ARC CENTRE OF EXCELLENCE
Coral Reef Studies

ANNUAL REPORT 2015

ANNUAL REPORT **2015**

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

COVER PHOTO ALEX VENN
BACK COVER PHOTO TALI TREIBITZ

ARC CENTRE OF EXCELLENCE
Coral Reef Studies

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, 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 collaborative, co-operative, multi-institutional and communicative.

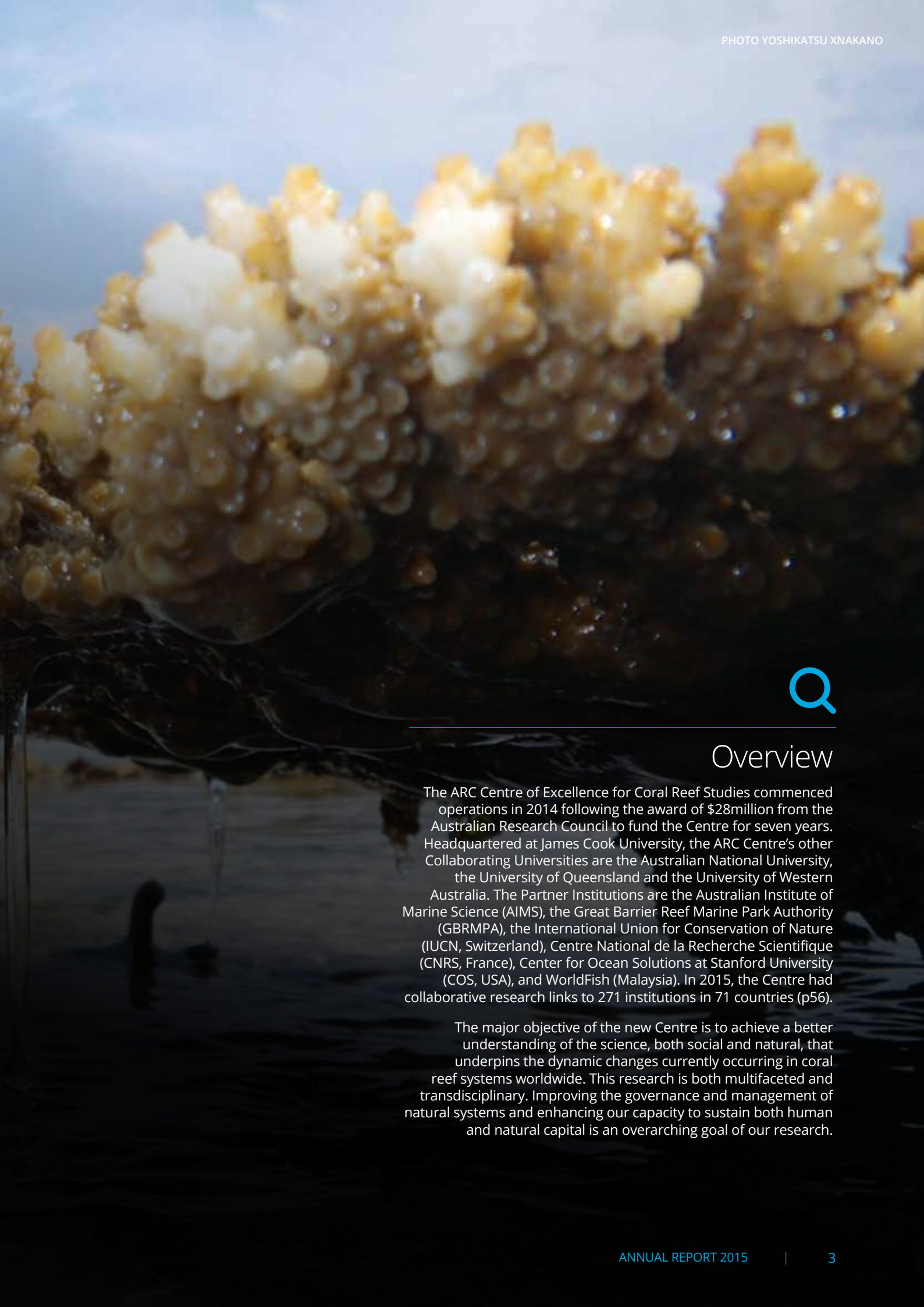

PHOTO YOSHIKATSU XNAKANO

Overview

The ARC Centre of Excellence for Coral Reef Studies commenced operations in 2014 following the award of $28million from the Australian Research Council to fund the Centre for seven years. Headquartered at James Cook University, the ARC Centre's other Collaborating Universities are the Australian National University, the University of Queensland and the University of Western Australia. The Partner Institutions are the Australian Institute of Marine Science (AIMS), the Great Barrier Reef Marine Park Authority (GBRMPA), the International Union for Conservation of Nature (IUCN, Switzerland), Centre National de la Recherche Scientifique (CNRS, France), Center for Ocean Solutions at Stanford University (COS, USA), and WorldFish (Malaysia). In 2015, the Centre had collaborative research links to 271 institutions in 71 countries (p56).

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

Welcome to the 2015 annual report of the *Australian Research Council (ARC) Centre of Excellence for Coral Reef Studies*. 2015 has been a huge year for us, and for coral reefs around the world. The status of the World Heritage listing of the Great Barrier Reef came to a climax during the year with UNESCO's decision not to list the Reef as "in danger", requiring Australia to report in 2016 on its plans to improve the Outstanding Universal Value of the iconic World Heritage Area. The focus now has turned to the 2050 Reef Long-Term Sustainability Plan, and our Centre is playing an important role in providing advice to the Queensland and Commonwealth governments on the Plan's development (p38).

At the end of 2015 a powerful El Nino event began to impact reefs in Hawaii, Fiji and elsewhere in the central Pacific, and it is expected to cause thermal stress and bleaching Australia's reef systems in March and April 2016. At the end of the year, we established the National Coral Bleaching Taskforce, to co-ordinate the research effort among Australia's marine science community in the event of a mass bleaching event on tropical reefs around Australia. The taskforce draws together 10 research institutions to co-ordinate the efforts of over 300 scientists. The associated research institutions are the ARC Centre of Excellence for Coral Reef Studies, the Australian Institute of Marine Science, the Great Barrier Reef Marine Park Authority GBRMPA), James Cook University, National Oceanic and Atmospheric Administration (NOAA, USA), University of Queensland, University of Sydney, University of Western Australia, CSIRO and WA Department of Parks and Wildlife. At the time of writing, in March 2016, we have recorded widespread and severe coral bleaching along the northern section of the Great Barrier Reef. This is the third major bleaching, following earlier events in 2002 and 1998.

We have made significant additions in personnel to the Centre during 2015, recruiting 12 new Research Fellows. Graeme Cumming and Tiffany Morrison have joined the Centre from the University of Cape Town and the University of Queensland respectively as part of James Cook University's succession planning for the ARC Centre. They have bolstered our critical mass in the cross-disciplinary and social sciences. We have also seen the arrival of new postdoctoral fellows from Australia, Hawaii, Norway and Hungary. These will add new expertise and perspective to our ongoing research programs. We also celebrated the awards several of our researchers achieved during 2015, particularly the L'Oréal-*UNESCO For Women in Science Australia Fellowship* to Jodie Rummer (p43) and the Pew Fellowship in Marine Conservation to Josh Cinner (p7).

In 2015, our student population continued to grow with 57 new students enrolling and 49 graduating from the Centre. There were 158 PhD students from 42 countries enrolled in the Centre during 2015. Similarly, 26 of our 31 early career postdoctoral researchers (83%) have been attracted to the ARC Centre from overseas (p44).

The Centre's researchers produced 319 publications in 2015, setting a new record. Twenty one of these papers appear in prestige journals such as *Science* and *Nature*. The average impact factor for the 295 journal articles in 2015 was 5.1, a significant improvement from 2014. Our co-authors this year came from 271 institutions in 71 countries reflecting our Centre's expansive collaborative network around the world. The Centre's three Research Program summaries on pp10-32 provide an overview of our activities throughout 2015.

The Centre held an extremely successful annual symposium in Hobart during early October. We chose Hobart this year because, despite the temperature difference, there is a strong resonance in research questions posed in both the tropics and cooler environments, creating opportunities for future collaborations. Over 160 people participated, including several of our "cold-water" colleagues from Tasmania who presented ten talks at the symposium.

Looking forward to 2016, we will be a major contributor to the 13th International Coral Reef Symposium in Honolulu, USA from the 19th to 24th June. It will be good not to be hosting 2000 delegates as we did in Cairns in 2012! The overarching theme for ICRS2016 is "Bridging Science to Policy" – a major focus within our Centre.

Lastly, I'd like to thank our many friends around the world for their contributions to an outstanding year, to the Centre's Advisory Board, to the four host Universities, and to our partners from many institutions in Australia and overseas. I am particularly grateful to our Chief Operations Officer, Jenny Lappin, Assistant Director David Yellowlees and the fantastic administrative team, Olga Bazaka, Vivian Doherty, Eleanor Gregory and Janet Swanson.

Terry Hughes
Director

Director's Report

Your [the ARC Centre of Excellence for Coral Reef Studies] contributions to the future sustainability of coral reefs worldwide are quite remarkable.

Professor Si Zhang
Director of South China Sea Institute of Oceanology
Chinese Academy of Sciences

PHOTO RANJAN MUTHUKRISHNAN

Recognition of Excellence by Centre Researchers

Centre researchers received a number of awards during 2015. Chief among these recipients were social scientist Josh Cinner and fish physiologist Jodie Rummer who both won major international fellowships. A significant number of other Centre Research Fellows were also recognised for their research contributions.

Josh was awarded a prestigious Pew Fellowship in Marine Conservation by the Pew Charitable Trusts in the USA (page opposite). The Fellowship recognises his contribution to social-ecological research and funds a new and innovative research proposal. The Fellowship provides a grant of US$150,000 over three years. Josh joins Centre members Laurence McCook, Garry Russ and Peter Mumby who have also been awarded recent Pew Fellowships. The project funded by the fellowship

- Jodie Rummer was awarded an ARC Discovery Early Career Research Award
- Both Jodie Rummer and Sue-Ann Watson were announced as Rising Stars of Queensland Science, a Queensland Government award designed to promote Queensland science and technology. This scheme is designed to increase scientific literacy and to encourage young Queenslanders to consider a career in science and technology. Jodie and Sue-Ann also both received Lizard Island Reef Research Foundation Fellowships.
- Sue-Ann Watson was one of three finalists for the Australian Museum Macquarie University Eureka Prize for Outstanding Early Career Researcher.
- Peter Mumby won the International Society for Reef

will build on previous research conducted by Josh and his collaborators focussing on *Understanding the World's Coral Reef 'Bright Spots'*.

In 2015, Jodie Rummer became the second Centre researcher to win a L'Oréal-*UNESCO For Women in Science Australia Fellowship* (p43), following Tracy Ainsworth's award in 2011. Each year, up to four Australian fellowships are awarded to researchers who have completed their PhD in the last five years. Jodie's nomination, *A Hot Future for Sharks*, is based on her collaboration with Serge Planes, a Partner Investigator in the ARC Centre from CNRS in France. The Fellowship provides Jodie with research support of $25k. On the day following the presentation she attended a "Girls in Science Forum" at the University of NSW with 300+ high school girls from all around Sydney. At the Forum, the four winners presented their videos, were interviewed, and participated in a Q&A session followed by a tour of science labs at UNSW.

OTHER EXAMPLES OF AWARDS AND PEER-RECOGNITION

- Nick Graham was awarded a Research Fellowship in the UK by The Royal Society, valued at $1 million. Nick moved to the University of Lancaster in late 2015.

Studies (ISRS) Mid-Career Award in recognition of excellence in research during the preceding ten years.

- Andrew Baird, Peter Mumby and John Pandolfi were elected Fellows of the ISRS for their service and research excellence.
- Nick Graham was awarded the inaugural Australian Coral Reef Society Medal or his contributions to science and conservation of Australian coral reefs.
- Andrew Baird was awarded a Fellowship by the Japanese Society for the Promotion of Science to support collaborative research in Japan.
- Andy Hoey received a Sally Connally Hardie Visiting Researcher award from the University of St Andrews, Scotland, to support a visit to the University.
- Both Jodie Rummer and Aurélie Moya were awarded grants by the Institut des Récifs Coralliens du Pacifique to conduct research projects in Moorea, French Polynesia. Jodie is collaborating with Serge Planes, a Partner Investigator in the Centre at the University of Perpignan and CNRS; and Aurélie is working with Laetitia Hedouin (Centre de Recherche Insulaires et Observatoire de l'Ennvironnement) and Chloé Brahmi (University of French Polynesia).

PEW FELLOWSHIP

Professor Josh Cinner

PHOTO TESSA HEMPSON

Professor Josh Cinner, a Chief Investigator in the ARC Centre of Excellence and an ARC Australian Research Fellow has been awarded a Pew Fellowship, one of the world's top prizes for research in marine conservation.

The Pew Charitable Trusts was established to solve today's most challenging problems with the mission of improving public policy, informing the public and invigorating civic life. Each year five scientists are selected to receive a prestigious *Pew Fellowship in Marine Conservation* by a panel of prominent international experts. The Fellowship comes with a US$150,000 grant, allocated over three years to complete an original, research-based marine conservation project. Josh's project is entitled *Understanding the World's Coral Reef 'Bright Spots'.*

Josh holds an undergraduate degree in marine affairs from the University of Rhode Island and a PhD from James Cook University. While his background is in human geography, he regularly works closely with ecologists to uncover complex linkages between social and ecological systems. His interest in the human dimensions of resource management is global, taking him to many countries including Jamaica, Mexico, Kenya, Mozambique, Madagascar, Tanzania, Mauritius, Seychelles, Indonesia, and Papua New Guinea. Josh has published >100 peer-reviewed journal articles including papers in *Nature*, *Nature Climate Change*, and *PNAS*.

Josh will pursue a project that he hopes will change how we approach marine conservation. "Typically, we have tended to look for the most pristine places and then lock them away from human use. That model really conceptualises people as the problem. However my project seeks to make people an integral part of the solution," he says.

He states that "the ongoing declines among the world's coral reefs require novel approaches to sustain these ecosystems and the millions of people who depend on them". He is using the prestigious award to spearhead a first-of-its-kind global analysis that promises to shed new light on ways of confronting the coral reef crisis. Drawing on theory and practice in human health and rural development, Josh's aim is to systematically identify and learn from the 'outliers'- places where ecosystems are substantially better ('bright spots') or worse ('dark spots') than expected, given the environmental conditions and socioeconomic drivers to which they are exposed. By their very nature, outliers deviate from expectations, and consequently can provide novel insights on confronting complex problems where conventional solutions have failed. He will be interviewing fishermen, traders, officials, researchers, community leaders, and managers in both bright and dark spots. Using this novel approach he will identify common socioeconomic or institutional conditions that can help to formulate policy for more sustainable reef governance in other regions of the world.

Josh has already identified 15 bright spots and 35 dark spots among a global survey of 2500 coral reefs. Importantly, bright spots are not simply remote areas with low fishing pressure – they include sites where human populations and use of ecosystem resources are high, providing new insights into how communities have successfully confronted strong drivers of change. The challenge ahead is to determine the social, economic, governance, and environmental conditions that help bright spots avoid the fate of similar places. Preliminary results suggest that investments in strengthening fisheries governance, particularly aspects such as participation and property rights, could facilitate innovative conservation actions that help communities defy expectations of global reef degradation.

AWARDED PEW FELLOWSHIP

DR GLENN ALMANY

1968–2015

PHOTO TANE SINCLAIR-TAYLOR

This year was a sad time for the Centre, losing one of its own, Dr Glenn Almany, who passed away in March 2015 following complications arising from a long and determined battle with lymphoma. At only 47, his life and career were cut tragically short. Glenn had been appointed recently as a research scientist with Centre partner, the Centre National de la Recherche Scientifique, to work at the Centre de Recherches Insulaires et Observatoire de l'Environnement in Perpignan (France) and Moorea (French Polynesia).

Glenn was a remarkable and energetic person, who was an internationally recognised coral reef scientist in a research career that spanned less than 20 years. Science was his second career, having joined the US Navy at the age of 17 on a mission to see the world. While in the navy, Glenn spent a few weeks in Guam where he was able to snorkel over coral reefs for the first time. This was a life changing experience and he left the military to enrol in a BSc at San Francisco State University. He went on to complete a PhD with Professor Mark Hixon at Oregon State University in 2002. The series of publications from his dissertation work in the Bahamas have made a huge impact on our understanding of the role of predation and habitat complexity on the ecology of reef fishes.

In recognition of his potential, Glenn received a Fulbright Postgraduate Scholarship in 2003 and he moved to Australia to work with Professor Geoff Jones and colleagues at James Cook University, joining the ARC Centre of Excellence as a Research Fellow in 2007.

For his contributions to science, Glenn will be particularly remembered for his ground breaking, highly cited paper in *Science* in 2007. This work featured the first field-based use of a new method of tagging fish larvae, of both a bottom (benthic) brooder and a pelagic spawner, allowing a novel comparison of their dispersal patterns.

The use of barium isotope tags enabled Glenn and his colleagues to understand the extent to which young fish return to their 'home' area or go off to interbreed with more distant populations. These technologies continue to be adopted by researchers around the world to build a more complete picture of the extent to which fish populations are connected or isolated from one another, essential knowledge for the sustainable management of fish stocks.

This pioneering area of research continued when Glenn was awarded a prestigious ARC Future Fellowship in 2009, to use these technologies to further his research on larval connectivity among fish populations and to develop practical guidelines for integrating connectivity into the design of networks of marine protected areas. Glenn began to bring this cutting edge science to remote communities in Papua New Guinea and the Solomon islands.

Central to Glenn was his belief that you could make a difference in this world. He worked closely with The Nature Conservancy and his work led directly to the development of marine protected areas, increased protection for spawning aggregations and the closing of mining sites that threatened juvenile habitat. Glenn's position as a leading scientist is evident from his publication record over little more than a decade. However, his real calling was to take his knowledge and ideas to the villages, where he lived and learnt about the real challenges of depending on local coral reef resources.

In addition to be being an outstanding researcher, Glenn will be remembered for his warmth, sense of humour and enthusiasm for life. Science has lost one of its best and we can only wonder about the discoveries he could have made. But the ultimate loss has been for his wife, Jeanine, and his young children, Maya and Ryan.

In recognition of Glenn's scientific legacy we are co-convening a special session at the International Coral Reef Symposium in Hawaii in June 2016, where his fields of study will be celebrated. In addition, the Centre of Excellence has announced an annual *Glenn Almany Memorial Prize* to acknowledge Glenn's achievements and inspire the next generation by his dreams. It will be awarded to a graduate student 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. For 2015, the inaugural winner of this award is Adrian Arias.

On the footnote to Glenn's emails he had highlighted Sir Richard Burton's words "*One of the gladdest moments in life is the departure upon a distant journey into unknown lands*". Glenn has left us, but his spirit of discovery lives on.

PHOTO GEORGINA GURNEY

RESEARCH PROGRAM 1

People and Ecosystems

RESEARCH PROGRAM LEADERS

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 an NSF Postdoctoral Fellow at the University of California, Santa Barbara 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 is also co-leader of Research Program 1. 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. He is an *ISI Highly Cited Researcher* with 25 papers in *Science* or *Nature*. He has been awarded three Federation/ Laureate Fellowships by the Australian Research Council, from 2002-2017, and is a Fellow of the Beijer Institute for Ecological Economics at the Royal Swedish Academy of Sciences in Stockholm.

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 issues involved in implementing conservation action. 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 (2008) *Australian Ecology Research Award* from the Ecological Society of Australia. In 2010, he was elected as 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 the WWF Australia's Eminent Scientists Group.

RESEARCHERS

Jorge Álvarez Romero, Neil Andrew, Michele Barnes, David Bellwood, Jessica Blythe, Jana Brotánková, Joshua Cinner, Pip Cohen, Ian Craigie, Graeme Cumming, Michael Fabinyi, Nick Graham, Georgina Gurney, Christina Hicks, Laurence McCook, David Mills, Tiffany Morrison, John Pandolfi, Garry Russ, Ruth Thurstan, Rebecca Weeks, Amelia Wenger.

PROGRAM 1 REPORT

PHOTO GEORGINA GURNEY

Program 1 is designed to expand the scope of contemporary coral reef science from its predominantly biological and geological focus to encompass a broader evaluation of the linkages between coral reef ecosystems, the goods and services they provide to people, and the wellbeing of human societies. The broad objective is to improve the governance and management of natural systems and to enhance the capacity to sustain both human and natural capital. Critical issues include how resource use and governance systems are influenced by levels of economic development, social capital, local history and culture, recognising that sustaining reefs, while simultaneously promoting human development and nation-building, represents a "wicked problem" with no simple, single solution.

The conservation planning research group led by Bob Pressey focuses on spatial solutions to diverse resource-management problems, involving the design of conservation areas and application of management actions. Systematic conservation planning provides a rigorous approach to decision-making that synthesizes advances in biology, geography, economics, the social sciences, and spatial modelling. The goal is to conduct research that provides practical solutions to management problems while promoting the persistence and sustainable use of natural resources. The ARC Centre places a high value on engagement with local communities, managers and policy makers, government agencies, and non-government organisations.

Program 1's research is undertaken across diverse study areas that differ strongly in their ecological, social, and economic contexts. In 2015, we conducted extensive fieldwork in Australia, Brazil, China, the Cook Islands, Costa Rica, Fiji, Hawaii, Indonesia, Kenya, Mexico, Micronesia, Papua New Guinea, the Philippines, the Solomon Islands, and Timor Leste.

Program 1's social science research was significantly boosted in 2015 by the recruitment of three additional postdoctoral fellows: Michele Barnes from the University of Hawaii and NOAA, Andrew Song from McGill University, and Georgina Gurney from JCU. Michele has been awarded a Research Fellowship from the USA National Science Foundation, and Andrew who will join us in early 2016 is co-funded with our Partner Institution, *WorldFish* (p56). Georgina has been examining the social impacts of marine protected areas on coastal communities in North Sulawesi. Two other recent arrivals are Professor Graeme Cumming from the University of Cape Town, and Principal Research Fellow Tiffany Morrison, who has moved in the past year from Brisbane to the Centre's JCU node in Townsville. Graeme's research focusses on social-ecological resilience across landscapes, while Tiffany studies multi-scale governance and climate change adaptation in Australia, the USA, South Asia and the Pacific. Four more social science PhD students were recruited during the year, further contributing to the Centre's capacity in social-ecological research. During 2015 we were also delighted to host and work closely with numerous distinguished social scientists, including Kate Brown and Neil Adger from the University of Exeter, UK and Terre Satterfield from the University of British Columbia, Canada.

The Centre's research activities with Partner Institution *WorldFish,* headquartered in Malaysia, also grew this year. *WorldFish* researchers Dave Mills and Pip Cohen continued their long-term secondment at the ARC Centre, joined now by two additional postdoctoral researchers who are co-funded by the ARC Centre and *WorldFish* – Jessica Blythe and Andrew Song. Dave works closely with fishing communities and governments in Timor Leste and the Philippines, and with indigenous communities in northern Australia. Pip and Jessica undertook their research mainly in the Solomon Islands, while Andrew's new position in the Centre will include a major focus on adaptation by Pacific nation fishers and fisheries to climate change.

PHOTO GEORGINA GURNEY

Centre Fellow Mike Fabinyi was seconded to *WorldFish* headquarters in Penang in 2015, where he is examining trans-national seafood commodity chains in the Asia-Pacific, including contested South China Sea fisheries and the sea cucumber trade from Papua New Guinea to Asian markets.

Program 1 convened more than a dozen productive research workshops and working groups in Australia, France, Hawaii, and Hong Kong throughout 2015. For example, Josh Cinner convened a social sciences working group to examine facets of adaptive capacity in tropical coastal communities, while Pip Cohen led a working group of international and interdisciplinary researchers to examine governance of small-scale fisheries. Tiffany Morrison and Terry Hughes led a workshop at the Centre's JCU node to develop a policy briefing for state and national policymakers on climate adaptation for the Great Barrier Reef. The workshop was co-funded with the National Climate Change Adaptation Research Facility, and the participants included representatives from the Queensland Tourism Industry Council, Natural Resource Management groups, local government, the Great Barrier Reef Marine Park Authority, researchers, and a range of reef-related industries.

Program 1 published nearly 100 journal articles in 2015, including high-profile papers in *Science, Nature* and *Nature Climate Change*. For example, in *Science*, Terry Hughes and colleagues examined the resilience of three iconic World Heritage Areas to climate change – the Great Barrier Reef, the Amazon basin, and Spain's Doñana wetlands. Josh Cinner and Christina Hick's research on governance of coastal resources in Kenya was published in *Nature Climate Change* and in *Global Environmental Change*. The conservation planners in Program 1 published three contributions in a themed issue of *Conservation Biology* on the effectiveness of abiotic surrogates (such as marine habitats or seascapes) as a basis for species conservation. Jorge Álvarez-Romero published a paper in *Biological Conservation* on integrated planning for terrestrial and marine objectives. Jorge's paper was the culmination of a working group on integrated catchment planning, co-funded by the ARC Centre and the Australian Centre for Ecological Analysis and Synthesis.

Georgina Gurney's PhD work on design of marine protected areas in Fiji was published in *Conservation Biology*. Other student papers in 2015 included Vera Horigue's modelling of expanding marine protected areas in the Philippines, and Rafael Magris' investigations on planning for climate-warming in Brazilian coral reefs. Bob Pressey edited a theme issue of *Philosophical Transactions of the Royal Society B* titled "Measuring the difference made by protected areas", which included his own contribution on the need for a shift in policy and practice toward maximizing the impact of protected areas, instead of just maximising their total extent.

Program 1's commitment to knowledge transfer was evident throughout 2015, with extensive collaborations and other engagements with local state and national governments, agencies and Non Government Organisations in many countries. For example, Bob Pressey continued his role in WWF Australia's Eminent Scientists Group, and Terry Hughes provided briefings in Paris and Berlin on the status of the Great Barrier Reef to ten country members of the UNESCO World Heritage Committee. Also in 2015, Georgina Gurney worked closely with the Wildlife Conservation Society to develop a new social-ecological monitoring framework that will be applied to coral reef sites in seven countries. Closer to home, the Centre is deeply involved in Australia's 2050 Reef Long Term Sustainability Plan (p38). The ARC Centre also convened the National Coral Bleaching Taskforce. The taskforce, comprising a network of ten institutions, is designed to coordinate research effort among Australia's marine science and reef management community in the event of mass coral bleaching in Queensland and Western Australia in early 2016 (p40).

07 APR
2015

We can fix the Great Barrier Reef


PHOTO ROGER BEEDEN

Leading coral reef scientists say Australia could restore the Great Barrier Reef to its former glory through better policies that focus on science, protection and conservation.

In a paper published in the journal *Nature Climate Change*, the authors argue that all the stressors on the Reef need to be reduced for it to recover.

An Australian Government report into the state of the Great Barrier Reef found that its condition in 2014 was "poor and expected to further deteriorate in the future". In the past 40 years, the Reef has lost more than half of its coral cover and there is growing concern about the future impacts of ocean acidification and climate change.

"We need to move beyond the gloom and doom to identify how the decline of the Great Barrier Reef can be turned around," says co-author Professor Terry Hughes from the ARC Centre of Excellence for Coral Reef Studies.

"Our paper shows that every major stressor on the Reef has been escalating for decades – more and more fishing, pollution, coastal development, dredging, and now for the past 20 years we're also seeing the impacts of climate change."

"We now have a very good handle on why the Great Barrier Reef is in trouble," adds co-author, Jon Brodie from the Centre for Tropical Water and Aquatic Ecosystems Research at JCU.

"The challenge is to use that scientific knowledge to prevent further damage and give the Reef some breathing space that would allow it to recover.

Co-author, Jon Day, also from the ARC Centre for Coral Reef Studies at JCU says an obvious first step is to prevent unsustainable growth in each of the stressors to reduce their cumulative impact.

"If that means less dredging, less coal mining and more sustainable fishing, then that's what Australia has to do. Business as usual is not an option because the values for which the Reef was listed as World Heritage are already deteriorating, and will only get worse unless a change in policy occurs."

The authors say that as countries around the world move to curb global carbon emissions, Australia has an opportunity to transition away from fossil fuels and to limit the development of huge coal ports alongside the Great Barrier Reef World Heritage Area.

"No-one is saying Queensland should not have ports. What we are saying is that all developments within, and adjacent to, the Great Barrier Reef need to be far more sustainable in the way that they are developed and operated, especially because they adjoin a World Heritage Area, "says Jon Day.

The authors agree that no one wants to see the Great Barrier Reef placed on UNESCO's 'World Heritage Area In-Danger' list.

"The economic case for better protecting the Great Barrier Reef is very clear – it supports more than 60,000 jobs, mostly in Reef-related tourism," says Professor Hughes.

"This paper raises awareness of the untapped opportunities to incorporate science into better policy to ensure we still have a magnificent Great Barrier Reef in the future," Terry Hughes adds.

Hughes, TP, Day, JC and Brodie, J (2015). Securing the future of the Great Barrier Reef. *Nature Climate Change* 5(6): 508-511.

15 DEC
2015

Targeted assistance needed to fight poverty in developing coastal communities

Researchers say there needs to be a better understanding of how conservation and aid projects in developing countries impact the people they are designed to help.

"Millions of dollars have been spent on integrated conservation and development projects that are aimed at improving people's lives in developing countries," says study lead author, Dr Georgina Gurney from the ARC Centre of Excellence for Coral Reef Studies.

"But our understanding of whether these projects are effective and how they impact people – positively or negatively – is very weak, particularly how they impact different groups within communities," Dr Gurney says.

Dr Gurney says conservation in developing countries has typically been based on the assumption that projects will be beneficial and affect all people equally, but this approach is too simplistic.

As part of their study published in a special edition (protected areas) of the Royal Society's journal, *Philosophical Transactions B*, the researchers explored the impact of marine conservation and development projects on fishing communities in Indonesia.

They examined how benefits and costs of the project were distributed across different groups within the communities, such as how the project affected men as opposed to women, or the elderly compared to young people.

"We found that the impacts are not always equal for everyone and this highlights a real problem when implementing projects," says Professor Bob Pressey from the Coral CoE.

"It's important to understand how different people are affected because unequal impacts can be seen as unfair, and this can lead to conflict and hinder poverty alleviation."

Dr Gurney adds that knowing how different community members respond to these projects means they can be tailored for the various sectors of society.

"For example, environmental education activities should be designed differently for different age groups because people's ability to learn new information varies," Dr Gurney says.

"A more nuanced understanding of how these projects affect people allows us to better design projects to alleviate poverty and ultimately, achieve objectives for environmental sustainability."

Gurney, GG, Pressey, RL, Cinner, JE, Pollnac, R and Campbell, SJ (2015). Integrated conservation and development: evaluating a community-based marine protected area project for equality of socioeconomic impacts. *Philosophical Transactions of the Royal Society B: Biological Sciences* 370(1681).

PHOTO TONI PARRAS

RESEARCHER PROFILE

Dr Rebecca Weeks

Rebecca is a Senior Research Fellow in Program 1. She moved to Australia after completing a Masters degree in Zoology at the University of Sheffield to pursue her passion for marine conservation. The first step towards her goal was a PhD from James Cook University studying the development of marine reserve networks in the Philippines. Her research examined how to establish effective marine parks within a challenging context of globally significant marine biodiversity, strong local dependence upon coral reef fisheries, and highly decentralised management of natural resources.

Subsequently, in collaboration with Philippine colleagues, Rebecca was awarded a NOAA International Coral Reef Conservation Grant to apply the results from her doctoral research to the development of the Philippines' first provincial scale network of marine protected areas.

Her interest in straddling the boundary between the natural and social sciences continued following the award of her PhD in 2011 when Rebecca undertook a fellowship with the Wildlife Conservation Society in Fiji. There, she worked with coastal communities across five qoliqolis (traditional fishing grounds) to help design and implement marine protected area networks to support fisheries-based livelihoods and to improve resilience to climate change. This research required not only identifying optimum marine protected area configurations from an ecological perspective, but also embedding this design process into a customary management context.

Rebecca has been closely involved in research that is assisting the development of conservation plans throughout the "Coral Triangle" and Western Pacific. As a mission-oriented scientist, she has found that the best way for her research to make a difference is to work directly with local resource users and owners, such as the communities in Fiji, who ultimately determine the effectiveness of any actions aimed at conserving biodiversity. Rebecca has presented at village meetings, talked around the kava bowl in Fijian villages, and organised multi-stakeholder workshops in the Philippines. As a member of the Marine Protected Areas Working Group advising the Coral Triangle Initiative for Coral Reefs, Fisheries and Food Security, she has also provided advice to government representatives of the six countries involved – Indonesia, Malaysia, Philippines, Papua New Guinea, Solomon Island and Timor Leste. These interactions have helped her to identify research questions that are both academically interesting and highly relevant to applied conservation efforts.

Among these research questions is how to design and implement management strategies that best suit local societies. Rebecca's PhD fieldwork in the Philippines (and later with the Wildlife Conservation Society in Fiji), made her realise the small spatial scale at which natural resource management was effectively implemented, typically under community-based or co-management arrangements. This motivated her to investigate whether a systematic approach to conservation planning, successfully applied to rezone the Great Barrier Reef in Australia, might provide an insightful approach to guide the expansion of local management to achieve broader conservation and fisheries management objectives.

Rebecca quickly identified that critical to this process of "scaling up" local management is an understanding of the relative spatial scales of ecological processes and governance institutions. Her current research on connectivity within linked social-ecological systems will take her back to the Philippines to pursue a unique opportunity to quantify the degree of fit between reef fish larval connectivity and emerging local government "alliances" for coastal resource management.

Marine conservation planners focus heavily on 'no-take' marine reserves and marine reserve networks. In reality, few no-take marine reserves are well managed, socially acceptable or adequately enforced. Most are very small, and in many regions there is a local tradition or preference for alternative management strategies. In the Pacific Islands, periodically harvested fisheries closures greatly outnumber no-take marine reserves, and many communities are interested in returning to these traditional forms of management. Rebecca is currently engaged in research which aims to better understand both fishers' preferences for different management strategies, and their relative effectiveness in achieving different objectives, with the ultimate goal of being able to produce more locally-relevant and effective management plans.

2015 Highlight

The Centre appointed six tenured research leaders to enhance its research capacity in the social sciences and quantitative biology.

PHOTO ROMEO SALDIVAR

RESEARCH PROGRAM 2

Ecosystem Dynamics: Past, Present and Future

PHOTO NEIL CHAN

RESEARCH PROGRAM LEADERS

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 postdoctoral 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 90 publications in leading international journals, including 11 papers in *Science* or *Nature*, and he has supervised 25 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, 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 focus on coral reef ecosystems is shedding light on a number of fundamental ecological questions where long-term data are essential. John has published more than 125 papers, including 16 contributions to *Science* or *Nature*. He has served as President of the *Australian Coral Reef Society*, and chief editor of *Paleobiology.* He is, or has been, primary supervisor for 16 PhD students. John has provided frequent briefings on coral reef management and policy (e.g. US Congress, Australian Senate) and has been invited to serve on numerous international working groups, including ones convened to evaluate the effects of humans and global change on coral reefs (Scientific Committee on Ocean Research; Panel on Climate Change and Coral Reefs; IPCC), the integrated management and conservation of Brazilian reefs, and the ecosystem function and biodiversity of coral reefs (UNESCO) and Caribbean reefs (IUCN). In 2001, he received the *Discovery Magazine* '*Science Story of the Year*' award. In 2013 he was awarded a prestigious *Discovery Outstanding Researcher Award* from the *Australian Research Council* (2013-2016).

RESEARCHERS

Andrew Baird, David Bellwood, Pim Bongaerts, Mary Bonin, Yves-Marie Bozec, Tom Bridge, Vivian Cumbo, Graeme Cumming, Nick Graham, Alastair Harborne, Hugo Harrison, Andrew Hoey, Terry Hughes, Jeremy Jackson, Geoff Jones, Michael Kingsford, Nils Krück, Ryan Lowe, Vimoksalehi Lukoschek, Laurence McCook, Mark McCormick, Vanessa Messmer, Peter Mumby, Philip Munday, Stephen Palumbi, Serge Planes, Morgan Pratchett, Jairo Rivera Posada, Garry Russ, Eugenia Sampayo, Ruth Thurstan, Greg Torda, Sue-Ann Watson.

PROGRAM 2 REPORT

PHOTO FAKHRIZAL SETIAWAN

Program 2 aims to understand the multi-scale dynamics of coral reefs, through the innovative integration of ecology, evolution, genetics, oceanography and paleontology. Program 2 scientists focus particularly in four key research areas. We study 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 influence. We aim to increase understanding of the dynamics and resilience of ecosystems, and to bring those findings to bear in the management of coral reefs. We also examine how populations of organisms living on different reefs are connected to each other through the dispersal of their offspring, as well as through the social impacts of human connectivity, coral diseases, and new species introductions. We study the level of functional diversity and redundancy in coral reef assemblages, modelling and assessing the 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 2015, Program 2 researchers published several key papers on the observed and potential consequences of climate change for marine ecosystems, including coral reefs. In a paper in *Nature,* Nick Graham and colleagues showed unequivocal evidence that regime shifts from corals to macroalgae can occur in response to coral bleaching, and they identified aspects of reef ecology that influence the likelihood of this occurring (p60). Laureate Fellow Pete Mumby also showed that global warming not only impacts the calcification rate and bleaching susceptibility of corals but these stressors have a synergistic negative impact on reef resilience. In a series of papers, Mark McCormick's group showed the high sensitivity of coral reef fish to global warming and the disruption of predator-prey interactions. And, in a paper in the journal *Nature Climate Change,* John Pandolfi, working with a large team of international researchers, used climate velocity trajectories, together with information on thermal tolerances and habitat preferences, to project changes in global patterns of marine species richness and community composition under IPCC Representative Concentration Pathways (RCPs) 4, 4.5 and 8.5 (p22). Results strongly suggest that the millennial stability of current global marine diversity patterns, against which conservation plans are assessed, will change rapidly over the course of this century in response to ocean warming. Philip Munday and colleagues, also publishing in *Nature Climate Change,* uncovered potential molecular processes of trans-generational acclimation to a warming ocean, showing the potential for resistance to climate change. John Pandolfi also published a major review in the *Annual Reviews in Ecology Evolution and Systematics* outlining outstanding issues and sources of uncertainty in our understanding of just how reefs might respond to ongoing and future climate change.

Program 2 researchers continued to pioneer work on the origins, maintenance, and consequences of coral reef biodiversity. In a paper in *Science,* John Pandolfi and a group of international colleagues assessed intrinsic extinction risk—extinction risk predicted by paleontologically calibrated models - for modern genera in marine groups. Mapping the geographic distribution of these genera identified coastal biogeographic provinces where fauna with high intrinsic risk are strongly affected by human activity or climate change. Such regions occur disproportionately in the tropics, raising the possibility that these ecosystems may be particularly vulnerable to future extinctions. Intrinsic risk provides a pre-human baseline for considering current threats to marine biodiversity. The geographic variability predicted by this study was shown empirically by Peter Mumby and colleagues' study in *Oikos* showing that Pacific corals are far more sensitive to algal phase shifts than their Caribbean counterparts. Program 2 also published a breakthrough paper that revealed how a small change in the form of a fish's mouth revolutionised the benthic ecology of coral reefs. In a paper in *Current Biology* this year David Bellwood and colleagues discovered how changes in the structure of a single bone could reveal how well fishes can catch elusive prey. In essence over the last 100 million years fishes have been increasingly able to protrude their mouths and suck up elusive prey. This ability changed the history of the oceans with prey such as crabs on reefs shrinking in size (as

PHOTO CATERINA SCHLOTT

they hide) while jaw-protruding fishes expanded their influence and dominated the seas.

Mary Bonin, in collaboration with Philip Munday, Geoff Jones and PhD student Lisa Boström-Einarsson, published an overview of competition among coral reef fishes in the *Annual Review of Ecology, Evolution and Systematics.* Their synthesis of this literature revealed that competition for limited resources is prevalent within and between species, and they provided guidance on future priorities for competition research in a changing world. For many years reciprocal cooperation has been assumed to require exceptional cognitive abilities and was regarded as a behaviour that is characteristic of large brained vertebrates such as mammals or birds. However, in a breakthrough study in *Scientific Reports* PhD student Simon Brandl and David Bellwood revealed the exceptional behaviour of rabbitfishes, where one fish stands guard for other as it feeds, before swapping roles. Entitled "You watch my back and I'll watch yours: coordinated vigilance and reciprocal cooperation in coral reef rabbitfishes" (p23) the paper was exceptionally well received in the media, including the NY Times.

Tom Bridge published a series of papers documenting community composition on submerged banks on the Great Barrier Reef and Coral Sea, on connectivity between submerged and emergent reefs, and on how to effectively protect mesophotic and deep-sea habitats in the absence of ecological data.

Reef connectivity was also highlighted in Program 2's research with Hugo Harrison finding regional barriers to gene flow in Saudi Arabia in a major study published in *Molecular Ecology*. Andrew Baird published a study showing that isolated coral assemblages on Lord Howe Island are dominated by species with the ability to establish populations through localised recruitment.

The Centre's emphasis on reef governance, policy and management continued in 2015 through efforts from Program 2 researchers. For example, Sean Connolly published a paper in *Ecological Applications* on the transient effects of no-take marine reserves on fishery yields, focusing on coral trout as a model species. This paper provides the first formal proof that setting up no-take areas will reduce fisheries yields initially, even in heavily overfished situations, and even if the reserve system produces greater long-term yields in the long-run. It also shows a hump-shaped risk of metapopulation collapse: increasing fishing effort in order to maintain yields may increase risk of metapopulation collapse when reserves are small, but decrease it when they are large, relative to a no-reserve case. Terry Hughes led a large team of researchers in a paper in *Ecological Applications* which falsified claims for negative impacts on fisheries following the rezoning of the Great Barrier Reef.

Groundbreaking research by PhD student Matt Young revealed the potential impact of spearfishing in the Coral Sea and on the Great Barrier Reef. In a series of papers in *Conservation Biology* and *Environmental Conservation,* Matt and co-authors Simon Foale and David Bellwood revealed the rapid increase in spearfishing over the last five decades, with the Coral Sea representing the 'Last Marine Wilderness'. However, they highlight the value of spearfishers as key players in the conservation of marine resources and the need for fishers, scientists, managers and policy makers to improve communication in order to conserve marine resources.

Peter Mumby published a paper in *Nature Communications* developing new techniques for integrating conservation concerns in the Coral Triangle, a region of particular interest to the ARC Centre of Excellence. Mary Bonin, along with Geoff Jones, Hugo Harrison, and David Williamson published a paper using genetic data to measure dispersal across a network of marine reserves in the southern Great Barrier Reef and they estimated the effective population size for an anemonefish that is harvested by the local aquarium trade. The work identified breeding adults in reserves as the primary source for local population replenishment, and also revealed significant input of larvae from outside the local reserve network. The authors are now working with the fishing industry and the Great Barrier Reef Marine Park Authority to better manage the fishery.

25 AUG
2015

Climate's profound impact on marine biodiversity

New research into the impact of climate change has found that warming oceans will cause profound changes in the global distribution of marine biodiversity.

In a study published in the journal *Nature Climate Change* an international research team modelled the impacts of a changing climate on the distribution of almost 13 thousand marine species, more than twelve times as many species as previously studied.

The study found that a rapidly warming climate would cause many species to expand into new regions, which would impact on native species, while others with restricted ranges, particularly those around the tropics, are more likely to face extinction.

Professor John Pandolfi from the ARC Centre of Excellence for Coral Reef Studies says global patterns of species richness will change significantly, with considerable regional variability.

"This study was particularly useful because it not only gave us hope that species have the potential to track and follow changing climates but it also gave us cause for concern, particularly in the tropics, where strong biodiversity losses were predicted," says Professor Pandolfi.

PHOTO NICK GRAHAM

"This is especially worrying, and highly germane to Australia's coral reefs, because complementary studies have shown high levels of extinction risk in tropical biotas, where localised human impacts as well as climate change have resulted in substantial degradation."

To model the projected impact of climate change on marine biodiversity, the researchers used climate-velocity trajectories, a measurement which combines the rate and direction of movement of ocean temperature bands over time, together with information about thermal tolerance and habitat preference.

They say the analysis provides the simplest expectation for the future distribution of marine biodiversity, showing recurring spatial patterns of high rates of species invasions coupled with local extinctions.

Professor Elvira Poloczanska from CSIRO says, "This study shows how climate change will mix up biodiversity patterns in the ocean. Ecological communities which are currently distinct, will become more similar to each other in many regions by the end of the century"

Professor Pandolfi warns the resultant novel combinations of resident and migrant species will present unprecedented challenges for conservation planning.

"Above all, this study shows the broad geographic connections of the effects of climate change – conservation efforts need to be facilitated by cooperation among countries to have any real chance of combating the potentially severe biodiversity losses that a changing climate might impose."

Molinos, JG, Halpern, BS, Schoeman, DS, Brown, CJ, Kiessling, W, Moore, PJ, Pandolfi, JM, Poloczanska, ES, Richardson, AJ, and Burrows, MT (2015). Climate velocity and the future of global redistribution of marine biodiversity. *Nature Climate Change* doi:10.1038/nclimate2769

25 SEP
2015

I've got your back – fishes really do look after their mates!

When it comes to helping each other out, it turns out that some fish are better at it than previously thought.

New research from the ARC Centre of Excellence for Coral Reef Studies has found that pairs of rabbitfishes will cooperate and support each other while feeding.

While such behaviour has been documented for highly social birds and mammals, it was previously believed to be impossible for fishes.

"We found that rabbitfish pairs coordinate their vigilance activity quite strictly, thereby providing safety for their foraging partner," says Dr Simon Brandl from the ARC Centre of Excellence for Coral Reef Studies.

"In other words, one partner stays 'on guard' while the other feeds – these fishes literally watch each other's back," Dr Brandl says.

"This behaviour is so far unique among fishes and appears to be based on reciprocal cooperation between pair members."

Reciprocal cooperation, which requires an investment in a partner, which is later reciprocated, is assumed to require complex cognitive and social skills. Skills that fishes have been deemed not to have.

Yet, Dr Brandl says their research shows clear coordination and presents intriguing evidence for reciprocal cooperation between the rabbitfish pairs.

"There has been a long standing debate about whether reciprocal cooperation can exist in animals that lack the highly developed cognitive and social skills found in humans and a few species of birds and primates," Dr Brandl says.

"By showing that fishes, which are commonly considered to be cold, unsocial, and unintelligent, are capable of negotiating reciprocal cooperative systems, we provide evidence that cooperation may not be as exclusive as previously assumed."

Co-author, Professor David Bellwood, also from the ARC Centre of Excellence for Coral Reef Studies, says

PHOTO JORDAN CASEY

that our perception of fishes as cold scaly automatons is slowly changing.

"Our findings should further ignite efforts to understand fishes as highly developed organisms with complex social behaviours," he says.

"This may also require a shift in how we study and ethically treat fishes."

Brandl, SJ and Bellwood, DR (2015). Coordinated vigilance provides evidence for direct reciprocity in coral reef fishes. *Scientific Reports* 5: 14556

RESEARCHER PROFILE

Dr Hugo Harrison


PHOTO TANE SINCLAIR-TAYLOR

Having grown up amongst the vineyards of the Loire Valley in France, diving the coral reefs of the world seemed an unlikely profession for Hugo. An ARC Discovery Early Career Researcher Award (DECRA) Fellow in the ARC Centre from 2016, his new research program will take him to some of the most remote reefs of the Australian continent in order to pursue his research goals.

Hugo first moved from France to Edinburgh, Scotland where he earned a Bachelor's degree with Honours in genetics. As any keen explorer would, he took to diving in the North Sea and discovered the underwater. This was a turning point, which led him to team up with Dr Stephen Simpson, then Natural Environment Research Council (NERC) Fellow at the University of Edinburgh, and to join a group of 24 undergraduate students for a research expedition to the southern coast of Oman on the Arabian Peninsula.

The objective of the expedition was to determine whether coral reef fish larvae could disperse between isolated reefs separated by over 400 km of sandy shores. Their findings depict the epic voyage that anemone fish (the famous *Nemo*) must endure to colonise new habitats and revealed the potential for connectivity in marine systems.

Hugo realised his background in molecular genetics could help address long-standing questions in marine science and he next pursued a co-tutelle PhD at James Cook University and University or Perpignan, France. His thesis on larval dispersal combined large-scale field studies with novel genetic approaches to address critical questions for the effective management of coral reef ecosystems in the Great Barrier Reef Marine Park. The research produced ground breaking results that can inform the placement of no-take zones in coral reef ecosystems. Knowing where the larvae come from, and go to, allows us for the first time to effectivity manage connectivity in the marine environment.

Today, Hugo's research is best described as addressing the molecular ecology and evolution of coral reefs, with emphasis on the population dynamics of coral reef fishes including: the dispersal ecology and recruitment dynamics of larval fishes, the reproductive success of adult fishes, and the role of hybridisation in speciation. Much of the theory in this field was introduced in the 1980's and has developed over subsequent decades. Until now, empirical demonstrations of theoretical concepts have been hindered by the difficulty of tracking larval offspring *in situ*.

Hugo's DECRA project aims to understand the processes that shape dispersal patterns in marine seascapes. Over the next 3 years, he will be leading research expeditions to some of the remote and pristine reefs of the Queensland plateau in the Coral Sea. Teaming up with other colleagues in the ARC Centre, the King Abdullah University of Science and Technology (KAUST) in Saudi Arabia and CSIRO in Hobart, Hugo plans to develop a mechanistic understanding of connectivity in coral reef ecosystems and establish management strategies that enhance conservation measures and fishery objectives.

2015 Highlight

Centre researchers produced a record 319 research publications with an average Impact Factor of 5.1

PHOTO SANDER DEN HARING

PHOTO VERENA SCHOEPF

RESEARCH PROGRAM 3

Responding to a Changing World

RESEARCH PROGRAM LEADERS

Professor Malcolm McCulloch *FRS, FAA*
Professor Malcolm McCulloch is one of the Centre's two Deputy Directors and co-leader of Research Program 3. Malcolm is an ARC Australian Laureate Fellow in the School of Earth and Environment at The University of Western Australia. His research addresses important contemporary issues such as the impacts of climate change and direct human activities on coral reefs, and he has developed innovative new indicators of climate change that are preserved in coral skeletons. His research is characterised by the development and application of new sets of quantitative tools utilising changes in the geochemistry of corals as proxies for determining sediment discharge into reefs, changes in freshwater river runoff, ocean temperatures, sea-levels, and most recently ocean acidification from rising CO_2 emissions. Malcolm is an elected Fellow of The Royal Society (London), the Australian Academy of Science, the American Geophysical Union, the Geochemical Society and the Geological Society of Australia. He was awarded the *Jaeger Medal* for career excellence in the earth sciences from the Australian Academy of Science, and an Honorary Doctorate from Curtin University. He held a WA Premier's Research Fellowship at UWA from 2009 to 2013.

Professor Bette Willis
Professor Bette Willis is co-leader of Research Program 3 and a Professor of Marine Biology in the College of Marine and Environmental Sciences at James Cook University. She received her doctorate from James Cook University in 1988. Her research addresses questions concerning the dynamics of reef corals in an era of climate change and increasing anthropogenic impacts. Her current research focuses on understanding inter-kingdom symbiotic partnerships that underpin coral biology, the causes of outbreaks of coral disease, and the potential for corals to acclimatise and adapt to a changing world. Bette has more than 135 publications in international journals, including 4 papers in *Nature* or *Science*. She was a recipient of the *POL Eureka Prize for Environmental Research* in 1992. She has supervised over 100 postgraduate students to completion and was awarded an Outstanding Career Achievement in Higher Degree by Research Supervision by James Cook University. She co-chaired the Global Environment Fund/World Bank Working Group on Coral Disease and participates in a range of national and international working groups to further understanding and awareness of the ecology of infectious coral diseases. In 2015 she was awarded the title of Distinguished Professor at JCU.

RESEARCHERS

Tracy Ainsworth, Andrew Baird, Dorothea Bender, Pim Bongaerts, Tom Bridge, Steeve Comeau, Sean Connolly, Christopher Cornwall, Juan Pablo D'Olivo Cordero, Sophie Dove, Jim Falter, Sylvain Forêt, Miguel Gongalez-Rivero, Hugo Harrison, Ove Hoegh-Guldberg, Mia Hoogenboom, Michael Kingsford, Andreas Kubicek, Bill Leggat, Janice Lough, Ryan Lowe, Vimoksalehi Lukoschek, David Miller, Aurélie Moya, Philip Munday, Stephen Palumbi, Morgan Pratchett, Jodie Rummer, Eugenia Sampayo, Verena Schoepf, Greg Torda, Madeleine van Oppen, Heather Veilleux, Sue-Ann Watson.

PROGRAM 3 REPORT

Program 3 aims to understand the responses of coral reef organisms to rapidly changing local and global environments. Our goal is to advance fundamental knowledge of processes underpinning reef resilience in three vital areas: the dynamics of coral-microbial associations that govern coral health, the integrity of carbonate reef frameworks that provide the foundation of the coral reef ecosystem, and the capacity of coral reef organisms to adapt to a challenging future. Such knowledge is key to understanding the future sustainability of coral reefs and the ecosystem services they provide to societies and economies.

In 2015, Program 3 researchers published new insights into the pivotal role that microbes play on coral reefs. Focussing on the ubiquitous presence of bacterial taxa in coral associations, Tracy Ainsworth, Bill Leggat, Ove Hoegh-Guldberg and Greg Torda discovered a core coral microbiome that was stable across coral species and broad geographic regions. This research provided new evidence for habitat partitioning of bacterial communities within the coral host, suggestive of significant diversity of roles in coral-bacterial symbioses. In *The International Society of Microbial Ecology Journal,* Centre PhD student Kim Lema, Bette Willis and their collaborators revealed the uptake of nitrogen-fixing bacteria into coral larvae using sophisticated NanoSIMS technology, highlighting the central role these bacteria play from the earliest life history stages in a nitrogen-limited ecosystem. Research published in *Scientific Reports* by Pim Bongaerts and Ove Hoegh-Guldberg revealed that deep mesophotic reefs harbour a specialised coral-endosymbiont.

To understand the implications of a changing climate for coral reefs, Bette Willis and a team of international researchers modelled disease susceptibility of corals under different CO_2 emission scenarios. In a paper in *Nature Climate Change,* they highlight that disease is likely to be a major cause of coral mortality in coming decades, potentially rivalling the impact of bleaching. The important role that zoning can play in the dynamics of corals within the Great Barrier Reef Marine Park was demonstrated for the first time by Centre PhD student Joleah Lamb, Bette Willis, Garry Russ and colleagues. In a paper in *Ecology,* they showed that marine protected areas mitigate coral diseases by reducing injuries from fishing and recreational activities that make corals more susceptible to infections (p30). PhD student Sybille Hess and colleagues demonstrated in *Scientific Reports* that suspended sediment on coral reef waters caused damage to the gills of clownfish and sharks.

At the ARC Centre's UWA node, the first ROV-based exploration of the Perth Canyon, using the Schmidt Ocean Institute's vessel the RV Falkor, was another research highlight in 2015 (p34). The Perth deep-sea canyon is the largest of its type along the Australian shelf-edge, and a number of highly specialised, charismatic fauna were discovered. The carbonate chemistry of the deeper canyon waters (> 1000m) was found to be barely-saturated with aragonite, making it a very challenging environment to sustain carbonate-based coral growth. Despite their relative isolation, deep-sea canyon ecosystems are not immune to the combined impacts of rapid warming and ocean acidification, raising questions about their vulnerability to CO_2-driven changes in climate and ocean chemistry.

PHOTO ADRIAN ARIAS

PHOTO SOFIA FORTUNATO

The implications of variation in coral growth for the structure and function of coral reef ecosystems in a changing environment were highlighted in a major review in *Oceanography and Marine Biology* by Centre researcher Morgan Pratchett and a team of Program 2 and 3 members, including Mia Hoogenboom, Janice Lough, Andrew Baird and John Pandolfi.

Program 3 members continued their ground-breaking research in 2015 on the capacity of reef organisms to acclimatise to future ocean warming and acidification. In a cutting-edge paper in *Nature Climate Change*, Centre researchers Heather Veilleux, Philip Munday and Bill Leggat, with overseas collaborators from KAUST in Saudi Arabia, revealed that key genes and molecular processes enable reef fish to adjust to a warmer environment over multiple generations. In a paper in *Global Change Biology,* Jodie Rummer demonstrated the interactive effects of ocean acidification and rising sea temperatures on prey mortality and predator selectivity in reef fish communities. Bill Leggat and Partner Investigator Madeleine van Oppen, from the Australian Institute of Marine Science (AIMS), described novel 'omics' approaches for exploring the adaptability and resilience of corals to environmental change, in *Frontiers in Marine Science.* The potential for building the resilience of corals to changing environments through assisted evolution was explored by Madeleine in a publication in the *Proceedings of the National Academy of Science.* Aurélie Moya and David Miller published a comprehensive survey of the apoptotic components of corals in *BMC Genomics,* providing a framework for future experimental studies aimed at understanding the genetic and cellular mechanisms of coral bleaching.

The unique coral reef environments of the macro-tidal Kimberley region in Australia's northwest is being used by Centre researchers to provide important insights into the capacity of corals to adapt or acclimatise to rapid climate change. Using a mesocosm experiment, Research Fellow Verena Schoepf, Malcolm McCulloch, Jim Falter and a colleague demonstrated that the Kimberley's extreme temperature environments can enhance the thermal tolerance of corals, although they are nevertheless highly vulnerable to coral bleaching and climate change (*Scientific Reports*). Ryan Lowe, Jim Falter, PhD student Renee Gruber and colleagues investigated intertidal hydraulics of a reef platform in the Kimberley's dominated by the largest tropical tides in the world (>8m) and found that large water level asymmetries were well-predicted using a 1-D numerical model (*Journal of Geophysical Research: Oceans*). In a paper in *Nature Communications,* Program 3 members Malcolm McCulloch, Janice Lough (AIMS) and their colleagues used coral cores to reveal important links between the behaviour of the Western Pacific Warm Pool and the intensity of marine heatwaves that cause widespread mass bleaching of corals.

Centre researcher Ove Hoegh-Guldberg and colleagues published a review paper in *Science,* which highlighted contrasting futures for oceans and society under different CO_2 emission scenarios. Ove, along with Sophie Dove, also participated in the successful COP 21 (21st session of the Conference of the Parties) in Paris, which set a global temperature target – a ceiling of 2°C warming, plus a stated goal of limiting warming to 1.5°C.

02 JUN
2015

Great Barrier Reef marine reserves combat coral disease

A new and significant role for marine reserves on the Great Barrier Reef (GBR) has been revealed, with researchers finding the reserves reduce the prevalence of coral diseases.

It's been known for some time that marine reserves are important for maintaining and enhancing fish stocks, but this is the first time marine reserves have been shown to protect coral health on the GBR.

Researchers from the ARC Centre of Excellence for Coral Reef Studies found that coral disease levels were four times lower inside no-take marine reserves, where fishing is banned, compared to outside reserves.

"We surveyed more than 80,000 corals around the Whitsunday Islands for six different diseases that commonly harm reef corals around the world," says lead author, Dr Joleah Lamb from the Coral CoE.

"We found three coral diseases were more prevalent on reefs outside no-take marine reserves, particularly on reefs with high levels of injured corals and discarded fishing line."

Wounded corals are more vulnerable to disease with damaged tissue providing sites where pathogens and parasites can invade, particularly as coral immune responses are lowered while they heal.

Dr Lamb says once a pathogen infects a coral, tissue loss typically spreads from the point of entry.

"It's like getting gangrene on your foot and there is nothing you can do to stop it from affecting your leg and ultimately your whole body."

"Disease outbreaks can take a heavy toll, with losses of up to 95 per cent of coral cover on some reefs in the Caribbean."

Given the difficulty identifying pathogens that cause disease, the researchers say it's vital to understand which activities increase the risk of coral diseases, and to protect against them.

They say discarded fishing line and levels of coral breakage, potentially from a variety of fishing-related


PHOTO KYDD POLLOCK

activities, outside the no-take zones on the Great Barrier Reef are indicators of the types of activities that contribute to the problem.

"Fishing line not only causes coral tissue injuries and skeleton damage, but also provides an additional surface for potential pathogens to colonise, increasing their capacity to infect wounds caused by entangled fishing line," Dr Lamb says.

The researchers hope their findings send a clear message to reef managers about the benefits of marine reserves for coral health.

"No take marine reserves are a promising approach for mitigating coral disease in locations where the concentration or intensity of fishing effort is relatively high," says Professor Garry Russ from the Coral CoE.

Professor Bette Willis, also from the Coral CoE, says the scientists are now expanding their research to examine other drivers of coral disease. "We've shown that there are strong links between damage and disease in this study, now we're interested in understanding and managing other potential drivers of diseases that involve injury– such as outbreaks of crown-of-thorns starfish, cyclones, and recreational activities like anchoring."

Lamb, JB, Williamson, DH, Russ, GR and Willis, BL (2015). Protected areas mitigate diseases of reef-building corals by reducing damage from fishing. *Ecology* 96(9): 2555-2567.

06 OCT
2015

Self-regulating corals protect their skeletons against ocean acidification

Scientists from the ARC Centre of Excellence for Coral Reef Studies (Coral CoE) have found a species of coral living in a dynamic reef system, which is able to protect itself from the impact of ocean acidification.

Ocean acidification, caused by rising CO_2, is one of the greatest long-term challenges facing reefs. It reduces coral's ability to form their skeletons and build reef structures.

Now Coral CoE researchers from the University of Western Australia and the University of Queensland have found that coral colonies of *Porites cylindrica* within Heron Island lagoon on the Great Barrier Reef have a unique internal solution to the problem.

"Our research shows that some corals living in dynamic reef systems have the ability to maintain a nearly constant pH within their calcifying fluid, regardless of the pH of the surrounding environment," says lead author, PhD student, Lucy Georgiou.

"This enables them to continue to form their calcium carbonate skeleton even under relatively low pH conditions."

PHOTO ANNA FROIK

Co-author, Professor Malcolm McCulloch, says the findings indicate the existence of physiological controls on the pH of the coral's calcifying fluid.

"In contrast previous aquarium experiments conducted under constant conditions of pH and temperature had indicated a partial dependence of the corals calcifying pH on the external seawater."

The regulatory mechanism allows the coral to grow at a relatively constant rate, suggesting they may be more resilient in this environment to the effects of ocean acidification than previously thought.

The researchers were able to study the colony in its natural environment using the innovative Free Ocean Carbon Enrichment (FOCE) technique to simulate the impact of ocean acidification.

"It was really important to do this, as many reef systems are highly complex environments," says Ms Georgiou.

While the findings are positive, it's not yet known if the adaptation is species specific and limited to colonies in dynamic reef systems.

"This is most likely only typical to corals from reefs such as Heron Island lagoon where temperature and pH fluctuations vary greatly on a daily to seasonal basis," says Ms Georgiou.

"The next step in this research is to explore if *P. cylindrica* colonies from more stable environments also have the ability to adapt and if they too can 'hold up' to increased acidity," she says. "We also need to explore what impact rising sea temperature has on the corals ability to maintain its internal pH."

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RESEARCHER PROFILE

Professor Ryan Lowe

PHOTO CORDELIA MOORE

Professor Ryan Lowe is a Future Fellow and Chief Investigator in the ARC Centre. He grew up on the coast in Laguna Beach, California where he developed an early passion for the ocean. After initially completing an undergraduate degree in Mechanical Engineering at the University of California, San Diego, Ryan decided to alter his career course to focus on the ocean, pursuing a PhD in Civil and Environmental Engineering at Stanford University with a specialisation in physical oceanography. At Stanford he had a unique opportunity to develop a joint multidisciplinary project with researchers at the Hawaii Institute of Marine Biology, which launched his career in coral reef science. His research specifically led to new understanding of how hydrodynamics (water motion induced by waves and currents) can regulate nutrient uptake and feeding by coral reef assemblages, using novel experimental facilities at Stanford to simulate coastal flows as well as complementary field studies in Hawaii.

Ryan moved to University of Western Australia (UWA) in 2007. Over the past 15 years, his research has expanded to more broadly investigate how ocean processes shape the productivity and function of coral reef ecosystems across a broad range of spatial scales, ranging from large-scale studies of how regional ocean currents influence coral reef systems down to small-scale biophysical studies of individual reef organisms. A major motivation of this research is to understand the complex ocean processes that affect how future changes in the world's oceans will impact local coral reef systems. These changes include local human impacts such as reductions in coastal water quality and sedimentation by dredging as well as the more global issue of climate change.

Ryan now leads the Coastal Dynamics group within the Oceans Institute at the UWA, where he is also an ARC Future Fellow. He has recently recruited outstanding PhD students, postdoctoral research fellows and forged links to academic collaborators with a diversity of backgrounds ranging from coastal engineering, to marine biogeochemistry, to coral reef ecology. "My research and understanding of coral reefs has really benefited from the multi-disciplinary expertise the ARC Centre brings together, which is needed to develop solutions to the complex challenges coral reefs face globally," Ryan says.

The UWA's unique location on the Indian Ocean has provided many exciting opportunities to focus on the historically poorly explored coral reef systems in north-western Australia. These reefs span from the World Heritage Ningaloo Reef in the south to the very remote inshore fringing reefs and offshore atoll reefs off the Kimberley coast in the north. Working in the coastal Kimberley has been a particular highlight of his research career, where diverse and productive coral reef systems experience tidal ranges exceeding 8m (the largest of any tropical region in the world), leading to temperature extremes and aerial exposure. "The fact that coral reefs not only persist but thrive in these conditions defies conventional wisdom and creates an ideal natural laboratory to investigate how reef organisms can respond to extreme environmental change," Ryan says.

In recent years, Ryan's work has increasingly concentrated on applied outcomes, particularly in efforts to enhance coastal zone management of coral reef coastlines both nationally and internationally. His projects include research directed at understanding the hazards associated with coastal erosion and flooding on coral reef islands in both the Pacific (e.g. Kiribati) and Indian Oceans (e.g. Mauritius). In addition, Ryan has contributed to major international training and capacity building efforts to improve coastal zone management of Small Island Developing States, supported by the Asian Development Bank and the Adaptation Fund established under the UN Framework Convention on Climate Change.

2015 Highlight

Centre researchers made significant contributions to the science underpinning the long-term sustainability of the Great Barrier Reef which informed UNESCO's deliberations on the listing of the GBR as a World Heritage site

PHOTO JILL HARRIS

27 FEB
2015

Perth Canyon research could provide crucial climate change information, researchers say

"It's a marine hotspot and climate change could suppress the activity of the canyon."

Professor Malcolm McCulloch

A group of scientists hopes to unlock the secrets of an unexplored deep-sea canyon 60 kilometres off the coast of Perth.

Little is known about the Perth Canyon but researchers believe it could provide crucial information about climate change.

A team from the University of Western Australia, led by Professor Malcolm McCulloch, together with researchers from the Western Australian Museum, CSIRO and the Institute of Marine Sciences in Italy will spend 12 days surveying the undersea canyon using a remote operated vehicle (ROV).

It will be the first time anyone has seen what lies beneath the trench that is up to four kilometres deep and as wide as the Grand Canyon.

Professor McCulloch said the research was focussed on taking samples of deep-sea corals from the canyon as they were sensitive to climate change.

"We think this is a region where the effects of climate change will be most felt," Professor McCulloch said.

"Normally people would think because the canyon is so deep, there wouldn't be any effect (of climate change) but we suspect that there is very hot water that cools down at the end of summer that sinks down into the canyon, and that water will have different characteristics than it used to, it's warmer and has more dissolved carbon dioxide."

Professor McCulloch said the warmer waters may diminish the corals, which could have substantial impacts for the ecosystem.

"The canyon acts as a food source, not just for the corals but the whales too," he said.

"It's a marine hotspot and climate change could suppress the activity of the canyon."

PHILANTHROPIC SCIENCE GROUP MAKES RESEARCH POSSIBLE

Professor McCulloch said the canyon had been surveyed using sonar technology but had not previously been explored or sampled.

"People have fished it, but no one's actually gone down and had a look at it," he said.

"It's so close to Perth, I don't understand why people haven't done it earlier."

Professor McCulloch said this research had been made possible after the group applied successfully to use the research vessel RV Falkor from a philanthropic science organisation set up by the billionaire executive chairman of Google, Eric Schmidt.

He said it had taken five years of preparation, including negotiating with the Navy.

"As long as we can dodge the submarines, and we made a pretty good arrangement with the navy, we should be alright," he said.

RV Falkor Captain Heiko Volz said the ROV had remote controlled arms to pick up specimens from kilometres below the ocean surface.

"It has lighting, cameras and manipulators, where we can actually get pictures from the sea floor and collect samples such as rocks, coral and even some fish," he said.

The samples collected from the canyon will inform the next three years of research work in the laboratory at the University of Western Australia's Oceans Institute.

The RV Falkor is next heading to Broome to study the Timor Sea Reef.

NEWS

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www.abc.net.au/news/2015-02-27/deep-sea-canyon-study-could-reveal-climate-change-information/6269672

Research Impact in 2015

Indonesia
Nils Krück and Peter Mumby in collaboration with WWF Indonesia and the Ministry for Marine Affairs and Fisheries, are helping to improve the design of marine reserve networks. They also provide training on the placement of new marine protected areas in the Sunda-Banda seascape, in south-eastern Indonesia. This engagement will facilitate both biodiversity conservation as well as fishery sustainability.

Seychelles
Kirsty Nash and Nick Graham provided advice to the Seychelles Fishing Authority to enhance small scale fisheries. They provided new tools for assessing stock status for inclusion in the Seychelles government's fisheries management plan.

Australia
Centre researchers are members of multiple expert panels providing advice to Australian and Queensland governments on a broad array of research, management and policy issues central to the Reef 2050 Sustainability Plan (p38). The Plan is Australia's primary framework for better management of the Great Barrier Reef, with specific targets for improvement in water quality.

Australia
Terry Hughes has been working with consultants to the Chief Scientist and the Australian Academy of Science who are preparing a report on the economic value of biological science to the Australian economy, using the rezoning of the GBR as a case study. The long-term goal is to promote careers and government investment in biological sciences.

Australia
The ARC Centre is the world's largest provider of graduate training in coral reef research, adding substantial research capacity to Australia and to overseas students from 41 countries.

Australia
Tom Bridge's research on predictive models of deep-water biodiversity has provided important new scientific information to managers on marine ecosystems in the Great Barrier Reef World Heritage Area and the Coral Sea Commonwealth Marine Reserve. Tom's results have prompted the GBR Marine Park Authority to identify deep-water coral reefs as a research priority in their 2014-2019 science plan.

Australia
Bob Pressey is developing scenarios for future land-use in the Great Barrier Reef coastal zone, coupled with Bayesian modelling of cumulative impacts of each scenario on selected coastal species and ecosystems. This research is improving GBRMPA's understanding of how to assess cumulative impacts.

China
The depletion of sharks worldwide, mainly for consumption in Asia, is an ongoing challenge. Mike Fabinyi has undertaken research on markets and supply chains leading to a reduction in shark fin consumption in China, in collaboration with the Pew Trust's Shark Program.

Micronesia
Alistair Harborne is informing marine spatial planning initiatives across Micronesia, including the design of marine protected area networks. He is working closely with The Nature Conservancy NGO and Adjunct Researcher Alison Green to map fishing pressure and fish standing stock on reefs across Micronesia, in order to improve marine stewardship.

Costa Rica
Adrian Arias has delivered new research findings on fisher behaviour to managers and stakeholders on Cocos Island, Costa Rica, leading to better enforcement of illegal fishing in marine protected areas (MPAs).

Timor Leste
Dave Mills is advising the Ministry of Agriculture and Fisheries in Timor Leste to facilitate the development of a Sustainable Coastal Fisheries Strategy. This activity in particular focuses on participatory processes in governance – the focus of substantial collaborative work by WorldFish and the ARC Centre in the Coral Triangle and across the Pacific.

Solomon Islands
Pip Cohen is engaged in research to improve practices and policies for small-scale fisheries governance, particularly in the Solomon Islands and elsewhere in the Pacific region. She provides advice to fisheries managers, national governments, regional agencies and NGOs, aimed at improving the livelihoods of millions of impoverished fishers in developing countries.

Australia
Ruth Thurstan provides advice to the Commonwealth's Fisheries Research and Development Corporation and stock assessment modellers at the Queensland Department of Agriculture, Fisheries and Forestry. The objective is to improve the sustainability of fisheries by incorporating historical data into contemporary population modelling.

Australia
Morgan Pratchett was the chief scientist involved in the latest Ecological Risk Assessment for the Marine Aquarium Fishery in Northern Territory. The ERA process draws on expert opinion from fishers, scientists and managers to assess the risk of current harvest strategies to populations of corals and anemones for the aquarium fishery in Northern Territory waters. The outcome will be a more profitable and sustainable fishery.

Australia
Blanche D'Anastasi's research with resource managers at the WA Department of Fisheries (WADoF) and WA Department of Parks and Wildlife, led to the re-discovery of sea snakes that were thought to be extinct. Her partnerships with WADoF, commercial fishers, and the Northern Prawn Fishery will lead to more informed status assessments, and improved conservation and fisheries policies, aimed at reducing impacts on sea snakes.

NATIONAL RESEARCH PRIORITY CASE STUDY

The Reef 2050 Plan

In 2015, the Australian Government developed a new set of *Science and Research Priorities* to encourage further research capacity in areas of critical importance to Australia. One of the major research priorities, *Environmental Change*, centres on Australia's ability "*to predict, measure and respond to the impact of environmental changes caused by climate and local factors*" (Australian Government, 2015). A major area of research impact and active policy engagement by the ARC Centre of Excellence for Coral Reef Studies focusses on understanding the dynamics of coral reefs – in Australia and elsewhere throughout the tropics – as they respond to rapid environmental change. In particular, our research provides vital information to help improve governance and management of the Great Barrier Reef region. Across the Centre's research and training programs, key areas of focus include social science, resilience and adaptation to global warming, ecosystem dynamics, threatened species, coral bleaching and disease, fish and fisheries, and conservation planning. The Centre's governance structure (p66) is specifically designed to facilitate knowledge transfer to our key government and NGO partners.

THE RESEARCH-POLICY INTERFACE: THE GREAT BARRIER REEF

Australia is internationally recognised for its world-class reef research and management, and is responsible for ensuring that the iconic Great Barrier Reef (GBR) retains its Outstanding Universal Value (i.e. the attributes that led to its designation as a World Heritage Area by UNESCO in 1981). The GBR supports a major tourism industry as well as commercial and recreational fisheries. These reef-dependent industries generate close to $6 billion per annum, and employ 65,000 people. However, over the past 3 years, UNESCO has expressed its concern for the serious deterioration in the condition of the Great Barrier Reef. For example, coral cover on the GBR has declined in recent decades by approximately 50%, while coral disease and coral bleaching due to global warming pose an increasing risk. The Centre's research is revealing why these changes occur, leading to tangible impacts on the development and implementation of specific management responses (Hughes et al. 2015). For example, in 2015 Centre researchers showed that the prevalence of coral disease is lower inside no-fishing zones compared to areas of the GBR that have lower levels of protection (Lamb et al. 2015, p30). Similarly, the Centre's cutting-edge research on larval spill-over from no-fishing zones into adjoining fished zones is providing new insights into the design and positioning of networks of protected areas and the sustainability of reef fishing (Hopf et al. 2015).

REEF 2050 LONG TERM SUSTAINABILITY PLAN

In response to UNESCO's concerns, the Australian and Queensland Governments have begun the development of the *Reef 2050 Long-Term Sustainability Plan*, which is described as the overarching framework for protecting and managing the Great Barrier Reef from 2015 to 2050. The Plan's vision is "*To ensure the Great Barrier Reef continues to improve on its Outstanding Universal Value every decade between now and 2050 to be a natural wonder for each successive generation to come*." Hence, the Plan focuses on securing and improving the resilience of the Reef in the face of a variable and changing climate. Achieving the Plan's vision and outcomes is contingent on translating scientific knowledge into improved governance and management. The Reef Plan draws together a broad range of stakeholders, including government agencies, Traditional Owners, scientists, natural resource managers, industry bodies and extension providers to identify gaps and inform investment decisions.

The Plan has seven overarching themes that map squarely onto the ARC Centre's three major research programs: ecosystem health, biodiversity, heritage, water quality, community benefits, economic benefits and governance.

In 2015, Terry Hughes and Ove Hoegh-Guldberg contributed to the operational structure of the Reef


PHOTO NEIL CHAN

Plan as members of an Independent Expert Panel (Chaired by Australia's Chief Scientist, Professor Ian Chubb). The Independent Expert Panel has been established to advise the Australian and Queensland governments on implementation and review of the Reef 2050 Plan and its funding mechanisms. The Chair of the Panel reports to the Great Barrier Reef Ministerial Forum twice a year.

Specifically, the Panel is providing advice to government on a broad array of research, management and policy issues. These include providing scientific input into:

- the achievement and review of the Reef 2050 Plan's targets, objectives, and implementation strategy;
- development of the Reef 2050 Plan investment framework, and the prioritisation of actions; and
- providing input into the five-yearly reviews of the Reef 2050 Plan, with the first due in 2020.

The Panel will also advise the Australian Government Minister for the Environment on funding priorities and actions, including:

- reducing the sediment and nutrient loads of terrestrial runoff entering the Reef;
- improving the resilience of coastal habitat; and
- restoring and protecting marine biodiversity by culling crown-of-thorns starfish, using techniques developed by the ARC Centre (Boström-Einarsson and Rivera-Posada 2015).

At the State level, the Queensland government also established a Great Barrier Reef Taskforce Review group in 2015, which includes Centre members Terry Hughes, Bob Pressey and Pete Mumby among its membership. Ove Hoegh-Guldberg is also a member of the Queensland government's GBR Water Science Taskforce. Its role is to provide recommendations on meeting the government's water quality targets and investment priorities in initiatives, scientific research and transitional arrangements to improved practices in primary production.

Arguably, the need for coral reef research, and for transfer of new scientific knowledge into best-practice management has never been greater. The ARC Centre is playing a key role at the science-policy-management interface, helping to improve the sustainability of the Great Barrier Reef through its research and engagement with the 2050 Plan. There is substantial public and international interest in the ongoing research-management-policy interface. The World Heritage Committee will assess Australia's progress in implementing the Reef Plan in 2017.

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09 JAN
2015

Looming coral reef disaster? Scientists divided

By Dennis Normile

"The sooner we put a limit on carbon emissions the better."

Professor Terry Hughes

Marine biologists are keeping a watchful eye on coral reefs stressed by rising temperatures in the western Pacific—and debating the signals. "The signs are still there that we may see the third global-scale bleaching event in 2015," says C. Mark Eakin, a coral reef ecologist in charge of the Coral Reef Watch, a service of the U.S. National Oceanic and Atmospheric Administration (NOAA), in College Park, Maryland. Others say the prognostication is premature. "I just don't think we know at this stage," says David Wachenfeld, Director of Reef Recovery for the Great Barrier Reef Marine Park Authority in Townsville, Australia.

The debate centers on how much to trust a computer model and how to assess the variability of local weather. There is a wild card as well: the episodic climatic event known as El Niño, which dramatically warms Pacific waters but affects weather worldwide. One point all reef scientists agree on is that rising seawater temperatures due to climate change make the survival of coral reefs increasingly precarious.

Corals harbor colorful symbiotic algae called zooxanthellae, which use photosynthesis to produce nutrients for themselves and their hosts. When the water gets too hot the corals expel the zooxanthellae and turn white, or bleach. If the water cools soon enough, the algae return. But prolonged bleaching can be lethal.

Previous extensive bleaching events occurred in 1998 when what was arguably the biggest El Niño on record heated up ocean waters, and in 2010, which was also an El Niño year. There may be a mild El Niño now getting under way. "A weak El Niño probably would not have triggered mass coral bleaching and mortality in the late 1990s but is much more likely to do so today after 25 years of ocean warming. This is why there is considerable concern among key scientific groups about the growing risks posed by even a mild El Niño event on the world's coral reefs," says Ove Hoegh-Guldberg, director of the Global Change Institute at the University of Queensland, St. Lucia, in Australia.

NOAA keeps a close eye on sea surface temperatures. Scientists with its Coral Reef Watch use satellite data to plot sea surface temperatures on online

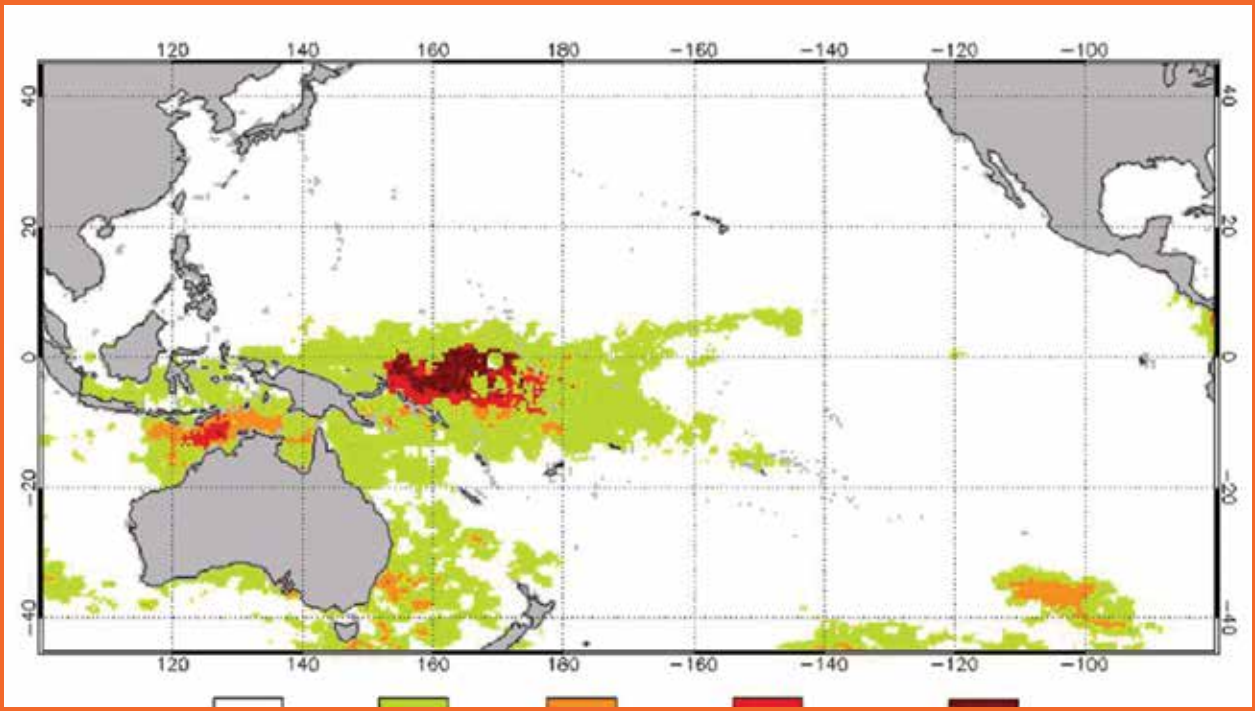
maps. Colors indicate four levels of concern for corals: watch, warning, alert level 1, and alert level 2. The office also forecasts seawater temperatures several months in advance.

Modeling late last year predicted the two highest stress levels occurring in January for many areas throughout the western Pacific, the Indian Ocean, and Australia's Great Barrier Reef.

The NOAA model is a long-term climate model that doesn't take into account short-term weather events. But with the most recent data on sea surface temperatures, Coral Reef Watch's latest modeling now shows just "watch" for the Great Barrier Reef through January with "alert level 1" arriving toward the end of February. Eakin says that higher temperatures that late in the austral summer probably won't produce severe bleaching on the reef. In addition, the Great Barrier Reef area got some welcome relief in late December from rain, winds that churned up cooler water, and shade from clouds.

Eakin remains concerned about significant and widespread bleaching elsewhere. Waters are warming up around the Pacific islands of Kiribati, Nauru, and the Solomons. "My big concerns are the reefs on these South Pacific Islands, the Indian Ocean, and perhaps Southeast Asia later this year," he says.

Given the uncertainties, Wachenfeld and other reef scientists want to see how conditions evolve in the coming weeks. Others note bigger threats, such as chronic pollution and destructive fishing. Reducing the impact of these insults will make reefs more resistant to bleaching, says Terry Hughes, a coral reef scientist at James Cook University, Townsville. And, voicing a common sentiment, he says it is already known what needs to be done to limit bleaching: "The sooner we put a limit on carbon emissions the better."



Science

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www.sciencemag.org/news/2015/01/looming-coral-reef-disaster-scientists-divided

Women in Science

Global statistics clearly reveal that women are under-represented in the higher levels of academia. The problem is most pronounced in science, technology, engineering, and mathematics (STEM) although it also exists in the social sciences. Coral reef science is no different, and males generally still dominate the upper echelons of this research field in Australia and elsewhere.

In 2015 the gender ratio of all university-based research scientists in the ARC Centre of Excellence for Coral Reef Studies was close to balanced (50:50) overall and in all research categories. However, among more senior academic levels the proportion of women is sharply lower.

The ARC Centre has been striving to achieve gender balance in recruitment, promotion, grants and awards. This is a global challenge, as illustrated by the high demand for our outstanding female postdoctoral alumni, most of whom have been recruited to more permanent positions around the world.

The ARC Centre has an enviable record of recruitment of PhD students. Entry to our program for PhD students is highly competitive and, as a consequence, we are graduating extremely bright, talented, and highly employable researchers, with a range of skills applicable to a number of disciplines. Of these, 57% are female.

Among the Centre's Research Fellows, we have actively recruited some of the most outstanding, high-performing women in their respective fields. Postdoctoral Fellows funded by the ARC Centre are expected to be independent thinkers and develop their own research program. The success of this strategy is illustrated by the awards achieved each year by many of our female Research Fellows.

Ashton Gainsford is one of our highflying graduate students. She has been selected as one of 78 women worldwide to participate in the Australian "Homeward Bound" climate science project in Antarctica at the end of 2016. This project aims to refine the participants' skills to design and execute strategy, and devise plans for future collaborations among women working towards a sustainable future. The project recognises that women are underrepresented globally in leadership positions and that change has been incredibly slow. By giving selected women the necessary leadership and strategic skills, this initiative seeks to kick-start a global collaboration of women who will influence policy and decisions toward a sustainable future.

Jodie Rummer was recruited to the ARC Centre in 2011 as an ARC Super Science Fellow, one year after completing her PhD at the University of British Columbia, Canada. Since then she has pursued her interest in fish physiology and climate change. She was promoted to Senior Research Fellow in 2014 and was awarded an ARC Discovery (DECRA) Fellowship in 2015. Also in 2015, Jodie was awarded a prestigious L'Oréal-UNESCO For Women in Science Australia Fellowship, a Lizard Island Reef Research Fellowship, and the George A. Bartholomew distinguished young investigator award in comparative physiology, biochemistry and functional and integrative biology.

Christina Hicks received her PhD in environmental social science in 2013, from the ARC Centre. Her research examines issues of human wellbeing, food security, and access to ecosystem services in coral reef-dependent coastal communities. After her PhD, Christina was awarded a joint Research Fellowship by the ARC Centre and the Center for Ocean Solutions at Stanford University, USA. In 2015 she secured a permanent faculty position in the Lancaster University, UK. She has given two plenary talks at international conferences, and has published extensively, in journals such as *Proceedings of the National Academy of Sciences*, *Science*, and *Frontiers in Ecology and the Environment*.

Tiffany Morrison was recruited one year ago from the University of Queensland to the JCU node of the ARC Centre to extend her work on complex environmental governance to the marine realm. At UQ, she held the position of Senior Lecturer and co-led a team of geographers, planners, economists, lawyers and ecologists to examine the multi-faceted challenges posed by sea level rise. As a Social Science Research Leader in the ARC Centre, Tiffany is setting new directions for the environmental social sciences, attracting new funding, and recruiting and mentoring new postdoctoral staff and PhD students. She was promoted to Principal Research Fellow in 2015.

ARTICLE

08 SEP
2015

WINNER L'ORÉAL-UNESCO FOR WOMEN IN SCIENCE FELLOWSHIP

Hot future for sharks

Dr Jodie Rummer swims with sharks for her research. She is fascinated by fish and their ability to deliver oxygen to their muscles 20 to 50 times more efficiently than we can. Her global research into salmon, mackerel, hagfish, and now sharks explains why fish dominate the oceans. Her L'Oréal-UNESCO For Women in Science Fellowship will help her predict how sharks and other fish will cope with rapidly changing oceans.

Jodie is a marine biologist at James Cook University and the Australian Research Council Centre of Excellence for Coral Reef Studies in Townsville.

Jodie grew up far from the sea, in Illinois. But she always loved the water, and watching Jacques Cousteau marine science documentaries and the Discovery Channel. When her parents bought her a mask and snorkel she spent hours exploring the backyard swimming pool. So it was perhaps inevitable that she'd go on to a career in marine science. Jodie first went to the University of West Florida, where for her Masters she studied the swim bladder of snapper. It's an amazing organ that allows many fish to move up and down in the water column without sinking. They rapidly pull oxygen out of their blood to fill the bladder.

Understanding this 'trick' led Jodie into a stellar early career research path taking her from Florida to the University of British Columbia, then City University Hong Kong, and now James Cook University in Townsville where she is Senior Research Fellow and holds an Australian Research Council Discovery Early Career Research Award (ARC DECRA). Jodie's research focus is on understanding how oxygen transport works in fish and how it is affected by stress and their ability to adapt to their habitats. What's different about their haemoglobin and other aspects of their biochemistry that makes them so efficient at transporting oxygen around their bodies? Jodie believes that this is what had made fish the dominant life in our planet's oceans.

She has studied mackerel that can swim at high speed for long distances. She's looked at how salmon swim thousands of kilometres to the river of their birth. And she's studied hagfish that can live inside dead whale carcases sitting on the ocean floor – a very low oxygen environment.

Fish have been evolutionary winners. But how will they adapt with the rapid changes taking place in the oceans now? "Fish have been on the planet for hundreds of millions of years. It's up to us to ensure they're here for the next 100 million years," Jodie says.

Jodie and her colleagues have already shown that fish living around the Equator are most at risk because they evolved in a local environment with a narrow range of temperatures. Just two or three degrees increase could affect the long term sustainability of fish that many communities depend on for food.

PHOTO LAURIC THIAULT

To get a better understanding of the capacity of fish to adapt, Jodie is working with sharks on the Great Barrier Reef, in Papua New Guinea, and in French Polynesia. In Townsville, she works with epaulette sharks. They live on coral reefs and tidal pools and can cope with severe oxygen depletion, elevated carbon dioxide, and high temperatures. Her L'Oréal-UNESCO For Women in Science Fellowship will enable her to expand her work in the world's largest shark sanctuary in Moorea, French Polynesia. There she will study sicklefin lemon sharks and black-tip reef sharks which may be less able to adapt to future ocean conditions, as they only come in to coastal lagoons to pup.

"My L'Oréal Fellowship will help me determine the mechanisms these sharks will require to adapt to warming oceans. In the long term, understanding how sharks will respond to future ocean conditions will help us make wise decisions needed to protect and conserve the world's fish populations in general," says Jodie.

Jodie's work has attracted global scientific and media attention. She is also a strong advocate for improving the status of women in science and authored three chapters in a new book, *Success Strategies from Women in STEM, A Portable Mentor.*

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PHOTO TALI XTREIBITZ

Graduate and Early Career Training

In 2015, 57 new students enrolled in graduate degrees across the four nodes of the ARC Centre. During the same period 49 graduated. At the close of 2015 the Centre provides supervision and research funding to 221 research students. Of these, 159 are studying for a PhD with the remainder being enrolled in either Honours or Masters degrees. The Centre also supports 31 Early Career Researchers, within 5 years of their PhD.

The Centre's current 159 international research students come to Australia from 41 countries (Africa – 4; Asia – 20; Europe – 53 Oceania – 5 North America – 51; and South America – 26). Similarly, 26 of the 31 ECRs come from overseas.

The research students are a critical component of the Centre, and they make a major contribution to our publication outputs. Students and their projects are individually highlighted on the ARC Centre's website at www.coralcoe.org.au/person_type/students. The Centre invests approximately 25% of its annual budget to cover graduate students' research costs, field trips, travel to conferences and workshops, and other research related support.

The Centre provides extensive mentoring and training to research students and ECRs on a range of generic and specific topics. Mentoring includes the provision of and guidance on specialised topics. Key among these is training in grant and fellowship applications, publication strategy, research presentation and writing skills, and media training. Where appropriate, we also send researchers to external workshops and courses to enhance their leadership skills; for example each year we sponsor female ECRs to attend the UQ Business School Executive Education's *Women in Research Leadership* course.

The Centre also funds two committees in support of the postgraduate students and the ECRs. They are allocated a total of $50k to support training, mentoring and leadership activities during the year. In 2015, the student committee was chaired by Zara-Louise Cowan and Tiffany Sih with the other members being Brock Bergseth, Sarah Buckley, Lucy Georgiou, Alejandra Hernandez, Taryn Lauberstein, Eva McClure, Lauren Nadler, Maria Palacios Otero, Katie Peterson, Laura Richardson, Peter Waldie and Megan Welch. As ever, Olga Bazaka, our Graduate Co-ordinator, provided invaluable assistance in making everything run smoothly throughout the year.

2015 has been a busy and highly successful year for the student committee who organised several academic development workshops, and a highly successful student retreat, following this year's Centre symposium in Hobart. The theme of this year's retreat was *The Future of Marine Students*, with a focus on the steps immediately following graduation. The retreat featured three mini-workshops aimed at boosting students' research portfolio: how to write a great paper; how to build your profile beyond the traditional research publications; and how to find and increase your success in getting a postdoctoral position.

Forty three postgraduate students attended the ARC Centre's Mentoring Day held in conjunction with the Australian Coral Reef Society's annual conference on Daydream Island, Queensland in late July. While most of the attendees were from the four nodes of the Centre, others came from as far away as China and Scotland. Contributions were provided by Centre researchers (Morgan Pratchett, Andy Hoey and Nick Graham), Centre adjunct and TNC researcher Alison Green and the Centre's Communications Manager, Eleanor Gregory.

The Centre's students and ECRs presented weekly talks throughout 2015 within a well-attended seminar program that is videoconferenced across the nodes of the Centre. On the JCU campus, postgraduate students also participated in the *My Research in 3 Minutes* competition under the expert tutorship of Dr Liz Tynan, an experienced journalist based in the Graduate Research School. In 2015 the ARC Centre was represented by Natalia Andrade (PhD student) and Jessica Blythe (ECR).

Awards to ARC Centre students in 2015 included:

- Patrick Buerger won the Great Barrier Reef Foundation's Bommies Award for a unique 3-D video on phage therapy for treating black band disease in corals. Tiffany Sih was runner up.
- Jessica Cramp was recognised as a National Geographic Emerging Explorer for her work on sharks in the Cook Islands. The award brought with it US$10,000 to support her research.
- Ten of the Centre's students received awards at the 89th Australian Coral Reef Society conference. Tiffany Sih was awarded the Terry Walker Prize while Taryn Foster received the Vicki Harriott Award, April Boaden, Maria Palacios, Tessa Hempson, and Rene van de Zande were Student Talk Prize winners. Lisa Boström-Einarsson won the Student Poster award while Kristen Anderson, Ciemon Caballes and Maria Palacios were winners in the photography competition.
- Benjamin Bai, an Honours student supervised by Sylvain Forêt, received the ANU University Medal, the highest ANU award for a graduate student.

- Joleah Lamb was the recipient of the JCU Dean's Award for Research Higher Degree Excellence. The award will support Joleah's exchange visit to Imperial College, London.
- Maria Palacios was the recipient of an Ian Potter Foundation 2015 Doctoral Fellowship at Lizard Island.
- During 2015, a large number of the Centre's students were recipients of travel grants to attend both national and international conferences.
- Adrian Arias was the winner of the inaugural *Glenn Almany Memorial Prize* for his research on management or practice in marine protected areas in Costa Rica:
  - Arias, A, Cinner, JE, Jones, RE and Pressey, RL (2015). Levels and drivers of fishers' compliance with marine protected areas. *Ecology and Society* 20(4): 19.
- The Centre's annual Virginia Chadwick awards for outstanding first-authored publications were won by Simon Brandl, Ian Butler, Lucy Georgiou, Joleah Lamb and Heather Veilleux:
  - Brandl S, Robbins WD, and Bellwood, DR (2015) Exploring the nature of ecological specialization in a coral reef fish community: morphology, diet and foraging microhabitat use. *Proceedings of the Royal Society B Biological Sciences* 282(1815).
  - Butler, IR, Sommer, B, Zann, M, Zhao, JX and Pandolfi, JM (2015). The cumulative impacts of repeated heavy rainfall, flooding and altered water quality on the high-latitude coral reefs of Hervey Bay, Queensland, Australia. *Marine Pollution Bulletin* 96(1-2): 356-367.
  - Georgiou L, Falter J, Trotter J, Kline DI, Holcomb M, Dove SG, Hoegh-Guldberg O and McCulloch M (2015). pH homeostasis during coral calcification in a free ocean CO_2 enrichment (FOCE) experiment, Heron Island reef flat, Great Barrier Reef. *Proceedings of the National Academy of Sciences of the United States of America* 112(43): 13219-24 (p31).
  - Lamb, JB, Williamson DH, Russ GR and Willis BL (2015). Protected areas mitigate diseases of reef-building corals by reducing damage from fishing. *Ecology* 96(9): 2555-67 (p30).
  - Veilleux HD, Ryu T, Donelson JM, van Herwerden L, Seridi L, Ghosheh Y, Berumen ML, Leggat W, Ravasi T, and Munday P (2015) Molecular processes of transgenerational acclimation to a warming ocean. *Nature Climate Change* 5(12): 1074–1078.

PHOTO FAKHRIZAL SETIAWAN

2015 PHD STUDENT MEMBERS OF THE ARC CENTRE

STUDENT	UNIVERSITY	COUNTRY	THESIS TITLE	ARC CENTRE ADVISERS
Michelle Achlatis	UQ	The Netherlands	Investigating future changes to bioerosion on reefs and potential downstream consequences for carbonate chemistry and calcification rates. (PhD)	O Hoegh-Guldberg, S Dove
Siham Afatta Taruc	UQ	Indonesia	Socio-ecological studies of climate change influence on marine resource and livelihoods of Indonesian small-scale fisheries system. (PhD)	O Hoegh-Guldberg
Catalina Aguilar Hurtado	JCU, ANU	Colombia	The immune response of the coral *Acropora millepora* under CO_2 stress. (PhD)	D Miller, S Forêt
Bridie Allan	JCU	New Zealand	The interactive effects of increased water temperatures and elevated dissolved CO_2 on the clutch quantity of two common reef fish: how does this impact on predator-prey interactions? (PhD)	M McCormick, P Munday
Mariana Alvarez Noriega	JCU	Mexico	Competition, growth form, and species coexistence in reef corals. (PhD)	S Connolly, A Baird
Ameer Ebrahim	UQ	Seychelles	The role of four species of rabbitfish in delaying or resisting regime shifts on reefs in Seychelles. (PhD)	P Mumby
Kristen Anderson	JCU	Canada	Effects of changing environmental conditions on the growth rates of branching corals: consequences for habitat. (PhD)	M Pratchett, A Baird
Natalia Andrade Rodriguez	JCU	Ecuador	Immunity and secondary metabolite production in the soft coral *Lobophytum pauciflorum* and the effects of stress (temperature; CO_2) on these processes. (PhD)	D Miller, A Moya
Adrian Arias	JCU	Costa Rica	Marine spatial planning for developing countries: overcoming obstacles. (PhD)	R Pressey, J Cinner
Jennifer Atherton	JCU	United Kingdom	Effect of the threat of predation risk on offspring through maternal effects. (PhD)	M McCormick, A Frisch, G Jones
Maria Eleanor Aurellado	UQ	Philippines	Effect of predation risk on the behaviour and habitat usage of coral reef fishes. (PhD)	P Mumby
Anne Bauer	JCU	USA	The effects of marine debris and fishing line on reef fish distribution and diversity. (PhD)	G Jones
Brock Bergseth	JCU	USA	Drivers of recreational fisher compliance on the Great Barrier Reef: implications for policy and practice. (PhD)	J Cinner, T Hughes, G Russ
Kathryn Berry	JCU, AIMS	Canada	Effects of bioeroding sponges on reef accretion in a changing climate. (PhD)	M Hoogenboom
Chico Birrell	UQ, Griffith University	Australia	Understanding the spatial and temporal variation in macroalgal growth and assemblage development on coral reefs. (PhD)	P Mumby
Shane Blowes	JCU	Australia	Territoriality, competition, and coexistence of butterflyfishes. (PhD awarded)	S Connolly, M Pratchett
April Boaden	JCU	Australia	Predator/prey interactions and the influence of predators on the abundance demography and growth of prey fishes on the Great Barrier Reef. (PhD)	M Kingsford
Teressa Bobeszko	JCU	Australia	The role of carbonic anhydrase in the coral-dinoflagellate symbiosis. (PhD)	B Leggat, D Yellowlees
Lynda Boldt	JCU	Australia	*Symbiodinium* photosynthetic genes and the effect of varying environmental conditions on photosynthetic processes. (PhD awarded)	B Leggat, D Yellowlees
Melissa Bos	JCU	USA	Marine conservation finance. (PhD)	R Pressey
Lisa Boström Einarsson	JCU	Sweden	Competitive interactions, habitat degradation and the structure of coral reef fish assemblages. (PhD)	G Jones, P Munday, M Bonin

STUDENT	UNIVERSITY	COUNTRY	THESIS TITLE	ARC CENTRE ADVISERS
Simon Brandl	JCU	Germany	Pair formation in herbivorous reef fishes: environmental and ecological implications. (PhD awarded)	D Bellwood
Kristen Brown	UQ	USA	Assessing macroalgal species abundance and diversity in the Coral Triangle. (PhD)	S Dove, O Hoegh-Guldberg
Dominic Bryant	UQ	Australia	Effects of population density and land use on the coral communities of the Maldives. (PhD)	O Hoegh-Guldberg, S Dove
Mark Buckley	UWA	USA	Wave transformation in fringing reef environments. (PhD awarded)	R Lowe
Sarah Buckley	UQ	Ireland	A reconstruction of historical baselines of Queensland fisheries since the Anthropocene. (PhD)	J Pandolfi
Patrick Buerger	JCU, AIMS	Germany	Viruses in coral diseases: bacteriophages and phage therapy. (PhD)	M van Oppen, B Willis
Ian Butler	UQ	Australia	Ecological and geomorphological changes in the coral reefs of Hervey Bay from the Holocene to the present. (PhD awarded)	J Pandolfi
Ciemon Caballes	JCU	Philippines	Environmental constraints on reproduction and development of crown-of-thorns starfish. (PhD)	M Pratchett, J Rivera
Margaux Carmichael	JCU, AIMS	France	Non-genetic inheritance of stress tolerance in corals. (PhD)	P Munday, M van Oppen,
Alexandra Carter	JCU	Australia	The effects of no-take zoning, region and year on reproductive output of the common coral trout, *Plectropomus leopardus*. (PhD awarded)	M McCormick, G Russ
Jordan Casey	JCU	USA	The role of territorial grazer behaviour and community structure in coral reef trophic dynamics. (PhD awarded)	S Connolly, T Ainsworth
Carolina Castro Sanguino	UQ	Colombia	Ecological drivers of *Halimeda* abundance and their implications for the carbonate production of coral reefs. (PhD)	P Mumby
Leela Chakravarti	JCU, AIMS	United Kingdom	The evolutionary potential of *Symbiodinium* and its role in assisting evolution in corals under rapid climate change. (PhD)	B Leggat, B Willis
Neil Chan	JCU, UQ	Malaysia	Modelling the effects of pH, temperature and flow on calcification of reef corals. (PhD awarded)	S Connolly
Tory Chase	JCU	USA	Effects of fish presence on coral health and bleaching tolerance. (PhD)	M Hoogenboom, M Pratchett
Pedro Cipresso Pereira	JCU	Brazil	Competition and habitat selection in coral-dwelling fishes. (PhD)	G Jones, P Munday
Harry Clarke	UWA	Australia	The use of coral geochemical records to deconvolve the impacts of dredging and ocean warming in the Onslow/Dampier region of Western Australia. (PhD)	M McCulloch, J Falter, J P D'Olivo Cordero
Geoffrey Collins	JCU	Australia	Hypoxia tolerance in barramundi fish. (PhD)	J Rummer
Jennifer Cooper	JCU	United Kingdom	Changing norms, social movements, and coral reef ecosystems. (PhD)	T Morrison, T Hughes
Zara-Louise Cowan	JCU	United Kingdom	The role of predation in population regulation of crown-of-thorns starfish (*Acanthaster* spp). (PhD)	M Pratchett, V Messmer
Jessica Cramp	JCU	USA	Small cryptic fishes on coral reefs: ecological effects of extreme life history traits. (PhD)	B Pressey
Kay Critchell	JCU, Macquarie University	United Kingdom	Presence and effects of microplastics in coastal environments. (PhD)	M Hoogenboom
Michael Cuttler	UWA	USA	Production, transport and fate of carbonate sediment in a fringing reef-system. (PhD)	R Lowe, M McCulloch, J Falter
Blanche D'Anastasi	JCU, UWA	Australia	Population genetics and genomic dietary analyses of Australian sea snakes. (PhD)	V Lukoschek

STUDENT	UNIVERSITY	COUNTRY	THESIS TITLE	ARC CENTRE ADVISERS
Sana Dandan	UWA	Denmark	Resilience of coral reef communities and coral metabolism in extreme environmental conditions. (PhD)	M McCulloch , R Lowe, J Falter
Benjamin Davis	JCU	United Kingdom	Temporal nekton dynamics in tidal floodplain wetlands. (PhD)	G Russ
Jon 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. (PhD)	R Pressey, T Morrison
Anderson de Sevilha	JCU	Brazil	Systematic conservation planning for the Parana River Basin, Brazil. (PhD)	R Pressey
Andreas Dietzel	JCU	Germany	Primary habitat requirements of key herbivorous fish and stress-tolerant coral species in the Great Barrier Reef: which ecological factors govern their distribution and how to draw lessons for coral reefs. (PhD)	T Hughes, S Connolly
Edwin Drost	UWA	The Netherlands	The impact of tropical cyclone forcing on Australia's north-western coastal system. (PhD)	R Lowe
Norbert Englebert	UQ	The Netherlands	Phenotypic and physiological responses of a widespread coral species to changing environmental conditions: functional variability in natural populations of *Stylophora pistillata*. (PhD)	O Hoegh-Guldberg, S Dove, P Bongaerts
Hannah Epstein	JCU, AIMS	USA	The role of microbes in acclimatisation of corals. (PhD)	P Munday, M van Oppen, G Torda
Jacob Eurich	JCU	USA	Processes underlying ecological versatility in an equatorial guild of fishes. (PhD)	G Jones, M McCormick
Nicholas Evensen	UQ	United Kingdom	Comparing sources of population bottlenecks among coral taxa. (PhD)	P Mumby
Taryn Foster	UWA	Australia	Impacts of ocean warming and acidification on multiple life stages of corals at the Houtman Abrolhos Islands. (PhD awarded)	M McCulloch, J Falter
Kerrie Fraser	UQ, JCU	Australia	Australia's marine protected areas – evaluating the impacts and effectiveness of conservation policy and management intervention on marine species and habitats. (PhD)	J Pandolfi, B Pressey
Ashton Gainsford	JCU	Australia	A multi-disciplinary evaluation of the hybrid anemonefish *Amphiprion leucokranos*: behaviour shaping evolutionary outcomes of hybridisation. (PhD)	G Jones
Anjani Ganase	UQ	Trinidad and Tobago	The use of a standardised method for a broad-scale survey of coral reefs worldwide, to identify the level of environmental impact on coral reef communities. (PhD)	O Hoegh-Guldberg, S Dove, P Mumby
Lucy Georgiou	UWA	United Kingdom	Constraining coral sensitivity to climate and environmental change: an integrated and experimental approach. (PhD)	M McCulloch, J Falter, J P D'Olivo Cordero
Sarah Gierz	JCU	Australia	Acclimation of *Symbiodinium* to thermal stress. (PhD)	B Leggat, D Yellowlees
Benjamin Gordon	JCU, AIMS	Australia	The metabolome of *Symbiodinium* phylotypes and their coral hosts. (PhD)	B Leggat
Rebecca Green	UWA	United Kingdom	Investigating biogeochemical responses to hydrodynamic processes at Scott Reef, a remote atoll off Western Australia. (PhD)	R Lowe, M McCulloch, J Falter
Renee Gruber	UWA	USA	Nutrient inputs and reef productivity: sources, transport and biogeochemical transformation in a macrotidal tropical ecosystem. (PhD)	R Lowe, J Falter
Georgina Gurney	JCU, University of Victoria	Australia	Improving the success of marine protected areas: integration of social considerations into conservation planning. (PhD awarded)	R Pressey, J Cinner
Melanie Hamel	JCU, IRD Noumea	France	Costs, effectiveness, and cost-effectiveness of habitat-driven conservation planning for Solomon Islands lagoons and reefs. (PhD awarded)	R Pressey, S Andréfouet

STUDENT	UNIVERSITY	COUNTRY	THESIS TITLE	ARC CENTRE ADVISERS
Margaux Hein	JCU	Monaco	Investigating the socio-ecological benefits of coral restoration to support reef resilience. (PhD)	B Willis
Tessa Hempson	JCU, AIMS	South Africa	Coral reef mesopredator trophodynamics in response to reef condition. (PhD)	N Graham, A Hoey, G Jones, A MacNeill
Alejandra Hernandez-Agreda	JCU, UQ	Venezuela	Coral core microbiome: composition, microhabitat distribution, host influence and response to environmental change. (PhD)	B Leggat, T Ainsworth
Sybille Hess	JCU	Switzerland	The impact of sediments on coral reef fish. (PhD)	J Rummer, M Pratchett, A Hoey
Jessica Hopf	JCU	Australia	Metapopulation analysis of the role of connectivity in marine protected areas design. (PhD)	S Connolly, G Jones
Adriana Humanes Schumann	JCU, AIMS	Venezuela	Interactive effects of water quality and climate change on the early life history stages of hard corals. (PhD)	B Willis
Matt Jankowski	JCU	United Kingdom	Effects of depth and aspect on distribution, habitat use and specialisation in coral reef fish. (PhD)	G Jones, N Graham
Michael Jarrold	JCU	United Kingdom	The effects of natural variation in CO_2 and rising CO_2, on coral reef fish. (PhD)	P Munday, M McCormick
Young Koo Jin	JCU, AIMS	South Korea	Nature or nurture? Testing the correlation between stress tolerance and genotype in *Acropora millepora* on the Great Barrier Reef. (PhD)	B Willis, M van Oppen
Saskia Jurriaans	JCU, Centre Scientifique de Monaco	The Netherlands	Thermal acclimation and the geographic range limits of reef-building corals. (PhD)	M Hoogenboom, S Connolly
James Kerry	JCU, AIMS	United Kingdom	Structural complexity and the ecology of large reef fish. (PhD)	D Bellwood
Sun Wook Kim	UQ	South Korea	The biological guide to moving: evolution and ecology of corals' range dynamics under climate change. (PhD)	J Pandolfi
Catherine Kim	UQ	USA	Determining drivers of benthic composition, marine biodiversity, and coral health in Timor-Leste. (PhD)	O Hoegh-Guldberg, S Dove
Chelsea Korpanty	UQ	USA	Central Indo-Pacific coral reef development surrounding the establishment of a novel climatic regime. (PhD)	J Pandolfi
Michael Kramer	JCU	New Zealand	The functional importance of benthic carnivory on coral reefs. (PhD)	D Bellwood, S Connolly
Felicity Kuek	JCU, AIMS	Malaysia	Organic sulphur metabolism in corals. (PhD)	D Miller, A Moya
Chaoyang Kuo	JCU	Taiwan	Functional groups and functional diversity of corals. (PhD)	A Baird, T Hughes, M Pratchett
Vivian Lam	UQ	China	Operationalising resilience: from metrics to measurement. (PhD)	P Mumby
Jacqueline Lau	JCU	Australia	Winners and losers in marine conservation: investigating access to coral reef ecosystem services. (PhD)	J Cinner, C Hicks
Susannah Leahy	JCU	Australia	The role of recruitment habitat in the effectiveness of a Philippine marine reserve network. (PhD)	G Russ, G Jones
Anne Leitch	JCU, CSIRO	Australia	Social resilience to climate change: the adaptive capacity of local government. (PhD)	T Hughes
Johanna Leonhardt	JCU	Australia	Spatial dynamics in the territories of *Stegastes* spp. Relative to coral growth, disease and mortality within Opal reef. (PhD)	M Pratchett, M Hoogenboom, A Hoey
Mauro Lepore	UQ	Argentina	Tracing temporal coral community change in the southern Great Barrier Reef, and evaluating the relative role of global, regional and local stressors. (PhD awarded)	J Pandolfi
Govinda Liénart	JCU, U.Saskatchewan	Austria	Temperature effects of chemically mediated predator-prey interactions. (PhD)	M McCormick

STUDENT	UNIVERSITY	COUNTRY	THESIS TITLE	ARC CENTRE ADVISERS
Mei-Fang Lin	JCU, ANU	Taiwan	Transcriptiomics of Corallimorpharian *Rhodactis indosinensis* (Cnidaria: Anthozoa) and its usefulness to understanding coral bleaching. (PhD)	D Miller, S Forêt
Zoe Loffler	JCU	Australia	Influence of canopy-forming macroalgae on key reef processes. (PhD)	A Hoey, M Pratchett
Judi Lowe	JCU, UQ	Australia	Dive tourism, alternate livelihoods and the management of marine protected areas in the Coral Triangle. (PhD)	R Pressey, V Adams
Chancey Macdonald	JCU	New Zealand	Depth patterns in coral reef fish distributions and microhabitat associations: are deep reefs a refuge? (PhD)	G Jones, T Bridge
Rafael Magris	JCU, U.Victoria	Brazil	Applying biodiversity conservation planning tools into the design of a long-term conservation strategy for Abrolhos Bank, Brazil. (PhD)	R Pressey, A Baird, R Weeks
Martino Malerba	JCU, AIMS	Italy	Optimizing microalgal production for future demand: insights from formulation and experimental evaluation of autoregressive dynamic models. (PhD)	S Connolly
Hannah Markham	UQ	United Kingdom	Long-term ecological dynamics along a gradient of anthropogenic activity on the inshore Great Barrier Reef. (PhD)	J Pandolfi, G Roff
Robert Mason	UQ, NOAA	Australia	Linking coral physiology to remote sensing of reefs. (PhD)	S Dove, O Hoegh-Guldberg
Samuel Matthews	JCU, AIMS	Australia	Modelling outbreaks of crown-of-thorns starfish: coupling biophysical, demographic and connectivity processes. (PhD)	M Pratchett, V Messmer
Emmanuel Mbaru	JCU	Kenya	Using fisheries dependent data and socio-economic indicators to develop ecosystem based fisheries management tools. (PhD)	J Cinner, N Graham, C Hicks
Eva McClure	JCU	Australia	The impact of typhoons on the effectiveness of marine reserve networks in the Coral Triangle. (PhD)	G Russ, A Hoey
Michael McWilliam	JCU	United Kingdom	Coral reef resilience – learning from the past. (PhD)	T Hughes
Mattheus Mello Althayde	UQ	Brazil	Metabolism and calcification rates of corals across distinct reef zones and in response to climate change. (PhD)	S Dove
Thane Militz	JCU	USA	Enhancement of mariculture techniques of marine ornamental fishes promoting long-term economic sustainability in developing island communities. (PhD)	M McCormick
Amin Mohamed Esmail	JCU	Egypt	Distribution and characterisation of chromerids and apicomplexans associated with coral reefs (PhD)	D Miller, B Willis
Stefano Montanari	JCU, AIMS	Italy	Hybridisation in reef fishes: ecological promoters and evolutionary consequences. (PhD)	M Pratchett
Christopher Mooney	JCU	Australia	Statoliths of Cubozoan jellyfishes: their utility to discriminate taxa and elucidate population ecology. (PhD)	M Kingsford
Lauren Nadler	JCU	USA	Influence on climate change on shoaling behaviour in coral reef fish. (PhD)	M McCormick, P Munday
Katia Nicolet	JCU	Switzerland	Aetiology of Indo-Pacific coral diseases: disease dynamics and the role of vectors in disease outbreaks. (PhD)	B Willis, M Hoogenboom, M Pratchett
Jessica Nowicki	JCU	USA	The roles of nonapeptides in modulating animal personality and reproductive behaviour in coral reef fish. (PhD)	M Pratchett
Rebecca O'Donnell	UWA	New Zealand	Last interglacial sea level and Leeuwin Current events: a dual stratigraphic and geochemical approach. (PhD)	M McCulloch
Maria Palacios Otero	JCU	Colombia	Ecological selection in a complex marketplace. (PhD)	M McCormick, G Jones
Pedro Pereira	JCU	Brazil	Competition, habitat selection and imprinting of coral dwelling gobies? (PhD awarded)	P Munday, G Jones

STUDENT	UNIVERSITY	COUNTRY	THESIS TITLE	ARC CENTRE ADVISERS
Katie Peterson	JCU	USA	Social-ecological dynamics of coral reef fisheries. (PhD)	T Hughes, S Connolly
Srisakul Piromvaragorn	JCU	Thailand	Spatial patterns in coral communities and recruitment in the Gulf of Thailand. (PhD)	T Hughes, A Baird, S Connolly
Chiara Pisapia	JCU	Italy	Resilience of coral colonies to synergistic effects of bleaching and predation. (PhD awarded)	M Pratchett
Andrew Pomeroy	UWA, CSIRO	Australia	The interaction between hydrodynamic processes and sediment dynamics in fringing coral reef environments. (PhD)	R Lowe
Davina Poulos	JCU	Australia	Prior residency effects and the dynamics of fish communities in a changing environment. (PhD)	M McCormick, G Jones
Martina Prazeres	UQ, AIMS	Brazil	Foraminifera as tools for analysis of interactions between water quality and climate change effects on the Great Barrier Reef: historical reconstruction and biology at community, individual and cellular scales. (PhD)	J Pandolfi
Mark Priest	UQ, Palau ICRC	United Kingdom	A multi-disciplinary approach to predictive management of coral reef fisheries. (PhD)	P Mumby
Kate Quigley	JCU, AIMS	Spain	Genetic and environmental basis for *Symbiodinium* specificity in the coral-dinoflagellate association. (PhD)	B Willis, B Leggat, L Bay
Veronica Radice	UQ	USA	Assessing echinoderm abundance, diversity and function across distinct coral reefs. (PhD)	O Hoegh-Guldberg, S Dove
Blake Ramsby	JCU, AIMS	USA	Effects of bioeroding sponges on reef accretion in a changing climate. (PhD)	M Hoogenboom
Tries Razak	UQ, AIMS	Indonesia	The effects of climate change on the growth rates of modern corals. (PhD)	P Mumby
Laura Richardson	JCU	United Kingdom	Effects of coral community composition on ecosystem structure, function and ecological interactions. (PhD)	A Hoey, N Graham
Justin Rizzari	JCU	USA	Reef sharks on the Great Barrier Reef: putting the bite on underwater visual census methods. (PhD awarded)	M McCormick, G Jones, A Frisch, A Hoey
Thomas Roberts	JCU, AIMS	Australia	Depth distribution patterns in reef-building corals. (PhD)	A Baird, T Bridge, G Jones
Jan Robinson	JCU	United Kingdom	Disentangling the causes of vulnerability to fishing in aggregating reef fishes. (PhD)	N Graham, J Cinner, G Almany
Melissa Rocker	JCU, AIMS	USA	Effects of local and global stressors on the energy budgets and fitness of inshore reef-building corals. (PhD)	B Willis
Giverny Rogers	JCU	Australia	Climate change in a stable thermal environment: effects on the performance and life history of a coral reef fish. (PhD)	M McCormick, P Munday, J Rummer
Claire Ross	UWA	Australia	Environmental controls on the growth and physiology of high-latitude coral in the south-west region of Western Australia (32°-35°S). (PhD)	M McCulloch, J Falter, V Schoepf
Theresa Rueger	JCU	Germany	Reproduction and habitat use in reef fishes. (PhD)	G Jones
Jimena Samper-Villarreal	UQ	Costa Rica	Carbon sequestration by seagrasses in Moreton Bay. (PhD)	P Mumby
Molly Scott	JCU, AIMS	Australia	Impacts of ocean warming and climate-induced habitat modification on the behaviour and ecology of coral trout and other key fisheries species. (PhD)	M Pratchett
Laura Segura Mena	UWA, AIMS	Costa Rica	A quantitative assessment of the morphological behaviour of southwestern Australian beaches on seasonal and event time scales. (PhD)	R Lowe
Tiffany Sih	JCU, AIMS	USA	Fisheries for deep sea snappers. (PhD)	M Kingsford

STUDENT	UNIVERSITY	COUNTRY	THESIS TITLE	ARC CENTRE ADVISERS
Jennifer Smith	JCU	Canada	Influence of patch dynamics on coral reef fishes on the southern Great Barrier Reef. (PhD)	G Jones, M McCormick
Brigitte Sommer	UQ, Southern Cross	Austria	Ecological dynamics and conservation of subtropical coral communities of eastern Australia under climate change. (PhD awarded)	J Pandolfi
Blake Spady	JCU, Griffith University	USA	The effects of projected near-future CO_2 on cephalopod behaviours and learning. (PhD)	P Munday, S-A Watson
Leanne Sparrow	JCU	Australia	Trophic transfer of ciguatoxins in marine foodwebs. (PhD)	G Russ
Jessica Stella	JCU, Australian Museum	USA	Climate impacts on coral-associated invertebrates. (PhD)	G Jones, M Pratchett, P Munday
Chun Hong Tan	JCU, AIMS	Malaysia	Environmental controls and evolutionary constraints on growth and reproduction in corals. (PhD awarded)	A Baird, M Pratchett
Brett Taylor	JCU	USA	Parrotfish demography throughout Micronesia: effects of life histories on environmental and fishery-induced variability. (PhD awarded)	G Russ
Loic Thibaut	JCU, U. Pierre et Marie Curie	France	Resilience in coral reef and model ecosystems. (PhD awarded)	S Connolly, T Hughes
Cheng-Han Tsai	JCU, AIMS	Taiwan	The structure and dynamics of reef fish communities. (PhD)	S Connolly, D Bellwood
Rene van der Zande	UQ	Curacao	Monitoring metabolic changes to reef sediment and framework in response to present day and future diurnal and seasonal dynamics. (PhD)	O Hoegh-Guldberg, S Dove
Arnold van Rooijen	UWA	The Netherlands	Modelling wave-driven hydrodynamics and sediment transport within aquatic canopies. (PhD)	R Lowe
Heather Veilleux	JCU	Canada	Olfactory mechanisms at the genomic level by which dispersing coral reef fish larvae orient towards settlement sites. (PhD awarded)	P Munday, B Leggat
Francisco Vidal Ramirez	UQ	Chile	Effect of possible future seawater environments on sea cucumbers and the sediments they process. (PhD)	S Dove
Estefania Maldonado Villacis	JCU	Ecuador	Biological conservation planning for multiple species habitat restoration in Ecuador. (PhD)	R Pressey
Peter Waldie	JCU, TNC	Australia	Toward the ecosystem-based co-management of exploited brown-marbled grouper spawning aggregations. (PhD)	J Cinner, G Almany
Megan Welch	JCU	USA	Transgeneration effects of CO_2 on fish behaviour. (PhD)	P Munday, M McCormick
Justin Welsh	JCU	Canada	Evaluating the spatial scale of ecosystem functions on coral reefs. (PhD)	D Bellwood, S Connolly
Wiebke Wessels	JCU, ANU	Germany	Genetic and molecular basis of coral embryonic development? (PhD)	D Miller
James White	JCU, AIMS	USA	Personality and predation risk in fishes. (PhD)	M McCormick
Gundula Winter	UWA, AIMS	Germany	An investigation of the nearshore hydrodynamics on contrasting open-coast and reef-protected beaches in Western Australia. (PhD)	R Lowe
Matthew Young	JCU	Australia	Reef fishing: a social ecological perspective. (PhD)	D Bellwood

GRADUATE PROFILE

Dr Simon Brandl


PHOTO JORDAN CASEY

The diversity of life on this planet is quite staggering. Yet, our knowledge of the role of biodiversity is still in its infancy, particularly in some of the world's most threatened ecosystems. Simon Brandl has been fascinated with biodiversity since since his school days.

While Simon's earliest explorations were largely restricted to terrestrial, suburban habitats, eventually leading to a degree in Biology, which he completed at the University of Innsbruck in Austria in 2010. While this degree had him wandering through the Alps in search for small insects, plants, and basic ecological paradigms, he completed the degree with an honours thesis on the ecology of clingfishes in the Adriatic Sea, setting the foundation for a postgraduate degree focused on marine environments.

Five years later, Simon has just finished his PhD at James Cook University under the supervision of Professor David Bellwood, investigating herbivorous fish communities and their effect on diverse benthic assemblages on coral reefs. This relationship has attracted great attention from coral reef community ecologists over the last decade, and several aspects, such as a classification of herbivores into functional groups depending on their feeding behaviour, are now widely incorporated into coral reef management and conservation around the world.

Simon's research, however, shows that contemporary classification of herbivores such as browsers versus grazers, appears to be overly coarse. In fact, by considering a ubiquitous component of coral reef ecosystems, the presence of micro-topographic complexity, his research demonstrates that much finer partitioning of resources modulates the functional role of herbivorous fishes.

Together with David Bellwood, Simon's goal was to provide a new way of disentangling niche partitioning based on *in situ* behavioural observations, to apply this analysis to herbivorous fish communities, and to investigate the consequences of fine-scale niche partitioning in herbivorous fishes for the coral reef benthos. Furthermore, Simon discovered that micro-topographic complexity is not only important for herbivorous fishes, but that it is also tightly interlinked with the abundance and distribution of benthic organisms. Overall, his PhD research has resulted in the publication of seven first-authored papers and six collaborative papers in top international journals. (p23)

Despite this, Simon always found time for his other interests while completing his PhD. These included good food, wine, writing, birds and early mornings (in any imaginable combination). But it is for his love of singing that he has gained most notoriety. He successfully auditioned for Opera Queensland's *Project Puccini* in 2014 and as a result performed as a member of their touring production of *La Boheme*, while being invited as a soloist for Opera Queensland's *Cloudsong* the following year

After handing in his thesis in August this year, Simon has now moved to the colder climes of Annapolis, Maryland, where he has taken up a prestigious fellowship with the Smithsonian Institution's Tennenbaum Marine Observatories Network. There he will be working alongside Dr Emmett Duffy, Dr Nancy Knowlton, Dr Valerie Paul, and Dr Ross Robertson on a large-scale assessment of biodiversity patterns and their effect on an ecosystem's response to disturbance.

The ARC Centre of Excellence for Coral Studies is the world's leading coral reef research institution by publications and citations (2010–2015)

Source: Scopus

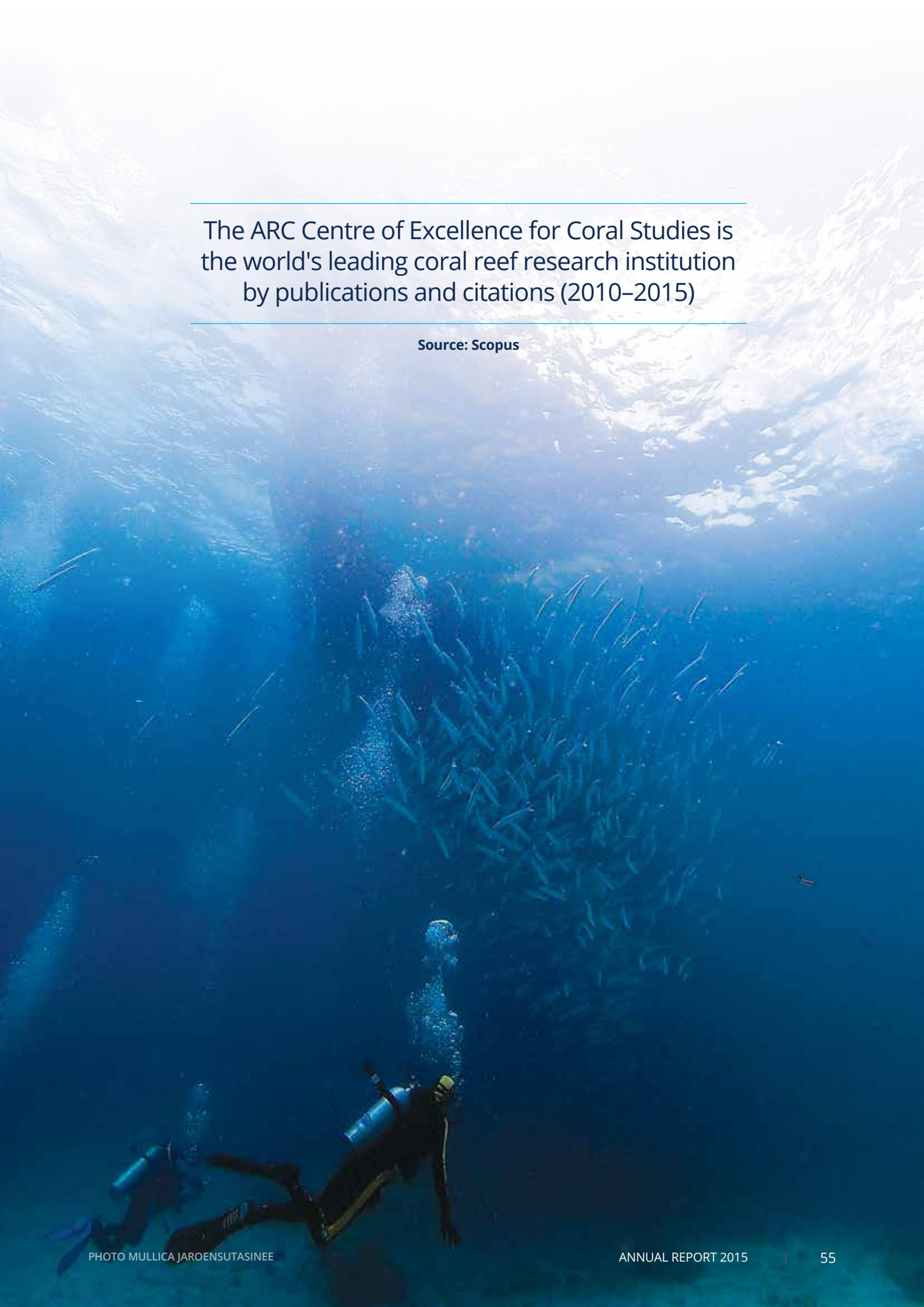

PHOTO MULLICA JAROENSUTASINEE

National and International Linkages

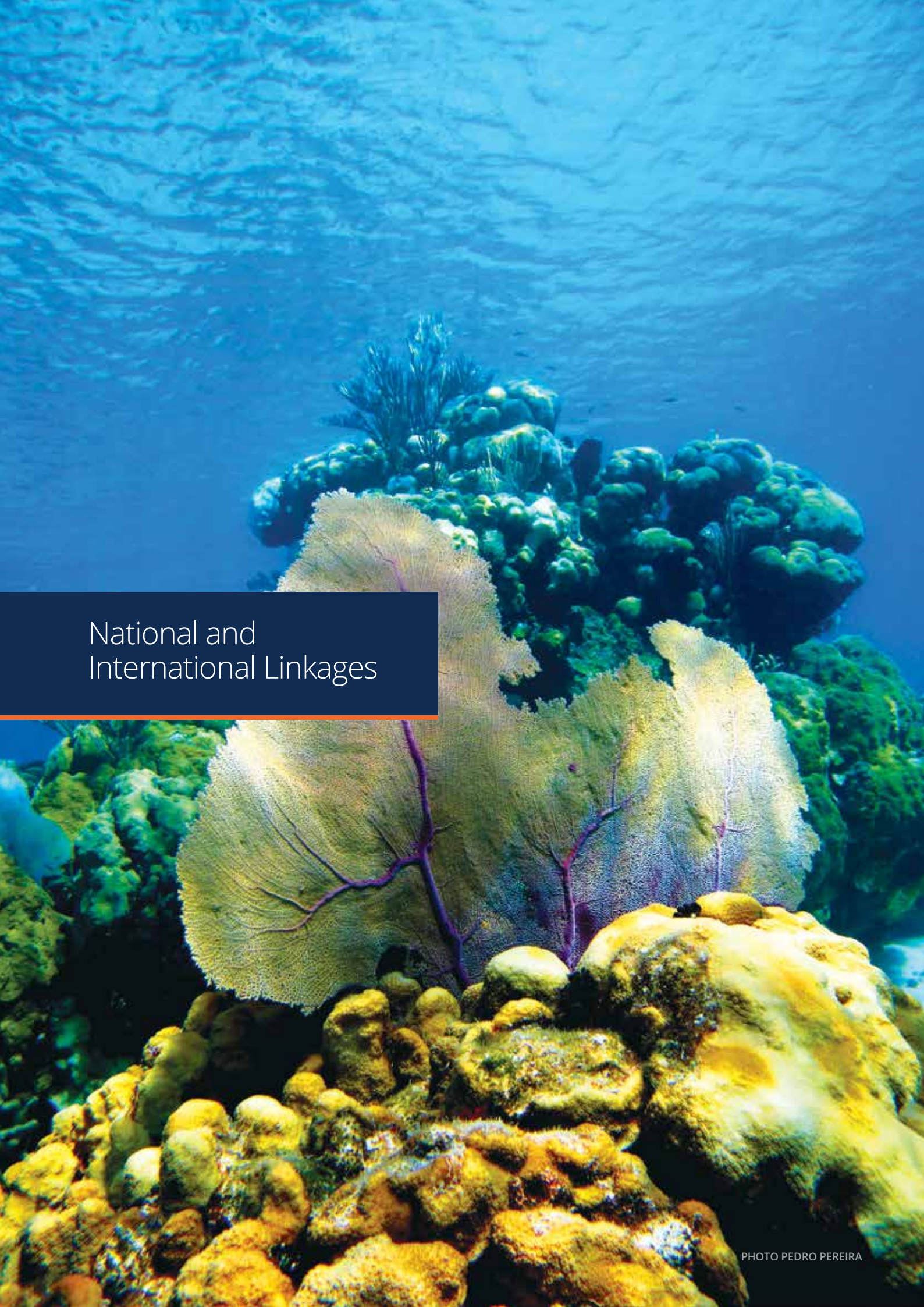

PHOTO PEDRO PEREIRA

The ARC Centre is a global hub for collaboration in transdisiplinary coral reef science. The Centre's engagement with the international science community is exemplified by our international collaborations and fieldwork, multi-institutional publications, the international working groups we convene, visits to overseas institutions, and by the number of scholars from overseas who we host at all four nodes of the ARC Centre. The Centre's research profile and reputation has attracted 159 of our current graduate students to Australia (p44), including 41 of our newest graduate enrolments in 2015.

In 2015, ARC Centre researchers produced 215 publications with cross-institutional co-authorship, involving researchers from 271 institutions in 71 countries. The ARC Centre convened 22 international working groups during 2015. During the year, we hosted 68 international visitors from 19 countries, and ARC Centre personnel visited 96 international collaborators at laboratories and research facilities in 38 countries.

The 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). Four Centre leaders, Ove Hoegh-Guldberg, Terry Hughes, Malcolm McCulloch and Bob Pressey are Fellows of the *Australian Academy of Science.* Malcolm McCulloch is also a Fellow of *The Royal Society* (London). Centre personnel are also members of many editorial boards and advisory committees around the world, and make leading contributions to many international research consortia.

The ARC Centre's larger international collaborations in 2015 include:

WORLDFISH, MALAYSIA

WorldFish is an international non-profit scientific agency headquartered in Malaysia, undertaking projects in Africa, Asia and the Pacific to 'reduce poverty and hunger through improving fisheries and aquaculture'. It has a global staff of about 330, permanent offices in seven countries and ongoing projects in 25 countries. WorldFish senior scientists David Mills and Pip Cohen are seconded to the James Cook University node of the ARC Centre while Centre Fellow Mike Fabinyi is embedded in the WorldFish headquarters in Penang. The Centre and WorldFish also co-fund two postdoctoral researchers: Jessica Blythe, who pursues research on governance and sustainability of Pacific Island coastal fisheries, and Andrew Song, who was recruited during 2015 and will commence with the Centre in early 2016. WorldFish Regional Director (Pacific), Neil Andrew, is a Partner Investigator and a member of the Centre's Advisory Board. WorldFish research is embedded in Program 1: People and Ecosystems and brings a particular focus to international development and human wellbeing. This ongoing collaboration creates strong links to end-users, including inter-governmental organisations and NGOs, local communities and governments of developing countries, particularly in the Solomon Islands, Timor Leste, Vanuatu and the Philippines.

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, it has state of the art facilities for both field- and laboratory-based coral reef research. In 2015, nine researchers conducted exchange visits between the ARC Centre and KAUST. Terry Hughes is a member of the inaugural Advisory Board of the Red Sea Research Center, a world class facility at KAUST. Two KAUST researchers, Michael Berumen and Darren Coker, are Centre of Excellence alumni. In 2015, Professor Tim Ravasi from KAUST and Philip Munday (ARC Centre) commenced a major three-year joint research project on the transgenerational acclimation to climate change in reef fish. In 2016, Centre Research Fellow Jodie Rummer will begin an additional new research project working with Tim and Philip to study the genomic evidence for adaptation of marine fishes to ocean acidification. Both of these projects are supported by KAUST and the ARC Centre.

UNIVERSITY OF EXETER, UNITED KINGDOM

The University of Exeter is a research-intensive university in Devon and Cornwall in the UK which undertakes world-class research while maintaining a strong focus on quality education for its >21,000 students. Exeter is one of the most highly ranked universities in the UK and in the top 100 in the world. The ARC Centre of Excellence has strong and growing collaborative links with Exeter's Environment and Sustainability Institute (ESI), an interdisciplinary research centre undertaking world-class research into finding creative solutions to environmental change. Professor Kate Brown, who holds the Professorial Chair in Social Science at the Environment and Sustainability Institute, is the ARC Centre's Distinguished International Researcher who chairs the Centre's Scientific Management Committee. During 2015 Kate and Professor Neil Adger, also from the University of Exeter, were visiting scholars at the ARC Centre of Excellence. In 2015, the ARC Centre hosted a number of joint working group meetings with their Exeter collaborators including Louisa Evans, an ARC Centre

alumnus, now a tenure-track researcher at Exeter. In 2016, ESI and the ARC Centre of Excellence will co-host a Working Group meeting at the University of Exeter on *Power, Authority and Performance in Polycentric Systems*.

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE (CNRS), FRANCE

CNRS lead the *Groupement de Recherche International* (GDRI), on *Biodiversity of Coral Reefs*, a consortium of 16 key research institutions in France, Australia, Israel, Japan, Taiwan and the USA. James Cook University is the Australian node, recently formalised under an Agreement between JCU, CNRS and the other partners. France has a globally-significant program of coral reef research, centred on field laboratories and other research facilities in French Polynesia, New Caledonia, the Indian Ocean and the Caribbean. Dr Serge Planes, the Coordinator of the GDRI is a Partner Investigator in the ARC Centre and his research group has a growing number of collaborations with researchers in both Program *2: Ecosystem Dynamics: Past, Present and Future* and *Program 3: Responding to a Changing World.* These new collaborations have resulted in a number of joint publications and in co-supervisory arrangements for graduate students. ARC Centre Research Fellows Jodie Rummer and Aurélie Moya were awarded grants by the *Institut des Récifs Coralliens du Pacifique* to conduct research projects in Moorea, French Polynesia. Jodie is collaborating with Serge Planes, and Aurélie is working with Laetitia Hedouin (Centre de Recherche Insulaires et Observatoire de l'Ennvironnement) and Chloé Brahmi (University of French Polynesia).

OVERSEAS VISITING RESEARCHERS

In 2015, 68 international visitors were hosted by one or more nodes of the ARC Centre.

PHOTO JULIEN DEBREUIL

INTERNATIONAL VISITORS TO THE CENTRE OF EXCELLENCE IN 2015

VISITOR	ORGANISATION	COUNTRY
Dr Rene Abesamis	Silliman University	Philippines
Prof Neil Adger	University of Exeter	UK
Dr Gabriella Ahmadia	World Wildlife Fund	USA
Prof Edward Allison	University of Washington	USA
Rolenas Baereleo	Pacific Regional Environment Programme	New Caledonia
Dr Gregory Bennett	WorldFish	Solomon Islands
Prof Michael Berumen	King Abdullah University of Science and Technology	Saudi Arabia
Prof Kate Brown	University of Exeter	UK
Prof Hanlin Chen	Zhejiang University	China
Prof Douglas Chivers	University of Saskatchewan	Canada
Dr Louisa Evans	University of Exeter	UK
Dr Maud Ferrari	University of Saskatchewan	Canada
Dr Pedro Frade	University of Vienna	Austria
Len Garces	WorldFish	Philippines
Prof Ruth Gates	Hawaii Institute of Marine Biology	USA
Dr Stefan Gelcich	Pontifical Catholic University of Chile	Chile
Prof Gabrielle Gerlach	University of Oldenburg	Germany
Dr Louise Glew	World Wildlife Fund	USA
Prof Emanuel Goncalves	ISPA	Portugal
Prof Martin Grosell	University of Miami	USA
Prof Zhiguo He	Zhejiang University	China
Dr Missaka Hettiarachchi	University of Moratuwa	Sri Lanka/ USA
Rachael Heuer	University of Miami	USA
Prof Susan Holmes	Stanford University	USA
Prof Jeremy Jackson	IUCN	Switzerland
Katya Jay	Macalester College	USA
Dr Jacob Johansen	University of Florida	USA
Rajani Kumaraswamy	Columbia University	USA
Dr Sjannie Lefevre	University of Oslo	Norway
Prof Xianhua Li	Chinese Academy of Sciences	China
Dr Rebecca Martone	Stanford University	USA
Rosalie Masu	Ministry of Fisheries and Marine Resources	Solomon Islands
Samantha Maticka	Stanford University	USA
Dr Robert McCall	Deltares	The Netherlands
Prof Monica Medina	Pennsylvania State University	USA
Videleen Meilinda	Petra Christian University	Indonesia
Dr Paolo Montagna	Institute of Marine Science	Italy

VISITOR	ORGANISATION	COUNTRY
Sara Mynott	University of Exeter	UK
Prof Goran Nilsson	University of Oslo	Norway
Kirsten Ohler	The Philipp University of Marburg	Germany
Dr Joseph Pollock	Pennsylvania State University	USA
Miledel Quibilan	University of the Philippines	Philippines
Dr Blake Ratner	WorldFish	Malaysia
Prof Tim Ravasi	King Abdullah University of Science and Technology	Saudi Arabia
Dr Johan Reyns	UNESCO-IHE Institute for Water Education	The Netherlands
Dr Manuel Ricca	University of Padova	Italy
Dr Vincenzo Ricca	Italian National Research Council	Italy
Dr Manuel Rigo	University of Padova	Italy
Prof Dano Roelvink	UNESCO-IHE Institute for Water Education	The Netherlands
Dr Taewoo Ryu	King Abdullah University of Science and Technology	Saudi Arabia
Nazamuddin Basyah Said	Syiah Kuala University	Indonesia
Hany Salem	US Greener Building Council	USA
Prof Terre Satterfield	University of British Columbia	Canada
Dr Brett Scheffers	University of Florida	USA
Dr Celia Schunter	King Abdullah University of Science and Technology	Saudi Arabia
Dr Anne-Maree Schwarz	WorldFish	Solomon Islands
Dr Reuben Sulu	WorldFish	Solomon Islands
Prof Dongsheng Sun	Petroleum Exploration & Production Research Institute	China
Matthieu Taymans	Universite Catholique de Louvain	Belgium
Ilona Urbarova	The Arctic University of Norway	Norway
Dr Ap van Dongeren	Deltares	The Netherlands
Prof Yigang Xu	Chinese Academy of Sciences	China
Prof Jinhui Yang	Chinese Academy of Sciences	China
Dr Julian Yates	University of British Columbia	Canada
Mariacharia Zaffani	University of Padova	Italy
Prof Lifei Zhag	Peking University	China
Prof Rixiang Zhu	Chinese Academy of Sciences	China
Karin Zwieo	University of Utrecht	The Netherlands

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2015

Predicting coral reef futures under climate change

Researchers examining the impact of climate change on coral reefs have found a way to predict which reefs are likely to recover following bleaching episodes and which won't.

Coral bleaching is the most immediate threat to reefs from climate change; it's caused when ocean temperatures become warmer than normal maximum summer temperatures, and can lead to widespread coral death.

A key unanswered question has been what dictates whether reefs can bounce back after such events, or if they become permanently degraded.

An international team of scientists found that five factors could predict if a reef was likely to recover after a bleaching event.

"Water depth, the physical structure of the reef before disturbance, nutrient levels, the amount of grazing by fish and survival of juvenile corals could help predict reef recovery," says study lead author, Dr Nick Graham from the ARC Centre of Excellence for Coral Reef Studies.

"Remarkably, the two most easily measured variables, water depth and the physical structure of the reef before disturbance, predicted recovery with 98% confidence," Dr Graham says.

As part of the research, published in the journal *Nature*, researchers from Australia, the United Kingdom, Canada and France examined nearly 20 years of coral reef data gathered from the Seychelles. Data was collected before and after an unprecedented coral bleaching event in 1998, in which 90 per cent of the country's corals across 21 reefs were lost.

Of the reefs affected by the episode, twelve recovered while nine did not. The event had a significant impact on the biodiversity of local fish populations, which changed substantially when reefs did not recover.

From their data the researchers identified thresholds for the factors that dictated whether reefs would recover.

"Putting numbers on the threshold points at which reefs either recover or degrade helps predict reef


PHOTO RACHEL GRAHAM

futures under climate change," says Study co-author, Dr Shaun Wilson from the Department of Parks and Wildlife, Western Australia.

"The beauty of this study is that easily acquired measures of reef complexity and depth provide a means of predicting long term consequences of ocean warming events," he adds. "The ability to predict which reefs have the capacity to recover is really important for mapping of winners and losers, and risk analysis."

Co-author Dr Aaron MacNeil from the Australian Institute of Marine Science says, "This gives reef management a major boost in the face of the threats posed by climate change and, encouragingly, suggests people can take tangible steps to improve the outlook for reefs".

"By carefully managing reefs with conditions that are more likely to recover from climate-induced bleaching, we give them the best possible chance of surviving over the long term, while reduction of local pressures that damage corals and diminish water quality will help to increase the proportion of reefs that can bounce back."

Graham, NAJ, Jennings, S, MacNeil, MA, Mouillot, D and Wilson, SK (2015). Predicting climate-driven regime shifts versus rebound potential in coral reefs. *Nature* 518: 94-97

2015 Highlight

72% of the Centre's 221 graduate student population and 70% of our 57 Research Fellows come from overseas

PHOTO MATHINEE YUCHAROEN

Media and Public Outreach

PHOTO OSMAR LUIZ

The ARC Centre of Excellence plays a leading national and international role in communication and outreach of coral reef science, serving a diverse global audience through a combination of traditional, online and social media, and a variety of public outreach and education activities.

The Centre employs a full time Communications Manager to develop, implement and oversee its communications strategy, which aims to promote awareness and understanding of coral reef science and management. The Communications Manager also develops and delivers media training and workshops tailored for Centre members, including early career Fellows and graduate students.

The Centre's communications strategy is multi-stranded and targets local, national and international news and current affairs outlets as well as popular social media sites. We promote the Centre's research through media releases, social media, public lectures, our annual symposium and our website.

Centre members engage in public outreach and education activities, including hosting community workshops, participating at international symposia and convening annual conferences. They also provide many government and industry briefings and generate reports and brochures on Centre activities.

The Centre's website is the most popular first point of contact for the public, attracting 14.6 million hits in 2015. It caters for multiple audiences, providing continually updated access to the latest Centre of Excellence research activities, resources and news. In 2015, the Centre designed a new mobile friendly website ready for launch early in 2016. The new site will link users to all our social media platforms, Facebook, Twitter, YouTube and Flickr and will embed the latest Centre videos and newsfeeds.

The National Library of Australia have decided to archive the Centre's entire website in Pandora, Australia's Web Archive. Pandora was established to ensure long-term access to online Australian research and publications.

PUBLIC OUTREACH

Centre members are actively engaged in public outreach and education programs and activities. In 2015 ARC Centre researchers delivered 26 international keynote addresses and participated in 64 public events, reaching local, national and international audiences.

The Centre has expanded its focus in 2015 on education and outreach engagement for school children, both primary and secondary. For example, Andrew Hoey participated in the popular Scientists in Schools program, providing presentations to primary school students in Townsville. Tom Bridge presented a seminar and led a discussion with high school teachers across Cairns on CoralNet, an online program for recording and analysis of benthic ecological data. Ove Hoegh-Guldberg gave presentations on "Coral reefs, Darwin and the key role of symbiosis" and "Climate Change on the ocean: challenges and solutions" to high school students in Brisbane. Terry Hughes gave a presentation to students at the Tropical Research Network Higher Degree Research Conference on governance challenges and coral reef management in the South China Sea.

In 2015 Centre members and students have increasingly embraced online and digital communications to engage with audiences around the world, participating in a range of digital education and outreach programs. Mia Hoogenboom participated in a number of national and international online community awareness presentations, focussing on her research on the impact of microplastics on coral reefs. The presentations were aimed at school students and the wider public. Verena Schoepf and Claire Ross contributed to a Google Hangout on their research on the Perth Canyon expedition. They also participated in live online video conversations and tours with school students and teachers during the expedition.

Philip Munday contributed to the US embassy's "Faces of Fulbright" social media campaign in the lead-up to *Our Ocean Valparaiso 2015*, a global conference hosted by Chilean Foreign Minister Herald Munos and attended by USA Secretary of State, John Kerry. This outreach activity highlighted the contributions of Fulbright scholars (past and present, American and Australian) to oceans and marine issues.

Centre members have given over 100 talks and presentations in 2015 at a diverse range of conferences around the world, with many providing keynote addresses at significant events. For example, Ove Hoegh-Guldberg delivered the keynote address to the International Scientific Conference in Paris: Our Common Future under Climate Change. Graeme Cumming gave the keynote address at the German Ecological Society in Gottingen, Germany, Philip Munday a plenary in Brazil at the Third International Symposium on the Effects of Climate Change on the World's Ocean in Brazil; and Jodie Rummer delivered the keynote address for the Society for Integrative and Comparative Biology in Florida, USA.

In 2015, the Centre continued to build and strengthen links with stakeholders, industry, business, government and policy makers through a host of briefings and workshops. For example in February Terry Hughes, Ove Hoegh-Guldberg, John Pandolfi and Bob Pressey briefed Australia's Chief Scientist, Professor Ian Chubb, on the Great Barrier Reef. In March, these same scientists briefed the Environment Minister, the Hon. Greg Hunt. Jorge Alvarez-Romero provided briefings and advice to federal, state and local government land and resource management agencies and industry representatives in Cairns on using social network analysis to study collaboration among natural resource management organisations in northern Australia. Pip Cohen provided briefings to WorldFish, Solomon Islands in Honiara on research priorities and plans. Terry Hughes briefed the German Minister for the Environment in Berlin, and members of the UNESCO World Heritage Committee in Paris. Ove Hoegh-Guldberg briefed Australia's Ambassador to the United Nations in Geneva on the future of the Great Barrier Reef and Mike Fabinyi advised the Pew Foundation Shark Program on the consumption of shark fin in China.

Centre researchers participated in a number of high profile public forums in 2015. For example, Terry Hughes participated in a public forum in Brisbane *The Great Barrier Reef – are we doing enough?* During the COP21 talks in Paris in December 2015, Ove Hoegh-Guldberg facilitated a panel discussion about the Great Barrier Reef with Sir David Attenborough, Sir Richard Branson, Dr Sylvia Earle, and Marco Lambertini, the Director General of WWF International.

The Centre's public forum in Hobart, *The Future of Marine Ecosystems* was hosted by popular science journalist and broadcaster, Robyn Williams. Presentations by David Bellwood, Tiffany Morrison, Jodie Rummer, Janice Lough and Mike Fabinyi covered a range of topics including governance of the Great Barrier Reef, the ability of fish to adapt to a changing environment, and the secrets revealed by coral skeletons.

SOCIAL MEDIA

In 2015 the Centre significantly expanded its social media and online presence, including the launch of its new Facebook page and an overhaul of the existing YouTube channel.

The Centre also established a dedicated Twitter account in 2015, reaching 1742 Followers and receiving an average of more than 33,000 Twitter 'impacts' per month. The Centre's work has been cross promoted on other highly successful social media accounts, including the popular *IFL Science* and actor Leonardo Di Caprio's personal Facebook and Twitter account, each of which has a reach of more than 12 million followers.

The Centre's YouTube account remains a popular platform for our talks, symposia and seminar videos. It will be reorganised to link in with the new website, which will feature all new and archived videos.

The addition of a Facebook page in 2015 strengthens the social media arm of the Centre's communications strategy and is a popular platform for disseminating news and media coverage of Centre publications. The Centre also regularly uses its social media platforms to advertise research positions and PhD opportunities.

MEDIA RELEASES

The Centre achieved widespread media coverage of new research activities throughout 2015 across online, print and broadcast news and current affairs at local, national and international levels. Coverage of our research has run in a diverse range of media, from internationally respected newspapers, including the *New York Times* in the United States and the *Financial Times* in Europe, to internationally popular science news sites such as *National Geographic* and *IFL Science*.

During 2015 the ARC Centre produced 33 media releases, which generated almost 4,400 media commentaries worldwide. Some highlights of the media uptake include:

New Straits Times – *Fears over plastic-eating coral in Australia's Barrier Reef*, M Hoogenboom, 24 February 2015 http://www.nst.com.my/node/73918

ABC TV News – *Researchers discover hidden coral reefs off Queensland,* T Roberts, T Bridge, 25 February 2015 http://www.abc.net.au/news/2015-02-25/researchers-discover-hidden-coral-reefs-off-qld/6262862

ABC News - *Perth Canyon research could provide crucial climate change information, researchers say,* M McCulloch, 27 February 2015 http://www.abc.net.au/news/2015-02-27/deep-sea-canyon-study-could-reveal-climate-change-information/6269672

ECOS - *Biological treasures need breathing room to cope with climate*, 24 March 2015, T Hughes https://blogs.csiro.au/ecos/biological-treasures-need-breathing-room-to-cope-with-climate/

NBC News, *Scientists spot deep-sea wonders off Australia's coast,* M McCulloch, 24 March 2015 http://www.nbcnews.com/science/environment/scientists-spot-deep-sea-wonders-australias-coast-n328931

Business Insider Australia - *Science says the Great Barrier Reef can be fixed*, T Hughes, J Day, 7 April 2015 http://www.businessinsider.com.au/science-says-the-great-barrier-reef-can-be-fixed-2015-4

Courier *Mail - Fish key to keeping reefs healthy,* N Graham, 8 April 2015 http://www.couriermail.com.au/news/breaking-news/fish-key-to-keeping-reefs-healthy-study/story-fnihsfrf-1227295706463

The Visayan Daily Star (Philippines) - *National scientist worried over coral reefs damage*, G Russ, 13 April 2015 http://www.visayandailystar.com/2015/April/13/negor3.htm

The Guardian - *Ask the real experts about ocean acidification, not the climate change deniers*, M McCulloch, O Hoegh-Guldberg, P Munday, 16 April 2015 http://www.theguardian.com/environment/planet-oz/2015/apr/16/ask-the-real-experts-about-ocean-acidification-not-climate-science-deniers?CMP=share_btn_tw

ABC Radio News, *A study of 23 million years of fossils has found marine ecosystems in the tropics are most at risk of extinction*, J Pandolfi, 1 May 2015

The Financial Times (European edition) – *Battle under the sea*, J Day, 20 May 2015 http://www.ft.com/intl/cms/s/0/5fa694fa-fae8-11e4-9aed-00144feab7de.html#axzz3aiuvJHX3

National Geographic - *Los corales enferman por culpa de la actividad del hombre*, J Pollock, 12 June 2015 http://www.nationalgeographic.es/noticias/corales-enfermedad-puerto-noticia

Reuters News, US edition – *Paving paradise: scientists alarmed over China island building in disputed sea*, T Hughes, 25 June 2015 http://www.reuters.com/article/2015/06/25/us-southchinasea-china-environment-insig-idUSKBN0P50UB20150625?feedType=RSS&feedName=environmentNews

ABC The World Today – *UN World Heritage Committee decides against declaring Great Barrier Reef 'in danger'*, T Hughes, 1 July 2015 http://www.abc.net.au/worldtoday/content/2015/s4266025.htm

CBS News – *Climate change could drain global seafood supplies*, P Munday, 2 July 2015 http://www.cbsnews.com/news/global-seafood-supplies-may-be-hit-by-climate-change/

Discovery News, ABC Science and ABC TV Catalyst – *Ancient fish evolved gills to survive acidic oceans,* J Rummer, 6 July 2015 http://news.discovery.com/animals/ancient-fish-evolved-gills-to-survive-acidic-oceans-150706.htm, http://www.abc.net.au/science/articles/2015/07/06/4257723.htm http://www.abc.net.au/science/articles/2015/07/06/4257723.htm?site=catalyst

IFLScience – *Damselfish in distress adapt to warmer waters*, P Munday, H Veilleux, 22 July 2015 http://www.iflscience.com/plants-and-animals/damsel-fish-distress-adapt-warmer-waters#

CNN Indonesia – *Pemerintah sulap kawasan konservasi jadi* Great Barrier Reef, L McCook, 7 August 2015 http://www.cnnindonesia.com/ekonomi/20150807062001-92-70606/pemerintah-sulap-kawasan-konservasi-jadi-great-barrier-reef/

The New York Times, *One fish stands watch while another eats*, D Bellwood, S Brandl, 28 September 2015 http://www.nytimes.com/2015/09/29/science/one-fish-stands-watch-while-another-eats.l?action=click&contentCollection=science&region=rank&module=package&version=highlights&contentPlacement=7&pgtype=sectionfront&_r=1

The Washington Post - *Think Usain Bolt is fast? Scientists say fish are the world's best athletes*, J Rummer, 8 October 2015 https://www.washingtonpost.com/news/speaking-of-science/wp/2015/10/08/think-usain-bolt-is-fast-try-racing-a-trout-scientists-say-fish-are-the-worlds-best-athletes/

New Scientist – *Global coral bleaching event: what you need to know,* J Pandolfi, 9 October 2015 https://www.newscientist.com/article/dn28310-global-coral-bleaching-event-what-you-need-to-know/

Discovery News – *Extendable jaws gave fish an evolutionary edge*, D Bellwood, 9 October 2015 http://news.discovery.com/animals/extendable-jaws-gave-fish-an-evolutionary-edge-151009.htm

ABC News - *Fat coral have a better survival chance, researchers find,* V Schoepf, 19 November 2015 http://www.abc.net.au/news/2015-11-19/fat-coral-have-better-survival-chance-researchers-say/6956662

ABC News - *WA 'super coral' more resistant to bleaching, but still hit by rising sea temperatures,* V Schoepf, J Falter, M McCulloch, 3 December 2015 http://www.abc.net.au/news/2015-12-03/wa-super-coral-may-recover-faster-after-bleaching-event/6995568

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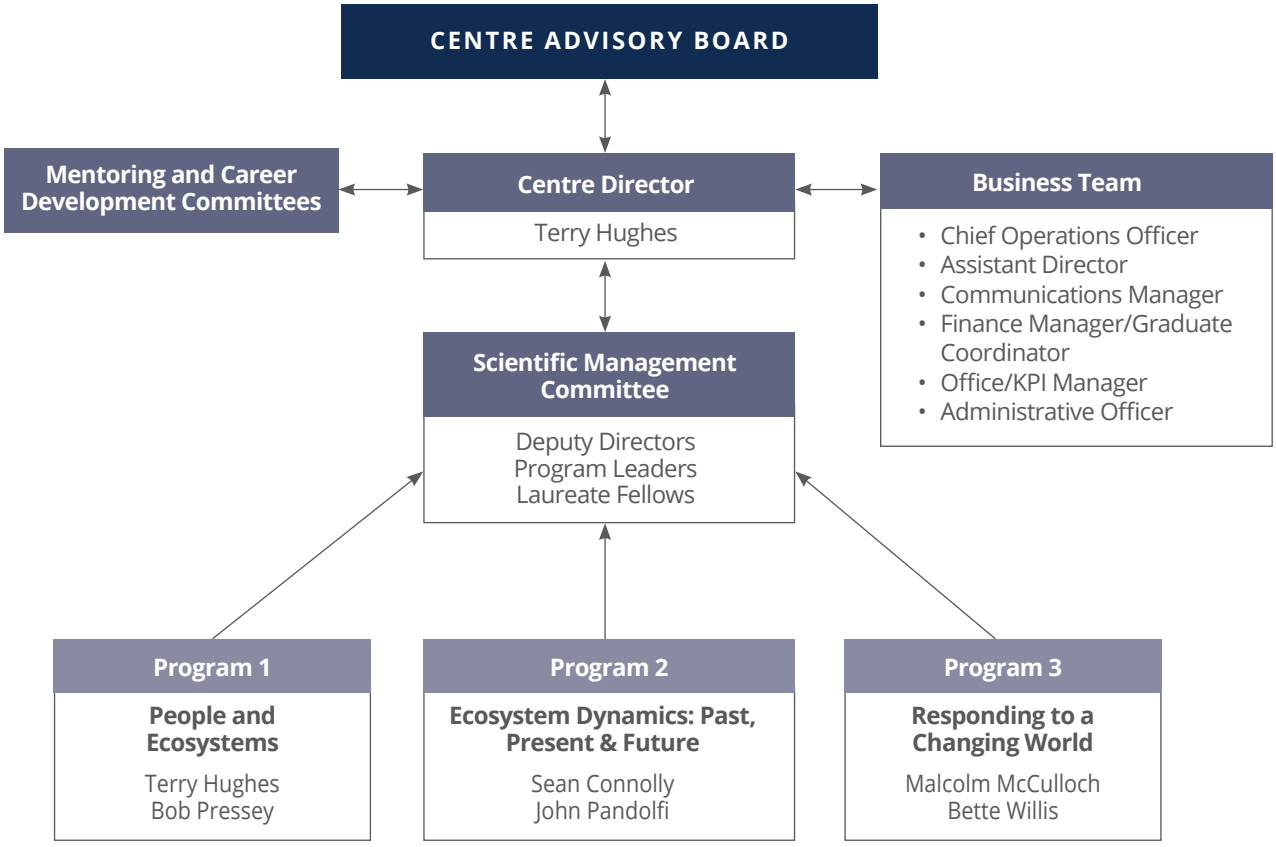
Governance

The Centre's governance structure oversees strategic planning, research program development, knowledge transfer and communications, management and operations. Responsibilities at each level of governance are clearly defined and effective.

James Cook University is the Centre's administering organisation where the Centre Director, Terry Hughes, reports directly to the Senior Deputy Vice-Chancellor, Professor Chris Cocklin. Operations are managed by the Chief Operations Officer, Jennifer Lappin, in consultation with the Centre Director and Assistant Director, David Yellowlees. Additional operating support is provided by Centre staff and others who are located at collaborating institutions.

The diagram below illustrates the Centre's governance structure and relationships. Terry Hughes oversees the Centre's research programs and liaises regularly with the two Deputy Directors, Ove Hoegh-Guldberg (UQ) and Malcolm McCulloch (UWA) on research planning matters. Chief Investigators are located in three Divisions at James Cook University, and at the Australian National University, the University of Queensland and the University of Western Australia. Partner Investigators are based at the Australian Institute of Marine Science, the Great Barrier Reef Marine Park Authority, and in key overseas research institutions. Adjunct researchers make a significant contribution to the Centre's research programs and are located at both national and international institutions.

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 with Jennifer Lappin as secretary. The Centre also supports two additional committees run by Centre graduate students and early career research Fellows, tasked with the organisation of annual retreats and training workshops, and contributing to career development (p44).



CENTRE ADVISORY BOARD

The Centre's Advisory Board provides high-level strategic advice to the Centre Director, and it facilitates and advises on building linkages between the Centre and the private sector, State, Territory and Commonwealth Governments, NGOs and the wider community. The Centre Director and Chief Operations Officer provide the link between the Centre Advisory Board, the Scientific Management Committee, and Centre operations.

Professor Brian Walker *FAA* is the chair of the Board. Membership of the Centre's Advisory Board reflects the Centre's strong multi-disciplinary research activities and includes the Chief Executive Officer of the Australian Institute of Marine Science, the Chair of the Great Barrier Reef Marine Park Authority, and a senior representative from WorldFish, an international nonprofit research organisation. The Centre Advisory Board met twice in 2015, on 20th July in Townsville and 8th October in association with the Centre's annual symposium in Tasmania. The key issues addressed by of the Centre Advisory Board meetings in 2015 were providing advice on existing and new research partners, and preparing for the Centre's mid-term review. 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)
Fellow
CSIRO Ecosystem Sciences

Dr Neil Andrew
Director, Natural Resources Management and Regional Director, Pacific
WorldFish
Malaysia

Professor Terry Hughes
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 David Souter
Research Manager
Australian Institute of Marine Science
(Delegate of the Chief Executive Officer, John Gunn)

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

SCIENTIFIC MANAGEMENT COMMITTEE

The Centre's Scientific Management Committee is responsible for planning and stewardship of the Centre's scientific research program and with high level Centre operational decisions. The Committee is chaired by eminent international social science researcher, Professor Kate Brown from Exeter University, UK. In October, Professor Bette Willis signaled her intention to retire at the end of 2016 and Dr Mia Hoogenboom was appointed as her replacement as Leader of Program 3. The transition will provide leadership mentoring for Mia, a feature of the Centre's gender policy.

The Committee met four times during 2015: in Canberra, Townsville (twice) and Hobart. Priorities in 2015 included refining the Centre's research programs, coordinating the Centre's key role in providing advice to Government on the Great Barrier Reef World Heritage listing and on the Reef 205 Long Term Sustainability Plan, establishing the National Coral Bleaching Taskforce in anticipation of a potential bleaching event in early 2016, recruiting high-quality research fellows and students, and planning for the Centre's significant presence at the quadrennial International Coral Reef Symposium in Hawaii in June 2016.

Membership of the Scientific Management Committee:

Professor Kate Brown (Chair)
Chair in Social Science
Exeter University, United Kingdom

Distinguished Professor Terry Hughes *FAA*
ARC Australian Laureate Fellow and Leader, Research Program 1

Distinguished Professor Bob Pressey *FAA*
Leader, Research Program 1

Professor Sean Connolly
Leader, Research Program 2

Professor John Pandolfi
Leader, Research Program 2

Professor Malcolm McCulloch *FAA FRS*
ARC Australian Laureate Fellow and Leader, Research Program 3

Distinguished Professor Bette Willis
Leader, Research Program 3

Professor Ove Hoegh-Guldberg *FAA*
ARC Australian Laureate Fellow and Deputy Director

Professor Peter Mumby
ARC Australian Laureate Fellow

Dr David Wachenfeld
Director – Reef Recovery
Great Barrier Reef Marine Park Authority

Membership

RESEARCHERS

In 2015, the Centre's membership grew to 67 Chief Investigators and Research Fellows and Associates, 27 Partner Investigators, resident international scholars and adjunct researchers and 221 Honours, Masters and PhD students. This year, 14 of the Centre's Research Fellows are funded by ARC awards (Laureate, Future, DECRA, Discovery and Super Science), one is a Queensland Smart Futures Fellow and another is a Society-in-Science Branco-Weiss Fellow.

In 2015, the Centre welcomed 12 new research fellows, including six tenured coral reef research leaders – Professor Josh Cinner, Professor Graeme Cumming, Dr Tiffany Morrison, Professor Philip Munday and Professor Morgan Pratchett. Dr Michael Bode will commence in 2017. The Centre achieved its gender equity goal by recruiting an equal number of female and male Research Fellows.

We also farewelled a number of our Research Fellows as they further their careers elsewhere and extend the Centre's international network of alumni collaborators: Ian Craigie, Vivian Cumbo, Nick Graham, Christina Hicks, Kirsty Nash, Jairo Rivera-Posada, Ruth Thurstan and Ke Zhang. We wish them well in their research careers.

CHIEF INVESTIGATORS AND RESEARCH FELLOWS

Professor Terry Hughes
Centre Director
ARC Australian Laureate Fellow
James Cook University

Dr Tracy Ainsworth
ARC Super Science Fellow
James Cook University

Dr Jorge Álvarez-Romero
Research Fellow
James Cook University

Professor Andrew Baird
Research Fellow
James Cook University

Professor David Bellwood
Chief Investigator
James Cook University

Dr Dorothea Bender-Champ
Research Fellow
University of Queensland

Dr Jessica Blythe
Research Fellow
James Cook University and WorldFish, Malaysia

Dr Pim Bongaerts
Research Fellow
University of Queensland

Dr Mary Bonin
Research Fellow
James Cook University

Dr Yves-Marie Bozec
Research Fellow
University of Queensland

Dr Tom Bridge
Research Fellow
James Cook University and Australian Institute of Marine Science

Dr Jana Brotankova
Research Associate
James Cook University

Professor Joshua Cinner
ARC Australian Research Fellow
James Cook University

Dr Steeve Comeau
Research Fellow
University of Western Australia

Professor Sean Connolly
Chief Investigator
James Cook University

Dr Christopher Cornwall
Research Fellow
University of Western Australia

Dr Ian Craigie
Research Associate
James Cook University

Dr Viv Cumbo
Research Associate
James Cook University

Professor Graeme Cumming
Research Fellow
James Cook University

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

Assoc Professor Sophie Dove
Chief Investigator
University of Queensland

Dr Michael Fabinyi
Society in Science Research Fellow
James Cook University

Dr James Falter
Research Fellow
University of Western Australia

Dr Sylvain Forêt
Discovery Early Career Researcher Award (DECRA)
Australian National University

Dr Sofia Fortunato
Research Fellow
James Cook University

Dr Manuel González-Rivero
Research Fellow
University of Queensland

Dr Nick Graham
Discovery Early Career Researcher Award (DECRA)
James Cook University

Dr Georgina Gurney
Research Associate
James Cook University

Dr Alistair Harborne
Research Fellow
University of Queensland

Dr Hugo Harrison
Research Fellow
James Cook University

Dr Christina Hicks
Research Fellow
James Cook University and Center for Ocean Solutions, Stanford University, USA

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

Dr Andrew Hoey
Discovery Early Career Researcher Award (DECRA)
James Cook University

Dr Mia Hoogenboom
Chief Investigator
James Cook University

Professor Geoffrey Jones
Chief Investigator
James Cook University

Professor Michael Kingsford
Chief Investigator
James Cook University

Dr Nils Krück
Research Fellow
University of Queensland

Dr Andreas Kubicek
Research Fellow
University of Queensland

Assoc Professor Bill Leggat
Research Fellow
James Cook University

Professor Ryan Lowe
ARC Future Fellow
University of Western Australia

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

Professor Mark McCormick
Chief Investigator
James Cook University

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

Dr Vanessa Messmer
Research Fellow
James Cook University

Professor David Miller
Chief Investigator
James Cook University

Dr Tiffany Morrison
Research Fellow
James Cook University

Dr Aurélie Moya
Research Fellow
James Cook University

Professor Peter Mumby
ARC Australian Laureate Fellow
University of Queensland

Professor Philip Munday
ARC Future Fellow
James Cook University

Dr Kirsty Nash
Research Associate
James Cook University

Professor John Pandolfi
ARC Discovery Outstanding Researcher Award
University of Queensland

Professor Morgan Pratchett
Research Fellow, Smart Futures Fellow
James Cook University

Professor Bob Pressey
Research Fellow
James Cook University

Dr Jairo Rivera Posada
Research Fellow
James Cook University and Australian Institute of Marine Science

Dr George Roff
Research Fellow
University of Queensland

Dr Jodie Rummer
Discovery Early Career Researcher Award (DECRA)
James Cook University

Professor Garry Russ
Chief Investigator
James Cook University

Dr Eugenia Sampayo
Research Fellow
University of Queensland

Dr Verena Schoepf
Research Fellow
University of Western Australia

Dr Ruth Thurstan
Research Fellow
University of Queensland

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

Dr Sue-Ann Watson
Research Fellow
James Cook University

Dr Heather Veilleux
Research Fellow
James Cook University

Dr Rebecca Weeks
Research Fellow
James Cook University

Dr Amelia Wenger
Research Associate
James Cook University

Professor Bette Willis
Chief Investigator
James Cook University

Dr Ke Zhang
Research Associate
James Cook University

RESIDENT INTERNATIONAL SCHOLARS

Dr Pip Cohen
Research Fellow
WorldFish, Malaysia

Dr David Mills
Research Fellow
WorldFish, Malaysia

Dr Michele Barnes
Research Fellow
National Science Foundation, USA

PARTNER INVESTIGATORS AND ADJUNCT RESEARCHERS

Dr Vanessa Adams
University of Queensland

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

Dr Neil Andrew
WorldFish Center, Malaysia

Professor Eldon Ball
Australian National University

Dr Line Bay
Australian Institute of Marine Science

Dr Daniela Ceccarelli
Marine Ecology Consultant

Dr Guillermo Diaz-Pulido
Griffith University

Dr Michael Bode
University of Melbourne

Dr Louisa Evans
Exeter University
United Kingdom

Dr Alison Green
The Nature Conservancy

Dr Richard Hamilton
The Nature Conservancy

Dr Anne Hoggett
Lizard Island Research Station

Professor Jeremy Jackson
International Union for Conservation of Nature, USA

Dr Alexander Kerr
University of Guam, USA

Professor Janice Lough
Australian Institute of Marine Science

Dr Tim McClanahan
Wildlife Conservation Society, Kenya

Dr Laurence McCook
Great Barrier Reef Marine Park Authority

Dr Aaron MacNeil
Australian Institute of Marine Science

Professor David Mouillot
Université Montpellier 2 Sciences et Techniques, France

Professor Stephen Palumbi
Stanford University, USA

Dr Serge Planes
University of Perpignan, France

Professor Madeleine van Oppen
Australian Institute of Marine Science

Dr David Wachenfeld
Great Barrier Reef Marine Park Authority

GRADUATE STUDENTS (SEE PAGE 44)

RESEARCH SUPPORT

Carlin Bowyer
University of Western Australia

Dr Christopher Goatley
James Cook University

Dr Maria Gomez-Cabrera
University of Queensland

David Hayward
Australian National University

Mizue Jacobson
James Cook University

Cindy Huchery
James Cook University

James Kerry
James Cook University

Anton Kuret
University of Western Australia

Anne-Marin Nisumaa-Comeau
University of Western Australia

Jue Sheng Ong
Australian National University

Deborah Pratchett
James Cook University

Kai Rankenburg
University of Western Australia

Dr Maya Srinivasan
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

Professor David Yellowlees
Assistant Director
James Cook University

Olga Bazaka
Finance Manager and Graduate Coordinator
James Cook University

Rosanna Griffith-Mumby
Administrative Officer
University of Queensland

Vivian Doherty
Events Co-ordinator and KPI Officer
James Cook University (from June 2015)

Eleanor Gregory
Communications Manager
James Cook University

Janet Swanson
Administrative Assistant
James Cook University

Karen van Staden
Administrative Officer
University of Western Australia

Rose-Marie Vasiljuk
Office Manager and KPI Officer
James Cook University (to May 2015)

Hayley Ware
Project Officer
University of Queensland

Publications

In 2015, researchers from the ARC Centre of Excellence produced 319 publications, including 295 journal articles, 20 book chapters, 1 conference paper, and 3 reports.

Centre researchers published 117 articles in journals with Impact Factors greater than four, including 21 in prestige journals - *Science*, the *Nature* Journals, *Trends in Ecology and Evolution*, *Proceedings of the National Academy of Sciences of the United States of America* and *Current Biology*. The average Impact Factor for all 295 journal articles in 2015 was 5.1. The Centre's research outputs were published in a total of 101 journal titles, spanning many fields of research and reflecting the multi-disciplinary breadth of the Centre's publication output.

According to Scopus, Centre of Excellence researchers were cited 26,535 times in 2015, twenty-two researchers were each cited more than 500 times and eight had more than 1,000 citations in the past 12 months.

The Faculty of 1000 recommended 6 of the Centre's journal articles:

- Brooker, RM, Munday, PL, Chivers, DP and Jones, GP (2015). You are what you eat: diet-induced chemical crypsis in a coral-feeding reef fish. *Proceedings of the Royal Society of London B*, 282: 20141887.
- Burrows, MT, Schoeman, DS, Richardson, AJ, Molinos, JG, Hoffmann, A, Buckley, LB, Moore, PJ, Brown, CJ, Bruno, JF, Duarte, CM, Halpern, BS, Hoegh-Guldberg, O, Kappel, CV, Kiessling, W, O'Connor, MI, Pandolfi, JM, Parmesan, C, Sydeman, W, Ferrier, S, Williams, KJ and Poloczanska, ES (2014). Geographical limits to species-range shifts are suggested by climate velocity. *Nature* 507: 492-495.
- Díaz, S, Demissew, S, Carabias, J, Joly, C, Lonsdale, M, Ash, N, Larigauderie, A, Adhikari, JR, Arico, S, Báldi, A, Bartuska, A, Baste, IA, Bilgin, A, Brondizio, E, Chan, KMA, Figueroa, VE, Duraiappah, A, Fischer, M, Hill, R, Koetz, T, Leadley, P, Lyver, P, Mace, GM, Martin-Lopez, B, Okumura, M, Pacheco, D, Pascual, U, Pérez, ES, Reyers, B, Roth, E, Saito, O, Scholes, RJ, Sharma, N, Tallis, H, Thaman, R, Watson, R, Yahara, T, Hamid, ZA, Akosim, C, Al-Hafedh, Y, Allahverdiyev, R, Amankwah, E, Asah, TS, Asfaw, Z, Bartus, G, Brooks, AL, Caillaux, J, Dalle, G, Darnaedi, D, Driver, A, Erpul, G, Escobar-Eyzaguirre, P, Failler, P, Fouda, AMM, Fu, B, Gundimeda, H, Hashimoto, S, Homer, F, Lavorel, S, Lichtenstein, G, Mala, WA, Mandivenyi, W, Matczak, P, Mbizvo, C, Mehrdadi, M, Metzger, JP, Mikissa, JB, Moller, H, Mooney, HA, Mumby, P, Nagendra, H, Nesshover, C, Oteng-Yeboah, AA, Pataki, G, Roué, M, Rubis, J, Schultz, M, Smith, P, Sumaila, R, Takeuchi, K, Thomas, S, Verma, M, Yeo-Chang, Y and Zlatanova, D (2015). The IPBES Conceptual Framework - connecting nature and people. *Current Opinion in Environmental Sustainability* 14: 1-16.
- Duarte, CM, Fulweiler, RW, Lovelock, CE, Martinetto, P, Saunders, MI, Pandolfi, JM, Gelcich, S and Nixon, SW (2015). Reconsidering ocean calamities. *BioScience* 65(2): 130-139.
- Graham NAJ, Jennings S, MacNeil MA, Mouillot D and Wilson SK (2015) Predicting climate-driven regime shifts versus rebound potential in coral reefs. *Nature* 518: 94-97.
- Moya, A, Huisman, L, Forêt, S, Gattuso, JP, Hayward, DC, Ball, EE and Miller, DJ (2015). Rapid acclimation of juvenile corals to CO2-mediated acidification by upregulation of heat shock protein and Bcl-2 genes. *Molecular Ecology* 24(2): 438-452.

PHOTO SANDER DEN HARING

PUBLICATIONS

BOOK SECTION (20)

1. Ban, N, Kittinger, JN, Pandolfi, J, Pressey, B, Thurstan, RH and Hart, S (2015). Incorporating historical perspectives into systematic marine conservation planning. In: Kittinger, JN, McClenachan, L, Gedan, K and Blight, L. (eds). *Marine Historical Ecology in Conservation: Using the Past to Manage for the Future*, University of California Press, 207-233 pp.
2. Bellwood, DR, Goatley, CHR, Cowman, PF and Bellwood, O (2015). The evolution of fishes on coral reefs: fossils, phylogenies, and functions. In: Mora, C. (ed). *Ecology of Fishes on Coral Reefs*, Cambridge University Press, 55-63 pp.
3. Bohensky, EL, Evans, LS, Anderies, JM, Biggs, R and Fabricius, C (2015). Principle 4 – Foster complex adaptive systems thinking. In: Biggs, R, Schlüter, M and Schoon, M. (eds). *Principles for Building Resilience: Sustaining Ecosystem Services in Social-Ecological Systems*, Cambridge University Press, 142-173 pp.
4. Brotankova, J, Randall, M, Lewis, A, Pressey, B and Wenger, A (2015). A genetic algorithm solver for pest management control in island systems. In: Chalup, SK, Blair, AD and Randall, M. (eds). *Artificial Life and Computational Intelligence*, Springer International Publishing, 273-285 pp.
5. Cinner, JE and Kittinger, JN (2015). Linkages between social systems coral reefs. In: Mora, C. (ed). *Ecology of Fishes on Coral Reefs*, Cambridge University Press, 215-220 pp.
6. Cohen, P, Evans, L and Govan, H (2015). Community-based, co-management for governing small-scale fisheries of the Pacific: a Solomon Islands' case study. In: Jentoft, S and Chuenpagdee, R. (eds). *Interactive Governance for Small-Scale Fisheries: Global Reflections*, Springer International Publishing, Cham, 39-59 pp.
7. Cuevas, SC, Peterson, A and Morrison, T (2015). An analytical framework for investigating complex institutions in climate change adaptation: The institutional environment matrix. In: Leal, W. (ed). *Handbook of Climate Change Adaptation*, Springer Berlin Heidelberg, 123-149 pp.
8. Darling, ES and Rummer, JL (2015). Strategically using social media In: Pritchard, PA and Grant, C. (eds). *Success Strategies from Women in STEM: A Portable Mentor,* Elsevier Science, 255-296 pp.
9. Day, JC, Laffoley, D and Zischka, K (2015). Marine protected area management. In: Worboys, GL, Lockwood, M, Kothari, A, Feary, S and Pulsford, I. (eds). *Protected Area Governance and Management*, ANU Press, Canberra, 609-650 pp.
10. Graham, NAJ (2015). Phase shifts and coral reef fishes. In: Mora, C. (ed). *Ecology of Fishes on Coral Reefs*, Cambridge University Press, 191-198 pp.
11. Graham, NAJ and Hicks, CC (2015). Adaptive management for novel ecosystems. In: Allen, CR and Garmestani, AS. (eds). *Adaptive Management of Social-Ecological Systems*, Springer Netherlands, 123-146 pp.
12. Holcomb, M, Rankenburg, K and McCulloch, M (2015). High-precision MC-ICP-MS measurements of $\delta^{11}B$: matrix effects in direct injection and spray chamber sample introduction systems. In: Grice, K. (ed). *Principles and Practice of Analytical Techniques in Geosciences*, The Royal Society of Chemistry, 251-270 pp.
13. Jones, GP (2015). Mission impossible: unlocking the secrets of coral reef fish dispersal. In: Mora, C. (ed). *Ecology of Fishes on Coral Reefs*, Cambridge University Press, 16-27 pp.
14. Kulbicki, M, Parravicini, V and Mouillot, D (2015). Patterns and processes in reef fish body size. In: Mora, C. (ed). *Ecology of Fishes on Coral Reefs*, Cambridge University Press, 104-115 pp.
15. MacNeil, MA and Connolly, SR (2015). Multi-scale patterns and processes in reef fish abundance. In: Mora, C. (ed). *Ecology of Fishes on Coral Reefs*, Cambridge University Press, 116-124 pp.
16. Pratchett, MS, Wilson, SK and Munday, PL (2015). Effects of climate change on coral reef fishes. In: Mora, C. (ed). *Ecology of Fishes on Coral Reefs*, Cambridge University Press, 127-134 pp.
17. Rummer, JL (2015). Networking. In: Pritchard, PA and Grant, C. (eds). *Success Strategies from Women in STEM: A Portable Mentor*, Elsevier Science, 23-60 pp.
18. Rummer, JL and Isom, L (2015). Communicating science. In: Pritchard, PA and Grant, C. (eds). *Success Strategies from Women in STEM: A Portable Mentor*, Elsevier Science, 201-253 pp.
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20. Wenger, AS, Fabricius, KE, Jones, GP and Brodie, JE (2015). Effects of sedimentation, eutrophication, and chemical pollution on coral reef fishes. In: Mora, C. (ed). *Ecology of Fishes on Coral Reefs*, Cambridge University Press, 145-153 pp.

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JOURNAL ARTICLE (295)

1. Abesamis, RA, Jadloc, CRL and Russ, GR (2015). Varying annual patterns of reproduction in four species of coral reef fish in a monsoonal environment. *Marine Biology* 162(10): 1993-2006.
2. Ainsworth, CH and Mumby, PJ (2015). Coral-algal phase shifts alter fish communities and reduce fisheries production. *Global Change Biology* 21(1): 165-172.
3. Ainsworth, TD, Knack, B, Ukani, L, Seneca, F, Weiss, Y and Leggat, W (2015). *In situ* hybridisation detects pro-apoptotic gene expression of a Bcl-2 family member in white syndrome-affected coral. *Diseases of Aquatic Organisms* 117(2): 155-163.
4. Ainsworth, TD, Krause, L, Bridge, T, Torda, G, Raina, JB, Zakrzewski, M, Gates, RD, Padilla-Gamiño, JL, Spalding, HL, Smith, C, Woolsey, ES, Bourne, DG, Bongaerts, P, Hoegh-Guldberg, O and Leggat, W (2015). The coral core microbiome identifies rare bacterial taxa as ubiquitous endosymbionts. *ISME Journal* 9(10): 2261-2274.
5. Allgeier, JE, Layman, CA, Mumby, PJ, Rosemond, AD and Kraft, NJB (2015). Biogeochemical implications of biodiversity and community structure across multiple coastal ecosystems. *Ecological Monographs* 85(1): 117-132.
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7. Anderson, KD, Heron, SF and Pratchett, MS (2015). Species-specific declines in the linear extension of branching corals at a subtropical reef, Lord Howe Island. *Coral Reefs* 34(2): 479-490.
8. Andrello, M, Jacobi, MN, Manel, S, Thuiller, W and Mouillot, D (2015). Extending networks of protected areas to optimize connectivity and population growth rate. *Ecography* 38(3): 273-282.

9. Andrello, M, Mouillot, D, Somot, S, Thuiller, W and Manel, S (2015). Additive effects of climate change on connectivity between marine protected areas and larval supply to fished areas. *Diversity and Distributions* 21(2): 139-150.

10. Anthony, KRN, Marshall, PA, Abdulla, A, Beeden, R, Bergh, C, Black, R, Eakin, CM, Game, ET, Gooch, M, Graham, NAJ, Green, A, Heron, SF, van Hooidonk, R, Knowland, C, Mangubhai, S, Marshall, N, Maynard, JA, McGinnity, P, McLeod, E, Mumby, PJ, Nyström, M, Obura, D, Oliver, J, Possingham, HP, Pressey, RL, Rowlands, GP, Tamelander, J, Wachenfeld, D and Wear, S (2015). Operationalizing resilience for adaptive coral reef management under global environmental change. *Global Change Biology* 21(1): 48-61.

11. Arias, A, Cinner, JE, Jones, RE and Pressey, RL (2015). Levels and drivers of fishers' compliance with marine protected areas. *Ecology and Society* 20(4):19.

12. Atherton, JA and McCormick, MI (2015). Active in the sac: damselfish embryos use innate recognition of odours to learn predation risk before hatching. *Animal Behaviour* 103: 1-6.

13. Ayling, BF, Chappell, J, Gagan, MK and McCulloch, MT (2015). ENSO variability during MIS 11(424-374 ka) from *Tridacna gigas* at Huon Peninsula, Papua New Guinea. *Earth and Planetary Science Letters* 431: 236-246.

14. Baird, AH, Cumbo, VR, Gudge, S, Keith, SA, Maynard, JA, Tan, CH and Woolsey, ES (2015). Coral reproduction on the world's southernmost reef at Lord Howe Island, Australia. *Aquatic Biology* 23(3): 275-284.

15. Baker, DW, Sardella, B, Rummer, JL, Sackville, M and Brauner, CJ (2015). Hagfish: Champions of CO_2 tolerance question the origins of vertebrate gill function. *Scientific Reports* 5: 11182.

16. Baldock, TE, Golshani, A, Atkinson, A, Shimamoto, T, Wu, S, Callaghan, DP and Mumby, PJ (2015). Impact of sea-level rise on cross-shore sediment transport on fetch-limited barrier reef island beaches under modal and cyclonic conditions. *Marine Pollution Bulletin* 97(1-2): 188-98.

17. Ban, NC, Evans, LS, Nenadovic, M and Schoon, M (2015). Interplay of multiple goods, ecosystem services, and property rights in large social-ecological marine protected areas. *Ecology and Society* 20(4).

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REPORT (3)

1. Alvarez-Romero, J (2015). *Catchment to coast planning: summary of key environmental management issues and activities undertaken by land managers in the Gilbert River catchment, Queensland, Australia.* Northern Gulf Resource management Group, 93 pp.

2. Nash, KL, Graham, NAJ and Wilson, SK (2015). *An assessment of the viability of fisheries independent data for determining stock status and deriving management advice for Seychelles inshore coral reef fisheries.*, Seychelles Government, 93 pp.

3. Wallace, B, Dutton, P, Marcovaldi, M, Lukoschek, V and Rice, J (2015). *First global integrated marine assessment.* United Nations Oceans & Law at Sea, 14 pp.

Financial Statement

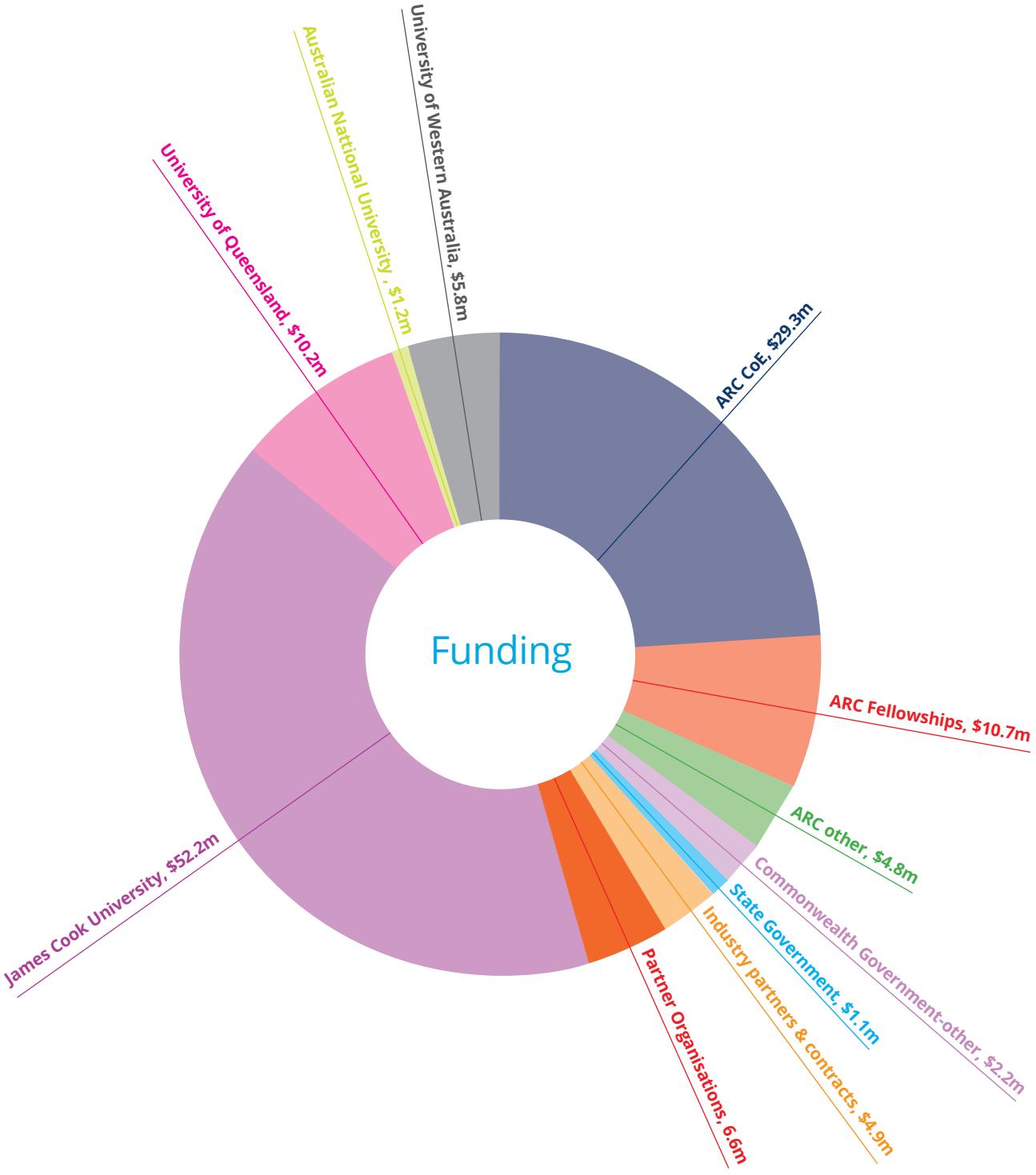
ARC CENTRE OF EXCELLENCE FOR CORAL REEF STUDIES

STATEMENT OF OPERATING INCOME AND EXPENDITURE FOR YEAR ENDED 31 DECEMBER 2015

	2014	2015	2016 forecast
Income	**$**	**$**	**$**
ARC Centre Grant	$4,120,882	$4,194,688	$4,265,997
ARC Fellowships	1,743,575	1,605,747	1,226,231
Host Institutions cash support	3,377,461	3,614,394	3,656,592
State Government	95,000	30,000	30,000
Commonwealth Government other grants	955,707	489,160	760,000
International and other contracts	523,347	1,009,862	1,030,000
Total Income	**$10,815,972**	**$10,943,851**	**$10,968,820**
Expenditure			
Salaries	$5,582,715	$6,969,931	$7,234,288
Equipment	402,277	492,963	495,000
Travel	1,235,412	1,356,655	1,561,975
Research maintenance and consumables	1,466,972	1,550,360	1,601,600
Scholarships	121,432	134,993	135,000
Public outreach and administration	77,779	92,105	100,000
Total Expenditure	**$8,886,588**	**$10,324,007**	**11,127,863**
Surplus (Deficit)	**$1,929,384**	**$619,844**	**$(159,043)**

Financial Outlook

As at December 2015 the total cash and inkind budget for the ARC Centre of Excellence for Coral Reef Studies for 1 January 2014 to 31 December 2020 totals $129m, 6% higher than the funding outlook when the Centre was established in 2014.



2016 Activity Plan

Highlights of the Centre's 2016 Activity Plan, in addition to ongoing research and operations.

1. Research

a. Coordinate the research effort among Australia's marine science research community for the National Coral Reef Bleaching Taskforce
b. Recruit Partner Institution AIMS - Centre of Excellence Research Fellow to study reef responses to climate change.
c. Undertake a review the Centre's Research Programs, co-ordinated by the Centre's Advisory Board
d. Continue to develop Centre's research capabilities in social sciences and people with cross disciplinary expertise through strategic recruitment of two mid-career research fellows

2. Research Training and Professional Development

a. Actively seek to recruit excellent PhD students, particularly with multi-institutional supervisory arrangements
b. Resource the attendance of Centre students presenting at the International Coral Reef Symposium (ICRS)
c. Present workshops on media training, international networking and publication strategies in advance of the ICRS
d. Facilitate new students to improve their profiles on the Centre's new website
e. Support students to develop a weekly mini-seminar series to improve presentation skills

3. National and International Linkages

a. Continue dialogue to formalise agreements with potential new Partner Institutions
b. Liaise with Partner Institution CNRS regarding arrangements for visiting scholar in coral reef management and spatial planning
c. Make a major contribution to the quadrennial ICRS in Honolulu, USA
d. Co-host a working group meeting in the UK with Environment and Sustainability Institute and the College of Life and Environmental Sciences, University of Exeter

4. Impacts and End User Engagement

a. Continue to engage with government and stakeholders on the Reef 2050 Long Term Sustainability Plan
b. Launch a new mobile friendly website to complement the Centre's existing online and social media presence
c. Strengthen social media engagement with an aim of attracting 3000 Twitter followers
d. Launch Centre Facebook page
e. Hold planning meetings and Research Program retreats in association with ICRS to engage end-users and members

5. Gvernenance

a. Expand membership of the Centre Advisory Board to include two representatives from end-user groups and industry
b. Incorporate mid-career women into Research Program leadership structure
c. Review funding to the Centre's Research Programs
d. Fill the current vacancies for an Assistant Director and Communications Manager
e. Review the current KPIs reported annually to the ARC
f. Resource Centre activities to achieve growth in performance against all KPIs

Key Performance Indicators

RESEARCH FINDINGS

MEASURE	TARGET 2015	OUTCOME 2015
No. of research outputs (p70)	275	**319**
Publications in journals with an Impact Factor > 4	70	**117**
Mean Impact Factor for journals published	3.7	**5.1**
Faculty of 1000 commentaries (p70)	6	**6**
Number of citations (p70)	17,000	**26,535**
No. of Centre researchers with >500 citations	16	**22**
No. of invited talks/papers/keynotes at international meetings	22	**26**
No. and nature of commentaries about the Centre's achievements (p62) • Articles • Media releases	 2,200 26	 **4,399** **33**
Awards, prizes or recognition (p6)	22	**34**

RESEARCH TRAINING AND PROFESSIONAL EDUCATION

MEASURE	TARGET 2015	OUTCOME 2015
No. of professional training courses for staff and postgraduate students attended	22	**46**
No. of Centre attendees at all professional training/ development courses offered by the Centre	85	**988**
No. of students mentored	160	**158**
No. of student attendances at the Centre's professional development events	65	**625**
No. of early career researchers participating in annual performance reviews, attending seminars, visiting other Centre nodes, attending ECR committee events	25	**31**
Stakeholder participation in Centre Working Group meetings, workshops and planning meetings	10	**14**
No. of new postgraduates enrolled (p44)	150 over life of Centre	**2015: 46 (93 to date)**
No. of postgraduate completions and completions times: • No. of completions • No. submitting within 4 years of commencement	 175 over life of Centre 15	 **2015: 34 (79 to date)** **12**
No. of new Honours students	80 over life of Centre	**2015: 11 (27 to date)**
No. of new postdoctoral researchers	40 over life of Centre	**2015: 12 (20 to date)**
No. of Early Career Researchers	12	**31**

INTERNATIONAL, NATIONAL AND REGIONAL LINKS AND NETWORKS

MEASURE	TARGET 2015	OUTCOME 2015
No. of international visitors (p56)	55	**68**
No. of national and international Working Groups held/ organised by the Centre	10	**22**
No. of visits to overseas laboratories and research facilities	85	**96**
Metrics of interdisciplinary research supported by the Centre:		
• No. of journal titles in which Centre outputs are published	85	**101**
• No. of four digit Field of Research disciplines in which the Centre research publications are classified	16	**17**
• No. of students with multidisciplinary supervisory arrangements	35	**35**

END-USER LINKS

MEASURE	TARGET 2015	OUTCOME 2015
No. of government, industry and business briefings (p62)	70	**106**
No. of Public awareness programs	32	**64**
No. of talks open to the public	42	**31**
Website hits	5.5m	**14.6m**

ORGANISATIONAL SUPPORT

MEASURE	TARGET 2015	OUTCOME 2015
Annual cash contributions from Administering and Collaborating Organisations:		
JCU	$1.0m	**$1.00m**
ANU	$0.05m	**$0.05m**
UQ	$0.27m	**$0.27m**
UWA	$0.20m	**$0.20m**
Annual in-kind contributions from Administering and Collaborating Organisations		
JCU	$5.8m	**$6.12m**
ANU	$0.056m	**$0.11m**
UQ	$1.19m	**$1.19m**
UWA	$0.61m	**$0.61m**
Annual cash contributions from Partner Organisations:		
AIMS	$109k	**$168k**
CNRS	$7k	**$7k**
Stanford	$54k	**$54k**
WorldFish	$56k	**$104k**
Annual inkind contributions from Partner Organisations:		
AIMS	$362k	**$362k**
GBRMPA	$25k	**$25k**
CNRS	$54k	**$54k**
Stanford	$167k	**$167k**
WorldFish	$100k	**$100k**
Other research income secured by Centre staff:		
ARC Grants	$2.5m	**$1.78m**
Other Australian competitive	$0.40m	**$0.42m**
Public sector	$0.33m	**$0.53m**
Industry and other research income	$0.27m	**$1.45m**
No. of new organisations collaborating with, or involved in the Centre	100 over life of Centre	**124**
Level and quality of infrastructure provided to the Centre	$1.43m	**$1.54m**

GOVERNANCE

MEASURE	TARGET 2015	OUTCOME 2015
Breadth, balance and experience of the members of the Advisory Board		**See page 66**
Frequency, attendance and value added by Advisory Board meetings	2 Centre Advisory Board meetings p.a. with 75% attendance 4 Scientific Management Committee meetings p.a. with 75% attendance	**See page 66**
Vision and usefulness of the Centre strategic plan	The Centre's progress against the plan will be formally reported to the Advisory Board and be renewed in light of outcomes	**Strategic Plan reviewed and endorsed by the Centre Advisory Board. Ongoing performance against plan reviewed at Scientific Management Committee meetings**
Adequacy of the Centre performance measure targets	Benchmarking against world leading research institutions	**The Centre is ranked #1 in the world for citations and outputs in coral reef science**
Effectiveness of the Centre in bringing researchers together to form an interactive and effective research team:		
• Participation in research program planning meetings	20	**40**
• Attendance at annual symposium	75	**138**
• No. of multi-institutional supervisory arrangements	42	**68**
• No. of cross-nodal publications	32	**45**
Capacity building of the Centre through scale and outcomes:		
• No. of countries where the Centre:		
• Undertakes fieldwork	21	**21**
• Advises governments and NGOs	10	**10**
• No. of international co-authors	32	**639**
• No. of overseas graduate student completions	100 over life of Centre	**2015: 28 (66 to date)**

NATIONAL BENEFIT

MEASURE	TARGET 2015	OUTCOME 2015
Measures of expansion of Australia's capability in the priority area(s):		
• Growth in no. of publications and citations in environmental sustainability	10% annual increase from 2014 benchmark	**25.7%**
• Interactions with industry, business and government	70 briefings	**106**
• Cross-institutional publications	140	**215**
Contribution to national research priorities	1 case study highlighted in the annual report	**See page 38**
Measure of reputation and competitiveness	Benchmarking of publications and citations against other world leading institutions	**The Centre is ranked first in the world for publications and citations in coral reef science**

CENTRE SPECIFIC PERFORMANCE INDICATORS

MEASURE	TARGET 2015	OUTCOME 2015
Prestige publications	100 publications over life of Centre	**2015: 21 (39 to date)**
Publications with cross-institutional co-authorships	160	**215**
New Centre graduate students attracted to Australia from overseas	100 over life of Centre	**2015: 41 (79 to date)**
Centre graduate students with cross-nodal supervision	120 over life of Centre	**2015: 43 (51 to date)**
Gender equity in research fellow appointments	50:50	**50:50** **6 females: 6 males**

Acknowledgements

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- Australian Academy of Science, Canberra
- Australian Genome Research Facility (AGRF)
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- Australian Institute of Marine Science (AIMS)
- Australian Coral Reef Society
- Australian Museum
- Austral University of Chile
- Bioplatforms Australia
- Center for Ocean Solutions, Stanford University, USA
- Centre National de la Recherche Scientifique, France
- Conservation International, Philippines
- David and Lucille Packard Foundation, USA
- Deutsche Forschungsgemeinschaft Excellence Cluster "Future Ocean", University of Kiel, Germany
- Ecology of Infectious Marine Diseases Research Coordination Network, USA
- ETH Zurich, Switzerland
- Fisheries Research and Development Corporation, Canberra
- Great Barrier Reef Foundation, Brisbane
- Great Barrier Reef Marine Park Authority, Townsville
- Ian Potter Foundation
- Institute for Pacific Coral Reefs, French Polynesia
- International Society for Reef Studies
- International Union for the Conservation of Nature
- James S. McDonnell Foundation, USA
- King Abdullah University of Science and Technology, Saudi Arabia
- Lizard Island Research Station, Queensland
- Lord Howe Island Board
- L'Oréal Australia
- Marine Parks Authority, Lord Howe Island Marine Park
- National Climate Change Adaptation Facility, Australia
- National Environment Research Program, Australia
- National Oceanic and Atmospheric Administration, USA
- National Research Foundation of South Africa
- National Science Foundation, USA
- New South Wales Office of Environment and Heritage
- Northern Gulf Resource Management Group, Queensland
- Okinawa Institute of Science and Technology Graduate University, Japan
- Palawan State University, Philippines
- Pew Charitable Trusts, USA
- Queensland Department of Science, Information Technology, Innovation and the Arts
- Queensland Parks and Wildlife Service
- RARE Conservation, Philippines
- Reef Rescue, Australia
- Resilience Alliance, Sweden
- Save Our Seas Foundation, Switzerland
- Sea World Research and Rescue Foundation
- Secretariat for the Pacific Community, Noumea
- Sesoko Station, Tropical Biosphere Research Center, University of the Ryukyus, Japan
- Seychelles Fishing Authority
- Silliman University, Philippines
- Smithsonian Marine Network, USA
- Stockholm Resilience Centre, Sweden
- University of Perpignan, France
- Virginia Chadwick Foundation, Australia
- Western Australian Department of Fisheries
- Western Australian Department of Parks and Wildlife
- Western Indian Ocean Marine Science Association (WIOMSA), Zanzibar
- Wildlife Conservation Society, New York
- Wildlife Preservation Society of Queensland
- WorldFish, Malaysia
- World Wildlife Fund (International), USA
- Yulgilbar Foundation, Australia

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