Earthwatch Australia

Recovery of the Great Barrier Reef

2022

Annual Report

Cover image: Great Barrier Reef

earthwatch
AUSTRALIA

Executive Summary

The Recovery of the Great Barrier Reef Project, sponsored by Mitsubishi Corporation is undertaking world-class research on coral reef health and restoration, developing critical methodological advances in reef restoration and management.

Focused on quantifying the ecological effects of macroalgal removal on near shore reefs at Magnetic Island, this project is providing the scientific evidence needed to allow reef managers to make informed decisions on the benefits and costs of active interventions and aid the management and conservation of these important ecosystems. The project is also one of the few reef restoration approaches that can engage local community groups and citizen scientists to provide a positive benefit to reef ecosystem health in addition to engaging and educating the broader population.

This season was our fourth at Magnetic Island. The Recovery of the Great Barrier Reef project undertook three field-based research trips to Magnetic Island, two of which were citizen-science based trips (July and October, including Mitsubishi Corporation fellows in July), and one with the James Cook University research team only (early July).

Over the course of the year, we performed extensive monitoring, algal removal, and juvenile coral seeding device surveys. Overall, results continue to support that coral reef recovery is significantly enhanced in plots where algae have been removed.

Scientific Highlights

Work from the year continues to show that removal of algae achieves a significant immediate reduction in algal biomass. Similar to the last reporting period, we observed that regrowth continues to be suppressed after multiple removal events. With removal being undertaken multiple times this year, we achieved a 92-93% reduction in pre-spawning (October) biomass in removed plots compared to control plots.

In October 2021, the field team including citizen scientists collected 22 fertile adult colonies of Acropora tenuis and transported them to the National Sea Simulator at the Australian Institute of Marine Science for spawning. Spawned gametes were collected and fertilized, resulting in 1.3 million coral larvae. When competent, approximately 50,000 larvae were settled onto aragonite plugs and allowed to grow under controlled conditions. The plugs were then installed within specialized devices and deployed to reef plots. Preliminary data indicates these devices are efficient at increasing juvenile coral survival and will continue to be monitored.

Citizen Science Contributions

Citizen scientists remain central to the success of the program and those involved in the 2022 expeditions continue to report high levels of satisfaction with their experience. The season saw the introduction of land-based activities for Mitsubishi employees, expanding the accessibility of the project. In addition to supporting dive team logistics, the land-based team contributed to the count and sorting of removed algal biomass, beach microplastic sampling, and nature discovery walks.

Advancing Early Career Scientists

Recovery of the Great Barrier Reef continued to directly support Early Career Researcher Hillary Smith, who published three peer reviewed scientific papers as the primary author, co-authored a book chapter with Principal Investigator Prof. David Bourne and co-authored an additional paper over the reporting period. A total of six peer reviewed papers were published in 2022 by the extended project team.

The project also contributed to the development of an additional 20 higher degree research students through field experience, supervision and mentoring. Four extended student research reports were completed and numerous snorkel, dive and data collection hours were contributed by James Cook University student volunteers.

Future

Late 2022, the Recovery of the Great Barrier Reef team was invited to submit a full funding application to CORDAP – the Coral research and Development Accelerator Platform. CORDAP is a highly regarded, international organization fully dedicated to funding global research and development for coral restoration and conservation. Our team's application focused on the potential expansion of the work being undertaken at Magnetic Island to another Australian location (Whitsundays) and internationally (Indonesia). We expect to hear the outcome of the application within the first half of the 2023 calendar year. The invitation represents an exciting development for the project. CORDAP awards are extremely prestigious and if successful, will affirm the research being undertaken at Magnetic Island as a viable global solution to reef recovery.

Our Partnership

Coral reefs around the world are under increasing threats from direct human activities and global climate shifts, which together are contributing to accelerating rates of reef deterioration. In Australia, the Great Barrier Reef is fundamental to the nation's economy and is a national icon that needs to be preserved to ensure ongoing sustainability of marine resources. Warming seawater, ocean acidification, and increased freshwater runoff carrying pollutants to the reef all impact on the health of corals, the major group of organisms that build the structural framework of reef ecosystems. Alarmed by increasing rates of deterioration globally, reef managers have shifted focus from monitoring reef health to active intervention on reefs in an attempt to increase resilience.

Internationally and in Australia, the Earthwatch Insititute and Mitsubishi Corporation have a long-standing partnership of working together towards the goal of creating a sustainable society. This partnership has supported critical scientific research into some of the world's most pressing environmental issues in an effort to mitigate the impacts of biodiversity loss, reduce our environmental footprint and help to conserve ecosystems, including reef environments.

In July 2011 Earthwatch Australia began working with the Mitsubishi Corporation through the Coral Reef Research Gift Agreement. The funding provided through this partnership enabled the establishment of a field research project "Recovery of the Great Barrier Reef" which has been examining the impact of natural disasters and the virulent Black Band Disease on the Great Barrier Reef and monitoring coral community recovery following major disturbance.

The Recovery of the Great Barrier Reef Project, sponsored by Mitsubishi Corporation continues to undertake world-class research on coral reef health and restoration, developing critical methodological advances in reef restoration. Importantly, the project is one of the few reef restoration approaches that can engage local community groups and citizen scientists to provide a positive benefit to reef ecosystem health in addition to engaging and educating the broader population.

Focused on quantifying the ecological effects of macroalgal removal on near shore reefs at Magnetic Island, this project is providing the scientific evidence needed to allow reef managers to make informed decisions on the benefits and costs of active interventions and aid the management and conservation of these important ecosystems.

Recovery of the Great Barrier Reef 2022 Highlights

532 kilograms of macroalgae removed	**1800** square metres of reef surveyed
3 Mitsubishi Corporation employees participating as citizen scientist	**16,337** macroalgae fronds counted and measured
1800+ reef photos taken to assess changes in the benthic community	**~200** coral recruits counted across 240 settlement tiles
1700 citizen science and JCU volunteer hours	**6** peer reviewed publications

Project overview

The "Recovery of the Great Barrier Reef" project quantifies the ecological effects of macroalgal removal on reefs at Magnetic Island, providing the scientific evidence to allow reef managers to make informed decisions on the benefits and costs of active interventions such as macroalgal removal and coral larval release and subsequently aid the management and conservation of these important ecosystems.

The UNESCO World Heritage-listed Great Barrier Reef is the world's largest coral reef and the largest living structure on Earth, supporting 10% of the world's fish species, over 600 types of coral, 215 species of birds and numerous marine mammals, turtles and sharks. However, corals now face a large number of threats and the Australian Institute of Marine Science reports that coral cover across the Great Barrier Reef has declined by approximately 50% during the last 30 years. Increasing sea surface temperatures (due to anthropogenic climate change) create conditions for coral bleaching, as well as increase the strength and frequency of major cyclones that can reduce coral reefs to rubble.

Land use change onshore can also lead to sediment and nutrient run-off on to the reef. Sediment can block out the sunlight corals need for growth, and the increased nutrient run-off is linked to increasing outbreaks of Crown-of-Thorn starfish (a predator of coral polyps). Coral reef disease (such as Black Band Disease, previously researched with Mitsubishi Corporation support) is also another challenge that coral reefs face. All of these ecological disturbances are happening more frequently, meaning coral reefs have less time to recover between disturbances and some coral reef communities are undergoing a phase shift to macroalgal (seaweed) dominated ecosystems, as this is what proliferates quickly after coral reefs are damaged.

Macroalgae is part of a healthy reef ecosystem and has both positive and negative effects on corals. For example, macroalgae can shade coral colonies from harmful solar irradiation, however it can also impede settlement of coral juveniles. Additionally, once macroalgae has settled, it proliferates and outcompetes corals, thus leading to a benthic (sea floor) ecosystem shift characterised by high macroalgal and low coral cover.

Removal of macroalgae is proposed as an active intervention measure to aid reef recovery through increasing available substrate for coral settlement, and reduced competition between corals and macroalgae. The project is rigerously testing the effects (positive and negative) of removing macroalgae as a reef management and restoration measure.

Citizen Science Contribution

The 2022 Field Season saw a welcome resumption of Citizen Science participation in field activities for the program. A total of nine Citizen Scientists participated in the July and October expeditions contributing 450 hours of dive and snorkel skills to the program.

As well as contributing to scientific research, the immersive, experiential learning opportunities Earthwatch offers aims to deepen participants' understanding of conservation issues and ecosystem services, as well as to connect people to nature to strengthen their motivation to protect it.

Citizen scientist feedback from the expeditions was overwhelmingly positive, with participants reporting overall enjoyment and satisfaction with the experience, as well as high degrees of satisfaction with the logistical arrangement and communications.

Participant satisfaction rating for the the overall expedition and research experience, logistics and communication arrangements

Mitsubishi Corporation Fellow Stellios Falieros (Nextfleet) "in the field" contributing snorkel skills to the research.

Community Outreach

The 2022 expedition year saw a strengthening of ties with local Magnetic Island environment and community groups, enabled by Mitsubishi Corporation support. Activities undertaken by the Earthwatch and JCU teams included:

- "Pub talk" night presentation on project objectives and outcomes to Magnetic Island community members
- "Sea-weeding at Yunbenun" update to the Wulgurukaba Traditional Owner working group
- Expert contribution, presentation and general participation in the Magnetic Island Community Action Plan workshop focused on contemporary environmental issues facing the Island and local action.
- Participation in the Magnetic Island Community Beach Clean Up Day (Florence Bay)
- Deepening connection to local school and community initiatives such as Mangrove surveys
- In-person and continued remote engagement with key community leaders in developing strategic and implementation plans for local environmental action.

Earthwatch Chief Scientist Dr Scott Wilson participated in the Magnetic Island Community Beach Clean Up Day at Florence Bay in July. Marine debris and microplastic pollution and the effects on reef health have been identified as environmental issues of concern by the Magnetic Island Community.

Field Report from the Scientific Team

2022 Field Season Summary

Recovery of the GBR undertook three field-based research trips to Magnetic Island this year, including 2 citizen-science based trips (July and October), and one with the research team only (July). Over the course of these expeditions, the team removed 352 kg of macroalgae from the 12 treatment plots. In total, the research team completed 51 days of in-water surveys and activities, resulting in approximately 1800 m2 of reef substrate surveyed this year (24 5x5m experimental plots, repeatedly surveyed by 3 teams during the year), ~200 coral recruits were counted across 240 settlement tiles, hundreds of fish were counted and identified, and 16,337 fronds (a cumulative 1246 m) of macroalgae were counted and measured. Additional efforts were undertaken this year to assess the impact of bleaching through the 2022 mass bleaching, assess survival of juveniles on coral seeding devices, examine monthly dynamics of algae growth, and perform an experiment in the Australian Institute of Marine Science. Over 1800 photographs were taken of the seafloor, which will result in 545,000 datapoints to assess changes in the benthic community. Overall, results continue to support that coral reef recovery is significantly enhanced in plots where algae have been removed.

Coral-algal dynamics

This season was our fourth at Magnetic Island, and represents a gigantic effort in continuing to collect detailed ecological data. In October 2018, 12 permanent 5x5m quadrats were established, covering an area of 300m2 of reef substrate over two sites, Florence Bay and Arthur Bay. In July 2019, the number of plots was doubled, to cover a total area of 600m2 of reef substrate. In 2022 and early 2023, monitoring efforts continued to include a wide variety of parameters such as coral bleaching, algal dynamics, and settlement device trials. Over the course of the year, we performed extensive monitoring, algal removal, and juvenile coral seeding device surveys.

We have learned valuable lessons from this year's data collection efforts. Consistent with other published work and last year's data, we have found that algal growth follows a seasonal pattern, reaching its peak abundance in summer.

Removal of algae achieves a significant immediate reduction in algal biomass (Figure 1A). Similar to last year, this year we observed that regrowth continues to be suppressed after multiple removal events (Figure 1B). With removal being undertaken multiple times this year, we achieved a 92-93% reduction in pre-spawning (October) biomass in removed plots compared to control plots (Figure 1A). Interestingly, algal biomass in Arthur Bay continues to be lower than the biomass observed in Florence Bay across both control and removal plots.

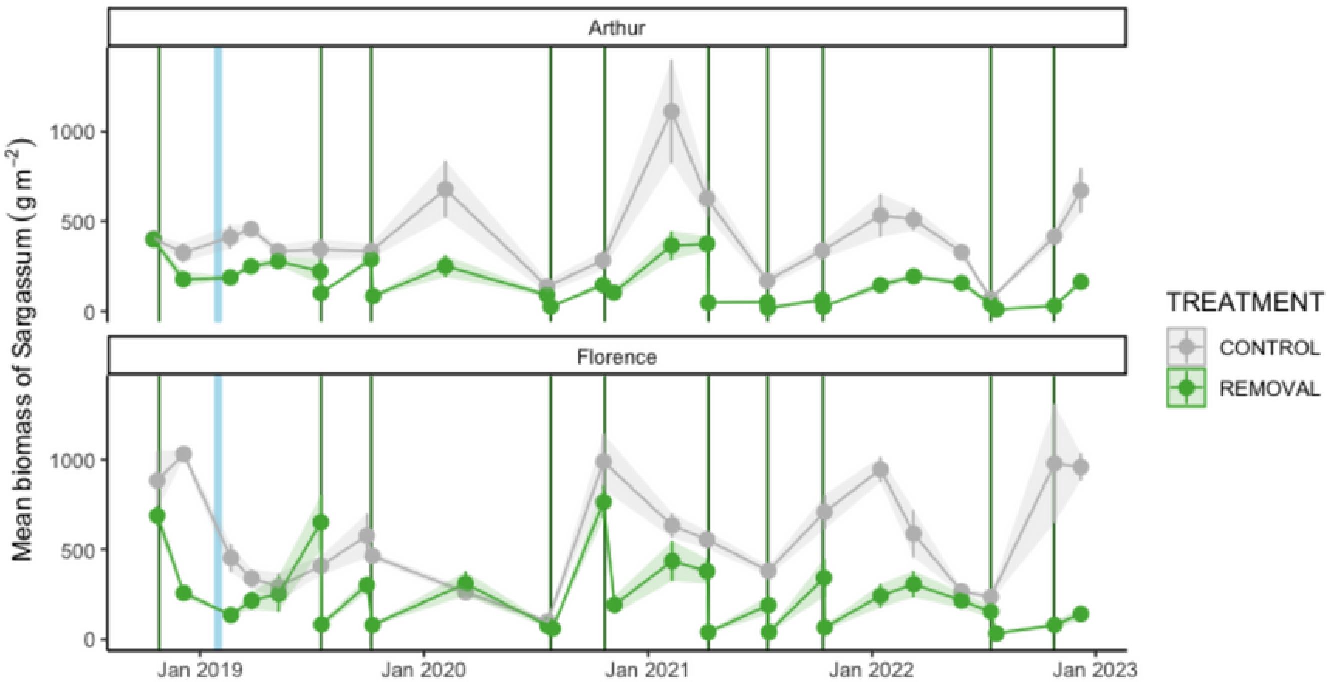

Figure 1. **A) The mean height of macroalgal canopy over time. Grey bars indicate macroalgae removal events**

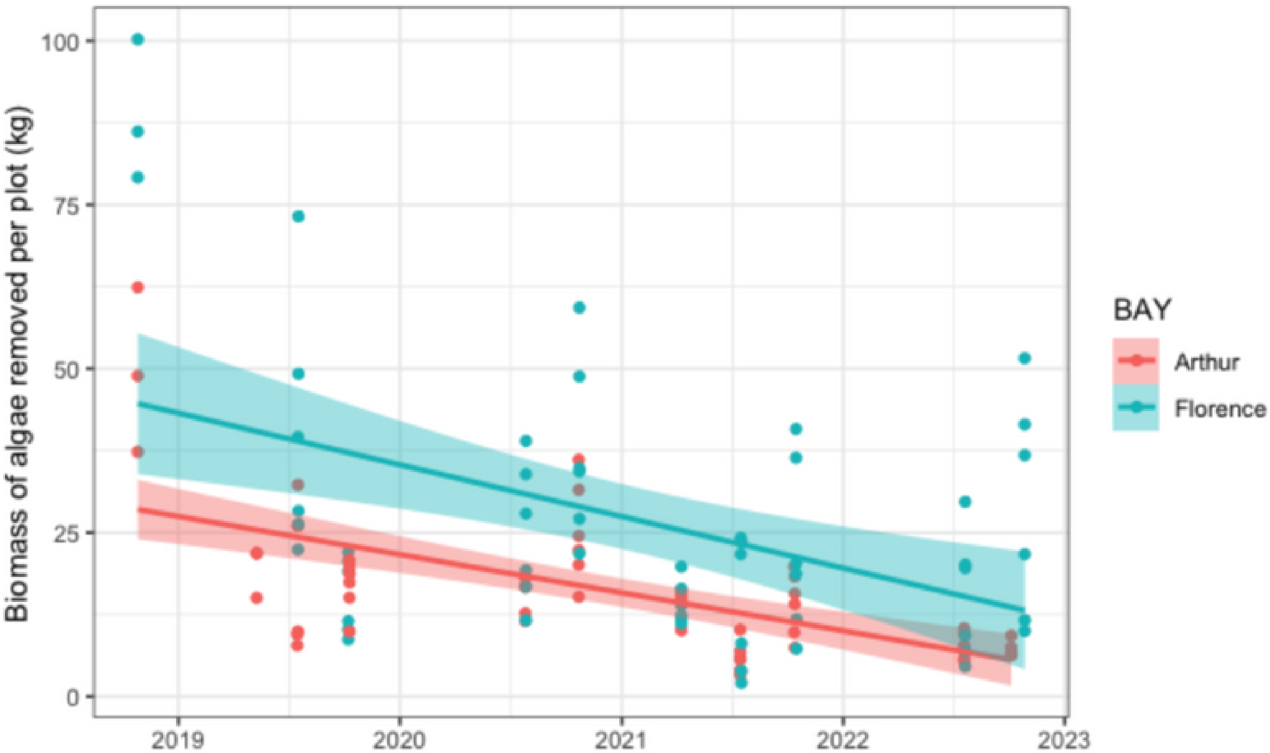

Figure 1. B) The removed biomass of macroalgae from removal plots at each removal event.

In October 2019, we began tracking natural coral recruits on the reef substrate in addition to using settlement tiles. In Arthur Bay, there are consistently higher numbers of recruits than in Florence Bay. Interestingly, in removal plots in both bays, there appears to be an annual cycle whereby pulse increases in the number of recruits are observed mid-year, with a drop in numbers coming into the October spawning period (Figure 2). These patterns suggest that removal of macroalgae may be effective at increasing initial settlement of juvenile corals, but that post-settlement processes through the year lead to mortality of recruits. Data has been collected to categorise recruits into morphology and size, and these data may help to resolve annual cycles of recruit dynamics, as these annual cycles should theoretically affect the smaller size classes. However longer-term data is needed to provide more robust patterns.

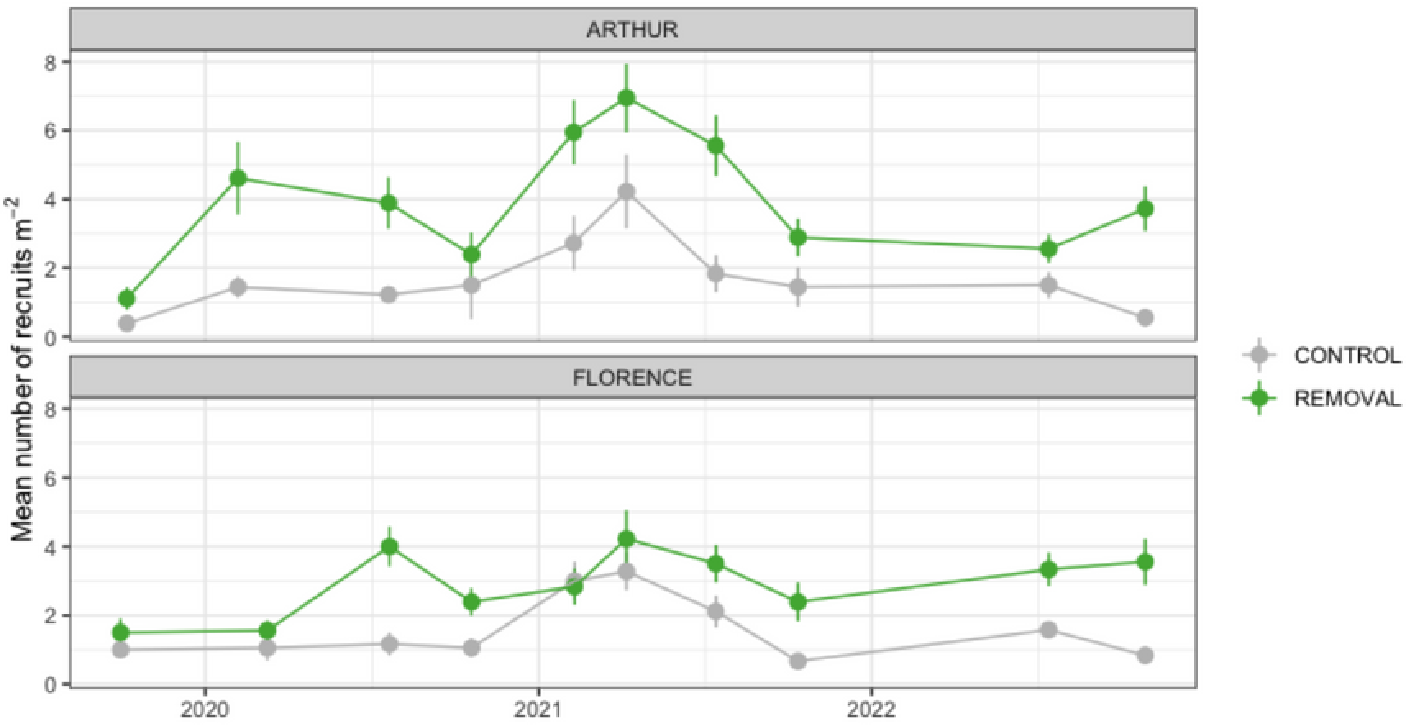

Figure 2. The mean number of recruits observed on the natural substrate over time.

Coral Settlement

Combined with the recruit data from natural substrata, settlement tiles continue to provide valuable insights into the impacts of macroalgae removal on coral recruitment processes. In the first two years of this study, settlement tiles were collected from the reef and treated with sodium hypochlorite (bleach), with the resulting juvenile skeletons counted under a microscope.

The patterns from the first two years of data showed strong support that removal of macroalgae enhances initial settlement of coral larvae (bottom left panel of Figure 3; Smith et al., 2022). Since 2020 in Arthur Bay, and since 2021 in Florence Bay, we transitioned methodologies to look at live settlement tiles, and re-deploy the tiles after each census to allow repeat monitoring of survival.

A significant drop in the number of coral juveniles was observed between methodologies, which allows us to better understand the dynamics occurring. While the first two years of data show that many more larvae are settling in algal removal plots, the same number are not necessarily surviving – for example, upwards of 30 juvenile skeletons were observed on bleached tiles from Florence Bay in each tile census of bleached tiles (2018 and 2019 spawning).

However, when looking at live tiles, it was rare to observe over 10 juveniles per tile. Interestingly, extremely low numbers of recruits were observed in both bays following the both the 2020 and 2022 spawning (note data collection is in progress for the first 2022 spawning census). It is possible that fecundity of adult corals was affected in 2020 and 2022 by the mass bleaching event (see section below), as decreased output of gametes is a known effect following bleaching in other locations. More detailed analyses of recruitment patterns to each tile face (i.e., top, bottom, sides) as well as recruit size are planned. Regardless, these patterns continue to indicate promise for direct macroalgal removal as a management approach to increase coral settlement.

Mitsubishi Corporation Fellows Leimin Pan (L) and Dannielle Kennedy (R) identifying, sorting and counting macroalgae removed from the reef.

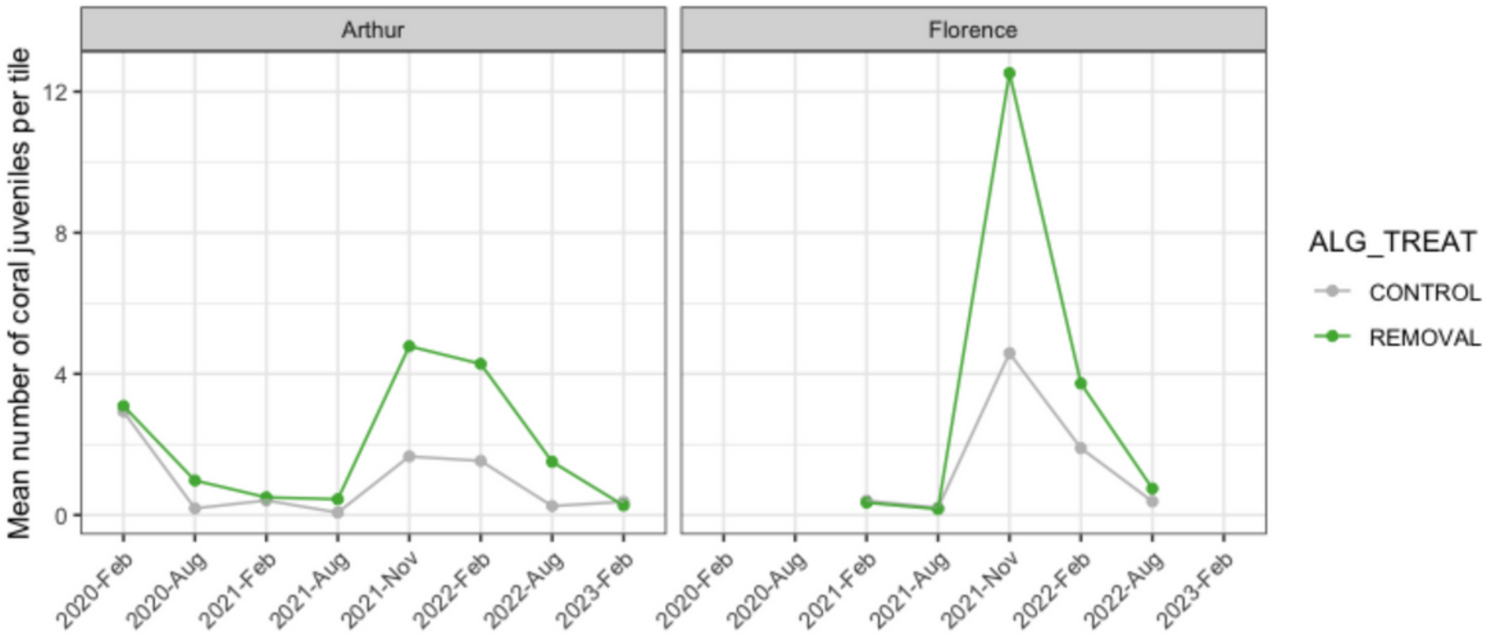

Figure 3. **The mean number of coral recruits per settlement tile from plots in Arthur and Florence Bays. Note, at the time of writing, February 2023 counts are in progress.**

Coral Larval Seeding

Coral larval seeding was trialled in Arthur Bay (2019 and 2020) and Florence Bay (2020), however strong results supporting implementation of the technique were not observed, likely due to extremely high post-settlement mortality. The drivers of mortality at this sensitive life phase are complex, but likely involve a combination of biotic and abiotic factors. As such, new research has been devoted to overcoming mortality in the first few months of coral life history. Specialised devices that aim to provide protection to coral juveniles through excluding fish grazing have been developed by project partners at the Australian Institute of Marine Science. These devices have been shown to increase survival of coral recruits on coral-dominated reefs, but have not yet been trialled on more degraded reefs characterized by macroalgae dominance. A new project partnership was established in the 2021 field season to trial these devices within the algae removal and control plots at Magnetic Island.

In October 2021, the field team including citizen scientists collected 22 fertile adult colonies of Acropora tenuis and transported them to the National Sea Simulator at the Australian Institute of Marine Science for spawning. Spawned gametes were collected and fertilized, resulting in 1.3 million coral larvae. When competent, approximately 50,000 larvae were settled onto aragonite plugs and allowed to grow under controlled conditions. The plugs were then installed within specialized devices and deployed to the control and removal plots at Arthur and Florence Bays (Figure 4). Post-deployment censuses were undertaken this field season in February, May, August, and December.

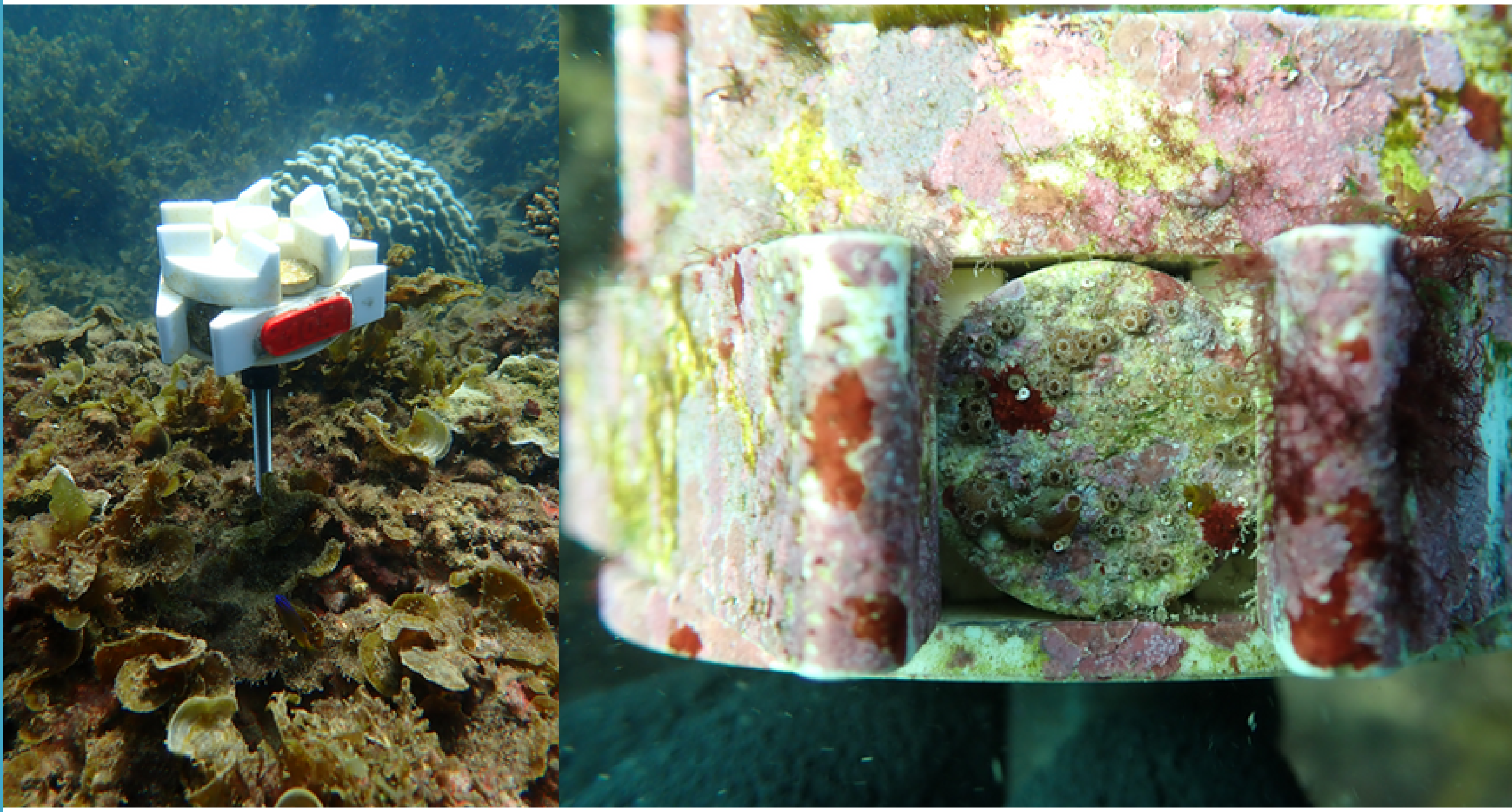

Figure 4. A) a settlement device installed in an algae removal plot in Arthur Bay.
B) Close-up image showing several live coral juveniles.

Preliminary analysis suggests that the settlement devices are effective in increasing survival of juvenile corals, with the sides of devices showing higher survival than the tops (Figure 5). Two more surveys are planned, with devices to be removed from the field in July 2023, when surviving corals will be measured for growth analysis, and tissue collected for genetic analysis.

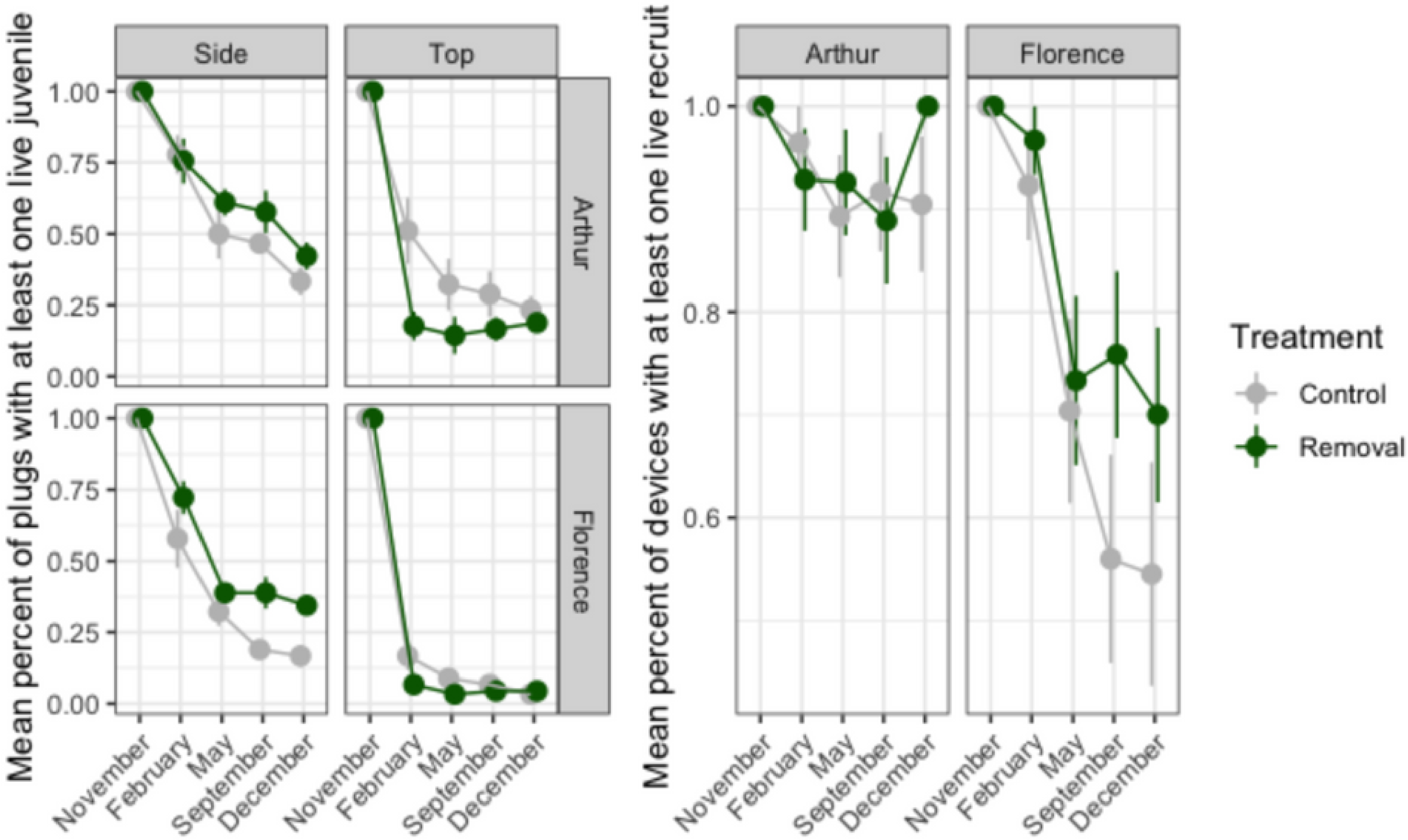

Figure 5. **Survival of coral juveniles on settlement devices in Arthur and Florence Bays in control and removal plots.**

Coral Health and Bleaching Events

At the end of 2021, predictions from the National Oceanic and Atmospheric Association (NOAA) indicated a high likelihood of extreme temperatures at Magnetic Island over the summer months. In anticipation of this, surveys of the coral communities were conducted in November 2021 to assess health. Reports of bleaching at Magnetic Island were made in early 2022, and hence surveys were repeated of coral communities to determine the prevalence and severity of bleaching in the experimental plots in January. Following an initial dissipation of heat stress in February, the region then experienced an extreme heat wave, and there were further reports of new bleaching emerging at Magnetic Island. Surveys were repeated again in March and May 2022 and data analysis is underway. Preliminary analysis reveals similar patterns to the 2020 bleaching event, with massive morphology colonies showing highest susceptibility to bleaching, and only minor differences in bleaching susceptibility between control and removal plots (Figure 6).

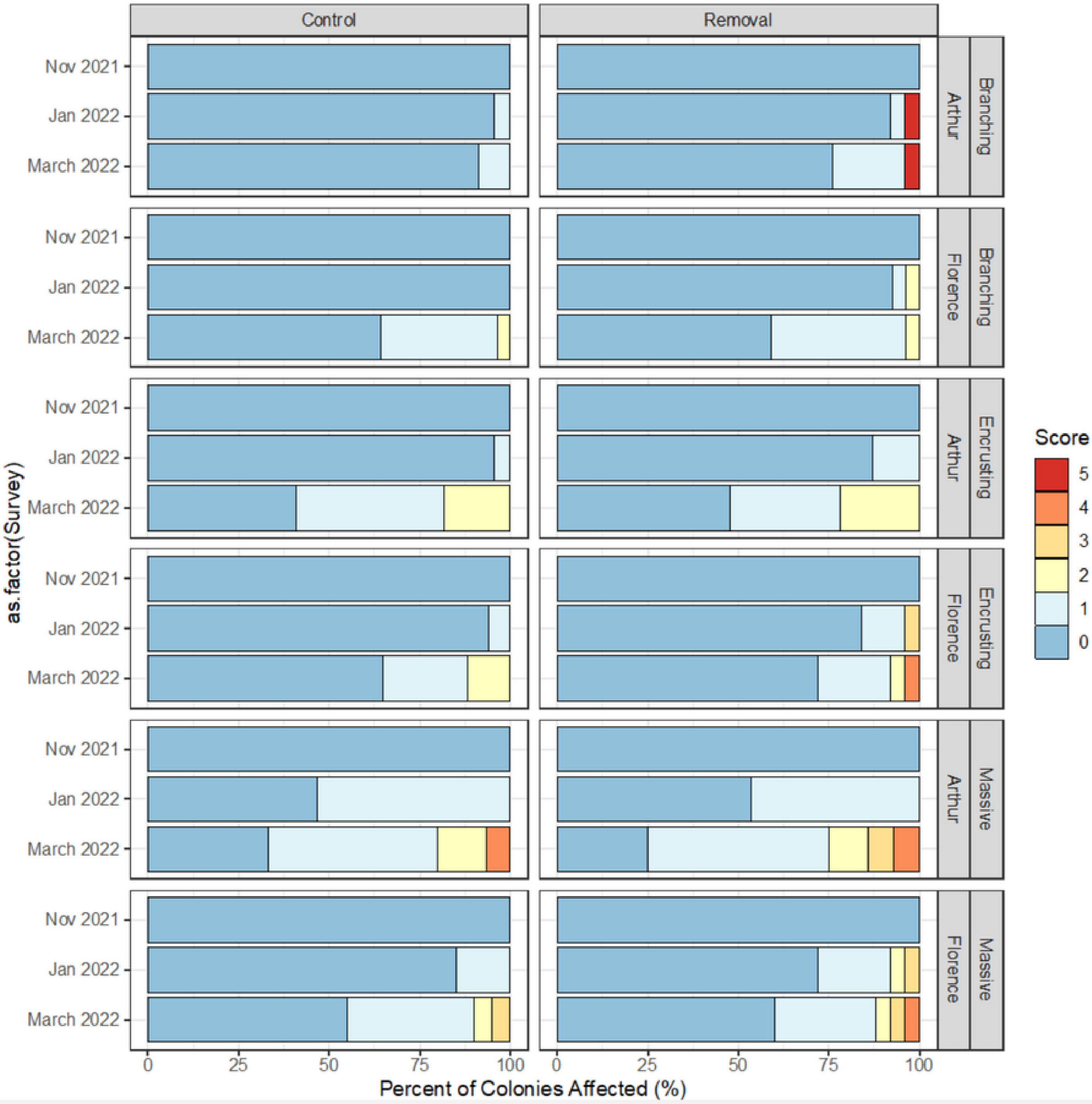

Figure 6. **Bleaching severity ranks (0 – no bleaching; 5 – severe bleaching) for encrusting, massive, and branching morphology corals in control and removal plots in Arthur and Florence Bays, in November 2021, January 2022, and March 2022.**

Surveys at the eighteen 3m x 3m quadrats showed a continuous trend in the abundance of coral juveniles and recruits from the previous years (Figure 6B). Previously, we observed signs of early recovery, especially at sheltered sites, in August of 2017. However, this field season documented a steady trend in coral juvenile abundances at both sheltered and exposed sites (Figure 6B). Given the general recovery of adult populations, it is somewhat surprising to observe a lack of increase in juvenile populations. It is possible that knock-on effects of the dual bleaching events have manifested in long-term lower reproductive output of adult corals. In addition, bleaching was again impacting the reefs around Orpheus Island in March 2020 and this may explain the low number of recruits observed this field season. Our results demonstrate that the consecutive bleaching events have ongoing impacts and will continue to impede the recovery of the cyclone-impacted reefs at Orpheus and Pelorus Islands, and that while short term studies may document initial recovery, longer term studies are required to delineate the true effects of such devastating events. Alternately, it is possible that in light of the strong recovery of adult populations, sufficient space does not exist on the reef substratum for juvenile settlement, or competition is too great post-settlement.

Summary

This field-based study has provided unique insights into long-term coral population dynamics following repeated disturbances and identifies the establishment of new coral populations as an important driver for replenishing cyclone-impacted coral communities. The frequency and severity of large-scale disturbances to coral communities are predicted to increase as climate change progresses and the recent 2016, 2017 and 2020 bleaching events are evidence of this phenomenon. Recovery of coral communities is thus becoming an increasingly important key to the resilience of reef ecosystems. The documentation of early and ongoing recovery dynamics within coral populations will contribute to predicting coral recovery rates and inform the role that effective management of these ecosystems can have in aiding reef recovery.

The data collected throughout the past year by the research team and Earthwatch volunteers will contribute to the understanding of reef ecology as it relates to macroalgal removal. The work also continues to support higher degree research students (Appendix 2). Further regular monitoring is planned for 2023 and will be invaluable in determining the best practice for coral reef restoration and connections with community groups and partner organisations (Appendix 3) will continue to be strengthened.

Challenges

With the relaxation of COVID-19 restrictions expeditions including Citizen Scientists were able to resume in 2022. Given the high rates of COVID-19 still within the community, additional measures were however put in place to minimize the likelihood of an infection being recorded in field teams including additional and private accommodation for citizen science team members. The budgetary impact of this was managed through the use of contingency and rolled over funds from the previous phase, as previously agreed.

Persistent La Nina conditions and associated extreme weather events impacted field activities throughout 2022. The planned April expedition was postponed due to winds and swells unsuitable for field activities, and was run back-to-back with the July expedition. Field activities during the October expedition were also hampered by strong winds and swells. A more stable field season is expected in 2023 with the weakening of La Nina conditions.

The JCU team (Hillary Smith, standing far left and Associate Professor David Bourne, kneeling far right) and the October Citizen Science team on a behind the scenes visit to the Australian Institute of Marine Science (AIMS) during challenging weather conditions.

Future opportunities

2023 Field Season

Three expeditions are planned for 2023, scheduled for early May, mid-July and late October. Planning and logistics are well advanced and recruitment for citizen scientists and Mitsubishi fellow attendance underway. The 2023 expeditions will be invaluable in both determining the best practice for coral reef restoration and strengthening relationships with the local Magnetic Island community and traditional owners of the reef. Land-based activities will again be made available to Mitsubishi fellows.

Potential Project Expansion

In late 2022, the Recovery of the Great Barrier Reef team was invited to submit a full funding application to CORDAP – the Coral research and Development Accelerator Platform. CORDAP is a highly regarded, international organization fully dedicated to funding global research and development for coral restoration and conservation. Our team's application focused on the potential expansion of the work being undertaken at Magnetic Island to another Australian location (Whitsundays) and internationally (Indonesia). We expect to hear the outcome of the application within the first half of the 2023 calendar year. The invitation represents an exciting development for the project. CORDAP awards are extremely prestigious and if successful, will affirm the research being undertaken at Magnetic Island as a viable global solution to reef recovery.

Mitsubishi Corporation Fellows Dannielle Kennedy (L) and Leimin Pan (R) sampling for microplastics at Arthur Bay as part of expedition land based activites.

Finances

PROGRAM EXPENDITURE	Year 1 April 22 - Dec 22 Budget	 Actual	 Variance
Implementation - macroalgae removal	$150,533	$118,603	$31,930
Research - methodology for removal of macroalgae	$75,000	$75,000	0
MC Employee Engagement	$24,670	$16,295	$8,375
Program Management	$18,803	$14,102	$4,701
TOTAL PROGRAM EXPENSES	$269,006	$224,001	$45,005

Notes on variances:

Reported part way through the contracted year, therefore a proportion of the expenditure remaims to be disbursed

Implementation - some major costs paid in previous reporting period (e.g. accommodation)

MC employee engagement has reduced expenditure in yr 1 as 3 of 6 budgeted fellows have fielded

Appendix 1- Publications

Peer-reviewed publications

Fulton SE, Smith HA, McLeod IMM, Page CA, & Bourne DG (In review). Sea-weeding: manual removal of macroalgae facilitates rapid coral recovers. Journal of Applied Ecology, ID# JAPPL-2022-01108

Smith HA, Chen CCM, Pollock FJ, Re M, Willis BL, & Bourne DG (In review). Drivers of coral mortality in non-acute disturbance periods. Marine Ecology Progress Series, ID# MEPS-2022-09-046.

McLeod IM, Hein MY, Babcock R, Bay L, Bourne DG, Cook N, Doropoulos C, Gibbs M, Harrison PL, Lockie S, van Oppen MJH, Mattocks N, Page CA, Randall CJ, Smith A, Smith HA, Suggett DJ, Taylor B, Vella KJ, Wachenfeld D, & Boström-Einarsson L (2022). Coral restoration and adaptation in Australia: the first five years. PLoS ONE 17 (11), e0273325.

Arjunwadkar CV, Tebbett SB, Bellwood DR, Bourne DG, Smith HA (2022). Algal turf structure and composition vary with particulate loads on coral reefs. Marine Pollution Bulletin 181, 113903.

Smith HA, Prenzlau T, Whitman T, Fulton SE, Borghi S, Logan M, Heron SF, Bourne DG (2022). Macroalgal canopies provide corals limited protection from bleaching and impede post-bleaching recovery. Journal of Experimental Marine Biology and Ecology 553, 151762.

Smith, HA, Boström-Einarsson L, Bourne DG (2022). A stratified transect approach captures reef complexity with canopy-forming organisms. Coral Reefs 41, 897-905.

Books and book chapters

Bourne DG, Smith HA, Page C. (2022). Diseases of Corals. In: Invertebrate Pathology. Oxford University Press.

Presentations

Invited pub talk – Hillary Smith, Magnetic Island Community Action Plan. "Our Fringing Reefs," 26 May 2022.

AMSA Conference – 15 minute talk. Hillary Smith. "Boosting reef health through removal of macroalgae," 11 August 2022.

AMSA Conference – poster. Hillary Smith. "Life in Layers: a stratified transect approach captures reef complexity with canopy forming members," 8 August 2022.

"Sea-weeding at Yunbenun" – update to the Wulgurukaba Traditional Owner working group, 13 July 2022.

Student Reports

Stella E Fulton (2022). Effects of macroalgal removal on inshore coral reef communities and sedimentation dynamics. James Cook University, MPhil Thesis (123 pp).

Megan H Williams (2022). Benthic community development on settlement tiles varies with macroalgal biomass on inshore reefs. James Cook University, MSc Minor Project (46 pp.)

Madison Becker (2022). The role of macroalgae canopy cover and coral morphology on bleaching severity in two fringing reefs on Magnetic Island in Great Barrier Reef Marine Park. James Cook University, MSc Special Topic (11pp).

Emma Martin (2022). Coral recruitment patterns on inshore reef ecosystems of the Great Barrier Reef. James Cook University, MSc Special Topic (22 pp).

Appendix 2 - Student Research Supervision

Student Name	Graduate Degree	Project Title	Anticipated Year of Completion
Stella Fulton	MPhil	Ecological implications of macroalgal removal for localized inshore reef restoration	2022
Sandra Erdmann	PhD	Effects of reef restoration techniques on the genetic diversity and connectivity in scleractinian populations of Magnetic Island, Australia.	2024
Julia Hung	PhD	Coral and microbial interactions during the progression of black band disease (BBD)	2024
Megan Williams	MSc	Benthic community succession in Sargassum dominated inshore reefs.	2022
Madison Becker	MSc	How do macroalgal canopy effects affect coral bleaching during minor and moderate thermal anomalies?	2022
Tehya Hines	Honours	Oceanography of Florence and Arthur Bays	2021
Emma Martin	MSc	Methodology matters: bleached vs live counts of coral recruits skews understanding of reef processes	2023
Belinda Phanphengdy	MSc	Community composition changes in response to macroalgae removal	2024

Appendix 3 - Partnerhips

Name of organization	Support Type	Years of assocation
Mitsubishi Corporation	Funding	2012-present
Great Barrier Reef Marine Park Authority	Management support, permits	2018-present
Australian Institute of Marine Science	Collaboration, cultural support	2019-present
Reef Ecologic	Collaboration, logistics	2018-present
Arthur Bay Beach House	Logistics, in-kind funding	2019-present
Port of Townsville Limited	Data	2019-present
National Geographic	Funding	2020-2022
University of New South Wales	Collaboration	2021-present
British Ecological Society	Funding	2021-present
Wulgurukaba Traditional Owner Group	Community Outreach	2021- present
Magnetic Island Community Action Plan	Community Outreach	2021-present
Reef HQ Volunteers Association	Funding	2022
Women Divers Hall of Fame	Funding	2023

Acknowledgements

Earthwatch and James Cook University thank all the participants who have contributed to the program. We thank our dedicated field and research teams who have contributed countless hours toward the success of field operations - Kathy Connellan, Taylor Whitman, Taleatha Pell, Stefano Borghi, Megan Williams, Callaway Thatcher, Daisy Church, Nico Briggs, Ynes Sanchez, Jihun Kim, Cecilia Martin, Christy Kong, Daniel Cossey, Emma Martin, Genevieve Dallmeyer-Drennen, Iris Lai, Jerry Watkins, Katie Sievers, Madison Becker, Mathilda Bates, Matthew Youd, Megan Bouch, and Belinda Phanphengdy. This work would not be possible without you.

Thanks also to Libby Evans-Illidge for facilitation contact with the Wulgurukaba traditional owner group to communicate our research goals and findings.

We acknowledge the Traditional Owners of Magnetic Island as the custodians of the land on which we work and pay respects to Elders past present and emerging.

Earthwatch and James Cook University sincerely thank Mitsubishi Corporation for their ongoing support of this program

Contact

Fiona Sutton Wilson
Cheif Executive Officer
fsuttonwilson@earthwatch.org.au

Elizabeth Irvine
Program Operations Manager
eirvine@earthwatch.org.au.

Earthwatch Institute
Suite G-06, 60 Leicester St, Carlton VIC, 3053
(03) 9016 7590
https://www.earthwatch.org.au/
hello@earthwatch.org.au
@earthwatch_aus