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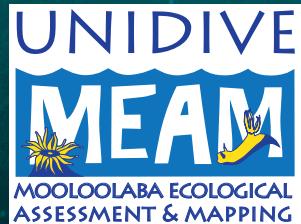
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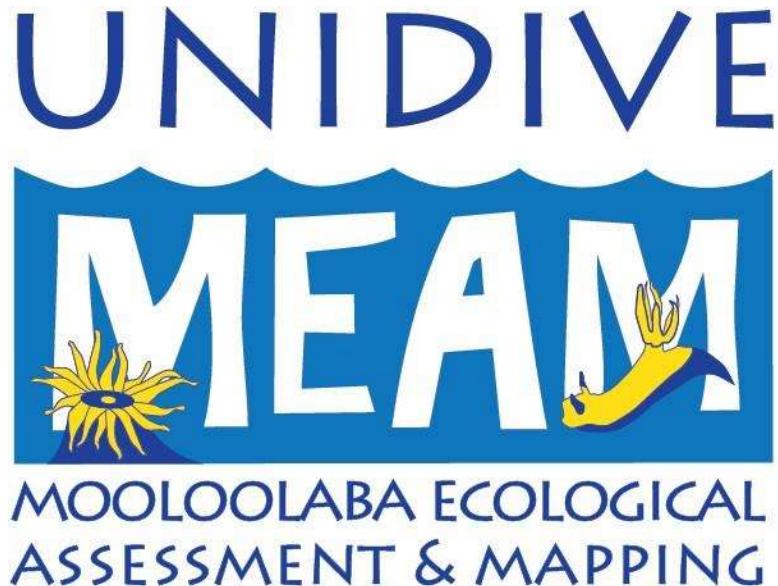
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# Ecological Assessment of the Flora and Fauna of Mooloolaba Reefs, Queensland

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## Final Report



*We, the participants of this project, would like to acknowledge the Gubbi Gubbi people and the Jinibara people, the Traditional Custodians of land and sea country of the Sunshine Coast.*

*We recognise that these have always been, and always will be, places of cultural, spiritual, social and economic significance. The Traditional Custodians' inherent connection to country, and ancient and enduring cultures deepen and enrich the life of our community. We wish to pay respect to their Elders – past, present and emerging. Together, we are all stronger.*

This report should be cited as:

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**The views and interpretations expressed in this report are those of the authors and not necessarily those of contributing agencies and organisations.**

## *Citizen Scientists Taking Care of Local Reefs*

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I am pleased to share this final report created by the citizen scientists of the UniDive project: Mooloolaba Ecological Assessment and Mapping (MEAM). This report represents the persistence and efforts of the volunteers, to highlight the beautiful and important reefs of Mooloolaba, including Mudjimba Island, and the Inner and Outer Gneerings. This project was supported by over 8,000 of hours of volunteer contributions to plan the project, organise trips, teach survey techniques and identification of flora and fauna, conduct surveys, collect thousands of photos, analyse the results, and create this report.

This project represents an extraordinary adventure and significant effort for the participants and their supporters. The report showcases an impressive reef system with high coral cover and amazing marine life on the doorstep of the Sunshine Coast. The report is also evidence of a persistent team of volunteers eager to learn and care for local reefs and help bring greater attention to its unique values and importance.

In early 2020, COVID was impacting the world. Many of us went into lockdowns and faced new physical and mental challenges. We were limited in what we could do and where we could travel. Many were concerned about the future and our loved ones, friends and family – which impacted our wellbeing. This was our motivation to start something positive and in July 2020 a group of eager UniDive members came together to make a difference to the health of local reefs and fellow divers.

MEAM started in September 2020. Online academic sessions (30+) enabled members across Brisbane and the Sunshine Coast to come together virtually to connect and learn. The easing of restrictions in April 2021 allowed us to start practical training in the pool and at Point Lookout reefs followed. Three survey weekends were originally planned but they faced considerable logistical challenges due to COVID restrictions, floods, extreme weather events, and reduced access to the UniDive boat “Down Under”. The project endured by adapting planned weekends to only day trips. Instead over 3 weekends in winter 2021, we surveyed over 10 months, where 11 day trips were completed and 23 were cancelled. The team persisted through the many challenges to proudly complete the project and deliver this report.

The report would not be possible without the effort of a core group of divers that organised trips, skippered the boat, prearranged tanks, prepared survey gear, ensured COVID safe protocols, collected survey data, entered survey data, processed survey data, captured photos, analysed photos, analysed data and wrote this report. Special mention goes to: Alice Twomey, Andrew O'Hagan, Andy Holland, Breanne Vincent, Bruce McLean, Catherine Kim, Cedric van den Berg, Cheryl Tan, Christina Lapid, Damien Shrier, Delphine Gonchond, Devin Rowell, Diana Kleine, Douglas Stetner, Hannah Barrenger, Henri Decoeur, Ilha Byrne, Isabelle Derouet, Jennifer Loder, Jodi Salmond, Jody Kreuger, Josh Passenger, Karen Johnson, Katharine Prata, Mark Stenhouse, Monique Grol, Nataly Gutierrez Isaza, Nicholas Hammerman, Philip Dunbavan, Rachel McVeigh, Ryan Booker, Sophie Kalkowski-Pope, Tania Alajo, Trevor Barrenger. There were many other volunteers involved in shaping and supporting this project.

The scientific project support and training team were crucial for enabling the academic expertise, practical training, quality control and analysis necessary for such an endeavour. The support team used their own time, experience, and skills to teach others as well as to help analyse the results and write this report. Thanks to: Alice Twomey (species list, review ecological data), Andrew O'Hagan (organiser supreme and setting the standard), Breanne Vincent (organiser supreme and setting the standard) Bruce McLean (finance and skipper), Catherine Kim (introduction and review), Cedric van den Berg (photogrammetry, training, presentations), Delphine Gonchond (project admin supreme, project support), Devin Rowell (mapping), Diana Kleine (CoralWatch, t-shirts, presentation, project support), Douglas Stetner (photoquadrat analysis, trainer, project support), Ilha Byrne (fish and other data), Jennifer Loder (overall input, trainer, discussion and recommendations), Jodi Salmond (Reef Check Supreme, trainer, project

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The MEAM project was financially supported by the volunteers themselves who paid for their own trips and accommodation, which were significantly discounted by the support of several organisations. A project such as this is not possible without assistance from many passionate businesses, not for profit organisations, communities and individuals. Our gratitude goes to the many project supporters, including:

- UniDive for use of the gear, subsidised use of the “Down Under” and use of club facilities
- The University of Queensland research groups, including: Remote Sensing Research Centre for mapping gear and expertise, the Visual Ecology Lab for cameras and processing power, the UQ Boating and Diving Facility for advice and tanks, CoralWatch for survey methods, data processing and gear, the Centre of Marine Science for support, and the UQ Aquatic Centre.
- Reef Check Australia for survey methods, data and gear
- The Australian Institute of Marine Science Reef Cloud project for photo analysis
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- ScubaWorld for tanks and gear washing
- Maroochy Squashcourt for accommodation
- Passionate local advisors including Gary Cobb for site coordinates, and Julie Schubert and Terry Farr for their knowledge and long term documentation of local habitats and inhabitants
- Aunty Bridgett Chilli for her generous time and local knowledge of her Gubbi Gubbi country

On behalf of the team, I would like to thank the Traditional Owners of the sea country we visited. We love and hope to help protect this Sea Country with this data and report.

Another UniDive citizen science project has come to an end. This was a challenging project in a challenging time –so my sincere thanks goes to those volunteers for their persistence, it was their persistence that kept me motivated to finalise the project. More projects will follow in the future, as we need to take care of our local reefs in order to take care of ourselves.

I'd especially like to thank Djoy, Anouk and Diana for their emotional support without which the MEAM project would not have happened.

Chris Roelfsema  
Volunteer UniDive MEAM Project Organiser  
***“Caring for Local Reefs”***

**Photo of the core MEAM divers during training weekend 1, March 2021**



Left to right top row: Henry Decoeur, Nick Hammerman, Monique Grol, second row: Isabelle Derouet, Damien Shrier, Rachelle McVeigh, Nataly Gutierrez, Delphine Gonchond, Sophie Kalkowski-Pope Third row: Chris Roelfsema, Josh Passenger, Ken Holzheimer, Ilha Byrne, Andy Holland, Breann Vincent, Hannah Barrenger, Cheryl Tan, Catherine Kim, Fourth row: Cedric van den Berg, Bruce McLean

**Photo of the core MEAM divers during training weekend 2, March 2021**



Left to right top row: Jodi Salmond, Kat Prata, Boeke Elbers, Andrew O'Hagan, Mark Stenhouse, Jody Krueger, Lucas de Castro, Ranishka Hewavisenthi, Chris Roelfsema second row: Ken Holzheimer, Amber Moran, Jen Loder, Donna Easton, Karen Jonson, Diana Kleine, Rob MacTaggart, Trevor Barrenger, Ryan Booker, Christina Lapid, Tanya Alajo, Devin Rowell, Jorn Geuss



# **Executive Summary**

## **Introduction**

Awareness of environmental crises and change are growing among the citizens of both Australia and the world. Against the backdrop of continual environmental devastation, the value of healthy ecosystems, and their biodiversity become increasingly apparent. We urge people to contribute their time to the current climatic and environmental challenges that societies face all over the world. The importance of documenting the state and current health of these ecosystems, and an ability to engage and educate the public are our proposed way forward.

The Sunshine Coast is forecast to have the second highest growth rate of any region in Queensland, through to at least 2036. Factors such as increased development and population along the Maroochy River and surrounds, and global climate change pose real threats to this marine ecosystem. As such, it is vital that long term monitoring continues, to provide an understanding of these reef areas and initiate appropriate actions when anomalies are observed.

During the midst of the COVID pandemic in September 2020, a group of UniDive members met, and discussed the idea that conducting a new citizen science project would provide a positive goal during this negative period. This initiative follows the successful Coastcare Point Lookout project (2001-2002), Endangered Greynurse Shark Habitat mapping project (2003-2004), the award-winning Point Lookout Ecological Assessment (PLEA)(2013-2014) and the Flinders Reef Ecological Assessment (FREA) (2016-2017) conducted by UniDive. As such, in our fifth citizen science instalment, we set our eyes on Mooloolaba, creating the Mooloolaba Ecological Assessment and Mapping (MEAM) project. The aims of the project were to:

***Conduct an ecological assessment of the flora and fauna at the main reefs around Mooloolaba, and report on the status and any changes of this marine environment when compared with existing ecological survey data.***

In October 2020, members were recruited for the project, and the online academic training started, with practical training running from March to April 2021. Once the COVID restrictions and weather conditions eased, the first surveys were conducted in August 2021. Ongoing challenges with covid lockdowns and unfavourable weather conditions, resulted in 23 trips postponed and only 11 successful trips. The ecological data was analysed and the results in this report provide an overview of our methods, results, discussion, and findings.

## **Outcomes**

- We observed a high proportion of hard and soft corals at Mudjimba Island, Inner and Outer Gneerings
- The relative abundance of both hard and soft corals was higher than those reported from previous surveys at Point Lookout and Flinders Reef
- Encrusting corals were the most abundant at all three Mooloolaba sites, followed by plating and foliose. Similar trends were also observed at both Flinders Reef and Point Lookout
- A high number of nudibranch species and individuals were observed, confirming Mooloolaba is an area with an exceptional nudibranch assemblage
- Coral damage, disease and marine debris were observed at all three Mooloolaba sites. Marine debris was the most common impact, with a higher prevalence at the Outer Gneerings and Mudjimba Island
- The largest variation in rugosity was shown at Mudjimba Island based on photogrammetric data
- The MEAM surveys were carried out successfully by volunteer divers, all 44 were certified in Reef Check Australia, CoralWatch and mapping survey methods

## **Recommendations for Management and Community**

The Sunshine Coast is forecast to have the second highest growth rate of any region in Queensland through to at least 2036. Factors such as increased development and population along the Maroochy River and surrounds, and global climate change pose real threats to this marine ecosystem. As such, now more than ever, it is critical to support targeted and collaborative efforts to care for our marine environment.

A summary of recommendations arising from the project data and active discussions are outlined below to help encourage further steps to support the unique subtropical reefs of Mooloolaba.

### ***Continued and improved monitoring of the Mooloolaba Reefs***

- Continuing annual reef health monitoring on a select number of sites and habitat mapping every five years for all reef areas, maybe beneficial for an increased understanding of the ecology of the area and for management and conservation. This information can be designed with, and shared with, local science and management agencies to help build collaborative partnerships.
- Integrating benthic imagery into monitoring offers efficiencies, long-term benthic records, and new opportunities for broader data applications. This should be considered as part of an ongoing monitoring approach to help maintain and build on existing citizen science monitoring efforts.

### ***Strengthening ways to care for Mooloolaba Reefs***

- Educating divers, spear fishers, snorkelers, fishers, and vessel skippers in practical ways to reduce physical damage through careful anchoring practices and to limit marine debris could help to reduce pressure on reef habitats and wildlife.
- Scoping the installation of boat moorings is recommended to allow safe site access, but reduce direct physical pressures, especially around heavily utilised Mudjimba Island.
- Exploring further options for site protection may be beneficial for protecting key values for the future. No marine protected areas are present within the Sunshine Coast region (except for the HMAS Brisbane shipwreck), despite Mudjimba Island being acknowledged as having cultural significance and the Outer Gneerings (Wobbe Rock) being an identified habitat for the critically endangered Grey Nurse Shark.

### ***Building awareness of the value of local reefs***

- Educating residents and visitors about Sunshine Coast reefs can help grow awareness about these unique reefs, strengthen social and environmental connections, and encourage more people to care for, and protect, these places for the future.
- Supporting opportunities for community members to contribute to citizen science can improve understanding about Sunshine Coast marine environments and wildlife.

### ***Supporting conservation of Sunshine Coast Reefs through sharing knowledge***

- Fostering opportunities to learn about Traditional knowledge, cultural connections and values of the Sunshine Coast land and sea country can assist in efforts to support more holistic understanding and conservation of the reefs and grow meaningful partnerships with Traditional Owners.
- Producing and sharing scientific publications, reports, and datasets (such as those from the MEAM project) with local authorities and managing bodies is recommended to help support management decisions and active dialogue across groups and individuals who care for the local marine environment. The results and data from this project will be made publicly available.

A more complete description of these recommendations is available in Recommendations for Management and Community.

## **1. Introduction**

### **1.1. General Introduction**

In 2020-2022, The University of Queensland Dive Club (UniDive) conducted an ecological assessment of flora and fauna across *eleven sites* at the Reefs around Mooloolaba, including Mudjimba Island, and the Inner and Outer Gneerings in Southeast Queensland, Australia. These sites comprise several rocky outcrops, with reef ecosystems that support and attract a diverse range of marine life. This report presents the data collected by the volunteer members of UniDive at these Mooloolaba Reefs, and where possible, compared the ecological observations with previous surveys conducted by Reef Check Australia and CoralWatch. The methods used have been used by UniDive for past projects that include: Coastcare Point Lookout project (2001-2002), Endangered Greynurse Shark Habitat mapping project (2003-2004), the award-winning Point Lookout Ecological Assessment (PLEA)(2013-2014) and the Flinders Reef Ecological Assessment (FREA) (2016-2017).

### **1.2. Past and Ongoing Monitoring of Mooloolaba Reefs**

The Mooloolaba Reefs are part of a high-latitude chain of rocky islands and reefs that have only recently been studied in the past few decades (Saenger 1991, Banks and Harriott 1995). Previous unpublished coral studies identified 37 coral species (Harriott, Banks, Harrison, Saenger unpublished data) present in the Mooloolaba Reefs, with published studies later identifying 77 coral species within the Gneering Shoals region (Harriott and Banks 1995). Coral species richness is low relative to the southern Great Barrier Reef (244) and Flinders reef (118), which could be due to physical attributes (waves, turbidity, temperature and depth) of the site (Banks and Harriott 1995). Mooloolaba reefs contain a veneer of coral on rocky substrata, and do not form true limestone carbonate reef platforms.

While organism inventories specific to the Mooloolaba Reefs do not appear in scientific literature, some of the sites surveyed in this project have been included in wider studies (Schlacher-Hoenlinger et al. 2009, DeVantier et al. 2010). The Queensland Museum and University of the Sunshine Coast conducted an inventory assessment of larger sessile invertebrates and fish that inhabited the Ex-HMAS Brisbane after scuttling and in the adjacent reefs. Within the adjacent reefs, 192 invertebrates and fish species across 47 families were observed between 2006-2009. However in 2009, 193 invertebrates and fish species across 40 families were identified (Schlacher-Hoenlinger et al. 2009).

Additional and more recent marine species observations are publicly available via citizen science databases such as iNaturalist, which reported 159 individual species for the Mooloolaba Reef region (downloaded 29th May 2022). Private databases, such as observations recorded by (Farr and Schubert 2022) contained 210 species observed at the Inner Gneerings, 463 species at Mudjimba Island and 417 species at the Outer Gneerings (observed between 2015-2022).

Within the Mooloolaba Reefs, Mudjimba Island reefs have been classified into four distinct sites, Northwest, Ledge 1, Ledge 2 and Ledge 3 and nearly all are monitored by Reef Check Australia since 2013 (Salmond and Schubert 2021). The report identified hard coral as the dominant substrate at

Northwest, Ledge 1 and 3 with rock dominating at Ledge 2 (Salmond and Schubert 2021). Inner Gneerings contains two sites, The Caves Site 1 and Site 2. Site 1 has been monitored by RCA since 2009 and Site 2 since 2013. The RCA report identified Rock as the dominant substrates for both Site 1 and Site 2. The Outer Gneerings sites included as part of the MEAM project have not been monitored by RCA.

### **1.3. Indigenous History of the Sunshine Coast**

For the following section we like to acknowledge Aunty Bridgett Chilli for sharing her Indigenous Knowledge of the lands and sea in which this project was completed on. Additional information has been sourced from Gubbi Gubbi leaders and local councils.

Mooloolaba and the surrounding Sea Country has been important to the Gubbi Gubbi Traditional Owners for thousands of years. The Gubbi Gubbi represents a language group made up of eight families, extending from the Burnett River and Fraser Island in the north, to the Pine River in the south. Their land takes in the eastern part of the coastal ranges including the volcanic Glasshouse Mountains and the great Mary River valley which flows from the Conondale Ranges to the sea near Maryborough.

*Kabi* is used for the word ‘no’ which distinguishes some of the Traditional Owner language groups in the area. Many of the places within the Sunshine Coast region retain their Gubbi Gubbi names such as Coolum, Ninderry, Caloundra, Maroochydore, Woombye and Mooloolaba - these areas were typically named after flora and fauna that were abundant in the area. For example, Woombye means black snake or scented myrtle, demonstrating the importance of plant-animal connections.

Mooloolaba, derives its name from the Aboriginal word mulu, meaning snapper fish, or mulla meaning Red-bellied Black Snake. It is recognised by Gubbi Gubbi elders as being associated with both. ‘Bah’ or ‘ba’ meaning ‘place of’ suggests that Mooloolaba was indeed recognised as ‘place of snapper’.

Gubbi Gubbi Traditional Owners offer stories about much of the Sunshine Coast geography including (but not limited to) Mount Coolum, Mount Ninderry, Tibrogargan, Ngungun, Beerwah and Mudjimba Island. Mudjimba Island finds its place in two Indigenous stories, although it is said that every family will tell the story a little differently, depending on the perspective, and the message they want to share.

The first story is about the creation of Mudjimba Island. There were two men: Coolum and Ninderry, who fought over a woman called Maroochy. Ninderry knocked Coolum’s head off and it landed in the sea to become Mudjimba Island. Maroochydore cried so much she created a river (Maroochy River) and turned herself into a black swan to swim along it searching for Coolum’s spirit.

The second story refers to an Aboriginal legend in which a woman became stranded on the island, where she lived into old age. The story goes, those two women walked down the coast from Bribie Island. When they got to Coolum they walked across a felled bunya tree to the island. When they arrived at the island a big wave pushed the tree away and the women were stuck there. They were

too old to swim back so they built a house and lived there. People would see smoke coming from the island and an old woman; so, it became known as Old Woman Island.

It must be noted that Sea Country is recognised as men's business, and as such, some information is not able to be shared here. Mooloolaba has long been associated with fishing and fishing nets. Historically, the area was known for good fishing, in particular snapper (mulla; snapper, bah; place of). Men spent time on the water, and women collected abundant shellfish, of which local middens are made of.

The Sunshine Coast has been known by Indigenous peoples as a country with plentiful food. This notion was carried through in early recreational fishing for snapper in particular: "I understand that the crowd went as far as Mount Coolum, near Noosa Heads, and tried drift as far south as Deep Caloundra and Old Woman's Island, places which for years have been considered the most prolific snappering grounds outside the northern part of Moreton Bay" (Fishing, 1916). While Gneering Shoals is still known for fishing, the sheer numbers being caught over 100 years ago likely indicate stocks have been overfished.

#### **1.4. Historical Usage and Fishing Last 100 Years**

Since as early as the late 1890s, recreational fishing off the Sunshine Coast has been a popular pastime. Articles detailing the fishing triumphs of weekend fishing parties were regularly printed in local newspapers such as (*Telegraph* 1901)(Figure 1). These fishing trips were a popular form of entertainment and often resulted in catching hundreds of fish. A survey of historical newspapers was conducted on Trove (a historical repository of newspaper and media articles) using the search terms "Gneering\* AND fishing" and returned 462 hits when filtered for Queensland.

Twenty-four articles describing fishing trips were found and the ones including references to a total catch were plotted (Figure 1). The total catch ranged from 90 to 1,540, but these totals were not standardised by fishing effort (i.e., length of fishing trip and number of fishers). The biggest catch of the trip and catch size were sometimes reported, "a very busy hour gave us about 100 fish, nearly all schnappe over 10lb, with an occasional big epaulette" (Mail 1927). Fishing trips by clubs were often taken over several days at multiple sites such as Caloundra, Mount Coolum, Roper Shoals, in addition to Gneerings Shoals.

**a**

### **Heavy Schnapper Haul.**

A party of a dozen compositors from the *Telegraph* staff, and a couple of friends, went fishing to Gneering Shoals on Saturday night, in the steamer Mystery. The fish were found at daylight next morning, and a very successful haul of nearly 700 fish, including a large groper, was made. The weather was delightful, but the heavy swell on the water caused some unpleasantness to a few of the unaccustomed fishermen. The captain and crew were most attentive, and greatly facilitated the fishing expedition.

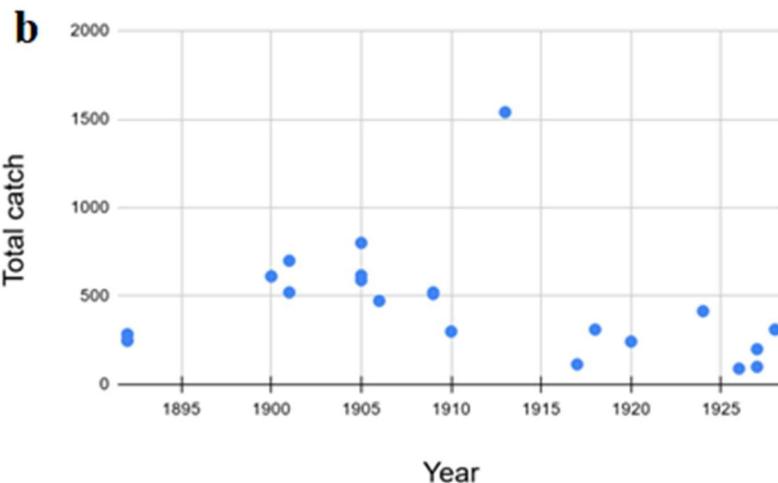


Figure 1: a) Example article of reporting of a “Heavy Schnapper Haul” of 700 fish at Gneering Shoals on August 5th, 1901, in *The Telegraph*. b) Plot of reported fish catch (total number of fish) in newspapers from Trove search of “Gneering\* AND fishing”.

## 1.5. Aims and Objective

The aim of the 2020-2022 UniDive Mooloolaba Reef Ecological Assessment (MEAM) project was to:

***Conduct an ecological assessment of flora and fauna at the main reefs around Mooloolaba, and report on the current status and any changes when compared with existing ecological survey data.***

- Conduct ecological surveys and mapping
- Test the inclusion of new RCA indicator categories
- Photogrammetry surveys to capture the 3D complexity at the surveyed sites

The survey methods were based on Reef Check Australia and CoralWatch Survey techniques, to enable a direct comparison and best mapping approaches developed by UniDive in collaboration with the Remote Sensing Research Centre at The University of Queensland. The results of these surveys will be communicated through this report, and presentations to the wider community, and to governmental agencies.

Ongoing ecological assessments of flora and fauna, substrate cover, coral types, and health impacts at the main reefs around Mooloolaba will be continually monitored by Reef Check Australia. Annual reports on the status and any changes when compared with existing ecological survey data is published and available at any time.

## **2. Methods**

### **2.1. Overview**

Ecological survey methods used were based on Reef Check Australia and CoralWatch methodology and mapping was consistent with the methodology used in the 2001, 2003, 2014, 2017 UniDive community projects (Roelfsema et al. 2016, Grol et al. 2019) to ensure data could be compared. However, Reef Check Australia protocols were adjusted with the aim to include more variety of locally interesting and relevant organisms. Further, the use of photogrammetry was introduced with the goal to test the feasibility of using a cutting-edge approach to capture 3D information of the surveyed area, such as rugosity. The systematic investigation of historical records on fishing activity added a further methodological novelty to this project in comparison to previous UniDive surveys.

Using local knowledge of the area of interest (Mudjimba & Gneerings), UniDive established eleven survey sites during the project. These were chosen to evenly survey the area of interest. Ten divers assessed a total of eleven sites evenly distributed around Mooloolaba Reef. Each survey involved broad scale mapping using a towed GPS (compass, depth readings and georeferenced underwater photos), 3D complexity surveys through photogrammetry, CoralWatch and Reef Check Australia transect surveys (4 x 20 m segments were assessed for substrate type, reef impacts, and fish and invertebrate species distribution and abundance). Finally, a survey of historical reports of fishing activity in the area was conducted.

UniDive volunteers were trained in the various survey techniques using online academics, pool training and during two dedicated survey training weekends. Over 60 volunteers participated in the academic training, and 44 of them participated in the practical survey weekend where they were trained in Reef Check Australia and CoralWatch survey methods from January-March 2021. All those conducting surveys completed an academic exam that included a review of the methods and identification of indicator categories for substrate, fish, inverts, and impacts surveys.

#### **2.1.1. Survey Sites and Timing**

Survey sites at Mudjimba Island and Gneerings Reefs were selected for this project due to their comparability locally, regionally, and internationally, as well as accessibility, and at a safe depth range. Eleven survey sites were established and surveyed (Figure 2). Surveys included fish abundance, benthic/substrate composition, key invertebrate species, and reef impact identification along transect lines deployed at a depth of 5 m - 15 m. Seven new transect sites were established and four sites were re-surveyed for comparison with annual reef health surveys conducted by Reef Check Australia since establishment in the area: 2007-2013. Surveys were conducted once at each location during the study period by the MEAM team to cover the spatial spread in the marine flora and fauna. Mapping of the area was conducted to characterise the bottom geography and composition.

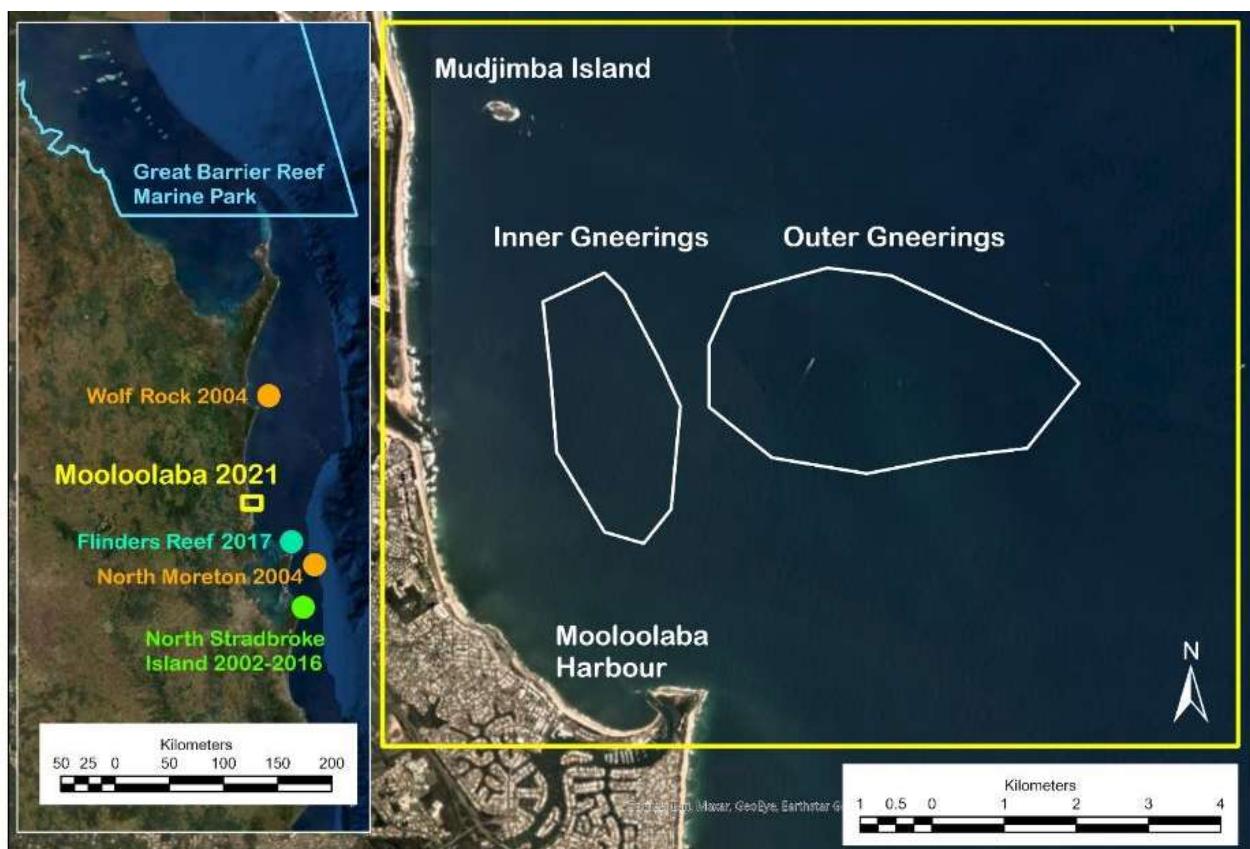


Figure 2: Mudjimba Island, Inner and Outer Gneerings Reefs at Mooloolaba, with reference to the location of previous UniDive project locations.

### 2.1.2. Survey Participants, Training and Quality Control

UniDive is The University of Queensland (UQ) Underwater Club (UniDive), it has over 300 members, of which 65% are mostly UQ staff and students. In 2020, UniDive initiated a baseline biological survey and mapping key of SCUBA dive sites of Mooloolaba Reef. All participants in the program were volunteers, certified divers, and members of UniDive. All survey divers had over 50 recent dives and were rescue diver trained or equivalent. These volunteers encompassed marine experts, SCUBA instructors, mapping experts and people interested in learning about the marine environment. See Appendix A for a detailed list of the volunteers and their main tasks during the project.

Over the course of 32 educational lectures, more than 60 UniDive members learned about local reef ecology in addition to Reef Check Australia, CoralWatch, 3D structural surveys and Mapping survey protocols. Lecture topics included: coral and rocky reef ecology; survey methods; identification and biology of coral, algae, substrate, fish, and invertebrates; causes and assessment of impacts; underwater photography and videography; 3D photogrammetry, mapping, and buoyancy control. Of the 44 participants, 24 were refreshed in their Reef Check Australia skills and 20 were separately trained and newly certified. Practical training was assessed in the pool and over two training weekends at North Stradbroke Island.

All divers were required to attend a series of lectures that provided training in survey methods. Competence in theory was assessed using online exams with over 120 identification questions (pass mark 85% or higher). In-water survey training consisted of two pool training sessions focussed on buoyancy and survey technique. Open water training was also conducted to ensure divers were able to correctly identify marine life, substrate categories and impacts, and that they were competent to conduct surveys. The 24 previously certified Reef Checkers were required to participate in a training weekend in which they refreshed their survey skills through practice surveys. Twelve of this group were additionally trained in Reef Check Fish ID. Reef Check training was supervised by qualified Reef Check instructors and Reef Check Australia Team leaders.

Regular review sessions were organised, and, on the eve of the first surveys of each survey weekend, the volunteers refreshed their memory by discussing survey categories with others who would have the same survey task. Data sheets were used for surveys (see Appendix B: Data Sheets), which aided in quality control. The data sheets were checked for errors or inconsistencies both directly after dives and during the data processing stage. Results derived from the quality-controlled data were presented after each survey by UniDive members with experience in Reef Check Australia and CoralWatch survey methods and or a marine science background in their field, thus providing additional quality control.

## **2.2. Habitat Mapping**

Mapping of the Mooloolaba Reef was conducted to generate maps including polygon features (e.g., substrate types) to support our ecological understanding, planning and zoning of the sites and water depth. Feature mapping was undertaken by two divers that conducted roving surveys around the transect sites, to a maximum depth of 20 m, and recorded characteristic features. High spatial resolution satellite imagery in combination with water depth (Beaman 2010) was used as a backdrop to identify areas of interest to plan additional surveys.

## 2.3. Ecological Surveys

### 2.3.1. General Survey Approach

At each survey location a 100 m transect was located based on previous Reef Check Australia Surveys for Mudjimba Island, The Ledge and North West, plus the Inner Gneerings, Caves. The other sites were newly established to characterise the main areas around the reef. Within this 100 m length, four 20 m segments were deployed and surveyed (Figure 3). Each 20 m segment followed the designated depth contour, separated from the next transect by a 5 m gap.

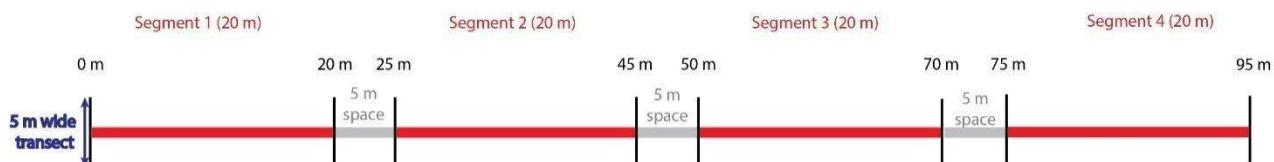


Figure 3: Placement of the transect lines Source: (Roelfsema et al. 2014, Roelfsema et al. 2016, Grol et al. 2019).

For each survey, five pairs of divers undertook mapping and/or transect surveys to identify indicator species present and major features at each site (Figure 4). Fish, invertebrates, impacts, substrate and benthos were all surveyed following Reef Check Australia protocols (Hill and Loder 2013). The Reef Check categories surveyed for counting were based on their ecological and/or economic value to both recreational and commercial fishing and the aquarium trade. Photos and video of the transects and the site fauna were taken to support identification of categories.

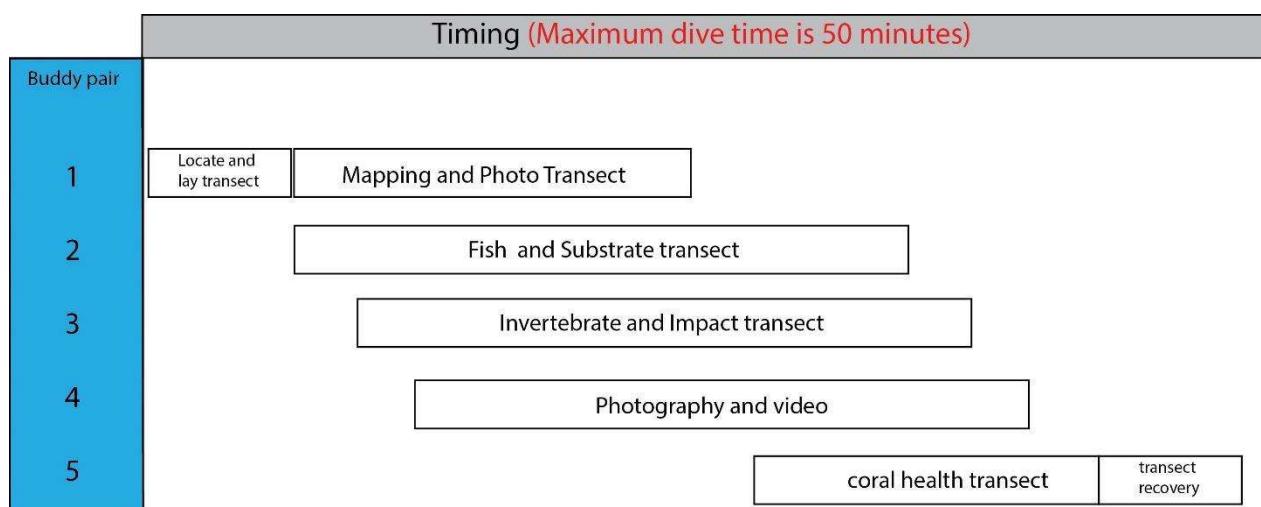


Figure 4: Timing of ecological survey dives, with a small break between buddy pair 1 and 5 so there is always a boat handler and assistant on the boat Source: (Roelfsema et al. 2014, Roelfsema et al. 2016, Grol et al. 2019).

### 2.3.2. Substrate and Benthos

Substrate surveys were conducted using the point sampling method, enabling percentage cover of substrate types and benthic organisms to be calculated. The survey method was based on the Reef Check Australia methods (Hill and Loder 2013) and was consistent with the methods used since 2001. The substrate or benthos under the transect line was identified at 0.5 m intervals, with a 5 m gap between each of the three 20 m segments (Figure 5). To the list of substrate categories recorded by the Reef Check Australia, macro algae was added to MEAM substrate surveys and included the *Asparagopsis* species, *Padina* spp, *Sargassum* spp. and *Turbinaria* spp. This was done to capture the abundance of major macro algae species on Mooloolaba Reefs, see Appendix B for data sheets and the categories surveyed.

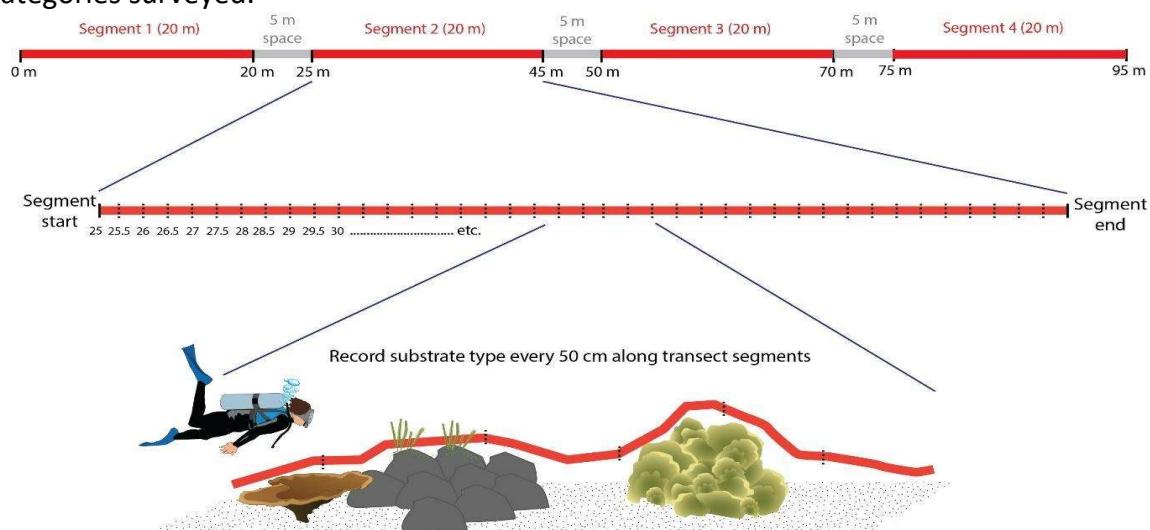


Figure 5: Detail of substrate survey transects. At every 0.5 m, using a plumb line to avoid bias, the benthic category located directly beneath the transect tape was recorded. Categories recorded included various growth forms of hard and soft coral, key species/growth forms of algae, other living organisms (i.e. sponges), recently killed coral, and, non-living substrate types (i.e. bare rock, sand, rubble, silt/clay). See Appendix B: Data for data sheet. The georeferenced photos taken along the transect (Section 2.2) provided an additional source for benthic assessment. Source: (Roelfsema et al. 2014, Roelfsema et al. 2016, Grol et al. 2019)

Visualisation and analysis of the benthic communities comprised barplots and stacked barplots. Key benthic groups, such as hard and soft corals were visualised separately with standard error to assess differences in benthic composition within and between Mudjimba, Inner Gneerings and Outer Gneerings survey sites. Further trends in benthic composition were also compared between the survey sites of MEAM and those from previous citizen science efforts, such as Flinders (FREA)(Grol et al. 2019) and Point Lookout (PLEA)(Hill and Loder 2013).

Temporal hard coral cover trends were assessed from the MEAM data and previously collected Reef Check Australia data from 2007 until present. These data were displayed as scatterplots, depicting hard coral cover through time from Mudjimba Island, Inner Gneerings, Outer Gneerings as well as previous citizen science efforts, FREA and PLEA.

For the eleven transect sites, photo quadrat surveys were conducted to gather additional information from photos and to test the ability to introduce this additional methodology to citizen science. Here photo quadrats were taken at 1 m intervals along the transect tapes, 0.5 m above the substrate providing a 1 m<sup>2</sup> footprint. This diver towed a dry bag in which a standard GPS logged the track of the transect (Figure 6).



Figure 6: Conceptual diagram of the georeferenced photo transects. Source: (Roelfsema et al. 2014, Roelfsema et al. 2016, Grol et al. 2019)

The collected images were analysed for benthic composition using machine learning through the Australian Institute of Marine Science's Reef Cloud photo database. More detail is available in the georeferenced photo transect manual (Roelfsema and Phinn 2009). All georeferenced photos that documented each of the reefs were plotted on top of the basic site map for each location to provide additional information for the mapping. Geolocated photos were analysed using machine learning to extract benthic and substrate categories, this was to support mapping and review the ability to include photographic surveys in future citizen science surveys.

### 2.3.3. Fish Species and Families

Fish populations were assessed using a visual census along the  $4 \times 20\text{ m}$  transects, following Reef Check Australia's protocols (Hill and Loder 2013). Each transect was 5 m wide (2.5 m either side of the transect tape), 5 m high and 20 m in length (Figure 7).

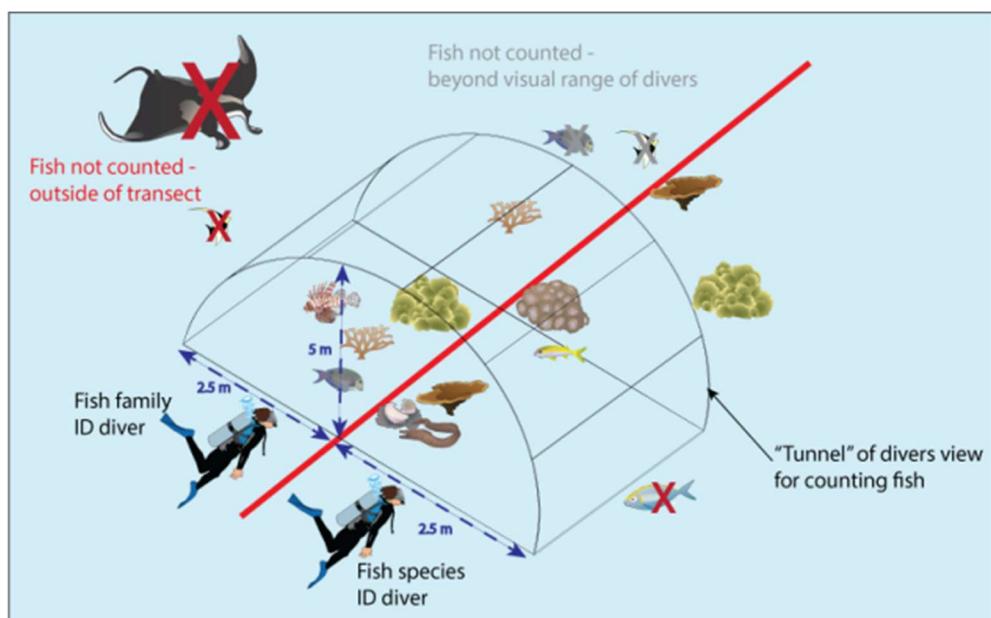


Figure 7: Diagrammatic representation of the fish survey transects showing the imaginary frame of the diver's view. Fish outside of the diver's view were only counted as well when they were seen within the transect site (e.g. manta rays). Source: (Roelfsema et al. 2014, Roelfsema et al. 2016, Grol et al. 2019)

A fish survey diver would record fish sightings on the data sheets (Appendix B: Data Sheets). Each 20 m transect was completed in 7-10 minutes to ensure quality control. The list of 23 fish groups (families and species) recorded by Reef Check Australia was expanded by including Blue grouper, Barrumundi Cod, Bumphead parrot fish, pink snapper, Spangled Emperors other snappers, other emperors, Morwong, and Wobbegong. All recorded fish groups were chosen for their importance and value to recreational or commercial fishers, or targeted by aquarium collectors, and that were easily identified by their body shape or other characteristics. Rare or otherwise unusual species such as turtles, rays and sharks were also recorded. Abundance within key fish groups were expressed as fish abundance per 100 m<sup>2</sup>, i.e. average fish number per segment per site per season. See Appendix B Data for datasheets and the categories surveyed.

#### **2.3.4. Invertebrates**

Invertebrate populations were assessed using visual census along the 4 x 20 m transects following Reef Check Australia protocols (Hill and Loder 2013). The diver surveying invertebrates conducted a ‘U-shaped’ search pattern, covering 2.5 m on either side of the transect tape (Figure 8). Each 20 m transect was completed in 7-10 minutes. See Appendix B: Data for datasheet.

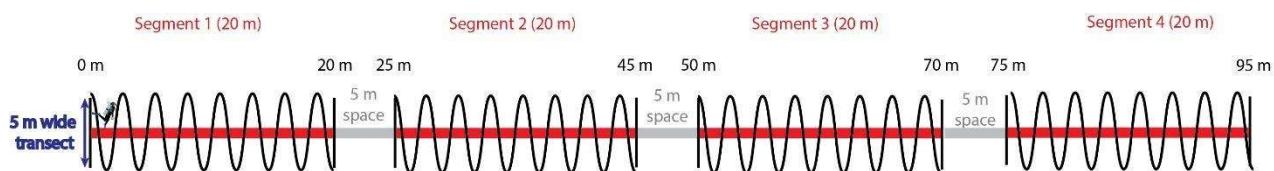


Figure 8: Diagrammatic representation of the invertebrate and reef impact survey transects. Divers swam a 5m wide transect in a U-shaped pattern along the transect tape Source: (Roelfsema et al. 2014, Roelfsema et al. 2016, Grol et al. 2019).

Invertebrate species were selected based upon their essential role in ecosystem health and functioning and/or their economic value to both commercial and recreational fishing or the aquarium trade. These species were aligned with the species selected by Reef Check Australia (Hill and Loder 2013). Additionally, other sea cucumbers and sea slugs (e.g. flatworms, and nudibranch species) were included in MEAM invertebrate surveys to contribute information about these cryptic organisms for Mooloolaba Reefs.

#### **2.3.5. Reef Impacts**

Target impacts were assessed using a visual census using the same approach as for the invertebrate survey (Figure 7) and included natural and anthropogenic impacts. Damage was assessed for scarring by the gastropod *Drupella*, only when individuals were present. Boat anchor damage also required the presence of anchor or chain to confirm. Unknown scars consisted of scraping of corallites without damaging the overall structure, while structural breakage of the coral without an obvious source was ranked as unknown damage. Fishing gear consisted of line, hooks, weights, or other fishing devices. Any other anthropogenic rubbish found on the reef was classified as general marine debris. Coral disease was identified through Reef Check standards. Photographs of the impacts were also taken for future reference.

CoralWatch, based at The University of Queensland, developed a non-destructive, inexpensive, easy-to-use tool to monitor coral health, the Coral Health Chart used in this study (Siebeck et al. 2006) (Figure 9). For each survey, coral health was measured for 20 corals along the 4 x 20 m segments. All observations within 2.5 m of a segment on either side were considered part of the transect. The surveyor swam along the segments accounting for its width and selecting at random five coral colonies per segment, i.e. 20 corals per transect. The chart was placed next to randomly chosen coral colonies and the colours on the chart were compared with the colours of the coral. The matching codes were identified for the lightest and darkest area of each coral colony and recorded on an underwater data slate. Where necessary, a torch was used to see true colours. Additionally, growth type was identified and recorded, i.e. branching, boulder, plate or soft coral.

The average colour score was calculated for each site and against previous data for both the Gneerings and Mudjimba. The average colour score and standard deviation was calculated for site groupings at the Inner Gneerings, Outer Gneerings and Mudjimba Island. Frequency distribution graphs showing the distribution of coral health scores for each of these areas were also created. Finally, the average colour health score data from MEAM surveys was compared with previous CoralWatch surveys at these sites to illustrate temporal trends.

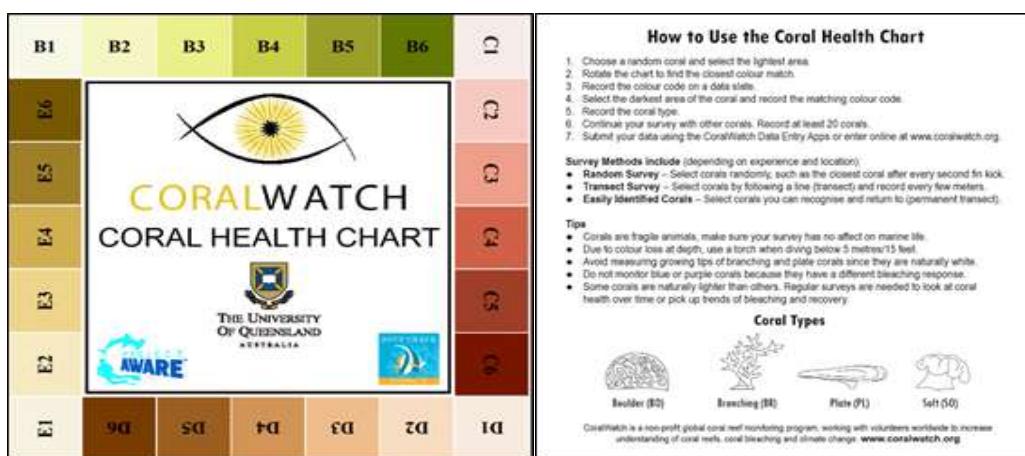


Figure 9: Coral Health Chart developed by The University of Queensland in association with the Vision, Touch and Hearing Research Centre and Centre for Marine Science in 2002. The image on the right is the front of the chart. It assigns codes to colours that suggest different levels of coral bleaching. The image on the left is the back of the chart. It provides instructions for the use of the chart.

### 2.3.6. Ecological Data Analysis

Analyses of the ecological data (Coral, Fish, Inverts, Impacts) focused on three levels, to assess:

1. Spatial variations around the eleven sites of the Mooloolaba area, these comparisons were conducted at both the site and area level (Mudjimba, Inner and Outer Gneerings)
2. Temporal variation of coral cover at the sites surveyed were compared to Reef Check Australia data
3. Lastly, differences in coral composition between Mooloolaba Reef sites were compared with other regions surveyed by Reef Check Australia, and UniDive in the Southeast Queensland region such as: Point Lookout, and Flinders Reef

## 2.4. 3D complexity surveys (Photogrammetry)

### 2.4.1. Photogrammetry Data Collection

To understand the three-dimensional complexity of the different study sites, photogrammetric data collection surveys were conducted, and 3D mosaics created to derive information on rugosity and complexity(Dustan et al. 2013). We used three GoPro Hero 3 black edition cameras on a 1.5 m long aluminium pole to enable the capture of multiple viewing angles and consequent depth of field. One camera was focusing straight down and two from the side with a 10-15 degree angle. The optimal angle for the tilted cameras was determined using a custom Python script (Figure 10c) and consequent dry trials at UQ.

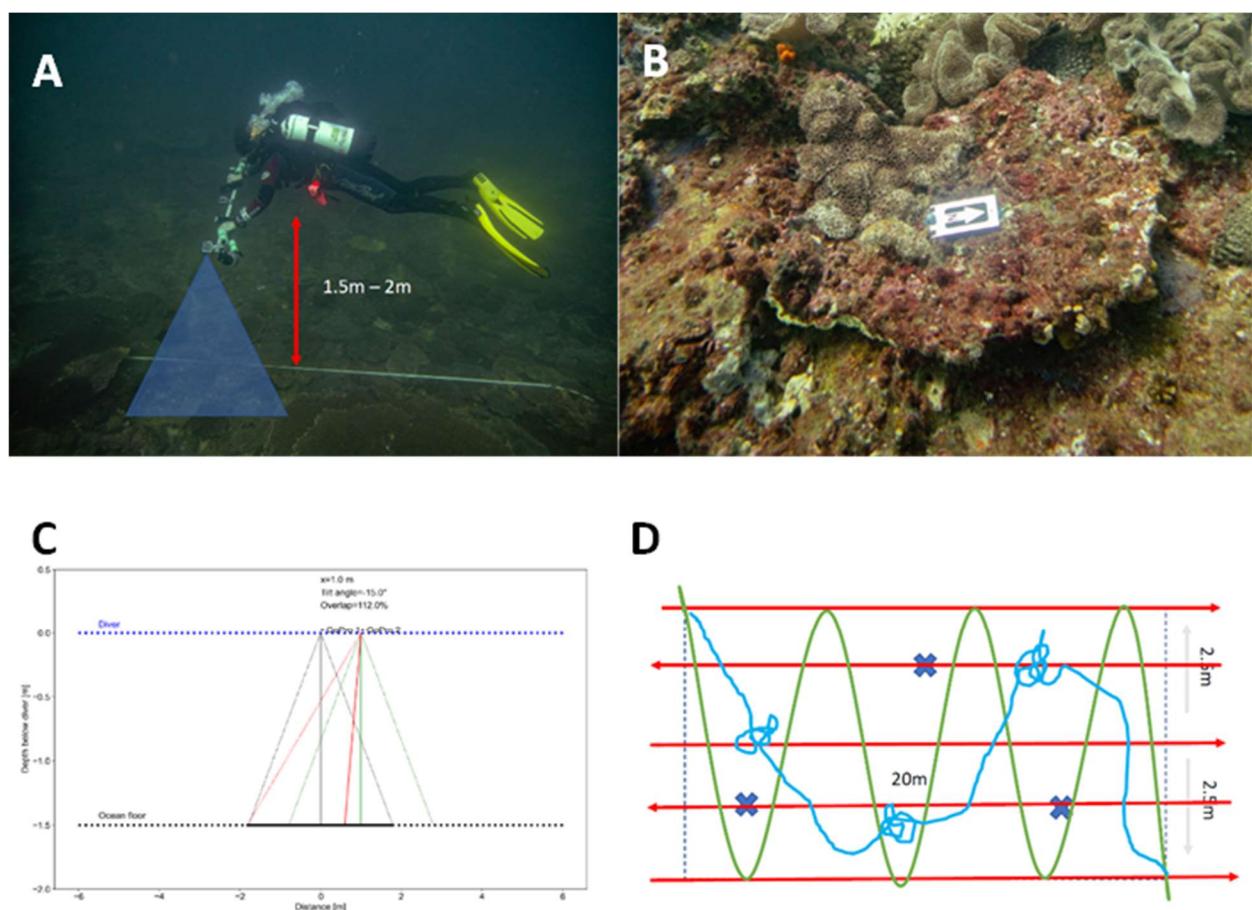


Figure 10: A) Volunteer collecting photogrammetry footage along the survey transect. The rough viewing angle is indicated in blue. The desired distance from the ground is indicated with the red arrow. B) Example of marker placed on the reef C) Schematic of overlap generated by tilted camera. D) Schematic of the sampling sequence across each 20 m transect segment. First, three markers were placed at random positions across the transect (blue crosses), then five straight repeats (red) of obtaining images were done, followed by a zig-zag pattern (green) and, finally, a 'clean-up' run to capture overhangs, crevices, and larger objects in detail.

At the beginning of each 20 m segment on a transect, the cameras were set to take two pictures per second. Before taking the footage of each segment, three markers (Figure 10b) were placed at random positions within each 20 m segment. This was done to aid in image alignment for the 3D model construction as well as potential scaling of the models at a later stage. Each 20 m segment

produced about 2,000-3,000 images (Figure 10b). Roughly 10 citizen scientist volunteers were trained in data acquisition and software use in two dedicated practical workshops and with online presentations.

#### ***2.4.2. Photogrammetry Data Analysis***

All images were manually screened for quality and any images out of focus were removed from the data. The images were then colour & contrast calibrated, noise levels reduced and sharpened using Adobe Lightroom. 3D models were created using Agisoft Metashape Standard licence (Agisoft LLC 2022). Using access to a free 30-day trial of an Agisoft professional licence we calculated the rugosity of each 20 m segment. This was achieved by calculating the ratio between the surface area of each 3D model to the projected area underneath it, relative to the best fitted level plane.

The median rugosity of each part of the survey area (Mudjimba Island, Inner Gneerings, Outer Gneerings) was calculated and correlations between rugosity and coral cover investigated across all sites.

## 2.5. Environmental Data

### 2.5.1. Data Type and Sources

Historical environmental data has been collected and reviewed to understand the potential influences of these factors on the Mooloolaba reef and provide insight into future environmental impacts. The environmental data analysed included atmospheric and sea data.

Atmospheric data: localised precipitation, air temperature, minimum and maximum, solar exposure, localised wind speed and direction. Atmospheric data was sourced from the Bureau of Meteorology, Station number 040861 ([Climate statistics for Australian locations \(bom.gov.au\)](https://www.bom.gov.au)). The Station is located approximately 3 km to the north-west of Mudjimba Island, and 11 km North-west of the outer Gneerings.

Sea data consisted of sea surface temperature, and wave height. Sea data was sourced from the Queensland Government wave monitoring site for Mooloolaba ([Mooloolaba wave monitoring | Environment, land and water | Queensland Government \(www.qld.gov.au\)](https://www.qld.gov.au/environment/land-and-water)). The wave buoy is located approximately 8 km to the north-east of Mudjimba Island, and 9 km North of the outer Gneerings.

Historical environmental data was collected to understand potential influencing factors on the Mooloolaba Reefs. The data included atmospheric temperature, precipitation, wind (direction and speed) and solar exposure. The weather station provided Minimum and Maximum temperatures, Total Rain and Average Daily global solar exposure (MJ/m\*m) per day from January 1994 to July 2022.

Global solar exposure is the total amount of solar energy falling on a horizontal surface. The daily global solar exposure is the total solar energy for a day. Typical values for daily global solar exposure range from 1 to 35 MJ/m<sup>2</sup> (megajoules per square metre).

### 2.5.2. Environmental Analysis

Due to a lack of completeness of atmospheric and sea data in periods prior to 2006, it was decided that analysis would only use data from January 2006 to July 2022. To allow comparisons and analysis of atmospheric data monthly figures have been calculated. In the case of month-by-month comparisons from January 2006 to July 2022.

- Precipitation - rainfall has been totalled per month,
- Air temperature, both for each month:
  - o highest maximum temperature and lowest minimum temperature are taken,
  - o average minimum and average maximum temperatures are calculated,
- solar exposure - daily recordings are averaged over the month.
- Wave height:
  - o the average wave height for a month is calculated,
  - o the minimum and maximum wave heights for each month are recorded.

To understand the potential influences of weather factors on the Mooloolaba reef over the survey period, data for years 2021 and 2022 are compared to averaged data for the years 2006 to 2020.

## **2.6. Species List**

Flora and fauna species lists were created through a literature review (Appendix C), by:

- 1) Identification of flora and fauna from photos and videos taken by divers at the dive sites during and outside the survey weekends.
- 2) Those volunteers with detailed knowledge of the local flora and fauna recorded any non-surveyed species.
- 3) Previous data sets collected by volunteers on the project, such as the dataset collated by Terry Farr and Julie Schubert(Farr and Schubert 2022), who have done hundreds of dives at the sites in the last two decades photographing and noting species.

The species list has been compiled in Appendix C and represents all marine species that have been observed at the Mooloolaba reefs.

### 3. Results

#### 3.1. General Overview

##### 3.1.1. Participants

The project took at least 8,000+ hours in volunteer time, that included 34 online meetings (academic training/planning), six pool training sessions, 60 training dives, and 132 survey dives, conducted between October 2020 and November 2022. Over 60 members participated in various activities and 20 were trained/certified or 20 were refreshed in Reef Check Australia, CoralWatch and mapping survey techniques. There were two training weekends, and 11-day trips organised, 23-day trips were organised but cancelled at the last moment due to COVID restrictions or weather conditions.

##### 3.1.2. Survey Considerations

Dives were conducted over a total of two training weekends and eight survey days from June 2021-Jan 2022. Table 1 summarises the environmental conditions documented during the survey dates. For the duration of the study, the water temperature at the surface (SBT) ranged from 20 °C in July to 25 °C in February. Based on divers observation, the visibility varied between 5-15 m. Figure 11 shows a significant variation from the average for November 2021 and February 2022. Both these months show a significantly higher rainfall than the long-term average. Rainfall is also below average for the winter months. Figure 12 shows a significant variation from the average wave height for January, February, and May 2022, however 2021 does not show significant variation. The higher wave height impacted on the survey work with many trips being cancelled due to adverse diving conditions or poor visibility.

Table 1: Environmental conditions during each of the survey weekends (Source: Bureau of Meteorology, Wave Rider Buoy).

Moolooba Survey Dive	Recording point	Rain 24 hour (millimeters)	Max. Daily Sea Surface Temperature (Celcius)	Maximum Wave Height (metre)	Air		Wind Direction	Wind Speed (Km/h)	Cloud Cover (%)	Sea Surface Tempurature (Celcius)	Wave Height (meters)
					Temperature (Celcius)	Wind Speed (Km/h)					
Saturday, 24 April 2021	Daily	0.0	24.8	1.6	NA	NA	NA	NA	NA	24.60	0.66
	Morning 9am				NA	NA	NA	NA	NA	24.70	0.57
	Afternoon 3pm				NA	NA	NA	NA	NA	24.70	0.57
Saturday, 31 July 2021	Daily	0.0	20.5	1.6	17.1	NW	9.0	0.0	20.30	0.68	
	Morning 9am				21.1	NNE	26.0	0.0	20.50	0.74	
	Afternoon 3pm				NA	NA	NA	NA	NA	NA	NA
Sunday, 1 August 2021	Daily	0.0	20.4	2.0	19.7	NW	19.0	0.0	20.30	0.69	
	Morning 9am				22.6	NNE	30.0	0.0	20.35	0.79	
	Afternoon 3pm				NA	NA	NA	NA	NA	NA	NA
Sunday, 19 September 2021	Daily	0.0	21.9	2.4	23.7	NW	24.0	0.0	21.60	1.01	
	Morning 9am				23.8	NNE	24.0	0.0	21.85	0.92	
	Afternoon 3pm				NA	NA	NA	NA	NA	NA	NA
Saturday, 25 September 2021	Daily	0.0	21.6	1.7	23.7	NNW	15.0	0.0	21.15	0.66	
	Morning 9am				24.4	NE	26.0	0.0	21.55	0.87	
	Afternoon 3pm				NA	NA	NA	NA	NA	NA	NA
Saturday, 6 November 2021	Daily	0.0	NA	2.8	23.6	ESE	17.0	7.0	NA	1.28	
	Morning 9am				23.0	ENE	17.0	8.0	NA	1.23	
	Afternoon 3pm				NA	NA	NA	NA	NA	NA	NA
Saturday, 20 November 2021	Daily	0.0	NA	2.2	26.5	NW	11.0	0.0	NA	0.75	
	Morning 9am				25.7	NNE	28.0	0.0	NA	0.79	
	Afternoon 3pm				NA	NA	NA	NA	NA	NA	NA
Saturday, 19 February 2022	Daily	0.0	NA	2.0	27.1	SE	15.0	7.0	NA	0.96	
	Morning 9am				28.2	SE	24.0	1.0	NA	0.82	
	Afternoon 3pm				NA	NA	NA	NA	NA	NA	NA

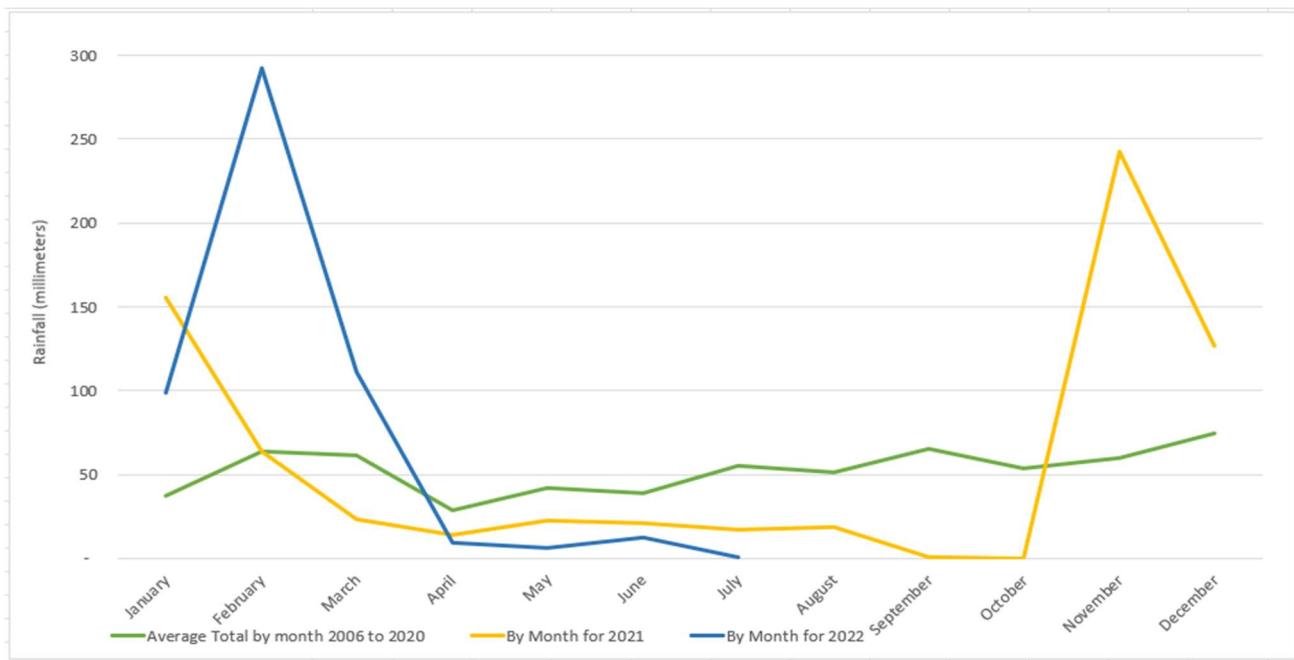


Figure 11: Monthly rainfall averaged for 2006 to 2020 compared to 2021 and the first 6 months of 2022.

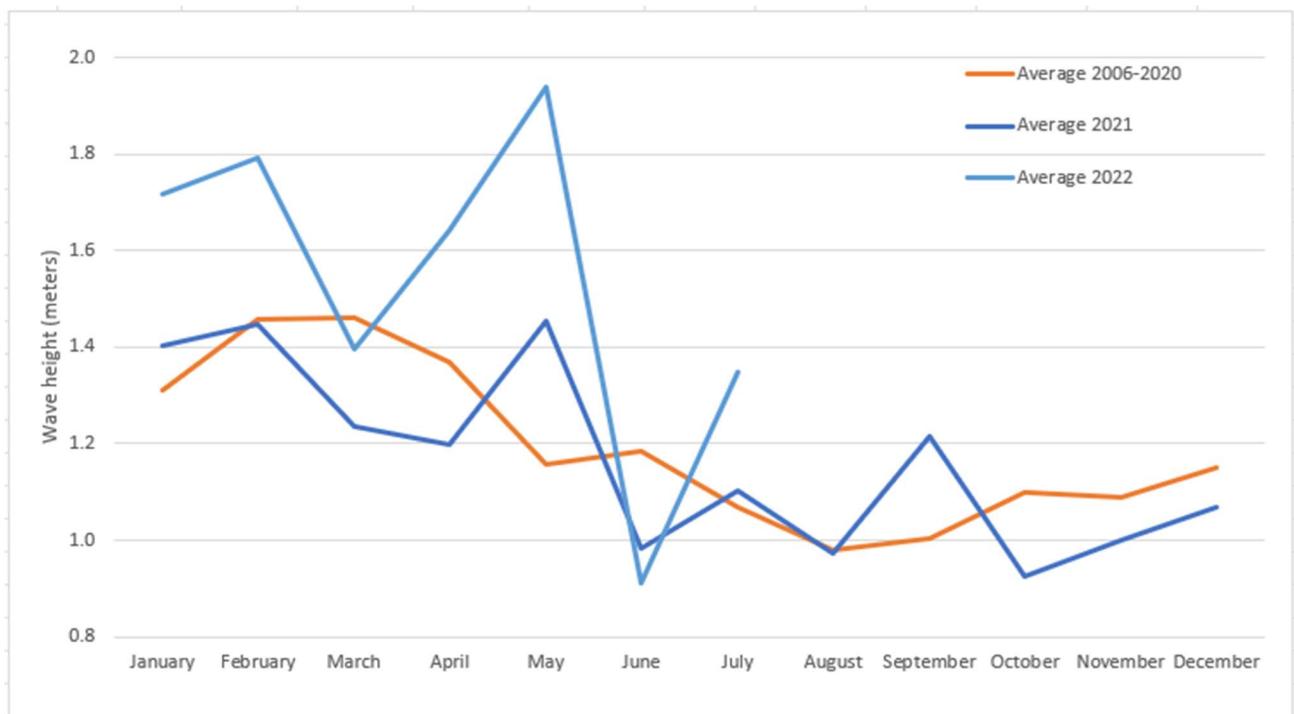


Figure 12: Monthly average wave heights and compares the average of 2006-2020 to the month average for 2021 and 2022.

### 3.1.3. Mapping

Georeferenced habitat maps (UTM-WGS84) were created for Mooloolaba reefs, which described the substrate type, water depth, and significant features. Mooloolaba was further divided into three sub regions, the Mudjimba Island, Inner Gneerings and Outer Gneerings (Figure 13).

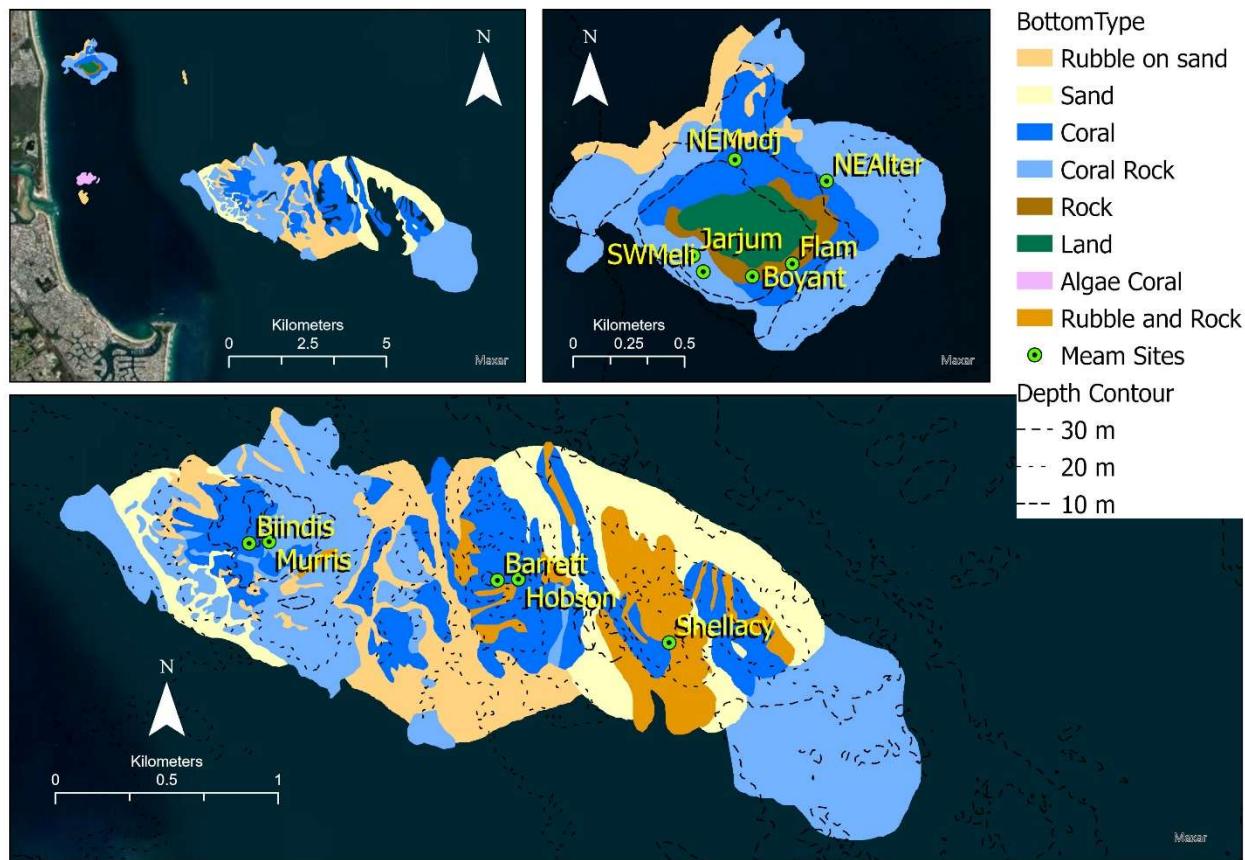


Figure 13: Prominent substrate features at Inner and Outer Gneerings, Mooloolaba Reef, Sunshine Coast Australia. Depth sourced from Beaman 2010. Worldview 2 satellite imagery used as backdrop.

### **3.1.4. Species Desktop Study**

Species present at the Mooloolaba Reefs was completed on 29th May 2022. The search revealed there has been limited research on species of the Mooloolaba Reefs in scientific articles (n=3). Observations within the Mooloolaba Reef area from the iNaturalist database within the past five years were included in the species list (n=159). Additionally, avid citizen scientists Terry Farr and Julie Schubert, who have done hundreds of dives at the sites in the last two decades have photographed and noted hundreds of species. We were provided access to their private observation database. Species were recorded from each source and duplicates were removed to leave a total of 1,192 species Table 2.

*Table 2: Species data sources identified in literature search*

Species	Source
1	Cribb, A.B., 1954. Records of marine algae from south-eastern Queensland (p. 1954). Brisbane: University of Queensland Press.
598	Farr, T., Schubert, J., Ocean Observation Database 2010-2022
118	iNaturalist search by area
9	Jeff Johnson personal communication
12	nudibranch.com.au
91	Queensland Museum 2014, Queensland Museum fishes collection records
363	Schlacher-Hoenlinger, M.A., Walker, S.J., Johnson, J.W., Schlacher, T., Hooper, J.N.A., Ekins, M., Banks, I.W. and Sutcliffe, P.R., 2009. Biological monitoring of the ex-HMAS Brisbane Artificial Reef: Phase II-Habitat Values. Technical Reports of the Queensland Museum Issue 003. University of the Sunshine Coast, Queensland.

The literature review identified 403 fish species from 66 families, 26 hard coral species, 41 soft corals species and 326 nudibranch species within the Mooloolaba Reefs region. In comparison, of the 463 species reported in the Point Lookout Ecological Assessment (Grol et al. 2019), 280 fish species were reported from 35 families, with 36 hard coral and 4 soft coral species and 4 nudibranchs.

## 3.2. Ecological Surveys

### 3.2.1. Substrate and Benthos

Hard coral cover was generally uniform across all three sites: Mudjimba Island (41%), Inner Gneerings (40%) and Outer Gneerings (37%). Hard coral was the dominant benthos for Mudjimba Island and Outer Gneerings (Figure 13). Rock was the dominant substrate cover for Inner Gneerings (46%) followed by hard coral. Soft coral varied at each site with 32% at Outer Gneerings, 11% at Mudjimba Island and 3% at Inner Gneerings. Recently killed coral was present at Mudjimba Island and Inner Gneerings with <1% cover for both. Coral rubble was only present at the Mudjimba Island sites. Mudjimba island had the highest diversity in substrates and benthos ( $n=10$ ) compared with Inner Gneerings ( $n=8$ ) and Outer Gneerings ( $n=7$ ).

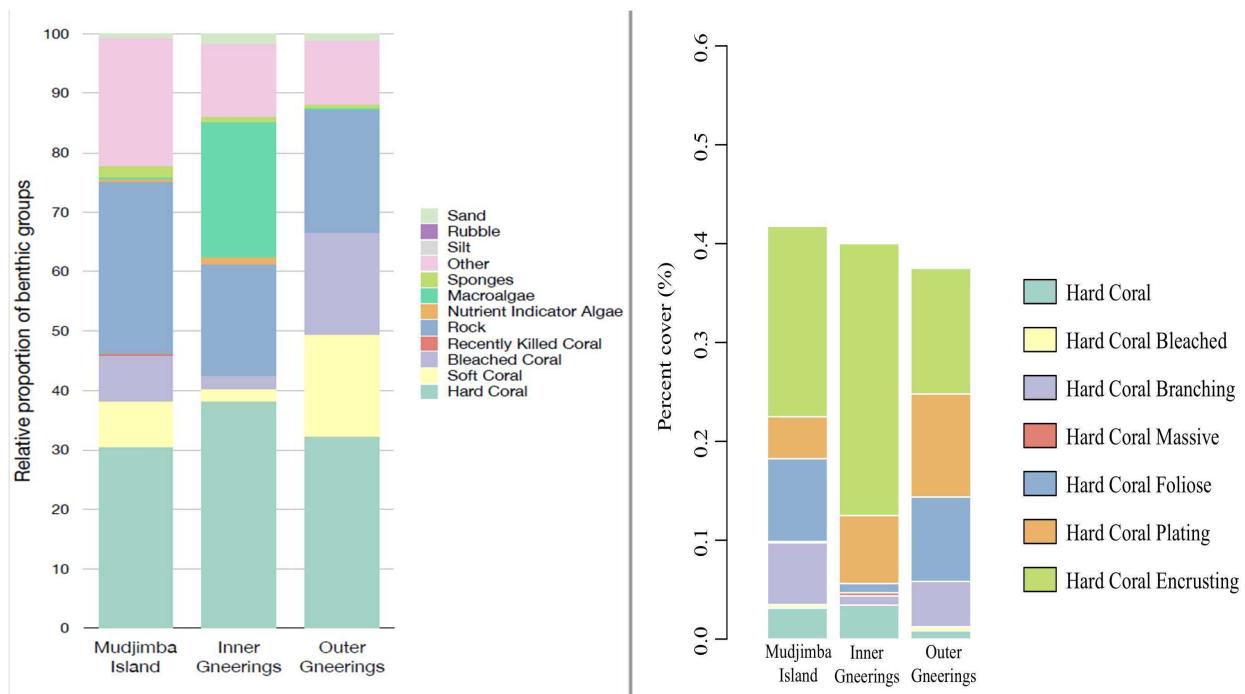


Figure 14: Stacked barplot of relative proportion of benthic groups per Mooloolaba area(left). Values are averaged from each area's sites. Stacked barplot of averaged hard coral cover per area and per hard coral type (right). Values are percent cover and averaged from each area's sites.

Hard coral cover was the most dominant benthos for half of the sites (Northeast Alternate, Southeast FLAM, Southeast Boyant, Barrett and Shellacey) with soft coral dominant at Hobson. Rock was the dominant substrate for four sites (Southwest Meli, Southwest Jarjurn, Murri, Bindi) (Figure 15). Both Outer Gneerings sites (Hobson and Shellacey) had the lowest diversity in benthos and substrates present ( $n=5$ ) with the highest diversity ( $n=8$ ) occurring in Northeast Alternate and Southwest Meli (Mudjimba Island) and Murri (Inner Gneerings). Bleached coral was present at three sites, Northeast Alternate (Mudjimba Island) and both Barrett and Shellacey (Outer Gneerings).

Hard encrusting coral was the most dominant hard coral present across the sites, ranging from 13-28% of the total cover of hard corals (Figure 14). Massive hard coral was the least abundant hard coral and located both at Southeast Boyant and Bindi (1% of total hard coral cover) (Figure 15).

Bleached hard coral was present at Mudjimba Island (Northeast Alternate 2%) and Outer Gneerings (Barett and Shellacey both 1%) (Figure 14).

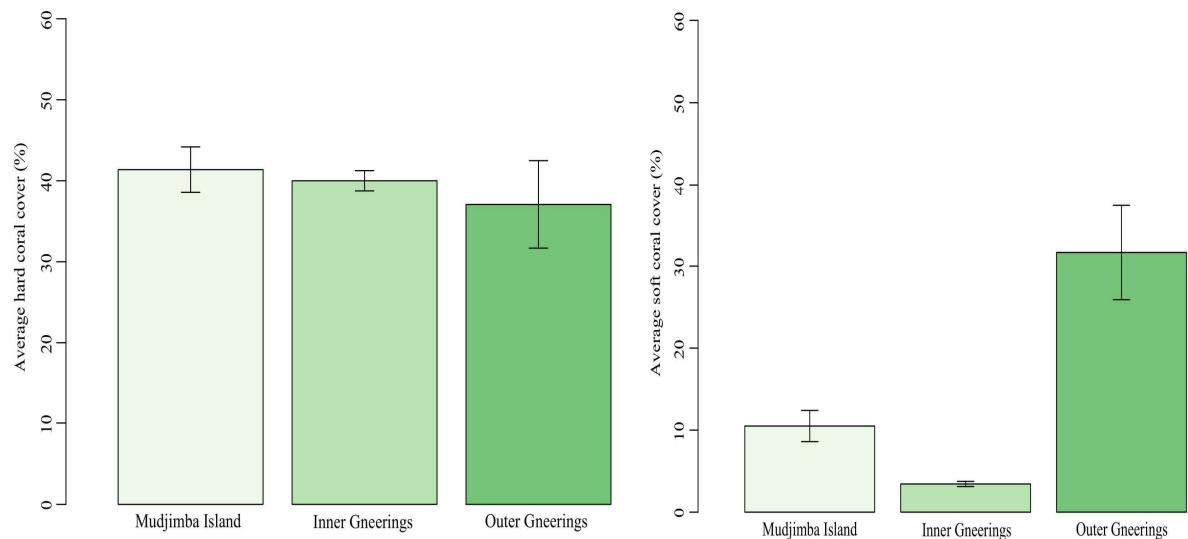


Figure 15: Barplot of averaged hard coral (left) and soft coral (right) cover per area with Standard Error. Values are percent cover and averaged from each area's sites.

### 3.2.2. Fish Abundance and Diversity

#### Overall fish abundance

Fish species were surveyed in this study based on the Reef Check Australia fish survey guidelines (Figure 16). Fish were only surveyed once at each site, and in most cases the number of fish observed was averaged across transects at each site. Overall, fish abundance was highest at Shellacy, and Jarjum, while some fish species were completely absent from several sites including Flam, Murris, Northeast Alternate and Northeast Mudjimba. Notably, overall abundance was lowest at the Inner Gneerings sites.

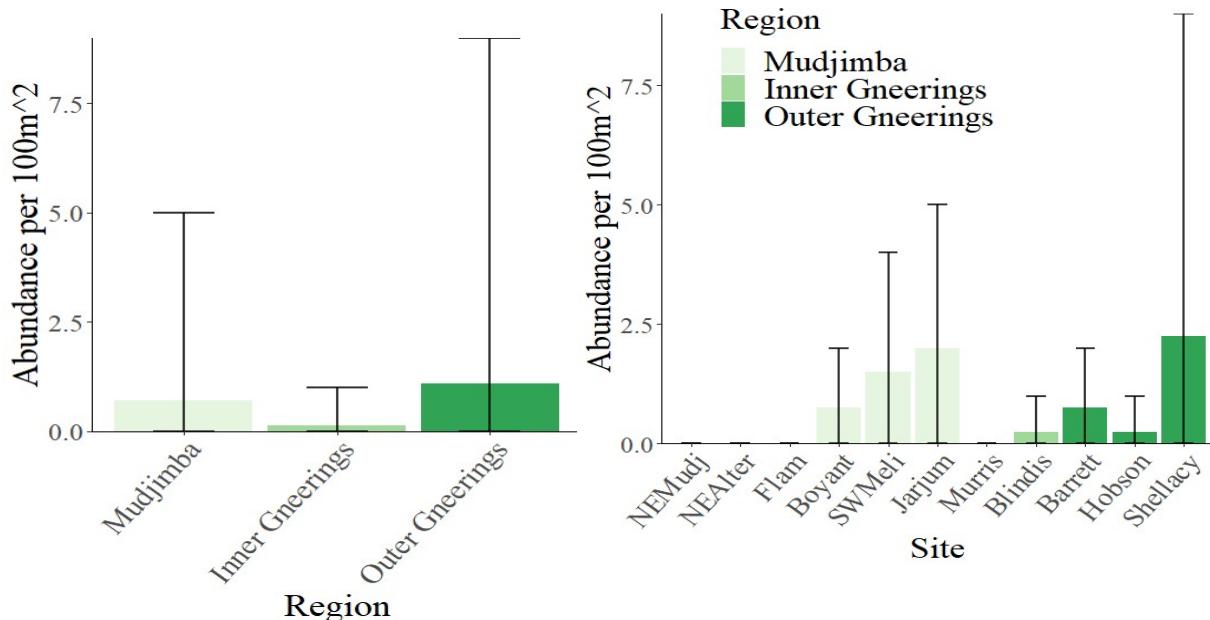


Figure 16: Average abundance of surveyed fish across the three main regions (right) and at each survey site (left) within the Mooloolaba reefs. Error bars indicate standard deviation.

#### Fish taxa

Several key groups of tropical and subtropical fish species were surveyed in this study. After the butterfly fish, snappers were the most observed fish, particularly at Jarjum, Shellacy, and Southwest Meli, (Figure 17). Interestingly, Moray eels, which are usually rare and hard to spot, were recorded on several occasions with sightings at Bindis, Boyant, Hobson and Jarjum (Figure 17).

Overall trends are similar across regions, which can be seen in Figure 17. This figure shows the total abundance of each taxon across the three surveyed regions. In the Outer Gneerings, snapper were the dominant group and the second most common taxon at Mudjimba (with Parrotfish being the dominant group at Mudjimba). Fish abundance and diversity was lowest at the Inner Gneerings, with only one Moray eel observed.

#### Butterflyfish

Overall, butterfly fish exhibited the highest total abundance at all sites. This group was omitted from Figure 17 (above) as their high abundances obscured trends in other groups. Butterflyfish abundance was highest at Shellacy, Southwest Meli and Murris, and lowest at Flam and Northeast Alternate. Overall, their abundance was higher at the Inner and Outer Gneerings than at Mudjimba. However, there was a high degree of variability in butterflyfish abundance across sites as evidenced

by the error bars shown below (Figure 18). Butterflyfish abundance was higher at the Inner and Outer Gneerings as compared to Mudjimba Island. However, there was a high degree of variability in butterflyfish abundance as evidenced by the error bars (Figure 18).

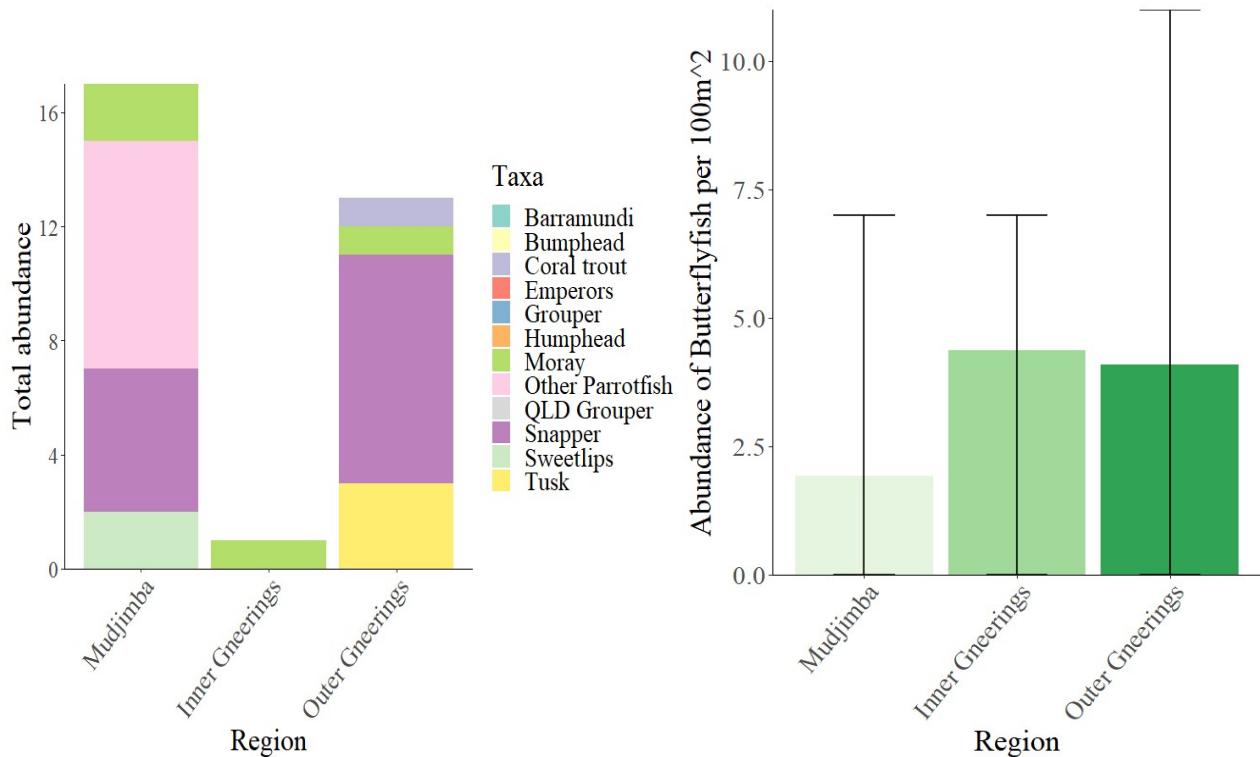


Figure 17: Abundance of targeted fish taxa across the three regions surveyed (Left) and average number of butterfly fish (100m<sup>2</sup>) across the three regions surveyed (right). Error bars indicate standard deviation.

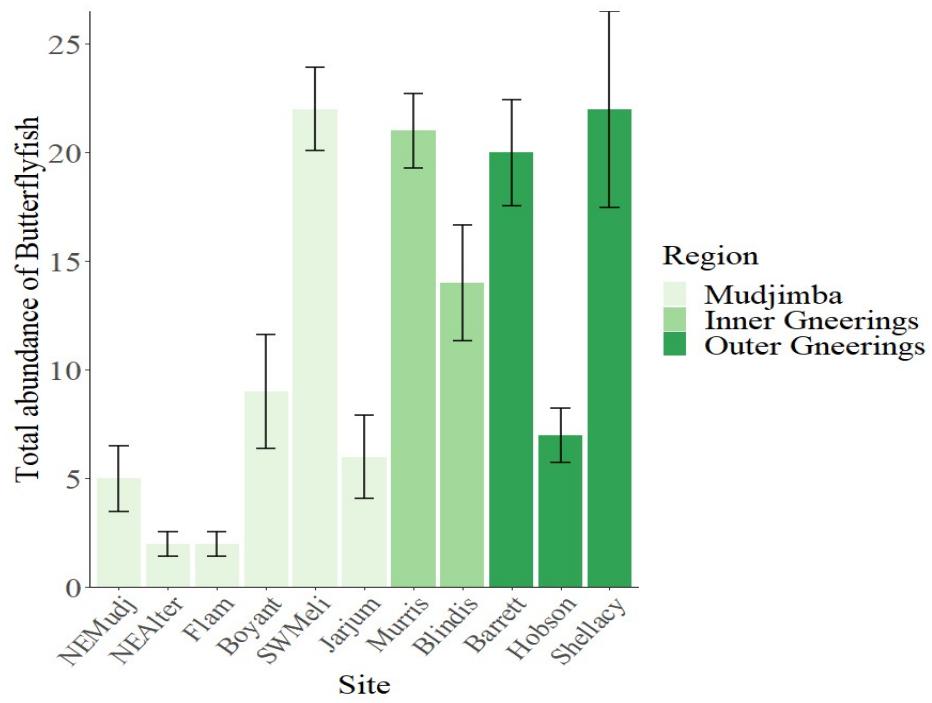


Figure 18: Average abundance of butterfly fish for the eleven sites surveyed. Error bars indicate standard deviation.

### 3.2.3. Invertebrates

In total, 258 invertebrates were recorded at the areas around Mooloolaba, 170 nudibranch species and 88 individuals of indicator invertebrates from Reef Check Australia. Particularly, a total of 99 individuals were recorded at Mudjimba ( $2400\text{ m}^2$ ) with an average of ~4 invertebrates per  $100\text{m}^2$  (0.38 SE), 75 individuals were recorded at Inner Gneerings ( $800\text{ m}^2$ ) with an average of ~9 invertebrates per  $100\text{ m}^2$  (0.60 SE), and 84 individuals were recorded at Outer Gneerings ( $1200\text{ m}^2$ ) with an average of ~7 invertebrates per  $100\text{ m}^2$  (1.35 SE) (Figure 19).

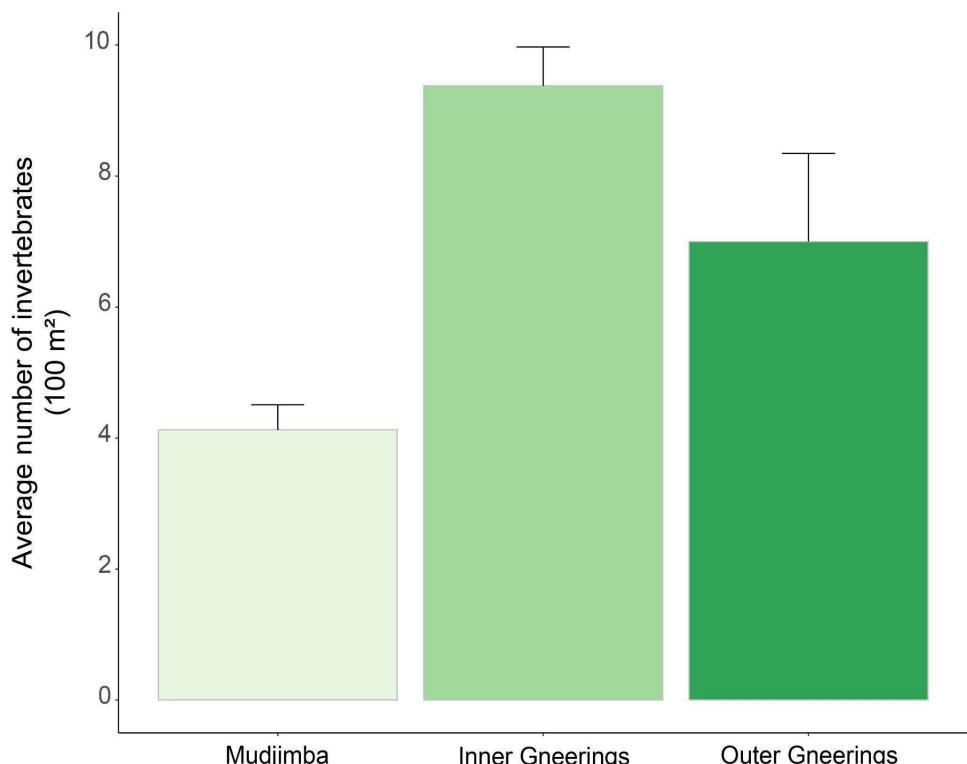


Figure 19: Average number of indicator invertebrates recorded per area including nudibranch species. Number of surveyed sites ( $100\text{m}^2$ ) differed among areas such as Inner Gneerings had two sites, Outer Gneerings had three sites, while Mudjimba had six sites. Note error bars indicate standard error.

Invertebrate sightings were on average below 10 individuals per  $100\text{ m}^2$  transects at all sites. Nudibranch species, *Drupella* snails, and clams were found in all three areas (Figure 20). The average observed abundance of nudibranch species was higher at Inner Gneerings than at any other area (~ $7/100\text{ m}^2$ ), whilst *Drupella* snails had the highest average abundance at Outer Gneerings (~ $3/100\text{ m}^2$ ). Excluding nudibranch species and *Drupella* snails, the average abundance of the recorded invertebrates was below  $1/100\text{ m}^2$  (Figure 20). Collector and pencil urchin were only sighted once at Mudjimba. Lobsters were low and only sighted at Inner and Outer Gneerings. Overall, five clams were recorded, two at Inner Gneerings, two at Mudjimba, and one at Outer Gneerings. Finally, most anemones were found without anemone fish at all areas, and only two anemones were found with fish at Mudjimba.

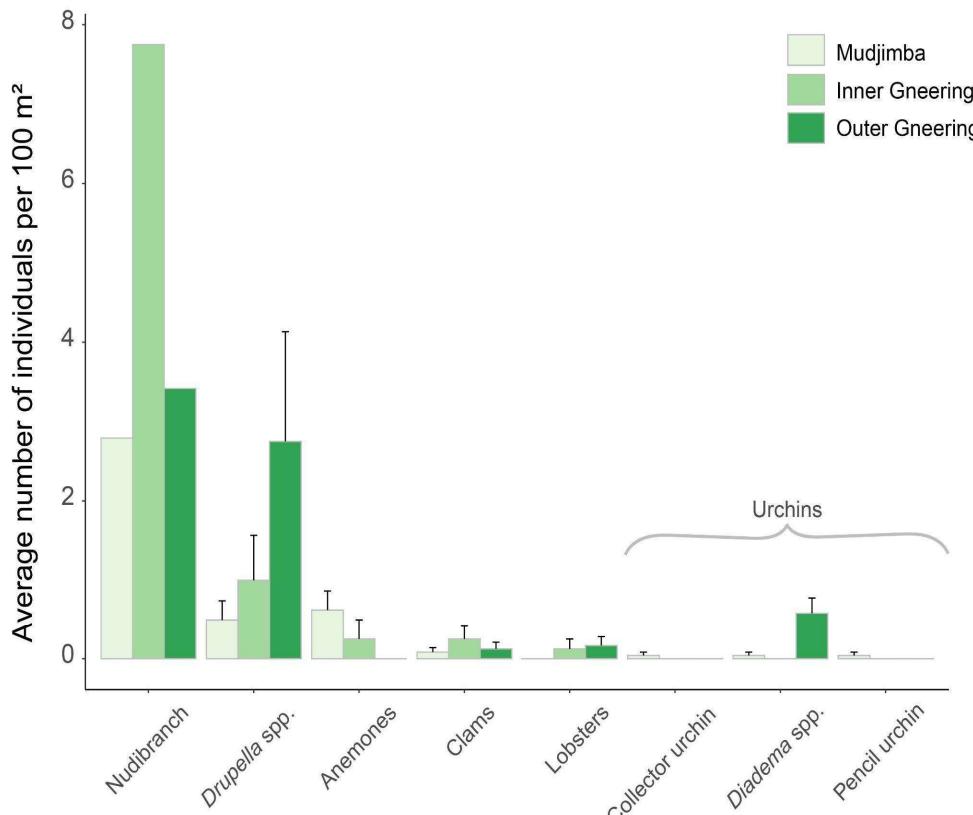


Figure 20: Average abundance of indicator invertebrates including nudibranch species recorded per 100 m<sup>2</sup> transects in each site. Note error bars indicate standard error.

### 3.2.4. Reef Impacts

#### Reef Health Impacts

Coral damage, disease and marine debris were observed at all three Mooloolaba sites with marine debris having the highest count of any impact (Mudjimba Island n=3.0, Inner Gneerings n=1.6, Outer Gneerings n=3.7) (Figure 21). All impacts were present at both Mudjimba Island and Outer Gneerings, whereas no scars (*drupella* or unknown) or coral bleaching was observed at Inner Gneerings. Of the 11 Mooloolaba sites, five sites did not have *Drupella* scars present. Within the Outer Gneerings sites, marine debris had the highest count per square metre for each site.

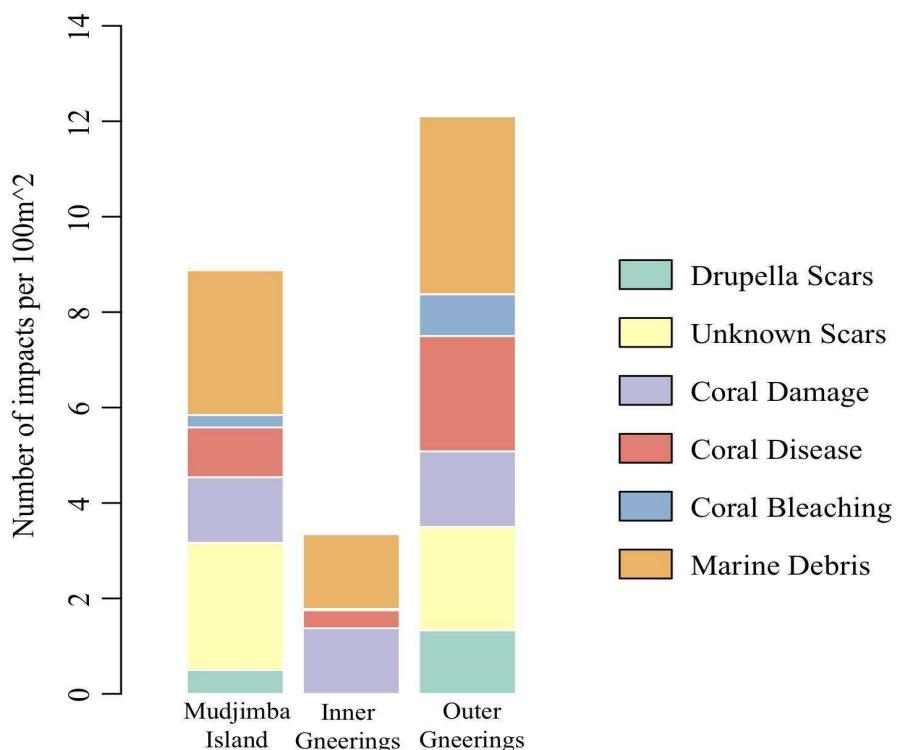


Figure 21: Stacked barplot of the number of impacts per 100 m<sup>2</sup> from the MEAM areas. Values are occurrence data and averaged per each area's sites.

#### Coral Health (bleaching)

A total of 140 corals were surveyed using the Coral Health Chart during the MEAM Project. For the period of observation, the recorded coral health was relatively high with all average values above four, and minimal recorded bleaching. Across all the seven sites surveyed, there was only one coral with a Coral Health score of 1 (bleached). The Inner Gneerings had an average colour health score of 4.61 ( $\sigma = 1.16$ ). The Outer Gneerings had an average colour health score of 4.3 ( $\sigma = 0.65$ ). Sites at Mudjimba has an average colour health score of 4.06 ( $\sigma = 0.70$ ) (Figure 22).

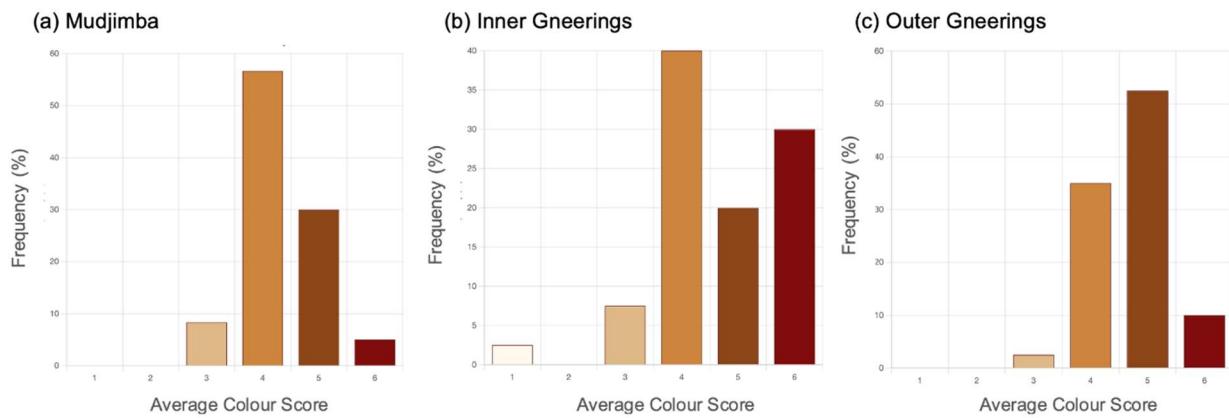


Figure 22: Coral Health Score for corals surveyed at (a) Mudjimba ( $n=60$ ), (b) Inner Gneerings ( $n=40$ ), and (c) Outer Gneerings ( $n=40$ )

Coral Health Score has fluctuated over time at the Gneerings (2015-2021). The lowest values occurred in October 2017 with a coral health score of 3.12, with the highest values recorded in November 2016 (4.33). The most recent data in 2021 shows a Coral Health score sitting around 4.06 (Figure 23).

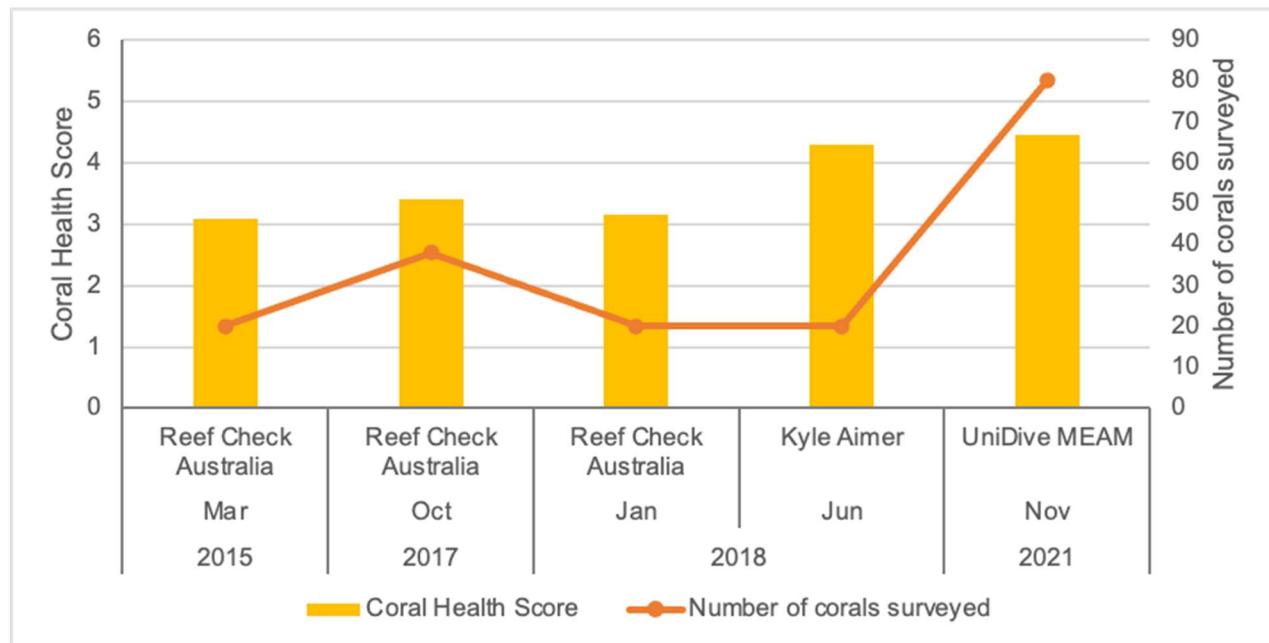


Figure 23: Coral Health Score and the number of corals surveyed over time for Mudjimba, Sunshine Coast.

Coral Health Score has been improving over time at Mudjimba (2015-2021). Coral health score has increased from a minimum of 3.08 in 2015 to a high of 4.46 in 2021.

### 3.2.5. Coral Cover Over Time (2008 – 2022) and Space (South East Queensland)

Hard coral cover has generally increased from 2008-2022 at both Mudjimba Island and Inner Gneerings (Figure 24). The surveys completed as part of the MEAM project generally continue the positive linear trend of increasing cover as observed from previous Reef Check Australia surveys. The Outer Gneerings have not previously been considered in the Reef Check Australia surveys and so the MEAM data has established a baseline. According to the most recent surveys, hard coral cover was on average highest at Flinders (32% in 2019) and lowest at Point Lookout (18.5% in 2021).

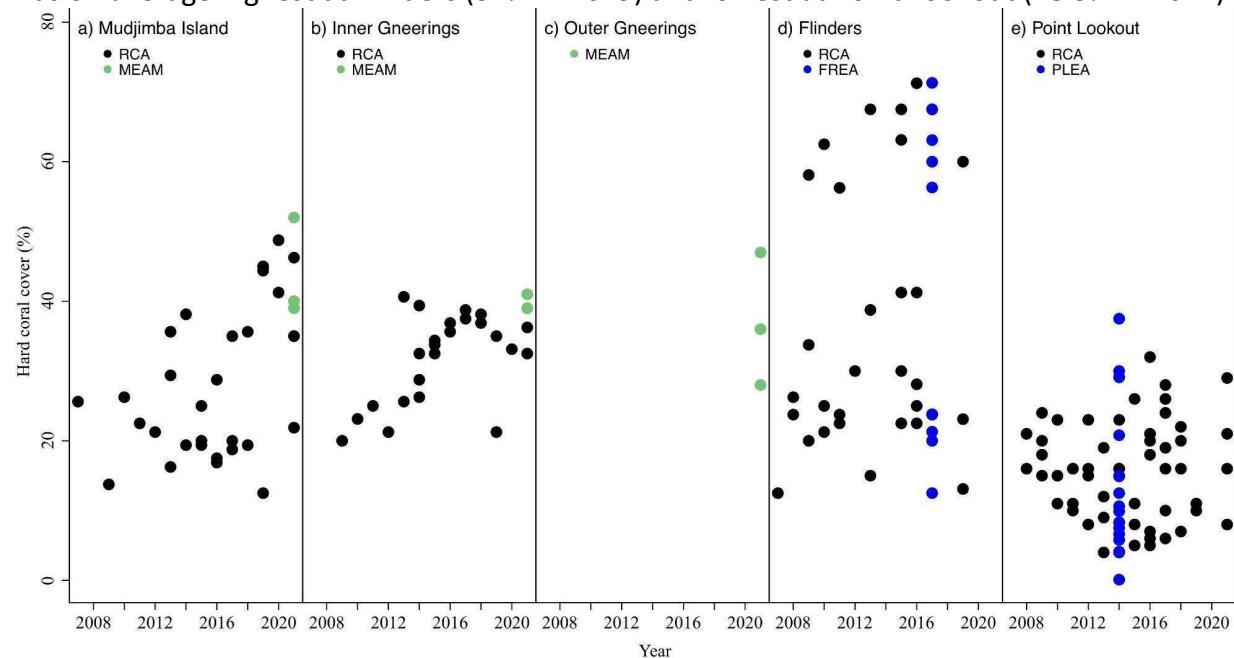


Figure 24: Temporal comparisons of hard coral cover (%) between Reef Check Australia (RCA) data and MEAM, Flinders (FREA) and Point Lookout (PLEA) data.

Hard coral cover per area was most abundant at the Mooloolaba sites compared with Flinders and Point Lookout (Figure 25). Hard encrusting coral was the most abundant hard coral at all three sites; Mooloolaba (19%), Flinders (16%) and Point Lookout (6%). Massive hard coral cover was <1% at all locations and absent from the Outer Gneerings. Bleached hard corals were not observed at Flinders and Point Lookout but were found at Mudjimba Island and Outer Gneerings (both <0.5%).

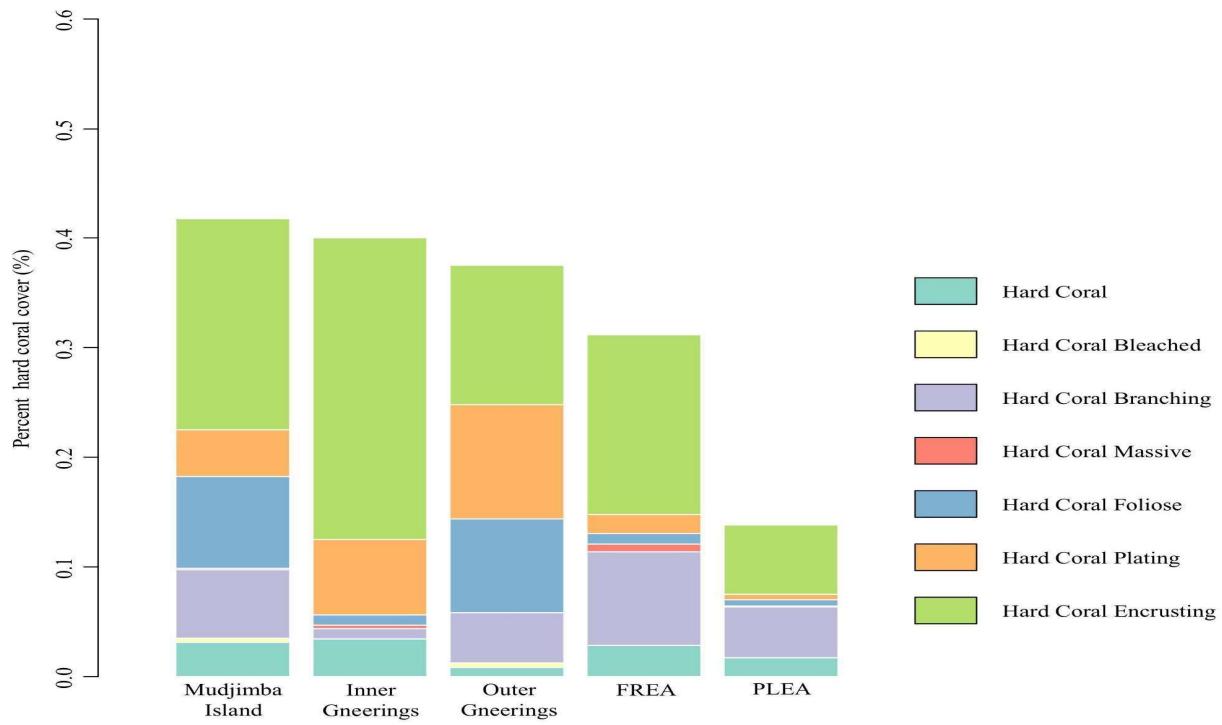


Figure 25: Stacked barplot of averaged hard coral cover per area and per hard coral type with comparisons to the FREA (Flinders) and PLEA (Point Lookout) data. Note FREA data is the combined average of all sites at Flinders reef or for Point Lookout reefs.

### 3.3. 3D Complexity

A total of 36 3D models of 20m segments along survey transects were created, covering a total of 3.6 km<sup>2</sup> (Figure 25). Additionally, two 100 m transects were modelled to visualise the extend of an entire survey transect (Figure 26). The original and edited images, as well as all 3D models have been made available online (van de Berg 2022). A record of 4K videos highlighting some of the models can be found at: [vimeo.com/user88153375](https://vimeo.com/user88153375).

Rugosity (or complexity of the shape of the bottom surface) analysis found that all sites had a similar level of structural complexity (Figure 27). However, sites around Mudjimba island showed a much larger variation in rugosity than the Gneerings and sites on the outer Gneerings were, on average, minimally more rugose. Importantly, we did not find any clear relationships between rugosity and coral cover (Figure 27b-d). Interestingly, the outer Gneerings showed a visibly larger degree of coral cover than the inner Gneerings, driven by the abundance of soft coral (Figure 27b-d). Mudjimba Island showed variability in coral cover and rugosity at the combined scale of the inner and outer Gneerings, reflecting the highly variable conditions around the island.

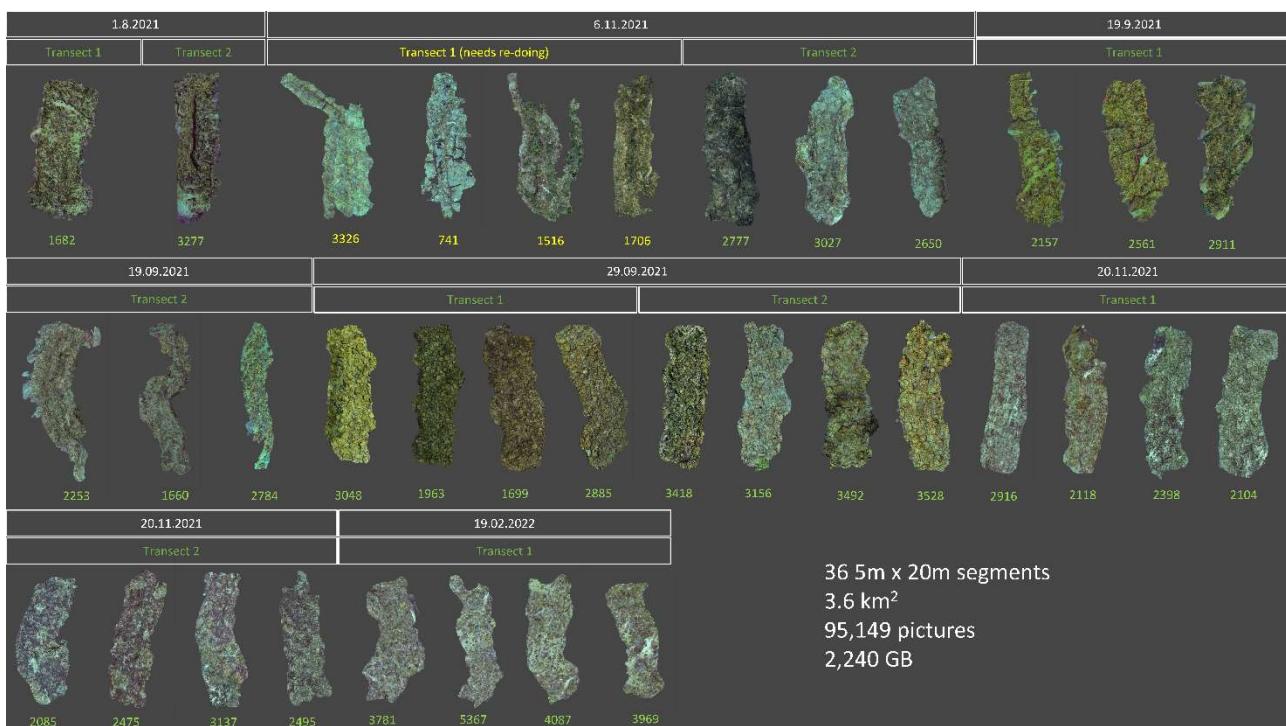


Figure 26: Top-down captures of each 20 m transect segment listed according to survey date and site. Headers in green indicate models available for rugosity analysis, yellow headers indicate models which did not align sufficiently well. Numbers underneath each segment indicate the number of images used to create the model.

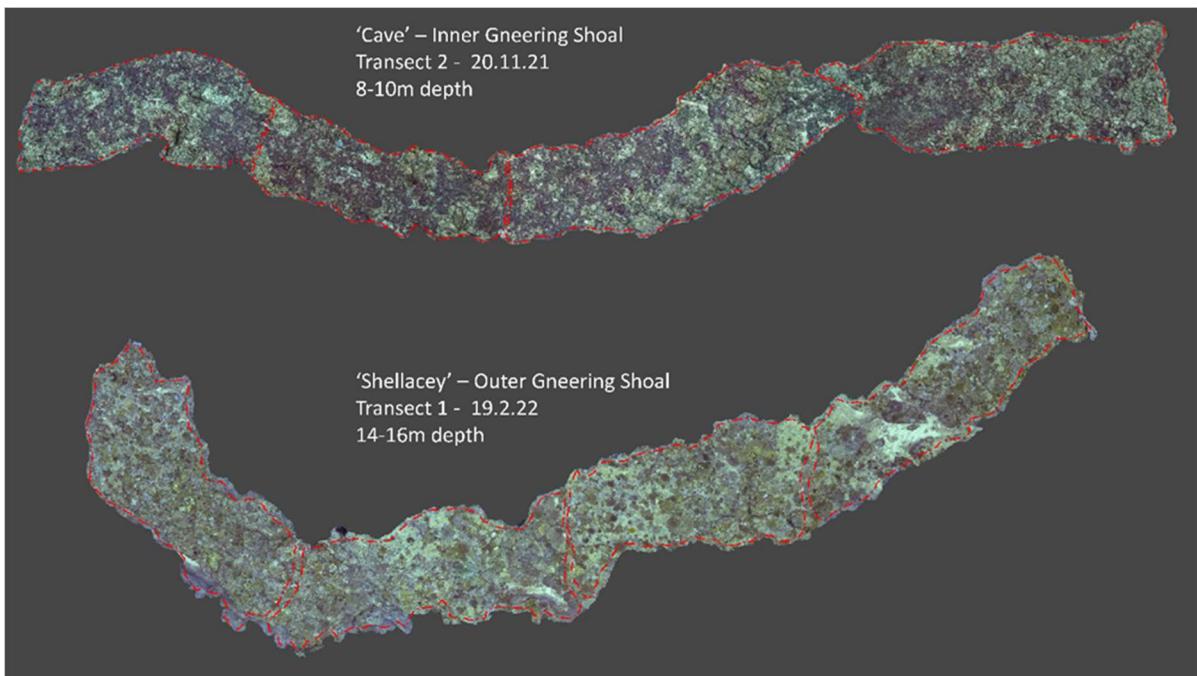


Figure 27: Top-down captures of two complete 100 m survey transect models with individual 20 m segment model outlines indicated with red dashed lines.

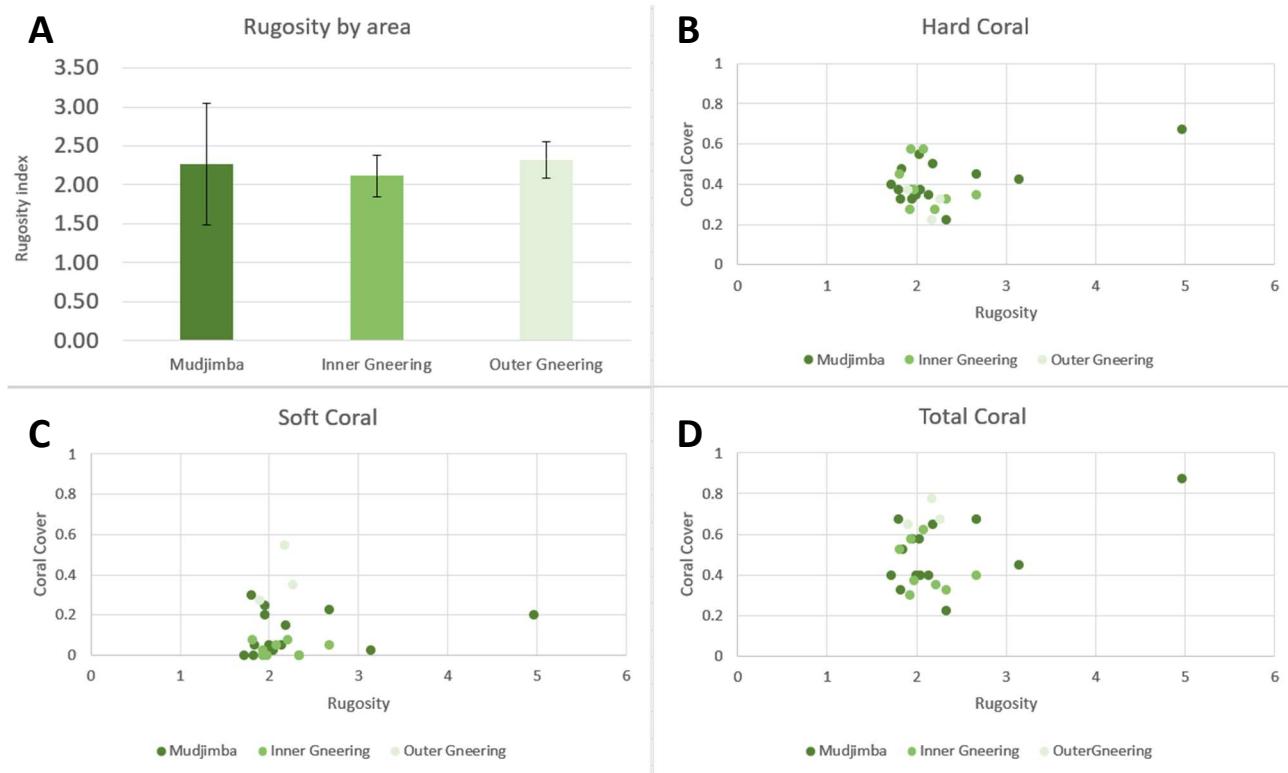


Figure 28: Summary of Photogrammetry results and comparisons with coral cover. A) Mean rugosity between sites. Error bars show standard deviation. B) Correlation between rugosity and hard coral cover. C) Correlation between rugosity and soft coral cover. D) Correlation between rugosity and total coral cover (hard & soft). B-D does not include all available survey data.

### 3.4. Review of the Adjusted Survey Methods

The survey methods applied provided the opportunity to assess the ability to collect additional information and introduce new methods.

The additional information was collected for the substrate, invert, and fish Reef Check Australia Surveys. For substrate point surveys the four macro algae (*Sargassum spp.*, *Padina spp.*, *Turbanaria spp.*, *Asparogopsis spp.*) were now marked along the transect if present. The volunteers required no additional skills but did provide more insight on what algae is occurring along the transects. For fish surveys, the additionally classes were easy to be identified, as they were commonly occurring fish species (e.g. Morwong, Wobbegong Sharks). For the invertebrates, a similar experience was noted, where the two changes included identifying and counting any sea cucumbers, other than the previously targeted sea cucumbers; and secondly counting of sea slugs that included flatworms and nudibranchs.

Next to the substrate Reef Check Australia survey, photo quadrat surveys were captured along the transect. Photos were analysed through machine learning for benthic composition and the results presented show that more categories were identified through photo quadrat survey compared to the traditional point intercept survey.

Although more analysis is required to fine tune the different categories for comparison, the results are promising (Figure 29). Additionally, the photos provided more information since the photos were captured at 1 m interval.

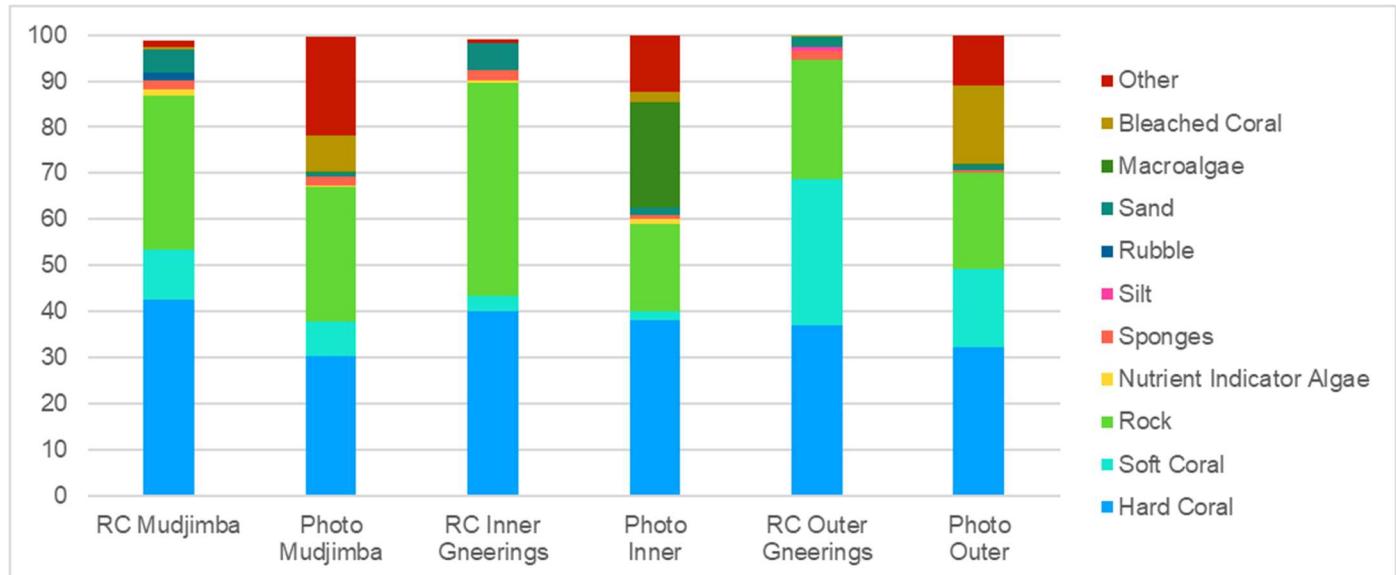


Figure 29: Example of photo quadrat surveys vs substrate reef check survey results summarised for the three main survey areas.

## **4. Discussion**

### **4.1. Setting the Scene**

The project was impacted by COVID restrictions and environmental conditions. However, when surveys were conducted, data was secured in a high-quality manner. Surveys were supposed to be completed between June and September 2021, but due to weather and COVID restrictions pushed our timeline to February 2022. In February and March 2022, flooding caused a significant run-off and associated reductions in water visibility. This together with limited access to the boat and continuing strong winds the decision was made to stop survey activities from this point. Although less surveys were conducted than expected the distribution of sites and the local knowledge together provided sufficient information to warrant this in-depth report.

### **4.2. Hard Coral and Rocky Substrate Dominance**

**A notable result of this study was the observed high proportion of hard and soft corals at Mudjimba Island, Inner Gneerings and the Outer Gneerings. The coral cover for the Mooloolaba sites was relatively high compared to previous work by the team at both Point Lookout and at Flinders Reef.** This is especially encouraging given the large area the Mooloolaba reefs extend over and that they are also important habitat for both commercial and recreational users. The analysis of coral cover trends over time revealed a general increase, which is considered positive due to ongoing environmental pressures (e.g. coral bleaching). However, the specific taxonomic assignment of the coral cover was not known and there is limited temporal data, especially for Outer Gneerings.

As coral cover has become an important metric to monitor on coastal reefs, these high cover findings are positive and therefore important. Climate change and the direct effects of anthropogenic inputs have caused severe reductions in coral cover and habitat complexity globally. Such reductions not only cause harm to the aquatic environment, but also led to reduced capacity for coral reefs to act as important break waters for adjacent coastlines.

**The specific growth forms of coral observed showed that encrusting forms were the most abundant at all three sites, followed by plating and foliose.** Similar trends were also observed at both Flinders Reef and Point Lookout (Roelfsema et al. 2016, Grol et al. 2019). This is encouraging given that foliose, plating, and encrusting corals are generally harder than branching corals. Although it was surprising to see the general lack of massive corals, which are perhaps the most resilient to thermal stress. Mooloolaba is an exposed reef area prone to strong sea conditions and large swell based on the information we gathered. Coral growth forms may follow suit given the strong hydrodynamics experienced within the reef system. Encrusting, plating and foliose growth forms can adhere to substrate better and are not as easily dislodged as compared to branching or delicate coral growth forms, and this may explain the observed patterns.

The abundance of hard and soft corals and the partition of their growth forms also warrant further monitoring. Future monitoring should aim to not only compare overall hard and soft coral cover, but also how the relative proportion of coral growth forms change through time. Much research has

shown many coral reefs have also transitioned from being hard coral dominated to being soft coral and algal dominated. Given the abundance of soft corals, it would be interesting to observe how these dynamics change or remains stable through time.

**Rock was also a very abundant benthic type. This is encouraging as rock covered in crustose coralline algae is an important settlement space for hard coral recruits.** In tandem, the general lack of macro algae and nutrient indicator algae is also encouraging since these algal types generally take over the benthos and can outcompete coral recruits for settlement space. What would be interesting to monitor is how these benthic types change through time and monitoring the abundance, type, and survivorship of coral recruits.

### **4.3. Fish Abundance and Diversity**

In this study, tropical and sub-tropical fish species, commonly found in this region (Johnson 2010), were observed at all survey sites. **Overall fish abundance and diversity was greatest at Mudjimba reef, which is not surprising since the Mudjimba sites are more sheltered than the Gneerings sites, and thus provide more suitable habitats for smaller reef fishes (Depczynski and Bellwood 2005).** Snapper, Parrotfish and Butterfly were the most commonly observed taxa, which is consistent with previous RCA surveys and accounts for this region (Salmond and Schubert, 2021). These taxa also tend to be the most easily identifiable given their discrete colouration and morphology (Johnson 2010). It is certainly comforting that Snapper and Parrotfish were observed on a few occasions, despite being popular taxa targeted by recreational and commercial fishers. However, Sweetlips, Coral Trout and Red Emperor, which are also targeted by fishers, were less abundant, which suggests that more thorough monitoring is needed for this region.

It is also interesting to note that Moray eels were observed on several occasions during our surveys, given that they are often rare and hard to spot (Buhlke and McCosker 2001). Our ability to frequently observe Moray eels speaks to the effectiveness of the in-water survey methods and highlights Mooloolaba as a potential hotspot for rarer organisms such as Nudibranchs (See section 4.4 below) and Moray eels.

**Fish diversity was lowest at the Inner Gneerings, which exhibited the highest abundance of Butterfly Fish.** This observation could be a result of environmental conditions on the days on which the Inner Gneerings sites were surveyed. Thus, continual monitoring of these sites would be particularly useful to gain a better understanding of the fish assemblages in the region and to explore temporal dynamics in fish presence and habitat use.

#### **4.4. Nudibranch (Sea Slug) Paradise**

Mooloolaba has been previously highlighted as a region which contains a high number of nudibranch species and individuals. Not surprisingly, within our surveys they were the most numerous invertebrates. Their intrinsic beauty and cryptic nature further add to the value of Mooloolaba reefs. The next most numerous invertebrates were the *Drupella* snails. While both nudibranchs and *Drupella* are corallivores (i.e., they fed on corals), the latter have the potential to become hyper numerous on a reef and become a real issue. In our surveys, *Drupella* never enumerated to more than a few individuals per coral head, but previous RCA surveys in Mooloolaba have encountered far greater numbers than during MEAM surveys, and *Drupella* have denuded reefs along the southern Great Barrier Reef (GBR). As such, our systematic surveys highlighted the importance of Mooloolaba reefs for charismatic invertebrates such as nudibranchs, but also reveal the potential for *Drupella* outbreaks, which could cause severe mortality to coral populations.

Anemones and clams were the next most abundant groups of invertebrates within the Mooloolaba reef system. However, they were again uncommon, with no more than a few individuals per site. This is not too unsurprising, given other citizen science efforts in Flinders Reef and Point Lookout (Roelfsema et al. 2016, Grol et al. 2019) also did not document high numbers of these groups. Both anemones and clams are photosynthetic and just as vulnerable to thermal stress as compared to their coral counterparts. As such, continual monitoring can reveal whether populations of anemones and clams are stable or ephemeral within the region.

Lastly, urchins and lobsters were very uncommon across all three sites. While Mooloolaba reefs did confer a relatively high level of rugosity (i.e., a measure of habitat complexity), there perhaps was not much preferential habitat for lobsters. In addition, the region does contain commercial vessels which target these invertebrates. As for urchins, it was surprising their numbers were so low. They are important herbivores and can consume algae which preferentially clears settlement space for coral recruits. We cannot offer a clear explanation for their low numbers, although they are also cryptic invertebrates, often found underneath coral heads and within overhangs and crevices. As such, a purely top-down visual survey may overlook their numbers. Indeed, as with other difficult to see invertebrates, such surveys may underestimate their numbers. These are also nocturnal creatures, and night-time surveys may reveal higher numbers of both lobsters, crabs and other mobile invertebrates.

#### **4.5. Prevalent Impacts**

Coral damage, coral disease and marine debris were observed at all three Mooloolaba sites. Marine debris was the most common impact, with higher counts at the Outer Gneerings and Mudjimba Island, suggesting that there could be actions taken to reduce debris loads. However, what was most encouraging was the general lack of coral bleaching. As climate continues to warm, the most direct and visually apparent effect is when corals become stressed, expel their endosymbiotic zooxanthellae, and become ghost white – bleaching. Coral bleaching has caused drastic reductions in coral cover from both the Caribbean and Indo-Pacific. The lack of observed bleaching, and the minimal reporting on recently dead coral at Mooloolaba is a welcome sight.

Mooloolaba reefs occur at high latitude, ~26-27 S, much research has shown high latitude reefs may be able to withstand the onslaught of thermal stress given their geographic position, and generally cooler ambient water temperatures. Thus, high latitude reefs like Mooloolaba may be important coral refugia for both tropical and sub-tropical corals into the future as climate continues to warm.

Another welcoming find at Mooloolaba was the lack of crown of thorn starfish (COTs) and the limited number of *Drupella* snails. Both echinoderms are known coral killers. Although COTS are more uncommon in higher latitudes, as water temperature continues to warm, monitoring for impacts may start to detect more COTS soon. Further, previous reporting by Reef Check Australia (RCA) has found considerable numbers of *Drupella* snails. The lack of snails in our surveys is encouraging, but their prevalence as detected from other surveys in the Mooloolaba region warrant concern. Targeted approaches have been developed to remove COTS directly from coral reefs, especially along the central and southern GBR, however removal or control of *Drupella* outbreaks is more difficult due to *Drupella* being more cryptic and often burrowing deep inside coral branches. While the general trends observed from our impact surveys are encouraging, further monitoring for impacts need to occur to be able to influence potential management actions.

Coral damage, rubble and overturned corals occurred within most surveyed transects. Rubble formation is not necessarily a concern for coral reefs, as rubble if stabilized, is important for seeding growth and substrate for coral recruits. However, if Mooloolaba experiences an increase in inclement weather, especially cyclonic activity as climate continues to warm, then rubble production and coral damage may increase. For now, this does not seem to be problematic for the region but should be carefully observed into the future.

Coral disease was also encountered on most surveyed sites. Coral disease has been shown to increase in prevalence in areas prone to coastal modification and resultant outflow of nutrients and pollutants. The shoreline of Mooloolaba is heavily modified with large construction occurring on adjacent beaches and the potential of sewage waste. Such direct effects can not only lead to eutrophication of the coastal marine habitats, but also act as a disease vector potentially harming coral population. While disease incidence was low within all three sites at Mooloolaba, further monitoring is essential to detect if peaks in disease occur, pinpoint where they occur and what coral types are most affected.

Lastly, Mooloolaba is not a green zone and there anecdotal it is intensive resource extraction from both commercial and recreational fishers. Not surprisingly, fishing line and marine debris were the most numerous impacts encountered within surveyed transects. While we did not record anchor damage, there are no permanent moorings within the surveyed sites and many recreational and commercial boats continually anchor in the area.

Thus, several different impacts were recorded within the surveyed sites of Mooloolaba. However, they are not yet numerous enough to warrant concern. But continual urbanization and modification of the adjacent coastline, as well as the effects of a warming climate do warrant the need for continual monitoring.

#### **4.6. 3D Projections of The Mudjimba Complex and Outer Gneerings.**

The largest variation in rugosity was shown at Mudjimba Island based on the photogrammetric survey data. This does not come as a surprise, as the survey sites were located on all sides of the Island, with the underwater geometry and benthic growth being strongly influenced by exposure to wave energy based on our environmental data collection. For example, the sheltered side of the island is known among local divers to have a distinct seabed morphology and benthic growth when compared to the exposed outer side of the island.

Our data further shows that, although similar in complexity to sites surrounding Mudjimba island, sites on the Inner Gneerings shoal were slightly less rugose than sites on the Outer Gneerings. This could be driven by both, the structure of the rocky substrate or the presence of benthic growth, namely hard and soft corals. The Inner Gneerings are closer the mainland and are substantially shallower than the Outer Gneerings. As such, the environmental conditions for benthic cover are likely substantially different with the inner Gneerings being subject to increased levels of wave energy and coastal runoff, consequently influencing the mechanical forces impacting benthic growth as well as light levels, temporal stability, and nutrient availability. It is hard to make a meaningful comment of the overall rock morphology between the inner and outer Gneerings as the surveys were intentionally placed on rather flat parts of the ocean floor at either site. However, the Outer Gneerings are home to much more pronounced geological features such as gullies and drop-offs than the Inner Gneerings. This, together with the difference in benthic cover explains the location of the most famous and popular dives sites on the reef. Indeed, the Inner Gneering showed a similar level of hard coral cover than the Outer Gneerings, however, the sites on the Outer Gneering had substantially higher cover of soft corals, driving the difference in absolute coral cover between the inside and the outside of the shoal despite only a moderate difference in the rugosity between sites. Despite the preliminary nature of these data, our results indicate that survey and conservation efforts of local reefs at the Sunshine Coast need to be approached with careful consideration of the local differences between distinct areas of the local underwater ecosystems.

In addition to these empirical insights, our project has produced an impressive and permanent geolocated visual record of the state of almost four square kilometres of underwater landscapes off the coast of Mooloolaba. Lastly and importantly, this project provides a crucial and pioneering example of the implementation of photogrammetry into large-scale citizen science efforts.

## **4.7. Project and Data Limitations**

**The MEAM surveys were carried out successfully by volunteer divers certified in Reef Check Australia, and all volunteers were trained in CoralWatch Survey and mapping techniques** (Appendix A). Whilst a high number of volunteers was imperative for project engagement, there was some variation in the results due to data that could not be explained through seasonality (e.g., Hard Coral cover) as the surveys were originally planned over to take place over three months instead of 12 months. Likely some of the variation arises from data being collected by different divers on different surveys. To reduce this variation, divers were trained to a high standard (pass mark ≥85% on written survey ID exams, and 95% for in water exams) and core divers were appointed to survey activities across trips for consistency, where feasible. Of the 44 Reef Check certified divers, 24 were certified previously and had past survey experience (PLEA, FREA or RCA), and the remaining 20 undertook the Reef Check Australia certification course. All had participated in academic and practical exams, and their diving skills were reviewed.

The substrate survey utilised a point intercept transect method. Some differences were also evident on comparison of field-based substrate data and photo transect data. The photo transect-based substrate survey allowed for rapid data collection in the field, and compared to previous analysis methods, they were analysed automatically through machine learning, speeding up data processing. Also in this study, the photo transect method provided a higher level of consistency in assessment of benthic composition as the photo analysis was done using machine learning and questionable analyses could be reassessed.

Surveys were carried out over a roughly 12-month period (see Appendix I). The environmental conditions (e.g. wind, swell, tides, visibility and temperature) during the surveys varied due to normal to extreme weather patterns, which could have influenced the flora and fauna present. Therefore, ongoing surveys are especially valuable to provide better knowledge of what is present or absent at different times of the year and in different conditions. Due to natural changes mentioned, notable variability would have been inherent and could contribute to potential intra-season differences as was noted in previous studies (Roelfsema et al. 2016, Grol et al. 2019). This was especially relevant for the fish survey, where transient or migratory schools of fish could greatly affect the overall counts. Surveying the entire Mooloolaba Reef region on a seasonal basis helps to differentiate between real changes such as seasonal migrations or regional preferences, as opposed to local transient populations.

## **5. Recommendations for Management and Community**

This citizen science project provides an opportunity to further consider ways to work collaboratively to understand, protect and manage the unique subtropical reefs of the Sunshine Coast. This is particularly important given the limitations in comprehensive marine monitoring, the intensive use of this area, and growing threats from climate change and population growth in the region. Some opportunities that have been identified through this project are outlined below.

### **5.1. Continued and improved Monitoring of the Mooloolaba Reefs**

**Continuing annual reef health monitoring on a select number of sites and habitat mapping every five years for all reef areas, may be beneficial for an increased ecological understanding and for management and conservation.** The results of this project build on the existing dataset for the region, with Reef Check Australia undertaking annual surveys at four sites since 2009. The more intensive seasonal survey approach used in this project expanded four of the number of locations with monitoring baselines, provided greater understanding of seasonal variation trends and augmented ongoing monitoring through photogrammetry and detailed habitat maps. Regular monitoring of reefs can improve understanding of ecological changes, including whether they are natural variations or caused by external factors such as fishing, pollution or physical damage.

There are also opportunities to further strengthen citizen science data applications. Integration of benthic imagery into Reef Check Australia citizen science surveys offers efficiencies, long-term benthic records, and new opportunities for broader data applications. Data analysis revealed that photo transect data was more consistent in documenting benthic composition across seasons but was not as strong as diver recorded data in picking-up variability. Beyond potential data processing benefits, adding complementary photo records to data recorded in situ offers an opportunity for other interested parties to access photo records for additional applications. This suggests that integrating this approach is worthwhile for the future.

Although the 3D photogrammetry mosaic provided a good source and record of detail information of the substrate, currently the method to create the mosaic and conduct the analysis would require a dedicated skilled volunteer to conduct that process.

This project and the ongoing efforts of Reef Check Australia reef health monitoring and reporting have shown that citizen science efforts are especially strong at reporting general trends in both coral cover and coral type. Beyond that, citizen science offers a cost-effective approach that also offers numerous social benefits through building community capacity, growing meaningful community engagement, generating educational outcomes and supporting cross-sector collaboration. We have expanded what is known about these reefs, as to our knowledge, this is the first time any systematic survey had been done at the Outer Gneerings. As such, continued citizen science monitoring efforts across all three Mooloolaba reef areas would be beneficial. In doing so, we can track how reefs change through time to contribute to efforts that inform management and community actions to protect these sites.

## **5.2. Strengthening Ways to Care for Mooloolaba Reefs**

**Educating divers, spear fishers, snorkelers, fishers, and vessel skippers in practical ways to reduce physical damage and limit marine debris may help to reduce pressures on reef sites. Coral damage, coral disease and marine debris were observed at the outer Gneerings, Inner Gneerings and Mudjimba Island.** While encrusting coral was the most common growth form, these sites also host delicate branching, plating and foliose corals, which are more vulnerable to physical damage. Anchor damage was not recorded on surveys, but snorkellers, divers and boat anchors may be attributing to unidentified coral damage recorded on surveys. Promoting boat anchoring practices and skills that use sandy patches and avoid coral dense areas could be beneficial for reducing pressure on reefs from physical damage. Divers should be encouraged, or ideally required, to follow a code of conduct that highlights the need for good buoyancy control to avoid touching the bottom, and the streamlining of dive gear to avoid entanglement in corals. Snorkelers should be encouraged not to touch or get close to the bottom, reducing their impact. Best practice fishing guidelines could be supported to avoid fishing near or close to the bottom to avoid line entanglement and/or loss of fishing gear and associated damage to corals.

**Collecting and sharing targeted information about reef health and values can enable discussions about further options for protecting the values of Mooloolaba reefs.** The HMAS Brisbane shipwreck is the only marine protected area within the Sunshine Coast region, despite Mudjimba Island being acknowledged as having cultural significance and the Outer Gneerings (Wobbe Rock) being an identified Grey Nurse Shark habitat (a critically endangered species). Protecting the unique cultural, social, ecologic and economic values of this area may require new approaches. Citizen science can help to activate these discussions and bring together diverse groups of people and organisations who care about this place to find solutions.

**Installing moorings at sites like Mudjimba Island could be considered to reduce direct site-use pressures.** Even though no anchor damage was recorded, the high coral cover could easily be damaged by frequent visitors, such as fisherman, snorkelers, and divers. Based on the ecological assessment and mapping activities, the project found that all sites are favourable for diving, however they do not have moorings and anchoring could be hard due to the observed reef complexity. Moorings can be an effective tool for managing visitation to high use areas.

## **5.3. Building Awareness of the Value of Local Reefs**

**Engaging residents and visitors of the Sunshine Coast reefs in citizen science and education efforts can help grow awareness about these unique reefs and encourage more people to understand how they can care for and protect these places for the future.** Anecdotal feedback collected from community engagement in the region (2007-present) indicates that many people are not aware of the presence and values of the unique subtropical reefs of Mooloolaba. Increasing knowledge about these special places and how personal actions can support their protection will be critical to help in the conservation of these ecosystems for the future. Further efforts to identify key audiences and actions could help to tailor targeted ways that people can take meaningful action.

**Community members can contribute to improving understanding of Sunshine Coast reefs through citizen science.** Already, many residents and visitors have a deep local knowledge and attachment to these reefs and the wildlife they support. Promoting and supporting multiple pathways for the broader community to get involved in citizen science can help to generate useful data and continue to strengthen community understanding about habitats and wildlife. Some relevant citizen science initiatives to consider include:

- Reef Check Australia (<http://www.reefcheckaustralia.org/>)
- CoralWatch (<http://www.coralwatch.org/>)
- Project Manta (<https://www.facebook.com/ProjectMANTA>)
- Spot the Leopard Shark (<http://www.uq.edu.au/whale/spot-the-leopard-shark>)
- iNaturalist (<https://www.inaturalist.org/>)
- Tangaroa Blue Foundation (<https://www.tangaroablue.org/>)
- Turtle Care: <https://www.sunshinecoast.qld.gov.au/Environment/Native-Animals/TurtleCare/TurtleCare-Volunteering>

## **5.4. Supporting Conservation of Sunshine Coast Reefs Through Sharing Knowledge**

**Learning about cultural connections and value of Mooloolaba reefs and connected habitats can help to support shared understanding and care.** The Sunshine Coast holds deep cultural value for the Gubbi Gubbi people, who have a long and rich connection to country. Building a shared understanding and learning from long term custodianship can benefit the flora, fauna and people using and depending on these habitats. Fostering opportunities to learn about Traditional Knowledge, cultural connections and values of the Sunshine Coast land and sea country can assist in efforts to support more holistic understanding and conservation of the reefs and grow meaningful partnerships with Traditional Owners.

**Collaborating and sharing knowledge to generate open access scientific information to fill key information needs can help strengthen partnerships and understanding to care for Mooloolaba reefs.** The scientific community, non-governmental organisations, management authorities, local area councils and interested citizens can use the findings of this research and future research projects to help support management decisions and guide further monitoring of the reefs. Growing active dialogue across groups and individuals who care for the local marine environment can help to strengthen collaboration for positive impact.

## 6. Reference and Publicly Accessible Project Data sets

- Substrate, Fish, Invert and Impact data accessible through Reef Check Australia Data Portal  
<https://www.reefcheckaustralia.org/data>
- CoralWatch Survey data is accessible through CoralWatch Data Portal  
<https://biocollect.ala.org.au/coralwatch>
- 3D Photogrammetric data models are available through (van de Berg 2022)  
<https://espace.library.uq.edu.au/view/UQ:2be1b1d>
- Photo quadrates will be made accessible through Pangaea Data Portal (in Progress).
- Maps will be made accessible through Pangaea Data Portal (in Progress).

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## Appendices

### Appendix A: Participants List

First name	Last name	Grants/funding/sponsorship	Organisation/Logistics	Reef Check Certified	Training weekends March 2021	Boating/diving and/or survey jobs	Science/data analysis team	Report writing
Alexandra	Lau			x	x			
Alice	Twomey						x	x
Amber	Moran		x	x	x	Surveys	x	
Andrew	O'Hagan		x	x	x	Surveys		
Andy	Holland		x	x	x	Surveys		
Boeke	Elbers				x			
Breanne	Vincent		x	x	x	Surveys		
Bruce	McLean		Treasurer	x	x	Boathandler, Surveys		
Catherine	Kim	x		x	x	Surveys	x	x
Cedric	van den Berg	x		x	x	Photogrammetry	x	x
Cheryl	Tan		x	x	x	Surveys	x	
Chris	Roelfsema	x	Project lead	x	x	Photos	x	x
Chris	Klaas			x				
Chris	Adams			x				
Christina	Lapid			x	x	Surveys		
Clarissa	Elakis							
Damien	Shrier		x	x	x	Surveys		

First name	Last name	Grants/funding/sponsorship	Organisation/Logistics	Reef Check Certified	Training weekends March 2021	Boating/diving and/or survey jobs	Science/ data analysis team	Report writing
Delphine	Gonchond		Secretariat, admin, website	x	x	Surveys		x
Devin	Rowell		Social media, photos	x	x		x	x
Diana	Kleine		Design, merch, publications	x	x	CoralWatch, Surveys		x
Donna	Easton	x	x	x	x			
Douglas	Stetner		x	x	x			x
Elliot	Peters		x					
Emily	Gregory			x			x	x
Fei	Yang							
Hannah	Barrenger			x	x	Surveys		x
Henri	Decoeur			x	x	Surveys		
Hisatake	Ishida							x
Ilha	Byrne			x	x		x	x
Isabelle	Derouet		x	x	x	Surveys		
Jenni	Calcraft			x				
Jennifer	Loder			x	x	Surveys	x	x
Jodi	Salmond			x	x	Surveys	x	x
Jody	Kreuger			x	x	Boathandler, surveys		
Joop	Sassen						x	x
Jörn Guy	Süß	x			x			

First name	Last name	Grants/funding/sponsorship	Organisation/Logistics	Reef Check Certified	Training weekends March 2021	Boating/diving and/or survey jobs	Science/ data analysis team	Report writing
Josh	Passenger		Data team lead	x	x	Surveys	x	x
Kade	Chambers			x			x	
Kane	James							
Karen	Johnson			x	x	Surveys		x
Katharine	Prata			x	x		x	
Leah	Clarke							
Lucas	de Castro			x	x		x	
Mark	Stenhouse		x	x	x	Boathandler		
Monique	Grol			x	x		Science team lead	
Nataly	Gutierrez Isaza	x	x	x	x	Surveys	x	x
Nicholas	Hammerman	x	x	x	x	Surveys	x	x
Philip	Dunbavan			x		Surveys	x	
Rachel	McVeigh		x	x	x	Surveys	x	x
Ranishka	Hewavisenthi		x	x	x			
Rikki	Andersen			x				
Robert	Mactaggart			x	x			
Ryan	Booker	x	x	x	x	Boathandler	x	x
Sophie	Kalkowski-Pope			x	x		x	x
Tania	Kenyon			x				
Tania	Alajo	x		x	x	Surveys	x	x

First name	Last name	Grants/funding/sponsorship	Organisation/Logistics	Reef Check Certified	Training weekends March 2021	Boating/diving and/or survey jobs	Science/ data analysis team	Report writing
Trevor	Barrenger		x	x	x	Boathandler		x
Vincenzo	Montalbano	x		x				
Zoe	Meziere						x	

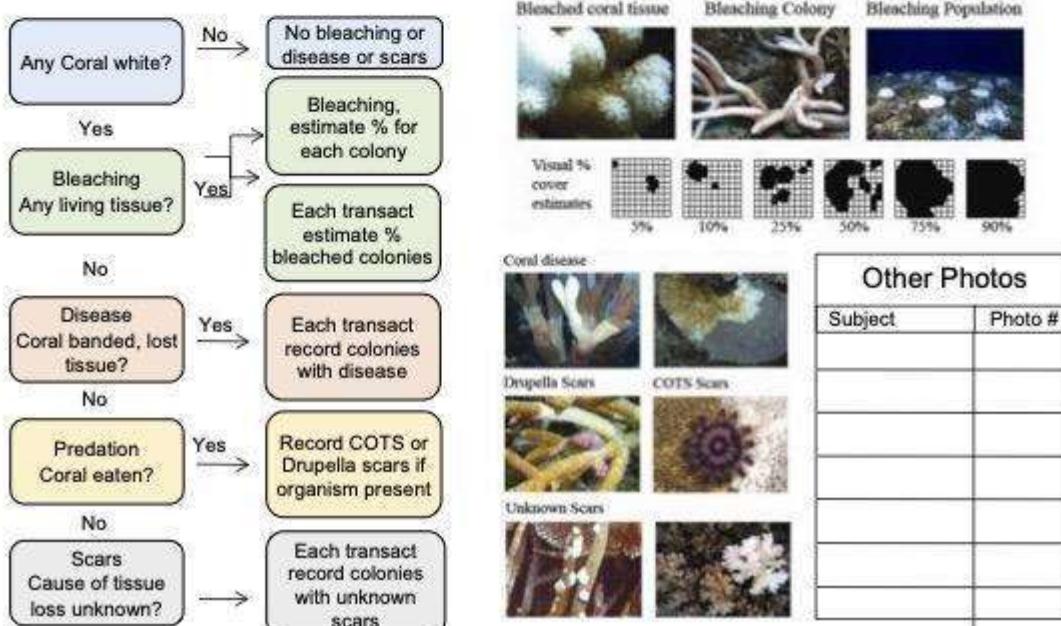
## Appendix B: Data Sheets

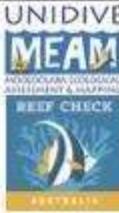
Reef Check Belt Transact – Substrate SEQ														
Dive site name:				Reef name:										
Date:				Depth										
Time:				Habitat:										
Data recorded by:				Site number:										
Camera ID:				Team leader:										
<b>HC – Hard Coral</b> HCB – Bleached hard coral HCBR – Branching hard coral HCM – Massive hard coral HCF – Foliose hard coral HCP – Plate hard coral HCE – Encrusting hard coral				<b>SC – Soft Coral</b> SCL – Leathery soft coral SCZ – Zoanthids SCB – Bleached soft coral				<b>RKC – Recently Killed Coral</b> RKNIA – Recently killed coral & NIA RKCTA – Recently killed coral & turf algae						
				<b>OT – Other</b> OTC – Corallimorph				<b>NIA – Nutrient Indicator Algae</b>						
<b>SP – Sponge</b> SPE – Encrusting sponge				<b>RC – Rock</b> RCTA – Turf algae RCCA – Coralline algae				<b>SI – Silt/Clay</b> RB – Rubble SD – Sand						
0-20m			25-45m			50-70m			75-95m					
0	10		25	35		50	60		75	85				
0.5	10.5		25.5	35.5		50.5	60.5		75.5	85.5				
1	11		26	36		51	61		76	86				
1.5	11.5		26.5	36.5		51.5	61.5		76.5	86.5				
2	12		27	37		52	62		77	87				
2.5	12.5		27.5	37.5		52.5	62.5		77.5	87.5				
3	13		28	38		53	63		78	88				
3.5	13.5		28.5	38.5		53.5	63.5		78.5	88.5				
4	14		29	39		54	64		79	89				
4.5	14.5		29.5	39.5		54.5	64.5		79.5	89.5				
5	15		30	40		55	65		80	90				
5.5	15.5		30.5	40.5		55.5	65.5		80.5	90.5				
6	16		31	41		56	66		81	91				
6.5	16.5		31.5	41.5		56.5	66.5		81.5	91.5				
7	17		32	42		57	67		82	92				
7.5	17.5		32.5	42.5		57.5	67.5		82.5	92.5				
8	18		33	43		58	68		83	93				
8.5	18.5		33.5	43.5		58.5	68.5		83.5	93.5				
9	19		34	44		59	69		84	94				
9.5	19.5		34.5	44.5		59.5	69.5		84.5	94.5				
MA Tally			MA Tally			MA Tally			MA Tally					
Air	Time		Air	Time		Air	Time		Air	Time				
 Comments about 'other' category:														
Rare Animals: Circle SI category for site: N L M H N – None L – Low some SI M – Medium, Surface have thin SI layer H – High, Surface have thick SI layer														
MAA – Asparagopsis	MAP – Padina	MAS – Saragassum	MAT – Turbinaria											

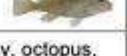


### Reef Check Belt Transect – Impacts SEQ

Dive site name:		Reef name:				
Date:		Depth				
Time:		Habitat:				
Data recorded by:		Site number:				
Camera ID:		Team leader:				
		0-20m	25-45m	50-70m	75-95m	Photo No.*
Bleaching	Estimate % impact for each bleached colony					
	Estimate % totals coral population					
Damage	Boat / Anchor					
	Coral Upside down					
	Other					
Coral Disease						
Coral Scars	Crown of Thorns					
	Drupella					
	Unknown/Other					
Trash	Fishing Line					
	Fish Nets					
	General Plastic					
	General not plastic					
Rare Animals						
Air						
Time						
Three dominant algae	1. Photo #	2. Photo #	3. Photo #			



 <b>REEF CHECK</b> <b>ANALOGUE AND DIGITAL BENTHOPHYTIC INVERTEBRATE RECORDING</b>		Reef Check Belt Transact – Inverts SEQ					
		Dive site name:		Reef name:			
		Date:		Depth			
		Time:		Habitat:			
		Data recorded by:		Site number:			
		Camera ID:		Team leader:			
		0-20m	25-45m	50-70m	75-95m	Photo No.*	
Anemone	With Fish						
	No Fish						
Banded Coral Shrimp							
COTS		< 6cm					
		6-15cm					
		15-25cm					
		>25cm					
Giant Clam		<10cm					
		10-20cm					
		20-30cm					
		30-40cm					
		40-50cm					
		>50cm					
Lobster, spiny & slippery							
Sea slugs							
Shells							
							
							
Sea Cucumbers							
							
							
	Other						
Sea Urchins							
							
							
Rare Animal							
	Air						
	Time						
		Dominant Algae	1)	2)	3)		

Reef Check Belt Transact – Fish SEQ						
	Dive site name:	Reef name:				
	Date:	Depth				
	Time:	Habitat:				
	Data recorded by:	Site number:				
	Camera ID:	Team leader:				
		0-20m	25-45m	50-70m	75-95m	Photo No.*
Barramundi Cod						
Butterfly						
Grouper	Coral Trout	30-40cm				
		40-50cm				
		50-60cm				
		>60cm				
Wrasse	Grouper	30-40cm				
		40-50cm				
		50-60cm				
		>60cm				
Wrasse	Queensland					
	Eastern Blue Groper					
	Tuskfish					
	Humphead					
Moray Eel						
Parrotfish	Bumphead					
	Other	0-20cm				
		> 20cm				
Snapper / Emperor	Snapper (generic)					
	Pink snapper					
	Emperor (generic)					
Morwong						
Sweetlip						
Rare animals (turtle, ray, octopus, zebra, wobbie, other shark, etc)						
	Air					
	Time					

## Appendix C: Species List

**Key:** PHYLUM, Species Name, Common name

### ANIMALS

#### **ANNELIDA (Worms)**

<i>Bispira porifera</i>	Spongy Fanworm
<i>Chloeria sp. 1</i>	
<i>Choleia sp. 2</i>	
<i>Eurythoe complanata</i>	Orange Fire Worm
<i>Filograna implexa</i>	Tube worm
<i>Hesione splendida</i>	Splendid Worm
<i>Lepidonotus melanogrammus</i>	Dark-marked Scale Worm
<i>Odontosyllis sp. 1</i>	
<i>Sabellastarte indica</i>	Tube worm
<i>Sabellastarte sp. 6</i>	
<i>Spirobranchus giganteus</i>	Christmas tree worm

#### **ARTHROPODA (Crustaceans/Barnacles)**

<i>Aethra scruposa</i>	Stealth Crab
<i>Allogalathea elegans</i>	Elegant Crinoid Squat Lobster
<i>Aretha edentata</i>	Smooth Elbow Crab
<i>Camposcia retusa</i>	Blunt Decorator Crab
<i>Ciliopagurus strigatus</i>	Halloween Hermit Crab
<i>Cymothoid sp. 1</i>	
<i>Etisus demani</i>	
<i>Hamodactylus sp. 3</i>	
<i>Hymenocera picta</i>	Harlequin Shrimp
<i>Lissocarcinus orbicularis</i>	Sea Cucumber Crab
<i>Majidae sp. 1</i>	
<i>Nerocila sp. 1</i>	Dark Stripe Fish Isopod
<i>Panulirus ornatus</i>	Ornate Rock Lobster
<i>Panulirus versicolor</i>	Painted spiny lobster

<i>Rhynchocinetes durbanensis</i>	Dancing Shrimp
<i>Scyllarides squamosus</i>	Blunt Slipper Lobster
<i>Stenopus hispidus</i>	Banded coral shrimp
<i>Thor amboinensis</i>	Squat Shrimp

#### **BRYOZOA (Moss Animals)**

<i>Bilustra sp. 1</i>	
<i>Celleporaria sp. 1</i>	
<i>Idmidronea sp. 1</i>	
<i>Philodoridae sp.</i>	
<i>Reteporella graeffei</i>	
<i>Triphillozoon sp. 1</i>	

#### **CHORDATA**

##### **Angelfish**

<i>Centropyge bicolor</i>	Bicolor angelfish
<i>Centropyge tibicen</i>	Keyhole angelfish
<i>Centropyge vroliki</i>	Pearlscale angelfish
<i>Chaetodontoplus meredithi</i>	Queensland Yellowtail Angelfish
<i>Pomacanthus semicirculatus</i>	Blue Angelfish

##### **Barracudas**

<i>Sphyraena obtusata</i>	Yellowtail Barracuda
<i>Sphyraena qenie</i>	Blackfin Barracuda

##### **Bigeyes**

<i>Heteropriacanthus carolinus</i>	Red Big-eye
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##### **Blennies**

<i>Aspidontus dussumieri</i>	Lance blenny
<i>Aspidontus dussumieri</i>	Lance Blenny
<i>Aspidontus taeniatus</i>	False Cleanerfish
<i>Cirripectes castaneus</i>	Chestnut Blenny

<i>Cirripectes chelomatus</i>	Lady Musgrave Blenny
<i>Cirripectes sp.</i>	
<i>Crossosalarias macrospilus</i>	Triplespot blenny
<i>Ecsenius bicolor</i>	Combtooth blenny
	Smallspotted Combtooth Blenny
<i>Ecsenius stictus</i>	
<i>Istiblennius meleagris</i>	Peacock Blenny
<i>Laiphognathus multimaculatus</i>	Many Spotted Blenny
<i>Meiacanthus lineatus</i>	Lined Fangblenny
<i>Omobranchus punctatus</i>	Muzzled Blenny
<i>Parablennius intermedius</i>	False Tasmanian Blenny
<i>Parenchelyurus hepburni</i>	Bluespotted Blenny
	Yellow sabretooth blenny
<i>Petroscirtes fallax</i>	
<i>Plagiotremus rhinorhynchos</i>	Bluestriped pigfish
<i>Plagiotremus tapeinosoma</i>	Piano fangblenny

<i>Heniochus varius</i>	Horned bannerfish
<i>Parachaetodon ocellatus</i>	Ocellate Butterflyfish

### Cardinalfish

<i>Apogon capricornis</i>	Capricorn Cardinalish
<i>Apogon crassiceps</i>	Little Red Cardinalfish
<i>Apogon doederleini</i>	Fourline cardinalfish
<i>Apogon lavus</i>	Yellow cardinalfish
<i>Apogon limenus</i>	Sydney cardinalfish
<i>Apogon properuptus</i>	Coral cardinalfish
<i>Cheilodipterus isostigma</i>	Toothy Cardinalfish
<i>Cheilodipterus macrodon</i>	Tiger cardinalfish
<i>Ostorhinchus capricornis</i>	Capricorn Cardinalfish
<i>Ostorhinchus doederleini</i>	Fourline Cardinalfish
<i>Ostorhinchus limenus</i>	Sydney Cardinalfish
<i>Ostorhinchus properuptus</i>	Coral Cardinalfish
<i>Rhabdamia gracilis</i>	Slender Cardinalfish
<i>Taeniamia fucata</i>	Painted Cardinalfish
<i>Taeniamia zosterophora</i>	Girdled Cardinalfish

### Butterflyfish

<i>Chaetodon auriga</i>	Threadfin butterflyfish
<i>Chaetodon citrinellus</i>	Citron Butterflyfish
<i>Chaetodon flavirostris</i>	Dusky Butterflyfish
<i>Chaetodon guentheri</i>	Guenther's butterflyfish
<i>Chaetodon kleini</i>	Klein's Butterflyfish
<i>Chaetodon lavirostris</i>	Dusky butterflyfish
<i>Chaetodon lunulatus</i>	Pinstripe Butterflyfish
<i>Chaetodon plebeius</i>	Bluespot Butterflyfish
<i>Chaetodon rainfordi</i>	Rainford's Butterflyfish
<i>Chaetodon trifascialis</i>	Chevron butterflyfish
<i>Chaetodon unimaculatus</i>	Teardrop butterflyfish
<i>Chelmon muelleri</i>	Muller's Coralfish
<i>Chelmon rostratus</i>	Beaked Coralfish
<i>Chelmonops truncatus</i>	Eastern talma
<i>Coradion altivelis</i>	Highfin coralfish
<i>Forcipiger flavissimus</i>	Forceps Butterflyfish
<i>Heniochus acuminatus</i>	Longfin bannerfish
<i>Heniochus chrysostomus</i>	Pennant bannerfish
<i>Heniochus diphreutes</i>	Schooling Bannerfish
<i>Heniochus monoceros</i>	Masked bannerfish

### Clinids

<i>Heteroclinus nasutus</i>	Large-nose Weedfish
<i>Heteroclinus whiteleggi</i>	Banded Weedfish

### Cods/Groupers/Anthias

<i>Cephalopholis argus</i>	Peacock Cod
<i>Cephalopholis miniata</i>	Coral rockcod
<i>Cromileptes altivelis</i>	Barramundi Cod
<i>Diplopion bifasciatum</i>	Barred soapfish
<i>Epinephelus coioides</i>	Gold spotted rockcod
<i>Epinephelus cyanopodus</i>	Purple rockcod
<i>Epinephelus fasciatus</i>	Blacktip rockcod
<i>Epinephelus maculatus</i>	Highfin groper
<i>Epinephelus malabaricus</i>	Blackspotted Rockcod
<i>Epinephelus quoyanus</i>	Longfin Rockcod
<i>Epinephelus undulostriatus</i>	Maori rockcod

<i>Plectropomus leopardus</i>	Common coral trout
<i>Pseudanthias squamipinnis</i>	Orange basslet
<i>Rainfordia opercularis</i>	

### Cornetfish/Fluemouths

<i>Fistularia commersonii</i>	Smooth Flutemouth
<i>Fistularia petimba</i>	Rough flutemouth

### Damselfish/Clownfish

<i>Abudefduf bengalensis</i>	Bengal sergeant
<i>Abudefduf sexfasciatus</i>	Sissor-tail Sergeant
<i>Abudefduf sordidus</i>	Black-spot Sergeant
<i>Abudefduf vaigiensis</i>	Indo-pacific sergeant
<i>Abudefduf whitleyi</i>	Whitley's Sergeant
<i>Amblyglyphidodon curacao</i>	Staghorn damsel
<i>Amphiprion akindynos</i>	Barrier reef anemonefish
<i>Amphiprion clarkii</i>	Clark's Anemonefish
<i>Amphiprion latezonatus</i>	Wideband anemonefish
<i>Amphiprion polymnus</i>	Saddleback Anemonefish
<i>Chromis atripepectoralis</i>	Blackaxil puller
<i>Chromis margaritifer</i>	Whitetail puller
<i>Chromis nitida</i>	Yellowback puller
<i>Chromis weberi</i>	Weber's puller
<i>Chrysiptera biocellata</i>	Two-spot Damselfish
<i>Chrysiptera lavipinnis</i>	Yellowfin demoiselle
<i>Chrysiptera rollandi</i>	Bluehead demoiselle
<i>Chrysiptera talboti</i>	Talbot's demoiselle
<i>Dascyllus reticulatus</i>	Headband humbug
<i>Dascyllus reticulatus</i>	Reticulated Dascyllus
<i>Dascyllus trimaculatus</i>	Three-spot Humbug
<i>Mecaenichthys immaculatus</i>	Immaculate Damsel
<i>Neoglyphidodon melas</i>	Black damsel
<i>Neoglyphidodon nigroris</i>	Scarface damsel
<i>Neopomacentrus azyron</i>	yellowtail demoiselle
<i>Neopomacentrus bankieri</i>	Chinese demoiselle
<i>Neopomacentrus cyanomos</i>	Regal pigfish

<i>Parma oligolepis</i>	Bigscale scalyfin
<i>Parma unifasciata</i>	Girdled Scalyfin
<i>Plectroglyphidodon apicalis</i>	Australian Gregroy
<i>Plectroglyphidodon dickii</i>	Dick's damsel
<i>Plectroglyphidodon lacrymatus</i>	Jewel Damsel
<i>Plectroglyphidodon leucozona</i>	Whiteband damsel
<i>Pomacentrinae</i>	
<i>Pomacentrus amboinensis</i>	Ambon damsel
<i>Pomacentrus australis</i>	Australian damsel
<i>Pomacentrus bankanensis</i>	Speckled damsel
<i>Pomacentrus brachialis</i>	charcoal damsel
<i>Pomacentrus coelestis</i>	Neon damsel
<i>Pomacentrus lepidogenys</i>	Scaly damsel
<i>Pomacentrus moluccensis</i>	lemon damsel
<i>Pomacentrus nagasakiensis</i>	Blue-scribbled damsel
<i>Pomacentrus wardi</i>	Ward's damsel
<i>Pristotis obtusirostris</i>	Gulf damsel
<i>Stegastes apicalis</i>	yellowtip gregory
<i>Stegastes fasciolatus</i>	Pacific gregory
<i>Stegastes partitus</i>	Coral sea gregory

### Dottybacks

<i>Ogilbyina novaehollandiae</i>	Multicoloured Dottyback
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### Dragonet

<i>Calliurichthys ogilbyi</i>	Ogilby's Stinkfish
<i>Diplogrammus goramensis</i>	Goram dragonet
<i>Eocallionymus papilio</i>	Butterfly Dragonet

### Driftfish

<i>Cubiceps whiteleggii</i>	Coastal Cubehead
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### Emperors

<i>Lethrinus genivittatus</i>	Threadfin Emperor
<i>Lethrinus laticaudis</i>	Grass emperor

<i>Lethrinus miniatus</i>	Redthroat emperor
<i>Lethrinus nebulosus</i>	Spangled emperor

### Flatfish

<i>Pardachirus hedleyi</i>	Peacock Sole
<i>Zebrias scalaris</i>	Many-band Sole

### Flatheads

<i>Cymbacephalus nematophthalmus</i>	Fringe-eye Flathead
<i>Platycephalus fuscus</i>	Dusky Flathead
<i>Platycephalus grandispinis</i>	Long-spine Flathead
<i>Thysanophrys cirronasus</i>	Rock Flathead

### Flounders

<i>Engyprosopon grandisquama</i>	Largescale Flounder
<i>Engyprosopon maldivensis</i>	Olive Wide-eye Flounder

### Foolfish/Leatherjackets/Shingles

<i>Anacanthus barbatus</i>	Bearded Leatherjacket
<i>Cantherhines pardalis</i>	Honeycomb leatherjacket
<i>Cantheschenia grandisquamis</i>	largescale leatherjacket
<i>Oxymonacanthus longirostris</i>	Harlequin filefish

### Foolfish/Leatherjackets/Shingles

<i>Aluterus monoceros</i>	Unicorn File-fish
<i>Aluterus scriptus</i>	Scrawled Filefish
<i>Anacanthus barbatus</i>	Bearded Leatherjacket
<i>Arotrolepis filicauda</i>	Threadfin Leatherjacket
<i>Cantherhines pardalis</i>	Honeycomb leatherjacket
<i>Cantheschenia grandisquamis</i>	largescale leatherjacket
<i>Oxymonacanthus longirostris</i>	Harlequin filefish
<i>Pervagor janthinosoma</i>	Blackbar Filefish
<i>Pseudomonacanthus peroni</i>	Potbelly Leatherjacket

### Frogfish

<i>Antennarius commerson</i>	Giant Frogfish
<i>Antennarius pictus</i>	Painted Anglerfish
<i>Antennarius striatus</i>	Blotched Anglerfish
<i>Histiophryne maggiewalker</i>	

### Fusiliers

<i>Caesio cuning</i>	Yellowtail Fusilier
<i>Pterocaesio chrysozona</i>	Yellowband fusilier
<i>Pterocaesio digramma</i>	Doubleline fusilier

### Goatfish

<i>Mulloidichthys vanicolensis</i>	Goldstripe Goatfish
<i>Parupeneus multifasciatus</i>	Banded goatfish
<i>Parupeneus spilurus</i>	Blacksaddle goatfish
<i>Upeneus tragula</i>	Bartail goatfish

### Gobies

<i>Amblyeleotris periophthalma</i>	Broad-banded shrimpgoby
<i>Amblyeleotris wheeleri</i>	Burgundy shrimpgoby
<i>Bathygobius cocosensis</i>	Cocos Frillgoby
<i>Bathygobius krefftii</i>	Frayedfin Goby
<i>Bathygobius laddi</i>	Brownboy Goby
<i>Bryaninops amplus</i>	Large Whippogoby
<i>Bryaninops loki</i>	Loki Whippogoby
<i>Callogobius depressus</i>	Flathead Goby
<i>Eviota</i>	Greenies
<i>Eviota albolineata</i>	Whitelined eviota
<i>Eviota cf. teresae</i>	Whitelined Eviota
<i>Eviota teresae</i>	Terry's Pygmygoby
<i>Fusigobius neophytus</i>	Neophyte Sandgoby
<i>Gobiodon quinquestrigatus</i>	Fiveline Coralgoby
<i>Istigobius decoratus</i>	Decorated sandgoby

<i>Istigobius nigroocellatus</i>	Blackspotted sandgoby
<i>Priolepis nuchifasciata</i>	Orange Reef-goby
<i>Valenciennea immaculata</i>	Immaculate glidergoby
<i>Valenciennea puellaris</i>	Orange-dashed Goby
<i>Valenciennea strigata</i>	Blueband glidergoby

#### Longfins

<i>Belonepterygion fasciolatum</i>	Banded Longfin
<i>Paraplesiops poweri</i>	Northern Blue Devil
<i>Trachinops taeniatus</i>	Eastern Hulafish

#### Marblefish/Sea Carp

<i>Aplodactylus lophodon</i>	Cockatoo Fish
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#### Hawkfish

<i>Cirrhitichthys aprinus</i>	Threadfin Hawkfish
<i>Cirrhitichthys falco</i>	Dwarf Hawkfish
<i>Cirrhitichthys oxycephalus</i>	Pixy Hawkfish

#### Monos/Moonfish

<i>Monodactylus argenteus</i>	Diamondfish
<i>Schuettea</i>	
<i>Schuettea scalaripinnis</i>	Eastern Pomfred

#### Lion/Stonewfish

<i>Dendrochirus zebra</i>	Zebra lionfish
<i>Parascorpaena aurita</i>	Golden Scorpionfish
<i>Parascorpaena picta</i>	Painted Scorpionfish
<i>Pterois volitans</i>	Common Lionfish
<i>Scorpaena</i>	
<i>Scorpaena cardinalis</i>	Eastern Red Scorpionfish
<i>Scorpaena jacksoniensis</i>	Eastern Red Scorpionfish
<i>Scorpaenopsis papuensis</i>	Papuan Scorpionfish
<i>Scorpaenopsis venosa</i>	Raggy scorpionfish
<i>Scorpis lineolata</i>	Silver sweep
<i>Sebastapistes cyanostigma</i>	Yellowspotted Scorpionfish
<i>Taenianotus triacanthus</i>	Leaf Scorpionfish

#### Moray Eels

<i>Echidna nebulosa</i>	Starry Moray
<i>Gymnothorax cribroris</i>	Crib Moray
<i>Gymnothorax eurostus</i>	Stout Moray
<i>Gymnothorax favagineus</i>	Tessellate Moray
<i>Gymnothorax meleagris</i>	Whitemouth Moray
<i>Gymnothorax pseudothyrsoideus</i>	False Spotted Moray
<i>Strophidon sathete</i>	Long-tailed Eel

#### Morwongs

<i>Cheilodactylus fuscus</i>	Red Morwong
<i>Cheilodactylus vestitus</i>	Crested morwong
<i>Goniistius vestitus</i>	Eastern Morwong

#### Lizardfish

<i>Saurida undosquamis</i>	Large-scaled Grinner
<i>Synodus dermatogenys</i>	Banded lizardfish
<i>Synodus jaculum</i>	Tailspot Lizardfish
<i>Synodus variegatus</i>	Variegated lizardfish
<i>Trachinocephalus myops</i>	Painted Lizardfish

#### Mullet

<i>Myxus elongatus</i>	Black Spot Mullet
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#### Parrotfish

<i>Scarus frenatus</i>	Sixband Parrotfish
<i>Scarus rubroviolaceus</i>	Redlip Parrotfish
<i>Scarus sp.</i>	Parrotfish

**Pipefish**

<i>Festucalex cinctus</i>	Girdled Pipefish
<i>Stigmatopora nigra</i>	Wide-bodied Pipefish

**Porcupinefish**

<i>Didemnium sp.1</i>	
<i>Didemnium sp.2</i>	
<i>Diodon hystrix</i>	Spotted porcupinefish
<i>Lissoclinum bistratum</i>	
<i>Lissoclinum sp.1</i>	

**Pufferfish**

<i>Arothron hispidus</i>	Stars and stripes puffer
<i>Arothron mappa</i>	Map Puffer
<i>Arothron stellatus</i>	Black-lined Pufferfish
<i>Canthigaster valentini</i>	Blacksaddle toby
<i>Lagocephalus cheesemanii</i>	Cheeseman's Puffer
<i>Marilyna pleurosticta</i>	Banded Toadfish
<i>Tetraclenos hamiltoni</i>	Common Toadfish
<i>Torquigener whitleyi</i>	Whitley's Toadfish

**Rabbitfish**

<i>Siganus argenteus</i>	Forktail Rabbitfish
<i>Siganus canaliculatus</i>	Whitespotted Rabbitfish
<i>Siganus fuscescens</i>	Black rabbitfish

**Ray-finned fish**

<i>Alectis ciliaris</i>	African Pompano
<i>Alepes</i>	
<i>Carangoides fulvoguttatus</i>	Turrum
<i>Carangoides gymnostethus</i>	Bludger Trevally
<i>Caranx sexfasciatus</i>	Bigeye Trevally
<i>Gnathanodon speciosus</i>	golden Trevally
<i>Platycaranx chrysophrys</i>	Longnose Trevally
<i>Selaroides leptolepis</i>	Yellowstripe Scad
<i>Seriola dumerili</i>	Greater Amberjack
<i>Seriola lalandi</i>	Yellowtail Kingfish

***Trachinotus****coppingeri*

Swallowtail Dart

***Turrum****fulvoguttatum*

Yellow spotted trevally

**Sandperches*****Parapercis clathrata***

Spothead Grubfish

***Parapercis queenslandica***

Blacktail Grubfish

***Parapercis stricticeps***

Whitestreak grubish

**Sea Bream*****Acanthopagrus australis***

Yellowfin bream

***Chrysophrys auratus***

Snapper

***Rhabdosargus sarba***

Tarwhine

**Sea Chubs*****Kyphosus bigibbus***

Brown Chub

***Microcanthus strigatus***

Stripey

**Sea Robins*****Chelidonichthys******Lepidotrigla umbrosa***

Blackspot Gurnard

**Shark*****Carcharhinus obscurus***

Black Whaler

***Carcharodon carcharias***

Great White Shark

**Sharks*****Brachaelurus waddi***

Blind Shark

***Orectolobus maculatus***

Spotted Wobbegong

***Orectolobus ornatus***

Banded wobbegong

***Orectolobus ornatus***

Banded Carpet Shark

***Stegostoma fasciatum***

Zebra Shark

**Snake Eels*****Malvoliophis pinguis***

Half-banded Snake-eel

**Snappers*****Dipterygonotus balteatus***

Mottled Fusilier

<i>Lutjanus argentimaculatus</i>	Mangrove jack
<i>Lutjanus bohar</i>	Red bass
<i>Lutjanus carponotatus</i>	Sydney snapper
<i>Lutjanus fulviflamma</i>	Blackspot Snapper
<i>Lutjanus kasmira</i>	<i>Lutjanus kasmira</i>
<i>Lutjanus monostigma</i>	Onespot Snapper
<i>Lutjanus quinquefasciatus</i>	Fiveline Snapper
<i>Lutjanus rivulatus</i>	Blubberlip Snapper
<i>Lutjanus russelli</i>	Moses' snapper
<i>Lutjanus russellii</i>	Moses' Snapper
<i>Lutjanus sebae</i>	Red Emperor
<i>Symphorichthys spilurus</i>	Sailfin Snapper

### Spadefish/Batfish

<i>Platax batavianus</i>	Batavia Batfish
<i>Platax teira</i>	Roundface Batfish

### Squirrelfish/Soldierfish

<i>Myripristis murjan</i>	Crimson soldierfish
<i>Sargocentron diadema</i>	Crown Squirrelfish
<i>Sargocentron melanospilos</i>	Blackspot squirrelfish
<i>Sargocentron praslin</i>	Brownspot Squirrelfish
<i>Sargocentron rubrum</i>	Red squirrelfish

### Stargazers

<i>Ichthyscopus nigripinnis</i>	Blackfin Stargazer
<i>Ichthyscopus sannio</i>	Northern Stargazer

### Stripeys

<i>Microcanthus joyceae</i>	East-Australian Stripey
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### Surgeonfish/Tangs/Unicornfish

<i>Acanthurus dussumieri</i>	Pencil surgeonfish
<i>Acanthurus lineatus</i>	Striped Surgeonfish
<i>Acanthurus mata</i>	Pale surgeonfish

<i>Acanthurus nigricans</i>	Velvet surgeonfish
<i>Acanthurus nigrofasciatus</i>	Dusky surgeonfish
<i>Acanthurus triostegus</i>	Convict Surgeon
<i>Acanthurus xanthopterus</i>	Ring-tailed Surgeonfish
<i>Naso annulatus</i>	Ringtail unicornfish
<i>Naso tonganus</i>	Bluntnose Unicornfish
<i>Naso unicornis</i>	Bluespine unicornfish
<i>Prionurus maculatus</i>	Spotted Sawtail
<i>Prionurus microlepidotus</i>	Australian sawtail
<i>Zebrasoma scopas</i>	Brown tang

### Sweepers

<i>Parapriacanthus ransonneti</i>	Golden bullseye
<i>Pempheris afinis</i>	Blacktip bullseye
<i>Pempheris analis</i>	Bronze Bullseye
<i>Pempheris ypsilophorus</i>	Ypsilon Bullseye

### Sweetlips

<i>Diagramma labiosum</i>	Painted Sweetlips
<i>Diagramma pictum labiosum</i>	Painted sweetlips
<i>Plectorhinchus chaetodonoides</i>	Spotted Sweetlips
<i>Plectorhinchus flavomaculatus</i>	Goldspotted Sweetlips
<i>Plectorhinchus gibbosus</i>	Brown sweetlips
<i>Plectorhinchus lavomaculatus</i>	Goldspotted sweetlips
<i>Plectorhinchus picus</i>	Dotted sweetlips

### Threadfin bream/Whiptail Bream/False Snappers

<i>Pentapodus aureofasciatus</i>	Yellowstripe threadfin
<i>Pentapodus paradiseus</i>	Paradise threadfin
<i>Scolopsis bilineatus</i>	Two-line monocle bream
<i>Scolopsis lineata</i>	Green-lined Spine-cheek
<i>Scolopsis monogramma</i>	Rainbow monocle bream

**Tonguefish**

<i>Paraplagusia bilineata</i>	Doublelined Tonguesole
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**Triggerfish**

<i>Balistoides conspicillum</i>	Clown Triggerfish
<i>Rhinecanthus aculeatus</i>	Hawaiian Triggerfish
<i>Sufflamen chrysopterum</i>	Eye-stripe Triggerfish
<i>Sufflamen chrysopterum</i>	Halfmoon triggerfish
<i>Sufflamen fraenatus</i>	Masked triggerfish

**Triplefin Blennies**

<i>Enneapterygius atrofasciatus</i>	Black Triple-fins
<i>Enneapterygius rufopileus</i>	Blackcheek Threefin
<i>Enneapterygius similis</i>	Blacktail Triplefin
<i>Enneapterygius sp.</i>	Enneapterygius
<i>Norfolkia squamiceps</i>	Lord Howe Scaly-headed Triplefin

**Trumpetfish**

<i>Aulostomus chinensis</i>	Trumpetfish
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**Trunkfish/Boxfish**

<i>Lactoria cornuta</i>	Cow-fish
<i>Ostracion cubicum</i>	Yellow Boxfish
<i>Ostracion cubicus</i>	Yellow boxfish
<i>Tetrosomus reipublicae</i>	Smallspine Turretfish

**Venemous ray-finned fish/Wasfish**

<i>Inimicus caledonicus</i>	Bearded Ghoul
<i>Minous versicolor</i>	Black-banded Wasp-fish

**Viviparous brotula**

<i>Dinematichthys</i>	
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**Wasfish/Sailback Scorpionfish**

<i>Centropogon australis</i>	Eastern Fortescue
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**Whiptail Stingrays**

<i>Taeniura meyenii</i>	Blotched fantail Ray
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**Whiting**

<i>Sillago ciliata</i>	Blue Nose Whiting
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**Wobbegongs**

<i>Orectolobus maculatus</i>	Spotted Wobbegong
<i>Orectolobus ornatus</i>	Banded wobbegong

**Wrasses**

<i>Achoerodus viridis</i>	Eastern Blue Groper
<i>Anampsese caeruleopunctatus</i>	Diamond wrasse
<i>Anampsese geographicus</i>	Scribbled wrasse
<i>Anampsese neoguinaicus</i>	Blackback wrasse
<i>Austrolabrus maculatus</i>	Blackspotted Parrotfish
<i>Bodianus axillaris</i>	Coral pigfish
<i>Bodianus dictynna</i>	False diana's pigfish
<i>Bodianus mesothorax</i>	Eclipse Pigfish
<i>Bodianus perditio</i>	Goldspot Pigfish
<i>Cheilinus chlorourus</i>	Floral maori wrasse
<i>Choerodon fasciatus</i>	Harlequin tuskfish
<i>Choerodon graphicus</i>	Graphic tuskfish
<i>Choerodon schoenleinii</i>	Blackspot tuskfish
<i>Choerodon venustus</i>	Venus tuskfish
<i>Cirrhilabrus punctatus</i>	Finespot wrasse
<i>Coris aurilineata</i>	goldlined wrasse
<i>Coris batuensis</i>	Variegated wrasse
<i>Coris pictoides</i>	Pixy wrasse
<i>Gomphosus varius</i>	Birdnose wrasse
<i>Gomphosus varius</i>	Bird Wrasse
<i>Halichoeres margaritaceus</i>	Pearly Wrasse
<i>Halichoeres prosopoeion</i>	Twotone Wrasse
<i>Hemigymnus fasciatus</i>	Fiveband Wrasse
<i>Labroides dimidiatus</i>	Common cleanerfish

<i>Labropsis australis</i>	Southern tubelip
<i>Leptojulis cyanopleura</i>	shoulderspot wrasse
<i>Macropharyngodon</i>	Choati choat's wrasse
<i>Macropharyngodon choati</i>	Choat's Wrasse
<i>Macropharyngodon meleagris</i>	leopard wrasse
<i>Macropharyngodon negrosensis</i>	Black leopard wrasse
<i>Notolabrus gymnogenys</i>	Crimson-banded Parrot-fish
<i>Oxycheilinus bimaculatus</i>	Little maori wrasse
<i>Oxycheilinus diagrammus</i>	Violetline maori wrasse
<i>Pseudocheilinus hexataenia</i>	Sixline wrasse
<i>Pseudolabrus guentheri</i>	Gunther's wrasse
<i>Scarus ghobban</i>	Bluebarred Parrotfish
<i>Stethojulis bandanensis</i>	Redspot wrasse
<i>Stethojulis interrupta</i>	Brokenline wrasse
<i>Suezichthys gracilis</i>	Slender rainbow wrasse
<i>Thalassoma amblycephalum</i>	Indo-Pacific Bluehead Wrasse
<i>Thalassoma lunare</i>	Moon wrasse
<i>Thalassoma lutescens</i>	Green moon wrasse
<i>Thalassoma nigrofasciatum</i>	Jansen's wrasse

<i>Solenostomus paradoxus</i>	Ornate Ghostpipefish
<i>Synanceia horrida</i>	Estuarine Stonefish
<b>Turtles</b>	
<i>Caretta caretta</i>	Loggerhead Sea Turtle
<i>Chelonia mydas</i>	Green Sea Turtle
<i>Cheloniidae</i>	Typical Sea Turtles
<i>Emydura macquarii</i>	Macquarie Turtle
<i>Eretmochelys imbricata</i>	Hawksbill Turtle

<b>Chordata - Other</b>	
<i>Ascidia latesiphonica</i>	Ascidia latesiphonica
<i>Ascidia sp. 2 (undet.)</i>	Ascidia latesiphonica
<i>Cnemidocarpa stolonifera</i>	Orange-spouted Sea Squirt
<i>Eusynstyela latericius</i>	
<i>Gomophia sp. 1</i>	Coleman's Sea Star
<i>Herdmania momus</i>	Pink Trumpet Sea Squirt
<i>Microcosmus exasperatus</i>	Orange Leather Sea Squirt
<i>Phallusia arabica</i>	
<i>Phallusia julinea</i>	
<i>Phallusia obesa</i>	
<i>Polycarpa ovata</i>	
<i>Polycitor giganteus</i>	
<i>Pyura stolonifera</i>	
<i>Rhopalaea crassa</i>	
<i>Salpa fusiformis</i>	Torpedo salp
<i>Zanclus cornutus</i>	Moorish idol

#### Fish - Other

<i>Alabes parvula</i>	Eel Clingfish
<i>Anguilla reinhardtii</i>	Australian Long-finned Eel
<i>Centroberyx affinis</i>	Nannygai
<i>Diploprion bifasciatus</i>	Barred Soapfish
<i>Epinephelus</i>	Rockcods
<i>Latropiscis purpurissatus</i>	Sergeant Baker
<i>Pataecus fronto</i>	Red Foreheadfish
<i>Pseudanthias fasciatus</i>	Redstripe Basslet
<i>Pseudanthias rubrizonatus</i>	Redbar Anthias
<i>Scatophagus argus</i>	Butterfish

#### **CNIDARIA (Corals, Anemones, Jellyfish, Sea Firs)**

##### Anemone

<i>Boloceroides mcmurrichi</i>	Swimming anemone
<i>Heteractis crispa</i>	Sebae anemone

##### Jellyfish

<i>Vesuriga anadyomene</i>	Giant Crinkled Jellyfish
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##### Sea Fir

<i>Macrorhynchia philippina</i>	White Stinging Sea Fir
<i>Macrorhynchia phoenicea</i>	Orange Stinging Sea Fir
<i>Plumularia sp. 1</i>	
<i>Sertularella diaphana</i>	

### Hard Corals

<i>Acanthastrea echinata</i>	
<i>Acanthastrea lordhowensis</i>	
<i>Acropora muricata</i>	
<i>Acropora solitaryensis</i>	
<i>Acropora sp.</i>	
<i>Aulactinia sp. 1</i>	
<i>Cyphastrea serailia</i>	
<i>Echinophyllia sp.1</i>	
<i>Entacmaea quadricolor</i>	Bubble-tip Sea Anemone
<i>Favia speciosa</i>	
<i>Favites sp.</i>	
<i>Goniastrea sp.</i>	
<i>Goniopora</i>	
<i>Goniopora djiboutiensis</i>	<i>Goniopora djiboutiensis</i>
<i>Heteractis aurora</i>	Beaded Sea Anemone
<i>Heteractis magnifica</i>	Magnificent Anemone
<i>Heteractis malu</i>	Delicate Anemone
<i>Lobophylliidae sp. 1</i>	
<i>Oulophyllia crispa</i>	
<i>Pocillopora damicornis</i>	
<i>Seriatopora hystrix</i>	
<i>Stylasterid</i>	
<i>Tubastrea faulkneri</i>	
<i>Tubastrea micrantha</i>	
<i>Tubinaria mesenterina</i>	
<i>Turbinaria peltata</i>	

### Soft Corals

<i>Acanthogorgia sp.</i>	
<i>Capnella sp.1</i>	

<i>Carijoa sp.1</i>	
<i>Carijoa sp.2</i>	
<i>Cespitularia sp.1</i>	
<i>Chironephtya sp.1</i>	
<i>Chironephtya sp.2</i>	
<i>Cladiella sp.1</i>	
<i>Clavularia sp.1</i>	
<i>Dendronephthya sp.2</i>	
<i>Dendronephthya sp.3</i>	
<i>Dendronephthya sp.4</i>	
<i>Dendronephthya spp.</i>	Prickly Tree Coral
<i>Dichotella spp.</i>	Dichotella Sea Whips
<i>Dipsastraea danai</i>	
<i>Dipsastraea favus</i>	
<i>Echinogorgia sp.1</i>	
<i>Echinogorgia sp.2</i>	
<i>Echinogorgia sp.3</i>	
<i>Echinogorgia sp.4</i>	
<i>Echinogorgia sp.5</i>	
<i>Echinogorgia spp.</i>	Maze Sea Fans
<i>Goniastrea australensis</i>	Australian Brain Coral
<i>Goniastrea favulus</i>	<i>Goniastrea favulus</i>
<i>Iciligorgia sp.1</i>	
<i>Isis hippuris</i>	
<i>Junceella sp.1</i>	
<i>Klyxum sp.1</i>	
<i>Lobophytum sp.</i>	
<i>Menella spp.</i>	Menella Soft Coral
<i>Mopsella sp.1</i>	
<i>Paraplexaura spp.</i>	Paraplexaura Soft Coral
<i>Plumigorgia spp.</i>	
<i>Rumphella sp.1</i>	
<i>Sansibia sp.1</i>	
<i>Sarcophyton sp.</i>	
<i>Sarcophyton spp.</i>	
<i>Sinularia sp.</i>	
<i>Tubastraera diaphana</i>	Black Cup Coral
<i>Tubipora sp.</i>	
<i>Turbinaria mesenterina</i>	Meso Turbinaria

**Other**

<i>Antipathes sp. 1</i>	Black coral
<i>Palythoa sp.1</i>	Zooanthid

**CTENOPHORA**

<i>Coeloplana astericola</i>	Seastar Benthic Ctenophore
<i>Ocryopsis sp. 1</i>	

**ECHINODERMATA (Urchins, Cucumbers, Starfish)**

<i>Acanthaster planci</i>	Crown-of-Thorns Starfish
<i>Anthenea sp. 2</i>	
<i>Asthenosoma periculosum</i>	Stinging sea urchin
<i>Astrobrachion adhaerens</i>	Grasping Brittle Star
<i>Astrobrachion constrictum</i>	
<i>Cenolia sp.</i>	
<i>Cenolia tasmaniae</i>	Tasmanian Feather Star
<i>Clypeaster virescens</i>	Clypeaster virescens
<i>Comanthina nobilis</i>	
<i>Diadema savignyi</i>	Savigny's Spined Sea Urchin
<i>Echinaster callosus</i>	Warty seastar
<i>Echinaster luzonicus</i>	Luzon seastar
<i>Echinostrephus aciculatus</i>	Burrowing sea urchin
<i>Echinothrix calamaris</i>	Banded Sea Urchin
<i>Fromia indica</i>	Indian seastar
<i>Gomophia mamillifera</i>	Ornamented seastar
<i>Holothuria difcillis</i>	Sea cucumber
<i>Jacksonaster depressum</i>	Depressed Sand Dollar
<i>Linckia laevigata</i>	Blue Sea Star
<i>Linckia multifora</i>	Multipore Sea Star
<i>Massinium magnum</i>	Magnum Sea Cucumber
<i>Nepanthia belcheri</i>	Belcher's Sea Star
<i>Oligometrides adeonae</i>	
<i>Ophidiaster sp.</i>	Banded starfish
<i>Ophidiaster sp. 1</i>	Dark Sea Star
<i>Ophiomastix endeani</i>	Ophiomastix endeani
<i>Ophiothela sp.</i>	
<i>Oxycomanthus bennetti</i>	

<i>Pentagonaster dubeni</i>	Vermillion seastar
<i>Petricia vernicina</i>	Velvet Sea Star
<i>Pseudoboletia maculata</i>	Spotted Sea Urchin
<i>Tamaria sp.</i>	
<i>Tripneustes gratilla</i>	Collector Sea Urchin

**MOLLUSCA (Bivalves)****Clam**

<i>Gafrarium dispar</i>	Gafrarium dispar
<i>Lamarcka avellana</i>	Flying-Bird Ark
<i>Lioconcha castrensis</i>	Zigzag Venus
<i>Pinna deltodes</i>	Razor clam
<i>Placamen lamellatum</i>	Placamen lamellatum
<i>Plicatula</i>	Kittenpaw Shells
<i>Solen vaginoides</i>	Southern Razor Shell
<i>Trapezium oblongum</i>	Oblong Trapezium Clam
<i>Tridacna crocea</i>	Burrowing Giant Clam
<i>Tridacna gigas</i>	Giant Clam

**Cockle**

<i>Glycymeris grayana</i>	Glycymeris grayana
<i>Vasticardium vertebratum</i>	Vasticardium vertebratum

**Oyster**

<i>Dendostrea folium</i>	Leaf oyster
<i>Hyotissa hyotis</i>	Giant Coxcomb Oyster
<i>Pictada maculata</i>	Spotted pearl oyster
	New South Wales Pearl Shell
<i>Pinctada imbricata</i>	
<i>Pteria lata</i>	Red wing oyster
<i>Pteria penguin</i>	Penguin wing oyster
<i>Saccostrea scyphophilla</i>	Cupped Rock Oyster
<i>Spondylus squamosus</i>	Spinous Thorny Oyster
<i>Spondylus violaceascens</i>	Cliff Oyster

**Scallop**

<i>Pascahinnites coruscans</i>	Pascahinnites coruscans
<i>Pecten fumatus</i>	Pecten fumatus

## Octopuses, Squid, Cuttlefish, Nautilus

<i>Hapalochlaena fasciata</i>	Blue-lined Octopus
<i>Metasepia pfefferi</i>	Flamboyant Cuttlefish
<i>Nautilus pompilius</i>	Chambered Nautilus
<i>Octopus cyanea</i>	Day Octopus
<i>Sepia latimanus</i>	Broadclub Cuttlefish
<i>Sepia plangon</i>	Mourning Cuttlefish
<i>Sepioteuthis lessoniana</i>	Bigfin Reef Squid

## Mollusca - Other

<i>Abronica sp. 1</i>	
<i>Abronica sp. 2</i>	
<i>Actinocyclus verrucosus</i>	
<i>Adamantia concinna</i>	Diamond Ovulid
<i>Aegires cf. citrinus</i>	
<i>Aegires citrinus</i>	
<i>Aegires exeches</i>	
<i>Aegires flores</i>	
<i>Aegires gardineri</i>	
<i>Aegires hapsis</i>	
<i>Aegires incusus</i>	
<i>Aegires minor</i>	
<i>Aegires villosus</i>	
<i>Aldisa pikokai</i>	
<i>Amoria zebra</i>	Zebra Volute
<i>Aplysia concavia</i>	
<i>Ardeadoris angustolutea</i>	
<i>Ardeadoris averni</i>	
<i>Ardeadoris egretta</i>	
<i>Ardeadoris electra</i>	
<i>Ardeadoris rubroannulata</i>	
<i>Ardeadoris sp. 1</i>	
<i>Ardeadoris symmetrica</i>	
<i>Astralium tentoriiforme</i>	Tent Turban
<i>Atagema albata</i>	
<i>Atagema ornata</i>	
<i>Atagema sp. 2</i>	
<i>Atagema spongiosa</i>	
<i>Atys semistriatus</i>	

<i>Atys sp. 2</i>	
<i>Atys sp. 7</i>	
<i>Astrocochlea porcata</i>	Zebra Top Snail
<i>Austrolittorina unifasciata</i>	Little Blue Periwinkle
<i>Babakina indopacifica</i>	
<i>Baeolidia variabilis</i>	
<i>Bembicium</i>	Bembicium
<i>Berthella martensi</i>	
<i>Berthellina delicata</i>	
<i>Bistolida stolida lorrainae</i>	Bistolida stolida lorrainae
<i>Biuve fulvipunctata</i>	
<i>Bornella anguilla</i>	
<i>Bornella sp. 1</i>	
<i>Bornella stellifer</i>	
<i>Bouchetiphora aspergata</i>	
<i>Bouchetiphora pallida</i>	Pallid Sinistral Creeper
<i>Bulbaeolidia alba</i>	
<i>Bulla vernicosa</i>	
<i>Cadlina sp. 1</i>	
<i>Cadlinella ornatissima</i>	
<i>Callistochiton antiquus</i>	Antique Chiton
<i>Callochiton crocinus</i>	Red-mark Chiton
<i>Caloria indica</i>	
<i>Calpurnus verrucosus</i>	Toenail Cowry
<i>Carminodoris flammea</i>	
<i>Carminodoris pustulata</i>	
<i>Carminodoris sp. 1</i>	
<i>Cellana tramoserica</i>	Variegated limpet
<i>Ceratosoma sp. 1</i>	
<i>Ceratosoma sp. 2</i>	
<i>Ceratosoma tenuie</i>	
<i>Ceratosoma trilobatum</i>	
<i>Cerithium echinatum</i>	Spiny Cerith

<i>Cerithium novaehollandiae</i>	New Holland Cerith	<i>Coralliophila monodonta</i>	Coralliophila monodonta
<i>Charonia tritonis</i>	Giant Triton	<i>Coriocella nigra</i>	Black Velvet Snail
<i>Chelidonura electra</i>		<i>Coriocella tongana</i>	Tonga Lamellaria
<i>Chelidonura hirundinina</i>		<i>Coryphellina exoptata</i>	
<i>Chicoreus ramosus</i>	Giant murex	<i>Coryphellina lotos</i>	
<i>Chromodoris</i>	Chromodoris	<i>Coryphellina pannae</i>	
<i>Chromodoris annae</i>		<i>Costasiella formicaria</i>	
<i>Chromodoris aspersa</i>		<i>Costasiella kuroshimae</i>	
<i>Chromodoris burni</i>		<i>Cratena affinis</i>	
<i>Chromodoris cf. magnifica</i>		<i>Cratena lineata</i>	
<i>Chromodoris colemani</i>		<i>Cratena simba</i>	
<i>Chromodoris elisabethina</i>		<i>Crenavolva tinctura</i>	Tinted Crenavolva
<i>Chromodoris kuiteri</i>		<i>Cribrarula cribaria</i>	Sieve Cowry
<i>Chromodoris lochi</i>		<i>Crimora edwardsi</i>	
<i>Chromodoris magnifica</i>		<i>Crimora sp. 1</i>	
<i>Chromodoris sp. 2</i>		<i>Cyerce kikutarobabai</i>	
<i>Chromodoris sp. 3</i>		<i>Cyerce sp. 2</i>	
<i>Chromodoris sp. 5</i>		<i>Cyllichnatys campanula</i>	
<i>Chromodoris splendida</i>		<i>Cymatium parthenopium</i>	Broad-ripped triton
<i>Chromodoris strigata</i>		<i>Cypraea sp.</i>	Cowrie shell
<i>Chromodoris willani</i>		<i>Cypraea tigris</i>	Tiger Cowry
<i>Clavus unizonalis</i>	One-zoned Turrid	<i>Dendrodoris albobrunnea</i>	
<i>Colinatys sp. 1</i>		<i>Dendrodoris coronata</i>	
<i>Colpodaspis thompsoni</i>		<i>Dendrodoris denisoni</i>	
<i>Conuber incei</i>	Conuber incei	<i>Dendrodoris fumata</i>	
<i>Conus ammiralis</i>	Admiral Cone	<i>Dendrodoris nigra</i>	
<i>Conus catus</i>	Conus catus	<i>Dendrodoris sp. 4</i>	
<i>Conus chaldaeus</i>	Conus chaldaeus	<i>Dendrodoris sp. 6</i>	
<i>Conus coronatus</i>	Coronated Cone	<i>Dendrodoris sp. 7</i>	
<i>Conus miles</i>	Soldier Cone	<i>Dermatobranchus</i>	Dermatobranchus
<i>Conus musicus</i>	Music Cone	<i>Dermatobranchus cf. tuberculatus</i>	
<i>Conus omaria</i>	Omaria Cone	<i>Dermatobranchus fasciatus</i>	
<i>Conus sp.</i>	Cone shell	<i>Dermatobranchus fortunatus</i>	
<i>Conus textile</i>	Textile Cone		
<i>Conus varius</i>	Freckled Cone		

<i>Dermatobranchus oculus</i>	
<i>Dermatobranchus ornatus</i>	
<i>Dermatobranchus rodmani</i>	
<i>Dermatobranchus semilunus</i>	
<i>Dermatobranchus sp. 13</i>	
<i>Dermatobranchus sp. 5</i>	
<i>Dermatobranchus sp. 7</i>	
<i>Dermatobranchus sp. 8</i>	
<i>Dermatobranchus sp. 9</i>	
<i>Dermatobranchus tuberculatus</i>	
<i>Diacavolinia longirostris</i>	
<i>Diminovula margarita</i>	Margarita Pearl-ovulid
<i>Discodorid sp. 2</i>	
<i>Discodoris coerulescens</i>	
<i>Discodoris lilacina</i>	
<i>Diversidoris aurantionodulosa</i>	
<i>Diversidoris crocea</i>	
<i>Diversidoris flava</i>	
<i>Diversidoris sp. 1</i>	
<i>Diversidoris sp. 2</i>	
<i>Diversidoris sp. 3</i>	
<i>Dolabrifera dolabrifera</i>	
<i>Doriprismatica atromarginata</i>	
<i>Doriprismatica dendrobranchia</i>	
<i>Doris sp. 1</i>	
<i>Doto racemosa</i>	
<i>Doto rosacea</i>	
<i>Doto ussi</i>	
<i>Drupella rugosa</i>	Purple-mouthed Drupe
<i>Elysia maoria</i>	
<i>Elysia pusilla</i>	
<i>Elysia sp. 11</i>	
<i>Elysia sp. 12</i>	
<i>Elysia sp. 13</i>	
<i>Elysia sp. 14</i>	
<i>Elysia sp. 17</i>	
<i>Elysia sp. 2</i>	
<i>Elysia sp. 24</i>	
<i>Elysia sp. 4</i>	
<i>Elysia sp. 5</i>	
<i>Elysia sp. 6</i>	
<i>Elysia sp. 9</i>	
<i>Engina zonalis</i>	Engina zonalis
<i>Epidendrium</i>	Epidendrium
<i>Erronea errores</i>	Erroneous Cowry
<i>Erronea xanthodon</i>	Erronea xanthodon
<i>Eubranchus mandapamensis</i>	
<i>Eubranchus sp. 11</i>	
<i>Eubranchus sp. 3</i>	
<i>Eubranchus sp. 6</i>	
<i>Euselenops luniceps</i>	
<i>Fabellina rubrolineata</i>	
<i>Facelina bourailli</i>	
<i>Facelina sp. 3</i>	
<i>Facelina sp. 6</i>	
<i>Facelina sp. 7</i>	
<i>Favorinus japonicus</i>	
<i>Favorinus sp. 1</i>	
<i>Favorinus sp. 2</i>	
<i>Favorinus sp. 3</i>	
<i>Flabellina sp. 9</i>	
<i>Geitodoris sp. 2</i>	
<i>Glaucus atlanticus</i>	Sea Swallow
<i>Glossodoris aeruginosa</i>	
<i>Glossodoris atromarginata</i>	
<i>Glossodoris cincta</i>	
<i>Glossodoris hikuerensis</i>	
<i>Glossodoris rufomarginata</i>	
<i>Glossodoris sp. 3</i>	
<i>Glossodoris sp. 4</i>	

<i>Glossodoris</i> sp. 5	
<i>Glossodoris vespa</i>	
<i>Goniobranchus albonares</i>	
<i>Goniobranchus albopunctatus</i>	
<i>Goniobranchus alias</i>	
<i>Goniobranchus aureopurpureus</i>	
<i>Goniobranchus coi</i>	
<i>Goniobranchus collingwoodi</i>	
<i>Goniobranchus daphne</i>	
<i>Goniobranchus decorus</i>	
<i>Goniobranchus geometricus</i>	
<i>Goniobranchus kuniei</i>	
<i>Goniobranchus leopardus</i>	
<i>Goniobranchus roboi</i>	Tooth-edged Nudibranch
<i>Goniobranchus rufomaculatus</i>	
<i>Goniobranchus</i> sp. 1	
<i>Goniobranchus</i> sp. 2	
<i>Goniobranchus</i> sp. 6	
<i>Goniobranchus</i> sp. 7	
<i>Goniobranchus</i> sp. 8	
<i>Goniobranchus splendidus</i>	
<i>Goniobranchus splendidus</i>	Splendid Goniobranch
<i>Goniobranchus tinctorius</i>	
<i>Goniobranchus verrieri</i>	
<i>Goniodoridella savignyi</i>	
<i>Gymnodoris alba</i>	
<i>Gymnodoris amakusana</i>	
<i>Gymnodoris okinawae</i>	
<i>Gymnodoris</i> sp. 10	
<i>Gymnodoris</i> sp. 3	
<i>Gymnodoris</i> sp. 7	
<i>Gymnodoris</i> sp. 9	
<i>Gyrineum lacunatum</i>	Isasa-bora Triton
<i>Halgerda albocristata</i>	
<i>Halgerda aurantiomaculata</i>	
<i>Halgerda elegans</i>	
<i>Halgerda</i> sp. 1	
<i>Halgerda</i> sp. 3	
<i>Halgerda tessellata</i>	
<i>Halgerda willeyi</i>	
<i>Halichoeres hortulanus</i>	chequerboard wrasse
<i>Halichoeres marginatus</i>	Dusky wrasse
<i>Halichoeres melanurus</i>	Hoeven's wrasse
<i>Halichoeres nebulosus</i>	Cloud wrasse
<i>Haliotis melculus</i>	<i>Haliotis melculus</i>
<i>Hallaxa translucens</i>	
<i>Haloa</i> sp. 7	
<i>Haminoea</i> sp.	
<i>Haminoeid long-tail</i> sp. 1	
<i>Hexabranchus sanguineus</i>	
<i>Hiatavolva depressa</i>	Depressed Ovulid
<i>Hydatina physis</i>	
<i>Hypselodoris</i>	Hypselodoris
<i>Hypselodoris apolegma</i>	
<i>Hypselodoris bullocki</i>	
<i>Hypselodoris decorata</i>	
<i>Hypselodoris emma</i>	
<i>Hypselodoris imperialis</i>	
<i>Hypselodoris jacksoni</i>	
<i>Hypselodoris lacuna</i>	
<i>Hypselodoris maculosa</i>	

<i>Hypselodoris maritima</i>	
<i>Hypselodoris melanescia</i>	
<i>Hypselodoris obscura</i>	
<i>Hypselodoris roo</i>	
<i>Hypselodoris sagamiensis</i>	
<i>Hypselodoris sp. 2</i>	
<i>Hypselodoris sp. 4</i>	
<i>Hypselodoris sp. 6</i>	
<i>Hypselodoris sp. 9</i>	
<i>Hypselodoris tryoni</i>	
<i>Hypselodoris whitei</i>	
<i>Hypselodoris zephyra</i>	
<i>Ischnochiton elongatus</i>	Elongated Chiton
<i>Jorunna parva</i>	
<i>Jorunna ramicola</i>	
<i>Jorunna sp. 2</i>	
<i>Jorunna sp. 3</i>	
<i>Jorunna sp. 4</i>	
<i>Jorunna sp. 6</i>	
<i>Kabeiro sp. 1</i>	
<i>Kaloplocamus acutus</i>	
<i>Lambis truncata</i>	Giant Spider Conch
<i>Liloa brevis</i>	
<i>Limenandra confusa</i>	
<i>Littorinidae</i>	Periwinkle Snails
<i>Lobiger sp. 1</i>	
<i>Lobiger viridis</i>	
<i>Luria isabella</i>	Queen Isabella Cowry
<i>Lyncina carneola</i>	Carnelian Cowry
<i>Mancinella alouina</i>	Yellow-mouthed Rock Shell
<i>Mariaglaja inornata</i>	
<i>Mariaglaja inornata</i>	Headband Headshield Slug
<i>Marianina rosea</i>	
<i>Marionia cf. rubra</i>	
<i>Marionia rubra</i>	
<i>Marionia sp. 2</i>	
<i>Marionia sp. 3</i>	
<i>Marionia sp. 5</i>	
<i>Marionia sp. 6</i>	
<i>Martadoris limaciformis</i>	
<i>Menathais tuberosa</i>	Menathais tuberosa
<i>Mexichromis aurora</i>	
<i>Mexichromis festiva</i>	
<i>Mexichromis macropus</i>	
<i>Mexichromis mariei</i>	
<i>Mexichromis pusilla</i>	
<i>Mexichromis trilineata</i>	
<i>Miamira magnifica</i>	
<i>Miamira moloch</i>	
<i>Miamira sinuata</i>	
<i>Micromelo guamensis</i>	Micromelo guamensis
<i>Micromelo undatus</i>	
<i>Mnestia sp.</i>	
<i>Monetaria caputserpentis</i>	Snakehead Cowrie
<i>Monophorus nigrofuscus</i>	
<i>Montfortula rugosa</i>	Cap-shaped False Limpet
<i>Murphydoris adusta</i>	
<i>Murphydoris cobbi</i>	
<i>Murphydoris puncticulata</i>	
<i>Murphydoris sp. 1</i>	
<i>Naria erosa</i>	Eroded Cowry
<i>Naria labrolineata</i>	Pitted-margin Cowry
<i>Nassa sertae</i>	Garland Thaid
<i>Nassarius gaudiosus</i>	Pointed Dogwhelk
<i>Nassarius papillosus</i>	Pimpled Dog Whelk
<i>Nembrotha lineolata</i>	
<i>Nembrotha purpureolineata</i>	
<i>Nerita albicilla</i>	blotched nerite
<i>Niparaya sp. 2</i>	
<i>Niparaya sp. 4</i>	
<i>Niparaya sp. 9</i>	
	Gardiner's Banana Nudibranch
<i>Notodoris gardineri</i>	Nudibranch
	Madagascar Nucleus Cowry
<i>Nucleolaria nucleus</i>	

<i>Okenia hallucigenia</i>	
<i>Okenia rhinorma</i>	
<i>Onchidoris sp. 1</i>	
<i>Orania ficula</i>	
<i>Ovula costellata</i>	Pink-mouth Egg Cowry
<i>Ovula ovum</i>	Common Egg Cowry
<i>Oxynoe jacksoni</i>	
<i>Oxynoe viridis</i>	
<i>Palmadusta asellus</i>	Little Ass Cowry
<i>Pardalinops testudinaria</i>	Tortoise Dove Shell
<i>Phalium bandatum</i>	Banded Bonnet Snail
<i>Phanerophthalmus anettiae</i>	
<i>Phenacovolva rosea</i>	Many-host Phenacovolva
<i>Phestilla melanobrachia</i>	Cup Coral Nudibranch
<i>Philine angasi</i>	
<i>Philine orca</i>	
<i>Philinopsis falciphallus</i>	
<i>Philinopsis lineolata</i>	
<i>Philinopsis orientalis</i>	
<i>Phyllidia cf. elegans</i>	
<i>Phyllidia coelestis</i>	
<i>Phyllidia elegans</i>	
<i>Phyllidia exquisita</i>	
<i>Phyllidia guamensis</i>	
<i>Phyllidia madangensis</i>	
<i>Phyllidia ocellata</i>	
<i>Phyllidia picta</i>	
<i>Phyllidia sp. 3</i>	
<i>Phyllidia sp. 4</i>	
<i>Phyllidia varicosa</i>	
<i>Phyllidiella annulata</i>	
<i>Phyllidiella cooraburrama</i>	
<i>Phyllidiella hageni</i>	
<i>Phyllidiella lizae</i>	
<i>Phyllidiella meandrina</i>	
<i>Phyllidiella pustulosa</i>	
<i>Phyllidiopsis burni</i>	
<i>Phyllidiopsis cardinalis</i>	
<i>Phyllidiopsis fissurata</i>	
<i>Phyllidiopsis krempfi</i>	
<i>Phyllidiopsis loricata</i>	
<i>Phyllidiopsis shireenae</i>	
<i>Phyllidiopsis xishaensis</i>	
<i>Phylloidesmium acanthorhinum</i>	
<i>Phylloidesmium colemani</i>	
<i>Phylloidesmium crypticum</i>	
<i>Phylloidesmium hyalinum</i>	
<i>Phylloidesmium macphersonae</i>	
<i>Phylloidesmium magnum</i>	
<i>Phylloidesmium opalescens</i>	
<i>Phylloidesmium sp. 2</i>	
<i>Phylloidesmium sp. 7</i>	
<i>Placida kevinleei</i>	
<i>Platydoris formosa</i>	
<i>Platydoris sanguinea</i>	
<i>Pleurobranchus peronii</i>	
<i>Pleuroolidia juliae</i>	
<i>Polycera sp. 1</i>	
<i>Polycera sp. 2</i>	
<i>Primovula rosewateri</i>	Rosewater's Primovula
<i>Prionovolva brevis</i>	Short Prionovolva
<i>Procalpurnus lacteus</i>	Netted Milky Ovulid
<i>Pteraeolidia semperi</i>	
<i>Purpuradusta gracilis</i>	Purpuradusta gracilis
<i>Pyrene flava</i>	Pyrene flava
<i>Retusa sp.</i>	
<i>Ringicula sp.</i>	
<i>Rissoina ambigua</i>	

<i>Robostra luteolineata</i>	
<i>Rostanga lutescens</i>	
<i>Roxaniella leucampyx</i>	
<i>Sabia conica</i>	Bonnet Limpet
<i>Sagaminopteron ornatum</i>	
<i>Sagaminopteron psychedelicum</i>	
<i>Sakuraeolis nungunoides</i>	
<i>Samla bicolor</i>	
<i>Samla macassarana</i>	
<i>Samla sp. 1</i>	
<i>Santia sp. 2</i>	
<i>Sclerodoris coreacia</i>	
<i>Sclerodoris sp. 4</i>	
<i>Sclerodoris sp. 8</i>	
<i>Scutus antipodes</i>	Elephant Snail
<i>Sebadoris fragilis</i>	
<i>Siphopteron sp. 1</i>	Siphopteron sp. 1
<i>Staphylaea staphylaea</i>	Staphylaea staphylaea
<i>Stiliger aureomarginatus</i>	
<i>Strigatella scutulata</i>	Strigatella scutulata
<i>Talparia talpa</i>	Mole Cowry
<i>Tambja amakusana</i>	
<i>Tambja caeruleocirrus</i>	
<i>Tambja morosa</i>	
<i>Tambja tenuilineata</i>	
<i>Tambja victoriae</i>	
<i>Tenellia diversicolor</i>	
<i>Tenellia melanobrachia</i>	
<i>Tenellia ornata</i>	
<i>Tenellia sibogae</i>	
<i>Tenellia sp. 1</i>	
<i>Tenellia sp. 11</i>	
<i>Tenellia sp. 13</i>	
<i>Tenellia sp. 20</i>	
<i>Tenellia sp. 23</i>	
<i>Tenellia sp. 24</i>	
<i>Tenellia sp. 3</i>	
<i>Tenellia sp. 33</i>	
<i>Tenellia sp. 35</i>	
<i>Tenellia sp. 36</i>	
<i>Tenellia sp. 39</i>	
<i>Tenellia sp. 4</i>	
<i>Tenellia sp. 40</i>	
<i>Tenellia sp. 41</i>	
<i>Tenellia sp. 44</i>	
<i>Tenellia sp. 45</i>	
<i>Tenellia sp. 50</i>	
<i>Tenguella marginalba</i>	Mulberry Whelk
<i>Terenolla pygmaea</i>	Pygmy Auger
<i>Thordisa tahala</i>	
<i>Thorunna australis</i>	
<i>Thorunna daniellae</i>	
<i>Thorunna florens</i>	
<i>Thorunna furtiva</i>	
<i>Thorunna halourga</i>	
<i>Thorunna sp. 3</i>	
<i>Thorunna sp. 4</i>	
<i>Thorunna sp. 5</i>	
<i>Thorunna sp. 7</i>	
<i>Thuridilla albopustulosa</i>	
<i>Thuridilla carlsoni</i>	
<i>Thuridilla carlsoni</i>	
<i>Thuridilla cf. splendens</i>	
<i>Thuridilla gracilis</i>	
<i>Thuridilla hoffae</i>	
<i>Thuridilla livida</i>	
<i>Thuridilla neona</i>	
<i>Thuridilla sp. 1</i>	
<i>Thuridilla sp. 5</i>	
<i>Thuridilla sp. 6</i>	
<i>Thuridilla sp. 7</i>	
<i>Thuridilla splendans</i>	
<i>Thuridilla vatae</i>	
<i>Tornatina avenaria</i>	
<i>Tornatina sp. 1</i>	
<i>Tornatina sp. 4</i>	
<i>Trapania brunnea</i>	
<i>Trapania gibbera</i>	
<i>Trapania reticulata</i>	

<i>Trapania vitta</i>	
<i>Tritoniopsis elegans</i>	
<i>Trivirostra oryza</i>	Sulcate Bean Cowry
<i>Turbo militaris</i>	Military Turban
<i>Turbo petholatus</i>	Cat's Eye Turban
<i>Tutufa bubo</i>	Large Frog Snail
<i>Tylocardia corticalis</i>	
<i>Tyrannodoris luteolineata</i>	Tyrannodoris luteolineata
<i>Verconia alboannulata</i>	
<i>Verconia cf. varians</i>	
<i>Verconia decussata</i>	
<i>Verconia haliclona</i>	
<i>Verconia laboutei</i>	
<i>Verconia norba</i>	
<i>Verconia romeri</i>	
<i>Verconia simplex</i>	
<i>Verconia sp. 2</i>	
<i>Verconia sp. 3</i>	
<i>Verconia verconiforma</i>	
<i>Vexillum daedalum</i>	Vexillum daedalum
<i>Volcula rostrata</i>	
<i>Weinkauffia reliqua</i>	

<i>Pseudobiceros gloriosus</i>	Glorious Flatworm
<i>Pseudobiceros gratus</i>	Pleasing Flatworm
<i>Pseudobiceros hancockanus</i>	Hancock's Flatworm
<i>Pseudobiceros sp. 13</i>	
<i>Pseudobiceros sp. 19</i>	
<i>Pseudobiceros sp. 21</i>	
<i>Pseudobiceros sp. 22</i>	
<i>Pseudobiceros sp. 3</i>	
<i>Pseudobiceros splendidus</i>	Splendid Flatworm
<i>Pseudoceros bimarginatus</i>	Bimargined Flatworm
<i>Pseudoceros iaticlavus</i>	Black and White Flatworm
<i>Pseudoceros leptostictus</i>	Thinspotted Flatworm
<i>Pseudoceros paralaticlavus</i>	Broadstriped Flatworm
<i>Pseudoceros scintillatus</i>	Scintillated Flatworm
<i>Pseudoceros sp. 25</i>	
<i>Pseudoceros sp. 29</i>	
<i>Pseudoceros sp. 49</i>	
<i>Pseudoceros sp. 51</i>	
<i>Pseudoceros sp. 7</i>	
<i>Pseudoceros sp. 8</i>	

#### Nemertea

<i>Baseodiscus hemprichii</i>	Dark-striped Ribbon Worm
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#### PLATYHELMINTHES (Flatworms)

<i>Acanthozoon sp. 16</i>	
<i>Cycloporus sp. 10</i>	
<i>Maritigrella eschara</i>	Scarred Flatworm
<i>Maritigrella fuscopunctata</i>	Dark-spotted Flatworm
<i>Maritigrella virgulata</i>	Red-striped Flatworm
<i>Pericelis sp. 1</i>	
<i>Pericelis sp. 3</i>	
<i>Phrikoceros fritillus</i>	Spotted Flatworm
<i>Pseudobiceros apricus</i>	Orange Flatworm
<i>Pseudobiceros bedfordi</i>	Persian Carpet Flatworm

#### PORIFERA (Sponges)

<i>Acanthella carvernosa</i>	
<i>Agelas mauritiana</i>	
<i>Amphimedon sp. 2776</i>	
<i>Aplysilla sulfurea 224</i>	
<i>Aplysinella sp. 1194</i>	
<i>Batzella sp. 2175</i>	
<i>Batzella sp. 4217</i>	
<i>Batzella sp. 4407</i>	
<i>Callyspongia (C.) sp. 3148</i>	

<i>Callyspongia</i> (C.) sp. 4328	
<i>Callyspongia manus</i>	
<i>Callyspongia</i> sp. 7	
<i>Carteriospongia</i> sp.	
<i>CeratopSION clavata</i>	
<i>Chondropsis</i> sp. 4131	
<i>Cinachyrella</i> <i>enigmatica</i>	
<i>Cliona orientalis</i>	
<i>CriBrochalina</i> sp. 2666	
<i>Dactylia</i> sp. 1	Mauve Finger Sponge
<i>Dactylia</i> sp. 1823	
<i>Didiscus aceratus</i>	
<i>Dysidea</i> sp. 16	
<i>Echinochalina</i> (E.) sp. 272	
<i>Euryspongia</i> <i>deliculata</i>	
<i>Grantiopsis</i> sp. 1582	
<i>Halichondria</i> (H) sp.	
<i>Halichondria</i> (H.) 3764	
<i>Haliclona</i> (H.) sp. 2584	
<i>Ianthella</i> <i>quadrangulata</i>	
<i>Iotrochota coccinea</i>	
<i>Ircinia</i> sp. 1255	
<i>Leucetta</i> <i>chagosensis</i>	
<i>Myrmekioderma</i> <i>granulata</i>	
<i>Neopetrosia pacifica</i>	
<i>Pericharax</i> <i>heterographis</i>	Abnormal Needle Sponge
<i>Phyllospongia</i> <i>papyracea</i>	
<i>Phyllospongia</i> sp. 2899	

<i>Psammocinia</i> <i>bulbosa</i>	
<i>Psammocinia</i> sp. 1191	
<i>Pseudoceratina</i> <i>clavata</i>	
<i>Pseudoceratina</i> sp. 1247	
<i>Pseudoceratina</i> sp. 2973	
<i>Siphonochalina</i> <i>deiciens</i> 582	Tubular Beautiful Sponge
<i>Siphonochalina</i> sp.	Sponge
<i>SpheciOSPONGIA</i> cf. <i>vagabunda</i>	
<i>Sycon</i> sp. 1	
<i>Trachycladus</i> <i>laevispirulifer</i>	
<i>Xestospongia</i> <i>testudinaria</i>	

### Plantae

#### **Chlorophyta (Green Algae)**

<i>Codium</i> sp.	Green algae
<i>Halimeda discoidea</i>	Green algae
<i>Ulva</i>	Sea Lettuces
<i>Valonia aegagropila</i>	

#### **Ochrophyta**

<i>Lobophora</i> <i>variegata</i>	Brown algae
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#### **Rhodophyta (Red Algae)**

<i>Corallinales</i>	Coralline algae
<i>Delisea pulchra</i>	Red algae
<i>Mesophyllum</i> <i>mesomorphum</i>	Red algae leafy
<i>Metagoniolithon</i> sp.	Red algae segmented
<i>Peyssonnelia</i> <i>capensis</i>	Encrusting red algae

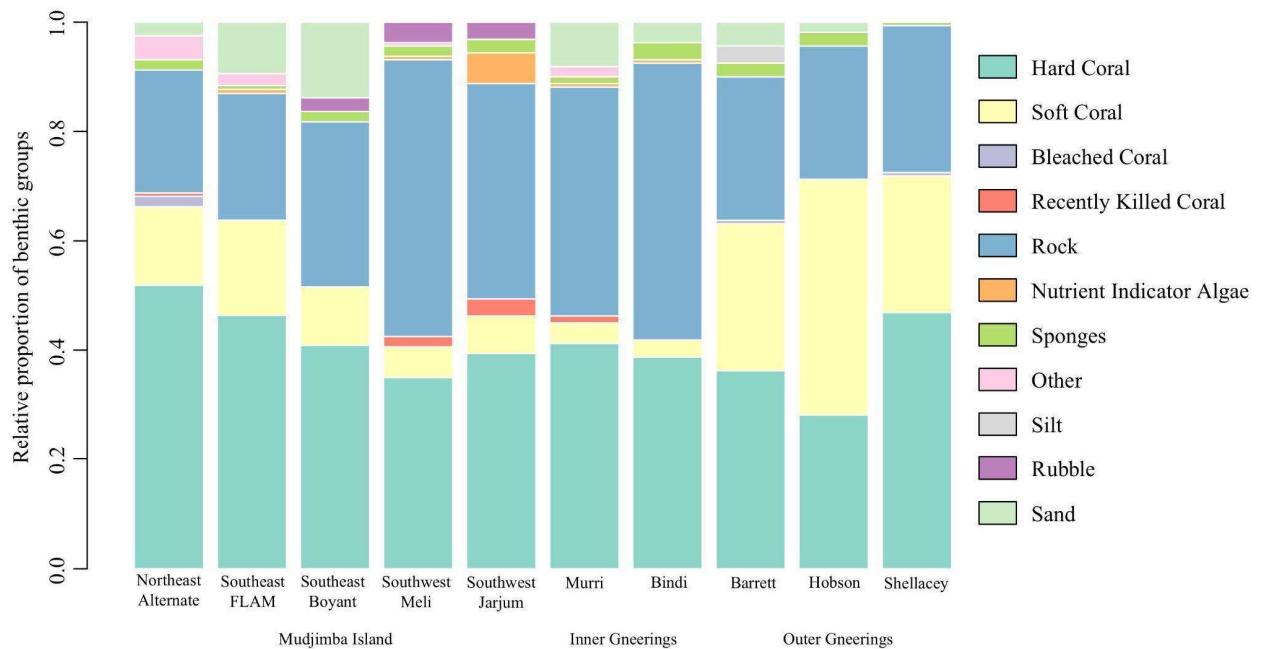
## Appendix D: Transect Coordinates

<u>Site Name</u>	<u>Coordinates Start</u>	<u>Coordinates End</u>
Inner Gneerings Bindi	153.159611E -26.645321S	153.159611E -26.645321S
Inner Gneerings Murri's	153.160675E -26.645514S	153.161576E -26.645171S
Mudjimba, North East	153.117079E -26.613983S	153.117959E -26.614127S
Mudjimba N.E. Alternative	153.114493E -26.611941S	153.117079E -26.613983S
Mudjimba SE Boyant	153.116153E -26.616047S	153.115212E -26.616112S
Mudjimba SE Flam	153.116169E -26.616062S	153.116886E -26.615489S
Mudjimba SW Jarjum	153.113345E -26.615858S	153.114290E -26.616016S
Mudjimba SW Meli	153.113270E -26.615787S	153.114216E -26.615879S
Outer Gneerings Barrett	153.182933E -26.648672S	153.183888E -26.648672S
Outer Gneerings Hobson	153.182933E -26.648672S	153.181989E -26.648672S
Outer Gneerings Shellacey	153.200951E -26.654217S	153.200952E -26.654051S

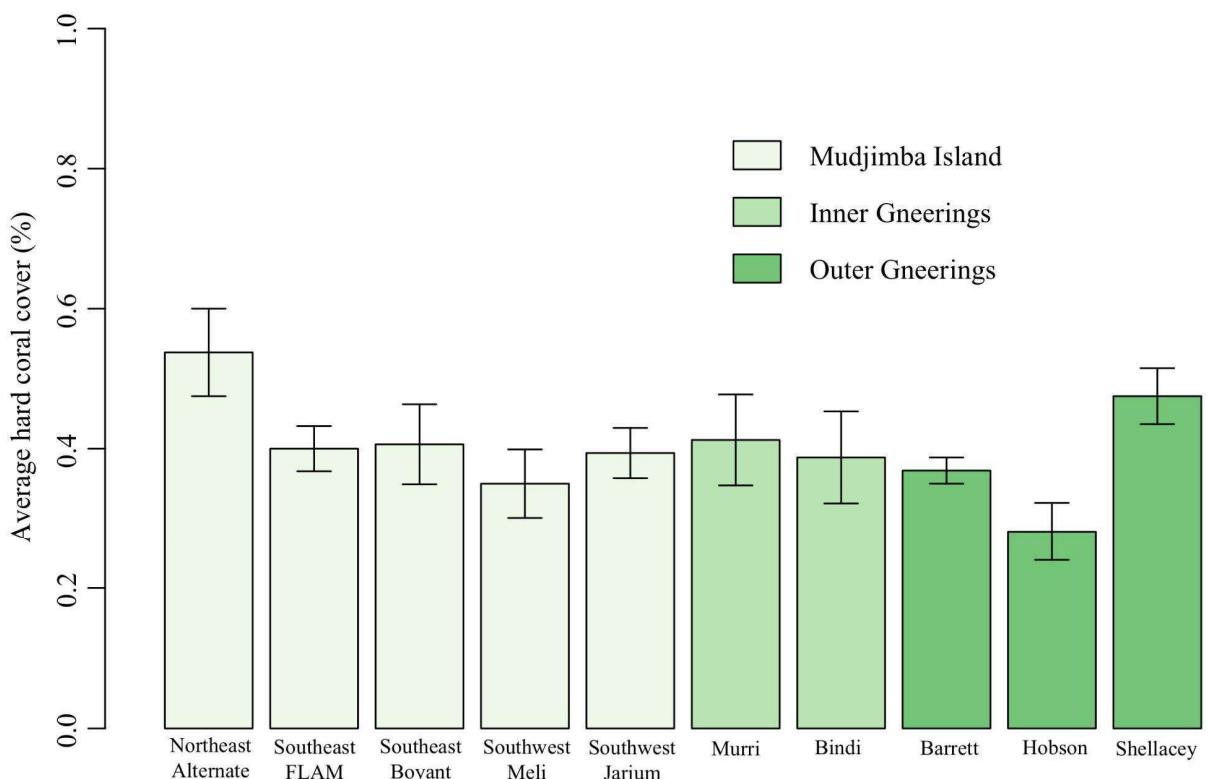
## Appendix E: Dive Statistics

Dates	Number of divers	Dive location	Type of dive
13/03/2021 and 14/03/2021 (weekend)	19	North Stradbroke Island (Point Lookout)	training dives
27/03/2021 and 28/03/2021 (weekend)	22	North Stradbroke Island (Point Lookout)	training dives
24/04/2021	10	Mooloolaba	exploratory dive
30/07/2021 and 01/08/2021 (weekend)	10	Mooloolaba	surveys, mapping
19/09/2021	10	Mooloolaba	surveys, mapping
25/09/2021	10	Mooloolaba	surveys, mapping
06/11/2021	10	Mooloolaba	surveys, mapping
20/11/2021	10	Mooloolaba	surveys, mapping
19/02/2022	10	Mooloolaba	surveys, mapping

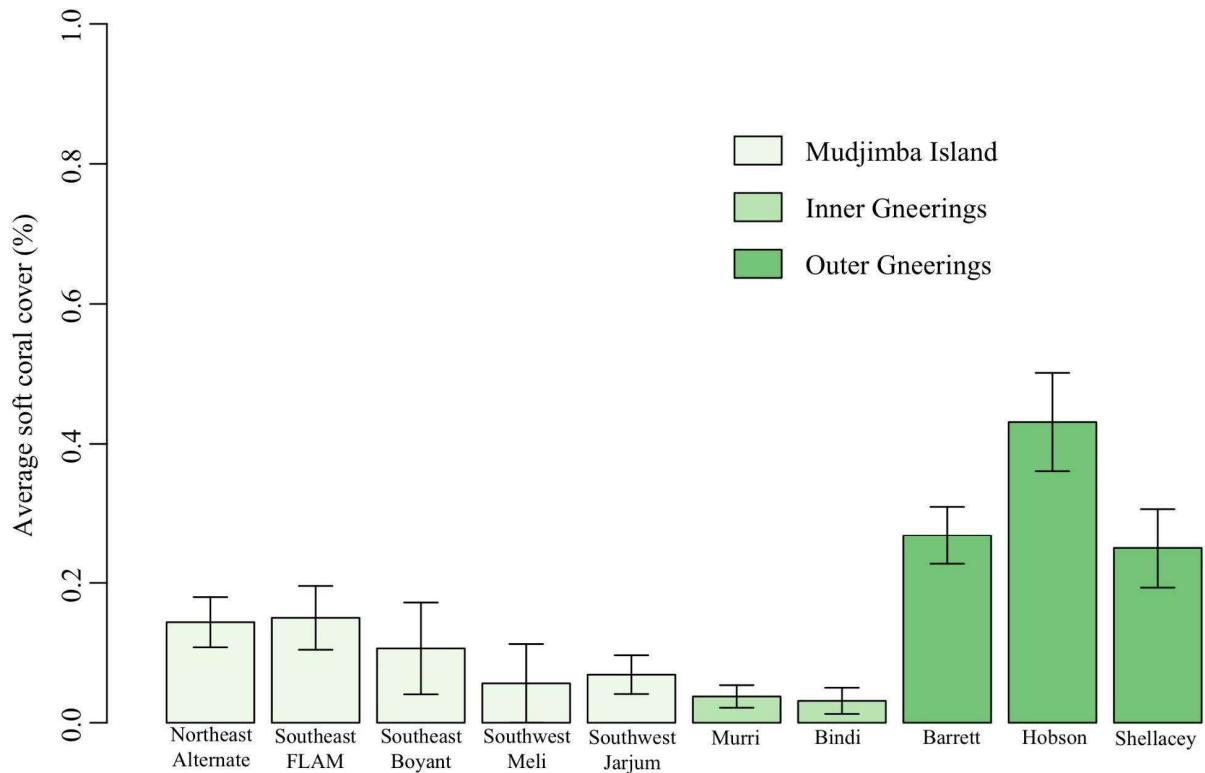
## Appendix F: Additional Results Figures



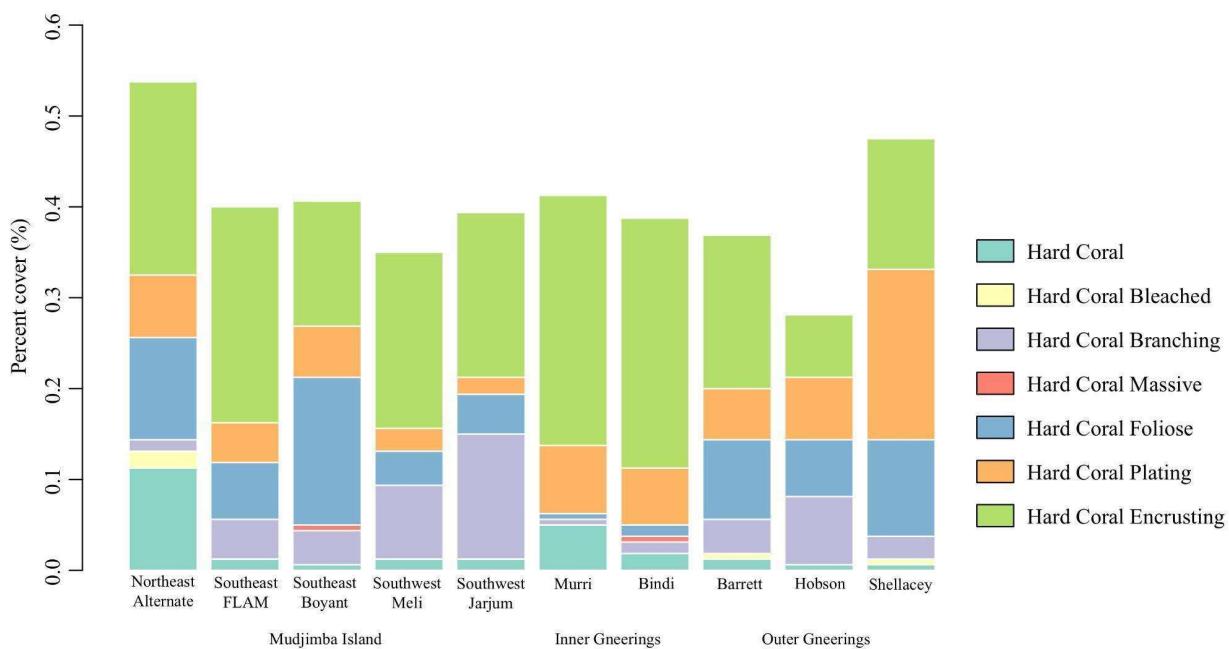
Stacked barplot of relative proportion of benthic groups per site. Values are averaged from each site's transects.



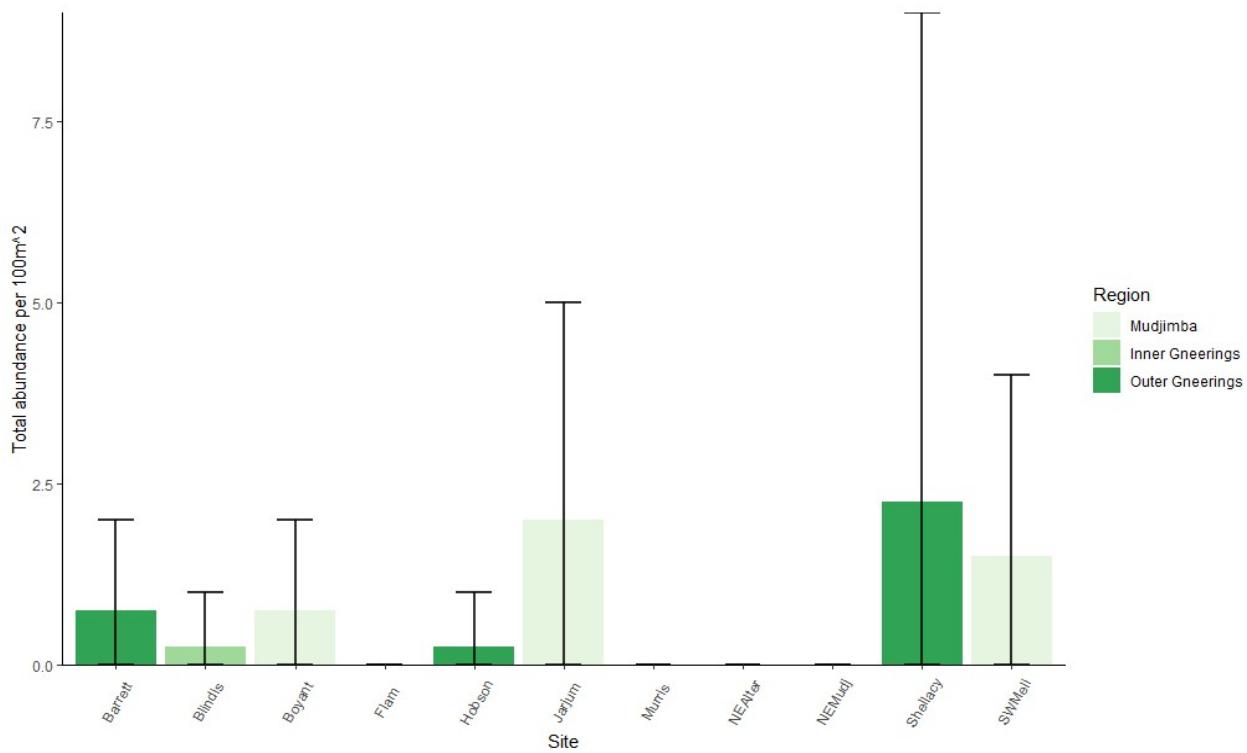
Barplot of averaged hard coral cover per site with Standard Error. Values are percent cover are averaged from each site's transects.



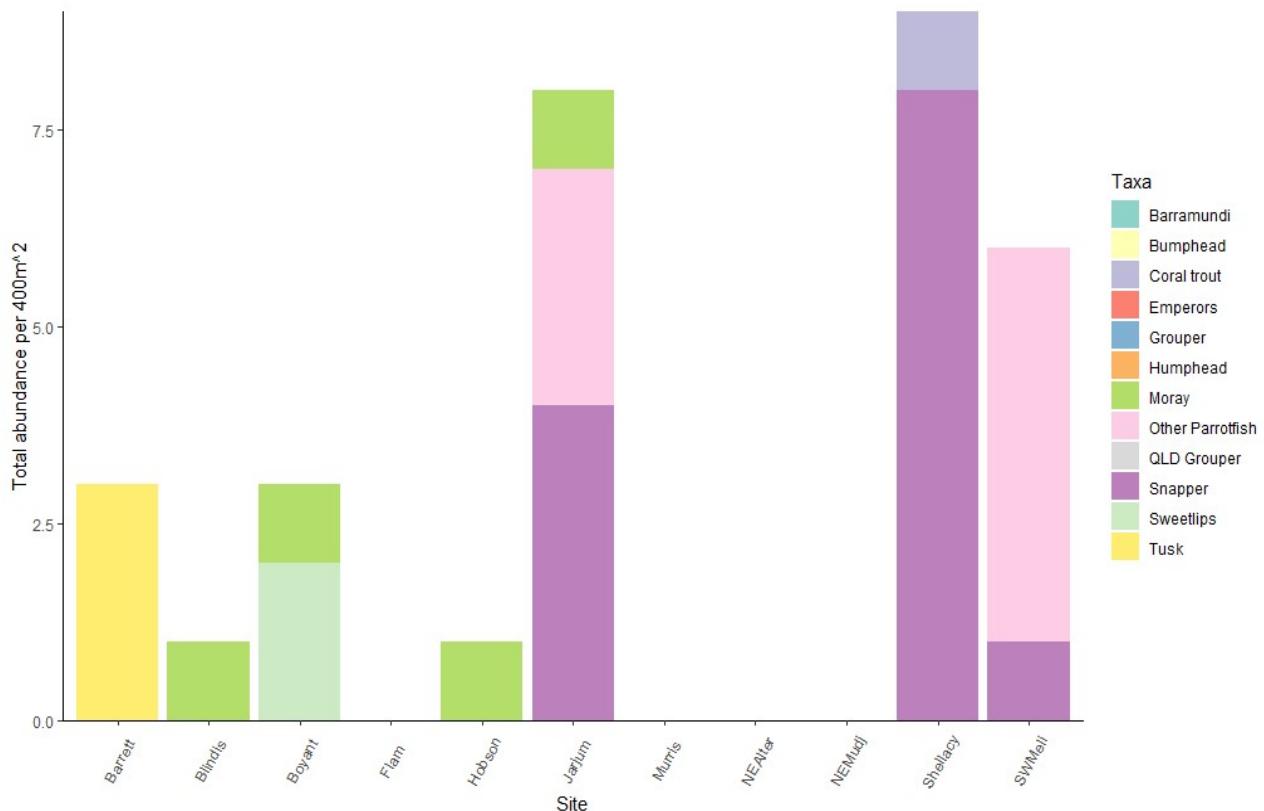
*plot of averaged soft coral cover per area with Standard Error. Values are percent cover and averaged from each site's transects.*



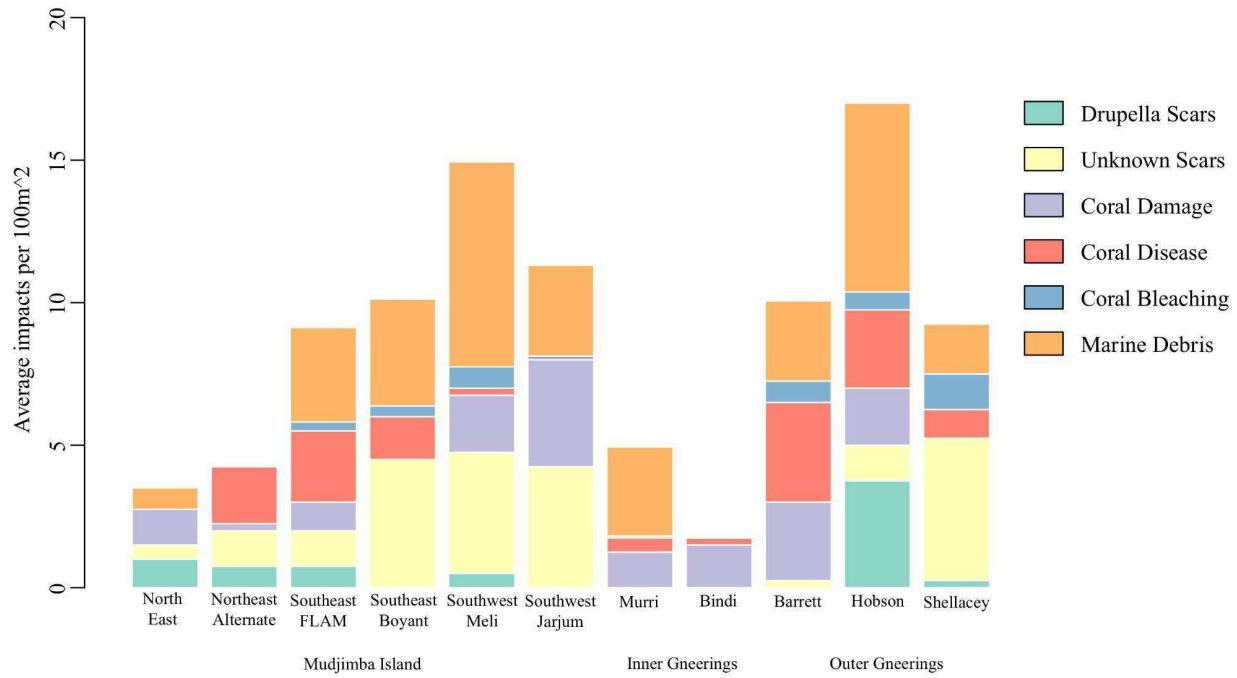
*Stacked barplot of averaged hard coral cover per site and per hard coral type. Values are percent cover and averaged from each site's transects.*



Average abundance of surveyed fish for the eleven sites at Mooloolaba reef (error bars indicate standard deviation).

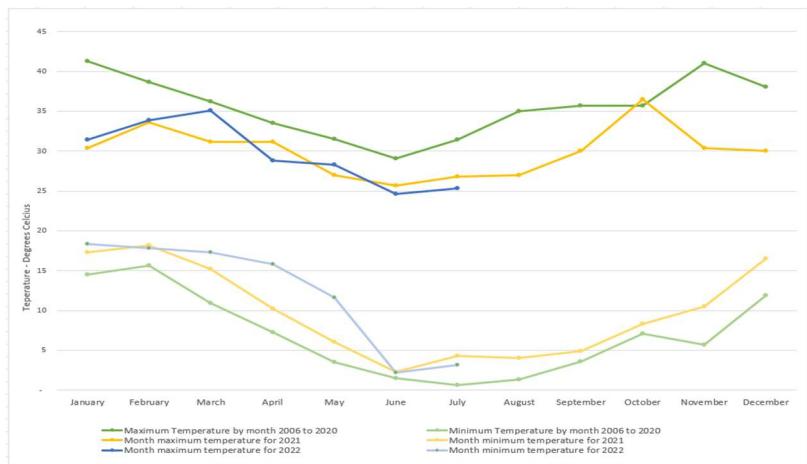


Total abundance of targeted fish taxa at each site surveyed



*Stacked barplot of the number of impacts per MEAM site per  $100m^2$ . Values are occurrence data and averaged per each site's transects.*

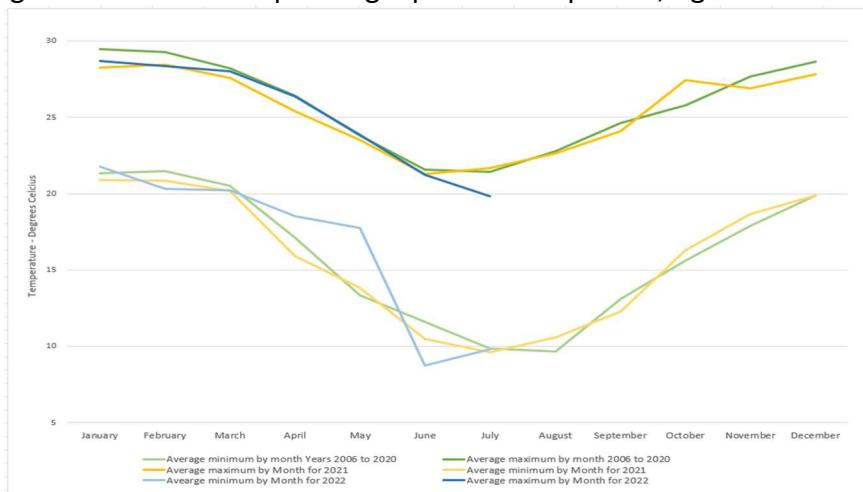
## Appendix G: Environmental Parameters.



The graph shows the minimum and maximum temperatures recorded for each month over the period 2006 to 2020, along with the minimum and maximum per month for 2021 and 2022. i.e. this is the peak max and min for the month.

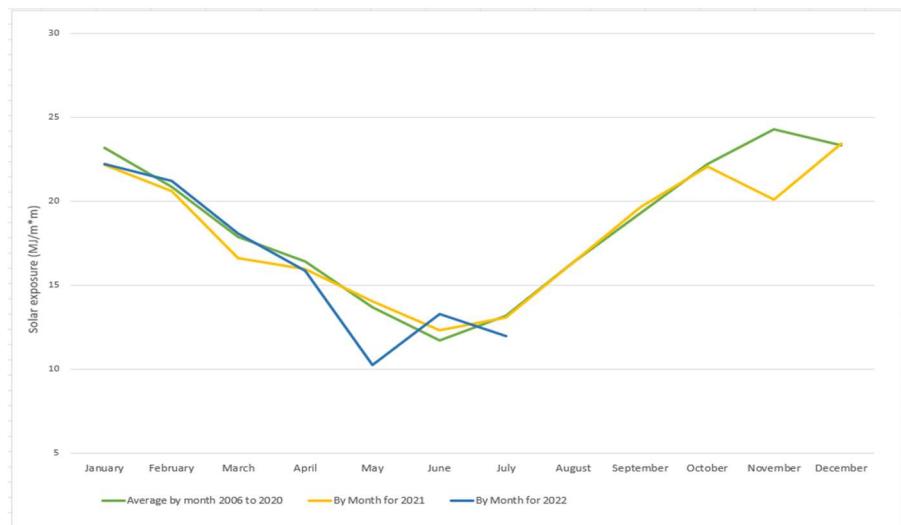
2021 and 2022 are broadly in-line with the long term recordings. Of note:

- A peak in October 2021, where the maximum October temperature exceeded the 2006-2020 recordings, and
- the period of March to May 2022 where the minimums are well above the 2006-2020 recordings. There is a corresponding dip in solar exposure, figure ??.



The graph shows the average minimum and maximum temperatures recorded for each month over the period 2006 to 2020, along with the average minimum and maximum per month for 2021 and 2022.

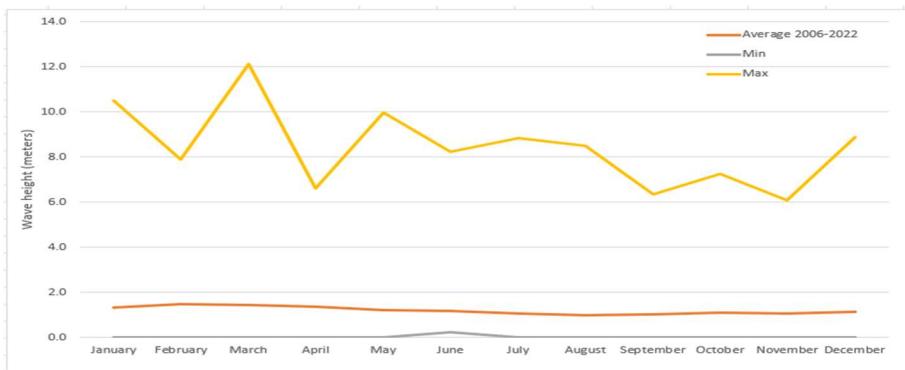
As per the peak maximum and minimum temperatures in figure above temperature for 2021 and 2022 are broadly in-line with the long term recordings. As per the peak graph this graph also shows the minimum for 2022 particularly in May higher than the long term average. Again this corresponds to the dip in solar exposure, figure above



The graph shows the long-term (2006-2020) monthly average solar exposure compared to the monthly average solar exposure for 2021 and 2022.

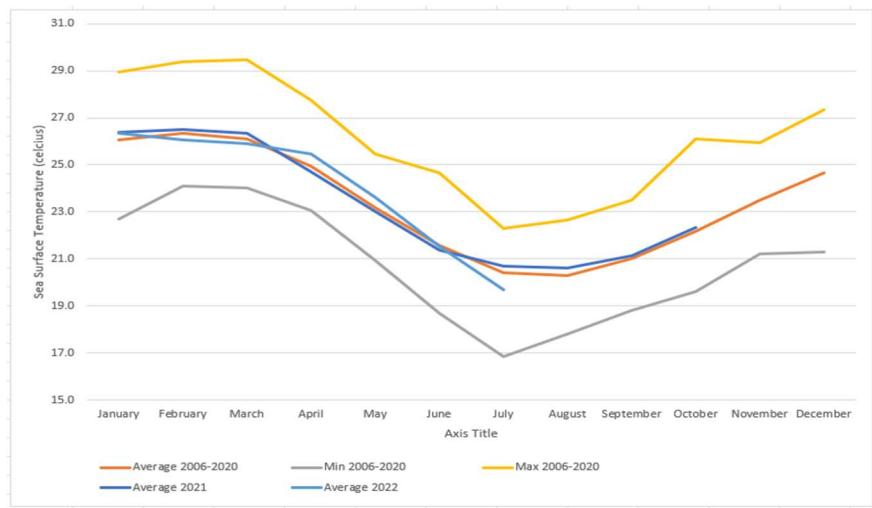
2021 and 2022 are broadly in-line with the long term recordings. Of note:

- November 2021 show a dip in average solar exposure and this does coincide with the significant rainfall of that month.
- May 2022 shows a dip in average solar exposure, this aligns to a higher average minimum temperature for that month. Further analysis could show an alignment to cloud cover.



The graph shows average wave height per month from 2006 to 2022, along with minimum and maximum wave heights recorded per month over the same period.

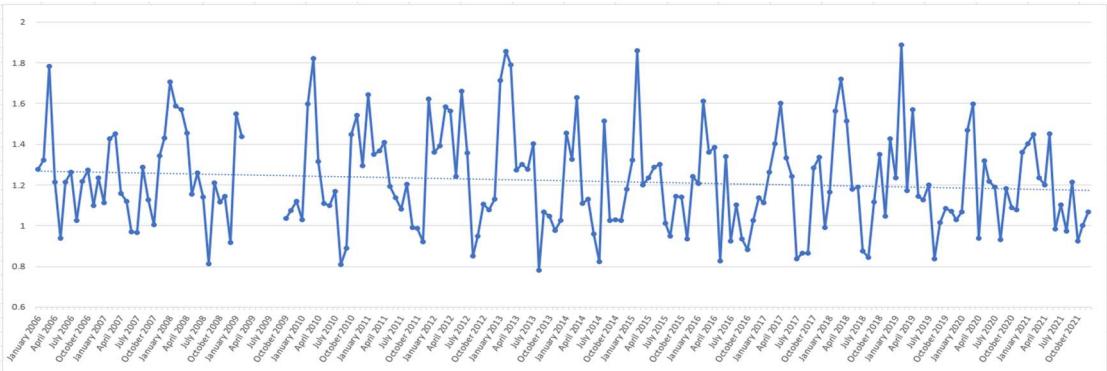
The average is under 2 metres for all months. Most months show there are times with no waves, June being the exception, but the minimum is still very low. The maximum wave heights are well above the average, so are likely evident for short time periods, ie during storms. There appears to be greater height and variance in the summer period, December to March.



The graph shows the long term average (2006-2020) sea surface temperature (SST) along with the monthly minimum and maximum SST for 2006-2020. This is compared to the monthly average for 2021 and 2022.

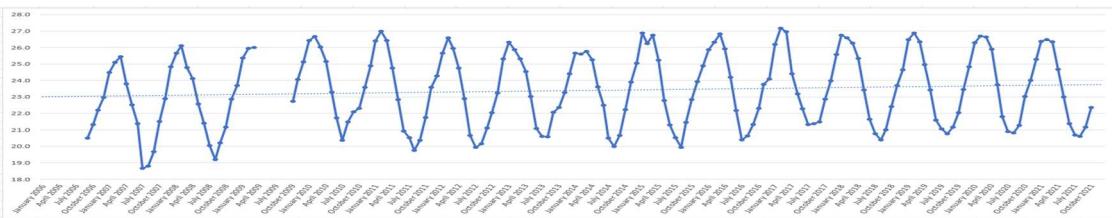
The average SST for long term, 2021 and 2022 show no significant variation to the long term average.

## Appendix I: Long Term Charts (Trevor)



*The graph shows the average wave height per month for 2006 to 2021.*

The average monthly wave height shows that typically there is greater wave action over the summer months. Most waves will fit to a 1 metre to 1.5 metre range.



*The graph shows the average sea surface temperature per month for 2006 to 2021.*

The average monthly sea surface temperature shows, as expected, that the temperature has a constant seasonal variation, with summer (December to March) having the warmest temperatures. The trend line shows that there is an increase in sea surface temperature over the 2006 to 2021 period of about 1.5 degrees.

## Appendix H: Mooring Options

Placing a private mooring on Mooloolaba reefs requires a marine park permit (from Queensland Parks and Wildlife Service- QPWS) and a buoy mooring authority (from Maritime Safety Queensland - MSQ). QPWS approval will depend on justification that the mooring, its installation and operation will cause the least damage to substrate when compared to alternatives. MSQ approval will depend on the mooring's location not causing a navigation hazard. Both mooring applications should be lodged together. Given its location, it would be beneficial to have a registered professional engineer or naval architect certify that the design is fit for purpose.

The Marine Park permit if approved, will require the permit holder to have public liability insurance of \$20 million.

There are three mooring options to consider: 1. Private, 2. Public but privately funded, and, 3. Public.

Mooring Type	Private	Public (Privately Funded)	Public
Owner (liable)	Trust, joint dive shops, one dive shop, or dive club etc.	QPWS,	QPWS
Funding	Whoever is interested and wants to use the mooring	Money is donated privately sufficient to fund at least three years maintenance and installation	QLD Government
Maintenance (responsibility of owner)	Given its environmentally sensitive location, the marine park permit may specify who, (e.g. someone who belongs to the Board of Professional Engineers (RPEQ)) can carry out and/or certify the maintenance	Every three months, by appropriate service provider	Every three months, by appropriate service provider
Liability Insurance (Paid by owner)	\$20 million	\$20 million	\$20 million
Mooring type: (refer to below)	Any class as approved by MSQ.	C class mooring	C class mooring
Users:	Only those with approval from the mooring owner; mooring is marked as limited access	Any user	Any user

Mooring Class	Colour Band	Max Wind Strength	Monohull Maximum Length	Multihull Maximum Length
Tender (T)	Brown	24 knots	6 metres	6 metres
Class A	Yellow	24 knots	10 metres	9 metres
Class B	Orange	34 knots	20 metres	18 metres
Class C	Blue	34 knots	25 metres	22 metres
Class D	Red	34 knots	35 metres	30 metres



## Citizen Scientists Taking Care of Local Reefs

