This close-up image of a black coral was taken by ROV *SuBastian* at a depth of 1,200 metres on the Cairns Seamount. It shows in amazing detail the delicate structures of this poorly understood coral.

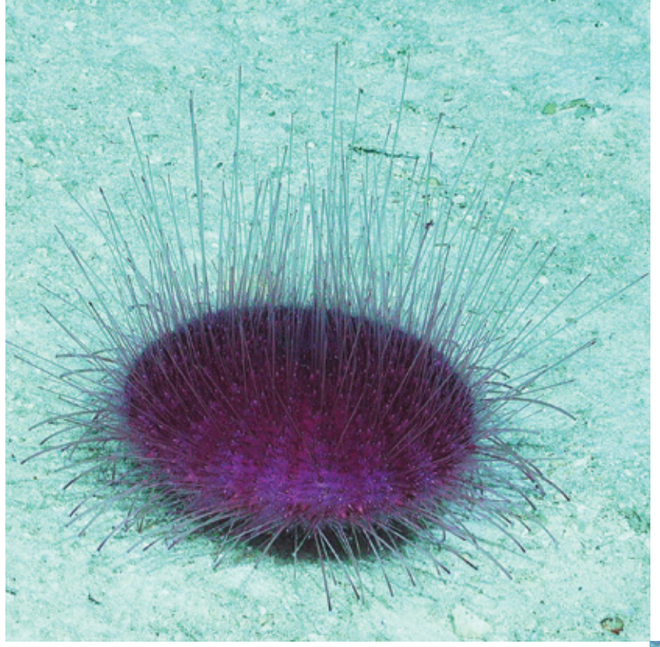
All images Schmidt Ocean Institute

Remote control

My (virtual) research voyage with RV *Falkor*

How do you coordinate a survey of hundreds of kilometres of Australia's ocean depths from your home, during a pandemic lockdown? Dr Robin Beaman shares his story of managing the 'Visioning of the Coral Sea Marine Park' expedition aboard the Schmidt Ocean Institute's RV *Falkor*.

I built a small virtual team from their locked-down homes across Australia, in readiness for a month and half of adventure



01

I FIRST REALISED that the Schmidt Ocean Institute's RV *Falkor* was in serious trouble early in April 2020, just as the COVID-19 crisis was sweeping across Australia. The ship had been in Australian waters since January, committed to a year-long series of deep-water expeditions. Having successfully completed expeditions in the Bremer, Perth and then Ningaloo canyons off Western Australia, *Falkor* was now caught up in the frantic shutdown of ports and quarantine restrictions. My email query to Eric King, Director of Operations at Schmidt Ocean Institute, received a terse reply: 'significant blow … very difficult'. Much was at stake.

Falkor is one of the world's most advanced research vessels, equipped with multibeam swath-mapping systems that provide a high-resolution 3D picture of the sea floor. The two Kongsberg EM302 and EM710 multibeam transducers are fixed to a gondola mounted underneath the hull to reduce bubbles and ship noise. Together, these systems can provide beautiful detail from depths ranging from 30 metres to more than 3,000 metres. They have the ability to resolve seabed features between 2 and 20 metres in length.

Research permits were already in place to allow *Falkor* to collect multibeam data around Australia. There is only one other blue-water research vessel in the country with similar mapping capabilities: the CSIRO's RV *Investigator*. Therefore, every opportunity must be taken to contribute mapping data to improve the detail of our large exclusive economic zone and network of marine parks. Having been involved with every blue-water research ship sailing through the Coral Sea in the past 15 years, I was looking forward to a Great Barrier Reef expedition on *Falkor*, scheduled for August 2020.

But with many research vessels now laid up due to the crisis, including Australia's *Investigator*, years of research fieldwork planning were cancelled. However, *Falkor* was still at sea and committed to its research program – if allowed by the authorities. I was already in lockdown at home in Cairns, Queensland, when *Falkor* finally escaped Western Australia in April. The vessel headed east, awaiting a decision. After a few very tense weeks, we got the word: *Falkor* had been granted an exemption and could remain in Australian waters to conduct science. It was such a relief!

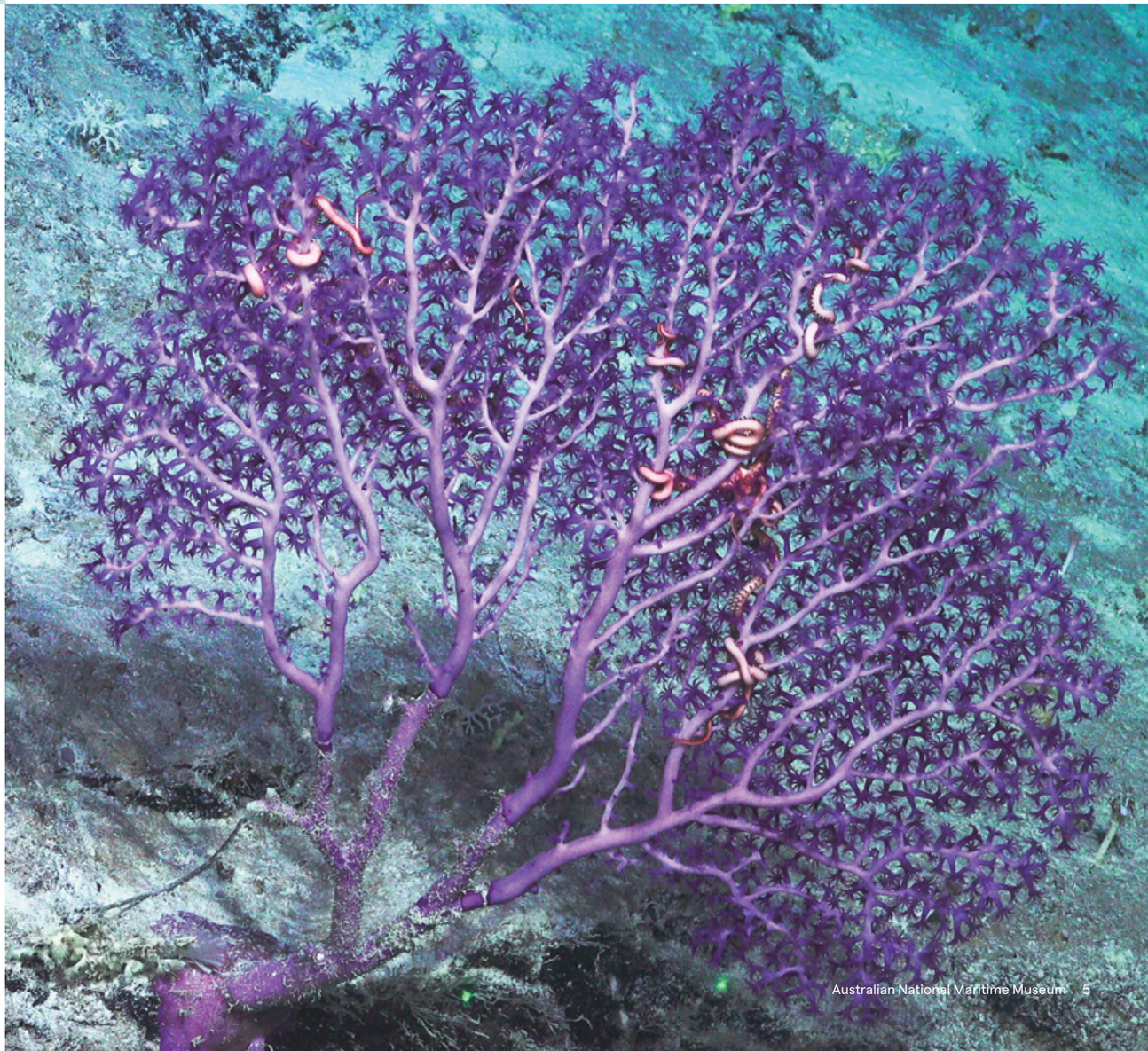
The ship was fully crewed, with 26 people on board, including a team to operate the purpose-built underwater robot *SuBastian*. Weighing 3.2 tonnes and rated to 4,500 metres depth, this remotely operated vehicle (ROV) has the ability to take exquisite 4K (4,000 pixel wide) videos and photos, and to collect physical samples. As a result of the shifting schedule, the Schmidt Ocean Institute asked whether I could plan an opportunistic expedition of a month and a half. I had just two weeks to prepare for and lead a virtual voyage without any scientists physically onboard. This intensive schedule of mapping and ROV dives had to be conducted entirely remotely.

01
Long-spined urchins graze on food detritus accumulating on the muddy seafloor at depths of more than 1,000 metres.

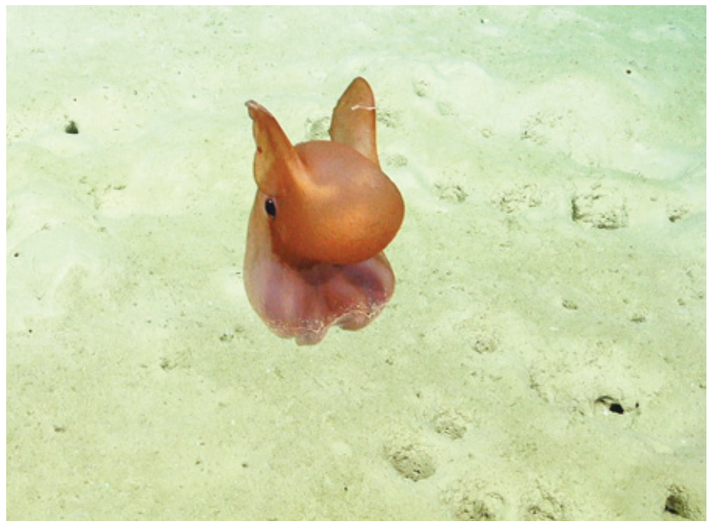
02
Gorgonian corals are known as soft corals as they don't have solid skeletons like the hard, reef-building corals. They are more flexible and look almost like underwater plants.

Several of the images in this article feature in our outdoor exhibition *Ocean Wonders*, opening on 1 December.

02



An intensive schedule of mapping and ROV dives had to be conducted entirely remotely



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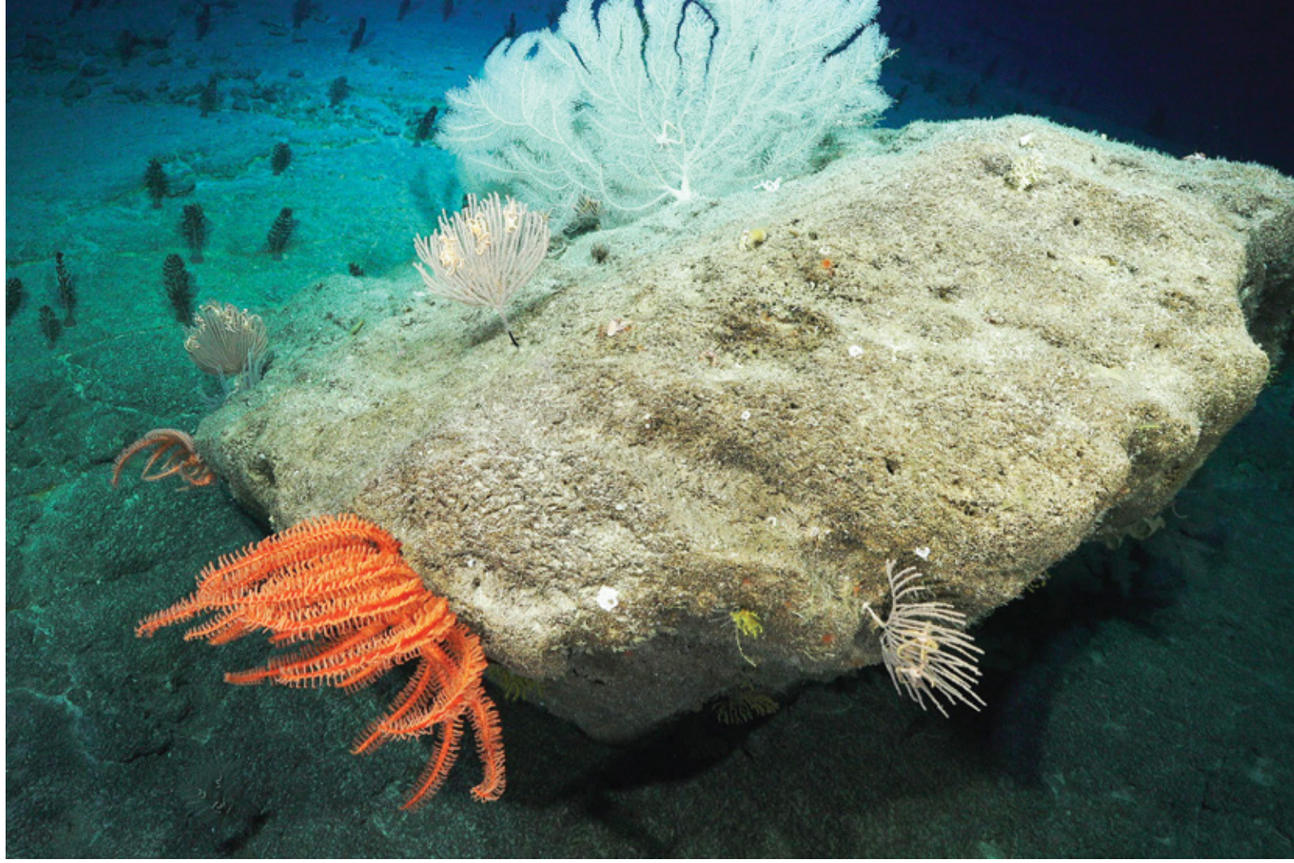

02

01
Dumbo octopuses are rare and found only in the deep open ocean. This sighting at 1,300 metres depth created much excitement.

02
Large orange-coloured brisingid seastars and other soft corals attach to exposed limestone rocks.

Choosing an area to study was easy. I had long gazed at maps of the Queensland Plateau within the Coral Sea Marine Park. It features a scattering of 30 shallow coral reefs and banks, including several of the largest atolls in the world. But, I wondered, what might its steeper flanks look like? Airborne LiDAR bathymetry collected by the Australian Hydrographic Office covered all of these reefs, so the underwater landscape was well understood to about 60 metres in depth. However, the detail beyond these shallows remained a mystery, except for a small area on northwest Osprey Reef where we had previously logged tourism dive-boat depth data to 800 metres.

Osprey Reef is considered the jewel in the crown of the Coral Sea Marine Park. Adventure vessels visit the reef regularly so people can dive with the abundant sharks. In 1987, Jacques Cousteau visited in the famous *Calypso*, then dived Osprey Reef using the submersible *SP350* to around 240 metres. In 2009, I was involved with the German 'Deep Down Under' expedition, which sent an ROV to 800 metres. Except for these infrequent efforts, virtually nothing was known of the Coral Sea's marine life beyond scuba depths. Here was an opportunity to map the steep flanks of all 30 reefs and reveal what marine life existed within their mesophotic (twilight) and deeper aphotic (lightless) zones.

As for conducting a survey entirely remotely? Well, that required a leap of faith. Neither I nor the Schmidt Ocean Institute had ever participated in such an operation. As chief scientist, I was determined to make this work. I built a small virtual team from their locked-down homes across Australia, in readiness for a month and a half of adventure. In late April, *Falkor* sailed from Cairns to Osprey Reef, and the 'Visioning of the Coral Sea Marine Park' expedition was born.

We soon settled into a daily routine of early morning video meetings with the captain, first officer, ROV lead pilot and the marine technicians who ran the ship's numerous instruments and multibeam systems. *Falkor* is a 24/7 operation, so discussions covered science objectives and numerous operational plans to allow for contingencies and the vagaries of weather. Any notes and plans were shared in Google Docs that we could all view and edit. Google Chat allowed us to text message each other when necessary. TeamViewer software became invaluable in sharing the multibeam mapping screens in real time.

I will never forget the first results of the multibeam mapping around Osprey Reef. The ship had completed several laps of the 30-kilometre-long Osprey Reef, with the multibeam pinging every few seconds.

Each ping generates up to 800 depth points in a swath that stretches 70 degrees on either side of the hull. Those millions of depth soundings were brought together into a 3D model that we viewed using visualisation software similar to that used by gamers. Marine technician Deborah Smith showed me the steep flanks, corrugated with many canyons cut into their sides. We also witnessed evidence of massive underwater landslides where whole pieces of the reef – some several kilometres long – had broken off and left debris blocks scattered at the base.

Planning for the ROV *SuBastian* dives was a serious business, as expected with a complex machine full of electronics. In morning video meetings, we would discuss the science objectives, such as visioning an underwater landslide or submarine canyon, plus factors to consider, including currents, terrain, distances and the weather.

The first dive at Osprey Reef was everything I hoped it would be. Descending past 200 metres, only the barest glimmers of sunlight remain in these clear waters. Below 400 metres the temperature rapidly drops, so that at 1,500 metres the seawater measures just 3°C. This is where *SuBastian* revealed the cold-water corals that are not reliant on sunlight. These corals exist in the darkness in a surprising variety of shapes and colours. Some appear as bright pink buttons with long tentacles. Others are attached to the dark iron-stained rock, including colonies bearing names such as golden, black and precious corals.

Being fully remote, this dive was the first test of audio commentary from my home office. It was quite a juggle, with numerous screens open to watch the live feed, speaking to what I could see and explain, all the while watching the YouTube chats coming in from many people watching from around the world. The video first travelled up *SuBastian*'s fibre optic cable to *Falkor*, and was then transmitted via satellite to a station on land. My voice travelled back via satellite, being received aboard the ship 300 kilometres away. The audio was mixed with the stream on board, then transmitted back to land via satellite, and shown live within seconds on YouTube and Facebook.

The next dive was at North Horn, Osprey Reef, a site known for chambered nautiluses. These strange-looking cephalopods are distantly related to extinct ammonites. They use their large pinhole camera eyes and up to 90 arms to scavenge food during daylight hours in depths below 500 metres. Soon our first nautilus bobbed into view at about 700 metres, perhaps attracted by the ROV's lights. By the end of the dive, we had counted 18 sightings, giving everyone a huge thrill to see these creatures thriving.

Virtually nothing was known of the Coral Sea's marine life beyond scuba depths

01
Chiroteuthidae squids have long necks, slender bodies and thin tentacles, so are sometimes called whip-lash squids. This mid-water squid was seen at 1,000 metres depth at Osprey Reef.

02
The nautilus is known as a living fossil, with a body plan largely unchanged for about 400 million years. Researchers spotted up to 18 on one dive at Osprey Reef, between 500 and 700 metres depth.

The ROV dives continued to amaze, from deep-sea dumbo octopus lazily swimming past using their ear-like fins, to nautiluses seen on nearly every dive

02

As the journey progressed, further ROV dives revealed abundant deep-water fish – particularly eels. I could see this variety was generating much interest among the fish experts watching from the shore. The YouTube chats were full of 'I think it's an [insert species]' or 'this could be a range extension', meaning a sighting for a fish beyond the area it is currently known to live in. I called them the 'fish army' and welcomed their input. I contacted one prolific Twitter contributor, Kai Tea from the University of Sydney, and asked whether he would like to join the science team. This development led to more scientists being added to the virtual expedition, including fish and coral reef specialists.

More underwater surprises appeared. Four conical-shaped drowned reefs were found on the plateau surface, 1 kilometre down. With heights of up to 600 metres, the peaks were probably drowned millions of years ago when the plateau subsided. Only reefs that maintained coral growth in that narrow photic zone were able to become the shallow, tall reefs we can see today. Yet for those ancient reefs that *Falkor* mapped, we witnessed the results of massive, catastrophic erosion. Hundreds of giant debris blocks lay scattered around their flanks where the edges of the reefs had collapsed.

The ROV dives continued to reveal amazing sights, from deep-sea dumbo octopus lazily swimming past using their ear-like fins, to nautiluses seen on nearly every dive.

A relict fauna of stalked crinoids – common in the fossil record – live in the depths of the Coral Sea where environmental conditions have remained near constant for millions of years. Delicate glass sponges are attached to rocks on long silica stalks like tulip bulbs. Giant isopods, similar to pill bugs, burrow into soft sediments leaving behind numerous holes like Swiss cheese. From the fish army, potential new species of fish were observed, together with many significant range extensions for fish living in the mesophotic zone.

So after its adventure, *Falkor* returned to Cairns, my hometown, which was still locked down. I couldn't even visit the ship at the wharf. The experience for me, and the rest of the science team, had been intense. We had all juggled family obligations, home schooling and work commitments, while engaging with the crew at sea from early morning until late at night. But the 'Visioning of the Coral Sea Marine Park' cruise was deeply satisfying, as the first fully virtual expedition by the Schmidt Ocean Institute. It was also a testament to the resilience of *Falkor*'s crew and the science team in overcoming the significant challenges brought on by the pandemic.

Dr Robin Beaman is a marine geologist at James Cook University. He has participated in numerous ocean-mapping expeditions around Australia, the South Pacific and Antarctica. His research focuses on revealing the deep Great Barrier Reef and Coral Sea underwater landscape using advanced mapping technologies and underwater imagery.