Email: Scott.Nichol@ga.gov.au

Geographical Area of Operation: The Queensland Plateau area of the Coral Sea Marine Park; and the outer margins of the northern section of the Great Barrier Reef

Cruise Objectives and Importance of this work:

The overarching goal of this project is to identify the influence of long-term environmental processes on the present-day characteristics and distribution of benthic biological communities

in an important but poorly known region of Australia's marine area, the northern Great Barrier Reef (GBR) and adjacent Queensland Plateau. By acquiring geophysical, geological, biological and oceanographic data and samples, we will vastly improve our knowledge of benthic environments in this frontier region, identify habitat-benthic community relationships for predictive modeling of communities, and help develop an integrated understanding of Australia's Coral Sea ecosystem. Our research has two key interrelated objectives:

1. To map, characterise and sample the spatial distribution (including bathymetric distributions - abyssal to mesophotic) of seabed substrates and benthic communities in submarine canyons on the outer margin of the GBR shelf. By acquiring these biological data and samples and comparing them with seabed geomorphology and geology, plankton (jellyfish) communities and oceanographic data, we can reveal the features and processes driving biodiversity patterns in these deep-water settings.
2. To map, characterise and sample the seabed, epibenthic and plankton communities on the margins of platform reefs on the Queensland Plateau. Surveying these reef margins will indicate their potential to provide refuges for communities impacted by a rapidly warming marine environment, and reveal the influence of past lower sea levels on reef morphology and the present-day spatial patterns of biodiversity.

Cruise Summary:1

Overview

We successfully acquired the planned sets of data that will enable us to address the key objectives of the project, namely to map and characterise the benthic and mid-water environments of the margins of platform reefs on the Queensland plateau and in canyons on the outer edge of the Great Barrier Reef. These data will enable us to identify the influence of long-term environmental processes on the type and distribution of benthic and pelagic biological communities, and greatly increase the knowledge base of major ecosystem processes in the GBR and Coral Sea Marine Parks.

Overall, we experienced exceptionally good sea conditions throughout the two legs of the cruise, enabling the acquisition of extensive bathymetry (MBES), imagery (ROV, AUV) and CTD data sets and samples. The focus of leg 1 was several reefs on the Queensland Plateau (Flinders, Herald, Malay Reefs) and Cairns Seamount, while leg 2 examined the GBR Canyons offshore Ribbon Reefs, northeast of Cairns, and Osprey Reef.

Cruise highlights include ROV dives across the full depth range of platform reefs and canyons, recording benthic species and communities from 1,800 m up to the mesophotic zone in around 100 – 60 m. We also imaged and sampled jellyfish through the water column during the descending phase of ROV dives, identifying undescribed species and new information on species distributions. AUV dives employed national standard methods to acquire high-resolution image transects across the mesophotic zone of three platform reefs that will enable

a quantitative assessment of biodiversity, a comparison with other national survey sites and can be revisited to monitor change.

Research Operations and Data Collection

Multibeam Sonar Mapping: The total area of the Coral Sea now mapped using high-resolution multibeam sonar is 38,395 square kilometres, which includes the margins of all major coral atolls on the Queensland Plateau (Coral Sea Marine Park) and canyons offshore from the Ribbon Reefs (GBR Marine Park) - for comparison, the city of greater Sydney is 12,400 km² – so, Falkor has mapped an area three times the area of Australia's largest city.

ROV Operations:

- 112 hours of high definition underwater video collected across 18 dives
- 105 samples of hard and soft corals
- 89 samples of seabed sediments and rocks
- 31 samples of jellyfish during mid-water dives
- Deepest video was acquired at a depth of 1825 m
- Deepest zooxanthellate alcyoniid coral ever collected in the GBR Coral Sea at 70 meters depth; and the deepest zooxanthellae Scleractinia coral at 130m.

AUV Operations:

- 91,186 high-resolution seabed images acquired across 7 AUV dives in mesophotic areas on the margins of Flinders, Herald and Malay Reefs and on the crest of Cairns Seamount.

CTD Casts:

- 11 stations: Flinders, Malay, Osprey, Tregrosse and Lihou Reefs, Herald Cay, Cairns Seamount, and Ribbon Reef 5 and Ribbon Reef 10 canyons.

Cruise Highlights

- High resolution maps of the seabed reveal new detail about the geomorphic processes operating within canyons and around the margins of reefs and seamounts, with undersea landslides, turbidity flow deposits and active sediment bedforms prominent features.
- Landslide blocks have been found to be important aggregation areas for seabed life in deeper waters adjacent to reefs, providing hard substrate for filter feeders and fine scale structures such as crevices and cave habitat for fish and crustaceans.
- Improved understanding of the link between the Great Barrier Reef lagoon and outer reefs, with data collected that maps the pathways of sediment transport from reefs to submarine canyons and the deep sea.
- First ever photography and samples of deep water seabed habitats in the Great Barrier Reef Marine Park, with cameras taken to 1800 m in the Ribbon Reef submarine canyons.
- First ever sample of the ancient bedrock that underlies the Great Barrier Reef, with a sample of mudstone estimated to be 40-50 Million years old collected at 1350 m depth from rock exposed in a canyon wall.
- At least 3 species of coral collected are new to science including a new species of black coral in the genus *Heteropathes*.

- High quality, undamaged coral specimens that can be used to extract DNA for genetic sequencing. The genetic data will be used to improve the taxonomy of hard, soft, and black corals, and answer long-standing questions about their evolutionary histories.
- First recorded observation for Australia of an extremely rare fish, *Rhinopias agroliba* – located in the deeper waters of Tregrosse Reef (Coral Sea).
- Huge extent of mesophotic coral reef in the Coral Sea Marine Park, with no evidence of bleaching from recent events that impacted on the Great Barrier Reef in 2020 (or earlier in 2016 and 2017).
- High-resolution multibeam mapping reveals ancient reef platforms that lie submerged in hundreds of metres of water. Younger reefs sit atop the ancient reefs, mostly sitting in 60-100 metres of water. ROV images reveal dramatic cliffs, overhangs and caves around the margins of the reefs. In contrast, modern surface reefs represent a small proportion of the reef platforms examined.
- First records for the southern hemisphere for over 15 species of jellyfish with very large differences in communities at different dive sites, highlighting their diversity. Several undescribed species were recognized, with many of these being sampled for further taxonomic work. This was the most comprehensive midwater ROV dive survey series to ever have been conducted in the South Pacific.
- The survey has integrated a range of technologies that have allowed us to work across the full range of ocean depths in the Coral Sea and to provide data for multiple disciplines (geology, biology, oceanography). The data acquired ranges from shallow water ROV and AUV vision of mesophotic seabed communities to ROV Subastian's mid-water and seabed video footage and still images of deep reefs and canyons.
- The combination of high resolution seabed mapping, ROV observations and samples provides us with robust data sets from which we can build models of habitat distributions for the Coral Sea Marine Park and canyons in the Great Barrier Reef Marine Park. Importantly, models can be built to represent patterns across depths and across geomorphic features (reefs, canyons, seamounts).
- These new maps, samples and images give us a new understanding of the geological diversity and biological wealth contained in different zones of the Coral Sea Marine Park. This information can support implementation of management plans for the marine parks.
- Media Outreach. Live streaming of the ROV dives has allowed the science team to share their knowledge and excitement of the voyage discoveries with the world; and to interact directly with people (via chat and our commentary). The 4K vision made these live streams all the more impactful.

Did you deploy and/or recover any Moorings, Bottom Mounted Gear, or Drifting Systems? No Equipment Used & New Technologies tested: ROV SuBastian; AUV Sirius; MBES Systems; Sub-bottom Profiler; CTD

Total number of CTD casts completed during the cruise: 11

Total number of AUV dives completed during the cruise: 8

Total number of ROV dives completed during the cruise: 21

Total number of ROV samples collected during the cruise: 226

Total number of Unmanned Aerial Vehicle (UAV) or other vehicle deployments during the cruise: 10

Summary of Operations and Data Collection:

Wednesday 29 April 2020

Wind 3 kn from 150°. Sea state 1. Nil swell.

0800 in position 16.823199°S 145.851310°E anchored at Cairns Harbour.

At 0800, *Falkor* left its anchor position and headed into Cairns Harbour for reprovisioning and refuelling at Cairns Wharf. At 1500, Dr. Rob Beaman visited the ship briefly to meet with the crew before sailing, with appropriate social distancing due to COVID-19 restrictions. At 1600, the vessel departed Cairns to commence Voyage FK200429. *Falkor* transited through Grafton Passage across the Great Barrier Reef (GBR) shelf and then turned northward towards the first Plateau cliff survey area. The EM302 multibeam was turned on after entering the Coral Sea Marine Park to collect new multibeam data on the transit.

Thursday 30 April 2020

Wind 12 kn from 120°. Sea state 3. Low swell.

0800 in position 14.503716°S 146.326232°E in vicinity of Plateau ridge survey area.

Falkor continued transiting northward through the night towards the Plateau ridge survey area. This survey target had already had some multibeam data collected across it from the previous Torres Strait - Cairns transit during voyage FK200409, so additional multibeam data were collected on the eastern side of the ridge. On completion, *Falkor* headed northeast towards the northern tip of Osprey Reef.

Friday 01 May 2020

Wind 12 kn from 130°. Sea state 3. Low swell.

0800 in position 13.984582°S 146.729155°E at the southeast corner of Osprey Reef.

Overnight the ship continued mapping around the northern and western side of Osprey Reef on the deeper flanks. During daylight hours, the ship mapped higher up the flanks towards the shallower reef around the eastern and southern side of Osprey Reef. At 1400, ROV SuBastian was lowered into the water at the southwestern corner of Osprey Reef for ROV dive #354. Target depth was 1564 m with a ~ 4-hour dive up to ~1000 m for a vertical transect up a steep cliff. This was the first test of the shoreside communications with Dr. Rob Beaman providing commentary through Rendezvous-Wirecast software. The broadcast seemed to go well, with

some highlights being the stalked crinoids, pygmy dumbo octopus and coldwater corals. The ROV was recovered around 1800 and *Falkor* commenced multibeam mapping through the night within the Osprey Reef survey area.

Saturday 02 May 2020

Wind 16 kn from 130°. Sea state 4. Low swell.

0800 in position 13.819541°S 146.553568°E at North Horn, Osprey Reef.

Falkor had completed much of the deeper flank mapping around Osprey Reef overnight including one pass around Shark and Vema Reefs. A large underwater landslide and debris boulders revealed a flank collapse of the Shark and Vema Reefs. The ship then transited towards North Horn at the very northwestern tip of Osprey Reef. At 0930, ROV SuBastian was launched with a live broadcast from ~1015 as ROV dive #355. The target was 1011 m at the base of a steep ridge and to generally follow the 2009 German Deep Downunder ROV transect up the ridge. The live broadcast went well but some lag was noticed between the timing of the video and the audio from shore. Highlights were the numerous nautilus bobbing around the ROV, over 15 counted, between ~700-500 m. We also saw the transition from coldwater communities to warmer mesophotic communities around ~500-400 m. The ROV was recovered at 1600 and the vessel commenced surveying the shallower flanks while in daylight.

Sunday 03 May 2020

Wind 16 kn from 115°. Sea state 4. Low swell.

0800 in position 13.926814°S 146.477337°E on west side of Shark and Vema Reefs.

The ship continued mapping through the night as the wind picked up. A second pass around Shark and Vema Reefs mapped the deeper parts of these reefs where the plateau flattens out. Through the morning with daylight, the vessel mapped the shallower flanks on the western side of Osprey Reef then turned southward again to map the deeper flanks of Osprey Reef. Through the afternoon, the shallower sides of Shark and Vema Reefs were mapped. These two elongate reefs were clearly once joined, with a low ridge stretching between them, separating the shallower reef tops. These two reefs are separate structures from Osprey Reef to the north, i.e. a deep trough lies between Osprey Reef and closest Shark Reef. At 1900, *Falkor* completed the Osprey Reef survey area and commenced transit southward towards the Bougainville Reef survey area.

Monday 04 May 2020

Wind 25 kn from 120°. Sea state 4. Moderate swell.

0800 in position 15.64370°S 147.06560°E in vicinity of Bougainville Reef.

Falkor continued its southerly track towards Bougainville Reef approx. 6 hours away. Rough seas slowed progress but multibeam mapping continued along the north-western side of the Queensland Plateau in depths 1700 to 1400 m, rising slowly towards Bougainville Reef. The vessel arrived in the morning and commenced a slow loop around the unmapped portions of Bougainville Reef. By 0800, the Bougainville Reef survey was completed and transit commenced towards the Cairns Seamount about 5 hours away. At 1500, *Falkor* arrived at the Cairns Seamount survey area and commenced a lap around the flanks of this small reef. Base depths are ~1300 with a relatively smooth eastern side.

Tuesday 05 May 2020

Wind 21 kn from 140°. Sea state 4. Low swell.

0800 in position 16.433116°S 147.80148°E in vicinity of Holmes Reefs.

Falkor completed mapping around the Cairns Seamount revealing an almost conical bank topped with a small (few 100s m wide) shallow coral reef. The ship then commenced transit towards Holmes Reefs, about 230 km east of Cairns. Through the morning, a wide pass was made around both reefs, which established the extent of the deeper drainage channels. From midday, a clockwise pass was conducted between the two reefs, then two shallower passes around West Holmes Reef to survey as high up on the flanks as possible.

Wednesday 06 May 2020

Wind 24 kn from 120°. Sea state 4-5. Low swell.

0800 in position 16.474130°S 147.950151°E in vicinity of Holmes Reefs.

With the wind still high, *Falkor* had to plan mapping away from the shallower edges of reefs. A transit was made around Flora Reef, about 1 hour away from the Holmes Reefs, then *Falkor* continued back to map the East Holmes Reef. Through the daylight hours, shallow mapping was done around the lee side of East Holmes Reef getting as close as possible to the reef. The multibeam backscatter shows high reflectance on the upper flanks, as expected, where mesophotic corals and harder substrate would be present. Down the flank, reflectance becomes lower as softer sediment drapes the lower slopes. The squally weather still restricted

windward mapping of reefs so from 1400, *Falkor* moved behind West Holmes Reef with the multibeam system turned off.

Thursday 07 May 2020

Wind 22 kn from 115°. Sea state 4-5. Low swell.

0800 in position 16.375277°S 147.850535°E in vicinity of Holmes Reefs.

Poor weather overnight required the ship to heave to in the lee of West Holmes Reef. No multibeam data were collected. At 0830, ROV SuBastian was launched for Dive #356 at the northern end of West Holmes Reef, but was recovered soon after because of a technical issue. The next ROV Dive #357 then commenced around 0930 starting at a target depth of 883 m. Through the day, the ROV climbed steadily upwards, at times traversing a prominent exposed rock wall comprised of rock strata, likely coral layers built up through time. Marine life was prevalent among the rock strata with coldwater corals, crinoids and the like clinging to the rock. The ROV traversed through the thermocline around 450 m and entered the lower mesophotic zone. Here we saw soft corals and black corals become more common attached to exposed rock cliffs and boulders. The ROV was recovered at 1600 then commenced a southwest transit towards Flora Reef to collect additional multibeam data around the deeper plateau surface adjacent to the reef.

Friday 08 May 2020

Wind 21 kn from 115°. Sea state 4-5. Low swell.

0800 in position 17.365697°S 148.142091°E in vicinity of Dart Reef.

Through the night *Falkor* mapped around McDermott Reef, a small reef lying between Flora Reef and the Flinders Reefs. Then a transit was made east to try to map an enigmatic seabed feature looking like a long meandering channel incised in the plateau surface over 30 km in length. More mapping was required to find the head of the channel where it drains to the western side of the plateau. From 0900, the vessel made a near pass around the small Dart Reef, then the western side of North Flinders Reef, taking advantage of the daylight to map the shallower upper flanks of this large atoll. From midday, *Falkor* mapped the South Flinders Reef in a clockwise direction. By the end of daylight, *Falkor* had completed one complete circle around South Flinders Reef and then headed up the eastern side of North Flinders Reef.

Saturday 09 May 2020

Wind 15 kn from 105°. Sea state 4. Low swell.

0800 in position 17.503978°S 148.278083°E in vicinity of North Flinders Reef.

The ship continued mapping through the night with winds easing to around 15 kn. A deeper loop commenced around South Flinders Reef, then northward along the western side of North Flinders Reef and then around Dart Reef. The hint of a wave cut platform was detected at ~120 m, possibly indicating maximum sea-level lowstand during previous glacial periods. A similar wave cut terracing had been detected on the adjacent Great Barrier Reef shelf edge. With the improved weather, *Falkor* continued mapping along the eastern North Flinders Reef flanks. Into the evening, the vessel mapped the area between Dart Reef, Heralds Surprise and North Flinders Reef.

Sunday 10 May 2020

Wind 14 kn from 145°. Sea state 4. Low swell.

0800 in position 17.879219°S 148.469603°E in vicinity of South Flinders Reef.

Overnight *Falkor* continued mapping around the outside deeper waters surrounding North Flinders Reef, Heralds Surprise and Dart Reef. Towards the morning, the ship mapped down the western sides of the Flinders Reefs to take up position for ROV Dive #358 on a landslide scarp found on the west side of South Flinders Reef. Dive #358 commenced at 0800 and on the bottom at 1006 m at ~0830 for a livestream. Through the day, the ROV followed a long vertical transect up the ~100 m high face of the scarp, then along the upper flanks and into the lower mesophotic zone. Towards the end of the dive, abundant soft corals and other mesophotic biota were observed, including the overhanging caves around 120 m, again possibly indicating lowstand sea-level positions, causing wave cutting of the limestone rock. The ROV was recovered at 1430 and the vessel commenced mapping of shallow areas on North Flinders Reef during remaining daylight hours.

Monday 11 May 2020

Wind 17 kn from 120°. Sea state 4. Low swell.

0800 in position 17.419672°S 148.921411°E in vicinity of Unnamed 5m Reef.

Through the evening, *Falkor* mapped farther along the incised channel east of Dart Reef on the main plateau surface to find the head of this long channel. The ship then transited towards the Unnamed 5m Reef lying about 30 km east of the Flinders Reefs. Previous LIDAR bathymetry

covers this shoal and the vessel mapped throughout the morning around the shallower flanks. By 1300, the Unnamed 5m Reef was completely mapped around the flanks and *Falkor* commenced the transit to Herald Cays in around 880 m depth across the plateau surface. From midday until 1800, the ship mapped the shallower upper flanks around Herald Cays reef, then during the night the deeper flanks of this reef.

Tuesday 12 May 2020

Wind 20 kn from 130°. Sea state 4. Low swell.

0800 in position 16.402862°S 149.165538°E in transit Herald Cays and Moore Reefs.

Falkor completed mapping around the Herald Cays and commenced the ~100 km transit northward to the Moore Reefs, lying northeast of Diane Bank. Around midday, the ship arrived and commenced mapping the three small shallow reefs that comprise Moore Reefs. This area is dotted with strange pinnacles in older mapping data so a systematic survey was commenced at 1600 to broadly map the surrounding plateau and see if these pinnacles are real. Throughout the day, the seafloor revealed a lack of pinnacles and relatively flat, thereby disproving the existence of multiple pinnacles.

Wednesday 13 May 2020

Wind 21 kn from 120°. Sea state 4. Low swell.

0800 in position 16.059367°S 149.137946°E in vicinity of Moore Reefs.

After a night of systematic surveying between the three Moore Reefs, no field of drowned reefs or pinnacles was revealed. The seafloor continued to be relatively flat or with only low scarps of exposed rock on the seafloor. At 0800, with winds easing, *Falkor* left the Moore Reefs and transited towards Diane Bank to map the shallower flanks during daylight hours and while weather was conducive for shallower mapping. *Falkor* arrived at the Diane Bank at 1100 and started an anti-clockwise survey of the shallower flanks.

Thursday 14 May 2020

Wind 21 kn from 125°. Sea state 4-5. Low swell.

0800 in position 15.789163°S 149.602273°E in vicinity of Diane Bank.

Falkor had continued the anti-clockwise mapping of Diane bank through the night, with the weather still quite windy. Depths between Diane Bank and the Willis Islets to the east were

around 350 m, quite shallower compared to the previous mapping over the plateau around 1000 m deep. Throughout the morning, the ship continued around the northern then western side of Diane Bank, mapping the shallower flanks during daylight hours. At 1600 the ship at reached the southern side of Diane Bank which revealed possible bedforms on the seafloor. From here, the ship transited towards the Willis Islets, east of Diane Bank.

Friday 15 May 2020

Wind 21 kn from 130°. Sea state 4. Low swell.

0800 in position 16.294416°S 149.984137°E in vicinity of Willis Islets.

Falkor worked in the deeper waters east of Willis Islets overnight, then at daybreak started mapping the shallower flanks near Willis Islets Bureau of Meteorology weather station. The shallower flanks were mapped with multibeam showing undercutting terraces around 100 m depth, indicating possible lowstand sea-level erosion. Through the day, *Falkor* worked into deeper water continuing the anti-clockwise survey around Willis Islets. The seafloor was ~600 m deep and covered in smaller disaggregated blocks lying stranded on the surrounding plateau surface.

Saturday 16 May 2020

Wind 20 kn from 125°. Sea state 4. Low swell.

0800 in position 15.849369°S 149.736014°E in vicinity of Diane Bank.

Overnight, *Falkor* continued mapping anti-clockwise around Diane Bank over the deeper flanks and plateau surrounding the bank. At 1100, the ship commenced east-west lines between the northern side of Diane Bank and the Moore Reefs to understand the low erosional feature between them in about 500 m depth. The systematic survey continued until 1900, revealing ~100 m high cliff faces along this erosional scarp, with superimposed dunes on top. Parts of these platforms have collapsed leaving large blocks stranded at depths ~1000 m. The ship then continued mapping the west side of Diane Bank.

Sunday 17 May 2020

Wind 20 kn from 125°. Sea state 4. Low swell.

0800 in position 16.030018°S 149.070580°E in vicinity of Moore Reefs.

In the early morning, a systematic survey commenced to the southwest of Moore Reefs. At 0800, a new seamount, likely a drowned reef, was discovered rising from 981 to ~370 m, very conical in shape. At 0900, the ship completed the systematic surveying and started the transit to Cairns. Around 1500, *Falkor* had made great progress and commenced mapping the shallower upper flank of East Holmes Reef, revealing a clear steeper zone before a flank filled with smaller gullies. By 1600, the ship continued on towards Cairns.

Monday 18 May 2020

Wind 15 kn from 140°. Sea state 4. Nil swell.

0800 in position 16.842108°S 145.822822°E at anchor near Cairns harbour.

The ship continued transiting across the Queensland Plateau and Queensland Trough towards Cairns. At 0400, the ship entered Grafton Passage and proceeded to the anchorage off Cairns Harbour entrance. At 0800 the ship came to anchor with all multibeam mapping systems turned off.

Tuesday 19 May 2020

Wind 16 kn from 120°. Sea state 4. Nil swell.

0800 in position 16.929636°S 145.779900°E at Cairns wharf.

Falkor remained at anchor overnight, then at 0730 left the anchorage and proceeded into the Cairns wharf, to be alongside by 0800. Crew changeover and reprovisioning occurred throughout the day.

Wednesday 20 May 2020

Wind 16 kn from 120°. Sea state 4. Nil swell.

0800 in position 16.848992°S 145.821052°E at Cairns port anchorage.

Falkor remained at anchor overnight and planned for a crew changeover by boat. At 1200, *Falkor* weighed anchor and departed for the Coral Sea Marine Park through Grafton Passage. The ship commenced surveying with the EM710 multibeam system and mapped across the shelf-break at ~100 m at 1540. Heading easterly, the ship transited across the Queensland Trough with the EM300 multibeam system and towards the Queensland Plateau. Around 2200, the ship approached the Cairns Seamount mapping along the southern and deeper sides.

Thursday 21 May 2020

Wind 20 kn from 085°. Sea state 4-5. Low swell.

0800 in position 16.570673°S 147.996868°E in vicinity of Holmes Reefs.

Falkor mapped between the Cairns Seamount and Holmes Reefs, filling some mapping gaps around the East Holmes Reef. At 1100, the ship started the transit to the Moore Reefs and Diane Bank area to continue mapping gaps in preparation for the next ROV dive. During the 1100-1200 live Ship2Shore discussion, *Falkor* mapped three small seamounts on the south side of East Holmes Reefs. The largest is 937 m at base, top at 659 m (278 height), with moats around their bases.

Friday 22 May 2020

Wind 13 kn from 110°. Sea state 3. Low swell.

0800 in position 15.882600°S 149.151228°E in vicinity of Moore Reefs.

Overnight, *Falkor* continued mapping around the Moore Reefs trying to determine whether enigmatic seafloor bumps were real seamounts. Only one new seamount was detected, so concluded that these bumps on the previous depth models were likely noise artifacts. The ship positioned itself on the lee side of the northwest Moore Reef and commenced ROV Dive #360 at 0900 and on the seafloor at 944 m. The dive site was chosen to give a complimentary deep dive against an earlier shallow-water survey that revealed high biodiversity in fish and coral life. This deeper dive also found much higher densities of coldwater corals, sponges and fish than we've seen on previous dives. In the mesophotic zone, were also high concentration of softcorals and fish. At 1730 the ROV was recovered and the ship commenced mapping towards the southern Diane Bank.

Saturday 23 May 2020

Wind 20 kn from 170°. Sea state 4. Moderate swell.

0800 in position 16.495350°S 149.706782°E in vicinity of Willis Islets.

Through the night, *Falkor* mapped around the flanks of Diane Bank and Willis Islets, ending up at the southwest side of Willis Islets for ROV dive #361. This dive aimed to confirm whether a large ~1.4 km long block-like feature lying at ~250 m depth was hard limestone and therefore likely to be the remains of an underwater landslide. At 0830, ROV SuBastian was on the seafloor at 260 m and sand ripples came into view. The dive transited up onto the rock and was clearly hard limestone with a veneer of soft sediments. Patches of softcorals sheltered mesophotic fish

species not described. Unfortunately, bad weather terminated the dive and the ROV was recovered at 1000. The ship commenced surveying between Diane Bank and Willis Islets as the weather deteriorated. Extensive dunes were observed lying between these two banks. By nightfall, *Falkor* had rounded the northern side of Willis Islets and headed down the eastern side into the rough seas.

Sunday 24 May 2020

Wind 15 kn from 190°. Sea state 4. Low-Moderate swell.

0800 in position 17.147235°S 149.752565°E in vicinity of Willis Islets.

Falkor transited from the Willis Islets towards the Coringa Islets to the south, and at daybreak, started mapping anti-clockwise around the western and southern side of Coringa Islets reef. Depths were relatively shallow, around 200-300 m with a gentler flank gradient extending to the plateau surface. At 1100, *Falkor* cut across the top of the bank over the lagoon in ~60 m depth, exiting on the northern side at 1200. During the remaining afternoon, the ship surveyed the northern upper flanks of Coringa Islets reef. At 1600, the vessel commenced mapping across the deeper plateau surface around 450 m depth.

Monday 25 May 2020

Wind 17 kn from 170°. Sea state 4. Low-Moderate swell.

0800 in position 16.526272°S 150.302846°E in vicinity of Magdelaine Cays.

Falkor continued mapping along the northern flank of the Coringa Islets towards the Magdelaine Cays reef at the northern end of this large ~80 km long bank. From daybreak, the ship commenced mapping around the Magdelaine Cays reef, identifying a potential ROV site for the next day. Through the morning the ship transited across to the Unnamed 17m Reef about 25 km east of the Magdelaine Cays reef. The ship commenced mapping the shallower upper flanks from 1200 for two laps around this reef. In the evening, the ship transited back to Magdelaine Cays and mapped the southern flank of this large bank.

Tuesday 26 May 2020

Wind 11 kn from 135°. Sea state 3. Low swell.

0800 in position 16.545512°S 150.269814°E in vicinity of Magdelaine Cays.

Falkor mapped the deeper southern flanks of the Magdelaine Cays reef through the night then positioned itself at the northernmost Magdelaine Cay reef for ROV Dive #362. ROV SuBastian entered the water at 0800 and conducted a dive up the southern wall with a start depth of 650 m. The dive concluded at 1330 having seen several live chambered nautilus and numerous seapens in deeper waters. At 1400, the ship departed and transited southwest towards a possible deep channel incised between Willis Islets and the Magdelaine Cays reef.

Wednesday 27 May 2020

Wind 11 kn from 150°. Sea state 3. Low swell.

0800 in position 17.038858°S 149.971757°E in vicinity of Coringa Islets.

Falkor continued mapping the deep channel between Willis Islets and Magdelaine Cays reef through the night, revealing ~30 km long, 700 m wide channel draining towards the northeast. The channel terminated at a series of eroded platforms, appearing like stepped terraces at 908, 935 and 990 m depth. The ship then continued mapping the northern flanks and surrounding plateau of the Magdelaine Cays and Coringa Islets area through the morning. At 1230, the ship passed through the narrow gaps separating the western-most reef from the larger bank. Through the afternoon and evening, the ship mapped around an isolated reef on the southwestern side of Coringa Islets, then continued along the southern deeper flank towards the ROV dive site on the north-eastern tip of Magdelaine Cays reef.

Thursday 28 May 2020

Wind 13 kn from 130°. Sea state 3-4. Low swell.

0800 in position 16.730229°S 150.445021°E in vicinity of Magdelaine Cays reef.

Falkor had mapped the southern flank of Magdelaine Cays reef through the night and positioned itself for a ROV dive on a promontory on the north-eastern point. Unfortunately, technical issues meant the dive was aborted and so the ship continued mapping the northern, deeper flanks of this large bank, heading anti-clockwise around the reef. By 1500, the ship was back in the large embayment at the southern side of the bank while mapping the shallower reef edge missing on previous mapping passes. Towards the evening, the ship passed again across the shallow sandy lagoon where the Knudsen sub-bottom profiler was tested. During the night, the ship continued mapping gaps within existing coverage along the southern side of Magdelaine Cays reef.

Friday 29 May 2020

Wind 15 kn from 150°. Sea state 3-4. Low swell.

0800 in position 16.725690°S 150.446294°E in vicinity of Magdelaine Cays reef.

Falkor continued mapping the southern margin of the Magdelaine Cays and Coringa Islets reef through the night and morning, filling in gaps within the existing multibeam data coverage. This included more passes around the Unnamed 23 m reef on the south-western side of Coringa Islets reef, then heading north-easterly towards the Unnamed 17 m reef. At 0800, the ship positioned itself at a site on the prominent 'horn' of reef on the northeast corner of Magdelaine Cays reef for ROV dive #363. The start depth was around 571 m and then climbed steadily upwards through the day towards the mesophotic zone in ~100 m depth. The dive completed around 1500 then continued mapping south-westerly towards the Coringa Islets side of the bank, and several laps around the Unnamed 23 m reef at the south-western corner of Coringa Islets reef.

Saturday 30 May 2020

Wind 16 kn from 135°. Sea state 3-4. Low swell.

0800 in position 17.768338°S 150.723981°E in vicinity of Diamond Islets reef.

Overnight, *Falkor* had mapped down the western side of Diamond Islets reef for the first time and then rounded the southern flanks. At 0800, the ship was half way along the southern flank then continued mapping the shallower depths close to the reef edge and then up around the prominent 'horn' of reef jutting out at the northeast side of Diamond Islets reef. Weather conditions were good and so the ship spent the remainder of the day and into the night adding more data coverage to this deeper southern side of the reef. A picture emerged of a very complex seafloor, including numerous gullies, a large canyon and the more familiar debris fields lying along the base of the reef.

Sunday 31 May 2020

Wind 15 kn from 140°. Sea state 3-4. Low swell.

0800 in position 17.901425°S 150.701289°E in vicinity of Diamond Islets reef.

Falkor had continued mapping along the southern margin of Diamond Islets reef, extending farther the extensive mapping coverage over the distinct y-shaped canyon that extended south of the reef. Closer to the reef, a series of prominent steps and ledges appeared. Superimposed

on top of the ledges were wide linear 'dunes' extending out across the ledges, each 'dune' seemingly lined up with the 'dune' on the lower ledges. The y-shaped canyon and ledges were decided as targets for the following ROV dives. Then ship continued mapping along this deeper >1000 m seafloor through the night.

Monday 01 June 2020

Wind 14 kn from 145°. Sea state 3-4. Low swell.

0800 in position 17.8421179°S 150.649971°E in vicinity of Diamond Islets reef.

Falkor had continued mapping the southern flanks of Diamond Islets reef to around 14 km away from the edge of the shallow reef. At 0800, the ship positioned itself over the left hand arm of the y-shaped canyon for ROV dive #364 with a start depth of around 935 m in the floor of the canyon. The early part of the dive was over sand with prominent ripples, before a gradual climb up the steeper sides of the canyon to an exposed friable chalky outcrop. The chalky outcrop was filled with small burrows and looked much eroded. A clue to the burrowing was seeing a large isopod inside the burrow and was likely the cause of the larger holes. The dive completed at 1700 and the ship continued mapping the outer flanks of the Diamond Islets through the night.

Tuesday 02 June 2020

Wind 12 kn from 145°. Sea state 3. Low swell.

0800 in position 17.792913°S 150.654080°E in vicinity of Diamond Islets reef.

Falkor had mapped some additional deeper seafloor to the south of Diamond Islets reef overnight, then at 0800 positioned over a site for ROV Dive #365. This site was the companion to the previous dive, with a start depth of 685 m and climbing up a series of steep steps to ledges at 550, 416 and 300 m, before the final climb into the mesophotic depths around 100 m. The dive showed an obvious transition from the coldwater environment, through the thermocline at ~450 m, into the lower mesophotic and upper mesophotic zones. Towards the end of the dive, we saw rhodoliths, then zooxanthellate corals, then *Halimeda* green algae meadows, before recovery at 1700. For the remaining night, the ship continued mapping along the southern flank of Diamond Islets reef, adding to the impressive mapping data over the complex canyons draining the steeper flanks.

Wednesday 03 June 2020

Wind 25 kn from 135°. Sea state 4-5. Low-Moderate swell.

0800 in position 17.496884°S 150.061359°E in vicinity of Unnamed 22 m reef.

Falkor mapped additional lines along the southern side of Diamond Islets, and then headed along the western steeper flanks, before a short western transit to the Unnamed 22 m reef situated northwest of Diamond Islets. The shallower flanks were mapped on this Unnamed 22 m reef through the evening, then *Falkor* transited back to the Diamond Islets reef and mapped along the northern side of reef. Weather conditions continued to deteriorate but the Diamond Islets reef provided some shelter as the ship headed easterly. The seafloor was generally smooth with occasional clusters of rock debris at base of the flanks.

Thursday 04 June 2020

Wind 25 kn from 135°. Sea state 4-5. Low-Moderate swell.

0800 in position 17.433262°S 151.157990°E in vicinity of Diamond Islets reef.

With the wind still quite high, *Falkor* continued mapping along the northern side of Diamond Islets reef. At 0800, the ship investigated a prominent reef extension on the north-eastern side of Diamond Islets reef in the event of the upcoming World Oceans Day ROV dive, which required a sheltered position. The ship then transited easterly towards Lihou Reef, this largest of all the Queensland Plateau reefs at ~100 km long. Through the day, the ship mapped the shallower flanks on the northern side of Lihou Reef. Depths were around 400 m at the base of the flanks. From 1330 to 1700, the ship hove to on the lee side of Lihou Reef for engine testing, then continued mapping along the deeper flanks through the night.

Friday 05 June 2020

Wind 25 kn from 120°. Sea state 4-5. Low-Moderate swell.

0800 in position 17.326870°S 151.497243°E in vicinity of Lihou Reef.

The windy conditions continued through the night and so *Falkor* remained mapping along the northern side deeper flanks of Lihou Reef. With daylight, the ship headed in a north-easterly direction towards the very eastern tip of Lihou Reef. By 1400, the ship had reached the eastern side of the mapped area, then turned around heading westerly again, continuing to map farther away from the reef edge and across the deeper surrounding plateau. At 1700 the ship sailed northward away from Lihou Reef then returned back to continue mapping the deeper flanks of Lihou Reef through the night.

Saturday 06 June 2020

Wind 20 kn from 120°. Sea state 4-5. Low-Moderate swell.

0800 in position 17.218074°S 152.141085°E in vicinity of Lihou Reef.

At daybreak, several potential ROV dive sites were visited along the northern Lihou Reef to test current speeds and risk. A potential dive site was chosen over an obvious landslide scarp and with minimal current. At 0900, the ship headed around the eastern point of Lihou Reef into the high winds. The ship then headed in a south-westerly direction along the southern flanks of Lihou Reef mapping a relatively steep wall down to over 800 m. At 1300, a short reverse in direction was made to survey a site identified as highly biodiverse from previous shallow-water surveys at Lihou Reef. A prominent ledge could be seen in the multibeam data around 350 m. The ship then continued mapping in a south-westerly direction, with several reversals to fill in gaps along the deeper flank. At 1800, *Falkor* reached the western limit of Lihou Reef, and because the weather continued to be windy, the mapping continued in a clockwise direction, adding to map data along the northern side.

Sunday 07 June 2020

Wind 20 kn from 115°. Sea state 4. Low-Moderate swell.

0800 in position 17.087801°S 151.913200°E in vicinity of Lihou Reef.

After a night of mapping around the deeper northern flanks of Lihou Reef, the ship positioned near the north-eastern side for ROV dive #366 at a prominent landslide where the entire flank appears collapsed. The ROV entered the water at 0800 for a target depth of 562 m. The dive transited across a debris field and several large blocks, and then across the exposed landslide scarp face. We observed exposed strata or the internal layers of the ancient reef, and the diverse coldwater community and mesophotic marine life attached to these layers. At 1530, the ROV was recovered. Through the night, *Falkor* continued mapping clockwise around the southern side of Lihou Reef.

Monday 08 June 2020

Wind 23 kn from 135°. Sea state 4-5. Low-Moderate swell.

0800 in position 17.490356°S 151.367634°E in vicinity of Lihou Reef.

Falkor continued mapping the southern side of Lihou Reef through the night, then positioned at the north-western side of Lihou Reef for ROV dive #367. This dive commenced at 0800 and had

a shallower starting depth of 391 m, then worked towards the reef over prominent debris blocks that had broken off the steeper reef flank. The last part of the dive crossed a relatively gentle gradient, upper flank to about 100 m depth, in search of interesting mesophotic marine life. ROV SuBastian was recovered at 1300 as the wind increased, with the ship then commencing a systematic survey of the area between Lihou Reef and Diamond Islets reef.

Tuesday 09 June 2020

Wind 18 kn from 130°. Sea state 4. Low-Moderate swell.

0800 in position 17.403006°S 151.048388°E in vicinity of Diamond Islets reef.

Falkor did some east-west mapping along the northern side of Diamond Islets reef through the night, then positioned at the north-eastern point for ROV dive #368. The ROV was in the water around 0900 for a World Oceans Day live event recorded to the world, target depth 549 m. The livestream was from 1000-1100 with speakers from around the calling in around their ocean experiences. On conclusion, the ROV dive continued in and around two large blocks of limestone as the remains of an underwater landslide in the long geological past. The dive was generally in depths around 500 m and again lots of nautilus were seen. The ROV was recovered at 1400 and the ship commenced a transit around the southern side of Diamond Islets, trying to minimise the effect of poor weather on the ship.

Wednesday 10 June 2020

Wind 14 kn from 130°. Sea state 4. Low-Moderate swell.

0800 in position 18.150732°S 149.595579°E in vicinity of Abington Reef.

Following a night mapping along the southern side of Diamond Islets reef, *Falkor* transited to Abington Reef bordering the southern Queensland Plateau. Several loops around Abington Reef were completed, then a short transit to Malay Reef, a deeper bank compared to Abington Reef. Several laps around the reef completed the survey at 1430, revealing very steep cliffs on the Townsville Trough side. The ship then commenced the long transit northwest towards the Flora Reef and Holmes Reefs area with the aim to add additional data to existing multibeam coverage while transiting past the Flinders Reefs area.

Thursday 11 June 2020

Wind 16 kn from 140°. Sea state 4. Low swell.

0800 in position 16.628276°S 147.277562°E in western margin of Queensland Plateau.

Falkor mapped around the eastern side of Flinders Reefs and Heralds Surprise through the night, heading across several anomalous bathymetry spikes in the gbr100 grid. Mapping revealed these to be drowned reefs with heights around 200 m above the surrounding seafloor depth of 1000 m. The ship then continued westerly towards the ROV dive #369 site about 15 km southeast of the Cairns Seamount with a target depth of 1548 m. The site was located at the western limit of the Queensland Plateau, close to the adjoining Queensland Trough, and well away from any coral reefs. The dive investigated some low relief, sculptured seafloor on the plateau surface in depths 1500-1300 m. The dive confirmed the seafloor substrate was mostly hard rock with a veneer of softer sediments on the top. At 1530, the ROV was recovered back onboard. The ship commenced a systematic survey between the Cairns Seamount and Holmes Reefs.

Friday 12 June 2020

Wind 16 kn from 140°. Sea state 4. Low swell.

0800 in position 16.638766°S 146.240979°E in Grafton Passage.

At the conclusion of the systematic surveying between the Cairns Seamount and Holmes Reefs, *Falkor* departed the area around 0100 and commenced transit westerly towards Cairns. The *Falkor* continued mapping while crossing the Queensland Trough, entering Grafton Passage at 0800. *Falkor* came to anchor off Cairns harbour at 1200, concluding the “Visioning of the Coral Sea Marine Park” expedition.