RV *Investigator* Voyage Plan

VOYAGE #:	IN2022_V07		
Version Number:	FINAL		
Voyage title:	HALO - *Halimeda* bioherm Origins, function and fate in the northern Great Barrier Reef		
Mobilisation:	Brisbane, Monday, 8 August 2022 – Thursday, 11 August 2022		
Pre-medical clearance period:	Brisbane, Friday, 5 August 2022 – Friday, 12 August 2022		
Depart:	Brisbane, Sunday, 14 August 2022		
Return:	Cairns, Wednesday, 7 September 2022		
Demobilisation:	Cairns, Wednesday, 7 September 2022		
Voyage Delivery Coordinator	Claire Grubb	**Contact details:**	claire.grubb@csiro.au
Voyage Manager	David Flynn	**Contact details:**	david.flynn@csiro.au
Chief Scientist:	Professor Jody Webster		
Affiliation:	University of Sydney	**Contact details:**	jody.webster@sydney.edu.au
Principal Investigators:	Dr Robin Beaman, James Cook University Professor Maria Byrne, University of Sydney Dr Luke Nothdurft, Queensland University of Technology Dr Mardi McNeil (Alternative Chief Scientist), Geoscience Australia Associate Professor Helen Bostock, University of Queensland Dr Trevor Graham, Queensland University of Technology Professor Dirk Erler, Southern Cross University Dr Angel Puga-Bernabeu, Universidad de Granada Professor Juan Carlos Braga, Universidad de Granada Dr Willem Renema, Naturalis, Biodiversity Center, Leiden, Netherlands Professor Yusuke Yokoyama, University of Tokyo		

Scientific objectives

Halimeda bioherms on the northern GBR shelf are the most extensive, actively accumulating *Halimeda* deposits in the world, contributing to their Outstanding Universal Value from a geological and geomorphological perspective. Our recent compilation of available high-resolution bathymetry data reveals that bioherms are much larger in area and have a far more complex morphology that previously thought. Compared with the adjacent coral reefs systems, little is known about the fundamental processes that control bioherm distribution and development, or their role as key inter-reef benthic habitats, and if they are susceptible to future climate changes.

Project **HALO** (***Hal**imeda* bioherm **O**rigins, function and fate in the northern Great Barrier Reef) has five main scientific objectives:

(1) define the spatial distribution and morphological variation of the *Halimeda* bioherms;

(2) explore the relationship of the bioherms to the deeper undersea landscape (channels, passages, slope, submarine canyons and basin) and key oceanographic processes;

(3) develop new 3D models explaining their origin and development, generate Holocene paleo-climate data, including novel archives of upwelling, paleo-flooding and water quality;

(4) quantify their total volume/area as a regional geological carbon sink within the context of the global carbon budget; and

(5) assess the importance of the bioherms as modern, inter-reef benthic habitats.

Voyage objectives

Project **HALO** will conduct detailed survey operations at three sites with *Halimeda* bioherms on the northern GBR shelf and the directly adjacent, deeper offshore areas (Fig. 1, 2). The shelf work aims to conduct dense grids of geophysical lines at the three bioherm sites, representing the variety of morphological sub-types, and spread between the Ribbon Reefs and Tijou Reef study areas (Fig. 3-6). We plan to spend ~6 days at each shelf grid site, roughly divided into 1-2 days each for geophysical mapping, sea floor imaging, sea water and seabed sampling. The transits between the shelf sites, are also important to investigate additional *Halimeda* bioherm areas, paleo-channels, inter-reef passages and the connections to the upper-slope and canyons wherever possible. The deep offshore work will be conducted towards the end of the voyage at three possible slope/basin sites offshore Princes Charlotte Bay and the Ribbon Reefs in transit to Cairns via Grafton Passage. The following instruments and methods will be applied during the voyage to provide data for the scientific objectives:

1) Bioherm surface and subsurface geomorphology (geophysical surveys)

Kongsberg EM710, EM122 and EM2040 multibeam mapping

Multibeam bathymetry and backscatter surveys (MBES) will determine the detailed bioherm surface morphology at each grid site. As the bioherms occur between depths of ~20-50 m, the EM710 in combination with the EM2040 will be used, and the EM710 during the transits off-shelf to a lower depth limit of ~800 m. The EM122 will survey continental slope depths greater than ~100 m for the offshore objectives (below). The depths offshore from the Princes Charlotte Bay and Ribbon Reefs area range to

~2000 m. Using an average bioherm depth of 20 m, the shelf survey sites are planned with grid line spacings of 50 m for ~30 min @ 7 kn, covering ~6 km with each line. With each grid taking 10-14 hours including turns and several crosslines, each grid potentially covers 6 km x 1 km. If time allows, and in the event that poor weather or other logistical constraints preclude deck operations, these survey grids will be expanded.

Sub-Bottom SBP120 profiler

The SBP120 will be operated in conjunction with the multibeam systems. The dense sub-bottom 2D profiles over the shelf grid sites are critical as they will be used to reconstruct the 3D sub-surface, including their internal reflections and the shape of the basement substrate, due to the closeness of the lines. This technique has been used successfully on previous voyages to generate 3D models of the antecedent topography and volumetric calculations of GBR shelf-edge reefs. The *Halimeda* bioherms have excellent sub-bottom structure and will be ideal for extending this 3D modelling technique over representative bioherm morphological sub-types. This subsurface information will also guide the sediment coring program using the multicorer and vibrocoring systems.

2) Bioherm internal structure and composition (sediment coring and rock sampling)

Vibrocoring system (User Supplied Equipment)

Given the nature of the *Halimeda* bioherm sediments and depth limitation of the shipboard coring system, we will use a vibrocoring system provided by Geoscience Australia (GA). We will collect replicate vibrocores from the bioherm crests and troughs to obtain a full sequence of the sediments overlying the karst Pleistocene surface. We aim to collect up to 6 m long sediment cores (up to 15 cores per shelf site) at each of the three shelf sites (~20-50 m). A transect approach will be employed to sample across the bioherms, in the event that penetration depths are limited by challenging lithologies, and also allowing access to older sequences on their flanks. Vibrocoring sites will be selected following the systematic MBES mapping and observation of the seabed within proposed shelf grid survey sites, using the MNF towed camera/and or drop camera systems.

Rock dredging

We will collect dredged rock samples from the outcropping rock pinnacles within the depressions and along the flanks of the bioherms to characterise the antecedent basement. The multibeam bathymetry and sub-bottom data will provide precise targets at the survey sites for standard rock dredging. Previous MNF voyages have successfully used this approach to recover Pleistocene-aged rocks and attached living benthos on the GBR and Fraser shelf edge (SS2007_V07; SS2013_V01). Any attached modern and fossil benthos will be analysed and archived by HALO biology team.

3) Bioherm modern habitats and biota (seabed imaging, seabed sampling and water sampling)

MNF towed camera system

We will collect seafloor imagery using the onboard MNF towed camera system as vertical dips. We will conduct several cross-shelf transects across bioherms at representative stations to assess the substrate types and character of the modern benthic biota associated with these habitats. Due to the shallow water depth the camera will not be towed continuously but rather lowered periodically by vertical dips to image the sea floor. The precise location of these cross-shelf transects will be identified following the geophysical mapping (multibeam and sub-bottom profiling) and will be designed to capture representative examples of the three main bioherm geomorphic types.

Smith McIntyre Grab, box corer & shallow CTD's

We will collect a dense transect of sediment grabs over targeted bioherms within the shelf sites. Grabs will be obtained across the crests, down the flanks and into the depressions. These sediments will later be analysed for grain size, texture, composition, and any recovered live biota (Halimeda, coralline algae, corals, large benthic foraminifera etc) identified and curated for further study including DNA analysis. A box corer will be deployed at representative sites to ensure the living surface fauna is collected. Several shallow CTD casts will be carried out across shelf to characterise oceanographic conditions, collect water for biogeochemical measurements and eDNA analysis of biodiversity in the different bioherm morphology types.

Water collection for nutrient analysis, trace and rare earth elements

We will collect water samples from the sediment/water interface that will be analysed by the MNF Hydrochem team and by the science party post-cruise for nutrients (oxygen, nitrate, phosphate, silicate, nitrite, ammonia), and trace and rare earth elements. Since the CTD niskin rosette cannot be deployed within 5 m of the seabed, we plan to use the multi-corer to collect sed/water interface water and also with a Niskin bottle attached.

4) The role of *Halimeda* algal habitat in tropical marine carbon and nitrogen biogeochemical cycling

The objective is to measure the contribution of *Halimeda* bioherms to marine carbon and nitrogen biogeochemical cycles, and greenhouse gas fluxes on the shelf. This will provide a crucial first step towards understanding biogeochemical cycling between the bioherms and adjacent coral reef habitats. We will collect *Halimeda* sediment short cores at the shallow shelf sites, followed by deck incubations. This will help constrain the diurnal flux of nutrients (C/N/P), oxygen etc., and specific rate processes (denitrification, DNRA, N2 fixation etc.). Bioherm sediment porewater chemistry will test whether the donut shapes are a result of some chemical process (e.g. sulphidic conditions and dissolution).

Sediment-water interface cores will be collected with the multicorer. However, there is concern that the multicorer may not penetrate the coarse carbonate sand/gravel, in which case we use the box corer. The sediment cores will be transferred to the chambers, placed in the incubation tanks and pre-incubated while the RVI is underway and engaged in other activities. During the onboard incubations a range of experiments and measurements will be performed including flux incubations (nutrients, pH, alk, DOC, DIC etc – Light and Dark experiments) under ambient conditions, and nutrient analysis (by the MNF hydrochem team). To complement the deck incubation experiments, we will take continuous in situ measurements of the water column within the bioherm ring-shaped hollows, and outside the hollows, by deploying a sonde with conductivity, temperature, depth, pH, and O2 probes attached.

5) Deeper undersea landscape (slope, submarine canyons and basin) and key oceanographic processes (multibeam mapping, sediment coring and water sampling)

The objective is to investigate the deeper seascapes offshore and establish the geomorphic, sedimentologic and oceanographic relationships between the *Halimeda* bioherms on the shelf. The deep offshore work will conducted at three possible slope/basin sites offshore Princes Charlotte Bay and the Ribbon Reefs in transit to Cairns. Multibeam (EM710, EM122) mapping and SBP120 sub-bottom profiling will be used, as required, to investigate the surface and sub-surface geomorphology of the slopes, canyons and basin and to select sampling sites. Using the Giant Piston Coring (GPC) system, we intend to collect piston cores from the slope and canyons to reconstruct paleoceanographic conditions (sea surface temperature, deep-water masses and upwelling etc.), and the history of shelf-to-basin sediment transport patterns. At each of the GPC stations we will also be conduct a CTD overnight.

Voyage Risk Assessment (VRA)

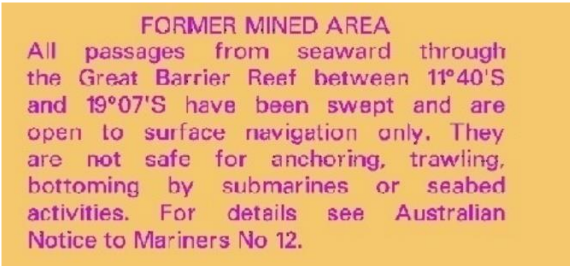
Great Barrier Reef - vessel operations

Navigational risks may exist around the various reefs and passages within the Great Barrier Reef zone as stated in this voyage plan.

To mitigate any possible risk ASP Ship management have outlined a minimum CPA of 1 nautical mile from grounding depths and will only transit passages when required to in day light hours.

Grid survey boxes on the shelf (Sites 1, 2, 3) will be finalised at sea, with approval of the Master.

As per the below note from AHO charts of the Great Barrier Reef, many of the passages into the reef system were formerly mined during WW2 and have since been cleared.


FORMER MINED AREA
All passages from seaward through the Great Barrier Reef between 11°40'S and 19°07'S have been swept and are open to surface navigation only. They are not safe for anchoring, trawling, bottoming by submarines or seabed activities. For details see Australian Notice to Mariners No 12.

This voyage will not be sampling in these passages and none of the selected grid sampling sites lie in these passages, e.g.

- Site 1 ~12 nm away from Cruiser Passage
- Site 2 ~14 nm away from One and a Half Mile Opening
- Site 3 ~10 nm away from Second Three Mile Opening

The MNF, ASP and the Chief Scientist have agreed the following risk management strategies:

1. RVI will not anchor, trawl or conduct seabed activities in the passages themselves.

2. Science operations will only be conducted within the selected grid sites well clear of the passages (as above).

A detailed voyage specific risk assessment will be conducted by the MNF covering all science activities and the vessel's operations within the Great Barrier Reef and shall be a part of the final IN2022_V07 Voyage Plan.

Media Activities

The MNF will seek to pursue opportunities that arise during the voyage to promote the science, scientists and ship, via conventional and social media channels, in consultation and/or collaboration with the relevant ship user.

The HALO team will plan to do Skype/Zoom ship-to-shore communications for media and other outreach activities throughout the voyage.

ORGANISATION	ACTIVITIES	TIMING	RESPONSIBLE PERSON
USYD	Chief Scientist undertaking interviews with networks to discuss science being undertaken	Pre-departure	Prof. Webster
HALO Team institution	Live cross to network and a range of stories and blogs to be released.	Throughout voyage	Prof. Webster & HALO team and their home institutions (ie. QUT/SEF Comms; Naturalis, Biodiversity Center (Netherlands))

Activity plan for first 24-48 hours of voyage

Day	Date	Time	Activity
Friday	12/08		Pre-departure medical clearance period. Vibrocoring system shakedown (alongside in port)
Saturday	13/08		Pre-departure medical clearance period. Vibrocoring system shakedown (alongside in port)
Sunday	14/08	0900	Depart Brisbane. Time TBC. Exit Moreton Bay, commence transit
Monday	15/08		Transit. Test CTD cast at waypoint 4 Fraser Canyon
Tuesday	16/08		Transit.
Wednesday	17/08	1800	Grafton Passage – Arrive Cairns pilot station Allow time for revised EM2040 calibration and patch test site
Thursday	18/08	0600	Arrive Site 1 Ribbon Reef 3. Commence MBES and SBP grid survey

Voyage track

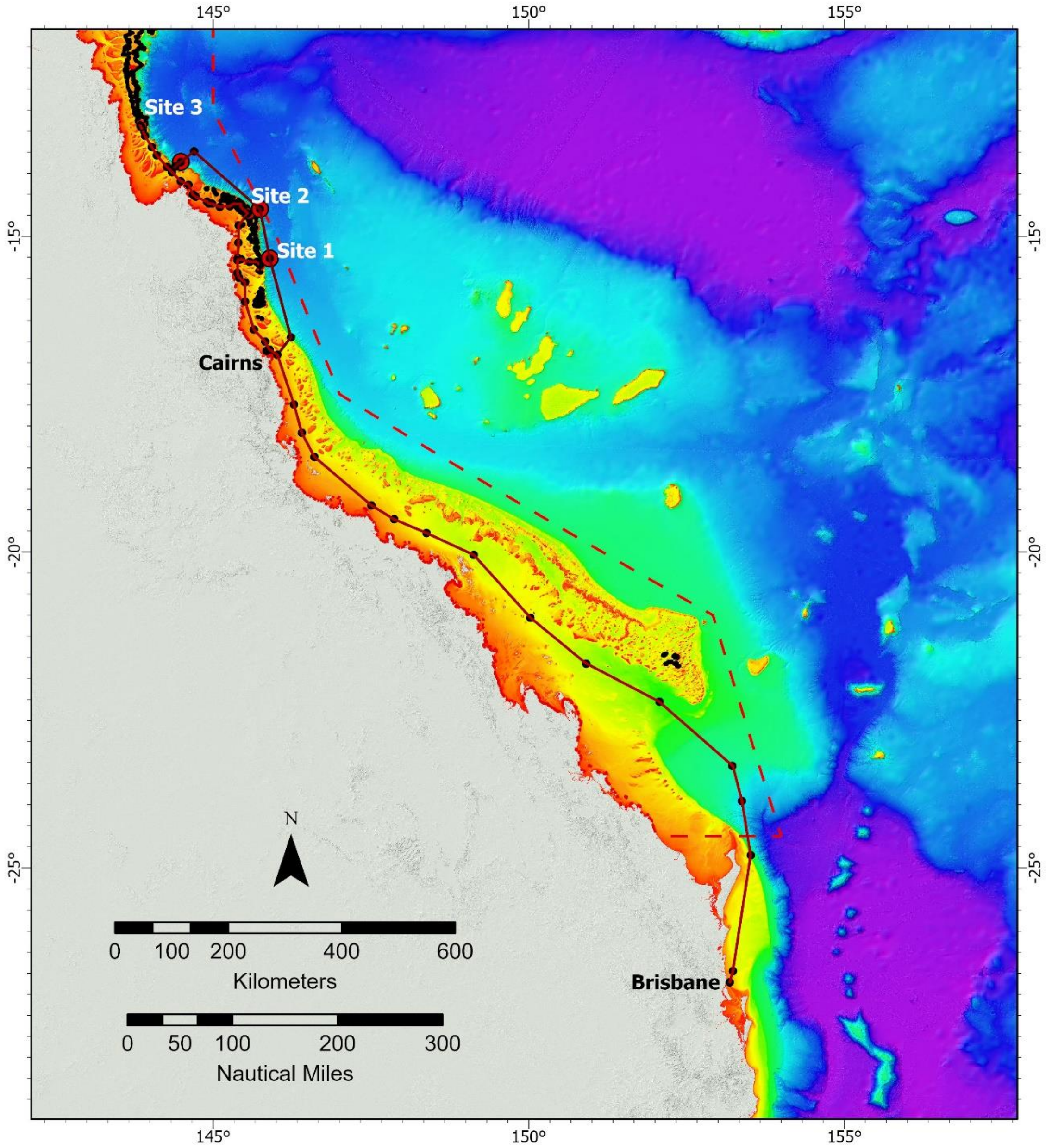


Figure 1. Map of IN2022_V07 voyage track (solid red line) joining waypoints (black dots) from Brisbane to the first survey site north of Cairns. Dashed red line is GBR Marine Park boundary. The three survey sites are labelled Site 1 – Ribbon Reef 3, Site 2 - Cormorant Reef, Site 3 - Tijou Reef. See Table 2 for way points.

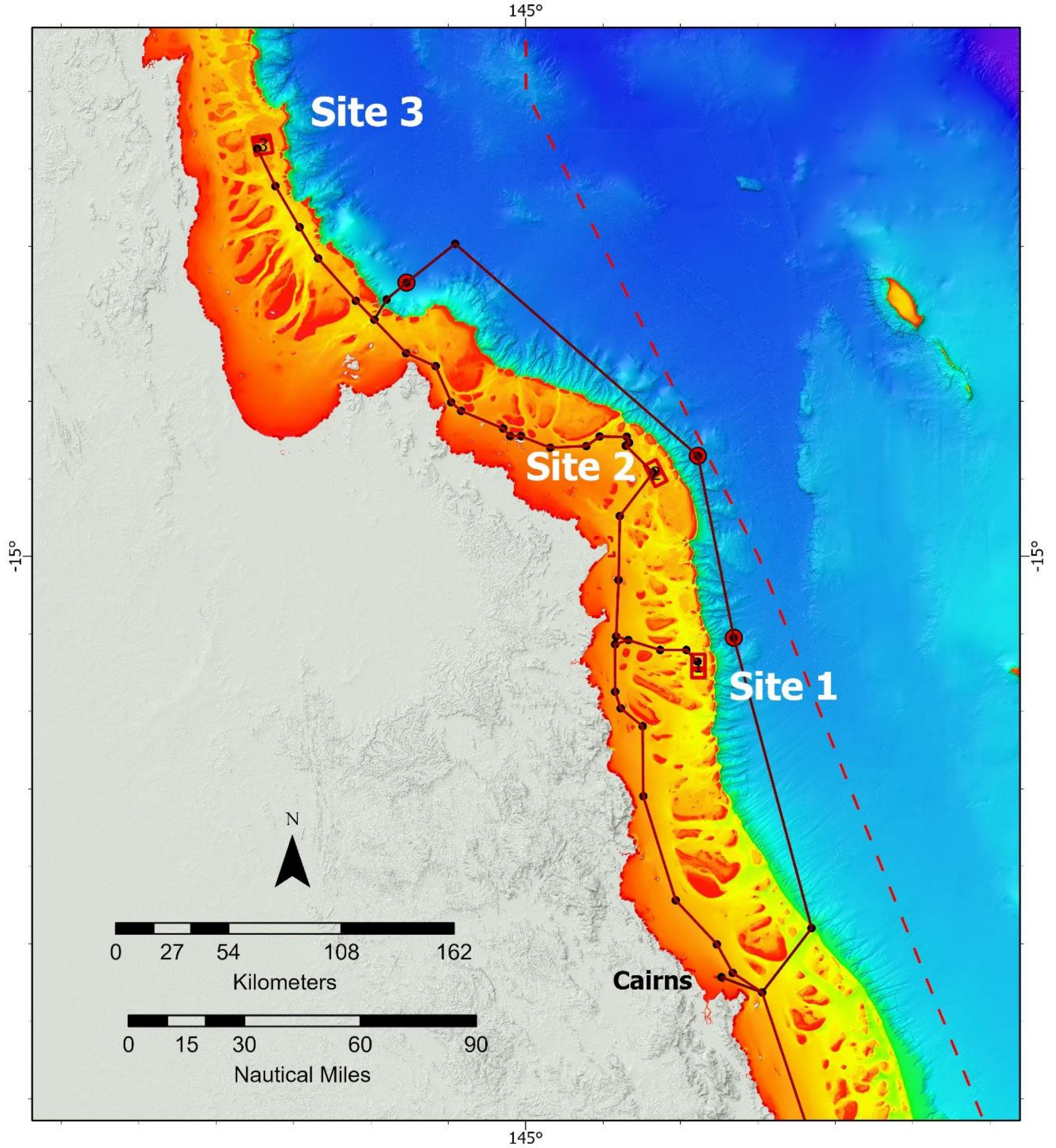


Figure 2. Region showing the three survey sites. Site 1 - Ribbon Reef 3, Site 2 - Cormorant Reef, Site 3 - Tijou Reef. Each site is characterised by operations areas on the shelf covering the *Halimeda* bioherms and proposed GPC sites directly offshore to sample from within the deeper seascapes.

See Tables 2-7 for transit way points

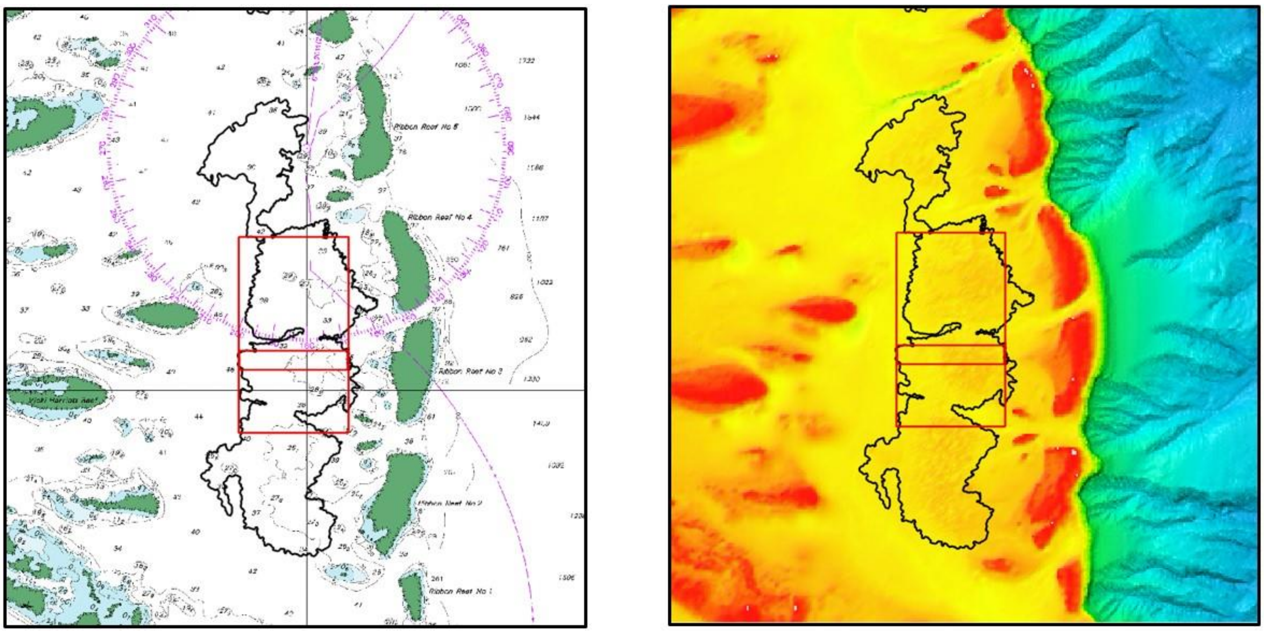


Figure 3. Close up showing Site 1 - Ribbon Reef. Auschart left panel; bathymetry right panel. Larger box represents permit locations. Smaller box represents targeted E-W site survey area for surface and subsurface mapping, sampling transects, and coring.

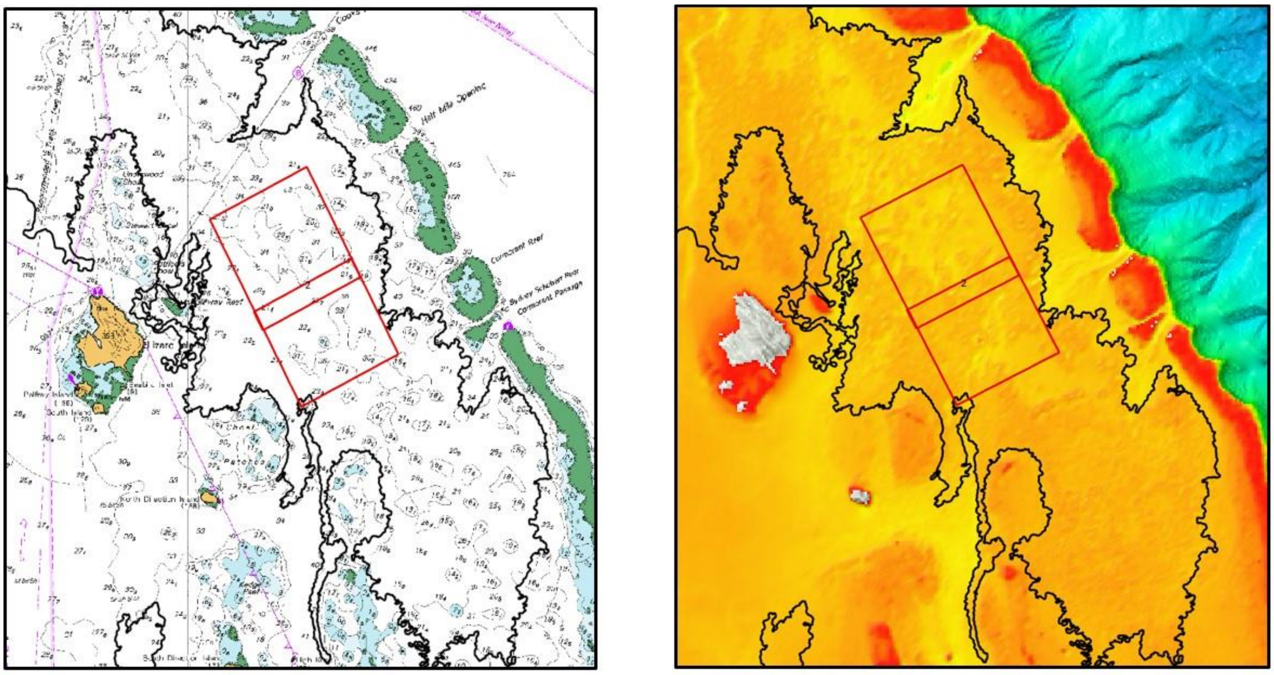


Figure 4. Close up showing Site 2 - Cormorant Reef. Larger box represents permit locations. Smaller box represents targeted E-W site survey area for surface and subsurface mapping, sampling transects, and coring.

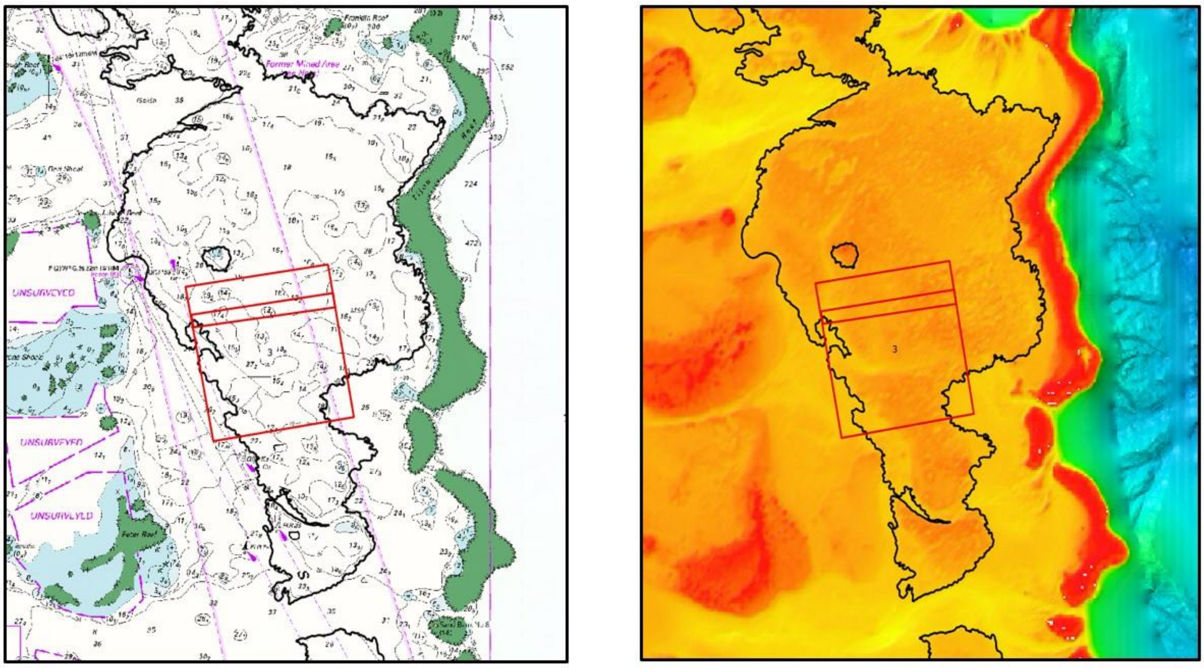


Figure 5. Close up showing Site 3 - Tijou Reef. Larger box represents permit locations. Smaller box represents targeted E-W site survey area for surface and subsurface mapping, sampling transects, and coring.

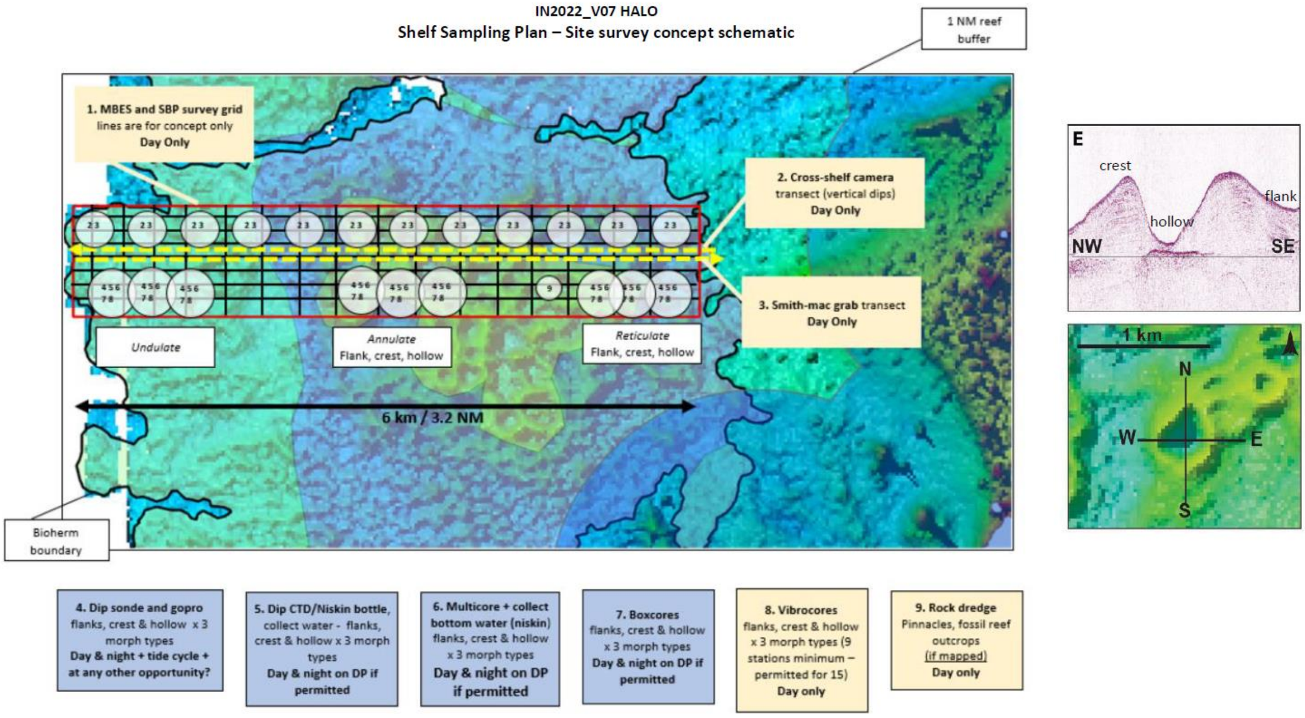


Figure 6. Representative schematic diagram of sampling activities at each shelf site survey. A high-resolution PDF document is available in the voyage planning sharepoint.

Waypoints and stations

Table 2: Leg 1 waypoints Brisbane to Cairns (pilot) to Site 1 Ribbon Reef 3

Waypoint	Location	Latitude DDM	Longitude DDM	Distance (nm)	Total Distance (nm)	Time (hrs) (10 kn)	Total time (hrs) (10 kn)
1	exit Moreton Bay	-26° 8.74158157	153° 11.02294002				
2	Fraser shelf	-26° 37.78707433	153° 14.03394666	11.24	11.24	1.124	1.12
3	Fraser Island	-24° 47.85626047	153° 30.89095938	110.86	122.10	11.086	12.21
4	Fraser Canyon 1034m Test CTD cast (1 hr)	-24° 35.53162122	153° 25.72075164	51.73	173.83	5.173	17.38
5	Fraser Canyon	-24° 23.21638401	153° 15.78672342	33.89	207.72	3.389	20.77
6	Capricorn Channel	-23° 00.63671391	152° 00.36542382	88.3	296.02	8.83	29.60
7	Capricorn Channel	-21° 56.77801713	150° 55.41376710	74.4	370.42	7.44	37.04
8	Sandpiper Reef	-21° 02.25139049	150° 01.52550438	66.13	436.55	6.613	43.66
9	Whitsunday Island	-20° 02.70871006	149° 07.79346774	77.47	514.02	7.747	51.40
10	Holbourne Is	-19° 41.77123781	148° 22.66437234	47.34	561.36	4.734	56.14
11	Pakhoi Bank	-19° 28.86087725	147° 51.98717130	31.66	593.02	3.166	59.30
12	Cape Bowling Green	-19° 15.48568900	147° 30.27934854	24.45	617.47	2.445	61.75
13	Palm Islands	-18° 29.55221682	146° 36.33815730	68.58	686.05	6.858	68.61
14	Kennedy Shoal	-18° 06.78746941	146° 24.23125686	25.41	711.46	2.541	71.15
15	Gouge Bank	-17° 39.65491952	146° 16.85037162	27.90	739.36	2.79	73.94
16	Fitzroy Island	-16° 52.55431752	146° 01.09569414	49.23	788.59	4.923	78.86
17	Cairns pilot	-16° 47.50219063	145° 53.49447474	8.85	797.44	0.885	79.74
18	Arlington Reef	-16° 40.11200883	145° 49.42007304	8.32	805.76	0.832	80.58
19	Satellite Reef	-16° 28.74757316	145° 38.75590710	15.25	821.01	1.525	82.10
20	Cape Tribulation	-16° 01.94294493	145° 30.40399896	27.85	848.86	2.785	84.89
21	Hope Islands	-15° 43.84714398	145° 30.18984744	18.00	866.86	1.8	86.69
22	Bee Reef	-15° 39.23098963	145° 24.55052490	7.11	873.97	0.711	87.40
23	Archer Point	-15° 34.91226790	145° 23.10500232	4.51	878.48	0.451	87.85
24	Boulder Reef	-15° 22.68778699	145° 23.08715634	12.16	890.64	1.216	89.06
25	Boulder Reef	-15° 21.62514346	145° 26.53443618	3.49	894.13	0.349	89.41
26	Williamson Reefs	-15° 24.15617502	145° 34.71777534	8.29	902.42	0.829	90.24
27	Williamson Reefs	-15° 24.16756581	145° 41.48390316	6.53	908.95	0.653	90.90
28	Ribbon Reef 3 site	-15° 27.16347698	145° 44.39897934	4.09	913.04	0.409	91.30

Table 3: Leg 2 waypoints Site 1 Ribbon Reef 3 to Site 2 Cormorant Reef to Site 3 Tijou Reef

Waypoint	Location	Latitude DDM	Longitude DDM	Distance (nm)	Total Distance (nm)	Time (hrs) (10 kn)	Total time (hrs) (10 kn)
1	Ribbon Reef 3 site	-15° 27.16347698	145° 44.39897934				
2	Williamson Reefs	-15° 24.16756581	145° 41.48390316	4.09	4.09	0.409	0.41
3	Williamson Reefs	-15° 24.15617502	145° 34.71777534	6.53	10.62	0.653	1.06
4	Cape Bedford	-15° 20.65065934	145° 23.38373106	11.48	22.10	1.148	2.21
5	Three Islands	-15° 06.09075229	145° 24.01116828	14.50	36.60	1.45	3.66
6	Rocky Islets	-14° 49.59011970	145° 24.32960496	16.42	53.02	1.642	5.30
7	Cormorant Reef site	-14° 38.42237972	145° 32.89131672	13.86	66.88	1.386	6.69
8	Hilder Reef	-14° 31.42058353	145° 25.87174314	9.73	76.61	0.973	7.66
9	Hilder Reef	-14° 30.66243617	145° 26.74995744	1.13	77.74	0.113	7.77
10	Hilder Reef	-14° 29.17723531	145° 26.14311588	1.59	79.33	0.159	7.93
11	Waining Reef	-14° 29.10486923	145° 19.13265270	6.79	86.12	0.679	8.61
12	Waining Reef	-14° 31.51961419	145° 15.70499316	4.10	90.22	0.41	9.02
13	Fly Reef	-14° 31.96481483	145° 06.32499438	9.10	99.32	0.91	9.93
14	Howick Island	-14° 29.00870227	144° 58.78874424	7.87	107.19	0.787	10.72
15	Mid Reef	-14° 29.01158342	144° 56.01773598	2.68	109.87	0.268	10.99
16	Watson Island	-14° 27.01577039	144° 54.17182284	2.67	112.54	0.267	11.25
17	Switzer Reef	-14° 22.47635936	144° 43.34613984	11.42	123.96	1.142	12.40
18	Barrow Islands	-14° 20.25811697	144° 40.79672622	3.31	127.27	0.331	12.73
19	Nth Warden Reef	-14° 10.94787079	144° 36.70744362	10.07	137.34	1.007	13.73
20	Pipon Islets	-14° 07.56723902	144° 29.15647872	8.06	145.40	0.806	14.54
21	Wilson Reef	-13° 58.96795429	144° 20.86942944	11.74	157.14	1.174	15.71
22	Corbett Reef	-13° 54.05845657	144° 16.13819292	6.70	163.84	0.67	16.38
23	Creech Reef	-13° 43.07545373	144° 06.33394902	14.50	178.34	1.45	17.83

24	Creech Reef	-13° 35.09831071	144° 01.55123244	9.20	187.54	0.92	18.75
25	Sand Bank 8	-13° 24.46053715	143° 55.35481782	12.18	199.72	1.218	19.97
26	Tijou Reef site	-13° 17.11476947	143° 50.80411146	10.80	210.52	1.08	21.05

Table 4: Leg 3 Site 3 Tijou Reef to Lowery Passage offshore piston core sites to Cairns

Waypoint	Location	Latitude DDM	Longitude DDM	Distance (nm)	Total Distance (nm)	Time (hrs) (10 kn)	Total time (hrs) (10 kn)
1	Tijou Reef site	-13° 17.14585671	143° 50.84604522				
2	Sand Bank 8	-13° 24.46053715	143° 55.35481782	10.71	10.71	1.071	1.07
3	Creech Reef	-13° 35.09831071	144° 01.55123244	12.18	22.89	1.218	2.29
4	Creech Reef	-13° 43.07545373	144° 06.33394902	9.20	32.09	0.92	3.21
5	Corbett Reef	-13° 54.05845657	144° 16.13819292	14.50	46.59	1.45	4.66
6	Wilson Reef	-13° 58.96795429	144° 20.86942944	6.70	53.29	0.67	5.33
7	Lowry Passage	-13° 53.68771181	144° 24.10252548	6.12	59.41	0.612	5.94
8	Rodda Reef canyon pistoncore	-13° 49.41053609	144° 29.19236460	6.52	65.93	0.652	6.59
9	Clack canyons offshore	-13° 12.19576596	144° 05.87364672	15.69	81.62	1.569	8.16
10	possible canyon pistoncore	-14° 34.07301917	145° 44.49754650	81.83	163.45	8.183	16.35
11	RR5 canyon pistoncore	-15° 21.01502590	145° 53.79172116	47.56	211.01	4.756	21.10
12	Grafton Passage	-16° 35.94324496	146° 13.88800218	77.03	288.04	7.703	28.80
13	Grafton Passage	-16° 52.55431752	146° 01.09569414	20.58	308.62	2.058	30.86
14	Cairns pilot	-16° 48.64242835	145° 50.58832002	10.79	319.41	1.079	31.94

Table 5: Vertices of the shelf survey boxes at Sites 1, 2, 3.

Site	Vertex	Latitude	Longitude	Decimal Latitude	Decimal Longitude
1	1	-15° 25.25820	145° 42.89760	-15.42097	145.71496
1	2	-15° 25.25820	145° 46.30200	-15.42097	145.77170

1	3	-15° 31.31700	145° 46.30200	-15.52195	145. 77170
1	4	-15° 31.31700	145° 42.89760	-15.52195	145.71496
2	5	-14° 36.57060	145° 30.68400	-14.60951	145.51140
2	6	-14° 35.07060	145° 33.67200	-14.58451	145.56120
2	7	-14° 40.51080	145° 36.50520	-14.67518	145.60842
2	8	-14° 42.03480	145° 33.50520	-14.70058	145.55842
3	9	-13° 11.94060	143° 49.34340	-13.19901	143.82239
3	10	-13° 11.27040	143° 53.85420	-13.18784	143.89757
3	11	-13° 15.75780	143° 54.66900	-13.26263	143.91115
3	12	-13° 16.48140	143° 50.21220	-13.27469	143.83687

Table 6: Vertices for the smaller systematic E-W survey grids within the shelf survey boxes at Sites 1, 2, 3.

Site	Vertex	Latitude	Longitude	Decimal Latitude	Decimal Longitude
1	1	-15° 28.78020	145° 42.91620	-15.47967	145.71527
1	2	-15° 28.78020	145° 46.28100	-15.47967	145.77135
1	3	-15° 29.36520	145° 46.28100	-15.48942	145.77135
1	4	-15° 29.36520	145° 42.91620	-15.48942	145.71527
2	5	-14° 39.27240	145° 32.08860	-14.65454	145.53481
2	6	-14° 37.72500	145° 35.02920	-14.62875	145.58382
2	7	-14° 38.27280	145° 35.31480	-14.63788	145.58858
2	8	-14° 39.82020	145° 32.36280	-14.66367	145.53938
3	9	-13° 12.75600	143° 49.50360	-13.21260	143.82506
3	10	-13° 12.11640	143° 53.99880	-13.20194	143.89998
3	11	-13° 12.53520	143° 54.07500	-13.20892	143.90125
3	12	-13° 13.13700	143° 49.57980	-13.21895	143.82633

CTD Configuration

The science party may be required to assist with sampling the Niskin bottles, preparing the bottles for deployment and for setting up and logging each deployment of the CTD. Training will be given by the MNF DAP and hydrochemistry teams on board.

Plan for the following maximum rate of analyses based on 2 hydrochemists:

- 48 nutrients, 48 dissolved oxygen, 48 salinity analyses per 24 hours; OR
- 72 nutrient, 36 dissolved oxygen, 36 salinity analyses per 24 hours; OR
- 160 nutrient analyses (only) per 24 hours.

	PLEASE SELECT:
Fundamentals:	
Which CTD rosette to be used for this voyage (24 or 36 Niskin bottles):	36
Likely total number of casts:	77 (3 deep ~ 2000 m & 74 shallow ~ 20-60 m)
Likely maximum depth of deepest cast:	2000 m
Lowered ADCP required:	Yes
Instrumentation (maximum 6 auxiliary channels in addition to 2x DO):	
2x pumped Temperature, Conductivity, Dissolved Oxygen circuits:	(Standard)
Altimeter (required if operating anywhere near the sea floor):	Yes
PAR Sensor (Biospherical QCP-2300):	Yes
Transmissometer (Wetlabs C-Star 25cm):	Yes
Fluorometer – Chlorophyll-a (Chelsea Aquatracka III – 430/685nm):	Yes
Fluorometer – CDOM (Wetlabs FLCDOM – 370/460nm)	Yes
Nephelometer (Seapoint Turbidity Meter)	Yes
ECO-Triplet (Chlorophyll-a, CDOM & backscatter – maximum depth 2000m)	No
Hydrochemistry Analyses:	
Salinity	Yes
Dissolved Oxygen	Yes
Nutrients: Nitrate	Yes
Nutrients: Phosphate	Yes
Nutrients: Silicate	Yes
Nutrients: Nitrite	Yes
Nutrients: Ammonia	Yes

The HALO project requires sampling from the CTD on the shallow shelf sites (water depth 20 to 60 m). We plan for a cross-shelf transect with three stations at each shelf site, and require 3 CTD casts at each station – one on bioherm outside flank, one on the crest (~20 m) and one from the depression (~45 m). These will be fast deployments with water collection from 2 depths (mid and bottom water) for nutrient analysis and eDNA. We require the bottom water to be collected from as close as possible to the sea bed, over the Halimeda meadow and will deploy a handheld niskin bottle or use the multi-corer to collect bottom water. Additionally, we will deploy the handheld niskin to collect a day/night time-series of bottom-water from bioherm crests and hollows, to be processed for nutrient analysis by the hydrochem team.

A Go-pro and dive torch may be fitted to the CTD frame or multicorer/handheld Niskin.

Defence eDNA requirements (piggy-back project) are two mid-water samples per shelf site, processed onboard with eDNA pump kit, together with matched 1 litre sample of water preserved with Lugols Solution. In total, six e-DNA samples plus six 1 litre samples of water from the shelf sites.

Offshore, a full ocean-depth CTD cast to 2000m will be deployed at each piston-coring site.

Time estimates

The following time estimates are based on a steaming speed of 11 knots and includes conservative estimates of all activities at the 4 main sites (including shelf & offshore) and all transits to/from and between the sites.

Note #1: MNF Hydrochemistry test CTD to 1,000m as noted above to be included in the Time Estimates table below.

DATE	TIME	ACTIVITY
05/08/2022	3 days	Quarantine – Brisbane
08/08/2022	4 days	Quarantine, equip mobilise
12/08/2022	2 days	Onto ship, Pre-voyage medical clearance, vibracore shakedown
14/08/2022	3 days	Depart Brisbane, transit & test CTD cast at waypoint 4 Fraser Canyon
17/08/2022	1 day	Grafton passage; arrive pilot station & transit to RR3 (Site 1), EM2040 patch test
18/08/2022	5 days	**Site 1 - Ribbon Reef 3** 1.5 day multibeam mapping & subbottom profiling (shelf) 2.5 days sea bed imaging (camera dips, sediment sampling (Smith-mac, multicore, boxcore), water measurements & sampling (CTD/Niskin, sonde, incubations) and rock dredge. 1 day vibracoring (shelf) Commence transit to CR (Site 2
23/08/2022	6 days	**Site 2 - Cormorant Reef** 2 day multibeam mapping & subbottom profiling (shelf) 3 days sea bed imaging (camera dips, sediment sampling (Smith-mac, multicore, boxcore), water measurements & sampling (CTD/Niskin, sonde, incubations) and rock dredge. 1 day vibracoring (shelf)
29/08/2022	1 day	Commence transit to Tijou Reef (Site 3) via Princes Charlotte Bay (PCB) shelf for limited sediment & water measurements & sampling (Smith-mac, multicore, boxcore and/or vibracore; CTD/Niskin, sonde)
30/08/2022	6 days	**Site 3 - Tijou Reef** 2 day multibeam mapping & subbottom profiling (shelf) 3 days sea bed imaging (camera dips, sediment sampling (Smith-mac, multicore, boxcore), water measurements & sampling (CTD/Niskin, sonde, incubations) and rock dredge.

DATE	TIME	ACTIVITY
		1 day vibracoring (shelf); end of vibrocoring ops - pack down vibrocorer
04/09/2022	3 days	Transit TR to offshore PCB via Lowry Passage; following a SBP transect a possible GPC & CTD on deep slope sites offshore PCB, CR and/or RR3; clean labs, pack and organize samples etc
07/09/2022	1 day	Arrive Grafton Passage & transit to Cairns. Commence demobilisation, ship all gear and samples etc

Permits

Science Party - GBRMPA Permit G20-43665.1, G22-47413.1

MNF - GBRMPA Permit Number G19-41954.2-Re-Issue. A Sample & Analysis plan specific to IN2022_V07 has been developed by the science party and appended to this blanket permit.

MNF - Parks Australia Permit Number PA2020-00041-5 – Coral Sea Marine Park

Science party is submitting a separate permit to Parks Australia for any IN2022_V07 specific activities not covered in this MNF blanket Commonwealth Marine Parks permit. Anticipated will only be required at one offshore piston-coring site that is proximal to the GBR Marine Park/Coral Sea Marine Park boundary.

Piggyback Project

Dinoflagellates & broader planktonic assemblage observation

Dr Matt Gordon (DSTG), (Remote)

Project outline

Dinoflagellates are a ubiquitous and ecologically important component of marine phytoplankton communities, with particularly notable species including those associated with harmful algal blooms (HABs) and those that bioluminesce. High-throughput sequencing offers a novel approach compared to traditional microscopy for determining species assemblages and distributions of dinoflagellates, which are poorly known especially in Australian waters.

The major aims for data collection activities during this voyage are:

1. collect water samples for taxonomic and molecular identification of dinoflagellate species;
2. record and compare environmental and physical characteristics (water quality parameters, sea state, wind, moonlight) against observed species composition / abundance.

A field kit with instructions has been provided to facilitate this sampling, in consultation with the Chief Scientist.

Sampling protocols

Water collection - CTD request

- 5L of water is requested from each discrete depth
- The majority of samples will be collected from 'shallow water sites' – ideally at ~50% of the water column depth but no more than 20m of depth
- 'Deep water' samples would ideally be from a depth of 20-50m
- Preferable parameters to be recorded: Temperature, salinity, chlorophyll, conductivity, DO, pH, and turbidity
- Additional parameters if possible, include nitrate, nitrite, phosphate, silicate

A 1 L water sample for each depth listed above is to be preserved in Lugols solution and stored @ ~4°C.

A further 4 L is to be processed through 5µ self-preserving eDNA filters.

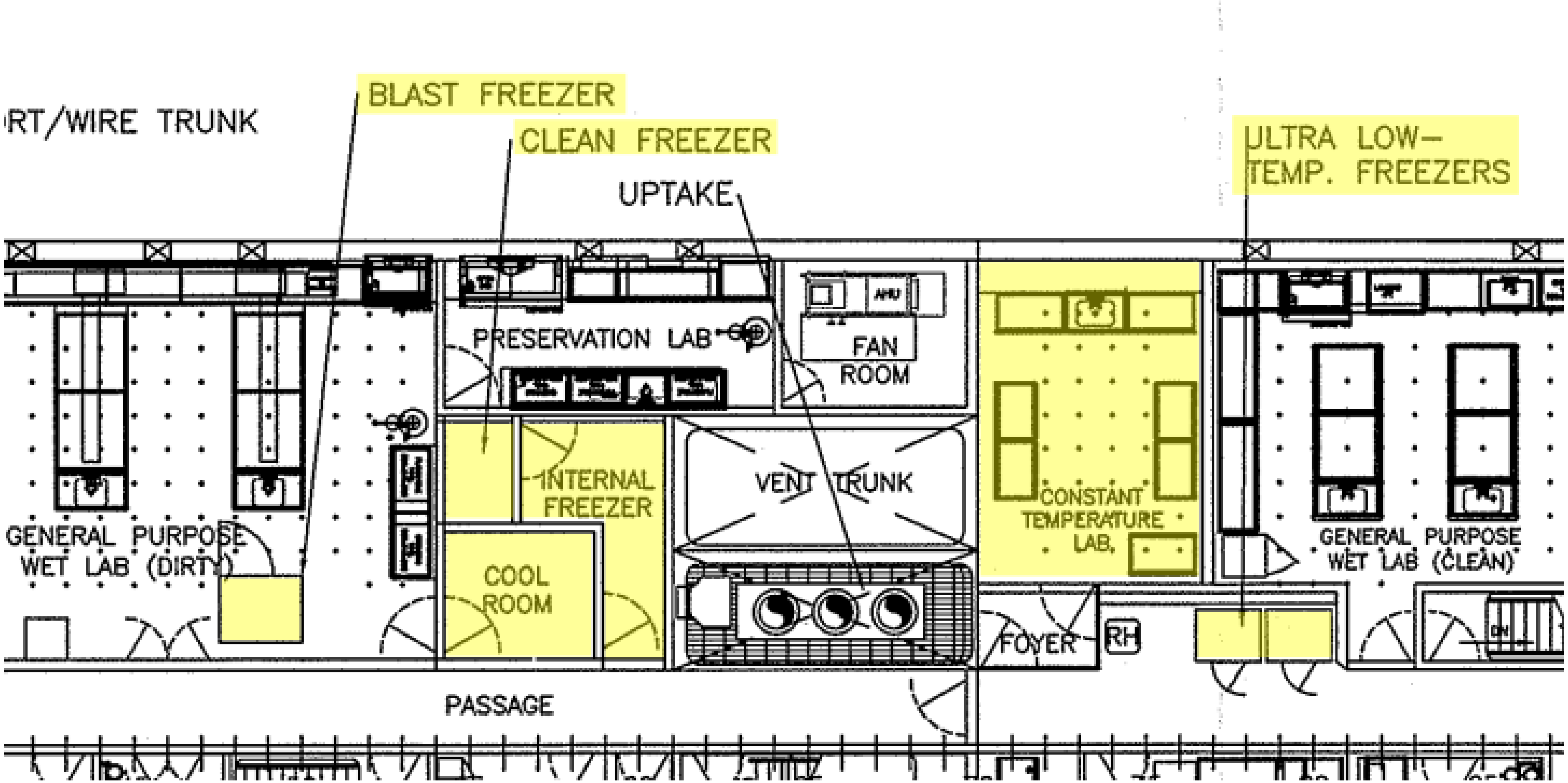
Appendix A

Scientific equipment and facilities provided by the Marine National Facility

Some equipment items on the list may not be available at the time of sailing. Applicants will be notified directly of any changes. Indicate what equipment and facilities you require from the Marine National Facility by placing an X in the relevant box.

STANDARD LABORATORIES AND FACILITIES		
NAME	REQUIRED	NOTES/COMMENTS
Aerosol Sampling Lab		•
Air Chemistry Lab		•
Preservation Lab		•
Constant Temperature Lab (Min temp: 2°C / Max temp 35°C)		•
Underway Seawater Analysis Laboratory	x	•
GP Wet Lab (Dirty)	x	• Sediments, biota
GP Wet Lab (Clean)	x	• Samples processing and microscopy
GP Dry Lab (Clean)	x	• Sample processing and microscopy
Sheltered Science Area	x	• General use by science party
Observation Deck 07 Level	x	•
Internal Freezer (Dirty Wet lab) (Min temp -25°C / Max temp 0°C) Volume: >20m³	x	• -20 setpoint temperature
Clean Freezer (Dirty Wet lab) (Min temp -25°C / Max temp 0°C)		•

STANDARD LABORATORIES AND FACILITIES		
NAME	**REQUIRED**	**NOTES/COMMENTS**
Volume: >2.5m^3 Co-located within the Internal freezer and separated by a door		
Blast Freezer (Dirty Wet lab) (Min temp -30^{o}C / Max temp 0^{o}C) Internal volume >1.5m^3 Capable of reducing the temperature of 150kg of water from +20C to -30C in one hour.	x	• -20 setpoint temperature
Cool Room (Dirty Wet lab) (Min temp 0^{o}C / Max temp 10^{o}C)	x	• 4^{o}C (sediment grabs, box core sediments, rocks)
Ultra-Low Temperature Freezers x2 (Main Deck) Min temp -80^{o}C / Max temp -80^{o}C)	x	• 1 x Ultra-low temp freezer set at -80
YODA Freezers (x2) (Clean Dry lab) (Min temp -20^{o}C / Max temp 10^{o}C)		•



MOBILE LABORATORY AND FACILITIES *(MAY REQUIRE ADDITIONAL SUPPORT)*			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Modular Isotope Laboratory			
Trace Metal Niskin Sampling Container (TM1-blue - 20ft)			•

MOBILE LABORATORY AND FACILITIES *(MAY REQUIRE ADDITIONAL SUPPORT)*			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Trace Metal Seawater Analysis Laboratory (TM2-white - 20ft)			•
Trace Metal Rosette and Niskin Storage Container			
Modular Hazchem Locker			
Stabilised Platform Container			
Clothing Container			

STANDARD SAMPLING EQUIPMENT			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
CTD - Seabird 911 with 36 Bottle Rosette	x		
CTD - Seabird 911 with 24 Bottle Rosette			
Lowered ADCP	x		
Continuous Plankton Recorder (CPR)			

SPECIALISED SAMPLING EQUIPMENT			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS (THESE ITEMS MAY REQUIRE ADDITIONAL MNF SUPPORT STAFF)**
TRIAXUS – Underway Profiling CTD			
Desired towing profile:			
Additional instrumentation:			
Giant Piston Coring System (GPC)	x		

SPECIALISED SAMPLING EQUIPMENT			
NAME	ESSENTIAL	DESIRABLE	NOTES/COMMENTS (THESE ITEMS MAY REQUIRE ADDITIONAL MNF SUPPORT STAFF)
Multi Corer	x		At representative shelf sites would request to use the multicorer to also sample seawater at the seabed interface.
Box Corer	x		GA corer to be mobilised by MNF
Kasten Corer			
Smith Mac Grab	x		
Rock Dredges	x		2 dredges
Rock Saw			
Seaspy Magnetometer			
Portable Pot Hauler			
Equipment to measure seawater sound velocity/CTD:			
XBT System			
Valeport Rapid SV	x		To be deployed as necessary to establish optimal sound speed profiles for use by multibeam systems.
Valeport Rapid CTD	x		To be deployed as necessary to establish optimal sound speed profiles for use by multibeam systems.
Valeport SVX2	x		
Trace Metal Rosette and Bottles			
Trace Metal In-situ Pumps (x6)			•

SPECIALISED SAMPLING EQUIPMENT			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS** **(THESE ITEMS MAY REQUIRE ADDITIONAL MNF SUPPORT STAFF)**
Deep Towed Camera	x		Deploy in 'vertical dip mode' since shelf sites are too shallow to deploy and tow safely
Drop Camera			
Sherman Epibenthic Sled			Not possible – stern ramp is IN
Brenke Sled			
Hydro-Bios MultiNet (Mammoth) (1m x 1m) *(has replaced the EZ net)*			
Surface Net (1m x 1m)			
Bongo Net 485mm diameter			
Beam Trawl			
MIDOC			
Pelagic Trawl System (net, doors)			
Demersal Trawl System (net, doors)			
RMT-8 (Rectangular Midwater Trawl)			
RMT-16 (Rectangular Midwater Trawl)			
Trawl Monitoring Instrumentation (ITI) (2,000m depth limit)			
Stern ramp		INSTALLED	Vibrocoring system will require Stern Ramp to be IN

RESEARCH SUPPORT INFRASTRUCTURE			
NAME	ESSENTIAL	DESIRABLE	NOTES/COMMENTS
Salt Water Ice Machine (Dirty Wet lab)			
Radiosonde Receiver System			
Laboratory Incubators (Clean Dry lab)			
Deck Incubators	x		Sealed tank and flow through system at ambient sea water temperature sourced from site specific underway water. We will use black plastic sheets for night time experiments.
Milli-Q System			
Sonardyne USBL System			

SCIENTIFIC / SAMPLE ANALYSIS SYSTEMS				
MICROSCOPES:				NOTES/COMMENTS
BRAND / MODEL	TYPE	ESSENTIAL	DESIRABLE	Refer to the “MNF microscopes procedure” for more information
Leica / M80	Dissecting	x		
Leica / M80	Dissecting	x		
Leica /MZ6	Dissecting	x		
Olympus / CH	Compound			
Olympus /CH	Compound			
Leica / MTU282	Camera tube			
Adapters for tube / Nikon	Pentax			
Ring Light *2 / MEB121	LED	x		
Heavy Duty Electronic Balance (80kg)				

SCIENTIFIC / SAMPLE ANALYSIS SYSTEMS			
MICROSCOPES:			NOTES/COMMENTS
Medium Duty Electronic Balance (15kg/5g resolution)	x		
Light Duty Electronic Balance (3kg/1g resolution)	x		For cataloging samples

Underway systems

ACOUSTIC UNDERWAY SYSTEMS			
NAME	ESSENTIAL	DESIRABLE	NOTES/COMMENTS
75kHz ADCP		x	
150kHz ADCP		x	
Multi Beam Echo Sounder EM122 12kHz (100m to full ocean depth)	x		
Multi Beam Echo Sounder EM710 70-100kHz (0-1000m approx.)	x		
Sub-Bottom Profiler SBP120	x		Kingdom software will be used onboard to visualise SBP120 data. Requires SEG-Y format files with instantaneous corrections applied.
Scientific Narrowband Echo Sounders EK60 (6 bands, 18kHz-333kHz)		x	EK60s will be onboard for use as a backup for EK80s and set in narrowband mode Quantitative measurements from scientific echosounders requires sphere calibration in the watermass of sampling
Scientific Narrowband/Broadband Echo Sounders EK80 (6 bands, 18kHz-333kHz)		x	EK80s will be used in narrowband mode unless otherwise requested Quantitative measurements from scientific echosounders requires sphere calibration in the watermass of sampling

ACOUSTIC UNDERWAY SYSTEMS			
NAME	ESSENTIAL	DESIRABLE	NOTES/COMMENTS
Multibeam Scientific Echo Sounder ME70 (70-100 kHz)		x	
Gravity Meter			

ATMOSPHERIC UNDERWAY SENSORS			
NAME	ESSENTIAL	DESIRABLE	NOTES/COMMENTS
Nephelometer	x		Data collection for collaborator Zoran Ristovski (QUT)
Multi Angle Absorption Photometer (MAAP)	x		Data collection for collaborator Zoran Ristovski (QUT)
Scanning Mobility Particle Sizer (SMPS)	x		Data collection for collaborator Zoran Ristovski (QUT)
Radon Detector	x		Data collection for collaborator Zoran Ristovski (QUT)
Ozone Detector	x		Data collection for collaborator Zoran Ristovski (QUT)
Condensation Particle Counter (CPC)	x		Data collection for collaborator Zoran Ristovski (QUT)
Picarro Spectrometer (analysis of CO_2/CH_4/H_2O)	x		For HALO project
Aerodyne Spectrometer (analysis of N_2O/CO/H_2O)	x		For HALO project
Cloud Condensation Nuclei (CCN)	x		Data collection for collaborator Zoran Ristovski (QUT)
Polarimetric Weather Radar	x		Data collection for collaborator Zoran Ristovski (QUT)

UNDERWAY SEAWATER SYSTEMS AND INSTRUMENTATION			
NAME	ESSENTIAL	DESIRABLE	NOTES/COMMENTS
Thermosalinograph	x		

UNDERWAY SEAWATER SYSTEMS AND INSTRUMENTATION			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Fluorometer	x		
Optode	x		
pCO2	x		

SEAWATER SYSTEMS			
NAME	**ESSENTIAL**	**DESIRABLE**	**NOTES/COMMENTS**
Trace metal clean seawater supply	x		
Scientific clean seawater supplied to laboratories	x		
Raw seawater available on deck and in laboratories	x		

EQUIPMENT AND SAMPLING GEAR REQUIRING EXTERNAL SUPPORT (MAY REQUIRE ADDITIONAL SUPPORT FROM APPLICANTS)			
NAME	**ESSENTIAL**	**DESIRABLE**	**PLEASE GIVE THIS CAREFUL CONSIDERATION, AS THERE IS NO GUARANTEE THAT THESE RESOURCES WILL BE AVAILABLE UNLESS SPECIFICALLY REQUESTED. LIAISE WITH YOUR VOYAGE OPERATIONS MANAGER AS REQUIRED. ADDITIONAL STAFF MAY BE REQUIRED FOR THESE ACTIVITIES.**
Seismic Compressors			
Seismic Acquisition System			

NON-MNF OWNED EQUIPMENT WHICH MAY BE ACCESSED			
NAME	**ESSENTIAL**	**DESIRABLE**	**PLEASE GIVE THIS CAREFUL CONSIDERATION, AS THERE IS NO GUARANTEE THAT THESE RESOURCES WILL BE AVAILABLE UNLESS SPECIFICALLY REQUESTED. LIAISE WITH YOUR VOYAGE OPERATIONS MANAGER AS REQUIRED. ADDITIONAL STAFF MAY BE REQUIRED FOR THESE ACTIVITIES.**
D & N Francis winch			
UTAS In-Situ Pumps (x2)			
EM2040	x		Shallow water multibeam echosounder system – given the shallow water depths of the three shelf survey sites (20-50m) the use of this EM2040 system will greatly improve the quality of the bathymetry and backscatter data we aim to collect.