MNF Voyage Summary

Voyage #:	IN2022_V08		
Voyage title:	Biodiversity assessment of Australia's Indian Ocean Territories #2.		
Mobilisation:	Darwin, Wednesday, 28th September 2022		
Depart:	Darwin, Friday, 30th September 2022		
Return:	Fremantle, 15:00 Thursday, 3rd November 2022		
Demobilisation:	Fremantle, Thursday, 4th November 2022		
Voyage Manager:	Margot Hind	Contact details:	margot.hind@csiro.au
Chief Scientist:	Tim O'Hara		
Affiliation:	Museums Victoria	Contact details:	tohara@museum.vic.gov.au
Principal Investigators:	Alan Williams (CSIRO, alan.williams@csiro.au) Shane Ahyong (Australian Museum, Shane.Ahyong@Australian.Museum) Lisa Kirkendale (Western Australian Museum, lisa.kirkendale@museum.wa.gov.au) Nerida Wilson (Western Australian Museum, nerida.wilson@museum.wa.gov.au) Andrew Hosie (Western Australian Museum, andrew.hosie@museum.wa.gov.au)		
Project name:	As above		

VOYAGE SUMMARY

Objectives and brief narrative of voyage

Scientific objectives

- Characterise benthic biodiversity from seamounts (100-5000 m) across the EEZ in Australia's Indian Ocean Territories (IOT) for the first time. This includes collecting representative samples of seabed invertebrates and fishes that can be preserved in museums for planned (and future) morphological and DNA analysis.
- Test whether the proposed bioregionalisation for the territories (Brewer et al 2009, derived from environmental data) is an adequate surrogate for patterns of seafloor diversity across a series of depth strata. In particular, test whether differences in geology or water mass drive community composition.
- Assess the conservation significance of these seamount communities, particularly the presence of Vulnerable Marine Ecosystems (VMEs) including cold water coral and sponge communities.
- Substantially contribute to the AusSeabed project by maximising new multibeam coverage through 1) transiting as much as possible along unmapped seafloor to/from the IOT, 2) mapping the majority of IOT seamount that summits in less than 1500 m, and 3) transiting between IOT seamounts along unmapped tracks.
- Understand the biogeographical relationships of the fauna through community and evolutionary (DNA) comparisons with other Australian, west Pacific and Indian Ocean faunas. In particular to estimate the influence of the 'Indonesian Throughflow' current on shaping patterns of biodiversity in the NE Indian Ocean.

Voyage objectives

1. Characterise benthic biodiversity from seamounts (50-5000 m) across the EEZ in Australia's Indian Ocean Territories (IOT) for the first time.
2. Provide specimens and tissues samples to taxonomists for species identification and descriptions.
3. Test whether the proposed bioregionalisation for the territories (Brewer et al 2009, derived from environmental data) is an adequate surrogate for patterns of seafloor diversity across a series of depth strata.
4. Assess the conservation significance of these seamount communities, particularly the presence of Vulnerable Marine Ecosystems (VMEs) including cold water coral and sponge communities.
5. Document spatial and bathymetric patterns of oceanographic characteristics and plankton distribution.
6. Substantially contribute to the AusSeabed project by maximising new Multibeam coverage.

7. Understand the biogeographical relationships of the fauna through community and evolutionary (DNA) comparisons with other Australian, west Pacific and Indian Ocean faunas.

8. Communicate the conservation values of the area to the Australian public.

Results

Voyage IN2022_V08 was the second half of the investigation begun on voyage IN2021_V04. While IN2021_V04 focused mainly on the eastern and central section of the Christmas Island MP (Marine Park), IN2022_V08 surveyed the western section of Christmas Island MP and the Cocos (Keeling) Islands MP.

The IN2022_V08 voyage successfully mapped and surveyed a series of seamounts, including the 'Balthazar' complex, 'Glögg', 'Attention', 'Lucia' in the Christmas Island MP, and 'Scrooge', the 'Rudist' complex, the seamount underlying the Cocos (Keeling) Islands, 'Noel', Raitt Ridge, Muirfield, 'Klaus', 'Santa Ridge' and two unnamed seamounts to the south-west of the Cocos (Keeling) Islands MP.

Several mapping projects produced stunning results, in particular the mapping of several massive seamount complexes, including the Cocos (Keeling) Islands, Muirfield and 'Balthazar'. These projects involved the careful design of spiral tracks around shallow features to ensure complete bathymetric coverage. For Muirfield, without any reliable prior bathymetric data, we progressed slowly towards the narrow cylindrical summit in ever decreasing circuits. Around Cocos (Keeling) Islands we mapped up to the 200 m contour which in places is less than 1 km from the coastline. Our voyage track across the abyssal plain also resulted in the discovery of new features such as new seafloor ridges and a circular volcanic cone south-west of Muirfield. On the inbound and outbound transits, we also collected substantial multibeam data in a series of Australian MPs, particularly Argo-Rowley and Abrolhos MPs.

In all, the survey collected materials and data from 40 beam trawls, 6 'Sherman' epibenthic sleds, and 6 deep-towed camera tows. The samples were successfully collected across target geographic, bathymetric and oceanographical gradients, with the original sampling design having the capability of evolving continuously as novel multibeam data was obtained. We obtained useful shallow water samples from difficult to sample (rocky) seafloors using the Sherman sled. The results for both IN2021_V04 and IN2022_V08 surveys will be combined into a single biogeographic and ecological analysis.

On IN2022_V08 we collected and provisionally identified 3690 lots (species/sample) lots of marine invertebrates, and 724 lots (species/sample) of fish. Several new species of fish have already been identified, including a blind cusk eel and an undescribed green eye fish which was abundant on the shallower SW Cocos seamount. The black coral specimens included a representative from every known taxonomic family and several new species. A rare marine serpulid worm, a living fossil, was rediscovered for the first time since its original description 50 years ago. Undoubtedly, numerous new invertebrate species will be described by taxonomists from these remote and under-sampled seamounts. On the abyssal plain we obtained valuable eastern Indian Ocean specimens of widespread species that are currently being analysed for global phylogeographical patterns. We removed tissue samples from most identified taxa to obtain reference DNA sequences (entire mitochondria) to support future eDNA projects.

We conducted 44 CTD casts, filling 35 bottles of the rosette at a range of specified depths for both hydrochemistry calibration and eDNA. In all 10L of water for 188 samples were filtered for faunal

eDNA, 10L for 44 samples for microbial metagenomics, and 283 2L samples for microbial amphicon eDNA.

The extensive education/outreach program by voyage collaborators, BushBlitz, resulted in live crosses to 27 schools across Australia and several community and local government organisations on the Cocos (Keeling) Islands. This included full explanations of the voyage, a live tour of the ship, and discussions with scientists. The Cocos Islanders were delighted by the flythroughs video of their seafloor and video footage from the deep-towed camera.

In summary, the voyage objectives were met as follows:

1. Benthic biodiversity can be characterised from seamounts from the seamounts surveyed.
2. Representative collections were made of benthic fauna from all seamounts and abyssal plain.
3. Sufficient samples were collected across ecological and spatial gradients to perform bioregionalisation analyses for the new Marine Parks.
4. We have data on the presence of Vulnerable Marine Ecosystems (VMEs) from deep-towed video and sample collections.
5. Spatial and bathymetric patterns of oceanographic characteristics and pelagic multicellular and unicellular organisms will be possible from the samples collected.
6. We substantially contributed to the AusSeabed project through the acquisition of a large novel multibeam dataset.
7. Sufficient tissue samples of some taxonomic groups were collected to investigate biogeographical patterns across the east Indian Ocean using genetic analyses.
8. We extensively communicated the conservation values of the area through >100 media items, live crosses to 27 schools, plus one to the Cocos Marine Care group and one to the Cocos (Keeling) shire council, and extensive social media outputs.

Voyage narrative

Transit from Darwin to Christmas Island (September 30th to October 5th, 2022)

The 6-day transit to Christmas Island initially traversed the Timor Sea, through the Oceanic Shoals Marine Park, and past the north face of Seringapatam Reef. We mapped transects through the Oceanic Shoals and Argo-Rowley Terrace Marine Park, the latter to supplement the previous mapping of the massive Argo Canyon. We then crossed into international waters passing between the Roo and Joey Rises to arrive at the Christmas Island Marine Park on the 5th of October.

Notable wildlife observed were whales, spinner dolphins and small Bluefin tuna in the Timor Sea, at least 6 species of flying fish in the high seas east of the Christmas Island Territory, Spinner dolphins over the Roo Rise and numerous seabirds including Greater Crested Terns and Green Pygmy Geese.

We conducted a test CTD deployment as we entered the Christmas Island MP to calibrate the sensors and test the eDNA equipment. On the way to the first sampling location at Balthazar

Seamount, we passed over the 'Eye of Sauron' caldera again to improve the 3D imagery of this amazing structure, and several previously unmapped seamounts.

Golden Bo'sunbird and Flying Fish Seamounts (October 6-9th 2022)

We arrived at SE of Balthazar seamount complex and mapped along its southern and south-western flanks. We started sampling at an enclosed sedimentary basin to the west of Balthazar at 3600 m, starting with a CTD (Op 102) and beam trawl (Op 103). We collected seawater at 7 depths for nutrient concentrations, microbe eDNA and macrofauna eDNA. The Beam Trawl collected numerous small pieces of pumice and breccia which tended to damage the catch, including some nice seastar specimens. A second CTD (Op 104) and Beam Trawl (Op 105) pair were conducted in a small basin of sediment to the south of the complex at 2600 m. The resulted in a good catch of invertebrates, dominated by brittle stars (mostly *Ophioplinthus*). Finally, a third beam trawl (Op 106) and CTD (Op 107) pair were conducted on a abyssal sedimentary plain to the SW at 4900 m. This was a replacement for the scheduled trawl/CTD on the Cocos Basin plain at 5400 m. The catch was small, possibly caused by having to unspool some wire on the haul-in due to a winch override. There were no manganese nodules.

Over the two voyages (IN2021_V04 and IN2022_V08) we mapped the entire Balthazar seamount complex (except two small patches on the west and east), including a smaller unnamed seamount to the NW. This is quite an accomplishment as the complex is massive, over 50 km long and 25 km wide.

The 'Glögg' seamount was previously mapped only at its NW corner, so again we completed its mapping before conducting a beam trawl (op 108) and CTD (op 109) at 1400 m on the NW corner of the summit. The beam trawl had some notable fishes, including a large cusk eel and some basket eels. There were numerous pumice stones and diverse but not abundant invertebrates.

We completed the mapping of 'Attention' seamount, conducting a CTD (op 110) then beam trawl (op 111) on the summit at 1370-1400 m. The CTD had a clear indication of an oxygen rich water mass at 500 m which we hadn't previously observed. The beam trawl sampled well, the highlights were some large *Lampogrammus* cusk eels, a tripod fish, numerous crustaceans and cup corals.

The transit to 'Lucia' crossed over a small previously unknown ridge with a particularly steep western flank that summited at around 4700 m. The mapping of 'Lucia' was completed and a CTD and beam trawl pair were conducted on the NW side of the summit at ~1950 m. Brittle stars dominated the invertebrate catch, mostly the large species *Ophiomusa lymani* and *Bathypectinura heros*. The catch also included some pieces of wood with a specialised wood-fall fauna on it.

Western Vening Meinesz Rise (October 10-12th)

The long transit to the Cocos (Keeling) Marine Park traversed mostly abyssal plain below 5000 m, with a few low volcanic cones. Our first target seamount was (the informally named) 'Scrooge'. This seamount differs from many others in the region by being developed into a peak instead of a flat plateau. The peak was too rugged to sample to we headed south to a flat plain at 2900 m and conducted a CTD (op 114) and Beam Trawl (op 115). The latter was rich in sea life, including a large lizard fish. The *RV Investigator* then headed north to map more of the 'Scrooge' southern ridge and beam trawled at 2000 m (op 116), the CTD cable being trimmed and rewired after multiple use. The most notable fish was a long-tailed snipe eel.

The transit to 'Rudist' seamount took 9 hours and traversed another unnamed guyot on the way. The first sampling at 'Rudist' was on the flat summit at 1950 m. The beam trawl (op 117) caught viper fish and deepsea spiderfish with plates instead of eyes. The CTD (op 118) was employed following the rewiring. The CTD (op 119) and beam trawl (op 120) sampling at the next site was on a flat plain between the 'Rudist' complex and 'Scrooge' at 3850 m. The beam trawl resulted in a small but diverse catch in amongst pumice stones.

We then traversed the Investigator Ridge and flanking western trough to sample on the abyssal plain at 4990 m with CTD (op 121) and beam trawl (op 122). Although the beam trawl was deployed without the USB, it resulted in a large catch of flat rocks and pumiced covered in a manganese crust. There was a large diversity of black corals and a new species of blind cusk eel. We identified a new slip transform fault ridge on the abyssal seafloor to the NE of North Keeling Island.

Cocos (Keeling) Islands Seamount (October 13-17th)

Our plan to map the Cocos (Keeling) seamount was to spiral around North Keeling first and then the southern Island group. We commenced a mapping circuit of North Keeling around the 900 m depth before deploying the CTD (op 123) and beam trawl (op 124) on a small sedimentary flat at the SW corner of the island at 1000 m. Numerous seabirds (mostly brown bobbies) surrounded the vessel, feeding on flying fish we disturbed, and roosting on the mast. Bands of frigate birds flew high overhead. Our second sample was from 800-850 m (CTD op 125 and beam trawl op 126). A third attempt at a beam trawl (op 128) in 350-400 m to the SW of North Keeling, outside of the Palu Keeling NP, was only partially successful due to a bent beam and torn net. We deployed our first deep-towed camera tow (op 129) from 360 to 680 m across the SW ridge. The last sampling (ops 130-1) was on the western flank of the seamount at around 1900 m.

After the mapping of North Keeling was complete, we started sampling a small ridge between the north and south Keeling Islands. This is known to the locals as the "Seamount" which they recreationally fish during the period of the doldrums. The Deep-towed camera (op 132) showed lots of fish life including Alfonsino (Red 'Sepat'), 6 gill sharks and rays. We sampled with the Sherman sled along the flat hard coral summit (op 134) which resulted in a small but distinct catch (cup corals, orange seastars). A CTD at 700 m (op 135) was pushed off the seamount summit onto the flanks at 900 m. The beam trawl (op 136) successful sampled at 700 m.

We then commenced a mapping survey around the entire coastline of the South Keeling group along the 500 m contour which was often 1km or less from the shoreline. Our multibeams successfully mapped up to the 200 m contour. We alerted islanders to our presence and several people took nice photographs of the *RV Investigator* just offshore. We commenced sampling on a sandy ridge just north of Palau Luar at 600 m. The CTD performed well (op 137) but beam was bent on the trawl (op 138). Our third deep-towed camera east of Home Island tow at 1100 m (op 139) showed steep but smooth seafloors with deep water fish, prawns and a discarded car tyre. We followed this with a successful CTD (op 140) and beam trawl (op 141). This was followed by another pair of samples at a similar depth to the SE of South Island, CTD (op 142) and Beam Trawl (op 143), the latter suffering from another bent pole. Our final sample was west of West Island at 3100 m, CTD (op 144) and beam trawl (op 145).

Overall, we completed the mapping of the entire seamount underlying both islands. On the transit to 'Noel' seamount to the west, we discovered a small low seamount to the west of CKI.

Northern Raitt Rise (October 18-19th)

On arrival at 'Noel', we completed a CTD (op 146) on the summit, but a change in wind direction prevented a beam trawl being conducted on the small amount of sediment available. Consequently, we trawled north of the seamount in 2700 m (op 147). A second set of samples was obtained from the southern end of 'Noel' at 1920 m, including CTD (op 148) and beam trawl (op 149). 'Noel' seamount was mostly covered in hard rock with volcanic cones and not suitable for sampling with our gear.

A seamount on the north Raitt Rise was also unsuitable for trawling due to its rugged peak, so we sampled at 3100 m near its base. The beam trawl (op 151) resulted in a small catch, mostly pumice, a few rattails, a loose jaw and a larval flat fish (with its eyes still on both sides). However, the next seamount was guyot shaped with a flat top which we sampled at 1700 m (CTD op 152, beam trawl op 153).

The last seamount in the northern Raitt chain did not appear to have much suitable trawlable ground at target depths either (although we did return to sample a small patch of sand to the south of the summit later, op 185), so we transited early to Muirfield seamount along a SW to NE track.

Muirfield Seamount (October 20-24th)

The plan for Muirfield was to multibeam in a spiral route from deep to shallow depths. Initially we circumnavigated the seamount along 2000 m contour (according to Navigation charts). This route revealed several ridges and valleys and identified several trawlable locations to the SW and east. Our first site was on a sandy plateau to the SW at ~1500 m (CTD op 154 and beam trawl 155). The beam trawl contained tripod fishes and eels, bamboo corals and glass sponges, and many squat lobsters and prawns. The second identified site was just to the NE of this location on a 1000 m flat plain with at least 70 m of sediment (CTD op 156 and beam trawl 157). We continued our circumnavigational mapping transect and next sampled to the northeast at ~600 m (CTD op 158 and beam trawl 159), which resulted in the largest catch of fish on the expedition so far, including a coffin fish. Finally, we sampled at ~800 m on the SE plateau (CTD op 160 and beam trawl 161). The beam was slightly bent on coral rocks. Echo sounders indicated a dense deep-scattering layer of fish at 700 m along the northern flank at night. We continued to sample the upper plateau at 510 m (CTD op 162 and beam trawl 163), 900 m (CTD op 164 and beam trawl 165) and 650 m to the SE of the peak (CTD op 166 and beam trawl 167).

We mapped the inner rim of the seamount at first light, managing to multibeam right to the lower limit (50 m) of the AHO Lidar data. We then spent the day sampling and imaging the cone underlying the seamount summit. Our first DTC deployment (op 168) on the SE corner of the reef starting at 100 m was abandoned in order to repair the video connection. Sampling occurred (CTD op 169 and Sherman op 170) across a NE transect at 290 m which had notable shallow water faunal elements (specialised species typical of this depth). The next sample (CTD op 171 and Sherman op 172) was even shallower at 170 m to the north of the summit and contained a large catch with coral rubble, sponges, black corals and a large dead conch shell. We then completed a second DTV transect from the NE corner (op 173) starting at 100 m. Fish life was concentrated around rocks, otherwise mostly a sandy/rubble plain with urchins, anemones, sharks and eels. Followed by a third (op 174) from the SE corner starting at <100 m. Abundant fish and soft coral life was visible at the reef drop-off at 100 m. We sampled a 400 m plateau to the SW (op 175, Sherman 176), and then another at 60 m across

the SW corner (CTD op 177, Sherman op 178). The Sherman failed due to a torn net, so it was repeated (op 179) and resulted in a good catch of shallow water sponges and soft corals.

The final two Muirfield samples were taken from deep water. The first (CTD 180, beam trawl 181) was at 2900 m on a small flank of soft sediment. Our final sample was at 4000 m (CTD 182, beam trawl 183) to the south which collected many rocks and seastars. A final lap around the base of the seamount failed to locate a suitable sampling site at the target of 2500 m.

Instead, we headed for the last seamount in the north Raitt Rise and sampled the summit at 1900 m in a small patch of sand (CTD op 184, beam trawl 185).

SW Cocos Seamounts (October 25-27th)

The 'Klaus' seamount to the south of Muirfield was sampled at 2500 m (CTD op 186, beam trawl op 187). The beam was bent halfway along the tow and resulted in a small catch. However, the next seamount to be sampled (number 2 along the Santa Ridge, starting from the SW) had adequate sedimentary seafloor at 1940 m (CTD op 188, beam trawl op 189) and resulted in a small clean haul with only a few rocks. Seamount 3 was sampled at 1300 m (CTD op 190, beam trawl op 191) and contained numerous eels. Seamounts 1 and 4 were unsuitable for sampling, the former being a notable star-shaped feature.

Due to the need to allow additional time to transit back to Fremantle due to poor weather to the south, we abandoned the survey of a group of seamounts to the SE and transited to the most southern seamounts near the EEZ boundary. On this transit we mapped a perfect circular volcanic cone arising from a 5000 m seafloor, with the rim 1000 m high and a crater that was 7 km across.

The first of the southern seamounts rose unexpectedly to less than 500 m below sea level. This is the second highest seamount in the region after Muirfield. Although backscatter indicated that most of the flanks were rocky, the summit was covered in a dome of thick sediment. We sampled at 480 m (CTD op 092, beam trawl op 193). This resulted in a large catch of small demersal fish including green-eye, various eels and flatfishes. Consequently, we adopted the name "Green eye Seamount for this peak. The second seamount to the east summited at 1450 m (CTD op 194, beam trawl op 195) and, while not a rich as the previous seamount, still resulted in a diverse sample. Our final beam trawl (op 196) was at 5430 m on the abyssal plain south of the seamounts. This is the deepest beam trawl ever deployed on the *RV Investigator*. The large catch was dominated by manganese nodules, with a rich haul of subfossil/fossil shark teeth and global abyssal invertebrates.

Transit to Fremantle (October 27th to November 3rd 2022)

On the long 7-day transit back to Fremantle, we towed a magnetometer behind the vessel on a slightly curved track designed by University of Tasmania scientist Jo Whittaker. We also maximised the acquisition of new multibeam data by avoiding existing mapped areas, travelling just to the south of the Wallaby Rise and through the Abrolhos Marine Park (adjacent to the track we mapped on IN2021_V04).

Outreach, education and communications activities

The Museums Victoria media department recorded over 100 media items associated with the voyage.

Media highlights during the voyage included:

- ABC News Darwin: Interview with Dr Tim O'Hara and Melanie Mackenzie on Friday 30th September, including overlay footage of previous voyages - broadcasted on ABC National and ABC World News.
- Radio Darwin, Friday 30th September
- 3AW, Thursday 29th September
- RN News, Saturday 1st October
- Radio Perth, Monday 3rd October
- Interview for the Cosmos online magazine (https://cosmosmagazine.com/earth/rv-investigator-cocos-islands/) October 24th.
- ABC News Hobart: Interview with Dr Tim O'Hara and Di Bray aired on Saturday 29th October, plus video and flythrough footage of Cocos Keeling - broadcast on ABC TV and news website.
- ABC TV News, live from the bridge with Dr Tim O'Hara and Di Bray on Monday 31 October.

Kate Cranney from the Department of Agriculture, Water and Environment's BushBlitz program hosted 29 live crosses from the vessel, including interviews with onboard scientists, to 27 schools. Kate and Tim O'Hara also hosted online sessions with the Cocos Marine Care group and the Cocos (Keeling) Shire Council.

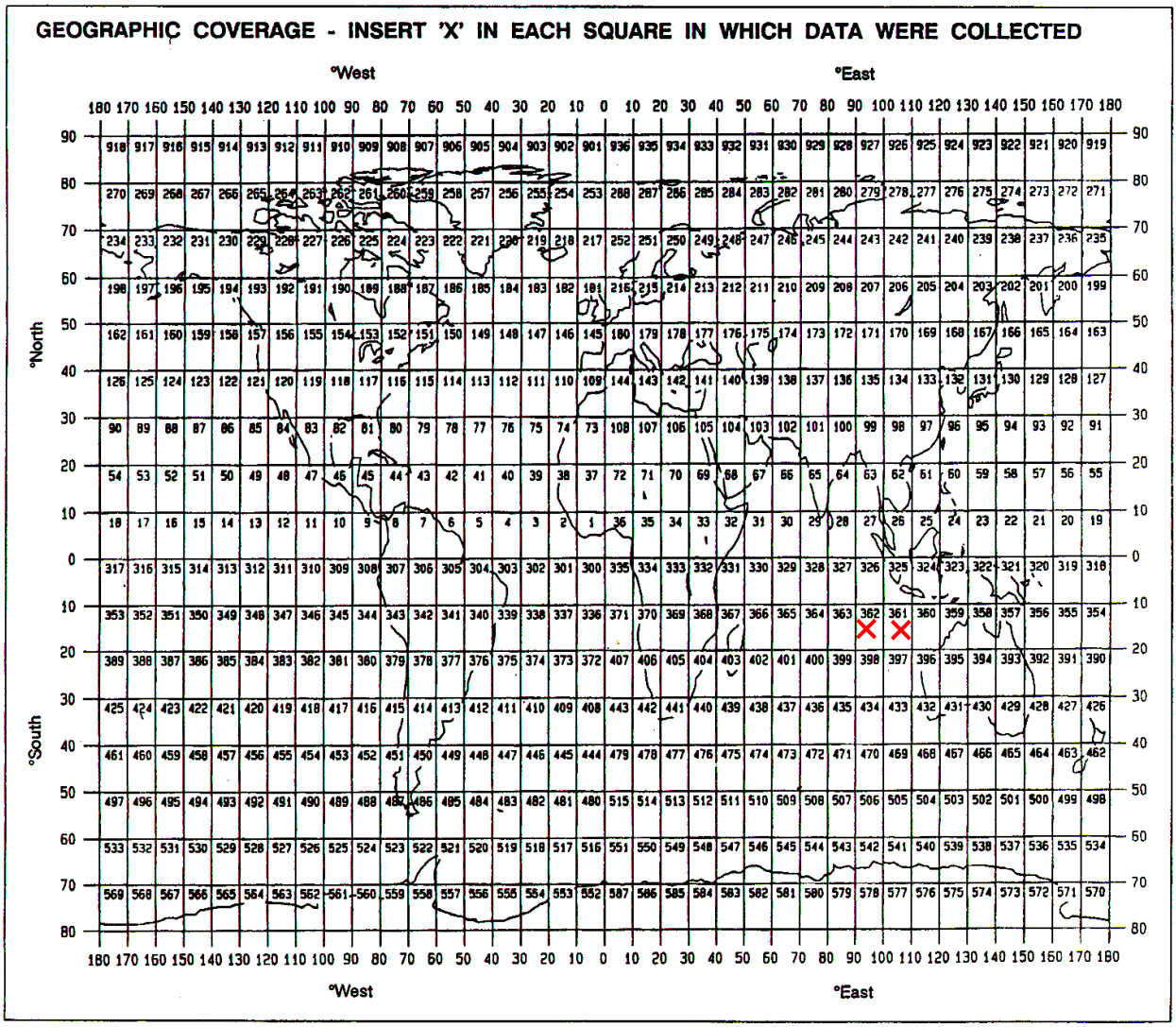
We also hosted the following PhD students/early career researchers on the voyage: Beth Flaxman (University of Sydney), Yi-Kai Tea (Australian Museum), Claire Rowe (Australian Museum), Jeremy Horowitz (Smithsonian Institution), Camille Moreau (Université Libre de Bruxelles), Angelina Eichsteller (Senckenberg Institute) and Tiffany Sih (Monash University).

The Australian Museum also hosted blog pieces on their website from the voyage, and numerous participants and collaborating institutions posted on social media.

Summary

We achieved much in the 22 days on site. We assembled comprehensive datasets on benthic and pelagic (eDNA) community composition, oceanography, and bathymetry for the numerous seamounts that we surveyed. Combining these data with those collected from the previous voyage to the region, will enable us to fully deliver on the proposed project objectives.

Marsden Squares



Summary of data and samples collected

Item Name, Identifier (e.g. serial number)	Principal Investigator (see Title Page)	NO (see above)	UNITS (see above)	DATA TYPE Enter code(s) from list in Appendix A	DESCRIPTION Identify, as appropriate, the nature of the data and of the instrumentation/sampling gear and list the parameters measured. Include any supplementary information that may be appropriate e.g. vertical or horizontal profiles, depth horizons, continuous recording or discrete samples, etc. For samples taken for later analysis on shore, an indication should be given of the type of analysis planned, i.e. the purpose for which the samples were taken.
Beam trawl samples	Tim O'Hara/Museums Victoria	40	samples	B18	Beam trawl biological samples. Archived into museum collections, including Museums Victoria, Australian Museum, South Australian Museum, Queensland Museum, Tasmanian Museum & Art Gallery, CSIRO National Fish collection.
Sherman epibenthic sled samples	Tim O'Hara/Museums Victoria	6	samples	B18	Sherman Sled biological samples. Archived into museum collections, including Museums Victoria, Australian Museum, South Australian Museum, Queensland Museum, Tasmanian Museum & Art Gallery, CSIRO National Fish collection.
Rock samples	Rebecca Carey/University of Tasmania	46	samples	G01	Rock samples from Beam Trawls (x40) and Sherman epibenthic sleds (x6), archived at the University of Tasmania for analysis
Deep-towed video	Tim O'Hara/Museums Victoria	6	Video transects	G08	Video footage and stills of 6 benthic transects around Cocos (Keeling) Islands (x3) and Muirfield Seamount (x3). DTC 4.0 was only partially successful due to a faulty camera lead.
Multicellular eDNA filter samples	Bruce Deagle/CSIRO	188	Filters	B07	Filtration of 10L water from 4 depths per 44 CTD casts. Frozen at -80C
Unicellular eDNA filter samples	Andrew Bisset/CSIRO	327	Filters	B09	Mostly filtration of 2L water from a range of standard depths per CTD casts. For 44 samples (10m above seafloor), 10L were filtered for metagenomics sequencing. All frozen at -80C.

Item Name, Identifier (e.g. serial number)	Principal Investigator (see Title Page)	NO (see above)	UNITS (see above)	DATA TYPE Enter code(s) from list in Appendix A	DESCRIPTION Identify, as appropriate, the nature of the data and of the instrumentation/sampling gear and list the parameters measured. Include any supplementary information that may be appropriate e.g. vertical or horizontal profiles, depth horizons, continuous recording or discrete samples, etc. For samples taken for later analysis on shore, an indication should be given of the type of analysis planned, i.e. the purpose for which the samples were taken.
CTD sensor data	MNF	44	Casts	H10	Temperature, salinity, conductivity, pressure, oxygen, turbidity, fluorescence
CTD hydrochemisty analyses	MNF/hydrochemisty	44	Casts	H10	Analysis of salinity, oxygen, silicate, nitrate+nitrite, phosphate concentrations from water samples.
Multibeam data	MNF/GSM	5594.7	n mi	G74	Multibeam data from the EM122 and EM710 sonars

Curation Report

Item #	Description	Storage	Access	Custodian
1.	Fish specimens	Museums Victoria & CSIRO National Fish Collection	Archived, scientific access	Martin Gomon & Di Bray (MV) and Alastair Graham & John Pogonoski (CSIRO)
2.	Invertebrate specimens: ophiuroids, holothurians, asteroids, crinoids, cephalopods, pycnogonids, isopods, tanaids, zooanthids, black corals	Museums Victoria	Archived, scientific access	Tim O'Hara & Melanie Mackenzie (MV)
3.	Invertebrate specimens: prawns, hermit crabs, barnacles, bivalves, hard corals, hydroids, bryozoans	Western Australian Museum	Archived, scientific access	Andrew Hosie & Ana Hara (WAM)
4.	Invertebrate specimens: sponges, anemones, amphipods	South Australian Museum	Archived, scientific access	Shirley Sorokin and Rachel King (SAM)
5.	Invertebrate specimens: carnivorous sponges	Queensland Museum	Archived, scientific access	Merrick Ekins (QM)
6.	Invertebrate specimens: jelly fish, gastropods, annelids, echinoids	Australian Museum	Archived, scientific access	Elena Kupriyanova & Shane Ahyong (AM)
7.	Invertebrate specimens: soft corals	Tasmanian Museum and Art Gallery	Archived, scientific access	Kirrily Moore (TMAG)

Track Chart

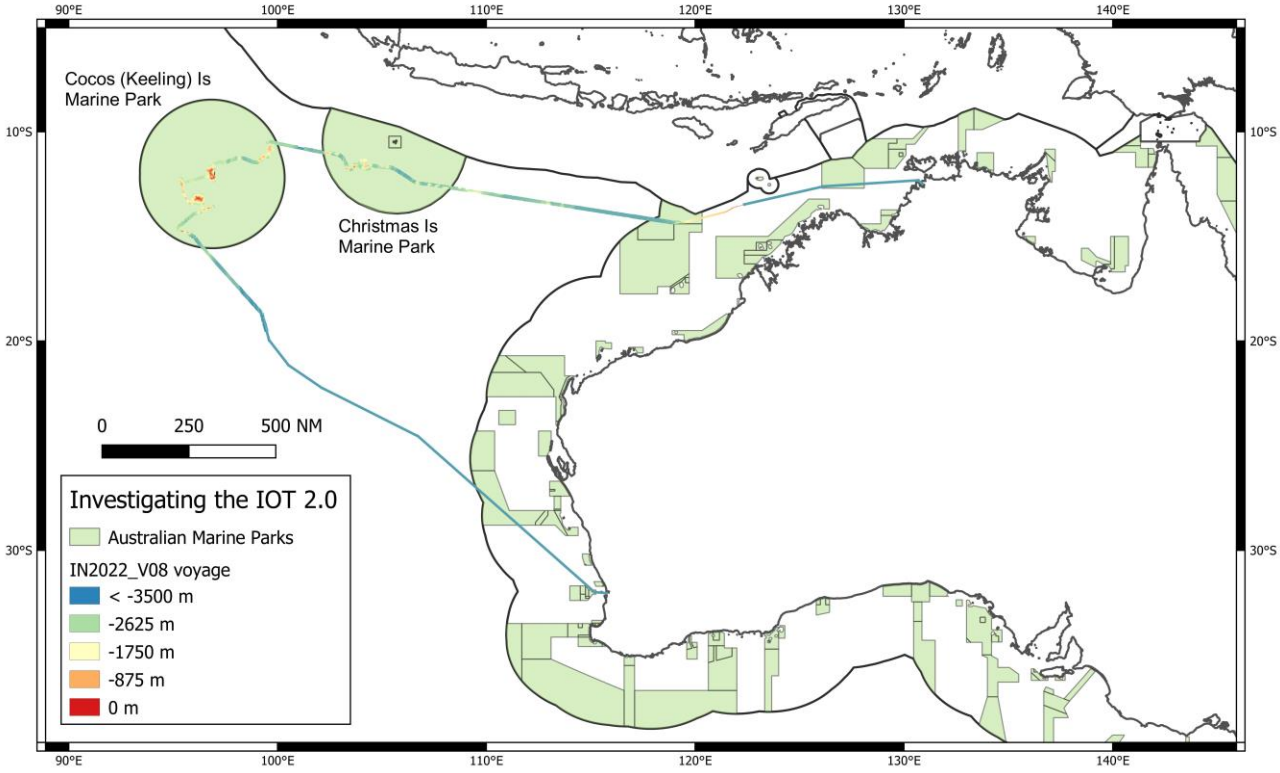


Fig. 1. Voyage track for IN2022_V08

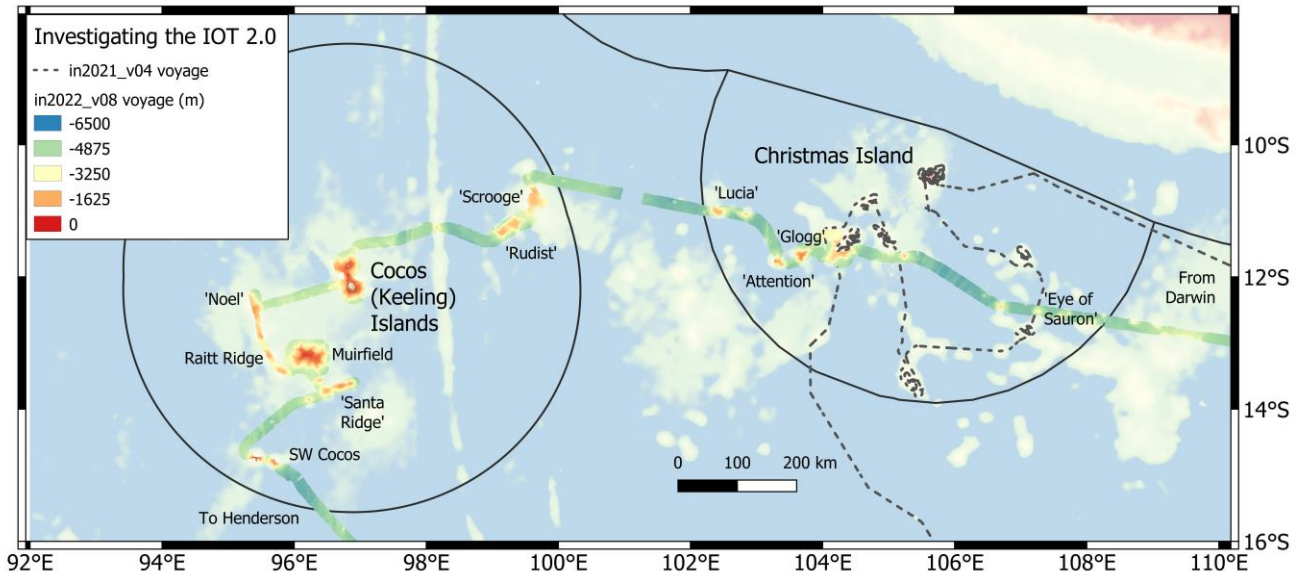


Fig. 2. Voyage track for IN2022_V08 within the Indian Island Territories.

Acknowledgements

The following science team participated on the expedition.

Margot Hind	Voyage Manager	CSIRO MNF
Hanuman Crawford	SIT Support	CSIRO MNF
Trevor Goodwin	SIT Support	CSIRO MNF
Phil Vandenbossche	GSM Support	CSIRO MNF
Nelson Kuna	GSM Support	CSIRO MNF
Richard Atkinson	DAP Support	CSIRO MNF
Stephanie Zeliadt	DAP Support	CSIRO MNF
Pavie Nanthasurasak	Hydrochemist	CSIRO MNF
Julie Janssens	Hydrochemist	CSIRO MNF
Curt Chalk	Field Operations	CSIRO MNF
Tim Lane	Field Operations	CSIRO MNF
Tim O'Hara	Chief Scientist	Museums Victoria
Bruce Deagle	Alt Chief Scientist	CSIRO
Di Bray	Science – fish	Museums Victoria
Martin Gomon	Science – fish	Museums Victoria
Ken Graham	Science – fish	Australian Museum
Yi-Kai Tea	Science – fish/eDNA	Australian Museum
Tiffany Sih	Science – fish/eDNA	Museums Victoria
Melanie Mackenzie	Science – inverts	Museums Victoria
Dani Measday	Science – inverts	Museums Victoria
Caroline Farrelly	Science – inverts	Museums Victoria
Elena Kupriyanova	Science – inverts	Australian Museum
Ingo Burghardt	Science – inverts	Australian Museum
Claire Rowe	Science – inverts	Australian Museum
Penny Berents	Science – inverts	Australian Museum
Beth Flaxman	Science – inverts	Australian Museum
Jeremy Horowitz	Science – inverts	Smithsonian Institution
Ana Hara	Science – inverts	Western Australian Museum
Camille Moreau	Science – inverts	Université Libre de Bruxelles
Angelina Eichsteller	Science – inverts	Senckenberg Institute
Kate Cranney	Education	BushBlitz
Ben Healley	Photographer	Museums Victoria

Unable to participate

Thomas Schlacher	Deputy Chief Scientist	University of the Sunshine Coast
Bentley Bird	Science – inverts	Museums Victoria
Nish Nizar	Science – inverts	Museums Victoria

Signature

Your name:	Dr Timothy D. O'Hara
Title:	Chief Scientist
Signature:	
Date:	3th November 2022

Appendix B – Photographs

See attached.

Appendix C – List of deck operations

				OnBottom				OffBottom				
Op	Station	Locality	Equipment	Date (UTC)	Latitude	Longitude	Depth	Date (UTC)	Latitude	Longitude	Depth	Op duration[1] (h:mm)
101	CTD 001	Wharton Abyssal	CTD - Seabird 911 with 36 Bottle Rosette	05/10/2022 7:14	-12.6708	108.2658	5173					0:53
102	CTD 002	Balthazar	CTD - Seabird 911 with 36 Bottle Rosette	06/10/2022 12:35	-11.3187	104.0028	3621					2:34
103	BT 001	Balthazar	CSIRO Four Metre Beam Trawl	06/10/2022 16:29	-11.359167	104.048167	3611	06/10/2022 17:58	-11.371167	104.057833	3510	4:31
104	CTD 003	Balthazar	CTD - Seabird 911 with 36 Bottle Rosette	07/10/2022 2:09	-11.635	104.1835	2576					2:10
105	BT 002	Balthazar	CSIRO Four Metre Beam Trawl	07/10/2022 5:04	-11.634333	104.190167	2435	07/10/2022 6:01	-11.661167	104.225833	2298	3:13
106	BT 003	Christmas Abyssal	CSIRO Four Metre Beam Trawl	07/10/2022 14:04	-11.645833	103.961333	4908	07/10/2022 15:49	-11.658167	103.9985	4944	6:10
107	CTD 004	Christmas Abyssal	CTD - Seabird 911 with 36 Bottle Rosette	07/10/2022 21:43	-11.6472	103.9783	4917					3:51
108	BT 004	Glögg	CSIRO Four Metre Beam Trawl	08/10/2022 5:41	-11.647833	103.639667	1451	08/10/2022 6:26	-11.6645	103.6555	1355	2:02
109	CTD 005	Glögg	CTD - Seabird 911 with 36 Bottle Rosette	08/10/2022 9:07	-11.6543	103.6498	1408					1:22
110	CTD 006	Attention	CTD - Seabird 911 with 36 Bottle Rosette	08/10/2022 15:45	-11.7512	103.2755	1466					1:12
111	BT 005	Attention	CSIRO Four Metre Beam Trawl	08/10/2022 17:43	-11.756833	103.280333	1408	08/10/2022 18:05	-11.7723	103.2882	1401	1:50
112	CTD 007	Lucia	CTD - Seabird 911 with 36 Bottle Rosette	09/10/2022 4:52	-10.9925	102.3535	2068					1:58
113	BT 006	Lucia	CSIRO Four Metre Beam Trawl	09/10/2022 7:40	-10.998953	102.382301	1968	09/10/2022 8:11	-11.000063	102.39845	1936	2:08
114	CTD 008	Scrooge	CTD - Seabird 911 with 36 Bottle Rosette	10/10/2022 8:43	-10.9255	99.7518	2888					2:05
115	BT 007	Scrooge	CSIRO Four Metre Beam Trawl	10/10/2022 11:54	-10.895765	99.766256	2973	10/10/2022 12:47	-10.872648	99.777118	2974	3:15
116	BT 008	Scrooge	CSIRO Four Metre Beam Trawl	10/10/2022 18:29	-10.790908	99.61083	1991	10/10/2022 19:43	-10.799809	99.62997	1957	4:00
117	BT 009	Rudist	CSIRO Four Metre Beam Trawl	11/10/2022 5:26	-11.318652	99.132731	1175	11/10/2022 6:12	-11.30773	99.152069	1764	2:41
118	CTD 009	Rudist	CTD - Seabird 911 with 36 Bottle Rosette	11/10/2022 8:33	-11.289	99.1805	1923					2:00
119	CTD 010	Rudist	CTD - Seabird 911 with 36 Bottle Rosette	11/10/2022 14:16	-11.0602	99.4023	3848					3:16
120	BT 010	Rudist	CSIRO Four Metre Beam Trawl	11/10/2022 18:39	-11.063075	99.44336	3839	11/10/2022 20:04	-11.064104	99.486905	3780	3:18
121	CTD 011	Investigator Ridge Abyssal	CTD - Seabird 911 with 36 Bottle Rosette	12/10/2022 11:06	-11.2553	97.94	4880					3:36
122	BT 011	Investigator Ridge Abyssal	CSIRO Four Metre Beam Trawl	12/10/2022 15:33	-11.257106	97.968963	4980	12/10/2022 16:27	-11.257948	97.992635	4990	4:53
123	CTD 012	Cocos (Keeling)	CTD - Seabird 911 with 36 Bottle Rosette	13/10/2022 10:22	-11.8583	96.7312	1090					0:56
124	BT 012	Cocos (Keeling)	CSIRO Four Metre Beam Trawl	13/10/2022 11:52	-11.858441	96.740316	1020	13/10/2022 12:13	-11.858239	96.751479	967	6:39
125	CTD 013	Cocos (Keeling)	CTD - Seabird 911 with 36 Bottle Rosette	13/10/2022 17:38	-11.7888	96.8223	1025					1:03
126	BT 013	Cocos (Keeling)	CSIRO Four Metre Beam Trawl	13/10/2022 19:14	-11.79153	96.84057	820	13/10/2022 19:55	-11.791735	96.859105	822	1:25

127	CTD 014	Cocos (Keeling)	CTD - Seabird 911 with 36 Bottle Rosette	14/10/2022 5:03	-11.8533	96.7802	506					0:43
128	BT 014	Cocos (Keeling)	CSIRO Four Metre Beam Trawl	14/10/2022 6:08	-11.8551	96.786015	404	14/10/2022 6:17	-11.857617	96.790092	328	0:53
129	DTC 001	Cocos (Keeling)	Deep Towed Camera System	14/10/2022 8:13	-11.856224	96.784738	368	14/10/2022 9:29	-11.871381	96.802302	678	1:53
130	CTD 015	Cocos (Keeling)	CTD - Seabird 911 with 36 Bottle Rosette	14/10/2022 13:28	-11.8172	96.6178	2256					1:45
131	BT 015	Cocos (Keeling)	CSIRO Four Metre Beam Trawl	14/10/2022 15:44	-11.832245	96.626654	1896	14/10/2022 16:34	-11.843736	96.648927	1589	2:17
132	DTC 002	Cocos (Keeling)	Deep Towed Camera System	15/10/2022 8:27	-11.978642	96.820454	363	15/10/2022 9:35	-11.99473	96.839991	758	1:48
133	CTD 016	Cocos (Keeling)	CTD - Seabird 911 with 36 Bottle Rosette	15/10/2022 11:08	-11.9745	96.8157	379					0:38
134	EBS 001	Cocos (Keeling)	Sherman epibenthic sled	15/10/2022 12:50	-11.972855	96.813593	353	15/10/2022 12:55	-11.976771	96.817803	356	0:23
135	CTD 017	Cocos (Keeling)	CTD - Seabird 911 with 36 Bottle Rosette	15/10/2022 16:34	-12.0193	96.846	917					0:58
136	BT 016	Cocos (Keeling)	CSIRO Four Metre Beam Trawl	15/10/2022 18:20	-12.019346	96.836526	754	15/10/2022 18:52	-12.025981	96.853407	890	1:25
137	CTD 018	Cocos (Keeling)	CTD - Seabird 911 with 36 Bottle Rosette	16/10/2022 5:46	-12.0478	96.8357	698					0:47
138	BT 017	Cocos (Keeling)	CSIRO Four Metre Beam Trawl	16/10/2022 7:11	-12.046842	96.83093	674	16/10/2022 7:23	-12.049999	96.837679	648	1:15
139	DTC 003	Cocos (Keeling)	Deep Towed Camera System	16/10/2022 9:23	-12.062727	96.888433	894	16/10/2022 10:14	-12.069289	96.903957	1136	1:54
140	CTD 019	Cocos (Keeling)	CTD - Seabird 911 with 36 Bottle Rosette	16/10/2022 12:13	-12.134	96.9887	1122					0:58
141	BT 018	Cocos (Keeling)	CSIRO Four Metre Beam Trawl	16/10/2022 13:56	-12.127953	96.980023	1139	16/10/2022 14:17	-12.133	96.989167	1110	1:23
142	CTD 020	Cocos (Keeling)	CTD - Seabird 911 with 36 Bottle Rosette	16/10/2022 17:58	-12.2377	96.972	1345					1:16
143	BT 019	Cocos (Keeling)	CSIRO Four Metre Beam Trawl	16/10/2022 19:56	-12.22544	96.959928	1113	16/10/2022 20:41	-12.239178	96.971079	1343	1:44
144	CTD 021	Cocos (Keeling)	CTD - Seabird 911 with 36 Bottle Rosette	17/10/2022 5:37	-12.1228	96.6582	3104					2:58
145	BT 020	Cocos (Keeling)	CSIRO Four Metre Beam Trawl	17/10/2022 9:31	-12.126546	96.683201	3078	17/10/2022 10:02	-12.130333	96.677363	3002	2:49
146	CTD 022	Noel	CTD - Seabird 911 with 36 Bottle Rosette	18/10/2022 2:34	-12.5127	95.4198	1664					1:40
147	BT 021	Noel	CSIRO Four Metre Beam Trawl	18/10/2022 6:01	-12.387654	95.394473	2617	18/10/2022 6:40	-12.395408	95.409873	2721	2:54
148	CTD 023	Noel	CTD - Seabird 911 with 36 Bottle Rosette	18/10/2022 10:57	-12.5907	95.4297	1895					1:34
149	BT 022	Noel	CSIRO Four Metre Beam Trawl	18/10/2022 13:16	-12.581511	95.418299	1904	18/10/2022 13:46	-12.589133	95.43105	1874	2:06
150	CTD 024	Raitt Ridge North	CTD - Seabird 911 with 36 Bottle Rosette	18/10/2022 20:51	-12.9705	95.4882	3123					2:31
151	BT 023	Raitt Ridge North	CSIRO Four Metre Beam Trawl	19/10/2022 0:09	-12.95748	95.469888	3053	19/10/2022 1:10	-12.974966	95.487425	3144	3:22
152	CTD 025	Raitt Ridge North	CTD - Seabird 911 with 36 Bottle Rosette	19/10/2022 6:07	-13.1875	95.6147	1728					1:29
153	BT 024	Raitt Ridge North	CSIRO Four Metre Beam Trawl	19/10/2022 8:26	-13.180971	95.600697	1736	19/10/2022 9:11	-13.188743	95.617259	1747	2:02
154	CTD 026	Muirfield	CTD - Seabird 911 with 36 Bottle Rosette	20/10/2022 2:22	-13.2778	96.0712	1460					1:26
155	BT 025	Muirfield	CSIRO Four Metre Beam Trawl	20/10/2022 4:19	-13.277921	96.068292	1459	20/10/2022 5:03	-13.283118	96.085863	1595	1:52
156	CTD 027	Muirfield	CTD - Seabird 911 with 36 Bottle Rosette	20/10/2022 7:25	-13.2485	96.085	1018					0:59
157	BT 026	Muirfield	CSIRO Four Metre Beam Trawl	20/10/2022 9:04	-13.243749	96.081331	1023	20/10/2022 9:44	-13.260717	96.0988	1019	1:33

158	CTD 028	Muirfield	CTD - Seabird 911 with 36 Bottle Rosette	20/10/2022 17:42	-13.1788	96.2673	606					0:51
159	BT 027	Muirfield	CSIRO Four Metre Beam Trawl	20/10/2022 19:02	-13.173588	96.260952	603	20/10/2022 19:35	-13.18272	96.273887	675	2:01
160	CTD 029	Muirfield	CTD - Seabird 911 with 36 Bottle Rosette	21/10/2022 0:20	-13.2132	96.1065	818					1:09
161	BT 028	Muirfield	CSIRO Four Metre Beam Trawl	21/10/2022 1:46	-13.220953	96.11142	811	21/10/2022 2:26	-13.227719	96.125829	808	1:29
162	CTD 030	Muirfield	CTD - Seabird 911 with 36 Bottle Rosette	21/10/2022 7:38	-13.1765	96.2435	517					0:41
163	BT 029	Muirfield	CSIRO Four Metre Beam Trawl	21/10/2022 8:44	-13.17441	96.237309	528	21/10/2022 9:23	-13.180701	96.250738	527	1:13
164	CTD 031	Muirfield	CTD - Seabird 911 with 36 Bottle Rosette	21/10/2022 13:08	-13.241	96.29	895					0:53
165	BT 030	Muirfield	CSIRO Four Metre Beam Trawl	21/10/2022 14:36	-13.242356	96.292061	932	21/10/2022 15:12	-13.252329	96.302906	965	1:27
166	CTD 032	Muirfield	CTD - Seabird 911 with 36 Bottle Rosette	21/10/2022 20:29	-13.2175	96.2447	647					0:52
167	BT 031	Muirfield	CSIRO Four Metre Beam Trawl	21/10/2022 22:00	-13.211997	96.241624	625	21/10/2022 22:42	-13.22255	96.256441	686	1:16
168	DTC 004	Muirfield	Deep Towed Camera System	22/10/2022 5:41	-13.1875	96.1872	79	22/10/2022 6:17	-13.203	-96.2012	622	0:36
169	CTD 033	Muirfield	CTD - Seabird 911 with 36 Bottle Rosette	22/10/2022 7:15	-13.1698	96.1873	256					0:26
170	EBS 002	Muirfield	Sherman epibenthic sled	22/10/2022 8:16	-13.168267	96.187213	271	22/10/2022 8:27	-13.174122	96.190228	311	0:42
171	CTD 034	Muirfield	CTD - Seabird 911 with 36 Bottle Rosette	22/10/2022 9:53	-13.1688	96.1753	171					0:22
172	EBS 003	Muirfield	Sherman epibenthic sled	22/10/2022 10:38	-13.168403	96.171452	176	22/10/2022 11:02	-13.168138	96.17901	169	0:36
173	DTC 005	Muirfield	Deep Towed Camera System	22/10/2022 12:47	-13.1677	96.1815	179	22/10/2022 13:26	-13.1767	-96.1978	419	0:52
174	DTC 006	Muirfield	Deep Towed Camera System	22/10/2022 14:01	-13.1885	96.1863	89	22/10/2022 14:35	-13.2055	-96.1895	599	0:52
175	CTD 035	Muirfield	CTD - Seabird 911 with 36 Bottle Rosette	22/10/2022 16:30	-13.1835	96.144	402					0:37
176	EBS 004	Muirfield	Sherman epibenthic sled	22/10/2022 17:27	-13.18705	96.147587	367	22/10/2022 17:41	-13.193417	96.15215	365	0:49
177	CTD 036	Muirfield	CTD - Seabird 911 with 36 Bottle Rosette	22/10/2022 18:42	-13.1887	96.164	97					0:31
178	EBS 005	Muirfield	Sherman epibenthic sled	22/10/2022 20:00	-13.185188	96.160379	94	22/10/2022 20:16	-13.189348	96.163745	137	0:56
179	EBS 006	Muirfield	Sherman epibenthic sled	22/10/2022 21:26	-13.184727	96.159621	121	22/10/2022 21:39	-13.188639	96.163431	111	0:29
180	CTD 037	Muirfield	CTD - Seabird 911 with 36 Bottle Rosette	23/10/2022 7:21	-13.0935	96.353	2921					2:12
181	BT 032	Muirfield	CSIRO Four Metre Beam Trawl	23/10/2022 10:03	-13.092538	96.352386	2923	23/10/2022 10:52	-13.106978	96.362669	2889	2:46
182	CTD 038	Muirfield	CTD - Seabird 911 with 36 Bottle Rosette	23/10/2022 19:33	-13.4362	96.3017	3939					3:06
183	BT 033	Muirfield	CSIRO Four Metre Beam Trawl	23/10/2022 23:20	-13.436569	96.304821	3948	24/10/2022 0:43	-13.451595	96.326443	4047	4:06
184	CTD 039	Raitt Ridge North	CTD - Seabird 911 with 36 Bottle Rosette	24/10/2022 12:24	-13.4362	95.8325	1900					1:35
185	BT 034	Raitt Ridge North	CSIRO Four Metre Beam Trawl	24/10/2022 14:34	-13.4365	95.831217	1913	24/10/2022 15:19	-13.44495	95.847983	1950	2:13
186	CTD 040	Santa Ridge	CTD - Seabird 911 with 36 Bottle Rosette	24/10/2022 23:47	-13.5665	96.3718	2334					1:57
187	BT 035	Santa Ridge	CSIRO Four Metre Beam Trawl	25/10/2022 2:54	-13.561669	96.368259	2418	25/10/2022 3:19	-13.552873	96.38213	2156	2:37
188	CTD 041	Santa Ridge	CTD - Seabird 911 with 36 Bottle Rosette	25/10/2022 7:31	-13.7202	96.4638	1977					1:32
189	BT 036	Santa Ridge	CSIRO Four Metre Beam Trawl	25/10/2022 9:39	-13.722167	96.468083	1943	25/10/2022 10:20	-13.723273	96.48167	1872	2:07

190	CTD 042	Santa Ridge	CTD - Seabird 911 with 36 Bottle Rosette	25/10/2022 14:34	-13.6535	96.6992	1312					1:06
191	BT 037	Santa Ridge	CSIRO Four Metre Beam Trawl	25/10/2022 16:04	-13.651867	96.6985	1304	25/10/2022 16:39	-13.66325	96.711367	1325	1:36
192	CTD 043	SW Cocos	CTD - Seabird 911 with 36 Bottle Rosette	26/10/2022 12:24	-14.7352	95.418	476					0:34
193	BT 038	SW Cocos	CSIRO Four Metre Beam Trawl	26/10/2022 13:23	-14.735353	95.417168	477	26/10/2022 13:49	-14.746763	95.422514	467	0:57
194	CTD 044	SW Cocos	CTD - Seabird 911 with 36 Bottle Rosette	26/10/2022 17:49	-14.7922	95.687	1428					1:26
195	BT 039	SW Cocos	CSIRO Four Metre Beam Trawl	26/10/2022 19:46	-14.790567	95.683131	1450	26/10/2022 20:13	-14.802188	95.6897	1426	1:35
196	BT 040	Cocos Abyssal	CSIRO Four Metre Beam Trawl	27/10/2022 2:24	-14.952489	95.917052	5414	27/10/2022 3:32	-14.97087	95.941532	3431	5:39

[1] = Recovery - deployment