REEF IN REVIEW

THE MAGAZINE OF THE AUSTRALIAN CORAL REEF SOCIETY

2018 #48

Colourful reefs
Colours, patterns, and coral reef fishes. pp 8-9

People & the GBR
How do people perceive ongoing changes in our iconic Great Barrier Reef? pp 10-11

ACRS Research Awards
2018 award recipients share their fascinating research. pp. 15-25

A large school of trevallies cruises along coral reef.
© Yen-Yi Lee/Coral Reef Image Bank

The Australian Coral Reef Society acknowledges the Traditional Owners of coral reefs throughout Australia. We pay respect to their elders, past, present, and emerging.

Message from the President

This year, like many others, has showcased the continued commitment of the ACRS to supporting student research, rewarding excellence in research and management, providing a voice for the reef through engagement, and facilitating terrific conferences that allow scientists and managers to come together and discuss solutions that may help conserve the reefs that we all love. All of this could not be achieved without a very hard-working Council. Their energy and professionalism is inspiring and deserves a big thank you!

The society is currently ~260 members strong, and this year we have introduced a perpetual membership. So for those of you that don't like keeping track of your payments and want to support the ACRS into the future, this might be a good option. We have also had a bit of a makeover, as we have rebranded and are incredibly proud of our new website. If you haven't checked it out yet, it's a one-stop shop for all things ACRS (membership, conference registration, merchandise, opinion pieces and submissions etc). We also have fantastic Facebook and Twitter feeds that provide numerous reef-related stories every week.

Our 2018 conference in Exmouth, Western Australia, was highly successful with 116 national and international delegates in attendance. This event showcased the high quality fundamental and applied research that is being done on reefs here in Australia and overseas, and has also provided a mechanism to ensure the exchange of ideas between researchers on both sides of the country. The Exmouth conference was also the first time that we included an adjoined the AGM. This facilitated much greater membership engagement and a fruitful discussion about ACRS activities.

While our northern reefs have fared relatively well in terms of bleaching of late, it is saddening to see patchy bleaching occurring on some of our more southern reefs. A reminder that subtropical locations are not necessarily a refuge during times of environmental change. As one of the more southern members of the ACRS, I personally would love to see more research occurring on these reefs and I hope to see a migration of researchers (even if you don't overwinter here!) exploring key questions relating to their function and susceptibility.

Anna Scott

ACRS President

Left: Mixed school of planktivorous reef fish on a tropical coral reef slope.
© Yen-Yi Lee/Coral Reef Image Bank

Editorial foreword

Dear members,

Australian coral reefs continued to be in the spotlight in 2018-19. We showcase some of this work and the important role of research stations and management partnerships in the 'new look' 2019 magazine (former ACRS newsletter).

In 2018 the ACRS Conference was held in Exmouth, attracting a large and diverse array of scientists and managers. Five exceptional keynote speakers covered a variety of subjects ranging from Marine Park monitoring, macroalgae as fish habitats, spatial resilience, meeting the challenge of climate extremes, and fish physiology. This year's conference will be held on Moreton Island from 7-9 May 2019 and we look forward to enabling important scientific insights into the study and conservation of coral reefs.

The ACRS continues to celebrate the beauty and value of coral reefs through its membership, mentoring of up-and-coming researchers, science communication and evidence-based advice to policy makers. In 2018 a submission was provided to the New South Wales government on their decision to abandon sanctuary zones in the proposed Hawkesbury Shelf Marine Bioregion. The submission reiterated the need for evidence-based management in marine spatial planning and refuted the proposal that conservation zones would provide adequate protection for species, habitats and dependent industries. The need for effective and representative planning in this area, but also around Australia is heightened given a growing population and pressures from climate change.

In 2019, coral reefs around Australia seem to be continuously recovering from an increased disturbance frequency. The 2018 ACRS medal recipient, Assoc. Prof. Tracy Ainsworth summarised it perfectly "it is now very clear that the future is going beyond what we ever imagined was possible, more than ever I am convinced that to meet this challenge, so too should we". So as we enter 2020, as engaged reef scientists, reef lovers, and managers, we need to be mindful of what the reefs around Australia are experiencing and what that may mean for Australians. We need to persuasively, accurately and honestly communicate what the ramifications for reefs will be and what can be done to fix it. This will require reaching different audiences in different ways, not just through scientific papers and conferences.

In this issue, we feature cutting-edge research by ACRS members across Australia. Also, recipients of the 2018 ACRS Awards made some room in their busy schedules to describe the progress of their exciting research projects. As in previous editions, we are excited to share with you the latest news straight from reef field research stations across Australia. Finally, Taryn Laubenstein, 2018 FameLab finalist and ACRS member, shares with us science communication tips to take scientific outreach for early career researchers to new heights.

We hope you enjoy the 2019 issue of Reef in Review, the magazine of the Australian Coral Reef Society.

Victor Huertas

Jessica Hoey

Peter Cowman

Chris Roelfsema

Left: Two spotted clownfish (*Amphiprion ocellaris*) shelter amongst the tentacles of their host anemone (*Heteractis magnifica*). © Victor Huertas 2017 ACRS Photo Competition

Table of contents

Cover: Titan triggerfish (*Balistoides viridescens*) © J. Thorogood. 2018 ACRS Photo Competition

Aboriginal and Torres Strait Islander readers should be aware that this publication may contain images or names of people who have passed away.

Mixed school of sweetlips © Fabrice Dudenhofer/Coral Reef Image Bank

Colours, patterns, and coral reef fishes

By Christopher Hemingson
James Cook University

Colouration can tell us a lot about how an organism behaves and interacts within its environment. Whether it is used for maintaining species boundaries, aiding mate selection or providing protection from predators; colouration is critically important. Therefore, it is no surprise that it has remained a central focus of biological, ecological, and evolutionary studies since the times of Charles Darwin and Alfred Russel Wallace.

New advances in image analysis techniques have opened the door to a plethora of new studies involving organism colouration. We now have powerful new tools that allow us to analyse the visual appearance of an organism; including both colour and pattern.

Measurement of colouration on coral reefs.

Coral reefs are one of the most visually diverse ecosystems on the planet. This vast diversity of colour patterns, and the subsequent messages they represent, have intrigued researchers since the dawn of modern sciences.

Professor Justin Marshall (University of Queensland) attempted to decode messages found within the colours of reef fishes. Blue and yellow were the most common colours used by reef fishes. These colours simultaneously matched their respective backgrounds (blue water and the yellow average colour of a healthy coral reef) but also highly contrasted - aiding signalling.

Spectrophotometers operate by detecting the intensity of electromagnetic radiation (light) at each wavelength, returning a distribution of light at various wavelengths (colours). Many studies in the field of colouration has used this robust technique. However, it isn't without its limitations. While it provides extremely detailed measurements of colour, it does not incorporate critical information about the organism's full visual appearance: its pattern.

The difficulty of patterns and their new solution.

Patterns have historically been an elusive concept to study. If colours are inherently based upon the visual capabilities of the viewer, then patterns are even more so. This is because the classification of patterns retains a human bias. What is the difference between stripes and bars? There is no consensus when classifying colour patterns, just approximation. This difficulty has resulted in the exclusion of patterns from many studies.

The most common colours found in reef fishes are blue and yellow.

Fortunately, new technological advancements have enabled and understanding of both colouration and pattern. 'Patternize' (a new computing package openly available in the R) is capable of objectively analysing both colour and pattern simultaneously, without human bias. Since pattern is just the organisation of colours within a spatial context, the software can record both what colour is present at a given location and where that location occurs.

Your neighbours determine your style.

Colouration, like any other method of advertising information, can effectively be considered a signal. This signal contains important details: who you are, how you behave, and how you fit into your environment. For many organisms that rely on visual cues, colouration is used to identify individuals of the same species and differentiate them.

Terrestrial research has shown when two closely related species co-occur (i.e. share the same habitat) the signals they use to identify themselves are more pronounced. We set out to see if this phenomenon

Above: 'Patternize' output, detecting the presence of yellow on a *Chaetodon fasciatus* individual. © Chris Hemingson

holds true for brightly coloured coral reef fishes. In butterflyfishes (genus: *Chaetodon)* both sexes are visually similar, many species form monogamous pairs, and have highly complex patterns that are limited in colours. Using 'patternize', similarity between pairs of closely related species were compared to determine their habitat range. Essentially, we wanted to know whether the patterns on butterflyfish pairs differed if they shared where they live with other pairs.

Surprisingly, we found exactly that. When a pair shares a lot of their 'home' with another species, and these homes are about the same size, the differences in appearance are more pronounced. In contrast, when these species have very different habitat ranges they become more similar.

If you want to learn more about this study, be sure to check out the original paper titled "Colour pattern divergence in reef fish species is rapid and driven by both range overlap and symmetry" that was published in Ecology Letters in November 2018.

You can read more here: https://onlinelibrary.wiley.com/doi/full/10.1111/ele.13180

Above: *Chaetodon reticulatus* (left) and *Chaetodon meyeri* (right), an example of closely related species that share homes but look very different. © François Libert

Monitoring community responses to change in the Great Barrier Reef

By Dr. Matt Curnock
CSIRO Land and Water, Townsville

As enlightened marine biologists know, coral reefs are linked social-ecological systems, within which the well-being of humans and reef-building corals are intertwined. Thus, when a major disturbance occurs, like a mass coral bleaching event, an effect on the dependent and associated human communities should be measurable. The Social and Economic Long Term Monitoring Program (SELTMP; led by Dr Nadine Marshall from CSIRO and funded by the Great Barrier Reef Marine Park Authority) for the Great Barrier Reef (GBR) provides a means of monitoring and understanding the state, trends, and relationships between human communities and the Great Barrier Reef. Since commencing in 2011, SELTMP has surveyed more than 12,000 people about their relationship with the GBR, including local residents living along the coast of the GBR catchment region, international and domestic tourists visiting the region, Marine Park tourism operators, commercial fishers, and Australian residents (via online surveys) around the country.

Perceptions of major threats to the GBR have changed among all of our survey groups, and climate change is now regarded as "an immediate threat requiring action".

Comparing results from our two major sampling periods so far, mid-2013 and mid-2017, has revealed some significant changes in these communities' perceptions, values and sentiments associated with the GBR, which are likely to reflect responses to the 2016-2017 mass coral bleaching events and a growing public awareness of the GBR's perilous outlook in the face of climate change. For

Above: GBR managers are seeking to better understand and engage with recreational users to improve their compliance and stewardship in the GBR Marine Park. SELTMP provides insights into peoples' values, attitudes, norms, and trusted messengers, helping managers to engage more effectively with different user groups. © Matt Curnock

Above: GBR tourism contributes >$5.7 billion annually to Australia's economy, but the industry is vulnerable to changing perceptions of the reef, as well as its changing biophysical state. SELTMP monitors the perceptions, sentiments and satisfaction of Australian and international tourists in the GBR, helping managers and industry respond and adapt to change. © Matt Curnock

example, among tourists, we found significant declines in their ratings of the quality of GBR-based activities, such as snorkelling and scuba diving, as well as in their perceptions of the GBR's health and aesthetic beauty. Perceptions of major threats to the GBR have changed among all of our survey groups, and climate change is now regarded as "an immediate threat requiring action" by the majority of GBR coastal residents, international and domestic tourists, and Marine Park tourism operators. Concurrently, we found significant increases in 2017 ratings by most groups for cultural values associated with the GBR, including its biodiversity value, scientific heritage, economic, lifestyle and icon values. An increasing proportion of respondents from most groups indicated that they "would like to do more to help protect the GBR"; however, corresponding ratings of self-assessed capacity to act (i.e. having the knowledge and skills to reduce impacts) fell significantly.

The GBR is still considered by Australians as the nation's most inspiring landmark.

Despite a widespread perception of declining reef health, the GBR is still considered by Australians as the nation's most inspiring landmark. Our results are helping GBR managers and community leaders to better understand the human dimensions of the GBR for adaptive management, more effective stakeholder engagement, and for statutory reporting (e.g. the Reef 2050 Plan and the forthcoming Outlook 2019 Report). Survey data from SELTMP are made publicly available online and can be analysed for myriad purposes. SELTMP 2013 data and reports are available via https://seltmp.eatlas.org.au/.

SELTMP 2017 data can be interrogated through several PowerBI™ online dashboards (https://research.csiro.au/seltmp/). A series of sectoral reports detailing the 2013–2017 changes will be made available in early 2019 via the Great Barrier Reef Marine Park Authority and SELTMP websites. For more information, feel free to contact matt.curnock@csiro.au and/or nadine.marshall@csiro.au.

2018 ACRS Early Career Research Medal

Assoc. Prof. Tracy Ainsworth

In 2018, the Australian Coral Reef Society presented Associate Professor Tracy Ainsworth with the ACRS Early Career Research Medal for her outstanding contribution to Australian coral reef research.

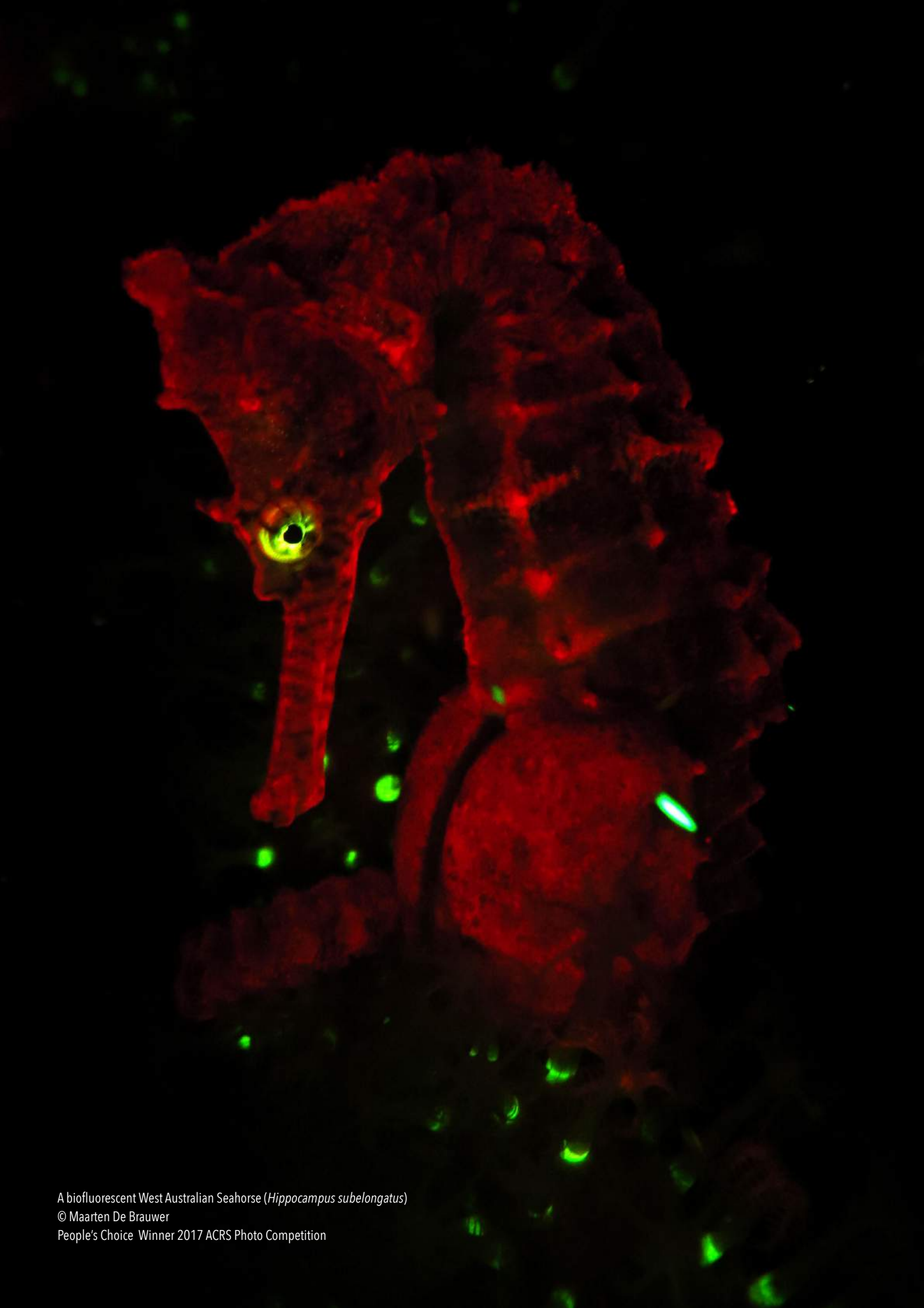
Associate Professor Tracy Ainsworth is a Scientia Fellow in the School of Biological, Earth and Environmental Sciences at the University of New South Wales. Ainsworth's research focuses on the impact of environmental stress on reef-building corals, their host-microbe interactions, symbioses, and disease outbreaks.

In a relatively short timeframe, Ainsworth has established herself as a reference in the coral biology field. She has produced 52 scientific articles, including two first author papers in Science. This prolific record has propelled her to the forefront of the fields of coral microbiology and stress biology, with significant contributions identifying unique prokaryotic coral symbionts, highlighting the significance of sub-bleaching thermal stress in corals, and improving our understanding of the rapid changes that coral microbial communities are experiencing in a changing ocean, to name a few.

Assoc. Prof. Ainsworth's impact, however, extends way beyond academic circles. She is as passionate about conducting cutting-edge research as she is at communicating it. For example, since being awarded her PhD in 2008, Ainsworth has contributed popular articles to The Conversation, engaged in numerous public interviews, and her work has been highlighted by international media such as the Washington Post, Time, and National Geographic.

Assoc. Prof. Ainsworth is an active member of the coral reef community. Her drive and commitment to expand and diversify our community is exemplified by her central role in the ARC Centre of Excellence Women in Science Group. Moreover, she is also dedicated to mentoring female researchers through the L'Oreal Women in Science Program and is an International mentor for a NSF international travel fellowship, and a member of the International Society for Reef Studies Council.

You can follow Assoc. Prof. Ainsworth on Twitter at @CoralTrace



A biofluorescent West Australian Seahorse (*Hippocampus subelongatus*)
© Maarten De Brauwer
People's Choice Winner 2017 ACRS Photo Competition

Two moray eels share the same crevice
© Ciemon Caballes
2017 ACRS Photo Competition

2018 ACRS Research Awards

Each year the ACRS supports the research of up to five students through provision of the ACRS Research Awards. The most outstanding proposals are awarded the Terry Walker Prize ($4,000) or the Danielle Simmons Prize ($4,000). Up to three additional ACRS Research Awards of $2,500 each are also awarded.

Below we present you the recipients of the 2018 ACRS Research Awards. In the following pages, you can read articles contributed by each awardee.

Terry Walker Prize

MARDI McNEIL

The role of macroalgae genus *Halimeda* in provision of inter-reef benthic habitat in the Great Barrier Reef.

Danielle Simmons Prize

COULSON LANTZ

The combined effect of ocean acidification, seawater warming, and eutrophication on carbonate sediment dissolution and metabolism.

ACRS Awards

SHANNON McMAHON

The effects of temperature and elevated CO2 on reef mesopredators.

MIKAELA NORDBORG

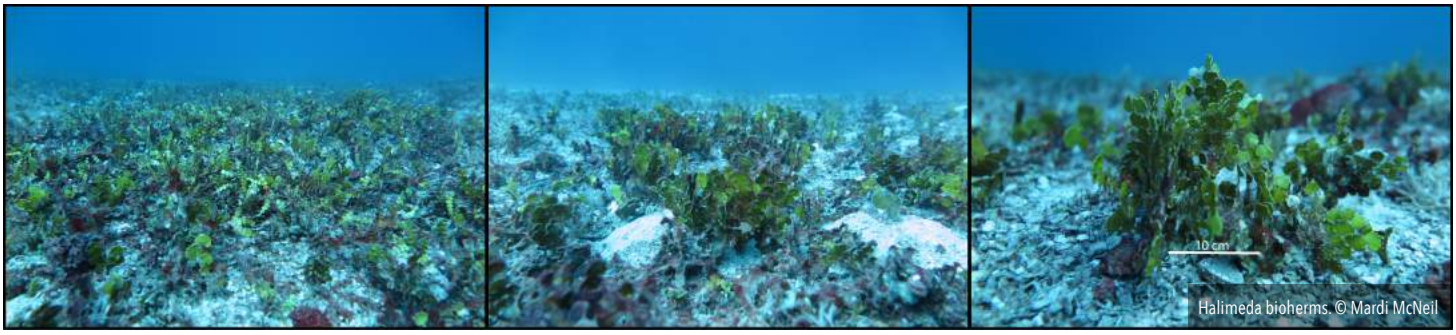
Cumulative impacts of future climate conditions and heavy fuel oil on key life stages of the coral A*cropora millepora*.

KELSEY SANBORN

Paleoecology of the last interglacial Tantabiddi Reef of Western Australia.

Getting to know the neighbours... *Halimeda* bioherms in the inter-reef seafloor of the GBR

By Mardi McNeil
Queensland University of Technology



Coral reef ecosystems are varied and complex, with many connected habitats. Some of these neighbouring inter-reef habitats may be in deeper water, remote, logistically challenging to access and survey, and lack the colourful coral colonies and charismatic fishes of their shallow reef neighbours. Consequently, these deeper inter-reef habitats are not as well-studied, and have been somewhat overlooked as productive and diverse ecosystems. However, the inter-reef seafloor of the Great Barrier Reef Province comprises a variety of geomorphic features, including submerged rocky shoals and pinnacles, carbonate sands, submarine canyons, and *Halimeda* bioherms on the outer continental shelf.

Recent efforts to develop a high resolution digital depth model for the entire Great Barrier Reef World Heritage Area (Project 3D-GBR) has combined multibeam sonar, satellite remote-sensing and lidar bathymetry survey data into a single bathymetric grid (gbr30). Development of this high resolution bathymetry DEM has revealed the complex topography and detailed

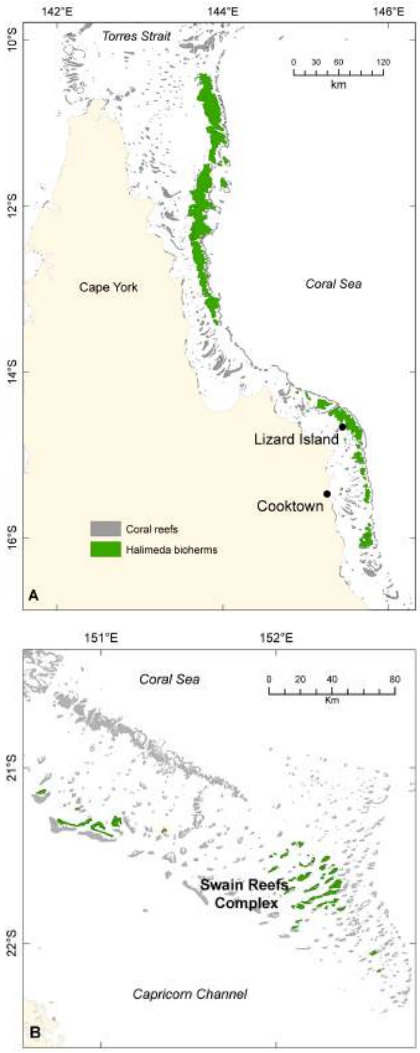


Figure 1. Distribution of mapped *Halimeda* bioherms in **A** Northern Great Barrier Reef, and **B** Swain Reefs complex, southern Great Barrier Reef. Bioherms were identified and boundaries delineated from high resolution multibeam and lidar bathymetry datasets from Project 3D-GBR. (credit: https://doi.org/10.6084/m9.figshare.7506251.v2).

structure of many of the deep inter-reef habitats for the very first time. A great example is the vast *Halimeda* algal bioherms of the Great Barrier Reef outer continental shelf (Fig. 1), and the subject of my PhD project.

"Bioherm" is a geological term which describes an *in situ* build-up of biogenic calcium carbonate sediment or limestone, with positive relief above the surrounding seafloor. *Halimeda* bioherms have built up since the end of the last ice-age, from the disarticulated skeletons of the calcareous macroalgae genus *Halimeda*. These complex geomorphic features can be up to 20 m thick, span over 6,000 km² and six degrees of latitude of inter-reef seafloor in the northern GBR, and are the second largest living structure on the Reef. *Halimeda* bioherms are structurally complex, appearing like large fields of donut shaped rings and reticulate honeycomb patterns (Fig. 2). This complexity may support a more diverse community of fish and invertebrates than previously thought.

The aims of my PhD project include reconstructing the spatial and temporal development of the *Halimeda*

bioherms throughout the Holocene using radiocarbon dating of *Halimeda* sediment cores and analysis of seismic sub-surface data; and investigating the role of *Halimeda* bioherms in the provision of deeper inter-reef habitat for fish and benthic invertebrates. The ACRS Terry Walker Award has provided funding for fieldwork towards this aim. In 2018, I lead two field trips to the Lizard Island Research Station, where *Halimeda* bioherms are located on the continental shelf between the island and the outer barrier reefs. It was a real thrill to finally dive on the *Halimeda* bioherm tops and see the vast green carpet of *Halimeda* algal meadows as far as visibility would allow. During fieldwork we surveyed the surface and sub-surface of the *Halimeda* bioherms using sidescan sonar, acoustic sub-bottom profiling, AUV water chemistry sensors, and ROV video, as well as collecting sediment and water samples for chemical analysis. I

Above: A sea of yellow: Preparing the survey equipment for fieldwork at Lizard Island Research Station; Edgetech sub-bottom profiler. **Right**: Iver Ecomapper and BlueROV2. © Mardi McNeil

am currently writing up my findings from the two Lizard Island field trips, and drafting manuscripts for the first two publications from this work.

In 2018 I also presented preliminary results of this study at an international sedimentology conference in Quebec, Canada, as well as the Australian Marine Science Association and Ecological Society of Australia conferences. Unfortunately, an attempt to visit the *Halimeda* bioherms known from the southern GBR Swain Reefs was thwarted by bad weather, however our research group has been awarded ship time on the CSIRO's R/V Investigator, to conduct a new survey in mid-2020.

Acknowledgements

I would like to acknowledge the support of ACRS for the valuable contribution to cover fieldwork-related expenses; my PhD supervisors Dr Luke Nothdurft, Dr Jody Webster, and Dr Oliver Gaede; and collaborators Dr Robin Beaman and Dr Dirk Erler. I would also like to thank Dr Lyle Vail and Dr Anne Hoggett and acknowledge the Australian Museum Lizard Island Research Station staff for support with fieldwork logistics.

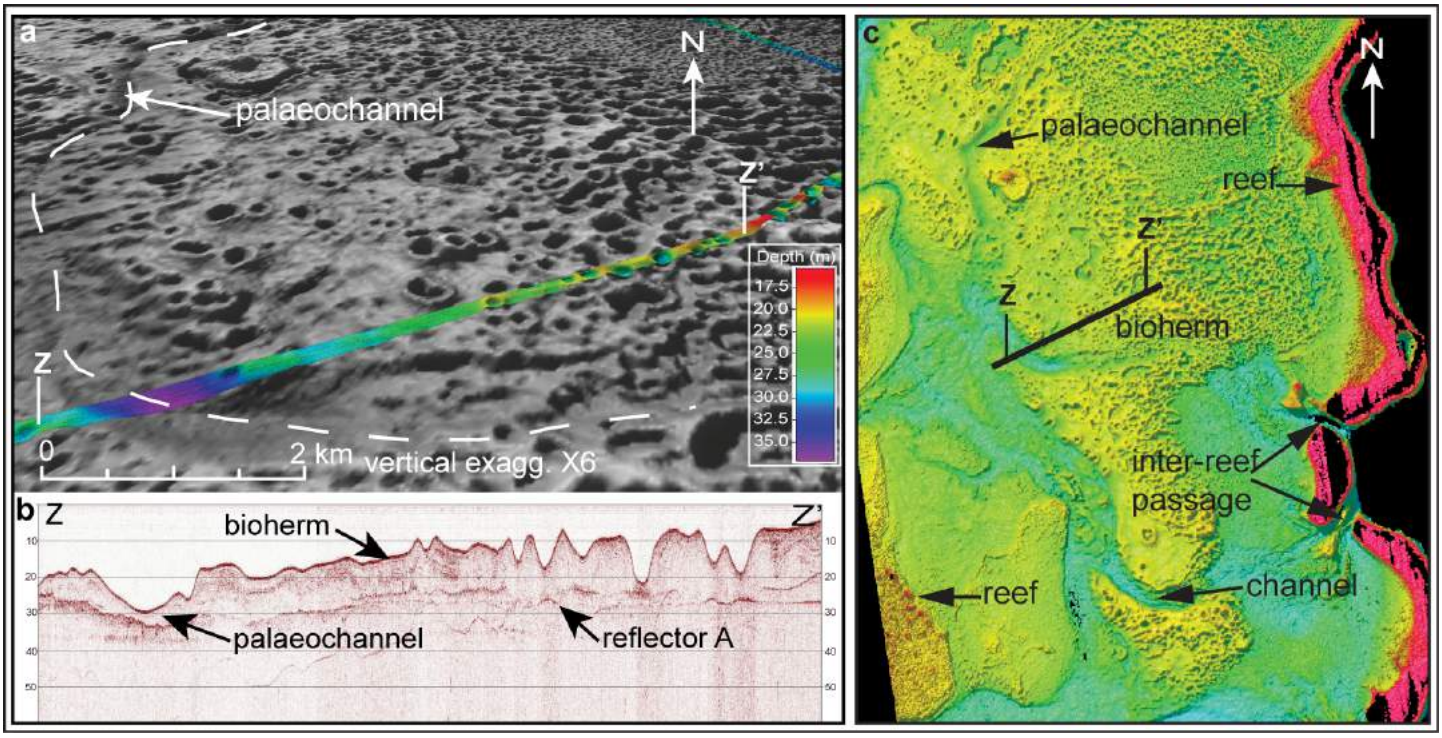


Figure 2. Three-dimensional view of **A** *Halimeda* bioherm complex in the northern GBR, with a 2 m multibeam data (rainbow scale) overlaid on 25 m lidar data (greyscale), **B** sub-bottom profile between points Z–Z' shows distinct *Halimeda* bioherm morphology accreting above a prominent seismic reflector. **C** The 25 m lidar data across the same area clearly reveals bioherms, reefs, and palaeochannels. Source: McNeil *et al*., 2016. (https://doi.org/10.1007/s00338-016-1492-2).

A shift in the sand

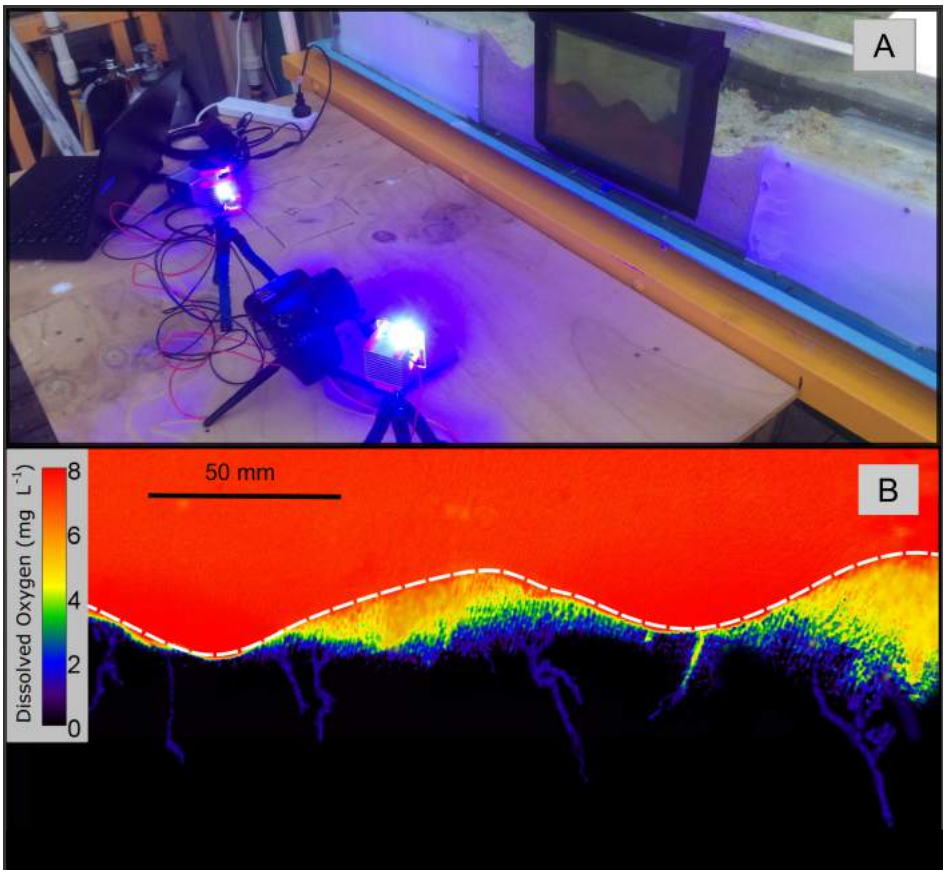
By Coulson Lantz
Southern Cross University

Calcium carbonate sediments account for roughly 70% of the benthic area of Heron Island's lagoon and house a rich biological community (e.g., worms, snails, clams, microbes) whose collective metabolism is responsible for recycling the majority of the locally produced organic matter (e.g., coral mucus, fish faeces). Relative to other marine environments, coral reefs generally contain low concentrations of organic matter (OM) in the water column.

The rapid recycling of these waste products that fall down into the sediment has been defined to be net autotrophic (Photosynthesis > Respiration over 24 hr), which elevates the pH of the sediment porewater enough to enable these sediments to be net calcifying (Calcification > Dissolution over 24 hr). However, there are concerns that global change stressors, such as the decline in seawater pH (ocean acidification) or the increase in concentrations of OM in the water column (coastal eutrophication), could act in concert to shift the balance in sediment metabolism away from the present-day autotrophic and calcifying behaviour.

To address these concerns, I used the Danielle Simmons Award to assist with the construction of four 105-L flume aquariums to replicate Heron Island's shallow lagoon sediment environment (with respect to light, temperature, and flow) and examine how ocean acidification (OA) and coastal eutrophication, both individually and in combination, affect the net autotrophic and calcifying behaviour of Heron Island's sediment communities.

Using buried sediment boxes, daytime and nighttime changes in dissolved oxygen, total alkalinity, calcium, and dissolved inorganic nutrients were measured to calculate the daily balance in photosynthesis/respiration and calcification/dissolution. A"heat map" of dissolved oxygen (mg L^{-1}) at the sediment surface was also produced. Initial analyses of dissolved oxygen and total alkalinity data suggest a positive effect from both OA and eutrophication on sediment dissolution. Relative to control flumes, both OA and eutrophication shifted the sediments from net calcifying to net dissolving, but the mechanism behind this increase in sediment dissolution differed between treatments. The increase in calcium carbonate sediment dissolution in response to OA was chemical, as rates of photosynthesis and respiration remained unaffected and dissolution was caused solely by an OA-mediated decline in the overlying seawater pH. In contrast, the eutrophication-mediated increase in dissolution was biological, as the enrichment of OM enhanced respiration more than photosynthesis, thereby shifting the sediments from net autotrophy to net heterotrophy and depressing the seawater pH. Carbonate dissolution rates under the combination of OA and eutrophication were slightly



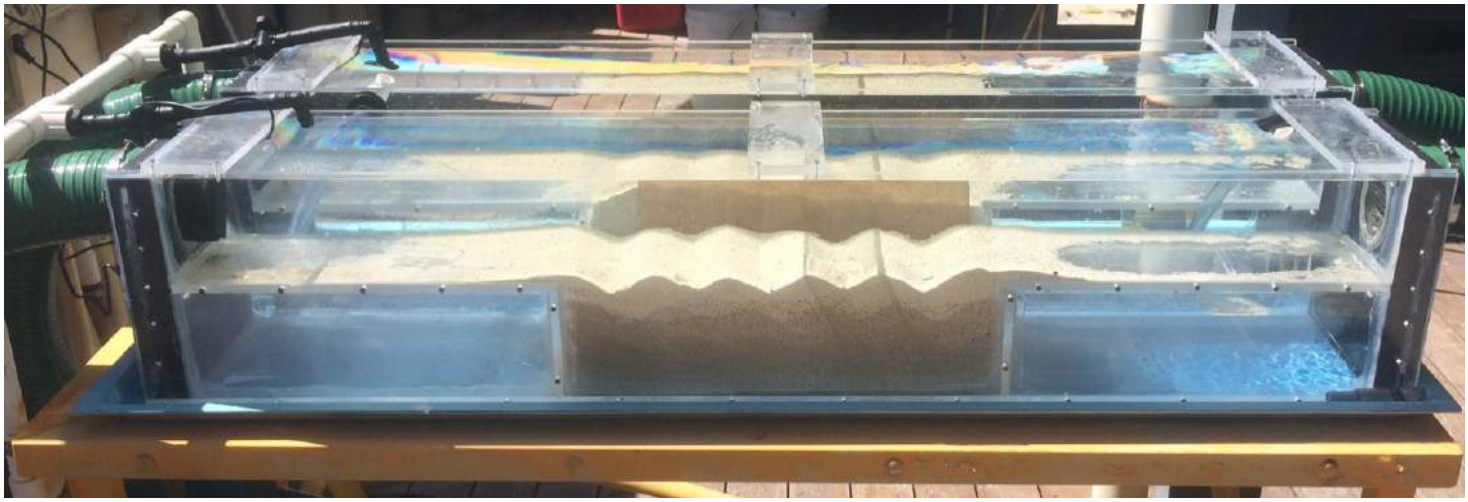
A Excitation of the opted luminophores using ultra blue 445 nm LEDs. **B** Processed "heat map" of dissolved oxygen (mg L^{-1}) at the sediment surface (dashed white line). © Coulson Lantz

higher than the effect from OA alone, but more data will need to be analysed (e.g., fluxes in Calcium or Nitrate) before any experimental effects can be deemed significant.

Altogether, the data analysed thus far suggest that coral reef carbonate sediment dissolution will be primarily driven by OA but could be exacerbated during periods of coastal eutrophication and subsequent OM enrichment of Heron Island's lagoon waters. These results will be an important contribution to future coral reef carbonate budgets and provide insight into how we may expect the shallow sediment communities at Heron Island to respond to a combination of global change stressors.

Acknowledgements

I would like to sincerely thank the Australian Coral Reef Society and its benefactors for providing me with the opportunity to conduct this research. I would like to also thank my advising committee, Dr. Bradley Eyre and Dr. Kai Schulz, for their guidance. This research was also supported in part by Southern Cross University and ARC Discovery Grant DP150102092. Sediments were collected under the Great Barrier Reef Marine Park Authority Permit G17/39703.1.



Above: 105L flume systems placed outdoors at the Heron Island Research Station. Each flume received the same light, temperature, and flow conditions. © Coulson Lantz
Left: Sandy bottom where sand collection took place. © Coulson Lantz

The effects of climate change on reef mesopredators

By Shannon McMahon
James Cook University

One of the greatest threats our coral reefs face is the advancement of anthropogenic climate change. Increasing temperatures and decreasing pH are serious concerns for many reef organisms. However, as climate change is a relatively gradual process there is the possibility that some species may have the capacity to adapt to these environmental changes. In fact, research on reef fish has shown that some species are able to restore a number of negatively affected traits, such as aerobic scope or growth rates, through as little as one generation. This has been shown for traits affected by both projected temperature and pH levels, which suggests that marine species may have the capacity to keep up with the environmental changes that anthropogenic climate change is generating.

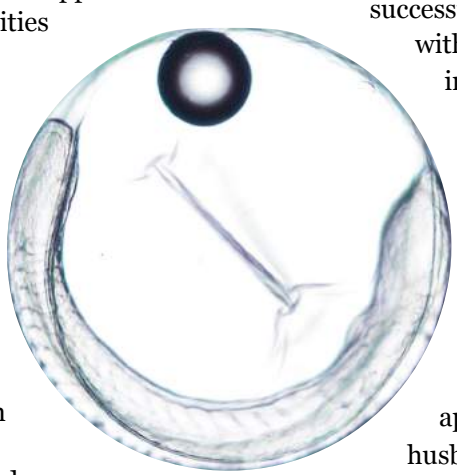
However, the majority of this work has been conducted on smaller, demersal spawning reef fish species. This has left us with a knowledge gap in respect to how larger, broadcast spawning species, especially mesopredators such as snapper and trout, will fare under these changing conditions.

One of the main reasons for this gap in knowledge is spawning and larval rearing of broadcast spawners has been historically difficult. An understanding of how reef mesopredators will cope in a changing ocean is critical.

Tropical snapper such as *Lutjanus carponotatus* are closely associated with the reef structure and are economically, recreationally, and ecologically important. They are a suitable species for reef mesopredator research, however, have not been spawned or reared in captivity. In order to gain the skills and husbandry needed to

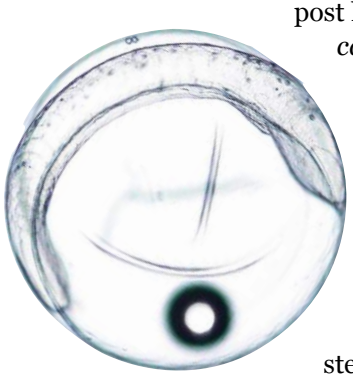
Above: The 35,000 l brood stock system where snappers have been bred at the Marine Aquaculture and Research Facility at James Cook University © Shannon McMahon. **Left**: a school of snappers (*Lutjanus fulviflamma*) in the Great Barrier Reef © Victor Huertas. **Below**: eggs of *Lutjanus carponotatus* 12 hours after fertilisation © Shannon McMahon

successfully spawn and rear a tropical snapper, I went to New Zealand to work at the National Institute of Water and Atmospheric Research with a similar species, the Australasian snapper, *Chrysophrys auratus*. This species has been the subject of aquaculture research for a number of years due to its economic importance, These learnings have now been applied to tropical Reef Snapper in rearing facilities in Townsville. Successful spawning requires healthy brood stock. 35,000 L temperature controlled aquaria system were built to house the brood stock. Mature adult snapper collected by hook and line from the northern Great Barrier Reef were then transferred to the rearing tanks.



Nutrition is critical to health and reproduction. Rotating diet of fish, aquaculture pellets, and specifically formulated feed was used to ensure brood stock received a complete diet, *L. carponotatus* were successfully spawned without any artificial inducement (e.g. hormones) after water temperatures reached 28°C and just before the new moon.

Following successful spawning correct timing and application of husbandry techniques was critical to producing a successful cohort of juveniles. The larvae have now progressed to first feeding (2 days post hatching) and transition to larger live food (*Artemia* at 25 days post hatching). Reared *L. carponotatus* will now be used to pursue critical climate change related questions with this model mesopredator species. For example, the next steps of my research will focus on investigating how thermally sensitive this species is during reproduction and early life stages, and the capacity to acclimate and adapt to future projected environmental conditions. By doing this I will be able to build expand our knowledge of how coral reef fishes will cope and their capacity to adapt to project climate change scenarios.



Cumulative impacts of future climate conditions and heavy fuel oil on corals

By Mikaela Nordborg
James Cook University/AIMS

Coral reef health and resilience are affected by both global (e.g. climate change) and local stressors such as oil pollution. As the impacts of climate change on coral reef ecosystems continue to increase[1] management and risk assessments relating to reef environments will have to account for the potential interactions between local stressors and climate change. Oil pollution remains a substantial threat to reef environments due to its interactions with environmental factors in reef environments (e.g. ultraviolet light; UV)[2], the often long recovery times following spill events[3] and the projected future increases in shipping in reef areas of high importance (e.g. the Great Barrier Reef region)[4].

The phototoxicity of petroleum oils (i.e. an increase in toxicity in the presence of UV light) is well documented[5] and illustrates the potential for cumulative impacts between oil pollution and environmental stressors. Increasing water temperature due to climate change may also affect the toxicity of petroleum oils but this remains largely untested. For reef-associated organisms, sensitivity to oil exposure has been most extensively studied in reef-building corals (Nordborg et al. *in prep.*). However, the vast majority of studies have not accounted for potential interactions with environmental factors, such as UV or increasing temperature, and no studies have combined all three stressors (Nordborg et al. *in prep.*). While methodological differences generally prevent direct comparisons between studies it appears that larval settlement and survival may be among the most sensitive endpoints for coral[6].

"The vast majority of studies have not accounted for potential interactions with environmental factors."

Additionally, many broadcast spawning coral larvae spend a substantial amount of time at or near the surface during early development where exposure to both oil and UV can be expected to be highest. Therefore, to investigate the potential interactions between heavy fuel oil toxicity, UV and high temperature (marine heatwave conditions and projected future increases), chronic exposures of *Acropora millepora* larvae were performed in the National Sea

Simulator at the Australian Institute of Marine Science, Townsville in November and December 2018.

Mass cultured *Acropora millepora* larvae were exposed to six concentrations of the water accommodated fractions of heavy fuel oil (including a seawater control) for 48 h at one of three treatment temperatures in the presence or absence of ecologically relevant UV. Larvae from each replicate were then transferred to individual wells, larval survival assessed and larvae induced to settle using extracts of the crustose coralline algae *Porolithon onkodes*[7]. Samples for chemical analysis were collected at the start of exposure as well as at the end of exposure for each combination of light and temperature treatment and sent to an accredited analytical laboratory for analysis.

Experiments went well and decoding of collected data (288 replicates, ~3000 larvae) is now underway. Once results from chemical analysis of treatment solutions have been finalized statistical analysis of data will commence.

Acknowledgements

I am very grateful to the ACRS for granting me an ACRS Student Research Award as it allowed me to undertake more complete chemical analysis of the treatment solutions used in the current project. This will ensure the results of this study can be utilized for management purposes as well as future modelling of oil toxicity to coral reef organisms. Additionally I'd like to thank the Great Barrier Reef Marine Park Authority for their financial support of this project, the Australian Institute of Marine Science, the National Sea Simulator, James Cook University, AIMS@JCU, my supervisors Dr. Andrew Negri (AIMS) and Assoc. Prof. Michael Oelgemöller (JCU) as well as the fantastic volunteers who assisted me during the 2018 coral spawning.

References

1. Hughes, T. P. *et al.* Global warming and recurrent mass bleaching of corals. *Nature* **543**, 373-377 (2017).

2. Nordborg, F. M., Flores, F., Brinkman, D. L., Agustí, S. & Negri, A. P. Phototoxic effects of two common marine fuels on the settlement success of the coral Acropora tenuis. *Sci. Rep.* **8**, doi:10.1038/s41598-018-26972-7 (2018).

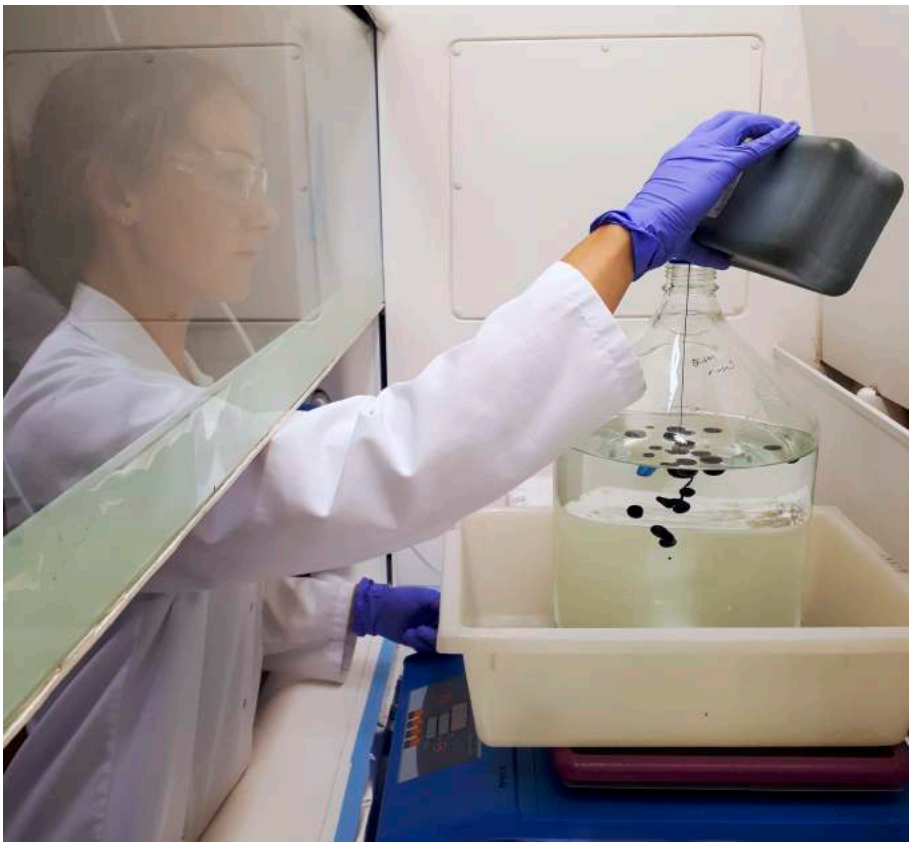
3. Haapkylä, J., Ramade, F. & Salvat, B. Oil pollution on coral reefs: a review of the state of knowledge and management needs. *Vie Milieu* **57**, 95-111 (2007).

4. NESMG. North-East shipping management plan. 2014. North-East Shipping Management Group, Australian Maritime Safety Authority, Canberra. https://www.amsa.gov.au/marine-environment/marine-pollution/shipping-management-plans/north-east-shipping-management-plan Accessed on 13 Sep 2018. (2014).

5. Barron, M. G. Photoenhanced Toxicity of Petroleum to Aquatic Invertebrates and Fish. *Archives of Environmental Contamination and Toxicology* **73**, 40-46, doi:10.1007/s00244-016-0360-y (2017).

6. Turner, N. R. & Renegar, D. A. Petroleum hydrocarbon toxicity to corals: A review. *Mar. Pollut. Bull.* **119**, 1-16, doi:http://dx.doi.org/10.1016/j.marpolbul.2017.04.050 (2017).

7. Heyward, A. J. & Negri, A. P. Natural inducers for coral larval metamorphosis. *Coral Reefs* **18**, 273-279 (1999).



Above: The author preparing heavy oil fuel WAF for testing the cumulative impacts of oil pollution, ultraviolet light and temperature on coral larvae. © Tristan Lever

Left: *Acropora millepora* releasing egg-sperm bundles at the National Sea Simulator, AIMS Townsville, during the 2017 coral spawning © Mikaela Nordborg

Clues from the past

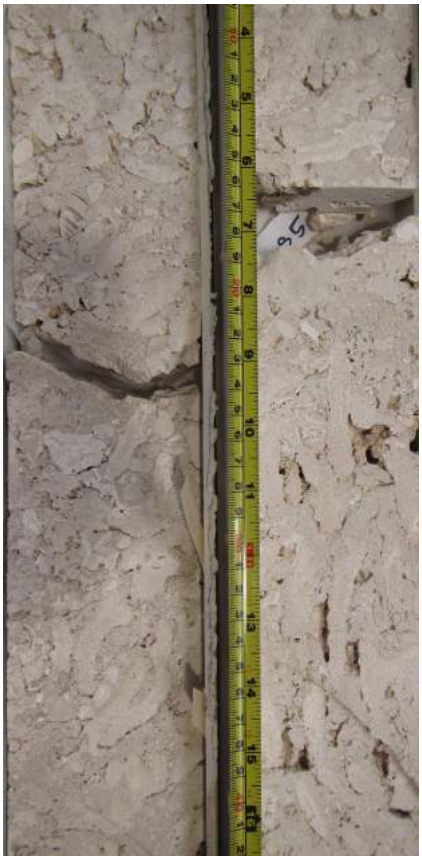
How fossil reefs help us to understand past sea-level changes and future reef resilience

By Kelsey Sanborn
University of Sydney

More than once, I've been met with confusion when describing how my research on coral reefs doesn't involve SCUBA diving or aquariums, but instead cores and outcrop samples of limestone rock exposed on land or from the deep seabed. As a geologist studying fossil coral reef systems, I'm interested in learning about what lies deep beneath the cover of living coral, and what it can tell us about past climate change.

As coral reef communities are already facing the effects of anthropogenic climate change, it is important to use information from the geological record to inform long-term future predictions. Using proxy data from fossil reefs, we can build an understanding of both how sea level has changed in the past, and how coral reefs have or have not been resilient to past climate change. With the generous support of ACRS through a 2018 student research award, I am currently investigating this on the Tantabiddi Terrace, by the modern Ningaloo Reef in northwest Western Australia.

The Tantabiddi terrace grew during the Last Interglacial (LIG) warm period (~125,000 years ago), prior to the last ice age (~20,000 years ago) when lower sea level allowed the migration of early Aboriginal Australians. This time period is valuable for understanding near-future climate scenarios, as polar temperatures were at least several degrees higher and global sea-level is thought to have been 6 to 9 meters above present-day levels. However, there is debate concerning the timing and nature of the LIG sea-level peak, which may help constrain predictions on sea level in the coming decades and centuries.



Above: Reef cores containing different morphologies & species of fossil *Acropora*. © Kelsey Sanborn

> ***"The Last Interglacial warm period is valuable for understanding near-future climate scenarios."***

There is evidence from global records that sea level did not just rise and fall with a single peak, but instead multiple small (meter) scale oscillations occurred as the ice sheets melted. Sea-level reconstructions from several existing studies show two LIG sea-level peaks separated by an ephemeral sea-level fall, which preliminary stratigraphic evidence from the Tantabiddi may also support. Given that most future sea-level projections describe a smooth rise under sustained global warming conditions, it is crucial that we use past records to improve our understanding of the dynamic

relationship between climate, ice-sheet melting and sea-level dynamics.

So, how do we do this? First, we must recover the fossil material from submerged or exposed fossil reef terraces using cores. From these cores, we use a several methods to describe and identify the communities of coral, coralline algae and associated reef taxa. Based on this, we can determine the water depth and environment that the fossil assemblage would have grown in using analogs from the modern reef environment. By pairing this with radiometric ages obtained by Uranium-Thorium dating, as well as spatial and geomorphic information, we can piece together a reconstruction of the reef through time.

Interpreting the morphology and species of corals and other reef biota in Tantabiddi, we identify vertical assemblage changes representing shallowing upwards (sea-level fall) and deepening upwards (sea-level rise), as well as potential changes in water turbidity and hydrodynamic setting. We are now working to temporally constrain these community changes, and integrate all evidence to determine how relative sea-level changed over time. As we develop our understanding of past climate, sea level and reef growth, we can improve projections to assist in future coastal management and resilience.

Below: Well-preserved small coral heads on exposed land © Kelsey Sanborn

A large whipgoby (*Bryaninops amplus*) on a sea fan © Maarten de Brauwer
2018 ACRS Photo Competition

Can extreme environments shape resilient corals?

By Maria Jung
University of Bremen/UWA

Ocean warming is one of the major threats to coral reefs today and leads to global mass bleaching events of increasing severity and frequency. In 2016, a strong El Niño associated marine heatwave caused unprecedented bleaching in the extreme macrotidal Kimberley region in northwestern Australia.

Our study site Shell Island is a great natural laboratory where strong differences in heat tolerance exist over very small spatial gradients, driven by a tidal range of up to 8 m. These conditions make Shell Island an exceptional location to evaluate the recovery capacity and physiology of Kimberley corals after the bleaching event. The study site presents two different environments: the intertidal and subtidal (see photo below). Both experience similar average temperatures during high tide and host similar coral communities which are dominated by branching *Acropora* spp. However, during low tide, the intertidal becomes a tide pool and corals become exposed to air for up to four hours while being subjected to strong daily temperature fluctuations of up to 7°C. In contrast, subtidal corals experience moderate daily temperature changes of only up to 3°C and are generally not exposed to air during low tides.

As part of my Master's studies in Marine Biology at the University of Bremen, Germany, I first documented both the recovery and extent of coral mortality six months after peak bleaching via photo-quadrat analyses. Results of the health surveys revealed divergent patterns of recovery: while intertidal corals had returned to pre-bleaching conditions, the majority of subtotal corals had suffered from extensive mortality despite being exposed to similar heat stress during peak bleaching . However, the observed differences in recovery capacity are consistent with the known patterns of heat tolerance for these corals.

Several physiological parameters of *Acropora aspera* from both environments twere then assessed to identify the mechanisms underlying both heat tolerance and recovery capacity of Kimberley corals. Analyses of symbiont dynamics confirmed visual differences in bleaching susceptibility and severity reported by previous studies with more severe bleaching in the subtotal than intertidal.

Although corals from both environments host the same symbiont genus (*Cladocopium*; formerly *Symbiodinium* clade C), genetic analyses are currently underway to determine whether more heat tolerant symbiont species were potentially present in intertidal corals.

Composition of energy reserves I can also play a key role in

Above:Study site at Shell Island in the Kimberley region. © Verena Schoepf

determining heat tolerance and recovery capacity. Surprisingly, only intertidal corals catabolized energy reserves when bleached, demonstrating that maintaining energy reserves during bleaching cannot guarantee survival. Therefore, this parameter appears to be a poor predictor of bleaching resistance and recovery capacity in Kimberley corals.

Our findings challenge the traditional view that high energy reserves contribute to bleaching resilience and survival. We suggest that future research should assess whether fitness trade-offs are associated with survival in sub-optimal conditions, particularly when combined with climate change stressors.

The faster recovery of intertidal corals in our study provides hope for reef habitats that suffered from extensive mortality during the 2016 bleaching event in the Kimberley region.

Above: Six months after the 2016 bleaching event: remarkable coral recovery in the intertidal (left) but extensive mortality in the subtidal (right) © Verena Schoepf

Acknowledgements

I am very grateful for the Kimberley Marine Research Station (KMRS) price awarded by the KMRS and the Australian Coral Reef Society. I would like to thank the staff at KMRS and Cygnet Bay Pearl Farm for assistance in the field and lab, and V. Schoepf and C. Richter for the supervision and examination of my thesis. I especially thank the Bardi Jawi Indigenous Rangers and Traditional Owners who enabled this research through their advice and consent to access their traditional lands.

Above: What determines whether a coral recovers from bleaching or not? © Verena Schoepf

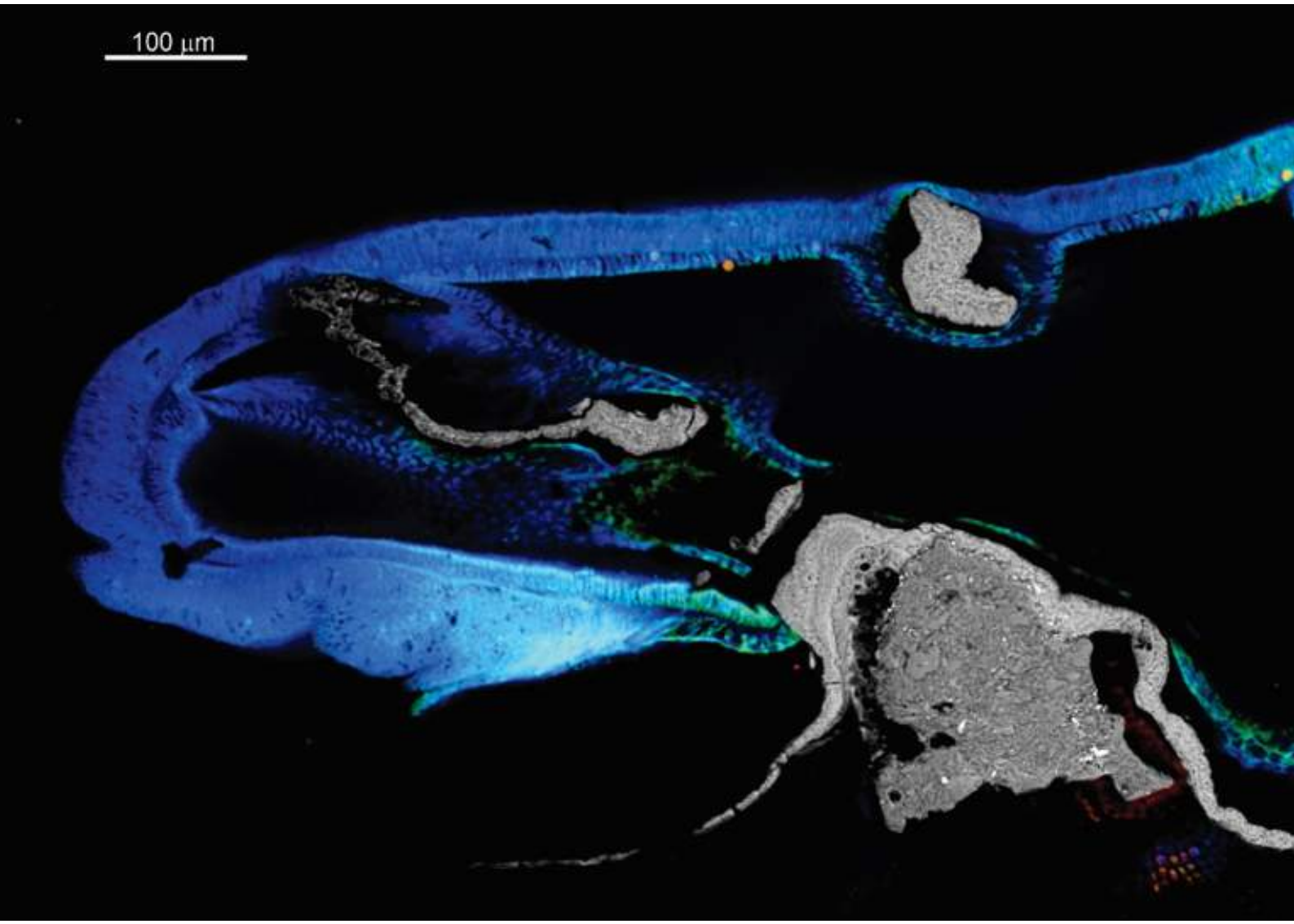
The multi-stage process during substrate attachment of *Acropora* fragments

By Brett Lewis
Queensland University of Technology

Some Scleractinian corals have adapted to constant fragmentation from severe storm and wave events by way of asexual reproduction. This process sees the new fragments quickly attach to the substrate and begin to form new colonies.

The initial success of asexual recruitment is dictated by the speed of attachment, recovery and regrowth which help the recruits avoid mortality during the "early growth phase" - the phase when they are most susceptible to disease, sedimentation, overgrowth and/or competition. Currently, asexual reproduction is central to a variety of coral reef restoration strategies.

Reef restoration relies on manually fragmented brood colonies (*in* and *ex-situ*) to be reared in nurseries until they form adult colonies. The adult colonies are then out-planted onto degraded reefs – allowing the corals to avoid the early growth phase. The success of restoration through nursery-grown corals is dictated by robust attachment of the colony. Despite its



Above: Backscatter SEM overlayed with confocal fluorescence microscopy image of the lappet appendage highlighting the complex morphology and sites of new skeletal formation. © Brett Lewis

important biological and restorative role, the biomechanics of coral attachment have not been documented.

This study used brood colonies of *Acropora* that were fragmented into 5 cm to 10 cm pieces to document the biomechanics of coral fragment and substrate interaction leading to attachment. Each fragment then had a large, immovable sediment clast placed onto its surface (Fig 1). The interface between the clast and the fragments tissues was observed using time-lapse light microscopy over a 28-day period.

Understanding the biomechanics of coral attachment allows for improved choice of substrates and coral taxa to maximise attachment and begin establish baselines for coral regrowth. We hope this creates a better framework for restoration management on degraded reefs requiring intervention strategies while also creating novel observational and sample preparation techniques.

<u>The three-stage process of substrate attachment:</u>

Stage 1 - Immune response (1-2 days):

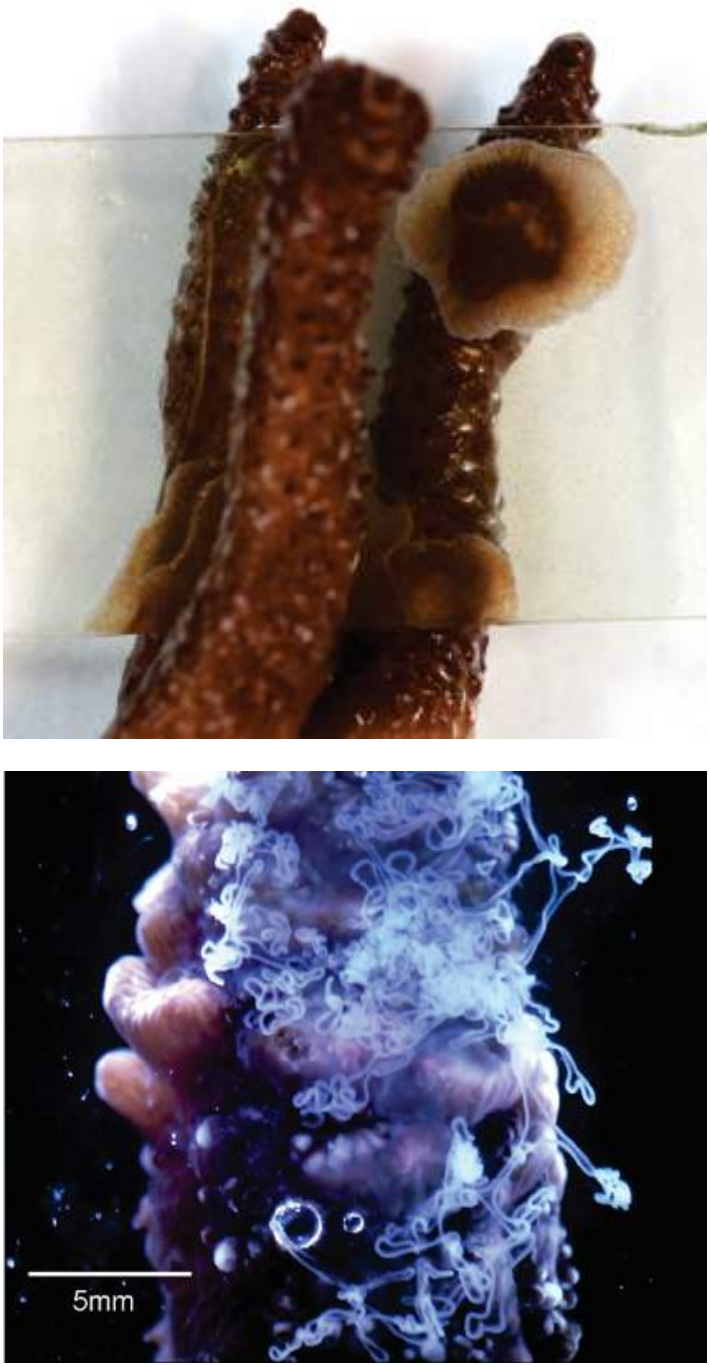
This stage is characterised by lesion formation, inflammation and increased mucus production at the interface between the coral tissue and the substrate. The coral formed a mucus shield that aided tissue recovery and protected the contact site from the surrounding environment. Mesenterial filaments cleaned the substrate and lesion while aiding mucus excretion (Fig 1). Increases in epitheliomuscular cells increased epithelial complexity leading to thickened and undulated morphology in tissue directly in contact with the substrate.

Stage 2 - Proto-lappet development (3-8 days):

A weak anchor to the substrate is created as epitheliomuscular cells continue to increase, and surface tissues undulate and extend to the substrate surface. We define this as the 'proto-lappet'. Once the proto-lappet has formed the coral deploys mesenterial filaments to surface inside the sealed area to carry out autolysis of the epidermal tissues. Despite the increase in mobility and a weak attachment, the proto-lappet has limited capacity for migration along the substrate surface.

Stage 3 - Lappet development leading to accretion (4 to 14 days):

The proto-lappet eventually forms a full lappet structure that was previously only seen in epithecate corals. The lappet acts as the junction between the epithelial layers (Fig 3). The increased morphological complexity and musculature help seal off the corals corallum and sites of new skeletal formation. A thin appendage or 'tongue' forms at the lappet transition zone and extends along the substrate between the lappet and the surface and accretes the initial skeletal layer. This thin layer of skeleton is thickened as the lappet migrates over the surface via systematic pulsing - facilitated by the increased musculature.



Images of the experimental process. **Top**: In some cases, glass was used as the sediment clast to get a better view of the coral/substrate interaction. **Bottom**: Timelapse image of the coral/substrate interface showing tissue inflammation and large number of mesenterial filaments active. © Brett Lewis

Painted sweetlips (*Diagramma pictum*) resting on a shallow reef © Victor Huertas

Science communication for early career scientists

By Taryn Laubenstein
ARC Centre of Excellence for Coral Reef Studies
James Cook University

ScienceTaryn

Great scientists have skills in experimental design, laboratory techniques, literature review, and statistics. However, an often-overlooked "soft skill" is just as essential to success in science: communication. The most sophisticated research cannot make an impact if it is not written clearly, so it is crucial to develop a strong foundation in communication.

During the course of my PhD, I have sought out a variety of opportunities for communicating my research and the research of others. These experiences have opened doors for me that I did not think possible, and have led me into a career path that will involve science communication. In this piece, I'd like to share some opportunities that I have found useful for improving communication skills, including oral, visual, written, and social media. This is not an exhaustive list, but you'll find once you enter the world of science communication, there are simply too many possibilities to try them all!

Oral

We all have to give talks at conferences, and it can be nerve-wracking to present your work to the top scientists in your field. Aside from having top-notch research, another way to calm your nerves and prepare for conferences is to seek out other opportunities for public speaking. There are informal events like Pint of Science (national) and Inspiration on Tap (university) that mix beer and science, a winning match. For those with a competitive streak, there are science communication competitions for PhD students, like Three Minute Thesis (university / national) and FameLab (national/ international) that come with free presentation workshops and training. You can also volunteer for one-off events: lead a tour group of teachers through your lab, visit your old high school to give a talk, or even attend a networking event. Each time you speak you'll get a little more relaxed and a little less nervous, so you can give your next conference talk without breaking a sweat.

"The most sophisticated research cannot make an impact if it is not written clearly."

Visual

If you are the type of scientist that has an artistic flair, there are plenty of opportunities to use your skills to promote your science. Visual artists can create stunning graphics for paper figures, visual abstracts, and social media posts. Some researchers have had success in freelance visual arts; for instance, Dr. Erin Walsh has helped me to create a figure for a paper as well as a gorgeous drawing of salmon for a popular science article. Photographers can apply to a variety of competitions, including the annual ACRS photo competition, or larger competitions like the Australian Geographic Nature Photographer of the Year (national) or the Royal Society Photo Competition (international). For videographers, there are lots of new opportunities each year; the Australian Society for Fish Biology has an annual video competition, and the Visualise Your Thesis competition (university/ national) launched in 2018. However, if you are not already talented in visual arts, you can still improve these skills. Many universities offer workshops or classes in photography, videography, and graphic design at a discounted rate or free to students.

Written

Peer-reviewed papers are the gold standard for written communication in science, but they are just the tip of the iceberg when it comes to science writing. You can branch out by writing for science blogs or magazines (like this one!) about your research. If you have a strong story, you could also pitch to The Conversation, a media outlet that publishes articles written by academics. However, if you'd like a break from writing about your own work, you can try freelance writing. Some journals, like Conservation Physiology and Evolution, have sections devoted to 500-word summaries of new papers that are aimed at a general audience. If you reach out, you could become a

contributor to these sections. There are also science magazines, like Lateral magazine, that are specifically designed for new science writers. You will have the opportunity to work directly with an editor who will evaluate the story that you pitch, give you feedback on your drafts, and help you pull together eye-catching graphics for the article. All these writing opportunities will strengthen your ability to tell a compelling story without using jargon, and make writing your academic papers that much easier.

"Don't be afraid to reach out and pitch your research"

Social Media

Ah, what would science communication be without a little social media? While some dismiss it as a waste of time, when used correctly, social media can boost your profile as a scientist and connect you to important research as it happens. There are lots of social media networks, but Twitter has become a hub for scientists (see how many Twitter logos you can see on conference slides at ACRS!) By creating an account and following researchers in ACRS and in your field, you will learn about new research the minute it is published. This can help you to make sure you've got the most up-to-date citations in your papers. Twitter can also help you to boost your Altmetrics score, which is a metric that captures how frequently your research is shared on social and traditional media. Each Tweet or re-Tweet of your paper will boost your score, and recent research shows that highly-Tweeted papers are 11 times more likely to be cited! Twitter can also bring together your skills in writing and visual media. Posts have to be less than 280 characters, so you need to be succinct, and images/ videos boost a Tweet's engagement, so use those photos from earlier to promote your research.

Final Advice

Having come to the end of my PhD, there are two things I wish I had done sooner that I will recommend to you. First, document your research. When it is time to share your results, the story will always be more compelling if you have photos of study species or videos of fieldwork, which you simply cannot replicate when the study has finished. Second, work with your local communications experts. Every university has a communications team that exists to promote your research. They can train you on social media skills, critique your conference talk, or coach you through your first TV interview. They are also hungry for good stories, so don't be afraid to reach out and pitch your research. Communication, whether oral, visual, written, or social media, will be a major part of your career as a scientist. So work on developing your skills, and of course, have fun!

2018 Social Media Snap Shot

@AustCoralReefs

@AustralianCoralReefSociety

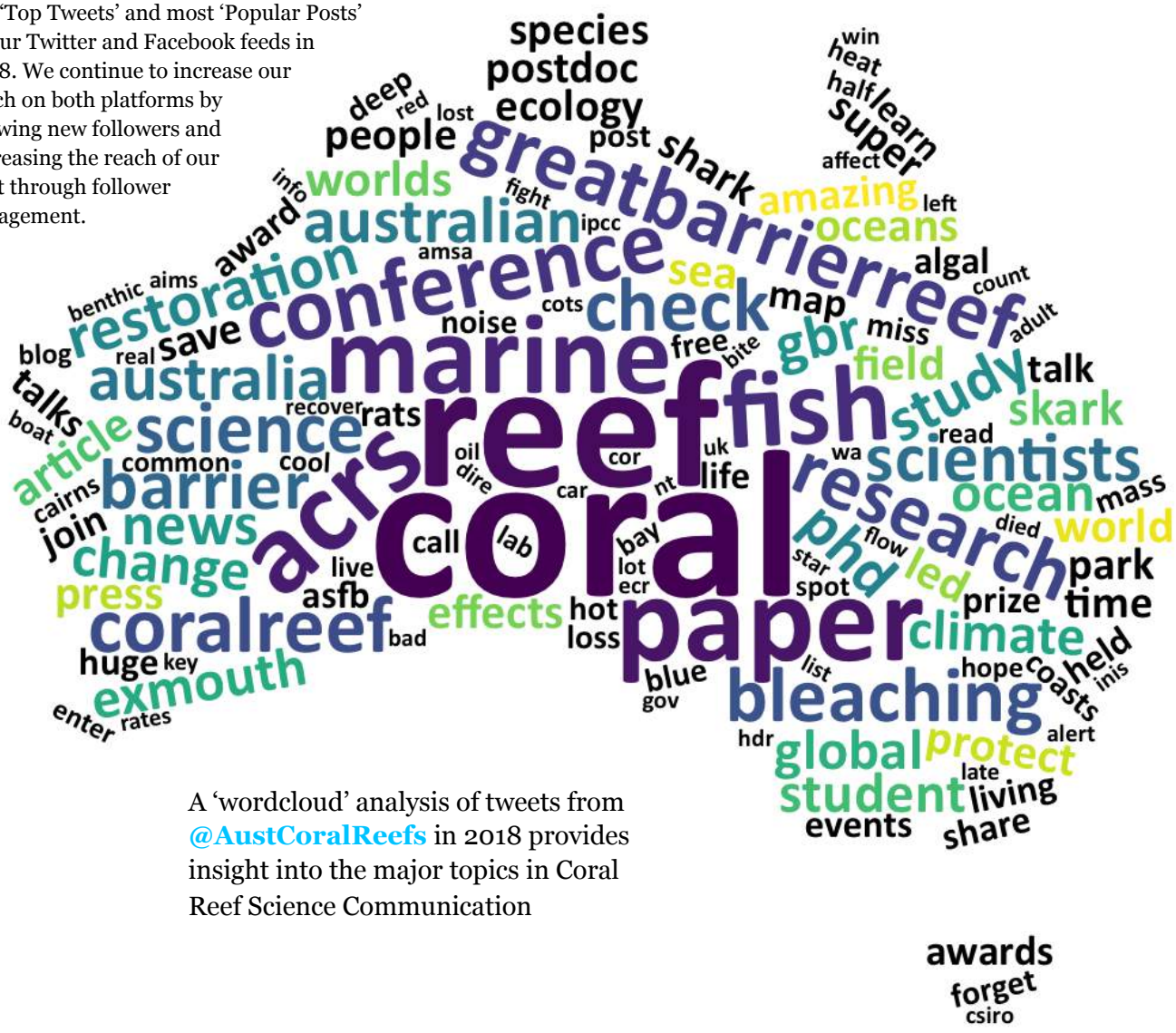
The Australian Coral Reef Society has had a social media presence on Facebook since 2010, and on Twitter since 2014. The Society uses these platforms regularly to engage with our members, the broader scientific community, and the general public.

The goals of the ACRS Social Media Team are to highlight the research and achievements of our membership, the release of new and important science and policy-related articles, and to publicise our annual ACRS conference.

Social media is an important tool to engage with ACRS members and the public. We have highlighted the 'Top Tweets' and most 'Popular Posts' in our Twitter and Facebook feeds in 2018. We continue to increase our reach on both platforms by drawing new followers and increasing the reach of our post through follower engagement.

Through Twitter, many of the attendees of the ACRS conference in Exmouth shared their experiences at the conference and the amazing research that was on display, using the hashtag '#ACRS2018'. This led #ACRS2018 to be a trending topic in Australia during the conference!

At this year's conference on Moreton Island, the Social Media Team would like to encourage those attending to continue this trend using **#ACRS2019.** Make sure to tag @AustCoralReefs in your posts!



A 'wordcloud' analysis of tweets from **@AustCoralReefs** in 2018 provides insight into the major topics in Coral Reef Science Communication

@AustCoralReefs
4,340 Followers (>800 new followers)
491 tweets
>800 retweets
Avg. 1,800 impressions per tweet
Avg. of 40 followers engage with each tweet

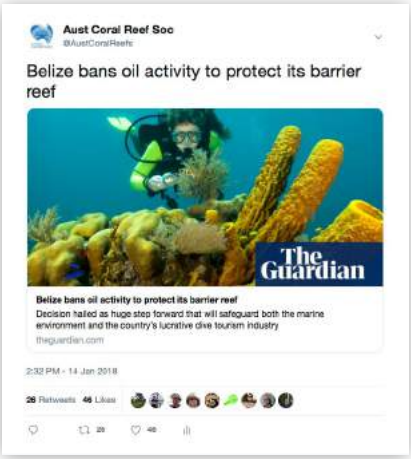
Follower Audience 39% Male, 61% Female

@AustralianCoralReefsSociety
5,157 followers (>900 new followers)
290 posts
70 photos, 188 links, 21 videos
Total annual reach +280k (Avg. 972 per post)
Total annual engagement >17k (Avg. 60 per post)

Follower Audience 48% Male, 52% Female

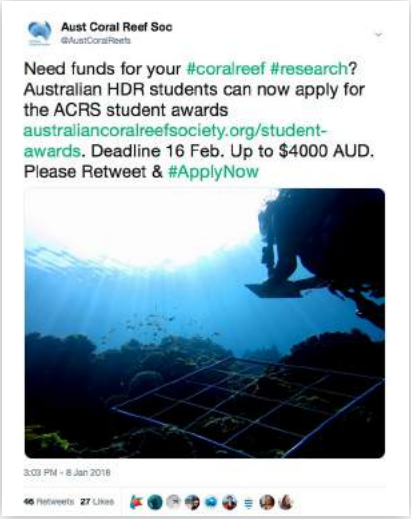
Top Tweets

Most favorited



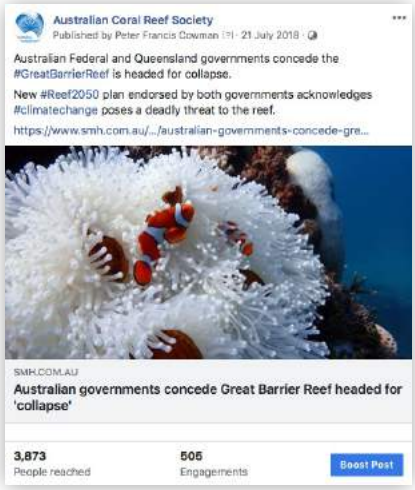
Most retweeted

Most engagement

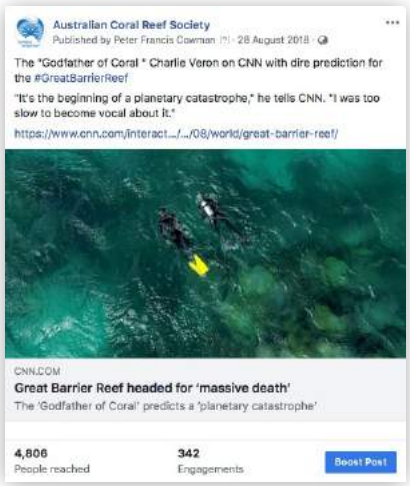


Popular Posts

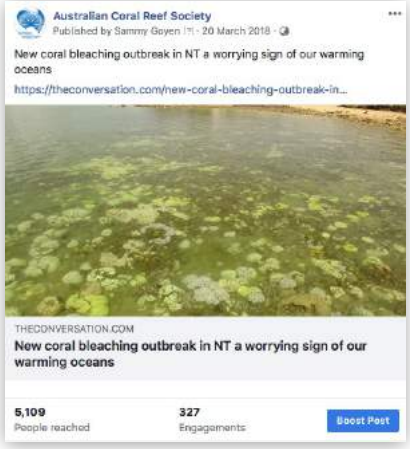
Most engagement



Most impressions



Most reach



2018 ACRS PHOTO COMPETITION

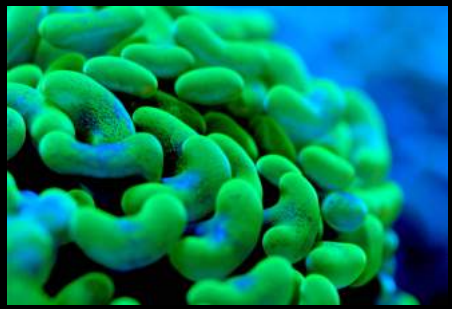
As in previous editions, the latest edition of the ACRS Photography Competition showcased numerous stunning images captured by many talented ACRS community members. In the following pages we present a selection of the images received, including the winners of each category.

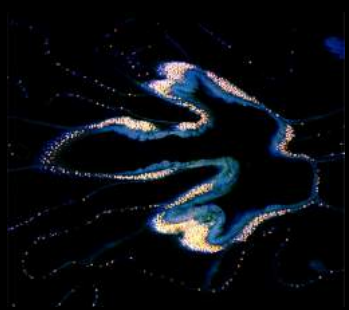
OVERALL Winner

Ciemon Caballes

MACRO Winner

Laura Puk



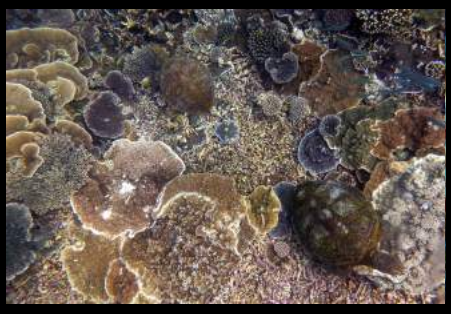


SCIENCE IN ACTION Winner

Melanie Trapon

DIVERSITY Winner

Christopher Brunner



Dotted around the coast are our Research Stations.

These 'research refugia' are the platforms for Australian coral reef science.

Their resources, facilities and amazing personnel enable our understanding of coral reef systems and the beauty they represent.

In the following pages you can learn about the coral reef research conducted at these stations in 2018 and keep up to date with their latest news.

Divers inspect a coral reef.
© Alex Tyrrell/Coral Reef Image Bank

Lizard Island Research Station

By Dr. Anne Hoggett and Dr. Lyle Vail

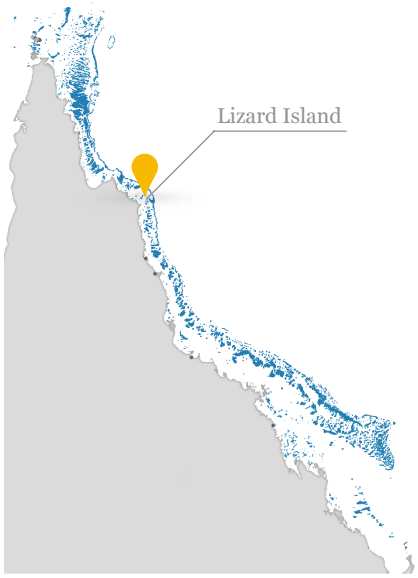
Lizard Island Research Station Managers, Australian Museum

After four consecutive years with major environmental disturbances in the Lizard Island area (category 4 cyclones in each of 2014 and 2015 and catastrophic coral bleaching in 2016 and 2017), summer 2018 passed without any disasters for local reefs.

Many tiny colonies of branching species survived the cyclones and bleaching and it appears that there has also been some recruitment. These young survivors and the apparent post-disaster recruits are growing at an amazing rate. While the recovery is patchy and the long-term outlook is for stronger cyclones and warmer water, this regrowth is very good to see. The coral spawning in late 2018 even looked a bit like "normal", after two years of very little spawn in the water due to the absence of large branching colonies.

Some numbers for 2018:

- 122 scientists and research students from 38 institutions in 9 countries conducted 100 research projects
- 107 new publications based on research at LIRS were added to the collection, bringing the total to more than 2,280
- 350 species were added to the online Lizard Island Field Guide (lifg.austraianmuseum.net.au), bringing the total to 2,530
- 9 new Fellows – a record number, commenced research at LIRS (funded by Lizard Island Reef Research Foundation (5 PhD students and 4 early career researchers)
- 2 new grants were awarded for Crown-of-Thorns Starfish research thanks to funding from the Ian Potter Foundation and the LIRRF
- 2 new grants were awarded for research into plastic pollution thanks to funding from the LIRRF



Above: Aerial view of Casuarina beach, Loomis reef and Palfrey and South Islands © Colin Price;
Below: Small coral colonies in a regenerating reef flat at Lizard Island. © Anne Hoggett/Lyle Vail

Standards covering operational procedures (AS/NZ 2299.2) and training/certification requirements (AS/NZ2815.6) for scientific divers are under review. It is too early to tell what the revised standards will contain although there will likely be some positives including greater recognition of recreational training pathways for scientific divers. However, it appears that there will be serious downsides such as a mandatory minimum dive team size of three and very high levels of diver training for dive supervisors.

It is likely that there will be a call for public comment on the revised diving standards in 2019. We urge all scientific divers to respond to this call when it's made.

Orpheus Island Research Station

By Johan Larson

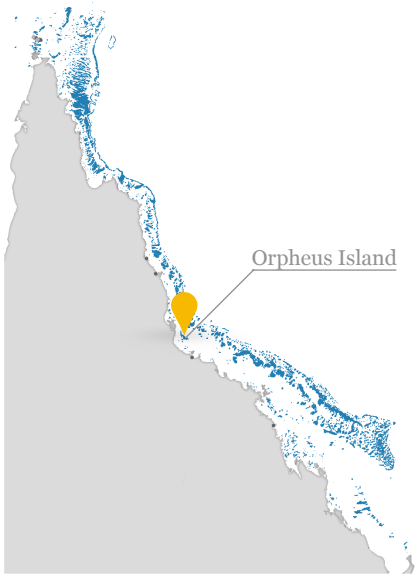
James Cook University (JCU) Services Coordinator

2018 was a busy and exciting year for Orpheus Island Research Station. We supported a diverse range of researchers and research topics throughout the year at the station. In addition to research groups we have also hosted 15 university field classes, 6 marine science high-school classes, a couple of Earthwatch trips, as well as some interesting workshops including one with "Reef Ecologic" looking at reef restoration.

We are excited to announce that OIRS is now powered by the sun! We have just finished installing solar panels on our buildings and a large battery bank. We are currently in the testing phase with the aim of generating 100% of the stations energy from the sun.

Classroom on the reef

We are thrilled to reveal we now have a "Classroom on the Reef", literally. We have installed an underwater, self-cleaning platform which streams live video from the coral reef off Orpheus Island. This platform has water quality sensors installed and combined with a nearby weather station, provides simultaneous live feed of environmental data to complement the video feed on the CotR website. Soon,



Above: Students gather around the exhibition tank at the Orpheus Island Research Station. © Johan Larson;
Below left: New solar panels power the Orpheus Island Research Station. © Johan Larson;
Below right: Underwater camera live-streaming reef life at Orpheus Island. © Johan Larson

we will replicate this sheltered underwater classroom on the exposed side of the island to enable students to make interesting comparisons.

CotR is a joint project between JCU and Education Queensland. It aims to provide an engaging and immersive learning experience for high school students studying marine science by giving them access to real data (and video). It is aligned with the Queensland marine science curriculum, as well as providing first hand practical experience in marine science at the research station.

Research project summary:

Dr David Williams conducted underwater visual surveys to track the status and condition of benthic and fish communities on these reefs while quantifying the ecological effects of no-take marine reserves.

Dr April Hall research has focused on evaluating the effectiveness of Conservation Park Zones (yellow zones) in conserving fish communities on the Great Barrier Reef, comparing them to no-take zones around the Palm Islands.

Katie Motson looked at the variation in parasitic assemblages in rabbitfishes (*Siganus doliatus*) between healthy and degraded reef habitats using caged field experiments.

Alexia Graba-Landry performed manipulative experiments on juvenile siganids to investigate the effect of temperature on growth and metabolic rates.

Emily Higgins investigated the effect of temperature on the performance of two species of stingrays and measured the range of temperatures the two species experience naturally.

Coral spawning: We reached full capacity for the 2018 coral spawning, with researchers studying the role of epigenetics in coral acclimatisation and adaptation, sex change in fungiid corals, species boundaries within the *Porites* an the effect of coralline algae and sedimentation on coral recruitment.

One Tree Island Research Station

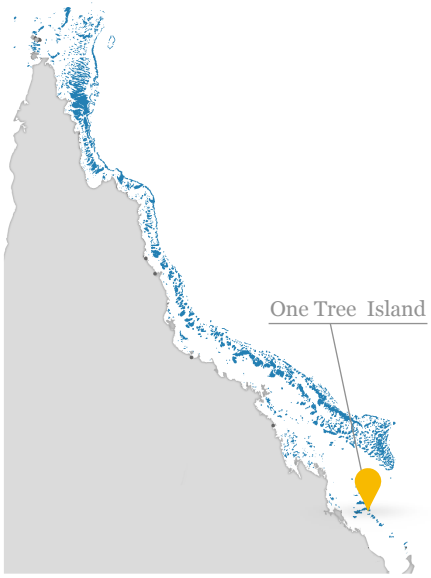
By Paul Baker and Ainsley Carlin

One Tree Island Research Station Managers

We are continually chipping away at general maintenance and upkeep duties, and the Station is looking great. Throughout 2018 we have helped coordinate some major upgrades here at One Tree Island. The station now has WAPS (wireless access points) installed in each of the Stations buildings, meaning there is now unlimited high-speed WIFI access across the station. A complete solar upgrade with state-of-the-art solar technology has provided the station with 11.1 KW of solar panels, 102 KWh of battery storage and a 13KVA generator. Since installation in November 2018 the diesel generator hasn't been required at all. Two new 4000 L water tanks have been installed, increasing fresh water storage capacity. Nonetheless, bucket showers remain the only ablution solution!

One Tree Island Research Station hosted a total of 15 different groups throughout 2018, accruing a total of 847 user-days. Some of the research topics included:

- Fish behaviour, abundance, habitat monitoring, and orientation studies.



Above: Two of the three new solar arrays recently installed at the One Tree Island Research Station (before bird nesting season left its signature mark). © Paul Baker/Ainsley Carlin;
Right: Making the most of some extra hands to reposition a new water tank. © P. Baker/A. Carlin;
Below: OTI station managers Paul Baker and Ainsley Carlin. © Ainsley Carlin.

- Crown of thorns starfish monitoring (age and population dynamics).
- 3D reconstruction of reefscapes using stereo imagery.
- Water and Crustose Coralline Algae sampling, micro-profiling O_2 and pH measurements; Coral larvae restoration.
- Tropicalisation and range shifts of tropical fish and coral species; Mineralogy of crustose and free-living coralline algae.
- Exploring the coastal protection services provided by coral reefs.
- Educational programs for university students - marine biology and geosciences.

Long-term observations of coral cover at One Tree has revealed that coral cover on the outer reef of One Tree is the healthiest and most abundant it has been in 10 years.

Following recovery of *Pisonia grandis* trees from two Hawk-Moth infestations, the trees are suffering considerable dieback across the Island due to limited rainfall in the last 6 months. This has affected the White-capped Noddy's breeding season as their nests are so exposed due to the lack of leaf cover. The Bridled Tern's however, appear to have had a successful breeding season.

Zone breaches by fishers continue to be a problem within the boundaries of the Scientific Management Zone in the waters surrounding One Tree. Policing efforts are ongoing and protecting the sanctity of the zone receives a lot of support from QPWS, GBRMPA and Queensland Fisheries.

All the best for your research and studies in 2019!

One Tree Island Research Station is currently being managed by Paul Baker and Ainsley Carlin. Will Figueira from the University of Sydney is the Director.

Heron Island Research Station

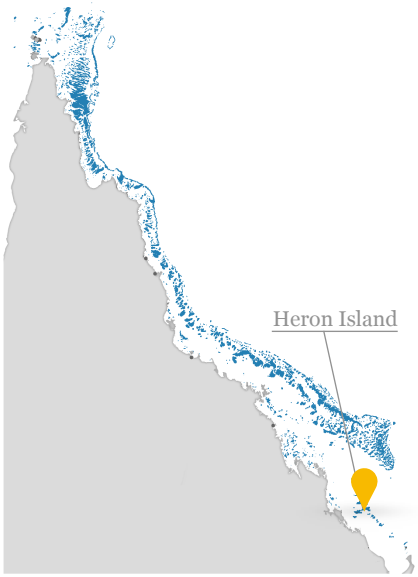
By Abbie Taylor

Heron Island Research Station
Deputy Station Manager

2018 was another massive year for Heron Island Research Station (HIRS) with our facilities enabling a wide range of ground-breaking research being undertaken by a diversity of local and international research groups visiting the Station.

The Live Learning Library has been a success with the station running activities with visiting high school groups, collecting and storing data which would otherwise not be used. The Live Learning Program has been successful with those participating school groups and we are looking forward to the continuation of the program through this year. The data collected is available online for anyone and will continue to receive updates during the year, both from student and research groups. If you are a research group wishing to contribute, please feel free to contact us for details on submitting your data.

The Station additionally farewelled two long term staff members from the Research Station during the year. Administration Officer Maureen Roberts, who many will remember as being their first contact with the station when planning a visit, left Heron Island after 17 years of service to the Research Station and its visiting researchers to spend more time with her family. Boating and Diving Officer Benjamin Potts also left the station to take on new career challenges elsewhere, taking with him his characteristic personality.



Above: a school group learns about coral biology at the HIRS exhibition tank. © Abbie Taylor;
Below: 'Ranina', a 6.5 m research vessel, is the latest addition to the HIRS fleet. © Abbie Taylor.

As such, there will be some new faces on the Research Station during your next visit, all eager to meet you, hear about your research and of course assist you wherever they can. We are also happy to announce a new management team now heading HIRS, Station Manager Mark Witham and Deputy Manager Abbie Taylor. Both are excited and enthusiastic about the upcoming year and beyond for the station, so be sure to say hi if you see them during your visit.

During the year the station received our new 6.5 m purpose-built rigid inflatable vessel which has been named 'Ranina'. This new vessel is able to carry up to seven people, and from all accounts is comfortable and easy to drive. We look forward to seeing plenty of interesting projects utilising this new addition to our fleet.

We were also excited to have started construction on a new solar array which will mean that all power used on station will come from renewable or ecofriendly sources. A large battery bank is also being constructed on site which will store any excess power which our solar panels generate. Small scale construction will continue throughout the year with an expected completion of the solar project being September 2019, just in time for our busiest time of the year, coral spawning.

As always, Station staff are excited to learn about upcoming research and the role we can play to support you, so please get in touch. We look forward to welcoming the coral reef community back to the station in 2019.

Kimberley Marine Research Station

By Liam Rawlins

Kimberley Marine Research Station Field Research Officer

Another incredible year has flown by at the Kimberley Marine Research Station (KMRS) with our research team and intern program running a range of environmental monitoring and research programs to keep a close eye on the beautiful Western Kimberley. 2018 saw the continuation of two long-term monitoring programs: assessing water quality and coral reef cover. We also expanded our Rock Oyster recruitment study and initiated two new projects; coral recruitment dynamics within the Cygnet Bay region and selective breeding of pearl oysters genetically resistant to Juvenile Pearl Oyster Mortality Syndrome (JPOMS).

The initiation of a new Cooperative Research Centres Project aims to breed resistance to JPOMS, a syndrome capable of inducing mortality rates greater than 90% in Australian pearl farms. This research is a collaboration among James Cook University, Ellies Pearls, Cygnet Bay Pearl Farm and the KMRS. Genome sequenced brood stock from Ellies Pearls are being re-settled onto farms around both Elizabeth Bay and Cygnet Bay. Ongoing sampling efforts before, during, and after outbreaks will help to uncover genetic traits that may drive survivorship during these events.

Above: left to right: Joan Goa and Tahlia Newnham (KMRS interns), Liam Rawlins (Field Research Officer), Abbie Leonhardt (KMRS intern), Gary Firman (Pearling Manager), and Elise Pinto (KMRS intern).
Below: Aerial view of Cygnet Bay. © Courtney Davies.

The rock oyster recruitment project led by Andrew Bossie has identified substrate which contained natural calcium (pearl shell and fibro cement) increased recruitment success of *Saccostrea* spp. We are undertaking studies over a 3 month period tracking survival and competition with other species across multiple locations and aim to explore the local environmental factors which may affect recruitment and survival.

Continued monitoring of our amazingly resilient intertidal coral reef systems has shown a healthy system overall following a mass bleaching event in 2016. Some small sections of bleaching were recorded along our permanent transect lines, most of which have recovered thus far. We hope to continue to expand our knowledge of the local systems with our transect surveys now being bolstered by a coral recruitment.

Our monthly water monitoring program has continued to highlight massive seasonal variations in the water column surrounding these large tidal bays. Physical parameters such as temperature, salinity, turbidity and pH were closely monitored, in conjunction with analysis of local phytoplankton communities.

In closing, 2018 has been an amazing year for KMRS, none of which would have been possible without the steadfast and ever present time and commitment of our intern team, so a big shout out to our 2018 team: Karyssa Arnett, Suzanne McCarthy, Danielle Hodgkinson, Andrew Bossie, Courtney Davies, Abbie Leonhardt, Elise Pinto, Joan Gao and Tahlia Newnham. As always, massive thanks to the Cygnet Bay Pearl Farm for the continued financial support, use of facilities, vessels and resources.

www.kmrs.com.au
Kimberley Marine Research Station
@KMRS2009
@kimberleymarineresearchstation

Above: Detail of the surface of a massive coral. © Ramona Brunner 2017 ACRS Photo Competition

Above: Marble shrimp (*Saron marmoratus*). © David Wiseman 2018 ACRS Photo Competition

News from the Great Barrier Reef Marine Park Authority

New Chair appointed for the Marine Park Authority

On 29 October 2018, the Great Barrier Reef Marine Park Authority (the Authority) welcomed Dr Ian Poiner as the new Chairperson of the Authority. Dr Poiner has a long history of involvement in Great Barrier Reef science and conservation, and is a former CEO of the Australian Institute of Marine Science. The Authority also welcomed the new Chief Executive Officer, Mr. Josh Thomas on 15 March 2019. Mr Thomas will take up the position for a five-year term. Appointments to the Marine Park Authority are made by the Governor-General on the recommendation of the Australian Government Minister of the Environment.

Above: Dr. Ian Poiner, new Chairperson of the Great Barrier Reef Marine Park Authority.

Above: Mr. Josh Thomas, new Chief Executive Officer of the Great Barrier Reef Marine Park Authority.

Reef 2050 Integrated Monitoring and Reporting Program

Since the summer of 2015–16, the Great Barrier Reef has faced an unprecedented combination of impacts, including two consecutive years of mass coral bleaching, outbreaks of coral disease and crown-of-thorns starfish, a category 4 tropical cyclone which crossed reefs in the Whitsundays, and a recent monsoon causing unprecedented levels of rain in North Queensland resulting in flood plumes extending out to the Great Barrier Reef.

The resulting decline in the ecological health of the Reef is unprecedented in our lifetime, with the attention on climate change as the primary driver. Consequently, the importance of resilience-based management actions to address the impacts of climate change has never been stronger. The Reef 2050 Integrated Monitoring and Reporting Program, currently under development will be an additional enabler of resilience-based management under the Reef 2050 Long-Term Sustainability Plan.

There are currently more than 90 monitoring programs operating in the Great Barrier Reef World Heritage Area and adjacent catchment. These programs have been designed for a range of purposes and operate at different spatial and temporal scales. The intent of the Reef 2050 Integrated Monitoring and Reporting program is not to duplicate existing arrangements, but to coordinate and integrate existing monitoring, modelling and reporting programs across disciplines.

Complementary work is underway to develop a prototype web-based visualisation portal for managers and users. The program's vision is for the knowledge system to enable resilience-based management of the Great Barrier Reef and its catchment, and provide managers with a comprehensive understanding of how the Reef 2050 Plan is progressing. Further information can be found in the program strategy.

Reef Joint Field Management Program

The Australian and Queensland governments' Reef Joint Field

Management Program provides a constant in-park presence, delivering a range of in-water and on-ground actions to protect the Great Barrier Reef World Heritage Area.

Upholding compliance and educating marine park visitors about the zoning rules, is a key priority. The program also monitors and maintains internationally-important turtle and seabird breeding islands, eliminates island pests, manages access to national parks, and protects coral habitat through the installation of reef protection markers and moorings. Marine Park rangers also undertake systematic reef health monitoring – to check for change.

Last year the joint program received an increased funding commitment of more than $17 million per year to $38 million by 2022. The staged release of funds allows for a considered and sustained expansion of front line compliance activities, including a second 24-metre vessel capable of operating Reef-wide. Find out more about the Reef Joint Field Management Program and the role it plays at www.gbrmpa.gov.au or download the Annual Report Summary 2017-18.

Master Reef guides

The Great Barrier Reef tourism industry plays a vital role in sharing the stories and values of the Great Barrier Reef to millions of visitors every year.

In February 2019, the Great Barrier Reef welcomed its first official Master Reef Guides, the world's leading reef ambassadors, interpreters and story tellers. Thirteen specially-trained guides will now liaise with visitors and share up-to-date information on the Marine Park, its management, responsible reef practices and citizen science opportunities with visitors in an educational and memorable way.

Below: Infographic summarising the central priorities of GBRMPA's Reef Joint Field Management Program. © Great Barrier Reef Marine Park Authority.

Citizen science news in 2018

by Jenn Loder
ReefCitizenScience.org

Citizen science is community participation and collaboration in scientific research. Numerous citizen science programs are actively engaging community members in scientific research across the Queensland's coastal and marine environments. Work in this space is gaining acknowledgement as an approach to engage the community in collecting valuable information which can contribute to science, management and social outcomes.

A study with the ARC Centre of Excellence for Environmental Decisions, UQ, showed that citizen science activities at ReefBlitz positively influenced stewardship (Dean et al 2018).

Virtual Reef Diver based out of Queensland University of Technology (QUT) launched as an image-based citizen science project for National Science Week 2018, using images to help make predictions of coral cover across the Great Barrier Reef.

The University of Queensland Underwater Club released results for the Flinders Reef Ecological Assessment project in Moreton Bay, bringing together multiple citizen science methods to release the first detailed ecological assessment and mapping project for this subtropical reef location.

The science and art of reef restoration are being explored through emerging initiatives across the Great Barrier Reef, including citizen science monitoring approaches

CoralWatch was featured as a way for reef visitors to get involved in data contribution, with almost 6,000 visitors to the GBR using the tool coral colour chart since 2002

Queensland Office of the Chief Scientist released the Queenslanders' perceptions and attitudes towards science 2018 report and launched the Queensland Citizen Science Strategy.

Research published in Nature using data from the Reef Life Survey (RLS) citizen science program describes upheaval among fish and invertebrate communities after a marine heatwave hit Australia's Great Barrier Reef and Coral Sea in early 2016.

From October – November 2018 members and partners of the Reef Citizen Science Alliance teamed up to engage 1654 participants through more than 55 citizen science and local action events across the state in ReefBlitz 2018. Participants recorded 38,392 data points for citizen science programs from coast to coral.

A NESP project is working with Traditional Owner rangers and local citizens of the Port Curtis Coral Coast (PCCC) TUMRA to develop a Mangrove Management Plan (MMP) that provides a strategic basis for estuarine repair activity and maximises water quality outcomes in the southern GBR incorporating Mangrove Watch citizen science methods.

To find out more about the Reef Citizen Science Alliance visit www.reefcitizenscience.org. To check out broader citizen science information visit the Australian Citizen Science Association https://citizenscience.org.au/.

Below: A diver records data on a coral reef. © Christopher Brunner. 2018 ACRS Photo Competition

Not exactly rocket science.

You may love your 3D robots, hyper spectral sensors, pulse amplitude fluoroscopes, and gamma radiation microscopic Geiger counters... But sometimes it is the little things that make the greatest difference. In this issue, we asked coral reef researchers across Australia to share with us examples of the wacky ways they use and modify ordinary items to push the limits of coral reef science.

What you see here are some of the best and most innovative uses of everyday products that ACRS members have repurposed to run their experiments or collect field data. As you can see, there is no shortage of creativity when it comes to data collection in the field.

Recycled plastic bottles for studying COTS larvae,
Ciemon Caballes

PVC pipes to create a frame for COTS pictures,
David Wiseman

Cookie containers for enclosing coral larvae,
Kerry Cameron

Hardcore hardware parts to secure micro-sensors,
Christopher Doropoulos

Cake carrier & zip ties,
Alana Boyles

Magna Doodle to record sample details,
Jessica Meeuwig

High visibility hats control points for drones,
Steph Duce

Bathmats for holding 2ml Eppendorf tubes,
Michelle Achlatis

THE GREAT BARRIER REEF

Biology, Environment and Management

- A book review by Dr. Sarah Hamylton -

As the range of pressures on the Great Barrier Reef intensifies, there is a growing need for the scientists working on this national treasure to consolidate and communicate their expertise. The Great Barrier Reef: Biology, Environment and Management is the second edition of an edited collection of insights from 48 leading coastal and marine experts across 32 chapters. To consolidate material from such a diverse range of disciplinary fields requires close editorial guidance driven by a clear overarching vision of how the many facets of 'Great Barrier Reef science' come together to make a coherent whole. The editors have done a good job of meeting this requirement.

The book is organised into three parts: The Nature of the Reef, Factors affecting the reef and Overview of reef biodiversity and organisms. For a book subtitled 'Biology, Environment and Management', it is a pleasant surprise that the first two chapters focus on reef geomorphology and geology. Having written one of the few comparable books about the Great Barrier Reef, David Hopley and Scott Smithers begin with a characteristically thorough and knowledgeable overview of the geomorphology of GBR coral reefs. In Chapter 2, we learn from coral and ice core records, as well as the raised fossil reef terraces in the Huon peninsula, how the reef has built incrementally with high sea levels over the last 600,000 years with historically lowers frequencies of disturbance than we see today.

One of the primary advantages of edited collections, particularly revised editions, is that they communicate the most recent advances in a given subject area. The new Chapter 7 on the outer reefs by Bridge et al., is a prime example of cutting edge GBR science, particularly the detailed bathymetric diagrams revealing the dramatic changing character of the outer shelf with latitude and the considerable extent of *Halimeda* bioherms, palaeochannels and submerged shoals, all reasonably new discoveries. One extraordinary photograph shows divers observing the steep canyon walls of the Starkey River palaeochannel 90 m below the surface. It is unclear whether they are student volunteers or the authors themselves.

In the second section of the book, on factors affecting the reef, the other newly introduced chapter on fisheries provides an informative snapshot of licence statistics within the GBR Marine Park. While management interventions have reduced the number of active licences across most fisheries, with almost 200 active trawling licences and recent collapses in scallop stocks, it would appear that there is still some way to go to ensure the sustainability of GBR fisheries.

Other management chapters cover human and natural disturbances, climate change, runoff and a review of the Great Barrier Reef Marine Park Authority's planning and management approach. Blue boxes signify some of the more pressing issues, detailing topics such as the Intergovernmental Panel on Climate Change and the Paris Agreement, in between predictions of the consequences of inaction: 'it is almost certain that back-to-back bleaching events will be commonplace in 5-10 years, driving coral cover within reef systems to very low levels' warns Ove Hoegh-Guldberg.

Life on the reef is a key focal area of this book, with 18 chapters devoted to GBR biodiversity from plankton to marine mammals, and a lot in between. It provides a handy overview for students wishing to learn more about a chosen organism.

This book is of considerable practical value for university students, the primary target readership. This value stems from both the cross-disciplinary understanding of the GBR that emerges from the

collective chapters, and from the depth with which many of the contributors treat their subject, delivering a wealth of curious facts that jump off the pages. In many cases, such attention to detail is accompanied by a broader commentary on the influence of climate change on the GBR.

More information on the flora and fauna of the islands, and the work on ecological genetics and its potential to address some of the pressing climate change threats would have been welcome. This is by no means a criticism of this book. The observation presents a broader challenge to Australia's coral reef community, to bring together a wide range of viewpoints and expertise across the Universities, Government and non-Government Agencies across the continent.

Overall, editors and authors teamed up to construct a coherent, accessible and comprehensive review of contemporary science on the Great Barrier Reef, particularly as it relates to management. Critically, in combining cutting edge science with the identification of management challenges on the horizon, this collection is also a useful guide to managers who wish to incorporate insights into their suite of management tools, placing this book at the forefront of the coral reef science literature.

The Great Barrier Reef: Biology, Environment and Management

Second Edition

Edited by: Pat Hutchings, Michael Kingsford, Ove Hoegh-Guldberg

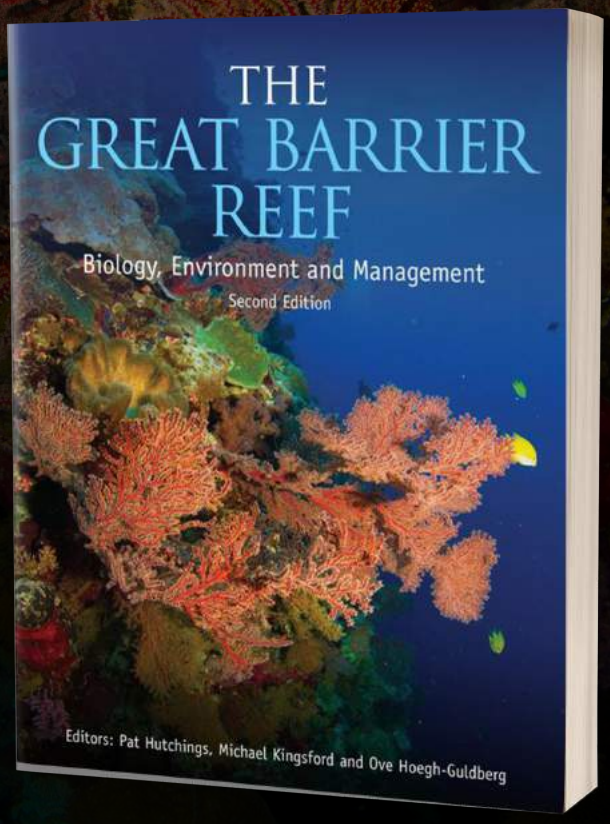
Pages: 472

Paperback

Published by CRC Press

You can buy it scanning here:

Profits from royalties help support the ACRS



Above: Up close with the reef. Investigating coral bleaching at the Blue Lagoon, Rangiroa, French Polynesia © Christopher Brunner
2017 ACRS Photo Competition

Meet the 2018-19 ACRS Council

Anna Scott

Southern Cross University

President

Sarah Hamylton

University of Wollongong

Vice-President

Andrew Hoey

James Cook University

Past President

Carrie Sims

University of Queensland

Secretary

Stephanie Duce

James Cook University

Treasurer

Samantha Goyen

University of Technology Sydney

Membership Manager

Victor Huertas

James Cook University

Magazine Editor

Jessica Hoey

Great Barrier Reef Marine Park Authority

Magazine Team

Peter Cowman

James Cook University

Magazine Team

Chris Roelfsema

University of Queensland

Magazine Team

Maria del Mar Palacios

Deakin University

Website Manager

Jennifer Donelson

James Cook University

Councillor

Selma Klanten

University of Technology Sydney

Councillor

Selina Ward

University of Queensland

Councillor

David Booth

University of Technology Sydney

Councillor

Paloma Matis

University of Technology Sydney

Councillor

Katie Motson

James Cook University

Councillor

Kerry Cameron

Southern Cross University

Councillor

Damian Thomson

CSIRO

Councillor

Sven Uthicke

AIMS

Councillor

Shallow coral reef © Alex Mustard/Coral Reef Image Bank

© Maarten De Brauwer
People's Choice Winner 2018 ACRS Photo Competition

GET IN TOUCH!

The Australian Coral Reef Society

austcoralreefsoc@gmail.com

www.australiancoralreefsociety.org

@AustralianCoralReefSociety

@AustCoralReefs

BECOME A MEMBER

DONATE. IT'S TAX-DEDUCTIBLE!

Australian
Coral Reef Society