At the ARC Centre of Excellence for Coral Reef Studies we acknowledge the Australian Aboriginal and Torres Strait Islander peoples of this nation. We acknowledge the Traditional Owners of the lands and sea where we conduct our business. We pay our respects to ancestors and Elders, past, present and future. The ARC Centre of Excellence for Coral Reef Studies is committed to honouring Australian Aboriginal and Torres Strait Islander peoples’ unique cultural and spiritual relationships to the land, waters and seas and their rich contribution to society.

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The ARC Centre of Excellence for Coral Reef Studies commenced operations in 2014 following the award of $28 million from the Australian Research Council to fund the Centre for seven years. Headquartered at James Cook University (JCU), the Centre’s additional nodes are The Australian National University (ANU), The University of Queensland (UQ) and The University of Western Australia (UWA). Our national and international partner institutions are the Australian Institute of Marine Science (AIMS), the Center for Ocean Solutions at Stanford University (COS, USA), Centre National de la Recherche Scientifique (CNRS, France), the Great Barrier Reef Marine Park Authority (GBRMPA), the International Union for Conservation of Nature (IUCN, Switzerland) and WorldFish (Malaysia). In 2018, the Centre has collaborative links and co-authorships with 440 institutions in 79 countries.

The major objective of the Centre is to achieve a better understanding of the science, both social and natural, that underpins the dynamic changes currently occurring in coral reefs worldwide. Our research is both multifaceted and transdisciplinary, improving the governance and management of natural systems and enhancing the capacity to sustain both human and natural capital is an overarching goal of our research.

The aims of the Australian Research Council (ARC) Centre of Excellence for Coral Reef Studies are:

1. Research
   Produce research that is world-best, innovative, collaborative, multi-disciplinary and highly relevant to coral reef management, adaptive governance and policy development.

2. Research Training and Professional Education
   Build human capacity and expertise in coral reef science worldwide.

3. National and International Linkages
   Create a global hub for integrated coral reef research collaborations.

4. Impacts and end-user engagement
   Exchange and transfer knowledge, technologies and research outcomes with end-users and partners.

5. Governance
   Continuously evolve Centre management to ensure it is co-operative, multi-institutional and communicative.

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Welcome to the 2018 annual report of the Australian Research Council (ARC) Centre of Excellence for Coral Reef Studies.

A highlight this year is a series of studies we published this year in *Nature*, *Science*, and *Nature Climate Change*, which has brought the impact of climate change on coral reefs to the forefront of the public consciousness. At a global scale, the Centre’s research in 2018 demonstrates that the frequency of global mass bleaching of corals due to anthropogenic climate change has increased nearly five-fold since 1980. On the Great Barrier Reef, back-to-back mass bleaching in 2016 and 2017 has transformed the Great Barrier Reef, killing approximately half the region’s shallow-water live coral, triggering a profound shift in the composition of survivors.

Our research in 2018 also shows that the loss of reef-building coral species has profound consequences for the rest of the reef ecosystem, reducing biodiversity and affecting many non-coral species such as commercially important fishes. Our focus in recent months has been the recoverability of the Great Barrier Reef, in the face of depleted brood stocks of corals, and altered stock-recruitment relationships. This information will be vital for the responses of agencies and governments responsible for reef management, for the industries that depend on coral reefs, and for assessing the World Heritage values of the Reef.

During the year, the Centre has undertaken fieldwork in 28 tropical countries, particularly in Australia, Papua New Guinea, Solomon Islands, Timor Leste, Indonesia, Brazil, French Polynesia, Micronesia, Saudi Arabia, Kenya, the Maldives, the Seychelles, Mexico, and the Caribbean. Centre researchers provided hundreds of government and industry briefings, capacity-building workshops and consultancies to governments, management agencies, non-government organisations (NGOs), industry groups and businesses. The impact and scale of these activities is global, with Centre researchers informing policy and practice around the world (p6).

The Centre’s three research Program summaries on pp12-37 provide an overview of our activities throughout the year. We implemented a new policy to further promote the discovery and dissemination of our digital research outputs in 2018. We added more than 40 items to our online data repositories in 2018, including unique and timely datasets on thermal exposure, coral bleaching and mortality. ARC Centre members also shared digital data and metadata via online repositories and databases, data journals and journal repositories (p52).

The Centre’s researchers produced a record breaking 383 publications in 2018, comprising 354 journal articles, 2 books, 18 book chapters, and 9 reports (p71). More than one third of these articles were published in journals with an Impact Factor greater than 4 and 33 articles appeared in prestige journals such as *Nature, Science* and *Trends in Ecology and Evolution*. Our co-authors this year come from 440 institutions in 79 countries, reflecting the Centre’s continuously expanding international collaborative network. Eight Centre researchers, were identified as 2018 Highly Cited Researchers by Clarivate Analytics, each ranking in the top 1% of researchers worldwide for their citations (p10).

In 2018, the Centre’s membership comprised 73 Chief Investigators, Research Fellows and Associates; 29 Partner Investigators, resident international scholars and adjunct researchers; and 176 research students (p43). Students and early career researchers are essential contributors to the Centre’s activities and outputs. In 2018, we recruited 12 new Research Fellows and Associates. Centre researchers this year were once again recognised internationally and in Australia for the excellence of their achievements (p10), and the Centre continued its commitment to promoting gender equity in research leadership and recruitment of new members.

I’d like to express my sincere gratitude to our many friends around the world for their contributions to an outstanding year, and to the Centre’s Advisory Board, our research partners and end-users from many institutions in Australia and overseas. I am especially grateful to our Chief Operations Officer, Jennifer Lappin, Assistant Director, Alana Grech and our talented multi-nodal operations team.

Terry Hughes
Director
Jon Brodie delivered a briefing to the Regional Organisation for the Protection of the Marine Environment (ROPME). The briefing was for the Protection of the global warming and climate change on the world’s coral reefs.

Ove Hoegh-Gulberg was a participant in the Intergovernmental Panel on Climate Change (IPCC) 1.5°C meeting held in Bonn, where he instructed members on the impacts of global warming and climate change on the world’s coral reefs.

Nils Krueck (p28) and Peter Mumby led a workshop to share knowledge and expertise in five countries across the Indo-Pacific. The workshops on scenario-planning and multi-objective planning in northern Australia, the work of Morgan Pratchett and Tom Bridge provided advice to Great Barrier Reef monitoring by tourism industry designed to inform government policy. The Great Barrier Reef Marine Park Authority conducted a media briefing to the United States Congress (Democrat, Rhode Island) presented a 15 minute address on the impact of climate change on the Great Barrier Reef. His presentation utilised multiple graphics, quotes and data from research papers produced by ARC Centre researchers.

The Outlook Report, published every five years, is an assessment of the status of the Great Barrier Reef designed to inform government policy.

The ARC Centre researchers. The program builds connections between traditional knowledge and coral reef researchers by engaging Indigenous high school students in exciting field-based programs and inspiring them to pursue tertiary education and careers in marine science.
In 2018, the Intergovernmental Panel on Climate Change (IPCC) released its latest special report concluding that “coral reefs would decline by 70-90 percent with global warming of 1.5°C, whereas virtually all (> 99 percent) would be lost with 2°C”.

Deputy Director of the ARC Centre, Ove Hoegh-Guldberg, was one of fourteen coordinating lead authors involved in the preparation of the report.

In a media statement Ove stated, “a key finding of the report is that 1.5°C is not a safe level of global warming; however it is much safer than 2.0°C. We are still going to see many challenges at 1.5°C”.

The researchers warn that failure to curb climate change, causing global temperatures to rise far above 2°C, will radically alter tropical climate change. But the Reef is changing.

“I think we will have a Great Barrier Reef in 50 or 100 years’ time if we can control extreme climate change. But the Reef is changing. It’s gone from one system 30 years ago to a different system today and it will continue those sorts of changes.”

A video abstract of the IPCC report featuring ARC Centre research produced by the Australian Academy of Science generated significant engagement and a viewership of over 100,000.

The report’s conclusions are based on more than 6,000 citations, including the recent high impact research on the back-to-back mass bleaching event on Great Barrier Reef led by Centre Director, Terry Hughes.

The scientific expertise of both Ove and Terry was highly sought after following the release of the report. Terry spoke with Carbon Brief about his views of the report’s key findings, stating, “I think we will have a Great Barrier Reef in 50 or 100 years’ time if we can control extreme climate change. But the Reef is changing. It’s gone from one system 30 years ago to a different system today and it will continue those sorts of changes."

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The year ended on a remarkable note for Terry. He was recognised as one of the world’s most influential scientists through Clarivate Analytics annual list of ‘Highly Cited Researchers’. In December, two peer-reviewed papers (published in Nature and Science) led by Terry were named as articles that captured the public imagination in the 2018 Altmetric Top 100 list of most-mentioned scholarly articles, securing the 9th and 28th position on the list.

Carbon Brief’s list of ‘Top 10 climate papers’ most featured in the media in 2018:


Recognition of Excellence of Centre Researchers

Highlights of the 43 awards ARC Centre researchers received in 2018:

Eight ARC Centre researchers, Joshua Cinner, Ove Hoegh-Guldberg, Terry Hughes, Geoffrey Jones, Peter Mumby, Philip Munday, Morgan Pratchett and Bob Pressey, were identified as 2018 Highly Cited Researchers by Clarivate Analytics, each ranking in the top 1% of researchers worldwide for their citations.

David Bellwood was honoured with the Australian Marine Sciences Association’s 2018 Jubilee Award for his outstanding contribution to marine research in Australia throughout his career.

Tom Bridge was awarded an ARC Discovery Early Career Researcher Award.

Joshua Cinner was elected a Fellow of the Academy of Social Sciences in Australia, in recognition of his exceptional contributions to the academic discipline of human geography and to broader society. He also received the Mid-Career Scientist Award of the International Coral Reef Society.

Jennifer Donelson received the 2018 James Cook University Award for Excellence in Research, for their work on understanding the plastic and adaptive capacity of reef fish to respond to climate change. Philip also received international recognition as a Fellow of the International Coral Reef Society (ICRS). The award recognises his commitment and service to ICRS, over a significant period of time.

Philip Munday was honoured with the Outstanding Career Achievement in Research Supervision award by James Cook University. Philip and Jennifer Donelson were joint recipients of the James Cook University Award for Excellence in Research, for their work on understanding the plastic and adaptive capacity of reef fish to respond to climate change. Philip also received international recognition as a Fellow of the International Coral Reef Society (ICRS) for his significant service and scientific achievement.

Andrew Hoey was awarded the James Cook University Primary Advisor of the Year for excellence in the supervision of research degree candidates. Andrew was also recognised as a Fellow of the International Coral Reef Society (ICRS). The award recognises his commitment and service to ICRS, over a significant period of time.

Verena Schoepf was selected to participate in the highly competitive Superstars of STEM program which aims to smash society’s gender assumptions about scientists and increase the public visibility of women in STEM.

The ARC Centre's alumni also received noteworthy recognition in 2018. Tracy Ainsworth was recognised for her support of students in minimising the challenges they face when studying with a disability.

Georgina Gurney was awarded a prestigious Fulbright Postdoctoral Fellowship to collaborate with leading researchers and practitioners in sustainability and environmental governance, at Harvard University, USA. She also received the Young Science Ambassador Award for scholarly excellence from the Australian Academy of Technological Sciences and Engineering.

Ove Hoegh-Guldberg was appointed a member of the World Commission on the Ethics of Scientific Knowledge and Technology by the Director-General of UNESCO. Ove was also named a member of the International Scientific Advisory Board of the Leibniz Center for Tropical Marine Ecology.

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Three of the ARC Centre’s early career researchers received this year’s prestigious Young Tall Poppy Science Awards, with Assistant Director, Alana Grech, receiving the 2018 Queensland Young Tall Poppys Scientist of the Year award.

The annual Young Tall Poppy Science Awards are run by the Australian Institute of Policy and Science, with campaigns held in each of the States and Territories. The Young Tall Poppy Science Awards are one of Australia’s most prestigious science prizes.

Alana’s Queensland Scientist of the Year award recognises not only her outstanding research achievements, but also her commitment to science engagement.

“My research uses spatial analysis to predict and map changes in coastal wildlife and habitats, with a particular focus on seagrass meadows in the Great Barrier Reef,” said Alana.

“The models allow me to predict locations where human activities, such as poor water quality, coastal development and fishing, are potentially damaging the environment, to help inform environmental policy and practice to protect the Reef”.

Also among the group of exceptional researchers were Georgina Gurney, a Research Fellow and Fulbright Scholar at the ARC Centre's James Cook University node, and Verena Schoepf, a Program Leader and Research Fellow at the University of Western Australia node. Both received Young Tall Poppy Science awards (in Queensland and Western Australia), celebrating their significant accomplishments.

Georgina is an environmental social scientist whose research focuses on the human dimensions of environmental governance and management, specifically relating to coral reefs in the Asia-Pacific region.

Verena’s research explores how reef-building corals are affected by climate and environmental change, with a special interest in Indian Ocean coral reefs and ‘super corals’ that are already adapted to naturally extreme environmental conditions.

The Young Tall Poppy Science Awards were created in 1998 to recognise up-and-coming scientists who combine world-class research with a passionate commitment to communicating science.
Professor Terry Hughes is the Director of the ARC Centre of Excellence and co-leader of Research Program 1. He received his PhD in 1984 from Johns Hopkins University in Baltimore, USA and was a National Science Foundation Postdoctoral Fellow at the University of California, Santa Barbara, USA, before moving to Australia and James Cook University in 1990. Terry has broad research interests in ecology, marine biology and the social-ecological dynamics of coral reefs. As Centre Director, he provides academic leadership and is responsible for the strategic development of the Centre. Terry was elected a Fellow of the Australian Academy of Science in 2001 in recognition of ‘a career which has significantly advanced the world’s store of scientific knowledge’. In 2007, he was awarded the Sherman Eureka Prize for Environmental Research and in 2008, he received the prestigious quadrennial Darwin Medal of the International Society for Reef Studies. From 2008-2010, he was a member of the ARC Advisory Council. Terry has been awarded three Federation/Laureate Fellowships by the ARC, from 2002–2017. In 2014, he was awarded an Einstein Professorship by the Chinese Academy of Science, and in 2016 Terry was recognised by Nature magazine as one of Nature’s 10 – the ‘ten people who mattered this year’. He is a Clarivate Highly Cited Researcher and received multiple awards in 2018 (p9) in recognition of his research and achievements.

Associate Professor Tiffany Morrison is a political geographer and co-leader of Research Program 1. Tiffany’s research combines human geography, political science and ecology to tackle increasing complexity in environmental governance. Tiffany received her PhD in 2004 from The University of Queensland, supported by a Land and Water Australia scholarship and a visiting fellowship at the University of Wisconsin-Madison, USA. From 2004–2008 she taught in the Master of Public Administration program in the School of Political and International Studies at Flinders University. During that time, she was awarded a visiting Fellowship at the University of Kyoto Disaster Prevention Institute, Japan. In 2008, Tiffany joined the School of Geography, Planning and Environmental Management at The University of Queensland where she co-led an interdisciplinary team of ecologists, geographers, planners, economists and lawyers working on an ARC Super Science funded program of research on sea level rise. Since joining the ARC Centre in 2015, she has developed and led a major new research program on the governance of climate adaptation and on conflict in large-scale reef systems. Tiffany serves on the Editorial Board of Earth System Governance and her recent studies of the complex governance of tropical ecosystems have been published in Nature, PNAS, Nature Climate Change and Global Environmental Change.

Professor Bob Pressey is a co-leader of Research Program 1. Bob’s research includes studies of biodiversity, geographic information systems, spatial modelling of species and human activities, software development, explicit frameworks for deciding on the location and timing of conservation investments, and the socio-economic considerations involved in implementing conservation. Prior to moving to James Cook University and the ARC Centre, he was a research scientist for the New South Wales National Parks and Wildlife Service for almost 20 years. During that time, Bob developed and applied leading-edge techniques in conservation planning, influencing policy and conservation practice. He has served on the editorial boards of leading conservation biology journals. Bob was awarded The Royal Botanic Gardens’ Eureka Prize for Biodiversity Research in 2002 and the inaugural Australian Ecology Research Award from the Ecological Society of Australia in 2008. In 2010, he was elected a Fellow of the Australian Academy of Science for his contributions to the field of systematic conservation planning. His understanding of conservation applications was recognised in 2012 by his appointment to WWF Australia’s Eminent Scientists Group. He was recognised in 2018 as a Clarivate Highly Cited Researcher in ‘Environment and Ecology’ (p10).

Researchers: Jorge Álvarez-Romero, Neil Andrew, Michele Barnes, David Bellwood, Michael Bode, Jon Brodie, Joshua Cinner, Pip Cohen, Graeme Cumming, Alana Grech, Georgina Gurney, Danika Kleiber, Laurence McCook, David Mills, John Pandolfi, Cristian Rojas, Garry Russ, Andrew Song, Fernanda Terra Stori, Rebecca Weeks.
Research in Program 1 focuses on understanding the linkages between coral reef ecosystems, the goods and services they provide to people, and the wellbeing of human societies. The overarching objective is to improve the governance and management of coral reefs worldwide, while simultaneously providing theory, insights and lessons for other ecosystems. Key research questions include how levels of economic development, social capital, local history and culture influence resource use and the dynamics of governance systems. Program 1 places a high value on engagement with local communities, managers and policy makers, government agencies and with non-government organisations. The conservation planning group led by Bob Pressey has the broad goal of providing decision-makers with more effective means of managing species and ecosystems by providing decision-support tools, guidelines for using information, and rigorous assessments of the adequacy of existing conservation measures.

In 2018, the geographic, social and ecological scope of Program 1’s research was very diverse, with major projects in northern, eastern and western Australia, and in Brazil, the Cook Islands, Costa Rica, Fiji, Indonesia, Kenya, Micronesia, Mexico, Papua New Guinea, the Philippines, the Solomon Islands, Tonga and the USA. For example, Georgina Gurney was awarded a $200k SNAPP (Science for Nature and People Partnership) grant to lead four workshops over two years at the US National Centre for Ecological Analysis and Synthesis (NCEAS), in Santa Barbara. The focus of the project is understanding and policymaking.

Fisheries and gender specialist Danika Kleiber joined the ARC Centre in 2018 as a joint research fellow with WorldFish. Two visiting researchers, Seth Sykora-Bode (Endeavour Fellowship) and Fernanda Terra Stori (São Paulo Research Foundation Scholarship), each conducted 6-month exchanges at the ARC Centre with Bob Pressey. Research Fellow Rebecca Weeks moved from the ARC Centre headquarters in Townsville to Western Australia, where she continues to collaborate with Program 1 researchers on protected area design and management.

Program 1 produced a record number of major publications in 2018, including the following examples:

- Joshua Cinner led a major synthesis paper in Nature Climate Change, co-authored with Tiffany Morrison, Terry Hughes, Michele Barnes (p18), PhD student Jacqui Lau and others. The paper provides guidance for climate change adaptation for governments, development agencies and civil society organisations in tropical coastal communities. Joshua also published an invited perspective in Science on how behavioural science can help conservation, and led a paper in Proceedings of the National Academy of Sciences entitled ‘Gravity of human impacts mediates coral reef conservation gains’ with Michele Barnes, Georgina Gurney and colleagues from France, Canada, the UK, USA, Israel, New Caledonia, Puerto Rico, West Indies and Germany (p16).
- Graeme Cumming led a major paper in Proceedings of the National Academy of Sciences entitled ‘Linking economic growth pathways and environmental sustainability by understanding development as alternate social–ecological regimes’, and another important sole-authored review in Conservation Letters entitled ‘A review of social dilemmas and social–ecological traps in conservation and natural resource management’. Andrew Song, along with Tiffany Morrison and their Norwegian colleagues, also led a novel conceptual paper in Fish and Fisheries on developing a clearer and more pragmatic understanding of fisheries governance.
- Jorge Álvarez-Romero, with Georgina Gurney, Bob Pressey and colleagues from the UK, USA, Canada and Brazil, lead a major paper in Biological Conservation entitled ‘Research advances and gaps in marine planning: towards a global database in systematic conservation planning’ (p17). Jorge was also lead author of a timely paper in Global Change Biology on designing connected marine reserves in the face of global warming. Alana Grech led a paper in Global Change Biology that measured the impact of cumulative disturbance events on seagrass connectivity in the Great Barrier Reef. Rebecca Weeks led a paper with ARC Centre alumnus Vanessa Adams in Conservation Biology on research priorities for conservation and natural resource management in Oceania’s small-island developing states.
- Brock Bergseth, who was awarded his PhD at JCU in 2018, led a major paper in Nature Sustainability with Georgina Gurney, Michele Barnes, Joshua Cinner and colleagues from Costa Rica. They provide a pathway for addressing poaching in marine protected areas through voluntary surveillance and enforcement (p20). Jessica Spijkers (a co-tutelle PhD student with Stockholm University and JCU), Tiffany Morrison and Graeme Cumming published a paper in Fish and Fisheries that analyses 31 fisheries conflicts worldwide. They developed a new, universal typology of conflict intensity to aid understanding and policymaking.

Program 1 researchers convened over a dozen workshops and mentoring activities during the year. Jorge Álvarez-Romero led a workshop in Australia on the integration of human values into natural resource planning; Tiffany Morrison led a workshop in France on governance of coral reefs in the Anthropocene with colleagues from Australia, the UK, the USA and the Netherlands. Georgina Gurney co-led a workshop on place attachment and ecological change on the Great Barrier Reef in Rome. Joshua Cinner ran a capacity-building workshop at WorldFish headquarters in Penang, on writing and publishing. An 11 part video of the workshop is now posted on the ARC Centre website and on YouTube. Michele Barnes hosted a 5-day workshop at JCU exploring the topic of adaptation and cooperation in the context of territorial use rights for fisheries. Graeme Cumming led a National Socio-Environmental Synthesis Center (SESYNC) working group in Maryland, USA on quantitative synthesis and modelling of social–ecological dynamics. Many Program 1 researchers also contributed popular articles to The Conversation in 2018, including Michele Barnes, Jon Brodie, Joshua Cinner, Georgina Gurney and Alana Grech (p61).
Marine reserves are vital – but under pressure

A massive study of nearly 1800 tropical coral reefs around the world has found that marine reserves near heavily populated areas struggle to do their job – but are a vast improvement over having no protection at all.

Professor Joshua Cinner from the ARC Centre of Excellence for Coral Reef Studies led a team of 37 scientists examining the effectiveness of different reef conservation strategies.

"Fish stocks were extremely depleted on reefs that were accessible to large human populations. Compared to marine reserves far from these human pressures, reserves near high human pressure had only a quarter of the fish and were a hundred times less likely to have top predators such as sharks," said Professor Cinner.

"A really novel and exciting part of our study found that in many places, social, economic, and cultural realities mean that marine reserves that entirely prohibit fishing are not an option. "So, we also looked at how effective other forms of reef conservation were, such as restricting the types of fishing gear that people use. Our results were promising – these restrictions certainly had better outcomes than doing nothing, but not as good as marine reserves. They were a sort of compromise," she said.

Professor Cinner said the study makes clear the benefits and limitations of implementing key coral reef conservation strategies in different types of locations. "Our research shows where managers will be able to maximise certain goals, such as sustaining fisheries species, and likewise, where they will be wasting their time," he said.


Media highlight: UPI.com - Marine reserves are essential, but increasingly stressed, 18 June 2018.

New database to better guide global conservation efforts

James Cook University researchers say a new global database will lead to better marine parks by helping to bridge critical gaps in marine conservation planning.

Dr Jorge Álvarez-Romero from the ARC Centre of Excellence for Coral Reef Studies at James Cook University led a study that looked at marine conservation planning worldwide.

"For this study, we developed a database to document conservation planning and analysed all marine studies available in the scientific literature. It clearly shows deficiencies in the present system," he said.

Dr Álvarez-Romero said systematic conservation planning studies, used to determine which areas would be most useful in conserving marine biodiversity, are growing very quickly.

"Despite this, there is no structured or reliable way of finding information on methods, trends and progress. There is little evidence of input from stakeholders. There are important gaps in geographic coverage and not enough work done on the areas most threatened," he said.

"We know the number and total extent of protected areas will increase significantly during the next few decades. The challenge is making this expansion count in terms of biodiversity conservation," he said.

Distinguished Professor Bob Pressey, Chief Investigator at the ARC Centre and co-leader of the study, said researchers from five countries led most studies, with Australia forging the way in global marine conservation planning.

"Australian organisations have contributed significantly to developing methods and tools that are widely used in conservation planning," he said.

"Despite these advances, the varying quality and detail in documentation of the studies limits opportunities to develop and apply best-practice principles," said Professor Pressey.

Dr Moreno Mills, conservation scientist at Imperial College London and co-leader of The Conservation Planning Database project, said a global database to track development, implementation and impact of conservation planning is urgently needed, along with a closer analysis of the literature, and continuous and comprehensive documentation of conservation planning exercises.

"The new database is a move towards a centralised repository of information of planning exercises and can advance conservation theory and practice," she said.

Professor Heather Leslie, an international leader in marine conservation science and Director of the University of Maine’s Darling Marine Center, said "With this database in hand, donors and non-governmental organisations can identify regions and local areas needing further work, and scientists, practitioners and policy-makers can learn from previous plans".

"In addition, it gives the scientific community - including peer reviewers - a means of assessing trends in conservation planning methods and applications, so that we can learn from our previous work and shape our new work accordingly," she said.


Michele Barnes

Michele Barnes is a Senior Research Fellow in the People and Ecosystems Program (Program 1), based at the James Cook University node of the ARC Centre. Her research draws on social network science to explore how complex interactions between people and reefs effect sustainable outcomes. Michele recalls that “for as long as I can remember, I have been absolutely fascinated by two things: people and the oceans”. Michele is a descendant of the Costanoan Rumsen Carmel Tribe, the First Nation people of Monterey Bay, California, USA. She grew up poking around tidal pools and exploring her ancestral coastal lands, sparking her passion for the oceans at an early age.

Michele undertook her PhD at the University of Hawai‘i, USA. Supported by the National Oceanic and Atmospheric Administration’s (NOAA) Pacific Islands Fisheries Science Centre, her doctoral research integrated social network science, ecological modelling and economics to provide a novel examination of how and why social networks matter for achieving social, economic and ecological sustainability in marine fisheries. Michele produced ground-breaking evidence that fishers’ social networks were associated with behaviours that directly impact ecosystems. She received invitations to present her research at Princeton University, and to join a working group at Stanford University’s Centre for Ocean Solutions on adaptive approaches to marine resource governance. Completed in just under three years, Michele’s thesis provided a rigorous case for the need to understand and manage the broader social context of environmental problems, rather than solely their biophysical context. Her thesis received both local and international recognition, and resulted in publications in leading journals, including Proceedings of the National Academy of Sciences. Michele believes her career greatly benefited from interdisciplinary PhD training and her affiliation with NOAA, “which gave me direct exposure to the science-policy interface, where experts from both the natural and social sciences worked collaboratively to deliver real-world outcomes”.

Upon completion of her PhD in 2015, Michele was awarded a highly prestigious Social, Behavioural, and Economic Sciences Postdoctoral Research Fellowship from the USA National Science Foundation (NSF), which she undertook as a visiting scholar at the ARC Centre. During her fellowship, she built an independent research program and established new collaborations with leading experts on coral reefs and social-ecological systems. She led an international team of interdisciplinary experts to develop and apply network modelling frameworks to capture key linkages, resulting in publications in Trends in Ecology and Evolution, Ecology & Society, and the International Journal of the Commons.

Michele transitioned from being a visiting scholar to a Research Fellow in the ARC Centre’s People and Ecosystem Program in 2017. The following year, she was awarded a prestigious ARC Discovery Early Career Researcher Award (DECRA). Starting in 2019, her DECRA project will focus on how social networks and power affect adaptive action by people in response to coral bleaching. This project has both a national and international focus, with far-reaching implications for the future of coral reefs and the people who depend on them.

“As reported in Science magazine in January, the interval between (coral) bleaching events is now six years, whereas it had been 30 years in the 1980s: and, if the “cool” La Niña events are now warmer than the “warm” El Niño’s were at that time, then the absolutely vital period of regeneration which the cool cycle provided may now not be available.”

HRH THE PRINCE OF WALES, LONDON, 14TH FEBRUARY 2018 (p59)
What would you do if you saw someone breaking the law? Would you report the offender to the police? Confront them? Or would you do nothing?

We recently asked more than 2,000 fishers in seven countries what they would do if they saw a poacher in a protected marine area.

Poaching – the illegal harvest of animals – plagues many of the world's marine protected areas. Illegal fishing undermines marine parks, and can threaten chronically over-fished species.

A key problem is the lack of enforcement resources. An increasing number of governments and management agencies are encouraging fishers to help, by understanding marine protection rules and reporting poachers.

Yet little is known about how fishers respond when they witness poaching. If you see something, say...nothing

We surveyed more than 2,000 fishers near 55 marine protected areas in Kenya, Tanzania, Madagascar, Indonesia, Papua New Guinea, Costa Rica, and Australia, asking if they had recently seen someone poaching – and if so, what they did.

We found nearly half had witnessed poaching in the last 12 months, and the most common response was to do nothing. This was particularly prevalent on Australia's Great Barrier Reef, where nearly 80% of fishers did nothing after observing poaching. In six of the seven countries we surveyed, fishers said their inaction was because they wanted to avoid conflict – a sensible strategy in places such as Costa Rica, where illegal drugs are commonly trafficked on boats from South America to the USA.

However, avoiding conflict was rarely the rationale around the Great Barrier Reef. Fishers in the Reef cited three main reasons for inaction:

- uncertainty as to whether it was illegal fishing
- a belief it was not their concern or responsibility
- perceived obstacles to reporting (such as not knowing where or how to report).

Given the growing concern over the health and future of the Reef, it's important to enlist fishers in the fight against poachers. Encouragingly, many of the reasons for inaction can be fixed with better education and community outreach efforts.

Poaching plagues the world's marine protected areas, largely due to a lack of enforcement resources. Fishers like the one above may be able to provide much needed surveillance and reporting, but care needs to be taken to ensure they are not put at risk in doing so.

For instance, the Great Barrier Reef Marine Park Authority already has a hotline that fishers can call to report suspected poaching. But we found fishers regularly said they did not know how or where to report. Promoting the hotline – perhaps by publicising times when it led to a poacher being fined or charged – would serve a double purpose. It would be more accessible to legitimate fishers, and act as a deterrent. Our past research has found that a perceived low risk of detection acts as a motivation to poach.

Legitimate fishers want to help

It's important to remember the vast majority of all fishers on the Great Barrier Reef do not poach. Almost all fishers think poaching is both socially and personally unacceptable.

But previous research suggests poachers do tend to overestimate how common poaching is. This is called "false consensus effect" in psychology, and helps poachers to justify their poaching behaviours because they believe "everyone else does it".

By promoting understanding of anti-poaching rules, and actively enlisting fishers as environmental stewards, we can reduce the (false) idea that poaching is common, justifiable and harmless.

Defending environmental rights can be a risky business and can expose fishers to potentially harmful retaliation by poachers; we certainly don't suggest fishers take the law into their own hands if they witness poaching.

But there are many non-risky ways for fishers to report poaching, such as hotlines in the case of the Great Barrier Reef. Promoting these avenues can help address the enforcement shortfall that is severely limiting the success of marine parks around the world.
PROFESSOR JOHN PANDOLFI

Professor John Pandolfi, from the School of Biological Sciences and Centre for Marine Science, at The University of Queensland, is co-leader of Research Program 2. John is the world's leading expert on coral reef palaeoecology. He has broad research interests in marine palaeoecology, with emphasis on the effects of anthropogenic impacts and climate change on the recent past history of modern coral reefs. His research on coral reef ecosystems asks fundamental ecological questions that are best answered by acquiring and using long-term data. John has published more than 150 papers, including 22 contributions to Science or Nature. He has served as President of the Australian Coral Reef Society, and Chief Editor of Paleobiology, and now is Associate Editor for Proceedings of the Royal Society B and Global Ecology and Biogeography. He has supervised 18 PhD students. John has provided frequent briefings on coral reef management and policy (e.g. to the US Congress and Australian Senate) and has been invited to serve on numerous international working groups. In 2001, John received the Discovery Magazine Science Story of the Year award. In 2013, he was awarded a prestigious Discovery Outstanding Researcher Award from the ARC (2013-2016). He was recently elected as a Fellow of both the International Society for Reef Studies (2015) and The Palaeontological Society (2016).

PROFESSOR SEAN CONNOLLY

Professor Sean Connolly, from James Cook University, is co-leader of Research Program 2. Sean combines mathematical and statistical modelling with fieldwork and laboratory experiments to study the dynamics of biological turnover at all scales, including ecophysiology, population dynamics, species interactions and biodiversity and macroevolution. He received his doctorate in 1999 from Stanford University in California, USA, for research on the ecology of rocky shores. In 1999-2000, he was a Research Fellow at the University of Arizona, USA, where he examined global dynamics of marine biodiversity in the fossil record. In 2000, he was recruited to JCU to develop and lead a research program in ecological modelling applied to coral reefs. Sean has more than 100 publications in leading international journals, including 11 publications in Science or Nature, and he has supervised 41 postgraduate and Honours students. In 2008, he was awarded an ARC Australian Professorial Fellowship (2008-2012), and in 2009, the Fenner Medal of the Australian Academy of Science, which honours outstanding research in the biological sciences by a scientist under 40. Sean has also twice received a national Citation for Outstanding Contributions to Student Learning, in 2006 and 2014, for his innovative and highly effective approaches to teaching ecological modelling to undergraduate students.

DR VERENA SCHOEPP

Dr Verena Schoepf is a Research Fellow and co-leader of Research Program 2 at The University of Western Australia node of the ARC Centre. Her research investigates how reef-building corals are affected by climate and environmental change. With a strong interdisciplinary background in biological and geological sciences, her research integrates eco-physiological, stable isotope and biogeochemical analyses to provide insights into the mechanisms and traits that enable resistance to multiple climate change stressors and promote the adaptive capacity of corals in a changing ocean. Verena received her PhD in 2013 from The Ohio State University, USA and has since been based at UWA. She has authored over 25 papers in leading international journals, including Nature and Science, and has won various prestigious awards, including a Presidential Fellowship at The Ohio State University and a Young Tall Poppy Science Award in 2018 (p11). Verena is also passionate about science communication and promoting women in STEM. Her discovery of the naturally heat-resistant 'super-corals' of the Kimberley region was featured in the 2016 documentary Verena Schoepf - Super Corals as part of the German/French broadcaster ZDF/ARTE television series, Ocean Heroines. In recognition of her efforts to promote an understanding of science and women in STEM, she was recently selected for the prestigious Superstars of STEM program which aims to increase the public visibility of women in STEM and create role models for young women and girls.

Program 2 aims to understand the multi-scale dynamics of coral reefs, through the innovative integration of ecology, evolution, genetics, oceanography and palaeontology. Program 2 researchers focus particularly in four key research areas. Firstly, Program 2 researchers examine the historical transition from pristine ecosystems to the linked social-ecological systems of today, improving knowledge of how the resilience of coral reefs evolves and responds to human impacts. Secondly, Program 2 aims to increase understanding of the dynamics and resilience of ecosystems over multiple spatial and temporal scales and in response to environmental change, and to use those findings to inform and improve the management of coral reefs. Thirdly, Program 2 examines how populations of organisms living on different reefs are connected to each other through the dispersal of their offspring, which promotes understanding of how reefs can recover from disturbances such as bleaching events. Fourthly, Program 2 researchers study the level of functional diversity and redundancy in coral reef assemblages, modelling and assessing the effects of changes in biodiversity on ecosystem function at regional to global scales, as well as investigating the effects of management on the dynamics of reef ecosystems.

In a series of three papers published this year in Nature, Science, and Nature Climate Change, Terry Hughes and colleagues brought the impact of climate change on coral reefs to the forefront of the public consciousness. They found that the frequency of global severe mass bleaching has increased nearly five-fold since 1980. On the Great Barrier Reef, this trend has culminated most recently in unprecedented back-to-back mass bleaching in 2016 and 2017. This event has transformed the Great Barrier Reef, killing approximately half the region’s shallow-water live coral, triggering a profound shift in the composition of survivors, because fast-growing habitat formers such as staghorn and tabular corals were disproportionately impacted. The loss of reef-building coral species has profound consequences for the rest of the reef ecosystem. For example, PhD student Laura Richardson, Morgan Prattchet and Andrew Hoey, along with international partners, showed in a paper in Global Change Biology, that mass coral bleaching dramatically reduces fish biodiversity. Program 2 researchers made numerous other important contributions this year to our understanding of the unfolding responses of coral reefs to climate change. In two reports in the journal Global Change Biology, Sue-Ann Watson, Philip Munday and colleagues revealed how ocean acidification is profoundly altering the development and behaviour of fishes and cephalopods. Similarly, a Nature Climate Change study co-authored by Andrew Baird and Andrew Hoey found coral-eating butterflyfishes become markedly less aggressive in response to coral bleaching, a likely consequence of the loss of the most nutritional coral types from their diets. Peter Mumby, working with an international team of researchers, reported in Nature that decreases in the capacity of corals to build skeleton, resulting from ocean acidification, would impair the capacity of reef growth to keep up with climate change-related sea level rise. In the journal Trends in Ecology and Evolution, John Pandolfi and colleagues highlighted the changes to conservation strategies and priority-setting that are required to respond to these rapidly-changing conditions.

In addition to their work on the effects of climate change, Program 2 researchers made important contributions in 2018 to our fundamental understanding of the ecology and evolution of reef systems. In Ecology Letters, Peter Mumby and colleagues revisited the classic concept of the ‘trophic pyramid’, where primary producers, such as plants, are typically more abundant than predators like lions or wolves. From the perspective of reef systems, this pyramid appears to be upside-down, with top predators like sharks being more abundant than species below them in the food chain. Program 2 researchers also made several advances in our understanding of evolution in the oceans, including Peter Cowman’s work in Nature documenting global-scale patterns of speciation in fishes, and David Bellwood’s article in Ecology Letters on why closely-related reef fishes evolve such different colour patterns. This year also saw the development of several new partnerships for Program 2 and the ARC Centre. For example, Tom Bridge and Sue-Ann Watson received joint appointments with the Museum of Tropical Queensland and the ARC Centre, with Tom also holding a prestigious Discovery Early Career Researcher Award (DECRA). Greg Torda and John Pandolfi developed a new partnership between the ARC Centre and the Beijing Genomics Institute, to study the adaptive capacity of coral populations and the historical genetics of exploited species on the Great Barrier Reef. Jon Brodie became a Collaborative Researcher at the Japanese Institute of Environmental Studies, where he is partnering with Japanese scientists to study runoff from sugarcane farms in the Ryukus Islands, Japan.

Program 2 researchers played key roles organising and participating in international collaborations during 2018. Sean Connolly and colleagues developed new insights into multiple environmental stressors in a wide range of ecosystems, at a workshop in Germany. Nils Krueck (p28) led workshops in Makassar, Indonesia and Tagaytay, Philippines on spatial planning to support reef fisheries and biodiversity. John Pandolfi joined a network of colleagues, one to develop new insights into the ecosystem services provided by marine systems, at Exeter University, UK, and also contributed to a cnidarian synthesis project at the King Abdullah University of Science and Technology, Saudi Arabia.

Program 2 researchers continued to make important contributions to policy and management at a variety of levels. Peter Mumby participated in the Coral Triangle Initiative’s Senior Officials Meeting in Manila, while Jon Brodie advised United Nation’s policy makers on wastewater pollution and coral reefs. Sean Connolly, Alana Grech, Jodie Rimmer and PhD student Sam Payet briefed the Governor-General of Australia, His Excellency General the Honourable Sir Peter Cosgrove, on the ARC Centre’s research, including its role in leading the research effort in the back-to-back bleaching of the Great Barrier Reef. In Canberra, Terry Hughes, Ove Hoegh-Guldberg, Tiffany Morrison and Graeme Cumming also briefed Australian parliamentarians on the implications of climate change for coral reefs.

In addition to briefings, Program 2 researchers were actively engaged in 2018 in capacity-building. Laurence McCook co-led a capacity-building workshop at James Cook University for 15 Australia Award Fellows from universities across Indonesia. Tom Bridge, Verena Schoepf and Terry Hughes led a coral identification workshop on Ningaloo Reef for 30 participants in association with the Australian Coral Reef Society’s annual conference, and Peter Mumby contributed to an international training course on the Coral Health Index in Denpasar, Indonesia.
Global warming is transforming the Great Barrier Reef

A new study published in *Nature* shows that corals on the northern Great Barrier Reef experienced a catastrophic die-off following the extended marine heatwave of 2016.

“When corals bleach from a heatwave, they can either survive and regain their colour slowly as the temperature drops, or they can die. Averaged across the whole Great Barrier Reef, we lost 30 per cent of the corals in the nine month period between March and November 2016,” said Professor Terry Hughes, Director of the ARC Centre of Excellence for Coral Reef Studies.

The scientists mapped the geographical pattern of heat exposure from satellites, and measured coral survival along the 2,300-km length of the Great Barrier Reef following the extreme marine heatwave of 2016.

The amount of coral death they measured was closely linked to the amount of bleaching and level of heat exposure, with the northern third of the Great Barrier Reef being the most severely affected.

The study found that 29% of the 3,863 reefs comprising the world’s largest reef system lost two-thirds or more of their corals, transforming the ability of these reefs to sustain full ecological functioning.

“The coral die-off has caused radical changes in the mix of coral species on hundreds of individual reefs, where mature and diverse reef communities are being transformed into more degraded systems, with just a few tough species remaining”, said co-author Professor Andrew Baird.


“We’re now at a point where we’ve lost close to half of the corals in shallow-water habitats across the northern two-thirds of the Great Barrier Reef due to back-to-back bleaching over two consecutive years,” said Professor Sean Connolly.

“But, that still leaves a billion or so corals alive, and on average, they are tougher than the ones that died. We need to focus urgently on protecting the glass that’s still half full, by helping these survivors to recover,” said Professor Hughes.

The study is unique because it tests the emerging framework for the International Union for Conservation of Nature (IUCN) Red List of Ecosystems, which seeks to classify vulnerable ecosystems as ‘safe’, ‘threatened’ or ‘endangered’.

“The Great Barrier Reef is certainly threatened by climate change, but it is not doomed if we deal very quickly with greenhouse gas emissions. Our study shows that coral reefs are already shifting radically in response to unprecedented heatwaves,” said Professor Hughes.


Media highlights: Scientific American – Recent ocean heat waves have “forever” altered Great Barrier Reef. 19 April 2018

Great Barrier Reef not bouncing back as before, but there is hope

The Great Barrier Reef is losing its ability to recover from disturbances, but effective local management could revive its capacity to bounce back.

Scientists at The University of Queensland, ARC Centre of Excellence for Coral Reefs Studies and the Australian Institute of Marine Science (AIMS) have found a decline in the ability of Great Barrier Reef Marine Park reefs to recover after bleaching events, outbreaks of crown-of-thorns starfish or cyclones over an 18-year period, from 1992 to 2010, even before the recent back-to-back bleaching in 2016 and 2017.

Dr Juan-Carlos Ortiz, lead author from the Australian Institute of Marine Science, said that during this time, average coral recovery rates showed a six-fold decline across the Great Barrier Reef.

“This is the first time a decline in recovery rate of this magnitude has been identified in coral reefs,” he said.

The decline is driven by a combination of the legacy effect of acute disturbances like coral bleaching and cyclones and the ongoing effect of chronic pressures like poor water quality and climate change.

Professor Peter Mumby of the ARC Centre at The University of Queensland, said that this was serious cause for concern, particularly given the accelerating impacts of climate change on reefs, but it is important to stress that not all reefs are failing.

“I believe there is scope for management to help remedy the situation,” he said.

“Our results indicate that coral recovery is sensitive to water quality, and is suppressed for several years following powerful cyclones.”

“Some reefs could improve their recovery ability if the quality of the water entering the reef is actively improved.”

Study co-author Dr Nicholas Wolff, from The Nature Conservancy, said that some areas of the Reef are faring better than others, but their overall finding was that action needs to be taken.

“While there was variability among regions, the decline in recovery rate was consistent in all coral types included in the study,” he said.

Dr Ortiz said that the frequency of acute disturbances was predicted to increase, making careful management key.

“The future of the Great Barrier Reef is threatened without further local management to reduce chronic disturbances and support recovery, and strong global action to limit the effect of climate change.”


Media highlights: IFLScience – Coral reefs are recovering poorly from disasters and deep reefs can’t help. 20 July 2018
Nils Krueck

Nils Krueck is a Research Fellow in the Ecosystem Dynamics: Past, Present and Future program at The University of Queensland node of the ARC Centre. Nils was born and raised in Germany’s industrial Ruhr Valley. However, he had regular access to the ocean, thanks to his grandfather and extended family who lived on the coast. It was here, in the cold waters of the Baltic Sea, where he became fascinated with marine systems.

Nils pursued an undergraduate degree in marine science at the University of Bremen, Germany. Supported by a scholarship from the German Academic Exchange Service, he left the cold behind to complete his final undergraduate thesis on inshore fish populations in eastern Australia. Nils subsequently began his PhD at The University of Queensland to expand his research on integrating ecology, oceanography and genetics for spatial management of fisheries. Nils recalls that he “was very interested in combining ecological field studies, biophysical models and population genetic data to study the relationships between fish abundance, the environment, fishing activities and fisheries productivity”. He received several student awards during his PhD, some of which enabled him to visit leading fishery researchers at the University of British Columbia, Canada and the University of Washington, USA.

After completing his PhD, Nils began a postdoctoral research fellowship with Professor Peter Mumby at The University of Queensland node of the ARC Centre. His research focus now encompasses the effective design of marine protected areas (MPAs). In a series of three complementary papers published in 2017 and 2018 in PLoS Biology, Ecological Applications and Conservation Letters, Nils demonstrated that the size and placement of Marine Protected Areas (MPAs) strongly influences their capacity to conserve biodiversity and benefit fisheries. His findings are ground-breaking, because biodiversity conservation and fishery management objectives were previously assumed to be in conflict. Nils’ research shows that this dilemma is unlikely to occur, specifically on tropical coral reefs, where both biodiversity conservation and more productive fisheries are urgently needed.

This bony creature, found in South Germany, lived about 156 million years ago and had the distinctive sharp teeth of modern-day piranhas. These Jurassic marauders used their razor teeth to tear chunks of flesh and fins off other fish. Other fish were found nearby which had been attacked by the ancient piranhas.

“We have other fish from the same locality with chunks missing from their fins,” said Dr David Bellwood of James Cook University, Australia, who is one of the authors of the study.

“Feed on a fish and it is dead; nibble its fins and you have food for the future.”

The researchers analysed the jaws and found long pointed teeth on the exterior of a bone that formed the roof of the mouth. They also found triangular teeth with serrated edges on bones that lie along the side of the lower-jaw.

The international team of scientists concluded that the pattern and shape of the teeth, jaw morphology and mechanics suggested a mouth well-equipped to slice flesh or fins.

“We were stunned that this fish had piranha-like teeth,” says Martina Kölbl-Ebert, of Jura-Museum Eichstätt, Germany, who led the study.

“It comes from a group of fishes (the pycnodontid) that are famous for their crushing teeth. It is like finding a sheep with a snarl like a wolf. But what was even more remarkable is that it was from the Jurassic.

“Fish as we know them, bony fishes, just did not bite flesh of other fishes at that time. Sharks have been able to bite out chunks of flesh but throughout history bony fishes have either fed on invertebrates or largely swallowed their prey whole. Biting chunks of flesh or fins was something that came much later.”

Why is this important?

It shows the remarkable connection between the time when dinosaurs walked the Earth and our modern world. Piranhas attack other fish and tear chunks out of their fins and fin bases. The scientists found injuries in the same places on fish that had been attacked by the pre-historic piranhas some 150 million years ago.

“This is an amazing parallel with modern piranhas, which feed predominantly not on flesh but the fins of other fishes,” said Dr Bellwood.

“It’s a remarkably smart move as fins re-grow; a neat renewable resource.”

It also shows the value of studying fossils, as the area where the fish were found is among the best known fossil locations in the world but continues to throw up surprise findings like this one.

Where do we find piranhas in the modern world?

Piranhas are now only found in freshwater areas in South America, with some 20 different species found in the Amazon. This is in contrast to the newly described fossil which was found in what was once the sea. Some modern piranhas have been found in other parts of the world but these are believed to be pets that were released into waterways.

Jurassic-era piranha is world’s earliest flesh-eating fish

Scientists have unearthed the fossilised remains of a piranha-like species that they say is the earliest known example of a flesh-eating fish.

Bbc news
ASSOCIATE PROFESSOR MAJA ADAMSKA
Associate Professor Maja Adamska, from The Australian National University, is co-leader of Research Program 3. She first studied biology in Poland, and carried out PhD work in Germany on the function of homeobox genes in inner ear development. During her postdoctoral work at the University of Michigan, USA, Maja followed complex crosses of mouse mutants to reveal the genetic interactions involved in limb patterning. Later, she moved to Australia and The University of Queensland to analyse developmental signalling pathways in the sponge, Amphimedon queenslandica. This work revealed surprising similarities in patterning of sponge and higher animal embryos. Subsequently, Maja was a group leader from 2007-2015 at the Sars International Centre for Marine Molecular Biology, in Bergen, Norway. In 2015 she returned to Australia as a Senior Lecturer in the Research School of Biology at The Australian National University, where she was awarded a 2017 ARC Future Fellowship. Her research team uses calcareous sponges and corals to gain insight into the evolutionary origin of a variety of key developmental processes, including segregation of germ layers and axial patterning of embryos and adults, as well as regeneration mechanisms. Maja is also interested in major transitions in animal evolution, such as the emergence of multicellularity and morphological complexity and their relationship to genomic complexity.

ASSOCIATE PROFESSOR MIA HOOGENBOOM
Associate Professor Mia Hoogenboom, from James Cook University, is co-leader of Research Program 3. Mia is an expert on coral reef ecophysiology. She received her PhD in 2008 from JCU and, during 2008-2011, she was a Research Fellow at the Centre Scientifique de Monaco and later at the University of Glasgow. Mia has broad research interests in physiology and ecology, and her research establishes mechanistic links between environmental change, physiology, and population and community dynamics. Mia’s research is multi-disciplinary and collaborative. Over the last 10 years, she has published papers with 82 authors in 15 countries, addressing diverse topics. Mia has published more than 40 papers in leading international journals, including Trends in Ecology and Evolution, Nature, Nature Climate Change and Global Change Biology. She has supervised 26 postgraduate and Honours students since 2010, and actively participates in educational outreach programs that provide exciting marine biology field and laboratory experiences for secondary school students. Her ecotoxicology research informs strategies for managing the impacts of environmental contaminants on coastal marine ecosystems.

PROFESSOR RYAN LOWE
Professor Ryan Lowe, from the UWA Oceans Institute at The University of Western Australia (UWA), is co-leader of Research Program 3. Ryan’s research examines how oceanic and atmospheric forcing drives the circulation, distribution of wave energy, and water level variability within the coastal zone, with a particular focus on processes that occur along coral reef coastlines. Major areas of his research focus on: understanding how ocean dynamics drive environmental variability within coral reefs; how these dynamics influence a range of complex biophysical processes; and, finally, how these processes can be numerically predicted and accurately forecast into the future. Ryan received his PhD in Civil and Environmental Engineering in 2005 from Stanford University, USA and has been based at UWA since 2007. He has authored more than 100 papers in leading international journals, as well as numerous technical reports for government and industry. Ryan is the Editor of the Journal of Geophysical Research – Oceans, serves on the Expert Group in Physical Oceanography for the Australian Meteorological and Oceanography Society and on Australia’s Surface Waves Working Group (SWWG) as part of the Forum for Operational Oceanography. In 2012, he received a four-year ARC Future Fellowship, and in 2014 he was the recipient of the UWA Vice Chancellor’s Mid-Career Researcher Award.

Research in Program 3 aims to understand and predict responses of the coral reef organisms and ecosystems to environmental changes. Biological response to changing conditions is studied from three highly interlinked and complementary perspectives: Firstly, the dynamics of complex associations of corals with other organisms, especially symbiotic dinoflagellates and microbes; secondly, the stability of carbonate reef frameworks, which are synthesised and dynamically maintained by corals and other reef building organisms, such as coralline algae; and thirdly, physiological plasticity and capacity for adaptation at organismal, population, species and ecosystem levels.

In 2018, Program 3 researchers made major contributions to our understanding of the complex interactions of various reef-building organisms, particularly the relationship between corals and dinoflagellates from the genus *Symbiodinium*. This mutualistic relationship can be disturbed by thermal extremes, resulting in mass coral bleaching, a phenomenon that is occurring with increasing frequency and severity due to anthropogenic global warming. Documenting and analysing this phenomenon, Janice Lough edited and contributed a number of chapters to the book *Coral Bleaching: Patterns, Processes, Causes and Consequences*. A large collaborative study published in the journal *Communications Biology Patterns, Processes, Causes and Consequences*. A long-term collaboration between Program 3 and KAUST led to several major publications in 2018. For example, one study in *Nature Climate Change* focussed on the epigenetic basis of transgenerational acclimation by fish to ocean warming, and another in *Nature Ecology and Evolution* presented a unique transgenerational experiment designed to determine the molecular response of a coral reef fish to ocean acidification. Jennifer Donelson and Philip Munday also published a major review in *Global Change Biology* on measuring transgenerational plasticity to climate change. They conclude that future research must improve experimental designs to simulate environmental conditions more realistically, in order for transgenerational plasticity to be adequately predicted.

An important event for Program 3 in 2018 was the Australian Academy of Science Boden Workshop *Origins and Function of the Animal Metaorganism*, organised and convened by David Miller and Mia Hoogenboom. This interdisciplinary workshop investigated the evolutionary success of coral-microbiome symbiosis (the metaorganism) and the conditions that sometimes cause their collapse. It was attended by world-leading researchers across fields as diverse as palaeontology, physiology, microbiology and bioinformatics, united by an interest in microbe - animal interactions. The international workshop was an important professional development and mentoring event for contributing ARC Centre students and early career researchers. In 2018, Program 3 researchers continued their ongoing commitment to public engagement at all levels, from schools to policy makers. For example, Maja Adamska conducted a class activity on coral bleaching for primary school children in Canberra, and Jennifer Donelson engaged with Townsville State High School as part of the National Science Week celebrations. Jodie Rummer conducted a class activity on coral bleaching for primary schools to policy makers. For example, Maja Adamska conducted a class activity on coral bleaching for primary school children in Canberra, and Jennifer Donelson engaged with Townsville State High School as part of the National Science Week celebrations. Jodie Rummer presented research on the effects of oil spills on larval and juvenile reef fishes to Greenpeace Australia Pacific, and produced a full-length documentary on her shark research in French Polynesia. Sue-Ann Watson was part of an ocean acidification project at the Australian Academy of Science’s Shine Dome in Canberra, a gathering that produced a policy brief on accounting for ocean acidification in climate risk assessments. Ove Hoegh-Guldberg co-authored the latest special report by the Intergovernmental Panel on Climate Change (IPCC), a landmark document that resonated around the world.
Reef fish inherit tolerance to warming oceans

Thanks to mum and dad, baby reef fish may have what it takes to adjust to hotter oceans.

In a rapidly changing climate, the decline of animal populations is a very real concern. Today, an international team of researchers report new evidence of reef fish adjusting to global warming conditions at the genetic level.

For the first time, researchers from the ARC Centre of Excellence for Coral Reef Studies and the King Abdullah University of Science & Technology (KAUST), have found that reef fish can inherit from their parents the genetic tools to adjust to ocean warming.

“When parents are exposed to an increase in water temperature, we found that their offspring improved their performance in these otherwise stressful conditions by selectively modifying their epigenome,” said senior author Professor Philip Munday of the ARC Centre at James Cook University.

Epigenetic change refers to chemical modifications in the DNA that signals genes to be switched on or off. A range of factors, including disease, famine, or in the case of this research, heat stress, can stimulate these subtle changes.

In this study, both parent and offspring experienced the same elevated water temperatures, responsive changes in their epigenome, via selective DNA methylation, were observed that enhanced the next generation’s ability to cope with the new, warmer temperatures.

“We reared spiny chromis damselfish, a common Indo-Pacific reef fish, for two generations under three different water temperatures, up to 3 degrees Celsius warmer than current-day ocean temperatures,” explained co-author Professor Timothy Ravasi of KAUST.

“The next generation appeared to be advantaged by parental exposure to elevated temperatures. The offspring’s altered gene expression, also referred to as ‘acclimation,’ allowed them to maximise oxygen consumption and energy use.”

“Acclimation may buffer populations against the impacts of rapid environmental change and provide time for genetic adaptation to catch up over the longer term,” said Professor Munday.

The authors of the study note that while this is good news for reef fish, the decline of their coral habitat, as a result of climate change, will continue to be an overriding concern for their survival.

Scientists from the ARC Centre of Excellence for Coral Reef Studies at The University of Western Australia have found that some corals are able to combat the effects of ocean acidification by controlling their own chemistry.

Coral reefs play an important role in protecting coastlines from damage caused by waves and storms, but also provide habitat and shelter for many marine organisms. However, major environmental challenges such as climate change, threaten the survival of coral reefs worldwide.

The world-first study is a breakthrough for marine science because the scientists have identified marine species that are resilient to ocean changes, which will help better understand how to protect coral reefs in the future.

Lead author Dr Thomas DeCarlo said rising carbon dioxide (CO₂) levels in the atmosphere were reflected in the ocean, which leads to ocean acidification.

“Acidification hampers the ability of the coral to form skeletons and shells which are the building blocks of reefs,” Dr DeCarlo said.

“In the past few decades, hundreds of experiments have shown that corals have a highly diverse response to ocean acidification depending on the species. However, the reasons why some are more tolerant than others are not clearly understood,”

Dr DeCarlo and his team developed a new method to understand the internal chemistry of corals by using specialised equipment that measures the characteristics of the molecules in coral.

“The method showed corals with the most resistance are tolerant because of the way they are able to regulate their calcium levels,” Dr DeCarlo said.

“This technique means scientists can identify species that are relatively resistant to ocean acidification.”

“However, we are also looking at the costs associated with resisting acidification, which may potentially make acidification-resistant corals more vulnerable to other stressors.”

Co-author Professor Malcolm McCulloch said previous studies found that even the more hardy coral species lose their ability to adapt to ocean acidification when they bleach under extreme heat events, as experienced in 2016.

“When a coral bleaches, it expels its ‘powerhouse’ zooxanthellae symbionts, and loses the energy needed to keep its internal mechanisms running,” he said. “The longer corals stay bleached, the less likely they are to recover.”


Media highlight: Science Daily – Internal control helps corals resist acidification, 2 May 2018
Researcher Profile: Malcolm McCulloch

Malcolm McCulloch is a Deputy Director of the ARC Centre, and a Chief Investigator in Program 3 at the University of Western Australia node of the Centre. His research focusses on understanding the effects of climate change and ocean acidification on coral bio-calcification, in both shallow and deep-sea reef environments. Malcolm grew up in the small coastal town of Busselton in south-western Australia (WA), now best known for its wooden pier jetty that extends more than 1.8 km out into the relatively shallow Geographe Bay. This setting, and the surrounding spectacular marine environment, left its indelible mark on Malcolm, spurring his desire to better understand the oceans and its many unique ecosystems.

After completing his Master's degree at Curtin University, Perth, Malcolm undertook PhD studies at the world-renowned Californian Institute of Technology (Caltech) in California, USA. After completing his PhD in 1980, Malcolm returned to Australia as a Research Fellow and then Professor at The Australian National University in Canberra. In 2009, Malcolm returned to WA as a highly prestigious Premier's Fellow, at The University of Western Australia (UWA). He believes that “in many ways, the coral reefs of WA provide a complementary window into the impacts of global change on coral reefs compared to the Great Barrier Reef. In the west, warming is driven mainly by out-of-phase La Niña conditions, and land-based impacts on reefs are generally more restricted due to its arid coastline.”

Malcolm's ongoing research, based mainly on the boron elemental and isotopic systematics in long-lived corals, provides a quantitative means for determining how biological processes modulate calcification and the impact of ocean acidification on them. His recent research also includes field-studies conducted along the extensive and diverse WA coastline. These field studies have been complemented by in-situ controlled experiments conducted at UWA’s marine facility at Watermans Bay, and by biogeochemical studies which provide new insights into the key processes of calcification by corals.

An important innovation led by Malcolm and his collaborators has been the development of novel proxies that enable a mechanistic understanding of the complete carbonate chemistry underpinning calcification. This break-through has been made possible by using a combination of novel tools allowing the determination of the complete carbonate chemistry of the calcifying fluid of corals during calcification, and its relationship to the chemistry of the ocean. Malcolm's research provides powerful insights into the response of coral calcification at a species level to the rapidly evolving forces of climate change.

Malcolm has also provided the first quantitative geochronological records from the carbonate skeletons of ~300 to 400 year old corals, giving unequivocal evidence for a five to ten-fold increase in sediment flux entering the Great Barrier Reef since the arrival of European settlers. This approach is now being used by various agencies (including the Great Barrier Reef Marine Park Authority) to assist catchment management programs, and is being extended to other coral reefs, such as those in Kenya.

Malcolm has published over 300 scientific papers in leading international journals, including 28 in Science or Nature. In recognition of these outstanding contributions, he was elected a Fellow of the Australian Academy of Science and Fellow of the American Geophysical Union in 2004. In 2009, he was awarded the Australian Academy of Science's Jaeger Medal in Earth Sciences. He was elected a Fellow of the Royal Society in 2010 and awarded a highly prestigious ARC Australian Laureate Fellowship in 2012.

Heroin Island is also home to the Barrier Reef’s oldest research station, where Sophie Dove, a biology professor (from the ARC Centre of Excellence for Coral Reef Studies at the University of Queensland), has lately been studying the effects of climate change on corals.

The problem, Dove explained, is twofold. As humanity pumps carbon dioxide into the atmosphere, the planet’s overall temperature rises; at the same time, some of the CO₂ from the air is absorbed by the oceans, acidifying the water. For corals, particularly those that live in the shallows, the resulting environmental changes can be catastrophic. Many species around Heron rely for their survival on a group of tiny photosynthesizing organisms called zooxanthellae, which, in exchange for a safe home in the corals’ body tissues, furnish their hosts with food and oxygen and give them their vibrant colors.

When the water gets too acidic, the corals’ rock-like skeletons break down. When it gets too warm, the zooxanthellae go into overdrive, producing dangerous amounts of oxygen. To protect themselves, the corals will expel the organisms, turning bone-white in the process—a phenomenon known as bleaching. Two springs ago, the Great Barrier Reef experienced its worst bleaching event in history. Another one followed in 2017, though Heron Island was spared the worst of it by an unseasonable influx of cold weather.

For the past several decades, marine biologists have devoted themselves to investigating how and why bleaching occurs, from the cellular level on up to the global level. Dove is interested in the area in between. Her lab setup consists of twelve “in-our-belts tanks, there had been a little more growth at the pre-industrial and industrial revolution. The second reproduces the cooler, less acid ocean environment before the fifth, “business as usual,” imagines what will happen by the end of the century if humans continue to burn fossil fuels at their current rate.

So far, Dove has found, the pre-industrial and present-day mini-reefs appear healthy. Left to their own devices, they are “chock-a-block” with coral. Dove still needs to crunch the numbers on the Paris tanks, but she hasn’t noticed a visual difference between this scenario and the present day. In the other two mesocosms, though, her results have been “really worrying.” The corals in those tanks thrive during the day, but, at night, when the zooxanthellae are no longer photosynthesizing (and thus no longer converting carbon dioxide to oxygen), the water acidity climbs and the corals begin to dissolve. In the pulling our belts in” model. The fourth mesocosm, which she calls “really pulling our belts in,” envisions what the future might look like if the signatories to the 2015 Paris climate agreement honor their pledges. The fifth, “business as usual,” imagines what will happen by the end of the century if humans continue to burn fossil fuels at their current rate.

Heroin Island, the world was just small enough—a mesocosm—for its precariousness to feel real.
Impacts of climate change on World Heritage coral reefs


The severity of current climate impacts on individual World Heritage properties varies. In most cases, the consequence of climate change is a decline in the values that collectively comprise the Outstanding Universal Value (OUV) for many coral reef World Heritage properties. The World Heritage Operational Guidelines (the documentation used for managing all World Heritage properties) has minimal tools to assess the effects of climate change on World Heritage values. Most World Heritage properties are potentially ‘In-Danger’ from the impacts of climate change, but it would be unrealistic to consider placing all World Heritage properties on the World Heritage In Danger List. To address this issue in 2018, ARC Centre researchers, led by PhD student Jon Day and Associate Scott Heron (USA National Oceanographic and Atmospheric Administration and James Cook University) began an innovative project to develop a Climate Vulnerability Index (CVI), a metric designed to improve the capacity of UNESCO to assess the vulnerability of World Heritage properties. The CVI aims to:

- be a rapid assessment tool, that can be consistently applied to all World Heritage properties (natural, cultural and mixed);
- be systematic and comprehensive, yet not overly complex, balancing scientific robustness with a level of practicality which enables it to be undertaken by managers or non-scientific users;
- rapidly assess the physical and ecological impacts of climate change on Outstanding Universal Value, but also provide a high-level assessment of the economic, social and cultural consequences of climate change;
- be transparent and repeatable, allowing for repeat assessments over time to assess trends, and enabling others to see exactly how the original assessment was arrived at;
- be proactive and put climate change into context. Climate change is becoming a dominant threat to many World Heritage values, along with many other cumulative pressures;
- assist in better understanding by local and Indigenous communities and users; and
- be sufficiently standardised to become part of the World Heritage processes (such as State of Conservation reports, periodic reporting and nominations).

The vulnerability of OUV to each of the three most-important climate drivers was evaluated as High (on a scale Low, Moderate, High), resulting in an assessment of High OUV vulnerability of Shark Bay to climate change. The capacity for local management was considered Low for each driver, whilst the technical support was Moderate for each. However, the effectiveness was evaluated as Very Low for extreme marine heat events and air temperature change, and Low for storm intensity and frequency, on a four-point scale (Very Low, Low, Moderate, High).

Following the success of the Shark Bay trial of the CVI, several other Australian World Heritage properties have subsequently indicated interest in a similar assessment in 2019, including the Sydney Opera House, Ningaloo, and the Gondwana Rainforests.


The devastating bleaching on the Great Barrier Reef in 2016 and 2017 rightly captured the world’s attention. But what’s less widely known is that another World Heritage-listed marine ecosystem in Australia, Shark Bay, was also recently devastated by extreme temperatures, when a brutal marine heatwave struck off Western Australia in 2011.

A 2018 workshop convened by the Shark Bay World Heritage Advisory Committee classified Shark Bay as being in the highest category of vulnerability to future climate change. And yet relatively little media attention and research funding has been paid to this World Heritage Site that is on the precipice.

Shark Bay, in WA’s Gascoyne region, is one of 49 marine World Heritage Sites globally, but one of only four of these sites that meets all four natural criteria for World Heritage listing. The marine ecosystem supports the local economy through tourism and fisheries benefits.

Around 100,000 tourists visit Shark Bay each year to interact with turtles, dugongs and dolphins, or to visit the world’s most extensive population of stromatolites — stump-shaped colonies of microbes that date back millions of years, almost to the dawn of life on Earth.

Commercial and recreational fishing is also extremely important for the local economy. The combined Shark Bay invertebrate fishery (crabs, prawns and scallops) is the second most valuable commercial fishery in Western Australia.

Under threat

However, this iconic and valuable marine ecosystem is under serious threat. Shark Bay is especially vulnerable to future climate change, given that the temperate seagrass that underpins the entire ecosystem is already living at the upper edge of its tolerable temperature range. These seagrasses provide vital habitat for fish and marine mammals, and help the stromatolites survive by regulating the water salinity.

Shark Bay received the highest rating of vulnerability using the recently developed Climate Change Vulnerability Index, created to provide a method for assessing climate change impacts across all World Heritage Sites.

In particular, extreme marine heat events were classified as very likely and predicted to have catastrophic consequences in Shark Bay. By contrast, the capacity to adapt to marine heat events was rated very low, showing the challenges Shark Bay faces in the coming decades.

The region is also threatened by increasingly frequent and intense storms, and warming air temperatures.

To understand the potential impacts of climate change on Shark Bay, we can look back to the effects of the most recent marine heatwave in the area. In 2011 Shark Bay was hit by a catastrophic marine heatwave that destroyed 300 square kilometres of seagrass — 36% of the total coverage.

This in turn harmed endangered species such as turtles, contributed to the temporary closure of the commercial crab and scallop fisheries, and released between 2 million and 9 million tonnes of carbon dioxide — equivalent to the annual emissions from 800,000 homes.

Some aspects of Shark Bay’s ecosystem have never been the same since. Many areas previously covered with large, temperate seagrasses are now bare, or have been colonised by small, tropical seagrasses, which do not provide the same habitat for animals. This mirrors the transition seen on bleached coral reefs, which are taken over by turf algae. We may be witnessing the beginning of Shark Bay’s transition from a sub-tropical to a tropical marine ecosystem.

This shift would jeopardise Shark Bay’s World Heritage values. Although stromatolites have survived for almost the entire history of life on Earth, they are still vulnerable to rapid environmental change. Monitoring changes in the microbial makeup of these communities could even serve as a canary in the coalmine for global ecosystem changes.

The neglected bay

Despite Shark Bay’s significance, and the seriousness of the threats it faces, it has received less media and funding attention than many other high-profile Australian ecosystems. Since 2011, the Australian Research Council has funded 115 research projects on the Great Barrier Reef, and just nine for Shark Bay.

Coral reefs rightly receive a lot of attention, particularly given the growing appreciation that climate change threatens the Great Barrier Reef and other corals around the world.

The World Heritage Committee has recognised that local efforts alone are no longer enough to save coral reefs, but this logic can be extended to other vulnerable marine ecosystems — including the World Heritage values of Shark Bay.

Safeguarding Shark Bay from climate change requires a coordinated research and management effort from government, local industry, academic institutions, not-for-profits and local Indigenous groups — before any irreversible ecosystem tipping points are reached. The need for such a strategic effort was obvious as long ago as the 2011 heatwave, but it hasn’t happened yet.

Due to the significant Aboriginal heritage in Shark Bay, including three language groups (Malgana, Nhanda and Yingkarta), it will be vital to incorporate Indigenous knowledge, so as to understand the potential social impacts.

And of course, any on-the-ground actions to protect Shark Bay need to be accompanied by dramatic reductions in greenhouse emissions. Without this, Shark Bay will be one of the many marine ecosystems to fundamentally change within our lifetimes.
The ARC Centre is the global leader in building human capacity and expertise in coral reef science. Students and Early Career Researchers (ECRs) are essential contributors to the Centre's activities and outputs. During 2018, the Centre provided supervision and research funding to 176 research students across our four nodes. Almost 85% of students are enrolled in PhDs, with the remainder pursuing Honours or Masters degrees. Twenty two students graduated in 2018, while 37 new students enrolled in graduate degrees. The ARC Centre also supports 32 ECRs, who are within five years of their PhD.

The ARC Centre attracts students and ECRs to Australia from around the world. In 2018, 126 international students came from 37 countries, representing 72% of our research student membership. Almost 70% of our ECRs are from overseas.

The ARC Centre provides an exciting and multi-disciplinary intellectual environment, with a major focus on training and mentoring the next generation of coral reef researchers. In 2018, the ARC Centre continued to support the advancement of quantitative and modelling skills. For example, in March more than 30 students and ECRs attended two one-week intensive courses on statistics in R, sponsored by the ARC Centre, and provided by Murray Logan, biostatistician at the ARC Centre’s partner, the Australian Institute of Marine Science.

In 2018, a recurring focus of the ARC Centre’s training activities was scientific writing and communication. In September, Joshua Cinner hosted a workshop for students and ECRs on how to structure manuscripts, navigate the peer review process and build a portfolio of publications. The Centre’s student committee organised an intensive four day writing retreat for graduate students on Magnetic Island in October. In November, Alana Grech, Peter Cowman and Sean Connolly conducted a training session for ECRs on writing ARC Research Opportunity and Performance Evidence statements.

The ARC Centre offered numerous other training events in 2018 for ARC Centre members, focussing on a broad spectrum of career stages. Niall Byrne (Director, Science In Public) conducted a session on developing concise summaries of research (‘1 minute pitch’), and Michael Hopkin (Energy and Environment Editor, The Conversation) provided training on pitching and writing popular articles. Our Communications Manager, Catherine Naum, also provided media training and one-to-one coaching to students, ECRs and senior researchers throughout 2018.

In November, the Centre organised a two day Mental Health First Aid Training course for researchers and support staff. The nationally-recognised course provided information on how to offer initial support to adults who are developing a mental health problem, experiencing a worsening of an existing mental health problem or experiencing a mental health crisis.

In 2018, the ARC Centre offered a range of mentoring activities to all Honours, Masters and PhD students attending the annual Australian Coral Reef Society Conference, a long-standing event sponsored by the Centre. The National Student Mentoring Day featured a coral identification course and field trip at the World Heritage-listed Ningaloo Reef. More than 30 students and Indigenous Rangers from the Western Australian Parks and Wildlife service attended the event. The coral identification course was taught by ARC Centre researchers Tom Bridge, Verena Schoepf and Terry Hughes.

The ARC Centre sponsors two committees in support of research students and ECRs, respectively. Each committee is allocated funds to support training, mentoring and leadership activities during the year. In 2018, the student committee was chaired by Grace Al Moajil-Cole, Shannon McMahon and Katie Sievers. Other members were Katie Lee and Karin Zwiep (UQ) and Netramani Sagar and Rebecca Green (UWA). The student and ECR committees are supported by Graduate Co-ordinator Olga Bazaka, Chief Operations Officer Jennifer Lappin and Assistant Director Alana Grech.

An important focus of the two committees is the design and implementation of the annual research student and ECR retreats, held the day before the ARC Centre’s Annual Symposium. Sixty one students attended the 2018 student retreat in Brisbane, which focused on careers outside of academia, effective coping strategies and life-balance during PhD studies, and techniques for scientific illustration. The ECR retreat featured a session on how to be a strategic researcher, delivered by Dr Hugh Kearns (ThinkWell), and a behind the scenes...
Students supported by the ARC Centre achieved many prizes and accolades in 2018, for example:

- Alexia Graba-Landy and Shannon McMahan received the Great Barrier Reef Marine Park Authority's Reef Guardians Research Grants for their targeted research on the Great Barrier Reef.
- Katie Sievers was awarded a PADI Foundation Research Grant and a David Pearse Bequest for Environmental Research.
- Sarah Lawless was awarded best student presentation at the 7th Global Conference on Gender in Aquaculture and Fisheries.
- Laura Puk received a research grant from the Winifred Violet Scott Charitable Trust.
- The Australian Coral Reef Society provided funding to support the travel of Shannon McMahan, Alexia Graba-Landy, and Laura Puk to their annual conference, held at Exmouth, Western Australia.
- Mia Cunones was awarded a Coral Reef Conservation Program Domestic Coral Reef Conservation Grant from the US National Oceanic and Atmospheric Administration.
- Kevin Bairos Novaik received a Pollock-Koch Foundation grant for his research on the Great Barrier Reef.
- The ARC Centre recognises outstanding research students for their first-authored publications each year, through our annual Virginia Chadwick Awards. In 2018, they were won by students at JCU, UQ and UWA – Mariana Alvarez-Noriega, Sun Wook Kim, Michael McWilliam, Laura Richardson and Claire Ross.

2018 PhD Students in the ARC Centre

<table>
<thead>
<tr>
<th>Student Name</th>
<th>Institution</th>
<th>Country</th>
<th>Thesis Title</th>
<th>ARC Centre Advisers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michelle Achliptis</td>
<td>UQ</td>
<td>The Netherlands</td>
<td>Boring sponges in a time of change: insights into the physiology and cell biology of a photosymbiotic coral-endoirying sponge. (PhD awarded)</td>
<td>S Dove, O Hoegh-Guldberg</td>
</tr>
<tr>
<td>Samantha Aird</td>
<td>JCU</td>
<td>Australia</td>
<td>Socio-ecological dynamics in archaeological shellfish fisheries: a case from the Kappel Islands, Great Barrier Reef, Australia. (PhD awarded)</td>
<td>A Hoey</td>
</tr>
<tr>
<td>Mariana Alvarez</td>
<td>JCU</td>
<td>Mexico</td>
<td>Coexistence-promoting mechanisms in reef-coral communities. (PhD awarded)</td>
<td>S Connolly, A Bair, O Hoeghboon</td>
</tr>
<tr>
<td>Natalia Andrade Rodriguez</td>
<td>JCU</td>
<td>Ecuador</td>
<td>Non-contact competition between soft and hard corals: a transcriptive perspective. (PhD awarded)</td>
<td>D Miller, M Aoya</td>
</tr>
<tr>
<td>Danielle Asson-Batzel</td>
<td>JCU, AIMS, CSIRO, Museum of Tropical Queensland (MTQ)</td>
<td>USA</td>
<td>Multi-scale patterns of benthic species composition in the Great Barrier Reef region and implications for spatial management.</td>
<td>R Pressy, S Connolly, T Bridge</td>
</tr>
<tr>
<td>Kevin Bairos Novaik</td>
<td>JCU</td>
<td>Canada</td>
<td>Metapopulation dynamics of coral polypl diosexual and juvenile fish recruitment after severe bleaching events</td>
<td>S Connolly, O Hoeghboon</td>
</tr>
<tr>
<td>Anne Bauer-Civello</td>
<td>JCU</td>
<td>USA</td>
<td>From people to reef, marine debris and plastic pollution in north Queensland.</td>
<td>M Hoeghboon</td>
</tr>
<tr>
<td>Brock Bergsjo</td>
<td>JCU</td>
<td>USA</td>
<td>Preaching in marine protected areas: Drivers of and responses to illegal fishing. (PhD awarded)</td>
<td>J Cinner, D Williamson, G Rusa</td>
</tr>
<tr>
<td>Chloë Boote</td>
<td>JCU</td>
<td>United Kingdom</td>
<td>The larval development, microbiome, and stress response of the mushroom coral <em>Heliopora</em> acuminata.</td>
<td>D Miller, M Aoya</td>
</tr>
<tr>
<td>Ian Broyoucos</td>
<td>JCU</td>
<td>USA</td>
<td>A challenging environment in a changing world for juvenile sharks: ecological energetics of climate change with implications for conservation. (PhD awarded)</td>
<td>J Rimmer</td>
</tr>
<tr>
<td>Christopher Brunner</td>
<td>JCU, AIMS</td>
<td>Germany</td>
<td>Cumulative impacts of water quality and climate change on the coral reef ecosystems. (PhD awarded)</td>
<td>M Hoeghboon</td>
</tr>
<tr>
<td>Ramona Brunner</td>
<td>JCU</td>
<td>Germany</td>
<td>The function and ligands of g-protein coupled receptors (GPCRs) in coral larval settlement.</td>
<td>D Miller, M Aoya</td>
</tr>
<tr>
<td>Dominant Bryant</td>
<td>UQ</td>
<td>Australia</td>
<td>The effects of global and local disturbance towards spatial patterns of coral in the Central Indian Ocean. (PhD awarded)</td>
<td>O Hoegh-Guldberg, S Dove</td>
</tr>
<tr>
<td>Alexander Buck</td>
<td>JCU</td>
<td>Australia</td>
<td>Microbiology of crown-of-thorns starfish.</td>
<td>M Prutchett</td>
</tr>
<tr>
<td>Cüneyt Caglar</td>
<td>ANU</td>
<td>Germany</td>
<td>Sponges and coral regeneration: Cellular and molecular characterisation of regeneration in reef-building invertebrates.</td>
<td>M Adamak</td>
</tr>
<tr>
<td>Pasila Joy Carterwright</td>
<td>UWA</td>
<td>Australia</td>
<td>Metazoan processes and anthropogenic influences in the southern coastal Pilliga/Ermoupoli Gulf: what are the primary drivers of water quality and habitat distribution?</td>
<td>R Lowe</td>
</tr>
<tr>
<td>Leela Chakravarti</td>
<td>JCU, AIMS, U</td>
<td>United Kingdom</td>
<td>Manipulation of coral photoproteins for enhancing resilience to environmental change.</td>
<td>M van Oppen, O Hoeghboon, B Williams</td>
</tr>
<tr>
<td>Tory Chase</td>
<td>JCU</td>
<td>USA</td>
<td>Effects of fish abundance and diversity on host coral dynamics.</td>
<td>M Hoeghboon, M Prutchett</td>
</tr>
<tr>
<td>Siewa Chawla</td>
<td>JCU</td>
<td>India</td>
<td>Understanding ecosystem service choices made by individual actors and their implications for social-ecological interactions.</td>
<td>G Cumming, T Morrison</td>
</tr>
<tr>
<td>Jessica Cheek</td>
<td>JCU</td>
<td>Brunel</td>
<td>Systematic conservation planning in marine environments - sensitivities of the planning framework to aspects of scale. (PhD awarded)</td>
<td>R Pressy, R Weeks</td>
</tr>
<tr>
<td>Harry Clarke</td>
<td>UWA</td>
<td>Australia</td>
<td>Resolving the impacts of ocean warming and shredding in coral cores collected from the NW shelf of Australia.</td>
<td>M McLachlan, J P D’Olive Cordero</td>
</tr>
</tbody>
</table>

tour of the Queensland Museum. The student and ECR committees also organised multiple social events across the four nodes during 2018, enhancing the ARC Centre's collaborative and supportive culture.
Student Name | Institution | Country | Thesis Title | ARC Centre Advisors
--- | --- | --- | --- | ---
Mia Theresa Bullecer Comeros | JCU | Philippines | Strengthening catchment to sea connections by evaluating the impacts of water quality on parrotfishes and successful assemblages in American Samoa. | A Hoey, G Russ
Mario Condé-Frias | UWA | Colombia | Investigating the sediment dynamics within submerged canyons for undirectional and oscillatory flows. | R Lowe
Bruna Centro de Godoy | AMU | Brazil | Genetic basis of evolutionary and developmental origin of animal cell types. | M Adamanska
Amy Coppock | JCU | United Kingdom | Climate change and disturbance events: the role of settlement larvae and larval connectivity in changes to coral reef fish communities. | G Jones, M McCormick
Jessica Cramp | JCU | USA | Evaluating the effectiveness of policy, fisheries management tools and large-scale marine protected areas on wide-ranging sharks. | R Pressey
Kay Critchell | JCU | United Kingdom | Using hydrodynamic models to understand the impacts and risks of plastic pollution. (PhD awarded) | M Hoogenboom, A Grech
Madeline Davey | UQ | Australia | Identifying marine reserve implementation strategies that are economically and ecologically achievable. | P Munday
Daniel Raj David | UWA | India | The interaction of WECs in an array and its influence on coastal processes. | R Lowe
Stephanie Di Perna | JCU, AIMS | Canada | Coastal acidification in the benthic boundary layer on inshore reefs: Implications on water chemistry and benthic communities. | M Hoogenboom
Andreas Dietzel | JCU | Germany | Primary habitat requirements of key herbivorous fish and stress-tolerant coral species in the Great Barrier Reef. | T Hughes, S Connolly
Adam Downie | JCU | Canada | How do coral reef fish develop into athletes? | J Rummer, P Cowman
Ameer Ebrahim | UQ, UQSC | Seychelles | The role of rabbithill in a marine environment, and their contribution towards the resilience of tropical coral reefs. | P Munday
Hannah Epstein | JCU, AIMS | USA | Investigating the drivers of microbial community composition in reef building corals. (PhD awarded) | P Munday, G Torda
Jacob Eurlch | JCU | USA | Processes underlying the fine-scale partitioning and niche diversification in a guild of coral reef damselfishes. (PhD awarded) | G Jones, M McCormick
Nicolas Ewens | UQ | United Kingdom | Bottleneck of coral recovery on degraded reefs. | P Munday, YM Bizuc
Legana Fingherutz | JCU | Netherlands | Genome wide detection and evolutionary analysis of antimicrobial peptide repertoires in corals. | D Miller
Eric Fisher | JCU, AIMS | Australia | Spawning aggregation sites on tropical reefs. | M McCormick
Renan Fonseca da Silva | UWA | Brazil | Understanding and predicting the impact of submerged structures on coastal processes with application to wave energy converters. | R Lowe
Kerrie Fraser | UQ, JCU | Australia | Marine protected areas: evaluating policy efficacy and impact in conserving biodiversity. | J Pandolfi, R Pressey
Gemma Galbraith | JCU | United Kingdom | Submerged pinnacle coral reefs; reef fish ecology and functional connectivity. | G Jones, M McCormick
Anjali Ganase | UQ | Trinidad and Tobago | Patterns and drivers that determine the structure and composition of Symbiotic Caribbean sponges. (PhD awarded) | D Hoegh-Guldberg, S Stone, P Munday
Betina Glad | JCU, AIMS | Austria | Microbial indicators for environmental stress and ecosystem health assessment. | B Willis

Student Name | Institution | Country | Thesis Title | ARC Centre Advisors
--- | --- | --- | --- | ---
Samuel Gonzalez Murcia | JCU | El Salvador | The impact of parrotfishes on the coral reef species. | G Jones, R Russ
Alexia Grubba-Landy | JCU | Canada | The effect of temperature on seaweed-herbivore interactions on tropical coral reef systems. | A Hoey, M Pratchett
Sharma Graefol | JCU | USA | Market structures, trade networks and governance of coral reef fisheries across a development gradient. | M Barnes, J Cinner, T Morrison
Ruby Grannum | JCU, WorkFish | United Kingdom | The temporal dynamics of reef fisheries as part of diversified coastal livelihoods. | C Cumming, D Mills
Rebecca Green | UWA | United Kingdom | Investigating biogeochemical responses to hydrodynamic processes at Scott Reef, a remote atoll off Western Australia. (PhD awarded) | R Lowe
Camille Mathilde Grimaldi | UWA | France | Oceanography drivers of coral reef connectivity of north-western Australia. | R Lowe, R Green
Mila Grinblat | JCU | Russia | Sex change and gene expression in fengile fungil as coral. | D Miller, P Cowman
Rodrigo Gudzuk | JCU, AIMS | Uruguay | Spatial and temporal connectivity dynamics on the Great Barrier Reef Marine Park: using genetics and biophysical modelling. | H Harrison
Nataly Gutierrez Izaoa | UQ | Colombia | Ecological stoichiometry of corals, symbionts and macroalgae along the latitudinal gradient in eastern Australia. | J Pandolfi
Vanessa Haller | JCU, AIMS | Germany | Ecosystem modelling to evaluate multiple uncertain threats on coral reefs. | M Bode, G Russ, R Pressey
Nicholas Hammerman | UQ | USA | Historical response of Red Sea coral habitats to environmental change. | J Pandolfi
Kelly Hannan | JCU | USA | The mechanisms underpinning maintained or enhanced performance of coral reef fishes under elevated carbon dioxide conditions. | J Rummer, P Monday
Margarita Hein | JCU, CSIRO, GBRMPA | Monaco | Characterising the effectiveness of coral restoration to build reef resilience: a socio-ecological perspective. | B Willis
Christopher Hemmingson | JCU | USA | The evolution, biogeography and ecological significance of colour in coral reef fishes. | D Bellwood, P Cowman
Alejandra Hernandez-Agreda | JCU, UQ | Venezuela | Deciphering the bacterial microworld in corals: structure, variability and persistence. (PhD awarded) | T Ainsworth, P Borgaerts, A Hoey
Sybille Hess | JCU | Switzerland | The effects of suspended sediments on the physiologay and behaviour of coral reef fishes. | J Rummer, A Hoey
Tessa Hill | JCU, MTQ | United Kingdom | Direct and indirect effects of ocean acidification on coral reefs. | M Hoogenboom, S-A Watson
Kyle Hildebrand | JCU | Australia | Latitudinal variations in age-based demography of three large predatory reef fishes (Zaprae zebra, Holacanthus malabaricus and Cephalopholis argirostriata) in Queensland, Australia. | G Russ, G Jones
Lucy Holmes McTugh | JCU, WorkFish | Australia | Power and participation in seascape conservation in the Antipodes: how are new governance models turning the tide? | T Morrison, A Song, P Cohen
Jeremy Horowitz | JCU, MTQ | USA | Predicting the unknown unknowns in the global oceans: increasing certainty of species distributions to inform conservation in marine ecosystems. | T Bridge, P Pressey
Victor Huertas Martin | JCU | Spain | Feeding ecology of coral reef fishes. | D Bellwood, S Connolly
Michael Jarrod | JCU | United Kingdom | The effects of natural variation in CO2 and rising CO2 on coral reef fish. | P Monday, M McCormick
Johanna Johnson | JCU | Australia | Development and implementation of a vulnerability assessment tool to inform decision-making in socio-ecological systems. (PhD awarded) | M Kingsford
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<tr>
<th>Student Name</th>
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<tr>
<td>Saskia Jurriaans</td>
<td>JCU, Centre</td>
<td>Netherlands</td>
<td>Thermal acclimation and the geographic range limits of reef-building corals.</td>
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<td>Tania Kenyon</td>
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<td>Physical and biological dynamics of post-disturbance coral reef bubble fields.</td>
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<td>Sun Kim</td>
<td>UQ</td>
<td>South Korea</td>
<td>Evolution and ecology of coral range dynamics.</td>
<td>J Pandolfi</td>
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<td>Catherine Kim</td>
<td>UQ</td>
<td>USA</td>
<td>Determining drivers of benthic community, marine biodiversity, and coral health in Timor-Leste.</td>
<td>Q Hoegh-Guldberg, S Dove</td>
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<td>Chelsea Karpanty</td>
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<td>Ecological dynamics of Pleistocene corals.</td>
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<td>Alyson Kuba</td>
<td>JCU</td>
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<td>Effects of ocean warming on coral reproduction and transgenerational effects: comparison of genetic and epigenetic mechanisms of resilience.</td>
<td>A Baird, M Hoogenboom</td>
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<td>Felicity Kuek</td>
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<td>Dimethylsulfoniopropionate (DMSP) metabolism within the coral holobiont.</td>
<td>D Miller, A Moya</td>
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<td>Marie Lapointe</td>
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<td>Understanding ecosystem service preferences and wellbeing benefits along a rural-urban gradient.</td>
<td>G Cumming, G Murney</td>
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<td>Taryn Laubenstein</td>
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<td>Adaptive potential of coral reef fishes to ocean acidification.</td>
<td>P Munday, J Rimmer</td>
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<td>Sarah Laness</td>
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<td>The diffusion of metanorms in natural resource governance.</td>
<td>T Morrison, P Cohen, A Song</td>
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<td>Katie Lee</td>
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<td>Early warning of tipping points of coral reefs.</td>
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<td>Johanna Leonhardt</td>
<td>JCU</td>
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<td>Spatial dynamics in the territories of Stegastes spp. relative to coral growth, disease and mortality within Ophal reef.</td>
<td>M Prattell, M. Hoogenboom, A Hoey</td>
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<td>Zoe Loffler</td>
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<td>Influence of canopy-forming macroalgae on key reef fish.</td>
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<td>Jake Lowe</td>
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<td>Effects of no take marine reserve protection on abundance and demography of tropical fishes.</td>
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<td>Chancay Macdonald</td>
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<td>Depth patterns in coral reef fish distributions and microhabitat associations: are deep reefs a refuge?</td>
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<td>Hannah Markham</td>
<td>UQ</td>
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<td>Long-term ecological dynamics along a gradient of anthropogenic activity on the inshore Great Barrier Reef. (PhD awarded)</td>
<td>J Pandolfi, G Riff</td>
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<td>Robert Mason</td>
<td>UQ, NOAA</td>
<td>Australia</td>
<td>Coral responses to temperature, irradiance and acidification stress: linking physiology to satellite remote sensing. (PhD awarded)</td>
<td>S Dove, O. Hoegh-Guldberg</td>
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<td>Eva McClure</td>
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<td>The impact of typhoons on the effectiveness of marine reserve networks in the Coral Triangle.</td>
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<td>Shannon McMahon</td>
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<td>Effects of rising water temperature and food availability on predatory reef fish.</td>
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<td>Jennifer McWhorter</td>
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<td>Michael McWilliam</td>
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<td>The functional diversity and redundancy of corals.</td>
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<td>Mathew Antonio</td>
<td>UQ</td>
<td>Brazil</td>
<td>Portes cyprhids (Dana, 1846), a resilient coral found on the Great Barrier Reef present and future coral physiology.</td>
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<td>Mello Athayde</td>
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<td>Michalis Mihalios</td>
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<td>Predator-prey interactions in coral reef fishes: ecology and function.</td>
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<td>Rebecca Millington</td>
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<td>Modeling the role of biodiversity in ecosystem resilience to climate change.</td>
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<td>Meira Mizrahi</td>
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<td>Maximizing potential impact of marine protected area (MPA) placement: an integrated socio-economic perspective.</td>
<td>R Pressay, R Weeks</td>
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<td>Jose Montalvo</td>
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<td>Mechanisms involved in the potential acclimation of corals to future environmental conditions.</td>
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<td>Stefano Montanari</td>
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<td>Causes and consequences of natural hybridisation among coral reef butterflyfishes (Chaetodon: chaetodontidae). (PhD awarded)</td>
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<td>Renato Morais</td>
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<td>Habitat effects on coral reef fish growth and biodiversity.</td>
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<td>Katie Motton</td>
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<td>The impacts of coral reef health on fish-parasite interactions.</td>
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<td>Pauline Narvae</td>
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<td>Food preferences of cleaner organisms and the impact of cleaning interactions on pathogen transmission.</td>
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<td>Tiffany Nay</td>
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<td>Physiological and behavioural strategies used by fish to mitigate the effects of ocean warming.</td>
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<td>Nery Costo Nieto</td>
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<td>Field observations of sediment dynamics within coastal benthic ecosystems.</td>
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<td>Samuel Petay</td>
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<td>The role of hybridisation in the evolution of coral reef fishes.</td>
<td>M Harrison, G Jones, M Prattell</td>
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<td>Katie Peterson</td>
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<td>Ecological drivers of community stability in space and time.</td>
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<td>Mark Priest</td>
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<td>A multi-disciplinary approach to predictive management of coral reef fisheries.</td>
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<td>Abdí Priyanto</td>
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<td>Marine spatial planning in Indonesia: options for improved efficiency.</td>
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<td>Laura Puk</td>
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<td>Population dynamics of the brown Macrotagrosia lobophora sp. and its control by herbivorous fish.</td>
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<td>Veronica Radice</td>
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<td>Trophic ecology and microbial communities of shallow and deep reef-building corals of the Maldives, Indian Ocean.</td>
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<td>Blake Ramsby</td>
<td>JCU, AMS</td>
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<td>The effects of a changing marine environment on the non-growing sponge Cliona orientalis. (PhD awarded)</td>
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<td>Jeremy Raynal</td>
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<td>Assessing the potential for recreational fishing to contribute to conservation of coastal marine species and habitats.</td>
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<td>Laura Richardson</td>
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<td>Variation in structure and function of reef fish assemblages among distinct coral habitats. (PhD awarded)</td>
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<td>Johan Riani</td>
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<td>Assessing the hydrodynamics and morphodynamics of a reef-fringed pocket beach.</td>
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<td>Thomas (Ed) Roberts</td>
<td>JCU, AIMS, MTQ</td>
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<td>Ecological determinants of depth zonation in reef-building corals. (PhD awarded).</td>
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<td>Claire Ross</td>
<td>UWA</td>
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<td>Environmental controls on the growth and physiology of high-latitude coral in the south-west region of Western Australia. (PhD awarded)</td>
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<td>Cristina Ruano Chamorro</td>
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<td>Equity in fisheries co-management: social-ecological determinants and trade-offs.</td>
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<td>Edmond Sacre</td>
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<td>Conservation planning to make a difference: developing strategies to maximise conservation impact.</td>
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Graduate Profile

Claire Ross

Claire Ross grew up close to the ocean in regional south-west Australia, where she developed a strong passion for nature and marine conservation. She recalls “learning to scuba dive and being completely awe of the ocean, especially Western Australia’s spectacular temperate reefs.” This passion and curiosity for the marine environment led Claire to pursue an undergraduate degree in marine biology and coastal management at The University of Western Australia, where she was awarded First Class Honours for her thesis on growth rates of corals at Rottentail Island.

After completing her Honours degree, Claire realised she was hooked on coral reef research. “Corals are renowned for their capacity to create spectacular calcium carbonate reef structures that harbour some of the most diverse ecosystems on the planet. I wanted to learn more about how corals grow.” The goal of her PhD was to investigate the mechanisms of coral growth and the use of coral skeletons as paleothermometers to reconstruct past temperature. Claire used a multi-disciplinary framework in her research that combined geochemistry and biology.

Western Australia is home to the largest fringing coral reef in the southern hemisphere ( Ningaloo), several sub-tropical Islands ( e.g. Rottnest Island near Perth), and many diverse temperate reefs bordering the Southern Ocean. “I decided to use these locations as natural laboratories to research coral growth and paleothermometry along a latitudinal gradient in temperature.” This work involved field trips to remote locations every 1 to 2 months to collect data of growth rates of reef-building branching and platy corals.

Claire completed her PhD in August 2018 under the supervision of Centre Research Fellows Malcolm McCulloch, Thomas DeCarlo and Verena Schoepf. Her research was the first study to apply new geochemical approaches for understanding coral growth and paleothermometry. This research provided novel insights into the complex relationships between the internal carbonate chemistry of corals and their growth rates. “We were then able to apply this new knowledge of coral growth to assess the utility of different emerging coral reef management techniques. Our research has direct implications for understanding how coral reefs responded to past and current changes in climate, as well as predicting the future of coral reefs in an era of rapid climate change.” Already, Claire’s research has resulted in the publication of eight articles in peer-reviewed journals.

Shortly after submitting her PhD, Claire was offered a marine research scientist position at the Western Australia Department of Biodiversity, Conservation and Attractions. She will be working in the Biodiversity and Conservation Science Division to research, monitor and conserve benthic marine ecosystems. Claire has “always been interested in the translation of science to management, especially given that Australia is an island nation with an incredibly large marine jurisdiction that extends across thousands of kilometres of coast. I am very excited about this opportunity to contribute to the management of Western Australia’s important marine ecosystems.”
Managed, Connected, Discoverable, Reusable

The ARC Centre of Excellence for Coral Reef Studies is committed to the responsible management of the substantial digital data generated each year by our researchers. In 2018, we implemented a new policy to further promote the discovery and dissemination of our digital research outputs. The policy supports the expectations articulated in The Australian Code for the Responsible Conduct of Research (2018): “the results of publicly funded research activities should be made widely available; and sharing and communication of research methodology, data and findings is done openly, responsibly and accurately.”

The ARC Centre continuously provides members with training in the development and use of databases, catalogues and metadata, to ensure that digital research data are retained in a durable, indexed and retrievable form at all of the Centre’s nodes. Digital research outputs include digital data sheets, statistical code, NVivo codebooks, spatial (GIS) data layers, digital databases, sound and video recordings, and more. Researchers are also trained to upload their data to internal online data repositories, including JCU Tropical Data Hub or ResearchOnline@JCU (JCU); UQ eSpace (UQ); ANU Data Commons (ANU); and UWA Research Repository (UWA).

The online data repositories of JCU, UQ, ANU and UWA are syndicated with the Australian Research Data Commons, and the associated metadata are made available via Research Data Australia. The ARC Centre has its own interface on the Research Data Australia search portal to make it easier to find our data. More than 40 items were added to the Centre’s search portal in 2018, including unique datasets on coral bleaching and mortality due to the global warming, published in Nature, Science and Nature Climate Change. In addition to each University node’s online data repositories, ARC Centre members regularly share digital data and metadata via online repositories and databases (e.g., GenBank, eAtlas, Dryad), data journals (e.g., Scientific Data) and journal repositories.

Coral bleaching records of the Great Barrier Reef

Two important datasets published in the journal Ecology and in the JCU Tropical Data Hub contain the outputs from aerial surveys conducted in 2016 and 2017 that measured the geographic extent and severity of bleaching on the Great Barrier Reef. Over 1,130 individual reef scores are made public for 2016, and 742 for 2017. The accuracy of the aerial scores was ground-truthed by measuring the extent of bleaching underwater on 104 reefs. The dataset also contains the Degree Heating Weeks (heat stress metric) experienced by each reef, in collaboration with the US National Oceanographic and Atmospheric Administration (NOAA).


Global conservation planning database: marine proof-of-concept

Systematic conservation planning has increasingly been used to prioritise conservation actions, including the design of new protected areas to achieve conservation objectives. Over the last 10 years, the number of marine planning studies has increased exponentially, yet there is no structured or reliable way to find information on methods, trends, and progress. The Conservation Planning Database project, led by Jorge Álvarez-Romero, created a global database to help track the development, implementation, and impact of conservation planning, and improve scholarship in the field. The developing database currently contains over 150 individual case studies (p17).


Global gravity of coral reefs

The gravity concept is that human interactions with a coral reef are a function of population size moderated by the time it takes to travel to a reef from a village, town or city. Travel time rather than the straight-line distance is used to account for the differences incurred by travelling around obstacles and over different surfaces, such as water, roads and tracks. PhD student Eva Maire calculated gravity across every populated location in the world within 500km of coral reefs, to generate an impressive spatial (GIS) dataset. Eva was able to estimate the accessibility of global coral reefs, and found that 58% are located < 30 minutes from the nearest human settlement. The dataset was used in 2018 by Joshua Cinner, Eva and colleagues to assess the capacity of marine reserves to deliver key conservation benefits. They found that only marine reserves in areas of low human impact consistently sustained top predators (p16).

National and International Linkages

The ARC Centre is continuously expanding its collaborations and interactions with Australian and international researchers and institutions. These collaborations help create a global hub for coral reef research excellence at the Centre that is increasingly transdisciplinary.

Examples in 2018:
- 306 publications with cross-institutional co-authorship, involving researchers from 440 institutions in 79 countries.
- 22 international working groups convened by Centre researchers.
- The ARC Centre hosted 78 international visitors from 27 countries.
- 126 of our current graduate students were attracted to Australia from 37 countries (p43), including 70% of our new graduate enrolments.
- The ARC Centre’s fieldwork in 2018 was conducted in 28 countries. In addition, the ARC Centre has formal international partnership agreements with the Center for Ocean Solutions at Stanford University in the USA, the International Union for the Conservation of Nature (IUCN), France’s Centre National de la Recherche Scientifique (CNRS), and WorldFish in Malaysia. Centre researchers also collaborate extensively with four international non-government organisations (NGOs): The Nature Conservancy (TNC), the Worldwide Fund for Nature (WWF), the Wildlife Conservation Society (WCS) and Conservation International (CI).

The ARC Centre’s national and international collaborations result in tangible outputs and impacts (p6), including the development of multiple trans-disciplinary research projects, cotutelle PhDs, exchange of researchers, recruitment of co-funded research fellows, and enhanced engagement and uptake of our research by end-users around the world. The links to major partners are clearly reflected in the Centre’s governance structure (p64), and in the performance targets used to measure our collaborative activities and outcomes (p87).

ARC Centre personnel are actively involved on many editorial boards for international journals. We undertake consultancies worldwide, and our outreach and media coverage is global (p59). The ARC Centre’s researchers are major contributors to intergovernmental organisations such as the Intergovernmental Panel on Climate Change (IPCC), the World Bank, UNESCO, and the International Council for Science (ICSU). Five Centre research leaders are Fellows of the Australian Academy of Science: David Bellwood, Ove Hoegh-Guldberg, Terry Hughes, Malcolm McCulloch and Bob Pressey. Malcolm McCulloch is also a Fellow of the Royal Society (London).

Highlights of some of the ARC Centre’s national and international collaborations in 2018 include:

**Great Barrier Reef Marine Park Authority**

The ARC Centre’s most important end-user in Australia is GBRMPA, the Australian government agency with the primary responsibility of protecting and managing the Great Barrier Reef (GBR) Marine Park and the GBR World Heritage Area. Their task is to assess, inform, and implement government policies to maintain the environmental quality of the Great Barrier Reef. GBRMPA’s partnership with the ARC Centre provides them with direct access to the research expertise of the ARC Centre, whose research goals are strongly aligned with the scientific information needs of GBRMPA. GBRMPA is firmly linked to the ARC Centre’s governance to facilitate research planning and the exchange of information and data: GBRMPA’s Chairman is a member of the Centre’s Advisory Board, and the agency’s Chief Scientist, David Wachenfeld, sits on the Scientific Management Committee. GBRMPA managers receive regular updates, advice and formal and informal briefings on the reef from ARC Centre researchers. The Centre also is a major contributor to technical courses and workshops, providing information and reviewing GBRMPA reports, education and training. For example, in 2018, eight Centre researchers participated in a 4-day scientific consensus workshop to inform the Great Barrier Reef Marine Park Authority’s Outlook Report 2019. Terry Hughes, James Kerry and others joined GBRMPA managers for presentations, information exchange and discussions at GBRMPA’s Pre-Summer Reef Health Workshop. Terry Hughes and Ove Hoegh-Guldberg are members of the Independent Expert Panel for the Great Barrier Reef 2050 Plan, providing advice to GBRMPA, the Commonwealth and State of Queensland. Alana Grech presented a seminar and briefing to 25 GBRMPA managers on her work assessing cumulative impacts on coastal seagrasses. In 2018, several graduate students also engaged with GBRMPA partners. PhD students Alexia Grabar-Landry and Shannon McMahon received funding from the GBRMPA’s Reef Guardians Research Grants for their targeted research on the Great Barrier Reef. Research from PhD student Brock Bergsve designed a GBRMPA media campaign to compel all visitors to the Great Barrier Reef to report suspected illegal fishing inside no-fishing zones.

**The Australian Institute of Marine Science**

The Australian Institute of Marine Science is the ARC Centre’s major Australian research partner outside of the University sector. AIMS undertakes a range of research on tropical marine environments and aquaculture, is responsible for the long-term monitoring of the Great Barrier Reef, and increasingly provides research services to industry, including oil and gas companies, government agencies, port authorities and other clients and partners, particularly in Queensland, Western Australia and the Northern Territory. The AIMS Chief Executive Officer, Paul Hardisty, is a member of the Centre’s Advisory Board and AIMS’ senior principal scientist, Janice Lough, is a very active Partner Investigator, working closely with the coral bleaching research team in the Centre. AIMS and the ARC Centre share valuable infrastructure, co-supervise graduate students (18 in 2018) and co-fund Research Fellows Kristen Anderson and Greg Torda. AIMS and ARC Centre researchers co-authored an unprecedented 53 papers in 2018 including key papers in Science and Nature.

**GBRMPA**

GBRMPA’s partnership with the ARC Centre provides them with direct access to the research expertise of the ARC Centre, whose research goals are strongly aligned with the scientific information needs of GBRMPA. GBRMPA is firmly linked to the ARC Centre’s governance to facilitate research planning and the exchange of information and data: GBRMPA’s Chairman is a member of the Centre’s Advisory Board, and the agency’s Chief Scientist, David Wachenfeld, sits on the Scientific Management Committee. GBRMPA managers receive regular updates, advice and formal and informal briefings on the reef from ARC Centre researchers. The Centre also is a major contributor to technical courses and workshops, providing information and reviewing GBRMPA reports, education and training. For example, in 2018, eight Centre researchers participated in a 4-day scientific consensus workshop to inform the Great Barrier Reef Marine Park Authority’s Outlook Report 2019. Terry Hughes, James Kerry and others joined GBRMPA managers for presentations, information exchange and discussions at GBRMPA’s Pre-Summer Reef Health Workshop. Terry Hughes and Ove Hoegh-Guldberg are members of the Independent Expert Panel for the Great Barrier Reef 2050 Plan, providing advice to GBRMPA, the Commonwealth and State of Queensland. Alana Grech presented a seminar and briefing to 25 GBRMPA managers on her work assessing cumulative impacts on coastal seagrasses. In 2018, several graduate students also engaged with GBRMPA partners. PhD students Alexia Grabar-Landry and Shannon McMahon received funding from the GBRMPA’s Reef Guardians Research Grants for their targeted research on the Great Barrier Reef. Research from PhD student Brock Bergsve designed a GBRMPA media campaign to compel all visitors to the Great Barrier Reef to report suspected illegal fishing inside no-fishing zones.

**WorldFish, Malaysia**

WorldFish is an international non-profit research organisation headquartered in Malaysia, engaged in research for development in Africa, Asia and the Pacific. Its primary aim is to improve food and nutrition security, and reduce poverty for the 800 million people globally who depend on fisheries and aquaculture. The ARC Centre and WorldFish share a common research interest in the dynamics and sustainable interaction between human societies and coral reef-associated fisheries.

**Outlook**

"With a management plan coming into effect for the Coral Sea for the first time in July this year, it is very important that we monitor the health of these isolated coral reef ecosystems and increase our understanding of these amazing places". The ARC Centre is leading a three year project to investigate the dynamics of the remote reefs of the Coral Sea Marine Park, commissioned by Parks Australia, including the impacts of coral bleaching in 2016 and 2017. In 2018, Morgan Pratchett, Andrew Hoey and Hugo Harrison led three expeditions to survey reefs across the region.

**Parks Australia**

Parks Australia, the Federal park agency, manages six Commonwealth national parks, the Australian National Botanic Gardens, and Australian Marine Parks. Parks Australia are part of the Commonwealth environment portfolio, in the Department of the Environment and Energy. The Director of National Parks is a statutory officeholder, charged under the Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act) with helping to conserve Australia’s biodiversity and cultural heritage. Since 2014, ARC Centre researchers have worked closely with Parks Australia and the Director of National Parks on multiple research projects in the Coral Sea Marine Park. The Coral Sea Marine Park has significant populations of internationally threatened species, as well as species found nowhere else in the world. Director of National Parks, Dr James Findlay, said in a press release in December 2018, “With a management plan coming into effect for the Coral Sea for the first time in July this year, it is very important that we monitor the health of these isolated coral reef ecosystems and increase our understanding of these amazing places”. The ARC Centre is leading a three year project to investigate the dynamics of the remote reefs of the Coral Sea Marine Park, commissioned by Parks Australia, including the impacts of coral bleaching in 2016 and 2017. In 2018, Morgan Pratchett, Andrew Hoey and Hugo Harrison led three expeditions to survey reefs across the region.

**WorldFish, Malaysia**

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### International visitors in 2018

In 2018, 78 international visitors were hosted by the ARC Centre of Excellence.

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Former Centre PhD student and research fellow, Pip Cohen is the Research Leader of the global program on resilient small-scale fisheries for WorldFish, and has been a Partner Investigator in the ARC Centre since 2017. During 2018, WorldFish and the ARC Centre continued the implementation of the FISH Cluster Research Program in which the ARC Centre contributes substantially to research on the resilience of coastal fisheries. As part of the FISH CRP collaboration, Joshua Cinner delivered a capacity building workshop in Penang and developed a series of video tutorials on how to structure manuscripts, navigate the peer review process and build a portfolio of publications. WorldFish senior scientist David Mills is based in the ARC Centre at the JCU node, where the Centre and WorldFish also co-fund two postdoctoral researchers; in 2018, Andrew Song and Danika Kleiber. Jacqueline Lau, whose research focuses on coastal fisheries, climate change and nutrition, will join the Centre as a postdoctoral fellow in mid-2019. Jacqueline received a Crawford Award in 2018 to conduct research with WorldFish partners in Penang and the Solomon Islands. Also in 2018, PhD students Sarah Lawless, Sarah Sutcliffe and Ruby Graham are jointly supervised by Centre and WorldFish researchers. Ruby Grantham was awarded a Crawford Fellowship to fund her collaborative work with a WorldFish ACIAR project in Timor Leste. This ongoing collaboration creates strong links to end-users, including many intergovernmental organisations and NGOs, as well as local communities and the governments of many developing countries, particularly in the Coral Triangle.

### King Abdullah University of Science and Technology, Saudi Arabia

The King Abdullah University of Science and Technology (KAUST) is Saudi Arabia’s premier coastal reef science institution. Its primary focus is developing a scientific basis for conserving and sustaining coastal reef environments along the Red Sea coast of Saudi Arabia. Situated just north of Jeddah, KAUST has state of the art facilities for both field- and laboratory-based coral reef research. Centre Director, Terry Hughes, is a member of the Advisory Board of KAUST’s Red Sea Research Centre. In 2018, the Centre hosted five visitors from KAUST associated with two large collaborative projects, being undertaken by Program 3: Genomic evidence for adaptation of marine fishes to ocean acidification, and Transcriptional program and the epigenome of transgenerational acclimation to climate change in reef fishes. In November, Philip Munday, Jacqueline Lau, Jennifer Donelson and Jodie Rummer hosted a joint workshop with KAUST in Western Australia to facilitate this research. Jennifer, based in the ARC Centre, is funded through this partnership. The collaboration between the Centre and KAUST led to a 2018 publication in Nature Climate Change on the epigenetic basis of transgenerational acclimation by fish to ocean warming (p34). Program 3 researchers John Pandolfi and Peter Mumby also contributed to a craniodian synthesis project at KAUST.
In 2018, the expertise of ARC Centre researchers continued to be sought by the media, government and industry, generating a diverse range of impacts (p6). A particular focus this year has been the future trajectory of the Great Barrier Reef in the wake of the 2016 and 2017 back-to-back coral bleaching event. One highlight at the beginning of year was the ARC Centre’s role in the HRH The Prince of Wales’ global call to action to save coral reefs, in a speech he delivered in February as part of the opening of the International Year of the Reef. In his highly publicised oration, The Prince of Wales referenced two of the ARC Centre’s research papers, published in the prestigious journal Science one month earlier, in January 2018.

The ARC Centre’s communications program actively promotes research outcomes through traditional and digital platforms. The Centre’s comprehensive and dynamic website recorded 11.9 million hits in 2018. The website’s blog, initiated in 2017, delivered 26 posts in 2018. The weekly multi-modal seminar program hosted 53 presentations this year, publicly accessible through the ARC Centre’s YouTube channel. The ARC Centre also supports a robust professional development program in communication and media training across its four nodes (p43).

The annual ARC Centre Coral Reef Futures Symposium and Public Forum continued to be a successful event this year, fostering collaborations and collegiality amongst internal and external stakeholders. In 2018 the two-day event was held in Brisbane at the Gallery of Modern Art. The sold-out Public Forum was hosted by popular media presenter, Adam Spencer and featured a panel of five of the Centre’s engaging researchers. The ARC Centre crowdsourced the most popular questions for the Public Forum’s panel and the event was webcast through Facebook Live.

Social media

During 2018, the ARC Centre’s digital engagement continued to expand. The number of Followers of the Centre’s Twitter account @CoralCoE grew by 31% to >8,100. The annual Coral Reefs Futures Symposium featured a targeted Twitter campaign, generating the highest number of monthly ‘Impressions’ for the year at 176,000. The event hashtag #CORAL18 reached trending status within the first few hours of the campaign. Overall, the ARC Centre’s Twitter activity achieved a record 1.2 million impressions during the year.

The ARC Centre’s Facebook page also grew rapidly in 2018 with a 30% increase in ‘Page Likes’. In collaboration with the Australian Academy of Science, the Centre delivered a range of video posts to promote our most significant research outputs. The most popular of these videos tracked over 100,000 views and was posted on Facebook on 5 January to coincide with the release of an ARC Centre-led, high impact Science paper.

Expansion of the ARC Centre’s video library was a priority activity for communications in 2018. Our YouTube channel provided an effective platform to improve accessibility and boost user engagement. During the 12-month period, the Centre recorded a >30% rise in subscribers.

Briefings

The ARC Centre continues to provide timely and informative advice and training on relevant coral reef science issues to key stakeholders. In 2018, researchers engaged in 105 briefings across both the public and private sectors. Regular briefings were delivered to partners at the Great Barrier Reef Marine Park Authority (GBRMPA) and the Australian Institute of Marine Science. For example, Terry Hughes, April Hall, Geoff Jones, Alana Grech, Andrew Hoey, Morgan Pratchett, Peter Mumby and PhD student Brock Bergseth all gave briefings to GBRMPA staff during the year, on topics such as bleaching response, climate change, poaching and inshore monitoring of the Great Barrier Reef. In May, eight ARC Centre researchers were invited to provide input to GBRMPA’s 2019 Outlook Report Science Consensus Workshop. The Centre’s researchers also provided multiple briefings to Parks Australia on the $1 million Coral Sea Monitoring Program, which is led by Morgan Pratchett, Andrew Hoey and Hugo Harrison. Morgan and Andrew also
provided briefings to the Queensland Government Department of Fisheries on the sustainability of coral harvesting in the Great Barrier Reef, and on the impacts of climate change on coral trout. Jon Brodie provided frequent expert input to the Queensland and Australian Governments on water quality and catchment management.

Alana Grech, Sean Connolly, Jodie Rimmer, and PhD student Sam Payet briefed His Excellency Peter Cosgrove, Governor General of Australia in May, as part of the 2018 International Year of the Reef. In October, under the auspices of the Australian Academy of Science, Terry Hughes, Tiffany Morrison, Graeme Cuminning and Ove Hoegh-Guldberg delivered a briefing on climate change and the Great Barrier Reef to Senators and members of the House of Representatives at Parliament House, in Canberra.

Internationally, the Centre’s researchers provided expert advice to a range of organisations across the globe. For example, in January, Ove Hoegh-Guldberg attended commemorations for the International Year of the Reef alongside HRH The Prince of Wales, and in April he briefed participants at the Intergovernmental Panel on Climate Change (IPCC) 1.5 Impact Meeting held in Botswana, Africa. In June, Terry Hughes briefed His Highness Prince Albert II of Monaco on the Centre’s climate change research. In September, Georgina Gurney travelled to Cuba to present her expertise in monitoring the impacts of marine protected areas on human well-being to the Wildlife Conservation Society.

Public talks and school outreach
Public engagement and outreach of the ARC Centre’s research is a core activity of the organisation. In 2018, Centre researchers participated in 70 outreach events and public talks, collectively reaching an estimated audience of 1.1 million. For example, in February, Terry Hughes joined a distinguished panel of international experts in weather, climate and marine science in a public forum entitled Myth-busting Climate Change. The event was associated with an international symposium co-hosted in Sydney by the Australian Meteorological and Oceanographic Society and the American Meteorological Society, which attracted 600 researchers from 28 different countries. In March, Ove Hoegh-Guldberg addressed a packed auditorium at the University of Hawaii as part of a special screening of the film Chasing Coral. Also in March, Malcolm Mc Culloch delivered an invited public seminar entitled: Coral reefs in a changing world at The University of Western Australia. In August, Morgan Pratchett addressed the local Townsville community at the annual Eco-Fiesta event, attracting an audience of close to 5,000 residents. Alana Grech participated in a round table discussion at James Cook University with former New Zealand Prime Minister, Helen Clark. Verena Schoepf presented a TEDx talk on super corals and the future of coral reefs in Perth. Verena Schoepf and Morgan Pratchett also gave a public talk at the Professors and Pints event held in conjunction with the Australian Coral Reef Society annual conference in Exmouth, Western Australia.

The ARC Centre continues to be a significant supporter of the Aboriginals and Torres Strait Islanders in Marine Science (ATSIMS) program, initiated by alumnus Joseph Pollock in 2013. In 2018, the Centre sponsored the delivery of five program modules to fifty-one Year 9 and 10 Indigenous students from six north Queensland secondary schools. In addition, PhD student Danielle Asson-Batzel represented the ARC Centre as an ATSIMS 2018 Ambassador, providing real-world advice and inspiration to the students.

The ARC Centre is committed to gender equality. In October 2018, the ARC Centre was a partner in the 7th Global conference on gender in aquaculture and fisheries, held in Bangkok, Thailand. Program 1 research fellow Danskia Kleiber, leading the communications committee for the conference, presented a special workshop on gender equity in small scale fisheries.

Many of the Centre’s researchers including Aleksey Sadekov, Jennifer Donelson, Peter Cowman, Verena Schoepf, Georgina Gurney and Maja Adamska also directly engaged with schools across the country and overseas to promote STEM research.

Plenary talks
In 2018, ARC Centre researchers delivered 42 keynote addresses at events hosted across the globe. For example, Terry Hughes was a keynote speaker in Berlin at the prestigious Falling Walls International Conference on Future Breakthroughs in Science and Society. His talk ‘How reef management can secure our oceans for future generations’ was globally accessible through the event’s live webcast and subsequent YouTube promotion. Terry also delivered a keynote talk at the 12th International Conference for Southern Hemisphere Meteorology and Oceanography, AMOS-ICSHMO 2018 in Sydney, and Huntington Medal plenary seminar, at the Bedford Oceanographic Institute, in Nova Scotia. Ove Hoegh-Guldberg presented a plenary address at the World Ocean Summit in Mexico. Alana Grech gave the opening address and keynote talk at the World Seagrass Conference, Singapore and Tiffany Morrison delivered a keynote address at the Boundary Spanning: Advances in Socio-Environmental Systems Research symposium in Annarolis, USA. Joshua Cinner delivered a keynote talk at the International Marine Conservation Congress in Kuching, Malaysia. Yves-Marie Bozec was an invited plenary speaker at the North Pacific Marine Science Organization (PICES) 2018 annual meeting and Peter Mumby also presented an invited plenary at the 4th Asia Pacific Coral Reef Symposium. Philip Munday was an invited keynote speaker at the Gordon Research Conference on Ocean Global Change Biology in New Hampshire, USA. Michael Kingsford presented a plenary address on his receipt of the K Radway Allen Award at the Australian Society for Fish Biology Conference in Melbourne and Jennifer Donelson also presented a plenary address. In addition, Graeme Cumming delivered a keynote address at the Australian Coral Reef Society Conference held in Exmouth, Western Australia.

The Conversation
The ARC Centre regularly publishes original research-based articles and commentaries using the popular online media resource, The Conversation. In 2018, nine ARC Centre researchers published eight articles. Several of the articles were syndicated in media outlets across the globe with a combined reach of close to half a million people. Examples of 2018 articles include:


Sarah Sutcliffe and Michele Barnes. Shark tourism can change your mind about these much-maligned predators. 7 September 2018. https://theconversation.com/shark-tourism-can-change-your-mind-about-these-much-maligned-predators-102766

PHOTO CAMILLE GRIMALDI
Media and Altmetrics

In 2018, the ARC Centre developed and distributed 36 media releases, generating 9,711 news items and commentaries, a record for the Centre. On average, Centre researchers and/or research were referenced in media articles 26 times per day. The ARC Centre’s news generated global interest in 2018 and was featured across multiple platforms - digital, TV, radio and print, and in many of the world’s most prominent news outlets such as the BBC, Washington Post, The Straits Times, Newsweek, Time and Forbes.

Altmetric scores provide a metric of the attention paid to a research publication by tracking the media, Twitter, Facebook, blogs, and other online sources. This year, Altmetric tracked and scored 2.8 million research outputs. Two ARC Centre publications were listed in The Altmetric Top 100 for 2018. In ninth place was the 19 April Nature paper ‘Global warming transforms coral reef assemblages’ which triggered 8,819 tweets, reaching an audience of 14.1 million Twitter followers. The twenty-eighth most talked about paper in 2018 was published by Centre researchers in Science on 5 January. It recorded 6,918 tweets, with an audience of 12.3 million followers. Both papers were also featured in the Top 10 Climate Papers of 2018 reported by Carbon Brief.

Additional media highlights throughout 2018 include:


Australian Women’s Weekly – Beautiful Australia: women of the Reef, J Rummer, February 2018


ABC North West – Coral reefs protect coasts from severe storms, M Cuttell, 04 April 2018


TIME Magazine – Extreme heatwaves killed half of the Great Barrier Reef’s coral in two years, study says, T Hughes, 19 April 2018 http://time.com/5246117/great-barrier-reef-coral-global-warming/


India Times – In last 2 Years, half of all coral in the Great Barrier Reef has died due to global warming, A Baird, 20 April 2018 https://www.indiatimes.com/news/world/in-last-2-years-half-of-all-coral-in-the-great-barrier-reef-has-died-due-to-global-warming-343851.html

VICE News Tonight on HBO – Australians can’t agree on how to save the Great Barrier Reef, T Hughes 2 May 2018 https://video.vice.com/en_us/video/australians-cant-agree-on-how-to-save-the-great-barrier-reef/5ae13eca1fcd30f693e8bf1


WIN TV Network News – Apollo towards poachers widespread in world’s marine protected areas, G Gurney and M Barnes, 15 August 2018


Firstpost.com (India) – Scientists have gone beyond finding Nemo, they’ve now mapped its entire genome, P Monday, 12 September 2018 https://www.firstpost.com/tech/science/scientists-have-gone-beyond-finding-nemo-theyve-now-mapped-its-complete-genome-5167031.html


Times Higher Education – interview with Munday, 12 September 2018 https://www.timeshighereducation.com/people/interview-terry-hughes

The Straits Times (Singapore) – Great Barrier Reef resilient to spikes in temperatures: study, T Hughes, 11 December 2018 https://www.straitstimes.com/asia/australian/great-barrier-reef-resilient-to-spikes-in-temperatures-study
Governance

The ARC Centre's governance structure engages key stakeholders in planning, research program development and knowledge transfer, reflecting its strategic priorities. Responsibilities and terms of reference at each level of governance are clearly defined and effective.

James Cook University is the Administering Organisation with Centre Director, Terry Hughes, reporting directly to the Provost, Professor Chris Cocklin. Operations are managed by the Chief Operations Officer, Jennifer Lappin, in consultation with the Centre Director and Assistant Director, Alana Grech. Business support is provided by staff of the Centre's nodes at The Australian National University, The University of Queensland and The University of Western Australia.

The diagram below summarises the Centre's governance structure and relationships. The Centre Director oversees the Centre's research programs and liaises regularly with the two Deputy Directors, Ove Hoegh-Guldberg (UQ) and Malcolm McCulloch (UWA). Chief Investigators, research fellows and students are located across three Divisions of James Cook University, and at the Centre's other university nodes. Partner Investigators are based at the Australian Institute of Marine Science, the Great Barrier Reef Marine Park Authority and in leading international research institutions (p54). Adjunct researchers (p70) based in institutions in Australia and overseas make a significant contribution to the Centre's research.

The Centre's two principal governance committees are the Centre Advisory Board and the Scientific Management Committee. Both committees are chaired by an eminent international researcher and provided with administrative support by Jennifer Lappin, as Secretary. The Centre also supports two additional committees run by Centre graduate students and early career researchers. These committees contribute to the career development and mentoring of these two integral components of the Centre's personnel, and are responsible for the organisation of annual retreats and training workshops for early career researchers (p43). An informal group, comprising all of the Centre's female staff, also provides mentoring and general support to female ECRs and students.

Centre Advisory Board

The Centre Advisory Board provides high-level strategic advice to the Centre Director, and facilitates and advises on strengthening linkages between the Centre, stakeholders, government and industry. The Centre Director and Chief Operations Officer provide the link between the Centre Advisory Board, the Scientific Management Committee (SMC) and Centre operations.

Distinguished international researcher Professor Brian Walker FAA, is current Chair of the Board. Brian brings enormous experience and knowledge of interdisciplinary research as a former Chief of Australia's CSIRO Division of Wildlife and Ecology. Membership of the Centre's Board in 2018 reflects the Centre's strong multi-disciplinary research activities and includes the Chief Executive Officer of AIMS, the Chair of the Great Barrier Reef Marine Park Authority, a senior representative from WorldFish and an independent senior university leader.

The ARC Centre of Excellence congratulates Brian Walker on being awarded Japan's 2018 prestigious Blue Planet Prize in recognition of his 'significant influence on the development of the concept of resilience in social-ecological systems' and its impact on solving global environmental problems.

In 2018, long standing member Neil Andrew retired from WorldFish and the Centre's Board. We sincerely thank him for his informed contributions and wise counsel for this Centre since its establishment in 2014. We wish Neil every success in his new Professorial position at the Australian National Centre for Ocean Resources and Security at the University of Wollongong.

The Board met formally on 18th July in Brisbane and informally by videoconference on 14th December. A key focus for the Board during 2018 was providing advice on the new ARC Centre of Excellence Expression of Interest for Centre of Excellence funding. We sincerely thank the members of the Board for generously sharing their time, expertise and advice.

Membership of the Centre Advisory Board:

Dr Brian Walker FAA (Chair)
Honorary Research Fellow
CSIRO Ecosystem Sciences

Dr Neil Andrew
Regional Director
WorldFish
Malaysia

Distinguished Professor Terry Hughes FAA
Centre Director
ARC Centre of Excellence for Coral Reef Studies

Margaret Johnson
General Manager, Policy and Stewardship
Great Barrier Reef Marine Park Authority
(Delegate of Dr Russell Reichelt, Chair)

Dr Britta Schaffelke
Research Program Leader, A Healthy and Sustainable Great Barrier Reef
Australian Institute of Marine Science
(Delegate of Dr Paul Hardisty, Chief Executive Officer)

Professor Mandy Thomas
Executive Dean, Creative Industries Faculty, Queensland University of Technology

Scientific Management Committee

The ARC Centre's Scientific Management Committee (SMC) is responsible for high level operational decisions and stewardship of the Centre's scientific research program. The Committee is chaired by distinguished social scientist and pioneer of interdisciplinary research, Professor Katrina Brown from the University of Exeter, UK (p67). Other members are the Deputy Directors of the Centre, leaders of each of the Centre's Research Programs, the Centre's current Australian Laureate Fellows and the Chief Scientist of the Great Barrier Reef Marine Park Authority.

The SMC met formally three times in 2018, twice in Townsville and once in Brisbane. A number of additional informal meetings were held to prepare an Expression of Interest for Centre of Excellence funding from 2020. Continuing priorities in 2018 were research planning associated with the 2016 and 2017 back-to-back bleaching on the Great Barrier Reef, and related research on the resilience of coral reefs in the face of changing environmental conditions.
Barrier Reef. Members of the SMC continue to take a key role in providing advice to the Queensland and Australian Governments on the Reef 2050 Long-Term Sustainability Plan. Other priorities included fostering outstanding transdisciplinary research across the Centre’s research programs and nodes, and recruiting high-quality postdoctoral fellows and students.

Each Program Leader manages their research program through regular planning and review meetings with the research and student members of their program. Budgetary allocations for the research programs are agreed by the SMC. The SMC reallocates program-level funds in view of the Centre’s changing research and activity priorities. Cross-Program research is facilitated by the overlapping membership of programs, and by the Centre’s annual symposium and associated planning activities.

Membership of the Scientific Management Committee:

Professor Katrina Brown (Chair)
Chair in Social Science
University of Exeter
United Kingdom

Distinguished Professor Terry Hughes FAA
Centre Director and Leader, Research Program 1
James Cook University

Associate Professor Tiffany Morrison
Leader, Research Program 1
James Cook University

Distinguished Professor Bob Pressey FAA
Leader, Research Program 1
James Cook University

Professor Sean Connolly
Leader, Research Program 2
James Cook University

Professor John Pandolfi
Leader, Research Program 2
University of Queensland

Dr Verena Schoepf
Leader, Research Program 2
University of Western Australia

Associate Professor Maja Adamska
Leader, Research Program 3
Australian National University

Associate Professor Mia Hoogenboom
Leader, Research Program 3
James Cook University

Professor Ryan Lowe
Leader, Research Program 3
University of Western Australia

Professor Malcolm McCulloch FAA FRS
ARC Australian Laureate Fellow
University of Western Australia

Professor Ove Hoegh-Guldberg FAA
ARC Australian Laureate Fellow and Deputy Director
University of Queensland

Dr David Wachenfeld
Chief Scientist
Great Barrier Reef Marine Park Authority

Honorary doctorate punctuates an extraordinary career

Chair of the ARC Centre’s Scientific Management Committee, Professor Katrina (Kate) Brown, a distinguished environmental social scientist, was awarded an honorary doctorate from Wageningen University, a leading Dutch university, on 9 March as part of the University’s centenary celebrations.

Kate specialises in how individuals and communities in developing countries cope with climate change. She has served as a key member of the ARC Centre’s leadership team and as the Chair of the Scientific Management Committee since 2014.

“I am absolutely thrilled to be awarded an honorary doctorate from Wageningen University,” said Professor Brown.

“I’ve been so fortunate to work with so many inspirational scientists during my career and I’ve learned a lot from students, colleagues and co-researchers. I believe wholeheartedly that the best science is collaborative and that the most useful knowledge is co-developed and co-produced across disciplines, fields and with stakeholders.”

“To tackle the pressing problems of rapid change in the Anthropocene we need to give voice to multiple knowledges and create space for transformative solutions. I’m looking forward to continuing work with the ARC Centre of Excellence for Coral Reef Studies to develop our joint research agenda and address critical challenges facing coral reefs around the world, and the many different communities who depend on them – directly and indirectly.”

She added, “I’m honoured to be only the fourth woman to be awarded an honorary doctorate in Wageningen’s 100-year history.”

A total of 58 honorary doctorates have been bestowed by Wageningen University between 1918 and 2018.
In 2018, the ARC Centre’s membership comprised: 73 Chief Investigators, Research Fellows and Associates; 29 Partner Investigators, resident international scholars and adjunct researchers; and 176 research students (p45). Eleven of the Centre’s Research Fellows were funded by ARC Fellowships (Australian Laureate, Future and DECRAs) and one by an Advance Queensland Fellowship.

In 2018, the ARC Centre welcomed 12 new Research Fellows and Associates: Natalia Andrade-Rodriguez, Severine Choukroun, Kay Critchell, Rebecca Green, Karlo Hock, Danika Kleiber, Robert Mason, Michael McWilliam, Oliver Mead, Tim Staples, Erin Vaughn, and Kennedy Wolfe. For the third consecutive year, the Centre achieved its goal of 50:50 gender equity in research fellow recruitment.

We also farewelled a number of researchers who have taken up new positions elsewhere, extending the ARC Centre’s network of alumni collaborators: Dorothea Bender-Champ, Michael Bode, Pin Bongaerts, Pip Cohen, Christopher Corrall, François Dufois, Sofia Fortunato, Vimoksalehi Lukoschek, Andrew Pomeroy, Heather Veilleux, Julie Vercelloni and Rebecca Weeks. We wish them well in their continuing research careers.

Chief Investigators and Research Fellows

Professor Terry Hughes
Centre Director
James Cook University

Associate Professor
Maja Adamska
ARC Future Fellow
James Cook University

Dr Jorge Álvarez-Romero
Research Fellow
James Cook University

Dr Kristen Anderson
Research Fellow
James Cook University and Australian Institute of Marine Science

Professor Andrew Baird
Chief Investigator
James Cook University

Dr Natalia Andrade-Rodriguez
Research Associate
James Cook University

Dr Michele Barnes
Research Fellow
James Cook University

Professor David Bellwood
Chief Investigator
James Cook University

Professor Sean Connolly
Chief Investigator
James Cook University

Dr Jennifer Donelson
Research Fellow
James Cook University

Dr Michael Bode
ARC Future Fellow
James Cook University

Dr Pim Bongaerts
Discovery Early Career Researcher Award (DECREA)
University of Queensland

Dr Yves-Marie Bozec
Research Fellow
University of Queensland

Dr Tom Bridge
Discovery Early Career Researcher Award (DECREA)
James Cook University and Queensland Museum

Professor Jon Brodie
Research Fellow
James Cook University

Dr Severine Choukroun
Research Associate
James Cook University

Professor Joshua Cinner
ARC Future Fellow
James Cook University

Dr Hugo Harrison
Discovery Early Career Researcher Award (DECREA)
James Cook University

Dr Karlo Hock
Research Fellow
University of Queensland

Professor Ove Hoegh-Guldberg
Deputy Director, ARC Australian Laureate Fellow
University of Queensland

Dr Andrew Hoey
Research Fellow
James Cook University

Associate Professor
Mia Hoogenboom
Chief Investigator
James Cook University

Professor Geoffrey Jones
Chief Investigator
James Cook University

Professor Michael Kingsford
Chief Investigator
James Cook University

Dr Danika Kleiber
Research Fellow
James Cook University and WorldFish, Malaysia

Dr Sofía Fortunato
Research Fellow
University of Queensland

Dr Kay Critchell
Research Associate
University of Queensland

Dr Alana Grech
Research Fellow
James Cook University

Dr Rebecca Green
Research Associate
University of Western Australia

Dr Rio Bongers
Research Fellow
University of Queensland

Dr Thomas DeCarlo
Research Fellow
University of Western Australia

Dr Juan Pablo D’Olivo
Cordero
Research Fellow
University of Western Australia

Dr April Hall
Advance Queensland Research Fellow
James Cook University

Professor Mark McCormick
Chief Investigator
James Cook University

Professor Malcolm McCulloch
Deputy Director, ARC Australian Laureate Fellow
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Dr Mike McWilliam
Research Associate
James Cook University

Dr Oliver Mead
Research Associate
Australian National University

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University of Queensland

Professor Phillip Munday
ARC Future Fellow
James Cook University

Professor Ryan Lowe
Chief Investigator
University of Queensland

Dr John Pandolfi
Chief Investigator
James Cook University

Dr Andrew Pomeroy
Research Fellow
University of Queensland

Professor Morgan Pratchett
Chief Investigator
James Cook University

Professor Bob Pressley
Chief Investigator
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Deputy Director, ARC Australian Laureate Fellow
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James Cook University

Professor David Miller
Chief Investigator
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Associate Professor
Tiffany Morrison
Chief Investigator
James Cook University

Dr Aurélie Moya
Research Fellow
James Cook University

Professor Peter Mumby
Chief Investigator
University of Queensland

Dr Andrew Song
Research Fellow
James Cook University

Professor Karen Reynolds
Chief Investigator
James Cook University

Dr John Pandolfi
Chief Investigator
James Cook University

Dr Sarah McCormick
Chief Investigator
James Cook University

Dr Iain McMillan
Chief Investigator
James Cook University

Professor Garry Russell
Chief Investigator
James Cook University

Dr Sue-Ann Watson
Research Fellow
James Cook University and Queensland Museum

Dr Rebecca Weeks
Research Fellow
James Cook University

Dr Kennedy Wolfe
Research Associate
University of Queensland

Resident International Scholars

Dr Pip Cohen
Program Leader
WorldFish, Malaysia

Dr Gal Eyal
Marine Curie Fellow
Israel

Dr Joaquim Garrauob
Senior Research Fellow
Institut de Ciències del Mar, Spain

Dr Björn Illing
Deutscher Akademischer Austauschdienst (DAAD)
German Academic Exchange Service scholar, Germany

Dr Laurence McCook
Research Fellow
South China Sea Institute of Oceanology, China

Dr David Mills
Research Fellow
WorldFish, Malaysia

Dr Ignasi Montero-Serra
Endeavour Fellow
University of Barcelona, Spain

Dr Fernanda Terra Stori
Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) scholar, Brazil

Dr Sharon Wismer
Postdoctoral Fellow
Swiss National Science Foundation Switzerland

Dr Jodie Rummer
Research Fellow
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Research Fellow
University of Western Australia

Dr Eugenia Sampayo
Research Fellow
University of Queensland

Dr Verena Schoepf
Research Fellow
University of Western Australia

Dr Andrew Song
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James Cook University and WorldFish, Malaysia

Dr Tim Staples
Research Fellow
University of Queensland

Dr Greg Torda
Research Fellow
James Cook University and Australian Institute of Marine Science

Dr Erin Vaughn
Research Fellow
Australian National University

Dr Heather Veilleux
Research Fellow
James Cook University

Dr Julie Vercelloni
Research Associate
University of Queensland

Dr George Roff
Research Fellow
University of Queensland

Dr Cristian Rojas
Research Fellow
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Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) scholar, Brazil

Dr Sharon Wismer
Postdoctoral Fellow
Swiss National Science Foundation Switzerland
In 2018, researchers from the ARC Centre of Excellence produced 383 publications, comprising 354 journal articles, 2 books, 18 book chapters, and 9 reports. Since 2014, journal article publications have increased 25%, exceeding one each day. Centre researchers published 155 articles in journals with an Impact Factor greater than four, including 33 prestige journals – Nature and other Nature journals, Science, the Trends journals, Genome Biology, Biological Reviews, Science Advances, ISEM Journal and Proceedings of the National Academy of Sciences. The average Impact Factor for all 354 journal articles in 2018 was 5.9. The Centre’s research outputs were published this year in a total of 136 journal titles, spanning many fields of research and reflecting the multidisciplinary breadth of the Centre’s activities.

According to Scopus, Centre researchers were cited 45,461 times in 2018, 26% more than 2017. In 2018, they had 730 citations with an h-index of 10.

The 7 articles published in 2018 that received the highest Altmetric scores for ARC Centre publications were:


**2018 Publications**

**Book (2)**


**Book Section (18)**


**Journal Articles**


113. Farfan, GA, Cordes, EE, and water insecurity in Southeast Asia marine resource use in 121-135. 31(1):
119. Goldberg, JA, Marshall, NA, and fishery management can balance conservation
126. Goldberg, JA, Marshall, NA, and other outcomes in terrestrial
125. Graham, NE, Wilson, K, C, and Meekan, MG, McCormick, MI, and Cappo,
113. Farfan, GA, Cordes, EE, and water insecurity in Southeast Asia marine resource use in 121-135. 31(1):
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126. Goldberg, JA, Marshall, NA, and other outcomes in terrestrial
125. Graham, NE, Wilson, K, C, and Meekan, MG, McCormick, MI, and Cappo,


2019 Activity Plan

1. Research
   a. Review the Centre's research programs in preparation for new and ongoing projects for 2019–2021.
   b. Develop further the Centre's research program ‘Coral Reefs in the Anthropocene’, with an emphasis on social science, governance and adaptation.
   c. Publish further outputs of the National Coral Bleaching Taskforce, targeting high profile journals, especially Science and Nature.
   d. Continue to extend the Centre's interdisciplinary research capacity by recruiting two Research Fellows: one with expertise in Social-Ecological Systems and one in the Centre's research theme of People and Ecosystems.
   e. Provide training to support Centre members' knowledge of the Australian Code for Resonsible Conduct of Research and the ARC Centre's Digital Data Management Policy.

2. Research Training and Professional Development
   a. Deliver professional development workshops on statistics, bio-informatics, grant writing, publishing strategies and skills, and preparing documentation for job applications.
   b. Deliver programs for the National Student Mentoring Day, Student and Early Career Researcher Retreats, and attendance at the Centre's annual symposium (Student and Postdoc Committees)
   c. Continue to progress a leadership development program for women in STEM for PhD students through to Research Fellows.
   d. Deliver workshops and mentoring in unconscious bias and gender stereotypes.
   e. Initiate a human ethics training program for ARC Centre social scientists.

3. National and International Linkages
   a. Strengthen the Centre's research with WorldFish on the Small-scale Fisheries Flagship project (FISH CRP), including the recruitment of a third Research Fellow based at the ARC Centre.
   b. Recruit a fourth Research Fellow, co-funded with the Australian Institute of Marine Science, who will focus on the population genetics of corals.
   c. Increase research fellow exchanges, working group meetings and co-tutelle PhD student arrangements with international partners and collaborators.
   d. Extend multi-institutional and/or multi-disciplinary supervisory arrangements for Centre students.

4. Impacts and End User Engagement
   a. Expand the Coral Reef Health in the Coral Sea Marine Park assessment project for the Australian Government Director of National Parks.
   b. Continue to engage with government and stakeholders to provide the science that underpins the Reef 2050 Plan.
   c. Plan and deliver the Centre's Annual Symposium and Public Forum on the Future of Coral Reefs in Sydney in October.
   d. Appoint a Digital Communications Officer, and review the Centre's social media engagement strategies – including expanding the Centre's video library and Instagram.

5. Governance
   a. Review membership of the Centre's Advisory Board to assist strategic planning for the future of the Centre.
   b. Review the ARC Centre's Strategic Plan for business continuity post ARC Centre of Excellence funding to strengthen and diversify income sources.
   c. Mentor female researchers and mid-career researchers into leadership roles in the Centre.
   d. Continue developing a Centre culture that values diversity, gender equity and family friendly practices.
   e. Review the Centre's KPI data collection and reporting system in view of changed reporting requirements.

Financial Statement

ARC Centre of Excellence for Coral Reef Studies
Statement of Operating Income and Expenditure for year ended 31 December 2018

<table>
<thead>
<tr>
<th></th>
<th>2017</th>
<th>2018</th>
<th>2019 forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARC Centre Grant</td>
<td>$4,329,987</td>
<td>$4,394,936</td>
<td>$4,478,439</td>
</tr>
<tr>
<td>ARC Fellowships</td>
<td>1,315,029</td>
<td>660,724</td>
<td>645,207</td>
</tr>
<tr>
<td>ARC Other</td>
<td>130,290</td>
<td>123,773</td>
<td>135,812</td>
</tr>
<tr>
<td>Host Institutions cash support</td>
<td>3,777,803</td>
<td>3,909,991</td>
<td>4,006,691</td>
</tr>
<tr>
<td>State Government</td>
<td>150,800</td>
<td></td>
<td>112,500</td>
</tr>
<tr>
<td>Commonwealth Government other grants</td>
<td>618,053</td>
<td>564,950</td>
<td>610,243</td>
</tr>
<tr>
<td>International and other contracts</td>
<td>1,268,373</td>
<td>1,173,993</td>
<td>1,222,930</td>
</tr>
<tr>
<td>Total Income</td>
<td>$11,590,335</td>
<td>$10,828,367</td>
<td>$11,211,823</td>
</tr>
</tbody>
</table>

|                             |         |         |               |
| Expenditure                 |         |         |               |
| Salaries                    | $7,503,235 | $7,709,719 | $7,905,116    |
| Equipment                   | 469,063  | 482,849 | 478,205       |
| Travel                      | 1,323,863 | 1,431,301 | 1,485,870     |
| Research maintenance and consumables | 1,215,379 | 1,328,190 | 1,422,977     |
| Scholarships and prizes     | 178,581  | 169,268 | 182,041       |
| Public outreach and administration | 134,183  | 129,245 | 142,610       |
| Total Expenditure           | $10,824,302 | $11,250,572 | $11,616,819  |

|                             |         |         |               |
| Surplus (Deficit)           | $765,113 | ($422,205) | ($404,996)    |
Financial Outlook

As at December 2018, the total cash and in-kind financial outlook for the ARC Centre of Excellence for Coral Reef Studies for 1 January 2014 to 31 December 2020 totals $149.9m, 23% higher than when the Centre was established in 2014. The ARC Centre of Excellence grant represents 20% of the total funding pool.

Key Performance Indicators

### Standard Key Performance Indicators for ARC Centres of Excellence

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Target 2018</th>
<th>Outcome 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of research outputs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Journal articles/books/book chapters (p71)</td>
<td>330</td>
<td>383</td>
</tr>
<tr>
<td>• Published Datasets (p52)</td>
<td>30</td>
<td>42</td>
</tr>
<tr>
<td>Quality of research outputs (p71)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Publications in journals with Impact Factor &gt;4</td>
<td>95</td>
<td>155</td>
</tr>
<tr>
<td>• Mean Impact Factor for journals published</td>
<td>4.5</td>
<td>5.9</td>
</tr>
<tr>
<td>• Citations: total by Centre researchers</td>
<td>25,000</td>
<td>45,461</td>
</tr>
<tr>
<td>• Centre researchers with &gt;500 annual citations</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>• Awards and prizes (p10)</td>
<td>28</td>
<td>43</td>
</tr>
<tr>
<td>Number of training courses held/offered by the Centre (p43)</td>
<td>26</td>
<td>30</td>
</tr>
<tr>
<td>(over and above the standard courses offered by institutions)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of workshops/conferences held/offered by the Centre (p43)</td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>Number of additional researchers working on Centre research (p43)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Postdoctoral researchers</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>• PhD students</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>• Masters by research/coursework students</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>• Honours students</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Number of postgraduate completions (p43)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• PhD students</td>
<td>25</td>
<td>22</td>
</tr>
<tr>
<td>• Masters by research/coursework students</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>• Honours students</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Number of mentoring programs offered by the Centre (p43)</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Number of presentations/briefings (p59)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• To the public</td>
<td>38</td>
<td>70</td>
</tr>
<tr>
<td>• To government/agencies/industry/business/end-users/NGOs</td>
<td>80</td>
<td>105</td>
</tr>
<tr>
<td>(national and international)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(in addition to workshops/conferences above)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of new organisations collaborating with, or involved in, the Centre</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Centre-specific Key Performance Indicators**

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Target 2018</th>
<th>Outcome 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publications (p71)</td>
<td>• Prestige publications (e.g., Nature, Science, PNAS) 100 over life of Centre</td>
<td>33 (129 to date)</td>
</tr>
<tr>
<td>Interdisciplinarity of research</td>
<td>• No. of journal titles in which Centre of Excellence research published (p71) 100</td>
<td>136</td>
</tr>
<tr>
<td></td>
<td>• No. of students with multi-disciplinary supervisory arrangements (p43) 50</td>
<td>52</td>
</tr>
<tr>
<td>Centre integration (p71)</td>
<td>• No. of publications with cross-institutional co-authorship 185</td>
<td>306</td>
</tr>
<tr>
<td>Global reach (p54)</td>
<td>• No. of countries where Centre undertakes field research 24</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>• No. of international co-authors 300</td>
<td>1,255</td>
</tr>
<tr>
<td></td>
<td>• No. of invited talks/papers/keynotes at international meetings 26</td>
<td>42</td>
</tr>
<tr>
<td>Media (p59)</td>
<td>• Commentaries about the Centre's achievements 4,000</td>
<td>9,711</td>
</tr>
<tr>
<td></td>
<td>• Articles 26</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>• Centre of Excellence Website hits 7.0m</td>
<td>11.9m</td>
</tr>
<tr>
<td>International visitors (p57)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender equity</td>
<td>• Research Fellow appointments (p68) 50:50</td>
<td>50:50</td>
</tr>
<tr>
<td></td>
<td>• Gender equity and diversity mentoring, and training activities: no. of participants and attendances (p43) 20</td>
<td>27</td>
</tr>
</tbody>
</table>

**Acknowledgements**

The ARC Centre of Excellence for Coral Reef Studies thanks the following organisations and partners for their ongoing support:

- Australian Academy of Science
- Australian Centre for Field Robotics, University of Sydney
- Australian Centre for International Agricultural Research (ACIAR)
- Australian Genome Research Facility (AGRF)
- Australian Government: Department of the Environment and Energy
- Australian Institute of Marine Science (AIMS)
- Australian Coral Reef Society
- Australian Marine Sciences Association
- Australian Museum
- Australian Society for Fish Biology
- Beijing Genomics Institute Australia
- Bigelow Laboratory for Ocean Sciences, USA
- Center for Ocean Solutions, Stanford University, USA
- Centre de Recherches Insulaires et Observatoire de l'Environnement (CRIOBE), French Polynesia
- Centre National de la Recherche Scientifique (CNRS), France
- Charles Darwin University, Australia
- Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia
- Company of Biologists, UK
- Conservation International
- Coral Reef Research Foundation, Palau
- Deutsche Forschungsgemeinschaft, Germany
- Deutsche Forschungsgemeinschaft Excellence Cluster 'Future Ocean', University of Kiel, Germany
- Fisheries Research and Development Corporation, Canberra
- Georgia Institute of Technology, USA
- Great Barrier Reef Foundation, Australia
- Great Barrier Reef Marine Park Authority, Australia
- Harvey Mudd College, USA
- Hotwater Wildlife Research Endowment, Equity Trustees Charitable Foundation
- Ian Potter Foundation
- Institut des récifs coralliens du Pacifique (IRCP), French Polynesia
- International Union for the Conservation of Nature
- James S. McDonnell Foundation, USA
- King Abdullah University of Science and Technology, Saudi Arabia
- Lizard Island Research Station and Foundation, Australia
- Lord Howe Island Board, Australia
- Mahonia Na Dari and Walindi Plantation Resort, Papua New Guinea
- Marine Parks Authority, Lord Howe Island Marine Park, Australia
- Ministry of Fisheries, Tonga
- Morris Family Foundation, Australia
- National Environment Science Programme, Australia
- National Institute for Environmental Studies (NIES), Japan
- National Institute of Water and Atmospheric Research (NIWA), New Zealand
- National Oceanic and Atmospheric Administration (NOAA), USA
- National Research Foundation of South Africa
- National Science Foundation, USA
- National Socio-Environmental Synthesis Center (SESYNC), University of Maryland, USA
- National University of Singapore
- Northern Territory Department of Primary Industries and Resources
- Oceania Chondrichthyan Society, Australia
- Okinawa Institute of Science and Technology Graduate University, Japan
- Palau International Coral Reef Center
- Paul M Angell Family Foundation, USA
- Pew Charitable Trusts, USA
- Prince Albert II of Monaco Foundation, Monaco
- Queensland Government Department of Agriculture and Fisheries
- Queensland Department of Environment and Science
- Queensland Department of Natural Resources, Mines and Energy
- Queensland Museum Network
- Reef Rescue, Australia
- Schmidt Ocean Institute, USA
- Sea World Research and Rescue Foundation, Australia
- Secretariat for the Pacific Community, Noumea
- Sesoko Station, Tropical Biosphere Research Center, University of the Ryukyus, Japan
- Smithsonian Marine Network, USA
- Society for Experimental Biology
- Stockholm Resilience Centre, Sweden
- The Crawford Fund, Australia
- The Nature Conservancy, International
- Torres Strait Regional Authority
- University of California, Los Angeles (UCLA), USA
- University of Exeter, United Kingdom
- University of Perpignan, France
- Western Australian Department of Primary Industries and Regional Development
- Western Australian Department of Biodiversity, Conservation and Attractions
- Western Indian Ocean Marine Science Association (WIOMSA), Zanzibar
- Wildlife Conservation Society, USA
- WorldFish, Malaysia
- World Wildlife Fund
- Yale Peabody Museum, USA