# Turning Rubble to Reef in the Mackay Whitsundays

# Long Term Management Plan

**Version 4**

**Date last reviewed: 18 December 2023**

Australian Government

REEF CATCHMENTS

Mackay REGIONAL COUNCIL

# Contents

# Detailed Project Overview

## Funding Acknowledgement

The Turning Rubble to Reef in the Mackay Whitsundays project (Rubble to Reef) is funded by the Australian Government's Fisheries Habitat Restoration Program (FHRP) and delivered through the Regional Land Partnerships models.

## Project Objectives

Installation of Habitat Reef (HR) modules are increasingly used to improve and restore reef ecosystems worldwide. Whilst the FHRP funding is aimed at the restoration of marine and estuarine fish habitats and engagement of local recreational fishing groups, Reef Catchments also designed the Rubble to Reef project with the intent of improving Reef resilience by addressing four threats:

1. *Loss of natural Reef ecosystems due to strike impacts, cyclones, bleaching, etc.*

Installation of replicate bommie reef structure (HR modules) specifically designed to increase the availability of food resources, refuge, and habitat for aquatic species. These HR modules will provide much needed hard vertical surface area for the colonisation of invertebrates, including coral recruits and bivalves.

2. *Lack of connected vertical relief substrate to facilitate recolonisation of coral reefs*

The HR modules have been specifically designed with advice from the Australian Institute of Marine Science (AIMS) and utilising findings from the scientific literature to maximise recruitment potential. The HR modules provide stable, hard, vertical relief substrate with increased surface area, roughened external surfaces, and vertical and horizontal complexity in the form of caves and refuge holes. These features are specially designed to facilitate invertebrate colonisation and the formation of a new living reef ecosystem.

3. *Fishing pressure on natural reefs*

Installing the HR modules is expected to have positive flow-on benefits for recreational fishing. Habitat reefs, like natural reefs, will attract and provide fish habitat. The presence of these structures in easily accessible offshore marine environments will therefore, likely attract recreational fishers. This is expected to ease fishing pressure on offshore natural reefs in the Mackay urban area.

4. *Loss of complex juvenile habitat*

The HR modules will provide the complexity of hard structural vertical relief habitat, which will encourage the colonisation of corals and bivalves. The colonisation and growth of sessile marine organisms in conjunction with specifically designed juvenile habitats on the HR modules will provide both adult and juvenile coastal and marine fish species required habitats to complete their life cycles.

Therefore, the overarching objectives of the Rubble to Reef project are:

- Increase the extent of available invertebrate settlement surfaces through the installation of up to 30 Habitat Reef (HR) modules
- Increase the extent of fish habitat through the installation of up to 30 HR modules
- Increase the diversity and abundance of recreationally important fish species at the deployment site(s)
- Increase the engagement with recreational fishers in activities that promote the long-term sustainability of the industry

- Make available data on the design effectiveness of Habitat Reef modules to assist in upscaling this project

## Project Development History

At the project's conception, the Mackay Local Marine Advisory Committee (LMAC), Ozfish Mackay Chapter and Mackay Recreational Fishers Alliance (MRFA) investigated the feasibility and local support for a project to restore fish habitat through the installation of HR modules. Each organisation confirmed their interest and provided letters of support, which helped Reef Catchments to secure funding for the project. The letters of support have been included in *Turning Rubble to Reef in the Mackay Whitsundays Appendices*. Once funding was secured, more detailed conversations were held with additional major project partners - Catchment Solutions and North Queensland Bulk Ports (NQBP).

Therefore, the members of the Rubble to Reef steering group are:

- Reef Catchments
- Catchment Solutions
- Mackay Regional Council
- North Queensland Bulk Ports (NQBP)
- James Cook University's Centre for Tropical Water and Aquatic Ecosystem Research (JCU TropWATER)
- Maritime Safety Queensland (MSQ)
- Ozfish Mackay Chapter
- Mackay Local Marine Advisory Committee (LMAC)
- Mackay Recreational Fishers Alliance (MRFA)

Catchment Solutions offer a range of specialised environmental services that combine technical expertise, innovation and collaboration. Reef Catchments formally contracted Catchment Solutions to facilitate the delivery of this reef restoration project in early 2021. Catchment Solutions role in the Rubble to Reef project is to support Reef Catchments in the following:

- Phase 1 – Community consultation, site selection criteria & project management
- Phase 2 – Baseline monitoring & site selection
- Phase 3 – State Government Approval process
- Phase 4 – Construction & deployment of HR modules

Starting early 2022, Reef Catchments and Catchments Solutions have been meeting monthly to discuss the project's progress, any challenges currently or previously being faced, and priorities for action in the month ahead. For example, some of the discussion topics at these monthly meetings include identifying a suitable barge operator; determining which State and Federal permits are required; and sharing lessons learnt from other reef restoration projects in Australia that we should incorporate in our project planning and implementation.

Reef Catchments first contacted NQBP in 2020 regarding placing HR modules within Port of Mackay limits. In 2021, these negotiations were expanded to include NQBP leading the long-term monitoring of the HR modules. NQBP has an existing award-winning partnership with JCU TropWATER to conduct extensive ambient marine environmental monitoring of water quality, coral and seagrass in the Mackay region. Reef Catchments have been working with NQBP to leverage and expand this activity to also incorporate monitoring the HR modules. The subsequent development of TropWATER's Offshore Reef Modules and Urban Biodiversity Monitoring proposal has evolved over many months and meetings. Most recently, in October 2022, Reef Catchments met with NQBP Director Environment

and TropWATER Co-Director and Deputy Director of JCU's Marine Data Technology Hub to confirm the methodology, timeline and reporting requirements of the monitoring proposal. This meeting resulted in the finalisation of the monitoring proposal and JCU offering to gather pre-baseline marine data within the project area to support our Sea Dumping Permit application. Reef Catchments' engagement with NQBP and JCU's TropWATER will be ongoing.

In April 2021, Reef Catchments formally engaged with Mackay Regional Council to brief Councillors about ownership of the HR modules. Reef Catchments attended two Council meetings (20 April 2021 and 6 May 2021), where an overview of the project goals, potential liabilities involved in ownership, and a request for Mackay Regional Council to 'adopt' ownership of the modules post-installation were discussed.

Mackay Regional Council raised a number of pertinent questions at the meetings, which were addressed by Reef Catchments staff. These questions include:

- What is the science around the HR modules working, and what are some other examples of artificial reef working?
- What lessons have been learned from other reef restoration projects?
- Average Recurrence Interval (ARI) 1/100 year – is it cyclones, flooding, storm surge? How often are 1/100 ARI events happening lately?
- Liability – if a ship hits a HR module, who is liable?
- Would North Queensland Bulk Ports own the HR modules?

The presentation and subsequent meeting (Appendix F) were very well received by Mackay Regional Council. Mackay Regional Council agreed to provide in-principle support to become owners of the HR modules. This resulted in a Memorandum of Understanding (Appendix G) being formalised between Mackay Regional Council and Reef Catchments. In brief, Mackay Regional Council have stated that they will accept ownership responsibility if Reef Catchments can provide evidence that:

- The proposed sites have been included in Maritime Safety Queensland navigational hazard charts
- The HR modules are RPEQ certified for stability for a 1/100-year ARI wave conditions
- All permits and approvals of any relevant authority have been obtained for the deployment and installation of the HR modules for the proposed sites

Reef Catchments agreed to satisfy each of the conditions stated above and work is well progressed on achieving each of the conditions of ownership. Reef Catchments regularly provides updates to Mackay Regional Council.

## Community & Stakeholder Engagement

### Local Community

Community engagement is fundamental to this project. It is important to recognise that installing the HR modules will positively affect recreational fishers. The HR modules provide new areas for recreational fishers to target, and this project intends to capitalise on this potential for community engagement. Mobilising Great Barrier Reef Marine Park users to participate in Reef restoration activities will foster community buy-in and stewardship for this reef resource.

Local recreational fishing groups such as Ozfish Unlimited, MRFA and Queensland Recreational Fishing Network, and other key stakeholders, including the LMAC, and boat hire companies have been engaged from the outset of this project, and these groups play a key role in providing local knowledge and advising communications and educational outputs of the project.

## Traditional Owners

The project area falls within the Traditional lands of the Yuwi people. The Yuwi Native Title Area was determined on 25 February 2020 and the Registered Native Title Body Corporate for the Determination Area is the Yuwi Aboriginal Corporation. The boundaries of the Yuwi country lay between the O'Connell River to the north of Mackay, Cape Palmerston in the South, west to the base of the Connor and Clark Ranges and the east encompassing the waters off the mainland between the north and south boundaries.

The Aboriginal and Torres Strait Islander Cultural Heritage Database and the Aboriginal and Torres Strait Islander Cultural Heritage Register (Appendix R) have been searched within the MSQ advised safe area. The search results found no Cultural Heritage Management Plans, Designated Landscape Areas, Registered Cultural Heritage Study Areas or National Heritage Areas (Indigenous values) recorded in the area.

A letter of notice (Appendix I) was provided to the Yuwi Aboriginal Corporation in December 2022. Reef Catchments reissued the letter of notice on 20th March 2023 in response to a discussion held at the Yuwi On-Country Trip on the 16th and 17th March 2023. At the On-Country Trip, Reef Catchments provided a verbal overview and project update (Appendix X) to the attending Yuwi elders and members. Questions raised by Yuwi members included what materials are being used to construct the HR modules and the criteria for site selection. In addition, Yuwi Aboriginal Corporation expressed an interest in participating in the monitoring of the HR modules. Further information was provided in response to their questions, as well as an invitation to further discuss how Yuwi Aboriginal Corporation would like to be involved in the ongoing monitoring of the HR modules was sent to Yuwi via email on the 20th March 2023 (Appendix Y). Reef Catchments is actively working to develop processes by which to inform and partner with Yuwi Aboriginal Corporation for on-ground delivery of future initiatives. Reef Catchments has also made the commitment to Yuwi Aboriginal Corporation and its members, to continue to update and extend opportunities for involvement. The project aims fit within the Yuwi Aboriginal Corporation Strategic Plan and Healthy Country Plan, which both mention protection and expansion of habitat as a key priority.

## Great Barrier Reef Marine Park Authority (GBRMPA)

In July 2021, Reef Catchments engaged the Great Barrier Reef Marine Park Authority to enquire about the feasibility of obtaining a marine park permit and deploying Habitat Reef modules within a two-year period. The consultation period consisted of two online meetings (Appendix W). Following the discussions, Reef Catchments concluded the timing and permit type were not suitable for the Rubble to Reef project, and thus perused other alternatives.

On 14 July 2023, in response to a Request for Further Information, Reef Catchments sent a project update letter to GBRMPA (Attachment 1). The purpose of this letter was to inform GBRMPA we had pursued the Rubble to Reef project outside of the Marine Park and share the location of our proposed deployment sites. Reef Catchments has since liaised with GBRMPA Assistant Director – Science, Government and Ports regarding the placement of the HR Modules. During this consultation period, additional information including the proposed central GPS coordinates and footprint of the Habitat Reef sites has been provided to GBRMPA. On 11 September 2023, Reef Catchments received a formal comment from GBRMPA (Attachment 2) which referred to their Policy on Fish Aggregating Devices and Artificial Reefs (dated 23 August 2023). After receipt of the letter, Reef Catchments carefully reviewed the content of both the response and the policy. Reef Catchments has subsequently informed GBRPMA (via a letter dated 22 September 2023) that we will not change the proposed location of the habitat modules (should permit be granted) as the location is outside of the Great

Barrier Reef Marine Park (therefore the policy does not apply), and that the proposed sites meet key criteria (water depth/ lowest astronomical tide, maritime safety, accessibility and absence of marine plants and existing habitat). Please refer to pages 15 and 25 of this plan for detailed justification of deployment site selections.

### Local Government

Mackay Regional Council is a key partner of this project and has been consulted from the early stages of this project with the intention that Mackay Regional Council would accept ownership of the deployed HR modules. Mackay Regional Council has a successful history with HR modules. In 2021, Mackay Regional Council implemented the Pioneer River Fish Habitat Improvement Project, which deployed 45 HR modules owned by Mackay Regional Council in the Pioneer River across 3 locations (funded by the Queensland Government). Due to the success of this previous project, Mackay Regional Council are supportive of the Rubble to Reef project. Mackay Regional Council has given their in-principle support to own the HR modules following deployment. Their support has been formalised in a Memorandum of Understanding between Mackay Regional Council and Reef Catchments (Appendix G), and a formal ownership agreement will be executed by both parties in 2023 (after all conditions have been met).

### State Government

Catchment Solutions fisheries ecologists, on behalf of Reef Catchments, had a meeting with Queensland's State Assessment Referral Agency (SARA) on the 27th of March 2020 to enquire about which approvals would be required to undertake a reef restoration project within in-shore waters adjacent to the Pioneer River. Pre-lodgement advice was received (Appendix H), which outlined that this project requires a Development Approval, triggering 'Tidal Works' (State Code 8) and 'Maritime Safety' (State Code 7).

### Commonwealth Government

Catchment Solutions fisheries ecologist commenced discussions with the Commonwealth in October 2019 to enquire whether reef restoration projects using specifically designed HR Modules with improved settlement surfaces would trigger Sea Dumping regulations. Since then, Reef Catchments and Catchment Solutions have maintained communication with the Queensland Assessments and Sea Dumping Branch within the Department of Climate Change, Energy, the Environment and Water. Since then, Reef Catchments sought advice regarding the Australian Government's draft interim policy on using plastics (including plastic fibre-reinforced concrete) in artificial reefs. As a result, Reef Catchments and Catchments Solutions modified the design of the HR modules to use steel-fibre reinforced concrete in their construction rather than plastic. A Senior Assessment Officer participated in a pre-lodgement with Reef Catchments on 16th November 2022.

## Map of Proposed Deployment Sites

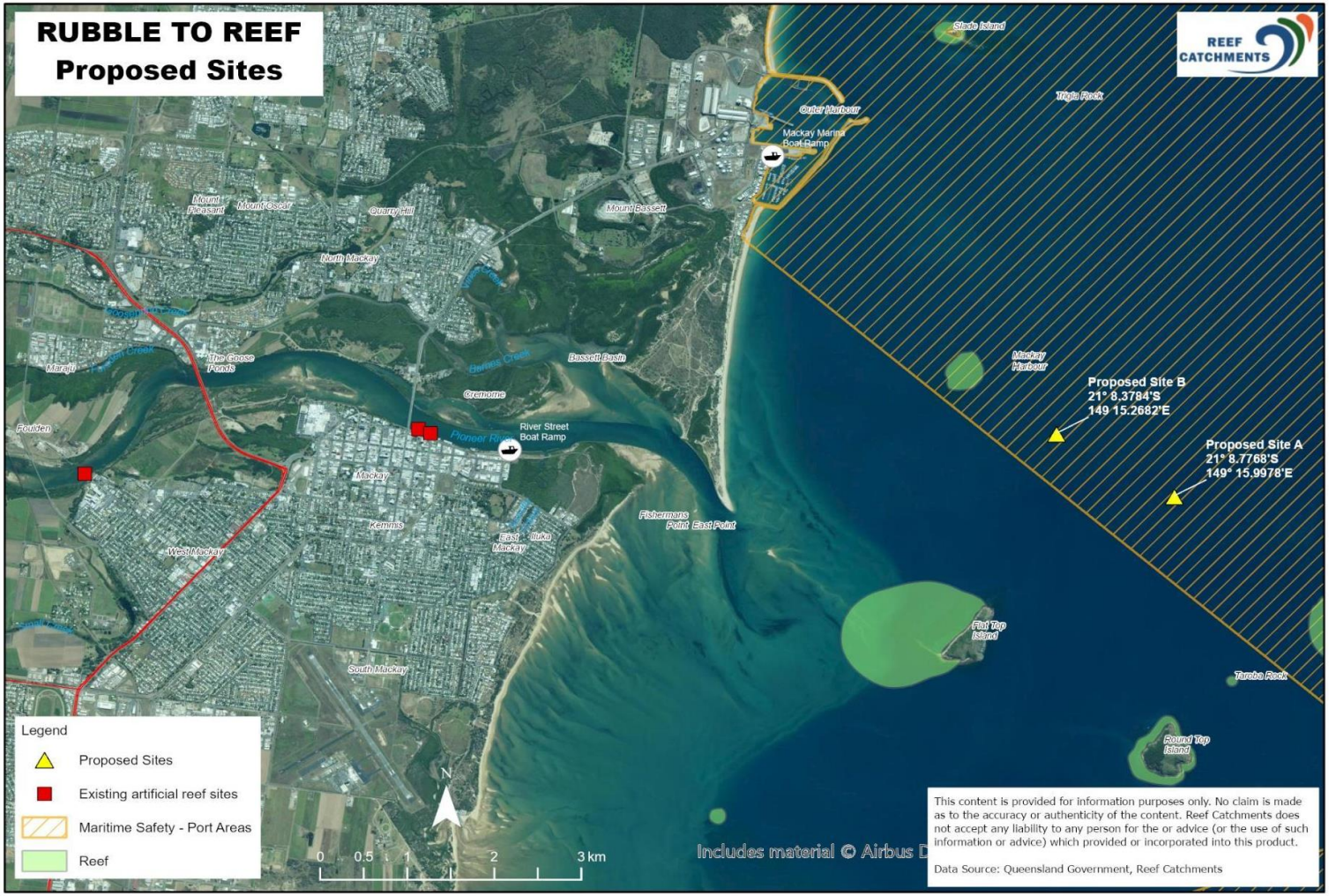


*Figure 1: Map of Proposed Deployment Sites (copy provided in Appendix J)*

# Habitat Reef (HR) Modules

## HR Module Design

The HR modules (Figure 2) are 1.6m x 1.6m x 1.6m purpose built concrete structures, each weighing approximately 1.6 tonnes, designed specially to facilitate the settlement of encrusting marine organisms and provide habitat for marine species.

The design of the HR modules has evolved over many years to incorporate updates and input from engineers, scientists, and local fisheries ecologists. The current model includes the latest findings from research on improved invertebrate settlement surfaces from around the world. The design features elements critical to optimising the settlement of encrusting marine organisms (e.g. oysters and corals), including: high surface area; roughened external surfaces; small groves throughout the roughened surfaces; and vertical and horizontal complexity. The calcium bicarbonate used in the concrete is also biologically suited to promoting and facilitating coral settlement and survival. Thus, the design features will ensure the HR modules support a variety of organisms, developing over time into healthy functioning reef ecosystems.

In addition to providing optimal settlement surfaces, the modules have been designed to provide habitat and refuge for both adult and juvenile coastal and marine fish species. This has been achieved by providing separated chambers accessible only to smaller-sized individuals and a larger cave hollow for larger species. It is proposed that providing refuge for a range of fish species and size classes will facilitate the formation of a stable and mature fish community. This may in turn provide critical benefits to coral recruitment and survival through a greater abundance of functional grazers in the resident and surrounding fish community.

The design of the HR modules has incorporated considerations of environmental risk. The use of concrete and super duplex stainless steel has been important in maximising durability within the marine environment. Stability and subsidence have also been considered in the design. The modules are heavily weighted (approximately 1.6 tonne) with a large footprint at the base coupled with 1.6m vertical height to reduce the likelihood of movement or subsidence in the substrate. Additionally, the HR modules have been assessed by a registered professional engineer of Queensland (RPEQ), Principal Coastal Engineer (Water & Maritime), as stable on the seabed for events up to and including the 100-year ARI wave event (Appendix N).

*Figure 2: Constructed Habitat Reef module*

## Proposed Reef Layout Design

This project seeks to restore hard vertical relief habitat through the installation of 30 HR modules in the Mackay offshore marine environment. The HR modules will be deployed at 2 sites – Site A and Site B. Site A and Site B will be situated within an approximately 1.90km$^2$ deployment boundary. The corner point co-ordinates (WGS84) for the boundary are situated at:

NW -21.13701˚149.25341 ,˚

NE -21.13924˚149.27064 ,˚

SW -21.14801˚149.25418 ,˚

SE -21,14819˚149.26996 ,˚

This is an advised 'safe area' as provided by Maritime Safety Queensland. Each site (A and B) will have 15 HR modules following the same reef layout arrangement (Figure 3). The arrangement is intended to take a broader approach to recreate healthy coral reef habitats rather than deploying single isolated units in areas where coral reefs are unlikely to form naturally.

The difference between Site A and Site B in terms of reef layout design is the spacing between the HR modules. At Site A, the distance between modules will be larger at intervals of 25m and 50m apart. Whereas the distance between modules at Site B will be smaller at intervals of 12.5m and 25m. Therefore, the Habitat Reef area of Site A is 7,807m$^2$ and Site B covers an area of 23,299m$^2$.

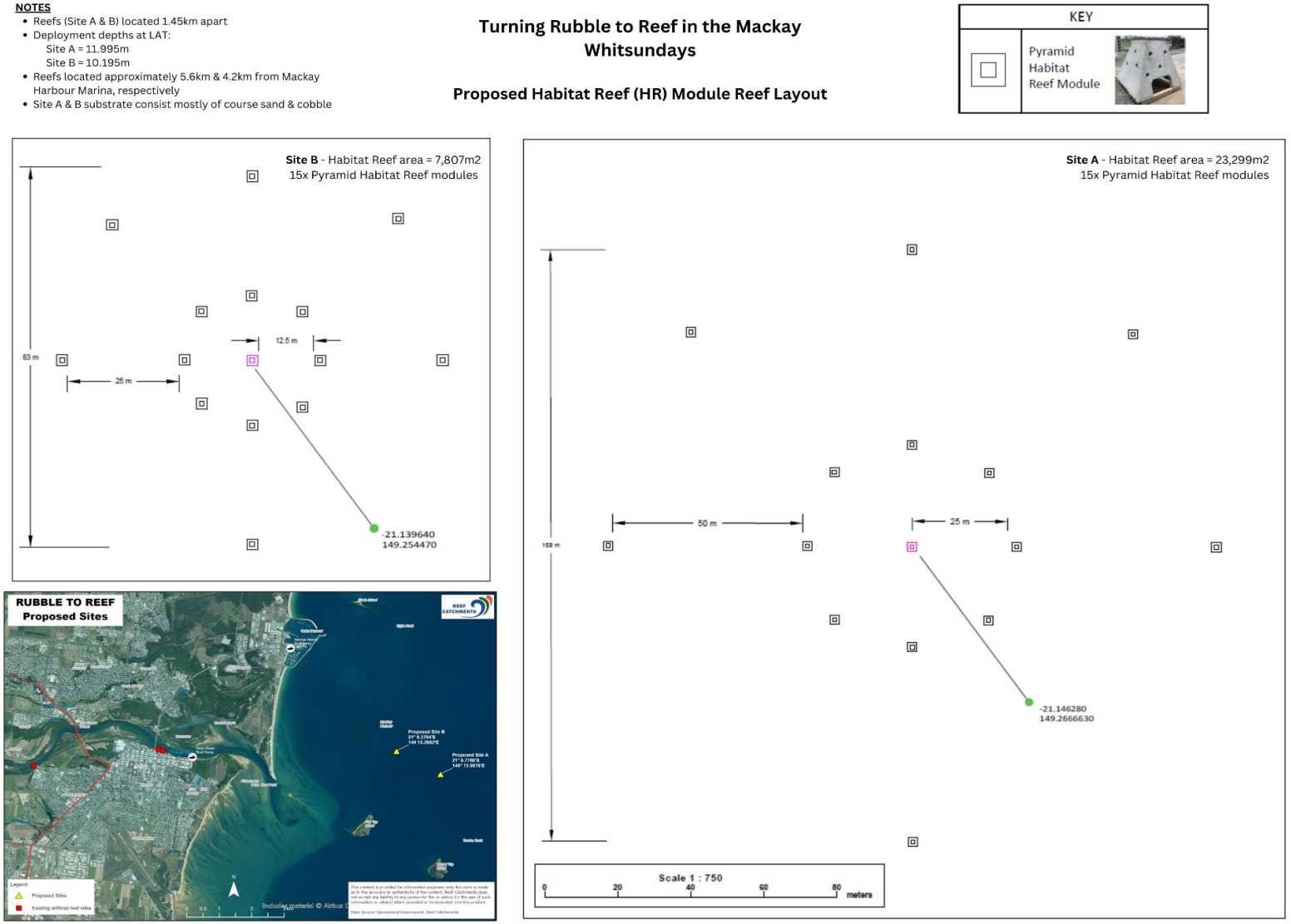


*Figure 3: Map of Proposed Habitat Reef Layout (copy provided in Appendix V)*

## Preparation of Materials

Batrosa Concrete Products, a local Mackay business, has been contracted to construct the HR modules. Please see Appendix K for the graphic design. The HR modules will be constructed on land at the manufacturer's facilities and will not be transported for sea deployment until the concrete has cured. The HR modules are available for inspection at the manufacturer's facility, located at 5 Graeme Heggie Street, Outer Harbour Mackay.

The decision to construct the HR modules using concrete was determined because:

- Concrete is highly durable, stable & readily available
- Concrete materials have been used successfully in the past as HR modules
- Concrete can be formed into any shape
- Concrete materials are compatible with the marine environment
- Concrete HR modules can provide roughened surfaces and habitats for the settlement and growth of organisms
- The calcium bicarbonate used in concrete is biologically suited to promoting and facilitating coral settlement and survival
- Concrete HR modules can incorporate caves and refuge holes offering habitat to invertebrates and fish.

Each HR module is constructed using 0.8$m^3$ of S50/10 super-workable concrete (commonly known as Ultra-flow), 50 MPA and 10mm aggregate. All sands and aggregates are washed and graded to size. It is important to note, none of the materials are recycled materials or made from recycled materials; nor are any Annex 1 or Annex II substances used in the construction of the HR modules. A copy of product data sheets has been attached as *supporting documentation*.

Specifically, 0.8$m^3$ concrete mix consists of:

- 360KG GP Cement Powder.
- 120KG Fly Ash.
- 664KG 10mm Aggregate Stone.
- 280KG Coarse Sand.
- 232KG Fine Sand.
- 1680ML Water Reducer.
- 2400ML High Range Water Reducer.
- 0 – 960ML Set Retarder
- 180L of clean water.

Other materials consist of:

- 1 meter of M16 all thread Stainless Steel Superduplex 2507 Rod.
- 1x Custom made M30 2507 superduplex U-Bolt lifting anchor.
- 3 litres of Molasses.
- 1 litre of Ecoratio – Betopro Wax G.
- 28KG steel S38 Fibre.
- 500ML HILTI RE500 pure injectable epoxy.

Batrosa Concrete Products confirm the design, materials and workmanship of all concrete will comply with the requirements of latest editions of the following Australian standards and Codes:

- AS1379 – Specification and supply of concrete
- AS1554.3 – Structural steel welding – welding of reinforcing steels

- AS3600 – Concrete construction
- AS3610 – Formwork for concrete
- AS4671 – Steel reinforcing materials

Furthermore, please see Appendix L for a copy of the standards and regulations of Batrosa Concrete Products with the technical drawings.

## Method of Construction

Batrosa Concrete Products have provided a copy of the precast concrete manufacturing process outlining the steps/ processes involved in constructing the HR modules. Please refer to Appendix M. It is important to note that this document is a simplified version of the manufacturing process and further Quality Assurance/ Quality Control (QA/QC) hold points & processes are completed before, during and after manufacturing.

# Deployment Site Selection

## Justification for Deployment Site Selection

The proposed deployment site (Figure 1) has been selected through consultation with local stakeholders, including recreational fishing groups MRFA & Ozfish (Mackay Chapter), advisory groups such as the Mackay LMAC, NQBP, Mackay Regional Council, Maritime Safety Queensland, and local fisheries ecologists. Some of the reasons for site selection were:

- Water depth (>10m LAT)
- Substrate type (mostly coarse sand)
- Coastal dynamics and processes (site not anticipated to impact on coastal processes or protection)
- Maritime safety (MSQ advised locations, and clear of shipping lanes and anchorages)
- Proximity to source reefs such as Dangerous Reef and Flat Top Reef for recruitment of marine sessile organisms and fish species
- Outside of the Great Barrier Reef Marine Park (sites located within Port of Mackay Limits)
- Accessibility of the site for user groups (two public access boat ramps & Mackay marina, and sites located in the offshore marine environment)
- Absence of sensitive habitats (e.g. seagrass meadows)

## Social and Economic Considerations

The *Recreational Boating Facilities Demand Forecasting Study 2016* (Mackay Regional Council, 2017) identified the Mackay local government area as having the largest number of boat registrations of any Queensland council area outside the south-east, with 13,732 boat registrations as of June 2016. Furthermore, available research indicates that approximately 90% of Mackay region residents use boat ramps in the Mackay area, with the Mackay Harbour boat ramp experiencing the highest volume of users. In addition, there were 49,000 fishing visitors to the Mackay Regional Council in 2016. Recreational fishing has contributed an estimated $23 million in tourism expenditure (Mackay Regional Council, 2017). Therefore, the demand for recreational fishing is high, and access to the marine environment is important to both the local community and visitors to the region (Mackay Regional Council, 2017). The installation of the HR modules in the nearshore marine environment offers a new, easily accessible location for families and other fishing groups to utilise and will ultimately help ease the fishing pressure at other well-known fishing spots in the region.

The HR modules are expected to attract a variety of user groups including scientists and researchers, marine recreational users (e.g. snorkelling, spearfishing), tourism & charter operators, and fishers including recreational, commercial and cultural. The location and accessibility of the HR modules is expected to deliver both social and broader economic benefits by increasing locations for recreational fishing opportunities in the region. The following have been identified as key beneficiaries of the reef:

- Recreational fishers who support healthy fish stocks and marine environment
- Tourism and charter operators who rely on the quality of the fishing experience and abundance of fish
- Boating and tackle industry who depend on having sustainable fish resources in the Mackay region
- Traditional Owners concerned about the changes in habitat and fish population sizes.

## Environmental Considerations

The proposed deployment sites are located in moderately disturbed, open coastal waters approximately 2.2km to the NNE of Flat Top Island, which is the closest land mass, and 5.6km SE from the Mackay Harbour Marina (Figure 4). Also nearby is Round Top Reef and Dangerous Reef, ideal for the self-seeding recruitment of marine sessile organisms and fish species to both proposed sites.

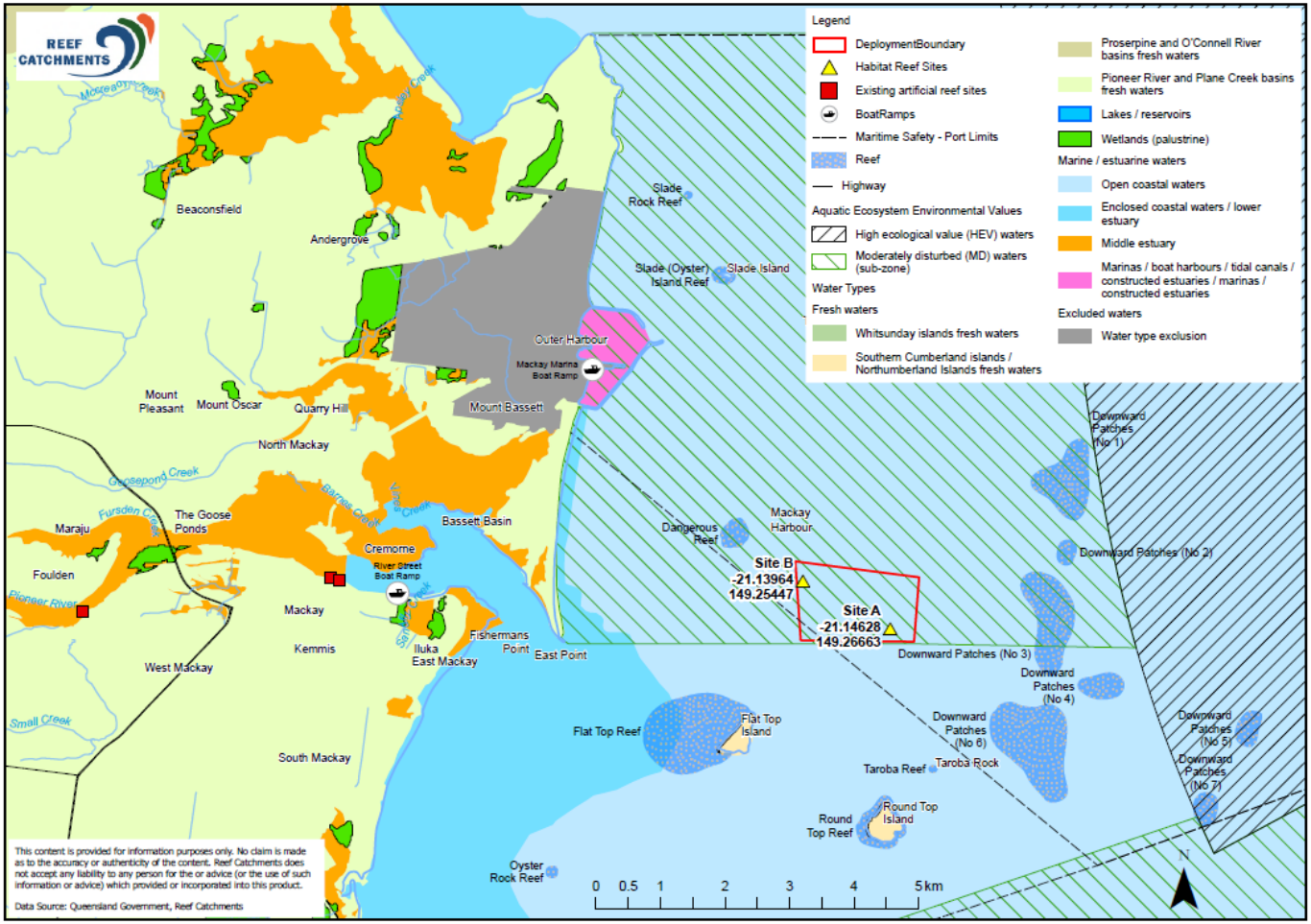


*Figure 4: Map of Mackay Coastal Water*

NQBP in partnership with JCU's TropWATER has been releasing annual ambient water quality monitoring reports in the Mackay region since 2014. The latest published annual report (2019-2020) has been attached as *supporting documentation*. In brief, there is a strong seasonal effect on water temperatures in the region ranging from 19.1˚C in the winter months to 32.6˚C in the summer months. Electrical conductivity (EC) tends to be within the range typical of seawater ranging from 48.7 to 56.8 mS cm-1. Dissolved oxygen ranged from 19.2 to 145.6% saturation, whilst pH ranged from 7.3 to 8.4. Additionally, NQBP release annual seagrass and coral condition reports for various locations in the Mackay offshore environment. NQBP have advised they expect to continue these ongoing programs into the foreseeable future.

Catchment Solutions investigated both proposed locations with the use of a Remotely Operated Underwater Vehicle (ROV) to inform the Site Inspection Report (Appendix O). Catchment Solutions focused on determining the presence or absence of marine plants and existing habitat, and the substrate composition. Following an analysis of the available data, no marine plants or fauna were visible at either proposed deployment sites. Imagery from the ROV also shows that the substrate is composed of sand and cobble. The cobble consists of some dull-white broken coral and seashells, with some rock also seen on top of the sand. Moreover, using side-scanning sonar technology on the vessel, the seafloor was noted to be flat with no indication of any structure. Therefore, it is not expected the installation of the HR modules will have any negative impacts on the biota at each site nor will they result in habitat substitution.

JCU's TropWATER performed a pre-baseline survey of benthos within the project area to inform deployment site selection and support this application (Appendix P). Three belt-transects (46 min in total) were completed during the pre-baseline survey which involved lowering a camera to approximately 30cm from the seabed at an angle of 70˚ and towed along a transect length of approximately 100 m over a period of 15 minutes. The benthos in the project area, from the three transects completed, comprised of course sandy material, some finer sediment was evident, with macroalgae, soft corals, sponges and some slightly larger boulders (<25cm diameter). The distribution of macroalgae was clumped and approximately covered between 0 and 10% of each metre square. Other species observed (e.g. sponges) were patchy and a single fish was recorded in the videos (Carangidae – trevally).

A Principal Coastal Engineer (Water & Maritime) and registered professional engineer of Queensland (RPEQ) has investigated the oceanographic conditions and sediment dynamics within the project boundary (Appendix N). Under ambient conditions, the significant wave height rarely exceeded 1.5m and the predominant wave direction occurs from the east. Mackay is subject to semidiurnal tides and is among the largest tidal ranges in Queensland with a maximum range of 6.62m and a mean spring tidal range of 4.53m. Additionally, the proposed deployment sites are in deeper water and are not subject to significant sediment transport or coastal processes.

The Yuwibara People are the Determined Native Title holders of land and sea in this area. The Aboriginal and Torres Strait Islander Cultural Heritage Database and the Aboriginal and Torres Strait Islander Cultural Heritage Register (Appendix R) have been searched within the MSQ advised safe area. The search results found no Cultural Heritage Management Plans, Designated Landscape Areas, Registered Cultural Heritage Study Areas or National Heritage Areas (Indigenous values) recorded in the area. The project aims fit within the Yuwi Aboriginal Corporation Strategic Plan and Healthy Country Plan, which both mention protection and expansion of habitat as a key priority.

## Biological Considerations

The selected placement sites of the HR modules will provide hard vertical substrate in otherwise bare, sandy substratum areas of the marine environment away from naturally occurring reefs. The design incorporates a roughened surface for the settlement of marine sessile organisms (hard & soft corals, sponges) with slanted walls to discourage sediment accumulation on the HR modules. In addition, the HR modules have been specially designed with two compartments. At the base, there is a large cave opening for large-bodied fish species, whilst the upper compartment consists of a series of smaller refuge holes to provide habitat for small-bodied and juvenile fish species. This will increase safe habitat available for a range of nearshore marine species, including demersal fish species such as *Plectropomus leopardus* (Coral Trout), *Lethrinus laticaudis* (Grass Emperor), *Morone saxatilis* (Striped Bass), *Argyrosomus japonicus* (Jewfish) and *Lutjanus johnii* (Golden Snapper), small bait species such as Hardyheads and Herring, as well as pelagic fish species including Mackerel and Tuna.

Coral Trout, for example, prey on many families of fishes such as *Pomacentridae* and *Scaridae* which are commonly found in demersal reef substrata habitat swimming around and above coral as well as using coral reefs for shelter (St John, 1995). In addition to Coral Trout, Grass Emperor are schooling fish and adults are commonly found over coral reefs. They are carnivores, feeding on smaller fish and crustaceans, whilst their main predators include sharks and larger predatory fish (MarineWise, 2022). Therefore, the HR modules are expected to attract a variety of species that inhabit the nearshore marine environment, and often seek shelter or hunt in and around underwater structures (e.g. coral reefs, rock outcrops). Over time, is it expected the HR modules will develop into healthy functioning reef ecosystems, supporting a myriad of organisms.

Whilst no invasive marine species were sighted in the proposed project area, this is an important consideration. NQBP has an ongoing marine pest early detection program with a series of settlement arrays/ plates installed at the Mackay Port. Monitoring is undertaken quarterly and will be used to inform the project team of the presence of marine pest species in the vicinity of the deployment sites. JCU's TropWATER will also record any observations of invasive marine species during their monitoring trips. Reef Catchments, as part of their long-term monitoring commitment, have made a commitment to monitor for the presence of invasive marine species at the deployment sites for the life of the permit.

### Threatened and protected species

An EPBC Act Protected Matter Report (Appendix Q) of the proposed deployment area with a 3km buffer area has been generated. Results of the database search revealed 11 species of birds, two species of marine mammal, one species of plant, six species of marine reptiles, and four species of sharks currently listed as threatened species occur within the project area and/ or surrounding buffer area (Table 1). Additionally, the project area is considered a "biologically important area" for five species (Table 2).

*Table 1: Threatened Species in the Mackay region*

| Scientific Name | Common Name | Threatened Category | Buffer Status |
|---|---|---|---|
| **BIRD** | | | |
| Calidris canutus | Red Knot | E | Project area |
| Calidris ferruginea | Curlew Sandpiper | CE | Project area |
| Charadrius leschenaultii | Greater Sand Plover | V | Buffer area only |
| Erythrotriorchis radiatus | Red Goshawk | V | Buffer area only |
| Fregetta grallaria grallaria | White-bellied Storm-Petrel | V | Project area |
| Hirundapus caudacutus | White-throated Needletail | V | Buffer area only |

| | | | |
|---|---|---|---|
| Macronectes giganteus | Southern Giant-Petrel | E | Project area |
| Neochmia ruficauda ruficauda | Star Finch (eastern) | E | Buffer area only |
| Numenius madagascariensis | Eastern Curlew | CE | Project area |
| Pterodroma neglecta neglecta | Kermadec Petrel (western) | V | Project area |
| Rostratula australis | Australian Painted Snipe | E | Buffer area only |
| **MAMMAL** | | | |
| Balaenoptera musculus | Blue Whale | E | Project area |
| Phascolarctos cinereus | Koala | E | Buffer area only |
| **PLANT** | | | |
| Phaius australis | Lesser Swamp-orchid | E | Buffer area only |
| **REPTILE** | | | |
| Caretta caretta | Loggerhead Turtle | E | Project area |
| Chelonia mydas | Green Turtle | V | Project area |
| Dermochelys coriacea | Leatherback Turtle | E | Project area |
| Eretmochelys imbricata | Hawksbill Turtle | V | Project area |
| Lepidochelys olivacea | Olive Ridley Turtle | E | Project area |
| Natator depressus | Flatback Turtle | V | Project area |
| **SHARK** | | | |
| Carcharodon carcharias | White Shark | V | Project area |
| Pristis zijsron | Green Sawfish | V | Project area |
| Rhincodon typus | Whale Shark | V | Project area |
| Sphyrna lewini | Scalloped Hammerhead | CD | Project area |

*Table 2: Biologically Important Areas*

| Scientific Name | Behaviour | Presence | Buffer Status |
|---|---|---|---|
| **DOLPHINS** | | | |
| *Sousa chinensis* Indo-Pacific Humpback Dolphin | Breeding | Known to occur | Project area |
| *Tursiops aduncus* Indo-Pacific/ Spotted Bottlenose Dolphin | Breeding | Likely to occur | Project area |
| **MARINE TURTLES** | | | |
| *Natator depressus* Flatback Turtle | Nesting | Known to occur | Project area |
| **SEABRIDS** | | | |
| *Sterna sumatrana* Black-naped Tern | Breeding | Known to occur | Project area |
| **WHALES** | | | |
| *Megaptera novaeangliae* Humpback Whale | Breeding and calving | Known to occur | Project area |

# Risks and Mitigation Strategies

## Risk Identification

### Navigation and Safety

It is possible that an increase or aggregation of fishing vessels in the vicinity of the proposed HR module locations may increase the risk of collision or boating accidents. All normal boating rules and regulations apply, and recreational fishing vessels should give way to movement of diver vessels. The HR modules spread across two deployment sites (Site A and Site B) should also diversify impact of recreational fishers. Additionally, the HR modules will be mapped on marine hazard charts.

There is a potential risk that vessels transiting over the reef may be damaged or damage the HR modules if their hull or propeller comes into contact with the structures. However, this will be mitigated by ensuring sufficient clearance at all tides and in high wave conditions. We recognise it is not possible to completely remove the risk of anchor fouling/ loss on the HR modules.

### Invasive Species

The proposed reef structures could provide a habitat suitable for invasive marine pests. The risk to threatened species from invasive marine pests and potential colonisation associated with the reef is considered low. Similarly, the risk of increased potential for disease associated with biota at the artificial reefs is considered to be low due to their isolation in the open ocean rather than in estuarine environments.

The HR modules will be closely monitored for the colonisation of marine pests. Monitoring will be undertaken twice within the first 12 months and annually in years 2, 3, 4, 5, 10, 15, 20 and 25 post-deployment. In the event marine pests are identified on the structures, management action will be informed by Queensland Biosecurity.

### Harm from Marine Debris

The installation of HR modules is likely to result in an increase in recreational fishing activity in the reef area. This potentially increases the risk of lost fishing gear and harmful marine debris entering the marine environment in the vicinity of the proposed reef area. Injury and fatality to vertebrate marine life caused by ingestion or, or entanglement in, harmful marine debris (EPBC Act) has been identified as a Key Threatening Process potentially relevant to this proposal. Threatened marine species, particularly marine turtles, can ingest or become entangled in marine debris, such as plastics. Potential harm to marine animals from build-up of marine debris such as lost fishing tackle, anchor lines and other pollution will be monitored and removed, if required, in years 2, 3, 4, 5, 10, 15, 20 and 25 post-deployment.

### Threatened and Protected Species

A list of all threatened and protected species can be found in Table 1 and all marine species identified to have biologically important areas within the project area are addressed below.

*Indo-Pacific Humpback Dolphin*

Indo-pacific humpback dolphins are widely distributed throughout the tropical waters of Australia, typically in water less than 20km from the nearest river mouth and depths less than 20m. Potential threats to indo-pacific humpback dolphins as a result of the proposal include: harm from marine debris and pollution, acoustic disturbance and boat strike. The likelihood and consequence of each of these risks can be managed by public education, ongoing monitoring and removal of marine debris, and following the *Australian National Guidelines for Whale and Dolphin Watching*. Therefore, the proposal is not considered to have a significant impact on indo-pacific humpback dolphins.

*Indo-Pacific/ Spotted Bottlenose Dolphin*

Indo-pacific/ spotted bottlenose dolphins are a coastal species, often maintaining year-round residence of their home range. Potential threats to indo-pacific/ spotted bottlenose dolphins as a result of the proposal include: harm from marine debris and pollution, acoustic disturbance and boat strike. The likelihood and consequence of each of these risks can be managed by public education, ongoing monitoring and removal of marine debris, and following the *Australian National Guidelines for Whale and Dolphin Watching*. Therefore, the proposal is not considered to have a significant impact on indo-pacific/ spotted bottlenose dolphins.

*Flatback Sea Turtle*

The risk to negatively impact marine sea turtles is also considered to be low. The reef sites are located approximately 3.5km from the nearest known turtle nesting beach along the Mackay coastline (Figure 5). The species will still have access to nesting beaches within the Mackay region and there should be minimal risk of increased predation of hatchlings. Additionally, the design of the HR modules incorporates a swim-through cave compartment minimising the risk of entanglement and subsequent drowning within the structure itself. The proposed monitoring program will closely monitor the risk of entanglement from marine debris. Therefore, the proposal is not considered to have a significant impact on marine sea turtles.

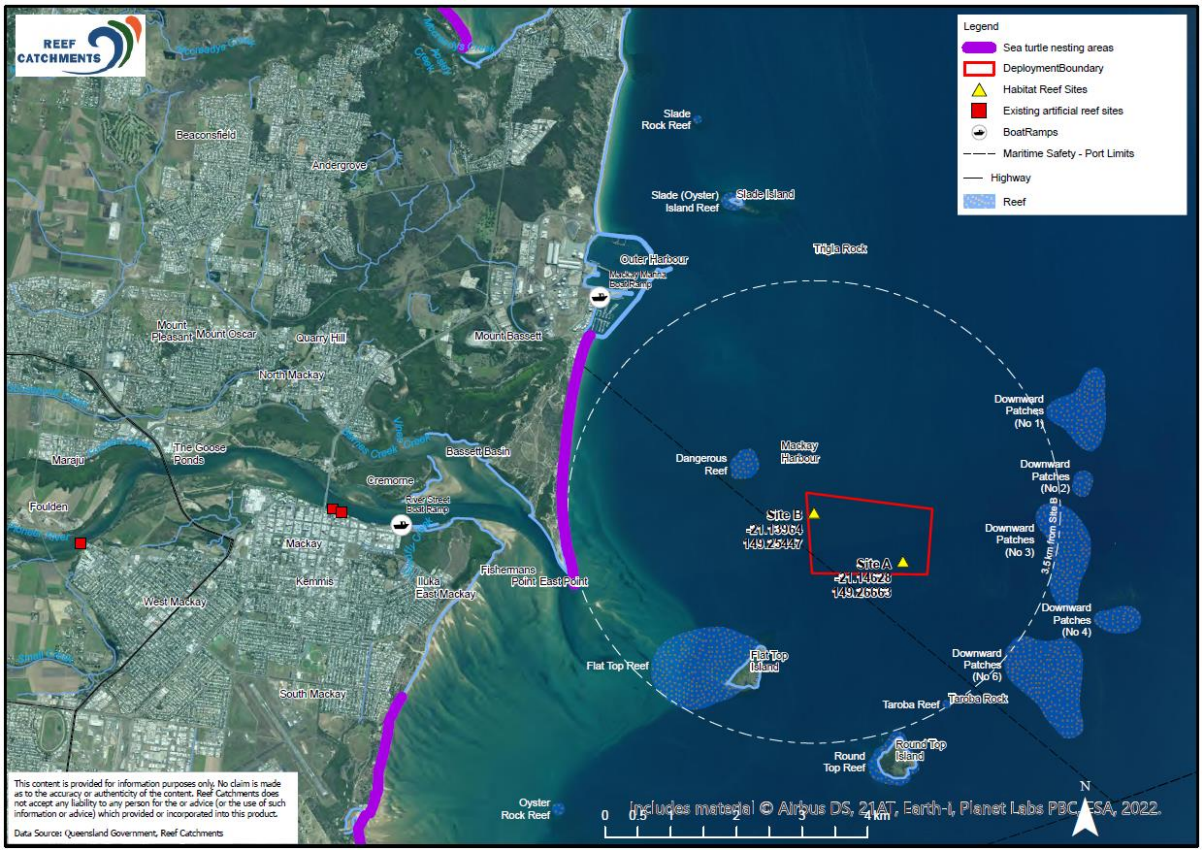


*Figure 5: Map of Known Sea Turtle Nesting Areas in the Mackay Region*

*Humpback Whale*

Humpback whales travel through the Mackay region on a seasonal basis during their migration between the Great Barrier Reef and Antarctica. The southern Great Barrier Reef region, particularly east of Mackay, is presumed to be an important breeding area for Humpback whales. Potential threats to humpback whales as a result of the proposal include: entanglement from marine debris, acoustic

disturbance and boat strike. The likelihood and consequence of each of these risks can be managed by public education, ongoing monitoring and removal of marine debris, and following the *Australian National Guidelines for Whale and Dolphin Watching*. Additionally, due to their transient nature, the proposal is not expected to disrupt the species' life cycle or place any local population at risk of extinction. Therefore, the proposal is not considered to have a significant impact on humpback whales.

*Black-naped Tern*

Black-naped terns breed and roost on islands along north-eastern Australia, foraging for fish in coastal waters. During the breeding season, >80% of Black-naped Terns forage within 2km of their colonies. Moreover, black-naped terns are highly sensitive to human disturbance when roosting or nesting. The Department of Climate Change, Energy, the Environmental and Water advise that 80m is the critical approach distance on shores. The Habitat Reef sites (Site A and Site B) are both greater than 2km from the nearest potential nesting area (Flat Top Island) and thus the level of disruption to nesting black-naped terns is minimal. Therefore, the proposal is not considered to have a significant impact on black-naped terns.

## Risk Assessment Methods

The risk analysis matrix (Table 3) provides the rationale for scoring likelihood of a hazard occurring and of the consequence if the hazard eventuated. Scores of likelihood and consequence are then combined to provide a subjective judgement of significance. Based on this, each hazard/ risk is identified as being of very low, low, medium or high significance (Table 4). The result of this risk assessment does not mean the project should not proceed, but rather that the issue may require greater or less effort in management/ mitigation. Note the health and safety impacts are assessed on a different scale to environmental impacts.

*Table 3: Risk analysis matrix*

| **Likelihood** | | | |
|---|---|---|---|
| A | Almost certain | It is expected to occur as a result of the project under most circumstances | >1 / month |
| B | Likely | Will probably occur as a result of the project in most circumstances | >1 / year |
| C | Possible | Could occur and has occurred in similar circumstances | 1 – 10 years |
| D | Unlikely | Could occur as a result of the project but is not expected | 10 – 100 years |
| E | Rare | Could occur only in exceptional circumstances | <1/ 100 years |
| **Consequence (environmental)** | | | |
| 1 | Catastrophic | Widespread extreme impact beyond the deployment area; limited prospect of full recovery | |
| 2 | Major | Substantial impact/ serious harm within the immediate deployment area; limited prospect of full recovery | |
| 3 | Moderate | Serious/ significant impact; recovery longer than 3 years | |
| 4 | Minor | Localised harm; recovery measurable within 1-3 years | |
| 5 | Minimal | No impact on the baseline environment; minimal or no mitigative actions required | |
| **Consequence (health and safety)** | | | |
| 1 | Catastrophic | Single or multiple fatalities | |
| 2 | Major | Catastrophic illness or injury | |
| 3 | Moderate | Extensive/ major injury | |
| 4 | Minor | Minor injury e.g. medical treatment | |
| 5 | Minimal | No medical treatment required | |
| | | **Likelihood** | |

| | | | A | B | C | D | E |
|---|---|---|---|---|---|---|---|
| | | | Almost certain | Likely | Possible | Unlikely | Rare |
| **Consequence** | 1 | Catastrophic | A1 | B1 | C1 | D1 | E1 |
| | 2 | Major | A2 | B2 | C2 | D2 | E2 |
| | 3 | Moderate | A3 | B3 | C3 | D3 | E3 |
| | 4 | Minor | A4 | B4 | C4 | D4 | E4 |
| | 5 | Minimal | A5 | B5 | C5 | D5 | E5 |

| | | |
|---|---|---|
| H | High Risk | Risk is significant and requires significant cost-effective measures for risk reduction and/ or management. |
| M | Moderate Risk | Routine and cost effective measures required to reduce and/ or manage risk. |
| L | Low Risk | Risk can be managed by routine procedures and/ or no further measures to manage the risk are required. |
| V | Very Low Risk | Risk is accepted, no further measure to manage the risk are required. |

## Risk Assessment

A risk assessment has been performed to identify, describe and mitigate all perceived risks as a result of the proposal in Table 4.

*Table 4: Risks and mitigation strategies*

| Risk Description | Risk Level | Mitigative Measures | Treatment Type | Risk Level |
|---|---|---|---|---|
| **Navigation and Safety** | | | | |
| Clearance | D4 | Sufficient clearance between the upper part of the HR modules and transiting vessels in severe weather conditions and under Lowest Astronomical Tide (LAT). Appropriate site selections, consultation and mapping on navigational charts. | Reduce likelihood | D4 |
| Collision from crowding | C3 | Education and effort is spread through the HR module reef layout. | Reduce likelihood | D3 |
| **Recreational Fishing** | | | | |
| Gear hook-up | B4 | Education. Monitor marine debris and remove as per Long-Term Management Plan. | Reduce likelihood | C4 |
| **Invasive Marine Pests** | | | | |
| Spread of invasive marine pests during transport and installation | C3 | Ensure equipment and vessels used during transport and installation are clear of all biofouling. Move directly to and from the loading port and deployment site to reduce the uptake of any marine pest or disease agent. | Reduce likelihood | D3 |
| Colonisation by invasive marine pests | C2 | Follow Biosecurity Queensland advice if marine pests are identified. | Reduce consequence | C3 Accept |
| **Indo-Pacific Humpback Dolphin** | | | | |
| Increased risk of boat strike | C3 | Education. Vessels anchored, drifting or trolling at idle speed. | Reduce likelihood & consequence | C4 |

| | | | | |
|---|---|---|---|---|
| Increased risk of acoustic disturbance from boat traffic | C3 | Follow the *Australian National Guidelines for Whale and Dolphin Watching*. | Reduce consequence | C4 |
| Harm from marine debris and pollution | B3 | Education. Monitor marine debris and remove as per Long-Term Management Plan. | Reduce likelihood & consequence | C4 |
| **Indo-Pacific/ Spotted Bottlenose Dolphin** | | | | |
| Increased risk of boat strike | C3 | Education. Vessels anchored, drifting or trolling at idle speed. | Reduce likelihood | C4 |
| Increased risk of acoustic disturbance from boat traffic | C3 | Follow the *Australian National Guidelines for Whale and Dolphin Watching*. | Reduce consequence | C4 |
| Harm from marine debris and pollution | B3 | Education. Monitor marine debris and remove as per Long-Term Management Plan. | Reduce likelihood & consequence | C4 |
| **Humpback Whale** | | | | |
| Increased risk of boat strike | C3 | Education. Vessels anchored, drifting or trolling at idle speed. | Reduce likelihood | C4 |
| Increased risk of acoustic disturbance from boat traffic | C3 | Follow the *Australian National Guidelines for Whale and Dolphin Watching*. | Reduce consequence | C4 |
| Entanglement from marine debris | B3 | Education. Monitor marine debris and remove as per Long-Term Management Plan. | Reduce likelihood & consequence | C4 |
| **Black-Naped Tern** | | | | |
| Increased disturbance at roosting or nesting sites | C3 | Sufficient distance (>2km) from the nearest potential nesting site. | Reduce consequence & likelihood | D4 |
| **Marine Sea Turtles** | | | | |
| Incidental capture/ entanglement from marine debris | B3 | Education. Monitor marine debris and remove as per Long-Term Management Plan. | Reduce likelihood & consequence | C4 |
| Increased risk of boat strike | C3 | Education. Vessels anchored, drifting or trolling at idle speed. | Reduce likelihood | C4 |
| Increased hatchling predation | C3 | Sufficient distance (>3km) from the nearest known turtle nesting site. | Reduce likelihood | D4 |

# Baseline Assessment of Proposed Deployment Sites

## Geographical Position

The location of the proposed reef restoration site is situated approximately 5.6km south-east of the Mackay Harbour marina, 2.2km north-northeast of Flat Top Island in an approximate depth of 9-12m Lowest Astronomical Tide (LAT). The water depth over the shallowest HR module will be approximately 8m. The size of the deployment boundary is approximately 1.90km$^2$. The corner point coordinates (WGS84) for the boundary are situated at:

NW -21.13701˚149.25341 ,˚

NE -21.13924˚149.27064 ,˚

SW -21.14801˚149.25418 ,˚

SE -21,14819˚149.26996 ,˚

The geographical position of the centre HR module at Site A and Site B are provided in Table 2. A global positioning system (GPS) will be used to determine the geographical position of the reef once it has been placed.

*Table 4: Geographical position of proposed Site A and Site B*

| Deployment Site | Latitude (WGS84) | Longitude (WGS84) | Depth (LAT) |
|---|---|---|---|
| Site A | -21.14628 ˚ | 149.26663˚ | 11.995m |
| Site B | -21.13964˚ | 149.25447˚ | 10.195m |

During the marine investigation, the proposed sites were absent of any threatened, sensitive or unique species or habitats in the area, as confirmed by ROV footage and side-scanning technology onboard the vessel. In addition, no structures that could be used as shelter from predators were sighted in the area using side scanning technology. In addition, the clearance depth over the HR modules at both Site A and Site B post deployment would be no less than 8m (LAT). This will be confirmed during and post HR module deployment.

## Locality of Proposed Deployment Sites

The location of the proposed deployment sites is within a Maritime Safety Queensland (MSQ) advised 'safe area', and therefore the presence of the HR modules will not impact any shipping lanes or anchorages. As per Mackay Regional Council conditions, the HR modules will be added to MSQ navigation hazard charts. The installation of the HR modules is of significant scientific (research and monitoring) and public interest, with several user groups expected to visit and utilise the sites. Therefore, it was important the deployment sites were easily accessible and located reasonably close to the Mackay coast.

Moreover, within the MSQ boundary, further investigation was undertaken to determine site selection. Of particular interest, no sensitive habitat (seagrass meadows or coral reef) was sighted at either of the proposed deployment sites. Furthermore, the installation and presence of the HR modules are not anticipated to negatively impact any endangered, rare or migratory species which may occur nearby. The EPBC Act Protected Matters Report revealed that there are no listed threatened ecological communities, critical habitats, or habitats critical to the survival of marine turtles within the deployment boundaries.

The Yuwi People are the recognised native title holders of land and sea in this area. Aboriginal and Torres Strait Islander Cultural Heritage Database and the Aboriginal and Torres Strait Islander Cultural Heritage Register have been searched within the MSQ advised safe area. Please refer to Appendix R. In short, it was found that there are no Cultural Heritage Management Plans, Designated Landscape Areas, Registered Cultural Heritage Study Areas or National Heritage Areas (Indigenous values) recorded in the search area.

## Proposed Site Photos

Photographs have been captured from the proposed Site A and Site B deployment sites; however, markers have not been established yet. The photographs below were taken to confirm the viability of deploying the HR modules in these locations. Permanent monitoring locations will be established by JCU's TropWATER when they formally commence their ecological monitoring program, following permit approvals.

*Figure 6: Still Photo of Site A seafloor*

*Figure 7: Still Photo of Site B seafloor*

## Oceanographic & Climatic Considerations

The HR modules will be subject to both wave action and tidal currents. The following information has been compiled by an experienced Principle Coastal Engineer (RPEQ), as part of a Habitat Reef Stability Assessment. This report is available in Appendix N.

The Hay Point Wave Rider Buoy (WRB) has been directional since August 2008 and is located 20km to the south-south-east of Mackay Harbour in a water depth of 10m. The Hay Point wave data will represent the nearshore wave conditions at the proposed reef restoration sites. Under ambient conditions, the significant wave height rarely exceeds 1.5m. The predominant wave direction occurs from the east, although it is not uncommon for the waves to come from the east-north-east and east-southeast (Figure 8). Tropical cyclones also transit the coast of Mackay during the wet season, affecting waves, current speeds and water levels. The largest recorded significant wave height at Hay Point is approximately 4m (less than a 1 in 100-year ARI event).

The Mackay Harbour area is subject to semi-diurnal tides. The Mackay Region tidal range is among the largest in Queensland, with a maximum range of 6.62m and a mean spring tidal range of 4.53m. Tidal currents at the proposed deployment site are relatively low and are not anticipated to significantly affect HR module stability.

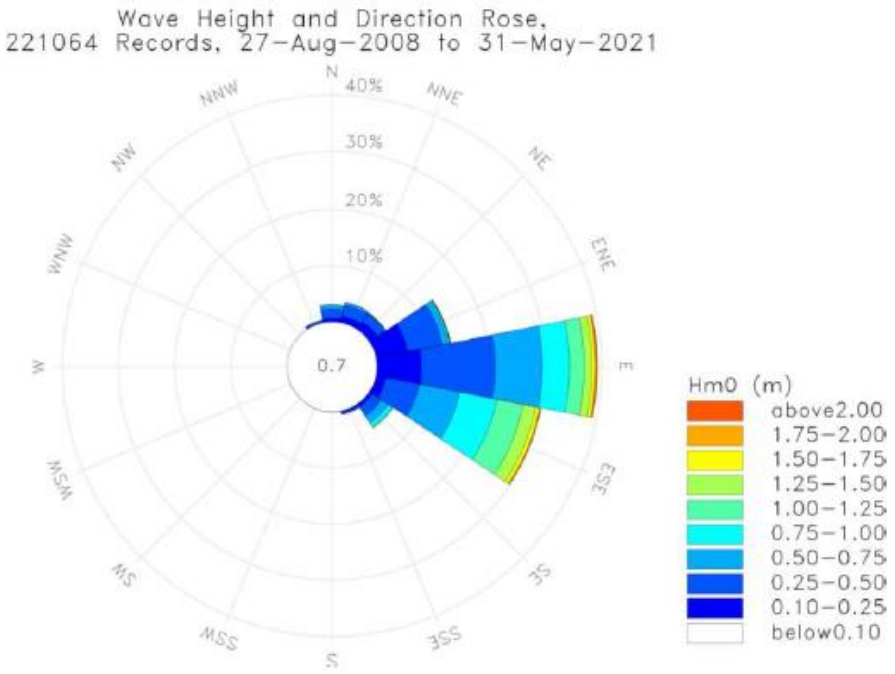


*Figure 8: Wave rose showing the measured wave conditions at the Hay Port WRB*

# HR Modules Monitoring Program

A collaborative monitoring program proposal has been developed to monitor the performance of the HR modules for the life of the permit. The proposed monitoring program consists of a short-term (12-months) monitoring component led by Reef Catchments with support from Mackay Regional Council, and North Queensland Bulk Ports (NQBP) in partnership with James Cook University's Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER), and a long-term monitoring component facilitated by Reef Catchments and Mackay Regional Council.

## Short-Term Monitoring Program

Reef Catchments with support from Mackay Regional Council, NQBP and its researcher TropWATER will deliver a comprehensive short-term (12 months post-deployment) monitoring program using two underwater video techniques to inform the performance of four key monitoring objectives (Table 5). In brief, the program will include a pre-survey by TropWATER prior to the deployment of the HR modules, followed by two rounds of each underwater video technique within a 12-month period post-deployment. A summary of the data and results will be presented in a final report at the conclusion of the short-term program.

TropWATER propose to conduct research using underwater video belt transects. Whereby, underwater cameras will be deployed adjacent to the HR modules for approximately 15 minutes, during the day. It is anticipated that 10 camera drops will be completed at each of the HR module reef sites, in addition to two local control sites (locations are yet to be finalised) as a benchmark to compare results.

Reef Catchments will complement this research with the deployment of a high-performance FIFISH V6 Expert remotely operated vehicle (ROV) at the two reef sites. The FIFISH V6 Expert is equipped with an ultra-high-definition 4K underwater camera lens, along with a 166 ultra-wide field of view, 12-megapixel resolution, a pair of ultra-bright 6000 lumen LED lights, and much more. Use of the ROV will deliver high quality images and footage of the HR modules.

In addition, if there is an event with wave heights exceeding 4.6m recorded at Hay Point waverider buoy within the first 12 months post-deployment, Mackay Regional Council will undertake a monitoring trip to confirm the positional stability of the HR modules.

The implementation of the proposed monitoring activities will depend on the appropriate weather and timing of the deployment of the HR modules.

*Table 5: Summary of short-term monitoring plan*

| **Monitoring objective** | **Monitoring methodology** | **Key stakeholder(s)** | **Timeframe** |
|---|---|---|---|
| Fish community | Monitoring will be conducted using underwater video techniques allowing for visual observation. | Reef Catchments, NQBP, TropWATER, Mackay Regional Council | A formal baseline will be established pre-deployment, and two monitoring trips will be conducted within 12 months post-deployment. |
| Structural integrity and positional stability, post storm events | Monitoring will be conducted using underwater video | Reef Catchments, Mackay Regional Council | Two monitoring trips will be conducted within 12 |

| | | | |
|---|---|---|---|
| | techniques allowing for visual observation. | | months post-deployment. |
| | Monitoring will be conducted using side scanning sonar technology to confirm the placement of the HR modules. Optional: Deployment of an underwater camera/ drone for visual inspection. | Mackay Regional Council, Reef Catchments | Within 6 weeks of a storm event with significant wave heights (Hs) exceeding 4.6m recorded at the Hay Point waverider buoy. |
| Invasive species | Monitoring will be conducted using underwater video techniques allowing for visual observation. | Reef Catchments, Mackay Regional Council | Two monitoring trips will be conducted within 12 months post-deployment.<br>Reef Catchments will notify Biosecurity Queensland in the event invasive species are observed on the HR modules. |
| Marine debris | Monitoring will be conducted using underwater video techniques allowing for visual observation. | Reef Catchments, NQBP, TropWATER, Mackay Regional Council | Two monitoring trips will be conducted within 12 months post-deployment. |

## Long-Term Monitoring Program

Reef Catchments with support from Mackay Regional Council will facilitate a long-term monitoring program to inform the performance of the monitoring objectives at the HR module reef sites for the life of the permit (Table 6). Monitoring will be conducted using side scanning sonar and underwater video techniques.

A single monitoring trip will occur in years 2, 3, 4, 5, 10, 15, 20 and 25 post-deployment, and within 6 weeks of a storm event with significant wave heights (Hs) exceeding 4.6m recorded at the Hay Point waverider buoy (whichever comes first) for the life of the permit.

There may be an opportunity to extend the short-term monitoring program through the inclusion of the HR module reef sites into NQBP's ongoing Annual Marine Biodiversity Monitoring Program. A proposal has been included (Attachment AA), which is currently under consideration by NQBP.

*Table 2: Summary of long-term monitoring plan*

| **Monitoring objective** | **Monitoring methodology** | **Key Stakeholder(s)** | **Timeframe** |
|---|---|---|---|
| Fish community | Monitoring will be conducted using underwater video techniques allowing for visual observation. | Reef Catchments, NQBP, TropWATER, Mackay Regional Council | Monitoring will occur in years 2, 3, 4, 5, 10, 15, 20 and 25 post-deployment. |
| | Monitoring will be conducted using underwater video | Reef Catchments, NQBP, TropWATER, | Monitoring will occur in years 2, 3, 4, 5, 10, 15, |

| | | | |
|---|---|---|---|
| Structural integrity and positional stability, post storm events | techniques allowing for visual observation. | Mackay Regional Council | 20 and 25 post-deployment. |
| | Monitoring will be conducted using side scanning sonar technology to confirm the placement of the HR modules.<br><br>Optional: Deployment of an underwater camera/ drone for visual inspection. | Mackay Regional Council, Reef Catchments | Within 6 weeks of a storm event with significant wave heights (Hs) exceeding 4.6m recorded at the Hay Point waverider buoy. |
| Invasive Species | Monitoring will be conducted using underwater video techniques allowing for visual observation. | Reef Catchments, NQBP, TropWATER, Mackay Regional Council | Monitoring will occur in years 2, 3, 4, 5, 10, 15, 20 and 25 post-deployment.<br><br>Reef Catchments will notify Biosecurity Queensland in the event invasive species are observed on the HR modules. |
| Marine Debris | Monitoring will be conducted using underwater video techniques allowing for visual observation. | Reef Catchments, NQBP, TropWATER, Mackay Regional Council | Monitoring will occur in years 2, 3, 4, 5, 10, 15, 20 and 25 post-deployment. |

## Management Action Trigger Values

Trigger points specify when a performance indicator has reached a level that suggests there is a problem with the activity and mitigative action(s) is required.

*Table 6: Trigger values and mitigation strategies*

| Monitoring objective | Trigger Value(s) | Mitigation Strategies |
|---|---|---|
| Fish community (e.g. fish abundance & diversity) | Long-term monitoring trends (5 years) indicate zero increase in fish abundance and/ or diversity at Habitat Reef sites. | • Temporary, voluntary 'catch and release' community campaign to allow the fish community to establish |
| Structural integrity and positional stability, post-storm events | Notification of significant structural damage (e.g. splitting of structure) or significant movement (>1m) of HR module(s) | • Consultation with RPEQ coastal engineer (or similar) to conduct an assessment<br>• If the damage is repairable in-situ, steps will be undertaken to complete such repairs using commercial divers<br>• If the damage is not repairable in-situ, consultation will determine if the damage is negligible and the installation can continue to remain at the site, or needs to be removed and repaired. |

| | | |
|---|---|---|
| Invasive species | Notification of marine invasive species on HR module(s) | • Notify Biosecurity Queensland and comply with their advice |
| Marine debris | Low observed impact<br>(e.g. small pieces of rope or embedded lures on HR modules) | • Community education<br>• Continuation of monitoring schedule as set out in *Table 5* of the LTMP – accumulation of debris to a medium observed impact will trigger removal |
| | Medium observed impact<br>(e.g. multiple pieces of sizeable rope or other marine debris such as anchors or large nets on HR modules that may pose a threat to marine life) | • Community education<br>• Removed by at least one qualified scuba diver using manual equipment (cutting tool)<br>• Complete removal at next available opportunity, within 6 weeks from notification of observation |
| | High observed impact<br>(e.g. large, heavy debris items around HR modules posing danger to structural integrity and other marine life) | • Community education<br>• Able to be removed by commercial divers using either manual equipment (cutting tool) and/ or other equipment (such as lift bags or cranes)<br>• Complete removal at next available opportunity, within 6 weeks from notification of observation |

## Decommissioning Considerations

The nominal lifespan of the HR modules is 40 years. Whilst the intention is for the HR modules to remain in the marine environment indefinitely, it is important to consider the circumstances by which decommissioning the HR modules may be deemed necessary and how this process might be undertaken. Reef Catchments and Mackay Regional Council acknowledge removal of the HR modules may be required if mitigative measures are not effective.

*Table 7: Proposed Decommissioning Action Plan*

| Scenario | Monitoring/ Assessment Method | Mitigation Measure(s) | When Removal Would be Necessary |
|---|---|---|---|
| Product failure or unforeseen physical damage. | Monitoring will occur in years 1-5, 10 and 15 post-deployment, and within 6 weeks of a storm event with significant wave heights (Hs) exceeding 4.6m recorded at the Hay Point waverider buoy (whichever comes first) for the life of the permit to confirm the structural integrity and placement of the HR modules using side-scanning sonar and underwater video techniques. | ○ HR modules each weigh approximately 1.6 tonnes<br>○ Design of the HR modules incorporates a large footprint for stability<br>○ HR modules have been designed & certified as stable in conditions up to 1/100-year events<br>○ Proposed deployment sites have considered oceanographic & climatic conditions<br>○ HR modules will be plotted on MSQ navigational hazard charts | ○ A HR module is identified as a safety or navigational hazard |
| HR modules are having a negative impact on other ecological or biophysical processes. | Monitoring will occur in years 1-5, 10 and 15 post-deployment, and within 6 weeks of a storm event with significant wave heights (Hs) exceeding 4.6m recorded at the Hay Point waverider buoy (whichever comes first) for the life of the permit. Utilising underwater video techniques, this will offer insight whether the HR modules are having any negative impact in the wider ecosystem. | ○ Distance from nearby reefs<br>○ Utilising best practice by other artificial reef projects<br>○ Innovative design – no plastic (reducing possible negative impact) | ○ HR modules are having an irrefutable negative impact on the surrounding marine environment |

| | | | |
|---|---|---|---|
| HR modules are colonised by invasive marine species, becoming an ecological hazard. | Monitoring will occur in years 1-5, 10 and 15 post-deployment, and within 6 weeks of a storm event with significant wave heights (Hs) exceeding 4.6m recorded at the Hay Point waverider buoy (whichever comes first) for the life of the permit.<br><br>Any observations will be recorded in the report, and action can be swiftly taken for eradication. | ○ Regular & comprehensive monitoring program for early detection<br>○ Encourage recreational fishers to clean their vessel regularly to prevent spread<br>○ Manual removal of invasive species (biosecurity protocol) | ○ HR modules are solely colonised by marine invasive species |
| HR modules not achieving intended purpose at the end of permitted life. | An assessment of the HR modules will be undertaken during the final 12 months of the active permit. This will enable determination of whether the HR modules are achieving their intended purpose. This will inform the decision-making process to determine whether the modules will need to be removed within the active permit timeframe. | ○ Implementation and revision of the Long-Term Management Plan throughout the life of the permit | ○ No fish abundance recorded at the HR module sites throughout the permit life |

## Decommissioning Methodology

Whether the HR modules are removed during or at the end of the life of the Sea Dumping Permit, structural inspections would be undertaken to inform which of the following options for decommissioning would be best:

- Option 1: Provided the structures are structurally sound for removal, the HR modules would be lifted intact by crane to a barge and transported to a waterside location, where the HR modules would be cleaned, dismantled and disposed of at an appropriate land-based facility;

- Option 2: If it is not feasible for the HR modules to be removed intact, then the method of removal of the HR modules would be subject to a tender process to ensure best practice methods for removal were employed at the time. The HR modules would then be transported to a waterside facility where the pieces would be cleaned and disposed of at an appropriate land-based facility;

- Option 3: HR modules would remain in-situ on the sea-bed and be allowed to gradually break-down over time. Monitoring of the structures would continue.

The above decommissioning options are currently being utilised by the NSW Department of Primary Industries as set out in their long-term management plan of Batemans offshore artificial reef. These options can be applied at any stage during the operational life of the reef.

It is likely that the main impact of removing the structures (options 1 or 2) would be a significant loss of attached marine flora and fauna, and a loss of fish habitat. The overall environmental impact, however, would likely depend on the length of time the HR modules had been in place.

## Project Reporting

Updates on the Rubble to Reef project will be placed on the Reef Catchments webpage, via social media platforms, and will be reported as required to other statutory agencies and departments.

## Long Term Management Plan Review

Review of this long-term management plan will be conducted as required from the date of approval and is the responsibility of Reef Catchments Limited and Mackay Regional Council.

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