



ANNUAL REPORT 2018

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VISION

Scientific knowledge that fosters sustainable use, adaptive governance and effective management of the world's coral reefs to enhance human wellbeing.

MISSION

To lead the global research effort in the provision of scientific knowledge necessary for sustaining the ecosystem goods and services of the world's coral reefs during a period of unprecedented environmental change.

AIMS

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.

OVERVIEW

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.



DIRECTOR'S
REPORT



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

PHOTO CHRISTOPHER BRUNNER

International Year of the Reef

HRH The Prince of Wales officially opened the *International Year of the Reef* in London with a highly publicised speech that referenced two of the ARC Centre's research papers, both published in the journal *Science* in January 2018.

Marine reserve effectiveness

Garry Russ and Rene Abesamis provided multiple briefings to communities and local government officials on the outcomes of their long-term marine reserve research conducted across the Philippines.

Coral Triangle Initiative

Peter Mumby presented a forum on methods for rebuilding fisheries to Ministers of Indonesia, Philippines, Malaysia, Solomon Islands, Timor Leste, and Papua New Guinea at a Coral Triangle Initiative meeting in Manila.

International impact

Senator Sheldon Whitehouse (Democrat, Rhode Island) presented a 15 minute address to the United States Congress 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.

Capacity building with partners

Joshua Cinner presented a two-day workshop for researchers at WorldFish headquarters, Penang on how to structure manuscripts, navigate the peer review process and build a portfolio of publications. WorldFish produced a series of training videos from the workshops and made them available to the public via YouTube.

Socioeconomic impacts of conservation

Georgina Gurney was an invited expert at a workshop held by the Wildlife Conservation Society on identifying and understanding the socioeconomic impacts of conservation. The workshop involved conservation practitioners and scientists associated with coral reef management in five countries across the Indo-Pacific.

Wastewater and coral reefs

Jon Brodie delivered a briefing in Kuwait, on wastewater management for coral reefs, to the Regional Organisation for the Protection of the Marine Environment (ROPME). The briefing was based on the findings of his report, commissioned by the United Nations Environment Programme (UNEP).

International environmental policy

Ove Hoegh-Guldberg was a participant at the Intergovernmental Panel on Climate Change (IPCC) 1.5 Impact Meeting held in Botswana, where he instructed members on the impacts of global warming and climate change on the world's coral reefs.

Spatial planning to support reef fisheries

Nils Krueck (p28) and Peter Mumby led a capacity building workshop with 35 key partners to share knowledge and expertise on spatial planning and marine reserves to support reef fisheries and biodiversity.

FameLab

PhD student Taryn Laubenstein was a national finalist in the *FameLab* competition for her 'tail' of two fishes dealing with climate change. *FameLab* is a live science communication competition that aims to discover charismatic early career scientists who can inspire people to see the world from new perspectives.

Multi-objective planning in northern Australia

Jorge Álvarez-Romero led two workshops on scenario-planning in the Fitzroy River Catchment, attended by 40 people from 32 organisations. The workshops developed scenarios describing possible and contrasting futures for the development of the region.

Torres Strait water quality

Jon Brodie provided multiple briefings to the Torres Strait Regional Authority and Torres Strait community on his research on ecosystem threats caused by pollution from the Fly River, Papua New Guinea.

Coral Sea Monitoring Program

Morgan Pratchett, Andrew Hoey and Hugo Harrison led a team of researchers and government representatives on expeditions to the Coral Sea as part of a multi-year coral monitoring program, commissioned by the Australian Director of National Parks (p55). The program was instigated after reports from ARC Centre researchers showed unprecedented bleaching in the Coral Sea during 2016.

Wildlife documentary

Jodie Rummer's research in French Polynesia was the central focus of a full-length documentary, *Introducing PHYSIOSHARK: Baby Sharks and Climate Change*. The film was aired at the New York City Wildlife Conservation Film Festival and Barbados Film Festival.

Recreational fishing compliance

The Great Barrier Reef Marine Park Authority conducted a media campaign to reduce illegal fishing. The campaign was motivated by the research of PhD Student Brock Bergseth who found that nearly one third of fishers surveyed from the Great Barrier Reef witnessed poaching, but most did nothing about it (p20).

Outlook Report Science Consensus Workshop

Eight ARC Centre researchers participated in a 4-day scientific consensus workshop to inform the Great Barrier Reef Marine Park Authority's *Outlook Report 2019*. The Outlook Report, published every five years, is an assessment of the status of the Great Barrier Reef designed to inform government policy.

Reef monitoring by tourism industry

Morgan Pratchett and Tom Bridge provided advice to Great Barrier Reef tourism operators about the viability of undertaking some simple monitoring on the reef, during a two-day forum in Cairns convened by Tourism Tropical NQ.

Indigenous capacity building

ARC Centre graduate students participated in the Aboriginals and Torres Strait Islanders in Marine Science (ATSIMS) program, sponsored by the ARC Centre. 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.

Climate change briefing to Parliament

Tiffany Morrison, Terry Hughes, Ove Hoegh-Guldberg and Graeme Cumming briefed Australian parliamentarians on climate change and the Great Barrier Reef, following the release of the 2018 IPCC Report in South Korea. Members of Parliament attending included the Shadow Minister for Climate Change and Energy, the Honourable Mark Butler MP, the Shadow Minister for Innovation, Industry, Science and Research, Senator the Honourable Kim Carr, and Queensland Senator and Deputy Leader of the Greens Party, Senator the Honourable Larissa Waters.

IPCC



PHOTO TOM GABRIEL JOHANSEN

Centre expertise contributes to latest IPCC report calling for swift response to climate change

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 reef ecosystems and undermine the benefits they provide to hundreds of millions of people, mostly in poor, rapidly-developing countries.

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.”

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.

WORLD RESEARCH LEADER



PHOTO PASCALE DIGEAUX

Global recognition of coral reef scientist

ARC Centre Director, **Terry Hughes** is recognised globally for his research on coral reefs. His innovative work has been cited more than 50,000 times and he is a recognised authority, being sought after and quoted in prestigious international media outlets such as *The New York Times*, *The Guardian*, *The Washington Post* and *BBC News*.

His commitment to better understanding coral reef ecosystems and his tireless drive to communicate the importance of coral reefs to the general public was recognised with multiple awards in 2018.

In June, HSH Prince Albert II of Monaco presented Terry with the **2018 Climate Change Award** at a prestigious ceremony held at the Grimaldi Forum in Monaco. The award recognises his contribution to advancing understanding of the influence of rapid climate change on the world’s coral reefs.

In November, at a ceremony in London co-hosted by the leading international scientific journal *Nature*, Terry was one of two recipients of the **John Maddox Prize**. The award recognises individuals who demonstrate commitment to public discussion about scientific research in the face of scrutiny and adversity. Terry received the award in recognition of his efforts to expose the extent of coral reef damage caused by climate change, despite hostility and criticism from climate sceptics.

Also in November, Terry was awarded the **AG Huntsman Medal** in recognition of his innovative science for sustainable management of coral reef biodiversity. The award was established by the Bedford Institute of Oceanography in 1980 and is presented by the Royal Society of Canada to a marine scientist of any nationality who has made ‘a significant influence on the course of marine scientific thought’.

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. The same two papers made **Carbon Brief’s list of ‘Top 10 climate papers’** most featured in the media in 2018:

Hughes, TP, Anderson, KD, Connolly, SR, Heron, SF, Kerry, JT, Lough, JM, Baird, AH, Baum, JK, Berumen, ML, Bridge, TC, Claar, DC, Eakin, CM, Gilmour, JP, Graham, NAJ, Harrison, H, Hobbs, J-PA, Hoey, AS, Hoogenboom, M, Lowe, RJ, McCulloch, MT, Pandolfi, JM, Pratchett, M, Schoepf, V, Torda, G and Wilson, SK (2018). **Spatial and temporal patterns of mass bleaching of corals in the Anthropocene**. *Science* 359(6371): 80-83.

Hughes, TP, Kerry, JT, Baird, AH, Connolly, SR, Dietzel, A, Eakin, CM, Heron, SF, Hoey, AS, Hoogenboom, MO, Liu, G, McWilliam, MJ, Pears, RJ, Pratchett, MS, Skirving, WJ, Stella, JS and Torda, G (2018). **Global warming transforms coral reef assemblages**. *Nature* 556(7702): 492-496.



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 inclusive practice award, 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.

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.

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.

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 by the Australian Coral Reef Society with award of the **Early Career Researcher Medal**. Joleah Lamb received the **Outstanding Early Career Alumnus Award** from James Cook University, and Susan McIntyre-Tamwoy was honoured with James Cook University's Outstanding Alumni Award.



Centre researchers recognised in Young Tall Poppy awards

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 Poppy 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".

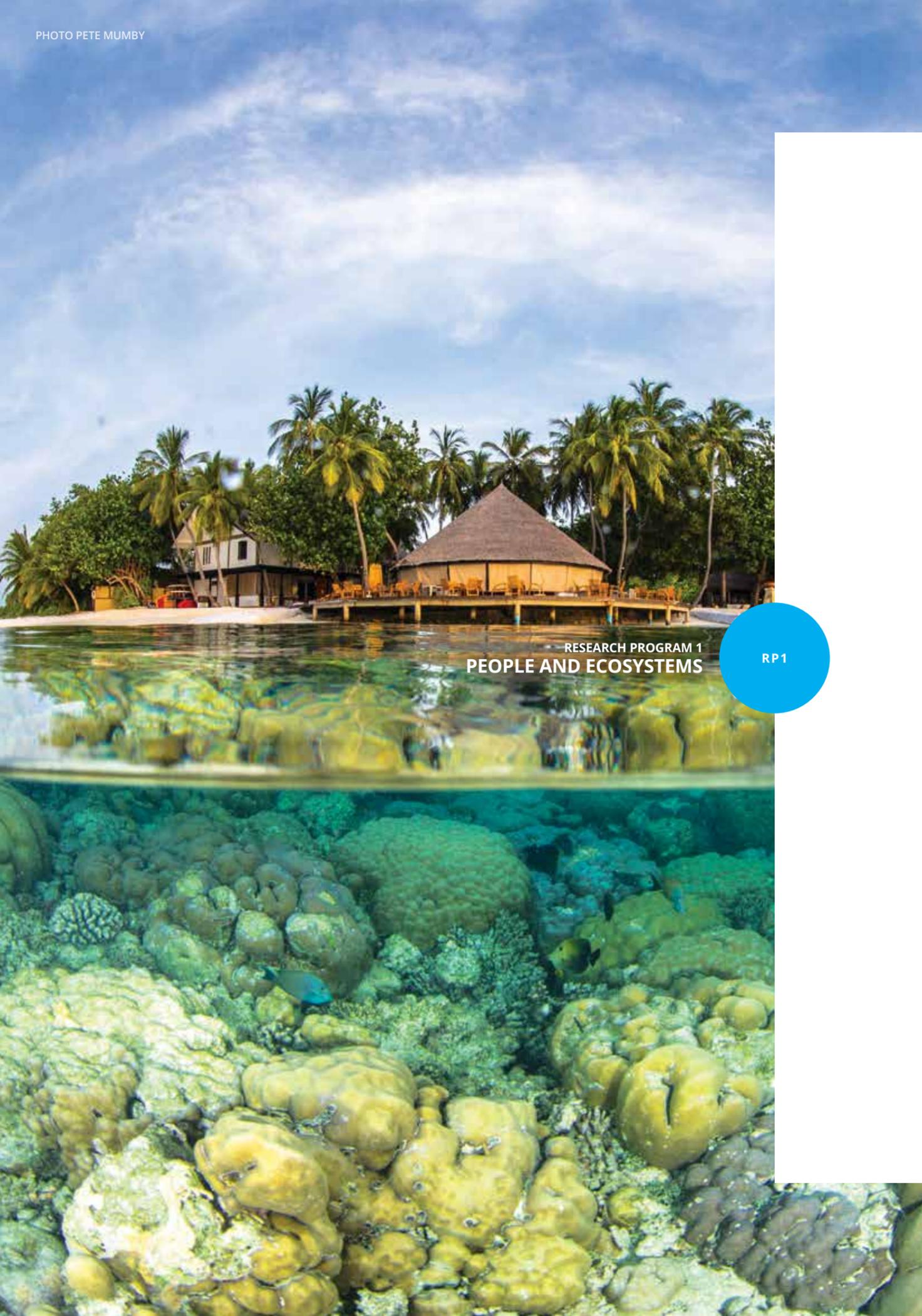
Also among the group of exceptional researchers were **Georgina Gurney**, a Research Fellow and Fulbright Scholar at the ARC Centre's James Cook University node, and **Verena Schoepf**, a Program Leader and Research Fellow at the University of Western Australia node. Both received Young Tall Poppy Science 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.





RESEARCH PROGRAM 1
PEOPLE AND ECOSYSTEMS

RP1



PROFESSOR TERRY HUGHES FAA

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

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*.



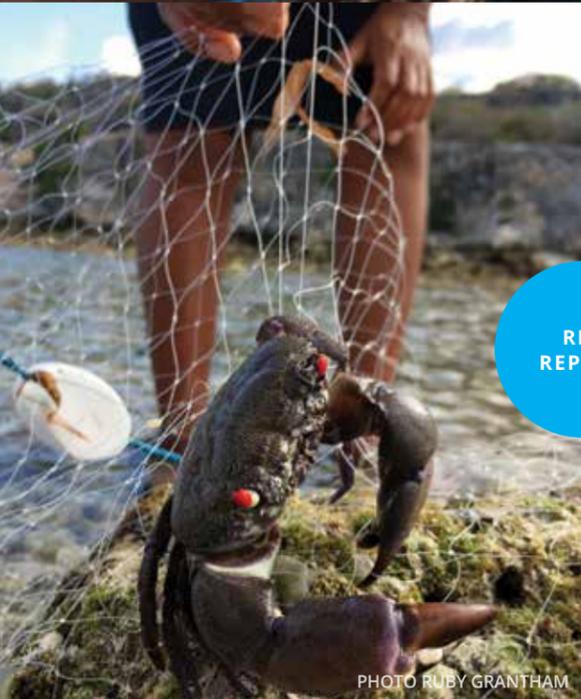
PROFESSOR BOB PRESSEY FAA

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.



PHOTO RUBY GRANTHAM



RP1
REPORT

PHOTO RUBY GRANTHAM



PHOTO RUBY GRANTHAM

Research in Program 1 focusses 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 the trade-offs and co-benefits in the multiple outcomes of marine management and conservation.

Fisheries and gender specialist Danika Kleiber joined the ARC Centre in 2018 as a joint research fellow with WorldFish. Two visiting researchers, Seth Sykora-Bodie (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, Italy. 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).

MEDIA
RELEASE
19 JUNE

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.

The scientists also studied how differences in ecological conditions between marine reserves, where fishing is prohibited, and places open to fishing changed as human pressures increased. “This tells you where you can get the biggest impact from implementing conservation,” said Professor Cinner.

“A really novel and exciting part of our study found that the greatest difference in fish biomass between marine reserves and places open to fishing was in locations with medium to high human pressure. This means that, for most fisheries species, marine reserves have the biggest bang where human pressures are medium to high,” he said.

“However, top predators such as sharks were a different kettle of fish,” said co-author Dr Aaron MacNeil from Dalhousie University.

The scientists encountered top predators on less

than 30% of their surveys conducted all across the globe, and very rarely in locations where human pressures were high.

Dr Michele Barnes from the ARC Centre said 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 top predators or improving the biomass of key fisheries species, and likewise, where they will be wasting their time,” he said.

Cinner, JE, Maire, E, Huchery, C, Aaron MacNeil, M, Graham, NAJ, Mora, C, McClanahan, TR, Barnes, ML, Kittinger, JN, Hicks, CC, D'Agata, S, Hoey, AS, Gurney, GG, Feary, DA, Williams, ID, Kulbicki, M, Vigliola, L, Wantiez, L, Edgar, GJ, Stuart-Smith, RD, Sandin, SA, Green, A, Hardt, MJ, Bejer, M, Friedlander, AM, Wilson, SK, Brokovich, E, Brooks, AJ, Cruz-Motta, JJ, Booth, DJ, Chabanet, P, Gough, C, Tupper, M, Ferse, SCA, Rashid Sumaila, U, Pardede, S and Mouillot, D (2018). **Gravity of human impacts mediates coral reef conservation gains.** *Proceedings of the National Academy of Sciences of the United States of America* 115(27): E6116-E6125.

Media highlight: UPI.com - **Marine reserves are essential, but increasingly stressed**, 19 June 2018

PHOTO NICK GRAHAM

The Conservation Planning Database

FIND OUT MORE

MEDIA
RELEASE
12 SEPT

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 Morena 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-government organisations can identify regions and topical 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.

Álvarez-Romero, JG, Mills, M, Adams, VM, Gurney, GG, Pressey, RL, Weeks, R, Ban, NC, Cheok, J, Davies, TE, Day, JC, Hamel, MA, Leslie, HM, Magris, RA and Storlie, CJ (2018). **Research advances and gaps in marine planning: towards a global database in systematic conservation planning.** *Biological Conservation*. 227: 369-382.

Media highlight: ECO Magazine **The Conservation Planning Database**, J Álvarez-Romero, Nov/Dec 2018



RESEARCHER
PROFILE

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.

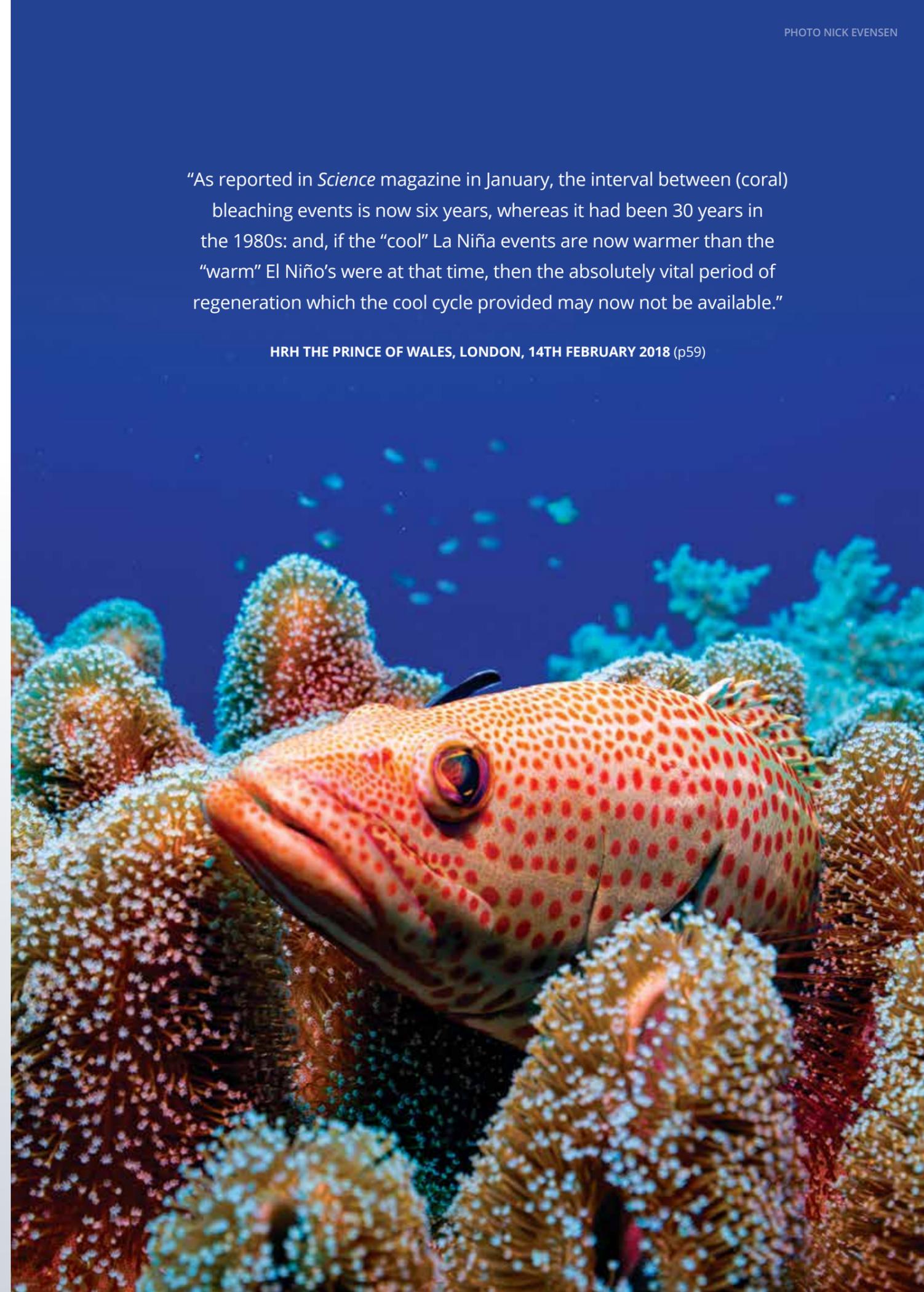
Michele undertook her PhD at the University of Hawai‘i, USA. Supported by the National Oceanic and Atmospheric Administration’s (NOAA) Pacific Islands Fisheries Science Centre, her doctoral research integrated social network science, ecological modeling and economics to provide a novel examination of 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)





The majority of people who see poaching in marine parks say nothing

By Brock Bergseth, Georgina Gurney and Joshua Cinner

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).

PHOTO JUSTIN RIZZARI

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.

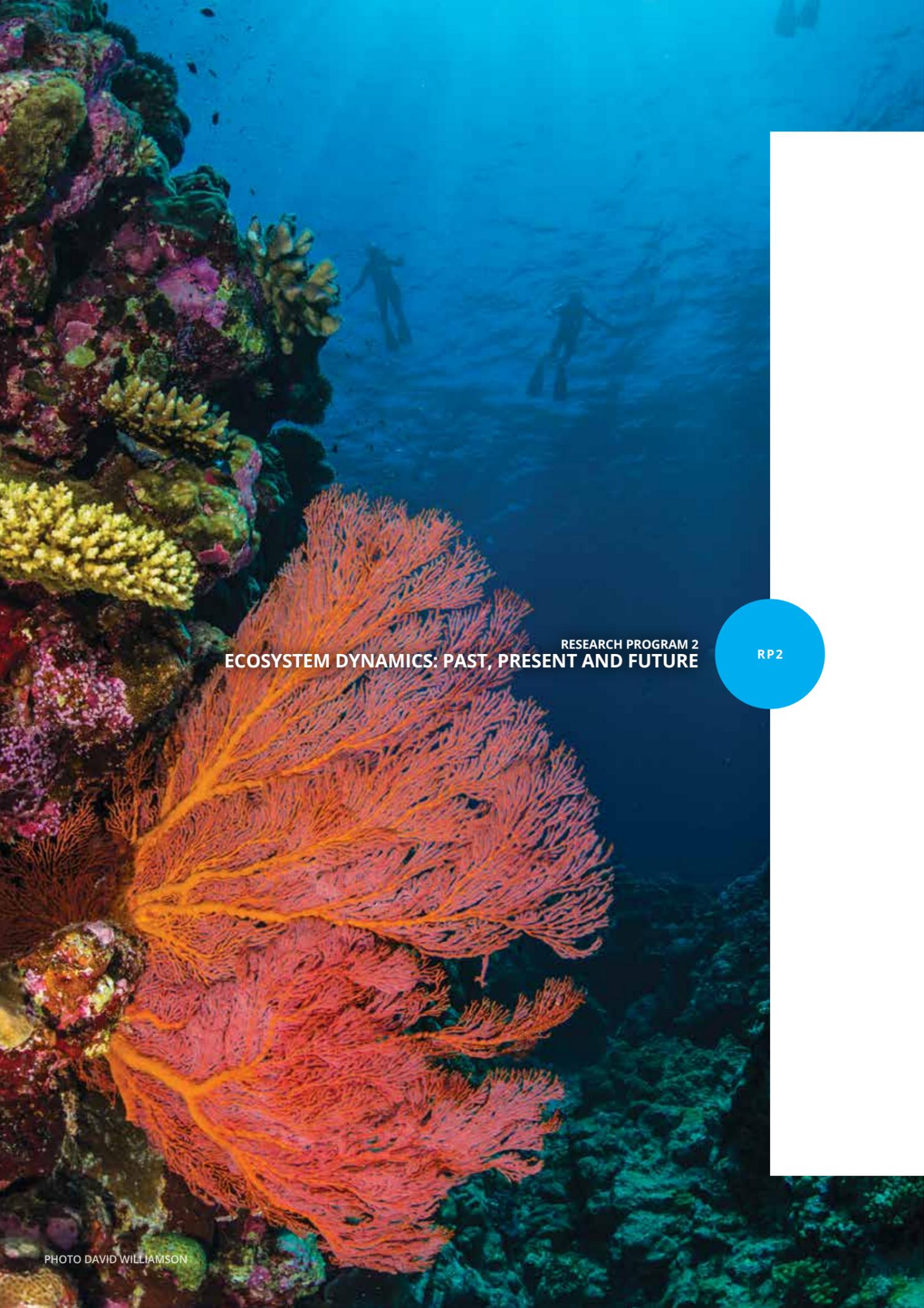
THE CONVERSATION

Original article: <https://theconversation.com/the-majority-of-people-who-see-poaching-in-marine-parks-say-nothing-101456>



PHOTO BROCK BERGSETH





RESEARCH PROGRAM 2
ECOSYSTEM DYNAMICS: PAST, PRESENT AND FUTURE

RP2



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.



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 Paleontological Society (2016).



DR VERENA SCHOEPF

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.

Researchers: Kristen Anderson, Andrew Baird, David Bellwood, Pim Bongaerts, Michael Bode, Yves-Marie Bozec, Tom Bridge, Jon Brodie, Severine Choukroun, Peter Cowman, Kay Critchell, Tom DeCarlo, Graeme Cumming, April Hall, Hugo Harrison, Karlo Hock, Andrew Hoey, Terry Hughes, Geoff Jones, Michael Kingsford, Nils Krueck, Ryan Lowe, Vimoksalehi Lukoschek, Robert Mason, Laurence McCook, Mark McCormick, Michael McWilliam, Vanessa Messmer, Peter Mumby, Philip Munday, Stephen Palumbi, Serge Planes, Morgan Pratchett, George Roff, Garry Russ, Eugenia Sampayo, Tim Staples, Greg Torda, Sue-Ann Watson, Kennedy Wolfe.



RP2
REPORT



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 Pratchett 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 Rummer 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.

"As part of a global heat and coral bleaching event spanning 2014-2017, the Great Barrier Reef

experienced severe heat stress and bleaching again in 2017, this time affecting the central region of the Great Barrier Reef," said co-author Dr Mark Eakin of the US National Oceanic and Atmospheric Administration.

"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.

Hughes, TP, Kerry, JT, Baird, AH, Connolly, SR, Dietzel, A, Eakin, CM, Heron, SF, Hoey, AS, Hoogenboom, MO, Liu, G, McWilliam, MJ, Pears, R, Pratchett, MS, Skirving, WJ, Stella, JS and Torda, G (2018) **Global warming transforms coral reef assemblages**. *Nature*. 556: 492 – 496.

Media highlight: Scientific American – **Recent ocean heat waves have "forever" altered Great Barrier Reef**, 19 April 2018



PHOTO PETER MUMBY

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."

Ortiz, J-C, Wolff, NH, Anthony, KR, Devlin, M, Lewis, S, and Mumby, PJ (2018). **Impaired recovery of the Great Barrier Reef under cumulative stress**. *Science Advances*. 4(7): eaar6127.

Media highlight: IFLScience! - **Coral reefs are recovering poorly from disasters and deep reefs can't help**, 20 July 2018

PHOTO MIA HOOGENBOOM





RESEARCHER
PROFILE

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.

The prospect that MPAs can be designed to benefit fisheries, especially in coral reef-dependent communities, triggered broad public interest in Nils' research, resulting in media articles and television and radio interviews. More importantly, Nils' discoveries have made real-world impact. His research findings and MPA design approaches are now the basis of three reserve design software programs, which he has co-developed. Since 2015, Nils has led 12 workshops and delivered courses on his research and the use of these software programs. He has also been closely involved in the development of marine spatial management plans for more than 30 regions around the world, primarily in Indonesia. Some of these plans have been officially approved for implementation. Nils's research is supported by the World Bank project *Capturing Coral Reef and Related Ecosystem Services* (CCRES), in close collaborations with the World Wildlife Fund, who are offering independent MPA design courses based on his work.

ARTICLE
19 OCT



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.

IMAGE LEFT: With sharp pointed teeth, the new piranha-like fish from Jurassic seas probably fed on the fins of other fishes. From the time of dinosaurs and from the same deposits that contained the first feathered proto-bird Archaeopteryx scientists recovered both this flesh-tearing fish and its scarred prey. Fishes with parts of fins missing point to the exploitation of a widespread and renewable resource. Credit: G. Horschitzky (Jura-Museum Eichstätt, Germany)

This bony creature, found in South Germany, lived about 150 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 forming 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, who led the study.

"It comes from a group of fishes (the pycnodontids) 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."

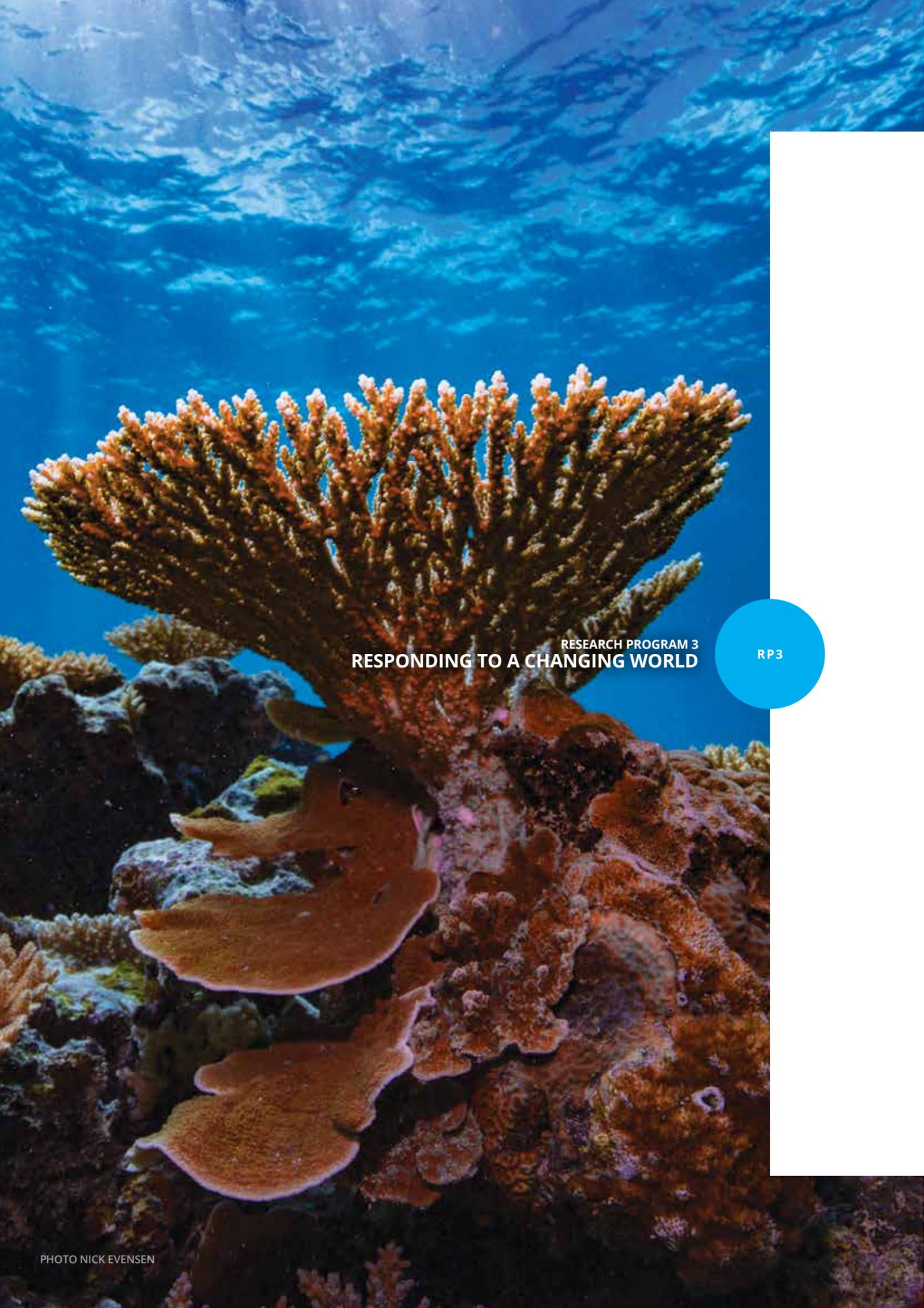
It also shows the value of studying fossils, as the area where the fish were found is among the best known fossil locations in the world but continues to throw up surprise findings like this one.

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.

BBC News

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RESEARCH PROGRAM 3
RESPONDING TO A CHANGING WORLD

RP3



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*, he 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*.

Researchers: Kristen Anderson, Natalia Andrade-Rodriguez, Andrew Baird, Dorothea Bender-Champ, Pim Bongaerts, Tom Bridge, Steeve Comeau, Sean Connolly, Christopher Cornwall, Peter Cowman, Thomas DeCarlo, Juan Pablo D'Olivo Cordero, Jennifer Donelson, Sophie Dove, François Dufois, James Falter, Sofia Fortunato, Rebecca Green, Hugo Harrison, Ove Hoegh-Guldberg, Björn Illing, Michael Kingsford, Janice Lough, Ryan Lowe, Vimoksalehi Lukoschek, Oliver Mead, David Miller, Aurélie Moya, Philip Munday, Stephen Palumbi, Andrew Pomeroy, Morgan Pratchett, Jodie Rummer, Aleksey Sadekov, Eugenia Sampayo, Verena Schoepf, Greg Torda, Erin Vaughn, Heather Veilleux, Julie Vercelloni, Sue-Ann Watson.



PHOTO NICK EVENSEN



RP3
REPORT

PHOTO MIKE McMILLIAM



PHOTO CAMILLE GRIMALDI

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*, involving Program 3 researchers David Miller and the late Sylvain Forêt, revealed the adaptive evolution of functions related to coral-dinoflagellate symbiosis. Genomes of multiple corals were sequenced and published in 2018 by an international research consortium, co-led by Sylvain Forêt and David Miller. These genomic resources are now publicly available, allowing unprecedented insight into the biology of corals and their symbionts.

A highlight of 2018 was the publication of a major study by PhD student Claire Ross (p51), Tom DeCarlo and Malcolm McCulloch (p36) on the environmental

and physio-chemical controls on coral calcification along the large latitudinal temperature gradient of the Western Australian coastline. Coral calcification rates and the internal carbonate chemistry of coral calcifying fluid compositions inside coral colonies were measured using geochemical proxies (boron isotopes, elemental systematics), to test the vulnerability of corals to ocean acidification. PhD student Rebecca Green and Ryan Lowe collaborated with the Australian Institute of Marine Science and the Schmidt Ocean Institute to investigate the biophysical oceanography at Scott Reef, a system of remote oceanic atolls off northwest Australia. Field observations and numerical modelling were used to investigate how large tides interact with the atolls to influence the hydrodynamics and circulation, and therefore control the spatial and temporal distribution of water quality parameters including nutrients and temperature. This research was documented in three ground-breaking papers, the last of which detailed localised patterns of temperature variability and how it influenced coral bleaching within the atolls during the 2016 global mass bleaching event.

Program 3 researchers have been active in building international collaborations. In November, Philip Munday, Jennifer Donelson and Jodie Rummer hosted a joint workshop co-sponsored by the ARC Centre and King Abdullah University of Science and Technology (KAUST), in Western Australia. This long-term collaboration between Program 3 and KAUST led to several major publications in 2018. For example, one study in *Nature Climate Change* (P34), 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 also 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 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 (p8).

MEDIA
RELEASE
1 MAY

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, when 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.

Ryu, T, Veilleux, H, Donelson, JM, Munday, PL and Ravasi, T (2018). **The epigenetic landscape of transgenerational acclimation to ocean warming.** *Nature Climate Change*. 8: 504 – 509.

Media highlight: UPI – **For reef fish, tolerance for warming waters comes from their parents' DNA**, 1 May 2018

PHOTO MARK MCCORMICK



PHOTO CLAIRE ROSS

MEDIA
RELEASE
2 MAY

Internal control helps corals resist acidification

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."

DeCarlo, TM, Comeau, S, Cornwall, CE and McCulloch, MT (2018). **Coral resistance to ocean acidification linked to increased calcium at the site of calcification.** *Proceedings of the Royal Society B*. 285:20180564.

Media highlight: Science Daily – **Internal control helps corals resist acidification**, 2 May 2018



RESEARCHER PROFILE

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-west 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 geochemical 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 Australia 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.



Tiny coral paradise in the Great Barrier Reef reckons with climate change

ARTICLE
3 FEB

By Helen Sullivan

PHOTO TORY CHASE

Heron 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 over-all 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 tanks, each containing a miniature reef: one or two sea cucumbers, a few small fish, and the same seven species of coral. Dove refers to the tanks as mesocosms ("medium worlds"). Over the past eight years, by varying the temperature and

carbon-dioxide levels of the water, she has been able to simulate how these mini-reefs respond to five climate-change scenarios. The first mimics the cooler, less acid ocean environment before the industrial revolution. The second reproduces the ocean of today, based on readings from buoys in the Coral Sea. The third conjures a world where we reduce emissions somewhat; Dove refers to this as 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.

So far, Dove has found, the pre-industrial and present-day mini-reefs appear healthy. Left to their own devices, she said, 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-in-our-belts tanks, there had been a little more growth than dissolution; in the business-as-usual tanks, there had been no growth at all. This is bad news not only for corals but for all the other species, on land and at sea, that depend on them.

One of the difficult things about climate change is that we struggle to imagine it. A living edifice such as the Great Barrier Reef can, to the human mind, seem too permanent, too complicated to fail. But here, on Heron Island, the world was just small enough—a mesocosm—for its precariousness to feel real.

THE
NEW YORKER

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<https://www.newyorker.com/tech/annals-of-technology/tiny-coral-paradise-in-the-great-barrier-reef-reckons-with-climate-change>

Impacts of climate change on World Heritage coral reefs

Climate change is affecting many World Heritage properties, and coral reefs are feeling the brunt of global warming. Contemporary mass bleaching and mortality of corals is already frequent and widespread throughout the tropics. The ARC Centre undertakes research in all of Australia's World Heritage listed coral reefs – The Great Barrier Reef, Ningaloo Reef, Shark Bay, and Lord Howe Island. In 2018, ARC Centre researchers published many high-profile papers on the back-to-back 2016 and 2017 bleaching event on the Great Barrier Reef, and on the third global bleaching event triggered by record-breaking sea temperatures in 2015–2016. In two reports commissioned by the United Nations Educational, Scientific and Cultural Organization (UNESCO), ARC Centre researchers Kristen Anderson, Ove Hoegh-Guldberg, Terry Hughes and PhD student Jon Day contributed to the first global scientific assessment of the impacts of climate change on the World Heritage-listed coral reefs, and their prospects for the future (Heron *et al.* 2017; 2018).

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 International Union for Conservation of Nature (IUCN) *Protected Areas Climate Change Specialist Group* has adopted the CVI as a project for their current (2018–19) work plan. The *Climate Change and Heritage Working Group* of the International Council on Monuments and Sites (ICOMOS) is also supportive of developing the CVI for assessing the vulnerability of cultural heritage places to climate change.



PHOTO CLAIRE ROSS

CASE STUDY

Shark Bay World Heritage Area, Western Australia

A **first application** of the CVI assessment was undertaken during a climate change vulnerability workshop at Shark Bay in September 2018, in collaboration with the Shark Bay World Heritage Advisory Committee and supported by various Australian government agencies. Twenty-one participants (including managers, practitioners and researchers) considered the attributes of OUV and the projected impact of three important climate drivers on Shark Bay: storm intensity and frequency, extreme marine heat events, and air temperature change. In the past decade, these three climate drivers have influenced more OUV attributes than any other drivers.

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.

Heron, S, Eakin, M, Douvère, F, Anderson, K, Day, J, Geiger, E, Hoegh-Guldberg, O, van Hooidonk, R, Hughes, T, Marshall, P and Obura, D (2017). **Impacts of Climate Change on World Heritage Coral Reefs: A First Global Scientific Assessment**. UNESCO World Heritage Centre, Paris.

Heron, S, van Hooidonk, R, Maynard, J, Anderson, K, Day, J, Geiger, E, Hoegh-Guldberg, O, Hughes, T, Marshall, P, Obura, D and Eakin, M (2018). **Impacts of Climate Change on World Heritage Coral Reefs: Update to the First Global Scientific Assessment**. UNESCO World Heritage Centre, Paris.

Shark Bay: A World Heritage Site at catastrophic risk

By Matthew Fraser, Ana Sequeira, Brendan Paul Burns, Diana Walker, Jon C. Day and Scott Heron

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 billions 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.

PHOTO W. BULACH/WIKIMEDIA COMMONS, CC BY-SA

To understand the potential impacts of climatic 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 900 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, Nhandu 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.



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THE CONVERSATION

Original article: <https://theconversation.com/shark-bay-a-world-heritage-site-at-catastrophic-risk-111194>

ARTICLE
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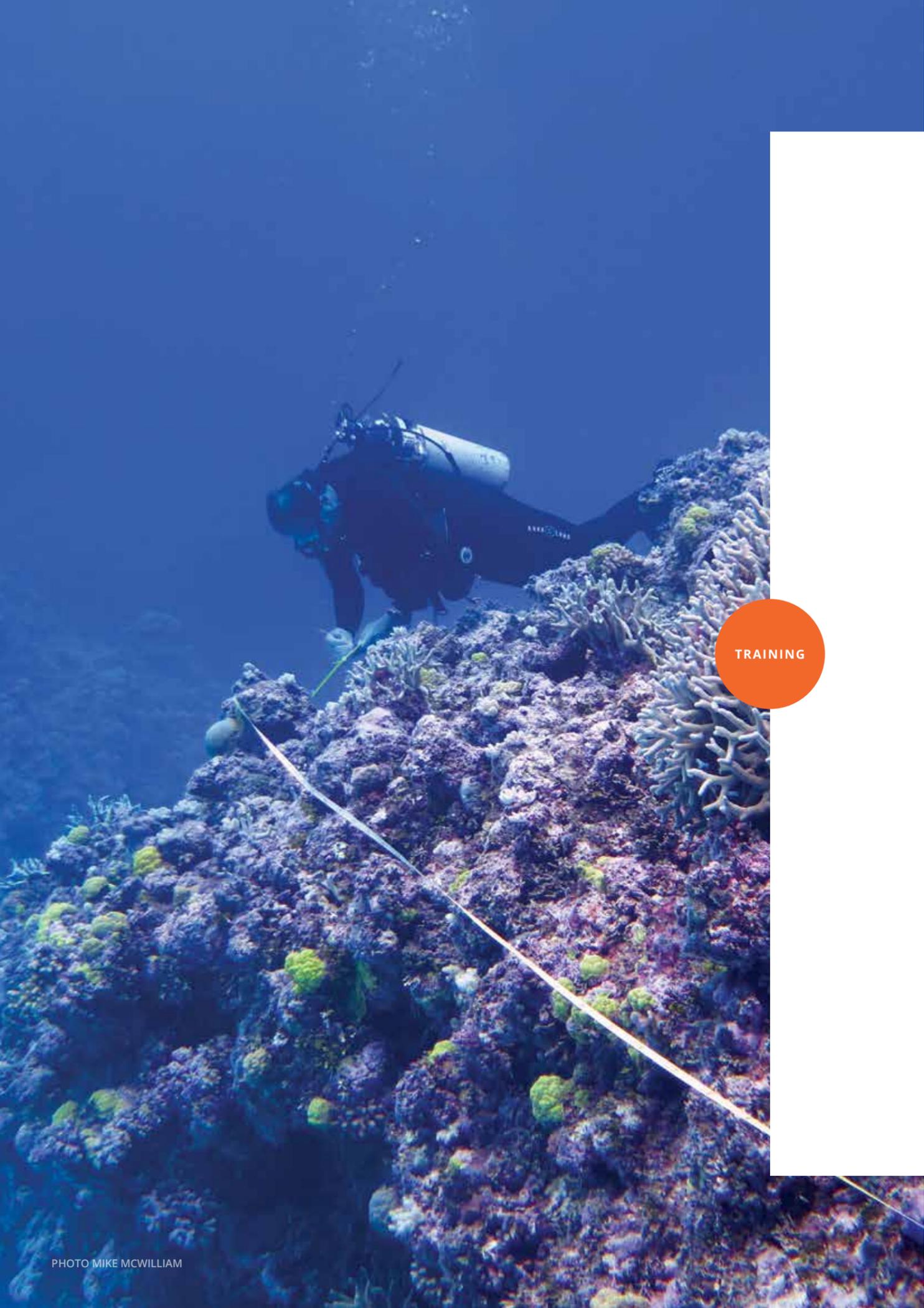


PHOTO MIKE MCWILLIAM

Graduate and Early Career Training

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

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.

Students supported by the ARC Centre achieved many prizes and accolades in 2018, for example:

- Alexia Graba-Landry and Shannon McMahon 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 McMahon, Alexia Graba-Landry, and Laura Puk to their annual conference, held at Exmouth, Western Australia.
- Mia Comeros was awarded a *Coral Reef Conservation Program Domestic Coral Reef Conservation Grant* from the US National Oceanic and Atmospheric Administration.
- Katie Motson was awarded a *Holsworth Wildlife Research Endowment Grant* from the Ecological Society of Australia.
- The Australian Society of Fish Biology provided funding to support the travel and research of Pauline Narvaez, Rachel Spinks, Renato Morais Araujo and Tiffany Sih, and awarded presentation prizes to Robert Streit and Christopher Hemingson at their annual conference.
- Shanna Grafeld was awarded a *Graduate Education Scholarship* from the American-Australian Association.
- Jacqueline Lau received an *International Agricultural Student Award* from the Crawford Fund to support her research in Malaysia and the Solomon Islands. She also received a *Student Presentation Award* at the Society of Conservation Biology's International Marine Conservation Congress.

- Veronica Radice received the *Ron Kenny Student Presentation Prize* at the Australian Marine Sciences Association annual conference, and Shannon McMahon received an *Outstanding Presentation Prize* at the Australian Coral Reef Society annual conference.
- Patrick Smallhorn-West received the 2018 *Glenn Almany Memorial Prize* for his research on marine reserves in Tonga. This prize is awarded to graduate students whose coral reef research required them to work with people beyond traditional academic boundaries, to make a difference, or which has the potential to influence policy, management or practice.
Smallhorn-West, PF, Bridge, TCL, Malimali, S, Pressey, RL, and Jones, GP (2018). **Predicting impact to assess the efficacy of community-based marine reserve design.** *Conservation Letters* 2018: e12602.
- 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.
Alvarez-Noriega, M, Baird, AH, Dornelas, M, Madin, JS and Connolly, SR (2018). **Negligible effect of competition on coral colony growth.** *Ecology* 99(6): 1347 – 1356.
Kim, SW, Blomberg, SP and Pandolfi, JM (2018). **Transcending data gaps: a framework to reduce inferential errors in ecological analyses.** *Ecology Letters* 21(8): 1200 – 1210.
McWilliam, M, Hoogenboom, MO, Baird, AH, Kuo, C-Y, Madin, JS and Hughes, TP (2018). **Biogeographical disparity in the functional diversity and redundancy of corals.** *Proceedings of the National Academy of Sciences* 115(12): 3084 – 3089.
Richardson, LE, Graham, NAJ, Pratchett, MS, Eurich, JG and Hoey, AS (2018). **Mass coral bleaching causes biotic homogenization of reef fish assemblages.** *Global Change Biology* 24(7): 3117 – 3129.
Ross, CL, Schoepf, V, DeCarlo, TM and McCulloch, MT (2018). **Mechanisms and seasonal drivers of calcification in the temperate coral *Turbinaria reniformis* at its latitudinal limits.** *Proceedings of the Royal Society B* 285: 20180215.

2018 PhD Students in the ARC Centre

Student Name	Institution	Country	Thesis Title	ARC Centre Advisors
Michelle Achlatis	UQ	The Netherlands	Bioeroding sponges in a time of change: insights into the physiology and cell biology of a photosymbiotic coral-eroding sponge. (PhD awarded)	S Dove, O Hoegh-Guldberg
Samantha Aird	JCU	Australia	Socio-ecological dynamics in archaeological shellfish fisheries: a case from the Keppel Islands, Great Barrier Reef, Australia	A Hoey
Mariana Alvarez Noriega	JCU	Mexico	Coexistence-promoting mechanisms in reef-coral communities.	S Connolly, A Baird, M Hoogenboom
Natalia Andrade Rodriguez	JCU	Ecuador	Non-contact competition between soft and hard corals: a transcriptomic perspective. (PhD awarded)	D Miller, A Moya
Danielle Asson-Batzel	JCU, AIMS, CSIRO, Museum of Tropical Queensland (MTQ)	USA	Multi-scale patterns of benthic species composition in the Great Barrier Reef region and implications for spatial management.	R Pressey, S Connolly, T Bridge
Kevin Bairos Novak	JCU	Canada	Metapopulation dynamics of coral polyp dispersal and juvenile fish recruitment after severe bleaching events	S Connolly, M Hoogenboom
Anne Bauer-Civiello	JCU	USA	From people to reef, marine debris and plastic pollution in north Queensland.	M Hoogenboom
Brock Bergseth	JCU	USA	Poaching in marine protected areas: Drivers of and responses to illegal fishing. (PhD awarded)	J Cinner, D Williamson, G Russ
Chloë Boote	JCU	United Kingdom	The larval development, microbiome, and stress response of the mushroom coral <i>Heliofungia actiniformis</i> .	D Miller, A Moya
Ian Bouyoucos	JCU	USA	A challenging environment in a changing world for juvenile sharks: ecological energetics of climate change with implications toward conservation.	J Rummer
Kristen Brown	UQ	USA	The dynamics of coral-algal interactions on coral reef ecosystems. (PhD awarded)	S Dove, O Hoegh-Guldberg
Christopher Brunner	JCU, AIMS	Germany	Cumulative impacts of water quality and climate change (sea surface temperature warming and ocean acidification) on important reef species.	M Hoogenboom
Ramona Brunner	JCU	Germany	The function and ligands of g-protein coupled receptors (GPCRS) in coral larvae settlement.	D Miller, A Moya
Dominic Bryant	UQ	Australia	The effects of global and local disturbance towards spatial patterns of coral in the Central Indian Ocean. (PhD awarded)	O Hoegh-Guldberg, S Dove
Alexander Buck	JCU	Australia	Microbiology of crown-of-thorns starfish.	M Pratchett
Cüneyt Caglar	ANU	Germany	Sponge and coral regeneration: Cellular and molecular characterisation of regeneration in reef-building invertebrates.	M Adamska
Paula Joy Cartwright	UWA	Australia	Metocean processes and anthropogenic influences in the southern coastal Pilbara/Exmouth Gulf: what are the primary drivers of water quality and habitat distribution?	R Lowe
Leela Chakravarti	JCU, AIMS, U Melbourne	United Kingdom	Manipulation of coral photosymbionts for enhancing resilience to environmental change.	M van Oppen, M Hoogenboom, B Willis
Tory Chase	JCU	USA	Effects of fish abundance and diversity on host coral dynamics.	M Hoogenboom, M Pratchett
Sivee Chawla	JCU	India	Understanding ecosystem service choices made by individual actors and their implications for social-ecological interactions.	G Cumming, T Morrison
Jessica Cheok	JCU	Brunei	Systematic conservation planning in marine environments – sensitivities of the planning framework to aspects of scale. (PhD awarded)	R Pressey, R Weeks
Harry Clarke	UWA	Australia	Resolving the impacts of ocean warming and dredging in coral cores collected from the NW shelf of Australia.	M McCulloch, J P D'Olivio Cordero

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 surgeonfish assemblages in American Samoa.	A Hoey, G Russ
Mario Conde-Frias	UWA	Colombia	Investigating the sediment dynamics within submerged canopies for unidirectional and oscillatory flows.	R Lowe
Bruna Contro de Godoy	ANU	Brazil	Genetic basis of evolutionary and developmental origin of animal cell types.	M Adamska
Amy Coppock	JCU	United Kingdom	Climate change and disturbance events: the role of settlement behaviour 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 Mumby
Daniel Raj David	UWA	India	The interaction of WECs in an array and its influence on coastal processes.	R Lowe
Jonathan Day	JCU, CSIRO	Australia	Planning and managing the Great Barrier Reef – lessons learned for the future planning of the Reef and implications for marine protected areas elsewhere.	R Pressey, T Morrison
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, USC	Seychelles	The role of rabbitfish in a marine environment, and their contribution towards the resilience of tropical coral reefs.	P Mumby
Hannah Epstein	JCU, AIMS	USA	Investigating the drivers of microbial community composition in reef-building corals. (PhD awarded)	P Munday, G Torda
Estefania Erazo Mera	JCU	Ecuador	Assessing cumulative impacts of land use in the wet tropics catchments on the Great Barrier Reef.	R Pressey, A Grech
Jacob Eurich	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 Evensen	UQ	United Kingdom	Bottlenecks of coral recovery on degraded reefs.	P Mumby, YM Bozec
Legana Fingerhut	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
Anjani Ganase	UQ	Trinidad and Tobago	Patterns and drivers that determine the structure and composition of typical Caribbean seascapes. (PhD awarded)	O Hoegh-Guldberg, S Dove, P Mumby
Bettina Glasl	JCU, AIMS	Austria	Microbial indicators for environmental stress and ecosystem health assessment.	B Willis

Student Name	Institution	Country	Thesis Title	ARC Centre Advisors
Saul Gonzalez Murcia	JCU	El Salvador	The impact of parrotfishes on the coral new recruits.	G Jones, G Russ
Alexia Graba-Landry	JCU	Canada	The effect of temperature on seaweed-herbivore interactions on tropical coral reef systems.	A Hoey, M Pratchett
Shanna Grafeld	JCU	USA	Market structures, trade networks and governance of coral reef fisheries across a development gradient.	M Barnes, J Cinner, T Morrison
Ruby Grantham	JCU, WorldFish	United Kingdom	The temporal dynamics of reef fisheries as part of diversified coastal livelihoods.	G 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 <i>Fungia fungites</i> coral.	D Miller, P Cowman
Rodrigo Gurdek	JCU, AIMS	Uruguay	Spatial and temporal connectivity dynamics on the Great Barrier Reef Marine Park using genomics and biophysical modelling.	H Harrison
Nataly Gutierrez Isaza	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 Munday
Kynan Hartog-Burnett	JCU	Australia	Population ecology of common baitfish species in the Indo-Pacific.	M Kingsford
Margaux Hein	JCU, CSIRO, GBRMPA	Monaco	Characterising the effectiveness of coral restoration to build reef resilience: a socio-ecological perspective.	B Willis
Christopher Hemingson	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 Bongaerts, A Hoey
Sybill Hess	JCU	Switzerland	The effects of suspended sediments on the physiology and behaviour of coral reef fishes.	J Rummer, A Hoey
Tessa Hill	JCU, MTQ	United Kingdom	Direct and indirect effects of ocean acidification on reef corals.	M Hoogenboom, S-A Watson
Kyle Hillcoat	JCU	Australia	Latitudinal variations in age-based demography of three large predatory reef fishes (<i>Lutjanus sebae</i> , <i>Lutjanus malabaricus</i> and <i>Lutjanus erythropterus</i>) in Queensland, Australia.	G Russ, G Jones
Lucy Holmes McHugh	JCU, WorldFish	Australia	Power and participation in seascape conservation in the Anthropocene: 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, R Pressey
Victor Huertas Martin	JCU	Spain	Feeding ecology of corallivorous reef fishes.	D Bellwood, S Connolly
Michael Jarrold	JCU	United Kingdom	The effects of natural variation in CO ₂ and rising CO ₂ on coral reef fish.	P Munday, 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

Student Name	Institution	Country	Thesis Title	ARC Centre Advisors
Saskia Jurriaans	JCU, Centre Scientifique de Monaco	Netherlands	Thermal acclimation and the geographic range limits of reef-building corals.	M Hoogenboom, S Connolly
Tania Kenyon	UQ	Australia	Physical and biological dynamics of post-disturbance coral reef rubble fields.	P Mumby, S Dove
Sun Kim	UQ	South Korea	Evolution and ecology of coral range dynamics.	J Pandolfi
Catherine Kim	UQ	USA	Determining drivers of benthic composition, marine biodiversity, and coral health in Timor-Leste.	O Hoegh-Guldberg, S Dove
Chelsea Korpanty	UQ	USA	Ecological dynamics of Pleistocene corals. (PhD awarded)	J Pandolfi
Alyson Kuba	JCU	USA	Effects of ocean warming on coral reproduction and transgenerational effect: comparison of genetic and epigenetic mechanisms of resilience.	A Baird, M Hoogenboom
Felicity Kuek	JCU, AIMS	Malaysia	Dimethylsulfoniopropionate (DMSP) metabolism within the coral holobiont.	D Miller, A Moya
Marie Lapointe	JCU	Canada	Understanding ecosystem service preferences and wellbeing benefits along a rural-urban gradient.	G Cumming, G Gurney
Jacqueline Lau	JCU, U.Lancaster	Australia	Winners and losers in marine conservation: investigating access to coral reef ecosystem services.	J Cinner, G Gurney
Taryn Laubenstein	JCU	USA	Adaptive potential of coral reef fishes to ocean acidification.	P Munday, J Rummer
Sarah Lawless	JCU, WorldFish	Australia	The diffusion of meta-norms in natural resource governance.	T Morrison, P Cohen, A Song
Katie Lee	UQ	Australia	Early warning of tipping points of coral reefs.	P Mumby
Johanna Leonhardt	JCU	Australia	Spatial dynamics in the territories of <i>Stegastes</i> spp. relative to coral growth, disease and mortality within Opal reef.	M Pratchett, M Hoogenboom, A Hoey
Zoe Loffler	JCU	Australia	Influence of canopy-forming macroalgae on key reef processes.	A Hoey, M Pratchett
Jake Lowe	JCU	Australia	Effects of no-take marine reserve protection on abundance and demography of tropical wrasses.	G Russ
Chancey Macdonald	JCU, MTQ	New Zealand	Depth patterns in coral reef fish distributions and microhabitat associations: are deep reefs a refuge?	G Jones, T Bridge
Eva Maire	JCU, U. Montpellier	France	How heterogeneity of socio-economic and ecological factors affect the facets of biodiversity in coral reef ecosystems.	J Cinner, A Hoey
Hannah Markham	UQ	United Kingdom	Long-term ecological dynamics along a gradient of anthropogenic activity on the inshore Great Barrier Reef. (PhD awarded)	J Pandolfi, G Roff
Robert Mason	UQ, NOAA	Australia	Coral responses to temperature, irradiance and acidification stress: linking physiology to satellite remote sensing. (PhD awarded)	S Dove, O Hoegh-Guldberg
Samuel Matthews	JCU, AIMS	Australia	Modelling outbreaks of crown-of-thorns starfish: coupling biophysical, demographic and connectivity processes.	M Pratchett, V Messmer
Emmanuel Mbaru	JCU, U.Lancaster	Kenya	Diffusion of a gear based conservation innovation in coral reef fisheries.	J Cinner, T Morrison, M Barnes
Eva McClure	JCU	Australia	The impact of typhoons on the effectiveness of marine reserve networks in the Coral Triangle.	G Russ, A Hoey
Shannon McMahan	JCU	Australia	Effects of rising water temperature and food availability on predatory reef fish.	J Donelson, P Munday
Jennifer McWhorter	UQ, U. Exeter	United Kingdom	Coral reef futures under climate change and ocean acidification.	P Mumby
Michael McWilliam	JCU	United Kingdom	The functional diversity and redundancy of corals.	T Hughes, M Hoogenboom
Matheus Antonio Mello Athayde	UQ	Brazil	<i>Porites cylindrica</i> (Dana, 1846), a resilient coral found on the Great Barrier Reef: present and future coral physiology.	S Dove

Student Name	Institution	Country	Thesis Title	ARC Centre Advisors
Michalis Mihalitsis	JCU	Greece	Predator-prey interactions in coral reef fishes: ecology and function.	D Bellwood, S Connolly and function.
Rebecca Millington	UQ, U. Exeter	United Kingdom	Modelling the role of biodiversity in ecosystem resilience to climate change.	P Mumby
Meira Mizrahi	JCU	Australia	Maximizing potential impact of marine protected area (MPA) placement: an integrated socio-economic perspective.	R Pressey, R Weeks
Jose Montalvo Proano	JCU, AIMS	Ecuador	Mechanisms involved in the potential acclimation of corals to future environmental conditions.	P Munday
Stefano Montanari	JCU, AIMS	Italy	Causes and consequences of natural hybridisation among coral reef butterflyfishes (<i>Chaetodon: chaetodontidae</i>). (PhD awarded)	M Pratchett
Renato Morais Araujo	JCU	Brazil	Habitat effects on coral reef fish growth and biomass production.	D Bellwood, S Connolly
Katie Motson	JCU	United Kingdom	The impacts of coral reef health on fish-parasite interactions.	A Hoey
Pauline Narvaez	JCU	France	Food preferences of cleaner organisms and the impact of cleaning interactions on pathogen transmission.	M McCormick
Tiffany Nay	JCU	USA	Physiological and behavioural strategies used by fish to mitigate the effects of ocean warming.	A Hoey, M Pratchett
Nery Contti Neto	UWA	Brazil	Field observations of sediment dynamics within coastal benthic ecosystems.	R Lowe
Samuel Payet	JCU	Australia	The role of hybridisation in the evolution of coral reef fishes.	H Harrison, G Jones, M Pratchett
Katie Peterson	JCU	USA	Ecological drivers of community stability in space and time.	T Hughes, S Connolly
Mark Priest	UQ, Palau ICRC	United Kingdom	A multi-disciplinary approach to predictive management of coral reef fisheries.	P Mumby
Abdi Priyanto	UQ, MMAF Indonesia	Indonesia	Marine spatial planning in Indonesia: options for improved efficiency.	P Mumby
Laura Puk	UQ	Germany	Population dynamics of the brown <i>Macroalga lobophora</i> sp. and its control by herbivorous fish.	P Mumby
Veronica Radice	UQ	USA	Trophic ecology and microbial communities of shallow and deep reef-building corals of the Maldives, Indian Ocean.	O Hoegh-Guldberg, S Dove
Blake Ramsby	JCU, AIMS	USA	The effects of a changing marine environment on the bioeroding sponge <i>Cliona orientalis</i> . (PhD awarded)	M Hoogenboom
Jeremy Raynal	JCU	USA	Assessing the potential for recreational fishing to contribute to conservation of coastal marine species and habitats.	B Pressey, R Weeks
Laura Richardson	JCU, U.Lancaster	United Kingdom	Variation in structure and function of reef fish assemblages among distinct coral habitats. (PhD awarded)	A Hoey, M Pratchett
Johan Risandi	UWA	Indonesia	Assessing the hydrodynamics and morphodynamics of a reef-fringed pocket beach.	R Lowe
Thomas (Ed) Roberts	JCU, AIMS, MTQ	Australia	Ecological determinates of depth zonation in reef-building corals. (PhD awarded)	A Baird, T Bridge
Claire Ross (p51)	UWA	Australia	Environmental controls on the growth and physiology of high-latitude coral in the south-west region of Western Australia. (PhD awarded)	M McCulloch, V Schoepf, T DeCarlo
Cristina Ruano Chamorro	JCU	Spain	Equity in fisheries co-management: social-ecological determinants and trade-offs.	J Cinner, G Gurney
Edmond Sacre	JCU	Australia	Conservation planning to make a difference: developing strategies to maximise conservation impact.	R Pressey, R Weeks
Netramani (Netra) Sagar	UWA	India	Reconstructing climate and anthropogenic signals on the Indian Ocean margins using geochemistry of marine calcifiers.	M McCulloch, A Sadekov

Student Name	Institution	Country	Thesis Title	ARC Centre Advisors
Katie Sambrook	JCU, GBRMPA	United Kingdom	Beyond the reef: the influence of seascape structure on fish communities and ecological processes on reefs.	A Hoey, G Cumming
Jodie Schlaefer	JCU	Australia	Determining the population structures of cubozoan jellyfishes with biophysical modelling.	M Kingsford
Molly Scott	JCU, AIMS	Australia	Mechanisms of behavioural thermoregulation in coral trout on the Great Barrier Reef, Australia.	M Pratchett
Katherine Sievers	JCU	USA	The influence of multiple habitat types on no take marine reserve performance, fish community structure, and demographics of important fishery species.	G Russ, G Jones
Tiffany Sih	JCU, AIMS	USA	Fisheries for deep sea snappers.	M Kingsford
Carrie Sims	UQ	Australia	Community ecology of corals and their symbionts.	J Pandolfi
Alexandre Siqueira Correa	JCU	Brazil	Regulators of coral reef diversity through space and time.	P Cowman, D Bellwood
Patrick Smallhorn-West	JCU, MTQ	Canada	Efficacy of community-based marine management in the Kingdom of Tonga.	G Jones, T Bridge, B Pressey, G Gurney
Blake Spady	JCU, MTQ	USA	The effects of projected near-future CO ₂ on cephalopod behaviours and physiology.	S-A Watson, P Munday
Jessica Spijkers	JCU, U Stockholm	Sweden	The future for governing highly migratory straddling stocks: conflict or cooperation?	T Morrison, G Cumming
Rachel Spinks	JCU	Australia	Keeping up with climate change: the evolutionary potential of coral reef fishes to rising sea temperature.	P Munday, J Donelson
Robert Streit	JCU	Kenya	Spatial ecology and space use in browsing herbivorous reef fishes: ecological drivers and effects on ecosystem function.	D Bellwood, G Cumming
Sarah Sutcliffe	JCU	Australia	Macro and micro level determinants of the contribution of fish to nutritional security.	J Cinner, M Barnes, A Song
Siham Afatta Kemal Taruc	UQ	Indonesia	An assessment of the sustainability and resilience of livelihoods within an Indonesian marine social-ecological system.	O Hoegh-Guldberg
Tullia Isotta Terraneo	JCU, KAUST	Italy	Species boundaries in the coral genus <i>Porites</i> : an integrated approach.	A Baird, D Miller
Jodi Thomas	JCU, MTQ	New Zealand	The neurobiological mechanisms through which ocean acidification effects invertebrate behaviours.	P Munday, S-A Watson
Damian Thomson	JCU	Australia	Resilience of coral assemblages in north west Australia.	A Hoey, M Pratchett
Cheng-Han Tsai	JCU, AIMS	Taiwan	The structure and dynamics of reef fish communities.	S Connolly, D Bellwood
Rene van der Zande	UQ	Curacao	Exploring the physiological flexibility of reef-building corals in a changing environment. (PhD awarded)	O Hoegh-Guldberg, S Dove
Arnold van Rooijen	UWA	Netherlands	Wave-driven hydromechanics in coastal canopies.	R Lowe
Laura Velasquez Jimenez	JCU	Colombia	Effects of boat noise on parental contributions to the dynamics of coral reef fishes.	M McCormick, G Jones
Casey Whalen	JCU	USA	Coral mediation of associated microbial community.	D Miller, A Moya
Adam Wilkinson	JCU	United Kingdom	The identification of potential links between fibropapillomatosis prevalence in green sea turtles (<i>Chelonia mydas</i>) and toxic metal contamination along the Great Barrier Reef, Australia.	J Brodie
Jennifer Wilmes	JCU	Belgium	Spatial variation in the density and demography of newly settled crown-of-thorns starfish (<i>Acanthaster cf. solaris</i>).	M Pratchett, A Hoey, V Messmer
Jessica Zamborain Mason	JCU	Spain	Towards the sustainability of coral reef fisheries: a functional approach.	S Connolly, J Cinner
Kim Zoeller	JCU	South Africa	Understanding the production of cultural ecosystem services and benefits	G Cumming, G Gurney
Karin Zwiép	UQ	Netherlands	Using DNA to reconstruct past coral reef ecosystems.	J Pandolfi



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 in 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 Rottneest 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. Rottneest 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 plating 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 paleothermometry 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 even 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).

Hughes, TP, Kerry, JT and Simpson, T (2018). **Large-scale bleaching of corals on the Great Barrier Reef**. *Ecology* 99(2): 501.

Hughes, TP, Kerry, JT, Connolly, SR, Baird, AH, Eakin, CM, Heron, SF, Hoey, AS, Hoogenboom, MO, Jacobson, M, Liu, G, Pratchett, M, Skirving, W and Torda, G (2018). **Ecological memory modifies the cumulative impact of recurrent climate extremes**. *Nature Climate Change* 9: 40-43.

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).

Álvarez-Romero, JG, Mills, M, Adams, VM, Gurney, GG, Pressey, RL, Weeks, R, Ban, NC, Cheok, J, Davies, TE, Day, JC, Hamel, MA, Leslie, HM, Magris, RA and Storlie, CJ (2018). **Research advances and gaps in marine planning: towards a global database in systematic conservation planning**. *Biological Conservation* 227: 369-382.

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).

Cinner, JE, Maire, E *et al* (2018). **Gravity of human impacts mediates coral reef conservation gains**. *Proceedings of the National Academy of Sciences* 115 (27): E6116-E6125.

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 transdisciplinary 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 Graba-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 Bergseth motivated 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*.

Parks Australia (Australian Department of Environment and Energy)

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

WorldFish is one of the ARC Centre's longest standing and productive international partners. 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.

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 focusses 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 inter-governmental 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

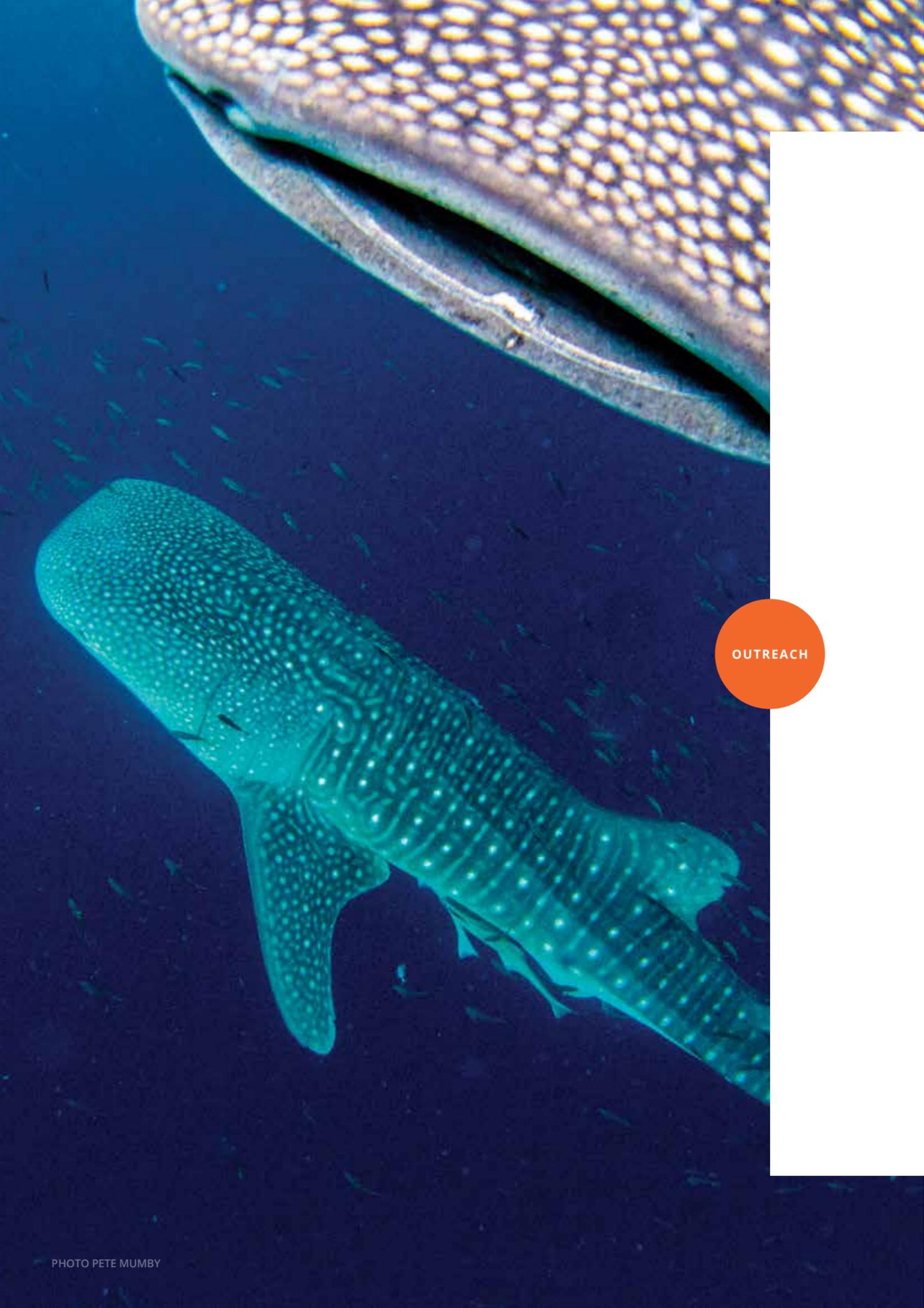
The King Abdullah University of Science and Technology (KAUST) is Saudi Arabia's premiere coral reef science institution. Its primary focus is developing a scientific basis for sustaining and conserving coral reef environments along the Red Sea coast of Saudi Arabia. Situated just north of Jeddah, KAUST 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, 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 cnidarian synthesis project at KAUST.

International visitors in 2018

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

Name	Overseas institution	Country
Prof Sigalit Abramovich	Ben Gurion University of the Negev	Israel
Prof Neil Adger	University of Exeter	United Kingdom
Yuichi Akita	Okinawa Prefectural Fisheries Research and Extension Center	Japan
Diego Alaguarda	Aix-Marseille University	France
Dr Bridie Allan	University of Otago	New Zealand
Dr Julia Baum	University of Victoria in British Columbia	Canada
Dr Andrew Bauman	National University of Singapore	Singapore
Mahaut Beghin	University of Manur	Belgium
Dr Francesca Benzoni	University of Milano-Bicocca	Italy
Prof Michael Berumen	King Abdullah University of Science and Technology	Saudi Arabia
Dr Patrick Bixler	University of Texas	United States
Dr Örjan Bodin	Stockholm Resilience Centre	Sweden
Elena Bogdaniuk	Université de Bretagne Occidentale	France
Lucrezia Bonzi	King Abdullah University of Science and Technology	Saudi Arabia
Prof Katrina Brown	Exeter University	United Kingdom
Dr Iain Caldwell	University of Hawai'i at Mānoa	United States
Lorie Chapuis	Université de Neuchâtel	Switzerland
Prof Douglas Chivers	University of Saskatchewan	Canada
Prof Ratana Chuenpagdee	Memorial University of Newfoundland	Canada
Dr Darren Coker	King Abdullah University of Science and Technology	Saudi Arabia
Kristan Cuny-Guirriec	Université Paris-Saclay	France
Dr Martina de Freitas Prazeres	Naturalis Biodiversity Center	Netherlands
Dr Michelle Devlin	Centre for Environment Fisheries and Aquaculture Science	United Kingdom
Isabel Ender	Manta Trust	United Kingdom
Dr Louisa Evans	University of Exeter	United Kingdom
Dr David Feary	MRAG	United Kingdom
Prof Maud Ferrari	University of Saskatchewan	Canada
Dr Joaquim Garrabou	Institut de Ciències del Mar-CSIC	Spain
Prof Stefan Gelcich	Pontifical Catholic University of Chile	Chile
Prof Amatzia Genin	The Hebrew University	Israel
Anna Groen	University of Köln	Germany
Dr Angela Guerrero	University of Bristol	United Kingdom
Mollie Gupta	Imperial College London	United Kingdom
Prof Emmanuel Hanert	Université Catholique de Louvain	Belgium
Johanna Hedlund	Stockholm Resilience Centre	Sweden
Dr Missaka Hettiarachichi	University of Moratuwa/WWF	Sri Lanka
Dr Lorien Jasny	Exeter University	United Kingdom
Prof Jamaluddin Jompa	Hasanuddin University	Indonesia

Name	Overseas institution	Country
Maria Jung	Universität Bremen	Germany
Dr Jonathan Lambrechts	Université Catholique de Louvain	Belgium
Ellis Larcombe	Swansea University	United Kingdom
Prof Maria Carmen Lemos	University of Michigan	United States
Dr Steve Lindfield	Coral Reef Research Foundation	Palau
Bruna Luz	University of São Paulo	Brazil
Prof Stéphanie Manel	Centre de Fonctionnelle et Evolutive	France
Prof David Mouillot	University of Montpellier	France
Dr Gerrit Nanninga	University of Cambridge	United Kingdom
Charlotte Page	Imperial College London	United Kingdom
Jeremy Pahler	Sup'Biotech - Paris	France
Ben Parry-Lemon	DePauw University	United States
Dr Chiara Pisapia	Maldives National University & IUCN Maldives	Maldives
Dr Timothy Ravasi	King Abdullah University of Science and Technology	Saudi Arabia
Dr Willem Renema	Naturalis Biodiversity Center	Netherlands
Dr Laura Richardson	University of Exeter	United Kingdom
Cyrielle Rigal	Universiti Malaysia Terengganu	Malaysia
Dr Sylvain Rigaud	Nanyang Technological University	Singapore
Dr Alice Rogers	Victoria University of Wellington	New Zealand
Dr Sonia Rowley	University of Hawaii	United States
Antoine Saint-Amand	Université Catholique de Louvain	Belgium
Hermione Sanderson	Swansea University	United Kingdom
Dr Celia Schunter	King Abdullah University of Science and Technology	Saudi Arabia
Gail Schwieterman	Virginia Institute of Marine Science	United States
Uzma Shaw	Columbia University	United States
Bryce Stewart	Environment Department University of York	United Kingdom
Dr Jarek Stolarski	Institute of Paleobiology	Poland
Seth Sykora-Bodie	Duke University	United States
Dr Fernanda Terra-Stori	Federal University of São Carlos	Brazil
Danna Titelboim	Ben Gurion University of the Negev	Israel
Dr Christine Veta Putnis	University of Münster	Germany
Dr Peter Waldie	The Nature Conservancy	Papua New Guinea
Maya Weis	Connecticut College	United States
Dr Heather Welch	University of California Santa Cruz and NOAA	United States
Prof Guojie Zhang	BGI and the University of Copenhagen	Denmark
Yuyang Zhang	South China Sea Institute of Oceanology	China
Jia Zhang	South China Sea Institute of Oceanology	China
Dr Victor Zykov	Schmidt Ocean Institute	United States



OUTREACH

Communication, Media and Public Outreach

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-nodal **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 Rummer, 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 Cumming 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 Hawai'i as part of a special screening of the film *Chasing Coral*. Also in March, Malcolm McCulloch 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 equity. In October 2018, the ARC Centre was a partner in the *7th Global conference on gender in aquaculture and fisheries*, held in Bangkok. Program 1 research fellow Danika 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

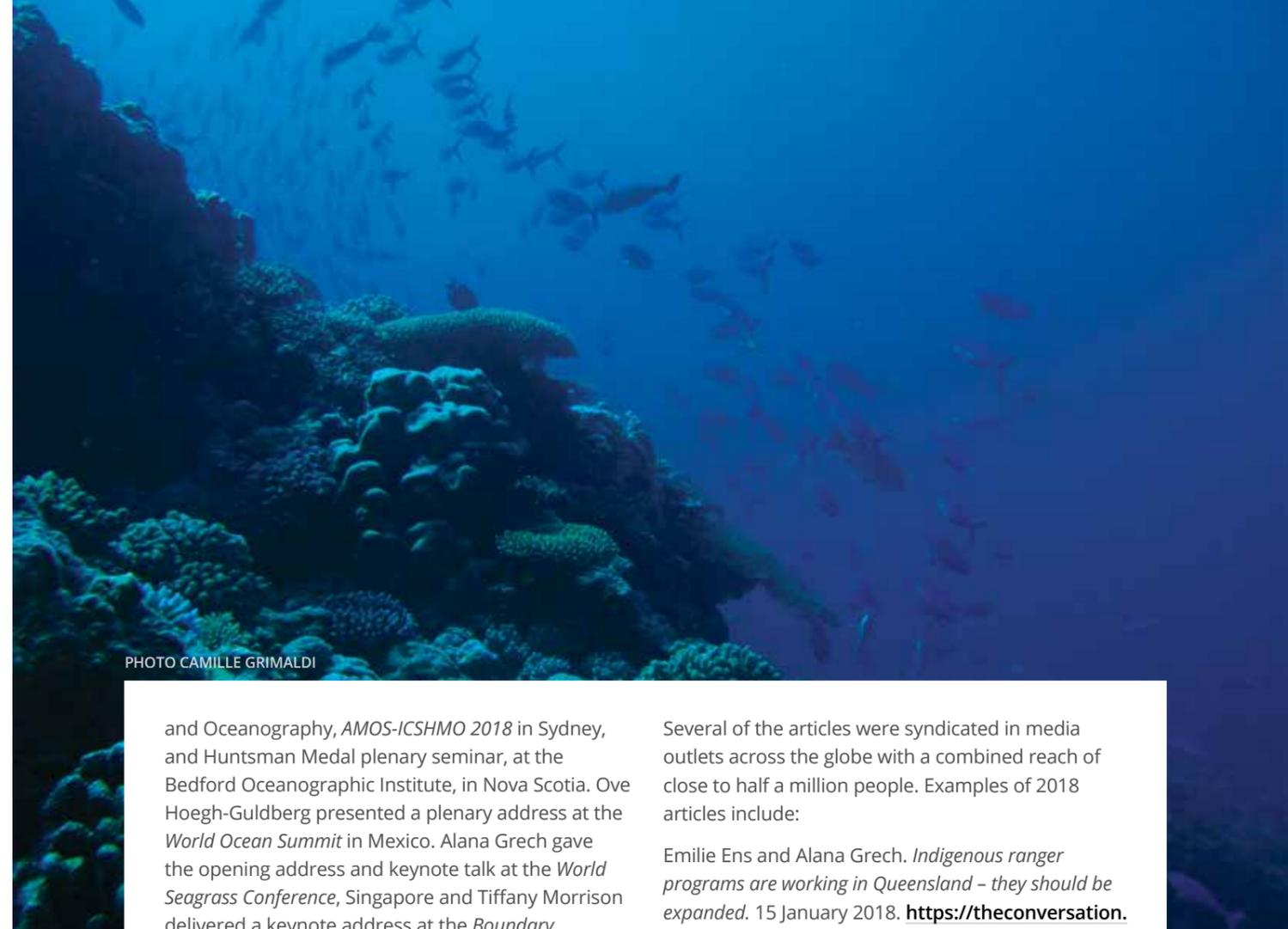


PHOTO CAMILLE GRIMALDI

and Oceanography, *AMOS-ICSHMO 2018* in Sydney, and Huntsman 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 Annapolis, 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:

Emilie Ens and Alana Grech. *Indigenous ranger programs are working in Queensland – they should be expanded*. 15 January 2018. <https://theconversation.com/indigenous-ranger-programs-are-working-in-queensland-they-should-be-expanded-89766>

Georgina Gurney. *Citizens of the Great Barrier Reef: going beyond our backyard to protect the reef*. 9 March 2018. <https://theconversation.com/citizens-of-the-great-barrier-reef-going-beyond-our-backyard-to-protect-the-reef-86858>

Jon Brodie. *\$500 million for the Great Barrier Reef is welcome, but we need a sea change in tactics too*. 3 May 2018. <https://theconversation.com/500-million-for-the-great-barrier-reef-is-welcome-but-we-need-a-sea-change-in-tactics-too-95875>

Samantha Tol, Alana Grech, Paul York and Rob Coles. *Dugong and sea turtle poo sheds new light on the Great Barrier Reef's seagrass meadows*. 25 May 2018. <https://theconversation.com/dugong-and-sea-turtle-poo-sheds-new-light-on-the-great-barrier-reefs-seagrass-meadows-95143>

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>

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:

The Washington Post – *Coral reefs are bleaching four times as frequently as they did in the 1980s, scientists say*, T Hughes, 4 January 2018 <https://www.washingtonpost.com/news/energy-environment/wp/2018/01/04/the-worlds-coral-reefs-used-to-bleach-once-every-few-decades-now-its-once-every-6-years>

BBC News – *Coral reefs head for 'knock-out punch'*, T Hughes, 5 January 2018 <http://www.bbc.com/news/science-environment-42571484>

National Geographic – *Window to save world's coral reefs closing rapidly*, T Hughes, 5 January 2018 <https://news.nationalgeographic.com/2018/01/coral-bleaching-reefs-climate-change-el-nino-environment/>

USA Today – *Coral reefs under siege: frequency of bleaching has increased almost fivefold since the '80s*, T Hughes, 5 January 2018 <https://www.usatoday.com/story/tech/science/2018/01/04/coral-reefs-under-siege-frequency-bleaching-has-increased-almost-fivefold-since-80-s/1003407001/>

The Verge – *Plastic pollution is making corals sick*, J Lamb, 26 January 2018 <https://www.theverge.com/2018/1/25/16929004/plastic-pollution-coral-reefs-disease-bleaching-climate-change>

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

BBC Radio 4 – *Costing the Earth: 'Coral versus Coal'*, T Morrison and O Hoegh-Guldberg, 7 March 2018 <https://www.bbc.co.uk/programmes/b09ttds6z>

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

LA Times – *Corals on Great Barrier Reef will never be the same after back-to-back heat waves, scientists say*, T Hughes, 18 April 2018 <http://www.latimes.com/science/sciencenow/la-sci-sn-great-barrier-reef-corals-20180418-story.html>

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/>

Nine News - Perth – *Australian scientists unlocking key to save world's coral reefs*, V Schoepf, 22 May 2018 <https://www.9news.com.au/national/2018/05/20/21/45/australian-scientists-unlocking-key-to-save-world-s-reefs>

NewsDeeply – *The hidden coral crisis: loss of fish diversity after bleaching strikes*, L Richardson, 10 April 2018 <https://www.newsdeeply.com/oceans/articles/2018/04/10/the-hidden-coral-crisis-loss-of-fish-diversity-after-bleaching-strikes>

Agence France Presse – Daily Mail - *Researchers find 'catastrophic' coral die-off on Great Barrier Reef*, T Hughes, 19 April 2018 <http://www.dailymail.co.uk/wires/afp/article-5632399/Researchers-catastrophic-coral-die-Great-Barrier-Reef.html>

CNET UK – *Great Barrier Reef 'cooked' by extreme temperatures: report*, T Hughes, 19 April 2018 <https://www.cnet.com/uk/news/great-barrier-reef-cooked-by-extreme-water-temperatures-report/>

HUFFPOST – *The Great Barrier Reef has been forever changed by global warming, scientists warn*, T Hughes, 19 April 2018 https://www.huffingtonpost.com.au/entry/great-barrier-reef-climate-change_us_5ad7c741e4b0e4d0715cfede

The Guardian – *Great Barrier Reef: 30% of coral died in 'catastrophic' 2016 heatwave*, T Hughes, 19 April 2018 <https://www.theguardian.com/environment/2018/apr/19/great-barrier-reef-30-of-coral-died-in-catastrophic-2016-heatwave>

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/5ae113eaf1c30f693e8bf1

ABC Radio National – *Small reef fish: born athletic champions*, J Rummer and A Downie, 1 June 2018 <http://www.abc.net.au/radionational/programs/scienceshow/small-reef-fish---born-athletic-champions/9825952>

The Independent – *Coral reef growth 'already failing to keep pace with sea level rise', study says*, P Mumby, 14 June 2018 <https://www.independent.co.uk/environment/coral-reef-sea-level-rise-climate-change-global-warming-great-barrier-a8397591.html>

Cina.org.cn – *Frigid polar oceans hot spots for species formation of marine fishes: study*, P Cowman, 6 July, http://www.china.org.cn/world/Off_the_Wire/2018-07/06/content_55139616.htm

ABC News – *Rats are wreaking havoc on our coral reefs and reducing fish numbers*, A Hoey, 12 July 2018 <https://www.abc.net.au/news/science/2018-07-12/pests-rats-damaging-coral-reefs-great-barrier-reef/9957628>

IFL Science – *Coral reefs are recovering poorly from disasters and deep reefs can't help*, P Mumby, 21 July 2018 <https://www.iflscience.com/environment/coral-reefs-are-recovering-poorly-from-disasters-and-deep-reefs-cant-help/>

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

CNN International – *'Saving Nemo': how Australian schools are protecting the clownfish*, J Rummer, 24 August 2018 <https://us.cnn.com/2018/08/23/world/saving-nemo-clownfish/index.html>

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

SBS News – *There's more than one: Australia's other great (and threatened) coral reefs*, V Schoepf, 9 October 2018 <https://www.sbs.com.au/news/there-s-more-than-one-australia-s-other-great-and-threatened-coral-reefs>

Newsweek – *Ancient flesh-eating piranha-like fish that lived alongside dinosaurs discovered*, D Bellwood, 19 October 2018 <https://www.newsweek.com/ancient-flesh-eating-piranha-fish-lived-alongside-dinosaurs-discovered-1175875>

ECO Magazine – *The Conservation Planning Database*, J Álvarez-Romero, Nov/Dec 2018 http://digital.ecomagazine.com/publication/?i=543413&p=&pn=#{%22issue_id%22:543413,%22page%22:42}

Times Higher Education – *Interview with Terry Hughes*, 6 December 2018 <https://www.timeshighereducation.com/people/interview-terry-hughes>

The Strait Times (Singapore) – *Great Barrier Reef resilient to spikes in temperatures: study*, T Hughes, 11 December 2018, <https://www.straitstimes.com/asia-australianz/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 and preparing the Centre for longer term business continuity post ARC 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)

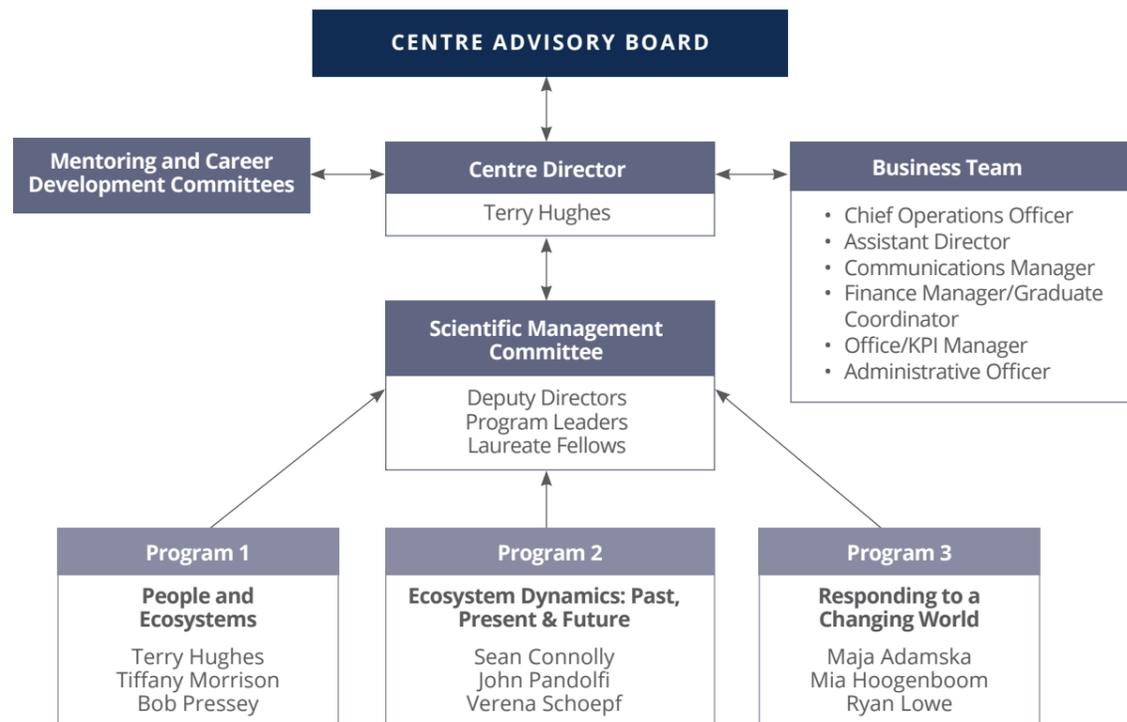
Dr Britta Schaffelke
Research Program Leader, A Healthy and Sustainable Great Barrier Reef
Australian Institute of Marine Science
(Delegate of Dr Paul Hardisty, Chief Executive Officer)

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. 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.



Membership

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 DECRA) 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, Pim Bongaerts, Pip Cohen, Christopher Cornwall, 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
Australian National 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

Dr Dorothea Bender-Champ
Research Fellow
University of Queensland

Dr Michael Bode
ARC Future Fellow
James Cook University

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

Dr Yves-Marie Bozec
Research Fellow
University of Queensland

Dr Tom Bridge
Discovery Early Career Researcher Award (DECRA)
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

Professor Sean Connolly
Chief Investigator
James Cook University

Dr Christopher Cornwall
Research Fellow
University of Western Australia

Dr Peter Cowman
Discovery Early Career Researcher Award (DECRA)
James Cook University

Dr Kay Critchell
Research Associate
University of Queensland

Professor Graeme Cumming
Research Fellow
James Cook University

Dr Thomas DeCarlo
Research Fellow
University of Western Australia

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

Dr Jennifer Donelson
Research Fellow
James Cook University

Associate Professor Sophie Dove
Chief Investigator
University of Queensland

Dr François Dufois
Research Fellow
University of Western Australia

Dr Sofia Fortunato
Research Fellow
James Cook University

Dr Alana Grech
Research Fellow
James Cook University

Dr Rebecca Green
Research Associate
University of Western Australia

Dr Georgina Gurney
Research Fellow
James Cook University

Dr April Hall
Advance Queensland Research Fellow
James Cook University

Dr Hugo Harrison
Discovery Early Career Researcher Award (DECRA)
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 Nils Krueck
Research Fellow
University of Queensland

Professor Ryan Lowe
Chief Investigator
University of Western Australia

Dr Vimoksalehi Lukoschek
Discovery Early Career Researcher Award (DECRA)
James Cook University

Dr Robert Mason
Research Associate
University of Queensland

Professor Mark McCormick
Chief Investigator
James Cook University

Professor Malcolm McCulloch
Deputy Director, ARC Australian Laureate Fellow
University of Western Australia

Dr Mike McWilliam
Research Associate
James Cook University

Dr Oliver Mead
Research Associate
Australian National University

Dr Vanessa Messmer
Research Associate
James Cook University

Professor David Miller
Chief Investigator
James Cook University

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

Professor Philip Munday
ARC Future Fellow
James Cook University

Professor John Pandolfi
Chief Investigator
University of Queensland

Dr Andrew Pomeroy
Research Fellow
University of Western Australia

Professor Morgan Pratchett
Chief Investigator
James Cook University

Professor Bob Pressey
Chief Investigator
James Cook University

Dr George Roff
Research Fellow
University of Queensland

Dr Cristian Rojas
Research Fellow
James Cook University

Associate Professor Jodie Rummer
Research Fellow
James Cook University

Professor Garry Russ
Chief Investigator
James Cook University

Dr Aleksey Sadekov
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
Research Fellow
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 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
Marie Curie Fellow
Israel

Dr Joaquim Garrabou
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
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

Partner Investigators and Adjunct Researchers

Dr Vanessa Adams
University of Tasmania

Dr Neil Andrew
WorldFish, Malaysia

Professor Serge Andréfouët
Institut de Recherche pour le Développement, New Caledonia

Dr Mary Bonin
Great Barrier Reef Marine Park Authority

Dr Ciemon Caballes
Ultra Coral Australia

Dr Louisa Evans
Exeter University, United Kingdom

Professor Nick Graham
Lancaster University, United Kingdom

Dr Alison Green
The Nature Conservancy

Dr Richard Hamilton
The Nature Conservancy

Dr Tess Hempson
Oceans Without Borders

Professor Christina Hicks
Lancaster University, United Kingdom

Dr Anne Hoggett
Lizard Island Research Station

Professor Janice Lough
Australian Institute of Marine Science

Dr Tim McClanahan
Wildlife Conservation Society, Kenya

Professor Stephen Palumbi
Stanford University, USA

Dr Serge Planes
University of Perpignan, France

Professor Madeleine van Oppen
University of Melbourne

Dr David Wachenfeld
Great Barrier Reef Marine Park Authority

Dr Peter Waldie
The Nature Conservancy

Professor David Yellowlees
Emeritus Professor

Graduate Students (see page 45)

Research Support Staff

Dr Rene Abesamis
James Cook University

Dr Nitin Bhatia
James Cook University

Joshua Biggs
University of Queensland

Carlin Bowyer
University of Western Australia

Dr Dani Ceccarelli
James Cook University

Aaron Chai
University of Queensland

Dr Maria Gomez-Cabrera
University of Queensland

Dr David Hayward
Australian National University

Sarah Hazell Pickering
Australian National University

Cindy Huchery
James Cook University

Mizue Jacobson
James Cook University

Dr James Kerry
James Cook University

Ayla Manwaring
Australian National University

Joanne Moneghetti
James Cook University

Dr Alison Paley
James Cook University

Kai Rankenburg
University of Western Australia

Dr Maya Srinivasan
James Cook University

Jane Tan
Australian National University

Sterling Tebbett
James Cook University

Cassy Thompson
James Cook University

Dr Annamieke Van Den Heuvel
University of Queensland

Dr David Williamson
James Cook University

Business Team

Jennifer Lappin
Chief Operations Officer
James Cook University

Dr Alana Grech
Assistant Director
James Cook University

Olga Bazaka
Finance Manager and Graduate Coordinator
James Cook University

Dr Rose Berdin
University of Western Australia

Vivian Doherty
Events Co-ordinator and KPI Officer
James Cook University

Rosanna Griffith-Mumby
Administrative Officer
University of Queensland

Catherine Naum
Communications Manager
James Cook University

Janet Swanson
Administrative Officer
James Cook University

Hayley Ware
Project Officer
University of Queensland

Publications

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 in prestige journals – *Nature* and other *Nature* journals, *Science*, the *Trends* journals, *Genome Biology*, *Biological Reviews*, *Science Advances*, *ISME 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 researchers were cited more than 500 times each and 17 had more than 1000 citations.

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

Hughes, TP, Kerry, JT, Baird, AH, Connolly, SR, Dietzel, A, Eakin, CM, Heron, SF, Hoey, AS, Hoogenboom, MO, Liu, G, McWilliam, MJ, Pears, RJ, Pratchett, MS, Skirving, WJ, Stella, JS and Torda, G (2018). Global warming transforms coral reef assemblages. *Nature* 556(7702): 492-496. **Altmetric 4349** (179 news outlets, Tweeted by 4496, ranked #9 in the Altmetric Top 100 of 2018).

2018 Publications

Book (2)

1. Hoey, A and Bonaldo, RM (2018). *Biology of parrotfishes*. CRC Press, Boca Raton, Florida, 1-417 pp.
2. Lough, JM and Van Oppen, MJ (2018). *Coral bleaching - patterns, processes, causes and consequences*. Springer, Switzerland, 1-365 pp.

Book Section (18)

1. Adamska, M (2018). Differentiation and transdifferentiation of

sponge cells. In: Kloc M, KJZ. (ed). *Results and problems in cell differentiation*, Springer, 229-253 pp.

2. Burkepile, D, Rasher, DB, Adam, T, Hoey, A and Hay, ME (2018). Functional variation among parrotfishes: are they complementary or redundant? In: Hoey, A and Bonaldo, RM. (eds). *Biology of parrotfishes*, CRC Press, 134-160 pp.
3. Eakin, CM, Lough, J, Heron, SF and Liu, G (2018). Climate variability and change: monitoring data

and evidence for increased coral bleaching stress. In: Van Oppen, MJ and Lough, J. (eds). *Coral bleaching - patterns, processes, causes and consequences*, Springer, 51-84 pp.

4. Emslie, MJ and Pratchett, M (2018). Differential vulnerabilities of parrotfishes to habitat degradation. In: Hoey, A and Bonaldo, RM. (eds). *Biology of parrotfishes*, CRC Press, 355-382 pp.
5. Harborne, AR and Mumby, PJ (2018). FAQs about Caribbean parrotfish management and their

role in reef resilience. In: Hoey, A and Bonaldo, RM. (eds). *Biology of parrotfishes*, CRC Press, 383-406 pp.

6. Hoey, A (2018). Feeding in parrotfishes: the influence of species, body size and temperature. In: Hoey, A and Bonaldo, RM. (eds). *Biology of parrotfishes*, CRC Press, 119-133 pp.
7. Hoey, A, Berumen, ML, Bonaldo, RM, Burt, JA, Feary, DA, Ferreira, CE, Floeter, SR and Nakamura, Y (2018). The ecology of parrotfishes on marginal reef systems. In: Hoey,

Hughes, TP, Anderson, KD, Connolly, SR, Heron, SF, Kerry, JT, Lough, JM, Baird, AH, Baum, JK, Berumen, ML, Bridge, TC, Claar, DC, Eakin, CM, Gilmour, JP, Graham, NAJ, Harrison, H, Hobbs, J-P, Hoey, AS, Hoogenboom, M, Lowe, RJ, McCulloch, MT, Pandolfi, JM, Pratchett, M, Schoepf, V, Torda, G and Wilson, SK (2018). Spatial and temporal patterns of mass bleaching of corals in the Anthropocene. *Science* 359(6371): 80-83. **Altmetric 2972** (77 news outlets, Tweeted by 3174, ranked #28 in the Altmetric Top 100 of 2018).

Kölbl-Ebert, M, Ebert, M, Bellwood, DR and Schulbert, C. (2018). A piranha-like pycnodontiform fish from the late jurassic. *Current Biology* 28(21): 3516-3521 e2. **Altmetric 796** (80 news outlets, Tweeted by 95).

Graham N, Wilson S, Carr P, Hoey A, Jennings S and MacNeil M (2018). Seabirds enhance coral reef productivity and functioning in the absence of invasive rats. *Nature* 559(7713): 250-253. **Altmetric 795** (36 news outlets, Tweeted by 663).

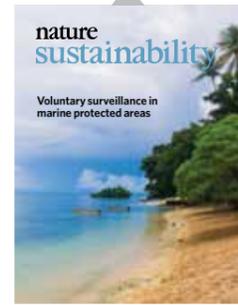
Cinner, JE, Maire, E, Huchery, C, Aaron MacNeil, M, Graham, NAJ, Mora, C, McClanahan, TR, Barnes, ML, Kittinger, JN, Hicks, CC, D'Agata, S, Hoey, AS, Gurney, GG, Feary, DA, Williams, ID, Kulbicki, M, Vigliola, L, Wantiez, L, Edgar, GJ, Stuart-Smith, RD, Sandin, SA, Green, A, Hardt, MJ, Bejer, M, Friedlander, AM, Wilson, SK, Brokovich, E, Brooks, AJ, Cruz-Motta, JJ, Booth, DJ, Chabanet, P, Gough, C, Tupper, M, Ferse, SCA, Rashid Sumaila, U, Pardede, S and Mouillot, D (2018). Gravity of human impacts mediates coral reef conservation gains. *Proceedings of the National Academy of Sciences of the United States of America* 115(27): E6116-E6125. **Altmetric 436** (12 news outlets, Tweeted by 498).

Perry, CT, Alvarez-Filip, L, Graham, NAJ, Mumby, PJ, Wilson, SK, Kench, PS, Manzello, DP, Morgan, KM, Slangen, ABA, Thomson, DP, Januchowski-Hartley, F, Smithers, SG, Steneck, RS, Carlton, R, Edinger, EN, Enochs, IC, Estrada-Saldívar, N, Haywood, MDE, Kolodziej, G, Murphy, GN., Pérez-Cervantes, E, Suchley, A, Valentino, L, Boenish, R, Wilson, M and MacDonald, C (2018). Loss of coral reef growth capacity to track future increases in sea level. *Nature* 558(7710): 396-400. **Altmetric 309** (Tweeted by 331).

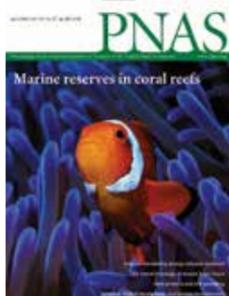
Cinner, JE, Adger, WN, Allison, EH, Barnes, ML, Brown, K, Cohen, PJ, Gelcich, S, Hicks, CC, Hughes, TP, Lau, J, Marshall, NA and Morrison, TH (2018). Building adaptive capacity to climate change in tropical coastal communities. *Nature Climate Change* 8(2): 117-123. **Altmetric 287** (10 news outlets, Tweeted by 319).

- A and Bonaldo, RM. (eds). *Biology of parrotfishes*, CRC Press, 276-301 pp.
8. Laffoley, D, Baxter, J, Day, J, Wenzel, L, Bueno, P and Zischka, K (2018). Marine protected areas. In: Sheppard, CRC. (ed). *World seas: an environmental evaluation, volume 3: ecological issues and environmental impacts*, Academic Press, 549-569 pp.
9. Marsh, H, Grech, A and McMahon, K (2018). Dugongs: seagrass community specialists. In: Larkum, AWD, Kendrick, GA and Ralph, PJ. (eds). *Seagrasses of Australia*, Springer International Publishing, 629-661 pp.
10. McClanahan, TR, Weil, E and Baird, AH (2018). Consequences of coral bleaching for sessile reef organisms. In: Van Oppen, MJ and Lough, J. (eds). *Coral bleaching - patterns, processes, causes and consequences*, Springer, 231-263 pp.
11. McCulloch, M, D'Olivo Cordero, JP, Falter, JL, Georgioui, L, Holcomb, M, Montagna, P and Trotter, JA (2018). Boron isotopic systematics in scleractinian corals and the role of pH Up-regulation. In: Marschall, H and Foster, G. (eds). *Boron isotopes. Advances in isotope geochemistry*, Springer, Cham, 145-162 pp.
12. Pratchett, M, Bridge, T, Brodie, J, Cameron, D, Emslie, MJ, Grech, A, Hamman, M, Hoey, A, Hooogenboom, M, Lough, J, Morrison, TH, Osborn, K, Read, M, Smithers, SG, Sweatman, H and Waterhouse, J (2018). Australia's Great Barrier Reef. In: Sheppard, CRC. (ed). *World seas: an environmental evaluation, Volume 2: The Indian Ocean to the Pacific*, Academic Press, 333-362 pp.
13. Pratchett, M, Thompson, CA, Hoey, A, Cowman, PF and Wilson, SK (2018). Effects of coral bleaching and coral loss on the structure and function of reef fish assemblages. In: Van Oppen, MJ and Lough, JM. (eds). *Coral bleaching - patterns, processes, causes and consequences*, Springer, 265-293 pp.
14. Questel, SA and Russ, GR (2018). No-take marine reserve effects on parrotfish and parrotfish-benthos interactions. In: Hoey, A and Bonaldo, RM. (eds). *Biology of parrotfishes*, CRC Press, 329-354 pp.
15. Quigley, KM, Baker, AC, Coffroth, M, Willis, BL and Van Oppen, MJ (2018). Bleaching resistance and the role of algal endosymbionts. In: Van Oppen, MJ and Lough, J. (eds). *Coral bleaching - patterns, processes, causes and consequences*, Springer, 111-151 pp.
16. Song, AM (2018). How to capture small-scale fisheries' many contributions to society? Introducing the 'value-ontribution matrix' and applying it to the case of a swimming crab fishery in South Korea. In: Johnson, D, Acott, T, Stacey, N and Urguhart, J. (eds). *Social wellbeing and the values of small-scale fisheries*, Springer International Publishing, 125-146 pp.
17. Van Oppen, MJ and Lough, J (2018). Introduction: coral bleaching - patterns, processes, causes and consequences. In: Van Oppen, MJ and Lough, J. (eds). *Coral bleaching - patterns, processes, causes and consequences*, Springer, 1-8 pp.
18. Van Oppen, MJ and Lough, J (2018). Synthesis: coral bleaching - patterns, processes, causes and consequences. In: Van Oppen, MJ and Lough, J. (eds). *Coral bleaching - patterns, processes, causes and consequences*, Springer, 343-348 pp.
4. Adams, VM, Mills, M, Weeks, R, Segan, DB, Pressey, RL, Gurney, GG, Groves, C, Davis, FW and Álvarez-Romero, JG (2018). Implementation strategies for systematic conservation planning. *Ambio* 48(2): 139-152.
5. Adams, VM, Moon, K, Álvarez-Romero, JG, Bodin, Ö, Spencer, M and Blackman, D (2018). Using multiple methods to understand the nature of relationships in social networks. *Society and Natural Resources* 31(7): 755-772.
6. Adger, WN, Hughes, TP, Folke, C, Carpenter, SR and Rockström, J (2018). Social-ecological resilience to coastal disasters. *Science* 309(5737): 1036-9.
7. Adjeroud, M, Kayal, M, Iborra-Cantonnet, C, Vercelloni, J, Bosserelle, P, Liao, V, Chancerelle, Y, Claudet, J and Penin, L (2018). Recovery of coral assemblages despite acute and recurrent disturbances on a south central Pacific reef. *Scientific Reports* 8(9680): 1-8.
8. Alexander, SM, Bodin, Ö and Barnes, ML (2018). Untangling the drivers of community cohesion in small-scale fisheries. *International Journal of the Commons* 12(1): 519-547.
9. Allison, EH and Mills, DJ (2018). Counting the fish eaten rather than the fish caught. *Proceedings of the National Academy of Sciences of the United States of America* 115(29): 7459-7461.
10. Altman-Kurosaki, NT, Priest, MA, Golbuu, Y, Mumby, PJ and Marshall, A (2018). Microherbivores are significant grazers on Palau's forereefs. *Marine Biology* 165(74): 1-11.
11. Álvarez-Noriega, M, Baird, AH, Bridge, TCL, Dornelas, M, Fontoura, L, Pizarro, O, Precoda, K, Torres-Pulliza, D, Woods, RM, Zawada, K and Madin, JS (2018). Contrasting patterns of changes in abundance following a bleaching event between juvenile and adult scleractinian corals. *Coral Reefs* 37(2): 527-532.
12. Álvarez-Noriega, M, Baird, AH, Dornelas, M, Madin, JS and Connolly, SR (2018). Negligible effect of competition on coral colony growth. *Ecology* 99(6): 1347-1356.
13. Álvarez-Romero, JG, Mills, M, Adams, VM, Gurney, GG, Pressey, RL, Weeks, R, Ban, NC, Cheok, J, Davies, TE, Day, JC, Hamel, MA, Leslie, HM, Magris, RA and Storlie, CJ (2018). Research advances and gaps in marine planning: towards a global database in systematic conservation planning. *Biological Conservation* 227: 369-382.
14. Álvarez-Romero, JG, Munguía-Vega, A, Beger, M, del Mar Mancha-Cisneros, M, Suárez-Castillo, AN, Gurney, GG, Pressey, RL, Gerber, LR, Morzaría-Luna, HN, Reyes-Bonilla, H, Adams, VM, Kolb, M, Graham, EM, VanDerWal, J, Castillo-López, A, Hinojosa-Arango, G, Petatán-Ramírez, D, Moreno-Baez, M, Godínez-Reyes, CR and Torre, J (2018). Designing connected marine reserves in the face of global warming. *Global Change Biology* 24(2): e671-e691.
15. Anderson, KD, Cantin, NE, Heron, SF, Lough, JM and Pratchett, MS (2018). Temporal and taxonomic contrasts in coral growth at Davies Reef, central Great Barrier Reef, Australia. *Coral Reefs* 37(2): 409-421.
16. Anushka, S, Amy, D, Gurney, GG and Tristram, RD (2018). Perceptions of cyclone preparedness: assessing the role of individual adaptive capacity and social capital in the wet tropics, Australia. *Sustainability (Switzerland)* 10(4): 1-16.
17. Aswani, S, Basurto, X, Ferse, S, Glaser, M, Campbell, L, Cinner, JE, Dalton, T, Jenkins, LD, Miller, ML, Pollnac, R, Vaccaro, I and Christie, P (2018). Marine resource management and conservation in the Anthropocene. *Environmental Conservation* 45(2): 192-202.
18. Attenborough, RMF, Hayward, DC, Wiedemann, U, Forêt, S, Miller, DJ and Ball, EE (2018). Expression of the neuropeptides RFamide and LWamide during development of the coral *Acropora millepora* in relation to settlement and metamorphosis. *Developmental Biology* 446(1): 56-67.
19. Atwood, TB, Madin, EMP, Harborne, AR, Hammill, E, Luiz, OJ, Ollivier, QR, Roelfsema, CM, Macreadie, PI and Lovelock, CE (2018). Predators shape sedimentary organic carbon storage in a coral reef ecosystem. *Frontiers in Ecology and Evolution* 6(8): 1-11.
20. Bainbridge, Z, Lewis, S, Bartley, R, Fabricius, K, Collier, C, Waterhouse, J, Garzon-Garcia, A, Robson, B, Burton, J, Wenger, A and Brodie, J (2018). Fine sediment and particulate organic matter: a review and case study on ridge-to-reef transport, transformations, fates, and impacts on marine ecosystems. *Marine Pollution Bulletin* 135: 1205-1220.
21. Baird, AH, Álvarez-Noriega, M, Cumbo, VR, Connolly, SR, Dornelas, M and Madin, JS (2018). Effects of tropical storms on the demography of reef corals. *Marine Ecology Progress Series* 606: 29-38.
22. Baird, AH, Keith, SA, Woolsey, E, Yoshida, R and Naruse, T (2018). Rapid coral mortality following unusually calm and hot conditions on Iriomote, Japan. *F1000Research* 6: 1728.
23. Baird, AH, Madin, JS, Álvarez-Noriega, M, Fontoura, L, Kerry, JT, Kuo, C-Y, Precoda, K, Torres-Pulliza, D, Woods, RM, Zawada, KJA and Hughes, TP (2018). A decline in bleaching suggests that depth can provide a refuge from global warming in most coral taxa. *Marine Ecology Progress Series* 603: 257-264.
24. Baird, AH and Thomson, DP (2018). Coral reproduction at Hall Bank, a high latitude coral assemblage in Western Australia. *Aquatic Biology* 27: 55-63.
25. Baker, CM, Bower, S, Tartaglia, E, Bode, M, Bower, H and Pressey, RL (2018). Modelling the spread and control of cherry guava on Lord Howe Island. *Biological Conservation* 227: 252-258.
26. Barlow, J, França, F, Gardner, TA, Hicks, CC, Lennox, GD, Berenguer, E, Castello, L, Economo, EP, Ferreira, J, Guénard, B, Gontijo Leal, C, Isaac, V, Lees, AC, Parr, CL, Wilson, SK, Young, PJ and Graham, NAJ (2018). The future of hyperdiverse tropical ecosystems. *Nature* 559(7715): 517-526.
27. Barlow, J, Stephens, PA, Bode, M, Cadotte, MW, Lucas, K, Newton, E, Nuñez, MA and Pettorelli, N (2018). On the extinction of the single-authored paper: the causes and consequences of increasingly collaborative applied ecological research. *Journal of Applied Ecology* 55(1): 1-4.
28. Barnes, MD, Glew, L, Wyborn, C and Craigie, ID (2018). Prevent perverse outcomes from global protected area policy. *Nature Ecology and Evolution* 2(5): 759-762.
29. Bell, JD, Cisneros-Montemayor, A, Hanich, Q, Johnson, JE, Lehodey, P, Moore, BR, Pratchett, MS, Reygondeau, G, Senina, I, Virdin, J and Wabnitz, CCC (2018). Adaptations to maintain the contributions of small-scale fisheries to food security in the Pacific Islands. *Marine Policy* 88: 303-314.
30. Bellwood, DR, Tebbett, SB, Bellwood, O, Mihalitsis, M, Morais, RA, Streit, RP and Fulton, CJ (2018). The role of the reef flat in coral reef trophodynamics: past, present, and future. *Ecology and Evolution* 8(8): 4108-4119.
31. Benzoni, F, Arrigoni, R, Berumen, ML, Taviani, M, Bongaerts, P and Frade, PR (2018). Morphological and genetic divergence between Mediterranean and Caribbean populations of *Madracis pharensis* (Heller 1868) (Scleractinia, Pocilloporidae): too much for one species? *Zootaxa* 4471(3): 473-492.
32. Bergseth, BJ (2018). Effective marine protected areas require a sea change in compliance management. *ICES Journal of Marine Science* 75(3): 1178-1180.
33. Bergseth, BJ, Gurney, GG, Barnes, ML, Arias, A and Cinner, JE (2018). Addressing poaching in marine protected areas through voluntary surveillance and enforcement. *Nature Sustainability* 1(8): 421-426.
34. Bergseth, BJ and Roscher, M (2018). Discerning the culture of compliance through recreational fisher's perceptions of poaching. *Marine Policy* 89: 132-141.
35. Bernal, MA, Donelson, JM, Veilleux, HD, Ryu, T, Munday, PL and Ravasi, T (2018). Phenotypic and molecular consequences of stepwise temperature increase across generations in a coral reef fish. *Molecular Ecology* 27(22): 4516-4528.
36. Beyer, HL, Kennedy, EV, Beger, M, Chen, CA, Cinner, JE, Darling, ES, Eakin, CM, Gates, RD, Heron, SF, Knowlton, N, Obura, DO, Palumbi, SR, Possingham, HP, Puotinen, M, Runting, RK, Skirving, WJ, Spalding, M, Wilson, KA, Wood, S, Veron, JE and Hoegh-Guldberg, O (2018). Risk-sensitive planning for conserving coral reefs under rapid climate change. *Conservation Letters* 11(6): 1-10.
37. Blay, C, Planes, S and Ky, C-L (2018). Crossing phenotype heritability and candidate gene expression in grafted black-lipped pearl oyster *Pinctada margaritifera*, an animal chimera. *Journal of Heredity* 109(5): 510-519.
38. Blay, C, Planes, S and Ky, C-L (2018). Optimal age of the donor graft tissue in relation to cultured pearl phenotypes in the mollusc, *Pinctada margaritifera*. *PLoS ONE* 13(6): e0198505.
39. Blythe, J, Silver, J, Evans, L, Armitage, D, Bennett, NJ, Moore, M-L, Morrison, TH and Brown, K (2018). The dark side of transformation: latent risks in contemporary sustainability discourse. *Antipode* 50(5): 1206-1223.
40. Bode, M, Bode, L, Choukroun, S, James, MK and Mason, LB (2018). Resilient reefs may exist, but can larval dispersal models find them? *PLoS Biology* 16(8): e2005964.
41. Bode, M, Williamson, DH, Harrison, HB, Outram, N and Jones, GP (2018). Estimating dispersal kernels using genetic parentage data. *Methods in Ecology and Evolution* 9(3): 490-501.
42. Bonebrake, TC, Brown, CJ, Bell, JD, Blanchard, JL, Chauvenet, A, Champion, C, Chen, I-C, Clark, TD, Colwell, RK, Danielsen, F, Dell, AI, Donelson, JM, Evengård, B, Ferrier, S, Frusher, S, Garcia, RA, Griffis, RB, Hobday, AJ, Jarzyna, MA, Lee, E, Lenoir, J, Linnertved, H, Martin, VY, McCormack, PC, McDonald, J, McDonald-Madden, E, Mitchell, N, Mustonen, T, Pandolfi, JM, Pettorelli, N, Possingham, H, Pulsifer, P, Reynolds, M, Scheffers, BR, Sorte, CJB, Strugnell, JM, Tuanmu, M-N, Twiname, S, Vergés, A, Villanueva, C, Wapstra, E, Wernberg, T and
43. Bongiorno, DL, Bryson, M, Bridge, TCL, Dansereau, DG and Williams, SB (2018). Coregistered hyperspectral and stereo image seafloor mapping from an autonomous underwater vehicle. *Journal of Field Robotics* 35(3): 312-329.
44. Boström-Einarsson, L, Bonin, MC, Munday, PL and Jones, GP (2018). Loss of live coral compromises predator-avoidance behaviour in coral reef damselfish. *Scientific Reports* 8(1): 7795.
45. Boussarie, G, Bakker, J, Wangensteen, OS, Mariani, S, Bonnini, L, Juhel, J-B, Kiszka, JJ, Kulbicki, M, Manel, S, Robbins, WD, Vigliola, L and Mouillot, D (2018). Environmental DNA illuminates the dark diversity of sharks. *Science Advances* 4(5): eaap9661.
46. Bouyoucos, I, Suski, C, Mandelman, J and EJ, B (2018). In situ swimming behaviors and oxygen consumption rates of juvenile lemon sharks (*Negaprion brevirostris*). *Environmental Biology of Fishes* 101(5): 761-773.
47. Bouyoucos, IA, Weideli, OC, Planes, S, Simpfendorfer, CA and Rummer, JL (2018). Dead tired: evaluating the physiological status and survival of neonatal reef sharks under stress. *Conservation Physiology* 6(1): coy053.
48. Bozec, Y-M, Doropoulos, C, Roff, G and Mumby, PJ (2018). Transient grazing and the dynamics of an unanticipated coral-algal phase shift. *Ecosystems* 22(163): 1-16.
49. Brandl, SJ, Goatley, CHR, Bellwood, DR and Tornabene, L (2018). The hidden half: ecology and evolution of cryptobenthic fishes on coral reefs. *Biological Reviews* 93(4): 1846-1873.
50. Branson, O, Fehrenbacher, J, Vetter, L, Sadekov, A, Eggins, SM and Spero, HJ (2018). LAtools: a data analysis package for the reproducible reduction of LA-ICPMS data. *Chemical Geology* 504: 83-95.
51. Brena, PF, Mourier, J, Planes, S and Clua, EE (2018). Concede or clash? Solitary sharks competing for food

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- assess rivals to decide. *Proceedings of the Royal Society B: Biological Sciences* 285(1875): 1-9.
52. Brito-Morales, J, García Molinos, J, Schoeman, DS, Burrows, MT, Poloczanska, ES, Brown, CJ, Ferrier, S, Harwood, TD, Klein, CJ, McDonald-Madden, E, Moore, PJ, Pandolfi, JM, Watson, JEM, Wenger, AS and Richardson, AJ (2018). Climate velocity can inform conservation in a warming world. *Trends in Ecology and Evolution* 33(6): 441-457.
53. Brooker, RM, Muñoz Ruiz, E, Sih, T and Dixon, DL (2018). Shelter availability mediates decorating in the majoid crab, *Camposcia retusa*. *Behavioral Ecology* 29(1): 179-185.
54. Brown, CJ and Hamilton, RJ (2018). Estimating the footprint of pollution on coral reefs with models of species turnover. *Conservation Biology* 32(4): 949-958.
55. Brown, KT, Bender-Champ, D, Kubicek, A, van der Zande, R, Achlatis, M and Hoegh-Guldberg, O, Dove, S.G. (2018). The dynamics of coral-algal interactions in space and time on the southern Great Barrier Reef. *Frontiers in Marine Science* 5(181): 1-13.
56. Buerger, P, Weyenberg, KD, Wood-Charlson, EM, Sato, Y, Willis, BL and van Oppen, MJH (2018). Novel T4 bacteriophages associated with black band disease in corals. *Environmental Microbiology* 20(10): 1-11.
57. Bussotti, S, Di Franco, A, Bianchi, CN, Chevaldonné, P, Egea, L, Fanelli, E, Lejeune, C, Musco, L, Navarro-Barranco, C, Pey, A, Planes, S, Vieux-Ingrassia, JV and Guidetti, P (2018). Fish mitigate trophic depletion in marine cave ecosystems. *Scientific Reports* 8(1): 9193.
58. Callaghan, DP, Baldock, TE, Shabani, B and Mumby, PJ (2018). Communicating physics-based wave model predictions of coral reefs using Bayesian belief networks. *Environmental Modelling and Software* 108: 123-132.
59. Camp, EF, Schoepf, V, Mumby, PJ, Hardtke, LA, Rodolfo-Metalpa, R, Smith, DJ and Suggett, DJ (2018). The future of coral reefs subject to rapid climate change: lessons from natural extreme environments. *Frontiers in Marine Science* 5(4): 1-21.
60. Camp, EF, Schoepf, V, Mumby, PJ and Suggett, DJ (2018). Editorial: the future of coral reefs subject to rapid climate change: lessons from natural extreme environments. *Frontiers in Marine Science* 5(433): 1-10.
61. Camp, EF, Schoepf, V and Suggett, DJ (2018). How can super corals facilitate global coral reef survival under rapid environmental and climatic change? *Global Change Biology* 24(7): 2755-2757.
62. Caron, AGM, Thomas, CR, Berry, KLE, Motti, CA, Ariel, E and Brodie, JE (2018). Ingestion of microplastic debris by green sea turtles (*Chelonia mydas*) in the Great Barrier Reef: validation of a sequential extraction protocol. *Marine Pollution Bulletin* 127: 743-751.
63. Caron, AGM, Thomas, CR, Berry, KLE, Motti, CA, Ariel, E and Brodie, JE (2018). Validation of an optimised protocol for quantification of microplastics in heterogenous samples: a case study using green turtle chyme. *MethodsX* 5: 812-823.
64. Chakravarti, LJ and van Oppen, MJH (2018). Experimental evolution in coral photosymbionts as a tool to increase thermal tolerance. *Frontiers in Marine Science* 5(227): 1-15.
65. Chase, TJ, Pratchett, MS, Frank, GE and Hoogenboom, MO (2018). Coral-dwelling fish moderate bleaching susceptibility of coral hosts. *PLoS ONE* 13(12): e0208545.
66. Chausson, J, Srinivasan, M and Jones, GP (2018). Host anemone size as a determinant of social group size and structure in the orange clownfish (*Amphiprion percula*). *PeerJ* 6(e5841): 1-12.
67. Chen, T, Roff, G, McCook, L, Zhao, J and Li, S (2018). Recolonization of marginal coral reef flats in response to recent sea-level rise. *Journal of Geophysical Research: Oceans* 123(10): 7618-7628.
68. Cheok, J, Pressey, RL, Weeks, R, VanDerWal, J and Storlie, C (2018). The plans they are a-changin': more frequent iterative adjustment of regional priorities in the transition to local actions can benefit implementation. *Diversity and Distributions* 24(1): 48-57.
69. Cinner, J (2018). How behavioral science can help conservation. *Science* 362(6417): 889-890.
70. Cinner, JE, Adger, WN, Allison, EH, Barnes, ML, Brown, K, Cohen, PJ, Gelcich, S, Hicks, CC, Hughes, TP, Lau, J, Marshall, NA and Morrison, TH (2018). Building adaptive capacity to climate change in tropical coastal communities. *Nature Climate Change* 8(2): 117-123.
71. Cinner, JE, Maire, E, Huchery, C, Aaron MacNeil, M, Graham, NAJ, Mora, C, McClanahan, TR, Barnes, ML, Kittinger, JN, Hicks, CC, D'Agata, S, Hoey, AS, Gurney, GG, Feary, DA, Williams, ID, Kulbicki, M, Vigliola, L, Wantiez, L, Edgar, GJ, Stuart-Smith, RD, Sandin, SA, Green, A, Hardt, MJ, Beger, M, Friedlander, AM, Wilson, SK, Brokovich, E, Brooks, AJ, Cruz-Motta, JJ, Booth, DJ, Chabanet, P, Gough, C, Tupper, M, Ferse, SCA, Rashid Sumaila, U, Pardede, S and Mouillot, D (2018). Gravity of human impacts mediates coral reef conservation gains. *Proceedings of the National Academy of Sciences of the United States of America* 115(27): E6116-E6125.
72. Clements, CS, Rasher, DB, Hoey, AS, Bonito, VE and Hay, ME (2018). Spatial and temporal limits of coral-macroalgal competition: the negative impacts of macroalgal density, proximity, and history of contact. *Marine Ecology Progress Series* 586: 11-20.
73. Clements, HS and Cumming, GS (2018). Traps and transformations influencing the financial viability of tourism on private-land conservation areas. *Conservation Biology* 32(2): 424-436.
74. Clements, HS, Kerley, GIH, Cumming, GS, De Vos, A and Cook, CN (2018). Privately protected areas provide key opportunities for the regional persistence of large- and medium-sized mammals. *Journal of Applied Ecology* 56(3): 537-546.
75. Collin, A, Hench, JL, Pastol, Y, Planes, S, Thiault, L, Schmitt, RJ, Holbrook, SJ, Davies, N and Troyer, M (2018). High resolution topobathymetry using a Pleiades-1 triplet: Moorea Island in 3D. *Remote Sensing of Environment* 208: 109-119.
76. Comeau, S, Cornwall, CE, DeCarlo, TM, Krieger, E and McCulloch, MT (2018). Similar controls on calcification under ocean acidification across unrelated coral reef taxa. *Global Change Biology* 24(10): 4857-4868.
77. Condie, SA, Herzfeld, M, Hock, K, Andrewartha, JR, Gorton, R, Brinkman, R and Schultz, M (2018). System level indicators of changing marine connectivity. *Ecological Indicators* 91: 531-541.
78. Condie, SA, Plagányi, ÉE, Morello, EB, Hock, K and Beeden, R (2018). Great Barrier Reef recovery through multiple interventions. *Conservation Biology* 32(6): 1356-1367.
79. Contardo, S, Symonds, G and Dufois, F (2018). Breakpoint forcing revisited: phase between forcing and response. *Journal of Geophysical Research: Oceans* 123(2): 1354-1363.
80. Cornwall, CE, Comeau, S, DeCarlo, TM, Moore, B, D'Alexis, Q and McCulloch, MT (2018). Resistance of corals and coralline algae to ocean acidification: physiological control of calcification under natural pH variability. *Proceedings of the Royal Society B: Biological Sciences* 285(1884): 1-9.
81. Cramp, JE, Simpfendorfer, CA and Pressey, RL (2018). Beware silent waning of shark protection. *Science* 360(6390): 723-724.
82. Critchell, K and Hoogenboom, MO (2018). Effects of microplastic exposure on the body condition and behaviour of planktivorous reef fish (*Acanthochromis polyacanthus*). *PLoS ONE* 13(3): e0193308.
83. Cumbo, VR, Van Oppen, MJH and Baird, AH (2018). Temperature and symbiodinium physiology affect the establishment and development of symbiosis in corals. *Marine Ecology Progress Series* 587: 117-127.
84. Cumming, GS (2018). A review of social dilemmas and social-ecological traps in conservation and natural resource management. *Conservation Letters* 11(1): 1-15.
85. Cumming, GS and Von Cramon-Taubadel, S (2018). Linking economic growth pathways and environmental sustainability by understanding development as alternate social-ecological regimes. *Proceedings of the National Academy of Sciences of the United States of America* 115(38): 9533-9538.
86. Cuttler, MW, Hansen, JE, Lowe, RJ, Trotter, JA and McCulloch, MT (2018). Source and supply of sediment to a shoreline salient in a fringing reef environment. *Earth Surface Processes and Landforms* 44(2): 552-564.
87. Dale, AP, Vella, K, Gooch, M, Potts, R, Pressey, RL, Brodie, J and Eberhard, R (2018). Avoiding implementation failure in catchment landscapes: a case study in governance of the Great Barrier Reef. *Environmental Management* 62(1): 70-81.
88. DeCarlo, TM (2018). Characterizing coral skeleton mineralogy with raman spectroscopy. *Nature Communications* 9(1): 5325.
89. DeCarlo, TM, Comeau, S, Cornwall, CE and McCulloch, MT (2018). Coral resistance to ocean acidification linked to increased calcium at the site of calcification. *Proceedings of the Royal Society B: Biological Sciences* 285(1878): 1-10.
90. DeCarlo, TM, Holcomb, M and McCulloch, MT (2018). Reviews and syntheses: revisiting the boron systematics of aragonite and their application to coral calcification. *Biogeosciences* 15(9): 2819-2834.
91. DeCarlo, TM, Ren, H and Farfan, GA (2018). The origin and role of organic matrix in coral calcification: insights from comparing coral skeleton and abiogenic aragonite. *Frontiers in Marine Science* 5(170): 1-13.
92. Delrieu-Trottin, E, Neglia, V, Verducci, M and Planes, S (2018). Origin, genetic diversity, and population history of a marine population (Chanidae: *Chanos chanos*) in an enclosed lagoon in French Polynesia. *Pacific Science* 72(2): 223-231.
93. DiBattista, JD, Alfaro, ME, Sorenson, L, Choat, JH, Hobbs, J-PA, Sinclair-Taylor, TH, Rocha, LA, Chang, J, Luiz, OJ, Cowman, PF, Friedman, M and Berumen, ML (2018). Ice ages and butterflyfishes: phylogenomics elucidates the ecological and evolutionary history of reef fishes in an endemism hotspot. *Ecology and Evolution* 8(22): 10989-11008.
94. DiPerna, S, Hoogenboom, M, Noonan, S and Fabricius, K (2018). Effects of variability in daily light integrals on the photophysiology of the corals *Pachyseris speciosa* and *Acropora millepora*. *PLoS ONE* 13(9): e0203882.
95. Dixon, DL and Jones, GP (2018). Influence of prior residents on settlement preferences in the anemonefish, *Premnas biaculeatus*. *Coral Reefs* 37(2): 519-526.
96. D'Olivo, JP, Sinclair, DJ, Rankenburg, K and McCulloch, MT (2018). A universal multi-trace element calibration for reconstructing sea surface temperatures from long-lived porites corals: removing 'vital-effects'. *Geochimica et Cosmochimica Acta* 239: 109-135.
97. Donelson, JM, Salinas, S, Munday, PL and Shama, LNS (2018). Transgenerational plasticity and climate change experiments: where do we go from here? *Global Change Biology* 24(1): 13-34.
98. Donovan, MK, Friedlander, AM, Lecky, J, Jouffray, J-B, Williams, GJ, Wedding, LM, Crowder, LB, Erickson, AL, Graham, NAJ, Gove, JM, Kappel, CV, Karr, K, Kittinger, JN, Norström, AV, Nyström, M, Oleson, KLL, Stamoulis, KA, White, C, Williams, ID and Selkoe, KA (2018). Combining fish and benthic communities into multiple regimes reveals complex reef dynamics. *Scientific Reports* 8(1): 16943.
99. Dornelas, M, Antão, LH, Moyes, F, Bates, AE, Magurran, AE, Adam, D, Akhmetzhanova, AA, Appeltans, W, Arcos, JM, Arnold, H, Ayyappan, N, Badihi, G, Baird, AH, Barbosa, M, Barreto, TE, Bässler, C, Bellgrove, A, Belmaker, J, Benedetti-Cecchi, L, Bett, BJ, Bjorkman, AD, Błażewicz, M, Blowes, SA, Bloch, CP, Bonebrake, TC, Boyd, S, Bradford, M, Brooks, AJ, Brown, JH, Bruelheide, H, Budy, P, Carvalho, F, Castañeda-Moya, E, Chen, CA, Chamblee, JF, Chase, TJ, Siegwart Collier, L, Collinge, SK, Condit, R, Cooper, EJ, Cornelissen, JHC, Cotano, U, Kyle Crow, S, Damasceno, G, Davies, CH, Davis, RA, Day, FP, Degraer, S, Doherty, TS, Dunn, TE, Durigan, G, Duffy, JE, Edelist, D, Edgar, GJ, Elahi, R, Elmendorf, SC, Enemar, A, Ernest, SKM, Escibano, R, Estiarte, M, Evans, BS, Fan, T-Y, Turini Farah, F, Loureiro Fernandes, L, Farneda, FZ, Fidelis, A, Fitt, R, Fosaa, AM, Daher Correa Franco, GA, Frank, GE, Fraser, WR, García, H, Cazzolla Gatti, R, Givan, O, Gorgone-Barbosa, E, Gould, WA, Gries, C, Grossman, GD, Gutierrez, JR, Hale, S, Harmon, ME, Harte, J, Haskins, G, Henshaw, DL, Hermanutz, L, Hidalgo, P, Higuchi, P, Hoey, A, Van Hoey, G, Hofgaard, A, Holeck, K, Hollister, RD, Holmes, R, Hoogenboom, M et al (2018). BioTIME: a database of biodiversity time series for the Anthropocene. *Global Ecology and Biogeography* 27(7): 760-786.
100. Drost, EJF, Lowe, RJ, Ivey, GN and Jones, NL (2018). Wave-current interactions in the continental shelf bottom boundary layer of the Australian North West Shelf during tropical cyclone conditions. *Continental Shelf Research* 165: 78-92.
101. Dudley, N, Hockings, M, Stolton, S, Amend, T, Badola, R, Bianco, M, Chettri, N, Cook, C, Day, JC, Dearden, P, Edwards, M, Ferraro, P, Foden, W, Gambino, R, Gaston, KJ, Hayward, N, Hickey, V, Irving, J, Jeffries, B, Karapetyan, A, Kettunen, M, Laestadius, L, Laffoley, D, Lham, D, Lichtenstein, G, Makombo, J, Marshall, N, McGeoch, M, Nguyen, D, Nogué, S, Paxton, M, Rao, M, Reichelt, R, Rivas, J, Roux, D, Rutte, C, Schreckenberg, K, Sovinc, A, Sutyryna, S, Utomo, A, Vallauri, D, Vedeld, PO, Verschuuren, B, Waithaka, J, Woodley, S, Wyborn, C and Zhang, Y (2018). Priorities for protected area research. *Parks* 24(1): 35-50.
102. Dufois, F, Lowe, RJ, Rayson, MD and Branson, PM (2018). A numerical study of tropical cyclone-induced sediment dynamics on the Australian North West Shelf. *Journal of Geophysical Research: Oceans* 123(8): 5113-5133.
103. Erler, DV, Shepherd, BO, Linsley, BK, Lough, JM and Cantin, NE (2018). Coral skeletons record increasing agriculture-related groundwater nitrogen inputs to a south pacific reef over the past century. *Geophysical Research Letters* 45(16): 8370-8378.
104. Etminan, V, Ghisalberti, M and Lowe, RJ (2018). Predicting bed shear stresses in vegetated channels. *Water Resources Research* 54(11): 9187-9206.
105. Eurich, JG, McCormick, MI and Jones, GP (2018). Direct and indirect effects of interspecific competition in a highly partitioned guild of reef fishes. *Ecosphere* 9(8): 1-15.
106. Eurich, JG, McCormick, MI and Jones, GP (2018). Habitat selection and aggression as determinants of fine-scale partitioning of coral reef zones in a guild of territorial damselfishes. *Marine Ecology Progress Series* 587: 201-215.
107. Eurich, JG, Shomaker, SM, McCormick, MI and Jones, GP (2018). Experimental evaluation of the effect of a territorial damselfish on foraging behaviour of roving herbivores on coral reefs. *Journal of Experimental Marine Biology and Ecology* 506: 155-162.
108. Evans, LS, Cohen, PJ, Vave-Karamui, A, Masu, R, Boso, D and Mauli, S (2018). Reconciling multiple societal objectives in cross-scale marine governance: Solomon Islands' engagement in the Coral Triangle Initiative. *Society*



- and *Natural Resources* 31(1): 121-135.
109. Fabinyi, M (2018). Environmental fixes and historical trajectories of marine resource use in Southeast Asia. *GeoForum* 91: 87-96.
110. Fabinyi, M (2018). Food and water insecurity in specialised fishing communities: evidence from the Philippines. *Natural Resources Forum* 42(4): 243-253.
111. Fabinyi, M, Dressler, WH and Pido, MD (2018). Moving beyond financial value in seafood commodity chains. *Marine Policy* 94: 89-92.
112. Fang, JKH, Schönberg, CHL, Mello-Athayde, MA, Achlatis, M, Hoegh-Guldberg, O and Dove, S (2018). Bleaching and mortality of a photosymbiotic bioeroding sponge under future carbon dioxide emission scenarios. *Oecologia* 187(1): 25-35.
113. Farfan, GA, Cordes, EE, Waller, RG, DeCarlo, TM and Hansel, CM (2018). Mineralogy of deep-sea coral aragonites as a function of aragonite saturation state. *Frontiers in Marine Science* 5(473): 1-15.
114. Feeney, WE, Brooker, RM, Johnston, LN, Gilbert, DJ, Besson, M, Lecchini, D, Dixon, DL, Cowman, PF and Manica, A (2018). Predation drives recurrent convergence of an interspecies mutualism. *Ecology Letters* 22(2): 256-264.
115. Ferrari, M, McCormick, M, Meekan, M, Simpson, S, Nedelec SL and Chivers, D (2018). School is out on noisy reefs: the effect of boat noise on predator learning and survival of juvenile coral reef fishes. *Proceedings of the Royal Society B: Biological Sciences* 285(1871): 1-8.
116. Fisher, EE, Choat, JH, McCormick, MI and Cappel, M (2018). Relative influence of environmental factors on the timing and occurrence of multi-species coral reef fish aggregations. *PLoS ONE* 13(12): e0209234.
117. Floeter, SR, Bender, MG, Siqueira, AC and Cowman, PF (2018). Phylogenetic perspectives on reef fish functional traits. *Biological Reviews* 93(1): 131-151.
118. Fovargue, R, Bode, M and Armsworth, PR (2018). Size and spacing rules can balance conservation and fishery management objectives for marine protected areas. *Journal of Applied Ecology* 55(3): 1050-1059.
119. Frade, PR, Bongaerts, P, Englebert, N, Rogers, A, Gonzalez-Rivero, M and Hoegh-Guldberg, O (2018). Deep reefs of the Great Barrier Reef offer limited thermal refuge during mass coral bleaching. *Nature Communications* 9(1): 3447.
120. Gallo-Cajiao, E, Archibald, C, Friedman, R, Steven, R, Fuller, RA, Game, ET, Morrison, TH and Ritchie, EG (2018). Crowdfunding biodiversity conservation. *Conservation Biology* 32(6): 1426-1435.
121. Geldmann, J, Coad, L, Barnes, MD, Craigie, ID, Woodley, S, Balmford, A, Brooks, TM, Hockings, M, Knights, K, Mascia, MB, McRae, L and Burgess, ND (2018). A global analysis of management capacity and ecological outcomes in terrestrial protected areas. *Conservation Letters* 11(3): 1-10.
122. Giakoumi, S, McGowan, J, Mills, M, Beger, M, Bustamante, RH, Charles, A, Christie, P, Fox, M, Garcia-Borboroglu, P, Gelcich, S, Guidetti, P, Mackelworth, P, Maina, JM, McCook, L, Micheli, F, Morgan, LE, White, A, Grorud-Colvert, K and Possingham, HP (2018). Revisiting success and failure of marine protected areas: a conservation scientist perspective. *Frontiers in Marine Science* 5(223): 1-5.
123. Goatley, CHR, Wroe, S, Tebbett, SB and Bellwood, DR (2018). An evaluation of a double-tailed deformity in a coral-reef surgeonfish *Acanthurus nigrofasciatus* (Acanthuridae) using micro-computed tomography. *Journal of Fish Biology* 92(5): 1645-1650.
124. Goetze, JS, Claudet, J, Januchowski-Hartley, F, Langlois, TJ, Wilson, SK, White, C, Weeks, R and Jupiter, SD (2018). Demonstrating multiple benefits from periodically harvested fisheries closures. *Journal of Applied Ecology* 55(3): 1102-1113.
125. Gold, Z and Palumbi, SR (2018). Long-term growth rates and effects of bleaching in *Acropora hyacinthus*. *Coral Reefs* 37(1): 267-277.
126. Goldberg, JA, Marshall, NA, Birtles, A, Case, P, Curnock, MI and Gurney, GG (2018). On the relationship between attitudes and environmental behaviors of key Great Barrier Reef user groups. *Ecology and Society* 23(2): 1-19.
127. Gonzalez-Zapata, FL, Bongaerts, P, Ramirez-Portilla, C, Adu-Oppong, B, Walljasper, G, Reyes, A and Sanchez, JA (2018). Holobiont diversity in a reef-building coral over its entire depth range in the mesophotic zone. *Frontiers in Marine Science* 5(29): 1-13.
128. Gordon, TAC, Harding, HR, Wong, KE, Merchant, ND, Meekan, MG, McCormick, MI, Radford, AN and Simpson, SD (2018). Habitat degradation negatively affects auditory settlement behavior of coral reef fishes. *Proceedings of the National Academy of Sciences of the United States of America* 115(20): 5193-5198.
129. Graba-Landry, A, Hoey, AS, Matley, JK, Sheppard-Brennand, H, Poore, AGB, Byrne, M and Dworjanyn, SA (2018). Ocean warming has greater and more consistent negative effects than ocean acidification on the growth and health of subtropical macroalgae. *Marine Ecology Progress Series* 595: 55-69.
130. Graham, NAJ, Wilson, SK, Carr, P, Hoey, AS, Jennings, S and MacNeil, MA (2018). Seabirds enhance coral reef productivity and functioning in the absence of invasive rats. *Nature* 559(7713): 250-253.
131. Grech, A, Hanert, E, McKenzie, L, Rasheed, M, Thomas, C, Tol, S, Wang, M, Waycott, M, Wolter, J and Coles, R (2018). Predicting the cumulative effect of multiple disturbances on seagrass connectivity. *Global Change Biology* 24(7): 3093-3104.
132. Green, RH, Lowe, RJ and Buckley, ML (2018). Hydrodynamics of a tidally forced coral reef atoll. *Journal of Geophysical Research: Oceans* 123(10): 7084-7101.
133. Grottolli, AG, Martins, PD, Wilkins, MJ, Johnston, MD, Warner, ME, Cai, W-J, Melman, TF, Hoadley, KD, Pettay, DT, Levas, S and Schoepf, V (2018). Coral physiology and microbiome dynamics under combined warming and ocean acidification. *PLoS ONE* 13(1): e0191156.
134. Gruber, RK, Lowe, RJ and Falter, JL (2018). Benthic uptake of phytoplankton and ocean-reef exchange of particulate nutrients on a tide-dominated reef. *Limnology and Oceanography* 63(4): 1545-1561.
135. Guest, JR, Edmunds, PJ, Gates, RD, Kuffner, IB, Andersson, AJ, Barnes, BB, Chollett, I, Courtney, TA, Elahi, R, Gross, K, Lenz, EA, Mitarai, S, Mumby, PJ, Nelson, HR, Parker, BA, Putnam, HM, Rogers, CS and Toth, LT (2018). A framework for identifying and characterising coral reef oases against a backdrop of degradation. *Journal of Applied Ecology* 55(6): 2865-2875.
136. Hamel, MA, Pressey, RL, Evans, LS and Andréfouët, S (2018). The importance of fishing grounds as perceived by local communities can be undervalued by measures of socioeconomic cost used in conservation planning. *Conservation Letters* 11(1): 1-9.
137. Harborne, AR, Green, AL, Peterson, NA, Beger, M, Golbuu, Y, Houk, P, Spalding, MD, Taylor, BM, Terk, E, Tremblay, EA, Victor, S, Vigliola, L, Williams, ID, Wolff, NH, zu Ermgassen, PSE and Mumby, PJ (2018). Modelling and mapping regional-scale patterns of fishing impact and fish stocks to support coral-reef management in Micronesia. *Diversity and Distributions* 24(12): 1729-1743.
138. Harris, DL, Rovere, A, Casella, E, Power, H, Canavesio, R, Collin, A, Pomeroy, A, Webster, J and Parravicini, V (2018). Coral reef structural complexity provides important coastal protection from waves under rising sea levels. *Science Advances* 4(2): eaao4350.
139. Harrison, HB, Álvarez-Noriega, M, Baird, AH, Heron, SF, MacDonald, C and Hughes, TP (2018). Back-to-back coral reef atoll. *Journal of Geophysical Research: Oceans* 123(10): 7084-7101.
140. He, S, Harrison, HB and Berumen, ML (2018). Species delineation and hybrid identification using diagnostic nuclear markers for *Plectropomus leopardus* and *Plectropomus maculatus*. *Fisheries Research* 206: 287-291.
141. He, S, Planes, S, Sinclair-Taylor, TH and Berumen, ML (2018). Diagnostic nuclear markers for hybrid nemos in Kimbe Bay, PNG *Aamphiprion chrysopterus* x *Aamphiprion sandaracinos* hybrids. *Marine Biodiversity* 22(60): 1-9.
142. Head, CEI, Bonsall, MB, Jenkins, TL, Koldewey, H, Pratchett, MS, Taylor, ML and Rogers, AD (2018). Exceptional biodiversity of the cryptofaunal decapods in the Chagos Archipelago, central Indian Ocean. *Marine Pollution Bulletin* 135: 636-647.
143. Head, CEI, Koldewey, H, Pavoine, S, Pratchett, MS, Rogers, AD, Taylor, ML and Bonsall, MB (2018). Trait and phylogenetic diversity provide insights into community assembly of reef-associated shrimps (Palaemonidae) at different spatial scales across the Chagos Archipelago. *Ecology and Evolution* 8(8): 4098-4107.
144. Hedley, JD, Roelfsema, C, Brando, V, Giardino, C, Kutser, T, Phinn, S, Mumby, PJ, Barrilero, O, Laporte, J and Koetz, B (2018). Coral reef applications of Sentinel-2: coverage, characteristics, bathymetry and benthic mapping with comparison to landsat 8. *Remote Sensing of Environment* 216: 598-614.
145. Hemingson, CR and Bellwood, DR (2018). Biogeographic patterns in major marine realms: function not taxonomy unites fish assemblages in reef, seagrass and mangrove systems. *Ecography* 41(1): 174-182.
146. Hempson, TN, Graham, NAJ, MacNeil, MA, Bodin, N and Wilson, SK (2018). Regime shifts shorten food chains for mesopredators with potential sublethal effects. *Functional Ecology* 32(3): 820-830.
147. Hempson, TN, Graham, NAJ, MacNeil, MA, Hoey, AS and Almany, GR (2018). Mesopredator trophodynamics on thermally stressed coral reefs. *Coral Reefs* 37(1): 135-144.
148. Hempson, TN, Graham, NAJ, MacNeil, MA, Hoey, AS and Wilson, SK (2018). Ecosystem regime shifts disrupt trophic structure. *Ecological Applications* 28(1): 191-200.
149. Hernandez-Agreda, A, Leggat, W and Ainsworth, TD (2018). A comparative analysis of microbial DNA preparation methods for use with massive and branching coral growth forms. *Frontiers in Microbiology* 9: 2146.
150. Hernandez-Agreda, A, Leggat, W, Bongaerts, P, Herrera, C and Ainsworth, TD (2018). Rethinking the coral microbiome: simplicity exists within a diverse microbial biosphere. *mBio* 9(5): 1-14.
151. Hess, S, Allan, BJM, Hoey, AS, Jarrold, MD, Wenger, AS and Rummer, JL (2018). Enhanced fast-start performance and anti-predator behaviour in a coral reef fish in response to suspended sediment exposure. *Coral Reefs* 38(1): 103-108.
152. Hoegh-Guldberg, O, Kennedy, EV, Beyer, HL, McClennen, C and Possingham, HP (2018). Securing a long-term future for Coral Reefs. *Trends in Ecology and Evolution* 33(12): 936-944.
153. Horowitz, J, Opreko, DM and Bridge, TCL (2018). Black corals (Anthozoa: Antipatharia) from the deep (916 m–2542 m) Coral Sea, north-eastern Australia. *Zootaxa* 4472(2): 307-326.
154. Horowitz, J, Pressey, RL, Gurney, GG, Wenger, AS and Pahang, KA (2018). Investigating stakeholder perceptions of fish decline: making sense of multiple mental models. *Sustainability* 10(4): 1-26.
155. Houlahan, JE, Currie, DJ, Cottenie, K, Cumming, GS, Findlay, CS, Fuhlendorf, SD, Legendre, P, Muldavin, EH, Noble, D, Russell, R, Stevens, RD, Willis, TJ and Wondzell, SM (2018). Negative relationships between species richness and temporal variability are common but weak in natural systems. *Ecology* 99(11): 2592-2604.
156. Howells, EJ, Dunshea, G, McParland, D, Vaughan, GO, Heron, SF, Pratchett, MS, Burt, JA and Bauman, AG (2018). Species-specific coral calcification responses to the extreme environment of the southern Persian Gulf. *Frontiers in Marine Science* 5(56): 1-13.
157. Huertas, V and Bellwood, DR (2018). Feeding innovations and the first coral-feeding fishes. *Coral Reefs* 37(3): 649-658.
158. Hughes, TP, Anderson, KD, Connolly, SR, Heron, SF, Kerry, JT, Lough, JM, Baird, AH, Baum, JK, Berumen, ML, Bridge, TC, Claar, DC, Eakin, CM, Gilmour, JP, Graham, NAJ, Harrison, H, Hobbs, J-PA, Hoey, AS, Hoogenboom, M, Lowe, RJ, McCulloch, MT, Pandolfi, JM, Pratchett, M, Schoepf, V, Torda, G and Wilson, SK (2018). Spatial and temporal patterns of mass bleaching of corals in the Anthropocene. *Science* 359(6371): 80-83.
159. Hughes, TP, Kerry, JT, Baird, AH, Connolly, SR, Dietzel, A, Eakin, CM, Heron, SF, Hoey, AS, Hoogenboom, MO, Liu, G, McWilliam, MJ, Pears, RJ, Pratchett, MS, Skirving, WJ, Stella, JS and Torda, G (2018). Global warming transforms coral reef assemblages. *Nature* 556(7702): 492-496.
160. Hughes, TP, Kerry, JT and Simpson, T (2018). Large-scale bleaching of corals on the Great Barrier Reef. *Ecology* 99(2): 501.
161. Hume, BCC, Ziegler, M, Poulain, J, Pochon, X, Romac, S, Boissin, E, de Vargas, C, Planes, S, Wincker, P and Voolstra, CR (2018). An improved primer set and amplification protocol with increased specificity and sensitivity targeting the *Symbiodinium* ITS2 region. *PeerJ* 6: e4816.
162. Iacona, GD, Sutherland, WJ, Mappin, B, Adams, VM, Armsworth, PR, Coleshaw, T, Cook, C, Craigie, I, Dicks, LV, Fitzsimons, JA, McGowan, J, Plumpton, AJ, Polak, T, Pullin, AS, Ringma, J, Rushworth, I, Santangeli, A, Stewart, A, Tulloch, A, Walsh, JC and Possingham, HP (2018). Standardized reporting of the costs of management interventions for biodiversity conservation. *Conservation Biology* 32(5): 979-988.
163. Jain-Schlaepfer, S, Fakan, E, Rummer, JL, Simpson, SD and McCormick, MI (2018). Impact of motorboats on fish embryos depends on engine type. *Conservation Physiology* 6(1): coy014.
164. Jarrold, MD and Munday, PL (2018). Diel CO₂ cycles do not modify juvenile growth, survival and otolith development in two coral reef fish under ocean acidification. *Marine Biology* 165(3): 1-12.
165. Jarrold, MD and Munday, PL (2018). Elevated temperature does not substantially modify the interactive effects between elevated CO₂ and diel CO₂ cycles on the survival, growth and behavior of a coral reef fish. *Frontiers in Marine Science* 5(458): 1-16.
166. Jeffrey, JD, Hannan, K, Hasler, C and Suski, C (2018). Chronic exposure of a freshwater mussel to elevated pCO₂: effects on the control of biomineralization and ion-regulatory responses. *Environmental Toxicology and Chemistry* 37(2): 538-550.
167. Johns, KA, Emslie, MJ, Hoey, AS, Osborne, K, Jonker, MJ and Cheal, AJ (2018). Macroalgal feedbacks and substrate properties maintain a coral reef regime shift. *Ecosphere* 9(7): 1-15.
168. Juhel, J-B, Vigliola, L, Mouillot, D, Kulbicki, M, Letessier, T, Meeuwij, J and Wantiez, L (2018). Reef accessibility impairs the protection of sharks. *Journal of Applied Ecology* 55(2): 673-683.
169. Keith, SA, Baird, AH, Hobbs, J-PA, Woolsey, ES, Hoey, AS, Fadli, N and Sanders, NJ (2018). Synchronous behavioural shifts in reef fishes linked to mass coral bleaching. *Nature Climate Change* 8(11): 986-991.
170. Kenkel, CD, Moya, A, Strahl, J, Humphrey, C and Bay, LK (2018). Functional genomic analysis of corals from natural CO₂-seeps reveals core molecular responses involved in acclimatization to ocean acidification. *Global Change Biology* 24(1): 158-171.
171. Kim, SW, Blomberg, SP and Pandolfi, JM (2018). Transcending data gaps: a framework to reduce inferential errors in ecological analyses. *Ecology Letters* 21(8): 1200-1210.
172. Kingsford, MJ, Becken, S, Bordehore, C, Fuentes, VL, Pitt, KA and Yangihara, AA (2018). Empowering stakeholders to manage stinging jellyfish: a perspective. *Coastal Management* 46(1): 1-18.
173. Kleiber, D, Harris, L and Vincent, ACJ (2018). Gender and marine protected areas: a case study of Danajon Bank, Philippines. *Maritime Studies* 17(2): 163-175.



174. Kölbl-Ebert, M, Ebert, M, Bellwood, DR and Schulbert, C (2018). A piranha-like pycnodontiform fish from the late jurassic. *Current Biology* 28(21): 3516-3521 e2.
175. Komyakova, V, Jones, GP and Munday, PL (2018). Strong effects of coral species on the diversity and structure of reef fish communities: a multi-scale analysis. *PLoS ONE* 13(8): e0202206.
176. Krueck, NC, Legrand, C, Ahmadi, GN, Estradivari, A, Jones, GP, Riginos, C, Trembl, EA and Mumby, PJ (2018). Reserve sizes needed to protect coral reef fishes. *Conservation Letters* 11(3): 1-9.
177. Kuempel, CD, Adams, VM, Possingham, HP and Bode, M (2018). Bigger or better: the relative benefits of protected area network expansion and enforcement for the conservation of an exploited species. *Conservation Letters* 11(3): 1-8.
178. Lam, VYY, Chaloupka, M, Thompson, A, Doropoulos, C and Mumby, PJ (2018). Acute drivers influence recent inshore Great Barrier Reef dynamics. *Proceedings of the Royal Society B: Biological Sciences* 285(1890): 1-9.
179. Lamb, JB, Willis, BL, Fiorenza, EA, Couch, CS, Howard, R, Rader, DN, True, JD, Kelly, LA, Ahmad, A, Jompa, J and Harvell, CD (2018). Plastic waste associated with disease on coral reefs. *Science* 359(6374): 460-462.
180. Lashley, CH, Roelvink, D, van Dongeren, A, Buckley, ML and Lowe, RJ (2018). Nonhydrostatic and surfbeat model predictions of extreme wave run-up in fringing reef environments. *Coastal Engineering* 137: 11-27.
181. Lau, JD, Hicks, CC, Gurney, GG and Cinner, JE (2018). Disaggregating ecosystem service values and priorities by wealth, age, and education. *Ecosystem Services* 29: 91-98.
182. Laverick, JH, Piango, S, Andradi-Brown, DA, Exton, DA, Bongaerts, P, Bridge, TCL, Lesser, MP, Pyle, RL, Slattey, M, Wagner, D and Rogers, AD (2018). To what extent do mesophotic coral ecosystems and shallow reefs share species of conservation interest? A systematic review. *Environmental Evidence* 7(15): 1-13.
183. Lehmann, R, Lightfoot, DJ, Schunter, C, Michell, CT, Ohyanagi, H, Mineta, K, Forêt, S, Berumen, ML, Miller, DJ, Aranda, M, Gojobori, T, Munday, PL and Ravasi, T (2018). Finding nemo's genes: a chromosome-scale reference assembly of the genome of the orange clownfish *Amphiprion percula*. *Molecular Ecology Resources* 18(5): 1-16.
184. Leitão, RP, Zuanon, J, Mouillot, D, Leal, C, Hughes, R, Kaufmann, P, Villéger, S, Pompeu, P, Kasper, D, de Paula, F, Ferraz, S and Gardner, T (2018). Disentangling the pathways of land use impacts on the functional structure of fish assemblages in Amazon streams. *Ecography* 41(1): 219-232.
185. Leite, JR, Pereira, P, Sanches, E, Moura, R and Hostim-Silva, M (2018). Bird-like complex nesting behaviour by the brazilian-endemic reef fish *Gramma brasiliensis*. *Marine and Freshwater Research* 69(6): 982-986.
186. Leonard, ND, Welsh, KJ, Clark, TR, Feng, Y-X, Pandolfi, JM and Zhao, J-X (2018). New evidence for far-field holocene sea level oscillations and links to global climate records. *Earth and Planetary Science Letters* 487: 67-73.
187. Levas, S, Schoepf, V, Warner, ME, Aschaffenburg, M, Baumann, J and Grottolli, AG (2018). Long-term recovery of Caribbean corals from bleaching. *Journal of Experimental Marine Biology and Ecology* 506: 124-134.
188. Lewis, SE, Lough, JM, Cantin, NE, Matson, EG, Kinsley, L, Bainbridge, ZT and Brodie, JE (2018). A critical evaluation of coral Ba/Ca, Mn/Ca and Y/Ca ratios as indicators of terrestrial input: new data from the Great Barrier Reef, Australia. *Geochimica et Cosmochimica Acta* 237: 131-154.
189. Liew, YJ, Zoccola, D, Li, Y, Tambutte, E, Venn, AA, Michell, CT, Cui, G, Deutekom, ES, Kaandorp, JA, Voolstra, CR, Forêt, S, Allemand, D, Tambutte, S and Aranda, M (2018). Epigenome-associated phenotypic acclimatization to ocean acidification in a reef-building coral. *Science Advances* 4(6): eaar8028.
190. Loffler, Z, Graba-Landry, A, Kidgell, JT, McClure, EC, Pratchett, MS and Hoey, AS (2018). Holdfasts of *Sargassum swartzii* are resistant to herbivory and resilient to damage. *Coral Reefs* 37(4): 1075-1084.
191. Loffler, Z and Hoey, AS (2018). Canopy-forming macroalgal beds (*Sargassum*) on coral reefs are resilient to physical disturbance. *Journal of Ecology* 106(3): 1156-1164.
192. Lopes, AR, Sampaio, E, Santos, C, Couto, A, Pegado, MR, Diniz, M, Munday, PL, Rummer, JL and Rosa, R (2018). Absence of cellular damage in tropical newly hatched sharks (*Chiloscyllium plagiosum*) under ocean acidification conditions. *Cell Stress and Chaperones* 23(5): 837-846.
193. Lough, JM, Anderson, KD and Hughes, TP (2018). Increasing thermal stress for tropical coral reefs: 1871-2017. *Scientific Reports* 8(1): 6079.
194. Lukoschek, V (2018). Congruent phylogeographic patterns in a young radiation of live-bearing marine snakes: pleistocene vicariance and the conservation implications of cryptic genetic diversity. *Diversity and Distributions* 24(3): 325-340.
195. Lukoschek, V (2018). Population declines, genetic bottlenecks and potential hybridization in sea snakes on Australia's Timor Sea reefs. *Biological Conservation* 225: 66-79.
196. MacDonald, C, Jones, GP and Bridge, T (2018). Marginal sinks or potential refuges? Costs and benefits for coral-obligate reef fishes at deep range margins. *Proceedings of the Royal Society B: Biological Sciences* 285(1890): 1-10.
197. MacDonald, C, Tauati, MI and Jones, GP (2018). Depth patterns in microhabitat versatility and selectivity in coral reef damselfishes. *Marine Biology* 165(138): 1-14.
198. MacKeracher, T, Diedrich, A, Gurney, GG and Marshall, N (2018). Who trusts whom in the Great Barrier Reef? Exploring trust and communication in natural resource management. *Environmental Science and Policy* 88: 24-31.
199. Madin, JS, Baird, AH, Bridge, TCL, Connolly, SR, Zawada, KJA and Dornelas, M (2018). Cumulative effects of cyclones and bleaching on coral cover and species richness at Lizard Island. *Marine Ecology Progress Series* 604: 263-268.
200. Magris, RA, Andrello, M, Pressey, RL, Mouillot, D, Dalongeville, A, Jacobi, MN and Manel, S (2018). Biologically representative and well-connected marine reserves enhance biodiversity persistence in conservation planning. *Conservation Letters* 11(4): 1-10.
201. Magris, RA, Grech, A and Pressey, RL (2018). Cumulative human impacts on coral reefs: assessing risk and management implications for brazilian coral reefs. *Diversity* 10(2): 1-15.
202. Magris, RA and Pressey, RL (2018). Marine protected areas: just for show? *Science* 360(6390): 723-724.
203. Maia, HA, Morais, R, Siqueira, A, Hanazaki, N, Floeter SR and Bender, M (2018). Shifting baselines among traditional fishers in São Tomé and Príncipe islands, Gulf of Guinea. *Ocean and Coastal Management* 154: 133-142.
204. Maire, E, Villeger, S, Graham, NAJ, Hoey, AS, Cinner, J, Ferse, SCA, Aliaume, C, Booth, DJ, Feary, DA, Kulbicki, M, Sandin, SA, Vigliola, L and Mouillot, D (2018). Community-wide scan identifies fish species associated with coral reef services across the Indo-Pacific. *Proceedings of the Royal Society B: Biological Sciences* 285(1883): 1-9.
205. Maisano Delsler, P, Corrigan, S, Duckett, D, Suwalski, A, Veuille, M, Planes, S, Naylor, GJP and Mona, S (2018). Demographic inferences after a range expansion can be biased: the test case of the blacktip reef shark (*Carcharhinus melanopterus*). *Heredity* 121(5): 1-11.
206. Malerba, ME, Palacios, M, Palacios Delgado, Y, Beardall, J and Marshall, DJ (2018). Cell size, photosynthesis and the package effect: an artificial selection approach. *New Phytologist* 219(1): 449-461.
207. Marchitto, TM, Bryan, SP, Doss, W, McCulloch, MT and Montagna, P (2018). A simple biomineralization model to explain Li, Mg, and Sr incorporation into aragonitic foraminifera and corals. *Earth and Planetary Science Letters* 481: 20-29.
208. Marshall, N, Barnes, ML, Birtles, A, Brown, K, Cinner, J, Curnock, M, Eakin, H, Goldberg, J, Gooch, M, Kittinger, J, Marshall, P, Manuel-Navarrete, D, Pelling, M, Pert, PL, Smit, B and Tobin, R (2018). Measuring what matters in the Great Barrier Reef. *Frontiers in Ecology and the Environment* 16(5): 271-277.
209. Mary George, A, Brodie, J, Daniell, J, Capper, A and Jonker, M (2018). Can sponge morphologies act as environmental proxies to biophysical factors in the Great Barrier Reef, Australia? *Ecological Indicators* 93: 1152-1162.
210. Mason, RAB (2018). Decline in symbiont densities of tropical and subtropical scleractinian corals under ocean acidification. *Coral Reefs* 37(3): 945-953.
211. Matis, PA, Donelson, JM, Bush, S, Fox, R and Booth, DJ (2018). Temperature influences habitat preference of coral reef fishes: will generalists become more specialised in a warming ocean? *Global Change Biology* 24(7): 3158-3169.
212. McCauley, DJ, Gellner, G, Martinez, ND, Williams, RJ, Sandin, SA, Micheli, F, Mumby, PJ and McCann, KS (2018). On the prevalence and dynamics of inverted trophic pyramids and otherwise top-heavy communities. *Ecology Letters* 21(3): 439-454.
213. McCormick, MI, Allan, B, Harding, H and Simpson, S (2018). Boat noise impacts risk assessment in a coral reef fish but effects depend on engine type. *Scientific Reports* 8(1): 3847.
214. McCormick, MI, Fakan, E and Allan, B (2018). Behavioural measures determine survivorship within the hierarchy of whole-organism phenotypic traits. *Functional Ecology* 32(4): 958-969.
215. McCormick, MI, Watson, S-A, Simpson, SD and Allan, BJM (2018). Effect of elevated CO₂ and small boat noise on the kinematics of predator – prey interactions. *Proceedings of the Royal Society B: Biological Sciences* 285(1875): 1-8.
216. McDonald, JA, Helmstedt, KJ, Bode, M, Coutts, S, McDonald-Madden, E and Possingham, HP (2018). Improving private land conservation with outcome-based biodiversity payments. *Journal of Applied Ecology* 55(3): 1476-1485.
217. McGowan, J, Bode, M, Holden, MH, Davis, K, Krueck, NC, Beger, M, Yates, KL and Possingham, HP (2018). Ocean zoning within a sparing versus sharing framework. *Theoretical Ecology* 11(2): 245-254.
218. McIntosh, EJ, Chapman, S, Kearney, SG, Williams, B, Althor, G, Thorn, JPR, Pressey, RL, McKinnon, MC and Grenyer, R (2018). Absence of evidence for the conservation outcomes of systematic conservation planning around the globe: a systematic map. *Environmental Evidence* 7(22): 1-23.
219. McMahon, SJ, Donelson, JM and Munday, PL (2018). Food ration does not influence the effect of elevated CO₂ on antipredator behaviour of a reef fish. *Marine Ecology Progress Series* 586: 155-165.
220. McWilliam, M, Chase, TJ and Hoogenboom, MO (2018). Neighbor diversity regulates the productivity of coral assemblages. *Current Biology* 28(22): 3634-3639 e3.
221. McWilliam, M, Hoogenboom, MO, Baird, AH, Kuo, C-Y, Madin, JS and Hughes, TP (2018). Biogeographical disparity in the functional diversity and redundancy of corals. *Proceedings of the National Academy of Sciences of the United States of America* 115(12): 3084-3089.
222. Meekan, MG, McCormick, MI, Simpson, SD, Chivers, DP and Ferrari, MCO (2018). Never off the hook-how fishing subverts predator-prey relationships in marine teleosts. *Frontiers in Ecology and Evolution* 6(10): 1-10.
223. Mizerek, TL, Baird, AH and Madin, JS (2018). Species traits as indicators of coral bleaching. *Coral Reefs* 37(3): 791-800.
224. Mizrahi, M, Diedrich, A, Weeks, R and Pressey, RL (2018). A systematic review of the socioeconomic factors that influence how marine protected areas impact on ecosystems and livelihoods. *Society and Natural Resources* 32(1): 4-20.
225. Mohamed, AR, Cumbo, V, Harii, S, Shinzato, C, Chan, C, Ragan, M, Satoh, N, Ball, E and Miller, D (2018). Deciphering the nature of the coral-chromera association. *ISME Journal* 12(3): 776-790.
226. Monteiro, LM, Brum, FT, Pressey, RL, Morellato, LPC, Soares-Filho, B, Lima-Ribeiro, MS and Loyola, R (2018). Evaluating the impact of future actions in minimizing vegetation loss from land conversion in the Brazilian Cerrado under climate change. *Biodiversity and Conservation* 27(331): 1-23.
227. Morais, RA and Bellwood, DR (2018). Global drivers of reef fish growth. *Fish and Fisheries* 19(5): 874-889.
228. Muir, PR, Wallace, C, Pichon, M and Bongaerts, P (2018). High species richness and lineage diversity of reef corals in the mesophotic zone. *Proceedings of the Royal Society B: Biological Sciences* 285(1893): 1-7.
229. Mumby, PJ and Steneck, RS (2018). Paradigm lost: dynamic nutrients and missing detritus on coral reefs. *BioScience* 68(7): 487-495.
230. Nadler, LE, Killen, SS, Domenici, P and McCormick, MI (2018). Role of water flow regime in the swimming behaviour and escape performance of a schooling fish. *Biology Open* 7(10).
231. Nakaoka, M, Sudo, K, Namba, M, Shibata, H, Nakamura, F, Ishikawa, S, Makino, M, Yamano, H, Matsuzaki, S-IS, Yamakita, T, Yu, X, Hou, X, Li, X, Brodie, J, Kanemoto, K, Moran, D and Verones, F (2018). Tsunagari: a new interdisciplinary and transdisciplinary study toward conservation and sustainable use of biodiversity and ecosystem services. *Ecological Research* 33(1): 35-49.
232. Nay, TJ, Gervais, CR, Hoey, AS, Johansen, JL, Steffensen, JF and Rummer, JL (2018). The emergence emergency: a mudskipper's response to temperatures. *Journal of Thermal Biology* 78: 65-72.
233. Nicolet, KJ, Chong-Seng, KM, Pratchett, MS, Willis, BL and Hoogenboom, MO (2018). Predation scars may influence host susceptibility to pathogens: evaluating the role of corallivores as vectors of coral disease. *Scientific Reports* 8(1): 52-58.
234. Nicolet, KJ, Hoogenboom, MO, Pratchett, MS and Willis, BL (2018). Selective feeding by corallivorous fishes neither promotes nor reduces progression rates of black band disease. *Marine Ecology Progress Series* 594: 95-106.
235. Nori, J, Leynaud, GC, Volante, J, Abdala, CS, Scrochi, GJ, Rodriguez-Soto, C, Pressey, RL and Loyola, R (2018). Reptile species persistence under climate change and direct human threats in north-western Argentina. *Environmental Conservation* 45(1): 83-89.
236. Nowicki, JP, O'Connell, LA, Cowman, PF, Walker, SPW, Coker, DJ and Pratchett, MS (2018). Variation in social systems within chaetodon butterflyfishes, with special reference to pair bonding. *PLoS ONE* 13(4): e0194465.
237. Nowicki, JP, Walker, SPW, Coker, DJ, Hoey, AS, Nicolet, KJ and Pratchett, MS (2018). Pair bond endurance promotes cooperative food defense and inhibits conflict in coral reef butterflyfish. *Scientific Reports* 8(1): 6295.
238. O'Brien, KR, Waycott, M, Maxwell, P, Kendrick, GA, Udy, JW, Ferguson, AJP, Kilminster, K, Scanes, P, McKenzie, LJ, McMahon, K, Adams, MP, Samper-Villarreal, J, Collier, C, Lyons, M, Mumby, PJ, Radke, L, Christianen, MJA and Dennison, WC (2018). Seagrass ecosystem trajectory depends on the relative timescales of resistance, recovery and disturbance. *Marine Pollution Bulletin* 134: 166-176.
239. O'Brien, PA, Smith, HA, Fallon, S, Fabricius, K, Willis, BL, Morrow, KM and Bourne, DG (2018). Elevated CO₂ has little influence on the bacterial communities associated with the pH-tolerant coral, massive *Porites* spp. *Frontiers in Microbiology* 9(11): 1-12.
240. Olsen, YS, Fraser, MW, Martin, BC, Pomeroy, O and Kendrick, GA (2018). In situ oxygen dynamics in rhizomes



of the seagrass *Posidonia sinuosa*: impact of light, water column oxygen, current speed and wave velocity. *Marine Ecology Progress Series* 590: 67-77.

241. Ortiz, J-C, Wolff, NH, Anthony, KRN, Devlin, M, Lewis, S and Mumby, PJ (2018). Impaired recovery of the great barrier reef under cumulative stress. *Science Advances* 4(7): eaar6127.
242. Palacios, MM, Malerba, M and McCormick, M (2018). Multiple predator effects on juvenile prey survival. *Oecologia* 188(2): 417-427.
243. Palmer, CV and Baird, AH (2018). Coral tumor-like growth anomalies induce an immune response and reduce fecundity. *Diseases of Aquatic Organisms* 130(1): 77-81.
244. Perry, CT, Alvarez-Filip, L, Graham, NAJ, Mumby, PJ, Wilson, SK, Kench, PS, Manzello, DP, Morgan, KM, Slangen, ABA, Thomson, DP, Januchowski-Hartley, F, Smithers, SG, Steneck, RS, Carlton, R, Edinger, EN, Enochs, IC, Estrada-Saldívar, N, Hayward, MDE, Kolodziej, G, Murphy, GN, Pérez-Cervantes, E, Suchley, A, Valentino, L, Boenish, R, Wilson, M and MacDonald, C (2018). Loss of coral reef growth capacity to track future increases in sea level. *Nature* 558(7710): 396-400.



245. Pesendorfer, MB, Baker, CM, Stringer, M, McDonald-Madden, E, Bode, M, McEachern, AK, Morrison, SA and Sillett, TS (2018). Oak habitat recovery on California's largest islands: scenarios for the role of corvid seed dispersal. *Journal of Applied Ecology* 55(3): 1185-1194.
246. Pirotta, V, Grech, A, Jonsen, ID, Laurance, WF and Harcourt, RG (2018). Consequences of global shipping traffic for marine giants. *Frontiers in Ecology and the Environment* 17(1):

- 39-47.
247. Pollock, FJ, McMinds, R, Smith, S, Bourne, DG, Willis, BL, Medina, M, Thurber, RV and Zaneveld, JR (2018). Coral-associated bacteria demonstrate phyllosymbiosis and copyphylogeny. *Nature communications* 9(1): 4921.
248. Pomeroy, AWM, Lowe, RJ, Ghisalberti, M, Winter, G, Storlazzi, C and Cuttler, M (2018). Spatial variability of sediment transport processes over intratidal and subtidal timescales within a fringing coral reef system. *Journal of Geophysical Research: Earth Surface* 123(5): 1013-1034.
249. Precoda, K, Baird, AH, Madsen, A, Mizerek, T, Sommer, B, Su, SN and Madin, JS (2018). How does a widespread reef coral maintain a population in an isolated environment? *Marine Ecology Progress Series* 594: 85-94.
250. Purcell, SW, Williamson, D and Ngaluafé, P (2018). Chinese market prices of beche-de-mer: implications for fisheries and aquaculture. *Marine Policy* 91: 58-65.
251. Quattrini, AM, Faircloth, BC, Dueñas, LF, Bridge, TCL, Brugler, MR, Calixto-Boña, IF, DeLeo, DM, Forêt, S, Herrera, S, Lee, SMY, Miller, DJ, Prada, C, Rádis-Baptista, G, Ramírez-Portilla, C, Sánchez, JA, Rodríguez, E and McFadden, CS (2018). Universal target-enrichment baits for anthozoan (Cnidaria) phylogenomics: new approaches to long-standing problems. *Molecular Ecology Resources* 18(2): 281-295.
252. Quigley, KM, Bay, LK and Willis, BL (2018). Leveraging new knowledge of *Symbiodinium* community regulation in corals for conservation and reef restoration. *Marine Ecology Progress Series* 600: 245-253.
253. Quigley, KM, Strader, ME and Matz, MV (2018). Relationship between *Acropora millepora* juvenile fluorescence and composition of newly established *Symbiodinium* assemblage. *PeerJ* 6: e5022.
254. Quigley, KM, Torda, G and Bay, L (2018). The use of larvae or recruits in coral restoration initiatives: *Symbiodinium* acquisition does not differ between coral life stages in the wild. *Restoration Ecology* 26(3): 422-425.

255. Quigley, KM, Warner, PA, Bay, LK and Willis, BL (2018). Unexpected mixed-mode transmission and moderate genetic regulation of *Symbiodinium* communities in a brooding coral. *Heredity* 121(6): 524-536.
256. Rabosky, DL, Chang, J, Title, PO, Cowman, PF, Sallan, L, Friedman, M, Kaschner, K, Garilao, C, Near, TJ, Coll, M and Alfaro, ME (2018). An inverse latitudinal gradient in speciation rate for marine fishes. *Nature* 559(7714): 392-395.
257. Raby, GD, Messmer, V, Tobin, AJ, Hoey, AS, Jutfelt, F, Sundin, J, Cooke, SJ and Clark, TD (2018). Swim for it: effects of simulated fisheries capture on the post-release behaviour of four Great Barrier Reef fishes. *Fisheries Research* 206: 129-137.
258. Ramsby, BD, Hoogenboom, MO, Smith, HA, Whalan, S and Webster, NS (2018). The bioeroding sponge *Cliona orientalis* will not tolerate future projected ocean warming. *Scientific Reports* 8(1): 8302.
259. Ramsby, BD, Hoogenboom, MO, Whalan, S and Webster, NS (2018). Elevated seawater temperature disrupts the microbiome of an ecologically important bioeroding sponge. *Molecular Ecology* 27(8): 2124-2137.
260. Reed, EV, Cole, JE, Lough, JM, Thompson, D and Cantin, NE (2018). Linking climate variability and growth in coral skeletal records from the Great Barrier Reef. *Coral Reefs* 38(1): 29-43.
261. Riaux-Gobin, C, Witkowski, A, Jordan, RW, Parravicini, V and Planes, S (2018). *Cocconeis kurakakea*, a new diatom species from Nukutavake (Tuamotu archipelago, South Pacific): description and comparison with *C. diruptoides* and *C. pseudodiruptoides*. *Phytotaxa* 349(2): 115-129.
262. Richards, ZT and Day, J (2018). Biodiversity of the Great Barrier Reef- how adequately is it protected? *PeerJ* 6: e4747.
263. Richardson, LE, Graham, NAJ, Pratchett, MS, Eurich, JG and Hoey, AS (2018). Mass coral bleaching causes biotic homogenization of reef fish assemblages. *Global Change Biology* 24(7): 3117-3129.
264. Rijnsdorp, DP, Hansen, JE and Lowe, RJ (2018). Simulating the wave-induced response

- of a submerged wave-energy converter using a non-hydrostatic wave-flow model. *Coastal Engineering* 140: 189-204.
265. Ringma, J, Legge, S, Woinarski, J, Radford, J, Wintle, B and Bode, M (2018). Australia's mammal fauna requires a strategic and enhanced network of predator-free havens. *Nature Ecology and Evolution* 2(3): 410-411.
266. Robinson, JPW, Wilson, SK, Robinson, J, Gerry, C, Lucas, J, Assan, C, Govinden, R, Jennings, S and Graham, NAJ (2018). Productive instability of coral reef fisheries after climate-driven regime shifts. *Nature Ecology and Evolution* 3(2): 183-190.
267. Rocha, LA, Pinheiro, HT, Shepherd, B, Papastamatiou, YP, Luiz, OJ, Pyle, RL and Bongaerts, P (2018). Mesophotic coral ecosystems are threatened and ecologically distinct from shallow water reefs. *Science* 361(6399): 281-284.
268. Rodgers, GG, Donelson, JM, McCormick, MI and Munday, PL (2018). In hot water: sustained ocean warming reduces survival of a low-latitude coral reef fish. *Marine Biology* 165(73): 1-10.
269. Roelfsema, C, Kovacs, E, Ortiz, JC, Wolff, NH, Callaghan, D, Wettle, M, Ronan, M, Hamylton, SM, Mumby, PJ and Phinn, S (2018). Coral reef habitat mapping: a combination of object-based image analysis and ecological modelling. *Remote Sensing of Environment* 208: 27-41.
270. Roff, G, Bejarano, S, Priest, M, Marshall, A, Chollett, I, Steneck, RS, Doropoulos, C, Golbuu, Y and Mumby, PJ (2018). Seascapes as drivers of herbivore assemblages in coral reef ecosystems. *Ecological Monographs* 89(1): 1-18.
271. Rogers, A, Blanchard, JL and Mumby, PJ (2018). Fisheries productivity under progressive coral reef degradation. *Journal of Applied Ecology* 55(3): 1041-1049.
272. Rogers, A, Blanchard, JL, Newman, SP, Dryden, CS and Mumby, PJ (2018). High refuge availability on coral reefs increases the vulnerability of reef-associated predators to overexploitation. *Ecology* 99(2): 450-463.

273. Rose, NH, Bay, RA, Morikawa, MK and Palumbi, SR (2018). Polygenic evolution drives species divergence and climate adaptation in corals. *Evolution* 72(1): 82-94.
274. Ross, CL, DeCarlo, TM and McCulloch, MT (2018). Environmental and physiochemical controls on coral calcification along a latitudinal temperature gradient in Western Australia. *Global Change Biology* 25(2): 431-447.
275. Ross, CL, Schoepf, V, DeCarlo, TM and McCulloch, MT (2018). Mechanisms and seasonal drivers of calcification in the temperate coral *Turbinaria reniformis* at its latitudinal limits. *Proceedings of the Royal Society B: Biological Sciences* 285(1879): 1-10.
276. Rueger, T, Barbasch, TA, Wong, MYL, Srinivasan, M, Jones, GP and Buston, PM (2018). Reproductive control via the threat of eviction in the clown anemonefish. *Proceedings of the Royal Society B: Biological Sciences* 285(1891): 1-6.
277. Russ, GR, Payne, CS, Bergseth, BJ, Rizzari, JR, Abesamis, RA and Alcala, AC (2018). Decadal-scale response of detritivorous surgeonfishes (family Acanthuridae) to no-take marine reserve protection and changes in benthic habitat. *Journal of Fish Biology* 93(5): 887-900.
278. Ryu, T, Veilleux, HD, Donelson, JM, Munday, PL and Ravasi, T (2018). The epigenetic landscape of transgenerational acclimation to ocean warming. *Nature Climate Change* 8(6): 504-509.
279. Saha, A, McRae, L, Dodd, CK, Gadsden, H, Hare, KM, Lukoschek, V and Böhm, M (2018). Tracking global population trends: population time-series data and a living planet index for reptiles. *Journal of Herpetology* 52(3): 259-268.
280. Salter, MA, Perry, CT, Stuart-Smith, RD, Edgar, GJ, Wilson, RW and Harborne, AR (2018). Reef fish carbonate production assessments highlight regional variation in sedimentary significance. *Geology* 46(8): 699-702.
281. Samper-Villarreal, J, Mumby, PJ, Saunders, MI, Barry, LA, Zawadzki, A, Hejnis, H, Morelli, G and Lovelock, CE (2018). Vertical accretion

- and carbon burial rates in subtropical seagrass meadows increased following anthropogenic pressure from european colonisation. *Estuarine, Coastal and Shelf Science* 202: 40-53.
282. Samper-Villarreal, J, Mumby, PJ, Saunders, MI, Roelfsema, C and Lovelock, CE (2018). Seagrass organic carbon stocks show minimal variation over short time scales in a heterogeneous subtropical seascape. *Estuaries and Coasts* 41(6): 1732-1743.
283. Schaffelke, B, Fabricius, K, Kroon, F, Brodie, J, De'ath, G, Shaw, R, Tarte, D, Warne, M and Thorburn, P (2018). Support for improved quality control but misplaced criticism of GBR science reply to viewpoint the need for a formalised system of quality control for environmental policy-science by P. Larcombe and P. Ridd (Marine Pollution Bulletin 126: 449-461, 2018). *Marine Pollution Bulletin* 129(1): 357-363.
284. Schiel, DR, Ayling, T, Kingsford, MJ, Battershill, CN, Choat, JH, Andrew, NL, Clements, KD, Ayling, AL, Leum, LL, Poynter, M and Jones, GP (2018). Change in the rocky reef fish fauna of the iconic Poor Knights Islands Marine Reserve in north-eastern New Zealand over 4 decades. *Marine and Freshwater Research* 69(10): 1496-1507.
285. Schlaefer, JA, Wolanski, E and Kingsford, MJ (2018). Swimming behaviour can maintain localised jellyfish (*Chironex fleckeri*: Cubozoa) populations. *Marine Ecology Progress Series* 591: 287-302.
286. Schoepf, V, Cornwall, CE, Pfeifer, SM, Carrion, SA, Alessi, C, Comeau, S and McCulloch, MT (2018). Impacts of coral bleaching on pH and oxygen gradients across the coral concentration boundary layer: a microsensor study. *Coral Reefs* 37(4): 1169-1180.
287. Schunter, C, Welch, MJ, Nilsson, GE, Rumber, JL, Munday, PL and Ravasi, T (2018). An interplay between plasticity and parental phenotype determines impacts of ocean acidification on a reef fish. *Nature Ecology and Evolution* 2(2): 334-342.
288. Schwartz, MW, Cook, CN, Pressey, RL, Pullin, AS, Runge, MC, Salafsky, N, Sutherland,

- WJ and Williamson, MA (2018). Decision support frameworks and tools for conservation. *Conservation Letters* 11(2): 1-12.
289. Segelken-Voigt, A, Miller, G and Gerlach, G (2018). Shell disease in *Crangon crangon* (Linnaeus, 1758): the interaction of temperature and stress response. *Journal of Experimental Marine Biology and Ecology* 500: 105-111.
290. Segura, LE, Hansen, JE and Lowe, RJ (2018). Seasonal shoreline variability induced by subtidal water level fluctuations at reef-fringed beaches. *Journal of Geophysical Research: Earth Surface* 123(3): 433-447.
291. Segura, LE, Hansen, JE, Lowe, RJ, Symonds, G and Contardo, S (2018). Shoreline variability at a low-energy beach: contributions of storms, megacusps and sea-breeze cycles. *Marine Geology* 400: 94-106.
292. Sheets, EA, Warner, PA and Palumbi, SR (2018). Accurate population genetic measurements require cryptic species identification in corals. *Coral Reefs* 37(2): 549-563.
293. Sinclair, EA, Ruiz-Montoya, L, Krauss, SL, Anthony, JM, Hovey, RK, Lowe, RJ and Kendrick, GA (2018). Seeds in motion: genetic assignment and hydrodynamic models demonstrate concordant patterns of seagrass dispersal. *Molecular Ecology* 27(24): 5019-5034.
294. Skinner, LC, Sadekov, A, Brandon, M, Greaves, M, Plancherel, Y, de la Fuente, M, Gottschalk, J, Souanef-Ureta, S, Sevilgen, DS and Scrivner, AE (2018). Rare earth elements in early-diagenetic foraminifer 'coatings': pore-water controls and potential palaeoceanographic applications. *Geochimica et Cosmochimica Acta* 245: 118-132.
295. Skirving, W, Enriquez, S, Hedley, JD, Dove, S, Eakin, CM, Mason, RAB, Cour, JLL, Liu, G, Hoegh-Guldberg, O, Strong, AE, Mumby, PJ and Iglesias-Prieto, R (2018). Remote sensing of coral bleaching using temperature and light: progress towards an operational algorithm. *Remote Sensing* 10(1): 1-19.
296. Smallhorn-West, PF, Bridge, TCL, Malimali, S, Pressey, RL and Jones, GP (2018). Predicting impact to assess

- the efficacy of community-based marine reserve design. *Conservation Letters* 12(1): 1-8.
297. Smith, SM, Fox, RJ, Booth, DJ and Donelson, JM (2018). 'Stick with your own kind, or hang with the locals?' Implications of shoaling strategy for tropical reef fish on a range-expansion frontline. *Global Change Biology* 24(4): 1663-1672.
298. Smythe, T and McCann, J (2018). Examining the role of integration in marine spatial planning: towards an analytical framework to understand challenges in diverse settings. *Ocean and Coastal Management* 167: 197-207.
299. Sommer, B, Beger, M, Harrison, PL, Babcock, RC and Pandolfi, JM (2018). Differential response to abiotic stress controls species distributions at biogeographic transition zones. *Ecography* 41(3): 478-490.
300. Song, AM, Bower, S, Onyango, P, Cooke, S, Akintola, S, Baer, J, Gurung, T, Hettiarachchi, M, Islam, M, Mhlanga, W, Nunan, F, Salmi, P, Singh, V, Tezzo, X, Funge-Smith, S, Nayak, PK and Chuenpagdee, R (2018). Intersectorality in the governance of inland fisheries. *Ecology and Society* 23(2): 1-16.
301. Song, AM, Johnsen, JP and Morrison, TH (2018). Reconstructing governability: how fisheries are made governable. *Fish and Fisheries* 19(2): 377-389.
302. Sørtdalen, TK, Halvorsen, KT, Harrison, HB, Ellis, CD, Vøllestad, LA, Knutsen, H, Moland, E and Olsen, EM (2018). Harvesting changes mating behaviour in European lobster. *Evolutionary Applications* 11(6): 963-977.
303. Spady, BL, Munday, PL and Watson, S-A (2018). Predatory strategies and behaviours in cephalopods are altered by elevated CO₂. *Global Change Biology* 24(6): 2585-2596.
304. Spijkers, J, Morrison, TH, Blasiak, R, Cumming, GS, Osborne, M, Watson, J and Österblom, H (2018). Marine fisheries and future ocean conflict. *Fish and Fisheries* 19(5): 798-806.
305. Steneck, RS, Mumby, PJ, MacDonald, C, Rasher, DB and Stoyle, G (2018). Attenuating effects of ecosystem management on

- coral reefs. *Science Advances* 4(5): eaao5493.
306. Streit, RP and Bellwood, DR (2018). Strong homing does not predict high site fidelity in juvenile reef fishes. *Coral Reefs* 37(1): 99-103.
307. Stump, E, Ralph, G, Comerós-Raynal, M, Matsuura, K and Carpenter, K (2018). Global conservation status of marine pufferfishes (Tetraodontiformes: Tetraodontidae). *Global Ecology and Conservation* 14: 1-12.
308. Sutcliffe, SR and Barnes, ML (2018). The role of shark ecotourism in conservation behaviour: evidence from Hawaii. *Marine Policy* 97: 27-33.
309. Swain, TD, Bold, EC, Osborn, PC, Baird, AH, Westneat, MW, Backman, V and Marcelino, LA (2018). Physiological integration of coral colonies is correlated with bleaching resistance. *Marine Ecology Progress Series* 586: 1-10.
310. Tan, CH, Pratchett, MS, Bay, LK, Graham, EM and Baird, AH (2018). Biennially horrible: very high mortality in the reef coral *Acropora millepora* on the Great Barrier Reef in 2009 and 2010. *Marine Ecology Progress Series* 604: 133-142.
311. Tebbett, SB and Bellwood, DR (2018). Functional links on coral reefs: urchins and triggerfishes, a cautionary tale. *Marine Environmental Research* 141: 255-263.
312. Tebbett, SB and Bellwood, DR (2018). Unusual caudal spines in the surgeonfish *Zebrafish scopas*. *Coral Reefs* 37(1): 251-251.
313. Tebbett, SB, Bellwood, DR and Purcell, SW (2018). Sediment addition drives declines in algal turf yield to herbivorous coral reef fishes: implications for reefs and reef fisheries. *Coral Reefs* 37(3): 929-937.
314. Tebbett, SB, Goatley, CHR and Bellwood, DR (2018). Algal turf sediments across the Great Barrier Reef: putting coastal reefs in perspective. *Marine Pollution Bulletin* 137: 518-525.
315. Tebbett, SB, Goatley, CHR, Huertas, V, Mihalitsis, M and Bellwood, DR (2018). A functional evaluation of feeding in the surgeonfish *Ctenochaetus striatus*: the role of soft tissues. *Royal Society Open Science* 5(1): 171111.
316. Teel, TL, Anderson, CB, Burgman, MA, Cinner, J, Clark, D, Estévez, RA, Jones, JPG, McClanahan, TR, Reed, MS, Sandbrook, C and St. John, FAV (2018). Publishing social science research in Conservation Biology to move beyond biology. *Conservation Biology* 32(1): 6-8.
317. Terraneo, TI, Arrigoni, R, Benzoni, F, Forsman, Z and Berumen, M (2018). The complete mitochondrial genome of *Porites harrisoni* (Cnidaria: Scleractinia) obtained using next-generation sequencing. *Mitochondrial DNA Part B: Resources* 3(1): 286-287.
318. Terraneo, TI, Arrigoni, R, Benzoni, F, Forsman, Z and Berumen, M (2018). Using ezRAD to reconstruct the complete mitochondrial genome of *Porites fontanesii* (Cnidaria: Scleractinia). *Mitochondrial DNA Part B: Resources* 3(1): 173-174.
319. Thurstan, RH, Buckley, SM and Pandolfi, JM (2018). Trends and transitions observed in an iconic recreational fishery across 140 years. *Global Environmental Change* 52: 22-36.
320. Titelboim, D, Sadekov, A, Hyams-Kaphzan, O, Almog-Labin, A, Herut, B, Kucera, M and Abramovich, S (2018). Foraminiferal single chamber analyses of heavy metals as a tool for monitoring permanent and short term anthropogenic footprints. *Marine Pollution Bulletin* 128: 65-71.
321. Torda, G, Sambrook, K, Cross, P, Sato, Y, Bourne, DG, Lukoschek, V, Hill, T, Torras Jorda, G, Moya, A and Willis, BL (2018). Decadal erosion of coral assemblages by multiple disturbances in the Palm Islands, central Great Barrier Reef. *Scientific Reports* 8(1): 11885.
322. Torrente, F, Bambridge, T, Planes, S, Guiart, J and Clua, EG (2018). Sea swallows and land devourers: can shark lore facilitate conservation? *Human Ecology* 46(5): 717-726.
323. Tsatsaros, JH, Wellman, JL, Bohnet, IC, Brodie, JE and Valentine, P (2018). Indigenous water governance in Australia: comparisons with the United States and Canada. *Water (Switzerland)* 10(11): 1-19.
324. Udyawer, V, Barnes, P, Bonnet, X, Brischoux, F, Crowe-Riddell, JM, D'Anastasi, B, Fry, BG, Gillett, A, Goiran, C, Guinea, ML, Heatwole, H, Heupel, MR, Hourston, M, Kangas, M, Kendrick, A, Koefoed, I, Lillywhite, HB, Lobo, AS, Lukoschek, V, McAuley, R, Nitschke, C, Rasmussen, AR, Sanders, KL, Sheehy, C, Shine, R, Somaweera, R, Sweet, SS and Voris, HK (2018). Future directions in the research and management of marine snakes. *Frontiers in Marine Science* 5(11): 1-16.
325. Urbarova, I, Patel, H, Forêt, S, Karlsen, BO, Jørgensen, TE, Hall-Spencer, JM and Johansen, SD (2018). Elucidating the small regulatory RNA repertoire of the sea anemone *Anemonia viridis* based on whole genome and small RNA sequencing. *Genome Biology and Evolution* 10(2): 410-426.
326. van de Water, JAJM, Chaib De Mares, M, Dixon, GB, Raina, J-B, Willis, BL, Bourne, DG and van Oppen, MJH (2018). Antimicrobial and stress responses to increased temperature and bacterial pathogen challenge in the holobiont of a reef-building coral. *Molecular Ecology* 27(4): 1065-1080.
327. van Oppen, MJH, Bongaerts, P, Frade, P, Peplow, L, Boyd, SE, Nim, HT and Bay, LK (2018). Adaptation to reef habitats through selection on the coral animal and its associated microbiome. *Molecular Ecology* 27(14): 2956-2971.
328. van Rooijen, A, Lowe, R, Ghisalberti, M, Conde-Frias, M and Tan, L (2018). Predicting current-induced drag in emergent and submerged aquatic vegetation canopies. *Frontiers in Marine Science* 5: 1-14.
329. Veilleux, HD, Donelson, JM and Munday, PL (2018). Reproductive gene expression in a coral reef fish exposed to increasing temperature across generations. *Conservation Physiology* 6(1): cox077.
330. Veilleux, HD, Ryu, T, Donelson, JM, Ravasi, T and Munday, PL (2018). Molecular response to extreme summer temperatures differs between two genetically differentiated populations of a coral reef fish. *Frontiers in Marine Science* 5(9): 1-12.
331. Veitch, J, Hermes, J, Lamont, T, Penven, P and Dufois, F (2018). Shelf-edge jet currents in the southern Benguela: a modelling approach. *Journal of Marine Systems* 188(12): 27-38.
332. Vercelloni, J, Clifford, S, Caley, MJ, Pearce, AR, Brown, R, James, A, Christensen, B, Bednarz, T, Anthony, K, González-Rivero, M, Mengersen, K and Peterson, EE (2018). Using virtual reality to estimate aesthetic values of coral reefs. *Royal Society Open Science* 5(4): 172226.
333. Wainwright, CE, Staples, TL, Charles, LS, Flanagan, TC, Lai, HR, Loy, X, Reynolds, VA and Mayfield, MM (2018). Links between community ecology theory and ecological restoration are on the rise. *Journal of Applied Ecology* 55(2): 570-581.
334. Wainwright, PC, Santini, F, Bellwood, DR, Robertson, DR, Rocha, LA and Alfaró, ME (2018). Phylogenetics and geography of speciation in New World *Halichoeres* wrasses. *Molecular Phylogenetics and Evolution* 121: 35-45.
335. Ward, M, Possingham, H, Rhodes, JR and Mumby, P (2018). Food, money and lobsters: valuing ecosystem services to align environmental management with sustainable development goals. *Ecosystem Services* 29: 56-69.
336. Watson, S-A, Allan, BJM, McQueen, DE, Nicol, S, Parsons, DM, Pether, SMJ, Pope, S, Setiawan, AN, Smith, N, Wilson, C and Munday, PL (2018). Ocean warming has a greater effect than acidification on the early life history development and swimming performance of a large circumglobal pelagic fish. *Global Change Biology* 24(9): 4368-4385.
337. Weeks, R and Adams, VM (2018). Research priorities for conservation and natural resource management in Oceania's small-island developing states. *Conservation Biology* 32(1): 72-83.
338. Welch, H, Pressey, RL and Reside, AE (2018). Using temporally explicit habitat suitability models to assess threats to mobile species and evaluate the effectiveness of marine protected areas. *Journal for Nature Conservation* 41: 106-115.
339. Wenger, AS, Adams, VM, Iacona, GD, Lohr, C, Pressey, RL, Morris, K and Craigie, ID (2018). Estimating realistic costs for strategic management planning of invasive species eradications on islands. *Biological Invasions* 20(5): 1287-1305.
340. Wenger, AS, Atkinson, S, Santini, T, Falinski, K, Hutley, N, Albert, S, Horning, N, Watson, JEM, Mumby, PJ and Jupiter, SD (2018). Predicting the impact of logging activities on soil erosion and water quality in steep, forested tropical islands. *Environmental Research Letters* 13(4): 1-13.
341. Wilmes, JC, Caballes, CF, Cowan, Z-L, Hoey, AS, Lang, BJ, Messmer, V and Pratchett, MS (2018). Contributions of pre- versus post-settlement processes to fluctuating abundance of crown-of-thorns starfishes (*Acanthaster* spp.). *Marine Pollution Bulletin* 135: 332-345.
342. Wilson, CE, Morrison, TH and Everingham, J-A (2018). Multi-scale meta-governance strategies for addressing social inequality in resource dependent regions. *Sociologia Ruralis* 58(3): 500-521.
343. Wilson, CE, Morrison, TH, Everingham, J-A and McCarthy, J (2018). Capture and crush: gas companies in the fracking dispute and deliberative depoliticization. *Geoforum* 92: 106-116.
344. Wilson, SK, Graham, NAJ, Holmes, TH, MacNeil, MA and Ryan, NM (2018). Visual versus video methods for estimating reef fish biomass. *Ecological Indicators* 85: 146-152.
345. Wojtasiewicz, B, Hardman-Mountford, NJ, Antoine, D, Dufois, F, Slawinski, D and Trull, TW (2018). Use of bio-optical profiling float data in validation of ocean colour satellite products in a remote ocean region. *Remote Sensing of Environment* 209: 275-290.
346. Wolfe, K, Vidal-Ramirez, F, Dove, S, Deaker, D and Byrne, M (2018). Altered sediment biota and lagoon habitat carbonate dynamics due to sea cucumber bioturbation in a high-p CO₂ environment. *Global Change Biology* 24(1): 465-480.
347. Wolff, NH, da Silva, ET, Devlin, M, Anthony, KRN, Lewis, S, Tonin, H, Brinkman, R and Mumby, PJ (2018). Contribution of individual rivers to Great Barrier Reef nitrogen exposure with implications for management prioritization. *Marine Pollution Bulletin* 133: 30-43.
348. Wolff, NH, Mumby, PJ, Devlin, M and Anthony, KRN (2018). Vulnerability of the Great Barrier Reef to climate change and local pressures. *Global Change Biology* 24(5): 1978-1991.
349. Xu, J, Lowe, R, Ivey, GN, Jones, NL and Zhang, Z (2018). Contrasting heat budget dynamics during two La Niña marine heat wave events along northwestern Australia. *Journal of Geophysical Research: Oceans* 123(2): 1563-1581.
350. Ying, H, Cooke, I, Sprungala, S, Wang, W, Hayward, DC, Tang, Y, Huttley, G, Ball, EE, Forêt, S and Miller, DJ (2018). Comparative genomics reveals the distinct evolutionary trajectories of the robust and complex coral lineages. *Genome biology* 19(1): 175.
351. Yuan, X, Cai, W-J, Meile, C, Hopkinson, BM, Ding, Q, Schoepf, V, Warner, ME, Hoadley, KD, Chen, B, Liu, S, Huang, H, Ye, Y and Grottolli, AG (2018). Quantitative interpretation of vertical profiles of calcium and pH in the coral coelenteron. *Marine Chemistry* 204: 62-69.
352. Zhang, Y-Y, McCook, L, Jiang, L, Lian, J-S, Liu, S and Huang, H (2018). An outbreak of sea cucumbers hinders coral recruitment. *Coral Reefs* 37(2): 321-326.
353. Ziegler, M, Quéré, G, Ghiglione, J-F, Iwankow, G, Barbe, VB, Oissin, E, Wincker, P, Planes, S and Voolstra, CR (2018). Status of coral reefs of Upolu (Independent State of Samoa) in the south west Pacific and recommendations to promote resilience and recovery of coastal ecosystems. *Marine Pollution Bulletin* 129(1): 392-398.
354. Zinke, J, Gilmour, JP, Fisher, R, Puotinen, M, Maina, J, Darling, E, Stat, M, Richards, ZT, McClanahan, TR, Beger, M, Moore, C, Graham, NAJ, Feng, M, Hobbs, J-PA, Evans, SN, Field, S, Shedrawi, G, Babcock, RC and Wilson, SK (2018). Gradients of disturbance and environmental conditions shape coral community structure for south-eastern Indian Ocean reefs. *Diversity and Distributions* 24(5): 605-620.

Report (9)

- Harrison, H, Alvarez-Noriega, M, Baird, AH and MacDonald, C (2018). *Recurrent coral bleaching in the Coral Sea commonwealth marine reserve between 2016 and 2017*. Director of National Parks and Department of Environment and Energy, Australia, 1-17 pp.
- Heron, SF, van Hooidek, R, Maynard, J, Anderson, KD, Day, JC, Geiger, E, Hoegh-Guldberg, O, Hughes, TP, Marshall, P, Obura, DO and Eakin, CM (2018). *Impacts of climate change on world heritage coral reefs: update to the first global assessment*. UNESCO, 1-16 pp.
- Hoey, A, Pratchett, M, Sambrook, K, Gudge, S and Pratchett, D (2018). *Status and trends for shallow reef habitats and assemblages at Elizabeth and Middleton Reefs, Lord Howe Marine Park*. The Director of National Parks, 1-65 pp.
- Johnson, JE, Brodie, J and Waterhouse, J (2018). *Wastewater pollution and coral reefs: science-to-policy brief*. United Nations Environment Programme, 1-16 pp.
- Johnson, JE, Welch, DJ, Marshall, P, Day, JC, Marshall, N, Steinberg, GR, Benthuyssen, JA, Sun, C, Brodie, J, Marsh, H, Hamann, M and Simpfendorfer, CA (2018). *Characterising the values and connectivity of the northeast Australia seascape: Great Barrier Reef, Torres Strait, Coral Sea and Great Sandy Strait*. United Nations Environment Programme, 1-94 pp.
- Jones, GP, Ceccarelli, DM, Williamson, DH and Russ, GR (2018). *Assessing the ecological effects of management zoning on inshore reefs of the Great Barrier Reef Marine Park*. NERP TE Project 8.2, 1-2 pp.
- Roscher, M, Eam, D, Suri, S, van der Ploeg, J, Hossain, ME, Nagoli, J, Cohen, PJ, Mills, DJ and Cinner, J (2018). *Building adaptive capacity to climate change: approaches applied in five diverse fisheries settings*. CGIAR Research Program on Fish Agri-Food Systems, 1-20 pp.
- Schaffelke, B, Anthony, K, Babcock, RC, Bridge, T, Carlos, E, Diaz-Pulido, G, González-Rivero, M, Gooch, M, Hoey, A, Horne, D, Kane, K, McKenzie, C, Merida, F, Molloy, F, Moon, S, Mumby, PJ, Ortiz, J-C, Pears, RJ, Phinn, S, Ridgway, T, Roelfsema, C, Singleton, G and Thompson, A (2018). *Monitoring coral reefs within the Reef 2050 integrated monitoring and reporting program: final report of the coral reef expert group*. The Great Barrier Reef Marine Park Authority, 1-16 pp.
- Waterhouse, J, Burton, J, Garzon-Garcia, A, Lewis, S, Brodie, J, Bainbridge, Z, Robson, B, Burford, M, Gruber, RK and Dougal, C (2018). *Synthesis of knowledge and concepts -bioavailable nutrients: sources, delivery and impacts in the Great Barrier Reef*. Bioavailable Nutrients Workshop, supported by Office of the Great Barrier Reef's Queensland Reef Water Quality Program, and the Australian Government National Environmental Science Program Tropical Water Quality Hub.

2019 Activity Plan

1. Research

- Review the Centre's research programs in preparation for new and ongoing projects for 2019–2021.
- Develop further the Centre's research program 'Coral Reefs in the Anthropocene', with an emphasis on social science, governance and adaptation.
- Publish further outputs of the National Coral Bleaching Taskforce, targeting high profile journals, especially *Science* and *Nature*.
- 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*.
- Provide training to support Centre members' knowledge of the *Australian Code for Responsible Conduct of Research* and the ARC Centre's *Digital Data Management Policy*.

2. Research Training and Professional Development

- Deliver professional development workshops on statistics, bio-informatics, grant writing, publishing strategies and skills, and preparing documentation for job applications.
- 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)
- Continue to progress a leadership development program for women in STEM for PhD students through to Research Fellows.
- Deliver workshops and mentoring in unconscious bias and gender stereotypes.
- Initiate a human ethics training program for ARC Centre social scientists.

3. National and International Linkages

- 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.

- Recruit a fourth Research Fellow, co-funded with the Australian Institute of Marine Science, who will focus on the population genetics of corals.
- Increase research fellow exchanges, working group meetings and co-tutelle PhD student arrangements with international partners and collaborators.
- Extend multi-institutional and/or multi-disciplinary supervisory arrangements for Centre students.

4. Impacts and End User Engagement

- Expand the *Coral Reef Health in the Coral Sea Marine Park* assessment project for the Australian Government Director of National Parks.
- Continue to engage with government and stakeholders to provide the science that underpins the *Reef 2050 Plan*.
- Plan and deliver the Centre's Annual Symposium and Public Forum on the *Future of Coral Reefs* in Sydney in October.
- 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

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

Financial Statement

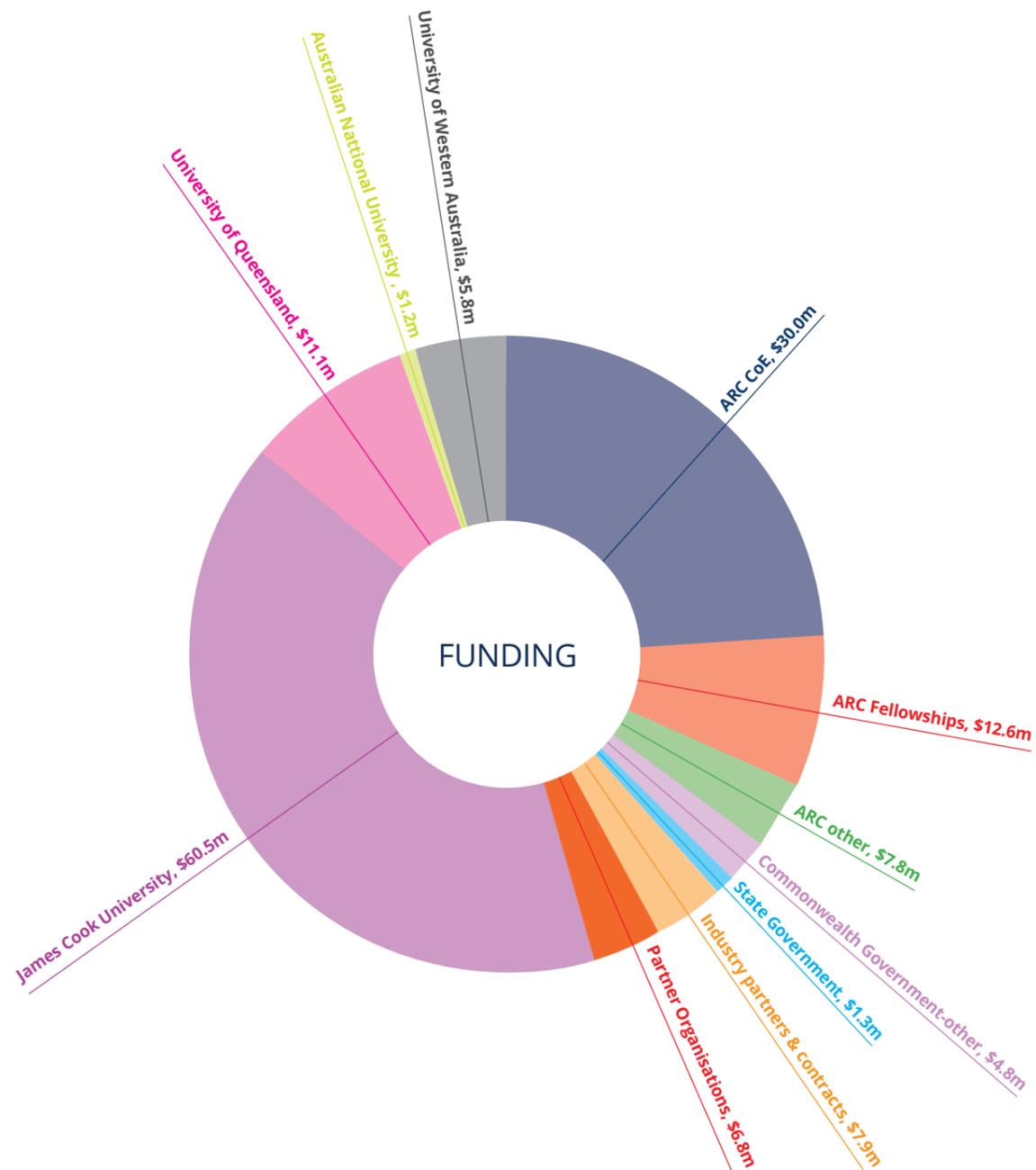
ARC Centre of Excellence for Coral Reef Studies

Statement of Operating Income and Expenditure for year ended 31 December 2018

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

Performance Measure	Target 2018	Outcome 2018
Number of research outputs		
• Journal articles/books/book chapters (p71)	330	383
• Published Datasets (p52)	30	42
Quality of research outputs (p71)		
• Publications in journals with Impact Factor >4	95	155
• Mean Impact Factor for journals published	4.5	5.9
• Citations: total by Centre researchers	25,000	45,461
• Centre researchers with >500 annual citations	20	26
• Awards and prizes (p10)	28	43
Number of training courses held/offered by the Centre (p43) (over and above the standard courses offered by institutions)	26	30
Number of workshops/conferences held/offered by the Centre (p43)	15	22
Number of additional researchers working on Centre research (p43)		
• Postdoctoral researchers	8	12
• PhD students	25	30
• Masters by research/coursework students	8	7
• Honours students	4	7
Number of postgraduate completions (p43)		
• PhD students	25	22
• Masters by research/coursework students	8	10
• Honours students	4	8
Number of mentoring programs offered by the Centre (p43)	12	15
Number of presentations/briefings (p59)		
• To the public	38	70
• To government/agencies/industry/business/end-users/NGOs (national and international)	80	105
(in addition to workshops/conferences above)		
Number of new organisations collaborating with, or involved in, the Centre	40	134

Centre-specific Key Performance Indicators

Performance Measure	Target 2018	Outcome 2018
Publications (p71) • Prestige publications (e.g. <i>Nature</i> , <i>Science</i> , <i>PNAS</i>)	100 over life of Centre	33 (129 to date)
Interdisciplinarity of research • No. of journal titles in which Centre of Excellence research published (p71) • No. of students with multi-disciplinary supervisory arrangements (p43)	100 50	136 52
Centre integration (p71) • No. of publications with cross-institutional co-authorship	185	306
Global reach (p54) • No. of countries where Centre undertakes field research • No. of international co-authors • No. of invited talks/papers/keynotes at international meetings	24 300 26	28 1,255 42
Media (p59) • Commentaries about the Centre's achievements • Articles • Centre of Excellence Website hits	4,000 26 7.0m	9,711 36 11.9m
International visitors (p57)	70	78
Gender equity • Research Fellow appointments (p68) • Gender equity and diversity mentoring, and training activities: no. of participants and attendances (p43)	50:50 20	50:50 27

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